



# Evaluation of district networks with shared sources for heating and cooling generation

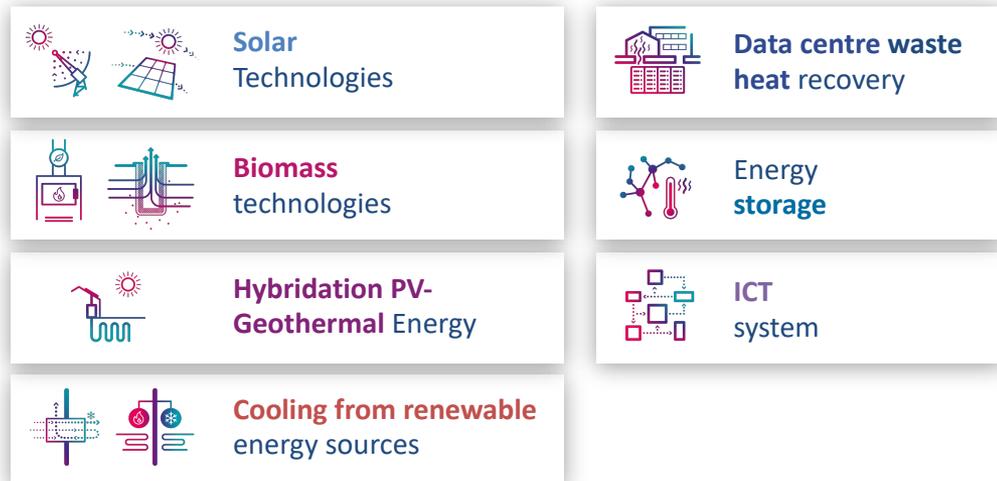
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# Introduction

- Framework: Wedistrict EU H2020 project;
- Objective: Integration of multiple source of renewable energies in order to achieve 100% renewable DHC;
- Technologies:



- Evaluation based on overall system and individual technology KPIs



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# Motivation

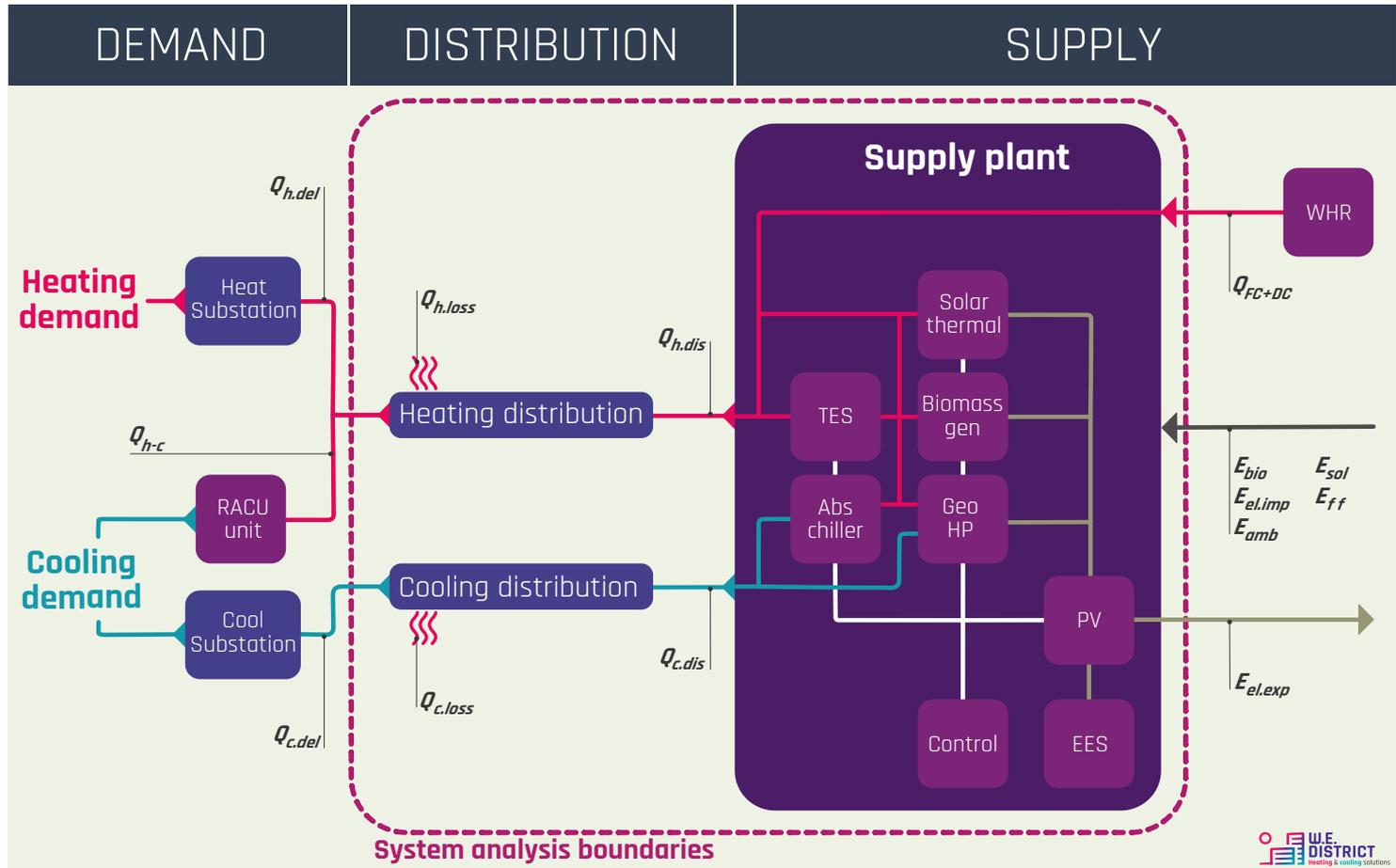
- Combination of DH and DC services in a same systems are more and more common;
- Renewable and waste energy integrated in a DHC Systems may be used for heating, cooling or for both of them;
- An objective comparison of different DHC configuration or DHC with individual systems, allocating inputs between the services;
- Need for evaluating heating and cooling service separately;
- The way for achieving a fair and clear comparison by introducing robust, consistent, transparent KPIs;



