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New opportunities for heat pumps in Swiss retrofit buildings

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Summary

Switzerland's present retrofitting potential in the buildings sector is considerable. Electrically driven heat pumps may represent an interesting proposition for heating and cooling commercial buildings in Switzerland, where environmental aspects constitute an increasingly important factor.

The following article reports on the retrofitting of a commercial building where two electrically driven heat pumps in bivalent-parallel operation with an oil-fired boiler were installed. The envelope improvements resulted in energy savings of 64 kWh/m² year. When compared to an oil-fired boiler system, the heat pump solution brought savings of about 60% on total energy consumption and showed no increase in heating costs. Besides this saving, annual emissions of 63 tonnes of CO_2 and 303 tonnes of NO_x have been avoided.

Introduction

One of the most important factors in determining the need for a building's retrofitting is its age. In order to maintain a building's effective value there is a need for periodic retrofitting. In general, it is considered that these retrofits should be made every 30-50 years with respect to the structure, and every 20 years when dealing with technical installations. Swiss real estate is relatively young. As can be appreciated from Figure 1, over 50% of commercial buildings were built after 1950, and therefore the present retrofitting potential is considerable. In spite of the great energy saving potential, only a few older commercial buildings and apartment blocks have been insulated and generally retrofitted since the energy crisis. This is due to economic and architectural difficulties.

Energy consumption in the building sector represents 29% of the total Swiss energy consumption. Therefore, now is the ideal time to "rethink" energy consumption in existing buildings and to introduce new energy technologies which are not only energy efficient but also help reduce atmospheric pollution.

These objectives are well within the framework of the swiss energy policy, especially those of the action programme "Energy 2000". This programme aims at:

- the stabilization of fossil fuel consumption and total CO_2 emissions by the year 2000, at 1990 levels, thereafter followed by a decrease of said levels;
- lowering the growth rate of electricity consumption, followed by a stabilization of electrical demand;
- the promotion of renewable energies in order to increase their share up to 0.5% of the total electricity production and

On the right the building complex during the retrofitting operation. Part of it is inside the old walls that surround the town of Bellinzona.

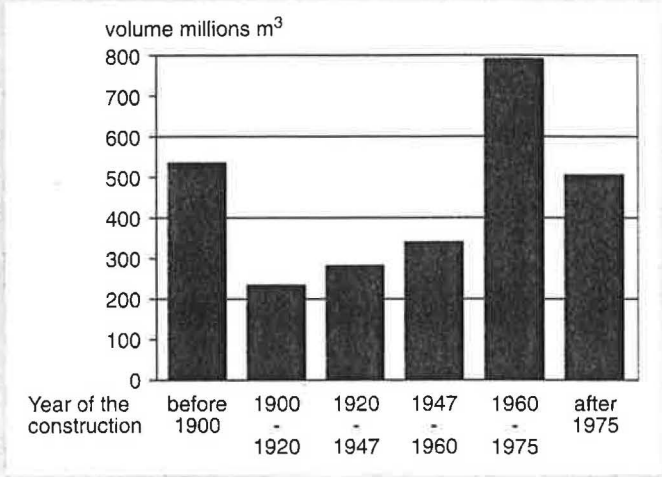

Figure 1: Structure of Swiss real state by its age and volume (1.1.90). Source: W&G data bank

up to 3% for the heat production.

Retrofitting a commercial building

The complex, retrofitted in this example, consists of three main commercial blocks linked by smaller ones, including a bar, a restaurant, offices, shops and apartments situated in the old part of the city of Bellinzona. The total volume is10,200 m³. The building is formed by different properties having different energy status, different internal conditions and different ages. The oldest one dates from the beginning of the 15th century. While renovation and retrofitting operations were being carried out, during the past decade the building showed thermal bridges in the envelope, poor indoor climate and a high energy consumption. The last retrofitting was carried out in 1989. It consisted of extending the building, followed by improvement of its overall quality and the decrease of annual energy demand for space heating and domestic hot water per m². With regard to energy there are two work phases. The first is the retrofitting of the envelope. The second is the installation of a new central HVAC system.

Envelope

A certain amount of renovation work was undertaken as far as the architectural aspects allowed (old walls remained intact). The building envelope was improved by additional insulation on facades and roofs, double glazed windows, air tightness improvement, etc. As a result, the energy demand for space heating (Eh) decreased from 523 MJ/m² to 339 MJ/m², (recommended value for a new building 280 MJ/m²) and the annual energy consumption for thermal use (Et) from 718 MJ/m² to 488 MJ/m².

Thermal energy supply system

A new system for heating, cooling, ventilation and supply of hot water was installed. For the heating and cooling, the building has been provided with 2 central electrically driven heat pumps (developed in Switzerland by TERMOGAMMA). This system works in a bivalent parallel operation with an oil-fired boiler meaning that heat pump and boiler work together to reach the temperature required. The heat pumps use as heat sources either the ambient air or a mixture of ambient air and flue gas from the fuel fired boiler, depending on whether the ambient air temperature is higher than the balance point temperature (see Figure 3). The design of the

