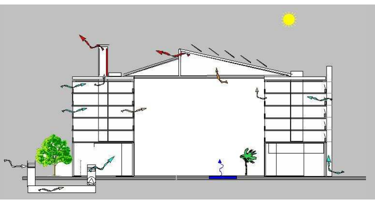
Innovative Building Technologies for
the 2000 Watt Society (House 2000)



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CCEM House 2000

Innovative Building Technologies for the 2000 Watt Society

Final Report

Content

Dübendorf, 15.12.2010

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1. Executive summary

The CCEM House 2000 project is looking for new technical solutions in the building construction sector to reduce the CO_2 emissions substantially. The projects are based on individual national and international research projects (SFOE, CTI, Swisselectric Research, International Energy Agency IEA) and cover the topics of building materials, advanced building installations and smart control. The results will be implemented in a demonstrator project, which will be the focus of the activities in the final stage of the project. The activities of the different work packages are summarized as follow:

A Advanced building materials and components

A1 High performance insulation materials based on fiber reinforced aerogels

A new generation of insulation material with a thermal conductivity below 20 mW/(mK) is based on the very good thermal performance of aerogels. Within a CTI project with an industrial partner a new process chain has been developed successfully. The CTI project has been completed, all reports are confidential.

A2 Advanced vacuum insulation panels (VIP of the 2nd generation)

New technologies such as vacuum insulation panels (VIP) offer the possibility to achieve highly insulating walls by slim overall wall thickness and better integration into buildings. Degradation and failure risks as well as high production cost are main drawbacks of existing market products. The main activities within this project, complementary to the activities in the CCEM-CH project Advanced Building Retrofit, are:

- Development of advanced building components with integrated VIP
- Service life investigation, improved quality control and product declaration procedures
- Design of the VIP building envelope for the demonstrator unit in cooperation with the industry
- In situ measurements of the hygrothermal behavior of VIP applications at different locations in Switzerland

A3 Colored glazed solar collectors for heating and cooling

The project aims at the development of new solar thermal façade systems with improved architectural quality, to help increase the use of solar energy for heating and cooling in buildings. To overcome the problem of users' and architects' dissatisfaction with the aesthetics of black solar absorbers' integration into facades, new coloured thin film glass coatings with selective reflection properties will be used. While letting most of the solar radiations reach the absorber, these coatings reflect a portion of visible light. Furthermore, the glass is treated to have diffusing characteristics. This coloured appearance and the choice of glass structure are expected to open new architectural options in façade design, with all the induced market opportunities. The work is divided into two subtasks related to the following problems to be solved:
- Thin film technology (optimising optical reflection and high solar transmission)
- Architectural integration (aesthetic and technical solutions for façade integration)

A4 Thermally activated ceiling panel with PCM

The concept of a thermally activated ceiling panel with phase change material (PCM) has been developed at EMPA and has been registered as international patent EP1470372 / WO03064931. The patent rights have now been sold to an industrial company. Within CEEM House 2000 the activities focus on checking the feasibility to apply the technology of PCM to the CCEM demonstrator unit.

B Soft heating and cooling technologies

B1 Open absorption systems for cooling and air conditioning

A conceptual design of a new type of air handling unit (AHU) was developed, built and tested experimentally in the laboratory. The AHU operate as an open absorption system (atmospheric pressure), although no direct contact takes place between the air and the liquid desiccant (LiCl). Air and desiccant are contacted through adequate membranes, thus avoiding desiccant aerosols and solving the attending corrosion and potential health problems. Furthermore, confining the desiccant also permits a reduction of the amount of desiccant required in relation to common open systems. The concept considers an absorber / dehydrator, an evaporative cooler and a desorber / regenerator, built as compact membrane contactors.

This type of AHU will reduce electric energy demand for air conditioning. The driving energy will be provided by a hot source at temperatures in the 70-90 °C range which might be delivered through district heating networks, since there is typically excess heat in summer. On the other hand, solar thermal energy becomes a real alternative, since the driving energy is required at a level well bellow that of traditional closed absorption systems. A pre-prototype shall be designed and build to proof the concept.

B2 Solar long-term sodium hydroxide heat storage

To push the use of solar heat, seasonal storage systems are needed. Conventional water storage systems are voluminous and loose energy during storage time. Chemical storages shall overcome these disadvantages but they are more expensive. To avoid the costs for a backup heating system, a mono-valent system consisting of a storage combined with sun collectors is envisaged. For a mono-valent system, it is essential that even with an almost empty storage (in spring), domestic hot water will be delivered at high temperatures.

Chemical heat stores for low temperature heat rely on absorption/desorption processes. Several combinations of sorption material and working fluid promise success. In this project, the working pair chosen is NaOH and water. The advantages of this working pair are high heat capacities (3 to 6 times higher heat capacity compared to conventional water storage systems), stable and relatively cheap reactants, and moderate environmental hazard compared to other working pairs.

Depending on the working pair, a heat storage system has to be developed, which is operating at an optimal working point. Since that system is new, there is no knowledge, what the optimal working point defines. Experimental work (variation of parameters) and simulations shall deliver theoretical and practical expertise.

B3 Solar thermal absorption cooling (STAC)

An increased economic interest on solar thermal cooling is noticed because of the high availability of solar energy in summer time (hot season) and because of a high price electrical energy peak cutting pressure. Common absorption chillers have originally been designed for large-scale industrial application of cooling power in the range of 100 kW_R, steady-state operation, mostly using comparably high generator driving temperatures (> 110°C for single-effect mach ines; > 185°C for double-effect machines).

This project focuses on a Swiss test facility for STAC applications, where applied R&D work can be made in the areas of system integration as well as controls using a newly developed 10 kW_R LiBr-H2O absorption chiller in combination with a 30 m^2 array of novel high-efficiency flat-plate solar hot water collectors at the HSR campus. The system integration with these flat-plate solar hot water collectors and optimal buffer storage devices as well as associated adaptive controls is now needed and will be supported by a new developed "solar cooling" module in the “Polysun” software to progress this promising technology development path.

A hybrid cooler for heat rejection in the mid temperature range was installed in a LiBr-H_2O solar thermal driven absorption cooling system. The heat rejection efficiency generally is increased by continuous water sprinkling on the heat conducting surface of the heat exchanger and the water evaporation thereof. To reduce the amount of water use the cooler heat exchanger was pulse-sprayed through nozzles. By decreasing the pulse cycle time the return fluid temperature to the absorber condenser unit of the absorption cooling machine could be lowered and reached the fluid temperature of the open cooling tower for comparison. A strong inhomogeneity of the temperature distribution on the hybrid cooler heat exchanger could be observed.

B4 Efficient heating and cooling with heat pumping technologies

The project aims to deliver new integrated solutions for combined operating systems covering heating, cooling and domestic hot water especially adapted to the requirements of low and ultra-low energy houses representing the vision of the 2000-Watt Society. Complete system solutions for MINERGIE® and MINERGIE-P® housing are to be developed using the most advanced active and passive systems combined with the use of heat pumping technology.

Problems to be solved by means of simulations and measurements are:
- Which building type requires which hydraulic design (capability, costs)?
- What is the best control scheme (efficiency, robustness, investment)?
- Which rules and guidelines can be derived?
- How can advanced heating and cooling concepts be disseminated with a real space unit?

During the report period the work was concentrated on the development of integrated system configurations covering heating, cooling and domestic hot water and a system selection method with the corresponding criteria for various residential heat pump types including heat sources and emission systems. Five standard solutions for an energy efficient heating and cooling of low energy buildings with heat pumps were derived.

Furthermore in a residential building in Muolen (canton St. Gallen) a pilot plant with ground coupled heat pump for heating, domestic hot water generation and passive cooling by means of a vertical borehole heat exchanger has been measured since beginning of this year and investigated.

