Small or medium-scale focused research project (STREP)

Energy Demand-Aware Open Services for Smart Grid Intelligent Automation

SmartHG

EU FP7 Project #317761

Deliverable D7.2.1

Second Year Dissemination Activity and Exploitation Plan

Deliverable due on	:	M26
Output of WP	:	WP7
WP Responsible	:	ATANVO

Consortium

Participant Organization Name	Participant Short Name	Country
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Aarhus University	AU	Denmark
IMDEA Energía	IMDEA	Spain
A. V. Luikov Heat and Mass Transfer Institute of the National Academy of Sciences of Belarus	HMTI	Belarus
ATANVO GmbH	ATANVO	Germany
Panoramic Power	PANPOW	Israel
Solintel	SOLINTEL	Spain
SEAS – NVE	SEAS	Denmark
Kalundborg Municipality	KAL	Denmark
Minskenergo	MINSKENG	Belarus
Develco Products A/S	DEVELCO	Denmark

Document Information

Version	October 8, 2015, 23:42
Date	October 8, 2015
Contributors	UNIROMA1, AU, IMDEA, HMTI, ATANVO, PANPOW, SOLINTEL, SEAS, KAL, MINSKENG, DEVELCO
Reason for release	Second year review
Dissemination level	Public (PU)
Status	Final

Project title	Energy Demand-Aware Open Services for Smart Grid Intelligent Automation
Project acronym	SmartHG
Project number	317761
Call (part) identifier	FP7-ICT-2011-8

Work programme topic addressed	
Challenge	**6**: *ICT for a low carbon economy*
Objective	**ICT-2011.6.1** *Smart Energy Grids*
Target Outcome	**d**) Home energy controlling hubs that will collect real-time or near real-time data on energy consumption data from smart household appliances and enable intelligent automation.

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Executive Summary

Objectives The role of WP7 in the SmartHG is to carry out dissemination and exploitation activities.

Retrospect The main achievements of WP7 during SmartHG first year were the following. Within task T7.1 (*Dissemination Plan*) we identified goals, strategy and audience for the dissemination activities. Within task T7.2 (*dissemination activities*) we presented SmartHG results in international conferences, published scientific papers and developed dissemination tools such as a first version of the project web site. Within task T7.3 (*Market Analysis*) we identified exploitation opportunities for SmartHG results and within task T7.4 (*Exploitation Plan*) we identified an exploitation plan for each partner and for the whole consortium. The main limitations in WP7 first year work were: 1) networking activity was not present and 2) exploitation plans for SmartHG services were not identified.

Achievements As for the dissemination activities (task T7.2), during SmartHG second reporting period project results were disseminated through 5 talks at international scientific events, 4 talks at international events, 9 scientific papers acknowledging EU support. Furthermore, networking activities with other projects have been carried out. Finally, all dissemination tools developed in the first year (project web-site, leaflet, etc) have been improved and brought to a mature level.

As for the exploitation activities (task T7.4), our second year exploitation plan identifies SmartHG services to be exploited along with their potential customers. This, in turn, defines an exploitation plan for each SmartHG partner as well as for the consortium as a whole.

Limitations and Future Work Our second year exploitation plan focuses on a medium term exploitation scenario, in the third year we plan to identify exploitation plans for short term exploitation scenarios.

Chapter 1

Retrospect

In this section we briefly recall the main achievements (and the main shortcomings identified) in the first year version of the SmartHG dissemination and exploitation activities, which was described in Deliverable D7.1.1. The advancements on dissemination and exploitation activities performed during the second year of SmartHG (described in this deliverable) w.r.t. the those performed in the first year (described in first year Deliverable D7.1.1) is summarised in Section 5.

During the first year, we defined a Dissemination Plan as well as an Exploitation Plan.

Our *Dissemination Plan* (Task T7.1) identified the potential audience, the contents to be disseminated, and tools to be used to promote project results. Moreover, it addressed technological and commercial aspects as well as the knowledge and social ones. The target audience were identified in the industrial as well as scientific and research communities. Project test-beds were identified as a valuable instrument to introduce SmartHG to technology congresses. Project partners planned to organise workshops at which interested industry audiences are invited. Moreover partners started disseminating project technology through education and training. SmartHG activities were identified as an opportunity to establish new networks of knowledge. Such dissemination plan also drives part of the dissemination activities in this second year.

The main *dissemination activities* (Task T7.2) in the first year have been the following: SmartHG has been presented at 3 scientific events. SmartHG partners gave talks in 12 conferences, published 6 scientific papers which contained a statement to indicate that the corresponding research was generated with financial support from the European Union and other 13 scientific papers related to the topics of the project, 2 magazine/newspaper articles and one on-line contribution. *Dissemination tools* activated in the first year were the first version of the project website, a newsletter, the first version of SmartHG accounts on social networks (Facebook and Twitter), and the first version of dissemination artefacts (project logo, templates for all kind of project documents).

The main limitations of the dissemination activities of the first year consisted in the fact that the dissemination tools needed to be improved, and that networking activities were only planned.

The Exploitation Plan has been defined on the basis of a detailed *Market Analysis* (Task T7.3) consisting of three parts. First, an analysis of *present and future opportunities* in the Smart Energy global market has been presented, addressing in particular Home Energy Management Systems (HEMS), smart meters and Demand Response (DR) electricity market. Second, a Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis has been accomplished to drive the technology developed by the SmartHG project to the market. Finally, a *market segmentation* has identified potential customers, taking into account product and geographic segmentation. The first year SmartHG *Exploitation Plan* (Task T7.4) focused on defining and exploitation plan for each partner and for the whole consortium.

The main limitations for the first year exploitation plan were: 1) identification of an exploitation plan for SmartHG services was missing; 2) identification of potential customers for each SmartHG service was missing.

Chapter 2

Introduction

WP7 focuses on dissemination activities (task T7.2) and SmartHG exploitation plan (task T7.4). Tasks T7.1 (*Dissemination Plan*) and T7.3 (*Market Analysis*) were concluded during SmartHG first year.

Dissemination and exploitation activities are essential to provide appropriate distribution of knowledge, networking within the scientific, industrial and social communities and, finally, to identify and explore markets for the project results. Dissemination and exploitation activities are the focus of WP7 in the SmartHG project, and are described in this deliverable, which reports about the work carried out in tasks T7.2 (dissemination activities and tools) and T7.4 (exploitation of SmartHG services).

During the second reporting period, several Dissemination Activities have been successfully carried out: SmartHG partners presented the project as a whole at 5 scientific events, gave talks related to SmartHG at 5 conferences/workshops/symposia, disseminated SmartHG at other 4 international events, published 9 scientific papers acknowledging EU support and other 7 scientific papers related to the project topics. Networking activities with other projects have also been carried out. Such activities have provided us with: synergies during Kalundborg test-bed deployment (FP7 project *URB-Grade*), Plug-in Electric Vehicle (PEV) data to use in our evaluation activities (Danish project *Test-an-EV*), and detailed information about residential user responsiveness to price incentives (e.g., FP7 project *ADVANCED*, SEAS-NVE project *Win with new electrical habits*).

Dissemination tools activated so far include: SmartHG project website [1], project newsletter [2], SmartHG accounts on social networks (Facebook [3] and Twitter [4]), and dissemination artefacts (a leaflet, two sets of presentation slides, templates for all kind of project documents). The General Section [1] of the project website contains all publishable material about SmartHG. The Technical Section [5] of the project website links to all Web Services of the SmartHG Intelligent Automation Services (IASs), and moreover shows, in the PANPOW dashboard, the energy usage of the individual homes monitored in the project pilot sites, namely Kalundborg and Central District.

Our second year exploitation plan focuses on identifying SmartHG services to be exploited, the partners involved in such an exploitation, the potential customers for such services and the expected revenues from the foreseen exploitation activity. With the goal of validating the envisaged exploitation plans, quantitative exploitation scenarios have also been identified. The above analysis defines an exploitation plan for each SmartHG partner as well as for the consortium as a whole.

Table 2.1: Mapping between WP7 tasks and sections of this deliverable

Task	**Task Name**	**Chapters**
T7.2	Dissemination Activity	Chapter 3
T7.4	Exploitation Plan	Chapter 4

2.1 Outline

The rest of this document is organised as follows:

Chapter 3 describes our second reporting period Dissemination Activities.

Chapter 4 presents the second iteration of our Exploitation Plan.

Table 2.1 shows a mapping between WP7 tasks and sections of this deliverable.

Chapter 3

Dissemination Activity

This section is devoted to summarise our dissemination activity in the second reporting period. It collects all scientific publications about SmartHG related topics produced by the project partners in the period. Moreover, the SmartHG project itself as a whole has been presented in 5 events. Project leaflet (see Section 3.2.1) has been distributed in other events to which SmartHG partner have participated. An complete list of SmartHG dissemination activities and publications (including also those of the first year) are shown in the periodic report (in the Project Management part).

3.1 Project Website

The SmartHG project website is hosted at `http://smarthg.di.uniroma1.it/` and is described in Deliverable D7.2.2 - Sections of Project Web-Site.

3.2 Dissemination Artefacts

Dissemination artefacts are useful tools to further support dissemination of project results. In this section, we describe SmartHG project dissemination artefacts realised or updated during the second reporting period.

3.2.1 Leaflet

A leaflet about SmartHG has been created to be handed out during the different events attended by partners. A PDF version has been published on the SmartHG website and distributed among the consortium partners. The leaflet has been designed to include general information and concept of the project and is shown in Figure 3.1.

3.2.2 Presentation Slides

Two sets of slides describing SmartHG have been prepared and showed at the events in which SmartHG has been presented (such events are listed in Section 3.5.3). SmartHG presentation slides are available on the project website.

Project at a Glance

Project Acronym: SmartHG

Project Title: Energy Demand Aware Open Services for Smart Grid Intelligent Automation

Project Number: 317761

Starting date: October 1, 2012

Duration in months: 36

Funding: € 3,299,998.00

Call (part) identifier: FP7-ICT-2011-8

Funding scheme: Collaborative project

Project Consortium

Sapienza University of Rome (Italy)
Coordinator

Aarhus University (Denmark)

IMDEA Energía (Spain)

A. V. Luikov Heat and Mass Transfer Institute of the National Academy of Sciences of Belarus (Belarus)

ATANVO GmbH (Germany)

Panoramic Power (Israel)

Solintel (Spain)

SEAS-NVE (Denmark)

Kalundborg Municipality (Denmark)

Minskenergo (Belarus)

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SmartHG

Energy Demand Aware

Open Services

for Smart Grid

Intelligent Automation

http://smarthg.di.uniroma1.it/

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EU FP7 Project
Grant Agreement 317761

Motivations

Currently the small prosumption of residential homes does not provide an interesting business opportunity for companies working on energy saving products or services. This prevents widespread uptake of intelligent Smart Grid automation services exploiting energy usage/generation data from residential homes.

Electric Distribution System
Residential Home | Residential Home | Residential Home | Distribution System Operator (DSO)
Low Value Home Intelligent Automation Services (HIASs) | High Value Grid Intelligent Automation Services (GIASs)

Objectives

- Develop *Grid Intelligent Automation Services* providing economic value to Distribution System Operators (DSOs) by optimising electric network operation through secure and safe control of the aggregate energy prosumption from many residential homes. This is achieved by computing a suitable demand aware price policy for each home.
- Develop *Home Intelligent Automation Services* providing economic value to residential homes by enabling them to securely and safely control their home appliances in order to follow DSO provided price policy.

Approach

SmartHG goals are achieved with a two-tiered control schema, whose security stems from the fact that home device data are only used locally:

- Upper tier (high value) consists of Grid Intelligent Automation Services computing a safe energy price policy for each home (global electric grid optimization).
- Lower tier (low value) consists of Home Intelligent Automation Services enabling homes to effectively follow DSO price policies (local home level optimization).
- Open communication services support data exchange between all entities involved.

Impact

- Economical advantages to all stakeholders.
- Automate *Autonomous Demand Response* overcoming the home data security and device safety issues involved in *Direct Load Control* schemes.
- Promote a market for energy services supporting DSOs in optimising electric network operation by computing demand aware price policies to steer aggregate energy demand.
- Promote an energy service market for residential homes.
- Improve overall energy efficiency and environment quality by supporting DSOs peak shaving and network load balancing goals.

Pilots

Smart sensors, smart meters and *Home Energy Controlling Hub* devices will be deployed in residential homes in SmartHG test-beds in Kalundborg (Denmark) and Minsk (Belarus). This will enable thorough technical, environmental and economical evaluation of SmartHG results.

Figure 3.1: SmartHG project leaflet

3.2.3 Templates

Newsletter, slide and deliverable templates (as well as project website) have been updated after the changes occurred to the project consortium during the second reporting period. Now newsletter and slide templates contain the project consortium logo shown in Figure 3.2.

Figure 3.2: SmartHG project consortium logo

3.3 Communication Channels Toward the Public

In this section, we describe SmartHG communication channels towards the public, divided by channel category.

3.3.1 Mailing List and Newsletter

SmartHG Newsletter #2, #3, #4, #5, #6, #7 and #8 have been published and delivered to the project mailing list, which contains email address of several coordinators of projects related to SmartHG topics. The newsletters contain information about project website contents and SmartHG news and upcoming events. The newsletters are available on the Newsletter page of the project website: `http://smarthg.di.uniroma1.it/index.php/newsletter`.

3.3.2 Social Networks

SmartHG is active on social networks with a Facebook [3] page and a Twitter [4] account.

Facebook page SmartHG Facebook page is active and available at `https://www.facebook.com/SmartHGproject`. Visiting the page, Facebook users can find updates about project activities.

Twitter account SmartHG Twitter account is active and available at `https://twitter.com/SmartHGProject`. It displays the project logo and information and news about the project activities. It is also used to follow other Twitter accounts related to SmartHG topics, in order to be constantly updated about their activities. Several tags are added to SmartHG tweets in order to be easily found by other Twitter users interested in the main topics covered by the project.

3.4 Networking and Cooperation

Networking and cooperation activities with the following projects have been undertaken.

3.4.1 ADVANCED

- **Project Data**

  Project Title: Active Demand Value And Consumers Experiences Discovery
  Project acronym: ADVANCED
  Consortium:

  - Demand Response Provider: Entelios.
  - Distribution System Operators: Enel Distribuzione, ERDF, Iberdrola, RWE.
  - Research: Universidad Pontificia Comillas, FEEM, TNO, TNS, VaasaETT.

  Period: From 2012-12-01 to 2014-11-30
  Website: `http://www.advancedfp7.eu/`
  Funded under: FP7-ENERGY
  Abstract: Leveraging on the empirical data and lessons learnt in real Active Demand (AD) experiences, the overall objective of the ADVANCED project is to develop actionable frameworks enabling residential, commercial and industrial consumers to participate in AD.

- **Networking and Cooperation**

  Enrico Tronci, SmartHG project coordinator (UNIROMA1), was invited to participate in Madrid and Rome Workshops of the FP7 ADVANCED project coordinated by Enel [6]. ADVANCED has conducted an intensive and very interesting study on user acceptance of Autonomous Demand Response (ADR) schemes. Two important messages from the ADVANCED project are:

  - Domestic users are very "reluctant" to change habits, this limits the effectiveness of ADR resting on user active participation.
  - Privacy is an important issue for domestic users so they are not happy to have Distribution System Operator (DSO) to monitor or even worst control their appliances.

  The interaction with the ADVANCED project has confirmed the SmartHG hierarchical control approach developed in SmartHG Work Packages WP3 and WP4, where the DSO computes power profiles for each user only on the basis of aggregated measurements from smart meters installed at home, whilst devices running in the user premises will monitor and control user appliances in order to follow the DSO suggested power profile.

3.4.2 Test-an-EV

- **Project Data**

  Project Title: Test-an-EV (Test-en-elbil)
  Consortium:

  - 24 Danish municipalities: Billund, Esbjerg, Faxe, Fredensborg, Fredericia, Gentofte, Gribskov, Holbæk, Hillerød, Høje Taastrup, Middelfart, Nordfyn, Nyborg, Næstved, Kalundborg, Kolding, Sorø, Sønderborg, Varde, Vejen, Vejle, Aabenraa, Aalborg, Århus.
  - 3 hospitals in the Capital Region: Herlev Hospital, Hvidovre Hospital, Rigshospitalet.
  - 5 companies: ALKA Insurance, NORDEN, SE, SEAS-NVE, Siemens.

  Period: December 2010 - June 2014
  Website: `https://www.clever.dk/test-en-elbil`
  Supported by: CLEVER, with the support of, among others, the Danish Transport Authority and the Danish Energy Agency.
  Abstract: The pilot project Test-an-EV has brought electric vehicles into the Danish homes where families have driven electric cars every day for a three month period to find out if electric cars are a realistic alternative to conventional cars.

- **Networking and Cooperation**

  In SmartHG, we used the data from Test-an-EV pilot project for the evaluation of the Demand Aware Price Policies for Homes (DAPP-H), Price Policy Safety Verification (PPSV), Energy Usage Modelling and Forecasting for Control (EUMF-K) and Energy Bill Reduction (EBR) services, carried out in Work Package WP5. Namely, by using such data we were able to virtually equip all homes in the considered scenarios with a Plug-in Electric Vehicle (PEV). This has been done by integrating data from Test-an-EV pilot project with data from deployed SmartHG sensors and smart meters. For a more detailed discussion, see Deliverable D5.2.1.

3.4.3 Win with new electrical habits

- **Pilot Study Data**

  Pilot Study Title: Win with new electrical habits (Vind med nye elvaner)
  Consortium: SEAS-NVE
  Period: October 2013 - October 2014
  Abstract: Aim of the pilot study was to explore the possibilities of a flexible electricity consumption by customers in single family houses without electric heating.

The test evaluated to what extent customers would move their consumption away from the cooking peak time, in response to a high cost incentive. The test involved 300 families and another 300 families in a control reference group.

- **Networking and Cooperation**

  The findings of this pilot study show that, even with a very low price (or even free of charge) for off-peak electricity, it is actually very hard to modify user habits. Accordingly, in SmartHG Work Package WP3 (Task T3.4 - Design and Development of home Energy Bill Reduction (EBR) service) we focus on methods and tools to implement ADR schemes that are transparent to the users. This has led us to model user flexibility as an energy storage capacity and to develop tools to exploit the flexibility stemming from energy storage appliances, such as electric water heater, storage heater [7], PEV or even batteries.

3.4.4 URB-Grade

- **Project Data**

  Project Title: Decision Support Tool for Retrofitting a District, Towards the District as a Service
  Project acronym: URB-Grade
  Consortium:

  - 2 Large Enterprises : TELVENT GLOBAL SERVICES SA (Spain) and SEAS-NVE HOLDING AS (Denmark).
  - 2 Small or Medium Enterprises: THT CONTROL OY (Finland) and FENIE ENERGIA SA (Spain).
  - 3 Research and Technological Development: ALEXANDRA INSTITUTTET (Denmark), IK4-TEKNIKER (Spain) and TTY-SAATIO (Finland).
  - 2 Cities: AYUNTAMIENTO DE EIBAR (Spain) and KALUNDBORG KOMMUNE (Denmark).

