Proposta di tesi: Sviluppo di un sistema di gestione e controllo per l'efficienza energetica e la vivibilità degli edifici domestici

Title	**Development of a Data Driven Control system for energy and liveability efficiency in proactive buildings**
Supervisors	Prof. Elio Usai Marco Barbagelata (STAM S.r.l.) Luigi Sechi (STAM S.r.l.) Sevastian Foglia (STAM S.r.l.) Giovanni Nieddu (STAM S.r.l)
Team/Company	**Università** degli studi di Cagliari **STAM** is a fast-growing engineering company that supports its clients in addressing new businesses and technology challenges leveraging on a multidisciplinary expertise and hands-on experience across four main industrial domains: security and transports, space and defence, robotics and industry 4.0, energy sustainability and circular economy. The firm serves a broad range of industries, public and private companies, research organizations, no-profit agencies. A large part of Stam's activities is related to the energy sector and the development of digital automation solution related to it (Optimal Demand Response, Anomaly Detection…). The company has a strong expertise in system control and integration both hardware and software. Moreover, it is used to work in close collaboration with entities and professionals from all over Europe.
Research field	Building Operations, Model Predictive Control, Energy Efficiency
Motivations and general objectives	**Thesis description** The framework for the proposed thesis is part of an ongoing H2020 project called *PRELUDE* - "Advanced proactive optimization service for buildings" - H2020 https://prelude-project.eu/ PRELUDE aims at facilitating the transition to green energy by combining innovative, smart, low-cost solutions into a proactive optimization service. The project is focused on assessing the right level of smartness needed for a residential building and then providing the optimal tools according to the needs of the user (occupant or tenant, owner or manager and energy service provider). It is designed to be versatile and to adapt to the monitoring and automation level of the building and to the engagement level of the tenants, motivating them to invest to increase the smartness of the households. Within the project, STAM is in charge of the development of a building Data Driven Control System. The Control System aims to predict the future response

of the building as a function of future controlled and uncontrolled inputs. The developed control will proactively use monitored data, simulations, and forecasts, to select the best sequence of future manipulated variables, according to specific performance indexes. The best sequence is obtained by solving a numerical optimization problem, that also considers the constraints on input and output variables that have to be satisfied during the operation of the facility.

The control system will be configurable depending on the level of automation of the building.

- If the building has low or no automation, the control will consist in sending suggestions to the users through a mobile application
- If the building is high automated the control system will interface with the installed devices and/or with the facility building manager.

From the beginning of the project, multiple models and modules have been developed; their output will serve as input for the Data Driven Control System which will act on Building Elements to proactively increase its efficiency and livability. The list of the main inputs is reported below:

- Weather data forecast
- Simulation of the building free running trend (24h headed)
- Simulation data of the indoor condition and of the users' comfort (24h headed)
- Estimation of the users' energy behaviors (24h headed)
- Energy consumption and production forecasts (24h headed)
- Predictive maintenance scheduling
- The comfort feedbacks from the users

The goal of this thesis is the development of a comprehensive control system algorithm able to optimize energy efficiency and users' comfort. Because of that, one of the main focuses is on the HVAC system (Heat, Ventilation and Air-Conditioning), but also other systems will be included in the control loop, depending on the demos technology level and their assets. Within the thesis work the preliminary phases will aim at defining the scope of work.

The expected methodology should properly model the assets, services relying on them, the control and the impacts affecting the energy and indoor performance of the building and the users' comfort.

Based on the forecasts in input, the model must reach the pre-defined optimal operation control strategies and to adapt them based on a near-real time closed-loop with the monitoring system and the feedback from the users. The methodology will be then implemented in a computation engine to be developed in Python.

The student will be involved in on-going EU research projects, being developed by international consortia of top-level organizations in the field of energy efficiency and proactive automation of buildings.

	Required skills 1. Interest in energy efficiency and IT automation systems topics 2. Minimum knowledge of HVAC systems and efficient energy management in residential buildings 3. Advance English level **Additional skills** 4. Knowledge of IT systems and current issues related to Model Predictive Control 5. Python coding **Proposed work plan and expected results** The following blocks of activities will define the expected results. Each block is supposed to deliver a complete a thesis. Ideally, the entire work should be carried out by two students paired. Block 1 1. Analysis of the main energy efficiency strategies for various type of residential buildings 2. Analysis of the comfort impacts related to Demand Response strategies 3. Development of the devices control strategy. The methodology should consider multiple scenarios of lack of input data. Block 2 4. Definition of a methodology to perform buildings energy optimization at different aggregation levels 5. Implementation of the defined methodology into a computation engine developed in Python 6. Tests in controlled environment
Place of activity	Open Campus, Località Sa Illetta Strada Statale 195 Sulcitana 09123 Cagliari (CA) - (In case of restrictions due to Covid-19, the students will work remotely) UNIVERSITY: Università degli studi di Cagliari – Dipartimento di Elettrica Elettronica (DIEE)
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