GUIDELINE: HOW TO MONITOR DEMAND RESPONSE PERFORMANCE

Abstract

In this guideline we are presenting one way to assess responses of (electricity) consumers to smart grid functionalities. The energy consumption is measured with technical equipment and then compared to its reference. Analysed information can be used for billing of consumed electrical energy or non-financial motivations, forecasting consumption or presenting (energy consumption related) feedback to the user.

What is it?

Monitoring is an important requisite for a project involving end users' changed energy consumption behaviour as a result from the smart grid environment. Its main purpose is detecting their response in comparison to a certain baseline (for more information on calculating the baseline please refer to the S3C guideline How to create a consumption baseline). This can be applied to both consumption and production: the former is more important in regard to demand-response policies, while the latter is more relevant regarding more comprehensive options like virtual power plants. Although monitoring can also be done without smart grids – it will then need the manual recording of energy consumption on a regular basis – in this guideline we will focus on how to use the smart grid equipment to monitor consumption behaviour.

The monitoring process starts with the collection of data from measurement equipment, followed by data processing and analysis in order to present them in a suitable way to the end users or to allow the utilities to use them for their purposes.

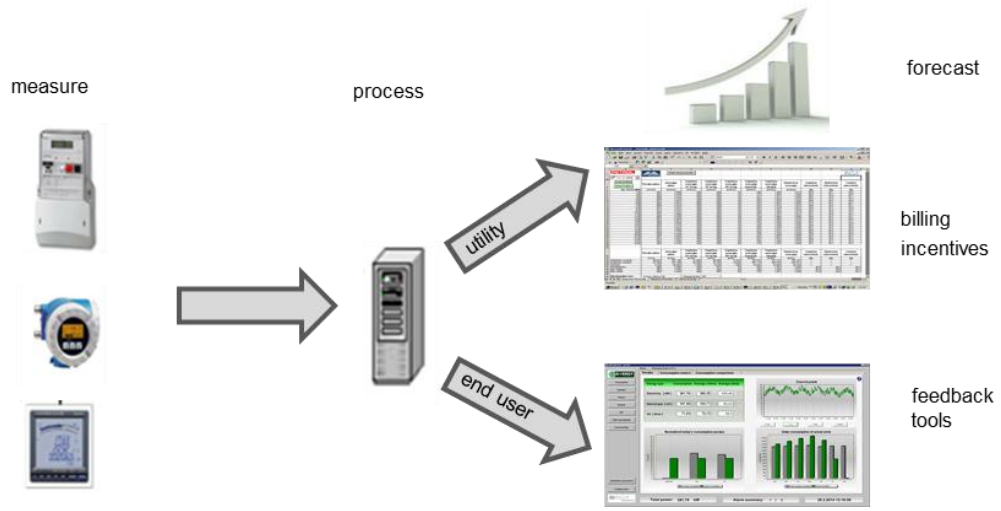

Figure 2: Monitoring process scheme (source: KIBERnet documentation)

Smart system architecture trial in 50 households (Energy@home, IT)

In the project 50 households (15 with photovoltaic panels) in urban cities in central and northern Italy received full smart grid set (5 plugs, smart washing machine, home gateway and display) in order to monitor their response – a smart meter was already installed. They have installed the smart infrastructure to experimentally validate the proposed (theoretical) technical solution based on the developed platform, test its capability to actively control domestic appliances and simplify the use of dynamic tariffs in order to increase end users' active participation in the smart grids. From the devices they received quantitative data such as: data of power and energy shown by the plugs (on average every 2 minutes); specific data from the washing machine at the end of each washing cycle (duration, type of wash cycle, peak power consumption etc.); data about the use of the web application to understand what is the most requested information; statistics about appliance usage; sequence of electrical loads activation/deactivation. The communication tools permit also to receive qualitative data, because end-users can interact and give their feedback, suggestions and solutions through the forum or the email, as well as through the final focus group/questionnaire.

