I. Publishable summary

HESMOS is a European FP7 industry-driven project particularly directed to the demand of PPP and BOT providers for an integrative view of energy efficiency and cost balance over the building life-cycle, bringing together, via integrated tools and a collaboration environment, architects, building services engineers, facility operators, public authorities, tenants and owners.

In the context of the thematic priority programme "ICT for energy-efficient buildings and spaces of public use", HESMOS anticipates that especially public use facilities developed as PPP projects can play a leading role in energy efficiency and sustainability. They provide the advantage that design, construction and operation can be seen as a whole thereby leading to strong industry interest in integrated solutions that would allow energy and costs simulation studies for better and more reliable decision-making than practiced today.

In accordance with that, the **major objectives** of the project are:

- To provide advanced simulation capabilities to decision makers in the whole life-cycle of buildings, taking into account energy savings, investment and life-cycle costs
- To connect CAD, FM and eeTools (energy efficiency tools) in order to enhance building industry actor's ee-competences
- To close the gap between Building Information Modelling (BIM) and Building Automation Systems (BAS) so that decisions can be made economically (energy and cost related) in all life-cycle phases
- To integrate various information resources thereby extending current Building Information Modelling (BIM) to an energy extended multi-model framework (eeBIM)
- To provide a new methodology for energy and emissions saving in BOT and PPP projects of public use facilities using BIM-based methods of working, and evaluate the developed methodology in performed real-life pilot projects.

The **product** of HESMOS will be an integrated ICT design and lifecycle management platform featuring an intelligent Integrated Virtual Laboratory for energy and emission studies of buildings (IVEL), including evaluation of investment, maintenance and reinvestment costs in the decision-making process for the achievement of optimal design, operation and refurbishment/retrofit solutions in line with the zero energy house directive of the European Commission. The envisaged platform will build upon existing software tools for building design, energy analysis, simulation, ICT control systems and cost calculation making them interoperable via a common energy extended information structure and a set of related infrastructure services.

Due to the envisaged flexible approach to energy analysis, simulation and results presentation, **expected users** of the HESMOS platform are architects and building services engineers, construction companies engaged in PPP projects, facility managers and building operators as well as building owners, public authorities and even tenants. In addition, the service-oriented architecture of the IVEL and its core services can be of interest to software vendors in the AEC/FM domain for partial adoption.

The project runs from 01.09.2010 with **duration** of three years. The Consortium features a mix of **six partners from 5 European countries** covering the key areas of research and development relevant to the project goals. They represent 4 types of market segments, namely:

- End-users (Royal BAM Group, The Netherlands and Obermeyer Planen + Beraten, Germany)
- BIM-based software developers (Nemetschek Slovakia and Olof Granlund, Finland)
- A BIM expert (AEC3 Ltd.)
- Academia (TU Dresden, Germany, with the three institutes Construction Informatics, Building Climatology and Technical Information Systems).

Coordinator of the project is the Institute of Construction Informatics of the TU Dresden.

In the **first year of the project** (01.09.2010-31.08.2011), the **focus of the RTD work** has been especially on the following issues:

- Analysis of current PPP processes and development of an envisaged energy optimised TO-BE life-cycle process as baseline for all further HESMOS developments and the creation of a new working methodology for PPP projects
- Specification of lifecycle user scenarios and requirements to the HESMOS IVEL
- Conceptual development of the BIM-based information framework of the HESMOS platform
- Conceptual development of the HESMOS platform architecture
- Conceptual development of the HESMOS nD Navigator for flexible presentation of energy analysis/simulation results to a variety of different involved actors
- Identification of energy relevant Key Performance Indicators (eKPIs) to guide the evaluation of energy analysis/simulation results and subsequent decision-making processes.

Analysis of current PPP processes was performed by the expert end-users in HESMOS in collaboration with energy, ICT and BIM experts. This led to the definition of a targeted TO-BE process, whose major features are schematically shown in Fig. 1 below. These are:

(1) The use of a common data repository on BIM basis that must be sustainable over a period of 30 or more years

(2) The enabled extended use of simulations as well as sensor data from building automation systems not only in the design phase but in various other lifecycle processes, too, via the services of the HESMOS IVEL.

