Newsletter

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Welcome to the fourth issue of the **HESMOS-Project Newsletter**. HESMOS is a so called STREP-Project funded by the EU under the 7th framework Programme. During the runtime of the project several newsletters are published. For further information and downloads please visit our website. There you can also register if you want to receive this newsletter automatically. **In this issue**, HESMOS presents developed methods and software related to the **operational phase of the building lifecycle and to facility management**. In each issue, some of the consortium partners are also introduced. This newsletter presents the partners who focus on measured data from already realized buildings.

HESMOS – PROJECT OBJECTIVES

HESMOS - **H**olistic **E**nergy Efficiency **S**imulation and Life Cycle **M**anagement Of Public Use Facilitie**S**. The overall objective of HESMOS is to develop an **Integrated Virtual Energy Laboratory** (IVEL) which allows decision makers to design and compare several energy and life cycle cost optimised alternatives as well as to optimize the operation of Public Private Partnership Projects (PPP). To achieve this objective **HESMOS IVEL** enhances existing Computer-Aided Design (CAD) and Facility Management (FM) tools with information from energy simulation and cost calculation as well as up-to-date data from the Building Automation Systems (BAS). To evaluate the functionality of the HESMOS IVEL, an extensive 30-month validation program will be **realized at two PPP projects**.

HESMOS – PARTNERS

IN THIS ISSUE

USE CASE DESCRIPTION

The three principal **use case scenarios** addressed by the HESMOS platform are: (1) design and tendering, (2) commissioning and operation, and (3) retrofitting and refurbishment. Subject of this newsletter is the Use Case 2 with focus on the operational phase. The presented results are part of work packages 4, 6 and 9 of the HESMOS project.

During the **commissioning & operation phase** sensor data from **Building Automation Systems** (BAS) are evaluated and analysed. The sensor data is recorded, visualised and analysed to detect indoor conditions, identify possible areas of improvement for Heating, Ventilation and Air-Conditioning (HVAC) systems and report changes in user behaviour. This information is the basis for optimizing the operating strategy of existing PPP projects and for improving the design and operating concept of future projects, especially with regard to energy consumption, emissions, and lifecycle costs.

Architectural building models and models of BAS are nowadays created by different companies with incompatible software. Typically, architects are not interested in details of the building automation systems. The latter are designed when the main work of the architects is already finished and the building starts to be constructed. In HESMOS things change since not only the design phase is of interest but also the **operation phase** as well as **refurbishments**. The proposals for refurbishments can be based on **comparisons** between the energy efficiency of **different solutions**. The energy efficiency of these solutions is found by simulations. However, simulation models are not very exact when there is no reliable validation of the simulation parameters. Hence, one main goal of HESMOS was to compare the simulated energy consumption of a building to the data monitored in operation. This facilitates decision making and allows improving the simulation models and making simulation-based analyses of possible refurbishments more accurate. Additionally, possible commissioning mistakes and device failures can be detected. The basis for comparing simulations with measured data is in the efficient access and evaluation to the measured data. On the HESMOS platform, this is achieved by a commonly applicable **web service**.

BUILDING AUTOMATION SYSTEMS WEB SERVICE

There are many different kinds of building automation systems, e. g. LON, BACnet and KNX. To make end users' work independent of their differences, it is necessary to create a common view on all technologies. In HESMOS, we developed a technology-independent web service which is (1) capable to support the access to all common types of building automation systems, and (2) provides the possibility to integrate new types of building automation systems in the IVEL.

A second motivation for creating the web service in that manner is that architects and energy evaluators are often not familiar with BAS and their ICT-oriented structure. Thus, end users should only select rooms and physical quantities like “room temperature” or “room air quality” which they want to evaluate. The web service allows selecting automatically the appropriate BAS devices and measurement point IDs which deliver the desired values.

