GUIDELINE: INTRODUCING SMART APPLIANCES

Abstract

We describe the future evolution of today's electric appliances into smarter devices. In this guideline you can learn about the potentials of connecting appliances to a smart grid, and their possible functions and benefits in doing so. Based on an extensive analysis of smart grid projects we have identified success factors for implementing smart appliances. This guideline is intended for demand response service providers, energy retailers and producers of smart equipment/appliances.

What is it?

The evolution of electric appliances will progress with the integration of smart technology. The smart appliances are electronic devices in the household environment, which are applicable to smart grid services like so-called demand response activities, remote monitoring, scheduling, energy consumption adaptation programs, etc. The interactive communication to the smart grid service is provided via various (wireless) protocols like Bluetooth, NFC[1], WiFi, 3G, etc. The automated control of the smart appliance energy consumption is provided by the service. It provides the minimum influence on the consumers' comfort and daily routines and can create a win-win situation for both sides – consumer gains the incentives and utility gets the grid balancing capacity.

Household electrical loads relevant to become smart appliances may be typical white goods such as refrigerators, freezers, dishwashers, ovens, stoves, washing machines and tumble dryers as well as air conditioners, circulation pumps for heating systems, electric storage heating systems and water heaters.

Smart appliances basically operate on two principles a) modification of the starting time of an appliance cycle and b) interruption of regular appliance operation.
In the first principle the user selects the finish time and the appliance selects the operation shift within this constraint. In the second option b) a normal operation is interrupted for a limited period of time which still conserves the consumer comfort – e.g. room temperature does not fall below the 20˚C for more than 4 hours.

[1] NFC stands for Near Field Communication. This allows radio communication between two devices when kept at a distance of typically 10 cm or less.

The most common effects of the control are:

- The completion of the load operation is delayed for a couple of hours (in the case of washing machine or dishwasher for example),
- The building temperature has minor variations (for about a 1 or 2 degree maximum),

The temperature of refrigerators and freezers deviates away from optimal for short (several hours) interval, while their content is kept intact.

Washing machines catching the sun (Jouw Energie Moment, NL)

The project Jouw Energie Moment (NL) had the goal to create learning experiences in a real life environment about the technical, economic and social possibilities for making household demand of energy more flexible and sustainable. The project installed smart washing machines, smart meters and interactive displays in several households. Their purpose was to reduce and shift their demand to hours of high solar electricity production.

The service provider introduced flexible pricing for ToU tariffs. Through the user friendly display the consumer had an insight to the potential financial saving stemming from flexible pricing. By choosing the most sustainable periods at daylight hours for the smart appliance operation the consumer changes his consumption behaviour to get incentives. Apart from feedback information via the in-house display (IHD) the consumers were also provided with a smart washing machine that could be remotely controlled (via the display). This allowed for the automatic scheduling of washing cycles to periods of high PV production. In the image on the left the interface of the IHD can be found, while on the right the electricity consumption for washing is compared between participants of this project (green line) and the average EU household (pink line). Clearly much of the energy demand during peak hours for this activity has been shifted to day-time hours.

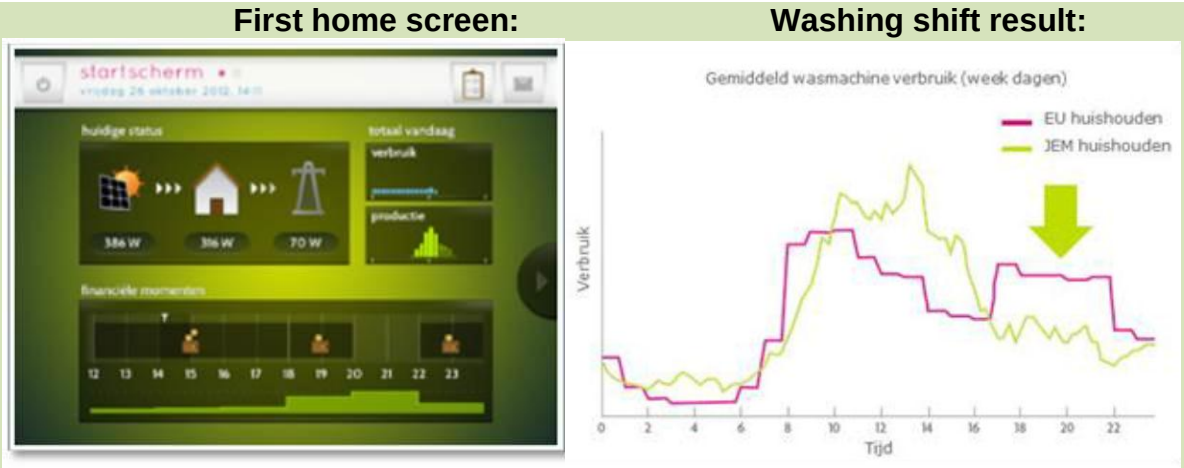

Figure 1: User interface on a smart appliance from the project 'Jouw Energie Moment' (Left) and Daily pattern of average consumption for washing in project (green) compared to EU average (pink) right (S3C Deliverable 3.2)

