A framework for Energy Performance Assessment of a large BREEAM certified GEOTABS implemented in Kortrijk

Julio Vaillant Rebollar
Tom Prinzie
Caroline Van Marcke
Arnold Janssens

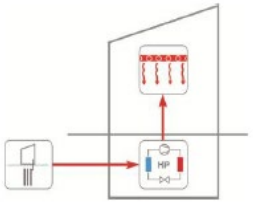
GHENT UNIVERSITY
AALBORG UNIVERSITY DENMARK
reINVEST
sEEnergies
Fonden Energi- & Miljødata www.emdfonden.dk
4DH
UN environment
DISTRICT ENERGY IN CITIES INITIATIVE
Innovation Fund Denmark
Van Marcke

5th International Conference on Smart Energy Systems Copenhagen, 10-11 September 2019

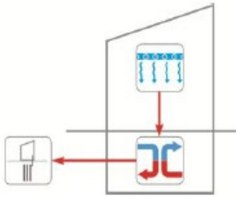
Subjects

- ➢ Context
- ➢ EDC Study Case Characterization
- ➢ Framework for further Investigation
- ➢ Closure Remark

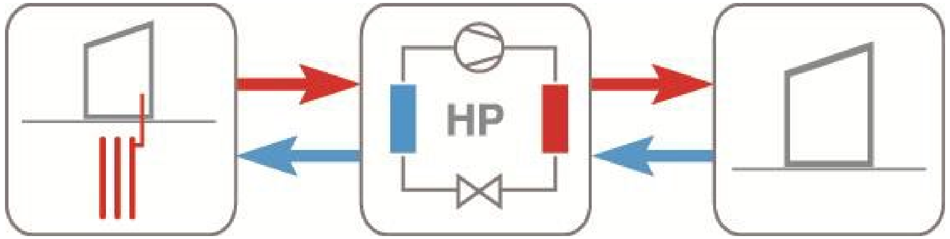
Geothermal



Heating with a Heat Pump



Passive Cooling

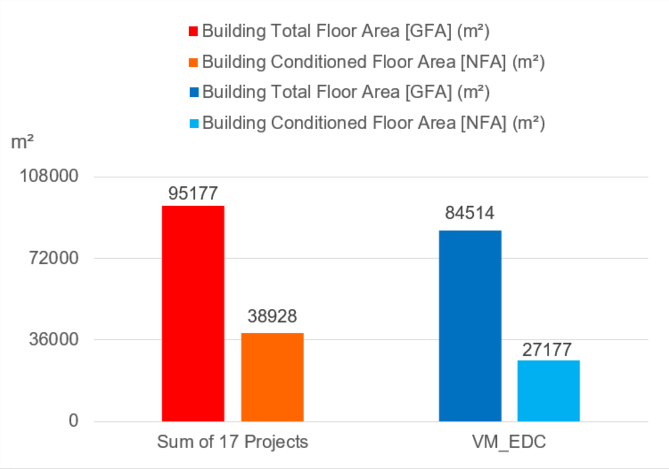


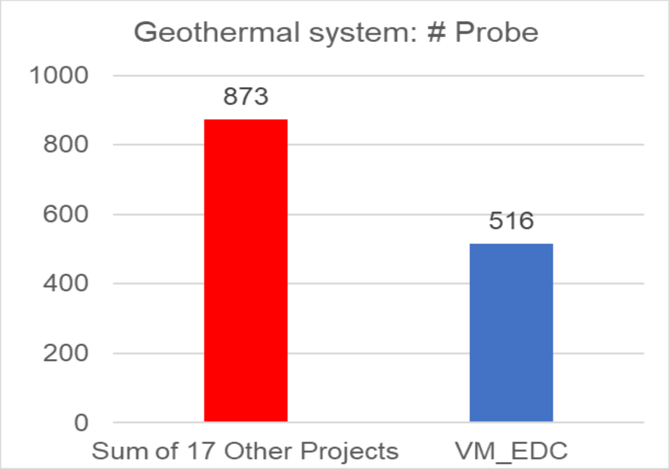
Thermally Activated Building System (TABS)
Radiant heating and cooling systems with pipes embedded in the building structure (slabs, walls)

