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Sustainable Smart ECO-Buildings

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ABSTRACT

The paper reports the main observations of the European project "Smart-ECO", which concluded in mid 2010. Smart-ECO was a Specific Support Action project funded by EU FP6, established to create and anchor a generic vision framework for Sustainable and Smart ECO-buildings in the period 2010 - 2030, to determine what innovations (technical and non-technical) that could be useful for realising this vision, and to identify those elements that have the highest potential impact, all while anchoring the work and the findings with a carefully selected wide ranging group of expert stakeholders involved in various aspects of the built sector. The defined Vision and Requirements has been met with great interest. The life cycle aspects of buildings were ranked as having the highest potential in achieving the vision of sustainable smart ECO-buildings, followed by miniming energy consumption, detailed monitoring the operational aspects of buildings, providing good user manuals of the buildings and their systems, flexibitlity of the buildings in being able to be adaptable to local and regional conditions. The paper focuses on the life cycle issues and the requirements resulting from a vision of sustainable and smart buildings.

KEYWORDS

Sustainability, ECO-buildings, Life Cycle, Vision, Requirements, Innovations.

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1 INTRODUCTION

Smart-ECO is the short name for the EU-FP6-project "Sustainable Smart Eco-Buildings in the EU". The project started in October 2007, was conducted by a project consortium consisting of 12 partners, and led by the Center for Built Environment at the University of Gävle in Sweden. The project concluded in July 2010.

The Smart-ECO objectives were to establish a Vision with its resulting Requirements for sustainable smart ECO-buildings over the time perspective 2010 – 2030, and to evaluate Technical and non-Technical Innovations together with their potential to contribute to acheiving this Vision. Such innovations will only be successful if the potential to implement and apply the new solutions are sufficiently promising. Combining the overal criteria, the innovations were deemed to have good potential if they satisfied the following:

- they contributed to developments which were in-line with the vision for sustainable building
- they met the desired performance requirements arising from the vision
- they were perceived as being feasible in having high potential by a wide range of stakeholders

Figure 1 describes how the Smart-ECO is structured in its work plan.

Figure 1. Overall structure of the Smart-ECO project.

The first essential project step was to identify the Vision for sustainable and smart ECO-buildings, discuss and anchor this with a relevant panel of stakeholders which were chosen to be wide enough to represent all legitimate views on sustainable development in the building and construction sector.

A group of some 230 potential expert stakeholders was formed to contribute to the establishment of the vision, to help evaluate and to provide legitimacy to the key reference points of the project.

The project's starting point was the current position regarding sustainable building as described by established practice, current policies, existing standards and current EU-directives. An analysis of recently completed as well as ongoing research and development projects provided indications of the short- and mid-term drivers for the current developments in the built sector. Strategies and policies addressing other closely related sectors, especially energy and transport, have also been considered as they often address aspects that are relevant to the building sector.

A vision is usually a rather descriptive and qualitative presentation of an overarching ambition but it is important that specific and measurable requirements and metrics are included to quantify progress towards realising the global goals aime for in the vision. The potential of technical and non-technical innovations to contribute to the realisation of such developments can then be discussed and assessed against the requirements.

This evaluation of innovation has applied these metrics, after discussion and agreement with the stakeholder group and this stakeholder perspective is a core novelty of the Smart-ECO approach. The implementation of such an evaluation routine can itself be interpreted as a non-technical innovation aiming at enhanced sustainability within the building sector. Likewise the application of formalised assessment methodologies as part of the evaluation of building sector products and services can be perceived as innovative inits own right. The project therefore applies a cycle of self-evaluation involving assessment methodologies such as Environmental Life Cycle Assessment (LCA), Economic Life Cycle Assessment (Life Cycle Costing LCC), Service Life Planning (SLP), Life Cycle Management Systems (LMS) or the concept of Performance-Based Building (PBB).

A summary report (CIB, 2010) presenting predominantly the Smart-ECO work on the Vision, the Innovations supporting the Vision, and the work on processing results with the Stakeholder Group was published by CIB (partner of Smart-ECO) towards the end of the project and released at the CIB World Building Congress 2010. The report is freely downloadable from http://cibworld.xs4all.nl/dl/publications/pub332.pdf or www.smart-eco.eu.

