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DESIGNING SUSTAINABILITY FOR ALL

Edited by Marcelo Ambrosio and Carlo Vezzoli

Proceedings of the 3rd LeNS world distributed conference

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Designing sustainability for all

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Double-Blind Peer Review.

Graphic project by:
Roman Maranov, Politecnico di Milano, Italy
Xinrui Wang, Politecnico di Milano, Italy
Yuting Zhang, Politecnico di Milano, Italy
Giacomo Bevacqua, Politecnico di Milano, Italy

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website: www.polidesign.net

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FOREWORD

Designing sustainability for All was a call for contributions and actions to the whole world design community, which is not limited to design researchers, design educators, and design practitioners but also unites other disciplines such as architecture, engineering, economy, policy-making, and sociology.

The Conference has been a unique event hosted simultaneously in Mexico City (Mexico), Curitiba (Brazil), Cape Town (South Africa), Bangalore (India), Beijing (China) and Milan (Italy), on 3rd-5th April 2019. In fact, in each of the 6 venues, it has been possible to listen to any of the presentations happening in the other ones.

LENSIN PROJECT

LeNSin, the International Learning Network of networks on Sustainability (2015-2018), is an EU-supported (ERASMUS+) project involving 36 universities from Europe, Asia, Africa, South America and Central America, aiming at the promotion of a new generation of designers (and design educators) capable to effectively contribute to the transition towards a sustainable society for all.

LeNSin ambitions to improve the internationalisation, intercultural cross-fertilisation and accessibility of higher education on Design for Sustainability (DfS). The project focuses on Sustainable Product-Service Systems (S.PSS) and Distributed Economies (DE) – considering both as promising models to couple environmental protection with social equity, cohesion and economic prosperity – applied in different contexts around the world. LeNSin connects a multi-polar network of Higher Education Institutions adopting and promoting a learning-by-sharing knowledge generation and dissemination, with an open and copyleft ethos.

During the three years of operation, LeNSin project activities involve five seminars, ten pilot courses, the setting up of ten regional LeNS Labs, and of a (decentralised) open web platform, any students/designers and any teachers can access to download, modify/remix and reuse an articulated set of open and copyleft learning resources, i.e. courses/lectures, tools, cases, criteria, projects.

LeNSin will also promote a series of diffusion activities targeting the design community worldwide. The final event will be a decentralised conference in 2018, based simultaneously in six partner universities, organised together by the 36 project partners form four continents.

THE LENS CONFERENCE

The Conference is the 3rd edition of one of the largest design international conferences for lecturers, researchers, professionals, and relevant institutions and organizations. It has become a reference event where experts from all over the world get together to present and share their knowledge, projects, tools, and visions to diffuse sustainability for all.

The Conference is organized as a part of the LeNSin, the International Learning Network of networks on Sustainability project (2015-2019, EU funded Ersamus+ program) that aims to be both visionary and pragmatic, and to stimulate new ways of thinking.

The scope is to share the latest knowledge and experiences around the concept of sustainability for all.

This will be achieved through cross-fertilizing a wide range of disciplines: predominantly design, but also engineering, economy, policy-making, and sociology.

LENS MANIFESTO

A new ethos for a design community: towards an open source and copy left learning-by-sharing attitude/action.

We, the undersigned, aware of both the urgent changes required by sustainable development, the potential role of design (and design thinking) in promoting system innovation in the way we produce, consume and interact, as well as the opportunities offered by the ever more interconnected society, propose the adoption and diffusion of a new ethos within a worldwide design community:

To view design as a unique multi-polar learning community promoting, enabling and activating any possible learning-by-sharing process aiming at effective knowledge osmosis and cross-fertilisation in design for sustainability in an open and copy left ethos.

We, the undersigned, commit our selves in such an ethos, trying our best to apply this in our daily life as individuals or representatives of institutions in the design community.

