HYBRIDGEOTABS
PASSIVE COOLING WITH CCA AND GEOTHERMAL ENERGY

September 30th, 2021

Eline Himpe (PhD)
Ghent University, Building Physics group

GHENT UNIVERSITY

hybrid GEOTABS

Atic for HVAC professionals

hybrid GEOTABS

Controlling the power of the ground by integration

HVAC CONCEPT

DEMONSTRATION BUILDINGS

DESIGN TOOLS

hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

hybridGEOTABS concept

hybrid GEOTABS

Atic for HVAC professionals

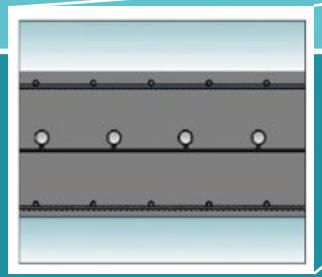
Controlling the power of the ground by integration

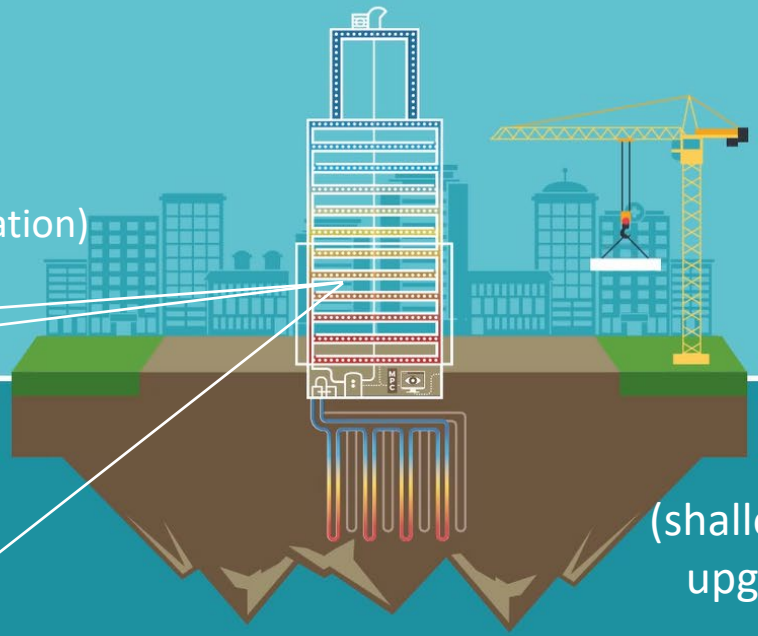
GEOTABS CONCEPT

TABS

Thermally Activated Building System

(e.g. Concrete Core Activation)

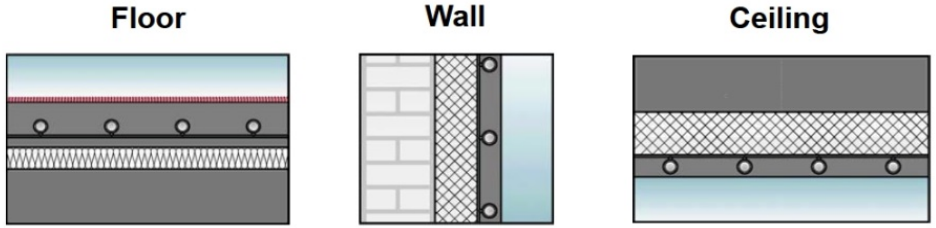




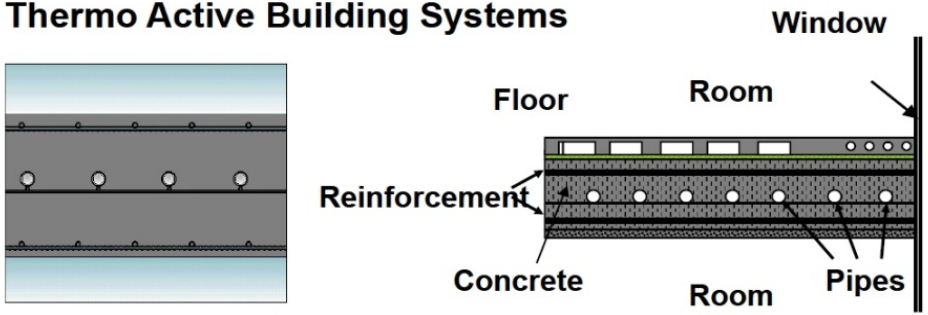
GEO

(shallow) **geothermal energy** upgraded using **heat pump**

RADIANT HEATING AND/OR COOLING SYSTEMS



Thermo Active Building Systems



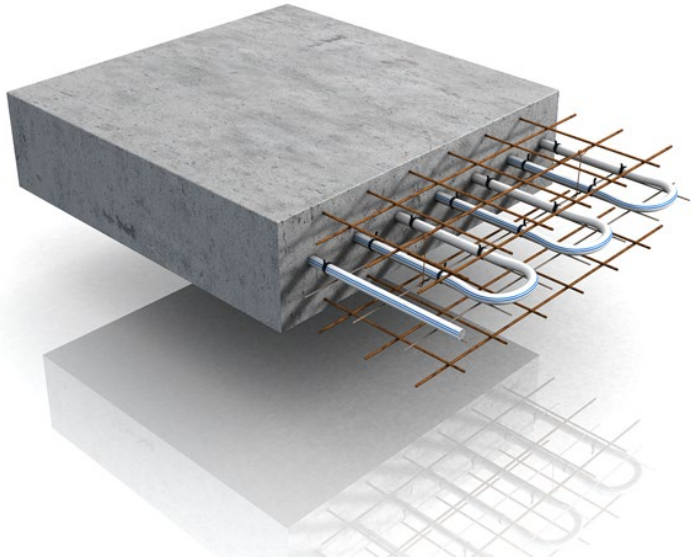
- Sensible heating and cooling emission
- > 50% radiant heat transfer
- ➢ **High thermal comfort & IEQ**
- Uniform temperature distribution
- Minimising risk of draught (↔ all-air systems)
- Quiet operation
- Increased room height (↔ suspended ceilings…)
- Flexibility of space (↔ radiators, FCU…)

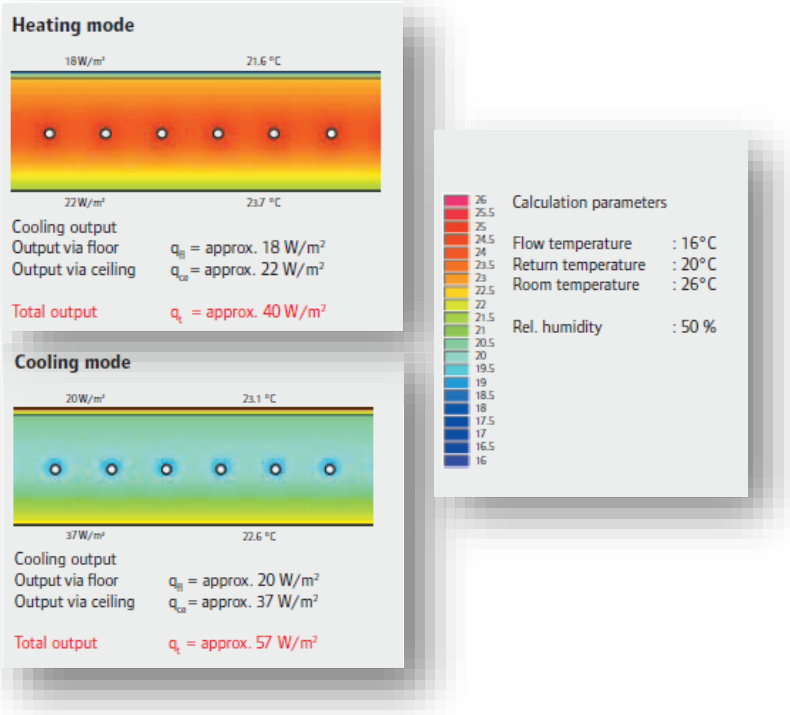
hybrid GEOTABS

Atic for HVAC professionals

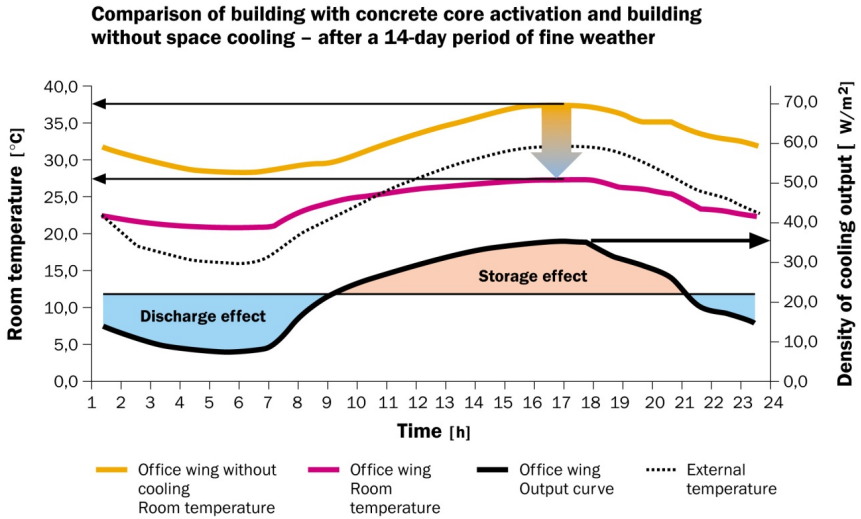
Controlling the power of the ground by integration

ACTIVATING BUILDING THERMAL MASS





THERMALLY ACTIVATED BUILDING SYSTEM



- Close-to-comfort temperatures over entire surfaces
  - Very low temperature heat (24°C-28°C)
  - High temperature cooling (16°C-21°C)
- High thermal inertia emission system
- Short-term (~day(s)) thermal storage

"Smart" features towards electricity grid:

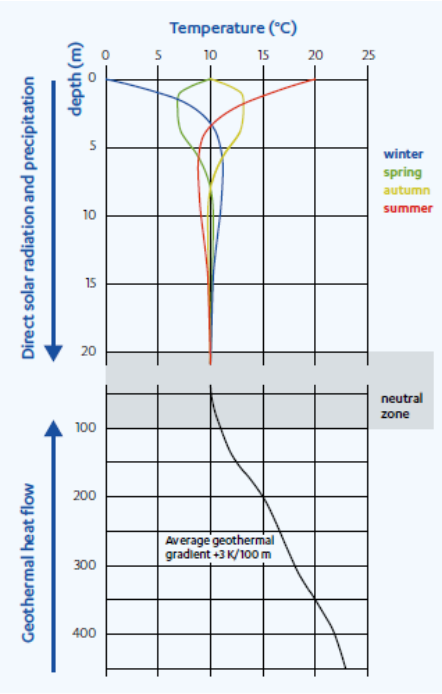
- ➢ Load buffering
- ➢ Peak shaving
- ➢ Grid flexibility

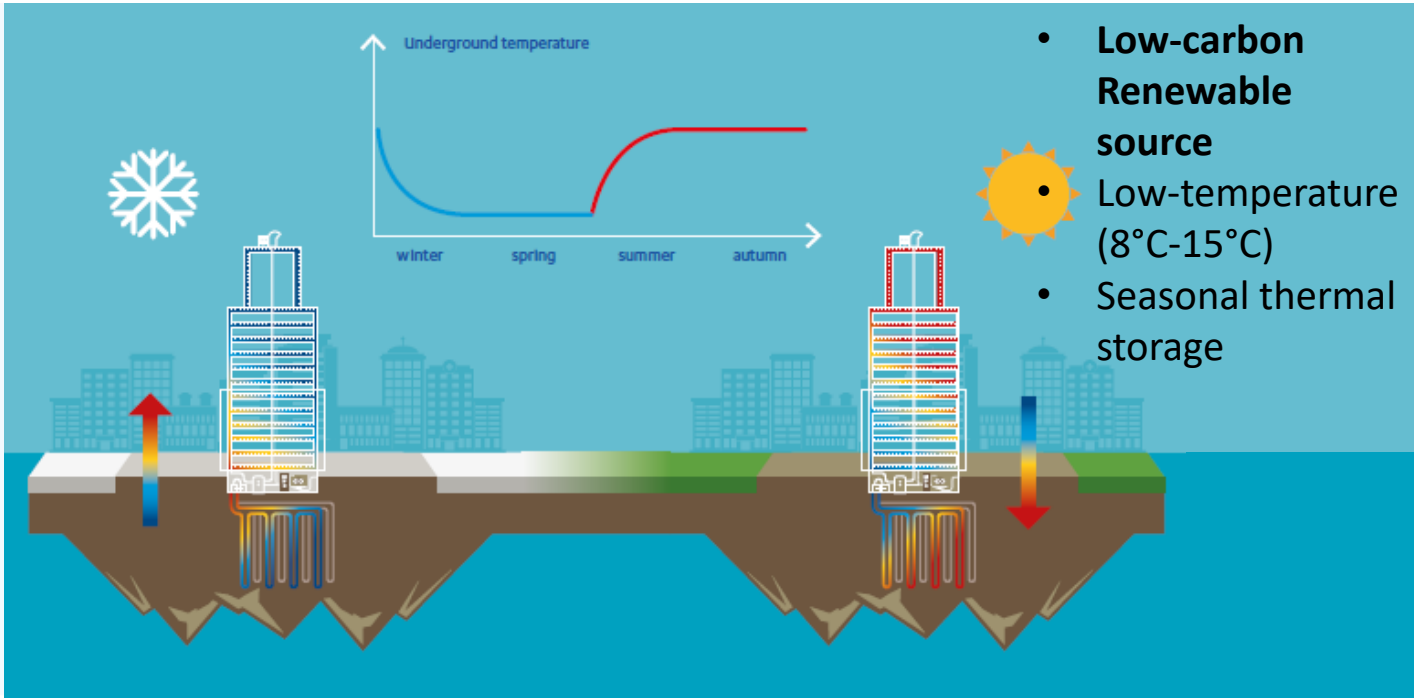
hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

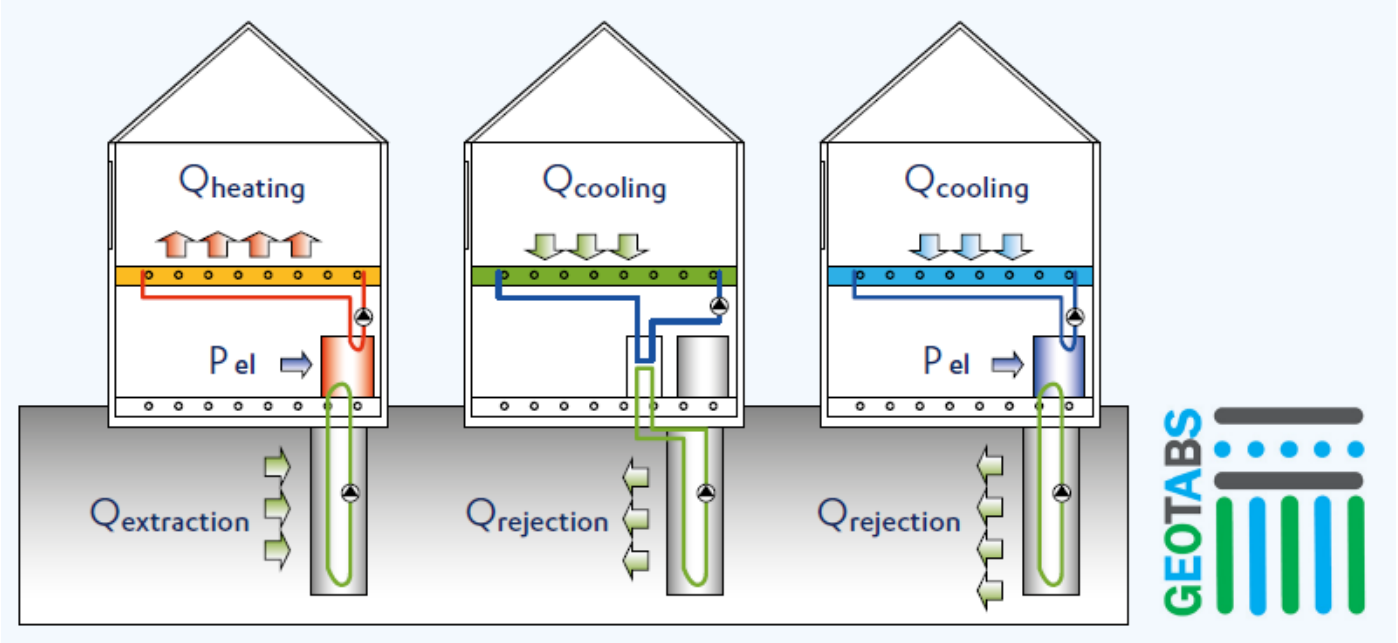
GEOTHERMAL ENERGY





- **Low-carbon Renewable source**
- Low-temperature (8°C-15°C)
- Seasonal thermal storage

GEOTABS WORKING MODES



Heating Passive cooling Active cooling

hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

GEOTABS

TABS

- Radiant heating/cooling
- ➢ High thermal comfort
- High thermal inertia
- ➢ Load buffering, peak shaving
- Low temperature heating (24°C-28°C) & high temperature cooling (16°C-21°C)

GEOthermal

- Low-grade RES
- ➢ Sustainable energy use
- Low-temperature source (8°C-15°C)

HEAT PUMP

- Small ΔT
- ➢ High energy efficiency
- ➢ Passive cooling

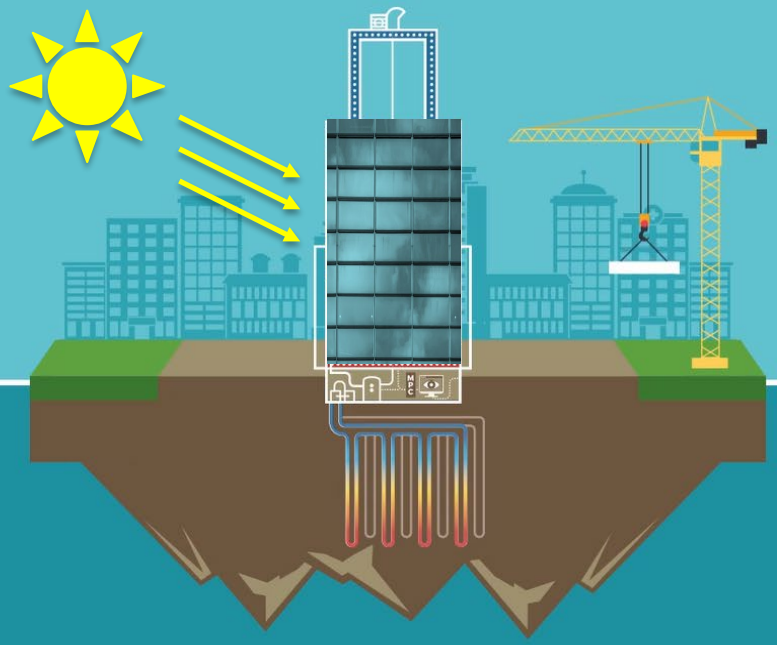
hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

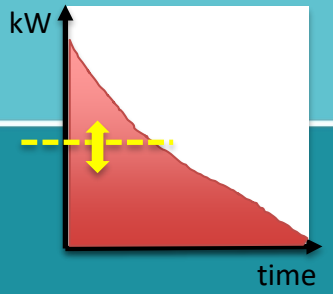
TABS

- High thermal inertia
- ➢ Intra-day shifts
  Heating ↔ cooling?



