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INTERNATIONAL BUILDING PERFORMANCE SIMULATION ASSOCIATION

Simulation of Unglazed Solar Thermal Integrated into Façade & Combined with Ultra Low Temperature District Heating

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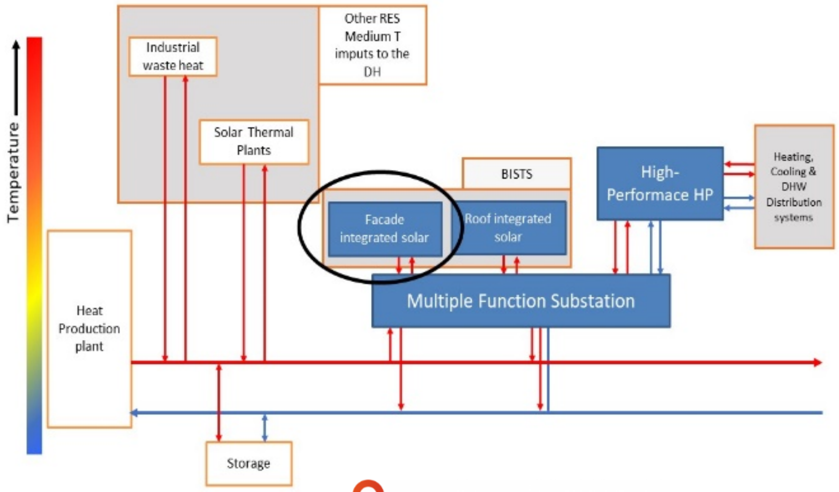
1. Introduction & Objectives

- What is presented?
  - Coupling algorithm for Unglazed Solar System & Ultra Low Temperature District Heating (DH)
  - Energetic & Economical assessment of the combined system
- Which are the main objectives of the study?
  - Present a control strategy for heat flows in the combined system
  - Demonstrate the economic viability of the presented system
  - Study the applicability for different districts

Introduction & Objectives

- 4th Generation District-Heating (4GDH)



- Ultra-Low Temperature (ULT) System (~45ºC)
- Decentralized DH network
- Buildings acting as energy nodes
- Substations allow for bi-directional heat exchange
- Incorporation of low-grade heat sources
- Heat Pumps recover heat from cooling applications
- Decentralized, Building Integrated Solar Thermal

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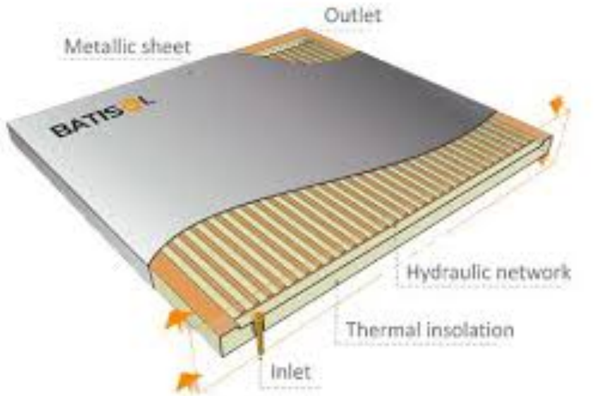
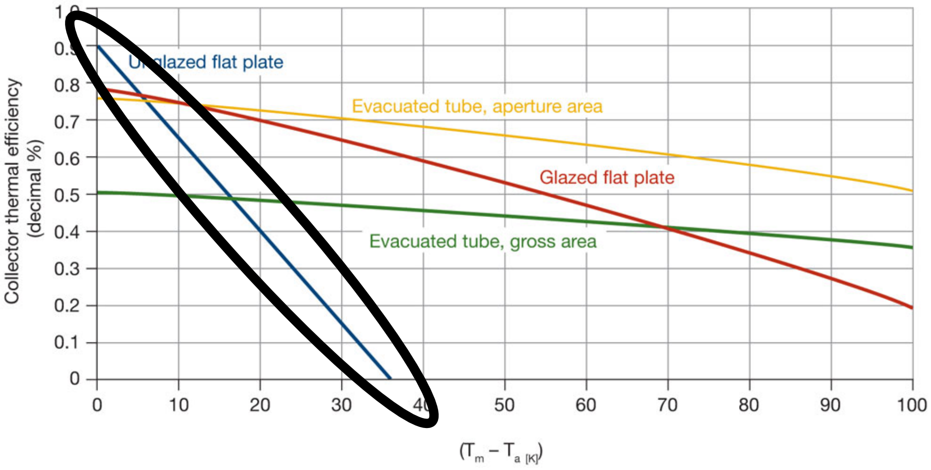
Introduction & Objectives

