hybrid GEOTABS

Controlling the power of the ground by integration

hybridGEOTABS design decision trees

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The hybridGEOTABS design decision trees provide estimates of the sizing and performance of the hybridGEOTABS concept for buildings, in function of high level design parameters. The decision trees are made for assisting the HVAC-engineer, energy concept designer or architect in the earliest stages of the building and HVAC design process (i.e. feasibility study and pre-design). They allow the designer to have a first impression of the feasibility of hybridGEOTABS for the project at hand, and to see the impact of some key building design choices such as glazing percentages or insulation levels. Thus, they may be used to optimise the building design to increase the possible share of GEOTABS as a sustainable core for providing thermal comfort in buildings.

The decision trees are provided for four different building typologies (focusing on buildings > 1.000 m² floor area): office buildings, school buildings, elderly home buildings and multi-family buildings. They are provided for the three major EU climate zones, as represented by the cities of Madrid, Brussels and Warsaw (mapping of the EU climate zones, see: https://doi.org/10.5281/zenodo.4724629). This dataset provides the design decision trees (.pdf). Note that in the decision tree, L"," M", and "H" respectively stand for "Low", "Medium" and "High" for different parameters. The meaning of "Low", "Medium", and "High" for different parameters, is explained in detail in Table 1. For each branch of the tree, the distribution of the following sizing and performance indicators is provided:

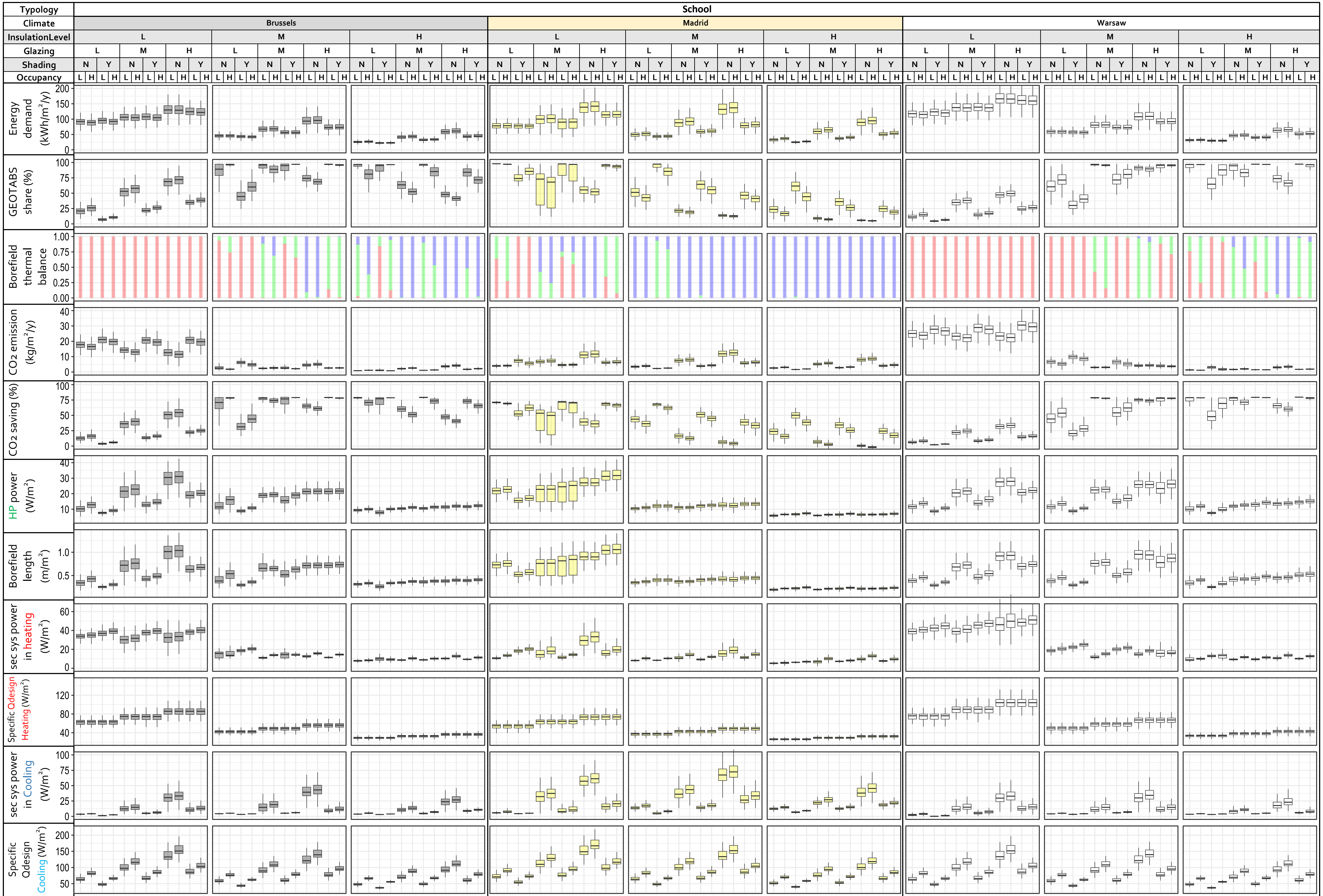
- Key energy design indicators for the building:
  - Energy demand in kWh/(m².year): sum of net heating and cooling demands of the building (at 22-24°C indoor temperature range)
  - Specific Q_{design} in heating, in W/m²: design heating power per conditioned floor area (estimated using classical steady-state design methods)
  - Specific Q_{design} in cooling in W/m²: design cooling power per conditioned floor area (estimated using classical steady-state design methods)
- Key performance indicators for the hybridGEOTABS design for the building:
  - GEOTABS share in %: share of the heating and cooling demands covered by GEOTABS (while providing thermal balance in the geothermal borefield)
  - Borefield thermal balance: relative frequency of heating dominated, balanced (60%-40%) or cooling dominated cases
  - CO_2-emissions in $kgCO_2$/(m².year): estimated CO_2-emissions for heating and cooling the building
  - CO_2-savings (%): savings in CO_2-emissions as compared to a nonGEOTABS scenario (100% of heating and cooling provided by a boiler and chiller)
- Key sizing indicators for the hybridGEOTABS design for the building:
  - HP-power (W/m²): specific power of the heat pump per conditioned floor area
  - Borefield length (m/m²): length of the geothermal borefield (m) per conditioned floor area (m²)
  - Sec Sys power in heating (W/m²): specific power of the secondary heating system per conditioned floor area
  - Sec Sys power in cooling (W/m²): specific power of the secondary cooling system per conditioned floor area

