



Rooftop solar photovoltaic energy potential at urban environments: Application example for the city of Athens in Greece

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With contribution from: Apostolos Katranitsas, Anastasios Tsavalos, Xinyuan Hou, Orestis Speyer, Stelios Kazadzis, Evangelos Gerasopoulos

Motivation



Influence of climatic conditions from the irrational use of the produced energy



Increase of the rooftop PV participation share in the total smart cities neutrality

Need for optimal urban planning

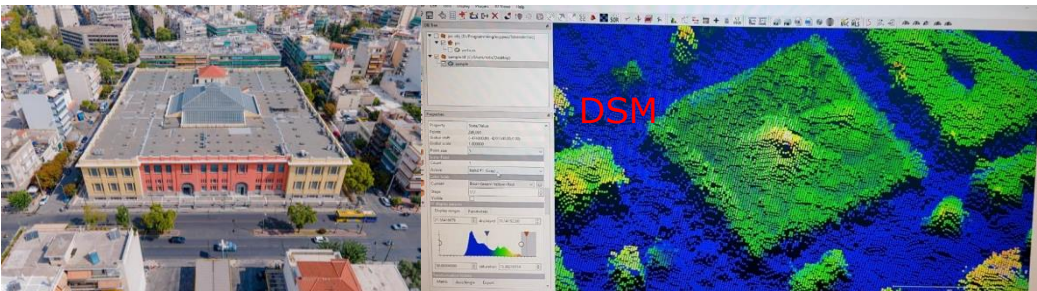
Energy Management:
An integral part of the local administration units

Efficient control and management of the energy supply and demands, and integration of the produced energy from solar systems into the electricity grid.



55% lives in cities
Rooftop PVs 32%
70% CO2 emissions by the 10% of population

Earth Observation

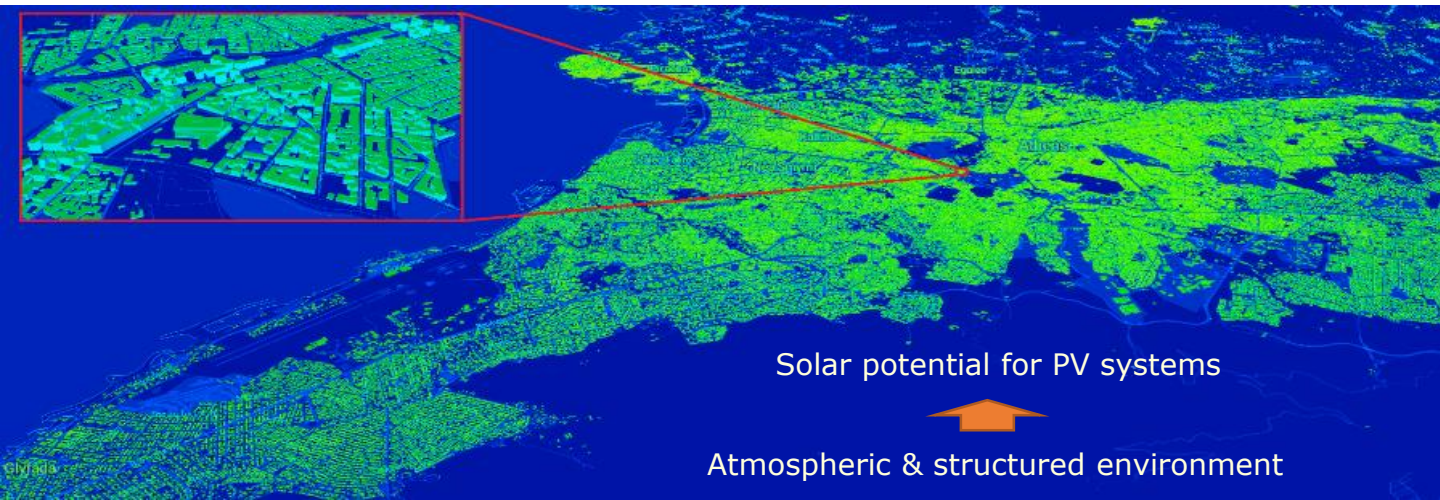


BSM



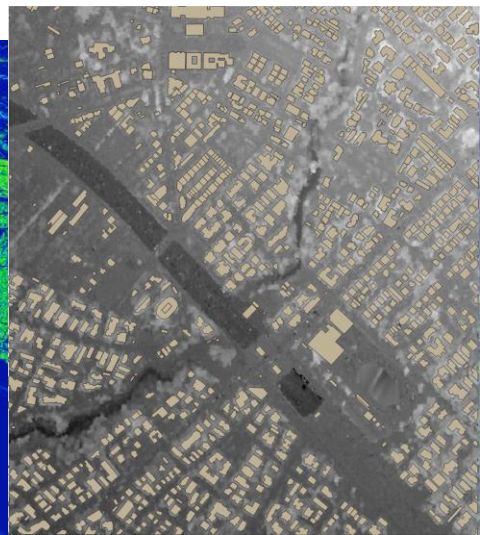
terrace & pitched rooftops

- Copernicus Urban Atlas & Building Height (10 m)
- Building Footprint OSM Buildings (3D shapes)
- Commercial tri-stereo DSM (0.5 m)
- UHD RGB Images for PV & DHW mapping
- QGIS plugins for building envelopes
- Thermal Images (Sentinel-3)



