Plotting a path to reduce the energy performance gap

Improving energy efficiency performance in buildings is a major priority for the European Commission, with a target of achieving 20 percent energy savings by 2020. The EU promotes solutions which reduce energy consumption in the building sector to achieve this, an area which forms the primary research focus for the **MOEEBIUS** project

The MOEEBIUS project is introducing a totally new approach to reducing energy consumption in the building sector, based on modelling the optimization of energy efficiency in buildings for urban sustainability. MOEEBIUS has been developing its work since the latter part of 2015, and the initial results are very promising.

The goal in the project was to elaborate products and services like the Integrated Energy Performance Optimization Framework, an Application for Consumers, or the multi-sensing NOD device that will enable the minimization of the aforementioned 'performance gap' and promote customer confidence in the effectiveness of Energy Performance Contracting (EPC). The project also looked at the ability of ESCOs (Energy Service Companies) to guarantee results and mutually agree with customers on savings targets, thus reducing the business risks that have hindered the growth of the ESCO market, especially at the EU level.

Technically, the system as a whole appears quite complicated. Standing on a white box modelling approach of buildings, systems and distributed energy resources, a diverse range of components have been developed that take advantage of the energy simulation of those models and the real time monitoring of key performance indicators in pilot sites. Those components are combined in different ways, depending on the business scenario, use case and end-users' needs. Selected applications are: Building Energy Performance Simulation tool, Demand Flexibility Engine, Dynamic Assessment Engine, Occupants' User Interface, Predictive Maintenance Advisor, Retrofitting Advisor Tool, Facility Manager & ESCO Management Tool, or Decision Support System.

MOEEBIUS-NOD, a wireless multi-sensor device.

From the data acquisition side, the project has introduced innovations in a multi-sensor wireless device, MOEEBIUS NOD, for indoor monitoring and distributed data acquisition and management middleware.

In the last stage of the project the partners focused on the validation of specific solution components at large-scale pilot sites, located in Portugal, the UK and Serbia, incorporating diverse building typologies, heterogeneous energy systems and spanning diverse climatic conditions. These components started from different Technology Readiness Levels (TRL) and have been developed by a diverse range of project partners, from universities to technological centres and large companies.

As Dr Pablo De Agustin, representing the MOEEBIUS project coordinator, mentions, the potential of these models, algorithms, tools, etc. is impressive. However, there is still work to be done to prove that they can work together. One of the biggest technical difficulties in the project is undoubtedly integrating all the components within the MOEEBIUS framework and adapting its architecture to the needs and constraints of each business scenario and use case.

Living Labs (LL) activities played a crucial role in elaborating solutions tailored to the needs of potential end-users, and were an element which differentiated MOEEBIUS from ostensibly similar EU projects on energy efficiency. This is an environment for experience sharing and exchange towards user-driven open innovation of products and services. The activities carried out within the MOEEBIUS Living Labs were oriented towards widely disseminating the project outcomes, creating opportunities for exploitation and replication of the project results.

Most importantly, the Living Labs served as a channel for gathering feedback from the end-users and interested stakeholders throughout the whole project. This provided a basis to optimize all project developments, so as to directly address the critical needs of end-users, building occupants and relevant stakeholders involved in the operation of the MOEEBIUS optimization framework.

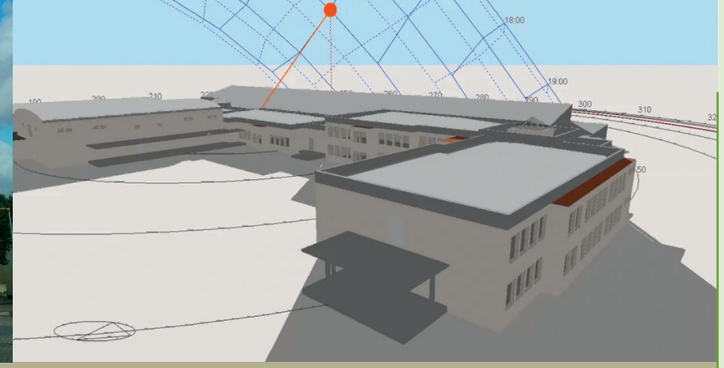
The pilot sites included a diverse range of building types and uses, where the contact people included professionals (ESCOs, Aggregators, Building Managers), with a solid knowledge of energy and technology aspects. Occupants of residential buildings also acted as contact points, as Dr De Agustin explains:

"These interactions with end-users convinced us that, in order to ensure that MOEEBIUS framework answered to stakeholders' needs in each pilot site, the solution had to be flexible and adaptable, and their requirements should be understood."

