The birth of a **EU**ropean **D**istributed **E**n**E**rgy **P**artnership

that will help the large-scale implementation of distributed energy resources in Europe

eu-deep

EU-DEEP BOOKLET PRESENTATION

INTRODUCTION TO THE BOOKLET

The European Targets are ambitious and need a change of the electric system (3 pages)

Distributed Energy Resources will play a key role by 2020 (4 pages)

The development of DER raises new challenges for the different stakeholders (2 pages)

The EU-DEEP project was launched in 2004 to develop innovative business models for a sustainable integration of DER. (10 pages)

THE 50 KNOWLEDGE BLOCKS OF THE EU-DEEP TEMPLE

Temple structure (13 pages)

Tests (5 blocks x2 = 10pages)

Foundations – Technical (7 blocks x2 = 14 pages)

Foundations – Energy (4 blocks x2 = 8 pages)

Foundations – Network (3 blocks x2 = 6 pages)

Foundations - Services (2 blocks x2 = 4 pages)

Foundations – Aggregation (4 blocks x2 = 8 pages)

Pillars – BM1 5 blc7ks x2 = 10 |14ges)

Pillars – BM2 (5 blocks x2 = 10 pages)

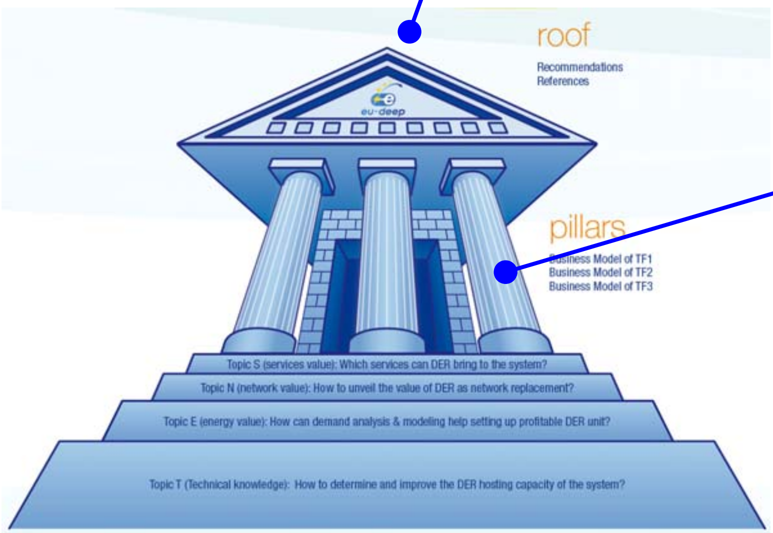
Pillars – BM3 (5 blocks x2 = 10 pages)

Roof (7 blocks x2 = 14 pages)

4 8

KEY MESSAGES TO THE STAKEHOLDERS
(9 x 4 pages)

- Policy makers
- Investors
- DSO
- Scientific community
- Regulators
- TSO
- Energy producers & retailers
- Consumers and energy end user
- Manufacturers



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INTRODUCTION

How does the EU-DEEP project started 5 years ago
meet the today's challenges?

Content

1. European energy targets by 2020: the electric system will evolve

1.1 The European energy policy orientations since 1996

1.1.1 The three pillars of EU energy policy

From a European perspective, energy policy is still a conflicting topic between Member States. Although the very first treaties of the European Community (EC) integrated some energy issues, regulation of the energy sector was left at the national level. The emergence of a common vision for a single EU energy market reaches back to the 1990s with the adoption by the EC of the white paper "An Energy policy for the European Union" (1995) paving the way to market integration and transparency.

Since the Energy Directive of 1996, Europe's policy orientations have progressively converged to three pillars, described in 2006 within the EC Green Paper entitled "A European strategy for sustainable, competitive and secure energy":

- **sustainability** - to take actions against climate change by promoting renewable energy sources and energy efficiency;
- **competitiveness** - to improve the efficiency of the European energy grid by creating a truly competitive internal energy market;
- **security of supply** - to better coordinate the EU's energy supply and demand within an international context

At that point in time, a common direction finally emerged from negotiations between the Member States: actions were initiated with regards to market consolidation and opening, taking care of environmental issues, and security of the system.

These policy orientations have been supported by a sequence of Directives and regulations which all produce a legislative framework that needs to be transposed into each European Member State national law or rules to come into application. For instance, **liberalization of the electricity industry** was initiated in 2003 with the implementation of the Directive concerning common rules for the internal market in electricity (Directive 2003/54/EC), and leading to:

- The opening of new generation capacity building to new producers
- **A regulated** access to the transmission network by producers and consumers
- The progressive **opening of the retail market** by 2007, from the large consumers down to the residential end users.
- The **unbundling** of generation, transmission and distribution activities: the legal separation of transmission system operators (TSO), Distribution system operators (DSO), and power producers.

1.1.2 The Kyoto protocol

Environmental issues entered the energy scene in 1997, with the Kyoto Protocol on Climate Change signed and ratified by the EU Member States. The protocol sets national targets for industrialized countries in order to reduce their collective greenhouse gas (GHG) emissions over the period 2008-2012 by 5.2% compared to the reference year 1990. "Cap and trade" policies have then been fostered, creating a market by setting pollution limits that require polluting entities – among which power plants – to hold tradable allowances, i.e. tradable rights to emit a certain amount of GHG). - In 2005, the EU launched the **European Union Emission Trading System (EU ETS),** today the world's largest emission trading scheme.

At the same time, each EU Member States implemented **public support schemes** to encourage electricity production through renewable energy sources and improvements in energy efficiency. Incentives developed may be direct support to investment, as well as advantageous regulated tariffs for electricity sell back (**Feed-in Tariffs** or FIT – the utility having the obligation to buy the electricity at the guaranteed price). Within a market-oriented approach, **tradable certificates** are designed to value avoided environmental impacts by producing electricity from renewable energy sources (green certificates were implemented in Sweden in 2003, ROC – Renewable Obligation Certificate – in the UK in 2002) or by increasing energy savings (white certificates in Italy in 2005).

1.1.3 The 2020 Targets

The 2007 EC "Energy and climate change package" led all Member States to share the following targets by 2020

- To reduce greenhouse gas emissions by 20% compared to 1990 levels
- To reduce primary energy use by 20% (through energy efficiency measures)
- To increase the level of renewable energy in the EU's overall final energy consumption to 20%.

A very detailed set of national targets for renewable energy use will be presented in the Directive on the promotion of the use of Renewable Energy Sources to be adopted in 2009: each Member State will choose its own route to meet the future targets which will be monitored by the European Commission. The accompanying **Strategic Energy Technology Plan** (SET-Plan) will support massive demonstration projects to boost innovation in low-carbon technologies and smart electricity networks, thus enhancing the funding at EU and Member State level to reach the above targets.

	Share of energy from renewable sources in gross final consumption of energy, 2005	Target for share of energy from renewable sources in gross final consumption of energy, 2020
Belgium	2.2%	13%
Bulgaria	9.4%	16%
The Czech Republic	6.1%	13%
Denmark	17.0%	30%
Germany	5.8%	18%
Estonia	18.0%	25%
Ireland	3.1%	16%
Greece	6.9%	18%
Spain	8.7%	20%
France	10.3%	23%
Italy	5.2%	17%
Cyprus	2.9%	13%
Latvia	32.6%	40%
Lithuania	15.0%	23%
Luxembourg	0.9%	11%
Hungary	4.3%	13%
Malta	0.0%	10%
The Netherlands	2.4%	14%
Austria	23.3%	34%
Poland	7.2%	15%
Portugal	20.5%	31%
Romania	17.8%	24%
Slovenia	16.0%	25%
The Slovak Republic	6.7%	14%
Finland	28.5%	38%
Sweden	39.8%	49%
United Kingdom	1.3%	15%

Table 1: National overall targets for the share of energy from renewable sources in gross final consumption of energy in 2020. *Source: European Parliament legislative resolution of 17 December 2008 on the proposal for a directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (Annex 1)* Everyone in the energy business has understood that a progressive, yet in-depth and irreversible, reshuffling of today's energy system is on its way:

- Local electricity production systems will combine with centralized ones, since massive renewable electricity generation guarantees a higher security of supply, but is produced where resources are available, i.e. very often far away from consumption sites: electricity networks must be adjusted.[TE2]
- Former supply-based designs of energy systems will combine with demand-based approaches to optimize the client's needs: the recent German Directive on renewable energy deployment favours the self consumption of the produced electricity, which in turn pushes new DER owners towards a revisit of their past energy needs.
- A low carbon electricity production – as a prerequisite to level off CO_2 production around 2040 worldwide – will mean more renewable electricity connected to the network, more volatility in generation, but probably also more volatility in consumption, since clients may change rapidly their consumption patterns under the pressure of highly varying electricity price signals.

On the top of such system changes, information technologies have today reached unprecedented performances that make them suitable to help distributed generation cooperate with the energy system in a reliable manner. Power electronics to control small generation units, cheap telecommunications for system supervision will provide system managers with new tools and concepts to revisit the optimization rules of the whole energy system and therefore to propose new strategies that will make life easier for all market participants.

1.1.4 Key EC Directives shaping today's European energy landscape

The table below summarizes the sequence of Directives which have progressively shaped the national European energy markets.

Table 2: Key EC Directives dealing with Energy

Regulations and European Directives dealing with Energy matters	
Reference	**Title**

Directive 1996/92/EC	Common rules for the internal electricity market
Directive 2003/54/EC	Common rules for the internal electricity market
Directive 2003/55/EC	Common rules for the internal gas market
Regulation N°1228/2003	Network access conditions for cross boundary electricity exchanges
Regulation N°1775/2005	Access conditions to the gas transport network
Directive 2004/8/EC	Promotion of cogeneration based on the EU heat internal demand
Directive 2005/32/EC	Specifications regarding eco-design of energy-using products
Directive 2006/32/EC	End use energy efficiency and energy services
Directive 2007/ ?/EC	Promotion of renewable energy sources
Strategic Energy Technology Plan	SET plan document 22.11.2007 COM(2007) 723 final
Draft Directive (19/09/2007)	Third legislative energy package (including addenda to Directives 2003 and Regulations 2003/2005)

1.2 Such policy orientations do impact the electricity system as it works today

Since the early stage of electricity development, network designs have relied on demand forecasting (the load) and growth perspectives for consumption, thus allowing the sizing of:

- centralized generation,
- transmission network, which carries electricity over long distances at high voltages,
- distribution network, which brings electric power down to the end-user sites through low voltage lines

[TE4]

Power plants with increasing nominal power have been constructed all over Europe since the end of World War II in order to lower the cost of energy generation. They are today interconnected through a pan-European Power Transmission System, whereas the distribution network deals with local electricity end users[TE5].

1.2.1 Evolving players in the electricity field

The 2003 Directive on internal electricity market led to the progressive transformation of vertically-integrated electricity companies into four sets of independent players[TE6]:

- **The regulated transport and distribution networks**: electricity networks have for long been recognized as natural monopolies. For a given unit surface area, doubling electrical energy distribution costs twice as much if there are two competing network operators, while costs increase by only 40% to 50% [TE7]if only one existing network is upgraded with necessary additional grid connections.
- **Generating companies**: most of them still operate very large power plants, connected to the transmission network (high voltage grid). Thanks to renewable electricity production, small producers are however entering the market, still mostly connected at distribution level[TE8].
- **Retailing companies**, whose job is to sell energy commercial packages to customers, thus cumulating generation, transport, distribution and retail costs.
- **Regulatory authorities,** whose mission is to ensure that companies under regulatory laws remain economically efficient, and that both generation and retail companies adopted fair and transparent practices to the benefits of the customers, while complying with the policy orientations declined by each Member State in coherence with the three pillars defined at the EU level.

1.2.2 New issues raised by the 2020 Targets

The March 2007 decision of the EU 27 Members States on the Energy Package has significant impacts on the evolution of the electricity system:

- "**Energy versus power**": the Energy Package sets energy targets, but does not address the issue of installed capacities. Generally speaking, actual generation of a power plant is only a fraction of its potential production since power plants are sometimes unavailable; yet, most renewable energy power plants experience even smaller capacity factors, due to the intermittent character of their resources. This has an impact on the sizing of the installed capacities required to reach the energy targets: fossil fuel or nuclear centralized units work almost all year round[1], whereas, for instance, wind power plants very seldom work beyond 4000 hours per year[2]. This means that, when wind blows during the night and energy is not needed, power flows have to be transported in hydro storage areas or consumed in areas where customers have needs.
- **"Can the network make it?":** renewable energy sources like wind or solar cells deliver electricity on sites where it might not be needed. Power must then be transported through one of the most complex interconnected system in the world: this interconnected system is experiencing a reduction of its stability margins since constructing more overhead lines is not accepted anymore. Similarly, tens of thousands of units connected to the distribution network in a sunny area of Europe can deliver backward power flows into the network which is highly intermittent because of clouds! The networks will have to deal with such volatility at unknown levels, while still being managed as natural monopolies[TE9].
- **"What about regulatory regimes?":** following the 1996 Directive, which initiated the unbundling of vertically-integrated utilities, the full unbundling [TE10]and market rules are in operations since July 1st 2007. Yet, most of the rules used to regulate network operations are still based on the old way of designing electrical systems. Centralized generation delivers power through transmission and distribution lines: network charges are calculated accordingly.[TE11] What about the network cost impacts of massive power flows going backward in distribution and transmission networks[TE12]? Should responsibilities between transmission and distribution be shared differently from today? How to improve coordination between transmission operators? The third Energy package adopted by the Member States in late 2008 will settle some issues at the transmission level, but leaving major issues at the distribution level opened, including DER connection standards and network charges[TE13].

1.2.3 Daunting investments in Renewable Energy Sources

The Renewable Energy Technology Roadmap up to 2020 published by the European Renewable Energy Council in 2007 provides some figures on the renewable energy generation today in EU 25, and some projections and expected growth rate to reach the 2020 EU targets. The tables below present forecasted installed capacity and the share in the electricity consumption.

Table 3: Renewable electricity installed capacity

Type of energy	2002 Eurostat	2006 Eurostat	2010 Projection	2020 Projection
Wind	23.1 GW	47.7 GW	80 GW	180 GW
Hydro	105.5 GW	106.1 GW	113 GW	120 GW
Photovoltaic[3]	0.5 GWp	3.2 GWp	18 GWp	150 GWp
Biomass	10.1 GWe	22.3 GWe	25 GWe	50 GWe
Geothermal	0.68 GW	0.7 GW	1 GW	2 GW
Solar thermal electric	-	-	1 GW	15 GW
Ocean	-	-	0.5 GW	2.5 GW

[1] *from 8300 hours (thermal) down to 8000 hours for the best nuclear power plants (except during the year of major overhauls)*
[2] *it highly depends on the design (selected MVA of the converter versus diameter of wind turbine + mean wind speed)*
[3] *2008 upgrades*

Table 4: Contribution of Renewables to electricity consumption

Type of energy	2005 Eurostat TWh	2006 Eurostat TWh	2010 Projections TWh	2020 Targets TWh
Wind	70.5	82.0	194	530
Hydro	346.9	357.2	356	384
Photovoltaic[4]	1.5	2.5	20	180
Biomass	80.0	89.9	138	300
Geothermal	5.4	5.6	7	14
Solar thermal electric			2	9
Ocean			3	15
TOTAL RES	504.3	537.2	707.5	1,313
Total Gross Electricity generation EU27 (Trends to 2030-Baseline)* (Combined RES and EE)**	3320.4	3361.5	3483 3314	4006 3250
Share of RES	15.2%	16.0%	20.3-21.3%	33.6-40%

** European Energy and Transport trends to 2030 – update 2007,2008, EC DG TREN*
*** European Energy and Transport: Scenarios on energy efficiency and renewables, 2006, EC DG TREN*

1.2.4 The changes to come

In a world where energy resources were abundant and available at low cost, the electricity supply industry was ruled by generation[TE14]: the supply capacity ensures the satisfaction of all end-user needs without any restraints. Industrialisation of the electricity system freed consumers from the natural variability of, for instance, hydro electric power.

Yet, there are signals that indicate future scarcity of fossil energy; and new environmental constraints further emphasize the urgent need to handle energy consuming systems with increased efficiency. One Euro of extra GDP should require less energy, combining increased efficiencies all along the energy value chain. In the end, thanks to Information and Telecommunication solutions, consumers could disconnect from the system and be remunerated for the negative energy spent[TE15]. This is demand side management [TE16]which will inevitably occur, since it can add another level of customer flexibility in front of intermittent generation coming from wind or photovoltaic.

2. Distributed energy resources: a rising solution in the electricity landscape

2.1 What are distributed energy resources (DER)?

IEEE 1547.3[5] understands DER units as a combination of distributed generators (delivering electrical power), distributed bidirectional storage units [TE18](delivering electrical power after storing it) and distributed electrical loads with Demand Response and control features.

Distributed Energy Resources encompass
distributed generation, distributed storage and demand response.

[4] *2008 upgrades*
[5] *"1547.3 IEEE guide for monitoring, information exchange, and control of distributed resources interconnected with electric power systems", 16 November 2007*

Demand Response encompasses any dynamic mechanism which helps manage customers' electricity consumption in response to supply conditions. This can be, for instance, the temporary reduction of customer's electricity consumption during peak hours through the use of dedicated control systems in response to a utility request [TE19]or to market price conditions[TE20]

Controllable Distributed Energy units are DER units which are capable of controlling active and/or reactive power: these control capabilities allow providing the electric system with both energy[TE21] and ancillary services[6][TE22].

The latter are the services that are requested for secure and cost efficient electric network operations, viz.: power/frequency control, voltage control, reduction of power losses[TE23], improvement of power quality and reliability.

System ancillary services [TE24]are the "services necessary for the operation of an electric power system provided by the system operator and/or by power system users"[7].

Small scale DER solutions allow exploiting renewable **energy sources available at or near the point of final consumption.** The electrical supply system then comprises also smaller energy resources spread along the distribution network. This is a shift of paradigm: in the 'centralized world', power flows only in one direction from the central power station to the network and the consumers. From now on, more and more small-scale generation sources will get connected to the distribution network, bringing new power sources into the system. The distribution network can no longer be considered as a passive network at the end of the transmission lines: the entire system has to be designed and operated with locally distributed generators.[TE25]

Yet, scaling-up of power generation devices still applies to the electricity generation based on renewable energy. The rated power of wind turbines has been multiplied by ten over the last ten years, approaching now 5 MW. The largest offshore wind farms today can reach 500 MW. The same trend applies to solar central power systems. These types of technical solutions should contribute to reaching the 2020 objectives, but leading to the same disadvantages as the traditional central power plants: long-term daunting investments in generation equipments, remote locations from the consumption points, and subsequent investments in additional transmission lines.

2.2 [TE26]DER development in recent years

DER units cover a wide range of implementation schemes:

- Use of renewable energy sources or not (wind technologies, solar technology for electricity and heat generation, etc.);
- Combined heat and power systems using gas or biomass or simple electricity generation units;
- Intermittent or stationary;
- Dispatchable or non-dispatchable;
- Stand alone configurations or connected to the distribution grid.

Wind power

[6] *M. Braun, "Technological control capabilities of DER to provide future ancillary services" International Journal of Distributed Energy Resources, 3, N°3 2007*

[7] *IEC " International Electro technical Vocabulary Part 617: organisation/market of electricity" DIN IEC 60050-617, IEC 1/2063/FDIS, Final Draft 2008*

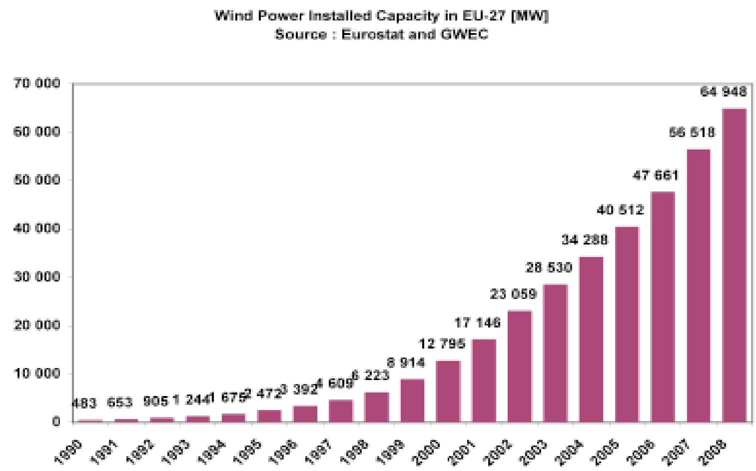


Figure 1: Wind Power Installed Capacity EU-27 [MW]

The figure above illustrates wind penetration, where generation can be connected at distribution or transmission levels depending upon the size of the wind farms.

Photovoltaic

Germany has clearly been leading the strong commercial and technical development of PV in Europe during the last 10 years, and now accounts for 42% of the global installed capacity in 2007[8] (**EPIA** / Greenpeace, 2008).

Different points of view must be confronted when looking at PV capacity projections. The European PV Technology Platform[9] estimates over 4.5 GW the PV installed power in 2012, while according to EPIA's roadmap[10], the cumulative installed on-grid capacity will be at least 41 GW in 2020.

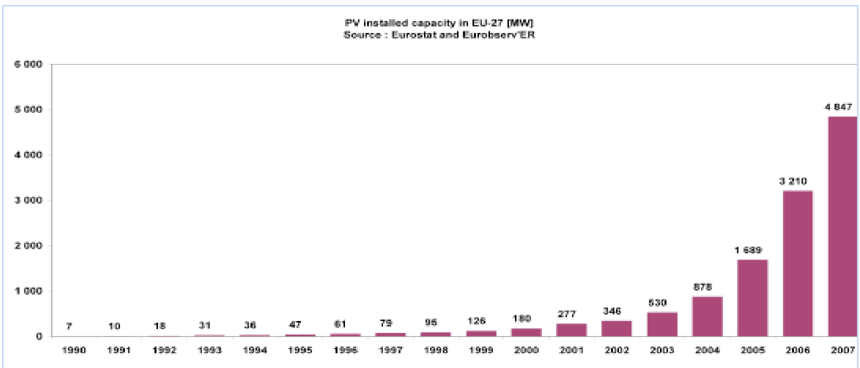


Figure 2: PV installed capacity in EU-27 [MW]

Concentrated Solar Power[TE29]

In Europe around **300 MW of solar thermal power plants** are either operating or under construction. The installed capacity in Europe is expected to be of 500-1,000 MW by 2010 and an amount of more than 20,000 MW by 2020 is reasonable[11]. The technical potential in Europe in the long run can be estimated at least at twenty times that figure within reasonable generation costs. An estimate of the "distributed" share in these capacities, following the present trends of market and technology, is roughly 5% of the installed power. According to

[8] European PV Industry Association - Greenpeace (2008). Solar Generation V.: www.epia.org/fileadmin/EPIA_docs/documents/EPIA_SG_V_ENGLISH_FULL_Sept2008.pdf

[9] Perezagua, E. (2008). Welcome Presentation at the 3rd General Assembly Ljubljana, 2008: www.eupvplatform.org/fileadmin/Documents/GA2008/PPT/AG_2008_1_1_Perezagua.pdf

[10] European PV Industry Association (2004). EPIA Roadmap: http://www2.epia.org/documents/Roadmap_EPIA.pdf

[11] The European Industry Association of the CSP Sector, ESTELA, expects to reach 30 GW by 2020, of which more 20 GW will be in Spain, the rest being placed in other south-European countries (mainly Portugal, Italy and France).

ESTELA, 1.5 GW capacity will be provided by Dish-Stirling systems, a technology especially well suited for distributed generation.

Biomass

Biomass includes Biofuels, Biogas, municipal wastes and Solid biomass for electricity generation. It is also used for heating, in co-firing of coal power plants and transport (biofuels). Germany and UK show a dynamic growth of their market, though still insufficient to fulfil the EU objectives.

The 2007 Eurobserv'ER barometer projections amount only to 105.3 Mtoe in 2010, while the Biomass Action Plan (2005) estimates 150 Mtoe for the same year. Regarding electricity generation, the FORRES 2020 report gives 141 TWh from biomass for year 2020 in the "Business As Usual" scenario and 338 TWh for a policy-driven scenario.

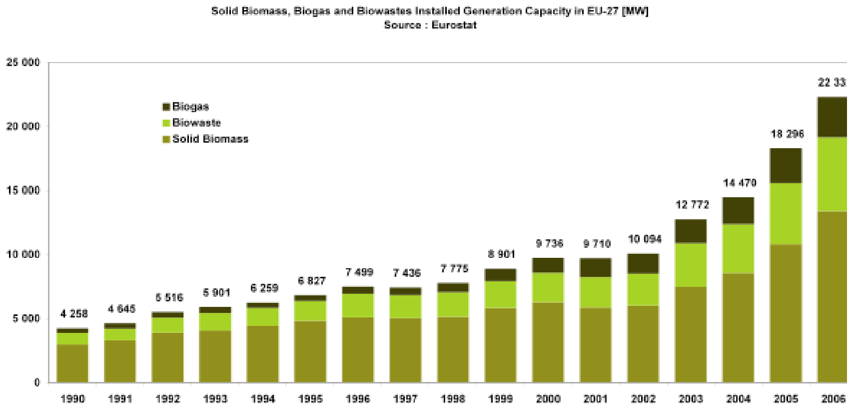
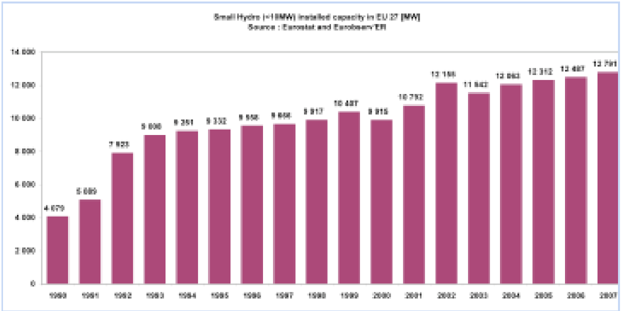


Figure 3: Solid Biomass, Biogas and Biowastes Installed Generation Capacity in EU-27 [MW]

Small hydropower and other renewable energy resources

Small hydropower capacity is approaching the limited potential in the EU countries. In addition, the possible effects of climatic change may limit these resources even further, especially in the South of Europe.

