ECODISTR-ICT

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Deliverable D 5.4

Conclusion report on the governance of retrofitting and the use of the ECODISTR-ICT tool

Concise report on performance prototype + Concluding reflection on the governance of retrofitting and the use of the ECODISTR-ICT tool: part B

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EXECUTIVE SUMMARY

An enormous diversity of stakeholders are involved in the built environment. The inhabitants, local policy makers, housing associations, developers, suppliers of components or subsystems, contractors/builders, service providers, and many others play a role in taking decisions about the design, the construction, occupation, retrofitting or renewal of buildings and districts. Currently, many of these stakeholders have their own decision-making processes that are not or only partially integrated.

The ECODISTR-ICT Integrated Decision Support System (IDSS) will facilitate intensive collaboration between diverse disciplines and different stakeholders, each with their specific goals, questions and decision-making processes concerning district retrofitting. The questions and goals of stakeholders - such as service providers - can differ greatly from other stakeholders - such as individual homeowners or facility managers -, but nevertheless they are closely interrelated and their choices can influence each other. The ECODISTR-ICT IDSS can help to align the stakes and decisions to reach a mutually supported vision, based on comprehensible data.

The objective of Work Package 5 (WP5) of ECODISTR-ICT is to test the IDSS through design, planning and implementation of real life case studies, bringing together communities, building owners, developers, tool owners and knowledge institutes. The case studies are mainly initiated by local architecture, design and planning firms with extensive experience in the local context and everyday practice. In the case studies, we provide a close cooperation with the research institutions and a broad range of local stakeholders. The feedback of these case studies allows an iterative development of the IDSS in close collaboration with actual users and stakeholders.

This Deliverable reports on the findings and conclusions of the activities of WP5. The IDSS has been tested in 5 different case studies. Each case tried to facilitate a process of retrofit planning, which responded to ongoing collective decision-making on pending issues in the area. This report includes a reflection on the role of the IDSS in these processes and explains how the case studies and stakeholder interactions influenced the development of the IDSS. Furthermore, recommendations are provided for future users of the IDSS. The activities and interactions that took place also provide valuable lessons and recommendation for the future development and use of the IDSS.

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GLOSSARY / LIST OF ACRONYMS

Alternative	A possible solution, represented by a set of related values for variables. Typically, a decision is based on a comparison of the KPI scores of alternatives in several contexts.
Ambition	A quantified vision that includes a target for each KPI (both the value and the time when to reach it)
Assessment	Quantification of the KPIs of an alternative within contexts.
Calculation modules	Calculation of KPIs
Component	A component is a smallest independent part of the IDSS-framework that performs a specific task within a module or in the IMB communication framework.
Context	A future situation which is determined by the external factors that the stakeholders in the decision-making process cannot influence
District	A subdivision of a city or municipality. In this project we expect a district to encompass +- 1000 buildings.
Dry run	A dry run or a practice run is a testing process where the effects of a possible failure are intentionally mitigated; a repetition process
End User	The user of the tool, e.g. a trained city planning professional.
ESCO	Energy service contracting company
Evaluation	The process of comparing the assessment score of a variant with the targets set in the ambition
Framework	Platform for integration of system components, e.g. based on Inter Model Broker
WKT + CSV file	A WKT + CSV file includes geometric data and other data per building, such as energy use expressed in kWh/m^2 for each building
ICT	Information and Communication Technologies
IDSS Dashboard	The interface of the end-users to the IDSS that enables them to use the IDSS in their decision-making processes.
IMB	Inter Model Broker
Integrated Decision Support System	Abbreviated as IDSS, refers to a tool that supports the decision-making process in district retrofitting activities.
Interface	In technical contexts, interface requirements are governed by standard conventions called protocols which could be so complex that the interface itself is considered a separate device or system. In the context of computers, three common interface types are: Hardware, Software and User interface.
KPI	Key performance indicator = a measurable indicator for one aspect of the users' ambition

KPI Value	Required or predicted score of a KPI
Measure	A punctual intervention (i.e. e Measure window replacement; Measure PV panels installation; Measure building demolition)
Model	A model performs calculations of KPIs as a view of reality. It makes use of data input and creates data as output.
Module	An independent functional part of the IDSS. A module can consist of several coherent components e.g. calculation model, IMB client, data storage, assessment of variants visualization (in order to gather, create, change, present, and/or analyse data)
On-the-fly	“On-the-fly" describes activities that develop or occur dynamically rather than as the result of something that is statically predefined.
Prototype	Pre-production model of a product, engineered for full service test. Changes based on test results are incorporated into the prototype which undergoes the same tests again. On achieving the desired results, the product is approved for volume production.
Scrums	A flexible and intensive software development method
Stakeholder	A person, group or organization that has interest or concern in an organization. Stakeholders can affect or be affected by the organization's actions, objectives and policies.

LIST OF FIGURES

READING GUIDE

This document is addressed to all stakeholders, partners, future users, researchers and others that show interest in the ECODISTR-ICT Integrated Decision Support System (IDSS) for district retrofitting.

Chapter 1 introduces the document and gives a brief overview of the purpose and scope of the project and the role of WP5 in the development of the IDSS.

Chapter 2 focusses on the nature of multi-stakeholder decision-making, explains the theoretical background of the functional design of the IDSS and the approach that was adopted for the development of the IDSS.

Chapter 3 summarizes the interactions that took place in WP5 during the whole project and how these discussions influenced the actual design of the ECODISTR-ICT IDSS.

Chapter 4 contains recommendations and lessons for future users of the IDSS, from the perspective of organising a decision-making process.

Chapter 5 develops conclusions and recommendations regarding the further elaboration of the IDSS.

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The objective of ECODISTR-ICT is to develop an integrated decision support system (IDSS) for sustainable retrofitting projects on district level, which can help to align all stakeholders and decision-makers to reach a mutually supported vision, based on comprehensible data. This includes two challenges. The first is to show all the different needs of stakeholders in a single, integrated software environment, as the ambition is to respond to the multidisciplinary character of retrofitting projects. The other is to create a truly integrated platform that combines the strengths of existing assessment tools on both building and urban level.

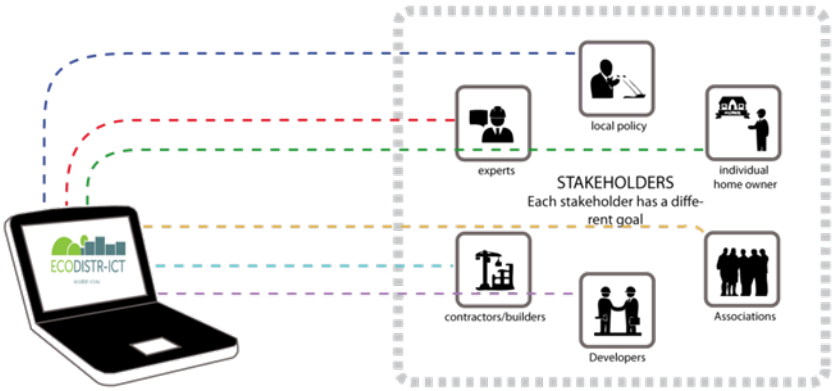

Figure 1 Scheme ECODISTR-ICT IDSS

In order to meet these challenges and to enhance the potentials and usability of the ECODISTR-ICT tool, the ECODISTR-ICT software development process was designed as an interdisciplinary (integrating various disciplines) and a transdisciplinary (involving real users) process, and is in that sense probably quite unique. As such, the software was tested in five real-life case studies in Antwerp, Rotterdam, Stockholm, Valencia and Warsaw, in a specific work package WP5. A geographical distribution of the case studies revealed contextual differences regarding culture, climate and policies in relation with energy-use and energy efficiency as well as with other retrofit issues. These differences were incorporated in the development of the tool, which should enhance the wide applicability of the tool.

WP5 thus primarily aimed to:

- test and demonstrate the scenarios developed in WP1, the data upload and reading of data in WP2, the software modules developed in WP3, and the integrated tool developed in WP4, through real life case studies
- discuss and test the ECODISTR-ICT software through design, planning and implementation of case studies

- establish a strong interaction with the other work packages through case studies and to provide continuous feedback of real-life cases allowing for an iterative development of the tool in close collaboration with actual users and stakeholders.

This deliverable D5.4 draws final conclusions on the testing of the IDSS in the interaction between the case studies and the software development, and the governance and use of the tool in decision-making processes in district retrofitting projects. It concludes with recommendations with regards to the use and further development of the IDSS.

1.2 ORGANISING COMPLEX INTERACTIONS IN A MULTIDIMENSIONAL SOFTWARE DEVELOPMENT PROCESS

The case studies were implemented by the partners OMGEVING and VITO (Antwerp), TNO and VABI (Rotterdam), White Architects and SP (Stockholm), Bipolaire (Valencia) and ARUP (Warsaw), who all have extensive experience in the local context and everyday practice. In the case studies, these partners developed a close cooperation with the software developers and research institutes on the one hand and a broad range of local stakeholders on the other. The testing thus interacted with decision-making in the ECODISTR-ICT consortium on the focus, target groups, business model, support modules and structure of the software, but - to a certain extent - also with decision-making in the case study areas themselves. As such, the role of the case studies was to take part in three parallel interactive processes:

1. creating the IDSS, using a scrum-like development process (as described in the Deliverables of WP4), in the ICT domain;
2. developing a multi-stakeholder interaction process for retrofitting districts, based on using the new IDSS, in the domain of the (urban retrofitting) process facilitation domain;
3. developing alternatives for a new retrofitted district, using an interactive process and the new IDSS, in the district retrofitting domain.

All of these processes can be seen as constituted by stages and/or tracks of specification, design, implementation and evaluation, as well as complex interactions and iterative feedback loops. Furthermore, they had different participants, lead partners, goals and speeds. On top of that, the people involved in these three processes had backgrounds in different domains, were framed by different trainings and theories, had different methodologies and approaches, and operated with different stakes in the development and implementation of the software. Choosing for an interactive approach in the ECODISTR-ICT development process, thus entailed organizing the alignment and the interaction between the people, methodologies and theoretical backgrounds of the three domains (ICT, process facilitation, district retrofitting).

