SEVENTH FRAMEWORK PROGRAMME OF THE EUROPEAN COMMUNITY
(EC GRANT AGREEMENT N° 288819)

INTELLIGENT SERVICES FOR ENERGY-EFFICIENT DESIGN AND LIFE CYCLE SIMULATION

Deliverable D1.2:

Use Case Scenarios and Requirements Specification

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Due date: 31.05.2012
Issue date: 10.08.2012
Nature: RE

Start date of project: **01.12.2011** Duration: **36 months**

Organisation name of lead contractor for this deliverable:

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History

Version	Description	Lead Author	Date
0.1	Initial draft, Content structure; Input UCS and documentation	Romy Guruz (TUD-CIB)	26.04.12
0.2	Partner input	NMI, LAP, OG, TRI, TUD	31.05.12
0.3	Extended scenarios and requirements	Tobias Mansperger (LAP)	14.06.12
0.4	Pre-final version	LAP	29.06.12
1.0	Final version	TUD-CIB	19.07.12
1.1	**Checked and approved final version**	TUD-CIB	10.08.12

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Citation

Jung R., Mansperger T., Guruz R., Forns-Samso F., Gudnason G., Kaiser J., Katranuschkov P., Kavcic M., Laine T., Zahedi A., Zingel U., Zschippang S. (2012): *ISES Deliverable D1.2: Use Case Scenarios and Requirements Specification*, © ISES Consortium, Brussels.

Acknowledgements

The work presented in this document has been conducted in the context of the seventh framework programme of the European community project ISES (n° 288819). ISES is a 36-month project that started in December 2011 and is funded by the European Commission as well as by the industrial partners. Their support is gratefully appreciated.

The partners in the project are TECHNISCHE UNIVERSITÄT DRESDEN (Germany, Coordinator), INSINOORITOIMISTO OLOF GRANLUND OY (Finland), UNIVERZA V LJUBLJANI (Slovenia), SOFISTIK HELLAS A.E. (Greece), NYSKOPUNARMIDSTOD ISLANDS (Iceland), NATIONAL OBSERVATORY OF ATHENS (Greece), LEONHARDT ANDRÄ UND PARTNER BERATENDE INGENIEURE VBI, GMBH (Germany) and TRIMO INZENIRING IN PROIZVODNJA MONTAZNIH OBJEKTOV, D.D. (Slovenia). This report was created through the joint effort of the above organisations.

Project of the SEVENTH FRAMEWORK PROGRAMME OF THE EUROPEAN COMMUNITY		
Dissemination Level		
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)	**X**
CO	Confidential, only for members of the consortium (including the Commission Services)	

TABLE OF CONTENTS

PART I: USE CASE SCENARIOS 5

1. USE CASE 1 – COMPONENTS DEVELOPMENT 7
2. USE CASE 2 – EARLY DESIGN 12
3. USE CASE 3 – REFURBISHMENT / RETROFITTING 22

PART II: REQUIREMENTS SPECIFICATION 29

4. MODELLING AND INTEROPERABILITY REQUIREMENTS 30
5. FUNCTIONAL REQUIREMENTS 32
6. REQUIREMENTS REGARDING STOCHASTIC LIFE-CYCLE SIMULATION 37
7. GUI REQUIREMENTS 39
8. LOCATIONS TO BE ANALYSED IN THE PROJECT 42

CONCLUSIONS 44

USED LITERATURE SOURCES 45

APPENDIX I: ACRONYMS 47

APPENDIX II: PROCESS MAPS 48

Executive Summary

The **objective** of WP1 is (1) to perform analyses of user roles, existing information resources and anticipated usage scenarios and needs, (2) to develop typical use cases that shall be used as baseline for all subsequent RTD work and, (3) to provide objective specification of the requirements regarding ICT-related energy and CO_2 emissions modelling and the interoperability needs for efficient application of advanced simulation methods.

This deliverable covers the overall work performed in WP1 within the following two tasks:

- T1.2 Use Case Scenarios
- T1.3 Requirements Specification.

Accordingly, the scenarios for the three major simulation cycles in ISES have been defined in detail. This includes detailed characterisation of user roles, processes and supporting tools, interoperability methods, data models and data interfaces. Acknowledged methodologies like ARIS or the Information Delivery Manual (IDM) approach of the Building SMART initiative (ISO 29481-1) were used as basis for the definition of relevant process maps and exchange requirements. The results obtained in Task 1.1 and Task 1.2 of WP1 were synthesized and requirements grouped in five categories were derived. These requirements were contributed from the expert point of view of each partner. Moreover, although the objectives of ISES and hence the requirements to the ISES Virtual Energy Platform are different from the related EU project HESMOS (Grant No. 260088), the general methodology and classification of requirements developed in HESMOS could be used as baseline, thereby enabling a straightforward approach.

The deliverable report is structured into two parts:

In the **first part** the developed use cases are described and documented, including process diagrams in the Business Process Modelling Notation, BPMN (www.bpmn.org), and descriptions of the activities, the main decision points (gateways) and the data objects. As basis, the IDM method was used as adapted and extended in the HESMOS project.

The **second part** specifies the ISES requirements, synthesizing the results of the preceding task in the following four groups: (1) Modelling and interoperability requirements, (2) Functional requirements, (3) Stochastic life-cycle simulation and (4) User Interface (GUI) requirements. In addition, an overview of the locations to be analysed in the project is provided.

The report is completed with a conclusions section, followed by a list of referenced literature sources and two appendices.

All partners were involved and each partner has contributed from their expert viewpoint as follows:

- **LAP** : Lead, all tasks from contractor and operator point of view, focus especially on T1.3 and the requirements specification;
- **TUD** : All tasks, especially definition of life cycle processes and their documentation (T1.2); structure and editing of the report
- **TRI** : Task 1.2 (Coordination UC1: Component Development), T1.3
- **OG** : All tasks (facility management, client and operator view), as well as modelling requirements (BIM)
- **UL** : Task 1.3
- **SOF** : Task 1.3
- **NOA** : Task 1.3
- **NMI** : Task 1.3.

A delay of approximately 2 months in the finalisation of the deliverable report was caused by difficulties in coordinating all partner contributions in the first phase of the project (month 1-6).

PART I:

USE CASE SCENARIOS

It is well known that the design phases have a significant impact on all following phases in the building life cycle. To improve energy design performance, ISES will develop an **Integrated Virtual Energy Laboratory** focusing on the use of probabilistic methods in combination with energy calculations to optimize the decision-making processes in the different design phases. In contrast to the related HESMOS project, with its basic idea to organize energy relevant life cycle components into a unified holistic process, ISES addresses a rather in-depth approach than one focussing on broadness of the covered processes.

As shown in Figure 1 below, the three focused processes are located in different life cycle stages. The first use case "**Components Development**" is set in the early stage of concept development of a prefabricated building product. The second use case "**Early Design**" covers the first period of the architectural design in the building life cycle. The third use case covers the planning stage of the "**Refurbishment/ Retrofitting"** phase and lies also at a strategically important decision point.

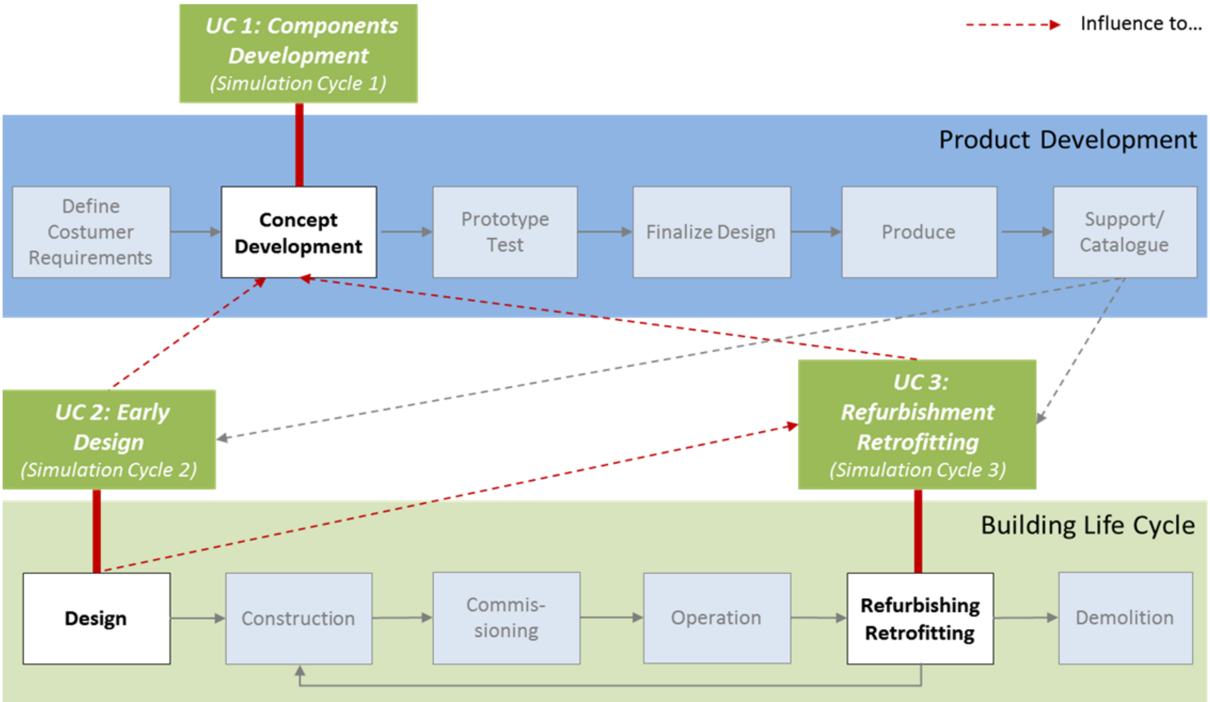

Figure 1: Local involvement of the three use cases including their dependencies as well

The dashed red lines on Figure 1 show also the possible impacts between the different phases. The building design requirements may have a direct influence on the development of a new product, and vice versa, the choice/use of a certain product determines properties of the building and its energy consumption. Moreover, the design of a new building provides the basis for the refurbishment phase. For the worked out uses cases, we have tried to specify the processes in detail, to find for each the optimum points for probabilistic evaluations.

To specify the necessary information flows we have used the Information Delivery Manual (IDM) as methodology. IDM in its pure form comprises three parts: (1) the Process Maps, (2) the Exchange Requirements and finally (3) the Functional Parts and Business Rules. For this deliverable, we applied the adapted IDM approach from the HESMOS project. Thus, we first developed the process maps, the responsible actors and the information flow that shall be supported by the Building Information Modelling (BIM) approach. This is the basis for defining how to connect tasks with the BIM and other information sources. The process information is assigned to swim lanes, which either contain the tasks of an actor or the Exchange Requirements (ER) for an information source. Accordingly, the BIM has its own swim lane that identifies the requirements of the related tasks. After discovering the processes, we allocated and identified the main exchanges. The so-called exchange requirements will be described in detail by business and IT experts in the upcoming Deliverable D3.1.

1. Use Case 1 – Components Development

Figure 2 illustrates the different triggering mechanisms to start the process (in the specifically examined case the façade elements development). The upper section is split in two parts, on the left side the *Innovation parts* and *on the right side* the external requirements in form of different codes. Together with the worked out customer requirements, the products are developed. The TRIMO Company (ISES partner – façade manufacturer) offers three categories of products, with different points of emphasis, i.e.: **Best Quality** (high price segment), **Best Performance** (medium price) and **BEST Price** (low price).