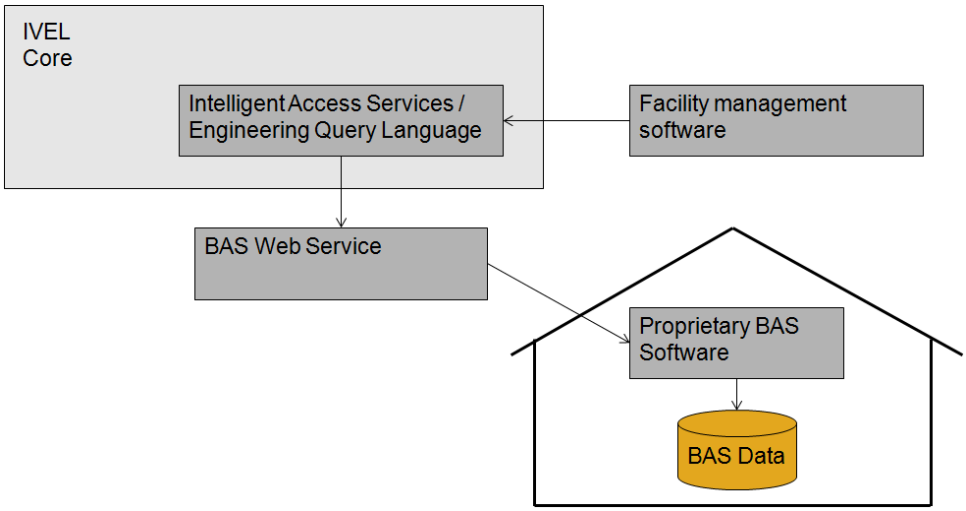

Figure 1: Principal concept of the BAS integration into the HESMOS IVEL

BUILDING AUTOMATION SYSTEMS ONTOLOGY

The wide variety of supported BAS technologies by the described web service is realized with the help of an **ontology** which describes both the structure of a given building and its BAS, and the semantics of different BAS technologies and device types. The developed ontology is suited for **all common building automation systems** and also for comparable **future developments**. To achieve that, it comprises an abstract part as well as a mapping to several common BAS technologies.

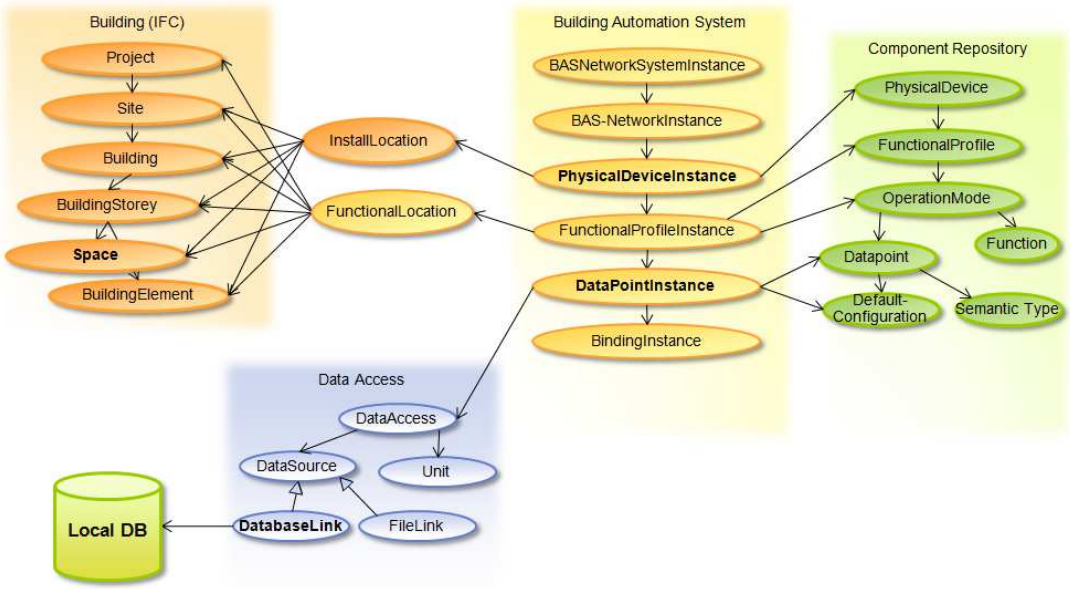

Figure 2: Simplified structure of the BAS ontology

FACILITY MANAGEMENT SOFTWARE

The integration and efficient use of the Building Automation Systems information with facilities management tools was one of the main objectives of the HESMOS project. For this purpose we have developed two web-based applications for two different use case scenarios for new and existing buildings. The first tool, WebRoomEx, supports the requirements management of energy related thermal conditions suitable for tenants, end-users and facilities managers. The second tool, Granlund Manager Metrix, supports the monitoring of energy-related system performance suitable for building owners, facility managers and operation managers.