More information: http://jouwenergiemoment.nl/

According to their operation principles there are three types of smart appliances:

- *Fully automatic:* the consumer has no influence on the operation. It is suitable for refrigerators and freezers.
- *Set and forget:* suitable for the washing devices, when the consumer defines the (daily) operation interval when the process needs to be finished and leave the smart appliance control to do the job.
- *Case by case decision*: at every operation cycle the consumer is asked how to proceed. E.g. via dedicated "smart" button it instructs whether to use an ordinary process or the operation is controlled by some demand response procedure. This is proper for the behaviour appliances (electrical hobs, hoods, ovens) for a situation when the user needs to decide on some external parameter, i.e. electricity market price before he starts operation.

When to use?

Smart appliances may be used in a demand response service, offered by the utility company, grid operator or aggregator to achieve one of its goals regarding the grid stability, peak levelling or RES integration. The service may also be a part of consumers' active market participation and energy shift trading.

How to use?

During operations the smart appliances involve the consumer and the service provider. Both have their own requirements and expectations regarding the smart appliance functionalities.

The consumer usually has the following requirements about smart appliance operation:

- The smart appliance should execute its working procedure correctly and achievement the expected results (e.g. the quality standards of the washing cycle). This should be achieved in both cases - when the load operations are performed by the consumer or if they are subject to an external control.
- There should be minimal influence of the smart appliance on the consumer's activities and comfort. Actually they should not even notice that there exists some load control in his surroundings.

With the inclusion of the smart appliances the service provider wants to perform certain grid stability actions or make profit on the electricity market by peak levelling, shifting the energy consumption, more efficient integration of RES, etc. Recommended smart appliance functionalities to cover those requirements are:

- Consumption: to display information to the consumers about their energy consumption (e.g. used energy, instant power consumption, etc.) together with additional features such as dispatching such information through Home Area Network (HAN) to in house display.
- Price: to communicate on energy price with the service provider through the smart meters, if dynamic tariffs are offered by the service provider.
- Cooperation: to operate cooperatively with service provider in order to optimize the energy usage through load shifting and/or load shedding. For example, to reduce the overall peak consumption the consumer may implement the consumption power limit. This will result in the smart appliance shifting the load to the off-peak time interval.
- Connectivity: Built in wireless connectivity (WiFi) to avoid construction work for wiring.
- Interaction: Shift autonomously consumer usage according to information coming from the external sources:
    - schedule the appliance when the energy is cheaper (fig. 2). The consumption follows the flexible pricing of the service provider.

Figure 2: Scheduling of the appliance operation with respect to the price of electricity
Source: RSE internal documentation

- schedule the appliance when the energy is greener (fig. 3). The consumption follows the production of (the consumer's own) RES.

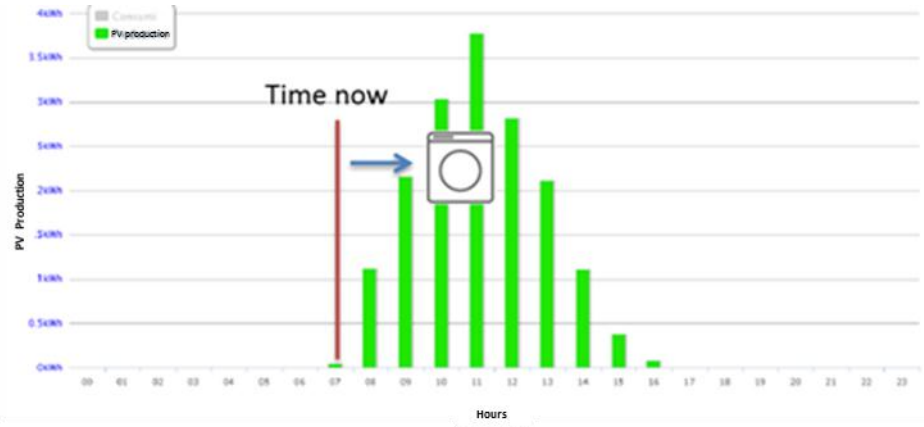

Figure 3: Scheduling of the appliance operation with respect to the source of production of electricity
Source: RSE internal documentation

Dynamic tariffs run the home appliances (Energy@Home, IT)

The Energy@Home project trial involved 50 household consumers that have been equipped with a smart system architecture composed of five smart plugs, a smart washing machine, a home gateway and a smart info display. The goals were to validate the proposed 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 consumers' active participation in the smart grids. The technical solution was well accepted by the participants which were able to control appliance through the smart phone application. On the other hand there was no progress of the consumer smart behaviour toward higher consumption efficiency until the publication of the personalized newsletter with comparison graphs and energy performance indicators, indicating that the use of feedback is remains vital for a behaviour change in consumers.

