# Simulation of Operation of GHP using a Sea-Water Heat Exchanger. Case Study: Elderly Facility Home at Alexandroupoli, Greece


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# What this presentation is about..

- *Presentation of the system – Elderly Facility Home, Alexandroupoli, Greece (case study)*
- *Heating and Cooling needs of the actual system*
- *Modelling of the Geothermal Heat Pump (GHP) with Sea-Water Heat Exchanger (SWHE).*
- *Technoeconomic Evaluation of the designed system*
- *Next Steps*

# IDEOGRAM

The **IDEOGRAM** research program is concerned with the investigation, analysis and evaluation of the potential exploitation of surface (regular) geothermal energy and specifically **Open- Loop GHPs**, which use *sea water* or shallow costal aquifers as a source of energy.

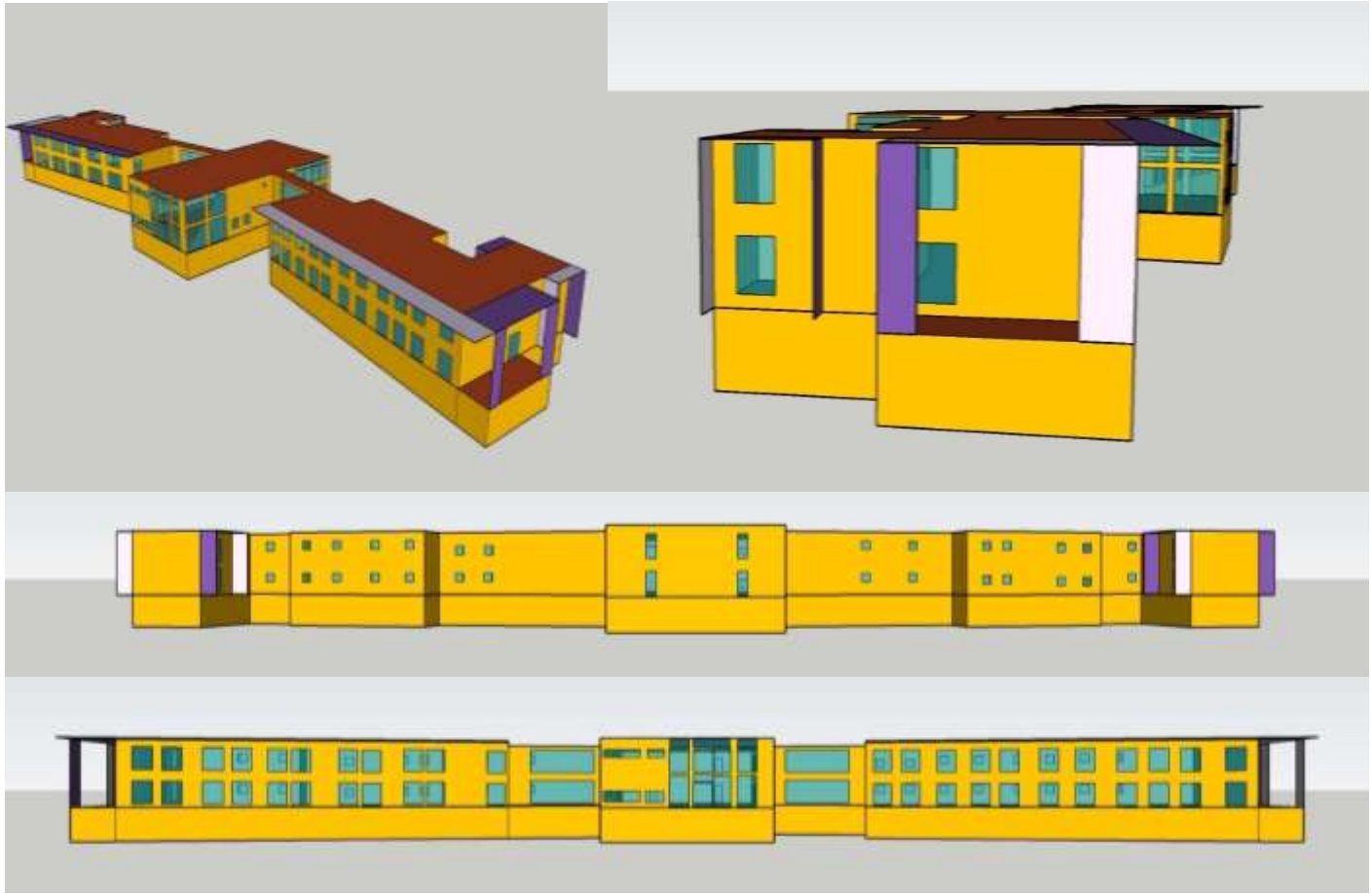
IDEOGRAM

Modelling the Open-Loop GHP SWHE using dynamic simulation software at all 4 climatic regions of Greece.