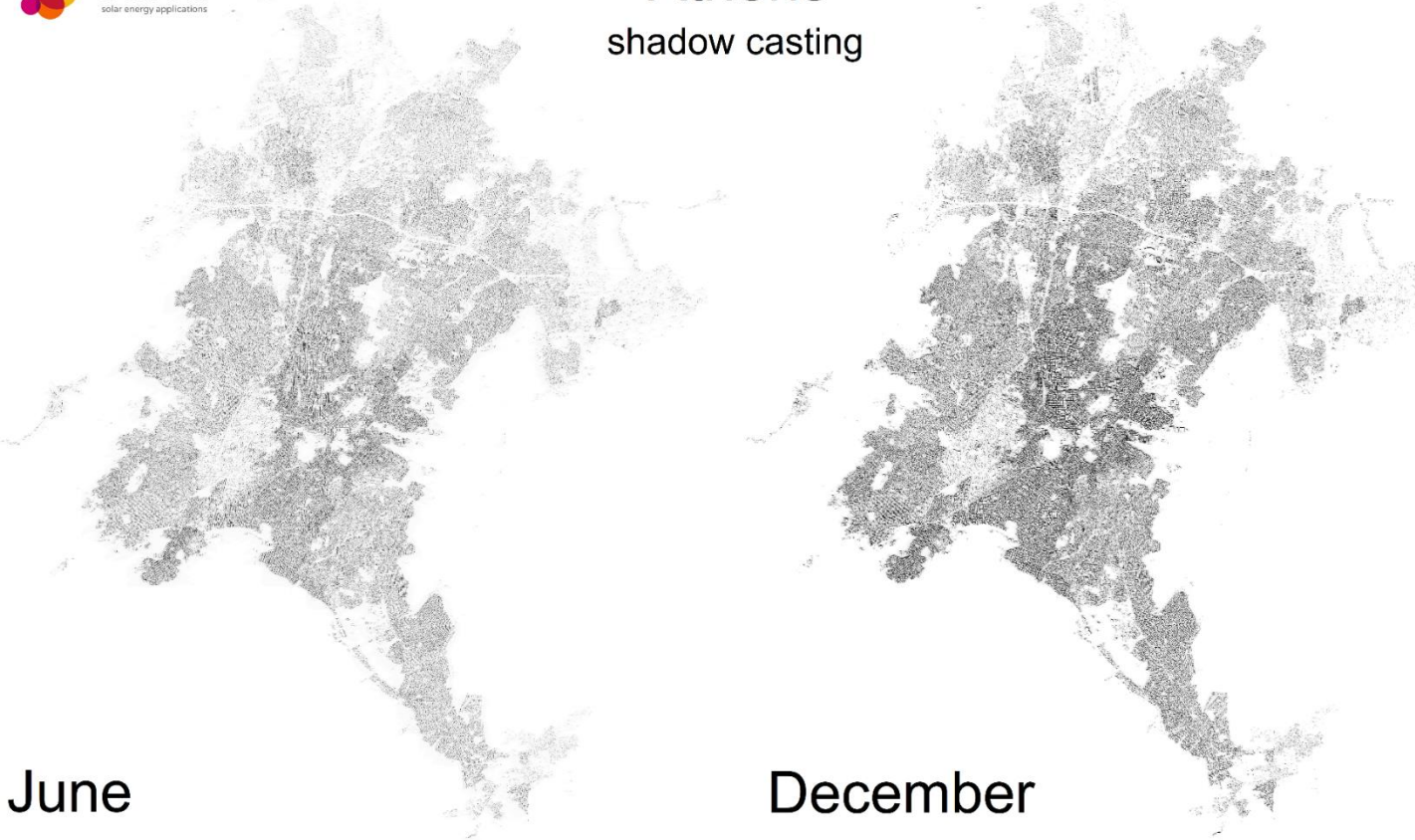
Solar potential for PV systems

Atmospheric & structured environment

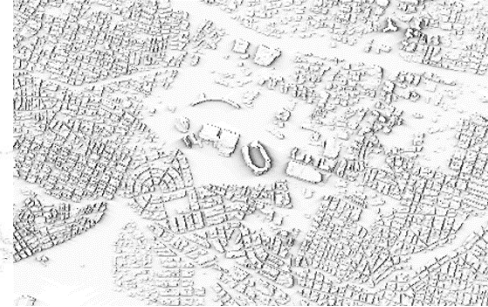


Shadows

Athens shadow casting



June



December



June

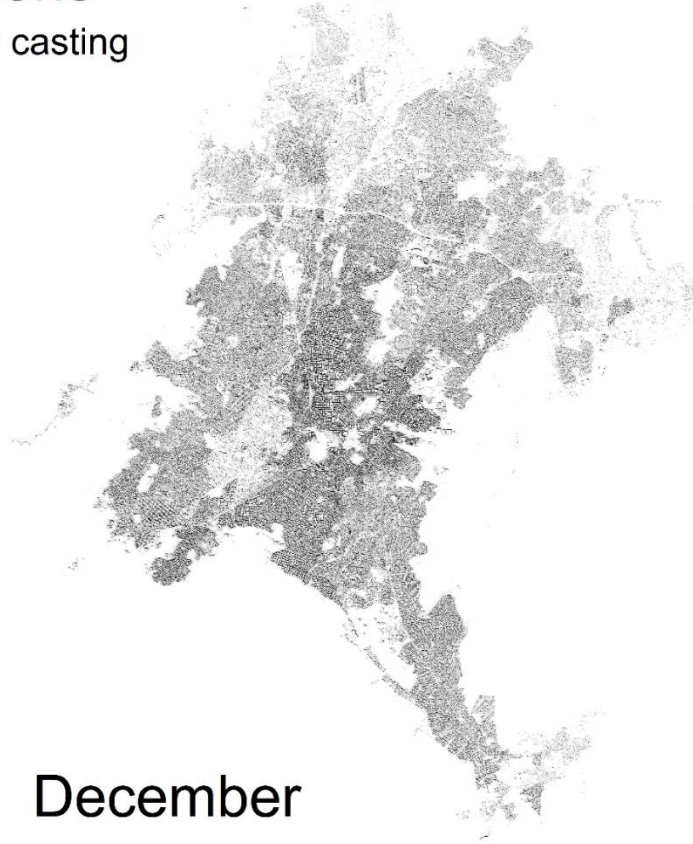
December