Context

VM_EDC

GEOTABS: Overview of some Existing Projects





17 Existing Projects

Source: www.hybridgeotabs.eu; www.geotabs.synavision.de

EDC Study Case Characterization

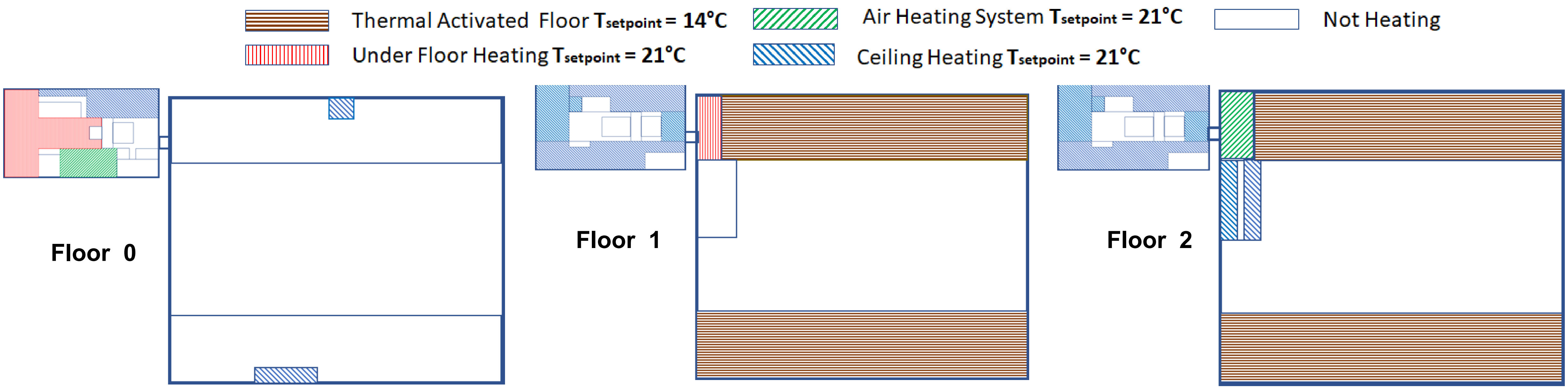
- ➢ European Distribution Center (EDC)
- ➢ Building area 90.000 m²
- ➢ *State of the Art* on Warehouse and Logistics: 80% of the orders are automatically processes
- ➢ Green Eelectricity: 13.000 PV Panels
- ➢ **Very Good** BREAM Certification

- Energy
- Transport
- Pollution
- Materials & Resources
- Water Efficiency
- Land Use & Ecology
- Health & Well Being

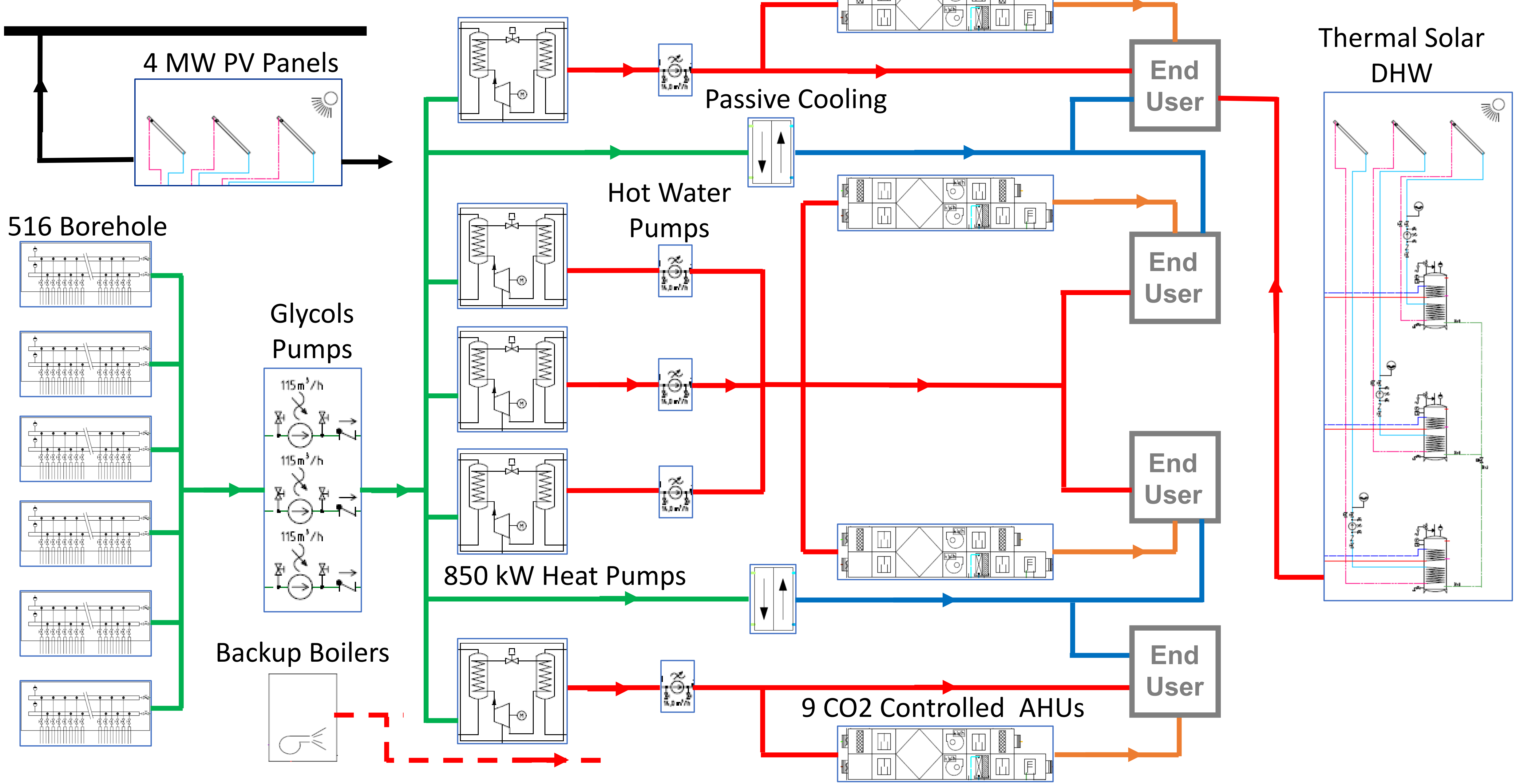
Building Research Establishment Environmental Assessment Method

