hybrid
GEOTABS

Controlling the power of the ground by integration

CONTROLLING hybrid GEOTABS

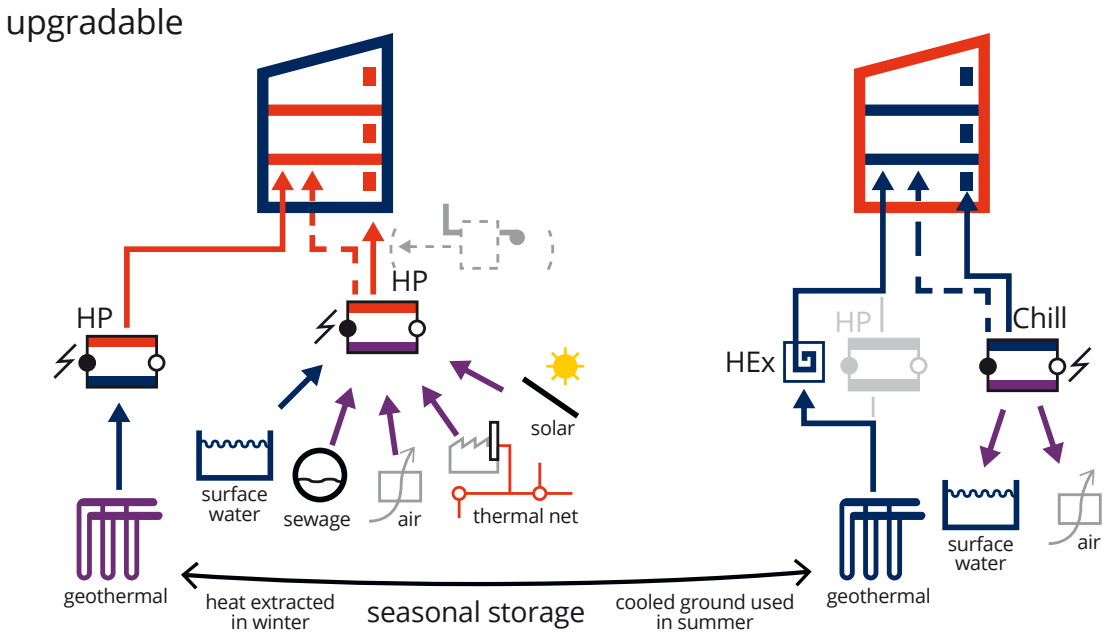
Optimised GEOTABS represent the 'perfect marriage' of technologies for heating and cooling of buildings. The radiant heating and cooling system has proven to be one of the most comfortable ways to condition indoor spaces, including multi-storey offices, apartment blocks and care homes. They allow low temperature heating and high temperature cooling, which optimally combine with geothermal heat pumps and other Renewable Energy Sources (RES). This efficient system offers significant energy and CO_2 savings over conventional systems.

When used with secondary heating/cooling systems and other RES, hybrid GEOTABS are widely applicable, including in buildings with unpredictable and variable loads. In each case, system components must be effectively integrated through careful design and control. Furthermore, TABS are characterized by high thermal inertia leading to large time constants. To work effectively, future changes ('disturbances') must be anticipated and acted upon to take this into account. Model Predictive Control (MPC) is used to achieve this, optimising geothermal heat exchangers, a heat pump, TABS and secondary systems and delivering integrated optimal design and control.

CONTROL STRATEGIES

hybrid GEOTABS allows intermittent operation with defined schedules to minimise cost:

- with a dead band (neutral mode between heating and cooling mode switching) for a specific range of temperatures or with seasonal downtime
- only during occupation hours ('night setback' for cooling, not for heating)
- independent from occupancy time, when the energy tariffs are lower (night cooling)



Funded by the European Commission under the Horizon 2020 Programme: project number 723649

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OPTIMISING TABS SYSTEM CONTROL

Conventional control strategies include:

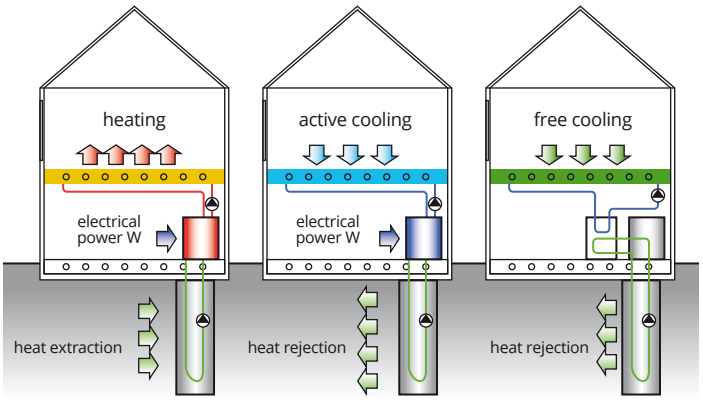
- Time based control
- Zone temperature control
- Weather dependent supply/average water-temperature control
- Intermittent pump operation control
- Constant concrete core temperature control
- Dead band (neutral mode) for switching between heating and cooling mode

