Parametric study of low energy buildings under different climate conditions

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Summary

1. Context
2. Objectives
3. Methodology
4. Results
5. Deliverables and Conclusions

Context

Bioclimatic architecture: different heating, sensible cooling, latent cooling loads, driven by different climate conditions are faced by passive solutions.

- Need of **passive strategies**, use of **RES** and **very efficient active systems** to reduce primary energy consumption and electrical peak load
- Recasted **EPBD**: "*Priority should be given to strategies which enhance the thermal performance of buildings during the summer period (…) avoid overheting*"
- Need of a **methodological approach**

EURAC HQs, Bolzano (I)

WAT building, Karlsruhe (D)

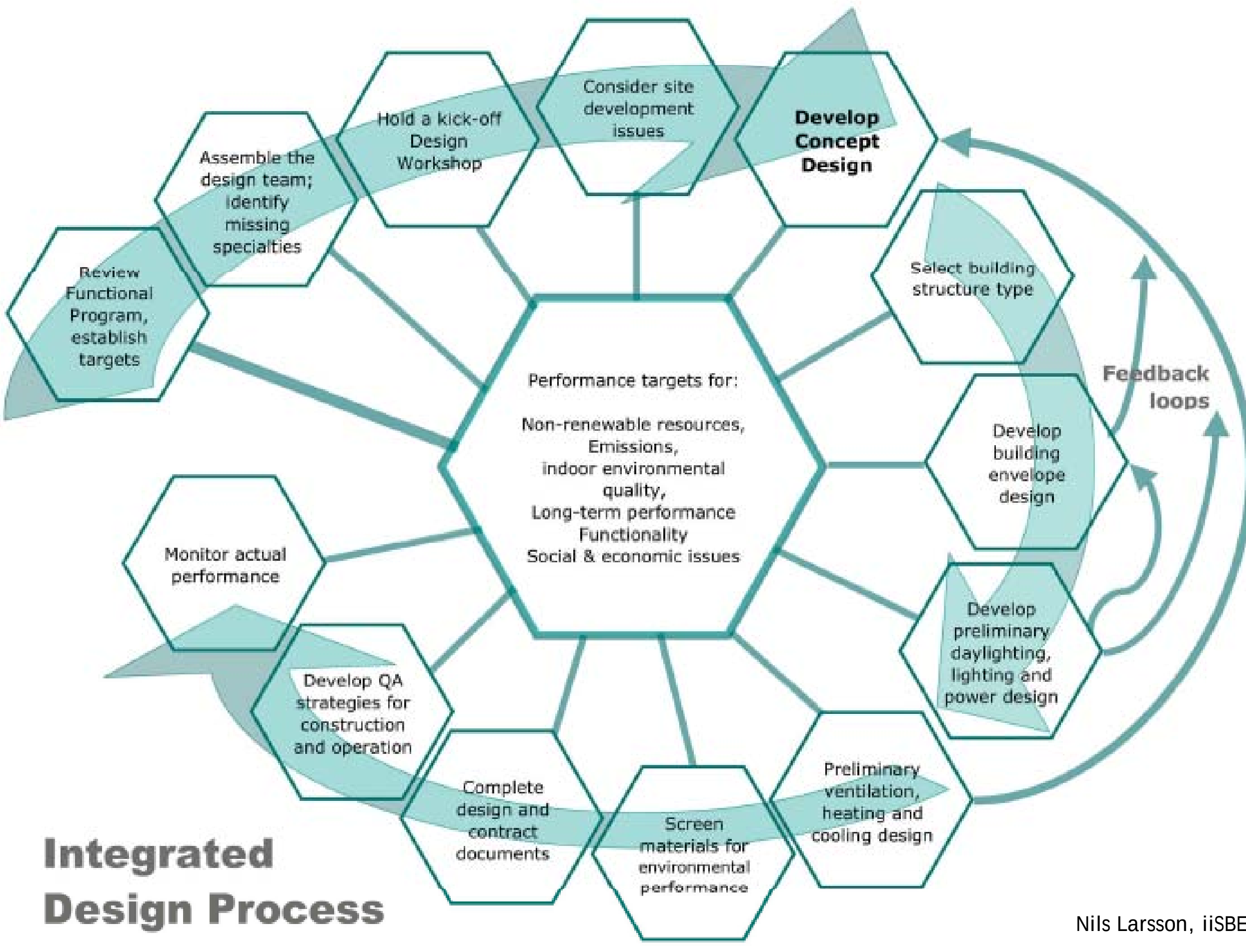
plankensteiner & steger architekten

Objectives

Scope of the work:

- to define a **methodological approach** based on parametric analysis
- to assess how this approach can **support architects** in different design stage

