CADDET energy efficiency IEA OECD

US 99.502/3A.F04

Radiant heating saves energy in homes

Radiant heating panels save energy in homes

Summary

In the United States, the most common forms of residential heating systems are based on convection, using air as a heat transfer medium. Radiant heating systems transfer heat directly to a person or object in a manner similar to sunlight. Similar levels of comfort can be achieved at room temperatures that are 3-4°C (6-8°F) lower than with conventional forced air and baseboard heating systems. When installed in a demonstration home the radiant panels realised energy savings of 33% over a conventional heat pump heating system and 52% over electric baseboard heating.

Highlights

- **33% energy savings over a conventional heat pump heating system**
- **52% energy savings over electric baseboard heating**
- **Reduced air infiltration and heat loss**
- **Modular, room-by-room temperature control**

Interior of a home equipped with radiant panels.

Aim of the Project

This project aimed to assess the performance and comfort levels associated with using the Enerjoy radiant heat panel compared to conventional convection heating systems. The study compared the panels to both a heat pump system and electric baseboard heating. The primary goal was to substantiate the following assertions made by the manufacturer of the panels:

- 10-20% less air infiltration than conventional convective systems,;
- significantly reduced installed heating capacity of the radiant system compared to a conventional forced-air, convective system at a given design load;
- significantly lower electricity consumption than zoned, electric baseboard heating;
- significantly lower energy costs than conventional convective systems under transient conditions;
- thermal comfort maintained with a 3-4°C temperature setback.

The Principle

The Enerjoy radiant heat panel is a solid-state heating panel consisting of a micro-thin composition of conductive pigments and copper electrodes bonded between two layers of dielectric polyester film. This film is backed with 2.5 cm (1-inch thick) 2.7 kg (6 lb) density fibreglass board, faced with a texture coating and framed in aluminium. Its radiant output is 95% of its input energy. Panels are constructed to be mounted on the ceiling and have a nominal wattage of 50 W per 0.09 m^2 (per ft^2). Panels are available in four voltages, 120 V, 208 V, 240 V, and 277 V and are sized in 0.3 metre (1 foot) increments up to a maximum size of 1.2 x 2.4 metres (4 x 8 feet). This technology has applications in industry (drying) as well as residential, commercial and institutional buildings.

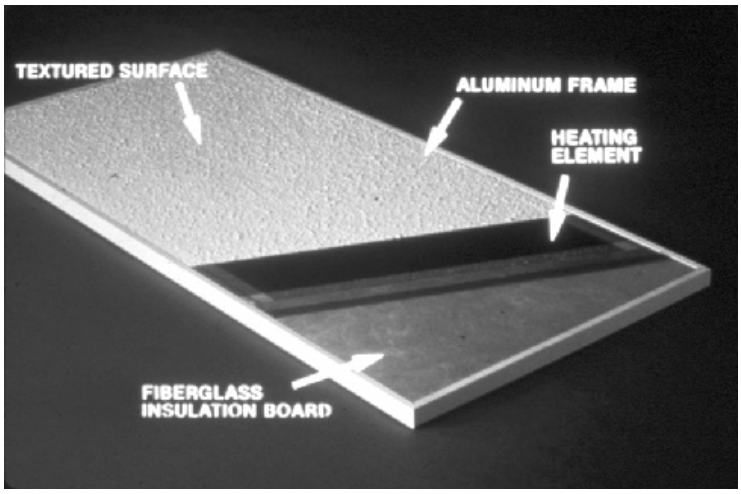

Figure 1: Cross-section of Enerjoy radiant heating pan

The Situation

The house, built in 1990, is a conventional two-storey house, approximately 204 m^2 (2,200 ft^2) in size. It was chosen because data on energy usage for both baseboard heat and heating with an air-to-air heat pump had previously been collected.

The manufacturer, SSHC Inc., specified the number, size and location of the heating panels. Thirteen zones consisting of 16 panels, totalling 16 m^2 (170 ft^2) were installed. This gave an average density of approximately 42.5 W/m^2 (4 W/ft^2) of floor area. These panels were coupled with hydraulic line voltage thermostats with a narrow operating differential and the ability to sense both radiant and ambient temperature effects.

The ducts from the heat pump system were sealed to lower the air infiltration rate. Because of the characteristics of radiant heat, the required installed capacity of the panels is significantly lower (8,100 W) than either electric baseboard heating (20,500 W) or the heat pump system (16,700 W). The heat pump system consisted of two heat pumps (a 1-ton unit for the second floor and a 2-ton unit for the first floor). Both heat pumps were new air-to-air units installed for this study. The units were selected by a local contractor as typical for the area. Both zones of the forced-air system were equipped with state-of-the-art programmable thermostats for separate weekday and weekend setback strategies.

Previous research at the test home involved installing baseboard electric heat throughout the house. Energy consumption as it relates to outdoor temperature was quantified for the baseboard heating system. This allowed comparison of the energy consumption of the radiant and baseboard heating systems for the same residence. Comparisons of energy requirements are shown in Table 1.