- Façade Solar Thermal (ST) System

Performance equation: $\eta_c(t) = \eta_0 - a_1 (T_m(t) - T_a(t)) / G_T(t) - a_2 (T_m(t) - T_a(t))^2 /$



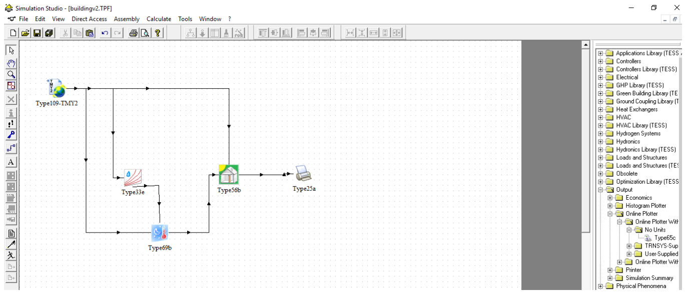
Unglazed ST Collector-
Batisol Project

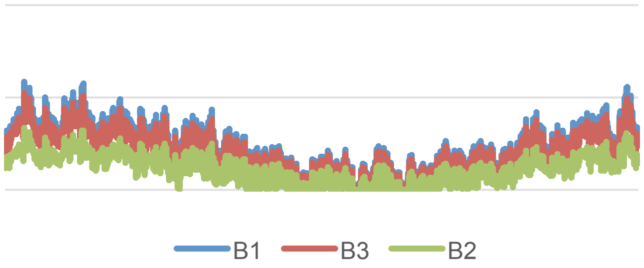


Inlet fluid parameter, °K; T_m equals mean collector fluid temperature; T_a equals ambient temperature.

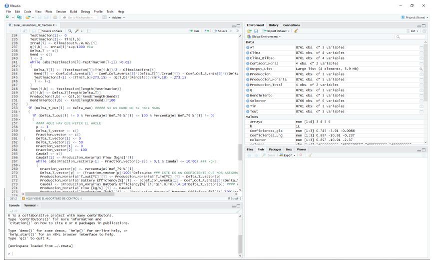
Methodology for calculations (Hourly basis)

- Heat Loads for different type of buildings (B1, B2 & B3) ← TRNSYS





- Solar Production simulations ← Rstudio (R software)

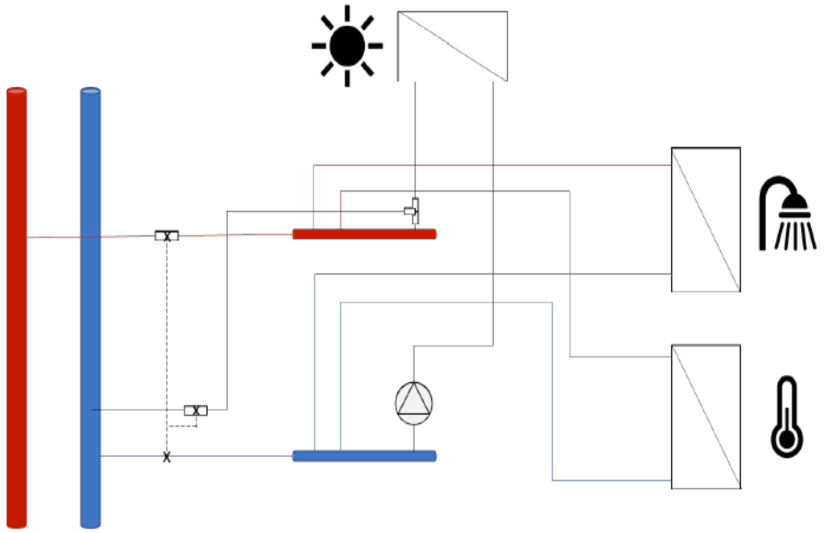


Reference:
Solar engineering of thermal processes / John A. Duffie, William A. Beckman