EDC Study Case Characterization

Equipment	Specification Parameter	Quantity
Heat Pump	Heating: 170 kW/39 kW, COP= 4,4 (850 kW)	5
Heat Exchanger	Passive Cooling 41 kW	2
	Passive Cooling 380 kW (454 kW)	1
Gas Boiler	107 kW (SH)	6
Air Handler Unit	1260 m³/h … 18120 m³/h	9
Glycol/Water Circulating Pump	115 m³/h	3
Hot Water Circulating Pump	22 m³/h; 52 m³/h	6
Cooling Water Circulating Pump	11 m³/h; 25 m³/h	6

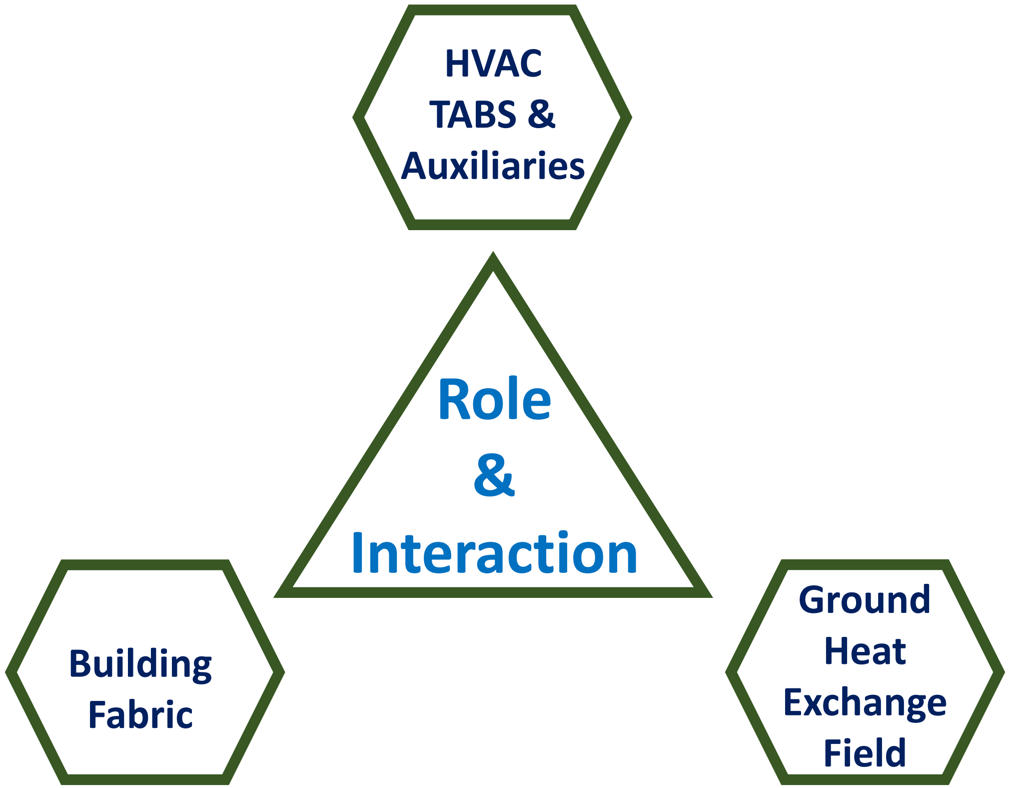


EDC Study Case Characterization



Framework for further Investigation

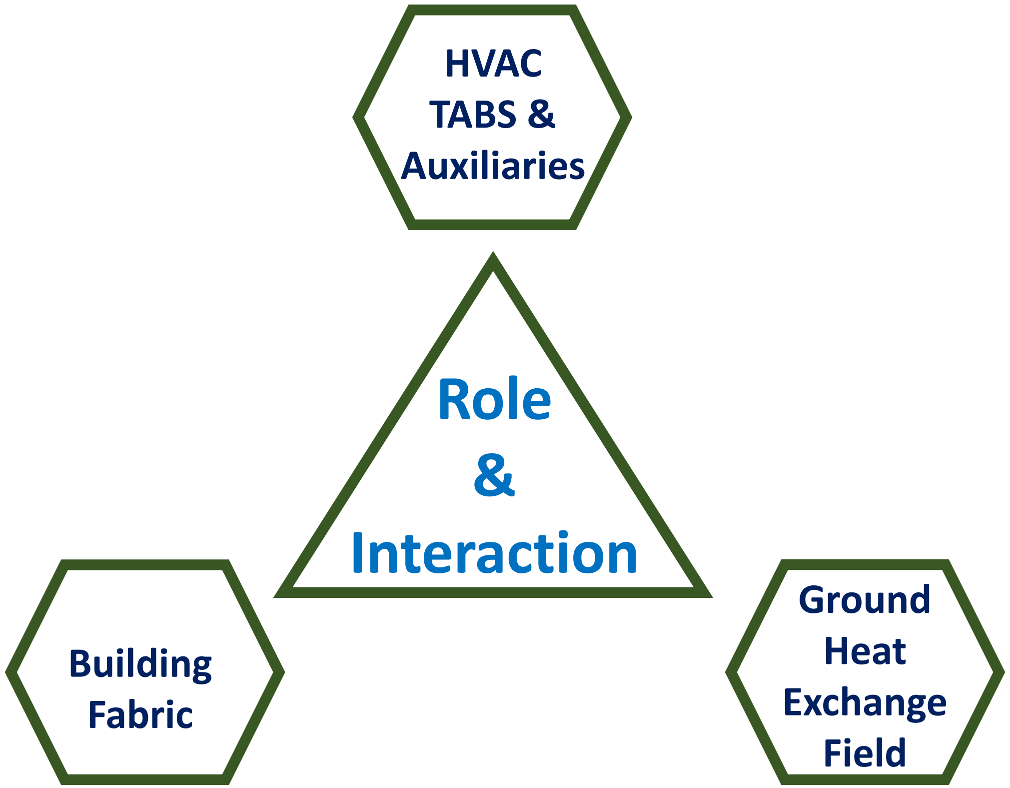
The formalization of a framework for the energy performance assessment

