EMPOWERING CUSTOMER ENGAGEMENT BY INFORMATIVE BILLING – A EUROPEAN APPROACH

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ABSTRACT

Programmes aimed at improving end-use energy efficiency are a keystone in the market strategies of leading distribution system operators (DSOs) and energy retail companies and are increasing in application, soon expected to become a mainstream practice. Informative services based on electricity meter data collected for billing are powerful tools for energy savings in scale and increase customer engagement with the energy suppliers enabling the deployment of demand response programmes helping to optimise distribution grid operation. These services are completely in line with Europe's 2020 strategy for overall energy performance improvement (cf. directives 2006/32/EC, 2009/72/EC, 2012/27/EU).

The Intelligent Energy Europe project EMPOWERING involves 4 European utilities and an international team of university researchers, social scientists and energy experts for developing and providing insight based services and tools for 344.000 residential customers in Austria, France, Italy and Spain. The project adopts a systematic iterative approach of service development based on envisaging the utilities', customers' and legal requirements, and incorporates the feedback from testing in the design process.

The technological solution provided by the leading partner CIMNE is scalable open source Big Data Analytics System coupled with the DSO's information systems and delivering a range of value adding services for the customer, such as:

- *comparison with similar households*
- *indications of performance improvements over time*
- *consumption-weather dependence*
- *detailed consumption visualisation and breakdown*
- *personalised energy saving tips*
- *alerts (high consumption, high bill, extreme temperature, etc.)*

The paper presents the development approach, describes the ICT system architecture and analyses the legal and regulatory context for providing this kind of services in the European Community. The limitations for third party data access, customer consent and data privacy are discussed, and how these have been overcome with the implementation of the "privacy by design" principle is explained.

1. INTRODUCTION

The idea of energy feedback services complementary to billing targeting improved end-use energy conservation is not new. Early studies reported in literature date from the 1970s and 1980s. The tested services ranged from monthly reports presenting comparisons with previous period's consumption [1], climatically corrected data [2], and comparisons to similar households [3], [4]. The communication was sent in paper complementary to bills and more recently by email, SMS or through more elaborated web portals. Considerable number of reviews of intervention studies and their effect on the energy consumption has been published [5], [6], to cite a few.

To engage users, the information should be understandable, permitting to analyse the own consumption and draw inferences about it, answering questions such as: "How much did I save this year?" or "Are my new energy-efficient appliances really saving energy?" or "How am I doing compared to people in houses like mine?" Comparisons should be perceived as valid and meaningful for the users (similar house characteristics, geographic location, lifestyle, etc.) and different criteria for producing of quality comparative groups have been investigated [7].

On the other hand, it was not before the last decade when these services received wider uptake in the utility sector due to technological advancements facilitating their implementation in large scale, permitting analytics by using weather, historical and other personal data. The relatively low-cost of such services and the potential they offer to improve customer satisfaction makes the offering not only to growing, but becoming a necessary part of the portfolio of the utilities in the competitive market.
There are actually a number of companies offering this kind of services as SaaS, some of them serving dozens of utilities with several millions of customers, primarily in the U.S. market (Opower, C3 Energy, Tendril). The penetration of these services in the European market has been slower due to the differences in the national legislations, diverse cultural attitudes and restrictions regarding privacy issues. Most of the initiatives have been limited to utility proprietary tool design projects, without common methodological standards, only partly based on social science knowledge [8], [9], [10], [11]. Despite of the strong marketing of such services recently, there is still lack of presented methodological approaches and the software implementations are only roughly outlined.

The present paper describes the approach adopted in the Intelligent Energy Europe project EMPOWERING [12] for developing and implementing of a range of insight based services and software tools for the utility companies' customers. The services target energy savings and increased customer satisfaction on a basis of detailed information bringing mutual benefit, trust and loyalty.

EMPOWERING starts over current state-of-the-art and is inherently suited for the European market due to its flexible and adaptable solution concept capable to address different requirements arising from dissimilar national legislation and utility-specific technical requirements, without major implementation effort.

