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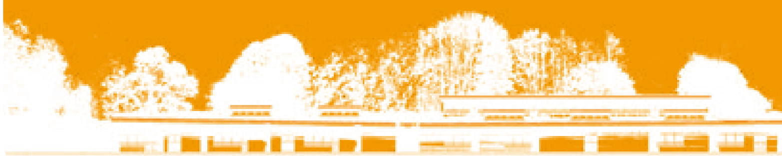

Sustainability & Durability of Energy Efficient Buildings in New Zealand

ECBCS Technical Day, held 15th November 2006

The latest ECBCS Technical Day took place on 15th November 2006 at the Victoria University of Wellington in New Zealand. This allowed ECBCS and New Zealand experts the opportunity to exchange their knowledge of and experiences with sustainable and energy efficient buildings.

After introductions by the host, Michael Donn, and from Morad Atif on behalf of ECBCS, speakers gave presentations about lessons that can be learnt on:

- residential buildings & energy efficiency,
- predicting & rating energy efficiency, and
- non-residential buildings & energy efficiency.

Residential Buildings & Energy Efficiency

Ultra Low Energy Houses

Robert Vale described the Hockerton Housing Project, UK, constructed in 1998, which demonstrates many features of zero-energy housing, such as high thermal mass earth-sheltered construction, passive solar, low-e triple glazing and even a communally-owned electric vehicle. The success of the project is demonstrated by the fact that winter indoor temperatures remained at 17°C despite external temperatures as low as -6°C. Microgeneration using grid-connected PV and wind supplies the electricity needs. The cost of this development was similar to that of conventional housing.

To demonstrate that the zero-energy approach can be used for older house retrofits, Robert Vale also presented two retrofit projects in New Zealand, on Waiheke Island. The first house is of single-storey lightweight timber frame construction with a steel sheet roof on timber trusses and aluminium single-glazing. The total load for the house was reduced to 5,000 kWh per year by using increased roof and floor insulation and insulated shutters over the windows, a solar water heater, and low energy fridge-freezer and lighting, and cold water laundry. Thirty-six PV panels produce around 5,300 kWh per year. He noted the refurbishment costs around the same as a large four-wheel drive vehicle would cost.

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Home Thermal Comfort from Minewater
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The second, larger house benefitted from double low-e replacement glazing in thermally-broken frames on a wall facing the sun, ceiling fans for summer cooling, solar hot water with a 315 litre storage cylinder under the house, a European A-rated fridge freezer, low energy lighting, and increased roof and floor insulation, contributing to an annual energy consumption of around 3,300 kWh. The energy consumption is one third that of an average New Zealand house. PV systems to be installed in 2007 will reduce demand to zero net consumption.

Nigel Isaacs presented details of the HEEP (Household Energy End-Use Project,1995-continuing). The HEEP project is a long-term study which has conducted an extensive analysis of New Zealand household energy use covering all fuel types and energy services, with the goal of formulating an energy model for New Zealand housing. The model will use physical building and appliance characteristics as well as socio-demographic factors to describe the energy consumption patterns and some of the energy services, in particular, indoor temperatures achieved in practice. The model will be used to understand current and future national household energy requirements, and as a tool to evaluate the implications of building and appliance performance changes. The final sample includes four hundred diverse houses throughout New Zealand. HEEP monitoring activities include a detailed occupant survey as well as a detailed house energy examination.

Per Heiselberg then related the ECBCS project "Integrating Environmentally Responsive Elements" to New Zealand domestic housing.

Predicting & Rating Energy Efficiency

Peter Wouters' presentation, "Usability of the EU Energy Performance Approach in New Zealand", explained how the European Energy Performance in Buildings Directive is being implemented. All Member States must comply by

Replacement sun-oriented double low-emissivity glazing in thermally broken frames for the Waiheke house.

adapting or producing national laws in line with the requirements. The objective is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. The Directive lays down requirements regarding:

- The general framework for a methodology of calculation of the integrated energy performance of buildings
- The application of minimum requirements on the energy performance of new buildings
- The application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation
- Energy certification of buildings, and
- Regular inspection of boilers and air conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old.

Related activities include technical support in the form of a mandate to CEN, EPBD Concerted Action and SAVE projects. Dissemination support includes the EPBD Buildings Platform information centre.

Peter Wouters noted that a familiarity with the EPBD could have relevance for New Zealand as regards procedural aspects, certification, avoiding negative effects such as inappropriate ventilation or overheating, support tools, economic issues, and encouraging innovation. The EPBD has considerable impact. Although many countries miss the implementation deadlines, there is nevertheless substantial progress in most countries, and the Directive has a proven and important influence on standardisation activities.

Katie Mathison described the New Zealand Energy Efficiency and Conservation Authority's new Home Energy Rating Scheme, which is under development between 2006-2007 and is due to be launched on a voluntary basis from December 2007. New Zealand homes are generally 'old and cold'; the average indoor temperature falls below the World Health Organisation recommendation, and 64% of the total housing stock was built pre-mandatory insulation standards (i.e. before 1977). It is estimated that more than 300,000 homes still have little or no insulation. New Zealand has one of the world's highest rates of respiratory illness, perhaps as a consequence of the condition of its housing.

Some progress has been made to date, however, by insulating 27,000 pre-1977 low-income homes using an 'Energywise' home grant. In 2005 HERS was recommended as an effective method of improving energy efficiency and comfort in New Zealand housing, with outcomes including economic, health and public awareness benefits and the development of a self-sustaining assessor industry.

The HERS will measure the energy efficiency of the building envelope plus space and water heating to generate a rating similar to the star rating on appliances. It will include

(Continued on page 14)

Testing and Validation of Building Energy Simulation Tools Annex 43 - Two New Reports in Collaboration with IEA-SHC

Ron Judkoff and Joel Neymark, Buildings & Thermal Systems Center, National Renewable Energy Laboratory, USA

Two new reports are soon to be published, and will be available in PDF format via the ECBCS Website.

