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NOTTINGHAM TRENT UNIVERSITY

Utilising Soil for Heat Storage in Local Space Heating Applications

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4DH
4th Generation District Heating Technologies and Systems

Outline

- Motivation
- Underground Thermal Energy Storage
- Research Aim & Methodology
- Experimental Work & Results
- Future Applications

MOTIVATION

'MEETING THE FUTURE NEEDS OF ENERGY CONSUMPTION'

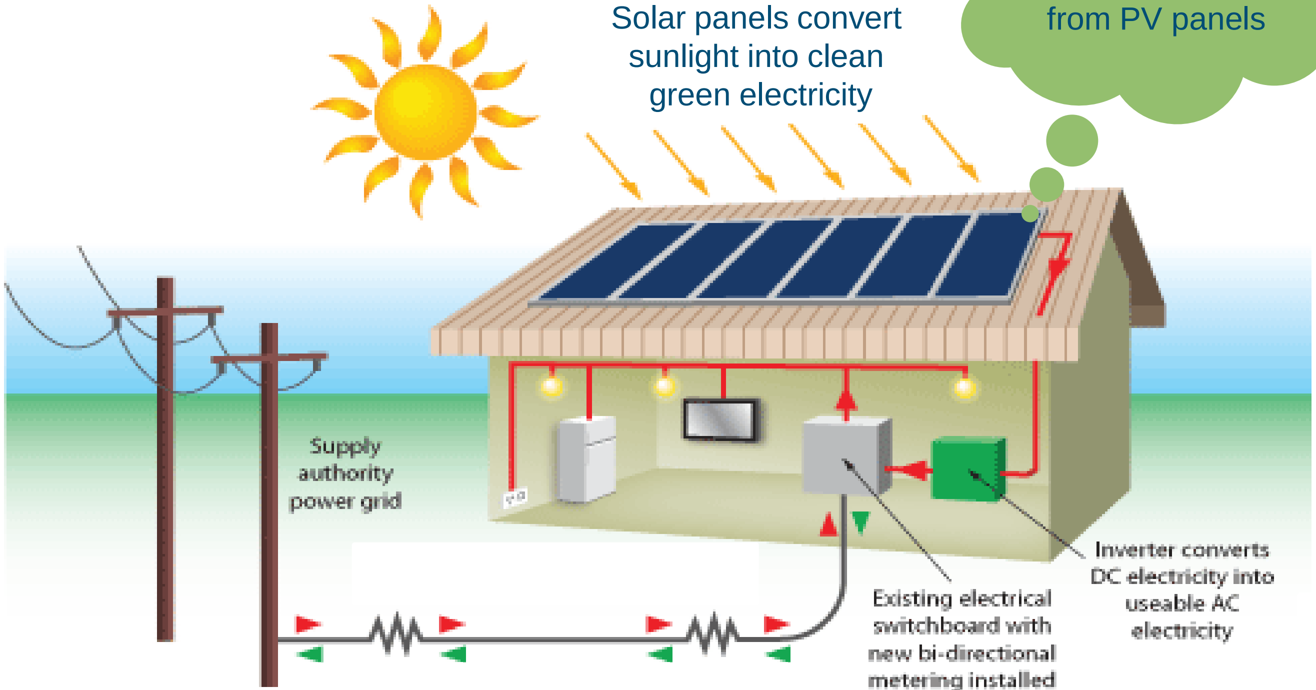
Available sustainable energy sources:

▪ Solar;	Electricity and Heat
▪ Wind;	Electricity
▪ Geothermal;	Heat (and Electricity)
▪ Biomass;	Electricity and heat
▪ Waste Heat;	Heat
▪ Others…	

The Solar Problem

Solar panels convert sunlight into clean green electricity

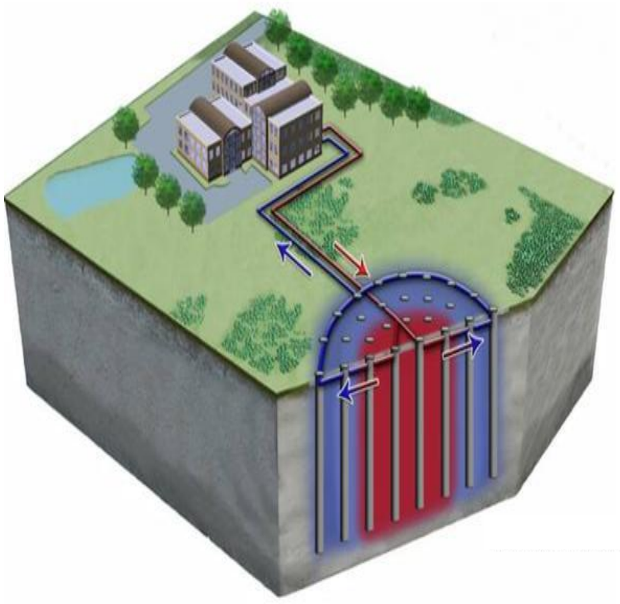
Only 20-30% of generated Solar Energy is used from PV panels