  Period: From 2012-11-01 to 2016-01-31
  Website: `http://urb-grade.eu/`
  Funded under: FP7-ICT
  Abstract: The URB-Grade project designs, develops and validates a Platform for Decision Support that will allow the city authorities and utilities to promote and choose the correct actions to upgrade a district to become more energy efficient, cost effective and to increase comfort for its citizens in a District as a Service Platform approach.

- **Networking and Cooperation**

Sevebølle, one of the SmartHG test-beds, is also one of the URB-Grade validation sites. There are several positive synergies in running both projects in the same area. In URB-Grade, Svebølle is profiled both from an anthropological and a grid perspective, which gives benefit in our SmartHG work. Coordinating with the URB-Grade project gives us knowledge about the citizens in Svebølle who can be interested in SmartHG, and helps us to get in contact with homeowners, mainly in newer houses and houses without district heating, who wants to participate. Furthermore, deployment and maintenance activities of both projects are coordinated.

3.4.5 SEMIAH

- **Project Data**

  Project Title: Scalable Energy Management Infrastructure for Aggregation of Households
  Project acronym: SEMIAH
  Consortium:

  - ICT: Aarhus University, Centre Suisse D'Electronique et de Microtechnique, University of Agder and Haute Ecole Specialisee de Suisse Occidentale.
  - Energy: Fraunhofer IWES, Agder Energi Nett, SEIC Teledis, EnAlpin, Misurio, and Develco Products.
  - Telecommunications: Devoteam Solutions and Netplus.

  Period: From 2014-03-01 to 2017-02-28
  Website: `http://semiah.eu/`
  Funded under: FP7-ICT
  Abstract: SEMIAH will develop a generic environment for the deployment and innovation of smart grid services in households. The SEMIAH concept will enable aggregation of all households connected to the system and will act through direct load control to remotely shift or curtail electrical loads according to users flexibility. Security and privacy functions will be integrated in all elements. Another essential cornerstone is the development of new business models for electricity players and residential customers.

- **Networking and Cooperation**

  The SmartHG project provides the opportunity to network and cooperate with a number of other research projects due to the involvement of the smart grid communications research group at AU. In particular, synergy between the FP7 project SEMIAH and SmartHG exist in the area of demand response services of the smart grid. Also there is a good overlap in choices of enabling technologies for the smart grid such as use of REpresentational State Transfer (RESTful) communication with HTTP over TCP/IP and in the area of smart grid security for the Home Area Network (HAN). Furthermore, networking and cooperation with the Danish national smart grid project Virtual Power Plant for Smart Grid Ready buildings and customers (VPP4SGR) has been established. Key points of cooperation include demand response protocols and control methods for Smart Home Hardware Device (SHHD) such as, e.g., white appliances. Both SmartHG partners AU end DEVELCO are involved in SEMIAH and VPP4SGR.

3.4.6 Networking at SmartGridComm 2014

SmartHG, SiNGULAR, INCREASE and Linear projects have participated in 5th IEEE International Conference on Smart Grid Communications (SmartGridComm 2014) "Integrating Renewables and Exploiting Customer Flexibility" workshop [8]. In such an occasion there has been a presentation of the main project results followed by a round table on approaches and future trends. Sections 3.4.6.1, 3.4.6.2 and 3.4.6.3 show general information about SiNGULAR, INCREASE and Linear projects, respectively.

Furthermore, some preliminary results of a project run by IBM Research-Zurich and E.On Metering have been presented at SmartGridComm 2014 [9] in the same session in which some SmartHG results have been presented. There, discussion with such project participants have taken place. Section 3.4.6.4 shows some general information about this project.

3.4.6.1 SiNGULAR

SiNGULAR
Smart and Sustainable Insular Electricity Grids Under Large-Scale Renewable Integration

- **Project Data**

  Project Title: Smart and Sustainable Insular Electricity Grids Under Large-Scale Renewable Integration
  Project acronym: SiNGULAR
  Consortium:

  - Universities: Aristotelio Panepistimio Thessalonikis (Greece), Politecnico di Torino (Italy), Universidade da Beira Interior (Portugal, project coordinator), Universidad de Castilla - La Mancha (Spain), Universitatea Politehnica din Bucureşti (Romania).
  - Distribution System Operators (DSOs): EDA Electricidade dos Açores (Portugal), ELECTRICA (Romania), HEDNO Diacheiristis Ellinikou Diktyou Dianomis Elektrikis Energeias (Greece).
  - Energy Companies and Agencies: ALSTOM (Switzerland), CS Concepto Sociologico (Spain), ENEA (Italy), INTELEN Services Limited (Cyprus), ITC Instituto Tecnologico de Canarias (Spain), Comune di Pantelleria (Italy), SMART-WATT Energy Services (Portugal), W4E Wave for Energy (Italy).

  Period: From 2012-12-01 to 2015-11-30
  Website: `http://www.singular-fp7.eu/home/`
  Funded under: FP7-ENERGY
  Abstract: SiNGULAR investigates the effects of large-scale integration of renewables and demand-side management on the planning and operation of insular electricity grids, proposing efficient measures, solutions and tools towards the development of a sustainable and smart grid.

3.4.6.2 INCREASE

- **Project Data**

  Project Title: Increasing the penetration of renewable energy sources in the distribution grid by developing control strategies and using ancillary services
  Project acronym: INCREASE
  Consortium:

  - Austria: Joanneum Research Forschungsgesellschaft mbH, Stromnetz Steiermark GmbH.
  - Belgium: Alenco NV, Eandis, ELIA, Universiteit Gent.
  - Greece: The Power Systems Laboratory (PSL).
  - Slovenia: Elektro Gorenjska, KORONA Power Engineering, University of Ljubljana.
  - The Netherlands: Liander, Mastervolt, The Dutch Eindhoven University of Technology.

  Period: From 2013-09-01 to 2016-12-31
  Website: `http://www.project-increase.eu/`
  Funded under: FP7-ENERGY
  Abstract: INCREASE wants to focus on how to manage renewable energy sources in LV and MV networks, provide ancillary services (towards DSOs but also TSOs), in particular voltage control and the provision of reserve.

3.4.6.3 Linear

- **Project Data**

  Project Title: Local Intelligent Networks and Energy Active Regions
  Project acronym: Linear
  Consortium: The research project of Linear is a cooperation between the research institutes EnergyVille (KU Leuven, VITO, imec) and iMinds and takes part in the Actieplan 'Vlaanderen in Actie'. It is financed by the Flemish governement and receives considerable support of Belgacom, Eandis, EDF Luminus, EnergyVille, Fifthplay, Infrax, Laborelec, Miele, Siemens, Telenet and Viessman. Also Agoria, EWI, IWT, VOKA and VREG are involved.
  Period: From May 2009 to the end of 2014
  Website: `http://www.linear-smartgrid.be/`
  Abstract: With the help of two remuneration models and four business cases, Linear is studying ways for households and producers or power grid operators to better tailor energy consumption in relation to energy generation. Linear is also studying four challenges for which demand-side management could be a sound technical and economically profitable solution.

3.4.6.4 IBM Research and E.On Internal Project on Electrical Storage Heaters

- **Project Data**

  Project Topic: Charging of electrical storage heaters
  Consortium: IBM Research - Zurich, E.On Metering
  Abstract: This internal project develops an approach to optimally schedule the charging of groups of electrical storage heaters to minimise energy-procurement costs.

- **Networking and Cooperation**

  At SmartGridComm 2014, SmartHG participants discussed with this project participants. This project aims at exploiting storage heaters to achieve flexibility. To avoid peak rebounds due to a large set of users turning on the heaters at the same time, they plan to use an approach very close to SmartHG Demand Aware Price Policies (DAPP) service. This on one side confirms validity of our approach on the other it opens an immediate market for the DAPP service.

3.5 Participations and Publications

During the second reporting period, SmartHG partners have given talks in 5 international events (conferences, workshops, symposia), published 9 scientific papers acknowledging European Union financial support, and other 7 scientific papers on topics related to SmartHG, plus 2 on-line contributions.

The following sections list SmartHG second reporting period participations and publications.

3.5.1 Conferences

Below we list the conferences in which publications acknowledging SmartHG financial support have been presented during the second reporting period,

- 5th IEEE International Conference on Smart Grid Communications [9] (SmartGridComm 2014) in Venice, Italy (November 2014).
- UKSim-AMSS 8th European Modelling Symposium [10] (EMS 2014) in Pisa, Italy (October 2014).
- 17th EuroMicro Conference on Digital System Design [11] (DSD 2014) in Verona, Italy (August 2014).
- CIRED Electricity Distribution Workshop on Challenges of implementing Active Distribution System Management [12] in Rome, Italy (June 2014).
- 22nd Euromicro International Conference on Parallel, Distributed and Network-Based Computing [13] (PDP 2014) in Turin, Italy (February 2014).

3.5.2 International Journals

Below we list the international journals in which publications explicitly acknowledging SmartHG financial support have been published during the second reporting period.

- ACM Transactions On Software Engineering And Methodology [14] (TOSEM) (February 2014).
- Wireless Personal Communications, Springer Journal [15] (May 2014).

3.5.3 Events

Below we list the events in which SmartHG has been presented during the second reporting period.

- "Integrating Renewables and Exploiting Customer Flexibility" workshop [8] at 5th IEEE International Conference on Smart Grid Communications (SmartGridComm 2014) in Venice, Italy (November 2014).
- First International Forum on Smart City [16] in Durres, Albania (November 2014).
- Work in progress session [17] of 17th Euromicro Conference on Digital System Design/40th Euromicro Conference series on Software Engineering and Advanced Applications (DSD/SEAA 2014) in Verona, Italy (August 2014).
- "Renewable Energy and Active Demand Management for Smart Buildings" talk at Aalborg University [18], in Aalborg, Denmark (June 2014).
- Energy Management in Smart Grids workshop [19] in Madrid, Spain (November 2013).

Below we list the events in which SmartHG has participated, during the second reporting period. In some of these events, the SmartHG leaflet (see Section 3.2.1) has been distributed.

- ADVANCED Final Workshop [20] in Rome, Italy (27th November 2014).
- 1st EECA Cluster networking event - ICT Communities building [21] and Horizon 2020 Eastern Partnership (EaP) Information Day: Research & Innovation in Information and Communication Technologies [22] organised by EU-funded projects EAST-HORIZON & EECA-2-HORIZON, in Baku, Azerbaijan (12th-13th November 2014).
- UK/DK Smart Cities Networking Event [23] in Copenhagen, Denmark (11th November 2014)
- European Utility Week 2014 [24] in Amsterdam, The Netherlands (4th-6th November 2014).
- 15th Western China International Fair [25] (WCIF) in Chengdu, China (23rd October 2014).

- 9th EU-China Business & Technology Cooperation Fair [26] in Chengdu, China (21st-23rd October 2014).
- ADVANCED 3rd SAB Workshop [27] in Madrid, Spain (19th September 2014).
- ENER2i EU Brokerage Event on energy [28], organised by ENER2i project and the European Sustainable Energy Innovation Alliance, in Brussels, Belgium (23rd June 2014).
- PICTURE Project Final event "Policy dialogue in ICT to an Upper level for Reinforced EU-EECA Cooperation" [29], Minsk, Belarus (21st May 2014).
- InfoDay on the Framework Program HORIZON 2020 [30], Minsk, Belarus (24-25 February 2014).

Furthermore, in August 2014 SmartHG has appeared on the Panoramic Power Blog in the post "Energy Productivity: Leading the Way in the EU" [31] and in January 2015 SmartHG has appeared on 2GreenEnergy website in the article "Energy Efficiency Initiatives in Sustainable Cities" by Panoramic Power [32].

3.5.4 Publications

This section shows the publications produced by the SmartHG project consortium during the second reporting period, which acknowledge the financial support from the European Union.

- B. Hayes, and M. Prodanovic. "Short-term Operational Planning and State Estimation in Power Distribution Networks." *In Proceedings of the CIRED Electricity Distribution Workshop*, 2014.
- B. Hayes, and M. Prodanovic. "State Estimation Techniques for Electric Power Distribution Systems." *In Proceedings of the 2014 UKSim-AMSS 8th European Modelling Symposium* (EMS 2014)., 2014.
- R. H. Jacobsen, and S. A. Mikkelsen. "Infrastructure for Intelligent Automation Services in the Smart Grid." *Wireless Personal Communications* 76, no. 2 (2014): 125–147. Springer US. ISSN: 0929-6212.
- T. Mancini, F. Mari, A. Massini, I. Melatti, and E. Tronci. "SyLVaaS: System Level Formal Verification as a Service." *In proceedings of the 23rd Euromicro International Conference on Parallel, distributed and network-based Processing* (PDP 2015), *special session on Formal Approaches to Parallel and Distributed Systems* (4PAD)., 2015. *To appear.*
- T. Mancini, F. Mari, A. Massini, I. Melatti, and E. Tronci. "Anytime System Level Verification via Random Exhaustive Hardware In The Loop Simulation." *In Proceedings of 17th EuroMicro Conference on Digital System Design* (DSD 2014) (2014).
- T. Mancini, F. Mari, A. Massini, I. Melatti, and E. Tronci. "System Level Formal Verification via Distributed Multi-Core Hardware in the Loop Simulation." *In Proceedings of the 22nd Euromicro International Conference on Parallel, Distributed and Network-Based Computing* (PDP 2014). IEEE Computer Society, 2014.

- F. Mari, I. Melatti, I. Salvo, and E. Tronci. "Model Based Synthesis of Control Software from System Level Formal Specifications." *Acm Transactions On Software Engineering And Methodology* (TOSEM) 23, no. 1 (2014): 6. Acm. ISSN: 1049-331x.
- E. Tronci, T. Mancini, F. Mari, I. Melatti, R. H. Jacobsen, E. Ebeid, S. A. Mikkelsen, M. Prodanovic, J. K. Gruber, and B. Hayes. "SmartHG: Energy Demand Aware Open Services for Smart Grid Intelligent Automation." *In Proceedings of the Work in Progress Session of DSD/SEAA 2014.*, 2014. ISBN: 978-3-902457-40-0.
- E. Tronci, T. Mancini, F. Mari, I. Melatti, S. Salvo, M. Prodanovic, J. K. Gruber, B. Hayes, and L. Elmegaard. "Demand-Aware Price Policy Synthesis and Verification Services for Smart Grids." *Proceedings of the 5th IEEE International Conference On Smart Grid Communications* (SmartGridComm 2014), 2014.

3.5.5 Other Consortium Publications

This section shows other publications produced by project partners during the second reporting period and related to SmartHG topics, but not directly supported by the SmartHG funding.

- B. Hayes, I. Hernando-Gil, A. Collin, G. Harrison, and S. Djokic. "Optimal Power Flow for Maximizing Network Benefits From Demand-Side Management." *IEEE Transactions on Power Systems* 29, no. 4 (2014): 1739–1747.
- R. H. Jacobsen, N. Torring, B. V. Danielsen, M. T. Hansen, and E. B. Pedersen. "Towards an app platform for data concentrators." *In Innovative Smart Grid Technologies Conference (ISGT), 2014 IEEE PES*, 1–5., 2014.
- E. V. Krivenko, S. A. Levchenko, and V. I. Lutsenko. "Smart grid technology as a basis for modernisation of water supply system for the future sustainable society development." *In Proceedings of the International Humboldt conference: Science and technology as a basis of modernization for future sustainable development*, 57–61., 2014.
- S. Levchenko, J. Unfried, and V. Schackmann. "Smart Grid Services for Optimized Production and Integration of Bio-Energy into Regional Electricity-, Gas- and DistrictHeating- Grids." *In Proceedings of 22nd European Biomass Conference and Exhibition.*, 2014.
- S. A. Levchenko, and S. V. Pluyta. "Service control system of smart electric grids by fuzzy model in conditions of initial data lacking." *In Proceedings of the International Humboldt conference: Science and technology as a basis of modernization for future sustainable development*, 31–32., 2014.
- S. A. Levchenko, and S. V. Pluyta. "Smart grids concept for sustainable development of Belarus energy system." *Proceedings of the National academy of sciences of Belarus* 3 (2014): 91–97.
- S. Pluyta, S. Levchenko, and A. Pluyta. "Standards application in smart energy." *Proceedings of the A.V. Luikov Heat and Mass Transfer Institute* HEAT-MASSTRANSFER – 2013 (2014): 43–47.

Chapter 4

Exploitation Plan

4.1 Introduction

The present section outlines our exploitation plan for the services in the SmartHG platform. To this end we proceed as follows.

In Section 4.2 we estimate the Technology Readiness Level (TRL) for the SmartHG platform. This enables us to identify the technological steps needed to bring the SmartHG platform to the market.

In Section 4.3 we summarise SmartHG exploitation opportunities identified by our evaluation activity.

In Section 4.4, resting on the considerations in Sections 4.2 and 4.3, we identify exploitation strategies and customers for the SmartHG platform.

In Section 4.6 we outline a SmartHG exploitation plan focusing on Distribution System Operators (DSOs) as customers.

In Section 4.5 we outline a SmartHG exploitation plan focusing on *Electricity Retailers* as customers.

4.2 SmartHG Platform TRL

The present section has the goal of assessing SmartHG Platform TRL. This is an essential step for the definition of an exploitation plan that is feasible from an economic as well as from a technological point of view.

4.2.1 TRL Table

Many, mostly similar, definitions for a system TRL are available. In the following we adopt the one from the European Commission (European Commission, *Technology Readiness Levels (TRL)*, HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 – Commission Decision C(2014)4995) and summarised in the following.

TRL 1 Basic principles observed

TRL 2 Technology concept formulated

TRL 3 Experimental proof of concept

TRL 4 Technology validated in lab

TRL 5 Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 6 Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 7 System prototype demonstration in operational environment

TRL 8 System complete and qualified

TRL 9 Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

4.2.2 TRL of SmartHG Platform

The *SmartHG platform* developed within the SmartHG project consists of a set of *integrated software services* aiming at reducing electricity costs for residential users by managing their energy demand in order to pursue the following, possibly conflicting, objectives:

- Reduce Electric Distribution Network (EDN) management costs, thereby providing a benefit for DSOs;
- Reduce electrical energy costs, thereby providing a benefit for *Electricity Retailers*;
- Reduce CO_2 emissions, thereby providing a benefit for the whole society.

The SmartHG platform consists of two main subsystems: the *SmartHG Grid Services* and the *SmartHG Home Services*. The former services focus on supporting DSOs in devising individualised *demand aware* time dependent power bounds (*power profiles*) for residential users in order to reduce EDN management costs. The latter services focus on efficient managing of home energy storage devices (such as batteries and Plug-in Electric Vehicle (PEV)) in order to support residential users in following the power profiles computed by the SmartHG grid services as well as *Electricity Retailers* in reducing electrical energy costs and CO_2 emissions.

Both grid and home services, in turn, consists of many subsystems. Accordingly, the TRL for the SmartHG platform is at most the minimum among the TRL of such subsystems.

Figure 4.1 shows TRL for each subsystem in the SmartHG platform as well as for the SmartHG platform itself. The nodes in the graph in Figure 4.1 are labelled with: the subsystem name and its TRL values at the beginning and at the end of the SmartHG project. The arrows in the graph denote the *subsystem* relationship. Thus the arrows outgoing from a node identify the subsystems of (the system associated to) that node.

