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Intelligent Services for Energy-Efficient Design and Life Cycle Simulation

ISES

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Proposal abstract

The objective of ISES is to develop ICT building blocks to integrate, complement and empower existing tools for design and operation management (FM) to a Virtual Energy Lab. This will allow evaluating, simulating and optimizing the energy efficiency of products for built facilities and facility components in variations of real life scenarios before their realization, acknowledging the stochastic life-cycle nature.

The focus of the prototype application domain is on buildings, factories and warehouses because in buildings about 40% of the global energy is used and 30% of CO_2 emissions and solid waste is created. There is a huge market for more energy-efficient design of new buildings and for refurbishing of the huge building stock through energy-efficient component products.

The goal of the project is to increase, by an order of magnitude, the quality of energy-efficiency in design through the development of an In-Silico Energy Simulator Laboratory, based on an interoperable ontology-supported platform. The focus of RTD is on multi-model design and testing, stochastic lifecycle analysis/simulation in combination with new supporting ontology and interoperability tools and services, and respective re-engineering of existing tools, making them more intelligent and smartly interoperable. Further goals are the combination of energy profile models with product development STEP models and building and facility BIM models.

The Virtual Energy Lab will be configured as an ontology-controlled SOA system with distributed services, distributed modelling and analysis/simulation tools and distributed data sources. This will allow concentrating the RTD work on ICT gaps, whereas existing, market-proof services, tools and data sources can be incorporated nearly development-free.

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Section 1: Scientific and/or technical quality, relevant to the topics addressed by the call

1.1 Concept and objectives

ISES will develop ICT building blocks to integrate and complement existing tools for design and operation management into a **Virtual Energy Lab** capable of evaluating, simulating and optimizing the energy efficiency of products and facilities, in particular components for buildings and facilities, before their realization and taking into account their stochastic life-cycle nature. This will offer potential of energy and CO_2 emission saving of more than 30%.

For the energy-efficient design and operation of products the semantic contexts of (a) product developers, (b) architects, civil and building services engineers (AEC), and (c) facilities managers need to be integrated. Only with a holistic approach the value chain will reap the full potential of benefits that today's loosely connected numerical analysis tools, modeller and graphical results representation tools are offering.

Indeed, energy profiles and consumption vary very much over the years of the life-cycle (for built facilities even over several decades), and are typically very random in nature. Therefore, a stochastic consideration is a must.

Firstly, the efficient design of products and their optimal control in operation need several feedback cycles to reach an optimal design and operation control process. Moreover, the new product is often a component in a bigger host product, such as a new or existing building, carrying some functionality, influencing the behaviour of the host product and providing considerable feedback even if the component is not necessarily a control component. A single, optimal design of the component as a market product is not ingenious due to the various contexts (hosts) in which the component product will have to be applied. Therefore variants of the component products have to be developed for the different possible contexts of the host product, which requires several product **design iterations** by the product designer.

Secondly, each variant component has to be complemented with several operation procedures concerning the functional behaviour of the component and the interaction with the functional behaviour of the system of the host product. In addition, these operation procedures have to be tuned for the built-in design and during operation, too. Due to the largely random nature of energy consumption over the life cycle, standard worst case evaluations of life cycle cost not only for the component product but for the interaction with the host systems has to be carried out during the build-in design by the AEC designer. This again requires several **design iterations**.

Thirdly, the stochastic life cycle issues have to be considered too. In practical terms, this means that the stochastic nature of the overall life-cycle has to be approximated by a stochastic discrete process of possible sequences of characteristic energy patterns and profiles. The design solutions sought are the worst cases resulting from the identification of the worst process pattern sequences. This can be achieved by an appropriate **simulation task**, namely the simulation of a large number of combinations of possible energy patterns sequences, with subsequent identification of the worst sequences for the design targets. However, such simulation tasks may require hundreds of individual simulations with target-oriented feedbacks between evaluated and further simulations, which cannot be anymore configured by hand but have to be managed highly automatically, with only general control interaction by the user.

To tackle these challenges and achieve the envisaged energy and CO_2 emission savings, a virtual energy laboratory is needed where the simulations can be configured, calculated and evaluated highly automatically, in order to be time- and cost-efficient and keep user interaction and control on a high level with only minimal interaction demands.

Existing ICT systems for design and operation management are strong in their related core functionality, such as either product modelling or cost calculation or structural or energy or air-flow analyses or facility management and they have domain specific or even proprietary data models. However, they are still weak in holistic energy-efficient design, the integration of multiple design aspects and multi-model analyses including stochastic considerations. Such features are important for energy-efficient investigations requiring concurrent consideration of energy, investment costs, maintenance costs, training costs (for maintenance personnel), various design requirements, quality of life requirements (architectural, structural, wind, earthquake, flood, fire), design appearance etc., as well as the stochasticity in the life cycle.

Analysis of legacy ICT products revealed the following considerable gaps in ICT support of energy-efficient design and operation, which will be the **focus of the developments** of ISES:

- Interoperability between energy analysis tools and product and building design tools
- Interoperability between product design tools (STEP) and building and facility design tools (BIM)
- Energy profiles for facilities and components are not sufficiently generic to be seamlessly integrated in automated design cycles concerning different climatic zones on fine granularity levels
- Energy consumption patterns for building facilities and components are not adequately represented for stochastic treatments and are not generic enough.
- Configurators and evaluators for combination of energy profiles for stochastic life-cycle consideration concerning e.g. expected extreme energy demands or extreme changes in energy consumption are missing.
- For multi-model concurrent engineering design only prototypes are available concerning managing, filtering, navigation and evaluation.
- Intelligent access methods of heterogeneous distributed information, catalogues, services, ICT building blocks and use of computing power in Grid or Cloud environments are still weakly developed and used.
- Flexible and fast inclusion of new product catalogues in product data models is largely missing.
- Intelligent and flexible interoperability methods for model and system interoperability based on ontology methods are not available.

The **objective of ISES** is to use existing ICT tools like CAD modellers, facility management systems (FM), energy simulation, moisture calculation, fluid dynamic analysis and cost calculation tools and Product Model (STEP), Building Information Modelling (BIM) and Building Automation Data Management Systems (BAS), which are all strong in their core business but mostly stand-alone, loosely integrated applications (see Fig. 1), and:

(1) Provide them with a sound interoperability structure on ontology-extended BIM and SOA basis through **development of a new data-model and system ontology** based on description logic with semi-automatic simulation model configuration capabilities;

(2) Complement them with **a set of new supporting services and tools**, enabling – as mentioned above – the simulation and evaluation of the energy life-cycle behaviour of the product, including (a) an energy pattern and use-case combiner, (b) a product-schema extender to formalize new products and their related new functionalities in BIM, (c) a multi-model manager, (d) a multi-model filter (STEP), (e) a multi-model navigator and (f) a multi-model evaluator;

(3) Provide a **new information logistic and intelligent access controller** for the ICT system management (services, tools and data) and for the interfacing to cloud facilities:

(4) **Extend existing data resources** by three currently missing databases, namely stochastically based climatic data scenarios and usage/user activity profiles, both structured and formalized according to the stochastic life-cycle demands, and a database variant manager to manage the alternatives and variations of new product designs and their application in larger systems.

The **targeted application domain** of ISES is buildings and facilities in particular new component products in order to increase the energy and emission efficiency not only of new but in particular of existing buildings and facilities. The reason is that the mean period to rebuild buildings is about 100 years, for office buildings about 50 years and for factories about 20 years, in comparison with the renewing period (refurbishment, retrofitting) of existing building and facilities is about 10 to 20 years. But ISES is not only directed to construction and product development for construction. Almost all of the developed ICT building blocks and the system interoperability and management methods will be generic, so that they can be also used in other domains or at least can serve as templates and best-practice cases.

Functionality of the virtual energy lab

The virtual energy lab should allow engineers and experienced architects to handle better the complex analysis of the energy-efficient design of products and take efficient and informed decisions. This comprises *three, partially conflicting tasks*, namely (1) the consideration of the stochastic nature of the energy performance and consumption profiles of the new product life-cycle, (2) the balanced design of the new products (components), their functionality and behaviour for the various possible life-cycle demands, and (3) the balanced interaction of the product component with the host product, i.e. the context system in which the new product is applied (or built in).

For the design of the new product (component), this means that several characteristic host products have to be analysed, which results in the design of several new variant products. However, for the use of the new product, the best-fitting variants of the product have to be selected and an optimal integration in the host product, i.e. the context system has to be realized. Each of the above three tasks requires several simulations with feedback cycles in order to reach an optimally balanced solution (see Fig. 1). The first task requires a simulation feedback cycle in order to obtain the worst-case scenarios, which are the baseline of the subsequent two design tasks. The latter need design feedback cycles for (a) optimizing the new product to be offered as a general market product, where the client can select out of several variants (task 2), and (b) in an independent later stage for the configuration of the new product in a specific host product, e.g. the design of a facility by an engineer or architect (task 3).

The design feedback cycles occur at different phases of design and production, whereby the first feedback cycle, i.e. the simulation feedback, is needed as sub-cycle in the two other feedback cycles. This means that the number of resulting feedback cycles is multiplicative. This requires not only a lot of computer power, which can be provided through the access to cloud computing facilities, but also a lot of model definition, adaptation and configuration work, which – if done by hand, as it is the case at present – would result in days or weeks of engineering work and therefore is even not imaginable to be carried out today. Hence, simplified designs with only a few model alternatives are currently done. The **breakthrough of the ISES approach** is to highly automate the configuration, management and evaluation of these hundreds of models for the various needed simulations by means of a set of innovative services and tools including navigation and inspection tools for the engineer, allowing him to involve only on high-level decision making tasks.

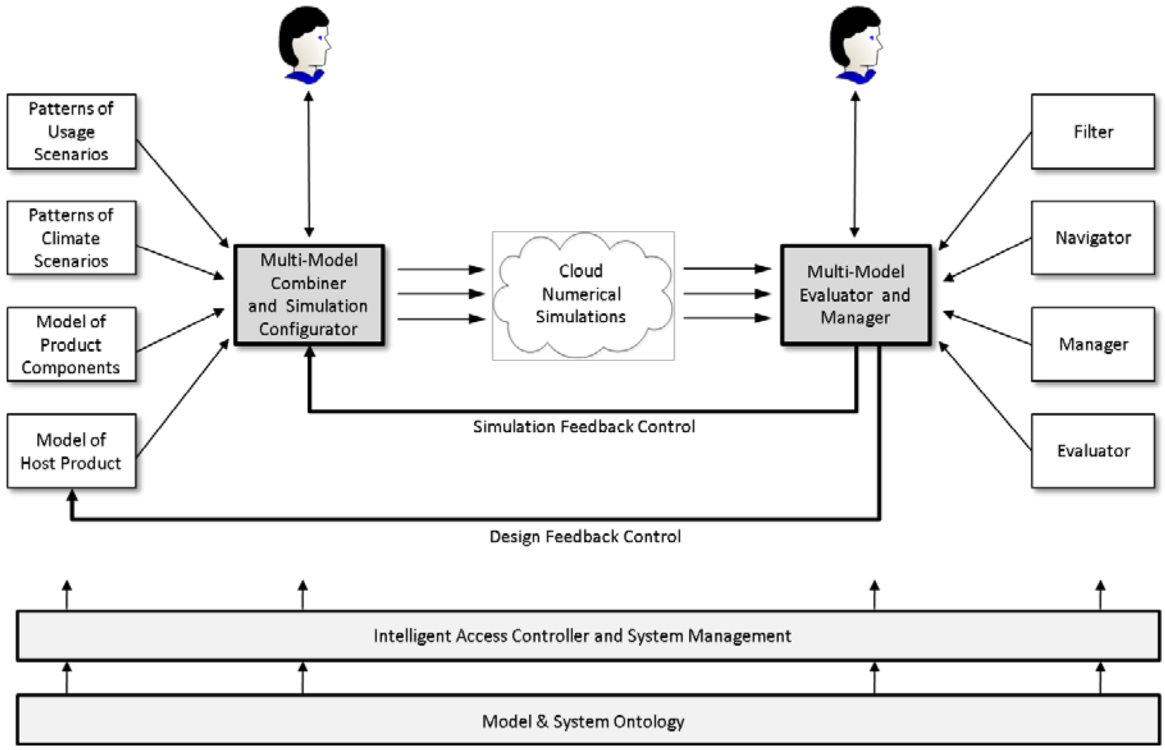

Fig. 1: Functional Architecture of the Virtual Energy Lab

Structuring of the virtual energy lab

The virtual energy lab is roughly structured into **four sequential tiers and two supporting tiers** (see Fig. 1) The process is organized in two feedback cycles, one for handling the stochastic life-cycle nature of climatic and usage conditions and one for the optimization of the design - to lay out the most beneficial variants for the new product and to select, configure and assemble the right variant products in the host product or even re-design the host product partially or as a whole.

The **first tier** (see Fig. 1, from left to right) is the domain modelling and input tier to the virtual energy lab. It comprises tools and databases for (1) the modelling of the new product, including a model schema extender to STEP, (2) the modelling of the host product itself, (3) the modelling of energy profiles and (4) patterns of energy consumption, which are for built facilities the patterns of the climate and usage scenarios. These four domain models have to be combined to one model and have to be configured appropriately to the various approximated stochastic simulation input models. The process has to be automated with the support of the tools of the second tier to provide the necessary efficiency.

This process has to be repeated continuously for each design cycle. Because these are nested cycles, several hundreds of simulations may be necessary to obtain an energy- and emission-efficient design solution. This cannot be carried out on reasonable scale on a single workstation, because one simulation run of a new product integrated in a host product considering (as the current practice) a characteristic time window of about one month with a time step of one hour (an already questionable approximation of the stochasticity for a facility) results in several or even tens of hours (typically nightly run). Therefore in the **third tier**, access tools for cloud computing are allocated to provide the necessary computing power. Also, the configuration of the various simulation models by an engineer would result in tens or more hours of labour, which is not acceptable. Therefore, in the **second tier** the *multi-model combiner* that combines the different domain models to one investigation model is complemented with a *simulation configurator*, which has the task to configure the simulation models automatically according to a few general input directives by the engineer provided via an easy-to-use GUI. The objective is to concurrently configure as many as possible simulation models in order to reduce sequential simulation and hence overall simulation time as much as possible. In order to optimally support such highly automated concurrent analyses also the evaluation of simulations and the feedback directives, at least for the simulation feedback, have to be carried out highly automatically.

Therefore the **fourth tier** is dedicated to new services and tools concerning the evaluation of multi-models, including *prioritisation of the results* and four supporting services, namely *multi-model filter*, *navigator*, *evaluator* and *manager*, providing easy user access with proactive support for requesting and selecting simulations to be compared. This fourth tier is the decision support and output tier. Therefore it features also the second GUI of the virtual lab platform. To avoid as much as possible time-consuming and tedious manual work, comparison and prioritisation of results and the suggestion of new simulation runs should be done by *decision support services* of the virtual energy lab. The end-user’s attention should be focused on decision-making, i.e. only on a few important simulations and aggregated results. Adequate comparison services (filter, navigator) should allow him to navigate easily and efficiently in the multi-model result space and hence support his efficient and informed decision-making.

These four design and simulation workflow support tiers are complemented with two lab system support tiers: one tier is subsuming the services for the intelligent, highly automatic access to databases, catalogues, models and the various services, including the access service to cloud computing. There are also services for the system management, i.e. for the orchestration of the various services.

The second lab system supporting tier contains the generic lab system model represented in a description-logic based ontology. This ontology describes the lab system and its components but it describes also on a high semantic level the various model schemes, their combination possibilities, the automation algorithms and the evaluation and feedback control information. Hence, the virtual energy lab will be embedded in a knowledge system, which will make the platform very flexible and will allow for high-level automation and control as well as decision making on very high and compact level.

System architecture of the virtual lab

The architecture of the virtual energy lab will be built using the SOA paradigm. It will be logically structured in five layers:

1. Numerical layer
2. Service layer
3. Kernel functional layer
4. Kernel Data layer
5. Auxiliary data layer

The new ICT building blocks to be developed are marked by the thick boxes (see Fig. 2). The virtual lab will be based on available commercial modellers and information management systems for design (CAD) and for operation management (FM) and their related standardized data structures for the Building Information Models (BIM), i.e. the product model standards IFC (ISO/PAS 16739) and STEP (ISO 10303), and the Building Automation System Models (BAS), i.e. the industry standards BACnet[1], LON[2] and the newer European standard KNX[3].

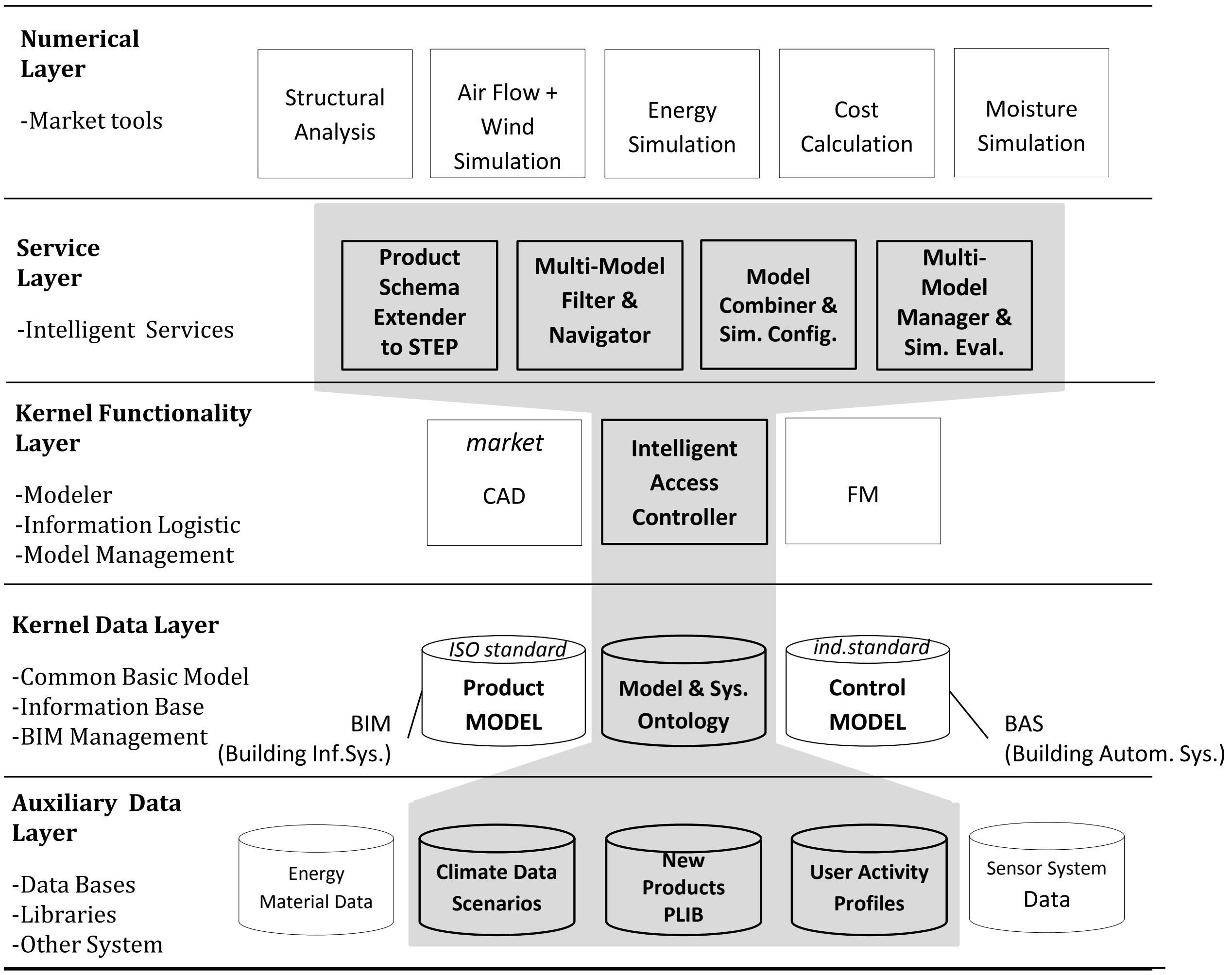

Fig. 2: System Architecture of the Virtual Energy Lab

1 Building Automation and Control Networks

2 Local Operating Network

3 KNX is a standardised (EN 50090, ISO/IEC 14543), OSI-based network communications protocol for intelligent buildings. KNX is the successor to, and convergence of, three previous standards: the European Home Systems Protocol (EHS), BatiBUS, and the European Installation Bus (EIB or Instabus). The KNX standard is administered by the KNX Association.

Today the numerical analysis tools are individually and directly connected with usually one of the two existing functional layer tools, often only with special proprietary interfaces. Model configuration and modification have to be carried out via the GUI of the CAD and FM tools for each particular model individually. Representations of numerical results are mostly done via individual proprietary graphical user interfaces. The analysis work is still tool-oriented and not appropriate for many design simulation feedback cycles. However many simulation and design cycles are important requisites of an optimal design for energy-efficient products and host products (like facilities). To overcome this drawback we will add a high-level model and system ontology to the **kernel data layer**, which describes the model of the product to be designed and the host product and the virtual energy lab system on a high semantic and generic level in order to provide the baseline to automate model configurations and modifications and automate the virtual energy lab processes, i.e. to build high-level orchestrations. In the **kernel functional layer**, the modellers and managers (CAD and FM) are complemented with an intelligent access controller, which (a) provides intelligent access to the various tools, services, data bases and cloud and b) automate the access and the process in the virtual energy lab by predefined flexible and easy-to interact orchestrations.

The numerical tools of the related **numerical tool layer** are all available on the market and can be used without or with minor modifications. As part of the intelligent access tool prototype APTs will be developed to integrate these numerical tools on a high semantic and hence flexible and standardized level. This integration is based on an extension of the ISO standardized BIM complemented with the model ontology represented in a description logic to an OntoBIM.

Energy-efficiency is one of the important objectives of design and operation of products, which was neglected in former times and is getting growing attention. However it is not the only objective. It has to be acknowledged that it is interrelated with usually all other objectives like costs or structural behaviour. The latter is often the leading one and will be most probably as important as the energy demand and CO2 aspect, also in the future. Therefore to provide a realistic optimum design for energy-efficiency a very balanced design for the various design and operation objective is sought and hence has to be supported by the virtual energy lab. This demands a multi-model analysis and a multi-model evaluation. At the moment this is only partly be supported, mainly through proprietary tools. Therefore an explicit **service layer** is introduced, containing new services for multi-model filtering and navigation, multi-model management and evaluation. Further services addresses stochastic treatment of the life-cycle design, which demands the simulation of tens or hundreds of sequences of climatic and usage scenarios. Their combination through a combined service and their evaluation through the evaluator service are already mentioned above.

The kernel data layer is complemented with an **auxiliary data layer**, in which data catalogues are located, such as material data or sensor system data. These catalogues have to be extended by two catalogues containing patterns about climate scenarios and about user/usage scenarios structured according to the needs of the semi-stochastic approach of stochastic sequences of scenario patterns. These catalogues are partially new. Existing catalogues for climate scenarios, which are managed world-wide by the D.O.E, USA, offering characteristic time histories per hour for one year with several climatic parameters. This is almost sufficient for mean and overall min/max behaviour analysis. However, what is missing is the change of climatic conditions, extreme changes during short periods of hours, extreme wind loads (what is very important for northern Europe), clustering and accumulation effects. Accumulation effects are important for complex (mixed) energy systems, which are the design baseline for facilities. Therefore the characteristic one-year approach offered by D.O.E is not sufficient for a lot of facilities.

Treatment of the stochasticity of the life-cycle

The highly non-stationary stochastic process concerning usage and climate is approximated by a stochastic process of partly stationary processes, which can be modelled as a discrete stochastic process where the discrete events are the stationary stochastic process modules. A further approximation can be done, because the stochastic nature in the modules is of minor importance and the design objective is either average values of the life-cycle or extreme values or extreme change values over a short time (e.g. hours) in order to obtain either the overall energy demand and CO_2 emissions or the worst cases of changes in heating and cooling to design the energy providing systems which is usually a mix of several systems and their elasticity. This approximation is the replacement of stationary stochastic modules by characteristic deterministic scenarios, i.e. deterministic patterns. Extreme values and extreme change values are the result of the respective worst-case sequences of the patterns. This means the task of non-stationary stochastic processes can be reduced and approximated by many (about analogous to Monte Carlo simulation) discrete deterministic sequence processes of the sequence of deterministic characteristic patterns[4]. Because the consequences of the patterns on the energetic behaviour of the designed product can be partially accumulative, the sequence of patterns is important and hence the combination of different sequences has to be considered. Therefore, the worst-case sequence can only be decided upon finally on the hands of the energy demand results. This means that for all the possible, at least feasible – if this can be decided – sequences simulation runs have to be carried out, which may easily result in several tens or hundreds.

1.2 Progress beyond the state-of-the-art

1.2.1 ICT Systems and Engineering Tools

An important domain of energy and emission reduction is the phase of the planning of new buildings and facilities or such to be refurbished. Another important domain is the design of new products. Products are often not stand-alone objects but part of a host product, such as buildings or facilities. Therefore the most important domain is the design of new products, concurrently considering their own energy behaviour and their interaction with the host product, both in dedicated design cycles.