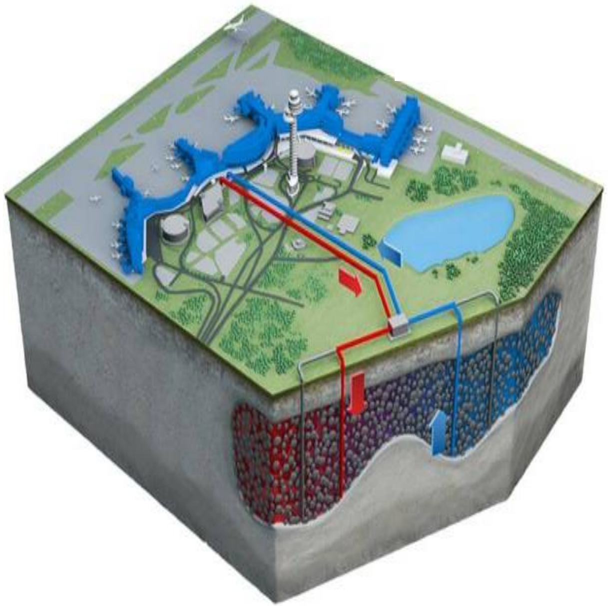
During the night/cloudy weather, electricity is imported from the grid

The Soil

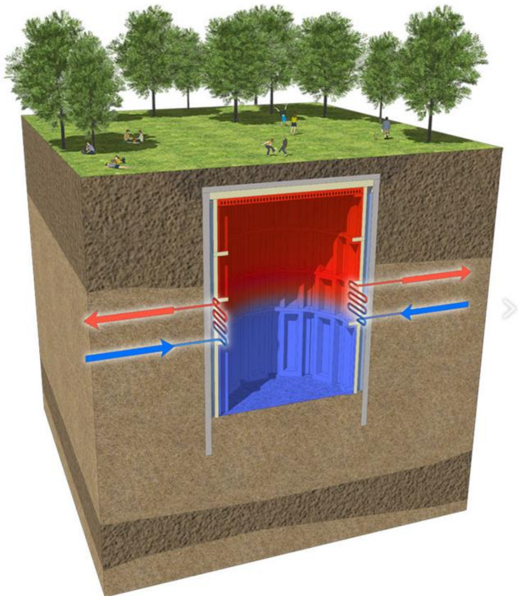
Current Heat Storage Systems



Borehole Storage



Aquifer Storage



Tank Storage

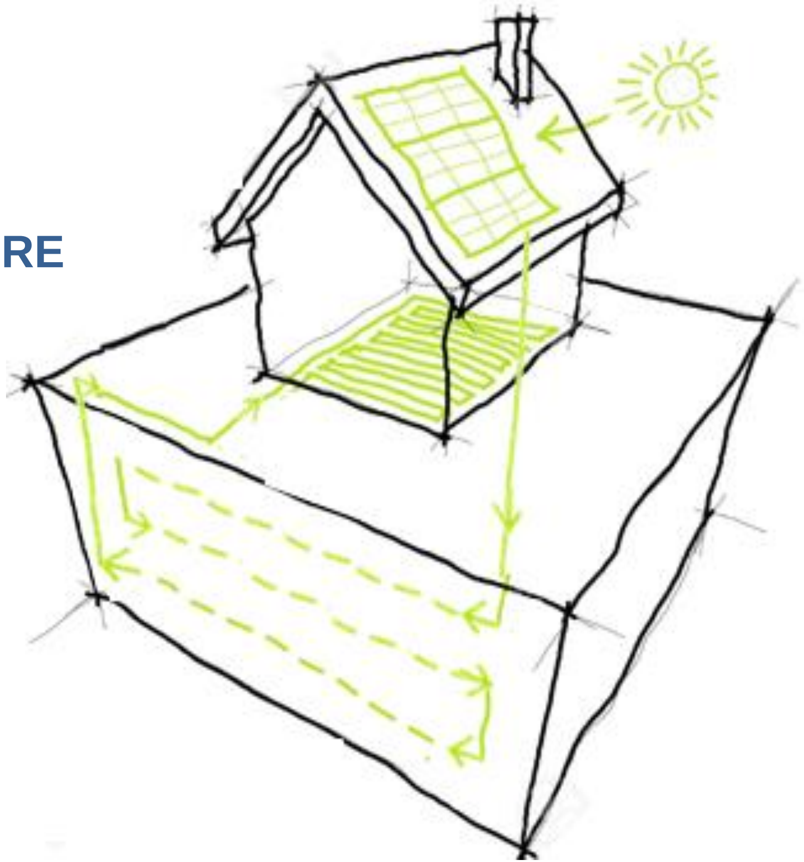
Aim

TO DESIGN A NOVEL INSULATED SOIL STORE

FOR LOW TEMPERATURE LOCAL HEATING

- To create a heat storage using soil
- Establish the efficiency of the storage

