Energy sector coupling: electric-thermal interaction through heat pumps

Tuesday 23th of October 2018

eurac research – *Institute for Renewable Energy*

NOI Tech Park, via A. Volta 13/A, Bolzano

This workshop has received funding from the EFRE- FESR 2014- 2020 programme- project "INTEGRIDS" n. 1042

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Integrids

eurac research

INTEGRIDS and FLEXYNETS projects

DHC networks, heat pump pools, and DSM

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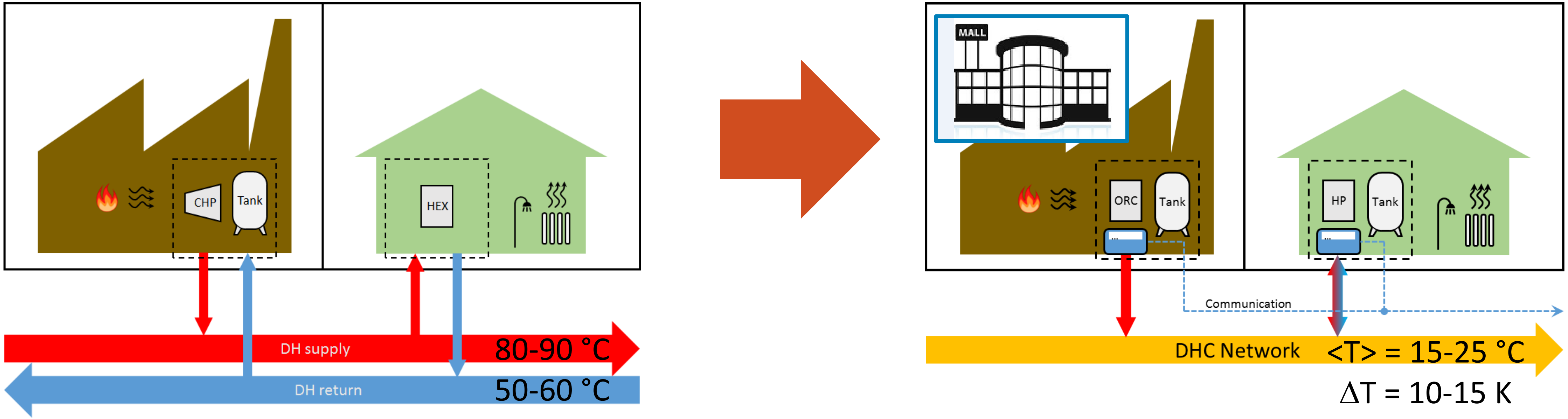
Eurac Research – Institute for Renewable Energy

Workshop on "Energy sector coupling: electric-thermal interaction through heat pumps"
Bozen October 23rd, 2018