In relation to our competencies and possibilities we will make our acquired knowledge to be, as far as possible, freely and easily accessible in a copy left and open source modality (while safeguarding our authorship and scientific recognised publication activity), that enable others in the design community to acquire them free of charge, with the possibility to replicate, modify, remix and reuse, through e.g. adopting creative commons licences.

As researchers, this knowledge includes our acquired research knowledge base (e.g. papers, books, etc.) and knowhow (e.g. methods and tools).

As educators, this knowledge includes our educational resources (slideshows, texts, video of lecture, educational support tools, etc.)

As designers and design thinkers, this knowledge includes the design for sustainability concept proposal of products, services, systems and scenarios, as well as a knowhow they used to design them.

We commit our selves to seek the commitment of other individuals or institutions in such an ethos within the design community. In relation to our competencies and possibilities we will:

do our best to commit individuals such as researchers, educators, professional designers and design thinkers as well as institutions such as research institutions, design schools, and designer's associations to adopt the same ethos

do our best to generate and/or enable open learning networking of sustainability of design researchers, design educators, professional designers and design thinkers.

the Learning Network on Sustainability

SMART HOME GRID: TOWARDS INTERCONNECTED AND INTEROPERABLE ELECTRICAL MODEL TO IMPROVE THE USAGE AWARENESS

Paolo Perego
Politecnico di Milano, Design Department, via Durando 38/a, Milan, Italy. e-mail: paolo.perego@polimi.it
Gregorio Stano
Politecnico di Milano, Design Department, via Durando 38/a, Milan, Italy. e-mail: gregorio.stano@mail.polimi.it

ABSTRACT

In the last decades, the evolution of technologies for the smart home enabled users to control the electrical usage of system and appliances. However, despite the widespread of IoT solutions, there is a poor integration between electrical utilities and products or services. This is mainly due to disaggregation of electrical data and the lack of interoperability between actors. These weaknesses bring to a non-supervised electrical "last mile" and poor awareness of detailed users' electrical consumption.

This work aims to introduce the concept of Smart Home Grid showing a first model with four main goals: gather data and extract usage patterns; improve the user experience by supporting the users through an electrical usage information system; share the usage between actors; push Energy-as-a-Service models for sustainability.

Key Words: Smart Home Grid, Energy-as-a-Service, IoT

1. INTRODUCTION

In the last years, smart technologies have experienced a period of wide spread. New devices with new advanced features show off on the market, both for customer (e.g. smartphone) and enterprise electronics (e.g. smart city grid infrastructures), promising enhanced functionality, connectivity and manageability.

Major technology developers, service providers and energy utilities are now lining up to extend smartness beyond specific devices towards home, considered in their complexity, and interconnected through meters, networks and cables belonging to energy suppliers. The advent of smart home, defined as a set of interconnected products and services and with an active role in sharing and processing data, can ensure that smart technologies become a habit of people's lives (Haines, Mitchell, Cooper, & Maguire, 2007).

Regardless the type of technology configuration of the smart home, its goal – according to technology developers – is "to improve the experience of living the home", depending on different methods with as many different domestic conditions. (McLean, 2011).

Essentially, a smart home collects and analyses data from the home environment, transmits information to the users and to the service providers, and increases the potential to manage different home system, such as heating, lighting, entertainment (Firth, 2013). Smart home technologies include sensors, detectors, interfaces, appliances and interconnected devices to allow automation and remote control of the home environment (Cook, 2012). In particular, there are different categories of product and services with the aim of monitoring and managing electricity consumption: these categories of product use different communication technologies and protocols, preventing or limiting the consumption overall management. These differentiation in communication is mainly known as a lack of standard and usually is the cause of non-interoperability between systems.

Smart homes are also the final node in smart energy management system, which could enable energy service providers to respond, in real time, to the energy demand of millions of inhabitants.