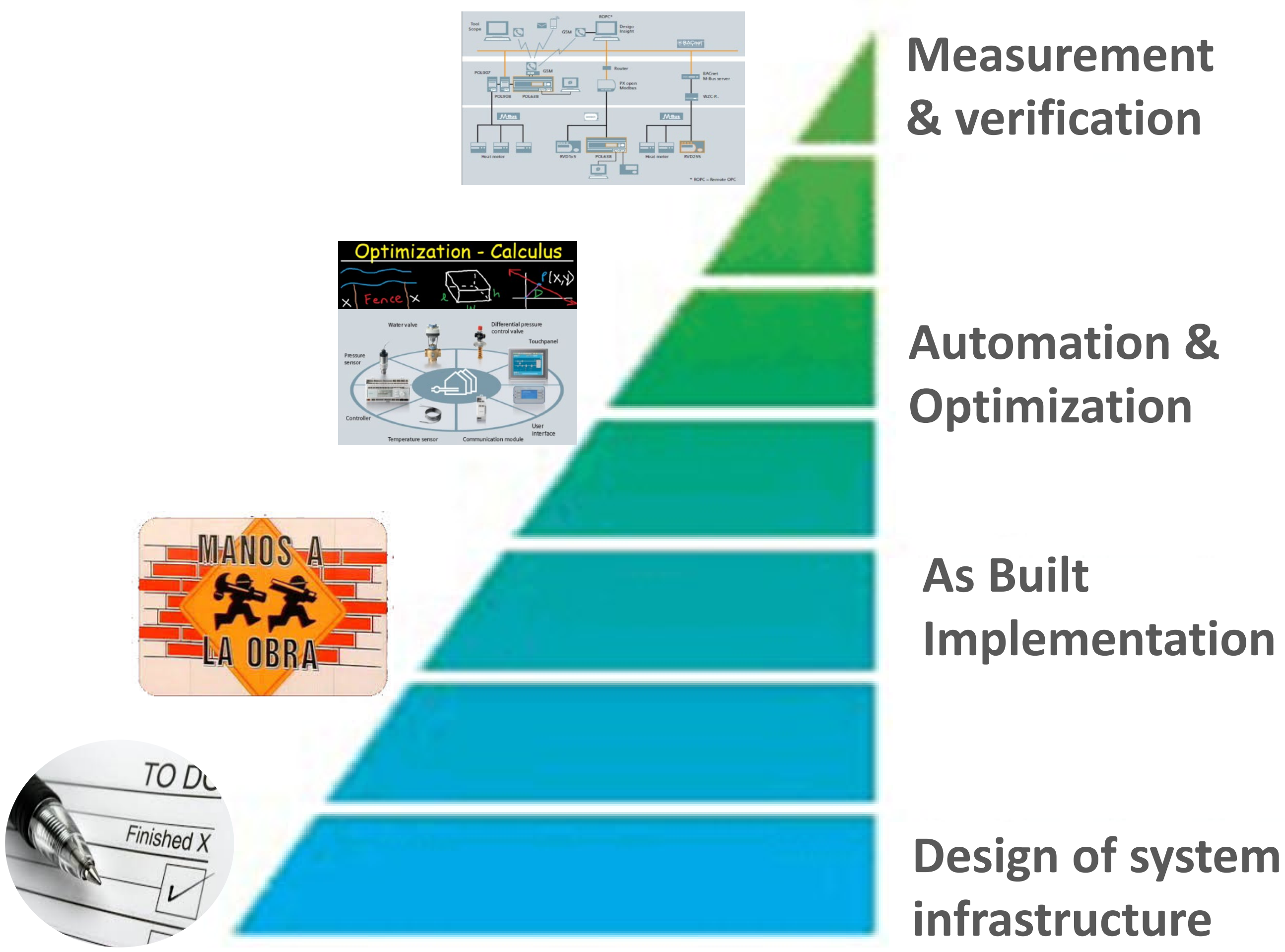


- ✓ Identify and define the share of the heating and cooling loads (base load and peak load)
- ✓ Performance characterization of main HVAC system components (Heat pump, Ground heat exchangers, TABS, Air Handle Units)
- ✓ Assessing the ground energy storage field performance to guarantee the long term thermal balance of the ground.

