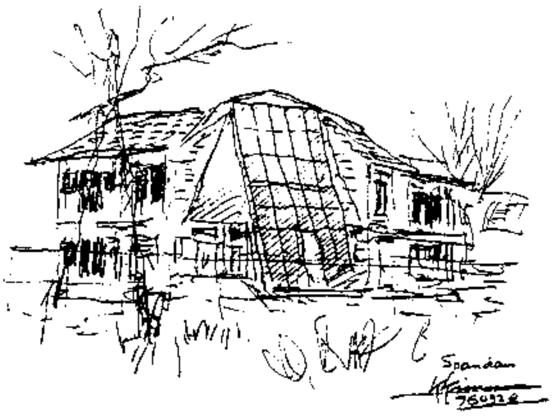
INTERNATIONAL ENERGY AGENCY
Solar Heating & Cooling Programme



TASK 13:
ADVANCED SOLAR LOW-ENERGY BUILDINGS

FINAL TASK MANAGEMENT REPORT
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TASK 13: ADVANCED SOLAR LOW ENERGY BUILDINGS

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Introduction:

Task 13: Advanced Solar Low Energy Buildings was initiated in 1989 as a result of a workshop in Watsonville, California, where proposals for starting new tasks on solar buildings were discussed. The conclusion of the workshop was that there should be two new tasks: Task 12: Building Energy Analysis and Design Tools for Solar Applications and Task 13: Advanced Solar Low Energy Buildings.

To facilitate the effective planning and implementation of the program of work in Task 13, a feasibility phase was conducted prior to initiation of the research phase. During this time, two workshops were conducted, in Hinterzarten, Germany and in Copenhagen, Denmark. The primary result of the feasibility phase was a detailed work plan. The research phase was started on September 1, 1989 and was scheduled to last until September 1, 1994.

As several of the experimental buildings developed in the Task were just completed at that time, the Executive Committee approved a two year extension, in order for the results of the monitoring of these buildings to be included in the Task. The Task was consequently completed on September 1, 1996.

The original concept paper for the Task was developed by S.Robert Hastings from Solararchitektur at the ETH in Zürich. At the start of the feasibility phase professor Anne Grete Hestnes from the Faculty of Architecture at the Norwegian University of Science and Technology was selected to be Operating Agent of the Task on behalf of the Norwegian Ministry of Industry and Energy.

The Task ended with a Final Task Symposium arranged in conjunction with the EuroSun '96 conference in Freiburg, Germany on September 17, 1996 and with a final Task meeting on September 20, 1996.

Objective:

The objective of the Task was "to advance solar building technologies through the identification, development, and testing of new and innovative concepts which have the potential for eliminating or minimizing the use of purchased energy in residential buildings while maintaining acceptable comfort levels".

Scope:

The focus of the Task was the application of passive and/or active solar technologies for space heating of single family and multi family residential buildings. The use of passive and active solar concepts for cooling, ventilation, and lighting was also addressed, as well as advanced energy conservation measures to reduce heating and cooling loads.

Since the emphasis was on innovation and long-range (after the year 2000) cost-effectiveness, the materials, components, concepts, and systems considered did not need to be currently feasible, economical, or on the mass market.

The knowledge regarding the properties of materials and components acquired in the IEA SHCP Task 10 and the experiences gained in Tasks 8 and 11 on designing and evaluating solar buildings were to be important inputs to the Task.

Means:

In order to accomplish the foregoing objective, the Participants undertook work in three subtask areas:

Subtask A: Development and evaluation of concepts:

This Subtask identified materials, components, and whole building concepts that had the potential for significantly reducing energy use, determined performance criteria, performed simulation studies to evaluate expected performance, and developed experimental building designs.

In order to facilitate the simulation of the new and often complex technologies and building designs, a special group, the Simulation Support Group, was set up within the Subtask. This group provided support to the various teams doing simulation studies.

The Leader of Subtask A was Hans Erhom from the Fraunhofer Institute for Building Physics in Stuttgart, Germany.