ICT systems for the energy and emission design of products are rare and not very comprehensively developed. Only some company-specific proprietary tools exist today. For the integrated design no ICT system is known, in particular not for the construction sector, because many products (almost all technical equipment) for buildings and facilities are designed and produced by others, but not by the construction industry. Therefore there exist no ICT tools, services and data models for product design that represent adequately, efficiently and sufficiently buildings and facilities, and vice versa, such products cannot be adequately represented in construction industry ICT applications. Therefore the important interaction design cycle of product and host product is not possible or only on a very approximate level, including a lot of assumptions. ISES is developing ICT building blocks and related engineering ICT services to provide a platform that goes beyond the state of the art and allows

- integrating design and energy analysis tools for a holistic energy-efficient multi-model design,
- testing products virtually in their envisioned future building and facility environments.

The virtual energy lab is complemented by a semi-stochastic component to adequately represent the stochastic nature for the product and the facility life-cycle, which will replace today’s deterministic consideration of life-cycle analyses using characteristic one year profiles. The semi-stochastic approach will result in considerably better capturing of the life-cycle and hence improved energy-efficient design of products and facilities. Today, stochastic lifecycle considerations in AEC are only common in civil engineering domains, like off-shore platforms, nuclear power plants, large span bridges, hydroelectric power plants and dams or other outstanding structures showing high risk consequences, where the main life-cycle aspect is structural safety.

Energy supply and energy control systems are not only technically very complex, they are also very cost-intensive. The main difficulty is therefore the right balance of energy-efficiency and investment and maintenance costs. Higher investment costs for technical equipment, building cladding, more sophisticated arrangements of energy resources and ICT control systems do not necessarily lead to lower maintenance costs. More sophisticated equipment and control systems, i.e. more complex systems bear a higher risk in good performance and may lead to higher maintenance, service and labour costs and lesser energy efficiency. Therefore, what is needed is a combined life-cycle energy simulation and cost calculation to find the right balance between investment costs, maintenance costs, non-sophisticated and robust technical equipment and low energy demand and CO_2 emission, respecting also the other design objectives. To meet that challenge ISES is developing a multi-model design and virtual testing lab.

[4] Stochastic stationary process means not that the physical process must be stationary too. The exact definition is covered by evolutionary stochastic process theory.

With current BIM-CAD applications an architect in a team of civil engineers is able to plan, design and define all building components and special structures. There are first implementations available where this information is being used to visualize energy validations based on national standards. This is a good first step; however these validations are only based on a static method, which is not more than a rough approximation. The validations are sufficient to meet current legal requirements but they are not appropriate to calculate the real energy performance of a building, and they frequently result in over- or under-dimensioned building service equipment. In both cases, the result is reduced efficiency and increase of costs.

Simulation tools as developed by ISES are needed for one major reason in the design phases – namely to study very early the complex energy system under dynamic life-cycle conditions in order to draw the right (i.e. energy and cost-efficient) design decisions, with preferably lowest system complexity and highest flexibility for component products as well as for whole facilities (for the latter, also considering the retrofitting potential). Today, without precise prediction tools, the risk of wrong decisions is high and hence leads to less innovative design solutions, less energy saving and less emission reduction.

There exist many state-of-the-art software tools for product and for building design, for cost analysis, for energy analysis, for facility management and for lifecycle analysis. Each of them has proven its efficiency and reliability in their particular domain, namely (1) CAD-STEP in product design, (2) CAD in building design, (3) Multizonal Building Energy Solvers (MBES) in energy consumption analysis and simulation, (4) Building Envelop System (BES) solvers in the analysis of heat and moisture transportation, storage and buffering analysis and simulation, (5) civil engineering analysis (structural, wind earthquake, flood, fire) using the Finite Elements Method (FEM), (6) facility management systems (FM) for the management of buildings concerning operation, maintenance and renting, and (7) cost calculation and estimation in the different design construction and operation phases. However, they are mainly stand-alone software tools, they are designed for experts, and they are mostly "closed-world" tools with limited, proprietary data interfaces concerning energy aspects. A basic problem is that a common model and model interoperability methods are missing. Hence, an integrative holistic approach is missing, making data gathering for any study a very tedious manual effort. Accordingly, today's design is only loosely coupled with energy analysis. Energy analysis is done – if at all coupled with design – on very simplified rough basis of classification of the building and its components in terms of "accepted/rejected" according to national codes and regulations requirements (EPBD). Even the layout and design of the HVAC system is based on simplified models lacking extended lifecycle scenarios. Energy analysis is mainly focused on the final design phase. Feasibility design is currently out of scope, i.e. not supported by the available tools. Detailed energy analyses with specialised tools are available but not coupled with design modellers or CFD (computational fluid dynamics) and CSD (computational structural dynamics) tools and hence need manually set up separate models, i.e. these are time and labour consuming manual processes, which are error-prone and do not integrate with design tools to allow real design simulation cycles and building energy system optimization, in particular under life-cycle studies. Testing of alternative products, services and user interactions under realistic conditions and life-cycle scenarios before realization are totally out of scope. This is technically possible but, because of the one-of-a-kind software products and the expensive computations involved (in terms of costs and time), it is not practically affordable. Simplified, specifically adjusted tools and models for simulation provide a realistic but expensive option, and the generality, objectivity and reliability of their results are very questionable with regard to industry practice.

The interaction of climate, building construction and occupancy in relation to heating, ventilation and air conditioning is very complex and not yet fully understood. A detailed exploration of the complex physics involved requires analysis of the effects of design decisions on energy consumption, comfort, equipment and enclosure durability of buildings.

Even though there are a variety of stand-alone tools available, there is still a lack of their flexibility and interoperability and hence their efficient integrative use and expense. Interoperable energy simulation tools as developed by ISES need to be further developed and integrated in the architectural, engineering and operation workflow.

The demand is not for stand-alone tools like an enhanced CAD system covering all the above features, but for an open, scalable system integrating distributed tools/services like CAD, MBES, BES, cost calculation, FM, model navigators and databases for energy, material and cost data, building data, BIM models, energy models, climatic data/scenarios, user activity profiles and interfaces to intelligent building control systems.

Therefore a system is to be developed by ISES as a hybrid open SOA system combining web services and remote calls. The system should be based on a common ontology and complemented with orchestration descriptions for different use scenarios in order to guarantee for the end-user integrated and error-free engineering working procedures.

In particular, methods for interfacing simulation models for products, whole facilities, buildings, building and envelope (cladding) parts will be developed. Especially for application in the early design stage of buildings and building components (from the supply industry), the ISES virtual energy lab will allow to combine a concise building model description and modelling and simulation capabilities for prediction of building energy performance and related costs, indoor air quality and energy demand.

The new ISES tools for product, facility and building energy performance simulation will be supported by suitable graphical user interfaces for generation of the related geometry. Adequate user interfaces are very important, since real buildings can be very complex and it would be very time-consuming, if at all possible, to develop real building models without the help of sophisticated tools. Hence, a library of characteristic buildings and facilities for virtual testing of new products will be developed and provided by ISES.

Energy and emission analyses are complex tasks, first due to the sophistic, mathematical and physical background, second due to the complexity of a facility (surrounding area zones – building envelop – building – building zones – room – room zones – wall/floor/roof details) and third due to the complexity of climatic and user activity scenarios, their variation and the inherent uncertainty. All this has resulted in two separate kinds of sophisticated and heavily numerical analysis programs. First, there are Multizonal Building Energy Solvers (MBES) for the analysis of the climatic conditions in the rooms, which are based on a Solver for multizonal energy flow in buildings providing:

- Solution of zone balance equations under transient climate conditions in different time scales (depending on the nature of the transport processes)
- Consideration of convective, conductive and radiative energy exchange (implementation of an air flow network)
- Different types of construction elements: storage elements, conductive elements
- Connection of thermal zones and construction elements by interfaces
- Internal sinks and sources due to user activity and scheduled HVAC operation.

Second, there are Building Envelop System Solvers (BES) for the analysis of the transient behaviour of the building envelop, including the behaviour in those internal walls that separate different climatic zones or rooms and which are important for the durability analysis, like moisture transport or accumulation. This includes:

- Transient solution of construction balance equations (heat and moisture response) under given climate conditions
- Consideration of dynamic heat storage and moisture buffering processes in great detail
- Output of temperature and moisture profiles in the constructions as function of time.

Both need different models which have to interact and in addition both need mappings from the BIM model to the energy analysis models, and the energy analysis models have to be mapped to the BIM FM model to study lifecycle costs. Today, these models are not compatible and have to be generated manually.

Advanced energy systems comprise a mix of different energy sources, energy buffers and energy suppliers and hence result in very complex multi-controllable systems. What is missing today is appropriate software to model and manage the various sub-systems, which are delivered by different suppliers in order to investigate their interaction and behaviour in advance and analyse their ill-performance through simulations.

Table 1 below show an overview of the complementary of the different tools opposing strength (what is there on a qualified level) and weakness (what is missing or still unqualified).

Tools	Strength	Current Weaknesses
BIM-based CAD	1. Building modelling 2. Building element model 3. Geometric representation (3D) 4. Animation Potential (4D) 5. nD building element information 6. Interoperability (BIM/IFC)	1. Energy analysis 2. Time and space dependent representations 3. Emission analysis 4. Climatic zone modelling 5. STEP interoperability 6. Openness 7. Simplified models 8. System interoperability
BIM-based FM	1. Building model 2. Spatial modelling 3. Space representation 4. Interoperability (BIM)	1. Energy simulation 2. Emission analysis 3. Durability analysis 4. Openness 5. System Interoperability
Energy Analysis MBES BES	1. Energy analysis 2. Energy consumption 3. Climatic zone modelling 4. Energy information	1. Building modelling, incl. spatial geometry modelling 2. New elements 3. New services 4. Openness 5. Interoperability (all kind)
Climatic Data Bases	1. Climatic information 2. Climatic models	1. Building models 2. Energy models 3. Interoperability 4. Stochastic consideration
User Activity Profiles	1. User activity models	1. Building model 2. Energy model 3. Stochastic consideration
ICT control systems	1. Individual system model	1. Interoperability (BIM) 2. Building model
nD Navigator	1. Building model (3D) 2. Ergonomic GUI	1. Energy model 2. Climatic model 3. User activity model 4. Time history model 5. Multi-Models 6. Model hierarchies
Model Filter, View Generator	1. Filtering on Schema- and Class-Level 2. Generic model view definitions (based on TUD-GMSD) 3. Generation of valid sub-schemas and –models 4. Reusable Sub-Views	1. Topological model queries 2. Support of geometry constructs 3. Instance-Level filtering 4. Re-usable and re-combinable view definition components 5. Multi-model filtering 6. Engineering model query language

Table 1: Overview on strengths and weakness of tools

The nD navigator is about a new development. There exist already components as part of FM tools or as graphical representations of energy analysis tools, but they are embedded components and show the related proprietary data structure of their host applications. However some functionality is available and can be used, hence we are not starting from scratch but can build on the experience and developments of our partners (OG, SOF). The most innovative input for the nD navigator is modelling, zooming and the related model hierarchies.

Cost estimation functionality is already available in FM (usually proprietary extensions) for operation cost calculation. The functionalities have to be extended and made interoperate via an ontology-based BIM (OntoBIM), in order to generate and provide total cost (construction, refurbishment, retrofitting, operation and maintenance) in the FM and the nD navigator.

The energy efficiency and emission behaviour of facilities and buildings are not evaluated according to one internal standardized method but according to individual national guidelines and codes. The most well-known ones are building performance assessment framework examples such as the Building Research Establishment's Environmental Assessment Method (BREEAM), the American Society for Testing and Materials (ASTM), the U.S. Department of Energy (DOE) High Performance and Sustainable Buildings Implementation Framework (HPSB), the US Green Building Council's LEED Green Building Rating System, the International Council for Building (CIB) Performance Based Building Program (PeBBu 2005), the German Energy Saving Regulation "Energieeinsparverordnung" (EnEV), the International Code Council (ICC) Performance Code for Buildings and Facilities (ICC 2000), and the US Department of Energy (DOE) High Performance Metrics Project, providing platforms to describe facilities. Initial building performance assessment is carried out at the design stage utilising various simulation tools. Further assessments are carried out in the form of commissioning tests, but there is little or no monitoring or feedback once the building is occupied (cf. US-DOE 2002). As a result, Directive 2002/91/EC by the European Parliament for energy performance of buildings was accepted in 2003. The directive requires owners to quantify the energy usage of their buildings against benchmarks set by government agencies throughout the building life cycle.

These guidelines will more or less lead to a kind of classification of good or bad energetic behaviour of a facility but are not of very high value for component product design or for sufficient determination of a modern energy system and energy-efficient design of a facility. More sophisticates methods based on detailed numerical energy calculation methods acceptable for component product, facility and building design still have the drawback of assuming a deterministic approach for the life-cycle through the application of a characteristic climate profile with 1-hour steps, as provided by the D.O.E, USA.

Activity and usage profiles are not standardized but assumed individually and applied as characteristic deterministic representatives of the life-cycle. The assumption of the characteristics is the heaviest drawback in these approaches. Climate change and user behaviour (society) change are not sufficiently recognised. Life-cycle is a stochastic process problem. Acknowledging this fact, ISES develops a semi-stochastic method, which can be applied to different stages of modelling granularities (as described in section 1.2.3 below for design phases), leading to a very differentiated energetic analysis respecting the design needs for component products as well as for facility design. For the application of this semi-stochastic approach ISES will develop several ICT building blocks like stochastic climate and user profiles, model combiner, simulation model configurator and semi-automatic simulation evaluation.

1.2.2 Data Models

A critical issue for running energy simulations is the data that is available about the component product and/or the facility to be built or renewed. Building Information Modelling (BIM) has become a key technology for collecting data about products within the AEC and FM industries. It consolidates and manages available product data from different sources to provide high quality and up-to-date information about the buildings. It thus acts as a single point of information that shall be used by energy simulation services to avoid time consuming and costly re-entering of differently structured component product and building data.

Whereas BIM stands for a powerful collaboration concept, it needs to be implemented in software and data models. In this regard the international IFC-Standard (ISO-PAS 16739) developed by the non-profit buildingSMART initiative (www.buildingsmart.com) is taking a leading role and meanwhile is supported by all major software vendors in the AEC and FM market. However, other data models such as gbXML (www.gbxml.org) or proprietary formats from software vendors may become interesting too and thus cannot be excluded from required data access specifications. A solution to this problem has been established by the IDM approach (ISO 29481-1) that first concentrates on specifying business needs, which are independent from any particular data model. On that level an IDM (Information Delivery Manual) defines processes and exchange requirements that formally clarify the interaction with other participants such as architects, building services engineers (HVAC) or facility managers. The second, ICT-related step is to provide mappings to data models such as the IFC 2x4 release including further implementation agreements (Model View Definitions - MVD, Hietanen 2006). Both steps are necessary to fit in the overall BIM concept and thus to improve communication in the AEC and FM industries.

Running energy simulation on the basis of BIM has been a topic of several research projects (e.g. in the EU projects InPro and STAND-INN), but mainly to show advantages of BIM-based data integration. In these projects energy analysis is seen as a typical downstream application that re-uses available design data and not as a driver for more sophisticated energy analysis methods and optimization purposes. Several pilot studies such as the HITOS projects in Norway (Lê et al. 2006) have been initiated to show the benefits of current BIM implementations. Besides making a start on IDM (http://idm.buildingsmart.no) and MVD specifications (http://www.blis-project.org/IAI-MVD/), including agreements for energy analysis, experiences have been used to work on the development of BIM guidelines, such as from the Senate properties in Finland (www.senaatti.fi), the General Services Administration in the USA (www.gsa.gov/bim) or the buildingSMART e.V. in Germany (Liebich & Hoffeller 2008). In February 2009 the GSA released series 05 of their BIM guide, which is dedicated to energy performance of buildings and thus provides a basis for this research.

Whereas the benefits of BIM-based energy analysis have been proved in general there are still a number of issues when used in normal projects or throughout the lifecycle of a building. Main problems are related to data quality and data maturity requiring appropriate concepts for data validation and stochastic approach. Accordingly, takeover of BIM data by building performance applications such as Autodesk Ecotect, Olof Granlund's Riuska or EnergyPlus still requires a lot of manual work for starting energy calculations. This in particular becomes critical if several design iterations shall be supported as needed for energy optimization purposes, in particular under stochastic considerations.

Besides building design, it should also be mentioned that continuous commissioning has a big influence on energy savings and provides valuable feedback to applied optimization tools, and thus enables adjusting of algorithms and models. This requires in particular better integration with MEP design, which - due to its complexity - is not yet used for handover of detailed operational data. Continuous commissioning as investigated in the BuildingEQ project (www.buildingeq.eu) and its link to BIM-based design would improve implementation of appropriate monitoring concepts. The findings of this project can be reused for new or updated product design.

The strategy is to use and enhance existing CAD-BIM tools which are strong in geometric and building element modelling as the component product and building modeller to play together with the FM-BIM tool the role of kernel software complemented with an ontology-extended BIM management system as the kernel data management systems for the Virtual Energy Lab (VEL). Such tools are widely available and are state-of-the-art tools in building design. However they lack in energy related issues, except some simplified rough energy code checkers. These FM tools will be enhanced (in the ISES project in particular for Riuska) concerning energy related data models and information in order to play the data hub in the VEL environment. Partially, more sophisticated and specialised data management issues will be outsourced as web services like model filters (for generating model views) and nD navigator. They will be completed by intelligent enhanced tools and data bases accessible via Web Services and remote calls in a hybrid SOA. All tools have first of all to be enhanced with regard to energy information aspects, and second they have to be enhanced with regard to interoperability aspects, namely (1) data interoperability, (2) model interoperability, and (3) system interoperability.

Today data management systems for BIM-IFC data structures are available, e.g. by EDM, Norway, or TUD-CIB and TNO, Netherlands, which are providing public BIM servers. However, ontology extensions are not available on the market. In that respect we shall build on up-to-date research, e.g. of the University of Delft, Netherlands, where Dr. Beetz (Ph.D. 2009) developed the complete IFC scheme in an OWL ontology representation. Other work was done concerning ontology-based virtual organization modelling in the construction industry for collaboration and management of numerical engineering computation (structural analysis, geotechnical analysis, airplane dynamic analysis) in the EU project InteliGrid (2004 – 2007) and for collaborative information management in particular defect management for the construction site in the German project BauVOGrid (2007 – 2010). Based on this research work, in which both academic ISES partners were involved as partners, co-ordinators or Ph.D. supervisors, the model and system ontology of ISES shall be developed, extending the available BIM-IFC to an interoperable OntoBIM.

The baseline of the integration of CAD, FM and energy analysis tools and furthermore the extension of these integrated tools to a simulation platform, which means seamless access to various information sources (see Table 2) must be a highly flexible and extendable data structure. The current IFC as the most developed data structure in AEC (Architecture, Engineering and Construction) is the most appropriate candidate here. Therefore the used CAD and FM must be BIM-based CAD and FM systems in order to show and utilise (a) the functionality and (b) the basic data structure interface. Such CAD and FM systems already exist, like the FM system of partner OG (belonging to the technical BIM leading ones). The same holds for the energy analysis tools. However, for these tools, no standardized data model exists, i.e. each tool uses its own proprietary data model. The most widespread exchange data structure is IDD/IDL developed in the context of the public domain energy calculation tool EnergyPlus. Hence, energy tools have to be extended by an interface to the BIM world. However, such interfaces are complex because they have to include not only data transformation but also model transformation, model mapping and model filtering (model views). Partially this functionality will be separated, generalized and made available as web services in ISES.

Furthermore, the BIM, more precisely IFC-BIM, which is an ISO-PAS 16739[5] standard has to be extended, because it was originally developed mainly for architectural design. It is meanwhile opened to other domains, like structural analysis, HVAC and Facility Management (FM), using a smooth architecture and a data structure platform concept with domain extension (current version 2x4). However, the STEP (ISO 10303) data models, usually applied for component product modelling, and the IFC (ISO-PAS 16739) data model, usually applied for the facility, are not sufficiently compatible. They have different objects and are structured differently, but they also use the same baseline, namely the same basic concepts, the same modelling language EXPRESS (ISO 10303, Parts 11 and 12) and the same exchange format SPF (STEP physical file format, ISO 10303, Part 21). Additionally, IFC uses all the resource models of STEP (ISO 10303, parts 40s). Therefore the basic technology for extension of the BIM with a STEP interface model is provided by ISO 10303. This extension is rather complex because a fully compatible system has to be modelled in the architectural system of IFC. However, excepting some simplifications concerning a simplified geometry and using the basic object of the STEP basic resource models (parts 40s), a reasonable interface will be developed by ISES.

Hence, in ISES the current BIM will be extended to the abovementioned interface to STEP, in particular to ISO 10303, Parts 203 and 214. In our approach we will first develop an interoperability model using the IFC property sets approach and bounding boxes for geometry, which is a standardized valid possibility of BIM, which can be object-specifically extended later on.

In modelling we have to switch back and forth between building element oriented models (as the current mechanical and construction CAD are structured), room element oriented models (as the current FM tools are structured) and climatic zone oriented models (as the energy models are structured), where one building element can belong to several zones (as a whole or as a subpart), or vice versa, one climatic zone may reference several building elements. This zone structuring and the transformation between zones, rooms and building elements incl. component products are basic enhancements of BIM, FM and CAD modellers in ISES, besides their enhancement for energy data and information.

The BIM, i.e. the existing BIM objects, will be enhanced for the energy information, which is mainly an extension on the level of attribute extension and basic resources and an interface to IDD/IDL.

[5] IFC is a derivate of the ISO 10303 STEP product model. It is the separation for the construction industry in the BuildingSMART initiative of the IAI (International Alliance for Interoperability) and it still uses the basic features of ISO 10303, namely all APs below 100.

Another important extension of the BIM is the separate but complementary ontology model. The ontology model serves for model interoperability of the system models. This is not a unique BIM task. However BIM with its already existing grouping functionality provides the basis for this extension. A group can be used for defining the set of the elements of the system, whereas the ontology defines the meaning of the system.

Integrating the monitoring system of facilities can be essential for control component products. Fortunately, in the last years IP-based gateway and middleware solutions like OSGi, OPC or SOAP have been established that may provide unified data access for common technologies like BACnet, KNX, LON, or EnOcean. However, accessing data from building monitoring and control systems requires profound knowledge about the installed building automation systems from available gateways down towards device and datapoint level inclusive their semantic meaning. The necessary information is still not integrated in the BIM, even though it is often available in network design databases or partly via self-reporting functions of gateway. ISES will take benefit of this information and develop a simplified data access interface based on the model ontology.

In Table 2 below, the BIM is analysed with regard to strengths (what is there) and gaps (what is missing). Simplified spoken, ISES will fill the identified gaps in the BIM by complementing BIM with energy information, STEP interoperability and model ontology. In particular, the developed OntoBIM will be capable of serving as a sufficient basis for integrating the different tools and databases, which will allow ISES to benefit from the strengths of the tools available on the market. Inter-linking web services will have to be developed, too, e.g. intelligent access services where model management functionality (as mentioned above) will be implemented. The related model interoperability needs modelling methods like subsumption and partitioning, which are not yet supported and will be solved by applying ontology reasoning based on description logic.

BIM	Strength	Current Gaps
BIM	1. Building model 2. Grouping mechanism (systems) 3. Building elements including HVAC and building service equipments 4. New elements via property sets 5. Interoperability	1. Energy system model 2. Energy information 3. Emission information 4. Hierarchical models 5. STEP interoperability 6. Ontology representation 7. Control system model 8. Openness

Table 2: Overview on strengths and weakness of BIM

1.2.3 Design and Operation Process

In the following we describe how the state-of-the-art (a) of the design and operation processes of a facility or building will change and (b) how the design process of a component product will change when working with the ISES virtual energy lab, which provides a multi-model energy integrated design environment and its virtual testing in virtual facility (host product) models.

Feasibility Design of facilities: The facility is modelled in a few zones, which show the principle energy and emission information and behaviour. Predefined templates of zones should be offered in intelligent libraries as semi-instantiated zone objects. In this phase basic energy scenarios are investigated and the classes of the energy subsystem (energy providing, heating, cooling, isolation, etc. systems) are determined. Today this is supported only by proprietary ICT tools.

This design state of facility models is of interest for the feasibility study of new component products. In particular this high-level model granularity is of advantage to study the variation of climate changes during life-cycle in order to find out whether or not a new or updated component product may be feasible. Today this is not possible at all.

Preliminary design of facilities: The facility is modelled in climatic zones where a zone reflects the group of rooms with about similar energy behaviour. The zone objects should already show a granularity of external, internal and semi-exposed walls, ceilings, roof, floors and sub-surfaces, windows areas, areas of permanent/ semi-permanent openings, parking area, energy buffer space etc.. Again predefined templates should be available in intelligent libraries. In this phase the components of the basic subsystems are determined, which means, the class of windows, wall structure, boiler, ventilation, etc. and their location are defined. Today this is only supported by proprietary stand-alone tools like DesignBuilder, which do not show interfaces to BIM, BAS or neither to STEP.

This model granularity of the facility is important for the conceptual variation study of a new component product, e.g. what is the variation of the functionality of the new product, in order to figure out the overall scope and bandwidth of the new component product. Today this is not possible, because component products are designed by CAD-STEP tools without interfaces to facility and building data modellers.

Final Design: Each room is a climatic zone, and rooms have to be subdivided in several climatic zones or several rooms have to unify to a climatic zone. The same holds for the different open spaces. This switching back and forth has to be done smoothly. For each zone a smoothly modification of energy related information must be possible (to run simulation alternatives). Also, the whole building and parts of the building have to be modelled and simulation results have to be presented on different time scales (time resolution) and granularity. In this phase the product types of each component and their exact location and interaction are determined. In order to optimize the layout of the energy behaviour of the facility, several semi-stochastic analyses are carried out. Today this interaction can only be carried out by hand, which means only very few interaction cycles are realized and a semi-stochastic analysis is not imaginable.

