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The concept of smart and NZEB buildings and the integrated design approach

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Abstract

As we are nowadays experiencing a transition period for the energy demand, there is a clear movement of the European energy market towards a new field of efficiency including reliable and smart systems that will upgrade the improvement of Europe's economic and environmental health. To this end smart systems introduce innovative applications with multiple and interdisciplinary characteristics: safe integration of additional renewables, distribution to the network, efficient delivery systems and monitoring control through demand response in order to achieve zero energy targets. The integration of smart technologies requires a holistic approach that takes into account all aspects of sustainability.

The implementation of highly efficient smart buildings is feasible through the integration of smart metering, renewable systems acting as generators/storage and energy management. The holistic system supports and fulfils demand load management and distribution network of future grids. . Moreover, the benefits of effective thermal and electrical storage are underlined as a crucial factor of smart systems and smart buildings. This paper highlights the principles of integrated design procedure and links the process with smart building technologies. Energy efficiency methodologies and innovative techniques applied at building level are presented. To this context current EU policy framework, trends and perspectives concerning integrated design as a supportive tool for zero energy concept are also provided.

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Keywords: Smart building; smart grid; integrated energy design; zero energy concept.

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1. Introduction

The share of the building sector in the global energy consumption is of 40%, a fact that demands major refurbishment and improvements of the built environment in order to minimize the ecological footprint and ensure energy sufficiency [1,2]. Additionally, the concept of zero energy buildings (ZEBs) has become an obligation providing energy independency and synergy with the grid [3,4,5]. A successful design and construction of a ZEB includes not only energy efficient measures and adoption of RES targeting to the minimization of the energy needs, but also an effective grid integration in order to accomplish the appropriate balance between consumption and production [6].

Zero energy targets involve multiple interconnected factors. Information and Computer enabled Technologies (ICT) and smart grids provide successful energy management and understanding of the operation of buildings in order to become “smarter” [7,8]. [8,9]. The connectivity of smart buildings with the grids should be compliant with important requirements as the integration of smart metering, demand response, interoperability and distribution system. [8,10]:

Another significant aspect of smart ZEBs is the integrated design [11]. The interrelation of NZEBs and smart technologies is a two-way process which requires an integrated design approach in order to address the complexity both in building and in community level.

All these aspects are addressed by the Horizon 2020 project SMART GEMS which contributes towards NZEB perspective by providing the necessary knowledge and state of the art uptake to move towards integrated design and smart grids integration in a large scale. It also raises awareness and improves understanding of the public with respect to the social value and the potential of smart grids towards a safer and healthier environment.

To this end the aim of this paper is to present the smart buildings in an interdisciplinary nature in order to accelerate the process towards zero energy buildings by focusing on:

a) smart buildings’ design phase and integrated design concepts: Since buildings are major consumers in smart grids, the integrated design methodology helps to develop a collaborative method for designing buildings for smart grids. The integrated design procedures requires a holistic approach from different related professions as stakeholders, architects, building owners starting from the concept phase to the completion and operational phase of the building. The establishment of concrete integrated design principles and decision making protocols are key aspects that ensure the success and efficiency of the procedure fulfilling at the same time the objectives of involved stakeholders. .
b) Smart buildings and smart technologies: Smart buildings’ operation is essential in order to assist the promotion of smart technologies. For example, smart controls and advanced monitoring for buildings’ operational phase are analyzed. Energy storage based control strategy development and implementation in the ZEB are implemented.
c) Zero energy buildings and integration in smart grids: This includes the implementation of energy load predictions and outdoor conditions’ predictions in order to evaluate load shaving applicability in conjunction with integrated design. The role of smart meters is emphasized.

