Zero Energy Buildings

Andreu Català

Systems Engineering and Automatic Control Department. Universitat Politècnica de Catalunya. andreu.catala@upc.edu; www.upc.edu/cetpd; www.icephd.org;

Abstract

The demand of energy in the world is growing fast; the International Energy Outlook (IEO2009) predicts an increase of more than 40% for the next 15 years and a 77% rise in the net electricity generation. The key issue is that by 2030 the electricity production still will be generated mainly by fossil fuels (80%)[1].

Oil, natural gas and coal combustion is the responsible of the Global Greenhouse Gas (GHG) emissions. With the above prediction it is impossible to achieve the EU Challenge of at least 20% reduction of energy consumption, 20% use of Renewable Energy Sources
and 20% reduction of CO2 emissions by 2020 and the 50% reduction by 2050. On the other hand the continuous increase and instability of the oil prices has a direct pernicious influence in the world economy. Alternative solutions like biofuel has demonstrated many drawbacks, like the destruction of local economies and biodiversity in Africa and Brazil while maintaining the CO2 problem if directly burn. With these perspectives in mind two lines of work arise: The increasing substitution of fuel power plants by renewable energy plants like wind farms inland or offshore, solar thermal, photovoltaic or geothermal to provide high energy demand industries, combined with the conversion of energy consumers to self-sufficient or sources of energy as the Zero Energy Building approach. The second idea implies the use of cheap and distributed renewable energy to satisfy the low and medium energy requirements for residential and commercial purposes. The building activity sector in EU consumes around 40% of the total generated energy and it is responsible for the 25% of CO2 emission.

The new paradigm is the design of collaborative and distributed energy systems for buildings, convert them in renewable energy power plants [2] with a storage capacity trough efficient batteries, hydrogen cells, flywheels, electric vehicles as an energy buffers or other local solutions.
How to design the interconnections is a technological challenging problem. New solutions have been theoretically demonstrated to be efficient like the hierarchical control of intelligent microgrids recently presented [3]. These flexible smarts grids composed of distributed generators, distributed storage and many different loads are capable to work islanded, interconnected with other microgrids or connected to the main power lines. The important thing is to generate the energy close to the consumer. Black start operation, frequency and voltage stability, active and reactive power flow control, active power filter capabilities, and storage energy management are the functionalities expected for these small grids. There are many problems to solve but this is an example in the right direction.
Smart grids need also smart ICT solutions; this is a claim of FP7 research action on Smart Energy Networks. In a new scenario where many different partners could act as energy consumer or as an energy dealer it is necessary to design new relations formulas and intelligent withdraws. In this sense the energy network must be monitored by a network of artificial intelligent agents able to predict the individual needs and able to negotiate the energy price between all of them. A desirable feature of the artificial system would be the possibility to perform as a collaborative recommender system to the final user acting as a coach for him, i.e. taking into account other user decisions in similar situations.

From the architecture point of view, the use of new materials combined with advanced domotic solutions is increasing drastically the buildings energy efficiency and, at the same time the inhabitants comfort. As a examples , the project proposed by the Pole Derbi and a group of Frech enterprises “Bâtiments à Très Haute Performance Energétique (THPE)”, where they experience new methodologies in order to reduce the waste of energy optimizing the energy management while enhancing the use of renewable sources, Acciona has constructed a building which has the ability to load its own renewable energy completely off grid, Walga Tech Park also in Spain generates its own energy and store the it in the form of hydrogen to restart when needed or to charge hybrid vehicles, the MediaTic building in Barcelona is an icon of the design of skinning buildings able to adapt of climate and light changes trough an ETFE flexible cover acting as if the building is breathing. These are some initial feasibility demonstrations that lose all his strength working isolated.

Finally, the U.S. Green Building Council defines Green Building as: “A systematic effort to create, sustain, and accelerate changes in practice, technology, and behavior to reduce building-related environmental impacts while creating places that are healthier and more satisfying for people”[4]. One of the most important tools is the Leadership in Energy and Environmental Design (LEED) green building certification program that certifies best practice in building construction or rehabilitation. This is another example of the necessary involvement of legal or at least credible associations to push the efforts on the preservation and improvement of the quality of life.

[1] Mudathir F. Akorede, Hashim Hizam, Edris Pouresmaeil. Distributed energy resources and benefits to the environment. Renewable and Sustainable Energy Reviews 14 (2010) 724–734
[2] Jeremy Rifkin Leading the Way to the Third Industrial Revolution:A New Energy Agenda for the European Union in the 21st Century. The Next Phase of European Integration. 2008
[3] Juan J. Vasquez, Josep M. Guerrero, Jaume Miret, Miguel Castilla, Luis García de Vicuña. Hierarchical Control of Intelligent Microgrids. Integration of Distributed Energy Resources into the Smart Grid. DOI. 10.1109/MIE.2010.938720. IEEE Industrial Electronics Magazine; December 2010; 23-29
[4]Chris Pyke, Sean McMahon, Tom Dietsche. Testing Green Building Strategies with Volunteered Geographic Information. Green Building & Human Experience.U.S. Green Building Council® Research Program White Paper.June 10, 2010