Energy flux for the future
- Utilization of solar-supported near-surface geothermal energy for energy savings in buildings

The heat flow continuously directed from the interior of the earth to its surface is estimated to be 4.10^{10} kW; referred to the surface of the earth this means approx. 0.7 kWh/m²/a. This value is too small for any direct utilization, and it is only geothermal anomalies that count to this effect: hot waters connected in aquifers and in most cases not having any natural connection to the surface of the earth except for geysers.

The thermal utilization of the subsoil is a common theme in Germany at present; herein, a distinction is made between the utilization of subterranean water by way of well systems and the utilization of the near-surface subsoil by way of geothermal energy collectors or geothermal energy probes using also foundation piles for heat transfer (“energy piles”). In all of these cases, heat pumps are being used to obtain the flow temperature required for the heating of buildings.

A completely different and substantially more economical approach has been followed by the Luxembourgian research scientist Dipl.-Ing. Emond D. Krecké by direct utilization of the near-surface temperature of the earth.

As is known, a temperature of 8°C to 10°C substantially independent of the earth atmosphere is prevailing in a depth of 2.5 to 3 m both in summer and in winter. Occasionally, this phenomenon is called wine-cellar temperature: this atmosphere is considered warm in winter and cool in summer. If this temperature available abundantly was used for practical purposes by “supplying” it to all external building components at a value of e.g. 8°C, even extremely low outdoor temperatures would not have any direct influence on the indoor temperatures. So to speak we would have provided a temperature barrier, and the energy consumption of the building would only be a function of the temperature difference between the indoor temperature and the temperature of the temperature barrier such as

$$\Delta t = t_i - t_{TB} = 22° - 8° = 14° \text{ C}$$

irrespective of the drop of outdoor temperature involved.

But how can the ground temperature be transmitted to external building components?

Narrow-spaced plastic piping having a diameter of 1 cm to 2 cm is installed in the sole plate for the recirculation of water. The water takes the ground temperature, is pumped into the external building components and after heat emission there is returned into the sole plate.

When constructing a building without cellar directly on the ground or with cellar in the ground and when the sole plate is insulating on its surface, the heat flux coming from the interior of the earth will accumulate underneath the sole plate and the temperatures there will rise until a balance is achieved with the heat flux escaping laterally from the building into the earth atmosphere. This temperature rise will also occur, of course, when the building is not being heated. Among other factors, the temperature rise will be a function of the foundation depth and the building ground plan area. The average temperature rise is 2°C to 4°C so that the temperature in the temperature barrier will be approx. 12°C and the energy consumption will depend on the temperature difference

$$\Delta t = 22° - 12° = 10° \text{ C}.$$

It is desirable to reduce this temperature difference further, i.e. to increase further the temperature in the temperature barrier, namely to a value ensuring comforting indoor temperatures without the necessity of energy supply. Of course, solar heat gains e.g. via windows or internal gains resulting from the utilization of building will be taken into account.

At this stage, Krecké, the research scientist, got the idea to “tap” another inexhaustible, extremely efficient and also free energy source. The sun!

Even in Germany, the annual insulation has an average energy of 1000 kWh/m²/a on horizontal areas.

Let us assume that an energy of 10 kWh referred to 1 m² area and per year was required for the supply of the temperature barrier, we could supply 100 floor areas with the insulation energy in Germany! A theoretical value from which losses would still have to be deducted, but nevertheless giving an idea of the dimension involved. Another point is the fact that in case of high buildings, in particular, it is not only the horizontal or inclined roof surfaces but also the vertical wall areas that could be used for absorption.

It is evident that the sun constitutes an energy source available to us by which we could provide the air-conditioning of buildings almost free of charge (the only question being that of absorption as well as energy transport and energy storage). With the ground, this energy source is available for cooling and the medium for storage of solar energy is provided. Such a technology is called Terra-Sol technology by us.

Underneath the roofing and to be more precise between the roofing and the heat insulation there will be installed the absorber lines, i.e. small plastic piping similar to the temperature barrier lines described hereinbefore; as far as absorber lines are required in the outside walls, they will be installed in the exterior rendering there. The water contained in the piping will be heated up to 80°C or 85°C in summer in case of sunshine and appropriate outside temperatures and up to useful 15°C to 20°C in winter even in case of minus degrees and sunshine.

As a function of the temperature the heated water is introduced into the sole plate via insulated piping, namely into the core zone in case of high temperatures or into the centre and boundary zones in case of lower temperatures. From the sole plate insulated on its surface the heat migrates into the ground for storage there. A corresponding insulation will be installed in the ground along the building ground plan, in order to reduce lateral heat losses, i.e. thermal energy escaping into the earth atmosphere. In case of need, the thermal energy stored in the ground will be used to heat the water contained in piping installed in the sole plate, and the water will be introduced into the outer shell of the temperature barrier where it will cool down and will be returned into the sole plate. A plurality of measurements performed in existing buildings has shown that the temperature of the water contained in the sole plate piping is 18°C to 20°C before being pumped into the outer shell; herein, the temperature of the ground underneath the sole plate needs to be approx. 20°C to 22°C.

