Evaluation of the potential of heat pumps in the reduction of energy consumption in energy communities: a case study in a Mediterranean district.

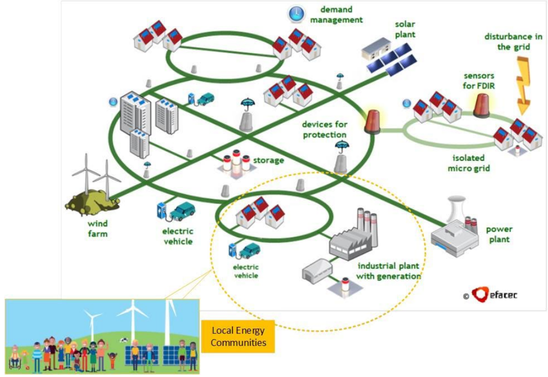
Ximo Masip[a], Rossana Boccia[b], Emilio Navarro-Peris[a*]

[a] Instituto Universitario de Ingeniería Energética, Technical University of Valencia, Spain

[b] Department of Civil and Mechanical Engineering, Technical University of Denmark,

emilio.navarro@iie.upv.es

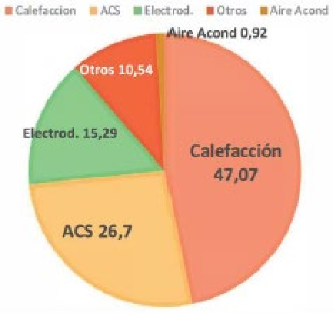
Introduction



- Energy communities have the potential for reducing the total energy consumtions in cities.
- This process has been mainly addresed from the point of view of electric energy communities.

<u>Drawbacks</u>

- ❑ Limited application in high density urban áreas.
- ❑ Usually do not consider the concept of thermal energy community.
- ❑ Most of the heating demand is satisfied by electric heaters or boilers.



75% of energy consumption in buildings is heating

Objective

2 main objectives:

- ❑Evaluate the potential of reducing emissions by the introduction of HPs to satisfy the demand of DHW.

- ❑Evaluate the potential of reducing emissions by the introduction of a thermal energy community using HPs to satisfy DHW

Methodology

Neigborhood of Lost Island:

- 150 Buildings
- Mainly residential
- Most of the buildings built before 1980
- 30 dwellings per building

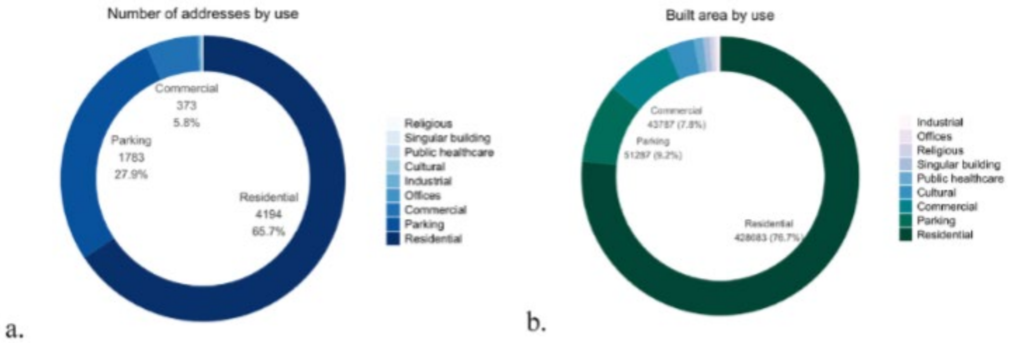
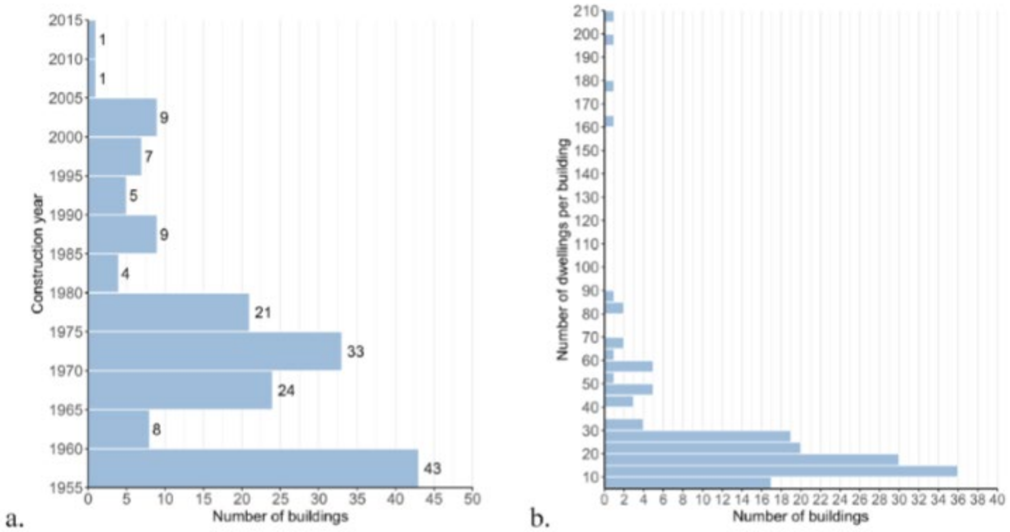