2 THE VISION ON SUSTAINABLE SMART ECO-BUILDINGS 2010 - 2030

As the building sector is strongly interlinked with other sectors of the economy (i.e. the energy sector, transport, and labour development and deployment), the perspective applied when establishing the vision needed to be extensive and all-inclusive. The project vision used as far as possible the current status of sustainable construction within the EU (including the major outputs of previous related EU projects and thematic networks) as the starting point and to set out an ambitious yet realistic roadmap of development.

The Smart-ECO Vision has had an early impact on policy and standards development. This is because the Smart-ECO Vision document was adopted by ISO as the foundation for further standardisation on sustainable building. In the development of a procurement handbook for sustainable building by the UN SUN initiative the Smart-ECO Vision was used as the fundamental document defining sustainable building.

For the Smart-Eco project, it was essential to establish a vision expressed in generic terms and complemented with clear targets. Only if so, the targets contained in the vision can be communicated and applied by the various concerned stakeholders. Additionally, clear and unambiguously expressed targets are needed to monitor progress and to assess options with.

Furthermore, the vision must be ambitious in order to point towards the ultimate target, and realistic enough to function as a motivator and enabler. This "carrot and rabbit" concept implies that the vision has a clear temporal anchor and that significant improvements of the building and construction sector in its progress towards sustainability and stronger regulatory requirements will lead to the situation

that the vision needs to be revised and targets need to be sharpened over time. The earlier the vision and the associated targets are appreciated as being outdated, the better!

Separating the general issues of the Vision from specified targets it is expected that the Vision may be adapted to such developments. An example of such a development is e.g. the European forthcoming Construction Products Regulation with its inclusion of sustainable use of resources. Addressing the life cycle of the building, and the total energy demand throughout the life cycle and aiming at "near zero energy buidlings" will push new construction significantly into the direction of the Smart-Eco vision.

2.1 The "ten commandments" of the Smart-ECO Vision

A key statement by ISO (ISO 15392:2008) was, after rigorous discussions, adopted as the following guiding principle:

Buildings contribute to sustainable development when designed and operated to match the appropriate fitness for use, with minimum adverse environmental impacts, while encouraging improvements in economic, social and cultural aspects at local, regional and global levels.

With this as a corner stone and within an iterative process with the stakeholder group, the Vision was elaborated, and is presented next in a condensed short-version. The full Vision and Requirements report (Chevalier, J-L, et al, 2010) is freely downloadable from www.smart-eco.eu.

The Vision of Sustainable Smart ECO-buildings should be the following:

- apply the general principles of sustainability
- be designed to meet the needs individually and collectively
- be integrated into a local/regional strategy
- encompass Life Cycle perspective in Design / Refurbishment
- deliver minimized adverse environmental impact over life cycle
- deliver economic value over time
- provide social and cultural value over time
- be healthy, comfortable and safe for users
- be user friendly, simple and cost efficient in operation, and have measurable performance
- be adaptable throughout service life, and have an end of life strategy.

3 INNOVATIVE SOLUTIONS

The work on analysing the market and research literature on possible technical and non-technical innovations that could support reaching the Vision has been extensive. The full resulting report (Saldini, et al, 2009) is freely down-loadable from www.smart-eco.eu. For reason of available space only some hints of the results can be given here. The accounting of the stakeholders views and rankings of the various innovation categories presented in the next section also only gives a tiny flavour of the full results obtained.

The work on innovation was basically structured on the following aspects:

- Holistic design approaches applying innovative technologies

This includes a life cycle approach considering that a building's long-term impacts on the environment have to be seriously considered if advances in building design are to become sustainable. To reach the ambitious goal of the Smart-ECO Vision requires an Integrated Design Process. Such an approach to the design is radically different to the common approaches of the 20th century and today, which typically distinguish the architectural design and the engineering completion and detailing,

hence loosing the important integration asepcts and the opportunities of reaching the desired target, i.e. sustainablity. Among specific innovation areas declared as having the most interesting characteristics appears to be advanced tools like Building Smart (BIM), and Life Cycle Management approaches.

- Innovative technologies and solutions, including both energy saving and energy generation and distribution

The focus of energy saving came out to be advances and improvments in thermal insulation, cladding materials, glazing, thermal storage in the building fabric, natural ventilation for comfort, overheating controls, and generally better control systems. As regards lighting the focus should be on natural lighting and shading, and innovations on artificial lighting.
The main area of energy generation and distribution – in the Smart-ECO case with a specific focus on renewable sources – focused both at the building level, the non-building or regional area levels, and considering issues like integrated generation of energy.

