JOINT FINAL CONFERENCE

Next Generation Energy Performance Assessment, Rating and Certification

Towards a Smart and Decarbonised Future for European Buildings

Part 3: Specific results of the 3 projects ePANACEA: The Smart Energy Performance Assessment Platform (SEPAP)

24 May 2023

Brussels and online

D2EPC ePANACEA E-DYCE

ePANACEA
Smart European Energy Performance Assessment & Certification

ePANACEA methodology- M1&M2

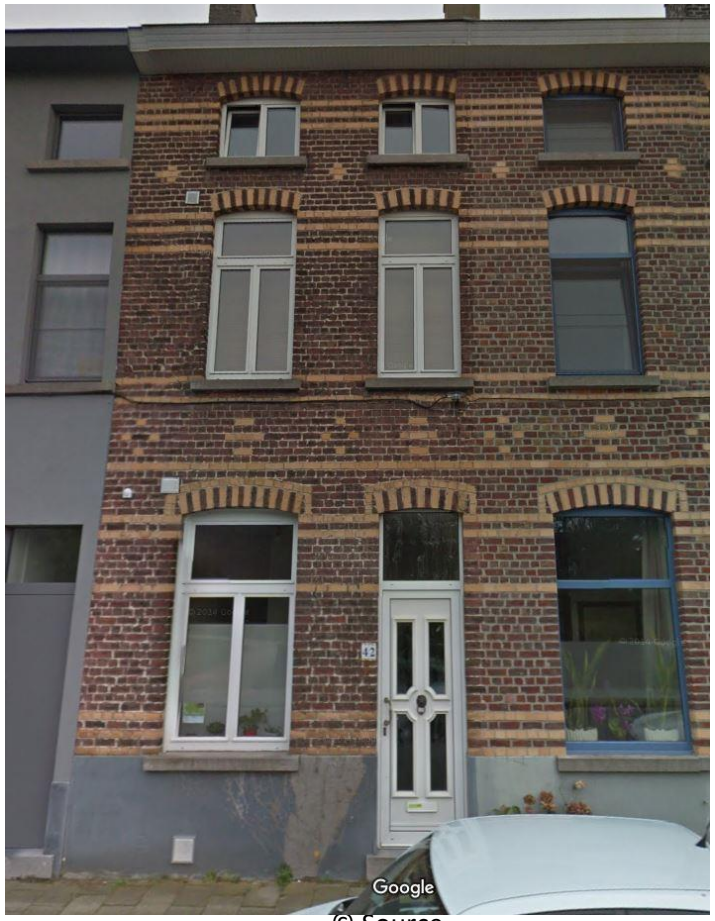
SEPAP

Mohsen Sharifi, Vito

This project has received funding from the European Union's HORIZON 2020 research and innovation programme under grant agreement No 892421

Belgium – BE-03

Name of building (e.g. Private Single Family Home…)	Single family house (Private house)
Building address (Zip code and city)	9040 Gent, Belgium
Year of construction	1904 (envelope renovated in 2017)
EPC rating for primary energy demand	B; 156 kWh/(m².a)
Building typology	Single family terraced city house
Available data from past periods	Energy and indoor environmental parameters hourly data (or higher frequency) 1/12/2017-31/1/2018
Main data source (e.g. smart meters, utility servers…)	Smart meters
Number of users/occupants (estimation)	2 adults + baby
Construction type	Heavy construction
Size of building (gross floor area) in m²	146,91
Conditioned gross volume in m³	496,9
Construction type	Heavy construction
U-value Average U-value [W/(m².K)] of the building	0,69
Information about windows	Average U-value of windows [W/(m².K)]=1,95
Information about shading	No shading
Infiltration rate	0,3705 1/h blower door



© Source

SEPAP

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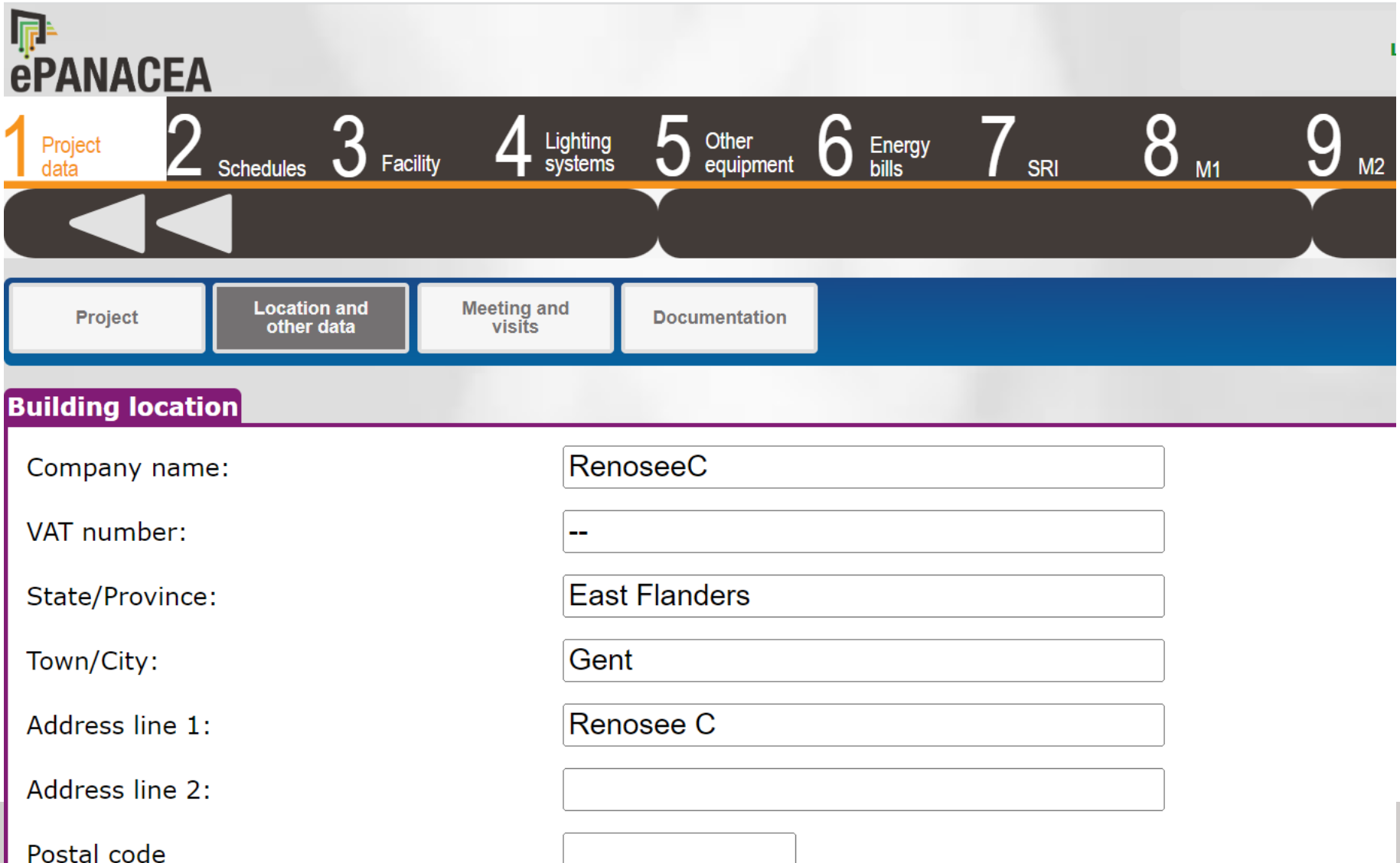