Introduction & Objectives

How do we couple ST & DH systems?

DH substation

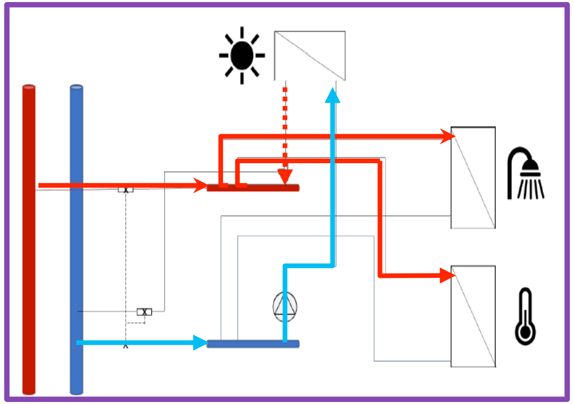


Functioning Algorithm

- Bidirectional heat flow
  - From the DH to the building
  - From the building to the DH.
- In function of the solar heat exergy.
  - Heat injected to return line of the DH
  - Heat injected to supply line of the DH
- Heat sink is avoided. Legionella issues are avoided if there is no water storage for DHW

Coupling algorithm between ST & Heat-Load (Main)

Mode 1

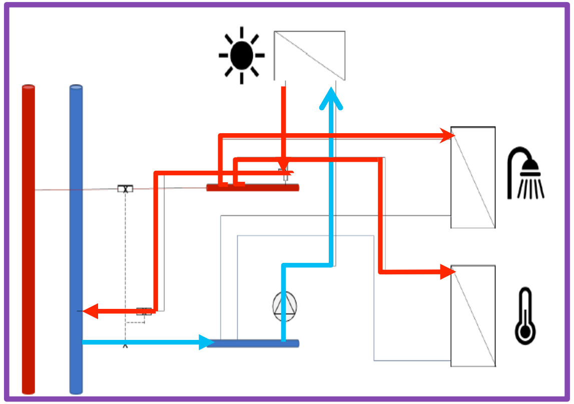


Heat demand exceeds solar production

⇩

Heat supply comes from DH supply & ST

Mode 2



Solar production exceeds heat demand but not supply T

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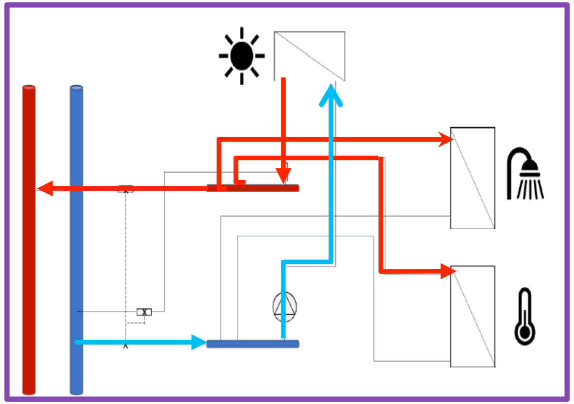
Excess heat is injected into return line of the DH

Mode 3



Solar production exceeds supply T of the DH

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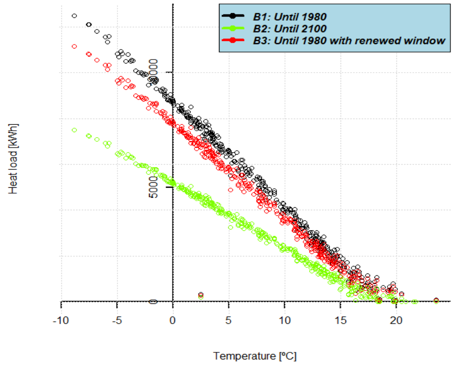
Excess heat is injected into the supply line of the DH