Subtask B: Testing and data analysis:

This Subtask was responsible for both the testing of materials and components and for the monitoring of the Task 13 experimental buildings. It selected materials and components to be tested, reviewed and agreed on the experiments to be performed, developed monitoring, instrumentation, evaluation, and reporting requirements for the experiments, and in some cases also arranged for the use of other countries' test facilities.

Subtask B also developed monitoring, instrumentation, evaluation, and reporting requirements for the experimental buildings and reviewed the results of the monitoring of these buildings. As this activity is not yet completed, the Subtask Leader has proposed an extension of the work within the framework of an IEA Working Group.

The Leader of Subtask B was Bjarne Saxhof from the Department of Buildings and Energy at the Technical University of Denmark in Copenhagen, Denmark.

Subtask C: Synthesis and documentation:

This Subtask dealt primarily with dissemination of the results of the Task. As a starting point, it reviewed the performance of existing advanced solar residential buildings, the monitoring techniques used, and what could be learned from those experiences. It then compiled the designs of the Task 13 building designs, produced working documents and technical reports on technologies and on simulation and testing activities, and prepared a book which includes all the results of the Task. Subtask C was also responsible for the planning and conduction of two Task symposia.

The Leader of Subtask C was S.Robert Hastings from Solararchitektur at the ETH in Zürich, Switzerland.

Participation:

Fourteen countries plus the European Commission have officially participated in the Task. These are:

Austria	Finland	Norway
Belgium	Germany	Sweden
Canada	Italy	Switzerland
Denmark	Japan	United Kingdom
E. C.	Netherlands	United States

Approximately 45 experts from these countries have participated in the work. They comprise both researchers, from public and private universities and research institutions, and architects and engineers, from private consulting companies. With a few exceptions the participation has been very stable, ensuring good continuity in the work of the Task.

The exceptions are primarily Austria, Italy, and the UK. The Austrian participation changed in the middle of the Task period due to funding problems. The Italian participation also changed, in this case twice. The UK participation did not change, but the experts only attended a few of the meetings.

These countries' problems are reflected in the fact that they also are the countries that were not able to build experimental buildings within the Task. As the Task had a relatively large number of countries participating in any case, the less than optimal participation from a few did not cause any serious problems for the Task as a whole, however.

All participating countries, and most of their experts, participated in all of the Subtasks of the Task.

Industry involvement:

Industry involvement in Task 13 has been indirect but significant. The main activity in the Task was the development, construction, and monitoring of experimental buildings. In this activity the building industry in the different countries was strongly involved, both by participating in design development, by providing materials and components to be used in the buildings, and by, naturally, constructing the buildings. In several cases this has resulted in a continuing cooperation between the industry and the research institutions involved.

Task meetings:

A total of 14 experts meetings have been conducted during the research phase of the Task. These are:

1	Boulder, Colorado	November 1989
2	Bregenz, Austria	March 1990
3	Utrecht, Netherlands	October 1990
4	Alton, Ontario	February 1991
5	Kandersteg, Switzerland	September 1991
6	Wadahl, Norway	March 1992
7	Tazawa-ko, Japan	September 1992
8	Spitzingsee, Germany	March 1993
9	Sorrento, Italy	November 1993
10	Nesjavellir, Iceland	June 1994
11	Waterloo, Belgium	January 1995
12	Rovaniemi, Finland	July, 1995
13	Grand Canyon, Colorado	January 1996
14	Hinterzarten, Germany	September 1996

At each of the meetings, between 25 and 30 experts participated. The meetings typically took three days, with a technical visit either at the end or beforehand. During the meetings, the participants reported on national status, discussed results, and planned further work. As all experts participated in all three Subtasks, there were very few parallel sessions. This ensured that the experts all were familiar with all the activities in the Task and that they therefore also felt responsible for the Task as a whole.

One important, and popular, activity at the meetings was the design review sessions, where the various countries' Task 13 building designs were presented and reviewed. Another important activity at the meetings was the socalled "expert ^{2}" presentations, where experts on specific technologies were brought in to give detailed technical talks. Operating Agents or other key persons from related IEA SHCP Tasks were also invited to give presentations.