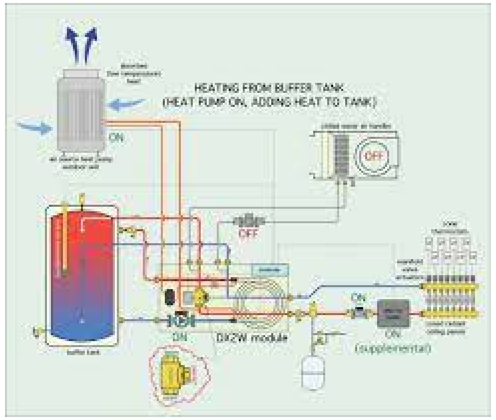
Fig. 3. Demographic data analysis of the Illa Perduda district.



Methodology


- DHW demand satisfied by 22% electric heaters and 68% of gas boilers
- Non collective systems

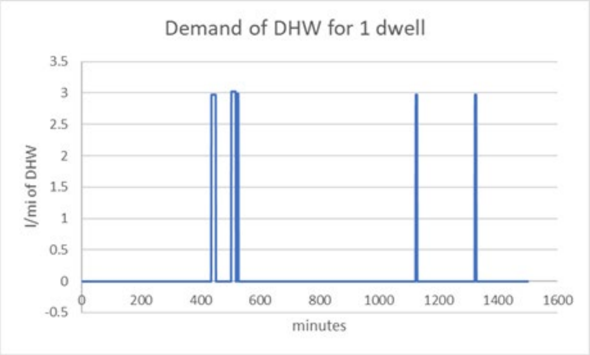
A-W HP for each dwelling



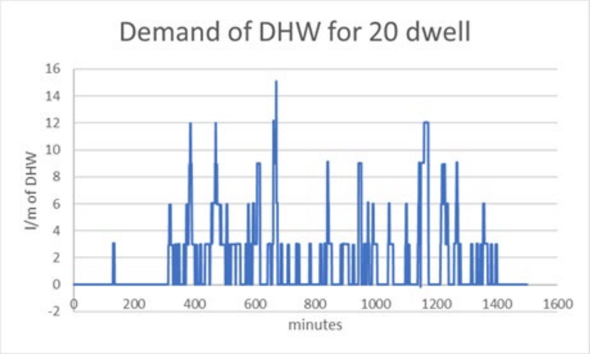
Collective A-W HP for each dwelling

Methodology

TRNSYS 18



DHWcalc



Immersion Electric Heater (IEH): 80 L storage tank with an aspect ratio of 2 and a nominal capacity of 1.5 kW and 55 ºC set-point temperature.