District Heating and Cooling with Heat Pumps

Traditional

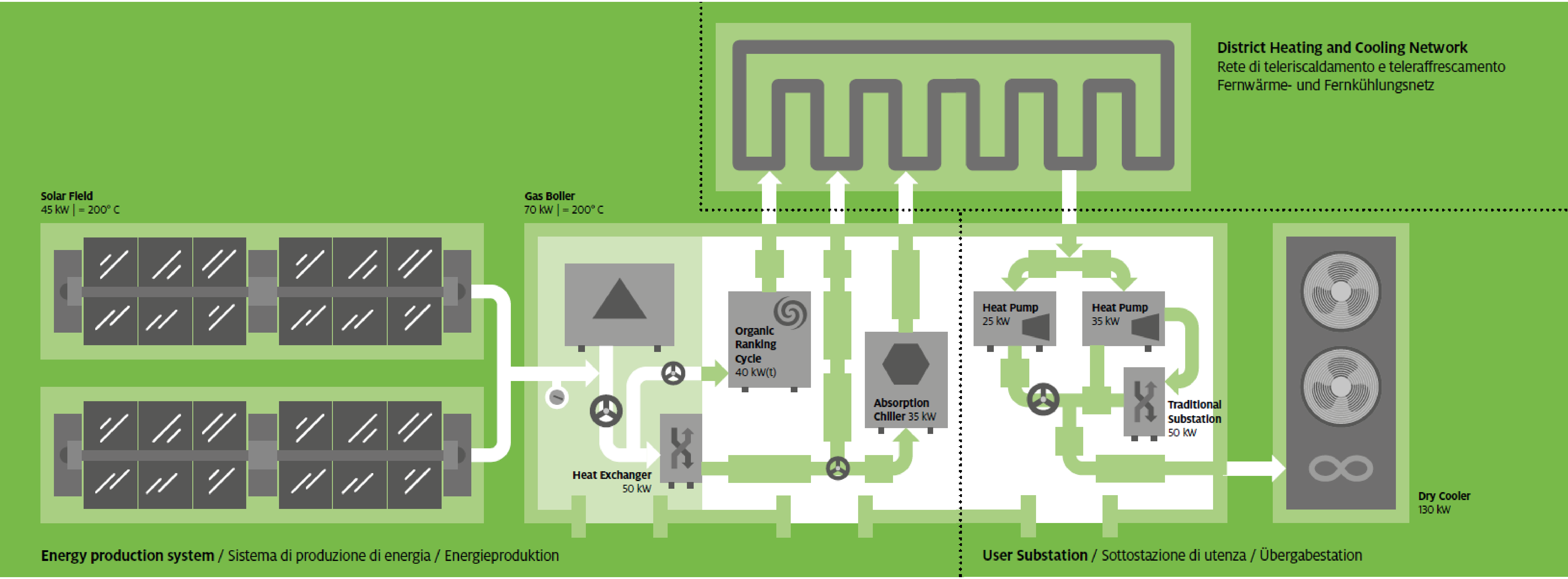
FLEXYNETS



FLEXYNETS

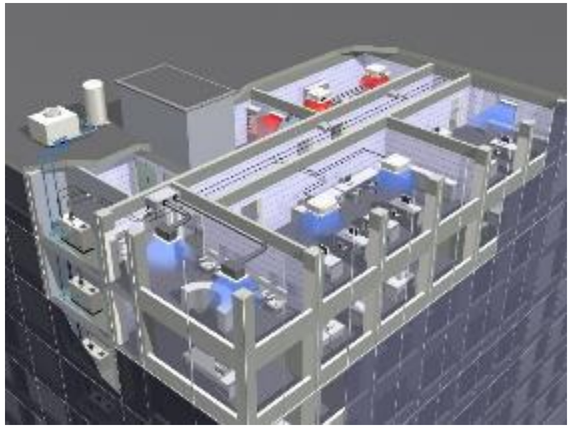
http://www.flexynets.eu

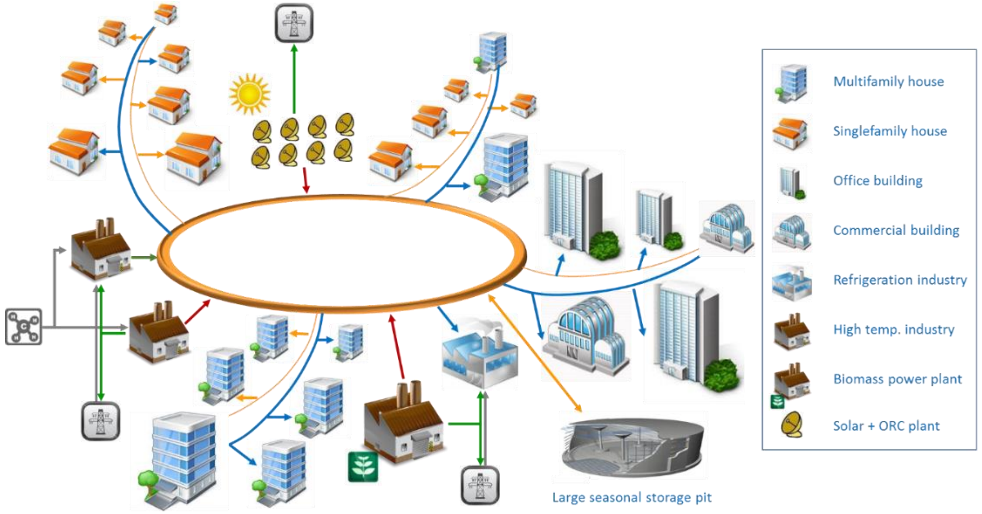
Laboratory – Energy Exchange lab



The FLEXYNETS approach

From the water-loop concept to a decentralised low-temperature DHC network



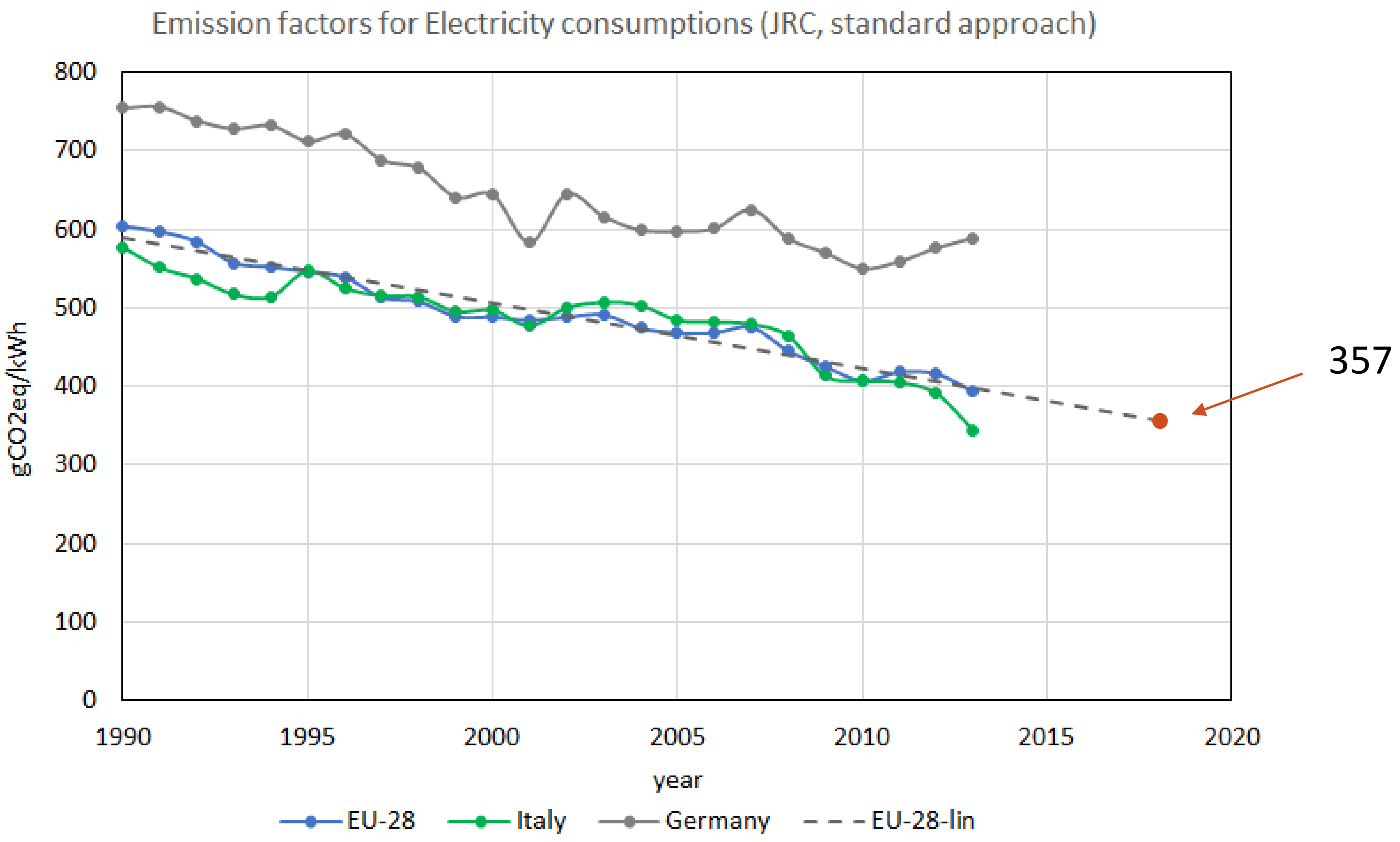


Disadvantages:
- Electricity costs (HPs and pumping)
- Heat pump investment costs

Advantages:
- Reduction of thermal losses or pipe costs
- Reversibility (heating AND cooling)
- Direct integration of low temperature waste heat
- Coupling with electric grid

Electricity CO2 emissions

Natural gas:
250 gCO2/kWh



Potential study on DSM in DHC networks with decentralized HPs

Buffa S., Cozzini M., Henze G. P., Dipasquale C., Baratieri M., Fedrizzi R.

