hybrid GEOTABS

THERMAL SYSTEMS SIMULATION

Controlling the power of the ground by integration

MODEL PREDICTIVE CONTROL AND ITS APPLICATION IN HYBRIDGEOTABS SYSTEMS

EnergyVille

hybrid GEOTABS

Controlling the power of the ground by integration

CONTEXT: SYSTEM INTEGRATION

THERMAL SYSTEMS SIMULATION

Energy Ville

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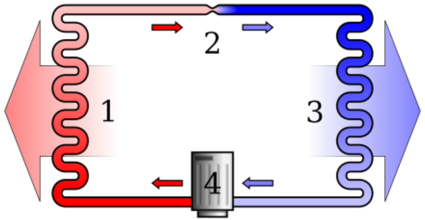

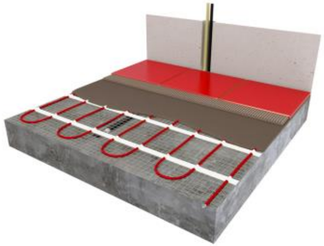

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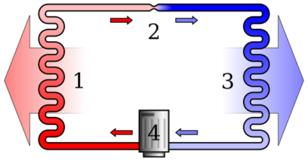
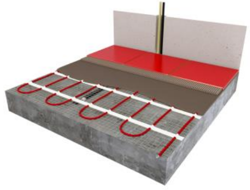
SYSTEM INTEGRATION

Integration of:

- Thermal mass and insulation: slow reacting system
- Heat pump: temperature-dependent COP
- Interaction ventilation and heating/cooling
- Hybrid systems
- Renewable energy sources





SYSTEM INTEGRATION

Challenging for control!

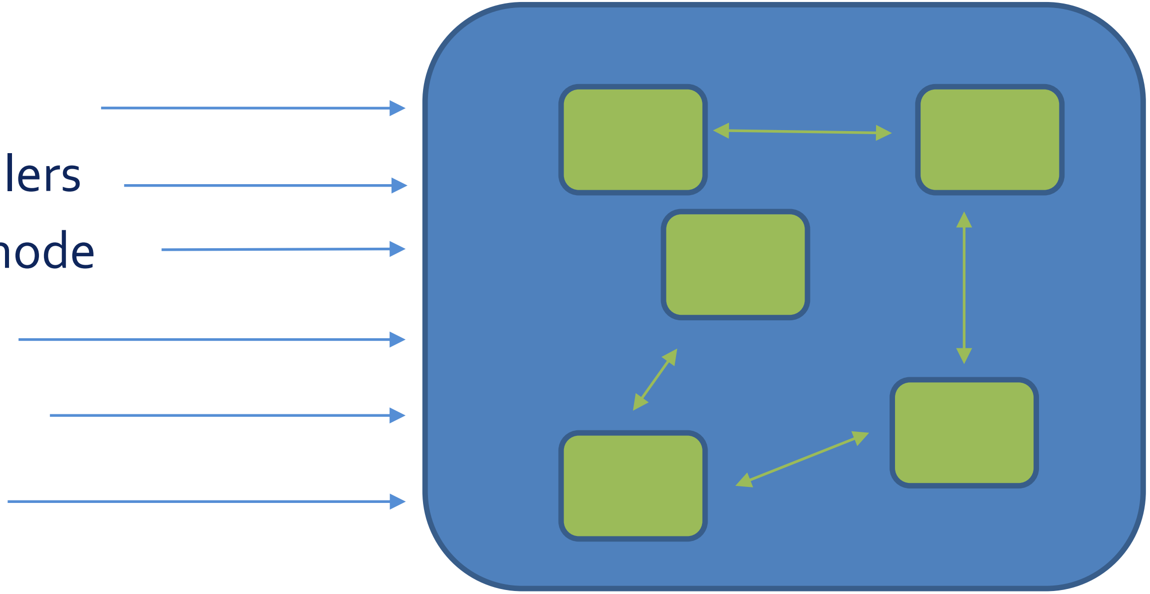
Optimization potential:

- Energy use
- CO_2 emissions
- Thermal comfort
- Commissioning cost
- Flexibility

CONTROL: CURRENT PRACTICE

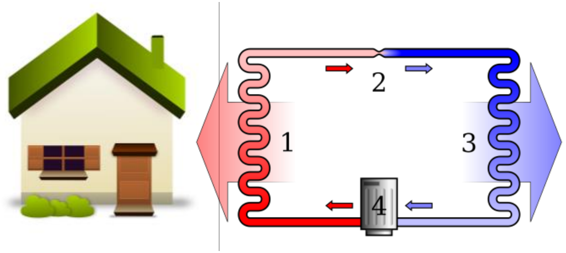
Rule based control:

- Heating curve
- Hysteresis controllers
- Heating/cooling mode
- Night set back
- Pre heating
- PI(D) controllers

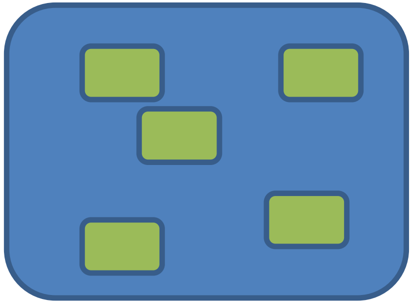


CONTROL: CURRENT PRACTICE

Manual implementation and time-intensive calibration of rules

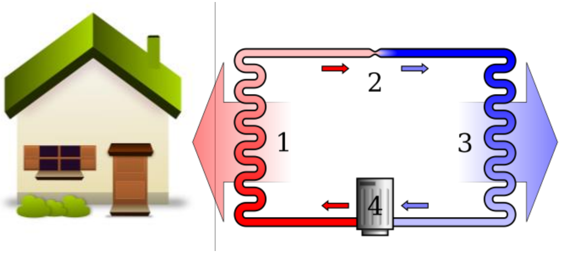


Controller

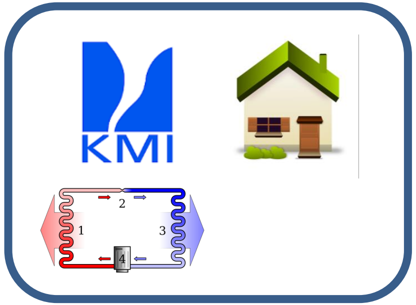


THE FUTURE: SMART BUILDINGS

Systematic and mostly automated implementation and calibration using a new type of control



