International Conference

GEO4CIVHIC

Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings

15th November 2023

Grand Hotel Excelsior - Great Siege Road, La Valletta - Malta

Co-funded by the European Union

Sizing GSHP and hybrid technologies for shallow geothermal design applied to real and virtual case studies

NAME

MICHELE DE CARLI, SAMANTHA GRACI, GIUSEPPE EMMI, LAURA CARNIELETTO, SARA BORDIGNON, ANGELO ZARRELLA

ORGANISATION

UNIVERSITY OF PADOVA

EMAIL

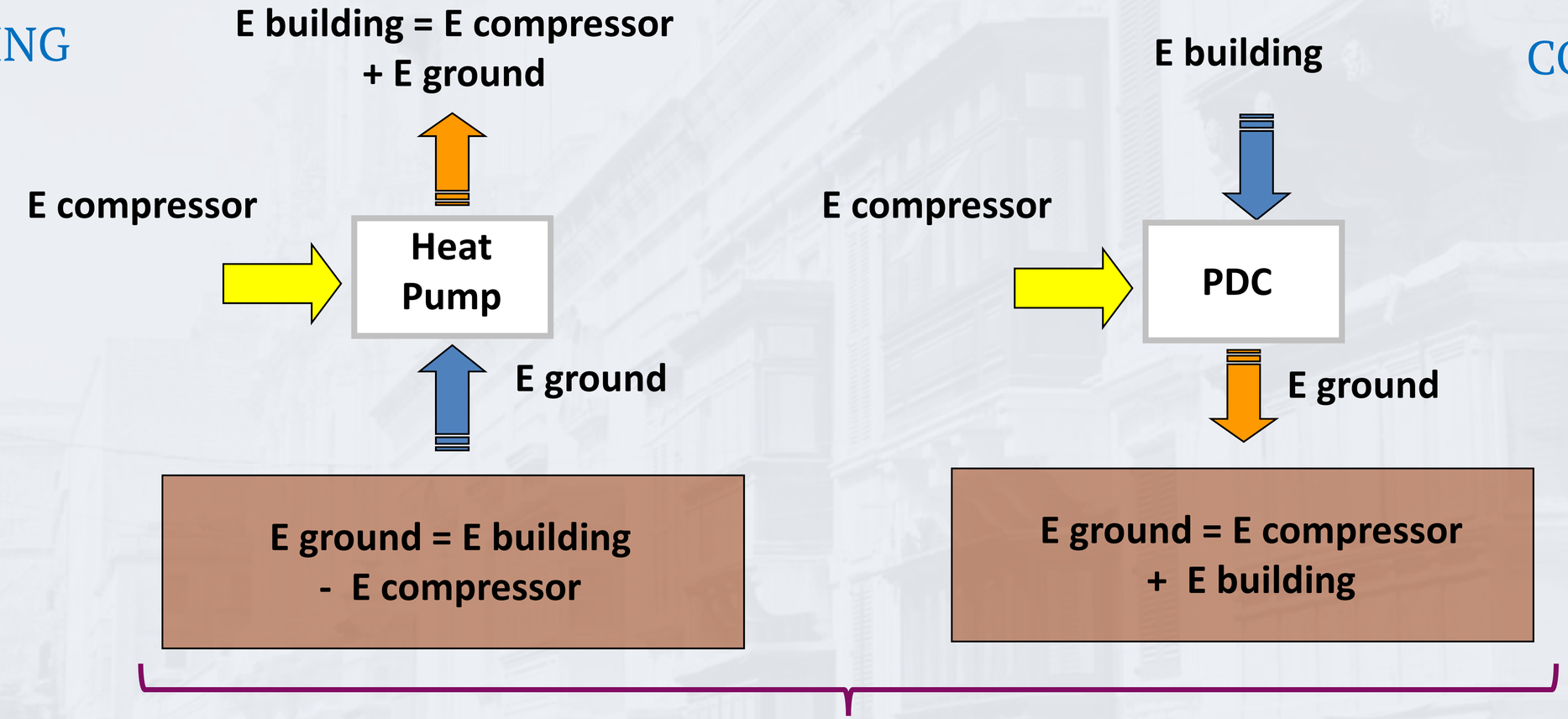
michele.decarli@unipd.it

WEBSITE

https://research.dii.unipd.it/betalab/

Co-funded by the European Union

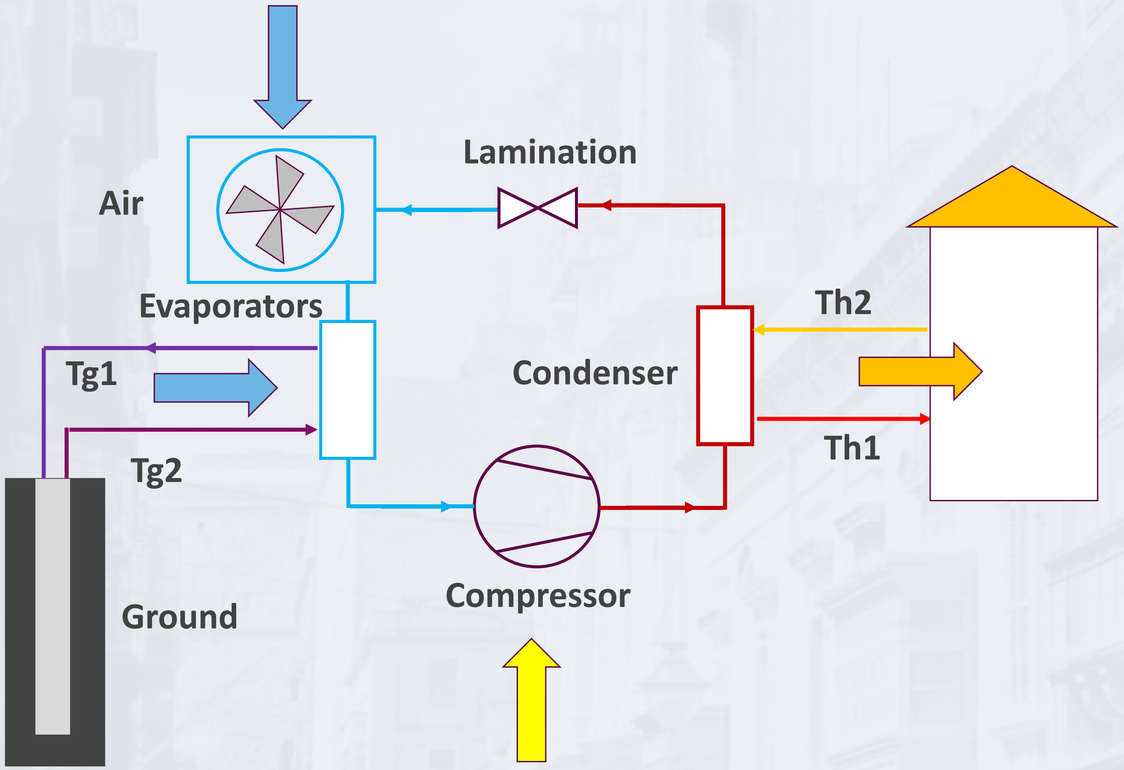
Energy in buildings and energy in the ground

