Decision Support Modules for Key Performance Indicators – building an Integrated Decision Support System

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Abstract

The objective of the EU FP7 project ECODISTR-ICT is to develop an Integrated Decision Support System (IDSS) for sustainable retrofitting of urban districts with a focus on energy efficiency. It connects the main stakeholders in urban district transformation programs, acting from different perspectives, with different time scales, to reach a coordinated approach that joins building retrofitting with district renovation. The system will have a modular structure and will result in an open access software tool. The interaction of different modules focusing on different aspects of sustainability will enable an interdisciplinary assessment of district retrofitting. Energy calculation models will be supplemented with modules regarding mobility, local green space and ecologic values of nature based solutions, life cycle impact assessment to quantify resource efficiency, quality assessment and modules on life cycle costing. This paper presents the latest news and findings from the evaluation and selection of the different ECODISTR-ICT decision support modules, including modules focusing on qualities such as energy performance, economic and environmental qualities, as well as social qualities. A special attention is given to the evaluation of urban green and nature based solutions where both environmental and social issues are addressed.

Keywords

Urban districts, district retrofitting, energy performance, economic qualities, environmental qualities, social qualities.

Introduction

There are several positive effects from up-scaling the efforts of energy renovations from individual building level to district scale. Apart from the technical opportunities and replication potential, the greatest reason to address energy retrofitting on a district level is to integrate a multi-disciplinary approach and investigate several areas of sustainability simultaneously and interconnected. Buildings in cities do not operate on their own, but are part of a complex network of other buildings, public services and transportation, not to mention the social interactions of people in the district.

Based on early results from ECODISTR-ICT several sustainability aspects were identified and included as presented in ECODISTR-ICT deliverables (Sauer and Pedrola, 2014) (Capener *et al.*, 2014):

- Environmental Quality
- Social/Functional Quality
- Economic Quality
- Technical Characteristics
- Process Quality
- Location

These concepts were upscaled to a neighbourhood level and a new aspect was introduced, Urban Quality, including elements such as urban mobility, urban density, diversity of activities, etc. The aspect of "Location" is hence included in Urban Quality and related KPI's are included.

Connecting Stakeholders Needs with the Selection of KPI's

From the full list of relevant KPI's the representatives from the 5 ECODISTR-ICT case studies ranked the most important KPI's applicable for their demonstration. Below, the prioritized KPI's are presented for each demonstration:

Antwerp, Belgium

For the Antwerp case, the main KPI's are:

- Quality of housing (low energy use, comfort, ease of management, ...) versus affordability
- Access to public facilities and public space
- Feasibility of investment in and especially management of large numbers of housing (social housing company, community land trust, bank)
- Production of renewable energy versus infrastructure adaptation cost and technological feasibility
- General environmental quality (water management, air quality, noise pollution, biodiversity, health)

Rotterdam, The Netherlands

For the Rotterdam case study, the prioritized KPI's are:

- Percentage of green dwellings (minimum of 80% that has label C)
- Affordable cost for the end consumer (same level or lower level as it is now)
- Affordable investment costs for Housing association (acceptable payback time)
- Sum of consumed energy - produced sustainable energy (zero or as low as possible)

Stockholm, Sweden

For the Stockholm case study, the proposed main KPI's are:

- Affordability from a tenants' perspective
- Return on Investment from an owners' perspective
- Lowering buildings' energy consumption (to the acceptable level for new built according to Swedish building legislation).
- Strengthening civil society and continue working with inclusive management
- Local job creation

Warsaw, Poland

For the Warsaw case study, the proposed main KPI's are:

- Total primary energy demand (GWh)
- Total primary energy supply (GWh)
- Share of renewable energy (%)
- Global warming potential (GWP)
- Net present value for large scale investments (NPV)
- Energy bill for consumers (Euros/year)

Valencia, Spain

For the Valencia case study, the proposed main KPI's are:

- Local production of renewable energy
- Improved connectivity
- Diversity of activities
- Improved public transportation
- Environmental quality of the public space

Final selection of ECODISTR-ICT Prioritised and Case Common KPI's

The final selection of the prioritized and case common KPI's was made end of December 2014. Five common KPI's for all demonstrations were proposed and agreed upon.