GEOthermal

- ➢ Technical Feasibility
- ➢ Financial feasibility



hybrid GEOTABS

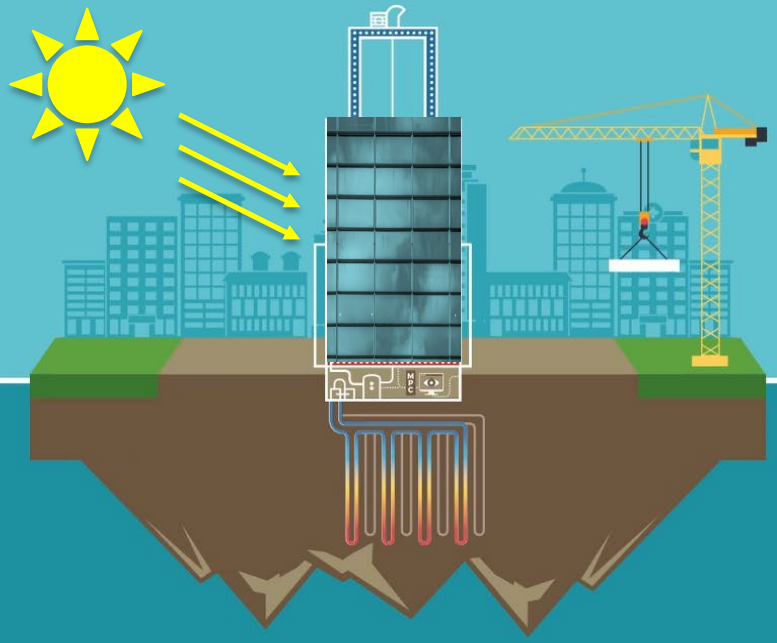
Atic for HVAC professionals

Controlling the power of the ground by integration

"EVERY BUILDING DESERVES A SHARE OF GEOTABS"

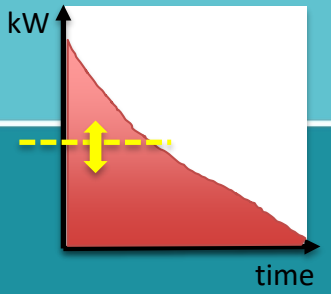
TABS

- High thermal inertia
- ➢ Intra-day shifts
  Heating ↔ cooling?



GEOthermal

- ➢ Technical Feasibility
- ➢ Financial feasibility



hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

hybridGEOTABS

TABS

- Intra-day shifts
  Heating ↔ cooling?
- fast-reacting secondary emission system

GEOthermal

- Technical feasibility
- Financial feasibility
- Secondary energy source

- Optimised control
  MPC

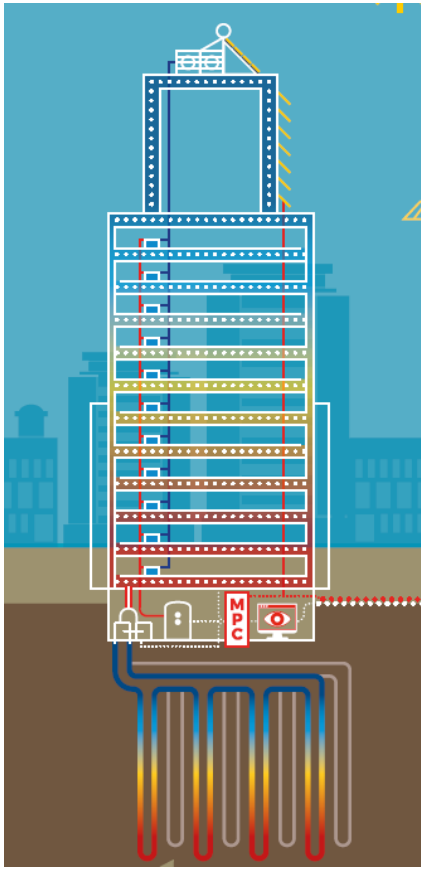
hybrid GEOTABS

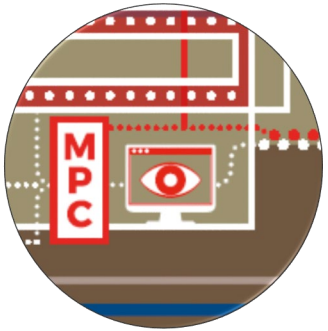
Atic for HVAC professionals

Controlling the power of the ground by integration

Integrated & optimised

DESIGN

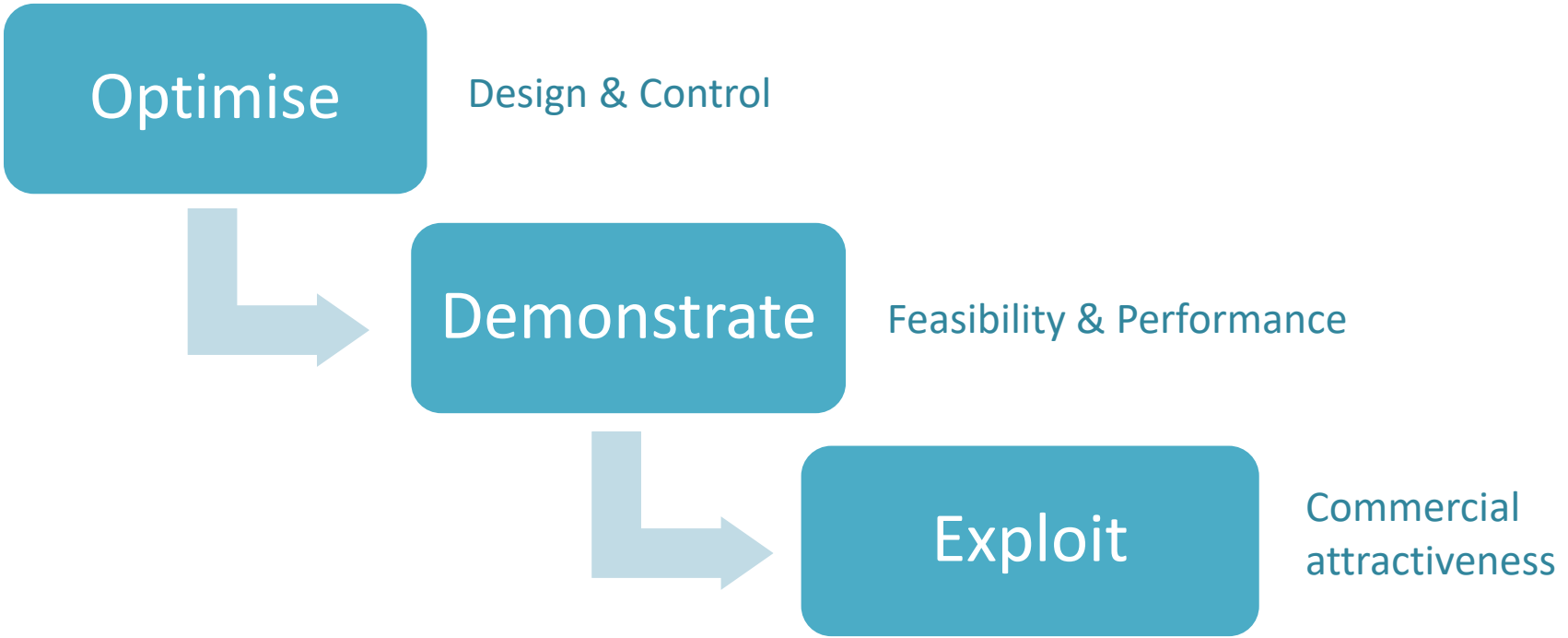




Optimised control

Model Predictive Control

hybridGEOTABS project



hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

PROJECT CONSORTIUM

GHENT UNIVERSITY

boydens engineering

KU LEUVEN

DTU

uponor

ENERGOKLASTR

Maastricht University

climate futures

REHVA Federation of European Heating, Ventilation and Air-conditioning Associations

Geoter GEOTHERMAL ENERGY

VIESSMANN climate of innovation

LEMON • CONSULT • ENERGY • EFFICIENCY • ENGINEERING

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723649. The original project acronym is "MPC-.GT".

hybrid GEOTABS

Atic for HVAC professionals

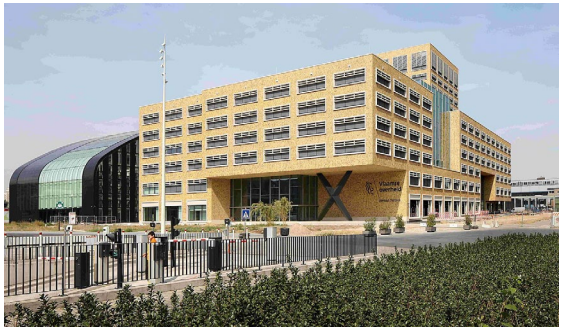
Controlling the power of the ground by integration

