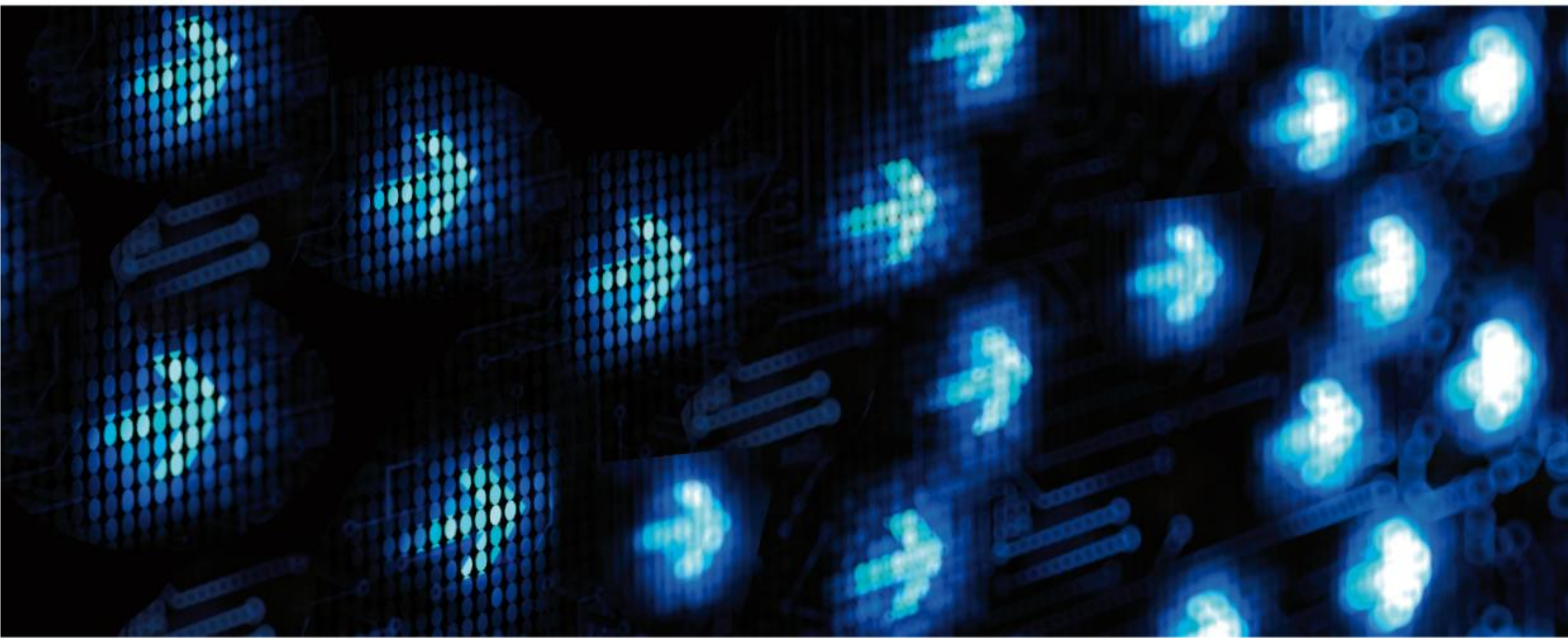
ADVANCED

Active Demand Value ANd
Consumers Experience Discovery



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Economic benefits of AD for stakeholders

D6.3

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Executive Summary

The objective of this document is to assess the inherent economic benefits of Active Demand (AD) on distribution business perimeter from a societal perspective, including the different stakeholders such as the DSO, consumers and AD aggregators. Furthermore, the regulatory barriers for the implementation of AD in the different contexts of the European scene, focusing on the countries where ADVANCED demos took place, are identified and some recommendations are provided in this sense in order to facilitate the future development of AD in electric power systems.

First, the economic benefits of AD are quantified as the distribution network reinforcements that a more efficient use of existing and new grid capacity due to AD could defer or avoid in a ten-year frame. This economic assessment is carried out for a set of country-specific case studies and scenarios. Each case study is made up of a set of exemplary urban and rural networks of each country in the ADVANCED project (Spain, Italy, Germany and France). The expected impact of AD on consumption has been exogenously defined according to average effectiveness levels of AD programs observed in the VaasaETT database, which includes the ADVANCED Pilot programs, and the participation rates associated to the economic and regulatory scenarios defined in task 6.1: Baseline, Optimistic and Technical Potential. The estimated investment needs are estimated by means of the distribution network planning tool Reference Network Model (RNM) to determine the optimal investments required in particular networks.

The results of the economic analysis show that under certain circumstances, AD could effectively help distribution network operators to reduce investment costs without endangering reliability, thus allowing for a more efficient network planning strategies. Various local and country-specific circumstances have been observed to have a significant impact on the desirability and the effectiveness of integrating certain forms of AD into network planning strategies for DSOs and regulators. In particular, the variety of network configurations, the projection of future demand growth and new DG connections, the degree of congestion of the current networks, the distribution of responsive consumers, the power intensity per squared kilometre and the rate of participation in AD have been identified as pertinent factors of analysis in view of the simulations that have been carried out.

In view of the results obtained from the simulations that have been carried out, AD has a great potential to defer network investments whenever they are driven by large load increases and

small or hardly any new DG penetration. AD can just very moderately alleviate the reinforcements needed to integrate higher levels of new Solar PV. Results have shown that AD could be expected to have a more positive impact on investments in highly constrained networks. According to the results, the highest investment savings predictable would be observed in urban networks with high utilization rates, where reinforcements due to future load increase are deemed more necessary. Another relevant finding is that the location of consumers has been observed to be relevant mostly for scenarios with low AD participation rates and it greatly depends on the type of reinforcements that are needed in the scenario of no Active Demand in place. A main conclusion of this work is that the potential of AD to defer distribution network investments is very dependent on the local circumstances, especially in the case of rural networks. Hence, in order to be able to extend or replicate the results to a different region or a whole country, additional research is required. This comparative analysis of the impact of AD on the investment needs of different types of distribution networks aiming to reflect some of the current concerns of DSOs about the possibilities of AD in four different countries in Europe is one of the main contributions of this work.

Part of these quantified benefits, or savings with respect to a hypothetical scenario, could be shared among DSOs and consumers. The discussion around the allocation of benefits is highly conditioned by the regulatory framework in place, in particular by the design of the DSO remuneration mechanisms and the distribution network tariffs. Retailers or aggregators could share part of these savings with final consumers. This means that even when the potential economic benefits of AD may be significant from the perspective of society as a whole, and therefore from the regulator standpoint, they may be disseminated across the value chain and among involved stakeholders. This may reduce the incentives for participation but maybe not the need for the efficiency improvement that AD could bring to electricity systems and society.

The full potential of Active Demand is still not achieved in most of the European scene. Its realization requires that certain mechanisms in the market are in place and that the regulatory conditions allow for its completion at wholesale, network and retail level.

From the revision of the main regulatory aspects that should be reviewed in order to unlock the potential of AD, the most critical concerns that have arisen are related to DSO regulation and network tariff design, but also to retail markets, standardization and consumer protection. It is advisable that the distribution activity were revised in order to incentivize DSO to make long-term efficient investments and reward innovation more than focus on short-term optimization. It would also be desirable that DSO were entitled the choice to count on certain forms of AD to alleviate congestions that remain to be defined and regulated. Regulation should also ensure that end users are charged cost-reflective network tariffs that incentivize the most efficient demand response as a whole. In addition to this, a competitive market without entry barriers should be guaranteed for retailers, aggregators and other commercial agents to provide smart AD services. Finally, consumer protection should be guaranteed beyond the security of the data to the rights of consumers to be informed and be provided the tools to understand the new smart tariffs and complex contracts to which they can be exposed.

It is hence possible to improve the current regulatory practices for the application of Active Demand in the European context and consequently contribute to the achievement of the EU targets of energy efficiency improvement and consumer engagement and protection.

9

List of figures

List of tables

1. Introduction

1.1. Scope of the document

The objective of the ADVANCED (Active Demand Value and Consumer Experience Discovery) project is to develop actionable frameworks enabling residential, commercial and industrial consumers to participate in AD initiatives, thus contributing to its mass deployment in Europe. The ADVANCED project comprises four pilot projects, currently underway or already finished, that test AD solutions among real residential consumers in different locations of four European countries: two ADDRESS pilots in Spain and France, the E-DeMa pilot in Germany and the Enel Info+ pilot in Italy. Furthermore, the ADVANCED project relies on a set of in-depth qualitative interviews and a vast amount of data collected in the VaasaETT database.

Within the ADVANCED project, the main goal of WP6[1] is to assess the inherent impacts of AD on electricity systems, in general, and in particular in T6.3, to evaluate the economic benefits of AD on DSO perimeter from a societal perspective, as well as their allocation between DSO, consumers and AD providers. This quantification is done under different scenarios of regulatory frameworks and economic boundary conditions that were defined and discussed in T6.1. Furthermore, the regulatory barriers for the implementation of AD in the different contexts of the European scene are identified and some recommendations are provided in this sense in order to facilitate the future development of AD in electric power systems. This document presents the results of the work carried out in this task.

1.2. Structure of the document

In addition to this introductory section, the document is structured into the following sections:

- Section 1: Introduction, including a project overview and a description of T6.3 objectives.
- Section 2: Benefits of AD and identification of the key stakeholders.
- Section 3: Methodology for the economic analysis.

[1] Work Package 6 of ADVANCED Project is entitled “Impact assessment of AD on electricity systems and overall conclusions of the project”. T6.3 full title is “Quantification of economic AD benefits for stakeholders in different regulatory frameworks”. The other involved tasks are: T6.1 “Quantification of flexibilities based on AD for the impact assessment”, T6.2 “AD applied for system services primarily in LV-MV grids”, T6.4 “Privacy and data protection impact assessment” and T6.5 “Overall conclusions and recommendations”.

- Sections 4, 5, 6 and 7: Country-specific case studies for the economic analysis of the benefits of AD for distribution networks (Spain, Italy, Germany and France, respectively).
- Section 8: Main findings of the economic analysis.
- Section 9: Allocation of the quantified benefits among stakeholders.
- Section 10: Analysis of the regulatory barriers.
- Section 11: Conclusions and recommendations.

1.3. Project overview

Active Demand (AD) has the potential to contribute to solving the challenges of electricity systems and offers significant benefits to consumers and is considered one of the largest so far untapped energy resources.

A significant barrier to realising this potential is insufficient consumer engagement and awareness regarding their own energy consumption. Another significant barrier is the lack of offerings made to consumers around Europe. Few consumers are offered viable choices which could help them lower their electricity costs or encourage energy savings. An understanding of best practice, consumer engagement mechanisms and required technologies is urgently needed within the industry. There is a lack of insights into the AD related behavioural barriers and unavailability of best practices for AD design.

The ADVANCED (Active Demand Value ANd Consumers Experiences Discovery) project aims to develop actionable frameworks enabling residential, commercial/industrial consumers to participate in AD, thus contributing to AD mass deployment in Europe. In the context of WP6, the project also quantifies the benefits of AD for key stakeholders and the inherent impacts on the electricity systems considering its potential contribution to system stability and efficiency, according to different scenarios.

The ADVANCED project is promoted by a consortium European energy utilities (Enel Distribuzione, ERDF, Iberdrola Distribución, RWE DEUTSCHLAND Deutschland), universities, research centers and consulting firms in the energy sector (Comillas, Universidad Pontificia, Fondazione Eni Enrico Mattei, TNO, VaasaETT), one of the European leading agencies specializing in market research (TNS) and one of the first Aggregators in Europe that offers active demand programs for commercial and industrial consumers (Entelios).

In order to reach the project objectives, real data made available by the 4 utilities participating in the consortium and collected through 4 major pilot projects currently running or finished shortly in Europe are analysed: 2 ADDRESS pilots (Spain and France), E-DeMa pilot (Germany) and Enel Info+ pilot (Italy). Furthermore, data collected in VaasaETT's database (from more than 120 European Active Demand projects with the participation of more than 450,000 residential consumers) is exploited. The outcomes of the quantitative analyses carried out in WP6 in general and in T6.3 in particular are based on actual data from these real AD experiences.

In the following sub- sections a brief description of each of the ADVANCED sites and a summary of the content of VaasaETT database are presented.

1.3.1. ADDRESS pilot sites

ADDRESS ("Active Distribution network with full integration of Demand and Distributed energy RESourceS") was a five-year large-scale R&D European project launched in June 2008 and co-funded by the European Community's 7th Framework program (FP7/2007-2013). The consortium, coordinated by Enel Distribuzione, consisted of 25 partners from 11 European countries spanning the entire electricity supply chain: Distribution System Operators (DSOs), Transmission System Operators (TSOs), Energy supply and retail qualified R&D bodies, Communications and ICT providers and home appliances and white goods manufacturers and consultants.

The aim of the project was to study, develop and validate a comprehensive commercial and technical framework to enable active demand and exploit its benefits in the smart grids of the future.

At the consumers' premises electrical appliances, distributed generation and thermal or electrical energy storage systems could be controlled and optimized by an Energy Box, which was the interface with the external world and with the consumer. The Aggregators, through the Aggregator Toolbox, were the mediators between the consumers and the markets, allowing power system participants to explore the flexibilities of the aggregated customers. DSOs could interact with the other power system participants via the markets. Three pilot field test were located in three European countries (Spain, France and Italy) with different network topologies, climate conditions and social acceptance which, taken together, provided a validation of the entire concept.

The Spanish field test was located in the 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 265 consumers were recruited to participate in the field test. The recruitment of the participants has been accomplished through Call Center effort (phone call campaign in the name of Iberdrola) and a well-known contractor in Castellón area that did the work locally (arranging dates with the consumers and signing the contracts).

The pieces of equipment installed in all the consumer premises were:

- Energy Box (EBox) to receive price-volume signals, generate automation commands to control appliances and register consumption;
- Five (5) smart plugs connected to different appliances and a measuring device, all of them communicated wirelessly with the Ebox.
- Additionally, 25 participants accepted to install in their houses a smart washing machine and 30 accepted to install air conditioning management equipment.

Previously an AMI system was fully deployed in the area (smart metering + remote management system and Meter Data Management System).

The pilot started the 1st of June 2012 and finished the 31st of July of 2013, a total of 13 months. Not all the participants got the equipment installed at the same time, then they did not start participating at the same time.

The Spanish field test analyses the relationship between the Aggregator Toolbox and the consumers through the Energy Box in order to be able to manage the demand and individual loads. In the pilot consumers behaviour, Home Area Network, Aggregator toolbox and Interoperability & Communications between Aggregator-Energy Box and in the Home Area Network were also tested.

The aim of the French field tests carried out in the Brittany Islands of Houat and Hoëdic was to test the whole ADDRESS chain, i.e. from the needs of the electricity system players to the controlled appliances in the consumers’ premises, including also consumers’ acceptance studies.

Around 30 residential customers and a few small commercial customers were involved in the project. Contracts signed between EDF and the customers included special clauses related to the protection of consumer data. Besides, a declaration of the consumer data collected was made to Commission nationale de l'informatique et des libertés (CNIL) and appropriate measures have been taken to ensure confidentiality of these data.

In the French ADDRESS test site, several scenarios were tested:

- Provision of services by AD based on:
    - Actual requests from electricity system functions/players (DSO, BRP, etc.),
    - Requests resulting from simulation of possible problems or needs of the players,
- AD services such as
    - Active power reserve, load/generation balancing services, load shaping,
    - Voltage control, overload/network congestion relief,
- Combination of AD with RES both for load/generation balance and grid aspects;
- Monitoring and forecast of RES production;
- Requests taking into account actual/present RES production and simulated future RES production based on future projects;
- Simulated market interaction of different players with aggregation platform.

These scenarios were tested along with technical performance tests:

- DSO's algorithms and in particular the technical validation of AD actions;
- Aggregation platform and its algorithms;
- Ebox, its algorithms and display;
- Communication and signals exchanged between aggregation platform, Ebox, meter and appliances;
- Control of appliances at consumers premises:
    - Washing machines;
    - Smart plugs: classical washing machines, dish washers, etc.;
    - Electric radiators, water heater.

The tests that were carried out also include social validation in order to assess consumers' commitment in field tests and acceptability with respect to AD and project concepts.

1.3.2. RWE DEUTSCHLAND Deutschlands E-DeMa pilot site

The publicly funded E-Energy project E-DeMa targeted an increased mobilization of flexibilities in electricity usage at the household level for the energy system of the future. In order to achieve this goal a regional energy market place, i.e. the "E-DeMa marketplace", connecting the approximately 700 households that have been participating was developed. This market place is an innovative ICT platform that enables current market roles (supply companies) as well as new ones (Aggregators) to offer new and innovative products, which in turn help to "harvest" flexibilities from the customers. The project started in 2008 as part of the E-Energy Programme of the Economics and Technology Ministry (BMWi) and Environment Ministry (BMU) and it was completed in May 2013.

The pilot participants were divided into two groups (see also Figure 1):

- Type 1: The consumers receive pricing information via their tablet, however it is basically up to them how to use this information. In this part of the pilot, the consumer decides how to react on this information.
- Type 2: The consumers have a totally automated environment. In order to use the washing machine they choose an end time for the washing machine, and the washing machine will be automatically switched on at the optimal price. This switching can be done based on a received price signal, or directly centrally controlled via de aggregator. In both cases the end user can override the decision, however that will cost them some extra money.

Of the potential 5,500 households in the towns Mülheim and Krefeld, 660 participate in the pilot. 550 households with a type 1 installation, and 110 with a type 2 installation.[2] The field test started in April 2012 and was completed in November 2012. The participants are selected based on a 'declaration of intention' they have signed, and a selection process based on technical as well as non-technical prerequisites. In addition, the recruitment process was designed together with a specialised communications agency, and based on dedicated and personal dialogues with potential participants. This approach has led to a high success rate in the recruitment process which is substantial to achieve the desired number of participants.

[2] However, due to data privacy reasons only users from the larger Mülheim group are analysed with ADVANCED.

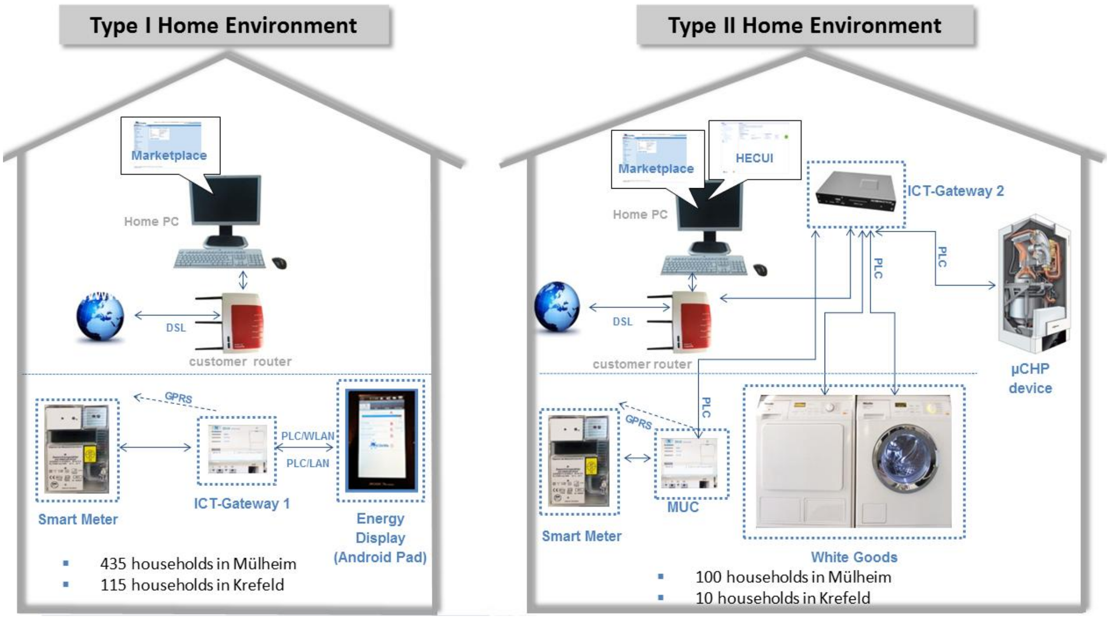

***Figure 1, a schematic view of the E-DeMa pilot installation*[3]**

Two types of interventions were used influence the participants' energy consumption: Energy Awareness/Efficiency and Demand Response. On the one hand, Energy Awareness/Efficiency was enhanced by providing feedback of the energy consumption to the consumer via a display and - in addition - via E-DeMa marketplace, i.e. using a website. On the other hand, home appliances like washing machines, dryers and dish washers as well as decentralized generation devices like micro CHP's were used as flexibilities to manage the energy system, i.e. demand response was realized with time of use tariffs which motivate the consumers to shift energy consumption from times with high prices to low price zones. The actual time of power usage was managed via price signals, which are distributed via the E-Energy market place. The control of the home appliances was achieved either manually by the consumer using the energy display or automatically controlled by the home energy gateway. Alternatively the consumer could leave the flexibility of an appliance to an Aggregator. In this case there would be a contract between the consumer and the Aggregator, i.e. the Aggregator would pay the participant a premium for "leaving" the flexibility to him for a minimum of 6 hours but would at the same time be allowed to use the flexibility whenever he wishes to in that time frame, i.e. even at prices higher than would have resulted from a start of the appliance that would be solely optimized against the tariff. Ideally Aggregator aggregates flexibilities of many home appliances to bigger quantity flexibilities which could be used for balancing power or potentially offered to

[3] E-DeMa.

wholesale markets – but for the field test the assumption was that the Aggregator had sold all his flexibilities to the DSO and would use them only in a network-friendly fashion.

Measurement of actual 1/4h load profiles was achieved by a smart meter infrastructure in each household. In addition, measurements of grid borne data were used to optimize the operation of the distribution grid. During the pilot several consumer interviews have been carried out to measure how the pilot is perceived by the consumers.

Data collected in the context of the E-DeMa field test were analysed with respect to the following results dimensions (KPIs):

- Shifting of demand (kWh),
- Shifting of load (kW),
- Usage of the automated white goods
- Reduction in consumption volume (kWh), even though it was originally not an aim of the project[4].

1.3.3. Enel Info+ pilot site

Enel Info+ is a large scale pilot of the Enel smart info device that has been designed by Enel Distribuzione to allow end users to have the certified information on electricity data managed by their electronic smart meter at their fingertips. The Trial is part of the “Isernia Project”, a project financed by the AEEG (“Autorità per l’Energia Elettrica e il Gas”) that foresees the installation of a model of smart grid on the grid connected to the Primary substation of Carpinone (a little town in the Isernia district). Enel Info+ involves a representative sample of low voltage households and small commercial consumers served by the Carpinone primary sub-station in some municipalities in the area of Isernia, the potential universe of participants includes about 8000 low voltage households.

The scope of the project is to demonstrate whether giving to end users a feedback on their energy consumption can address more efficient energy behaviours. The consumers participating to the project thus receive an energy monitoring kit including Enel smart info and

[4] E-DeMa used an individual calibrated standard load profile for each participant as a baseline. While this approach worked well for the calculation of demand and load shift (the main project objectives) it did work less well for the calculation of demand reductions – inter alia because the standard load profile is not subject to holidays. I.e. when participants went on holidays within the field test and thus reduced their electricity demand the demand forecasted by the load profile was higher and the difference automatically counted as kWh saved.

dedicated interfaces that they use for one year to view how much electricity is currently being used in their household and to process their historical consumption data. "Prosumers", consumers who are also producers of renewable energy (by photovoltaic or mini-eolic plants), receive an additional Enel smart info in order to manage both production and consumption metering data.

The Enel Info+ kit and the related monitoring solutions are modular and foresee three levels of analysis.

- The first one is based on the use of Smart Info Display, a full colour, touch screen in-house display, that lets the consumers keep an eye on their household energy consumption pattern easily. Smart Info Display provides both close to real time and historical information on energy consumption, which are shown in bar graphs and pie charts to highlight their mean value and how they split in tariff time bands for different periods of time (a single day, one week, one month, a bi-month, one year). Consumption habits are displayed together with the measured consumption data in the graphs, helping consumers identify variations. Historical data is stored for about three years. The instantaneous power is reported together with a scatter plot of its maximum historical values for different periods of time (a single day, one week, one month), thus the consumer can check whether its supply electricity contract is consistent with its actual needs. The instantaneous power values can be refreshed automatically as well as on demand. Tariff time bands are displayed, together with the date and time of tariff time bands switching and colour settings can be modified to be consistent with the user’s tariff structure. Alarms can be set by the user to receive an alert when energy usage gets to modifiable thresholds, helping consumers keep it under control and reach their goals of personal improvement. When the contractual power is exceeded an alarm is automatically generated likewise, so that load shedding is prevented. Moreover additional feedback contents are given such as alarms at pre-defined, modifiable thresholds and when the contractual power is exceeded, DSO’s announcements and contractual data. Through a dedicated wizard the customer can also measure the power used by a specific appliance.
- The second monitoring solution is based on Smart Info Manager, a software application that allows the consumers to examine their consumption data in depth on their personal computers and the energy prosumers to compare production and consumption data.
- The third monitoring solution is based on the smartphone App Smart Info Mobile that enables the consumers/prosumers remote access to their own energy data.

As the current level of knowledge and awareness regarding electricity of the potential participants to Enel Info+ is quite poor a step by step approach for their involvement in the project has been chosen. At the beginning they only receive Smart Info Display, that is they are equipped with the simplest feedback means. This choice is expected to incline end users towards the subject matter avoiding their rejection of the kit as “too difficult”. After a few months their kit is gradually upgraded to provide them with an increased complexity and value. A web portal (www.enelinfopiu.it) has been designed to provide general information about the project and technical support to the experimenters (who can also refer to a dedicated help desk).

The consumption of the families living in the municipalities included in the project have been observed by Enel Distribuzione since 2011. Moreover the experimenters’ consumption will be observed by Enel Distribuzione for the whole duration of the trial and compared with the pre-pilot ones as well as analysed in relation to other factors (e.g. household size, number and type of appliances, etc..) having received the consumers’ written consent to data management. Besides, a “control group” of consumers who will not take part to the trial will be selected and monitored, to verify that the use of the Enel Info+ kit is actually responsible for any change in the load curves.

Additional information are gathered by means of interviews that are carried out among an appropriate representative sample of consumers participating to the trial and among the control group likewise. Moreover in-depth qualitative interviews with approximately 20 consumers will be carried out within the scope of the ADVANCED project and their outputs will extend the study with some insights into socio-economic drivers of consumers’ behaviour.

In order to successfully activate consumers Enel Distribuzione conducted an advertising campaign for conveying the objectives of the trial. At the beginning a meeting with the mayors of the municipalities included in the project and a meeting with the local consumers’ associations were arranged for presenting Enel Info+ and establishing a collaboration aimed at the achievement of the recruitments goals. Then the company has been present at summer local fairs and other events for a large scale promotion, while a “pre-trial” test involving about 60 clients helped to fine-tune the technological solution and the communication efforts. Since the end of 2012 some dedicated meetings have been arranged with the potential participants for them to know the project in greater detail and to receive their own monitoring kit.

1.3.4. VaasaETT database

VaasaETT keeps up-to-date a database which currently comprises over 120 feedback and dynamic pricing pilot programs from around the world. These pilots are selected from a larger pool which include pilots whose design or reporting of results were not sufficiently detailed or comparable with the others to be included. Final reports, presentations and academic papers analysing the selected pilots are collected from numerous sources. Papers published in academic journals are collected from academic databases. Public pilots' reports are collected directly from the organizer (often local regulators or public utilities). In addition, VaasaETT draws on its extensive network of practitioners around the world to collect pilots whose results were not made public usually from technology providers or investor-owned Utilities. Analysing and comparing such a large number of pilots offers the possibility to spot consistent results and allows visualization of emerging pattern.

1.4. Objectives of T6.3

The main goal of WP6 is to assess the inherent impacts of AD on electricity systems. In the context of this Work Package, the main objective of T6.3 is to quantify the economic benefits of AD for the key stakeholders at distribution network level under different boundary conditions materialized in a set of scenarios previously defined in T1.3 and further developed in T6.1. Stakeholders considered include DSOs, consumers and intermediary AD providers. The defined scenarios cover a range of combinations of specific technological, regulatory, economic and societal local conditions that could affect the performance of AD and the impact on the system and all involved agents. Furthermore, some of the main regulatory barriers for the implementation of AD in the different contexts of the European scene are identified. As a conclusion, a series of recommendations are provided in this sense in order to facilitate the future development of AD in electric power systems.

The aim of T6.3 could be particularized in a scenario-based analysis of the following specific aspects:

- The characterization of the expected responsiveness of consumers to different types of AD programs in terms of load changes in the different countries and scenarios. This estimation is based on real consumption data collected from the ADVANCED pilots and the quantified AD flexibilities provided by T6.1.
- The quantification of the potential economic benefits coming from AD on the operation and investment costs of distribution networks in each scenario.

- The discussion around the allocation of these benefits among DSOs and other stakeholders, including AD providers acting as intermediaries between end consumers and the system, according to the regulatory arrangements present in each national context.
- The identification of the most relevant regulatory barriers for the practical implementation of AD in the European context and the provision of some recommendations to overcome them.

1.5. Notations, abbreviations and acronyms

AD	Active Demand
CBA	Cost Benefit Analysis
DER	Distributed Energy Resources
DG	Distributed Generation
DOW	Description of Work
DP	Dynamic Pricing
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
EE	Energy Efficiency
EED	Energy Efficiency Directive
EU	European Union
EV	Electric Vehicle
FB	Feedback
GA	General Assembly
KPI	Key performance indicator
MB	Management Board
MS	Member State
MS	Member State

NRA	National Regulatory Authority
PC	Project Coordinator
QA	Quality Assurance
QAP	Quality Assurance Plan
QAS	Quality Assurance System
QM	Quality Manager
QMO	Quality Management Office
QO	Quality Objective
RNM	Reference Network Model
SM	Smart Meter
SME	Small to Medium Enterprise
TB	Technical Board
TM	Technical Manager
WP	Work Package
WPL	Work Package Leader

Table 1, abbreviations

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2. Benefits of AD and involved stakeholders

This section presents the definition of AD in the context of the project and brief overview about the main benefits that can be brought by AD in electric power systems from the perspective of different stakeholders. The purpose of this description is to contextualize and identify the scope of the economic and regulatory analysis carried out in this task.

Active Demand (AD) management presents a range of potential benefits for electricity systems. AD is widely recognized as a key resource to cope with the current and future challenges of power systems, such as the need for additional flexibility that is required to accommodate the increased electrification of energy consumption and the growing penetration of renewable intermittent energy. More precisely, the promotion and development of AD solutions is a fundamental objective of the European Union energy policy (EC 2011; EC 2013b; EC 2013a; EC 2012).

Electricity systems have traditionally been operated following the paradigm that both ample network capacity and generation capacity and flexibility should be guaranteed to reliably supply an inflexible demand for electricity. The increasing development of smart metering infrastructure and control and information technologies is enabling a change of paradigm by which the demand side could also provide flexibility to the operation of the system, adjusting consumption to the needs of the system according to the signals received. AD refers to this capacity of end/consumers to change their usage of electricity from their normal consumption patterns in response to a signal that incentivizes a more efficient usage of electricity from the perspective of some part or another of the power system. In particular, the definition of AD in the context of the ADVANCED project is the following (DOW):

> “Providing electricity consumers with information on their consumption and the ability to respond to time/based prices (either manually or automatically) as well as with other types of incentives, thus motivating them to actively manage their consumption by altering usage in line with the network conditions, such that modifications in consumer demand become a viable option for addressing challenges of electricity systems such as the increase of efficiency and reliability, infrastructure planning and investment deferral.”

The definition of AD implies that the variety of signals sent to end/consumers and of causes of the need for flexibility in the system gives the way to a variety of forms of AD. Within the ADVANCED project, the broad concept of AD is classified into two categories Energy Efficiency

(EE) and Demand Response (DR). These categories are further on partitioned into several program types according to the form of the signal send to the customer, the purpose of this signal and the means of reacting to this signal, as is seen in Figure 2.

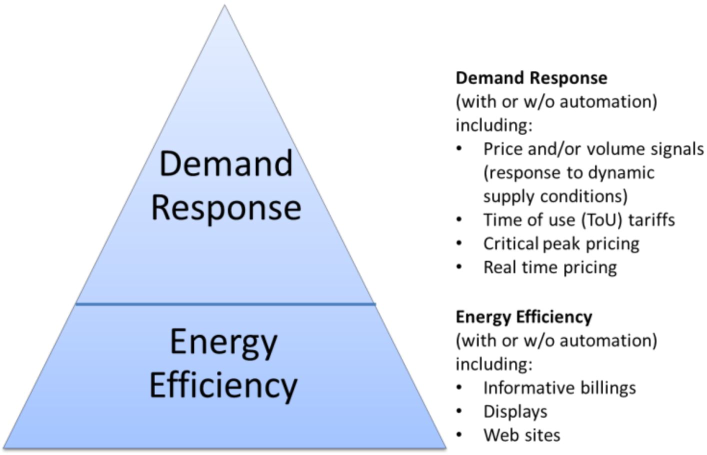

Figure 2, classification of AD program types in the ADVANCED project. Source: (D1.3, 2013)

On the one hand, **Energy Efficiency** (EE) encompasses all initiatives aimed at incentivizing or encouraging a permanent and long/term reduction of electricity usage (D1.3 2013). This can be done by means of improving the information to consumers regarding their own consumption or by directly funding the replacement of old electrical appliances for new equipment that consumes less electricity while providing the same quality of service to the customer. These programs are also referred to as **Feedback** (FB) programs in this context. The following means of information to the customer are considered throughout WP6 (D6.1 2014) and also in this task:

- Informative billings
- In-home displays
- Web site

On the other hand, **Demand Response** (DR) focuses on the flexibility of consumption in reaction to time/based signals, such as dynamic pricing structures or other forms of incentives to adjust load, which incentivize shifts of electricity usage in time. Therefore, DR can result of a wide range of signals (CEER, 2014). The objective of these signals is the modulation of electricity usage in order to optimize the cost of operation at the stage of the system where the signal originally stems from. In contrast to EE, DR does not necessarily affect the overall consumption level but the time when electricity is consumed. These signals could be the means of indirect participation, through an aggregator or other intermediary agent, of the end consumers in market mechanisms or for the provision of system services to network operators. In the context of WP6 and this task, special interest will be placed in **Dynamic Pricing** (DP) as the means to induce DR, in particular in the following forms of DP (D6.1 2014):

- Time of Use (ToU), which divide the day into pre-established time blocks to which different prices apply, usually fixed for long periods.
- Critical Peak Pricing (CPP), by which an unusually high retail price, characteristic of critical situations of the system, which can be either established for a predefined and limited number of hours during certain days or not fixed in advance and communicated in short notice.
- Real-time pricing (RTP), which are designed to charge the actual price of electricity at each hour to the actual consumption in that hour.

Consumers can react to any of the previously described forms of DP either manually (no automation) or with the help of **automation** of electric devices. For example, the consumer may have a series of appliances prepared to run automatically and connected to a smart energy management system, or Energy Box, so that they can be scheduled optimally according to the pricing signals received. On the other hand, the response can depend exclusively on conscious decisions made by the consumer to switch on and off, or control the consumption level (e.g., with thermostats), **manually** without the help of automation technologies.

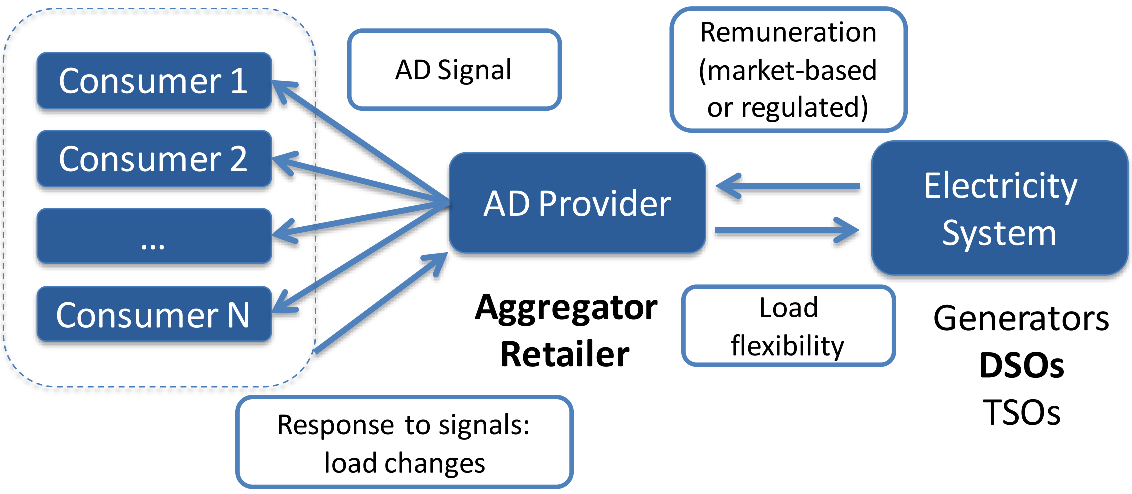

Figure 3, identification of the basic interrelations of the key stakeholders of AD.

By making consumers aware of the real costs of electricity and conditions of the network, AD induces changes (reduction/shift) in consumption that have value for various agents throughout the whole energy system, from generators to TSOs, DSOs, market operators, retailers, aggregators and consumers. The way these agents are interrelated is schematically depicted in Figure 3. When consumers are not prepared to interact directly with the wholesale market and the network operators, the final signal is sent to the end-consumer through some intermediary agent. This agent (retailer, aggregator, etc.) acts on behalf of an aggregation of relatively small consumers to provide the flexibility of their consumption as a service to some agent of the electricity system. This figure especially applies to DR, but also to EE, where the signal is in the form of some type of feedback on consumption and the resulting response is an overall reduction of energy consumption.

The added value of AD for the system, regardless of the parties involved, is a more efficient use of existing generation and network capacity, thus resulting in a reduction of network congestion and generation costs in the short-term. As a consequence, in the long-term, AD can reduce the need for additional generation adequacy and network reinforcements to integrate further renewable energy in the system and satisfy the load growth. Therefore, the value of AD lies in the possibility of reducing or postponing investments in network and generation capacity (Hancher et al. 2013). AD provides particular benefits for consumers, allowing them to reduce their energy bills by adjusting their consumption to the requirements or incentives received[5].

The scope of T6.3 is focused on the distribution system level and the agents related to the local impact of AD, usually involving small to medium consumers. At this level, a proper design of distribution network tariffs could incentivize an efficient use of network capacity that reduced consumption during local peaks or times of occasional congestion, assuming the price signal to the end consumer were strong enough. Certain Feedback or Energy Efficiency programs could enable a reduction in overall consumption, and therefore of the peak consumption. DSOs could also take advantage of the load flexibility provided by AD by offering specific products for system services in order to operate networks more efficiently, as described in (D6.2, 2014). As a consequence of many of these forms of AD, the simultaneity of peak loads and congestions at critical times could be reduced, thus moderating the need for new investments. As long as the expected avoided investments outweigh the costs of implementation, AD could replace investments in network reinforcements and provide a net social benefit. This process would be possible if DSOs could reliably incorporate the foreseeable positive impacts of AD on customer load in the worst scenarios into network planning. These critical scenarios would occur during

[5] Consumer benefits from participating in AD really constitute a wealth transfer from, or sharing with, other system agents. For example, the reduced energy costs for consumers come from a cost (and revenue) reduction for generators while a network tariff reduction would involve a reduction in the revenues of regulated network activities.

periods of local peak demand and during hours of low demand and high amounts of simultaneous non-dispatchable distributed generation. The benefits of AD at distribution level are quantified in this work according to the methodology presented in section 3, for a series of case studies comprising a combination of national network realities and scenarios (sections 4, 5, 6 and 7).