The design decision trees are an outcome of a holistic design methodology, that takes into account the building physical behaviour of the building (incl. hygienic ventilation), the dynamic behaviour and performance of the GEOTABS and secondary systems as well as how the building systems are integrated and optimally controlled. By pre-simulation and pre-engineering, the hybridGEOTABS sizing and performance are obtained for almost 150,000 cases from the different typologies, climates and building geometrical and energy-related properties. The research study behind this methodology, as well as a more detailed explanation of the parameters and performance indicators, are documented in deliverable D2.5 (https://doi.org/10.5281/zenodo.4704647).

Table 1: Building parameters (more information and source: https://doi.org/10.5281/zenodo.4706967)

Parameters	Value in the tree		Values used in simulations for each typology			
			Office	School	Elderly home	Multi-family
Glazing	Low		20%	20%	20%	20%
	Medium		40%	40%	35%	35%
	High		60%	60%	50%	50%
Shading system	No		No-Shading	No-Shading	No-Shading	No-Shading
	Yes		External shading system	External shading system	External shading system	External shading system
Insulation level	Low	Envelope U-value (w/m²/k)	0.5	0.5	0.5	0.5
		Window U-value (w/m²/k)	2.5	2.5	2.5	2.5
		Glass g-value	0.6	0.6	0.6	0.6
		air-tightness n50 (h^{-1})	5	5	5	5
	Medium	Envelope U-value (w/m²/k)	0.27	0.27	0.27	0.27
		Window U-value (w/m²/k)	1.5	1.5	1.5	1.5
		Glass g-value	0.56	0.56	0.56	0.56
		air-tightness n50 (h^{-1})	2	2	2	2
	High	Envelope U-value (w/m²/k)	0.15	0.15	0.15	0.15
		Window U-value (w/m²/k)	0.8	0.8	0.8	0.8
		Glass g-value	0.4	0.4	0.4	0.4
		air-tightness n50 (h^{-1})	0.6	0.6	0.6	0.6
Internal heat gains	Low	Occupants density	1 Person/10m²	1 Student/2.5m²	1 Elderly/24m²	3 persons / dwelling
		Occupancy load (W/m²)	5	21	____	1.2
		Lighting (W/m²)	8	8	____	1.5
		Appliances (W/m²)	5.5	4	____	4.8
		Total (W/m²)	18.5	33	____	7.5
	High	Occupants density	1 Person/10m²	1 Student/2.5m²	1 Elderly/24m²	3 persons / dwelling
		Occupancy load (W/m²)	10	30	3	3.6
		Lighting (W/m²)	8	8	3.75	2
		Appliances (W/m²)	15	4	4	23
		Total (W/m²)	33	42	10.7	28.6