hybridGEOTABS demonstration

hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration



hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

Fluvius/Boydens kantoren, Dillbeek

Rusthuis Ter Potterie, Brugge

School in Libeznice, Tsjechië

hybrid GEOTABS

Controlling the power of the ground by integration

DEMONSTRATION BUILDINGS

Libeznice school

Ter Potterie

Infrax/Fluvius office

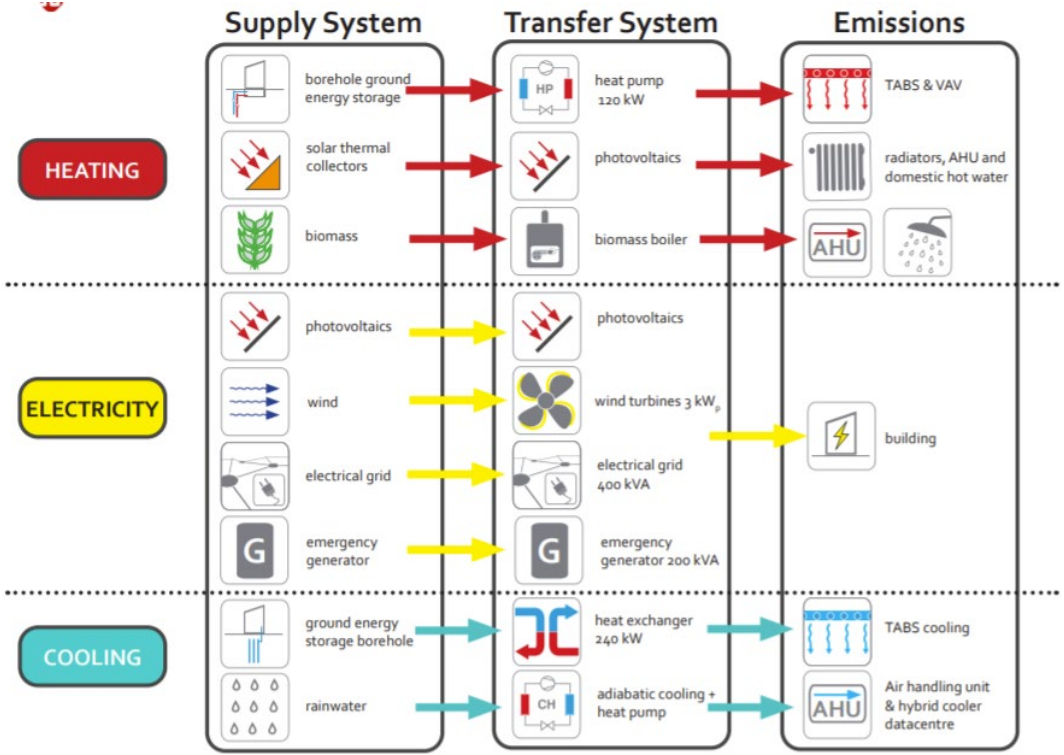
Solarwind

hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

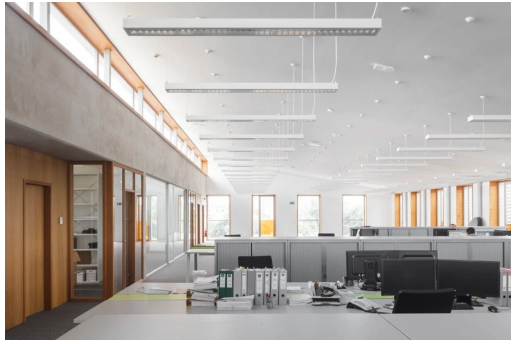
HYBRIDGEOTABS OFFICE IN SOLARWIND (LUX)

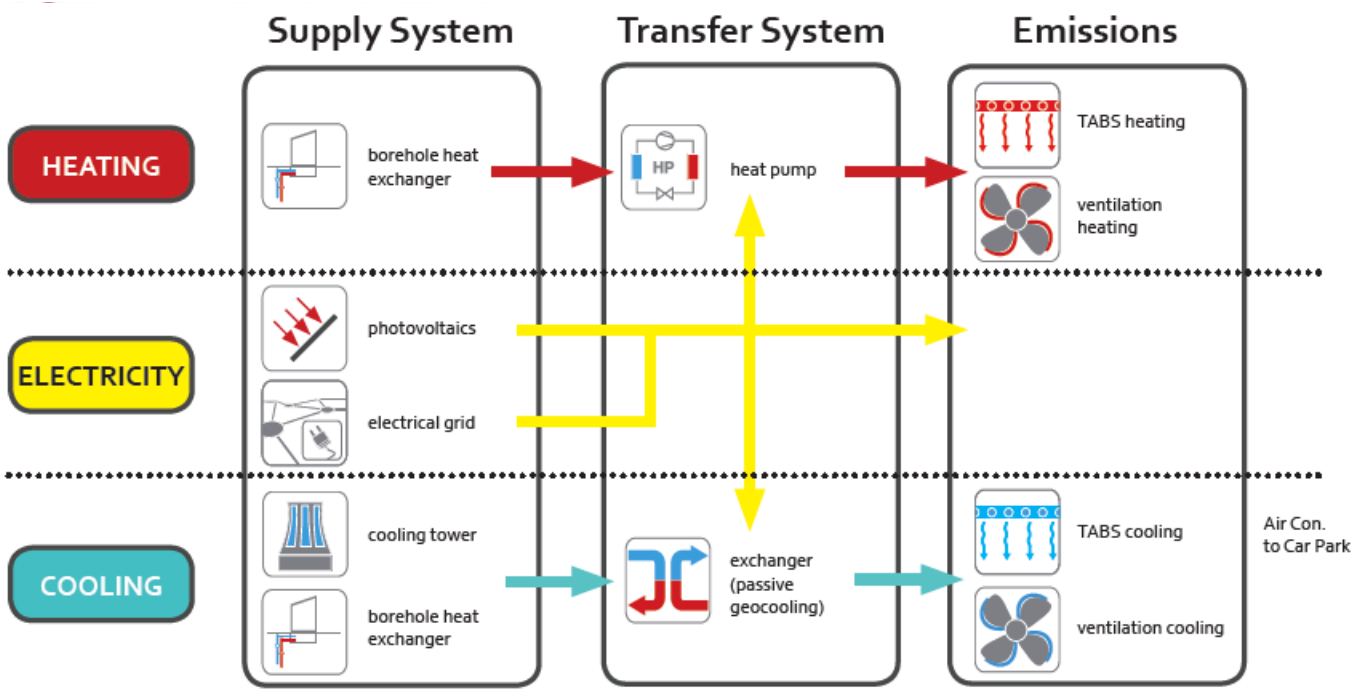


hybrid GEOTABS

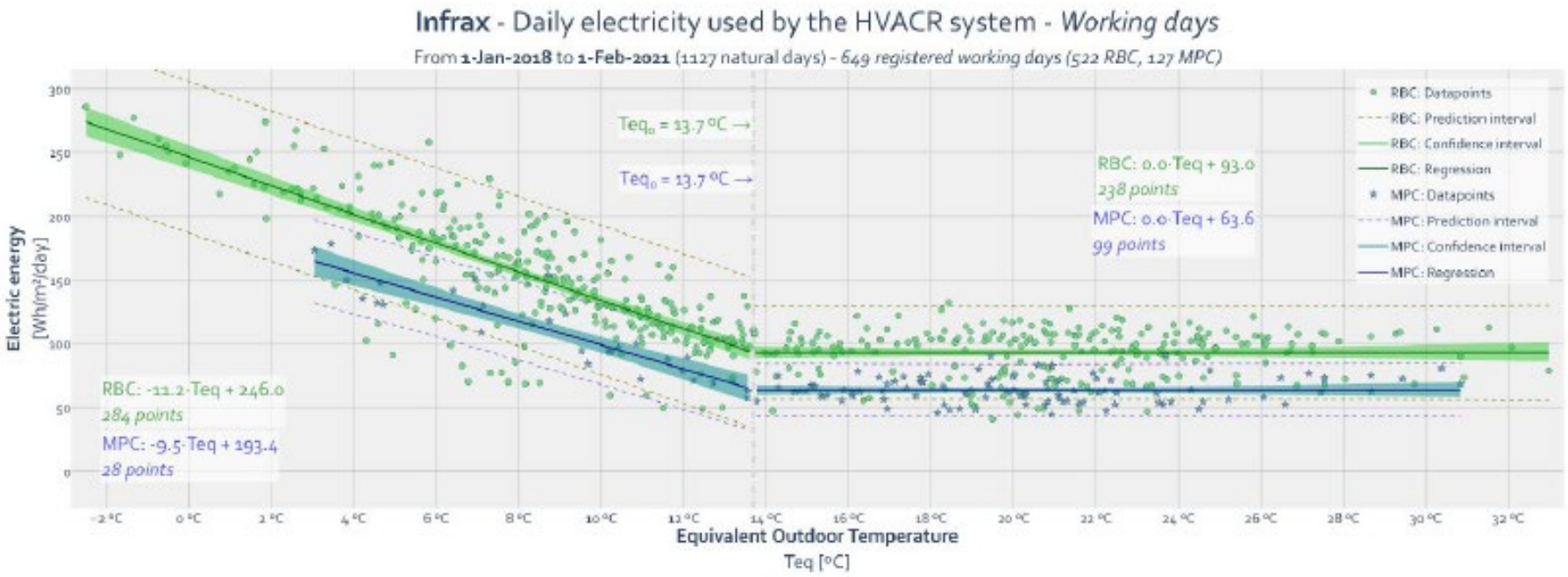
Controlling the power of the ground by integration

FLUVIUS/INFRAX (DILBEEK, BE)



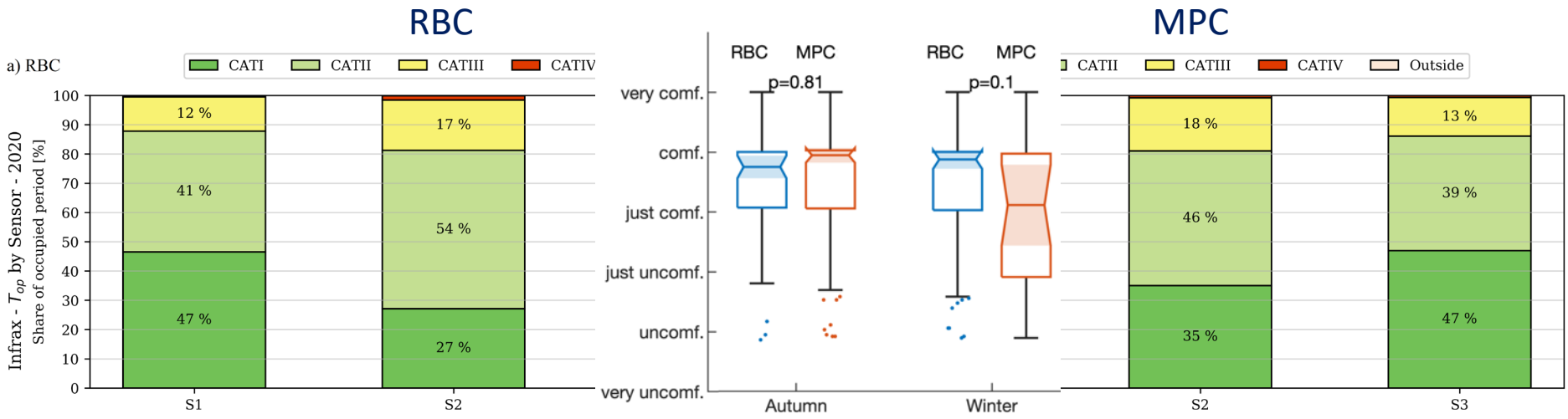


MPC in FLUVIUS/INFRAX (DILBEEK, BE)



