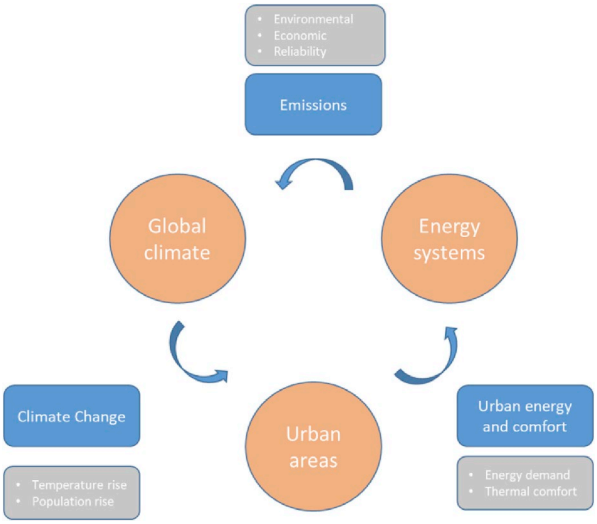
URBAN DATA MINING, ARTIFICIAL INTELLIGENCE & SIMULATION

Project leaders: Dr Dasaraden Mauree / Dr Roberto Castello
Post-doctoral fellow: Dr Silvia Coccolo
PhD students: Amarasinghage T. Dasun Perera, Dan Assouline, Alina Walch
in collaboration with: Prof. Vahid Nik (Lund/Chalmers University), Dr Nahid Mohajeri (Oxford University)



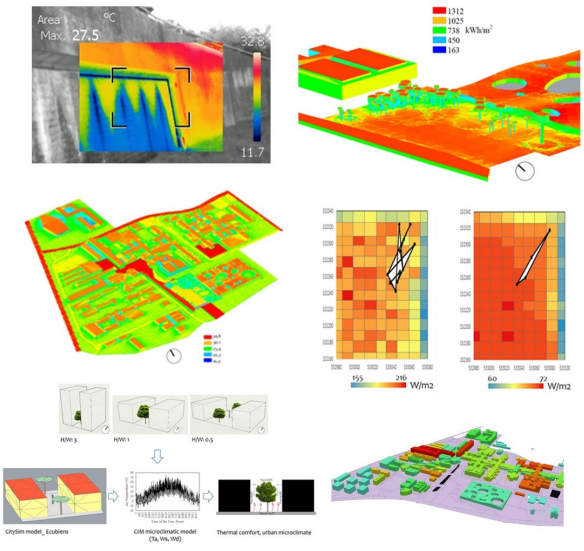
This research group studies urban systems through their physical processes, by modelling their dynamics and their renewable energy potential in order to improve their environmental sustainability. The objective is to gain a better understanding of the urban environment from the perspectives of both energy and comfort. In this framework, a large variety of approaches (machine learning, deterministic modelling, simulation tools, and geographical information systems) is used to address the problem at different scales (national, regional and local).

Dr Dasaraden Mauree and Dr Roberto Castello combine their expertise of senior scientists to rapidly expand knowledge in the field. They head activities in the following topics respectively:

- Urban simulation and monitoring / Topic Leader: Dr Dasaraden Mauree
- Machine learning for the built environment / Topic leader: Dr Roberto Castello

A. URBAN SIMULATION AND MONITORING

Topic Leader: Dr Dasaraden Mauree



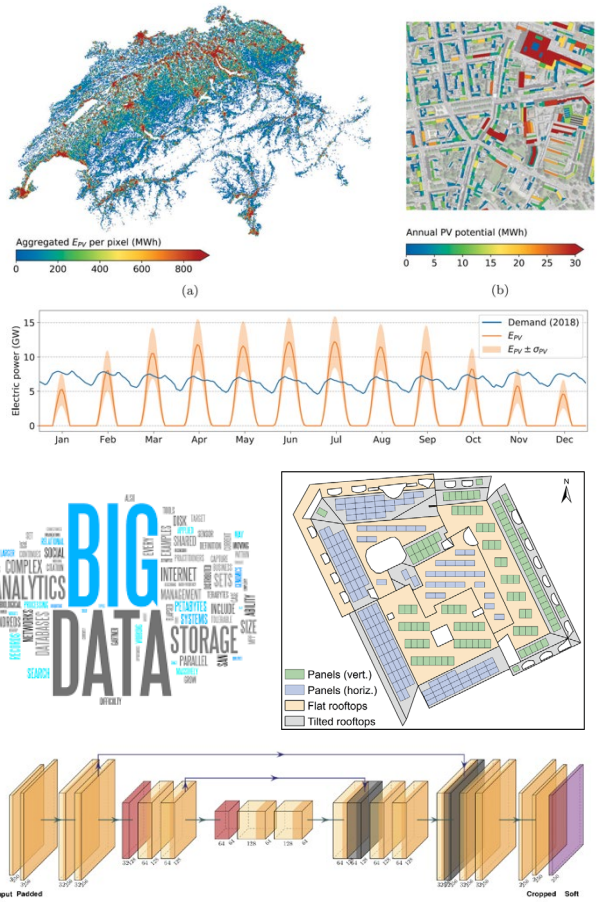
Simulation methods are developed for multi-scale modelling. Additionally, climatological variables are measured in urban areas with stationary and mobile stations. The objective is to analyse urban systems in depth and to account for the numerous interactions occurring between the elementary building objects and the natural environment. Their relation to the availability of energy resources is also studied.