1.3 AGILE PRODUCT DEVELOPMENT

Concomitant to the previous, from its start, the ECODISTR-ICT project adopted an agile product development approach. This concept is often used in software development in which requirements and solutions evolve through the collaborative effort of self-organizing cross-functional teams. [1]

The manifesto for agile software development released in 2001 was based upon following principles: [2],

- Individuals and interactions should be valued over processes and tools
- Working software should be valued over comprehensive documentation
- Customer collaboration should be valued over contract negotiation
- Responding to change should be valued over following a plan

During the development of the ECODISTR-ICT IDSS, the project members did not only apply these principles to the development of the software code itself, but also to the definition of the functional needs and the preparation and testing in the five case study project areas. In a truly iterative process, IT developers, case study partners and external stakeholders were mutually involved in shaping the ECODISTR-ICT IDSS 'along the way'. This is opposed to a more traditional approach in which the software would have been developed completely before using it in practice. As such, during the project incremental updates were developed and tested, including short feedback loops and multiple testings, thus reducing the risk, and enabling to adapt to changing requests and user needs.

Although this concluding deliverable D5.4 mainly addresses how the IDSS can be used in district retrofitting processes, we will refer quite a number of times to these very challenging but rewarding multidimensional interactions.

1.4 APPLICABLE DOCUMENTS

- ECODISTR-ICT Description of Work (DoW, d.d. 3rd December 2012)
- ECODISTR-ICT Deliverable D1.1 List of specifications for the decision tool in function of stakeholder input (d.d. 28th February 2014)
- ECODISTR-ICT Deliverable D1.2 Stakeholders' objectives and decision-making criteria and mutual interdependencies (d.d. 30th November 2015)
- ECODISTR-ICT Deliverable D4.1 Functional Design of the IDSS (d.d. 31th March 2014)
- ECODISTR-ICT Deliverable D3.1 A first survey of existing tools and methods supporting evaluation of indicators for urban district retrofitting and renewal (d.d. 31st August 2014)

[1] https://en.wikipedia.org/wiki/Agile_software_development
[2] Manifesto for Agile Software Development - http://agilemanifesto.org/

- ECODISTR-ICT Deliverable D5.1 A roadmap for the analysis of the case studies (d.d. 31st May 2014)
- ECODISTR-ICT Deliverable D4.9 Concise report on performance prototype (d.d. 30th, November 2016)
- ECODISTR-ICT Deliverable D5.3 Final report of the different case studies, a strategy for sustainable renewal of the district (d.d. 31st October, 2016)

All documents can be found on esites.vito.be/sites/ECODISTR-ICT/Deliverables/Forms/AllItems.aspx[3]. The public documents can be accessed via ecodistr-ict.eu/.

[3] For access to the ECODISTR-ICT SharePoint site at Vito, please, contact Ighor Van de Vyver, ighor.vandevyver@vito.be, for more information.

2 THE NATURE OF MULTI-STAKEHOLDER DECISION-MAKING

2.1 INTRODUCTION

In order to make the IDSS useful in an environment of 'urban governance', the first step was to understand how decision-making processes take place in general and therefore also in an urban multiple stakeholder context. The theoretical background on decision-making processes was thus included in D4.1 and briefly summarized in this chapter. For a further elaboration of how this framework informed the functional design of the IDSS, we refer to D4.1 and the other deliverables of WP4.

2.2 BASIC PHASES AND STEPS IN DECISION-MAKING

The basic decision-making process to be supported in ECODISTR-ICT was based on the models of Carpenter et al. (2009) and Steinitz (2013). If we look at the abstraction phases of Carpenter et al.'s model (2009), the ECODISTR-ICT focusses on the first two phases of the decision-making process: define ambition and decide. These phases also have in-between steps particularly in shaping Phase A) **definition of ambition** of the stakeholders and Phase B) pathways to arrive to the suitable **decision**. There are also iterations among these steps within software-supported decision-making processes as seen in Steinitz (2013). These steps, the iterations and the support needed (i.e. collection of data; access to databases, calculation through process & capability modules etc.), are elaborated in Figure 2 and 3.

Figure 2 illustrates the software-supported basic steps that assist in Phase A - defining the ambition. It connects the data collection modules, use of KPIs, and assessment and calculations modules that were based on Steinitz (2013) and positioned into the decision-making process. The ambition of each stakeholder is formulated to address a 'problem' that needs to be solved. Analysis of the problem starts with defining (1) the state of the art of the problem and (2) the boundary conditions of the stakeholders (i.e. budget, cost, needs, requirements etc.). Based on the boundary conditions and wishes, the problem is analysed resulting in the definition of the Key Performance Indicators (KPIs) that are relevant for deciding about this problem. Assessing the problem requires data, enabling the problem analysis to become more concrete. In this project, data are collected by means of different data collection modules integrated in the IDSS. Assessment and calculation modules use the collected data to calculate the actual values of the KPIs in the AS-IS situation. In the ambition step, each stakeholder defines which KPIs are relevant for his/her decision. Within the boundary conditions and wishes, the 'TO-BE' ambition is defined in the form of target values for the KPIs for each stakeholder. The KPIs will later also be used to assess the proposed alternative solutions.

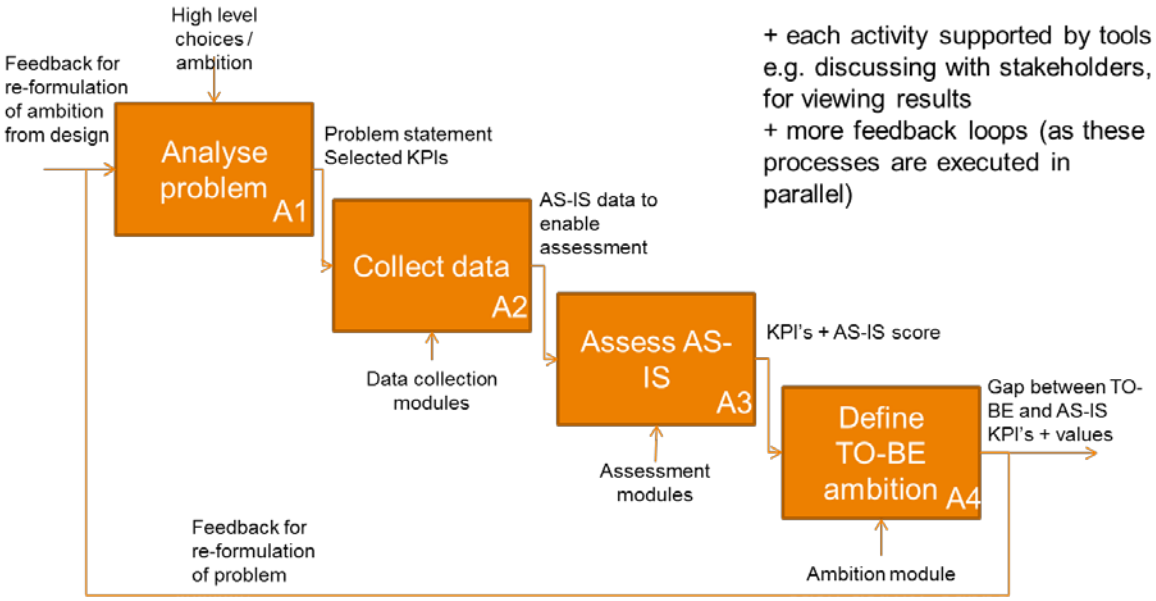

Figure 2 Basic decision-making process steps, second level: Phase A - Defining the ambition

After defining the 'TO-BE' ambition, alternatives, as different *design proposals* are developed in Phase B. Figure 3 illustrates the basic steps needed to select the 'best' *alternative*. The essence of developing alternatives lies in filling the gap between the AS-IS and the TO-BE situation. The design alternatives are developed, but also the *context* in which alternatives are positioned is relevant for the assessment.

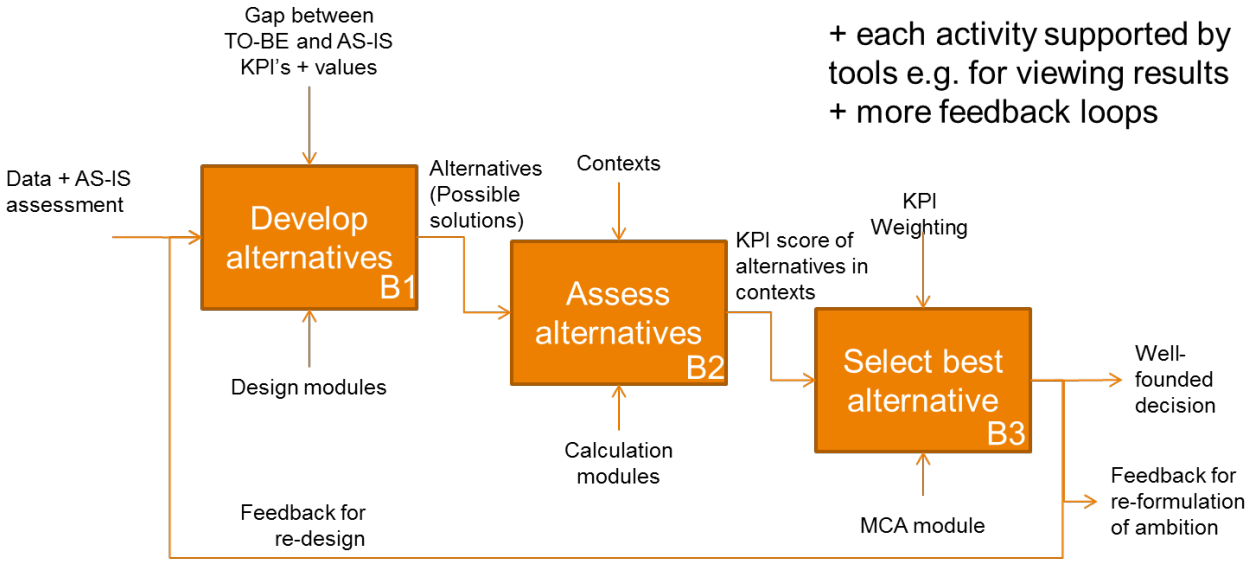

Figure 3 Basic decision-making process steps, second level: Phase B - Decide

The essential question in the first step is how to develop alternatives that fulfil the performance expectations of the stakeholders. This step is highly iterative with assessing the alternatives. The alternatives are being developed by using the design modules, and end-users (professional users

of the modules) assess their alternatives against KPIs of decision-makers by using assessment or calculation modules. At this stage, pre-eliminations can be made among the alternatives, for example the ones which might score very low in every KPI. This pre-elimination is in the nature of design development processes and a result of iterations among development and assessment of alternatives. Through assessing alternatives against KPIs, it becomes clear to what extend they adhere to the ambitions of the decision makers. This process allows the decision-makers to take a well-founded decision, which has a desired score of KPIs, meets the target values and is robust to different contexts.