Our analysis shows that at the beginning of the project the TRL for the SmartHG platform was 2 (by regarding SmartHG proposal as the *formulation of the technology concept* requested by TRL 2). At the end of the project SmartHG platform TRL is about 6.

Such an assessment stems from the following considerations. First, the SmartHG platform is a set of *software services* running on commercial (and thus with TRL 9) hardware. Second, a *relevant environment* (as required by TRL 6) for software is defined by the host machine(s) on which the software is running as well as from the data the software will be elaborating.

In our setting all SmartHG services have been implemented and demonstrated on a relevant environment. In fact, all SmartHG software services run on their target hardware (namely a Linux server for grid services and a Raspberry PI for home services) and have been evaluated on real world data gathered from our test beds. On such a basis, we evaluate to 6 the TRL currently attained by SmartHG software services. A more detailed analysis is presented in Appendix A.

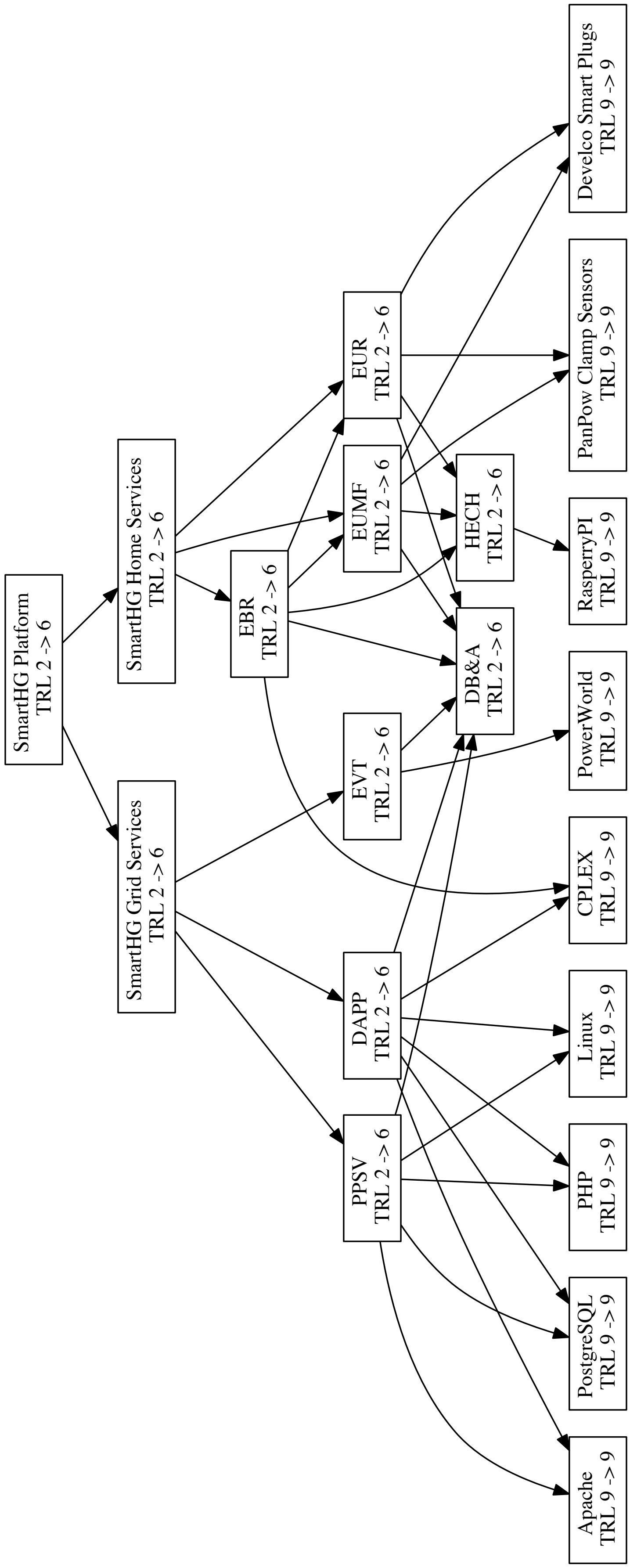

Figure 4.1: SmartHG Platform subsystems and their TRL.

4.3 Exploitation Opportunities Identified from SmartHG Evaluation

In this section we summarise SmartHG exploitation opportunities identified by our evaluation activity. This information will help us in defining a strategy to transform SmartHG technological achievements into economic and social benefits.

Section 4.3.1 outlines the costs incurred when adopting SmartHG technology. Any exploitation plan should generate enough revenues to cover such costs.

Section 4.3.2 outlines Transmission and Distribution (T&D) investment deferral enabled by the SmartHG platform. By comparing such figures with those in Section 4.3.1 we can identify a SmartHG exploitation plan seeing DSOs as the main customers for the SmartHG platform.

Section 4.3.3 outlines savings in electricity costs enabled by the SmartHG platform. By comparing such figures with those in Section 4.3.1, we can identify a SmartHG exploitation plan seeing *Electricity Retailers* as the main customers for the SmartHG platform. Of course a holding owning both a DSO *and* an Electricity Retailer may be able to harvest both type of economic benefits (T&D investment deferral *and* electricity cost saving).

Section 4.3.4 outlines savings in CO_2 emissions enabled by the SmartHG platform. Such savings can be achieved either when a DSO uses the SmartHG platform to optimise EDN management or when an electricity retailer uses the SmartHG platform to minimise electricity costs. Savings in CO_2 emissions is a benefit for the whole society that, using CO_2 certificates, can also become a further economic benefit for SmartHG customers (DSOs or Electricity Retailers).

Of course we do not expect residential users to take the lead in installing any device in their homes. Instead we envision that SmartHG customers (DSOs or Electricity Retailers) will install the needed equipment (sensors, computational devices and, above all, batteries) at user premises with a kind of leasing contract with the residential user. By sharing SmartHG economic benefits with residential users SmartHG customers will recover the cost of SmartHG infrastructure, get economic benefits and provide economic benefits to residential users.

4.3.1 SmartHG Deployment Costs

In this section, resting on our evaluation activity, we show (average) SmartHG deployment costs for residential homes as a function of household annual electricity consumption.

SmartHG deployment costs basically consist of the cost of the energy storage devices (i.e., batteries and power electronics), since sensor cost is negligible with respect to energy storage cost.

Figure 4.2 shows the distribution (y axis) of the annual consumption of electricity (x axis) for the households in Kalundborg SmartHG test bed. The aggregated data for the households considered in our Kalundborg test bed are the following:

- Number of households: 186.
- Total annual electricity consumption: 1422.65 MWh.
- Average annual electricity consumption: 7.65 MWh ($= \frac{1422.65}{186}$).
- Total battery capacity: 1.516 MWh.

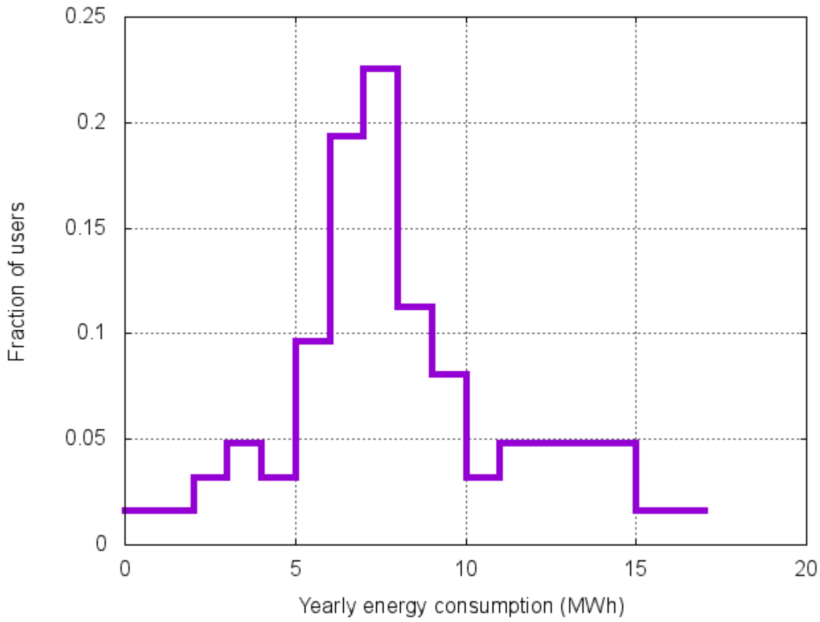

Figure 4.2: SmartHG household year electricity demand distribution.

- Average battery capacity: 8.15 kWh ($= \frac{1516}{186}$).
- Power rate of each battery: 2 kW.
- Total power rate of household energy storage: 372 kW ($= 2 \cdot 186$).
- Average battery capacity for each MWh of annual electricity consumption: 1.065 kWh/MWh ($= \frac{1.516 \cdot 1000}{1422.65}$).

Considering Lead-Acid batteries with a cost of about 300 EUR/kWh (this includes batteries as well as the power electronics needed to manage them) and an amortisation period of 10 years for energy storage costs, we have:

- Total energy storage cost: 454 800 EUR ($= 300 \cdot 1516$).
- Average energy storage cost for each MWh of annual electricity consumption: 320 EUR/MWh ($= \frac{454\,800}{1422.65}$).
- Amortised (over 10 years) average energy storage cost for each MWh of annual electricity consumption: 32 EUR/MWh.

Figure 4.3 shows, as a function of the annual household electricity consumption, the average SmartHG deployment costs. More specifically: the x-axis shows the annual household consumption (in MWh); the left y-axis shows the annual cost of SmartHG deployment assuming an amortisation time of 10 years; the right y-axis shows the battery capacity. For example, considering a household with an annual electricity consumption of 5 MWh, from Figure 4.3 we see (right y-axis) that we need on average a battery capacity of about 5 kWh which costs (left y-axis) about 160 EUR per year.

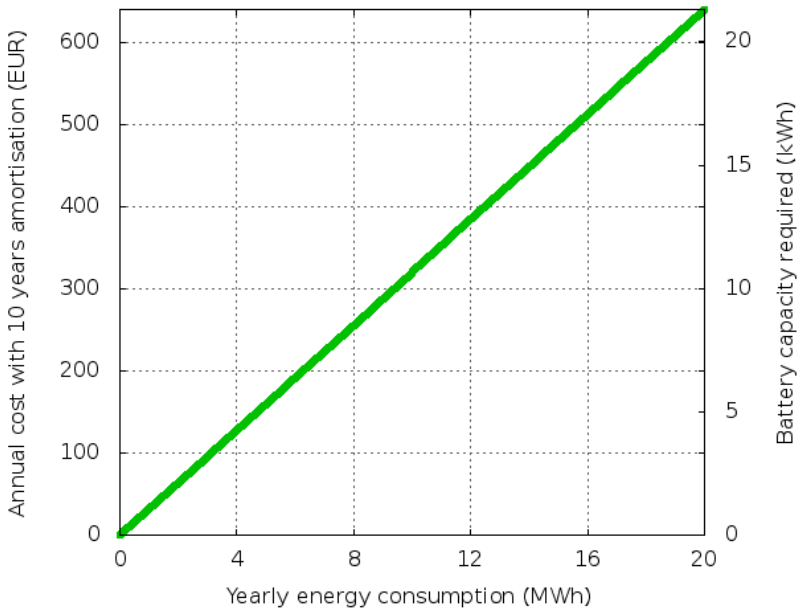

Figure 4.3: SmartHG average deployment costs (left y-axis) and average battery capacity (right y-axis) as a function of household annual electricity consumption (x-axis).

4.3.2 SmartHG Enabled T&D Investment Deferral

The SmartHG platform enables DSOs to optimise management of the EDN by exploiting SmartHG infrastructure deployed at residential homes, in order to move electricity demand (*peak shaving*) thereby reducing wear of EDN components (mainly transformers). Of course, the saving (due to T&D investment deferral) actually achieved depends on how much the EDN is actually stressed. For example, if electricity demand peaks are well below the nominal power of substation transformers, peak shaving brings no real benefit. On the other hand, if electricity demand peaks lead substation transformers to work for a long time well above their maximum power rate, then peak shaving will bring a benefit.

Thus, the actual saving yielded by peak shaving depends on the EDN operating conditions. For our purposes this can be modelled by saying that peak shaving will enable saving of a certain percentage of the electricity distribution cost charged to a residential customer.

In our analysis we consider the following electricity costs:

- Total electricity cost (tax included): 0.25 EUR/kWh.
- Energy cost (tax included): 0.11 EUR/kWh.
- Distribution cost (tax included): 0.12 EUR/kWh.
- Transmission cost (tax included): 0.02 EUR/kWh.

The above costs are slightly below current electricity costs in, e.g., Denmark and Italy, but provide meaningful electricity costs for most European countries. Figure 4.4 shows the T&D saving enabled by SmartHG for many plausible scenarios. On the x-axis we have the annual electricity consumption (in MWh) for a household, whereas on the y-axis the T&D saving enabled by SmartHG platform as a fraction p of the distribution cost.

We consider the following three scenarios.

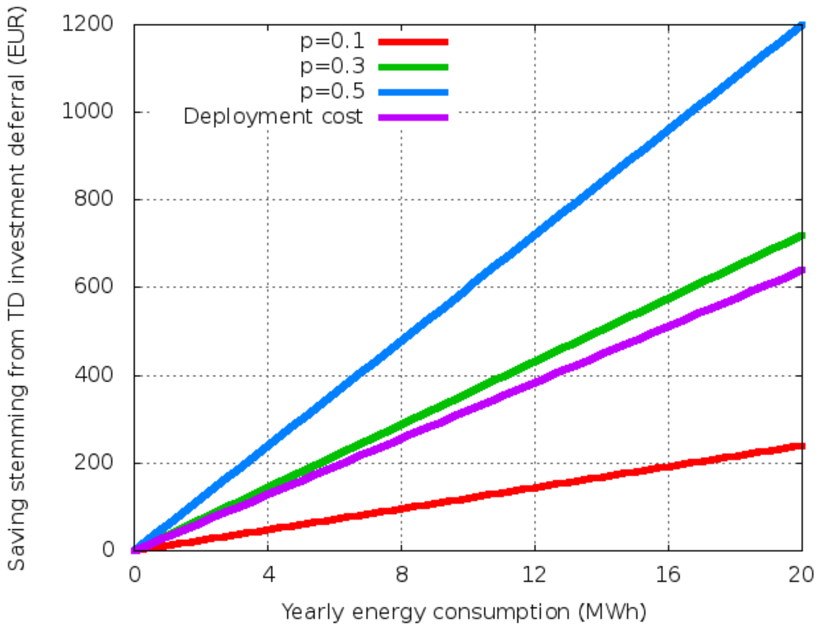

Figure 4.4: SmartHG enabled savings stemming from T&D investment deferral.

- Peak-shaving would just enable a 10% saving (EDN is not *stressed*) in distribution costs ($p = 0.1$). This yields an annual saving of about 12 EUR/MWh which is not enough to cover SmartHG average deployment cost (Section 4.3.1) of about 32 EUR/MWh per year.
- Peak-shaving would enable a 30% saving in distribution costs ($p = 0.3$). This yields an annual saving of about 36 EUR/MWh, which barely covers SmartHG average deployment costs.
- Peak-shaving enables a 50% saving (EDN is quite *stressed* and peak shaving substantially reduces wearing of EDN components) in distribution costs ($p = 0.5$). This yields an annual saving of about 60 EUR/MWh which covers SmartHG average deployment costs and yields a net saving of 28 EUR/MWh (that is about 40 000 EUR per year with our annual aggregated demand of 1422 MWh).

4.3.3 SmartHG Enabled Electricity Cost Savings

The SmartHG platform enables saving on the energy costs by leveraging on price differences during the day. That is, we can buy electricity when its price is low, store it and then use it when the electricity price is high (*arbitrage*).

Using the day-ahead electricity prices for the Denmark (DK2) market from the Nord Pool Spot (`http://www.nordpoolspot.com/`) we can compute the electricity cost (without taxes) from our historical data. Resting on our test bed data, we compute final (i.e., tax included) energy prices for customers from day-ahead prices by multiplying for 2.875 (which accounts for taxes and leverages). Accordingly, the electricity cost (tax included) for the above scenarios is: 136 823 EUR.

Using the very same data, we can compute (tax included) electricity cost when using the SmartHG platform (namely, the SmartHG Home Services) to minimise energy costs. This amounts to: 53 252 EUR.

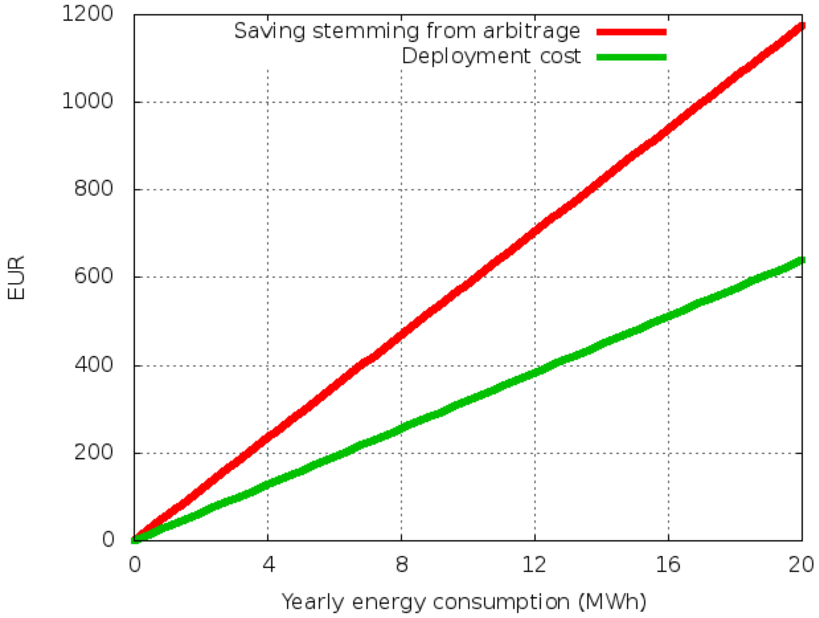

Figure 4.5: SmartHG enabled savings stemming from arbitrage.

Thus the saving, for residential users, enabled by the SmartHG platform is 83 571 EUR (i.e., a 61% saving). Considering (see Section 4.3.1) that the annual aggregated demand is 1422 MWh we get an average annual saving of about 58.77 EUR/MWh. This covers the annual SmartHG deployment cost of 32 EUR/MWh and yields a net annual saving of 26.77 EUR/MWh (that is about 38 066 EUR per year with our annual aggregated demand of 1422 MWh).

Figure 4.5 summarises the above computation. More specifically, on the x-axis we have the annual electricity consumption (in MWh) for a household, whereas on the y-axis we have the average saving (tax included) achievable by using the SmartHG platform.

We note that by using batteries and the control strategies in the SmartHG platform we can also increase the amount of self-consumption for residential homes equipped with PhotoVoltaic (PV) panels. Typically this takes self-consumption from 30% (without batteries) to 60% (with batteries). Even with a small size PV installation producing about 3.3MWh per year, this means taking self consumption from about 1MWh per year to about 2MWh per year. When there are no incentives (the case more and more common in Europe) this yields a money saving of almost 250 EUR per year (the cost of 1MWh in our setting) for each household equipped with PV panels.