Double Skin Facades, A Literature Review

Harris Poirazis, Lund University, Lund Institute of Technology, Sweden

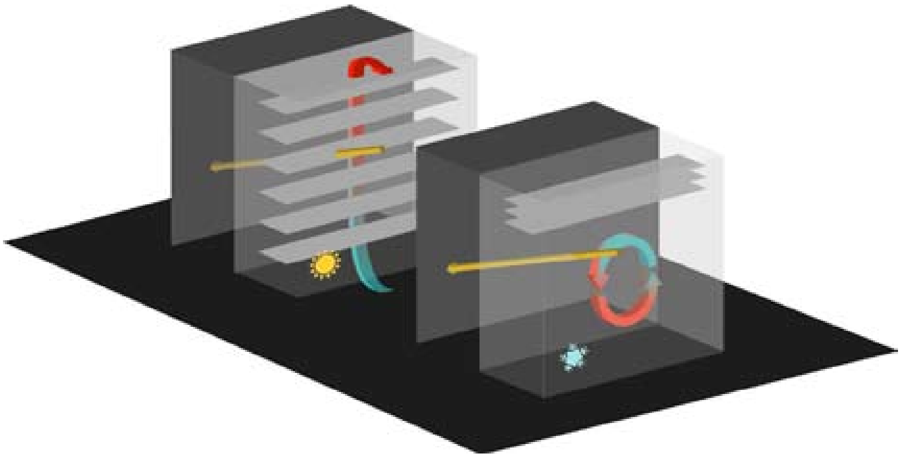
The main aim of the report is to describe the concept of double skin façades based on different sources of literature; 97 references are cited.

An introductory chapter gives a brief description of the concept and history of double skin façade systems. A presentation of different construction types follows, including a system classification. The different façade types are categorized according to the cavity geometry and the ventilation strategy.

In the third chapter the author provides a technical description is provided, regarding: (a) the structural design of the façade, (b) the geometry of the cavity, (c) the type of ventilation of the cavity, (d) opening principles of the cavity (interior and the exterior façade), (e) the type of glazing, shading and lighting devices, (f) the material choice for the glazing panes and the shading devices, and (g) the positioning of shading devices.

The connection to SHC Task 34/ECBCS Annex 43, “Testing and Validation of Building Energy Simulation Tools”, is that there is an extensive description of modelling approaches and methods, and empirical and experimental studies, for double skin façades. The difficulties regarding the modelling process and different techniques are explained, including their advantages and disadvantages.

Furthermore, the possibilities and limitations of double-skin façades are described and overall advantages and disadvantages are presented as found in different sources of literature. Daylight simulation control strategies are also discussed.



Double-Skin Façade Schematics for Heating and Cooling Modes.

Fifty Case Studies

Finally, roughly 50 case studies – of buildings located in ten countries – are briefly presented. The information provided focuses on the façade type, the ventilation strategy, the façade construction, the glazing panes and shading devices used, and the HVAC strategy of the building.

The literature sources point out that individual façade design, and its integration during the early design stage, is a key to an optimized performance. A sound knowledge of the physics inside the cavity can lead to an improved system performance. The geometry of the façade influences the air flow, and thus, the temperatures at different heights of the cavity. Different types of glazing panes and shading devices result in different physical properties. The interior and exterior openings of the façade can influence the type of flow and the air temperatures of the cavity. All together, these parameters determine the use of the double skin façade and the HVAC strategy that has to be followed in order to succeed in creating a building with a good indoor environment and low energy use.

ABB Business Center, Sweden, Cavity View

Empirical Validations of Shading/Daylighting/Load Interactions in Building Energy Simulation Tools

Peter Loutzenhiser and Heinrich Manz, Swiss Federal Laboratories for Material Testing and Research, Switzerland, and Gregory Maxwell, Iowa State University, U.S.

Buildings with highly glazed façades are becoming increasingly popular around the world. Shading devices are vital components for preventing overheating in buildings during the summer and reducing and/or eliminating the need for active cooling. Building energy simulation programs are tools that can be used to predict and optimize energy performance in buildings. The integrated approach, by which all relevant energy transport paths are simultaneously processed, makes these programs essential for designing modern buildings. However, successful application of a program requires careful and thorough validation. This is especially true when assessing solar gain and daylighting models. Even now, there are still very few high-quality data sets for empirical validation of solar gain and daylighting models available.

Therefore, the purpose of this project was to create empirical data sets for use when evaluating the accuracy of models for glazing units and windows with and without shading devices. Program outputs were compared with experiments performed at two research facilities designed for these types of studies. The two facilities included an outdoor test cell located at the Swiss Federal Laboratories for Material Testing and Research (EMPA) in Duebendorf, Switzerland, and the Energy Resource Station (ERS) located in Ankeny, Iowa, U.S.

A series of eight experiments that subsequently increased in complexity was performed in an outdoor test cell. The experimental series consisted of two characterization experiments and six experiments with solar gains.

Particular emphasis was placed on accurately determining the test cell characteristics. The first two experiments were run without solar gains to specify the thermophysical properties, including the thermal bridges, of the test cell. The first experiment was a steady-state experiment that was used in conjunction with a three-dimensional heat transfer simulation to quantify the thermal bridges. In the second experiment, the air temperature inside the test cell was allowed to float in response to a pseudo-random heat input. This experiment was simulated by seven building energy simulation programs and results from the programs were used to conclude that test cell specifications were very accurate for empirical validation.

Prior to the solar gain experiments, a preliminary exercise was performed to identify the most accurate tilted surface radiation model in each program. A series of experiments was then carried out to evaluate solar gain models in building energy simulation programs starting with the simplest case and increasing in complexity with each experiment. Increasing the complexities of subsequent experiments allowed for careful assessments and diagnoses of the results.

Robust experimental and sensitivity analyses were used to assess the impact of uncertainties of the measurements and program inputs. A set of comprehensive statistical parameters was employed to compare results of building energy simulation programs with the experiments, applying 95% confidence limits to determine whether the programs were validated or not. Up to seven programs were evaluated for each experiment. The impact of these validation exercises is already being realized. As a result of this work so far, several program errors and deficiencies in the programs have been identified with respect to solar radiation, glazing, shading, and surface heat transfer. The ability to perform such diagnosis demonstrates the usefulness of the experimental data set.

Two additional experiments were performed at the ERS to evaluate daylighting algorithms and the associated interactions in building energy simulation tools and subsidiary software. Analyses were then performed to assess the overall performance of the programs.