C Smart control and user interfaces

C1 Control of thermally activated buildings systems (TABS-Control)

The control of thermally activated building systems has been investigated in detail within a CTI project, which was completed with a public hand book in 2009. The project focused on the following tasks:

- Develop comprehensive solution(s) for the control of thermally activated building systems (TABS)
- Implementation of software functional units in existing control systems
- User-friendly description of the concepts for HVAC- and control engineers (guide book)

C2 Advanced bio-mimetic user-adaptive blind and lighting controller using wireless sensors

The CTI research and development project BELControl, carried out by LESO-PB/EPFL (Lausanne) and Adhoco (Winterthur) is the base for the contribution to the CCEM-Retrofit and CCEM-House 2000 projects. The project includes 3 tasks:

- Control algorithm development for user-adaptive blind and lighting control
- Experimental tests preparation
- Field tests

The CCEM-CH specific tasks address two issues: the specificity of control system issues for a building retrofit, and the experimentation on a demonstration building unit which will be implemented on the EPFL campus in Lausanne, in the framework of the CCEM-House 2000 project. The tasks below are specific to the CCEM-CH project:

- Elaboration of a simulation and design tool for control systems
- Guidelines and catalogue of existing solutions for retrofit
- Retrofit field tests
- Field tests on the CCEM-demonstration building units

C3 Use of weather and occupancy forecasts for optimal building control (OptiControl)

The OptiControl project deals with the development of predictive control strategies that aim in minimizing the energy usage of buildings whilst maintaining or even improving occupant comfort and reducing peak electricity demand.

During the first two project years the focus was on the application “Integrated Room Automation” (IRA), and on office buildings. IRA deals with the automated control of blinds, electric lighting, heating, cooling, and ventilation of an individual building zone or room.

The project successfully provided improved conventional (rule-based) IRA control algorithms, as well as a family of entirely new, Model Predictive Control (MPC) algorithms that were tailored to the needs of building control. These works are paving the way towards the development of a new generation of controllers offering an unprecedented efficiency, robustness, flexibility and quality of control.

A second major achievement was the development of a general methodology, as well as of corresponding software tools and data sets that can be used for the systematic, quantitative assessment of building control approaches. The availability of appropriate modeling and simulation tools is pivotal for the development and analysis of advanced control approaches. Such approaches are increasingly needed in order to meet the demanding requirements posed by many modern building control tasks.

A comprehensive simulation study was undertaken to assess the savings potential of predictive control for IRA. The study involved ~23’500 whole-year, hourly time step dynamic simulations that compared various control algorithms for five carefully selected combinations of heating, cooling and ventilation subsystems, and for different façade orientations, construction types, building standards, comfort requirements, internal gains levels, locations etc.

A further achievement consisted in the development of specialized algorithms related to the derivation and improved forecasting of hourly weather data relevant for building simulation and control. In general, forecast biases could be successfully removed on a seasonal basis.

D Demonstration, dissemination and education

D1 Design and construction of an energy sufficient space unit using advanced building technologies

The self sufficient space unit SELF is a demonstrator for energy efficiency and sustainable construction. It has special focus on technologies developed under CCEM House2000. The purpose of this demonstrator is to apply and evaluate the interaction of various advanced building technologies in a real application. It will be used to demonstrate CCEM related innovations, to perform system studies with students and to use the experience gained for training courses and seminars.

The design study and the energy concept developed within a diploma work of students of Zurich University of Arts (ZHdK) and the Institute for Energy in Buildings of the University of Applied Sciences of North-Western Switzerland (FHNW) was used for the realisation of the demonstrator. In addition, user needs and requirements for a self sufficient space unit were analysed by students of the FHNW School of Applied Psychology.

During 2008, the detailed design of the demonstrator unit and its components has been completed and the construction of two units has been started in 2009. The first has been exhibited at the 2010 Swissbau in Basel. Unfortunately the unit was destroyed by a fire in April 2010. A second unit will be built up in 2010 with an external storage container for the lithium-ion batteries.

Core team: Mark Zimmermann, Empa (lead), Thomas Frank, Empa (lead CCEM House2000), Christian Roecker, EPFL Leso-PB, Roland Stulz, Novatlantis

Figure 1: Photorealistic rendering of the two self sufficient space units (design by Bijörn Olsson and Sandro Macchi)

2. Current state of projects compared to the proposal's aims /milestones

The CCEM project House 2000 started in May 1st 2007 and has been completed in April 30th 2010. One difficulty observed was that the different projects involved in House 2000 have different running periods due to the heterogenic external funding situation. The current state of the projects is summarized as follow:

A Advanced building materials and components

A1 High performance insulation materials based on fiber reinforced aerogels

The CTI project has completed the material development successfully. The process optimization and up-scaling phase has been finalized. The design of a small pilot plant has reached a final status and was the basis for the decisions to be taken by the industrial investor. The CTI project has been completed in 2009, results and reports are confidential.

A2 Advanced vacuum insulation panels (VIP of the 2nd generation)

VIP optimization: The activities on optimization of the VIP system (core / barrier / environmental parameters vs. service life) was continued during this year. New activities have be started together with an industry partner in 2009.

Encasement: Two industry partners (Porextherm, Glas Trösch) agreed to support investigations on encased VIP. Test elements are designed and produced to investigate the aging behavior of sealed VIP in comparison with non-sealed VIP.

Aging, service life, modeling: The monitoring activities (SFOE project 101'478) on VIP floor/roof areas were continued as planned. Results are reported in publications and in the Annual Reports of CEEM-CH Advanced Building Retrofit and SFOE.

Building elements: New VIP façade constructions were realized in collaboration with industry partners (ZZ Wancor AG, neofas AG, Akzo Nobel AG).

A declaration procedure for the thermal conductivity of VIP products is needed, taking into account the aging effects during the lifetime of the product. A new project sponsored by SFOE has been started.

Space units: The design phase of the self-sufficient space unit has been completed. The construction phase has been launched.

A3 Colored glazed solar collectors for heating and cooling

On the filter development side, a major improvement has been the reception, installation and operation of an "old" vacuum evaporation system, given by the industry. This system has been restored, improved and tested at the beginning of the year by Dr. Schüler team. This system allows us to develop thin film layers on one side of the glasses, giving results very close to the industrial version achieved by magnetron sputtering, as opposed to the 2-sides version obtained by dip-coating.

On the architectural side, the search for industrial extra-white glasses with one side diffusing treatment has been conducted, collecting glass samples to be measured for their energy transmission properties. A large collection of glasses has been assembled, but ending with very few interesting products. One industrial product at least has been identified, but further search has been frozen by the finding of an innovative and promising diffusing treatment by Dr. Schüler team. Discussions with industrial partners are under way. Main result is that the possibility to obtain real size samples for pilot installations at a reasonable price is now obtained.

Several contacts with potential industrial partners have been established for the use of these glasses, but the major contract between the LESO and the company Swissinso, financing two PhD. students, makes these contacts more delicate to handle.

The architectural integration theory has progressed well with the PhD thesis completed by end of 2008 (MariaCristina Munari Probst, at LESO-PB). Several simulations have been produced using the new glazing, showing the advantages for the architects to use the same glass in front of collectors and insulation.
The LESO is also a major player in a new IEA Task (Task 41, "Solar Energy and Architecture"), and integration of the developed glasses are part of a broader strategy to increase the quality of solar thermal integration into buildings.

A4 Thermally activated ceiling panel with PCM

The patent transfer negotiation to an industrial partner is completed. The use of a PCM material for the CCEM demonstrator has been evaluated. A design of the wall sections of the demonstrator space unit with VIP and PCM has be completed.

B Soft heating and cooling technologies

B1 Open absorption systems for cooling and air conditioning

The focus of the main project work lies on the build-up of a prototype to verify experimentally the functional behaviour of the membrane system in the laboratory. The work plan defines the following milestones :

- Design and building up an example of a membrane contactor module, concluded.
- Test a laboratory-scale prototype of an air handling unit with build-in contactors, concluded.
- Evaluation of a possible patent registration, concluded.
- Definition of a follow up project with an industrial partner, concluded.

The project has ended 2008, a final report is available from SFOE. The definition of a follow up project is finished and submitted to the SFOE. Due to changes in the focus of research at the building technology lab, Empa is not a partner in the following project any more.

B2 Solar long-term sodium hydroxide heat storage

The objectives and milestones of the project are:

- Development, design and construction of a laboratory-prototype with one absorption stage to show the functionality, concluded.
- Start of operation, completion and fine tuning of the construction with one absorption stage, concluded.
- Test of functionality and performance of the first stage, concluded.
- Upgrade the storage with the second absorption stage, which allows a much higher energy density, in progress.
- Development of a mathematical model of the storage to simulate and optimize the storage, in progress.
- Theoretical optimization of the storage construction, concluded.
- Modelling of a storage system with all components (solar collectors, ground heat exchanger and buffer storage), to do.
- Definition of a storage system for the CCEM demonstrator, to do.