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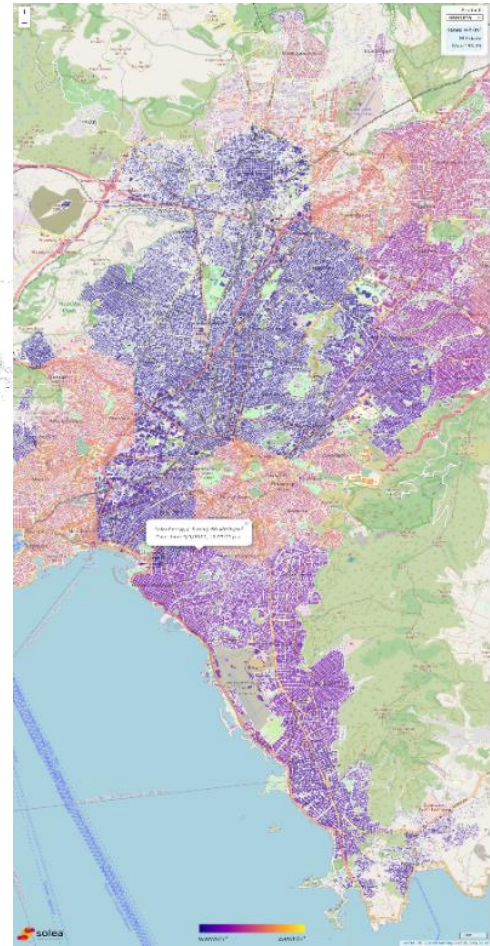
Athens shadow casting

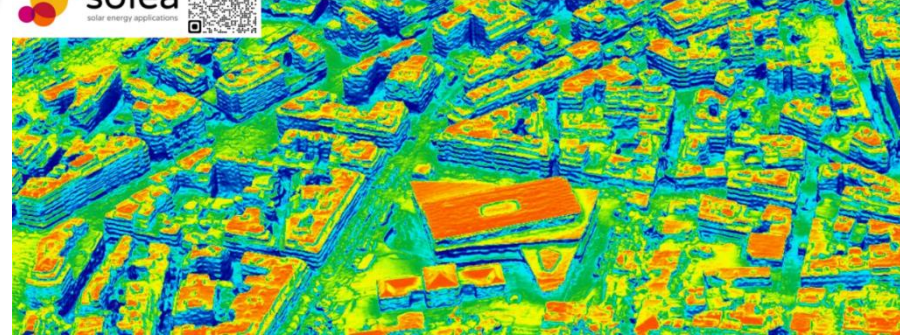
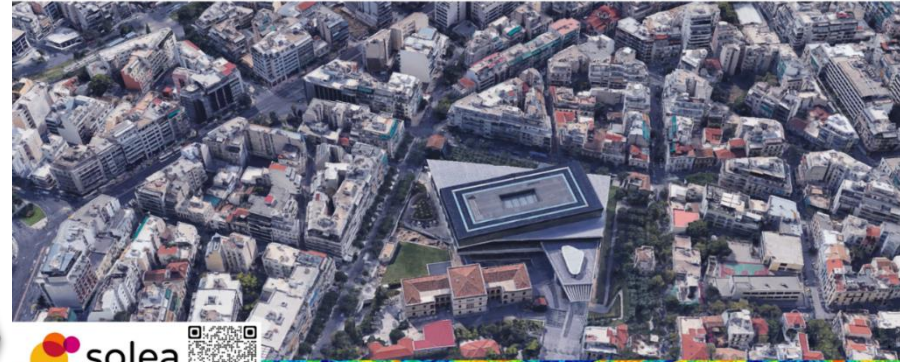
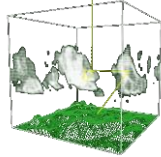
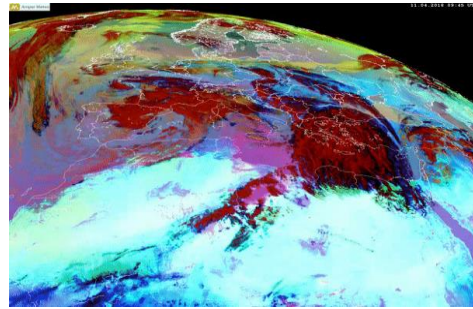


