URBAN DATA MINING, ARTIFICIAL INTELLIGENCE & SIMULATION

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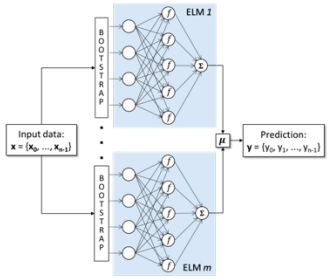

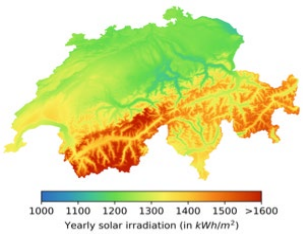

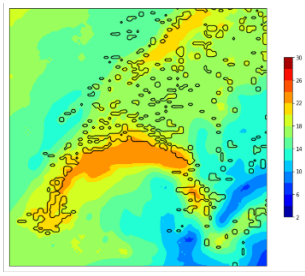

Mean monthly 2m air temperature (°C) at 05.00

The group studies urban systems through their physical processes, by modelling their dynamics and their renewable energy potential in order to improve their environmental sustainability.

Urban systems are analysed in depth to account for the numerous interactions occurring between the elementary building objects and the natural environment in relation to the changing availability of energy resources. The impact of climate change on the energy demand in the future and the influence of urban planning scenarios are assessed. Furthermore, the group works on the integration of decentralized energy systems in urban areas.

Machine learning algorithms and simulation tools are applied to model the spatio-temporal variability of renewable energy potential and energy demand in the built environment. They rely on the large amount of data, satellite imagery and remote sensing mostly accessible via open access databases. Combined with state-of-the-art deterministic models, they are used to model environmental variables in the urban canopy, to measure the uncertainty associated to predictions, and to forecast their long-term evolution.

Published work relates to

- Building energy demand in urban settings
- Distributed energy systems
- Multi-scale modelling of urban energy fluxes
- Big Data and Machine Learning methods for renewable energy potential
- Urban microclimatology
- Statistical modelling of the built environment
- GIS (Geographic Information Systems) and spatial data analysis

2018 Activities

The Urban Systems Simulation group was involved in multiple projects and initiatives, within the framework of the Swiss Competence Center for Energy Research - Future Energy Efficient Buildings and Districts (SCCER-FEEB&D) and the Swiss National Science Foundation PNR 75 series of projects. Its main focal points were urban microclimate, distributed energy systems, renewable energy potential estimate using Big Data, urban planning and climate change impacts.

Current Projects

SCCER FEEB&D Phase II, Task 2.3.1 Analysis and assessment of RDES cases
Funding: Innosuisse/ Duration: 2017- 2018

Development of new modelling tools and transfer of findings into practice with the assessment of demonstrators and applications in typical project cases. Renewable decentralised energy systems (RDES) require new integrated energy system solutions. Multi-energy grid (MEG) and energy hub (EH) are expected to help facilitate their effective operation and integration. The purpose of this project is to analyse and assess RDES cases with a quantitative illustration of the energy and emission reduction potentials using RDES solutions with MEG/EH and comparing with conventional or alternative approaches.

SCCER FEEB&D Phase II, Module 3.2 Spatio-temporal renewable energy modeling
Funding: Innosuisse / Duration: 2017-2020

We develop a novel methodology combining Geographic Information Systems (GIS) and a Machine Learning (ML) algorithm, Random Forests, to estimate the technical potential for rooftop PV solar energy at the scale of a country. The study focuses on Switzerland and provides the rooftop PV technical potential for each pixel of a grid covering the entire country. It is generalizable to any region for which similar data is available. Prediction Intervals are also provided to measure the uncertainty of estimations.

MOTUS
Funding: ENAC Equipment call / Duration: 2016-2019

A 27m mast with instruments at a regular interval (4m) along the vertical axis to obtain a high-resolution profile of meteorological parameters was installed in 2016. The installation was completed with 6 additional anemometers on the LESO-PB south façade to improve the understanding of turbulent processes and the automated control of blinds. Extension for its funding was obtained until December 2019.

HYENERGY - Hybrid renewable energy potential for the built environment using big data
Funding: Swiss National Science Foundation – National Research Program 75 "Big data" / Duration: 2017-2020

Development of a method for forecasting the spatio-temporal potential of a combination of renewable energy sources for built areas. A data-driven approach and machine learning algorithms are used to (i) estimate the hybrid renewable energy potential in the built environment, in order to mitigate the effects of variability in individual energy resources and improve the reliability of power generation, (ii) process & analyse spatio-temporal environmental data, (iii) apply developed algorithms to the built environment for predicting energy generation, (iv) analyse forecasting models, (v) estimate uncertainty & validate models using measurement data, and (vi) propose a Building Renewable Energy Data-base (BRED), geo-visualisation tools and renewable energy mapping to support evidence-based decision-making processes.

Integrating urban form and sociotechnical potentials of decentralised energy supply for sustainable urban development
Funding: SNSF – Advanced Postdoc Mobility Fellowship Dr Nahid Mohajeri (University of Oxford)
Duration: 2017-2019

The project aims to refine our knowledge of the resource and PV potential for Switzerland with application to other areas and to analyse how solar energy technologies and associated acceptance and affordability evolve together and how this may affect sustainable urban development and energy policies.

Selected 2018 publications

- Assouline D., Mohajeri N., Scartezzini J., Large-scale rooftop solar photovoltaic technical potential estimation using Random Forests, in Applied Energy, vol. 217, p.189-211 , 2018
- Mauree D., Blond N., Clappier A., Multi-scale modeling of the urban meteorology: Integration of a new canopy model in the WRF model, in Urban Climate, vol. 26, p.60-75 , 2018
- Mauree D., Coccolo S., Perera A., Nik V., Scartezzini J.-L., Naboni E., A New Framework to Evaluate Urban Design Using Urban Microclimatic Modeling in Future Climatic Conditions, in Sustainability, vol. 10, num. 4, p.1134 , 2018
- Perera A.T.D., Coccolo S., Scartezzini J.-L., Mauree D., Quantifying the impact of urban climate by extending the boundaries of urban energy system modeling, Applied Energy, vol.222, p.847-860 , 2018
- Coccolo S., Kämpf J. H., Mauree D., Scartezzini J.-L., Cooling potential of greening in the urban environment, a step further towards practice, in Sustainable Cities and Society , 2018
- Mohajeri N., Assouline D., Guiboud B., Bill A., Gudmundsson A., Scartezzini J.-L., A city-scale roof shape classification using machine learning for solar energy applications, in Renewable Energy, vol.121, 2018
- Le Guen M., Mosca L., Perera A.T.D., Coccolo S., Mohajeri N., Scartezzini J.-L., Improving the energy sustainability of a Swiss village through building renovation and renewable energy integration, in Energy and Buildings, vol. 158, p.906-923, 2018
- Honeck, E., Castello, R., Chatenoux, B., Richard, J.-P., Lehmann, A., Giuliani, G. From a Vegetation Index to a Sustainable Development Goal Indicator: Forest Trend Monitoring Using Three Decades of Earth Observations across Switzerland, ISPRS International Journal of Geo-Information. 2018;7(12):455