Objectives: non linear process

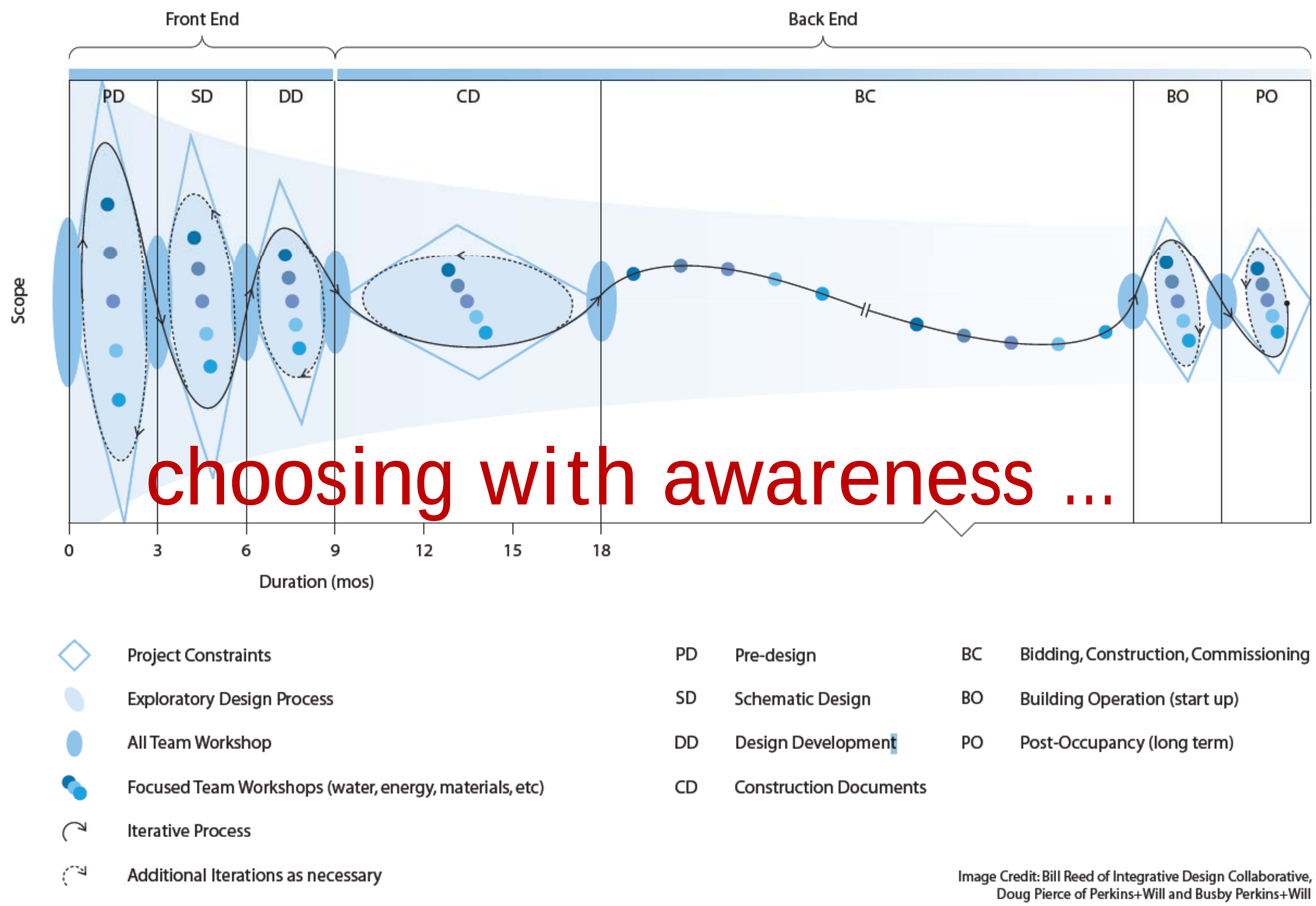


Nils Larsson, iiSBE 2005

Towards low energy buildings

1. Defining performance targets and preliminary strategies
2. Reducing loads and optimise daylighting, handling architectural and building variables
3. Using of RES and efficient HVAC systems
4. Producing at least a couple of design concepts and itering the process to enhance the building configuration

Objectives: facing the restraints



choosing with awareness ...

