E2SG

Energy to Smart Grid

Electricity distribution has changed radically over the last few years, due to different forms of generation and the introduction of domestic renewable sources such as solar and wind that feed surplus energy into the grid. This project is addressing the automated control of supply and demand within electricity grids by developing methods for detecting and controlling energy flows in the grid.

Main Project Team

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Funding Agencies

ENIAC JU	**2,000€**
Start Date	01/04/2012
Ending Date	31/03/2015

Indicators

Conference papers	3
Concluded PhD	1

Two Main Publications

.F. B. Saghezchi, A. Nascimento, J. Rodriguez, **Game-Theoretic Based Scheduling for Demand-Side Management in 5G Smart Grids**, IEEE Symposium on Computers and Communications (ISCC), Larnaca, Cyprus, July, 2015.

F. B. Saghezchi, A. Nascimento, J. Rodriguez, **Game Theory and Pricing Strategies for Demand-Side Management in the Smart Grid**, IEEE/IET International Symposium on Communication Systems, Networks and Digital Signal Processing - CSNDSP, Manchester, United Kingdom, July, 2014.

PROJECT WEBPAGE URL

https://www.it.pt/Projects/Index/2095

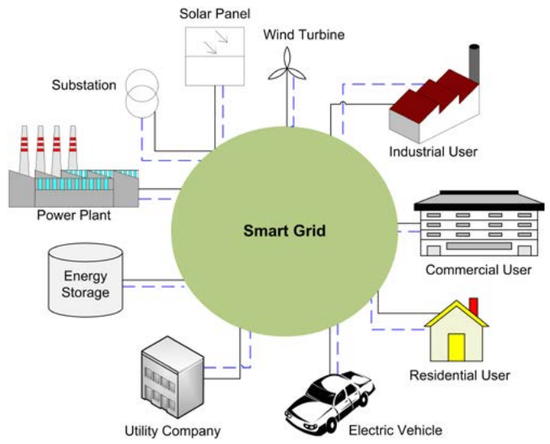

Fig. 1 Smart Grid establishes two-way power and information flows between the grid and the end-consumers, enabling distributed generation and storage.

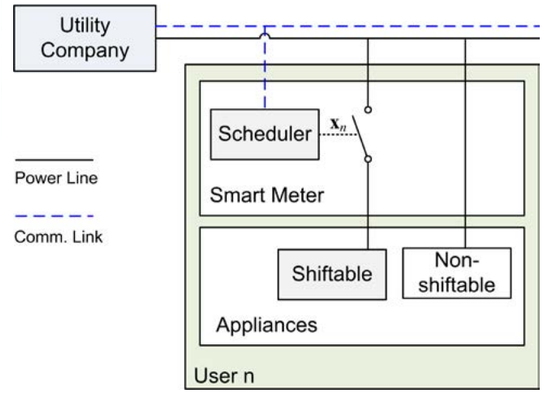

Fig. 2 The scheduling algorithms defer only the user's shiftable appliances (e.g., Electric Vehicle changing), without interfering her non-shiftable ones (e.g., cooking appliances, ITlights, etc.)

GENERAL MOTIVATION AND OBJECTIVES

The reduction in the energy consumption is a social challenge – as contribution to the climate change and to secure resources for the future. Therefore on the European level, the 20-20-20 target was put forward to improve the efficiency and performance of the global energy system and supply chain. It is the intention to achieve a 20% increase in energy efficiency, 20% share of renewable energies and a 20% decrease in CO2 emissions by 2020.

This target is supported by the transformation of today's power grid to an intelligent grid, the so-called smart grid. It enables a more efficient use of the available energy and helps to significantly reduce the consumption of private, industrial and public consumers.

The target of the overall E2SG project is investigate mechanisms and policies to assemble, monitor and control smart grids, i.e. a set of interconnected nodes whose primary goal is to generate, exchange and consume electrical energy in the most efficient and reliable way by exploiting distributed information that is sensed, transmitted and processed over the same set of nodes and links. E2SG aims at addressing the challenges entailed in evolving the concept of smart grid to the level needed by both the industrial players and next generation customers, as well as providing environmentally aware solutions which will lead to the increasing exploitation of renewable energy sources. To do so, E2SG aims at developing and demonstrating key enabling technologies in the following fields: (1) node-grid interfaces – especially between generating nodes and the grid; (2) grid-sensing/metering – to collect the information needed for management and control; (3) over-the-grid communication – to effectively carry sensing and control information where it is needed; (4) grid-topology and control – to understand and design connection-induced behaviours improving reliability and to control (local) energy production/distribution by exploiting advanced storage policies; (5) energy routing – to develop flexible and efficient mechanism to transmit energy between nodes, e.g., by properly choosing AC or DC links depending on temporary operating conditions for power consumption.

CHALLENGE

The electric power grid infrastructure is facing considerable challenges as a result of significant shifts in generation and consumption caused by an increasing reliance on renewable energy. Control and measurement techniques for the generation and consumption of electricity have improved, providing better knowledge of flows within national grids. However, there is still margin for innovation as dependency on renewable sources have grown in popularity. Surplus energy from solar and wind sources is increasingly being routed to the grid, adding further complication to the already complex monitoring processes. Whilst the need for driving further effective energy management in the grid has grown, with a need to distribute and encourage energy consumption throughout the day.

The role of IT team was to investigate incentive mechanisms and demand-side management strategies to encourage end-consumers to reduce their peak-to-average demand ratio, by shifting part of their energy consumption from peak hours to off-peak hours.

WORK DESCRIPTION AND ACHIEVEMENTS

IT developed two different appliance-scheduling techniques, one based on Mixed-Integer Linear Programming (MILP) and the other based on Quadratic Programming (QP), and studied the payoff they can provide to the players. The results show that the MILP approach can reduce the peak-to-average demand ratio by up to 56% and the consumers can save on their electricity bills by up to 32%. However, if the company adopts a quadratic pricing tariff, and the users respond by QP scheduling, the payoffs of all players could rise, indicating a pareto-optimal strategic improvement. In particular, this pareto-optimal strategy can achieve up to 62% PAR reduction for the grid operator and up to 50% saving in the users' energy bills.