

# METHODOLOGICAL APPROACH ON THE BUILDING ENVELOPE OPTIMIZATION USING PCM

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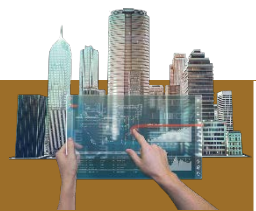
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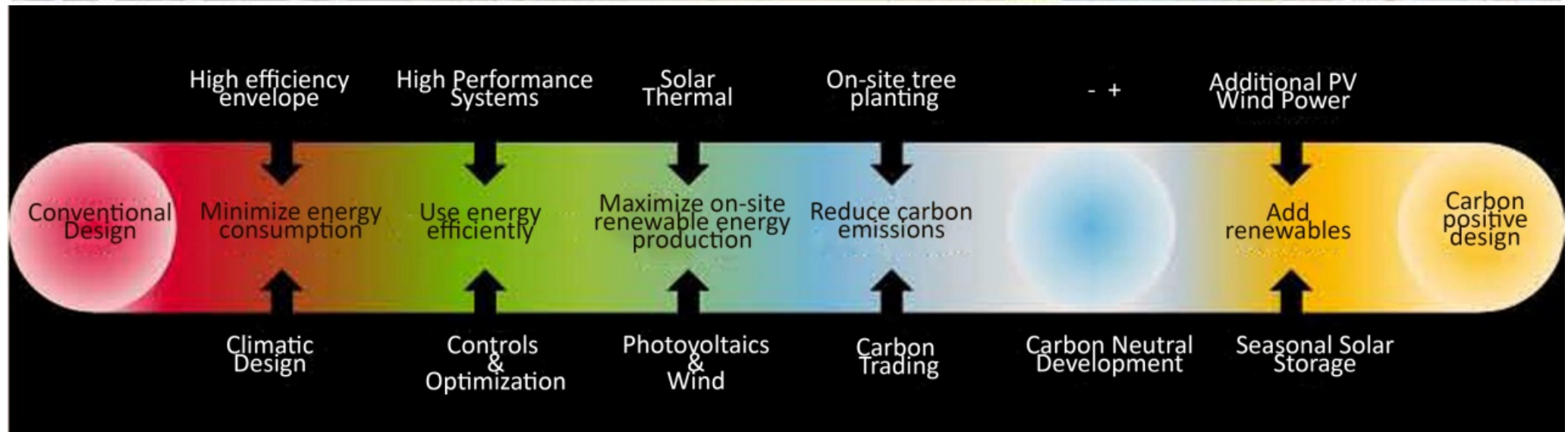


”A well designed building, meaning a well designed shelter, is able to accommodate many of the functions that we want to achieve in any given climate through its architecture. The more we are able to let the architecture do the work, the smaller our systems can be.”

Nico Kienzl, Atelier Ten  
Analysis Tools for High Performance Design (2008)  
Seminar for Sustainable Design, University of Texas, Austin