The designers could face the restraints of the specific case:

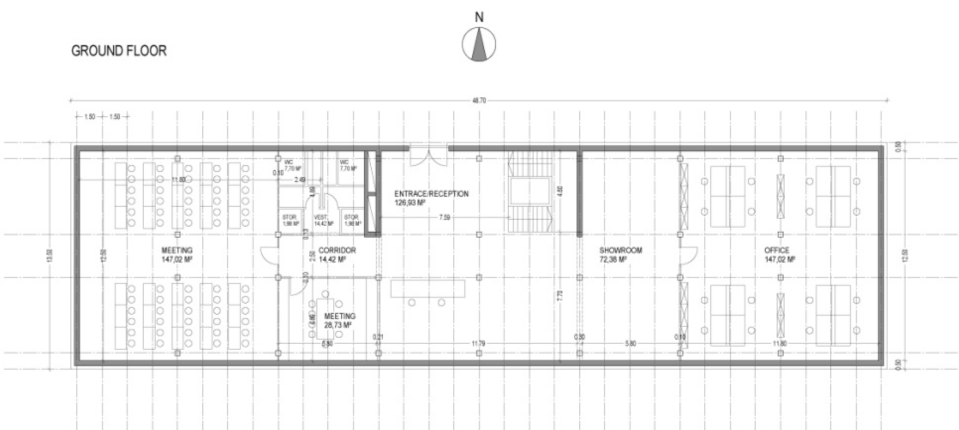
- urban context
- functions
- aesthetic
- etc.

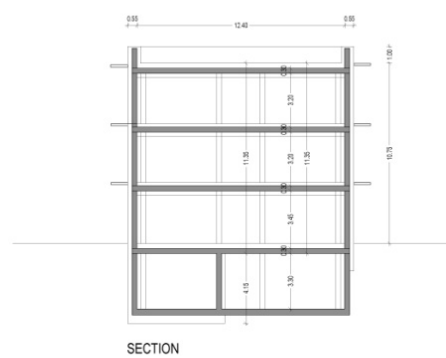
Objectives: case study

The developed approach was applied to:

- a low energy building in **Mediterranean climates**;
- an **office building**, chosen due to high internal loads;

analysing **heating, cooling, primary energy** and **overheating** during summer without air conditioning system





Methodology

<u>Independent variables</u> (model inputs)

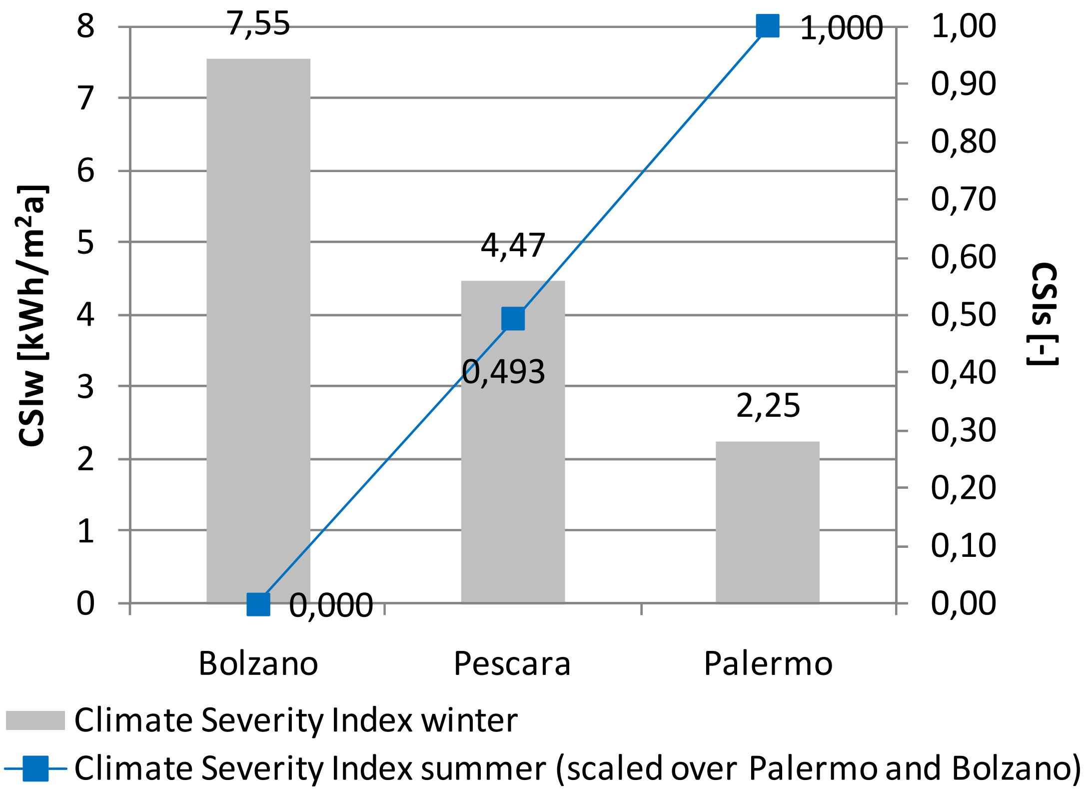
1. Climate
2. Architectural
3. Building
4. Functional

Other parameters fixed as set by Italian Laws and Standards in force

<u>Dependent variables</u> (model outputs)

1. Heating load
2. Cooling load
3. Primary Energy demand
4. Summer overheating percentage

Methodology



Chosen locations:

- Bolzano
- Pescara
- Palermo

CSIs [Santamouris, 2005] has been normalized as the maximum value in Italy is 2.78 kWh/m^{2}a (Palermo) and the minimum is 2.1 kWh/m^{2}a (Milan). Climate source data is Meteonorm6.1.