The allocation of the net social benefits is a critical issue in the design and evaluation of AD programs. Even in those situations where the benefits outweigh the costs, these are distributed among different stakeholders (DSOs, consumers[6] and AD providers) and society as a whole, according to the business models and the regulation in place, possibly dispersing or reducing individual incentives for participation. Notwithstanding, even if participation incentives are low, if AD improves social welfare, it is the role of regulators to facilitate the development AD to the extent that it is reasonable. Given that the distribution activity is a regulated monopoly, the allocation of benefits among stakeholders would be greatly dependent on the regulatory framework. Part of these avoided investments could be transferred to final customers through a reduction in network tariffs in the end. Part of the economic savings achieved by consumers would in turn be shared with the intermediary agents acting on their behalf. Following the quantification of the overall benefits for distribution networks, the allocation of the quantified benefits in relation to regulatory conditions is discussed in section 8.

The analysis of regulatory framework along with the results obtained from the economic analysis will allow us to look into the regulatory barriers for AD implementation in section 10. This combined analysis will yield relevant insights about the potential repeatability of AD experiences in different contexts and the most important regulatory barriers that will be found.

[6] The reader should keep in mind that if all the benefit that is generated by AD in a distribution network would be passed through to consumers (i.e. the flexibility is priced according to what is saved) no benefit for society would result as the cost of the network would be the same as in a situation without AD; the only changes occurring would be distributive.

3. Methodology for the economic analysis

This section presents the methodology for the quantification of the economic benefits of AD in electricity at local distribution level, i.e. on the distribution grid and at end-consumer level. Such benefits are evaluated in terms of avoided investments in network reinforcements for different scenarios of AD application in comparison to a benchmark scenario without AD, for a specified time frame. The basis of this analysis is depicted in Figure 4. These savings should be contrasted with the associated costs of each type of AD program and form of implementation to determine the convenience of promoting AD from the regulatory perspective.

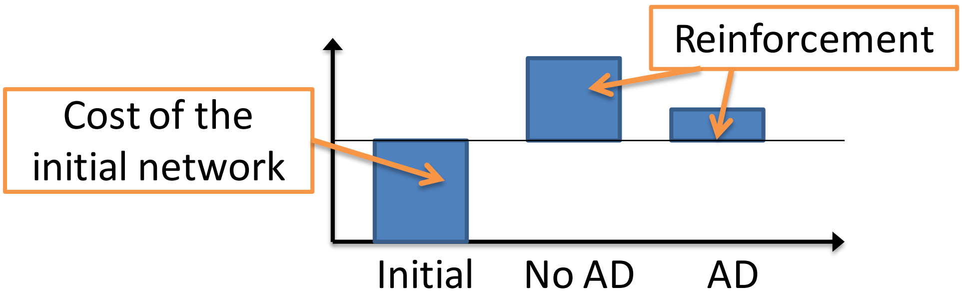

Figure 4, basis of the evaluation of the economic benefits of AD in terms of avoided or deferred investments on network reinforcements.

The analysis is based on the use of a distribution network planning tool called Reference Network Model (RNM), developed by Comillas (see Annex A), to determine the optimal investments required in particular networks. Due to the complexity of the model used, whole countries cannot be modelled so a set of exemplary urban and rural networks for each of the countries of the ADVANCED project (Spain, Italy, Germany, France) are designed for the analysis to build a series of case studies (sections 4, 5, 6 and 7).

It must be noted that the results obtained for each case study cannot be directly extrapolated to the whole country without precaution. These networks are aimed at being exemplary and useful to evaluate certain situations in which AD could be beneficial in each national reality but not necessarily fully representative of every network of each country.

As a result, this analysis provides a quantitative scenario-based estimation of the impact of different forms of AD on investment needs, allowing us to understand how network typologies and the location of participating consumers in the grid can affect the economic value of AD for distribution networks. The analysis intends to provide general conclusions that can be valuable beyond the scope of the pilot programmes themselves and allow us to derive general conclusions and regulatory recommendations.

3.1. Assumptions

The methodology presented in this section is conditioned by the following assumptions. Many of them stem from T6.1, on which many the inputs for this task are strongly based, especially in the definition of scenarios. Other assumptions affect the approach to evaluate the economic benefits at distribution level, the allocation of benefits among stakeholders and the identification of the main regulatory barriers. These assumptions are the following:

- The main economic value of AD at distribution level is assumed to turn into network investment reduction or deferral due to a more efficient use of the network capacity, regardless of the origin of the AD program.
- A bottom-up approach is used in the study of these economic benefits. It relies on a comparative analysis of the outcomes of different case studies built on exemplary distribution networks. These are not real networks but a feasible and realistic approximation of real distribution grids built using a network model[7]. In the case of France, the networks used are built using data of load configurations from real networks provided by ERDF.
- DSOs are assumed to be the network planners and also to have perfect information of the consumption and generation patterns of the network under their service[8].
- The effects of each of the AD program on electricity consumption are exogenously defined and correspond to the input received from T6.1, which is the effectiveness of the AD programs. The effectiveness for each program in relative terms (%) is assumed to be uniform and equal for all consumers taking part in each type of AD program.
- Consumers are expected to participate in only one type of AD program at once.
- The potential benefits of different AD programs are analysed aggregately into Feedback (FB) and Dynamic Pricing (DP) for each scenario, in line with T6.1 methodology.
- The network investment decisions are simulated following a cost minimization criteria under the assumption that the network planners are informed about the foreseeable load behaviour of consumers connected to their networks, including their participation in AD.

[7] Note that a real network that did “grow” in an organic / real life environment will always be less efficient than a newly modelled / greenfield” one.

[8] The reader should be aware that this is a very strong albeit necessary assumption to make use of network models. In reality, DSOs do not know perfectly how demand is going to develop and where. What is true is that network planning criteria could be adapted according to AD that is known to be in place.

- The economic savings evaluated in distribution networks are seen as a global economic benefit for society as a whole, which can be allocated among the different stakeholders (DOSs, consumers, intermediaries) depending on the DSO remuneration mechanism, the design of network tariffs and the type of participation of intermediaries.
- The regulatory barriers impact on the expected economic benefits for the agents inasmuch as they hinder or reduce the incentives for the realization of each type of AD, or do not enable a fair allocation of these benefits.

3.2. Methodological approach

The economic value of AD for distribution grids can be evaluated with this methodology in terms of a deferral of investment needs, due to a more efficient use of the network capacity. This is, in addition to energy losses, the main cost factor that bears direct relation to the electricity demand and affects the regulated remuneration of the distribution activity in the context of incentive regulation. Note that the reduction of energy losses is a side-effect of any AD but not an objective itself and that the investment costs are by large the major cost component so here the focus is set on investment costs.

The methodology consists of modelling a set of real size exemplary distribution networks and simulating the planning decisions for a long-term horizon in different scenarios with and without AD. A long-term scenario (ten-year horizon) of network expansion is taken into consideration. Comparing the results with respect to the scenario of no AD (benchmark scenario) will allow us to quantify the benefits of AD in terms of reduction in network investment (CAPEX).

Initially, a series of exemplary networks are characterized for each of the studied countries (Spain, Italy, Germany and France) and type of area (rural and urban). These distribution grids are built using a network planning tool that is able to design reference networks from scratch, the Reference Network Model (RNM), see Annex A. These networks are built following the guidelines of the DSOs involved in ADVANCED project about consumption and generation data and typical network parameters in each country.

The RNM is a large-scale distribution network planning tool that is used for assessing the efficient investment costs for DSOs in a context of incentive-based remuneration of the distribution activity. In both models, the design problem consists of minimizing the total investment cost in new installations plus associated operational costs, mainly energy losses, in order to supply the expected demand and accommodate the foreseeable distributed generation resources while meeting reliability and quality of supply criteria. This problem is highly complex and computationally demanding. The main features of the RNM used in this work are presented in (Gómez et al. 2013) and (Mateo et al. 2011) and explained in further detail in Annex A.

While the Greenfield version of the RNM is used to design the initial exemplary networks, the Expansion version is applied to estimate the optimal reinforcements and additions that are necessary to face future situations, such as a demand growth or the connection of new distributed generation[9], in the different scenarios. The network planning criteria and the hypotheses on new network needs are specific of each country reality.

The networks users are characterized in terms of power consumption needs (or injections, in the case of DG) and expected critical load/generation profiles. The consequences of AD programs on the consumption levels and profile shapes of participating consumers are estimated in order to evaluate the impact of AD on network investment needs and operational costs. This presumed effect of AD on consumption also serves for the estimation of the economic savings that could be achieved by consumers from participating in AD. An overview of the process is shown in Figure 5.

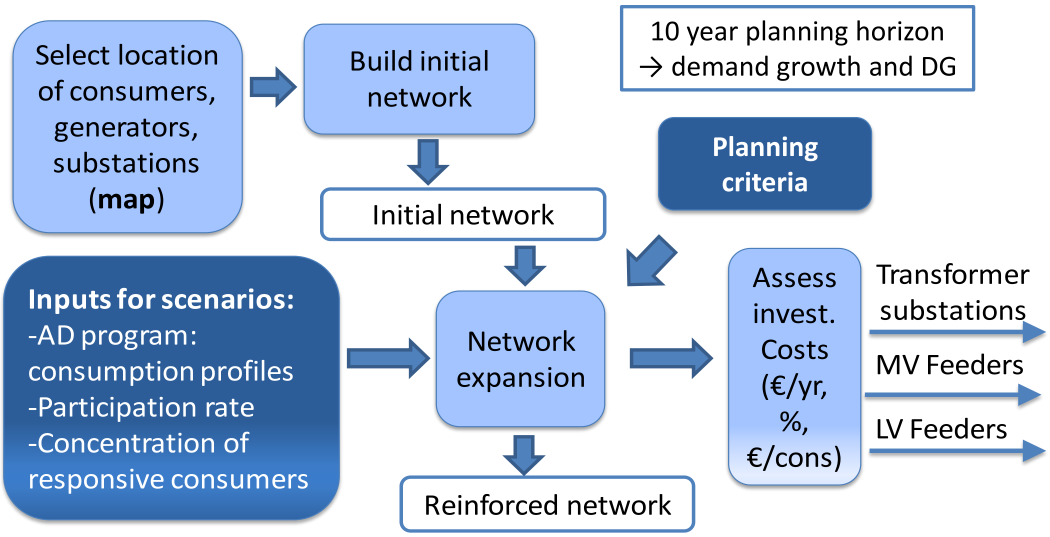

Figure 5, overview of the methodology for the estimation of the economic benefits of AD for distribution networks

[9] Distribution network reinforcements are planned to satisfy the load of expected new customers, the injection of new DG or a demand growth. If the demand does not increase or no new network users are connected, the existing network is sufficient.

3.2.1. Characterization of network users: consumption and responsiveness

For each case study of analysis, a variety of residential, commercial and small industrial consumers, as well as certain distributed generation units, are assumed to exist in the MV-LV networks. In order to characterize these network users, first, the scope of analysis is delimited. Secondly, the users are identified and modelled by means of characteristic profiles of consumption and generation. Afterwards, customers are classified in segments and groups according to their expected behaviour. Finally, the impact of AD on their consumption is analyzed and the consequences of these load changes are evaluated from the perspective of the network operator and the consumer.

3.2.1.1 Delimiting the scope of networks

In distribution networks, the HV grid feeds the distribution substations (HV/MV) and the HV consumer, typically large industries. Large distributed generation units are connected to this grid. The MV grid supplies medium and small industries and commercial customers, plus the secondary substations, or MV/LV transformers. The LV network feeds the smallest consumers, which include residential and small commercial consumers. Distributed generation resources connected in the MV and LV are of a more reduced size and include self-generation units at the end consumption points. The case studies analysed in this work only includes the MV and LV grids, so large industrial consumers and big distributed generation facilities are not considered in them, as is remarked in Figure 6.

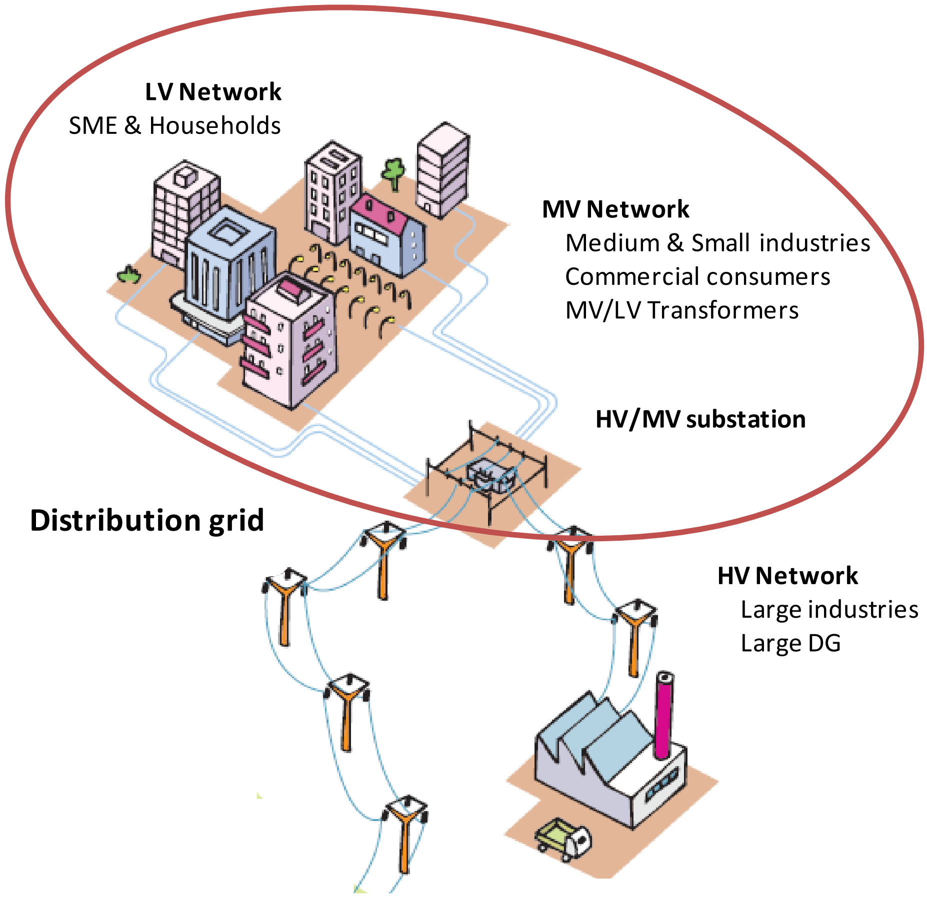

Figure 6, schematic representation of the hierarchy of network users connected to a distribution grid according to the voltage level. The scope of the exemplary networks used in this report is highlighted in the red circle (MV and LV networks).

3.2.1.2 Characterizing customers by means of load / generation profiles

Each of the modelled consumers, prosumers or generators in the networks is characterized by means of a load, or generation, pattern. The patterns of all the consumers of a network altogether are aimed at representing a variety of combined load and generation scenarios, indicative of either normal operating conditions or extreme situations for the grid. In particular, at least three types of load profiles are of interest for the evaluation of the economic benefits of AD for different stakeholders and are used in this report:

1. The **maximum consumption** profile, which is the register of the maximum electric power that is consumed by a consumer in each hour of the day. This is the magnitude that has to be taken into consideration to dimension network assets when planning the expansion and reinforcements of the distribution grids in those cases where the load growth is the only, or most relevant, network expansion driver.

2. The **average** and the different **percentiles**[10] of the **daily load profile,** both throughout the year and for different typical days of the year. This information is valuable to understand the normal consumption patterns of consumers. It would allow us to quantify the final cost of energy for consumers with and without AD based on existing and new tariffs, electricity market prices and additional incentives for participating in AD – even though assumptions would have to made on the resulting load behaviour, i.e. after AD is introduced.

Figure 7 represents an example of the maximum, average and percentile 95 load profiles that can be observed in a single consumer throughout a year, in contrast to the same measures taken from an aggregate sample of a pilot program of more than five hundred residential consumers[11] in Figure 8. The vast difference between each of these profiles can be noticed. This reveals the huge variability of residential electricity consumption and the infrequency of peak consumption among residential consumers. In contrast, industrial and commercial consumers present a more stable consumption profile which depends a lot on their economic activity.

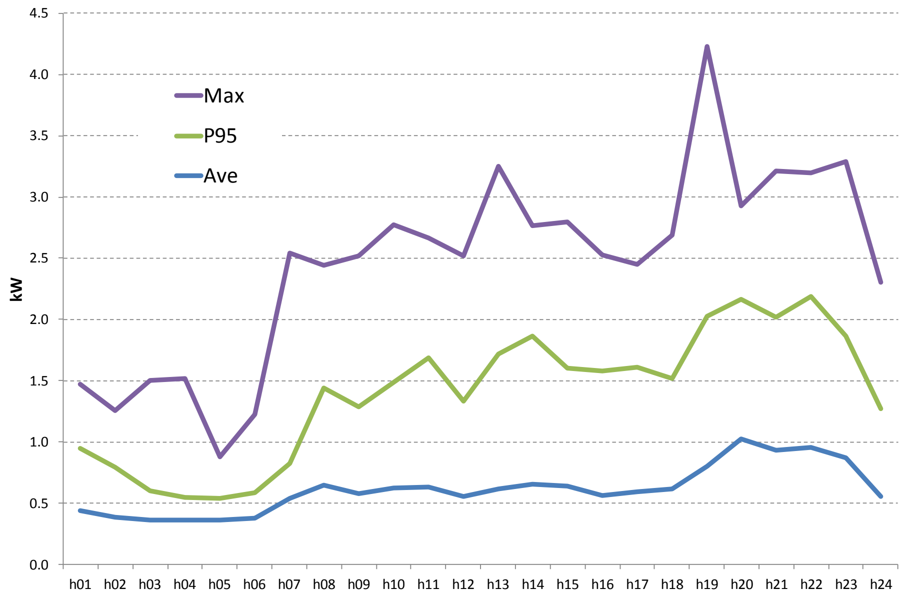

Figure 7, example of representative load profiles of a single consumer, in kW, including the maximum consumption (Max), the average consumption (Ave), the median and other percentiles; built from the Spanish ADDRESS pilot data

[10] By the percentile X of the consumption pattern we mean the consumption levels for each of the 24 hours of a day below which a given percentage X of observations in the sample of consumers fall. For example, P95 is the load profile below which the consumption at each hour of the day lies during 95% of the days.
[11] E-DeMa Pilot program consumption data provided by RWE in the context of this task.

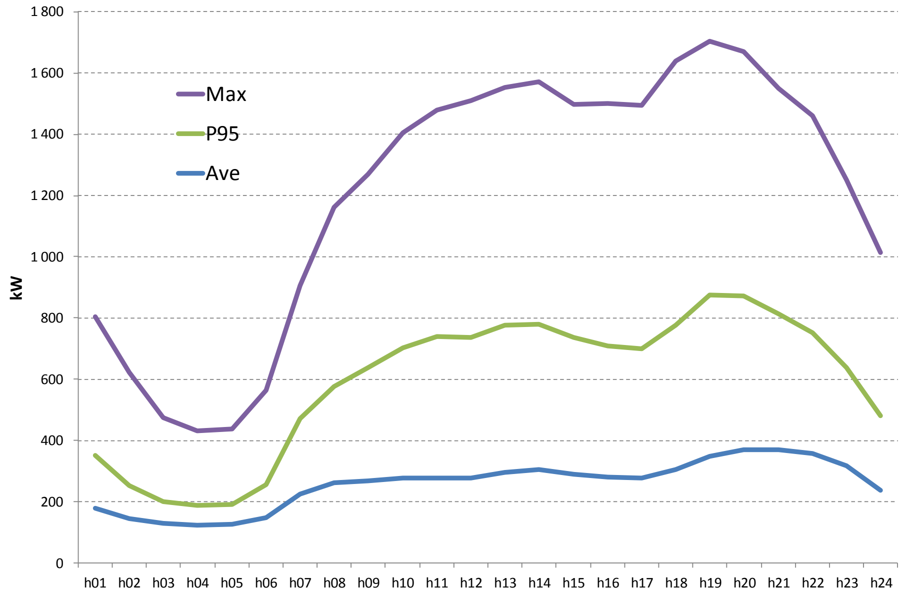

Figure 8, aggregate representative load profiles of all consumers from the German E-DeMa pilot, in kW, as an example of the maximum consumption (Max), the average consumption (Ave) and the percentile 95 (P95) of a population of consumers

3. An **extreme load profile**, which takes into consideration the worst scenarios of load for each hour of the daily profile, particularly subject to the type of distributed generation or special loads that are, or are expected to be integrated in the network. For example, in an area where there is a significant amount of solar PV generation to be integrated, the extreme, or critical, load profile of consumers would correspond to the minimum or average consumption during the hours of highest solar PV energy production and to the maximum consumption during the rest of the day. This hypothetical and artificial load profile is a representation of the extreme circumstances of the load that are important for dimensioning the network expansion needs. An example of extreme profile for a group of consumers is presented in Figure 9, along with the assumed solar PV maximum generation profile, illustrating the importance of using it to design networks with high PV penetration.

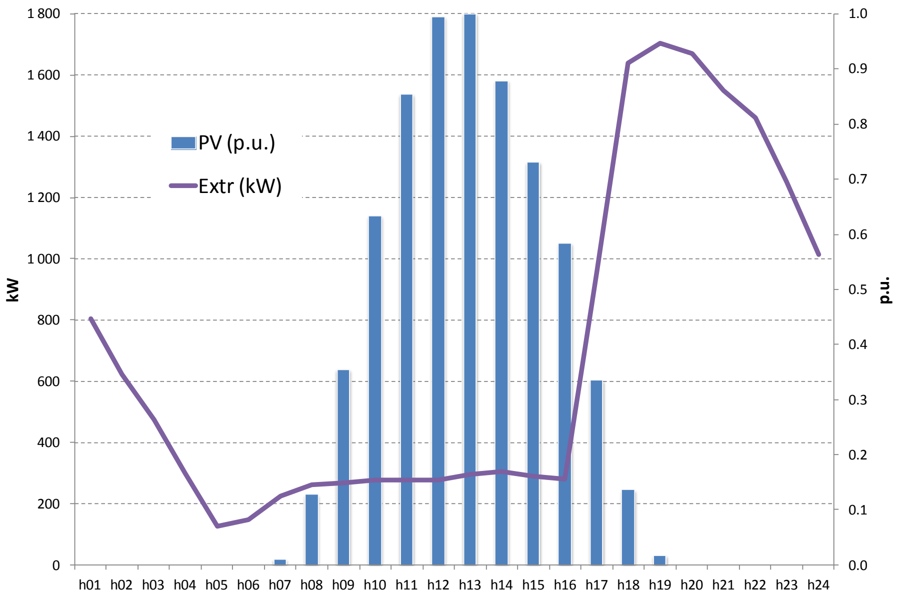

Figure 9, aggregate representative "extreme" load profile (Extr) of all consumers from the German E-DeMa pilot in a year, in kW, compared to the critical PV generation profile, in per unit values

Distributed generation is modelled through its maximum generation profile in order to account for the most critical state to which the network can be exposed due to the connection of these DG units. In this work, as it can be seen in the description of the scenarios and case studies in section 3.4, only the increase of solar PV generation in distribution networks is taken into consideration in network planning because it is an unpredictable source of energy with the highest penetration rate in the countries analysed that is connected at all voltage levels[12].

3.2.1.3 Identifying customer segments and groups

As previously indicated in this section, see Figure 6, network users can be classified according to their voltage level and the activity related to their electricity consumption into: LV customers, including households and small and medium size commercial consumers, and MV customers, which cover service and commercial buildings and small and medium size industries. The usual power requirements of each of these customers are below the values indicated in Figure 10, even though the power rates may vary among countries and have been adjusted accordingly for the modelling process. Distributed generators are assumed to be connected to both the LV and the MV networks.

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[12] The reader should be aware that depending on its size/load per unit and per wind park, on-shore wind can be and will be connected directly to MV/HV stations in some countries; thus causing additional enhancement needs on the networks.

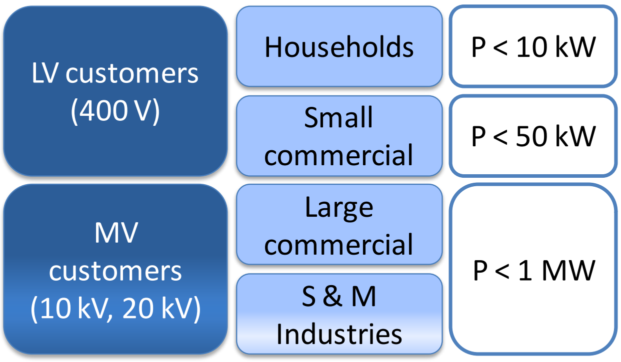

Figure 10, consumer categories in the analysed networks and usual contracted power ranges

Within each of these consumer categories, a range of consumer groups are distinguished according to different load patterns and consumption levels. These groups are defined in two different ways depending on the category of consumers:

- The load patterns of **residential** consumers are based on the household-level consumption data collected in the ADVANCED pilot program of the country of each particular case study. Nonetheless, it is not the particular individual load profiles of each consumer that are used in the case studies but certain representative behavioural patterns of consumption based on a statistical analysis of the sample collected in the pilots, as explained below[13]. In addition to this, the power rates have been adjusted to the usual subscribed power levels among consumers according to the best information available.
- The load patterns of different types of **commercial** and **industrial** consumers that may be connected to either the LV or the MV of a distribution network correspond to standard or generic load profiles that are provided by the National Regulatory Authorities or feasible profiles of several types of customers taken as examples from other information sources such as public reports.

The procedure that is used to classify the residential consumers from the pilots into representative groups according to their consumption profiles is a basic clustering partitioning algorithm: K-means. Clustering techniques allow us to create groups, or segmentations, of elements in a sample of data, in such a way that the objects that belong to the same cluster are very similar and objects in different clusters are very distinct. According to the K-means

[13] This is done in order to simplify the use of this information in the model and to avoid the particularity of individual consumption characteristics.

algorithm, each cluster in the partition is defined by its member objects and by its centroid. The centroid for each cluster is the point to which the sum of distances from all objects in that cluster is minimized.

For the analysis carried out in T6.3, residential consumers of each of the pilots are classified into ten categories with similar behaviour. These consumer groups are distributed randomly throughout the networks according to the same probability of distribution of the different classes observed in the sample. An example of the outcomes of this procedure is illustrated below. Figure 11 presents an example of the individual maximum load profiles observed in the sample of the Spanish AD Pilot and Figure 12 shows the resulting ten categories of similar consumption behaviour identified using the clustering algorithm.

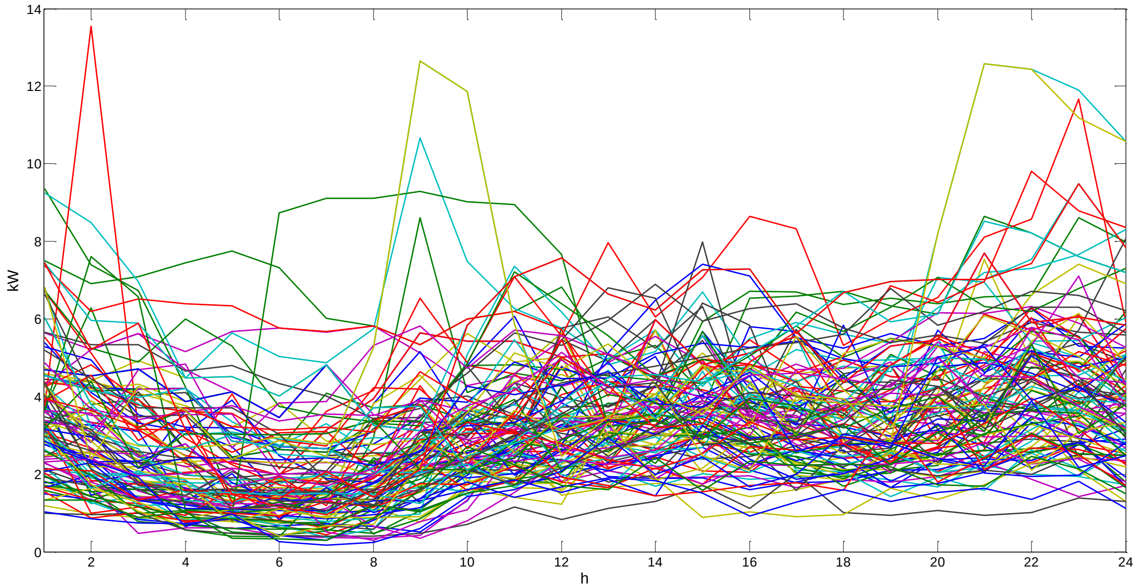

Figure 11, individual maximum load profiles observed in the Spanish Address Pilot

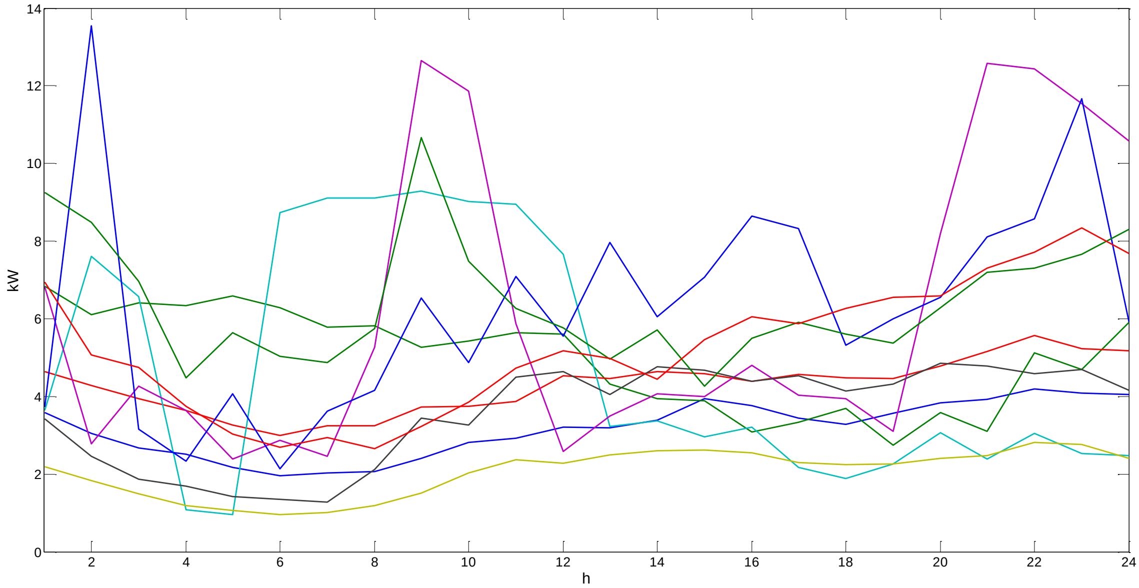

Figure 12, clustering of the individual maximum load profiles of the Spanish Address Pilot into ten categories of consumers with similar behaviour

Among the load profiles used to model the non-residential consumers in the case studies, in Figure 13 are presented some examples of the usual electricity consumption pattern of some small and medium size commercial customers.

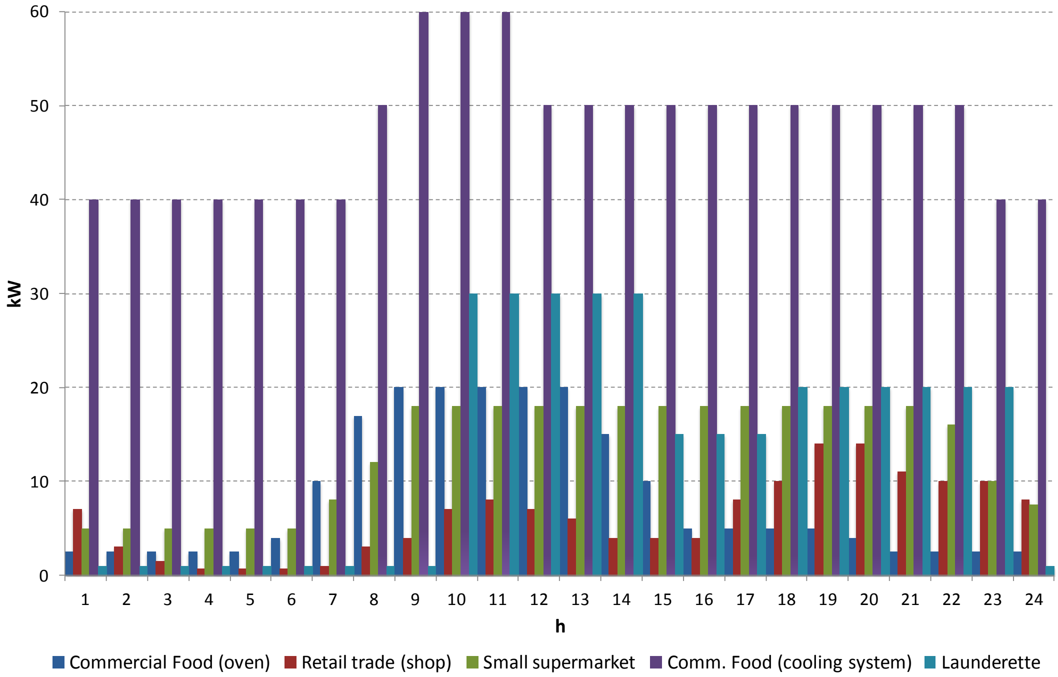

Figure 13, some examples of average load profiles for possible different types of commercial consumers. Own elaboration based on data from (AVEN, 2005)

3.2.1.4 Evaluating the impact of AD on consumption for network planning

The desired impact of AD on normal load profiles is to induce a load changes that benefit the electricity system to some extent, e.g. reducing the system peak load. However, the final impact of AD on any particular consumer will depend on the pattern of consumption and the type of AD program, especially in terms of the value and the form of the signal received and the capability of responding to this signal.

All the previously described consumption profiles are referred to as the baseline consumption profiles, this is, those that correspond to normal consumption patterns in the absence of any AD program[14]. The assumed resulting load profiles from the participation of AD will be used to compare with respect to the baseline profiles:

- The impact on **distribution network** planning investment **costs**.
- The different **cost of electricity for consumers** under each AD program and scenario (individual benefits).

The methodology to estimate the assumed impact of AD on consumption is based on the inputs received from T6.1 (D6.1 2014). The AD flexibilities of demand that have been quantified in T6.1 measure the average effectiveness that different AD programs are expected to have on the load of households. Those effectiveness values will be assumed to apply also for other non-residential consumers connected to the LV and MV. The expected result of these programs is an overall decrease of the energy consumption (Feedback programs, FB) or a reduction of the peak load (Dynamic Pricing programs, DP). These flexibilities are provided in terms of a potential percentage reduction either of energy or peak power.

The reduction on energy consumption or peak demand is applied directly to the maximum load profile, uniformly in the case of feedback programs or focused on the peak hours of the system in the case of dynamic programs. This is done under the following assumptions:

- **Feedback programs** (**FB**) encourage a reduction on consumption, regardless of the time of the day. Therefore, it can be assumed that the average, the maximum and the extreme load profiles are uniformly reduced in the percentage effectiveness of energy reduction that is expected of certain Feedback program. This effectiveness is the one taken from T6.1. An example of the resulting aggregate extreme load profile of the

[14] Apart from those existing already in that are not included in the evaluation here, like in France.

residential consumers of a network participating in a Feedback program with respect to the baseline consumption is presented in Figure 14.

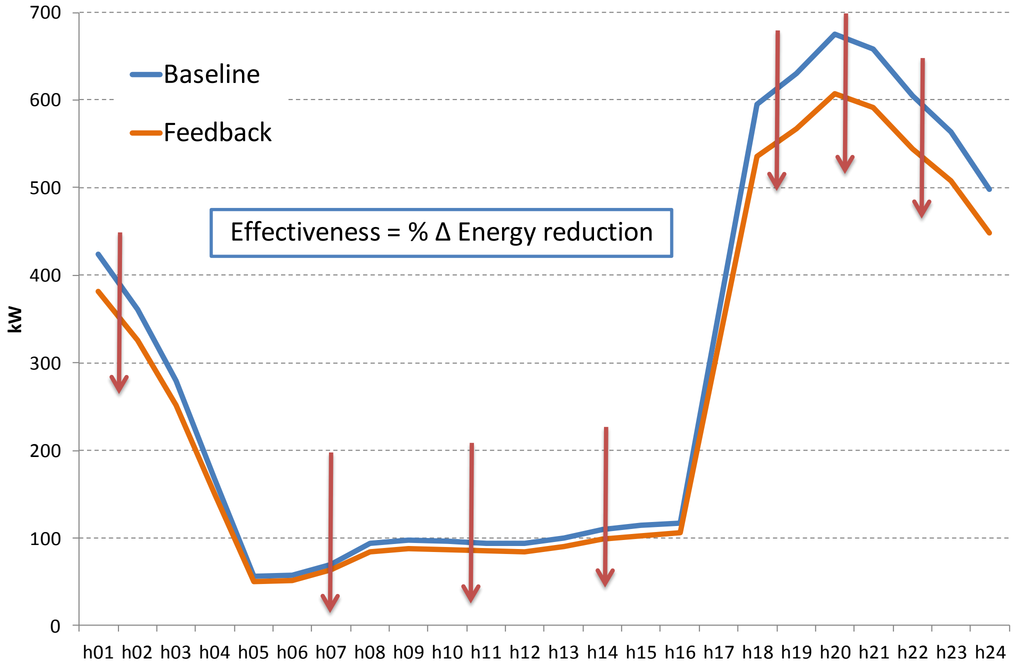

Figure 14, example of the expected effect of a feedback program on the baseline "extreme" consumption profile of a group of residential consumers, assuming an effectiveness of 10%. Based on the consumption profiles from Enel Info+ Pilot

- **Dynamic Pricing** (**DP**) and other demand response programs, have effect on the peak demand during certain hours of the day. Therefore, the maximum load profile of each consumer is assumed to experience a reduction equal to the assumed effectiveness of the program only during the supposed peak hours of the system to which the case study belongs and during which the high price takes place. For instance, it is assumed that Critical Peal Pricing (CPP) Programs have a more local effect on the load curve (only a few hours) than Time of Use (TOU) programs, which would be expected to affect a larger frame of hours while their effectiveness is usually lower. An example of the resulting maximum load profile of the aggregate consumption of all residential consumers in an area is presented in Figure 15.

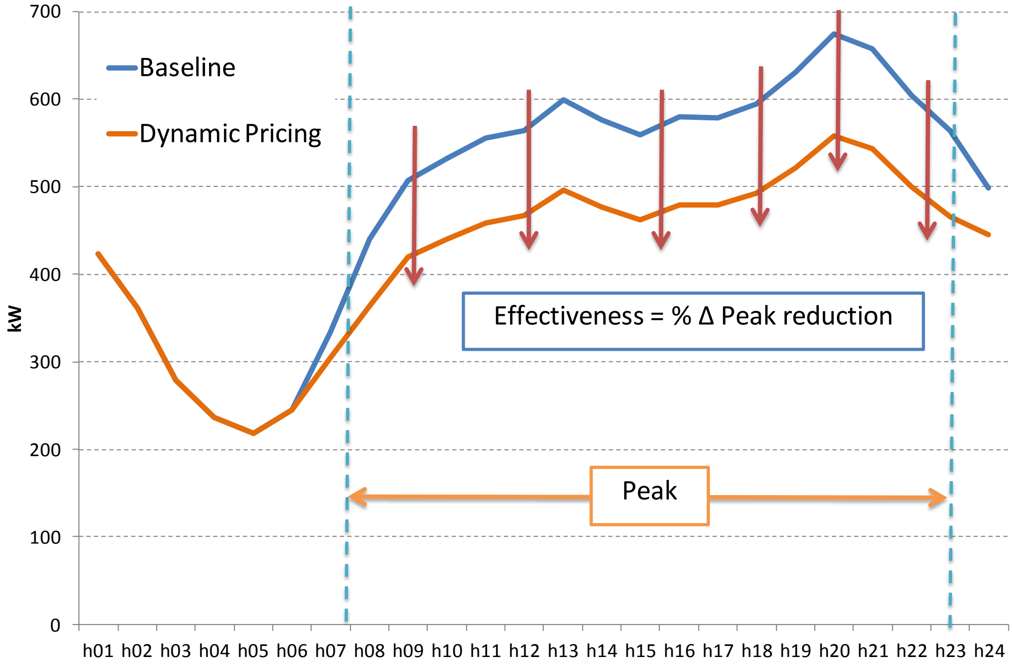

Figure 15, example of the expected effect of a Dynamic Pricing program on the baseline "maximum" consumption profile of a group of residential consumers, assuming an effectiveness of 17%. Based on consumption profiles from Enel Info+ Pilot

In areas where the penetration of DG is a critical issue, it could be beneficial to increase minimum or average consumption during those hours of the day when the uncontrollable distributed generation is producing more energy, rather than reducing peak consumption at any time. For this reason, the impact of AD on the extreme profile is a reduction of maximum consumption during the system peak hours, when the price signal is expected to take place, while the minimum consumption would increase during the hours of highest uncontrollable DG. This way the expected most critical situations to which the network can be exposed due to simultaneous high peak demand or simultaneous very low demand in combination with high volume of DG, become less severe requiring lower network reinforcements. An illustrative extreme example of this effect (the effectiveness of the AD programme is assumed to be very high) on the residential consumers of an area is presented in Figure 16.