Other renewable energy resources – geothermal, wave & tide energy… – either have a very limited potential in Europe or are at a very early stage of development. However, some of them may achieve a significant contribution by 2020. According to the RES 2020 Reference Scenario [Ragwitz 2006] tide & wave energy may generate 49.3 TWh in 2020, while geothermal will generate a mere 2.4 TWh, mainly in Italy. The DER share in these figures will remain at a quite low level.



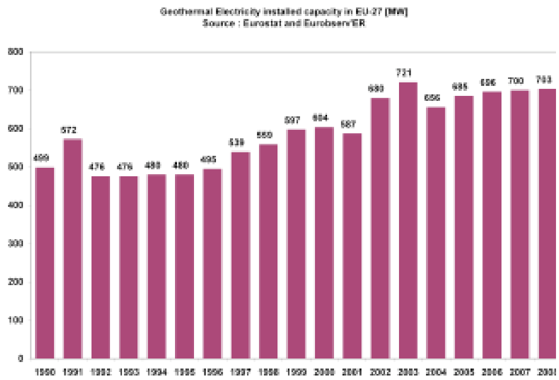


Figure 4: Small Hydro and Geothermal Installed Capacity in EU-27 [MW]

Combined heat and power

Combined Heat and Power (CHP) systems include a range of technologies to generate both power and heat. Natural gas can be used in all types of equipment, [TE30]while coal and biomass are mainly restricted to steam turbine CHP units. So far, CHP applications have been restricted to the industry and services buildings. It is only recently that small-scale CHP systems have started experiencing development growth, due to the large **potential market in the residential and commercial sectors**. Small CHP units of 100 kWe and above represent a steadily growing market, while micro-CHP, particularly below 20 kWe, are still in the R&D and demonstration phase (Stirling engines, organic Rankine cycle, micro-turbine[TE31]): market applications of that size in the EU use internal combustion engines Stationary fuel cells display high electrical efficiency, but still experience a very limited deployment.

In 2006, the installed CHP capacity in the EU-27 was about **95 GWe**, generating about 11% (366 TWhe) of electricity demand. When trying to size the "decentralized" part of this production, data from USA[12] and some European countries[13] [14] lead to estimates around **50% of the total CHP generation in the range of P < 10 MW.**

With regards to projections, the CHP *installed capacities* for the EU-27, assumed to be in the baseline, reach **160 GWe in 2020.** Since CHP technologies are also expected to enter the residential and commercial sectors, one can estimate that 70% of this capacity will be within the range of DER, thus resulting in an estimated DER CHP capacity of about 110 GW_e, and a generation of electricity close to 400 TWh_e by 2020.

[12] Energy and Environmental Economics (2008). EPUC / CAC existing CHP generation data. http://www.ethree.com/GHG/Data Sources for Calculations- EIA and SCE QF Data.032408.doc

[13] Basque Energy Board (EVE) (2004). OPET Cluster District heating and co-generation WP 2. Small and Micro Scale CHP. Deliverable Nº 2-11-1. National Report On State Of SSCHP Policy And Sector Situation. Spain. http://www.opet-chp.net/download/wp2/WP2_Country_Report_Spain.pdf

[14] Berliner Energieagentur (2004). OPET CHP/ DH Cluster: Workpackage 2: Micro and Small Scale CHP. National Report on State of SSCHP. Policy and Sector Situation in Germany. http://www.opet-chp.net/download/wp2/WP2_country_report_Germany.pdf

2.3 Electricity production in Europe by 2020

2.3.1 DER contribution

Starting from the RES 2020 scenario described above and based on the above estimates, one can assess the DER share within today's and tomorrow's EU electricity consumption. The figure below illustrates the past growth trends.

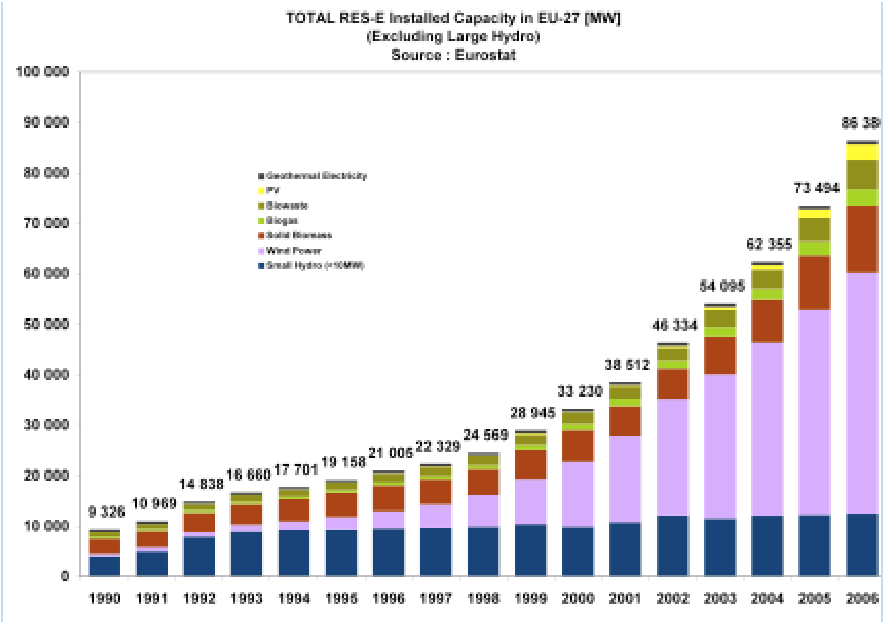


Figure 5: Total RES-E Installed Capacity in EU-27 [MW] (excl. Large Hydro)

The main assumptions with regards to the future share of distributed generation within the overall generation per type of technology are as follows:

- 0% of wind is considered as distributed
- 75% of photovoltaic capacity (PV)
- 5% of solar thermal power capacity (STP)
- 80% of biomass capacity
- 100% of solar heating power capacity (SHP)
- 70% of combined heat & power capacity (CHP)

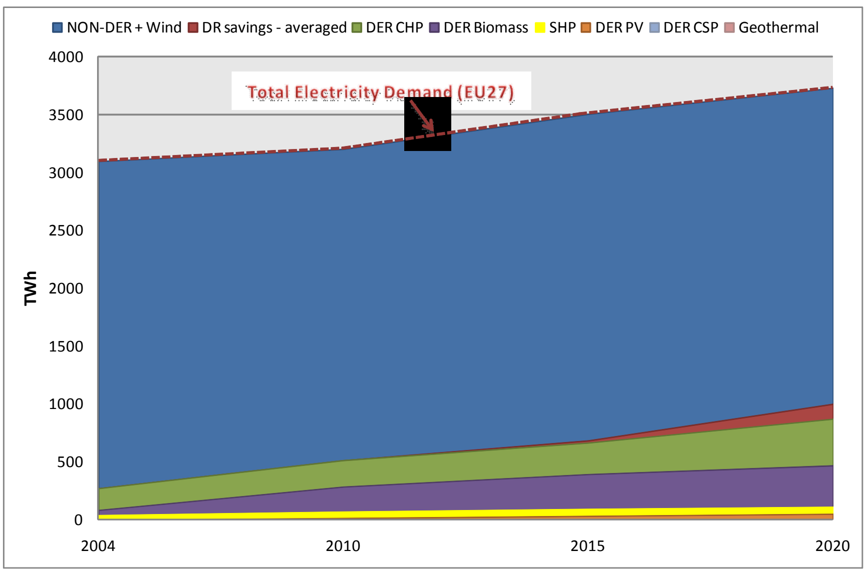


Figure 6: DER contribution to total electricity demand

The red dotted line represents the total electricity demand (EU27) in a conservative scenario. Savings reached through Demand Response (DR) in an intermediate scenario are represented by the red area. The electricity demand that has to be covered by conventional, fossil-fired or nuclear power plants, wind energy or other renewable energies in plants of capacity bigger than 10 MW (most of CSP plants, large PV plants, big CHP, etc.) is included in the NON-DER + Wind category, represented by the blue area.

The most significant DER contribution will be provided by CHP and Biomass, with an important potential for DR savings. PV and Solar Thermal Power technologies (STP) have a high potential to increase their share in the total electricity generation; yet, in this case, plant capacity will probably be outside the limits of DER. According to these figures, the total DER contribution to EU electricity demand in 2020 will be between 25% and 30%, while total renewable energy contribution could be close to 40% in a dynamic – but feasible – scenario.

2.3.2 Demand response contribution by 2020

Demand response (DR) programmes, unlike dynamic demand mechanisms, are supposed to manage the customer consumption of electricity in response to supply conditions: for instance, it leads electricity customers to reduce their consumption at critical times, such as peak hours or in response to market prices. Demand response mechanisms answer explicit requests to shut off power, whereas dynamic demand devices passively shut off when stress in the grid is sensed. Demand response can involve curtailing actions on the used power or starting on site generation which may or may not be connected in parallel with the grid. This is complementary to energy efficiency, which means using less power to perform the same tasks, on a continuous basis or whenever that task is performed.

Demand Response programmes have been implemented since the late 1980's worldwide with a major goal in mind[TE34]: reduce the wholesale market prices, especially at peak load conditions, which in turn make wholesale electricity markets more efficient. To day, in the UCTE system, it represented only 3 % of system peak load for year 2008[15]. In the near future, Demand Response will gain further attention since it will also boost the concept of prosumer, the client being a producer and a consumer of electricity, and therefore will promote a more efficient penetration of renewables.[TE35]

The further development of Demand Response in Europe will lean on the advent of smart metering, which introduces both technical and regulatory challenges[15]. An overview report[16] published in 2008 shows a rough prediction of the smart metering penetration in each of the EU-15 countries in 2010 and 2020: it also assesses the current interest in demand response (demand flexibility). It expects that, by 2020, smart metering penetration will be about 100% in France, 60% in UK, 50% in Spain and Greece and 30% in Germany, if the current trends in regulatory, technical and market conditions apply. The report estimates energy savings between 59 TWh (low profile scenario) and 202 TWh (high profile scenario), with peak generation capacity avoided of 28 GW and 72 GW, respectively[TE36].

On 28 October 2008, after the publication of the report, the UK government announced that it will mandate smart metering to all households with an indicative timetable that the rollout will be completed by 2020. In Spain in 2007 a government order was given that requires full

[15] "SMART METERING : AN OVERVIEW OF TECHNOLOGICAL AND REGULATORY CHALLENGES", Jorge Vasconcelos, NEWES, Florence School of Regulation, February 6, 2009

[16] *Capgemini (2008). Demand Response: a decisive breakthrough for Europe, How Europe could save Gigawatts, Billions of Euros and Millions of tons of CO2. Report prepared by Gapgemini in collaboration with VaasaETT and Enerdata.*

penetration by 2018. Regarding Germany and Greece the development still seems highly uncertain and 50% penetration in Greece in 2020 seems rather optimistic.[TE37]

It is therefore highly probable that regulators will integrate demand response in market design, mandating Transmission System Operators to promote DR and take due account of DR in their future work flow[TE38].

3. DER will progressively impact all the electricity market stakeholders

3.1 A fuzzy energy future

Over the past five years the **macro economic environment** and the world energy scene have drastically changed. The evolution of oil prices, the increasing environmental concern and the recent financial crisis leave most of the options opened, except reaching the 2020 targets which will require huge investments[17].

Table 5: Evolution in the macro economic environment

	in 2003	Up to end of 2007[18]	Trend
Oil price (in USD/barrel)	30 USD	100 USD	Short and long term estimation is difficult[TE40]
Awareness of the climate change effect	Only among part of scientific community No public awareness	The *IPCC*[19] publications are read by politicians / Public awareness is increasing Green business is discussed at the Davos conference	Acceleration
Renewable energies share of primary energy consumption in the countries of the European Union	5.48% in 2003 for EU25 Objective[20] 2010 is 12%	6.92% in 2006 for EU25 7.83% in 2007 for EU27 (9.2% of final energy consumption in 2007 for EU27)	Objective 2020 is 20% of final energy consumption
PV penetration in Europe *(PV cumulated capacity installed in MWp in Europe)*[21]	EU: 573 MWp	EU[22]: 4690 MWp	Booming X8[TE41]
Electricity generation (in Tera Watt hours, world)	2003: 16770 TWh	2006: 18930 TWh (IEA)	Steady increase

[17] *The recent IEA study quotes investments in excess of 1 Trillion € over the next 20 years to make the European electric systems meet a unique goal: decarbonising electricity production.*
[18] *If no mention of the date the information provided to the table corresponds to 2007*
[19] *Intergovernmental Panel on Climate Change*
[20] *COM(97) 599 final Energy for the future - renewable sources of energy: White Paper*
[21] *Source PV NET*
[22] *According to the Observ'er source the progression was: 1010MWp in 2004 ; 1791.7 MWp in 2005 ; 3217 MWp in 2006*

3.2 Beyond the existing EU policy orientations, other drivers will catalyze DER expansion

3.2.1 Innovative ICT

The ageing of the grid infrastructures[TE42] means that grid upgrades will be required, involving cheap ICT solutions[TE43] combining wireless telecom and smart sensors and meters. The emergence of new control, automation and communication technologies allows implementing new practices in distribution system operations thus facilitating DER use. Interval metering will become the rule. The production of DER can be known and invoiced more accurately.

3.2.2 The steady increase of electricity prices

There are at least three reasons that could push electricity prices upwards, and therefore make DER financially more attractive:

- A highly probable long term pressure on the price of fossil energy due to the increasing world demand and the scarcity of fossil energy;
- The lack of investment in generation during the past years and the resulting scarcity in terms of generation reserves pushing towards higher electricity prices especially during peak periods[TE44];
- The possible switching towards CO2 sequestration which requires the adjustment of existing energy conversion processes and therefore additional, significant increases in terms of investments and a decrease of the overall efficiency of the conversion process.

3.2.3 The convergence of electricity market architectures

For the time being market architectures remain highly country specific. During the coming years a convergence process will take place at least at spot market level, thanks to the interconnected pan European transmission system[TE45].

3.2.4 The upcoming ISO energy management standards

On March 2008, the creation of a project committee **ISO/PC 242/ Energy management** was approved, mandated to develop an international standard on energy management, due to be in operation in early 2010. The standard will provide a practical and widely recognized approach to increase energy efficiency, reduce costs and improve environmental performance by addressing both the technical and management aspects of rational energy use. The standard is intended to be broadly applicable to various sectors of national economies, including manufacturing, commercial building, general commerce. This will help increase energy efficiency, by providing energy managers with a complete framework to re-analyse their own consumption patterns, and reassess technology options and contracts to meet their future energy needs.

3.2.5 The emergence of energy service companies

Thanks to the liberalization of gas and electricity markets, new types of energy offers have emerged in Europe. Utilities now provide energy services in addition to the mere supply of gas and electricity. They allow reducing the end-user's energy bill, either through increased energy efficiency (for instance a CHP at the customer's site), or through the valuation of the customer flexibility in consumption (demand response equipment).

Utilities will be in a position to promote new contractual options to prosumers, such as:

- <u>Providing energy services to final energy users</u>, including the supply and the installation of the energy efficient equipment, its maintenance and operation and also the supply of energy (including heat). Services are provided on a fee basis like in outsourcing contracts developed by IT companies since the mid 1990's.

- Providing a "guaranteed savings contract" to the customer, guaranteeing a level of energy savings to the customer by contract, but without bearing the investment in energy efficiency equipment (the customer bears the investment through a loan to a third party).
- Providing a "shared savings contract", in which the technical risk is shared with the customer: the company finances the operation of an energy system, shares the performance risk with the client, while the client takes some part of the performance risk but no financial risk.

These options lead to various contractual formats for energy service companies (ESCO), i.e. any company providing energy supply services (e.g. provision of heating in public building, etc.). ESCOs are so far companies using the energy performance contracting: their remuneration is linked to the level of energy savings finally achieved [23].

3.3 All the energy stakeholders will be impacted by DER expansion

There are nine main stakeholders to be impacted by the growth of DER units all over Europe:

1. Policy makers
2. Regulators
3. Investors
4. Electricity consumers and energy facility managers
5. Electricity producers and retailers
6. Electricity distribution operators
7. Electricity transmission operators
8. Equipment manufacturers
9. Researchers

The 2020 targets push for more renewable energy sources and highly efficient combined generation of heat and power in order to reduce the CO_2 content of our energy generation and end uses. The sharp increase in fossil fuel prices will further enhance demands for more efficient energy uses: this is where Distributed Energy Resources (DER) can help make a break, when implemented in Commercial and Residential buildings as well as in Industry, Agriculture or in remote areas.

3.3.1 Policy makers

The recent IEA study quotes investments in excess of 1 Trillion € over the next 20 years to make the European electric systems meet a unique goal: decarbonising electricity production. The investments will include a large share of decentralised electricity production, both from renewables and combined heat and power facilities. They will also address the transmission and distribution networks in order to increase their capacity to withstand DER connection onto the distribution network, without loosing on system reliability and power quality.

Challenges for policy makers

Can the existing network take large amounts of DER by 2010 and beyond?

Can dispersed generation investments avoid public subsidies?

Are existing regulations catalysing DER expansion in Europe[TE46]?

23 Energy service companies in European countries; current status and a strategy to foster their development, P. Bertoldi, S. Rezessy, E. Vine, Energy Policy 34 (2006) 1818-1832

3.3.2 Regulators

The 2020 EU targets push for more renewable energy and more high efficiency distributed CHP units. Together with increased demand flexibility, these trends will change the way that electricity is to-day generated, transported and used.

An accurate estimation of the resulting technical investments and an ex-ante cost assessment of their impacts on society as a whole brings several challenges. So far, most of the regulators have remained fairly passive and short-sighted with regards these issues, even though it has been shown that present engineering models can adequately address both the technical and part of the economic aspects of this integration. A crucial and still open question is then to which extent and for what purpose normative engineering models can provide relevant information for economic network regulation?

Assuming that system operators will keep the responsibility of developing and maintaining the transmission and distributions networks based on exogenously defined targets, new boundary conditions will mean new targets in relation with updated energy policy goals. The whole process must be catalyzed by regulatory bodies.

Challenges for regulators

Which regulatory environment is the most suited for a smooth and sustainable development of distribution networks?

What are the *prerequisites to set* sustainable and efficient "Use of System charge" tariffs for distribution networks?

How to build "Use of System" tariffs that are able to unveil the value of DER as "network replacement"?

What is "hosting capacity" for DER of the present distribution networks

What is the rationale to upgrade network design criteria allowing for more flexible DER integration?

3.3.3 Investors

The Strategic Energy Technology Plan of the European Commission is foreseeing 400 to 450 Billion Euros of investments in network infrastructures over the next three decades (25% transmission, 75% distribution) with 70% of private investment completing 30% of public money. Before the 2008 financial crisis, the investor community had changed its mind when investing into renewable technologies and, overall Distributed Energy Resources. 45 clean-energy companies were already listed on US stock exchanges by the end of 2008. This development is built on grounds more robust than the ones which fired the dotcom boom. A political consensus exists in the EU27 to keep Europe as the world leading continent on new energy technologies. The Venture Source Institute published early 2008 an EU rise in equity towards clean energy of 27%, reaching 266 millions Euros. Opportunities exist in technology development, both at Transmission and Distribution levels, leading to a grid supporting the intermittency of renewables, the volatility of customers that can switch on or off depending upon price signals, but also capable of more reliable operations at reduced costs and emissions based on Demand Side Management approaches.

Challenges for investors

Are EU directives and subsequent regulations favouring DER investments?

Are there business models that are free from public subsidies, thus involving long term energy demand shifts?

Can DER compete one day with fossil fuel electricity?

What are the critical technologies that can become blockbusters ?

What are the most promising business models for DER development?

3.3.4 Electricity consumers and energy managers

On the one hand, individual electricity consumers may become prosumers, thus producing and consuming energy in a way that can reduce their bill significantly.

On the other hand, energy managers do face compliance issues with the agreements that have been reached in December 2008 on the Climate and Energy Package. The 2020 targets require unprecedented measures to meet these new requirements, and optimize energy-related costs. **Optimization of consumption and generation takes on a crucial importance** under new constraints and strategic adaptation: energy management will support **profitability** and **compliance with those new standards**. Starting today, energy managers have the opportunity to consider use of the two levers they have at their disposal: **distributed generation** for decentralized energy production, and **demand response** for power consumption optimization process.

Last but not least, energy managers in commercial, residential or industrial companies will be invited to use the ISO standard ISO/PC 242/ Energy management, due to be in operation in early 2010. The standard will provide all types of organizations and companies a practical and widely recognized approach to increase energy efficiency, reduce costs and improve their environmental performance by addressing both the technical and management aspects of rational energy use.

Challenges for consumers and energy managers

How to assess the pertinence of launching a DER project within a given site?

To what extent will DER change the relationship between consumers and energy players?

What are the new commercial offers that will come into play ?

3.3.5 Electricity producers and retailers

The integration of Distributed Energy Resources (DER) has started. The ambitious 2020 targets and the broadening scope of industrial activities subject to the Emissions Trading Scheme will undoubtedly contribute to an increase in DER penetration and its extension to new market players in the years to come.
Since the liberalisation of the European energy sector, utilities have had to deal with a number of evolutions including energy markets integration, tightening environmental regulations and increasing volatility of commodity prices, prompting them to adapt their business models to the changes in the environment and take on new roles (multi-utility model, renewable generation…).
DER may be seen as a threat to conventional business models but also as a tremendous opportunity where power producers are in a privileged position to build new DER and retailers may provide innovative energy-related services to their customers. There are myriads of business opportunities for retailers: they represent a multi-dimensional matrix spanning from early-stage "technology play" to mature "infrastructure play" on the one hand, and from active "asset owner + operator" to passive "asset financing" on the other hand.

Challenges for electricity producers and retailers

To which extent DER will modify the relationships between energy consumers and suppliers?

Are there any promising business model for DER?

Which market segments show a significant revenue potential for DER implementation?

3.3.6 Electricity transmission operators (TSO)

Design and operations of the existing transmission and distribution networks, together with the associated regulatory and market rules were decided on the basis of a centralized system, thus leading to unidirectional powers flows in the distribution network [TE47]–since only demand was connected to the distribution network. Currently these assumptions do not hold true any more due to the growth of Distributed Energy Resources (DER). The exact location of DER units in the electricity supply chain and the associated techno-economic consequences introduce new challenges for grid operators, utilities, market operators and regulators. Being responsible of system operational security TSO are at the fore front of the DER integration process.

Challenges for TSOs

Which technical issues can be expected in a system with a significant penetration of DER?

How the TSO business model will be impacted by Distributed Generation?

How can TSO benefit from Distributed Generation?

How can *"DER Aggregators"* help TSOs when balancing the system?

Which are the consequences that DER considered as "network replacement" bring onto system security ?

[TE48]

3.3.7 Electricity distribution operators (DSO)

The 2020 milestone naturally increases the demand for renewable energy sources, often small and distributed in low and medium voltage networks. Further, increase in fossil fuel prices will enhance the attractiveness of demand efficiency measures, for example micro-CHP units.

Design and operation of incumbent transmission and distribution networks, together with the associated regulatory and market rules were decided on the basis of a centralized system, thus leading to unidirectional power flows in the distribution network, meaning here medium and low voltage networks.

Given the fast developments of Distributed Energy Resources (DER), these assumptions do not hold true any more. Due to the technical and economic changes induced by DER and its location in the electricity supply chain, DER integration sets new challenges on network players, particularly distribution networks operators.

Challenges for DSOs

Which technical issues can be expected in a distribution network with significant penetration of DER?

How the DSO business will be impacted by Distributed Generation?

How can DSOs benefit from Distributed Generation?

Can *"DER Aggregators"* help DSOs in managing the grid?

How to unveil the value of DER as "network replacement"?

[TE49]

3.3.8 Equipment manufacturers

Whereas DER equipment costs follow a traditional learning curve, manufacturers of DER units still need to reduce manufacturing costs and increase energy conversion efficiencies. Meanwhile, public support is required to alleviate the high initial costs incurred at the beginning of such learning curves, through subsidising schemes.

The integration of DER units into distribution networks also requires technologies. It will follow two complementary routes:

- a passive integration process under the "fit and forget" approach: DER units are allowed operating on their own, as long as the impact on network operation remains limited once appropriately connected.
- the active management of DER-penetrated networks with progressive use of control, telecommunication and metering devices.

The transition from the 'fit and forget' integration to active network management should occur independently of the level of local DER penetration into networks: active control can be implemented for both existing and newly-introduced DER units. The motivation for implementation of active network management will therefore vary from regions to regions.

[TE50]

Challenges for manufacturers

What are the cost targets that DER manufacturers must meet?

What is the hosting capacity of the today network?

What are the critical functionalities that ICT technologies must meet to smooth the transition from passive to active grid control and when?