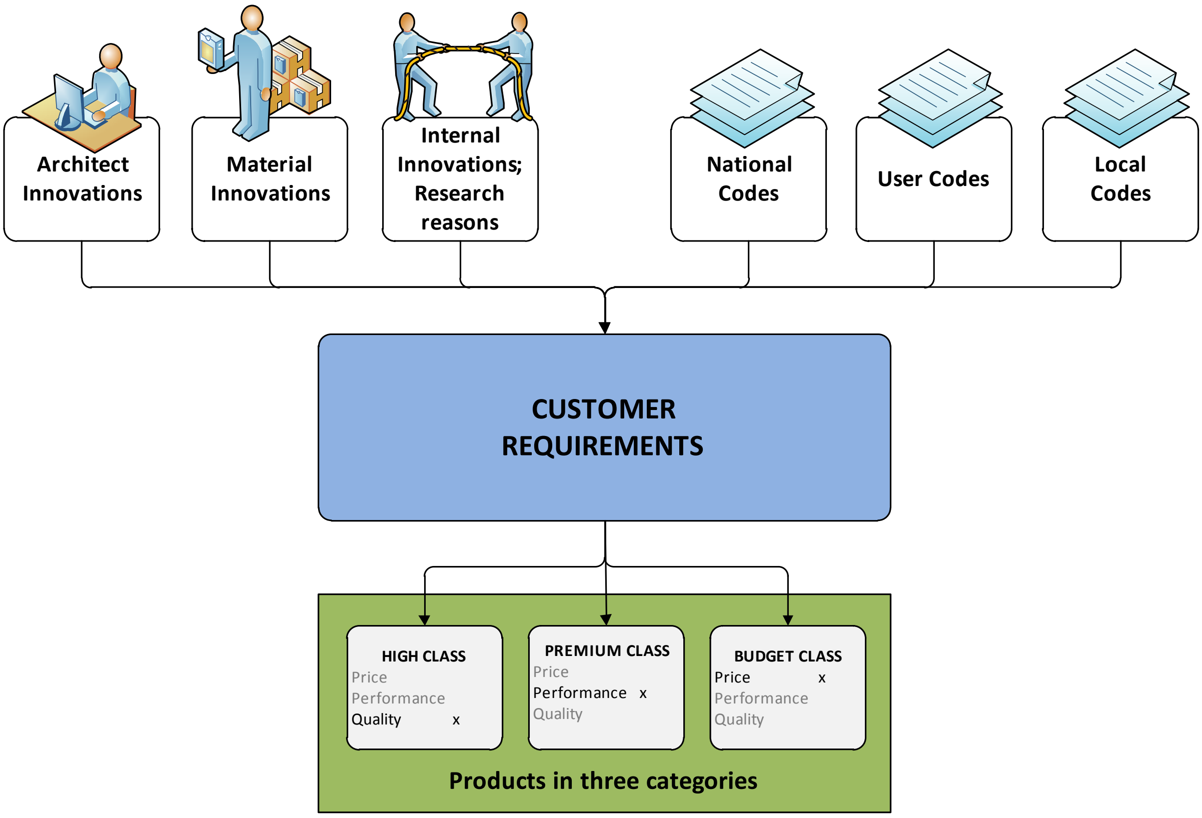

Figure 2: Different triggers to start the product development process,
Results: products in three categories (with different points of emphasis)

The *ISES Component Development* process is set in the early stages of the façade elements development. In this phase, many strategic decisions about the products are taken and its possible applications might be placed.

The **first probabilistic part in ISES (1)** takes place after checking the new products concept (marketing and research). In the context of task **1.1.6 Preliminary technical analysis** on the Process Map (see Appendix II and the next section 1.1), a comprehensive study of the boundary conditions is necessary. Main variables are on the one hand, the **climatic conditions/ location set** (such as great climatic variations in Germany; temperatures can drop to minus 20-30°C during winter and reach plus 30°C in summer; or the variations between European countries like Iceland and Greece). On the other hand, there are the **user requirements** that differ depending on the end use of a building. For example, there are different needs for a swimming hall in Iceland or Finland than for one in Greece or Slovenia.

The support of the components designer, in creation of the optimal façade element for each location and user, is in the main focus of this process. Additionally, the integration in the BIM process should be achieved through the use of the IFC standard in this phase. This needs to give a consolidating view to the product libraries, especially in the aim of simplified information paths.

Figure 3 shows the Simulation Cycle 1 which is applied to develop the energy related building components. The necessary simulation input parameters/variables are categorized under stochastic parameters and semi-stochastic processes. The obtained results are represented in probabilistic manner which will be used in the decision making process.

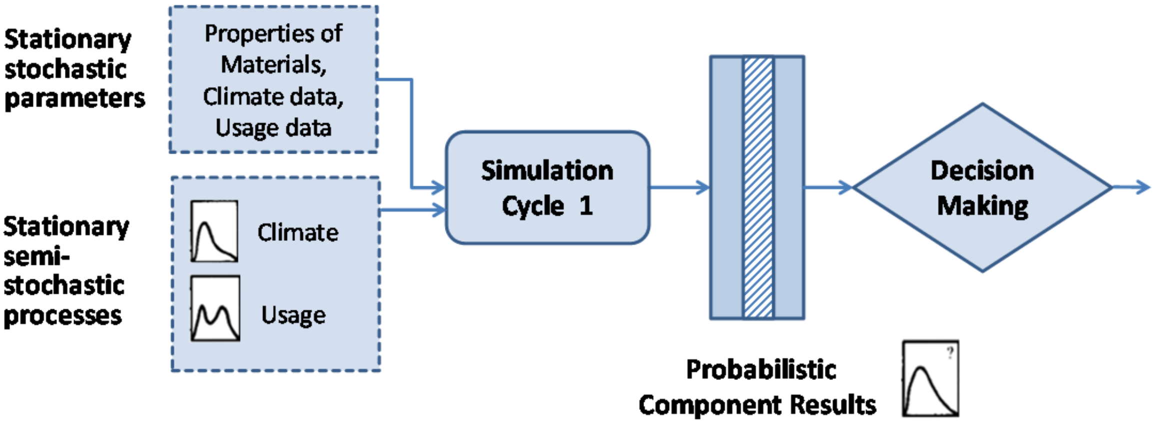

Figure 3: Envisaged ISES Probabilistic Simulation Cycle #1

The TUD-IBK tool DELPHIN will be used to investigate the hygroscopic and thermal properties of a wall within this probabilistic calculation cycle. For the energetic analysis of the building envelope, the physical properties have to be examined in advance. The thermal behaviour of the building envelope will be investigated with the tool NADRAD (Grunewald et al. 2012).

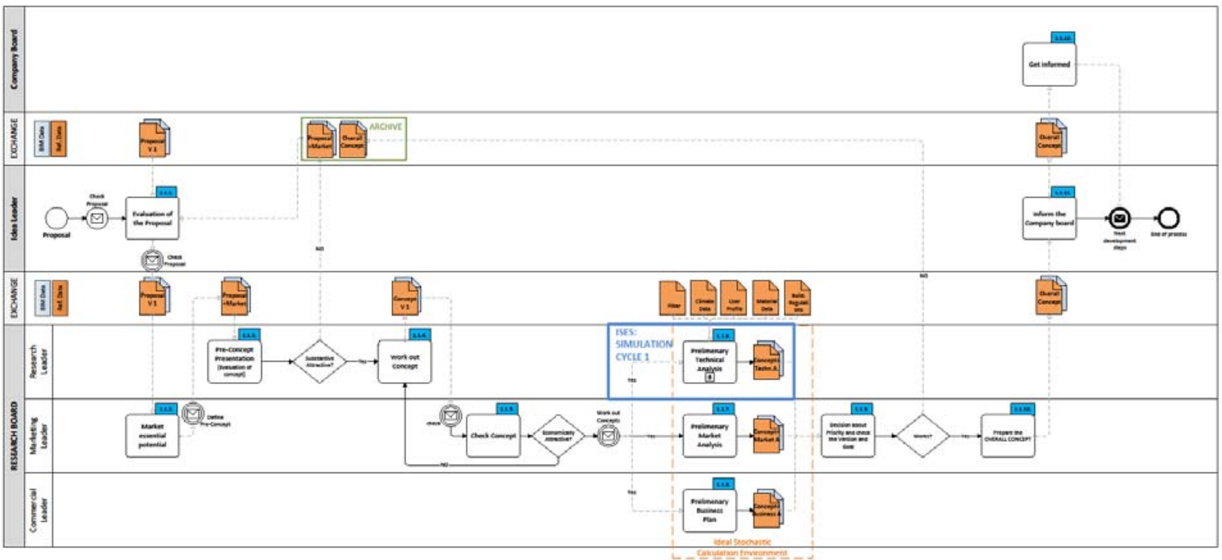

Figure 4: Component Development Process (see Appendix II for full process on larger scale)

The various tasks comprising this scenario are elaborated in the following section. The task targeted and supported by the ISES Virtual Energy Lab platform is denoted specifically - marked by dark red colour for easier reference in the provided documentation in the next section. This is Task 1.1.6 (see also Appendix II).

1.1 Specification of the Tasks

For better orientation, all tasks are identically numbered in the process map and the documentation below.

1.1.1. Evaluation of the Proposal

Type	TASK
Documentation	Initial document of proposed idea/project is put together. The documentation describes all initial data and the specification of product material. A brief business model and solutions for customer needs are described. The Unique Selling Point (USP) is stated.

1.1.2. Market essential potential

Type	TASK
Documentation	First market segmentation is presented and customer needs are revised.

1.1.3. Pre-Concept Presentation (Evaluation of Concept)

Type	TASK
Documentation	All documents of the project are presented: • Project description • Market potential • Research description

1.1.4. Work out Concept

Type	TASK
Documentation	The concept of the project is developed, project documentation is initiated. A Preliminary Business plan is prepared.

1.1.5. Check Concept

Type	TASK
Documentation	Presentation of concept evaluation in three different aspects: (1) Marketing, (2) Research, (3) Technology.

1.1.6. Preliminary Technical Analysis

Type	TASK
Documentation	**This is the task related to the ISES Simulation Cycle #1.** Within that task, preliminary technical analyses are made and integrated in the business plan/document.

1.1.7. Preliminary Market Analysis

Type	TASK
Documentation	Preliminary Market analysis is made and integrated in the Business plan/document.

1.1.8. Preliminary Business Analysis

Type	**TASK**
Documentation	Preliminary Business analysis is made and integrated in the Business plan/document.

1.1.9. Decision about Priority and Checking the Version and Goal

Type	**TASK**
Documentation	Based on business plan, resources, costs and time table the priorities of the project are determined.

1.1.10 / 1.1.11. Prepare the OVERALL CONCEPT & Inform the Company's Board

Type	**TASK**
Documentation	The project is included in the company's portfolio and the company's Board is informed.

1.2 Specification of Gateways

1.2.1. Substantive attractive?

Type	**DECISION POINT**
Documentation	The research leader evaluates the Pre-Concept. Is it attractive in the required levels? *If so:* start to work out the concept. *If not:* store the pre-Concept with specific files.

1.2.2. Economically attractive?

Type	**DECISION POINT**
Documentation	The Marketing Leader checks the Concept (received from Research) for its financial viability. *If so:* start to work out the concept. *If not:* store the pre-Concept in archive.

1.2.2. Works?

Type	**DECISION POINT**
Documentation	The Marketing Leader checks the final version and goals and decides about its priority. *If so:* prepare the document "Overall Concept". *If not:* store the pre-Concept in archive.

1.3 Specification of Library Data Objects

1.3.1. FILTER

Type	DATA OBJECT
Documentation	Variable data, depending on the actual context.

1.3.2. MATERIAL DATA

Type	DATA OBJECT
Documentation	Variable data, depending on the actual context.

1.3.3. CLIMATE DATA

Type	DATA OBJECT
Documentation	Variable data, depending on the actual context.

1.3.4. LOCATION DATA

Type	DATA OBJECT
Documentation	Variable data, depending on the actual context.

1.3.6. BUILDING REGULATIONS

Type	DATA OBJECT
Documentation	Variable data, depending on the actual context.

1.4 Specification of Exchange Requirement Data Objects

1.4.1. ER Proposal (+Market)

Type	DATA OBJECT
Documentation	see D3.1: ER Requirements / Component Proposal

1.4.2. ER BIM Component Concept (Overall)

Type	DATA OBJECT
Documentation	see D3.1: ER Requirements / BIM Component Concept

2. Use Case 2 – Early Design

During early design the requirements for the building should be determined based on the values and needs of the owner, the future users and the limitations of regulations. At this stage the relations between the different requirements are not known without performing an analysis of several different solutions. Figure 5 presents a TO-BE use case scenario for early design, utilizing collaborative working methods.