The database of pre-simulated and pre-engineered hybridGEOTABS designs that is the basis of the decision trees, is also publicly available via the hybridGEOTABS design webtool, available from www.hybridgeotabs.eu. This tool allows to consult the results for the specific building cases that are most similar to the designers project at hand, as well as a whole range of additional outcomes to support the designer in the feasibility study and pre-design, such as monthly heating and cooling demands, the effect of the controller on the design, estimates of the energy, environmental and life-cycle costs and a comparison of hybridGEOTABS with other HVAC-solutions.



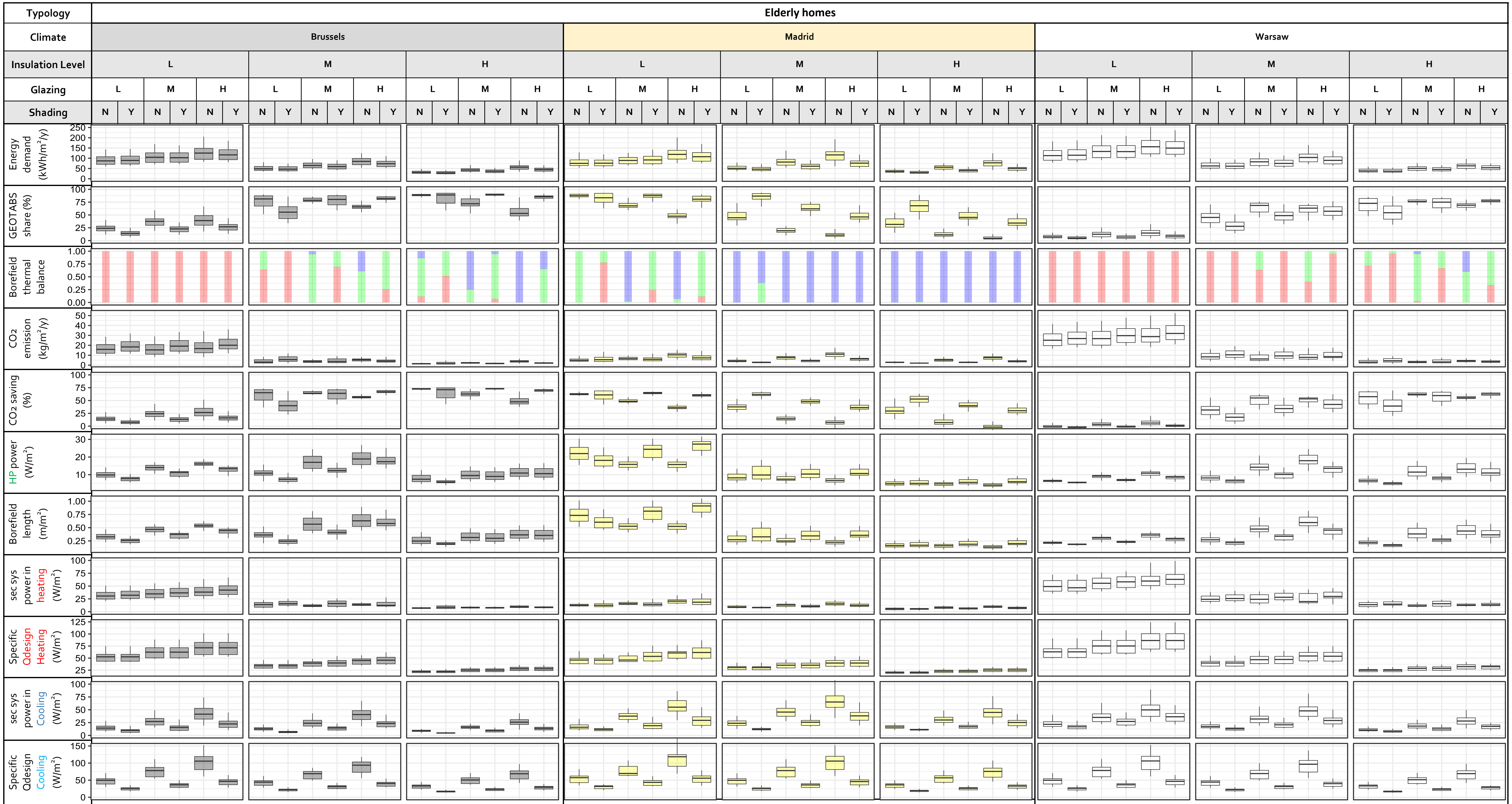
Notes:

1- The borefield balance graph shows the relative frequency of cases which are inherently heating (red) or cooling (blue) dominated or balanced (green) in each subgroup.