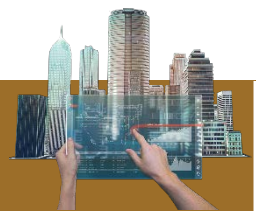


# towards carbon positive development

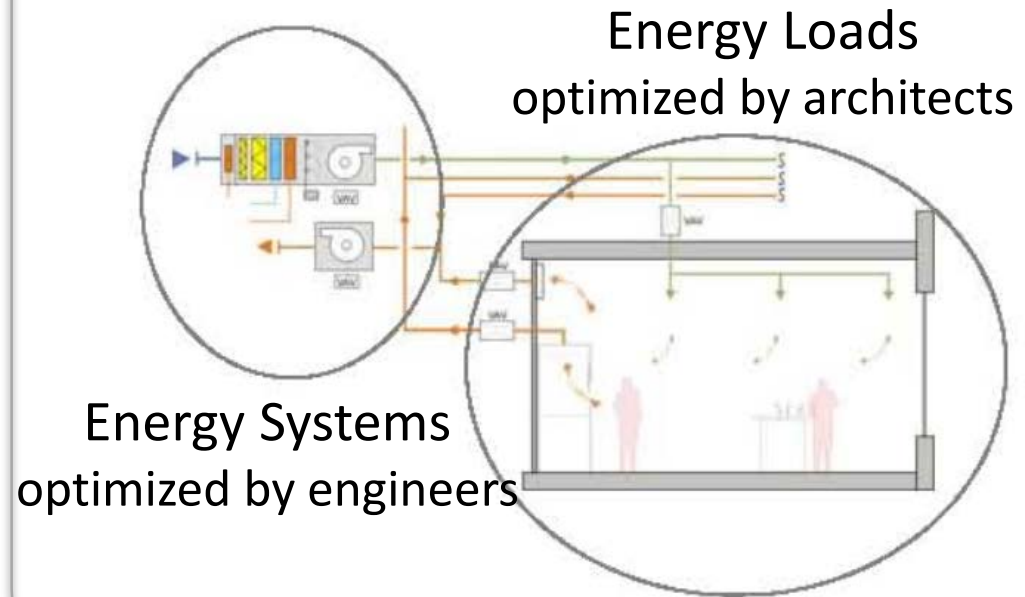


Nico Kienzl, Atelier Ten,

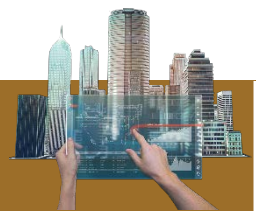
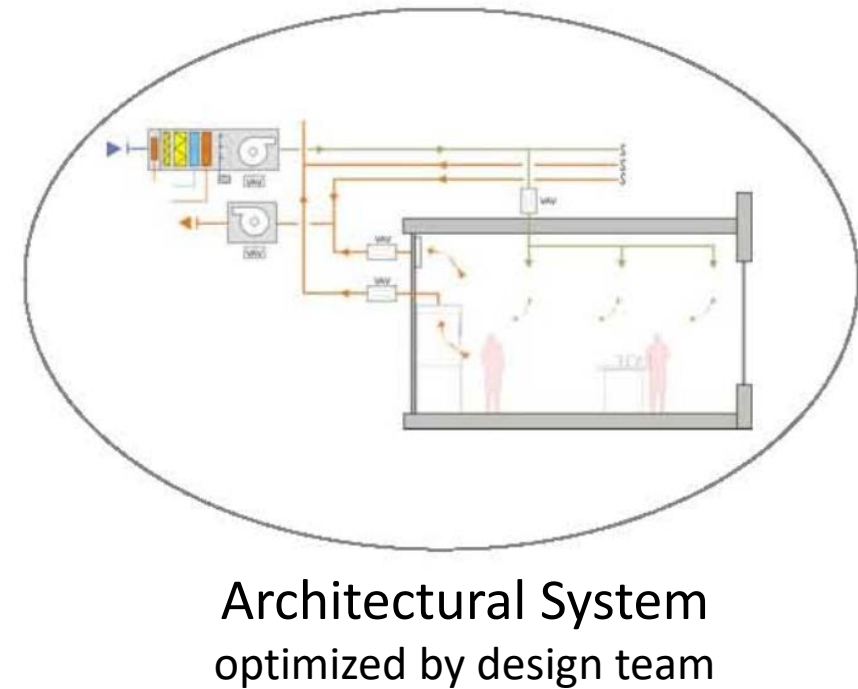
Analysis Tools for High Performance Design (2008)