Building envelope, HVAC and bills

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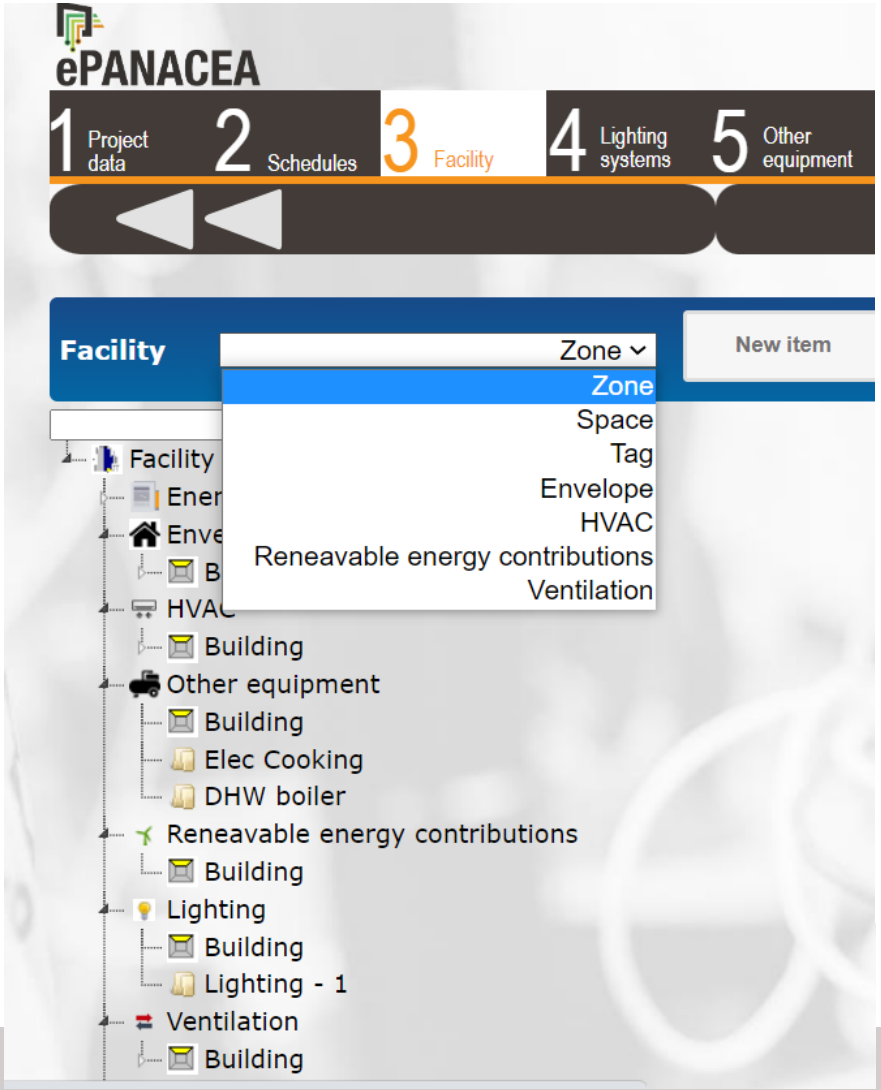
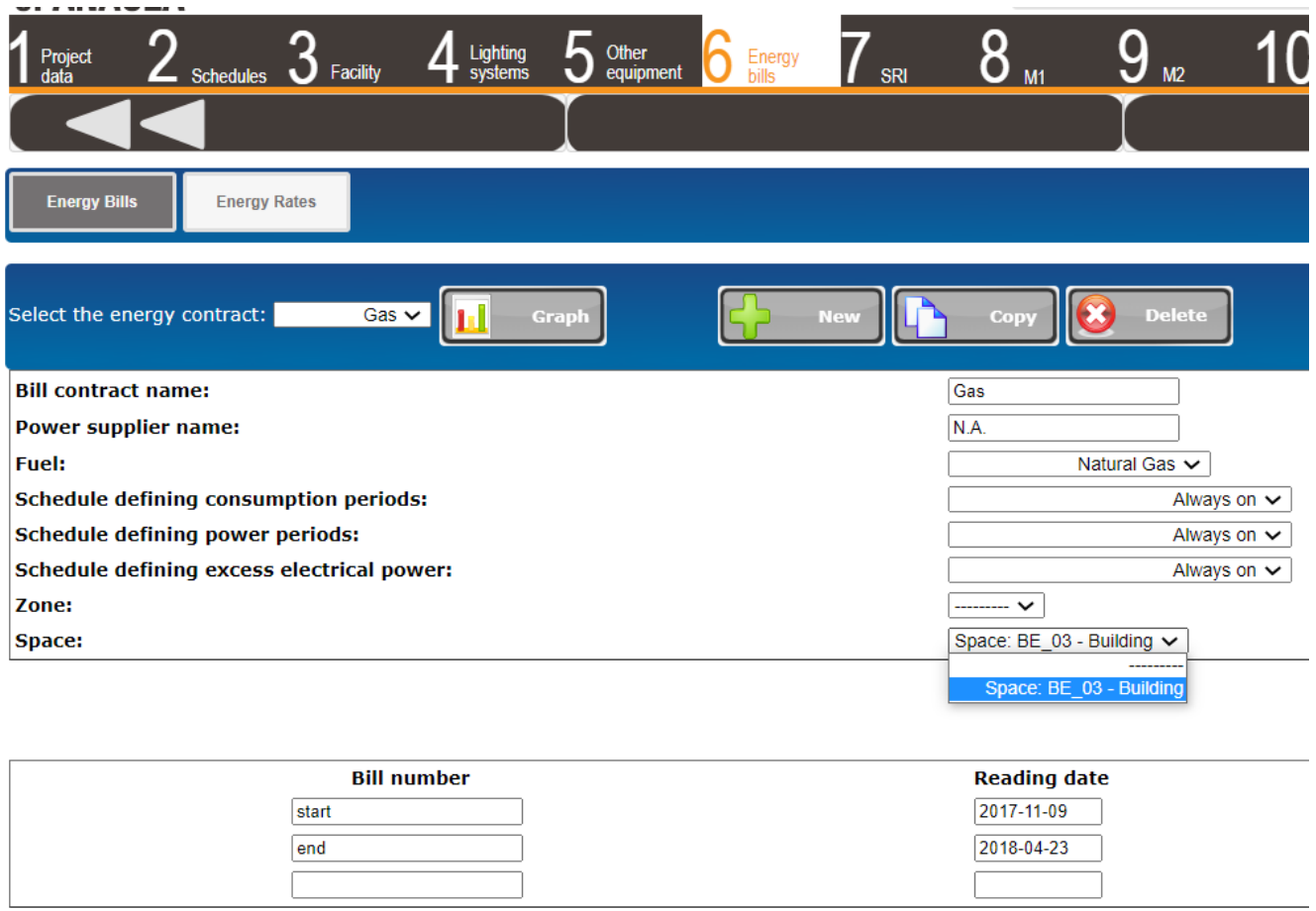
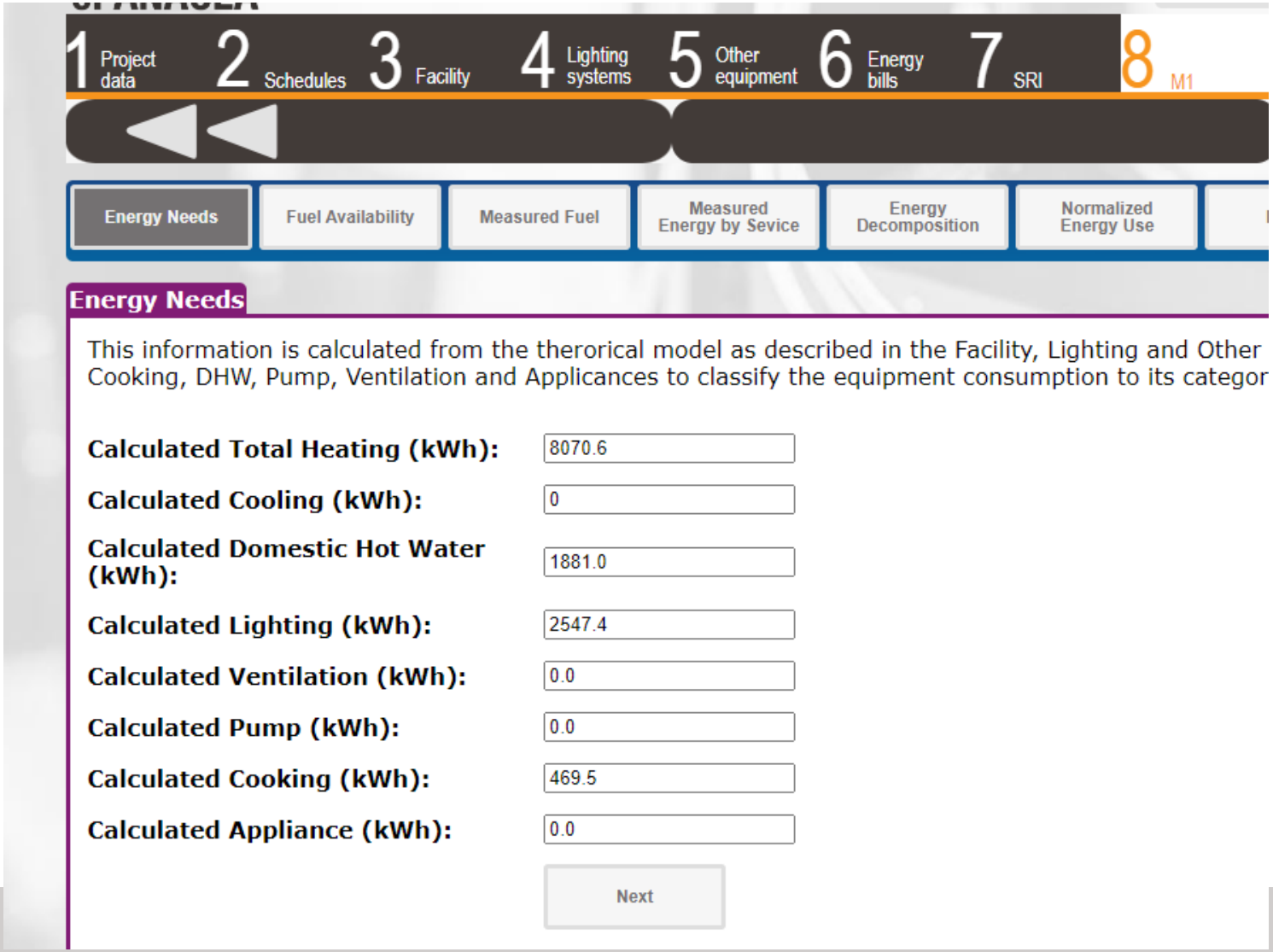




Results


1 Project data
2 Schedules
3 Facility
4 Lighting systems
5 Other equipment
6 Energy bills
7 SRI
8 M1
Energy Needs
Fuel Availability
Measured Fuel
Measured Energy by Sevice
Energy Decomposition
Normalized Energy Use
Energy Needs
This information is calculated from the therorical model as described in the Facility, Lighting and Other
Cooking, DHW, Pump, Ventilation and Applicances to classify the equipment consumption to its categor
Calculated Total Heating (kWh): 8070.6
Calculated Cooling (kWh): 0
Calculated Domestic Hot Water (kWh): 1881.0
Calculated Lighting (kWh): 2547.4
Calculated Ventilation (kWh): 0.0
Calculated Pump (kWh): 0.0
Calculated Cooking (kWh): 469.5
Calculated Appliance (kWh): 0.0
Next

Outcomes

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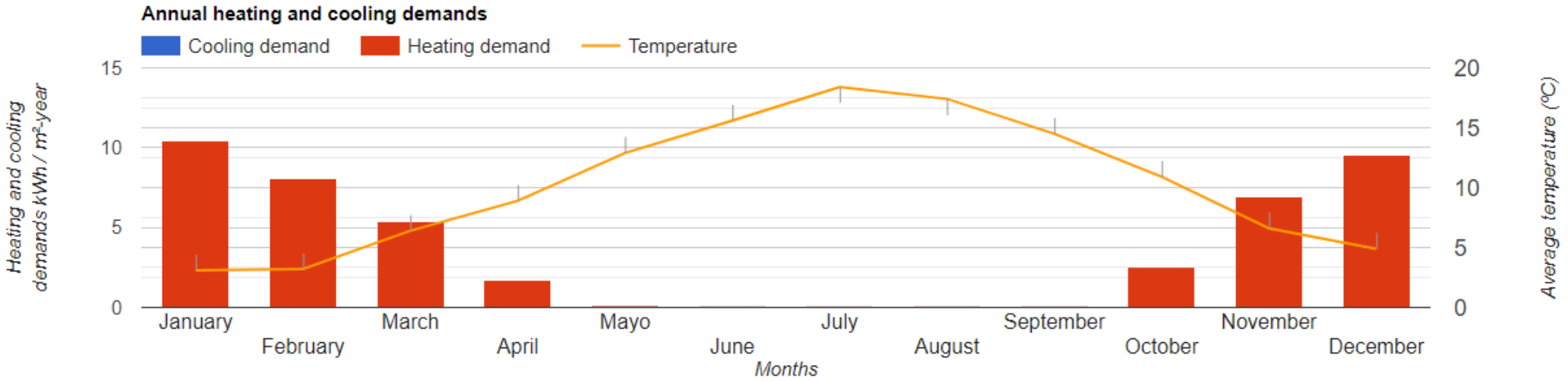
Annual heating demand: 6521.18 kWh/año (44.67 kWh/m²-año)
Annual demand for refrigeration: 0.00 kWh/año (0.00 kWh/m²-año)



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Thank you for your attention

For further information, please contact via contact@epanacea.eu

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This project has received funding from the European Union's HORIZON 2020 research and innovation programme under grant agreement No 892421

