Seasonal store of solar heat for passive and super passive houses in a mild climate.

After 3 years of construction of more than 25 individual passive houses in Ireland, Scandinavian Homes Ltd. in Galway is currently researching the possibility of generating 100% of the space heat and domestic hot water required for a single family house by passive means. It is the ultra low space heat demand of our passive and super-passive houses in the mild Irish climate that triggered the idea to strive for a completely zero-heat house.

Passive Hibernia in Co. Wicklow with a floor-area of 300m2 and a 23m3 under-ground seasonal storage tank connected to 16m2 flat-plate solar collectors in use since 2006.

First we have to realize that to heat space and water we have 3 practical alternatives:

a) Use electricity; resistive load, or preferably a heat-pump.
b) Burn something, preferably a non-fossil plant-based fuel.
c) Solar, but then we need a seasonal store for the winter months.

Wind power is a fantastic source of energy, especially on a larger scale. The efficiency of wind generation improves dramatically with the size of the windmill. Noise, lifespan and safety distance to buildings must be considered. These considerations make wind a less realistic option for the vast majority of homeowners.

Photovoltaic generation of electricity could be an alternative in a future when (if) the price of the cells comes down dramatically. But the power must then be either sold to the grid at a reasonable price, or be stored from day to night and over season. That is very costly and environmentally dubious considering the enormous amounts of lead/acid batteries required.

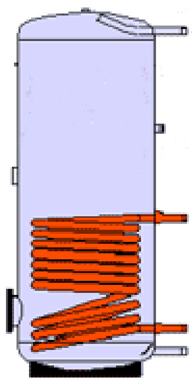
We chose the sun option:

The space heat requirement for a passive house is 15 kWh/m2/yr, and for our super passive house it is 7.5 kWh/m2/yr. Example: A passive 150 m2 house will have a yearly space heat demand of 2250 kWh/yr; the super-passive version will need 1125 kWh/yr. Add the domestic hot water which we calculate to be 2190 kWh/yr for a typical family of four. This gives a total energy requirement of 4440 kWh/year for the passive version; the super passive version needs a total of 3315 kWh/yr.

Sun-King Vacuum-U-tube collectors on roof

Solar-collectors required:

Assume storage and system heat losses of 50% gives a required energy of 4440 x 2 = 8880 kWh/yr required for a passive house, and 3315 x 2 = 6630 kWh/yr for the S-passive house. Sun-King vacuum tube collectors of 1.8m2 aperture area per module produce 586 kWh/m2 according to test by the Swedish state test institution Statens Provningsanstalt. (Tests were done with Stockholm weather data at 59N latitude). Galway is located at 53N latitude. This means that we require 8880 / 586 = 15.2 m2 collector area for the passive house and 6630 / 586 = 11.3 m2 collector area for the Super Passive house. (Note: The Sun-King vacuum-tube collectors used are of the U-tube type that does not lose output over time)



Tank 1, located in utility-room

Tanks required:

Tank 1; In the utility room a standard 300 liter tank with one coil is connected to solar panels on roof.

Tank 2; A large 23m3 underground concrete tank (Carlow Pre-cast tanks) is externally insulated with 2 x 200mm of expanded polystyrene and 2 x 100mm Soya-based PU spray insulation (Abbey Insulation) of the walls. The top and bottom is insulated with 2 x 300 mm expanded polystyrene. Total average U-value of 0.059 W/m2C

Tank 2 on 600mm insulation

Tank 2 with a total of 600mm insulation

Tank 2 with a wrap of HD polyethylene

Thermo-dynamics inside of large tank.

22mm finned copper pipe used for coils in tank 2.

The large tank is equipped with a baffle made of concrete blocks in the center of the tank. This baffle sits on a lintel 200mm from the bottom and reaches a height of 1500mm from the bottom. The solar heat-circuit is located at the bottom on one side of the baffle and the two pick-up coils are located near the top at the other side of the baffle.
This arrangement is expected to create a gentle flow of water raising over the solar circuit and sinking under the two pick-up coils on the other side of the baffle. When little or no solar heat or usage of tap-water, or floor-heating takes place, a thermal stratification is expected to take place inside the tank with warmer water near the surface. But when any circuit is in usage, the water flowing past the coils increases the thermal exchange.

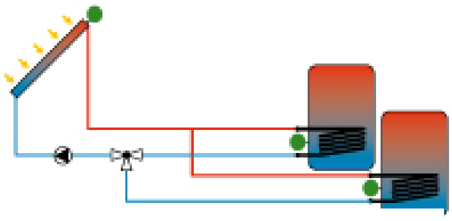
Coils in large tank:

Finned Cupori copper tubes laid in a circular pattern. This type of fin increase the surface area of the pipe by a factor of 3.6, compared to the same dimension pipe with a smooth surface.

- The solar coil is shaped in a circular pattern at 50mm height in the far end of tank 2.
- The coil that pre-heats the domestic hot water is shaped in a circular pattern; it is 7m long and located near top of tank.
- The floor-heating circuit is located near the top of tank 2, under the DHW circuit, at the opposite side of the solar circuit.

Function of system:

Priority for small tank for DHW. The collectors on the roof heat the water in tank 1, the internal 300 liter tank. A standard coil is used in this tank. When 65°C is reached in this tank, the water-flow is redirected with a 3-way valve, to heat the underground tank, tank 2.



Simplified schematic of the solar circuit

Schematic shows principle of priority heating of tank 1 that is located inside the house. The large amount of collectors on the roof will heat tank 1 very quickly. When reaching 65°, the flow is simply redirected and the large underground tank 2 is charged. It is however the difference in temperature between the top of the collectors and the temperature at the bottom of tank 2 that determines if the pump is running or not.

Insulated culvert. The large underground tank, -tank 2, is connected to the house via an insulated culvert made from 160mm flexible land drainage pipe. This culvert contains a total of five pre-insulated 20mm flexible stainless steel pipes. PU insulation foam will be injected into the duct to improve the insulation further.

- One pair for the solar heat circuit of the coils at bottom of large tank.
- One pair for floor-heat circuit to coil at top of large tank.
- One single pipe to for pre-heating of incoming water in coil near top of large tank.

Domestic hot water. DHW is fed into the small tank from a coil in the large tank via one of the pipes in the culvert through the ground into the house and into the utility room. Tank 1 is also equipped with a back-up electric heater to make it possible to heat up the water to over 65 degrees to eliminate the risk of bacteria growth.

The critical time of year is considered to be December and particularly January when the sun is low over the horizon and the heat generated by the summer sun and stored in the large tank is being depleted. In February, the contributions from the sun are considered enough for the daily usage, and later in the spring we expect the large thermal storage tank to start to increase its temperature again.

Space-heating of super passive house. The house is equipped with a minimal amount of PEX floor-heat pipes. One 60m length in the utility room, one 60m length under the floor of the upstairs shower-room and one 60m length divided between the bathroom and en-suite at ground floor. A total of 180m. To complement this there is a circular VEAB duct heater installed on the supply air to the rooms.
A low energy Grundfos circulation pump and mixing valve connect directly to a manifold to distribute the heat to the four circuits.

Duct heater for supply air

Pump and manifold for floor-heat and duct heater

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