International Energy Agency
Energy Conservation in Buildings and Community Systems Programme

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Project Summary Report

Solar Sustainable Housing

Energy Conservation in Buildings & Community Systems
& Solar Heating and Cooling Programmes

ECBCS
Annex 38 /
SHC
Task 28

Solar Sustainable Housing

ECBCS Annex 38 / SHC Task 28 Project Summary Report

Edited by Robert Hastings, Janet Brown and Jack Shepherd

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Sustainable Solar Housing Volumes 1 & 2, edited by Robert Hastings and Maria Wall,
Bioclimatic Housing: Innovative Designs for Warm Climates, Edited by Richard Hyde,
The Environmental Brief: Pathways for Green Design, Richard Hyde, Steve Watson, Wendy Cheshire, Mark Thomson,
Business Opportunities in Sustainable Housing: A Marketing Guide Based on Houses in 10 Countries, Synnove Elisabeth Aabrekk and Trond Haavik, Segel, Norway, Co-author, Edward Prendergast,
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Preface

International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster co-operation among the twenty-eight IEA participating countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D). The IEA co-ordinates research and development in a number of areas related to energy.

Energy Conservation in Buildings and Community Systems Programme

The mission of the IEA Energy Conservation for Building and Community Systems Programme is to develop and facilitate the integration of technologies and processes for energy efficiency and conservation into healthy, low emission, and sustainable buildings and communities, through innovation and research.

The research and development strategies of the ECBCS Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Building Forum Think Tank Workshop, held in March 2007. The R&D strategies represent a collective input of the Executive Committee members to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy conservation technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and will impact the building industry in three focus areas of R&D activities:

- Dissemination
- Decision-making
- Building products and systems

Overall control of the program is maintained by an Executive Committee, which not only monitors existing projects but also identifies new areas where collaborative effort may be beneficial. To date the following projects have been initiated by the executive committee on Energy Conservation in Buildings and Community Systems (completed projects are identified by (*)):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)

Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HEVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings
Annex 45: Energy Efficient Electric Lighting for Buildings
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings
Annex 48: Heat Pumping and Reversible Air Conditioning
Annex 49: Low Exergy Systems for High Performance Buildings and Communities
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings
Annex 51: Energy Efficient Communities
Annex 52: Towards Net Zero Energy Solar Buildings
Annex 53: Total Energy Use in Buildings: Analysis & Evaluation Methods
Annex 54: Analysis of Micro-Generation & Related Energy Technologies in Buildings
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance & Cost (RAP-RETRO)

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - Energy Efficient Communities

(*) – Completed

Solar Heating and Cooling Programme

The IEA Solar Heating and Cooling Programme was one of the first IEA Implementing Agreements to be established. Since 1977, its members have been collaborating to advance active solar and passive solar technologies and their application in buildings and other areas, such as agriculture and industry.

A total of 44 Tasks have been initiated, 35 of which have been completed. Each Task is managed by an Operating Agent from one of the participating countries. Overall control of the program rests with an Executive Committee comprised of one representative from each contracting party to the Implementing Agreement. In addition to the Task work, a number of special activities—Memorandum of Understanding with solar thermal trade organizations, statistics collection and analysis, conferences and workshops—have been undertaken. The Tasks of the IEA Solar Heating and Cooling Programme, both underway and completed are as follows:

Current Tasks:

Task 36:	Solar Resource Knowledge Management
Task 37:	Advanced Housing Renovation with Solar & Conservation
Task 38:	Solar Assisted Cooling Systems
Task 39:	Polymeric Materials for Solar Thermal Applications
Task 40:	Towards Net Zero Energy Solar Buildings
Task 41:	Solar Energy and Architecture
Task 42:	Compact Thermal Energy Storage
Task 43:	Solar Rating & Certification Procedure
Task 44:	Solar and Heat Pump Systems

Completed Tasks:

Task 1:	Investigation of the Performance of Solar Heating and Cooling Systems
Task 2:	Coordination of Solar Heating and Cooling R&D
Task 3:	Performance Testing of Solar Collectors
Task 4:	Development of an Insolation Handbook and Instrument Package
Task 5:	Use of Existing Meteorological Information for Solar Energy Application
Task 6:	Performance of Solar Systems Using Evacuated Collectors
Task 7:	Central Solar Heating Plants with Seasonal Storage
Task 8:	Passive and Hybrid Solar Low Energy Buildings
Task 9:	Solar Radiation and Pyranometry Studies
Task 10:	Solar Materials R&D
Task 11:	Passive and Hybrid Solar Commercial Buildings
Task 12:	Building Energy Analysis and Design Tools for Solar Applications
Task 13:	Advance Solar Low Energy Buildings
Task 14:	Advance Active Solar Energy Systems
Task 16:	Photovoltaics in Buildings
Task 17:	Measuring and Modeling Spectral Radiation
Task 18:	Advanced Glazing and Associated Materials for Solar and Building Applications
Task 19:	Solar Air Systems
Task 20:	Solar Energy in Building Renovation
Task 21:	Daylight in Buildings
Task 23:	Optimization of Solar Energy Use in Large Buildings
Task 22:	Building Energy Analysis Tools
Task 24:	Solar Procurement
Task 25:	Solar Assisted Air Conditioning of Buildings
Task 26:	Solar Combisystems
Task 28:	Solar Sustainable Housing
Task 27:	Performance of Solar Facade Components
Task 29:	Solar Crop Drying
Task 31:	Daylighting Buildings in the 21st Century
Task 32:	Advanced Storage Concepts for Solar and Low Energy Buildings
Task 33:	Solar Heat for Industrial Processes
Task 34:	Testing and Validation of Building Energy Simulation Tools
Task 35:	PV/Thermal Solar Systems

Completed Working Groups:
CSHPSS, ISOLDE, Materials in Solar Thermal Collectors, and the Evaluation of Task 13 Houses

Executive Summary

The aim of this report is to summarise the very positive findings of the joint IEA ECBCS-SHC research project "Solar Sustainable Housing", in order to highlight its benefits for architects, developers and potential buyers and encourage them to design, build and buy solar sustainable homes. Emphasising a holistic approach, it offers a path through the wide choice of technologies and methods available. Solar sustainable housing has the positive impact of helping to protect the planet, establish healthier and more comfortable living, and for developers, a chance to expand into a new and reputation-enhancing area of business.

Contents

1. Introduction

Housing has come full circle since the early twentieth century and before, when fuel was expensive and often just a single room was heated. As oil and gas became cheap and plentiful, homes acquired heating in all rooms and little attention was paid to conserving that heat. Today designing houses to need very little energy has again become a high priority, but nowadays we demand a much higher level of comfort as standard. The sustainable house must fulfil the comfort and quality of life needs of today's homeowners.