4.3.4 SmartHG Enabled CO_2 Emission Savings

The SmartHG platform enables saving on CO_2 emissions by leveraging on the fact that the amount of CO_2 emissions needed to produce a MWh of electrical energy changes during the day, and such figures are known beforehand.

Using SEAS data for Denmark market, we can compute the CO_2 emissions from historical data of our Kalundborg test bed. This amounts to: 408 163 Kg. Considering (see Section 4.3.1) that the annual aggregated demand is 1422 MWh, we get an average value for CO_2 emissions of about 287 Kg/MWh.

Using the very same data, we can compute CO_2 emissions when using the SmartHG platform (namely, the SmartHG Home Services) to minimise CO_2 emissions. This amounts

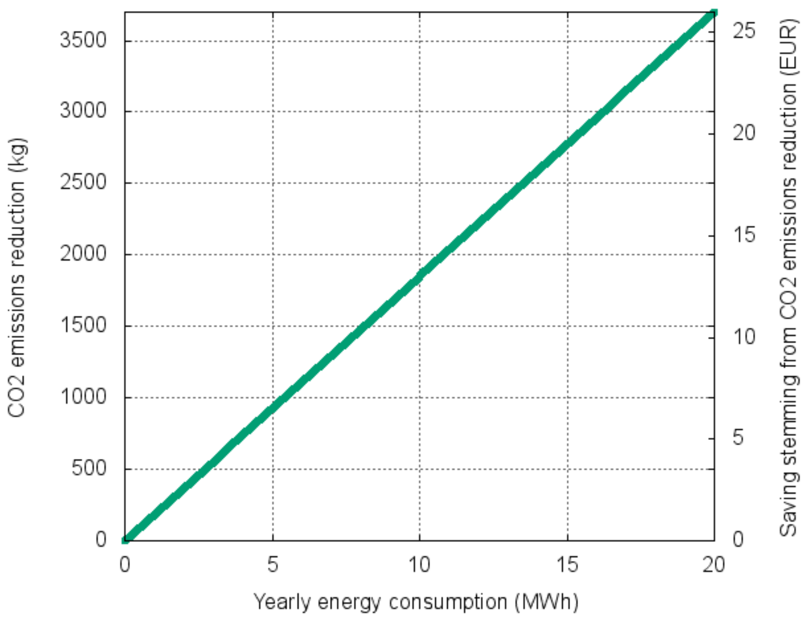

Figure 4.6: SmartHG enabled reduction in CO_2 emissions.

to: 144 910 Kg. This yields a saving of 263 253 Kg in CO_2 emissions. Furthermore, reasoning as above, we get an average value for CO_2 emissions of about 102 Kg/MWh.

Thus, on average, the saving in CO_2 emissions enabled by the SmartHG platform is 185 Kg/MWh, that is a 64.50% reduction in CO_2 emissions.

Furthermore, we should consider that CO_2 emissions can be traded. For example, using the data from the *Nord Pool Spot* (`http://www.nordpoolspot.com/`) we see that, presently, the CO_2 emission price in Denmark is about 7 EUR/tCO_2.

Thus, the money saving from CO_2 emission reduction enabled by the SmartHG platform is about 1842 EUR ($= 263.253 \cdot 7$) which translates into about 1.3 EUR/MWh ($= \frac{1842}{1422}$).

Of course, reducing EDN operation cost (Section 4.3.2), electricity cost (Section 4.3.3), and CO_2 emissions are conflicting goals. The SmartHG platform enables stakeholders to decide the best trade-off among such conflicting objectives.

Since SmartHG enabled CO_2 emission reduction does not cover the cost of SmartHG infrastructure, we foresee that EDN operation and electricity cost reductions will be the driving force for SmartHG adoption. CO_2 emission reduction will come as an extra benefit for the society as a whole.

Figure 4.6 summarises the above considerations. More specifically: on the x-axis we have the annual electricity consumption (in MWh) for a household; on the left y-axis we have the average saving of CO_2 emissions achievable by using the SmartHG platform; on the right y-axis we have the average economic gain stemming from the above saved CO_2 emissions.

4.4 Exploitation Strategy

In this section we identify the technological and economic issues to be addressed in order to bring the SmartHG platform to the market. Resting on such considerations in Section 4.5,, we outline SmartHG energy oriented exploitation plan that sees electrical energy retailers as main customers, whereas in Section 4.6 we outline SmartHG grid oriented exploitation plan that sees DSOs as main customers.

4.4.1 Technological Issues

From Section 4.2 we note that the SmartHG research project took the SmartHG platform from the technology concept outlined in the project proposal (say, TRL 2) to a technology demonstrated in a relevant environment, that is TRL 6. While this clearly shows the technological feasibility of SmartHG technology, a TRL of 9 is needed to put the product on the market. Thus, our exploitation plan should envisage an effective way to take SmartHG technology from the current TRL 6 to the needed TRL 9. The best way to attain such a result appears to be through a research project such as an H2020 project or a privately funded project. National project are also a possibility but may be hard to accommodate SmartHG international consortium within a purely national framework. A mix of the above is, of course, also a possibility. Accordingly, our exploitation plan will outline the issues to be addressed to take SmartHG technology from TRL 6 to TRL 9.

4.4.2 Economic Issues

Section 4.3.2 suggests an exploitation plan for the SmartHG platform focusing on optimising EDN management. Of course, the SmartHG customers for such a *grid focused* exploitation plan are mainly DSOs.

Section 4.3.3 suggests an exploitation plan for the SmartHG platform focusing on minimising electrical energy costs. Of course, the SmartHG customers for such an *energy focused* exploitation plan are mainly electrical energy retailers.

We discussed the above opportunities with many DSOs and retailers. In the following we summarise the outcome of such discussions.

While all DSOs agree that at some point in the future the distribution network will be stressed to the point that the saving from the SmartHG technology will be interesting, as for now it is not obvious that this is the case, also taking into account the reduction in electricity consumption triggered by the economic crisis. Accordingly, we regard the grid focused exploitation plan as a *medium term* exploitation opportunity.

Presently the electrical energy retail market is a quite competitive one with retailers working hard to attract customers by offering competitive energy prices as well as energy services. The point is that, while residential users may easily switch from one retailer to another one, this is not the case for their DSO. Accordingly, no matter the retailer selected by a residential user, the DSO will typically stay the same. Retailers are thus quite interested in technologies that may allow them to attract new customers. In such a setting, the cost saving enabled by the SmartHG home services appears of course quite interesting to retailers, also considering the fact that selling locally generated electricity (e.g., from PV) to the grid is not incentivised anymore in many European countries. Accordingly, we regard the energy focused exploitation plan as a *short term* exploitation opportunity, since the market appears ready for it.

4.5 SmartHG Exploitation Plan Towards Retailers

In this section we present our SmartHG exploitation plan that sees *Electricity Retailers* as the main customers for the SmartHG platform.

SmartHG energy oriented exploitation plan focuses on using SmartHG Home Services to reduce, for each household, the cost of electrical energy by storing energy when its price is low and by using stored energy when the energy price is high (*arbitrage*).

The economic advantages of such an approach have been described in Section 4.3.3. However, to bring forward such advantages, we need to take the TRL of SmartHG Home services from the present value (about 6, see Section 4.2) to value 9, needed to put the technology on the market. Accordingly, in the following we outline the obstacles we face, the steps we plan to overcome them, and potentially interested enterprises we have contacted, besides those in the SmartHG consortium, to support such actions.

4.5.1 Attaining TRL 7

To attain TRL 7 we need to demonstrate SmartHG home services in an operational environment.

In our setting an operational environment consists of many residential homes equipped with the hardware and software needed to support SmartHG home services.

To install SmartHG home services in residential homes we need to install in *each* home in the test bed: a battery system, an inverter, battery sensors as well as SmartHG software (namely, Energy Bill Reduction (EBR), Energy Usage Modelling and Forecasting (EUMF), Energy Usage Reduction (EUR)) controlling charging/discharging of the battery accordingly to SmartHG policy.

We note that, while SmartHG sensors have been already deployed at homes, this is not the case for the actuation hardware and its controlling software. In fact, to save on hardware money, during the SmartHG project we have interfaced our SmartHG home services with the batteries and inverters at IMDEA Micro grid, where we have also tested SmartHG home services using measurements gathered from our test beds in Kalundborg and Israel.

However, a typical operational environment will consist of inverters and batteries (possibly of different brands) in each home. Accordingly, we need to extend SmartHG interface software so that it can interface not just with IMDEA Micro grid inverter but also with some widely used inverter (battery charge/discharge is typically controlled through the inverter, thus interfacing with inverters is basically all we need). Accounting for at least two inverter brands in our operational environment is important in order to test *vendor neutrality* of the overall SmartHG platform.

In the following we outline our plan to address the above issues.

4.5.1.1 Battery Systems

We have identified two enterprises offering battery systems suitable for our purposes: Tesla and Mercedes-Benz.

Tesla produces PowerWall (`http://www.teslamotors.com/powerwall`) that meets our needs because of its price (about 3000 EUR), its small size (important to fit residential home space constraints), its 10 year guarantee, its neutrality with respect to the inverter to which it has to be connected. Furthermore, PowerWall model with 7kWh capacity and 2KW power rate would nicely fit most of the households in our test bed (see Section 4.3.1).

Recently (June 2015) also Mercedes-Benz has announced an interesting home battery system (http://www.theverge.com/2015/6/9/8752791/mercedes-benz-daimler-home-battery) that could be considered in our scenario.

We have contacted both Tesla and Mercedes-Benz to address interfacing issues of the systems they provide with our SmartHG platform.

4.5.1.2 Inverter Systems

We have identified three enterprises offering inverters, sensor and open interfaces suitable for our purposes: SolarEdge, SMA and Victron.

SolarEdge has specific integration plans with the PowerWall system (e.g., see http://www.solaredge.com/groups/products/storedge), this may considerably ease integration issues.

SMA offers a charger/inverter for which sensors and interfaces are available: Sunny Island (http://www.sma.de/en/products/battery-inverters/sunny-island-60h-80h.html). This can considerably ease integration with the SmartHG services controlling the battery charge/discharge.

Although Victron (http://www.victronenergy.com/inverters-chargers) main focus so far has been on the industrial (marine) market, it offers a quite open and modular system that also nicely matches our goals.

We have already contacted SolarEdge, Victron and SMA to verify the possibility of interfacing external software (SmartHG software in our case) with their equipment.

We think that a demonstration in an operational environment should involve around 200 houses. Assuming a cost of about 5K EUR (including installation) per home, we should consider about 1M EUR for the demonstration costs in our project to bring SmartHG to the market.

4.5.1.3 Interfacing

To complete the SmartHG services we basically need to develop interfaces towards the inverter systems we decide to support. In order to verify *vendor neutrality* of the pursued approach we should have at least two brands in our foreseen operational environment.

Development of interface software can be done with the same approach we used to interface to DEVELCO Smart Plugs that have sensors as well as actuators. Accordingly, we anticipate that this work can be easily done within the SmartHG consortium. Of course, at least initially, we will focus on inverters used in the foreseen test bed in order to avoid wasting too much time in building interfaces that will not be used in the test bed.

4.5.2 Attaining TRL 8

To attain TRL 8 we should complete our system and qualify it.

A complete system has been basically built with the activities planned to reach TRL 7. Here we focus on qualification. In our setting, this entails evaluating the SmartHG platform on more than just one operational environment and finally testing the software in order to attain a given degree of reliability.

4.5.2.1 Operational Environments

In order to enable evaluation of the SmartHG platform in a variety of operational environments, we discussed our project with many electricity retailers (most of them part of a holding owning also a DSO) as well as energy management companies as described in the following.

First, of course, we discussed our plans with SEAS-NVE (`http://www.seas-nve.dk/`) and MinskEnergo (`http://www.minskenergo.by/`) since they are part of SmartHG consortium.

Second, during the SmartGridComm 2014 conference (November 2014) in Venice, we discussed our plans with IBM Zurich (`http://www.zurich.ibm.com/`) and E.ON (`http://www.eon.com/en.html`), who presented preliminary results of an internal project of theirs, pursuing the same approach of SmartHG: exploit demand-awareness to optimise management of home devices (storage heaters in their case).

Third, during FP7 project *Advanced* workshops in Madrid (September 2014) and Rome (November 2014) we discussed our plans with ENEL (`https://www.enel.it/it-it/azienda`), EDP (`http://www.edp.pt`) as well as with energy market analysis company VaasaETT (`http://www.vaasaett.com/`), and energy management and aggregator Entelios (`http://entelios.com/`).

Fourth, during the Smart Grid workshop organised by IMDEA (September 2015) we discussed our plans with: the electricity retailer Energrid (`http://www.energrid.it/`).

4.5.2.2 Testing SmartHG Home Software

System qualification requires a careful testing of the system. The SmartHG software managing home batteries is not a safety critical system since batteries are protected from overcharging by the Battery Management System (BMS). However, a malfunctioning of the SmartHG home software may decrease the revenues expected from it. Accordingly, it has to be regarded as a *mission critical* system, that is, one whose malfunctioning may entail loss of money.

Furthermore, we should keep in mind that the SmartHG home services are to be considered *autonomous systems* since they have to behave correctly even when the Internet connection is lost (otherwise we may have the situation where a loss of Internet connection may result in a home blackout).

To carry out such a testing activity we have already contacted an enterprise specialised in testing software for autonomous systems (e.g., for space, defence and automotive): NEXT (`www.next.it`).

4.5.3 Attaining TRL 9

To attain TRL 9 we should prove our system in its operational environment.

In our context, after the activities planned to reach TRL 8, this just means running for 6 months or more the SmartHG home services in the operational environments identified in Section 4.5.1 and 4.5.2 and evaluate the data gathered from a technical as well as economic point of view.

4.5.4 Bringing SmartHG to Electricity Retailer Market

At the end of the project outlined above we will have a complete qualified system (TRL 9) whose economic profitability has been shown in an operational environment. Customers are also identified (retailers). However, in order to bring SmartHG technology to the market we need a company that actually takes care of this. A natural way of doing this is to start a company dedicated to the development and commercialisation of SmartHG technology.

IP of SmartHG services is regulated by SmartHG consortium agreement. On such a basis, we can define partner roles and shares in such a foreseen enterprise.

While the above analysis shows the advantages for the customer (retailer) of the SmartHG platform, in order to bring SmartHG technology to the market we also need to make sure that this activity is profitable also for the above mentioned enterprise providing the SmartHG technology. This is addressed in the following, details are in Appendix B.

From Section 4.3.3 we know that we can expect an electricity cost saving of about 26.77 EUR/MWh, that is 26.77 EUR for each MWh of annual household electricity consumption. Such a saving is basically the profit that has to be shared among: the residential user (to motivate him/her to install SmartHG devices at home), the retailer (to motivate it to participate in such a schema), the ICT enterprise providing SmartHG technology.

Assuming an equal share (for sake of simplicity), we have that the ICT company gets (yearly) about 9 EUR/MWh with which we need to cover hardware costs, computational costs, personnel costs.

An analysis of the profitability from the technology provider point of view is presented in Appendix B.

Shortly, providing SmartHG home services costs about 10 EUR/year per user. From Section 4.3.1 we have that the average annual electricity consumption of a user is about 7.65 MWh. Accordingly, we have that the SmartHG service cost is on average ($\frac{10}{7.65} =$) 1.31 EUR/MWh per year.

Taking such a cost away from the 9 EUR/MWh estimated above, we have a net revenue of 7.69 EUR/MWh. This means, for example, that for each 1000 households adopting the SmartHG home services we get on average an annual return of about ($1000 \cdot 7.65 \cdot 7.69 =$) 58.80 KEur. As for electricity retail, 1000 households has to be considered a modest number of customers. So the above computation shows that we do not need a huge number of customers to make the SmartHG business opportunity attractive for ICT enterprises providing the SmartHG technology.

4.6 SmartHG Exploitation Plan Towards DSOs

In this section we present our SmartHG exploitation plan that sees DSOs as the main customers for the SmartHG technology.

SmartHG DSO oriented exploitation plan focuses on exploiting SmartHG grid services to optimise EDN management. This is done by using a hierarchical approach where: the higher network levels (e.g., substations) provide constraints to be met; the SmartHG grid services compute, from such constraints, power profiles for the lower network levels (e.g., households); SmartHG home services are used to steer power demand on the lower network levels (namely, residential homes) so that the given power profile constraints are met.

Accordingly, although we are focusing here on exploitation of SmartHG grid services, we need anyway to have the SmartHG home services in place to implement demand side management (accordingly to goals set by SmartHG grid services).

SmartHG grid services are used to compute power profiles for the lower levels in the network hierarchy (e.g., households) on the basis of the network topology and higher network level (e.g., substations) constraints, whereas SmartHG home services are used to drive lower network levels.

An exploitation plan for SmartHG home services has been presented in Section 4.5 where also deployment of SmartHG home services has been discussed. Such a deployment can take place *before* or *together* with that of the SmartHG grid services. Accordingly, in this section we focus on presenting an exploitation plan for SmartHG grid services assuming availability of SmartHG home services.

The economic benefits that a DSO can harvest from SmartHG grid services have been discussed in Section 4.3.2. However, much as for SmartHG home services, to bring forward such advantages we need to take SmartHG grid services TRL from the present value of 6 (Section 4.2) to the value of 9 needed to put the technology on the market. Accordingly, in the following we outline the obstacles we face to reach such a goal as well as the actions we plan to overcome them along with potentially interested enterprises we have contacted, besides those in the SmartHG consortium, to support such actions.

4.6.1 Attaining TRL 7

To attain TRL 7 we need to demonstrate SmartHG grid services in an operational environment. In the following we discuss the steps needed to attain TRL 7 from the current implementation of SmartHG grid services.

The starting point for the computations in the SmartHG grid services is the EDN topology. This is an input to the SmartHG grid services.

Ideally, such information could be exchanged with DSOs using the Common Information Model (CIM) standard as defined by IEC 61970-301 and IEC 61968 along with its XML format for network model exchanges as defined by IEC 61970-501 and 61970-452.

Although many DSOs are currently in the process of adopting network management software based on CIM standard (in order to have an open interface towards other systems) it is not the case that all DSOs currently run CIM based network management software.

SmartHG approach will be that of offering a CIM based interface to DSOs and then work together with them to interface towards proprietary formats as needed. Thus, in order to experiment with several operational scenarios, we will need to involve in our exploitation activities several DSOs along with enterprises working on electricity distribution management software.

4.6.1.1 Adding Operational Environments

In order to enable evaluation of the SmartHG platform on many operational environments, we discussed our project with the following DSOs.

First, of course, we discussed our plans with SEAS-NVE (`http://www.seas-nve.dk/`) and MinskEnergo (`http://www.minskenergo.by/`) since they are part of SmartHG consortium.

Second, during the SmartGridComm 2014 conference (Nov. 2014) in Venice we discussed our plans with Elektro Gorenjska (`http://www.elektro-gorenjska.si/`, Slovenia DSO).