What are the standards to be encouraged?

3.4 Yet, barriers to massive deployment of DER still exist

The pace of DER deployment is still low, since facing barriers involving **technology, market, and regulation issues**. Removing these barriers for a massive DER deployment requires more research and demonstration work.

The first barrier is the current **lack of profitability of DER business models**: the production costs of decentralized power are not yet able to compete with the prices of centralized generation[TE51]. This is first due to the high costs of the DER technologies, which are at the beginning of their learning curves. On a financial standpoint, the support schemes developed by the Member States partly allow bridging the gap to profitability, either through direct support to investment, or feed-in tariffs[TE52]. More viable incentives lie in measures which allow valuing externalities (like avoided CO2 generation) through mechanisms called green or white certificates.

The second barrier is technical: as mentioned earlier, when connected DER impacts the network, the network can also impact DER units back[TE53]. **Integrating massively DER** to the network will raise a set of **technical issues for which research is required**, in order to develop technical solutions, design new system architecture and innovate on new network management modes. These technical issues will have cost impacts for the electricity system: the sharing between DER owners and network operators must be rethought, based on **new regulatory approaches on cost allocation**.[TE54]

Thirdly, DER could be more profitable if DER operators would easily **access the electricity market**: market participation could bring economic benefits directly through the optimized purchase and selling of decentralized electricity at spot prices, but also through the provision of new services to the network operators to help them operate the system (balancing). But energy markets are designed to work using centralized generation and bulk trade: this prevent small players from accessing energy markets – both generators and consumers. The benefits from trading electricity for a small individual generator can be too small when compared to the costs. The level of investment, the knowledge required for accessing the market information or merely the access fees represent a high barrier in terms of risks for individual small generators. This barrier can be overcome through the aggregation [TE55]of DER units, requiring additional investments and uncertainties that still question DER profitability.[TE56]

Last but not least, final consumers are not yet acquainted with DER capabilities, lacking information and training about the benefits it can bring. Environmental concern is growing in the public, but large efforts are still needed from the public authorities, the educational bodies, and also the energy industry to make the end-users change their consumption behaviours.

4. EU-DEEP: a research project to develop and to validate innovative business models which integrate distributed energy resources into existing electricity networks in a sustainable way

4.1 The project ambitions and methodology

4.1.1 The project objectives

Initiated by eight European utilities, EU-DEEP was a research and development project coordinated by GDF-SUEZ. It started in January 2004 and ended in June 2009 with a total budget close to M€ 30, half of it being funded by the European Commission Sixth Framework Programme for Research and Technological Development.

In 2003, several EU policy orientations including the **liberalisation** of the **energy markets,** the use of **renewable energy sources,** the **security of energy supply** and the **quality of services**, were already driving the growth of (DER)[24] in Europe. And yet, at the time, a number of **barriers, both technical and non-technical, were** preventing a larger penetration of DER. Amongst the most significant ones, EU-DEEP was structured to address:

- *<u>Market integration</u>: what are the most robust DER business models on expanding or new markets which will benefit both to end-users and utilities?*
- *<u>Regulation adaptation</u>: how can regulatory bodies design market rules (through incentives, tariffs and directives) that will increase the benefits promised by DER?*

[24] ***DER****:* <u>for the purpose of this project</u>, DER is defined as the generation or storage of electrical energy (including associated generation of heating, cooling or chemicals), that is independent from the electrical grid or connected to the **distribution level** of the electrical grid, and located **close to the point of consumption**, irrespective of technology, but **smaller than 10 MWe** of electrical power.

- *<u>Connection technologies to the grid</u>: what are the innovative solutions which will connect DER generator sets to existing grids, so that utilities can offer new services to end-users, while providing the appropriate power quality and security?*
- *<u>Grid impact</u>: how to improve on existing grid management strategies to increase the amount of connected DER while creating overall positive impacts at the transmission / distribution levels?*
- *<u>DER systems</u>: how to finalise the development of prototype DER systems (generator, storage, grid connection and communication) in order to fit best the requirements of energy markets?*

Thus the single overarching goal of EU-DEEP was

To design, develop and validate an innovative methodology, **based on future energy market requirements,** and able to produce **innovative business solutions for enhanced DER deployment** in Europe by 2010.

The EU-DEEP unique assumption was that a sustainable grid integration of DER must be based on **validated energy demand profiles that intrinsically favour DER solutions**. Once end use sectors prone to DER integration have been detected over the whole Europe, proper **business options must be found** that solve the integration issues with a validation based on experiments.

The resulting project ambitions were therefore to address removal of the above barriers by providing **proactively** solutions based on this **demand-pull approach,** meaning:

- ✓ Innovative business **options to favor DER grid integration**
- ✓ Equipment and electric system specifications **to connect safely more DER units to existing grids**
- ✓ **An in-depth understanding of the effect of large penetration of DER** on the performances **of the electrical grid system and on the electricity market**
- ✓ Market rules recommendations **to regulators and policy makers that will support the three studied aggregation routes**
- ✓ **A comprehensive** set of dissemination actions **targeting all stakeholders of DER in Europe**

4.1.2 The project organisation

The project gathered 41 organizations to address the technical, market and regulatory challenges and solutions required to massively integrate DER into **the existing electricity networks.**

Thus, the EU-DEEP consortium included partners from utilities, manufacturers, research centres & academics, business developers, investors and regulators. They brought complementary competences from the development of electric equipments to the analysis of the energy markets mechanisms.

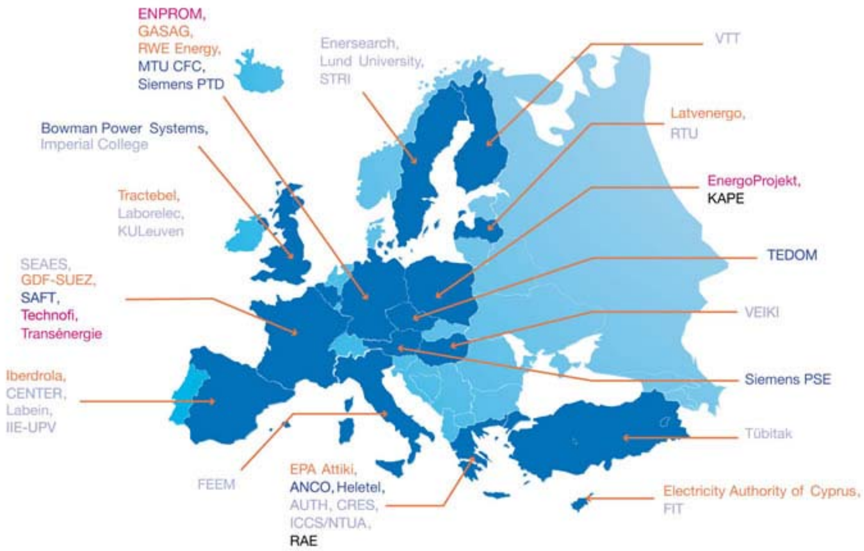


Figure 7: The EU-DEEP consortium

Legend:
In grey academics and technical centres
In black energy agency and regulator
In orange utilities
In pink energy and business development professionals
In blue manufacturers

4.2 The DER integration issues addressed by EU-DEEP

Since the advent of the electricity power system, it is the first time that generating units will be manufactured at very large scale, hence at relatively low costs and high reliability. Consequently for the first time different generation technologies of radically different sizes can integrate the existing electricity system in order to make it tomorrow more carbon free, more sustainable and more efficient. Integration issues encompass:

1) **The energy value of aggregated DER** which is the starting point whatever the primary energy source considered: "local integration" of a single DER system is a classical distributed generation planning problem that has been well addressed by numerous approaches. The challenge is to validate the potential of aggregation of DER units. [TE57]
2) **System integration** which raises the role of DER as a substitute to network investments. The competition with centralized generation for delivering kWh of electricity is taking place via the market.
3) **Societal integration** which raises policy issues that will impact the stakeholders (final customers, industry (T&D operators; generation; manufacturers).

The pieces of new knowledge created by EU-DEEP covered

- **Technical, economical and system solutions** needed to integrate DER into the existing energy system: this is where the necessary conditions for sustainable DER expansion are created and shaped
- **The business options** within which aggregated DER units can be properly valued from a system perspective
- The future **framework conditions** that will catalyse sustainable DER development, at least in the next ten years.

4.2.1 Technical, economical and system solutions

The new knowledge gathered by EU-DEEP is compulsory to facilitate massive and sustainable DER expansion.

How to determine and improve the DER hosting capacity of the electric system? Answers deal with impacts of DER integration on existing and future grids as well as the consequences of different modelling and analysis approaches. One may further split this layer into two side layers: network - system design and network - system operations.
How can demand analysis and modeling approaches help setting up profitable DER units? Answers deal with energy value capture and monitoring based on consumer needs and acceptance at using DER units: this in turn leads to market segmentation and market areas where DER can bring an energy value including flexibility
How to unveil the value of DER as network replacement? Once connected, DER can bring value to the distribution network, helping for instance a DSO face issues such as network expansion or power quality[TE58].
Which services can DER bring to the system? Small DER units are not allowed by regulation to participate to electricity markets such as balancing. Yet, once aggregated they may contribute to the safe operation of the electric system. When incidents occur, TSOs call for generators and consumers directly connected to the network to modify very rapidly their generation or consumption patterns. [TE59]It is noticeable that, recently, regulators have been addressing cross-border TSO balancing procurement rules between France, UK and Ireland (Paper published on April 15th 2008), which shows that such markets will grow in the coming years.

4.2.2 The innovative business options

EU-DEEP has focused on aggregation routes to study promising business models. The need for aggregation of DER units is first of all a consequence of the standard market architecture for Europe; it is also a necessity for maintaining the reliability performances of the electrical power system when DG becomes significant. Consequently the basic assumption for a massive deployment of DER in the system is that aggregation of local DER units is required.

Aggregation therefore means:

The definition of an intermediate structure consolidating end users and /or energy generators operating into a coordinated fashion

This assumption results from:

- The secured operation of the system on one side;
- And the possibility to access the electricity markets for small players and make profit of it on the other side.

But at the same time raises two questions:

- The technical ability to operate the aggregated system autonomously without any exchange of information between local generation units;[TE60]
- And the minimum size of unit for which aggregation remains possible for operation purposes and still acceptable for profitability.

Thus, EU-DEEP has produced integrated knowledge needed to shape a business platform where aggregated DER units effectively participate in energy markets. Each business idea must answer the following questions:

- What is the underlying business idea based on aggregation, which will combine technical and market issues to have DER units make sustainable profits?
- How can such business ideas grow depending upon the unit geographical areas where it is profitable and/or where the economic scenarios prevailing in Europe are more or less favourable?
- What are the optimal combinations of distribution network configurations and market sectors where the aggregation of DERs units contribute to energy needs, while leaning on favourable climates to develop solar, wind, biomass, geothermal or hydro solutions?
- How to involve the future end users of the business concept in the demonstration?

4.2.3 The future framework conditions

There are future framework conditions which will catalyse and even enhance DER expansion. Beyond the common good practices and common language background to cooperate on a European basis, three types of framework conditions have been provided by EU-DEEP:

1. **Future technology standards:** distribution networks will become more active to allow for the deployment and large scale integration of Distributed Generation units. An increased number of participants on the energy market, together with the increased involvement of smaller generation units, consumers and possibly storage, require a cost efficient and reliable data exchange between the different players through all the voltage levels. It is necessary to set up an affordable communication environment based on standardized protocols. However, today, ICT is applied only in transmission and sub transmission networks down to 110 kV, but not in medium/ low voltage distribution networks for cost reasons. Different standard and partly proprietary protocols for various levels and for different kinds of equipment are used to-day. What are the key areas within which standardisation bodies should work to accelerate DER penetration in European grids, based on increased automation and demand integration (thus leading to promising business cases)?[TE61]
2. **The needs for future larger scale experiments:** several research and demonstration projects at national and EU level have looked after DER integration into the electricity grid at distribution level. EU-DEEP has been performing demonstrative experiments as well. The scale of the work appears to be too small to infer answers about issues such as future customer behaviour, technology reliability, influence of regulatory regimes, replication of the observed results. Integrated experiments (10.000 customers and beyond) over long periods of time and large areas will be most probably needed in a way similar to what was implemented by ENEL Distribuzione to launch smart metering in Italy. What are the scaling rules required to size the demonstration projects? How replicable are the experimental results obtained in such large projects?
3. **Recommendations for future novel regulatory regimes:** the EU27 targets to decarbonise electricity production by 2020 (and beyond) foresee the increased use of distributed energy resources. These ambitious orientations have been taken within framework conditions for the electricity system that originated from the 1996 EU directives. Some of these frameworks conditions must evolve to enhance further decarbonisation of electricity production in Europe through market mechanisms that maximise the welfare of European citizens. What are the conditions which will catalyse all together coherent network planning and operation and the development of new business approaches within regulations which maximize European citizen welfare[TE62]?

4.3 THE EU-DEEP work flow and deliverables

It is to reach a real integration of the different research results produced that the project work was organized within a matrix approach, along two dimensions:

- Eight technical work packages (WP), each focusing on a specific technical issue or type of activity,
- Three task forces transversal to the WPs, exploiting their results and providing outputs valued in WP8.

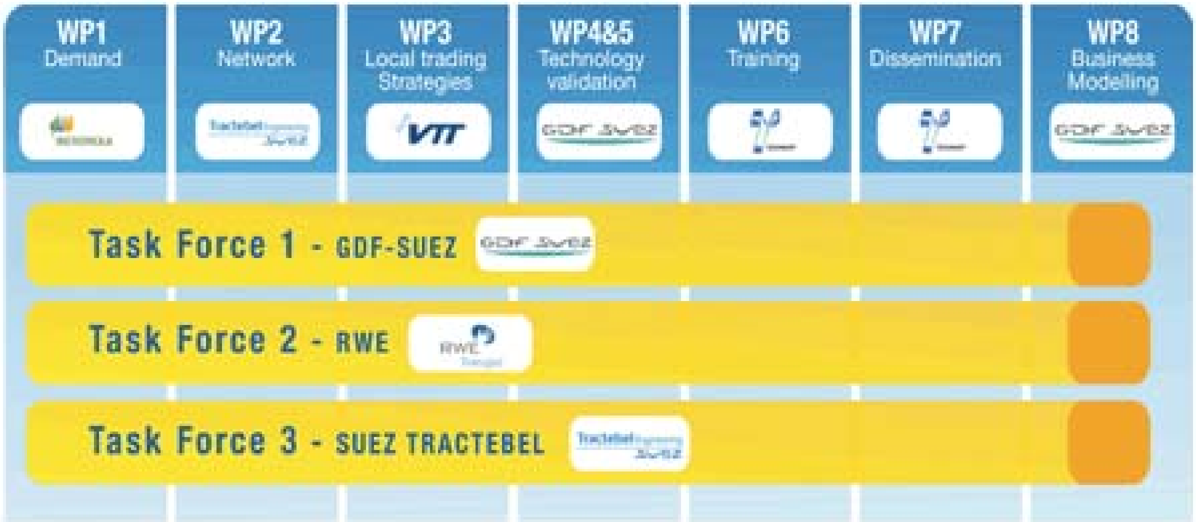


Figure 8: Work organization: work packages and task

The work package objectives and deliverables are briefly listed below

WP1 : Demand segmentation and modelling	a market assessment methodology able to detect promising demands for DER technologies
WP2: Grid and Market integration	Technical issues and needed changes and upgrades in power system desing and operation, the potential change in power system costs due to DER, and their allocation
WP3: Local Trading Strategies	the potential, market applicability and technical requirements of the new trading possibilities and market/network services brought by DER
WP4&5: Technology validation (field tests)	Experimental validation of the results, tools and methodologies developed in WP1 and WP3, and provide field data feeding WP2 network simulations and WP8 business model fine tuning Integration experiments of existing technologies
WP6: Training	training methodologies addressing decision making in DER investment
WP7: Dissemination	dissemination of the project results
WP8: Business modelling	innovative business models involving DER aggregation recommendations on future large-scale demonstrations an ad hoc legal structure for the exploitation of the project results.

The **Task Forces** were set up to develop one specific business model each, using the methodologies and tools developed in the work packages 1 to 8. The resulting knowledge produced was packaged in work package 8.

EU-DEEP paid a particular attention with the integration of the theoretical research results produced, through task forces acting as business explorers

- **illustrating flexibility of demand**
- **assessing profitability conditions of DER**
- **applying technical and economic aggregation concepts to real contexts**
- **elaborating recommendations for future electric systems and markets**

4.4 THE EU-DEEP PROJECT WITHIN THE PORTFOLIO OF R&D PROJECTS SUPPORTED BY EU FUNDS

The 5th Framework Programme, funded research projects[25] on DER integration issues, which were grouped together in the IRED cluster[26] from 2002. The cluster was funded by the EC in 2004 and its membership expanded to new European projects in the area.

The more recent research, technological development and demonstration projects (i.e. financed by the EC 6th and 7th Framework Programmes) include the following projects, which were reviewed during a two-day workshop held in June 2008 in FRANKFURT, under the coordination of the EU-DEEP players with the contribution of the project managers from the covered projects.

Tableau 6: List of project reviewed

Project	***Acronym title***	***Total budget*** *In M€*	***Start date***	***End date***
EU-DEEP	*"The birth of a European Distributed EnErgy Partnership that will help the large-scale implementation of distributed energy resources in Europe"*	30	01/2004	06/2009
FENIX	*Flexible Electricity Networks to Integrate the eXpected 'energy evolution'*	15	10/2005	09/2009
ADDRESS	*Active Distribution network with full integration of Demand and distributed energy RESourceS*	15.72	06/2008	05/2012
INTEGRAL	*Integrated ICT-platform based Distributed Control in Electricity Grids*	16.00	01/ 2007	12/ 2009
MORE MICRO-GRIDS	*Advanced Architectures and Control Concepts for More Microgrids*	7.85	01/2006	12/2009
SUSPLAN	*Development of regional and Pan-European guidelines for more efficient integration of renewable energy into future infrastructure*	4.7	09/2008	08/2011
DER-LAB	*Network of DER Laboratories and Pre-Standardisation*	4.1	11/2005	10/2011

[25] *These projects are:*
- *SUSTELNET - Policy and Regulatory Roadmaps for the Integration of DG and the Development of Sustainable Electricity Networks*
- *DGNET - European Network for Integration of RES and DG*
- *INVESTIRE - Investigation on Storage Technologies for Intermittent Renewable Energy*
- *DISPOWER - Distributed Generation with High Penetration of Renewable Energy Sources*
- *MICROGRIDS - Large Scale Integration of Micro-Generation to Low Voltage Grids*
- *CRISP - Distributed Intelligence in Critical Infrastructures for Sustainable Power*
- *DGFACTS - Distributed Flexible AC Transmission Systems*

[26] *Integration of Renewable Energy Sources and Distributed Generation into the European Electricity Grid*

SOLID DER	*Coordination Action to Consolidate RTD Activities for Large-Scale Integration of DER into the European Electricity Market*	1.5	11/2005	10/2008
Total		85.17		

This sample of projects was chosen for three main reasons:

- They all integrate the key stakeholders needed to make grid integration of the studied DER feasible and sustainable,
- They all address both the technology and business contents of DER integration,
- They all directly deal with ways and means to comply with the European 2020 Energy policy.

Several other EC supported contracts were not studied, since either not yet finalised on contractual standpoints, or not directly related to DER integration[27].
The GANT chart below positions each of the projects over a ten year time scale.

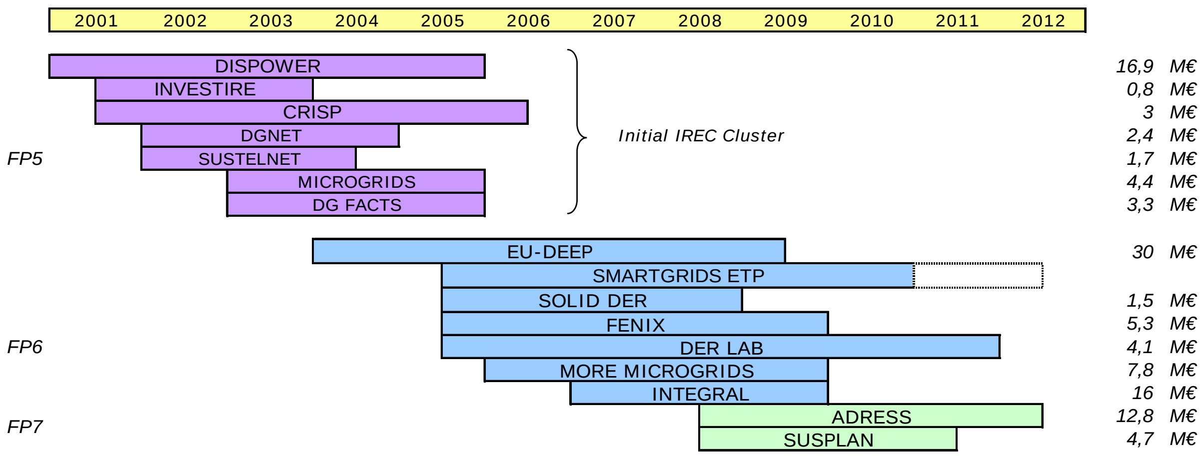


Figure 9: Chronological overview of EC supported research projects for DER integration

It shows the complementary character and some unavoidable overlaps between projects: overlaps are not an issue provided that the knowledge delivered covers competing options to resolve the same well described question. It must be emphasized that all projects, except SUSPLAN and DER-LAB, deal with both technical and market solutions, thus proving the increased concern of EU support to address the implementation issues very early in R&D projects. This comparison shows also the diversity of DER technologies that are considered in the integration studies, as summarized below.

- What are the technical and market solutions to adjust existing networks and DER technologies in order to reduce the volatility introduced by the increased used of intermittent energy sources and the flexibility of demands? **(EU-DEEP)**
- What are the technical and market solutions required for designing scalable aggregations of small DER units in the residential market? **(INTEGRAL)**
- What are the technical and market solutions which will help distribution system operators face network congestions in areas where massive DERs can no longer deliver the energy they are supposed to produce? **(FENIX)**

[27] *Amongst such projects, let us mention: REALISEGRID, CRISTAL, VSYNC, GROW-DERS, ADINE, IRENE40*

- What are the technical and market solutions required in order to develop and to operate micro grid architectures in future districts where the sustainability and reliability of supply are maximised ? **(MORE MICROGRIDS)**
- What are the technical developments (at consumer premises and system level), market mechanisms, socio-cultural accompanying measures and regulatory evolutions needed to enable the active participation of domestic and small commercial customers in the power system markets and in the provision of services to power system participants (active demand), this participation thus supporting the full integration of distributed energy resources? **(ADDRESS)**
- What are the regional and pan European guidelines that will help decision makers prepare RES generation and network investments for optimal use Renewable resources in Europe up to 2050? **(SUSPLAN)**
- What are the standards that will catalyse DER development in Europe? **(DER-LAB)**
- How can one consolidate and continuously enhance knowledge on DER integration, benefits and solutions? **(SOLID-DER)**

This comparative approach allows showing that eight key knowledge components are studied and delivered at research and demonstration levels by most of the projects in order to understand and assess the value of DER integration over the time span 2010-2020:

1. *Control of DER units (local versus central) to face current or unexpected system behaviour*
2. *Control of load flexibilities combined with generation to provide guaranteed power to system operators*
3. *Evolution of distribution network assets and operations to cope with the intrinsic volatility of DER*
4. *Scalability of technologies and markets, which must cover all technological requirements (including ICT and their evolution), all personnel skills and their costs*
5. *Potential of aggregation business models allowing small DER units to participate in electricity markets*
6. *Regulatory recommendations to implement improved, fair and non-discriminatory rules to give DER access to electricity markets*
7. *Expected profitability of the future business options involving aggregation and new regulatory options*
8. *Knowledge blocks which are indispensable to consolidate the value of DER integration throughout Europe (basically: good practices, standards and regulations).*

The table below summarizes using a qualitative colour scale the contribution of the studied projects to knowledge generation and use. A close examination of this matrix shows that a majority of R&D projects are investigating technical and market aspects of aggregation business models, and their resulting profitability, based on appropriate scalability rules and robust DER control technology. Yet, it seems that the use of load flexibility and the implementation of new regulatory approaches would deserve more attention, because of their potential impacts on facilitating DER integration in electricity networks.

Table 7: Topics covered by FP6 projects on DER integration

Key knowledge components	EC supported projects						
	EU-DEEP	**INTEGRAL**	**FENIX**	**MORE MICROGRIDS**	**ADDRESS**	**SUSPLAN**	**DER LAB**
Control of DER							
Control of load flexibility							
Distribution network evolution							
Scalability of technology and markets							
Aggregation business models							
Regulatory recommendations							
Expected profitability							
Knowledge framework for effective DER integration							

Depth of study: **Critical** | **High** | **Low** | **Marginal**

MIDDLE PART

KNOWLEDGE BUILDING STRUCTURE

The EU-DEEP results in 41 elementary knowledge blocks

1. How to read this book

On the left side, the reader will find:

- A framework about research on massive DER integration, including a historical background, the current status for DER penetration, the identification of the remaining barriers against DER integration and related research initiatives launched at European level
- The presentation of the EU-DEEP project and key research issues addressed.

On the right side, the reader will find:

A synthesis of the key findings of the EU-DEEP project, **addressing different stakeholders' points of interest**:

- Policy makers
- Investors
- Scientific community
- DSO
- TSO
- Regulators
- Energy producers & retailers
- Consumers energy end user
- Manufacturers.