Thermal comfort was also assessed. One of the advantages of the radiant panels is that it is possible to set back the thermostat in any non-occupied zone. Setback temperature for the demonstration was 15.5°C (60°F) and set-forward temperature was 20°C (68°F). Occupants felt that acceptable thermal conditions could be achieved in approximately 10-15 minutes, with total room comfort being achieved after 30-45 minutes. Therefore a few behavioural changes were needed. Room occupancy had to be anticipated for immediate comfort, and users had to remember to set back the thermostat when leaving. At the end of the study, both occupants stated their preference for the radiant heating system over conventional systems.

Room temperatures also had much lower levels of temperature stratification than from a conventional convection-based system. Average room temperatures had minimal variation from floor to ceiling.

The Organisation

The National Association of Home Builders has 190,000 members including over 50,000 who build more than 80% of all US homes. The NAHB Research Center was founded in 1964 as a separate not-for-profit subsidiary of the NAHB. The research centre has a professional staff of 75, including scientists, engineers, economists, architects, planners etc. The centre builds homes in a research home park to evaluate innovative technologies that relate to residential construction.

Economics

The estimated savings from heating with the radiant panel for a typical record year heating season in this geographic area are listed in Table 2 below. This data results from a monitoring and data acquisition system used for the field study. The system obtained and recorded data on thermal comfort and energy consumption from various points located throughout the home.

The estimated cost of the radiant heating system, less installation, is USD 4,200 which includes the panels and the thermostats. The payback period for this system will vary depending on whether it is installed as original equipment in a new building, as substitute for a system that requires replacement, or as a retrofit to an existing system. The cost difference between the conventional system and this system need to be taken into account. As this innovative system becomes more commonplace, it is anticipated that costs will decline. Additionally, these panels can be installed to provide supplemental heating in situations where conventional system capacity is insufficient or in areas that are not adequately heated with the current heating system.

Table 1: Comparisons of energy requirements for a typical record year.

Heating system	**Heat pump**	**Radiant panel**	**Electric baseboard**
Estimated annual electric consumption (kWh)	10,764	7,229	15,108

Table 2: Consumption, costs and savings using the radiant panels.

Typical record year information: heating season	**Heating system**		
	Radiant panel	Heat pump	Electric baseboard
Estimated annual electric consumption (kWh)	7,229	10,764	15,107
Estimated annual heating costs (at USD 0.055/kWh)	USD 398	USD 592	USD 831
Estimated annual savings from radiant panels	Base	USD 194 (33%)	USD 433 (52%)

Manufacturer and Supplier

SSHC Inc.
146 Elm St., PO Box 769
Old Saybrook, CT 06475, USA
Tel.: +1-860-3883848
Fax: +1-860-3880525
Contact: Mr R. D. Watson
E-mail: rwatson@sshcinc.com
Internet: http://www.sshcinc.com

Host and Monitoring Organisation

NAHB Research Center
400 Prince George's Blvd.
Upper Marlboro, MD 20772, USA
Tel.: +1-301-2494000
Fax: +1-301-2490305
Contact: Mr P. Yost
E-mail: pyost@nahbrc.org
Internet: http://www.nahb.com

Funding Organisation

US Department of Energy
1000 Independence Ave., S.W.
Washington, DC 20585, USA
Tel.: +1-202-5869471
Fax: +1-202-5861628
Contact: Mr J. Stone
E-mail: jonathan.stone@hq.doe.gov
Internet: http://www.eren.doe.gov/buildings/

Please write to the address below if you require more information.

CADDET energy efficiency IEA * OECD

Swentiboldstraat 21,

6137 AE Sittard,
PO Box 17, 6130 AA Sittard,
The Netherlands,
Telephone: +31-46-4202224,
Telefax: +31-46-4510389,
E-mail: caddet@caddet-ee.org
Internet: http://www.caddet-ee.org

* IEA: International Energy Agency
OECD: Organisation for Economic Co-operation and Development

IEA

The IEA was established in 1974 within the framework of the OECD to implement an International Energy Programme.
A basic aim of the IEA is to foster co-operation among the 24 IEA Participating Countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology, and research and development (R&D).

This is achieved, in part, through a programme of energy technology and R&D collaboration currently within the frame-work of 40 Implementing Agreements, containing a total of over 70 separate collaboration projects.

The Scheme

CADDET functions as the IEA Centre for Analysis and Dissemination of Demonstrated Energy Technologies. Currently, the Energy Efficiency programme is active in 12 member countries and the European Commission.

This project can now be repeated in CADDET Energy Efficiency member countries. Parties interested in adopting this process can contact their National Team or CADDET Energy Efficiency.

Demonstrations are a vital link between R&D or pilot studies and the end-use market. Projects are published as a CADDET Energy Efficiency 'Demo' or 'Result' respectively, for ongoing and finalised projects.

This brochure is printed on 100% chlorine-free bleached paper *April 1999*