INFRAX/FLUVIUS THERMAL COMFORT

- No sign. differences between MPC and RBC



hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

hybridGEOTABS design

hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

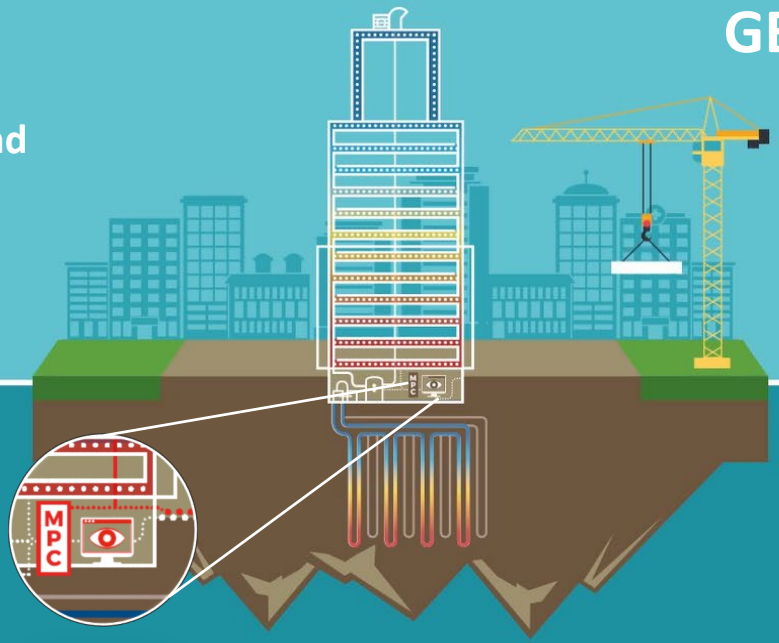
DESIGN CHALLENGES

TABS + hybrid

- Dynamic behaviour and peak shaving of TABS?
- System share & size?

GEOthermal + hybrid

- System share & size?
- Geothermal balance?



MPC

- Impact of control on sizing?

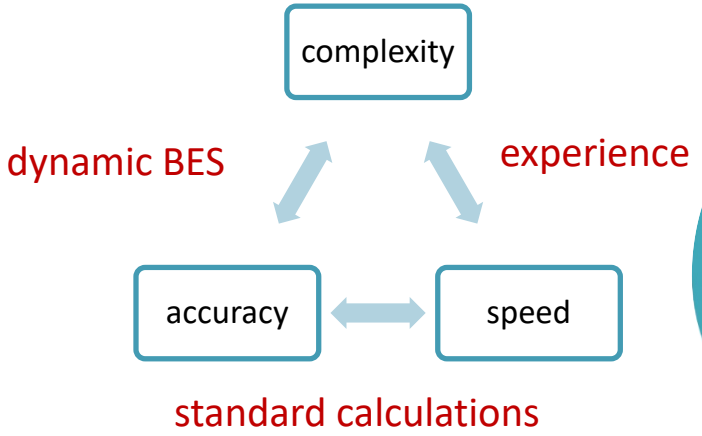
Dynamic behaviour <-> steady-state design methods

hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

STRAIGHTFORWARD PRE-DESIGN METHODS FOR HYBRID STORAGE-INTEGRATED HVAC-SYSTEMS?

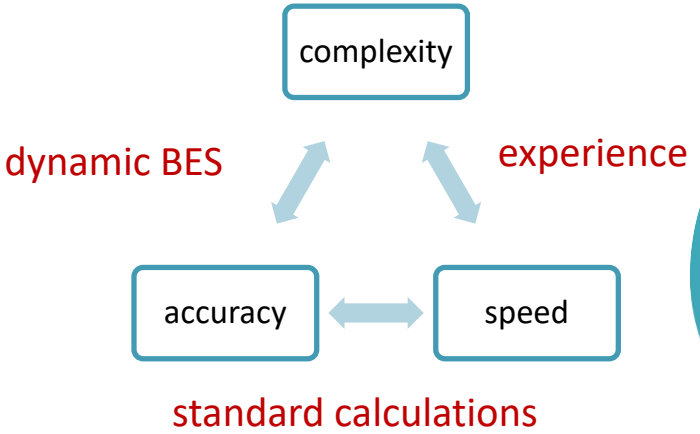


hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

STRAIGHTFORWARD PRE-DESIGN METHODS FOR HYBRID STORAGE-INTEGRATED HVAC-SYSTEMS?



- pre-simulation
- pre-engineering
- database + tool

hybrid GEOTABS

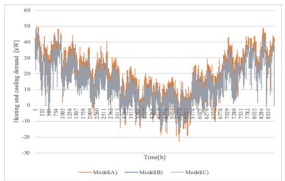
Atic for HVAC professionals

Controlling the power of the ground by integration

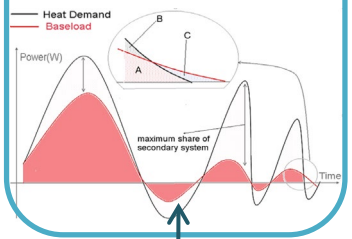
(PRE-)DESIGN METHODOLOGY

Step 1
Building Stock Database

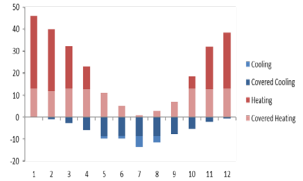
Step 2
Dynamic BES
of heating and cooling loads



Step 3
Load Splitting Algorithm
for hybrid, storage-integrated systems



Step 4
Sizing and Performance estimation
of HVAC system



Outcome
Building stock Sizing and Performance

Database & Design tools

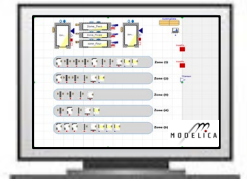
Verification Control-Integrated design study

hybrid GEOTABS

Atic for HVAC professionals

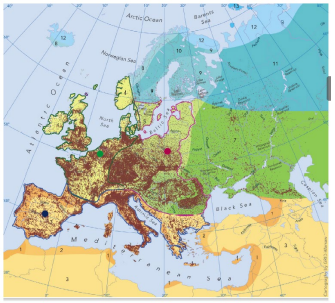
Controlling the power of the ground by integration

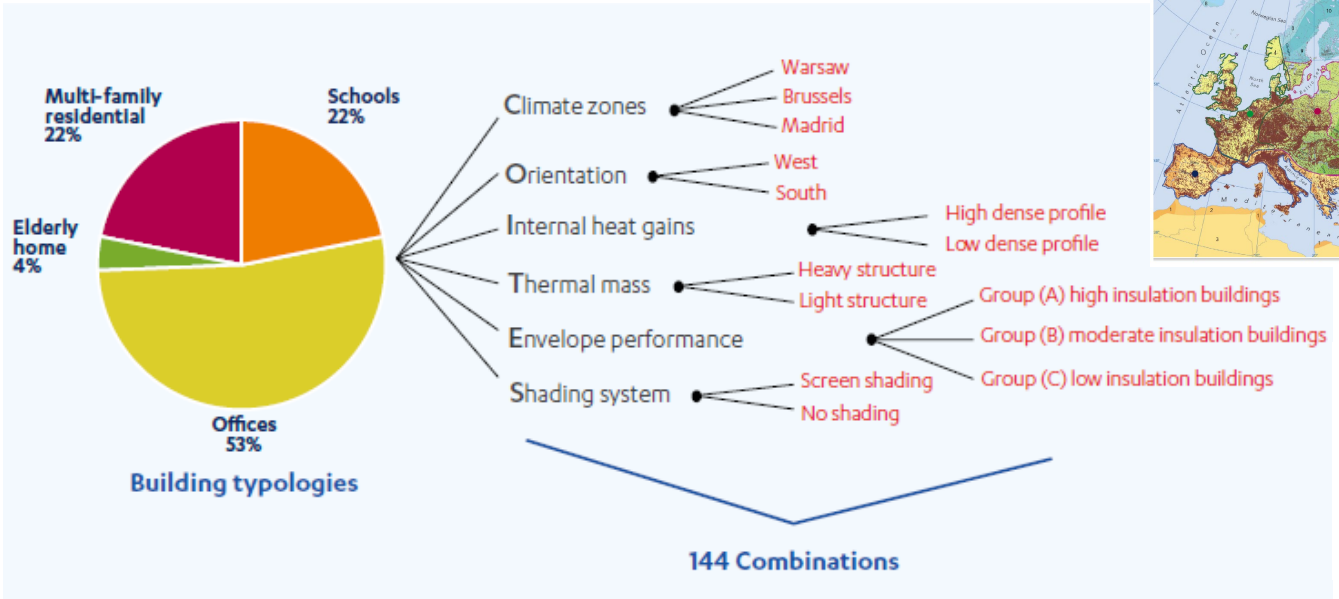
BUILDING STOCK MODELLING

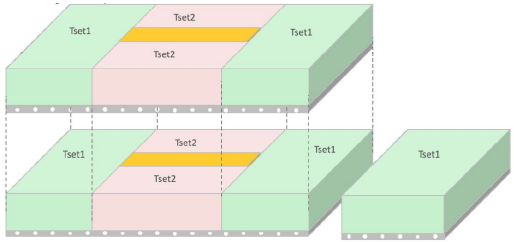


MODELICA

- Pre-simulation of heating and cooling load time series
- **> 140.000** building cases using dynamic multi-zone BES-models







hybrid GEOTABS

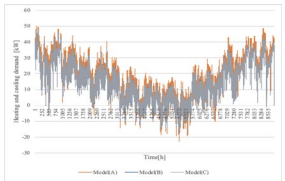
Atic for HVAC professionals

Controlling the power of the ground by integration

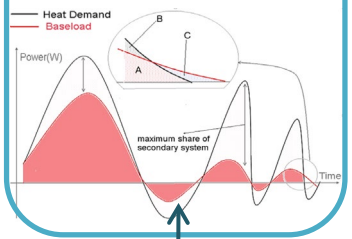
(PRE-)DESIGN METHODOLOGY

Step 1
Building Stock Database

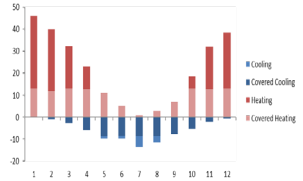
Step 2
Dynamic BES
of heating and cooling loads