June



December





<http://solea.gr/athens-solar-cadastre/>

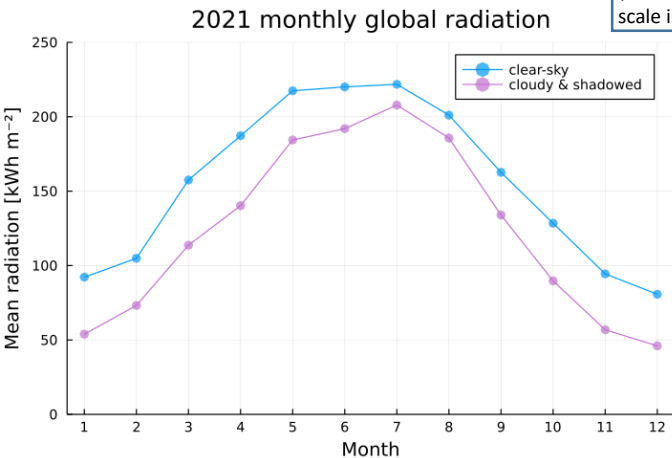
Energy calculations example

cloudy

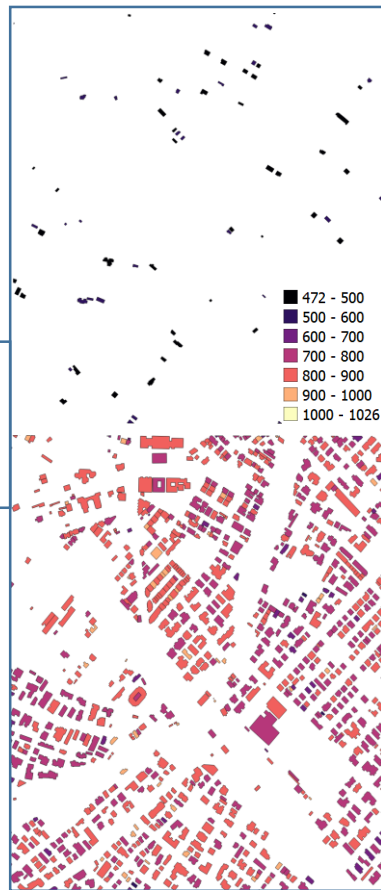
- $G_{cl} = G_{cs} \cdot CMF$
- Ratio R of diffuse to global radiation under certain sza & CMF
 - 2D interpolation from result matrix running radiative transfer model
- $F_{cl} = G_{cl} \cdot R$
- $\rightarrow D_{cl} = G_{cl} - F_{cl}$

shadowing

- shadowing effect for diffuse radiation $sh = \frac{F_{sh}}{F_{cs}}$
- $F_{cl,sh} = F_{cl} \cdot sh$
- sum up hourly $G_{cl,sh} = \sum (D_{cl} + F_{cl,sh})$

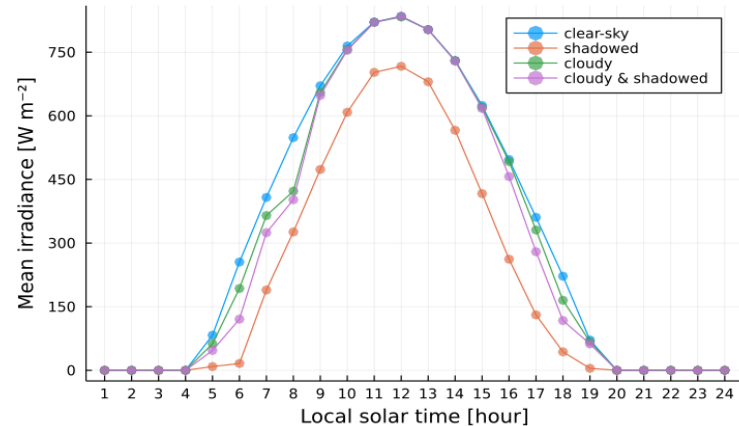


Rooftop global irradiance [W/m²] at 9 am (upper) and 1 pm (lower) of same scale in 21-06-21

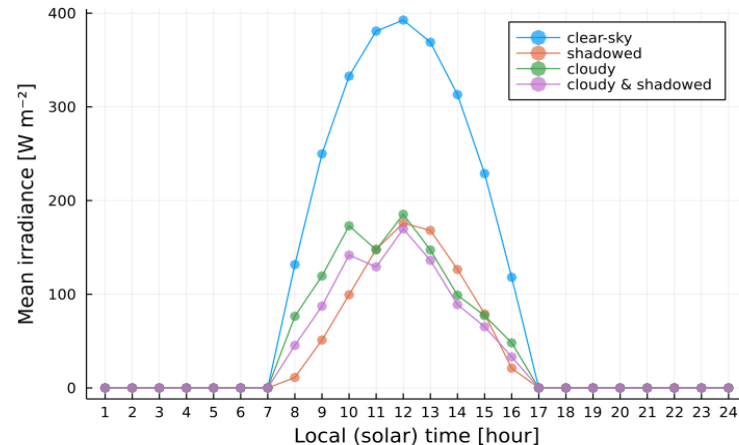


Xinyuan et al. (under preparation)