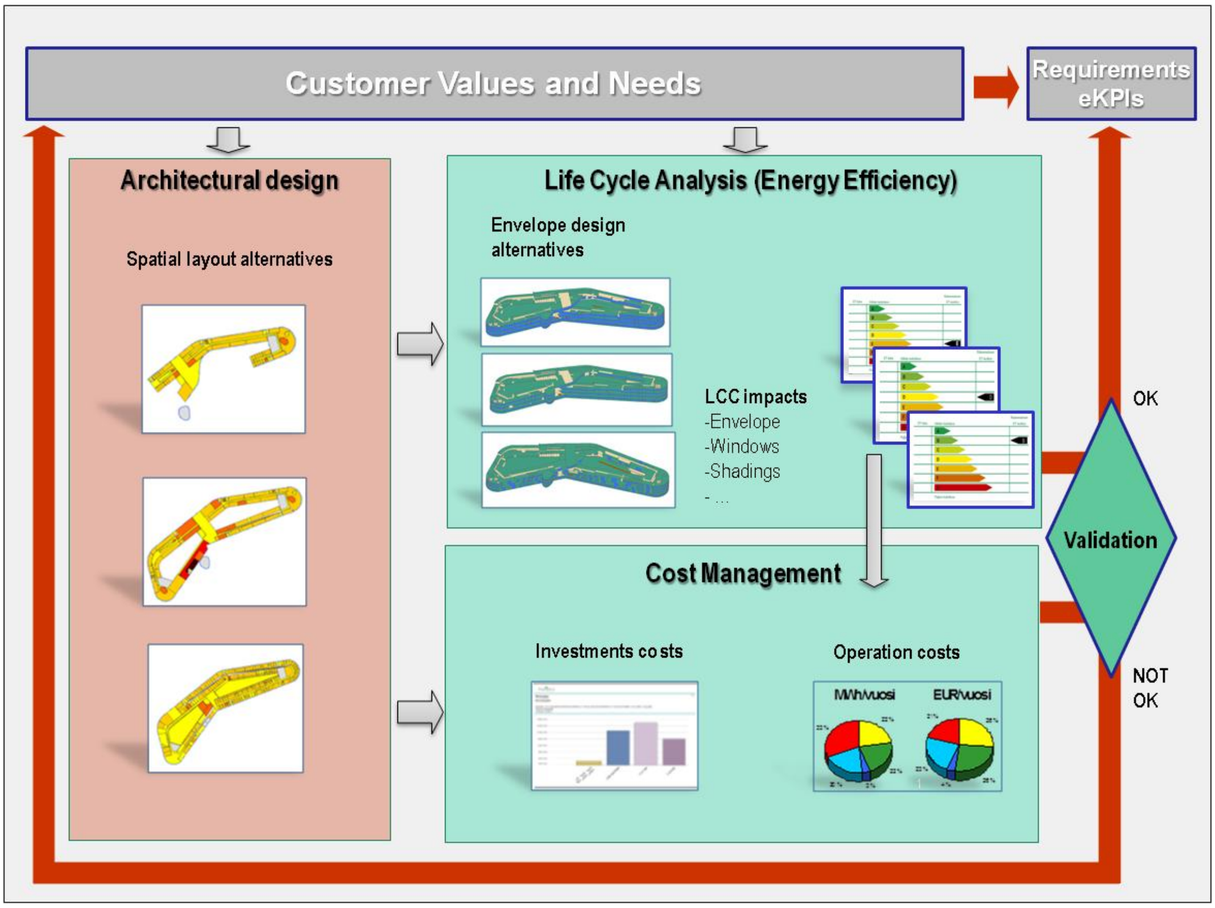

Figure 5: Envisaged TO-BE collaborative process for early design

The resulting requirements include energy key performance indicators (eKPI) as the benchmarks, which are used for requirements management through the following design, commissioning, construction and also operation phases. In the early phase the architectural alternatives are designed concentrating on the spatial layouts and functions with attention paid to both energy efficiency and life cycle costs. The focus is on the spatial model, which can be defined as an extended space programme in BIM format. The spatial model comprises primarily space objects. Building physical elements, such as walls and windows, are not necessarily included in the model in this phase. The window openings, for example, are defined only as a spatial property of required amount of opening area (percentage portion of the space area or outside wall area). The energy expert and architect work together to define several different envelope design alternatives, in which the openings, window structures, shadings etc. are considered. From all of the different spatial layout alternatives several energy and cost analyses are performed.

This iterative and collaborative process produces multiple different solution alternatives (e.g. 3x5x4=60, i.e. 3 spatial layout alternatives -> 5 envelope design alternatives with different window openings and orientations -> 4 different window and shading structure alternatives). Typically, the resulting amount of simulation cases (even when no stochastic or fuzzy variable ranges are considered) is much higher than it is possible to perform efficiently in real projects using state-of-the-art technology. This is the biggest gap with regard to energy in early design. With the results from the life cycle analysis and the information from different spatial layout alternatives the actual energy consumption is calculated to determine the operational costs. The operational costs also include other maintenance costs (e.g. cleaning and repairing works) that are taken into account by an expert in the field. The challenge is to create investment cost estimates by utilizing space and space type information as the main information source. Validation is performed on the basis of the life cycle and cost analysis to see if the customer values and needs are met. The iteration process continues until the different values and needs are fulfilled or compromised to the acceptable level. Usually a prioritization of the different values and needs is a good tool for verification. Based on the results from the design alternative analysis, the requirements and the related meters can be established - as eKPIs for the next phases of design, construction, commissioning and operation.

Two probabilistic simulations cycles can be applied within the developed early design process.

Simulation Cycle 2a shown on Figure 6 below is related to the early design of building energy properties. The necessary input simulation parameters/variables are categorized under stationary stochastic parameters, deterministic parameters, semi-stochastic processes and stochastic (or uncertain) parameters. The obtained results will be represented in probabilistic manner and applied into the decision making process.

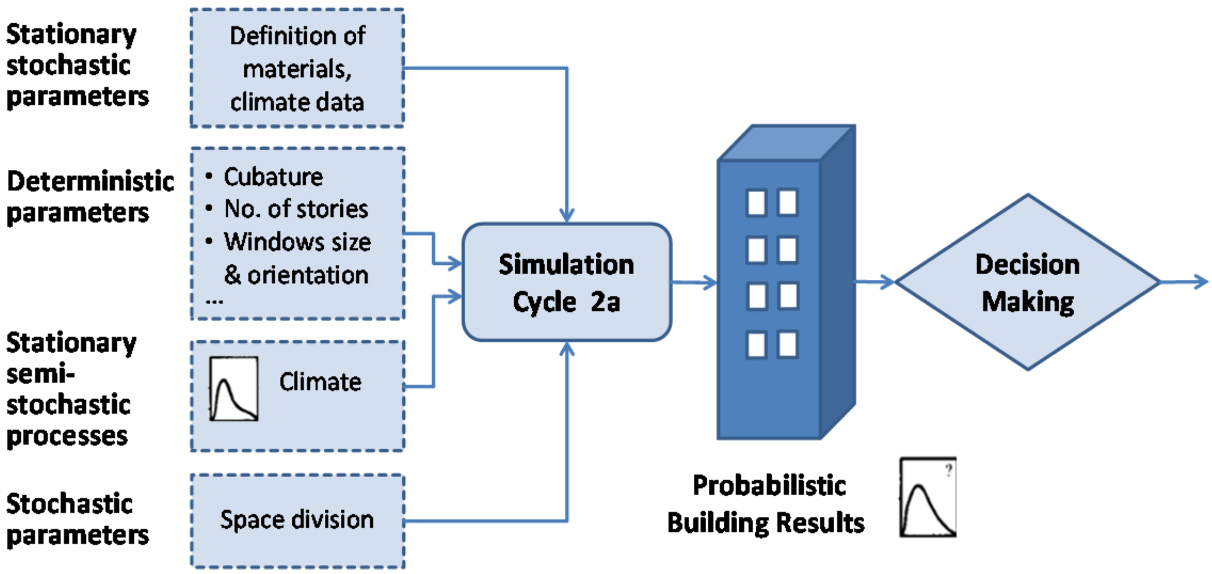

Figure 6: Envisaged ISES Probabilistic Simulation Cycle #2a

Simulation Cycle 2b takes place after the tasks to find an economical type of heating and cooling, which is possible after defining the rooms.

Figure 7 shows the Simulation Cycle 2b which is applied to the early design of building energy with already defined heating, ventilation and air-conditioning (HVAC) types. The required input parameters/variables are again categorized under stationary stochastic parameters, deterministic parameters, semi-stochastic processes and stochastic (uncertain) parameters. The obtained results will be represented in probabilistic manner and applied into the decision making process.

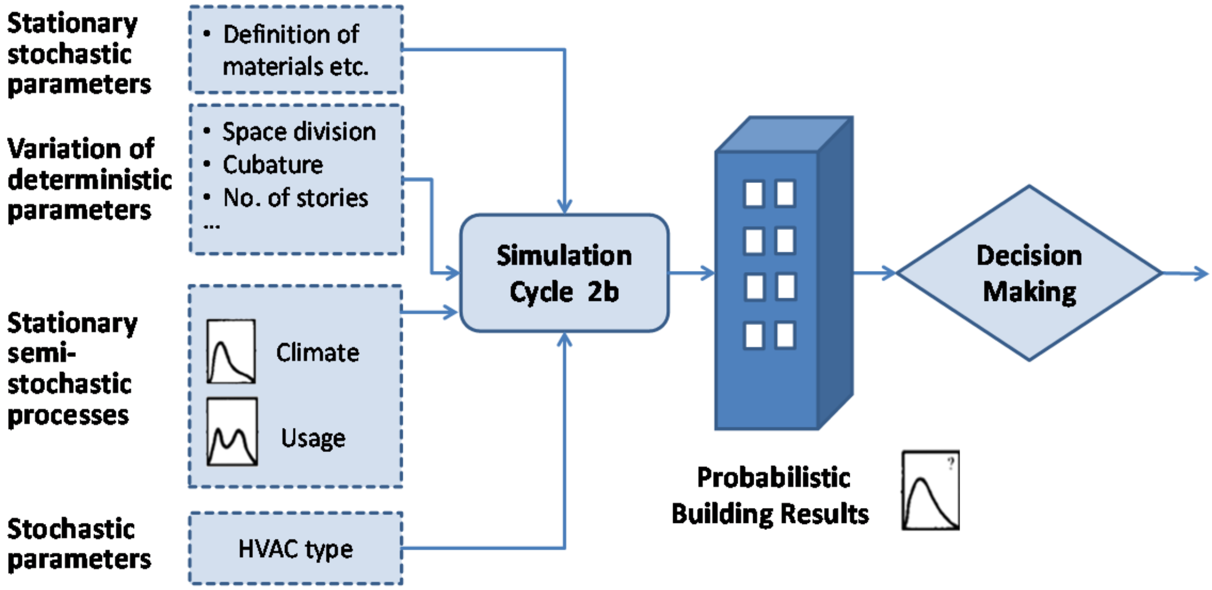

Figure 7: Envisaged ISES Probabilistic Simulation Cycle #2b

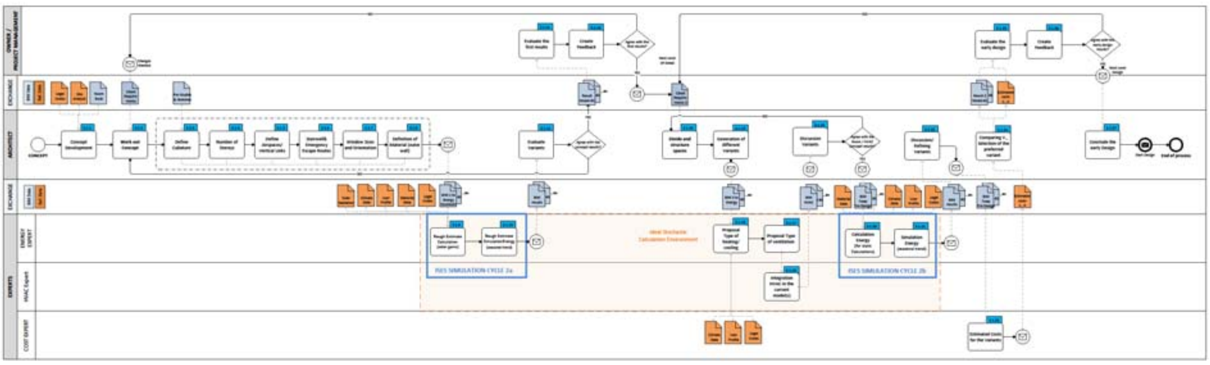

Figure 8: Early Design Process (see Appendix II for full process on larger scale)

The various tasks comprising this scenario are elaborated in the following section. The tasks targeted and supported by the ISES Virtual Energy Lab platform are denoted specifically - marked by dark red colour for easier reference in the provided documentation in the next section. These are Tasks 2.1.9, 2.1.10, 2.1.20 and 2.1.21 (see also Appendix II).

2.1 Specification of the Tasks

For better orientation, all tasks are identically numbered in the process map and the documentation below.

2.1.1. Concept Development

Type	**TASK**
Documentation	This is the preliminary stage to the following design process at which the first building geometry is defined. The architect uploads the already established *room book* (space program) *), and the construction specifications (thermal / system requirements). In case of paper or unstructured text documents the requirements should be digitalised (in BIM) or structured for verification. The analysis of the location is carried out; all essential data resources are included, usually using only unstructured text form.

2.1.2. Work out Concept

Type	**TASK**
Documentation	The conditions to start work on the concept are: • The Space Program • The (analysed) Site Location • All client specifications. The Goals for this process are: • Development of the Preliminary Design (3D geometry of the building - beams, columns, curtain walls, walls, slabs/floors, ceilings, stair flights, doors, windows etc.) • Definition of spaces by setting their space boundaries • Definition of boundary requirements for the HVAC system and the sun protection • Rough cost estimation.

2.1.3. Define Cubature

Type	**TASK (GROUP)**
Documentation	This task specifies the shape of the building and the orientation of the facades. Various aspects are involved e.g. urban development arrangement, type of the building, lighting requirements and so on.

2.1.4. Determine Number of Storeys

Type	**TASK (GROUP)**
Documentation	This can be concluded from the area that is available for building, and the demand for rooms (incl. airspaces and stairwells)

*) *Room book* is, literally translated, a German term, usually bearing the same sense as „Space Program“. However, in German construction practice it is used broader, to denote various construction specifications related to spaces / rooms. We use the term here as it has been officially used in the same way by many AEC/FM software vendors, even though it may be strictly speaking not correct English.