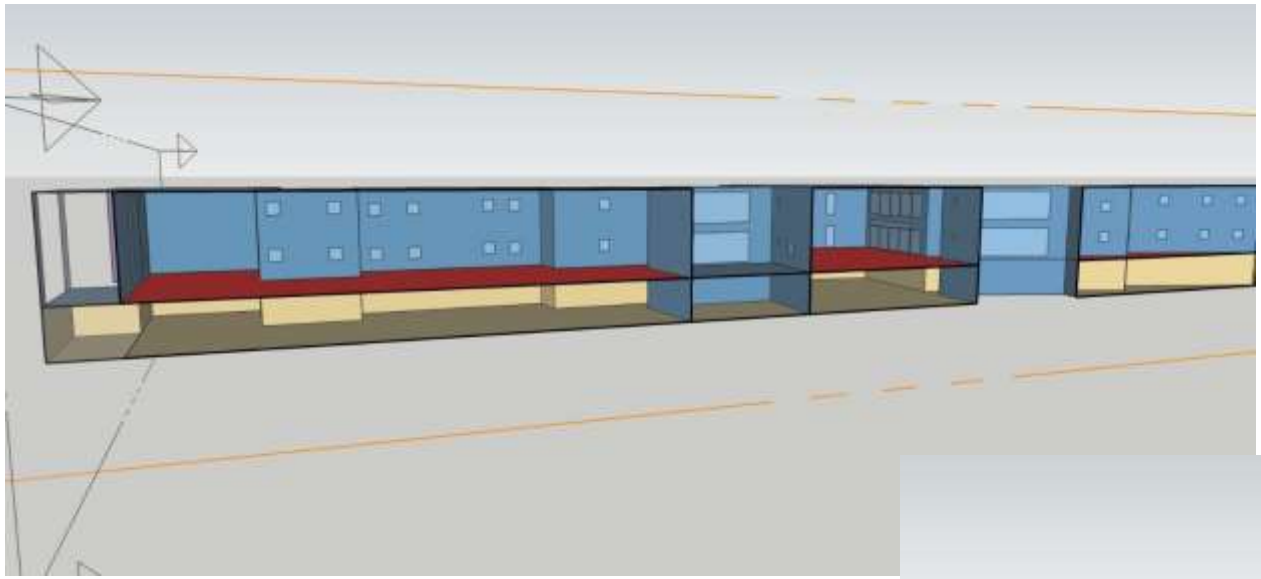
# Elderly Facility Home, Alexandroupoli, Greece

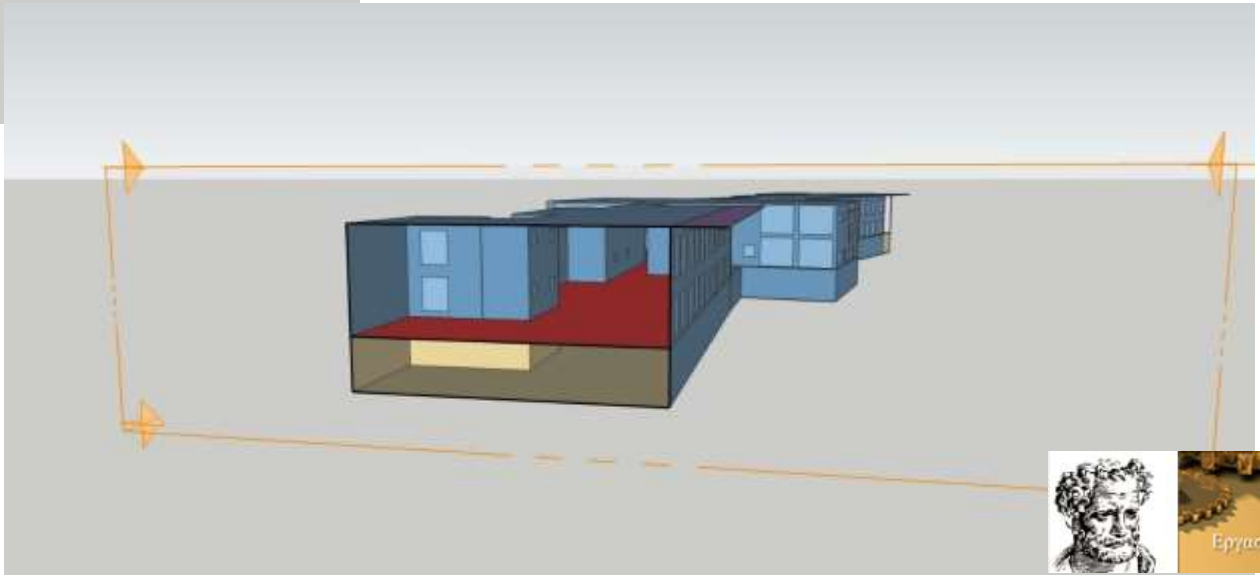
| Zone | Area(m^2) | Volume (m^3) |
|---|---|---|
| Basement | 1.689,20 | 5.336,80 |
| Main | 1.525,58 | 9.763,71 |
| Total | 3.214,78 | 15.100,51 |