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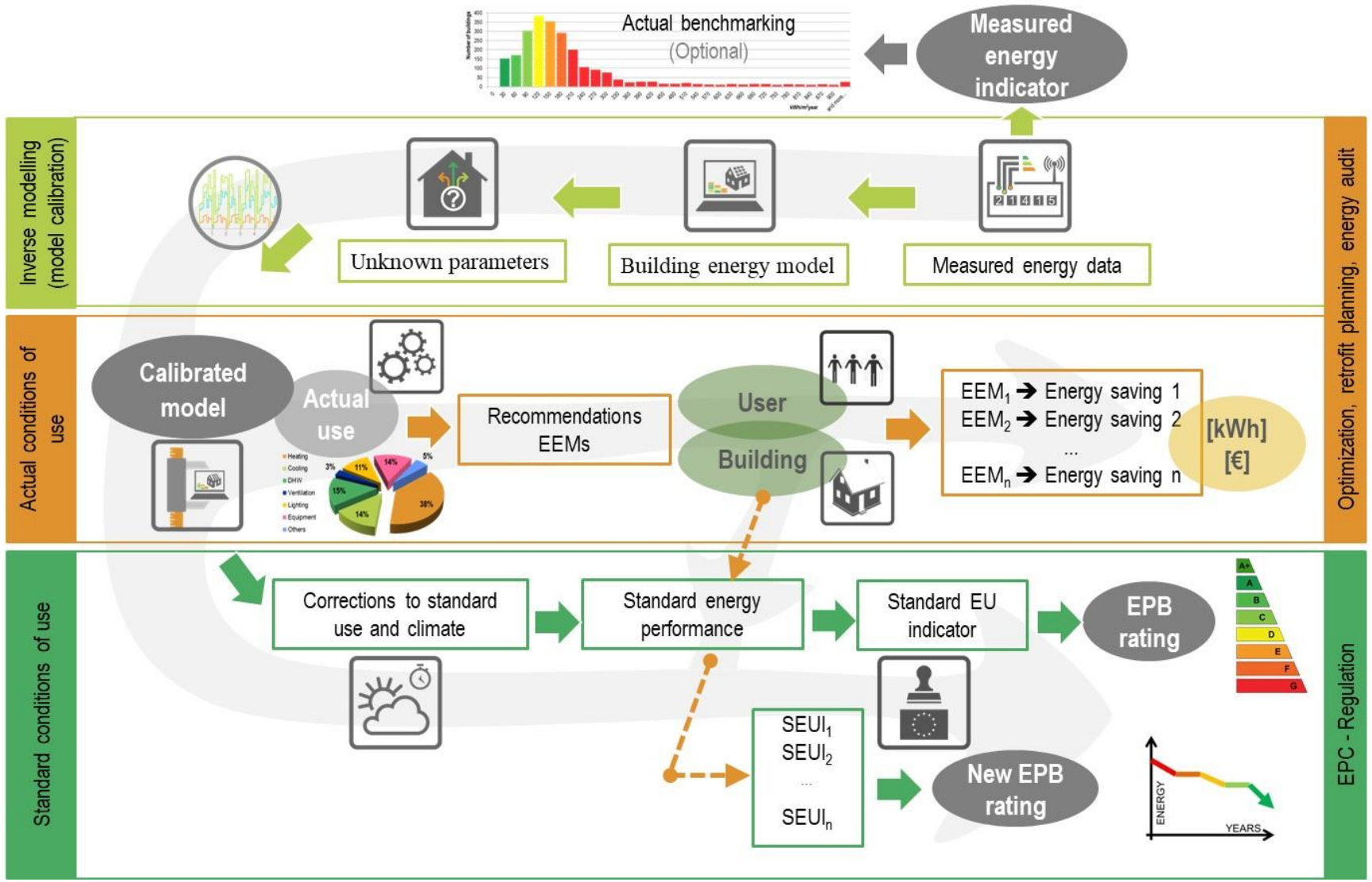
ePANACEA methodology- M3

Auto-calibration of white-box BEMs for EPCs

María Fernández Boneta, National Renewable Energy Centre - CENER

This project has received funding from the European Union's HORIZON 2020 research and innovation programme under grant agreement No 892421

Report on the use of innovative certification schemes and its implementation | Zenodo



The EPC cycle

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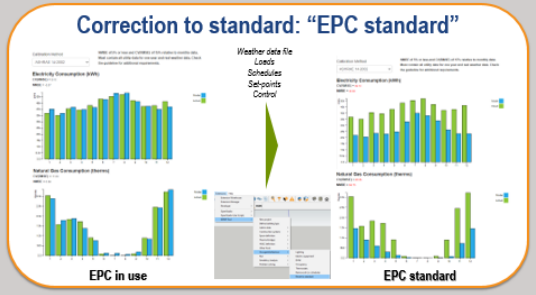
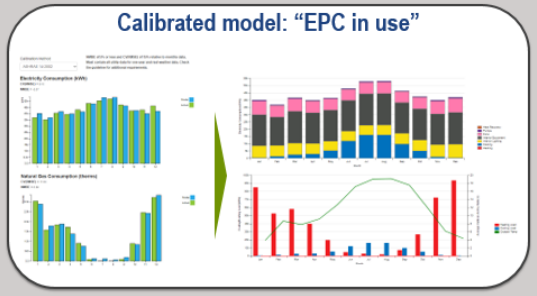
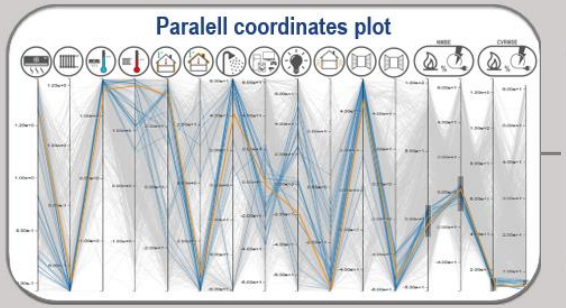
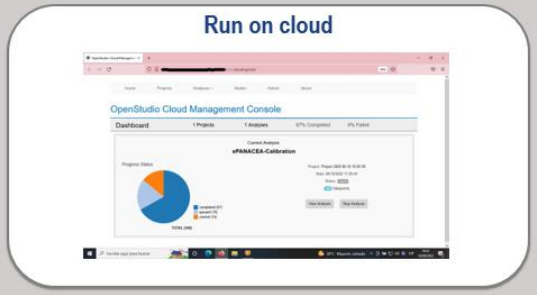
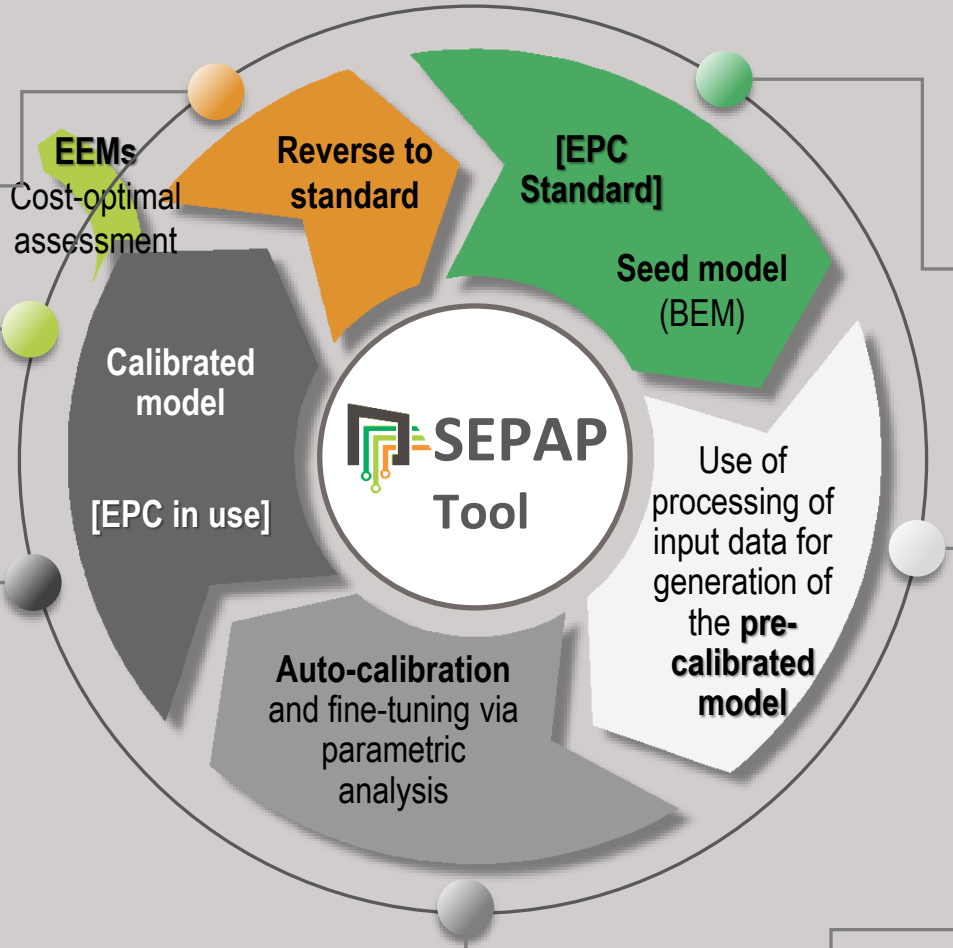
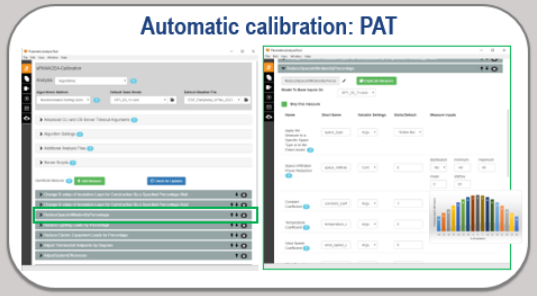