The venues were chosen to enable the participants to visit as many of the Task 13 buildings as possible. The venues were also chosen with the intent of minimizing distractions, ensuring that the participants spent their whole time together, exchanging ideas and information. In a session reviewing the Task as a whole, the experts all agreed that these remote locations had been successful choices.

Accomplishments:

The objective of the Task was reached through a number of activities, the most important of which being the development and testing of whole building concepts. In the end, eleven of the countries constructed a total of fourteen experimental buildings. This was clearly beyond the expectations of the Operating Agent at the beginning of the Task. The building projects are:

Belgium/E. C. :	The PLEIADE rowhouse unit in Louvain-la-Neuve
Canada:	The Advanced House in Brampton, Ontario
	The Green Home in Waterloo, Ontario
Denmark:	The Solsikkeparken rowhouses in Vonsild, Jutland
Finland:	The IEA5 Solar House in Pietarsaari
Germany:	The Zero Heating Energy House in Berlin
	The Ultra House in Rottweil
Japan:	The WISH House 3 in lwaki
Netherlands:	The Urban Villa in Amstelveen
Norway:	The IEA rowhouse unit in Hamar
Sweden:	The low cost prototype at Rörskär
Switzerland:	The duplex in Gelterkinden
USA:	The Exemplary House at Grand Canyon
	The Exemplary House at Yosemite

These buildings, which range in size from single family houses to a large apartment building, have all been designed in part as a team effort by the Task 13 participants. At Task meetings each country's design was extensively reviewed and discussed. After the meetings, the designs were revised. Each design therefore benefitted from the knowledge and experience of the group as a whole.

Italy, one of the countries unable to build an experimental building due to problems with finding a site and a contractor, instead simulated their building design for three different Italian climates. The results of this activity also provided useful information for the participants.

The most useful results were the results of the building activities, however. The experimental buildings provided information about the performance of the various materials and components and of the buildings as complete systems. They also provided information about builder and user behavior and about the design processes required in the design of advanced solar houses. The most important lessons learned from the design, construction, and monitoring of these buildings are listed in a separate attachment.

The buildings were also the best way of creating an interest both in the results of Task 13 in particular and in solar buildings in general. And, they were good catalysts of knowledge exchange between the participants.

One particularly promising accomplishment is the fact that the building industry in some of the countries now have started using the results. For instance, in Germany the main prefab housing manufacturer has included the Berlin Zero Heating Energy concept in his catalogue and has already constructed a prototype, in the Netherlands a refined version of the Urban Villa is now under construction, and in Sweden a major social housing organization has set up a company together with the Swedish Task 13 participants and will include the Swedish concept in their portfolio.

To summarize, the main results of Task 13 are:

- fourteen experimental buildings with exceptionally low total energy use
- substantial new knowledge about/experience with:
  - advanced solar technologies
  - simulation and monitoring of solar buildings
  - design processes
  - cooperation with builders and contractors
  - user behaviour and user reactions to solar technologies
- a number of technical reports, a brochure, a booklet, and a book
- two international symposia and a number of national seminars
- market introduction of some new solar concepts

Information dissemination activities:

As stated above, the experimental houses have been most effective in gaining attention from the building industry, thereby providing opportunities for dissemination also of other Task results. The buildings have been presented in videos and TV programs in several of the countries, and they are the goal for numerous visitors, from kindergarten groups to journalists. For instance, in Canada the "Green Home" is featured as part of an educational program for school kids on energy and resource use.

Apart from the buildings, the most important accomplishment, and the best source of information about the Task results is the final Task 13 report, titled *Solar Low Energy Houses: Strategies, Technologies, Examples.* This book is presently being printed at James & James Science Publishers Ltd. and will be available before the end of the year. The publisher displayed a draft copy of the book at their stand at the EuroSun '96 conference, where they also had a flyer about it, and they have already received quite a few orders.

In addition, the Task has produced a number of working documents and technical reports, a booklet on the building designs, a brochure about the buildings, and page on the WorldWideWeb. The working documents were mainly for internal use, but quite a few of the participants felt that they could have had a wider audience. The technical reports also seem to have a limited, but highly interested audience, while the brochure and the book about the houses have been in high demand. These documents are, however, primarily useful as ways of informing the public in general about the Task, and of creating an interest in the final Task report. In general, the experience, also from Task 11, is that this type of book in the long run will have most impact, as it is available world wide, and as it has a longer life span than the brochures and reports.