2.1.5. Define Airspaces / Vertical Links

Type	TASK (GROUP)
Documentation	As described

2.1.6. Stairwell & Emergency Escape Routes

Type	TASK (GROUP)
Documentation	As described

2.1.7. Window Sizes and Orientation

Type	TASK (GROUP)
Documentation	In this task, the rough estimate of the arrangement of the façade is in focus. It includes: 1. The rate of transparent / opaque areas and their orientations 2. First ideas for the type of glazing (heat protection, solar protection) 3. Arrangement of shading elements (passive / active).

2.1.8. Definition of Material (outer walls)

Type	TASK (GROUP)
Documentation	Definition of materials (specification, dimension and configuration of the wall layers) as basis for evaluating of the heat storage capacity

2.1.9. Rough Estimate Calculation (solar gains)

Type	TASK
Documentation	**This and the next task comprise the ISES Simulation Cycle #2a.** Various steps have to be executed for simulating solar gains, including: • Import of preliminary design data from BIM-IFC • Defining the location and orientation • Defining the weather data (design days, annual) • Checking building codes • Linking building structures to material databases • Defining/importing space type requirements. The results can be assessed by the Energy Experts in the project.

2.1.10. Energy Simulation (seasonal trend)

Type	TASK
Documentation	Various steps have to be executed for simulating energy and thermal performance as well. In addition to the steps listed under task 2.1.9 above, this includes also: • Using templates to define zoning by mapping space types to spaces **Run simulation** • Export air-conditioning requirements (sized air flows, cooling/heating) • Export as-analysed thermal performance (design day min/max) • Export energy consumption results.

2.1.11. Evaluate Variants

Type	**TASK**
Documentation	Compare results from alternative scenarios. Selection of suitable variant(s).

2.1.12. Evaluate the first results

Type	**TASK**
Documentation	Evaluation with the requirements. Evaluating and selection of the favoured variant.

2.1.13. Create Feedback

Type	**TASK**
Documentation	At this point, the client must decide whether all requirements have been met effectively. If so, he notifies the designer that the design process can continue or that it can be finished. If the requirements are not met, he will notify the designer accordingly, identify problems and/or pending issues and return the project to the design team for review.

2.1.14. Divide and structure spaces

Type	**TASK**
Documentation	This is the second milestone in early design. Area and volume are nearly set, dimensioning of the rooms can be started.

2.1.15. Generation of different variants

Type	**TASK**
Documentation	Usually, the division and structuring of the space is carried out in two or three different variants.

2.1.16 / 2.1.17. Proposal for type of heating / cooling / ventilation

Type	**TASK**
Documentation	The energy expert (or the HVAC designer) evaluates the current BIM model and the location (renewable resources, district heat etc.), and develops a first usable type of heating / cooling / ventilation according to the client's / architect's requirements. This is the initial concept which is basis for energy simulation.

2.1.18. Integration of HVAC in the current model(s)

Type	**TASK**
Documentation	The HVAC designer integrates the main aspects of the HVAC system with the help of a BIM-CAD tool in the BIM model.

2.1.19. Discussion of variants

Type	**TASK**
Documentation	The architect, optionally together with energy experts, compares the results from alternative examined scenarios. Selection of the suitable variant(s) for probabilistic calculations with regard to user behaviour is made.

2.1.20. Calculation of Energy (for static calculations)

Type	**TASK**
Documentation	**This and the next task comprise the ISES Simulation Cycle #2b.** Various steps have to be executed for static calculation of energy and thermal performance (i.e. without considering stochastic). This includes: • Importing building and space data from BIM-IFC • Defining the location and orientation • Defining the weather data (design days, annual) • Linking building structures to material databases • Defining/importing space type requirements However, these steps may often utilised already determined data in the preliminary design phase and may thus not have to be repeated. **Run simulation** • Export energy-related requirements • Export passive cooling requirements • If necessary, give advice for changes

2.1.21. Simulation of Energy Performance (seasonal trend)

Type	**TASK**
Documentation	Various steps have to be executed for simulating energy and thermal performance of a building. They are essentially the same as listed in the previous task above. **Run simulation** • Export as-analysed thermal performance (seasonal) • Export energy consumption results (value tables) • If necessary, give advice for changes

2.1.22. Discussion/Refining of the Variants

Type	**TASK**
Documentation	The architect, optionally together with energy experts, compares the results from alternative examined scenarios. Selection of the suitable variant(s) for probabilistic calculations is made.

2.1.23. Estimated Costs for the Variants

Type	**TASK**
Documentation	The cost expert receives the results of the analysis of every alternative and calculates the alternative with the highest quality for a given budget or the lowest life cycle costs for a given quality level.

2.1.24. Comparing Variants, Selection of the preferred variant

Type	**TASK**
Documentation	Compare results from alternative scenarios. Selection of suitable variant(s).

2.1.25. Evaluate the early design

Type	**TASK**
Documentation	Evaluation with the requirements. Evaluating and selection of the favoured variant.

2.1.26./ 2.1.27 Create Feedback & Conclude the Early Design

Type	**TASK**
Documentation	At the final task, the Client has to decide whether all requirements have been implemented effectively. A notify Feedback will be sent to the designer that the Preliminary Design process can be finished. If the requirements are not met, the project will be sent back to the design team for review.

2.2 Specification of Gateways

2.2.1. Agree with the concept results?

Type	**DECISION POINT**
Documentation	At this point, the architects discuss the obtained results (if necessary, together with the energy experts) as to whether the preliminary design is feasible. If so: the base case(s) are sent / presented to the Client. If not: the architects check which requirements are not met, make changes on relevant parts as necessary and the process cycle is restarted.

2.2.2. Agree with the first results?

Type	**DECISION POINT**
Documentation	At this point the Client must decide whether all requirements have been implemented effectively. If so: a Notify feedback will be sent to the designer and the design process can continue with the next Milestone. If not: the Client checks which requirements are not met and gives feedback to the architects.

2.2.3. Agree with the Room / HVAC Concept results?

Type	**DECISION POINT**
Documentation	At this point the Client must decide whether all requirements regarding room and HVAC concept have been implemented effectively. If so: the design process can be finished. If not: this part of design/HVAC selection has to be changed and repeated.

2.2.4. Agree with the early design results?

Type	**DECISION POINT**
Documentation	After considering the preliminary design results, he Client has to de-cide whether all requirements have been implemented effectively. If so: a notify Feedback will be sent to the designer and the process can continue with the next Milestone. If not: the Client checks which requirements are not met and gives feedback to the architects.

2.3 Specification of Library Data Objects

2.3.1. LEGAL CODES

Type	**DATA OBJECT**
Documentation	Variable data, depending on the actual context.

2.3.2. SITE ANALYSIS

Type	**DATA OBJECT**
Documentation	Variable data, depending on the actual context.

2.3.3. CLIMATE DATA

Type	**DATA OBJECT**
Documentation	Variable data, depending on the actual context.

2.3.4. LOCATION DATA

Type	**DATA OBJECT**
Documentation	Variable data, depending on the actual context.

2.3.6. BUILDING REGULATIONS

Type	**DATA OBJECT**
Documentation	Variable data, depending on the actual context.

2.4 Specification of Exchange Requirement Data Objects

2.4.1. ER Clients Requirements

Type	**DATA OBJECT**
Documentation	see D3.1: ER - BIM Client Requirements

2.4.2. ER Room book

Type	**DATA OBJECT**
Documentation	see D3.1: ER – Room book

2.4.3. ER Pre-studies / sketches

Type	**DATA OBJECT**
Documentation	see D3.1: ER - Pre Studies

2.4.4. ER BIM 1 Energy Stochastic

Type	**DATA OBJECT**
Documentation	see D3.1: ER - BIM 1 Energy stochastic

2.4.5. ER BIM Results

Type	**DATA OBJECT**
Documentation	see D3.1: ER - BIM results

2.4.6. ER BIM 2 Energy

Type	**DATA OBJECT**
Documentation	see D3.1: ER - BIM 2 Energy

2.4.7. ER BIM HVAC

Type	**DATA OBJECT**
Documentation	see D3.1: ER - BIM HVAC

2.4.7. ER BIM total Pre-Design

Type	**DATA OBJECT**
Documentation	see D3.1: ER - BIM total Pre-Design

3. Use Case 3 – Refurbishment / Retrofitting

If building components or technical installations of existing buildings do not meet current technical, economical, ecological or regulatory requirements, the client or facility manager can choose between different alternatives of retrofitting or refurbishment measures on the basis of the results from energy simulations.

Any Refurbishment / Retrofitting need, from energy performance viewpoint, may mandate the implementation of several collateral measures, to ensure high sustainable quality. A meticulous and elaborate site measurement, along with technical and energy analysis, is the basis for the successful planning of a refurbishment or retrofitting project.

Two probabilistic simulations cycles can be applied within the developed retrofitting/ refurbishment process.

3a) Figure 9 shows the **Simulation Cycle 3a** which denotes the retrofitting or refurbishment regarding energy related building properties. It is set after the status analyses of the building, i.e. after the energy experts and the architects have completed their status reports and the site measurements.

The required input parameters/variables are categorized under deterministic parameters, semi-stochastic processes, stochastic (or uncertain) parameters and stationary stochastic parameters. The obtained results will be represented in probabilistic manner and applied into the decision making process.

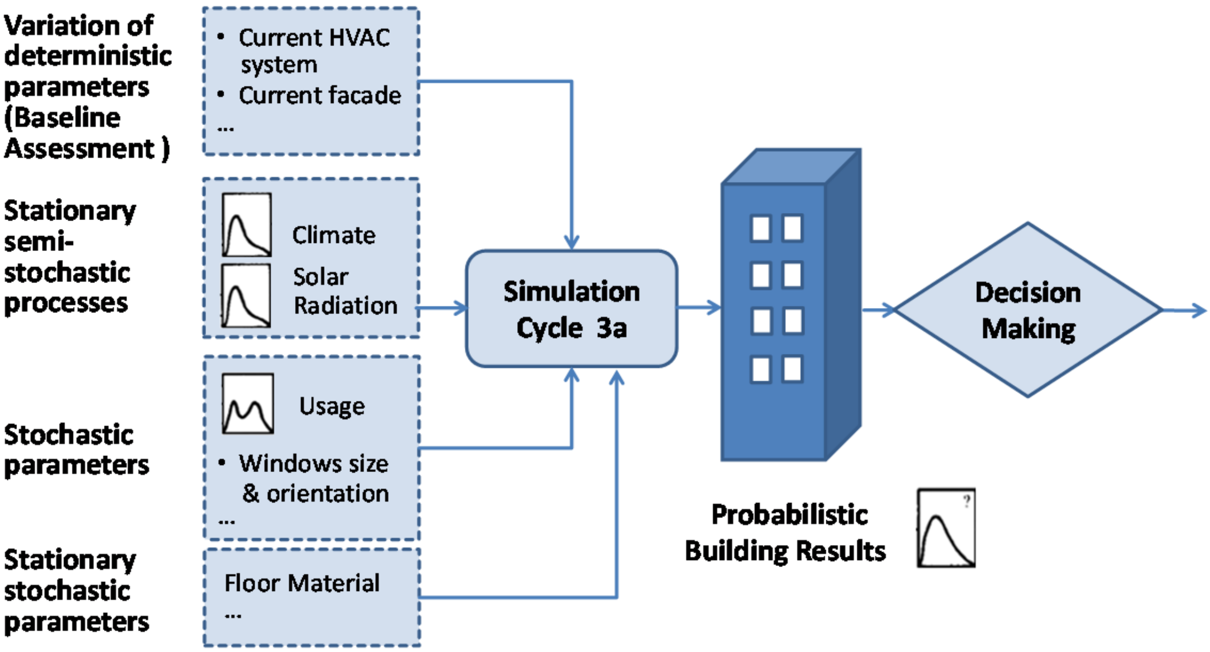

Figure 9: Envisaged ISES Probabilistic Simulation Cycle #3a

3b) Figure 10 represents the **Simulation Cycle 3b** which denotes the Retrofitting & Refurbishment of building energy HVAC types and façade materials. It is set after the modification of the rooms and within the design process of the building's new / partly new facade. The idea is to test the impact of different alternative building elements on the overall building energy performance.

The required input parameters/variables are again categorized under deterministic parameters, semi-stochastic processes and stochastic (uncertain) parameters. The obtained results will be represented in probabilistic manner and applied into the decision making process.