→ Optimise the efficiency of the storage



Research Methodology

01 Litrature Review

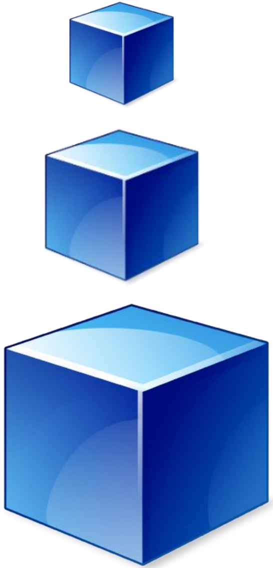
02 Laboratory testing

03 Numerical Simulation

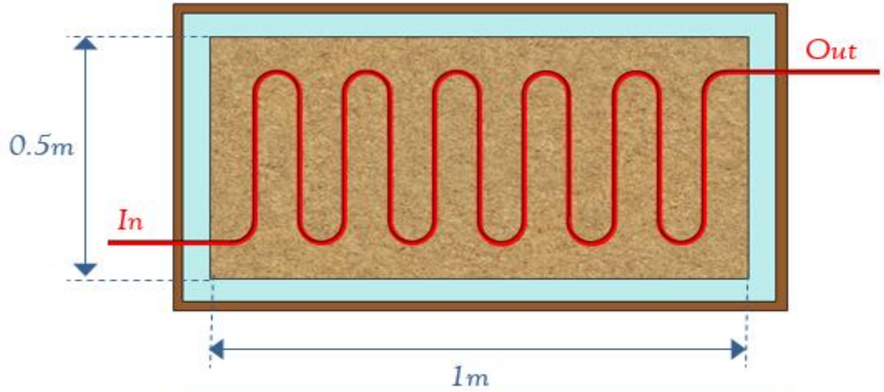
04 Compare and Optimise storage design

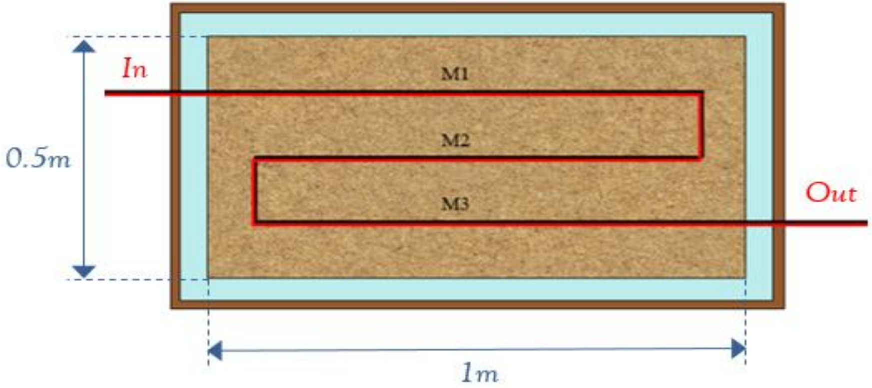
Preliminary Testing

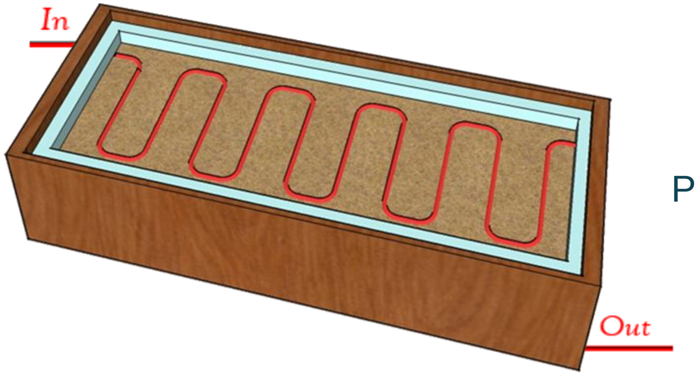
Soil → **Insulation** → **Storage pit Layout** → **Equipment**