06-21 global radiation



12-21 global radiation



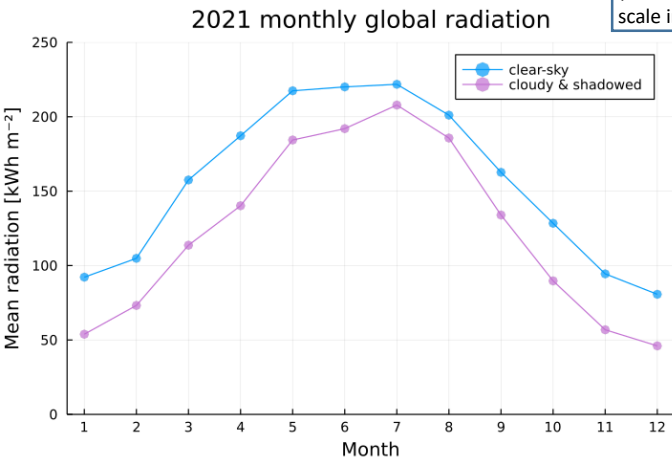
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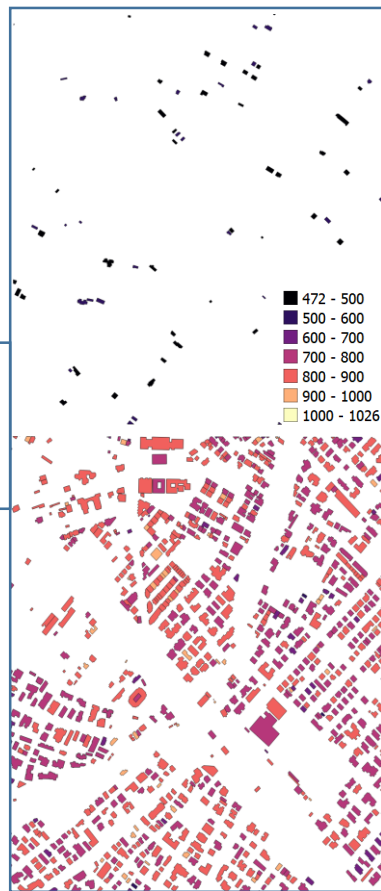
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