As can be seen, this basic decision-making process involves many other decisions in itself (selecting KPIs, weighting, re-prioritizing, dealing with the new decisions emerging with the alternatives, etc.). Thus, even the basic decision-making process is not easy without a support of tools, particularly if there is no integration among them. Moreover, in reality, decision-making processes are even more complex as they take place at different levels, involve multiple stakeholders, face different and even conflicting ambitions, and have to handle different performance expectations. Therefore, also the complexity of decision-making processes in retrofitting projects needs to be taken into account.

2.3 COMPLEX DECISION-MAKING PROCESSES

The complexity of decision-making processes in district retrofitting can be identified by looking at their features. Van Loon and Wilms (2006) draw these features as follows.

- Decision-making involves mutual interdependencies between the stakeholders that are involved and have different (also conflicting) interests.
- It accommodates constantly changing partnerships due to different investors that take part in projects. Currently, the hierarchical role of local governments is challenged, and projects are realized by project-based partnerships (i.e. tailor-made partnerships).
- Decision-making has uncertain final outcomes. It involves an open-ended process that requires a flexible attitude on the part of all the parties that produce this outcome. There are various types of plans (outcomes) in current practice, including regional plans, urban visions, district visions, master plans, etc.

The features identified by Van Loon and Wilms (2006) provide a good basis to identify the complexity of decision-making in retrofitting urban areas. In ECODISTR-ICT, the following characteristics are therefore specifically addressed:

- multiple stakeholders, including a wide range of stakes and priorities;
- multiple decision levels;
- multiple time horizons, project time frames and phases;
- multiple rationalities;
- dynamics and iteration.

Figure 4 illustrates four levels of decision-making processes and the focus of ECODISTR-ICT on both Program and Project levels. Program and project level stakeholders use ECODISTR-ICT tools to present results to policy and people level stakeholders. Policy and people level stakeholders give input (high level ambition, stakeholder input) and use the results of ECODISTR-ICT.

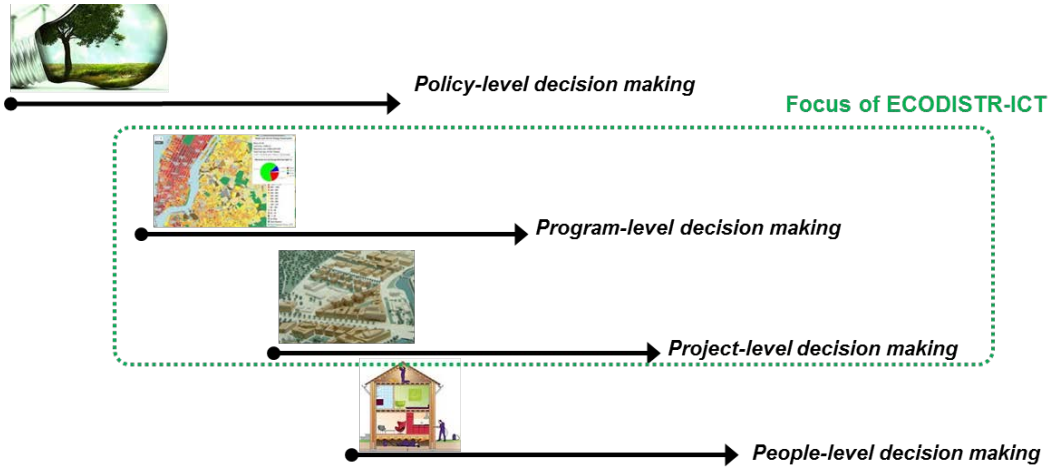

Figure 4 The four levels of decision-making processes and the focus of ECODISTR-ICT

2.4 SUMMARY OF DECISION-MAKING PROCESS REQUIREMENTS

Since the aim of ECODISTR-ICT is to support professional stakeholders in complex decision-making processes, the IDSS was developed interactively, using the seven steps of basic decision-making as building blocks. To cater for the complexity of decision-making, the IDSS was therefore developed as a flexible and modular structure, allowing users to repeat the basic steps as often and in whatever sequence as deemed necessary, to work on different levels, to address a wide range of KPIs, etc. The technical aspects of the functional design of the ECODISTR-ICT IDSS are explained in the WP4 deliverables. In the next chapter we elaborate on how the most important decisions in the interactive process of making the IDSS emerged and how this explains its current structure and use.

3 DEVELOPING THE ECODISTR-ICT IDSS

3.1 INTRODUCTION

In order to provide some background for the nature of the ECODISTR-ICT IDSS, this chapter describes some of the interactions between software developers, WP5-partners and the external case study stakeholders which took place during the project. As already elaborated in the introduction of this report, these interactions to a large extent shaped the development of the IDSS and the case study results. Below, some of the main interactions are addressed, followed by a discussion of the main decisions taken regarding the development of the IDSS. The focus is on interactions between the ICT, process facilitation and district retrofitting domains. For the interactions within the ICT domain, we refer to the WP4 deliverables.

3.2 INTERACTIONS IN THE ECODISTR-ICT IDSS DEVELOPMENT PROCESS

3.2.1 Assessing stakeholders needs

The decision-making process for district retrofitting involves multiple stakeholders who have a wide range of stakes, objectives, priorities and expectations from the decisions made. At the start of the project, the specifications for the ECODISTR-ICT IDSS were further refined from the perspective of stakeholders. This included literature review on the context of urban retrofitting and the processes taking place there, and an analysis of stakeholders roles and preferences by means of role-playing sessions, interviews, etc. In D1.1 'List of specifications for the decision tool in function of stakeholder's input' 43 distinct stakeholder profiles were identified, which were grouped into 10 categories. In the first year of the project the WP5-partners prepared the test locations, reached out to possible stakeholders and took initiative in connecting to local decision-making processes. The aim was to set up the first contacts, to get a view on the data availability, and to prepare for the testing periods.

D1.2 listed the stakeholders' objectives and decision-making criteria and mutual interdependencies. These were mainly based upon an actor-institutional analysis of the 5 ECODISTR-ICT case studies and the ongoing processes of sustainable renewal taking place there. As such, a number of requirements for a truly interactive and integrated decision-support system were formulated. These include:

- the need to be able to go back and forth between calculated results and KPI input, enabling different rounds of KPI input and of software mobilisation and thus of a collective definition of the KPIs that matter
- the need for: interactivity between different calculations; automatic calculation and visualisation of changes in different parameters following changes in other parameters; touch screen functionality showing different maps at the same time; etc.

- the need to include a broad range of KPIs, move (far) beyond energy related issues, and combine complex issues like energy poverty, mobility, green spaces, public spaces, home ownership, affordability, etc.
- the need to support the definition and the inclusion of KPIs, and to make explicit both quantitative and qualitative KPIs in the IDSS, even though there may not be an automated calculation module (yet)
- the challenge to identify, integrate and develop calculation models or qualitative assessment tools for the KPIs that are identified by stakeholders, implying a need of rather complete sets of KPIs and high demands towards software availability and complexity
- the challenge to be able to mobilize the IDSS in situations where power among stakeholders is rather equally distributed and situations where there are power differences
- in the case of a top-down one-stakeholder situation, the need to have a user-friendly IDSS
- in the case of true collective decision-making, the need to ensure emancipatory conditions of mobilization of the software, e.g. transparency on how KPIs are selected and calculated, data are selected and imported, calculation modules mobilized etc.
- the need to integrate the stakeholder-analysis and their definition of KPIs into the IDSS-supported process.

Most of these requirements were addressed during the IDSS development process. Based on these analyses and direct feedback from the projects case study reference groups, it was also decided not to focus the IDSS on some specific target groups, but keep the flexibility of addressing a large set of stakeholders, and a flexible set of KPIs and goals.

3.2.2 Developing the cases studies

To facilitate the interactions between software developers, WP5-partners and the external case study stakeholders, processes for the five case studies were developed. A comprehensive description of the all the case studies is included in deliverable D5.3. In general the following steps were taken.

- The case studies created platforms for software testing in interaction with ongoing or emerging neighbourhood development processes. Some cases were able to build on well-established neighbourhood development networks (Valencia), others had to create their own decision-making environments (Antwerp, Stockholm, and Warsaw).
- Within these trajectories, the WP5 partners organized series of interviews, bilateral meetings, focus groups, workshops, demo-sessions, etc. as ways to interact with the case study stakeholders.
- WP5 partners elaborated brief actor-institutional analyses, in order to identify key-issues in the case study areas (see D1.2 ‘Stakeholders’ objectives and decision-making criteria and mutual interdependencies’), KPIs as indicators for these key-issues, and suggestions for software modules to connect to the IDSS.

- WP4 partners presented different versions of the IDSS dashboard to the WP5 case study partners. In a number of demo-sessions, WP5 partners gave feedback, feeding in consecutive improvements to the IDSS. In some of the feedback sessions, case study stakeholders were directly involved.
- The general case study roadmap, explained in D5.1, was specified with respect to the software testing. WP4 and WP5 partners thus agreed on the following order of testing in the different case studies: Rotterdam, Valencia, Stockholm, Warsaw, Antwerp.
- By cooperating in various WP2 and WP3 working groups, WP5 partners gave inputs to the handling of data (WP2) and the integration of software modules in the IDSS (WP3).
- The Rotterdam and Valencia case studies were actually brought to a final testing of the IDSS in September resp. October 2015. In this stage, WP5 partners actively challenged WP2, WP3 and WP4 partners to improve the IDSS and enable implementation in the case study workshops. In 2016, this was repeated for Stockholm (January 2016), Warsaw (September 2016) and Antwerp (October 2016).

Case study	**IDSS version**	**Modules tested**
Rotterdam Ruubroek	IDSS 1.0	VESTA model (energy calculation) VABI software Common Sense visualisation module MCMSMA
Valencia Campanar	IDSS 1.1	LCA Module (Renobuild Green Module (Berlin version) Thermal Comfort Module (Rayman model) Common Sense visualisation module MCMSMA
Stockholm Hovsjö	IDSS 1.2 and 1.1	Dimosim Energy module Affordability module LCC module LCA module Green module MCMSMA
Warshau Służewiec Przemysłowy	IDSS 1.3 and 2.0	Mobility module Dimosim Energy module Green module Design module MCMSMA
Antwerp Kiel West	IDSS 2.0	BIM Energy Map LCC module Affordability module Green module Design module MCMSMA module

Rotterdam was the first case study in which a very rudimentary version of the IDSS (version 1.0) was tested. Only a limited amount of modules could calculate KPIs - outside the IDSS - and the supporting modules were not fully developed yet, such as the multi-criteria/multi-stakeholder/multi-alternative (MCMSMA) module. The involved stakeholders were very

motivated, such as the housing corporation Havensteder, as they were planning to retrofit the district in the future, as well as the gas, electricity and district heating infrastructure operators. The focus of the Rotterdam case study was on the choice to be made between renewing the gas infrastructure, extending the district heating infrastructure, and/or upgrading the buildings to energy-neutral. Also water retention in the light of climate change was an important issue. This case study clarified several KPI issues (e.g. selection of a limited amount of KPIs prevents overload and retains power of distinction) and emphasised the difficulty of bringing social aspects into the IDSS. This first real test case helped to understand what was important in every step of the IDSS.