The project involves 4 European utilities (DSOs & retail companies) (Linz AG – Austria, GEG – France, IREN – Italy and El Gas – Spain) and an international team of university researchers, social scientists and energy experts. The technological solution developed by the lead partner CIMNE in close collaboration with the utilities is an open source big data analytics system exchanging data with the utilities under high security and privacy standard.

Delivered services involve 344.000 customers and after the initial phase of developing and testing have been deployed to an experimental group of 272.000 customers to run during one year of pilot operation until October 2015, maintaining a control group of 72.000 customers for evaluation of results.

The project pretends considerable impact and the meeting of a number of quantitative performance indicators such as energy savings ranging from 4-8% on average for customers with conventional and smart meters, and 15-20% increase in customer satisfaction evaluated in comparison to the control group. The strategic objective towards year 2020 is the achievement to deliver the EMPOWERING services to 2.5% of the electric and gas market in the participating countries.

The following sections present the European legal context, the development approach, the services and system architecture and discuss the challenges and the way they have been met in the practical implementation.

2. EUROPEAN LEGAL CONTEXT

Within the EMPOWERING project, a strong emphasis has been placed on the analysis of the legal context when providing energy feedback services based on collected metering data on a European level. The use of smart meters offers numerous new ways for delivering services to the customers, but at the same time raises concerns about the collection and access to fine granularity consumption, considered personal data.

The type of data (nature/interval of measure) to which the utility has access to within the exercise of their duty determines the types of services that may be deployed and how. Each type of data should be analysed from the following perspective:

- *Are data necessary for billing? In this case the utility shall not require additional consent of users to collect it and use it for providing the informative services.*
- *Or do the data require customer's consent to be collected and displayed? This may be the fine granularity data such as 15 min data points.*

The large-scale roll-out of smart electricity metering in Europe is mostly conducted by the DSOs, which includes purchase, installation, operation and maintenance. Each Member State defines the conditions of data processing that require consent of end-users to be performed as well as defines under which criteria aggregated data may be no more considered confidential. The Member States have different approaches to the conditions in which DSOs are allowed to treat personal data for the exercise of their duty. This is an essential point since unambiguous consent is difficult to obtain timely from an end-user and may be revoked at any time thereby weakening the energy savings potential and economic viability of services offered. Table 1 gives an overview of the essential questions that should be asked when implementing the EMPOWERING services in a country.

EMPOWERING has carefully addressed these potential issues to minimise the risks and increase the customers' acceptance of new metering technologies by analyzing carefully the European legislation. The results from this analysis have been adopted in the design approach in order to enable the widespread adoption of the services across Europe.

Table 1. Key questions for implementation

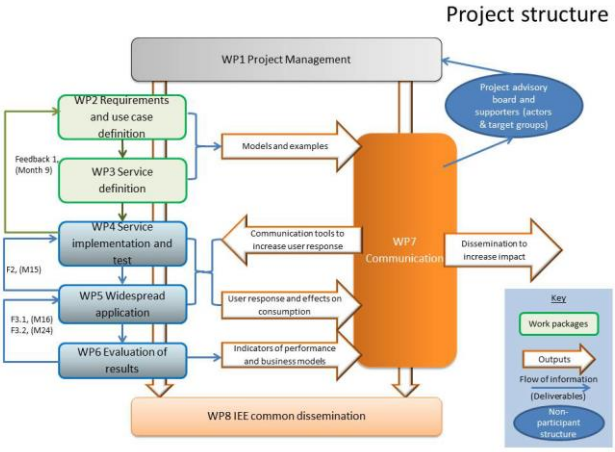
Nº	Key questions
1	Is energy consumption data considered private?
2	Is the DSO or retailer allowed to treat end-user data without asking for consent from the user?
3	Must the consumer give consent to the DSO to communicate a couple "energy consumption data - contract number" with or without a building ID to a third party?
4	Must consumers be informed that data processing is performed by a third party if data is not anonymized (contains name and/or address)?
5	Is aggregated data at the scale of a building considered private?
6	Are DSO or retailer subject to energy efficiency targets?
7	Is there a clear attribution of role concerning the provision of energy services?