In the Task work plan it was specified that the Task would conduct two symposia. The first of these was conducted after three years, in conjunction with a CIB symposium in Stuttgart in 1993. The second one was conducted at the end of the Task, in conjunction with the EuroSun '96 conference in Freiburg in 1996. At both of these events there was a special session on Task 13. These sessions had quite a few participants and can in that sense be considered successful.

The tendency at such events is that the audience consists of colleagues, i.e. of persons who already know a lot about solar buildings, rather than of persons from the building industry and architects in private practice, however. The Task participants have therefore conduded that national seminars, using local languages and relating the results to the local context is a much better way of disseminating the results. Most of the participants have conducted such seminars and workshops. Many of them are also producing reports and books in their local languages, using the Task 13 documents as a basis. For instance, the Belgian and Dutch Task 13 participants are jointly writing a book in Dutch and French, and the German and Swiss are both producing various material in German.

Management issues and recommendations:

As a result of the fact that the main activity in the Task was the development, construction, and monitoring of experimental buildings, the objective always seemed relatively clear to the participants, making it easy to structure the work and to measure the progress of the Task. Its success is also, inevitably, measured by this production of buildings.

However, due to this focus, other activities may have suffered somewhat, and countries not able to build may have lost some of their interest in the work. In a task review it was pointed out that the design review activity, which was regarded as highly creative, should have continued also after the Task 13 buildings had progressed to the construction phase. Discussions of monitoring results were considered useful, but not quite as intellectually stimulating. It is clearly important to ensure that there are creative activities at task meetings, as the meetings otherwise may become more like "shopkeeping sessions".

The fact that there was a great degree of stability in the Task participation, with no changes at the management level and with only a few changes at the expert level, also made the Task relatively easy to manage. Considerable effort was spent at the beginning of the Task to make the participants feel like friends and colleagues working towards the same goals. Little time was therefore needed to work out disagreements at later stages, and little time was spent on "international diplomacy". This is reflected in the fact that the participants all seem to think that they could have spent yet another seven years working together.

Seven years is a very long time, however. It was a natural result of the need to build and monitor experimental buildings, as timing of many of these activities could not be controlled by the Task 13 experts. The work otherwise scheduled went fairly much according to plan, taking into account the fact that most work is produced just in time for upcoming meetings. This means that meetings at least every half year are essential to get the work done. Clear minutes and action items distributed without much delay after the meetings also help keep the work on track.

One problem of timing is that the national program schedule, and therefore funding, in many cases does not correspond in time with the task schedule, and also that no country will have guaranteed funding for more than a part of such a long task. This is, of course, a problem that is difficult to solve, but that the Executive Committee members should be aware of when defining the length of a task.

Another problem of the timing of Task 13 was the need to coordinate the work with the work in Task 12. The original intention was that Task 12 should provide Task 13 with support in simulating the building concepts developed. As it turned out, most of the simulation had to be done before Task 12 had developed the necessary tools. Task 13 therefore had to this themselves. Several participants were also active in Task 12, however, ensuring that the work could be shared and that no duplication of work occurred.

Conclusions:

In general it can be concluded that Task 13 built on the experiences and results of Tasks 8 and 11 and significantly further advanced solar building design. For the first time a building related task dealt with all solar technologies, i.e. with both passive, active, and photovoltaic technologies in combination, successfully integrating these technologies in ways that resulted in buildings that use only 25% of the energy used in typical residential buildings today.

It must therefore be considered a successful task, thanks to the large number of very knowledgeable and motivated experts that participated in the work.

Lessons learned in Task 13:

The Task has demonstrated that it is possible to design very low energy buildings that at the same time have high thermal comfort, good indoor air quality, and* low *environmental impact.

Task 13 has shown that it is possible to reduce the total energy consumption to a small fraction of the typical consumption today. The average total energy consumption of the experimental buildings developed in the Task is 44 kWh/m^2 per year. This is only about 25% of the typical consumption in residential buildings in the participating countries.

