# PRIVACY IN ACTIVE DEMAND SYSTEMS

E.G. (Gerben) BROENINK
TNO - the Netherlands
gerben.broenink@tno.nl

G.B. (George) HUITEMA
TNO, RuG - the Netherlands
george.huitema@tno.nl
g.b.huitema@rug.nl

G. (Gabriela) BODEA
TNO – the Netherlands
gabriela.bodea@tno.nl

R. (Raúl) BACHILLER PRIETO
Iberdrola – Spain
rbpr@iberdrola.es

L. (Lorenzo) PIZZOFERRO
Enel - Italy
lorenzo.pizzoferro@enel.com

## ABSTRACT

*This paper presents an overview of the privacy issues and measures which have been taken into account at a number of smart grid pilots on Active Demand, a technology which raises the efficiency of the energy system. Since Active Demand is based on the gathering of detailed information about the energy consumption of consumers it might impact their privacy. As part of ongoing research privacy issues are identified, and a number of possible mitigation strategies dealing with those privacy issues are studied and presented in the form of a Privacy Impact Assessment. This paper is based on preliminary results of the research project ADVANCED[1].*

## INTRODUCTION

Currently, many active demand pilots are held all over Europe. Active Demand (AD) is a technology used to increase the efficiency of the energy grid. With AD systems the balancing of the energy network can be improved by actively managing the demand at the consumer side. By this AD capacity the system efficiency will improve and the feed in of renewable power, with a strong fluctuating production profile, can be done without disturbing effect on the stability of the grid.

As AD management requires much more detailed information about the needs of the consumers than in a traditional energy context, the use of AD techniques also could impact the privacy of the consumer. In this context, privacy is understood as the right of the individual to have his identity, agency and action protected from any unwanted scrutiny and interference. It reinforces the individual's right to decisional autonomy and self-determination. (As described in [4]) As a consequence, private usage and consumer data may be processed by one or more related parties in the energy delivery business through the overlaying data network. Additionally, an AD system can also partly control end-users appliances, i.e. by switching devices on and off in the home. Thus AD could affect the autonomy of the consumer. In summary, the use of AD may cause privacy issues. Of course the impact of these privacy issues will depend on the context in which the consumer and the related energy parties operate. For a good working business environment, proper mitigation strategies limiting the privacy issues have to be developed. At the same time however, implementing those mitigation strategies can cost part of the potential functionality of AD. So, while mitigation strategies could be formulated, implementation challenges remain. The nature of these implementation challenges can vary widely and be of different natures: technical, operational, legal, etc. Figure 1 gives a schematical view on the setup of the problem domain.

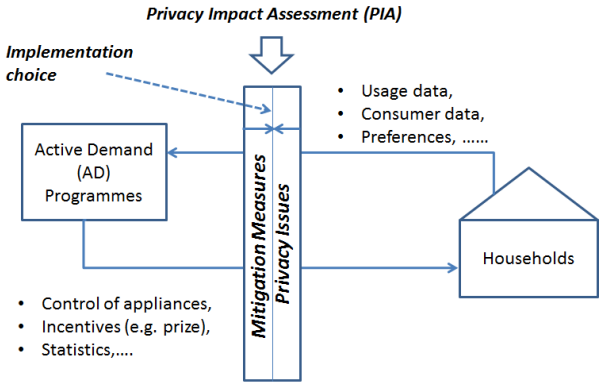


Figure 1. Set-up of the problem domain: AD programs interact with households. A PIA gives insight in the related privacy issues and possible mitigation measures, thus helping in making a deliberate choice when implementing.

Up to now a number of AD pilots have been carried out in Europe. Most of them were focused on the AD techniques itself and its effect on the energy efficiency. Very little attention has been paid to the impact on the privacy and how to secure it whilst keeping the AD benefits. This paper presents an overview of the privacy issues and mitigation measures which have been taken into account in some EU smart grid pilot sites.

1 ADVANCED (Active Demand Value ANd Consumers Experiences Discovery) is a research project co-funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 308923, that aims to shed light on ways to overcome the barriers hindering the mass deployment of Active Demand (AD) in Europe.

Moreover we apply a so-called Privacy Impact Assessment (PIA) to the AD domain. As this analyses privacy issues and matches those privacy issues to possible mitigation strategies, it is believed that this will be a very helpful tool to be used in the early development and implementation of AD programs.

The paper is based on preliminary results of the research carried in the FP7 project ADVANCED[1]. The ADVANCED project is built on a unique empirical knowledge base including data generated in four different real life AD demonstration projects[2] and a database[3] containing a meta-analyses of other 100 AD pilots, involving 450.000 residentials. The overall goal of ADVANCED is to derive key success factors of AD and give recommendations for the future design of AD programs [3]. As a basic methodology ADVANCED uses cross case analyses performed on the AD database in which the various pilot conditions are tested for their effect on the relevant KPIs [6].