With the ISES virtual energy lab, the semi-stochastic simulation analysis and the several design iterations of the new product can be carried out in order to optimize the various product variants and design a good portfolio of the new product, which is a critical competition issue. This is a sophisticated engineering task, because the host product system is to be assembled from components coming from different suppliers (where standardization is not always given) resulting in a lot of variant systems from which the characteristic ones for the design rational have to be selected.

Operation phase of facilities: nearly similar to final design. In this phase the system as given is tuned in the daily operation in order to improve delivery and efficiency. The operation phase can be used for three purposes. First, it can be used in the virtual energy lab for the simulation of different ways of operation behaviour in a proactive concurrent engineering manner during the design phase in order to find out the best variant product and the optimal operation process of the variant product. Second, it can be used during the real operation of the facility to tune the overall facility system incl. the behaviour of the component product (tuning of the product processes). Third, it can be used for retrofitting studies in order to find out what the best replacement component product is in order to enhance energy and emission efficiency.

This phase can only be used for component product developers to collect requirements for new or updated products.

Lifecycle Analysis of facilities: Life cycle considerations which had to be done today on a deterministic basis of a one year characteristic climate profile can now carried out on a semi-stochastic level with ISES for any of the four above design phases for acknowledging the stochastic nature of climate and use. However, in addition the life-cycle studies can now with ISES carried out to improve the operation of the system for the future concerning control and workflow and also to detect weakness or study the exchange of products, processes and services for improvement, i.e. retro-fitting of the system which may accumulate in a renovation of the energy system or the whole facility.

1.3 S/T methodology and associated work plan

1.3.1 Overall Strategy of the Work Plan

The strategy of ISES is set in correspondence with its objectives, the overall functional approach shown in Fig. 1 and the layered software architecture concept presented in Fig. 2. On these layers, ISES anticipates that many of the needed ICT building blocks are already available on the market, but are not integrated into a consistent Virtual Energy Lab. Therefore, the focus of ISES research and development work will be on (1) bridging the gaps between the existing services and tools, (2) developing new knowledge, process and simulation management and information logistics services, and (3) providing a coherent environment where advanced processes improving design and operation solutions can be fulfilled. The detailed work package objectives target in first place the development of services for the inner three layers of the suggested architecture, i.e. the kernel data layer, the kernel functionality layer and the i-services layer. Accordingly, the work plan is structured into 8 RTD (WP 1-8), 1 demonstration (WP 9) and 1 management (WP10) work packages, reflecting the overall functional approach and associated major activities.

In **WP1** we shall analyse the requirements from end-user and information availability and analysis perspective. A survey of available information resources and analysis / simulation tools will be performed, gaps will be identified and the use cases and scenarios for the Virtual Energy Lab will be set up.

WP2 will develop in detail the overall stochastic approach, and on that basis the detailed software architecture of the platform, its components, principal APIs and data exchange methods will be defined. Special attention will be paid to the methods ensuring service interoperability and the adaptation of existing and new services and tools for a cloud environment, to support large numbers of parallel analyses and simulations.

WP3 is dedicated to the functionality of the kernel data layer. It will provide (1) a model ontology and knowledge-based system that will help inter-linking the heterogeneous resources on the lower auxiliary data layer to a consistent logical system enabling reasoning on decision-maker level, and (2) a system ontology explicating all system aspects (organisational, functional, services, data and processes) in a coherent formal model that enables efficient information logistics and advanced process support, including appropriate service orchestration and workflow support.

In **WP4** the services for intelligent access to the required information resources (climate data bases, stored user profiles and behaviour use cases, energy material data) and the catalogues of designed new and existing products and components containing their energy-related features will be developed. Templates combining characteristic features of the multiple involved resources will be defined and on that basis, using the developed intelligent access services, a number of distributed information resources will be studied and patterns will be developed to replace the overall non-stationary life cycle stochastic processes by partly stationary processes that can be modelled as separate discrete events.

In **WP5** and **WP6**, which will run in parallel, advanced methods for the preparation of appropriate simulation models (WP5) and the evaluation of performed simulations (WP6) will be developed to support the design and decision-making processes for the development of new products and for their appropriate use in architectural and energy design of built facilities. In particular, services will be provided for multi-model integration of the data in the host product model and stochastic profile-based multi-model pattern combination (WP5), and for multi-model filtering, simulation synthesis, evaluation and model version management and user-friendly multi-model navigation (WP6). Four kinds of users will thereby be targeted: (1) designers of new products, (2) energy experts, (3) architects and (4) FM operators.

WP7, following directly the completion of WP2 and using the developed software design therein, will set up early a cloud test-bed for all other software developments, provide the technical service APIs for the cloud, develop a workflow execution and monitoring service for the simulation processes and adapt selected tools for better use of high throughput computing capabilities as example for further opportunities and RTD work.

WP8, the last of the RTD work packages of ISES, is dedicated to the dissemination, exploitation and IPR management activities, with particular attention on the organisation and support of target end-user groups to achieve raised awareness and faster impact of the project’s results in industry.

WP9, starting directly after completion of WP1 and continuing in parallel to the RTD work packages until the end of the project has the goal to (1) identify and prepare pilot demonstrators, (2) provide key performance indicators for objective validation of current and improved (via ISES) energy-related design and operation activities and decision-making procedures for both new product development and for the design of built facilities, (3) perform the demonstrators and evaluate the impact of the developed new services and tools and the ISES platform as a whole, and (4) make recommendations to standardisation and to practice.

Finally, **WP10** (project management), completing the work structure, will provide the usual managerial support and control activities.

1.3.2 Timing of the Work Packages and Their Components

The Gantt chart below (Fig. 3) represents the timing of the work packages and their components, following basically an overall **waterfall** structure.

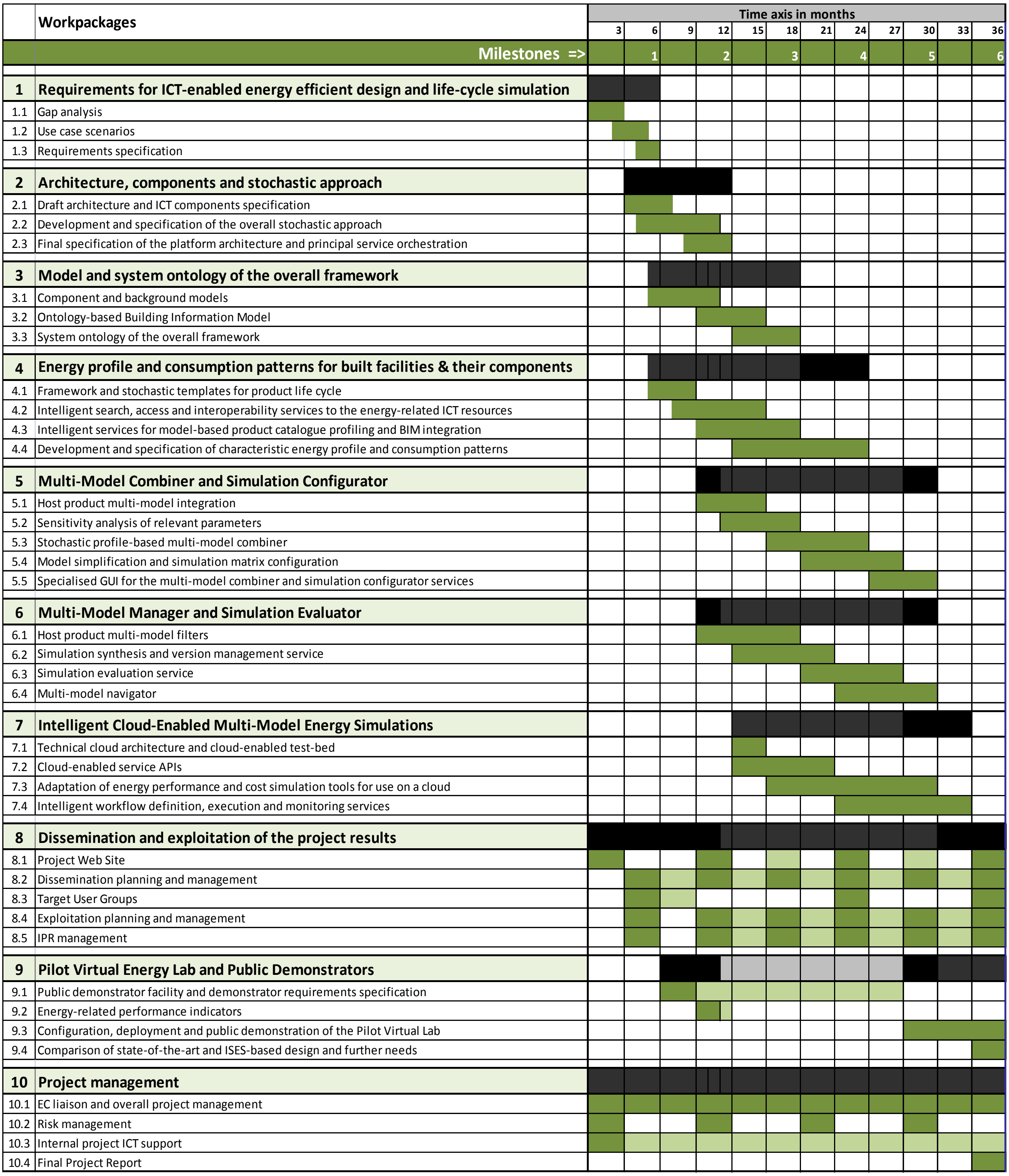

Fig. 3: Project Gantt chart

1.3.3 Detailed Work Package Description

Work package list

Work package No[6]	Work package title	Type of activity[7]	Lead partic. no.[8]	Lead participant short name	Person-months[9]	Start month[10]	End month[10]
1	Requirements for ICT-Enabled Energy Efficient Design and Life-Cycle Simulation	RTD	7	LAP	30	1	6
2	Architecture, Components and Stochastic Approach	RTD	1	TUD	34	4	12
3	Model and System Ontology of the Overall Framework	RTD	3	UL	40	6	18
4	Energy Profile and Consumption Patterns for Built Facilities and Their Components	RTD	5	NMI	60	6	24
5	Multi-Model Combiner and Simulation Configurator	RTD	1	TUD	60	10	30
6	Multi-Model Manager and Simulation Evaluator	RTD	2	OG	54	10	30
7	Intelligent Cloud-Enabled Multi-Model Energy Simulations	RTD	3	UL	54	13	33
8	Dissemination and Exploitation of the Project Results	RTD	4	SOF	32	1	36
9	Pilot Virtual Lab and Public Demonstrators	DEM	8	TRI	50	7	36
10	Project Management	MGT	1	TUD	32	1	36
	TOTAL				**446**		

[6] Work package number: WP 1 – WP n.

[7] Activities (one per work package) are indicated as follows:
RTD = Research & technological development; DEM = Demonstration; MGT = Management of the consortium

[8] Number of the participant leading the work in this work package.

[9] The total number of person-months allocated to each work package.

[10] Measured in months from the project start date (month 1).

List of Deliverables

The ISES deliverables comprise **14 technical reports** (marked as “Other to distinguish from the specifically required reports by the EC in FP7), **3 management reports** (as required), **12 software prototypes**, incl. the integrated prototype of the Virtual Energy Lab, **two final project publications** planned for dissemination by a known publisher (D9.2 and D10.4) and **10 deliverables of other nature**, such as practice demonstrators, web site, newsletters etc. as shown below. Some of the technical deliverables are rolling documents that will be appropriately updated in the course of the RTD work. There is also a set of deliverables that will be issued periodically and have therefore a third number, indicating the respective issue, e.g. D8.2-2 is the second of a series of project newsletters.

Del. no. [11]	**Deliverable name**	**WP no.**	**Nature** [12]	**Dissem. level** [13]	**Delivery date** [14] **(proj. month)**
D1.1	Gap Analysis	1	O	PU	m3
D1.2	Use Case Scenarios and Requirements Specification	1	O	RE	m6
D2.1	Overall stochastic approach for the Virtual Energy Lab Platform	2	O	PU	m12
D2.2	Architecture and components of the Virtual Lab Platform	2	O	CO	m12
D3.1	Ontology specification	3	O	PU	m15
D3.2	Ontology prototype	3	P	CO	m18
D4.1	Technical specification of the overall framework and principal energy profile and consumption patterns	4	O	RE	m12
D4.2	Prototype of the intelligent search, access and interoperability services to the energy-related ICT resources	4	P	RE	m15
D4.3	Prototype of the intelligent services for BIM-based product catalogue profiling and BIM integration	4	P	RE	m18
D4.4	Characteristic energy profile and consumption patterns for the ISES Virtual Energy Lab	4	O	PU	m18
D5.1	Prototype of the multi-model integration services	5	P	RE	m15
D5.2	Prototype of the multi-model combiner	5	P	RE	m24

[11] Deliverable numbers in order of WPs and delivery dates.
Numbering convention <WP number>.<number of deliverable within that WP>.
For example, deliverable D4.2 would be the second deliverable from work package 4.

[12] Indicates the nature of the deliverable using one of the following codes:
R = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

[13] Indicates the dissemination level using one of the following codes:
PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).

[14] Measured in months from the project start date (month 1).

D5.3	Prototype of the simulation configurator	5	P	RE	m27
D6.1	Prototype of the host product multi-model filters	6	P	RE	m18
D6.2	Prototype of the simulation synthesis and the version management service	6	P	RE	m21
D6.3	Prototype of the simulation evaluation service and the multi-model navigator	6	P	RE	m27
D7.1	Cloud-enabled test-bed	7	O	CO	m15
D7.2	Cloud-enabled software integration	7	O	RE	m30
D7.3	Prototype of the developed intelligent workflow definition, execution and monitoring services	7	P	RE	m33
D7.4	Use of the Prototyped Virtual Energy Lab on a Cloud Environment	7	O	PU	m33
D8.1	Project Web Site	8	O	PU	m3
D8.2-1/5	Project Newsletters	8	O	PU	m6, m12, m18, m24, m30
D8.3-1/2	Public Workshops	8	O	PU	m24, m36
D8.4-1/4	Exploitation, Dissemination and IPR Management Reports	8	O	CO	m9, m18, m30, m36
D9.1-1/2	Public demonstrators of the Virtual Energy Lab	9	D	PU	m24, m36
D9.2	End user report on the Virtual Energy Lab pilot	9	R	PU	m36
D10.1-1/3	Periodic Management Reports	10	R	CO	m12, m24, m36
D10.2	Project Collaboration Infrastructure	10	O	CO	m3
D10.3	Project Manual	10	O	CO	m3
D10.4	Final Project Report	10	R	PU	m36

The ordering of the deliverables by delivery dates is shown in the table below.

Proj. month	Deliverable nos.	Milestone
m3	D1.1, D8.1, D10.2, D10.3	M1
m6	D1.2, D8.2-1	
m9	D8.4-1	M2
m12	D2.1, D2.2, D4.1, D8.2-2, D10.1-2	
m15	D3.1, D4.2, D5.1, D7.1	M3
m18	D3.2, D4.3, D6.1, D8.2-3, D8.4-2	
m21	D6.2	M4
m24	D4.4, D5.2, D8.2-4, D8.3-1, D9.1-1, D10.1-2	
m27	D5.3, D6.3	M5
m30	D7.2, D8.2-5, D8.4-3	
m33	D7.3, D7.4	M6
m36	D8.3-2, D8.4-4, D9.1-2, D9.2, D10.1-3, D10.4	

List of Milestones

Milestone number	Milestone name	Work package(s) involved	Expected date [15]	Means of verification[16]
M1	Requirements	1	m6	Requirements and user scenarios are defined and ICT resources for life cycle energy performance consideration are surveyed. WP 1 is finished.
M2	Architecture	2, 3, 9	m12	The architecture of the Virtual Energy Lab Platform and all model and service components are defined. WP 2 is finished.
M3	Basic concepts, methods and services	3, 4, 5, 6	m18	The overall model and system ontologies are in place, the concepts for all services are developed and the basic support modules as well as the services of WP4 are implemented. WP3 is finished.
M4	Service prototypes	4, 5, 6, 7	m24	The service prototypes from the core WPs 4, 5 and the multi-model filter and the version management tools are developed with all features. A comprehensive public workshop presenting the functionality of ISES is performed. WP4 is finished.
M5	Full prototype of the Virtual Energy Lab (beta)	5, 6, 7	m30	The full integrated prototype of the Virtual Energy Lab is implemented and tested on the cloud with all components. Pilots are prepared for full demo runs. WPs 5 and 6 are finished.
M6	Final system prototype, pilot demonstrator and final report	8, 9, 10	m36	Pilot demonstrators are performed, evaluation of the results is done, the final workshop is conducted and the final project reports are issued.

15 Measured in months from the project start date (month 1).

16 Shows how the project will confirm that the milestone has been attained, referring to indicators if appropriate. For example: a laboratory prototype completed and running flawlessly; software released and validated by a user group; field survey complete and data quality validated.

Work package description

Work package number	**1**	**Start date or starting event:**				**1**		
Work package title	**Requirements for ICT-Enabled Energy Efficient Design and Life-Cycle Simulation**							
Activity type	**RTD**							
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant	2	2	3	3	4	4	6	6

Objectives

The complexity of the energy efficient design and the stochastic life cycle consideration of built facilities and their energy-relevant components (facades and internal walls, HVAL and lighting equipment etc.) lies in the very broad scope of the factors that need to be considered. These include user influences, material and component influences, automation systems and the facility as such (space and space boundaries, exterior envelope and so on). Similar considerations are relevant when new products are planned and developed or existing products are upgraded by component and subsystem providers, and when subsystems have to be configured for a given cultural and climatic location. Due to that complexity, considerable gaps still exist in the information use and the information flows between the involved design / analysis / simulation and FM systems and tools.

Therefore, before planning the realization of an efficient virtual energy lab platform, substantial analysis of user roles, existing information resources and anticipated usage scenarios and needs has to be performed. This WP shall analyse in objective way the requirements of ICT-related information and energy and CO_2 emissions modelling and the interoperability needs for the efficient application of advanced simulation methods using typical usage scenarios as baseline.

All partners are involved and each will draw requirements from their expert viewpoint (cf. Section 2.2, 2.3).

Description of work

T1.1 Gap analysis. A survey of existing databases and other ICT resources for climate and user profiles as well as relevant product catalogues will be performed with special focus on essential parameters needed for energy and CO_2 performance assessment. Gaps will be identified and their impact on the virtual lab platform operability will be investigated. Data models and functionalities of state-of-the-art tools to be used in ISES will be analysed in parallel. These include: basic design CAD systems and FM systems as well as various analysis and simulation tools in the scope of the project (heat, moisture, air flow etc.)

T1.2 Use case scenarios. Scenarios will be defined in detail for the three major simulation cycles identified in the project objectives (two design cycles and one internal simulation feedback cycle). This includes detailed characterisation of user roles, processes and supporting tools, interoperability methods, data models and data interfaces. Acknowledged methodologies like ARIS or the IDM (Information Delivery Manual) approach of the BuildingSMART initiative (ISO 29481-1) will be used as basis for the definition of relevant process maps and exchange requirements.

T1.3 Requirements specification. The results of T1.1 and T1.2 will be synthesized and requirements structured in the following groups will be derived: (1) Modelling and interoperability requirements, (2) Functional requirements, (3) Stochastic life-cycle simulation requirements and (4) GUI requirements.

Deliverables

D1.1 Gap analysis (technical report) m3

D1.2 Use case scenarios and requirements specification (technical report) m6

Work package number	2	Start date or starting event:		4			
Work package title	Architecture, Components and Stochastic Approach						
Activity type	RTD						
Participant number	1	2	3	4	5	6	7	8
Participant short name	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI
Person-months per participant	12	8	6	8				

Objectives

In this work package the overall cloud-based architecture, including data preparation via local CAD and FM systems as well as distributed and local databases for climate data, user profiles and product catalogues will be set up. Furthermore, component services will be specified and their inter-relations will be initially defined to prepare for the needed APIs that will be developed in WPs 3-7. To provide a technically adequate and realistic software architecture aligned with the objectives of the project, the overall stochastic approach for the Virtual Energy Lab platform will be defined. The platform itself will be developed using the SOA approach and the general conceptual layer structure described in section 1.1 and shown in fig. 2. It will take into account both remote web services, especially the services for life cycle energy, CO_2 and cost simulations executed on a cloud, and the local CAD, FM and product catalogue systems that will be used in ISES. Specific attention will be paid to the central role of an FM system for the overall Virtual Energy Lab platform, and to the ICT building blocks that will be newly developed from scratch. The latter include not only completely new services, such as the Multi-Model Combiner (WP5) or the Multi-Model Filtering, Evaluation and Navigation Services (WP6), but also components enabling the interoperability of existing tools on the Virtual Energy Lab platform, such as plug-ins and adapters. WP2 will also identify the cloud enabled environment of ISES and the prerequisites for multiple parallel simulation runs on the cloud, which is one of the central ideas of the project. Hence it will prepare directly the basis for the development work in WP7, specifically dedicated to the cloud environment.

The work will be carried out by the academic partners and the partners engaged in the technical software development (OG, SOF).

Description of work

T2.1 Draft architecture and ICT components specification. Early draft specification of the overall platform architecture will be performed to facilitate as much as possible parallel developments in the other RTD work packages. The components of the platform will be identified and their principal interactions and information flows will be defined and formalised in UML activity and component models. Modelling will be performed in close cooperation with WP3 which will develop the system ontology of the whole framework.

T2.2 Development and specification of the overall stochastic approach. The stochastic processes involved in the envisaged energy, emissions and cost simulations will be analysed from systemic point of view in order to develop a pragmatic, manageable treatment of the stochasticity of the product life-cycle. Prioritisation of the stochastic parameters to be considered will be worked out and the treatment of stochastic issues in the separate components of the Virtual Energy Lab will be principally defined. Consequences regarding the ICT components will be deduced and the baseline for the detailed stochastic approach in WPs 4, 5 and 6 will be set up.

T2.3 Final specification of the platform architecture and principal service orchestration. The findings from T2.1 and T2.2 and the feedback from WP3 and WP4 will be synthesized in a final specification of the platform architecture. Based on the gap analysis from WP1 and acknowledged data exchange, interoperability and communication standards such as STEP physical files and IfcXML (for data) or WSDL (for the web services), the service APIs will be defined and aligned with the ontology developed in WP3. Furthermore, using the developed scenarios, orchestration of the services will be carried out, formalised in BPEL.

Deliverables

D2.1 Overall stochastic approach for the Virtual Energy Lab Platform (tech. report) m12

D2.2 Architecture and components of the Virtual Lab Platform (tech. report) m12

Work package number	**3**	**Start date or starting event:**			**6**			
Work package title	**Model and System Ontology of the Overall Framework**							
Activity type	**RTD**							
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant	8	10	16		6			

Objectives

The information resources for the envisaged Virtual Energy Lab are numerous and it is hardly imaginable to harmonize them using a coherent single model schema. For multi-model interoperability and reasoning upper level concepts have to be developed, enabling resource data inter-linking via common ontologies and over-arching rules. In ISES two major ontologies will be developed for that purpose:

1) a *model ontology* that enables integration of the multi-model resources (climate data, user profiles, product catalogue data etc.) on higher conceptual level, and
2) a *system ontology* of the overall framework that enables uniform definition of all system components, thereby providing for high-level queries, informed decisions about workflows and scenarios, and hence for adequate business process support.

For the modelling of built facilities, the major targeted host product of ISES, the standard IFC model (ISO PAS 16739) will be used as basis. However, whilst IFC is an increasingly acknowledged reference model with regard to the host product, it contains too much geometry details that make derivation of generalized geometry data suitable for energy/cost simulations difficult. Furthermore, product catalogue data are not readily available from IFC, and queries and inferences regarding product components are difficult to realize due to the insufficient expressiveness of the underlying meta model (subset of STEP/EXPRESS). To tackle these problems and enable high-level reasoning on all models related to the Virtual Energy Lab, an ontology-based BIM (OntoBIM) will be also developed within WP3 and forwarded to BuildingSMART as suggestion for standardisation.

Description of work

T3.1 Component and background models. Background (resource) models that need to be considered will be examined and high-level concepts of the model ontology enabling their coherent treatment will be developed, together with rules and methods for ad-hoc inspection and inclusion of native attributes of the data objects in the resource databases. The background models to be analysed include climatic database schemas, user profile schemas, product catalogue schemas (STEP, PLIB) and building information models (BIM). For the latter, the IFC model is preselected. The other background models will be defined on the basis of the findings from WP1. Specific attention will be paid to the integration of product catalogue information with BIM on high semantic level, suitable for the needs of the Virtual Energy Lab.

T3.2 Ontology-based Building Information Model (OntoBIM). A high-level ontology-based representation of the facility data will be developed using the IFC model as starting point. The goal is to provide a lean model that does not contain all BIM data but can reference them via dedicated services as needed. The specific focus of the RTD work will be on energy and cost issues, and in second order on related other engineering issues. Findings from earlier EU projects like e-COGNOS, SWOP, InPro and InteliGrid as well as IfcOWL will be examined and adopted as much as possible.