The project has a delay of about 9 months compared to the original working plan.

B3 Solar thermal absorption cooling (STAC)

The following aims and milestones have been achieved:

- Preparation of the engineering design of a complete STAC test system, installed at the HSR campus.
- Installation and commissioning of all key components, including comprehensive data monitoring system.
- Development and implementation of a fist step absorption chiller software module in the Polysun software tool to simulate the solar system part and the cooling need of a predefined building.
- Multi-parameter tests to generate quality data for the development of a TRNSYS-based system performance model.
- Development and verification of optimized system control algorithms for fixed and variable cooling mode options.
- Preparation of design details for down-scaled STAC technology for domestic applications.

The increased need of air conditioned working and living rooms leads to a higher energy consumption. The regional dependence of the climatic conditions allows the use of water operated open cooling tower for efficient heat rejection from the absorber condenser unit of the absorption cooling machine. In these open cooling towers the cooling effect is mainly affected through the evaporation of water out of the cooling water stream. The cooled water can in principle reach wet bulb temperature. While water is evaporated the same amount of water has to be added to keep a constant water level in the cooling tower sump. To avoid the accumulation of lime scale, debris and the contamination of the water with dust, pollen and growing algae the cooling water has to be replaced and to be treated with biocides . To avoid hazardous legionella in the sump of the cooling tower a chemical treatment of the water has to be done periodically. Fresh water as valuable resource should be saved and sustainably used. In a hybrid cooler for heat rejection the efficient evaporative cooling effect can be applied by a continuous water sprinkling on the heat conducting heat exchanger surface. In the following an alternative system of continuous operating sprinkling system, namely heat rejection by pulsed water spraying on a hybrid cooler heat exchanger in a LiBr-H_2O solar thermal absorption cooling (STAC) system is presented.

B4 Efficient heating and cooling with heat pumping technologies

The SFOE project "Heating and cooling with ground-coupled heat pumps" has been finished in August 2007. The final report and a fact sheet are now available on the website www.energieforschung.ch (report No 270057).

In the SFOE project "SEC: Standard solutions for Efficient Cooling with heat pumping technologies" the evaluation of the defined systems layouts and control concepts by simulation, a scheme for the system selection and a design tool for a floor heating and cooling systems have been developed. The field measurements of a single family residential house with ground coupled heat pump for heating and passive cooling started in winter January 2009 with an extended commissioning and optimization period. The evaluated measurement period started in spring 2009 and will last for one year (see [B4-34] and [B4-39]). The project SEC has been extended until end of June 2010.

In the SFOE project demonstration building Cosyplace a MINERGIE-P® multi family house with 5 apartments and a ground-coupled heat pump for heating, domestic hot water and passive cooling has been monitored for two years until end of September 2009. Interim results have been published (see [B4-32] and [B4-35]), and the final report will be published in spring 2010.

The project IEA Heat Pump Program Annex 32: Economical Heating and Cooling Systems for Low-Energy-Houses started in January 2006. Work is carried out task-shared and cost-shared with support of member countries and the SFOE. By the end of 2009 the national projects will be concluded. In the first half of 2010 the draft final report with deliverables regarding the system solutions, design recommendations, developed prototypes and field monitoring results will be completed. Publishing is expected in autumn 2010 after reviewing by the HPP ExCo. Publications in the frame of the IEA HPP Annex 32 in 2009 are listed in [B4-25], [B4-26], [B4-27], [B4-28], [B4-29] and [B4-30].

C Smart control and user interfaces

C1 Control of thermally activated buildings systems (TABS-Control)

The CTI-Project TABS-Control has officially been terminated by the end of 2008. One of the main products of the project, the handbook and the simulation tool for TABS-Control solutions were finalized. With the publication of the handbook in spring 2009 the CTI-project was also internally (Empa and Siemens) terminated.

Technology transfer actions concerning the application in a CCEM demonstrator are possible but have not been taken up until now. A major knowledge transfer has taken place

C2 Advanced bio-mimetic user-adaptive blind and lighting controller using wireless sensors

A new PhD student (David Daum) has started his work at LESO-PB/EPFL, on April 1st, 2008. After some investigation, we have decided to use the same simulation tool (IDA/ICE) already used by the CCEM retrofit project partner in charge of work package A5 (Integrated HVAC solutions). We will therefore be able to share the simulation work in a more efficient way.

We have started the simulation of a simple building (specifications are close to the LESO building), with an advanced controller based on the use of Fuzzy Logic. A novel approach has been defined, where we consider a multi-objective minimization and mutually contradictory objective functions. As an illustration of this method, we can show the case of a blind controller trying to minimize simultaneously the heating/cooling demand and the lighting discomfort, by finding the optimal value of the Fuzzy Logic rule base parameters. Genetic algorithms are used for the minimization, and the IDA/ICE tool is used for the simulation. Objective one is the integrated heating/cooling demand energy during a given period, and objective two is the visual comfort of the occupant (considering as an example a simple definition of the lighting discomfort, i.e. the number of hours where the daylighting inside illuminance is less than 300 lux).

This approach allows a careful tuning of a controller if we have a good simulation model of the building. It is not exclusive with the optimization by using the user interactions, as it was done in the LESO-PB/EPFL AdControl project and in the CTI/KTI BELControl project. Of course, we need to take into account a better definition of the comfort, including both visual and thermal comfort (and probably two separate objective functions) and the total energy consumption including the electric lighting.

C3 Use of weather and occupancy forecasts for optimal building control (OptiControl)

During its first two years the OptiControl project has successfully answered many important questions related to the potential, utility and feasibility of predictive building control. In particular, promising new control algorithms were developed, and two suitable buildings for demonstration purposes were identified.

From a more methodical point of view, the project has pioneered research at the interface of buildings, applied meteorology, modeling/simulation, and control. These results have only been possible thanks to the excellent collaboration between all project participants and the unique combination of expertise in the project team.

Most milestones of project Phases I ("Initial Exploration and Sensitivity Analyses") and II ("In-Depth Investigations") were reached successfully.

Nevertheless, a scientifically sound comparison of control approaches revealed to be much more challenging than initially expected. The main reasons related to the unexpectedly high complexity of the systems considered and the large number of variants and choices involved.

Also, additional work remains to be done in order to make the novel, predictive control strategies suitable for use in practice. This includes their integration in commercial Building Automation and Control systems and the appropriate consideration of internal heat gains that so far have not been treated in as much detail as originally planned.

For these reasons it was agreed with the main sponsor swiss*electric* research to postpone the demonstration objective to a follow-up project and to redefine the goals for the third project year / Phase III (initially "Demonstration") as follows: (i) Finalization of at least one novel, rule-based predictive control algorithm for IRA (the algorithm will accommodate weather forecasts as one option). (ii) Pushing further the development of Model Predictive Control (MPC) algorithms for IRA towards their finalization at prototype level. (iii) Further simulation-based assessments on the theoretical savings potential and the benefit/cost of predictive control.

Figure 2 gives an overview of the developed Model Predictive Control (MPC) procedure for buildings. The procedure requires that measurements of the building state and the local weather conditions are available. These measurements are sent to the MPC controller alongside weather predictions that are corrected with local measurements , as well as information about energy costs and comfort criteria.