2. Smart buildings’ design phase and integrated design

The design phase of a building is of primary importance for the energy efficiency and the reduction of the energy demand. This phase demands the involvement and cooperation of a team of different specialists: engineers, building physicists, architects etc. For the demand side concept of a building the most appropriate HVAC system should be applied. Activating of thermal mass for example requires the interaction between the structural designer and HVAC engineers. Alternative energy systems have to fit to the concept design and the building energy systems. The implementation of NZEBs is a task that involves multiple aspects and requires interdisciplinary approach. The formation of the design team interacting from the start until the end of the project in every iterative step is a prerequisite. The interaction facilitates the prompt problem solving, the decision making concerning the application of most appropriate solutions and technologies and the identification of advantages and disadvantages of alternatives. Each decision is then based on solid and transparent facts. The IED procedure is also resulting in the most cost effective solutions as it identifies and confronts with the problems at an early stage where changes can be applied at low cost. Therefore, IED is the most appropriate methodology to implement the high targets of ZEBs Best practice projects that have adopted the IED principles promote valuable knowledge and experience proving the efficiency of the procedure in all different aspects : energy, environmental, cost, comfort. [12].

The methodology of IED meets and supports the criteria of NZEB as their principles are based on a holistic concept addressing all aspects of energy efficiency, environment, sustainability, cost, aesthetics, comfort. The feasibility of the nZEB implementation is described in the following terms. [13]:

- To comply with existing energy standards and legislation
- To adapt with the local climate and specific character (site of archeological or traditional interest)
- To define clearly the project objectives and follow the sustainability principles for a successful implementation
- To take into account all recent and innovative technologies and ensure technical and financial feasibility
- To be elaborated in compliance with the decisions and agreement of the interdisciplinary team of specialists
- To be extrovert and promote the IED and nZEB principles

Within this context, one main objective of the SMART GEMS project is the design of common projects concerning smart buildings in an interdisciplinary nature in order to accelerate the process towards zero energy buildings through integrated design. The buildings under investigation are tabulated in Table 1.

Table 1. The buildings under investigations for the IED

Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
SUMMA	Offices & Warehouse	Via Fiume, 16, 60030 Angeli di Rosora, Ancona, Italy 1985 constructed	**External Walls (Summa):** Cladding, Insulation (Polystyrene), Plasterboard (U_v=0.45 W/m^{2}K) **External Walls (TM):** Cladding, Plasterboard (U_v=1.36 W/m^{2}K) **Internal Walls: -** (U_v=1.674 W/m^{2}K) **Roof:** fiberglass (hardboard), concrete **Windows/Doors:** Double glazed (U_w =2.34 W/m^{2}K **Industrial Door:** (U_v=3.50 W/m^{2}K / U_g=5.46 W/m^{2}K / U_w=3.30 W/m^{2}K)	119.4MWh (2014 before implementation of the Heat Pump excluding energy coming from the grid. Compared to recorded energy data of 2015/2016 the energy consumption of the building is reduced.	• Approximately 100 implemented smart meters recording the energy consumption of the building and also the produced energy by the PV systems. • Renewable energy production by the installed PV systems on the roof of the building. The results show a cumulative energy production of 34.525kWh. • Reduced CO_2 emissions throw RE production. • Connection with the micro grid and the thermal storage establishing energy efficiency. -- • Although half of the building is well insulated (U_v=0.452 W/m^{2}K), the remaining part (TM warehouse) has poor thermal performance (U_v=1.365 W/m^{2}K) Sliding doors cause a poor value in air tightness, resulting in an infiltration rate of 1,63 ACH
Kite Lab	Offices, Labs and Test rooms	Via Fiume, 16 – Angeli di Rosora (AN), built at 2015	Combination of different types of uses. Typical rectangular construction, still in progress in the 6th test room of the building. Improved insulation, highly efficient HVAC systems installed, connected with the micro-grid and the thermal storage. Installation of highly efficient PV panels.	Data provided from April 2016 and forth. Consumption for April to August 2016 is 132 MWh or 37.6 kWh/m^2	The Kite Lab is newly constructed and meets the requirements of IED procedures and NZEB concepts. All of the specifications of the materials, components and HVAC systems are documented. The building is self-sustainable by means of renewable energy consumption in some extent. The connection with the micro-grid ensures that all energy produced by the hydro plants and the PV systems is distributed throughout the network. The Thermal storage ensures that the excessive energy is saved and distributed in less productive stages. The HVAC system installed is highly efficient strengthening the efficiency of the grid. The building is still modified and optimized. Smart metering ensures that each component is monitored and recorded for further analysis. With the use of the 3d modeling of the building further analysis and optimization of the buildings systems can be conducted.