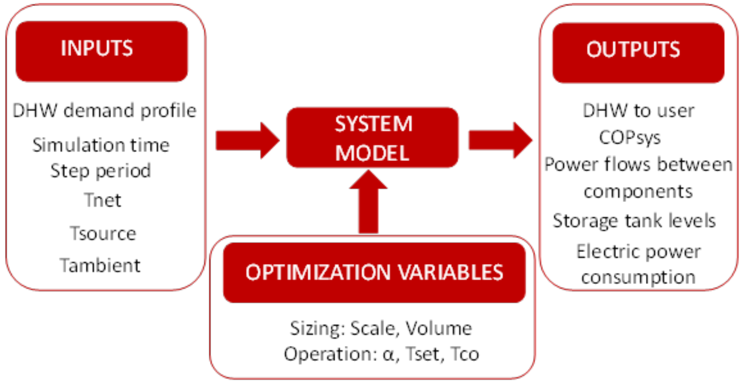
Gas Boiler (GB): it consists of an instant-heating system of 28 kW and 92 % efficiency.

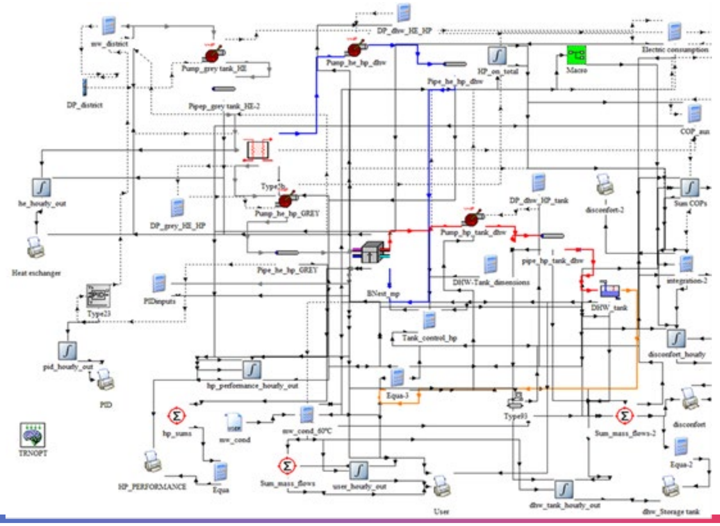
Individual ASHP: an individual ASHP commercially available has been modelled at HP unit level using IMST-Art software.

The HP works with propane as natural refrigerant and has 1 kW heating capacity and 180 l storage capacity.

Collective ASHP: the individual HP unit of the ASHP model has been optimized using IMSTart to work under collective conditions. In order to take into account the re-circulation losses, a 10 % annual energy consumption reduction has been considered.

Model description





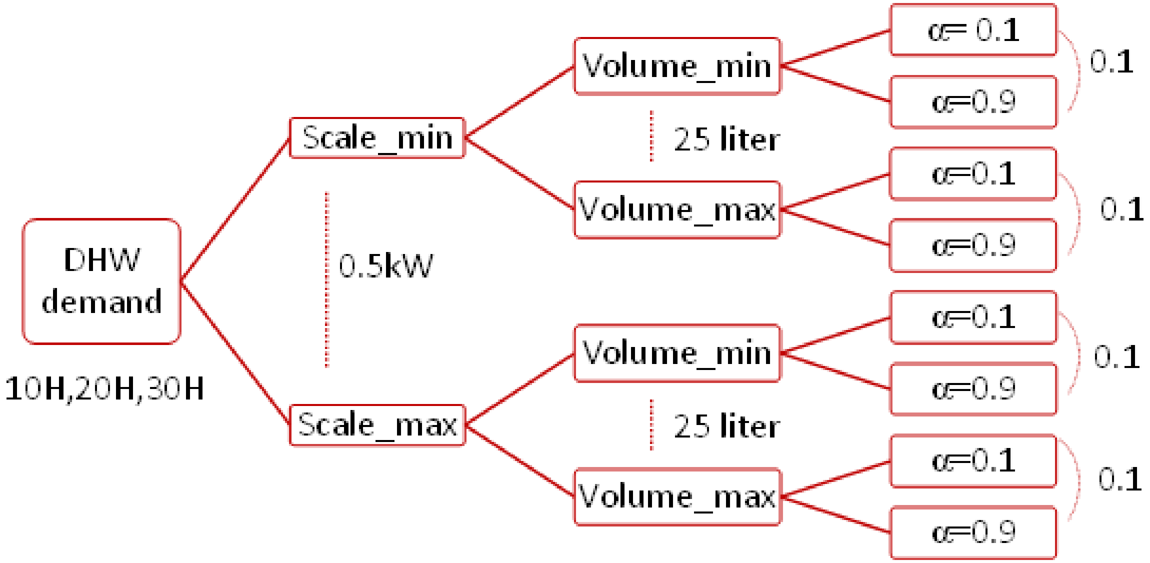
Target of the model:

Find the best combination of HP-Tank and the best control strategy which minimizes the energy consumption.

Performed simulations

INPUTS

DHW demand profile:	20H/10H/30H
Simulation time:	8760h
Step time:	1 minute
Tnet:	10°C
Tsource:	20°C
Tambient:	20°C

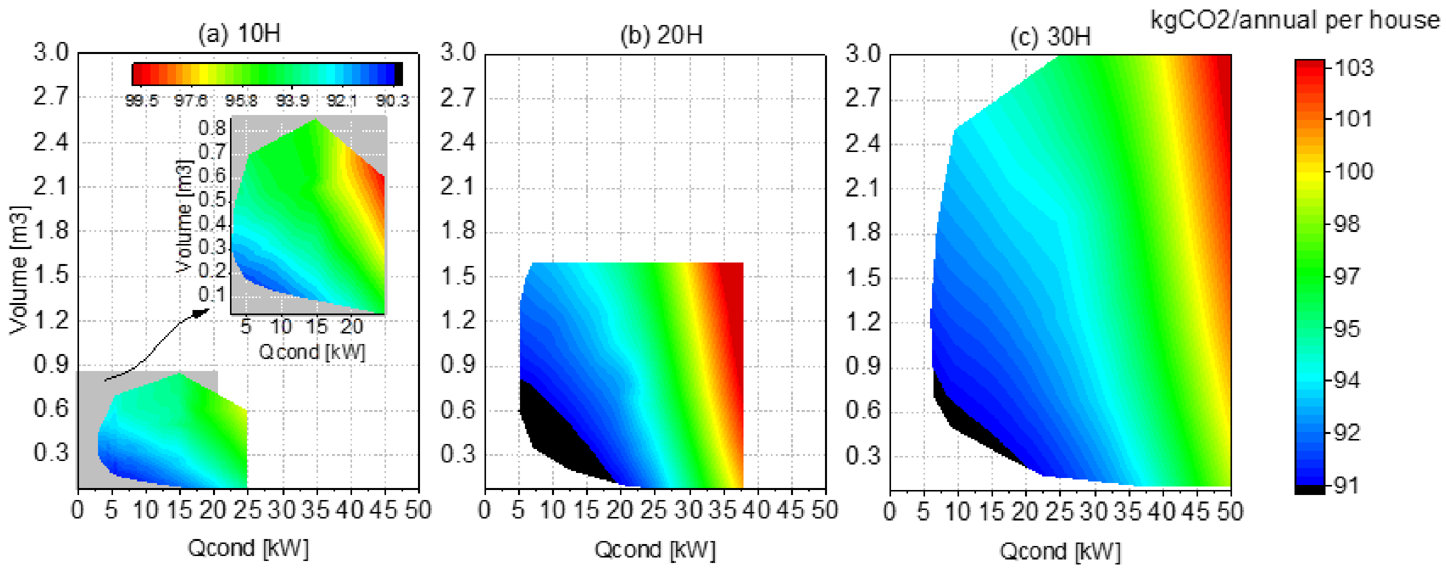


Scale: HP size
Volume: water tank volumen
α: Percentage of the volumen filled.