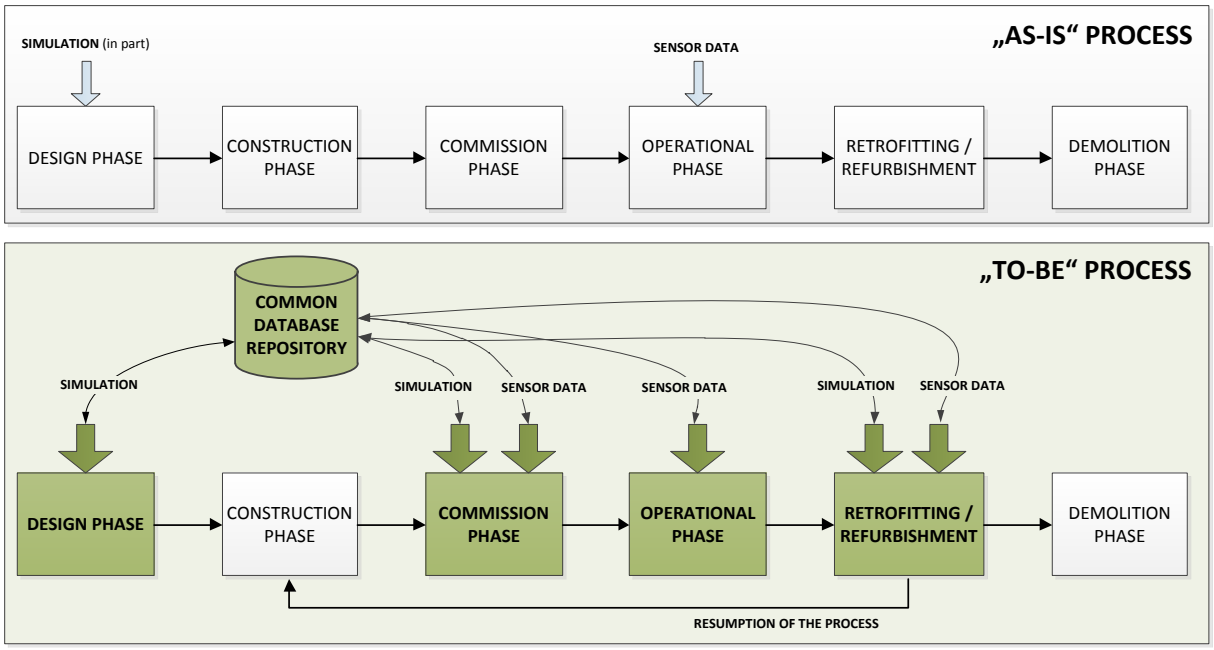

Figure 1: Schematic Comparison of the Current and the Envisaged Business Process in PPP Projects

On the basis of the developed TO-BE Process, four **User Scenarios** were identified and formally elaborated using BPMN. These are: (1) Design, (2) Commissioning, (3) Operation and (4) Retrofitting / Refurbishment. For all these scenarios, information requirements, needed software services, the involved actors and the data exchange between these actors were specified in detail.

Furthermore, HESMOS developed a **methodology for requirements gathering and synthesis** that adapts and extends the IDM approach of BuildingSMART (ISO 29481-1) leading in ordered and straightforward manner not only to the definition of BIM exchange requirements and information needs but also to requirements to the software architecture and the needed services and tools as well

as possible implementation technologies, including such issues as distributed information management and cloud computing. Requirements to the platform have been defined according to various aspects and subdivided into four principal groups: (1) functional, (2) modelling, (3) simulation and (4) operational requirements.

Using these findings the concept of the HESMOS **energy extended BIM-based information framework** has been defined. HESMOS anticipates that neither current standard BIM (IFC 2x3) nor future IFC development can cover all aspects, all systems and all behavioural characteristics of a building and its environment. Hence, whilst BIM provides a basis and a reference schema where all information can be rooted, there are a number of other information resources to be considered in a particular domain. With regard to energy, such resources include climate data, material data and device data from building automation systems as well as user profiles. The HESMOS approach is not to extend the BIM model itself, but to interlink it with such external resources with the help of a dedicated Link Model, based on the concept of the Resource Definition Framework (RDF) of the World Wide Web. This creates a multi-model framework integrated via the developed Link Model and a set of supporting model management services for model filtering, automated link creation and retrieval and model transformations (mappings). The latter are important to create elements of the eeBIM framework that have a different data structure than the input data used. In order to provide an exploitable solution on the short term, HESMOS abstains from definition of an overarching high-level ontology to bridge information spaces, even though – as partial approach – an ontology is developed to connect BIM and BAS.