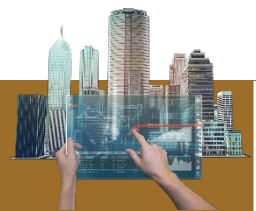
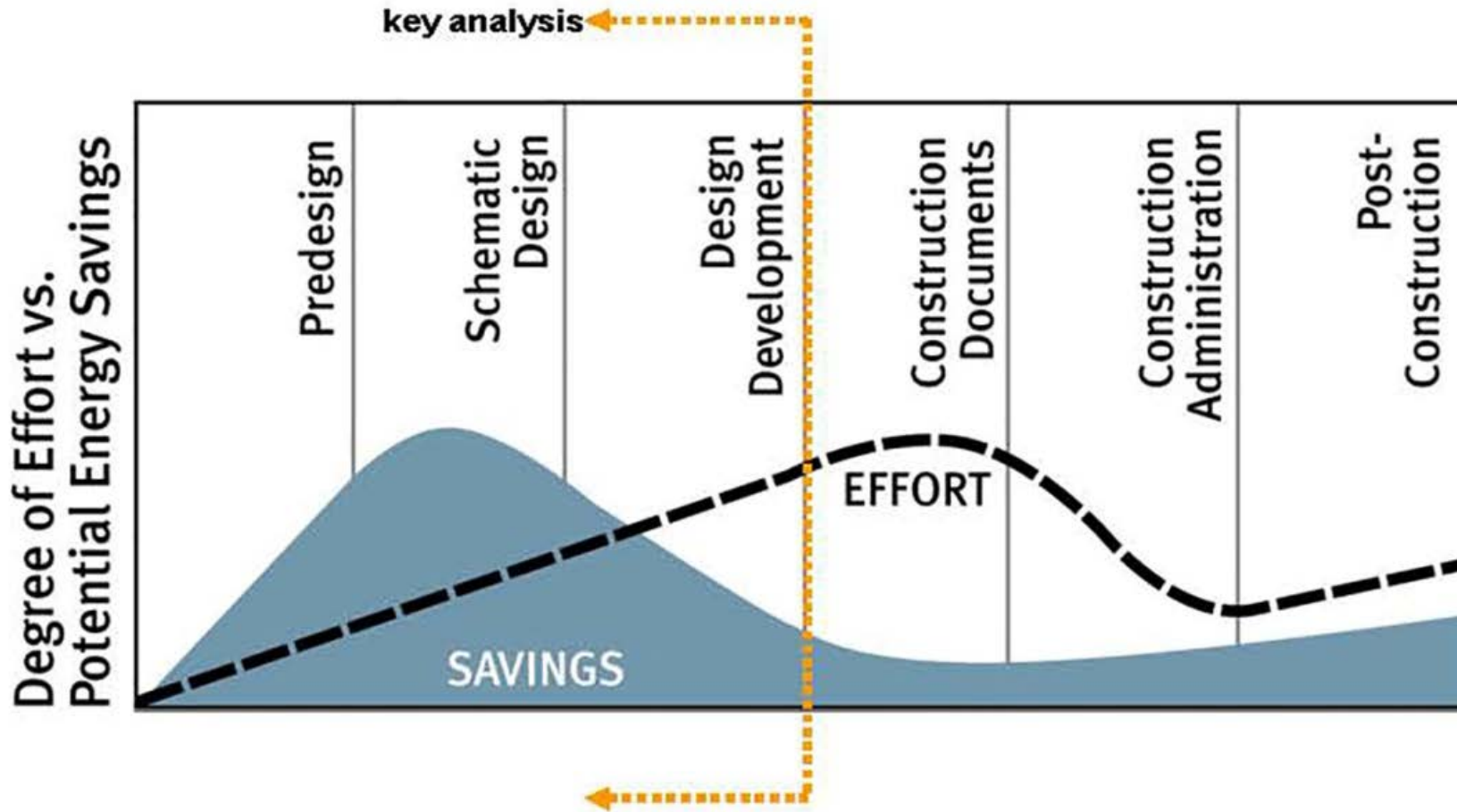


## Conventional design process



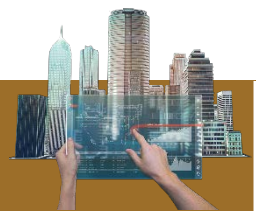
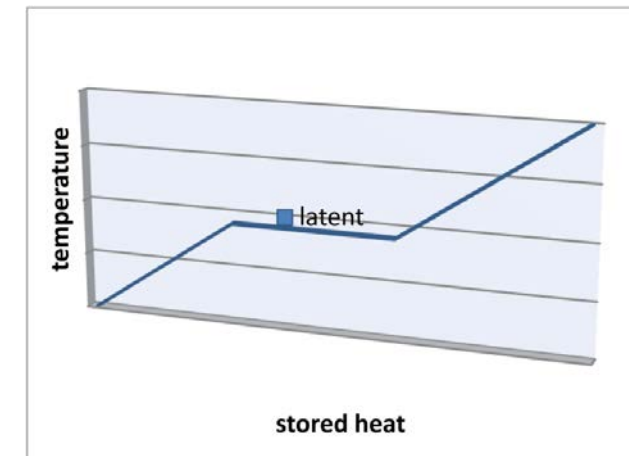
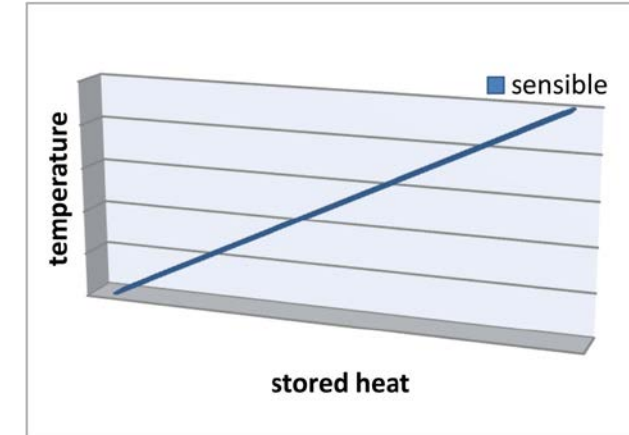
## Integrated design process