T3.3 System ontology of the overall framework. Minimized manual work, support of design and operation processes and informed decision making are only possible if a knowledge-based platform that "knows" its components (i.e. its data models, organisational model, service model, activity model, user model etc.) and that can act on the basis of overarching systemic rules is established. In this task, the system ontology of the overall framework will be developed and implemented to answer these needs. Findings from the EU project InteliGrid and the German project BauVOGrid will be used as basis to avoid development from scratch. Technically, the ontology will be implemented using OWL and RDFS, to align the work with the Semantic Web concepts, thereby enabling intelligent service interoperability and knowledge-intensive user support.

Deliverables

D3.1 Ontology specification (tech. report) m15
D3.2 Ontology prototype (software) m18

Work package number	**4**	**Start date or starting event:**			**6**			
Work package title	**Energy Profile and Consumption Patterns for Built Facilities and Their Components**							
Activity type	**RTD**							
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant				9	18	15	6	12

Objectives

The ISES Virtual Energy Lab platform will use a large variety of data sources that provide the external environment conditions and the use case scenarios, such as climate data, energy profiles, product/component technical properties etc., providing the specific analysis and decision-making context in simulation configuration. Whilst on high level this data will be interlinked by the overall model ontology from WP3, methods and services are also needed to retrieve actual parametric values and organise them in characteristic profiles that can be arranged and analysed in different combinations for the given facility and component configuration context. Such data include characteristic localised weather profiles and concrete climatic events, specific user profiles for different usage categories (e.g. factory hall, exhibition hall, supermarket, office facilities) etc. However, they are typically collected for many different purposes and from heterogonous sources that make them differently structured and organised. A similar issue exists with product catalogues that vary largely in form and content, even when the same technical properties are addressed. In addition, much of the data is only semi-structured or even only in textual form. Hence, to find typical patterns and to filter out the needed relevant data for subsequent energy-efficient design and life-cycle simulations, a large amount of preparatory work has to be done. This includes:

- Specification of characteristic stochastic templates arranged in catalogues for capturing climate data, product life-cycle energy and consumption patterns and product information
- Development of services/tools enabling search, retrieval, filtering, mapping and profiling the target data
- Survey of the information resources using the above tools, and
- Semi-automated definition of stochastic patterns enabling combination of a wide range of possible cases.

Current state-of-the-art tools do not yet utilise such precise data. Analysis and simulations are therefore still limited to the use of pre-defined reference data sets or indicators, such as the PMV, providing good mean values and profiles but lacking the coverage of a broader spectrum of probabilities.

Description of work

T4.1 Framework and stochastic templates for product life-cycle. The service framework for the search and retrieval of data held as distributed, semi- or non-harmonised IT resources will be set up, meeting national requirements like climate zones, energy profiles, regulations for indoor air quality, energy demand and end-user comfort. Templates capturing relevant parameters will be developed to facilitate automated information retrieval and filtering for the development of climate scenarios and energy profile and consumption patterns for different usage scenarios. The focus will be on capturing data describing both deterministic and stochastic processes and conditions simulating variations in the product environment.

T4.2 Intelligent search, access and interoperability services to the energy-related ICT resources. Services enabling search, retrieval, filtering, mapping and profiling of captured data from non-harmonised, distributed databases and other available web resources will be developed using the templates established in T4.1 as well as appropriate data mining and clustering algorithms. The services will be conceptualised to work with minimal end user interaction, so that – once appropriately configured – search and retrieval can be largely "robotized". Task 4.4 will directly use the developed services but they will be also available for later and broader needs – for detailed studies or even in other domains. To achieve that, the implementation will be as generic as possible.

T4.3 Intelligent services for model-based product catalogue profiling and BIM integration. In this task, the services for integration and configuration of new products in BIM will be developed. This includes: (1) extension of BIM with regard to product catalogue data (focused on the energy and cost issues addressed in ISES), (2) implementation of interfaces between product representation standards from ISO 10303 STEP (mainly AP 203 and AP 214) and ISO 13584 (PLIB), which are mainly supported by mechanical CAD systems, and the BIM standard IFC (ISO PAS 16739), mainly supported by building design CAD systems, and (3) intelligent knowledge-based catalogue search, using appropriate deduction and subsumption methods.

T4.4 Development and specification of characteristic energy profile and consumption patterns. The templates developed in T4.1 and the services from T4.2 and T4.3 (partially in beta state) will be used to extract, filter and categorise actual data that will be applied as building blocks by the Multi-Model Combiner (WP5). To achieve that, intelligent request templates will be configured and used for the retrieval of data from the identified data sources (especially in large amount with regard to climate data). Adapting the captured data to the developed templates will be performed partially manually, but for typical data sets (such as reference climate data from IEA or the US D.O.E.) dedicated mapping tools will be developed and applied. Data will be prepared for a wide range of conditions to cover a broad set of parameters (e.g. for climatic parameters data will be collected for a maximal European range, i.e. from Greece to Finland and Iceland).

Deliverables

D4.1	Technical specification of the overall framework and the principal energy profile and consumption patterns for built facilities and their components (tech. report)	m9
D4.2	Prototype of the intelligent search, access and interoperability services to the energy-related ICT resources (software and tech. report)	m15
D4.3	Prototype of the intelligent services for BIM-based product catalogue profiling and BIM integration (software and tech. report)	m18
D4.4	Characteristic energy profile and consumption patterns for the ISES Virtual Energy Lab (tech. report)	m24

Work package number	5	Start date or starting event:			10		
Work package title	**Multi-Model Combiner and Simulation Configurator**							
Activity type	**RTD**							
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant	24			14	6	10	6	

Objectives

Detailed stochastic simulations run on a cloud environment can provide a clearer picture of life-cycle energy performance and consumption and deliver more exact prognosis regarding costs, energy, emissions and secondary effects. Another goal of such simulations is to point out weak places or critical situations where underperformances or ill operation of the developed products may occur, leading to malfunctions, excessive energy consumption and costs and hence even loss of image of the producer as well. However, since they require a complex, huge mass of data, in current practice only simplified aggregation methods are used, the most common being the test reference year (TRY) method. This is not sufficient to satisfy the above goals. Therefore, methods, services and tools have to be developed to enable the definition of multiple simulation models in a coherent and well-balanced *variant matrix*, appropriate for the computing power provided by the specific cloud environment used. Required are methods that can combine stochastic events to various critical scenarios, provide suitable model simplifications (to keep simulation runs manageable) and configure the simulation cycle workflow, thereby preparing for the use of the actual analyses services on the top level of the platform architecture (air flow and wind simulation, energy simulation, moisture simulation, cost calculation and so on – see. Fig. 2).

Description of work

T5.1 Host product multi-model integration. Preparing simulation data requires to first put all parameters that need to be investigated in the context of the host model. For that purpose, using basic interoperability services from WP4 the data collected from all other resources will be inter-linked with the host model. In the case of BIM that means e.g. to relate climate, environmental, user profile and product / components data with individual walls, floors, rooms and spaces, as well as the building envelope (facades, roofs) and the building as a whole in accordance with EN 15251:2007. A generalised link model will be developed and methods will be designed as generic as possible to enable different integration scenarios for different types of facilities. Product catalogue data will be mainly integrated with BIM by achieving schema level integration of IFC and ISO 13584 “Parts Library” (PLIB). This will enable importing product characteristics directly from mechanical CAD systems such as CATIA or SolidWorks.

T5.2 Sensitivity analysis of relevant parameters. Analyses of the sensitivity of the overall host system with regard to the identified typical stochastic parameters required for detailed simulations will be performed in order to determine their adequate levels of discretisation. For parameters showing higher sensitivity such analyses shall be carried out for different typologies of the host product and for different climatic zones (Greece, Middle Europe, Iceland). Special focus will be put on variations in the design parameters of new products to provide for greater flexibility and more dynamic choice of configuration options.

T5.3 Stochastic profile-based multi-model combiner. Using the series of collected data and the energy profile and consumption patterns developed in WP4, a service enabling the combination of these patterns, taking into account various possible arrangements of the patterns over time and inter-linking the stochastic variables of the involved modelling domains (climatic data, user profiles, product characteristics and costs) will be developed. Emphasis will be put also on user preferences and their inter-relationship to stochasticity, such as the amount of uncertainty and risk that can be taken, limits for investment and operational costs, energy performance, CO_2 emissions etc.

T5.4 Model simplification and simulation matrix configuration. Even with the strongly increased computational power through the use of a cloud environment, simulations can be very time-consuming and can easily become impractical in real-life situations. To avoid that, simulation models require goal-oriented simplification so that accuracy loss is minimal and computational speed is maximised. To cope with that problem, in this task model simplification methods will be developed, especially with regard to geometry and its relationship to the other required data. In addition, possible simulation models will be configured into a variant matrix and prioritised in accordance with general and specific user preferences. These preferences, matched with the principal service orchestration templates from WP2 will provide the input for the workflow definition, execution and monitoring services that will be developed in WP7 as part of the supporting cloud utilities of the Virtual Energy Lab.

T5.5 Specialised GUI for the multi-model combiner and simulation configurator services. The developed multi-model combiner and the simulation matrix configurator will not be executed fully automatically. They require substantial user interaction to adjust project and tool/service parameters to the specific user needs and context. Taking into account that the end user evaluating the results of the set of simulation runs (with typical role of decision maker) may often not be the same person preparing the data and running the simulations themselves (usually an experienced energy consultant, process engineer or architect) a separate GUI will be developed to round up the software tools of WP5 and make them applicable as an individual module. Special care will be taken to provide the end-user with capabilities for informed queries using a novel engineering query language enabling quick simulation configurations on the basis of the developed stochastic patterns and the model ontology from WP3.

Deliverables

D5.1	Prototype of the multi-model integration services (software and tech. report)	m15
D5.2	Prototype of the multi-model combiner (software and tech. report)	m24
D5.3	Prototype of the simulation configurator (software and tech. report)	m27

Work package number	**6**	**Start date or starting event:**			**10**			
Work package title	**Multi-Model Manager and Simulation Evaluator**							
Activity type	**RTD**							
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant	18	24					6	6

Objectives

Whilst with the services and tools from WP4 and WP5 a basis for detailed analyses and life-cycle simulations of energy performance will be provided – to help designers to improve the design of new products and architects to improve the behaviour of built facilities – it is equally important to be able to understand correctly, evaluate properly and present in compact form the results of such comprehensive analyses to decision makers. Therefore, in this work package a set of services and tools will be developed to achieve these goals, ranging from appropriately filtering the output of simulation runs, synthesising the results obtained from multiple parallel simulations and managing the various simulation models used to intelligent evaluation and navigation services enabling fast and convenient examination of the results by non-simulation experts (product designers, architects, managers, process engineers and FM operators). The objective is to enable the different roles engaged in the overall design and life-cycle operation processes to take informed decisions on the basis of the advanced functionality enabled via the ISES Virtual Energy Lab.

Description of work

T6.1 Host product multi-model filters. To enable focused presentation of results and prepare the data for efficient simulation evaluation and model navigation, a set of multi-model filters linking various types of data to the host product (building or other facility) will be developed. Coverage of a broad range of cases and models will be provided via a generic approach, using a high-level filter definition language based on STEP/EXPRESS and operating on STEP, IFC and XML model data with the help of the model ontology of the platform (WP3). Functionality on class level (view definition) will be complemented by a set of geometry-oriented algorithms such as zoning, space separation and enclosure etc.

T6.2 Simulation synthesis and version management service. Due to parameter variation and the combination of different patterns to different life-cycle simulation models, a large variant matrix comprising these simulation models has to be processed simultaneously on the cloud environment. To cope with that issue, a service will be developed that will consolidate and synthesise the simulation results before passing them over for detailed engineering evaluations. Moreover, to provide the basis for the execution of feedback simulation cycles and to enable storing suitable models and profiles for future use in similar situations, a supporting version management service will be realised, linking together the used multi-model data so that they can be easily reconstructed whenever necessary.

T6.3 Simulation evaluation service. Simulations will be evaluated and their results will be prioritised according to multiple criteria. Special attention will be paid to criteria relating energy performance and consumption to investment and operational costs in order to provide a sound basis for balancing environmental and economic aspects. An important development topic will be the evaluation of life-cycle behaviour of designed new products and components taking in consideration different use cases and scenarios.

T6.4 Multi-model navigator. To enable goal-oriented focusing on different aspects and easy examination of simulation results for decision makers, including ordering and prioritisation in accordance with different user criteria, a multi-model navigator capable to switch between various modelling representations will be designed and implemented. It will provide novel cockpit functionality to allow decision-makers to easily examine and judge the impact of design decisions on the basis of appropriate aggregated values. Additional advanced utilities enabling focused drill in the simulation results will include a geometry-based product viewer as well as various diagramming and tabular views. This is new functionality today that will be developed largely from scratch.

Deliverables

D6.1	Prototype of the host product multi-model filters (software and tech. report)	m18
D6.2	Prototype of the simulation synthesis and the version management service (s/w & tech. rep.)	m21
D6.3	Prototype of the simulation evaluation service and the multi-model navigator (s/w & tech. rep)	m27

Work package number	7	Start date or starting event:			13		
Work package title	**Intelligent Cloud-Enabled Multi-Model Energy Simulations**						
Activity type	**RTD**						
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant	6	12	24	12				

Objectives

Based on the constraints of the requirements analysis, the use case specifications and state of the art analysis, as well as several initiatives including FoI, IoT and e-Innovation, the technical ISES cloud architecture will be defined and a cloud-based infrastructure using private and public computing resources will be established. As already indicated in WP2, the ISES architecture will be based on open standards and technologies. It will follow formal international standards such as ISO and IEEE, industrial de-facto standards and best practices, and EU expert groups' recommendations. Specifically, the objectives of WP7 are set up as follows:

- to develop the overall cloud architecture based on the requirements and use-cases from WP1,
- to refine the platform architecture with regard to specific experience and constraints of cloud-based software integration,
- to develop a suite of ISES APIs for integration of the required software services and tools,
- to provide the adaptation of selected analyses/simulation tools for efficient use of cloud computing facilities,
- to develop intelligent workflow services based on the system ontology developed in WP3, and
- to design and implement required supporting cloud services (execution, monitoring, etc.).

Description of work

T7.1 Technical cloud architecture and cloud-enabled test-bed. The ISES cloud infrastructure will be established on the basis of the requirements and use cases from WP1 and the work done in WP2 (draft architecture) and WP3 (system ontology). A test-bed will be set up in order to (1) enable early use of off-the-shelve and adapted for ISES simulation services on the cloud, and (2) provide actual input for the management and evaluation services that will be developed in WP6.

T7.2 Cloud-enabled service APIs. This task will design and implement the required cloud-enabled ISES APIs for integration and adaptation of the selected analyses/simulation software. Several aspects will guide API development: (1) completeness of the API functions with regard to the project's objectives, (2) contract rules, and (3) security rules. Care will be taken to ensure all necessary prerequisites to guarantee that the required analysis/simulation services can be a part of the ISES cloud.

T7.3 Adaptation of energy performance and cost simulation tools for use on a cloud environment. Selected analyses/simulation software will be adapted and re-engineered for more efficient use of the ISES cloud. This includes parallelisation of software processes including partial redesign and re-implementation of existing modules. The goal is to show the benefits of such adaptations, quantify the needed efforts and provide best practice examples. Dynamic air flow simulation, being one of the most difficult and costly energy simulations in current practice, is tentatively selected as first choice candidate.

T7.4 Intelligent workflow definition, execution and monitoring services. Within this task an intelligent workflow definition will be developed based on ontologies and models defined by WP3. This will enable an intelligent execution of computing jobs, real-time monitoring of cloud infrastructure.

Deliverables

D7.1	Cloud-enabled test-bed	m15
D7.2	Cloud-enabled software integration (tech. report)	m30
D7.3	Prototype of the developed intelligent workflow definition, execution and monitoring services (software and tech. report)	m33
D7.4	Use of the prototyped Virtual Energy Lab on a Cloud Environment (tech. report)	m33

Work package number	**8**	**Start date or starting event:**				**1**		
Work package title	**Dissemination and Exploitation of the Project Results**							
Activity type	**RTD**							
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant	3	2	4	12	3	3	2	3

Objectives

The goal of the exploitation activities is to package results into products and services, identifying elements suitable to be commercialised and assessing related risks and opportunities according to the developed IPR management approach. The goal of the dissemination activities is to ensure that the generated knowledge from ISES is propagated to large audiences, in particular in the construction and the related equipment and element production sectors, the ICT sector and the energy sector, including academic and research institutions EU wide and beyond. Therefore, along with traditional dissemination activities a dedicated target user group and an international scientific advisory committee will be established to enable faster creation of network effects.

Description of work

T8.1 Project Web. Within this task, the corporate image of the project will be designed, the project web site (including Flash Video clips) and a mailing list for interested parties will be set up and maintained, and an e-Forum on energy efficient construction, design and development of new energy-related equipment and components as well as facilities operation and management will be established to capture and propagate valuable findings and specifications.

T8.2 Dissemination Planning and Management. This task is dedicated to the planning and performing of various dissemination activities such as publications and presentations at conferences, fairs etc. It includes also the issuing of half-yearly newsletters that will provide concise, up-to-date insight of developed concepts, achieved results and RTD plans. The newsletters will be distributed electronically and as flyers at conferences and other events. Additionally, two major public workshops for academia and industry will be held at m24 and m36 respectively.

T8.3 Target End-User Groups. A target end-user group will be set up to bring together interested companies from the construction, component production, ICT and energy sectors, providing them with active insight to the project results and enabling synergies and cross-fertilization of ideas as well as creation of network effects.

T8.4 Exploitation Planning and Management. This task is dedicated to the planning and the management of the project's exploitation activities. The goal is to develop a clear vision, for each individual partner as well as together as a consortium, as to how to bring the developed platform services to the market. Four consecutive versions of the exploitation plan will be generated – an initial plan at the outset (m6), two intermediate plans at months 18 and 30, and a final plan at project end.

T8.5 IPR Management. While also related to WP10 "Project Management", this task requires study of various legal issues and is therefore defined as a separate RTD activity. It will provide the final IPR agreement, replacing the consortium agreement and covering the IPR aspects of the exploitation of the project results.

Deliverables

D8.1	Project Web Site (continuously updated upon set up)	m3
D8.2-1/5	Project Newsletters	m6, m12, m18, m24, m30
D8.3-1/2	Public Workshops	m24, m36
D8.4-1/4	Exploitation, Dissemination and IPR Management Reports	m9, m18, m30, m36
	D8.4-1 Market context and preliminary plan	
	D8.4-2 Updated plan (second version)	
	D8.4-3 Updated plan (third version)	
	D8.4-4 Final Report	m36

Work package number	9	Start date or starting event:			7		
Work package title	Pilot Virtual Lab and Public Demonstrators						
Activity type	DEM						
Participant number	1	2	3	4	5	6	7	8
Participant short name	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI
Person-months per participant	3	6	3	6	3	8	8	13

Objectives

Very important for the achievement of short-term marketable results and dissemination of the project findings to a broad audience of industry practitioners is the high quality testing and validation of the developed Virtual Energy Lab in practical environments. Therefore the full ISES prototype will be deployed and demonstrated in real-practice scenarios illustrating the three targeted feedback cycles, i.e.:

1) the design of new products and components, taking into account a range of typological contextual issues, such as cold/moderate/warm climatic zones, different facility uses (industrial, exhibitional, sales, office use etc.), material/dimensioning variations and so on,
2) the design or re-design of existing facilities for the use of more efficient energy related components of the services systems, facades, separation walls etc., and
3) the simulation feedback cycle, allowing to obtain more accurate results and/or refine use cases for future application.

The objective is to show the practical achievements of ISES but also to demonstrate the benefits of the developed overall approach and to provide a grounded comparison of state-of-the-art solutions and the results of ISES, comparing the energy demand of one and the same facility designed by current state-of-the-art and new ISES methods, thereby enabling quantification of the exploitation potential and benefits.

All partners will participate according to their competences and profiles, with distinct focus on the end-users.

Description of work

T9.1 Public demonstrator facility and demonstrator requirements specification. Early preparatory work in selecting appropriate demonstrator facility and respective demonstrator requirements specification will be carried out, starting immediately after completing WP1 “Requirements”, in order to avoid practical or administrative risks of achieving good pilot cases as much as possible. The RTD work in WPs 4-7 will also benefit via the provided opportunity for early real-life testing.

T9.2 Energy-related performance indicators. Synthetic energy-related key performance indicators will be defined at an early stage to enable objective validation of the results obtained via ISES. They will be obtained by selecting and deriving aggregated energy/emissions values and relating these to investment and operational costs as well as other (soft) constraints. The work will be done independently from WP5 to avoid unwanted bias, but possible later cross-linking will be also taken into account.

T9.3 Configuration, deployment and public demonstration of the Pilot Virtual Lab. The full developed prototype of the Virtual Energy Lab will be configured and deployed for the targeted public demonstrators. Two such demonstrators are planned: (1) *Early demonstrator at month 24*, when the basic functionality of the platform will be already in place, but advanced, user-friendly and cloud functionality will still be under development, and (2) *Final demonstrator at month 36*, which will provide, test and show all platform features. The intention of the first demonstrator is to facilitate early interest in the ISES results and enable public feedback for the final development phase.

T9.4 Comparison of state-of-the-art and ISES-based design and further needs. The final task of WP9 will provide a report on the ISES findings from end-user viewpoint, comparing state-of-the-art practice with the new ISES method. IT will draw conclusions about benefits, eventual shortcomings and further needs and it will produce a public document that will present the major project results in concise industry-friendly form.

Deliverables

D9.1-1/2	Public demonstrator of the Virtual Energy Lab	m24, m36
D9.2	End user report on the Virtual Energy Lab Pilot (report on the ISES findings from end-user point of view)	m36

Work package number	**10**	**Start date or starting event:**			**1**		
Work package title	**Project Management**						
Activity type	**MGT**						
Participant number	1	2	3	4	5	6	7	8
Participant short name	**TUD**	**OG**	**UL**	**SOF**	**NMI**	**NOA**	**LAP**	**TRI**
Person-months per participant	18	2	2	2	2	2	2	2

Objectives

The goal of this work package is to ensure that the project achieves its mission in time and within budget, and that partner efforts harmonically and synergistically lead to the achievement of the common project objectives.

Description of work

T10.1 EC liaison and overall project management. This task is dedicated to the overall coordination of the RTD work, ensuring timely deliverables submission, management and financial progress monitoring, control and reporting, organization of internal project meetings and technical workshops, accounting support for the project, payment distribution and, last but not least, liaison with the EC. It includes also the operational management of the Target End-User Group and the Scientific Advisory Committee.

The task's duration is equal to the full duration of the project. It will be performed by the coordinator (TUD) with support of all project partners and especially the S/T manager and the WP leaders who will coordinate locally the RTD work in their respective work packages. However, the technical part of this support work is a necessary component of the cooperative RTD work of the partners and will be respectively identified as such in the Consortium Agreement.

T10.2 Risk Management. In this task, a suitable risk management methodology for risk identification, assessment, classification, prioritization and monitoring will be developed and an online system for continuous risk management will be set up. To achieve that, know-how from the FP6 project InteliGrid as well as known risk management approaches e.g. from the Australian RM standard (AS/NZS 4360:1999) or the Swinburne OH&S Management System will be applied.

T10.3 Internal project ICT support. This task will develop the technical *Project Manual*, identify QM procedures and set up and maintain the internal project collaboration infrastructure including DMS and BSCW services.

T10.4 Final Project Report. Concluding the project, this task will be specifically dedicated to the editing and submission of the Final Project Report. It is planned to produce the Final Report as a book published by a known publisher. However, a large part of the actual content of the report will be provided by the RTD work packages on the basis of their achieved results and documented in their technical WP deliverables.

Deliverables

D10.1-1/3	Periodic Management Reports (as required by EC, incl. risk management – see T10.1 / T10.2)	m12, m24, m36
D10.2	Project Collaboration Infrastructure (related to T10.3)	m3
D10.3	Project Manual (identifying the technical details of internal project collaboration, QM procedures and the project calendar, thereby complementing the DoW)	m3
D10.4	**Final Project Report**	**m36**

Summary effort table
(full duration of project)

The table below indicates the number of person months used over the whole duration of the planned work, for each work package and by each participant. The work package leader for each WP is identified by showing the relevant person-month figure **in bold**.

	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI	Total Partners
Research / innovation activities									
WP1: Requirements for ICT-Enabled Energy Efficient Design and Life-Cycle Simulation	2	2	3	3	4	4	**6**	6	30
WP2: Architectures, Components and Stochastic Approach	**12**	8	6	8	0	0	0	0	34
WP3: Model and System Ontology of the Overall Framework	8	10	**16**	0	6	0	0	0	40
WP4: Energy Profile and Consumption Patterns for Built Facilities and Their Components	0	0	0	9	**18**	15	6	12	60
WP5: Multi-Model Combiner and Simulation Configurator	**24**	0	0	14	6	10	6	0	60
WP6: Multi-Model Manager and Simulation Evaluator	18	**24**	0	0	0	0	6	6	54
WP7: Intelligent Cloud-Enabled Multi-Model Energy Simulations	6	12	**24**	12	0	0	0	0	54
WP8: Dissemination and Exploitation of the Project Results	3	2	4	**12**	3	3	2	3	32
Total research / innovation	**73**	**58**	**53**	**58**	**37**	**32**	**26**	**27**	**364**
Demonstration activities									
WP9: Pilot Virtual Lab and Public Demonstrators	3	6	3	**6**	3	8	8	13	50
Total demonstration	**3**	**6**	**3**	**6**	**3**	**8**	**8**	**13**	**50**
Management activities									
WP10: Project management	**18**	2	2	2	2	2	**2**	2	32
Total consortium management	**18**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**32**
TOTAL ACTIVITIES	**94**	**66**	**58**	**66**	**42**	**42**	**36**	**42**	**446**

1.3.4 Graphical Presentation of the Components and Their Interdependencies

The general structuring of the work outlined in section 1.3.1 and the break down and timing of each individual work package lead to the principal logical inter-dependencies of the major components of the RTD work shown on the figure below.