Section two of this report is an examination of what is meant by Sustainable Solar Housing. Section three looks at the technologies available for reducing the operational impact of the houses we build. Section four addresses the particular challenges that different climates present, considering cold, temperate and mild climates. Best-practice computer modelling was used to generate high performing dwelling solutions for apartment buildings, row houses and single family detached houses considering minimizing losses and maximising renewable energy use. Section four also includes an exploration of solutions for designing low energy dwellings for warm climates, wherein cooling rather than heating is the primary domestic energy use. The examples from architects, energy consultants and buildings physicists provide insights into the difficulties of balancing different strategies, as not all strategies will be appropriate for each climate, and some strategies may conflict with each other, such as highly insulating envelopes versus large window areas for passive solar gains. Section five examines existing exemplary low energy housing projects across Europe.

The present report attempts to give a flavour of the project and to give an overview and introduction to the subject. However, for a full analysis and supporting technical detail, the reader is recommended to consult the original documents.

1.1. The Research Project

This project brought together the combined research strengths of the IEA Energy Conservation in Buildings and Community Systems and Solar Heating and Cooling Programmes to develop a strategy whose ambitious goal was to achieve a significant penetration of solar sustainable housing in the housing markets, with a greater than 5% penetration envisaged by the year 2010. The project aimed to achieve this by providing builders and institutional real estate investors with:

- good examples of built projects, with proven success;
- hard facts to make cost/benefit decisions on the mix of solar and conservation strategies; and
- guidance to improve the energy, environmental and cost performance of their designs.

In the course of the research, topics covered were: market assessment and communication; design and analysis; construction and demonstration; and measurement and evaluation. A selection of strategies for very low energy housing was examined, with the challenge in mind of balancing strategies for low energy whilst being attractive to homeowners and investors.

Embedded energy from construction materials, as well as low operational energy, was taken into consideration. In order to weigh the many factors involved in optimising the design, methods of multi-criteria decision making were employed, and the importance of quality control throughout the design and construction process was highlighted. Careful targeting of the market was also considered for these 'new products', i.e. low energy sustainable homes. The findings were incorporated into the publications listed in section 7.

2. What is Sustainable Solar Housing?

Defining a low-energy dwelling is complex and context-specific. Two examples are Factor-Four Plus *Housing*, which is designed to require a quarter or less of the purchased heating energy of houses built to current standards; and the *Passive House* concept, which stipulates a maximum of 10 W of space heating per m^2, amounting to a energy demand of 15 kWh/m^2y in temperate climates.

The technology for these houses is proven, and until now has depended on the reduction of heat losses, i.e. (in cold and temperate climates) compact building form, thick insulation, and ventilation heat recovery. Sustainable *Solar* Housing specifically considers increasing energy gains with the use of solar technologies, optimising this technological mix to reduce energy use and increase marketability of such properties.

Figure 1: 4000 high performance houses already have owners in Europe, and the industry is expanding. The project's goal was to accelerate this expansion by optimising the mix of technologies for maximum economy. For further information on the photographs and the houses shown, see page 16.

2.1. Features of high performance housing

'Superinsulation' and airtightness with heat recovery ventilation contract the heating season such that conventional heat systems can become uneconomic. High-efficiency heating systems shared between several homes can be the economic solution. Other energy aspects such as water heating and electricity usage become relatively more important.

The methods considered in this project included the following:

- passive solar design;
- active solar systems for domestic hot water and space heating;
- PV electric supply systems;
- improved daylighting (for improved living quality); and
- natural cooling and solar/glare control.

Over 4000 high performance houses have already been built in Europe. These buildings require only 15 kWh/m^{2}y end energy or less for space heating. Their total primary energy use for space and water heating and electricity for technical systems does not exceed 45 kWh/m^{2}y. Such housing, to date, tends to cost up to 10% more than conventionally built housing. This, however, can be considered to be the investment needed to build future-proof housing.

2.1.1. Conservation

Conservation strategies must reduce the energy needed to offset transmission and infiltration losses, supply and temper ventilation air, produce hot water and run technical systems (fans, pumps and controllers). Opportunities to conserve energy along these paths include reducing the demand, increasing the efficiency of devices and recovering heat.

Transmission Losses

Transmission losses can be reduced by:

- improving the building insulation;
- using active insulation (transparent insulation materials) to compensate envelope heat losses by passive solar gains;
- interrupting thermal bridges across constructions; and
- making the building form more compact to reduce the amount of envelope heat losses for the enclosed heated volume.

Ventilation

Minimum ventilation rates are around 30 m^{3}h per occupant and cannot be reduced for health and comfort reasons; therefore maximising the system's efficiency is important.

Hot Water

For hot water, heat recovery may not be the best choice as these systems can demand high maintenance, therefore using renewables is often the solution.

2.1.2. Passive Solar Contribution in High-Performance Housing

Using sunlight to heat buildings in winter is a simple and age-old concept. The special conditions of a high-performance house limit passive solar gains; the features of available sunlight, glass transmittance and effectiveness have to outweigh heat losses. The contribution to be made is small in low-energy housing because of the shortened heating season as a result of thick insulation and ventilation heat recovery. In northern cold climates passive solar gains do not offset the heat losses, so the window area should be designed according to daylight and aesthetic requirements.

2.1.3. Using Daylight

Daylight has a considerable effect on occupant comfort and house marketability. However in high-performance housing even good windows lose up to five times more heat than a highly insulated opaque wall. Good design for daylight can use factors other than window size to achieve excellent results, such as window proportion, window position, cross-section of the window opening in the wall, treatment of room surfaces and glare protection.

The research concluded the following points:-

- a window to south façade ratio of up to 50% is desirable;
- windows are positioned ideally on two walls offering bi-directional and more uniform light distribution;
- flared head and sides of the window are recommended for improved illuminance, as is a deep, light-coloured sill;
- light colouring for the floor and walls to the sides of the window are useful;
- daylighting spaces in the centre of the house are recommended, with e.g. light pipes; and
- curtains should be widely mounted so they can be drawn entirely aside to allow maximum light penetration. In overcast skies, fixed architectural shading can block valuable zenith light, which is the strongest light direction.

2.1.4. Energy

Using Active Solar Energy

An active solar system can cover more than 50% of hot water energy demand in high-performance housing. A combi-system which also supplies some space heating can be a valuable component of sustainable housing, if there is to be a radiant heating system. Façade integrated collectors can make the system less prone to summer overheating.

Producing the Remaining Energy Efficiently

The energy strategy presents simple objectives of conservation, renewable energy and optimum efficiency of any remaining fossil fuel energy services. Remaining energy refers to the energy still needed after conservation measures and optionally active solar heat or photovoltaic electric production. For high-performance housing, the system should have minimal fixed costs, for example, for a condensing gas boiler, using very little gas the fixed costs will be disproportionately high. The system chosen needs to be simple, fast reacting, well insulated, compact, with low parasitic power and low base costs.

Examples are: fossil fuel combustion systems, biomass combustion systems, combined heat and power systems, heat pumps and direct electric heating, which may be economic given the very small heating demand, especially if the source is renewable energy.