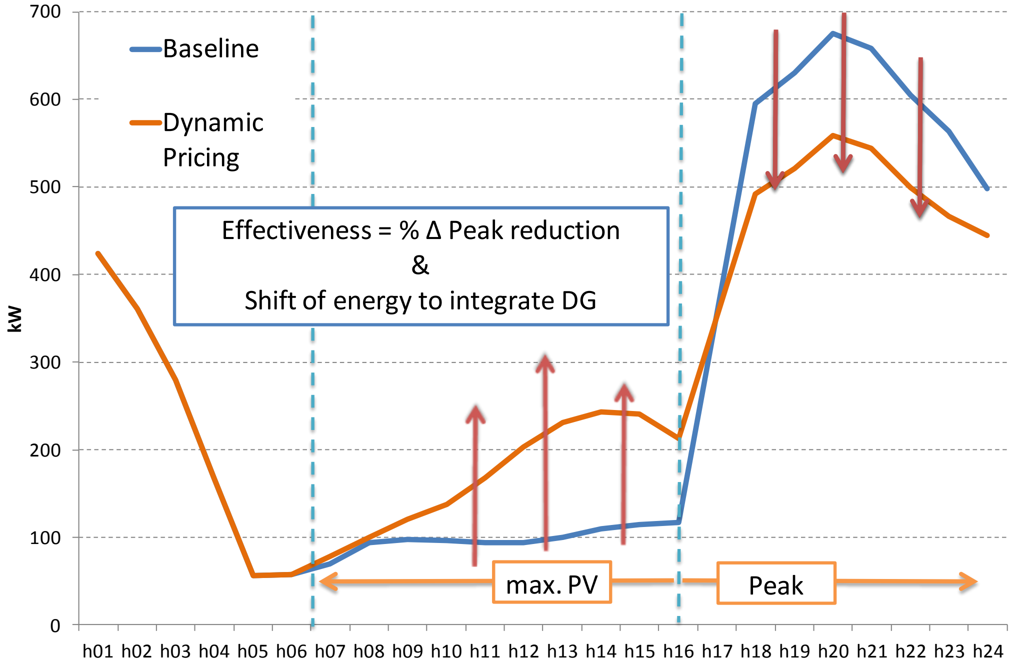

Figure 16, extreme example of the expected effect of a Dynamic Pricing program with high effectiveness on the baseline "extreme" consumption profile of a group of residential consumers, assuming an effectiveness of 17%. Based on consumption profiles from Enel Info+ Pilot

Contrary to the result of DP on the maximum load profile, the impact of DP on the average load profile necessarily has to reflect the effect of load shifting from the peak hours to the off-peak hours. It is assumed that the reduction that is observed in the maximum consumption profile during the peak hours due to DP is distributed throughout other hours of the day and not to a specific hour in particular, being it improbable that the maximum consumption of other times of the day is exceeded with respect to the baseline maximum profile. However, in the average load profile, this load shifting is visible but is not expected to take place in 100%. This is, given the energy that is not consumed during the peak hours cannot be completely shifted in time, part of it is assumed to be curtailed or reduced and the rest is assumed to be moved to the valley hours. This profile, as shown in Figure 17 is used to estimate the average economic impact on consumers.

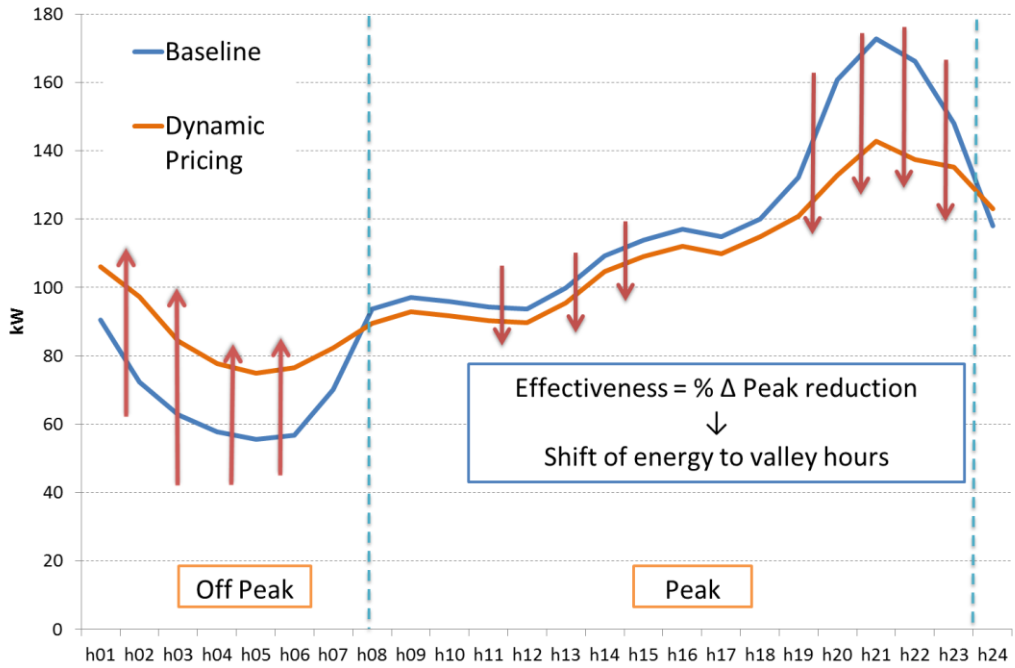

Figure 17, extreme example of the expected effect of a Dynamic Pricing program with high effectiveness on the baseline "average" consumption profile of a group of residential consumers, assuming an effectiveness of 17%. Based on consumption profiles from Enel Info+ Pilot

3.3. Link with other WP6 tasks

Task 6.3 of the ADVANCED project is interrelated to the rest of the Work Package, but is especially consistent with the assumptions underlying the methodology and the definition of macroeconomic scenarios of T6.1. Additionally, the quantification of the economic benefits of this amount of flexible demand for the distribution networks that is carried out in T6.3 stems from the assumption that the mechanisms described in T6.2 for DSO to take advantage of this flexibility are in place, without entering into specifications in that sense in this deliverable.

As a matter of fact, the whole structure of boundary conditions that are used to characterize scenarios of analysis and the specific values and attributes assigned to each of the scenarios in each country in (D6.1 2014) are the reference used in this work to build the case studies. The underlying assumptions in the estimation of the overall impact of AD programme types on the country electricity load profile are also used here. This means that instead of separately analysing the foreseeable impact of each AD programme type in the different countries, networks and macroeconomic scenarios, a combination of the subtypes of AD programmes grouped into Feedback and Dynamic Pricing, respectively.

The assumed effectiveness of AD programmes and the classification of AD programmes itself are inputs of particular importance in the methodology used in T6.3 for the evaluation of the economic benefits at distribution network level. Those values, expressed as an average percentage of energy or power reduction in the peak hours as a consequence of AD programmes, are applied individually to those consumers connected to the simulated networks that are assumed to participate in AD, according to the participation rates of the particular scenario.

Therefore, even though the methodology used in T6.3 is of a different nature to that of T6.1, their underlying scenario structure and most important assumptions are taken as inputs for the simulations of T6.3. This way, a coherent framework is preserved in the Work Package.

3.4. Definition of scenarios

The definition of scenarios that is used in this task is almost completely inherited from D6.1 2014, except for two additional boundary conditions that are network-related: the type of area (rural or urban) and the location of consumers participating in AD (dispersed or concentrated). This scenario structure is summarized again in this section. The description of the final case studies is also provided.

A case study is prepared for each of the countries under study in the ADVANCED project: Spain, Italy, Germany and France, in line with the rest of the WP6 tasks. In each of these countries, two exemplary networks are built: a rural and an urban network, in order to incorporate the impact of the network typology in the achievable savings from network investments with the help of AD. Networks in urban areas serve a higher density population than rural areas, and are designed using different configuration parameters, such as a higher rate of underground lines with respect to aerial lines.

In each of the exemplary networks evaluated, the potential benefits of the two main categories of AD programs that have been considered in T6.1 are separately evaluated: Feedback (FB) and Dynamic Pricing (DP) programs, categorized as in section 2. The assumed application of both FB and DP are really a combination of the different sub-types of each category among the population of consumers according to the specified proportions of participation that are defined in each macroeconomic scenario. Consumers are expected to participate only in one type of AD program at once.

The potential economic impact of these types of AD on each country-specific exemplary network is analysed under the three macroeconomic scenarios that were initially proposed in D1.3 and later on extended in D6.1. These macroeconomic scenarios are defined on the basis of the current status of electricity markets in Europe and their possible evolution in the horizon of 2020 according to a combination of parameters and conditions that determine the boundary conditions. Such enabling and impedimental factors include the regulatory framework, the market penetration of AD services, the level of consumer participation and the degree of development of enabling technologies. Three scenarios have been defined in the context of the project according to (D1.3 2013): *Baseline*, *Optimistic* and *Technical Potential*.

The *Baseline* scenario projects the business as usual trends of the current economic and regulatory progress. The *Optimistic* scenario takes more ambitious assumptions while the *Technical Potential* scenario is defined as a hypothetical situation where the full potential of AD that is physically and technologically feasible. Therefore, the *Technical Potential* scenario allows us to analyze the technical factors that limit the potential of AD to defer investments while the *Baseline* and *Optimistic* scenarios allow us to evaluate the economic and regulatory conditions that bound the potential of AD as a substitute for network investments.

In particular, these scenarios are defined in each country according to the following boundary conditions, or variables:

- **Quantitative variables (%):**
    - AD Program effectiveness
    - SM roll-out
    - AD-Program uptake rate
- **Qualitative variables:**
    - Communication and technical capabilities of SM
    - Assets that can be automated or controlled
    - Balancing regime and usage of load profiles
    - Data privacy issues

Among the quantitative variables, the SM roll-out and the AD program uptake rate influence on the final rate of participation in AD for each program type in a given population. The AD program effectiveness, which is only uniform across all scenarios for a particular AD program, is used to determine the load changes from AD in each participating consumer according to their own baseline profile, as described in 3.2.1.4. Additionally, the qualitative variables reflect the regulatory barriers that would hamper the possibilities of carrying out certain AD program type.

In T6.1, these scenarios serve as the basis for the elaboration of a registry of the potential at a system scale of each of the AD programs in each national reality and scenario. In this task, the same final participation rates in each AD program type that are assumed to take place in each scenario and country are taken as inputs for the definition of scenarios in the case studies.

Summarizing, the scenarios evaluated in the case studies are a combination of:

- **Country** (Spain, Italy, Germany, France).
- **Network** type (urban, rural).
- **AD** Program type (Feedback, Dynamic Pricing).
- **Macroeconomic** scenario (Baseline, Optimistic, Technical Potential), which is translated into a list of **participation rates** in each of the sub-types of ad programs for each of the scenarios. The participation rate is the product between the SM roll-out level and the AD uptake rate among those consumers with SM availability. The Technical Potential scenario is only an upper bound that reflects the technical limitations of reducing network reinforcements through actions on the loads. The baseline and the optimistic scenarios are feasible situations that could take place in the near future, not without the corresponding actions and investments that would enable such a degree of AD implementation.
- **Location** of **responsive consumers** in the network. Consumers participating in AD can be randomly **dispersed** throughout the network, or rather **concentrated** in specific locations. The reason for this sensitivity is the possible different outcomes that can be expected in these two situations. For instance, a high concentration of participative consumers in certain zones of the distribution networks could possibly avoid the reinforcement of power intensive assets that affect a large group of consumers, or rather not be sufficient to avoid reinforcements if these are widely scattered geographically.

3.4.1. AD program effectiveness

The basis for the determination of the impact of AD on the load profiles of different consumers is the AD program effectiveness. This effectiveness represents the impact as the percentage reduction on the total energy consumption and on the peak consumption for Feedback and Dynamic Programs, respectively. As stated in (D6.1 2014), the values of the AD programs effectiveness are provided by the ADVANCED knowledge base, including both the pilots sites and the VaasaETT database.

	AD programs	Program Type Effectiveness
Feedback programs	Informative bill	5,68%
	In-Home Display (IHD)	9.1%
	Website	4.38%
Dynamic Pricing programs	Time of Use (no-automation)	5.16%
	Time of Use (automated)	15.45%
	Critical peak (no-automation)	16.63%
	Critical peak (automated)	32.47%
	Real-time pricing (no-automation)	10.19%
	Real-time pricing (automated)	11.25%

Table 2, AD program effectiveness (D6.1, 2014).

These values are common to all countries and scenarios. For this reason, they are introduced here, out of the specifications of the case studies for each country that are presented in the description of the case studies.

4. Case study: Spain

This chapter presents the economic analysis of the potential benefits of AD for distribution networks in Spain[15]. These benefits are quantified as the network reinforcement investments that could be avoided by counting on the effects of AD on the loads to improve network planning.

The analysis is based on two exemplary initial LV-MV networks of different population density (rural and urban) that have been created with the Reference Network Model (RNM) of Universidad Pontificia Comillas (see Annex A). The initial networks are optimally designed with the Greenfield RNM based on the street map of example locations, a characterization of network users and normal characteristics of Spanish distribution grid assets, as agreed with Iberdrola. These networks are not representative of all networks in Spain but are appropriate and realistic examples to quantify the order of magnitude of the potential of AD to defer investments in distribution grids for different scenarios of AD application.

The investment needs for each scenario are estimated with the Expansion RNM for similar requirements of load growth and reliability constraints but with different expected consumption patterns from those consumers participating in AD, according to the participation rate of each scenario. The model provides the minimum cost solution both for investments and for energy losses, while complying with the legal reliability requirements (voltage limits and continuity of supply indices).

The remaining subsections of this chapter describe the characteristics of the initial networks, the expansion scenarios and the results of the economic benefits of AD in distribution network investment deferral for the Spanish case study.

4.1. Description of the exemplary networks

The configuration and the composition of the exemplary networks used for the Spanish case study are shown in Figure 18 and Figure 19. Table 3 - Table 7 display the characteristics of consumers, the number of network elements, and the total peak power of network users, the nominal power of transformers and substations and length of the lines. The equipment used to

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[15] The reader should be aware that each case study has particular characteristics and network types and that the results obtained in each are not entirely comparable.

design the network, both initially and in the expansion scenarios, has the standard sizes and power rates and average costs found in multiple equipment catalogues.

The peak power needs of the non-residential consumers connected to the Spanish urban network are characterized according to the building census[16] of several Spanish cities and the legal minimum technical requirements established in the low voltage electro technical regulations[17] for each type and size of buildings. Residential consumers are categorized according to the clustering of maximum load profiles of the ADDRESS Pilot. The statistical representation of network users' peak power needs is summarized in Table 3.

Residential consumers LV (0.4 kV)

Power (kW)	3	4	5	6	7	8	9	11	13	14	Total
Urban & Rural (%)	30%	27%	12%	18%	3%	6%	1%	1%	2%	1%	**100%**

Non-residential consumers LV (0.4 kV)

Power (kW)	10	12.5	15	17	20	50	Total
Urban & Rural (%)	1%	1%	17%	31%	35%	15%	**100%**

Consumers MV (10 kV, 20 kV)

Power (kW)	75	100	150	200	250	Total
Urban & Rural (%)	91%	5%	2%	0%	3%	**100%**

Table 3, Consumer peak power characterization in the Spanish networks

The urban network is based on the street map of a sub-urban location. Among LV consumers in the urban network, residential consumers account for 90%. The largest proportion of lines is underground and the reliability requirements are higher than in the rural network, as seen in Table 4.

	No. Consumers		Contracted power (MW)		Network length (km)			
					Aerial		Underground	
	No.	%	MW	kW/cons.	km	%	km	%
LV	65 848	97%	424.2	6.4	19.7	7%	266.1	93%

[16] Censo de Población y Vivienda 2011, Instituto Nacional de Estadística (INE), Spanish Institute of Statistics.
[17] Reglamento Electrotécnico de Baja Tensión (REBT) and other technical documents.

MV	2276	3%	186.7	82	39.1	13%	258.4	87%

Table 4, Spanish urban network customer and network characteristics

Three primary distribution substations, two of 120 MVA and one of 80 MVA connect the transmission substation to the MV network, where the regular sizes of MV/LV transformers are 250 MVA and 630 MVA, as shown in Table 5.

	Vn1 (kV)	**Vn2 (kV)**	**Sn (kVA)**	**No.**	**%**
Transmission ST	400	132	106	1	-
HV/MV ST	132	20	120 000	1	-
	132	20	80 000	1	-
MV/LV TR	20	0.4	1 000	36	15%
	20	0.4	630	59	24%
	20	0.4	400	44	18%
	20	0.4	250	92	37%
	20	0.4	100	17	7%

Table 5, Spanish urban substation facilities, where ST stands for substation and TR stands for transformer

Figure 18 corresponds to the resulting urban network for the Spanish case study.

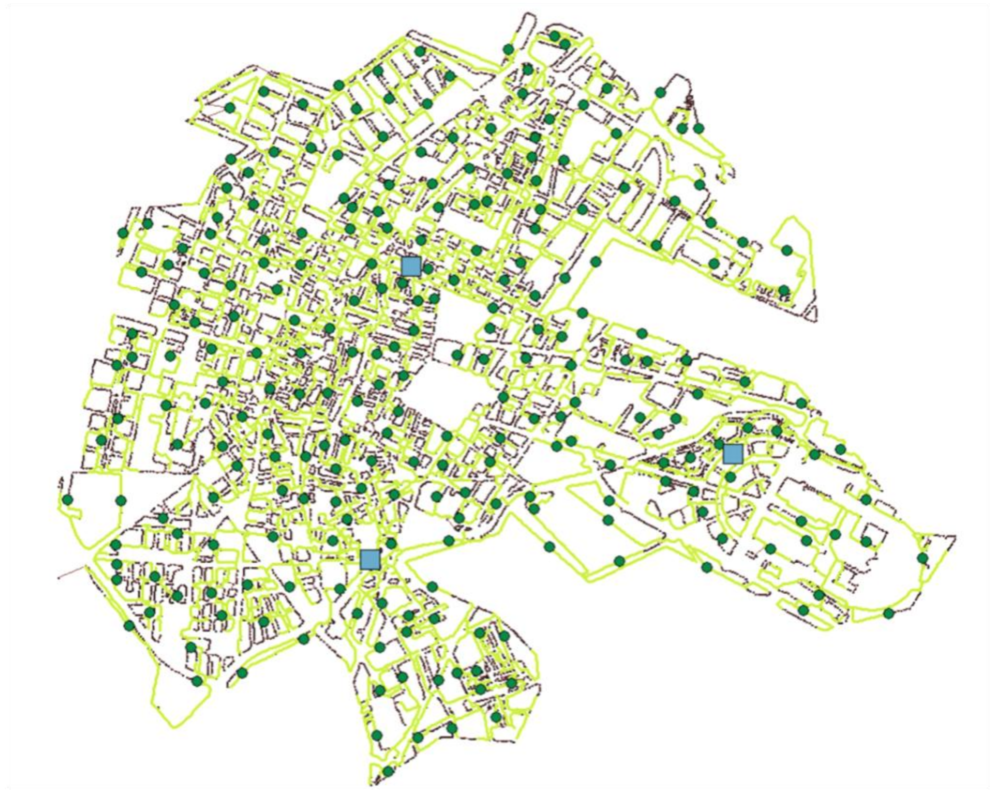

Figure 18, exemplary urban network for Spain. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation, the green dots represent the location of MV/LV transformers and the purple lines represent the LV network.

The rural network is based on the street map of a set of dispersed rural locations of Spain. It can be easily noticed in the figure below that the population density of the region is much lower and that the final configuration of the network differs significantly in structure. It can be noticed that the proportion of LV consumers is higher in the rural area and that among LV consumers, residential consumers account for 96% in contrast to the 90% or the urban network. The proportion of aerial lines is higher and transformers are generally lower in size than in the urban network, as can be seen in Table 6.

	No. Consumers		**Contracted power (MW)**		**Network length (km)**			
					Aerial		**Underground**	
	No.	**%**	**MW**	**kW/cons.**	**km**	**%**	**km**	**%**
LV	11 218	99%	60.8	5.4	140.4	89%	18.2	11%
MV	156	1%	12.8	82	182.1	92%	15.4	8%

Table 6, Spanish rural network customer and network characteristics

Figure 19 corresponds to the resulting rural network for the Spanish case study, which is made up of distant small locations connected to the substation through the MV aerial lines.

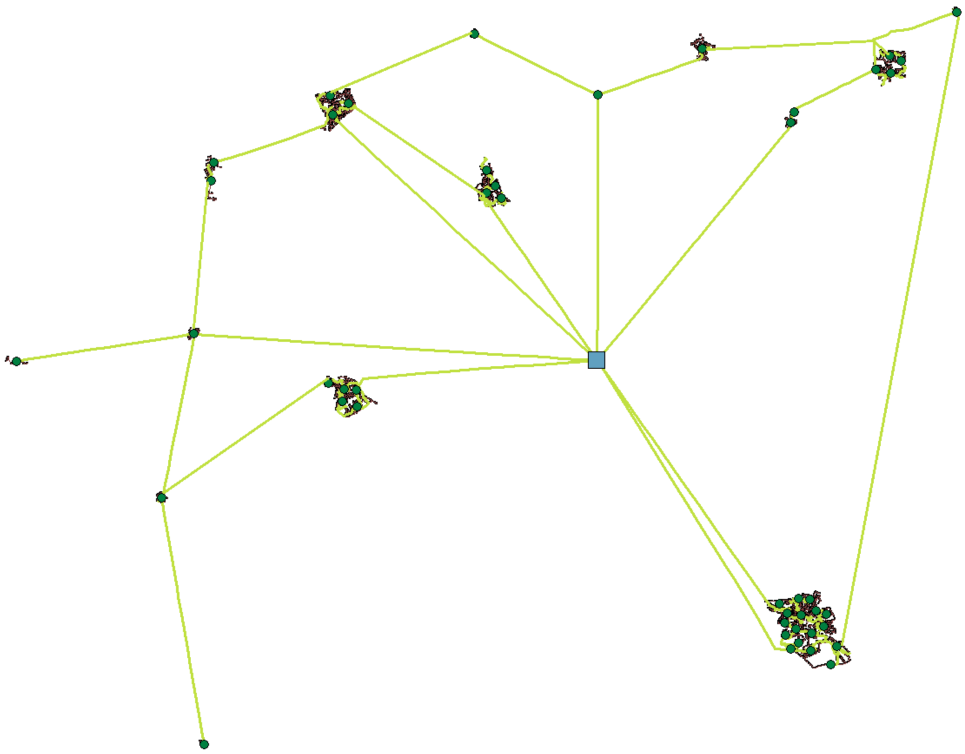

Figure 19, exemplary rural network for Spain, made up of some dispersed locations. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation, the green dots represent the location of MV/LV transformers and the purple lines represent the LV network.

One primary distribution substation of 80 MVA connects the transmission substation to the MV network, where the regular sizes of MV/LV transformers are 250 MVA and 400 MVA, as shown in Figure 6.

	Vn1 (kV)	Vn2 (kV)	Sn (kVA)	No.	%
Transmission ST	400	132	106	1	-
HV/MV ST	132	20	80 000	1	-
MV/LV TR	20	0.4	1 000	3	7%
	20	0.4	630	9	20%
	20	0.4	400	11	24%
	20	0.4	250	15	33%
	20	0.4	100	5	11%
	20	0.4	50	2	4%

Table 7, Spanish rural network facilities, where ST stands for substation and TR stands for transformer

4.2. Network expansion planning scenarios

The main assumptions taken for planning the networks, both from scratch and in the expansion model to simulate the investment planning decisions in the a ten-year horizon are the following:

- The main driver for network expansion is load growth (3%/yr in the ten-year horizon).
- No relevant increments of DG are taken into consideration to dimension the network needs at residential and commercial level in LV and MV for the near future in Spain.
- Reliability and quality of supply requirements:
  - Voltage limits: 1.03 pu and 0.97 pu.
  - Reliability indexes according to Spanish regulation definitions.
- The participation rates, i.e. the proportion of consumers participating in the AD programs, for each macroeconomic and regulatory scenario are as defined in the previous deliverable D6.1 of ADVANCED and shown in Table 8. As occurs in all countries, the Technical Potential scenario consists of a 100% participation in the AD program of highest effectiveness of the Feedback and the Dynamic Pricing programs, which are the installation of an in-home display and CPP with automation, respectively.

Spain

Participation (SM roll-out x Uptake rate)	Baseline	Optimistic	Technical

Spain

Participation (SM roll-out x Uptake rate)		Baseline	Optimistic	Technical
Informative bill	FB1	17.78%	36.00%	
In-Home Display (IHD)	FB2	0.59%	1.20%	100.00%
Website	FB3	1.38%	2.80%	
		20%	**40%**	**100%**
Time of Use (no-automation)	DP1	0.14%	3.91%	
Time of Use (automated)	DP2	0.33%	11.73%	
Critical peak (no-automation)	DP3			
Critical peak (automated)	DP4			100.00%
Real-time pricing (no-automation)	DP5	7.86%	13.34%	
Real-time pricing (automated)	DP6	3.37%	10.92%	
		12%	**40%**	**100%**

Table 8, AD program participation rates for scenarios in the Spanish case study

- The load profiles that are taken as critical profiles for the state of the network and which are therefore used as an input to the network model to design the expansion requirements are the **maximum load profiles**. In particular, the characterization of residential consumer maximum load profiles is based on the aggregate representation of the ADDRESS Pilot program through clusters of similar pattern. The profiles of commercial and industrial consumers are based on feasible load patterns that can be observed in normal commercial profiles that have been found in other public sources, such as (AVEN, 2005).
- The expected impact of AD on the maximum load profiles of participative consumers is the reduction of overall consumption (Feedback) or peak consumption (Dynamic Pricing) on the maximum load profile, as explained in 3.2.1.2.
- The allocation of participative consumers in AD in the networks is done randomly (**dispersed** scenario) or by grouping them in several locations close to each other (**concentrated** scenario).

4.3. Results of the economic impact of AD on investments

The investment scenarios are studied for a ten-year horizon. The investment costs in the scenario without AD are expressed in Table 9 as a percentage of the initial cost of the corresponding voltage level or type of network component. The total reinforcement cost is expressed with respect to the total initial cost of each network.

Reinforcement costs (%)	LV network	MV/LV subs.	MV network	HV/MV subs.	Total
Rural	**14.7%**	**31.2%**	**0.0%**	**0.0%**	**5.3%**
Urban	**16.2%**	**28.1%**	**3.4%**	**0.0%**	**6.6%**

Table 9, costs of the required reinforcements in the benchmark scenario of no AD in the Spanish networks, as a percentage of the costs of the initial network per component or voltage level (LV, MV/LV, MV, HV/MV)

This base case scenario for network planning is taken as a benchmark to compare with the total reinforcement needs for a similar time horizon and annual demand growth rate under the described AD scenarios, which are compared in Figure 20. It can be noticed that the investments required to reinforce the network to address the expected needs in the next ten years is a relatively low percentage of the initial cost of the networks. Also note that they are evaluated on the basis of the same cost parameters as the new investments. The highest decrease of investment needs for the optimistic scenario is 1.4% of the initial cost, in the case of dynamic pricing in the urban network. In relation to the type of AD program, Feedback programs generally achieve better results than Dynamic Pricing Programs for the Baseline and Optimistic scenarios. This occurs because Feedback programs have a uniform impact on the whole load curve, reducing consumption at every hour of the day. Consequently, both the overall peak of the network and the local peaks of different areas are reduced accordingly. However, Dynamic Pricing programs have localized impact on a few hours of the day, which may not always coincide with the individual peak consumption, reducing the effectiveness to avoid reinforcements.

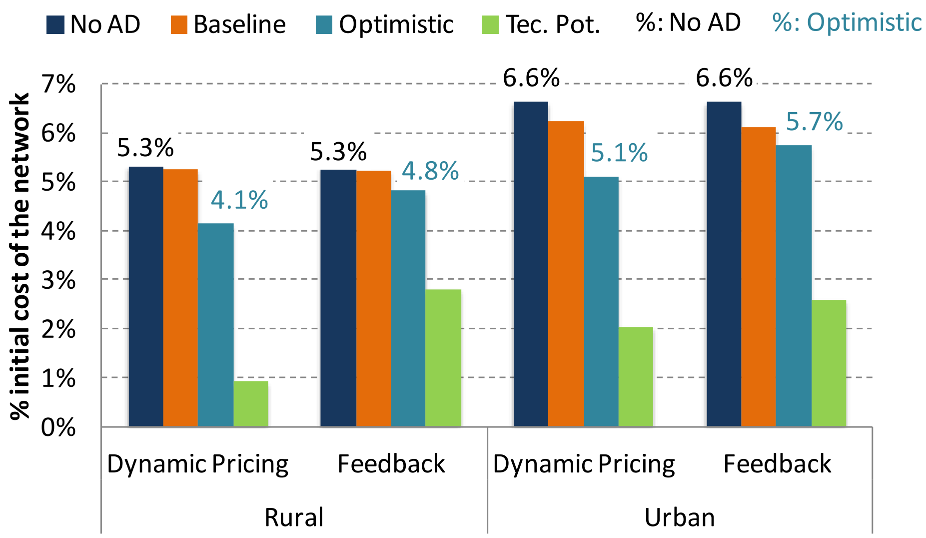

Figure 20, reinforcement investments needed, as a percentage of the initial cost of the network, in the Spanish urban and rural networks for each AD scenario

The resulting economic savings in terms of network reinforcements that could be avoided under each of the AD scenarios are presented in Figure 21 with respect to the investments required in the benchmark scenario of no AD.

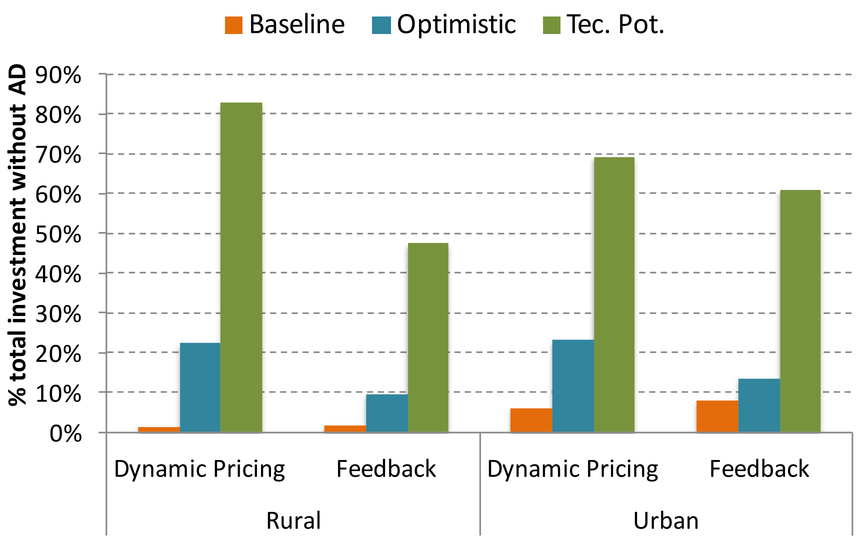

Figure 21, avoided reinforcement investments, as a percentage of the benchmark (no AD) investment needs, in the Spanish urban and rural networks for each AD scenario

AD has a great potential to defer network investments whenever they are driven by large load increases and small or hardly any new DG penetration, as is the case of these networks. The

Technical Potential of demand flexibility to avoid investments is very high in the Spanish case, where investments are only led by a significant growth in demand (3%/year). The more realistic scenarios Baseline and Optimistic, which impose technical, economic and regulatory barriers to this technical potential, indicate that the highest savings are around 20%, most of which are concentrated in the LV network and the MV/LV transformers.

In the Spanish networks there are small differences between the concentrated and dispersed cases in the baseline and optimistic scenarios. For low participation rates, the concentrated location of AD participants presents a slight improvement in the urban network, but not in the rural. In the technical potential, as the penetration is 100%, the concentrated and dispersed cases are similar. For this reason, the previous figure only represents the results for the case in which AD participation is concentrated in specific locations of the network.

The graphical representation of the avoided investments in the network diagrams can be found in Annex B, for further information.

5. Case study: Italy

This chapter presents the economic analysis of the potential benefits of AD for distribution networks in Italy[18]. These benefits are quantified as the network reinforcement investments that could be avoided by counting on the effects of AD on the loads to improve network planning.

The analysis is based on two exemplary initial LV-MV networks of different population density (rural and urban) that have been created with the Reference Network Model (RNM) of Universidad Pontificia Comillas (see Annex A). The initial networks are optimally designed with the Greenfield RNM based on the street map of example locations, a characterization of network users and normal characteristics of Italian distribution grid assets. These networks are not representative of all networks in Italy but are appropriate and realistic examples to quantify the order of magnitude of the potential of AD to defer investments in distribution grids for different scenarios of AD application.

The investment needs for each scenario are estimated with the Expansion RNM for similar requirements of load growth, new DG connections and reliability constraints but with different expected consumption patterns from those consumers participating in AD, according to the participation rate of each scenario. The model provides the minimum cost solution both for investments and for energy losses, while complying with the legal reliability requirements (voltage limits and continuity of supply indices).

The remaining subsections of this chapter describe the characteristics of the initial networks, the expansion scenarios and the results of the economic benefits of AD in distribution network investment deferral for the Italian case study.

5.1. Description of the exemplary networks

The configuration and the composition of the exemplary networks used for the Italian case study are shown in Figure 22 and Figure 23. Table 10 to Table 14 display the number of network elements, total peak power of network users, nominal power of transformers and substations and length of the lines. The equipment used to design the network, both initially and in the

[18] The reader should be aware that each case study has particular characteristics and network types and that the results obtained in each are not entirely comparable.

expansion scenarios, has the standard sizes and power rates and average costs found in multiple equipment catalogues.

The peak power needs of the consumers connected to the Italian networks are characterized according to the distribution of loads in typical networks provided by Enel. The statistical representation of network users' peak power needs is summarized in Table 10.

Residential consumers LV (0.4 kV)

Power (kW)	2.5	3	4	Total
Urban & Rural (%)	13%	63%	25%	**100%**

Non-residential consumers LV (0.4 kV)

Power (kW)	7.5	10	12.5	Total
Urban & Rural (%)	12%	63%	25%	**100%**

Consumers MV (10 kV, 20 kV)

Power (kW)	25	75	125	175	225	275	325	375	425	475	525	Total
Urban (%)	3.9%	9.1%	27%	38%	0.6%	19%		0.6%	0.6%		0.6%	**100%**
Rural (%)	35%	46%	10%	3.7%	5.3%				0.5%	0.5%		**100%**

Table 10, Consumer peak power characterization in the Italian networks

The urban network is based on the street map of a sub-urban location. Among LV consumers in the urban network, residential consumers account for 88%. The largest proportion of lines is underground and the reliability requirements are higher than in the rural network, as seen in Table 11.

	No. consumers		**Contracted power (MW)**		**Network length (km)**			
					Aerial		**Underground**	
	No.	**%**	**MW**	**kW/cons.**	**km**	**%**	**km**	**%**
LV	6 718	100%	26.7	4.0	5.61	12%	42.83	88%
MV	7	0%	1.1	161	0	0%	13.61	100%

Table 11, Italian urban network customer and network characteristics

One primary distribution substation of 80 MVA connects the transmission substation to the MV network, where the regular sizes of MV/LV transformers are 400 MVA and 630 MVA, as shown in Table 12.

	Vn1 (kV)	Vn2 (kV)	Sn (kVA)	No.	%
Transmission ST	400	132	1,000,000	1	-
HV/MV ST	132	20	80,000	1	-
MV/LV TR	20	0.4	630	49	65%
	20	0.4	400	23	31%
	20	0.4	250	3	4%

Table 12, Italian urban substation facilities, where ST stands for substation and TR stands for transformer

Figure 22 corresponds to the resulting urban network for the Italian case study.

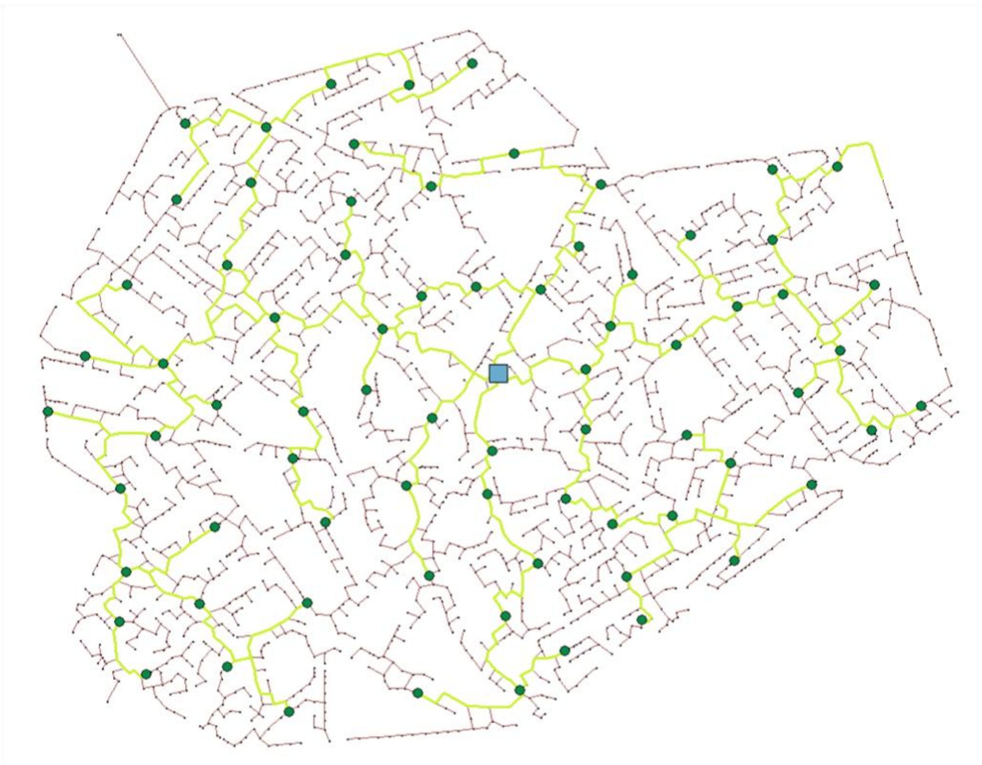

Figure 22, exemplary urban network for Italy. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation, the green dots represent the location of MV/LV transformers and the purple lines represent the LV network.

The rural network is based on the street map of a set of dispersed rural locations of Italy. It can be easily observed in the figure below that the population density of the region is much lower and that the final configuration of the network differs significantly in structure. It must be noted that the proportion of LV consumers is higher in the rural area and that among LV consumers, residential consumers account for 96%, in contrast to the 88% of the urban LV network. The proportion of aerial lines is higher and transformers are generally lower in size than in the urban network, as can be seen in Table 13.