In addition to low energy use, some of the Task 13 design teams also paid special attention to other resource use. The Canadian house in Waterloo, which makes extensive use of recycled materials, has reduced purchased water use by 73%, ozone depleting chemicals by 99%, and waste sent to landfill by 98%. The other buildings do not have quite as impressive numbers for resource use reduction, but they all demonstrate both reduced energy use and therefore also reduced environmental impact.

The total energy consumption does not differ very much from country to country.

This is partly due to the fact that the consumption for water heating, lights, and appliances is relatively independent of climate, but also to the fact that the building codes are not. The insulation levels are generally low in countries with mild climates and high in countries with cold climates. The energy consumption per square meter therefore does not differ as much as one would expect when looking at the climatic differences.

The energy consumption for water heating is as large as the energy consumption for space heating, and, more importantly, the energy consumption for lights and appliances is also quite large.

In most of the Task 13 buildings, the electricity demand is as large as the thermal energy demand. This is due to the fact that the emphasis in many of the countries so far has been on technologies for reducing space heating consumption and that this consumption therefore has been reduced more than the rest. It is now necessary to consider the buildings' other energy uses as well. This actually provides more opportunities for innovation, as can be seen in the Task 13 buildings.

It is necessary to consider the total energy use, and not to focus on space and/or water heating only.

It is, for instance, important to consider both heating and cooling, as several countries found that focusing on one season only could lead to problems during the other season. Also, reducing cooling loads was often a greater challenge than reducing heating loads.

The largest reduction in energy consumption for space heating in the Task 13 buildings is achieved by the use of traditional energy conservation technologies. A further reduction in the energy consumption for space heating, and a reduction in the consumption for water heating, lights, and appliances, required the use of solar technologies. As the objective of the Task was to reduce the total consumption, all of the Task 13 buildings therefore use both energy conservation and solar technologies.

It is necessary to consider the building as a system, where the different technologies used are integral parts of the whole.

The order in which the technologies are introduced into the design appears to be quite important. Generally, energy conservation technologies are considered first, passive solar second, and active solar third. In most cases all of these technologies are used, often in combined systems. The emphasis in Task 13 has therefore been on developing whole building concepts rather than on developing specific technologies.

Energy conservation, using high levels of insulation and super-windows, should be the first option considered.

High levels of insulation are beneficial in all climates, including those where cooling is the major issue. Super-windows, i.e. windows with multiple layers, low-E coatings, and gas fillings, are also always beneficial. They proved to be a better option than windows with transparent insulation. Such super-windows render orientation less critical, allowing the use of larger glazing areas to non-south orientations.

Mechanical ventilation systems appear to be essential in low energy buildings, but their use should be challenged.

All the Task 13 buildings use some form of mechanical ventilation, and many also use heat recovery on ventilation air. The need for such systems should be challenged, however, both as they use electricity and as they add complexity. Parasitic power consumption was found to be unreasonably high in many of the buildings.

The problems of mechanical ventilation systems should be, and were, addressed during the design phase. It is clear that there is a need further development, especially in the area of low energy fans and low pressure heat exchangers.

Passive solar gains can make a major contribution to space heating in all climates and do not lead to overheating if proper solar protection is used.

Passive solar cooling also proved to work. Both in the heating and in the cooling situations it was necessary to include thermal mass in the direct gain passive solar designs, as that extended the usability of the systems by increasing the time constant and slowing down heat build-up in the summer.

Phase change storage materials did not function properly in the cases where the technology was tried, however. PCM's were tested in the Japanese house and simulated for the Netherlands house. In both cases the results were quite negative, indicating that that particular technology is not yet mature.

Passive solar systems can offer several benefits and give solar houses a market advantage.

Sunspaces and daylighting systems add amenity value to the buildings and contribute to their energy performance when properly designed. Sunspaces are especially attractive in dwellings, where they can reduce space heating when used to preheat ventilation air. The amenity benefits have clearly helped market these houses.

Solar DHW is an effective way to reduce the water heating requirements.