# Elderly Facility Home– Sketch Up Design – TRNSYS Modelling



# Elderly Facility Home– Distribution of Thermal Zones



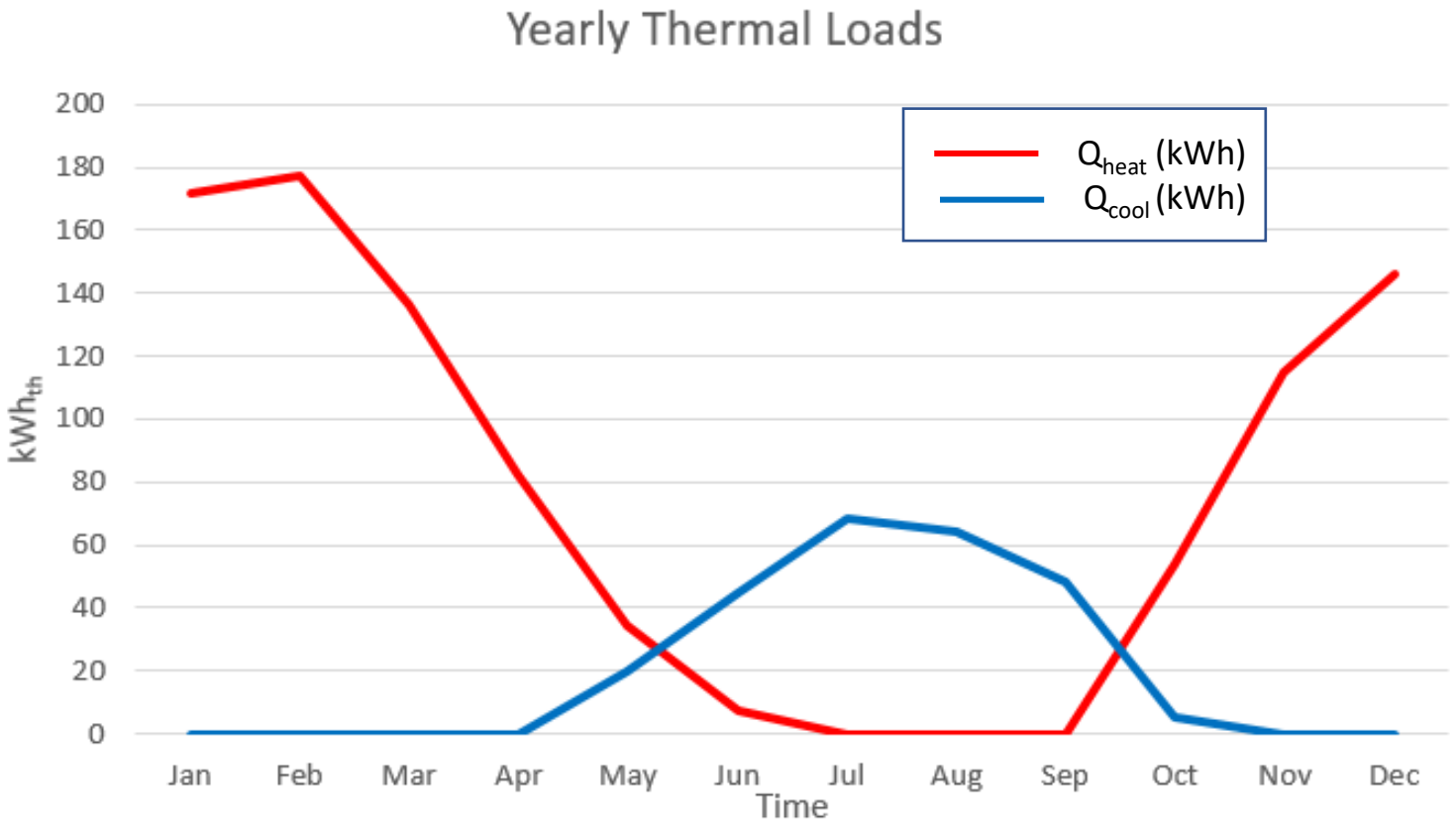


# Heating and Cooling Needs base on TRNSYS simulations

| Month | Qheat main (kWh) | Qheat basement (kWh) | Qheat Total (kWh) | Qcool main (kWh) | Qcool basement (kWh) | Qcool Total (kWh) |
|---|---|---|---|---|---|---|
| Jan | 107,23 | 64,62 | **171,84** | 0 | 0 | **0** |
| Feb | 107,86 | 69,43 | **177,29** | 0 | 0 | **0** |
| Mar | 78,51 | 57,54 | **136,06** | 0 | 0 | **0** |
| Apr | 42,01 | 40,56 | **82,57** | 0 | 0 | **0** |
| May | 10,78 | 23,88 | **34,66** | 19,78 | 0 | **19,78** |
| Jun | 0 | 7,6 | **7,6** | 45,08 | 0 | **45,08** |
| Jul | 0 | 0 | **0** | 68,11 | 0 | **68,11** |
| Aug | 0 | 0 | **0** | 64,18 | 0 | **64,18** |
| Sep | 0 | 0 | **0** | 48,04 | 0 | **48,04** |
| Oct | 32,53 | 21,5 | | | 0 | **5,52** |
| Nov | 72,09 | 4 | | | | **0** |
| Dec | 89,55 | 5 | | | | **0** |
| **Total** | **540,56** | **384,1** | | | **0** | **250,71** |