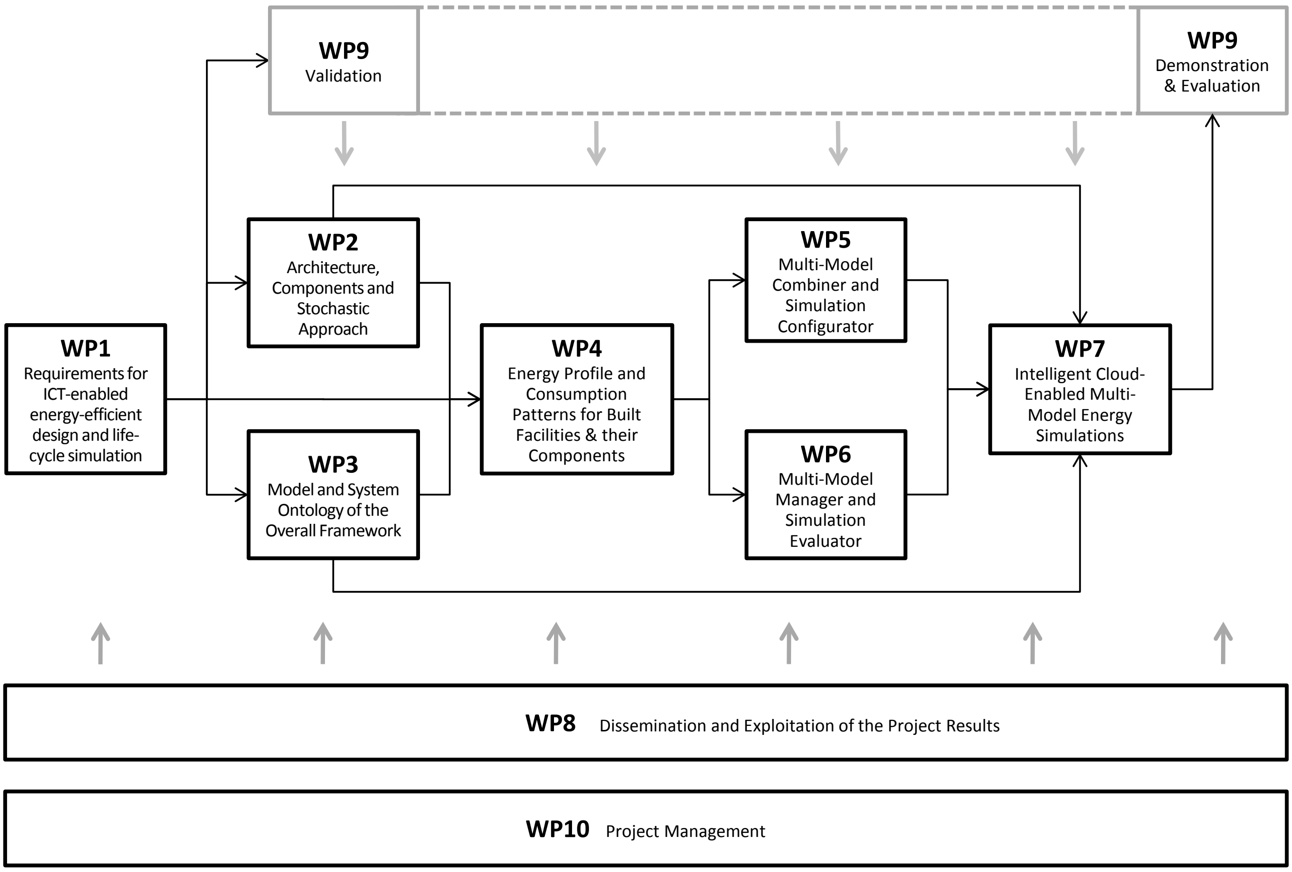

Fig. 4: Graphical presentation of the dependencies between the major project components

1.3.5 Risks and Associated Contingency Plans

Due to the novelty of the proposed approach and services infrastructure, and the assumed model-based product design and management, certain **risk factors** can be anticipated and need to be taken into account at the outset:

- Availability of model-based data and supporting model management methods are central for the integration and interoperability concepts of ISES. However, whilst there exist well-developed individual models in all addressed subdomains, advanced model-handling methods are yet largely missing and inter-model operability is also weakly supported. ISES will develop a set of such methods (for filtering, navigation, multi-model linking) but will also rely on methods and tools providing basic functionalities and data access, which are not yet completely stable. Initial data sets prepared by CAD or FM systems and describing the designed products at least in a draft design phase are also assumed as given. The quality of this data is another issue to worry about. All these potential problems may require mitigation measures. Therefore especially WPs 2 and 3 will be under special monitoring to detect constraints early and react with practice-oriented solutions.
- Similarly, the access to needed ICT resource like climatic databases, user profiles and product catalogues may prove more difficult than expected due to poor or inadequate structuring of the data and greater than the originally assessed heterogeneity. To minimize the possible risks, a survey will be undertaken very early (Task 1.1) and concepts and contingency solutions will be developed already at the beginning of WP 4, which is the one most affected by this risk.

- The interoperability and actual performance of the planned services on the cloud environment can be an issue of concern with regard to scalability. From known experience processing limitations should not provide a critical problem, but actual tests must nevertheless be performed early enough to align the practical capabilities of high-throughput computing with the design and life-cycle analysis and simulation methods that will be developed in ISES, especially with regard to the adequate size of the variant simulation model matrix. The risk here is not very high, but consequences regarding practical exploitation of the results should not remain neglected. This concerns mainly the WPs 6 and 7.
- Ontology scalability may also impose limitations on the envisaged practical scope of application for the planned business pilots. This issue will be taken into account during all development phases.
- The stochastic based methods that will be developed in WPs 4, 5 and 6 provide a natural source of risk due to their novelty. The work plan and resource distribution of the project is already considering that risk by providing as much as possible buffer to these work packages. Nevertheless, these work packages will be in the focus of risk management during the whole middle half of the project to enable early recognition of problems and possible fallback actions, and – if necessary – drawing up expert consultancy and help.
- Last but not least, ISES work will depend on standards concerning BIM, Part Libraries, Cloud Computing and various protocols, web services and SOA. The objectives and work program of ISES are based on the current state of these standards. A radical change is not to be expected but possible evolution and major updates require narrow observation. ISES will extend BIM to integrate product catalogue information with regard to energy and CO_2 performance and consumption relying on the consortium expertise and insider knowledge (3 of the partners being active members of BuildingSMART, and another 3 participating in IEA). This provides for the necessary expertise to cope with possible standards evolution and react adequately informed and in due time.

To react to such possible problems, **continuous assessment and evaluation** of the respective market and technology segments will be performed by the risk manager of the project **for the early recognition of risks and elaboration of adequate contingency plans**. For that purpose, a specific task has been assigned within **WP 10** and a risk manager assistant to the project manager will be installed. Collaborative software support for timely risk identification and management will be set up as part of the internal IT collaboration infrastructure of the project.

As a whole, **risk management** will follow the usual phases:

- Identification,
- Continuous qualitative assessment of the risk with regard to goals, costs and schedules,
- Risk mitigation through pro-active management and alternative contingency plans,
- Post risk analysis where risks are re-assessed, and
- Fallback Plans, to identify actions that need to be taken if everything else fails.

The accumulated knowledge of the coordinator TUD from its role as risk manager in previous projects (most recently the FP6 project InteliGrid and the German collaboration project MEFISTO) and the tools developed for that purpose will greatly facilitate the overall effort and ensure solid and reliable risk management procedures. As mentioned in the description of WP 10, an approach adapting issues from the Australian RM standard (AS/NZS 4360:1999), the Swinburne OH&S Management System and the Kasse RM methodology for the scope and goals of the project will be applied.

Section 2: Implementation

2.1 Management structure and procedures

The project management will ensure that all contractual, financial, legal and management issues, including risk and time management, are taken into account. In regard to the European Commission special care will be taken to meet all deadlines and to produce all reports in good quality. In regard to developers and researchers special care will be taken to minimise paperwork and let them concentrate on the innovative part of the work. In regard to the partner organisations (the Contractors) care will be taken to ensure that all financial issues are handled in timely fashion. The project will create two documents to specify how work is done and define the internal relations:

1. **The Consortium Agreement** (CA), which will define the management structure, the relations among the partners, the IPR issues and other legal aspects of collaboration.
2. **The Project Manual,** which will define the technical and procedural details of project collaboration, i.e. the tools, file formats, file naming conventions, workflows of documents, quality assurance procedures and the project calendar, including internally defined deadlines for the reports and deliverables.

2.1.1 Management Structure

The overall management structure is presented in the figure below. The management roles and personnel are defined in the following subsections.

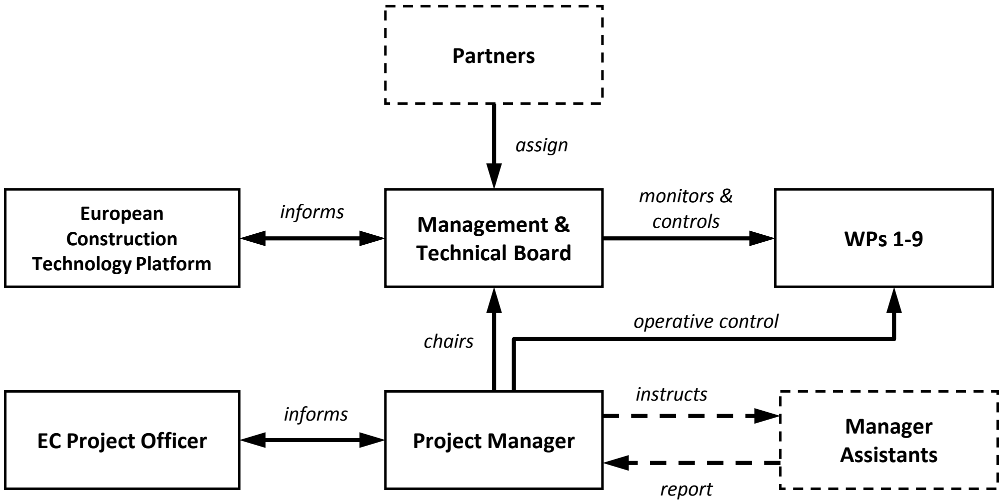

Fig. 5: Overview of the overall management structure

<u>**Management and Technical Board (MTB)**</u>

In accordance with the relatively low complexity of a STREP, the competence of the partners and the high know-how, experience and technical abilities of their senior representatives in the project, the *Management Board* – typically responsible for the overall management of resources and the fulfilment of schedules and goals, and the *Technical Board* – responsible for monitoring and controlling the RTD work in the project's work packages, will be joined into a single body – the **MTB**.

The MTB will be the top decision-making body of the project, comprised of one representative of each contractor. Its role will include:

- Proper management of resources in order to meet the project's objectives
- Ensuring the quality management of the project and the separate WPs
- Monitoring and controlling the progress of the RTD work
- Tracking of costs related to the budget
- Tracking of risks

- Tracking of the exploitation plan and IPR issues
- Ensuring compliance with legal obligations
- Resolution of conflicts

The Project Manager shall invite for and chair all meetings of the MTB. Such meetings shall be convened at least once every 6 months and upon written request of at least three contractors in the case of an emergency situation. Any decision requiring a vote at a MTB meeting must be identified as such on the invitation. Should a contractor suggest adding a discussion/decision to the proposed agenda, they shall do so in writing to all other contractors at least seven calendar days prior to the meeting date. MTB meetings may be organized as face-to-face meetings or as online telecom or video-conferences. The MTB is the final authority for project-related decisions. It is responsible for all legal, financial and operational matters associated with the execution of the project in accordance with the commission contract.

Project Manager

The Project Manager from the coordinator (**Prof. Scherer, TUD**) is responsible for the scientific and operative management of the project. He is head of the MTB and chairs the MTB meetings. His operative management functions involve the steering of the project, both technically, financially and administratively, according to the contract documents, consortium agreement, project manual and the decisions made by the MTB. This includes the management of dependencies between various tasks and work packages, co-ordination of technical progress, final approval of technical reports and deliverables and resolution of problems of technical and administrative nature. He is responsible for implementing the decisions of the MTB and tracking the progress of the project. He supervises the project administration, is responding to important changes during the project life and coordinating necessary adaptation to meet conditions of the external environment. He is in charge of dealing with the contract, work plan, reporting and billing of efforts, budget and review organisation, and assumes the responsibility of representing the project in front of the EC. The Project Manager is the primary interface of the Consortium to the European Commission. To ensure coherent management of all critical project aspects, his tasks encompass:

- **Financial management**, including budget supervision, preparing the final consolidated cost statements sent to the EC, obtaining audit certificates and bank guarantees as and when required;
- **Scientific management**, including a scientific community watch, evaluating RTD work related to the scientific progress, matching it with the scientific watch and the exploitation strategy; the matching results will be presented at each MTB meeting together with a draft of adjusted and updated project objectives;
- **Risk management**, including analysis of internal and external projects risks, selection of risk mitigation measures and development of contingency plans, and presentation of a synopsis at each MTB meeting.

Manager Assistants

Whilst strategic management will be performed by the MTB and operative management by the Project Manager on daily basis, there are various management related tasks that are less critical but require more detailed technical knowledge. For such tasks the Project Manager will be supported by three manager assistants as indicated below. They will have only **advisory status**, including monitoring, reporting, synthesizing outcomes, preparing actions and suggesting alternatives, whereas all final decisions are taken by the MTB and – operatively – by the Project Manager.

The **S/T manager assistant**, **Dr. Katranuschkov of TUD**, will be supporting the Project Manager in his daily work. Therefore, it is important that he is from the same contractor company and possesses adequate management and technical abilities and experience.

The role of the S/T manager assistant comprises:

- **Technical support**, including collection of the partner progress reports and drafting of the consolidated PPRs, organising and maintaining the project management infrastructure, technical help in tracking work progress, and preparing respective management tables, charts and diagrams;
- **Financial management suppor**t, including book-keeping, collecting partner cost statement, checking of costs and preparing respective cost tables and diagrams;

- **Quality management support**, including the setting up of a quality handbook as part of the project manual, monitoring quality assurance practices[17];
- **Risk management support**, incl. the collection of risks identified by the partners in periodic request rounds, managing and consolidating these risks, generating risk reports and diagrams of risk developments and risk categories;
- **Scientific management support**, incl. scientific community development watch, inquiries on specific topics, preparation of reports and presentation material.

The **Dissemination, Exploitation and IPR Manager Assistant**, **Dr. Protopsaltis of SOF**, will be responsible for all dissemination work, i.e. collection of information from partners, running web page newsletters, scheduling fairs and conferences, promoting papers, designing PR material, arranging, printing and distributing flyers etc. Furthermore, he will be responsible for the development of the exploitation strategy of the consortium together with the partners, respecting the IPR of the individual partners, and the generation of an evolving exploitation plan presented and discussed at the MTB meetings. His actions have to be agreed with the MTB, and the Project Manager has to be informed and to approve beforehand. Content has to be circulated in the Consortium and agreed in due time before publishing. IPR has to be respected and content has to be adopted accordingly.

Work Package Leaders

The work package leaders assist the Project Manager in addressing specific work package related issues. They have the responsibility for the day-to-day detailed management of the work packages. They report to the Project Manager and prepare progress and management reports related to their respective WP. The appointed project manager, exploitation manager and work package leaders are named in the following table.

Management role	**Participant**	
	Organisation	**Person**
Project Manager	TUD	Prof. Scherer
Dissemination, Exploitation & IPR Manager	SOF	Dr. Protopsaltis
Leader WP1	LAP	Mr. Zschippang
Leader WP2	TUD	Dr. Katranuschkov
Leader WP3	UL	Prof. Turk
Leader WP4	NMI	Mr. Gudnasson
Leader WP5	TUD	Prof. Grunewald
Leader WP6	OG	Mr. Laine
Leader WP7	UL	Dr. Dolenc
Leader WP8	SOF	Dr. Protopsaltis
Leader WP9	TRI	Mr. Zaletelj
Leader WP10	TUD	Dr. Katranuschkov

European Construction Technology Platform (ECTP)

Leading European experts from the ECTP will be invited to monitor the project and give advice with regard to working culture and their knowledge and views. In this way, the ECTP will contribute to more general and internationally valid results. The participating members will take care that objectives of the different regions are properly considered and adapted in the re-engineered design, refurbishment and retrofitting processes of public use facilities. In exchange, they will have privileged access to restricted project deliverables, and will benefit from early awareness and better insight into the project results.

[17] Neither the S/T manager assistant nor the Project Manager is responsible for the content of deliverables. This is the responsibility of the owning partners and those contributing.

2.1.2 Management Infrastructure

The management infrastructure comprises the following issues:

- **The Project Manual**: (as defined at the beginning of this section).
- **Project meetings.** Project meetings will be held at the start of the project (the kick-off meeting) immediately before review meetings and half way between review meetings if required. The board will meet on each of these occasions headed by the Project Manager. Communication between partners outside meetings will be via exchange of documents (progress reports, working papers etc) and informal correspondence. These communications will remain confidential to the project partners, but will be used by the Project Manager as basis for the Progress Reports.
- **Intra-project collaboration.** The coordinating partner will set up a Web based infrastructure for intra-project collaboration which will include a document management system, conferencing and email lists, shared calendar, as well as real time communication channels such as video-conferencing.

E-Mail, videoconferencing, document management and the World Wide Web will be used as the *main communication channels* for internal communication and document exchange. The meetings mentioned above will be held to tackle discussions on important issues that require the participation and opinion of all partners. This is also an opportunity for partners to meet in small workshops in order to solve technical problems, doubts and requests not concerning the whole project.

2.1.3 Quality Assurance and Decision-Making Procedures

The project will operate within certain administrative procedures, which will be defined at a very early stage. They will cover management reporting, document standards, collaborative specification and development, review, configuration, change control and quality assurance. The quality reviewing functions are important to make sure that all contributions and conclusions are consistent to meet the requirements of the deliverables. A common format will have to be agreed upon for the preparation of all documentation and the deliverables.

Decision making will be made by consensus or by voting, with each partner having a single vote. In case of a tie, the Project Manager will have a casting vote. Decisions that are related to changing the funding of the project or adding new contractors need to be supported by 2/3 majority or all partners. At least 2/3 of the partners need to take the vote for a voting to be valid. A specific conflict management procedure for serious technical / financial / legal issues will be defined in the Consortium Agreement.

2.1.4 Exploitation Planning and Management of Intellectual Property

Together with the partners, the exploitation and IPR manager assistant Dr. Protopsaltis of SOF will develop a marketing strategy by identifying marketable products in the very early stage of the project, track the development of these products and market development, and refine and adapt the exploitation strategy accordingly to result in an optimized exploitation strategy at the end of the project. According to the evolving character of the exploitation strategy the exploitation plan worked out by the exploitation manager will be an evolving document, which will be consolidated as a deliverable five times during the project life cycle, namely at the **six milestones of the project on m6, m12, m18, m 24, m30** and **m36** respectively. The development of the exploitation plan will be supervised by the project manager and will be presented to the consortium at the MTB meetings to get a common consensus, identify exploitation risks continuously and hence very early and develop commonly a strong exploitation perspective.

In parallel, the exploitation manager assistant will develop the IPR agreement proposal, co-ordinating the individual interests of the partners and their IPR rights. He has to take care for the consistence of the exploitation plan and the IPR agreement. He will be responsible for drafting the IPR agreement, which will be verified by the project manager before it will be discussed in the kick-off meeting, and as a part of the Consortium Agreement it will be agreed upon in written form by all partners. The partners will sign the Consortium Agreement at an early stage to clearly identify IPR, exploitation rights, dissemination policy and possible future collaborations (after the end of the project). All partners will have the rights to use the deliverables for internal purposes. The IPR for exploitation will be developed together with the exploitation plan during the project, reported as part of the corresponding deliverables and agreed upon in written form by all the partners at the final project meeting. The project manager will supervise and ensure that (1) rules are identically applied to all contractors, and (2) rules concentrate on the principles and provisions considered necessary for efficient co-operation and appropriate use and dissemination of the results.

2.1.5 Risk Management

The goal of risk management in the project is to identify, quantify and manage risks that could endanger the project or its parts. The risk management process will be set up as a part of the Project Management WP. Collaborative software support for risk identification and management will be set up on the Web. Risk management will proceed through the typical risk management phases, namely:

(1) **Identification,**

(2) **Qualitative Assessment of the risk** that can be between **'**Very High' and 'None' and is related to schedule, cost and end-user satisfaction,

(3) **Actual Risk Management** focusing mostly on the process of risk mitigation through pro-active management which involves the identification of remedial action for the risks that require active management, segregates those that only require monitoring and records secondary risks that might arise from implementing the risk mitigation plans,

(4) **Post-Risk Evaluation** where risks are re-assessed, and finally

(5) **Fallback Plans** to identify actions to be taken should a risk occur in spite of risk management actions.

In ISES the particular focus of the risk management will be in WP2–WP7 that must keep the goals in realistic frames so that they can be properly implemented and exploited, and the WP 9 related to the demonstration and validation of the overall platform on real scenarios. Already identified risks to be mentioned are listed in sect. 1.3.5 above.

2.2 Individual participants

In the following the profile of each participating organisation is presented. These profiles are structured uniformly providing (1) an overview of the organisation, if applicable, with the specific department engaged in the project, (2) the specific skills and know-how that are relevant to and will be brought into the project, and (3) key personnel that will be involved in the work. For the co-ordinator, TUD, the expertise related to project management is indicated in addition.

2.2.1 Technische Universität Dresden, Germany

Technische Universität Dresden (**TUD**) is one of the oldest and largest technical universities in Germany. It is member of the group of the 9 leading Technical Universities in Germany ("T9 Board"). TUD is a full-scale university with 14 faculties, 36000 students, over 4500 employees and about 600 professors. In ISES it will be represented by the Institute of Construction Informatics (**CIB**) and the Institute of Building Climatology **(IBK)**.

The research areas of **CIB** comprise product and process modelling, concurrent engineering, virtual organisations, ontologies, information logistics, Internet-enabled network infrastructures, Semantic Web technology, stochastic simulation and fuzzy methods. The institute works on the application of distributed systems and multi-dimensional data management as well as on methods of artificial intelligence for dynamic business process modelling. Software technology know-how encompasses advanced Internet solutions based on EJB, Java, XML, Web Service and Grid technology. Teaching activities include four basic and four advanced courses in construction IT along with active participation in the European ICT Euromaster program.

Research at **IBK** focuses on the theoretical basis of combined heat, moisture, air and salt transport in building materials as well as other areas of building physics. An important goal of the research work is the dissemination of new knowledge to other research institutes and practitioners. Therefore, IBK continuously integrates new findings in its user friendly software and calculation tools. The institute has long-term experience in development of efficient numerical solvers for solution of coupled parabolic differential equations with highly non-linear transport coefficients. This is typical for transient building physics problems related to durability and energy. The solvers are completed by professional user interfaces and material and climate data bases. The software helps other research institutes in their work, assists students in learning fundamentals of building physics, and supports the work of engineers, architects and others working in the field.

<u>Specific skills in relation to the project:</u>

1. Related to the Project Management

TUD-CIB will be the ISES **co-ordinator**. Its competence for both the management and RTD work is grounded on numerous national and international research projects. TUD-CIB co-ordinated the three EU projects COMBI, ToCEE and ISTforCE and the national research projects iCSS, IuK-Bau and BauVOGrid, participated in the management of the EU projects e-Sharing and IntelliGrid, and currently co-ordinates the EU project HESMOS and the German lead project MEFISTO (equivalent to an IP) addressing knowledge management and construction simulation. Through these activities it gained considerable experience in the co-ordination of national and international research projects as well as in the development of systems for supporting project-comprising, inter-enterprise, inter-activity and inter-trade collaboration, management of resources and information exchange.

2. Related to the RTD work

As already mentioned above, TUD-CIB has considerable experience in process and product modelling, ontologies, interoperability, distributed system SOA and Web service development in construction IT and stochastic and fuzzy methods in computational engineering. Related papers are published in specialised journals as ITcon, Artificial Intelligence and Automation in Construction, and conferences like eChallenges, ICE, ICCCBE, CIB-W78 and ECPPM. TUD-CIB has been a leading developer of BIM and related standardization groups - in particular STEP and IFC models and related intelligent management methods - for more than 20 years. Due to its knowledge in distributed systems (e.g. from projects like TOCEE, ISTforCE, InteliGrid and BauVOGrid) TUD-CIB will lead the design architecture of the ISES platform (**WP2**) from ICT point of view. In addition, it will provide its special knowledge in ontologies and description logics for the development of intelligent access services (**WP3**) and it will provide the expertise in multi-model combination (**WP5**), multi-model management and simulation evaluation (**WP6**).

