The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement No. 608957.

PlanGridEV

Deliverable 3.2

Specification of energy grid/ Functional and service architecture

Short name of the project partner	TECNALIA
Title of the publication	D3.2 - Specification of energy grid / Functional and service architecture
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Abstract / summary

D3.2 Specification of energy grid / Functional and service architecture

The work developed in the frame of PGEV task 3.2 presents the general elements that permit to define high level smart grid system architectures and analyse related uses cases and scenarios considering the technical and business model perspectives.

Based on the Smart Grid Model Architecture (SGAM) approach, the following elements have been identified and proposed for use case and scenario definition:

- **Services**, which represent the core of business models
- **Functions** that enable services development.
- **Information** describing the most typical data exchanged in order to carry out functions and services. This is one of key aspects of the study.
- **Communication technologies** addressing the most physical aspects of information exchange.
- **Components**, which consist in devices and systems but also in actors/roles/parties that communicate with each other and carry out the objectives set by functions.
- **Market models** that define the market structure influenced by regulatory and business aspects.

With this framework in mind, three **business cases** leading to three network scenarios have been defined:

- **Proactive/Smart Grid**: it considers advance metering infrastructure (AMI) and distribution automation (DA) technologies deployment, together with the EV related smart charging for network operation. Hourly prices based on dynamic network fees are proposed during normal operation of the network, while critical peak pricing (CPP) strategies and generation premiums are used to leverage customers' flexibility for ancillary service provision, supporting unexpected conditions in the network.
- **Safe/proactive**: it is based on the extensive implementation of time of use tariffs and on the basic management of EV charging processes during network contingency situations.
- **Conventional (business as usual)**: it assumes that current network operation and planning procedures remain unchanged in the future.

The following diagram sums up, in a graphical way, the proactive/Smart Grid business case during normal operation.

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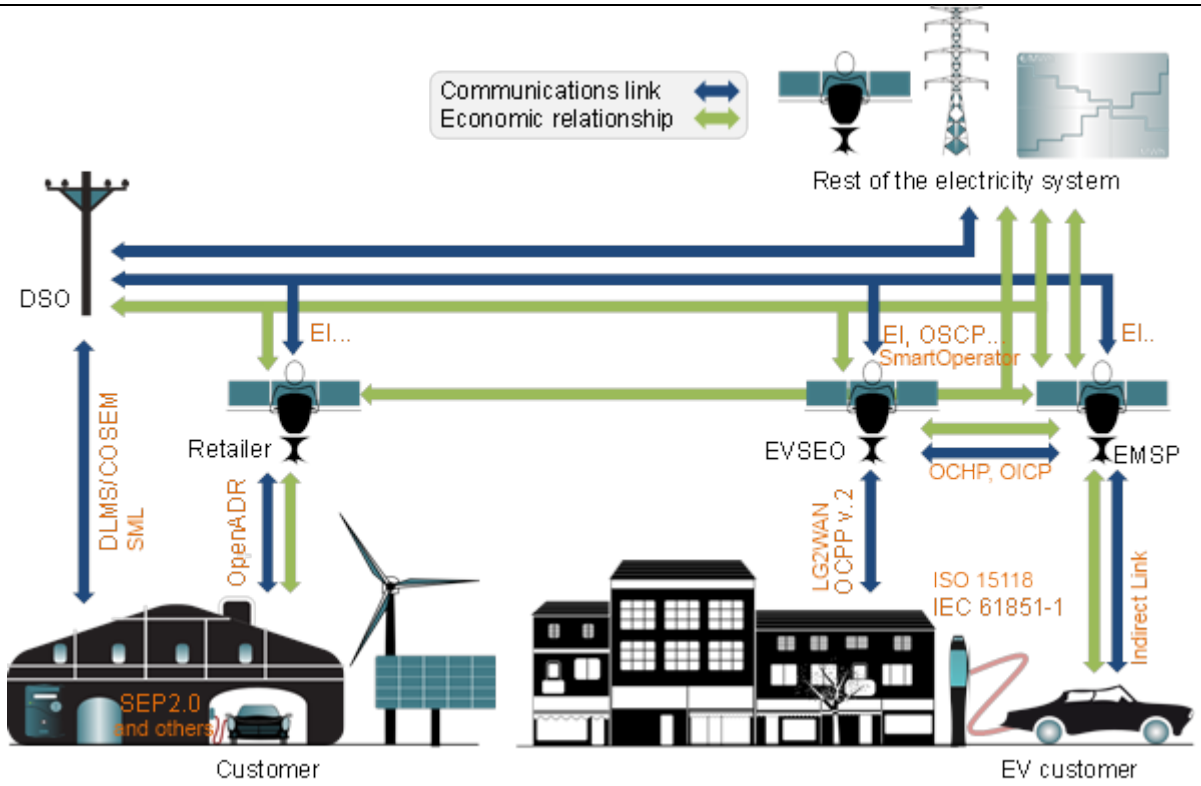

Figure 1 Proactive/Smart Grid business model. Normal operation

Business cases have been described using standardised formats and, from them, **network scenarios** have been derived. Simplified scenarios are defined, considering the most relevant characteristics that will permit to perform the economic assessment, including concepts such as maximum and minimum demand in the system, electricity consumption, infrastructure capacity, distribution losses, DER hosting capacity and generation, reliability and CO_2 emissions.

