Early Building Design: Heating and Cooling Plant Approach the Architect

Milica Grahovac

28.06.2012

2nd Colloquium of the Munich School of Engineering

Buildings Should Consume Less Energy

Buildings account for 40%

Roughly a half of that is consumed by HVAC

Regulations, Legislations, National policies, Certification

BEP Simulation Tools

Of total energy consumption (Germany, US, World).

A significant reduction potential exists in HVAC (Heating, Cooling and Air-Conditioning) domain.

e.g. EnEV 2012 (implements EU-Directive 2010/31/EU and DIN V 18599:2010)

- Imagine we omit to simulate or test cars and plains, as we commonly do with buildings! – **simulation improves planning**
- Buildings as smart grid objects – **predicting building behaviour demands simulation**

BEP – Building Energy Performance

Sources:

- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings,
- U.S. Energy Information Administration. Annual Energy Outlook 2011 With Projections to 2035. *Report DOE/EIA-0484*, Washington, DC, USA, 2011
- http://service.enev-online.de/bestellen/EnEV_2012_Was_kommt_Novelle_Energieeinsparverordnung.pdf)

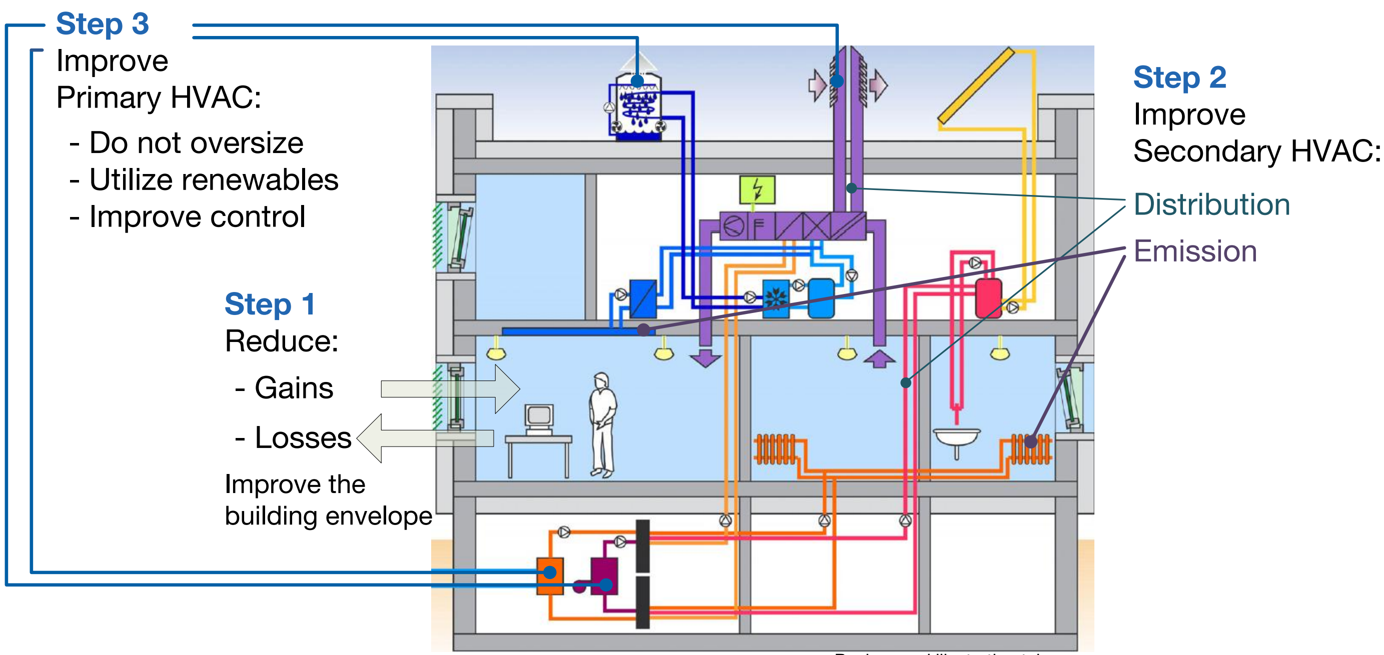
Introducing the Developed Tool

When to apply the tool?

- Appliable already during conceptual design

Which building component is in focus?