TUD-IBK investigates the theoretical basis of combined heat, moisture air, and salt transport in building materials. Its expertise includes modelling and software development, energy-efficient building, durability and risk analysis. TUD-IBK focuses on a dynamic hygrothermal room model and building envelope and its integration into a multi-zone building simulation environment. It was one of four institutions that constituted the *Energy-efficient building (EnOB)* accompanying team which ensures cross-project documentation of demonstration buildings and related research and practice-related activities. Special emphasis is placed on the term “zero-energy building” which is going to play a decisive role in the new-built (EnBau) and refurbishment (EnSan) sectors. TUD-IBK software can be used during planning phases to estimate the condensation risk of a construction under various environmental conditions, or to investigate the impact of thermal bridges. It can be used also to determine the causes of damage to constructions or materials, to test new materials for potential application areas and limits, and to help optimize materials accordingly.

<u>Key Personnel</u>

Prof. Dr. Raimar J. Scherer, the head of CIB, has about 30 years of experience in construction IT, including 25 years as full professor at TU Dresden at the University of Karlsruhe and several years of practice in the construction industry. His research activities include the broad spectrum of construction IT aspects as described under CIB above. He did his PhD in stochastic natural hazard engineering. Prof. Scherer is chairman of the European Association on Product and Process Modeling in the Building Industry, chairman of the German DIN group for Technical Product Documentation in construction, and member of ISO TC184/SC4, the German IAI, the International Joint Committee of Structural Safety and the D-GRID advisory board. Prof. Scherer has more than 200 scientific publications.

Prof. Dr. John Grunewald is managing director of IBK und professor for building physics at TUD since 2007. He was also associate professor and acting director of the Building Energy and Environmental Systems Laboratory (BEESL) at the Syracuse University, Department of Mechanical and Aerospace Engineering, NY, USA. Professor Grunewald has initiated and coordinated several research projects, such as the EU project INSUMAT and the German DFG Priority Programme Project SPP1122 “Prediction of damage processes in capillary porous building materials” (2001-2007). He received his doctoral degree at the faculty of civil engineering at TUD in 1997. He has 20 years of experience in modelling and simulation, software development and building performance applications.

Dr. Peter Katranuschkov is an engineer with nearly 25 years of experience in construction IT. Before joining CIB in 1995, where he currently holds the senior engineer position, he worked at the University of Karlsruhe for 3 years and as a developer of advanced CAD solutions for construction for more than 10 years. He was the chief development manager for CIB in the European ToCEE, ISTforCE, ICCI and InteliGrid projects. His accumulated know-how on product modelling (BIM, IFC, STEP), ontologies, distributed systems and SOA enables him to manage research teams of CIB and derive integrative views of the complex distributed processes in engineering projects. Dr. Katranuschkov has more than 80 scientific publications.

Dr. Gerald Faschingbauer, is a civil engineer with 8 years of experience in research and teaching in construction informatics. He joined CIB in 2002 and worked on seismic hazard analysis and probabilistic analysis of multi-layered media. His Ph.D. Thesis was on simulation-based system identification in geotechnical monitoring with focus on a description logic-based product and process model that allows integration of BIM with ontologies and combines BIM modeling with knowledge explication using logical reasoning. He will contribute to ISES especially with his experience in stochastics, ontology modeling and integration of BIM.

Mr. Ken Baumgärtel, is a computer scientist with specific knowledge in service-oriented architectures, web applications, web services and research in the field of IT component adaptation and Mashups. He will contribute to ISES as Oracle certified Java programmer with his experiences in component specification and the composition of heterogeneous components in one holistic system.

Dr. Andreas Nicolai is head of the Software Development and Traineeship Department at IBK since 2008. He did his Ph.D. studies at Syracuse University, USA, and he was research assistant at KU Leuven, Belgium. Dr. Nicolai has participated actively in the German DFG Priority Programme Project SPP 1122 “Prediction of damage processes in capillary porous building materials”.

2.2.2 Insinööritoimisto Olof Granlund Oy, Finland

Olof Granlund Oy (OG) is a Finnish building services consulting firm consisting of headquarters in Helsinki and subsidiaries in Lahti, Kuopio, Tampere, Vaasa and Moscow. It employs over 350 technical experts. Its core businesses are building services design, facility management consulting, energy consulting and the development and sale of design, facility management and energy performance evaluation software. It is the leading company in its field in Finland and has a subsidiary and strong presence in Russia, projects in several European countries and increasingly in the USA. Total sales in 2007 were 27 million Euros, with export shares of 17%.

Specific skills in relation to the project

In the development of integrated energy analysis and FM software Granlund is one of the leading companies in the world. It is a pioneer to widely implement building information models and other advanced ICT in design and facility management tools to generate reliable and timely information that supports clients' decision making processes throughout design, construction and management of facilities. OG software enables informed management of energy efficiency, environmental impacts and good indoor environment throughout the facilities lifecycle. OG will lead the evaluation of simulation results and the management of multi-models (**WP6**) and will provide its special knowledge for the adaptation of energy performance and cost simulation tools in a cloud-enabled environment (**WP7**).

Key Personnel

Mr. Tuomas Laine, M.Sc. in Mechanical Engineering, Manager for R&D at Granlund, has 22 years’ experience in energy simulation and mechanical engineering and 17 years’ experience in research and development. He has been heavily involved in the development of processes and tools utilizing BIM and IFC data transfer since 1996. He has actively participated in the work in IAI / BuildingSMART in the Implementation Support Group (ISG) and the development of Information Delivery Manuals. He is the author of Finnish BIM guidelines for building services design: “ProIT product modeling guidelines for the construction industry” (2007) and “BIM guidelines for Senate Properties” (2007). His special interests are in virtual technologies and advanced energy and environment analysis and simulations.

Mr. Antti Karola, M.Sc. in Mechanical Engineering, has 16 years' experience in ICT research and development. He has carried responsibility of energy simulation software development at Granlund for 12 years. His special interests are in interoperability and BIM-based processes supporting building energy analysis. He has worked at the simulation research group in Lawrence Berkeley National Laboratory, USA in 1999, participating in the development of the D.O.E-2.1E and EnergyPlus energy simulation engines.

Dr. Piia Sormunen, Ph.D. in Mechanical Engineering has expertise in energy efficiency in building process, reporting building systems for operation phase and energy auditing. Special interests: capturing and managing the client requirements and value creation throughout the facility lifecycle.

2.2.3 University of Ljubljana, Slovenia

The University of Ljubljana (UL) is the largest University in Slovenia, with over 56,000 students and 3,700 staff. In ISES it will be represented by the Institute of Structural Engineering, Earthquake Engineering and Construction IT (ISE) at the Faculty of Civil and Geodetic Engineering (FGG). UL-ISE has considerable experience in participation and management of international projects. In 1993, it was among the first in the field to start publishing on the Internet and the WWW (among the first 1,000 Web servers worldwide) and to study the role of communication media on industry practice. Over the last 35 years UL-ISE has developed into the largest teaching and research unit at FGG and is mainly involved in three fields: (1) structures, (2) earthquake engineering and (3) construction information technology. Through the FGG-founded company "Institute FGG", looking at exploiting research results commercially, the institute already sells engineering analysis software as well as an integrated suite of applications. UL-ISE has been working on several EU TEMPUS and ERASMUS projects, in the Esprit projects ToCEE, SCENIC and ETTN-CONNET and in the IST projects ISTforCE, ICCI and ProdAEC. It has been co-ordinator of the FP5 IST project SciX and the FP6 IST project InteliGrid (InteliGrid.eu-project.info), and technical co-ordinator of the FP6 IST project DataMiningGrid (www.dataminninggrid.org). The institute hosts the first Web based academic journal ITcon (www.itcon.org), the bibliographic database CUMINCAD (cumincad.scix.net) and many others.

Specific Skills in Relation to the Project

UL-ISE has great competences in the field of data management, service-oriented architectures and the development and integration of web services. This knowledge is applied in the fields of cloud, grid and high-throughput computing, where the usage of multiple computer resources over long periods is addressed. In the scope of the ISES project UL-ISE will mainly focus on semantic technologies for the development of a system ontology (**WP3 leader**) and on intelligent workflow definition for the cloud-enabled simulations (**WP7 leader**).

Key Personnel

Prof. Dr. Žiga Turk is the chair in Construction Informatics at the Faculty of Civil and Geodetic Engineering at the University of Ljubljana. Born in 1962, he holds a B.Sc. in Civil Engineering, M.Sc. in Computer Science and Ph.D. in technical sciences. His academic interests include construction informatics (construction information technology), computer integrated construction, internet, Web and grid computing, design communication, philosophy of conceptual modeling and CAD. In 2007 and 2008 dr. Turk was a Minister for growth in the government of Slovenia and chairman of the national Sustainable Development Council. During the Slovenian presidency to the EU, he was in charge of the updates to the Lisbon Strategy and involved in the management of the energy and climate change package.

Dr. Matevž Dolenc, born 1969, holds B.Sc. and Ph.D. in Structural Engineering from the University of Ljubljana. He was an invited speaker at several international conferences and lectures on HPC for Engineers. His academic interests include construction information technology, design communication, the Web and grid/cloud computing. He has technical expertise in client-server systems, component-based and service-based software development, grid/cloud technology, high-throughput and high-performance computing systems, open standards, and open source technologies. He participated in many national and EU projects.

Dr. Robert Klinc holds B.Sc. and Ph.D. in Structural Engineering from University of Ljubljana. His research interests are oriented towards computer-integrated construction, communication in construction, mobile computing and Web 2.0. He is also responsible for the technical support of the Journal of Information Technology in Construction (ITcon) and more than 30 other Web places.

2.2.4 SOFiSTiK Hellas S.A., Greece

SOFiSTiK Hellas S.A. is a Greek software house focusing in the area of structural and mechanical engineering. SOF offers state-of-the-art software tools for bridge engineering, structural steel, tunneling, and wind loading on structures resulting from CFD calculations, aerodynamic plus fluid-structure interaction problems, and energy-related design optimizations of structures and mechanical components. SOF works intensively together with leading software companies in Germany and acknowledged Greek experts, including Greek Technical Universities R&D teams. Besides software development SOF delivers engineering consulting activities, especially in the areas of reinforced concrete design, the mechanical behavior of structures and energy performance. With a portfolio of about 400 customers it belongs to the most prominent engineering consulting offices in Greece, and is among the first 50 in South and East Europe. SOF has extensive experience in cooperating with partners in international research projects and has the ability to market their results. The company has been taking part in several EU projects such as COMBI, ToCEE, INSIDE, InteliGrid and the FP7 project SARA.

Specific Skills in Relation to the Project

SOFiSTiK provides a wide spectrum of knowledge in numerical methods, CFD computations, energy simulations, geometrical modelling of complex geometries and the engineering of analysis software. SOF expects the following from the project: (a) to develop an advanced software product which will provide the company with a decisive competitive advantage; (b) to be able to offer its existing customers new advanced versions of its products with enhanced cloud computing capabilities; (c) to gain more experience on a new promising market for energy simulation and energy efficiency applications; (d) to gain experience on evaluation of results of real tests; (e) to gain experience on building models according to IFC; and (f) to provide to its customers the innovative capability of a use-and-pay-per-demand HPC environment. SOF will provide its special knowledge about numerical methods to the intelligent search services (**WP4**) and the stochastic profile-based multi-model combiner (**WP5**). It will also be active in the adaptation and re-engineering of existing simulation tools for their most efficient use on cloud.

Key Personnel

Dr. Byron Protopsaltis, has more than fifteen years' experience in developing and marketing software solutions for mechanical and civil engineering. He has been responsible for many finite element computations in large structural engineering projects and was one of the leading developers in the EU projects COMBI, TOCEE, INSIDE and ISTforCE as well as three national funded research projects where he has been technical or exploitation manager. He is the editor of five books about SOFiSTiK Software and structural analysis. Dr. Protopsaltis is shareholder of SOFiSTiK Hellas.

Dr. Theodora Pappou has worked for more than 15 years in Research and Application Projects in the field of Computational Methods in Fluids, Aerodynamics, Structures, Fluid-Structure interaction problems, Optimization Techniques and 3D mesh generation techniques. She has published scientific results in more than 20 papers in international journals and conference proceedings. Dr. Pappou has been engaged in all the European research projects where SOF has participated.

Mr. Sotiris Bitzarakis has graduated at the Civil Engineering Department of the University of Athens. After his study he joined a postgraduate group in the same university where he worked on research about parallel algorithms. Mr. Bitzarakis has published numerous papers on numerical techniques and design for structural and mechanical engineering products. His research interests include finite elements and parallel computation techniques as well as wind influence on structures.

Thrasos Rekouniotis has extensive experience in designing applications with object-oriented languages and the Microsoft Development Environment. He has been engaged extensively in the European Projects ToCEE ISTforCE and INTELIGRID where he worked on product modeling within a CAD environment and on Java Client applications for accessing process, product data and document servers as well as on implementing applications for Grid and Cloud computing. He has long experience on data exchange using IFC and STEP and will be the leading programmer of SOF in these areas.

2.2.5 Nyskopunarmidstod Islands, Iceland

NMI, Nyskopunarmidstod Islands (Innovation Center Iceland), operates under the Ministry of Industry and receives revenue from both the public and private sectors. The Innovation Center is a leading institute in technological R&D in Iceland. It is a multidisciplinary research institute with research areas ranging from material, environmental and energy to nano and building technology. Projects include applied and basic research in these key areas, consultation and technology and knowledge transfer. NMI has technical divisions in Concrete Technology, Building Technology, Geology and Soil Mechanics, Road Research and ICT in Construction. NMI maintains a close relationship with organizations and associations in the construction industry, universities, energy companies and the Energy Office.

Specific Skills in Relation to the Project

The unit in this project provides expertise in sustainable design and construction, service life planning, LCC, LCA, environmental assessments, renewable energy, energy performance and energy efficiency of new and existing buildings and ICT development including domain semantics, usage scenarios, information modelling and management, web-service and Internet technologies and interoperability. The institute has participated in over 70 EU and international R&D projects in the field of building and construction. In the ISES project, NMI mainly focuses on the definition of energy profile and consumption patterns for built facilities and their components (**WP4 leader**).

Key Personnel

Mr. Gudni Gudnason is the Manager of Computer and Information Systems since 1987, with special skills on R&D in Construction Informatics. His current interests focus on ICT and Building Information Modelling for sustainable buildings and facilities management. He has participated in state sponsored programs on energy efficiency and developed and maintains several on-line information products. He has been the coordinator of national R&D projects and partner in the EU funded projects I-SEEC (2000) and SciX (2001), ECO-SERVE (2003), CONNIE (2004) and the Nordic funded projects eProCon (2002) and AO Barometer (2009). He is a board member in BIM Iceland, the LCC working group and the National Specifications working group.

Dr. Bjorn Marteinsson is research specialist in thermal insulation and energy efficient building technology for new and old houses, e.g. development of building elements and components and (re-) insulation of walls and roofs in buildings, building damages and durability and service life planning (SLP). He has participated in Scandinavian projects and working groups on behalf of NORDTEST and also international projects and working groups; Nordtest (1982-2000), EUREKA project EU 615 EUROCARE WETCORR (1990-1994), the CRAFT project “GECA - wood composite elements” (1998 – 2000), the CRAFT project “Low energy heat engine ” (2000 – 2001), LIFETIME an EU-GROWTH Thematic Network (2002 – 2005) and the Nordic projects LCC – for byggverk (2002 – 2005), Weather Protection Systems (2002 – 2005) and SURE (2009).

2.2.6 National Observatory of Athens, Group Energy Conservation, Athens, Greece

The National Observatory of Athens (**NOA**) is a public organization founded in 1842, in Athens Greece. NOA has five institutes and is among the leading research organisations in Greece. As a public organization, it operates under the auspices of the General Secretariat of Research and Technology, Ministry of Education. The Institute for Environmental Research & Sustainable Development (**IERSD**) at NOA covers the fields of energy planning and conservation, renewable energy sources, meteorology, climatology, atmospheric pollution, water resources, and GIS. The **Group of Energy Conservation (GREC)** is an entity within IERSD at NOA, active since 1995 through research and development in energy efficiency issues, focusing in the building sector. GREC activities cover energy conservation, thermal and solar building applications, building renovations, analysis and numerical modelling of thermal energy systems, building energy audits, thermal simulations, indoor environmental quality assessment, HVAC systems with an emphasis on solar cooling, large scale solar heating systems, solar radiation and meteorological measurements, and related software development. Over the years, GREC-IERSD-NOA has concluded over 36 European and national projects, collaborated with international and national organisations, the European Commission and industry. GREC has published over 180 papers in international journals, books and conferences, and over 160 technical reports.

Specific Skills in Relation to the Project

NOA will offer expertise, in-depth knowledge and access to a calculation engine for performing building energy use calculations and building thermal performance based on the EPA-NR software, in compliance with existing European EN standards. It will work in ensuring compliance with revised or new relevant EN standards treating, for example, passive building systems, preparation of enhanced libraries etc. In addition, NOA will provide computational and programming capabilities for software adaptation in compliance with the ISES requirements in an effort to couple the building energy calculation engine with the data from other models. The usage scenarios focusing on the building stock and the validation and energy efficient building design are further know-how that NOA will share with main focus on **WP4** and **WP5**.

Key Personnel

Dr. Constantinos Balaras is mechanical engineer and Research Director at GREC. He holds Ph.D. (1988) and M.Sc. (1985) in thermal sciences from the School of Mechanical Engineering, Georgia Institute of Technology, USA and B.Sc. (1984) in energy from the School Mechanical Engineering, Michigan Technological University, USA. He is engaged in numerous activities in the areas of energy conservation and rational use of energy in buildings and industry, development of methodologies and software for energy audits and assessment of buildings (EPA-NR, EPA-ED, EPIQR, INVESTIMMO, TOBUS, XENIOS), national EPBD implementation and development of the national regulations and technical guidelines, air conditioning, solar energy, indoor environmental quality, renewable energy facilities and HVAC systems.

Dr. Elena Daskalaki is a Buildings Natural Environment Research Associate (C Division). She holds Ph.D. (1998) Physical built environment, M.Sc. (1990) and B.Sc. Physical Environment (1987) from the Physics Department of the Faculty of Sciences of the University of Athens. Her activities are in energy saving, thermal simulations of buildings, buildings CFD applications, computational analysis and natural ventilation.

Athena Gaglia is a M.Sc. (2004) in Production and Energy Management from the National Technical University Athens. Her activities are in savings and energy management, energy audits of buildings, design and dimensioning of electromechanical installations, calculating energy loads, and renewable energy sources.

Calliopi Droutsa is a M.Sc. (1995) and B.Sc. Physical Environment (1992) from the Physics Department of the Faculty of Sciences of the University of Athens. Droutsa's activities are in savings energy, renewable energy, environmental impacts of energy use, indoor air quality and software programming (EPIQR, TOBUS).

2.2.7 Leonhardt, Andrä und Partner, Germany

Leonhardt, Andrä und Partner (LAP) was founded in 1939. It is a leading German design company in the field of structural engineering, and especially in structural dynamics. New calculation methods have been developed and transferred into computer programs which simulate the dynamic loads and the reaction of the structure as a linked system and also visualise the performance of the structure via monitoring the results on screen. In this way the design of different structures has been improved, e.g. bridges, towers and computer chip production plants. Together with partners and collaborators, LAP has contributed decisively to the development of incrementally launched bridges, cable-stayed bridges, suspended roofs, post-tensioning systems, Neopot bearings, shear comb connectors. Newer areas of interest include the design of "green" facilities and zero-energy housing.

Specific Skills in Relation to the Project

LAP provides expertise in design and construction, usage scenarios, information modelling and management. It has developed calculation methods which simulate the dynamic loads and the reaction of the structure as a linked system and also visualize the performance of the structure in multiple domains (structural response, energy performance, emissions etc.) via monitoring the results on screen. With that knowledge LAP has been engaged extensively in many national and European projects in the past. In ISES, LAP will lead the definition of requirements for energy efficient design and life-cycle simulation (**WP1**) and is strongly involved in the development and the practical pilot implementation of the Virtual Energy Lab (**WP9**).

Key Personnel

Mr. Sven Zschippang, Diploma at the Technische Universität Cottbus 1994, has 17 years' experience in construction and design. He has particular expertise in managing projects and is also responsible for the quality management of LAP. He has published several journal and conference papers about the construction of glass roofs.

Mr. Matthias Kahl, Diploma at the Technische Universität Dresden 1993, has 18 years' experience in structural design and is a qualified planner for supporting structures. During his work at LAP he gained great experience in managing R&D projects. Mr. Kahl is the head of LAP Dresden and will provide integrative expertise for several end-user domains targeted by ISES.

2.2.8 Trimo d.d., Slovenia

Trimo is engaged in the engineering and production of pre-fabricated buildings. It is a high-tech company providing with its product range comprehensive solutions in steel prefabricated buildings, roofs and facades, steel structures and containers. The company has production facilities in Slovenia, Russia, Serbia and the United Arab Emirates. Its products are sold in more than 40 countries around the world through an extensive network of companies, offices and agents. Trimo is high above the industry average in value added per employee, share of exports and R&D investments and has been recognized as one of the most innovative Slovenian companies receiving a significant number of awards and prizes in the field of development and innovation.

Specific Skills in Relation to the Project

Trimo holds a number of patents relevant to the building sector and will be strengthening the consortium with product development know-how. In addition to the central R&D Department and a registered R&D Centre, the Trimo group established the company CBS Institute, with 40 researchers. It is regularly invited to various international meetings for exchange of practice in business processes and innovative practices. The core activity of the CBS Institute is research & development in new construction materials, elements and structural systems where there is a possibility for marketing to other interested companies and organizations. Trimo will provide its expertise in the development and specification of the energy profile and consumption patterns (**WP4**), the product catalogues and the use cases for new product design (**WP1**, **WP4**) and will lead the development, configuration, deployment and demonstration of the Virtual Energy Lab (**WP9**).

Key Personnel

Viktor Zaletelj obtained a Ph.D. in the field of mechatronics systems at the Faculty of Mechanical Engineering of the University of Ljubljana. He is actively engaged in the research of supervisory and complex adaptive systems, with special emphasis on fine-grained agent software architectures for modelling, control, and collaboration. His research covers the domains of manufacturing, hypermedia technology and its application to information management and supporting tools. He is head of Systems Development at the Trimo Company and is currently actively involved with the development of interactive facade system, where local autonomy of highly redundant small dedicated systems and their collaboration play a vital role for the next generation of building skin and building itself.

Boštjan Černe, Mech. Eng., Ph.D. (2006), is involved in research and solution development in the field of heat and mass transfer, renewable energy sources and energy efficiency in buildings. During that work he gained experience in design and thermal analysis of different types of radiators, convectors and solar collectors. He was responsible for calculation and optimization of building energy efficiency together with day lighting distribution.

Ludmila Koprivec, obtained a Ph.D. for the development of a new classification of materials suitable for use in façade wrapping that has not yet been presented in the field of architecture. She identified the advantages and disadvantages of different families of materials and their importance in the facade. Koprivec' main focus is on technological, aesthetic and economic impacts, which are important catalysts for the further development of a modern building envelope. These skills are essential for the application to the facades as they may contribute to innovative approaches and, consequently, progress in the development of new cladding systems.

Miha Kavčič is head of the Research Centre, focused on developing new material and new sustainable solutions for building envelope. He developed new insulating materials with low embodied energy based on natural materials. Beside material optimisation, he designed a technology to set up a pilot plant and with new-insulating materials he developed several solutions with combination of traditional materials and solutions. Mr. Kavčič will be particularly interested in the development and use of stochastic patterns for better life-cycle energy consideration of new material performance.

2.3 The consortium as a whole

2.3.1 Consortium Overview

The ISES consortium features a mix of 8 partners from 5 European countries, covering the whole knowledge transfer chain and all key areas of research and development relevant to the project goals. They represent 4 types of market segments:

- **End Users (TRI, LAP)**. End-users are construction companies and component product developers, architectural and engineering companies which respectively will apply the ISES software and which are the drivers of the project. They provide the knowledge on the business processes, the needs of the component product developer and the building operators/owners, the workflow and orchestration process information needs, the granularity of the models and the management of multi-models. LAP and TRI are focused on the design and construction and offer architectural and engineering services. Their skills and business objectives are complementary.
- **Software developers (OG, SOF)**, whose major functions are to provide (a) software from architectural design (CAD), building operation (FM) and energy analysis and (b) provide the human resources and knowledge for the development work for enhancing the basic software, development of web-services and navigator and to prototype them. Both are highly complementary. SOF covers the computational engineering and stochasticity aspects, whereas OG covers the life cycle management and energy aspects (FM). OG is focused on engineering services for energy efficiency design and operation (energy part).
- **Academic organisation (TUD, UL)**. Two institutes of TUD provide the scientific knowledge on (a) energy analysis, (b) BIM, interoperability, ontology, (c) SOA architecture and orchestration and (d) stochastic modelling. They are highly complementary, namely TUD-CIB is expert in BIM, SOA, interoperability and UL is expert in cloud computing and related orchestration, management and ontologies. TUD-IBK is expert in energy analysis and provide own sophisticated software to complement OG.
- **Research institutes (NMI, NOA)**. They provide the knowledge on BIM modelling and management, including model view, transformation, mapping and interoperability and the knowledge in climatic, usage and user activity modelling.

The consortium is well-balanced from the point of view of the 3 different technology areas to be merged in the project, namely:

- **Energy Life Cycle and Cost Analysis** - we have a software developer (OG), an academic partner (TUD-IBK), and three end-users (OG, LAP, TRI) for facility management, design of facilities and design of component products as well as construction of facilities, respectively.
- **Distributed SOA Systems and Cloud computing** - we have two academic partner (TUD-CIB, UL) and one software developer (OG) who have professional implementation knowledge,
- **BIM and ontology** - we have two academic partners (TUD-CIB, UL), one research institute (NMI) and two software developers (OG, SOF) who are experts in BIM and related services.