Framework for further Investigation

The formalization of a framework for the energy performance assessment





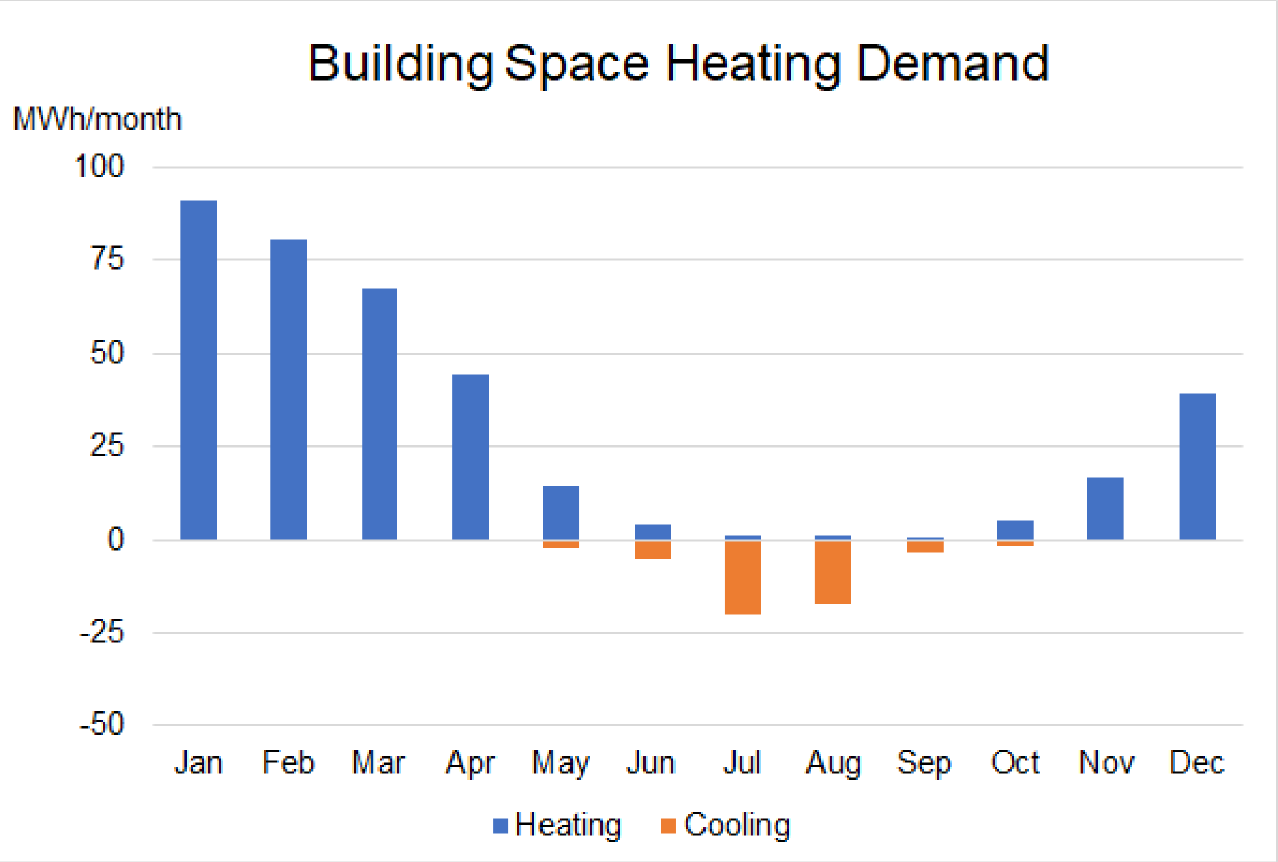
Operational Optimization as a Process

Framework for further Investigation

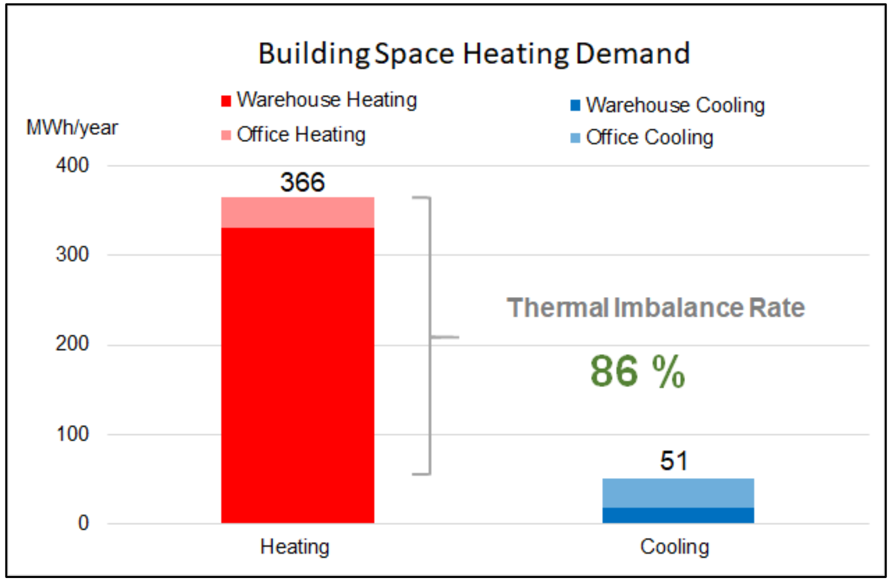
Design of system and infrastructure

Surface	Description	U-value [W/m².K]
Distribution center		
Floor on ground	30 cm heavy concrete	Rt = 0.14 m².K/W
Facade	8 cm heavy concrete, 10 cm PIR, 6 cm heavy concrete	0.22
Roof	18 cm heavy concrete, 10 cm PIR, 0.1 cm asphalt	0.21
Internal wall	14 cm heavy concrete	Rt = 0.06 m².K/W
Internal floor	32 cm hollow core concrete slabs, 14 cm light concrete	Rt = 0.23 m².K/W
Door	U_{value} = 2.0 W/m².K	
Office		
Floor on ground	1 cm tiles, 7 cm concrete, 10 cm PUR in situ, 15 cm heavy con-crete	Rt = 4.46 m².K/W
Facade	8 cm heavy concrete, 10 cm PIR, 6 cm heavy concrete	0.24
Roof	18 cm heavy concrete, 16 cm PIR, 0.1 cm asphalt	0.14
Internal wall	1 cm gypsum, 10 cm mineral wool, 1 cm gypsum	Rt = 2.87 m².K/W

(Source: Building Design Master Plan)