- Building construction and operation

The work towards solution in this area focused on materials sourcing and the manufacture of components and systems, site assembly and logistics, and demolition and recycling. The stakeholders stated that construction is not as critical as design and operation in meeting the requirements of the Smart-ECO vision, although innovations in, for example, materials production would reduce waste, increase the efficiency of processes, and improve performances and sustainability aspects throughout the supply chain.

- Ways to meeting future requirements

This focussed the identification of changes that will affect the building sector in the near future. Adaptation strategies and other relevant aspects are considered to illustrate how Smart-ECO buildings, over their service life, could meet these future requirements and the stakeholders identified the following areas to be most critical:

Energy and environment:This includes mitigation and adaptation for climate change, integration of buildings in the energy networks, and using building strategies to reduce depletion of resources

Changing requirementsand use: This calls for sustainable design processes, which requires that service life considerations are integrated into the design process. The design for flexibility and adaptability are key criteria which allow buildings to be continued to be used even when changes need to be made.

Depletion of resources: The use of building materials should be reduced considerably to improve efficiency of resources. The revised and up-dated European Construction Products Directive/Construction Products Regulations will in the future demand proof of the environmental impact of building materials in accordance with full life cycle assessments. The extension of materials life-cycle could be obtained by promoting the extension of the life expectancy in buildings, i.e. by means of conversion / transformation of existing buildings instead of going for new constructions.

4 THE STAKEHOLDER PROCESS AND SOME RESULTS

At the start of the Smart-ECO project a stakeholder group was established, and a plan for their involvement in the project was set up. The following categories of experts were established:

1. Technical experts, comprising researchers, engineers, scientists, etc, all with vested interest in developing innovations for a sustainable construction sector
2. Industrialist involved in manufacturing and commercialising products for construction
3. Devolopers involved in real estate development and planning
4. Materials specialist to support the variety of matarials needed in construction

5. Architects involved in design of green and eco-friendly buildings in particular
6. Builders, ranging from domestic house builders to construction companies involved in building large commercial structures
7. Occupants of various categories, to give feedback from a general viewpoint on the acceptability of innovations being considered for adoption
8. Educationalists involved in traning and education of different types of stakeholders in the construction sector
9. Authorities, ranging from governmantal bodies to professional organisations involved in developing policy and having activities related to the construction area.

For the Stakeholder Group, a list of 238 contacts were created from the Smart-ECO consortium from the above mentioned wide range of sectors. From these contacts, a Stakeholder Group of 66 experts was created. The report for the Stakeholders Group describes the activities carried out in setting up the group and formulating the questionnaires to engage the Stakeholders with the Smart-ECO project and the work being carried out in 1) formulating the vision for sustainable construction, 2) identifying the innovations needed to realise the vision, and 3) evaluating the innovations for monitoring success. Three questionnaires have been formulated to distribute initial drafts of the work carried out within Smart-ECO in these three areas and responses from the Stakeholder group passed back to the Smart-ECO partnership for prioritising the details of the work in each of the tasks being carried out. The details of these questionnaires, and the results obtained, are presented in the Stakeholder Group report (Virk, G S, et al, 2010) which can be downloaded from www.smart-eco.eu. Following on from this work a market perspective on eco-buildings is created and also presented in the report but short summaries are presented next for convenience.

4.1 The Way of Working and Stakeholders Ranking of Eco-Efficient Measures and Innovations

The first Smart-ECO questionnaire (Q1) focused on ensuring the Vision comprised the most important elements and that the ranking of each component was appropriate as assessed by the Stakeholder Group. A total of 58 Q1 questionnaires were completed and the most important issues that should be included in the Smart-ECO vision (in ranked order) have been assessed to be as follows:

1. Lifecycle of building
2. Minimum energy consumption
3. Monitoring of building
4. Building user manuals
5. Building adaptability
6. Local issues
7. Dismantling building phase
8. Setting up building phase

The second Smart-ECO questionnaire (Q2) focussed on identifying the innovations (technical and non-technical) that had the potential to contribute to realizing the Smart-ECO Vision. A total of 51 Q2 questionnaires were completed with the questions aimed at assessing a variety of issues; the most important of these related to the innovations are summarised here.

