Monitoring of Seasonal Thermal Energy Store installation at Scandinavian Homes Ltd by University of Ulster

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Overview

Scandinavian Homes Ltd. a manufacturer of Passive Homes for the Irish and international market has recently installed an underground Seasonal Thermal Energy Store at its base in Moycullen, Galway.

Lars Pettersson, the MD of Scandinavian Homes has initiated the demonstration project. He hopes to showcase the potential of the underground seasonal thermal energy store for space heating and domestic hot water for the Scandinavian Homes Passive Show House.

Shane Colclough of The University of Ulster is researching the area of Thermal Energy Storage and as part of a Doctoral Thesis. He is applying the use of Thermal energy storage to the Passive House standard in Ireland. He has engaged with Scandinavian Homes with the aim of objectively monitoring and reporting on the performance of the Seasonal Store installation over a heating season. Following this period he will make recommendations for future iterations of the Seasonal Store as part of his doctoral submission.

Full details on the Seasonal Storage at Scandinavian Homes can be found at http://www.scanhome.ie/research/solarseasonal.php

Objective

The objective of the monitoring is to twofold;

1. Examine thermal stratification and losses from the tank and pipework and
2. Determine the solar fraction of the installation

In order to do this UU will gather data on:

1. the water temperatures achieved in the tank.
2. the thermal stratification within the tank (on both sides of the baffle)
3. the losses through the tanks insulation
4. the quantity of heat input to the tank from the solar panels
5. the quantity of heat drawn from the tank to provide space & DHW heating.

6. The quantity of electrical energy used for DHW and space heating
7. The environmental conditions to which the system is subject to i.e. external and internal temperatures, solar radiation etc.

From item 4 and 5 above the quantity of seasonal heat lost through the insulation surrounding the tank can be calculated.

From 5 and 6, the solar fraction can be calculated.

Monitoring

Figure 1 depicts the set up of the monitoring equipment for the installation.