An exemplary base case electricity network scenario has been built in order to prove a top-down approach methodology to analyse complete distribution systems. Three different evolution options, in accordance with the business cases presented before, have been analysed, leading to the conventional/business as usual (BaU), safe/proactive and proactive/Smart Grid network scenarios. The base case example is built on data coming from the scenarios defined in WP1 and WP4 (D1.2 and D4.2) and extended, when required, with additional information from real distribution systems. The following table summarizes the network characteristics in all four scenarios.

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Table 1 Network characteristics in all scenarios

Characteristics	Base case	Conventional	Safe / Proactive	Proactive / Smart Grid
Total number of customers	10 900 000	10 900 000	10 900 000	10 900 000
Maximum demand (MW)	15 170	29 151	28 808	28 651
Minimum demand (MW)	7030	8303	8303	8303
Annual electricity consumption (GWh)	93 133	115 148	113 905	113 905
Min. limit for transport capacity (summer) (MW) Capacity margin (%)	16 687 10	32 066 10	31 689 10	29 472 5
Average total distribution losses (%)	8	8	7,8	7,7
DER hosting capacity (%)	20	20	20	25
Maximum DER power availability (MW)	3337	6413	6338	7368
Annual DER generation (GWh)	8390	16 121	15 932	18 521
Reliability: SAIDI (min./year) SAIFI (outage/year)	 104 2,2	 104 2,2	 104 2,2	 88,4 1,8
Bulk generation: Energy from bulk generation (GWh) Related CO_2 emissions (ton/year)	 84 744 23 019 835	 99 027 26 899 694	 97 973 26 613 482	 95 384 25 910 171
Avail. flexibility during contingency (MW)	0	0	0	612

In a final step, these different scenarios have been evaluated from an economic perspective in order to determine the best solution based on the costs related to them, both for the DSO and the total system. Results are gathered in the two tables below (all amounts in million euros, 2014).

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Table 2 DSO related CAPEX and OPEX costs (M€, 2014)

CAPEX Concept	Conventional			Safe/proactive			Proactive/Smart Grid		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Distribution infrastructure	*14 918*	*34 295*	*24 606*	*14 754*	*34 196*	*24 475*	*12 825*	*31 435*	*22 130*
Business as usual	14 918	34 295	24 606	14 552	33 455	24 003	12 401	28 510	20 455
AMI				202	742	472			
AMI, DA							424	2925	1675
Financing costs	*746*	*1715*	*1230*	*738*	*1710*	*1224*	*641*	*1572*	*1106*
Total (M€, 2014)	**15 664**	**36 010**	**25 837**	**15 492**	**35 906**	**25 699**	**13 466**	**33 007**	**23 236**
OPEX Concept	**Conventional**			**Safe/proactive**			**Proactive/Smart Grid**		
	Min.	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**
Operation and maintenance	*704*	*819*	*765*	*707*	*1033*	*839*	*718*	*1688*	*1049*
BaU	704	819	765	697	810	756	697	810	756
SG				10	222	83	21	878	293
Metering savings				*-26*	*-60*	*-43*	*-26*	*-60*	*-43*
Service outage mgt. savings				*-3*	*-3*	*-3*	*-3*	*-3*	*-3*
Reliability	*1450*	*2899*	*1812*	*1450*	*2899*	*1812*	*1232*	*2464*	*1540*
Emissions	*350*	*699*	*403*	*346*	*692*	*399*	*337*	*674*	*389*
Total (M€ 2014/year)	**2504**	**4418**	**2980**	**2474**	**4562**	**3005**	**2258**	**4764**	**2933**

Table 3 System related CAPEX and OPEX costs (M€, 2014)

CAPEX Concept	Conventional			Safe/proactive			Proactive/Smart Grid		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Bulk generation infrastructure	*83886*	*124695*	*104290*	*81829*	*121638*	*101734*	*80887*	*120237*	*100562*
Transmission system costs	*5959*	*7728*	*6844*	*5813*	*7539*	*6676*	*4954*	*6424*	*5689*
Financing costs	*4492*	*6621*	*5557*	*4382*	*6459*	*5420*	*4292*	*6333*	*5313*
Total (M€, 2014)	**94337**	**139044**	**116691**	**92025**	**135635**	**113830**	**90133**	**132994**	**111563**
OPEX Concept	**Conventional**			**Safe/proactive**			**Proactive/Smart Grid**		
	Min.	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**
Losses T&D	*950*	*2128*	*1520*	*920*	*2060*	*1472*	*911*	*2041*	*1458*
Reserves and regulating power savings							*-26*	*-39*	*-32*
Total (M€ 2014/year)	**950**	**2128**	**1520**	**920**	**2060**	**1472**	**885**	**2002**	**1425**

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The work presented here proposes a procedure for smart grid services analysis from the business point of view. This top-down approach permits to define use cases and scenarios for economic evaluation.