Methodology

8 different **architectural cases** depending on:

- orientation
- presence of balconies
- low/high transparent area

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Methodology

Variable	Maximum value		Minimum value	
Orientation	E-W		N-S	
Balcony	Yes		No	
	E-W	*N-S*	*E-W*	*N-S*
Transparent area N (m^2 & %)	371 (67.2%)	87 (56.5%)	101 (18,3%)	27 (17.6%)
Transparent area E&W (m^2 & %)	174 (56.5%)	742 (67.2%)	54 (17.6%)	203 (18.3%)
Transparent area S (m^2 & %)	371 (67.2%)	87 (56.5%)	101 (18.3%)	27 (17.6%)

Architectural variables

Methodology

Variable	Maximum value			Minimum value		
	Bolzano	Pescara	Palermo	*Bolzano*	*Pescara*	*Palermo*
U-value walls (W/m²K)	0.34	0.36	0.48	0.11	0.11	0.11
U-value glazings (W/m²K): N, S, E&W	1.7	1.9	2.7	0.51	0.51	0.51
g-value glazings (-): N, S, E&W	0.7			0.4		
specific capacity (Wh/m²K)	204			60		

Building variables

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Methodology

Variable		Maximum value	Minimum value
Shading reduction (%)		0.79	0.34
Summer ventilation (1/h)		2	0.5
Internal loads (W/unit)	PC	80	10
	Monitor	28	20
	Phone	90	64

Functional variables

Methodology

Used approach:

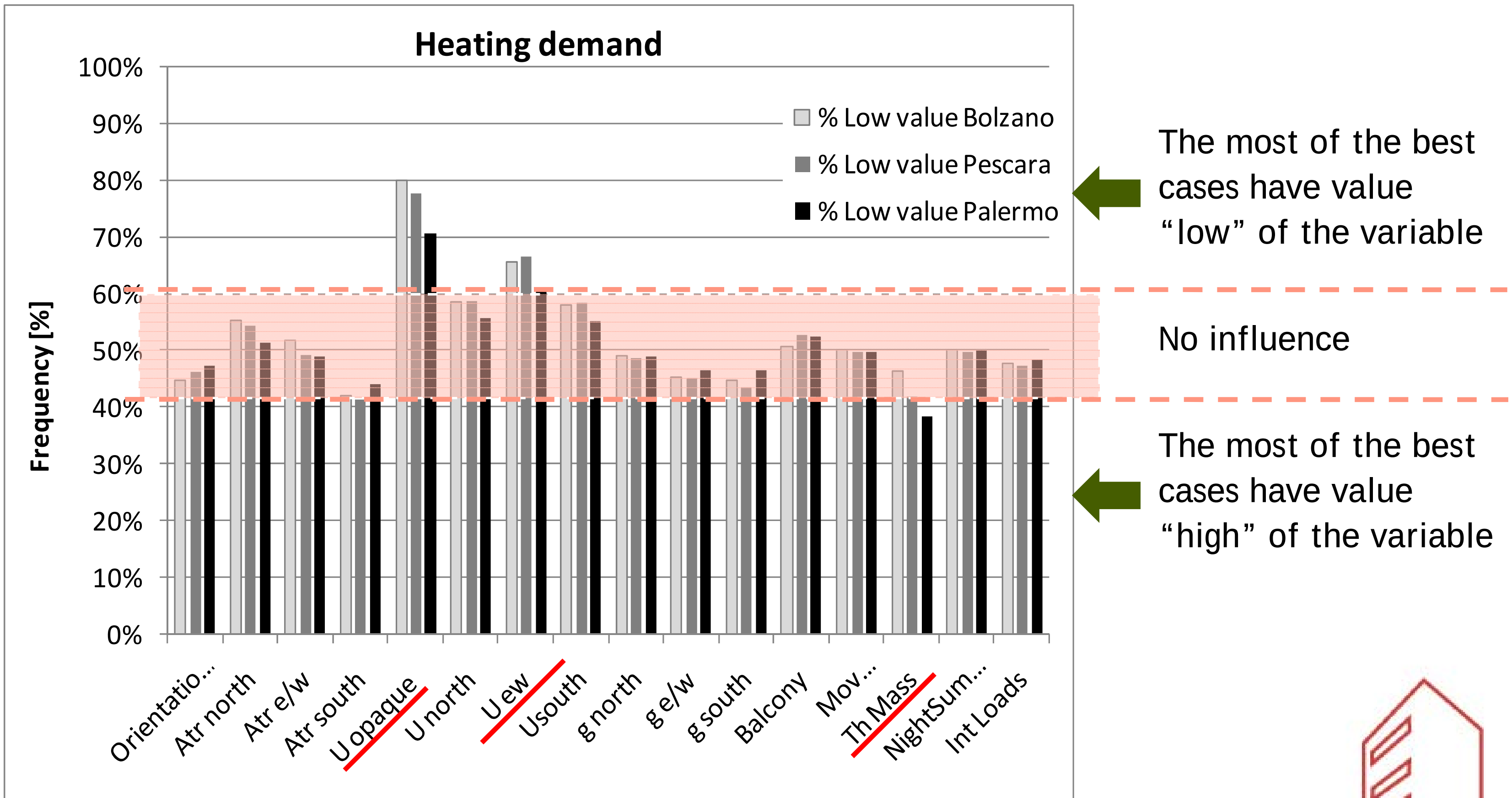
→ 16 variables with two levels: low and high