Third, during FP7 project *Advanced* workshops in Madrid (September 2014) and Rome (November 2014) we discussed our plans with ENEL Distribution (https://eneldistribuzione.enel.it/), ERDF (http://www.erdf.fr/), RWE (https://www.rwe.com/web/cms/en/8/rwe/) EDP (http://www.edp.pt).

Fourth, during the Smart Grid workshop organised by IMDEA (September 2015) we discussed our plans with: IBERDROLA (http://www.iberdrola.es/inicio#) and Gas Natural Fenosa (http://www.gasnaturalfenosa.com).

4.6.1.2 Electricity Distribution Management Software

In order to evaluate the SmartHG platform interface with the electricity distribution management software installed at DSO premises, we are discussing our plans with enterprises working on such a software, namely: PSI (http://www.psi.de/en/home/, producing the software currently installed at SEAS), INDRA (http://www.indracompany.com/en/industries/energy), Schneider-Electric http://www.schneider-electric.us/en/product-category/54300-network-management-software/) ALSTOM (http://www.alstom.com/grid/products-and-services/electrical-network-systems/electrical-distribution-management). General Electric (https://www.gedigitalenergy.com/uos/catalog/poweron_fusion.htm).

Both INDRA and General Electric participated in the Smart Grid Workshop in Madrid organised by IMDEA in September 2015.

4.6.2 Attaining TRL 8

To attain TRL 8 we should complete our system and qualify it. In the following we outline the steps we foresee to reach such a goal.

First, we need to have interfaces towards measurements from the field so that SmartHG grid services can always have an updated picture of the network status. To this end, during the SmartGridComm 2014 conference (November 2014) we discussed our plans with an enterprise in the field, namely SIRTI (http://www.sirti.it/EN/Pagine/default.aspx).

Second, we note that most of the SmartHG software services will run in the cloud. Accordingly, in order to complete the SmartHG platform, its services should be deployed in the cloud. In order to support such a goal we discussed our plan with Haugstad & Terkelsen (http://haugstad-terkelsen.com/home/), an enterprise actively working towards developing cloud based software services and acquainted with SmartHG approach since one of its co-founders was previously in the SmartHG consortium.

Third, system qualification requires a careful testing of the system. We note that the SmartHG software affects the operation of the electrical grid. Thus, a software malfunctioning may entail a loss of money (safety is not much of an issue in our context since substations and batteries have protections of their own). For the above reason our SmartHG grid services have to be regarded as a *mission critical* system. Accordingly, in order to carry out testing of the SmartHG software accordingly to mission critical software standards, we have discussed our plans with NEXT (www.next.it), an enterprises specialised in testing of mission critical software with whom UNIROMA1 has a long-standing relationship stemming from aerospace related project activities.

4.6.3 Attaining TRL 9

To attain TRL 9 we should prove our system in its operational environment.

In our context, this just could mean running for 6 months or more the complete system (from Section 4.6.2) in our test beds (from Section 4.6.1) and evaluate the data gathered from a technical as well as economic point of view.

4.6.4 Bringing SmartHG to DSO Market

At the end of the activities outlined in the previous sections, we need to actually bring SmartHG technology to the market.

IP from SmartHG is regulated by the SmartHG consortium agreement. On such a basis, we can define partner roles and shares for the enterprise(s) that will bring the SmartHG grid services to the market.

Section 4.3.2 shows the advantages for the SmartHG customer (DSO), while the present section so far has outlined the steps needed in order to bring the SmartHG technology to the market. However, in order to make this plan come true, we need to make sure that there is indeed a profit also for the ICT enterprise that will take the SmartHG platform to the market and not just for SmartHG customers. This is addressed in the following, details are in Appendix B.

Of course, we focus on the case in which peak-shaving would yield a substantial benefit to the EDN, say a 50% saving in electricity distribution cost. From Section 4.3.2 we see that this yields a net saving (i.e., after having paid back deployment of SmartHG platform infrastructure) of about 28 EUR/MWh, that is 28 EUR for each MWh of annual household electricity consumption. Such a saving is basically the profit that has to be shared among: the residential user (to motivate him/her to install SmartHG devices in his home), the DSO (to motivate it to participate in such a schema), the ICT enterprise providing SmartHG technology.

Assuming an equal share (for sake of simplicity), we have that the ICT company gets (yearly) about 9 EUR/MWh with which we need to cover hardware costs, computational costs, personnel costs.

An analysis of the profitability from the technology provider point of view is presented in Appendix B.

Shortly, providing SmartHG grid services (using a cloud based infrastructure) costs about 0.30 EUR/year per user. Assuming (see Section 4.3.1) that the average annual electricity consumption of a user is about 7.65 MWh, we have that the SmartHG service cost is on average ($\frac{0.30}{7.65} =$) 0.039 EUR/MWh per year. To be on the safe side, we heavily overapproximate such a cost to 1 EUR/MWh.

Taking the above cost away from the 9 EUR/MWh estimated above we have a net revenue of 8.0 EUR/MWh. This means, for example, that for each 1000 households adopting the SmartHG home services we get on average an annual return of about ($1000 \cdot 7.65 \cdot 8.0 =$) 61.20 KEur. We note that, as for electricity distribution, 1000 households has to be considered a modest number of customers in our context. So the above computation shows that we do not need a huge number of customers to make the above described business opportunity attractive for ICT enterprises providing the SmartHG technology.

Chapter 5

Conclusions

According to the dissemination plan developed in the first year, SmartHG dissemination activities devised many different ways to reach the target audience. The consortium was able to concretise the dissemination plan with a strategy agreed by all partners.

Besides a responsive website, SmartHG communication tools include: event list, newsletter, mailing lists, social network accounts and more classical approaches such as participation at conferences and publications in international peer-reviewed papers in conferences or journals. Second year networking activity was also very important since provided us with data about Plug-in Electric Vehicle (PEV) to be used in our evaluation, and also provided very useful feedbacks about project using demand-aware price policy approaches similar to that of SmartHG.

Focusing on a medium term scenario (where *peak shaving* is a need for Distribution System Operators (DSOs)) we defined exploitation plans for all SmartHG services. Furthermore, when meaningful, we validated our envisaged exploitation plans by identifying quantitative exploitation scenarios and estimating revenues and break even points.

This section is divided in three parts. First of all, in Section 5.1 we compare this year SmartHG dissemination and exploitation activities with their first year versions (Deliverable D7.1.1). Then, in Section 5.2 we discuss the limitations of this year iteration of such activities, and we outline the foreseen work to be done in the third year.

5.1 Advancements

The dissemination activities in the first year consisted in preparing the first version of the project Web site and in disseminating project results at international conferences and publications. This year dissemination activities, besides improving the project Web site and continuing to disseminate project results at international conferences and publications, also encompasses networking with other international projects on the same topic as SmartHG, which allowed us to also improve both Intelligent Automation Services (IASs) design and evaluation.

The exploitation plan prepared in the first year consisted in identifying the market opportunities offered by SmartHG IASs, also encompassing a Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis of the same IASs. This year activity extends such initial study by presenting an exploitation plan for each SmartHG IASs.

5.2 Limitations and Future Work

The exploitation plan described in this document focuses on a medium term scenario where *peak shaving* is the driving force for the business model of SmartHG services. During our third year we plan to identify *short term* exploitation plans for SmartHG services. That is, exploitation plans that do not depend on the assumption that *peak shaving* is the main problem to be addressed. Furthermore, our third year networking activity will focus on commercial stakeholders and elaboration with them of short and medium term exploitation plans.

During the last period of the project, we expect an increasing number of scientific publications about project results by project partners, as well as an increasing number of presentations of SmartHG in scientific events.

In May 2015, there will be a workshop and a dissemination event in Svebølle and Kalundborg (Denmark test-bed), which will bring together researchers, public and private stakeholders, and industries. Furthermore, the participation of the stakeholders from the Covenant of Mayors is foreseen. The workshop will be an occasion to disseminate and discuss project results and envision further developments and cross-fertilisations with the Covenant of Mayors community, as well as with the Smart Grid community at large.

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Appendix A

Assessing Technology Readiness Level (TRL) for SmartHG Services

A.1 SmartHG Platform TRL

The SmartHG project develops a suite of *integrated software services* (the *SmartHG Platform*) aiming at steering residential user energy demand in order to:

- Keep operating conditions of the electrical grid within given healthy bounds,
- Minimise energy costs,
- Minimise CO_2 emissions.

This is achieved by exploiting knowledge (*demand awareness*) of habits (as for electrical energy production/consumption) of residential users as gained from SmartHG sensing and communication infrastructure.

The *SmartHG Platform* (Figure A.1) consists of a set of integrated *software services* supporting management of the Electric Distribution Network (EDN) (*SmartHG Grid Services*) as well as of the home devices (*SmartHG Home Services*) along with a communication infrastructure enabling reliable and secure communication among such services.

SmartHG approach consists of a two-tier hierarchical control schema. At the top tier (Figure A.2) the Distribution System Operator (DSO) sets operational constraints for the EDN and gets from the SmartHG Platform (Grid Services) a *power profile* (i.e., time dependent power constraints) for each residential user. At the bottom tier (Figure A.3), the SmartHG Platform (Home Services) monitors and control home devices (namely energy storage devices) in order to keep at each time the home power demand within its given power profile.

The SmartHG platform is fully automatic from a residential user perspective. That is, no involvement is expected from the user. Demand steering is achieved by controlling energy storage devices, namely batteries installed to support SmartHG as well as batteries from Plug-in Electric Vehicle (PEV).

The SmartHG home services control charge and discharge of home batteries in such a way that the home power demand to the EDN meets the power constraints provided by the DSO for that home. Of course, effective planning of battery usage requires forecasting of future energy needs for the home. Accordingly, SmartHG home services also provide home energy usage forecasting capabilities.

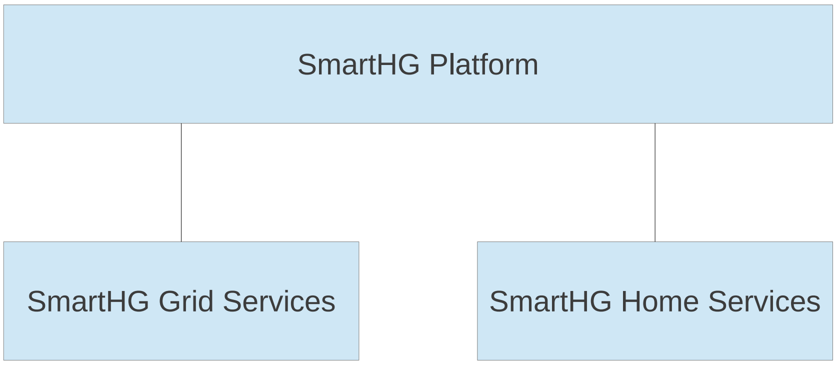

Figure A.1: The SmartHG Platform and its main Services

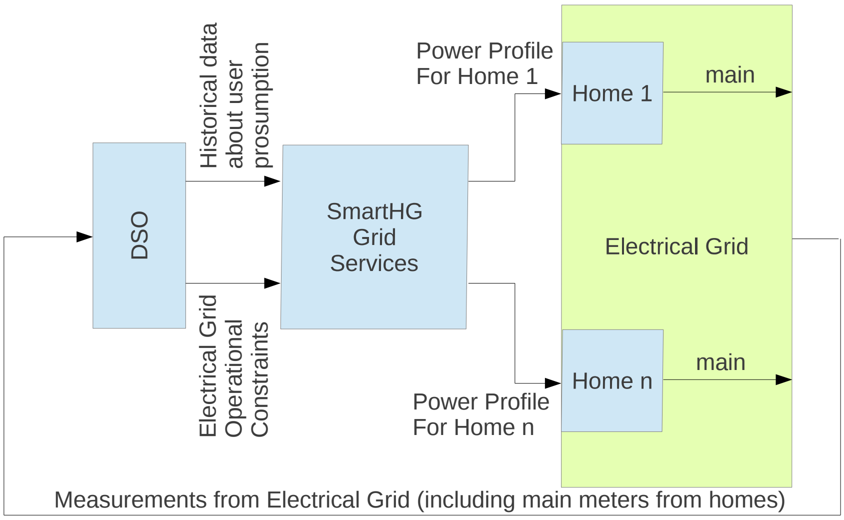

Figure A.2: SmartHG Services for Grid Operators

In order to control home energy storage devices, SmartHG home services measure the home main meter, status of the batteries, local generation (if any), energy consumption from home appliances (to improve forecasting quality).

Note that no data about home usage of appliances need to be sent outside the home in our two-tier approach. Indeed, once the power constraints from the DSO are received, SmartHG home services can work even without Internet connection (power constraints will not be updated then) making them, as a matter of fact, *autonomous systems*.

Experimentation with energy storage devices cannot be done at the home premises. Accordingly we use a Micro grid to experiment with actuation. To this end we have a dedicated test facility at IMDEA Smart Energy Integration Lab (SEIL) where we drive Micro grid loads using sensor data from SmartHG home test-beds and we drive Microgrid batteries using data from PEV usage (recorded from the Danish project Test-an-EV) and SmartHG services. This allows us to carry out experiments with actuation much as if we were in one of the homes in our test-beds equipped with a PEV and a battery.

This accounts for the three top nodes in Figure 4.1 assuming correctness of the TRL evaluation for SmartHG grid and home services. TRL for both such subsystems will be discussed in the following sections.

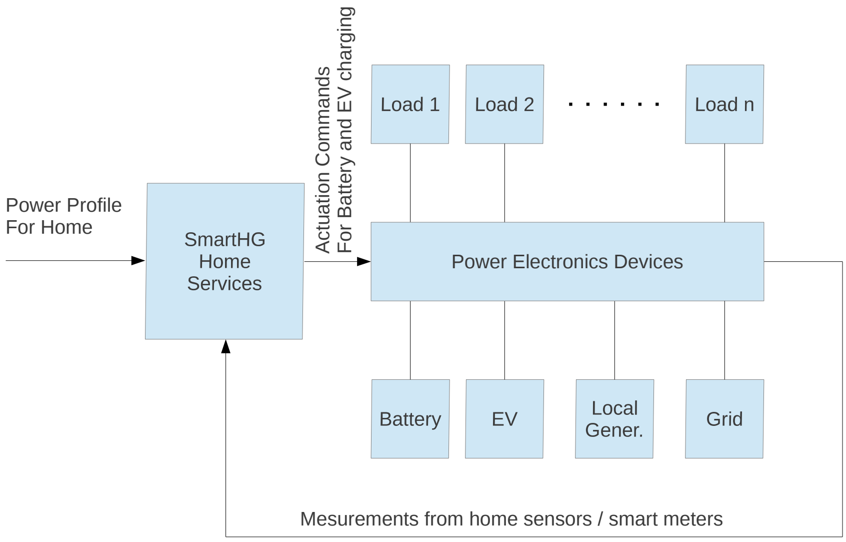

Figure A.3: SmartHG Services for Residential Users

A.1.1 SmartHG Grid Services

SmartHG Grid Services have four main goals:

- Enable secure storage of household main metering data outside DSO computing infrastructure (this is mandatory in many current regulations) as well as of data gathered by SmartHG sensors and provide an open protocol to access such data. This is done by the Database and Analytics (DB&A) grid service.
- Support the DSO in identifying power constraints for each EDN substation of interest. This is done by the EDN Virtual Tomography (EVT) grid service.
- Support the DSO in computing a power profile for each residential home connected to a substation of interest, starting from substation power constraints identified by the EVT grid service. This is done by the Demand Aware Price Policies (DAPP) grid service.
- Support the DSO in evaluating *robustness* (e.g., with respect to variations in electricity demand from residential users) of power profiles computed by the DAPP service. This is done by the Price Policy Safety Verification (PPSV) grid service.

In the following we evaluate TRL for each SmartHG grid service.

A.1.1.1 DB&A TRL

The DB&A service provides secure data storage for all SmartHG services along with a RESTful open protocol to access such data. This is needed to provide effective communication among services as well as to experiment with secure main meter data storage outside DSO computing infrastructure.

The DB&A is implemented on top of PostgreSQL (`http://www.postgresql.org/`) DBMS using JSON (`http://json.org/`) format to exchange data using an open RESTful protocol. Both PostgreSQL and JSON are well established products, thus we estimate their TRL to be 9. The current implementation of DB&A has been successfully evaluated by interfacing it with systems from SEAS, DEVELCO and Panoramic Power as well as with all SmartHG services. Since this is a relevant environment for DB&A we estimate DB&A TRL to be 6.

Furthermore, data storage has also been implemented on the Home Energy Controlling Hub (HECH) devices developed within the SmartHG project. Such a device consists of a Raspberry PI (whose TRL is 9, being a commercial product) with Linux running on it. The HECH has been deployed in homes within the Kalundborg test bed and tested there. Accordingly, also the HECH has achieved a TRL of 6.

A.1.1.2 EVT TRL

The EVT service takes as input the EDN topology as well as available measurements from EDN sensors. It returns as output voltage, current and power values for EDN nodes where sensors are not available. This enables the DSO to analyse the status of the whole EDN and to set suitable power constraints on substations.

EVT rests on the PowerWorld simulator (`http://www.powerworld.com`) to carry out EDN analysis. PowerWorld is a well established commercial product, thus we estimate its TRL to be 9. The current implementation of EVT has been successfully evaluated on EDN topologies provided by SEAS-NVE. Since this is a relevant environment for EVT, we estimate EVT TRL to be 6.

A.1.1.3 DAPP TRL

The DAPP service takes as input from the DSO power constraints for a substation as well as historical data on electricity consumption (main meter) for the households connected to such a substation. It returns as output a power profile for each household such that the aggregated demand will meet the DSO provided power constraints.

DAPP formulates the above control problem as a *Mixed Integer Linear Programming* (MILP) problem and then uses CPLEX (`http://www-03.ibm.com/software/products/en/ibmilogcpleoptistud`) to solve such a MILP. Furthermore DAPP reads data from the DB&A and returns data to the DB&A (although it can also work by just uploading data from the web).

CPLEX is a well established commercial product, thus we estimate its TRL to be 9, whereas DB&A TRL has been evaluated to be 6 (Section A.1.1.1).

The current implementation of DAPP has been successfully evaluated on data provided by SEAS-NVE about two substations and spanning more than one year of electricity demand from the residential users connected to such substations. Since this is a relevant environment for DAPP we estimate DAPP TRL to be 6.

A.1.1.4 PPSV TRL

The PPSV service takes as input the DAPP output and evaluates its *robustness* by adding to the expected electricity demand from users a random *disturbance* and checking that notwithstanding such deviations the power constraints on the aggregated demand are still met most of the time.

PPSV reads data from the DB&A and returns data to the DB&A whose TRL has been evaluated to be 6 (Section A.1.1.1).

The current implementation of PPSV has been successfully evaluated on data provided by SEAS about two substations and spanning more than one year of electricity demand from the residential users connected to such substations. Since this is a relevant environment for PPSV we estimate PPSV TRL to be 6.