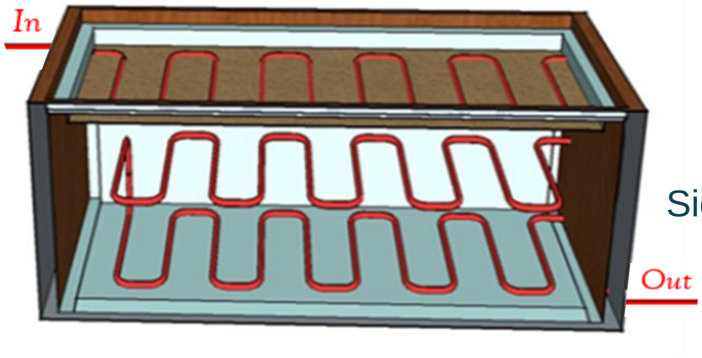
Storage Set-Up





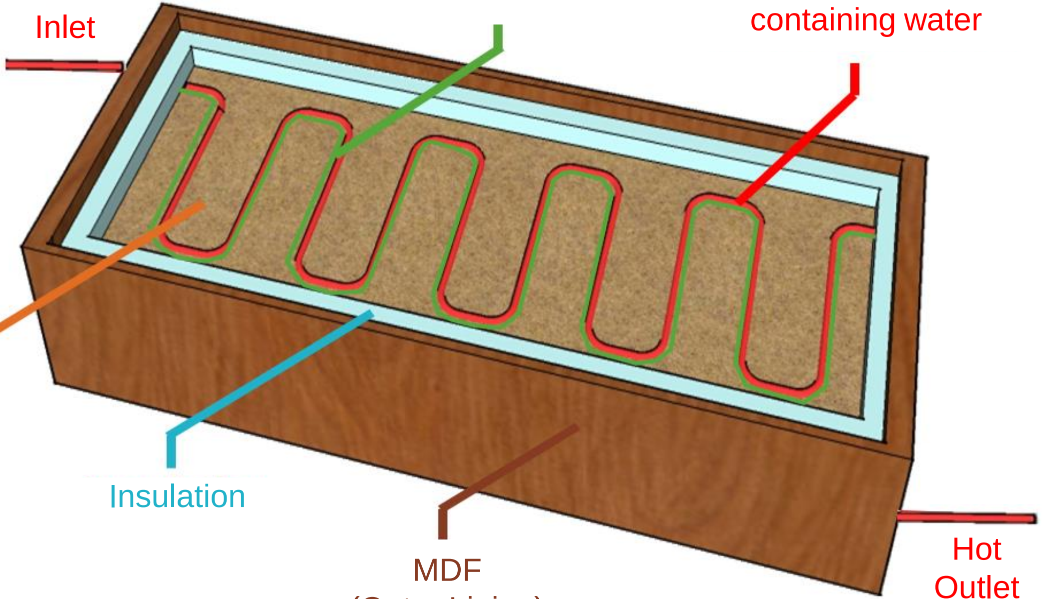


Plan View



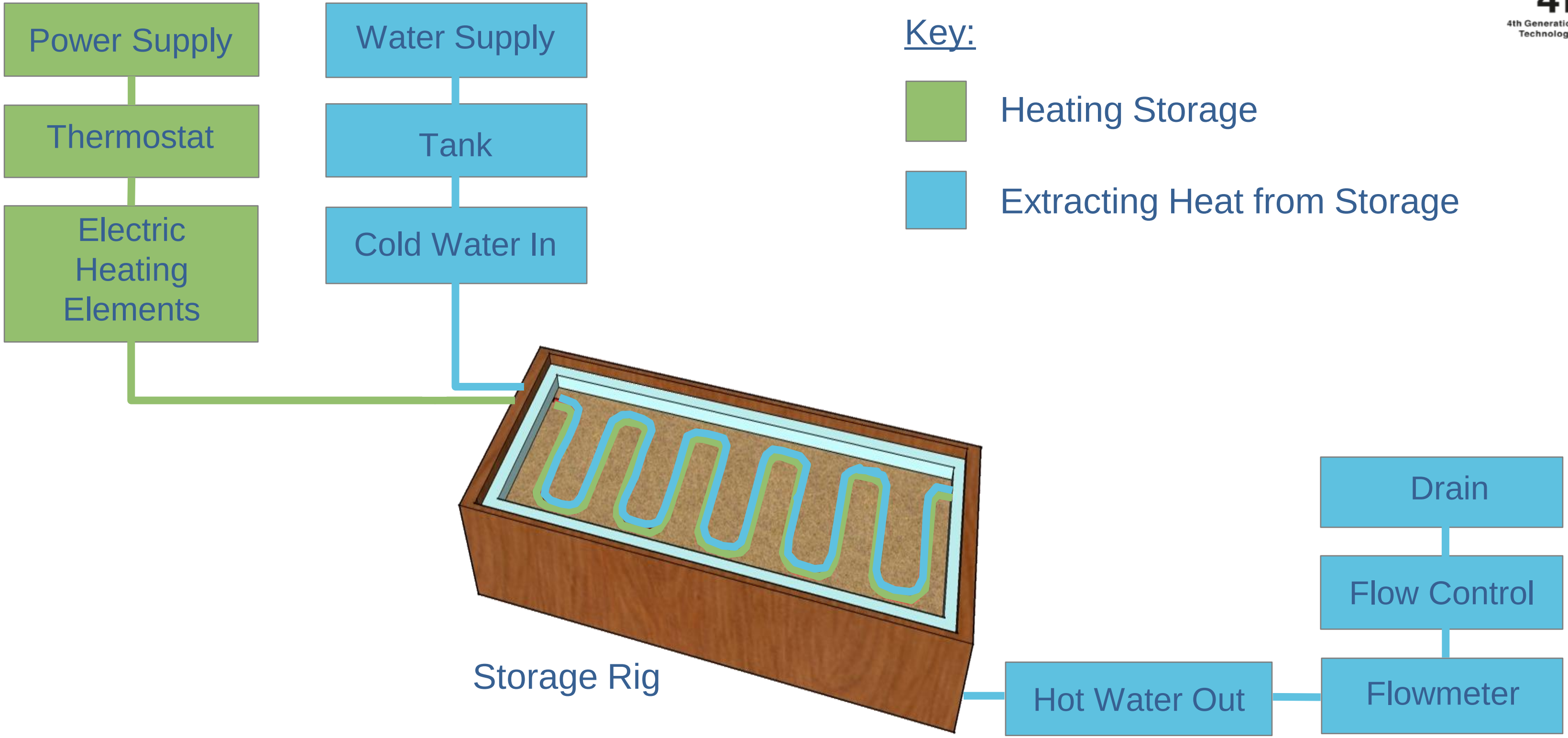
Side View

Storage Set-Up



- Soil Volume 0.25m^3