3. APPROACH

The EMPOWERING concept was initially conceived as a central analytical engine exchanging data with the utility systems and providing the services to the customers through utility own-built interfaces – informative energy reports complementary to billing or online tools.

The system was conditioned to the requirements imposed by treating with utility data from smart meters, a data set that can increase in size and attain petabyte scale. The other stipulation was to enable powerful analytic capabilities, implementing a system using 100% open

Figure 1. Project work structure



source software. No additional limitations were imposed and the system should be capable to address the requirements of any utility and adapt easily to different requirements set by national legislations. The specific system features were naturally shaped during the iterative development process by collecting service and utility system requirements followed by prototype development, testing and redesign.

The development process included two end-user and utility staff feedbacks in the design phase obtained by specifically designed surveys for evaluation of usability at each of the 4 pilots, and a feedback from an external board of experts from energy companies' associations, consumer associations and municipalities, widely representing the service target groups. After the development and final testing, the services were extended to the whole experimental group of 272.000 customers. The project work structure is presented in Figure 1.

The starting point of the development was the collection of the service and data requirements, commented below.

The service definition was preceded by analysis of the state-of-the-art of existing services. An exhaustive revision was done, extended over all the information resources available to the partners, such as reports, articles and web resources. Additionally, the 4 partner utilities defined services from their own ideas and necessities. The final collection resulted in a comprehensive set of services falling into 9 conceptual groups (see Table 2).
For each service the necessary data input and output was defined. The data input consisted basically of: i) utility available data (consumption, contract details), ii) end-user data (dwelling characteristics, main equipment, family size) and iii) third party data (meteorological data).

In parallel, a description of the available data in each of the utilities was collected, including consumption data granularity as well as specific relations in the utility databases. The latter permitted in a next stage to define the generic EMPOWERING data model allowing the decoupling of the data exchange from the specific database characteristics.

Table 2. Conceptual groups of services

Nº	Service component groups
1	Comparisons with similar households
2	Comparisons with the own previous consumption
3	Detailed consumption displaying
4	Energy saving tips
5	Analysis of consumption-weather dependence
6	Estimated prediction of consumption
7	Alerts
8	Consumption goal setting and follow-up
9	Challenges to raise awareness and rewards

By cross-comparing the obtained set of services with the available data, the possible services for each utility became evident. Consequently, the utilities made their final selection of services and implemented in their systems the user interfaces displaying the service output to the customers. On the other side, the analytical part of the services requiring big data handling capabilities was implemented in the EMPOWERING Analytical Engine.

In order to maintain the customer's privacy and inherently comply with the European legislative requirements, the EMPOWERING solution adopted largely the "privacy-by-design" principle. This was achieved by accepting only strictly anonymised data and adopting treatment procedures that do not permit individual customer to be recognised outside the utility, or customers to be able to recognise those to which are compared to. In any case, only the necessary information for the services is exchanged and is kept in the system only for the necessary time. Some details over the specific solutions are provided in the next section.

The EMPOWERING system permits the delivery of utility-tailored services due to its scalable and modular structure and a series of enhancements in its design.

1) The grouping criteria for comparison with similar households or users are completely flexible and can be set upon virtually any existing parameter (location proximity, household size, age, electricity tariff type, etc.) or combinations of them. The grouping criteria are set by configuration, separately for each utility company, allowing also similar services to run differently for different utilities.
2) For quality grouping, additional criteria for cutting off extreme outliers can be configured, as, e.g., skewed distribution or presence of outliers in the group can pose a potential problem by making e.g. an "average" consumer look like "low" consumer compared with the group average.