	No. consumers		Contracted power (MW)		Network length (km)			
					Aerial		Underground	
	No.	%	MW	kW/cons.	km	%	km	%
LV	2 011	99.9%	6.9	3.4	12.23	28%	31.84	72%
MV	3	0.1%	0.2	58	5.96	44%	7.65	56%

Table 13, Italian rural network customer and network characteristics

Figure 23 corresponds to the resulting rural network for the Italian case study, which is made up of distant small locations connected to the substation through the MV aerial lines.

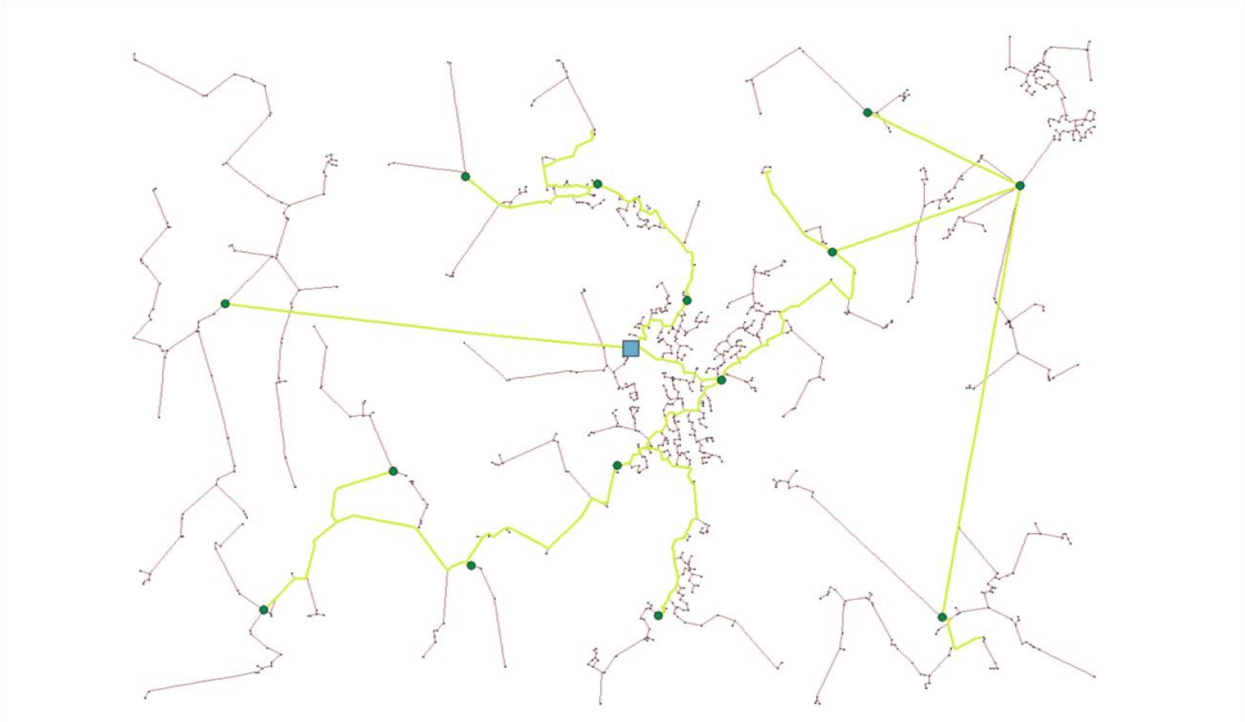

Figure 23, exemplary rural network for Italy, made up of dispersed regions of consumers. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation, the green dots represent the location of MV/LV transformers and the purple lines represent the LV network.

One primary distribution substation of 80 MVA connects the transmission substation to the MV network, where the regular sizes of MV/LV transformers are 100 MVA, as shown in Table 14.

	Vn1 (kV)	Vn2 (kV)	Sn (kVA)	No.	%
Transmission ST	400	132	1,000,000	1	-
HV/MV ST	132	20	80,000	1	-
MV/LV TR	20	0.4	400	1	7%
	20	0.4	250	7	47%
	20	0.4	100	7	47%

Table 14, Italian rural network facilities, where ST stands for substation and TR stands for transformer

5.2. Network expansion planning scenarios

The main assumptions taken for planning the networks, both from scratch and in the expansion model to simulate the investment planning decisions in the a ten-year horizon are the following:

- The drivers for network expansion are both load growth and the connection of new DG, especially solar PV at these voltage levels. Both the increase of demand and the growth of PV installed capacity are moderate. Load is expected to grow at a 1.2% rate per year in the rural area and at 0.5% per year in the urban area. Meanwhile, the new connections of DG that are expected are in line with the trends for the whole Italy (about 2.5% increase in installed capacity, most of it in the rural areas), as follows:

	Probability of new PV in existing connections %	**Total new installed capacity (kW)**		**Average size of the units (kW)**	
		LV (0.4 kV)	**MV (20 kV)**	**LV (0.4 kV)**	**MV (20 kV)**
Urban	2.4%	339	575	6	300
Rural	5.8%	368	287		

Table 15, New Solar PV generation units in the Italian networks in relation to the existing connection points

- Reliability and quality of supply requirements: standard continuity of supply indices (which are not decisive because they remain constant in all scenarios), and voltage limits of 1.1 pu and 0.9 pu.
- The participation rates, i.e. the proportion of consumers participating in the AD programs, for each macroeconomic and regulatory scenario are as defined in the previous deliverable D6.1 of ADVANCED and shown in Table 16. It has to be noted that

the participation rate in Dynamic Pricing programs in the Optimistic scenario has been halved with respect to the values of D6.1 because it was very close to the Technical Potential. Therefore, the Optimistic scenario represents an intermediate scenario between the Baseline and the Technical Potential. As occurs in all countries, the Technical Potential scenario consists of a 100% participation in the AD program of highest effectiveness of the Feedback and the Dynamic Pricing programs, which are the installation of an in-home display and CPP with automation, respectively.

Italy

Participation (SM roll-out x Uptake rate)		Baseline	Optimistic	Technical
Informative bill	FB1			
In-Home Display (IHD)	FB2	3.00%	35.00%	100.00%
Website	FB3			
		3%	**35%**	**100%**
Time of Use (no-automation)	DP1	10.00%	35.00%	
Time of Use (automated)	DP2		15.00%	
Critical peak (no-automation)	DP3			
Critical peak (automated)	DP4			100.00%
Real-time pricing (no-automation)	DP5			
Real-time pricing (automated)	DP6			
		10%	**50%**	**100%**

Table 16, AD program participation rates for scenarios in the Italian case study

- The load profiles that are taken as critical profiles for the state of the network are the **extreme load profiles**. These are therefore used as inputs to the network model to design the expansion requirements, as explained in 3.2.1.2. These profiles capture both the peak consumption during the evening-night and a much lower consumption during the periods of highest PV generation. This way the extreme system states that result from peak load alone and from a combination of peak PV generation with low demand, are taken into consideration to dimension the requirements of network capacity, with and without AD. In particular, the characterization of residential consumer extreme load patterns is based on the aggregate representation of the Enel Info+ Pilot program through clusters of similar behaviour, even though the peak power is adjusted to be like in Table 10.

- The profiles of commercial and industrial consumers are based on feasible load patterns found in public sources.
- The expected positive impact of AD on the extreme load profiles of participative consumers is the reduction of overall consumption (Feedback), or the reduction of peak consumption in combination with the increase of demand in those critical hours of low demand that occur in the period of high PV generation (Dynamic Pricing), as explained in 3.2.1.2.
- The allocation of participative consumers in AD in the networks is done randomly (**dispersed** scenario) or by grouping them in several locations close to each other (**concentrated** scenario).

5.3. Results of the economic impact of AD on investments

The investment scenarios are studied for a ten-year horizon. The investment costs in the scenario without AD are expressed in Table 17 as a percentage of the initial cost of the corresponding voltage level or type of network component. The total reinforcement cost is expressed with respect to the total initial cost of each network. Most reinforcements in the rural network are needed at the LV and MV/LV levels while most reinforcements are due to the MV network in the urban area.

Reinforcement costs (%)	LV network	MV/LV subs.	MV network	Total
Rural	**7.5%**	**7.7%**	**2.9%**	**1.4%**
Urban	**2.1%**	**7.9%**	**9.1%**	**2.6%**

Table 17, costs of the required reinforcements in the benchmark scenario of no AD in the Italian networks, as a percentage of the costs of the initial network per component or voltage level (LV, MV/LV, MV, HV/MV)

The initial rural network is designed in such a way that it is more robust than the urban network to guarantee higher demand increases and a larger amount of new Solar PV capacity, so the required investments are comparatively lower than in the urban network. This occurs because the initial network was designed to connect geographically dispersed loads, leading to a starting point of relatively underused network capacity, not so close to power or voltage constraints. However, in the urban area, many small overloads appear due to a relatively moderate load increase, making it necessary to reinforce existing network assets network. In any case, the investment needs are quite modest in relation to the initial cost of the networks because of the moderate assumptions of expected growth of load and DG capacity.

This base case scenario for network planning is taken as a benchmark to contrast with the total reinforcement needs for a similar time horizon and annual demand growth rate under the described AD scenarios, which are compared in Figure 24. It can be noticed that the strongest technical and economic potential of AD lies in the urban network because most of the requirements for reinforcements can be avoided with sufficient number of comparatively small modifications in the loads.

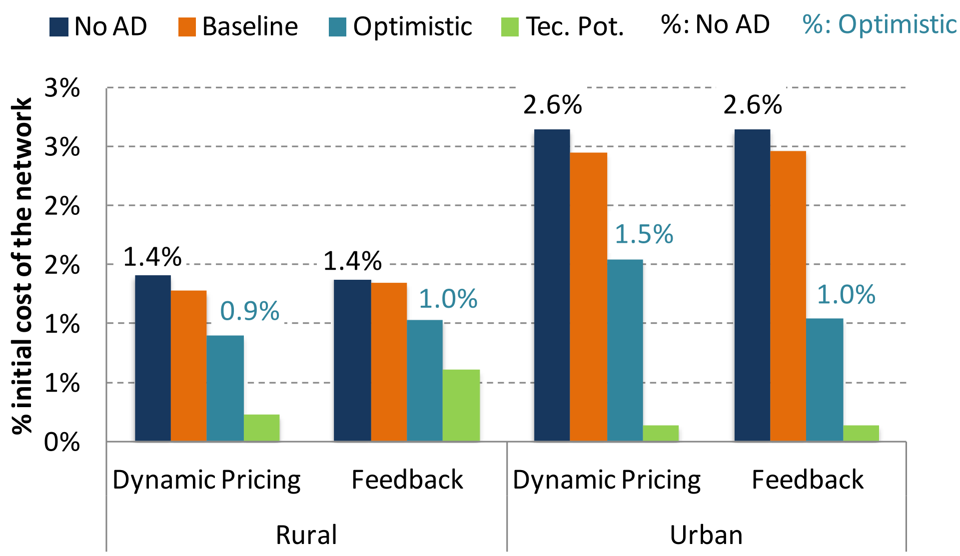

Figure 24, reinforcement investments needed, as a percentage of the initial cost of the network, in the Italian urban and rural networks for each AD scenario

The Baseline scenario is very close to the scenario of no AD because the participation rates are very low. In contrast, for the Optimistic scenario AD has a significant impact on investments even though they are still far from the economic benefits that are technically achievable, which are reflected in the Technical Potential scenario. In the rural network, the required reinforcements can hardly be avoided using AD because they are needed to connect new consumers. The investments to reinforce the urban network are driven by slight increase in the demand, which can be more easily tackled through AD. It can be noticed that the incremental effectiveness of AD to reduce reinforcements is intensified as the participation rate increases.

With reference to the type of AD program, in spite of having a lower participation rate, Feedback programs achieve better results than Dynamic Pricing Programs in the rural network. This may occur because Feedback programs have a uniform impact on the whole load curve, reducing consumption at every hour of the day. Consequently, both the overall peak of the network and the local peaks of different areas are reduced accordingly. However, Dynamic Pricing programs have localized impact on a few hours of the day, which may not always coincide with the individual peak consumption, reducing the effectiveness to avoid reinforcements to connect new consumers, which is the main driver for investment in the rural network. In the urban network, Dynamic Programs have a stronger impact on investments, as could have been expected due to the participation rate.

The resulting economic savings in terms of network reinforcements that could be avoided under each AD scenario are presented in Figure 25 with respect to the investments required in the benchmark scenario of no AD. It can be observed that even for low participation rates, AD has a significant potential to avoid part of the required investments to accommodate a moderate increase of demand and DG connections. Most avoided reinforcements are observed in MV/LV transformers and MV network.

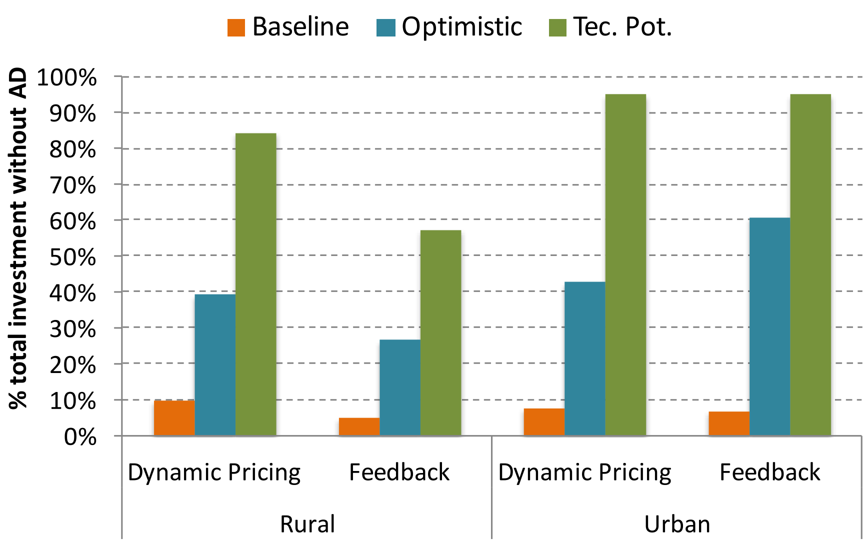

Figure 25, avoided reinforcement investments, as a percentage of the benchmark (no AD) investment needs, in the Italian urban and rural networks for each scenario

In the Italian networks there are small differences between the concentrated and dispersed cases in the baseline and optimistic scenarios. Both in the urban and rural networks, slightly higher investment reductions could be achieved if the consumers are dispersed in the network because the required reinforcements are also uniformly distributed across the networks. In the technical potential, as the penetration is 100%, the concentrated and dispersed cases are similar. For this reason, the previous figures only represent the results for the case in which AD participation is concentrated in specific locations of the network.

The graphical representation of the avoided investments in the network diagrams can be found in Annex B, for further information.

6. Case study: Germany

This chapter presents the economic analysis of the potential benefits of AD for distribution networks in Germany[19]. These benefits are quantified as the network reinforcement investments that could be avoided by counting on the effects of AD on the loads to improve network planning.

The analysis is based on two exemplary initial LV-MV networks of different population density (rural and urban) that have been created with the Reference Network Model (RNM) of Universidad Pontificia Comillas (see Annex A). The initial networks are optimally designed with the Greenfield RNM based on the street map of example locations, a characterization of network users and normal characteristics of German distribution grid assets, as agreed with RWE. These networks are not representative of all networks in Germany but are appropriate and realistic examples to quantify the order of magnitude of the potential of AD to defer investments in distribution grids for different scenarios of AD application. In particular, they allow us to investigate the potential of AD on distribution networks in the foreseeable scenario of a great penetration of Solar PV in rural areas of Germany with an expected stagnation of load growth based on the same methodology as for the other European countries.

The investment needs for each scenario are estimated with the Expansion RNM for similar requirements of load growth, new DG connections and reliability constraints but with different expected consumption patterns from those consumers participating in AD, according to the participation rate of each scenario. The model provides the minimum cost solution both for investments and for energy losses, while complying with the legal reliability requirements (voltage limits and continuity of supply indices).

The remaining subsections of this chapter describe the characteristics of the initial networks, the expansion scenarios and the results of the economic benefits of AD in distribution network investment deferral for the German case study.

[19] The reader should be aware that each case study has particular characteristics and network types and that the results obtained in each are not entirely comparable.

6.1. Description of the exemplary networks

The configuration and the composition of the exemplary networks used for the German case study are shown in Figure 26 and Figure 27. Table 18 to Table 22 display the number of network elements, total peak power of network users, nominal power of transformers and substations and length of the lines. The equipment used to design the network, both initially and in the expansion scenarios, has the standard sizes and power rates and average costs that are in line with those used for German networks in the context of the Grid4EU project. Contrary to the other case studies, no MV expansions and investments are observed for the exemplary German networks due to data restrictions, i.e. the enhancement costs calculated include only LV systems and LV/MV stations that connect these systems to the MV grid.[20].

The peak power needs of the consumers connected to the German networks are characterized according to the distribution of loads that is summarized in Table 18, as agreed with RWE.

Residential consumers LV (0.4 kV)

Power (kW)	7	9	11	14	16	22	24	25	30	Total
Urban & Rural (%)	34%	30%	11%	11%	5%	3%	3%	2%	1%	**100%**

Non-residential consumers LV (0.4 kV)

Power (kW)	10	20	50	Total
Urban & Rural (%)	25%	50%	25%	**100%**

Consumers MV (10 kV, 20 kV)

Power (kW)	100	200	300	400	500	600	Total
Urban (%)	20%	30%	20%	15%	10%	5%	**100%**
Rural (%)	25%	25%	25%	15%	10%	0%	**100%**

Table 18, Consumer peak power characterization in the German networks

The urban network is based on the street map of a sub-urban location. Among LV consumers in the urban network, residential consumers account for 97%. The largest proportion of lines is

[20] Enhancements needs that would occur in MV networks due to a rise in the penetration of PV, a situation which arises regularly based on RWE's experience, cannot be observed in the analysis. Additionally, for the exemplary grids, there is a focus on PV growth, but wind developments, which are also part of the expected German developments, are neglected as well.

underground and the reliability requirements are higher than in the rural network, as can be seen in Table 19.

	No. consumers		**Contracted power (MW)**		**Network length (km)**			
					Aerial		**Underground**	
	No.	**%**	**MW**	**kW/cons.**	**km**	**%**	**km**	**%**
LV	5 836	97%	67.3	11.5	0	0%	12.58	100%
MV	171	3%	47.5	278	0	0%	11.59	100%

Table 19, German urban network customer and network characteristics

One primary distribution substation of 80 MVA connects the transmission substation to the MV network, where the regular sizes of MV/LV transformers are 400 MVA and 630 MVA, as shown in Table 20.

	Vn1 (kV)	**Vn2 (kV)**	**Sn (kVA)**	**No.**	**%**
Transmission ST	400	110	1000000	1	-
HV/MV ST	110	20	80 000	1	-
MV/LV TR	20	0.4	630	6	11%
	20	0.4	500	6	11%
	20	0.4	400	6	11%
	20	0.4	315	13	24%
	20	0.4	200	14	25%
	20	0.4	100	10	18%

Table 20, German urban substation facilities, where ST stands for substation and TR stands for transformer

Figure 26 corresponds to the resulting urban network for the German case study.

Figure 26, exemplary urban network for Germany. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation, the green dots represent the location of MV/LV transformers and the purple lines represent the LV network.

The rural network is based on the street map of a set of dispersed rural locations of Germany, surrounded by farms, where elevated capacities of solar PV are expected to be installed. It can be easily observed in the figure below that the population density of the region is much lower and that the final configuration of the network differs significantly in structure. It must be noted that the proportion of LV consumers is higher in the rural area and that among LV consumers, residential consumers account for 93% in contrast to the 97% or the urban network. The proportion of aerial lines is higher and transformers are generally lower in size than in the urban network, as can be seen in Table 21 and Table 22.

	No. consumers		**Contracted power (MW)**		**Network length (km)**			
					Aerial		**Underground**	
	No.	**%**	**MW**	**kW/cons.**	**km**	**%**	**km**	**%**
LV	981	97%	11.1	11.3	4.43	31%	10.07	69%
MV	26	3%	6.8	262	1.61	28%	4.15	72%

Table 21, German rural network customer and network characteristics

Figure 27, exemplary rural network for Germany, made up of some dispersed locations. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation, the green dots represent the location of MV/LV transformers and the purple lines represent the LV network.

Figure 27 corresponds to the resulting rural network for the German case study, which is made up of distant small locations connected to the substation through the MV aerial lines.

Due to the small size of the exemplary network, one primary distribution substation of 30 MVA connects the transmission substation to the MV network, where the regular sizes of MV/LV transformers are 200 MVA and 315 MVA, as shown in Table 22.

	Vn1 (kV)	Vn2 (kV)	Sn (kVA)	No.	%
Transmission ST	400	110	1000000	1	-
HV/MV ST	110	20	30 000	1	-
MV/LV TR	20	0.4	400	1	8%
	20	0.4	315	4	33%
	20	0.4	200	6	50%
	20	0.4	100	1	8%

Table 22, German rural network facilities, where ST stands for substation and TR stands for transformer

6.2. Network expansion planning scenarios

The main assumptions taken for planning the networks, both from scratch and in the expansion model to simulate the investment planning decisions in the a ten-year horizon are the following:

The main driver for network expansion is the connection of new DG, especially solar PV at these voltage levels. The load is not expected to increase in the near future so it has been assumed that it does not change. Given the favourable regulatory incentives, the current and future penetration of PV in certain rural areas could be substantial, even possibly leading to periods of net generation injected in the transmission network. With the aim of reflecting this critical situation for the grid, the expansion scenario of the rural network is characterized by a high penetration of new DG in the form of solar PV, as shown in Table 23. In contrast, new PV rooftop panels are restricted in urban areas by a limitation of space. The expansion scenarios are projected to accommodate both the currently installed solar PV (year 0) and the accumulated capacity that is expected to have been installed in the next ten years (year 10). The PV generation units have a feasible variety of sizes that could be observed in a rural network with high PV penetration in Germany, the average of which is shown in the table.

		Probability of PV in existing connections (year 0) %	Probability of PV in existing connections (year 10) %	Total installed PV capacity (kW) (year 0)	Total accum[21]. installed PV capacity (kW) (year 10)	Average size of the units (kW)	
						LV (0.4 kV)	MV (20 kV)
Urban		0%	5%	0	1 110	13	106
Rural	**Villages**	25%	50%	-	4 060	25	147
	Farms	60%	90%				

Table 23, New Solar PV generation units in the German networks in relation to the existing connection points

- Reliability and quality of supply requirements: standard continuity of supply indices (which are not decisive because they remain constant in all scenarios), and voltage limits of 1.1 pu and 0.9 pu.
- The participation rates, i.e. the proportion of consumers participating in the AD programs, for each macroeconomic and regulatory scenario are as defined in the

[21] Accumulated.

previous deliverable D6.1 of ADVANCED and shown in Table 24. As occurs in all countries, the Technical Potential scenario consists of a 100% participation in the AD program of highest effectiveness of the Feedback and the Dynamic Pricing programs, which are the installation of an in-home display and CPP with automation, respectively.

Germany

Participation (SM roll-out x Uptake rate)		Baseline	Optimistic	Technical
Informative bill	FB1	30.00%	40.00%	
In-Home Display (IHD)	FB2	15.00%	50.00%	100.00%
Website	FB3		10.00%	
		45%	**100%**	**100%**
Time of Use (no-automation)	DP1	6.00%	1.00%	
Time of Use (automated)	DP2		3.00%	
Critical peak (no-automation)	DP3		1.00%	
Critical peak (automated)	DP4		5.00%	100.00%
Real-time pricing (no-automation)	DP5			
Real-time pricing (automated)	DP6			
		6%	**10%**	**100%**

Table 24, AD program participation rates for scenarios in the German case study

- The load profiles that are taken as critical profiles for the state of the network are the **extreme load profiles**. These are therefore used as an input to the network model to design the expansion requirements, as explained in 3.2.1.2. These profiles capture both the peak consumption during the evening-night and a much lower consumption during the periods of highest PV generation. This way the extreme system states that result from peak load alone and from a combination of peak PV generation with low demand, are taken into consideration to dimension the requirements of network capacity, with and without AD. In particular, the characterization of residential consumer extreme load patterns is based on the aggregate representation of the EDeMa program through clusters of similar behaviour, even though the peak power is adjusted to be like that found in Table 18. Industrial and commercial consumers, both at LV and MV level, are categorized according the typical consumption profile. These profiles are taken from the definition of Standard load profiles for settlement purposes in Germany. Figure 28 presents the extreme profiles (combining the maximum and minimum load in and out of the PV generation hours) in per unit values with respect to their peak load, obtained from the official Standard profiles.

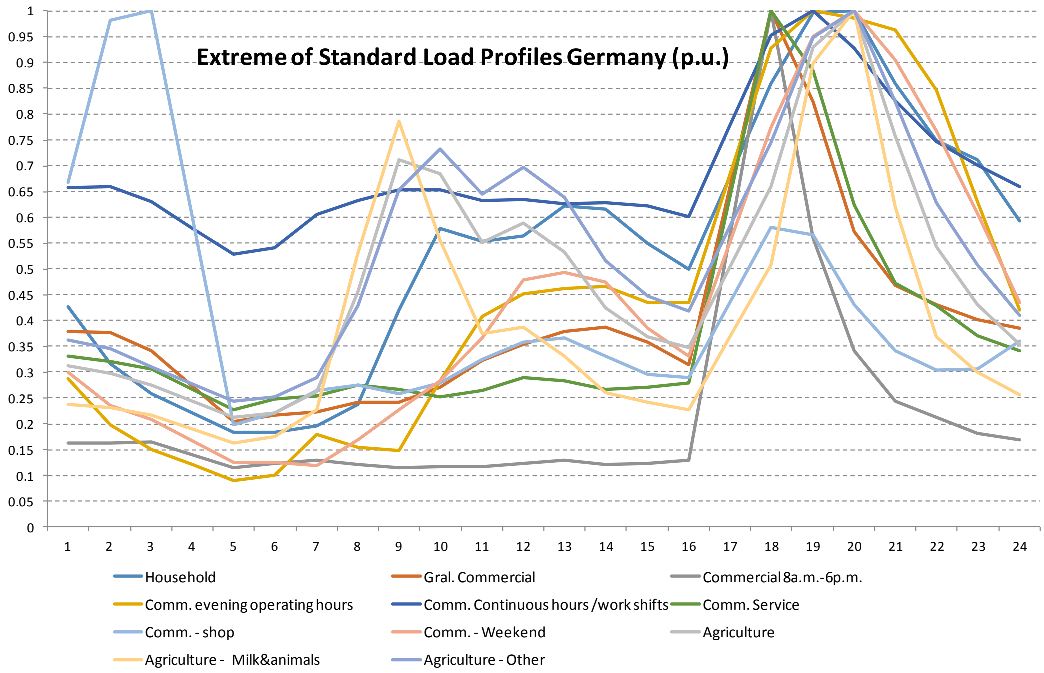

Figure 28, non-residential extreme load profiles assumed in the German networks, in per unit values with respect to the peak load

- The expected positive impact of AD on the extreme load profiles of participative consumers is the reduction of overall consumption (Feedback), or the reduction of peak consumption as indicated by the AD program effectiveness in combination with the increase of demand in those critical hours of low demand that occur in the period of high PV generation (Dynamic Pricing), as explained in 3.2.1.2. In the particular case of Germany, the energy consumption that is assumed to be moveable to the central hours of the day to compensate high solar PV generation only lasts for about an hour given that most appliances that can be shifted in time of use have such short working cycles.
- The allocation of participative consumers in AD in the networks is done randomly (**dispersed** scenario) or by grouping them in several locations close to each other (**concentrated** scenario).

6.3. Results of the economic impact of AD on investments

The only expansion driver studied in the German case study is the connection of new DG,which in the most cases leads to voltage problems within the grid (generally, overvoltage). Under this assumption, AD can only offer limited benefits as a substitute for network reinforcements because it can only partially compensate for the increased net generation in certain areas. The initial networks are dimensioned for the current consumption needs of consumers and the currently assumed installed capacity of PV. The expansion scenarios are projected to accommodate the additional capacity that is expected to be installed in the next ten years.

The investment costs in the scenario without AD are expressed in Table 25 as a percentage of the initial cost of the corresponding voltage level or type of network component. Due to the small size of the German rural network, only the reinforcements in the LV and the MV/LV network levels are representative, so MV network reinforcements have not been included.

Reinforcement costs (%)	LV network	MV/LV subs.	Total
Rural	**14.7%**	**66.7%**	**7.3%**
Urban	**0.3%**		**0.1%**

Table 25, costs of the required reinforcements in the benchmark scenario of no AD in the German networks, as a percentage of the costs of the initial network per component or voltage level (LV and MV/LV).

The urban network only requires minor investments (0.3% of LV networks) because of the expected low increase of PV capacity while the rural network has to be intensely reinforced. The reinforcements required in the rural network to accommodate the additional massive amount of new capacity expected in the next ten years are observed in Figure 29.

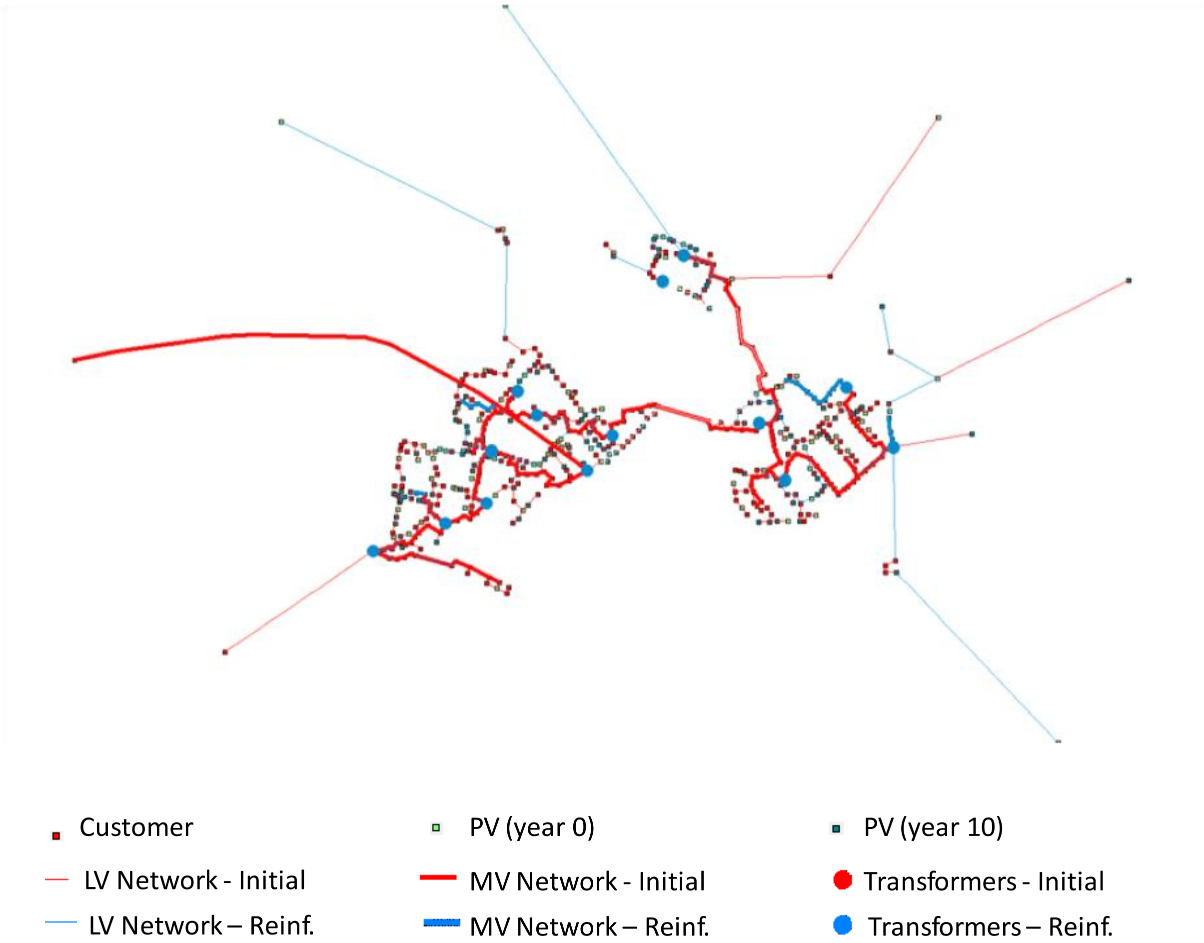

Figure 29, reinforcements required in the German rural network to accommodate the total installed PV capacity expected in the ten-year horizon

This base case scenario for network planning is taken as a benchmark to compare with the total reinforcement needs for a similar time horizon and PV penetration under the described AD scenarios. Reinforcement needs are extremely low in the urban network, where only a small amount of new PV connections is expected, and already quite extensive in the rural network, where a massive penetration of PV is analyzed. These scenarios are compared in Figure 30.

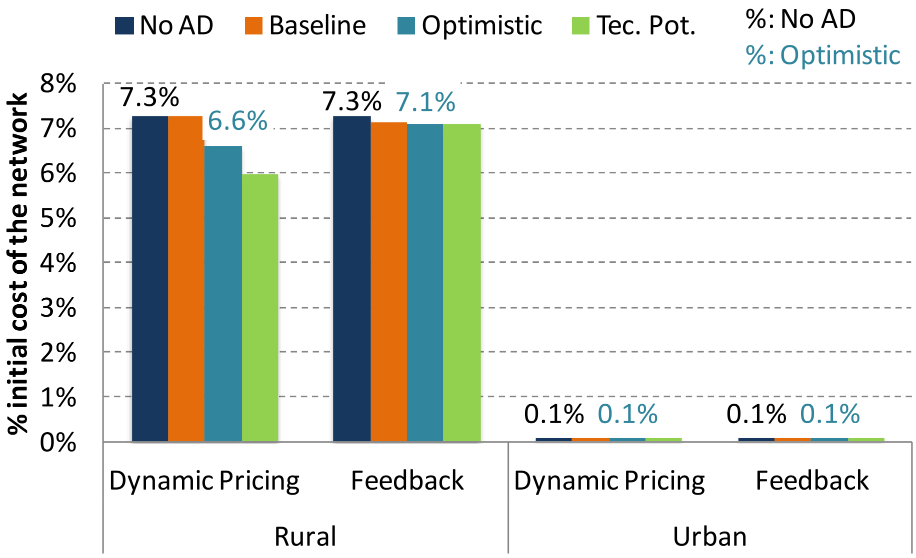

Figure 30, reinforcement investments needed, as a percentage of the initial cost of the network, for the German urban and rural networks and each AD scenario. The values for the "No AD" and "Optimistic" scenarios are labelled

The avoided investments, as a percentage of the required investments in reinforcements, are presented in Figure 31. In a situation where peak load growth is not a concern and with a vast penetration of solar PV, the major positive impact AD could have on network planning is certain energy shift associated to flexible loads from the peak hours to those periods of maximum PV generation. This is possible with Dynamic Pricing, which could theoretically save up to 9% in the optimistic scenario. Therefore, the impact of AD is moderate in the case of Dynamic Pricing, while it is hardly appreciable in the case of Feedback programs, especially in the urban area. The baseline scenario is rather pessimistic in the German case study, with scarce savings achievable with AD in network investments.

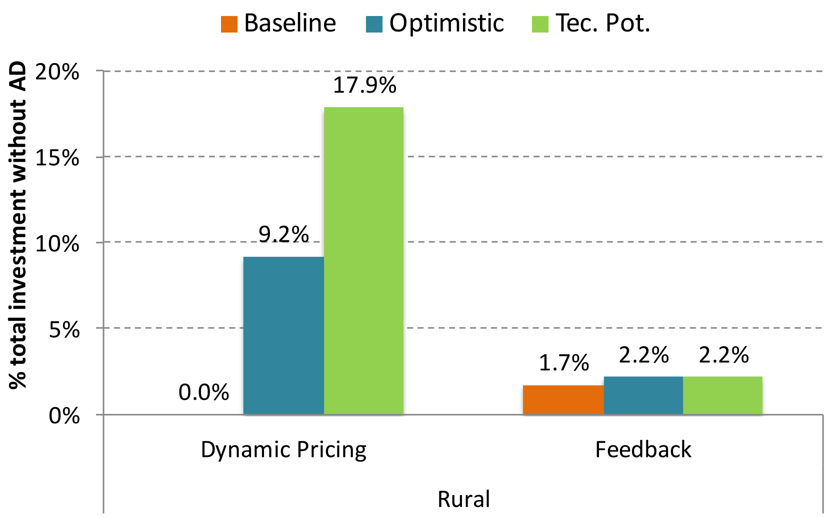

Figure 31, avoided reinforcement investments, as a percentage of the investments without AD, for the German rural networks and each AD scenario

There are a few relevant differences between the concentrated and dispersed cases in the baseline and optimistic scenarios. More investments can be avoided if participation in AD is concentrated in certain locations. In particular, the 9.2% investments avoided in the Optimistic scenario with Dynamic Pricing turn into 2.8% and no savings are achieved in the Baseline by Feedback programs if responsive consumers are scattered in the network. In the technical potential, as the penetration is 100%, the concentrated and dispersed cases are similar. The previous figures only represent the results for the hypothetical case in which AD participation is concentrated in specific locations of the network.

The results obtained here indicate that AD has a restricted potential to reduce network investment costs in the German context, where a stagnation of demand is expected and strong increases of DG are predicted. The strongest potential possibly exists in the rural areas where vast amounts of new solar PV are expected to be installed, and even in these situations the potential is narrow. These conclusions are generally in line with the main results obtained in relation to AD and network investments in several rigorous and detailed studies fostered by German authorities and institutions[22].

[22] E.g. Dena, "Ausbau-und Innovationsbedarf der Strom-verteilnetze in Deutschland bis 2030", and E-bridge, Offis and IAEW, "Verteilernetzstudie Studie im Auftrag des Bundesministeriums für Wirtschaft und Energie (BMWi)", 12th September 2014.

The graphical representation of the avoided investments in the network diagrams can be found in Annex B, for further information.

7. Case study: France

This chapter presents the economic analysis of the potential benefits of AD for distribution networks in France[23]. These benefits are quantified as the network reinforcement investments that could be avoided by counting on the effects of AD on the loads to improve network planning.

The analysis is based on two exemplary initial MV networks of different population density (rural and urban) that have been created with the Reference Network Model (RNM) of Universidad Pontificia Comillas (see Annex A). The final network configurations are optimally designed with the Greenfield RNM but in contrast to the other case studies, the location and power loads and injections of network users in these networks are not based on a street map but on the actual location and characteristics of two real MV networks operated and used for network studies by ERDF. These grids are of a smaller size in comparison to the previously described networks.

These networks are not representative of all networks in France but are simulated examples that can be appropriate to quantify the order of magnitude of the potential of AD to defer investments in distribution grids for different scenarios of AD application. In particular, they allow us to investigate the potential of AD on exemplary, and synthetically built with the RNM, congested distribution networks, but only at MV level.

The investment needs for each scenario are estimated with the Expansion RNM for similar requirements of load growth, new DG connections and reliability constraints but with different expected consumption patterns from those consumers participating in AD, according to the participation rate of each scenario. The model provides the minimum cost solution both for investments and for energy losses, while complying with the legal reliability requirements (voltage limits and continuity of supply indices).

The remaining subsections of this chapter describe the characteristics of the initial networks, the expansion scenarios and the results of the economic benefits of AD in distribution network investment deferral for the French case study.

[23] The reader should be aware that each case study has particular characteristics and network types and that the results obtained in each are not entirely comparable.

7.1. Description of the exemplary networks

The configuration and the composition of the exemplary networks used for the French case study are shown in Figure 32 and Figure 33. Table 26 to Table 30 display the number of network elements, total peak power of network users, nominal power of transformers and substations and length of the lines. The equipment used to design the network, both initially and in the expansion scenarios, has the standard sizes and power rates and average costs found in multiple equipment catalogues.

The peak power needs of the consumers connected to the exemplary networks used for the French case is characterized according to the distribution of loads that is summarized in Table 26, which corresponds to the contracted power of consumers from the ERDF networks.