One of the tasks of the ADVANCED project is to identify main privacy issues related to AD systems based on literature research and the evidence gathered from the four EU pilot sites. Main categories of privacy issues are evaluated and, mitigation strategies are formulated.

This paper focusses on the mitigation strategies which are based on the pilot experiences. Moreover a general framework is presented, which can be used to systematically identify main AD privacy issues and possible countermeasures. Preliminary results of this research underscore certain differences within the European Union. For example, differences in the perception of people about privacy and data protection have been identified.

## ACTIVE DEMAND (AD) MANAGEMENT

The electricity consumption of final consumers varies in time. Besides, the integration of distributed energy resources and intermittent renewable energy, supply varies in time as well. The aim of Active Demand (AD) management is to bring this variation on both sides (consumption-generation) in balance by acting on the demand side. Such management can be done e.g. by providing the consumers with precise information on their usage together with means to react to incentives, in particular, price schemes.

Various AD technologies and strategies facilitate the flexibility at the demand side. Some of these are: smart energy displays, smart plugs, smart appliances and differentiated price plans. All these technologies basically aim at facilitating adaptive electricity consumption of households such that the electricity consumption is stimulated when e.g. power is available in abundance and restricted when it is scarce on the market.

The informed consumers can thus be motivated to change their consumption behavior. Ultimately the overall energy efficiency is increased as well as the system reliability. Moreover, the availability of active demand management is an important factor in the planning of infrastructure and related to that in the investment strategy. An indication of the large potential of AD is given in [1]. Given the latent capacity of AD further development of adequate AD solutions has become a key priority of European energy policy. Since the EU still has a long way to go to reach their intended energy efficiency goals by 2020 and beyond, further deployment of AD will unlock additional energy savings.

## AD CASE STUDIES: HANDLING PRIVACY ISSUES

Within the ADVANCED project several smart grid pilots are analyzed for their active demand solutions. This paper will focus on two pilot sites which represent different AD approaches: A. Castellón ADDRESS pilot and B. Enel INFO+ pilot. In the following subsections both pilots will be explained together with a main focus on their privacy issues and mitigation strategies carried out.

### A. Castellón ADDRESS pilot

**Pilot description**

The Castellón ADDRESS[4] field test was located in the Spanish city of Castellón (Mediterranean Coast). The network in this region is feeding 100.000 points of supply (200.000 inhabitants) with a meshed MV network typology with radial exploitation. Around 300 consumers were recruited to participate in the field test. The equipment installed in all the consumer premises were the following: an Energy Box (EBOX) to control and register the appliances within each household, (5) smart plugs to connect appliances, an energy meter, a smart washing machine and (in some houses) air-conditioning management equipment. To manage the demand and individual loads, home devices were

2 Enel Info+, E-DeMa (RWE), ADDRESS pilot sites (Iberdrola and ERDF).

3 This database is constructed and maintained by VaasaETT.

4 ADDRESS ("Active Distribution network with full integration of Demand and distributed energy RESourceS") was a five-year large-scale R&D European project (June 2008- June 2013) and co-funded by the European Community's 7th Framework program (FP7/2007-2013). http://www.addressfp7.org

switched on/off by the corresponding Energy Box, automatically based on the received price-volume signal. To improve the feedback of the pilot, several questionnaires were analyzed during the pilot.

**Aim of the pilot: Demand Response**
This field test analyzed the relationship between the so-called Aggregator Toolbox and the consumers through the Energy Box. In order to be able to manage the demand and individual loads, consumer behavior, home area network, aggregator toolbox and interoperability & communications between aggregator-energy box the home area network were also tested.

**Handling privacy**
The data generated by the participants in the pilot is owned by the distribution network operator, Iberdrola Electricity Distribution Company. The latter has no direct access to consumer personal data and also never contacted the consumers (it was Iberdrola Generation Company). The distribution network operator only received anonymous data from the consumers. The anonymous data included: 15-minute interval data of the total active energy used (measured by another device different to the official smart meter in the pilot), the energy used of those appliances connected at the smart plugs, data generated by a smart washing machine and the answers given to a series of questionnaires. This information was used to analyze the effectiveness of a certain price-volume signals sent to the Energy Box generated by the Aggregator Toolbox and consumer behavior.

In Spain the deployment of smart meters and remote management systems is mandatory. The data is collected by the DSO (owner of the meters) and not given to the retailer because, at this moment, there is not a regulation that supports it. Data generated by the smart meters in the country is analyzed for different proposes.