In the middle part, the reader will find:

1. An overview of all results presented within an integrated body of knowledge: the image of a Greek temple building is used to introduce the pieces of knowledge ("building blocks of knowledge"), which are grouped according to three major pieces: the foundations, the pillars and the roofing. This structure highlights the integration of all results into one coherent "knowledge building", while allowing a brief introduction to each individual project result.

It must be noticed that some of the "knowledge blocks" go beyond self-standing project results: rather, they address background knowledge which is needed to comprehend the new knowledge presented in the other building blocks

2. An analytical part where each of the knowledge blocks (the individual results) is represented by a single "knowledge card" comprising the following sections:

- The background introducing the addressed challenge
- A short description of the results
- The references and data sources for complementary information
- The relevance of the new knowledge for the various energy stakeholders
- The contact name.

A short glossary with key concepts ends this middle section

2. The EU-DEEP Knowledge Building to deploy DER in Europe

2.1 ORGANIZING THE KNOWLEDGE PRODUCED: THE BUILDING STRUCTURE

Sharing efficiently the results of the EU-DEEP project with the different players of the DER field requires providing them with an overall picture on the whole knowledge gained during the project. Then, each unitary result needs to be positioned within this overall picture in a structured way, so as to make the relationship with the project objectives straightforward enough.

It is therefore proposed to consider the set of EU-DEEP results as a **"knowledge building"** made of such unitary research results. The architecture is designed to address all categories of users of the results: academics, business actors, regulators and policy makers as depicted below.

Why such a building?

EU-DEEP investigated **three business models** to exploit the different types of value possibly tapped when aggregating distributed generation and/or individual loads within a given energy and regulation context:

1) Aggregation of demand flexibility to balance renewable intermittent generation

2) Residential-scale flexible µCHP integration in electricity markets

3) Energy Service Company aggregating flexible CHP facilities in industrial and tertiary sectors.

The knowledge gained when exploring the value of aggregation within this business background constitutes the **three pillars** of the EU-DEEP knowledge building.

Each of these pillars required some **common background knowledge** that is consistent and robust enough to support the complete development of a business case. This background knowledge relates to the technical integration of DER into the power system, to the different sources of value that DER can bring, and to the aggregation of such sources. This knowledge is seen as the **foundation** on which the three pillar-business models can be built.

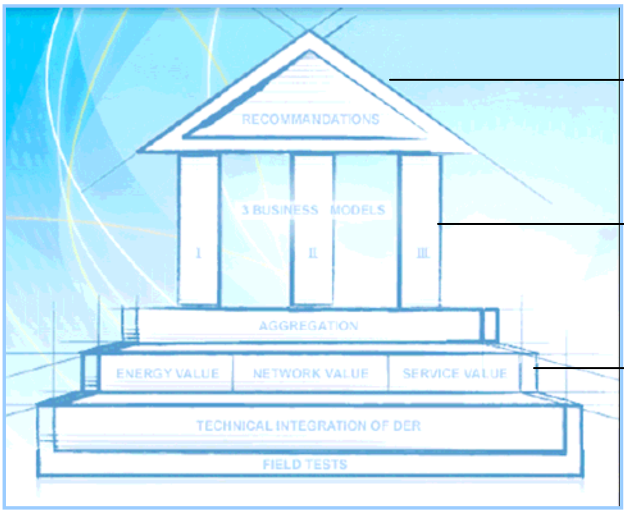
Finally, the experience gained from the **integration work** performed to build the pillars-business models can nourish recommendations for improved framework conditions to expand the existing business options. These recommendations can be used to design business models more safely, thus involving "new pillars" for the knowledge building i.e. new business models valuing DER for their best. These recommendations on framework conditions are called the **roofing**.

Three components for three objectives

The EU-DEEP results are therefore organized and presented in this book according to a structure made of three types of knowledge components – foundations, pillars, roofing.

These three components fulfil three steps towards the expansion of DER:

1. *Create the necessary conditions for sustainable DER expansion (foundations)*
2. *Explore DER aggregation businesses (pillars)*
3. *Propose recommendations to further expand business activities (roofing)*



The table below synthesizes the knowledge type and objective attached to the three components.

Component	***Related Knowledge***	***Objective***
Foundations	*Knowledge which is consistent and robust enough to "support the whole building" pushing for a sustainable DER expansion*	Create the necessary conditions for sustainable DER expansion
Pillars	*Knowledge gained by exploring the possibilities of DER aggregation in the three business models developed*	Explore DER aggregation businesses
Roofing	*Knowledge capitalized on the integration work, which can serve in the future to develop further technical research and business investigation.*	Propose recommendations on framework conditions

All EU-DEEP results are organized within these three knowledge types. Each unitary result is considered as a "**knowledge block**" being either a part of the foundations, the pillars, or the roofing. In total, 42 unitary blocks of research knowledge compose the building.

2.2 THE FOUNDATIONS: CREATE THE NECESSARY CONDITIONS FOR SUSTAINABLE DER EXPANSION

The foundation is the common background knowledge that is consistent and robust enough to support the complete development of business cases (the pillars). This knowledge relates to the technical integration of DER into the power system, to the different sources of value that DER can bring, and to the aggregation of such values. The foundations are made of 26 unitary knowledge bocks clustered in six domains reflecting the key topics mentioned.

The first domain of knowledge deals with the technical aspects of DER integration into the power system:

- **T** (**Technical knowledge** related to system issues): how to determine and improve the DER hosting capacity of the system?

The next three domains of knowledge address the three types of values that can be brought by DER, presented below in a decreasing order of value (in the present conditions):

✓ *Energy value: it consists in selling energy, whatever its type: electricity, heating or cooling;*

- ✓ *Network investment saving value: DER can, to a certain extent, be considered as a substitute to network investments. Thus the incidence of DER (and load) on the network must be evaluated and made explicit through the regulatory environment.*
- ✓ *Supply of ancillary services: When aggregated DER can provide additional services. In the short term, services are related to power system balancing (in terms of power and energy, kW or kWh), but in the longer term other services could eventually be supplied.*

The knowledge developed with regards to these three sources of value therefore aims at answering the following questions:

- **E** (for **Energy value**): How demand analysis & modelling can help setting up a profitable DER unit?
- **N** (for **Network value**): How to unveil the value of DER as network replacement?
- **S** (for **Services value**): What services can DER bring to the power system and market actors?

In the end, trying to capture the maximum value of DER considering these three sources requires an optimization process, which is performed through aggregation. Therefore the 5th domain of knowledge relates to:

- **A (Aggregation layer)**: a way to optimize the three different DER values mentioned above (energy, network, and service values).

Finally, a series of field experiments was performed, allowing to confront the knowledge developed in T, E, N and S blocks to reality, and to test and validate some of the tools and methodologies developed. The last domain of knowledge of the foundations therefore includes five tests results:

- **TESTS (Field tests):** Exploiting the identified DER aggregation values in real life

The following sections detail each knowledge block included within these five domains.

2.2.1 Technical knowledge related to system issues (T)

The technical knowledge related to system issues aims at answering the following question:

How to determine and improve the DER hosting capacity of the system?

It addresses two different aspects of power system integration: the integration into the current networks as they are today, and the integration into new networks as they are expected to be designed in the future. In addition, several technical issues related to the integration of DER into the power system are addressed.

The network today (present design, "fit and forget")

- **T1) Design of power system: background elements**

The fundamental objective of power system is to supply customers at the requested reliability at minimum distribution cost. Today, distribution networks, which means for EU-DEEP medium and low voltage networks, are designed according to the "fit and forget" principle. This means that no control action is required during normal operation. The technical features of such systems facing DER integration have been defined and possible solutions for increasing the proportion of DER have been proposed. This was developed according to local and global categorization, in order to prepare a co-ordinated approach for the research.

- **T2) "Hosting capacity" of the existing distribution network**

The "hosting capacity" must be referred to a reference, which must be defined based on the distribution network design criteria. It is closely related to the diversity of the demand. It was generally built on the maximum consumption of the "mean client" from a specific market segment during peak conditions (the load curve) .

A similar concept can be considered for local generation. Important additional parameters must be taken into account: are consumption and generation coincident? Are feeders homogeneous in terms of load and generation proportion? Etc.

In depth analyses of system characterised by significant penetration of DER and related to protection, power – frequency control, voltage and "var" control, system losses, etc., showed that margins exist in present distribution systems allowing for significant penetration of DER, without requiring radical design or operational changes, at least when DER present certain properties.

- **T3) Extending the "hosting capacity" of existing networks: incremental approach**

An incremental approach for increasing the "hosting capacity" of the distribution network has been developed. This is based on the minimum possible changes to existing infrastructures and on active management, where controls replace "copper". A method has been proposed for using the existing margins within distribution networks. This is based on the fact that urban and semi-urban networks present voltage control margins. The parameters of the distribution voltage control can be adjusted for making room for generation. Changes of reference voltage are often sufficient and active management not always necessary. This means that, in a majority of cases "fit & forget" principle can be extended.

The network tomorrow (new design and active management)

- **T4) New design principle**

The DER hosting capacity of the present networks can only be increased when and where margins exist (see T3). When this is not the case, the concept needs to be extended for network renewal or for new network development. For these cases, new design principles have been proposed. Ideally they should be based on exogenous requirements in relation with energy policies objectives, for example the peak power equivalent of DG taking account of diversity, the proportion of RES that is expected to be installed in the distribution network, the possibility or not to curtail generation, particularly RES, during critical periods, the role of coincidence of load and generation in relation with their homogeneity along feeders, etc. As soon as the objectives and the corresponding parameters are known, the set up of upgraded design criteria becomes quite straightforward. The results got from simulation of typical system indicate how the reinterpretation of the classical principles can lead to higher "hosting capacity" for DER.

- **T5) New design and operation**

Distribution networks based on new design criteria allows for increased "hosting capacity" for DG. This means new opportunities that can be developed based on "soft" and "hard" active management when distribution network is respectively in "N" or in "N-1" state. The rules proposed in T4 is a mix of investments, new operation rules, involving active management of voltage and also DG power curtailment far ahead of the previous "fit and forget" concept.

- **T6) Extending hosting capacity for RES: RES as source of power.**

In the long term RES (especially PV) investment costs are expected to decrease sufficiently leading to possible overinvestment in RES capacities, turning them from energy sources towards power sources. This necessarily means potentially too high peak power generation during favorable weather conditions. To manage possible over-voltage or overload in the network it will become necessary to accept power generation curtailment. This should remain a globally economical target for Society.

System issues

- **T7) Large proportion of DER in the system changes the rules**

System control and system security management must evolve as DER penetration is increasing. The compatibility of DER and RES with frequency and voltage operational ranges of the network in normal and emergency and defense conditions is mandatory for guaranteeing the preservation of system security. This supposes coherence between DSO and TSO requirements. The progressive reduction of control capacities from conventional generators means equivalent control capacities from DER and RES. However the situation is not equivalent for power – frequency where this is possible and voltage – reactive control where it is not. Emergency control and defense actions *via* load shedding must be upgraded to avoid inconveniences of present design. Significant progresses could result from the implementation of emergency demand response directly from small customers' installations leading to electricity delivery from the system at variable levels of reliability of supply.

2.2.2 Knowledge related to the energy value of DER (E)

By energy value is meant the value caught from selling energy whatever its type: electricity, heating or cooling. The knowledge developed with regards to this value aims at answering the following question:

How can demand analysis & modelling help setting up a profitable DER unit?

The knowledge blocks included are:

- **E1) Detecting high potential segments for DER : the "DER-prone segments database":**

Sharing data on energy demand is critical to assess the DER potential. A methodology has been designed for the segmentation of the energy demand in the industrial, commercial and residential sectors throughout Europe. A database of typical loads per segments characterized by their final end use has been set up accordingly, thanks to the sharing of data among several utilities via an agreed format. The segments are then ranked according to computed parameters related to their potential for distributed generation, distributed storage and demand response.

- **E2) Modeling electric and thermal loads: physical model of end uses**

For demand participation in electricity markets, accurate energy end use modeling of electric and thermal loads is required in order to evaluate the flexibility part of such loads. Physically-based models were developed for end uses simulation, taking into account weather parameters, building physical description and customer behavior. Overall, 12 different commercial segments, 17 residential segments and 5 industrial segments have been modeled. A validation of the models was conducted by comparison with the real flexibility observed on test customer sites.

- **E3) Modeling impacts of DER and DR on thermal and electric loads**

This building block deals with the packaging of the models presented in E2 into user friendly tools. Three tools were then developed under MATLAB and EXCEL. One tool for commercial and residential segments displays very high accuracy, requiring and high input data requirements and training for software use. The two others present simplified results but with much lower input requirements.

- **E4) Optimizing the energy value of a single DER unit**

Reducing the uncertainty of one particular DER investment requires assessing the values of the energy flows. Several simulation tools were either upgraded or developed to design the installation and operate it on a daily basis, fed by inputs such as electricity market prices, demand profiles, DER technical performance, etc. Those tools were validated through real life experiments of DER implementation.

2.2.3 Knowledge related to the network value of DER (N)

By Network value is meant the value of potential network investment savings, considering that DER can, to a certain extent, be a substitute to network investments. Thus the incidence of DER (and load) on the network must be evaluated and should be reflected in the regulatory environment. The knowledge developed with regards to this value aims at answering the following question:

How to unveil the value of DER as network replacement?

The knowledge blocks included are:

- **N1) The limits of the today "Use of System" charges schemes**

The challenge today is to make network cost allocation cost reflective. Prerequisites are however required. Current schemes allocating the "Use of the System" (UoS) charges often mix them with incentives. This is often the case with "net tariffs" that are charging only UoS costs on the net consumption (they can transiently, partly accepted for example in case of lack of adequate metering). The analysis also led to conclude that "efficient" tariffs must be based on a clear separation between load and generation from a same site because their footprint is obviously different.

- **N2) Efficient "Use of System" charges schemes**

Further to the analysis performed in N1, a number of concepts were developed to set up efficient "Use of System" charges schemes accounting for DER footprint on the network. A marginal approach was selected *a priori* for this development due to its intrinsic "efficiency". Elements of answer include the separation of DER/RES support schemes from the UoS charges scheme, and the independent treatment of load and generation from a same site. Large scale interval metering is required as well as large scale *ex post* data treatment. However to be implementable, this method requires simplifications of the metering infrastructure, consideration of equality of treatment principles, further tariffs must be made stable enough from one year to the next. At each stage of the simplification process, the original "efficiency" of the scheme must be as much as possible preserved.

- **N3) Long term trend for system cost under the new regulation**

The total cost of the distribution network can be seriously affected by DER introduction. This depends on the type of DER, its design, but also its operational behavior when compared to load, coincidental or not as well as the homogeneity of DER and load along feeders in the network of a same substation. This is also highly depending on energy policy choices (pushing for specific technologies for instance). The challenge is then to maintain the system costs at acceptable level while integrating DER as smoothly as possible according to energy policy requirements. The developed method relies on ‘efficient” tariffs and should lead to overall system cost reduction. The separation of the distribution network regulation process from the distribution tariffs which are just defining the respective contribution of the different customers avoid the “DER risks” for DSO.

2.2.4 Knowledge related to the services value of DER (S)

By services value is meant the value that DER can bring to the network through the provision of services. In the short term, services are related to balancing (in terms of power and energy, kW or kWh), but in the longer term other services could eventually be supplied. The knowledge developed with regards to this value aims at answering the following question:

Which services can DER bring to the system & market players?

The knowledge blocks included are:

- S1) Providing balancing services in today’s market

This building block investigates how DER can participate to the balancing activity, in order to increase the possible revenue of DER such as they could become profitable.

- S2) Potential services to be provided by DER

This building block investigates which type of additional services DER can provide to the network in order to improve the profitability of DER businesses. These services include Power - frequency control and reserves to TSO, Reactive power compensation to DSO, and Security of supply (“network replacement”) to both TSO and DSO.

2.2.5 Knowledge related to aggregation (A)

DER Aggregation here is considered as a way to optimize the three types of DER values that are mentioned above:

Aggregation as a way to optimize the different DER values

The knowledge blocks included are:

- **A1) A typology of aggregators according to their offers**

The aggregation concepts currently developed need to be embodied by real life entities. These entities will consolidate or aggregate a number of individual customers and/or small generators into a coherent group, with the aim of optimizing energy supply and consumption both at economic and technical levels. This opens many combinations in generation assets and customers: a typology of possible aggregators has been designed according to the type of service they can provide, in view of studying their respective profitability.

- **A2) Four sources of values can already be captured by aggregation businesses**

EUDEEP identified three promising DER business models which attempt to maximize the benefits of DER aggregation for system balancing. Regulatory conditions having a large impact on the value sources of aggregation businesses, this card reminds the regulatory barriers to the aggregation road.

- **A3) Energy end user habits will change to benefit from innovative DER offers**

Deploying DER offers requires an active participation from the customer side. A methodology to assess the social acceptance of flexibility was developed and applied in three test campaigns in different countries. Qualitative interviews were led with end users participating to tests, and all other actors involved. Outcomes allow building a commercial strategy according to the individual customers' perceptions.

- **A4) Expansion of DER aggregation needs minimum common requirements in ICT infrastructure**

The developments in enabling technologies might reduce the barriers to aggregation and penetration of flexible DER. A comprehensive State of the Art of smart metering-related issues was carried out, illustrating the diverse national initiatives to development such infrastructure, and the need for harmonization in data communication. Recommendations are drawn on minimum requirements for data communication & metering functionalities.

- **A5) A 50-parameter analysis allows to assess DER aggregation business models in a given local context**

The profitability of a business model on DER aggregation depends on a number of key parameters related to technology infrastructure and costs, customer behaviour, market and regulation. Identifying and quantifying them is critical to assess the robustness of a business model to different local contexts. 15 clusters of 50 parameters impacting the profitability of aggregation businesses are proposed with a methodology ranking the current values of each critical parameter which allows comparing different national contexts.

- **A6) Four scenarios by 2020 picture different potential futures for DER aggregation businesses**

Based on the previous result, four scenarios are proposed to describe possible futures by 2020 of the European energy scene, based on three fundamental drivers: CO_2 reduction, competition policy focused on market efficiency, security of supply. Each scenario has its own set of 50 parameter values for the six studied Member States. The impact of plausible of energy context evolutions by 2020 can thus be more easily recognized.

- **A7) A validated toolbox allows the economic evaluation and optimization of DER-portfolio operation**

Aggregators need validated tools for decision making in DER investment, and for design and operation of their portfolio of flexible loads and generation assets. A set of tools were developed and/or upgraded for such purpose. They were used for simulation of business cases and operation in test campaigns.

2.2.6 Knowledge related to the field tests (TESTS)

Five field experiments allowed to confront the knowledge developed in the previously mentioned blocks to reality, and to test and validate some of the tools and methodologies developed.

Exploiting the identified DER aggregation values in real life

The knowledge blocks included are:

- **TEST 1: Testing the integration of a composite CHP system for market interaction, office building segment, Grenoble, France**

An installation was operated by GDF SUEZ in an office building in Grenoble. The primary goal was to assess the potential market segment "offices building of North Europe" in terms of DER acceptance and needs. Secondly, a design of a fully integrated system comprising all the different DER components (generator, batteries, control systems) was necessary in order to make DER interactions with the power markets easier. The third purpose was to test and assess the corresponding cost of the automatic reconnection to the network after a grid failure.

- **TEST 2: Testing the integrating of a composite trigeneration system for market interaction, Education building segment, Athens Greece**

Attiki Gas Supply Company was in charge of a test concerning segment "educational buildings of South Europe". The test objectives were similar to those of Grenoble test site: to operate a composite DER system as a single entity. However the complexity of the system was higher due to site requirements (heat, cold and electricity demand). Also the battery functionalities allowed to interact with power markets.

- **TEST 3: Testing the technical feasibility of aggregating 10 kW to 1,5 MW scale DER in the UK commercial market segments.**

Beyond its function of testing some tools and methodologies developed within the previously mentioned knowledge blocks, this experiment is closely related to the Business model I investigated within the project, as introduced in the next section (Pillar knowledge).

The aggregated customer portfolio tested was made up of 8 small industrial and commercial sites from 20 to 1500 kW of flexible loads, 2 controllable generators (500 kW diesel engines), and one wind farm (30 MW). All these sites were equipped by local controllers. GDF SUEZ Energy UK played the role of aggregator using a centralized control software.

- **TEST 4: Testing the technical feasibility of aggregating micro CHPs in the German residential sector**

In the same idea as for test 3, this experiment is related to the Business model II investigated within the project, as introduced in the next section (Pillar knowledge).

A portfolio of 10 residential customers of GASAG (gas company located in Berlin) was tested for aggregation. All these sites were equipped with a Micro-CHP (1 kWe) installed in the basement of each house. A large heating water storage allowed to decouple the use of heat and electricity. An aggregator could remotely manage the Micro-CHP via a controller communicating through a GPRS connection, in order to allow "on demand" electricity production. RWE played the role of aggregator using a centralized control software (Siemens DEMS®).

- **TEST 5: Testing the technical feasibility of a decentralized control architecture for aggregation of load and generation**

This experiment is related to the Business model III investigated within the project, as introduced in the next section (Pillar knowledge).

This last field test was more technology oriented compared to the two previous ones. A decentralized control architecture was tested in real-time: the Multi-Agent Software technology. The test was performed on a portfolio of real customers including both demand response and generation

2.3 THE PILLARS: EXPLORE DER AGGREGATION BUSINESSES

The Pillars correspond to the knowledge gained by exploring the possibilities of DER aggregation in the three business models developed in real local contexts. Three pillars are considered, one for each business model explored. This section defines what business modelling is, justifies the business ideas selected, and describes the structure of the pillars, i.e. the structure of the knowledge developed on each business model. Furthermore, the key features of the three business models are described.

2.3.1 Business model definition

Building on the work of Osterwalder and Pigneur[28], one may conceive a business model as the missing link between strategy and business processes. The proposed definition of a business model is:

- ✓ *The description of the value of an offer to one or several segments of customers*
- ✓ *The strategy to be on the market (including the architecture of the firm, the management, the network of partners for creating, marketing and delivering this value and the time to market)*
- ✓ *Its relationship with capital i.e. its capacity to generate profitable and sustainable revenue streams.*

This definition includes, among other things, the product innovation, the relationship to customer (target customers, the way the company delivers the product and the way it builds a relationship with them), the infrastructure management, and finance (cash flow projections).

2.3.2 Coverage of the three business models selected

The selection of business models based on DER aggregation and the provision of balancing services relies on the finding that massive DER integration will require aggregation both on a technical and economic standpoint. Amongst the possible streams of revenues that DER can initiate beyond electricity trading, those connected to the balancing activities are the **most promising ones in the short term,** because no other ancillary service is yet possible.

> EU-DEEP intended to study three different business models, trying to cover ranges of technology, demand segments and commercial configurations as various as possible, and addressing business opportunities from the ones already existing today up to some, riskier ones, that could emerge tomorrow.

[28] *Clarifying Business models: origins, present and future of the concept, Osterwalder, A., Y. Pigneur, and C. L. Tucci. 2005*

Three types of **DER technologies** were considered: intermittent renewable energy sources, Combined Heat and Power, and flexible demand. As for the **customers**, the market segment and the size are quite linked to each other: Residential customers (small), Commercial customers (small to medium) and Industrial customers (medium to large). The **types of companies** investigated to implement DER aggregation are the electricity suppliers, the energy suppliers (electricity and gas) and the Energy Services Companies (ESCO). The ESCO usually owns the equipment to be installed, so that the involvement in the project of the customer company is deeper.

Considering all these options, the three following business cases were selected. (Note that here the term "business case" is used as opposed to "business model", because applied to one real national context).

Business Case	Size of DER	Techno.	Sector	Type of actor	Native Country	Minimum Number Of units
BC I	MEDIUM 10–100 kW	Wind + Demand Response	Industrial Commercial	Electricity retailer	UK	1 000 to 10 000
BC II	SMALL 1 kW	Micro CHP	Residen-tial	Electricity + gas retailer	Germany	10 000 to 100 000
BC III	MEDIUM 100 kW	CHP + Demand response	Commercial	ESCO	Greece	100 to 1 000

In terms of time horizon and level or risk, Business Case I can already be operational today, Business Case III is the extension of an existing ESCo business to new emerging services, and Business Case II has a long-term focus while it appears today as a risky case. This enables studying DER aggregation development both for "today" and "tomorrow".

2.3.3 Main sources of revenues from DER aggregation

The revenues resulting from aggregation may come from several contributions:

- **Obtainment of Best electricity Prices in the Market** (OBPM), based on the existence of price differentials between the marginal cost of flexibility and the electricity spot prices.
- **Reducing the Imbalance Costs** (RIC): the system operator responsible for balancing charges the market participants for their non-compliance with the electricity generation and/or consumption profiles they committed to. DER flexibility and aggregation enable reducing the imbalances and the related penalties.
- **Provision of Frequency Control Services** (PFCS) to the grid, to make offers as standing reserves or to participate to the balancing market according to the possibilities offered by the national energy context regarding balancing markets and reserves.
- **Reduction of capacity-related grid fees** (RCGF): DER can reduce the needs for transmission and distribution when the DG unit is placed at end user site – i.e. where it is directly consumed – and can therefore decrease the related charges (Use of System charges).
- In addition to these values, the aggregator may be interested in acting as DER owner and not only as unit operator. This may give him access to additional sources of revenues.