Step 3
Load Splitting Algorithm
for hybrid, storage-integrated systems



Step 4
Sizing and Performance estimation
of HVAC system



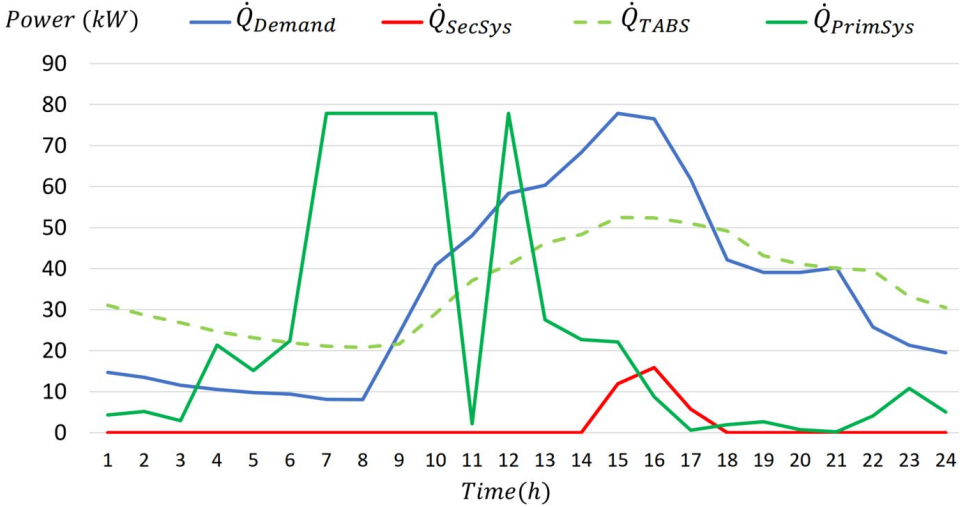
Outcome
Building stock Sizing and Performance

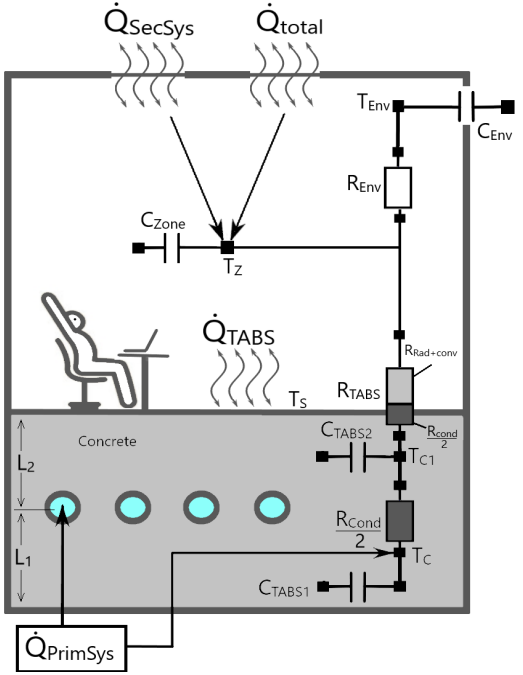
Database & Design tools

Verification Control-Integrated design study

LOAD SPLITTING ALGORITHM

- for hybrid systems: splitting baseload and residual load
- accounting for ***dynamic behaviour*** of TABS thermal storage and mimicking control behaviour
- Simplified RC-model of building + ***fast*** optimisation algorithm





hybrid GEOTABS

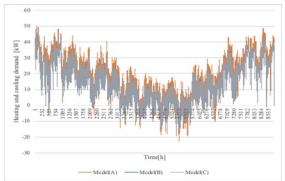
Atic for HVAC professionals

Controlling the power of the ground by integration

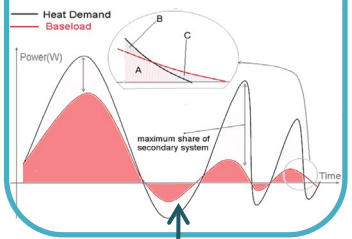
(PRE-)DESIGN METHODOLOGY

Step 1
Building Stock Database

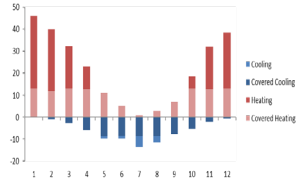
Step 2
Dynamic BES
of heating and cooling loads



Step 3
Load Splitting Algorithm
for hybrid, storage-integrated systems



Step 4
Sizing and Performance estimation
of HVAC system



Outcome
Building stock Sizing and Performance

Database & Design tools

Verification Control-Integrated design study

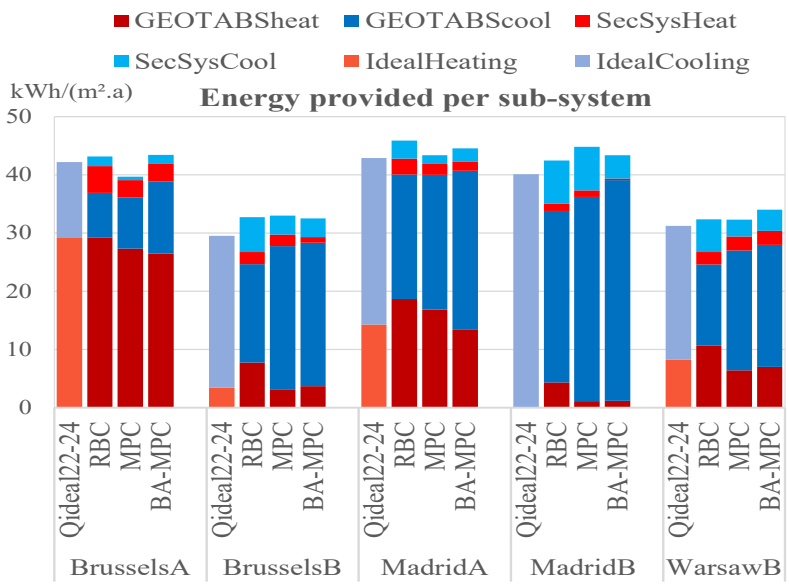
hybrid GEOTABS

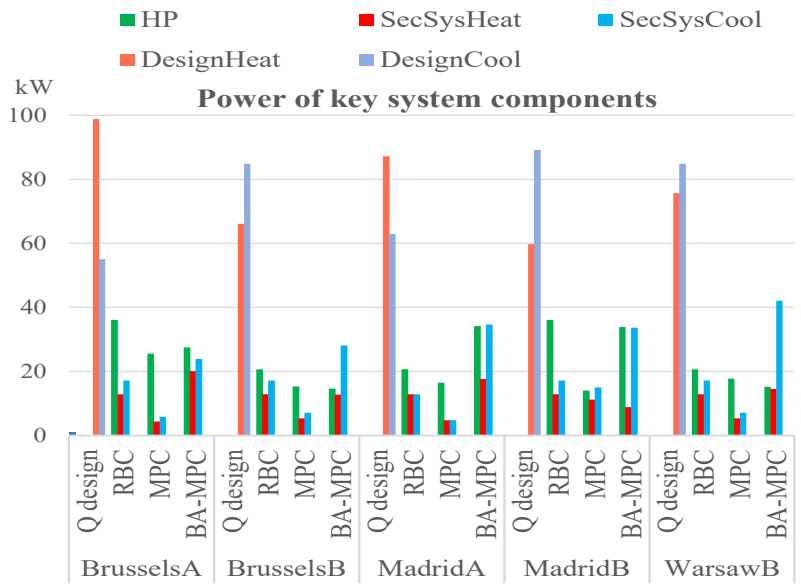
Atic for HVAC professionals

Controlling the power of the ground by integration

VERIFICATION: CONTROL-INTEGRATED DESIGN

- Nested optimisation algorithm integrating building, HVAC design and MPC
- Simulation of various HVAC component sizes and optimisation of design, for 5 cases





hybrid GEOTABS

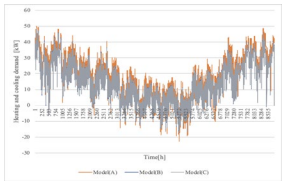
Atic for HVAC professionals

Controlling the power of the ground by integration

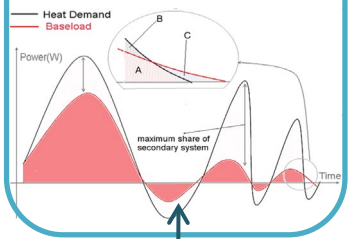
(PRE-)DESIGN METHODOLOGY

Step 1
Building Stock Database

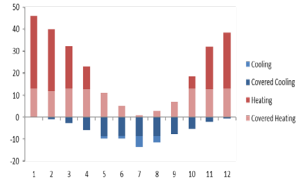
Step 2
Dynamic BES
of heating and cooling loads