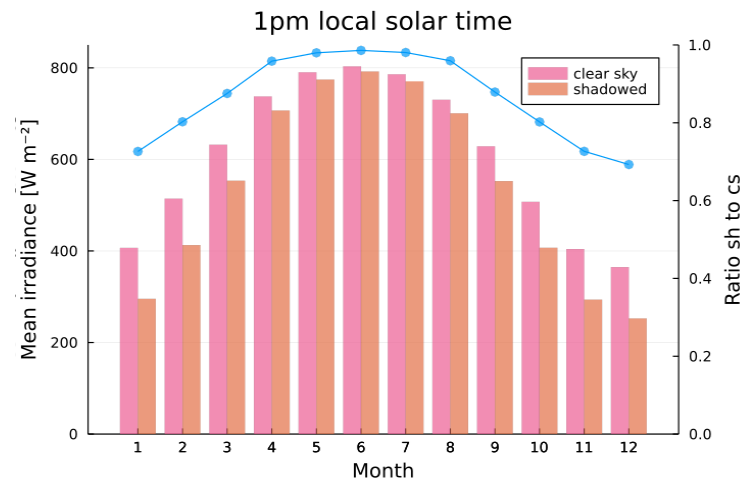
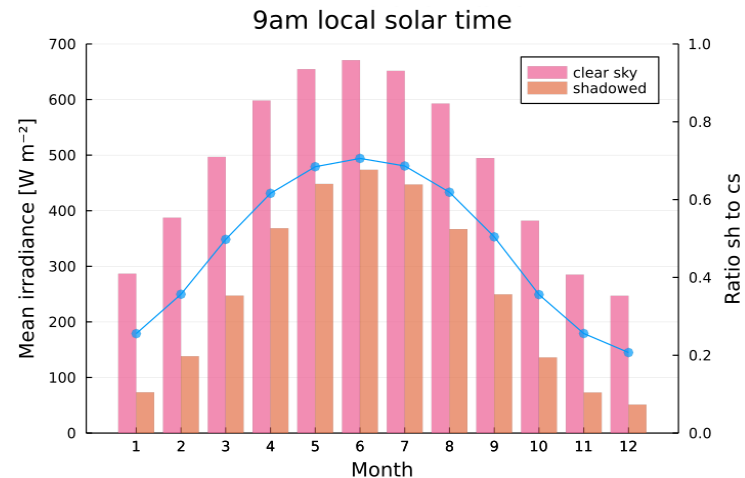
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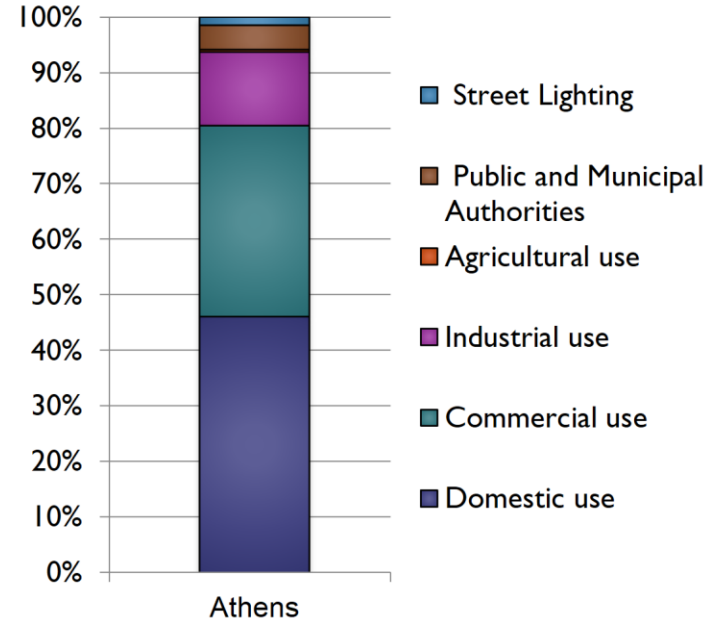
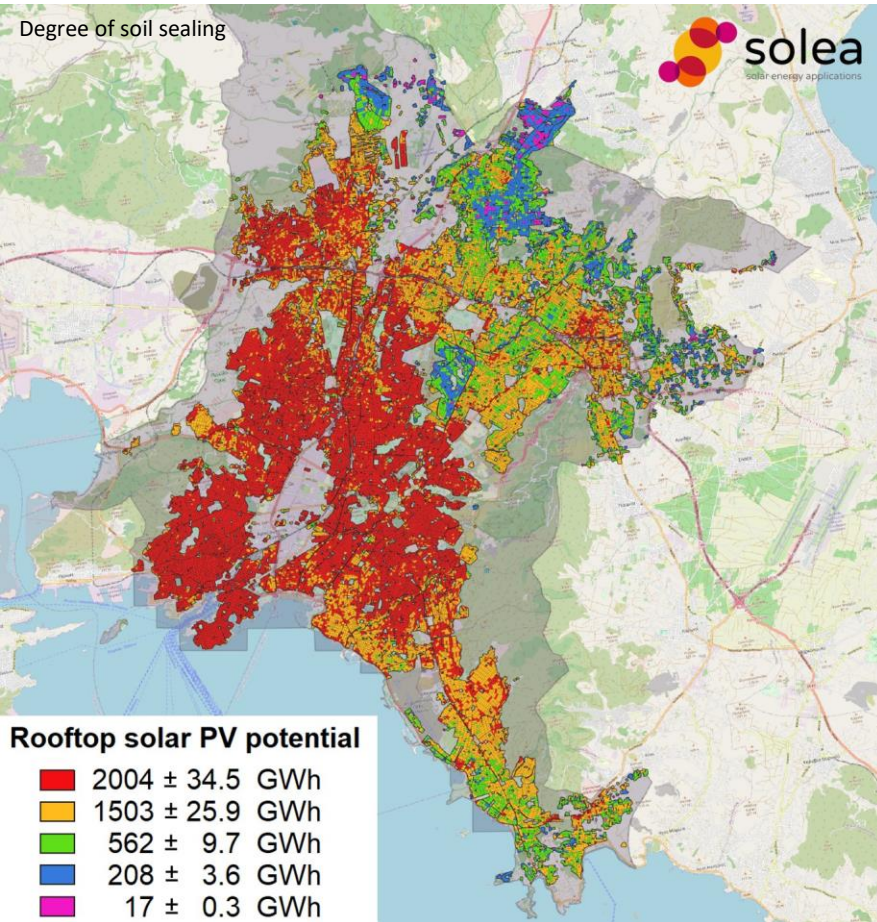
