

Transforming Energy Efficiency into an Entirely New Customer Experience—An Effective Way to Engage Consumers—The UtilitEE Project Concept [†]

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Abstract: In this paper, we present the concept of UtilitEE project, an innovative and realistic solution for delivering a customer-oriented Behavioural Change Framework based on an open ICT ecosystem integrated into the building with low cost, off-the-shelf sensors. The solution also incorporates human-centric intelligent control features that use occupant comfort profiles and supportively control HVAC and lighting systems to minimize energy waste, while always keeping occupants comfortable and preserving a healthy indoor environment. Key part of the technical development work is the end users' involvement in co-designing the user interfaces and its features. In the following sections, the objectives and the preliminary high-level system architecture are presented along with the pilot deployment activities for system validation and demonstration.

Keywords: behavioural change; customer engagement; energy behaviour profiling; human-centric intelligent guidance; semi-control; energy-as-a-service; new business models

1. Introduction

The push towards the clean energy transition is becoming stronger and multilateral as the European Union increasingly outlines and rules on the common goals, this leads to increased awareness and empowered to impact the climate change [1].

The energy market is being driven towards consumer centricity on several levels. For example on the policy side the European Commission is paving the way; the vision of the Energy Union is stated by the Energy Union Strategic Framework as following “with citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market” [2]. European Economic and Social Committee support this approach in their communication as part of the New Deal for Energy Consumers release [3]. As the customer needs to be treated as a fundamental actor in the market, only provided opportunities to choose between energy suppliers is not adequate; Consumers need to be given the option to be actively part of the market even to the extent of becoming a “prosumer”. Clean energy for all Europeans package is a new energy rulebook published in May 2019 by the European Union to guide Member States and the actors towards clean energy transition. Following the recent trends, also this publication focuses on the consumer empowerment, rights and centricity.

Additionally, the Clean energy for all Europeans addresses the energy performance in buildings. At present buildings account for the largest single consumption sector with roughly 40% of energy consumption and 36% of CO₂ emissions produced in EU. Although the building repairs and

refurbishments are foreseen as the major solution for improving building efficiency, the need for low-cost and off-the-shelf solutions is evident. Household customers need to be provided with day-to-day solutions that are not resource-consuming but still engaging and purposeful in increasing energy efficiency. The need for off-the-shelf tools and economically viable smart home applications is thus foreseen to increase towards this end. [3]

The end-customers are disrupting the market by placing high expectations on the market players. The phase of living has picked up speed as the consumers are accustomed to on-demand services tailored to their needs and available with only a few clicks on their smart device. Energy is not just a commodity any more, in fact energy is becoming part of our lifestyle, thus the consumers expect the energy services to reflect on their environmental, economic, technological and societal values. Therefore, the energy suppliers, in order to keep levels of customer engagement high enough, should find ways to shift from sole kWh providers to service providers [4].

2. UtilitEE Energy Behaviour Change Approach

The UtilitEE Energy Behaviour Change Approach (EBCA) serves the intervention strategies definition and targets in changing the energy consumption behaviour (ECB) of consumers. The EBCA is developed based on findings from the literature on energy behaviour change by considering trigger points and interventions, segmentation as well as behavioural change phasing.

The EBCA follows an adaptive approach by taking into account the different types of behaviour, the trigger points and interventions [5]. Regarding the types of behavior, ECBA focuses on energy services rather than energy inputs in the consumption domains of heating and electricity, and specifically on habitual behavior. For example, subconscious routines, rather than consciously taken actions. Trigger points such as knowledge, emotions, values, norms, perceived behavior controls are the potential explanatory factors for ECB which can be influenced by interventions. Interventions target one or several trigger points in order to induce and/or sustain change in ECB. In the context of the UtilitEE project, information, feedback (e.g., historical and peer comparison, goal-setting), recommendations upon energy waste identification, confirmation and automation/remote control are regarded as relevant interventions that may induce and maintain ECB change.

Furthermore, the EBCA has been also developed on the basis of the approach described in [6] where the under consideration ECBA is user oriented and adaptive at the same time. In particular, the ECBA that the applied to the developed behavioural change-oriented intervention strategies should be: (1) type-specific, (2) group-specific, (3) multi-factorial, (4) dynamic and (5) integrated.