Step 3
Load Splitting Algorithm
for hybrid, storage-integrated systems



Step 4
Sizing and Performance estimation
of HVAC system



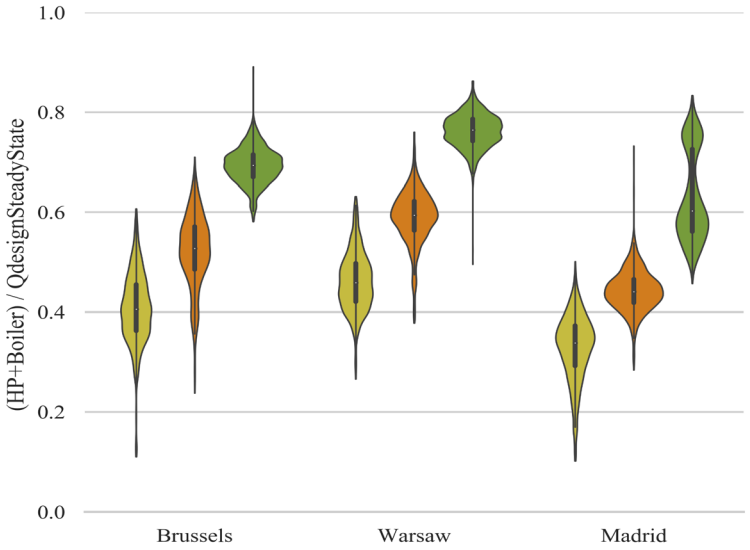
Outcome
Building stock Sizing and Performance

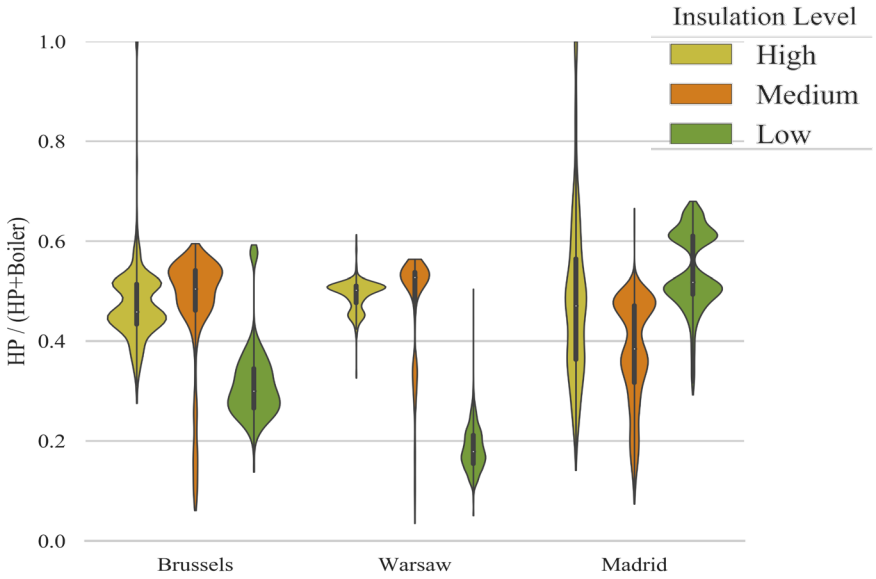
Database & Design tools

Verification Control-Integrated design study

HYBRIDGEOTABS SYSTEM POWER (40.000 OFFICES)

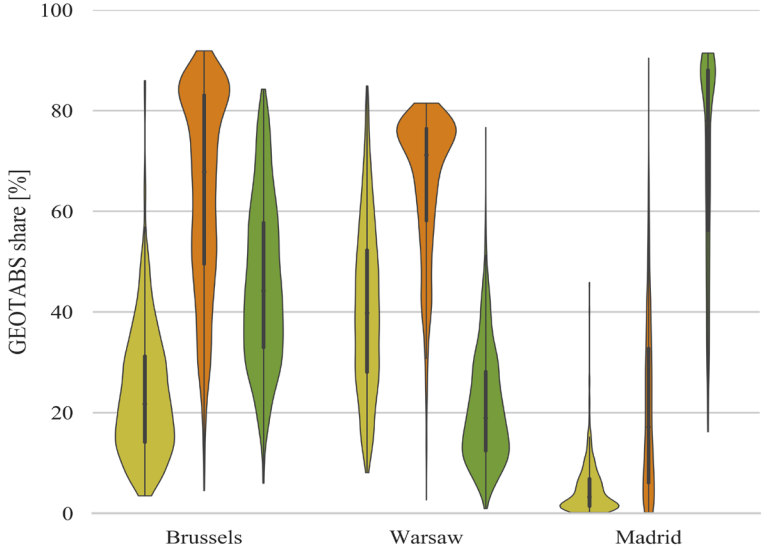
- Total system power: 30-80% of steady-state design power
- Heat Pump power: 40-60% of total system power

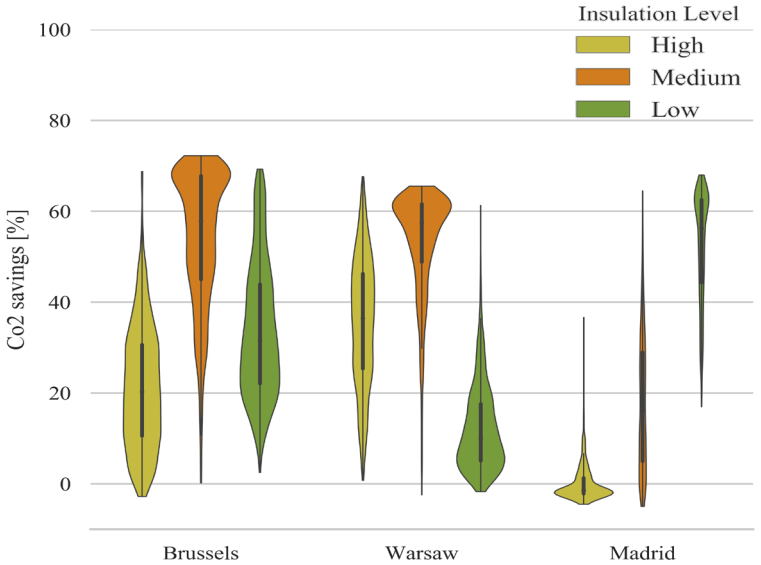




HYBRIDGEOTABS PERFORMANCE (40.000 OFFICES)

- Share of GEOTABS up to 90%, optimising building design for each climate
- CO2-savings up to 70% compared to conventional systems
- GEOTHERMAL BALANCE CONSTRAINT



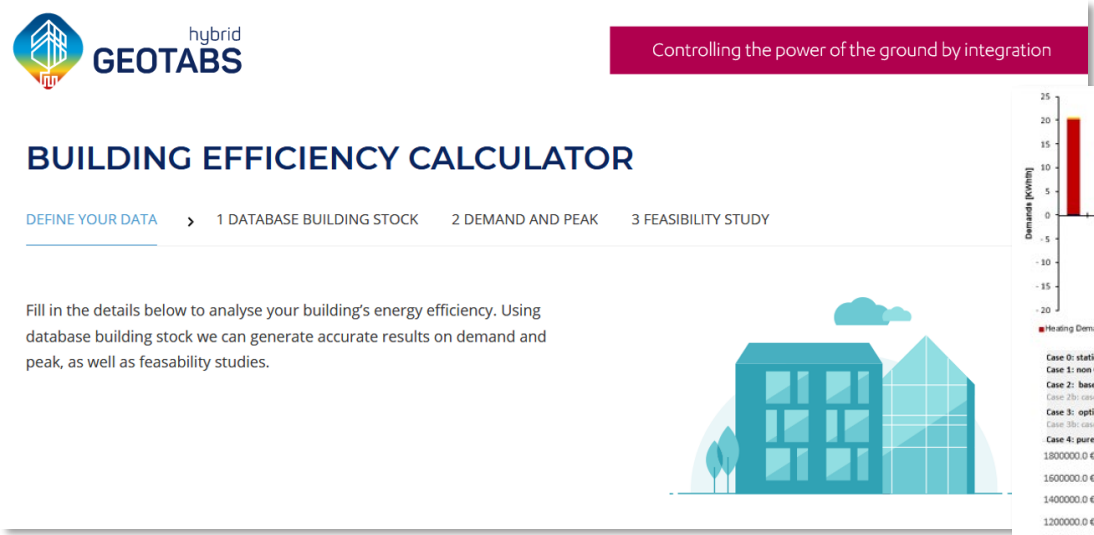


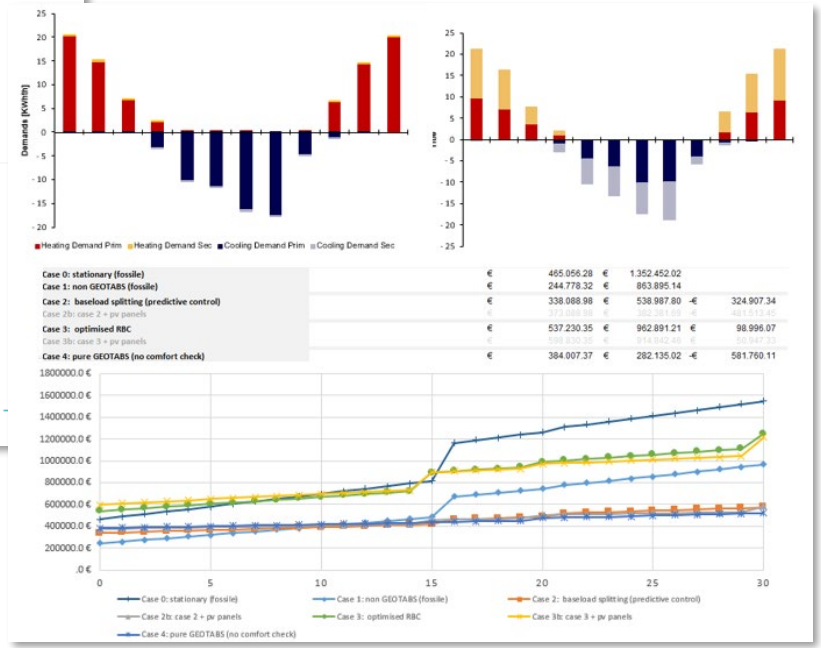
hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