- Soil Capacity = 400kg
- Water Capacity = 0.5L
- 50mm Insulation
- 25mm MDF Lining

Experimental Set-Up

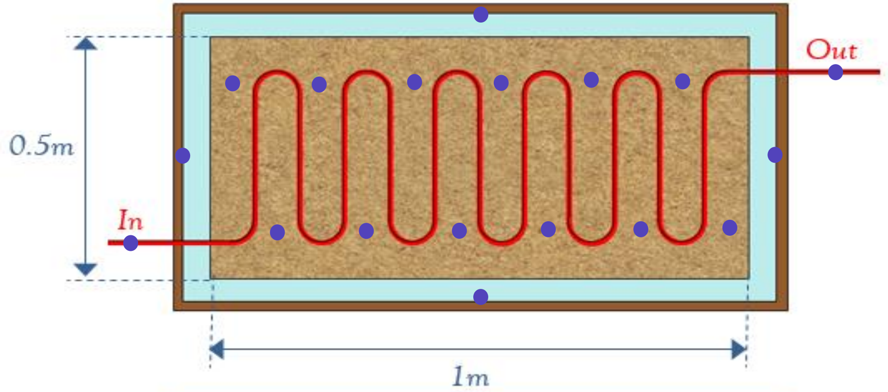


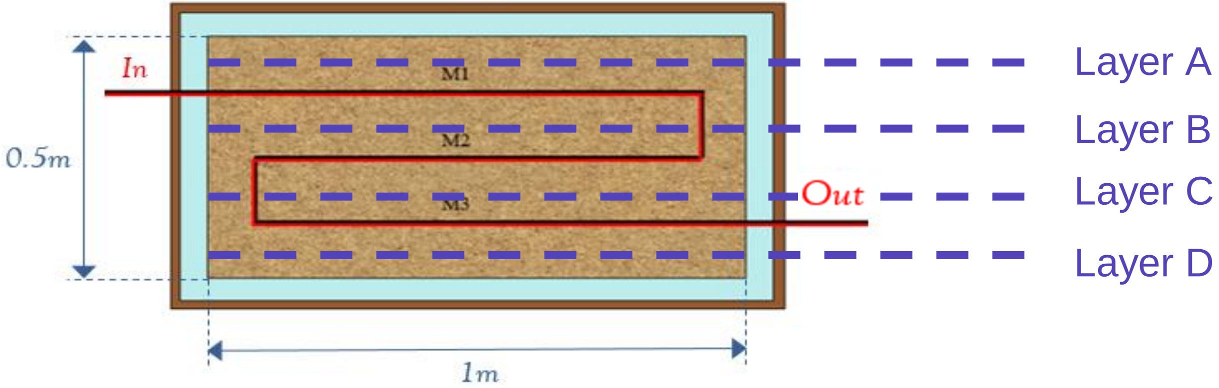
Key:

Heating Storage

Extracting Heat from Storage

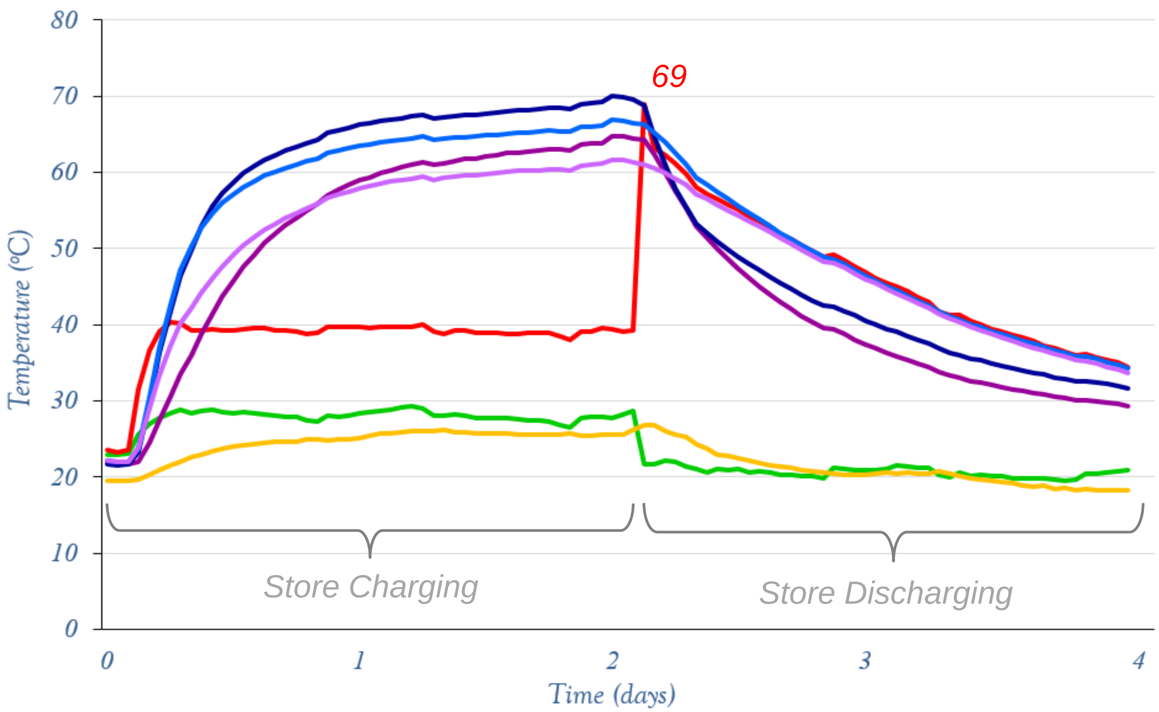
Temperature Readings





- 54 Temperature sensors
- 12 Sensors on each sand layer
- 4 Sand Layers (A-D)
- 4 Sensors on Insulation
- Water Inlet & Outlet

Experimental Results (0.1L/min)

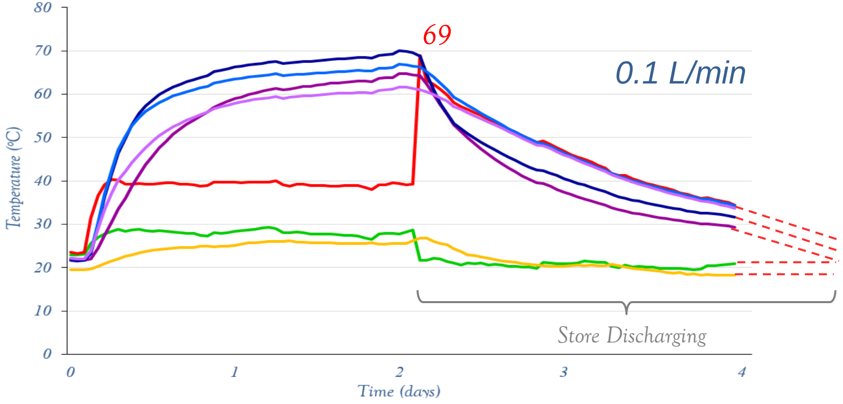


Key:

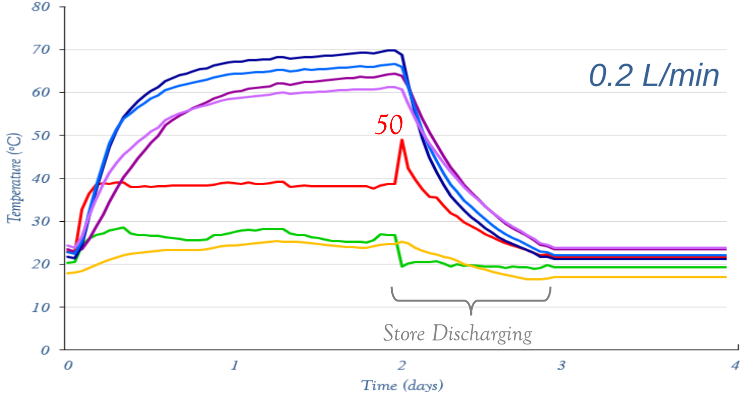
- Sand Layer B
- Sand Layer C
- Sand Layer A
- Sand Layer D
- Insulation
- Water Inlet
- Water Outlet