2.1.5. Embodied Impacts

In houses that consume very little energy to maintain comfort, the embodied energy of the construction process and materials over the life cycle of the building become relatively more important, so that in some cases choices of materials or components have more effect on the impact of the development than measures to reduce heating energy. The researchers have presented four selected methods to assess the sustainability of buildings from an ecological viewpoint:

- Cumulative energy demand (CED), which includes the whole life cycle of buildings (production, construction, use, demolition and disposal); focuses on quantitative results for the used energy over the whole life cycle.
- Life-cycle analysis (LCA), which also addresses aspects such as eco-toxicity.
- Total quality assessment (TQA), which addresses ecological aspects, as well as economical and social aspects, and quantifies their influences.

- The methodology of architecture towards sustainability (ATS), which explores how a building performs in environmental, social, economic and political dimensions, in order to improve quality of life.

2.2. Minimising the Cost

Although the technology to achieve this type of housing has been available for some time, the costs have tended to be prohibitive. At present the costs of the relevant technologies are reducing, and with fuel costs rising, the technologies become increasingly attractive. However, with a complex mix of technologies needed for such housing, it remains crucial to look carefully at the costs involved.

The project aimed to minimise the cost of reducing energy losses and increasing useable solar gains whilst maintaining the dwellings' high performance.

The project also carried out studies of national trends in housing and governmental goals for the housing industry in order to develop a comprehensive strategy for increasing market share.

Looking at these various high-performance components, it can be seen that the added benefits in terms of comfort and healthy living can quickly justify the extra initial costs. Good insulation and a tight, well built envelope without thermal bridges improves comfort by warming interior surfaces and excluding draughts, and minimises condensation, structural decay and mould; high performance windows provide similar benefits. Mechanical ventilation with heat recovery ensures correct levels of carbon dioxide and good indoor air quality. For home buyers whose purchase is at the borrowing limit, the drastically reduced energy costs protect them from the financial stress of the volatility of imported energy prices.

3. Available Technologies

When considering low-energy housing, a crucial factor is the role of the building envelope which, simply put, is to keep heat inside in the winter and outside in the summer. The envelope must be airtight, hence a ventilation system with heat recovery is needed. To supply the greatly reduced amount of heat now required for space and water heating, and electricity, highly efficient and/or renewable technologies must be carefully considered.

3.1. Building Envelope

Maximising the insulation of the opaque parts of the building envelope is essential, although the thickness of insulation can reduce the available living area. Vacuum insulation is a better option but is uneconomic at the moment. The construction must also be detailed to minimise short circuits (e.g. structural bearing elements penetrating the insulation), and be airtight.

The windows need careful consideration, and U-values can be lowered through technology such as low-emissivity coatings and argon or krypton in the cavity. However, glazing areas must also be carefully sized with possible summer overheating in mind; provision for external shading is beneficial in this case.

3.2. Ventilation

Heat recovery ventilation is essential for comfort in an airtight construction, and ideally can be used to deliver the small amount of space heating necessary in a highly insulated home. Economical home mechanical ventilation needs to be excellently designed to avoid problems such as heat stratification, draughts, noise, sound transport and dust propagation.

3.3. Heat Production

Several good methods are available to produce the small amount of heat required in high performance houses during the winter months: ventilation heat recovery (possibly enhanced by a ground heat exchanger); modern wood pellet stoves combined with a condensing gas boiler can be very effective if used for multi-family buildings such as apartments or row houses, however, costs may be too high for the small amount of heat needed in single-family high performance houses.

The large reduction in demand for space heating in these houses magnifies the importance of the water heating requirements, which are relatively constant and depend on occupant behaviour. In addition, domestic hot water needs a temperature of around 50°C - 60°C compared with 20°C - 22°C for space heating, which is more energy intensive. Heat pumps or wood pellet stoves can be used to produce hot water, although a highly effective solution is to use a combination with a solar thermal system, which can cover half the water heating demand if 1 m^2 - 2 m^2 of collectors is used per occupant.

3.4. Heat Delivery

Often this can be achieved economically by heating the ventilation air to a maximum of 50°C. Careful design is important to avoid low humidity from cold outside air causing discomfort. The fan motors must use electricity efficiently and/or use renewable electricity. Defrosting may be necessary, as the humid room air is cooled by the incoming cold air, sometimes achieved by drawing the outside air through a preheating earth tube, or by employing a rotating-type heat exchanger. Residential ventilation and heat delivery systems are much improved and optimised today and available on the market.

3.5. Sensible Heat Storage

For space heating, thermal mass as in masonry or concrete construction serves well to store any winter passive solar gains through glazing in the daytime, releasing them at night. However lightweight timber frame construction is becoming increasingly popular in Europe and is already well established in North America, and does not have the thermal mass storage capacities. Phase change materials are being explored to remedy this but are not widely marketable at the moment.

3.6. Electricity

This is the most expensive energy form, and the least efficient to produce. For this reason photovoltaic generation at home is highly desirable. Photovoltaic conversion of light to electricity is a proven technology, has no moving parts, produces no noise and no emissions, and is reliable over decades. The only limitation is cost, and therefore optimising the energy conservation properties of the home first is of the utmost importance. To optimise photovoltaic systems, hybrid systems can capture and transport some of the waste heat for other uses, e.g. to temper ventilation air in winter.

For electricity, the ‘unused’ kilowatt hour is the most important one, and therefore energy conservation by use of highly efficient domestic appliances, and fans and pumps for mechanical services is most important.

3.7. Building Information Systems

Home automation systems as opposed to the well established commercial building systems, are found infrequently. However with the increasing complexity of systems, and the need to optimise energy use for such systems, a growing market is likely to arise for these systems in residential buildings, notably for multi-family structures.

Building control or home automation systems measure, control and manage the entire complex of building services by programmable microprocessors using mainly ‘bus’ systems. Installation buses have several applications in residential buildings, including:

- lighting, e.g. time-switching, occupancy dependent lighting;
- controlling louvers, blinds and windows;
- heating, e.g. zone controls;
- ventilation, e.g. shut of when windows are open, indoor air quality control;
- load management, e.g. switching to night time low cost electricity operation, switching off appliances on standby; and
- building safety.

Common examples of bus systems include European Installation Bus (EIB), Local Operating Network (LON) bus, wireless bus systems and EIB Powerline.

4. Solutions

This section proposes optimum combinations of technologies to minimise energy use in each of the particular combinations of climate and house type found. For more information on the technologies in this chapter, see chapter 3. Two design approaches are presented, one with the emphasis on conservation (reducing losses) and the other with the emphasis on renewable energy supply (increasing gains). Computer simulations and sensitivity analyses were carried out to optimise the solutions and quantify the importance of key design parameters.

The goal of this chapter is to show the sensitivity of energy use to variations in selected design features. No detailed analyses of thermal bridges were carried out; these losses were reflected in setting the average U-values of the building envelope. When a real design of a building is made, details must be conceived so as to avoid thermal bridges.

Of the house types, the single family house presents the biggest challenge in cooler climates, due to the relatively large ratio of heat-losing envelope area to the floor area, compared with either row or apartment buildings. For the row houses, the building geometry makes it easier to achieve low space heating requirements and therefore a single heating system for the row is often an economical solution. For the apartment building, very efficient ventilation heat recovery is important, although insulation thickness is of less importance. Regional reference buildings were defined using National building codes for 2001.