These studies are some of the most detailed empirical validations of solar gain models implemented in building energy simulation programs ever performed. The authors' intention is that the data are widely used by program developers and modellers for future validation efforts. A test specification and input and output Excel files for all of the validation exercises from the suite of experiments performed at EMPA are now available for download at www.ecbcs.org/annex47.

EMPA Test Cells, Exterior View.

Low Exergy in Practice: The European Mine Water Project

Peter Op't Veld, Cauberg-Huygen,The Netherlands
Elianne Demollin-Schneiders, Municipality Heerlen, The Netherlands
Dietrich Schmidt, Fraunhofer Institute for Building Physics, Germany

Abandoned and flooded mines have a high potential for geothermal utilisation as well as heat or cold storage of water volumes in the remaining underground spaces. The use of mine water as a heat and cold source for the supply of buildings is one important aspect of a rational and sustainable utilisation of post-mining infrastructure and could result in positive socio-economic results for communities in 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 the heating and cooling of buildings and using mine water as a sustainable source of energy.

Mines have large water volumes with different temperature levels. In Heerlen, the deeper layers (700m – 800m) have temperatures of 30°C – 35°C; in shallow layers (200m), temperatures are between 15°C and 20°C. These water volumes can be considered as heat/cold storage as well as geothermal energy sources. Most crucial however is the fact that these sources provide low valued energy (with a low exergy content) at only a moderate temperature level. As on the demand side, heating and cooling for buildings also requires low valued energy, the intended design strategy is to carry out the tempering of the buildings in this pilot project directly through the use of mine water. The combination of low temperature emission systems with advanced ventilation technology, and integrated design of buildings and building services provides excellent thermal comfort for 365 days a year, including sustainable heating and cooling and improved indoor air quality. This sustainable energy concept yields a reduction of primary energy and CO_2 emissions of 50% in comparison with traditional concepts.

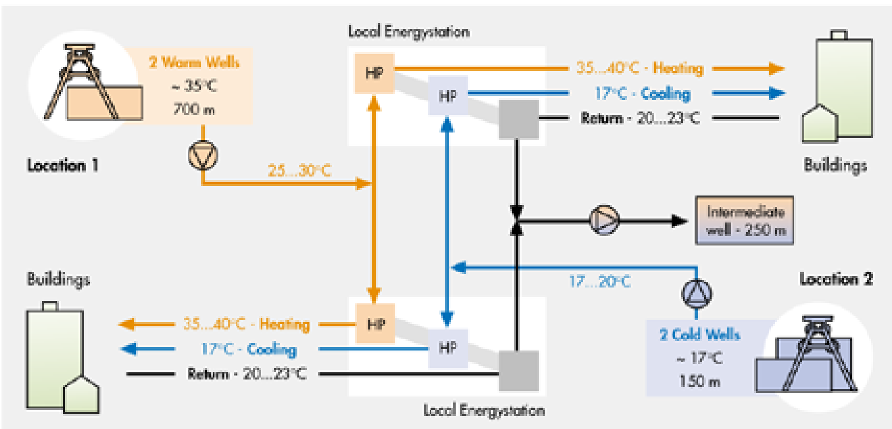
The project is funded by the European Commission and the Dutch Ministry of Economic Affairs. Furthermore, the project is an example of the practical applicability of the exergy concept being studied by ECBCS Annex 49: Low Exergy System for High-Performance Buildings and Communities.

The Energy Concept

In Heerlen, the mine water is extracted from different wells with different temperature levels. In a first location, the mining took place down to a level of 800m, where the warm wells (30°C) can be found. In a second location, mining took place down to a level of about 400m, where the cold wells are situated. The extracted mine water is transported by a primary energy grid to a number of local energy stations. In these energy stations, the heat exchange takes place between the primary grid (wells to energy station) and the secondary grid (energy station to buildings). The secondary energy grid provides a supply of low temperature heating (~ 35°C–40°C) and high temperature cooling (16°C-18°C) with one combined return line (20°C - 23°C). The temperature levels of the heating and cooling supply are "guarded" in the local energy stations using a poly-generation concept, which integrates heat pumps in combination with gas fired boilers and maybe a combined heat and power (CHP) plant in combination with local heat storage tanks. The CHP would then provide the electricity to power the heat pumps but also the higher temperature levels (65°C–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. The surplus of heat in buildings (for example, in summer, cooling, process heat) which can not be used directly in the local energy stations can be lead back to the mine water volumes for storage. The total system is to be controlled by an Intelligent Energy Management System.

Integrated Design Approach versus Traditional Approach

The presently increasing development of energy efficient buildings requires an integrated design approach. A few



Schematic view of the energy concept in Heerlen, connection of the wells and energy stations of decades ago, energy efficient design and building mostly focussed on improving a certain technique or single components. Nowadays, an energy efficient building, supported by an energy efficient installation, has to be combined into one integrated energy efficient concept with an optimal performance in terms of indoor climate, thermal comfort, user satisfaction, and so on. This demands an integrated design approach in which well balanced choices are made. It is crucial in sustainable building projects to consider the design and realisations of the sources, the heat generation (especially with non-traditional solutions such as heat pumps, cogeneration, heat/cold storage) distribution and emission together, including all possible interactions with the building, building properties and building users. Only this approach can lead to a set of well-defined performance criteria concerning energy performance, sustainability, indoor air quality, thermal comfort (365 days/year, winter and summer conditions), and health.

Conclusions

Abandoned and flooded mines can be reutilised as new sustainable energy supplies for the heating and cooling of buildings. The mine water project in Heerlen shows that temperatures of 28°C–30°C can be found at 700m, and 16°C-17°C at 200m. These temperatures can be used for heating and cooling buildings if the buildings are very well insulated, have energy efficient ventilation systems and have suitable emission systems which can be operated with moderated temperatures like floor heating or concrete core activation. Despite the rather high investment costs, such projects can be economically profitable by avoiding additional cooling systems and with integrated design, and if energy exploitation is organised by the investors.