The second case study was **Valencia** where IDSS version 1.1 was used, in which some calculation modules were (partially) integrated such as LCA and Green. The Valencia case had an intensive interaction with stakeholders during the process (ten workshops). The lack of visualisations in the IDSS was a recurrent comment which had to be solved. Data collection was rather difficult as almost no data for the selected KPIs were available, and data had to be gathered on site and inserted manually into the IDSS. In the Valencia case there was no local technical facilitator. The process facilitator had to interact with a technical facilitator working remotely, which added to the complexity and created significant extra workload.Thanks to the Valencia case, more attention was given to a data template communicating with a central database. By testing the basic version of the IDSS in Valencia and Rottderdam, many bugs were solved and the further development of the IDSS was enriched.

Figure 5 Pictures of the workshops in the case study Campanar in Valencia (May 2014)

Stockholm as following test case mainly used IDSS version 1.2. The previous IDSS version 1.1 was also used for certain visualisations, since the design module was not ready yet. The biggest challenge for Stockholm was to decide on the case study location, as the district Telge Hovsjö strongly depended on the housing company which underwent many internal changes (CEO changed several times), delaying the overall process. The Stockholm case aimed to use five modules of which there were three new ones. At the stage of the development of the IDSS and the remaining time left, this appeared to be too ambitious, also because of mixing two versions of the IDSS. Some small bugs were fixed and adaptations were done thanks to the Stockholm case, such as allowing negative values for KPIs, long names of KPIs, etc.

The fourth case study was **Warsaw**, using IDSS version 1.3 and IDSS version 2.0. Besides a newly connected mobility module, four other calculation modules were used, as well as the new design module. The Warsaw case struggled most with data collection. It was not clear which data were needed in which format - as the data templates changed multiple times - and the Dimosim energy calculation module - not integrated yet into the IDSS - caused delays and difficulties as the results were needed as inputs for other calculation modules. The design module in the last version was very valuable as it improved the communication with the stakeholders. The Warsaw case did also good proposals - such as filtering - to make the MCMSMA module more understandable. However, visualizing the content of the alternatives would even further enhance the comprehensiveness. Warsaw stressed the importance of communication between ECODISTR-ICT partners and also between facilitators and stakeholders in order to have more efficient and effective usage of the IDSS. Warsaw also emphasized the need of a manual explaining the steps of the IDSS.

The final case study in **Antwerp** used IDSS version 2.0. All calculation modules were for the first time fully integrated into the IDSS, which included a new energy module (BIM Energy Map). The Antwerp case helped improving the data collection: the - final - data template was configured, an automatic data upload functionality into the central database was developed and a crowd sourcing module was designed to help the datacollection. These changes implied a lot of time-consuming effort, which reduced the post-processing phase to a minimum. The Antwerp case also suggested improvements to the graphic lay-out of the dashboard, but due to time and budget limitations these were not implemented. The focus in the Antwerp alternatives was on cost-optimal energy-related retrofitting strategies, which was not extended enough according to the stakeholders. They preferred to focus more on the qualitative, participative KPIs instead. Discrepancies between the facilitator and the stakeholders were partially due to the prolonged testing period of Antwerp, as this case study had at first been planned to take place in the very beginning, but finally ended last, making it difficult keep stakeholders involved during the IDSS development process.

Figure 6 Pictures of the workshop in the case study Kiel, Antwerp (October, 2016)

3.2.3 Coping with differences and similarities in case studies and their contexts

The case studies contributed to the successful development of the IDSS thanks to their different approaches and sets of objectives. The geographical dispersion of the case studies was deliberately chosen in order to amplify differences. The alterations that occurred in the diverse cases can be related to cultural differences, different backgrounds of the facilitators and the stage of the IDSS at the time of testing.

The most and main differences between the cases were due to the stage of development of the IDSS. The first case studies - Rotterdam and Valencia - focused mainly on participation and interaction with stakeholders as the IDSS did not contain a lot of functionalities. They used their testing period mainly to prepare workshops with stakeholders instead of dealing with issues on the technical aspects of the IDSS. They were the precursors who quickly experienced the shortages of the IDSS in order to have a fluent and flexible tool. The latter case studies mainly focused on functionalities that could be useful for a future exploitation of the IDSS. Calculation and supporting modules were improved and new ones were developed. According to the stage of development of the IDSS the focus changed from involving stakeholders in order to have discussions on improving the IDSS in order to end up with an optimal decision-support tool.

Energy was always the main emphasis in every case study as the project deals with retrofitting of districts. Rotterdam paid a lot of attention to gas and water, which can be related to the specific interests of the gas provider. Valencia focused on green and the proximity to services as they received a lot of support from their stakeholders that wanted a ‘better’ environment. Stockholm introduced a new green module, adapted to colder climates, which is an added value of the IDSS for northern countries. Warsaw implemented a mobility module, which added infrastructure as an issue. Antwerp focused on energy and feasibility (related to costs - affordability) and how this could have an impact on social aspects such as ownership and cultural differences within the district. It is obvious that the case studies tried to stress very diverse aspects, which can be related to their district properties but also their culture, climate, politics, background, discipline etc.

Despite the differences between the case studies, the testings also showed similarities. In every case study the data collection was rather difficult, the involvement of the stakeholders was an asset, qualitative KPIs were needed to feed the discussion, calculation modules took a lot of effort and were time-consuming, proper visualisation is essential to support a good process, etc. As such, the case studies were instrumental in the development of the structure, form, appearance, improved user friendliness and current content of the IDSS. The next section explains a number of key-characteristics of the IDSS influenced by the interactions during its making.

3.3 DISCUSSIONS AND DECISIONS ON THE FUNCTIONAL DESIGN AND USE OF THE IDSS

3.3.1 A flexible design

The functional design of the IDSS is subject of deliverable 4.1[4], in which the general structure of the IDSS is defined. The functional design is mainly based on the requirements from the user's perspective (WP1 and WP5) and the developers' perspective (WP2, WP3 and WP4). Based on the general conclusions from the user perspective, the ECODISTR-ICT consortium decided to develop the IDSS as a flexible, iterative, collaborative, compatible, data handling, easy-to-use (within complexity) and supportive tool, as can be seen in the modular structure of the IDSS as a whole as well as the flexible design of the dashboard. This specifically responds to two important comments from the WP5-partners, who have insisted on the non-linearity of decision-making processes and an openness for a range of possible users, including community groups who can become professional users as well.

3.3.2 A broad range of both quantitative and qualitative key performance indicators

The actor-institutional analyses in the case studies in year 1, revealed some common objectives that seemed to recur in most case studies. This formed the basis for a shared set of five KPIs that would be integrated in each of the five case studies and guided the connection of calculation modules to the IDSS. However, the analyses also identified a broad range of issues in the case study areas, which confirmed the need to design the IDSS such that it can cope with a wide range of KPIs and a concomitant number of calculation modules.

Furthermore the issue of having qualitative KPIs in the IDSS was brought up, since they are often more effective to characterize the as-is situation or feed the discussion. For example, energy issues are interrelated to social features, which also need to be addressed. The IDSS now includes the possibility to add an unlimited amount of quantitative and qualitative KPIs in order to fulfil this condition. Moreover, by determining benchmarks it is possible to compare both types of indicators. For the definition and selection of KPIs in the IDSS, a good understanding of the case study and collaboration with the stakeholders is needed. It is also possible to collectively determine the meaning of the KPI values. This improves the involvement of stakeholders and increases the transparency on KPIs.

The use of KPIs opened a discussion among ECODISTR-ICT partners, regarding the implantation of existing sets of KPIs and its relation to existing assessment tools (such as BREEAM, LEED, VERDE, DGNB, HQE etc). Although one partner stated that including certified KPIs could be an advantage from a commercial point of view[5], most project partners agreed that the IDSS should focus on a case specific set of KPIs and not include certified full KPI sets. It was decided to focus on a case specific approach in which stakeholders can create and define their own set of KPIs.

[4] Deliverable 4.1, Functional design of the integrated decision support system (31/03/2016)
[5] In the Warsaw case study, the stakeholders wanted to know which renewal solution could potentially complement the BREEAM label on an urban and building scale.

3.3.3 Calculation and support modules

Building on the actor-institutional analyses of the five case studies in WP1, related KPIs were identified and later prioritized by the ECODISTR-ICT case study representatives. The final selection of prioritized KPIs was made at the annual ECODISTR-ICT meeting held in December 2014 in Valencia. Based on this input an evaluation was made of the available modules in D3.2.[6]

In July 2015 all project partners submitted their 'wishlist'[7], which included their top 12 of new 'IDSS and supporting modules' to be implemented. This led to a 'priority list', a ranking of items grouped into 4 priority levels. Since the motivations for defining priorities were very different in nature (commercial, practical, feasible etc.) and according to the type of partner, various discussions were organised.
Discussions on the priority list were then further elaborated in various working groups in WP1, WP2, WP3 and WP4 on the selection and elaboration of modules. The following components of the IDSS were thus developed (see D4.9):

1. Dashboard
2. Framework
3. Data storage and data collection
4. Design and Visualisation Module
5. Connectors to Calculation Modules, based on an Excel Module which was used with the LCC Module, Affordability Module, Green Berlin Module, Green Stockholm Module, Renobuild Module (LCA) and the Mobility Module and for the BIM Energy Map Module.
6. Multi-Criteria, Multi-Stakeholder, Multi-Alternative Module

As a consequence of the agile development approach, some of the priorities changed during the course of the project. Some features which were initially foreseen in the development plan were judged less essential by the case study representatives and external stakeholders.

This includes for example the automatic analysis of variants under the light of different contexts, such as changes in energy costs or changing local climatic conditions. The consortium partners agreed to remove these contexts from the dashboard to make the process less complex. Thanks to the fact that the IDSS is set up in a flexible way, users can still exploit the functionality of testing the robustness of the district in multiple 'potential futures' by a clever choice of the alternatives. In a similar fashion, the IDSS can be used to explore the long-term planning of a district, by defining multiple alternatives, each representing the district in a specific time frame, e.g. 10, 20 and 30 years from now.