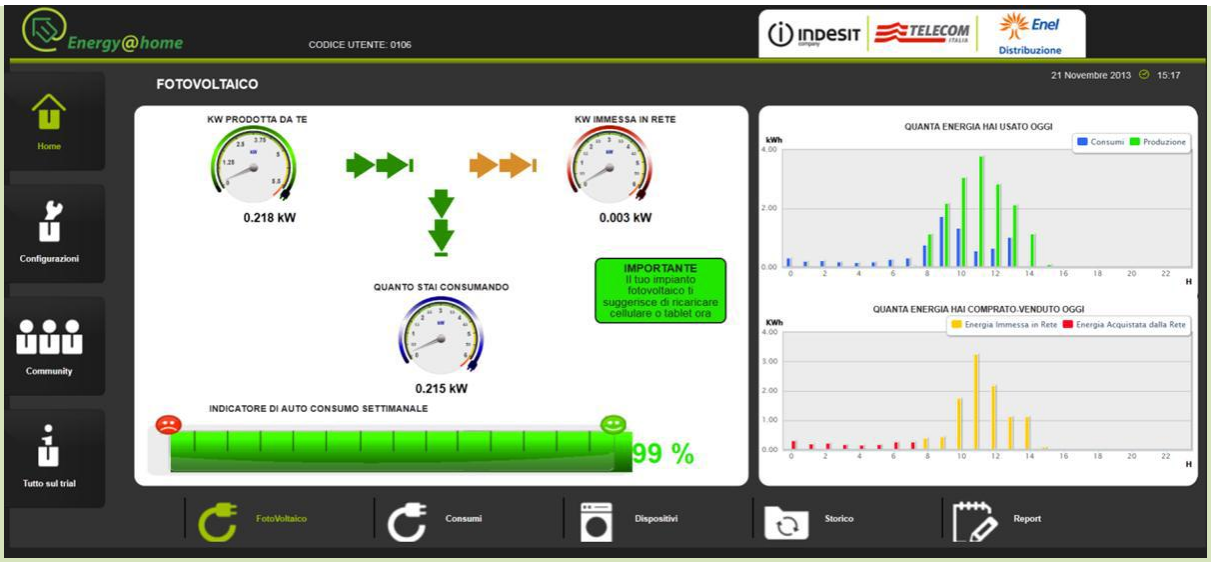

Figure 1: Customer web interface was used to monitor the customer's response (source: S3C D3.2)

More information: http://www.energy-home.it/SitePages/Home.aspx

When to use?

Usually the information obtained by monitoring is used to see how well the project scores on the key performance indicators (KPIs) that it has defined, for more information on what to do with the monitoring data see the guideline KPIs for energy consumption effects. These KPIs can be used for the final evaluation of the project, but can also be used during the execution phase to see how well participants are scoring and this can be used to give them (personal|) feedback as well as to determine what (non-)monetary incentives they have earned with their energy consumption behaviour. The end user having to face the effects of his actions is a strong motivator for changing the consumption behaviour and pattern.

Project management point of view, monitoring is used for measuring the demand response effects of a certain tool/approach on a certain group. This is valid for tools like automatic demand response, the introduction of a new ToU tariff and dynamic pricing, etc. Usually the introduction of a tool is limited to a specific group and the results are compared to the reference data. The reference data is provided either from another reference group or from the same group during the specific period before the introduction of a new demand response tool (using a baseline method as described in our guideline How to create a consumption baseline). Utilities use the monitoring of the production and consumption also for generating the forecasts,

which in case of sudden changes result in balancing the grid and demand response actions.

Installing smart grid infrastructure and services in Evora (InovCity, PT)

Different demand response (manual type) products and services were tested on selected segments of customers and validated against control groups in the project Inovcity. The starting point of monitoring in Evora was the installation of smart meters. On top of this key device they have developed web applications, which enabled the users to visualise energy consumption and access to products (PC software + display and enhanced consumption monitor) and services (SMS alerts, load diagrams, time of use tariffs, 3 tier tariffs, "target kWh" tariff, comparison to control groups etc.) which have been offered.