WebRoomEx

WebRoomex is a tool developed for requirements management of thermal conditions throughout the whole facility lifecycle. It is the upgrade web version of the desktop application RoomEx of partner Granlund. The web based solution gives the user an easy way of monitoring and controlling thermal conditions of the building from any location with internet access. WebRoomEX web services can import IFC 2x3 files created in the design phase and updated during construction to be used in the operations phase. WebRoomEX interface visualises the building in a 2D floor plan view, the preferred view by facility managers, enabling easy and focused examination of various issues related to thermal conditions of the building. The interface consists of three main functionalities as described below.

Spaces

The space functionality contains the target and simulated values for cooling, heating and supply air flow rate for each space of the building. In addition, measured values icons provide real-time sensor data related to minimum and maximum temperatures, minimum and maximum CO_2 concentrations and minimum and maximum humidity percentage. The values are represented in different colours for easy visualization.

Space Groups

The space group functionality contains the technical system service areas such as heating, ventilation and air conditioning. The spaces classification is colour coded and contains information such as room code, name, area and volume. A further function offer air conditioning space groups that contain information about the service areas for the air handling units (AHUs). These space groups are classified by zones that define the spaces, area and volume for air conditioning units. The colour coded visualization of the different zones is critical for facilities managers to know what spaces belong to which zones for maintenance purposes.

Comparisons

The comparison functionality is the most important one in WebRoomEX. It allows the user to compare and visualize the differences of simulated and measured values against predetermined target values. The simulated values are retrieved from energy simulation software such as Granlund's RIUSKA. The target value setting strategy starts in the design phase, and it is validated and monitored in the operational phase. Target values represent good performance of the building conditions and can be determined through user experience or by building codes. The comparison feature shows e.g. a colour differentiation for the spaces that exceed a 5% difference with the target values as illustrated in Figure 3 below. This option allows the facility manager or end user to rapidly focus on the rooms that are not functioning according to the target temperature values. The comparison with actual measured values achieved by the web service connection to the building automation systems allows taking immediate action to solve a maintenance issue. The described functionalities support green lease initiatives that encourage owners, tenants and occupants engagement in the building performance by providing real time reporting of performance metrics such as heating and cooling temperatures.

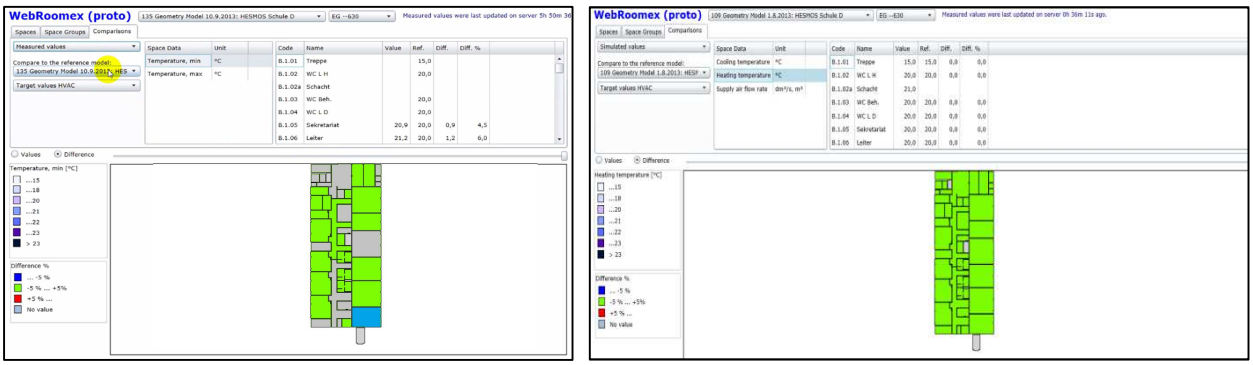

Figure 3: Application of comparisons functionality in the Pilot Project "Vocational School Building" in Pforzheim