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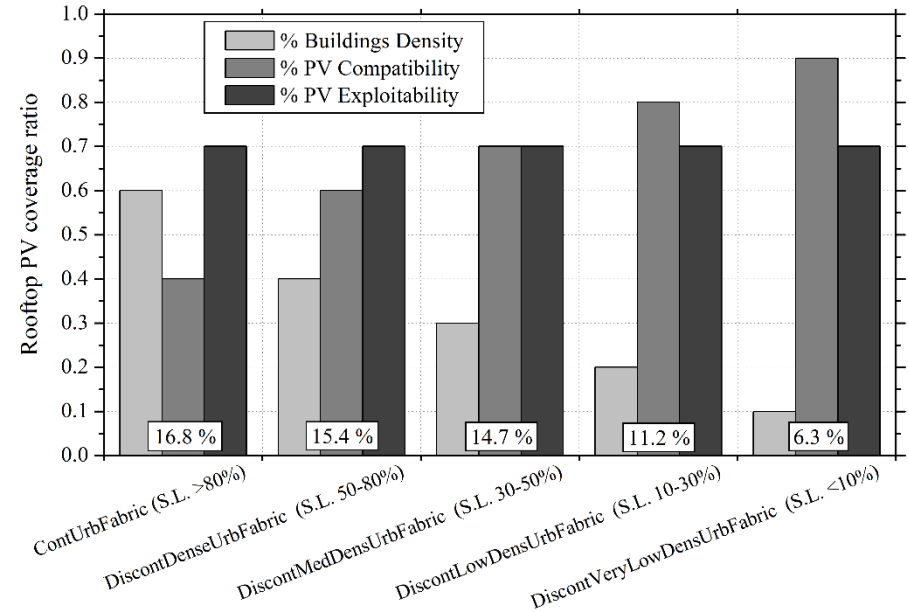
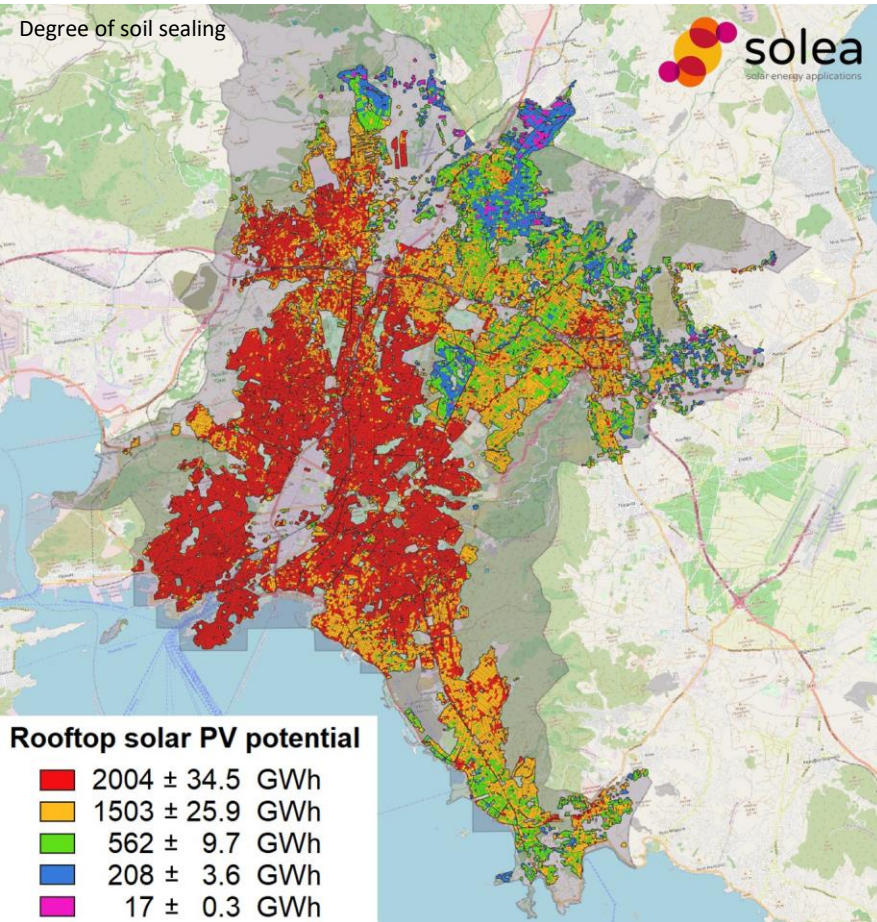
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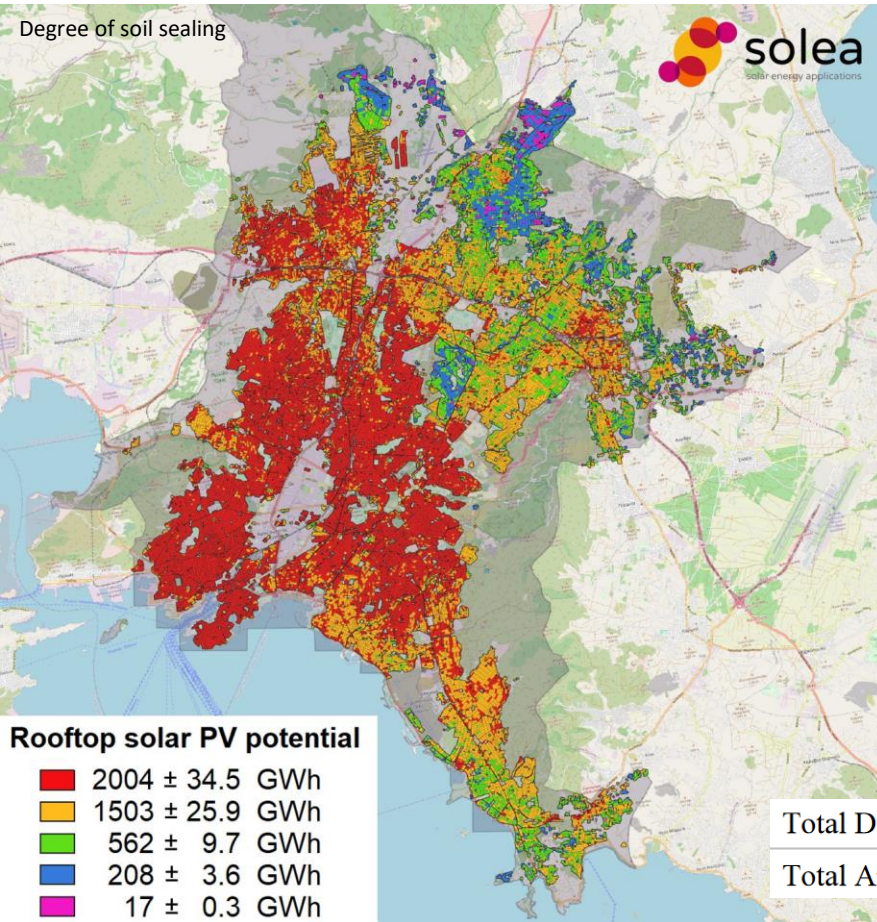
Athens solar cadastre – Energy planning



