Urban context and climate change impact on the thermal performance and ventilation of residential buildings

A case-study in Athens

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° 768576

PRELUDE

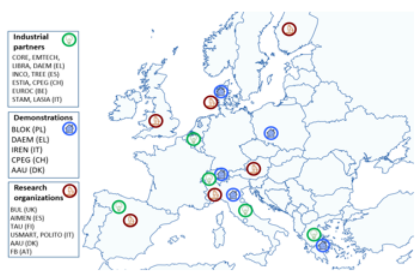
PRELUDE: Prescient building Operations utilizing Real Time data for ENergy Dynamic Optimization

21 Partners

Started in December 2021

To complete in November 2024

https://prelude-project.eu/



8 pilot buildings in Denmark, Poland, Switzerland, Italy and Greece

A testing Living Lab in Austria

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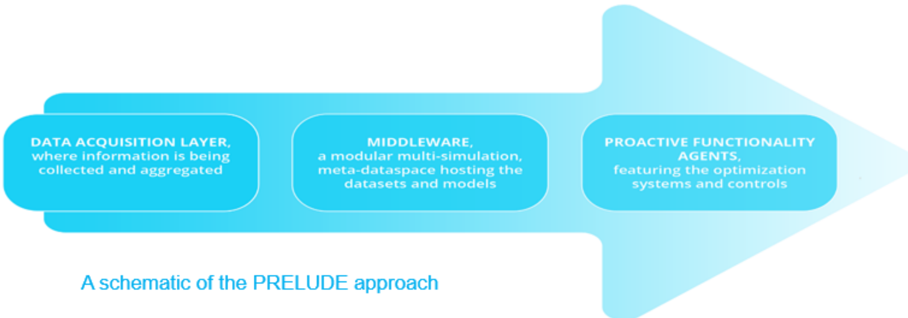

A schematic of the PRELUDE approach

The PRELUDE project focusses on assessing the right level of smartness necessary for any given household/building and then providing the optimal tools according to the needs of the user.

The system is designed to be versatile and adapt to the engagement, monitoring, and automation level of the building.

- Passive solutions, such as natural ventilation and cooling, are prioritized through a free-running strategy.
- Predictive maintenance is implemented to reduce costs, emphasizing Renewable Energy Sources.
- Big data and advanced analytic tools are used to facilitate flexible building side demand and ease the integration into district heating and electricity grids.
- Proactive optimization is to be achieved through data predictive control.

PRELUDE pilot buildings

Geneva

Torino

Athens

Rye

PRELUDE Pilot Buildings

Egernsund

Krakow

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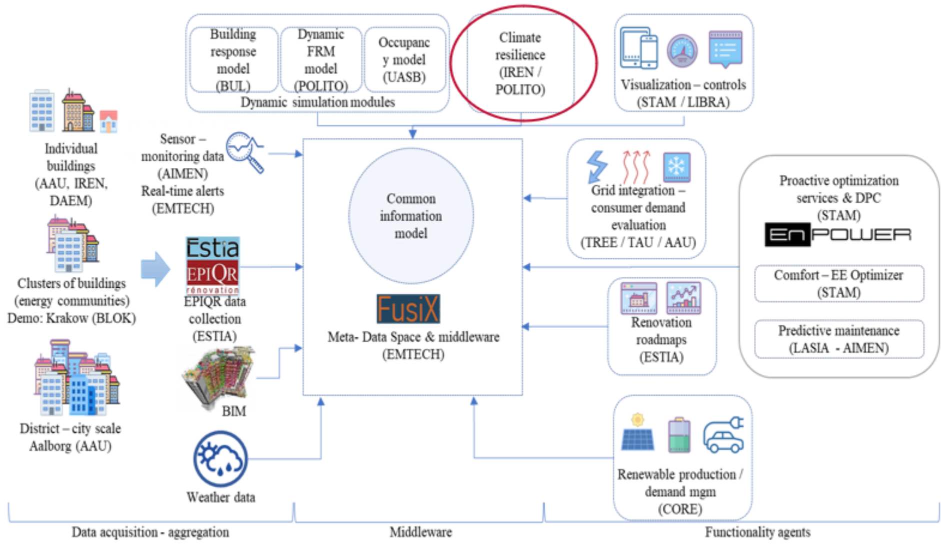
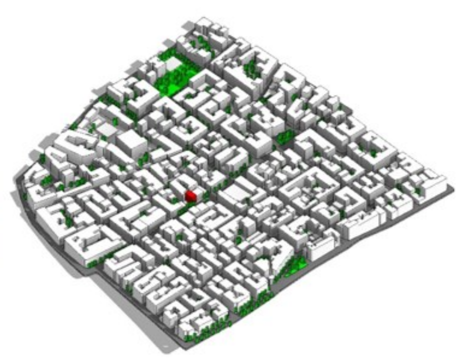
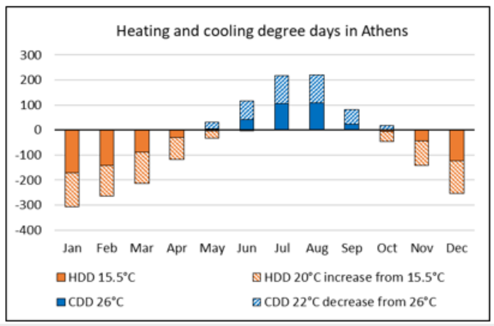