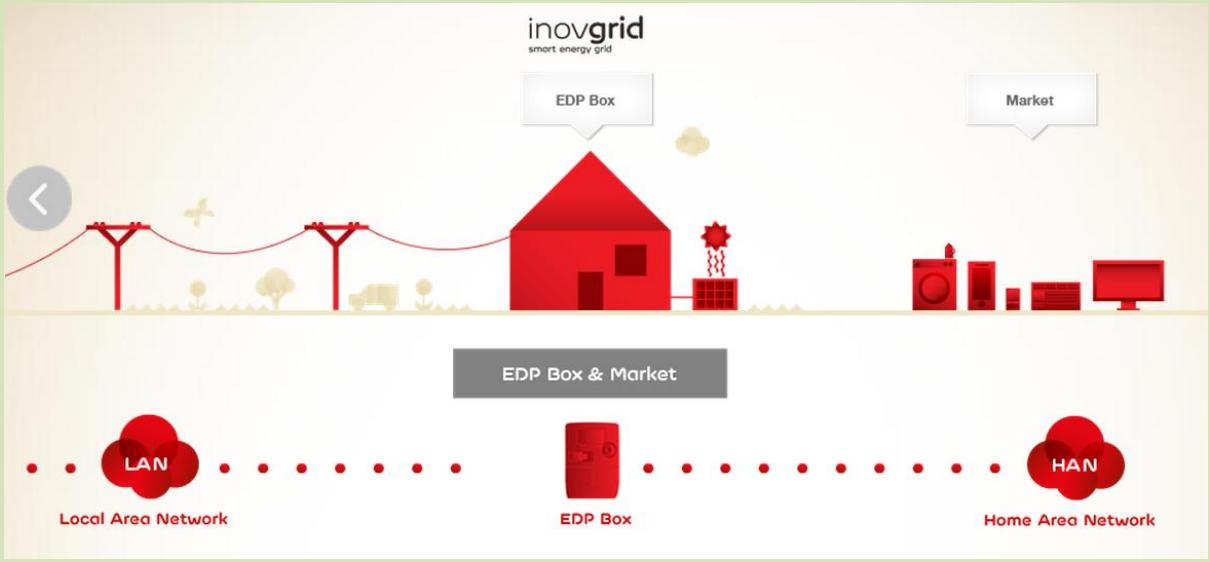

Figure 3: Communication architecture is an essential part of demand response technology – example of InovGrid system design (source: http://www.inovgrid.pt/en)

More information: http://www.inovcity.com/

What do you need to do?

Installation of the proper measurement equipment is one of the most important prerequisites for providing the monitoring. For the residential end users and SMEs the smart meter covers the majority of the monitoring needs from collecting the data and communication with the utility.

Definition of the measurements collection frequency affects the purpose of the data usage. Closer to real time the monitoring is performed, more accurate options for end user feedback support may be offered. But there are several considerations. The one hour scale, which usually satisfies the necessities of the grid operator for measuring the demand response effects, is not enough for the advanced end user

services regarding the consumption feedback and learning, which requires smaller time frames (closer to a minute scale). The real time data monitoring is best performed via in-house monitoring displays.

The decision about the communication channel and feedback tool used depends on several factors - from the end user character to the goals the utility wants to achieve with the monitoring demand response. The web and smart phone applications are very attractive for a certain group of the population and suitable to achieve certain goals in the community. On the other hand, with using the dynamic pricing and time of use (ToU) tariffs it is recommended to install the in-house display unit which enables persistent presence of the consumption information and immediate reaction. It also enables monitoring on particular appliances which is very welcomed by the end users. More information on feedback mechanisms is available in the guideline How to make energy visible through feedback. Online monitoring feedback tools are generally not necessary when automated solutions are implemented. Informing the user regularly (e.g. once per month) should be enough to keep them engaged.

The introduction of the performance indicators is an important step to challenge the feedback (for more information please refer to the guideline KPIs for energy consumption effects. They must be prepared in a readable and understandable form (without detailed technical data), presenting the production efficiency, consumption efficiency, and load shift efficiency and including the financial savings on the personal or/and community level.

An additional important issue is to address the end users' privacy and security issues in data processing (more on this can be found in a guideline Privacy and data protection). This is especially true when other personal sensitive data is collected (such as the size of the dwelling) for the calculation of specific indicators. Handling and storing such data requires a strict safety policy, which must be clearly presented to and approved by end users. The goals of the utility introducing the monitoring need to be explained as clearly and transparently as possible in order to create a trust bond with the end users who are going to use the monitoring system. Moreover, constant assistance is required throughout the duration of the project in order to not cause end users to feel abandoned.