Other features were firmly expanded compared to the initial development plan. Most notable is the fact that almost all parts of the IDSS are now operating in a webbased environment (also

[6] D5.3, Scheme of chosen and verified decision support tools for indicators (22-12-2014).
[7] Minutes Wishlist meeting 2015-07-03

referred to as 'the cloud'). This required significant IT development efforts, but greatly expanded the usability since users only need an up to date browser for working with the IDSS instead of installing software on their computer. Furthermore this greatly increases the possibility to work with different people on the same district project (even remotely) and reduces the calculation time for some of the KPIs significantly.

Another noteworthy scope change was based on case study feedback highlighting the need for tools that can assist in the collection of data. Therefore the 'monitoring' tool developed in D1.5 was created in a flexible way, so it can also support other forms of data collection. The facilitator can edit the questionnaires, in order to gather the missing data. The tool can be set up for a specific district, so the answers gathered are geotagged and can be imported directly into the WKT + CSV database.

3.3.4 Data upload

During the testing of the case studies, it became clear that feeding the case study data in the IDSS was not evident. The main cause of these problems were the difficulties encountered when implementing the Data module and its connection to the IDSS. The CityGML format in conjunction with application domain extensions proved to be poorly standardised and hard to handle. Finally the consortium partners agreed to switch to a 'flat' data structure in a later stage of the project, as discussed in D4.9. The delay in the availability of a smoothly working data storage and upload functionality hindered the progress in the project considerably and caused significant delays in the case studies Stockholm and Warsaw, which also affected the testing of the case study in Antwerp.

However, the discussions led to two important options in the IDSS which support a userfriendly use of the IDSS in the future. First, it was decided to handle all data in one single data module handling both CityGML data and WKT + CSV files, second a data upload module and template were provided eliminating the need for knowledge of databases by the facilitator.

3.3.5 Access for stakeholders

In D4.1 the users of the dashboard were described as follows[8]:

- **Facilitator**: This is a professional that configures and sets up the decision-making process with relevant data, module usage and result views within the dashboard.
- **Stakeholder**: This is any stakeholder or person on program or project level that is affected by parts of the decision support process, and should be allowed to participate in the process within the dashboard.

After testing the first case studies the question was raised how stakeholders should interact with the IDSS. Earlier in the process it was already mentioned by WP5-partners that online access and a login to the dashboard for each stakeholder could help to get more reliable input. In the Rotterdam case this was tested successfully: some stakeholders were able to select KPIs and set

[8] D4.1 Functional Design, 30-10-2014

ambition levels, at their offices, in preparation of the workshop. As a result, it was suggested that stakeholders have unlimited read access to the IDSS (to foster transparancy) and to provide them limited writing access (e.g. the two pages selecting KPIs and setting ambitions). Project partners had often different opinions on how stakeholders could interact with the IDSS. This relates to the question whether the user-interface of the IDSS should focus on the experienced facilitator or any possible stakeholder. For the prototype version of the IDSS the choice was made to focus on the facilitator first.

3.3.6 IDSS interface

In between the testing periods, WP5-partners discussed that stakeholders should be able to follow and understand the different steps of the IDSS. This implied that the functional design of the IDSS had to be made more attractive and understandable. As a result, the IDSS dashboard and the MCMSMA module were gradually improved to support case study stakeholder interaction.

3.3.7 Design module

During the process WP5-partners and the case study stakeholders showed great interest in the use and integration of the design module. This design module allows stakeholders to manipulate the district database using a graphical interface, and build alternatives by applying a set of measures to buildings in the district. The design module was integrated and tested in the last two case studies Warsaw and Antwerp. The design module was of great use in these case studies for a rapid creation of alternatives by the facilitator. It is worthwile to investigate whether it is also useful to iteratively create alternatives in close collaboration with multiple stakeholders, or even allow non-expert stakeholders using this design module themselves.

3.3.8 Technical support

During the project, different versions of the IDSS dashboard were presented and tested by the WP5 case study partners. Since many functionalities of the IDSS depend on a proper connection with modules and data sets, a good technical support was needed during the test cases. The case studies which lacked a good technical support, were often confronted with significant delays or extensive preparations. It was an important comment and question of the stakeholders and WP5 partners to become less dependent on the technical support. The latest version of the IDSS, with a data upload functionality, should allow the use of the IDSS without technical support.

3.4 CONCLUSIONS

The ECODISTR-ICT project posed high ambitions regarding the role and integration of the case studies as a parallel track during the project. As the discussions described in this chapter show, WP5 partners managed to reflect and translate the stakeholders' concerns to the software developers, leading to decisions that were taken during the development process and some very specific functionalities of the IDSS. The process the ECODISTR-ICT partners went through in the development of the IDSS and case study testing, together with stakeholders, can thus be

considered a valuable learning process integrating people from different backgrounds, working with different worldviews, theories, knowledge systems, and methodologies, which definitely contributed to the quality of the end-product.

The agile development method of the IDSS proved useful to adapt to changing needs, but also bears some intrinsic challenges, including the following.

- Continuous communication and discussion amongst a large set of partners with different backgrounds and stakes is necessary. Software engineers, city-planners, sociologists,… need to find a common language to express expectations, technical bottlenecks, deal with changing scopes, etc. Significant efforts need to be dedicated to enable this conversation on a regular basis, and try to reach common understanding on the goals of the next design sprint.
- The agile approach with constantly changing scopes and priorities needs to be matched with the more rigid set-up of a large scale European RTD project with fixed budgets and a predefined set of deliverables and intermediate deadlines.
- The agile development relies on partner organizations or even individuals taking the responsibility for testing and upgrading specific parts. There are no clear boundaries between tasks and work packages, requiring commitment and trust from all partners beyond the 'legal agreements' made in the description of work and consortium agreement.
- According to the agile development method, incremental updates are delivered and tested. The five ECODISTR-ICT case studies were initiated in a chronological order. This required testing 'immature' prototypes in some of the case studies. The feedback of these tests were very valuable for the further development of the IDSS, but for case study representatives and external stakeholders, testing such a non-complete prototype is less rewarding than showcasing a finalized product. Dealing with frustration from using intermediate versions, requires keeping the attention and focus of the stakeholders and trying to organize a discussion on the content, as well as providing valuable feedback to the software developers. Finding ways to align the timing imposed by the case studies with the pace of development in the distinct work packages, data, calculation modules, dashboard etc., is essential to maintain trust and cooperation between the different participants of the development process.
- The pathways of the agile development were mixed with activities taking place 'in real life' in the case study locations. It proved hard to attune the testing phase with existing processes of renewal in the neighbourhood. The challenge here is to choose testing moments concomitant to the 'momentum' in the ongoing case study processes and the agendas of their stakeholders.

4 HOW TO USE THE ECODISTR-ICT IDSS

The retrofitting of an urban district is by nature a complex process in a complex system. The complexity of the decision-making process in these projects was already pointed out in chapter 2. In this chapter we first address how to prepare for a decision-making process in which the IDSS can be used, and then explain how to develop the different steps in the IDSS. The insights presented are mainly derived from applying the IDSS in the five ECODISTR-ICT case studies. Whether or not an IDSS should be used for supporting decisions in a specific urban project area, and who should initiate this use, is outside the scope of the report as this requires more feedback from applications in real-life conditions.

4.1 ORGANIZING AN INTERACTIVE PROCESS

4.1.1 Project area

When mobilising the IDSS in a decision-making process, the first task is to define the project area. This immediately raises a key question: what is the ideal scale of the district to operate on? Is it possible to quantify the range of buildings that should be included? Or maybe other "systems" might be more appropriate, such as the city, building block or the street? The answer to this question determines the number of actors to involve, issues to address, data to collect, etc., in other words, the level of complexity. Table 1 presents an overview of the district scale in the case studies. The number of dwelling units ranges from 1.616 to 4.500, while the number of inhabitants ranges from 4.079 to 7.600.

Table 1: Scale of the case study districts

Case study district	# dwellings	# inhabitants
Rubroek, Rotterdam	4.500 dwellings	7.600 inhabitants
Campanar, Valencia	1.616 dwellings	4.079 inhabitants
Hovsjö, Stockholm	2.200 dwellings	6.000 inhabitants
Służewiec Przemysłowy, Warsaw	(*)	(*)
Kiel-west, Antwerp	2.500 dwellings	6.310 inhabitants

(*) figures on the number of dwellings and inhabitants in this mainly commercial district were not provided.

A strong feature of the IDSS, is the fact that it offers enough flexibility to respond to the characteristics of the district (as it is possible to define new KPIs) and at the same time can handle the complexity of involving multiple stakeholders, multiple criteria and multiple alternatives for district retrofitting. It bridges the gap between assessments on building level (or even down to building component level) and on the larger level of streets, neighbourhoods, districts or even cities.

Given the complexity of setting up the IDSS, gathering the local data and connecting to many stakeholders, a few 100 buildings will probably be the minimal scale to make it worthwhile using

the ECODISTR-ICT IDSS. In the current IDSS, no limitation on the maximum amount of buildings or other objects has been set. It should however be noted that incorporating vast amounts of buildings will influence calculation time, but also impact the smooth interactions with the design and visualisation modules. Furthermore, working on a too large scale could limit the willingness of stakeholders with valuable local knowledge to interact. Therefore, it is suggested that the IDSS is best suited for the district scale, ranging from a few 100 to 10.000 buildings.

The figures in Table 1 give a first indication of a possible district scale. Further use of the IDSS will provide more leads to the "ideal" scale.

4.1.2 Preparing the case study

When mobilising the IDSS in a decision-making process, it is important to decide on the perimeter of the case study area. The IDSS was designed to be used for districts with approximately 10.000 inhabitants or 500 buildings. However, it could be used in projects of different scales. Secondly one should get a good view on the issues to be tackled and the stakeholders to be involved. Therefore interviews with key-stakeholders are needed, that can provide valuable information about the case study area. Obviously, the scope of the process and the amount of stakeholders might change during the process. Although the case studies learned that there should be some consistency of the composition and scope of the decision-making process, the process needs to deal with changing conditions.

4.1.3 Involving stakeholders

A second key question, which relates to the previous one, is: *"How many stakeholders should ideally be involved?"* Furthermore, is it possible to identify certain *stakeholders* that are highly recommended (or even mandatory) to be involved? The answer to these questions will greatly impact the process and influence the outcome.