Interestingly, as shown by Figure 2 below, the space heating demands for reference houses in the mild climate were greater than for those in the temperate and cold climates. This is partly due to building codes in the mild region being less ambitious.

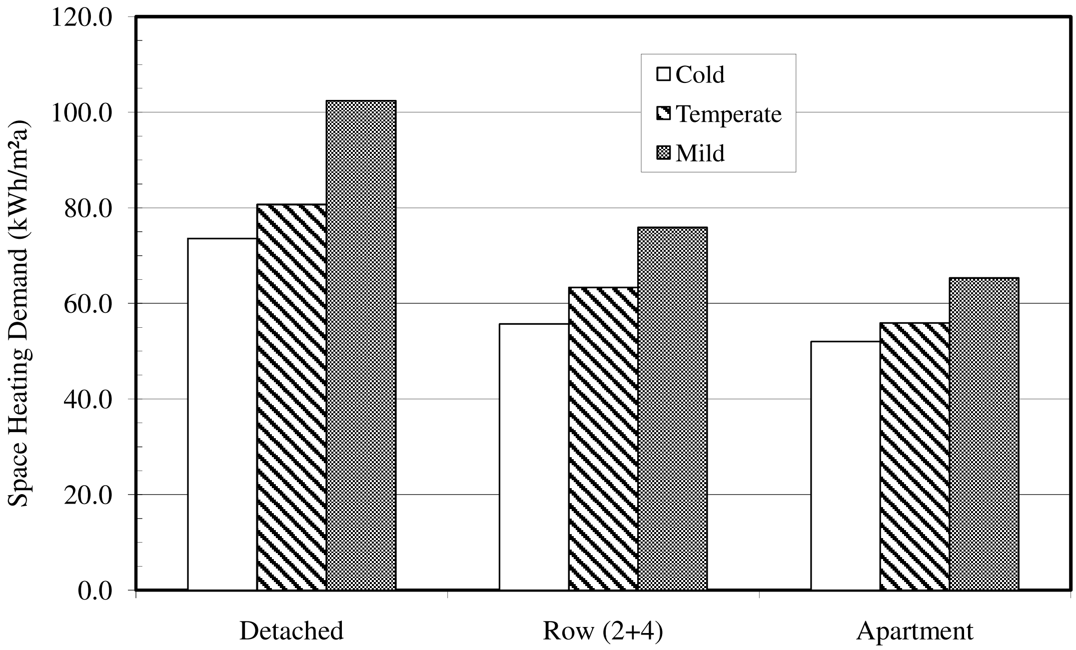

Figure 2 Space heating demand for the regional reference buildings with standards based on building codes for the year 2001: the reference climates have been used

4.1. Targets for space heating and for non-renewable primary energy demand in cold, temperate and mild climates.

For the conservation approach, the space heating targets that were set were 15 kWh/m^2y for the apartment building and row houses, and 20 kWh/m^2y for the single family house. For the renewable energy approach – 20 kWh/m^2y for the apartment building and row house and 25 kWh/m^2y for the single family house.

The target for non-renewable primary energy demand was set at a maximum of 60 kWh/m^2y, including domestic hot water and space heating, system losses and electricity for fans and pumps (the building codes 2001 reference level is 124 kWh/m^2y).

4.2. Cold Climates

4.2.1. Cold climate design and characteristics

For the cold climate, meeting the energy targets requires that the building envelope, including the windows, has a very low U-value. There can be very little infiltration, so good air quality depends on mechanical ventilation with heat recovery. The northern latitude and cold climate place limitations on supplying energy from solar gains.

4.2.2. Single family house in a cold climate – example solutions

Solutions	Whole building U-value/ W/m²K	Space heating demand/kWh/ m²y	Heating distribution	Heating system	DHW heating system
Conservation Solution 1	0.12	11.5	Supply air	Direct electric resistance	Solar collectors with electrical backup
Conservation Solution 2	0.17	20	Hot water radiant heating	Heat pump (outdoor air to water) or a borehole heat pump for a group of houses (local district heating)	Heat pump (outdoor air to water) or a borehole heat pump for a group of houses (local district heating)
Renewable energy solutions1 and 2	0.21	25	hot water radiant heating	Solar combi-system with biomass boiler (solution 1) or condensing gas boiler (solution 2)	Solar combi-system with biomass boiler (solution 1) or condensing gas boiler (solution 2)

Finding an inexpensive heating system is a problem for the single family house, since the annual energy consumption will be very low. For all the solutions the non-renewable primary energy use is cut by 75% or more.

4.2.3. Row houses in a cold climate – example solutions

Solutions	Whole building U-value/ W/m²K	Space heating demand/kWh/ m²y	Heating distribution	Heating system	DHW heating system
Conservation	0.21	15	Hot water radiant heating	District heating	District heating
Renewable energy	0.28	20	Hot water floor or wall radiant heating, supply air heating	Solar combi-system and condensing gas boiler	Solar combi-system and condensing gas boiler

Apartment building in a cold climate – example solutions

Solutions	Whole building U-value/ W/m²K	Space heating demand/kWh/ m²y	Heating distribution	Heating system	DHW heating system
Conservation Solution 1	0.21	6.5	Supply air heating	Direct electric resistance heating	Solar system with electrical boiler
Conservation Solution 2	0.34	15	Hot water radiant heating	District heating	District heating
Renewable energy	0.41	20	Hot water radiant heating	Solar combi-system with biomass burner	Solar combi-system with biomass burner

4.3. Temperate Climates

4.3.1. Temperate climate design and characteristics

Zurich has an average annual temperature of 9.1℃. The temperate climate is characterised by a heating season with a moderate number of degree days, low direct solar gains in winter and a summer season with no extreme temperatures. High-performance housing was first established in this climate, since heat losses can be relatively easily reduced extending the insulation thickness and including mechanical ventilation with heat recovery. There is good solar availability for hot water production. Passive solar gains can be valuable in the heating season. There are many solutions which will serve to achieve the desired standard of high-performance in this climate. Achieving the targets is relatively easy for row houses and apartments with their low area-to-volume ratios, but careful consideration of systems must be given to single family houses to achieve a similar result with economy in mind.

