Energy solution: BEE

Piloting in: Helsinki & Stavanger

Introduction

The BEE solution not only controls the building in an optimal way and helps to save emissions, but also uses buildings as a storage capability in the energy grid by using energy in times with a high availability of renewables. The BEE System integrates into the buildings management system (BMS), where it gathers data about the energy consumption, as well as indoor air quality data. The central data storage combines this data with third party data sources.

Every day, the system derives a forecast for the next day's energy grid mix, weather conditions and the buildings utilization and capability to use energy flexible. Based on that the system calculates an optimized control schedule for heating, ventilation, cooling, water heating, EV charging and other flexible appliances. The schedule shifts energy usage towards renewables and minimizes the energy usage through a pro-active control, while maintaining a comfortable environment for the buildings users.

The challenge

While each year more renewable energy is being generated, our consumption is not aligned with the fluctuation in the production - putting a lot of stress on our energy grids. At the same time, Most of today's buildings are dumb – they do not know how the weather is going to be tomorrow or which rooms will be occupied. Controlled by fixed routines they waste a lot of energy for heating, cooling and lighting. By connecting buidlings with their environment and the energy grid BEE offers an innovative solution, that not only saves energy and emissions, but also makes buildings available as a storing capacity for renewable energy.

The solution

BEE – Building Energy Efficiency is an AI-based building sensing and control system. It uses multiple machine learning models to forecast the utilization of the building a day ahead and based on these forecasts CO2 emissions are reduced in two different ways: first by shifting the energy usage of the building to times, when more renewable energy is available in the grid, second by optimizing the overall energy usage of the building through a pro-active control. The system derives an optimized schedule for the control of heating, ventilation and air control, water heating and, if applicable, EV-charging for the next 24 hours and adapts this plan in real-time to the actual conditions during the day.

One of the main challenges for smart building solutions is the integration into different buildings and building management systems (BMS). To tackle this, BEE uses Platform of Trust – an integration layer with a standardized interface for various BMS and the capabilities to harmonize data, manage permissions and data ownership management. The setup of BEE into a building is done in two steps – sensing and controlling. After connecting the BMS via Platform of Trust, BEE will gather data from the building and external sources and display it on a dashboard.

One of the core-features of BEE to save CO2 emissions is the capability of shifting energy usage to times with a high availability of renewables. This feature is especially important, because the expansion of renewable energy is increasing worldwide, with many countries already using more than 50% renewables. Since energy production of renewables depends on the weather and can't be controlled, it becomes more and more important to use energy flexibly and to use more energy when more is available. To shift energy usage, BEE forecasts the amount of renewable energy in the country or city

grid for the next 24 hours. It does this by using publicly available energy data about the energy grid mix and calculating a carbon emission factor for the energy mix.

At the same time, BEE needs to derive an energy flexibility forecast for the building, that provides information about the buildings' energy demand, as well as the capabilities and timeslots to use energy flexibly. Therefore, it forecasts the buildings occupancy, available EV charging times and energy demands a day ahead. In the next step, the control optimization will align the controls of the building with the energy grid forecast and schedule flexible tasks into timeslots with more renewables available.

The second approach for saving CO2-emissions is a pro-active control approach. BEE uses the weather forecast, as well as the buildings utilization forecast to adapt the heating and ventilation control in the building and minimize energy usage. The overall goal for the system is to provide the buildings users a comfortable environment. Therefore, the optimisation starts with the forecast of the occupancy and ensures that in these times the rooms will have a comfortable temperature, humidity, and carbon content. In times with no occupancy, the system will reduce heating or cooling to save energy. In a second step, BEE also controls the building pro-actively according to outside weather changes. For example, emissions will be saved by reducing heating or cooling earlier, when a temperature change from the outside is predicted.

BEE's AI Engine consist of a utilization forecast, which predicts the behaviour of the energy grid, the weather, and the utilisation of the rooms for the next day, as well as a control optimizer, that calculates a control signal schedule for HVAC, water heating and EV charging based on the forecast. A real-time execution module ensures the derive schedule gets executed and adapted to the current situation in the building. The goal of the AI engine is to ensure the users comfort while reducing the buildings CO2 emissions by shifting the energy usage to renewables and pro-actively controlling the building based on the forecast.

BEE & AI4Cities

Before piloting its solution in Helsinki and Stavanger, the consortium developed a full technical concept, that was implement as a working prototype within a lab environment. The goal was to prove the feasibility of two emission saving aspects: optimising the energy usage and shifting usage to times with high supply of renewables. Therefore, a prototype was implemented in a test lab within the Metropolia UAS, that consists of a room with a ventilation machine and sensors to measure temperature and CO2.

Next, BEE implemented the AI-Engine concept and tested it in the prototype, starting by building a consistent dataset of the building, combined with data from the energy grid, weather and calendrical data. The dataset then was cleaned, outliers were removed and missing values were filled with forward filling. A pipeline was implemented that runs once a day to add new building data to the dataset, while a time-series forecast algorithm was trained on this dataset, deriving a forecast for the next 24h of:

- Energy Grid emission coefficient
- Temperature inside rooms
- Energy usage of building
- CO2 Content inside rooms
- Room Occupancy

This resulted in a state-of-the-art performance of around 80% accuracy. BEE also found that only executing a pre-planned schedule will not be enough for the building control, because it also needs to react to real-time changes in the environment, like a too high CO2 content in a room. Consequently,

they developed a rule-based real-time controller on top of the AI-based controller, that compares the initial plan with the status of the building and reacts accordingly. The rules are based on boundaries set by the user, like a maximum temperature or CO2-level

“AI4Cities has been the perfect opportunity for us to develop new approaches within an innovative environment and always close to a real-world usage”, says Lucas Spreiter, founder of Unetiq; one of the members in the BEE consortium. *"Not only did the partners find each other through the AI4Cities project, but also the continuous exchange with the cities and the access to real data, helped BEE to develop their product in less than a year".*

The consortium

BEE is an acronym for Building Energy Efficiency and is represented by an European consortium consisting of Eeneman Oy, Unetiq GmbH and the Metropolia University of Applied Sciences in Helsinki.

Eeenman Oy is a Finnish smart energy company, that is specialized in the management of controllable loads, as well as data integration and handling. The company has multiple years’ experience in controlling energy consumption in different buildings and assets, measuring, and visualizing indoor conditions and metering energy consumption from electricity and heating usage.

Unetiq GmbH is a German – Dutch software agency, specialized in the development of sustainable Artificial Intelligence and web applications and supporting its clients from first idea to final product. Founded in 2018, Unetiq has already developed more than 30 projects and operates productive apps with thousands of users every day.

The Metropolia University of Applied Sciences is supporting the project with specialists in building construction and operation and in the assessment of emissions. Furthermore, the university provides a test lab, as well as data from its most modern campus, which integrates more than 3000 sensors into a complete digital twin.

- Eeneman (https://eeneman.com/)
- Unetiq (https://www.unetiq.com/)
- Metropolia University of Applied Sciences (https://www.metropolia.fi/en)

Contact: tapio.toivanen@eeneman.com