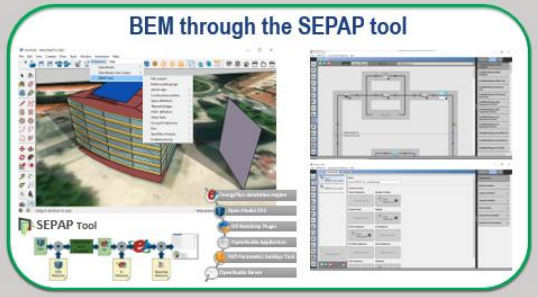


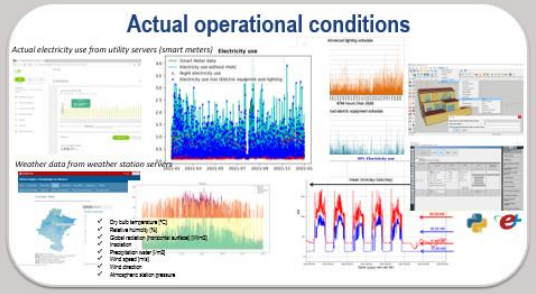


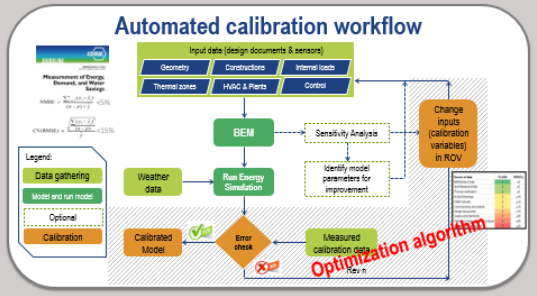




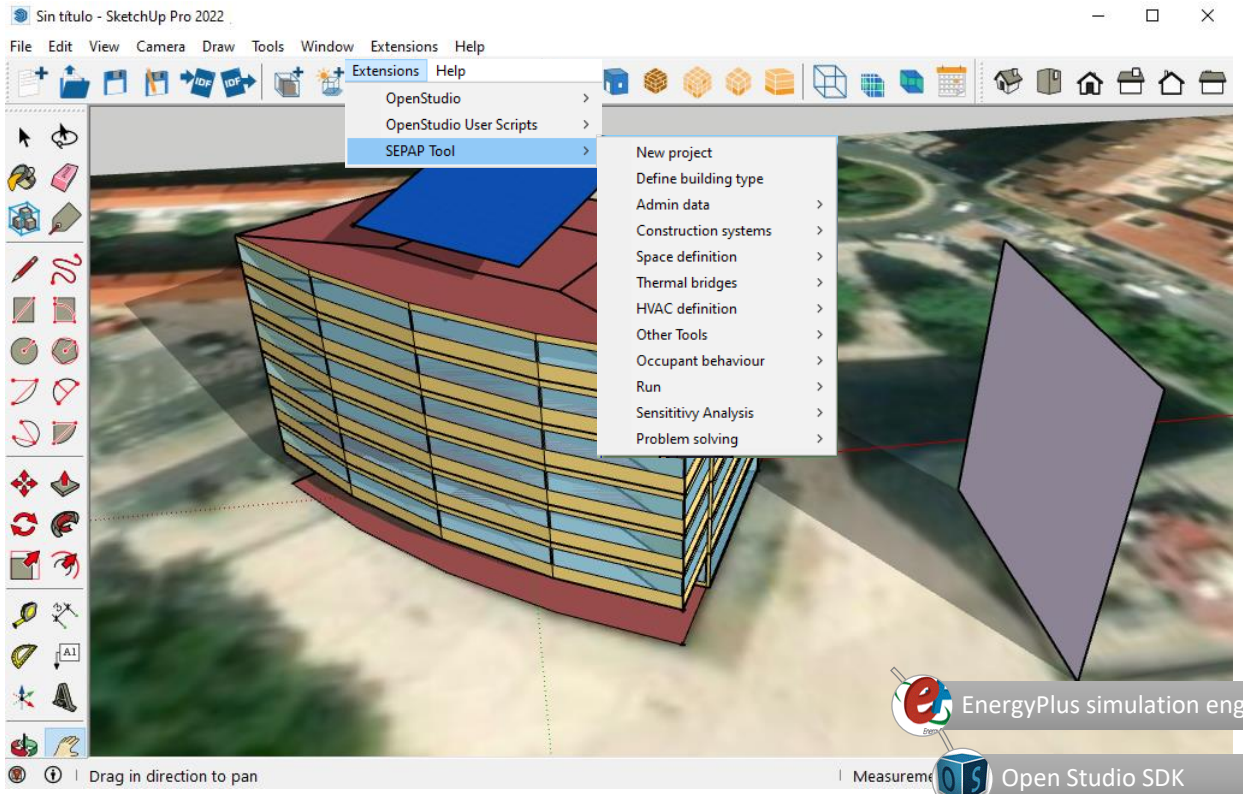


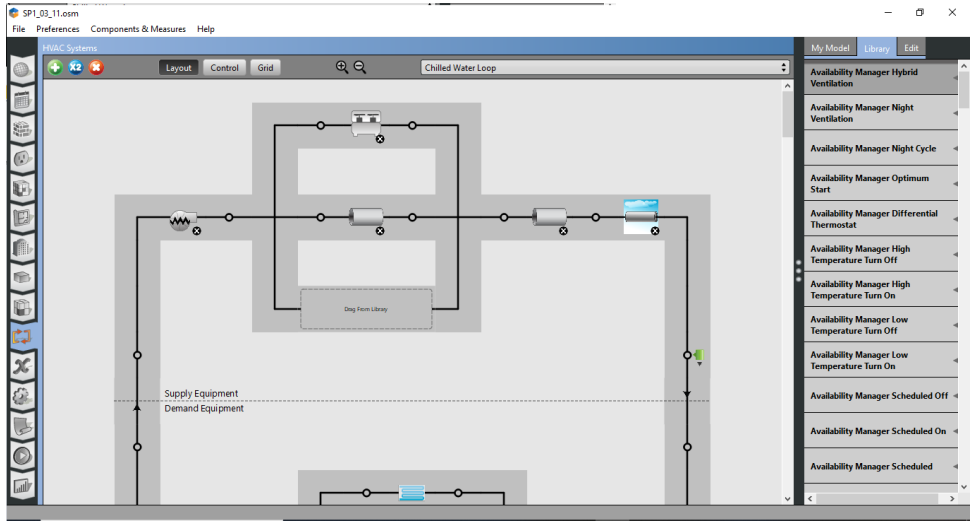


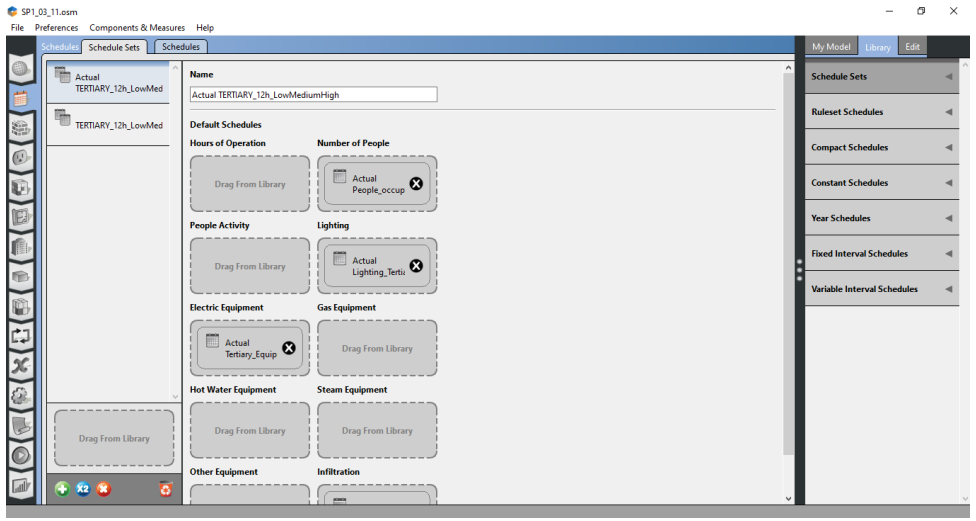




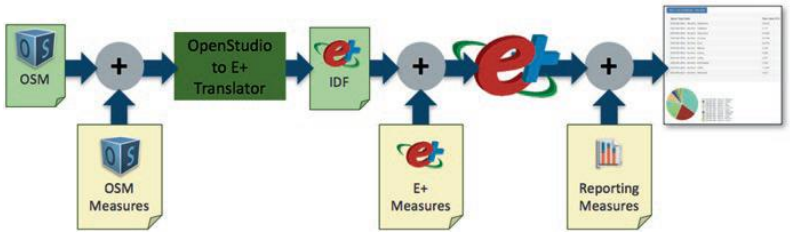
BEM through the SEPAP tool







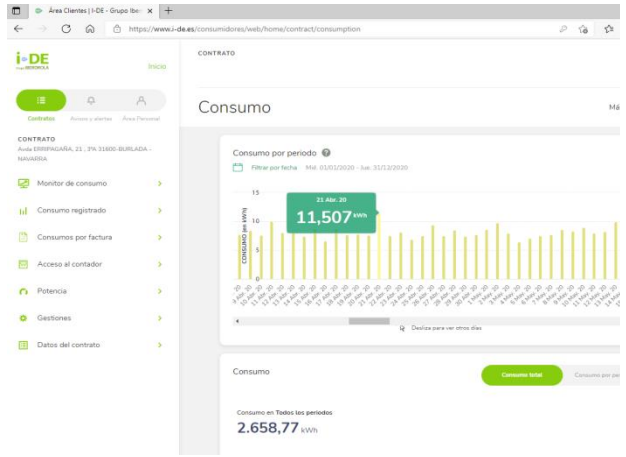
SEPAP Tool

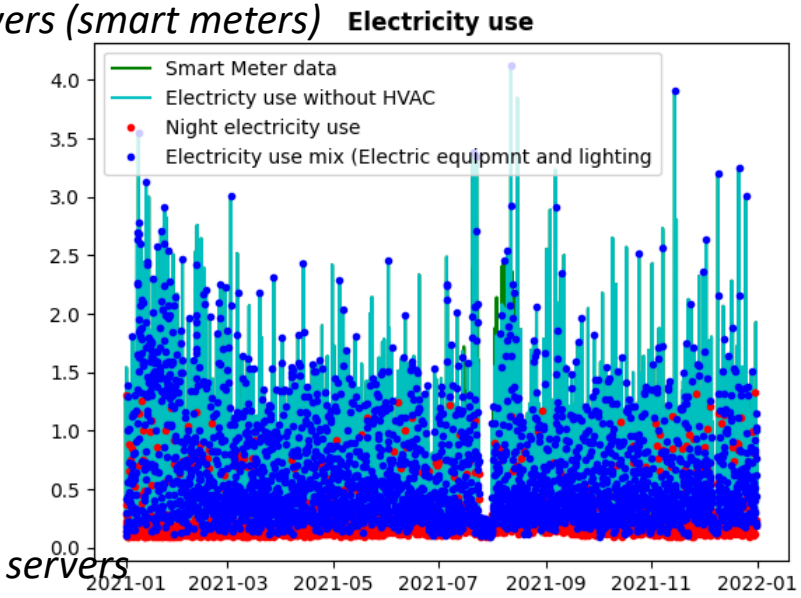


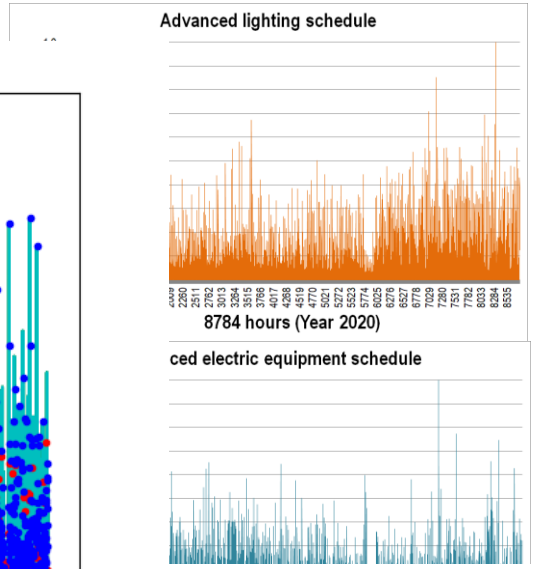
- EnergyPlus simulation engine
- Open Studio SDK
- OS SketchUp Plugin
- OpenStudio Application
- PAT-Parametric Analisys Tool
- OpenStudio Server