The 5 case common Key Performance Indicators are:

- Energy Performance of Buildings
- Proportion of Renewable Energy
- Return on Investment (ROI) /Life Cycle Costing (LCC)
- Affordability (e.g. housing costs)
- Availability/Level of Services, including:
    - Services (public facilities, shops)
    - Mobility
    - Green
    - Safety
    - Employment
    - Health

In addition to the five common KPI's, case specific issues can be introduced where applicable and when supported by coupled calculation modules. The Integrated Decision Support System (IDSS) will help decision makers to select the best strategy to increase several case specific indicators and issues including energy efficiency and the overall sustainability of the whole district. Utilising the connected decision support modules the IDSS will enable new energy and resource efficient retrofit solutions to be incorporated in district retrofitting projects. A draft list of case specific KPI's includes:

- Antwerp: Housing suitability (adaptation of the building stock to dweller's profiles)
- Rotterdam: water retention, collective decision making
- Stockholm: daylight access, collective decision making
- Valencia: modal split (public vs private transport), heat stress
- Warsaw: modal split, LEED, BREEAM, DGNB,... labelling tools if we take a specific measure, how does this help for getting our LEED credits?

Evaluation of Decision Support Tools for Indicators

Based on the assessment process proposed in ECODISTR-ICT, an in-depth evaluation was carried out for all the previously screened tools and methodologies. The assessment took place in a two-stage process where the screening criteria is explained below. In the first-stage evaluation, all tools were evaluated based on:

LANGUAGE	1	Not in English and cannot be translated or used
	2	Not in English but belongs to a partner or can be translated
	3	In English
LICENCE	1	Commercial and cannot be bought
	2	Commercial but belongs to a partner
	3	Freeware
SUPPORT	1	No support address is provided
	2	Support address is provided but we are not sure if it is active (e.g. the project ended)
	3	Active support is available

Table 1: First stage evaluation of decision support tools.

In addition to the three criteria above, the tools were also categorized into families depending on what sustainability feature they focused on.

FAMILY	1	Energy calculation on building and district level incorporating both domestic and commercial buildings
	2	Life-cycle based analysis for costs and environmental impact such as Green House Gas emissions
	3	Social aspects for comfort, quality and health indicators, interior and exterior
	4	System based approaches for detecting opportunities for modelling connections with networks and related installations (transport, energy, water, waste)
	5	Cultural heritage aspects and City-ecology

Table 2: Categorisation by sustainability feature.

After the first-stage evaluation several promising tools were still strong candidates and the second-stage evaluation performed a more thorough assessment where many more selection criteria were imposed. Utilising the sub-criteria set-up earlier, defining the easiness of coupling to the IDSS-framework, the 2nd evaluation focused on more features of the tools but input also included the basic data. In short, the evaluation consisted of the features below and also correlated to the list of KPI's described in deliverable D3.2 (Capener *et al.*, 2014):

General description

Name of tool or sub-tool /Methodology /Website /Developer /Owner /ECODISTR-ICT partners involved (yes/no)

Recommendation part

Description of the tool /Strengths /Weaknesses /Overall recommendations

Feasibility part

The feasibility part included topics from the stage-one evaluation; language, licence, availability and support but also addressed topics such as Status (e.g. under development, final, not up-to-date etc.). It also considered input data and data format; describing data models and use of ICT. Coupling and configuration was assessed describing the level of complexity and data handling (including user options on input data, output format, databases and iterative processes). The programming code is of importance where commonly used programming languages are preferred over more exotic or old compiler versions.

Needed part

In the "needed part" the tools were also evaluated on which main decision makers it supported, which category it belonged to (as from the stage-one evaluation), whether it supported district or building level, aspects in the design process (e.g. feasibility studies, planning & design, decision making, implementation, assessment), related KPI's and PI's involved as well as criteria on accuracy, accessibility, ease of use, relevance and adoptability.

Conclusions on the Selection of KPI's and Calculation Tools for Indicators

The results and the complete evaluation of the tools can be found in ECODISTR-ICT deliverable D3.2 (Capener *et al.*, 2014). Since many of the proposed tools are methodologies and not fully developed tools they will need modifications and further development in order to be incorporated in the IDSS. However, the remaining candidates are tools that are either the result of previous research and show promising result, or have a strong position and acceptance in their field. Below, some of the tools and conclusions are mentioned for the different category indicators.

Recommendations on Energy Calculation Tools

The output of the evaluation process for energy analysis tools on building and district level followed by a consortium discussion resulted in a list of potential candidates for inclusion in the IDSS. In house-tools included VIP-Energy from Strusoft, Energy consumption from TNO, Dimosim from CSTB, PV-potential from TNO and Assets Energy and Assets Policy simulation from VABI.