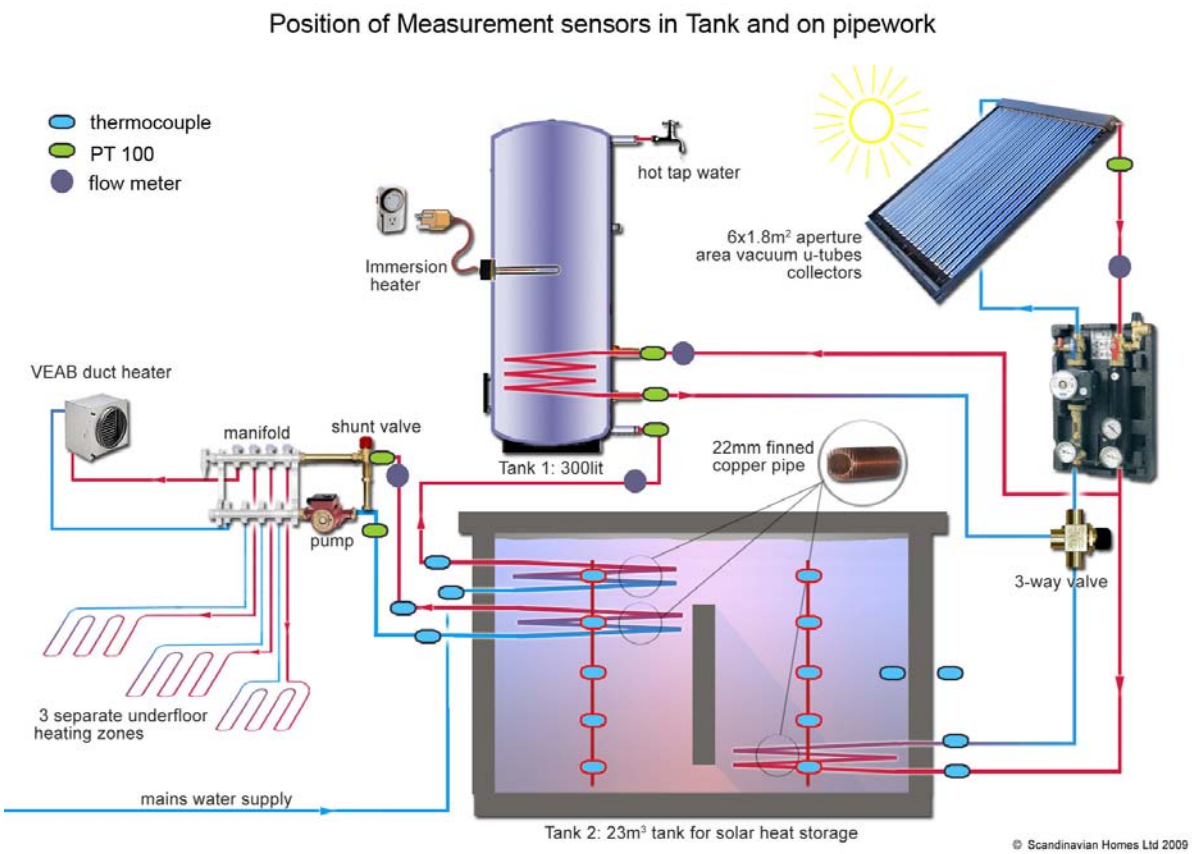

Figure 1 Temperature Monitoring

Monitoring Equipment

Equipment locations

A DT 85 data logger with Extension Module is located in an insulated wooden box in the greenhouse at the seasonal storage tank (approximately 25m from the house). Ventilation is provided from the box to the air outside the greenhouse to avoid the build up of heat which may affect the DT85.

Thermocouples exclusively are used to measure tank and ancillary temperatures and are wired to the DT85 directly (i.e. without being connected to a termination point).

A 50 pair cable runs from the DT85 to the utility room and is terminated on a block. From here the four wire PT100's, two wire energy meters and two wire electrical energy meters are connected to the DT85.

Seven PT 100's are used at the Passive House and measure Temperature at:

1. Flow & return of underfloor heating

2. Flow & return of DHW tank

3. Temperature at solar collector

4. Internal house temperature

5. Potable Water feed at the base of the DHW tank

Forty two thermocouples are located at the following locations at or near the tank:

1. Five on RHS (i.e. thermal feed side) of tank at the following heights from tank base:

    a. 0.15m (called bottom sensor),

    b. 0.51m, (quarter height sensor)

    c. 1.07m, (mid point sensor)

    d. 1.53m, (3/4 height sensor) and

    e. 2.0m (ie top sensor).

    These are duplicated for redundancy purposes. {10 TC's}

2. Five on LHS (i.e. thermal draw side)of tank at the same heights as above i.e.

    a. 0.15m (called bottom sensor),

    b. 0.51m, (quarter height sensor)

c. 1.07m, (mid point sensor)

d. 1.53m, (3/4 height sensor) and

e. 2.0m (ie top sensor).

These are duplicated for redundancy purposes. {10 TC's}

3. Flow and return of solar feed plus duplicates {4 TC's}
4. Flow and return of DHW preheat circuit leaving tank plus duplicates {4 TC's}
5. Flow and return of Underfloor heating circuit leaving tank plus duplicates {4 TC's}
6. Wall temp inside tank, wall temp outside tank and soil temp 1m from tank plus duplicates {6 TC's}
7. External air temperature {2 TC's}
8. Glasshouse air temperature {2 TC's}

An Internet hub is located in the Utility room of the Passive House. The DT 85 is connected via an RJ45 connection to an RJ45 socket of the hub, allowing the downloading of information on a periodic basis.

Temperature Measurements

Outdoor Temperature measurement

Temperature measurements of the collector flow and return at the seasonal storage tank are made using Thermocouples.

In addition, the external ambient temperature, and incident solar radiation is measured using a Delta-T model GSI-214 pyranometer, with the sensor being located to avoid solar gains affecting the measurement (i.e. the sensor is shaded).

The Thermal stratification of the tank is measured using two arrays of 5 T-type thermocouples, with an accuracy of +/- 0.1°C, mounted on a plastic pipe and evenly distributed along the vertical axes of the storage tank, as shown in Fig 1.

Flow and return temperatures are measured using T type thermocouples mounted on the pipes at the tank. These sensors are buried and require insulation surrounding them.

Soil temperature is measured using 2 T Type thermo couples located at a depth of 1m, one at the interface of the tank insulation and the soil and the other at a distance of 1 meter from the tank.

The Temperature at the inside tank wall is measured using a T Type Thermocouple, located opposite the external Thermocouple.

External air and greenhouse air temperatures are measured using shielded Thermocouples.

Temperature measurement at the Passive House

Temperature measurements of the heating system flow and return are made using platinum resistance temperature sensors (PT100's). Further, a PT100 is used to measure the temperature of the potable water input to the tank .