4.3.2. Single family house in a temperate climate – example solutions

Solutions	Whole building U-value/ W/m²K	Space heating demand/kWh/ m²y	Heating distribution	Heating system	DHW heating system
Conservation Solutions 1 and 2	0.21	19.8	Hot water radiant heating	Hot water radiant heating, condensing gas boiler (solution 1a) or wood pellet stove (solution 1b)	Solar collectors and condensing gas boiler (solution 1), or solar collectors and wood pellet stove (80%) and electricity (20%) (solution 2)
Renewable energy	0.25	25.0	Hot water radiant heating	Hot water radiant heating	Solar combi-system and biomass boiler

4.3.3. Row houses in a temperate climate – example solutions

Solutions	Whole building U-value/ W/m²K	Space heating demand/kWh/ m²y	Heating distribution	Heating system	DHW heating system
Conservation Solution 1	0.32	15	Hot water radiant heating	Oil or gas boiler	Solar collectors and oil or gas boiler
Conservation Solution 2	0.32	15	Hot water radiant heating	Ambient air heat pump	Ambient air heat pump
Renewable energy	0.38	19.4	Hot water radiant heating, fresh air heating	Solar combi-system and gas boiler	Solar combi-system and gas boiler

4.3.4. Apartment building in a temperate climate – example solutions

Solutions	Whole building U-value/ W/m²K	Space heating demand/kWh/ m²y	Heating distribution	Heating system	DHW heating system
Conservation	0.40	10	Hot water radiant heating	Condensing gas boiler	Solar collectors and condensing gas boiler
Renewable energy	0.40	10	Hot water radiant heating	Biomass boiler	Solar collectors and biomass boiler

4.4. Mild Climates

4.4.1. Mild climate design and characteristics

Milan has an average yearly temperature of 11.7℃. The mild climate has a heating season with a low number of degree days, higher solar gains than the other two climate regions and higher outdoor temperatures.

Until recently the mild climate has enabled housing with poor insulation and other energy conservation measures to be the norm. After a considerable increase in insulation, the supply system should have the emphasis on renewable energy. With the very high air tightness that high-performance construction demands, a mechanical ventilation system is more appropriate than user-dependent natural ventilation. Passive solar gains even in the winter will exceed heat losses through windows, and therefore passive solar design is important for this climate. Cooling concerns in the summer mean that window size must be a consideration, and window shading is essential. Thermal mass in the building can even out temperature fluctuations to increase thermal comfort. Biomass energy is more geographically limited while solar energy is plentiful. District heating is becoming common in urban areas.

4.4.2. Single family house in a mild climate – solution examples

Solutions	**Whole building U-value/ W/m^{2}K**	**Space heating demand/kWh/ m^{2}y**	**Heating distribution**	**Heating system**	**DHW heating system**
Conservation	0.28	18.7	Hot water radiant heating	Condensing gas boiler	Solar collectors and condensing gas boiler
Renewable energy	0.32	23.6	Hot water radiant heating	Solar combi-system and condensing gas boiler	Solar combi-system and condensing gas boiler

4.4.3. Row houses in a mild climate – solution examples

Solutions	**Whole building U-value/ W/m^{2}K**	**Space heating demand/kWh/ m^{2}y**	**Heating distribution**	**Heating system**	**DHW heating system**
Renewable energy	0.38	13.2	Hot water radiant heating	Outdoor air to water heat pump	Outdoor air to water heat pump
Renewable energy	0.46	16.1	Hot water radiant heating	Borehole heat pump	Borehole heat pump

4.5. Warm Climates

Climatic trends dictate that staying cool in warm climates is of ever increasing importance; fundamental to our adaptation to a warmer world is the adoption of more effective methods for passively cooling buildings. Homes in traditionally warm climates have come to rely on cheap energy rather than traditional design for cooling, and homes in more temperate Europe are not equipped for the type of heatwave which we will experience more frequently as the climate changes. This research aims to anticipate the demand for cooling and to put forward economic low energy methods before the more typical air conditioning systems are resorted to. The researchers set out the design challenges and a range of effective solutions, and examined case studies to show how the proposed cooling strategies have been successfully applied in different climates. Note that for the warm climates stage of the research, energy use targets were not set and energy use data was not compiled.

4.5.1. The Mediterranean: a Cool Temperate Climate

The climate is characterised by hot dry summers and mild wet winters. Thermal comfort can be achieved without insulating clothing and people can live outside almost year round.

This case study examined work on the development of bioclimatic housing for a development in Umbertide, Umbria, in Italy. The brief was to design new territorial, ecological, energy-sensitive and bioclimatic residential development focused on an appropriate structure for sustainable transport.

The design involved improving ventilation within the public open space carried out according to the direction of the prevailing wind during the changing seasons (wind corridors); protection from winter wind (through rows of trees) and promotion of summer wind penetration, all of which served to reduce energy demand.

Fluid dynamic software simulations optimised the architectural form and functions of the building spaces.

A cooling system for ventilation used stack effect, integrated with the convective loop system and combined with the use of a chimney to achieve a cooling and ventilation system producing a good microclimate in summer. Obstruction/reflection elements outside the windows permit sun radiation to be screened during hot periods and reflect the direct solar radiation onto the ceiling in winter, so that the ceiling becomes a thermal storage element.

4.5.2. Adelaide, South Australia: A Warm Continental Climate

The emphasis here is on passive cooling strategies appropriate for this climate. Passive heating is also needed for the cool winter months. Monitoring of the indoor temperature and humidity of all the dwellings in the case study was performed for a year and a weather station was installed. The case studies covered three types of dwelling in an urban situation (a townhouse, an apartment and a detached cottage) and one, a single detached dwelling in the countryside.

The features examined for this climate are as follows:-

- Compact block shape, stretched along the east-west axis, if possible with the main glazed area on the northern walls for passive solar heating
- Use of roof and wall thermal insulation
- Use of thermal mass (particularly in the floors), which should not be exposed to solar radiation
- Shading to exclude summer solar radiation, but allowing winter sun penetration
- Operable windows.

4.5.3. Tehran: A Hot Arid Climate

The heating period is from mid November to early March and the cooling period from early June to the middle of August. Because of the very dry conditions, temperature fluctuation between day and night is rather high, about 8 °C in summer and 10 °C in winter.

Solutions for this type of climate are usually based on traditional courtyard and compact urban design with thermal mass. Detached, row and apartment buildings need to be set out along an east-west access with extensive glazing for passive solar gain, which incorporates shading on top to block solar radiation in summer. Trees should provide shading to the east and west. The north side should have minimum openings to provide cross-ventilation in summer and minimum heat loss in winter.

4.5.4. Tokyo: A Warm Temperate Climate

The climate changes throughout the year from requiring heating to requiring cooling and drying. Insulation and air sealing are basic solutions. Shading and cross-ventilation are important in the cooling season. Passive solar gains can supply almost all of the heating on sunny days in winter. Solar thermal and photovoltaics are important sources of energy year-round in this climate.

The case studies cover the Eco-Village, Matsudo, Japan, a house in Motoyama, Kochi, Japan, and the environmental symbiosis house project, Nara, Japan. There is a variety of solution sets which show that the hybrid of the passive solution methods and the active solution methods is not easily achieved.

4.5.5. Brisbane: A Subtropical Climate

Brisbane typically has hot humid summers and pleasant warm nights. There can be very hot days in summer. Winters are mild and dry with plenty of sun. In order to enhance naturally occurring breezes it is important to site the building to capture the prevailing breezes and ensure that the location maintains open air flow to other buildings.