*Storage Temperature vs. Time graph with a **0.1L/min Flowrate***

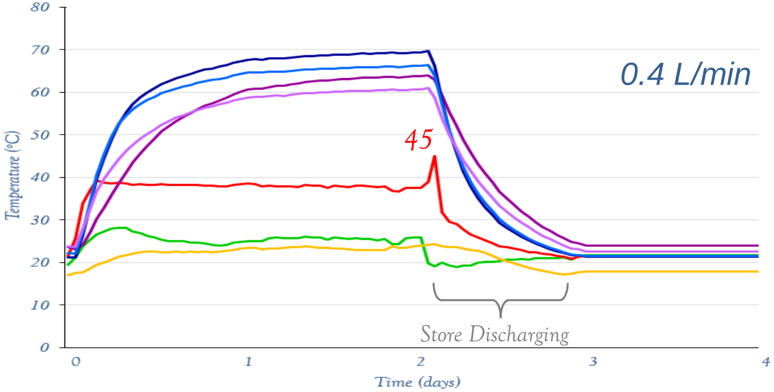
Analysis



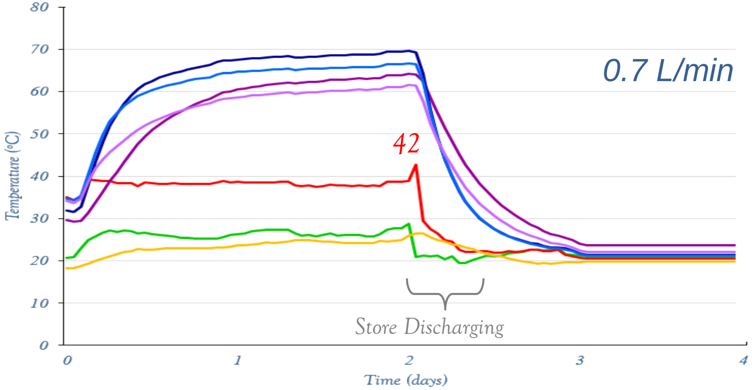
80
70
60
50
40
30
20
10
0
Temperature (°C)
69
0.1 L/min
Store Discharging
0
1
2
3
4
Time (days)



80
70
60
50
40
30
20
10
0
Temperature (°C)
0.2 L/min
50
Store Discharging
0
1
2
3
4
Time (days)

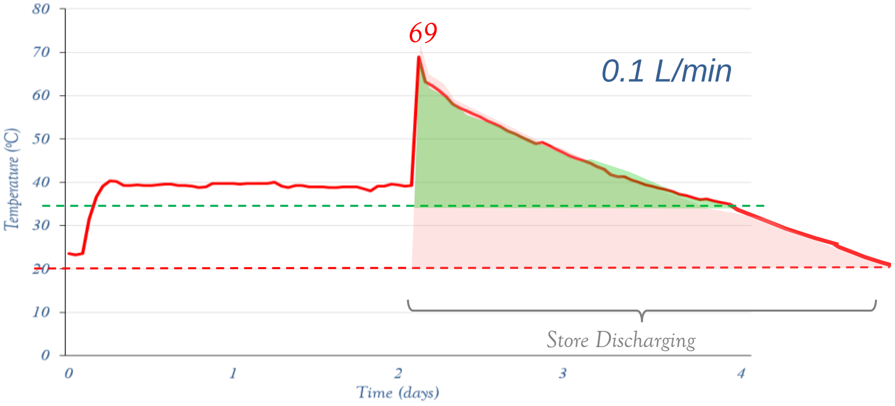


80
70
60
50
40
30
20
10
0
Temperature (°C)
0.4 L/min
45
Store Discharging
0
1
2
3
4
Time (days)

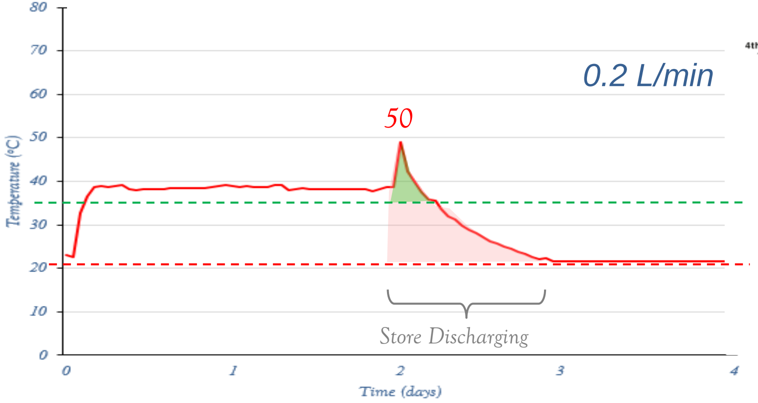


80
70
60
50
40
30
20
10
0
Temperature (°C)
0.7 L/min
42
Store Discharging
0
1
2
3
4
Time (days)