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Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
AEA	Offices, Laboratories, production line	Via Flume n. 16 – 60030 Angeli di Rosora (An), 2002	The scope of the optimization procedure is to suggest measures which will result in the best energy performance, taking into account the building's incorporation in the micro grid. • Use of innovative materials • Replacement of systems for heating, cooling, hot water with the geothermal heat pumps, district heating/cooling systems, adsorption chillers, hybrid boilers. • Installation of PV with improved collectors. • Thermal/Chemical storage	558747 kWh (for 2014)	The choice and/or the combination of measures that provide economical/technical solutions. This would be the result of the optimization process taking into account not only the investment/installation costs but also the variable running costs. The scope after all is to ensure that the AEA Building would be an nZED Building meeting the IED standards.

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The methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data.

To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool.

Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented. The purpose of CFD analysis is enumerated analytically below:

1) Accurate assessment of occupancy; thermal comfort is essential for successful building design.
2) Assessment of Comfort as it can vary considerably for different thermal zones depending on factors such as the location of supply diffusers, radiators, computer equipment, etc.
3) Detailed evaluation of both HVAC system and air flow (cold/hot air) inside each thermal zone.
4) The HVAC system requires more than simply making sure that mechanical heating or cooling system offer sufficient capacity to offset spatial loads.
5) It is equally important to determine that the delivery system is providing an adequate distribution of temperature and fresh air throughout the space.

The correlation of measured and simulated values has also been examined in order to assess the performance and implementation of smart technologies at the buildings.

3. Smart buildings and smart technologies in operational phase

The operational performance of industrial, residential, educational and commercial buildings has been investigated, analyzed and optimized with the use of dynamic and quasi dynamic simulation tools. Energy efficient technologies, renewable energy technologies, storage, as well as smart monitoring and controls have been audited to highlight their significance for integration of different type of buildings in the smart grid. Various measures have been used in this analysis including normalized energy consumption, energy saving contribution and potential, primary energy consumption, energy cost etc. Smart monitoring and indoor conditions measurements have been intensively exploited to allow the extraction of robust results and the validation of dynamic building energy models.

In specific, smart controls and advanced monitoring for buildings operational phase have been thoroughly examined and assessed in terms of energy performance at a residential and an industrial building of the Leaf Community in AEA, Italy. This was combined with the development of building energy dynamic models, indoor and outdoor environment measurements and a careful consideration of power production and consumption data. Specific issues have been addressed and generic as well as case specific conclusions have been drawn to be used as the basis for establishing and implementing solutions in the near future.

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Moreover, the energy efficiency of the New Technologies Laboratory Building (NTLB) of Cyprus Institute with a Linear Fresnel Collector and combined HVAC systems' operation has been optimized in terms of minimization of consumption and full exploitation of solar plant integration.

Dynamic modelling and evaluation of Concentrated Solar Power (CSP) technology and in specific, the IDEA FRESCO system was assessed for the integration in Near Zero Energy Buildings (NZEBs) and smart grids. A model of the Fresnel System was developed and exploited to fully understand the operational phase of such systems. Furthermore, assessment of primary and secondary optic elements in CSP systems and their performance is being carried out to evaluate the effects of ageing and dust deposition and assess the performance on new materials and components.

Also, work on building modelling, energy performance assessment and improvement has been performed in building No 20 in Fiera del Meditteraneo of Palermo, Italy. Table 2 summarizes the main operational characteristics, smart technologies and energy data of the studied buildings.