Granlund Manager Metrix

Granlund Manager Metrix supports monitoring of energy related system performance. It focuses on existing buildings that utilize building automation systems. Measured sensor data obtained from BAS are transferred into energy related performance management metric. BAS data are transformed into a performance metric by comparing actual measurements with predetermined targets. Such pre-determined performance targets represent good performance of the building and can be derived from building standards/guides or according to the equipment manufacturer's information.

The purpose of energy performance metric is to obtain actual measured data in order to improve the energy performance of heating, ventilation and air conditioning (HVAC) systems. It aims to reduce energy consumption and to improve indoor environmental conditions by continuously tracking and monitoring issues related to HVAC equipment. Contrary to the practice of tracking energy use measures, energy performance metric will concentrate on the *factors that affect energy use* in facilities. Usually, energy savers in buildings are gained by correction of operational and control deficiencies related to HVAC systems such as adjusting set points and changing time schedules or parameter settings. The measured factors are air handling units (AHU) time schedules efficiency and heat recovery efficiency. The energy performance metric is calculated as an average of these two sub-measures.

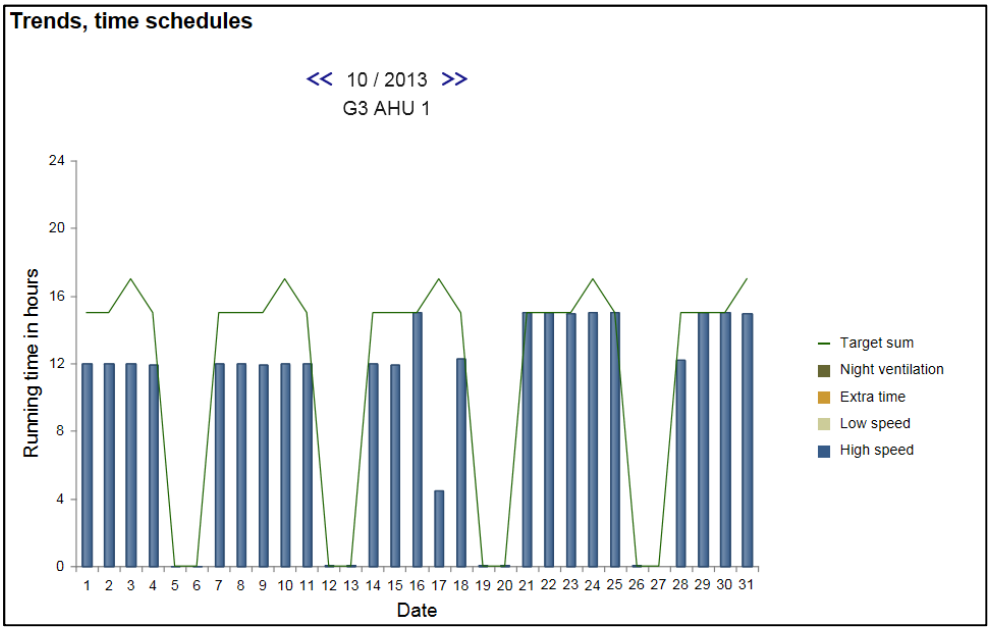

Figure 4: Example of time schedule efficiency in the Pilot Project - Pforzheim Building