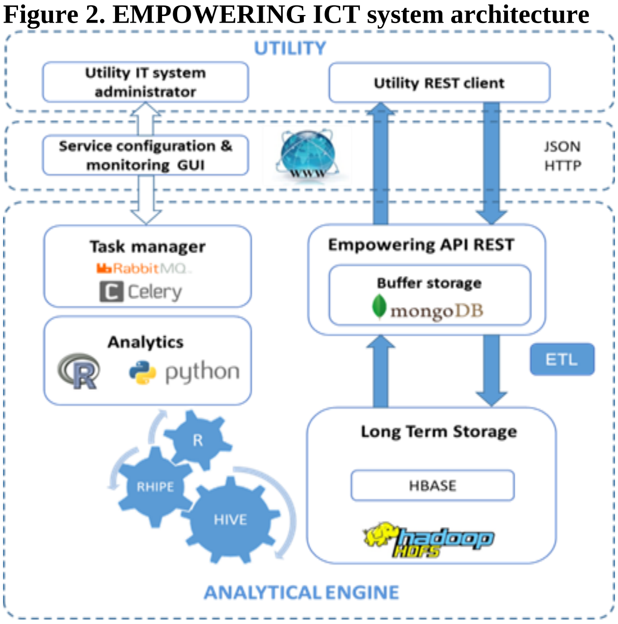
3) Services are adaptable to different data granularity and their operational periodicity is freely configurable, permitting also different levels of service complexity depending on the availability of data for each customer. This guarantees a minimum level of service for all customers based on the utility-available data, while additional data provided by the customer lead to more advanced and personalised services.
4) A web interface is provided to the utilities where, after secure identification, the configuration of all service parameters can be done by themselves.

4. SYSTEM ARCHITECTURE

The EMPOWERING ICT system architecture has been implemented as a central engine providing analytic services to multiple utilities by exchanging data with them through a standard API. The Analytical Engine is an open source solution based on the Apache Hadoop's "ecosystem" of tools for handling large-scale data. The end-user interfaces (informative billing reports generators, online tools) are integrated in the utility IT systems and existing web portals.

This approach has been considered to have several advantages. First, the analytical part is concentrated in one place, avoiding high implementation and maintenance costs. Second, the Analytical Engine is easily coupled with the utilities through a standard Application Programming Interface (API) with minimum effort on their side. Third, the integration of the end-user interfaces within the utility permits to offer a unique presentation style for the services, reinforcing the corporate image towards customers, facilitating also the integration with the customer service.
A schematic diagram of the EMPOWERING architecture indicating the used technologies is presented in Figure 2.

Figure 2. EMPOWERING ICT system architecture



The Analytical Engine can be divided in 4 conceptual domains:
Application Programming Interface (API): Based on the Representational State Transfer (REST) architectural style, the API is implemented in JSON codification and allows secure data exchange between the utility IT system and the Analytical Engine (encrypted two-stage certification). The API permits the utilities to insert and delete data, and retrieve results from analysis.
Task management system: Synchronises the operation of the system and permits the different technologies to work together (based on RabbitMQ and Celery).
Storage: Divided in two parts of the system:
i) a buffer storage in MongoDB is used to allocate the data received by the utility and the results to be retrieved, integrated with the REST API. The buffer storage keeps data only the necessary time to assure fluent service performance.
ii) long term storage in HBASE over Hadoop is used to finally allocate the data necessary for analysis. Scalable and distributed over different machines on demand, it has huge capacity for storage and backup of data.
Analytics: Integrated set of technologies and software libraries, specifically designed for energy data processing, analytics and machine learning in big data environment. Based on Hadoop MapReduce paradigm and Hadoop Distributed File System (HDFS), the EMPOWERING solution enables the use of the R and Python open software packages and libraries, both supported by large scientific communities.

The EMPOWERING services operate asynchronously; data can be pushed by the utility all the time and the results are requested on a schedule. The services are implemented as separate modules and their mode of operation is configured through a web-based Graphic User Interface (GUI) made available to the utility IT administration staff. The GUI permits to configure the type of services, the operational schedule, the grouping criteria, outlier elimination criteria, as well as monitoring of the calculation progress.

Preserving the data privacy has been a primary concern for the design of the EMPOWERING architecture. This has been solved through design - all the customer data is anonymised and transferred coded with unique identifiers. Any personal data (name, address, etc.), remains at the utility. The geographic location needed for some of the services is specified broadly, not permitting any particular customer to be recognised outside the utility.