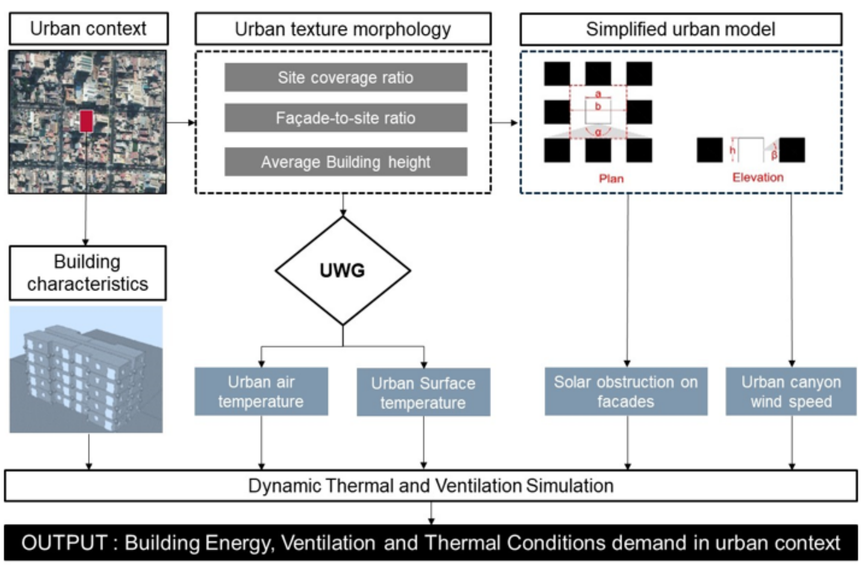
Impact of microclimate on the Athens pilot



Typical weather file – Athens airport



Urban Settings: how to model?



Source: Salvati, A., Palme, M., Chiesa, G., & Kolokotroni, M. (2020). Built form, urban climate and building energy modelling: case-studies in Rome and Antofagasta. Journal of Building Performance Simulation, 13(2), 209–225. https://doi.org/10.1080/19401493.2019.1707876

Urban weather generator calculations

Autodesk *Revit* was used to generate the required building information for the UWG program. After the UWG's .xlsm files and other source files are co-simulated using Matlab, two urban weather files for current and future scenarios were obtained

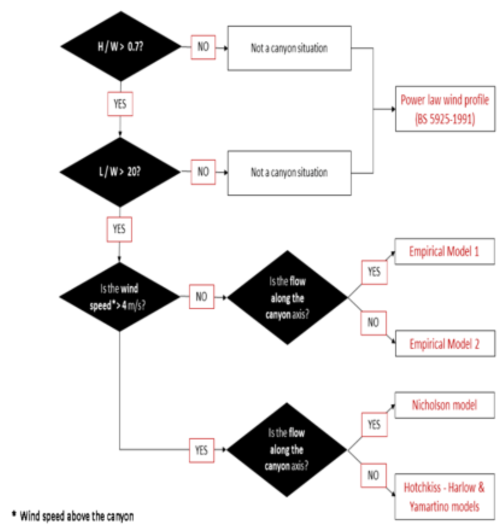
Urban Characteristics	Input data	Vegetation Parameters	Input data
Average Building Height	15.78	Urban Area Veg Coverage	0.0157
Fraction of waste heat into the canyon	1	Urban Area Tree Coverage	0.0245
Building Density	0.473	Veg Start Month	1
Vertical to Horizontal Ratio	1.078	Veg End Month	12
Urban Area Characteristic Length	250	Vegetation Albedo	0.25
Max Dx	62.5	Latent Fraction of Grass	0.5
Road Albedo	0.1	Latent Fraction of Tree	0.5
Pavement Thickness	0.5	Rural Road Vegetation Coverage	0.8
Sensible Anthropogenic Heat (Peak)	20		
Latent Anthropogenic Heat (Peak)	2		