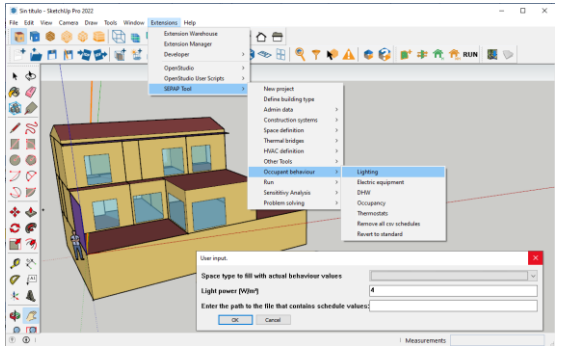
Actual operational conditions

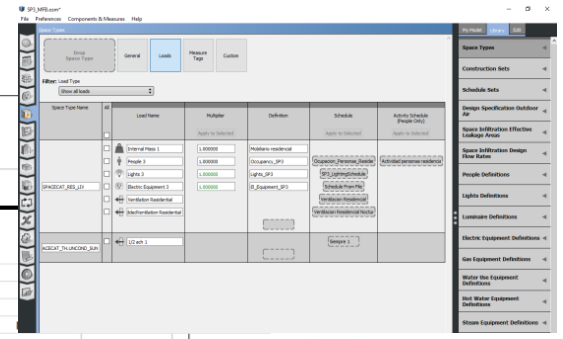
Actual electricity use from utility servers (smart meters)



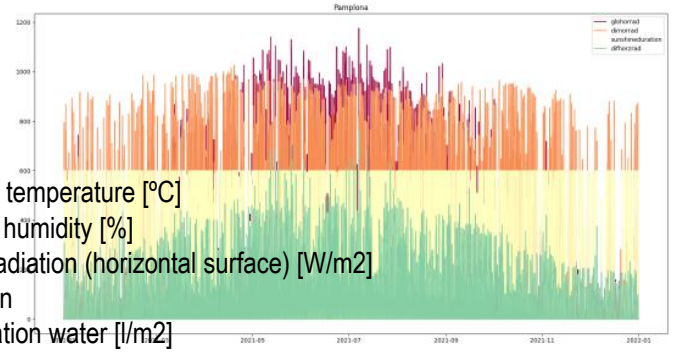




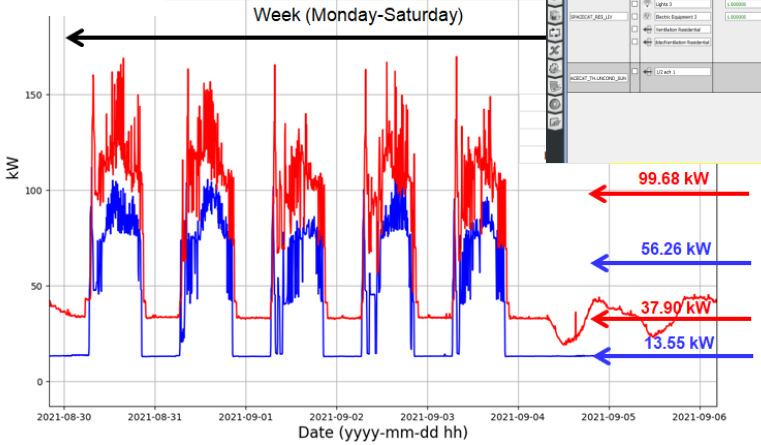




Weather data from weather station servers



- ✓ Dry bulb temperature [ºC]
- ✓ Relative humidity [%]
- ✓ Global radiation (horizontal surface) [W/m2]
- ✓ Insolation
- ✓ Precipitation water [l/m2]
- ✓ Wind speed [m/s]
- ✓ Wind direction
- ✓ Atmospheric station pressure



Automated calibration workflow

$$NMBE = \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)}{(n-p)\times \bar{y}} \quad <5\%$$

$$CV(RMSE) = \frac{\sqrt{\frac{\sum(y_i - \hat{y}_i)^2}{(n-p)}}}{\bar{y}} \quad <15\%$$

Legend:

- Data gathering
- Model and run model
- Optional
- Calibration

Input data (design documents & sensors)

- Geometry
- Constructions
- Internal loads
- Thermal zones
- HVAC & Plants
- Control

BEM

Sensitivity Analysis

Identify model parameters for improvement

Change inputs (calibration variables) in ROV

Weather data

Run Energy Simulation

Error check

YES!

NO!