There were a series of privacy and data protection measures which were taken during the pilot:

- The Energy Box could only switch devices, while staying within the boundaries given by the consumer. Moreover, there was the option at the participants' disposal to override the whole system or certain appliances to avoid being controlled by the system. In this way, the consumer always stayed in control. The privacy issue which was protected by this requirement was that the consumer should be in control of his own devices.
- There were clear statements about information distribution. The distribution network operator only received anonymous data. The privacy issue which was protected by this requirement is third-party data sharing.
- There were four contact moments with the consumers. While this (probably) had more reasons than only privacy reasons, it was a clear way of informing the consumer about what is happening. In this way, the privacy issue taken into account in this way is that consumer should be informed about what is happening to his data.
- A contract was signed in which obligations and rights of the parties involved in the pilot regarding participation and data protection were gathering. In this way the privacy issue addressed was that of informed consent.

Moreover, in the questionnaire conducted at the end of the pilot some questions where included to deal with participants' perception about privacy of data and personal feelings about technology intrusiveness.

## B. Enel INFO+pilot

**Pilot description**
The Italian electric grid operator Enel Distribuzione started in 2011 in the South of Italy with the Isernia Project the development of a high performance, reliable and secure smart grid environment. The scope of the project was the implementation of innovative solutions aiming at optimally regulating the bi-directional energy flow on the Medium Voltage distribution networks while integrating Distributed Energy Resources (DERs) with the assurance of high system reliability and security. The Enel Info+ pilot is part of this context through the involvement of consumers in terms of an increased understanding and control of their own usage of energy representing the first step towards active demand. In this large-scale pilot, an Enel smart info device is used by a representative sample of families served by the Carpinone primary substation in some municipalities in the area of Isernia that started in December 2012. The consumers participating in the project receive an energy monitoring kit including Enel smart info and dedicated interfaces that they are supposed to use for one year to view how much electricity is currently being used in their household and to process their historical consumption. A full color, touch screen in-house display (Smart Info Display), and two software applications (Smart Info Manager and Smart Info Mobile, for personal computers and smart-phones respectively) have thus been conceived to monitor, collect and analyze energy data. Prosumers, consumers who are also producers of renewable energy, here by photovoltaic or mini-eolic plants, receive an additional device in order to manage both production and consumption metering data. The consumers living in the 19 municipalities included in the project have been observed by Enel Distribuzione since 2011. This data has been compared with the pre-pilot ones as well as analyzed in relation to other factors.

**Aim of the pilot: Energy Efficiency**
The scope of the pilot project is to demonstrate whether giving end-users feedback on their energy consumption may cause more efficient energy behavior.

**Handling of privacy**
Participation in the Enel Info+ pilot project is voluntary, and it requires the consumer to sign an agreement with Enel Distribuzione defining terms and conditions of the pilot and the rights and liabilities of the related parties. This agreement also addresses the privacy issues related to the collection and processing of sensitive consumers data during the trial. Key aspects concerning privacy issues are:

- The consumer is aware that his personal data will be processed by Enel Distribuzione only for purposes related to the pilot;
- All pilot data is processed by Enel Distribuzione with the cooperation of universities and specialized institutions acting for this purpose;
- The personal data is automatically collected and stored just for the time that is necessary to achieve the target of the pilot.
- Enel Distribuzione will use this data in aggregated and anonymous form only for technical and scientific purposes.
- In order to study the trends in electricity consumption of consumers participating in the project, Enel Distribuzione will use the consumption data of the consumers from the year before the beginning of the pilot.

At this time more than 4.000 kits have been delivered to the involved customers. No consumers refused to take part to the pilot due to privacy issues. This scenario reflects what already happened in Italy during the introduction of electronic smart meter where no particular claims with respect to privacy were registered. Anyway, privacy issues have been handled with great care and transparency during the pilot. Before the pilot started the project was presented to local consumer associations obtaining their support. Every customer has been informed of the pilot through a letter describing the project and a copy of the agreement in order to let people be aware of terms and conditions.

## PRIVACY IMPACT ASSESSMENT (PIA) IN ACTIVE DEMAND

Within Active Demand technologies privacy is considered to be an important issue, see the smart meter cases [2], [7]. As a result, privacy should be taken into account when designing active demand technologies. First questions to arise are how privacy should be taken into account, which privacy issues are to be accepted, which issues should be solved or mitigated, and finally at what price. Especially when it is considered that some mitigation strategies might reduce the possible gains of AD. To solve this issue, the creation of a specific, so-called Privacy Impact Assessment (PIA) matrix for AD purposes has been started.