This gives smart home the opportunity to align with the energy service provider's needs, to limit or change energy availability if, for example, infrastructures is overloaded, de-potentiated or out of service (Darby, 2010).

Therefore, the smart home should be not only an automation tool, but also an important part of an intelligent and efficient energy management system, which allows to reduce the overall energy demand and help to alleviate the overloading of power plants during peak periods (Firth, 2013).

The widespread diffusion of smart home technologies has long been expected by many public governments and it is considered an important component for the creation of smart grids; smart home experts agree that climate change and energy policies will drive the development of the smart home market. Italy, on the other hand, has adopted a new National Energy Strategy since 2013, identifying as priority developments the energy efficiency, the sustainable development of renewable energy sources and the creation of smart grids, with the aim of growing energetically with zero emission, and ensure the energy provision for the medium (2020) and long term (2050).

Furthermore, Italy was the first European country to adopt smart meters connected with the electrical power distribution infrastructure since 2000s. Enel's smart meters (Figure 1), since 2006 (Van Gerwen, Jaarsma, & Wilhite, 2006), have become mandatory for all Italian energy providers, establishing minimum functionalities in order to allow all the electrical company to correctly measure the quality of supply, directly through the meter.

Moreover, starting from 2017, "e-distribuzione" (the new name of the national electricity provider) is gradually replacing the old smart meters with the new generation ones (Figure 1), which allow a more accurate measurement and allow for interoperability with other devices, in order to prepare the infrastructure for an on-demand energy market (Balta-Ozkan, Boteler, & Amerighi, 2014).

[Figure 1] On the left the first Enel Smart Meter, installed during 2000s in 32 million houses. On the right Open Meter 2.0, e-distribuzione smart meter, the second-generation meter with higher accuracy, ready for the smart home and equipped with interoperable communication protocol.

2. THEORETICAL BACKGROUND

Since the 2000s, technological innovations created new market segments, made technology and connectivity more democratic and, above all, radically changed the users' habits and their interaction with the machines (consider how smartphone has radically changed everyone's life routine). The launch on the market of new technologies, such as multitouch, smartphones, wearables and wireless connections have deeply renewed the relationship between man, technology and mobility, thus forcing companies to improve the human-computer interaction related to products and services, focusing on the user in every research and technological development process. Therefore, the human-centered design has led companies to perceive the importance of offering their customers not only high-performance product on technological point of view, but also usable products, pleasing in appearance and use, and easily configurable (Norman, 2010).

One of the technologies that most needs a user-centered approach is domotics. The home automatic has evolved from technologically advanced but too complex solutions, to more familiar and reliable solutions, perceiving a new opportunity for creating a home infrastructure which is pleasant, usable and easily scalable.

Until a few years ago, home automation solutions were produced mostly by the same companies that where demanded to the distribution of energy, lighting and automation. Technological evolution has brought domotics and the new smart home towards companies and manufacturers that until last years had been unimaginable: IT companies (Staff, 2013). Products and services move from being complex, painstakingly customizable and scalable domotics system (which require expensive infrastructures), to system designed to be a network of devices able to store every data exchanged with other products of the system. This new systems optimize their operation thanks to algorithms which profiles the users, in order to comply more and more users' preferences or, in some cases, to predict their behavior (Yang & Newman, 2013).

These services and products, or better the model of technological development connected and with intelligence, is more generally diffused with the term "Internet of Things" (IoT). IoT is the phenomenon of "connected things", i.e. devices, plants and systems, tangible products and materials, work and goods, machine and equipment, all connected to the Internet and able to exchange information autonomously with one or multiple objects connected to the same network, or communicate with other network thanks to standard communication protocols (LAN, WLAN, Bluetooth, ZWave, ZigBee) (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015).

Unlike home automation system, whose main business in the last two decades has been focused on a technology-push approach that led the companies to focus just on the stand-alone product, the brand-new IoT product, infrastructures and interfaces that make up the smart home are no longer considered as separated technologies. Instead, they became a complex ecosystem of different solutions led by underlying services, designed on the real people demand.