Further information

www.minewaterproject.info
www.ecbcs.org/annexes/annex49.htm
dietrich.schmidt@ibp.fraunhofer.de

Factor 4: A "Win-Win" Strategy for Building Trades in France

France Commits to Reduce Greenhouse Gas Emissions by 75% by 2050

Pierre Herant, French Environment and Energy Management Agency (ADEME) and ECBCS Executive Committee member for France

France's Commitments

Following the lead given by the President of France and the Prime Minister, France has made the commitment to reduce the country's greenhouse gas emissions by three-quarters, by 2050. This is called the Factor 4 strategy.

The buildings sector has resolutely taken up this ambitious challenge, and a broad array of measures is currently being implemented, including:

- a national programme of support for R&D and demonstration buildings,
- strong incentives for energy-efficiency improvements,
- more stringent regulatory requirements,
- communication campaigns to reach the general public, and
- training schemes for professionals.

Most decision-makers agree that in order to ensure sustainable development for our societies, greenhouse gas production must be halved between 2000 and 2050, on the scale of the planet. Taking into account that developing countries have little room for manoeuvre and that their emissions can only increase, this means that emissions in industrialised countries must be reduced by a factor of four or five in under 50 years.

If this objective is attained, global warming could be limited to a few degrees.

Factor 4, A Challenge

In order to achieve success, solidarity between all governments must be full and complete. France has included the Factor 4 objective of reducing emissions by three quarters in its National Sustainable Development Strategy, its Climate Plan of July 2004, and the Programme Law of July 2005 setting energy policy objectives.

The buildings sector constitutes one of the keys to meeting the environmental challenge, and has scope for major change.

The Key Role of the Buildings Sector

Buildings can use several types of energy resources, including renewable energy, which can be combined and if necessary modified several times over the course of a building's life. Work to improve building energy performance can be planned over several years, leading to improvements which can enhance a building's asset value. Changes in occupant behaviour and needs occur, if at all, over long cycles and can reasonably be anticipated.

Buildings Sector - Current Situation

The buildings sector currently consumes 43% of total final energy consumption (or one tonne oil equivalent per capita per year). It generates 25% of national emissions of CO_2 (or half a tonne of carbon per capita).

CO_2 is the dominant greenhouse gas. Two-thirds of energy consumption is in homes, and one third in commercial and institutional buildings. This proportion has remained more or less constant over the last 20 years (see Table 1).

The Factor 4 objective will involve unprecedented rehabilitation efforts in the existing three billion heated m^2 of old and recent building stock.

For the period 1990–2002, the average value of new buildings was 300 000 housing units and 12.4 million m^2 of heated floorspace in commercial/institutional buildings. This average has risen sharply in recent years (see Table 2).

The Weight of Existing Building Stock

The rate of replacement of old buildings by new construction is in the order of 1% per year. If no extra steps are taken, at this low replacement rate and the current pace of renovation and rehabilitation it will take more than a century to improve the energy efficiency of all buildings built before 1975.

The large number of buildings built before thermal regulations were applied ("old" buildings) is thus very significant. This proportion could represent 60% to 75% of the building stock in 2050.

A steady reduction of total consumption has nonetheless been observed in the old building stock. Consumption fell by 44% between 1973 and 2001, due to replacement of obsolete boilers, which have a useful life much shorter than that of building structures, and work carried out by households to improve thermal insulation.

Research commissioned by ADEME to measure the ratio of energy-efficiency improvements and investments made by households each year reveal that a relatively stable proportion of 11% to 12% of households invest on average 25 euros per m^2 of habitable surface area.

Table 1: Building stock broken down by energy use and consumption (2002 – average climate conditions)

	Number of housing units (millions)	Surface area (millions m2)	Consumption Electricity (TWh)	Consumption Gas (TWh)	Consumption Other (TWh)	Total Consumption	%
Single Family Dwellings	14	1442	85.5	99.7	99.9	285	43.2
Multi-family Dwellings	10.5	693	42.1	89.8	35.0	167	25.3
Total Primary Residences	24.5	2135	127.6	189.5	134.9	452	68.5
Commercial/ Institutional Buildings		814	84.4	68.6	55.2	208	31.5
Total		2949	212	258.0	190.1	660	100

Table 2: Breakdown of primary residences by age and final energy consumption (2002 - average climate conditions)

	Old		Recent		New
	Stock Number of Housing Units (millions)	Consumption (TWh)	Stock Number of Housing Units (millions)	Consumption (TWh)	Stock Number of Housing Units (millions)
Single Family Dwellings	9.1	192.6	4.9	92.5	0.22
Multi-Family Dwellings	6.8	123.6	3.7	43.3	0.10
Total Housing Units	15.9	316.2	8.6	135.8	0.32

These improvements are far from sufficient, however, to put the buildings sector on a Factor 4 trajectory.

To achieve Factor 4, a much higher investment is needed: in the order of 200 Euros per m^2 for buildings that are relatively easy to treat, and up to 400 Euros per m^2 for buildings that are more complicated to rehabilitate or that require large-scale integration of renewable energy. At this rate, for the total stock of 3 billion m^2 of heated building space mentioned above, total cumulative investment from now to 2050 would come to between 600 and 1 200 billion Euros, in order to bring the total energy consumption for all buildings in use into line with the Factor 4 level. Two-thirds of this investment would involve households, with amounts in the order of 20 000 to 40 000 Euros to be invested per housing unit over three to four decades, or around 1,000 Euros/yr.

New Measures

A number of new measures have been implemented in France in order to make progress towards this energy improvement of the building stock, primarily under the impetus of the European Directive on building energy performance. These include:

- energy regulations for new and existing buildings,
- building energy audits,
- periodic inspection of boilers and air-conditioning equipment,
- financial support (tax credits) for investment in energy management, and
- energy savings certificates, among others.

It will be necessary to supplement these measures in order to go further, and enable the energy rehabilitation of nearly all the existing stock. This will require massive organisational, technological and financial efforts in the coming years.

Building Energy Regulations, Setting up a 'Virtuous Circle'

By regularly raising mandatory performance levels, energy regulations provide a way to stimulate research on building components, equipment and overall design, which in turn allows new regulatory requirements to be set. This virtuous circle is necessary, in order to simultaneously mitigate global warming and anticipate depletion of traditional energy resources. Thermal regulations for new construction have been issued at an increasing pace in France since 2000. In parallel, regulatory requirements are being implemented for existing buildings.