A.1.2 SmartHG Home Services

SmartHG Home Services have three main goals:

- Support each residential user in reducing electrical energy usage. This is done by the Energy Usage Reduction (EUR) home service.
- Forecast electricity demand of each residential users. This is done by the Energy Usage Modelling and Forecasting (EUMF) home service.
- Support each residential user in following the power profile provided by the DSO (actually, computed by DAPP) thereby reducing the home electricity bill. This is done by the Energy Bill Reduction (EBR) home service.

In the following we evaluate TRL for each SmartHG home service.

A.1.2.1 EUR TRL

We developed two versions of the EUR service: a general purpose one and one focusing on homes with a heat pump. Since our short/medium term exploitation plan targets homes with a substantial electricity consumption, we will focus here on the EUR version addressing homes equipped with a heat pump.

Such an EUR service takes as input home sensor data about heat pump electricity consumption, inside temperature, outside temperature and provides as output an estimate of the average home thermal insulation and thermal capacity. This allows an estimation of the home U-value and provides the home owner with a chart estimating the reduction in electricity usage (for heating) due to a reduction of the home U-value or to an increase of the heat pump Coefficient of Performance (COP).

The EUR rests on data from DEVELCO smart plugs and Panoramic Power clamp sensors and carries out computations using CPLEX (as DAPP). The above are all well established commercial products, thus we estimate their TRL to be 9.

The current implementation of EUR has been successfully evaluated on sensor data from 6 homes in the Kalundborg test bed. Since this is a relevant environment for EUR we estimate its TRL to be 6.

A.1.2.2 EUMF TRL

We developed two versions of the EUMF service: one focusing on predicting long term electricity consumption patterns in a household and another one focusing on predicting short term (about 12 hours) electricity consumption patterns in a household. Since our exploitation plan aims at reducing electricity costs leveraging on short term predictions of consumption patterns we will focus here on the EUMF version aiming at predicting short term electricity consumption patterns in a household.

Such an EUMF service takes as input home sensor data and provides as output an estimate of home electricity consumption in the next 12 hours or so.

The EUMF rests on data from SEAS main meter, DEVELCO smart plugs and Panoramic Power clamp sensors. The above are all well established commercial products, thus we estimate their TRL to be 9.

The current implementation of EUMF has been successfully evaluated on data from the homes in the Kalundborg test bed. Since this is a relevant environment for EUMF we estimate its TRL to be 6.

A.1.2.3 EBR TRL

The EBR service takes as input home sensor data, a power profile to be followed, and energy prices. It returns as output an actuation plan for the energy storage devices available in the home (i.e., batteries and PEV, if any) so as to minimise the electricity bill for the user.

EBR rests on CPLEX (as DAPP) to carry out its computations. CPLEX is a well established commercial product, thus we estimate its TRL to be 9.

The current implementation of EBR has been successfully evaluated on sensor data provided by our Kalundborg test bed and with actual batteries and inverters in the IMDEA Micro grid. Since this is a relevant environment for EBR we estimate EBR TRL to be 6.

Note that running the EBR in a home would not require any change in the EBR but would only require changes in the interface with the battery manager and the inverter. These are the same changes needed when porting EBR from one home to another equipped with a different inverter brand.

Appendix B

Exploitation Plan for SmartHG Technology Providers

Focusing on second year SmartHG project achievements, in this chapter we describe exploitation plans for all categories of partners involved in SmartHG consortium: ICT enterprises (Section B.1), Distribution System Operators (DSOs) (Section B.2), Municipalities (Section B.3), Research institutions (Section B.4). This is done by identifying services to be exploited along with their potential customers. When meaningful, the envisaged exploitation plan is validated by presenting a few quantitative exploitation scenarios.

Our second year exploitation plan mainly focuses on the case in which *peak shaving* is a critical DSO need. While it is acknowledged that this will be the case in the medium term, we should also note that for many DSOs this is not the case at the preset time. Thus our exploitation plan should be considered (mostly) a medium term one. In the next project iteration we will explore short term exploitation plans for the project results.

B.1 Exploitation for ICT Enterprises

In this section we describe the exploitation plan envisaged for the Information and Communications Technology (ICT) services and products developed in the project. Involved partners are mainly Small and Medium-sized Enterprises (SMEs) (DEVELCO, PANPOW, ATANVO, SOLINTEL) as well as possible spin-offs from SmartHG research institutions (UNIROMA1, AU, IMDEA, HMTI).

In the following we describe the exploitation opportunities for the classes of ICT services and products we identified. Namely: communication and infrastructure software services and hardware devices (Section B.1.1), Grid Intelligent Automation Services (Section B.1.2), Home Intelligent Automation Services (Section B.1.3) and R&D consulting activities (Section B.1.4).

B.1.1 Infrastructure Software Services and Hardware Devices

In Section B.1.1.1 we describe the exploitation plan for the computational infrastructure (i.e., the Database and Analytics (DB&A) service, see Deliverable D4.2.1) enabling communication among SmartHG services and sensing and actuation devices (i.e. the Home Energy Controlling Hub (HECH), see Deliverable D3.2.1). In Section B.1.1.2 we describe the exploitation plan for the hardware and the software deployed in the homes (i.e., sensors, smart meters, and actuators, see Deliverable D3.2.1).

B.1.1.1 Software and computational devices

DB&A stores sensor data and allows SmartHG services to read or write data according to given access control policies. Communication between home sensors and DB&A is handled by HECH. In this project iteration the focus of DB&A design has mainly been on Database Service (DBService) and SmartHG Market Controller (SMC). Accordingly, DB&A exploitation will focus on those services. The partner mainly involved in such activities is AU.

A number of opportunities for exploitation have been identified, both through other EU or national funded projects as well as through commercial exploitation. Here are the main opportunities identified:

- The HECH offers the opportunity for residential households to deploy a gateway capable of running SmartHG compliant cloud services while protecting the privacy of the consumer.
- SmartHG DBService offers the opportunity to provide an operation infrastructure service for smart grids.
- SmartHG DBService also offers the opportunity for an open repository (App store) for SmartHG intelligent automation services and third party services compliant with the SmartHG interfaces.

For the coming period, AU will focus on *development* and *business* plans for these opportunities. The *development plan* is based on building software applications for the smart grid services. Applications are the database services and the HECH (Raspberry Pi) configurations. A bitbucket repository has been used to host such applications [33]. AU is considering to offer validation and certification services on consultancy basis for interested third parties.

The *business plan* is to make a complete smart grid product kit to demonstrate the SmartHG objectives. The product assures a high level of data security and protects customer's privacy.

The HECH kit (see deliverable D6.2.1 for a picture of it) consists of a Raspberry Pi board, ZigBee devices, ZigBee gateway, USB stick, Internet cable and power supply. The consumers can easily install the kit and subscribe to the database services [34] and benefit from the services' algorithms to consume power in a smart way.

B.1.1.2 Sensing and actuation devices

Currently, intelligent automation is economically viable only for commercial building, since the economic saving for residential users is not enough to pay for the cost of the equipment.

The main goal of SmartHG is to make intelligent home automation economically viable also for residential customers, by developing software services for the DSO that take advantage of home automation.

Hence, SmartHG services open new opportunities within the residential market for enterprises working on sensing devices. Accordingly, SmartHG partners mainly involved in exploiting such opportunities are PANPOW (Section B.1.1.2.1) and DEVELCO (Section B.1.1.2.2).

B.1.1.2.1 PANPOW Panoramic Power currently delivers a range of hardware and software products: Sensors, bridges and cloud based analytic software packages (see deliverable D6.2.1 for examples). As part of the project, these products are being made compatible with the SmartHG services so as to be able to utilize them as an integral part of the project. The hardware will monitor the energy consumption in the residential homes that are part of the pilots of the project, and the software will integrate the data and present it on the project dashboard for various uses of the project.

After the end of the SmartHG project, during 2016, Panoramic Power plans to exploit the results of the project by offering its products to DSOs, utilities, energy aggregators and energy services providers that will offer residential homes to participate in SmartHG programs via various incentives. The sales via these channels is expected to provide a growing stream of income, starting from about 1M Euros in 2016 and growing to 34M Euros by 2020.

Recently, Panoramic Power has formed a strategic partnership with a large US entity for general commercial goals of the company. This entity has shown an interest in the residential market. Once the project is commercially mature, Panoramic Power will be able to add the project results to the current offering, and begin strategic discussions with the partner regarding their exploitation in the residential market.

B.1.1.2.2 DEVELCO Together with the rest of the world, Denmark faces a global climate dilemma: the demand for energy is expected to increase dramatically by 2050, and at the same time, Denmark must be clear of fossil fuels. Wind, solar, and biomass will be the new energy sources which also mean that the energy will come and go "as wind is blowing" – and this makes new demands from our energy system. We must i.e. be able to instantly make use of the energy or to store it in the energy system. Furthermore, the consumption must be adjusted to the flexible production.

This challenge is a highly prioritized focal point in Develco Products. The point of rotation for the green conversion and the development of Smart Grid is intelligent energy technology.

Develco Products is a small Danish company specialized in communication systems for Smart Metering combined with Home Automation. Develco Products has deep and long-standing expertise in wireless communication and provides products for sensoring, metering, and load control, among these relays, sensors, meter interfaces, and gateways.

In the SmartHG project, Develco Products will contribute by delivering hardware and embedded software for energy monitoring and load control, standardization of the communication with the backend server, and upgrade from IPv4 to IPv6.

If in the SmartHG test trial we can show that the required massive investment in grid capacity can be reduced by deploying a more intelligent way of using the energy infrastructure, then this will have a remarkable effect on the business of our company – not only in Denmark but in Europe as a whole.

The SmartHG project results will become an essential part of Develco Products' market understanding and will, together with input from customers and a wide range of stakeholders, compose the basis for decision on which products to develop and bring to market in the future. For instance, we might consider expanding our product portfolio with integration for electric vehicles and heat pumps.

SmartHG provides Develco Products with several exploitation possibilities. Besides the above mentioned exploitation opportunities, the project will also give us valuable insight in the customer's behavior and feedback on the intelligent energy services as well as on our products. We will get feedback from "real" energy consumers that are not marked by energy professionals. How will the end users react? How will the installed products affect their consumption? And what do they think of the functionality and design of our products (at the moment, we consider redesigning some of our products according to future demand).

Another exploitation area of huge interest for us is the trial test in partnership with utilities and research organisations as well as service oriented stakeholders who potentially could be customers of Develco Products. We will this way get valuable insight in their thinking and help us learn how in an optimum way we can benefit to their businesses.

Hence, the cooperation with the other partners constitutes a valuable contribution to our daily work. Furthermore, SmartHG brings about synergy with several other research projects. Develco Products participates actively in national and international research projects, all focusing on Smart Grid. We play a leading role in SEMIAH, just as we also participate in FINESCE, INCAP, iPower, and VPP4SGR. Through these projects, we get access to the newest knowledge from pilot tests and project results/experience within the fields of Smart Grid and demand response - knowledge that will also benefit SmartHG.

B.1.2 Grid Intelligent Automation Services

In this section we describe our exploitation plan for the Grid Intelligent Automation Service (GIAS) services: EDN Virtual Tomography (EVT) (Section B.1.2.1), Demand Aware Price Policies (DAPP), Price Policy Safety Verification (PPSV) (Section B.1.2.2).

B.1.2.1 EDN Virtual Tomography (EVT)

We first shortly summarise the EVT service (Section B.1.2.1.1) and outline our exploitation plan for it (Section B.1.2.1.2)

B.1.2.1.1 Service description The EVT service takes as input the Electric Distribution Network (EDN) topology and, using the PowerWorld simulator, estimates the status of the grid where no sensors are present.

B.1.2.1.2 Exploitation plan In the second year of the SmartHG project, the researchers at Institute IMDEA Energy have collaborated closely with the project partners and other external interested parties to identify the possibilities for the exploitation. The exploitation has been considered at commercial and research levels through national and international projects.

- A test grid in IMDEA Smart Energy Integration Lab (SEIL) will be used for simulation of the Kalundborg Testbed network and the surrounding area according to the data provided by SEAS-NVE. The test lab offers possibilities for further development and pre-installation tests of services for both final users and DSOs (such as SEAS-NVE).
- The GIASs developed within the scope of the SmartHG project are highly important to IMDEA for the exploitation. The experience and algorithms developed for GIAS surpass the existing knowledge and practises in monitoring and control of the network. Also, by combining the state estimation techniques and the novel pricing schemes new services for DSO can be proposed and created.

- In order to improve the customer billing and reduce the energy costs, detailed knowledge of customer's behaviour and adoption of the Home Intelligent Automation Service (HIAS) is paramount. In particular, the understanding and the motivation for using the HIAS is of particular importance.

In the remaining period the most important aspects of the exploitation will be the following:

- Further studies will be made regarding the aggregation of the demand in both Kalundborg and Minsk testbeds. The final user and the test site experience built up over the project will be used as a model for creation of future services for the DSO partners inside and outside the project. How to engage the customers so they gain tangible benefits from the schemes is in the focus of the activities.
- The integration of renewable energy is closely related with finding an additional level of demand flexibility. IMDEA Energy works closely with its industrial partners in finding possible solutions for demand response schemes and storage integration in low and medium voltage networks. The results developed within the SmartHG project framework will help build up the necessary portfolio and experience in alternative methods of managing demand. IMDEA Energy will continue to work with exploitation in the extension of SmartHG project.
- Building a network of European contacts is an important task in the following period. By working with relevant universities and commercial partners in SmartHG a set of new interested parties in the project results has been found and more possibilities for future collaboration work created.

B.1.2.2 Demand Aware Price Policies (DAPP) and Price Policy Safety Verification (PPSV)

DAPP and PPSV services have a common exploitation plan, since PPSV is basically used to verify safety of DAPP computed policies. In the project next iteration we will investigate exploitation plans for PPSV as a stand-alone service.

Section B.1.2.2.1 summarise the DAPP service. Section B.1.2.2.2 summarise the PPSV service. Section B.1.2.2.3 outlines our envisioned market opportunities for the above services. Section B.1.2.2.4 estimates the cost to provide the services and the expected revenues. Finally, Section B.1.2.2.5 validates the envisaged exploitation plan for DAPP and PPSV by evaluating its portability on some meaningful scenarios.

B.1.2.2.1 Demand Aware Price Policies (DAPP) The DAPP service is offered in two versions, namely Demand Aware Price Policies for Homes (DAPP-H) and Demand Aware Price Policies for Substation-Level Energy Storage Control (DAPP-K).

DAPP-H, given the power requirements of a substation and the predicted power profiles of the residential users connected to the substation, computes individualised power profiles to be followed by each such user and a minimal capacity for energy storage devices to be installed at each home in order to comply with the assigned power profile without requiring user behaviour changes. Power profiles guarantee that the aggregate demand satisfies the substation power requirements.

DAPP-K computes a control strategy to charge/discharge the energy storage equipments installed at a substation. DAPP-K will be economically interesting when Energy

Storage System (ESS) costs will decrease (which is the expected trend), however with present ESS costs, as discussed in Deliverable D5.2.1, it is not economically interesting. For this reason in the present exploitation plan we will focus on DAPP-H.

B.1.2.2.2 Price Policy Safety Verification (PPSV) As users might deviate from their assigned power profiles, the PPSV service supports DSOs in evaluating how well the substation line remains safe when subject to deviations in the user behaviours. In particular, given individualised price policies for all users connected to a substation and a probabilistic model of their possible deviations, PPSV computes the probability distribution of the aggregated power demand of the substation line.

The PPSV service comes in two version: the "Robustness analysis" version allows the DSO to perform a robustness analysis of the power profiles assigned to the users (e.g., those computed by DAPP-H), and to verify that the probability of aggregated power demand dangerous peaks is acceptably low. The "Economic analysis" version of the service allows the DSO to predict the economic gain obtainable by proposing given power profiles (e.g., those computed by DAPP-H) to the users connected to a substation.

B.1.2.2.3 Market opportunities The ever increasing presence of local electricity generation (e.g., from PhotoVoltaic (PV)) and the heavy electricity demand stemming from Plug-in Electric Vehicle (PEV) and heat pumps will severely stress the electricity grid.

In order to delay or avoid the heavy infrastructural investments needed to cope with such challenges, one of the main goals of the smart grid R&D activity is to devise intelligent home automation strategies to manage local electricity demand and generation in order to optimise the grid operation.

To address the above challenges, SmartHG proposes a hierarchical control schema where the DAPP service is used by the DSO to compute an individualised power profile for each user. In turn, each user will use the Energy Bill Reduction (EBR) service (whose exploitation plan is described in Section B.1.3.1) to control home equipment in order to comply with the proposed power profile. Additionally, the DSO will use the PPSV service to evaluate reliability and economic profitability of the computed power profiles.

Figure B.3 (from [35]) shows the number of DSOs operating in each EU country (as of 2011). The table in Figure B.2 also reports the overall number of served residential users in each country. In particular, the great presence of small DSOs in many EU countries could make easier for us to perform the first steps in bringing our services into the market, as small DSOs are typically more flexible in their organisation and more sensible in exploiting new opportunities to reduce their operational costs.

Finally, [36] shows that the percentage of EU residential users who have (as of 2007) an electricity contract with an electricity supplier (i.e., a retailer) affiliated to a DSO is extremely high (almost everywhere above 90%). This means that DSOs which own or control electricity supply companies currently are by far the strongest players in the residential electricity market. To this end, in the following we focus on estimating the gains coming from the usage of DAPP and PPSV services by such players, who are the primary source for short-term exploitation. Such companies are able to save both on electricity arbitrage and on Transmission and Distribution (T&D) investment deferral. We delay to future work the evaluation of how these SmartHG services can support, in the mid-term, a wider opening of the electricity supply market.