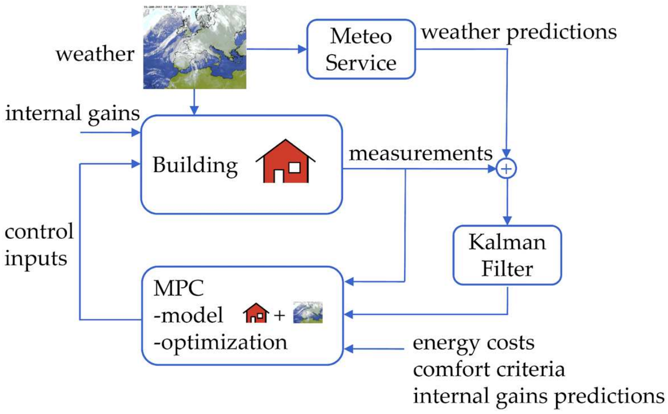

Figure 2: Application of Model Predictive Control MPC to building control (Reference Oldewurtel [C3-12])

D Demonstration, dissemination and education

D1 Design and construction of an energy sufficient space unit using advanced building technologies

The first demonstration space unit was completed with great support by the industry by the end of the year 2009 and spring 2010. It contains the full functionality as a self sufficient space unit for living and work. In addition to the original plans, the space unit includes additional innovative solutions with the assistance of labs from eawag and empa for:

- Water usage and recycling
- Hydrogen production and storage for optimized usage of estival solar electricity gains
- Power station for electric mobility

Due to the fire accident which destroyed the unit, a second space unit has been built up during 2010 and will be finalized in spring 2011.

3. Main results

A Advanced building materials and components

A1 High performance insulation materials based on fiber reinforced aerogels

The up-scaling of the material production process has been completed successfully, the patent situation has been evaluated. A cost optimization study on the up-scaling process has been performed. The investment cost for a small pilot process chain has been analyzed in detail. The CTI project has been completed.

A2 Advanced vacuum insulation panels (VIP of the 2nd generation)

In order to start the activities on optimized core materials vs. service life, contacts with interested industry partner have been established.. Optimized evacuated insulation panels have be investigated in work package 3.

The updated monitoring results on VIP in roof/floor areas show good agreement of predicted and measured aging effects. Aging effects are in an acceptable range even in building envelope applications with rather high temperature and humidity loads, and is almost negligible in cold and dry environment as in the floor of a cooling / freezing chamber.

Two pilot façade areas with VIP insulation were planned and built in collaboration with industry partners (ZZ Wancor, neofas, Akzo Nobel). Sensors and data logging systems were installed for monitoring the thermal and hygric behavior. Functioning of the VIP façades have been checked by infrared imaging.

The quality project on VIP with SFOE support (Project No. 102'134), continued with Eicher & Pauli AG and several VIP manufacturers. Rules for the quality management and for the determination of the long-term performance of VIP have been defined and are now applied for actual products.

A3 Colored glazed solar collectors for heating and cooling

Glazing with several new colours with improved transmission coefficients have been obtained, for measurement purpose and to offer the choice to the architectural integration team. A special set of demonstration boxes for small size samples has been set and used for colour selection. They have also been presented to several visitors and potential industrial partners.

Figure 3: Mini demoboxes with coloured collector glass samples

On the architectural side, the search for industrial extra-white glasses with one side diffusing treatment has been conducted, collecting glass samples to be measured for their energy transmission properties. A large collection of glasses has been assembled, but ending with very few interesting products. One industrial product at least has been identified, but further search has been frozen by the finding of an innovative and promising diffusing treatment by Dr. Schüler team. Discussions with industrial partners are under way. Main result is that the possibility to obtain real size samples for pilot installations at a reasonable price is now obtained.

A4 Thermally activated ceiling panel with PCM

The patent rights have been successfully transferred to an industrial partner. The building and systems simulation cases with TRNSYS, used in the master thesis on the application of PCM ceiling panels in combination with earth-coupling and heat pumps, were further used for the simulation and evaluation of chilled ceilings in combination with earth-coupling. The results of this study have been presented at a EMPA workshop [A4-1].

B Soft heating and cooling technologies

B1 Open absorption systems for cooling and air conditioning

The project has ended in summer 2008, therefore no new achievements are given for 2009.

The main goal of the project, showing the feasibility of an air handling unit working with open absorption and membranes was partly achieved. The absorber/dehydrator was working very well. The results in dehumidification the air had been until 150% better than comparable systems. Unfortunately, the desorber/regenerator couldn't stand the temperatures above ca. 65℃, therefore we hadn't been able to test this mo dule seriously.

As a secondary goal, a design of the heat and mass exchanger elements was developed, in which the membrane can be handled in a safe manner. Other findings concern the design of the module. So, the follow up project has the aim to change the construction of the module in a manner that it can stand temperatures until 90℃. Additionally, a newly developed membrane will be tested.

B2 Solar long-term sodium hydroxide heat storage

The prototype of the storage system with one absorption stage has been completed, some changes in the design of the construction were necessary (change of the position of the inlet and outlet, incorporation of a radiation barrier to reduce heat losses, change of the tube material, improving the tightness of the system). Measurements show until now a good correspondence with calculated results.

In 2009 a series of tests were carried out:

- The functionality of the prototype with low concentrated NaOH lye has been verified.
- A high heat loss in the heat/mass exchanger was detected. For the decharging cycle, which is working with about a speed of 1/3rd compared to the charging cycle, the heat losses are therefore significant.
- With high concentrated NaOH lye, crystallization made the pumping process impossible. Different measures to prevent the crystallization were not successful.

All the findings of this functionality tests flow into an improved design of the newly planned second stage. This second stage shall be installed by end of January.

The work on the simulation model in conjunction with TRNSYS is not yet completed and has to be experimentally validated.

B3 Solar thermal absorption cooling (STAC)

The STAC test system at the HSR campus is ready for use and first measurement results are available.

The absorption machine has a designed refrigeration power of P_R = 10 kW_R. A flat-plate collector field of 30 m^2 was installed and for the cooling energy distribution 80 m^2 radiand ceillings are used. For the heat rejection to the ambient an open water cooling tower is installed. The hot water stoarge tank of 970 l equalizes the available solar power and the absorption machine heat energy use or the buliding cooling energy need, respectively.

The 10 kW_R SK Sonnenklima LiBr-H_2O STAC machine is usually equipped with an open cooling tower type wct23kW for heat rejection. Such a machine is installed at SPF-HSR for investigations. To reduce water consumption a dry cooler was installed at SPF-HSR in addition to the cooling tower. This dry cooler was equipped with spray nozzles. With the water sprayed on the lamella of the heat exchanger through the nozzles a higher heat rejection efficiency of the dry cooler can be achieved. In this hybrid heat rejection mode a reduction of the water use / consumption can be reached by increasing the OFF period in spray cycle time. The spray cycle time consists of the sum of the ON and the OFF times of the magnetic valve – open and closed water pipe.

The most efficient cooling principle is reached by fluid evaporation e.g. a phase transition from liquid to vapour, because the latent heat of evaporation Δh_v is generally several times higher than the specific heat capacity $c_p(T)$ of the fluid.

Conclusion and outlook:

In a heat rejection system open cooling towers can be replaced by hybrid coolers. The rejected heat power has the same level in both system types but the temperature of the return fluid to the absorption cooling machine is slightly higher in case of the hybrid cooler. The temperature difference can be reduced by decreased spray cycle times e.g. shorter OFF time periods. In contrary the water consumption is increased and the advantage of low water use holds no longer. A higher return fluid temperature has the consequence of a decreased cooling power by 0.7kW/℃ [3] of the absorption c ooling machine.

A better dispersion of the sprayed water on the lamellas would increase the heat rejection power and a lower cooling fluid temperature should be reached. In further experiments the effect of a homogeneous wetting of the heat exchanger surface on the return fluid temperature has to be examined and has to be compared to the effect of reduced magnetic valve cycle time.

B4 Efficient heating and cooling with heat pumping technologies

In the project "SEC: Standard solutions for Efficient Cooling with heat pumping technologies" integrated system configurations covering heating, cooling and domestic hot water have been defined for various residential heat pump types including heat sources and emission systems. The evaluation of these systems applied to a newly defined residential reference building is nearly finished. For the passive ground coupled cooling mode the influence on the heat pump seasonal performance in heating and domestic hot water mode was evaluated. The increase in the borehole heat exchanger outlet temperature with a cooling load up to 41% of the heating load is of minor significance for the space-heating mode. Nevertheless, the increase in the yearly average outlet temperature during DHW operation lies between 0.7 K and 1.7 K and the resulting increase in the performance factor of the heat pump lies between 2% and 5%. During cooling days the outlet temperature rises between 1.9 K and 4.8 K and with this the heat pump performance increases between 6% and 16%.

