1 Publishable Summary

The ENCOURAGE project aims to develop technologies that will enable energy optimization of buildings, focusing initially on the optimal control of *internal* sub-systems, but then also providing adequate mechanisms for effective interaction with *external* world, including other buildings, local producers, or electricity distributors. Embedded intelligent controls and middleware technologies for integration of heterogeneous data coming from sub-meters and sensor networks will be developed with the purpose to efficiently monitor and control appliances and sub-systems in buildings, and increase their energy efficiency by purely ICT-based technologies. These technologies will enable optimization at different levels:

- **Device-level**: optimization of individual devices energy consumption supported by continuous monitoring and diagnostics to detect deteriorated performance
- **Building-level**: optimization through the coordinated control of local consumption, generation and storage devices.
- **District-level** (or neighbourhood level): optimization through the ability to perform energy exchange with other participants connected to the electricity grid.

The energy optimization objectives will be achieved in three complementary ways:

- Developing **supervisory control strategies** that will be able to coordinate larger subsystems (heating, ventilation, air conditioning, lighting, renewable energy generation, thermal storage, etc.) and orchestrate operation of the numerous devices in such systems. Energy use in buildings will be optimized as a trade-off between occupants comfort, energy costs and environmental impact, while taking into account people's habits, weather conditions, electrical characteristics of appliances and devices, thermal characteristics of buildings, local energy generation and storage capacities and market conditions, such as existing tariff structures.
- Through the development of an intelligent gateway with embedded logic supporting **inter-building energy exchange**. This brokerage agent will communicate directly with other buildings and local producers to negotiate possible use of the electricity produced locally in their premises. This mechanism will aim to increase interoperability of buildings and will address challenges related to deployment the future Smart Grid concepts and technologies.
- Developing novel virtual **sub-metering** technologies and **event-based middleware** applications that will support advanced monitoring and diagnostics concepts. Systematic performance monitoring will ensure the achieved savings are sustained over long period of time without being degraded by deteriorated performance of both mechanical equipment and the monitoring and control system itself.

The primary application domains are non-residential buildings and campuses, but the project has relevancy also to residential buildings and neighbourhoods. This will be expressed through a series

of demonstrators in different countries, comprising public and private office buildings, experimental buildings, and private homes.

Work performed M1-M24
During the two project years, the focus has been on project set-up in WP1 (Milestone 1, project month 4), system requirements specification in WP2 (Milestone 2, project month 16), analysis, design and implementation work on the technical work packages WP 3-6, and preparation of the three project demonstrators in WP7. Also, project dissemination and market assessment have been addressed in WP8. More specifically, the following work and deliverables (DX.Y) have been realized:

- WP1, Project Management, has delivered the project plan (D1.1), a project repository (D1.2), and the project handbook (D1.3) including an internal review plan for deliverables.
- WP2, System Requirements and Architecture, has defined the business cases and customer needs (D2.1) to be used by the project demonstrators, the high-level systems requirements (D2.2), the overall systems architecture (D2.3), and the detailed specification of functional scenarios for the project demonstrators (D2.4).
- WP3, Sub-metering and Building Networks, has made an analysis and evaluation of possible communication technologies and protocols to be used by the middleware based on the requirements specified by WP2 (D3.1). Also, work on sub-metering has been initiated.
- WP4, Smart Abstraction Middleware and Cloud Based Services, has analysed and evaluated possible communication infrastructures to be used by the ENCOURAGE middleware (D4.1). Based on this, the RABBITMQ infrastructure has been chosen and implemented as the basic infrastructure. On top of this, the individual middleware components (as defined in D2.3) have been implemented by WP4, WP5 and WP6. The first version of the middleware will be demonstrated as part of the year 2 project review
- WP5, Supervisory Control Strategies, has defined the operating scenarios and requirements for generation and storage of energy (D5.1) – including requirements for metering. Also, a flexible building model has been developed in Simulink, and it has been used as the basis for implementation of the supervisory control module of the middleware.
- WP6, Energy Brokerage and Business Intelligence, has worked on all subtasks: definition of the gateway for intelligent buildings, development of the consumption forecasting algorithms and progress on generation forecasting integration in the Platform, decision support for energy brokerage, and business intelligence. A first prototype of the dashboard resulting from the BI module has been released. A first version of those prototypes will be demonstrated as part of the year 2 review.
- WP7, Integration and Demonstration, has initiated the planning of the ENCOURAGE demonstrators in Denmark, Italy and Spain through the activities in subtask 7.1. This includes collection of data for the demonstrator baselines as planning the installation of metering equipment. The detailed requirements for the demonstrators have been described in deliverable 7.5 and a more detailed analysis of the scenarios related to the campus demonstrator in Terrassa, Spain. One of the demonstrators will be shown during the year 2 project review.

- WP8, Exploitation, Standardisation, Dissemination, has established a project web site (D8.1), a dissemination plan (D8.2), a plan for standardization and projects liaison, and also an initial and an intermediate assessment and analysis of the market (D8.3, D8.4). Furthermore, the project had a booth at the Artemisia/Itea Co-Summits 2011 and 2012, and also, the individual partners have presented the project at various events. A "project liaison" link with CEN-CLC-ETSI Smart Grid Coordination Group (SG-CG) is currently being established.

Main results for M1-M24

The main results of the two first project years are the establishment of a framework for collaboration as defined in the project handbook and the project plan (D1.1, D1.3), the formulation of business cases and their corresponding high level system requirements (D2.1, D2.2), and the definition of the overall ENCOURAGE middleware architecture (D2.3). A first version of the middleware will be demonstrated at the year 2 project review. The detailed demonstrator requirements have been defined in deliverable D7.5, and the companies have formulated their initial assessments of the market (D8.3, D8.4) indicating high expectations from the results of ENCOURAGE.

Expected final results

The final results will include

- Design and implementation of the Encourage middleware and technology platform for intelligent building metering, control, brokerage and business intelligence.
- Demonstration of the Encourage middleware and technology platform through application in the Danish, Italian and Spanish setups resulting in 20% energy reduction compared to the project baselines.

Expected potential impact and use

- The expected 20% energy reduction will have an immediate effect on reduced environmental effect and monthly bills. An explanation on how the energy reduction will be measured and on what the potential impact is further detailed in Annex A .
- The encourage middleware platform will support future interoperability between the Products or Services proposed by the contributing members, and interoperability with other initiatives outside ENCOURAGE.
- The project will support the collaborative business processes across partners, supporting the further growth of ARTEMIS Tool Platform eco-systems.