Indeed, the Living Lab community included both end-users of the pilot sites and external experts from academia and energy business sectors, who provided feedback during the project


Building Energy Model for a residential building in Belgrade, Serbia.


External view of a residential building in Belgrade, Serbia.



External view (left) and Building Energy Model (right) of a primary school and sport hall complex in Mafra, Portugal.

lifetime through questionnaires and workshops. This approach helped project partners in the co-creation process and in adapting the solution to each country and use case.

Moreover, the general reaction of Living Lab participants on the proposed solutions was very positive; "We really appreciate LL members' attitude, both in answering online questionnaires and actively participating in the workshops," dr Pablo De Agustin adds.

"In exchange, our intention was to propose useful solutions to diverse stakeholders in the energy market, from ESCOs and aggregators right through to consumers. Solutions are currently being evaluated in the pilot sites, and we can already confirm that project partners are considering MOEEBIUS framework components as solutions that will help them in their decision making processes and in their day-to-day operations, working towards the goal of achieving energy savings.

These partners include a district heating company in Serbia, an aggregator in the UK, and building managers in Portugal,. On the other hand, consumers are already enjoying an informative consumption and billing mobile app, which is expected to raise awareness of energy efficiency among the general public."

The main challenge faced by the MOEEBIUS project remains the energy performance gap: this is the deviation between the predicted energy performance of buildings and their actual performance. This 'performance gap' is reflected in the inaccuracy of business-as-usual modelling techniques as a method of representing the realistic use and operation of buildings.

A variety of factors are usually simplified through assumptions, not updated or even not included in static/passive models. These factors include the occupant's behaviour, the complexities of the building (i.e. thermal bridges, infiltrations), alterations on building fabric, services, usage and controls during building life time, non-efficient control strategies, loss of performance due to low quality building practices and environmental inaccuracies (i.e. local weather, surrounding modelling). All these multiple and heterogeneous aspects are considered in the holistic MOEEBIUS approach.

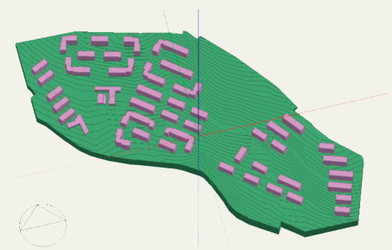
Continuous calibration of the models is necessary in order to adjust the energy model to reality and keep them aligned over time. In this sense, the building energy models have been developed in EnergyPlus open-source software and standardized in order to allow dynamic modification of multiple parameters. A Building Energy Performance Simulation tool has been established in a server to run the models and update them according to inputs from other components, such as occupancy or user behavioural profiles, or weather forecasts.

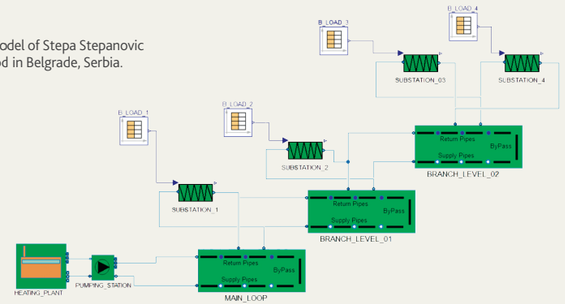
On the other hand, a Dynamic Assessment Engine launches simulation requests, which results in Key Performance Indicators. These are compared with the real data measured at the building, modifying multiple calibration parameters and repeating the simulation requests until, through Bayesian models, the loop converges. An analogous approach has been implemented for the district level energy models, in this case based on Modelica.

The reduction of the 'performance gap' is also a real challenge for ESCO's. As Post–Occupancy Evaluation studies in built and occupied buildings have demonstrated, the measured energy use can be as much as 2.5 times higher than the predicted energy use (more than 70 percent in the retail sector, 100 percent in residential, 150 percent in offices, and over 250 percent in the education sector). So current predictions tend to be unrealistically low whilst actual energy performance is usually unnecessarily high.

In more detail, the 'performance gap' generates a consequent gap between payback estimates and techno-commercial Return-On-Investment calculations in ESCO projects which still use previous energy audits based on simplistic and inaccurate calculations. Due to this, ESCOs are not able to provide customers with appropriate simulations on acceptable paybacks of 2-5 years using low-cost interventions.