The impact of climate change on the energy demand in the future and the influence of urban planning scenarios are assessed. Adaptation and mitigation scenarios are developed for urban areas.

Furthermore, the group works on improving the integration of decentralized energy systems in urban areas.

B. MACHINE LEARNING FOR THE BUILT ENVIRONMENT

Topic leader: Dr Roberto Castello



Machine learning algorithms are exploited to model the non-linear temporal and spatial variability of renewable energy sources (solar, wind, geothermal) in the built environment and to derive their potential and the associated uncertainty.

As input, large amounts of data from national databases, satellite imagery and remote sensing are leveraged and processed using data mining techniques and GIS tools.

Machine Learning algorithms are also applied to detect anomalies in energy consumption temporal patterns and to improve energy efficiency of buildings.

Deep neural networks are combined with satellite imagery and remote sensing measurements to monitor the level of integration of renewables in the built environment and to predict the future evolution in relation to urban socio-economic features.

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

Activities

The Urban Data Mining, Intelligence and Simulation group has been involved in multiple projects and initiatives within the framework of the SCCER 'Future Energy Efficient Buildings and Districts' (FEEB&D) and the SNSF NRP 75 series of projects. The research work in this framework has been carried out in close collaboration with Prof. Kanevski's team at UNIL (Faculty of Geosciences and Environment). The group is also involved in a new interdisciplinary project funded by Innosuisse "Smart and Safe Blind and Lighting Control".

Dan Assouline defended his PhD thesis titled "Machine Learning and Geographic Information Systems for large-scale mapping of renewable energy potential". Based on machine learning methods and GIS, his mapping of the Swiss renewable energy potential for different technologies suggests that it is effectively possible to cover the energy needs of Switzerland solely with renewables.

A.T.D Perera defended his PhD thesis titled "*Modeling and Assessment of Urban Energy Systems*". His work focused on the implementation of renewable energy systems in urban energy systems. With the help of newly developed methodologies and models, he demonstrated that the energy transition to low-carbon energy system was possible.

Current Projects

SCCER FEEB&D Phase II, WP3 Energy Performance at Regional and National Scale

Funding: Swiss Innovation Agency (Innosuisse)

Duration: 2017-2020

A novel methodology combining Geographic Information Systems (GIS) and a Machine Learning (ML) algorithm, Random Forests, is used 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. Prediction Intervals are also provided to measure the uncertainty of estimations.

SCCER FEEB&D Phase II, Task 5.1.1 Towards Climate & Building Energy Adapted Urban Planning

Funding: Swiss Innovation Agency (Innosuisse)

Duration: 2019- 2020

Development of multi-scale models to evaluate the regional climate and the impact of the future climate on the local urban climate. The tools developed will be used to assess the cooling need and thermal comfort maps for the future for specific case studies. An analysis of retrofit and urban planning scenarios will be performed in combination with the impact on the energy systems.

SCCER FEEB&D Phase II, Task 6.2.1 Mapping Hourly Real-time Renewable Energy Systems

Funding: Swiss Innovation Agency (Innosuisse)

Duration: 2019- 2020

Real-time mapping of the variations of solar and wind energy potential for urban and rural areas for a case study in Switzerland. Focus is on PV panels on building rooftops and micro-wind turbine technologies located at district/urban boundaries. The project aims at developing a novel computational tool to model and optimize the functioning of grid-connected decentralized renewable energy systems, by including the state-of-the-art techniques of energy storage.

Safe and Smart Blind and Lighting Control (WP1 & WP5)

Funding: Swiss Innovation Agency (Innosuisse)

Duration: 2019- 2020

The objective of this project is to push further the development of a control system that was previously developed in the framework of the SCCER FEEB&D. Work focuses on improving blind and lighting control systems by including the solar gains, decreasing the glare and increasing the reliability of the blinds by considering the wind speed.

MOTUS

Funding: ENAC

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 south façade to improve the understanding of turbulent processes and the automated control of blinds.

HYENERGY - Hybrid renewable energy potential for the built environment using big data

Funding: SNSF NRP 75 "Big Data"

Duration: 2017-2021

Developing a method to predict the potential of a combination of renewable energy sources for built areas at different temporal and spatial scales. Data-driven approach and Machine Learning algorithms are used to: (i) estimate the hybrid renewable energy potential of renewable energy sources, (ii) process and analyse environmental geospatial data, (iii) predict energy generation and forecast future potential, (v) estimate uncertainty & validate models using measurement data, and (vi) propose a Building Renewable Energy Data-base (BRED) and a geo-visualisation tools for 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 (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 publications

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- Mauree D., Castello R., Mancini G., Nutta T., Zhang T., Scartezzini. J.-L., Wind profile prediction in an urban canyon: a machine learning approach. *Journal of Physics: Conference Series* 1343: 012047, 2019. https://doi.org/10.1088/1742-6596/1343/1/012047.
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- Perera A.T.D., Wickramasinghe P.U., Nik V. M., Scartezzini J.-L., Machine learning methods to assist energy system optimization, in Applied Energy, vol. 243, p.191-205, 2019. http://dx.doi.org/10.1016/j.apenergy.2019.03.202.
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