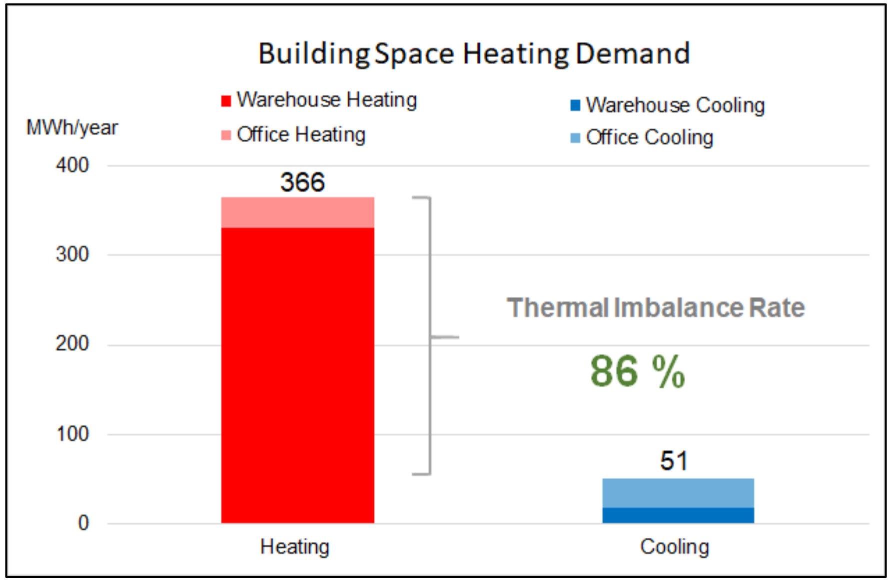
Framework for further Investigation



Problems caused by Ground thermal imbalance

- ❑ Decrease of the outlet temperature of ground heat exchanger (GHE)
- ❑ Deterioration in the heating performance of the ground-coupled heat pumps
- ❑ Heating reliability will decline indoor air temperature falling below design range

Framework for further Investigation

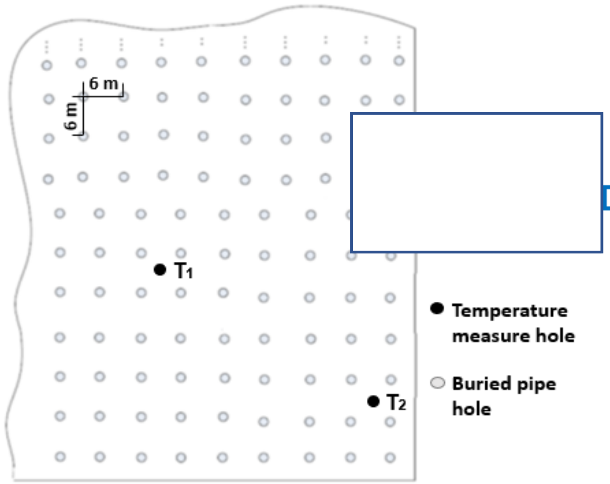


Problems caused by Ground thermal imbalance

- ❑ Decrease of the outlet temperature of ground heat exchanger (GHE)
- ❑ Deterioration in the heating performance of the ground-coupled heat pumps
- ❑ Heating reliability will decline indoor air temperature falling below design range

Geothermal Response Test Results

Parameter	Value
Ground heat conductivity coefficient	1.82 W/m K
Heat capacity of the Ground	2.5 MJ/m³/K
Undisturbed Ground temperature	12 °C
Geothermal heat flow	0.07 W/m²



Earth Energy Designer

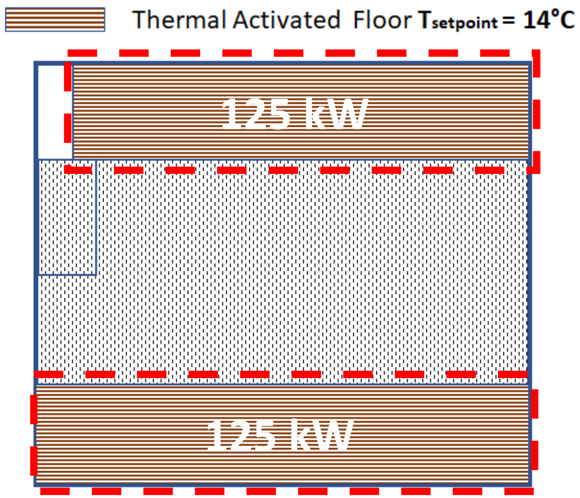
GHE solutions for Ground thermal imbalance