The interim results of the field monitored multi-family house CosyPlace showed a good thermal comfort with room air temperatures of mostly 20℃ to 24℃ in the winter and 21℃ to 26℃ in the summer period. The settings of the heat pump in heating mode have been optimized with reduced space heating flow temperatures and an optimized buffer storage use which increased the heat pump generator performance factor from 4.0 for the winter 2007/2008 to 4.3 for the winter 2008/2009. The space heating energy demand is still substantially higher than expected. Also the cooling operation could be improved by lower flow temperatures which result in a more intensive cooling with equal energy expenditure. This was highly appreciated by the inhabitants of an apartment, while inhabitants of another apartment didn't use the cooling function at all.

The collaboration within the IEA HPP Annex 32 is an excellent opportunity to exchange results from research activities on heat pumping technologies from different countries worldwide. In 2009 interim results have been discussed on two Annex 32 working meetings and presented on an IEA Workshop "Towards Net Zero Energy houses" and on the national Heat Pump Symposium of the SFOE research program. Updated information on the IEA HPP Annex 32 is found at the project website at URL http://www.annex32.net.

C Smart control and user interfaces

C1 Control of thermally activated buildings systems (TABS-Control)

The CTI project is officially terminated, the main results are:

- Publication of the project handbook and of the Excel-design-tool for TABS.
- Integration of control algorithms into the Siemens *Desigo* product line.

C2 Advanced bio-mimetic user-adaptive blind and lighting controller using wireless sensors

The main goals of the CTI project were achieved, tested products are commercially available from the industry partner Adhoco (Winterthur) and operational and energy comparison tests were performed. The energy comparison was done by simulation only. The industry partner decided not to file a patent application. Instead, they will keep the control algorithm details confidential.

For the CCEM-CH specific project, the following work items are considered:

- Definition and start of a PhD thesis including the requirements of both CCEM-Retrofit and CCEM-House 2000.

- First simulations with the IDA/ICE tool on a simple building using an advanced blind controller based on Fuzzy Logic for minimizing simultaneously the heating and cooling demand and the lighting discomfort.

C3 Use of weather and occupancy forecasts for optimal building control (OptiControl)

Detailed information on the project is presented in the web site under www.opticontrol.ethz.ch. The website was designed to serve the following purposes: (1) Presentation of the OptiControl project to a wider public, (2) Provision of software and data (public & internal; e.g., literature list on the topic of predictive building climate control), (3) Support of project work, (4) Running documentation of results (in particular see the "Internal" section).

During the first two project years the focus was on the application "Integrated Room Automation" (IRA) and on office buildings. IRA deals with the automated control of blinds, electric lighting, heating, cooling, and ventilation of an individual building zone or room.

The project lead to the formulation of improved conventional (rule-based) IRA control algorithms, as well as a family of entirely new, Model Predictive Control (MPC) algorithms that were tailored to the needs of building control and that support the integration of weather forecasts and the uncertainty in the predictions. The MPC algorithms differ in their degree of sophistication, computing requirements, and robustness to disturbances and modeling errors. Detailed comparisons of annual non-renewable primary energy usage and various comfort statistics for 18 representative building cases suggested that the more advanced MPC algorithms systematically outperform the best available present-day solutions. The work done so far paves the way towards the development of a new generation of controllers offering an unprecedented efficiency, robustness, flexibility and quality of control.

A second major achievement was the development of a general methodology and of corresponding software tools and data sets that can be used for the systematic, quantitative assessment of building control approaches. This outcome is significant because requirements for building control are likely to increase in the future, and the needed solutions can only be developed and analyzed with the aid of appropriate modeling and simulation tools.

The developed methodology was applied to assess the theoretical savings potential of predictive control for IRA. To this purpose a comprehensive modelling and simulation study was undertaken that compared state-of-the- art, rule-based control approaches with perfect predictive control that assumed perfectly known systems and disturbances (weather, occupancy). Considered were ~23'500 whole-year, hourly time step dynamic simulations for five carefully selected combinations of heating, cooling and ventilation subsystems, and for different cost functions, locations, building standards, construction types, facade orientations, window area fractions, internal gains levels, ventilation strategies and thermal comfort requirements.

In 80% of all investigated cases for the "Passive House" building standard the found theoretical savings potentials were between 0.7 and 4.7 kWh/m^2/a (2–18%). For the "Swiss average" building standard this range was 2.2–5.3 kWh/m^2/a (4–16%). In several cases the theoretical savings potentials were well above 20%. Our simulation studies gave an insight not only into the comparative performance of control approaches, but also into the relative importance of changes in key factors affecting the control performance (e.g., presence vs. absence of night/weekend set-backs, variations in thermal comfort range width etc.). Generally, the large spread of the results highlighted the importance of the newly developed software and tools for the comparison of different controllers and key assumptions on a case-by-case basis.

A further achievement consisted in the development of specialized algorithms to improve hourly weather forecasts relevant for building simulation and control. Forecast biases could be successfully removed for the most part on a seasonal basis. The root mean square error of local air temperature and wet bulb temperature predictions for the first 24 hours ahead was reduced by on average 20–30%. For global radiation components on vertically oriented surfaces no reductions or slight increases were obtained for winter and summer, but reductions of 10–60% were achieved for spring and autumn.

Two candidate buildings for demonstration of the new control technologies were identified, and corresponding project sketches were formulated. The first building was a representative modern office building, building "C1" of Actelion Pharmaceuticals Ltd. in Basel/Allschwil, Switzerland. The second building is a highly glazed office building of another major company located in Basel (negotiations with all stakeholders for the second building are currently ongoing).

Finally, thanks to the above successes both the industry partner Siemens, as well as the main sponsor swiss*electric* research, took a positive decision regarding the continuation of the project during a third project year (Period August 2009 – July 2010).

D Demonstration, dissemination and education

D1 Design and construction of an energy sufficient space unit using advanced building technologies

The main achievements of this year are:

- Detailed design and specification of systems and components.
- Project definition with Eawag for the water system and Empa Hydrogen Lab for the hydrogen system
- Project definition with Empa Electronics & Metrology Lab for the electrical system including PV and smart control
- Dynamic energy simulation of the final design (see Figure 4)
- Commissioning of the different building components and technical systems
- Negotiations with industry partners
- Construction of first space unit (see Figure 5)
- Preparation work and partial construction of second space unit
- Development of scenarios for the use of the Self Sufficient Space Unit (Scenario 1: Swiss Alps; Scenario 2: University Campus) (FHNW School of Applied Psychology)
- Evaluation of the concept of the Self Sufficient Space Unit on user acceptance and user requirements. The results have been documented and disseminated.

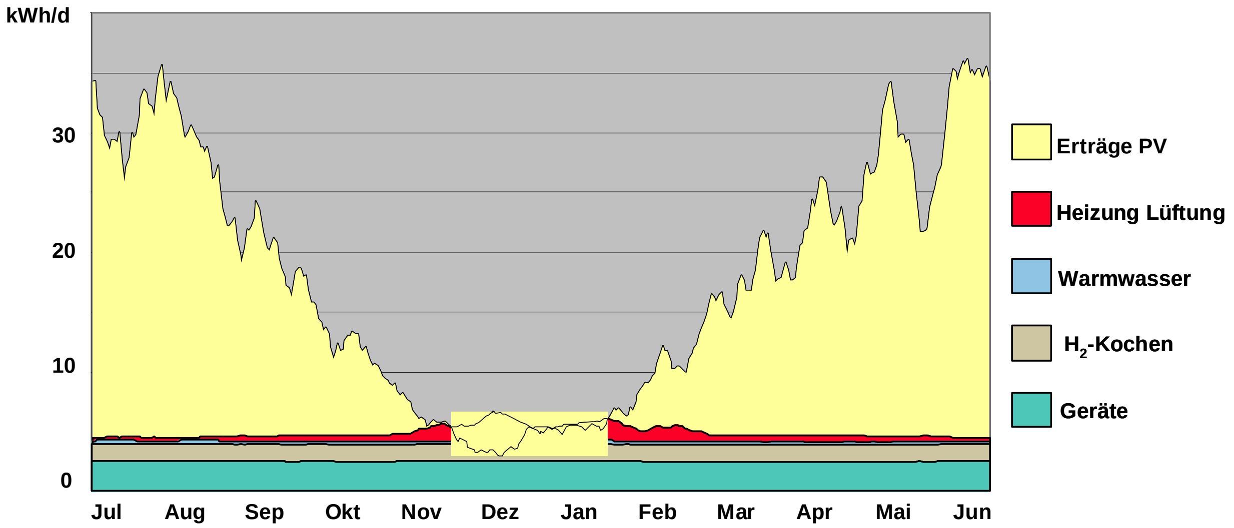

Figure 4: Simulated energy gains (PV) and usage by heating/ventilation, hot water, cooking with hydrogen, and appliances, average year for Zürich

Figure 5: Insulation works with Aerogel blankets and vacuum insulation panels (VIP) at the inside of space unit 1

4. Publications, patents of the whole duration of the project

A Advanced building materials and components

A1 High performance insulation materials based on fiber reinforced aerogels

An international patent registration procedure has been started; a general overview on high performance insulation in buildings has been given at the International Aerogels Conference in Boston.