After conservation, solar heating of domestic hot water was found to be one of the most effective technologies. It is therefore used in many of the buildings. In the Canadian house, it proved to be the most cost effective way of further reducing consumption. This is due to the fact that the water heating load is relatively constant, making it possible to take advantage also of the high solar gains in summer.

Active solar space heating is technically feasible but not cost effective.

Such a system is used in only one building. In this building, the German house in Berlin, it is used in combination with a seasonal storage system. The goal for that project was to totally eliminate auxiliary energy demand for space heating. In such a case active solar and seasonal storage is one of only a few options.

With increasing levels of insulation, the heating season becomes shorter, and heat demand is concentrated to mid winter, when there is little solar gain. Seasonal storage is therefore necessary. But, the storage can be reduced as the insulation levels increase. This is an essential step towards cost effectiveness.

Photovoltaics is not, presently, cost effective for general use, but PV systems that operate other solar equipment may make sense.

A few of the Task 13 houses use grid-connected photovoltaic systems that supply general power. None of these are cost effective. Cost effectiveness may be achieved, however, in cases where the system is used to operate solar equipment, such as shading devices or pumps for solar thermal collectors, or where the cost of connecting to the grid is high, such as may be the case for outdoor lighting.

The Canadian house in Waterloo has a PV-powered pump for the solar water collector that is more reliable and costs less than an ordinary controller and pump. The use of PV as a heat source for preheating ventilation air, as in the Japanese house, is, on the other hand, a technically feasible but not cost effective solution.

Designing new, innovative building concepts requires a multidisciplinary design team.

The extensive use of solar technologies, which often are integral parts of the design, requires that the design process is somewhat different from the traditional one. It requires that the energy aspects are considered already at the early design stage, and also that the architects and engineers work together from the start. The fruitfulness of the Task 13 workshops, where architects, engineers, physicists, and materials scientists worked together to develop schematic designs, shows this quite clearly.

There is a lack of advanced calculation tools for integrated design.

Integrated designs require the use of tools that can evaluate total building concepts with a number of different energy conservation and solar technologies. As such tools were not available when the Task started, the Task participants had to work with several tools in combination, thereby making it harder to evaluate the buildings as total concepts. Most of the models that were available were also not user friendly.

Simulation can be reasonably accurate and give a good indication of how the building will perform, before it is built.

All the Task 13 design teams used hourly simulation programs to guide design decisions. Such hourly simulation provided an insight into the building performance not otherwise available using more conventional calculation tools. The simulation of building and system perfomance was also useful for designing the monitoring programs used in evaluating the performance in practice.

Most energy consumption figures presented are results of these theoretical analyses, as there only is sufficient monitored data from a few of the buildings at this point. The monitored results available do show that the actual energy consumption in almost all cases slightly exceeds predictions.

This is partly a result of the fact that the users do not behave quite as expected. They typically do not optimize their behavior from an energy point of view. Also, the builders do not always build as airtight or as exact as prescribed. The monitored results are therefore somewhat poorer than what is predicted in the idealized situation created for the computer.

Training of builders and on-site supervision is particularly important in low energy buildings.

In the case of very low energy buildings, the energy consumption is more strongly influenced by construction practices and by user behavior than in conventional buildings. For instance, airtightness and the avoidance of thermal bridges is much more important in a well insulated building than in a traditional building, and the tightness of the ductwork is more critical as these buildings have more mechanical equipment.

In many of the countries, the acceptance of new technologies by the trades is difficult.

More innovative features were simulated and tested in the laboratory than were actually built. Some of the more innovative ideas developed did show an extremely high energy savings potential. But, insufficient funding for the extra cost of prototype solutions, as well as liability problems for the builders, limited the number of new systems actually used in the buildings. Many of the very innovative ideas in the original designs had to be replaced by today's most suitable, commercially available products.

Laboratory testing of new and innovative components is necessary and useful.

A number of the prototypes designed required testing in the laboratory first. This turned out to be a very useful activity, helping the design teams gain confidence in their solutions and further refine some of the components and systems. A few solutions were abandoned because of negative test results. In some cases, a laboratory in one country was used also for testing the components developed by another country, thereby illustrating the usefulness of international cooperation.