Controller

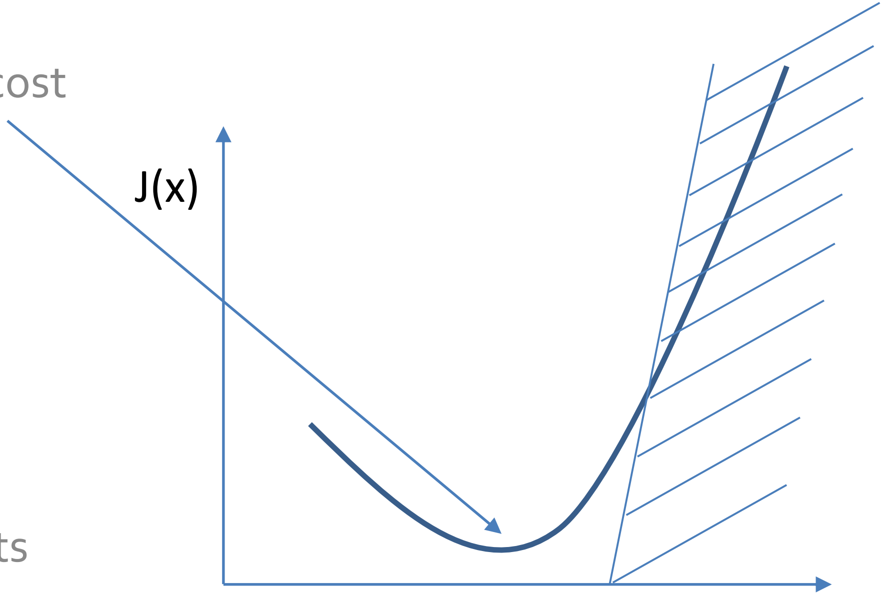


MODEL PREDICTIVE CONTROL

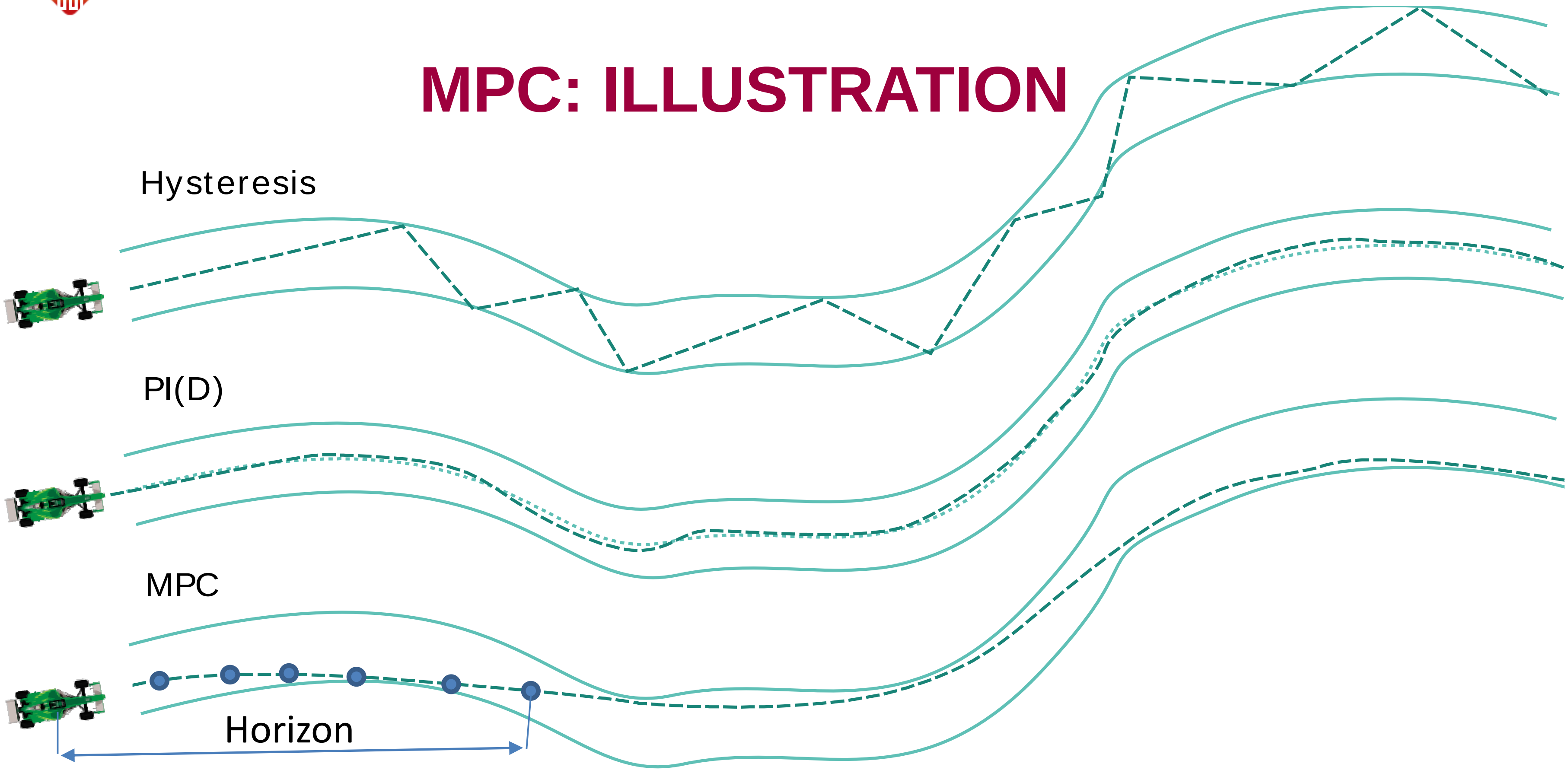
MODEL PREDICTIVE CONTROL (MPC)