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Proceedings 1st Swiss Building and Urban Simulation Conference IBPSA-CH (bus2009), Lucerne, November 2009

C Smart control and user interfaces

C1 Control of thermally activated buildings systems (TABS-Control)

[C1-1] M. Gwerder, B. Lehmann, J. Tödtli, V. Dorer, F. Renggli,
Control of thermally activated building systems (TABS),
Applied Energy, Vol. 85 (2008), pp. 565-581, Elsevier Science

[C1-2] Lehmann B., Dorer V., Koschenz M.
Application range of thermally activated building systems tabs
Energy and Buildings, Vol 39/5, pp 593-598, 2007

[C1-3] Tödtli J., Gwerder, M., Lehmann, B., Renggli F., Dorer V.
Integrated design of thermally activated building systems and its control
Clima 2007, Helsinki, 10th – 14th June 2007

[C1-4] Gwerder M., Tödtli J., Renggli F., Lehmann B., Dorer V.
Control of thermally activated building systems
Clima 2007, Helsinki, 10th – 14th June 2007

[C1-5] Renggli F., Gwerder M., Tödtli J., Lehmann B., Dorer V.
Effect of The Hydraulic Piping Topology On Energy Demand And Comfort In Buildings with TABS
Clima 2007, Helsinki, 10th – 14th June 2007

[C1-6] Tödtli J., Lehmann B., Gwerder M., Renggli F., Dorer V., Haas A., Hildebrand K.
TABS-Control: Regelung und Steuerung von thermoaktiven Bauteilsystemen
14. Schweizerisches Status-Seminar, Energie- und Umweltforschung im Bauwesen Zürich, 2006

[C1-7] Güntensperger W., Gwerder M., Haas A., Lehmann B., Renggli F., Tödtli J.
Control of Concrete Core Conditioning Systems
Clima 2005, Lausanne, 9th – 12th October 2005

[C1-8] *TABS-Control: Planung und Regelung von TABS* (Arbeitstitel), Faktor Verlag, Dezember 2008

[C1-9] M. Gwerder, J. Tödtli, B. Lehmann, V. Dorer, F. Renggli,
Control of thermally activated building systems (TABS) in intermittent operation with pulse width modulation,
Submitted to Applied Energy, 22.08.2008

[C1-10] Tödtli J., Gwerder M., Renggli F., Lehmann B., Dorer V., Hildebrand K.
Regelung und Steuerung von thermoaktiven Bauteilsystemen (TABS)
15. Schweizerisches Status-Seminar, Energie- und Umweltforschung im Bauwesen, Zürich, 2008

[C1-11] Tödtli J., Gwerder M., Lehmann B., Renggli F., Dorer V.,
TABS-Control - Steuerung und Regelung von thermoaktiven Bauteilsystemen, ISBN: 978-3-905711-05-9, Faktor Verlag Zürich, 2009

[C1-12] Gwerder, M./Toedtli, J./Lehmann, B./Dorer, V./Güntensperger, W./Renggli, F.,
Control of thermally activated building systems (TABS) in intermittent operation with pulse width modulation, Journal of Applied Energy 86 (2009) 1606-1616 (doi:10.1016/j.apenergy.2009.01.008)

[C1-13] Tödtli J., Gwerder M., Renggli F., Güntensperger W., Lehmann B., Dorer V., Hildebrand K., Regelung und Steuerung von thermoaktiven Bauteilsystemen (TABS), Bauphysik 31. Jahrgang (2009) Nr. 5 - Oktober, pp. 319-25, DOI:10.1002/bapi.200910042

[C1-14] Excel design tool „TABSDesign“, download from http://www.faktor.ch/?page=tabs

For the UBB method, Siemens has applied for a patent. Titel: „Verfahren zur Steuerung und/oder Regelung einer Raumtemperatur in einem Gebäude“. International publication number: WO 2007/042390 A1.

C2 Advanced bio-mimetic user-adaptive blind and lighting controller using wireless sensors

The main basic principles used in the CTI project are given in the PhD thesis of Antoine Guillemin. Further information on the controller products are available in the commercial documentation from Adhoco.

[C2-1] D. Daum, N. Morel
Coupling thermal simulation and multi-objective optimization for blind controller design
Proceedings of the CISBAT 2009 International Conference, Lausanne 2009

[C2-2] Antoine Guillemin
Using Genetic Algorithms to Take Into Account User Wishes in an Advanced Building Control System
PhD thesis n° 2778, 2003, EPFL

[C2-3] D. Daum and N. Morel
Assessing the saving potential of blind controller via multi-objective optimization,
Building Simulation, volume 2, number 3, pages 175-185, 2009.

[C2-4] D. Daum and N. Morel
Coupling thermal simulation and multi-objective optimization for blind controller design,
CISBAT 2009 Conference, Lausanne, pp 377-382, 2009.

[C2-5] D. Daum and N. Morel
Identifying important state variables for a blind controller
Building and Environment, volume 45 number 4, pp. 887-900, 2010.

[C2-6] D. Daum and N. Morel
Assessing the total energy impact of manual and optimized blind control in combination with different lighting schedules in a building simulation environment
Journal of Building Performance Simulation, volume 3 number 1, pp. 1--16, 2010.

[C2-7] D. Daum, F. Haldi and N. Morel
A personalized measure of thermal comfort for building controls
Building and Environment, article in press, 2010.

C3 Use of weather and occupancy forecasts for optimal building control (OptiControl)

[C3-1] Gyalistras, D., Gwerder, M., Dorer, V., Frank, T., Gähler, C., Jones, C., Lehmann, B., Morari, M., Oldewurtel, F., Schubiger, F., Stauch, V., Steiner, P. & Tödtli, J.
OptiControl - Verwendung von Wetter- und Anwesenheits-Vorhersagen für die optimale Gebäudeklimaregelung.
Poster presentation, «swisselectric research award 2007», 4. Sep. 2007, Technopark Zurich, Switzerland.
(available under http://www.opticontrol.ethz.ch/Results.html)

[C3-2] V. Stauch, M. Gwerder, D. Gyalistras, B. Lehmann, F. Schubiger
Statistical adaptation of COSMO-7 predictions and their impact on predictive control of indoor building climate
Annual Meeting EMS08, Conference on Applied Climatology, 29.9.-3.10.2008, Amsterdam

[C3-3] F. Oldewurtel, C.N. Jones, M. Morari
A tractable approximation of chance constrained stochastic MPC based on affine disturbance feedback
IEE Conference, 9.-11.December 2008, Cancun, Mexico (submitted)

[C3-4] F. Oldewurtel, A. Parisio, C.N. Jones, M. Morari, D. Gyalistras, M. Gwerder, B. Lehmann, V. Stauch
Stochastic model predictive control for building climate control using weather forecasts
European Control Conference, 23.-26. August 2009, Budapest (submitted)

[C3-5] Gwerder, M., Tödtli, J., Lehmann, B., Dorer, V., Güntensperger, W. & Renggli, F. (2009). *Control of thermally activated building systems (TABS) in intermittent operation with pulse width modulation*. Applied Energy, 86(9): 1606-1616. doi: 10.1016/j.apenergy.2009.01.008

[C3-6] Gyalistras, D., & Fischlin, A., Morari, M., Jones, C.N., Oldewurtel, F., Parisio. A., Frank, T., Carl, S., Dorer, V., Lehmann, B., Wirth, K., Steiner, P., Schubiger, F., Stauch, V., Tödtli, J., Gähler, C. & Gwerder, M. (2009). *Saving energy by improved building control*. In: Abstracts Book of the Annual Meeting of The Alliance for Global Sustainability: Urban Futures: the Challenge of Sustainability, 26-29 January 2009, ETH Zurich, Switzerland, p36..