Consumers MV (20 kV)

Power (kW)	35	75	150	250	350	500	1000	2000	3000	Total
Urban (%)	27%		5%	5%	5%	9%	36%	9%	5%	**100%**
Rural (%)	86%	9%	6%							**100%**

MV/LV Transformers (20 kV/0.4 kV)

Power (kW)	35	75	150	250	350	500	1000	2000	Total
Urban (%)	15%	3%	3%	5%	12%	8%	40%	13%	**100%**
Rural (%)	34%	18%	16%	12%	9%	8%	4%		**100%**

Table 26, Consumer contracted capacity characterization in the exemplary networks for the French case study (MV)

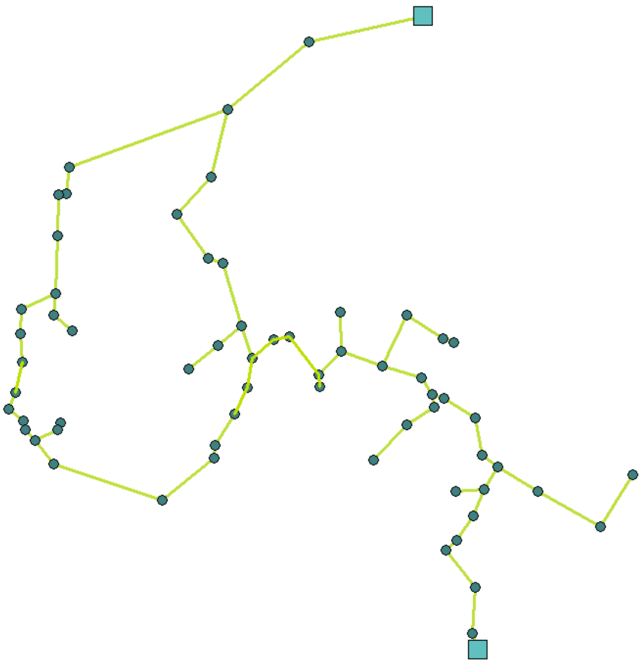

Figure 32, exemplary MV urban network for France. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation and the green dots represent the location of MV consumers and MV/LV transformers.

The exemplary urban network used in the French case study is represented in Figure 32. In contrast to the other networks described in this section, it is only a MV network; LV consumers are assumed to be grouped downstream MV/LV transformers.

As shown in Table 27 and Table 28, the network consists of a total of 22 customers and 60 transformers that are fed by two HV/MV substations of 80 MVA. These substations feed other feeders that have not been considered in this study and are therefore not described in this document.

	No. Customers	**No. MV/LV Transformers**	**Total contracted power (MW)**	**Network length (km)**	
				Aerial	**Underground**
MV	22	60	62.6	0	6.47

Table 27, exemplary MV urban network for France: customer and network characteristics.

	Vn1 (kV)	Vn2 (kV)	Sn (MVA)	No.
HV/MV ST	132	20	80	2

Table 28, exemplary urban substation facilities, where ST stands for substation

The exemplary rural network for the French case study is also a MV network which is larger than the urban network, as shown in Figure 33.

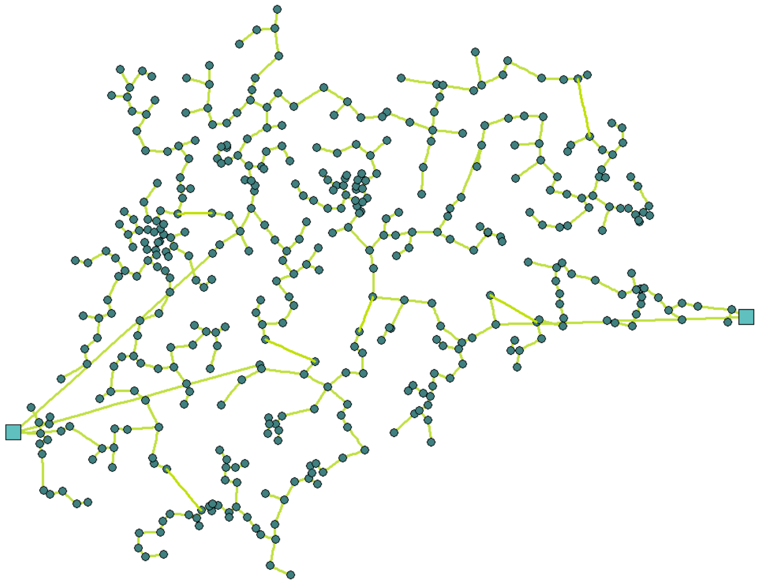

Figure 33, representative MV rural network for France. The blue square marks represent the location of the HV/MV substations, the green lines represent the MV network delineation and the green dots represent the location of MV consumers and MV/LV transformers.

As shown in Table 29 and Table 30, this network is larger than the urban grid. It consists of a total of 35 customers and 400 transformers that are fed by two HV/MV substations of 80 MVA. It can be seen that the proportion of aerial lines is higher than in the urban network.

	No. Customers	No. MV/LV Transformers	Total contracted power (MW)	Network length (km)	
				Aerial	Underground
MV	35	400	78	257.9	0

Table 29, exemplary MV rural network for France: customer and network characteristics

	Vn1 (kV)	Vn2 (kV)	Sn (MVA)	No.
HV/MV ST	132	20	80	2

Table 30, exemplary rural substation facilities, where ST stands for substation

7.2. Network expansion planning scenarios

The main assumptions taken for planning the networks, both from scratch and in the expansion model to simulate the investment planning decisions in the a ten-year horizon are the following:

- The drivers for network expansion are both load growth and the connection of new DG, especially solar PV at these voltage levels. Both the increase of demand and the growth of PV installed capacity are moderate. Load is expected to grow around 20%, which is equivalent to a 1.8% rate per year in 10 years or a 1.3% rate in 15 years.
- Only a few new connections of DG are expected. All connection points in the urban MV network are assumed to have new installed solar PV, representing both MV and LV network users, the latter aggregated downstream the MV/LV transformers.

	Probability of new PV in existing connections %	Total new installed capacity (kW)	Average size of the units (kW)
			MV (20 kV)
Urban	100%[24]	880	15
Rural	5.0%	705	30

Table 31, New Solar PV generation units in the exemplary networks for France in relation to the existing connection points at MV level

- Reliability and quality of supply requirements: standard continuity of supply indices (which are not decisive because they remain constant in all scenarios), and voltage limits of 1.1 pu and 0.9 pu for LV networks, 1.05 and 0.95 for MV networks.
- The participation rates, i.e. the proportion of consumers participating in the AD programs, for each macroeconomic and regulatory scenario are as defined in the previous deliverable D6.1 of ADVANCED and shown in Table 32. As occurs in all countries, the Technical Potential scenario consists of a 100% participation in the AD

[24] 100% means that there is at least one PV unit downstream every transformation centre.

program of highest effectiveness of the Feedback and the Dynamic Pricing programs, which are the installation of an in-home display and CPP with automation, respectively.

France

Participation (SM roll-out x Uptake rate)		Baseline	Optimistic	Technical
Informative bill	FB1	5.85%	3.20%	
In-Home Display (IHD)	FB2	0.65%	4.80%	100.00%
Website	FB3	58.50%	72.00%	
		65%	**80%**	**100%**
Time of Use (no-automation)	DP1	9.00%	9.00%	
Time of Use (automated)	DP2	34.00%	34.00%	
Critical peak (no-automation)	DP3	2.00%	2.00%	
Critical peak (automated)	DP4	1.00%	6.00%	100.00%
Real-time pricing (no-automation)	DP5			
Real-time pricing (automated)	DP6			
		46%	**51%**	**100%**

Table 32, AD program participation rates for scenarios in France.

- The load profiles that are taken as critical profiles for the state of the network are the **extreme load profiles**. These are therefore used as inputs to the network model to design the expansion requirements, as explained in 3.2.1.2. These profiles capture both the peak consumption during the evening-night and a much lower consumption during the periods of highest PV generation. This way the extreme system states that result from peak load alone and from a combination of peak PV generation with low demand, are taken into consideration to dimension the requirements of network capacity, with and without AD.
- The shapes of the load profiles are based on the average profiles of those measured among real consumers in the Nice Grid project. According to this set of data, consumers are classified in relation to their maximum power consumption, segment (residential and non-residential) and tariff group (simple tariff and double tariff), as is indicated in Table 33. The absolute peak values are the real ones observed in the ERDF networks. For the sake of the exercise, even though the sample is of clients below 36 kV, MV consumers directly connected to the grids are randomly allocated some of the non-residential

profiles, while consumers downstream the MV/LV transformers are allocated combinations of the residential (mostly) and some of the non-residential load profiles, according to the same distribution of probability found in the sample.

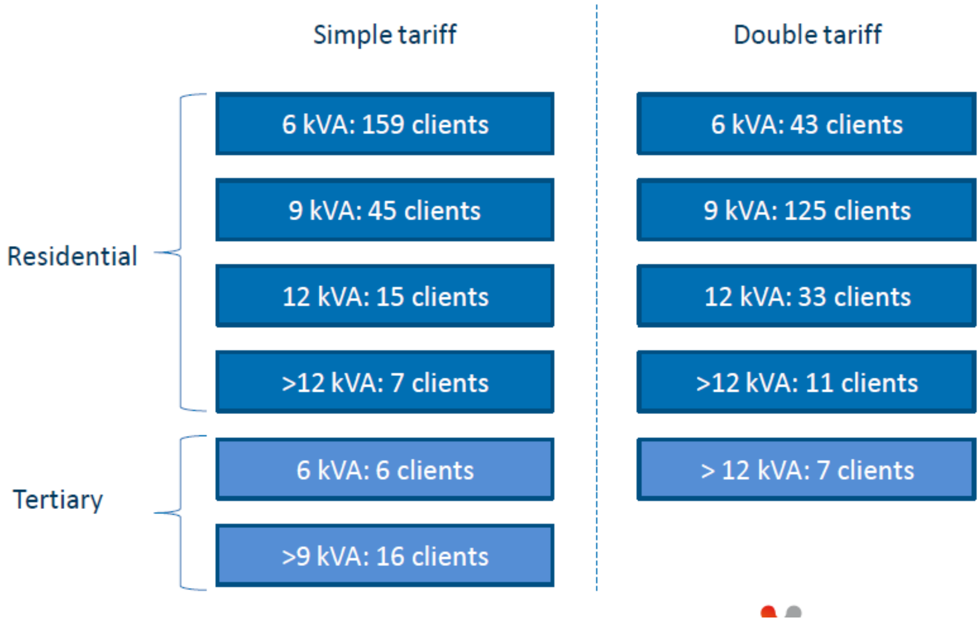

Table 33, categorization that serves as the base for the characterization of consumer profiles in the exemplary networks for France. Source: Nice Grid Project.

- The expected positive impact of AD on the extreme load profiles of participative consumers is the reduction of overall consumption (Feedback), or the reduction of peak consumption as indicated by the AD program effectiveness in combination with the increase of demand in those critical hours of low demand that occur in the period of high PV generation (Dynamic Pricing), as explained in 3.2.1.2. It must be noted that the proportion of consumers already participating in a double tariff do not experience any change in their consumption as a consequence of time of Use pricing because they are already participating in one and their load is already modified accordingly.
- The allocation of participative consumers in AD in the networks is done randomly (**dispersed** scenario) or by grouping them in several locations close to each other (**concentrated** scenario).

7.3. Results of the economic impact of AD on investments

The initial networks are designed to reflect a constrained state. For this purpose, they are dimensioned for the contracted capacity instead for the actual peak power of connected consumers. The investment scenarios are studied for a ten-year horizon starting from this constrained state of the networks and a 1.8% load growth per year.

The investment costs in the scenario without AD only represent the MV network. In the scenario of no AD, an underground cable of 0.34 km has to be reinforced in the urban network, as shown in Figure 34, and a single overhead MV line of 8.25 km has to be reinforced in the rural network, as can be observed in Figure 35. The total reinforcement cost, expressed with respect to the total initial cost is 1.2% and 0.2% for the rural and urban networks, respectively.

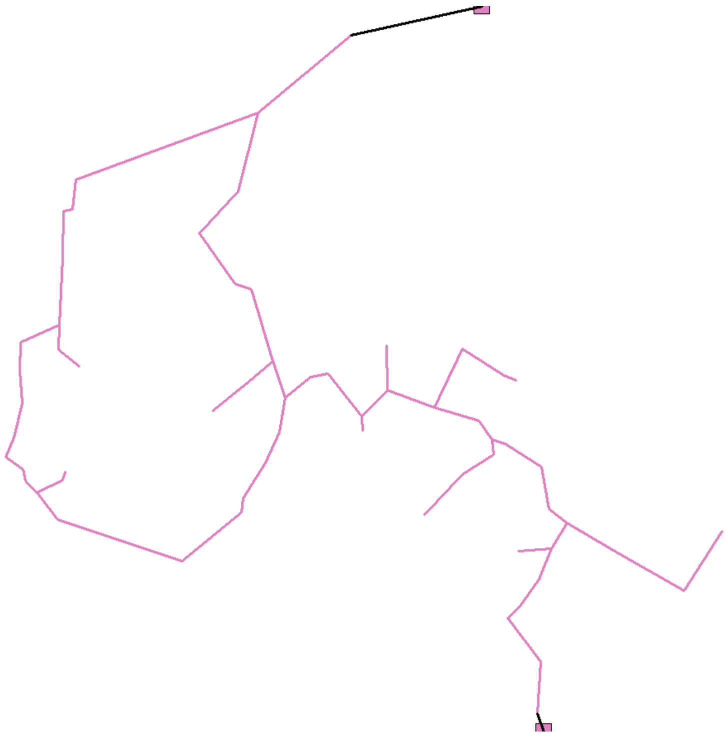

Figure 34, reinforcements required in the urban network of the French case study in the scenario of no AD

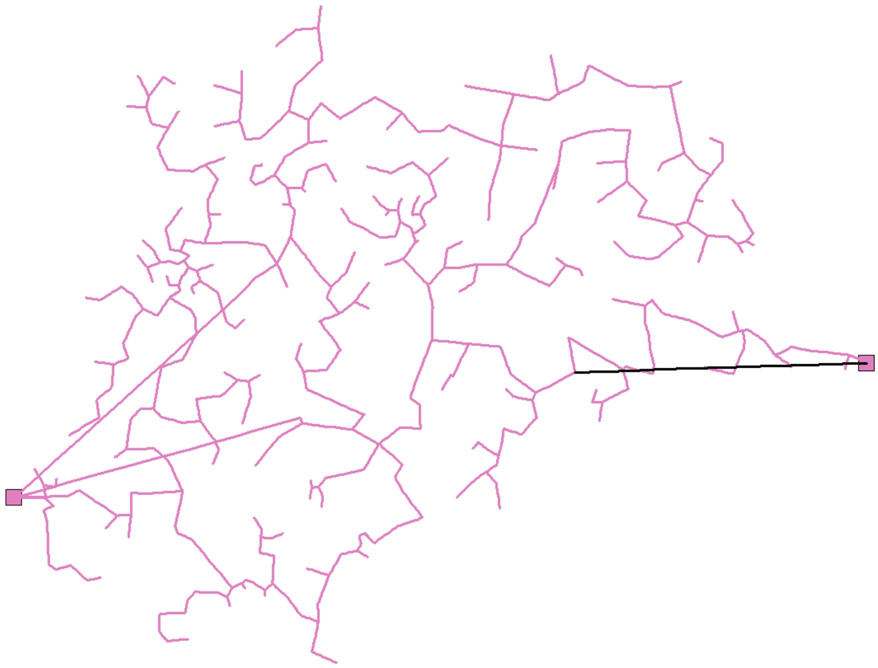

Figure 35, reinforcements required in the rural network of the French case study in the scenario of no AD

This base case scenario for network planning is taken as a benchmark to compare with the total reinforcement needs for a similar time horizon and annual demand growth rate under the described AD scenarios, which are compared in Figure 36.

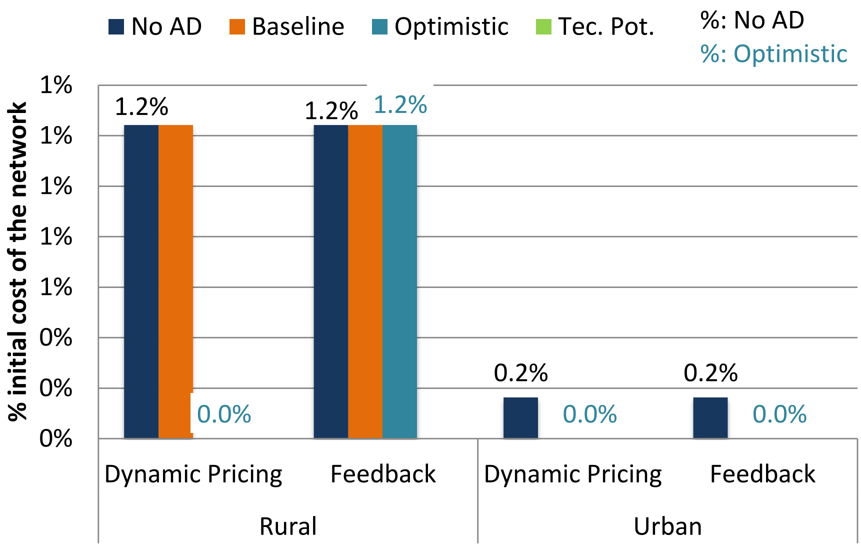

Figure 36, reinforcement investments needed, as a percentage of the initial cost of the network, in the exemplary urban and rural networks for each AD scenario

The resulting network reinforcements that could be avoided under each of the AD scenarios are presented in Table 34.

		Baseline	Optimistic	Technical Potential
Urban	DP	Avoided	Avoided	Avoided
	FB	Avoided	Avoided	Avoided
Rural	DP	Required	Avoided	Avoided
	FB	Required	Required	Avoided

Table 34, Ability of AD to avoid the single reinforcements required in the exemplary urban and rural networks analysed for France (required or avoided reinforcement)

Drastic changes are observed in the results because a single discrete reinforcement can either be avoided or not because of the small size of the studied networks. In this particular case, AD is much more helpful in the urban network to avoid the required investment, which on the other hand is much lower investment.

The results of the previous figure and table are presented for the scenario in which AD participation is randomly dispersed in the network instead of concentrated in a few specific locations. Given the discrete nature of the avoided reinforcements observed in this case study, significant differences can between the concentrated and dispersed cases in the baseline and optimistic scenarios. In particular, the reinforcement that is avoided in the Optimistic Scenario in the rural area with Dynamic Pricing programs cannot be eluded if the participative consumers are not dispersed in the network. In the technical potential, as the penetration is 100%, the concentrated and dispersed cases are similar.

According to ERDF, the lack of need of reinforcement after a 20% growth of loads while those networks were designed to reflect a constrained state before the growth questioned the ability of the RNM to create constrained initial networks for those two exemplary load configurations. In line with ERDF, it is therefore not possible to extract conclusions about the impact of boundary conditions on the potential of AD to defer investments in distribution networks when only MV is considered. This case study is nevertheless a good example based on networks generated by the RNM that AD proves to be helpful to avoid reinforcements in low constrained networks if they are mainly driven by demand increases. It can also be concluded that for particular reinforcements at MV level and low participation rates, the location of responsive consumers to AD certainly makes a difference in the potential to avoid network investments.

The graphical representation of the avoided investments in the network diagrams can be found in Annex B, for further information.

8. Allocation of benefits among stakeholders

The potential benefits of AD for distribution networks, as quantified in the previous case studies, have to be understood as gross benefits. Such benefits have been evaluated in terms of saved investments in network reinforcements for different scenarios of AD application in comparison to a benchmark scenario without AD for a specific period. These savings should be contrasted with the associated costs of each type of AD program and form of implementation to determine the convenience of promoting AD from the regulatory perspective. When the net benefit is positive, the question is how these could be allocated among the different stakeholders according to the regulatory framework and the business models in place.

This section presents a qualitative discussion on the distribution of benefits across the value chain of the activities of distribution and supply of electricity to final consumers and the management of their demand flexibility. This is how the local economic impact of AD could affect DSOs, consumers and intermediaries (retailers, aggregators, etc.). The discussion around the estimation of the individual benefits of AD for consumers is illustrated with an example for the Spanish case study based on a stylized approach.

8.1. Benefits for DSOs

Given that distribution of electricity is a regulated activity, the allocation of the potential benefits of AD in reduced network investments to DSOs is directly related to their planning processes and their remuneration mechanism.

Under an incentive-based regulation, DSOs are encouraged to cut costs by updating the calculation of their allowed revenue according to either real or estimated efficient expenses once in every regulatory period (usually from 3 to 5 years). By using AD as a possible substitute for network investments in their network planning strategies, DSOs would be expected to reduce investments and thus reduce their CAPEX (i.e. depreciation and interest) in the short-term. At the same time, it could involve an increased OPEX depending on how the AD program is implemented and remunerated. As long as the CAPEX is included in the cap already, and the increased OPEX does not surpass this reduction, the DSO could make additional benefits. This would last until the end of the regulatory period, when the financial effects of investing less should be passed through to consumers by means of the update of the allowed revenue and the network tariffs.

Therefore, both the incentive to carry out AD investments by DSOs and the transfer of these benefits to DSOs would be dependent on the length of the regulatory period and on the exact costs that were recognized as efficient costs to determine the allowed revenue for that regulatory period.

8.2. Benefits for consumers

Consumers could receive part of the estimated benefits for distribution networks through the actualization of the network tariff component that recovers the costs of distribution networks. Depending on the frequency of updating these tariffs, consumers would profit faster or slower from the savings on network investments, i.e. they would receive a larger or smaller proportion. In addition to this, depending on the degree of cost-reflectiveness of network tariffs and the complexity of the tariff design (e.g., dynamic or flat structure, energy and capacity component or only energy component, etc.), these benefits could be transferred mostly to the consumers that are participating, or reacting more intensely to the AD signals, or rather distribute them throughout all consumers, whether or not these consumers have contributed to reduce these network costs by participating in AD. If the means of providing AD flexibility to reduce network investment needs are specifically compensated though incentives other than the network tariff, these would definitely compensate only customers participating in AD.

According to the origin of the need for flexibility, AD can be a mechanism driven by costs of energy in the market or by the needs of the network to reduce congestion. Both signals can be combined in a final electricity price composed by the tariff and the energy prices, or even with other incentive mechanisms of AD. Consumers are expected to find an incentive to respond to any of these AD signals inasmuch as their participation helps them to reduce their electricity expenses. In any case, consumers responding to dynamic prices that reflect the costs of energy in addition to the signals of the network conditions would face further economic benefits that would be added to the reduced network tariff resulting in an overall lower final price for electricity on an average basis. These individual benefits are wealth transfers and not real social benefits, but may allow us to understand the incentives for consumers to participate in AD. This is stated under the assumption that the AD signals sent from the network perspective are coincident with the system AD signals in time, therefore complementary instead of obstructive.

8.2.1. Illustrative example: Spain

A stylized example of the estimated benefits AD for consumers in the Spanish case study is presented in this section to illustrate the discussion. This quantitative approach allows us to understand the possibilities and limitations of AD to bring value to consumers and provides some insights into the orders of magnitude of the achievable individual economic savings.

This evaluation is focused mostly on residential customers. From the customer standpoint, AD brings benefits that are directly related to the load changes they make in response to the AD signals they receive. Therefore, the estimation of these benefits is based on a direct relation between the following elements:

1. The increment of **energy consumption** in each hour of an average daily load profile as a result of the load changes induced by the specific form of AD.

   This element is estimated from the baseline profiles used in network case studies. Nonetheless, this time an average load profile is used instead of the extreme or maximum consumption profiles in order to assess the savings that could be achieved on a regular basis. The effectiveness levels for each AD program are applied directly to these load profiles as described in section 3.2.1.4. This is, either decreasing overall consumption uniformly (Feedback) or inducing a shift of energy from the peak hours to the valley hours (Dynamic Pricing).

2. The components of the **final average retail price** of electricity that are subject to a time variation or that are related to the positive impact of AD on the system costs. In particular, the following two major cost components in electricity retail prices are analyzed in this sense:
   - The **energy component**, based on wholesale day-ahead market hourly prices of 2012. This element is based on day-ahead whole-sale market prices of 2012. Given that the approach to estimate the benefits for consumers is to observe the average savings, the contribution of the energy component to the consumer savings due to any load shifting and reductions is valued according to an average hourly price profile.
   - The **distribution network tariff component**, based on the benefits for distribution networks estimated in the previous section. These results are in fact used as an estimated upper bound for this component, for it can be interpreted as the maximum transfer of benefits through the network tariff. According to the frequency of updating these tariffs, consumers would receive a larger or smaller proportion of the estimated avoided network investments. In any case would all these economic savings be completely transferred to customers because that would prevent AD from providing any net social benefit to society.

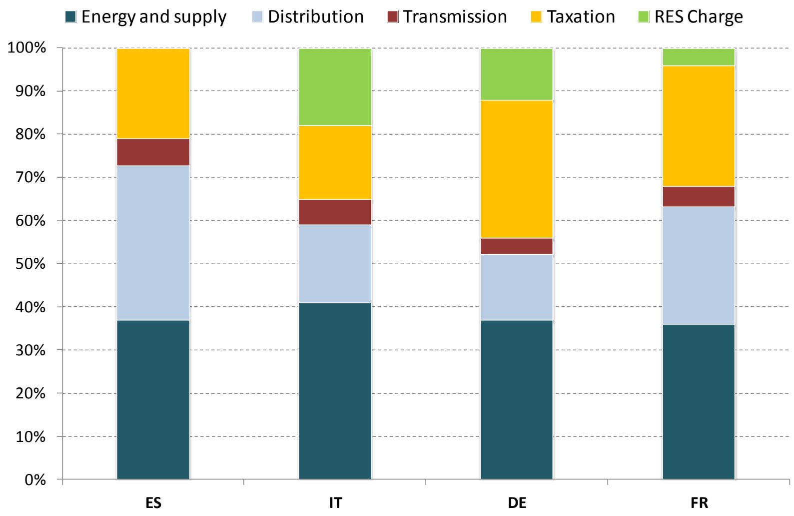

Figure 37, households total electricity costs and bill break-down in each of the ADVANCED countries, for 2012. Source: own elaboration based on information from (ACER/CEER, 2013) and (EC, 2014b)

It can be observed in Figure 37, that the energy component (in dark blue) is a significant, but not the only one that should be considered, component in the final price, from 36% in France to 41% in Italy. It can also be noted that the charge related to the distribution activity is by far more substantial, from 15% in Germany to 36% in Spain, than the share associated to the transmission activity, generally around 5%. Nevertheless, note that in the Spanish figures, the RES payments are included in the distribution share. Actual distribution costs should be around 15% according to the latest figures published by the NRA[25]. Other cost components are not directly related to the supply of electricity could barely be transformed in the context of any AD program, such as taxes and other levies, including specific charges for the promotion of RES.

The average load profile for households is based on the data collected in the Spanish ADDRESS Pilot, resulting in an individual average 11.58 kWh daily consumption, which amounts to an average annual consumption of 4 227 kWh per customer. The wholesale electricity price curve on which the economic value of shifting and lowering load for the customer is assessed is built from data of 2012, original from the Market Operator OMIE database. Both patterns are observed in Figure 38.

[25] CNMV, https://www.cnmv.es/

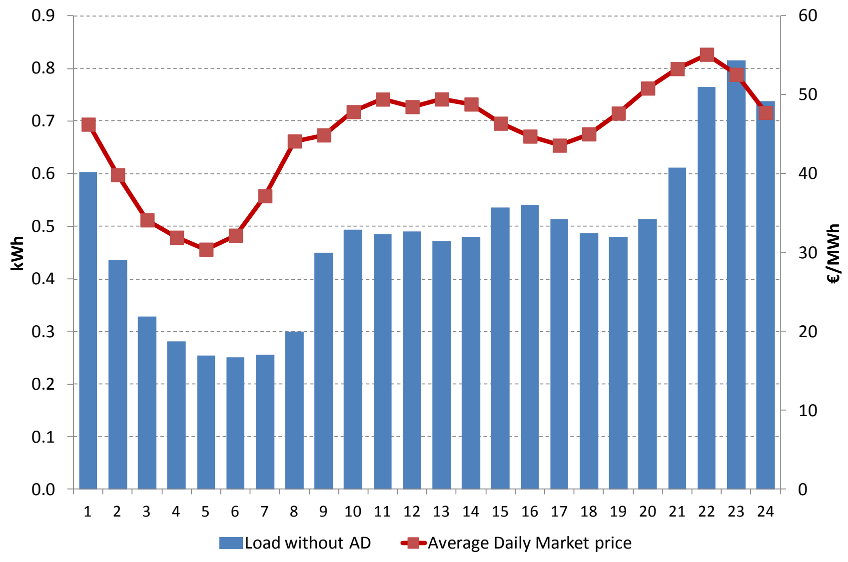

Figure 38, average residential load profile, based on the ADDRESS Pilot data, and average electricity day-ahead market price profile in 2012, based on data from the Spanish Market Operator, OMIE (www.omie.es)

For each of the defined AD programs in the scenarios of T6.1 and T6.3, the average load modifications are estimated according to the effectiveness values used throughout this deliverable. The assumed impact of Feedback programs is an overall reduction that is distributed uniformly across the daily load profile. The assumed impact of Dynamic Pricing Programs is a reduction of the consumption during the peak load, which is assumed to last a larger number of hours in the case of TOU than in the case of CPP, and a rise of consumption during the valley hours (from 2 a.m. to 8 a.m.), so that the total consumption in an average day is not modified. The effect of RTP is directly related to the relative deviation of the price from the daily average. This way, the economic effect can only be attributed to the effect of load shifting.

The potential economic savings for the customer are afterwards calculated as the difference of the cost associated to the consumption pattern without AD and the resulting cost of the consumption pattern under AD, both evaluated with the average hourly price. The average price pattern is aimed at capturing the average effects of different levels of peaks and valleys in the prices throughout the year, not particular infrequent events in the system.

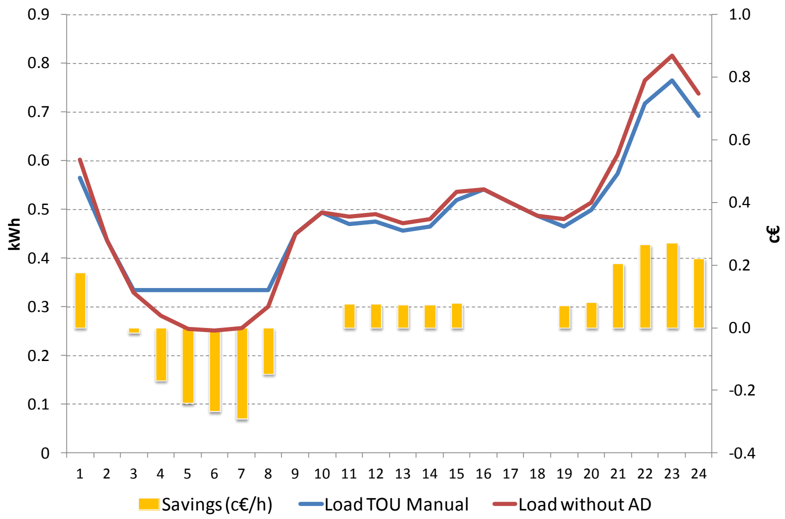

Figure 39, assumed modification of the average load profile for a consumer under TOU without automation, according to the effectiveness of T6.1 (6.29%), and the contribution of the energy component to the associated savings for the consumer

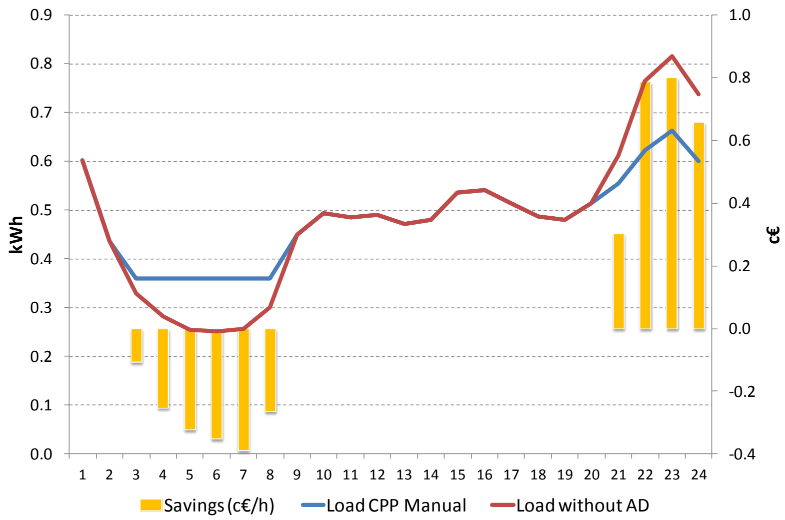

Figure 40, assumed modification of the average load profile for a consumer under CPP without automation, according to the effectiveness of T6.1 (18.65%), and the contribution of the energy component to the associated savings for the consumer

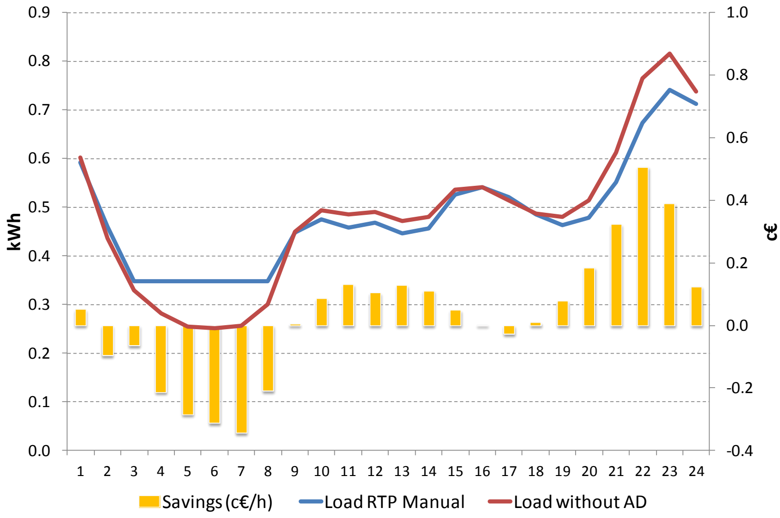

Figure 41, assumed modification of the average load profile for a consumer under RTP without automation, according to the effectiveness of T6.1 (12%), and the contribution of the energy component to the associated savings for the consumer

Figure 39, Figure 40, Figure 41 show some examples of the different average potential savings in each hour of the day for each of the DP programs without automation. The positive quantities (savings), from the peak reductions, compensate the negative ones (extra costs), from the load increases in the valley hours.

The added up results are summarized in Table 35, where each AD program presents an average immediate economic benefit for the customer in the range of 1 to 18.9 euros per year. In the long-term, the price differential in the market could be reduced due to the interplay of demand and supply, especially if the presence of AD in the system increases considerably. Therefore, the incentive for consumers would, on average, be reduced as far as the energy component is concerned.

		Ave. Savings per customer in energy cost		**Max. saving network**
		(c€/day)	(€/year)	(€/year)
FB	Informative bill	2.60	9.5	7.2
	In-Home Display (IHD)	5.17	18.9	
	Website	1.63	5.9	

		Ave. Savings per customer in energy cost		Max. saving network
		(c€/day)	(€/year)	(€/year)
DP	Time of Use (no-automation)	0.54	2.0	5.3
	Time of Use (automated)	1.43	5.2	
	Critical peak (no-automation)	0.86	3.1	
	Critical peak (automated)	1.39	5.1	
	Real-time pricing (no-automation)	0.74	2.7	
	Real-time pricing (automated)	0.29	1.0	

Table 35, estimated consumer savings from AD in the energy component of the final price of electricity along with the maximum avoided investments per customer and AD program type in distribution networks (not to be fully transferred to customers).

It is important to highlight that the estimated savings computed in this subsection are based on the implicit assumption that end-consumers are exposed to wholesale prices (once the load profile after AD is fixed). However, as discussed above, this is frequently not the case. In order to estimate the actual savings attained by a specific consumer, it would be necessary to consider the composition of the retail tariffs. The most relevant parameters to take into account are the division between the energy and power components as well as whether time discrimination is incorporated. Notwithstanding, these calculations would allow the estimation of the savings in generation costs which retailers/aggregators can consider when defining the tariffs for end-consumers (to achieve a win-win situation and hedge risks). Furthermore, the previous figures show that the maximum instantaneous consumption can be reduced thanks to AD mechanisms. Hence, another potential source of economic savings for consumers is the reduction in a contracted or maximum measured load.

It may seem that the average individual benefit perceived by consumers is relatively low, apparently indicating that there is no business case for retailers, aggregators to offer AD products to residential consumers and even for them to accept them. However, this means that while some consumers will probably not find any incentive to participate or adjust their consumption at all, others will be flexible and meaningful enough for the system to enable a positive business case. A real life example that demonstrates this is the successful initiative carried out by Electricity North West Limited (ENWL), a United Kingdom DSO, to use a Demand

Side Response based scheme called Capacity to Customers (C_2C)[26] to manage contingencies in their networks with the aid of demand flexibility. According to ENWL, it is estimated that C_2C could save up to £1 billion to customers in UK in general and in particular, up to £10 000 to £30 000 per MVA[26].

8.3. Benefits for intermediaries

Intermediary agents in AD gather or manage the response of multiple consumers in a coordinated way and act as procurers of their flexibility on their behalf in different markets, even at local level for the provision of network services to DSOs.

Intermediaries for AD mostly make sense as long as consumers are small and are not prepared to interact directly with the complexity of electric power systems or face great barriers in accessing energy markets and system operation mechanisms. Transaction costs associated to such participation on an individual basis may be too high for consumers that do not meet the necessary conditions. In addition to this, consumers are not always prepared and willing to receive complex signals or assume the control of their appliances on their own.

The main value of aggregation and intermediary action is the ability to better manage the loads of individual consumers that do not find and incentive on their own to enter complex and expensive mechanisms for which they do not have the necessary knowledge and expertise. The role of intermediaries is to make up for these deficiencies and provide two services:

- They ensure a degree of responsiveness in the demand they control to the system agent to whom they are selling the flexibility they are aggregating. This way, the DSO, for example, will rather count on the reliability of the service provided by the intermediary of a large amount of residential consumers than of the small consumers themselves.
- They provide consumers easy ways to respond with their flexible behaviour or allowing some control over their appliances in exchange for some incentive or remuneration mechanism. The incentive for consumers is to gain this compensation payment.

In compensation for this service, intermediaries are expected to legitimately keep part of the benefits that obtained by the consumers they attend. Additionally, retailers acting as AD intermediaries would benefit from optimizing a portfolio of energy trade. Managing flexible loads

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[26] http://www.enwl.co.uk/c2c

gives the option of arbitraging between generation and demand response to meet obligations in the market.

Given the commercial nature of their activity and direct relation with the customers, retailers are expected to assume the role of intermediaries when interacting with residential and SME customers in most cases, even assuming specific roles of aggregation and load management that are typical of AD programs.

It would be difficult to provide a quantified estimate of the benefits of an intermediary, for they would depend on many uncertain factors. Nevertheless, the estimated benefits for other stakeholders involved gives us an order of magnitude of the benefits that could be obtained by an intermediary if we take into consideration that the margin of their activity is made out of these benefits. Therefore, it is reasonable to expect that the commercial role of the retailer or the aggregator would make a positive business case as long as the amount of consumers they represent is large enough.

9. Main findings of the economic analysis

The potential economic benefits of AD at local level have been quantified for a set of country-specific case studies and scenarios. These benefits have been measured as the avoided distribution network reinforcements that a more efficient use of existing and new grid capacity due to AD could defer or avoid. The expected impact of AD on consumption has been exogenously defined according to average effectiveness levels of AD programs observed in the ADVANCED knowledge base and the participation rates associated to the economic and regulatory scenarios defined in T6.1: Baseline, Optimistic and Technical Potential.