Do's and don'ts

- **Keep the comparison of data consistent.** It is important to acquire the measured data from the end users during a comparable timeframe (i.e. the same period in which the pilot project is taking place) in order to have consistent comparison among them.

- **Compare measured data to references.** Additional comparisons represent a formidable tool to know more in depth end users' habits and propose corrective actions, such as:
  - Gathering data for a more robust baseline, for example taking into account two or more comparable periods instead of a single one;
  - Gathering data from a control group (a representative sample from households who are not suggested to the effects of such a project).

  These additional comparisons are in fact especially useful to minimize the effects of anomalies in the data derived from meteorological events (an extremely cold winter leads to an increase of energy consumption in the households) for instance.
- **Do not disturb end users at equipment installation.** It is recommended to use the equipment with a minimal impact on the home installation and set a time limit on the measurement storage (a couple of years, for example), remembering to mention it in the contracting documents with end users. To ease the installation process, have a look at our tool Training Installers.
- **Use standard communication protocols.** It is also recommended to use smart meters with standardized output for monitoring, which can be used by competitive vendors for equipment installation and service offering.
- **Don't exaggerate with the accuracy of measured data.** It is not necessary to implement a short time scale data collection if the monitoring goal does not require it. For example, it is senseless to collect data on the minute scale if the service includes the web application display with several hours of data delay.

Reducing power consumption by wireless monitoring (BeAware, IT/FI/SW)

BeAware used ICT-based solutions to involve end users in energy efficiency efforts. The main goal was to reduce power consumption within households by 15% through the use of wireless monitoring and a flashlight–like instrument. A smartphone application turned the users into game players. As a system that was wirelessly connected to the house, called Energy Life, kept track of electricity consumption and built a historic baseline. The effects of energy efficiency measures have then been compared to the baseline. Based on the monitoring system they have been able to set a measurable goal: -15% consumption reduction. It was observed that the participants changed their consumption habits and became more aware of energy efficiency. During the trial electricity consumption effectively decreased. Furthermore, it was noticed that it wasn't through the amount of interactions with the interface but rather through the feedback received with regarding to single specific behaviour that users reduced their electricity consumption.

More information: http://www.energyawareness.eu/beaware/

Further reading

- End user feedback (S3C D.3.4). http://www.s3c-project.eu/Deliverables.html
- Schneider Electric (2011). Monitoring Energy Use: The Power of Information, http://www2.schneider-electric.com/documents/support/white-papers/monitoring_energy_use.pdf
- Energy@Home (2015). Data Model (descriptions of system architecture and monitoring functionalities), http://www.energy-home.it/SitePages/Activities/Download.aspx?RootFolder=Documents/Technical%20Specifications.

This guideline was developed in the S3C project, and is freely available from www.smartgrid-engagement-toolkit.eu.

S3C paves the way for successful long-term end user engagement, by acknowledging that the "one" smart consumer does not exist and uniform solutions are not applicable when human nature is involved. Beyond acting as a passive consumer of energy, end users can take on different positions with respective responsibilities and opportunities. In order to promote cooperation between end users and the energy utility of the future, S3C addresses the end user on three roles. The *smart consumer* is mostly interested in lowering his/her energy bill, having stable or predictable energy bills over time and keeping comfort levels of energy services on an equal level. The *smart customer* takes up a more active role in future smart grid functioning, e.g. by becoming a producer of energy or a provider of energy services. The *smart citizen* values the development of smart grids as an opportunity to realise “we-centred” needs or motivations, e.g. affiliation, self-acceptance or community.

S3C performed an extensive literature review and in-depth case study research in Smart Grid trials, resulting in the identification of best practices, success factors and pitfalls for end user engagement in smart energy ventures. The analysis of collected data and experiences led to the development of a new, optimised set of tools and guidelines to be used for the successful engagement of either Smart Consumers, Smart Customers or Smart Citizens. The S3C guidelines and tools aim to provide support to utilities in the design of an engagement strategy for both household consumers and SMEs. The collection of guidelines and tools describe the various aspects that should be taken into account when engaging with consumers, customers and citizens. More information about S3C, as well as all project deliverables, can be found at www.s3c-project.eu.