Calibrated Model

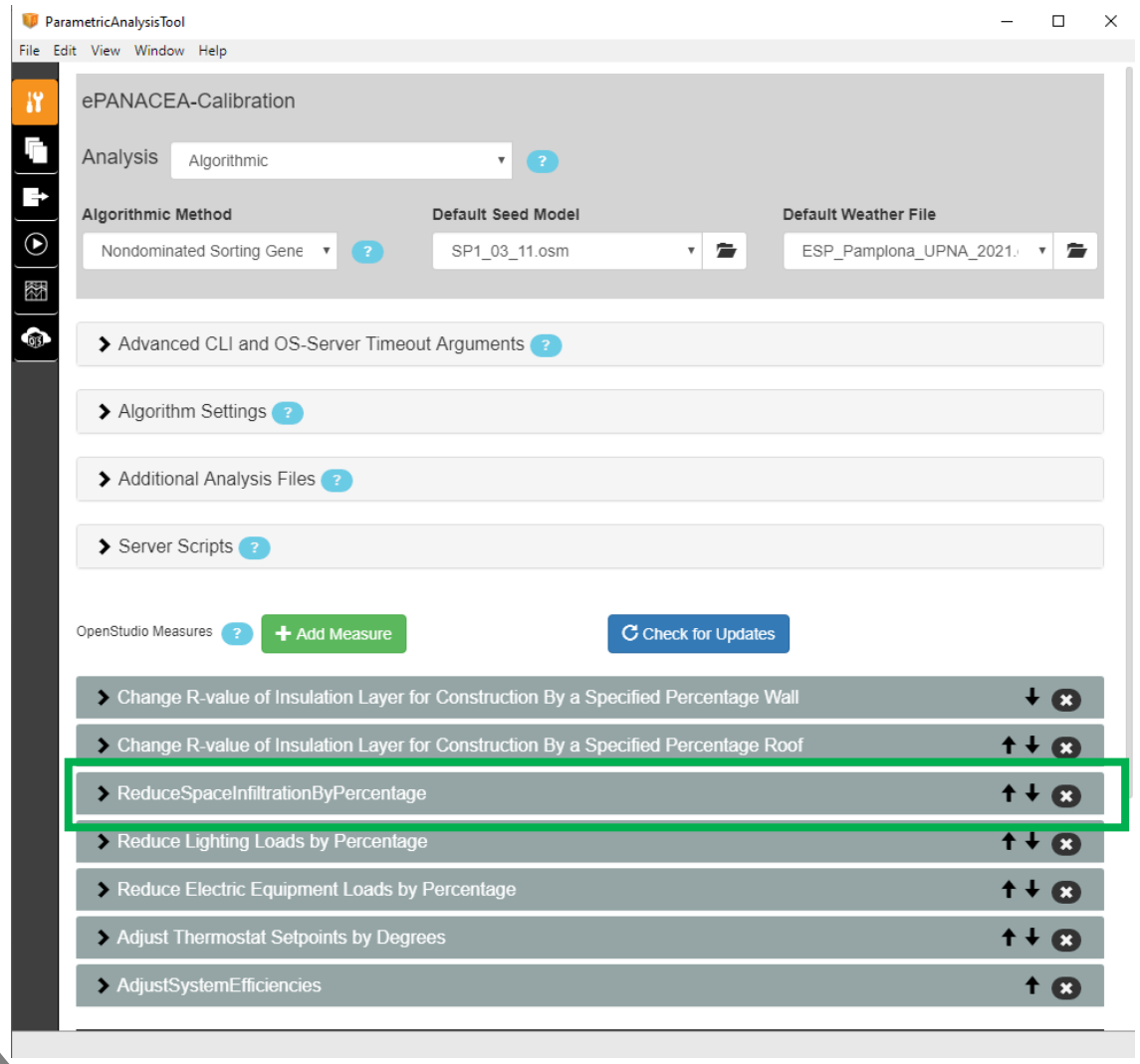
Measured calibration data

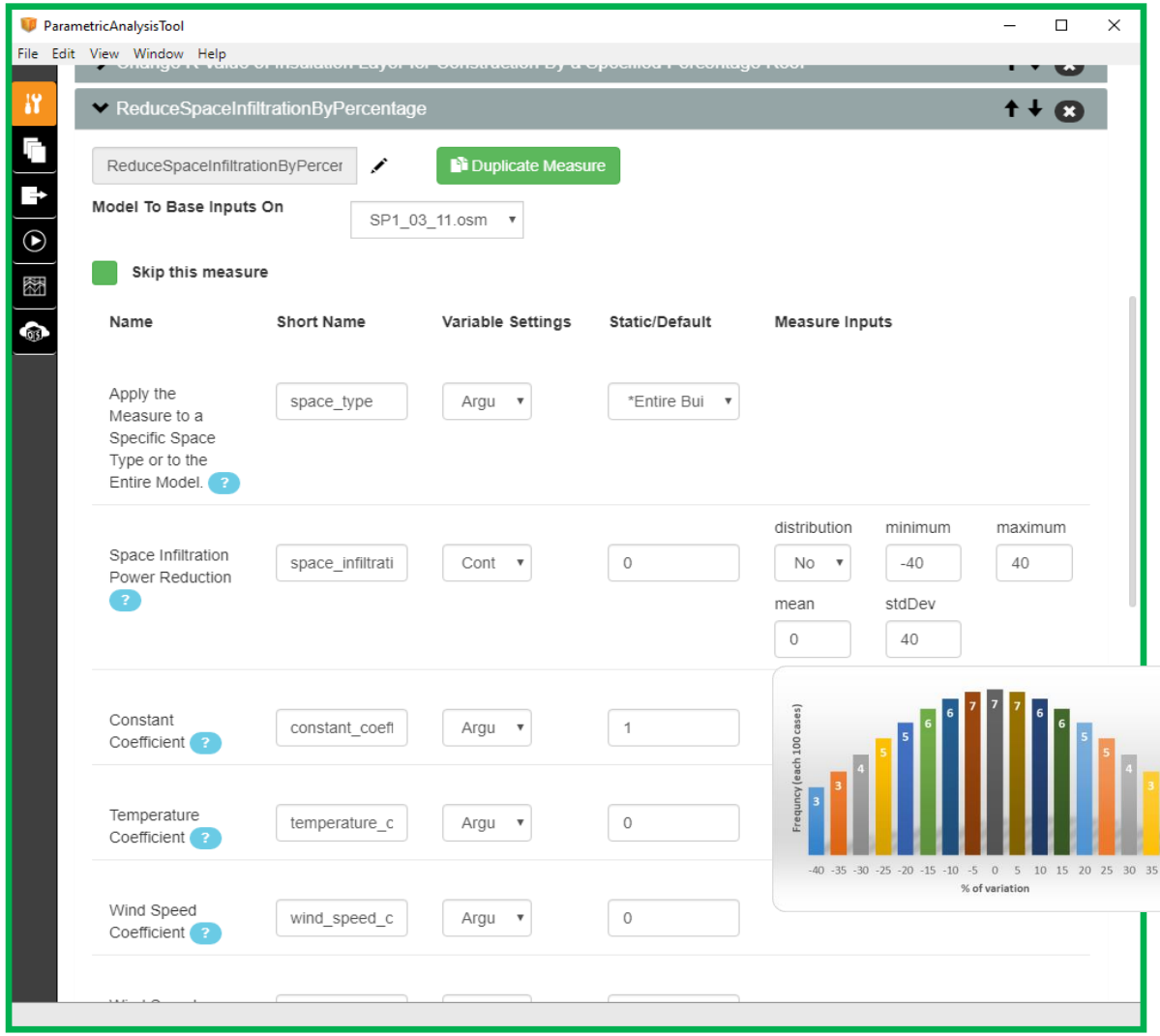
Rev n

Optimization algorithm

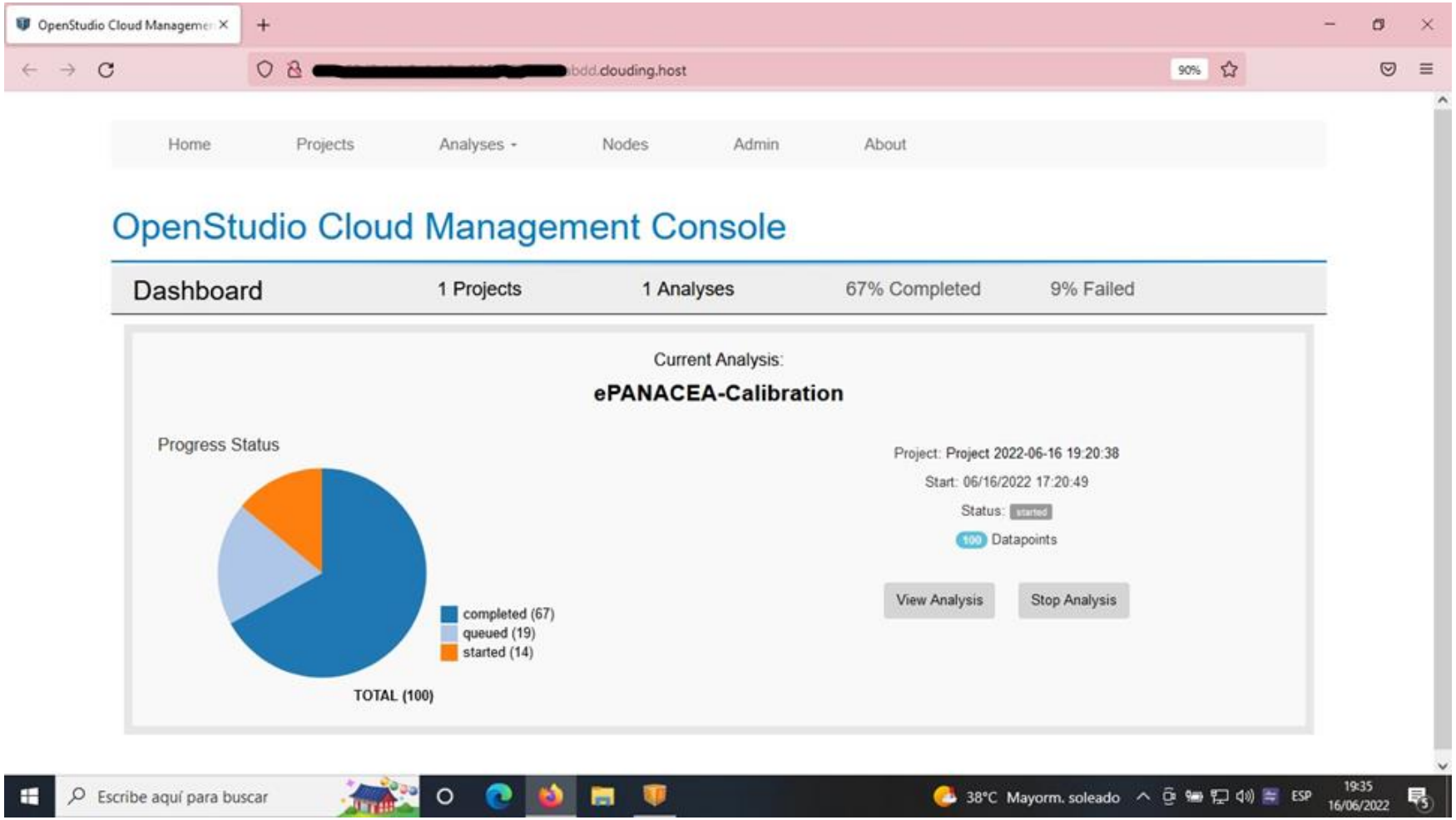
Source of data	CLASS	ROV(%)
BMS/Sensor Data	1	±2
Spot Measured data	2	±5
Physical verification	2	±5
As-built drawings	3	±10
O&M manuals	3	±10
Commisioning documents	3	±10
Design documents	4	±15
Guides and standards	5	±30
Reference manuals / default values	6	±40
No available information	7	±50

Automatic calibration: PAT

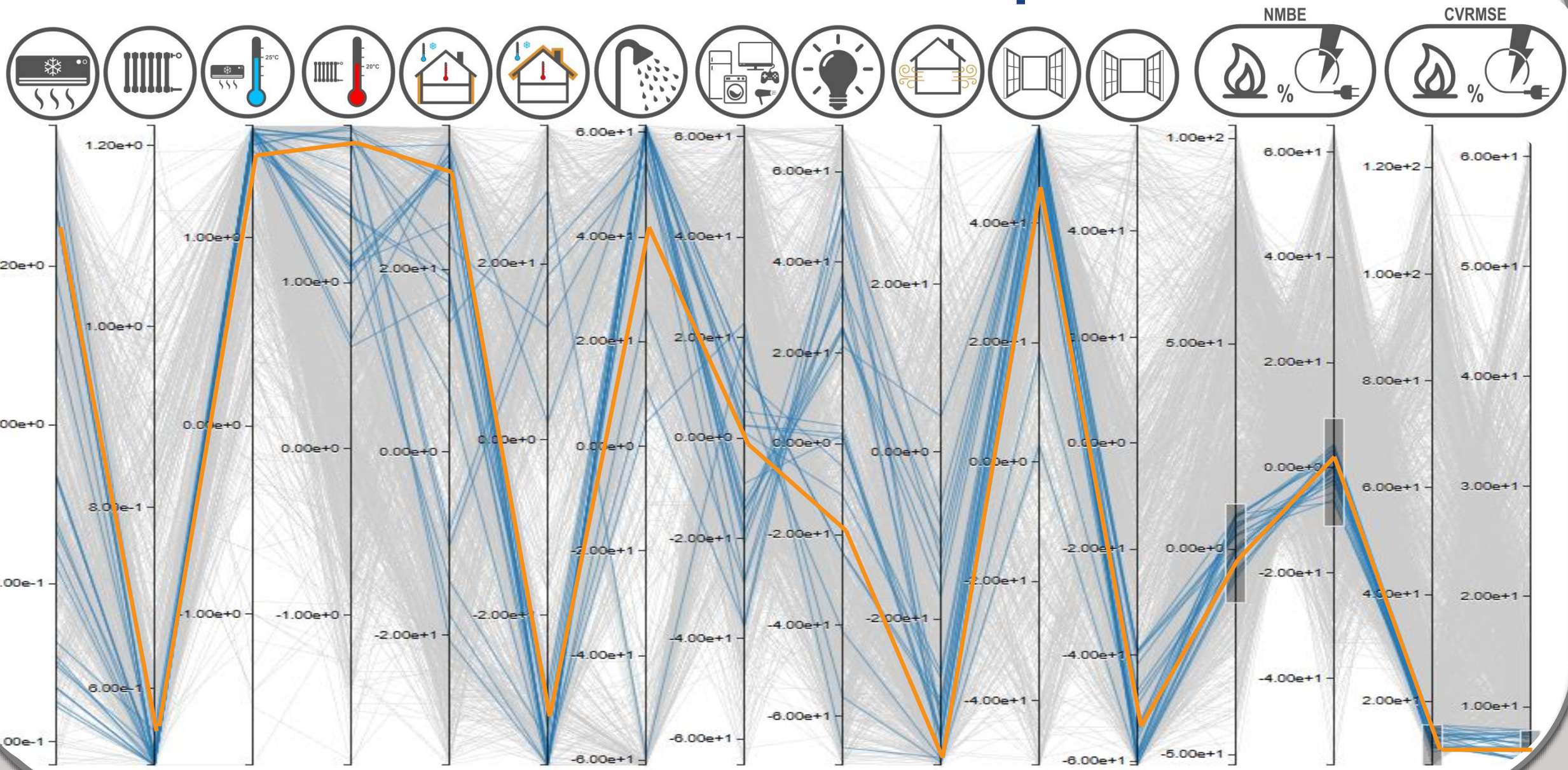




Run on cloud


OpenStudio Cloud Managemer
[redacted]bdd.clouding.host
90%
Home
Projects
Analyses
Nodes
Admin
About
OpenStudio Cloud Management Console
Dashboard
1 Projects
1 Analyses
67% Completed
9% Failed
Current Analysis:
ePANACEA-Calibration
Progress Status
completed (67)
queued (19)
started (14)
TOTAL (100)
Project: Project 2022-06-16 19:20:38
Start: 06/16/2022 17:20:49
Status: started
100 Datapoints
View Analysis
Stop Analysis
Escribe aquí para buscar
38°C Mayorm. soleado
ESP
19:35
16/06/2022

Paralell coordinates plot



Calibrated model: “EPC in use”

Calibration Method

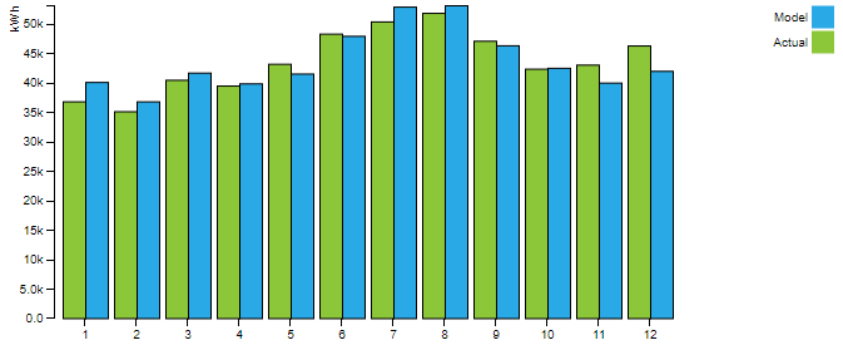
ASHRAE 14-2002

NMBE of 5% or less and CV(RMSE) of 15% relative to monthly data. Must contain all utility data for one year and real weather data. Check the guideline for additional requirements.