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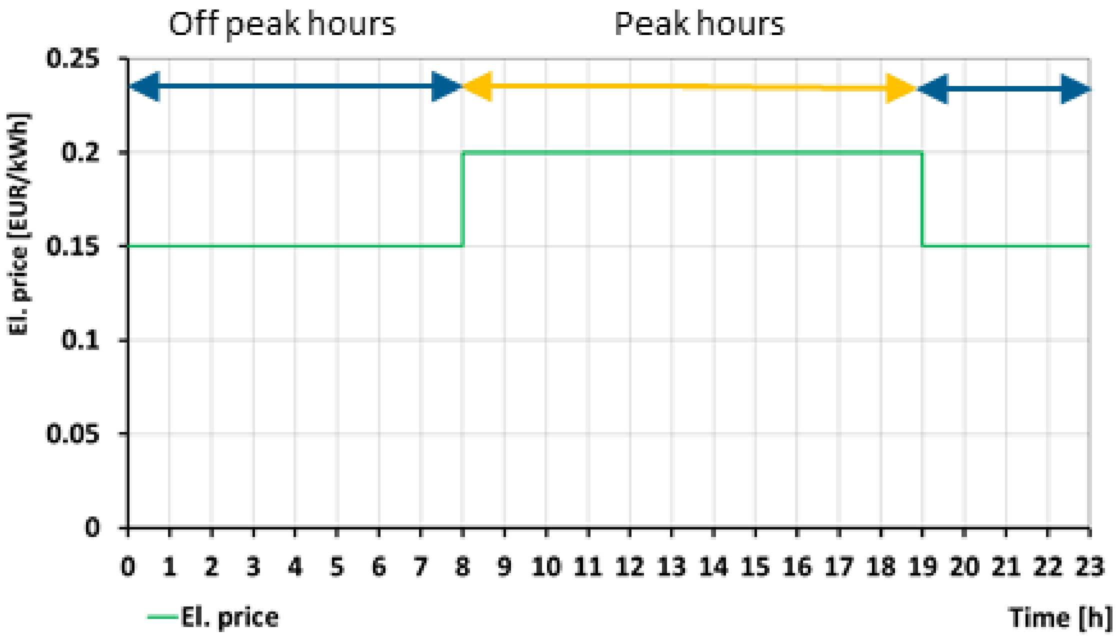
Free University of Bolzano

ISEC 2018, Graz

DSM in DHC networks with HPs

Time-of-use pricing
(as opposed to real-time pricing)



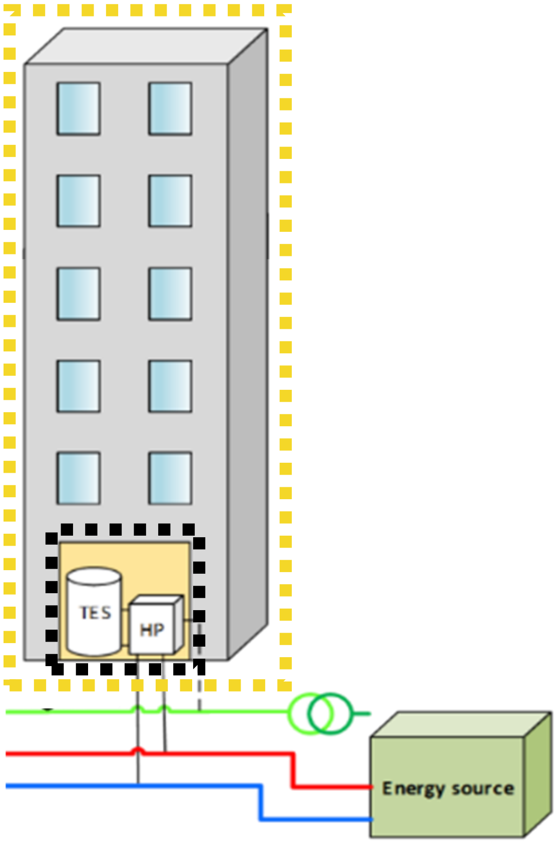
Possible DSM strategy:

- Exploit **DHW tank** for thermal flexibility
- Control **HP** for **DHW production** according to pricing

DHW demand always present (no seasonality)
DHW tank always present (with HPs)

Building model

TRNSYS model



Building type: multi-family house (s-MFH) of 10 apartment

Space heating (SH) net demand: ~ 45 kWh/(m^2 year)

Domestic Hot Water (DHW) demand: ~ 25 kWh/(m^2 year)

Heated surface: 50 m^2 per apartment

Occupancy level: 2 people/apartment

Water-source heat pump (WSHP) capacity: ~ 25 kWth

DHW TES capacity: 450 litres

DHC energy source: ideal thermal source suppling heat at the desired temperature set-point

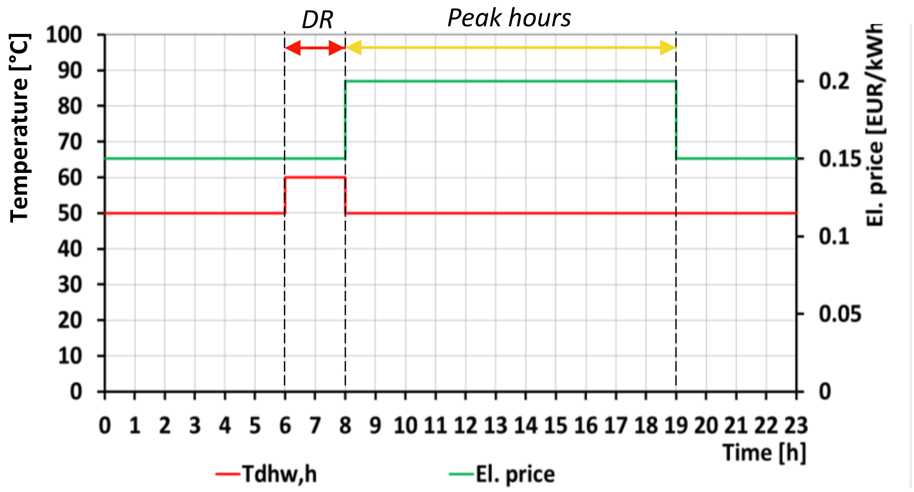
Price vs efficiency

Overall cost = amount of electricity × electricity price

(+ minor effects…)

Competing effects:
- Exploit **lower pricing**, thanks to thermal storage
- Suffer **higher electricity consumption**, due to higher temperature and lower efficiency

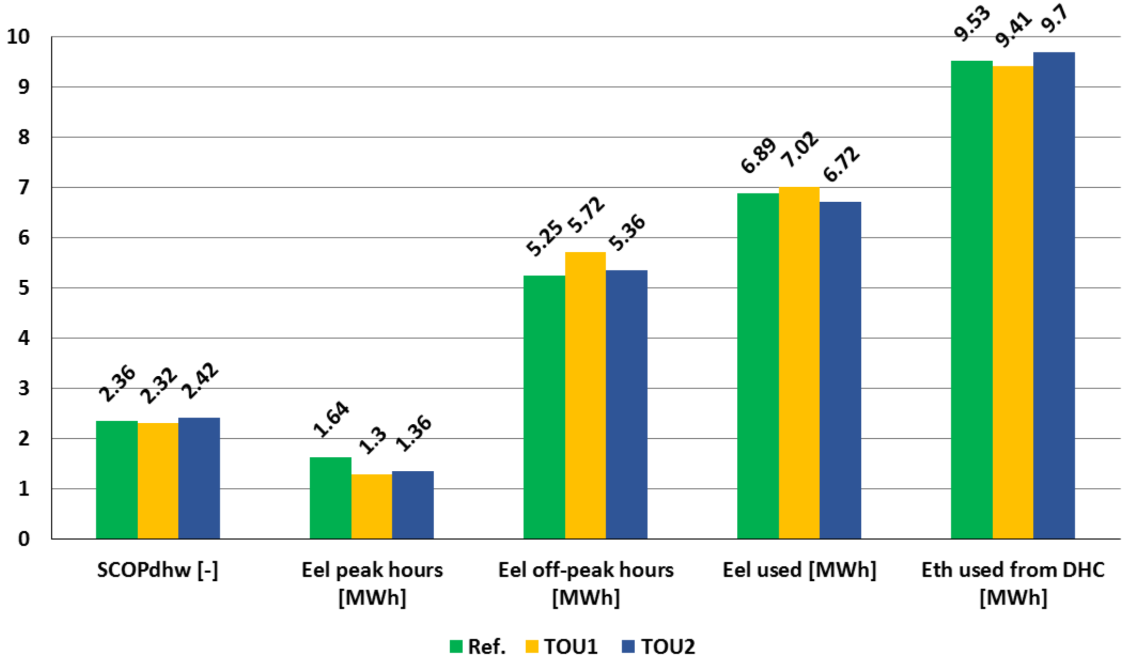
$$c_{el,off-peak}\,\frac{(E_{th}+E_{th,add.\,losses})}{COP_{DR}} < c_{el,peak}\,\frac{E_{th}}{COP_{max}}$$