[C3-7] Oldewurtel, F., Jones, C.N. & Morari, M. (2008). *A tractable approximation of chance constrained stochastic MPC based on affine disturbance feedback*. In: Proc. 47th IEEE Conference on Decision and Control, December 9-11, 2008, Cancun, Mexico (CDC08).

[C3-8] Stauch, V., Gwerder, M., Gyalistras, D. & Schubiger, F. (2008) *Statistical adaptation of mesoscale numerical weather forecasts for designing predictive control of indoor building climates*. In: Proc. 8th Annual Meeting of the EMS and 7th European Conference on Applied Climatology, 29 September - 3 October 2008, Amsterdam, The Netherlands, Vol. 5, EMS2008-A-00545.

[C3-9] Oldewurtel, F., Parisio, A., Jones, C.N., Morari, M., Gyalistras, D., Gwerder, M., Stauch, V., Lehmann, B., Wirth, K. *Energy efficient building climate control using stochastic Model Predictive Control and weather predictions*. Paper presented at the 2010 American Control Conference (ACC2010), Baltimore, Maryland, USA, 30 June - 2 July, 2010

[C3-10] Gwerder, M., Gyalistras, D., Oldewurtel, F., Lehmann, B., Wirth, K., Stauch, V. & Tödtli, J. (2010). *Potential assessment of rule-based control for Integrated Room Automation*. Paper presented at the 10th REHVA World Congress Clima 2010, 9-12 May 2010, Antalya, Turkey, 8pp

[C3-11] Gyalistras, D., Gwerder, M., Oldewurtel, F., Jones, C.N., Morari, M., Lehmann, B., Wirth, K., & Stauch, V. (2010). *Analysis of energy savings potentials for Integrated Room Automation*. Paper presented at the 10th REHVA World Congress Clima 2010, 9-12 May 2010, Antalya, Turkey, 8pp.

[C3-12] Oldewurtel, F., Gyalistras, D., Gwerder, M., Jones, C.N., Parisio, A., Stauch, V., Lehmann, B. & Morari, M. (2010). *Increasing energy efficiency in building climate control using weather forecasts and Model Predictive Control*. Paper presented at the 10th REHVA World Congress Clima 2010, 9-12 May 2010, Antalya, Turkey, 8pp

D Demonstration, dissemination and education

D1 Design and construction of an energy sufficient space unit using advanced building technologies

[D1-1] M. Zimmermann *Plichtenheft Demonstrator „Energie-autarke Raumzelle*“, Empa Dübendorf 2008

[D1-2] M. Zimmermann *Aufgabenbeschrieb Diplomarbeiten 2008 - Konzeptentwicklung Demonstrator „Energie-autarke Raumzelle“,* Empa Dübendorf 2008

[D1-3] B. Olsson, S. Macchi *Energieautarke Raumzelle – self* http://www.autark-wohnen.ch Masters Diplomarbeit Zürcher Hochschule der Künste ZHdK, Industrial Design, Zürich, Mai 2008

[D1-4] M. Lähns Hänggi, C.M. Wegner-Sänger *Demonstrator – Konzept einer “energieautarken” Raumzelle* Diplomarbeit Nachdiplomstudium Energie, FHNW, Muttenz, Juni 2008

[D1-5] Macchi, S./Olsson, B., Fünf Wege in eine neue Zeit - Planen und Bauen für die 2000-Watt-Gesellschaft, Hochparterre, November 09

[D1-6] Metry, B., Riesen, C., Widmer, D., Meyenberg, I. & Schneider, L. (2009). Energieautarke Wohneinheit Self in den Schweizer Alpen und auf dem Hochschulgelände: eine Szenarienevaluation. Internal project report, FHNW School of Applied Psychology.

[D1-7] Meyenberg, I. Nutzenszenarien intelligenter Klima-Kontrollsysteme im Smart Home Bereich, Semesterarbeit, 4. Semester Hochschule für Angewandte Psychologie FHNW, August 2008

[D1-8] Riesen, C. Anwendung der Theorie des geplanten Verhaltens von Ajzen und Fishbein im Bereich umweltbewusstes Verhalten in einer energieautarken Raumzelle, Semesterarbeit 2, Hochschule für Angewandte Psychologie FHNW, August 2008

[D1-9] Metry, B. Elektronisches Feedback und energiebewusstes Verhalten, Semesterarbeit 2, Hochschule für Angewandte Psychologie FHNW, August 2008

[D1-10] Macchi, S./Olsson, B., Fünf Wege in eine neue Zeit - Planen und Bauen für die 2000-Watt-Gesellschaft, Hochparterre, November 09

Homepage www.empa.ch/self

5. Activities within the project such as events, talks, workshops

Final Project Meeting

All project results have been presented at the final project meeting at the EMPA Academy, 28. April 2010

A Advanced building materials and components

A1 High performance insulation materials based on fiber reinforced aerogels

The CTI project team has met quarterly for internal project coordination between EMPA, ZHAW and Industry.

Poster presentation at the NanoEurope Conference, 16.-17. September 2008, St. Gallen

Talks: M. Koebel, *Silica Aerogel as high-performance insulation materials,* Nanothech Northern Europe, 23.-25. September 2008, Copenhagen

A2 Advanced vacuum insulation panels (VIP of the 2nd generation)

Several meetings and workshops were held regarding VIP integrated façade components and constructions. Two prototype VIP compact façades could be inspected in situ by project partners.

Presentations: S. Brunner, M. Stiefel, K. Ghazi Wakili, Microscopic Investigation of Laminates for barriers of Vacuum Insulation Panels, Vacuum Insulation Panel (VIP) and Aerogel, IVIS 2009: 9th International Vacuum Insulation Symposium, 18-19 Sept. 2009, London.

S. Brunner, H. Simmler, Quality assurance and declaration of Vacuum Insulation for building application, Vacuum Insulation Panel (VIP) and Aerogel, IVIS 2009: 9th International Vacuum Insulation Symposium, 18-19 Sept. 2009, London.

A3 Colored glazed solar collectors for heating and cooling

- Invited presentation at Schweizer Metallbau AG seminar, Geneva, 4/5-February 2009
- Presentation at BiSol seminar Luzern, 23/24 March 2009
- Presentation at NUS (National University Singapore) 2 April 2009
- Invited presentation at Austrian conference in Graz (AU), 24 April 2009
- Kick-off meeting Task 41 à Malmö, 4/7 May 2009
- Presentation architect's commission Swissolar, 23 June 2009
- Presentation at LESO to several potential investors and users during official visits at EPFL

A4 Thermally activated ceiling panel with PCM

Presentation at COST TU0802 NeCoE-PCM (Next generation cost effective phase change materials for increased energy efficiency in renewable energy systems in buildings), meeting in Dublin, 09-10 July 2009

B Soft heating and cooling technologies

B1 Open absorption systems for cooling and air conditioning

An general overview of desiccant-based air-conditioning systems has been presented at an international conference.

Talks: M. Conde-Petit, Liquid desiccant-based air-conditioning systems – LDACS
1st European Conference on Polygeneration, 16./17. October 2007, Tarragona

M. Conde-Petit,
Open absorption system for air conditioning using membrane contactors
15. Schweizerisches Status-Seminar Energie- und Umweltforschung im Bauwesen, ETH Zürich 2008

B2 Solar long-term sodium hydroxide heat storage

Events: Joint IEA SHC Task 42 - ECES Annex 24 “Compact Thermal Energy Storage: Material Development for System Integration“,
Kick-off meeting in Bad Tölz, 11.-13. 2.2009.

Joint IEA SHC Task 42 - ECES Annex 24 “Compact Thermal Energy Storage: Material Development for System Integration“,
2nd meeting in Lleida, 23.-25. 9.2009.