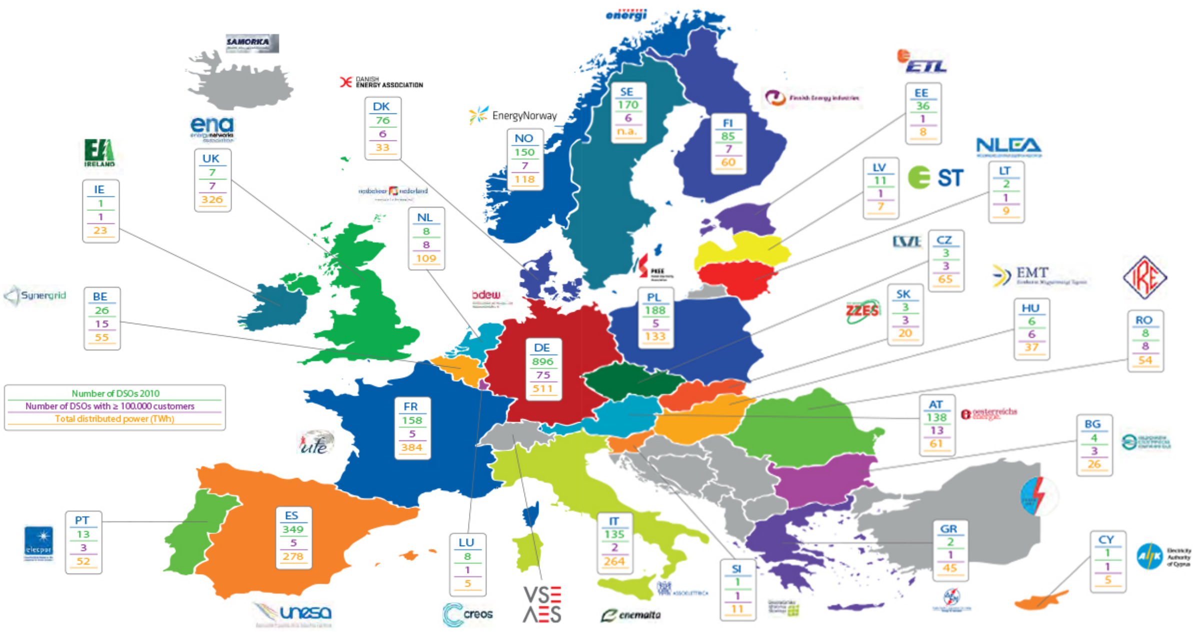

Figure B.1

Country	Number of DSOs 1997	Number of DSOs 2003	Number of DSOs 2010	Number of DSOs 2011	Number of DSOs with ≥ 100.000 customers	Total Number of Connected Customers	< 1 kV Customers (LV)	1- 100 kV Customers	> 100 kV Customers	Total distributed power (TWh)
AT	137	137	138	138	13	5,870,000	5,700,000	150,000	100	61
BE	36	29	26	24	15	5,243,796	5,178,890	64,906	0	55
BG		8	4	4	3	4,915,497	4,909,374	6,123	0	26
CY			1	1	1	535,050	512,972	646	0	5
CZ	8	8	3	3	3	5,837,119	5,812,727	24,258	134	65
DE	1000	900	896	880	75	49,294,962	n.a.	n.a.	n.a.	511
DK	211	119	76	72	6	3,277,000	n.a.	n.a.	n.a.	33
EE			36		1	652,000	651,000	1,000	0	8
ES	540		349		5	27,786,798	27,682,771	103,630	397	278
FI	115	93	85		7	3,309,146	3,305,268	3,761	117	60
FR			158		5	33,999,393	33,903,690	95,703	0	384
GR			2	2	1	8,195,725	8,184,378	11,347	0	45
HU	6	6	6	6	6	5,527,463	5,520,991	6,334	138	37
IE	1	1	1	1	1	2,237,232	2,235,681	1,545	6	23
IT	200	195	135	144	2	31,423,623	31,331,656	90,949	1,018	264
LT	1	2	2	1	1	1,571,789	1,570,584	1,205	0	9
LU	12	11	8	6	1	n.a.	n.a.	n.a.	n.a.	5
LV			11	11	1	873,856	872,930	926	0	7
NL		10	8	11	8	8,110,000	n.a.	n.a.	n.a.	109
PL	33	27	188	184	5	16,478,000	16,456,000	31,000	300	133
PT	4	1	13	13	3	6,137,611	6,113,839	23,772	0	52
RO	1	8	8		8	2,639,318	2,633,625	5,602	91	54
SE	230	190	170	173	6	5,309,000	5,300,000	9,000	n.a.	n.a.
SI	2	5	1		1	925,275	820,000	105,275	2	11
SK	4	4	3	3	3	2,392,418	2,379,672	12,664	82	20
UK	12	8	7	7	7	30,828,266	n.a.	n.a.	n.a.	326
NO	200	157	150	155	7	n.a.	n.a.	n.a.	n.a.	118

Figure B.2

Figure B.3: Statistics on DSOs operating in EU countries (source: [35])

Percentage of new connections contracting with a supply company affiliated to the DSO	EU member state
97.5% – 100%	Estonia, France, Greece, Ireland, Luxembourg, Poland, Slovakia
95% – 97.5%	Austria, Germany, Spain
90% – 95%	Italy
<90%	Netherlands, United Kingdom

Table B.1: Percentage of new connections contracting with a supply company affiliated to the DSO in 2004. (European Commission 2007). Table from [36].

B.1.2.2.4 Cost and revenue analysis In order to estimate the profitability of the DAPP and PPSV services on a commercial Software as a Service (SaaS) basis, we proceed as follows. First, we estimate the costs of offering such services to DSOs using a commercial SaaS platform. Second, we estimate the potential revenues. The difference between revenues and costs provides an estimation of the expected profitability of the services.

B.1.2.2.4.1 Expected costs The costs to provide the DAPP and PPSV services on the market can be grouped in three main categories:

1. costs to be sustained upfront, e.g., to develop a fully engineered production version of the services, starting from the prototypes developed in SmartHG
2. costs to offer the service mostly independent of the business volume, e.g., to employ sales and technical personnel in order to support service commercialisation towards DSOs and to ensure technical maintenance
3. costs to offer the service essentially proportional to the business volume, e.g., to pay for the infrastructure used in computations (as the services are brought to the market using the SaaS paradigm).

We define the business volume for a service as the number of residential users served (indirectly via customer DSOs) by that service.

In the following we will evaluate the expected revenues and costs in category 3. From this data we can evaluate if the gains are enough to pay for the costs in categories 1 and 2.

The DAPP and PPSV deployed using the SaaS paradigm might require heavy computations and thus we need to use a powerful computational infrastructure. In order to reduce the total amount of upfront investment, a popular current approach is to exploit the Infrastructure as a Service (IaaS) paradigm and rent cloud-based elastic computational infrastructures until the business is solid enough to justify the purchase and maintenance of a private computational infrastructure.

We plan to follow this approach, at least during the first years of the services commercialisation, in order to minimise initial investment and financial risk.

To this end, Table B.2 reports the estimated time to perform single DAPP and PPSV computations on a 8-core machine, and their respective periodicities (as reported in Deliverable D5.2.1). For each service, we show the computation time needed on a 8-core

service	computation time (8-core machine) on reference scenario	time between consecutive executions
DAPP-H	3 min	1 days
PPSV (robust. anal.)	6 min	1 days
PPSV (econ. anal.)	1.5 days	365 days

Table B.2: Expected time to compute single computations of each service for the reference scenario (see Deliverable D5.2.1) comprising 186 residential homes, and associated frequencies for each DSO

IaaS	price per CPU-hour
Amazon	USD 0.665
Google	USD 0.421
Reference IaaS	EUR 0.55

Table B.3: Typical costs to buy computational power from some popular IaaS providers (8-core server)

machine on the reference scenario (as defined in Deliverable D5.2.1) and the expected time between consecutive executions.

Table B.3 shows current typical costs to buy computational power (8-core machine similar to that we used in Deliverable D5.2.1 to compute values of Table B.2) from some popular IaaS providers, as well as the (safe) estimation we will use in the following cost assessments. Note that such cost is also a safe approximation of the cost to buy and maintain an ad-hoc computational infrastructure dedicated to the deployed services.

Finally, Table B.4 shows the envisioned costs of running each service. In particular, column "*cost per comp.*" shows the cost of each single service computation by multiplying the CPU cost-per-hour from Table B.3 and the computation time for that service from Table B.2. Column "*cost / year*" shows the computational cost to run each service during an entire year for a single DSO substation, and is obtained by multiplying the value in column "*cost per comp.*" with the average number of computations performed in a year (from Table B.2). Finally, column "*est. cost per resid. user / year*" shows the estimated portion of the yearly computational cost to run each service due to a single residential user connected to the substation. Such estimations are obtained by dividing the values in column "*cost / year*" by the number of residential users connected to a substation in our Kalundborg test-bed (i.e., 186).

service	cost per comp.	cost / year	est. cost per resid. user / year
DAPP-H	Eur 0.03	Eur 10.95	Eur 0.06
PPSV (robust. anal.)	Eur 0.06	Eur 21.90	Eur 0.12
PPSV (econ. anal.)	Eur 19.80	Eur 19.80	Eur 0.11
Total	Eur 19.89	Eur 52.65	Eur 0.29

Table B.4: Envisioned costs to run each *cloud* service on reference IaaS

B.1.2.2.4.2 Expected revenues Table B.5 summarises the average gains for DSOs, residential users and the SmartHG technology provider as discussed in Section 4.6.4.

B.1.2.2.5 Exploitation scenarios The objective of this section is to validate the envisaged exploitation plan for DAPP and PPSV by evaluating its profitability on some meaningful scenarios. This is done building on the results in Tables B.4 and B.5.

From Section B.1.2.2.4.1, it follows that, in order to correctly evaluate the profitability of DAPP and PPSV, we need to estimate: (1) costs to be sustained upfront, and (2) yearly costs mostly independent of the business volume. Sections B.1.2.2.5.1 and B.1.2.2.5.2 describe a possible scenario.

B.1.2.2.5.1 Costs to be sustained upfront The prototypes of the various services designed and developed within the project are a good starting point from which a production version of the software can be designed, built, and deployed.

The main costs to be sustained upfront (which correspond to costs of category 1 in Section B.1.2.2.4.1) are essentially those needed to build and deploy such a production version of the services.

In our exploitation scenario, we envision to hire one software engineer and two skilled programmers for about one year, for an overall development cost of about 100 000 EUR.

B.1.2.2.5.2 Costs mostly independent on the business volume As the services above are completely automated, a light organisation is sufficient. We can safely estimate the costs to run the organisation (which correspond to costs of category 2 in Section B.1.2.2.4.1) to about 200 000 EUR/year.

These costs would be largely sufficient to rent a small venue for the company headquarters, and to hire the staff we would need (e.g., a manager also in charge of sales towards DSOs, a single unit of administrative staff and two units of technical staff to perform systems maintenance).

B.1.2.2.5.3 Years to Break-Even Figures B.4–B.6 show the Years to Break-Even (YBE) points under the assumptions above and under different possible dynamics of the business volume. Here, the business volume is defined as the number of residential users served by the DSOs who are customers of our services. We emphasise that our customers for DAPP and PPSV are DSOs, and not directly residential users. We reason in terms of residential users only in order to take into account the different sizes (in terms of market shares) of our customer DSOs.

service	average DSO gain per year per residential user per year	average residential user gain per year	average SmartHG technology provider gain per residential user per year
DAPP-H	Eur 68.85	Eur 68.85	Eur 61.20

Table B.5: Estimated economic gains exploiting the output of DAPP-H

As an example, Figure B.5 shows the YBE point in a scenario where the business volume is envisioned as to grow linearly by 1500 units per year. For each year x (horizontal axis), the red curve shows the expected accumulated costs up to year x, i.e., the sum of costs of categories 1, 2, and 3 (see Section B.1.2.2.4.1), as defined, respectively in Sections B.1.2.2.5.1, B.1.2.2.5.2 and B.1.2.2.4.1. Analogously, for each year x, the blue curve shows the expected revenues accumulated by the SmartHG technology provider up to year x, as a consequence of Table B.5. The black circle indicates the intersection between the red and the blue curves. Its value on the x coordinate gives us the expected YBE point for this scenario.

Figures B.6 and B.4 show, respectively, a more optimistic and a more pessimistic scenario, where served residential users grow linearly by, respectively, 2000 and 1000 units per year.

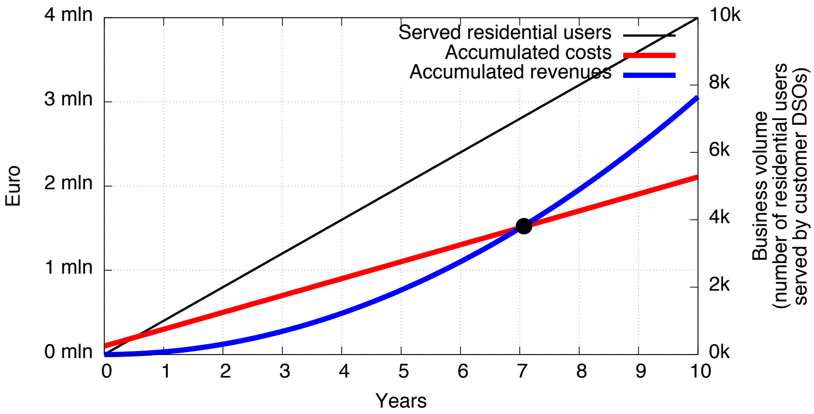

Figure B.4: Exploitation of DAPP and PPSV: YBE when business volume (i.e., number of served residential users) grows linearly by 1000 units per year

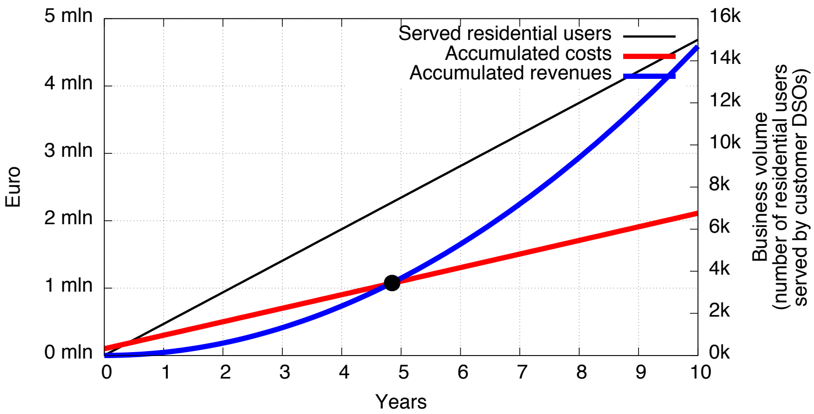

Figure B.5: Exploitation of DAPP and PPSV: YBE when business volume (i.e., number of served residential users) grows linearly by 1500 units per year

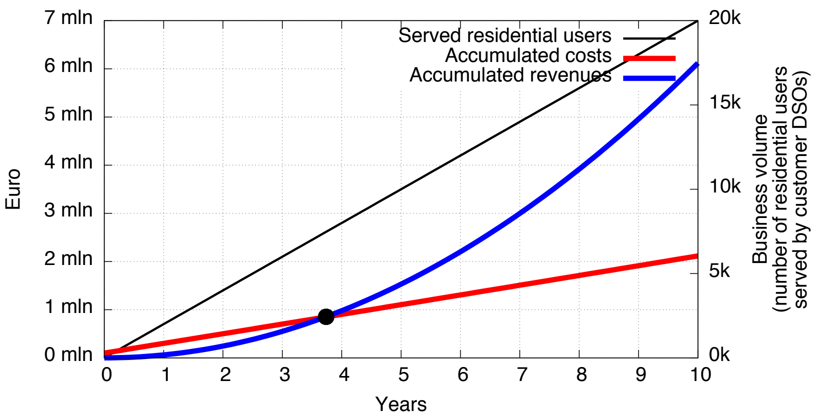

Figure B.6: Exploitation of DAPP and PPSV: YBE when business volume (i.e., number of served residential users) grows linearly by 2000 units per year

B.1.3 Home Intelligent Automation Services

In this section we describe our exploitation plans for the SmartHG HIASs. Namely: EBR (Section B.1.3.1), Energy Usage Modelling and Forecasting (EUMF) and Energy Usage Reduction (EUR). For the latter two services, we distinguish between those focussing on short term (a few hours) predictions supporting predictive control strategies for home equipment in the EBR (namely Energy Usage Modelling and Forecasting for Control (EUMF-K) and Energy Usage Reduction for Control (EUR-K), see Section B.1.3.2), and those focussing on the long term (many days) predictions for home users (namely, Energy Usage Modelling and Forecasting for Homes (EUMF-H) and Energy Usage Reduction for Homes (EUR-H), see Section B.1.3.3).

B.1.3.1 Energy Bill Reduction (EBR)

In this section we describe our exploitation plan for EBR. To this end: Section B.1.3.1.1 summarises EBR service description; Section B.1.3.1.2 outlines EBR market opportunities; Section B.1.3.1.3 outlines costs incurred to provide the EBR service. Finally, in order to validate the above considerations, Section B.1.3.1.4 shows some possible scenarios.

B.1.3.1.1 Service description EBR supports residential users in following given power profiles (e.g., those computed by DAPP-H), in order to minimise home electricity bill. Accordingly, taking into account foreseen local generation and consumption as well as the given energy price policy, EBR computes a control strategy for charging/discharging energy storage devices, such as PEV and home batteries. It is foreseen to extend the control strategy in order to also control heat pumps and energy storage heaters (that store thermal energy by exploiting home thermal capacity).

B.1.3.1.2 Market opportunities We can reasonably assume that each residential user subscribing to the DAPP-H energy tariff will also subscribe to the EBR service in order to easily take advantage of DAPP-H tariff schema. Accordingly, we consider the market opportunities for EBR to be the same as those for DAPP-H and discussed in Section B.1.2.2.4. In other words, we assume that basically DAPP-H customers will also be EBR customers.

B.1.3.1.3 Cost analysis To estimate the costs incurred to provide the EBR service we can follow the same approach used for DAPP-H in Section B.1.2.2.4. Accordingly, we have a cost for developing the service, one for maintaining it and one for running it. The first two costs do not depend on the number of customers (residential users), whereas the last one is basically proportional to the number of served users. Such costs are estimated as follows.

1. **Set up costs.** We estimate to 100,000 EUR the cost to be incurred upfront to develop a fully engineered version of EBR, starting from the prototypes developed in SmartHG.
2. **Maintenance costs.** We estimate to 200,000 EUR/Year the cost to offer the EBR service. This cost basically does not depend on the business volume. Such a cost covers, e.g., sale personnel in order to support service commercialisation towards end users and technical personnel in order to ensure technical maintenance.

3. **Running costs.** We estimate to 10 EUR/Year per user the cost to offer the service. This cost is basically proportional to the number of users and accounts for the cost of the computational infrastructure allowing users to download EBR as well as for the cost of some customer care.

Note that no computation for the EBR is currently carried out on the server (service) side since each user runs the EBR service on his hardware at home. Taking into account that hosting a web service will cost less than 200.00 EUR/Year (for example, see `https://contabo.com/?show=webhosting`) and taking into account that one such web services can easily handle thousand of users we see that the cost of 10 EUR/Year per user is mainly due to customer care costs.

B.1.3.1.4 Exploitation scenarios From Section 4.5.4 we have that a SmartHG technology provider gains, on average 58.80 EUR per residential user per year.

In order to validate our exploitation plan for EBR, in this section we show a few exploitation scenarios for EBR. Assuming that DAPP-H and EBR will have basically the same customer base, we can carry out an analysis similar to the one developed for DAPP-H in Section B.1.2.2.5.

On such a basis we consider three scenarios:

- The number of EBR residential customers grows linearly at 1000 units per year.
- The number of EBR residential customers grows linearly at 1500 units per year.
- The number of EBR residential customers grows linearly at 2000 units per year.

Resting on above assumptions, Figures B.7, B.8 and B.9 show the YBE point in a scenario where the business volume is envisioned to grow linearly by, respectively, 1000 (our pessimistic scenario), 1500 and 2000 (our optimistic scenario) units per year. Here, the business volume is defined as the number of residential users served by our EBR service.

For each year x (horizontal axis), the red curve shows the expected accumulated costs up to year x, (i.e., the sum of setup costs, maintenance costs and customer care costs as described in Section B.1.3.1.3). Analogously, for each year x, the blue curve shows the expected accumulated revenues up to year x, as a consequence of our expected revenues (58.80 EUR per year per residential user). The black circle indicates the intersection between the red and the blue curves. Its value on the x coordinate gives us the expected YBE point for this scenario.

