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Solar energy in building renovation — results and experience of international demonstration buildings

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Abstract

If the use of solar energy is to mean that significantly less fossil fuel will be consumed, solar systems must be readily adaptable to existing buildings as well as new buildings. Under the Solar Heating and Cooling Programme of the International Energy Agency (IEA), Task 20 ''Solar Energy in Building Renovation'', a number of the most promising solar concepts and systems for building renovation were explored. The first activity was a performance analysis of existing solar renovation projects [J.-O. Dalenbäck, Solar Energy in Building Renovation, Energy in Buildings, 24 (1996) 39–50.]. Drawing on the information gained from these case studies, promising concepts with respect to energy savings and replication potential were identified and investigated by simulation studies [A. De Herde, Improved Solar Concepts, Technical Report, 1997, Centre de Recherche en Architecture, Université Catholique de Louvain, Belgian.]. Strategies for incorporating these concepts into the renovation process were developed [O.B. Jørgensen, Solar Renovation Demonstration Projects, Technical Report, 1998, Esbensen Consulting Engineers, Copenhagen, Denmark.]. Fourteen demonstration projects mostly focusing on multifamily dwellings featuring solar concepts were initiated, implemented, and evaluated. This article summarises the cross-analysis of the demonstration projects, evaluated between 1995 and 1998. The analysis covers technical, economic, and building physic issues of solar collectors, glazed balconies, and solar walls.

The aim of a renovation design process is generally not to find the cheapest solution to maintain a proper building function. Renovation deals with a balance of maintenance, improvement, and architectural topics within a given budget. The analysis of the demonstration projects proves that solar technologies have their place — financially, technically and architecturally — as part of integrated renovation concepts. Many of the demonstration projects evaluated tend to be ''solar dominated'' as the analysis of the technology is a main topic. A wider market penetration of solar concepts needs compromises in the size of the solar systems with respect to the investment. The first and primary requirement for future projects is improved cost competitiveness of solar concepts compared to the regular renovation measures.

Keywords: Building renovation; Building integration; Solar energy; Solar collectors; Glazed balconies; Solar walls; Transparent insulation; Monitoring results

1. Introduction

All buildings undergo renovation at some point after construction. The motivation for renovation ranges from repair to increased comfort and living space. High energy consumption is only one aspect in this list of arguments. On the other hand, energy use and energy-related emissions from the existing building stock are dominant compared with the effect of about 1–2% of new (low-energy) buildings each year. Regardless of the reason, renovation presents both special challenges and the opportunity to apply solar technologies to buildings [1].

The analysed demonstration projects in six countries mostly focus on an integrated renovation approach instead of just adding solar (Table 1). A detailed description of each of the demonstration projects is given in Ref. [8]. The solar concepts in the 14 projects focused on (Fig. 1) the following.

Building-integrated solar collectors [2]. Solar collectors are installed with the main purpose of preheating domestic hot water (DHW) and/or to cover a fraction of the space heating (SH) demand. In the context of building renova-

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Table 1
List of the demonstration projects

No.	Location	Country	Type	Age	Size	Standard renovation		Solar renovation				
					Number/floors/floor area (m^2)	Improved insulation	Efficient HVAC-system	Solar collector	Glazed balcony	Solar wall	Day-lighting	Photovoltaic
1	Niederurnen	CH	multifamily	1971	1/4/966	+	–	–	–	84 m^2	–	11 m^2
2	Hedingen	CH	multifamily	1969	1/3/702	+	+	43 m^2	–	80 m^2	–	–
3	Erfurt	DE	school	1981	3/3–4/3980	+	+	–	–	–	+	–
4	Freiburg	DE	residential[a]	1912	1/3/750	+	+	7.5 m^2	–	53 m^2	–	–
5	Oederan	DE	multifamily	1983	7/4/2170	+	+	700 m^2	–	–	–	–
6	Salzgitter	DE	industry hall	1940	1/1/43,000	+	–	–	–	–	7500 m^2	–
7	Wurzen	DE	school	1978	1/4/4100	+	+	–	–	300 m^2	–	–
8	Aalborg	DK	multifamily	1900	1/4/544	+	+	18 m^2	+	–	–	25 m^2
9	Den Haag	NL	multifamily	1961	1/4/504	+	+	17 m^2	+	–	–	5 m^2
10	Zaandam	NL	multifamily	1968	1/14/30,720	+	+	760 m^2	+	–	–	90 m^2
11	Stockholm	SE	multifamily	1961	6/8/40,000	–	–	1200 m^2	–	–	–	–
12	Henan	SE	school	1965	2/1–2/10,000	–	–	725 m^2	–	–	–	–
13	Örebro	SE	multifamily	1963	1/2/2500	–	–	112 m^2	–	–	–	–
14	Golden	US	exhibition	1994	1/1/560	–	+	–	–	–	+	–