Wind speed and solar obstruction

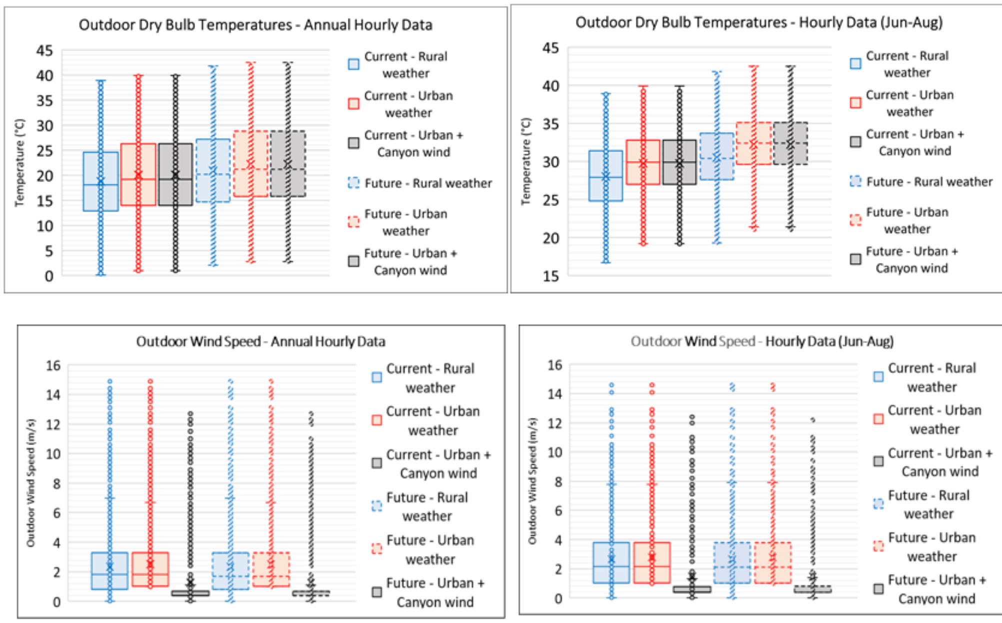
The hourly wind speed was calculated using the algorithms developed from experimental data in Athens (similar canyons). These were carried out under the European project UrbVent almost 20 years ago.

Hourly wind speed values of canyon wind were calculated for the undisturbed wind and wind direction values found in the rural weather files. The urban canyon wind speed values were then replaced with the urban weather files generated from the UWG program.