Table 2 The buildings under investigation for the operational phase

Building	Type	Location and Year of construction	Main characteristics	Operational Characteristics and smart technologies	Normalized Electrical Energy consumption
Leaf Lab	Industrial	Angeli di Rosora, Italy, 2014	Nearly Zero (A+) Energy Efficiency Industrial connective building/biPV production coupled with high efficiency heat pumps and thermal storage/LED artificial lighting systems/Gas-free	Automated shading control, lighting and presence sensors, biPV, thermal storage, advanced monitoring via MyLeaf platform, integrated energy management and controls	47kWh/m^2
Leaf House	Residential	Angeli di Rosora, Italy, 2007	Nearly Zero Energy Building/PV production/ thermal solar pipes/Electrical storage system /Heat pumps/High thermal mass of the building/Radiant floor heating/cooling pipes/AHU/gas-free (to be), 8 regular tenants + guests(max.4), 6 apartments for 2 persons, Rain water collection for watering and toilets	Smart monitoring & controls, building integrated photovoltaics, geothermal air preconditioning with high efficiency heat pumps, solar thermal collectors, electrical storage, user friendly energy management system for residents engagement	64kWh/m^2
Novel Technologies Laboratory	Tertiary: Education / Research	Nicosia, Cyprus, 2007	Renovated NZEB based on bioclimatic design principles; double façade in western and eastern facades for natural convection chimney and filtering of direct sun radiation, low percentage of south façade windows, VRV heat pumps with FCU controlled by thermostats	15kWp biPV, 75kW Fresnel Solar Concentrator System, thermal storage, presence detection for lighting control, building energy management system	17kWh/m^2

In this direction specific and generic guidelines are outlined below:

- The optimization of the operational phase of buildings is a complicated task which requires deep knowledge and holistic data about the building design and operating systems.
- Data from monitoring and measurements of energy related parameters is a prerequisite for the reliable analysis, design and implementation of effective solutions to improve energy performance.
- Monitored energy data analysis needs to be carefully conducted to avoid misinterpretation or extraction of wrong conclusions due to errors in the data sets or misconception of what is actually being measured.
- The role of renewables and storage in buildings is of major importance to minimize energy demand and allow flexibility in their integration in smart grids.
- Significant space of improvement exists in energy management both in terms of exploiting advanced control algorithms and energy pricing information.
- User active engagement for the improvement of energy performance is a major challenge which in most cases is not adequately addressed.
- Reaching Near Zero Energy Building (NZEB) operational performance requires a combination of bioclimatic design, efficient energy technologies, smart monitoring and renewable energy deployment.
- Advanced technological solutions for buildings to become net zero energy prosumers are available but still require a high investment cost and a long payback period.
- The integration of Linear Fresnel Concentrating Solar Thermal systems in buildings is a technically feasible and energy prominent solution of minimum visual impact.
- Advanced and robust building energy models provide the basis for advanced real time energy management solutions to be designed, implemented and tested.
- Reducing energy consumption to zero net levels requires a) a systematic approach including technological advances, scientific state of the art techniques, c) organizational measures d) continuous efforts and investments to make the most of each measure and minimize energy losses and e) active user engagement

4. Zero energy buildings and integration in smart grids

The smart grid concept captures the transition from conventional power grids to advanced modern infrastructure providing new functionalities, improved operations, higher intermittent renewable energy penetration, decentralised control and self-healing capabilities. Smartness is based on the active engagement of users with the adoption of ICT technologies and innovative applications, advanced metering infrastructure (AMI), wide area monitoring, power data analysis, predictive maintenance and control. Demand response is expected to play an important role in the shaping of the future smart grid and integration potential of ZEB in particular. This is due to the increased visibility of the consumption and production of energy and the exploitation of high-end applications for the effective management of energy in return of financial incentives as well as environmental and social benefits. In this respect the wide scale integration of NZEB in smart grids is linked to the transparent and open regulatory framework of the energy markets fostering the development of new business models, the promotion of new technological capabilities and the introduction of high value services.

This section focuses on zero energy buildings and their integration with smart grids; such an analysis goes through the following parts: components, systems, services and controls. The need of investigating these is given by the increasing share of smart grids where Zero Energy Buildings (ZEBs), and Nearly ZEBs, are ubiquitous: in such a scenario, ICT (Information and Communication Technology), RESs (Renewable Energy Source) and customers are crucial. In this view, the work performed addresses the features that boost such an integration: interoperability, sustainability, users, comfort, and savings.

One of the key components in integrating ZEBs, and NZEBs, with smart grids is the metering device, i.e. a smart meter. Energy production and consumption, for instance, must be measured and these values, then, sent to a database accessible to users and processed by the control systems. Interoperability, when several smart meters from

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different brands and with different communication protocols cooperate, must be guaranteed; for this purpose, this deliverable develops a series of testing activities in order to identify possible interoperability problems among the tested devices ensuring interoperability in a simulated building scenario with multiple smart meters connected.