$\sim Q_{heat\ Total} = 104{,}02\ MWh_{th}/year$

# Heating and Cooling Needs base on TRNSYS simulations

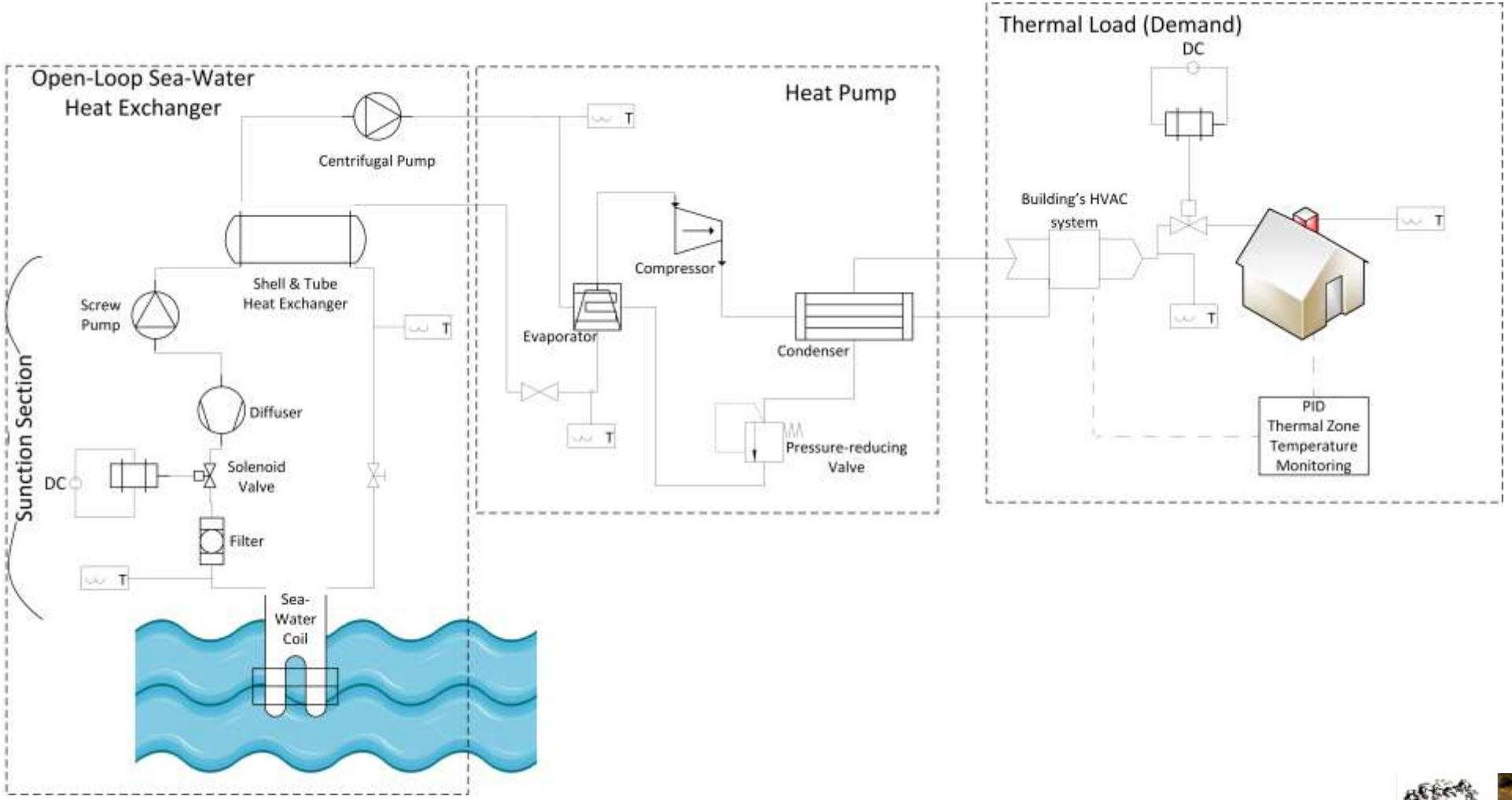



*Assumptions*

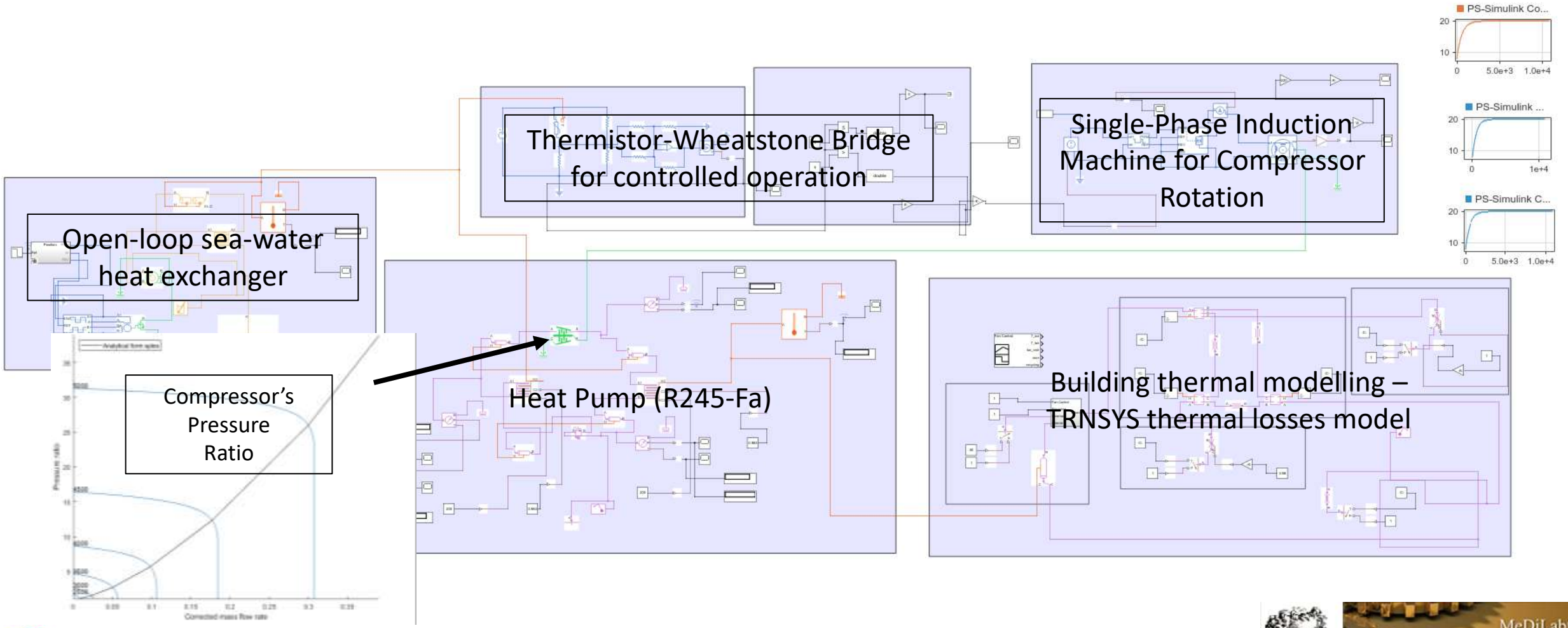
- **20 °C indoor space temperature, winter (ambient -9 °C)**
- 26 °C indoor space temperature, summer (ambient 36 °C)

National Technical Energy Directives 20701−1/2010 ”Analytical national directives of parameters for calculating the energy efficiency of buildings”