BENEFITS OF THE HESMOS IVEL FOR THE FM TEAM

To validate the implementation of the Integrated Virtual Energy Laboratory two pilot projects of BAM Deutschland AG were used, along with selected smaller test cases. Building Information Models were created according to the international modelling standard IFC based on the design and construction documents. The administrative building “Financial Center Kassel” was used to validate the simulation and decision-making capabilities during the design and tendering phase. For the vocational school building “Alfons-Kern-School Pforzheim” a SQL data base was installed to collect the required sensor data and provide it to the HESMOS IVEL by the BAS Web Service – for thermal comfort monitoring with WebRoomEX, and for system performance monitoring with Granlund Manager Metrix. During the validation phase on the pilot projects experience was gained and conclusions were drawn showing how and to what extent the developed components of the HESMOS IVEL, together with their respective functionalities, contribute to the optimisation of the working processes regarding time and quality, as well as the optimisation of the building itself with respect to environmental quality, comfort level and costs.

Benefits: process optimisation

The current working processes were analysed, gaps in current practise were identified and use case scenarios of the integrated processes as well as the required data exchange over the whole building life cycle were defined using the Information Delivery Manual Methodology (IDM). For documentation of building process optimization potential the conventional processes performed on the pilot projects were compared to the standardised processes supported by the HESMOS IVEL and time savings as well as a development in the maturity level according to the Interactive Capability Maturity Matrix (I-CMM) of the US National Building Information Modeling Standard (NBIMS) were identified by the experts and summarized for facilities management purposes.

Time

An energy-enhanced Building Information Model (eeBIM) created during the design phase and updated during construction and commissioning, provides a consistent resource of valuable data that can be used by the FM team for monitoring and simulation of optimisation measures to improve the efficiency of building operation. The facilities managers have remote access to sensor data by web services visualised in the model or as performance metrics. This saves about 15% through the reduction in travel and presence on site, enabling comparison at any time and from anywhere via the web as well as reduced efforts for the energy management processes. In particular, the use of WebROOMEX for thermal comfort analyses strongly reduces the required time for the validation process because requirements per room and the associated measurements are available on the shared database and visualised in colour coded floor plans. This avoids the time consuming process of manually checking if each room meets the requirements. The system performance metric and easy to read time series plots within Granlund Manager Metrix support the FM team to quickly detect inefficiencies of heat recovery and time schedules, and reduce time and efforts for the analysis of ventilation systems. If inefficiencies are identified, the energy manager can save 20% of his time for the decision of improvement measures due to the intuitive access to relevant up-to-date eeBIM data.

Quality

The transparent, consistent and standardised HESMOS eeBIM approach leads to a development in the maturity levels in the categories data richness, life cycle views, roles and disciplines, business processes, timelines/responses, delivery method, graphical information, spatial capability, information accuracy as well as interoperability (hence in the NBIMS standard, the highest “platinum” level can be achieved). For example, an increase in the data richness was reported after implementing the HESMOS IVEL because up-to-date consistent data is always available for monitoring as well as verifying optimization measures by BIM-based energy simulations. Because of the standardized life cycle views and business processes, data is available when it is needed, risks can be mitigated and with this the process quality can be increased.

Real-time sensor data and the capability to locate deviations in the BIM increase the maturity level in

the category timeline and responses because the FM team can react immediately when inefficiencies of system performance or deviations from required thermal comfort conditions occur. This allows making decisions on accurate real time data. Instead of a tedious technical analysis on the BAS interface, which contains isolated information, the sensor data is integrated in the FM module of the HESMOS IVEL and visualised in easy to track performance metrics and colour coded floor plans from the model. The information accuracy is increased because of the data richness of the model, the continuous updated data as well as the access to real time sensor data. The needed interoperability is provided by using the IFC exchange format.

Benefits: optimisation of the building

For the operation phase indicators which have the most impact on energy savings had been identified to be among others the running hours of ventilation equipment, the heat recovery of ventilation equipment as well as the adjustment of temperature settings (heating and ventilation). These indicators can be monitored in the FM module of the HESMOS IVEL. However, performing energy saving optimisations should never affect thermal comfort of the tenants which can also be proven in the FM module of the HESMOS IVEL. To document the quality of the building during the operational phase and to reliably determine actual savings for final energy, costs and greenhouse gases a Measurement & Verification plan according to the International Performance and Verification Protocol (IPMVP) was set up.