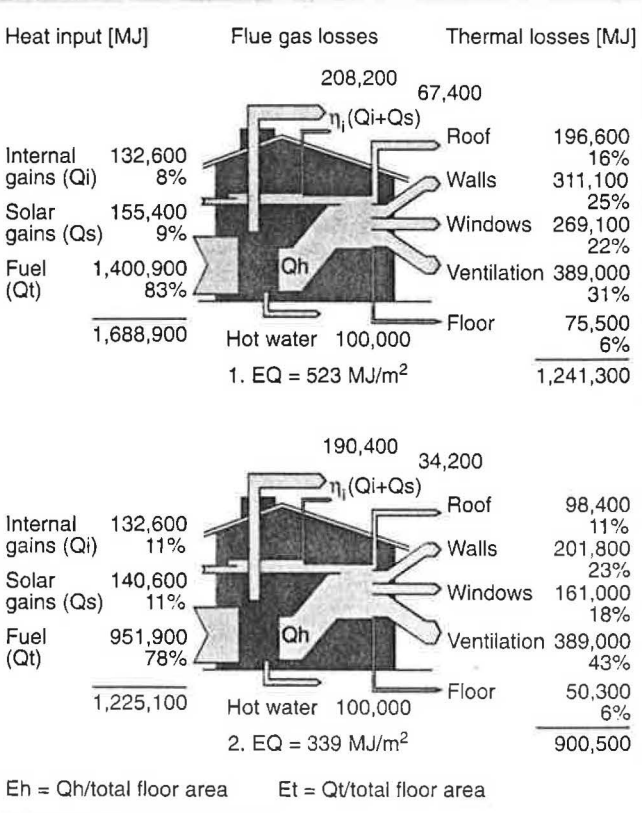

Figure 2: Annual thermal energy balance of the building. Situation before 1) and after the envelope improvements 2).

installation allows two operating modes: heating and cooling. The heat produced is used for space heating and domestic hot water and the cold is used for air-conditioning.

Results

With this system, 85% of the total heat demand (space and water) is delivered by the heat pumps, the remainder by the boiler. This fact allows us to point out the following advantages of the system when compared to an equivalent conventional oil-fired boiler.

- Total annual energy savings of about 60%.
- Annual savings in fuel oil consumption of about 20 tonnes.
- Reduction on the annual CO_2 emissions of 63 tonnes. Yearly reduction of the emissions of NO_x of tonnes.
- No extra mechanical cooling system is needed.

Furthermore, in regard to an alternative bivalent system, the adopted solution shows the following benefits:

- Supplementary energy savings. Very high combustion efficiency due to the low pressure created by the running heat pump. Total heat recovery from the flue gases (sensible and latent heat) considerably increases the condenser thermal power, when compared to the cycle with the boiler switched off, resulting in a general efficiency improvement.
- Supplementary reduction of SO_2 emissions, elimination of soot and dust in the flue gases due to the double washing.
- Reduction of the frequency and time period for defrosting operation.

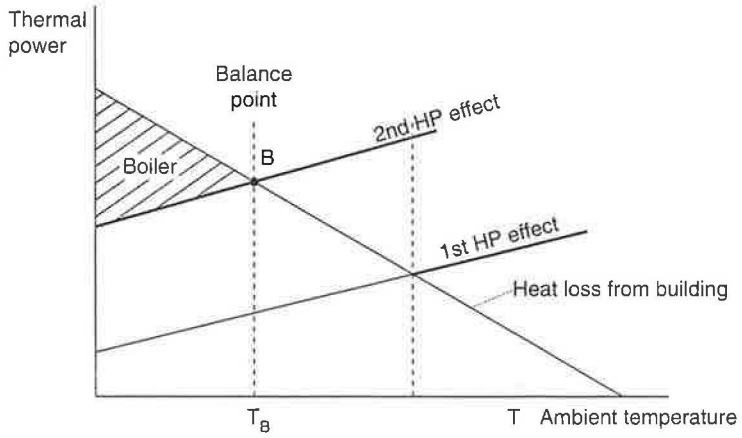

Figure 3: The heating effect of the system is plotted against the ambient air temperature. The system is designed so that the heat pumps can supply the entire heat requirement above T_B. Below this temperature the oil-fired boiler is switched on and flue gases mixed with fresh air reject their heat to evaporator.

- Elimination of the stack (and stack losses).
- Reduction of the fuel oil tank size.

Conclusions

The present example illustrates the main benefits of the heat pumps for space heating and air-conditioning applications. Compared with other forms of heating, heat pump systems offer an immediate advantage; an oil-fired boiler efficiency may be about 0.80 whereas the coefficient of performance of a heat pump in practice may be about 3.

From the environmental point of view, heat pumps are strongly dependent on the type of electricity generation system. In Switzerland, electricity is mainly generated by hydro and nuclear power plants. This leads us to conclude that in Switzerland electric heat pumps are an effective move toward the reduction of the CO_2 emissions into the atmosphere. Since the oil crises of 1979, about 3000 heat pumps have been sold every year in Switzerland. The majority of these are for space and water heating purposes, in either new or retro-fitted residential and commercial buildings. This is a very small figure when compared to the 40,000 new boilers that are fitted into commercial buildings every year.

We can estimate that every year new Swiss heat pump installations, as a substitution technology for oil-fired boilers, contribute to an additional reduction of the emission of CO_2 of about 42,000 tonnes. Therefore, heat pump systems represent a promising technology for the achievement of the objectives of the action programme "Energy 2000". To conclude, the growing need for retrofitting and in particular the ever important greenhouse issue are two factors that confirm the real opportunity for a significant growth of the heat pump market in Switzerland.

For further information please contact the Swiss National Team as listed on page 30 of this publication.

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