A PIA is a methodology to assess the possible impact of a technology on the privacy of the consumer. The aim of the PIA is to specify these impacts, together with possible countermeasures, so they can be used in the early development and entire lifecycle of the technology and its applications. In this way, privacy is incorporated in the design phase (privacy by design) and privacy issues can be mitigated or accepted. Thus the resulting PIA matrix can be used to analyze active demand use cases and make privacy decisions while the technology is still in the design phase. In this way, a balance can be found between privacy and the costs of mitigation strategies. The PIA methodology has been described in several papers, and is used in different contexts[8]. In this paper, we will use the definitions of Bodea[4] and Bodea e.a. [5]. In [4] the intent of the PIA is described to be : *"(…) to identify, in a timely manner, risks posed to the individual's privacy by the system (…) and to identify and devise appropriate solutions either by process or in the design and deployment of the technology in order to minimize the privacy risks."*

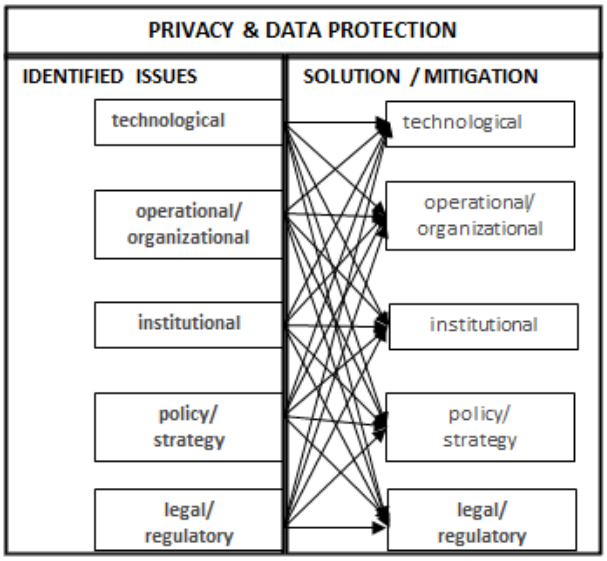


Figure 2: The PIA matrix in AD, showing a mapping of identified issues to mitigation strategies. (a simplification from [5]).

A PIA is not only a methodology to find issues, but it also specifies possible solutions or mitigation strategies. This is schematically visualized by the matrix (Figure 2), a simplification from [5]. As shown, the identified issues are Technological, Operational/organizational, Institutional, Policy/strategy and Legal/regulatory. At the same time, the Solutions/mitigations are divided in the same categories, and all the issues are matched to

the categories of Solutions/mitigations. As a result, it is possible to solve an operational risk with a technical solution, and vice versa.

This matrix gives a broad scope to the PIA. The scope is not limited to the technological data protection issues but all privacy issues are in scope. Following Bodea [5]: *"a PIA should not only include data protection, but also privacy protection"*; also, *"a PIA should not be limited to a risk assessment, but also include risk management"*. Finally, *"a PIA should not be limited to a general nature, but certain technologies require specificly defined PIAs. As a result, a PIA should be technology specific, and include specific solutions and mitigation strategies."*

## CONCLUSIONS

In this paper we presented a few possible mitigation strategies dealing with the identified privacy issues in Active Demand (AD) pilots and presented them in the form of a Privacy Impact Assessment. Within the ADVANCED project we are applying the PIA methodology on some AD programs. Our preliminary conclusions are twofold:

**Use of Privacy Impact Assessment (PIA)**
It has been found that:

- The PIA could be an effective methodology to assess the privacy impact of AD technologies
- Privacy is a relevant topic for the AD pilots held so far, however, the pilots are not actively researching privacy as topic
- Privacy should be researched with the aim to discover new ways of impact mitigation within AD programs.

**Preliminary PIA results of ADVANCED**
In ADVANCED the first step is to gather information from the AD pilots in order to determine possible privacy issues. The next step will be to formulate corresponding solutions and/or mitigation strategies. This work is currently in progress, and will be published when it is ready. This paper focuses only on a number of privacy issues identified within the pilots. Moreover in the two pilot descriptions, the discovered privacy issues are already given. Combined with the information from other pilots within the ADVANCED project (ADDRESS France, EDema Germany), the following preliminary list of potential privacy issues, which are actively mitigated by the pilots, is produced:

1. Data distribution to third parties should be limited
2. Informing the user about why the data is gathered, and what's happening with the data
3. No more information should be gathered than needed for a given purpose
4. The user needs to give his consent to the gathering of the information
5. Data should be protected
6. The consumer should be in control of his own devices.

We conclude that within the pilots there is a focus on measures which are obligatory by law, and those measures are implemented. Even some additional measures are taken, e.g. the consumer should be in control of his own devices, however, privacy is no main subject of study in any of the pilots.

Finally, it is noted that privacy legislation can have an effect on research projects. Main part of the ADVANCED project is to combine lessons learned from multiple pilots, and combine data from those pilots to extract KPIs (Key Performance Indicators) for user participation in AD. However, to achieve this goal, personal information of the consumers in the pilots had to be combined within the ADVANCED project. Thus some actions had to be implemented in order to gather this information complying with privacy legislation, and in some cases the methodology was extended to cover particular cases.

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