Good practice TABS control:

- TABS temperatures vary only slightly (high temperature cooling and low temperature heating), so keeping TABS at a constant temperature is an effective control strategy, exploiting the self-regulating effect of TABS
- concrete surface temperature is the controlled variable, water flow rate and temperature are the manipulated variables
- heating on, if average outdoor temperature is lower than heating set point (e.g. 10°C)
- cooling on, if average outdoor temperature rises above the cooling set point (e.g. 14°C)
- heating/cooling curve which is slightly higher/lower (3°C) than determined by the steady-state design
- neutral zone of 24 hours between heating and cooling regimes

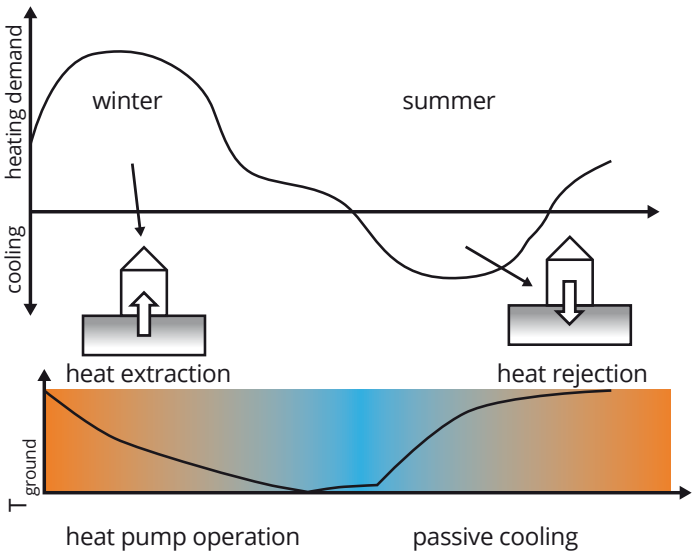
STRATEGIES TO OPTIMISE GEOTHERMAL CONTROL

- Avoid frequent switching between heating and cooling operation modes to decrease unnecessary use of auxiliary energy
- Heat/cold injection into the ground when these sources are cheaply available (solar collectors, electricity from RES) in order to maintain the thermal balance in the ground, which guarantees the availability of direct cooling and high heat pump performance



hybrid GEOTABS CONTROL STRATEGIES

- operation of the fast reacting systems (i.e. supplementary heating and cooling) at moderate ambient air temperatures (typically mid-seasons)
- activation of the TABS for a longer time period when the building is in heating mode (winter) or cooling mode (summer), preferably during the night when fast reacting system is not active
- operation of the TABS during night and use fast reacting system during daytime
- supplementary systems must not overrule the TABS in normal operation
- simultaneous heating and cooling by using both sides of the heat pump or different modes for TABS and supplementary system in different zones of the building



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MPC FRAMEWORK

An MPC model is developed and used to predict future control inputs and responses, which are optimised as the system is used in real time. It can be set to include information about outside temperature and occupancy, to minimize energy use whilst maintaining comfort.

This is particularly relevant in TABS buildings, where the thermal inertia is high and the building cannot react to sudden changes in demand efficiently.

INDICATORS TO MEASURE SYSTEM EFFICIENCY

MPC optimizes control actions to maximise system performance, which may be measured using various indicators depending on the objective function used:

- Seasonal Performance Factor (SPF), which is the ratio of annual thermal energy output to annual consumed electrical energy
- Energy cost, which can be variable in time and typically depends on the primary energy sources used
- CO2 emissions, which highly depend on the energy sources used and the production efficiency
- Share of renewable energy sources (RES)
- Flexibility to support the electricity grid infrastructure

HOW MPC WORKS

MPC is an optimal controller that will optimize an 'objective cost function' such as energy or the use of renewable energy sources.

