# PROJECT PERIODIC REPORT

## 1 Publishable summary

### 1.1 Project facts

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| Project Acronym | GreenerBuildings |
| Project Title | A ubiquitous embedded systems framework for energy-aware buildings using activity and context networks |
| Grant Agreement number | FP7-258888 |
| Duration | 36 months (September 1st, 2010 – August 31st, 2013) |
| Budget (EU Funding) | 1 849 791 EURO |

### 1.2 Consortium

| Organization | Short Name | Country | Scientific contact |
|---|---|---|---|
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### 1.3 Objectives

The goal of the GreenerBuildings project is to develop generic principles and a scalable framework to conserve energy in office buildings based on recognised occupant activity and building context. The approach essentially builds on cooperative sensing, processing, and actuation in large-scale distributed networks that dynamically minimise energy consumption and adhere to occupant comfort.

### 1.4 Research Activities

In order to support the GreenerBuildings goal, the following topics will be investigated in the context of the project:

- Activity and context recognition
  - Research and development is performed on ambient activity and context recognition approaches to derive information on occupant routines and usage patterns of building spaces and infrastructure.

    - New algorithms will be developed that consider a combination of sensors (number, modalities, and location) as complementary sources for dynamically self-adaptive pattern models. The work will start from recognising typical occupant activities in the least invasive manner (in terms of the number of sensors and their types) and continuously advance to hierarchical behaviour models and inference.
    - Dynamic sensing and inference of context categories is performed from distributed sensors and processing resources. Considered context categories include: occupant behaviour, dynamic building state, environmental conditions, and operational conditions.
- Middleware: service-oriented and energy-aware
    - Project efforts target research and development of a highly scalable service-oriented framework that can cope with spatial distribution of sensors, actuators, and processing in multi-floor buildings.
    - Definition of the conceptual and technical architecture of building-wide energy-aware cooperating objects, referred to as the service composition layer. This objective is concerned with the middleware enabling energy optimisation both at local level and at global building level. Finally, the building interconnection and smart-grid interface is considered.
    - The architecture for cooperation of the energy-aware sensors/actuators will be designed. This will be a peer-to-peer (P2P) middleware for handling dynamic membership of elements, hiding heterogeneity and semantically describing energy demands and offers. To optimise energy usage in public and semi-public buildings, the middleware implements control and orchestration services, and incorporates control inputs.
    - Combination of complementary information sources to leverage savings that are not feasible at the local view of individual devices.
- Device-level sensing and processing operation
    - The project will investigate cheap self-powered sensors to acquire building state and occupant activity information. These devices for sensing and processing need to be installable and maintainable at low cost.
    - The coordination of heterogeneous devices is required that interoperate in a dynamic, structured environment in order to sense and process information on the building's state and occupant behaviour.
    - Design of a scalable distributed system architecture that can be flexibly implemented in buildings and provides sensing, processing, communication, and actuation functionalities.
- Building thermodynamics and building simulation
    - Develop novel models to predict the thermodynamic state of a building space.
    - Sensor placement will be optimised using thermo-fluid dynamic simulation approach for individual spaces and at the full building level.
    - Design and implement an occupant simulation based on activity and behaviour models and simple actuation rules.
- Adaptive building living-labs & validation
    - Evaluate devices and modules in lab and living-lab buildings, perform system integrations and test their feasibility in living-lab case studies.
    - Validate quantitative effectiveness of first and second versions of the GreenerBuildings energy-aware adaptation framework regarding energy conservations in living-labs.
    - Evaluate usability and occupant experience improvements of first and second versions of the GreenerBuildings energy-aware adaptation framework.

## 1.5 Impact

Near future buildings will include thousand of cheap sensors, actuators and smart devices that collaborate with each other in a distributed manner, aiming at increasing the level of comfort and safety of the inhabitants. This trend is growing stronger and opening a number of technological challenges. Research and industrial projects that aim at improving energy efficiency of buildings are underway. However, previous and current initiatives hardly consider occupant behaviour monitoring to conserve energy in building automation.

The main expected impact of the GreenerBuildings project is to develop an ICT infrastructure that is energy-aware and conservatory in response to occupant behaviour, while at the same time exploit the potentials of existing buildings. Large-scale networks of intelligent collaborating devices are the primary means to realise the GreenerBuildings framework. Thus, the impact of the project is two-fold:

- an improved energy management in individual building sections (local),
- an advanced control and cooperation mechanism to reduce the overall building consumption (global).

Final results of the GreenerBuildings project will have the following impacts:

- **Retrofitting solution.** GreenerBuildings will be self-adaptive, considering the context of the building and of its users in order to provide comfort, and, at the same time, relevant energy reductions in the global running of the building. This will be achieved by ambient sensing, thus will be easy-to-use for the people working in the building. The GreenerBuildings framework can be retrofitted to existing buildings.
- **Novel devices.** Partners of the GreenerBuildings project produce miniature wireless devices, building appliances, and investigate energy harvesting nodes. These will form a founding infrastructure to realise the GreenerBuildings vision. However, the GreenerBuildings framework does not depend on a particular standard or type of infrastructure to operate.
- **Socio-economic impact.** The successful running of GreenerBuildings will provide a technology for energy saving that will, in turn, reduce the emission of $CO_2$ and create more sustainable office spaces.
- **New products and services.** The consortium of GreenerBuildings is an excellent blend of large industrial partner and emerging SMEs together with academic research institutes that have a long standing tradition. The consortium aims to carefully consider the business potential of novel services and products that will be derived from the performed research.
- **Global partnerships and outreach.** The consortium can count among its members ITRI, a large research institute from Taiwan (more than 6000 researchers), which participates using its own resources and can both provide cutting edge technology and profit from the collaboration with European institutions. Furthermore, standardisation efforts stemming from GreenerBuildings may count on a truly international support.
- **Continued building research.** GreenerBuildings will use the concept of a Living-Lab and deploy proof of concepts and prototypes in buildings of selected consortium partners. The user will thus have the full experience of the prototypes, and will influence the research not only by providing abstract initial requirements, but actual experience-based feedback.

### 1.6 Project Logo

GreenerBuildings

## 1.7 Project Web Site

The address of the public GreenerBuildings project website is: http://www.greenerbuildings.eu.

The site provides public information on GreenerBuildings, including general information on the project and publicly available results (deliverables, software prototypes, demonstrations, etc.) and a publication list.

In addition, a dedicated Web-based project repository is used for the collaboration in GreenerBuildings. This private area contains a repository, a content management system, mailing lists, etc., which are used as a collaborative tool by the Consortium itself during its day-to-day operations. The area is restricted in access and uses encrypted access mechanisms.