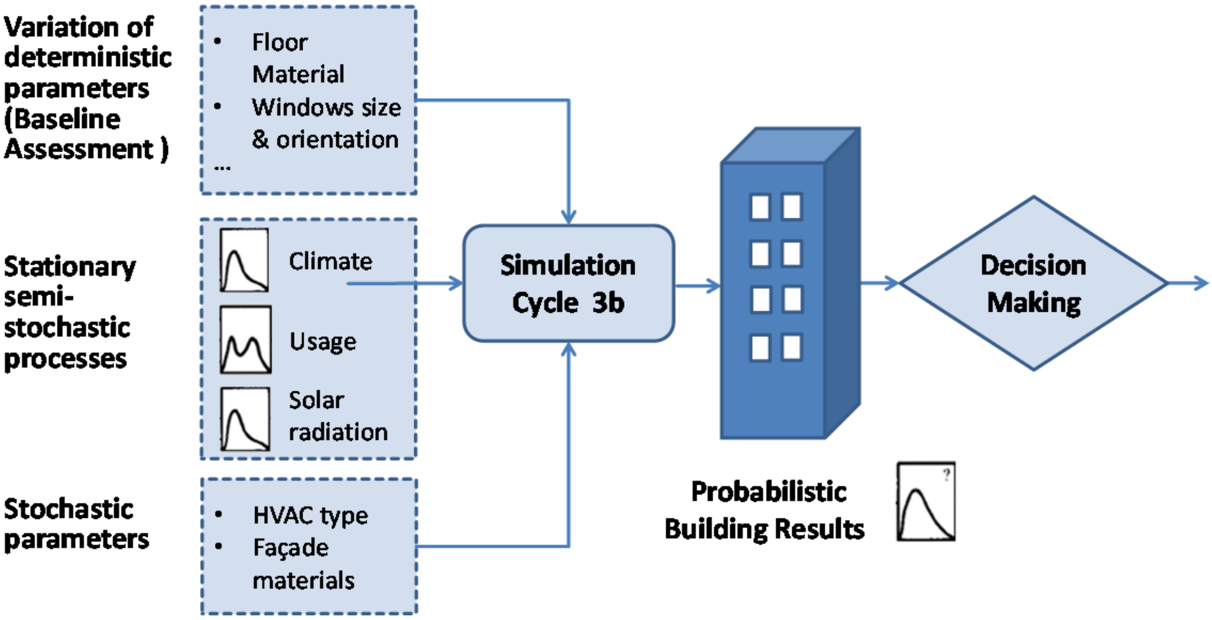

Figure 10: Envisaged ISES Probabilistic Simulation Cycle #3b

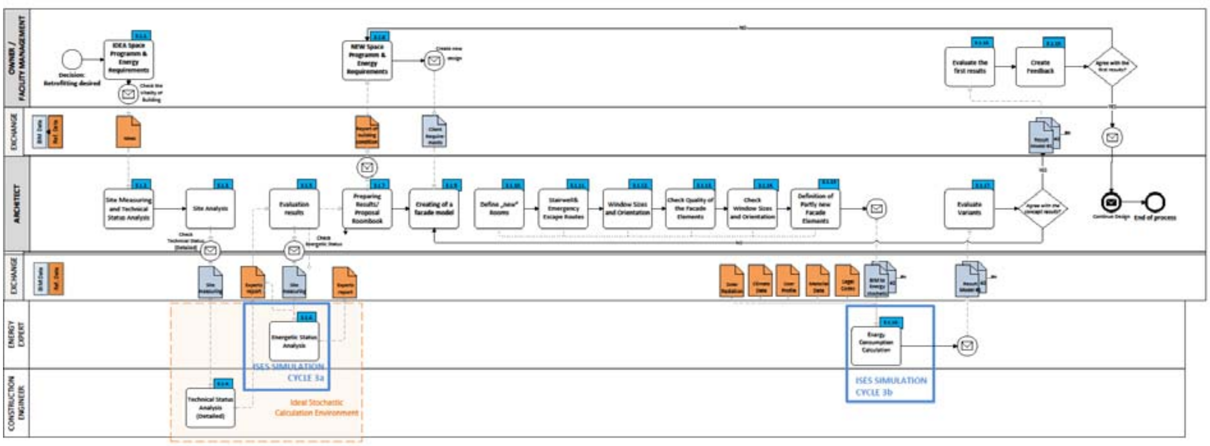

Figure 11: Retrofitting/ Refurbishment Process (see Appendix II for full process in larger scale)

The various tasks comprising this scenario are elaborated in the following section. The tasks targeted and supported by the ISES Virtual Energy Lab platform are denoted specifically - marked by dark red colour for easier reference in the provided documentation in the next section. These are Tasks 3.1.6 and 3.1.16 (see also Appendix II).

3.1 Specification of the Tasks

For better orientation, all tasks are identically numbered in the process map and the documentation below.

3.1.1. IDEA: Space Program & Energy Requirements

Type	**TASK**
Documentation	This task provides the preliminary stage to the following retrofitting / refurbishment process. The Client (or the Facility Manager) uploads the first ideas for facility use, space program and initial (light-weight) construction specifications (including thermal / system requirements). In case of hard copy or text documents the requirements could be digitalised (in BIM) or structured for verification. Analysis of the location and of the total technical energetic status is required. If there are no older building models or 2D plans, site measuring to determine the status is also required.

3.1.2. Site Measuring and Technical Status Analysis

Type	**TASK**
Documentation	In this task, the architect gains an overview of all existing digital and/or hard copy plans and/or models of the building. After this, a building audit will be necessary. Based on the collected data, it is possible to determine what kind of follow-up analyses will be required. The goals of the task are: • Detailed Site Measurement • Elaborated Technical Status.

3.1.3. Site Analysis

Type	**TASK**
Documentation	In practice, a site evaluation is the first step, taking into account soft and hard criteria, as follows: Soft criteria: • Overall attractiveness of the location • Quality and formal qualifications of urban quarter/district etc. Hard criteria: • Infrastructure • Restrictions, e.g. environmental protection • Market situation etc.

3.1.4. Technical Status Analysis (Detailed)

Type	**TASK**
Documentation	For a detailed technical status analysis, a civil engineer is needed. In common engineering practice, the estimated workload is defined with the inspection of: • Building components • Situation of neighbouring buildings • Plumbing • Anchoring, etc. Evaluation of the existing conditions and possible damages includes: • Moisture penetration and mold formation • Woodworm damage indoors and outdoors.

3.1.5. Evaluation of results

Type	**TASK**
Documentation	In this task, the opportunities and limitations of the existing building(s) and the surrounding lots are evaluated. The refurbishment of existing buildings has to adhere to numerous restrictions, compared to the liberty designers have when designing a new building. The existing building location and envelope provide clear guidance and influence the potential future use of the building, to ensure that the project remains within a reasonable budget. This task is related to the Task 3.1.6 below, specifically targeted in ISES. It is part of the design cycle enclosing the simulation cycle that shall be supported by the ISES Virtual Energy Lab.

3.1.6. Energetic Status Analysis

Type	**TASK**
Documentation	**This is the task related to the ISES Simulation Cycle #3a.** The energy performance analysis includes the building's envelope, i.e. exterior walls, roofs, windows, doors, and the entire spectrum of the building's HVAC systems (heating, cooling, water heating and ventilation). Where appropriate, the user requirements and the energy consumption must be stated. Potentially problematic components in terms of energy heat losses or gains need to be given closer attention, e.g. • non-insulated building components (e.g. walls, roofs, etc.) • windows, doors • defective seals on walls, around chimneys and other openings etc. Comparison of elements in different buildings is not appropriate because differences in energy consumption can occur due to the actual realisations of the buildings or to different user behaviour.

3.1.7. Preparing Results/ Proposal Roombook

Type	**TASK**
Documentation	Discussion of the results and first room book proposal.

3.1.8. Evaluation of the Building condition/New Space program

Type	**TASK**
Documentation	Evaluation of the building's existing condition. Additionally, the new indoor space use has to be defined.

3.1.9. Creation of a facade model

Type	**TASK**
Documentation	The current façade is available from the site measuring model. The creation of a façade model is the goal for iteration tasks 3.1.10-3.1.15.

3.1.10. Defining „new" Rooms

Type	**TASK**
Documentation	The indoor space use and layout is worked out and has to be "translated" to meet the existing building structure.

3.1.11. Check Stairwell & Emergency Escape Routes

Type	**TASK**
Documentation	As described; if they do not comply with current codes, then new ones are drafted.

3.1.12. Window Sizes and Orientation

Type	**TASK**
Documentation	In this task, existing windows and the new indoor space layout are checked for possible discrepancies. "Wrong" windows/rooms that will have to be changed are respectively marked.

3.1.13. Check Quality of the Facade Elements

Type	**TASK**
Documentation	Problematic building elements are marked according to the results from the energy performance analysis.

3.1.14. Check Window Sizes and Orientation

Type	**TASK**
Documentation	Brings together the results from both previous tasks.

3.1.15. Definition of partly new Façade Elements

Type	**TASK**
Documentation	Designing the new façade, by replacing the problematic building elements and/or integrating new/additional elements.

3.1.16. Energy Consumption Calculation

Type	TASK
Documentation	**This is the task related to the ISES Simulation Cycle #3b.** Various steps have to be executed for simulating energy and thermal performance, including: • Importing building and space data from BIM-IFC • Determining location/orientation • Defining the weather data (design days, annual) • Linking building structures to material databases • Defining/importing space type requirements **Run simulation** • Export energy-related requirements (if necessary give advice for changes)

3.1.17. Evaluate Variants

Type	TASK
Documentation	Compare results from alternative scenarios. Select suitable variant(s).

3.1.18. Evaluate the first results

Type	TASK
Documentation	Compare against requirements and owner specifications. Evaluate and select best favoured/suitable variant.

3.1.19. Create Feedback

Type	TASK
Documentation	At the final task, the client has to decide whether all requirements have been implemented effectively. If so: provide feedback to the designer that this part of the design process is completed. If not: provide feedback with justification to the design team for further review, and repeat the process as necessary.

3.2 Specification of Gateways

3.2.1. Agree with the results?

Type	DECISION POINT
Documentation	Architects in consultation with the energy experts evaluate the results and determine whether the façade design is appropriate. If so: the base case(s) are sent/presented to the Client. If not: the architects check which requirements are not met, make changes on relevant parts as necessary and the process cycle is restarted.

3.2.2. Agree with the first results?

Type	**DECISION POINT**
Documentation	The Client decides whether all requirements have been implemented effectively. If so: a Notify feedback will be sent to the designer and the design process can continue with the next milestone. If not: the Client determines which requirements are not met and gives respective feedback to the architects.

3.3 Specification of Library Data Objects

3.3.1. USER PROFILES

Type	**DATA OBJECT**
Documentation	Variable data, depending on the actual context.

3.3.2. / 3.3.3 / 3.3.4 MATERIAL DATA / CLIMATE DATA / LOCATION DATA

Type	**DATA OBJECT**
Documentation	Variable data, depending on the actual context.

1.3.5. LEGAL CODES / BUILDING REGULATIONS

Type	**DATA OBJECT**
Documentation	Relevant data from codes and regulations (as above - cariable data, depending on the actual context).

3.4 Specification of Exchange Requirement Data Objects

3.4.1. ER SITE MEASURMENTS (same BIM TO ENERGY)

Type	**DATA OBJECT**
Documentation	see D3.1: ER Requirements / BIM total Pre-Design

3.4.2. CLIENT REQUIREMENTS

Type	**DATA OBJECT**
Documentation	see D3.1: ER Requirements / BIM Client Requirements

3.4.3. ER BIM to Energy Stochastic

Type	**DATA OBJECT**
Documentation	see D3.1: ER Requirements / BIM Energy Stochastic

PART II:

REQUIREMENTS SPECIFICATION

4. Modelling and interoperability requirements

A structured data exchange is necessary to ensure efficient support to the different users of the ISES Integrated Virtual Energy Laboratory. It can greatly facilitate the coordinated use of information from working documents, the interoperability of different tools and the integration of energy templates and unstructured data (such as freeform text found in operational estimates, analysis, etc.). However, for a seamless sharing of data, the use of a common exchange model is also necessary. In ISES, the standardised open BIM, IFC, will be used for that purpose as well as a BIM-based system ontology.

Modelling Activity	Modelling Requirements
Component Development	
Proposal **(+ market perspective)**	**Define Product Objects** Digital representation of the components with their necessary attributes on the basis of industry catalogue information. Attributes include: Geometry (XYZ), Surfaces, Material, Physical Attributes etc.
BIM Component Concept	**Define Object-Data-Sets (for Product Libraries)** The energy and probabilistic simulations require graphical and non-graphical information such as tender, energy and lifecycle information. Non-graphical information should be prepared independently from the geometrical definition of the objects. Object data sets are relevant input for the energy analyses/simulations. They have to be linked to the graphical object representations before starting a simulation. Attributes include: Energy related properties, Service Lives, Intervals etc.
Building Design and Retrofitting	
Upload/Download Object Libraries to the ISES Platform	**Content Upload/Download Functionality** The online platform must allow upload/download of predefined content libraries and linking these with a project BIM-IFC model. **User-defined Upload/Download of project templates and product libraries** As above; in addition, the user should be able to modify certain properties and save the updated templates/catalogue data in the project's space. Interoperability issues include: Password/Login, Selection of libraries (typologies), Property changes etc.
Create architectural BIM	**Use of predefined objects** Draw walls, beams, columns, floors, ceilings, windows, doors, rooms, etc. **Attributes** • Geometry • Location of each element • Element properties linked to the product / component representation **Use of product catalogues** Include catalogue data in the model. As far as possible this should be using an off-the-shelve CAD-BIM system. Alternatively, it can be done externally afterwards, e. g. within the platform's nD Navigator, when creating the energy-extended BIM model.
BIM Model storage system	**This system must enable:** • BIM Model Data Upload/Download • Conversion of native Data to IFC-Format or other data formats • Portal Access / Administration Rights (password/login) • Administration of BIM Versions and Variants.