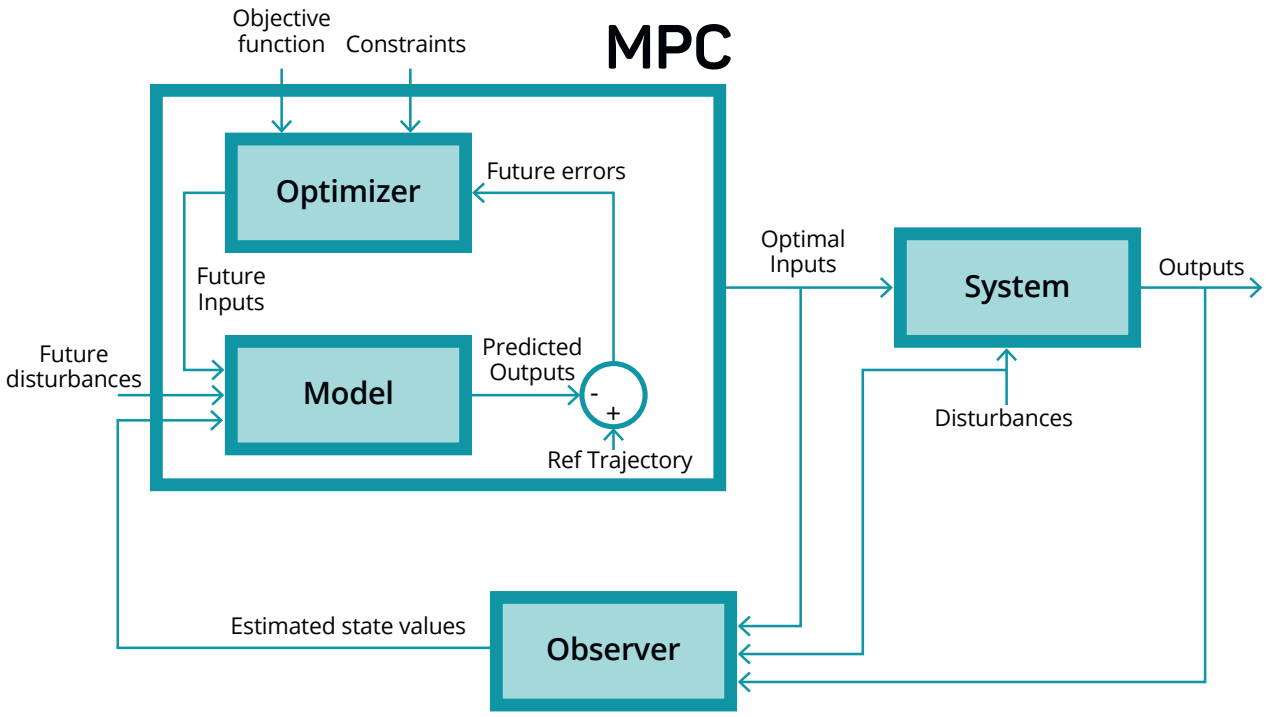
It usually operates within some constraints, especially to keep the building within a comfortable temperature band.

MPC has been likened to controlling a car by looking out of the front windscreen rather than making adjustments based on what's been seen in the rear view mirror.

MPC MODEL

The MPC model used to predict future inputs and responses can be a black-box, grey-box or white-box model. Within the GEOTABShybrid project the white-box approach is further developed in order to automate the MPC Toolchain as much as possible. White-box models benefit from physics included, thereby limiting the model-mismatch.

Adapted from REHVA guidebook 20
"Advanced system design and operation of GEOTABS buildings".



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GEOTABS^{hybrid} is an active research project to optimise the predesign and operation of a hybrid combination of geothermal heat pumps (GEO-HP) and thermally activated building systems (TABS). It will design an improved, automated 'Model Predictive Control' (MPC) solution for testing on hybrid supply and emission systems in demonstration buildings such as offices, elderly care homes, schools and apartment blocks. Applying MPC to hybrid GEOTABS optimises the performance and efficiency, making it more economically attractive and increasing take up.

GEOTABS^{hybrid} TECHNICAL BRIEFINGS

- This paper is one of a series of technical briefings authored by the **GEOTABS**^{hybrid} project
- Other briefings include 'Introduction to hybrid GEOTABS' and 'Designing hybrid GEOTABS'
- Find them at **www.hybridgeotabs.eu/technology**

MORE INFORMATION

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PARTNERS

GEOTABS^{hybrid} brings together a transdisciplinary team of SMEs, large industry and research institutes, experienced in research and application of design and control systems in the combined building and energy world.

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