The results that have been obtained vary significantly from case to case, always in relation to the assumptions and input data that were used for the analysis. Various local and country-specific circumstances have been observed to influence to a greater or lesser extent the desirability and the effectiveness of integrating certain forms of AD into network planning strategies for DSOs and regulators. In particular, the variety of network configurations, the projection of future demand growth and new DG connections, the degree of congestion of the current networks, the location of responsive consumers and the rate of participation in AD have been identified as pertinent factors of analysis.

Certain local environments where AD could add value for distribution networks, and therefore its potential should be explored, are the following:

- Investment needs driven by high demand growth expected in a ten-year horizon or longer.
- Networks constrained close to capacity limits, at LV or MV, where a small increase in demand or new connections would necessarily require a huge amount of reinforcements. This occurs more easily in urban networks with a high density of population.
- Controlled and concentrated location of participative consumers, unless the participation rates are sufficiently high and the reinforcement needs are uniformly distributed throughout the network.
- Massive penetration of Solar PV. AD could help to relieve critical states of the network (inverse flows, voltage limits, etc.) during periods of maximum generation and usually low demand by incentivizing shift consumption from the usual peak hours to those periods, especially if sufficient amounts of consumers and loads were concentrated close to the Solar PV:.

On the contrary, the circumstances in which AD has a limited potential to reduce investment costs for distribution networks are as follows:

- Low or null peak demand growth expected in a ten-year horizon or longer.
- Investment needs only driven by new DG connections, especially if these are moderate.
- Networks designed with ample capacity to absorb new connections and load increases, which occurs mainly in rural networks that supply scattered and relatively low loads.
- Geographically dispersed and uncontrolled participation in AD at LV level if the participation rate is low and certain zones of the network are particularly constrained or congested.

In this analysis, it has also been appreciated that the location of responsive consumers participating in AD in the network is not always relevant. It can be especially important in a scenario of low penetration of AD, in which it is more beneficial to the network if these consumers are concentrated in a few locations instead of randomly spread throughout the network. In contrast, when the required reinforcements in a scenario without AD are rather diffused in the network, a dispersed response is also more beneficial. In any case, one of the key conclusions of this analysis is that the potential benefits of AD for distribution networks are very dependent on local characteristics of the networks.

The resulting net benefits of AD for distribution networks, evaluated in terms of avoided investments minus the associated costs of implementation of AD, could be partly transferred to DSOs and consumers. This allocation among the different stakeholders would very much depend, as has been discussed, on the regulatory framework and the business models in place. In particular, it would be strongly conditioned by the design of the remuneration mechanisms (e.g. on the length of the regulatory period and on the exact costs that were recognized as efficient costs to determine the allowed revenue for that regulatory period) and the distribution network tariffs imposed in each specific country reality. In addition to this, under a proper design of the AD program or tariff, the benefits that would be transferred to consumers would not be uniformly distributed but allocated to those effectively responding to the AD signals and providing flexibility in an efficient way, probably enabling a positive business case for some but not all consumers. Retailers and other intermediaries could share part of the savings achieved in the demand-side with customers in exchange for their ability to better manage the loads of individual consumers that do not find and incentive on their own to enter complex and expensive mechanisms for which they do not have the necessary knowledge and expertise.

Furthermore, in a scenario of low penetration of AD, consumers could face an additional incentive it their load changes are aligned with the energy market prices profile in a way that they reduce consumption in the peak hours to shift it to the valley hours. Alternatively, in the case of Feedback programs, any reduction in consumption will inevitably be compensated by a reduction in the energy bill proportional to that reduction and the average price of electricity. These savings for customers are additional incentives for participation but do not necessarily translate into benefits for society. An estimation of these benefits has been provided for the Spanish case study, based on the implicit assumption that end-consumers are exposed to wholesale prices (once the load profile after AD is fixed), providing us with apparently low figures in terms of € per consumer and year on an average basis but comparable to the unitary savings in network investments.

These calculations would allow the estimation of the savings in generation costs which retailers/aggregators can consider when defining the tariffs for end-consumers (to achieve a win-win situation and hedge risks). This allows us to better understand the relative importance of each cost component in the final price of electricity (network, energy) and how each of them could be transformed for final customers with the application of AD either driven by the network or by the market.

10. Regulatory barriers for AD

The full potential of Active Demand is still not achieved in most of the European scene. Its realization requires that certain mechanisms in the market are in place and that the regulatory conditions allow for its completion at wholesale, network and retail level.

An adequate regulatory framework must establish what is necessary to realize AD but leaving participants to decide to what extent invest on and participate in AD, ensuring a transparent and fair environment. In addition to this, it must facilitate the conditions for regulated activities to take advantage of this source of value to improve the efficiency of their investment and operation strategies.

The main regulatory barriers to develop AD are related to the difficulties for equal access and operation in the electricity markets. Some of these impediments are only physical or technological, but others are regulatory. And even the technological ones may be further hampered due to inefficient regulation. Other barriers are related to difficulties already encountered when putting in practice any form of AD.

In this section, some regulatory barriers to the development of AD in Europe are discussed and the regulatory environment regarding those issues is compared among the four countries analysed in the context of the ADVANCED project: Spain, Italy, Germany and France. This section has been completed with the inputs provided by the participating partners through a set of regulatory questionnaires, part of which has been inserted in Annex C for further reading.

10.1. DSO remuneration

Under certain circumstances, AD can replace part of the investments required for network reinforcements to cope with increasing demand and DG capacity, as has been quantified for various case studies. Therefore, the role of DSO is crucial in AD, and the design of remuneration schemes is the key to the motivation of making use of AD, or simply enabling AD and not imposing barriers to its implementation by other market agents, providing the necessary Smart Metering and Information Communications Technology (ICT) infrastructure.

The remuneration mechanism for DSO significantly influences their incentives for investments in assets in general and in enabling AD in particular. The regulatory approach in most EU member states consists of determining the amount of revenues a DSO is allowed to recover through the network tariffs. In particular, Incentive regulation is the most common regulatory scheme in Europe (Eurelectric, 2014). In contrast to the traditional cost-of service regulation, under this type of scheme, the regulatory authority sets the allowed revenues or prices to grid operators for a regulatory period of three to five years. It therefore focuses on short-term cost reduction rather than on long-term efficiency. This form of remuneration may impose some obstacles to the development of AD, in particular:

- The allowed revenues are usually determined ex-ante from historical expenses, benchmarking techniques, reference networks, etc. Therefore, innovative solutions that affect network conditions that differ from the past, such as those provided by AD, are difficult to incorporate in the planning process if the allowed revenues are not adapted to this reality.
- Due to the difficulty of regulating long-lived network investments, some, but not all (e.g. in Germany), regulators opt to exclude CAPEX from efficiency requirements so as to prevent insufficient network investments which could cause security of supply problems. However, this effectively discourages DSOs from deferring or avoiding some investments by exploiting the AD potential.
- The positive impacts of AD measures may take some time to happen at a large scale, so it is difficult to observe benefits from considerable upfront investments needed to test AD in such a short time length as the regulatory period. This disincentives innovative investments on enabling technologies for AD and experiments of forms of AD, such as pilot programs, in opposition to investments on network extensions.
- DSOs have been mandated to roll out smart metering, which is a key enabler for AD, in most European countries (EC, 2014a)[27]. This leads to additional costs that comprise both the cost of installing the meters as well as the costs of collecting metering data and settlement. However, the recovery of these expenses is not always clearly guaranteed in the DSO regulation. Thus, regulators should establish a stable framework allowing DSOs to recoup these costs in a way that fits the roll-out schedule and the expected benefits from SM.

[27] In three out of the four countries considered within the ADVANCED project (France, Italy and Spain), a large-scale roll-out of smart meters has been mandated by 2020 or earlier, being the DSO the entity responsible for this roll-out. In Germany, the CBA did not yield conclusive results as only some types of consumers would benefit from smart metering. Therefore, German regulation does not mandate a large-scale substitution of conventional meters. Moreover, the metering activity has been liberalized. Thus, consumers may freely choose a metering supplier (DSOs remain as metering suppliers by default).

- Active management of distribution networks is not envisaged by current regulation. DSO are usually obliged to dimension their networks according to the peak demand. However, in order to permit AD bring value to distribution networks, DSO should be allowed to consider both the traditional investment solution, which is investing on network reinforcements for a higher capacity, and the flexibility-based solution counting on AD for instance, or a combination of both, depending on what is most efficient.

Table 36 contains the comparative state of the regulation regarding the previously described issues in the four analysed countries.

	Spain	**Italy**	**Germany**	**France**
Incentives for innovative investments (RD, Smart Grid, etc.)	Additional costs are currently not taken into account in the reference grid model. No specific incentives besides calls for funding R&D projects are provided to DSO.	Extra WACC for new efficient technologies (refurbishment & substitution)	(Non-funded) costs for network innovation could be included into determining regulatory costs if the costs stem from a programme that is funded by the government.	Yes (RD and Smart Grid expenses are covered by the network tariff)

	Spain	**Italy**	**Germany**	**France**
Install - Owner of AMI **Cost of AMI by DSO and recovery**	DSO. Consumers pay a monthly rental fee if the SM is not owned by the consumer. DSO owns the AMI. This investment is indicated to the NRA as any other investment in distribution so it is recognized in the remuneration. It is unclear whether this covers only the SM or the full AMI.	DSO Included in RAB and OPEX	The responsible party is the metering point operator. The incorporation of roll-out costs into the regulated revenue is still under discussion	ERDF is responsible for the roll-out of AMM but does not own SM (property of local authorities). Cost of AMM by DSO is recognized by the NRA.
Active management of networks – Consideration of AD in network planning	Not explicitly (even though the RNM[28] for planning accounts for demand variations)	No	Historically, some tariff incentives for electrical heating exist. Further developments for other AD options are currently under consideration.	No Not explicitly (only existing CPP regulated tariffs are taken into account in network planning)

[28] Reference Network Model, like the one used in the economic analysis in this deliverable

	Spain	Italy	Germany	France
Fear of no recovery of costs	Fears come from the design of network tariffs, which are the only means of cost recovery for DSO.	No	The AMI cost recovery has not been secured in the German energy law / incentive regulation yet	n.a.

Table 36, regulatory aspects about DSO remuneration that affect the implementation of AD in the studied countries

Any adaptation of the remuneration mechanisms for DSO should cope with a revision of the priorities of different regulatory goals and incentives. In order to promote AD[29], the economic regulation of DSO should be revised in order to incentivize DSO to make long-term efficient investments and reward innovation more intensely rather than focus on short term optimization. More specifically, the following guidelines would contribute to achieving these goals:

- The analyses presented in this document have clearly shown that there is a certain trade-off between network investments and AD solutions. However, some regulatory frameworks but not all (e.g. the German case) encourage DSOs to opt for CAPEX-based solutions over OPEX-based ones. This could be mitigated by equalizing the incentives to reduce OPEX and CAPEX. In order to attain this, remuneration mechanisms should not differentiate between both types of costs. Despite the fact that this is not straightforward since DSOs need to secure a reliable electricity supply, there are several regulatory mechanisms available such as profit-sharing schemes[30] or CAPEX rolling accounting methods.
- The mechanisms to benchmark distribution costs ought to adopt a more forward-looking approach that internalize the new types of network users and smart grid technologies,

[29] This comment is also relevant to encourage an efficient integration of other types of DER such as DG or distributed storage.
[30] Profit-sharing schemes consist in setting an ex-ante revenue path together with an ex-post correction based on pre-defined rules. This allows mitigating the uncertainties faced by DSOs in a purely ex-ante framework, which can be greater when alternatives to network reinforcements are considered, and at the same encourage cost reductions. An example of this, in combination with menu regulation, is the information quality incentive (IQI) implemented in the UK.

whose impact will presumably not be captured in past information. Additionally, as shown in the previous technical analyses, the impact of AD can be significantly different in each distribution area. For instance, the results showed that the effect of having a concentrated or dispersed AD participation may have opposite consequences in different distribution areas.

- One of the main goals of DSOs is to secure a reliable electricity supply. Hence, they may decide to carry out investments in spite of the AD potential should they deem AD unreliable. In order to overcome this barrier, DSOs may be entitled to resort to local AD (and other types of DER) to alleviate network constraints in case necessary. Regulators should then ensure that this is done in an efficient and non-discriminatory way through the definition of specific mechanisms such as obligations, economic incentives, local markets, etc.

As discussed above, the reduction of distribution network losses is at most a side effect of AD rather than a truly relevant driver. Nevertheless, the variation in consumption profiles will definitely affect these losses. Consequently, the standard loss factors used to define the reference level in incentive schemes, which are usually calculated from historical data, may be rendered inappropriate to the new context. Therefore, these parameters should be updated according to the new behaviour of distribution network users.

10.2. Tariff design

Energy Efficiency Directive (2012/27/EU) requires the removal of network tariffs that would impede energy efficiency and/or demand response. The frequent use of flat network tariffs that do not charge network users according to the costs they cause to the system is a major barrier to the exploitation of the value Active Demand through price signals for distribution networks.

Tariffs should encourage a more efficient use of the network capacity by shifting the peak consumption to hours of lower congestion or by simply reducing it. This should allow cost savings to be achieved in distribution networks by lowering the costs of delivery or of network investments and a more optimal operation of the network.

However, it should be borne in mind that distribution costs amount to a limited share of the overall retail costs paid by end consumers. The remaining cost components may contradict or dilute the power of more cost-reflective network tariffs. On the one hand, time varying electricity prices (or how these are transferred to the retail tariffs) may dilute the power of the economic incentive of time-varying network tariffs, depending on the demand structure and generation mix in each country. On the other hand, there are several components of the regulated tariffs which are not necessarily set by energy regulators (contrary to network tariffs) and which can amount to a very significant share of overall costs (e.g. RES payments, duties and taxes).

In the end, regulation should ensure that end users are provided with cost reflective tariffs so that these agents can make more efficient decisions based on the overall system costs, at least for the share corresponding to regulated costs, i.e. all but electricity costs and retailing fees. Hence, the following discussion, in spite of referring specifically to network tariffs, would be broadly applicable to the whole design of the regulated part of the tariffs.

In this regard, special attention has to be paid both to cost drivers and tariff components and structure. Given that the major network costs are related to the installed capacity of network assets, which is determined by the peak demand, in the case of consumer, and peak generation in the case of prosumers, that should be reflected in the tariff in two ways:

- By charging the tariff in two components: a capacity component (€/kW) and an energy or volumetric component (€/kWh) and finding the right balance between them. The aforementioned capacity charge can be based on an ex-ante contracted capacity defined at the moment of connection to the grid or on the maximum instantaneous consumption observed ex-post through the meter. In any case, this tariff structure would discourage high instantaneous power consumptions, thus allowing DSOs to defer or avoid grid reinforcements.
  However, network tariffs for households and small businesses are frequently entirely based on energy volume (kWh) through the volumetric component. Moreover, even when there is a capacity component, it may sometimes represent a low share of the revenue recovery.
  This recommendation turns increasingly important when prosumers become widespread as, otherwise, free-riding and cost recovery problems may arise. Prosumers would essentially reduce the payments made through the volumetric tariff component[31]. In case this volumetric charge incorporates many of the fixed system costs, this would force an increase in the volumetric charge as the same costs are paid by fewer consumers (or fewer kWh of consumption). At the same time, this would increase the incentives for self-

[31] Because the net demand is lower and the volumetric tariff component is charged in proportion to that energy. The contracted capacity can be hardly reduced as consumers would still need a similar amount of power in those months with low generation (e.g. winter months in case of solar PV). Similarly, the observed maximum instantaneous consumption may only be reduced in times of generation availability.

consumption worsening the problem. In the end, this could endanger the recovery of system costs and/or charging excessively those consumers without self-generation.

Additionally, tariffs may only account for the capacity required for consumption but not the additional capacity required for the accommodation of generation in the case of prosumers. Thus, these prosumers would be paying less grid charges even though they may use the network more than other users. Therefore, the capacity charge ought to be based on the maximum net capacity injected or withdrawn.

- By providing a smart structure to the volumetric component of the tariff (€/kWh), allowing it to vary according to the Time of Use (ToU) or even according to other forms of dynamic pricing, such as Critical Peak Pricing (CPP), driven by network conditions. This way, the use of the network during hours of high probability of congestion would be discouraged, shifting consumption of hours of lower network saturation and reducing the need for new network capacity reinforcements (assuming electricity prices do not go in the opposite direction). Network tariffs are still flat in many countries, impeding this form of AD in distribution network tariffs.

Network tariffs can be a significant component of the final electricity rate paid by end customers. Sometimes retail prices for small customers are also designed and collected centrally by the regulatory authority. This is not necessarily a barrier to the implementation of AD through dynamic pricing, because this pricing system could be fostered by the regulatory authority instead of by commercial agents.

Another relevant topic related to network tariffs consists in whether network users are to be ensured with a firm network access. Being this the case, a new network user or group of users may require a reinforcement of the grid to prevent constraints that may arise during a few hours per year. These reinforcements are either passed-through to these users through deep connection charges or socialized among rate payers. However, as mentioned before, AD mechanisms may prevent this costly solution through non-firm network access. The lack of mechanisms through which the DSO could make certain arrangements with the newly connected network user for these purposes is a barrier for the implementation of this type of AD by DSOs. These cases are particularly relevant with regard to large MV customers.

Table 37 contains the comparative state of the regulation regarding the previously described issues in the four analysed countries.

	Spain	Italy	Germany	France
Customers with regulated tariffs[32]	75% of residential customers	80%	0% - fully open market for all types of consumers	93% of residential and 87% of non-residential
Network tariff charges (connection, capacity, volumetric)	Fixed (€) + Capacity (€/kW) + Energy (€/kWh) charges	Capacity (€/kW) + Energy (€/kWh) charges	Energy (€/kWh) but most consumers in LV also pay a fixed charge; for industrial customers also Capacity (€/kW)	Capacity (€/kW) + Energy (€/kWh) charges
Structure of tariff (time variation of volumetric charge, voltage differentiation...)	Voltage and power differentiation and time variation up to 6 periods according to the system peaks.	Time of Use differentiation	Time of Use differentiation for certain installation (heating systems, heat pumps etc.)	Voltage and Time of Use differentiation
Regulated tariff	Voluntary Price for the Small Consumer that is optional to small customers (04/14). Energy cost is based on hourly price of daily and intraday markets.	Mandated ToU tariffs for residential customers since 2010, AEEG	No regulated retail tariff but energy law calls for suppliers to offer at least one tariff that incentivizes “saving energy”.	Yes (for consumers under 36 kVA – for larger consumers regulated tariff will disappear at the end of 2015)

[32] From Deliverable D1.3

	Spain	Italy	Germany	France
Prosumers	Separate meter for consumption and generation is required. Net metering is not allowed at LV.	No separate meter Not net metering	Separate metering is the norm but due to different “business models” and past changes in the RES law no homogeneity exists	Domestic consumers with DG have separate meters. Feed-in tariffs vs. retail prices: no incentive to be a prosumer

Table 37, regulatory aspects about network tariff design that affect the implementation of AD in the studied countries

10.3. Market roles and business models

The roles for market players appears not be clearly defined in most European countries yet, especially in relation to the role of emerging market participants, such as aggregators, and the relationship between TSO, DSO and market operators. In addition, there may be different views among stakeholders on this issue. Nevertheless, these intermediary agents are crucial for the development of Active Demand among small and dispersed electricity consumers like households because of their lack of expertise and size to be direct market participants.

There is an ongoing discussion regarding the following roles in relation to smart metering:

- The roll-out of smart metering: smart metering is an essential enabler for AD. Member States shall ensure that 80% of consumers shall be equipped with a smart meter by 2020 or run a CBA (Directive 2009/72/EC) to decide on their specific roll-out volumes. The input data and assumptions to carry out this CBA were up to each MS (EC, 2014a).
- The responsibility for investment in and owning the required AD enabling technologies, in-home displays, smart appliances or load automation are clearly within the scope of liberalized activities and, as such, should not be subject to regulatory intervention (or rather just be regulated on a technical level to assure compliance with network codes and interoperability).
- The right and obligation to access, collect and manage smart metering data: this task is commonly carried out by DSOs and is expected to evolve in the future smarter environment. Notwithstanding, there are two more models under discussion. On the one

hand, some stakeholders propose a central regulated hub only devoted to data collection and management, i.e. independent of DSOs. The main reason for this is to allow DSOs to focus on the network activities and to better guarantee transparency and competitiveness for market related AD due to a potential lack of unbundling between DSOs and liberalized activities. Lastly, another model under discussion is contrary to the two previously mentioned, based on a decentralized solution known as data access-point manager (EG3, 2013).

A good overview of the situation regarding the situation on smart metering across EU countries can be found in (EC, 2014a) and its accompanying documents. Most countries have decided to proceed to a large-scale roll-out of smart meters by 2020 or earlier. However, a relatively large share of countries still has not decided for such deployment due to a negative or inconclusive result of the CBA. Some countries even reported that the CBA was only positive for certain groups of consumers. In any case, the DSO would be the responsible for such deployment and retain the ownership of the meter, except for a few cases (namely the UK, where suppliers are responsible and Germany, where due to a liberalised metering market also third parties will run smart meters). In relation to metering data collection and management, the alternative where DSOs perform this role seems to be the most common one across EU countries, even in those who have not yet decided to go for a large-scale roll-out. On the other hand, a few countries have opted for the central hub alternative (despite the fact that the DSO would still be the meter owner in most cases) and fewer still are evaluating alternative models.

Table 38 contains the comparative state of the regulation regarding the previously described issues in the four analysed countries.

	Spain	**Italy**	**Germany**	**France**
AMI investment	DSO	DSO	Responsible metering point operator	DSO only operation and maintenance

	Spain	Italy	Germany	France
Data management	DSO	DSO	Smart Meter Gateway Administrator and DSO for billing data	DSO
DSO access to data	Yes	Yes Operational purposes	Yes, as stipulated by the energy law Operational purposes	Yes
DSO and AD	Data, collected and managed by DSO, cannot be used by them for commercial purposes. No AD at DSO level.	n.a.	DSM measures from the pre-liberalization era persist: DSO control over domestic heating appliances but also (new) heat pumps enter that regime; network user gets reduced fee for electricity supplied to (interruptible) installations	DSO control over hot water boilers through the definition of off-peak periods at local level.

	Spain	Italy	Germany	France
Agents in place and regulation	Aggregators are not allowed. Ongoing discussion. There is a new figure: the charging manager (Electric Recharge Grid Operators), responsible for purchasing and managing energy necessary to charge PEV batteries, to follow demand response commands for network operators (neither TSO or DSO). DSO no commercial activity. There are no ESCO.	No aggregators (only ESCO, no network services) No regulation ESCO provide energy efficiency measures	Agents exist and even though their business is not too large yet, there is a lively market for ESCOS and their services. C&I customers are participating through their own balance group or through aggregators in minute reserve markets and TSO mechanism to switch loads. ESCO energy efficiency measures	Aggregators exist and are mostly directly dealing with TSO. Regulation is progressively recognizing the role of DSOs for consumers involved in AD and connected to the distribution network (see D6.2).

	Spain	Italy	Germany	France
Interaction regarding data sharing	The System Operator and Market Operator establish a series of requirements and rules for information exchange between registered agents operating in their markets and services. Moreover DSO must ensure access to Retailers to certain data contained a data base called Data Base of Points of Supply (see D6.4)	n.a.	Small consumers act through their supplier, who is the intermediary between them and the DSO. Energy law already includes sector-specific data privacy regulation that will be further detailed in a special decree Data sharing among parties to be defined in that process (involve DSO)	DSO shares data with retailers and with the roll-out of SM, will share data directly with consumers (they will have access to their data through a website – See D1.3 and D6.1). Regulation for third parties access to SM data is under discussion.
DSO fully unbundled	Yes	Yes	Yes	Yes

	Spain	Italy	Germany	France
Retail sector competitiveness, consumer switching rate	Increasing switching rate – opening barriers of entry	5,9%	Yes, approx. 7.8% of all households consumers switched in 2012 (even higher quotas in C&I); some 250 supply companies are operating nation-wide	Market share of alternative suppliers is low (see D1.3)

Table 38, regulatory aspects about market roles and business models that affect the implementation of AD in the studied countries

In spite of the fact that national regulation has deeply changed over the last years (and remains to do so), the role of DSOs is not fully defined in several countries. Moreover, it is unclear what the conditions for the installation of smart metering is in those countries where a roll-out is not mandated due to a negative CBA but where certain consumers may indeed benefit from it. This lack of clarity makes it difficult for DSOs, suppliers and aggregators to take advantage of the possibilities of flexible demand to improve efficiency.

Due to the fact that DSOs generally have an advantageous position in relation to access to metering data, ensuring a proper implementation of unbundling provisions becomes more relevant in order to ensure a properly functioning retail market. Otherwise, their privileged position could mean an asymmetry of information in relation to other market agents. Hence, evaluations such as the one presented in (CEER, 2013) are deemed to be very important.

Finally, retailers, aggregators and other commercial agents are expected to provide the smart AD services, especially dynamic pricing schemes in relation to the real price of energy in the market. A competitive market without entry barriers should be ensured. The retail switching rates registered by CEER among European electricity consumers reveal that there are still barriers for market access and transparency in the retail sector of many countries, which hamper the entrance of new market actors providing novel services related to AD. In this regard, smart meters may be seen as an essential enabler of retail electricity markets. Hence, member states which have obtained a negative CBA should be encouraged to review the parameters and methodology in order to ensure that at least those segments where smart metering may yield a positive CBA are identified and measure are taken to unlock the existing potentials.

10.4. Standardization

The standardization of products, operation procedures, and services is a fundamental requirement for the development of the plurality of AD mechanisms that can be applied in different countries of Europe and regions within each country.

Some standardization is still missing at EU level. This is of particular relevance in relation to minimum required smart meter functionalities, where there is still no harmonized legally binding definition for all MS. This could be helpful in some way but the specific circumstances of MS should also be taken into account. Certain functionalities of SM are the enablers of complex and varied forms of AD, even incorporating automation. The lack of homogeneous and complete functionalities among SM simply blocks certain forms of sophisticate AD due to limited capacities.

There is also a need for interoperability in the new emergent infrastructure for ICT and the new technologies that are being connected to the distribution networks in relation to AD, from smart Meters to other devices that enable automation and remote-control functionalities.

The characteristics of household electrical equipment could improve in relation to standardization as well in order to make AD more effective. Without making an explicit obligation from legislation, it is very difficult that appliances incorporate smart and automation and control functionalities, without which it is very difficult that automated forms of AD can take place. Even if not all appliances have to be ready for automation, there should be some homogeneous characteristics among those that are designed with this functionality.

Additionally, there is not a unified vision in relation to the measurement and verification of the provided flexibility, this is, the determination of the baseline (the level of consumption in the absence of AD). Some forms of AD require a comparison with the baseline to assess performance and but they cannot be competitive if it cannot be measured and certified.

Table 39 contains the comparative state of the regulation regarding the previously described issues in the four analysed countries.

	Spain	**Italy**	**Germany**	**France**
SM functionalities	Yes, established by national regulation: RD 1110/2007 (see Annex C)	Yes, established by national regulation. (see Annex C)	Unfinished technical minimum requirements hampering roll-out process (see Annex C)	Yes, established by national regulation: remote reading, remote change of subscribed power, remote sending of mobile peak, display data. (See D1.3)
Interoperability	No legal specifications regarding AMI infrastructure, protocols, etc.	n.a.	Interoperability is an aim explicitly named in the energy law (cf. § 21c Abs. 5 EnWG)	Yes
Smart appliances regulation	No regulation	No regulation	No regulation so far – applicability of smart meter protection profile discussed for “steering boxes”	No regulation

	Spain	Italy	Germany	France
Baseline verification	No regulation. (AD does not participate in the adjustment services in the Spanish electricity market apart from interruptibility for emergency situations - TSO)	No regulation	No regulation	Regulation is under discussion to take into account the roll-out of SM

Table 39, regulatory aspects about standardization that affect the implementation of AD in the studied countries

10.5. Consumer protection

The main issues that affect consumer protection in the context of AD are those related to the access to and the control of their consumption data and consequently, to privacy and data protection. Regulation has traditionally contemplated only the need for data processing for billing only a few times a year, while now the task becomes more complicate issue, dealt with in detail in T6.4.

Consumer protection should go beyond the security of the data in relation to data privacy legislation alone to the address the rights of consumers to be informed and be provided the tools to understand the new smart tariffs and complex contracts to which they can be exposed. Consumers sometimes find it difficult to understand some tariffs or mechanisms for AD (ACER/CEER 2013). This challenge must be dealt with if consumers are expected to be engaged in AD.

In addition to this, they should have complete freedom to choose electricity rate structure and supplier and any additional contractual agreement with aggregators and other agents offering this kind of services.

The impact of consumer participation in certain forms of AD sometimes brings about benefits that are not completely transferred to these customers but to others as well. The way this is done depends on regulation of DSO remuneration, tariff design, retail sector competitiveness and other aspects. Regulatory authorities should supervise how the benefits from AD finally reach consumers and take measures about it if the result is not fair.

Table 40 contains the comparative state of the regulation regarding the previously described issues in the four analysed countries.

	Spain	**Italy**	**Germany**	**France**
Data protection	n.a.	n.a.	Federal law on data protection and special provision in the energy law (cf. § 21 g EnWG)	Yes (see D6.4) The French data protection authority (CNIL) only authorizes the collection of load curves for consumers under 36 kVA in very restricted cases.
Clear billing (separate components)	Bill is unique but includes all the terms separately	Yes	Yes	Yes
Consumer acceptance	Campaigns in the last years to help consumers understand electricity bills. Minimum informative content of the bill is legally binding.	n.a.	n.a.	n.a.

Table 40, regulatory aspects about consumer protection that affect the implementation of AD in the studied countries

10.6. Main findings of the regulatory analysis

This section has reviewed the main regulatory aspects that should be reviewed in order to unlock the potential local economic benefits of AD.

It has been discussed that DSO regulation should be revisited and adapted to the new context characterized by a wider range of available technologies and distribution network users. In particular, it should be revised in order to incentivize DSO to make long-term efficient investments and reward innovation more than focus on short-term optimization.

The different tariff components may sometimes conflict among them. Nonetheless, regulation should ensure that end users receive cost-reflective tariffs to make the most efficient decisions as a whole (considering as well simplicity concerns).

In line with the previous guideline, it is recommended to avoid purely volumetric tariffs. This is particularly relevant due to the advent of prosumers and self-consumption. Otherwise, cost recovery and free-riding problems may arise.

Adjusting regulation to enable the implementation of AD has the difficulty of clearly defining the roles of new emerging actors in this context. For example, it has been concluded that DSO should be entitled the possibility to resort to new forms of AD to alleviate congestions but a direct commercial relationship with customers may not be advisable in order to boost new market players and business. In addition to this, a competitive market without entry barriers should be ensured for retailers, aggregators and other commercial agents to be able to provide smart AD services to their customers.

Another critical issue in relation to the effective development of AD is the standardization in relation to Smart Metering functionalities and smart appliances. The lack of homogeneous and complete functionalities among SM simply blocks certain forms of sophisticate AD due to limited capacities. Some harmonization in this aspect is therefore recommended at EU level.

Meanwhile, consumer protection should also be guaranteed beyond the security of the data to the rights of consumers to be informed and be provided the tools to understand the new smart tariffs and complex contracts to which they can be exposed. This key challenge must be dealt with if consumers are expected to be engaged in AD.

11.Conclusions and recommendations

In this work, the potential economic benefits that AD could have at local level have been quantified for a set of country-specific case studies and scenarios. These benefits have been measured as the avoided distribution network reinforcements that a more efficient use of existing and new grid capacity due to AD could defer or avoid. The regulatory barriers that hamper the achievement of these quantified benefits have also been analysed and some recommendations are provided.

The results of the economic analysis show that under certain circumstances, AD could effectively help distribution network operators to reduce investment costs, allowing for a more efficient network planning strategies. These avoided investments have been observed especially at LV networks and MV/LV transformers and not only in the MV network. Notwithstanding, one of the main conclusions of this work is that this potential is very dependent on local characteristics of the networks and too low to provide a strong signal to many consumers, but not all. Various local and country-specific circumstances have been observed to influence the desirability and the effectiveness of integrating certain forms of AD into network planning strategies for DSOs and regulators. In particular, the following aspects have proved to be of great relevance:

- **Network expansion drivers**. AD has a great potential to defer network investments whenever they are driven by significant load increases and small or hardly any new DG penetration, and only Dynamic Pricing has some potential to help to reduce reinforcement needs to integrate massive amounts of new Solar PV.
- **Network typology**. In general, urban networks capacity utilization is higher so reinforcements due to load increases are deemed more necessary. Therefore, AD has a strong potential to defer investments in that kind of scenario. However, this is clearly conditioned by the expansion drivers.
- **Current level of network constraint**. AD is expected to have a more positive impact on investments in highly constrained networks. For example, in densely populated areas where small load increases would easily cause overloads in network assets. This aspect is related to the network typology and the network expansion criteria because grids that have been designed to have ample capacity to absorb load increases and new network users or that supply geographically scattered small loads are in general less constrained.

- **Location of responsive consumers**, especially for low participation rates in AD. In general, it is more beneficial from the perspective of network investments that the location of consumers participating in AD is concentrated and under control by the network planner. A dispersed location is favourable if required reinforcements are uniformly distributed across the network.

It has been discussed that part of the achievable net benefits at distribution network level could be transferred to final customer and part could be kept by DSOs, according to the design of the remuneration mechanisms and the distribution network tariffs in the specific country reality. Retailers and other intermediaries could share part of these savings with customers. This means that even when the potential economic benefits of AD may be significant from the perspective of society as a whole, and therefore from the regulator standpoint, they may be dispersed across the value chain and among involved stakeholders. This may reduce the incentives for participation but not the need for the efficiency improvement that AD could bring to electricity systems and society.

From the revision of the main regulatory aspects that should be reviewed in order to unlock the potential of AD, the most critical concerns that have arisen are:

- The main **regulatory barriers** to develop AD are related to the difficulties to equally access and operate in the electricity markets. Some of these impediments are only physical or technological, but others are regulatory. Other barriers are related to difficulties already encountered when putting in practice any form of AD.
- **DSO regulation** could be revised in order to incentivize DSO to make long-term efficient investments and reward innovation more than focus on short-term optimization.
- Regulation should ensure that end users receive cost-reflective **tariffs** to make the most efficient decisions as a whole (considering as well simplicity concerns).
- DSO could be entitled the choice to count on certain forms of AD to alleviate **congestions**, which remain to be defined and delimited but a direct commercial relationship with customers may not be advisable in order to boost competition and new business models.
- A **competitive market** without entry barriers should be ensured for retailers, aggregators and other commercial agents to provide smart AD services.
- **Standardization** in relation to Smart Metering functionalities and smart appliances is an open issue of discussion but under certain circumstances, it could be advisable not only at MS level but even at EU level.

- **Consumer protection** should be guaranteed beyond the security of the data to the rights of consumers to be informed and be provided the tools to understand the new smart tariffs and complex contracts to which they can be exposed.

It is hence possible to improve the current regulatory practices for the application of Active Demand in the European context and consequently contribute to the achievement of the EU targets of energy efficiency improvement and consumer engagement and protection.

12. References

12.1. Project documents

List of reference document produced in the project or part of the grant agreement

DOW Description of Work

GA Grant Agreement

CA Consortium Agreement

D1.3. 2013. Active Demand Impact Assessment Methodology. Deliverable. ADVANCED project. Companies contributing: Comillas, Enel, Entelios, ERDF, Iberdrola, RWE.

D6.1. 2014. Scenario-Based Report on the Flexibilities AD Might Offer. Deliverable. ADVANCED project. Task responsible: RWE. Companies contributing: Comillas, Enel, Entelios, ERDF, Iberdrola.

D6.2. 2014. AD based system services. Deliverable. ADVANCED project. Task responsible: ERDF. Companies contributing: Comillas, RWE, Enel, Entelios, Iberdrola.

D6.4. 2014. AD based system services. Deliverable. ADVANCED project. Task responsible: ERDF. Companies contributing: Comillas, RWE, Enel, Entelios, Iberdrola

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13. Revisions

13.1. Revision history

Version	Date	Author	Notes
0.1	29/07/2014	Mercedes Vallés, Pablo Frías, Javier Reneses, Carlos Mateo	First draft
0.2	24/09/2014	Mercedes Vallés, Carlos Mateo, Pablo Frías, Javier Reneses	Second draft and contributions from partners
1.0	07/10/2014	Mercedes Vallés, Pablo Frías, Carlos Mateo, Rafael Cossent, Javier Reneses	First release (for internal revision within the task)
2.0	18/10/2014	Mercedes Vallés, Pablo Frías, Carlos Mateo, Rafael Cossent, Javier Reneses	Second release (update after internal revision within the task and circulation among task partners, TC and PC)
2.1	24/10/2014	Mercedes Vallés, Pablo Frías, Carlos Mateo, Rafael Cossent, Javier Reneses	Third release (new update for second revision by the WP Leader and all task partners)
2.2	05/11/2014	Mercedes Vallés, Pablo Frías, Carlos Mateo, Rafael Cossent, Javier Reneses	Fourth release (update after revision by WP leader and task partners)
2.3	22/11/2014	Mercedes Vallés, Pablo Frías, Carlos Mateo, Rafael Cossent, Javier	Fifth release (update after internal revision by the TM)

		Reneses	
3.0	30/11/2014	PC-QM	Final version (PC-QM final check and submission)

Annex A. Reference Network Model (RNM)

This Annex presents in more detail the main features of the Reference Network Model (RNM) that has been used for the evaluation of the economic benefits of AD for distribution networks in this report. The contents of this Annex are based on the description provided in (Gómez et al. 2013) and in (Mateo et al. 2011), in addition to various technical user guides developed by the authors of the model at the Comillas Pontifical University.

Like other Reference Network Models (RNM), the RNM used here is a large-scale distribution network planning tool that can be used by policy makers and regulators to estimate efficient distribution costs. It is an optimization model able to design an electrical reference or adapted network that compiles the same geographical, reliability and technical constraints as the actual grid at minimum cost.

Figure 42 presents the schematic representation of a distribution grid and how the investment decisions are hierarchically made by the RNM in relation to the location and size of new high voltage/medium voltage (HV/MV) substations, new medium voltage/low voltage (MV/LV) transformers, and new HV lines, and MV and LV feeders.

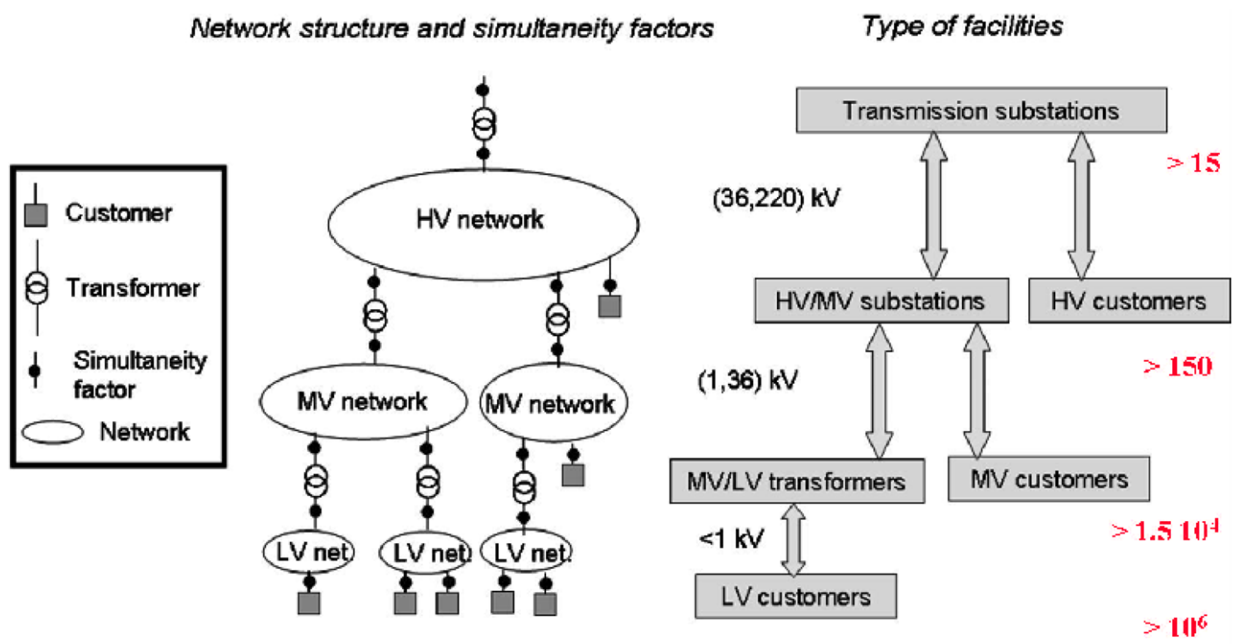

Figure 42, Hierarchical structure of distribution grids by voltage levels and size in the RNM. Source: (Gómez et al. 2013)

There are two different approaches to obtain a reference network: the green-field model and the expansion planning model. The former approach builds an optimal network from scratch while the latter approach takes the current, or the reference, network as the starting point and then builds the necessary reinforcements to accommodate both horizontal (new network users) and vertical (changes in load or generation capacity) growth in demand and DG production. Furthermore, the initial network considered by the expansion planning RNM can be obtained with the green-field model, which is the approach used in this task to design the initial networks of analysis in each country.