2- For reading about the background of the decision trees check https://doi.org/10.5281/zenodo.4704647

3- "L"," M", and "H" respectively stand for "Low", "Medium",and "High" for different parameters. To know what "Low", "Medium", and "High" refer to for different parameters, check https://doi.org/10.5281/zenodo.4724848

4- The design decision trees are a result of the hybridGEOTABS project (www.hybridGEOTABS.eu), funded by the European Commission H2020 research and innovation programme under grant agreement No. 723649



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2- For reading about the methodology used for deriving the decision trees check https://doi.org/10.5281/zenodo.4704647

3- In the elderly home typology, no differentiation is made between low and high occupancy levels (only one typical level is assumed)

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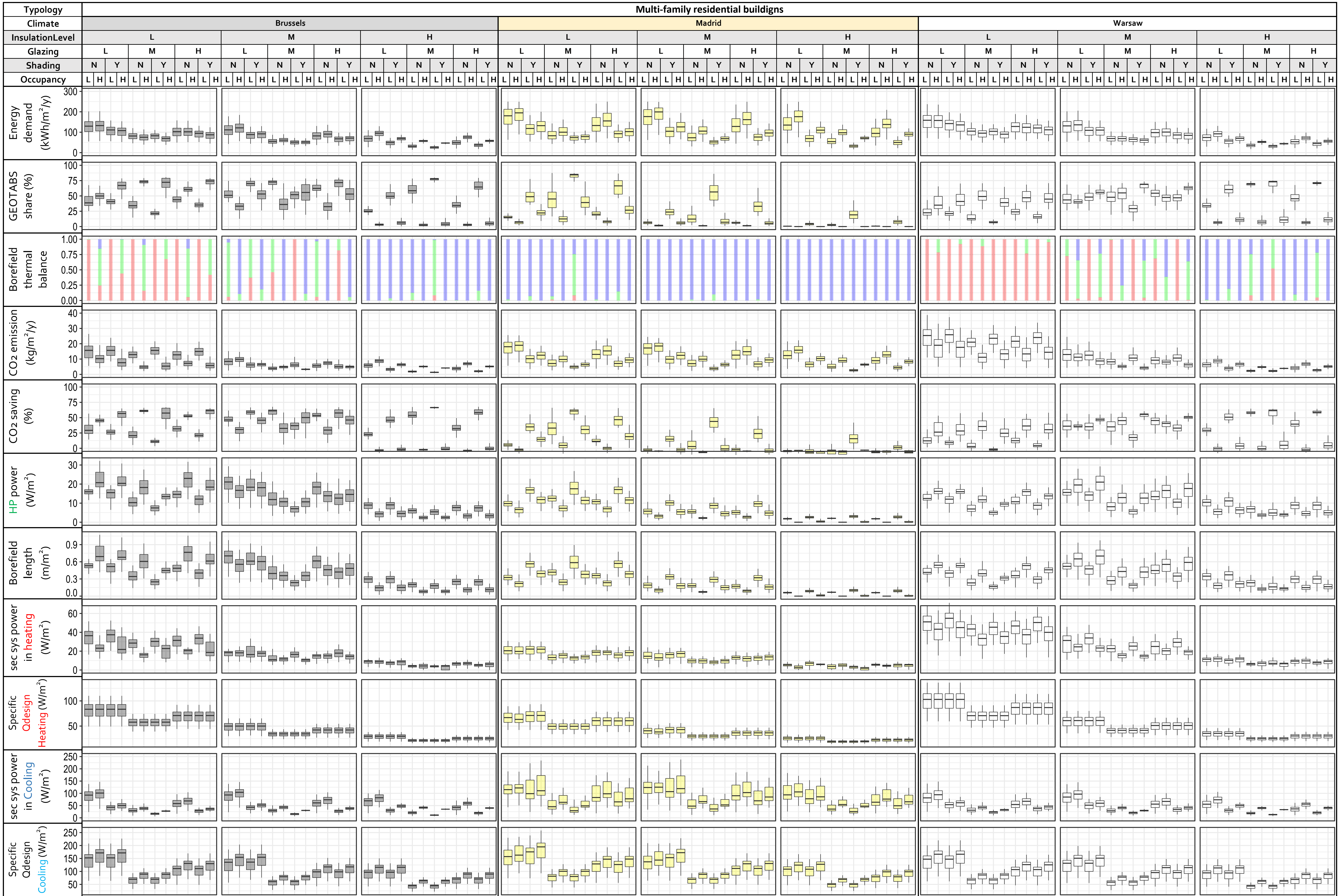