Recommendations on LCA/LCC Tools

The output of the evaluation process for life-cycle based analysis tools for costs and environmental impact such as greenhouse gas emissions gave several possibilities. Many of the energy calculation tools also include life-cycle assessment to some degree and are also considered in this group. Apart from some of the already mentioned tools the Renobuild LCA tools from SP is also included (and coupled to the IDSS). For life-cycle costing there are several simple tools available but some modification is necessary in order to support the requested KPI of affordability.

Recommendations on Tools for Social Aspects

The output of the evaluation process for social aspects tools for comfort, quality and health indicators, interior and exterior gave a short list of candidates. Many tools available are in fact methodologies and modifications are needed to transform these into useful tools to be coupled to the IDSS. UrbanStrategy of TNO already contain certain aspects useful for evaluating social aspects such as noise from traffic and the S2020 methodology from the city of Gothenburg is also under consideration in the implementation stage. A GIS based tool will be developed that considers indicators such as distance to certain services and possibly transport. Here, services can also include nature based services and KPI's such as distance to high quality green areas for recreational use.

Recommendations on Tools covering System Based Approaches

The output of the evaluation process for tools investigating system based approaches for detecting opportunities for modelling connections with networks and related installations did not deliver any strong candidates for application in the ECODISTR-ICT IDSS. Since the mapping and final selection of stakeholders and case studies common KPI's didn't request any indicators related to these tools, the need to investigate further candidates is not required at this stage. However, since the open and modular structure of the ECODISTR-ICT IDSS does allow further development by future users there is always the possibility of adding new modules covering this aspect.

Recommendations on Tools for Cultural Heritage Aspects and City-Ecology

The output of the evaluation process for cultural heritage aspects and city-ecology tools gave a short list of potential tools. ENVI-met was a strong candidate to consider but given the complexity of the software and the large amount of input required by the user it was considered too complex for full direct integration in the IDSS. A possible candidate for investigating heat stress is the Rayman model, closely linked to ENVI-met. The biotope area factor proposed by many European cities is a strong candidate for implementation. A modified simple version, possibly originating from the Stockholm methodology GYF, will be developed for the IDSS including features on water retention, urban heat island mitigation and biodiversity. The same GIS based tool mentioned above could also be used to estimate indicators such as proximity to green spaces, available green spaces per capita, and space available for recreational use – related to the social indicators.

Outlook and future work

In the next steps the proposed tools will be used and evaluated in the five ECODISTR-ICT case studies, some examples are given below. The first demonstration, Rotterdam (summer 2015), have tested the following tools: For energy and renewables the VABI tool + PV potential tool + TNO tool have been evaluated. For the KPI's on Return on Investment, RoI, and affordability use the VABI tool was used. For KPI's on social issues and services, the social indicator wheel (being early in the project no other tools are available). Water management is also considered but at this stage no tool has been fully coupled to the IDSS. Next up is the case study of Valencia (October 2015) who will try a test run of the coupled Dimosim from CSTB for energy assessment. For social and services the

proposed GIS distance tool based on google distance metrics API will be tested. The Rayman model will be used for heat stress evaluation and for greenery and nature based services the Biotope area factor will be tested in a beta version. For Stockholm (winter 2015) the Dimosim will be used again for energy assessment and the modified LCC tool from SP will be used for RoI and affordability. Again, the Biotope area factor will be used for assessing nature based services and for social and other services a tool proposed by White Architects could be assessed. In 2016, Antwerp and Warsaw will be the case studies to test the tools and build on the already evaluated tools as described above as well as other tools on infrastructure and mobility.

Discussion

The ECODISTR-ICT project has just reached halfway and much work lies ahead. Several tools for evaluating indicators have been identified and most of the prioritised KPI's have been covered building on previous research projects and well established tools in the field. However, there are some gaps that need to be filled in, especially for the tools evaluating social indicators and services. With the GIS tool under development many of these will be covered and for the green KPI's and nature based services there is also development ongoing. Utilising the biotope area factor will be a significant contribution to investigating nature based services. With the modular structure of the ECO-DISTRICT approach it will be possible to couple tools after the project realisation, enabling state-of-the-art research on a multitude of qualities to be utilised by district stakeholders. Considering the way the IDSS is being set-up it will also be possible to use non-coupled tools to investigate further KPI's and compare scenarios and alternatives for stakeholders not covered by the ECODISTR-ICT case studies.

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References

Sauer, B., Pedrola, B. (2014). *A first survey of existing tools and methods supporting evaluation of indicators for urban district retrofitting and renewal.* ECODISTR-ICT Deliverable D3.1

Capener, C-M., Poirazis, H., Esad, A. (2014). *Scheme of chosen and verified decision support tools for indicators.* ECODISTR-ICT Deliverable D3.2