Quality

Granlund Manager Metrix was used in the pilot school building to monitor the system performance of ventilation equipment and to identify inefficiencies of heat recovery and operating time schedules. Once inefficiencies are identified, the FM team develops optimisation measures such as improving the schedules of ventilation systems or heat recovery efficiency by adjusting building controls or exchanging the heat recovery unit. The influencing factors - measurement boundary, key parameters, operating cycle, baseline data and expected performance - as well as the energy saving potential identified by a BIM-based RIUSKA simulation when improving the heat recovery were documented in the M&V plan. In addition, measurements for meeting thermal comfort conditions were continuously performed for every room in the building. For monitoring of thermal comfort with WebRoomEX the as-built model was prepared with the min. / max. temperatures, the air flow requirements as well as the internal loads, and sensor data from the database of the building was provided via web access. The optimisation of thermal comfort was documented during the pilot project by conducting RIUSKA simulations with actual operational data and verified in the colour-coded floor plans from the model. In the case of the pilot project, optimization potential was identified and localized in a laboratory room and as optimization measure a 50 mm additional inside fibre glass insulation of the elevator shaft and a double leaf steel door was analysed and implemented.

Costs

By implementing the HESMOS IVEL, operating costs could be reduced because the FM tools WebRoomEX and Granlund Manager Metrix support the FM team to complete its tasks more efficiently. Risks of thermal comfort deviations are minimised by monitoring with WebRoomEX and as a result penalties from the client can be avoided. By implementing Granlund Manager Metrix, system performance can be optimized and verified by BIM-based energy simulations. In this way, the best alternative can be chosen and energy costs can be significantly reduced.

Costs: implementation of the HESMOS IVEL

Because of more efficient processes and improved environmental and indoor quality of buildings, the costs for implementation of the HESMOS IVEL platform, i.e. software, hardware and training costs, will be redeemed quite quickly.

PARTNER PROFILES IN THIS NEWSLETTER: Granlund and TUD-TIS

GRANLUND Oy - Industry

Granlund Oy, located in Helsinki Finland is part of Granlund Group, Finland's leading building services consulting firm employing over 500 professionals in building mechanical, electrical and plumbing engineering and technology, real estate, and software development, with core expertise in energy efficiency. Granlund's core businesses are building services design, facility management consulting, and the development and sale of design and facility management software. Granlund's software development is based on integrated Building Information Models (BIMs) and open data standards. The company was established in 1960.

TECHNISCHE UNIVERSITÄT DRESDEN – Research

Technische Universität Dresden (TUD) is one of the oldest and largest technical universities in Germany. Member of the group of the nine leading Technical Universities in Germany ("T9 Board"), TUD is a full-scale university with 14 faculties, 36,000 students, over 4,500 employees and about 600 professors. It is represented in HESMOS by three institutes, namely the **Institute of Construction Informatics** (CIB), the **Institute for Building Climatology** (IBK) and the **Chair for Technical Information Systems** (TIS) of the Institute of Applied Computed Science.

CHAIR FOR TECHNICAL INFORMATION SYSTEMS

The Chair for Technical Information Systems (TIS), presented in this Newsletter, deals with automation systems both in buildings and industry. The chair, led by **Prof. Kabitzsch**, employs more than 30 researchers. TIS is one of five chairs of the Institute for Applied Computer Science. Its main focus regarding buildings is the automated design of building automation systems (BAS). TIS has been developing for more than 5 years a BAS ontology based on the German standard VDI 3813 which allows: (1) Defining user requirements with respect to building automation systems including energy efficiency, (2) Generation of a technology-independent BAS design from the requirements, (3) Automatic creation of several realizing designs using a specially developed optimization approach including multiple optimizing criteria like costs, technology, and network load. Other research topics related to buildings are ambient assisted living and temperature control using energy-efficient level-crossing sampling.

Besides research in building automation systems, TIS focuses on research for automation systems in semiconductor factories, including monitoring, system identification, production optimization, and predictive maintenance. Other research domains are public transport and automotive industries.

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