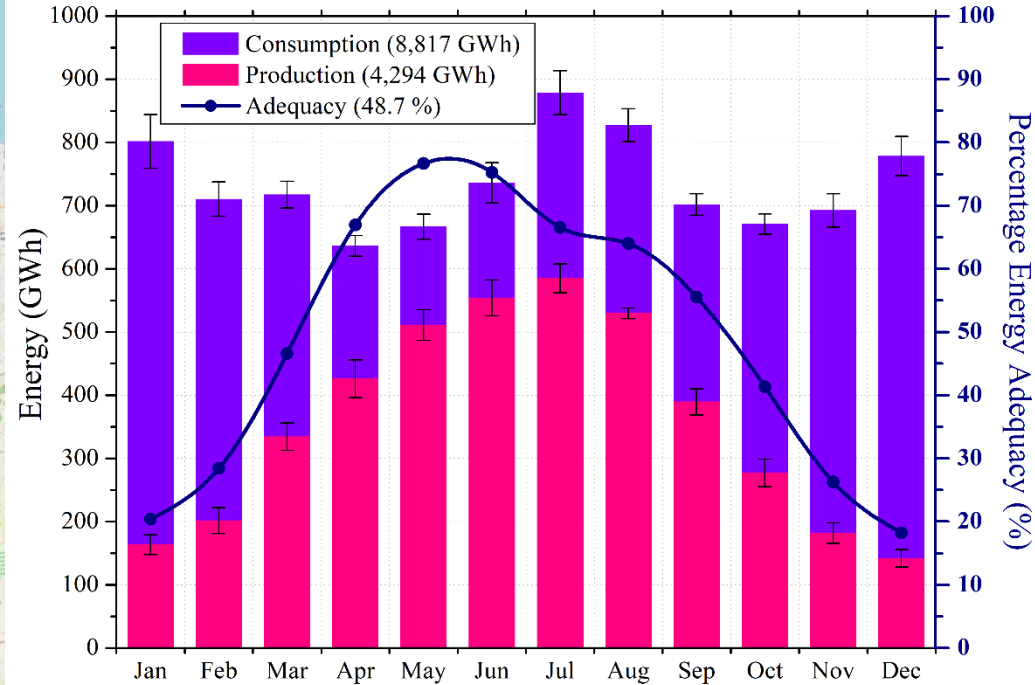
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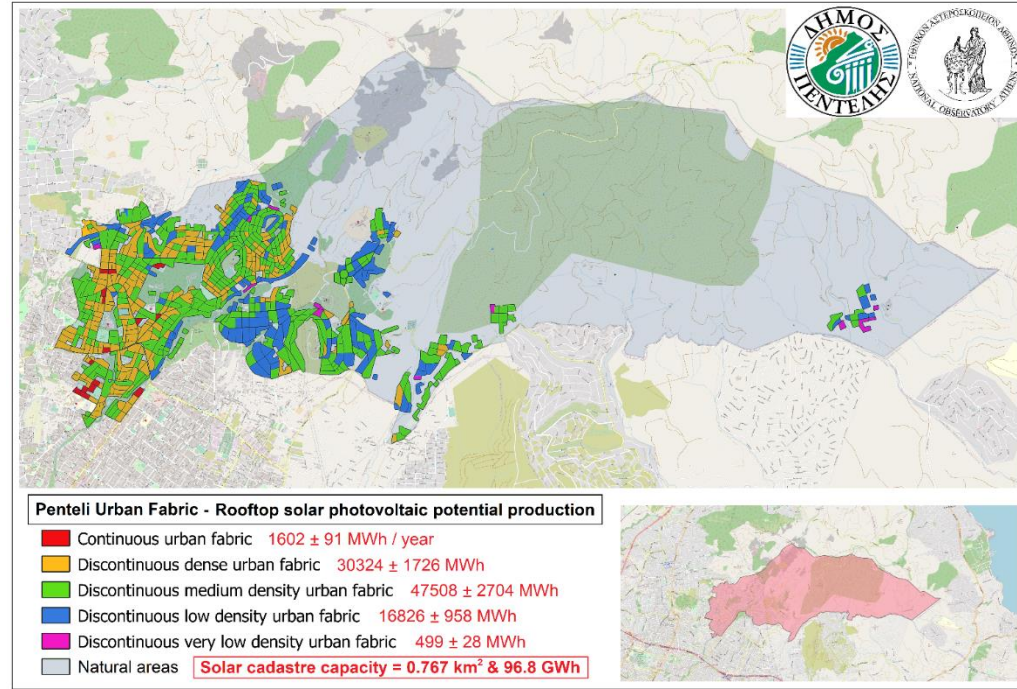
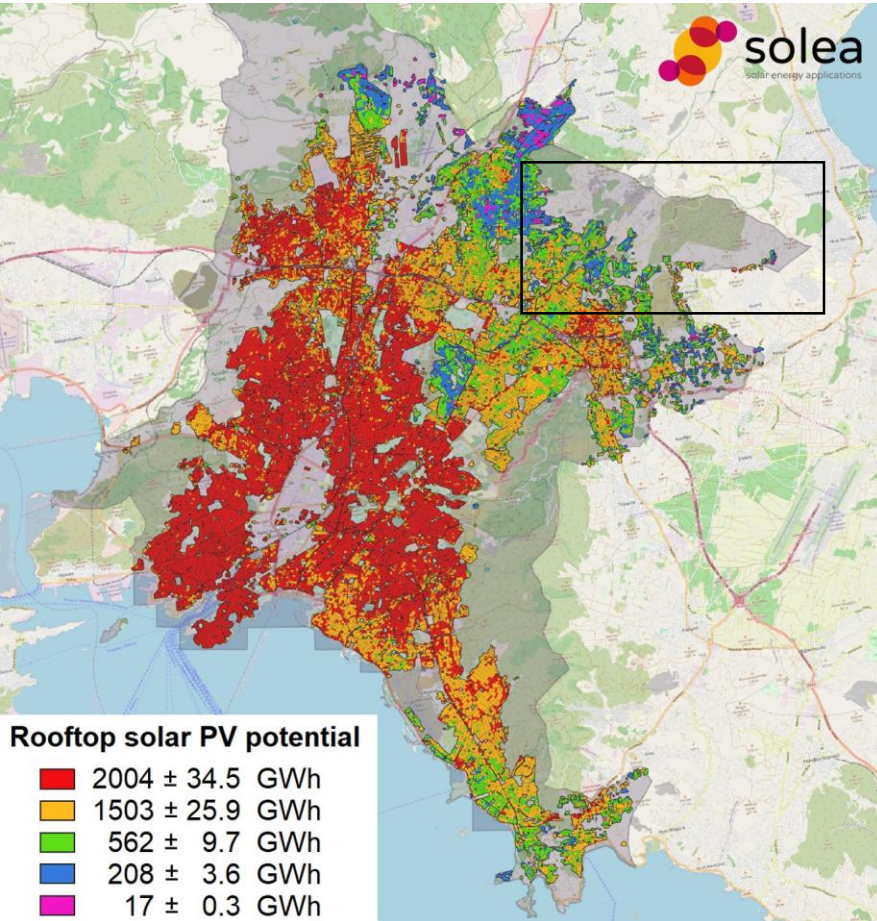


Save annually 0.7 billion cubic meters of natural gas.



Total Discounted Cost for	2020 - 2030	[€billion]	30.5
Total Amount of Emissions for	2020 - 2030	[MTon CO ₂ -eq]	225.75

Athens solar cadastre – Energy planning



Penteli has almost 35K citizens and is able to host rooftop solar photovoltaics that can cover the 63.7% of the total energy consumption (152 GWh) in an annual basis by exploiting just the 2.65% of its area.

The way forward

The urban planning and rooftop solar PV management is able to provide:

- ➡ Access to solar nowcasting and forecasting for smart grids stability and DSO support.
- ➡ Adaptability to urban environment (roof-top PVs) for sustainable and renewable cities.
- ➡ Real-time solutions for decision makers & producers promoting the exploitation of solar energy.



In 14 and a half seconds, the sun provides as much energy to Earth as humanity uses in a day.



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