Results: energy assessment

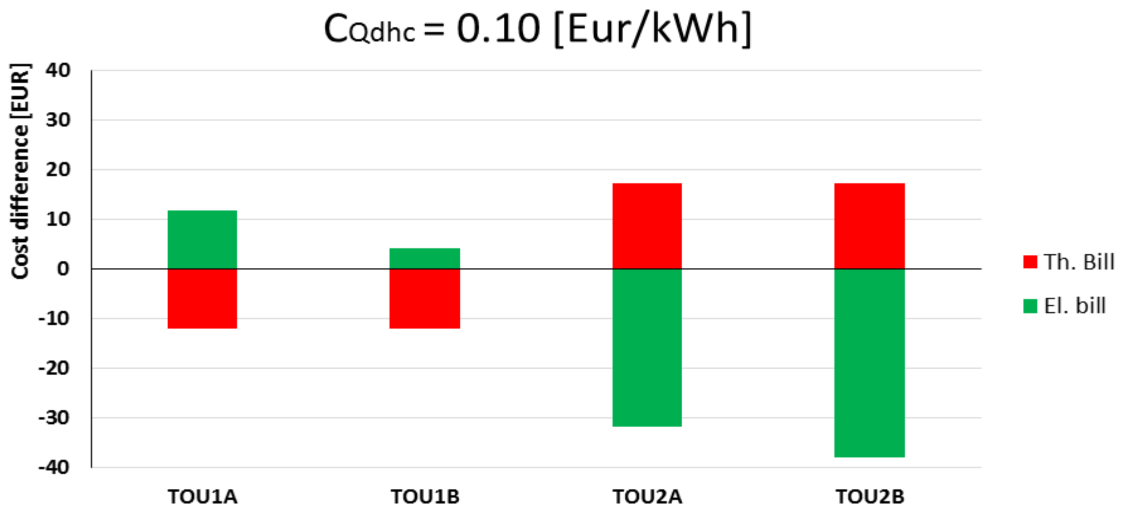
Reference vs scenarios based on time-of-use pricing DSM (yearly simulations):

- TOU1: constant network temperature (10 °C)
- TOU2: optimized network temperature (10-20 °C)



Results: economic assessment

	Unit	Scenario TOU1A Tdhc const. (10°C)	Scenario TOU1B Tdhc const. (10°C)	Scenario TOU2A Tdhc var. (10÷20°C)	Scenario TOU2B Tdhc var. (10÷20°C)
Cel off-peak /Cel peak	[-]	0.87	0.77	0.87	0.77
Eel prices off-peak hours	[EUR/kWh]	0.15	0.15	0.15	0.15
Eel prices peak hours	[EUR/kWh]	0.17	0.20	0.17	0.20



ΔTot costs	[EUR]	-0.4(-0.02%)	-7.9(-0.4%)	-14.6(-0.7%)	-20.8(-1%)

Conclusions and future work

- Little but non-negligible margin of load shifting with TOU pricing
- Higher impact expected with real-time-pricing
- Flexibility comes at the price of slightly higher consumptions

- Tank temperature variation limits to be investigated
- Optimization to be performed
- Analysis for a single substation: pool effect to be investigated
- DSM based on electricity real-time emission factors rather than pricing

… and much more…

Thank you for the attention!