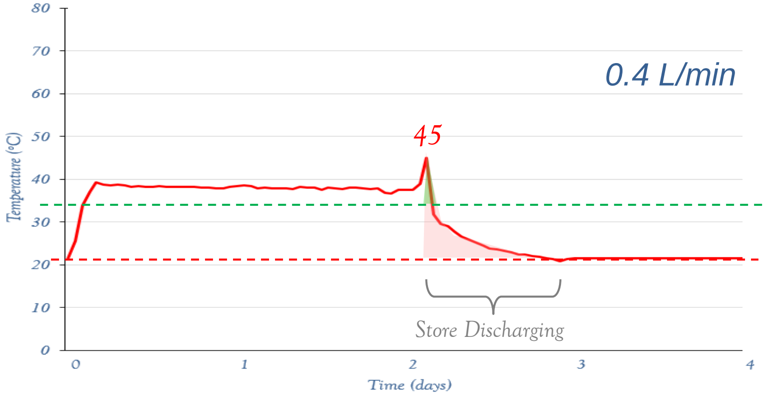
Analysis



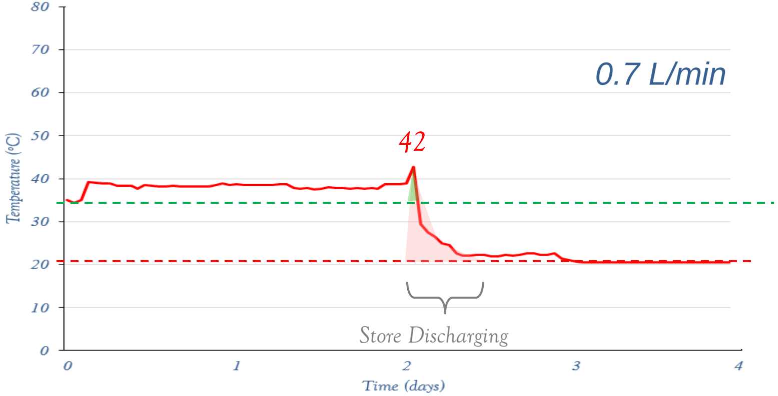
0.1 L/min
69
Store Discharging
Temperature (ºC)
Time (days)



0.2 L/min
50
Store Discharging
Temperature (ºC)
Time (days)



0.4 L/min
45
Store Discharging
Temperature (ºC)
Time (days)



0.7 L/min
42
Store Discharging
Temperature (ºC)
Time (days)

Calculating Storage Effeciency

Flowrate (L/min)	Max. Output Temperature (°C)	Complete Discharge Time (hr's)	Hot water Discharge Time (hr's)	Total Quantity Hot water (L)
0.1	69	36	16	96
0.2	50	24	8	96
0.4	45	19	4	96
0.7	42	12	2	84

Calculating Storage Effeciency

$$Q = mC_p \Delta T$$

- SAND CHARGING PROCESS , Q_{CHARGE}= *14400KJ*

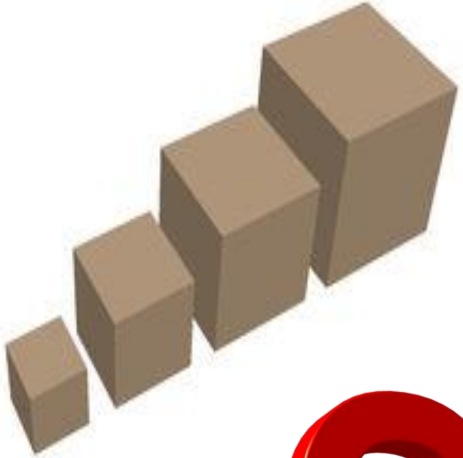
  $C_{p,sand}$= 800J/kgK ρ_{sand}=1600kg/m^3 *ΔT* = 45K *Volume*= 0.25m^3

- WATER DIS-CHARGING PROCESS, $Q_{DISCHARGE} =$ *11693 kJ*

  $C_{p,water}$= 4200J/kgK ρ_{water}=1000kg/m^3 *ΔT* = 29K *Volume*= 0.096m^3

- STORAGE EFFICIENCY = $Q_{DISCHARGE}/Q_{CHARGE}$ = 0.8 = *80 %*

Improving Storage Effeciency



OR + ...

Conclusion and Applications

- Soil storage created and tested with various flows
- Efficiency of the storage at 80% and acceptable
- Need to increase the storage discharging period using additional enhancing materials
- Applications include retrofitting local homes for low temperature heating systems (e.g. Underfloor)
- Uses the natural soil and available materials which makes application cheaper, easier & sustainable

THANK YOU FOR LISTENING

Any questions?

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