Following the work in Bornemann et al. [6] where there is a strong argument on the selection of a group-specific governance as a changing ECB strategy, the diversity of addressees in the context of the UtilitEE project is taken into account by dividing the pilot end users into groups. For this purpose, consumers are segmented into three groups along the established core values explaining pro-environmental behaviour across cultures as defined in literature [7,8], biospheric values, altruistic values and a egoistic combined with hedonic values [8,9]. The interventions (recommendation, feedback) are tailored to the three segments. Third, following literature on the interplay of multiple factors determining ECB change, the above-mentioned trigger points for changing ECB are identified and specified for the different interventions. Fourth, two phases of behaviour change are distinguished. Bamberg in [9] shows that phase-based interventions have a bigger effect on behavioural change than one-shot interventions. Taking the phase model developed by Bamberg as a starting point, we distinguish between the following phases: In the initial phase, 'breaking up routines' or 'unfreeze', old routines are re-evaluated and changed to an alternative behaviour. Then, 'setting new routines' and finally 'refreezing' to establish the new behaviour to avoid a fall-back to old behavioral patterns is implemented. Finally, interventions strategies applied combine different tailored interventions described above in a systematic policy mix [10–15]. The so developed intervention strategies of the ECBA are systematically set up to target the different trigger points, segments and types of behaviours.

3. Business Models under Consideration

UtilitEE investigates and proposes new business models that must enable the application of highly effective energy efficiency schemes by utilities. These business models will be implemented in real conditions in the five UtilitEE pilot sites, therefore they are analysed in the framework of national regulations, focusing the fulfilment of detected constraints while they also facilitate the transition into easily accessible energy markets.

Two main approaches are examined in this context. On the one hand, regulatory landscape related to energy efficiency measures both at European and national level was studied, demonstrating that policy makers are putting great efforts in achieving 2020–2030 energy targets and CO₂ emissions reduction target. This led to the proposition of the following strategies a “Retailer as an ESCO” approach, built upon UtilitEE Energy Behaviour Change Framework. On the other hand, the legal framework affecting the development of demand response mechanisms has been examined too. Although demand response is gaining prominence as a means of providing flexibility in the electricity network, its development is hindered by the emergence of a new player in the electricity market: The Aggregator. The regulatory treatment of this new actor and its relationship with existing players appears to be a challenge and at the EU level demand response legal framework remains relatively sketchy and foundational, but demand response strategies are adopted on largely national basis. Therefore, the “Retailer as an Aggregator” model is thought to consider energy utilities to leverage on the energy saving by bidding consumer flexibility in energy markets, highlighting that this relies on the maturity of demand-response markets in national regulations and the more or less DSO/supplier profile of the pilot sites that will validate these models.

The active enrolment of the business stakeholders (pilot partners and end users) from the very beginning of the project has led to the selection of the final list of business models to be implemented and validated. Through the living labs activities, a set of questionnaires and surveys was used to collect feedback from the pilot sites in order to understand their business needs and interests. The Table 1 summarizes the business models that attracts the interest of the UtilitEE pilot partners. As a note, the prioritization on which business models will be tested in detail is not presented in the Table 1 for simplicity, although as the validation phase of the UtilitEE project is a 12-month period particular focus will be given to Comfort Preserving Energy Efficiency and Dynamic Retailers Pricing Schemas and Supply & Demand Management Business Models, the ones that appeal to all pilot partners.

Table 1. UtilitEE Business Models per pilot site under consideration.

Business Strategy	UtilitEE Business Models	Greece	France	Germany	Poland	Spain
Retailer as ESCO	Energy Efficiency Audits towards Near Zero Energy Building	x		x		
	Comfort preserving energy efficiency	x	x	x	x	x
	Supply-demand/Imbalance management	x	x	x	x	x
Retailer as Aggregator	Community VPPs				x	x
	DSO Costs Minimization	x	x	x		x
	Dynamic Retailer Pricing Schemas	x	x	x	x	x

4. UtilitEE Solution Architecture

UtilitEE’s vision is to deliver an ICT-based framework to encourage behaviour change toward energy efficiency by changing energy measurements into personalized feedback brought through engaging user interfaces. To realise this challenge, UtilitEE expects dynamic, spatially fine-grained and real time extension of building-level Operational Rating methodologies and enhanced Display Energy Certificates to deliver a comprehensive view of energy use in residences and office spaces rather than entire buildings. Revealing the impact of occupants’ behaviour on energy use will allow for the design and successful deployment of behavioural change framework via personalised messages is envisioned. In addition to the behavioural based approach, the system should enable end

user to directly interface with building devices either through sample monitoring and control or through enabling full automation on the basis of the different business models defined in the project. Along with the end customer viewpoint, the overall framework should enable access to the platform from Utilities as the key stakeholders setting their business objectives towards optimal energy management.

Addressing the list of the high-level functionalities as stated on the aforesaid description, the conceptual architecture is portrayed in the Figure A1, providing a high-level view of the major building blocks of UtilitEE Architectural framework.

5. Demonstration and Validation Activities

The main purpose of the pilot demonstration activities is to evaluate the UtilitEE framework performance, which also reflects the achievement of the project's objectives. Six groups of validation criteria have been identified: the Energy Efficiency criterion, the Environmental criterion and the Economic criterion are related to the energy consumption of users; the User comfort preferences criterion relies on indoor environmental quality parameters; the Behaviour change criterion focuses on the effect of the interventions during roll-out; and finally, the Business models acceptance criterion is used to validate the most interesting business models for the utilities.