Principle:

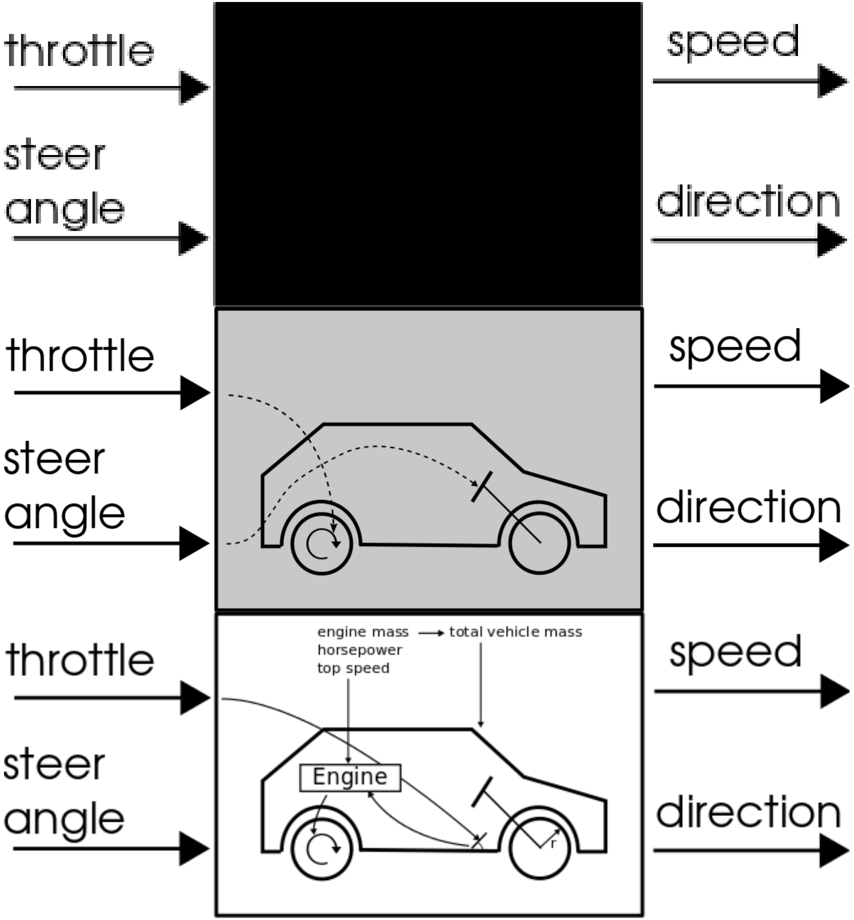
- Mathematical optimization
  - Minimization of (operational) cost
- Constraints
  - Comfort: temperature
  - Technical: capacity limits, etc
- Building model
  - Prediction of dynamics
- Feedback
  - Correction using measurements