→ Total number of simulated cases 2^{16}=65’536

→ Three **steps** to “read” the big amount of results:

1) **Freqency** (%) with which the low value of a variable appears in the population of the best “n” building configuration
2) Study of 8 different **architectural cases** (depending on orientation, presence of balconies, low/high transparent area: 2^3)
3) Choice of **high performance cases** in hot climate

Results: heating (step 1)



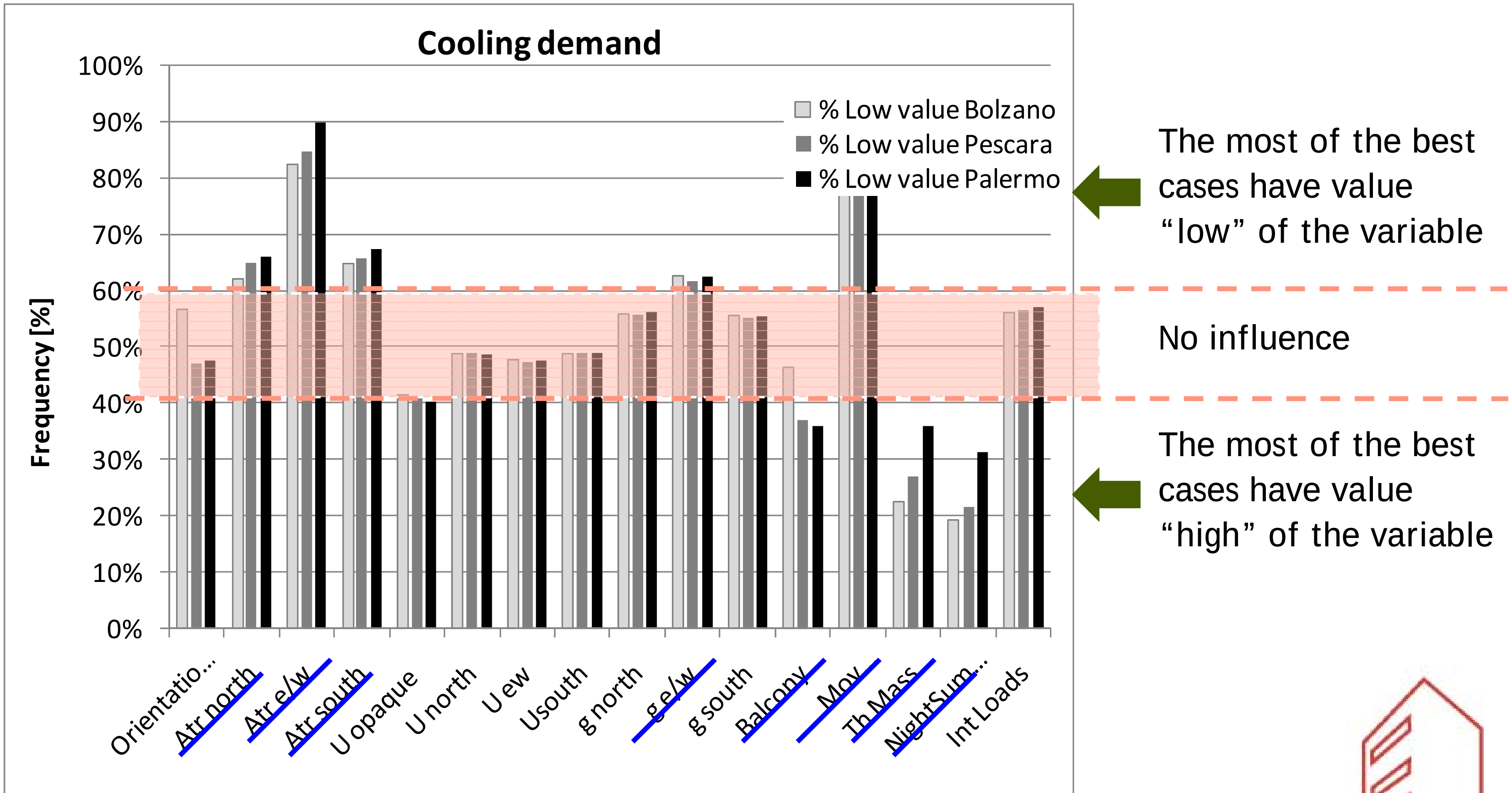
The most of the best cases have value "low" of the variable