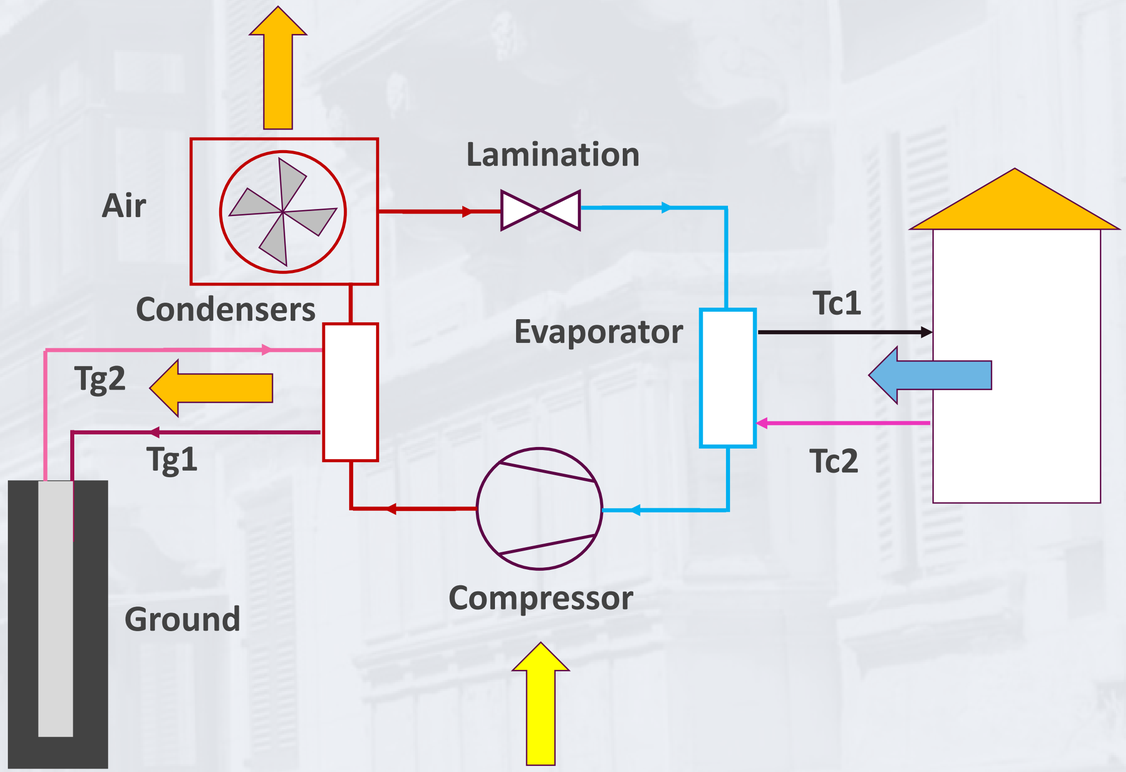


Energy in the ground should be balanced between heating season and cooling season

Co-funded by the European Union

What is a hybrid solution?





Hybrid solution means that air is also used as:

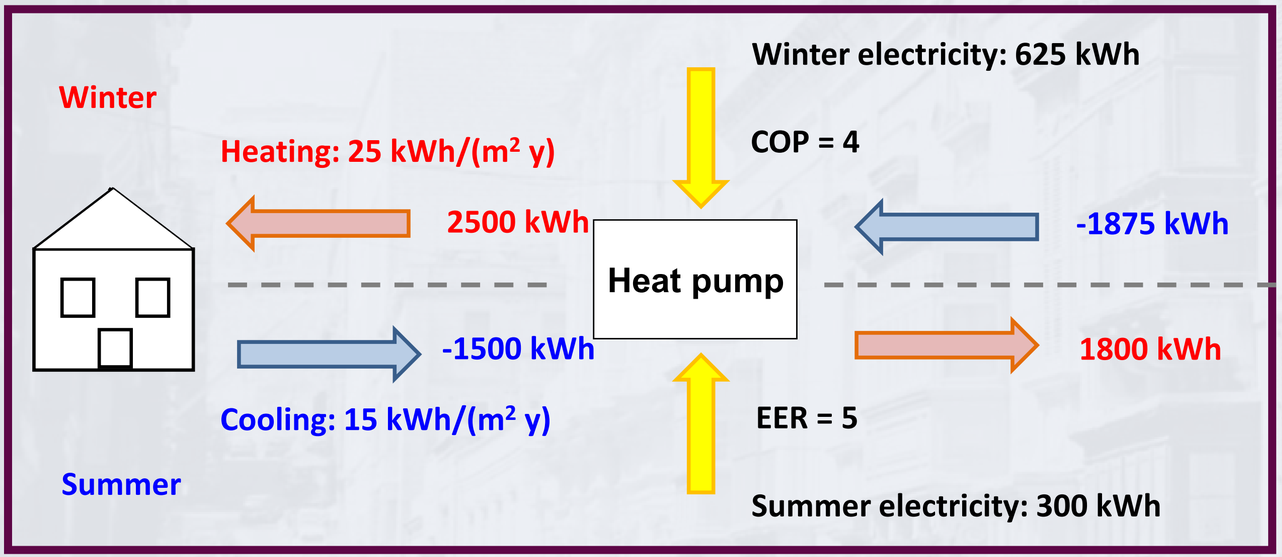
- Source in winter
- Sink in summer

Co-funded by the European Union

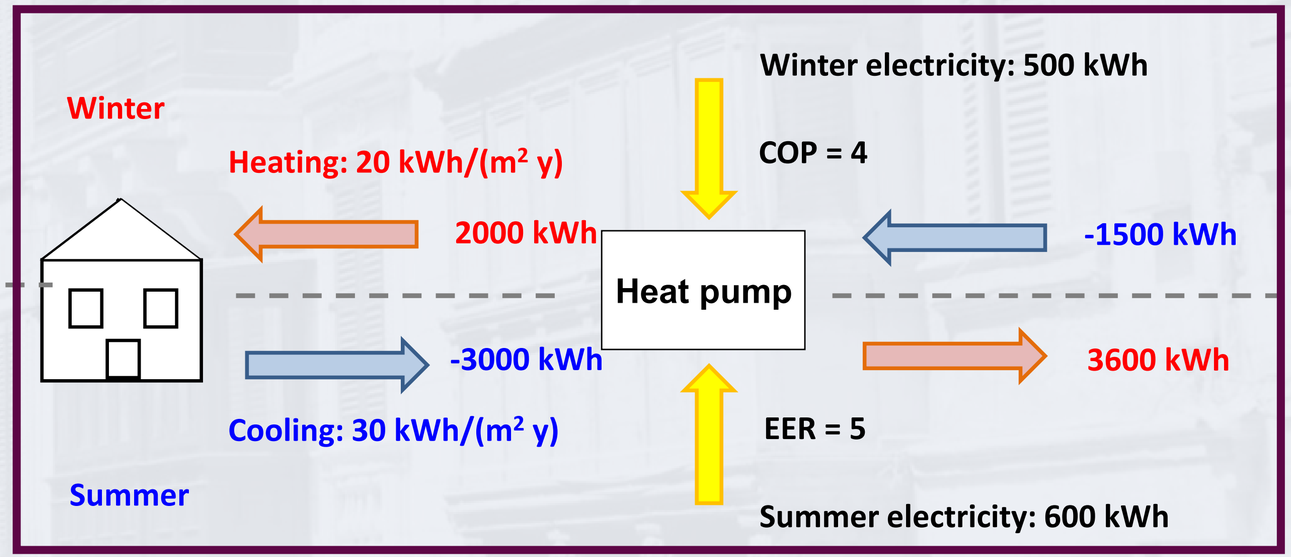
PROBLEM #1:
the balance of the energy needs

Building with a floor area of 100 m^2

building heat demand > building cooling demand



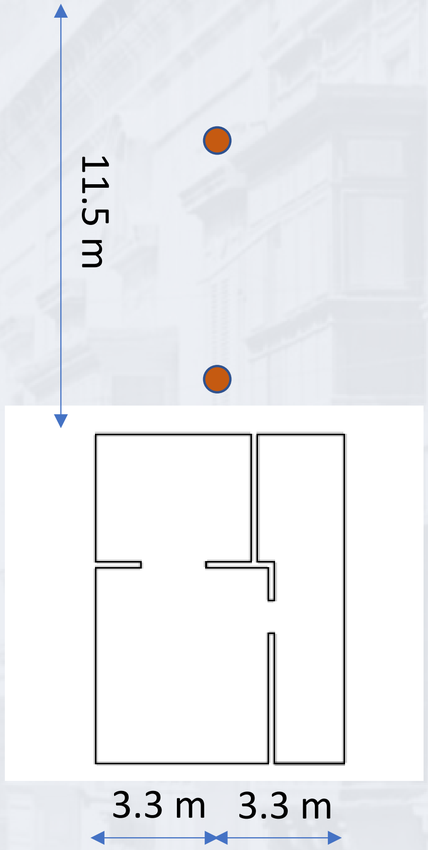
building heat demand < building cooling demand