Two types of sustainable house design have been presented by the researchers. The first is a low-rise building set at one metre off the ground, allowing wind ventilation. It has a narrow plan, one room deep, allowing cross-ventilation and passive cooling. The building is oriented to the north-east to capture the prevailing breezes. The façade has many openings and there is an efficient roof construction to minimise radiant heat into the living space. The second design is aimed at clustered buildings, primarily narrow plan with outdoor spaces for communal living. The building provides sun shading to the windows, as well as to the majority of the western walls. A thermal mass to the southern side of the building to act as a cooling mass. The rest of the construction should be lightweight.

4.5.6. Kuala Lumpur: A Hot Humid Climate

These climates are warm all year round with little seasonal variation. Humidity and rainfall is high throughout the year. Coastal areas enjoy trade winds, but internal regions are windless. Cloud conditions mean the solar radiation varies widely. This is the most difficult climate to design for passive ventilation and cooling. Since the majority of these countries are developing ones, it is important to minimise thermal stress by environmentally friendly and low-technology design solutions.

Strategies include the following:-

- Minimise the effects of direct sunshine and heat by use of shading, reduced glazing, low thermal mass and large overhangs.
- Maximise natural ventilation by large north and south ventilation openings, single room plans, cross-ventilation, open wide spaces between buildings, large volumetric ventilation, spacing of buildings for breezes, elevated construction
- Use orientation optimally, by long facades facing north-south, use of cooling winds, sun and wind control using landscaping
- Roofs should be pitched for rain drainage
- Low mean radiant temperature with use of reflective roof, ventilated air space and reflective foil above ceilings and insulated ceilings
- For row houses, courtyards and air wells on the ground floor, cross-ventilation and daylight.

In this climate it will be difficult to avoid high-energy air conditioning, but careful design can minimise its use. Energy efficient design should be directed towards energy demands through natural and fan-assisted ventilation, correct opening schedules, higher set-point temperatures (as residents are comfortable at higher than standard temperatures), good orientation and siting, reduction of solar gain, low U-values, low energy equipment and plant and improved daylighting. Trees and gardens surrounding houses can also contribute to cooling.

5. Exemplary Buildings

A growing number of housing projects currently demonstrate that achieving ultra low energy housing is possible and affordable in real market situations. Presented below are a selection of six exemplary housing projects which combine aesthetics and very low energy demand and low life-cycle impact. This chapter also looks at the technologies behind the designs, including building envelope systems, ventilation systems, heat delivery, heat production, heat storage, electricity production and control systems.

Projects from Sweden, Germany, Austria and Switzerland are examined here, with three building types: single family detached housing, row housing and apartment blocks. All of the projects except one achieve extremely low primary energy use for space and water heating, including electricity for building services. Interestingly, the amount of energy used for domestic hot water in these dwellings is very similar to that required for space heating.

Each project has its own distinct features. While one architect focused mainly on finding and demonstrating an economical construction of a Passive House building, the others worked to develop sophisticated energy concepts, optimising ecological aspects or integrating solar technologies within the building design. U-values for the walls, roof and floors were very low, ranging from 0.10 to 0.15 W/m^2K. U-values for windows including frame and glazing were also low, at 0.64 to 0.9 W/m^2K.

A method of life cycle analysis called Cumulative Energy Demand was used to compare the dwellings. This method of analysis quantifies energy use from manufacture of materials through construction, operation and eventual demolition.

All the houses used solar thermal systems. Four of the six had grid-connected photovoltaic installations. All the projects had mechanical ventilation with heat recovery, with 80% to 95% efficiency. Three projects had earth pipes for preheating of supply air to prevent freezing of the heat exchanger in winter. For top-up heating a full range of technologies was used: heat pumps, biomass, gas or electric-resistance elements.

For full details of the technologies employed, see the original text – details on page 26.

5.1. The Lindås Passive House Project in Goteborg, Sweden

These are impressive because they achieve high-performance in a cold northern climate with long winter nights. Also of note is the courage of the client and architect in building a whole estate of row houses. Solar hot water heating is used successfully despite the short and overcast days for six months of the year in Sweden, offset by six months of long days and sunshine.

Figure 3: The Lindås Passive House Project in Goteborg, Sweden**.** *Source: Maria Wall*

5.1.1. <u>Energy Concept</u>

- No conventional heating system;
- highly insulated, air tight building envelope with:
    - a mean U-value of 0.16 W/m^2K
    - an air tightness measured to be 0.3 l/sm^2 at 50 Pa;
- minimised thermal bridges;
- energy efficient windows with a mean U-value of 0.85 W/m^2K;
- efficient ventilation with heat recovery (~80%); and
- 5 m^2 of solar collectors for DHW per housing unit.

5.1.2. <u>Energy Performance</u>

- The monitored energy use of the houses was approximately 15% of the average for Sweden.
- More energy is actually needed than was planned. This is partially explained by occupants heating the houses to higher indoor temperatures and having more electric appliances than was assumed during the planning stage.
- The variation in energy use among households is large, varying between 45 kWh/m^2y and 97 kWh/m^2y. There is no strong correlation between total energy use and number of occupants per household, nor whether the house is an end or middle unit.

5.1.3. Cost

- The building costs are somewhat higher than for a conventional house, but the payback time is very short. When the houses are mass-produced, the costs should be the same or even lower than for a conventional house because they do not need a conventional heating system.

5.2. Gelsenkirchen Solar Housing Estate, Germany

This is a housing estate of single family houses built on a former coal mine site as one of the first of fifty planned ‘solar settlements’ in Germany’s North Rhine Westphalia. The site of 38000 m^2 is located centrally in the town. In the southern part of the site, twenty two houses in lightweight construction and sixteen thermally massive construction houses were built. The northern part of the site consists of thirty three thermally massive houses with gable roofs

These houses afforded the opportunity to analyse high performance in varying construction types, and whole life cycle energy consumption, from construction through fifty design years of service to demolition. The emphasis here was on high performance housing on a community scale. All the houses were built to have a maximum heating demand of about 40 kWh/m^2y, achieved with passive and active solar energy use.

5.2.1. Heat Production and Distribution

- Some of the houses have their own solar-assisted gas fired condensing boiler for space heating and hot water, the rest have a micro-district heating system per house row.
- Solar collectors (managed by the local utility) cover up to 65% of the energy demand for DHW production in both configurations.

5.2.2. Life-Cycle Analysis Conclusions

- The thermally massive houses gave a Cumulative Energy Demand that is 20% higher than the houses in lightweight construction.
- The Cumulative Energy Demand from additional insulation and solar technologies is easily justified by the resulting energy savings.
- Over 50 years, the primary energy demand for heating is in a similar range to that for construction, maintenance and decommissioning.

5.2.3. Cost

- The additional costs for the energy-related measures can be assumed to be less than 5% more than conventional house construction.

5.3. Sunny Woods Apartment Building, Zurich.

Prize-winning architectural design went hand in hand with ultra low energy performance for this development. Evacuated tube solar collectors were integrated in the façades as balcony balustrades, large windows maximised passive solar and daylight gains, and a photovoltaic roof completed the aesthetic appeal of the project.