3. RESEARCH METHOD

As described in the previous chapters, the market is full of different solutions which can record and share data regarding energy usage and efficiency inside the home, but in most cases, they are stand-alone product and data are limited inside the house or in a private cloud, and cannot be used for statistics, profiling or improving the energy consumption. Analyzing the market of smart plugs (see chapter 2) it is clear that non interoperability problem is due to two main problems:

- Lack of communication standards and "lack of API" (there is no standard in traditional/legacy like BTicino and KNX); API could enable and simplify data exchange between different systems and interoperable communication processes between machines/devices.
- Lack of full-cloud logic: in a product-service system, the cloud allows for the complete remote management of a system, the control by the user and, theoretically, by the energy supplier. These features could also allow for the ordinary, extraordinary and predictive maintenance of the installed product. This logic is currently available in IoT products and services, but rarely in traditional/legacy product because gathered data are bordered within the home environment.
- These two technological lacks bring to:
- Fragmentation of energy consumption information which cause a lack of awareness of the user because he has to interact with more touchpoints in order to know the exact amount of energy the user is consuming.
- Flawed user journey: the presence of multiple non well-managed touchpoints, together with the different service levels, prevents controlling the acquisition of energy consumption information by the energy suppliers and consequently, fails to guarantee a good service quality from an information point of view, also in case of malfunctioning.

[Figure 2] The Electrical Flow of Information: difference between as-is (red) and to-be (green) flow in order to increase usage awareness.

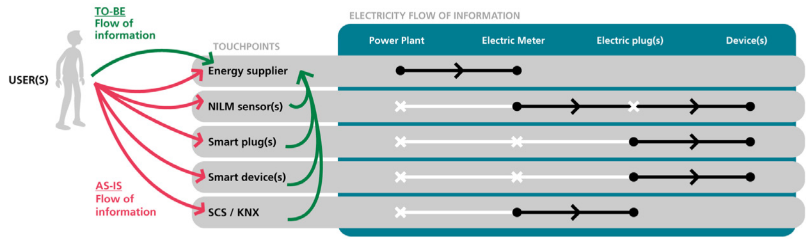

Figure 2 show the matrix of energy "miles" with the various touchpoints. This matrix has been studied by means of research on different touchpoints and interview with stakeholders, in order to identify all the phases of the

user's journey and the communication shortage between touchpoints.
Figure 2 shows:

- in red the information flow in the current state (today): the user needs to poll each element which measure energy consumption, then take care himself of creating a "sum" and eventually managing the consumption according.
- in green the information flow as it should be: the information coming from the single elements that measure energy consumption act in an "underlying" way, transmitting all the data to the energy provider. This process them and resend back to the user, who no longer has to worry about interrogating all the meters but only have the energy provider as single touchpoint (who could access through the app at any time, or at the end of the month though a bill enriched with details of individual consumption (i.e. by type of products, consumption category, etc.).

Innovation brought by IoT has allowed to the energy sector (electrical, energy, heating and air conditioning, etc.) to develop new strategic assets, influencing the consumer choice of more than 30%, who are increasingly oriented towards technologically advanced solutions able to offer a huge quantity of information (Vodafone, 2018). The advent and adoption of these new technologies has allowed the evolution of smart grid.

The smart grid is, at the origin, a combination of an information network and a distribution network, which makes it possible to smartly manage the electricity grid under different aspects or functionality, as it is able to distribute electricity in an optimized way (Belcredi, Modernell, Sosa, Steinfeld, & Silveira, 2016). Smart grids are constantly evolving, scaling more quickly and adapting to the needs, such as at urban dimension level, industrial or commercial centre, down to smaller systems for home management. In such cases, these grids take the name of micro grid (tens, up to thousands of housing and commercial) and nano grid (single housing or commercial) (Hebner, 2017).