2.3.4 Business model development: the structure of a pillar

Starting from the business model idea, the complete development of a business plan has been carried out along 5 steps, from a local context, to extrapolations in time and space. These steps constitute the 5 knowledge blocks for each pillar-business model:

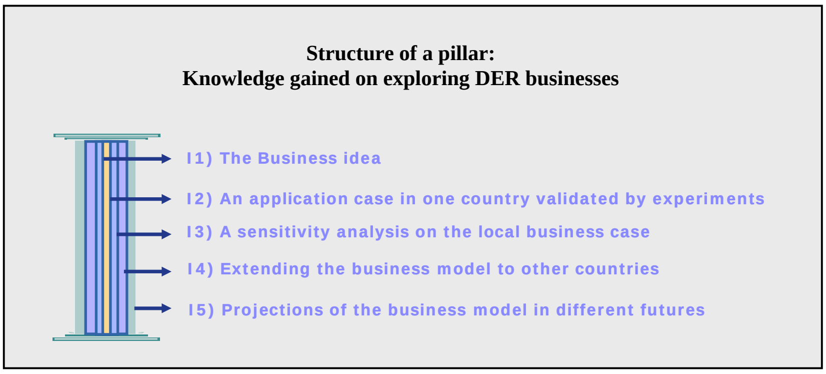
1) The Business Idea: a detailed description of the business model idea, the stakeholders involved, the relationships and flows between stakeholders, and the sources of value created.

2) An Application case in one country, validated through experiments. Each business model has been developed in one specific local context (UK, Belgium, and Germany). Using the tools developed in the project, the opportunities offered by the local market and regulatory context are investigated. The demand of a specific portfolio of end-users is analyzed to value its flexibility. The aggregation of load flexibilities and distributed generation means is simulated. The resulting economic evaluation is confronted to real experiments.

3) The Sensitivity analysis of the local business plan to the key parameters influencing profitability.

4) The expansion of the business model to different national contexts. Five European countries were studied in detail (the UK, Germany, Greece, France and Spain).

5) The projection of the business model into different futures: 4 scenarios of future were designed to "test" the business models according to varying key business parameters. Three clear-cut scenarios were designed, each driven by one key factor among the following: competition policy focusing on energy market efficiency; strong policy towards CO_2 reduction; and concern for security of supply. An intermediate scenario reflects a lack of coordinated European policy with respect to these drivers.



The knowledge blocks for each business model are itemized from I1) to I5) for Business model I; from II1) to II5) for Business model II and from III1) to III5) for Business model III.

2.3.5 Business model I: Aggregation of demand flexibility to balance renewable intermittent generation

Business case I deals with an electricity supplier in the UK, using flexible demand from medium-sized industrial and commercial customers in order to balance renewable energy sources and integrate DER units into electricity markets. The system operator, as responsible for generation / consumption balance in the system, has to contract many resources, so that they can respond to any unexpected event and keep the balance. As a result, the system operator **charges market participants for non-compliance** with committed electricity generation and/or consumption profiles. Wind power, facing today a rapid development, is quite difficult to predict, and therefore **highly exposed to imbalances**. Business model I thus analyses the use of demand flexibility to better integrate wind power in electricity markets.

The main question asked when studying this business model is:

Down to which power level is it profitable to aggregate demand flexibility in order to reduce wind-related imbalances?

Graphical representation of the main stakeholders and interactions in the business model I

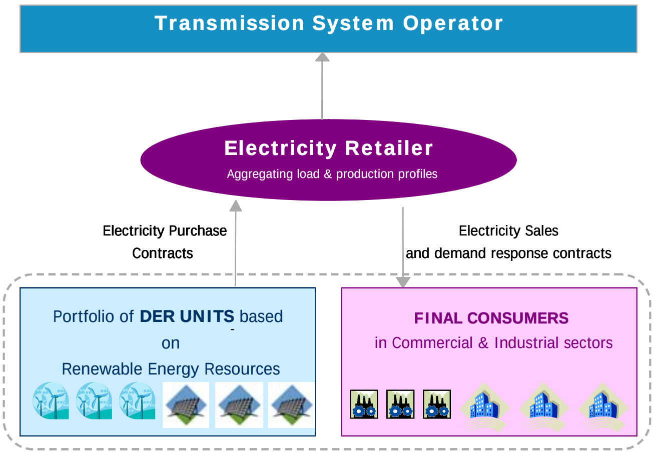


Figure to be updated

2.3.6 Business model II: Residential scale flexible µCHP integration in electricity markets

Business case II deals with an energy retailer in electricity and gas that aggregates flexible micro-CHP units owned by residential customers. Single micro-CHP units, whose electricity output is difficult to predict as depending on heat demand, need to be aggregated to participate in the electricity markets. Electricity retailers are candidates for this aggregation activity (acting as **Virtual Power Plant operators**) since they will negotiate optimal prices when selling their electricity outputs. The use of **heat storage** can additionally provide some flexibility in generation.

The main questions asked when studying this business model are:

How to decouple electricity and heat production?

What is the minimum size of a CHP units portfolio?

Graphical representation of the main stakeholders and interactions in business model II

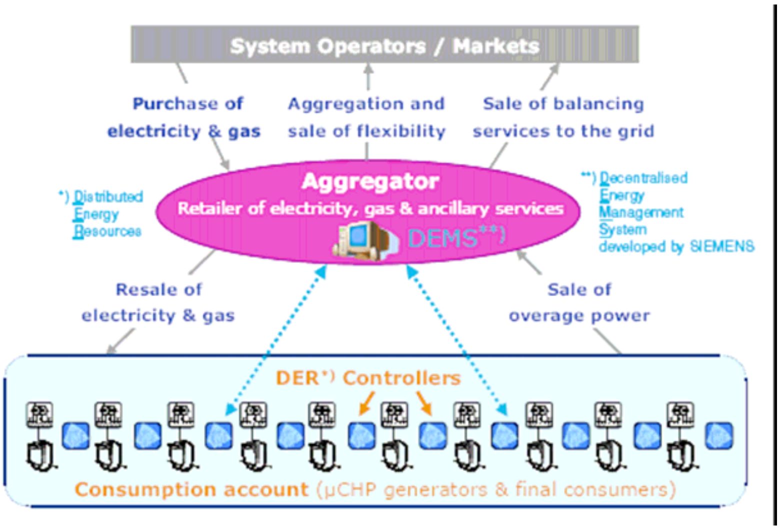


Figure to be updated

2.3.7 Business model III: Energy Service Company aggregating flexible CHP facilities in industrial and tertiary sectors

Business case III deals with an Energy Service Company (ESCo) owning CHP units and proposing demand response contracts to its commercial customers. Installing small units at the customers' sites often allows reducing power losses, and, possibly, higher energy efficiency. Owners of high energy efficiency installations can apply for energy efficiency certificates, or benefit from feed-in tariffs or premium systems.

The business idea is an **extension of an existing CHP business model**, by adding more flexibility through demand response and heat storage. In other words, the ESCO business is profitable today, down to a certain level of heat demand. Aggregating flexible loads and CHP units leads to additional sources of revenues (selling services to the TSO, avoiding balancing penalties...), and therefore allows **reducing the profitability threshold**.

Is it possible to extend today's existing ESCO businesses?

In this case, flexibility is provided both by demand and CHP. Flexibility on CHP units is implemented through boilers and heat storage tanks installed by the ESCO at each customer site.

Graphical representation of the main stakeholders and interactions in the business model

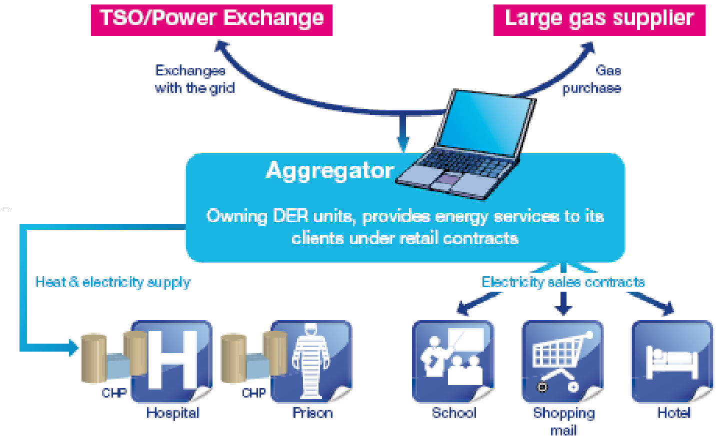


Figure to be updated

2.4 THE ROOFING

The knowledge gained through the integration work that can serve in the future to develop further technical research and business investigation is organized in three components:

R1) Recommendations for future large-scale experiments

An issue in future research and demonstration is the scaling rules required to size the demonstration projects, and the replicability of such experiments. EU-DEEP proposes to segment the approach to large-scale experiments into three main steps: secure "up to the meter" experimental infrastructures, secure "beyond the meter" samples of real clients, and "system" experiments involving DER and DSM contribution to the electric system.

R2) Recommendations on market, regulation and grid architecture

In the context of decarbonisation of the electricity production by 2020, the conditions for a massive deployment of DER must be prepared taking into account power system design rules. The charges related to the use of system must be reallocated more fairly, taking into account DER contributions to the network. EU-DEEP recommends a methodology for such cost allocation and formulates recommendations to upgrade the existing design criteria of future distribution networks.

R3) Beyond EU-DEEP: standards

An affordable information and communication environment based on standardized protocols is required to face the deployment of DER and the multiplication of aggregating actors. However, today, ICT is not applied to medium/low voltage distribution networks for cost reasons. Recommendations are made to standardisation bodies to work on overall communication standards and protocols for:

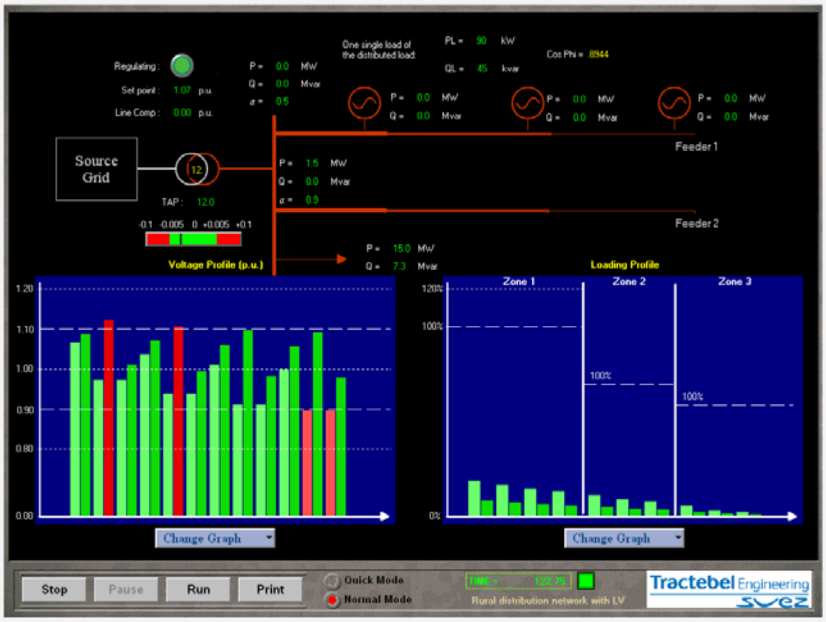
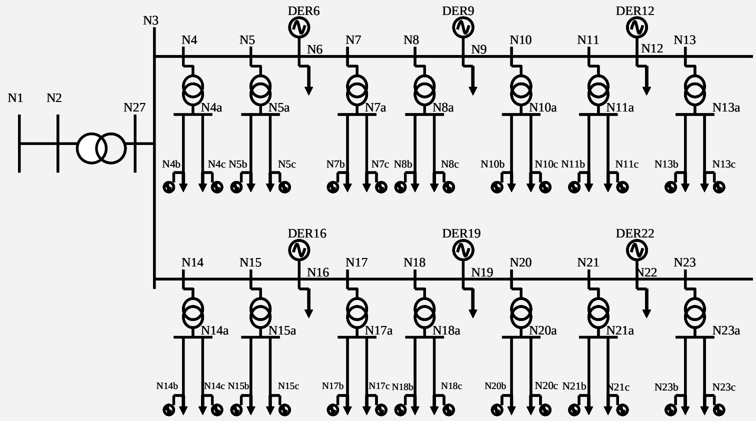
- seamless exchange of data: continuation of work on interoperability and worldwide marketing of the developed standard series
- smart metering requirements: development of a harmonized Smart meter standard in Europe
- ensure coordination at the international level for DER integration.

2.5 A GLOSSARY

In addition to the knowledge cards description a glossary on DER concepts is added in annex. There is indeed a need for a common language on DER so that all stakeholders of the energy field have the same understanding of the key concepts. A glossary was thus developed, build upon the technical and conceptual terminology needed for aggregation. It includes new items or emerging concepts explored by EU-DEEP and other on-going R&D projects.

Knowledge Block n°	T1
Title	**Power system design is a key parameter for the introduction of Distributed Energy Resources**
Context (50 words)	The basic principles used for developing and operating Power Systems are valid whatever the scale of the considered system. The main goal is to get the targeted reliability for customers at an acceptable price. Such systems can be characterised by a set of properties. Some of them could be put under pressure following the introduction of Distributed Energy Resources.
Challenge (1 question, max. 25 words)	What are the consequences of an increasing deployment of Distributed Energy Resources on the validity of system design principles and on system reliability?

Results (max. 6 results, max. 500 words for the whole section)	**The basic principles lying behind power systems development and operation are valid whatever the system considered.** Preventive security margins are the cornerstone of the design of electrical power systems. Respecting these margins means that the system is robust facing a predefined list of contingencies (i.e. "secured" events such as loss of a line or a generating unit). In case of more severe incidents, system security is restored by deploying dedicated defence actions. Power system control in quasi steady-state is implemented for preserving security margins. It is deployed using a 2 or 3 layer control. Short term control is purely local (i.e. "primary control") while the mid & long term controls are based on communication means ("secondary" & "tertiary" controls). **The principles of electrical power system operation can be prolonged in presence of DER.** Distributed Energy Resources will impact the system as a whole as well as transmission and distribution networks, calling for adjustments of both networks operation. Built initially for rotating generators, AC power system operating principles are also compatible with power electronic interfaces and demand response. This means that the present structure of control can be prolonged. To maintain security, the TSO however needs more information than before. This mainly concerns status, type and operating point of DG units. Aggregation of DER units is a provisional way to manage this information before emergence of Smartgrid solutions. **For the good understanding of networks technical issues the distinction between transmission and distribution networks must be based on technical criteria rather than on administrative limits.** Technical issues can be *de facto* classified into two main categories: local and global. The local ones concern the distribution networks and include overload, voltage control, protection, Power Quality and risk of islanding. The global ones related to system security concern the transmission system and include power–frequency control, voltage–reactive power compensation, system protections, emergency control procedures, defense plans and system restoration. When studying DER issues, this limit between transmission and distribution must be located where the structural layout of the system is radically changing. This is usually where radially operated medium and low voltage networks connect to the meshed structure of the high voltage transmission system. **A certain amount of DER can be connected to distribution networks following the "fit & forget" principle.**[OS63] Currently the basic design is referred to as "fit & forget" principle. The system is set up for being unconditionally adequate. This means that such network respects voltage, flow, fault current requirements for all possible expected scheduled load demand without any intervention of the distribution network operator, except in case of fault. The current design rules depend on load density and are characterised by the duality between overload and voltage control. At distribution level, in medium and low voltage, adequacy is given by sufficient capacity for urban networks or voltage drop margin for rural networks. This means that control margins exist in urban and semi-urban networks in terms of voltage control, while few or no margin exists in rural networks. The available margins allow thus for a connection of a certain amount of DER. Going further is possible but is conditional on load diversity – materialized by the physical aggregation through the network- and on "coincidence" between load and DER functions.
Illustrations	

(1 or 2, with max. 30 words per legend)	 **Figure 2-1 This figure from the EGIDE simulator shows the incidence of non-homogeneous feeders in rural distribution: MV feeder 1 with no generation and MV feeder 2 with micro-CHP is installed in Low Voltage. Seven pairs of LV feeders are represented not visible on the picture), each pair is supplied by a distribution transformer with 90 % of micro-CHP is installed along one LV feeder and 10 % along the other one.**  **Figure 2-2 This figure shows a more detailed representation of the simulated network. Two LV feeders are represented for each distribution transformer. The equivalent micro-CHPand load are connected; voltage at feeder end correctly represents the voltage drop of continuous distributed load and generation along LV feeder.**
Integration (no maximum)	– See also Knowledge Blocks T2 to T6 – N1 to N3 – And S1 & S2[LG64]
References (max 3 references, max. 150 words)	– "Power System and Market Integration of DER, the EU-DEEP1 Approach", Dr J. Deuse et al. CIRED 2005 Conference, Turin, Italy – "EU-DEEP INTEGRATED PROJECT – TECHNICAL IMPLICATIONS OF THE 'HOSTING CAPACITY' OF THE SYSTEM FOR DER", Dr. J. Deuse et al. International Journal of Distributed Energy Resources, Volume 4, Number 1, January 2008
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com Olof Samuelsson, IEA-LTH, olof.samuelsson@iea.lth.se Christine Schwaegerl, Siemens, christine.schwaegerl@siemens.com

Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	T2
Title	**Existing distribution networks present a significant “hosting capacity” for Distributed Energy Resources**
Context (50 words)	Distribution networks have been developed by the electrical supply industry under the vertically integrated paradigm with little or no generation at the distribution level in medium and in low voltage networks. Introduction of Distributed Energy Resources in distribution leads to technical issues that become more and more critical when the proportion of DER in the system is increasing.
Challenge (1 question, max. 25 words)	How much DER can be connected to the current distribution network without unacceptable inconvenience?

Results (max. 6 results, max. 500 words for the whole section)	**The "hosting capacity" methodology permits the determination of the maximum proportion of DER that can be connected to a specific network.** The “hosting capacity” methodology is used to determine how much DER of a certain type can be connected to a given network, for specific network situations before a performance limit is passed. In a first step a large number of performance limit parameters that characterize grid behavior are reviewed. Then a second step consists of setting an acceptable sorting range for each of these parameters, and to value each of them as a function of the DER penetration level. A third step is sometimes required for analyzing some aspect more in detail. This is often needed when considering DER incidence on protective scheme in distribution. **Distribution networks developed using the “fit and forget” principle, are exhibiting operational margins that allow for accepting a significant proportion of DER.** Most distribution networks developed using the “fit and forget” principle present margins that can be securely exploited with a significant proportion of DER. This “hosting capacity” is function of the type of interaction that is considered. For the most important questions that are related to system loading and voltage control, a series of parameters must be considered such as the coincidence of demand and generation, the homogeneity of the HV – MV substation feeders in terms of location of load and generation, the voltage control margins, etc. Voltage control can be implemented mainly following two options: limit the risk of flow inversion along feeders, which limits *de facto* penetration or implement active management for the medium voltage control settings. **When determining the “hosting capacity”, design criteria must be selected as the reference.** The limits defined by design criteria must be used as the reference when dealing with penetration ratios of DER. This is in close relationship with the “diversity” of the demand. The key parameter is the maximum consumption of the “mean client” during peak conditions (like U.K. “After Diversity Maximum Demand” or ADMD). A similar concept can be considered for local generation (it could be referred to as “After Diversity Maximum Generation” or ADMG). Generation can be “naturally” coincident or can be “made” coincident with load using suitable control actions. For instance PV generation and air conditioning can be coincident, micro-Combined Heat and Power can be operated for being coincident with peak load (like “Power-Matcher” does). However, load and generation functions are different and thus ADMG lower or equal to ADMD states only about the risks of voltage issues. But active management can only be used when feeders are homogeneous, meaning that they represent similar demand – generation patterns. **Technical issues with small DER (DG) in most cases are not materialised.** Protection schemes as used in the distribution systems may not be adequate in presence of large amounts of DER. This critical questions when the distribution networks is operated in island (micro-grid) is no longer true when interconnected because the operation of the protection scheme is dominated by the short circuit power supplied by the HV network. Small DER units installed in low voltage generally do not supply short-circuit power. Hence, they cannot disturb protection operation.

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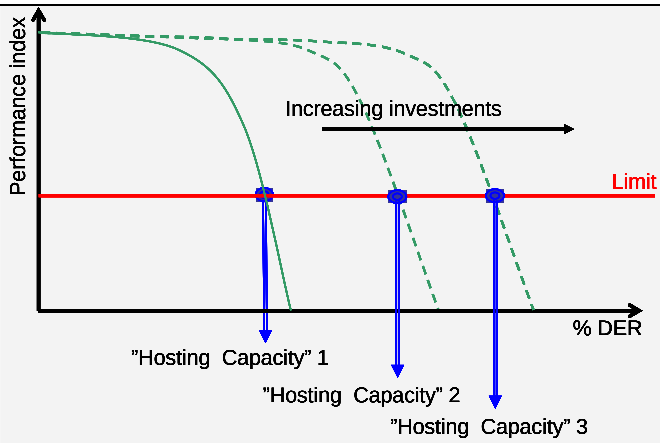

Figure 2-3

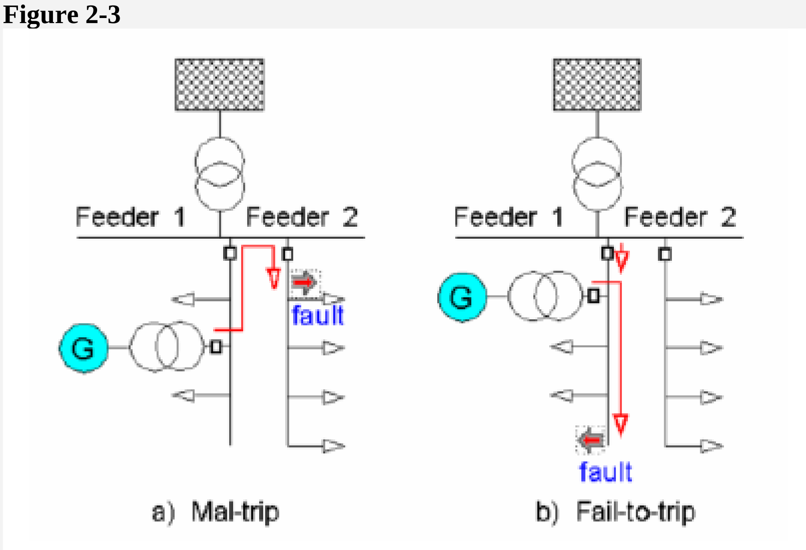

Figure 2-4 This is a classical example showing detrimental incidence of DER on protection. Detailed investigations on realistic cases show that short-circuit power from HV network dominates. Only high power DG[LG65] **could eventually lead to such failure.**

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<td>Integration
(no maximum)</td>
<td>– See also Knowledge Blocks T3 to T6
– Knowledge Blocks N1 to N3
– And Knowledge Blocks S1 to S2</td>
</tr>
<tr>
<td>References
(max 3 references, max. 150 words)</td>
<td>– EFFECTIVE IMPACT OF DER ON DISTRIBUTION SYSTEM PROTECTION”, Dr J. Deuse et al. CIRED 2007 Conference, Vienna, Austria
– “EU-DEEP INTEGRATED PROJECT – TECHNICAL IMPLICATIONS OF THE ‘HOSTING CAPACITY’ OF THE SYSTEM FOR DER”, Dr. J. Deuse et al. International Journal of Distributed Energy Resources, Volume 4, Number 1, January 2008</td>
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– XXX</td>
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<td>Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com
Math Bollen, STRI, math.bollen@stri.se
Christine Schwaegerl, Siemens, christine.schwaegerl@siemens.com</td>
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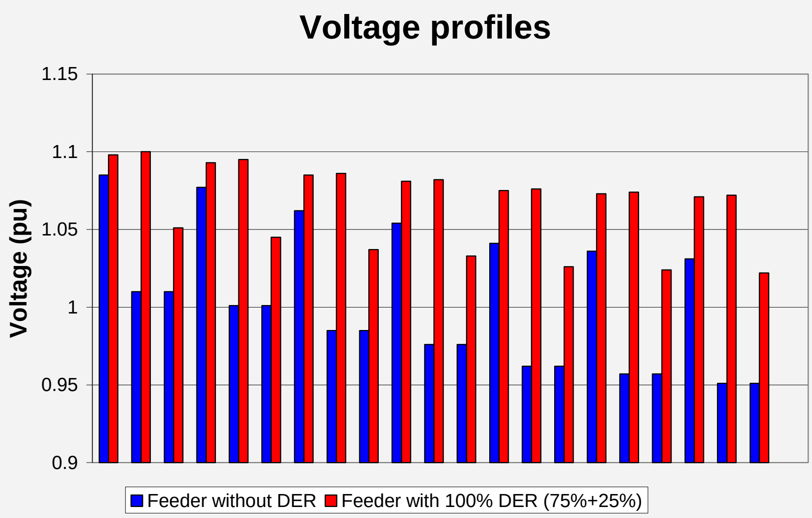
Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	T3
Title	**The "hosting capacity" of present networks can be extended based on "static" voltage adjustment or on active management.**
Context (50 words)	Technical analyses show that margins exist within distribution networks for hosting significant amount of DER. This is particularly true for urban and semi-urban networks because they present voltage control margins. Set point of the voltage control can eventually be adjusted for making room for DER. This leads to the extension of the "fit & forget" principle or it allows for active management through adjustment of the medium voltage setting.
Challenge (1 question, max. 25 words)	How to find the easiest way to increase the hosting capacity?