Figure 4: Sunny Woods Apartment Building, Zurich. *Source: Beat Kämpfen*

5.3.1. Energy Concept

- highly insulated, air tight building envelope with:
  - a mean U-value of 0.24 W/m^2K
  - an air tightness measured to be 0.6 h^{-1} at 50 Pa;
- minimised thermal bridges;
- energy efficient windows with a mean U-value of 0.8 W/m^2K;
- efficient ventilation with heat recovery (90%) and ground preheating;
- photovoltaic roof, grid connected thin film solar cells: 16.2 kW_e;
- 6 m^2 of vacuum collectors for DHW and heating per housing unit; and
- efficient appliances.

5.3.2. Heat Production and Distribution

- Heat is distributed by the fresh air supply.
- Air is heated with a water-air heat pump supplied by the solar collectors.
- Radiators in the bathrooms provide additional comfort.

5.3.3. Life-Cycle Analysis conclusions

- The thick insulation results in a 5% - 7% negative impact for embodied energy compared to the resulting large energy savings; and
- heating hot water uses three times more energy than space heating.

5.3.4. Marketing Learning Points

- Marketing was made difficult by the new kind of building: concerns about flammability and durability of the timber construction, and unease regarding the Passive House concept.
- Ecological aspects were secondary for homebuyers, favourable location and high floor-plan quality had a higher significance.

5.4. Wechsel Apartment Building, Stans, Switzerland

Aimed at ‘middle of the market’ buyers, these incorporated photovoltaics and thermal solar as well as mechanical ventilation with heat recovery, and were constructed to a more limited budget.

5.4.1. Energy Concept

- Highly insulated, air tight building envelope with:
  - a mean U-value of 0.26 W/m^2K
  - an air tightness measured to be 0.6 h^{-1} at 50 Pa;
- minimised thermal bridges;
- maximised solar gains: south-facing façade has a window ratio of 50%
- efficient ventilation with heat recovery (80%) and ground preheating;
- energy efficient windows with a mean U-value of 0.9 W/m^2K - 1.07 W/m^2K;
- 5 m^2 of solar collectors for DHW and heating per housing unit;
- wood pellet heating system: 9 kW – 25 kW, 70% coverage
- photovoltaic roof, grid connected thin film solar cells: 1.44kW_e; and
- efficient appliances.

5.4.2. Heat Production and Distribution

- The solar collectors and wood pellet heating system both supply a combi-boiler.
- The wood-pellet heating system only turns on when the collectors cannot supply demand.

5.4.3. Life-Cycle Analysis Conclusions

- The total impact for the whole life cycle is only 42% (design value) to 47% (measured value) of the reference building.
- Operation of the building accounts for 13% - 19% respectively of the life-cycle impact.

5.5. Vienna Utendorfgasse Passivhaus Apartment Building

The challenge of this project was to build high-performance social housing with a very limited budget. Careful design to solve problems like thermal bridging and fire breaks on a small budget was required.

Figure 5: Vienna Utendorfgasse Passivhaus Apartment Building. *Source: Helmut Schoeberl*

5.5.1. Heat Production and Distribution

- Central heat production plant (80 kW gas fired boiler serves the whole complex of buildings for space heating and DHW).
- Circular pipeline supplies hot water to each apartment air register for space heating, and a separate circuit provides DHW.

5.5.2. Cost

- 7% in extra costs above the budget for social housing.
- Main sources of extra costs were the improved quality of the building envelope and the high-efficiency ventilation with heat recovery.

5.6. Plus Energy House, Thening, Austria

This is an example of a single-family detached house, with the traditional problems of high area-to-volume ratio presenting relatively high heat loss from the building envelope.

5.6.1. Energy Concept

- 17 m^2 façade solar collector.
- ventilation system with 85% heat recovery for heating and cooling.
- 13050 W_{peak} power grid connected photovoltaic system on the roof.
- Roof is sloped 10° to the south, allowing the photovoltaic panels to be architecturally integrated.
- One third more electricity produced than consumed.

6. A Discussion of Marketing Approaches

6.1. Introduction

With the objective of this research project being to help achieve a significant penetration (more than 5%) of sustainable housing into the housing market of each of the participating countries by the year 2010, an analysis of marketing strategies became a priority. The aim was to provide parties in the housing market with the necessary documentation and examples in the form of realised built projects, information about design and technical issues, and guidance on marketing sustainable solar housing based on experiences from realised built projects.

One of the main findings from the case studies has been that it is a mistake to focus on the financial benefits in marketing these houses. Experience demonstrates that focusing on other benefits is a better way to market the homes.

In future marketing, these values must be mentioned and focussed on, showing that these new sustainable houses – in spite of using high technology – are for ordinary families and people. In addition they get low housing costs and valuable energy savings.

6.2. Marketing Case Studies

6.2.1. Passive Houses: Switzerland

Anliker is the biggest company of its type within the Lucerne area, with a good reputation in the market as well as good public relations. The sustainable housing market was regarded as relatively untapped, with significant growth potential.

Private funding and banks strongly influence the market in Switzerland and take little interest in being an active part in the development of the private housing market. However the Cantonal Bank of Lucerne had taken a public position that environmental concerns were high on its agenda, therefore, free press coverage was considered a possibility.

A major challenge to overcome in marketing sustainable housing was the calculation that designing houses to Passive House standards would result in 7% higher construction costs. As today's buyers were considered to be more concerned about initial than long-term costs, the price was set at just 7% higher than conventional houses.

The passive house is at the early stage of its product cycle, and therefore the marketing strategy needs to identify the niche market to target. The company fixed on young families who are concerned about the environment as their niche market. The emphasis was placed on designing conventional-looking buildings where energy features were as unobtrusive as possible. The passive house blocks have attractive architecture, generous bright rooms, an emphasis on good daylighting and a flexible floor plan and ventilation system. Anliker's perceived lack of sustainable building credibility was mitigated through association with the Technical College of Lucerne and by achieving the Passive House certification.

Communication was effected by employing an advertising agency which designed publicity, arranged media coverage and promoted comfortable and healthy living for the whole family, with energy saving and payback time aspects given less emphasis. A potential buyers list was created and these were invited to the head office to be introduced to the project; they were also kept updated on progress.

The advertising company chose to market sustainability through association rather than listing technical details of the buildings, and this has proved extremely effective. The importance of promoting positive images, such as happy children playing in fields (the project's logo), cannot be overestimated, addressing people as it does on an intuitive level. The Passive House Certification was mentioned in the literature, but details were left out, leaving people with the impression of high quality in a simple manner. The passive house flats sold very quickly, so quickly in fact that it was decided to build the originally planned semi-passive house flats to passive house standard as well.

In future marketing, these values must be mentioned and focussed on, showing that these new sustainable houses – in spite of using high technology – are for ordinary families and people. In addition they get low housing costs and valuable energy savings.

6.2.2. The World Wildlife Fund in the Netherlands

The WWF housing project is a good example of using mutually beneficial alliances in a marketing campaign. In this project, three parties worked together to achieve a profitable situation for all parties.