Overshadowing was calculated from the EnergyPlus program

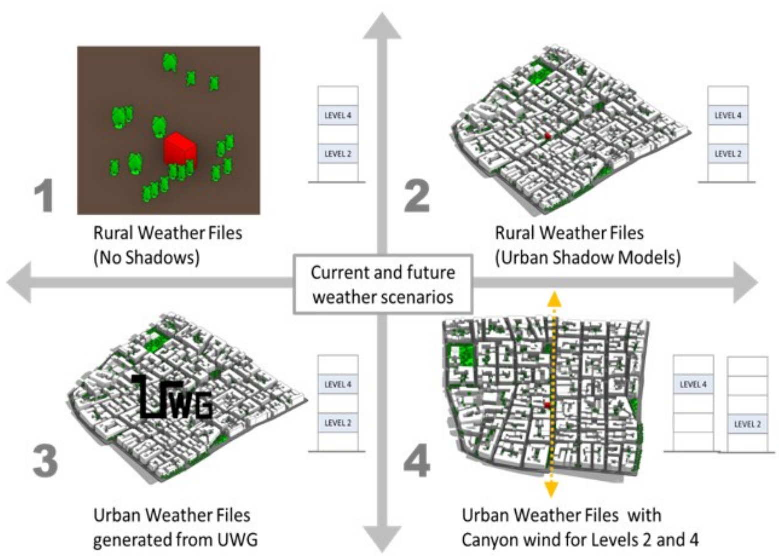


Weather data comparison

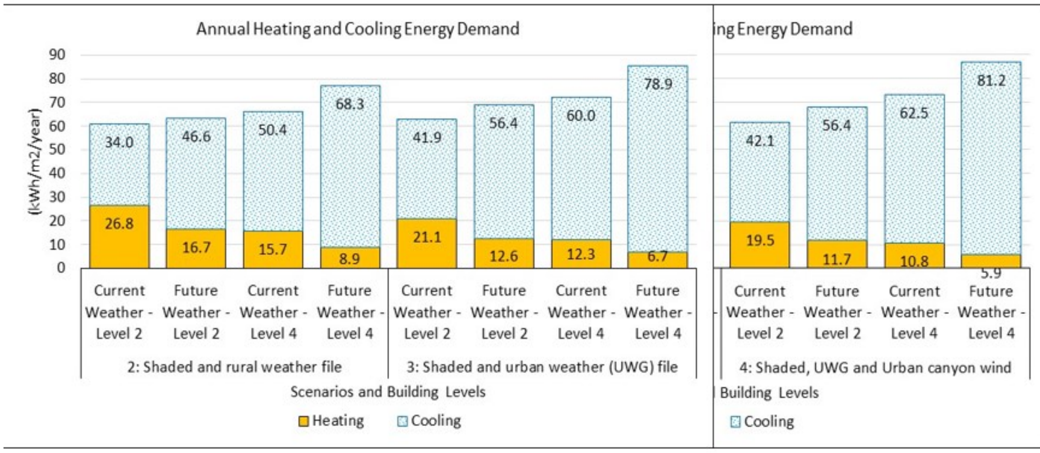


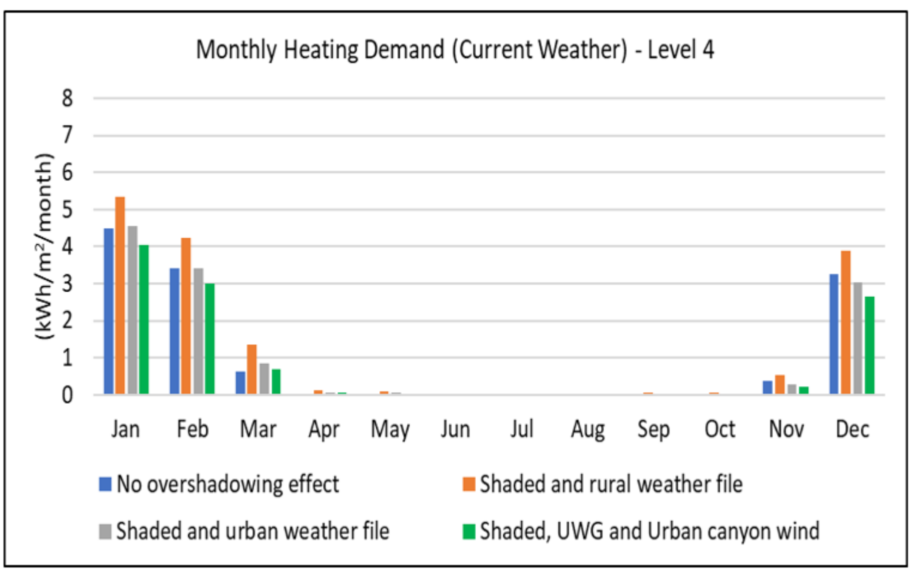
Future weather is RCP8.5 scenario for the year 2050