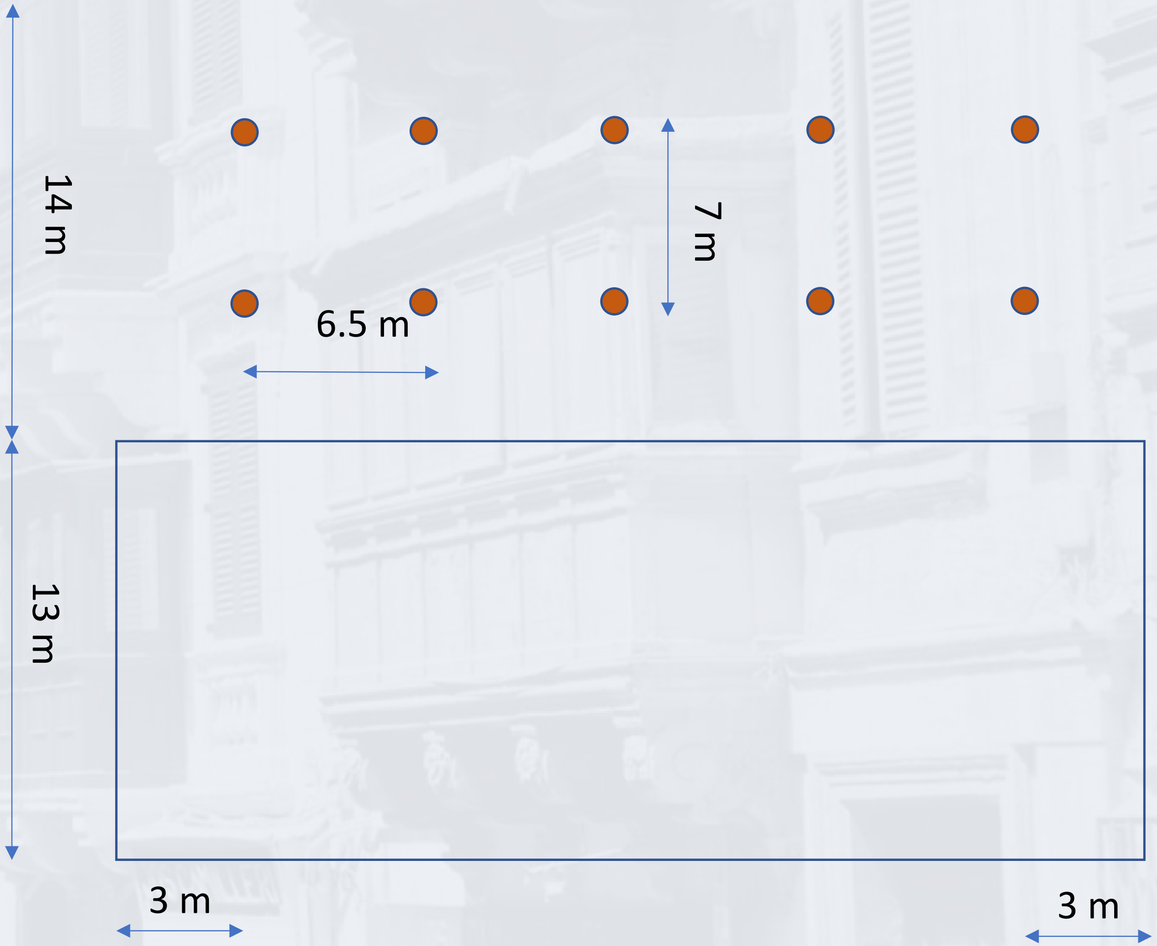


Co-funded by the European Union

PROBLEM #2:
available space in the surrounding area of the building

Example of potential space in an urban environment for a terraced house and an apartment block, which are the most common types of buildings in urban environments





Co-funded by the European Union

CASE STUDIES

- Real case studies: case studies where some specific innovations have been tested
- Virtual case studies: case studies where a feasibility analysis has been done based on measured data or on detailed simulations

In the former project Cheap-GSHPs there have been
6 virtual case studies

In GEO4CIVHIC there have been
14 case studies

Co-funded by the
European Union

VIRTUAL CASE STUDIES IN CHEAP-GSHPs

- Virtual cases represent different **historical buildings in Europe**: different archetypes, different uses, different climates, different grounds

- Almost all the considered historical buildings present higher heating demand and a limited cooling demand (energy required for **heating** is as average **about 10 times the energy for cooling**)

- This unbalanced condition can cause an **undercooling effect in the ground**; using solar collectors to restore the temperature in the ground is complicated when dealing with historical buildings (local regulations for the roof).

- The simulations have anyway shown that a **small undercooling** may happen, but, if the sizing of the BHEs field is done properly there is no risk to have too low temperatures in the ground and consequently risk a poor operation of the GSHP.

- In terms of final energy, regardless to the type of building (small or large), relative age (very old or modern), use (residential, museum or office) **the final energy saving is between 70% and 75% (with fan-coils)**.

