ENERGETICS

AMMIN/DENERG - Urban-Morphology Optimization Framework for Building Energy Modeling

Funded By	Dipartimento DENERG Politecnico di TORINO [P.iva/CF:00518460019]
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Context of the research activity	The Clean Energy for all European Package encourages all state members to increase energy efficiency and the use of renewable energy sources (RES) to promote the sustainable development of cities, especially for the buildings sector. Reducing the energy consumption of buildings is one of the main goals of European policies, in order to increase the livability and sustainability in urban areas. Analyzing energy consumption of buildings at urban scale can support the identification of proper urban planning for both the design of new neighborhoods and the priority of retrofit interventions on existing building stock. The development of urban building energy modeling (UBEM) is an active and very broad research field, which allows to assess the energy performance of buildings while accounting for their relationships with the surrounding environment. The configuration of the urban environment and local climatic conditions can significantly affect solar gains and heat losses, leading to variations in building energy performance. Several tools and models have been developed to estimate building energy consumption at city scale, the most used are: CitySim, UMI, Simstadt, CityBES and open formats as CityGML. Since the relationship between buildings and urban form influences energy consumption, it is essential to describe the urban environment in more detail.
	Research Gap: Lack of comprehensive computational frameworks that quantitatively connect urban morphological-typological parameters and local climate conditions, to the energy performance of buildings and the environmental quality of the surroundings. Objectives: 1. Create parametric urban morphology models to improve energy consumption modeling 2. Implement multi-scale buildings' simulation framework for urban contexts 3. Quantify high-resolution relationships between morphological parameters, local climate conditions and energy performance metrics 4. Develop optimization methodology for context-specific urban environments

Objectives	5. Generate evidence-based design guidelines for policy implementation. Methodology Framework and Tools: 1. GIS-based Data Collection, Processing & Spatial Analysis: The process begins with the use of QGIS/ArcGIS for collecting and processing geospatial data, creating geo-packages for energy modeling. 2. Core Modeling Environment: Local climate conditions in the buildings surrounding are analysed with specific tools such as: Rhino for the base modeling environment and Grasshopper for the parametric modeling. 3. Environmental Analysis Tools: Typical variables and dimensionless numbers are calculated for characterizing the local climate conditions in the urban environment. This phase includes tools such as: Ladybug for climate analysis and solar radiation mapping, Honeybee for energy and daylight simulation, SimScale for cloud-based CFD simulations of wind patterns and outdoor comfort. 4. Building Energy Performance Simulation: This phase refers to urban building energy modeling. Data-driven and process-driven UBEMS can be compared with EnergyPlus, CitySim Pro and UrbanOpt. Some tools like CONTAM can handle multizone airflow analysis and indoor air quality predictions. 5. Optimization: multi-objective evolutionary optimization tools can be used for advanced evolutionary computation analytics for future scenarios and policies.

Skills and competencies for the development of the activity	• Master's Degree in: Architecture, Urban and Regional Planning, Energy and Nuclear Engineering, or Digital Skills for Sustainable Societal Transitions • Experience in renewable energy technologies and urban buildings energy modeling (UBEM) • Mastery in the use of Rhino, Grasshopper, EnergyPlus, ENVI-met, QGIS or ArcGIS.