The process of distribution planning is done by the model following a hierarchical order between voltage levels, as shown in Figure 43. The distribution network is built taking into account the actual location of network users and network components, as well as other geographical constraints, such as environmental factors or street maps within urban areas, This is possible thanks to the interaction between the planning algorithms and the a geographical information system (GIS), which allows the model to include the cost increase required to comply with geography and topology constraints. This interaction is shown in Figure 43. The networks are also designed internalizing a series of simultaneity factors at different levels so as not to over-dimension network assets.

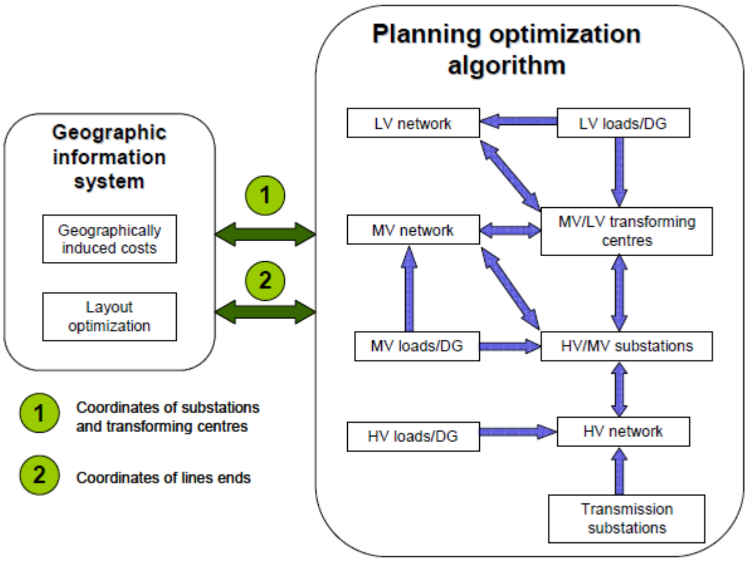

Figure 43, Interaction between planning algorithms and the GIS. Source: (Gómez et al. 2013)

In urban and sub-urban areas, the actual distribution networks must be built following the streets and cannot cross buildings or parks. The RNM used in this study emulates this behaviour by obliging the lines to go in line with the streets of the street map that is used to design the network. The final topology is strongly related to the shapes of the street map and this can cause a great impact on the final distribution network costs. Outside urban areas, some geographical constraints must be also observed and the RNM can take them into consideration.

Figure 44, example illustration of the identification of the street contours in an image of certain location taken from Open Street Map to locate network users and geographical constraints

The multiple constraints taken into consideration by the model include the rate of subterranean vs. aerial lines, the maximum allowed voltage limits, limits to continuity of supply indexes, geographical factors, such as forbidden areas or the sketch of the street map.

The main inputs and outputs of the model are listed below. A visual example of the inputs and outputs of the Greenfield model are shown in Figure 45.

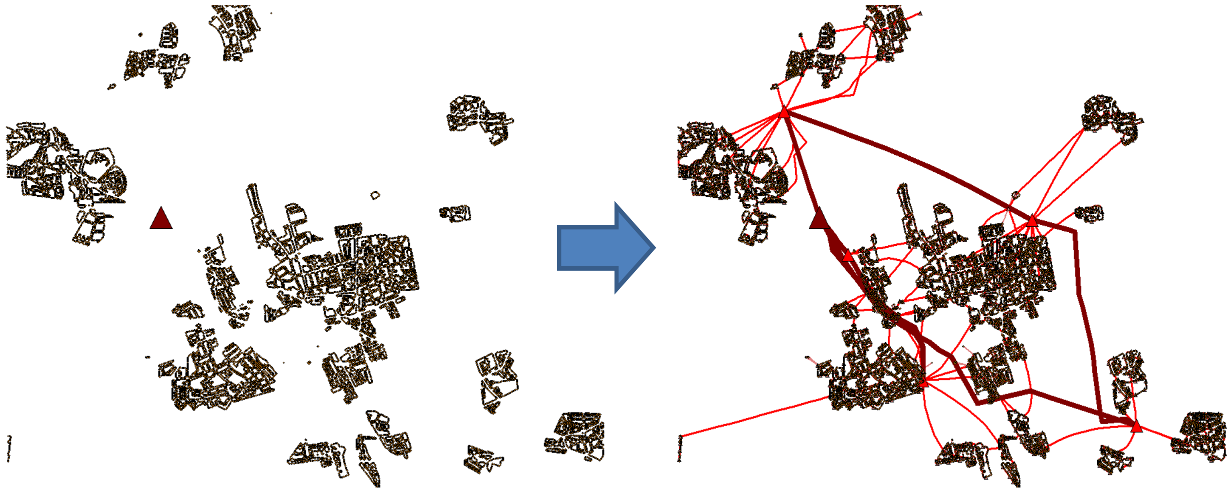

Figure 45, example of a map representing the consumer settlements and geographical constraints of a service area (left) that is fed into the Greenfield RNM to design the Reference Network (right). The red triangle symbolizes a HV/MV substation, while the small red triangles represent the MV/LV transformers. The dots are connection points and the lines are conductors of different voltage levels for each different colour.

Inputs

- Network users, including the exact GPS location, voltage level, power capacity and power factor, or the load/generation profiles.
- Transmission substations location and characteristics, as this is generally out of the DSO control.
- Library of standardized network equipment, including investment and maintenance costs, rated capacity, electrical properties (e.g. impedances) and useful life.
- Other modelling parameters, such as simultaneity factors, economic parameters, load modelling and GIS related parameters (e.g. street maps, connection points, etc.) and technical and quality constraints (e.g. reliability indices and voltage limits).

Outputs

- Designed network components in detail, per network element.
- Costs of building or reinforcing the network, per network element.
- Detailed graphical output files representing the networks.

Annex B. Detailed results of the economic benefits for distribution networks

Some complementary results that go further into the detail of the simulations carried out with the RNM in this study are presented in this section.

Spanish Case study

The results on avoided network investments with AD are shown graphically for both types of networks. The following figures show the needed reinforcements for the scenario without AD and in the Technical Potential scenario of Dynamic Pricing.

Figure 46, graphical results of the reinforcements needed in the Spanish urban network, without AD, in blue.

Figure 47, graphical results of the reinforcements needed in the Spanish urban network, with Dynamic Pricing, with the Technical Potential scenario, in blue.

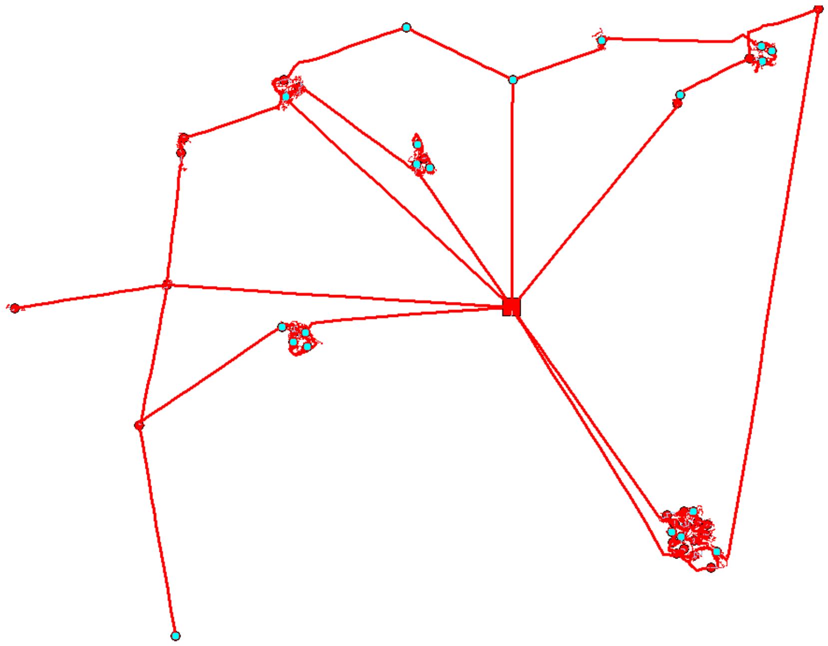

Figure 48, graphical results of the reinforcements needed in the Spanish rural network, without AD.

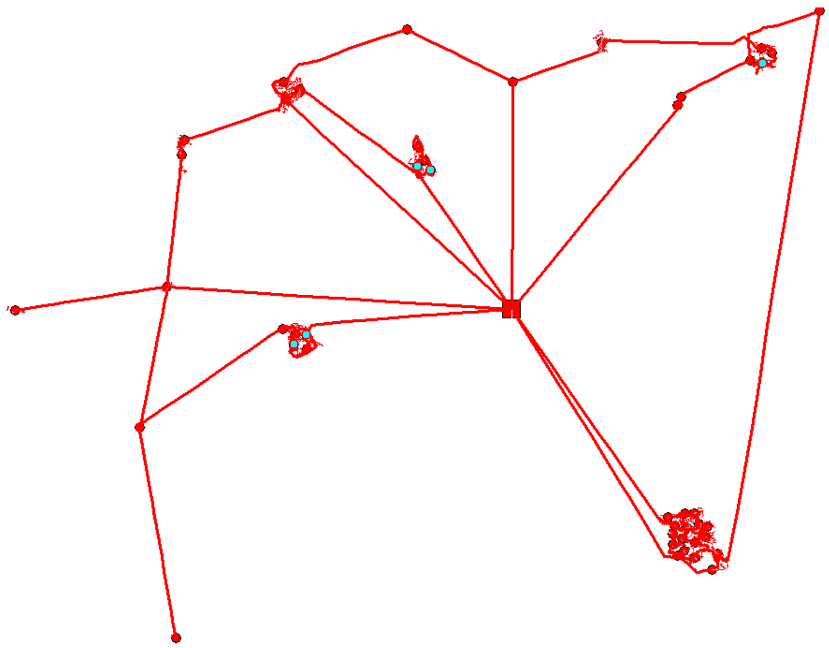

Figure 49, graphical results of the reinforcements needed in the Spanish rural network, with Dynamic Pricing, in the Technical Potential scenario.

The results on avoided network investments with AD are shown graphically for both types of networks. The following figures show the needed reinforcements for the scenario without AD and in the Technical Potential scenario of Dynamic Pricing.

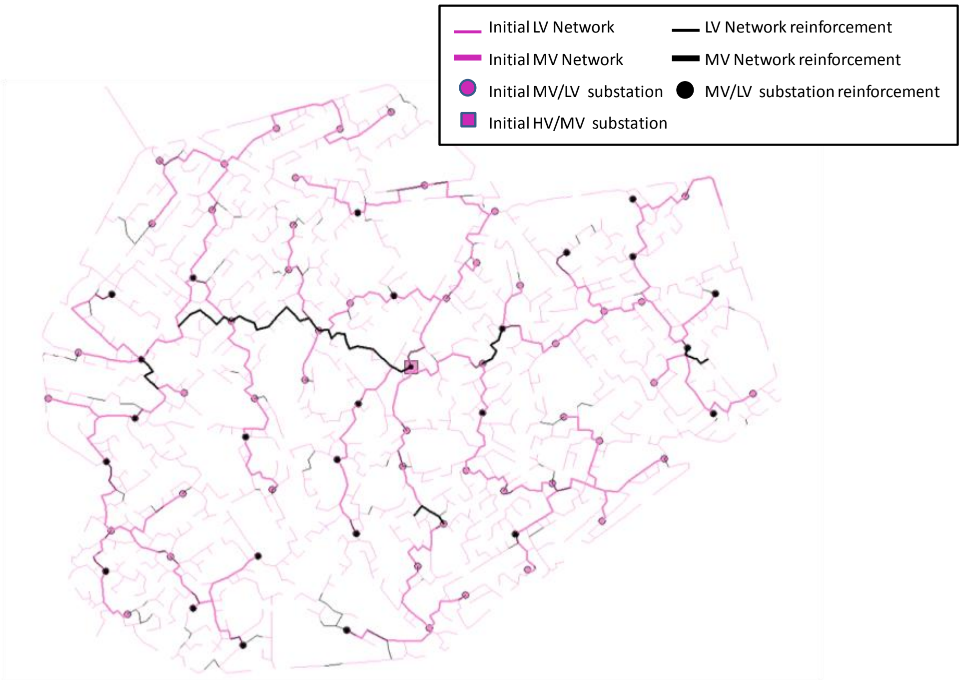

Figure 50, graphical results of the reinforcements needed in the Italian urban network, without AD.

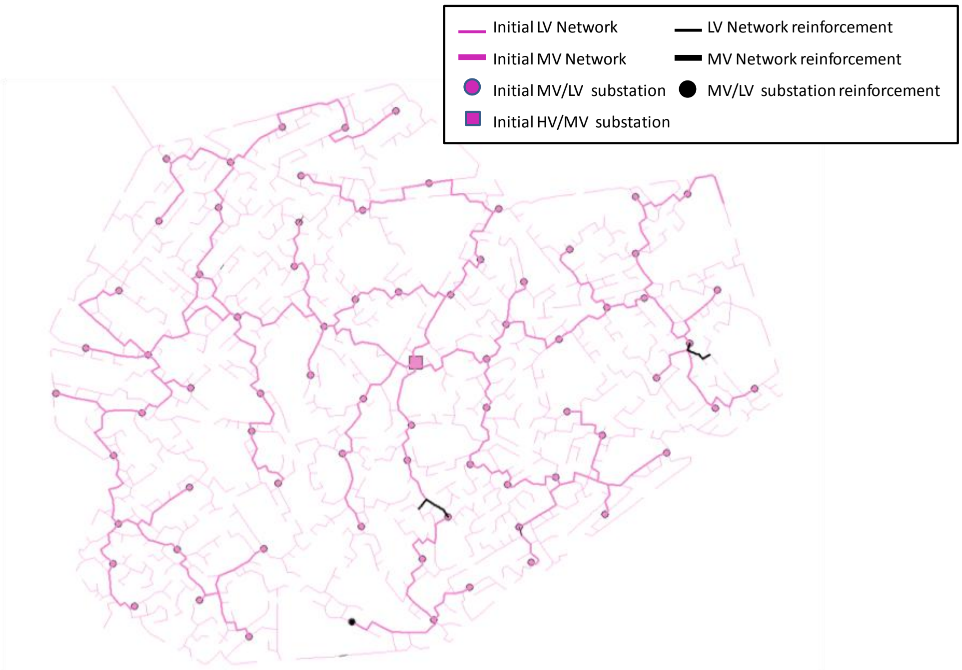

Figure 51, graphical results of the reinforcements needed in the Italian urban network, with Dynamic Pricing, with the Technical Potential scenario.

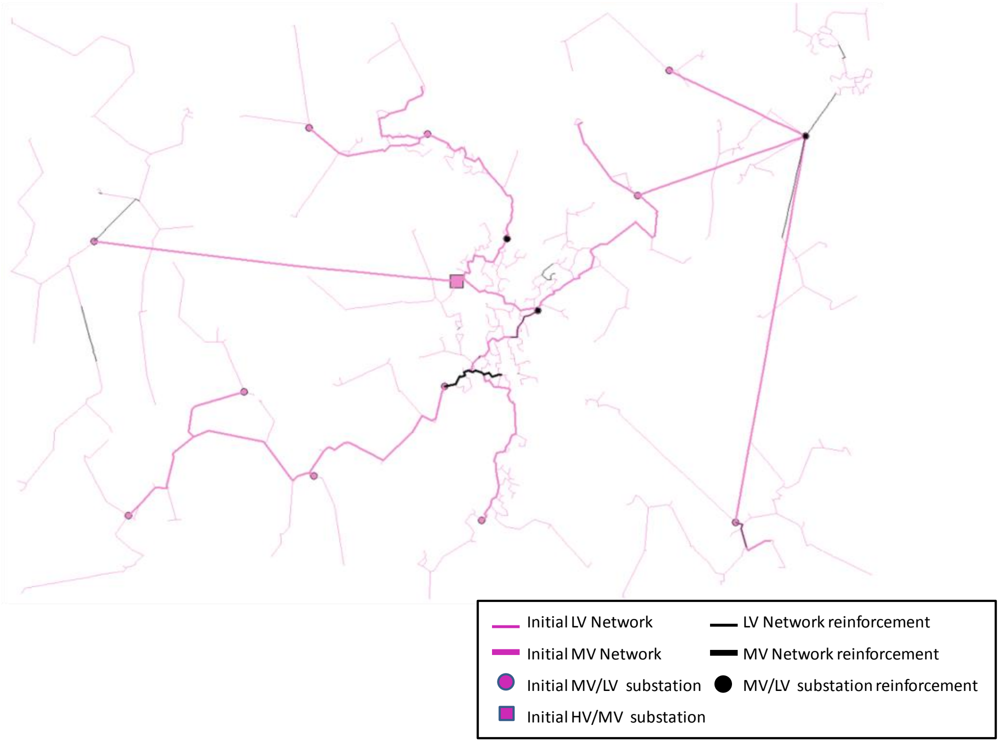

Figure 52, graphical results of the reinforcements needed in the Italian rural network, without AD

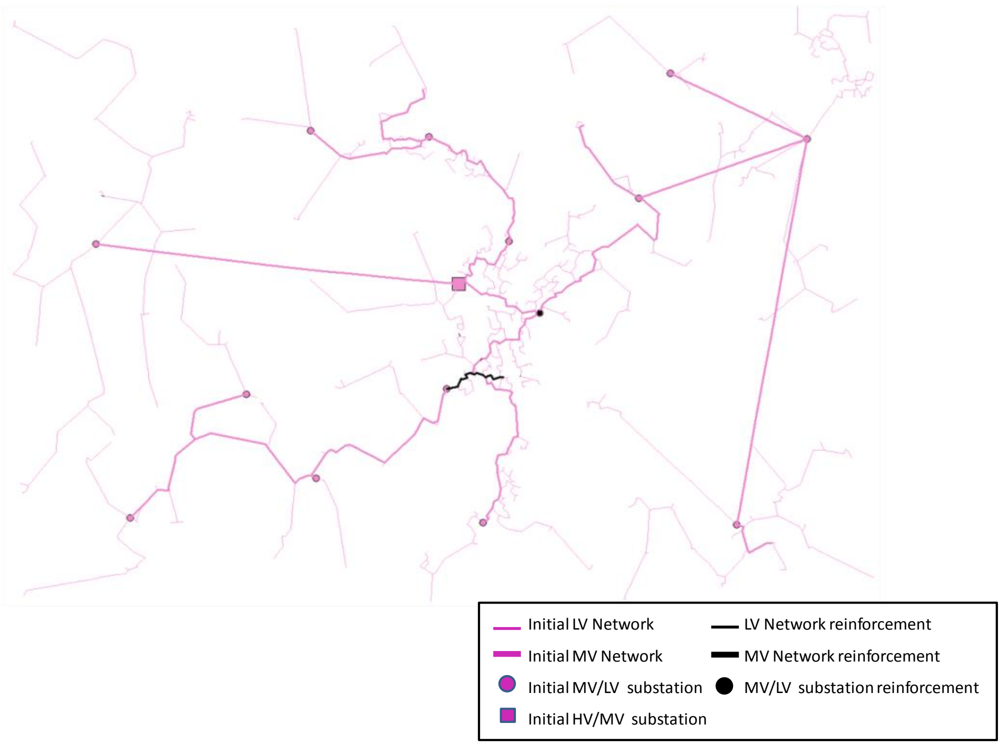

Figure 53, graphical results of the reinforcements needed in the Italian rural network, with Dynamic Pricing, in the Technical Potential scenario

German Case study

The results on avoided network investments with AD are shown graphically for both types of networks. The following figures show the needed reinforcements for the scenario without AD and in the Technical Potential scenario of Dynamic Pricing.

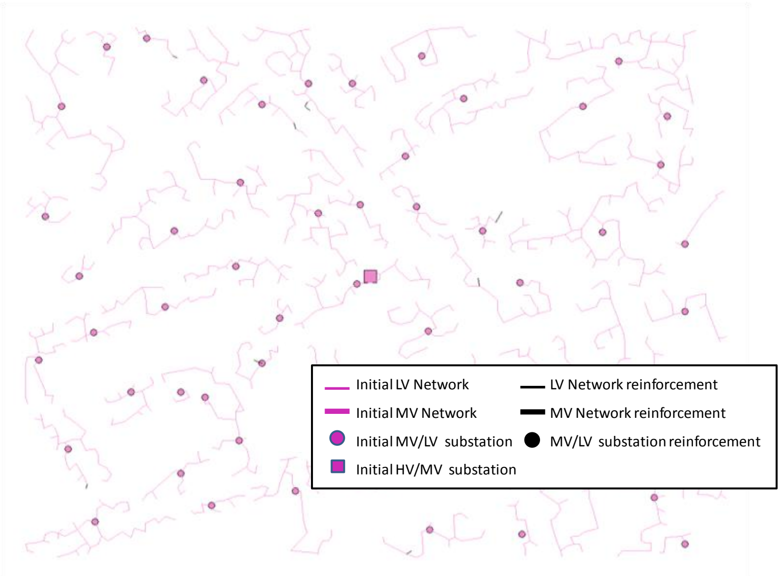

Figure 54, graphical results of the reinforcements needed in the German urban network, without AD.

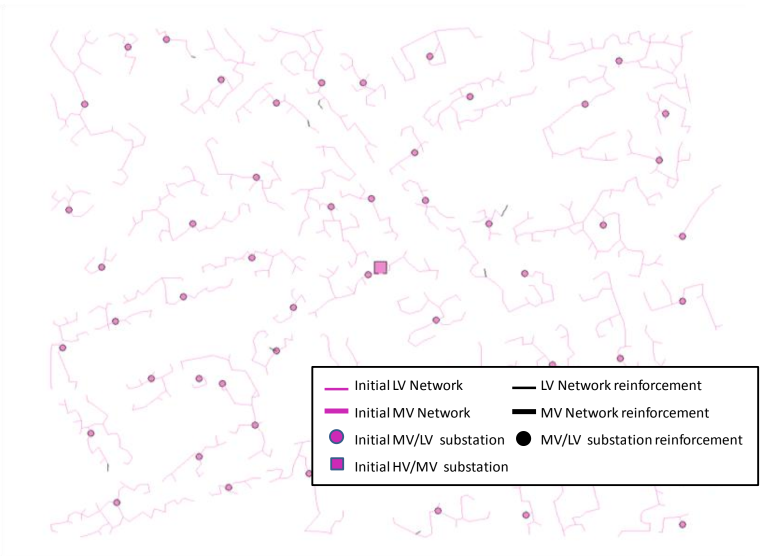

Figure 55, graphical results of the reinforcements needed in the German urban network, with Dynamic Pricing, with the Technical Potential scenario.

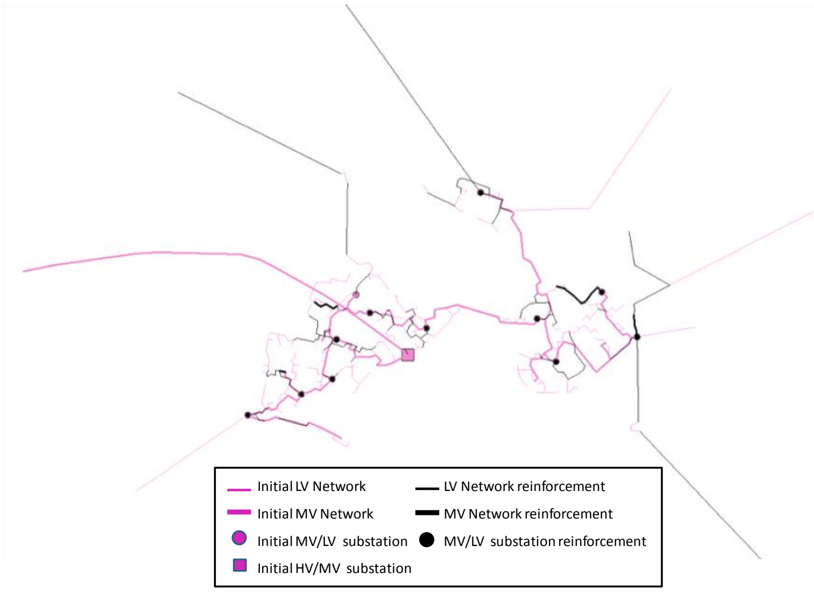

Figure 56, graphical results of the reinforcements needed in the German rural network, without AD.

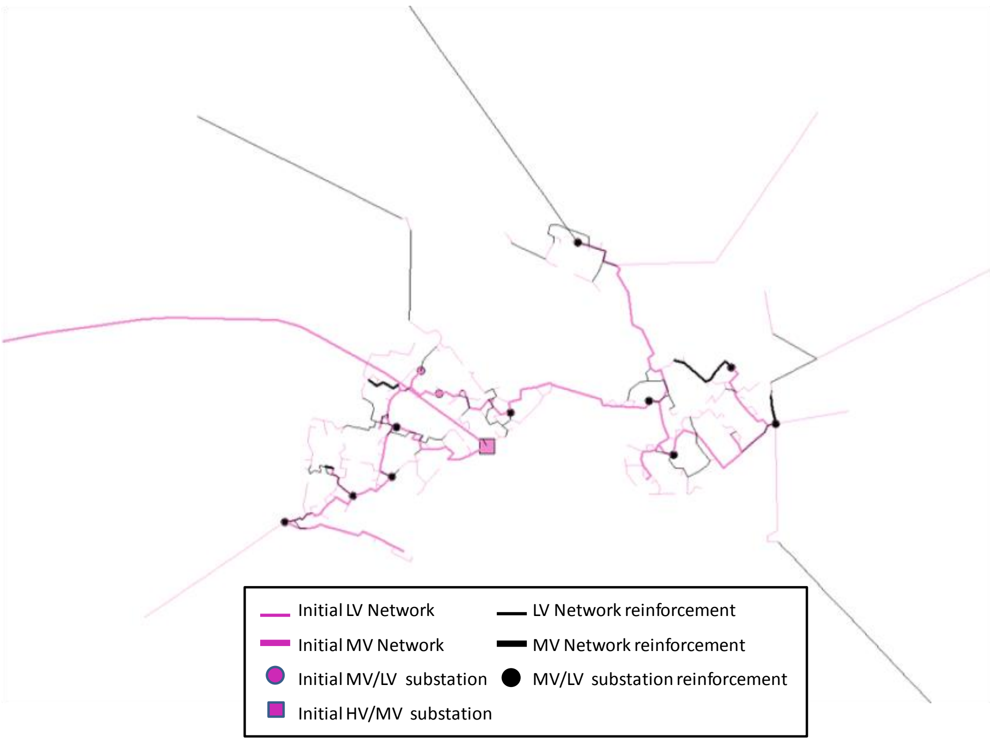

Figure 57, graphical results of the reinforcements needed in the German rural network, with Dynamic Pricing, in the Technical Potential scenario.

French Case study

The results on avoided network investments with AD are shown graphically for both types of networks. The following figures show the needed reinforcements for the scenario without AD and in the Technical Potential scenario of Dynamic Pricing.

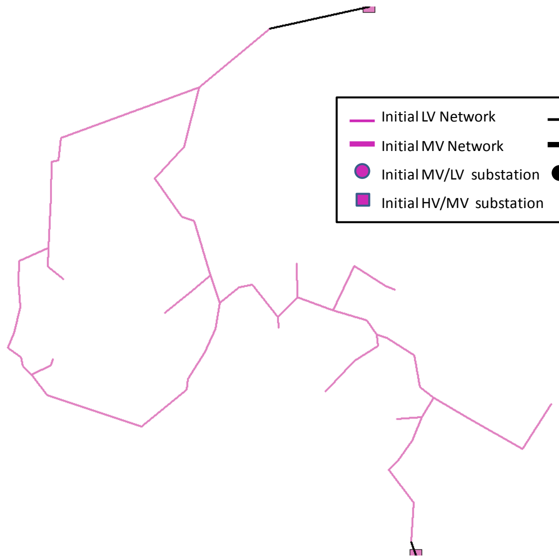

Figure 58, graphical results of the reinforcements needed in the French urban network, without AD.

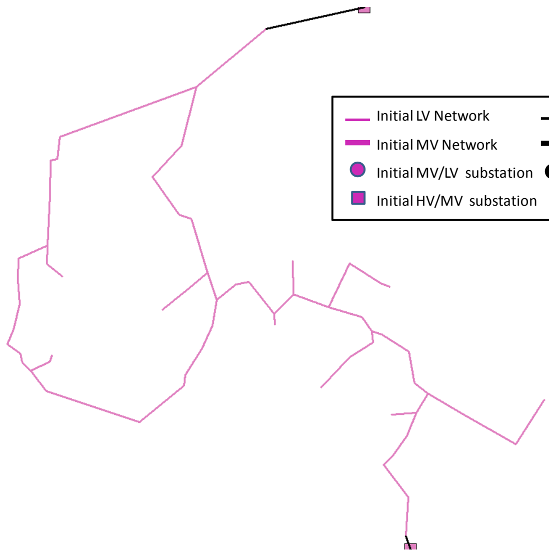

Figure 59, graphical results of the reinforcements needed in the Italian urban network, with Dynamic Pricing, with the Technical Potential scenario.

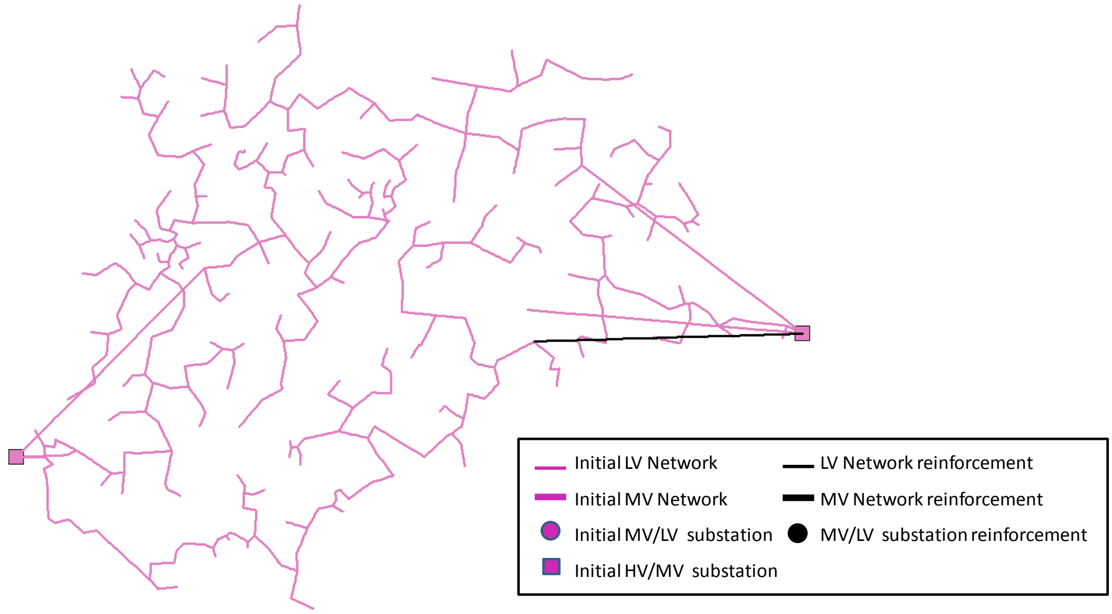

Figure 60, graphical results of the reinforcements needed in the French rural network, without AD.

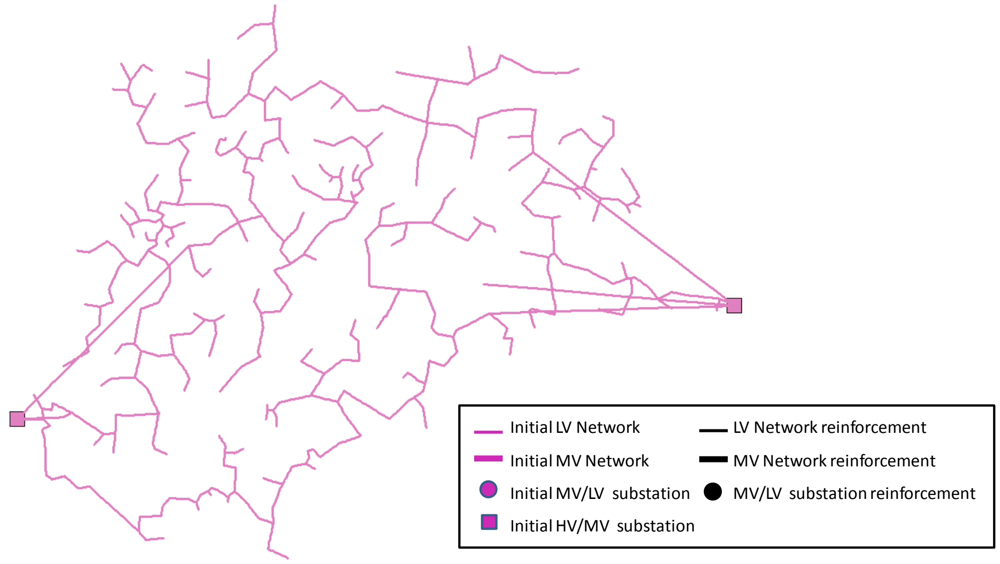

Figure 61, graphical results of the reinforcements needed in the French rural network, with Dynamic Pricing, in the Technical Potential scenario.

Annex C. Regulatory questionnaires to DSOs

Some of the answers to the initial regulatory questionnaires that have been completed with the help of the DSOS participating in the task and on which the discussion of chapter 10 is based are provided in this Annex for further reading. The answers included here are those that provide extended additional information, which may be of interest for readers help them to better understand the regulatory issues discussed in the main body of the document.

Some answers to the regulatory questionnaire for Spain

DSO Remuneration

1. What is the current scheme to recognize DSO costs (OPEX and CAPEX) when calculating the DSO revenues in your country? (And tools, this is, benchmarking, pass-through, engineering models, etc.). Are revenue allowances based on historically incurred costs?

The last methodology was established in the RD 1048/2013, 27th of December. The methodology developed in this Royal Decree for the remuneration of the distribution activity is aimed at establishing the criteria for the remuneration of the construction, operation and maintenance of distribution networks, encouraging continuous improvement in management effectiveness, efficiency economic and technical, improving the quality of supply, reduction of losses and the reduction of fraud, all with uniform criteria for all the Spanish territory and at the lowest possible cost to the electrical system. The remuneration of the distribution activity is set for regulatory periods of six years duration.

The mentioned Royal Decree has the objective of establishing a formulation to compensate distribution activity with a clear, stable and predictable methodology that helps to provide regulatory stability and thus the costs of financing the distribution activity and reduce including the electrical system.

The new model introduces a ceiling on investment annually recognized two years prior to the perception of the retributions due to these activities. The remuneration allocated to each dealer for the distribution activity will be calculated annually by the competent administration according to the current methodology. This is aim at making feasible the performance of reasonable forecast of the evolution of costs arising from such activity and in order to send a signal of stability. Thus, it should ensure distribution companies investments and to link this compensation to the investment plan submitted and the investment eventually executed.

Regarding incentives, there has been a reformulation in order to achieve greater simplicity in application. It will be established an incentive to each DSO to improve the goals set by themselves previous years regarding quality service and the reduction of network losses. With the increase in electricity fraud it has introduced a new incentive for distribution companies to achieve a reduction in energy fraud since these companies are the owners of the networks responsible for reading.

The Network Reference Model is still of application. The National Commission on Financial Markets and the Competition (CNMC in Spanish) must have it as a tool to support and contrast figures. The Network Model Reference determines the optimal distribution network which is necessary to link the network operator or distribution network with the final electricity consumers and generators connected to their networks, based on their geographical location, power supply and demand and / or generation of power and energy, all in compliance with the quality requirements set forth in the basic state regulations.

Market roles and business models:

1. Who bears the costs of AMI (investment, operation and maintenance, management)? How are these costs passed through to consumers?

The average price that consumers pay monthly (in the electric bill) as a rental fee for the Smart Meters do not account only the price of the equipment itself but also the costs associated with its installation and verification as well as operation and maintenance. These prices are regulated and fix by the Minister of Industry, Energy and Tourism. The last published values are included in the IET/1491/2013. Moreover, consumers have the option of owning the Smart Meter.

2. Who is the owner of the required infrastructure (AMI) (the DSO, the supplier, an independent agent)? In case it is property of the DSO, how is it accounted for by regulation? Is it included in the asset base?

RD 1110/2007 established that Smart Meters for supply points with power contracted P ≤5kW and U≤1kV must be integrated into a system of remote management and telemetry which is implemented by the actor in charge of the reading. These systems (developed by the reading responsible), associated equipment and, where appropriate, the specific protocols, will be subjected to approval by the corresponding Administration.

3. Who owns, who operates and who manages the data associated to this technology (the DSO, the supplier, an independent agent)? How is it done?

DSO. collect the consumption of each supply points that they are responsible of with the frequency established by regulation. The information managed by the DSOs cannot be used for commercial purposes due to regulation rules. Information for billing is passed to the corresponding retailer. Moreover, the System Operator and Market Operator establish a series of requirements and rules for the information interchanged between them and the registered agents to participate in the different markets and services operated by the formers. This information is publically available.

4. Are there any problems with confidentiality and data protection? What is the regulation on this topic? Who is the owner of consumers' data and who is allowed to access the information?

Consumers are the owners of these data which are collected by DSOs and shared with the corresponding retailers only for billing purposes. The data privacy law is applicable to this context. The National Data Protection Agency ensures that all the partners' activities are compliance with current legislation.

5. Demand response may be regulated from the side of the DSO, having the possibility to switch of certain consumers. This is mostly regulated through a contract between DSO (and energy supplier) and consumer through lower electricity tariffs (or network tariffs). Is something introduced in your country (or in some regions?) For what kind of consumers (industrial, commercial, domestic)?

Interruptibility contracts for very large industrial consumers exist at transmission level (manage by the only Spanish TSO). Such a scheme does not exist at distribution level.

The practical limitation on the power demanded by end users to pre-established values in supply contracts, either via limiters (general case of residential consumption) or via economic penalties at exceeding values, is a powerful tool that helps to reduce demand peaks. The RD 1454/2005 establishes that DSOs have to control the power demanded by the consumer in such a way it does not exceed the contracted values. The Smart Meters incorporate a power limiter.

6. Are there agents, such as aggregators, supplier aggregators or other business arrangements that manage different loads (commercial and domestic consumers) connected to the distribution network?

Aggregation of DG is carried out, although only for wholesale trading purposes or to reduce imbalances. Similarly retailers manage their portfolio of customers (assumed to behave passively) to purchase energy at the wholesale level handling deviations. No distribution services are provided in any of these cases.

