CONNECTION OF SOLAR AND NEAR-SURFACE GEOTHERMAL ENERGY IN ISOMAX TECHNOLOGY



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Summary

The advantages of the two approved processes of solar engineering and utilization of geothermal heat are combined in an amazingly simple form by the utilization of solar energy in connection with the near-surface geothermal energy. Many examples already realized in all climatic zones verify the efficiency of this system extremely favourable in regard to both manufacturing and operating costs. In order to optimize and also to be able to "calculate" this building technology, further research and development are necessary. The objectives of further investigations are to gain control of the calculation of heat exchange processes and to optimize insulation thicknesses. The experience already gained, however, permits an eco-friendly and economical application of the Isomax building technology already today.

Keywords: Low energy house, sustainable development, renewable energy

1 Introduction

Energy plays the tremendous role in the mankind’s life. Its production and consumption creates the base for all processes of life on the Earth. Besides food and air, the energy constitutes one of the most important material requirements of people. The use of energy allowed to achieve the contemporary level of culture and civilization and shaped the current state of the world’s economy.

Rapidly increasing consumption of energy caused also the negative consequences for the environment. The emissions associated with fossil fuels burning were the reason for the appearance of acid rains and substantial degradation of the environment. They contributed also to the creation of greenhouse effect which has the negative consequences of global warming and climatic changes. The energy crises and disclosure of the energy barrier of economic development caused the significant transition of the views concerning the fuels and energy economy. The world understood that the oil supply capabilities are limited and the era of cheap oil became the past. It was recognized that the fuels and energy conservation, and particularly oil conservation, is the necessity. In many countries the long-term activities and action programs were initiated in order to limit the growth of oil consumption and to substitute the oil with the other energy sources – mainly natural gas, coal, nuclear energy, and renewable energy sources.

According to the classification applied by the World Energy Council, the world's energy resources have been divided into two categories: renewable and non-renewable. The renewable energy sources include: hydropower, fuel wood, biomass other than wood, **solar energy**, **geothermal energy**, wave and tidal energy, oceans' thermal energy.

Currently the renewable energy sources play – comparing with the fossil fuels – the relatively small role in covering the world energy requirements, though in some countries their share in the primary energy consumption is considerable or even high.

The theoretical potential of geothermal energy is large, but the reserves feasible for exploitation are estimated at 5000 EJ (12 Gtoe). The current utilization of geothermal energy resources is very small. In 1999 the installed capacity of geothermal power plants was 7.7 GW and the annual production of electricity 51.9 TWh (mainly USA and Philippines, in Europe- Italy and Iceland). In some countries the geothermal energy is utilized also as the source of heat for space heating and for the preparation of domestic hot water.

The other sources are the solar energy, sea wave's energy and the thermal energy of the oceans. These sources are used to the minimum level despite their tremendous energy potential. The solar energy is used to the biggest extent from the mentioned sources, particularly for heating of houses, preparation of domestic hot water and air conditioning.

Above-mentioned economic and environmental aspects enforce population to serious treating questions of utilization of energy of the sun and the ground and of thermal protection of buildings. Nowadays, about 40 % of all energy raw materials such as crude oil, natural gas and coal are being used for air-conditioning purposes for heating and cooling of buildings – an unjustifiable luxury considering the fact that both ecologically friendly and economically useful alternatives are available.

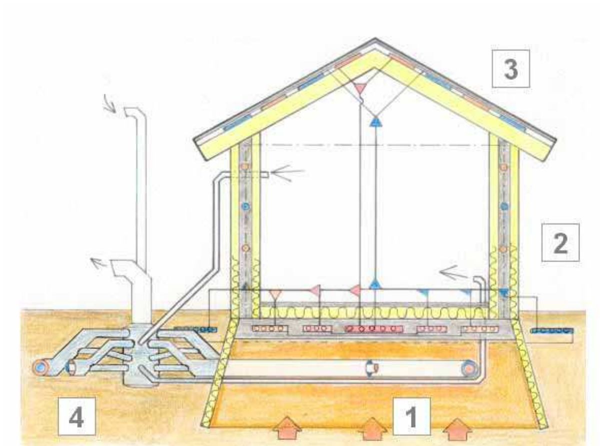
Despite a great variety of activities regarding the utilization of renewable energies the expenditure of primary energy for the manufacture of such systems and facilities as well as the initial costs for photo-voltaic installations, solar collectors or heat pumps are definitely still too high as compared with the energy savings achievable.