Fig. 2 below shows a generalised view of the developed distributed eeBIM framework with its major integrating inter-relationships.

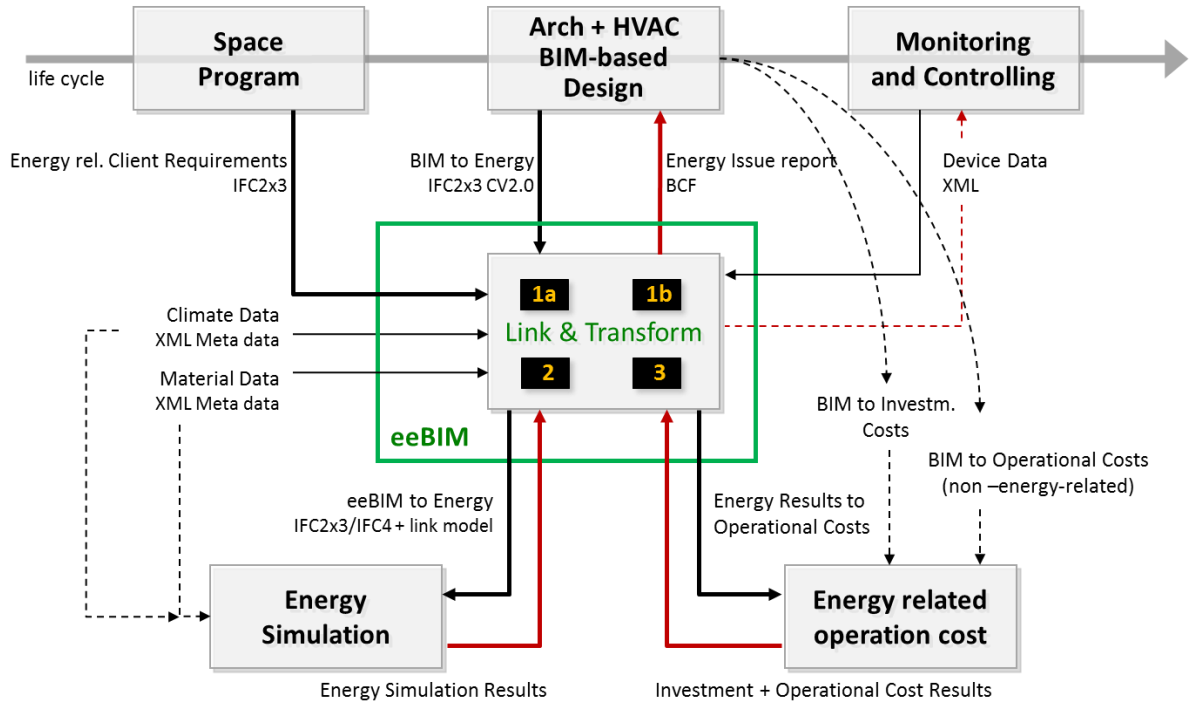

Figure 2: The HESMOS eeBIM framework

The **platform architecture** supporting the developed distributed multi-model framework applies the SOA concept, following a general modular approach. It comprises several types of services and applications, bound together by an *IVEL Core Module* that acts as the middleware providing the required data and functional interoperability. Modularisation of the platform components is consistent with the identified actor roles and respective use cases. Within this modular approach, four types of

software tools are supported, i.e. (1) Local applications, (2) Web applications, (3) Batch applications acting like Web Services, and (4) Pure Web Services. For each type, respective interfaces and plug-ins are conceptualised providing the basis for technical software development in the next phase.

Figure 3 shows a generalised view of the outlined software architecture of the IVEL with its principal component modules, services and applications.