RD 671/2011 created a new agent called Electric Recharge Grid Operator who is responsible for purchasing and managing the energy necessary to charge the batteries of PEVs. The regulation states that charging managers must be connected to a control centre to follow demand response commands from network operators (it is not specified whether this refers to the TSO, DSOs or both). There are currently 11 Electric Recharge Grid Operators registered[33].

7. Are DSO obliged to connect any new network user without delay? Are they allowed to make arrangements with new customers counting on AD to reduce to some extent the cost of that connection?

Any network user (retailer offering PVPC, retailer in the free market or customers directly in the market) have to fulfil a series of requirements established by the Minister of Industry, Energy and Tourism to be registered correctly. The System Operator and the Market Operator participate in this process as well. DSO provides the network access right, as indicated in the Electric Power Sector Law 24/2013.

Network tariff design

1. What are the main costs that are included in the calculation of grid tariffs?

From the RD 1164/2001 of 26th October was established which were the main costs (according to the new terminology *access tolls* and *charges*) that should be included in the calculation of the tariffs for grids access. The *access tolls* are the payment to contribute to cover the costs derived from the transportation and distribution activities; while *charges* are those payments related to other regulated aspects of the system.

[33] https://sede.cne.gob.es/web/guest/gestores-de-carga

The tariff of grid access is the mechanism to reward financially all the system cost apart from the energy cost and the management cost of retailers. The *access tolls* (together with the *charges*) are passed on to all the consumers regardless if they obtain the energy by regulated price mechanisms or bilateral contract with retailer.

These tariffs are unique in the whole country and they do not include any type of tax. Moreover, they take into account the specifics derived from voltages and power levels and characteristics of electric consumption in different period (see question 3). The order IET/107/2014 published the prices for 2014. These values are calculated by the Minister of Industry, Energy and Tourism using the methodology in force at each moment and also it is in charge of reviewing them annually (apart from special occasions when it can be done quarterly) The relative weigh of each concept have varied during the last years.

The main pieces of cost are the following one:

- Cost of transmitting electric energy
- Cost of distributing electricity energy
- Cost of commercial managing
- Cost of diversity and security of supply:
    - Nuclear moratorium
    - Second cycle of nuclear combustible
    - Service of Interrumpibility in the market
    - Bonus for special generation
    - Extra-peninsular compensation
    - Annual payment to financing the deficit
    - Commission for the National Commission on Financial Markets and the Competition

As mentioned the Administration is in charge of calculating the access tariffs. These values include all the concepts listed before. It is aimed, apart from covering all the regulated costs of the system, to generate efficient economic signals to the system players. Then, together with the price of the energy in the market reflect the social cost of consuming electric energy at any moment and for voltage level. It is intended to motivate efficient consumption and investment decisions. However, if the value of these tariffs is not enough to ensure the coverage of the regulated cost that a tariff deficit in the takings will be created leading to negative effect on the System. It is happening in Spain since 2000.

Without the aim of going deeply on this topic, it is worth noting that DSOs in Spain do not withhold incomes from the access tariffs but they are mere tax collectors. The incomes are transferred to the final system account from where the Minister of Industry, Energy and Tourism is in charge of the liquidation process.

2. What is the network tariff structure? Are they applied to kWh, kW or both?

The structure is binomial. There are capacity (€/kW) and energy (€/kWh) charges. Specifically they are comprised of:

- power charge (€/kW):
- active charge (€/kWh)
- in some cases, reactive energy (€/kWh) and surcharge for demanding more energy that the contracted.

Moreover, at the end of 2011 a new access grid tariff for generators was established (€/MWh). These charges appear on the electric bill within a Power term and an Energy term. The Power part depends on the power contracted by customers. It is a fix value due to the fact that the networks must be designed to guarantee the supply the power contracted at any moment. The Energy part depends on the consumption. It is a variable value due to the fact it depends on the amount of energy that has flowed through the networks.

Recently the relative weight of both charges, power and energy, have been modified. Before, the power charge was lower than the energy one. However, currently it is in the other way around. The adaptation has been gradual from January 2013 to February 2014 as shown in Table 41.

Apart from two tariffs of LV (2.0A and 2.1A) the price for the rest of access grid tariffs (energy term) vary in function of the period when consumption takes place. The objective is to reflect that the consumption of energy does not have the same cost during peak periods than in valleys.

Relative average weight of access grid tariffs (fix/variable charge)	January 2013	December 2013	February 2014
Fix part (power charge)	35%	50%	60%

Variable part (energy charge)	65%	50%	40%

Table 41, Relative average weight of access grid tariffs (fix/variable charge) [Source: Minister of Industry, Energy and Tourism]

3. Are they differentiated by network voltage level or subscribed power?

The access tariffs are classified according to voltage level and power contracted. It is worth noting the existence of tariffs which values depend on different periods of time. The starting times for these periods change in winter and summer (not for tariff of super valley). Tariff 2.0.DHS and 2.1.DHS have been defined recently taking into account the activity of the Charging Managers in the systems who offer services of energy charging (e.g. for electrical vehicles) Then a super-valley period is defined in the structure with the lowest energy charge (the power charge is the same for the same group of tariff).

4. Are tariff schemes already adapted to the data provided by smart meters?

The tariff schemes associated to Meter Type 5 (P≤5kW and U≤1kV), a part for the creation of the super valley ones, have not needed adaptations to the data provided by smart meters. It is worth nothing that the tariff with two discriminatory period (2.0 DHA y 2.1 DHA) existed before the installation of SMs (a second Meter was required). However, further modifications could be included in the following years to get advantage of the potential offered by the Smart Meters, as it is currently be discussed.

The process to calculate the energy price for those customers who choose to get the electricity under the regulated option (U≤1 kV and P≤10 kW) changed the 1st of April 2014. From 1st April onwards, small consumers (with a power supply of less than 10 kW) may remain in the regulated market with the new system called the Voluntary Price for the Small Consumer (PVPC in Spanish), with no need to do anything on their part. This new mechanism for setting the price for consumers takes into account the cost of generating electricity, tolls and the corresponding retailing costs. The cost of producing energy is calculated on the basis of the hourly price of the daily and intraday markets managed by the market operator during the invoicing period. In addition, this cost will incorporate other technical management processes involving the System Operator. This process substitutes the former one based on auctions performed some months in advanced. Then the calculations for determine the bill are performed hourly (if the consumer has a SM installed and included in the AMI).

The RD 1110/2007, 24th of August, established the minimum characteristics of Smart Meters type 5 (for customers with a P≤15kW and U≤1kV) which are being deployed currently due to the massive roll out. They have to be integrated in the AMI responsible of the party in charge of the measurements. They have to allow:

- performing remote metering and management
- 6 programed periods of time discrimination at least
- registering P and Q in all quadrants
- registering the maximum power quarterly with time and date
- integrating with a time base of 1 hour
- registering and saving the load curve for active and reactive energies during 3 months at least

Then, the access tariff could be divided even in more periods.

5. Is there any kind of regulatory incentives for consumers to actively control their load pattern? Are regulated and competitive tariffs obliged to include an economic signal for consumers on time period of consumption (price differentiation for peak/base periods, super-valley tariff, dynamic pricing, etc.)?

Yes. There are a series of access tariffs that show different levels of temporal discrimination depending on voltage and the contracted capacity of consumers: two-period or three-period tariff for consumers up to 15kW and a 6-period tariff for HV consumers (above 1kV).

For example, the Voluntary Price for the Small Consumer (PVPC in Spanish), offers two options (i.e. 2.0 DHA and 2.0 DHS) depending on the number of periods (2 and 3 periods).

Regarding the signals, a part from the access tariffs which are publically available and identified in the bills, from the 1st of April 2014, the hourly prices for energy are published one day ahead in the web page of the Market Operator. In such a way, customers can know when the energy will be cheaper to modify their consumption patterns. This new system for setting the price for consumers takes into account the cost of generating electricity, tolls and the corresponding retailing costs.

Smart meter deployment and other technologies

1. What is the progress of the Smart Metering roll-out in your country?

In 2011 the regulator published a report regarding the level of compliance with the plan of installing these meters. The results, at the end of 2010, were far away from the milestone established in the roll out planning. The DSOs responsible of this process had substituted only 1.4% of all meters that make up the national park, compared to 30% originally envisaged in the plan. In round numbers, 383,000 meters of a total of 27.7 million units. The main reason was the need for a further industrial development of smart meters. This had resulted in a shortage of units. For this reason the persantage of smart meters intalled during the three period on the plan was modified (see question 1)

The Ministry of Industry forecasts that at the end of this year (2014) there will be, at least, seven million of smart meters installed and fully operated which would be close to the target.

2. How is it being carried out? How are the costs being recovered or expected to be recovered?

Each DSO is conducting a massive roll out projects in those regions where it is responsible for the distribution networks. The process might vary slightly. Basically, it consists on different stages at different levels. In the DSO´s premises systems to collect and manage all measurements are installed; while at Secondary Substations, data concentrators and finally, SMs in clients' premises. It is worth mentioning that in Spain, a part from some rural areas and other small number of cases, SMs are located in a single room in each building. Then, the customers are not visited one by one when the changing process takes place. They received a notification if some reparation is needed on the installation and when the substitution is going to take place. Moreover, they are told that will suffer a very short shortcut of electricity supply.

When the billing process was modified due to the fact of having SM, clients were informed by a notification included in the bill (the content was fixed by regulation)

As mention before the Smart Meter cost should be recovered by the rental fee included in the bill.

3. Are there any requirements for the smartness of new electrical appliances, e.g. in order to make them compatible with Home Energy Management Systems?

No. Since the regulation does not obligate DSOs to implement such kind of system beyond the SMs, there are not any requirements. Even though, a series of pilots using different technologies and approaches are been conducted nowadays to explore these alternatives (for example in home display, energy boxes...).

State of the retail sector

1. How are settlements for the procurement of energy in the retail market currently made? Do consumers purchase this electricity from suppliers or specific agents? Are there any standardized load profiles for those customers (and if so, what are the application criteria)?

The procurement of energy can be done through different methods:

- Retailer of reference
- Retailer in the free market
- Participating as an agent directly on different markets

Retailers that offering the Voluntary Price for the Small Consumer (PVPC). Volunteer for the Small Consumer Price (old tariff of last resort -TUR-) is the maximum price that may be charged by reference marketers to consumers benefiting from this price. The conditions of contract are regulated and bounded. There can be no special provisions or additional services. There a 5 retailers of this type.

The latter retailers are also obligated to offer a fixed price for 12 months as an alternative to the PVPC. This price will be set by each trading company but with standard conditions and easily comparable. This modality was introduced in 2014. They are also in charge of supplying electricity to the customers who under the Social Bonus tariff (vulnerable consumers) and to those who have not right to benefit from the voluntary price for the small consumer who temporarily lack a supply contract with a marketer in the free market.

Retailers in the free market can sign bilateral contracts with consumers. In this case, the latter secure the power supply with a price and conditions agreed between both of them. The offers on the open market, unlike the annual fixed price included in most cases, special provisions or additional services that must be taken into account when assessing offers a homogeneous approach. There are around 525 retailers allow to offer this kind of contract.

Traditionally retailers have used historical registers of consumption to foresee the amount of energy to purchase energy in the different markets. Nowadays, thanks to the possibility of SMs of registering hourly profiles, this process could become more precise.

For example, however, the Spanish TSO is currently working in a project to improve typical load profiles thanks to the information registered by SMs hourly. It is important due to the fact that energy on the Spanish market is managed hourly. Consumption profiles are used by retailers to buy their energy in the market and to estimate average hourly value by distribution companies. Greater precision in these profiles will leads to an optimization of the management of the system and therefore a more efficient electrical system. Regarding the operation of the system this fact will reduce the need for Adjustment Services due to achieve a closure of final energy in the market more real (precise) and then less unbalances will happen during the real time functioning of the system afterwards. At the same time, a better knowledge about both household consumption patterns and an important part of small shops and services will be generated.

2. Is there a regulated retail price, even if it is optional to final customers? What kind of regulated tariff structure does it have?

Yes. As mentioned before, the regulated retail price is called Voluntary Price for the Small Consumer (PVPC in Spanish). From 1 April onwards, small consumers (with a power supply of less than 10 kW) may remain in the regulated market with the new system called the Voluntary Price for the Small Consumer (PVPC in Spanish), with no need to do anything on their part. This new system for setting the price for consumers takes into account the cost of generating electricity, tolls and the corresponding retailing costs. The cost of producing energy is calculated on the basis of the hourly price of the daily and intraday markets managed by Market Operator during the invoicing period. In addition, this cost will incorporate other technical management processes involving the System Operator. This service is provides by retailers of reference.

3. Is the electricity bill clearly disaggregated into components, or are there separate billings?

The bill is unique and includes all the terms. The bill is disaggregated into components. The structure and concepts are regulated. During the last years different campaigns have been launched to help customers to understand the content of the electricity bill.

The Government, through the resolution of May 23, 2014, established the minimum content and the model of electric bill to be used by the reference retailers in order to ensure its understanding by the consumer. Some aspects depend on the type of contract. This model will be mandatory from 1 October 2014 for reference retailers providing consumers with the voluntary price for small consumers, including vulnerable consumers who applies the social bond, and no right to benefit consumers voluntary price for the small consumer who temporarily lack a supply contract with a marketer in the free market.

Through this model, electric bills intend to provide information on their consumption to customers and associated costs clearly. In order to facilitate comparisons between different offers and enable knowledge about the cost of supply, prices, fees and general conditions of access and use of electricity services. The allocation of the invoice amount, the origin and environmental impact of the electricity consumed are also incorporated as part of the content of the bill.

4. What is the retailer switching rate? Is the retail segment competitive?

There is a Supplier Switching Office. From July 2014, the role is under the responsibility of the CNMC. It is responsible for monitoring changes in supplier under the principles of transparency, objectivity and independence. For the exercise of his activity the supervisor will have access to the databases of Consumers and Supply Points gas and electricity.

Consumer can make the change of retailer at no cost and within a maximum of 21 days in the legal terms and regulations established. Moreover, tthese consumers entitled to Volunteer for the Small Consumer Price can always return to PVPC if they have opted for one of the alternative modes of procurement.

During 2011, more than 2.9 million customers (around 2 million of such switches were from the former last resort supply to the liberalized market). 2009: 27.113.874. 2010: 27.406.46. 2011: 26.654.921 (provisional). Most of the customers that switch supplier are domestics. 2009: 4.39% 2010: 6.61% 2011: 10.04%

Wholesale market arrangements

1. What kind of heavy requirements are there (fixed trading charges, minimum trading volumes, minimum capacity) in order to qualify for participation on wholesale markets, such as the reserve market, the day-ahead market and the intraday market?

The market for the production of electricity on the Iberian Peninsula is structured into a Daily Market, an Intraday Market, Forward Markets and Services Adjustment Market. Bilateral contracts are also included in it.

OMIE (the Market Operator) manages the daily and intraday market. The daily market involves the purchase and sale of electricity for the next day. The purpose of the intraday market is to cater for the supply and demand of energy that may occur in the following hours, after the Viable Daily Schedule has been set.

The Market Operating Rules contain the procedures and conditions of a general nature that are required for the effective operation of the daily and intraday markets for the production of electricity and, specifically, for their financial management, and for the participation both of those entities that undertake activities involving the supply of electricity and of direct market consumers. They are publicly available.

As Market participants are understood those authorised players that act directly in the electric power market as buyers and sellers of electricity. To exercise the right to buy and sell power in the market, participants must, in addition to complying with the requirement to record their data in the Administrative Registers, have confirmed their adherence to the Production Market Activity Rules by signing the corresponding Contract of Adherence.

All available production units that are not bound by physical bilateral contracts are obliged to present bids for the daily market. Units with installed powers of less than 50 MW, or those that upon the entry into effect of Law 54/97 had not availed themselves of Royal Decree 1538/1987, are not obliged to furnish bids to the daily market; production units with installed powers of more than 1 MW may furnish bids for any schedule periods that they deem appropriate; self-producers and producers under the special regime are also not obliged to declare surplus power to the market, and may alternatively furnish bids to the market and will continue to be entitled to receive the incentives established for that regime. Non-resident retailers authorised to present electricity sale bids may also present these bids.

Regarding the intraday market, all agents authorised to present electricity sale bids on the daily market and those agents authorised to present purchase bids on the daily market and who have participated in the corresponding daily market session in which the intraday market session is opened, or who have executed a physical bilateral contract, may participate in the intraday market. The aforementioned agents authorised to present purchase bids on the daily market may only participate in the intraday market for the hourly periods corresponding to those included in the daily market session in which they have participated.

2. How can consumers sell their energy reductions or offer their bids and under what conditions (in the wholesale market, through contracts with suppliers or aggregators, etc.)? How is this remunerated (tariffs, dynamic prices, incentives...)?

To operate on the market managed by OMIE, one must first register as a market agent. Acquiring the status of market agent involves fulfilling certain prior prescriptive requirements and following an electronic procedure, through which the data required for the granting of that status are submitted to OMIE. All the requirements are publically available.

3. How can the data be shared among parties, such as the retailer, the aggregator, the balancing responsible party

As mentioned before, the System Operator and Market Operator establish a series of requirements and rules for the information interchanged between them and the registered agents to participate in the different markets and services operated by the formers. This information is publically available.

The sharing of information with Aggregator is not regulated in Spain since the latter actor is not allowed. Balancing Responsible Parties are not specific parties that only participate on adjustment process but market agents that participate as well in the daily and intra daily market. Actually, they do not acquiring this name in the electric system. These agents must a series or requests established by the system operator.

Existing Active Demand

1. What are the existing initiatives in relation to Active Demand in your country?

    - Consumption shift from peak to the valley periods by time discrimination tariffs. This include super valley tariff aimed at charging electrical vehicles.
    - Reduction of demand during critical moments through the service of interruptibility.
    - Implementation of power limiting in homes.
    - Creation of the Electric recharge grid operators

2. Are there any plans to develop any new AD initiative from the regulator?

    - Promoting the modulation around the industrial demand
    - Increase the potential of the Smart Meters
    - Discussions about tariff structure, new players (e.g. aggregator) and the use of storage

Some answers to the regulatory questionnaire for Italy (Enel)

DSO remuneration

The DSO remuneration system has a great impact on the incentives for DSOs to facilitate the infrastructure for the fair and equal participation of third parties in Active Demand and even allow them to take advantage of the demand flexibility potential to improve their operation and investment strategies.

1. Is the impact of AD on the incremental DSO costs (CAPEX, OPEX) for the future needs of the grid explicitly taken into account when DSO revenues are calculated under the current regulatory scheme in your country? Is this mechanism consistent with the structure of tariffs and connection charges?

The regulatory framework of the DSO allows the capitalization of OPEX in the case of added value/services to the current infrastructure.

2. Are R&D costs seen as efficient costs of the distribution activity? Are there any incentive schemes for innovative solutions, such as R&D in smart grids, AD pilots, etc.?

Just for innovation, there are some incentives, through extra-WACC (+1,5% ÷ 2%) for the refurbishment of MV networks in historical centres, for the substitution of MV/LV substations with low-losses transformers and for the refurbishment of primary substations in critical areas.

Market roles and business models:

1. Who bears the costs of AMI (investment, operation and maintenance, management)? How are these costs passed through to consumers (do consumers pay a fixed amount for AMI rental)?

It is the DSO that includes them in the distribution tariff (RAB and Opex).

2. Who is the owner of the required infrastructure (AMI) (the DSO, the supplier, an independent agent)? In case it is property of the DSO, how is it accounted for by regulation? Is it included in the asset base?

It is the DSO. The AMI is included in the RAB.

3. Who owns, who operates and who manages the data associated to this technology (the DSO, the supplier, an independent agent)? How is it done?

The DSO.

4. Are there any problems with confidentiality and data protection? What is the regulation on this topic? Who is the owner of consumers' data and who is allowed to access the information?

The metering data are protected trough a proprietary protocol. The consumer is the owner of data, who can give access to third parties for commercial reasons upon consent. The DSO has access to metering data for network stability and operation but cannot provide these data to third parties for commercial purposes.

5. Does the DSO have the visibility of the consumption profiles for grid operation purposes?

The DSO doesn't have visibility in real time of the consumption (and generation) profiles for grid operation purposes. The DSO has the knowledge of the consumption (and generation) profiles for grid planning purposes, through monthly meter's data reading.

6. Can flexible demand participate, either interacting directly with the DSO (as a regulated activity) or through a market agent acting as an intermediary, in local congestion management, provide flexibility services or any other services to the DSO in your country?

In 2010 Italian Regulatory Authority AEEG set the introduction of mandatory Time-of-Use tariffs for residential customers under the universal supply regime, which was possible because of the massive installation of smart meters. To date, two time bands tariffs are applied to about 25 million customers.

7. Are there any plans to modify in the near future the current situation regarding AD as a provider of network services?

At the moment there is no regulation in place.

8. Are there agents, such as aggregators, supplier aggregators or other business arrangements that manage different loads (commercial and domestic consumers) connected to the distribution network?

At the moment there aren't agents and there isn't any regulation in place.

9. How would the DSOs deal with market agents, such as retailers and aggregators in relation to the data from consumers and the grid? Can they interact and sign

agreements?

At the moment there is no regulation in place.

10. Is the figure of the Energy Service Companies (ESCO) contemplated by regulation? What kind of additional services do they offer?

ESCOs are contemplated by regulation, but not as providers of services to the network, but as providers of services to the final customer (energy efficiency services e.g. energy audits etc.).

11. Are DSO obliged to connect any new network user without delay? Are they allowed to make arrangements with new customers counting on AD to reduce to some extent the cost of that connection?

For the distribution network, the connection rules (CEI 0-16 and CEI 0-21) are defining technical requirements for enabling possible AD services, at least for active customers.

Network tariff design

The design of network tariffs is an essential element to collect the revenue required by DSOs to recover the network costs and investments allowed by the regulatory authority. Tariffs are themselves a tool to deliver AD for network purposes, by sending the appropriate economic (price) signal to the final customer in relation to the costs caused to the network according to time and location. It is crucial to know what the methodology to determine the network tariffs is.

1. Is there any kind of regulatory incentives for consumers to actively control their load pattern? Are regulated and competitive tariffs obliged to include an economic signal for consumers on time period of consumption (price differentiation for peak/base periods, super-valley tariff, dynamic pricing, etc)?

Our smart metering enables the following demand response functionalities:

- -Breaker and demand control algorithm on board
- -Remote reduction of the available power until disconnection
- -Display on board
- -Interval metering for customers with available power of more than 55 kW.
- -Time of Use tariffs

Smart meter deployment and other technologies

1. Is the implementation of smart metering regulated (is it mandatory or left to DSO or market initiative)? Are there any specific smart metering rollout programs?

The implementation of Smart metering was mandatory through Resolution 292/06, that defined also the roll-out schedule for DSOs.

2. What is the infrastructure considered by regulation (just the smart meters at consumers' location, does it also include data concentrators, communication networks, etc)?

The whole structure is included in the RAB, meters, concentrators and communication network.

3. What is the progress of the Smart Metering roll-out in your country?

Enel has provided the installation of more than 32 million smart meters through the whole country and as for 31/12/2011 covers over 95% of electricity customers.

4. How is it being carried out? How are the costs being recovered or expected to be recovered?

In 2006 the Italian Regulator (AEEG) set a mandatory installation programme of electronic meters, with minimum functional requirements for all the DSOs and LV customers.

It is a 100% private investment (recovered in tariff since 2003).

5. Are there any minimum functionalities required for SM? What are they (remote reading, load limitation, etc)?

Up to date, the main functionalities are

- Remote readings (deployed)
- Remote contract management (deployed)
- Remote connection/disconnection, including load limitation (deployed)
- Tailored tariffs (deployed)
- Fraud detection (deployed)
- Bi-directional measurements for active customers (deployed)
- Power quality measurements and diagnostics (deployed)
- Customer web portal (deployed for Business customers)
- Meter to home functionalities – Smart Info device and Energy@Home (pilot phase)

6. Are there any requirements for the smartness of new electrical appliances, e.g. in order to make them compatible with Home Energy Management Systems?

The smart meters installed in Italy are compliant with a set of minimum functionalities that are described in the previous question.

State of the retail sector

1. Are DSOs fully unbundled?

In the case of Enel Distribuzione SpA, the company has followed the partial demerger on the sales activities from 1 January 2008, in line with the provisions of Decree 18 June 2007 n. 73, converted into Law no. 125 of 3 August 2007 on behalf of the implementation of EU Community provisions on the liberalization of energy markets, and now is engaged solely in the transportation and metering of electricity in the country.

2. Is there a liberalized retail sector?

The Electricity market in Italy started on 1/4/2004 in implementation of Article 5 of Legislative Decree no. 79/99 in accordance with the Decree of the Minister for Productive Activities of 19 December 2003 and partially redesigned as of 1/11/2009 pursuant to Law 02 / 2009.

3. How are settlements for the procurement of energy in the retail market currently made? Do consumers purchase this electricity from suppliers or specific agents? Are there any standardized load profiles for those customers (and if so, what are the application criteria)?

The Italian electricity market is divided into three submarkets: Day ahead market, where producers, wholesalers and eligible customers can sell / buy electricity for the next day. Intraday market where producers, wholesalers and end users can change the planned injection/consumption determined in the DAM. Ancillary services market where Terna SpA procures ancillary services necessary for the management and control of the power system.

4. Is there a regulated retail price, even if it is optional to final customers? What kind of regulated tariff structure does it have?

Customers can choose their supplier on the free market, at liberalized prices, or on the protected market, at a regulated price, which is determined by the National Regulatory Authority (AEEG), based on the price paid by the Single Buyer in the wholesale market.

5. Do you think there are many barriers for aggregators to enter the market? In what sense?

The role of the aggregator is not yet regulated.

6. Are suppliers offering smart and dynamic pricing products?

Thanks to the massive roll-out of smart meters in Italy, clients have the possibility of innovative electricity products (e.g. ToU).

Wholesale market arrangements

1. What kind of heavy requirements are there (fixed trading charges, minimum trading volumes, minimum capacity) in order to qualify for participation on wholesale markets, such as the reserve market, the day-ahead market and the intraday market?

The following table shows the characteristics of every segment of the Italian electricity market (minimum energy volumes, minimum price steps, etc.):

	Market segment	Trading	Sittings	Timeline	Minimum offering	Market Price	Resulting generation program binding?
Market matching	Day-ahead	☒ Discrete ☐ Continuous	☒ 1 ☐ 6 ☐ Other: value	GCT(s): 9:15 a.m. D-1	Energy: 1 kWh Price step: 0.01 €/MWh	Technical maximum: no maximum price Technical minimum: zero	☒ Yes ☐ No
	Intraday	☒ Discrete ☐ Continuous	☐ 1 ☐ 6 ☒	GCT(s): 12:30 p.m. D-1, 14:40 p.m. D-1, 7:30 a.m. D, 11:45 a.m. D	Energy: 1 kWh Price step: 0.01 €/MWh	Technical maximum: no maximum price Technical minimum:	☒ Yes ☐ No

	Market segment	Trading	Sittings	Timeline	Minimum offering	Market Price	Resulting generation program binding?
			Other: 4			zero	
	Dispatching Services (ex-ante)	☒ Discrete ☐ Continuous	☐ 1 ☐ 6 ☒ Other: 3	GCT(s): 16:40 p.m. D-1; for the other two sittings whose results are published on 9:50 a.m. D and on 14:05 a.m. D, the same bids of the first sitting are used	Energy: 1 kWh Price step: 0.01 €/MWh	Technical maximum: no maximum price Technical minimum: zero	☒ Yes ☐ No
	Balancing	☒ Discrete ☐ Continuous	☐ 1 ☐ 6 ☒ Other: 5	GCT(s): 16:40 p.m. D-1, 5:00 a.m. D, 11:00 a.m. D, 15:00 p.m. D, 21:00 p.m. D	Energy: 1 kWh Price step: 0.01 €/MWh	Technical maximum: no maximum price Technical minimum: zero	☒ Yes ☐ No

2. How can consumers sell their energy reductions or offer their bids and under what conditions (in the wholesale market, through contracts with suppliers or aggregators, etc.)? How is this remunerated (tariffs, dynamic prices, incentives...)?

The Article 11, paragraph 1, of the Electricity Market Rules states that: There is no minimum size in the Day-ahead and in the Intra-day markets. In the Dispatching Services and in the Balancing markets the minimum size is 10 MW and the participating units must have adequate technical characteristics specified in the network code. Generators and consumers (pump storage) can sell/buy energy in the different market segments described above.

In the case of multiple sell offers at the same price, priority access is given in this order: Must Run units for the safety of the network, energy coming from renewable energy, cogeneration units.

3. How can the data be shared among parties, such as the retailer, the aggregator, the balancing responsible party

The Market Operator requires information concerning the operation of the system (e.g., network limits) before the opening of the market segment. The TSO is informed of the unit commitment for every market segment.

Existing Active Demand

1. What are the existing initiatives in relation to Active Demand in your country?

Enel Distribuzione worked in the FP7 ADDRESS project for the definition of AD services in the future Active Demand system. Specifically, the Italian field test was carried out in Carpinone, in the Molise Region, and focused on the Distribution System Operator control system.

2. Are there any plans to develop any new AD initiative from the regulator?

As of today this is an open issue.

Some answers to the regulatory questionnaire for Germany (RWE)

DSO remuneration

1. What regulatory mechanism is used in your country to compensate and provide incentives to DSO for energy losses reduction?

In Germany the mechanisms used by the regulator differ with regard to prices and amounts. Amounts are capped at different maximum percentage values per network level the regulator has calculated using a non-published model. The maximum amount of kWh the regulator recognizes as losses can thus be calculated by multiplying the maximum percentage value per network level with the amounts of energy transported.

With regard to prices there has been a longer discussion/legal battle between the regulator and the network operators which resulted in the following solution: The price of losses is calculated using a percentage figure for base and peak electricity and the 365-day average EEX prices for these futures which were realized on the market approx. 18 to 6 months in advance.

Capped amounts multiplied by the resulting average price are considered to be non-influential costs for the DSO (i.e. are not subject to the incentive regulation) if the DSO has declared its self-commitment to actually purchase losses in a certain fashion. So most of the price risk but not all (if the DSO is small it might be forced to buy all losses on a single day) are covered by the current scheme.

No further incentivization besides the fact that losses are capped (cf. above) and priced according to a formula thus a DSO is incentivized indirectly to have lower losses than the cap (if technically possible) as this would result in profits.

Market roles and business models:

1. Who bears the costs of AMI (investment, operation and maintenance, management)? How are these costs passed through to consumers (do consumers pay a fixed amount for AMI rental)?

Finally the costs will have to be borne by the customer; the exact payment model is still under discussion and will be regulated in one of the four ordinances described above. Regulated and non-regulated MPO are legally obliged to roll-out meters but the DSOs (as regulated MPO) cannot avoid the duty

2. Who is the owner of the required infrastructure (AMI) (the DSO, the supplier, an independent agent)? In case it is property of the DSO, how is it accounted for by regulation? Is it included in the asset base?

Ownership depends on the choices the connection user has made. If the DSO will be in charge as the market role metering point operator rests with him, it is possible for the DSO to generally make any legal economic choice (ownership, rent, leasing etc.). But as the administration of gateways will be highly complicated, it is expected that many smaller DSOs will not choose to become administrators and own the necessary equipment. They might still be owners of the gateways and meters themselves though. The DSO cost recovery has not been secured in the German energy law / incentive regulation yet.

3. Who owns, who operates and who manages the data associated to this technology (the DSO, the supplier, an independent agent)? How is it done?

The smart meter gateway administrator is in charge of operating the gateway. But in any single case it might be the DSO, another DSO or an independent party that chooses to offer such services, make the necessary investments and proof the necessary qualifications (Inter alia it is necessary to be certified by the Federal Office of Information Security (BSI). A measure that is expected to cost about 600.000 € per case).

Reading: Generally the Gateway administrator even though there is also the idea that the gateway once programmed correctly, automatically feeds eligible parties with the data they need.

Generally the customer is considered the owner of its own data due to the German data privacy law.

4. Are there any problems with confidentiality and data protection? What is the regulation on this topic? Who is the owner of consumers' data and who is allowed to access the information?

The energy law gives some guidance on data protection already. So does the Federal law on data protection itself. All issues of technical data security were presumably solved in the context of the BSI protection profile.

5. Demand response may be regulated from the side of the DSO, having the possibility to switch of certain consumers. This is mostly regulated through a contract between DSO (and energy supplier) and consumer through lower electricity tariffs (or network tariffs). Is

something introduced in your country (or in some regions?) For what kind of consumers (industrial, commercial, domestic)?

There are traditional Demand Side Management (DSM) measures in Germany that stem from the pre-liberalization era and that for the most part cover domestic heating appliances (e.g. night-storage-heaters which are often quite load intensive). In most cases installations covered by this scheme have their own meter which allows for a separate billing process from the DSO's as well as from the supply company's point of view. Special network fees in addition to technical measures are used to steer the consumption patterns of these installations into the night hours which traditionally have a low load profile. Nonetheless, the steering mechanism only works in relation to fixed restrictions given by the DSOs. Because the DSOs steer the installations according to fixed time schedules that are known to all market parties, it is easy to involve the supply companies into the scheme as they procure and deliver the electricity for appliances covered by the scheme according to so called tLPs (temperature dependent load profiles) that do also respect the fixed switching times. Similar measures exist for heat-pumps. § 14a of the energy law will introduce more (eventually) steerable loads in LV but a federal decree is missing to activate that measure.

6. Does the DSO have the visibility of the consumption profiles for grid operation purposes?

No. DSOs only have access to generation data for operation purposes; the law allows for a possibility that DSOs access technical data but only if an additional federal decree especially clarifies that issue.

7. Are there agents, such as aggregators, supplier aggregators or other business arrangements that manage different loads (commercial and domestic consumers) connected to the distribution network?

Generally such agents exist but their business (with the exemption of the direct marketing of DER produced electricity under a special clause of the RES law [EEG]) is not yet too large. Also there are traditional Demand Side Management (DSM) measures in Germany that stem from the pre-liberalization era and that for the most part cover domestic heating appliances (e.g. night-storage-heaters which are often quite load intensive). In most cases installations covered by this scheme have their own meter which allows for a separate billing process from the DSO's as well as from the supply company's point of view. Special network fees in addition to technical measures are used to steer the consumption patterns of these installations into the night hours which traditionally have a low load profile. Nonetheless, the steering mechanism only works in relation to fixed restrictions given by the DSOs. Because the DSOs steer the installations according to fixed time schedules that are known to all market parties, it is easy to involve the supply companies into the scheme as they procure and deliver the electricity for appliances covered by the scheme according to so called tLPs (temperature dependent load profiles) that do also respect the fixed switching times.

Also C&I customers are participating either through their own balance group or through aggregators in (minute) reserve markets or in another measure that calls for the TSO to “collect” and contract switchable loads (AblaV).

8. How would the DSOs deal with market agents, such as retailers and aggregators in relation to the data from consumers and the grid?

There is no final agreement on legislation on aggregators as of yet but there is a discussion in the platform at the Federal of Ministry of Economics whether the traditional German DSM schemes as mentioned can be re-designed to work in a more flexible manner (e.g., allowing for the use of flexibility also during day time) without breaching technical restrictions on the network side and thus causing an additional need for network expansion is openly discussed at this time -> § 14a EnWG.

9. Is the figure of the Energy Service Companies (ESCO) contemplated by regulation? What kind of additional services do they offer?

So far the term ECSO or its German equivalent “Energiedienstleister” is not explicitly mentioned in the German energy legislation but the EED and other EU directives have not been transposed fully into German law as of yet. Albeit there exists a rather large and well-functioning market for such services (cf. result of the dena/frontier economics study). Services offered include all kind of possible approaches e.g. energy efficiency measures when building or renovating houses (most often these can be combined with special loans from the KfW – the German Federal Promotional Bank). Services offered do also include contracting for heat, direct marketing of RES produced electricity, energy management for industry and aggregation services.

Network tariff design

1. Are tariff schemes already adapted to the data provided by smart meters?

As the smart meter roll-out in Germany is delayed due to unfinished technical minimum requirements (inter alia to be provided by the Federal Office for Information Security and to become part of a special ordinance later) there are no smart meter data that could be used currently across the whole market. The latest amendment to the energy law introduced a new (third) balancing regime besides the two described above – in it the idea is to have a smart meter collect a kWh-value every 1/4-h and to use these values for balancing purposes (could be considered to be rLM light).

2. Are DER owners (mainly domestic consumers with DG and/or EV) obliged to have a separate metering for generation and consumption or are metering and tariffs based on net consumption? Are they charged a volumetric tariff or a capacity tariff? Is the figure of prosumer contemplated by regulation?

Separate metering is the norm albeit the DER owner might choose the metering operator at the relevant DER, i.e. not all DER are metered by the DSOs. The capability and number of meters at any DER installation depends on the technology and business model the DER owner actually uses (most RWE DSOs “know” of at least five alternatives including some form of net consumption / net metering). There are also quite a large number of PVs whose proprietors also receive a reduced FIT for electricity self-consumed but the relevant section of the RES law has been abolished i.e. cannot be used for new installations.

After the abolishment of the relevant section of the RES law, there is no longer any explicit regulation on self-consumption in Germany but it has to be recognized that kWh used as part of any self-consumption are not obliged to pay a couple of fees, duties and levies (electricity tax, concession fee, network fee, EEG surcharge etc.) which makes self-consumption especially from smaller PV on houses extremely attractive. For new installations the newest version of the EEG introduces a (reduced) renewables surcharge for kWh that are self-produced and consumed for installations > 10 kW.

So far the German legislation does not use the word prosumer as such, but the idea/philosophy is clearly present in current discussions.

Smart meter deployment and other technologies

1. Is the implementation of smart metering regulated (is it mandatory or left to DSO or market initiative)? Are there any specific smart metering rollout programs?

The implementation of smart metering is regulated even though the German metering market is liberalised. The smart meter (the German law uses the term "intelligent" metering systems) are to be provided by the responsible metering point operator. As DSOs still perform this duty on any given metering point where the user of the connection has not chosen a different metering operator they will most probably have to deliver most of the roll-out.

It is currently unclear if and how the Federal Government plans to include CBA results in further amendments to the law. Anyhow the Ministry of Economics has already announced that it is working on a package of four new ordinances that should clarify all remaining issues (inter alia one ordinance on the roll-out itself and one on data communication and data privacy issues plus one that “legalizes” the work on the Protection Profile).

2. What is the infrastructure considered by regulation (just the smart meters at consumers’ location, does it also include data concentrators, communication networks, etc)?

Due to the Protection Profile as designed by the Federal Office for Information Security not only meters are included in technical regulations but also gateways and all the communication equipment that is used to communicate within this equipment and from the WAN to these gateways. Smart meter gateway administrators will be forced to build up a public key infrastructure to make sure that all data send to and collected from smart meter gateways are correct, were not tampered with etc. All data will also have to be encrypted when being sent around.

3. What is the progress of the Smart Metering roll-out in your country?

Federal decree that orders the final start of the roll-out is still missing. Political discussion continues.

State of the retail sector

1. Is there a liberalized retail sector?

For customers of all sizes. About 1000 supply companies are active in the market of which approx. 250 operate nationwide. All processes between the DSOs and the suppliers (supplier switching etc.) are regulated through stipulations by the federal regulator (BNetzA). These stipulation describe the syntax (EDIFACT) as well as the time frames and information that need to be exchanged in any “use-case”.

2. How are settlements for the procurement of energy in the retail market currently made?

Do consumers purchase this electricity from suppliers or specific agents? Are there any standardized load profiles for those customers (and if so, what are the application criteria)?

Most consumers “act” through their supplier, who is the main intermediary between them and the network, i.e. the supplier is the network user not the consumer. (Standard and analytical) load profiles are used to determine the amounts to be delivered per 1/4h (albeit for customers > 100.000 kWh 1/4h interval metering applies). Amount risks for profiled customers lie with the DSOs intraday (they operate a difference balance group). Total kWh amounts that were delivered through profiles are controlled for yearly by checking what was actually consumed against what was delivered via the profile and settling differences financially.