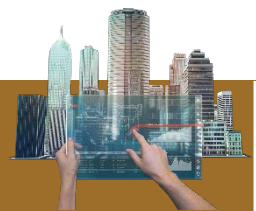
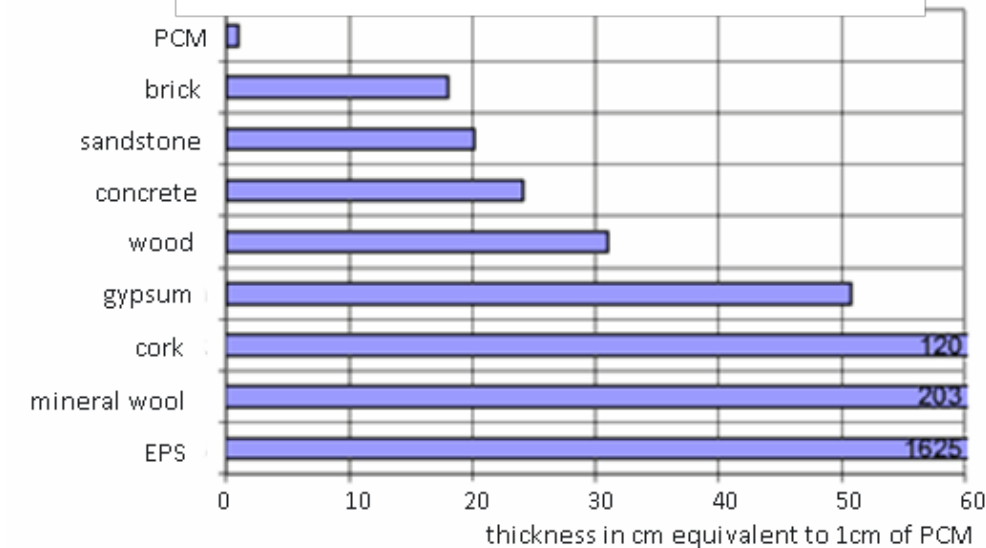
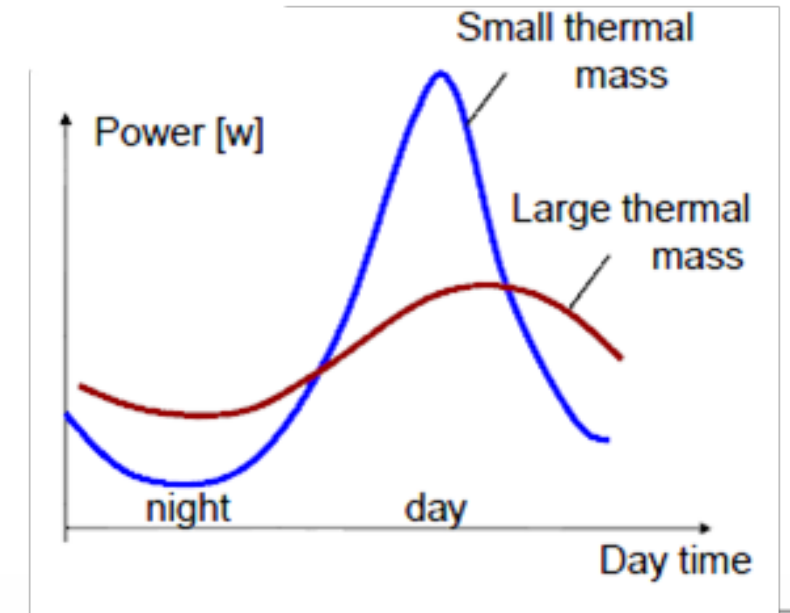