Dedicated methodologies such as actor analysis of the district or one step further, actor-institutional analysis[9], could be used to find an answer to these questions. However, these questions should also be approached from a practical point-of-view.

The following profiles were identified in the case studies as very relevant to include:

- Decision makers: Local authority, (social) housing corporation, energy providers or private developer;
- Data providers: Actors who are willing to share non-public data, such as Distribution System Operators (DSO) for energy consumption data, or municipalities for GIS-based data;
- Experts: This does not necessarily have to relate only to energy or environmental consultants or city planners, but could also relate to "social" experts e.g. community workers;

[9] Actor-institutional analysis was applied in the ECODISTR-ICT case studies. See ECODISTR-ICT deliverable report D1.2 "Stakeholders' objectives and decision-making criteria and mutual interdependencies"

- Citizens or inhabitants.

Stakeholder management is a key activity when using the IDSS in urban renovation processes. Each case demonstrated in their own way how to manage a group of stakeholders. Nevertheless, it is possible to draw common conclusions:

First, the level of involvement required from the stakeholders depends on the role of the stakeholder in the project (for instance, a decision maker versus an inhabitant). The main expected users of the IDSS are local authorities and/or public developers, as developing and using the IDSS might be feasible for a city that already has access to data or possesses needed expertise. It might be less feasible for a small municipality or private developers, who have less resources available and/or can be more hesitant to invest a lot of effort to use this tool.

It might be useful to draw a distinction between two different groups of stakeholders. In this case one could distinguish a group of key-actors who are more closely involved in the process, for instance to provide data and to support the KPI definition and selection of measures. For instance, in the Antwerp case study this group consisted of the city of Antwerp, the social housing company and the distribution system operator. A second, broader group, could include the other stakeholders who are very relevant for the district but do not necessarily have to be involved at all times. For instance, in the Valencia case, where the participation of the inhabitants was key, the inhabitants were involved in several public and carefully prepared workshops.

Second, despite the large amount of stakeholders that could possibly be involved using the IDSS, from a practical point of view, it is recommended to limit the number of “active” participants. A range of three to seven stakeholders in a session is feasible. The group can include many different stakeholders, but should be more or less balanced regarding the professional, educational and social background of the stakeholders so everyone can contribute to the workshops. In order to tackle specific questions the facilitator can also choose to not always involve the whole group in each session. Likewise, the group can change during the process with new stakeholders entering and others leaving the group. New participants in particular need a kind of intermediate introduction session in order to engage them efficiently in the process.

The involvement of inhabitants requires further consideration. It appears to be beneficial for creating a broader basis for support of the district retrofitting and could ensure that social issues or pre-existing neighbourhood initiatives are integrated in to the decision-making process. There could however also be risks associated with this. When the decisions are still on a very strategical level, and implementation of these decisions will take a very long time, involving inhabitants might not be relevant, and might only create unrealistic expectations. How to involve local inhabitants depends on the district and an appropriate format should be chosen carefully in order to ensure the engagement of inhabitants. For instance, in he Antwerp case study (a multi-ethnic neighbourhood), digital tools such as the crowd-sourcing tool might only reach part of the

population, while in the Valencia case residents were eager to attend several workshops and showed commitment by providing significant support and feedback.

4.1.4 Timeline

The time that is needed to prepare the IDSS largely depends on the project. However, as evidenced in the case studies, this should not be underestimated as preparation could be rather time-consuming[10]. Key activities that could have a significant influence on the timing are: the data collection, the use of calculation modules and composing the alternatives. For instance, even when plenty of data are available, this does not mean that these datasets are immediately useful or have the correct format. Post-processing of data is a time-consuming task.

When the stakeholders and project area are decided on, the interactive process with the stakeholders and the interaction with the IDSS can be planned according to the following steps and indicative time slots.

1. Preparation of the IDSS (1 month)
2. Workshop 1: kick-off (select KPIs, define ambitions)
3. Configuring the IDSS (1 month)
4. Workshop 2: progress (develop base alternatives, asses base alternatives)
5. Optimize the alternatives (1 month)
6. Workshop 3: conclusion (refine alternatives, asses refined alternatives, decide upon best alternative)

4.1.5 The role(s) of the facilitator

Operating the IDSS requires a facilitator, as there are many stakeholders involved and multiple criteria to manage in these kind of complex district renovation processes. At the same time, it is the facilitator who configures the IDSS. One thus can distinguish two key skills for this facilitator, although they are very different.

On the one hand, the facilitator has to have organizational and social skills to guide the stakeholders through the process. He or she will identify the ambition and concerns of the stakeholders and the district and translate these into the IDSS. Furthermore, he or she is responsible for setting up efficient and stimulating workshops, communicates with the stakeholders and tries to keep them motivated during the process.

[10] Note that the IDSS software was still under development during the testing of the case studies.

On the other hand, the facilitator needs technical skills to manage the IDSS. He or she will take care of the configuration of the IDSS, operate the calculation modules and manage the data flow. This means that the required input data have to be uploaded by the technical facilitator, the KPIs are defined, the modules are connected and ready and the alternatives are generated. This also includes the validation of the results.

The combination of these two very different competences can be quite challenging. This was illustrated in the case studies, as each case study preferred to distribute these tasks among two parties: a "process" facilitator and a "technical" facilitator. This is certainly a valid possibility, under the condition that there is a close collaboration between the two facilitators.

Different workshops have to be planned in order to use the IDSS in a multi-stakeholder environment. This requires a proper preparation of the facilitator of each session. The step-by-step structure of the IDSS reflects the process that should be (iteratively) followed.

The number and format of workshops depend on the project. In the case studies, a variety of workshop formats were applied:

- Workshops with a broad audience such as social actors or inhabitants. These workshops have an exploratory nature and the objective is to make an inventory of area characteristics (*"getting-to-know-the-neighbourhood"*), key actors, main issues, etc. Examples: workshop with inhabitants in Valencia or a student workshop in Antwerp.
- Focused (bilateral) meetings in a small group with experts. The purpose is to gather feedback and support on the definition of KPIs, alternatives, scenario building and data collection. Example: Meetings in Valencia with energy experts.
- Sessions with dedicated stakeholders. Interactive sessions where the results of the IDSS and the ambitions and priorities of stakeholders are discussed. Examples: closing sessions of all case studies with IDSS.
- Closed sessions. These could e.g. be used by a real estate developer or city administration to perform feasibility studies for a district without interacting with other stakeholders. In that case it is used as an expert tool, instead of a discussion platform.

Note that the IDSS does not necessarily have to be used in each workshop (as the purpose of some of the workshops are to prepare the input for the IDSS). It has to be kept in mind that the main purpose of the workshops is to gather stakeholder input and to integrate it in the IDSS. Therefore, stakeholder input could be required for the following topics:

- Contribute to the data collection;
- Define the issues, translated in qualitative or quantitative KPIs;
- Set the priority and ambition per KPI;
- Provide input for the alternatives and their measures;
- Evaluate the qualitative KPIs for the alternatives; and
- Assess the alternatives to come to a joint decision.

Stakeholders' involvement is needed throughout the whole process. It is essential to keep the stakeholders fully committed and motivated. Therefore it is important to have the process within a reasonable timeframe and to have regular contact with the stakeholders.

4.1.6 Supporting a series of decisions

The IDSS should be used to support one decision at the time. However, a complete process can consist of a series of decisions, one building upon the previous, possibly with a new set of stakeholders. For each decision, the IDSS could be used. For example, in the process starting with the strategic decision on the main direction of the retrofitting solution until the tactical planning of the most robust retrofitting district solution for the coming 25 years, the process could look something like this:

- First, to analyse the problem and define ambitions
- Second, to define and assess 'extreme' alternatives (such as 'All electric', 'All passive housing') to understand the possibilities; jointly select a strategy for the alternative, most often a combination of the extreme alternatives; re-iterate problem analysis and ambition setting if needed;
- Third, to elaborate alternatives within the selected strategy, assess and decide; re-iterate problem analysis and ambition setting if needed;
- Fourth, to assess the robustness of the selected alternative by changing data input mimicking different contexts (i.e. possible future scenarios); adapt selected alternative if needed; re-iterate problem analysis and ambition setting if needed;
- Fifth, to place measures of the selected and adapted alternative in time, using the alternatives in the IDSS for assessing the measures; assess the consequences for each time frame.

4.2 USING THE IDSS

4.2.1 Selecting KPIs

The IDSS is instrumental in clarifying the priorities of stakeholders. The latter have their ambitions and priorities that are important to feed discussions, thus opening controlled confrontation and making the interests of stakeholders a bit more abstract. Stakeholders that are more difficult to reach, can still be involved when helped to fill in KPIs, ambitions and weights or when represented.

However, defining the issues of the district that will be addressed with the IDSS is not an easy but still essential task. A good understanding of the district is needed and for this purpose, participation of the stakeholders is crucial. Therefore, it should be carefully planned. It might be

interesting to conduct dedicated interviews with key actors to obtain valuable information about the district.

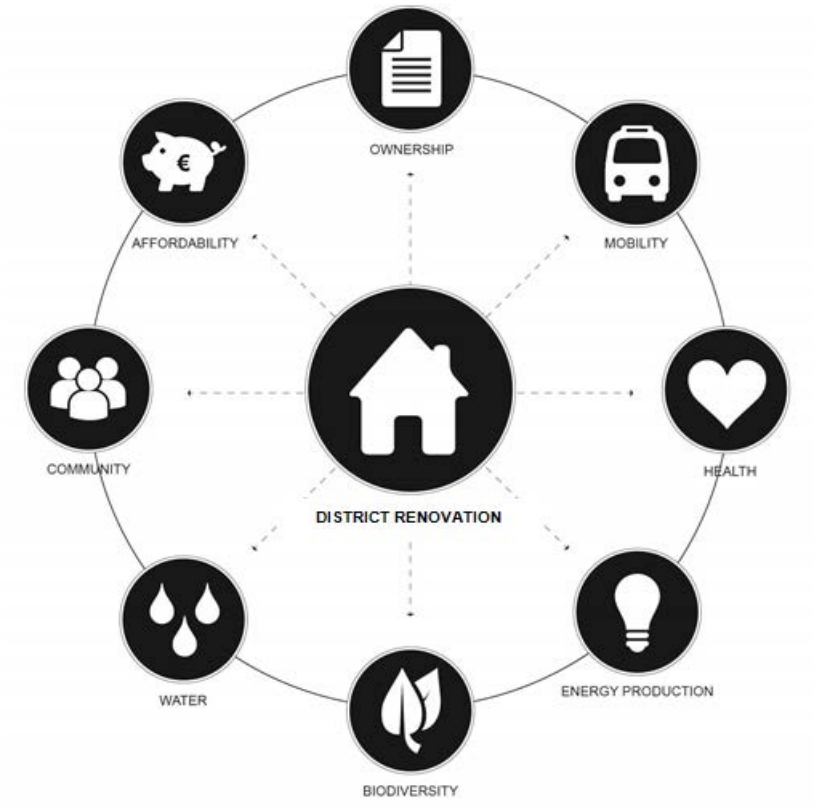

Figure 7 Scheme representing a number of topics in relation to district renovation

It is the task of the facilitator to translate these issues - identified by stakeholders – into meaningful Key Performance Indicators (KPIs).