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# System boundaries



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# Key Performance Indicators

## Energy

- RER Renewable energy ratio [-]
- $f_{nr}$  Non-renewable primary energy factor [-]

## Environment

- $k_{CO_2}$  Equivalent CO<sub>2</sub> emission coefficient [g/kWh]
- $k_{xx}$  Pollutant emission coefficients (“xx” being SO<sub>x</sub>, NO<sub>x</sub>, PM<sub>2,5</sub>) [g/kWh]

## Economy

- CAPEX Capital expenditures [€/kW]
- OPEX<sub>f</sub> Fixed operational expenditures [€/kW]
- OPEX<sub>v</sub> Variable operational expenditures [€/kWh]
- LCOE Levelized cost of energy [€/kWh]

## Socio-economic

- sc Environmental social cost [€/kWh]



# Challenges

- When the same energy source is used for providing both heating and cooling, the KPIs are becoming fuzzy;
- Need to clarify which part of the used thermal energy goes for which service;
- Similar when the same equipment is used for providing both heating and cooling, the Economy KPIs are not straightforward;

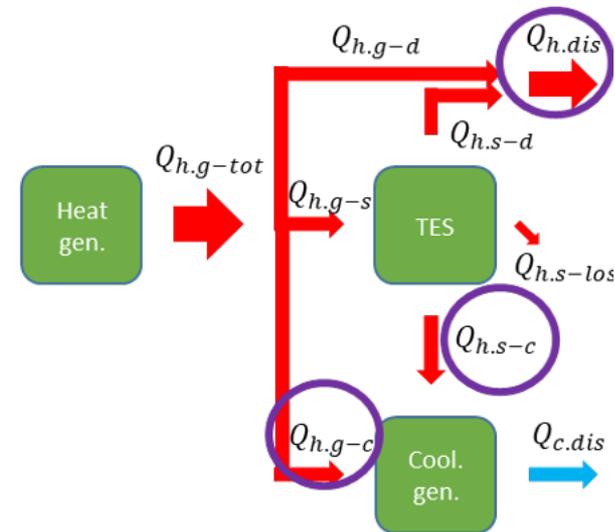


# Step 1:

## Introduction of Energy Share Factors:

- Separation of energy used for cooling and for heating;
- Based on the energy balance of the system;

$$\alpha_h = \frac{Q_{h.dis}}{Q_{h.g-c} + Q_{h.s-c} + Q_{h.dis}}$$



# A quick example (1)

Renewable Energy Ratio :