# Open-Loop GHP SWHE system- Modelling



# Modelling in Matlab – Simulink for simulation of operation scenarios



# Modelling in Matlab – Simulink for simulation of operation scenarios

*Assumptions*

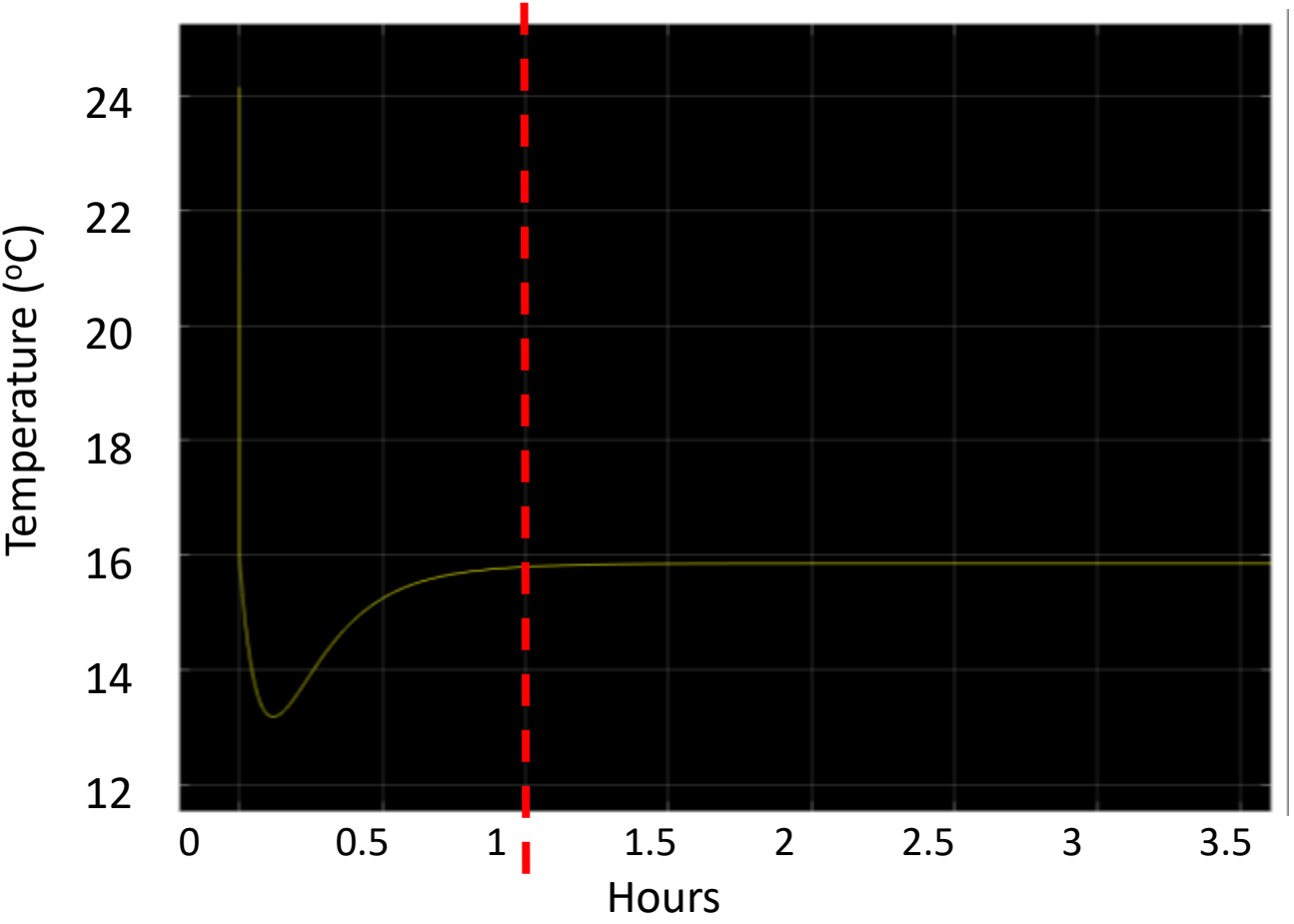
- **20 ºC indoor space temperature, winter (ambient -9 ºC)**

National Technical Energy Directives 20701−1/2010 ”Analytical national directives of parameters for calculating the energy efficiency of buildings”

