SEMIAH: Scalable Energy Management Infrastructure for Aggregation of Households

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I. Introduction

With the advent of smart grids [1], new solutions for energy management become available. During the last decade, manufacturers have focused on the development of smart appliances. However, a large market uptake of smart appliances is not expected to occur in the short-term.

Demand response, which is defined as changes in electricity usage by consumers from their normal consumption patterns in response to signals from the grid operations or the energy markets, is considered one of the key solutions to improve energy efficiency and for reducing peak demand [2]. However, no automated demand response programs have been implemented for European households despite the fact that households represented approximately 27% of the total energy consumption in Europe in 2010 and were responsible for 10% of the carbon dioxide emissions in 2007.

Currently, demand response is in its nascent stage in Europe with the existing programs essentially aimed at large industrial customers, which are easier to manage as one large client representing hundreds of households in terms of energy consumption. Fortunately, the project can leverage on the research from a number of related European projects such as ENCOURAGE [3], ADDRESS [4], and MIRABEL [5].

The consortium behind the *Scalable Energy Management Infrastructure for Aggregation of Households* (SEMIAH) project [6] aims to pursue a major technological, scientific and commercial breakthrough by developing a novel ICT infrastructure for the implementation of demand response in households. The SEMIAH infrastructure enables the shifting of energy consumption from high energy-consuming loads to off-peak periods with high generation of electricity from renewable energy sources.

II. The Project

The SEMIAH project promises to provide a novel and open ICT infrastructure for the implementation of automated demand response in households. The SEMIAH concept, shown in Figure 1, will enable aggregation of all households connected to the system and will act through direct load control to remotely shift or curtail electrical loads in a secure manner taking into account the privacy and flexibility of users.

The system concept comprises the following elements:

- A back-end system, consisting of a central server which manages and controls information from the households connected to the system network, and which provides intelligent services for energy management of households.
- A home energy management gateway to control customers loads based on the *Open Gateway Energy Management Alliance* (OGEMA) framework [7].
- A user interface (smartphone application and consumer web portal) that allows the user to configure the settings of household equipment and add/remove equipment to/from the system.

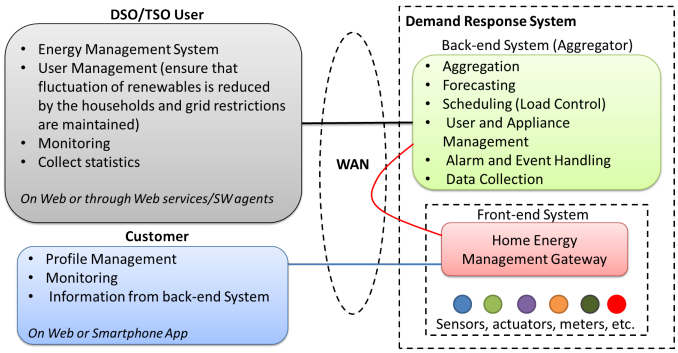

Fig. 1. SEMIAH overall system concept

The second and third elements represent the front-end system of SEMIAH.

The demand response system of SEMIAH connects the *Distribution System Operator* (DSO) and the *Transmission System Operator* (TSO) over a *Wide Area Network* (WAN) infrastructure. This enables actors in telecommunication and the energy sector in a joint effort to pursue a more secure and sustainable energy supply for the future.

A. Research and technological development

The SEMIAH consortium will develop a novel solution for households, where the central aggregator system will simultaneously optimize and manage a large number of partial loads according to the generation of electricity from *Renewable Energy Systems* (RES) (bulk or distributed energy resources). To the knowledge of the consortium, this will imply step-change innovation in the field where there are currently no similar solutions.

1) Specifications: The effort of SEMIAH project will be mainly related to the *external actor* (Smart Grid Market Role) which interacts with the system functions and components in the home or home automation network through the energy

management communication channel. Examples of such market roles are the energy services provider and the aggregator.

2) Front-end design: The project's innovative approach is based on the development of an open framework that will promote an environment for the deployment of smart grid services for households. Two companies are involved in this design, OGEMA[1] which will provide the home energy management gateways while, Develco Products[2] will provide sensors, actuators, meters and servers for smart home internetworking.

3) Back-end design: A centralized system for demand response service provisioning based on aggregation, forecasting, and scheduling of electricity consumption will be developed. Due to deadline constraint of the customers, e.g., the systems makes contracts with the customers promising when a given appliance has run to completion, this constitute a non-trivial optimization problem for the scheduling of electricity load. This is complicated further by the set of guarantees that the aggregator should provide to the grid operations.

4) Simulation and demonstration: In order to provide a demand response of significance to the grid operation, a large quantity of households must be aggregated. The project will use a simulation approach that promise to scale to at least 200.000 households and that provides a tool for aggregator to plan their demand response programs and act accordingly on the energy markets. The simulation tool will be validated against two demonstration sites with a total of 200 households from Norway and Switzerland, respectively.

5) Security and Privacy: The project will take a multi-faceted approach to threat modeling and start by enumerating important factors including system elements, valuables, attacker types and motivations, possible attacks, and potential attack points.

B. Impact

SEMIAH will hence significantly contribute to EU energy policies and bring benefits to the electricity market (residential customers, energy utilities, and grid operators).
The main project impacts are:

- to reduce the gap between energy produced and energy consumed;
- to reduce and shift of electricity peak loads;
- to increase of renewable energy sources and combined heat and power stations connected to the distribution grid;
- to have a positive impact on the end-users participating in the SEMIAH project;
- to contribute to EU's societal and political goals on energy and climate.

[1] ogema.org
[2] develcoproducts.com

III. Partners

The consortium consists of twelve partners from four different European countries.
In the following, partners are listed together with their contribution field:
ICT: Aarhus University (Denmark), Centre Suisse D'Electronique et de Microtechnique (Switzerland); University of Agder (Norway), and Haute Ecole Specialisee de Suisse Occidentale (Switzerland).
Energy: Fraunhofer IWES (Germany), Agder Energi Nett (Norway), SEIC Teledis (Switzerland), EnAlpin (Switzerland), Misurio (Switzerland), and Develco Products (Denmark).
Telecommunications: Devoteam Solutions (Norway) and Netplus (Switzerland).

IV. Conclusions

The SEMIAH project aims to develop a generic environment for the deployment and innovation of smart grid services in households. The SEMIAH concept enables aggregation of households connected to the grid system and acts through direct load control to remotely shift or curtail electrical loads according to users' flexibilities. Security and privacy functions are also considered and will be integrated in all elements. Another essential cornerstone is development of new business models for electricity players and residential customers.

We believe SEMIAH project has a significant potential to improve the relation between ICT, Energy and Telecommunication sectors which will lead us to have a comprehensive and scalable energy management infrastructure for households aggregation. Finally, through novel and innovative business models, customers are provided with incentives to offer flexibility in their energy consumption that will lead to a more secure and sustainable energy supply.

Acknowledgment

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