$$RER = \frac{E_{Pren}}{E_{Ptot}}$$

All Sources only for Heating (standard DH):

$$RER_h = \frac{\sum_i (f_{r,i} E_{i,h})}{\sum_i (f_{t,i} E_{i,h})}$$

f – Primary energy factor  
 E – Final energy

Sources Shared for Heating and Cooling:

$$RER_h = \frac{\sum_i (f_{r,i} E_{i,h}) + (\alpha_h) [\sum_i (f_{r,i} E_{i,hc})]}{\sum_i (f_{t,i} E_{i,h}) + (\alpha_h) [\sum_i (f_{t,i} E_{i,hc})]}$$



## Step 2:

### Introduction of Investment Share Factors:

- Separation of investment for cooling and for heating equipment;
- Weighted by the energy balance of the system.

$$\beta_h = \frac{C_{d.h} + \alpha_h C_{d.hc}}{C_{d.c} + C_{d.h} + C_{d.hc}}$$



# A quick example (2)

Heating CAPEX:

$$CAPEX = \frac{C}{P} [\text{€/kW}]$$

All Equipment for Heating (standard DH):

$$CAPEX_h = \frac{C_{d.h}}{P_h}$$

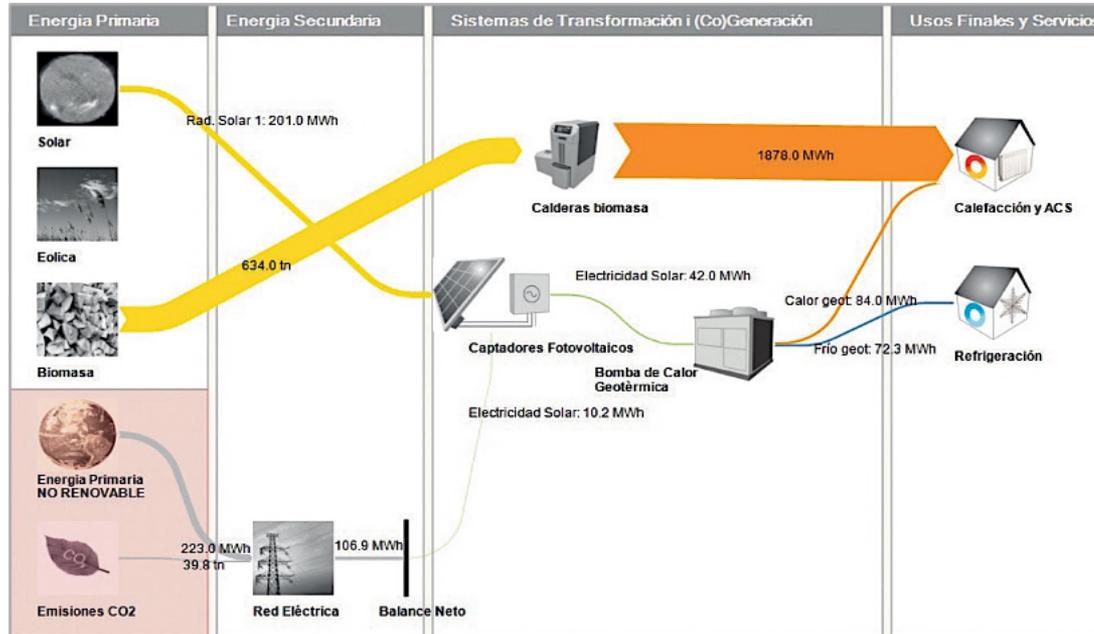
Equipment Shared for Heating and Cooling:

$$CAPEX_h = \frac{[C_{d.h} + (\beta_h)(C_{d.hc})]}{P_h}$$





# Example: DHC Olot, Spain



$$\alpha_h = 0,96$$

$$\beta_h = 0,89$$

$$RER_c = 0,199$$

$$RER_h = 0,939$$

$$CAPEX_c = 789,7 \text{ €/kW}$$

$$CAPEX_h = 1.139 \text{ €/kW}$$



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# Conclusions

- In order to achieve a clear picture on energy, environmental and economic results of each service provided by a DHC with common sources, the share factors based on the energy balance and investment weighting ratio have been defined.
- With the presented approach a robust and consistent KPIs have been obtained.





Thank you for your attention!

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