More than 12000 simulations cases performed

Methodology

Determination of the size of the collective heat pump and storage tank

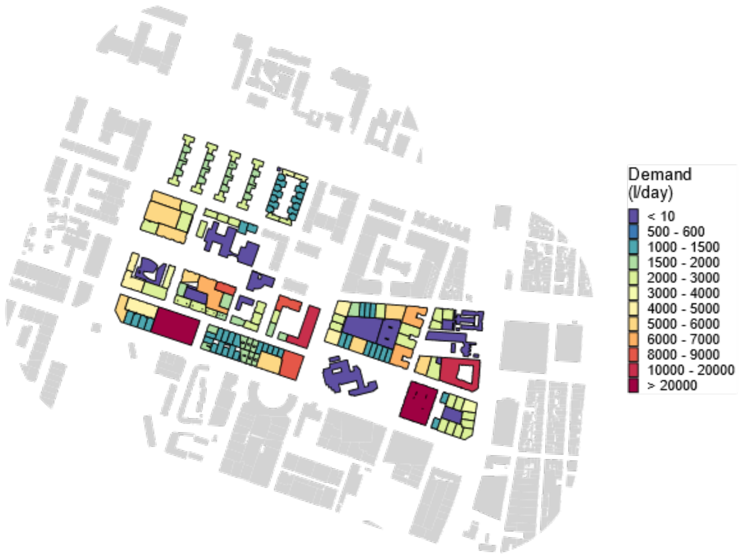


CO2 annual emissions per house for each HP-ST size and (a) 10H demand, (b) 20H demand, and (c) 30H demand

Results

	Total Energy Consumption (MWh/year)	Emisions (tCO2/year)
Electricity	15121	3063
Gas	4511	907
Total		3970

Base case

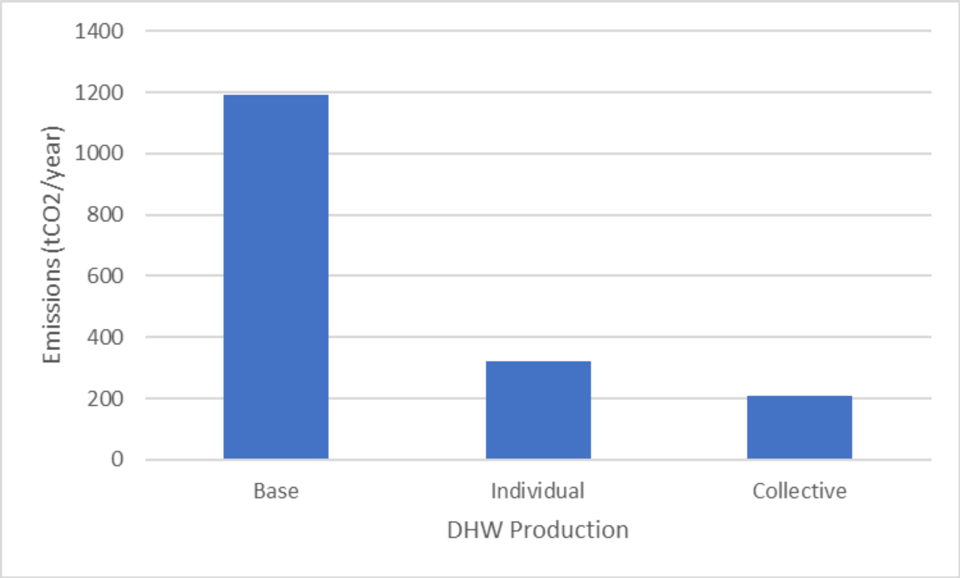


DHW demand

DHW production correspond to 284 kg COP2/year per dwelling
And 662 kgCO2/year per dwelling is associated to electricity