- Primary HVAC – energy generation and storage (Step 3)



Background illustration taken
from: DIN V 18599-1

Basic Features of the Tool

Time domain simulation (hourly quasi - stationary)

- Implementing intermittent RES and thermal storage
- Considering part load efficiency;

Preconfigured system models and control

- Optimal boiler and chiller staging
- The user does not configure the system
- Preset values provided and adaptive to provided user input

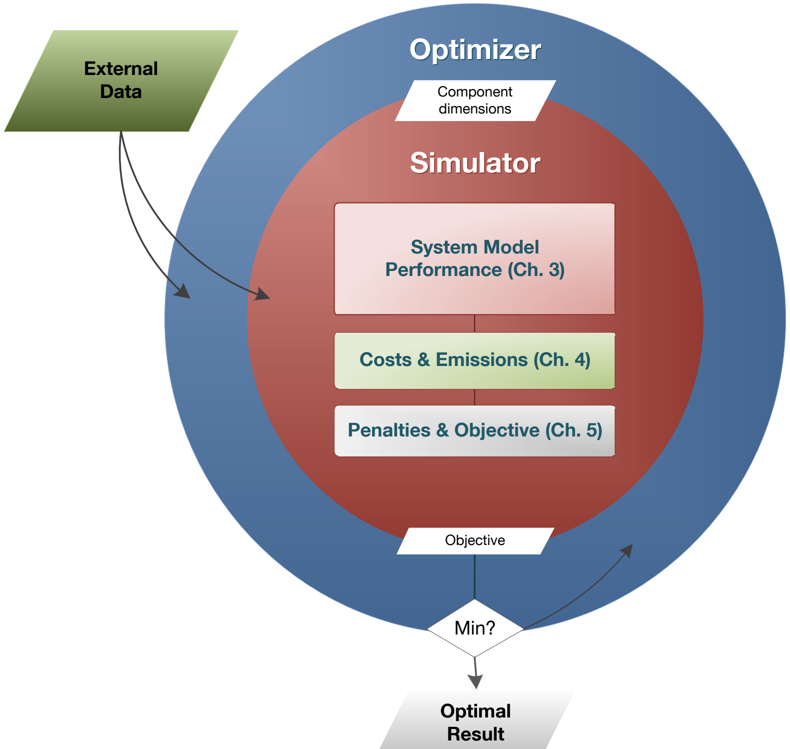
Component size optimization, always combinable with an annual solar ration target:

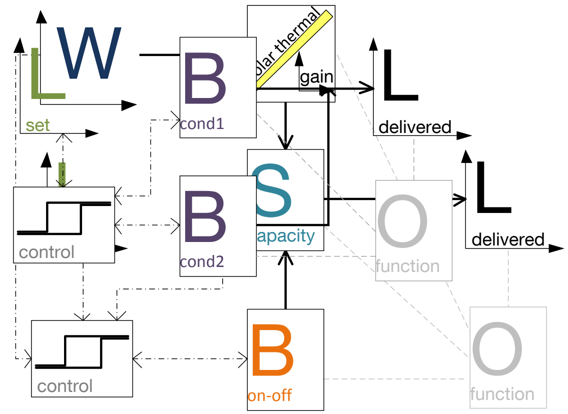
- Total cost minimization
- Investment cost minimization
- Carbon emission minimization
- Fuel consumption minimization