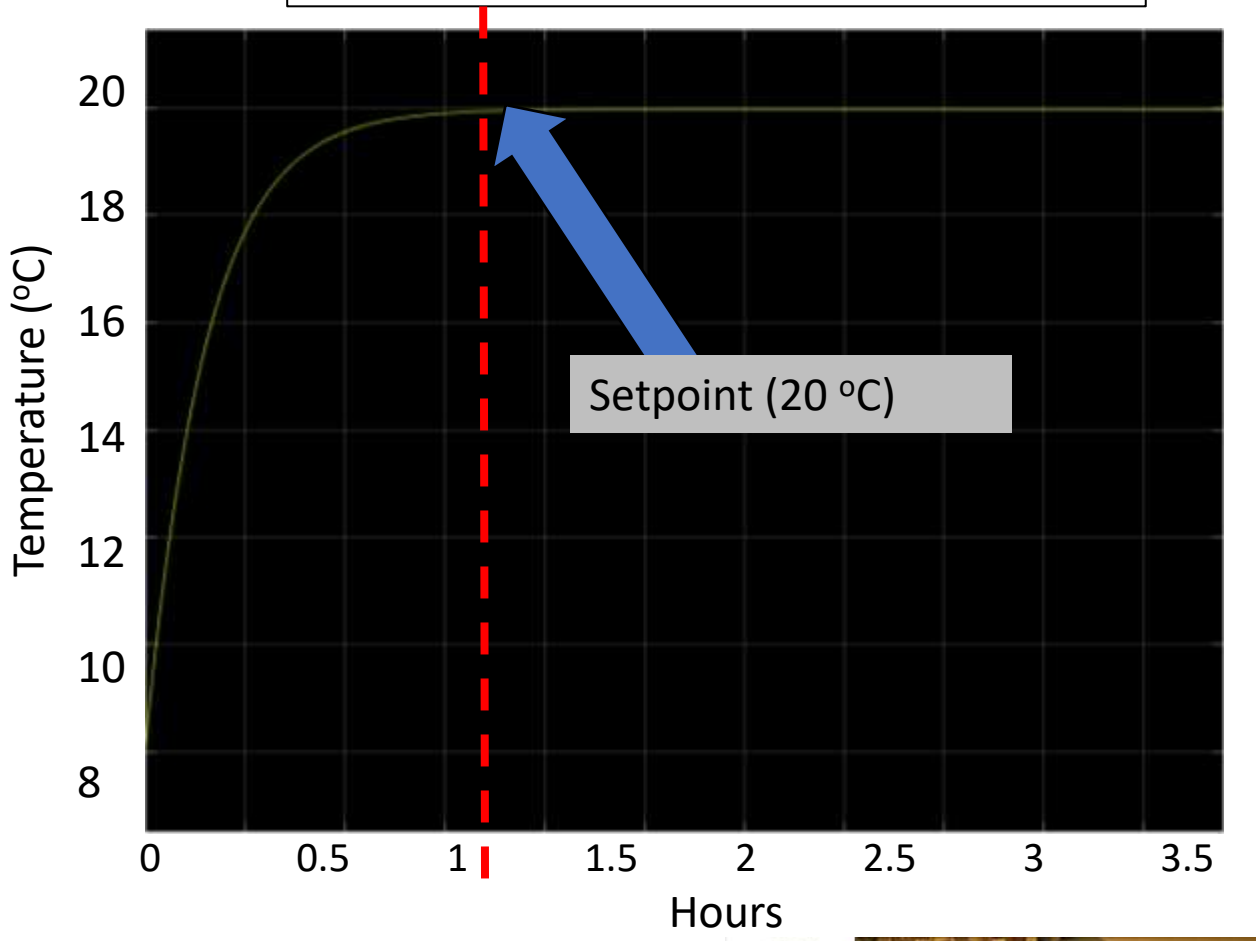
*Operation Scenario under investigation*

# Modelling in Matlab – Simulink for simulation of operation scenarios

*Thermocline region temperature~ 3 $m^3$*




*Indoor main areas temperature*

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# Technoeconomic Evaluation of the designed system

The day with the highest heating load
*(January – 171.84 $kW_{th}$)*

**Production** →

Heating: *117.28 $kW_{th}$*

The day with the highest heating load
*(January – 171.84 $kW_{th}$)*

**Consumption** →

Electrical (8 hours of operation): 18.56 $kWh_e$
Heating: *428.6 $kW_{th}$*

**COP = 0.34 ή 34.2%**
**CEER = 6.32**

*~ 67% cost reduction*

- Existing oil boiler heating system (210 kW – 20% capacity increase coeff. / 1.5€/lt 2022 Greece fuel prices): **14,570 €/year**
- Open-Loop GHP SWHE: **4,810 €/year**

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# Technoeconomic Evaluation of the designed system

**Open-Loop GHP SWHE system of installed capacity 190 $kW_{th}$**

- *Expected CAPEX: ~ 60,000 €*
- *Expected Maintenance cost (annual): ~ 700 €*
- *Expected annual profit: 14,570 – 4810 = 9,760 €*
- *Expected annual thermal energy production: ~105 $MWh_{th}$*

**LCoE : ~ 0.57 €/$kWh_{th}$**

***Payback Period : 8 years***

***ROI: ~16%***

**Next Steps:**

- Simulating operation scenarios in partial load situations. Simulation of the cooling loads.
- Sensitivity analysis of key aspects of the system (ratio of water flow between the sea-water screw pump and the actual heat pump, investigation of different compression ratios of the compressor of the heat pump, use of different working fluids-mediums in the heat pump etc.)
- Hybridization of the system using PV panels to cover the electrical loads of the system and to reduce its carbon footprint.