Presented in this paper will be a technology for the air conditioning of buildings utilizing the ground underneath the building as a storage medium and the solar energy as an energy carrier. This Isomax building technology will require but minimum amounts of current and constitutes an economical alternative to conventional heating and air-conditioning systems both in regard to manufacturing and operating costs and in addition to the aspects of conservation of nature and environmental protection which are becoming more and more important for future generations.

2 Energy concept in Isomax building

The basic idea of the Isomax building technology consists in that solar energy is collected via the shell of a building adjoining the surrounding air, via roofing and walls and that this thermal energy is stored in the ground underneath the building and in case of need will be used for heating and cooling as well as for ventilation and aeration of a building. Collection of the solar energy, feeding thereof into the ground as well as tempering of walls and roofing will be effected via concealed plastic piping installed in building components and/or in the ground and filled with water. Via the roof absorber piping the solar energy is collected by heating the water contained in said piping up to a temperature of 80 °C (summer season average temperature 30 °C) and fed into the ground underneath the sole plate by means of insulated piping. The ground underneath the sole plate is “diked” laterally with insulation so as to serve as an efficient storage for the heat supplied. The storage is subdivided into different temperature zones by an appropriate control system.

Apart from heating and/or cooling of walls and roofing, an additional aeration and ventilation of buildings by means of a “Pipe-in-Pipe” counter flow system is deemed useful. To heat the inside of a building, the fresh air which enters via the described double pipe systems, is fed past the outgoing air according to the principle of counter flow and thermal/cold energy from the outgoing air is transferred to incoming fresh air and thus recuperated to the highest degree.



1 – Underground storage system layout (energy reservoir) – alternative building foundations
2 – Outer wall design with temperature barrier (climate barrier)
3 – Roof structure with solar absorbers
4 – Co-axial pipe-within-a-pipe counter flow extraction / ventilation system for heating and air-conditioning

Fig. 1 Schematic diagram absorber- wall- foundation plate

The outer walls involved consist of a concrete core of 15 cm thickness into which the temperature barrier is integrated, with heat insulation (PS 15, SE 040) of 5,0 cm thickness each on the inside and outside. The direct comparison between the wall without temperature barrier and the wall with temperature barrier +18 °C shows that the transmission heat losses $Q_{Tinside}$ are reduced from 21.02 to 3.28 kWh/season per m² wall surface. This corresponds to a reduction of the heat demand for heating purposes by 81 % referred to the transmission heat losses of the outer wall (**Fig. 2**).

In case of a conventional wall design the transmission heat loss will be determined via the temperature gradient from the inside to the outside and by the U-value for the entire wall cross-section. With a building component with temperature barrier water preheated by the ground storage is passed through piping integrated in the wall cross-section and through the solid wall "embedded“ in heat insulation both on the inner and the outer sides. The wall cross-section will be heated to approx. +14 °C to +18 °C depending on the temperature of ground storage. The transmission temperature loss will thus be determined only by the temperature gradient from the inside (indoor temperature according to EnEV) to the temperature barrier. In principle, the outside insulation will no longer play a role in relation to the transmission heat loss provided sufficient energy will be supplied by the ground storage for maintaining the wall temperature. Herein, attention should be paid that the ground storage will be supplied with thermal energy by insulation via the roof absorbers also in winter.