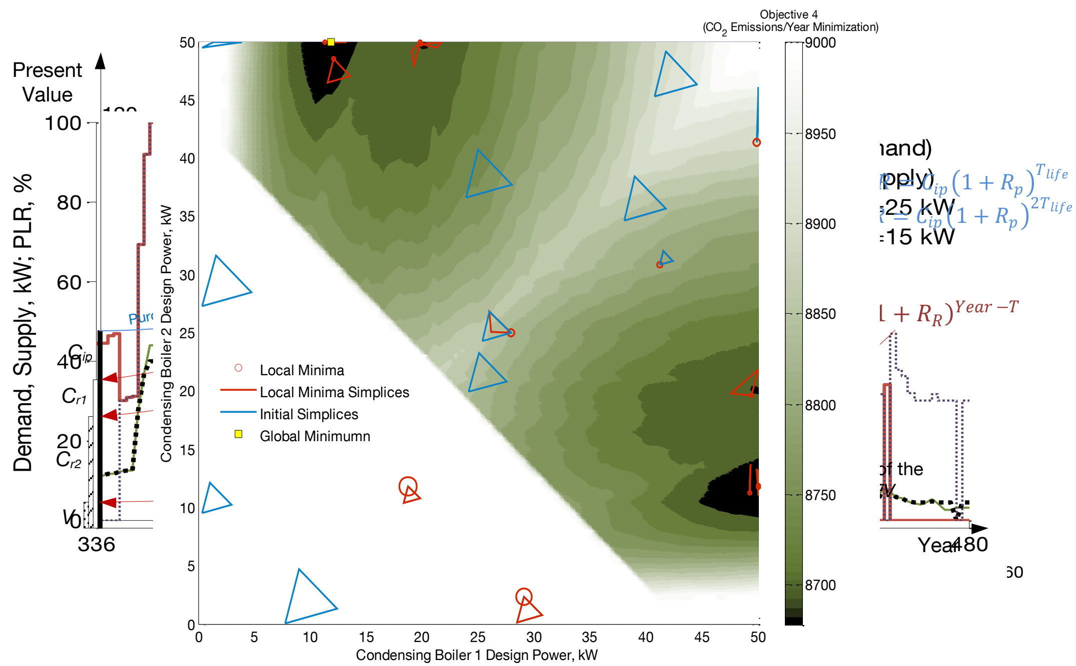
Obligatory input

- Climate data
- Building thermal load (“ideal load”) data

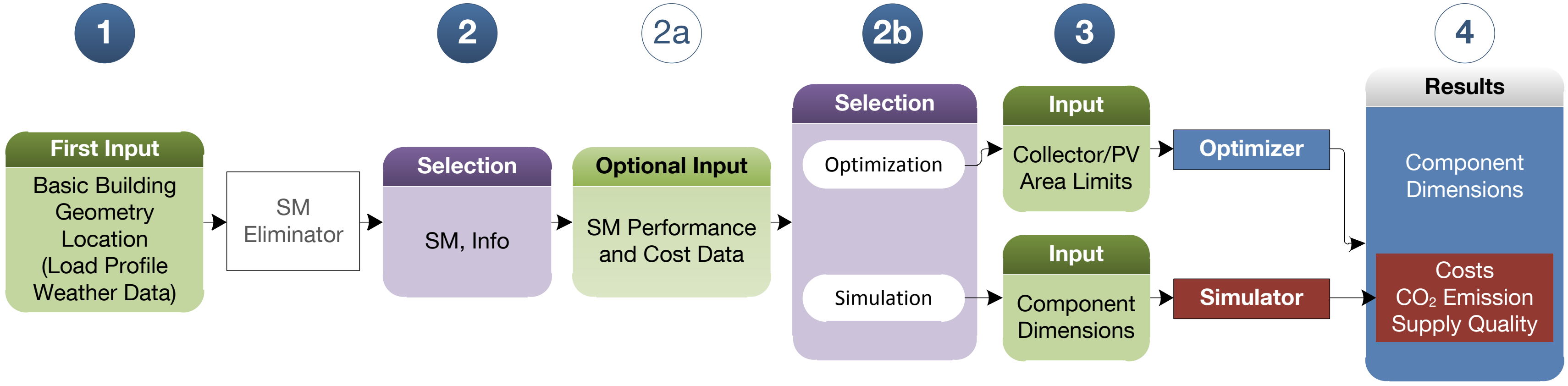
Tool Structure – Developer Perspective







Tool Structure – User Perspective: PROBA



PROBA - primary system optimization
for buildings
targeting architects

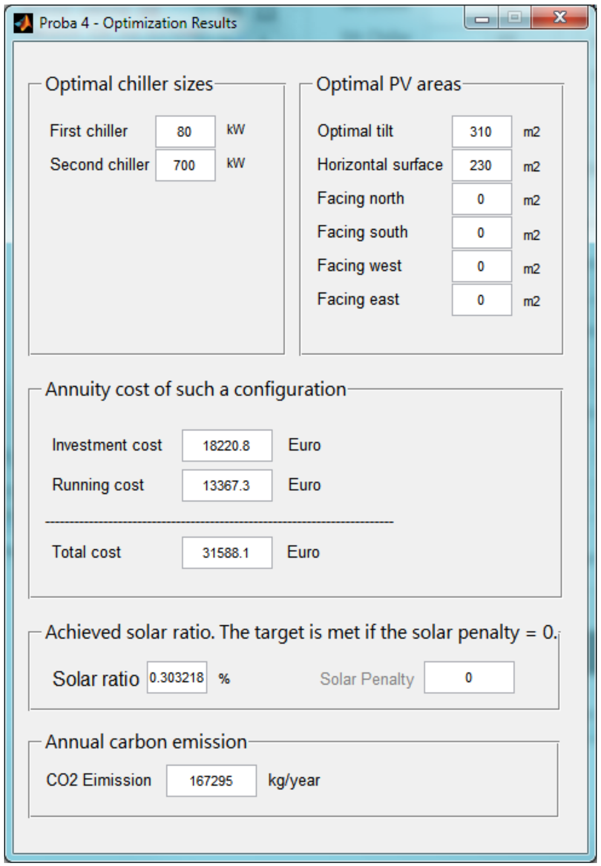

Simplicity is the essence of happiness

Alternative design

Initial building can reach the solar ratio (SR) target of 20%

If higher SR is required, the design is to be changed and optimization rerun

Alternative Design:


Proba 4 - Optimization Results

Optimal chiller sizes

First chiller	80	kW
Second chiller	700	kW

Optimal PV areas

Optimal tilt	310	m2
Horizontal surface	230	m2
Facing north	0	m2
Facing south	0	m2
Facing west	0	m2
Facing east	0	m2

Annuity cost of such a configuration

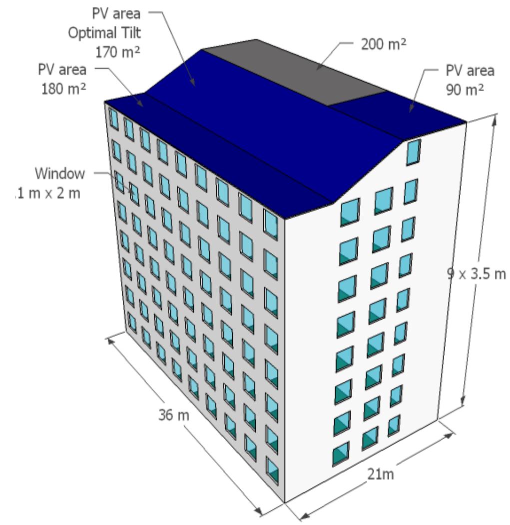
Investment cost	18220.8	Euro