These meters are also crucial for a commercial point of view when business plans to convert traditional and old buildings into zero, or at least nearly zero, energy by including renewable energy production must be done; to do so, this deliverable studies the consumption of four dorms in Athens in the view of developing business plants of solutions that cause an increase in energy savings. Such an analysis is performed from a commercial and industrial point of you, by starting from the energy consumptions and the structures of the buildings, and then calculating the related Pay Back Period (PBP).

Moreover, the integration of ZEB with smart grids must be efficient and reliable, satisfy user's needs and guarantee their comfort. In this view, this work focuses on services and controls that aimed to satisfy users' need in the most economical way.

Control strategies are then tailored on users' needs by processing measurements coming from the smart meters and then controlling the HVAC systems in the buildings analyzed. In particular, the proposed control systems have been tested, in simulation, on two case studies: the School of Design and Enviroment-3 building at National University of Singapore and the K1 building at Technical University of Crete. Additionally, control strategies also comprise models for predicting outdoor measurements and energy loads.

Users are decisive in the future energy scenario, thus, this work also investigates their engagement in energy saving and comfort. In the former case, past and actual tenants of the Leaf House, a nearly Zero Energy Building of Loccioni Group in Italy, answer a questionnaire that has been structure within this work in the view of designing the level of awareness and engagement of the users regarding energy savings; the results underline that tenants would gladly be more involved and, most of all, informed on energy saving strategies. Another point investigated in this deliverable addresses internal thermal comfort in the Leaf Lab, an office building of Loccioni Group that is connected to the industrial micro-grid of the company. Employees have been asked to answer a right-now survey three times a day for seven working days: results show that their thermal comfort is guaranteed regardless gender and where they are seated in the office spaces.

To sum up, this work has identified and describes how to successfully integrate ZEBs, and NZEBs, with smart grids. Table 3 describes main parameters of the investigated buildings for the integration in smart grids.

Table 3 The buildings under investigation for integration in smart grids

Building	UOA Dorms	Leaf House	Leaf Lab	K1, TUC	NUS
Type	Dorms	Residential	Office building	University, offices	University, offices
Location and Year of construction	Athens, 2013	Angeli di Rosora, Italy, 2007	Angeli di Rosora, Italy, 2014	Chania, Crete	Singapore
Main characteristics	4 dorm buildings, one has also a restaurant and offices. In two buildings, heating is via generators driven by oil, and one building has not heating system at all; therefore,thermal consumptions are difficult to estimate	Nearly Zero Energy Building/ PV production/thermal solar pipes/Electrical storage system /Heat pumps/High thermal mass of the building/Radiant floor heating/cooling pipes/AHU gas-free (to be), 8 regular tenants + guests(max.4), 6 apartments for 2 persons, Rain water collection for watering and toilets	Nearly Zero Energy Building, A+ energy efficient/connective building/PV production/Electrical storage system+thermal/Heat pumps/High thermal mass of the building/AHU/Gas-free	Energy management based on advanced HVAC genetic algorithms optimisation with load prediction based on neural network models and fuzzy logic techniques/ IP remote access integrated energy management system	Installation of monitoring systems
Energy consumption	Annual consumption of each building (May 2014-April 2015): 1. 2.016 GWh 2. 209,264 kWh 3. 385,724 kWh 256,127 kWh	40,000kWh (approx.)	606,000kWh	276,000kWh (136kWh/m^2)	n/a
User engagement	No	Analysed in Smart GEMS via focus groups and questionnaires with tenants	No	Yes	Yes
Smart metering	Yes, since May 2014	Yes since 2007, data collected on	Yes, data collected on the Loccioni	Monitoring of temp., RH%,	Yes, data is collected

		the Loccioni proprietary web-based platform MyLeaf	proprietary web-based platform MyLeaf	presence, CO_2,illuminance, energy consumption	
Renewable Energy Sources	Addressed in Smart GEMS	PVs,Thermal Solar	PVs	Not installed yet	Analysed in previous projects
Internal comfort	Not addressed	Not addressed	Analysed in Smart GEMS project via right -now survey	Not installed yet	Analysed in Smart Gems

In this framework, Smart GEMS has evaluated how RESs, such as PV, could cause savings. However, due to the usage of these buildings (UoA Dorms) and the very low price of electricity, the proposed solution causes a PBP of about 18 years. A possible solution would be to include hybrid PVs in order to cover also thermal consumptions of the buildings, and storage systems to store energy during the day and to use it, then during the evening when students are back from the university.
The work done within the Smart GEMS project has revealed that tenants would like to be more informed about the energy behavior of the apartment where they live in and to change their behaviors aimed to increase energy savings. But to do so, they need to be trained on how to do it.
The survey done within the Smart GEMS project has shown that, in the Leaf Lab, the internal comfort is guaranteed and no major discomfort has resulted, however an increase in the air flow would be appreciated.