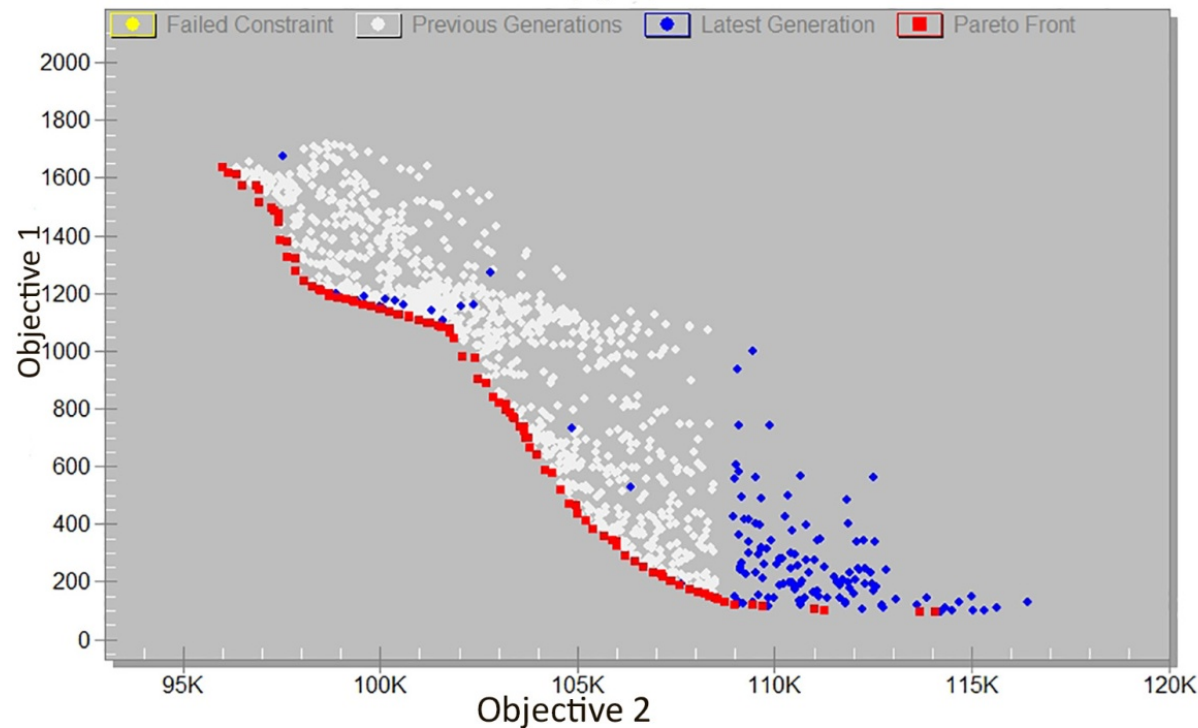
- › building envelope
  - › reduction of the building's energy demand, while improving its life-cycle environmental impact
- › thermal energy storage in the building envelope
  - › sensible energy storage
    - heat that is transferred to the storage medium leads to temperature increase
    - low heat storage potential
  - › latent energy storage with PCM
    - heat absorption or release when material undergoes a phase change
    - high energy storage density
    - stores heat at constant temperature



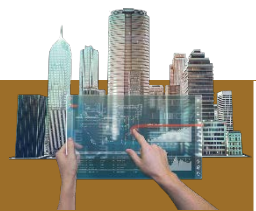
- › smaller mechanical systems
  - shifting space cooling from day to night
- › better efficiency of cooling systems
  - shifting space cooling from day to night
- › use of solar energy for heating
  - larger accumulation capacities
- › better temperature control
  - lower temperature swings
- › lightweight buildings
  - high thermal mass in small material volume