For a significant fraction of the old building stock, however, it will not be possible to reduce greenhouse gas emissions by a factor of four, and therefore all new buildings will have to be extremely energy efficient in order to compensate.

Only five years elapsed between the thermal regulations issued in 2000 (RT 2000) and those issued in 2005 (RT 2005) that reinforce requirements for new buildings in France by 15% (compared to 12 years between RT 1988 and RT 2000). Public authorities have already announced new thermal regulations, and a new 15% jump, for 2010.

New buildings will have to push their energy performance higher and higher, by applying results obtained through research and integrating renewable energy on a very large scale.

Nonetheless, even if new buildings attain a factor 7 or 8 (i.e. greenhouse gas emissions that are seven or eight times lower than for the same building built in 2000), it will not be possible to balance the emissions budget, given the very low impact of new construction compared to existing building stock.

Positive Energy Buildings, a Challenge to Drive Research

To achieve Factor 4, a large proportion of new buildings will have to offer even higher energy performance. They will have to no longer consume energy, no matter how little, but be designed from the start to be net energy producers, through large-scale integration of renewable energy devices. This ambitious goal can be met only through very substantial efforts devoted to R&D and experimentation.

A concrete example: 'Le Tournesol' ('The Sunflower') in Villeurbanne, France, is a good example of the optimisation of energy consumption in a residential building.

These are the aims of PREBAT, the National Programme for Research and Experimentation on Energy Use in Buildings launched in France in 2005 for a first phase up to 2009, and to be renewed in the future.

PREBAT involves five ministries along with five national agencies. The programme supports through regular calls for proposals hundreds of participants in the buildings sector who want to become more advanced.

It creates the conditions necessary for the broadest mobilisation possible, to optimise or renew traditional technologies, but also to bring renewable energy into the buildings sector, on a much larger and more intensive scale.

The results will be seen starting in 2007 when highly energy-efficient demonstration buildings will be completed in France. Construction and monitoring of the first years of operation will also be funded under PREBAT.

The results obtained through research and experiments will spur new regulatory requirements, which in turn will call for further research.

A Win-Win Strategy

This highly proactive framework offers many opportunities. Refined techniques, expansion of trades, greater technical skill, and creativity, are some of the advances proposed for the building trades.

Potential crises can become opportunities, as long as they are anticipated. This evolving framework aims to put building trades in France on a Factor 4 trajectory as rapidly as possible, giving a 'win-win' strategy.

Tackling this challenge will enable us to both confront global warming and create new opportunities to incite young people to train for construction trades, at work sites, in engineering firms, technical centres and research laboratories.

Cost-Effective Commissioning for Buildings

Developments in ECBCS Annex 47

Natascha S. Castro, National Institute of Standards and Technology, USA

Many buildings fail to meet performance expectations due to problems that occur at various stages of their life cycle, from building design to operation. These problems, which often originate from building systems and their interactions (including the building envelope, heating, ventilating, and air-conditioning (HVAC) systems, and lighting systems), can trigger increased CO_2 emissions, energy costs, occupant discomfort and health problems, reduced productivity, and higher maintenance costs. Building commissioning is a quality assurance process that if applied more widely and at earlier stages in the building life cycle has the potential to dramatically reduce building energy consumption and improve performance. Methodologies and tools to realize these goals are being studied by the ECBCS research project on “Cost Effective Commissioning in Existing and Low-Energy Buildings”, Annex 47.

The project, underway since June 2006, includes 12 participating countries represented by over 50 organizations. The shared objectives are to:

- develop tools that utilize design data and the buildings’ own systems in commissioning,
- automate the commissioning process to the extent practicable,
- develop methodologies and tools to improve the operation of buildings in use, and
- quantify and improve the costs and benefits of commissioning.

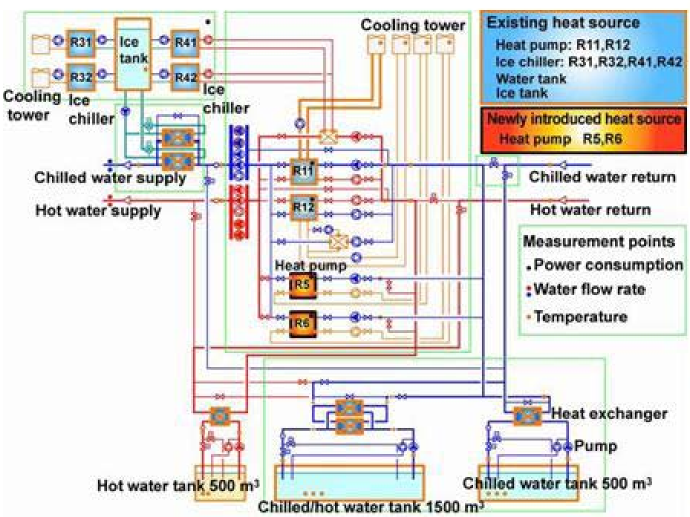
The scope includes initial commissioning for advanced and low-energy systems, re-commissioning and optimizing existing buildings (the focus of this update), and quantifying the costs and benefits of commissioning.

One of the challenges in developing commissioning tools is to address the different needs of existing buildings and new low energy buildings. Low-energy buildings emphasize an integrated systems approach throughout their life cycle; some buildings may comprise novel and/or advanced technologies and system operation strategies, while others take full advantage of existing technologies.

Existing Buildings

For conventional buildings, the interest to improve methodologies and develop automated and semi-automated tools for commissioning and optimization is based on the sheer number of buildings, their high energy consumption, and the fact that very few have been commissioned. Therefore significant energy savings will be attained at the national level by applying cost effective processes for commissioning and optimization of building envelopes, HVAC systems, and the building energy management systems (BEMS) in conventional buildings.

Conventional buildings often lack design data, have limited monitored data and the addition of new sensors and minor refinement of present systems must be shown to be cost-effective. Furthermore, the goal for re-commissioning is usually to get the best performance with existing systems (e.g, run fault detection and diagnostic (FDD) algorithms and if problems are identified then run specific functional performance tests (FPTs).



A generic commissioning tool is under development for the energy plant which supplies chilled/hot water to three commercial buildings.