Electricity Consumption (kWh)

CV(RMSE) = 5.10

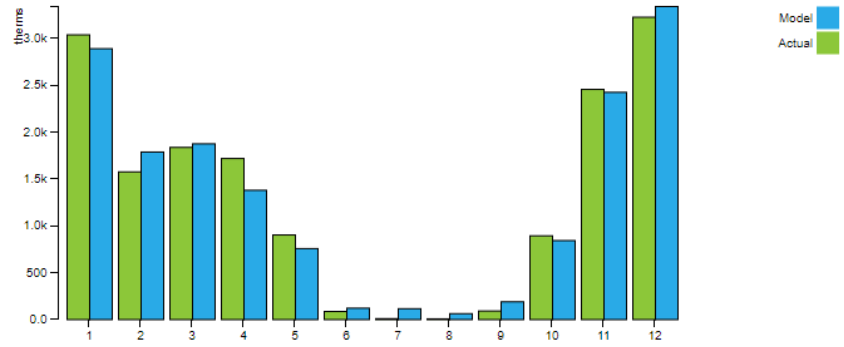
NMBE = -0.07

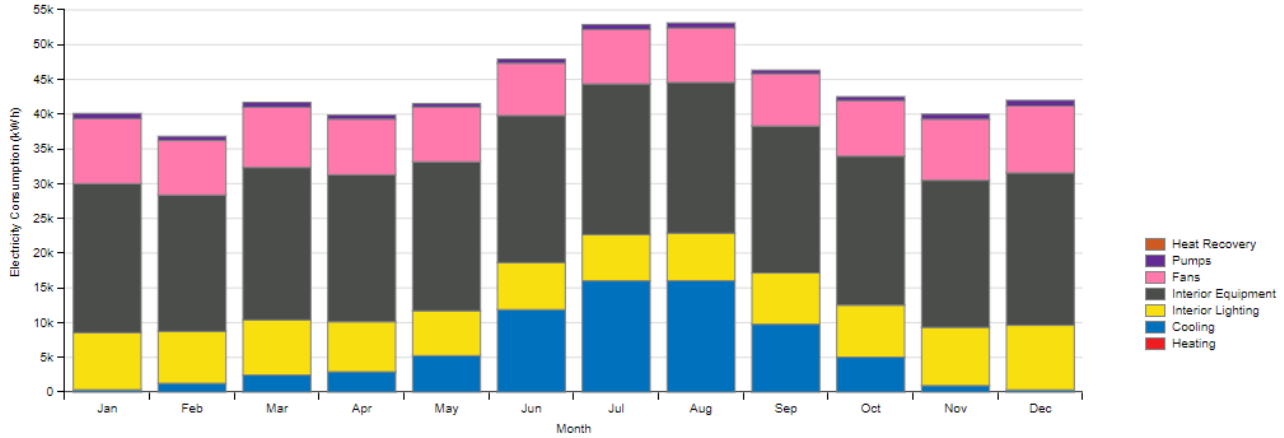


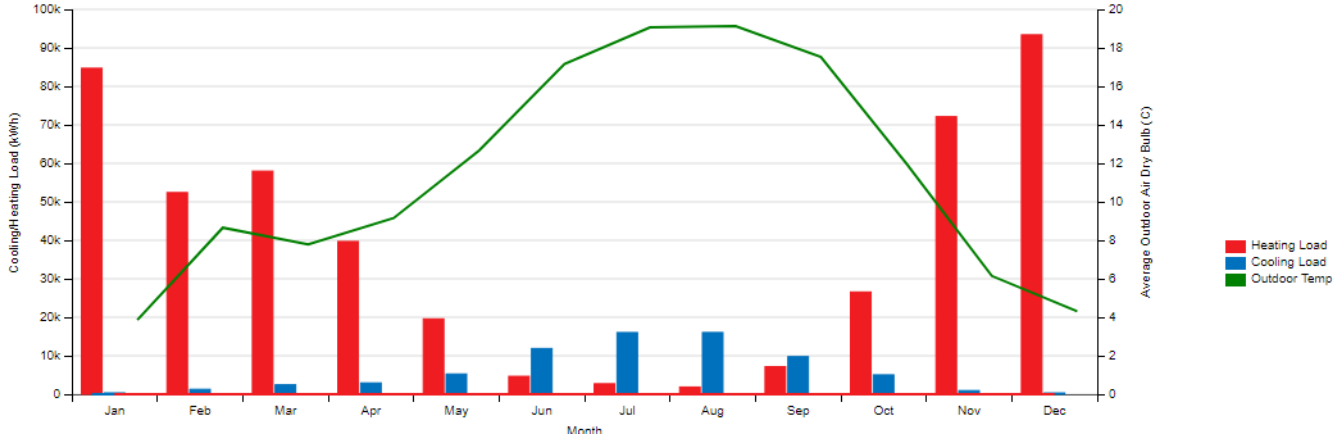
Natural Gas Consumption (therms)

CV(RMSE) = 11.33

NMBE = 0.38







Correction to standard: “EPC standard”

Calibration Method

ASHRAE 14-2002

NMBE of 5% or less and CV(RMSE) of 15% relative to monthly data. Must contain all utility data for one year and real weather data. Check the guideline for additional requirements.

Electricity Consumption (kWh)

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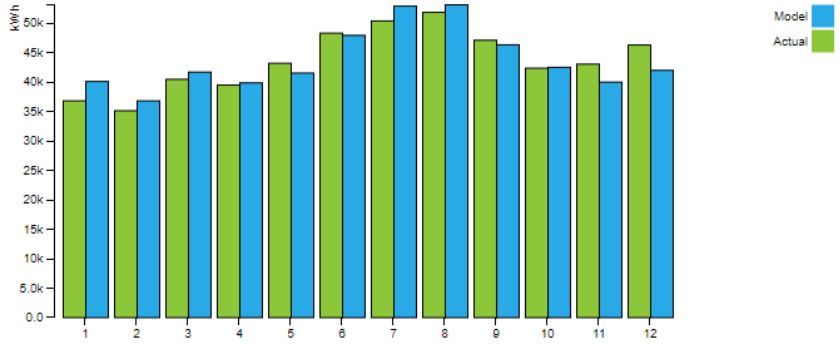
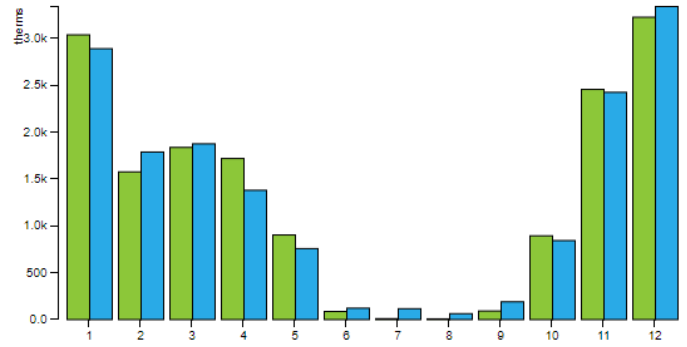
NMBE = -0.07



Natural Gas Consumption (therms)

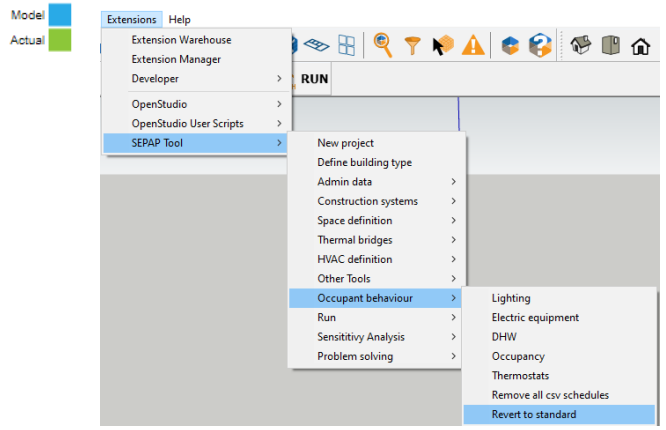
CV(RMSE) = 11.33

NMBE = 0.38



EPC in use

Weather data file
Loads
Schedules
Set-points
Control



Calibration Method

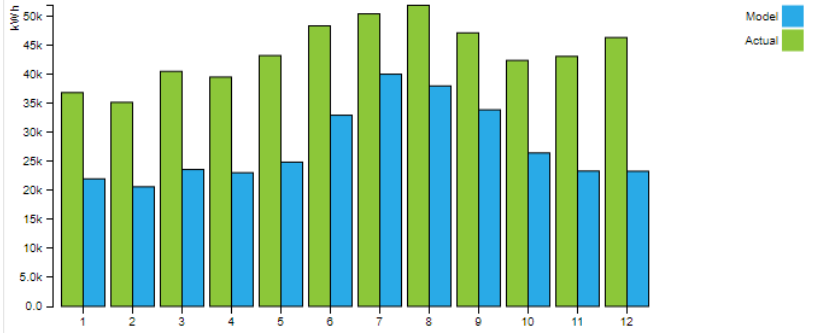
ASHRAE 14-2002

NMBE of 5% or less and CV(RMSE) of 15% relative to monthly data. Must contain all utility data for one year and real weather data. Check the guideline for additional requirements.