[a]Actual office use.

tion, solar collectors may improve the building envelope, e.g. when a flat roof is rebuilt to an inclined ''solar roof'' or new space is created by adding a ''solar attic'' onto a flat-roofed building.

Advanced glazed balconies [3,4]. Glazing a balcony means enclosing it with openable glass elements. The motivation is dominated by the value of the added sun space. In the context of renovation, problems with facade degradation and thermal bridges are reduced. An advanced approach integrates the balcony with a system for mechanical or natural ventilation of the apartment.

Solar wall heating with transparent insulation (TI) [5]. Today, the most prominent and energy-effective candidate for passive solar wall heating is a design including TI. A

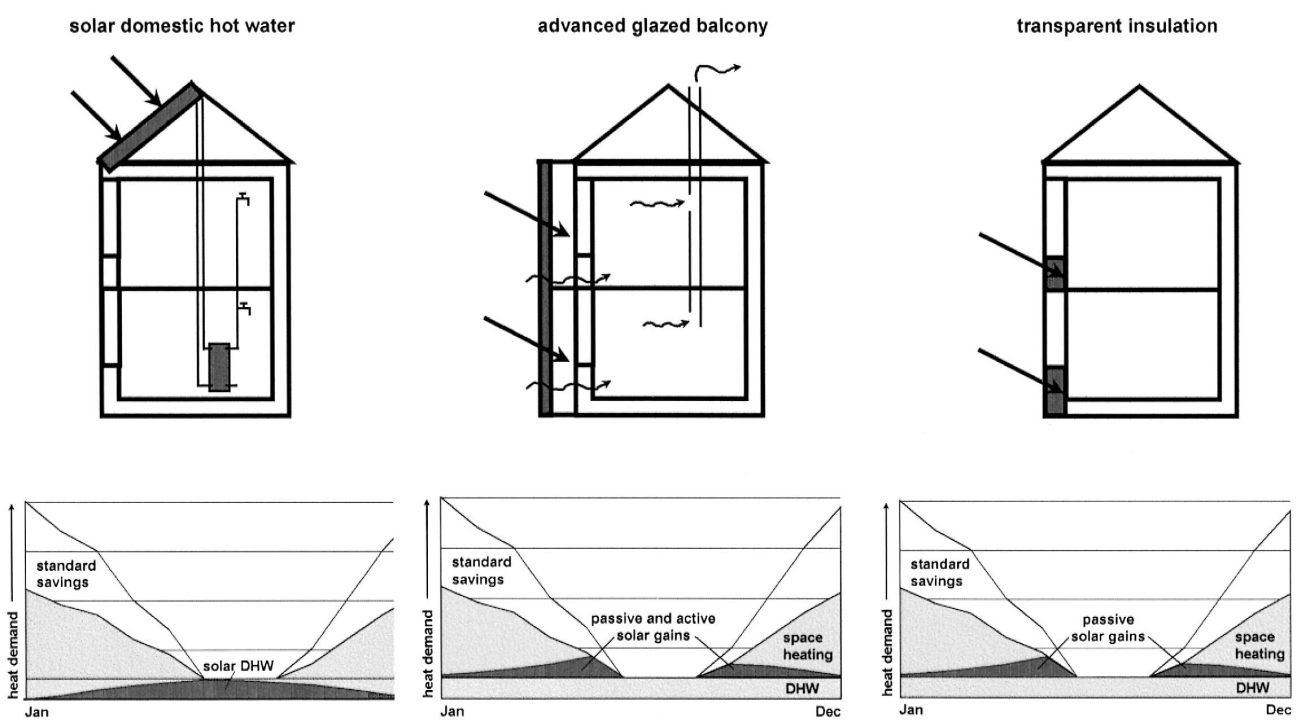

Fig. 1. Selected solar concepts suitable for building renovation. As the solar system is integral part of a ''standard renovation'' the space heating demand is typically decreased 50% by improved insulation of the building envelope.