Running cost	13367.3	Euro
Total cost	31588.1	Euro

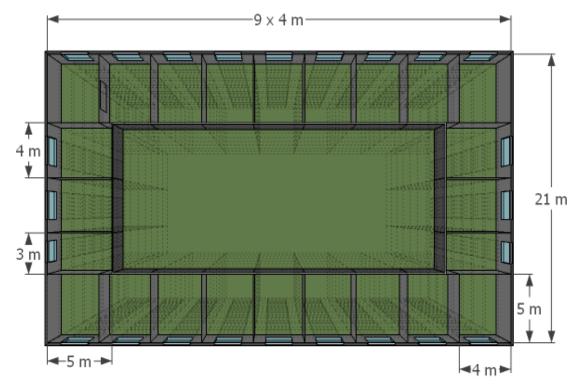
Achieved solar ratio. The target is met if the solar penalty = 0.

Solar ratio 0.303218 % Solar Penalty 0

Annual carbon emission

CO2 Eimission 167295 kg/year





Results and advantages of PROBA utilization:

- The tool provides dimensions, annual costs, energy consumption and emissions of the optimized system.
- Comparing alternative designs leads to early recognition of environmental or/and financial advantages of particular systems and components compared to other.

Beyond PROBA – the potentials of the underlying simulation tool:

- Abilities to perform energy analysis of the existing building stock or help planning multiple buildings.
- Optimization of primary HVAC systems of existing buildings (retrofit planning)

Outlook

- Model validation and the consequent model adjustments
- Integration of additional generation and storage components

