TECHNOLOGY PROCUREMENT TO IMPROVE THE ENERGY EFFICIENCY OF ELECTRICITY UCE IN DETACHED HOUSES

A PROGRAM FOR 1993-1996

Arne Lögdberg

National Board for Industrial and Technical development
Stockholm
Sweden

BACKGROUND

Today in Sweden, about 650 000 detached houses are heated solely by direct-acting electric heating, with a further 450 000 heated by electricity, but which can also be heated by some other fuel.

Over the years, many projects have been carried out with the aim of demonstrating that energy can be saved, or made better use of, in the country's electrically-heated housing stock. Most of these projects have concentrated on individual buildings or, in come cases, on groups of houses, which has meant that the results cannot be generalised to apply to the entire detached housing stock, but can serve only as examples of how the efficiency of electricity use in detached houses could be improved.

Some technology procurement projects have been run in the detached house sector. A couple of examples are the energy-efficient windows project (NUTEK and Vattenfall) and the white goods projects (NUTEK). There has also been some technology procurement of existing and established technology. An example of this is to be found in the field of domestic hot water heaters. By purchasing large numbers of heaters, two local energy utilities (Halmstad and Nacka) have been able to press the manufacturers to improve the thermal insulation performance and other aspects of the heaters, while getting the price down by about 30%.

A large number of R&D projects have been carried out, or are being carried out. However, it has been found that the results of many of them have not been subsequently monitored, or that it has not been possible so to do, so that it has not been possible to demonstrate the expected energy savings to more than a limited extent.

The present situation is therefore that we know that electricity can be saved in individual houses or groups of houses through application of existing technology. However, we know altogether too little about how such technology might be improved, or in what order various energy conservation measures should be applied, whether from the point of view of the house owner, who is concerned with the cost, or from the point of view of the local energy utility, looking for improvements in the load factor by lopping peaks and filling troughs.

THE OBJECTIVE OF THE PROJECT

The objective of this project is to put forward proposals for measures or combinations thereof (primarily such as will improve the efficiency of electricity use) which are suitable for use in existing housing stock.

PROJECT PROPOSALS

1. HEAT RECOVERY

Background

The Building Regulations governing buildings constructed since the end of the 1970s have placed considerable emphasis on airtightness of the structure. This is necessary in order to reduce uncontrolled ventilation (air that flows through the building without passing through the fan), which is essential if mechanical ventilation systems are to operate properly.

The Swedish Council for Building Research (BFR) has installed a number of experimental heat recovery units in existing detached houses and in a two-storey apartment building. At SEK 25 000 - 40 000 per dwelling unit, the systems were relatively expensive, and at about 1500 kWh/house or apartment, energy savings were modest.

These heat recovery units were not installed with the prime objective of saving energy, but in order to improve the indoor climate. The occupants of the buildings have been very much in favour of this particular R&D project, and without exception feel that their indoor climate conditions have been substantially improved without increasing energy use.

Further improvements of the ventilation units and ducts, in terms of performance and efficiency, can probably result in savings of about 30%. Optimisation of fan efficiency will avoid the need for oversized motors. In addition, the pressure drop across the heat exchangers must be minimised, in order to reduce the fan drive power required. The sizes of ventilation ducts, and of bends, also need to be optimised.

Working proposals

A performance specification should be drawn up, essentially as follows:

A review of existing heat recovery systems at present available on the market.

Optimisation of ventilation units: possibly development of a special unit intended for retro-installation in existing detached houses from the 1970s and 1980s as an improvement measure.

Development of suitable ducting systems for retrofitting applications.

Assessment of which types of detached houses (considering factors such as age, airtightness etc.) are suitable for installation of mechanical ventilation systems with heat recovery.

Optimisation of costs of the ventilation/heat recovery units and of the ducting.

2. CONTROL SYSTEMS AND 'COMFORT HEATING'

Background

Most of the electric radiators that were installed during the 1970s are still in operation. However, over the years, thermostats tend to fail, so that the switching cycle can take up to a couple of hours instead of a few minutes, with the result that the radiators are either far too hot or stone cold, which of course considerably reduces indoor comfort,

Development

By installing a new control system, that takes over the part played by the radiators thermostats in various ways, radiator temperatures can be kept more constant and comfort improved. Such systems are known as comfort electric heating systems.