More information: http://www.energy-home.it

What do you need to do?

Integration of the smart appliances requires consideration of various economical and technical issues, which are briefly stressed below:

1. **Business model**
   The utility needs to create the proper business model which would provide attractive incentives to consumers. The business model could include direct financial incentives (e.g. lower network tariff) and indirect incentives like discounts for purchasing communication equipment and smart appliances.
   It is also recommended to make a business relationship between service provider and equipment supplier. Beside the compatibility of the smart service with the smart device also customer support must be synchronized.
2. **Contract**
   The service provider needs to make a contract to the consumer. The contract must contain an agreement about the obligations and rights of both parties. Overall, it should cover the following aspects:
   a. Incentives (financial and non-financial);
   b. Calculation procedure (for the incentive amount calculation);
   c. Authorization to install the control unit. In addition, permission to collect and store measured data, and other personal data.
3. **Equipment installation**
   The installation of the smart appliances should be done by the smart appliance supplier, which has a contracted relationship with the service provider. The service provider should the responsible entity to which the consumer refers in the case of problems. The staff that is involved in the installation process needs to be familiar with the operation and capable of providing the necessary information to the consumer during the installation. The installation of the appliance and corresponding communication equipment needs to be provided with minimal reconstructions and adaptations of users' homes. For more information about the installation, see the S3C guideline Training installers.
4. **Operation monitoring and evaluation**
   The consumption profiles of consumers' needs to be measured in order to evaluate the effects of the service on the consumer behaviour. Regular monitoring of the consumer consumption profile provides information about his level of the smart appliance usage. Based on the evaluation results the service provider can start certain activities to increase the consumer activity. This may be done individually – e.g. by calculation personal performance indicators and their delivery to the consumers (see guidelines KPIs for energy consumption effects and How to make energy visible through feedback for more information). This may encourage the consumers, which are below the expectations, to provide more intensive feedback. Another possibility is addressing larger audience by organisation of the marketing campaign. The campaign beside the characteristics and benefits of the smart appliances addresses common goals like increasing environmental and ecological awareness.

Do's and don'ts

- **Deliver thoroughly tested equipment.** Make sure to deliver properly working equipment which has been preliminary tested both in terms of hardware and software.
- **Automate if possible, but leave final control to the consumer.** The system should be automated as much as possible, keeping low interaction with the consumer. However, the consumer should keep the final decision about operation. It is therefore necessary to always leave an overrule option for the users.
- **Only automate un-process loads.** It is recommended that only so called un-process loads are automated. Such loads are not involved in consumer's daily operations or leisure activities in the residential sector. Examples of such loads are air conditioning devices, coolers, refrigerators, freezers, heat pumps for heating buildings.
- **Use wireless technology.** For communication use the wireless technology as much as possible. Avoid additional construction adaptations like wiring.
- **Explain that smart appliances do not consume less energy.** Smart appliances do not directly save the energy, since their consumption is the same as for the ordinary ones. Their effect is load shift which enables larger integration of renewable energy sources. The promotion should contain this information to avoid misunderstandings of the audience.
- **Motivate consumers by promoting for the motivations behind smart grids.** Consumers should feel they are doing something important, not only for themselves but also for the environment and future generations.
- **Provide constant support to users throughout the project.** Consumers should be able to install the provided equipment but they should never feel alone. It is fundamental to assist them during the different stages of the project, especially at the beginning.

Further reading

- S3C Consortium (2014). *Report on case analyses, success factors and best practices (S3C D3.4).* http://www.s3c-project.eu/Deliverables.html,
- Frey H. *Case Studies: Results and Conclusions*, D6.2, from Smart-A project, http://www.smart-a.org/W_P_6_D_6_2_Case_Studies_Report.pdf
- Vanthournout, K., Ectors, D., Bogaert, S., Viegand, J., Stamminger, R., Geppert, J., Rivière, P., Götz, T. (2015). Ecodesign Preparatory study on Smart Appliances, March 2015, http://www.eco-smartappliances.eu/Documents/Ecodesign%20Smart%20appliances_Discussion%20note_workshop_150310.pdf

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.