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PROBA Tool

Dipl.-Ing.
Milica
Grahovac

Lehrstuhl für Energiewirtschaft
und Anwendungstechnik

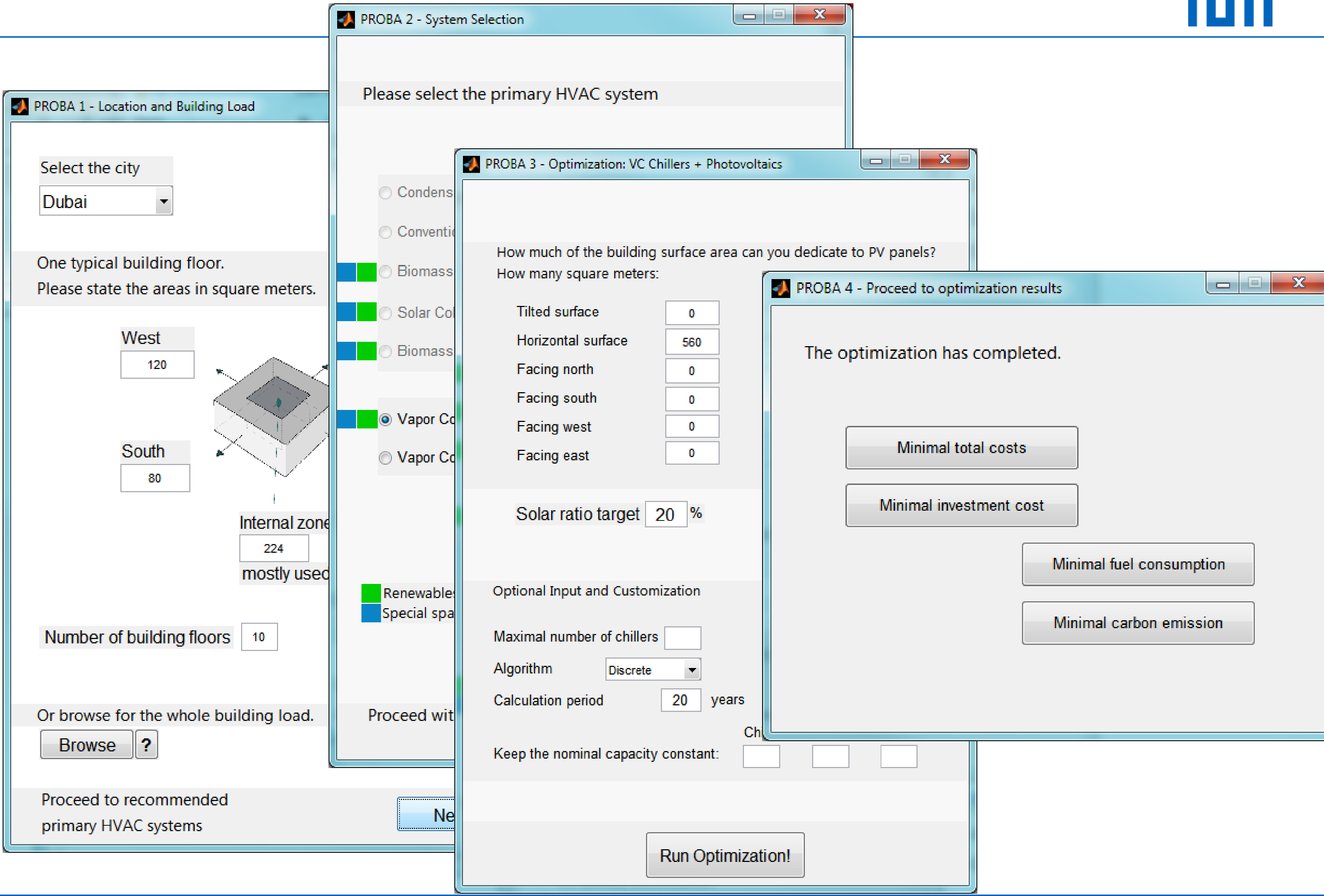
Technische Universität München

Fakultät für Elektrotechnik und
Informationstechnik

Arcisstraße 21
80333 München

Tel +49 89 289 - 28314
Fax +49 89 289 - 28313

mgrahovac@tum.de


PROBA 1 - Location and Building Load
Select the city
Dubai
One typical building floor.
Please state the areas in square meters.
West
120
South
80
Internal zone
224
mostly used
Number of building floors
10
Or browse for the whole building load.
Browse
?
Proceed to recommended
primary HVAC systems
PROBA 2 - System Selection
Please select the primary HVAC system
Biomass
Renewable
PROBA 3 - Optimization: VC Chillers + Photovoltaics
How much of the building surface area can you dedicate to PV panels?
How many square meters:
Tilted surface
0
Horizontal surface
560
Facing north
0
Facing south
0
Facing west
0
Facing east
0
Solar ratio target
20
%
Optional Input and Customization
Maximal number of chillers
Algorithm
Discrete
Calculation period
20
years
Keep the nominal capacity constant:
Run Optimization!
PROBA 4 - Proceed to optimization results
The optimization has completed.
Minimal total costs
Minimal investment cost
Minimal fuel consumption
Minimal carbon emission