HYBRIDGEOTABS DESIGN TOOLS





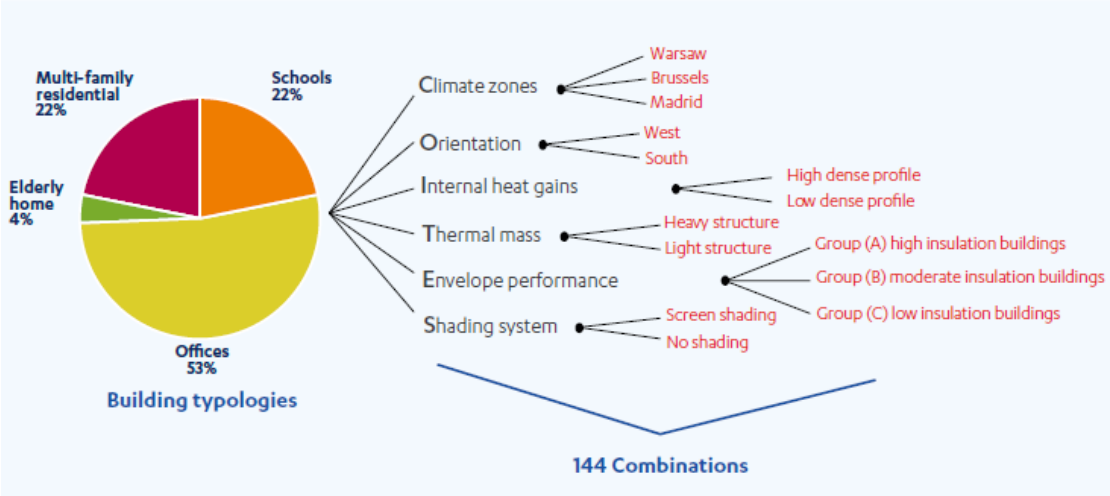
➢ Available on: www.hybridgeotabs.eu

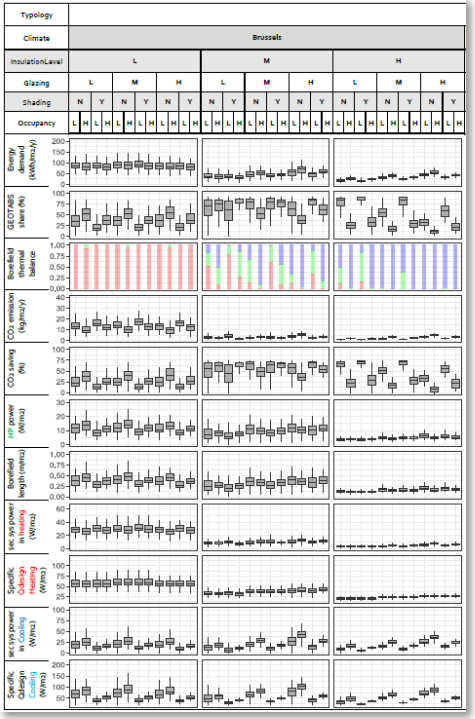
hybrid GEOTABS

Atic for HVAC professionals

Controlling the power of the ground by integration

HYBRIDGEOTABS DESIGN DECISION TREES

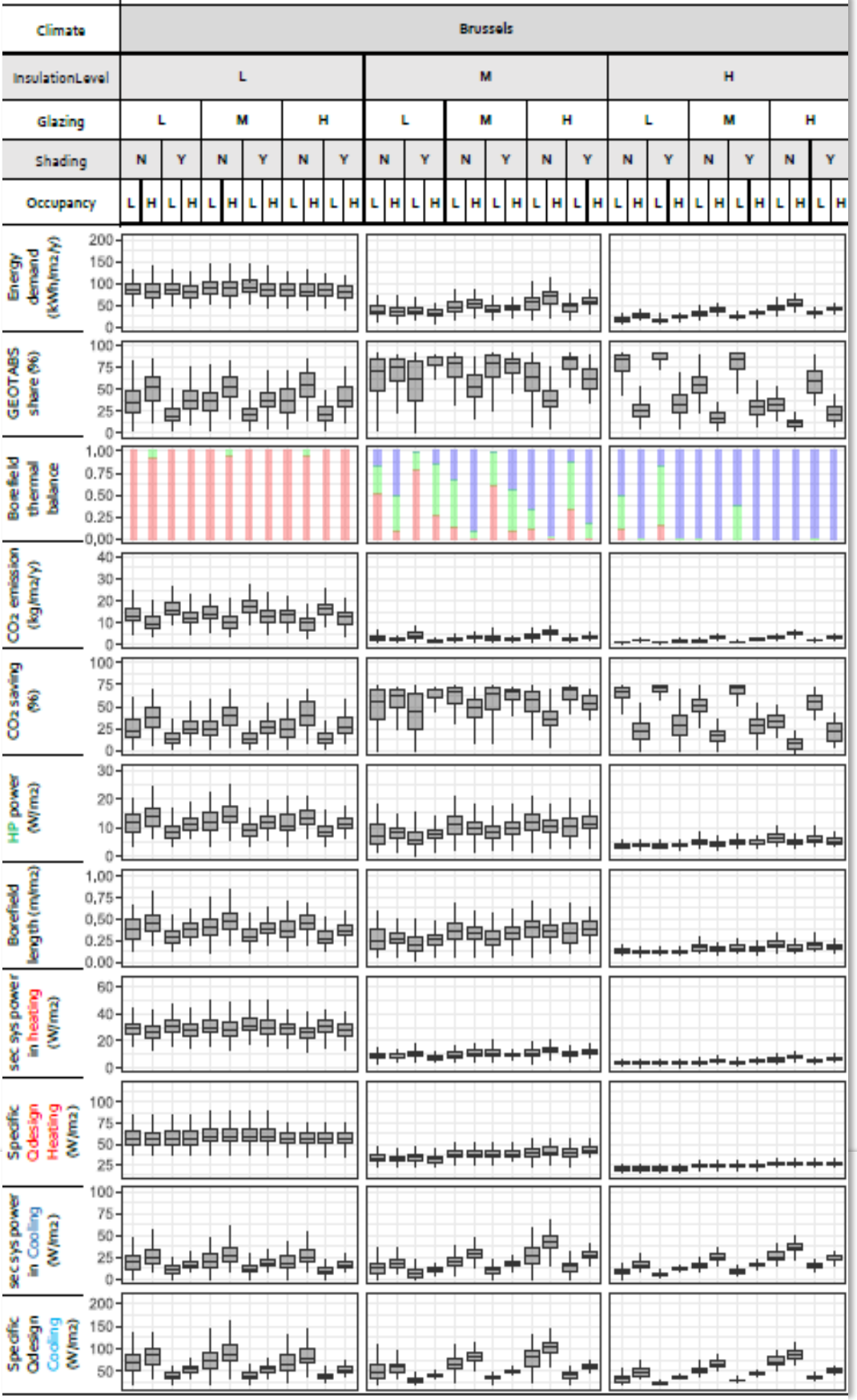




Available from…

www.hybridgeotabs.eu/technology

https://doi.org/10.5281/zenodo.4724848


Climate
Brussels
InsulationLevel
L
M
H
Glazing
L
M
H
Shading
N
Y
Occupancy
L
H
Energy demand (kWh/m2/y)
GEOTABS share (%)
Borefield thermal balance
CO2 emission (kg/m2/y)
CO2 saving (%)
HP power (W/m2)
Borefield length (m/m2)
sec sys power in heating (W/m2)
Specific Qdesign Heating (W/m2)
sec sys power in Cooling (W/m2)
Specific Qdesign Cooling (W/m2)

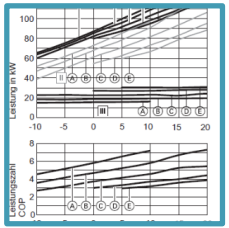
hybrid GEOTABS

Atic for HVAC professionals

...f the ground by integration

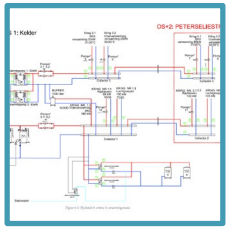
enerCORE Knowledge Centre

Enhanced Geothermal Response Test

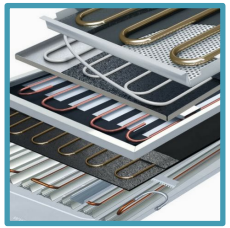


Modular system concept and design optimisation of key components

Hydraulic schemes for hybridGEOTABS solutions



Radiant panels with **PCM**



Generic documentation for **TENDERING**

Energy Dashboard

hybrid GEOTABS

Atic for HVAC professionals

f the ground by integration

enerCORE Knowledge Centre

WWW.HYBRIDGEOTABS.EU

Book

Video's: https://www.youtube.com/channel/UCQDBfhimW-bqATt31u8xQVg

Training curriculum

How to exploit HybridGEOTABS

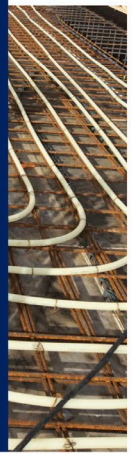
This training introduces the hybridGEOTABS concept and its key assets and is accessible for everyone fascinated by sustainable building.
The curriculum is targeting mainly business-oriented audiences organised in 5 modules - each of them covering a different topic - with a total duration of approximately 1hr 40min.

Start Training

How to Design and Operate HybridGEOTABS

This training introduces the hybridGEOTABS concept and its main benefits and challenges, providing insights into the technical principles underlying the concept and the design.
The curriculum is organised in 9+1 modules - each of them covering a different topic - with a total duration of approximately 11 hrs.

Start Training



HYBRIDGEOTABS
PASSIVE COOLING WITH CCA AND GEOTHERMAL ENERGY

September 30th, 2021

Eline Himpe (PhD)
Ghent University, Building Physics group

GHENT UNIVERSITY

hybrid GEOTABS

Atic for HVAC professionals