The Task 13 buildings provided motivation to experiment with new technologies.

The Task created a forum for a very fruitful exchange of ideas. The experiences, the contexts, and the climates of the participating countries differ. Therefore, the participants all had something to learn and something to contribute to the development of each of the experimental buildings presented.

There is a market for low energy buildings, at least in some of the countries.

In Germany, the Task 13 buildings have provided good examples and have resulted in a noticeable demand for similar types of buildings. There, the driving force appears to be energy savings, while in Canada the driving force appears to be environmental impact and amenity value. Obviously, buildings that can demonstrate both low energy use, low environmental impact, and high amenity value, such as many of the Task 13 buildings do, should therefore be attractive options in the future market in any country.

Task 13 publications:

Major Working Documents:

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Hestnes, A.G. (editor), *Technology Summaries for Solar Low Energy Houses, Part II,* NTH, Trondheim, 1992.

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Saxhof, B. (editor), *Component and System Testing,* DTU, Copenhagen, 1995. ISBN 87-984610-3-6.

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Hestnes, A.G., S.R.Hastings, and B.Saxhof, *Solar Energy Houses: Strategies, Technologies, Examples,* James & James Science Publishers Ltd, London, 1996. ISBN 1-873936-69-9.

General papers about Task 13 in journals and conference proceedings:

Hestnes, A.G., *Advanced Solar Low Energy Buildings: An Update of Task 13 of the lEA's Solar Heating and Cooling Programme,* in *Sun World,* Volume 16, Number 3, Sept. 1992.

Hestnes, A.G., *Our New Solar Buildings*, in *Sun at Work in Europe,* Volume 10, Number 1, March 1995.

Hestnes, A.G., *Advanced Solar Low Energy Buildings. Task 13 of the lEA's Solar Heating and Cooling Programme,* Proceedings of CIB-symposium, Stuttgart 1990, The International Symposium on Energy Efficient Buildings, Leinfelden-Echterdingen, Germany 1993, Innovative Housing '93, Vancouver 1993, ISES Solar World Congress, Budapest 1993, 4th European Conference on Solar Energy in Architecture and Urban Planning, Berlin 1996, and EuroSun '96, Freiburg 1996.

In addition, there is a large number of papers about specific Task 13 activities published in journals and proceedings from conferences around the world.

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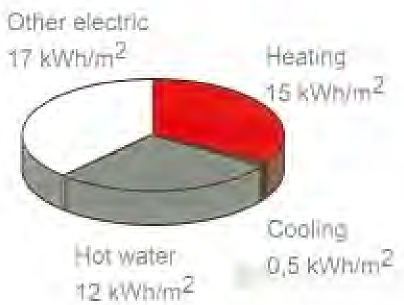
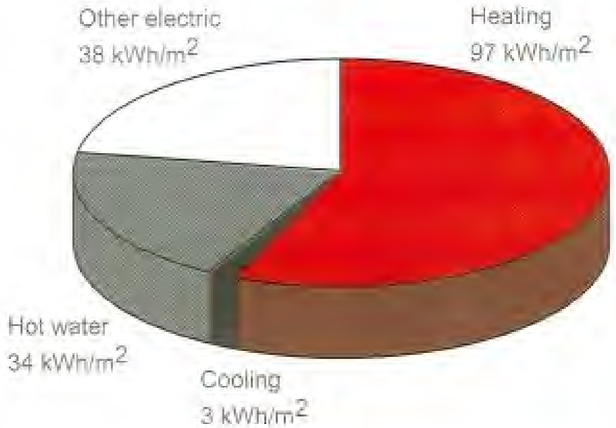
INTERNATIONAL ENERGY AGENCY
Solar Heating & Cooling Programme

SOLAR LOW ENERGY HOUSES OF TASK 13

Within the framework of IEA Task 13: «Advanced Solar Low Energy Buildings», 15 experimental houses have been designed. The calculated energy consumption values for these houses show that the total annual energy consumption, for all end uses, averages only 44 kWh/m². This is about 25% of the consumption in traditional houses today. The houses are now being monitored, and the results that have been evaluated so far indicate that the consumption is fairly close to target. All the houses use a combination of energy conservation and solar technologies to reach these very low levels of consumption. The houses vary from single family houses, for instance in Finland and in Canada, to a large apartment building in the Netherlands.