About 15 different proprietary systems are available on the market, with varying degrees of sophistication. Prices are about SEK 10 000:-, installed and ready to use. Several energy utilities, including Vattenfall, sell complete turnkey systems to their customers, while others refrain from such sales, maintaining that the systems are expensive and unreliable.

Working proposals

A performance specification should be drawn up, essentially as follows:

Determination of the functions to be controlled/provided by the system.

Requirement for cheap and simple installation.

Controls and displays to be simple and easily understood.

- Modest price levels.

3. HEAT PUMPS

In general, heat pumps systems in existing detached houses are far too expensive to be financially viable in terms of domestic budgets when employed in the typical sizes involved in replacing direct electric heating systems (20-25 MWh/year). The only ones that are reasonably modestly priced are the background heat pumps, which have come down in price as a result of very large numbers of sales for air-conditioning units. In addition, installations are very simple, with direct evaporation outdoors and direct heat release from the condenser to the indoor air. Some heat pumps supply their heat to a liquid heat exchanger. However, all such installations have significant shortcomings, such as:

- Installing compressors and electronic controls in the outdoor portion results in energy losses and reduced life.
- Direct evaporation involves a risk of loss of refrigerant.
- The majority of systems have no facility for heating domestic hot water (at least, not simply).
- Energy savings potentials are limited (4-6 MWh/year).
- Systems are not suitable for subsequent expansion (heat can be collected at only a single point).

- If the system breaks down, it may be necessary to replace it in its entirety, as parts made by different manufacturers cannot be easily interconnected.

Development requirements

As an alternative to background heat pumps and exhaust air heat pumps, a simple liquid/water heat pump could be of interest. It could be designed as a self-contained unit, and would be suitable for more or less any application. If possible, it should be produced in two sizes: one with an output power of about 2-3 kW, and one with a power of about 3-4 kW.

Several Swedish manufacturers produce such units, but as a result of limited production quantities they are expensive. At present, units of this type cost about twice as much as a background heat pump, despite the fact that they are much simpler. It is therefore difficult for individuals to justify such units on cost grounds.

Despite the fact that the liquid/water heat pump would have good prospects of being the most cost-effective and environmentally beneficial alternative in the long term, both for the individual owners and for society as a whole, the high initial cost puts potential purchasers off.

A technology procurement programme should help to bring the price down to a reasonable level. In the longer term, such a programme would result in larger production quantities and reduced unit costs.

Working proposals

A technology procurement project/competition should aim at the development of a simple liquid/water heat pump, having an output rating of 2-4 kWh and complying with the following performance requirements:

Requiring little space, suitable for installation entirely indoors, and simple to maintain.

The parts of the unit must be easy to replace. If the entire unit has to be replaced, it must be possible to fit a similar unit from another manufacturer.

The heat source can be earth, rock, outdoor air, ventilation exhaust air or any combination thereof.

Distribution of the output heat must be possible by fan heaters, low-profile convectors, conventional radiators, floor heating, ceiling heating, airborne heating, top-up heating or combinations thereof.

A domestic hot water heating facility must be available.

It must be possible to expand the system progressively, e.g. as electric radiators/thermostats, electric water heaters etc. are replaced.

4. DOMESTIC HOT WATER HEATERS

Some advances have been made in this area, partly as a result of the work of the Halmstad and Nacka bulk purchasing enterprises. No formal technology procurement project is probably necessary here, as the actual technology is well known. However, it is important to produce a performance specification in some way, covering aspects such as heat losses, type of control system etc., which can provide guidelines for manufacturers and users (the customers).

5. OIL-FIRED BOILERS / BIOMASS FUEL BOILERS

Small high-efficiency oil-fired boilers are available on the market today, having extremely compact combustion chambers. They require only a 50 mm diameter flue, which can be installed through an outer wall where suitable. No conventional chimney is needed.

Development pressures aim at the production of such units suitable for burning rape-seed oil instead of mineral oil. Rape-seed oil has approximately the same calorific value as mineral oil, which simplifies its storage. However, a drawback of this oil relative to mineral oil is that it needs to be preheated before it can be burnt.