Conclusions

The design and operational phase of a building is of great importance in order to achieve high energy efficiency targets and minimize the building's carbon footprint. NZEBs are not only a requirement but also an obligation by the adaptation of national standards to the European directives. The achievement of zero or nearly zero energy consumption in buildings must be accomplished by 31 December 2020. New public buildings should meet the same criteria by 31 December 2018. The integration of the operation and management of the building in smart grids is an evolving technological approach for minimizing energy consumption. To this end demand response and interaction between consumers and energy sources in the grid is emphasized. These procedures should be implemented in a holistic way taking into account all aspects of sustainability from the early design phases of the building in order to take fully advantage of the benefits of the process and the opportunities that smart grids offer.

This paper presents the three main aspects of the interdisciplinary nature of smart buildings in order to accelerate the process towards zero energy design and implementation:

1. Smart buildings' design phase and integrated design concepts: The methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data. To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented.
2. Smart buildings and smart technologies: In specific, smart controls and advanced monitoring for buildings operational phase have been thoroughly examined and assessed in terms of energy performance combined with the development of building energy dynamic models, indoor and outdoor environment measurements and a careful consideration of power production and consumption data. Moreover, the energy efficiency with a Linear Fresnel Collector and combined HVAC systems' operation has been optimized in terms of minimization of consumption and full exploitation of solar plant integration. Dynamic modelling and evaluation of Concentrated Solar Power (CSP) technology and in specific, the IDEA FRESCO system was assessed for the integration in Near Zero Energy Buildings (NZEBs) and smart grids. A model of the Fresnel System was developed and exploited to fully understand the operational phase of such systems. Furthermore, assessment of primary and secondary optic elements in CSP systems and their performance is being carried out to evaluate the effects of ageing and dust deposition and assess the performance on new materials and components.

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3. Zero energy buildings and integration in smart grids: The integration of ZEB with smart grids must be efficient and reliable, satisfy user's needs and guarantee their comfort. In this view, this work focuses on services and controls that aimed to satisfy users' need in the most economical way. Control strategies are tailored on users' needs by processing measurements coming from the smart meters and then controlling the HVAC systems in the buildings analyzed. Additionally, control strategies also comprise models for predicting outdoor measurements and energy loads. Users are decisive in the future energy scenario, thus, this work also investigates their engagement in energy saving and comfort. Another point investigated addresses internal thermal comfort. Employees have been asked to answer a right-now survey three times a day for seven working days: results show that their thermal comfort is guaranteed regardless gender and where they are seated in the office spaces.

The proposed 3-phase methodological approach provides a coherent framework for the implementation of smart grids at building and community level. The various levels of analysis allow for adequate consideration of important concepts such as the integrated design, users' engagement, exploitation of ICT capabilities, demand response optimized control and integration in smart grids at community and city level. In parallel a holistic perspective on major components of smart grids such as alternative renewable energy technologies, smart metering and the technological platform for overall concerted operation through IP connectivity is addressed. The research activities in the Smart GEMS project comprise multidisciplinary efforts in establishing generalized principles and effective integrative techniques through modelling and testing of a wide framework of applications to drive the future design and implementation of Smart Grids.

In this direction conflicts' management and major criteria for Smart Cities is put under the microscope for analysis and evaluation. This work will become the leverage for future collaborations, innovation and entrepreneurship. Vital prerequisites for the wide scale implementation of the proposed framework relate to the removal of energy market barriers and to the creation of a transparent investment and operational framework allowing a balance in sharing costs, benefits and risks, addressing smart consumer and consumer protection policies, fostering international collaboration etc.

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