B.1.3.2 Energy Usage Modelling and Forecasting for Control (EUMF-K) and Energy Usage Reduction for Control (EUR-K)

Sections B.1.3.2.1 and B.1.3.2.2 shortly summarise Energy Usage Modelling and Forecasting for Control (EUMF-K) and Energy Usage Reduction for Control (EUR-K) services whereas Section B.1.3.2.3 outlines our exploitation strategy for them.

B.1.3.2.1 Energy Usage Modelling and Forecasting for Control (EUMF-K) EUMF-K is used by the control software in a home equipment (EBR) to predict electricity consumption in the next (about 12) hours. EUMF-K input consists of data from the sensors deployed in the home whereas EUMF-K output consists of a forecast of the home electricity consumption.

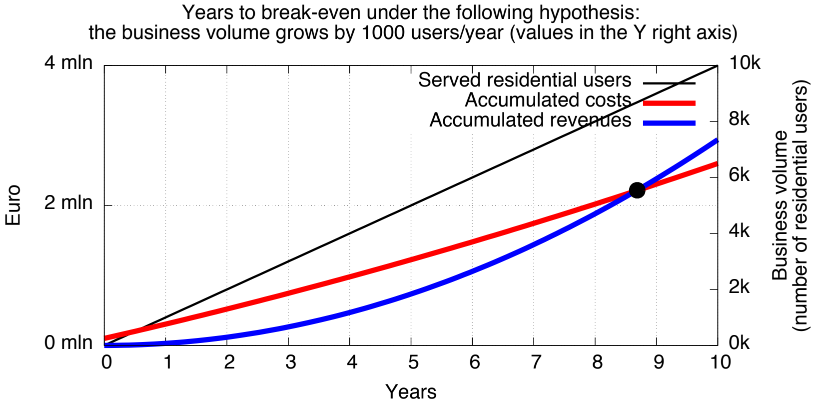

Figure B.7: Exploitation of EBR: YBE when business volume (i.e., number of EBR residential customers) grows linearly at 1000 units per year.

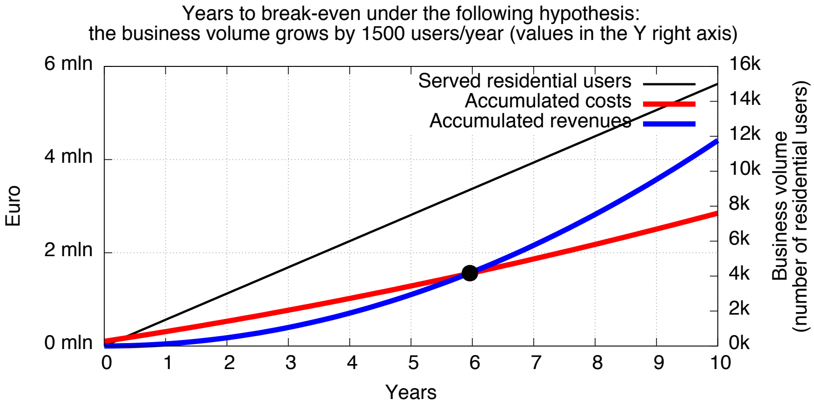

Figure B.8: Exploitation of EBR: YBE when business volume (i.e., number of EBR residential customers) grows linearly at 1500 units per year.

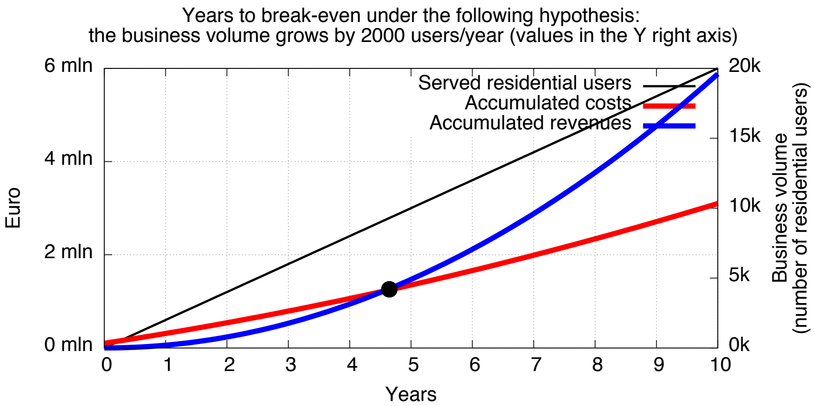

Figure B.9: Exploitation of EBR: YBE when business volume (i.e., number of EBR residential customers) grows linearly at 2000 units per year.

B.1.3.2.2 Energy Usage Reduction for Control (EUR-K) By exploiting sensor data (namely: outside temperature, inside temperature and heat pump energy consumption), EUR-K estimates the average thermal insulation, the average U-value (given the home surface) and the thermal capacity of the monitored home. By using such estimates, EUR-K will allow EBR to devise control strategies for the heat pump exploiting the thermal energy storage capability of the monitored home. Furthermore, EUR-K can be used to evaluate the energy saving yielded by home retrofits reducing the U-value.

B.1.3.2.3 Exploitation plan We plan to exploit EUMF-K and EUR-K together with EBR, since the first two are ancillary services for the third.

However, EUR-K can be also used by home owners to evaluate the energy saving stemming from a reduction of the home U-value. By comparing the cost of reducing U-value with the economic saving stemming from energy saving EUR-K can support home owners in evaluating the best strategy.

In the remainder of this section we focus on such an exploitation opportunity for EUR-K.

Such a service can be exploited immediately by enterprises providing web-based electricity monitoring services for commercial and residential buildings (e.g., DEVELCO and PANPOW in SmartHG consortium). Accordingly we envision a Business to Business (B2B) exploitation plan for the EUR-K service.

This service will provide an added value to the data gathered from residential users. Since currently the economic saving stemming from intelligent automation for residential buildings is small when compared to the automation cost itself, providing such an added value will help boosting this market.

The EUR-K software service will be deployed on a cloud infrastructure. Each computation takes a few seconds, hence, by using the same approach of Section B.1.2.2.4.1, we estimate its cost to be less than 0.10 EUR. We note that the results of this computation only depend on the home physical properties and the heat pump characteristics (e.g., Coefficient of Performance (COP)). Hence, such a computation does not need to be run frequently by the same residential user. A couple of computations per year on average will do.

The above described EUR-K computational service could be made available to interested enterprises for a small fee (a few Euros) per computation. This approach will easily cover infrastructure as well as maintenance costs and will also yield a reasonable revenue. We may reasonably assume an average revenue of 10 EUR per residential user. Further income may come from targeted advertising (e.g., for house refurbishment). For example, knowing that a certain home has poor insulation (high U-value), the service could recommend suitable products and house refurbishment services. Of course, such an extension will require an explicit consent to the data usage from the home owner. We believe this will not be an obstacle, since people are accustomed to receive targeted advertisements when using low cost services.

UNIROMA1 and interested SmartHG partners are in touch with potential customers and are evaluating strategies to bring EUR-K service to the market.

B.1.3.3 Energy Usage Modelling and Forecasting for Homes (EUMF-H) and Energy Usage Reduction for Homes (EUR-H)

Sections B.1.3.3.1, B.1.3.3.2 shortly summarise Energy Usage Modelling and Forecasting for Homes (EUMF-H) and Energy Usage Reduction for Homes (EUR-H) services whereas Section B.1.3.3.3 outlines our explopitation strategy for them.

B.1.3.3.1 Energy Usage Modelling and Forecasting for Homes (EUMF-H) The EUMF-H service takes as input the home geographical location (from which a weather forecasting is obtained) and hystorical data about home electricity consumption. It returns as output the forecasted home electricity consumption for the next months.

B.1.3.3.2 Energy Usage Reduction for Homes (EUR-H) The EUR-H service takes as input data about the home geographical location, home equipments and home electricity consumption and returns as output an evaluation of how efficiently electrical energy is used in the home.

B.1.3.3.3 Exploitation plan Energy Usage Reduction for Homes (EUR-H) and Energy Usage Modelling and Forecasting for Homes (EUMF-H) have been developed by ATANVO AG and HMTI SmartHG partners. ATANVO AG has got a vast experience in the planning and the realisation of access networks for energy-, gas-, water- and heating- and the related service platforms. Together with power utilities, system providers as well as governmental institutions and organisations we globally support our customers in Powerline, WLAN, Voice over IP and AMR projects. Ongoing research at the A. V. Luikov Heat and Mass Transfer Institute of the National Academy of Sciences of Belarus (HMTI) is aimed at an outcome as well in general power engineering area.

In the following we outline the envisioned exploitation plan for EUR-H and EUMF-H. First of all, we note that, for EUR-H we may propose an exploitation plan similar to the one of EUR-K, with the following difference: EUR-H is a lightweight version of EUR-K which aims at providing residential users with updated information on their home thermal usage. Thus, it will be used on a more frequent basis than EUR-K. The same reasoning may be applied to EUMF-H, which will provide residential users with updated information on their home future consumption profile.

Furthermore, HMTI plans to enhance the developed models and the knowledge acquired in the SmartHG project in further scientific research and technology development. In particular, the TechDom heat balanced model (TDBM) and Fuzzy Logic Library (FLL) modules, which are at the core of both EUMF-H and EUR-H, will be used for this purpose. Namely, the TDBM can be disseminated as independent open Web service to help residential user improving an efficient heat and energy usage.

B.1.4 R&D consulting activities

SOLINTEL will use the knowledge generated in SmartHG in further scientific research and technology development. The exploitation will be done by re-using the project results as a basic for future, publicly and privately funded projects on the national and international level, as well as in its own in-house research. The target is to undertake further research to improve and update the developed business models, energy management systems, modeling and simulation technologies in a dynamic way. In addition results knowledge will also be used for setting up new consulting, Research & Development (R&D) activities and integrated solutions in the area of ICT based energy efficiency and energy management.

Besides, under the concept of market oriented innovation of SOLINTEL, the purpose of exploiting the project results will be market oriented leading into more improvements and benefits in the operation results of our company. Focusing on the potential market demand, SOLINTEL will exploit the project results giving more priorities on the following markets, customers, products, service and model depending on the final evaluation of the project outputs.

B.1.4.1 Market opportunities

As a Spanish SME, SOLINTEL collaborates with Energy Service Companies (ESCOs), Heating, Ventilating, and Air Conditioning (HVAC) and electrical installers, architects, constructors and promoters not only in EU, but also in Latin America and China. SOLINTEL has its own construction projects in Valencia (Spain), David (Panama) and Colombia, the possibility to integrate and promote the technologies developed in the project is high. Considering the high initial investment of the equipment, in Latin America may have greater economical and culture barriers which impede the introduction of the products, the initial targeted market that SOLINTEL considers will be mainly Spain and China, while trying to exploit the possibility in other countries in EU, America and even South Africa.

The strategy in different countries will vary due to the market characteristics and available resources.

In Spain, SOLINTEL will mainly focus on the collaboration with ESCOs, HVAC and electrical installers and promoting the final products for the tenants of its own housing projects. Service related to economic feasibility study, energy efficiency calculation, modeling will always be offered to customers with the add value from the SmartHG products.

In China: Thanks to the fast development of the economy and lack of regulation, market demand, large market may be shown for the integrated solution of HIASs. High barrier may be found for the GIASs due to the grid property – state owned grid, it will be very difficult to penetrate the market with the GIASs from the beginning. Instead, the project results could be exploited by setting up bilateral programs between EU and China. From the point of view of target customers, rental apartments and medium income families will be the main ones since they have more willing to reduce the energy consumption and their consumption profiles are more flexible. To be successful in market exploitation, business models need to be further studied and designed.

B.1.4.2 Exploitation plan

Beside the two main outputs of the project: GIASs and HIASs, the system components used in the project are also attractive, such as the wireless and low intrusive monitoring system, direct control based energy storage system.

1. GIASs: Since such services will help DSO to optimise the management of the entire EDN (global optimisation), SOLINTEL will collaborate with its industrial partners in Spain to look for the possibility of further cooperation with DSOs, together to offer the GIASs to the end users who are having high/medium consumption. Due to the difficulty to penetrate the traditional state owned grid of China, presentations

of the project results, extension of SmartHG project ideas could be developed orienting to the R&D institutes and National Torch Program of China for developing new/high tech industries in China in collaboration with EU entities, with the aims of introducing project concepts and results to the involved parties (research center, government, providers of grid components etc.). The relationship with Chinese universities, Torch China need to be further reinforced and more workshops need to be attended.

2. HIASs: With the main purpose of helping householders to reduce energy costs and consumption, HIASs could be attractive for the tenants and medium income families. By reducing energy usage altogether, for example by identifying causes of energy losses, the HIASs may contribute a lot in CO2 and GreenHouse Gas (GHG) emission reduction. To be successful products, the HIASs need to have an easy management and configuration, and to be a compact and cost effective product. The strategy for exploiting these products could include showing the pilot data of SmartHG project (in form of real results) for the end users, mouth to mouth strategy, online selling (China has great development in Online2Offline (O2O) market), integration of the products in consulting service (recommendation of the developed products) and R&D projects.

3. Low intrusive monitoring system: The Panoramic Power products - the low intrusive real time metering system, are attractive for SOLINTEL. Thanks to the easy installation and management, SOLINTEL will consider collaborating with the electrical and HVAC installers in Spain, engineering company and trading/selling company in China for further exploitation. Large commercial buildings where need more fine monitoring data have higher priority thanks to the potential and larger buying volume. However, the high price may appear to be a serious barrier not only in EU market, but also Chinese and other market.

4. Battery based energy storage system: As many battery energy storage system, the SmartHG direct control system coupled with energy storage system has the economical barrier as in many countries. Although it is expected that the technologies in battery are advancing and prices are reducing in recent years, the initial investment in battery remains being an issue. “Shared” battery could be attractive enabling the user to exploit the SmartHG results and the battery in other products (Electric Vehicle (EV), bicycle etc). The widely used electrical motorbikes in China seem can facilitate a wider application of energy storage system. Factories, public buildings where have large amount of electrical bicycles will have higher interest in it, and normal households with energy awareness and wish to reduce their consumption is another potential customer. SOLINTEL, is also offering grid connected and off grid photovoltaic “Kit” to the end customers in Africa and EU. The advance in energy storage system with HIASs integrated is expected to make our products more competitive. For the future exploitation, SOLINTEL can integrate the HIASs to our catalogue as the additional solution for the end user, orienting it to the EU market and Chinese market principally.

Depending on the final evaluation results of the final product and the proposed business models, SOLINTEL is willing to exploit the research products and take them to the market, even we consider to set up spin-off companies dedicated in the commercialization of the final products in Spain and China. Additionally, public funded EU projects, as well as bilateral programs are always an option for SOLINTEL to increase the further impact of the developed systems.

B.2 Exploitation for Distribution System Operators

In the SmartHG project we have two DSOs involved: SEAS-NVE and MINSKENG. In the following, we focus on the exploitation plan as identified by SEAS-NVE. A similar exploitation plan also applies for MINSKENG.

SEAS-NVE has worked with and identified a number of possibilities for exploitation. The exploitation can be done through SEAS-NVE own local development projects and other EU or national founded projects.

- IMDEA, a partner in SmartHG has developed a test grid in their Grid Lab mostly designed from the grid typology information from SEAS-NVE simulating the Kalundborg Testbed grid and surrounding area. This IMDEA test grid and test lab offers many possibilities for a DSO as SEAS-NVE to proceed the testing and developing work with a representative grid in a safe testing environment.
- The SMARTHG Grid Intelligent Automation Services being developed in SmartHG project is another area for exploitation for SEAS-NVE. The GIASs offer some very exciting opportunities to monitor the grid and to work with shaping the demand for electricity by working with pricing policies in a way that SEAS-NVE has not done before.
- Another mayor area of interest in SEAS-NVE exploitation plans is knowledge about customer's behavior, interest and reaction to the Intelligent Automation Services and the testing equipment they will meet during the SmartHG testing phase. How will the customer understand the IAS and how can they be motivated to use IAS in the future?

In the coming period those areas will be the focus areas for SEAS-NVE to work with in exploitation.

First of all the coming period and the work with the Kalundborg Testbed will give a lot of knowledge about customers interest, behavior and willingness to relate to the SmartHG project IAS. SEAS-NVE is looking forward to the work with the Testbed and people outside the SmartHG project. Learn how they feel and related to our current wok with automation services. Will it be of any interest in their current everyday life?

The future challenge in the low voltage grid with growing penetration of renewable energy and growing demand of electricity due to heat pumps and EV's will require massive investment in grid capacity unless we manage to solve these changes in a more intelligent way. SEAS-NVE works intensely on getting knowledge about every possibility to monitor the low voltage grid more closely and to control the grid more intelligent in order to balance central and local production with the growing demand. In this content, the knowledge and the results from SmartHG fits very well and SEAS-NVE will continue to work with exploitation in the extension of SmartHG project.

In addition SEAS-NVE will continue to work on extension of network relations with relevant universities and partners in SmartHG in order to accomplish even more knowledge and results than it is possible to achieve within the timeframe and resources of SmartHG.

B.3 Exploitation for Municipalities

Kalundborg Municipality has pointed out a suitable district for tests and demonstrations in SmartHG context. The district for test and demonstration is a district without district heating (which is very common in Denmark) and with a relatively high rate of PVs and heat pumps. PVs and heat pumps are relatively new in Danish homes, but have become more used the later years.

Kalundborg Municipality have a long tradition for corporate with companies in different sustainability project, and the Smart HG project is a good opportunity to get in contact with citizens, involving them in the efforts to develop and find new technologies to support the transition to a more sustainable future, not only for companies, but also for the citizens.

For recruiting the citizens in Svebølle, a citizens meeting has been held, informing about the project. During the test period, we are in close contact with the participating families, to get their response and inputs. Adapting SmartHG shall also be seen as a step in the consideration of defining Svebølle as a living lab for testing smart technologies.

In the long run, participation in Smart HG and other similar project is a natural part of our brand as a "green industrial municipality" that want to be attractive for various sorts of companies and well educated employees.

B.4 Exploitation for Research Institutions

In addition to the industrial exploitation opportunities identified in the previous sections, research institutions will continue to exploit know-how developed in the project for teaching and research purposes.

Selected scientific problems and development tasks from SmartHG will be subject to master and bachelor student projects. Furthermore, SmartHG will be used as a case study in courses on information technology education. Knowledge and results from SmartHG will be exploited in related EU and national funded projects.

As an example, AU intends to exploit its know-how with DEVELCO home automation technology and use cases involving demand response in the Scalable Energy Management Infrastructure for Aggregation of Households (SEMIAH) (EU FP7) and the Virtual Power Plant for Smart Grid Ready buildings and customers (VPP4SGR) (Danish Ministry of Energy, Buildings and Climate) projects. UNIROMA1 plans to exploit the know-how acquired in SmartHG project in a national project focusing on tools to support automatic analysis of mission critical systems (such as Smart Grids).

Finally, SmartHG activities have also identified many interesting opportunities for PhD level research in the Smart Grid field. Accordingly, such research problems will be proposed as topics for PhD thesis.