New Low Energy Buildings

In contrast, new low energy buildings do have design data and the goal for commissioning is performance verification. Here, FPTs can be used to clarify or diagnose any abnormal operation. In all buildings, thorough documentation is important to build the benchmark for persistence of energy savings and system performance.

Tools

The tools that are being adapted and/or developed are classified as follows:

1) tools for active testing, where setpoint changes or control overrides are used to force equipment and system responses;

2) tools for passive monitoring, where performance is assessed under normal and optimal operating conditions;

3) tools for data management, which help facilitate testing and data analysis; and

4) tools for system operator training.

The following are examples of more than a dozen tools under development in the specific project research area of "Recommissioning and Optimizing Existing Buildings."

1) Commissioning (Cx) tool for HVAC Systems

The Functional Test Analysis Tool uses automated fault detection and diagnosis techniques to analyze measurements from manual active functional testing of air handling units. The tool is designed to be used after the start-up tests and the testing and balancing (TAB) have been performed. It tests the mechanical equipment, including the sensors and actuators, but does not test the control programming or loop tuning.

2) Cx Tool For The Whole Building

This tool is based on continuous monitoring of overall heating, cooling, electricity consumption and indoor temperatures that are inputs to the overall performance energy analysis and optimization of commercial office buildings.

3) Cx Tool For Energy Plants

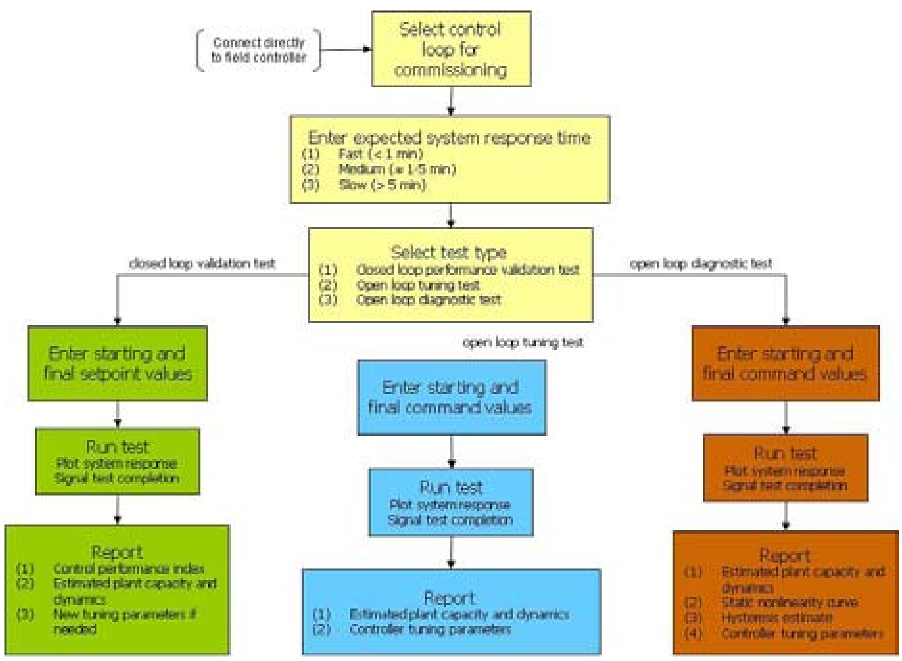
A model-based tool for optimizing the operation of heating/cooling plants, including a visualization module to display system operation and identify faults and a performance simulation module to verify proper operation and achieve optimal operation.

4) Control Loop Cx Software

This tool performs active tests on HVAC control loops in either open or closed loop conditions to determine system capacity, control dynamics, and optimal tuning parameters. It may also be used to characterize the extent of static nonlinearity and hysteresis in a system. The identified static nonlinearity may then be compensated for in software instead of replacing a physical device.

These tools will be tested and documented in case studies that will be published as part of the project deliverables. Early results of Annex 47 were disseminated in October 2006 in 24 technical papers and presentations at the 6th International Conference on Enhanced Building Operations and 1st Asian Pacific Conference on Building Commissioning in Shenzhen, China.

The links for these published papers and more information can be found at www.ecbcs.org



Workflow for control loop commissioning tool

Energy Research in the Netherlands Built Environment

Piet Heijnen, SenterNovem, The Netherlands and ECBCS Executive Committee member for the Netherlands

Energy Research Subsidy

As the Netherlands Government shifts its research strategy focus to the long term, it has identified the built environment as one of five energy research priority areas, now presented as formal energy research programmes.

Long Term Research Programme: Built Environment

The built environment research area covers both new construction and the existing stock of residential and other buildings. The focus is not only aimed at the approach to individual buildings, but primarily towards an integrated approach to clusters of buildings at several scale levels (suburb/town section) including the associated energy infrastructure.

Vision

The following vision has been formulated:

Since it is responsible for around 35% of the energy consumption in the Netherlands, the built environment plays an important role in the transition to a sustainable (affordable, reliable and cleaner) energy supply in the future. The contribution to this transition is achieved by introducing integrated systems aimed at various forms of synergy, e.g. between supply and demand, various technical components, and the built environment with other user sectors. This approach leads to several benefits, including heat-neutral buildings (averaged out over the year), where the necessary electricity is largely generated in a sustainable manner.

Objectives

The Built Environment programme aims to encourage long-term research into solutions that lead to a sustainable energy supply that is clean, affordable and reliable. Objectives include:

- Improve efficiency and effectiveness of publicly financed long term energy R&D in the Netherlands.
- Ensure continuity of long term energy R&D into sustainable, efficient and secure supply of energy whilst the sector is transformed by liberalisation and internationalisation.
- Support the transition to sustainable energy supply
- Support the Dutch technology position within international, cooperative networks.