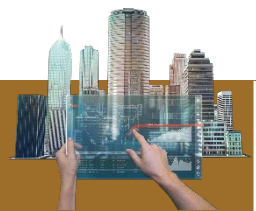
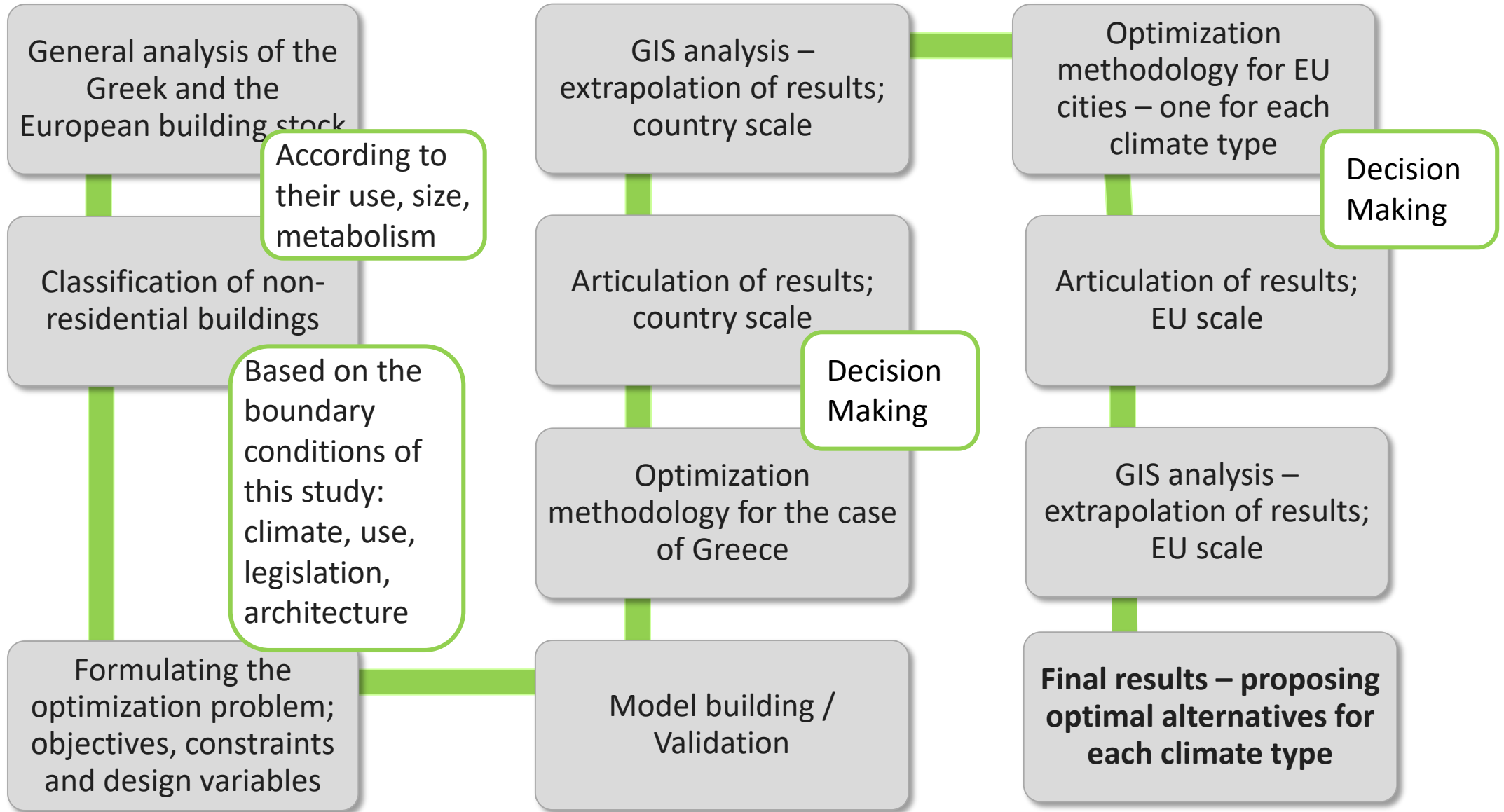
Optimization: finding one or more feasible solutions which correspond to extreme values of one or more objectives and simultaneously satisfy a number of specified constraints