Results (max. 6 results, max. 500 words for the whole section)	**The voltage control margins in urban and semi-urban networks can be exploited for increasing the "hosting capacity."** The simplest method uses the existing margins in urban and semi-urban distribution networks. Operational voltage must be adjusted for making room for DER. However, provided voltage margins are sufficient active voltage control is not required allowing for extending the "fit & forget" principle. The extension of the "fit & forget" principle is based on the "reinterpretation" of network design criteria. As voltage drops along feeders, the voltage set point is traditionally adjusted near to the upper limit so that the highest possible voltage permits reducing the losses in the system. In presence of local generation and in case of non-homogenous location of load and generation along feeders, voltage profiles can increase and decrease along the various feeders depending on the coincidence between load and generation. The existing margins can be used allowing for the coexistence of load and generation dominated feeders. The reference voltage must be adjusted downwards and the "fit and forget" approach can be prolonged. This supposes sufficient regularity in terms of behaviour of the load and generation customers. All other things being equal this increases the losses in the network due to the lower mean operating voltage. **Active management can be implemented when voltage control margins are not wide enough when load and generation functions present suitable properties.** Solutions are more complex in these cases because they depend on network characteristics in terms of homogeneity between feeders, or shapes for loads and generations functions, if they coincide or not, etc. Behaviour facing micro-CHP or PV should be totally different in northern part of Europe for example. In a first case, little or no voltage margin exists but feeders are homogeneous. This means that it is possible to adjust the supply voltage as a function of network loading. In a second case, little or no voltage margin exists and feeders are not homogeneous. Instead peak generation and peak consumption are not taking place during the same period of time. It is then possible to keep voltage within range by adjusting the voltage set point in the HV – MV substation. The controlled voltage is systematically adjusted as a function of the operating conditions that can be sensed in the distribution substation. This is mainly relevant for rural networks. **Critical cases concern installations that lay outside of network design rules.** The risk of overload and too high short-circuit level issues concern urban situations and large DER installations. The increased connection costs for DER affects marginally their profitability. Photovoltaic installations constitute a recurrent example of critical case. They are generally out of range as compared to the design of this network. The above implies that only limited penetration ratios are allowed in such cases.

Illustrations (1 or 2, with max. 30 words per legend)	 **Figure -1 These profiles show voltages at both sides of LV feeders of a rural network. Two LV feeders are represented by distribution transformers. For MV feeder 1 there is no DG in LV, for the MV feeder 2 DG units are present 75 %** [OS66]**on one LV feeder and 25 % on the second LV feeder. This illustrates that margins exist allowing fro DER integration with non homogeneous feeders in MV and LV (% refer to load)**
Integration (no maximum)	– See also Knowledge Blocks T4 to T6 –
References (max 3 references, max. 150 words)	– "EU-DEEP INTEGRATED PROJECT – TECHNICAL IMPLICATIONS OF THE 'HOSTING CAPACITY' OF THE SYSTEM FOR DER", Dr. J. Deuse et al. International Journal of Distributed Energy Resources, Volume 4, Number 1, January 2008 – USE OF SYSTEM CHARGES METHODOLOGY AND NORM MODELS FOR DISTRIBUTION SYSTEM INCLUDING DER", Dr J. Deuse et al. CIRED 2007 Conference, Vienna, Austria – "DER profitability, distribution network development and regulation", Dr. J. Deuse et al., CIRED 2009, Prague, Czech Republic
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com Christine Schwaegerl, Siemens, christine.schwaegerl@siemens.com Math Bollen, STRI, math.bollen@stri.se
Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	T4
Title	**Further increasing the "hosting capacity" means active management and new design criteria**
Context (50 words)	DER "hosting capacity" of present distribution networks can be increased using active management. This is only possible when an where margins exist, particularly if the transient reduction of DER generation can not be considered as a control option. One way for increasing "hosting capacity" consists of adopting new design rules. This is valid for network renewal or for new network development.
Challenge (1 question, max. 25 words)	Finding [0]suitable active management solutions and design criteria.

Results (max. 6 results, max. 500 words for the whole section)	**Increasing the "hosting capacity" of distribution networks requires the definition of new design criteria complemented by the implementation of active management.** Increasing the “DER hosting capacity” requires the definition of new design criteria for developing or exploiting distribution networks. This will generally include active management. This is necessary because larger ranges are needed if reduction on power injection, i.e., “curtailing”, must be avoided as much as possible. This means that “exogenous” objectives, for example defined within the energy policy, are necessary. They could fix limits such as limitation of ADMG (After Diversity Maximum Generation), penetration ratio for DER or the allowed curtailment limits for generation. **New design rules should define at least the required margins for developing active management of the distribution voltage.** The basic principle is to adjust the design of the system when required for making active management possible. This assumes that system conditions have been defined integrating demand and generation characteristics in connection with the objectives of the energy policies. This is particularly valid for renewables, good example being the mean size of PV installations which is often not in line with the system capabilities. The main objective is to extend the flexibility of the distribution network for integrating higher proportion of DER whatever the location and size. Voltage control issues that cannot be solved using active management are most often resulting from the existence of non homogeneous feeders (different proportion of load and DER along the different feeders of a same HV – MV substation), the non-coincidence of load and generation, and further the lack of physical room for implementing additional voltage control device on feeders. By default of these characteristics the lack of margins does not allow the deployment of the active control of the voltage in the HV - MV substation. Consequently active control on the power generated by DER becomes necessary, which means power curtailment. **An optimal design for distribution could be characterised by limited margins for “soft” active management for normal situations (in "N"), and requiring DER limitation for faulty "N-1" situations.** The basic principles of upgraded design criteria can be based on the following steps. (1) Exogenous information (energy policies, common use of electricity, etc.) fixes limits for the accepted degree of homogeneity, load - DER coincidence, etc. (2) Peak contribution for “mean” customers can be proposed (like ADMD); similarly peak contribution for the different DER type can be evaluated (by analogy with load: ADMG can be defined), (3) as an example EU-DEEP proposed the “flexible symmetrical design”. It is based on a fully symmetric design for non-homogeneous feeder, with ADMG = ADMD, but other possibilities exist like ADMD = k x ADMG (ADMG > ADMD, k<1), or ADMD and ADMG independently defined. These values are defined for a class of customers or are DER type dependent and are closely coupled with proportion of installed capacity (see for example PV). The approach concerns normal operation only. In case of “N-1” situation DG curtailment can be implemented. **Exogenous objectives for the distribution network are required allowing for defining new design criteria, including the role of active management.** New design criteria for distribution networks can easily be developed as soon as clear objectives are defined. These objectives should be defined outside of the electrical supply industry, but with its participation. The exact sharing between design and active management is an integral part of the process.

Illustrations
(1 or 2, with max. 30 words per legend)

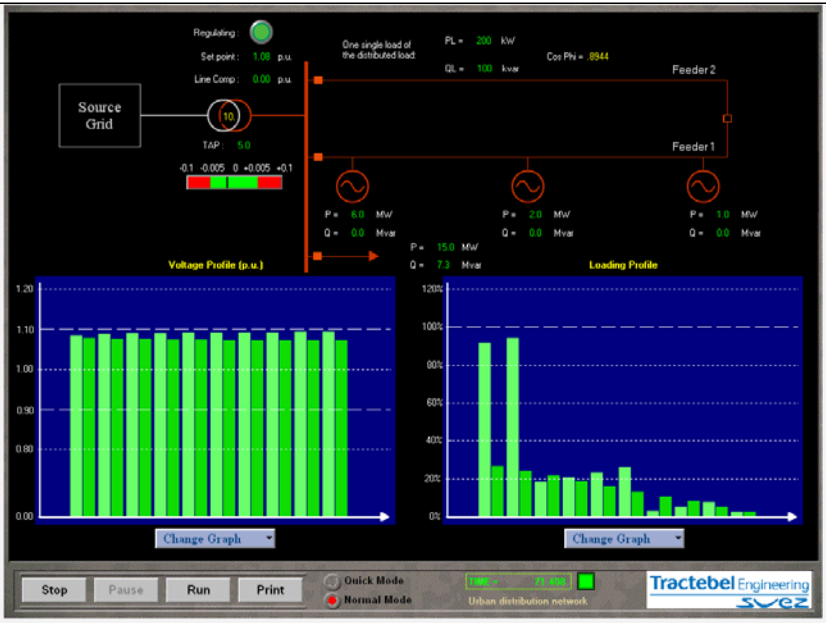


Figure -1 This figure shows an urban network where DG units are installed along one feeder. They are characterized by a rather high nominal power, particularly the first one near the substation. This is acceptable in normal conditions because the very low voltage drop.

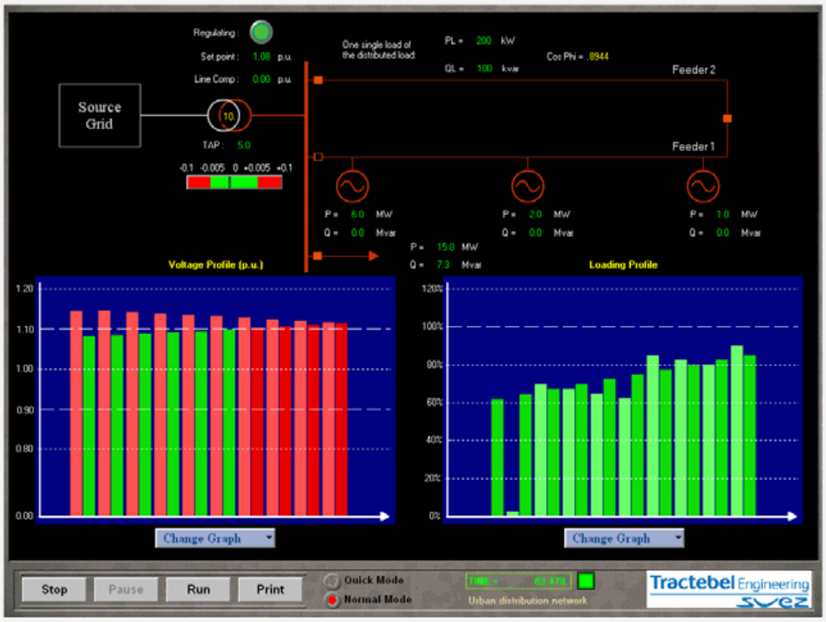


Figure -2 Following a fault on the first segment of feeder 1, this feeder is backward supplied from normal open point on the loop. The high power injected by the first DG leads to too high voltage along the feeder.

Integration
(no maximum)

- See also Knowledge Blocks T1 to T3 & T5 to T6
-

References
(max 3 references, max. 150 words)

- "EU-DEEP INTEGRATED PROJECT – TECHNICAL IMPLICATIONS OF THE 'HOSTING CAPACITY' OF THE SYSTEM FOR DER", Dr. J. Deuse et al. International Journal of Distributed Energy Resources, Volume 4, Number 1, January 2008
- "DER profitability, distribution network development and regulation", Dr. J. Deuse et al., CIRED 2009, Prague, Czech Republic

Stakeholders
(max. 8 stakeholders)

[Not to be filled for the moment]

- XXX

Contacts

Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com

(max. 3 contact names)	Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Math Bollen, STRI, math.bollen@stri.se
Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	T5
Title	**A new "symmetric" and "flexible" design is proposed as an example allowing for higher DER penetration ratios**
Context (50 words)	Distribution networks based on new design criteria present an increased "hosting capacity" for DER. Operational rules for such system that integrate active management, mean new opportunities for higher proportion of DER. This can be developed based on "soft" and "hard" active management when distribution network is respectively in "N" or in "N-1" state.
Challenge (1 question, max. 25 words)	New design and operation rules permit to solve technical issues that limit the "hosting capacity" of distribution networks, but design criteria must integrate long term objectives taking account of the life cycle of power networks.

Results (max. 6 results, max. 500 words for the whole section)	**New design is the only way to further increase the "hosting capacity" of distribution networks. The "symmetric" design is presented as one example for new design criteria.** New design principles have been proposed. They should be developed integrating explicitly the requirements for active management. The basic principle is getting the required capacity for generation and consumption while remaining within voltage range and to share this range between generation and consumption in function of their respective footprint. The first type of upgrade that is used here as an example can be referred to as "flexible symmetric design" for which the "equivalent peak power" of DER and of load (ADMG & ADMD) are equivalent whether these are coincidental or not. **The "fit and forget" principle can be extended for distribution network operation within design.** The "flexible symmetric design" remains close to actual design, but gets rid of the "non homogeneous" feeders limit issue. It can be simply used as an upgraded version of the "fit and forget" design imposing a static change in voltage set point only, which could be simply set at nominal voltage, without further voltage adjustments during operation. Based on this design, it is possible to extend further the "hosting capacity" of system based on such upgraded design by using active control of the voltage during operation but excluding direct control of sources. Such practice could be referred to as "soft" active management. This approach is recommendable for being implemented when the system is in "N" state, i.e. in absence of contingency. **When the operating point reaches design limits, "soft" active management must be implemented. However, for more critical conditions and in case of contingency, "harder" active management could include DER control.** Developed for operation under an upgraded "fit & forget" principle, the new design can integrate "soft" active management using updated voltage set point when it is required. It can also integrate "harder" active management options, when the system is operating under "N-1" conditions, if generation or loads are stressing the network. Indeed in case of high stress in the network due to generations, loads or both simultaneously, active management of generation can be implemented on the generation side (or even on the load side). Limiting generation during "N-1" operation permits maintaining the system voltage within limits. The new design principles are first setting up room for making the system more flexible for accepting higher proportion of DER presenting some features. Indeed design criteria must be defined having in mind the type of constraints that will take place. As an example, network that integrates large amount of PV would require higher cross section of the cables if voltage has to remain below limits in favorable conditions and if the supplied power by renewable cannot be limited during high generation periods of time. It must be recalled here that diversity of PV along a feeder remains limited due to the "common mode" of sunshine. Even if total installed capacity remains significantly lower than subscribed power, like for example 10 kW PV for 15 kW.

Illustrations
(1 or 2, with max. 30 words per legend)

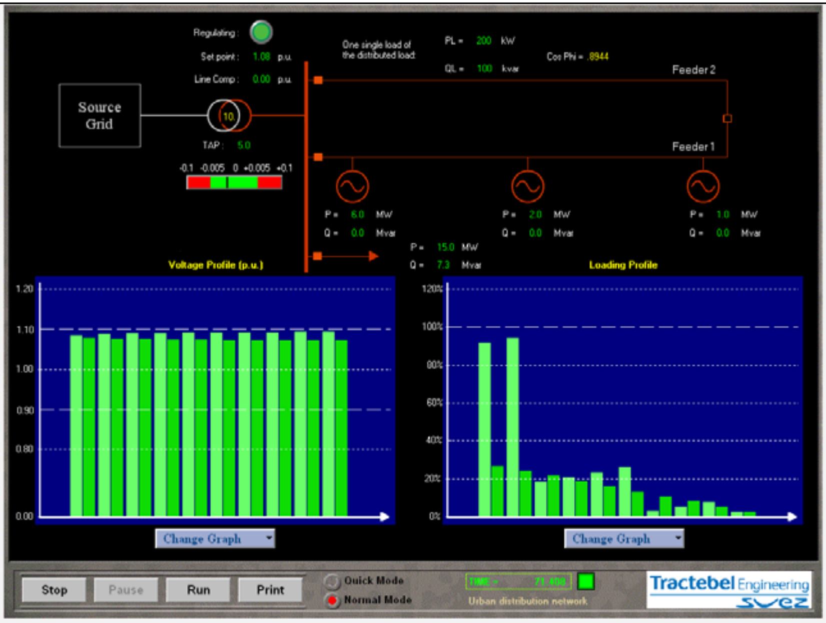


Figure -1 This figure shows an urban network where DG units are installed along one feeder. They are characterized by a rather high nominal power, particularly the first one near substation. This is acceptable in normal conditions because the very low voltage drop.

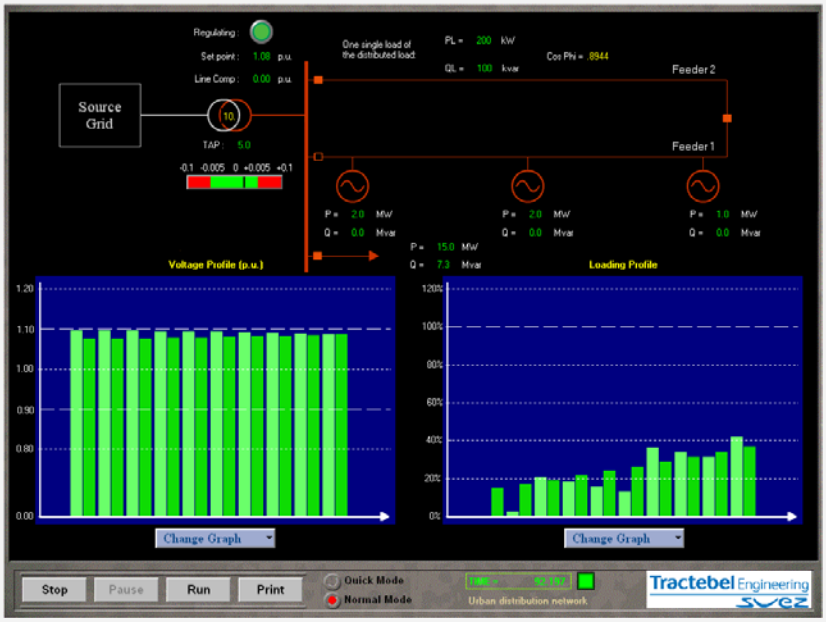


Figure -2 Following a fault on the first segment of feeder 1, this feeder is supplied back from normal open point on the loop. Reducing the power injected by the first DG unit allows for limiting the voltage within specified limits which is acceptable as it corresponds to some tens of minutes per year.

Integration
(no maximum)

- T4 and T6
-

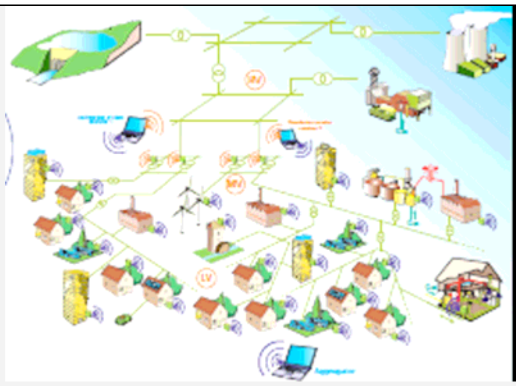
References
(max 3 references, max. 150 words)

- "EU-DEEP INTEGRATED PROJECT – TECHNICAL IMPLICATIONS OF THE 'HOSTING CAPACITY' OF THE SYSTEM FOR DER", Dr. J. Deuse et al. International Journal of Distributed Energy Resources, Volume 4, Number 1, January 2008
- "DER, network design and system security" – Dr J. Deuse, Third International Conference on Integration of Renewable and Distributed Energy Resources, Nice – France, December 2008

	– "DER profitability, distribution network development and regulation", Dr. J. Deuse et al., CIRED 2009, Prague, Czech Republic
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Math Bollen, STRI, math.bollen@stri.se
Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	T6
Title	**In the long run the "hosting capacity" for RES could be extended further with RES most often considered as a source of power than as a source of energy**
Context (50 words)	One day costs of RES will be such that over-investment could become the rule. Optimum size will be a function of the techno-economical situation that is far beyond the present knowledge. In such situation RES will require active management even during not too favourable weather conditions.
Challenge (1 question, max. 25 words)	Control capacity of RES should permit suppressing limitations in terms of installed power. This will allow for a better position in terms of supplied power locally. The total energy delivery will become *de facto* limited by the design of the network.

Results (max. 6 results, max. 500 words for the whole section)	**With time going on, investment costs for RES will decrease and over-investment will take place for securing power supply for longer periods.** In the long term one can expect that investment costs for RES will significantly decrease. Simultaneously generation costs from fossils fuels will significantly increase. Consequently over investment in RES could be justified. Doing so, RES will progressively change from energy sources to power sources for a more substantial part of the time. During the most favorable hours the generation from RES could become extremely high. The adjustment of the operating point of these installations will become mandatory for limiting the risk of excess of power that will put distribution network at risk. **At that time horizon it is expected that Information and Computer Technology solutions as promoted by Smart Grid will be readily available for managing such issues.** It has already been assumed that active management of the distribution network is implemented. This starts first for the dynamic control of network voltages at the HV – MV substation. In the next steps voltage issues are solved using orders to decentralized generations asking for compensating reactive power and further to reduce active power injections. It could also be completed using load control action as it is assumed that demand response towards higher or lower consumptions will be implemented in function of RES position. **"Integration" of DER is not standardised yet but different EU projects are dealing with this important question.** As a short term project, EU-DEEP tested integration of DER but did not consider distribution network adequacy as an issue requiring practical investigation during its tests. But other EU research projects are dealing with such issues. The Commercial and the Technical Virtual Power Plant concept as proposed by FENIX, materialized by the "FENIX box", are means to solve these issues at large scale in the future. Other control methods have also been proposed and tested in previous projects and are still under development in Europe. Some are based on agent software, like Multi Agent System MAS developed by NTUA – Greece (used within EU-DEEP in the aggregation tests implemented in Greece) or the Power-Matcher developed by ECN in The Netherlands. **In the long run an optimum must be defined balancing the issues of RES local penetration, storage and network design.** Design criteria for distribution network remain an open question That must be addressed soon taking account of the lifetime of power network. The proposed practice implicitly assumed that some optimum has been determined for the design criteria of the network balancing additional costs required for system development and the value of renewable energy that could be lost during favorable conditions due to distribution network constraints. They should be in agreement with objectives set up in the framework of climate change policies. The role of electrical storage in the mid-term could become significant.

Illustrations (1 or 2, with max. 30 words per legend)	 Instructions: updated version of this picture where a large number of RES are implemented: PV on roofs and micro-wind (for example vertical axis turbines…) and special connections from substation…
Integration (no maximum)	– States of the Art –
References (max 3 references, max. 150 words)	– No references
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com Christine Schwaegerl, Siemens, christine.schwaegerl@siemens.com Math Bollen, STRI, math.bollen@stri.se
Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	T7
Title	**Power System controls can be deeply impacted by DER, requiring adequate system integration.**
Context (50 words)	Power systems controls (power – frequency control and voltage – reactive power control) in normal and in emergency conditions have been developed based on centralised generation. They must be re-evaluated in depth due to the presence of DER. Preserving security of operation supposes a sufficient degree of coordination and integration of DER even at limited penetration ratios.
Challenge (1 question, max. 25 words)	What are the requirements for preserving the operational security of the system in presence of significant amount of DER?

Results
(max. 6 results, max. 500 words for the whole section)

In case of large penetration of DER in a system, their participation to power - frequency control will become a necessity.

A sufficient amount of control capacity is required for maintaining the mid –term balance between generation and consumption in the system. The transfer of control capacities from conventional generators towards DER and RES becomes necessary when the contribution of classical power plants is decreasing. Up to a certain penetration ratio it is not necessary for DER & RES to participate to system control, in fact as far as the total amount of reserves can be deployed on classical units. This amount is a function of the selected reliability criteria. It is quite clear that for high penetration of DER and RES such participation becomes mandatory. This is already integrated in the rules for RES in certain systems, Ireland for example.

For the stability of operation of the system, the coordination of frequency ranges between TSO and DSO is mandatory.

Coordination of frequency ranges between large and small plants is needed. For normal operation the frequency remains near to nominal. This means ± 200 mHz for the European system for example. When the system is facing a “secured event” (loss of 3000 MW) the frequency can transiently decrease down to 49 Hz. In case of incident beyond “secured event” the frequency can decrease down to 47.5 Hz. It is then mandatory that generation of whatever type remains connected to system for avoiding a further deterioration of the system state.

In case of high penetration of DER in the system, voltage control will require new investments in reactive power compensation.

For the transmission system the electrical balance of the system is playing an important role. DER will modify the loading of the UHV and HV networks, which in case of large penetration of DER will change the voltage behavior of the system, requiring additional voltage compensation means.

In systems with large proportion of DER, load shedding schemes must be adjusted and preferably replaced by load shedding implemented locally at LV.

Load Shedding schemes are implemented at HV – MV substations by tripping MV feeders. With high penetration of DER units, this practice is not anymore optimal as feeder tripping means disconnection of load but also disconnection of generation.
The mid-term answer should be the best possible selection of feeders for implementing the load shedding scheme. The long-term answer should be the inclusion of emergency demand response and load shedding within the smart system–customer interface.