When nano grid has smart and intelligent component which is able not only to collect data, but also to process them we can call it smart home grid. By means of a decision support system based on user energy profile, smart home grid is able to take decision and talk both with energy provider and home actuator with the aim to minimize wastefulness and request energy only when needed.

4. RESULTS AND ANALYSIS

Most of the homes and buildings appliances don't support smart environment yet, due the lack of APIs and legacy operating systems. This causes information silos and limit data gathering. Brand-new technologies for smart home, like Google Home or Amazon Alexa, are partially solving this issue: they can be used as a hub for connecting different devices and services, form multiple operators and company, and analyze gathered information in order to extract data which can be useful both user profiling but also for energy saving. An example are the smart thermostats (e.g. Nest) which can be controlled by the smart assistants but, at the same time, work in connection with other sensors inside the house in order to smartly control the temperature to optimize comfort and efficiency; some other thermostats, directly produced by gas supplier or boiler manufacturers, directly send information to the producer with the aims of optimizing boiler operation forecasting an ad-hoc maintenance, and of effectively measuring gas consumption.

	Home automation (Domotics)	*IoT-based Smart Home Grid*
Goal	Application of information technology and electronics to the home management	Devices recognize each other and acquire intelligence because of their ability to share information with other devices and retrieve pooled data within the network
Architecture	Hierarchically designed network and facility	Single and independent devices
Intelligence	"Dumb" devices	"Smart" product and services
Industry (market)	Electrical Builders and Facility solutions manufacturers	Electronics and information technology manufacturers
Connectivity	Centralised and managed by a system	One-to-one connection between network and device
Output	Just offline data for the user, without suggestions or improvement for usage	Integrate and merge data from different touchpoints and sources; compare them with external dataset to enhance the accuracy; improve the development of new energy-as-a-service solutions
Strengths	*Load monitoring; priority consumption management*	*Load monitoring; high infrastructure flexibility; plenty of API and data sharing services*
Weaknesses	*Lack of infrastructure flexibility; lack of API; no data sharing*	*Expensive technology; rare priority consumption management*

[Table 1] *Main difference between Home automation (Domotics) and IoT-based Smart Home Grid.*

This is a first attempt to connect different touchpoints. By introducing the concept of smart home grid in the domestic environment, it is possible to extend the chance to gather data, both from smart and non-smart appliances and services. Specifically, a set of electrical sensors, both native or 3rd-party, can measure the electrical load of each appliance or service. All the data from sensors can be stored and processed in a single data system or a distributed one in order to maximize safety and reliability. All the data can be then aggregated in order to have all the information about the electrical usages and automate the energy loads according to users' needs and choices. At the same time, algorithm of machine learning can profile users from their data with the aim to provide energy on demand maximize efficiency, minimize wastefulness and costs. Table 1 shows the main differences between the home automation technology (domotics) and the IoT-based Smart Home grid.

This new paradigm of IoT-based Smart Home Grid mainly consists of smart plugs and appliances capable to measure their own electrical consumption and transmit them to the energy providers. This feature would allow to create a mesh of interconnected final touchpoints inside the home, defining this new "interoperable network of the energy" between the same users, energy providers and other services. Interconnectivity and interoperability would produce new benefits both for users, which can control and optimize energy usage thanks to a detailed (plug-by-plug) consumptions, and energy suppliers which can provide energy based on real needs without overcharge the network.

Thanks to this improved circulation of information about the electrical performance, the above-mentioned network can represent a new model to raise the awareness of the consumptions. In fact, a new kind of set of information, based on single usage data and no longer on aggregated one, can support the user to be aware of his habits, every time he turns on an appliance, even if no necessary. Another assumption could be in the association of these data with average usage data (i.e. per zone, time frame, usage habits per similar users, back data, etc.). This association can contribute to create and enhance new models that aim to make the user more capable to manage his usage and energy habits.

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