The main stages for the pilot validation plans are defined as follows: (i) Identification of the preparatory activities, which includes the selection, acquisition and installation of the equipment needed for sensing and monitoring activities at pilot areas, (ii) Definition of the roll-out plan, in which the UtilitEE services are identified based on the level of intervention in the pilot sites as well as the different type of users participating in the pilot activities, (iii) Identification of the key aspects to report by the end of the validation process (iv) Setup of a specific timeline of the pilot activities plan for each pilot site.

The UtilitEE solution will be implemented and demonstrated in five pilot sites (Greece, France, Germany, Poland and Spain) involving various energy use cultures, market and climatic conditions. The selected pilot sites are of both residential and commercial use, exact figures with regards to the five UtilitEE pilot sites.

A crucial task of the pilot sites is to define active and passive zones in premises, as well as to decide which of the residential dwellings will be monitored based on the results of an extensive audit. For validation purposes, we define the "Target group" as the active participants/users for whom UtilitEE interventions will be activated during roll-out. The "Control group" refers to passive participants for whom only consumption data will be considered with no additional metering information as it can be seen in the Table 2 below.

Table 2. UtilitEE Pilot sites characteristics across EU.

Location and Climate	No. and Type of Buildings	No. of Active Pilot Zones (Target Group)
Athens, Greece—Mediterranean North Climate	2 Commercial	10
	53 Residential dwellings	25
Maurienne Valley, France—Alpine South Climate	1 Commercial	5
	2 Residential (91 dwellings)	20
Wroclaw & Katowice, Poland—Continental Climate	2 Commercial	7
	300 Residential dwellings	40
Trier, Germany—Atlantic Central Climate	2 Commercial	35
	4 Residential (32 dwellings)	54
Murcia, Spain—Mediterranean South Climate	2 Commercial	35
	4 Residential (120 dwellings)	35
TOTAL		266

The UtilitEE monitoring system has been designed with suitable equipment that can be easily installed & configured in pilot premises for seamless operation. This system will be able to sense the

ambient conditions inside the zone, to capture the thermostat(s) setpoints, to meter the total energy consumption of the zone (electric, heating/cooling were applicable), to provide extended recommendation to its users according to their behavioural profiles extracted through sensor reading, to eliminate vampire loads, to provide ad-hock remote control over specific loads (Lighting, HVAC, Radiator Valves, Plug Devices) and to automatically intervene over the same loads in order to minimise the energy footprint of the zone without affecting its users' comfort. Different combinations of this monitoring equipment will be implemented in order to allow the implementation of several Building Intelligence Levels: No Intelligence (BIL1), Only metering (BIL2), Partially Fledged (BIL3) and Fully fledged (BIL4). The relation between LoSs and their match with different BILs is shown in Figure 1 below.

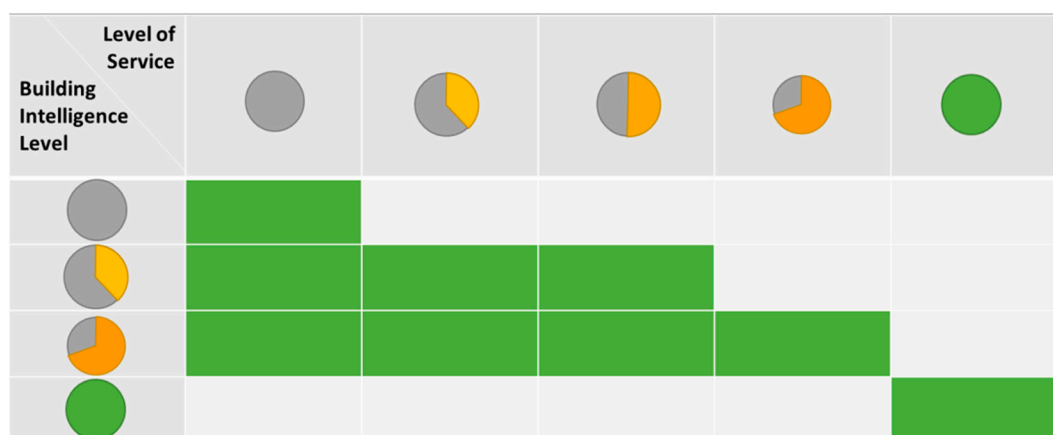


Figure 1. UtilitEE combination of Level of Services & Building Intelligence Levels.