A distinction has to be made between “quantitative” KPIs and “qualitative” KPIs:

- Quantitative KPIs are KPIs, which can be measured or assessed (for instance, by making use of a calculation module). Example: Average primary energy consumption in the district, expressed in kWh/m².year.
- Qualitative KPIs are KPIs, which can be rated with input from stakeholders. Example: Willingness to renovate, which can be rated from “low” to “high”.

Quantitative KPIs need to have a clear definition and benchmark values. Defining the benchmark values is a difficult exercise and requires a skilled facilitator. Many stakeholders emphasised the importance of providing accompanying background information and references. Likewise, qualitative KPIs need time and discussion to be defined carefully, as an appropriate rating system has to be considered and agreed upon with the stakeholders.

A point of attention is the fact that, while the IDSS allows to create KPIs at will and this way presents a large degree of flexibility, there is a risk that the process of creating new KPIs can be perceived as too complex. To address this issue, the IDSS contains a database of previously defined KPIs so end-users can find inspiration from other projects. Moreover, defining KPIs that are really useful in the decision making process at hand is complex and asks for an experienced facilitator. Incorrect KPI definitions can influence the results to a large extent. In a later stage also setting the ranges (sufficient – maximum) is an art in itself, as it determines to what extent alternatives are distinguishing.

An important achievement of the IDSS is the fact that it facilitates communication between the stakeholders and stimulates debate. Stakeholders gain insight in the ambitions and priorities of other stakeholders, beyond their own fields of expertise. The results of the IDSS are important *triggers* for group discussions.

4.2.2 Gathering data

The IDSS relies on the accuracy and reliability of data. This starts with the collection of data. Data requirements have been defined early in the ECODISTR-ICT project[11], but clearly depend on the final selection of modules and the (public) availability. The data collection has been facilitated due to a data template and an automatic data upload function into the central database. It is possible to upload GIS-data in the IDSS using this data upload functionality.

However, the resources needed for the data collection process should not be underestimated. Data gaps are inevitable on a district level. Extrapolations and assumptions were required in every case study to address these data gaps, which limits the data accuracy. The data collection process is therefore very challenging, as not only the issue of data gaps but also data quality and data validation should be addressed. The crowd-sourcing tool can support the data collection to some extent, but assumptions will be needed nonetheless as it is very improbable to reach 100% response in a neighbourhood.

4.2.3 Selecting modules

The IDSS contains a number of modules to calculate KPIs (calculation modules[12]) or to support the process (supporting modules[13]).

One of the main strengths of the ECODISTR-ICT IDSS is that it operates as a platform that can be expanded in a modular way. As an example: throughout the ECODISTR-ICT project three different energy calculation modules have been used for the different case studies. This enables tailoring

[11] ECODISTR-ICT Deliverable report D2.1 Exhaustive list of data required for accurate and reliable energy simulations at district scale, with an acquisition protocol, and identification of data providers
[12] http://ecodistr-ict.eu/calculation-modules/
[13] http://ecodistr-ict.eu/supporting-modules/

the IDSS for specific local needs; e.g. in Rotterdam the energy calculation tool was based on the official Dutch calculation procedure for energy performance certification. Additionally, many efforts have been put into making the process of coupling new modules less complex, e.g. by developing a generic module for coupling Excel based spreadsheets as calculation engines. This ability to link simplified excel sheets to the IDSS is as an important feature of the IDSS. Nevertheless the process of connecting and configuring new modules to the IDSS could still be further improved, to really exploit this modular aspect. It is recommended to future users to make use of previously configured calculation modules as far as possible. Coupling new modules can be time consuming and often requires specialised IT skills. Furthermore, the best way to assess whether more elaborate calculation modules are needed, is to do this in consultation with the stakeholders after reviewing the simulation outcomes. During the ECODISTR-ICT case studies, the accuracy level of the simulation results was hardly ever discussed by the stakeholders. The IDSS was mainly used for envisioning and discussion, hence quick and easy calculation methods can be as valuable as more complex tools which would require additional calculation time and tedious data collection

4.2.4 Assessing the "as-is"-situation and defining the ambitions

Every stakeholder has its own ambitions and priorities. The IDSS is very useful to clarify these ambitions and priorities of each stakeholder. Stakeholders who participated in the case studies pointed out that knowing each other's ambitions and priorities proved to be very informative and this was much appreciated. This facilitated communication between the stakeholders and stimulates debate as stakeholders get insight in the ambitions and priorities of other stakeholders, beyond their own field of expertise. The results of the IDSS are important *triggers* for group discussions.

4.2.5 Designing alternatives

Introducing future paths in the software is a very important step in the process. Every alternative is the sum of a set of measures and can be defined together with the stakeholders. To help this alternative development, a design module was introduced in the IDSS. The design module helps to communicate and create the alternatives togheter with the stakeholders given its ability to visualize the KPI's and apply measures selecting buildings and building groups.

Measures can not only target buildings, but also spaces (or areas) and the district as a whole and could cover a number of topics. Identifying which measures to apply on which buildings or spaces clearly depends on the KPIs and modules selected. As a result, the IDSS does not include a fixed list of measures, as this will vary depending on the project and the connected calculation modules. In case new measures have to be added to the design module, support by IT developers can be needed.

When building alternatives, the challenge is to make them comprehensible and comparable. The alternatives must help to understand the impact of (groups of) measures and evolve to an optimized scenario. The most interesting and realistic alternatives, should be developed as

complex storylines on the future of the district. Although it is still difficult in the current version of the IDSS to design such a multidimensional alternative, a work around is to create different combinations of variables, like was for example done in the Warsaw case study.
Regarding the design of alternatives, the involvement of local experts could be of great value. In the Valencia case, alternatives were designed in consultation with specific stakeholders, for instance energy and climate experts with thorough knowledge of the district. Typically, in a joint workshop the main directions for the alternatives are defined; afterwards the local experts elaborate these main directions into full-fledged alternatives.

There is a danger that people may (miss)use the IDSS to push forward specific kinds of development, and limit the range of design solutions. Since the 'best' alternative does not exist, the IDSS has to be used as a support tool, forcing the facilitator to create a transparent process, and enable access for different types of stakeholders.

Finally, it has to be taken into account that the IDSS captures a snapshot of the district. However, district retrofitting will never happen all-at-once but staged (e.g. building block per building block in case of social housing corporation). While multiple alternatives can be defined (each addressing a different moment in time), in its current version the IDSS might still be perceived as a rather static tool by the stakeholders and the ability to capture dynamic processes might not be immediately recognized.

4.2.6 Comparing alternatives

The main purpose of the IDSS is *decision support*. It will not take the decision on its own, rather it will support the process to come to a decision. In addition, the IDSS can be seen as a *discussion*-support, as it facilitates communication between the stakeholders and stimulates debate.

An important feature of the IDSS in this respect is the Multi Criteria, Multi Stakeholder, Multi Alternative (MCMSMA) module which supports the assessment of the developed and calculated alternatives. It translates the results to a graphical representation and allows to compare the results of the KPIs of the alternatives to each other. In addition, stakeholders can see each other's ambitions and priorities for each KPI. This way, it supports the discussion among the stakeholders and thereby the decision-making

In the assessment of the alternatives it is important to not only look at the new values that were calculated by the modules. The facilitator should also go through the qualitative KPIs and manually input the scores of these KPIs per alternative based on the (group) judgement of the stakeholders. At this point of the process, there is a big chance that stakeholders will come up with new KPIs that are affected by the measures but were intitially not on the KPI-list. This will require to go back to step 2 (select KPIs) and might imply the need for new data or calculation modules. This is part of the iterative nature of the process.

In the communication and understanding of the results of different alternatives and its relation to stakeholders interests, the MCMSMA module is a very helpful tool. It provides the necessary context for decision-makers in order to support the decision-making process, but is not necessarily suited to directly communicate to all stakeholders. Depending on the nature of the process and the composition of the stakeholder group, the MCMSMA module can be used interactively or seperatly.

The process facilitator can have a role as intermediate to post-process the outputs of the IDSS to create clear and concise information for stakeholders such as local inhabitants.

4.3 CONCLUSION

The purpose of the IDSS is to support decision-making processes in district retrofitting processes. This chapter described key lessons learned regarding the use of the IDSS, based on the experience during development and the testing of the system in the case studies. Key conclusions that emerged are:

- The IDSS targets the district scale and therefore, the tool has a large degree of flexibility so it can be tailored to the specific characteristics of the district.
- To offer this kind of flexibility, the tool should be highly user-friendly, in particular with regards to the data upload, the connection of modules, the configuration of the dashboard and the design of measure packages and alternatives.
- The IDSS is a decision-support system, but the emphasis can differ, for instance regarding the following aspects: stakeholder management and discussion support; communication and participation tool; analysis, evaluation and monitoring etc.

The purpose of using the IDSS should be made clear early in the process: will the tool be used for district retrofitting through local policy support, as a platform to engage multiple stakeholders, as an expert tool with detailed calculation modules or rather a tool for vision creation? These choices affect the set-up of the IDSS and the organisation of the process.

5 RECOMMENDATIONS ON THE FURTHER DEVELOPMENT OF THE ECODISTR-ICT IDSS

5.1 RECOMMENDED FURTHER DEVELOPMENTS

The ECODISTR-ICT Integrated Decision Support System (IDSS) has been initiated in the EU-funded RTD project ECODISTR-ICT and evolved in three years to a prototype version 2.0. Its next phase is extended use of the current version in practice and further development in new (R)TD development initiatives. The previous chapter identified recommendations for using the IDSS. This chapter focuses on the further development.

Many of following recommendations in this chapter were already briefly mentioned in the previous chapter. It concerns mainly further development of the existing software tool and the implementation of items that, due to the RTD character of the project, could not all be addressed in the ECODISTR-ICT project.