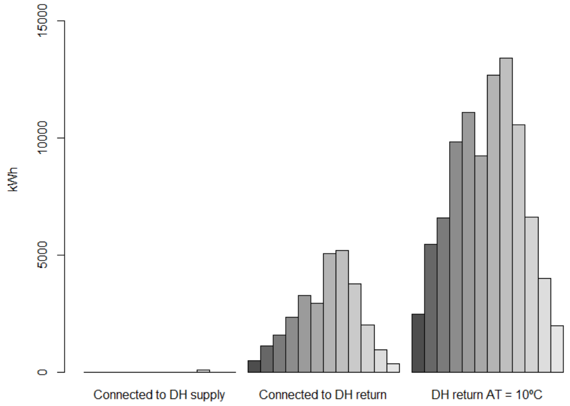
Heat-Loads and Solar production

Heat Loads for B1, B2 & B3



~ Linear dependency of outdoor temperature and the Space-Heating loads.

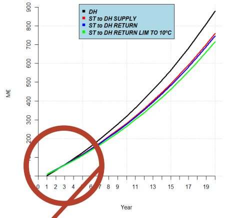
Solar heat production in function of output temperature

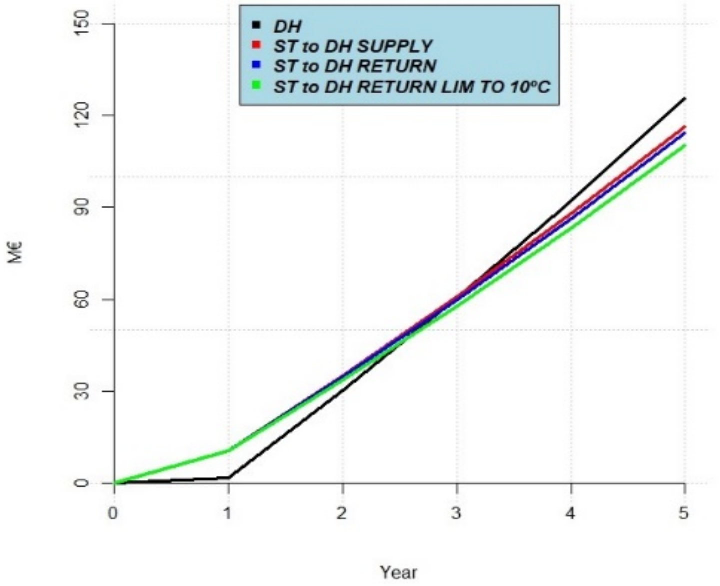


- Unglazed collectors don't perform in a correct way when high working temperatures (>45ºC)
- Outdoor high temperatures reduce heat losses and improves efficiency.
- If ΔT is limited by varying the flow rate inside the pipelines of the solar collectors, obligying the ST system, production notably increases.

Economic assessment

$$Demand_{DH} = Demand_{building} / BSF \, [-]$$





Economic metrics:

$$ROI = dNPV / I_0$$

$$dNPV = \sum_{i=1}^{T} Q_i / (1+r)^i - I_0$$

ROI Values	Supply	Return	Return AT = 10 ºC
BSF = 0%	1.21	2.35	2.88
BSF = 50%	1.19	2.10	2.34

Discussion & Conclusions

- 4GDH system enable a high efficiency way of distributing heat to high density areas, enabling reduced heat losses and incorporation of renewable low grade sources (such as unglazed ST).
- Unglazed solar system needs alternative energy sources (by now).
- Limited ΔT increase energy production by 200%
- Payback times for incorporation of ST rounds 3 years.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768567.

http://www.relatedproject.eu/

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Questions and Comments

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