An incremental roll-out of the behavioural change interventions will help to quantify the additive impact of more complex services (e.g., real-time feedback compared to informative billing, or semi-automation compared to personalized real-time feedback, etc.). The different level of services that will be rolled-out will define what can be measured and how the final evaluation can be performed. Accordingly, pilot trials and validation scenarios will be progressively rolled-out in different phases: (1) Initial calibration of behavioural profiles, (2) First real-life trial of the UtilitEE system and evaluation of its impact on occupants' behaviours, energy consumption and comfort/indoor quality preservation, (3) Optimization of behavioural change strategies and roll out of the second trial phase and respective evaluation, (4) Monitoring and evaluation of the persistence of pilot occupants' behavioural change.

6. Conclusions

In this paper, we have presented the concept of UtilitEE project. A project that anticipates to deliver a feasible solution mainly for achieving energy efficiency and energy cost reduction through end users behavioural change in residential and tertiary buildings. At the same time, UtilitEE solution aims to become an attractive tool in the hands of energy market actors and key stakeholders who will invest in innovative energy services.

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Appendix A

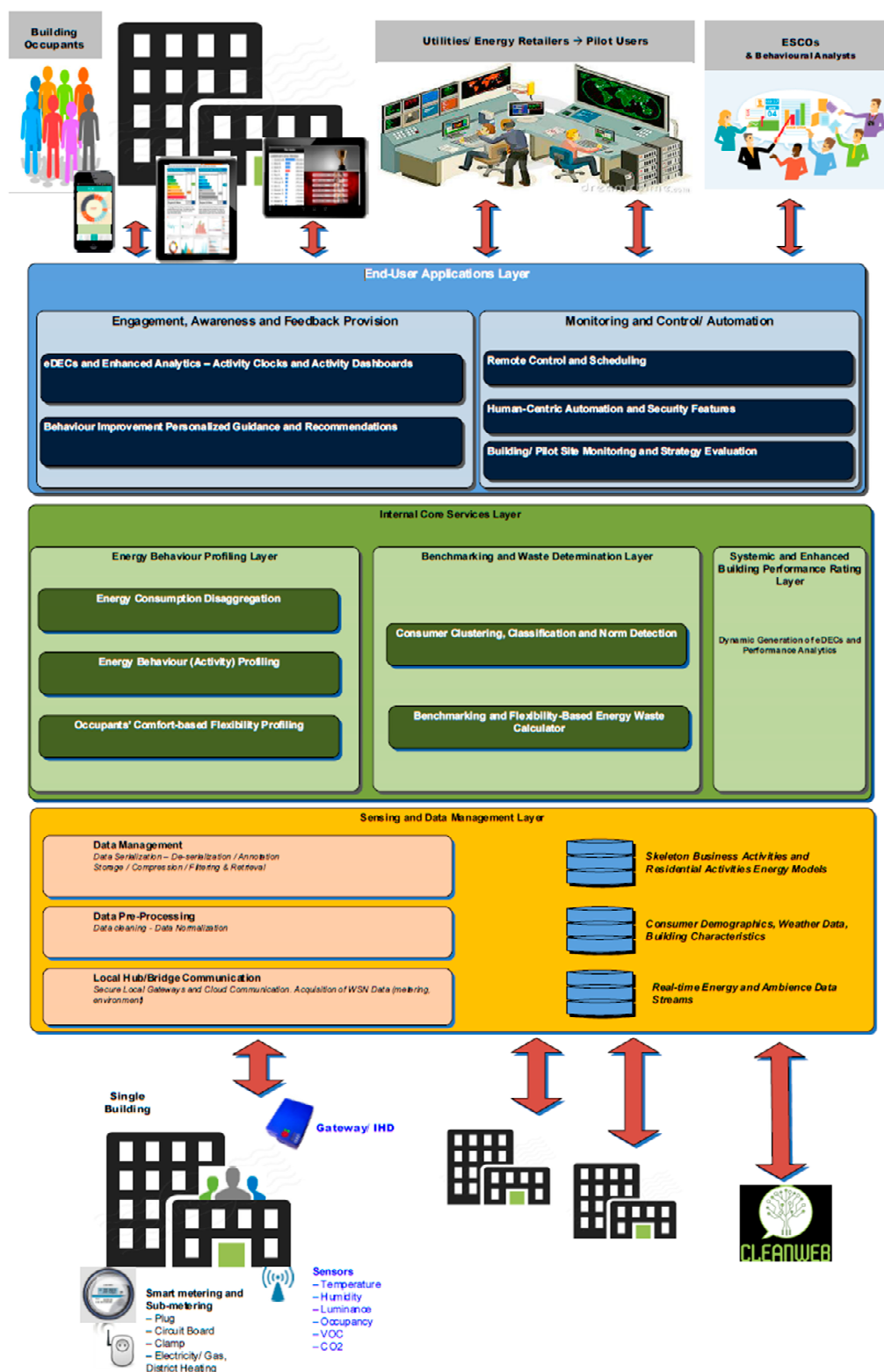


Figure A1. UtilitEE Conceptual Architecture.

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