Total energy use for the IEA task 13 dwellings is 44 kWh/m2



Total energy use for the reference dwellings is 172 kWh/m2

The American single family house at Grand Canyon is located in a climate with cold and sunny winters. Passive solar gains are provided by south facing windows and Michelle Trombe solar walls.

The American single family house at Yosemite is located in a climate with hot summers. Cooled down-canyon breezes are used for natural cooling during summer nights. The walls have both high mass and high insulation.

The Belgian house, called the PLEIADE, is a two story row house that uses both energy conservation and passive solar technologies. One of its most innovative features is a highly advanced home automation system that provides effective control of the various systems.

The Canadian house in Waterloo, called the «Green Home», uses a PV operated solar water collector. One of its most interesting features is the clerestory windows with thermocromatic films for solar control. The «Green Home» also emphasis the use of environmentally friendly and recycled materials.

The Canadian house in Brampton uses an integrated mechanical system that provides both space heating, cooling, ventilation, and water heating. Heat is recovered from exhaust air and from gray water, while fresh air is preheated in a two-story sunspace.

The Danish row houses have been designed for two different site orientations, with house rows running north-south and east-west. Both concepts reach extremely low heating energy demands using nearly the same passive and active solar features.

The Finnish house is located on a beautiful lakefront site in Pietarsaari. It features a 2 kW photovoltaic system, a smaller solar thermal collector, and a ground coupled heat pump. It is one of the houses with the absolutely lowest energy consumption.

Japan

ermany

Germany

e **German house** in Rottweil opens like a fan, with maximum southern and minimum northern
posure. All living spaces are supplied with daylight from the south side, in which a two story
nspace is imbedded.

e **German house** in Berlin can be called a Zero Heating Energy House. Sufficient solar energy
collected in summer so that the building needs no fossile fuel for heating purposes in winter. The
rage consists of a three story tall water tank placed in the middle of the house.

e **Italian** apartment building uses a solar heating and cooling system that shares storage and
tribution, and a DHW system, all integrated into the building structure.

e **Japanese** house, in Iwaki, is a duplex designed for a family of three generations. It uses both
otovoltaics and solar thermal collectors. In addition, it is the only house testing the use of phase
ange storage materials.

e **Netherland´s** project is a large apartment building near Amsterdam. It consists of two multi
ry units connected by a large atrium. The southfacing unit features a curved south facade that
timizes solar gain and that incorporates both direct gain windows, a passive cooling system,
ading devices, and auxiliary heating.

e **Norwegian** house is a row house unit with a superinsulated envelope, a sunspace with trans-
rent insulation, a solar assisted ground-coupled heat pump, and a grid-coupled PV system.

e **Swedish** house is modeled on the traditional farmhouse. Its most innovative feature is a three
nentional variable window system that provides for increasing solar gain, sunshading, or night
ulation.

e **Swiss** house has south facing windows extending from the ground to the roof. Interior floors
d walls are massive to provide thermal mass, while exterior walls and roof are light weight to
comodate thick insulation.

Italy

Sweden

Switzerland

Norway

The Netherlands

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Publications:

Simulation strategies for selected technologies, IEA report.
Distributed through: DAMEN Consultants, Oostmaaslaan 71, NL - 3063 AN Rotterdam.
Component and system testing, IEA report.
Distributed through: Thermal Insulation Laboratory, Technical University of Denmark, DK - 2800 Lyngby
Solar low energy houses of IEA Task 13, IEA report.
Published by: James & James Ltd., 5 Castle Rd, GB - London NW1 8PR
Solar energy houses: Strategies, Technologies, Examples, IEA report.
To be published Aug. 1996 by James & James Ltd.

Conference presentations:

Solar Energy in Architecture and Urban Planning, 26 - 29 March 1996 in Berlin, Germany.
EuroSun '96, 16 - 19 September 1996 in Freiburg, Germany.

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