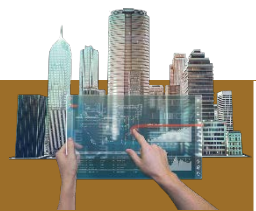
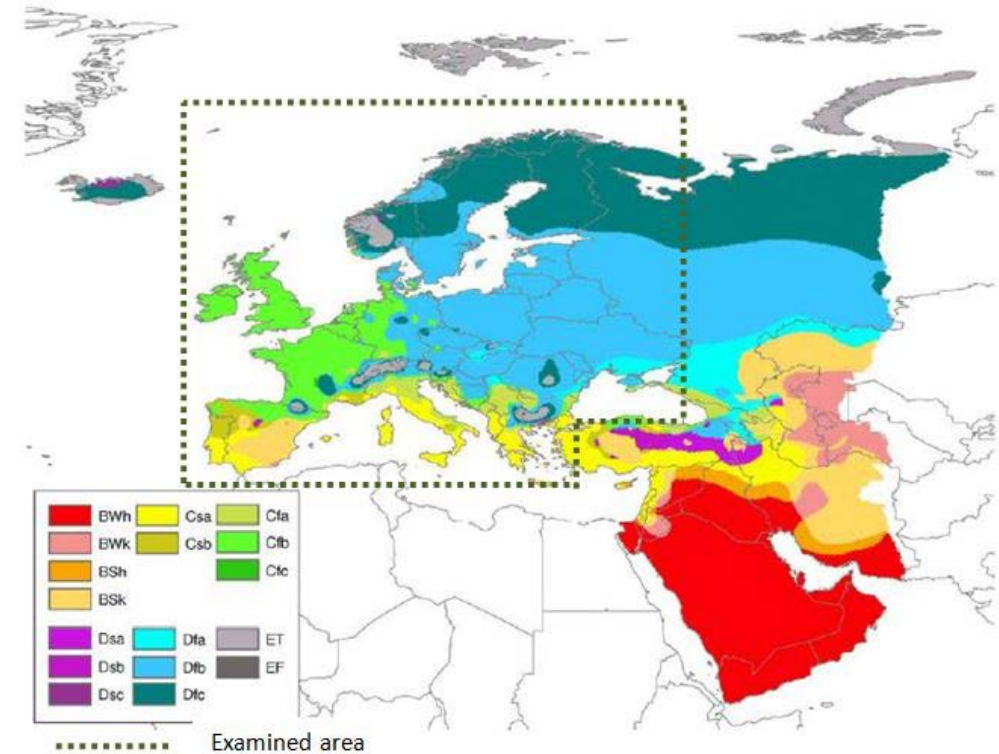
- › multiple, usually conflicting, objectives
- › set of alternative solutions involving different trade-offs, called Pareto optimal or non-dominated solutions
- › consists of three phases: model building, optimization and decision making





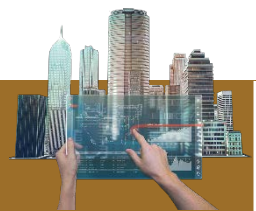


- › Climatic
  - › Köppen climatic types
- › user related
  - › office buildings – high energy demand
- › technical and legal
  - › EPBD requirements - nZEB
- › architectural
  - › open and closed office space





- › Design Builder simulation software
- › multi-objective optimization tool
  - Genetic Algorithm (GA)
  - NSGA-II method (Non-Dominated Sorting Genetic Algorithm)
- › limitations of Design Builder optimization tool:
  - a simulation run with monthly/annual output for the model should be performed before initiating the optimization procedure.
  - the daylight availability is not yet enabled,
  - it is not yet possible to store multiple optimization results sets within the Design Builder model
  - it can reach an optimization of only two objectives, while including up to ten design variables in the analysis



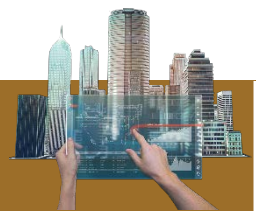


## objectives

- › minimize total carbon emissions
- › minimize cost; construction and operational

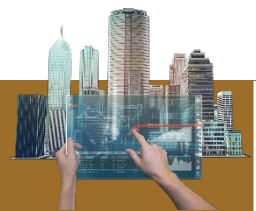
## constraint

- › keep discomfort hours under a certain level, based on Summer CEN 15251 Adaptive Category I



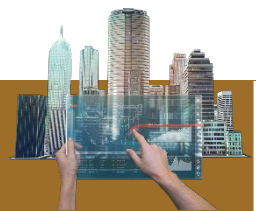


- › building orientation
- › window-to-wall ratio
- › shading percentage of the facade
- › construction template
  - insulation thickness
  - thermal mass materials
    - › Conventional materials – sensible storage
    - › Phase Change Materials (PCM) – latent storage
  - positions
- › control strategies
  - load shifting control strategy
  - demand limiting control strategy





- › is it possible to distribute PCM in the building envelope in a way that we can control charging and discharging on a daily basis, even in air-conditioned buildings, and achieve an improvement in the building energy performance?
- › what are the optimal combinations of parameters leading to this achievement in different climatic conditions?



Thank you for your attention!

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