Areas where innovations have the most potential for achieving the Smart-ECO Vision (in ranked order) are:	The energy saving and efficient technologies with high potential to impact Smart-ECO buildings (in ranked order) are:
1. Renewable energy generation	1. Insulation
2. Passive design measures	2. Passive cooling
3. Operation of building	3. Passive solar
4. Finance and incentives	4. Lighting
5. New materials	5. Orientation

6. Management and processes 7. Education 8. Policies 9. Recycling 10. Communications 11. Water conservation	6. Innovative material 7. Water conservation and storage

The renewable energy technologies with high potential to impact Smart-ECO buildings (in ranked order) are: 1. Solar thermal 2. Co-generation 3. Earth energy 4. PVs 5. Biomass 6. Wind related technologies 7. Fuel cells	The most important operational innovations with high potential to impact Smart-ECO buildings (in ranked order) are: 1. Building management systems 2. Automation for energy saving 3. Robustness to user behaviour 4. Post occupancy monitoring 5. Waste management plan 6. Intelligent lighting 7. Air quality control 8. Daylight dependent control systems

The third Smart-ECO questionnaire (Q3) focussed on evaluating the innovations identified in Q2 and their potential for realizing the Vision aims from Q1. A total of 18 Q3 questionnaires were completed with the questions aimed at assessing the various innovations via different evaluation criteria and the results are summarised here. From a holistic viewpoint the most important issues in ranked order are:

1. Technical performance
2. Economic
3. Sustainable
4. Regional pre-conditions
5. Social

Some of these criteria have been further assessed. For example the main issues that should be included in the regional pre-conditions (in ranked order) are: 1) climatic conditions, 2) local building regulations and local policies (equal second), and 4) geographical features; and the main issues to be included in the performing the technical evaluations (in ranked order) are: 1) requirements are met, 2) reliability, 3) robustness, and 4) maintainability. The economic evaluations should include (in ranked order): 1) cost-benefit analysis, 2) the set up costs, 3) the operational costs, and 4) service life time.

The various innovations have been assessed from different viewpoints such as minimising energy consumption, being easy to use, reliant on local issues, being adaptable, easy to set up, easy to dismantle, taking into account life cycle aspects and the increasing awareness of the user.

The market potentials of the various innovations have also been assessed by the Stakeholders. For example the market potential of the energy saving innovations (in ranked order) are:

1. Insulation products (with average score of 4.4 and market take up potential of 84% by 2030)
2. Lighting products (with average score of 4.1 and market take up potential of 69% by 2030)
3. Passive solar products (with average score of 3.2 and market take up potential of 52% by 2030)
4. Passive cooling products (with average score of 2.8 and market take up potential of 38% by 2030)
5. Building orientation (with average score of 2.7 and market take up potential of 32% by 2030).

Also, the market potentials of the renewable energy innovations have been assessed (in ranked order) as:

1. Co-generation products (with average score of 3.6 and market take up potential of 46% by 2030)
2. Solar thermal products (with average score of 3.5 and market take up potential of 54% by 2030)
3. Photovoltaic products (with average score of 3.4 and market take up potential of 42% by 2030)

4. Biomass products (with average score of 2.5 and market take up potential of 36% by 2030)
5. Earth energy products (with average score of 2.5 and market take up potential of 27% by 2030).

5 CONCLUSIONS AND DISCUSSION

The paper has presented the Smart-ECO project and outlined the main findings from the project in how the built sector community wishes to move towards becoming more sustainable within 2010-2030. This is a huge issue for us all and the built sector being a major consumer of energy and natural resources, needs to be more active in adopting sustainable approaches. It was the aim of the Smart-ECO project to develop a viable Roadmap for realising sustainable building community where holistic methods are used in designing, building, operating, maintaining and finally re-cycling constructions. To do this Smart-ECO has created a Vision that is properly grounded with the wider stakeholder community and has idenified the innovations (both technical and non-technical) which have the most potential in achieving the Vision. How the success of the community (or not) in realising a sustainable built sector has also been investigated and the most important metrics that should be used have been identified. The work carried out within the projet in these areas has been throughly assessed and various options put forward have been ranked by a wide range of experts who agreed to act as the Stakeholder Group for the project. This feedback from the wider community has been invaluable and ensures that we maximise our gains early by adopting the measures having maximum potential and then as new innovations emerge we can make even larger steps towards becoming a sustaianable society.

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