Modelling Activity	Modelling Requirements
Preparing BIM for Energy Analysis / Simulation	
Define space boundaries	Define the virtual surfaces around each space/room in the building model and link them to the building structures. For thermal simulations, at least the so called second level space boundaries are needed. If the architectural model contains no space boundaries, these need to be automatically created. If the model contains first level space boundaries, these have to be automatically transformed to second level. The system should be able to check and determine the necessary action without user intervention.
Define simulation zones	Energy analyses and simulations may be necessary not only for separate rooms or the whole building, but also for specific functional zones. It is a requirement to be able to define such zones on the basis of the BIM model before starting a simulation. ER: • Selected zone (graphically or via a filtering request) including the IDs of the contained spaces, • Zone use type
Create Simulation Model	The simulation is based on the geometrical shape, object characteristic and additional energy-related data resources and rules. A flexible exchange of object characteristics and calculation rules shall enable various simulation alternatives to be created in parallel. **The used modelling and model management tools should enable:** • Selection of different materials, climate data, usage profiles etc. • Providing the needed database connectivity • Providing various BIM-IFC filters • Providing capabilities to support Model Subset Definitions (MVD) for easier generation of needed model subsets
Alternatives & Version Management	This issue is related to (and extends) the model management. The requirement is to support and be able to process simultaneously multiple simulation models (in the simulation cycle) as well as to keep track of BIM versions (in the design cycle).
Postprocessing of Energy Analysis / Simulation Results	
Exchanging the data in a consistent format	The BIM exchanges data with analytical tools including but not limited to energy consumption, CAD systems etc. To guarantee the integration of various tools, Data converters to/from BIM are required. This is a more challenging issue in post-processing than in the simulation preparation phase because generated simulation data can be very verbose, especially when multiple semi-stochastic alternatives are run in parallel. **Data exchange formats**: IFC, XML, ASCII (CSV). Binary formats should be avoided to enable greater transparency and easier maintenance of the platform.
Alternatives & Version Management	Same as above but more challenging from IT point of view, due to heavier performance considerations. In addition, correlation of BIM and output data has to be provided.

5. Functional requirements

The ISES Virtual Energy Laboratory will be accessible on the Internet via a standard Web Browser. It will support product manufacturers, architects, HVAC designers and energy experts in component development, new building design and retrofitting/refurbishment of existing buildings by enabling comprehensive simulation of energy efficiency and evaluation of performance and comfort, taking into account probabilistic input values and semi-stochastic computational methods. Moreover, different iteration cycles will be supported, as well as the fast and simultaneous examination of alternatives using high-throughput computing provided via cloud technology.

To achieve specification of the functional requirements to the Virtual Energy Laboratory, various relevant end-user activities were investigated and linked to the exchange requirements of the defined use cases.

5.1 Simulation Cycle 1

Activity / Function	Functional Requirements	Product Data	
		Data Input	Data Output
Requirements Pre-Processing			
Create model **Create calculation scenarios**	• Input BIM data • Import energy data of construction materials • Build up a virtual mock-up • Set up virtual test environment according to the application area • Upload or create energy require-ments • Create sufficient amount of test scenarios (weather, occupancy, material) for stochastic analyses	BIM data Reference Data: • Filter spec. • Material data • Climate data • Location data • HVAC system data • Building regulations	BIM Component Concept
Requirements Processing			
System and model check **Simulation**	• Simulation with one extreme shor-tened scenario (estimated worst case) and one average shortened scenario for system check and de-tection of major problems • Calculation of all scenarios • Perform semi-stochastic analyses of all relevant results		Product results Simulation results
Requirements Post-Processing			
Output of results	• Output of simulation results • Output of Energy Key Performance Indicators (eKPIs) • Output of the total embodied energy of the analysed product • Indication of model weaknesses		Synthetic calculation results for decision makers

5.2 Simulation Cycle 2a

Activity / Function	Functional Requirements	Product Data	
		Data Input	Data Output
Requirements Pre-Processing			
Create model	• Input BIM data • Import energy data of structural materials • Add energy relevant elements • Set up virtual test environment according to the building location and orientation • Upload energy requirements and space program	BIM data Energy data	Energy-extended BIM
Create calculation scenarios	• Edit energy requirements and space program • Create sufficient amount of test scenarios (weather, occupancy, material) for stochastic analyses	Energy requirements	
Requirements Processing			
System and model check	• Simulation with one extreme shortened scenario (estimated worst case) and one average shortened scenario for system check and detection of major problems		BIM results Simulation results
Simulation	• Semi-stochastic analysis of all relevant alternatives		
Requirements Post-Processing			
Output of results	• Output of stochastic results • Output of Energy Key Perfor-mance Indicators (eKPIs) • Output of the total energy • Indication of model weaknesses		Synthetic calculation results for decision makers

5.3 Simulation Cycle 2b

Activity / Function	Functional Requirements	Product Data	
		Data Input	Data Output
Requirements Pre-Processing			
Create model **Create calculation scenarios**	• Input BIM data • Import energy data of construction materials • Add energy relevant elements • Set up virtual test environment according to the building location and orientation • Upload energy requirements and space program • Edit energy requirements and space program • Create sufficient amount of test scenarios (weather, occupancy, material) for stochastic analyses	BIM data Energy data Energy requirements	Energy-extended BIM
Requirements Processing			
System and model check **Simulation**	• Simulation with one extreme shortened scenario (estimated worst case) and one average shortened scenario for system check and detection of major mistakes • Calculation of all scenarios • Semi-stochastic analyses of all relevant alternatives		BIM results Simulation results
Requirements Post-Processing			
Output of results	• Output of stochastic results • Output of Energy Key Perfor-mance Indicators (eKPIs) • Output of the total energy • Indication of model weaknesses		Synthetic calculation results for decision makers

5.4 Simulation Cycle 3a

Activity / Function	Functional Requirements	Product Data	
		Data Input	Data Output
Requirements Pre-Processing			
Create model	• Input BIM data • Import state of building exper-tise • Edit which parts of the buil-ding can be left as is, and which have to be renovated or replaced • Import energy data of cons-truction materials • Add energy relevant elements • Set up virtual test environment according to the building's location and orientation	BIM data State of building expertise Energy data	Energy-extended BIM
Create calculation scenarios	• Upload energy requirements and space program • Edit energy requirements and space program • Create sufficient amount of test scenarios (weather, occupancy, material) for stochastic analyses	Energy requirements	
Requirements Processing			
System and model check	• Simulation with one extreme shortened scenario (estimated worst case) and one average shortened scenario for system check and detection of major mistakes		BIM results Simulation results
Simulation	• Semi-stochastic analysis of all relevant alternatives		
Requirements Post-Processing			
Output of results	• Output of Energy Key Perfor-mance Indicators (eKPIs) • Output of the total energy • Indication of the model weaknesses		Synthetic calculation results for decision makers

5.5 Simulation Cycle 3b

Activity / Function	Functional Requirements	Product Data	
		Data Input	Data Output
Requirements Pre-Processing			
Create model **Create calculation scenarios**	• Input BIM data • Import state of building expertise • Edit variants of intervention in the building structure • Import energy data of all construction materials • Add energy relevant elements • Set up virtual test environment according to the building's location and orientation • Upload energy requirements and space program • Edit energy requirements and space program • Create sufficient amount of test scenarios (weather, occupancy, material) for stochastic analyses	BIM data State of building expertise Energy data Energy requirements	Energy-extended BIM
Requirements Processing			
System and model check **Simulation**	• Simulation with one extreme shortened scenario (estimated worst case) and one average shortened scenario for system check and detection of major mistakes • Calculation of all scenarios • Calculation of variants of intervention in the building structure • Semi-stochastic analysis of all relevant results		BIM results Simulation results
Requirements Post-Processing			
Output of results	• Output of stochastic results • Output of Energy Key Performance Indicators (eKPIs) • Output of the total energy • Compared variants of intervention in the building structure • Indication of model weaknesses		Synthetic calculation results for decision makers

6. Requirements regarding stochastic life-cycle simulation

It was previously elaborated that the solutions of ISES are focused on three main scenarios in the life-cycle of buildings and facilities:

(1) Development of new building components and products

(2) Design and engineering of new buildings and facilities

(3) Refurbishment and retrofitting of existing buildings and facilities

The simulation outputs resulting from the three main scenarios are the probabilistic components and the probabilistic building results. Regarding the analysis intent several semi-stochastic, deterministic and uncertain design parameters (variables) have to be applied to the simulation engine. In building component product development and design of facilities, almost all design parameters are subject to uncertainty. There are a few research efforts that have attempted to model the whole building under uncertainty, using over 1000 uncertain parameters when evaluating the energy efficiency of buildings. As mentioned in chapter 8.4.1 of the ISES Deliverable D1.1 (cf. Kavcic et al. 2012) applying the screening methods can be very beneficial in such cases in which the number of parameters is very large. Screening methods simplify the models and reduce the number of uncertain input parameters propagating through the model. The task is to properly identify the input parameter or a set of input parameters that have the least influence on the variability of the model outputs. These non-influential parameters can then be fixed at any given value of their range of uncertainty without reducing significantly the model output and without significant loss of information (Saltelli et al. 2006).

The stochastic approach addresses all the categories of the parameters space, climate profiles, solar gain, usage profiles, and energy related building material properties. Because of the direct influence of occupancy (or activity) patterns on the energy consumption profile, it is preferred to develop the occupancy profile which is used to model the usage profile. The sensibility of the model outcome to changes in the model inputs can be assessed by performing sensitivity analyses. The sensitivity analysis method provides a powerful tool to illustrate the consequences of alternative assumptions about a given model and as such, an important method for checking the quality of the model as well as for checking the robustness and reliability of the model analysis.

Simulation Cycle	Data Requirements	Data Domain
Component Development **Simulation Cycle 1**	• Properties of materials • Climate data • Usage data	*Stationary stochastic parameters*
	• Climate • Usage (Occupancy)	*Stationary semi-stochastic process*
Early Design **Simulation Cycle 2a**	• Definition of materials • Climate data	*Stationary stochastic parameters*
	• Cubature • Number of stories • Windows size and orient-ation	*Deterministic parameters*
	• Climate	*Stationary semi-stochastic process*
	• Space Division	*Stochastic parameters*

Simulation Cycle	Data Requirements	Data Domain
Early Design **Simulation Cycle 2b**	• Definition of materials • Climate data etc.	Stationary stochastic parameters
	• Space division • Cubature • Number of stories etc.	Variation of deterministic parameters
	• Climate • Usage (Occupancy)	Stationary semi-stochastic process
	• HVAC Type(s)	Uncertain Parameter (Fuzzy or bandwidth)
Retrofitting & Refurbishment **Simulation Cycle 3a**	• Actual HVAC system • Actual façade elements • …	Deterministic parameters
	• Climate • Solar radiation	Stationary semi-stochastic process
	• Usage Profile • Windows size and orientation • …	Stochastic parameters
	• Floor Material	Stationary stochastic parameters
Retrofitting & Refurbishment **Simulation Cycle 3b**	• Floor material • Windows size and orientation	Variation of deterministic parameters
	• Climate • Usage (Occupancy) • Solar radiation	Stationary semi-stochastic process
	• HVAC Type • Façade	Stochastic parameters

7. GUI requirements

7.1 Model and parameter input

When using the ISES platform it is of great importance to have proper guidance during the input process and to have various options to check if the inputs are both correct and complete. Therefore, a general scheme has to be defined, that shows what kind of input is already available and what is missing, and what does not fit to the targeted investigations. Accordingly, there should be a connection between a 3D visualisation of the model to the corresponding input parameters. A directory tree can be used as an outline and a checklist to help the user keep track of important parameters that are needed for the calculation. The corresponding parameters should be visible in the 3D model. In this way, the 3D visualisation will help the user to navigate through the building and to obtain an overview of the set parameters.

Figure 12 below illustrates the overall concept of the envisaged GUI of the Virtual Energy Laboratory. It comprises the following areas:

- Toolbar - used to save, print, set options, etc.
- Directory tree - enables the user to switch between all input parameters and provides guidance through the input process
- Input box – provides the actual working space for all inputs that are done on the platform, including the insertion of external data
- Visualisation (2D and 3D) - provides visual feedback of the location where the user makes an input, the corresponding numerical value of the selected parameters, and also where the platform expects the user to provide input.