MPC: ILLUSTRATION



MPC: MODEL TYPES



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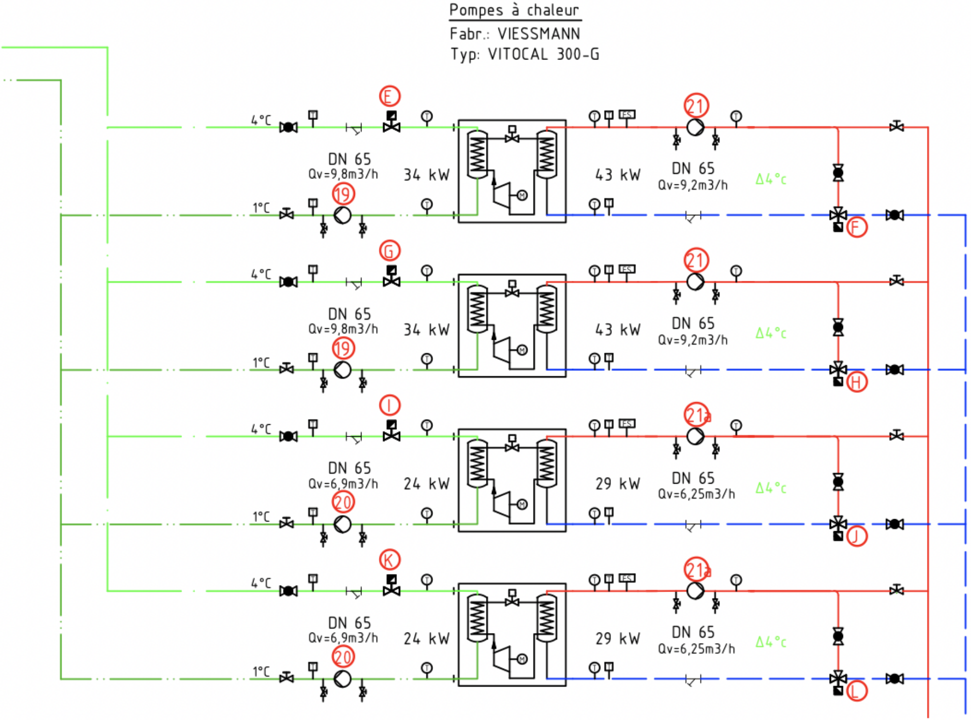
MPC: METHODOLOGY

Three main elements, using Modelica

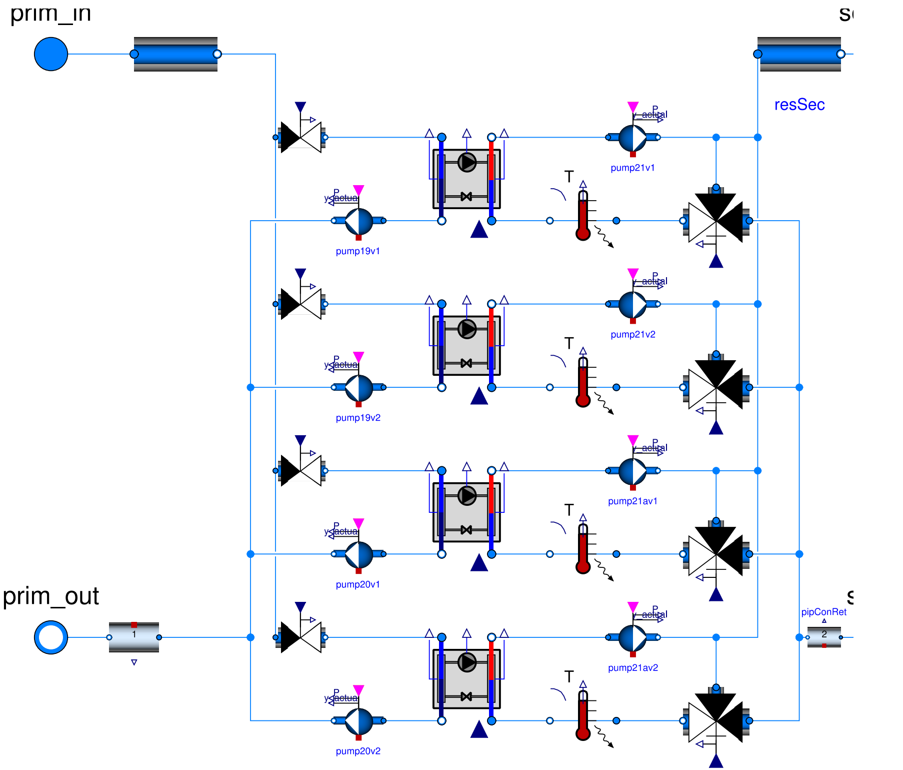
1. Modelica libraries: IDEAS
2. Building model: 1 to 1 mapping
3. Optimization toolchain