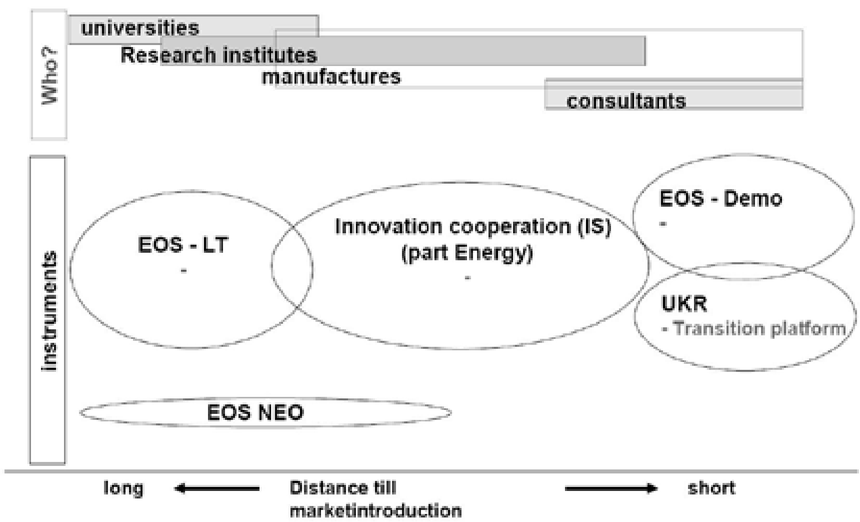
An integrated approach (design, innovative concepts, intelligent systems etc.) should lead to buildings being built or renovated in a sustainable manner. The use of fossil fuels for building-related functions (heating, cooling, ventilation) should be minimal. For new construction, gas or electricity should generally not be converted to heating or cooling alone; for renovation this should be reduced by at least 50% (compared to 2004). At least 60% of the electricity consumption in new buildings should be generated locally from renewable sources. The built environment as a whole aims to have at least 10% of the electricity consumption generated from renewable sources.

Long-term objectives can only be realised if short-term steps are taken towards a system approach. However, research that can be implemented in the short term is not included in this ERS programme.

Strategy

A strategy is required in order to achieve these objectives, whereby the targets for saving energy are placed within the wider framework of social and economic aspects of buildings and living conditions. This framework can be characterised as:

- **People:** The research results must meet people's requirements concerning reliability, safety and comfort. The quality of the living and working environment should benefit from this research.
- **Planet:** Applying the *trias energetica*. This is the general strategy for implementing a cleaner energy supply. The three steps are:



Long-term research objectives for the built environment (>10 years)

1) Reducing the demand for energy;

2) Using renewable sources;

3) Efficiently converting fossil fuels to meet the remaining demand.

In addition, the general starting point assumes that high-grade energy (gas, electricity) will only be used for high-grade applications (driving equipment, heat pumps etc.)

- **Profit:** Research should always strive to provide affordable and reliable solutions, although the term 'affordable' greatly depends on the context. If these two conditions are not met, solutions will never be accepted in the market (on a large scale), and will never form a substantial part of the (sustainable) energy supply.

The phase leading up to heat-neutral buildings will be a gradual process. Research over the next few years is expected to focus on the component level. This should create the necessary room for integrating new components into systems. Eventually, large-scale experiments will be conducted in integral concepts. The experience gained should mean another step towards energy-neutral buildings and energy systems that can supply all energy functions in the built environment at considerably lower fossil fuel consumption and CO_2 emissions.

Implementation of new techniques is only possible if there is an adequate knowledge infrastructure and if principals and implementers in the built environment are encouraged to apply these new developments.

Research Areas

The ERS programme for the built environment consists of the following research areas:

a) System approach in the built environment

- Integral concepts at higher system level (including exergetic optimisation of the chain);
- Integral concepts for buildings or suburbs.

Apart from the physical built environment, traffic and transport also play an important role in the integral system of energy supply. Integrating living and working conditions (mobility) will be included in alternative attitudes to living and working concepts, which will eventually contribute to a more efficient energy consumption. In short, this means synergetic relationships between buildings, (local) infrastructure and users.

b) Local energy generation

- Decentralised energy generation;
- Using ground-air heat in the built environment through heat pumps;
- Solar conversion or PV.

  This research area encourages efforts towards components and their integration into the system for (local) generation and transport of renewable energy, efficient and clean conversion of fossil fuels, as well as using renewable sources plus extra fossil-based energy.

- This research area also concerns photovoltaic conversion of solar energy (PV).

For more information, see www.senternovem.nl/eos

Research Funding

From the five different subsidy regulations, the Long Term Research is the most relevant one for the work of ECBCS. Each year there are two or three tenders for long term research. The first tender for proposals was at the end of 2004. The total annual budget will be around € 35 Million, each year. The intention of the Ministry is to continue this ERS programme at least for eight years. Up to August 2006 there have been five long term tenders. In all, about 160 research projects have been selected, about 50 approved, of which 20 are within the area of the Built Environment

International Co-Operation

One aspect of the ERS programme is national and international knowledge dissemination. ECBCS is an excellent platform to exchange knowledge between researchers.

The most ideal situation would be in (some) Dutch ERS research, taking part in ECBCS activities. At the moment Annex 44 (Integrating Environmentally Responsive Elements in Buildings) and Annex 50 (Prefabricated Systems for Low Energy Renovation of Residential Buildings) are examples of the most desirable situation: Dutch ERS research forms part of the ECBCS work. In the Netherlands, the work of the ECBCS projects will be followed up by a mirror group to exchange knowledge and to inform Dutch researchers about work in the ECBCS.

Conclusion

The focus for long term energy R&D has been defined in those areas that are considered crucial for a sustainable energy supply. An element of this is the integral system approach at the community or the building level.

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Further information

www.senternovem.org

Solar Sustainable Housing – New Publications

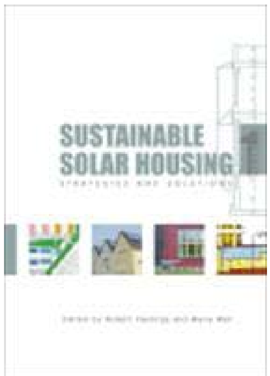
Joint project ECBCS Annex 38/SHC Task 28

The objective of the Solar Sustainable Housing research effort was to help achieve a significant penetration of such housing in the housing markets in participating countries (i.e. more than 5%) by the year 2010, by providing builders and institutional real estate investors with:

- Good examples of built projects with proven success, and
- Hard facts to make cost/benefit decisions on the mix of solar and conservation strategies.

Guidance to improve energy, environmental and cost performance of their own designs.

The following publications arose from the work.