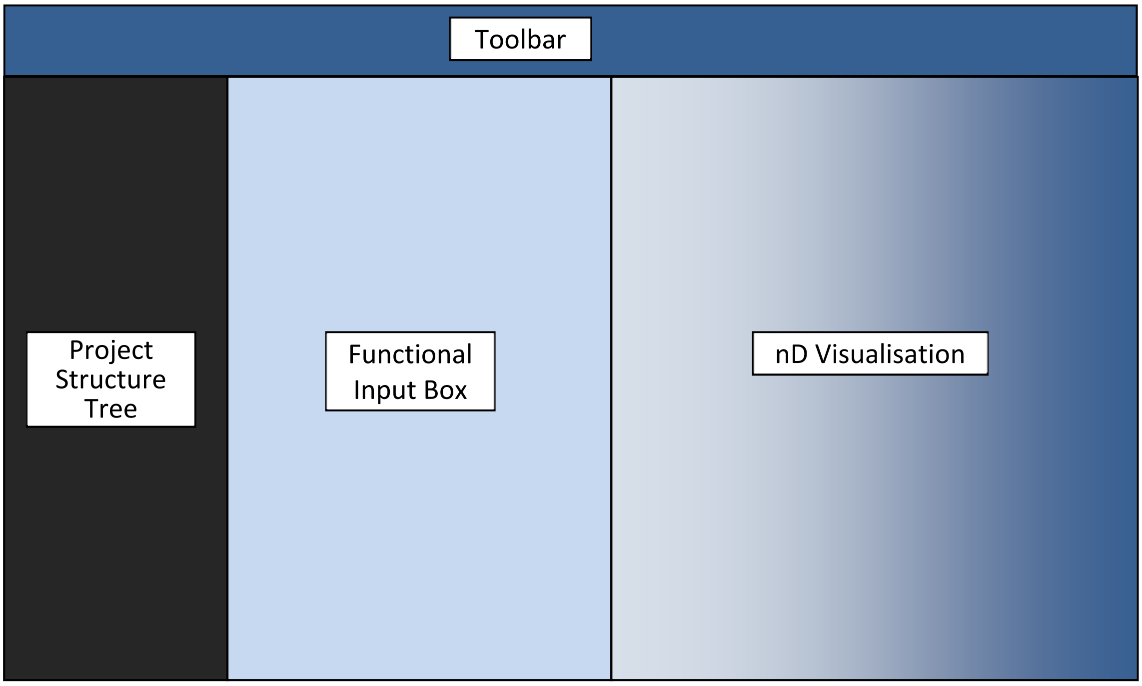

Figure 12: Proposed principal graphical user Interface (GUI) of the ISES Virtual Energy Lab

7.2 Graphical results output

The Virtual Energy Lab will typically produce a huge amount of results in each user session. Hence, it is very important to help the user of the platform to navigate through this information, filter governing scenarios and make decisive results visible and easy to comprehend.

Therefore, it is necessary to provide results both graphically (two and three dimensional) and numerically. Graphic output can identify the point in time of the corresponding weather trend of the analysed period so that the impact of extreme weather events can be taken into consideration.

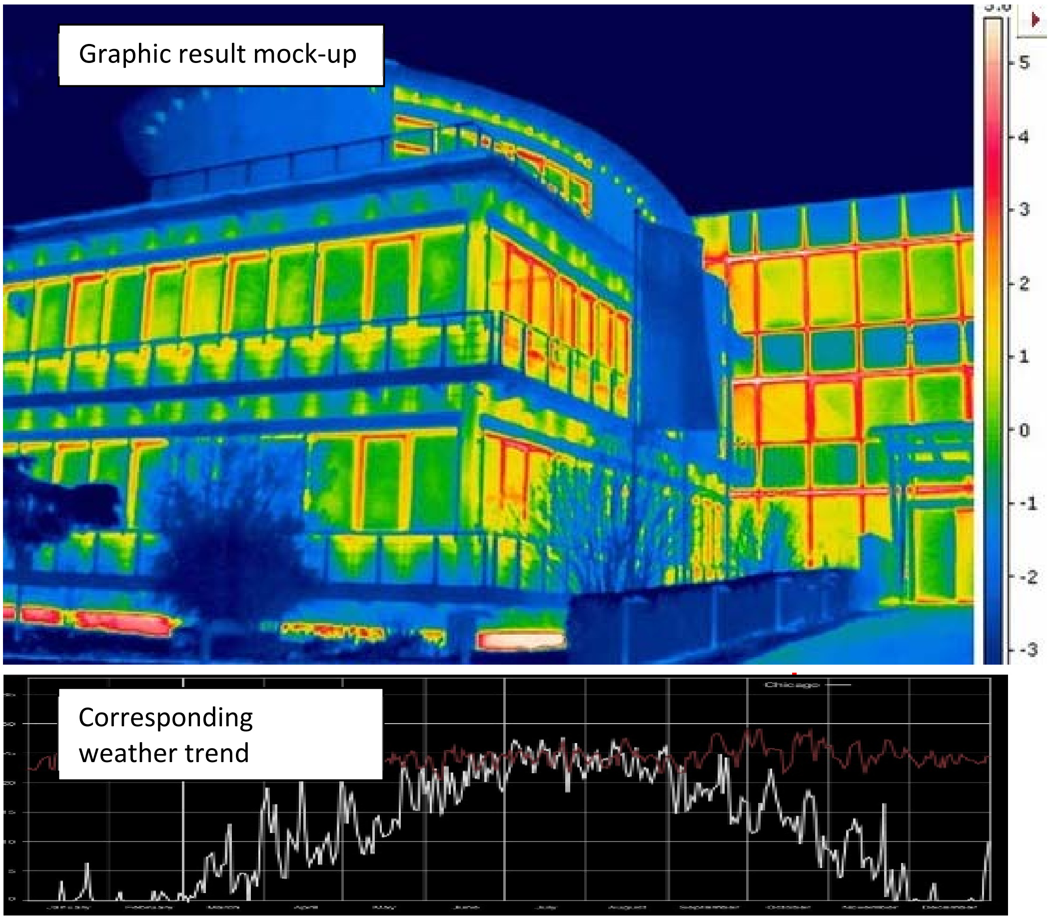

Figure 13: Mock-up of the tentatively envisioned graphic result connected to a point in time of the test year

7.3 Comparison of results

Simulation results should be graphically comparable to the requirements of each part of the building. In addition, the aberration during extreme scenarios should be comparable to average results. The GUI of ROOMEX shown on the next figure illustrates the principal concept.

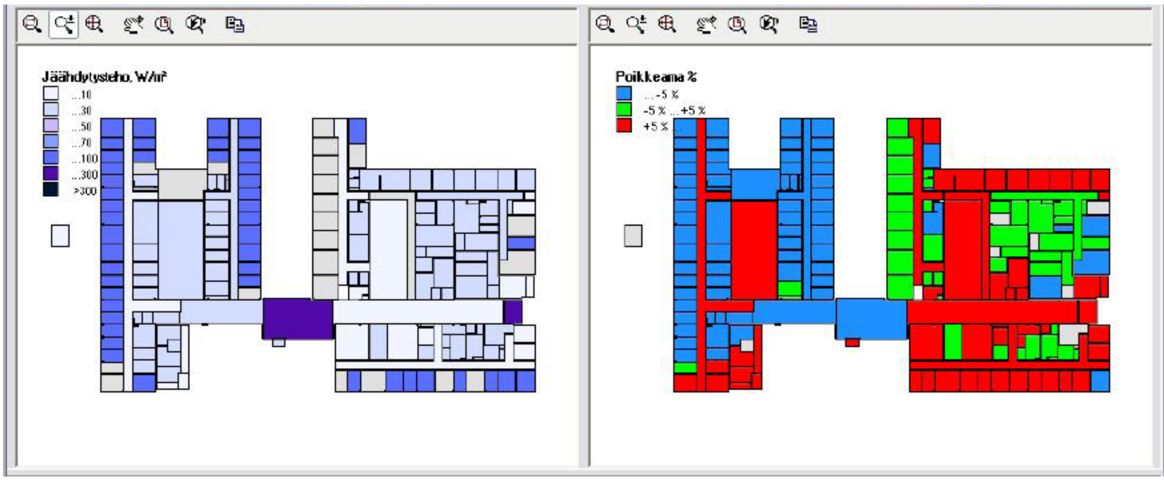

Figure 14: GUI of ROOMEX (partially)

7.4 Stochastic results

Results from stochastic calculations, when presented on a chart against their relative frequency, produce a Gaussian normal distribution. This curve illustrates all analysed test years, gives the arithmetic average and shows the likeliness of extreme scenarios that will occur during the building life cycle. This will be a valuable tool to optimize HVAC design.

Results of stochastic calculations put on a chart by showing results in relation to their relative frequency produce a Gaussian normal distribution. This curve gives a very good image of all analysed climates, gives the arithmetic average and shows the likeliness of extreme scenarios that will occur during the building life cycle. This will be a valuable tool on decision making and help to optimize energy design. It will also enable the user to classify the results.

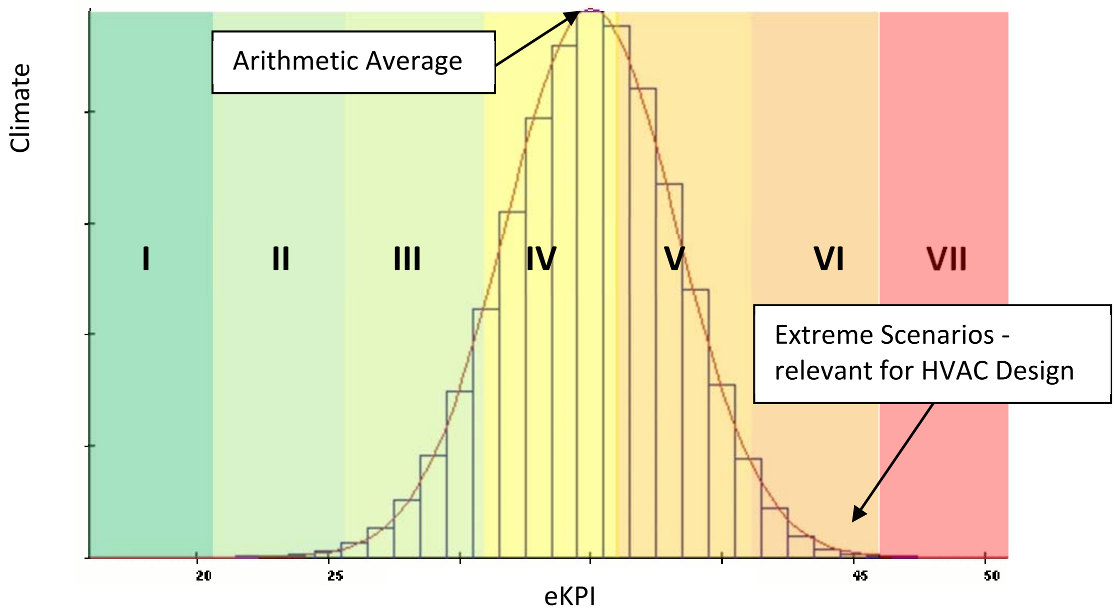

Figure 15: Gaussian Normal Distribution of eKPI (e.g. Energy Consumption)

8. Locations to be analysed in the project

Simulation software requires weather data to calculate energy balance of buildings and HVAC systems. Additional, for the ISES probabilistic considerations, weather data are also needed. Currently, there are several weather data sets available for this purpose as elaborated in Deliverable D1.1.

In ISES, a broad variety of European regions covered by the consortium partners and featuring very different climatic and cultural conditions will be investigated, as shown on the figure below.

Figure 16: Overview of the ISES locations

As a starting point, Typical Meteorological Years (TRY) available for Athens, Greece will be used. This provides measured data from the meteorological station of NOA in Athens during the period of 1975-2004. Weather data for other locations of the project partners is also available e.g. from the Meteo-Norm database. The available data includes 8,760 hourly values for an entire year of the following parameters: Total solar radiation on horizontal [MJ.h-1.m-2], Diffuse solar radiation on horizontal [MJ.h-1.m-2], Temperature [^{o}C], Relative humidity [%], Wind speed [m.s-1], Wind direction [deg].