Results

- Impact of HP for DHW

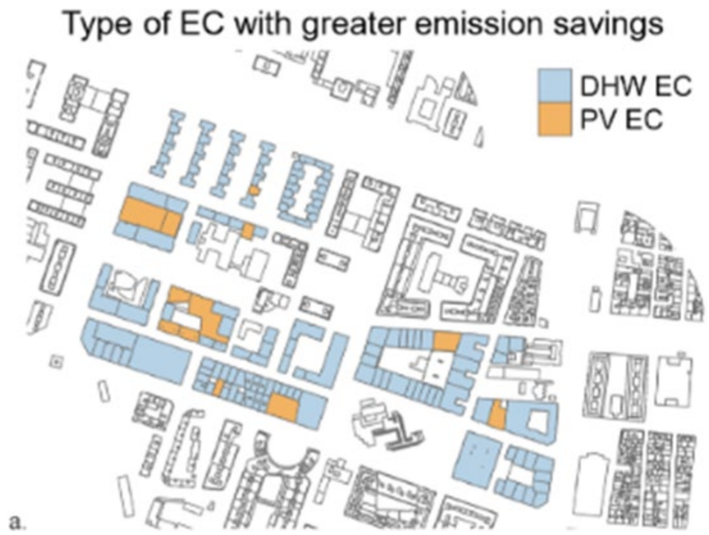


- ❑ Potential saving of approx 70% of emissions associated to DHW by the introduction of HP in the domestic sector.
- ❑ This amount could be increased up to almost 80% is collective instalations per building are considered.
- ❑ The collective instalation will require 60% less of heating capacity but 85% less water storage volumen than a system based on individual installations.

Results

Photovoltaic potential:

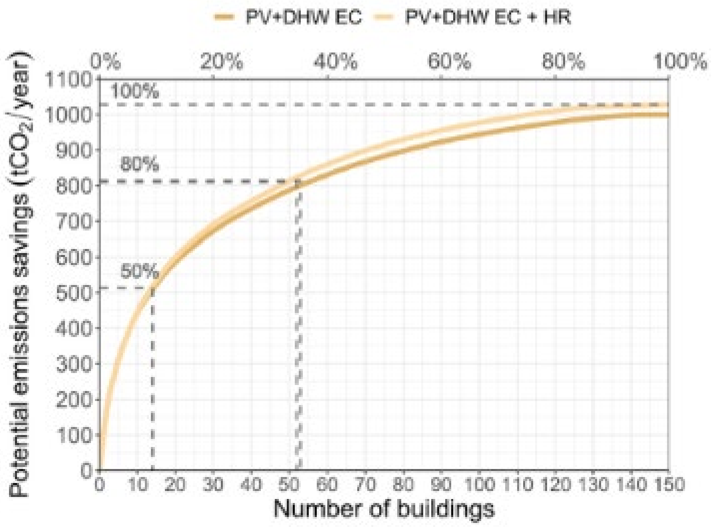
- Minimum available area without shadows 7 m2
- 1.5 m2 from roof walls
- Minimum width of 1m
- EC for each building.



Fuster-Palop E, Prades-Gil C, Masip X, Viana-Fons JD, Paya J. Innovative regression-based methodology to assess the techno-economic performance of photovoltaic installations in urban areas. Renew Sustain Energy Rev Oct. 2021;149:111357.

- ❑ Only 55% of the total roof area is available for installing PV pannels.
- ❑ The PV could reduce the energy emissions up to 55% in some specific buildings.
- ❑ PV is able to reduce the CO2 emissions in the neighbourhood of 23%.
- ❑ Combining PV panels with collective HP systems for DHW could derive in 55% emissions savings.

Results



Acting on 10% of the building will imply 50% of savings

Acting on 35% of the buildings will imply 80% of savings.

Conclusions

- The use of heat pumps for satisfying the DHW demand shows a high potential to reduce the CO_2 emissions in cities.
- The development of Thermal Energy communities to satisfy this demand increase the effectivity of these systems and reduce the volumen required for thermal storage.
- Although PV energy communities are receiving a significant attention they have a limited potential of reducing the emisions in zones with high population density.
- A combination of both strategies could reduce the emisions in more than 50%.

Thanks for your attention!