# A web application for automated building energy analyses and monitoring using semantic web technologies*


## Extended Abstract

Improving the energy efficiency of buildings is crucial for achieving carbon neutrality. According to the German Environmental Agency[1], approximately 35% of the total energy consumption is attributed to residential and commercial buildings, with the majority used for maintaining a comfortable indoor climate through Heating, Ventilation and Air Conditioning (HVAC) systems. To improve the energy efficiency during the operational stage, Building Management Systems (BMSs) are implemented to monitor, analyze, and control the HVAC systems. However, the existing BMSs use dominantly vendor-specific software, and often lack flexibility to integrate new smart services, such as Model Predictive Control (MPC)[2], because these new features require a lot of data from different disciplines with good quality.

Against that background, this study develops a web application that supports the data preparation for control-oriented modeling and visualizes the pre-processed energy data in an automated manner, using Semantic Web technologies (SWTs)[3]. The web application allows exporting a BIM model directly from Autodesk Revit into a semantic graph, which describes building information about, including geometry, HVAC systems and sensors using openly available ontologies. The Python-based backend application can query the semantic graph stored in the graph database (Ontotext GraphDB) and fetch the corresponding historical measurements from a time-series database (InfluxDB). Then, it can pre-process the time-series data and run energy analyses.

More specifically, we use the metadata together with the measurements to automatically calculate the convective heat transfer from the ventilation system (a variable air volume system) and the heating system (a radiator heating system) for an individual room, as well as the energy efficiency of the heat recovery device and the fans located at the central air handling unit (AHU). This data is required to train the model-oriented control in an MPC algorithm. Next, the energy analyses are written back into the time-series database and the metadata about the analyses is updated into the semantic graph, which is ready to be used for model training.

Moreover, we utilize the metadata and Grafana API[1] to automatically generate the dashboards for visualizing energy analyses as well as the historic measurements. Eventually, a web-based frontend is built with IFC.js[2] to visualize the 3D representation of the building and call the Grafana dashboards, which enables a more intuitive interaction by the user with the building and the energy analyses. The implementation of the web application is demonstrated with a use case of a three-story office building in Germany, and the analyses for its operation during the wintertime of year 2023 was performed successfully. Dashboards for six rooms, 23 radiators and one AHU have been generated.

As such, this study provides some insights on how SWT can contribute to the energy analyses and monitoring, as well as future-proof services such as MPC.


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[1] https://grafana.com/docs/grafana/latest/developers/http_api/
[2] https://github.com/ThatOpen/web-ifc-viewer