No influence

The most of the best cases have value "high" of the variable

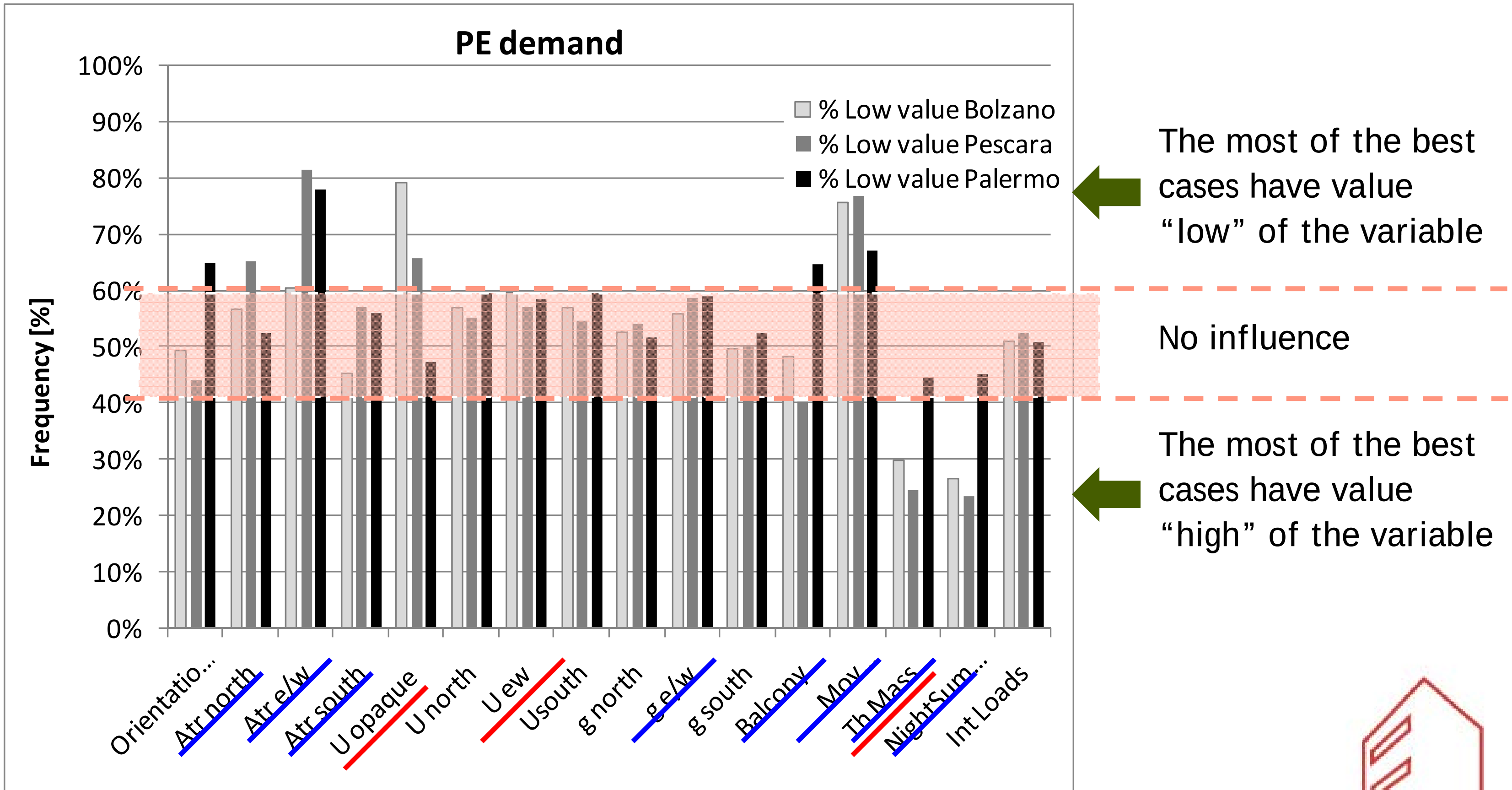
Frequency of variable low value for heating (Heating Loads < 15 kWh/m²y)