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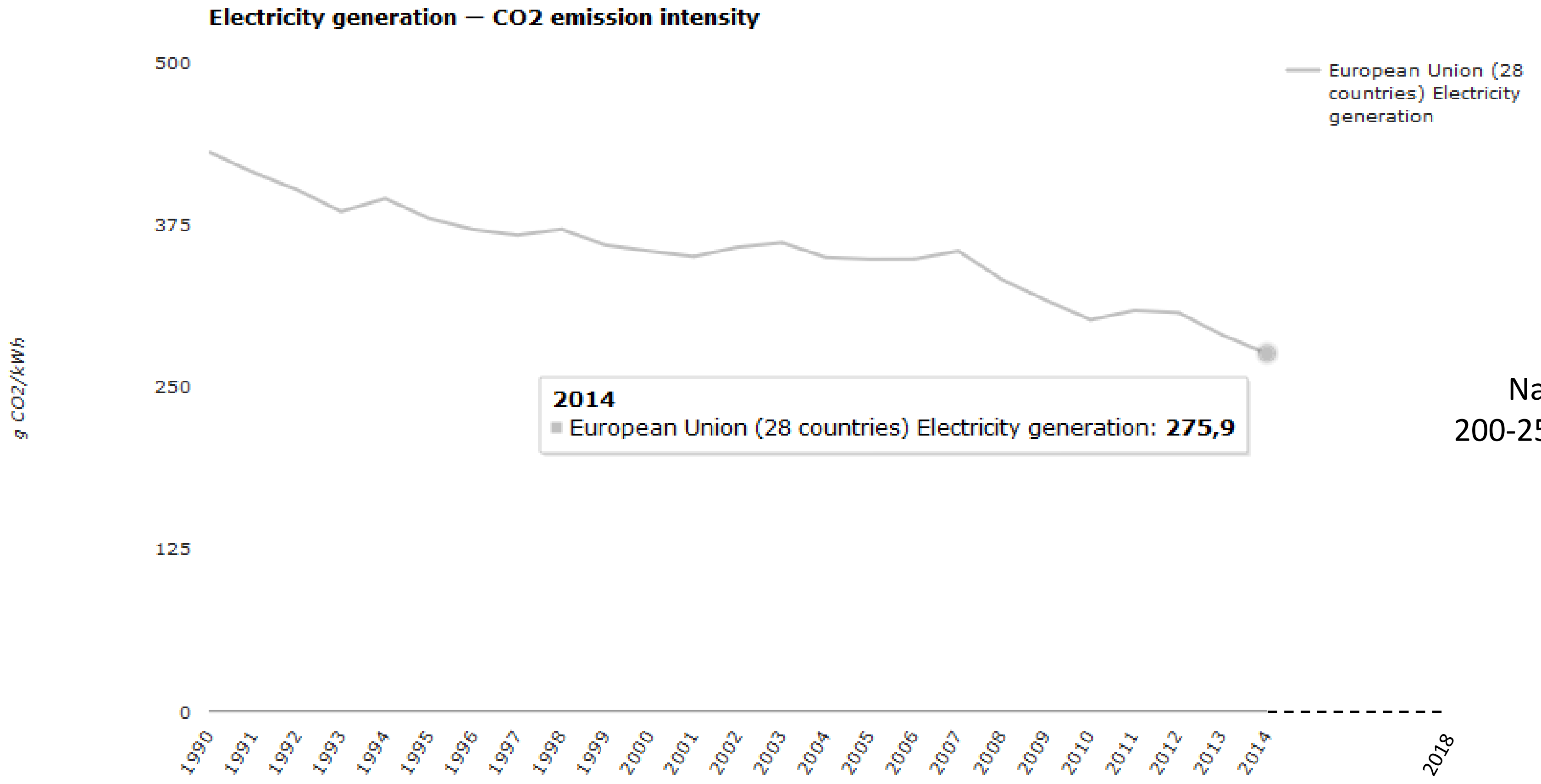
Electricity CO2 emissions