Co-funded by the European Union

GEO 4 CIVHIC

Co-funded by the European Union

VIRTUAL SITES IN GEO4CIVHIC

Small size

Residential Romania 1

Residential Romania 2

Small-medium size

Library in Greece (H)

Administrative building Spain (H)

Medium-large size

University Germany (H)

Residential Holland

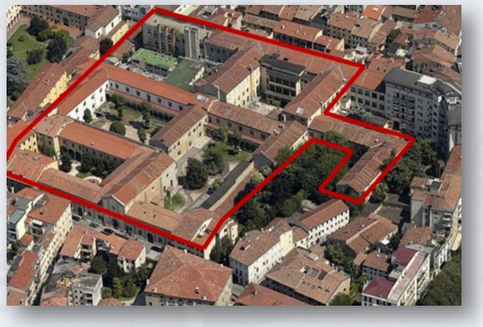
Library Ireland (H)

Residential Spain

Large size

Castel Belgium (H)

University Italy (H)



University Switzerland

Museum Croatia (H)

Virtual case studies in GEO4CIVHIC

	Before		After			After G4C		
	Boiler	Direct expansion	Envelope	Emission	Generation	Envelope	Emission	Generation
V1		x	x			x	x	x
V2	x				x			x
V3	x						x	x
V4	x		x	x	x	x	x	x
V5	x	x	x	x	x	x	x	x
V6	x				x		x	x
V7	x				x			x
V8	x				x			X
V9	x				x			x
V10	x				x			x
V11	x		x		x	x		x
V12	x		x		x	x		x

Generation system

HVAC & generation system

Deep retrofit

Envelope & generation

Co-funded by the European Union

Case studies subdivided by size

	Just generation	HVAC	Deep retrofit
Small size (< 10 kW)		V3	V4
Small-medium size (~25 kW)	V2		V1
Medium-large size (~50 kW)	V7, V9		V11, V12
Large size (> 80 kW)	V8, V10	V6	V5

Co-funded by the European Union

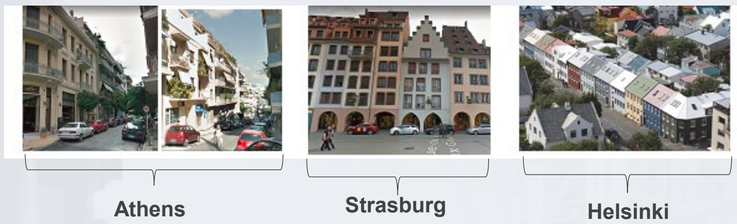
Results on Virtual case studies

	Small size		Small-medium size		Medium-large size		Large size			
	shallow	deep	Generat.	deep	Generat.	deep	gen. V8	gen. V10	shallow	deep
Overall CapEx [k€]	11	21	55	100	110	540	365	645	340	6700
Δ CapEx [k€]	9	9	55	30	110	115	365	645	195	720
OpEx savings [%]	50%	70%	35%	70%	25%	70%	10%	70%	65%	77%
CO_2 savings [%]	50%	90%	55%	60%	30%	70%	30%	30%	80%	80%
ROI	7	8	3	12	20-30	13-21	21	8.5	5.5	23

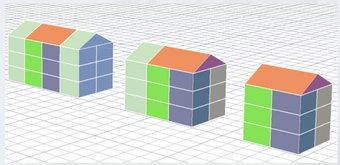
Co-funded by the European Union

Results from archetypes

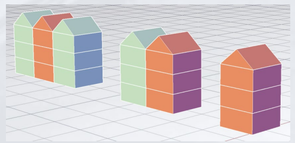
Archetype definition specific for urban areas (cities)