MPC: 1 TO 1 MAPPING

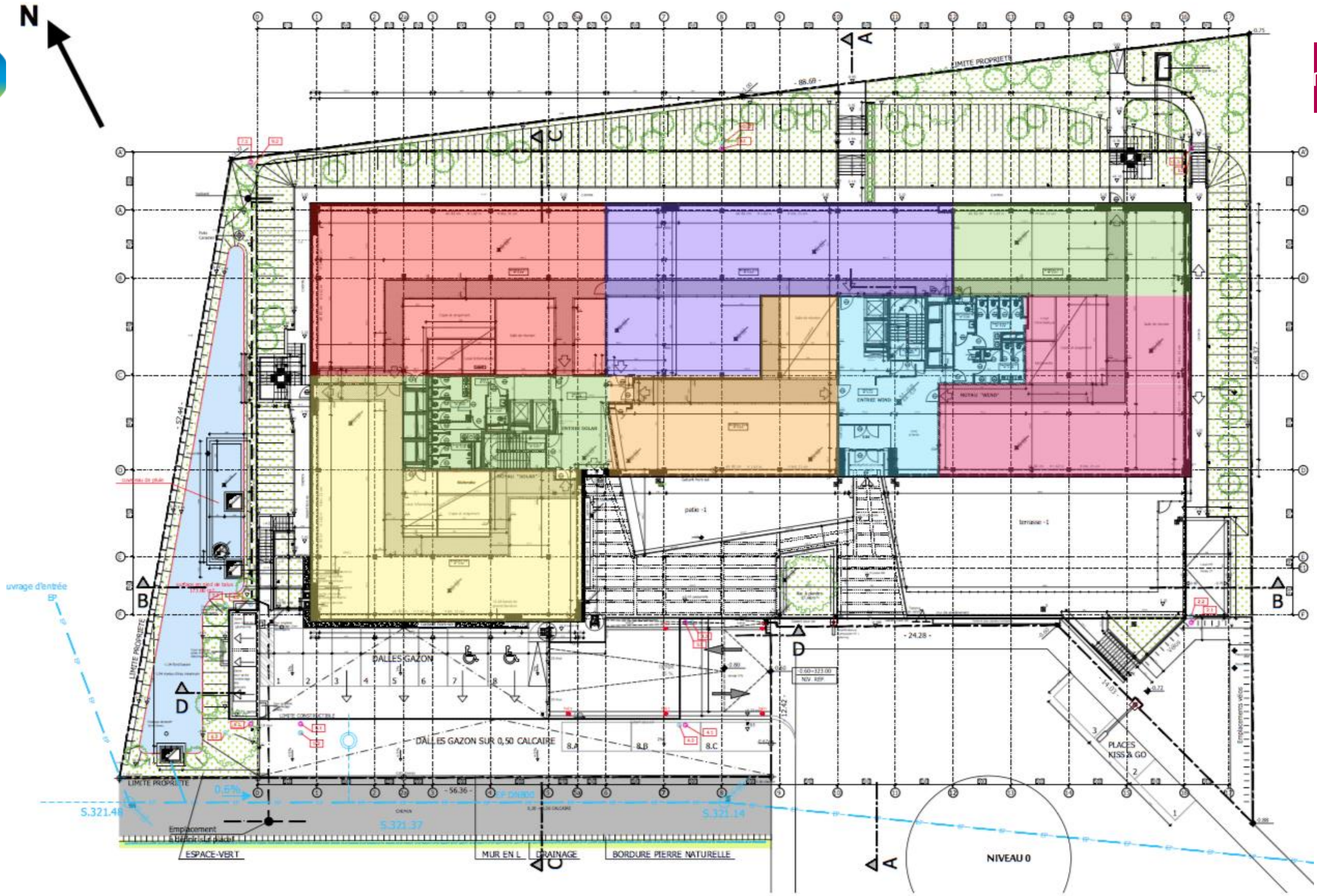
Schematic



Model



ntegration


N
LIMITE PROPRIETE
- 86.69 -
uvrage d'entrée
EP
patio -1
terrasse -1
DALLES GAZON
DALLES GAZON SUR 0,50 CALCAIRE
8.A
8.B
8.C
- 24.28 -
- 56.36 -
PLACES
KISS & GO
S.321.46
S.321.37
S.321.14
0.5%
LIMITE PROPRIETE
Emplacement
ESPACE-VERT
MUR EN L
DRAINAGE
BORDURE PIERRE NATURELLE
NIVEAU 0
A
B
C
D

POTENTIAL FOR HYBRIDGEOTABS

HYBRIDGEOTABS CONCEPT

hybridGEOTABS system components

- TABS: thermally activation building systems
  - Concrete core activation
- GEO: geothermal heat pumps
  - Heat pump
  - Geothermal borefield
- Hybrid:
  - Secondary emission and product system

=> Dynamics, non-linear performance and system coordination

SIMULATION RESULTS AND CASE STUDY

hybrid GEOTABS

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MPC: RESULTS

Solarwind:

Office building, 10 000 m^2,

2 air handling units, 24 zones (VAV + concrete core activation + heating coil), 4 heat pumps, geothermal bore field, frequency controlled pumps and fans: 92 control variables

Compared to rule based control (simulations):

> 50 % energy savings [kWh_{el}]

Improved thermal comfort

MPC: RESULTS

Savings:

- COP: 4.5 => 5.5
- Frequency controlled fans and pumps
- Coordination ventilation and concrete core activation

Table 10.1: Comparison between rule based controller (RBC), model predictive control (MPC), MPC with modified thermal comfort bounds (T) and a modified MPC implementation for the borefield (GEO) of annual electrical (Ele) and thermal energy use [MWh] for heating (Hea) and cooling (Coo) of the main HVAC units and their pumps. The indicated cooling energy for the air handling units is the net cooling provided by both units.

	Concrete core activation						VAV	AHU			Heat pumps		Borefield & pumps				Total
	Hea		Coo		Ele		Hea	Ele		Coo	Hea	Ele	Hea	Coo	Ele		Ele
	N	S	N	S	N	S		1	2						1	2	
RBC	19.4	24.9	31.3	29.5	7.4	7.7	21.2	18.6	18.9	176.5	70.4	15.5	56.2	58.9	2.7	0.1	70.9
MPC	2.2	3.8	61.5	43.8	0.5	0.4	0.9	5.4	4.3	52.9	7.1	1.3	6.5	102.2	0.2	0.1	12.2