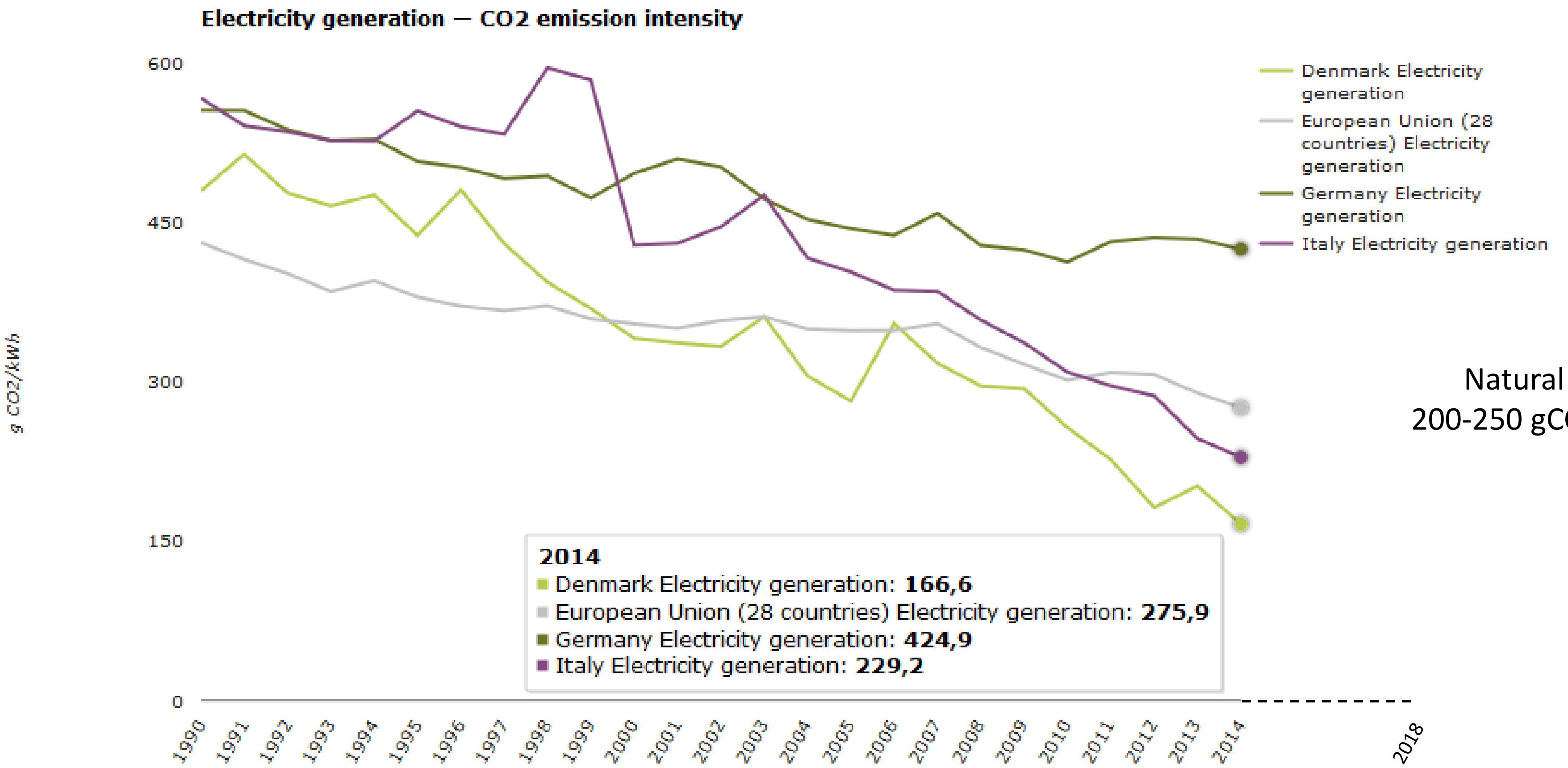
European Environment Agency



Natural gas:
200-250 gCO2/kWh

Electricity CO2 emissions

European Environment Agency



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