Higher temperatures will not be attained in the ground storage even though particularly high absorber efficiencies may have been achieved before: The volume of ground storage will increase instead of a temperature rise.

The experience of many decades has shown that in case of an intensive utilization of roof areas as absorber areas substantially more thermal energy will be available than is actually required.

In most cases, a so-called core storage “insulated“ on all sides is provided within the core zone of a building which is interspersed by hose pipe assemblies in contrast to the remaining ground storage. This permits water temperatures of up to 35°C to be attained which are used for the preheating of service water.
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The hose pipe assemblies of temperature barrier which are used for heating of the building shell in winter, will be used for cooling in summer. Until just recently, hose pipe assemblies were installed in the ground outside of the building ground plan and hence outside of the ground storage so that low water temperatures were attained accordingly. Here, a simplification could be achieved now: the hose pipe assemblies from the boundary zones of the ground storage are used for cooling in summer, since the temperatures attained there will not be higher than 20°C to 22°C as mentioned above. Apart from the saving effects by considerably shorter lengths of the hose pipe assemblies this offers the advantage that in summer in case of cooling when the water temperature within the temperature barrier is increased, this higher temperature may be emitted further and stored.

In regard to temperature control the air-conditioning, i.e. heating and cooling of a building via the temperature barrier in the outside building components constitutes a comparatively sluggish system. It is for this reason that a quick-acting component is added in the form of a specific and also patented ventilation – the pipe-in-pipe counter-current system. The exhaust air is dissipated via an outer pipe of larger diameter and fresh air is supplied via an inner pipe of smaller diameter. The piping system is installed underneath the sole plate in the ground storage. Heat recovery efficiencies of up to 98 % are achieved by the two interposed pipes which are fabricated by winding of thin special steel plates in place.

Extremely low energy consumption figures between 5 and 12 kWh/m²/a are achieved by means of the system described. For comparison, the following values should be noted:

- Passive houses 15 - 25 kWh/m²/a
- Low-energy houses 40 - 60 kWh/m²/a
- Buildings in accordance with the 1995 German ordinance regulating thermal protection 90 to 100 kWh/m²/a
- Existing buildings in Germany 200 kWh/m²/a on average
- Glazed office buildings 500 kWh/m²/a and more

Herein, the extremely low energy consumption figures for buildings with Terra-Sol technology are not paid for by higher building costs; the contrary is actually the case. As compared with normal passive houses the following advantages result:

- comparatively low prime costs
- extremely slender outside walls since minor insulation thicknesses only; hence, a gain in additional living and/or office space

- no highly insulated expensive windows required
- no need for excessively tight outside building components
- “Instructions for use” for the residents in regard to ventilation behaviour, actuation of sunshades and the like are not necessary.

So far, we have discussed the temperature barrier in solid outside walls wherein the temperature carrier used for air-conditioning of the outer shell has been represented by the medium water. In conclusion, we would now like to describe a novel development for provision of a temperature barrier in glazed areas.

In the recent years, office buildings have been constructed to a growing extent with a comparatively small portion of solid outside walls, but more and more glazed area; with some office buildings the outside wall surfaces are completely made of glass wherein the energy demand is mainly attributable to the enormous cooling loads in summer. A temperature barrier with air as the temperature carrier medium has been developed for translucent surfaces. The warmed up air is introduced at the floor level of a storey, supplied to the storey ceiling in a “chamber” and again dissipated from there. The “chamber” is constituted by two panes spaced 6 cm to 8 cm apart and/or by a pane on the outside and a blind or shutter and/or a corresponding curtain on the inside. The blind or shutter and/or curtain, of course, is not airproof which fact, however, is not of decisive importance in regard to the efficiency of the chamber as evidenced by the experience made with a multi-storey glazed atrium of an office building in China.

Same as the carrier medium water, the air of the temperature barrier will stream through the ground storage to pick up the temperature of 18°C to 20°C there. As a function of the outdoor temperature, the air contained in the chamber of the temperature barrier will be cooled in winter and heated in summer again taking the temperature prevailing in the ground storage. This circuit permits heat accumulated via the glazed wall surfaces to be dissipated into the ground and stored there in addition to the heat accruing from the roof absorber surfaces. With this revolutionary and yet extremely economical development from Luxembourg it will be possible in future to plan and to construct also large glass facades paying due attention to the aspects of energy saving and ecology or environmental acceptability.