MPC: DEMONSTRATIONS

EU-H2020 hybridGEOTABS

Infrax building

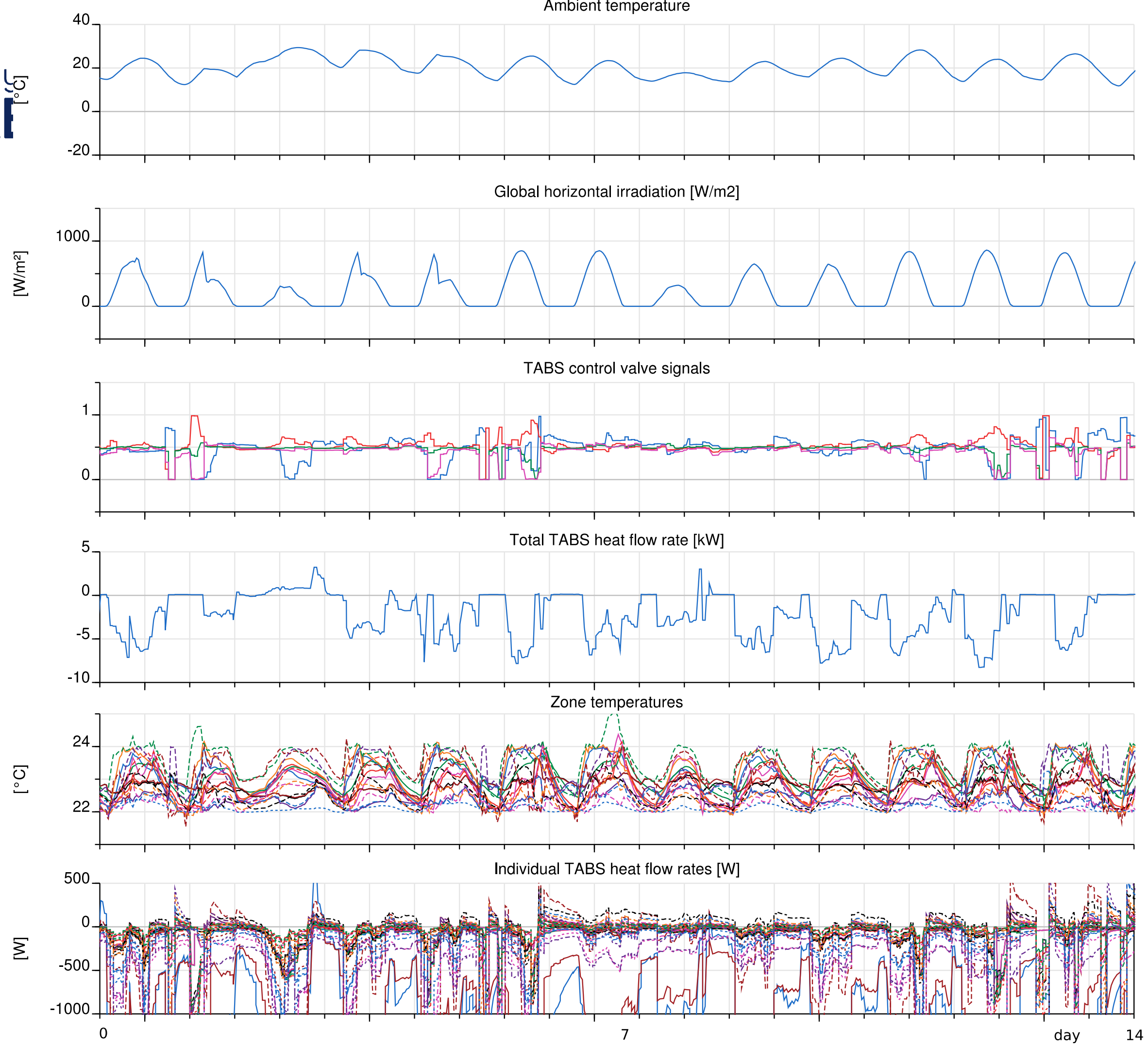
- Office building, 3000 m^2
- Final preparations on-going

Ter potterie

- Elderly care home, 10 000 m^2

Solarwind

round by integration



CONTROL-INTEGRATED DESIGN

MPC-INTEGRATED DESIGN

Design affects control:

- Heating/cooling capacity is affected by HVAC design
- Heating/cooling needs are affected by envelope design

Integrated design and control using MPC

- MPC readjusts itself to the design automatically
- Automated optimal sizing of primary and secondary heating/cooling systems and geothermal borefield

Result:

- Optimized operation cost and size of borefield, heat pump and secondary systems

WITH THE HELP FROM

- hybridGEOTABS consortium
- studiebureau boydens
- 3E – SynaptiQ building
- Infrax
- Priva
- Mervis

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