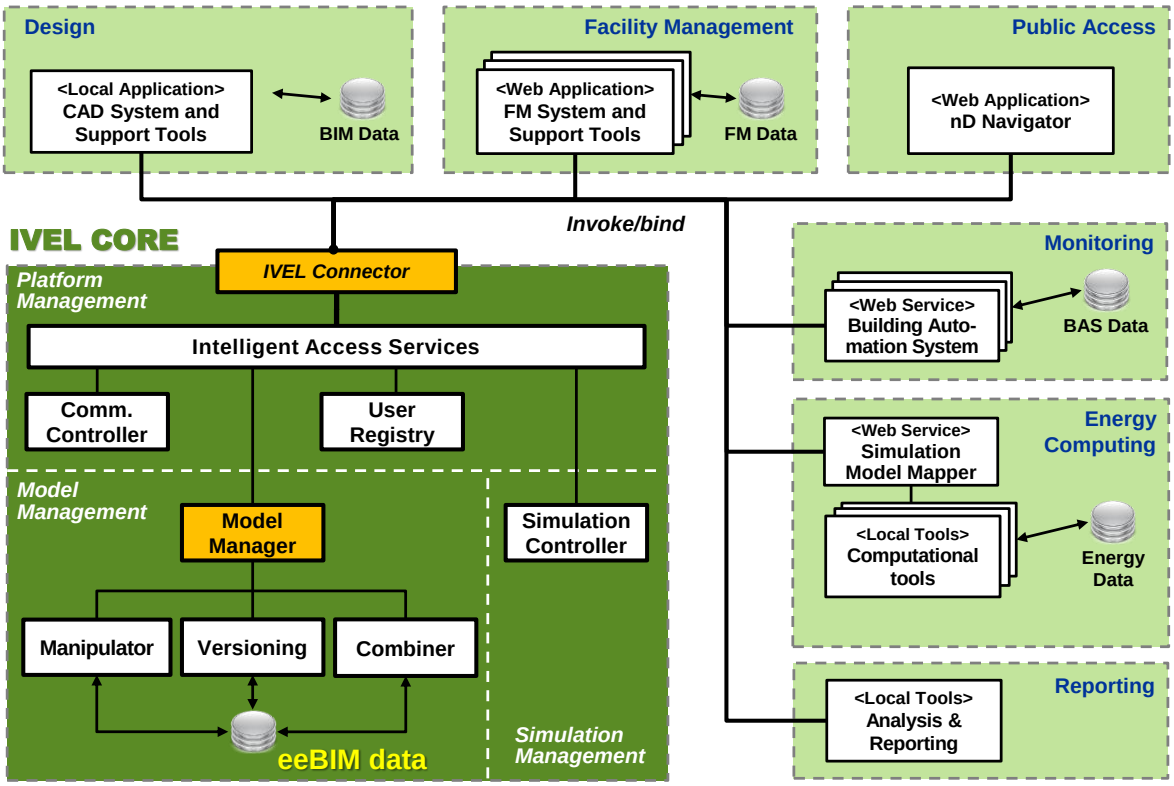

Figure 3: Software architecture of the HESMOS IVEL

However, whilst the IVEL core shall provide the necessary infrastructure to inter-link design and FM tools with advanced energy and costs analysis / simulation tools, it is not sufficient on its own to enable improved, more reliable and more flexible decision-making at all lifecycle phases by the various actors involved in the process. To achieve that, appropriate **presentation** of analysis and simulation results is needed. In HESMOS, an **nD Navigator** providing for easy-to-use, adaptable navigation in the nD information space is being developed for that purpose. It will enable presentation of simulation results not only in detailed engineering representation formats but also in intuitive manner based on perception aspects and criteria for quick preliminary design and/or client evaluation.

In the current period, the overall concepts of the nD Navigator were developed and documented. Three different technologies were tested for its subsequent implementation, and it was decided to use X3DOM technology and IFC2x3 as well as the HESMOS Link Model as data input, in full alignment with the overall HESMOS architecture outlined above.

Last but not least, even with flexible navigation capabilities, **correct interpretation** of the observed results, especially by non-energy specialists such as building operators, clients and owners is needed. For that purpose, a methodology for the development of **energy-related Key Performance Indicators (eKPIs)** has been developed and a set of eKPIs has been identified grouped in three sustainability dimensions: (1) Ecological value, (2) Socio-cultural value, and (3) Economical value.

More results, summaries of all deliverables and a download section containing all public material issued so far can be found on the project's **Web Site**: http://www.hesmos.eu.