Results: cooling (step 1)



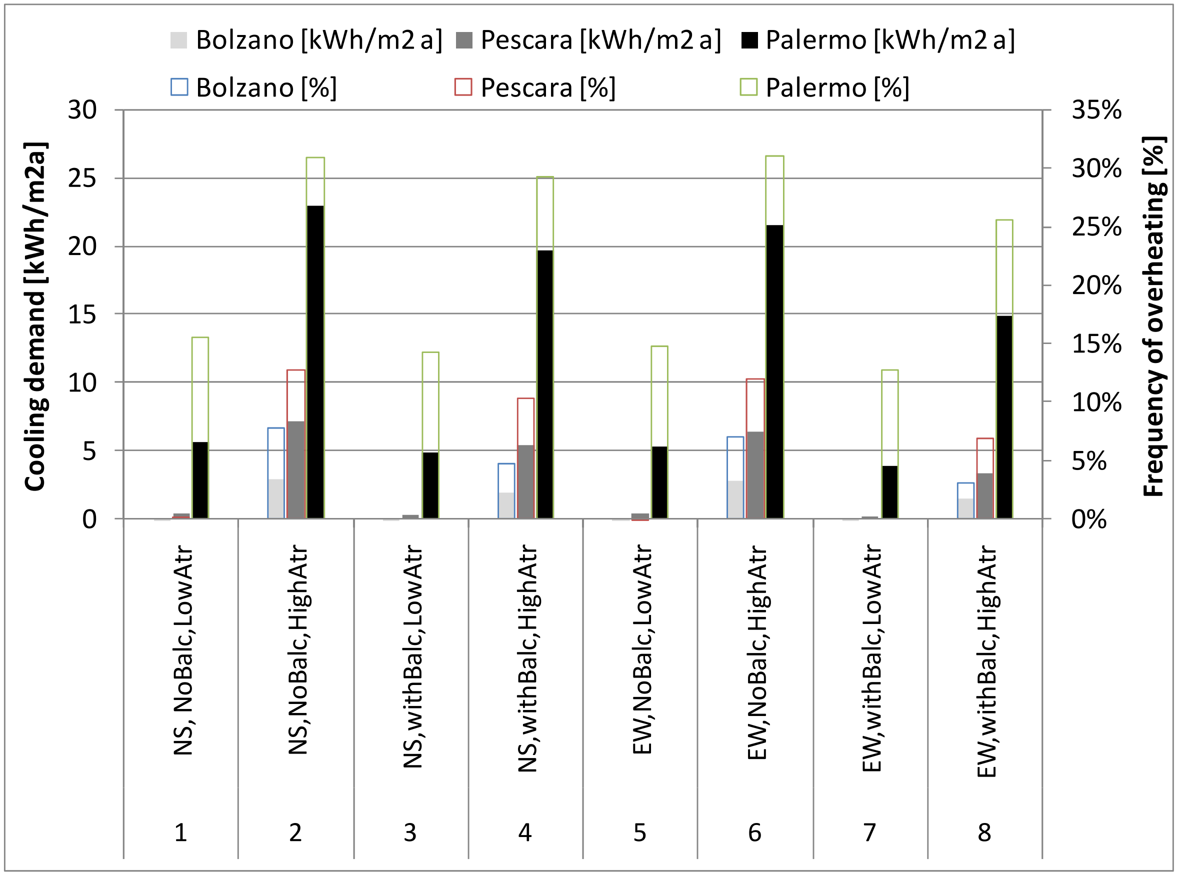
Frequency of variable low value for cooling (Cooling Loads < 15 kWh/m²y)

Results: annual PE (step 1)



Frequency of variable low value for PE (PE for heat. & cool. < 50 kWh/m²y)

Results: Cooling demand(step 2)



Average of the cooling demand of the best 100 cases

Possible configuration for hot climate (step 3)

Palermo: **Orientation EW**, Balcony, High thermal mass, Summer ventilation, low internal loads, high rate summer movable shadings

Variable	Best Case	High Perf. Case
Ratio Transp Area (%)	N & S (18.3), E & W (**17.6**)	N & S (18.3), E & W (**56.5**)
U_{north}, $U_{e/w}$, U_{south}, U_{op} (W/m^2K)	0.51, **2.70**, 0.51, **0.11**	0.51, **0.51**, 0.51, **0.48**
g_{north}, $g_{e/w}$, g_{south}	0.4, 0.4, **0.4**	0.4, 0.4, **0.7**
Heat Demand (kWh/m^2y)	**0.0**	**0.5**
Cool Demand (kWh/m^2y)	**3.90**	**6.45**
PE (kWh/m^2y)	**8.51**	**14.55**
Overheating (%)	**14**	**17**