Proba 4 - Optimization Results: Total Cost Minimized

Optimal chiller sizes

First chiller	120	kW
Second chiller	780	kW

Optimal PV areas

Optimal tilt	0	m2
Horizontal surface	420	m2
Facing north	0	m2
Facing south	0	m2
Facing west	0	m2
Facing east	0	m2

Annuity cost of such a configuration

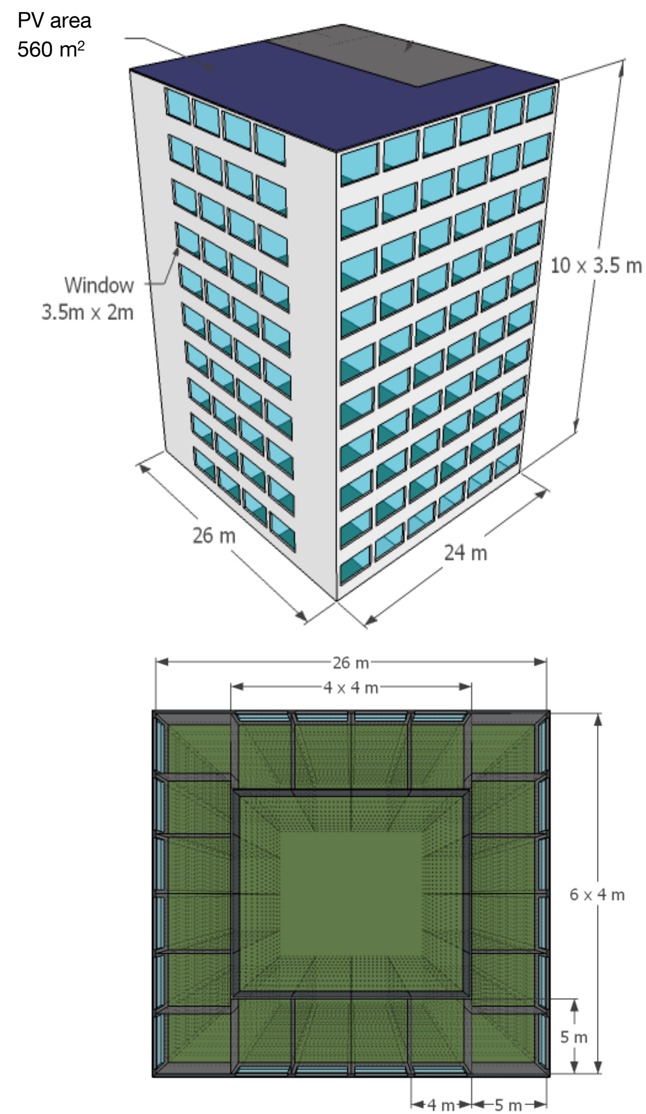
Investment cost	17183.7	Euro
Running cost	15902.7	Euro
Total cost	33086.4	Euro

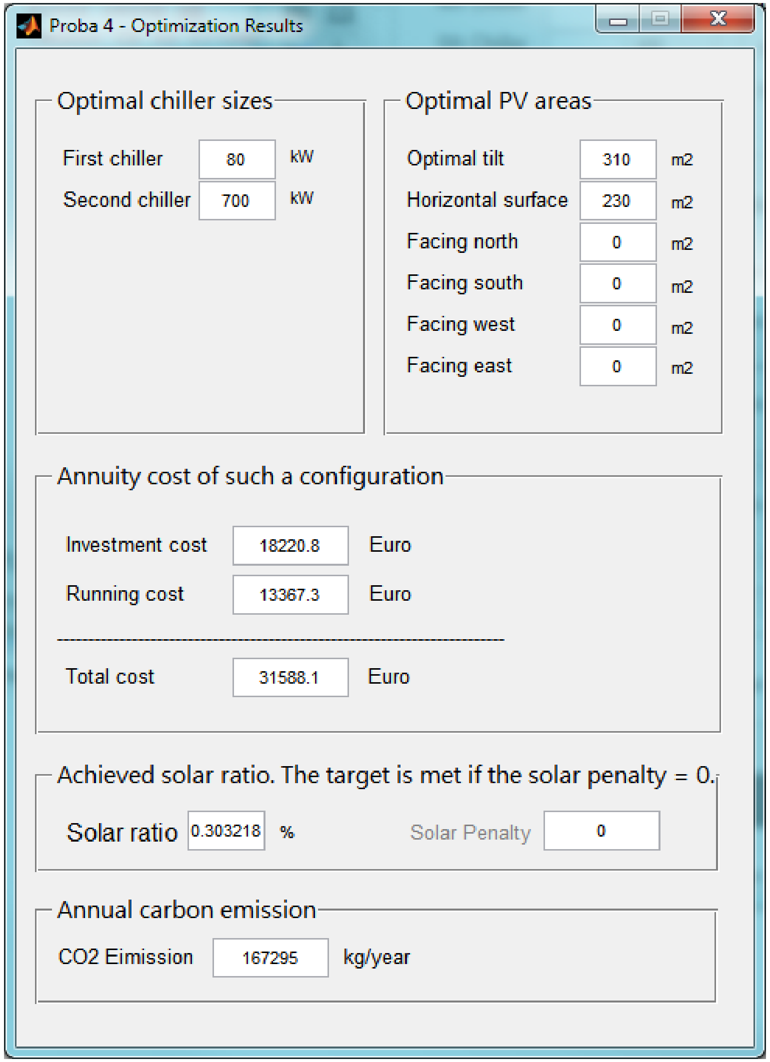
Achieved solar ratio. The target is met if the solar penalty = 0.