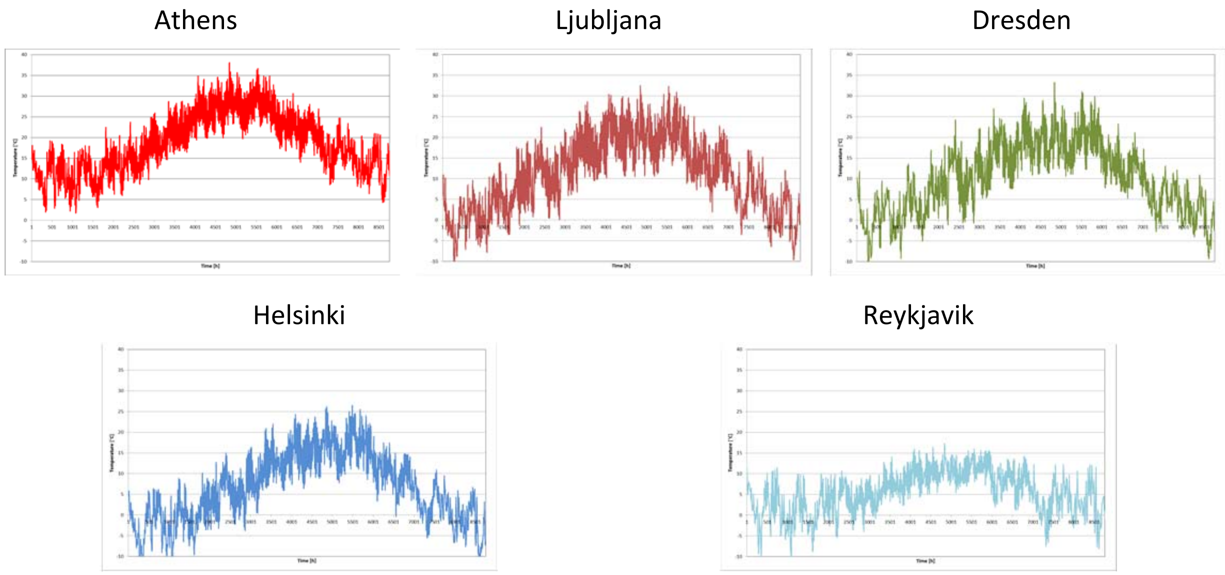

Figure 17: TRY temperature data for the test locations that will be examined in ISES, clearly showing the climatic differences that will be taken into account in the usage scenarios

Conclusions

The purpose of Deliverable D1.2 of the ISES project has been twofold:

(1) To define the main scenarios that will be targeted by the RTD work and the subsequent validation of the achieved results

(2) To provide high-level requirements from end user perspective that will set up the frames, the scope and the major issues of interest to be researched and realised by the project partners.

Three main scenarios in the drafted overall life cycle processes were identified where energy simulations on the envisaged ISES Virtual Energy Laboratory can have greatest impact. These are:

(1) Conceptual manufacturer product / component development

(2) Design of new buildings

(3) Refurbishment / retrofitting of existing facilities.

These scenarios provided guidance for the specification of requirements, especially with regard to the functionality of the ISES platform and the use of stochastic methods, which were critically pre-planned in accordance with the targeted tasks.

Thus, deliverable D1.2 achieved its goal to check and assess the project objectives from the DoW and firm up development plans via a set of structured requirements giving substantial advice for the RTD work in work packages 3-7. The participation of all project partners additionally helped to strengthen cooperation and improve the understanding of common project goals.

Some of the specified requirements cannot be confirmed in the project schedule at this stage and should thus be seen as “nice to have” issues as yet. However, such requirements are not removed from the report, neither are they respectively separated from mandatory ones. This was done on purpose – to avoid too great precaution and eventual early narrowing the scope of the RTD works. Such concretisation will take place within the conceptual work packages WP2 and WP3, which shall complete the development basis of the ISES platform with technical specifications, detailed exchange requirements / interfaces, and data schemas.

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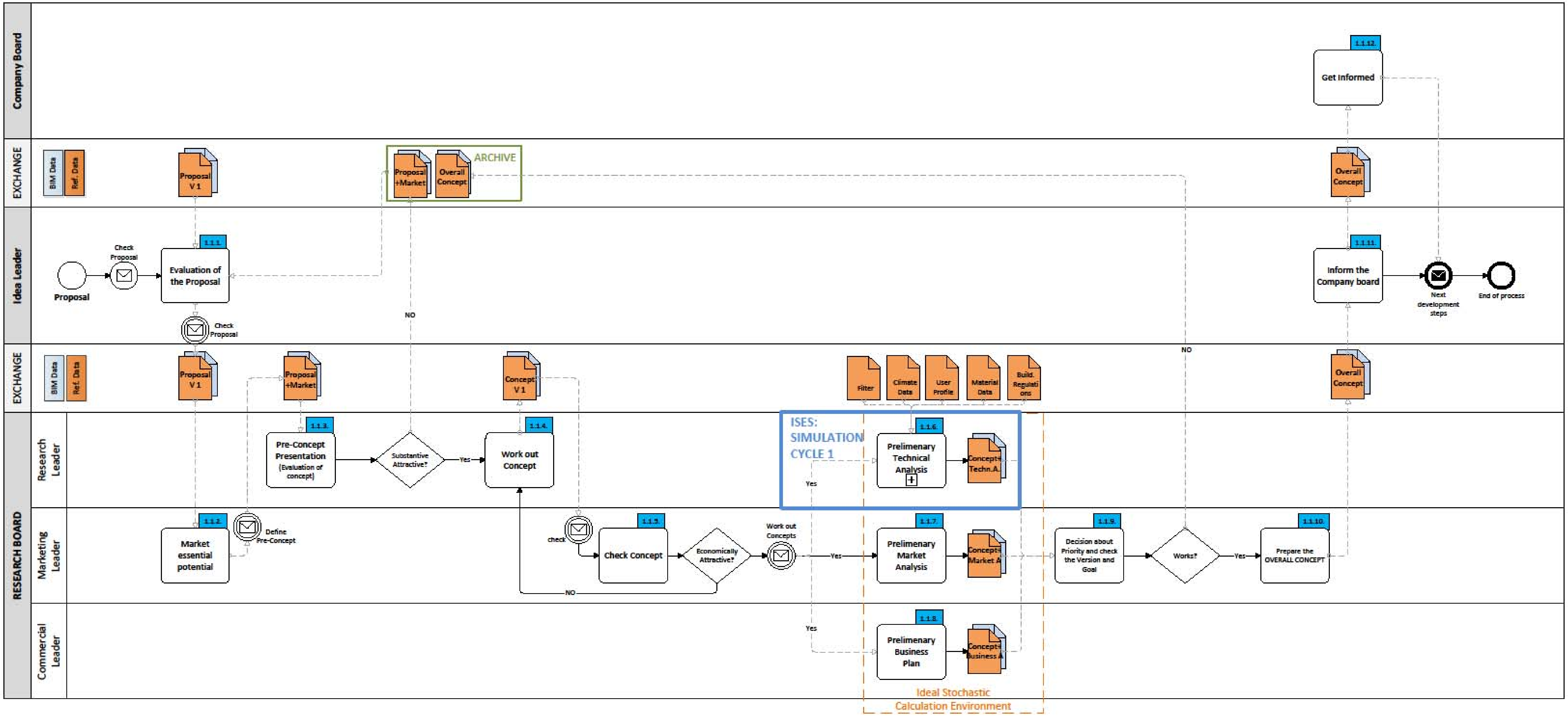
Appendix I: Acronyms

AEC	Architecture, Engineering and Construction
AHU	Air Handling Unit
ARIS	Architecture of Integrated Information Systems
BIM	Building Information Modelling (Model)
BPMN	Business Process Model Notation
eKPI	Energy Key Performance Indicators
ER	Exchange Requirements
FM	Facilities Management
HESMOS	EU Project No 260088 "ICT Platform for Holistic Energy Efficiency Simulation and Lifecycle Management Of Public Use FacilitieS"
HPC	High Performance Computing
HTC	High Throughput Computing
HVAC	Heating, Ventilation, Air Conditioning
IAQ	Indoor Air Quality
ID	(unique) Identification
IDM	Information Delivery Manual
ICT	Information and Communication Technology
IFC	Industry Foundation Classes
RTD	Research and Technology Development
TMY	Typical Meteorological Years
TRY	Test Reference Year
USP	Unique Selling Point
WP	Work Package
XML	Extensible Mark-up Language
XSD	Extensible Mark-up Language Schema Definition

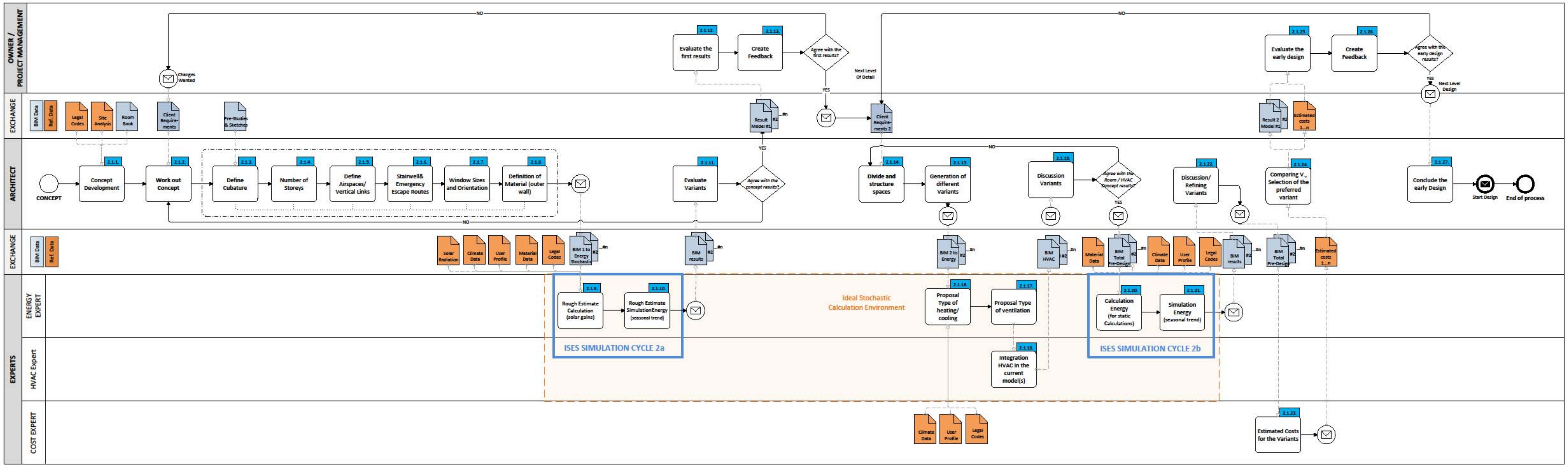
Appendix II: Process Maps

On the following pages, the developed process maps, schematically shown in Part 1 of this report, are presented in larger scale.

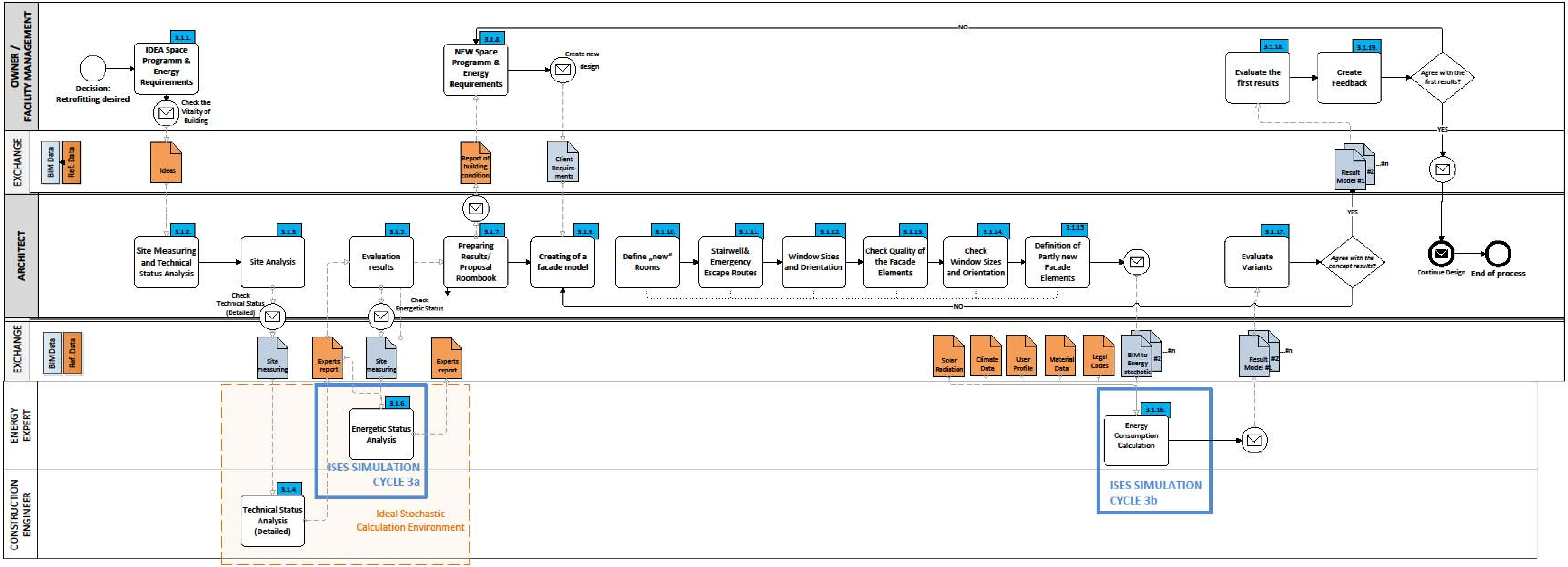
However, the original worked out maps are even larger and contain a considerable number of items and symbols. Hence, for detailed view the original **BPMN diagrams** should be referenced.



BPMN Process Map: USE CASE 1 - Component Development



BPMN Process Map: USE CASE 2 - Early Design



BPMN Process Map: USE CASE 3 – Retrofitting/ Refurbishment