FLEXIBLE SMART METERING FOR MULTIPLE ENERGY VECTORS WITH ACTIVE PROSUMERS

CINI Annual Workshop on ICT for Smart Cities and Communities (I-Cities 2015)

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Keywords: distributed software infrastructure, smart metering, smart grid, demand response, distributed systems, distribution network

ABSTRACT

The electricity market was introduced in the European countries following the Directive 96/92/EC of the European Parliament and of the Council concerning "common rules for the internal market in electricity". Up to now the market is working properly for big producers, retailers and users, while the small consumers and prosumers cannot access directly the market and cannot be influenced by signal pricing. Distributed generation from renewable and non-programmable energy sources is becoming widespread. This requires a more flexible management of distribution grids, also involving energy storages, both at the prosumers and on the network. For these reasons, a "smarter" grid is needed by Transmission and Distribution System Operators (TSOs and DSOs) together with retailers and market operators in order to face in their activities.

To move forward along this direction, a flexible smart metering architecture for multiple energy vectors (FLEXMETER) is needed. Hence, such architecture must be able to: i) integrate the already available components and devices in the grid; ii) combine and correlate information from meters of different services (e.g. electricity, water, gas and district heating); iii) provide advanced services to users, DSOs, retailers and other utilities; iv) enhance the retail market.

Proposed approach

The existing applications acknowledge that metering infrastructure is an enabling technology that needs to be coupled with innovative services to reach energy management by means of rewards, automation and information. In order to reinforce customers' engagement in achieving energy efficiency, number of utilities already operates demand response and direct load control to limit and shift the peak loads. However, new services can be integrated focusing on more complex technical applications, transparent for the end-user but nevertheless with higher social impact. FLEXMETER pursues the ambition of innovating this scenario exploiting:

- multi-service approach that uses information coming from heterogeneous smart meters (e.g. electric, water, gas, district heating) to provide general purpose services;
- substation meters to improve fault tolerance and demand response capabilities of the network, taking into account local electric storage and generation;
- advanced Non-Intrusive Appliances Load Monitoring (NIALM) techniques to profile user behaviours and introducing a user signature of energy consumption/production regarding electricity, gas, water and heating;
- demand response and load prediction algorithms that exploit information about energy flows from meters and NIALM profiles.

To achieve this, as shown in Figure 1, FLEXMETER integrates heterogeneous off-the-shelf smart meters placed at the users for electric, water, heating and gas metering. Such heterogeneous meters directly communicate with a building concentrator, which is in charge to enable a bidirectional communication with the central cloud system. For what concern the electricity grid, FLEXMETER also integrates off-the-shelf electric smart meters deployed in MV/LV (Medium Voltage/Low Voltage) substations. The central cloud system is in charge of: i) collecting data from the building concentrators, thus from the different meters at user's home, and from MV/LV substation meters; ii) post-processing incoming information exploiting algorithms for data collection, fusion and mining; iii) providing a set

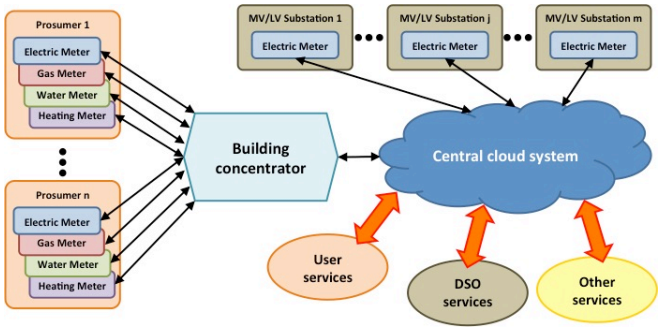

Figure 1. FLEXMETER architecture

of API and tools for general purpose services. In addition, following the IoT (Internet of Things) view, FLEXMETER to ensures (near-) real-time bidirectional communication with each meter in the Smart Grid for enabling: i) (near-) real-time readings management; ii) (near-) real-time accounting activities management; iii) (near) real-time information to customers; iv) detection of energy thefts; v) (near-) real-time grid level and user level fault detection allowing optimal alarming and first intervention systems to be adopted; vi) demand response together with optimal integration of distributed generation and storage systems.

Expected impacts

The availability of (near-) real time data at every level of energy distribution chain will be the turning point for promoting the active involvement of different energy operators (e.g. utility providers, retailers and prosumers) and fostering other working actors, such as energy managers, ESCOs and aggregators, in providing innovative services. No one of the actors playing in a Smart City scenario can really make the difference without analysing and exploiting data with such granularity as to show consumers habits, electric devices status and faults. Hence, enabling the interoperability and interconnection between different smart meters and the FLEXMETER architecture, which can be considered also as a common data-exchange platform, will foster the spreading of innovative services. From a preliminary analysis, it might seem that utility companies already offers some of the proposed features such as: i) on-line available user profiles; ii) on-line consumption information; iii) suggestions for consumption optimization; iv) basic predictions for future consumption. However, the back-end block for data acquisition and processing is missing. Moreover, FLEXMETER aims on enabling a multi-service and multi-utility platform where different utilities converge. Therefore the impact will be important both on energy provider and consumer side. For instance, energy operators provide services for: i) predicting short term energy demand by profiling consumer energy behaviours with NIALM algorithms; ii) integrating distributed generation and storage systems; iii) supplying demand response; iv) detecting faults; v) providing real-time services to end-users.
Moreover, social impacts will be strictly related to (near-) real-time data availability even at consumer level. Indeed, the knowledge of own consumption is the starting point for other more integrated and innovative services that will change people behaviours. In this scenario, FLEXMETER provides detailed knowledge of the household consumption for each appliance and suggest personalized tips to reduce energy waste. Generally, the benefits for customers are summarized in the following:

- knowing the disaggregated energy of the household appliances;
- discovering which appliance is the most inefficient by comparing its consumption with more efficient models present in other apartments;
- being aware of consumption for each appliance in terms of energy, money and CO_2 footprints;
- comparing the disaggregated appliance consumption among different weeks, months or years;
- observing the energy consumption in real-time by mean of a smartphone applications to monitor the apartment and receive alarms whenever the energy situation is not as expected.

Conclusions

In this work, we presented FLEXMETER, a flexible multi-utility and multi-service metering architecture for energy vectors with active prosumers. We exposed our proposed approach and discussed the benefits and the expected impacts that such architecture can have in a Smart Grid context. Indeed, FLEXMETER integrates different meters into a distributed infrastructure with the aim of gathering, post-processing and analysing heterogeneous information from different smart meters and data-sources. Thus, FLEXMETER provides an overview of both energy consumption and production in the grid from different viewpoints, fostering working actors in promoting new and innovative services.