Electricity Consumption (kWh)

CV(RMSE) = 39.10

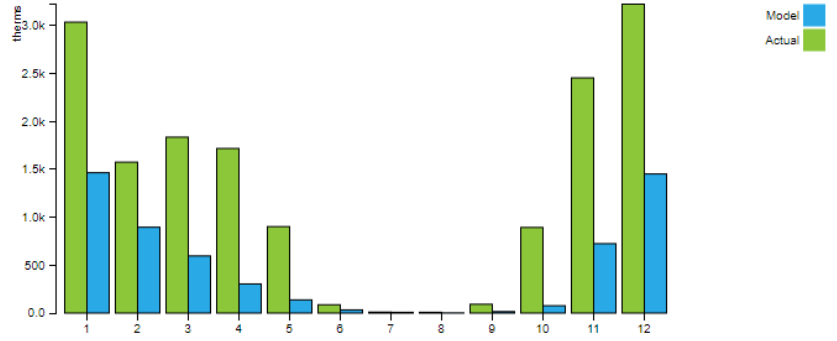
NMBE = 40.09



Natural Gas Consumption (therms)

CV(RMSE) = 85.06

NMBE = 69.75



EPC standard

Cost optimal via PAT

ParametricAnalysisTool

File Edit View Window Help

ePANACEA - Cost-optimal

Analysis: Algorithmic

Algorithmic Method: Design Of Experiments (DOE)

Default Seed Model: calibratedSP1_office.osm

- Advanced CLI and OS-Server Timeout Arguments
- Algorithm Settings
- Additional Analysis Files
- Server Scripts

OpenStudio Measures + Add Measure | Check for Updates

- SetLifecycleCostParameters
- Add Insulation Layer for Walls
- Add Insulation Layer for Roofs
- Replace with high efficiency glasses
- Reduce Lighting Loads by Percentage Optimal Cost
- OptimizationHighEfficiencyBoiler
- OptimizationHighEfficiencyChiller

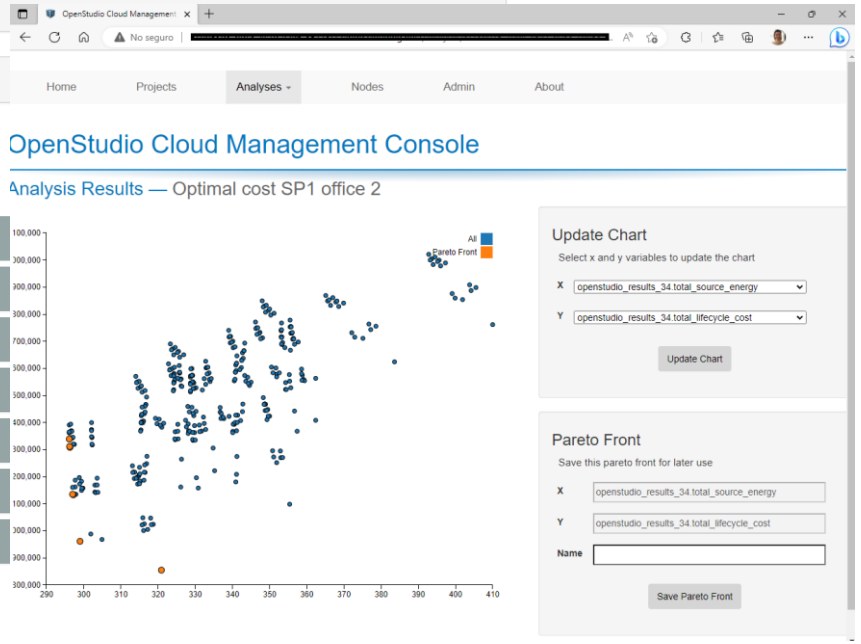
ParametricAnalysisTool

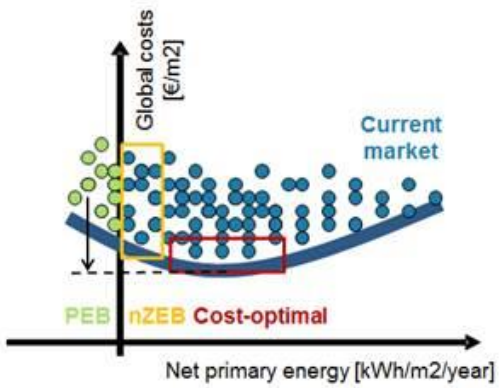
File Edit View Window Help

Outputs

OpenStudio Results 3.4

Display Name	Short Name	Variable Type	Visualize	Objective Function	Output Selection / Objective Function Settings: Target Value	Units	Weighting Factor
total_lifecycle_cost	total_lifecycle_cost	Double	true	true	0		1
total_source_energy	total_source_energy	Double	true	true	0		1





Comparison

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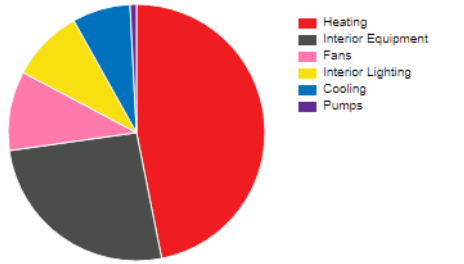
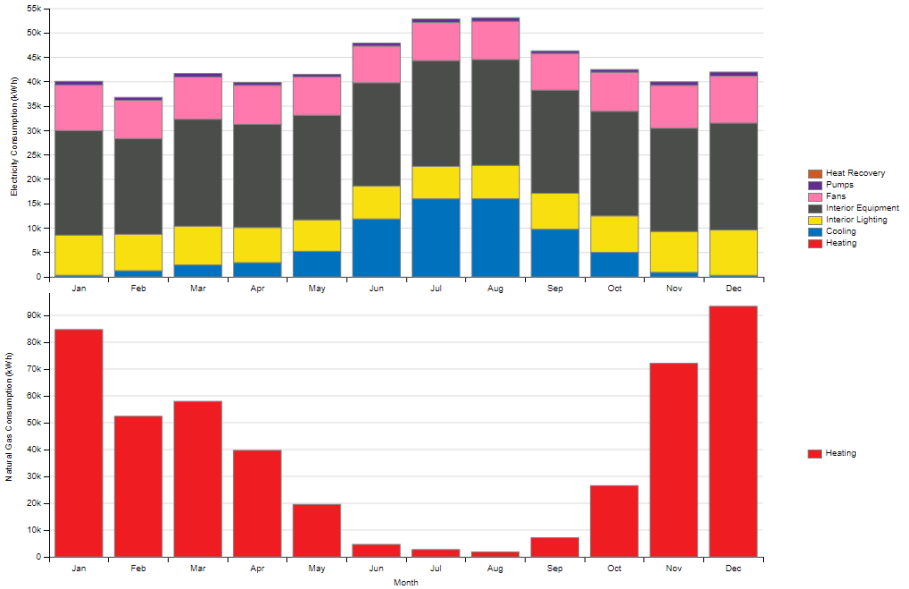
Calibrated model with 'actual use'

End Use	Consumption (kWh)
Heating	462,786
Cooling	72,258
Interior Lighting	90,058
Exterior Lighting	0
Interior Equipment	255,803
Exterior Equipment	0
Fans	98,831
Pumps	7,897

PEC_{nren} = 286.7 kWh/m²año
Emissions = 53.0 $kgCO_2/m^2$año



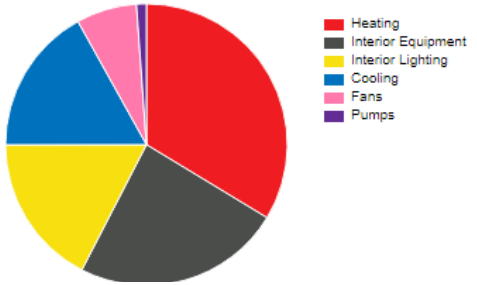


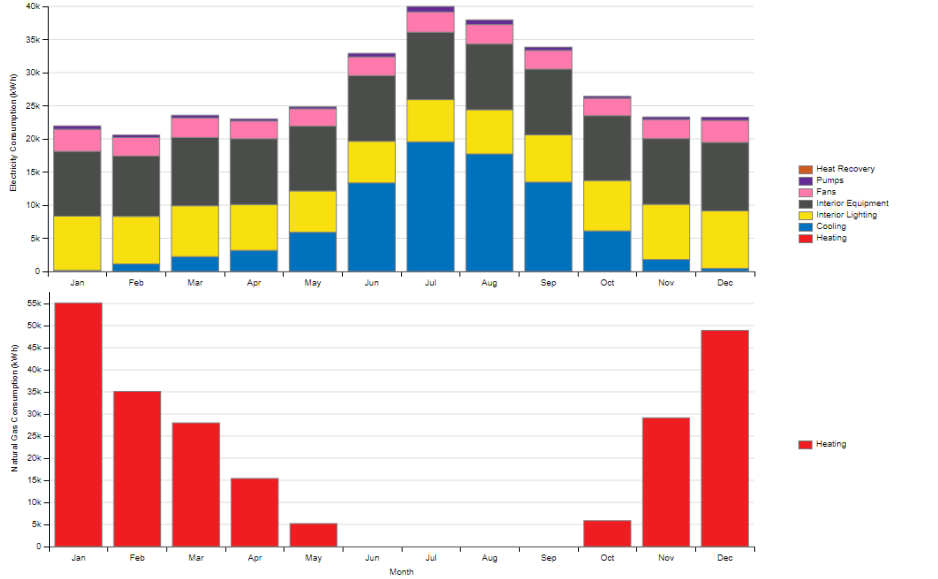
Weather data files
Loads
Schedules
Set-points
Control

Corrected model to 'standard use'

	End Use	Consumption (kWh)
-64%	Heating	167,456
+17%	Cooling	84,242
-4%	Interior Lighting	86,575
	Exterior Lighting	0
-54%	Interior Equipment	118,847
	Exterior Equipment	0
-65%	Fans	34,500
-29%	Pumps	5,625

PEC_{nren} = 147.3 kWh/m²año
Emissions = 26.6 $kgCO_2/m^2$año





Conclusions and next steps

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- **Conclusions**
  - The development of accurate models that reduce the current performance gap between theoretical and actual consumption is possible with cost-effective procedures (e.g. 2-3 working days for complex buildings).
  - With the appropriate tools, it is possible and feasible to extrapolate the methodology based on auto-calibrated white-box models, from the scientific to the commercial environments.
  - Multi-objective optimization based on genetic algorithms plus parametric analysis in the cloud allows to reduce the computational cost of the calibration process.
  - The automation of the workflow based on available computational tools will reduce the need for professional training in terms of cost and time.
  - If the estimation of energy savings resulting from the implementation of energy efficiency measures is not based on the actual energy use of the building (i.e. calibrated model), we cannot guarantee the accuracy.
  - The use of calibrated models within EPC schemes would reduce the uncertainty of some parameters, also used for the "EPC standard", such as envelope thermal transmittance or outdoor air renovation (ach)
  - End-users show a higher level of engagement with energy efficiency when the EPC information is based on their occupant behaviour patterns (i.e. actual energy use) and they perceive this information as helpful in making decisions about investments.
- **Next steps and future research lines**
  - Test and validation phase through 15 case studies in 5 countries to confirm initial findings (still ongoing)
  - Automated cost-optimal assessment through a multi-objective optimisation (via PAT) to achieve nZEB (still ongoing)
  - Integration of the methodology into national simplified procedures (future developments)

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Thank you for your attention

For further information, please contact via contact@epanacea.eu

Video tutorial on YouTube channel: (171) ePANACEA Method 3 of Assessment - Tutorial - YouTube

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