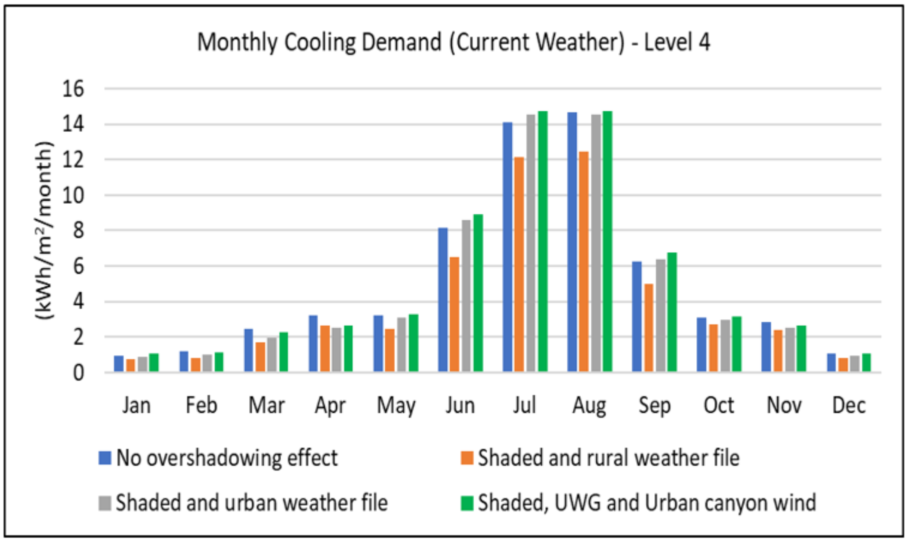
Simulations using EnergyPlus



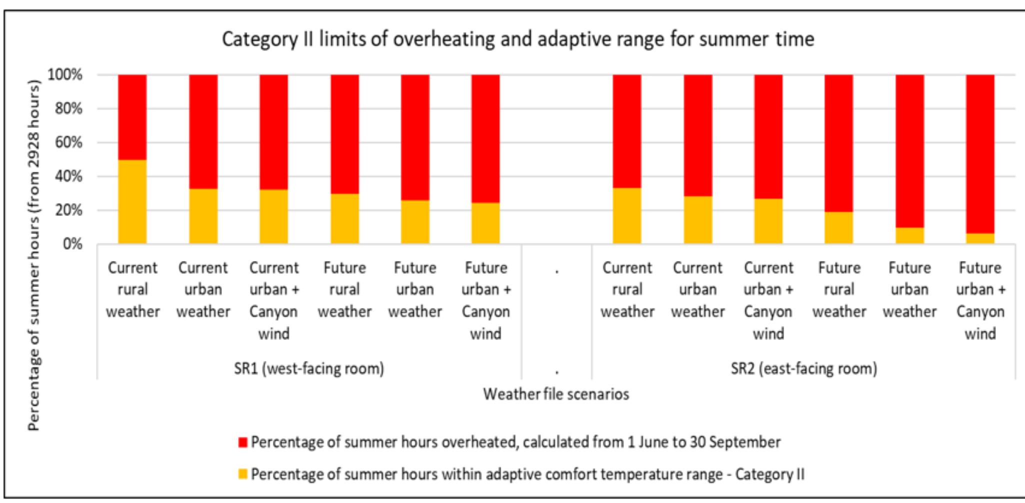
Energy use simulation results







Overheating assessment



Conclusions

- The confounding effects of urban density, urban textures and exposure to the wind, building design and human activities alter weather characteristics over and around urban areas.
- Weather files were generated from the UWG program and urban canyon wind calculation, and were used to compare how different weather impacts building performance. The overshadowing effects from the surrounding buildings were considered as it is relevant to an urban setting.
- The case study building is located in Athens within an urban canyon with data obtained from the PRELUDE H2020 project.
- Simulations showed (typical weather file compared with fully modified urban weather file)
  - an increase of the cooling demand by 24%. In the future (2050) we will have a 66% increase in cooling demand
  - total energy demand (heating and cooling) increased only 3% for lower floors and 12% for higher floors due to the reduction of heating demand. In the future we will have an increase 32% for higher floors and 13% for lower floors.
  - If the building is free floating an adaptive thermal comfort analysis indicated that only 25% of the summertime will be comfortable in the future in comparison to 50% prediction by current typical weather.
- Therefore, the use of a suitable weather file to include urban external conditions in thermal simulations is essential for more accurate predictions of energy demand and internal avoidance of overheating in free-running buildings.

Thank you