5.1.1 Stakeholder interaction

As a result of the experiences in the Rotterdam case, the IDSS dashboard is set up in such a way that stakeholders have unlimited read access to the IDSS (to foster transperancy) and are provided with limited writing access (e.g. to the two pages selecting KPIs and setting ambitions).

It might be worthwile to allow the facilitator to set up the dashboard in a less transparent way. In very sensitive decision processes, stakeholders might request that their ambitions and weights to KPIs are not displayed to other users. Furthermore, there might be a need to block viewing rights to some of the sensitive data on household level.

5.1.2 (Graphic) interface of the dashboard

In order to make the IDSS more comprehensible and attractive to use in a stakeholder environment it is recommended to further develop the interface of the dashboard. On the one hand, this relates to the way functionalities are organized and the terminology that is used. On the other hand, some work is needed on the graphic design.

In the discussion with the WP5-partners, following issues were mentioned:

- to reduce and simplify the amount of steps in the IDSS
- to group the stakeholders
- to use more icons and graphics in the representation of data and information
- to group the KPIs in categories

- to show aggregated scores per category.

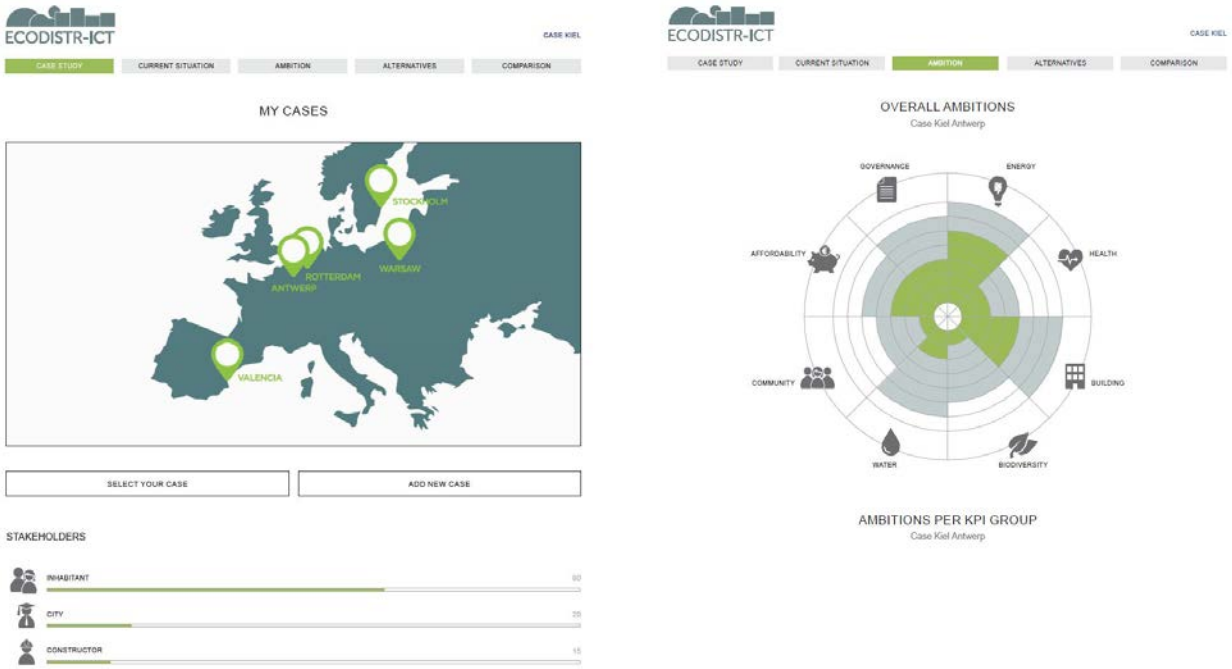

Figure 8 Proposals for the graphical and functional improvement of the IDSS (OMGEVING)

5.1.3 Data collection and implementation

The integration of data sets and connections with the IDSS and modules was often a struggle during the case studies. It has to be taken into account that the database structure has to correspond with the modules that are connected to it, and therefore the data templates and related guidelines are subject to change. It might therefore make sense to anticipate on additional data needs of future modules and define additional data slots accordingly. It is also recommended to keep compatibility to different data structures.

The crowd sourcing module can be a valuable contribution to the data collection process. Since it is not directly coupled to the current version of the IDSS yet, this can be improved in a further phase of development, although the facilitator should be able to check the data before upload, to ensure compatibility with the database.

A recurrent discussion during the case studies was the question wheter the IDSS should have a functionality to include non-quantitative data that can support the qualitative KPIs. It concerns pictures, interviews, podcasts, movies etc. that can also be considered valuable data on the condition of the district.

5.1.4 The design module

The design module was considered a valuable and helpful tool by the WP5-partners in the case studies. Since the module was only implemented in the latest stage of the project there is still some work needed to attune it better to its use in decision-making processes.

- The colour legend for each KPI is determined by the "sufficient" and "excellent" values set in the dashboard. However, a side-effect of this interdependency is the fact that a good representation in the visualization module can be more decisive than carefully selected and properly justified values. A way around this could be to make a distinction between these two functionalities.
- Not all the features are implemented yet, although they certainly enhance the user-experience: quick selection using queries, presenting object properties, etc.
- When applying a lot of different measures on different objects, it becomes difficult to keep an overview. A functionality to filter measures or make it more clear which measures apply to which buildings, would contribute to an increased user-friendliness.
- It is not possible to alter alternatives on the spot in the IDSS, which limits the flexibility.

5.1.5 Availability of modules

In order to make the IDSS fully useful in a process of district renewal, a large set of applicable modules have to be available. This is due to the need to include a broad range of KPIs, move (far) beyond energy related issues, and combine complex issues like energy poverty, mobility, green spaces, public spaces, home ownership, affordability, etc. as well as the challenge to identify, integrate and develop calculation models or qualitative assessment tools for all KPIs that are identified by stakeholders, implying a need of rather complete sets of KPIs and high demands towards software availability and complexity. Current practice shows that these modules are not yet available. We expect that the ability to use these kind of modules in an integrated process (using the IDSS), will stimulate their development.

5.1.6 Dynamic coupling of modules

In order to calculate and assess complex alternatives, with a large set of measures, a dynamic coupling of the modules is needed. This means interactivity between different calculations, automatic calculation and visualisation of changes in different parameters following changes in other parameters. The current set-up of the IDSS with its flexibility towards the integration of new modules in the system and the powerful district database for sharing input and output data, offers the potential to support this dynamic coupling of modules. Further use in practice and, if needed, further development of the IDSS and its components, will prove whether the set-up is powerful enough.

5.1.7 Technical support

As expressed before, the case studies heavily depended on intensive technical support. It was an important comment and question of the stakeholders and WP5 partners to become less dependent on this technical support, certainly for future phases. The latest version of the IDSS, with a data upload functionality, allowed the use of the IDSS with less technical support. However, since remaining time was limited, more testing is needed. Further diminishing of the need for technical support is crucial to the success of the implenmentation of the IDSS in practice. A suggestion would be to offer the complete functionality of the IDSS as a service, which can be invoked over the internet upon request from a future facilitator.

5.2 RECOMMENDATIONS ON THE PROCESS OF FURTHER DEVELOPMENT

5.2.1 A parallel development of the next version of the IDSS

In the ECODISTR-ICT research project three processes were conducted in close interaction: (1) developing the IDSS, (2) developing a new facilitation process based on this IDSS, and (3) responding to five retrofit districts with stakeholders in the five case studies. The main objective of ECODISTR-ICT was to develop the IDSS. Therefore, focus was on the first and, to a lesser extent, second process. This implied that the case studies were mainly instrumental for these two processes, and that, due to different temporalities of software development, case study testing and ongoing retrofitting, the interaction with the ongoing retrofitting remained limited.

For the future development of the IDSS it could be expected that these processes can be conducted with less interaction and thereby with less dependencies. This implies that in the next phase the prototype of the IDSS can both be used in real-life projects and be developed further in (R)TD initiatives.

5.2.2 An in-depth case study testing

At this point the ECODISTR-ICT software is mature to be tested in-depth in a real life context. In the 5 case studies the main focus was the software development, which made it difficult for the WP5-partners to organize an actual discussion on the content that could evolve in concrete actions and commitments. Furthermore the timings of the software development and the case studies were hard to streamline. It is recommended to test the IDSS in a case study where there is a momentum for a process on district renewal and stakeholders show great interest. This process should be able to use the existing functionalities in order to keep the focus on the case study and not so much the software.

5.2.3 Scrum-like development of new functionalities

For new domains and new functionalities still a close interaction and a scrum-like approach with future users is recommended. In this approach it is important to manage the expectations. When developing new functionality, the progress might conflict with the needs in the real-life case. It

should be ensuredthat the case is flexible enough to handle these conflicts, e.g. by conducting the case to support development parallel to the real-life case, which uses another (more traditional) approach without the IDSS.

5.2.4 User differentiation

The current IDSS is designed in such a way that it can cater for the needs of a lot of different users: city planning experts, energy grid operators, policy level, social housing organisations, etc. The inherent flexibility can also be a barrier to some users, as it increases the complexity. New developments could work on multiple parallel versions, e.g. a dashboard and database specifically geared towards real estate professionals with preconfigured KPIs and calculation modules.

5.3 FINAL CONCLUSION

The ECODISTR-ICT project developed an integrated decision support system (IDSS) for sustainable retrofitting projects on district level. Responding to the complexity of urban retrofit projects, the ECODISTR-ICT development process was designed as an interdisciplinary (integrating various disciplines) and a transdisciplinary (involving real users) process. In a truly iterative approach, IT developers, researchers, case study partners and external stakeholders were mutually involved in shaping the ECODISTR-ICT IDSS ‘along the way’.

This report describes how the most important interactions and decisions in the interactive process of making the IDSS emerged and how this explains its current structure and use. The key lessons learned from testing the system in the five project case studies have been discussed and the report concludes with insights on further use and potential further development of the IDSS.

Interactions with stakeholders learn that there is indeed a need for tools to support urban retrofit projects and to gain knowledge out of the growing availability of data. Thanks to the agile development method, the ECODISTR-ICT IDDS is largely adapted to cope with these challenges. The experiences of the case studies prove that the IDSS can help to inform decisions based on a stakeholder and process oriented approach. Further lessons will be learned by applying the IDSS in practice. The partners in ECODISTR-ICT encourage future users to share their real-life experiences, and contribute to the further development of this open source system.

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