Figure 6: The WWF Endorsement. *Source: moBius consult bv.*

WWF, the initiator of the project, wanted to change attitudes towards building sustainable housing; they wanted more of these houses built. Five Project Developers: were invited by the WWF to take part in the project. By doing so they achieved three objectives: positive image building by association with the WWF; gaining experience in using new techniques; and getting new local government contacts.

Local governments: were able to get high profile and ambitious houses built in their regions. Thus they could contribute to the goals set in relation to the Kyoto Protocol, without making investments. This project is a good example of how branding can be used to aid a marketing campaign. By using a well-known, reliable and popular brand, immediate credibility was attained for each project. This meant that the houses were seen as sustainable and 'good' by all parties without having to know any of the technical details. This fact was especially important for attaining free press coverage – a crucial factor in convincing project developers to build these houses.

6.3. Key learning points

I. *Do not skip any steps in the marketing process*

- Information gathering
- Analysis
  - Internal: strengths and weaknesses of the product and organisation
  - External: opportunities, threats and driving forces
- Define and quantify goals
  - People normally focus on what can be measured, more success can be achieved by defining concrete and measurable objectives
- Define strategies
  - Who are you going to sell to?
  - Clear definition of all Ps – Product Price, Place and Promotion
- Make a plan of action
  - Communication actions
  - Costs
  - Time schedule
- Control, measure and modify

II. *Financial incentives are a potential blind spot*

- Starting a promotion with the message that 'if you buy this product, you will receive funding' can be perceived as saying that there is something wrong with the product.
- Initially having focussed on financial incentives related to the product, it can be difficult to later sell it at a normal price
- Often early buyers are not very price sensitive

III. *Be market-oriented instead of product-oriented*

- Start with the question of who you are going to sell to and define the product that best fulfils their needs. If you can't offer this on your own, consider strategic partnerships with complementary businesses, suppliers or competitors.

IV. *Conscious use of media, especially using any free publicity available.*

- If a product or service is new to a region, the media may be keen to cover the story - make use of this free publicity

V. *Build credibility*

- Work with established institutes

7. Further Information

The products of this project, which ran from April 2000 to April 2005, comprised three commercially published reference books, and a marketing guide and forty demonstration house pamphlets.

Sustainable Solar Housing Volumes 1 & 2, edited by Robert Hastings and Maria Wall, Earthscan, 2007, ISBN 978-1-84407-325-2/326-9

Bioclimatic Housing: Innovative Designs for Warm Climates, Edited by Richard Hyde, Earthscan, 2008, ISBN 978-1-84407-284-2

The Environmental Brief: Pathways for Green Design, Richard Hyde, Steve Watson, Wendy Cheshire, Mark Thomson, Taylor & Francis, 2007, ISBN 978-0-415-29044-9

Business Opportunities in Sustainable Housing: A Marketing Guide Based on Houses in 10 Countries, Synnove Elisabeth Aabrekk and Trond Haavik, Segel, Norway, Co-author, Edward Prendergast, moBium consult, The Netherlands available at www.iea-shc.org

Sustainable Solar Housing: Marketable Housing for a Better Environment (Brochure) available at www.iea-sch.org/task28

To access a digital copy of this report, and others go to www.ecbcs.org

Appendix: Participants

Austria

Gerhard Faninger, Unversity of Klagenfurt
Helmut Schoeberl, Schoeberl + Poell OEG, Vienna
Sture Larsen, Architect, Hoerbranz

Australia

Richard Hyde, Univ. of Queensland, Brisbane

Belgium

Andre de Herde, Kristel de Myttenaere, Univ. Catholique de Louvain

Brazil (observer)

Marcia Hammerle, Fed. Univ. of Minas Gerais Belo-Horizonte

Canada

Pat Cusack, Arise Technology, Kitchener ONT

Czech Republic

Miroslav Safarik, Czech Envir. Institute, Praha

Finland

Jyri Nieminen, VTT Bld. & Transport, Espoo

Germany

Andreas Buehring, Christel Russ, Karsten Voss, Fraunhofer ISE, Freiburg
Hans Erhorn, Johann Reiss, Fraunhofer IBP, Stuttgart
Frank D Heidt, Udo Giesler, Universitaet-GH Siegen
Berthold Kaufmann, Passivhaus Institut, Darmstadt
Joachim Morhenne, Ing. Buero Morhenne GbR, Wuppertal
Carsten Petersdorff, Ecofys GmbH, Koeln

Iran (observer)

Vahid Ghobadian, Azad Islamic, Tehran

Italy

Valerio Calderaro, University La Sapienza of Rome
Luca Pietro Gattoni, Politecnical di Milano
Francesca Sartogo, PRAU Architects, Roma

Japan

Ken-ichi Hasegawa, Akita Prefectural Uni., Akita
Motoya Hayashi, Miyagigakuin Womens College, Sendai
Nobuyuki Sunaga, Tokyo Metropolitan Univ., Tokyo

Netherlands

Edward Prendergast, Peter Erdtsieck, MoBius consult bv., Driebergen-Rijsenburg

New Zealand

Albrecht Stoecklein, Building Research Assoc., Porirua

Norway

Tor Helge Dokka, SINTEF, Trondheim
Anne Gunnarshaug Lien, Enova SF, Trondheim
Are Rodsjo, Norwegian State Housing Bank, Trondheim
Harald N. Rostvik, Sunlab/ABB, Stavanger

Sweden

Hans Eek, Architect, Goeteborg
Tobias Bostroem, Uppsala University
Bjoern Karlsson, Vattenfall Utveckling AB, Alvkerleby
Maria Wall, Johan Smeds, Helene Gajbert, Lund University

Switzerland

Robert Hastings, AEU Ltd., Wallisellen
Tom Andris, Renggli AG, Sursee
Daniel Pahud, SUPSI-DCT-LEEE, Canobbio
Alex Primas, Annick d'Epinay, Basler & Hofmann AG, Zuerich
Anne Haas, EMAP, Duebenford

UK

Goekay Deveci, Robert Gordon University, Aberdeen

USA

Guy Holt, Coldwell Banker Assoc., Kansas City, MO.

International Energy Agency (IEA)
Energy Conservation in Buildings & Community Systems (ECBCS)
& Solar Heating and Cooling (SHC) Programmes

The International Energy Agency (IEA) was established as an autonomous body within the Organisation for Economic Co-operation and Development (OECD) in 1974, with the purpose of strengthening co-operation in the vital area of energy policy. As one element of this programme, member countries take part in various energy research, development and demonstration activities. The Energy Conservation in Buildings and Community Systems Programme has co-ordinated various research projects associated with energy prediction, monitoring and energy efficiency measures in both new and existing buildings. The results have provided much valuable information about the state of the art of building analysis and have led to further IEA co-ordinated research. The Solar Heating and Cooling Programme similarly co-ordinates research and conducts a variety of projects in advanced active solar, passive solar and photovoltaic technologies and their application in buildings and other areas, such as agriculuture and industry.

www.iea-shc.org

www.ecbcs.org

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

International Energy Agency
Energy Conservation in Buildings and Community Systems Programme