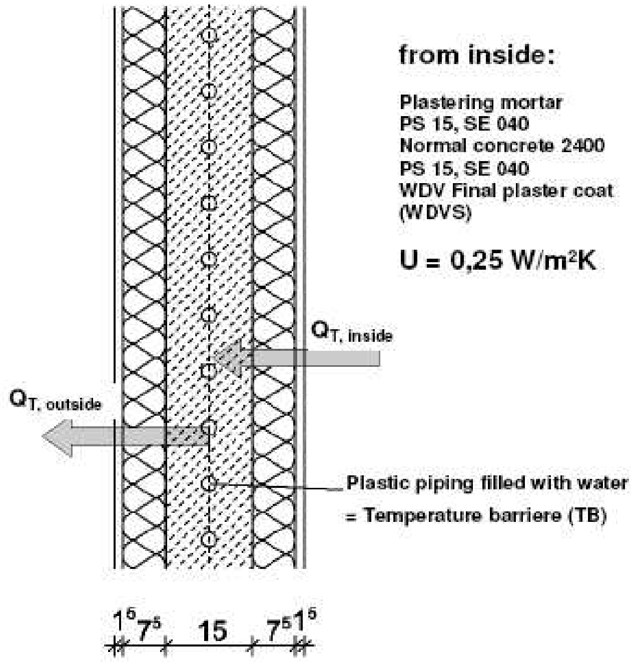


Fig. 2 Schematic diagram of cross-section of outside walls involved

Initially illustrated in (**Fig. 3)** is the transmission heat loss of the entire outer wall without temperature barrier (T_B). Considering the T_B with a water temperature of +14 °C and/or +18 °C a distinction was made between:

- the inner wall portion (Q_{Ti}) taking into account the insulation on the inside as well as the inner half of the concrete
- the outer wall portion (Q_{Ta}) comprising the outer half of the concrete cross-section and the insulation on the outside.

The following formula applies for determination of the transmission heat loss of wall without temperature barrier (T_B):

$$Q_T \sim U\, \Delta t \quad \text{wherein} \quad \Delta t = t_i - t_a \tag{1}$$

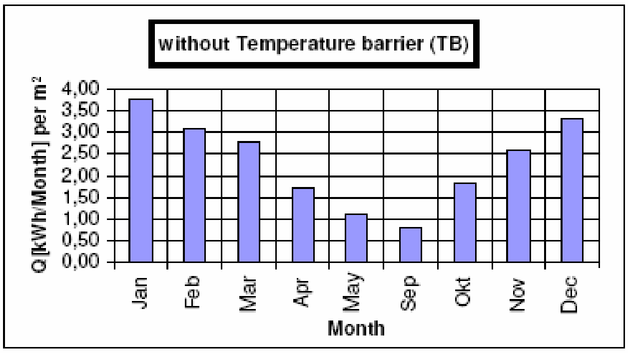
For determination of the transmission heat losses of the inner and the outer wall portions the following formulas shall apply analogously (taking twice the U-value as a basis!)

$$Q_{Ti} \sim 2\,U\,(t_i - t_B) \quad Q_{Ta} \sim 2\,U\,(t_B - t_a) \tag{2}$$

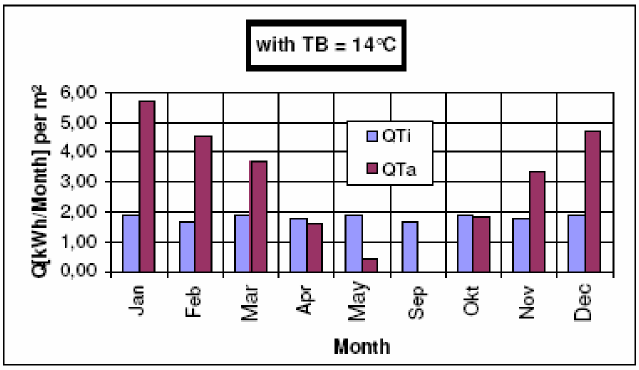
Thus, the transmission heat losses of the wall with temperature barrier as a whole is double that of the wall without temperature barrier. The loss in the outer wall portion is covered by the ground storage and "free of charge".

Logically, the loss in the inner wall portion needs to be minimized by reduction of the difference t_i - t_B. With the increasing of values of temperature barrier, the transmission heat losses are "shifted" from the inner wall portion to the outer wall portion so that mainly energy from the ground storage and less the energy from the rooms is being consumed. The temperatures of temperature barrier by months and for the entire heating period assumed have been taken as constant for reasons of this calculated comparison only. In practice, the temperature will continuously be adapted and optimized as a function of the desired indoor temperatures and the prevailing outdoor temperatures; this will apply both to heating and cooling of the buildings.

without TB	
	Q_T
	kWh/Month per m²
Jan	3,78
Feb	3,09
Mar	2,77
Apr	1,71
May	1,13
Sep	0,83
Oct	1,84
Nov	2,57
Dec	3,29
Sum	21,02



with TB = 14°C		
	Q_{Ti}	Q_{Ta}
	kWh/Month per m²	
Jan	1,86	5,69
Feb	1,68	4,50
Mar	1,86	3,68
Apr	1,80	1,62
May	1,86	0,41
Sep	1,66	0,00
Oct	1,86	1,82
Nov	1,80	3,35
Dec	1,86	4,72
Sum	16,24	25,80



with TB = 18°C		
	Q_{Ti}	Q_{Ta}
	kWh/Month per m²	
Jan	0,37	7,18
Feb	0,34	5,85
Mar	0,37	5,17
Apr	0,36	3,06
May	0,37	1,90
Sep	0,36	1,30
Oct	0,37	3,31
Nov	0,36	4,79
Dec	0,37	6,21
Sum	3,28	38,76