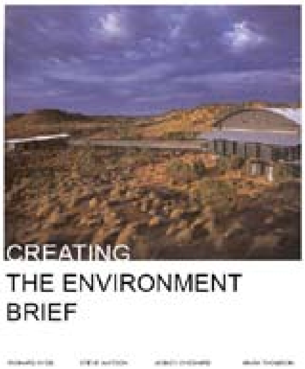


Sustainable Solar Housing

Edited by Robert Hastings and Maria Wall

Volume 1: Strategies and Solutions
Volume 2: Exemplary Buildings and Technologies
UK, Earthscan, 2006

Insights from monitoring, simulation and the experts with sections on strategies, solutions, exemplary buildings and technologies.



The Environmental Brief: Pathways for Green Design

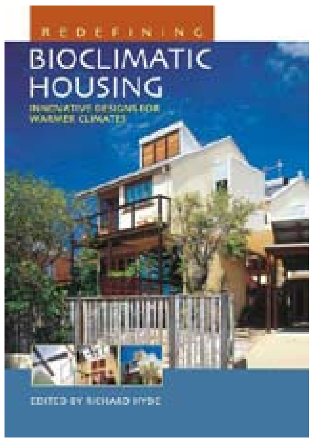
Richard Hyde, Steve Watson, Wendy Cheshire, and Mark Thomson
Taylor and Francis, 2006, 336pp.

The purpose of the book is to improve the uptake of ecological sustainable development through green design. It has three parts: a review of theory; an account of tools and methods; and case studies.

Bioclimatic Housing: Innovative Designs for Warm Climates

Edited by Richard Hyde
UK, Earthscan, due 2007

Covers sustainable architecture in warmer climates. Uses the approach of bioclimatic housing to explore how sustainable architecture interacts with its environment. Explores a range of global case studies from the Middle East, Asia, Europe and Australasia, forming an overview of strategies and showing how these can be developed into practice.



Business Opportunities in Sustainable Housing: A Marketing Guide Based on Houses in 10 Countries

Free Download available Solar Heating and Cooling Website
www.iea-shc.org/task28/downloads/IEA_Sustainable_Housing_Marketing_Guide.pdf

Exemplary Sustainable Solar Houses

A series of 40 brochures describing demonstration sustainable solar housing projects. Available at the ECBCS Website www.ecbcs.org/annexes/annex38.htm#p.

(ECBCS Technical Day Continued from page 2)

incentivisation/cost balances to encourage uptake of the scheme and establish links with Building Code standards. The development stream for HERS covers six streams of work: selection, modification and testing of the energy tool; develop a delivery mechanism; marketing and public education programme; training and accreditation of assessors and stakeholder consultation.

Mark Riley discussed how Canadian experiences can inform New Zealand in predicting and rating energy-efficiency. He gave a presentation on CANMET Energy Technology Centre's (CETC) Sustainable Buildings and Communities programme, of which he is the Director. Their mandate is to develop and demonstrate energy efficient, alternative and renewable energy technologies and processes.

The programme aims to accelerate the introduction of innovative energy technologies into the marketplace and its 75+ experts facilitate the advancement of energy technologies from fundamental research to market deployment.

Energy use in the residential sector in Canada is the highest in the world averaging 127 GJ (or $1,400) per household per year. There are 12.8 million dwelling units, with single detached houses a preferred choice. About 85% of the Canadian housing stock is 15 years or more old. The energy performance rating system used is EnerGuide for Houses, which promotes energy efficient retrofits in existing homes, and aims to encourage homeowners to take action, sourcing actual home energy savings for statistical and programme evaluation purposes.

Around 320,000 EnerGuide for Houses evaluations have been performed to date, leading to an average 20% to 31% reduction in total energy consumption, and average homeowner rebate of $735 (after retrofits), average saving of $140 to $210 in utility bills, and a CO_2 reduction from 1.9 to 5.8 t/y per house.

Mark Riley went on to describe the HOT2000 Energy Analysis Program, which is a low-rise residential energy analysis and energy compliance software tool, with over 20 years of development, and has been used to evaluate the energy efficiency of more than 500,000 houses in Canada and is used in over 143 countries worldwide. The outputs include formatted homeowner reports, technical reports, comparison reports and customisable HTML reports, which can be formatted using standard HTML tags. HOT3000 is released in April 2007, and is expected to replace HOT2000 in Canadian programmes within five years.

Non-Residential Buildings & Energy Efficiency

After Liisa Halonen had talked about energy efficient lighting for New Zealand buildings, Michael Donn gave a presentation on daylighting commercial buildings for the 21st century. This is an IEA Solar Heating and Cooling Task whose outcomes are as follows:

- generic descriptions of daylighting requirements for inclusion in codes,
- a technology roadmap for designers with performance targets,
- guidelines for control system interface design to account for user reaction,
- user friendly computer tool releases with working documents on plug-in specifications for sky models and complex fenestration systems,
- guidelines on appropriate use of tools,
- the transference of results to architects, engineers, industry and building owners by means of workshops, regional support groups and an international web site that includes: data sets of user preferences, building performance targets, cost benefit studies and case studies of noteworthy buildings.

Steve Dixon described the New Zealand Ministry for the Environment's Govt3 and Sustainable Buildings programme, which aims to influence the commercial buildings sector by paying attention to the sustainability of NZ government buildings. Government is responsible for more than 30% of buildings in New Zealand.

Formed in 2003 and becoming a Cabinet requirement in 2006, its directive is to accelerate the adoption of sustainable building practices. Forty seven agencies have signed up focussing support in four areas, including buildings.

The effect on improved productivity cannot be overlooked in relation to sustainable buildings. The author concludes that the number of sustainable buildings is increasing rapidly, with Govt3 as a driver, there is a large amount of Government and local government activity and standards are improving dramatically. He speculates that the future could hold 'environmentally restorative design' as the major buildng design concept.

The Technical Day concluded with an update of the ECBCS projects given by Alexander Zhivov.

Further information:

EPBD Concerted Action (www.epbd-ca.org)

EPBD Buildings Platform information centre (www.buildingsplatform.org/cms)

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42 COGEN-SIM : The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems
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43 Testing and Validation of Building Energy Simulation Tools (Solar Heating and Cooling Task 34)
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45 Energy-Efficient Future Electric Lighting for Buildings
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46 Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings
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