# Thank you for your attention!!!


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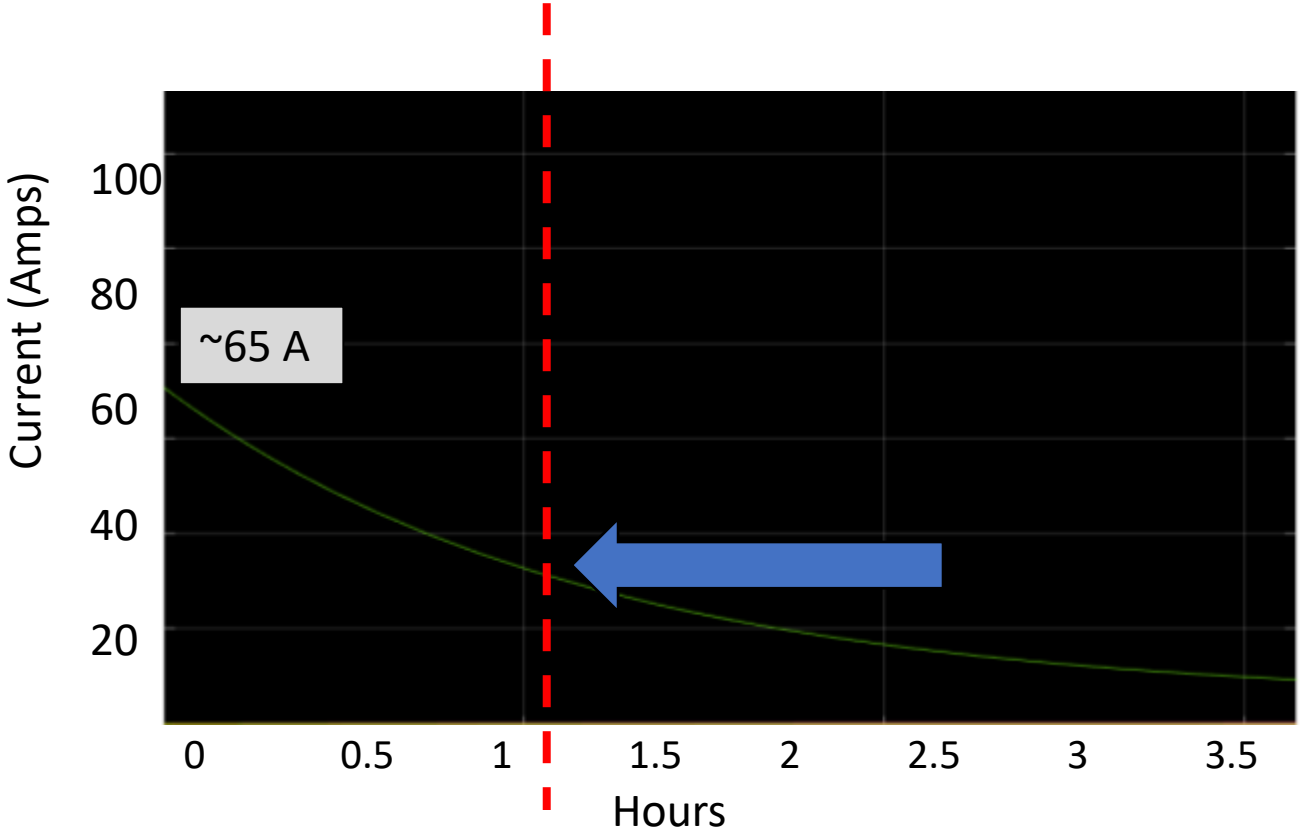
# Complementary material



# Complementary material

| HP | Starting Load (kW) | Amps (480 V 3-phase) |
|---|---|---|
| 15 (x2) | 30 | 42 |
| 30 (x2) | 60 | 42 |
| 40 | 40 | 57 |
| 40 (x2) | 80 | 57 |
| **25 (x2)** | **50** | **71** |
| 50 | 100 | 71 |