The consortium comprises a balanced group of three types of organisations, namely:

- **2 SMEs**: SOF, LAP
- **1 Medium-sized company:** OG
- **1 Large companies**: TRI
- **2 Research organisations and Government**: NMI and NOA
- **2 Academic partner**: TUD (CIB, IBK) and UL.

All of them are working internationally, participate in international industrial projects or are involved in EU research projects and in international work and standardisation groups.

The **complementary know-how of the partners** that is needed to guarantee the success of the project, thereby justifying the allocated RTD efforts and the European dimension of the research is schematically outlined on the figure below. The detailed participant profiles and their relevant know-how and roles in the project have been provided in section 2.2.

#	Work packages	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI
1	WP1: Requirements for ICT-Enabled Energy Efficient Design and Life-Cycle Simulation	▒	▒	▒	▒	▒	▒	■	▒
2	WP2: Architectures, Components and Stochastic Approach	■	▒	▒	▒				
3	WP3: Model and System Ontology of the Overall Framework	▒	▒	■		▒			
4	WP4: Energy Profile and Consumption Patterns for Built Facilities and Their Components				▒	■	▒	▒	▒
5	WP5: Multi-Model Combiner and Simulation Configurator	■			▒	▒	▒	▒	
6	WP6: Multi-Model Manager and Simulation Evaluator	▒	■						▒
7	WP7: Intelligent Cloud-Enabled Multi-Model Energy Simulations		▒	■					
8	WP8: Dissemination and Exploitation of the Project Results	▒		▒	■		▒		
9	WP9: Pilot Virtual Lab and Public Demonstrators		▒		▒		▒	▒	■
10	WP10: Project management	■							

Note:
Black boxes denote the WP leader, grey boxes – strong contribution, white boxes – no or minor contributions.

Fig. 6: Overview of the complementary competence and know-how of the consortium partners in the project

2.3.2 Subcontracting and Other Countries

Not applicable.

2.3.3 Partner Overview

Part. no.	Participant legal name	Org. Type	Key competencies	Role in the project
1a DE	TUD – Institute of Construction Informatics (co-ordinator) **TUD-CIB**	University	BIM model hierarchies, data management, interoperability, model mapping, model view, SOA, web services, orchestration, ontologies,	Academic research and development Leader WP 2,5,10 Project manager
1b DE	TUD – Institute for Building Climatology **TUD-IBK**		Energy and comfort analysis methods and software tools	Academic research and development
2 FI	Olof Granlund Oy **OG**	Industry	Energy consumption, lifecycle FM methods and software, SOA, web services and end-user (provide engineering services), cost estimation software	S/W developer, integrator and consultant Leader WP 6
3 SI	University of Ljubljana **UL**	University	Data management, SOA, web services, cloud/grid computing and high-throughput computing	Academic research and development, Leader WP 3,7
4 GR	SOFiSTiK Hellas S.A. **SOF**	Industry	Numerical methods, CFD computations, modelling of complex geometries and the engineering of analysis software	S/W developer, integrator and consultant Leader WP 8
5 IS	Nyskopunarmidstod Islands **NMI**	Research	Sustainable design and construction, service life planning, LCC, LCA, environmental assessments, renewable energy, energy performance and energy efficiency	Developer and knowl. provider Leader WP 4
6 GR	National Observatory of Athens **NOA**	Research	In-depth knowledge and access to a calculation engine for performing building energy use calculations and building thermal performance	Developer and knowl. provider
7 DE	Leonhardt, Andrä und Partner **LAP**	Industry	Detailed design, construction engineering, site supervision, facility designer of technical and engineering aspects.	End user, Leader WP 1
8 SI	Trimo d.d. **TRI**	Industry	New construction materials, elements and structural systems. Component product and facility developer.	End user, Leader WP 9

2.4 Resources to be committed

The proposed budget for ISES is 4.389.850 EUR. The breakdown into type of activities and type of partners is shown in the table below. The eight consortium partners mobilise the critical mass of necessary ressources for success. They are willing to commit the necessary resources, which means 1.399.969 EUR, i.e. 32% of the total budget. The funding rate is 68% respectively. The project costs have been calculated using the most economic and appropriate means for each partner to ensure quality of the results within the allocated timeframe and budget. Each of the project partners evaluated the costs to enable the project to be successful.

RTD	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI	Total
Number of Person months	73	58	53	58	37	32	26	27	364
Personnel costs	379600	504600	265000	398750	141525	92800	115700	113400	2011375
Travel	24500	21000	18500	21000	16000	15000	12000	15000	143000
Subcontracting	0	0	0	0	0	0	0	0	0
Other Specific Project costs	2000	0	5000	0	0	0	0	0	7000
Total other direct costs	26500	21000	23500	21000	16000	15000	12000	15000	150000
Total RTD direct costs	406100	525600	288500	419750	157525	107800	127700	128400	2161375
Overhead RTD costs	243660	420480	173100	251850	220535	64680	121315	25680	1521300
TOTAL RTD	649760	946080	461600	671600	378060	172480	249015	154080	3682675
% Requested	75%	50%	75%	75%	75%	75%	75%	50%	
EC RTD contribution	487320	473040	346200	503700	283545	129360	186761	77040	2486966

DEMONSTRATION	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI	Total
Number of Person months	3	6	3	6	3	8	8	13	50
Personnel costs	15600	52200	15000	41250	11475	23200	35600	54600	248925
Travel	0	0	0	0	0	0	0	0	0
Subcontracting	0	0	0	0	0	0	0	0	0
Other Specific Project costs	0	0	0	0	0	0	0	0	0
Total other direct costs	0	0	0	0	0	0	0	0	0
Total DEMO direct costs	15600	52200	15000	41250	11475	23200	35600	54600	248925
Overhead DEMO costs	9360	41760	9000	24750	16065	13920	33820	10920	159595
TOTAL DEMONSTRATION	24960	93960	24000	66000	27540	37120	69420	65520	408520
% Requested	50%	50%	50%	50%	50%	50%	50%	50%	
EC DEMONSTRATION contribution	12480	46980	12000	33000	13770	18560	34710	32760	204260

MANAGEMENT	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI	Total
Number of Person months	18	2	2	2	2	2	2	2	32
Personnel costs	93600	17400	10000	13750	7650	5800	8900	8400	165500
Travel	2500	0	2500	0	2000	0	0	0	7000
Subcontracting	0	5000	0	5000	0	2500	2500	2500	17500
Other Specific Project costs	0	0	0	0	0	0	0	0	0
Total other direct costs	2500	0	2500	0	2000	0	0	0	7000
Total MANAGEMENT direct costs	96100	17400	12500	13750	9650	5800	8900	8400	172500
Overhead MANAGEMENT costs	56160	13920	6000	8250	10710	3480	8455	1680	108655
TOTAL MANAGEMENT	152260	36320	18500	27000	20360	11780	19855	12580	298655
% Requested	100%	100%	100%	100%	100%	100%	100%	100%	
EC MANAGEMENT contribution	152260	36320	18500	27000	20360	11780	19855	12580	298655

TOTAL	TUD	OG	UL	SOF	NMI	NOA	LAP	TRI	Total
TOTAL BUDGET	826980	1076360	504100	764600	425960	221380	338290	232180	4389850
REQUESTED EC CONTRIBUTION	652060	556340	376700	563700	317675	159700	241326	122380	2989881

Other costs are allocated for **travel** (with approximately 4 travels per person year), **equipment** (computer hardware for the cloud test-bed) and **subcontracting for audits** as follows below:

Issue	Costs per participant
RTD Activities;	
Travels	**TUD** 27.000 EUR; **OG** 21.000 EUR, **UL** 21.000 EUR, **SOF** 21.000 EUR, **NMI** 18.000, **NOA** 15.000 EUR, **LAP** 12.000 EUR, **TRI** 15.000 EUR.
Equipment	**TUD** 2.000 EUR; **UL** 5.000 EUR.
Management Activities	
Subcontracting for audits:	Two audits (5.000 EUR) for those organisations that receive an EC contribution higher than 375.000 EUR, i.e. **OG** and **SOF**, and one audit (2.500 EUR) for **NOA**, **LAP**, **TRI**. *Note: TUD, UL and NMI have approved internal audits which are calculated as part of the direct costs for management.*

The following figures show the person-month and budget distribution among the ISES participants, and on country level. They show the ballancing of the work load within the Consortium as well as its ballanced European dimension (Germany, Greece, Slovenia, Finland, Iceland) in terms of expertise and project participation.

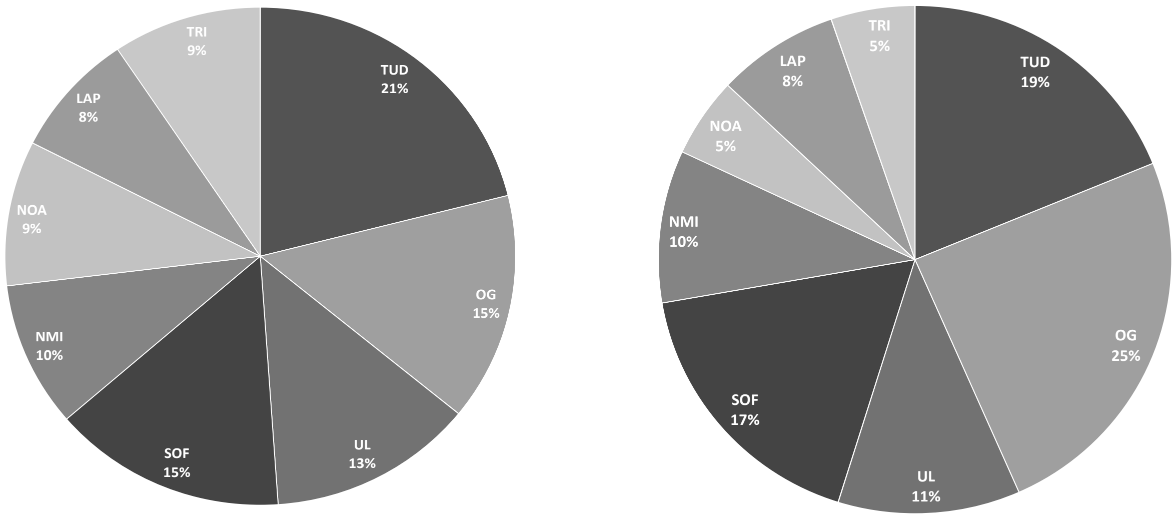

Fig. 7: Person Month distribution (left) and Budget distribution (right) per partner in %

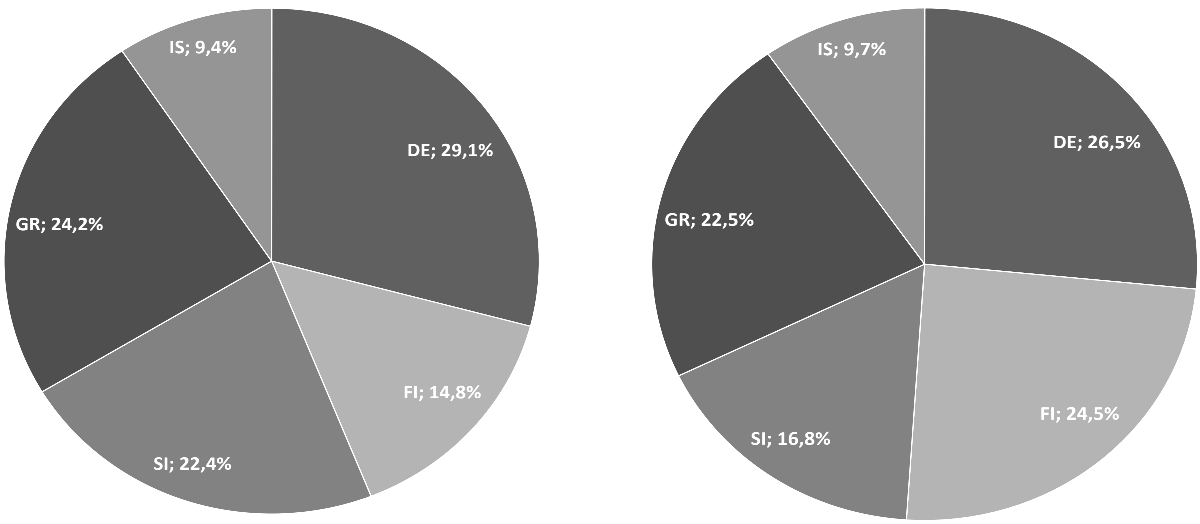

Fig. 8: Person Month distribution (left) and Budget distribution (right) per country in %

Section 3: Impact

3.1 Expected impacts listed in the work programme

3.1.1 Impact Domains

The main impact of ISES is the supply industry for the construction domain and the construction industry itself. The construction section is responsible for 40% of the energy use and 30% of greenhouse gasses emitted. The ISES virtual energy lab will have a big impact on the reduction of these energy consumption and emission, because:

Firstly, ISES provides a virtual lab to product developers, which allows the development of highly energy-efficient and emission-efficient and at the same time cost-balanced component products. With the lab, these products can be tested and validated their products under development virtually in the host products, i.e. the facilities and buildings and hence together with other component products which configure the host system. ISES will close a big gap that exists today and which has been identified as one of the main reasons why the target energy-efficiency of component products in the host product cannot be realized, because the component product is about developed independently from the host product today. Only some requirements or very simplified assumptions about the host product, its system and context can be modelled. Actual CAD systems for product design are mechanical or electrical CAD systems, which do not provide adequate modelling capabilities for facility or building modelling, nor exist libraries with models of characteristic facility or building which can be used for component product testing. Therefore today, full scale tests are needed, which are very cost-intensive and are single representative examples of the host product, i.e. the facility or building. Variants of the host product are even not imaginable. ISES virtual energy lab would allow extensive tests of virtually new component products in all variations of the host product and hence on low-cost basis before expensive realization. Therefore it is expected that ISES virtual energy lab will have a considerable impact on improving energy and emission reduction of facilities and buildings through the validated improvement of functionality of component products by about 30% or even more. ISES strongly contributes to the reduction of energy and CO_2 emission and contributes to the delivering a sustainable, low-carbon society and helps lessen the negative impact of our built environment on climate and on energy consumption.

Secondly, ISES provides a concurrent engineering design tool to the facility and building designers allowing them to optimize energy-efficient facilities and buildings and tests and hence validate their designed complex energy systems under virtual stochastic life-cycle conditions and overcome the today's praxis of designing facilities and buildings by architects independently from their energy analysis done by service engineers and more than that the stochastic life-cycle, which is simplified today by assumed deterministic one-year time histories for the climate. The advanced ISES capabilities will have an impact of lowering the energy demand and green gas emission of facilities and buildings by at least further 20% and at the same time reducing reinvestment costs for malfunctioning energy systems of built facilities and buildings.

Thirdly, ISES will open the green building and facility market for the general ICT industry, too, because ISES provides an integrated virtual energy design and test lab on an open SOA basis with full modelling of any possible facility and building providing the integration of STEP models of component products in the BIM model of facilities and buildings. Further on, the open SOA allows the integration of mechanical and electrical engineering tools and third-party ICT building blocks and is a basis to integrate and test ICT control equipment of the Building Automation Systems, too.

3.1.2 Matching of the expected impact to the topics listed in the call

The project addresses the different key items of the *call text* as follows:

Definition of energy profiles and energy consumption patterns and their interrelation to support the development of ICT building blocks addressing energy efficiency and CO2 emissions reduction. Incorporation of these building blocks into one of the following types of systems:
Systems to support development and planning. Examples are: modeling, simulation and design tools to assess the full life-cycle energy associated with new products and systems before their realization: decision

support systems for urban planning to provide an understanding of the system implications, in terms of energy-performance and cost-effectiveness, of different design and planning alternatives.
ISES will develop ICT building blocks to enhance existing design tools and systems to an integrated virtual energy lab in order to design holistic energy-efficient products and facilities and test them before realization virtually for their possible life-cycle conditions acknowledging the stochastic life-cycle nature. In this context also stochastically useful energy profiles and energy patterns in particular climate profiles and user activity patterns will be developed and existing deterministic ones appropriately enhanced respectively.

Appropriate validation of the resulting systems. Based on defined indicators, during this phase, projects shall record evidence of energy savings and CO2 emissions reductions, total cost of operations versus potential benefits, user acceptance and replication potential and extract lessons that may be used in different settings.
ISES will validate the efficiency of the virtual energy lab through the design of a building component product in the state-of-the-art fashion of today and also through the application of the virtual energy lab and will oppose the resulting energy demand of a characteristic virtual facility with the product designed according to the state-of-the-art and another one designed in the virtual-energy-lab manner is built in.
In addition ISES will design a whole facility in the state-of-the-art fashion of today and with the virtual energy lab running a semi-stochastic life-cycle analysis and oppose the energy demand of both designed facilities.

In addition to partners with expertise in ICT, consortia must include partners from the relevant application domain. The final users must be involved in the validation phase but not necessarily as consortium partners.
The ISES consortium comprises two end-users, one component-product designer and producer and one facility designer, who are responsible for requirement analysis and validation. In addition, two energy and climate experts are partners, one from the Mediterranean climate zone and one from the very northern climate zone. Also, two ICT developers are partners, one is a facility software developer and at the same time facility management consultant, the other one is a structural engineering software developer and consultant, too. The two other remaining partners are academic ones, which are experts in engineering data modelling, ontologies, grid and cloud computing SOA, energy calculation methods and stochastic engineering methods.

Verifiable and transparent methods of measuring energy performance.
The ISES virtual energy lab allows to virtually model a complete facility with all technical energy system components and sensors and hence provides the possibility to run simultaneously to map the measure energy use and the sensor data and hence identifies the energy performance of the facility and energy system components in an objective way.

Strengthened and consolidated European excellence in engineering at the intersection of control engineering, computer science, communications technologies and power engineering.
The ISES RTD work will strengthen the European excellence in the intersection of applied computer science and engineering concerning product and facility modeling with ontology and description logic, high-performance computing, semi-automatic simulation set-up, multi-model management, navigation and evaluation.

Quantifiable and significant reduction of energy consumption and CO2 emissions, achieved through ICT.
Through the improvement of the design of component products and their assembly design to facilities and buildings concerning energy efficiency, ISES virtual energy lab will considerably reduce the energy consumption and CO2 emission of facilities, significantly and quantifiably (see above).

3.1.3 Policy Context and Expected Impacts

ISES will develop a cost-effective integrated energy, emission and cost simulator designed as a virtual lab for the design of facilities, supporting also the analysis of weaknesses in existing facilities to draw strategies for retro-fitting, and also to test and optimize building products and services before their realization in the facility concerning their energy and emission efficiency, maintenance and cost efforts. In addition it will provide a basis of integrative operation of ICT energy and non-energy control systems and hence will open the construction market for ICT providers.

The ultimate goal is to considerably reduce the energy need and emissions of new and existing facilities as well as interactively view the ICT control systems. This will be achieved through (1) an innovative ICT system, namely a SOA-based integrated system integrating actual in-depth tools and data bases, which will considerably increase the efficiency of design and decision-making of component products, facilities and buildings, (2) the re-engineering of the design, process and (3) the involvement of the owners in the decision process by providing them the technical results of the analysis and simulation in an easy-to-understand 3D building model based representation. ISES will contribute to the transformation of the EU industry from a (human) resource-intensive to a knowledge-intensive one and foster the use and further development of new technologies for the EE-building area, hence contribute strongly to economic stimulus packages.

The construction sector

The construction industry is the biggest industrial employer in Europe with 26 million workers and their products during usage are those, where most of the energy is used and emission produced. In the EU27[18] it is one of the biggest industrial sectors with an annual turnover of about 1,200 million Euros in 2006, what represents about 10.4% of the GDP. The great majority comprises SMEs, namely about 98%. The industry is very fragmented and due to the one-of-a-kind products and the one-of-a-kind projects (construction consortia) an in-depth planning and monitoring of the construction process is of utmost importance in order to guarantee a proper realization of the very complex energetic system of a facility.

Due to the high uncertainties concerning the dynamic life-cycle and due to the high complexity of the diverse energy systems assembled for a building from different providers, an in-depth simulation before realization as well as an intensive monitoring phase after commission is to be considered. Moreover, an in-depth analyse of the operation of the facility is required by an expert team co-operating via internet on a cost-efficient basis to tune the system, analyse gaps and ill-performances and work out overall cost-efficient retro-fitting strategies.

In this context the integration of building energy simulation and optimization and the design of buildings incl. shop floor drawings are a prerequisite to obtain this goal. The energy saving potential for new buildings is about 40%, whereas for old buildings this may increase up to 80%, where most of the potential is embedded in new supply products. The European building stock is consuming about 40-50% of the total energy and is responsible for about 30% of the carbon emission[19]. Only in a concerted action of product and facility designer, operator and service-business engineer during the design and operation phases supported by seamlessly integrated and interoperable tools, this savings potential can be activated.

Energy Policy

ISES will considerably contribute to achieve the mandate of the Action Plan on Energy Efficiency in Europe[20], which is a 20% saving by 2020 compared to the numbers of 2005 and will have stabilized the energy consumption at a level of 1990 by 2050 and contribute to EU energy independency. The contribution will have a leap effect, because about 90% of the EU wealth is invested in the built infrastructure (remark: about 8% in shares), which represents for Germany about 5,500 billion Euro and less than 0.5% a year are new buildings and up to 1.7% are refurbished buildings (if any small refurbishment is considered). Here the EU will increase this rate up to 3%. Therefore, the stronger impact may result from refurbishment and retrofitting of buildings. ISES is directed to both: new and refurbished buildings are included in its integrative view as well as the surrounding used as open space. ISES will increase the energetic investigation of new and existing buildings because the CAD-FM-integrated easy-to-apply sophisticated energy analysis tools will increase cost- and energy-efficient workout solution as well as because herewith it reduces considerably investment risks.

Environmental Politics

ISES will considerably contribute to the fulfilment of the Kyoto Protocol 1999[21] and related agreements, such as the Bali Declaration 2007 and the SET Plan that declares its target to reduce the greenhouse gas until 2020 by 20% compared to 1990 and to reduce CO_2 emissions by 60-80% until 2050. Due to the leap effect of renewing the building stock the efforts of the construction industry impacts more on the targets for 2050 and only partially on those for 2020. The scale of impact depends strongly on the activation potential of knowledge through easy to apply integrated concurrent engineering tools in collaboration environments and

[18] FIEC (European Construction Industry Federation)
[19] REEB, Roadmap, http://www.ict-reeb.eu
[20] Renewed in the SET Plan from 07.10.2009
[21] http://unfccc.int/resource/docs/convkp/kpeng.pdf

an integrative view and management of the complex energetic multi-systems under dynamic demands. Single tools, single views or single products and services do have mainly an under-potential impact.

Competitiveness Policy

On the Lisbon agenda[22] declaration was made to transform the EU industry from a resource-intensive to a knowledge-intensive one and at the same time to increase productivity and competitiveness of EU enterprises. ISES will contribute to this transformation. First, ISES will reduce the human-resource intensive working process for energy and emission efficiency design, re-design and retro-fitting and transform it to a knowledge-intensive one and second, ISES will decrease the consumption of energy and emission of buildings and publicly used facilities.

3.1.4 Steps needed to bring about these impacts

Besides a successful RTD work the following steps are needed

(1) A successful dissemination and raising awareness in the product designer and AEC community, construction companies and also among real estate companies and individual building owners but also among the ICT industry

(2) The integration of the whole value chain in design, simulation and testing of buildings and building components

(3) Best-practice cases based on the pilot platform, e.g. impressive use cases from practice with a sound comparative validation “before/after”

(4) A well-structured exploitation plans establishing a win-win situation for each partner to generate a strong team also beyond the project

(5) A strong technology implementation plan at the end of the project for the future commercial deployment of the project results

(6) The creation of possible joint ventures to multiply strength and investments of the partners for the commercialisation of the results

3.1.5 European Approach

Greenhouse effect, energy and emission efficiency of buildings are (1) global request, (2) influenced highly of the climatic zones of the building location and (3) the problem to be solved, namely sophisticated BIM, hierarchical modelling, BIM interoperability, BIM management, sophisticated 3D-BIM-CAD, sophisticated energy analysis and international experience in design and upgrading buildings need on the one hand side international experienced partners and second advanced knowledge in the above mentioned topics. This is hardly to be gathered on national level. To be a lean RTD team, the consortium is to be cross-disciplinary, where the partner should show in-depth knowledge in construction, ICT and energy analysis, at least in two of these three main top areas in order to obtain seamless, progressive cooperation. The partners should show experience in international industrial and/or RTD work and should show experience in at least national, better international RTD projects. To receive sustainable exploitation results, these result should have an international impact, hence partners with an international standing and profile are needed. The problem to be solved is impacting all EU member states. It should address the different needs of the different EU member states, which can only be fulfilled if a cross-European consortium is developing the solution. It requires enough critical mass and complementary skills around Europe. With 8 partners from 5 different EU member states the consortium reflects the EU dimension.

3.1.6 Other national and international research activities

The partners are involved in various national and international research projects from which account is taken for the RTD work of ISES. They are grouped in BIM-related, in Energy-related and in Computational Engineering projects.