This constitutes a significant barrier to the development of the ESCO market, believes Ander Romero, coordinator of the MOEEBIUS project; "ESCOs are forced to add installations and commissioning services, project management, man hours, measurement and verification costs to hedge risk induced by prediction uncertainty and inaccuracy." It makes many contracts totally unattractive, including in cases where the ESCO takes responsibility for the full implementation of a refurbishment project (from auditing to design and implementation). This introduces extra risks for ESCOs and significantly reduces their profit margins.





District Energy Model of Stepa Stepanovic neighbourhood in Belgrade, Serbia.

Hence, through significantly reducing the 'performance gap', the holistic approach introduced in MOEEBIUS enhances the ability of ESCOs to guarantee attractive energy savings. "This will, in turn, eliminate the need for the addition of risk-hedging costs on-top of pure energy services, consequently increasing the payback attractiveness of energy performance contracts and reinforcing the confidence of customers regarding EPC effectiveness. This is crucial for the growth of the ESCO market, especially on the EU level," says Ander Romero.

It's obviously possible to indicate potential beneficiaries of the new solution. ESCO's and DSM (Demand Side Management) Aggregators have been identified as main system stakeholders and as core business entities in the project. But occupants of buildings have their interest, too. According to assumptions of different innovative business models elaborated within the framework of MOEEBIUS, there are four innovative approaches tailored to the needs of the novel system users. In the business model suggesting a new energy management based on enhanced Energy Performance Contracts, owners of specific buildings (public or commercial) could benefit from energy savings of up to 50 percent per side, which could be boosted by the incorporation of contextual and operational building parameters on optimization process.

Another efficiency business model for ESCO assumes that revenue per service will be offered by the ESCO to building managers (so that savings are shared). Along with the third proposed business model, raising occupants' awareness is proposed as a tool for generating energy savings. Eventually, the valorisation of buildings through energy certification would serve as a revenue source for all system stakeholders.

In conclusion, MOEEBIUS enables the development of different business models in two areas - ESCO and demand response. The project offers the possibility of providing users with fast, clear, easy, and always available insights into their own consumption and the cost of the energy used for heating. It enables users to learn, train, and make progress in their behaviour and demand response. It also enables remote monitoring of conditions in the apartment and control of the heating system. It enables ESCO firms, at the same time, to calculate more accurately the savings achieved by raising awareness and educating users about ways to save energy, which reduces the risk of poor EPC contracts and enables development in this area. So MOEEBIUS creates a win-win situation for all the stakeholders involved.

Interactions with end-users convinced us that, in order to ensure that **MOEEBIUS framework** answered to stakeholders' needs in each pilot site, the solution had to be **flexible and adaptable**, and their requirements should be **understood**

After nearly four years of international collaboration, the MOEEBIUS project will soon conclude its activities. The culmination will be the project's final conference on 28th of February 2019 in Wels, Austria, in the framework of World Sustainable Energy Days, which brings together more than 650 delegates from over 50 countries from business, the research community and the public sector.

This international event is one of the largest annual conferences on sustainable energy in Europe. Every year it features policies, technologies, innovation and market development through a unique combination of conferences and interactive events.

We encourage you to follow the Moeebius project website www.moeebius.eu to keep up-to-date with the project's achievements and the details of the final Moeebius event.

MOEEBIUS

Modelling Optimization of Energy Efficiency in Buildings for Urban Sustainability

Project Objectives

MOEEBIUS introduces a Holistic Energy Performance Optimization Framework that delivers innovative tools which deeply grasp and describe real-life building operation complexities in accurate simulation predictions. The system reduce „performance gap" and enhance optimization of building energy performance.

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Project Partners

• http://www.moeebius.eu/partners

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Dr Pablo De Agustin is an energy efficiency researcher at TECNALIA, he has worked on energy efficiency in buildings and renewable energies' integration since 2011. His professional background includes simulation and experimental works focused on energy efficiency, electric and thermal metering, buildings as energy storage systems, and trigeneration and self-consumption solar heating and cooling systems.

Agnieszka Kowalska holds the roles of International Cooperation Department Director and Senior Project Manager within ASM. She has been involved in over 25 international research projects. Expert in market research, socio-economic analysis, perception of innovative solutions by end users as well as business models and exploitation plans development.

Ander Romero is a Project Manager in the Sustainable Construction Division of TECNALIA. He joined TECNALIA in 2007 as a senior researcher in the field of energy efficiency in building design and retrofitting, focusing on energy modelling and the integration of innovative and sustainable solutions to optimize urban and building energy performance.

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