Apartment blocks



Terraced house

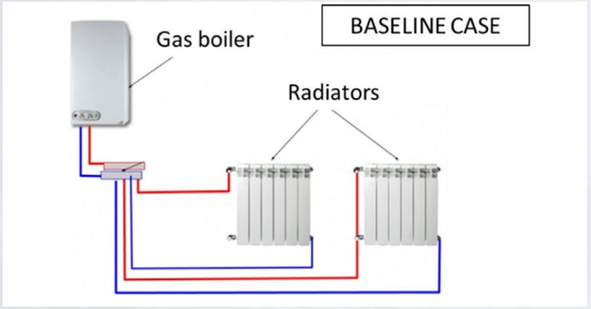


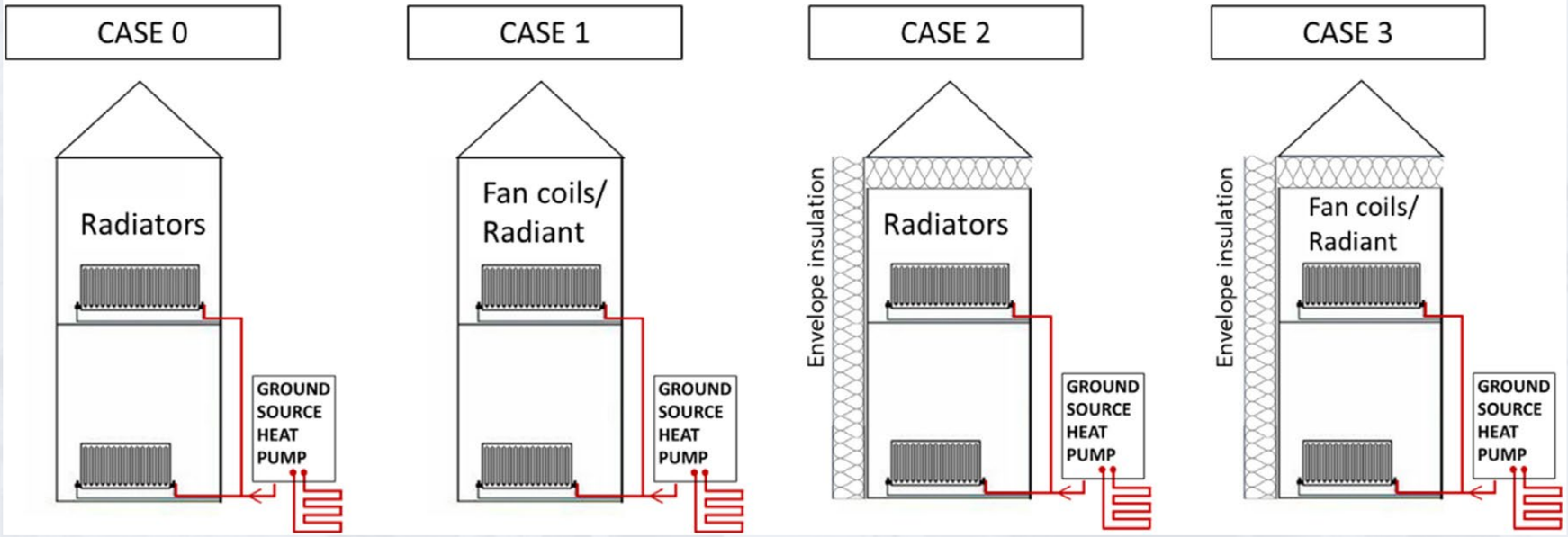
Just replacement of existing boiler with the heat pump (no change in HVAC & envelope)