Talks: R. Weber; Long-term Heat Storage with NaOH,
CISBAT 2009: 2. – 3. September 2009, EPFL, Lausanne

B3 Solar thermal absorption cooling (STAC)

Talks: P. Gantenbein et al., Solar Cooling – Oekonomische Bewertung & CO2 Bilanzierung,
OTTI 10. Symposium Thermische Solarenergie, Mai 2009 in Bad Staffelstein

B4 Efficient heating and cooling with heat pumping technologies

Events: SFOE-Symposium of UAW research program in Burgdorf (June 2007)

Presentation at IEA HPP Annex 32 Meetings (Mai & December 2007)

Presentation at IEA ECBCS Annex 48 Meeting in Liège (Oktober 2007)

IEA HPP Annex 32 Workshop in the frame of the 9th IEA Heat Pump Conference Zurich (May 2008)

Presentation Annex 32 at HPP ExCo meetings (May & November 2008)

Presentation Annex 32 at IEA ECBCS Annex 48 Meeting in Münster and Lyon (April & October 2008)

SFOE-Symposium of UAW research program in Burgdorf (June 2009)

Presentation at IEA HPP Annex 32 Meetings (March & September 2009)

Presentation Annex 32 at HPP ExCo meetings (May & November 2009)

Presentation Annex 32 at IEA ECBCS Annex 48 Meeting in Torino (April 2009)

Invited talks: IBPSA Building Simulation 2007 Conference in Beijing (September 2007)

CCEM-House 2000 BAC Workshop ETHZ, 9. February 2007

EMPA Academy heating and cooling with geothermal energy, March 2008

2nd CCEM-House 2000 BAC Workshop ETHZ (April 2008)

12. Internationale Passivhaustagung, Nuremberg (April 2008)

9th IEA Heat pump conference Zurich, May 2008

15th Swiss status seminar ETHZ (September 2008)

IEA EUWP/EEWP Workshop “Towards Net Zero Energy houses”, Paris (April 2009)

Forum Holz/Bau/Energie in Köln (June 2009)

1st Swiss Building and Urban Simulation Conference IBPSA-CH in Lucerne (November 2009)

C Smart control and user interfaces

C1 Control of thermally activated buildings systems (TABS-Control)

Professional training courses were initiated by SWKI and Siemens.

C2 Advanced bio-mimetic user-adaptive blind and lighting controller using wireless sensors

Talks:

N. Morel; *Advanced bio-mimetic user-adaptive blind and electric lighting controller using wireless sensors,* CCEM-House 2000 BAC Workshop ETHZ, 9. February 2007

Thomas Schumann; *Optimierung von bestehenden Bauten unter Einbezug des Benutzers*
ETH, Spezialfragen Bauphysik, Zürich, 9. Februar 2007

N. Morel; *Advanced bio-mimetic user-adaptive blind and electric lighting controller using wireless sensors,* CCEM-House 2000 BAC Workshop ETHZ, 1. April 2008

C3 Use of weather and occupancy forecasts for optimal building control (OptiControl)

Talks:

Gwerder, M. (2008). Verwendung von Wettervorhersagen in der Gebäudeautomation. Presentation at the MeteoSchweiz COSMO-2 Kundenanlass, 12. June 2008, Zurich, Switzerland.

Gyalistras, D. (2009). Prädiktive Regelung von Gebäuden: Methoden, Werkzeuge und Fallstudie Integrierte Raumautomation. Presentation, 26 Oct. 2009, Hochschule Luzern/Teilschule Technik und Architektur, Horw, Switzerland.

Gyalistras, D. (2009). Use of MPC for Building Control. Presentation, Short Course on Model Predictive Control, 24 February 2009, ETH Zurich, Switzerland.

Gyalistras, D., & Fischlin, A., Morari, M., Jones, C.N., Oldewurtel, F., Parisio. A., Frank, T., Carl, S., Dorer, V., Lehmann, B., Wirth, K., Steiner, P., Schubiger, F., Stauch, V., Tödtli, J., Gähler, C. & Gwerder, M. (2009). Saving energy by improved building control. Poster presentation, Annual Meeting of The Alliance for Global Sustainability: Urban Futures: the Challenge of Sustainability, 26-29 January 2009, ETH Zurich, Switzerland.

Gyalistras, D., Morari, M. & Fischlin, A. (2009). OptiControl - Integrierte Raumautomation für Bürogebäude. ESC Newsletter, April 2009, p.3.

Morari, M. & Tödtli, J. (2008). Weather forecasts enhance comfort and save energy. Presentation at Smart Energy Strategies 2008 Conference, 8-10 September 2008, ETH Zurich, Switzerland.

Morari, M., Gyalistras, D. & Oldewurtel, F. (2009). Energy efficient building climate control. Presentation at the Smart and Efficient Energy Council (SEEC'2009), 8-9 October 2009, Trento, Italy.

Niedermann, C. (2008). Wetterfee steuert Gebäudeautomation. cash Innovation, 12. Dec. 2008, Ringier AG, Zofingen, p24.

Steiner, P., Stauch, V., Gwerder, M., Gyalistras, D., Lehmann, B., Morari, M. & Schubiger, F. (2008). Numerical weather prediction at MeteoSwiss - Statistical postprocessing for building climate control. Poster presentation, 30th meeting of the European Working Group on Limited Area Modelling (EWGLAM) and 15th meeting of the Short Range Numerical Weather Prediction network (SRNWP), 6-9 October 2008, Madrid, Spain.

Gyalistras, D. (2010). Der energetische "Performance Bound" – eine rechnerische Messlatte für die Gebäuderegelung. Presentation, 6. Planerseminar Hochschule Luzern - Technik & Architektur, 23. March 2010, Horw, Switzerland.

Gyalistras, D. (2010). Use of MPC for building control. Presentation, Short Course on Model Predictive Control, 4 March 2010, ETH Zurich, Switzerland

D Demonstration, dissemination and education

D1 Design and construction of an energy sufficient space unit using advanced building technologies

Events:

ETH-Exhibition for formation of the ITA Institute for Technology and Architecture (ex. HBT)
23. September -31. October 2009

Kraftwerk Haus - Vision oder Illusion? Technologie Briefing "Das Potential für erneuerbare Energien in der Schweiz", Empa Akademie, 9.11.2009

Swissbau + Plattform Zukunft Bau, first presentation of SELF, Basel, 12.-16. January, 2010

Immomesse St. Gallen, presentation of SELF, St. Gallen, 19.-21. March, 2010

Zurich University of Arts, Design workshop, 23 March – 2. April 2010.

SF1 Einstein-telecast, April 8, 2010

6. List of all involved industrial and institutional partners

(* confidential disclosure agreement CDA)

Project (leading institute)	Institutional partners	Industrial partners
A1 (EMPA)	ZHAW	Flumroc AG *
A2 (EMPA)	FHNW ZHAW	ZZ Wancor Neofas AG Akzo Nobel AG Forster-Arbonia Holding *
A3 (EPFL)	ISE (EC-project)	Swissinso SA Glas Trösch AG Fällander Glas Schweizer Metallbau H+S Solar GmbH Rio Vetro OMEGA GlAS GmbH
A4 (EMPA)	-	N.N. *
B1 (EMPA)	-	M. Conde Engineering *
B2 (EMPA)	IEA SHC Task 42	-
B3 (SPF-HSR)	-	Vela Soraris AG Soltop AG Energie Solaire SA Phönix Sonnenwärme GmbH
B4 (FHNW)	IEA HPP Annex 28 and 32	Viessmann (Schweiz) AG SATAG Thermotechnik
C1 (EMPA)	-	Siemens Building Technologies *
C2 (EPFL)	-	Adhoco *
C3 (ETHZ)	EMPA MeteoSwiss	Swisselectric research Siemens Building Technologies *
D1 (EMPA)	FHNW EPFL Novatlantis Eawag, Dübendorf Empa, Hydrogen Lab Empa, Electronics & Me-trology Lab	1a Hunkeler, 6030 Ebikon, Schweiz AGI, 8050 Zürich,Schweiz Drexel&Weiss, 6922 Wolfurt, Österreich Du Pont, 1218 Le Grand-Saconnex / Geneva Geberit Vertriebs AG, 8640 Rapperswil Sky-Frame, Ellikon a. d. Thur Sofraver SA, 1754, Avry Solventure, Hausen AG va-Q-tec, 97080, Würzburg, Deutschland. Siemens Building Technologies, Schweiz Zumtobel Licht AG, Schweiz digitalSTROM.org