The minimum number of customers in a comparison group may suppose a privacy problem in some national legislation and may vary from one country to another. Utilities may also impose additional limitations, but imposing fixed criteria is not possible. In EMPOWERING this has been solved by delivering of the comparison group size together with the result of the service, where applicable. In that way the utility can apply the required filters on its side, without necessity to any modification in the Analytical Engine.

The above considerations and features embedded in the EMPOWERING system design make it very appropriate solution for the European market end-user energy saving services.

5. DISCUSSION

The EMPOWERING project wants to trigger the most market-oriented utility companies to offer at least 2 new energy services to their customers (from low cost measures to specific measures over the space heating and cooling systems). In other words, the EMPOWERING consortium aims to accelerate the transition of the use of this type of services from pioneer companies to mainstream best practice.

The offered energy feedback services wants to improve customer satisfaction in regard to DSOs and energy retail companies, as shared information in a competitive market leads to trust and mutual benefit. The services are especially helpful in convincing customers in the need for rolling-out smart meters to a large majority of households.

The challenge is to use new metering technologies and more information in order to change energy consumption. When customers are receiving more insight into their energy usage, they also obtain more value from their utility, and this allows utilities to improve customer engagement.

Increased engagement not only allows utilities to build a better relationship with their customers, it also helps them achieve efficiency goals. Although the massive roll-out of smart meters can be a part of energy savings, many utilities now recognise that motivating people to change their behaviour can have a significant and persistent impact on energy usage.

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[1] S.C. Hayes, J.D. Cone, 1981, "Reduction of Residential Consumption of Electricity Through Simple Monthly Feedback", *Journal of Applied Behavior Analysis*, vol. 14, 81-88.

[2] L.L. Layne, W. Kempton, A. Behrens, R.C. Diamond, M.F. Fels, C. Reynolds, 1988, "Design criteria for consumer energy report: A pilot field study", *PU/CEES Report No. 220*, Center for Energy and Environment Studies, Princeton University.

[3] W. Kempton, 1995, "Improving Residential Customer Service through Better Utility Bills", *E-Source Strategic Memo*, SM-95-1, E-Source, Boulder, CO, 1995.

[4] W. Kempton, L. Layne, 1994, "The consumer's energy analysis environment", *Energy Policy*, vol.22 (10), 657–665.

[5] W. Abrahamse, L. Steg, C. Vlek, T. Rothengatter, 2005, "A review of intervention studies aimed at household energy conservation", *Journal of Environmental Psychology*, vol. 25, 273-291.

[6] S. Darby, 2006, "The Effectiveness of Feedback on Energy Consumption", *Environmental Change Institute*, University of Oxford, April 2006.

[7] M. Iyer, W. Kempton, C. Payne, 2006, "Comparison groups on bills: Automated, personalized energy information", *Energy and Buildings*, vol. 38, 988-996.

[8] J. Froehlich, L. Findlater, J. Landay, 2010, "The Design of Eco-Feedback Technology", *Proceedings of ACM CHI 2010 Conference on Human Factors in Computing Systems*, Atlanta, Georgia, USA.

[9] M. Weiss, T. Staake, F. Mattern, E. Fleisch, 2012, "Powerpedia: changing energy usage with the help of a community-based smartphone application", *Personal and Ubiquitous Computing*, vol. 16, 655–664

[10] K. Ehrhardt-Martinez, K. A. Donelly, J. A. Laitner, 2010, "Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity Saving Opportunities", *Report Number E105*, American Council for an Energy-Efficient Economy, Washington. ,U.S.A.

[11] K. Farley, S. Mazur-Stommen, 2014, "Saving Energy with Neighborly Behavior: Energy Efficiency for Multifamily Renters and Homebuyers", *ACEEE White Paper*, American Council for an Energy-Efficient Economy, Washington, U.S.A.

[12] Empowering customers to save energy by informative billing (EMPOWERING), Intelligent Energy Europe project, contract number IEE-12-697-SI2.645843 (www.iee-empowering.eu)