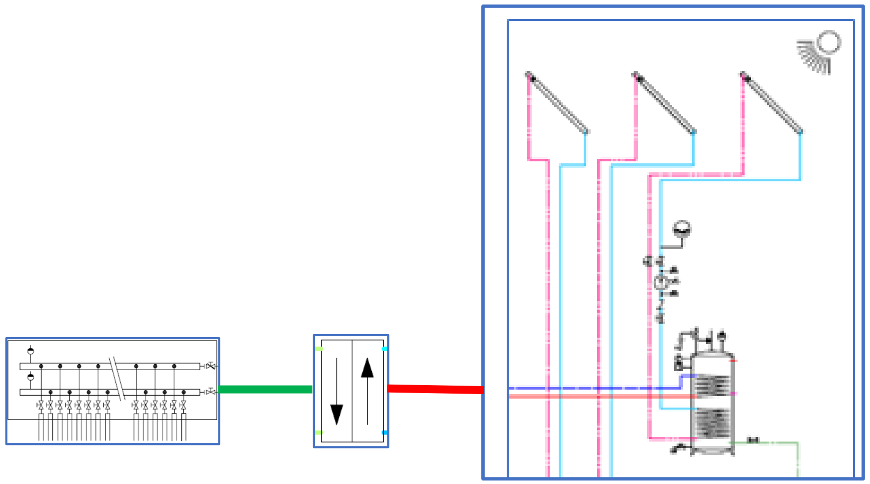
- Borehole space
- Borehole length
- Borehole layout
- *Improving thermal properties*

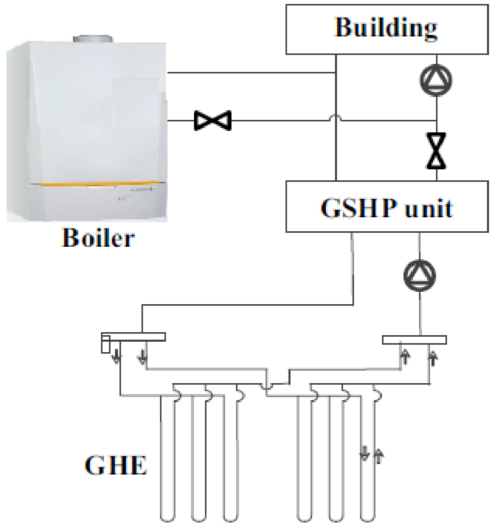
Framework for further Investigation

HVAC System-modified solutions for thermal imbalance of GCHPs

- The solar collector can release heat to the soil for recharging GHE
- Identify the best combination of TABS and secondary emission system
- Utilization of the of auxiliary condenser boiler (214 kW) to take on the peak heating load
- Increases the cooling demand by connecting TABS that were not foreseen to receive passive cooling
- Utilization of the industrial process waste heat as compensation by mean of heat injection into the soil.







Framework for further Investigation

Operation-modified solutions for thermal imbalance of GCHPs (REHVA Guidebook no. 20)

- **Intermittent operation strategy**
  - Seasonal operation strategy
  - Rule Based Control strategies
  - *Model Predictive Control strategies*

- **Control strategies for TABS :**
  - Time based or zone temperature control
  - Weather dependent supply/average water temperature control
  - Intermittent pump operation control
  - TABS surface temperature is the controlled variable,

Closure Remark

1. A framework for the energy performance assessment GEOTABS building defining the key element to approach the ***Operational Optimization of the System as a Process*** have been proposed

2. Potential ***Problems caused by the Ground thermal imbalance*** due to the significant difference of Cooling and heating demand have been highlighted

3. Ground Heat Exchanger - solutions to overcome the thermal imbalance like increasing borehole space/length/depth and the design of the borehole layout have to be closed follow up by mean of ***Measurement of ground temperature behaviour***.

4. Possible ***Solutions and priorities*** to carry out future in-depth studies have been presented

Closure Remark

Suggestions of further Investigation priorities

- **Integrating the gas boiler** to take on about 25% heating load can achieve better economy as well as lower energy consumption.

- **Integration of solar energy** to recharge the ground during summer or night time can avoid the thermal imbalance and improve the heating COP of the heat pumps

- **Integration with waste heat** from the industrial process can improve the thermal imbalance, but is restricted by the amount and generating occasion of waste heat.

- **Seasonal operating strategy** can make full use of the advantages of the auxiliary energy at different periods in hybrid GCHP systems to eliminate the thermal imbalance.

- **Intermittent operation** can also be an interesting option to evaluate, a suitable intermittent strategy is 12 h operation and 8–12 h downtime.

A framework for Energy Performance Assessment of a large BREEAM certified GEOTABS implemented in Kortrijk

Thank you

Julio Vaillant Rebollar
Tom Prinzie
Caroline Van Marcke
Arnold Janssens

GHENT UNIVERSITY

AALBORG UNIVERSITY DENMARK

reINVEST

sEEnergies

Fonden Energi- & Miljødata
www.emdfonden.dk

4DH

UN environment

DISTRICT ENERGY IN CITIES INITIATIVE

Innovation Fund Denmark

Van Marcke