Retrofit of the HVAC, no retrofit on the envelope

Retrofit on the envelope; replacement of the boiler with HP

Deep retrofit: envelope, HVAC plants and generation system

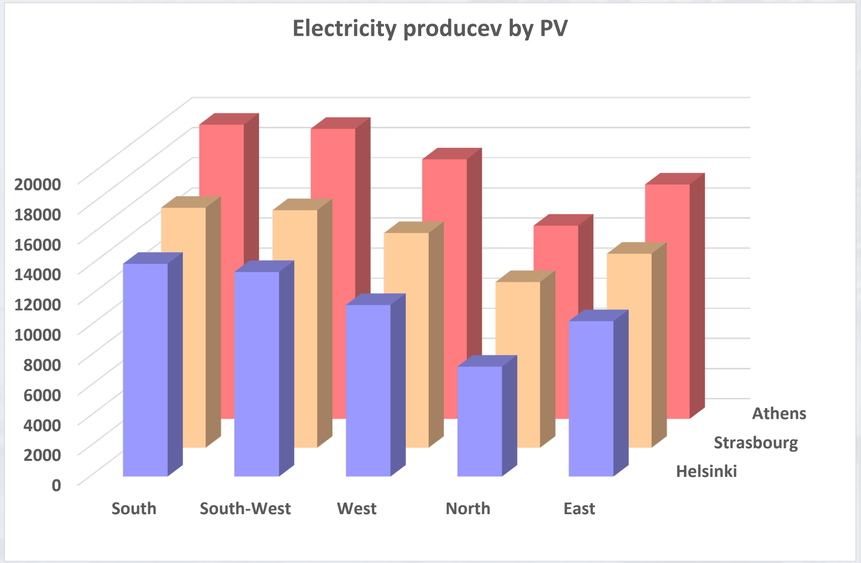




Co-funded by the European Union

Combination of retrofit & PV

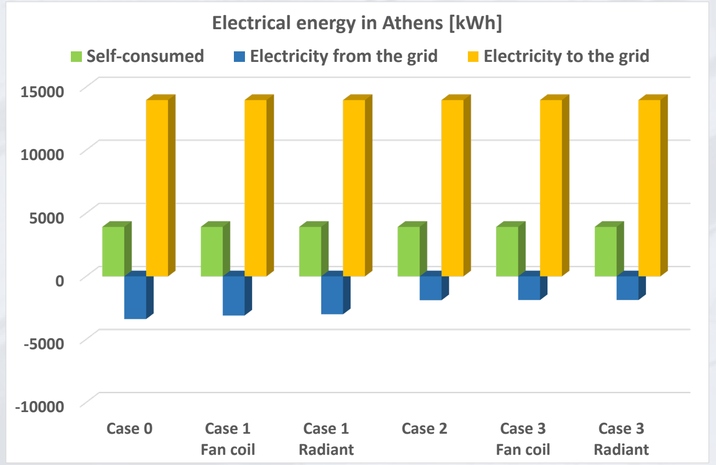
	Gross roof area [m^2]	Roof Inclination
Athens	59	0°
Strasbourg	117	30°
Helsinki	121	40°

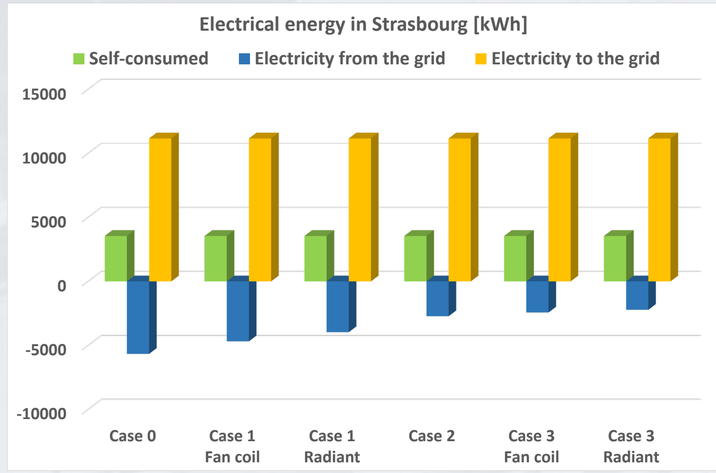


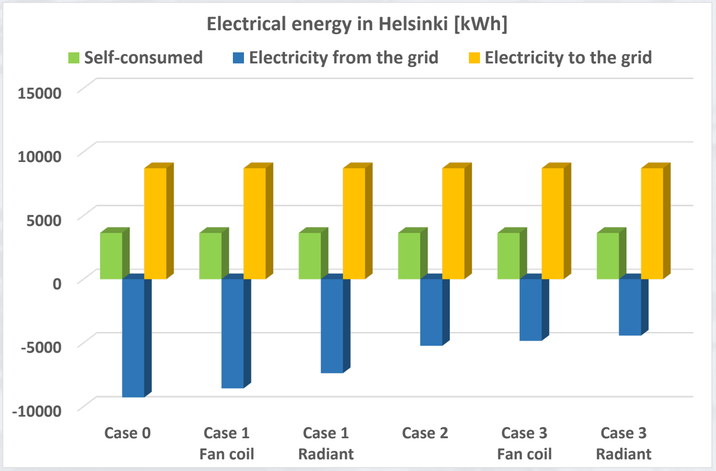
Retrofit + GSHP + PV in Athens

Retrofit + GSHP + PV in Strasburg

Retrofit + GSHP + PV in Helsinki







Co-funded by the European Union

THANK YOU

DII - Department of Industrial Engineering
Università degli Studi di Padova

BETALAB
Building Energy
& Technology Assessment
Research group

https://research.dii.unipd.it/betalab/

/geo4civhic

@geo4civhic

@GEO4CIVHIC

/Geo4Civhic

geo4civhic.eu

Co-funded by the European Union

GEO4CIVHIC has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement number 792355