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Possible configuration for hot climate (step 3)

Palermo: **Orientation NS**, Balcony, High thermal mass, Summer ventilation, low internal loads, high rate summer movable shadings

Variable	Best Case	High Perf. Case
Ratio Transp Area (%)	N & S (**17.6**), E & W (18.3)	N (**56.5**) & S (17.6), E & W (18.3)
U_{north}, $U_{e/w}$, U_{south}, U_{op} (W/m²K)	**2.70,** 0.51, 0.51, **0.11**	**0.51**, 0.51, 0.51, **0.48**
g_{north}, $g_{e/w}$, g_{south}	0.4, 0.4, **0.4**	0.4, 0.4, **0.7**
Heat Demand (kWh/m²y)	**0.0**	**2.22**
Cool Demand (kWh/m²y)	**4.96**	**5.19**
PE (kWh/m²y)	**10.81**	**13.54**
Overheating (%)	**16**	**15**

Conclusion

PRESENTED APPROACH FEATURES

Practical

- First step towards the implementation of the **parametric simulations** approach into a useful design tool.
- The methodology can be used **in every phase of the design process** for:
  - o fast and operative method to assess the energy performance of different building features.
  - o **Design choice revision**, when there is the need to reconsider some previous taken design decisions.

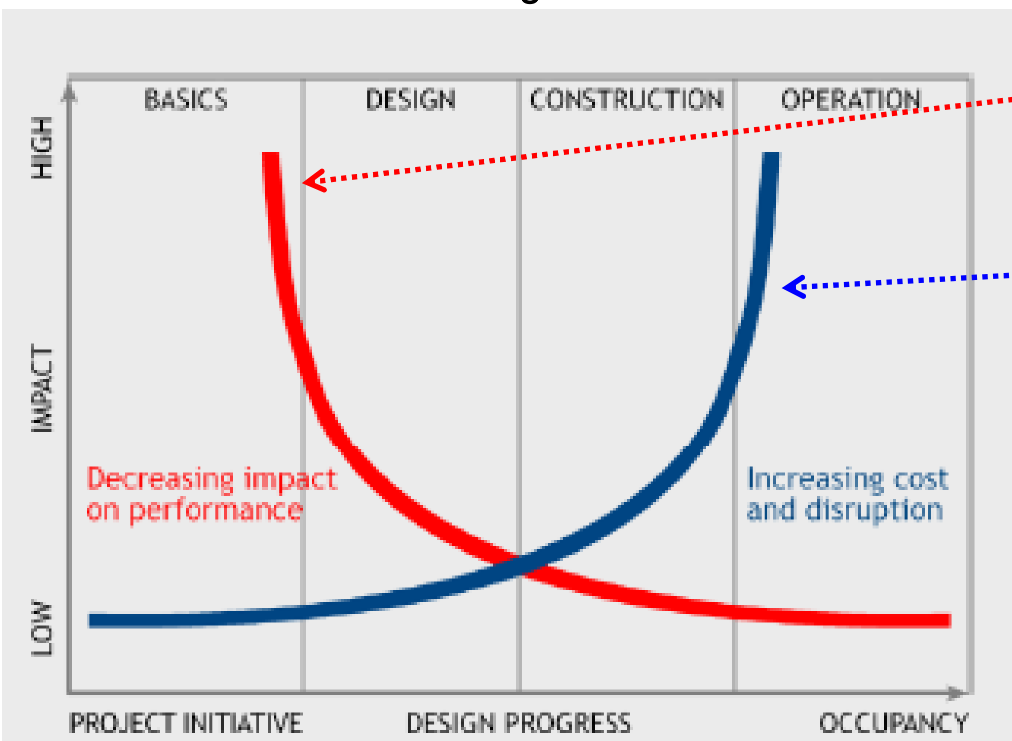
Theoretical

- **Comparing** different architectural and technical building solutions **under different climate conditions**.

Conclusion

TOOLBOX

- **Software**: Parameterization models
- **Handbook**: Technologies



High **potential** EE optimization in the early design phases!

High **costs** for low impact actions in the final phase!

Conclusion

SOME POSSIBLE TIPS

The presented cases highlight

- Importance of reducing transparent areas in hot climate
- In case of highly glazed buildings, technical solutions can compensate:
  - movable summer shading devices
  - high energy capacitance
  - reduction of the internal loads (high efficient appliances),
  - ...

Grazie per l’attenzione

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