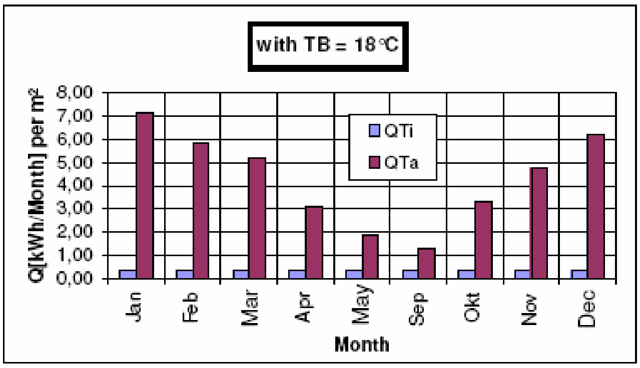


Fig. 3 Transmission heat losses of an outside wall without temperature barrier, with temperature barrier = +14 °C and with temperature barrier = +18 °C [1]

3 The Single-Family home

When applying the considerations contained in the preceding section to a typical single family home with basement, ground floor and garret storey with double pitch roof, the heat demand for heating purposes will be as shown in **(Fig. 4).**

The floor area of the building involved is 88 m² with the heated building volume amounting to 397 m³. In both cases, the building components as well as the boundary conditions not influenced by the Isomax building technology have been taken as identical as a basis for the calculation.

Components: Roof – U = 0.18 W/m²K, Windows – U = 1.4 W/m²K of area portion 17 %, The Wall – U = 0.25 W/m²K, as well as a free ventilation with an air change rate of 0.7 h^{-1} have been taken as a rating basis for the conventional construction.

In the calculation by the Isomax building technology and with a U-value of 0.50 W/m²K "half" the wall cross-section with a constant temperature barrier temperature of +18 °C as well as the „Pipe-in-Pipe" counter flow system with 85 %-90 % heat recovery have been taken into consideration. Based on the parameters specified above, the heat demand for heating purposes in a single family home is calculated as follows:

- Outside walls without temperature barrier Q_h = 15 488 kWh/a
- Outside walls with temperature barrier = +18 °C, WRG, Q_h = 4 412 kWh/a
- Referred to the building useful area A_N = 255 m²:
- Outside walls without temperature barrier E_A= 60,7 kWh/m²a
- Outside walls with temperature barrier = +18 °C, WRG E_A = 17,3 kWh/m²a

Setting out from this calculation there can be verified that the annual heat demand for heating of a building with Isomax building technology consisting of temperature barrier and Pipe-in-Pipe counterflow system is approximately equal to that of a passive house standard with an annual heat demand for heating purposes of E_A = 15 kWh/m².

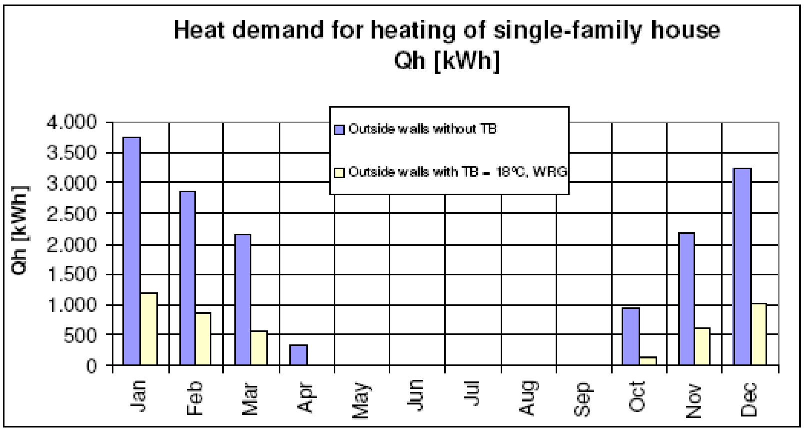


Fig. 4 Comparison of the conventional construction of a single-family home with the Isomax building technology [1]

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