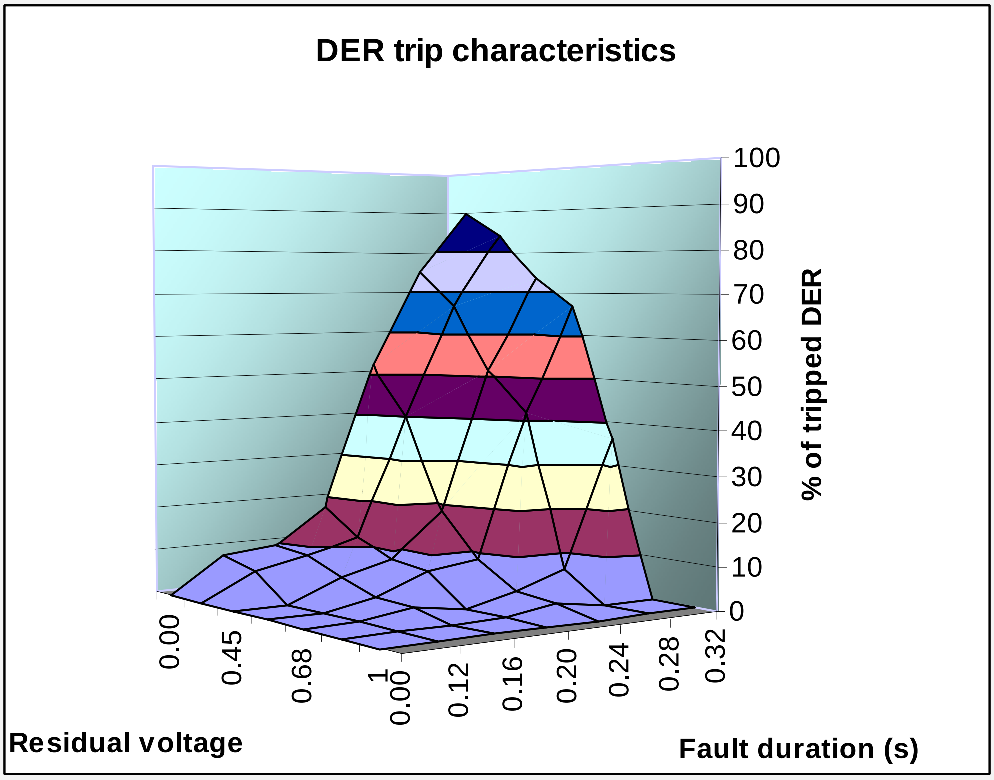
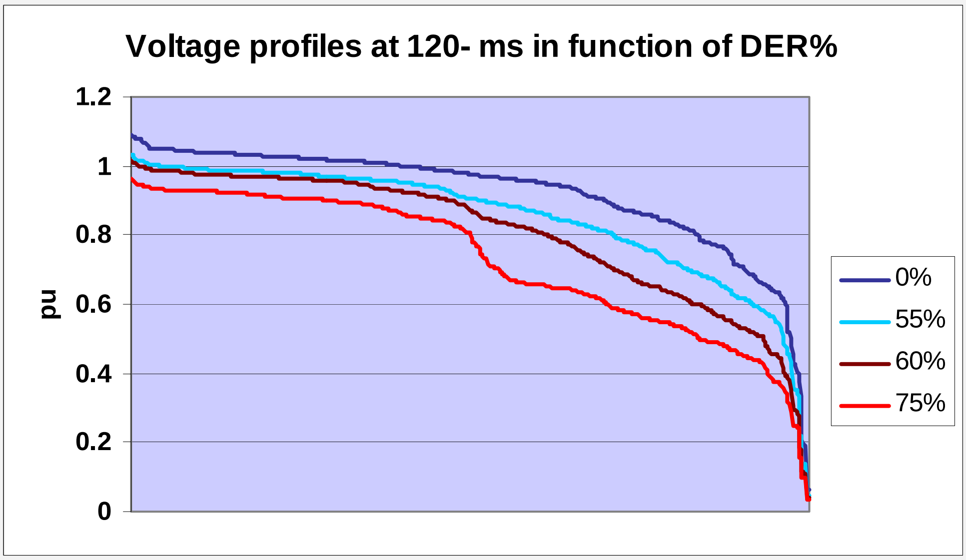
The emergency load shedding will be implemented using the smart interface (time horizon is in that case in the order of half an hour, whereas defense load shedding will be implemented based on local criteria for frequency and for voltage.

Maintaining system security imposes that DER present “low voltage ride through” capability facing transmission system faults.

High proportion of DER in the system means a reduced number of large generators on line. For stabilizing the voltage in the UHV system additional compensation is required. The short-circuit power will decrease leading to higher voltage sensitivity during transient conditions. Faults will lead to dips deeper in voltage and geographically more widespread. DER must present sufficient robustness facing these voltage dips. At least low voltage ride through capability facing normally cleared faults should be recommended.

Reliability of system supposes a complete identification of DER in the system.

For maintaining system reliability it is important to have a comprehensive knowledge of the respective contributions of load and generation in the resultant loading of the distribution networks as well as the transmission system. Indeed the network elements could become unable to supply load in absence of local generation. It is important to have information allowing for identifying these situations. It will become important to have demand response in emergency conditions to make, for instance, feeder restoration possible for such cases.

Illustrations (1 or 2, with max. 30 words per legend)	 **Figure -1 This figure shows the voltage ride through capability of the DER implemented in the model. It has been built for being robust versus normally cleared three phase faults (120 ms) and for back-up cleared single phase faults (300 ms)**  [KP67] **Figure -2 This figure shows voltage profiles in the UK transmission system at the end of a three phase fault just before clearing for 4 cases with DER proportion from 0 up to 75 %.**

<table>
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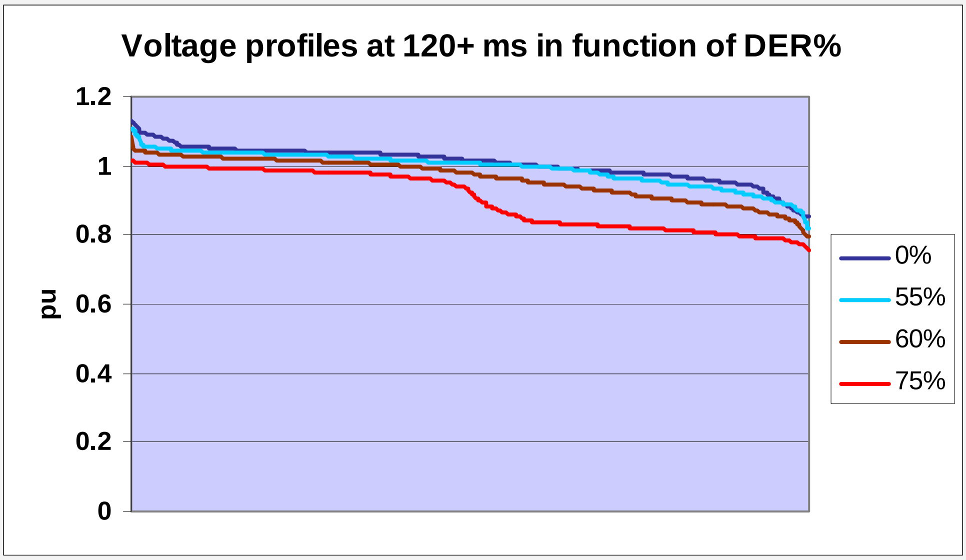

[KP68]

Figure – 3 This figure shows voltage profiles just after clearing. It shows that a "transition" takes place when increasing DER penetration from 60 to 75 %.
</td></tr>
<tr><td>Integration
(no maximum)</td><td>–</td></tr>
<tr><td>References
(max 3 references, max. 150 words)</td><td>
– EFFECTIVE IMPACT OF DER ON DISTRIBUTION SYSTEM PROTECTION", Dr J. Deuse et al. CIRED 2007 Conference, Vienna, Austria
– "Massive DER penetration and power system control", Dr J; Deuse, Third International Conference on Integration of Renewable and Distributed Energy Resources, Nice – France, December 2008
– "Interactions of Dispersed Energy Resources with power system in normal and emergency conditions", Dr J. Deuse et al. CIGRE 2006, Paper C6 – 101XXX
</td></tr>
<tr><td>Stakeholders
(max. 8 stakeholders)</td><td>[Not to be filled for the moment]
– XXX</td></tr>
<tr><td>Contacts
(max. 3 contact names)</td><td>Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com
Vladimir Chuvychin, RTU, chuvychin@eef.rtu.lv
Math Bollen, STRI, math.bollen@stri.se</td></tr>
<tr><td>Pictures of the Contacts
(max. 3 pictures)</td><td>



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</table>

Knowledge Block no	E1
Title	Detecting high potential segments for DER : the “DER-prone segments database"
Context (50 words)	Detecting high potential demand segments for DER implementation must be based on adequate segmentation (to provide homogeneous segments), segment data and a ranking methodology to pre-select most promising ones to perform detailed test/ studies /simulations and so create the necessary knowledge for large scale DER implementation in those segments.
Challenge (1 question, 25 words)	– What are the demand segments presenting the highest potential for DER throughout Europe?
Results (1 to 5 results, 500 words for the whole section)	**DEMAND SEGMENTATION** **A systematic European energy demand segmentation has been necessary to be developed in order to carry out relevant market analysis. It allows describing typical average customer demand in the commercial, residential and industrial sector** The developed segmentation methodology is customer oriented. It extends previously existing segmentations, such as NACE (statistical Nomenclature of economic Activities in the European Community) with additional categorization criteria (consumption ranges, Energy end uses, climate region, type of dwellings,…) to approach the typical average customer with the appropriate granularity. It also takes into account the prior existence of DER in a given segment. The general structure of the methodology is based on a top-down segmentation differentiating three different levels: • First level: Traditional sector division: Commercial, Residential and Industrial • Second level: Based on the activity of the customer. • Third level: Based on qualitative evaluation of energy end-uses On first level, divisions are called Sectors; the second level divisions are referred as Classes and the third level ones as Segments. The application of this methodology led to the creation of a database of typical energy profiles organized by demand segment. **DEMAND DATABASE DEVELOPMENT** **A database describes the load curves of typical average customers in Europe according to the defined segmentation.** This database results from the characterization of each of the segments in terms of end uses of the energy (heat, lighting, cooling, cooking,… for the commercial/residential sector, or more specific processes for the industrial case, such as cooling and heating processes, motors,…) Database is available under Access format and covering over 250 market segments. Three different databases were created, one per sector (commercial, residential and industrial). Given the sector templates are different, the data files in the correspondent database have also different parameter tables. It includes load curves for electricity and other end-uses (yearly totals, as well as typical summer and winter days) providing a basis for the detection of the most promising segments for DER. **RANKING METHODOLOGY** **A ranking technique was developed to detect DER prone segments** The ranking is based on a set of factors whose objective is to account for, in a summarized way, all segment characteristics that are relevant for Distributed Energy Resources (Distributed Generation = DG, Distributed Storage = DS and Demand Response =DR). A factor for EU-DEEP ranking purposes is a customer characteristic, defined as a numerical figure, containing information about the potentiality of the segment for the implementation or enhancement of distributed energy resources For instance, results show that the top ranking segments to host DER in the commercial sector are sub categories of office building, malls, hospitals, Universities and hotels.

Illustrations
(1 or 2, with 30 words per legend)

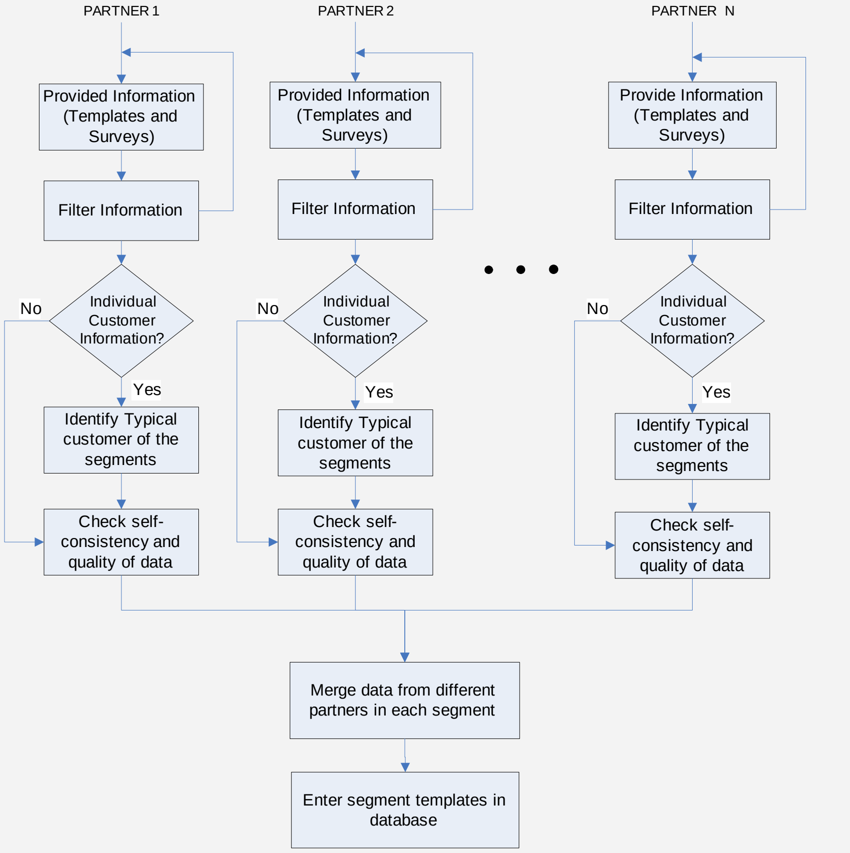


Figure 1. Data gathering and processing methodology

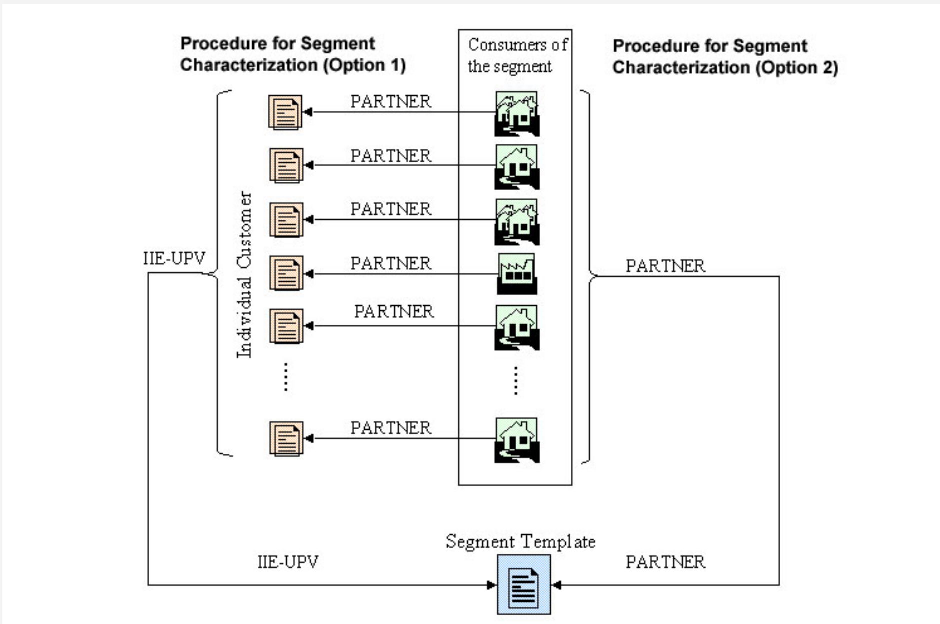


Figure 2: Segment characterization options

Use of Knowledge
(no maximum)

- Demand Analysis Tools
- Business Simulation Tools
- Technology and Country Database
- Demand Knowledge
- Cost Analysis
- Regulation Knowledge

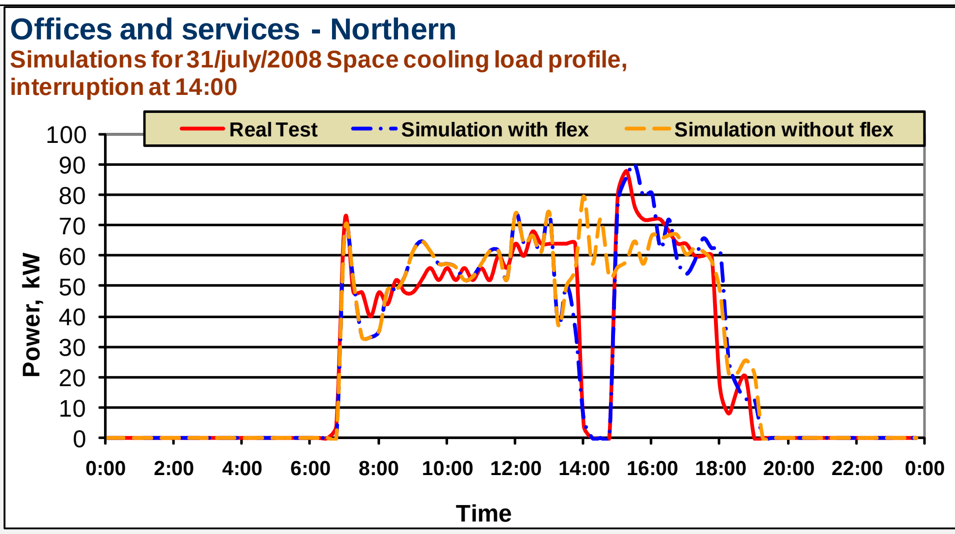
References
(max 3

- "Energy Market Segmentation for DER Implementation Purposes
Authors: N.Encinas, D. Alfonso, C. Álvarez, A. Pérez-Navarro and F. García-

references, 100 words)	Franco.IET generation, Transmission and Distribution vol 1, issue 2, March 2007" - "A methodology for ranking of customer segments by their suitability for Distributed Energy Resources applications. Authors: D. Alfonso, A. Pérez-Navarro, N. Encinas, C. Álvarez, J. Rodríguez, M. Alcázar.Elsevier Energy Conversion and Management 48 (2007)."
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts	– Carlos Álvarez Bel, IIE-UPV, calvarez@die.upv.es – Agustin Delgado Martin, Iberdrola, adelgadom@iberdrola.es, – Pedro Martinez Cid, Iberdrola, pedro.mcid@iberdrola.es
Pictures of the Contacts	   Carlos Alvarez Bel Agustin Delgado Martin Pedro Martinez Cid

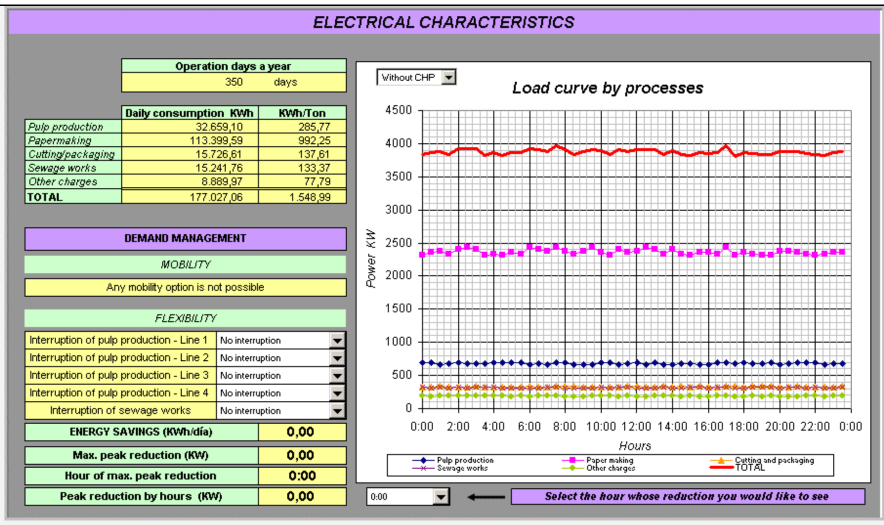
Knowledge Block no	E2
Title	Modelling electric and thermal loads: physical model of end uses
Context (50 words)	Active Demand-Side participation in electricity markets requires accurate flexibility assessment of consumers energy end uses, which are strongly related to weather parameters, building physical description, customer behavior and specific industrial processes so physically-based models (PBMs) are the only way to account for these interrelations.
Challenge (1 question, 25 words)	How to assess the flexibility level of an energy consumer in commercial, industrial or residential sector?

Results (1 to 5 results, 500 words for the whole section)	***The physical modeling of each energy end-use is required to assess the flexibility level of any energy consumer. Introducing demand participation into the electricity markets requires a thorough flexibility evaluation based on accurate modeling of electric and thermal loads.*** **Comprehensive round-up of energy end-use modelling tools focusing on demand flexibility as been carried out.** Typical main commercial energy end-uses (space heating & cooling, lighting, ventilation,…) are strongly depending on weather parameters (temperature, humidity,…), physical description of the building and customer behavior. Physically-based models (PBMs) are a validated approach allowing to capture such dependencies. For industrial segments, the dependency on climatic conditions is lower. However, in-depth understanding of each energy-related process (cooling/heating processes, milling,…) is still required to assess flexibility and again physical modeling methods are well adapted to that purpose. Research efforts have already been performed in the past for the development of software for the energy modeling of buildings (building modeling), namely in the field of “energy efficient” buildings. Nevertheless, available models are not so focused on flexibility evaluation and modeling. Where flexibility is intended as the capability of the customer to modify energy consumption profile according to external inputs (i.e. electricity prices), and sometimes associated to loss of comfort or productivity, typical flexibility actions are load interruption, load reduction or load shifting (i.e. during night period). **A PBM-based methodology has been defined and rolled-out for different market segments.** EU-DEEP intended to bridge this knowledge gap for a set of selected residential, commercial and some industrial customers. PBM approach has been implemented through modeling tools (see E3), and data needs gathering based on specific modeling questionnaires for commercial, residential and industrial customers including: - Building description, energy supply load curves, customer operation schedules, local weather data, total electricity and gas load curves - Energy end use equipment (HVAC, lighting,..), present energy generation / storage equipment installed in the site, main industrial process description. Perceived flexibility (for interruptions and loss of comfort). When this data is partially not available, general data gathered in DER-prone segment Database (E1) can be employed as support. PBM tools are based on dynamic energy balances and stochastic approaching in order: - To model first the processes in which the energy is used in the customer facilities - To aggregate them either at the customer level (by aggregating all the consumptions in a single customer) or at a higher level (for example, aggregation of a specific consumption process in several customers). **Conclusive PBM application to 34 relevant commercial, residential and industrial segments.** Overall, 12 different commercial segments, 17 residential segments and 5 industrial segments have been modeled. Among the typical results of PBM application that have been reported, modeled customers are representative of important demand segments in Europe as office buildings, hotels, educational and research buildings, and industries with cold storage. The developed tools and obtained results have been validated thanks to several tests performed on real customers in UK and Greece with support of the EU-DEEP project and, when accurate input data for modeling is provided, differences between the model and tests were lower than 20%. Additional applications and PBM validation have been performed for assessing the flexibility level in two of the business cases explored, mainly for commercial customers and some specific industrials (industries with cold storage). Some pre-validations of the model have been performed by IIE UPV prior to the project.

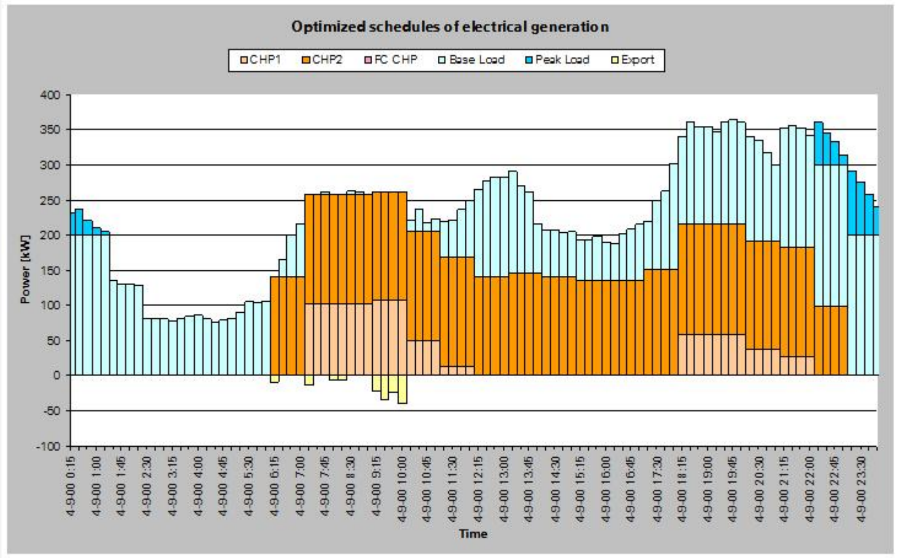
Illustrations (1 or 2, with 30 words per legend)	 Figure 1: Flexibility and modified load curve associated to space cooling interruption during 1 hour.
Use of Knowledge (no maximum)	– States of the Art – Demand Analysis Tools – Business Simulation Tools – Demand Knowledge – Cost Analysis
References (max 3 references, 100 words)	– "Assessment and Simulation of the Responsive Demand Potential in End-User Facilities: Application to a University Customer. Authors: Carlos Álvarez, Antonio Gabaldón, Ángel Molina, IEEE Transactions on Power Systems. Vol. 19, n 2, pp. 1223-1231. May 2004" – "Implementation and assessment of physically based electrical load models: application to direct load control residential programmes. Authors: Molina, A. Gabaldón, J. A. Fuentes, and C. Álvarez, IEEE Proceedings on Gener. Transm. and Distribution, vol. 150, pp. 61–66, January 2003" – "Physically based load modeling og HVAC loads with some kind of energy storage. Authors: Gabaldón, C. Álvarez, F.J. Cánovas, J.A. Fuentes, & A. Molina, Fourth Int. Congress on Energy, Environment and Technological Innovation, Rome, 1999, 329-335"
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts	– Carlos Álvarez Bel, IIE-UPV, calvarez@die.upv.es – Agustin Delgado Martin, Iberdrola, adelgadom@iberdrola.es, – Pedro Martinez Cid, Iberdrola, pedro.mcid@iberdrola.es
Pictures of the Contacts	   Carlos Alvarez Bel Agustin Delgado Martin Pedro Martinez Cid

Knowledge Block no	E3
Title	Modelling impacts of DER on thermal and electric loads: simulation tools
Context (50 words)	Modelling, forecasting and management of customer demand flexibility require specific and easy to use simulation **tools** to promote large Active Demand-Side participation in electricity markets. This knowledge block implements the principles described in E2
Challenge (1 question, 25 words)	How can the physically-based models developed in the framework of Eudeep be easily used for assessing demand flexibility and demand response?