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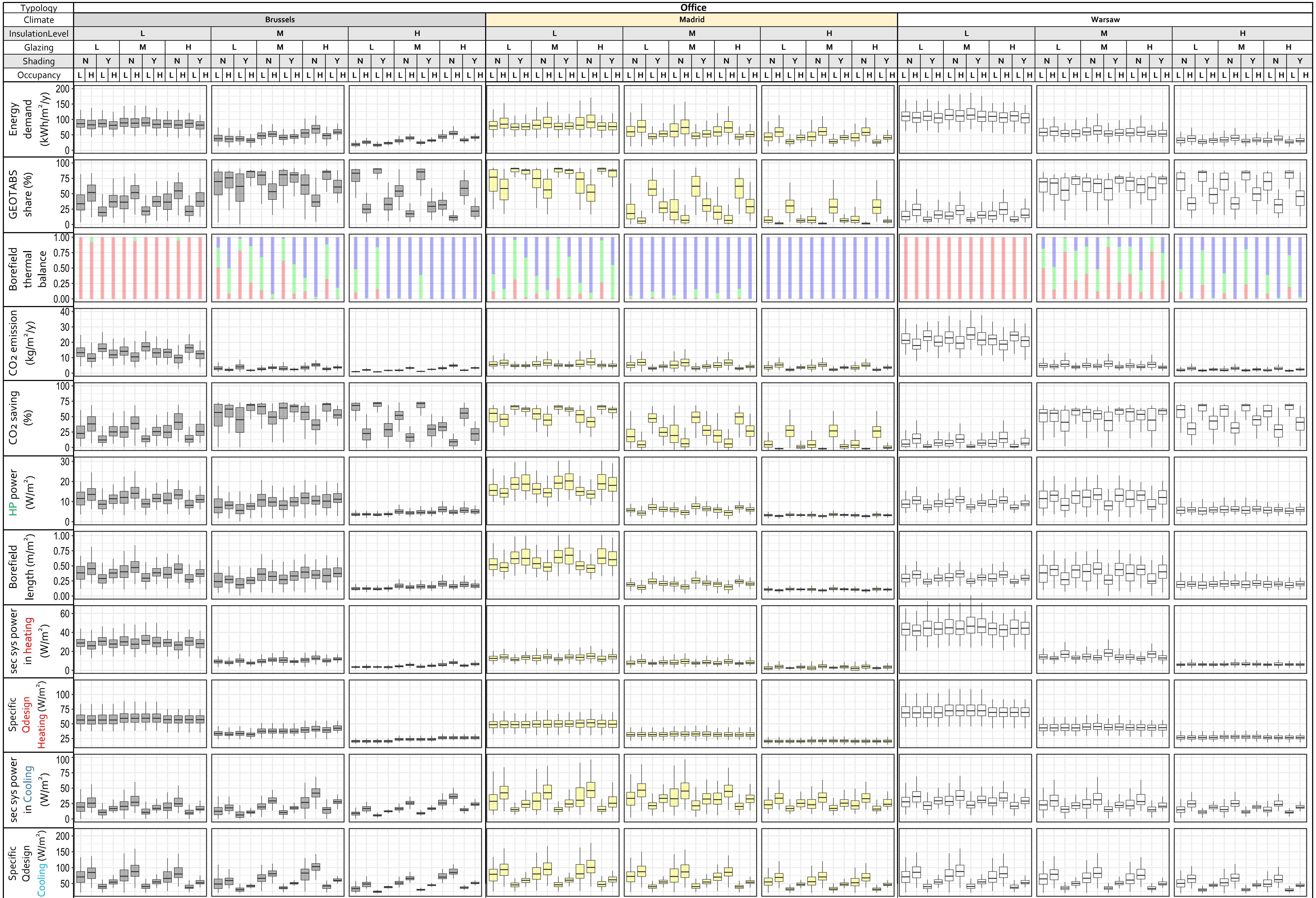

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