Solar ratio 0.207849 % Solar Penalty 0

Annual carbon emission

CO2 Eimission 208225 kg/year

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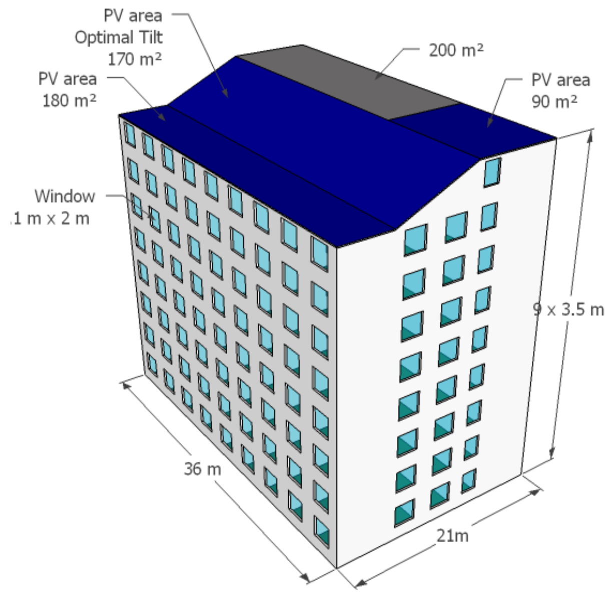
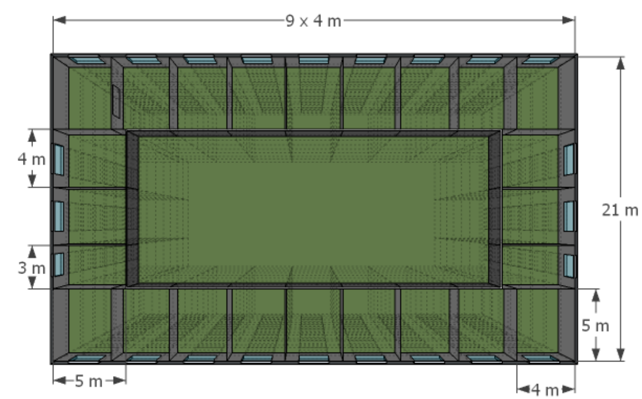
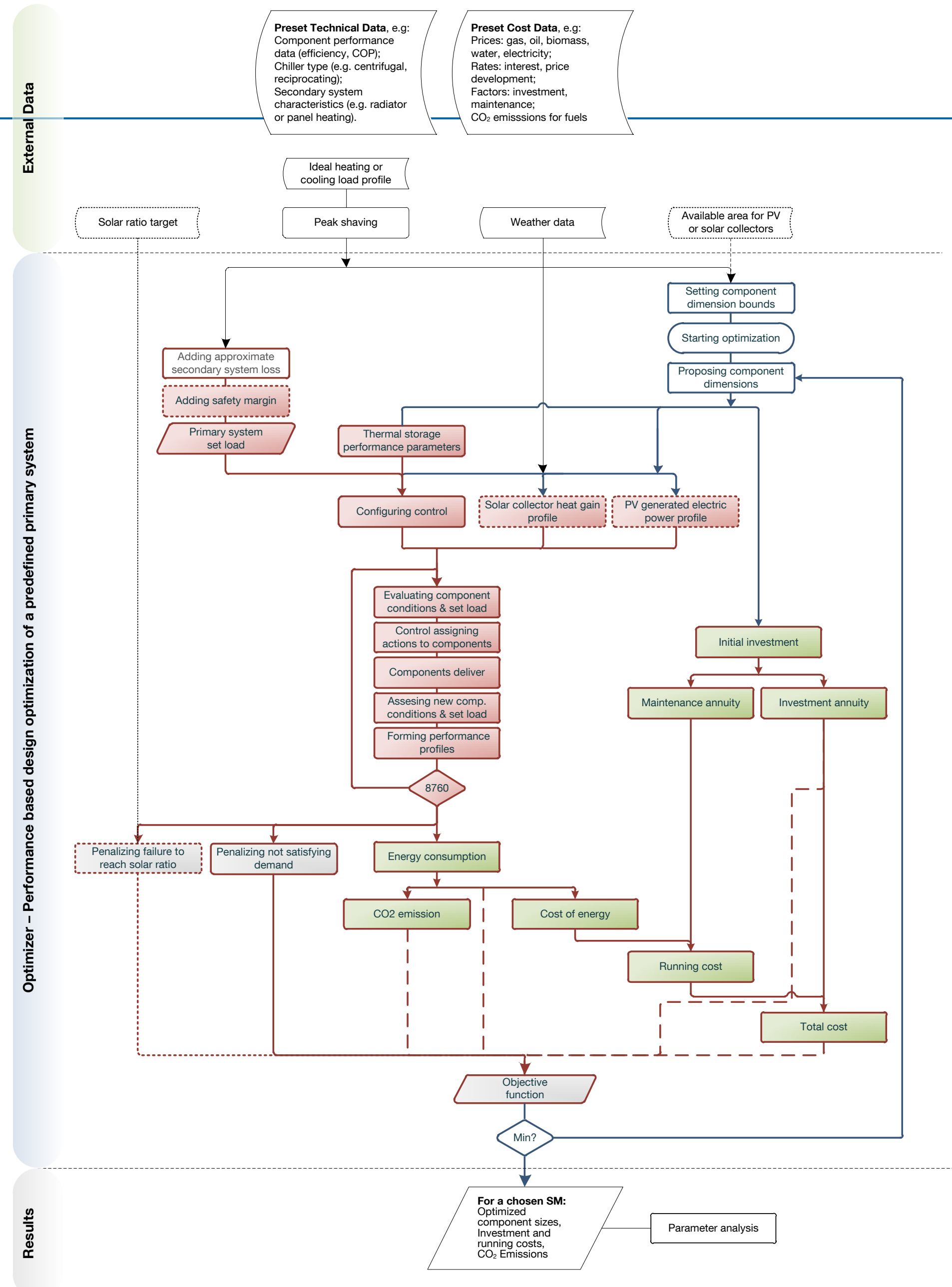