Internal temperatures at the flow & Return of the underfloor heating, the Flow and return of the DHW tank (at the DHW tank) and the ambient temperature of the living room is recorded. The PT100' s is connected via 4 wires per PT100 to the DT85 datalogger.

Heat Measurement

The quantity of heat delivered to the Seasonal Store by the solar panels, and that drawn off seasonal store by the heating and Domestic Hot Water (DHW) is measured.

To achieve this an Energy meter is located on the flow of each of three secondary circuits i.e.

1. Collector circuit

2. Underfloor heating circuit
3. Potable water preheat
4. DHW tank supply from solar panels

Two Whr meters will measure the electricity used for

1. DHW
2. Space Heating

Circuit	Temp {^{0}C }	heat per pulse {Whr}
Solar Panels	20 – 100	100
Underfloor Heating	30 – 60	10
Preheat to Domestic Hot Water	8 – 80	10

Data Logger

Data is recorded using a DT85 multi channel logger with data sampled every 5 minutes and the average value of these parameters recorded every hour using the multi channel logger.

The DT85 uses channels 1 and 2 as reference channels to ensure accurate temperature measurements are attained.

Communications links

Cabling is provided from the monitoring devices in the passive house to the DT85 which is located in the glasshouse at the seasonal storage tank (a run of 25m) via a 50 pair Shielded cable.

The Thermocouples are wired directly to the DT85.

The multichannel data logger is connected to the communications hub in the passive house utility room via an RJ45 cable and thus connected to the internet to facilitate uploading of information to

1. an offsite persistence layer
2. the Scandinavian Homes website

Parts list

Part	Purpose
DT85	Data Logging
CEM20	Extension Module
42 x Thermocouple	Temp measurement
2 x Pole	Hosting thermocouples
7 x PT 100	Temp Measurement
Electricity Meter	Power to DHW & Space
4 x Energy Meter	Heat in & out of tank
Housing for DT85	Protect electronic equipment
Power socket	Power DT 85
35m RJ45 Cable	connect DT85 to Router
35m 50 pair cable	connect PT100's & Energy meters to DT85

DT85 Channel Allocation

Physical Channel	**Use**
Analogue Channel	
Ch 1	Ref
Ch2	Ref
Ch3 - 10	***Tank Stratification and air Temperature measurement***
Ch3	bottom, quarter and mid height in RHS (i.e. Solar Supply Side)
Ch4	bottom, quarter and mid height in RHS (i.e. Solar Supply Side) (Duplicate)
Ch5	¾ and top sensor in RHS (i.e. Solar Supply Side), Ext air temp
Ch 6	¾ and top sensor in RHS (i.e. Solar Supply Side), Ext air temp Dup
Ch7	bottom, quarter and mid height in LHS (i.e. Heating Load Side)
Ch8	bottom, quarter and mid height in LHS (i.e. Heating Load Side) (Duplicate)
Ch9	¾ and top sensor in LHS (i.e. Heating Load Side), Glasshouse air temp
Ch 10	¾ and top sensor in LHS (i.e. Heating Load Side), Glasshouse air temp Duplicate
Ch 11 & 12	**Tank wall and soil temperatures**
Ch 11	1m depth inside wall Temp at tank, outside wall temp and soil temp1m from tank
Ch 12	1m depth inside wall Temp at tank, outside wall temp and soil temp1m from tank (Duplicate)
Ch 13 – 16	**Heating, DHW & Collector temps at Tank**
Ch 13	Heating Flow and Return, Solar Collector Flow at Tank,
Ch 14	Heating Flow and Return, Solar Collector Flow at Tank, Duplicate
Ch 15	DHW Flow and return, Solar Collector Return at Tank

Ch 16	DHW Flow and return, Solar Collector Return at Tank Duplicate

Ch 17 – 23	***Heating and DHW at House (4 wire PT100)***
Ch17	Heating Flow at house
Ch18	Heating Return at House
Ch19	DHW Flow At house
Ch 20	DHW Return at house
Ch 21	DHW preheated feed at tank
Ch 22	Internal air temp at house
Ch 23	Solar Collector flow at solar collector

Digital Channels

Ch1 to 4	Flow meters;
Ch 1	DHW preheat,
Ch2	Underfloor Heating,
Ch3	Solar Feed to DHW and
Ch4	Solar feed to Seasonal Store

Ch 5 to 6	Electrical Energy
Ch 5	Electricity to DHW
Ch 6	Electricity to Space Heating