[22] Lisbon European Council, Presidency conclusions, March 2000

BIM-related Projects

Project	Partner	ISES related project content
COMBI	TUD, LAP, SOF	Application of advanced IT methods, that can provide for integrating the activities of those involved in the design and construction process, reduce design errors and speed up delivery times.
ISTforCE Intelligent Services and Tools for Concurrent Engineering	TUD, SOF, UL	Open collaboration platform for integration of services and tools, infrastructure for online e-business by integrating seamlessly legal and financial transactions at all system levels.
InteliGrid Interoperability of Virtual Organizations on a Complex Semantic Grid	TUD, SOF, UL	The project is extending the semantic grid paradigm to support dynamic virtual organizations that collaborate on the design, production and maintenance of products that are described in complex, structured, product model databases.
BauVOGrid Grid-based platform for virtual organizations in the building industry	TUD	Success-oriented building planning and developing based on an effective co-operation and the efficient use of suitable information technologies supports of the virtual organization (VO).
ToCEE Towards a Concurrent Engineering Environment in Building and Engineering Structures Industry	TUD, SOF, UL	The primary goal of the project is to establish and validate in a software prototype a general methodology and an overall architecture of a concurrent engineering IT environment for the technical work to be done in the areas of the design of buildings, construction process planning, facility management, project management. As a basis of such environment a conceptual framework which decomposes an abstract concurrent engineering model into a set of hierarchically structured interrelated and interoperable modelling spaces, was developed.
Trans-IND	TUD	Development of an integrated design and construction process for the production of polymer bridges more cost efficient based on BIM-interoperability.
SARA	TUD, SOF	Development of an integrated design and virtual test lab for wind-induced buildings, based on an interoperable BIM environment.
Mefisto	TUD	Towards a 5D construction planning and management platform supporting simulation of production logistics and cost based on an interoperable BIM complemented by an ontology to seamlessly manage virtual enterprises and construction sites.
GeoTechControl Knowledge-based Service Platform for the Monitoring and Prognosis of Geotechnical Engineering Constructions	TUD	A simulation-based system identification method will be developed to interprete monitory data obtained continuously in geotechnical project in order to control and adopt the construction process and intervene in care of unsafe situations. The construction and geotechnical system is modelled in BIM and the overall monitoring and evaluation system is embedded in an ontology extended BIM model formulated in description logic.
InPro Open Information Environment for Knowledge-Based Collaborative Processes throughout the Lifecycle of a Building	OG	Set to achieve the development and deployment of an Open Information Environment that enables the various stakeholders in early design to collaborate based on the building information modelling principle. Energy analysis in early design is one of seven key processes that are in special focus of this project.

INSIDE Integrated simulation and design system for civil and structural engineering	SOF	The objective was to create a High Performance analysis and design tool for the Structural and Civil Engineering Industry, based on optimized, quality assured finite element solutions and parallel computing, integrated into a domain-specific CAD system.
BIM Guidelines	NMI	Development of guidelines for BIM/IFC handover model delivery to public clients.
VERK	NMI	Development of a national specification system, BIM based approach.
LCC-R	NMI	Development of LCC information system, LCC information modelling and integration with design tools.
ePROCON	NMI	Parametric building product information repositories, information exchange specifications and integration through open interfaces.

Table 3: BIM-related projects of all partners

Energy-related Projects

Project	Partner	ISES related project content
HESMOS ICT Platform for Holistic Energy Efficiency Simulation and Lifecycle Management Of Public Use Facilities	TUD, OG	Industry-driven holistic approach for sustainable optimisation of energy performance and emission reduction through integrated design and simulation.
REEB The European Strategic Research Roadmap to ICT enabled Energy-Efficiency in Building and Construction	TUD	Use ICT to support and develop “building Automation” and the improvement of energy-efficiency in the Built environment. REEB also structures the future R&D targets in terms of all ICT methods, models, applications and systems to support future energy efficiency.
ENOB Monitor	TUD	Documentation and scientific analysis of 60 Projects, where concepts for energy efficient refurbishment concepts of different building types have been developed.
Development of climate data sets for simulation-based design methods in civil engineering	TUD	Using GIS climate-nature-space relationships will be analysed in order to estimate future trends of climate for energy efficient building design
Development and calibration of a design tool for non-residential buildings with special room-climatic requirements	TUD	The project will enable fast simulation-based estimation and control of room temperature
Development of a dynamic hygrothermal room model and its integration into a multi-zone building simulation environment	TUD	The project is on modelling and software development in the field of building performance simulation. It focuses on a dynamic hygrothermal room model and building envelope and its integration into a multi-zone building simulation environment
INSUMAT	TUD	Test and simulation of surface-active insulation at real buildings
Annex 41 Whole Building Heat, Air and Moisture Response (MOIST-ENG)	TUD	Acquire better knowledge of the whole building heat, air and moisture balance and its effects on indoor environment, on energy consumption for heating, cooling, air humidification , air drying, and on the envelope's durability
BuildingEQ	OG	Strengthen the implementation of the EPBD (Energy Performance of Buildings Directive) by linking the certification process with commissioning and optimization of building performance and that way to intelligize building energy management.

HosPilot	OG	Develops a holistic solution and service to tailor, install and tune an ICT based system that will significantly reduce the energy consumption - regarding lighting and HVAC - in a hospital environment.
AUTEG	TUD	Automatic design of networked building automation systems, based on BIM and product data bases
InsituAPC	TUD	Advanced process control in energy consuming plants for process-, manufacturing- and building industries
AUDRAGA	TUD	Automatic design of wireless networked building automation systems, based on BIM and product data bases, including prognosis of network load, real time constraints and energy consumption
AUTAGEF	TUD	Monitoring of user activities in buildings, development of activity models by machine learning
3D-MAS Funded by the Hellenic General Secretariat for Research and Technology (GSRT)	SOF	The purpose of the project was the development of integrated software for three-dimensional modeling and discretization of tunnels, and more accurate, enhanced with additional design criteria multi-stage tunnel analysis.
ASME Funded by the Hellenic General Secretariat for Research and Technology (GSRT)	SOF	The purpose of the project was the development, of integrated software covering the problems of design and analysis of mechanical components, and the modeling of coupled problems of flow control and structural analysis.
BBB Better Built Environment	NMI	Evaluation of the quality of environment in cities from the point of sustainability and energy efficiency.
ÞaI	NMI	Evaluation of roof constructions quality and development; safety against leakage, energy and moisture properties and guidelines regarding design and quality aspects.
ORKUNOT	NMI	Energy performance of the existing building stock; energy consumption, effect of climate and refurbishment potential.
Building regulations and energy requirements	NMI	Study of the economic feasibility of increased thermal insulation in building parts in districts with sustainable geothermal heating.
SGLiB	NMI	Effect of large glazing areas in the building envelope on thermal comfort and indoor environment in buildings.
CREDIT Construction and Real Estate – Development of Indicators for Transparency	NMI	Development of performance indicators to assess the sustainability and efficiency of buildings.
SURE Sustainable Refurbishment – life-cycle procurement and management by public clients	NMI	Development of guidelines for sustainable procurement.
“Einsparung von Ressourcen im Hochbau”	LAP	Development of design and decision fundamentals and reduction of material and energy consumption with 4 aspects of: law, financial support of the government, new technologies and social quality rate.
ETECH Development of Technology for High-Technology E-Construction Site	TRI	Key results of the development: (a) robot/manipulator for installing panels; (b) panel holders; (c) appropriate positioning using sensors; and (d) system for fastening panels. It is an international project co-financed by Eureka.

SEONES	TRI	Coloured selective - energy effective coatings for façade elements for low-energy consumption buildings).
Q-SPAI Quality control in the production line of sandwich panels with AI methods.	TRI	Ensure as high quality as possible by choosing the right input materials and the right settings on the production line. Impact of parameters on product quality by using the methods of artificial intelligence (especially machine learning and advanced visualizations) on available (material type, production line settings) and measured data (current line state, quality).

Table 4: Energy-related projects of all partners

Computational Engineering-related Projects

Project	Partner	ISES related project content
3D-MAS Funded by the Hellenic General Secretariat for Research and Technology (GSRT)	SOF	The purpose of the project was the development of integrated software for three-dimensional modelling and discretization of tunnels, and more accurate, enhanced with additional design criteria multi-stage tunnel analysis.
ASME Funded by the Hellenic General Secretariat for Research and Technology (GSRT)	SOF	The purpose of the project was the development, of integrated software covering the problems of design and analysis of mechanical components, and the modelling of coupled problems of flow control and structural analysis.
ICE4RISK High-throughput computing environment for seismic risk assessment	UL	The purpose of the project is towards a better design of structures, steel, masonry and reinforced concrete structures, structural optimization, soil-structure interaction and concrete gravity dams.

Table 5: Computational Engineering-related projects of all partners

Assumptions and External Factors

For the success of the project and a successful exploitation we have assumed

(1) That model-based work (BIM- and STEP-based) will further increase and distributed information and product model management will continuously make progress

(2) Ontologies will become not too complex and hence will be computable to serve as the meta-data method for system integration

(3) Energy models and climatic scenarios can be generalized and modularized that they can be applied through appropriate instantiation at any climatic location in semi-stochastic process approach.

The success of ISES from the research perspective is not depending on these assumptions, as the project is not relying on developments expected in advance. However, its exploitation potential is depending on external developments and evolution of standards. Therefore, ISES will periodically synchronize assumptions about possible factors and developments influencing the project with the respective state-of-the-art really observed. ISES members will be strongly engaged in dissemination and related standardization activities in order to influence and promote these and continuously watch developments for their possible feedback to the project and its evolving exploitation strategy and plan.

3.2 Dissemination and/or exploitation of project results, and management of intellectual property

3.2.1 Dissemination

A *dissemination plan* will be prepared and implemented along the project and beyond. The plan will permit: to establish target audiences and define key messages, to select the appropriate modes and tools of communication, to implement the dissemination activities among partners. It will be mainly targeted to the construction and construction supplier (equipment, components, ICT) industries stakeholders and to the ICT industry but also to citizens for fulfilling the societal objectives of spreading education and generating enthusiasm for energy efficiency and emission reduction. In relation to dissemination activities, a dedicated website will be developed, at the beginning of the project, and maintained. This website will enable the publication and updating of the new advances to a wider audience. This site will be linked to all relevant organizations and maintained after the conclusion of the project, for being interactive and accessible by professionals and researchers. In addition the web-seminar will be organized for experts and for the public in particular for research directed journalists and video clips will be produced and published on the ISES website and on public websites like Youtube, too.

Dissemination to the *industry* will be done through the newsletters, web portals and the presence of the industrial partners and the research institutes at trade shows. ISES aims at becoming visible in the global construction community by presenting itself on the ETCP.

In addition the *academic and research* partners will publish scientific papers and participate in conference in the (1) energy and emission efficient buildings, (2) building and facility component developers, (3) BIM/model-based design, (4) distributed, collaborative systems and concurrent engineering, (5) ontologies and virtual enterprises. They will use their position in the editorial boards of conferences and journals (TUD, UL) to promote the idea of integrated collaborative energy and emission simulation tools and interoperability of STEP-BIM-BAS and organise special issues and sessions. Open access media will be preferred, because they allow faster and wider dissemination. The academic partners will also build the findings into their graduate and postgraduate curricula.

Dissemination Manager

A *dissemination manager* acting as assistant for the project manager will be installed in order to coordinate on a daily basis the dissemination activities. This position is given to SOF, which has long time experience in this area.

Plan for using and disseminating knowledge

Within the consortium the knowledge will be used according to the exploitation plans of the partners. The dissemination targets outside of the consortium include:

- *Energy Efficiency in particular ICT related Projects.* The project will participate actively in concerted activities, in particular organized by ICT4EE. It will be active in organizing concerted events.
- *The research community.* The partners will actively participate in the events and publish in journals in energy efficient design and construction, collaborative working, ICT in construction and engineering informatics communities. It will organize sessions and special issues at conference tracks such as ECPPM, CIB W78, ICCCBE, IABSE, FIP, ICT4SH, and make contributions to IAI/buildingSMART.
- *Green Building Initiatives.* The partners of ISES are active in these initiatives and enhance the promotion the important role of ICT to receive sustainable impact in improving energy efficiency.
- *The European Construction Technology Platform.* Several ISES partners are members of ECTP and will disseminate ISES findings and results there and will organize workshops and seminars in the course of ECTP.
- *The industry in general.* The industrial partners in the project will take care of the visibility of the project in the trade fairs and other promotional activities that they are making.
- *Education.* The academic partners will build the research results of this project into the graduate curricula and enhance and extend lecturing there.

Raising public participation and awareness

The project will encourage publication of the project results in the popular green press and Real Estate and daily newspapers, such as the scientific supplement of the leading national dailies. The professional press and Web sites as well as professional events (trade fairs, addressed in the previous Section) will be targeted as well.
The main dissemination and awareness targets are:

- Building and facility product suppliers.
- FM companies and consultants as well as FM software developers.
- Architectural companies.
- Construction companies.
- Building owners and real estate companies. The people there are the secondary potential users of the ICT project results.
- Software developers. The authors of AEC software are the potential users of the project results.
- Associations, in particular ECTP and EAPPM as well as national associations in construction and energy agencies.
- Standardization committees, with focus on IAI/Buildingsmart and STEP.

Dissemination and awareness methods include:

- Project's *Web presence* will be used to inform the public about the project's progress and link to other resources addressed below. A series of sites is envisioned addressing various activities as well as languages and regions.
- Video clips will be produced and distributed on public providers, such as Youtube.
- *Wiki on ICT* for energy and emission efficiency will be established directed to the ICT construction, public authorities and real estate community. The Wiki will be built up in coordination with ICT4EE.
- *Newsletters* will be published semi-annually. Aimed at non-specialists they will summarize the results of the network. They will be distributed electronically.
- *European Technology Platforms.* Several partners (TUD, OG, UL) have positions in different platforms addressing the one-of-a-kind industry. They will spread ISES information and results over these platforms and provide the findings and lessons learned to future roadmap studies.
- *Seminars.* The project will organize pan-European as well as regional, local and web seminars.
- Project's *digital library* will be set up, using the technologies developed in projects like FP5-IST SciX and which will be used to archive and make available, to the targets addressed above, the project results. The archive will include all reports, working papers, preprints, public deliverables etc. created within this project. Advanced searching, classification, commenting, annotating facilities will be provided.
- *Scientific publishing.* The consortium includes a number of persons from TUD and UL that are involved in editorial boards of prestigious journals and that will use their influence to speed up the publishing of project results in academic journals. Since, to a large proportion, the project is funded with public funding, preference will be given to publications that allow for open access from the Internet.

International Awareness

Almost all partners of ISES have international relationships. They will use their contacts to disseminate ISES results on an international level, in particular the academic partners through conferences, journal papers and research co-operations.

3.2.2 Exploitation

Market Potential

"Green Building", "Energy Efficiency", "CO_2-Emission Control", "Sustainable Buildings" are key headlines which are widely discussed, nowadays. Experts are expecting the construction sector to become one of the double winners in this area, by activating private and public investments. The main winners are those who are integratively considering the whole lifecycle. The "Green"-market is already an important market segment for component product (building or equipment components) suppliers, facility operators/managers and building designers (architects and engineers) and this share will be increased for them in the future, especially in the fields of renovation of existing buildings, but also for the design of new buildings. Any means and tools, which will help them to improve their competence in this area, are an additional advantage. The most important end-users are component product suppliers, building planners and facility managers and therefore TRI, SOF and OG expect a considerable market potential for BIM-applications which are enhanced by functionality and interoperability, supporting energy-efficiency and CO_2-emission calculation and cost prognosis.
The project will deliver new methods, tools and data models for energy efficient design and operation of component products, facilities and buildings including integrated lifecycle testing, ill-performance indication and cost prognosis through simulation, which is in particular for large scale facilities of upmost important. Today there is a considerable gap to calculate operation cost, come up with sustainable best energy mix and analyse and identify ill-performance to draw the right consequences already during component design and hence before realization. It is expected that these ISES developments will have noteworthy impact on collaborative processes within the AEC, the related supply and FM industries. This in particular means for partner NMI, TUD, UL and OG as a consultancy company too that there is a need for knowledge transfer to decision makers and training activities for adoption of new methods and tools. OG and SOF furthermore expect that special emphasis will be requested on integration of energy optimization tools into existing design and operation processes, which depending on used tools and design principles requires further studies of provided interfaces and research on data integration tools. For the future NMI, TUD and UL also see great potential in the field of small and medium enterprises (SMEs), not for typical consultancy work but for affordable training programs and access to know-how databases. This view is supported by all other partners in particular the industry partners.

Main deliverables for exploitation

ISES will develop ICT building blocks and a SOA integrated system. Therefore there are two kinds of exploitable results, namely the integrated platform system and the individual components.

1) **The integrated ISES platform can be exploited**
   1a) as a technical Virtual Energy Lab to study new products (building components, technical components) and services before their realization and analyse in-depth ill-performance under lifecycle conditions to draw the right tuning or decisions and
   1b) as a concurrent engineering design tool for the design and redesign of facilities and buildings to study in depth alternatives under various life-cycle conditions to come up with the best-balanced design decision for the facility owner.
   1c) as a system analysis tool to analyse the energetic and emission behaviour of existing facilities and buildings in order to find out their weak components or ill-operation and make suggestions to the owner for redesign, retrofitting or reengineering of the operation processes.
2) **There are the individual components which can be used as stand-alone tools or together with other tools, which provide BIM based interoperability infrastructure.** These are
   2a) Building Operation (FM) tools which are enhanced with sophisticated energy and emission analysis tools, enhanced with BIM based interoperability capabilities and hence access capabilities to energy and climatic data and scenarios and enhanced graphical representation to study life cycle behaviour of the building and investigate upgrading scenarios.
   2b) Sophisticated energy and emission analysis tools enhanced with BIM model and interface related interoperable interfaces, which provide beneficial use of the service supported BIM world like Data Bases (e.g. the Oracle IFC interface) presentation tools (e.g. the various browser, xml-based 3D presentation tools and e.g. Acrobat R9 with the IFC-interface for pdf presentations).

2c) Intelligent Access Services as web services, which can be provided as ASP for intelligent data access in particular for BIM model and cloud and mapping capabilities for various uses.
2d) API interfaces for various numerical engineering tools (structural, wind, airflow, moisture, cost) for the BIM model.
2e) User sensitive multi-model navigator as a web service for general purpose use to represent nD information space, preferable simulation data of space (rooms, zones) structured objects (buildings), to be used by experts providing very detailed technical representation capabilities as well as by lay persons, like building owners with easy-to-understand 3D representation and navigation capabilities, like the cockpit functionality.
2f) Multi-model filter to generate model views for several interlinked models, which have the BIM model as basic model.
2g) Model combiner incl. semi-stochastic process combination and simulation for energy studies, which configures variations of a simulation model according to a variation matrix of the variation parameters and a simulation analyser that analyses and priorizes the simulation according to pre-defined criteria.
2h) An interface from BIM to STEP models, which is focused on a simplified geometric but full functionality representation of the STEP-modelled product.
2i) OntoBIM, a model ontology for BIM models to generically manage various BIM domain models, e.g. a supporting service for multi-model management, filtering and navigation.
2j) A product catalogue management system for management of BIM component products or STEP-imported products.

Exploitation Domains

There are five different exploitation channels, which will be developed by the indicated partners during the project:

(1) Selling of the ISES platform as a whole as well as partially. This is the interest of SOF and OG.
(2) Application of the platform or components in the own company in order to improve efficiency becoming a market leader in their domains and improve reputation. This is the main interest of TRI for new building components and construction projects and of LAP for design of new buildings and refurbishment.
(3) Improve education and lecturing. This is the main exploitation interest of the academic partner TUD and UL.
(4) Consultancy to industry and specific client developments. This is the interest of the industry partners OG and LAP and the public-institute partners NMI and NOA.
(5) Improvement of research and competitiveness for research project. This is the exploitation interest of all partners.

The exploitable results, grouped in 2 exploitable packages, are described above. The grouping into selling packages will be done during the project, when feedback comes from the industry based on promoted mock-ups.

Exploitation Plan

An Exploitation Plan will be elaborated and continuously updated during the project as an enrolling document with the first version submitted to milestone M1. The exploitation plan will be structured in an integrated exploitation plan for all partner and individual exploitation plans for each partner serving the individual market segments of the partners. The exploitation plan will contain:

1) Identification of the exploitable results of the project, classified in products (software), services (consultancy) as well as scientific knowledge (acquiring future RTD projects, updating lecture courses) and technical knowledge (consultancy and acquiring industrial projects). These exploitations are further classified according to their commercial potential, expected barriers to enter the market, further investments in technical developments and advertisements and inherent risks,
2) Market analysis, structured in the partners' national market, EU market and world-wide market. Due to the internationality of the software products and the business areas of the partners the EU and the world market plays a considerable role for all partners. There the relevant target groups will be identified and the competitive level will be examined. A continuous market watch will be carried out and documented in the enrolling

exploitation report, resulting in trend analysis which will improve the objectiveness and stability of our prognosis of the final exploitation at the end of the project,

3) A strategy and methods for the management of the tangible and intangible results generated in the project based on the IPR agreements stated in the consortium agreement document, but continuously updated during the project paying attention the dynamic market developments and the results achieved during the project,
4) The impact of the project to standardisation, recommendations and regulatory aspects, i.e. the results of our efforts from dissemination and hence the socio-economic impact of the project,
5) development of a risk plan opposing opportunities, strength, weakness and failure
6) draft of business plans for the individual exploitations, routes of exploitation and related risks (from top 5)
7) installation of a technology implementation plan for the future commercial deployment of the project results

Intellectual Property Rights

IPR of each component developed belong to the developing partner. In the case more than one partner is sharing the work for the development of a component, the IPR will be shared according to their invested PM (foreground knowledge). Provided technology and knowledge (background knowledge) will be considered only in the case, when an objective and heavy impact on the developed component can be shown. It will be considered as a weighting factor for the invested PM. Formal procedures and rules will be worked out in the consortium agreement. Publication has to be announced in time, that each partner can take his veto in a serious care. Publications have to respect agreed confidentially on IPR, as a basic rule.

Expected Exploitation Benefits per Partner

The exploitation expectations per partner are listed in the following ROI table. They have to be considered very preliminary and are based on a market study carried out for similar products by SOF and OG and for technologies by TRI and LAP. Transferring these general numbers to the individual ISES situations is therefore highly subjective. These numbers will be put on objective criteria in the first version of the exploitation report (M1). The expected savings given in Table 6 are those expected in the beginning of the learning curve.

	Annual Turnover 2009 [million Euro]	partner's own contribution to ISES [million Euro]	Investment [million Euro]	5-year earnings [million Euro]	ROI [million Euro]
TUD*)	1,50	0,18	0,20	1,00	0,62
OG	27,00	0,52	1,00	3,70	2,18
UL*)	0,50	0,13	0,10	0,50	0,27
SOF	0,76	0,20	0,50	1,50	0,80
NMI	7,20	0,11	0,20	0,60	0,29
NOA	5,60	0,06	0,15	0,60	0,39
LAP	18,00	0,10	0,16	0,90	0,64
TRI	154,34	0,11	0,80	2,70	1,79
Sum	214,90	1,40	3,11	11,50	6,99

*) Only the participating institutes, earnings are the funding of new RTD projects in ISES topics

Table 6: Very preliminary expected Return of Invest

Section 4: Ethical Issues

The project consortium, fully respects the ethical requirements of the 7th Framework Programme. These requirements are not something that can be achieved spontaneously; rather, they must be planned for and built into all stages of the project.

Hence, the project consortium hereby commits itself to carry out all research activities in strict conformity with EU and national legislations. First and foremost, *the Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data* will be vigilantly adhered to throughout the course of the project, prior to any research/development activity to which this Directive bears relevance. The project also plans to follow established general principles (such as 97/66 EC and other rules defined by ISTAG and eEUROPE), namely:

1. Obtain the explicit consent of the subscriber.
2. Provide complete information about the use and storage of the data.
3. Only use the data for the purpose for which they were collected.
4. Erase personal data after use or make them anonymous.
5. Give the user the possibility to restrict transmission of information.
6. Ensure the security of the network.
7. Not transfer the data to a third party without the consent of the subscriber.

The project further considers ethical and socio-economic aspects with its intention to make technology disappear from the user's interface. It has been widely acknowledged that many user groups feel cut off from recent communication technology developments due to the perceived difficulty of using the new technology.

ETHICAL ISSUES TABLE

	YES	PAGE
Informed Consent		
• Does the proposal involve children?		
• Does the proposal involve patients or persons not able to give consent?		
• Does the proposal involve adult healthy volunteers?		
• Does the proposal involve Human Genetic Material?		
• Does the proposal involve Human biological samples?		
• Does the proposal involve Human data collection?		
Research on Human embryo/foetus		
• Does the proposal involve Human Embryos?		
• Does the proposal involve Human Foetal Tissue / Cells?		
• Does the proposal involve Human Embryonic Stem Cells?		
Privacy		
• Does the proposal involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)		
• Does the proposal involve tracking the location or observation of people?		
Research on Animals		
• Does the proposal involve research on animals?		
• Are those animals transgenic small laboratory animals?		
• Are those animals transgenic farm animals?		
• Are those animals cloned farm animals?		
• Are those animals non-human primates?		
Research Involving Developing Countries		
• Use of local resources (genetic, animal, plant etc)		
• Impact on local community		
Dual Use		
• Research having direct military application		
• Research having the potential for terrorist abuse		
ICT Implants		
• Does the proposal involve clinical trials of ICT implants?		
I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	**YES**	