PV area
Optimal Tilt
170 m²
200 m²
PV area
180 m²
PV area
90 m²
Window
1 m x 2 m
9 x 3.5 m
36 m
21m


9 x 4 m
4 m
3 m
21 m
5 m
5 m
4 m



External Data
Optimizer – Performance based design optimization of a predefined primary system
Results
Preset Technical Data, e.g: Component performance data (efficiency, COP); Chiller type (e.g. centrifugal, reciprocating); Secondary system characteristics (e.g. radiator or panel heating).
Preset Cost Data, e.g: Prices: gas, oil, biomass, water, electricity; Rates: interest, price development; Factors: investment, maintenance; CO_2 emisssions for fuels
Ideal heating or cooling load profile
Solar ratio target
Peak shaving
Weather data
Available area for PV or solar collectors
Setting component dimension bounds
Starting optimization
Proposing component dimensions
Adding approximate secondary system loss
Adding safety margin
Primary system set load
Thermal storage performance parameters
Configuring control
Solar collector heat gain profile
PV generated electric power profile
Evaluating component conditions & set load
Control assigning actions to components
Components deliver
Assesing new comp. conditions & set load
Forming performance profiles
8760
Initial investment
Maintenance annuity
Investment annuity
Penalizing failure to reach solar ratio
Penalizing not satisfying demand
Energy consumption
CO2 emission
Cost of energy
Running cost
Total cost
Objective function
Min?
For a chosen SM: Optimized component sizes, Investment and running costs, CO_2 Emissions
Parameter analysis