Results (1 to 5 results, 500 words for the whole section)	A numerical simulation toolbox (FLEXMOD) has been developed to physically model the impact of DER on the thermal and electric loads of a customer. FLEXMOD is a set of simulation tools to model the impact of DER (including distributed generation, distributed storage and demand response) on thermal and electric loads, based on the physical modelling of end uses described in E2. FLEXMOD is structured in three modelling tools under Matlab and Excel: **FLEXMOD1-DECRET, the DEtailed Commercial and REsidential TOOL has been applied to relevant demand segments** Load profiles for space heating, space cooling, thermal storage and hot water are able to be simulated by using this tool. A proper physical description allows electrical and thermal loads to be modelled. This tool was validated through different real tests performed in UK, applied on large office buildings, hotels, educational buildings (Universities and research centres) and other commercial/residential segments. The European climatic diversity is taken into account in the model, since simulations are strongly dependent on weather conditions. **FLEXMOD2-DEIT, the DEtailed Industrial TOOL for thermal and electric modelling, was developed and validated for 5 relevant demand segments**. It consists on a set of user friendly interactive excel files specifically developed for each one of the studied industrial segments. Five different tools for five particular cases, identified by EU-DEEP as the most promising ones regarding DER issues, were developed: furniture, sewage treatment, ceramics, papermaking and cheese production. These tools are specific for each segment, and they only has been implemented for the TF1 industrial customers, as only this task has required the models. This set of tools includes as well a detailed thermal and electrical analysis. Additionally, the impact of different flexibility actions identified in each segment can be easily assessed. Each specific tool has been validated by comparison between the load curve from real customers and the simulated profile provided by the model. **FLEXMOD3-DEFFORT, the DEmand and Flexibility FORecasting TOOL was developed and validated during the project for 10 customers of 6 different demand segments.** This is the user friendly adaptation of both DECRET and DEIT tools and it is applicable to commercial, industrial or residential customers for flexibility management and forecasting purposes. It is less accurate than the previous ones, but an important advantage is the **very low input data requirements**. It is_based on a neural networks interpolation between simulations issued from the above tools. It was validated by comparison between real tests and simulations of similar strategies. A closed interaction with customers for validation purposes during tests was carried out, so an iterative process of methodology improvement was followed. For a defined control strategy (i.e. space cooling interruption) DEFFORT generates the following results: ➢ ***Forecasted electricity load curve*** for a typical day in summer or winter (depending on the selected season) ➢ Forecasted electricity load curve after ***the implementation of a flexibility option*** (depending on the selected strategy) ➢ Electricity load curve by ***end uses before and after the implementation of the flexibility option.***

Illustrations (1 or 2, with 30 words per legend)	 Figure 1: Screen shot of FLEXMOD DEIT. Modelling Tool for a papermaking industry. Electrical characteristics screen.
Use of Knowledge (no maximum)	– Demand Analysis Tools – Business Simulation Tools – Demand Knowledge – Cost Analysis
References (max 3 references, 100 words)	– Assessment and Simulation of the Responsive Demand Potential in End-User Facilities: Application to a University Customer. Authors: Carlos Álvarez, Antonio Gabaldón, Ángel Molina, IEEE Transactions on Power Systems. Vol. 19, n 2, pp. 1223-1231. May 2004 – Implementation and assessment of physically based electrical load models: application to direct load control residential programmes. Authors: Molina, A. Gabaldón, J. A. Fuentes, and C. Álvarez, IEEE Proceedings on Gener. Transm. and Distribution, vol. 150, pp. 61–66, January 2003 – Physically based load modeling og HVAC loads with some kind of energy storage. Authors: Gabaldón, C. Álvarez, F.J. Cánovas, J.A. Fuentes, & A. Molina, Fourth Int. Congress on Energy, Environment and Technological Innovation, Rome, 1999, 329-335
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts	– Carlos Álvarez Bel, IIE-UPV, calvarez@die.upv.es – Agustin Delgado Martin, Iberdrola, adelgadom@iberdrola.es, – Pedro Martinez Cid, Iberdrola, pedro.mcid@iberdrola.es
Pictures of the Contacts	   Carlos Alvarez Bel Agustin Delgado Martin Pedro Martinez Cid

Knowledge Block no	E4
Title	Optimizing the energy value of a single DER unit
Context (50 words)	*Numerical simulation tools are needed to optimize the most evident value of a DER when considered as a single unit: the value generated by the energy exchanges. Configuration and optimization impact this value.*
Challenge (1 question, 25 words)	How to carry out the economic analysis of DER for design and operation of a single DER unit to reduce the uncertainty in DER investment considerations?
Results (1 to 5 results, 500 words for the whole section)	Four numerical simulation tools were developed or upgraded to optimize the energy value of a single DER unit They provide economic value of implementing a DER unit for given demand profiles (and demand uncertainty) using energy market price information. Adequate unit sizes can be chosen by investigating a number of scenarios, allowing informed investment decisions and customer selection. **Flexproof optimizes the DER operation with a stochastic approach** This tool developed by VTT allows a stochastic optimization for day-to-day operation of DER units, thus helping in investment decisions. Flexprof focuses on uncertainty in market prices and RES generation. Its results have been compared to real-time tests with customers in the UK presenting load flexibility (Demand Response), including offices, cold stores, shops and hotels. **CleanPower optimizes DER operation and supports investment decisions** It is an optimization tool developed and used by Tractebel Engineering for improving day-to-day operations of energy resources and support DER investment decisions. The model is deterministic, and allows for user-defined commodities (power, heat, cooling, waste, etc). **DEMS allows optimum sizing, analysis and operation of DER and DSM** It is a generic deterministic tool upgraded by Siemens PSE DEMS that can be used for economic optimization (off-line simulation) as well as control for optimized operation of decentralized energy supply systems (on-line supervision). DEMS allows to model an arbitrarily energy / media flow topology (power, heating, cooling, CO_2 emissions, water, etc.) considering technical side constraints and related operation costs / revenues of energy / media markets. The optimization algorithm is based on Mixed Integer Linear Programming. Demand and renewable generation forecasts are built based on weather conditions, consumption patterns or production plans and calendar information and feed the operation planning. DEMS includes Generation, Storage and Demand Side Management in parallel. A daily optimization of CHP in one site is presented in Fig 1 **CABSON models the impact of DG operation using demand curves** CABSON for Centralized Approach Based Simulator Of NTUA, developed by NTUA, is a deterministic tool using typical demand curves to model the impact of Distributed Generation operation on each end-use. This tool simulates the impact of one or more DG units, either in electricity or CHP mode, in one site (actual or even in virtual power plant mode), on the resources demand, operating cost and emissions avoidance. Simultaneously, if requested, CABSON can simulate the impact of controllable loads (ON/OFF decisions) and storage device operation in cycling mode. Within EU-DEEP, this tool has been used in the analysis of various sites like dairy and ceramics industry. Moreover, some students in NTUA have started using it in order to get accustomed to DG impact on the networks. Additional features of those tools for aggregation businesses are presented in the card A2.

Illustrations (1 or 2, with 30 words per legend)	 Figure 1: Screenshot of SIEMENS DEMS software: daily optimized operation of a set of CHP units on one site CHP1, CHP2: gas engine CHP units FC CHP: Fuel Cell CHP unit – not used because of low heat demand Base load: Supply Contract with moderate energy price Peak load: Supply Contract with higher energy price Export: electricity sold to the grid when CHP generation exceeding the load The operation schedule of the CHP's is basically following the heat demand, considering minimum stable power and minimum up time and minimum down time as well as start up costs. During the morning hours, the heat demand allows the CHP's to be scheduled close to nominal power; thus compensating the need for electricity import completely (and even sell back electricity to the grid). Principally the CHP' could be scheduled to avoid peak load import at higher prices; but there are times where this operation would violate e.g. the minimum up time or minimum stable power constraint.
Use of Knowledge (no maximum)	– One-Year Test Campaign – States of the Art – Demand Analysis Tools – Business Simulation Tools – Demand Knowledge – Cost Analysis – Regulation Knowledge – Power System Knowledge – Energy Market Knowledge – Forecast and Optimization techniques
References (max 3 references, 100 words)	– "Scheduling and Control of Distributed Energy Resources in the European Electricity Market Environments", Erich Fuchs, IRED 2008
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts	Erich Fuchs, SIEMENS AG Austria, erich.fuchs@siemens.com Antonis Tsikalakis, NTUA, atsikal@power.ece.ntua.gr Jussi Ikäheimo, VTT, jussi.ikaheimo@vtt.fi Konrad Purchala, Tractebel Engineering, konrad.purchala@tractebel.com Roch Drozdowski, GDF SUEZ, Roch.drozdowski@gdfsuez.com

Pictures of the Contacts	    

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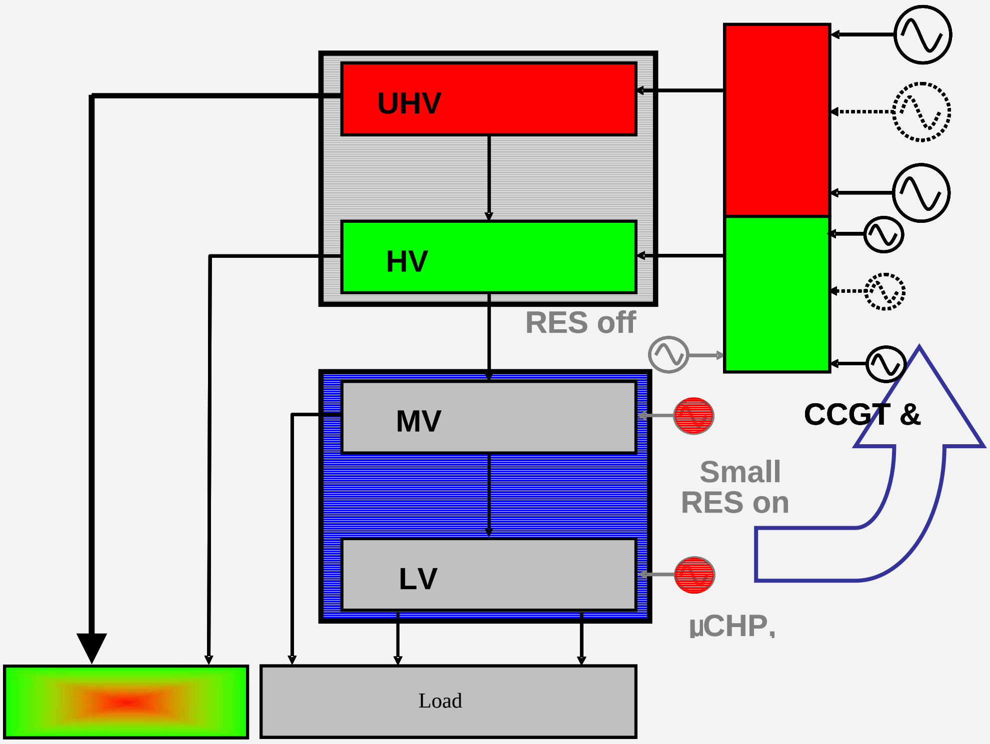
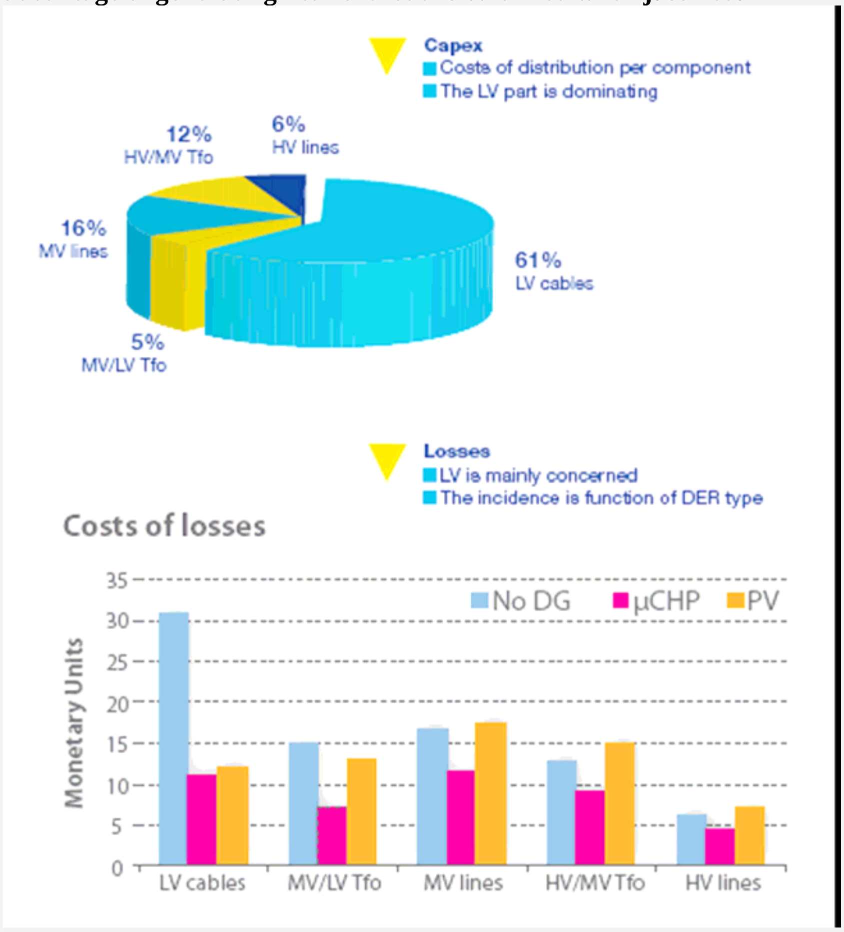
Knowledge Block n°	N1
Title	**Actual "Use of System" charges schemes can not valorize DER that represent a value for the system**
Context (50 words)	Generating electrical energy at the distribution level relieves the network and thus presents an additional value when compared to UHV generation. The actual "Use of System", UoS, charges mechanisms are unable to take account of that specificity of DER.
Challenge (1 question, max. 25 words)	What upgrades are necessary for better UoS tariffs that could account for load and DER footprints on infrastructure?

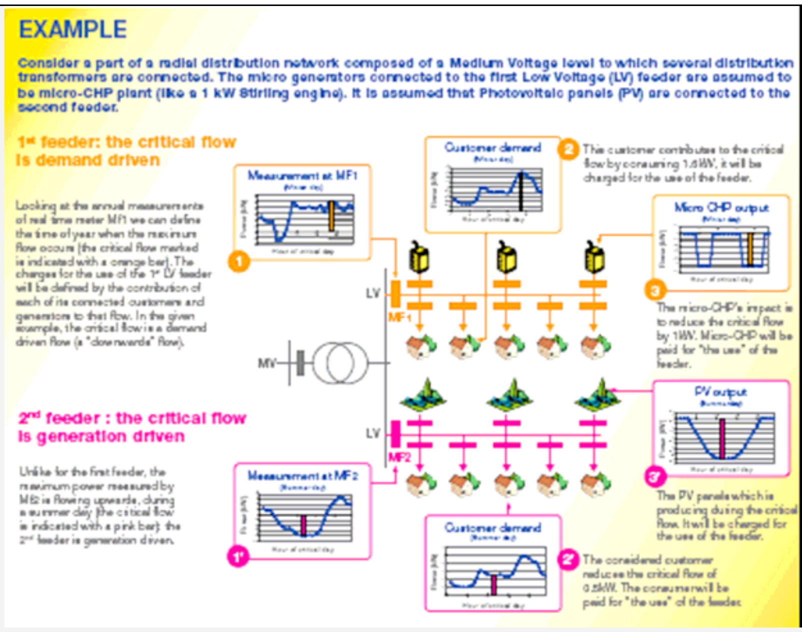
Results (max. 6 results, max. 500 words for the whole section)	**The actual "Use of System" charges schemes are not "efficient".** Presently implemented "Use of System" tariffs are not transparent and unable to take account of the specificity of DER. This is resulting from different considerations: (1) the technical limitation of metering systems in the past; (2) the limited requirement in terms of metering under the vertical integration paradigm; and (3) the lack of ICT solutions for off-line data management. Under the vertical integration paradigm, most of the considerations were taken into account when elaborating tariffs for the different categories of clients using load curves; this could have been rationally extended for DER. Consequently, the present UoS tariffs are built on two terms: fixed charges and charges proportional to consumption. The variable part is often the most important for small customers (the limit being about 100 MWh per year) because only energy is metered. Such schemes cannot be "efficient" in terms of reflecting the footprint of load and generation on the system. **UoS tariffs must respect some *prerequisites*, which is a first step towards "efficiency".** End user's energy bills generally combine the different components of electricity delivery *via* kW and kWh terms. The supply contract separates components relating to the energy supplier, transmission and distribution companies, and to others. These additional components include contribution to the regulation task, renewable energy support, etc. A clear separation of UoS tariff from incentive is necessary; for sites equipped with DER, load and generation cannot be treated as a single component. Avoiding these practices is required for getting "efficient" tariffs. **In the present status of UoS distribution tariffs, those that tend to valorise DER position, make it in an irrational way.** Tariffs that valorise the position of DER already exist. They are most often applied for RES in the form of net tariff for load and generation combined on a one year time window. In the USA this tariff is used in a large majority of states for RES and practically never in case of cogeneration plants. For sites subject to net tariff, no variable charges will be paid if generation and consumption are balanced on the time window of one year. Being balanced on this long time period does not mean that network is not necessary for site operation. Net tariff does not check if DER represents effectively a value for the distribution system. If PV is used as an example for N-W Europe, the highest contribution takes place during low load period (summer days) and much less during high load conditions (winter evenings). This can not justify that site does not pay for distribution infrastructures. **Inadequate UoS tariffs can deeply affect the resources of DSO.** Net tariffs taken here as an example can lead to serious issues in terms of DSO revenue if they are prolonged when DER penetration is increasing in the system. Net tariffs can be considered as a kind of subsidies. **Regulation of Distribution Companies must be made independent of UoS tariffs.** Regulation for DSO should be made such as the revenue of the company takes care of the presence of DER but is not detrimentally affected by this presence. This can be implemented by making a clear distinction between the regulation of the revenues of the DSO and the way the CAPEX and OPEX are shared by the different customers that are connected to the network operated by this DSO. Regulation by norm is a good candidate.
Illustrations	

(1 or 2, with max. 30 words per legend)	 **DG connected to medium and low voltage networks will sooner or later enter in competition with "centralised generation". A fair competition supposes that the advantage of generating near the load is valorized when justified.**  **Figure -2 Investment costs and cost of losses are the main drivers of distribution network design. The first part of the figure indicates that LV is particularly concerned by as concentrating the essential of the investment. The second part of the figure indicates different impact for different technology on network losses.**

Integration (no maximum)	– Ref to Tx,u,z –
References (max 3 references, max. 150 words)	– "Power System and Market Integration of DER, the EU-DEEP1 Approach", Dr J. Deuse et al. CIRED 2005 Conference, Turin, Italy – USE OF SYSTEM CHARGES METHODOLOGY AND NORM MODELS FOR DISTRIBUTION SYSTEM INCLUDING DER", Dr J. Deuse et al. CIRED 2007 Conference, Vienna, Austria – "DER profitability, distribution network development and regulation", Dr. J. Deuse et al., CIRED 2009, Prague, Czech Republic
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Daniele Benintendi, FEEM, daniele.benintendi@feem.it
Pictures of the Contacts (max. 3 pictures)	  

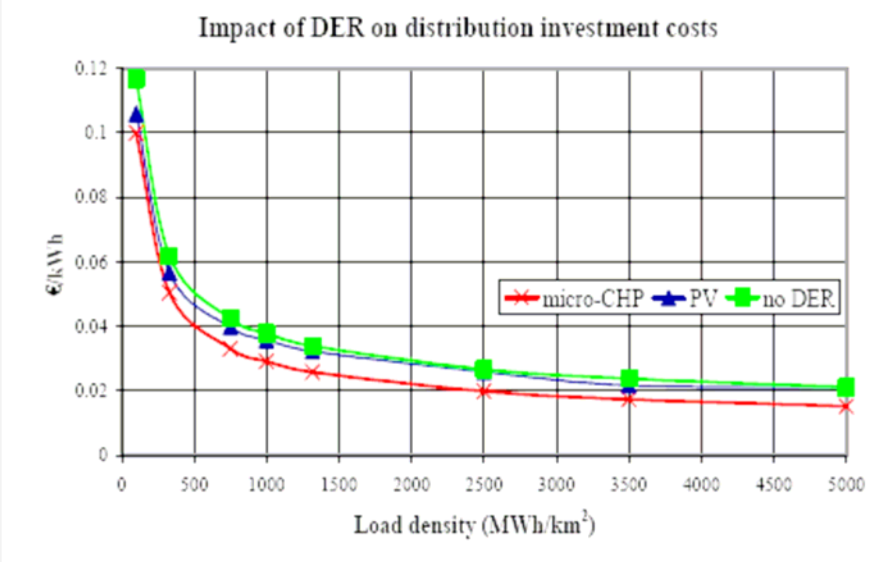
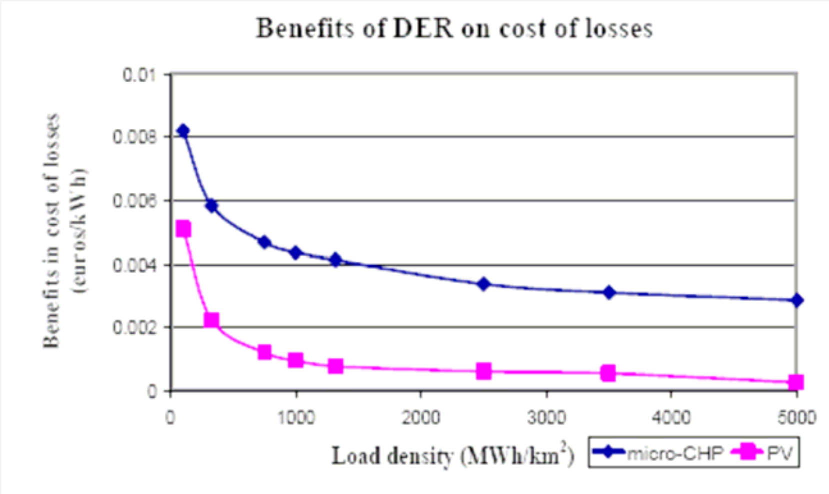
Knowledge Block n°	N2
Title	**Efficient "Use of System" tariffs can be set up that unveil the value of DER as "network replacement"**
Context (50 words)	Presently used UoS tariffs are not able to unveil the value DER can represent as "network replacement". The emerging of generation in distribution networks leads to new issues that ask for the determination of the footprint of customers (generation or load) on network infrastructures.
Challenge (1 question, max. 25 words)	DER can represent a significant value for the system, how to make such contribution explicit?

Results (max. 6 results, max. 500 words for the whole section)	**A new method, based on a "marginal" approach has been developed allowing for unveiling the footprint of load or generation on the distribution network infrastructure.** The University of Manchester presented in CIRED 2005 a new methodology for setting up "Use of System" charges schemes. It is based on a marginal approach and it has been developed for being applicable in HV distribution networks (particularly suited for England & Wales power system). In fact it uses two load flows corresponding to peak load and off-peak load situations. This method is able to unveil the footprint of load and generation on the distribution network and leads to positive and negative charges. However, due to its complexity, this method cannot be used as such in medium and in low voltage networks. For this reason, it has been updated for being applicable at lower voltage levels, requiring large scale metering systems and *ex-post* data management. **The impact of load and generation must be determined separately as they play symmetrical but complementary roles. Ideally they should be determined for all upstream elements in the network.** Load and generation from the same site must be treated independently, because their footprints are different and often complementary. In theory the footprints of generation or load must be determined for all components in the radial part of the distribution network, up to the HV – MV substation, because peak loading of the different network elements can take place at different moments depending on the behavior of the grid users. **Implementation requires large scale deployment of smart metering with automatic meter reading and *ex post* data treatment.** The determination of generation and load footprints requires setting up of a large scale smart interval metering system including automatic meter reading. The collected data have to be analyzed *ex post* in detail for determining the contribution of load and generation on the loading of the different component during the yearly peak of this element. Such UoS tariff makes explicit the positive and negative impacts of generation (or load) onto the network. In the example, valid for North-West of Europe, the value of micro CHP as "network replacement" can be partly remunerated. This is however not the case for PV. Conversely, considering PV in South of Europe where peak consumption takes place in summer (i.e. due to air-conditioning), the value of PV as "network replacement" could be partly remunerated. **For being applicable the method must be simplified while integrating complementary characteristics relative to equality of treatment and to tariff stability.** To be implemented, this method requires simplifications of the metering infrastructure. It has also to integrate equality of treatment principles to avoid penalising customers due to their geographic position in the system. Further tariffs must be made stable enough from one year to the next, but at each stage of the simplification process, the original "efficiency" of the scheme must be as much as possible preserved. Tariff stability can be obtained by using load / generation profiles set up based on interval metering data collected amongst customers and in the network. This could be considered as a generalisation of the "triad" method used in England & Wales for Transmission tariffs, but more suited to small customers.

Illustrations (1 or 2, with max. 30 words per legend)	 **Figure – 1 Example of application of UoS charges scheme for a sub-part of the system**
Integration (no maximum)	– States of the Art –
References (max 3 references, max. 150 words)	– "Power System and Market Integration of DER, the EU-DEEP1 Approach", Dr J. Deuse et al. CIRED 2005 Conference, Turin, Italy – USE OF SYSTEM CHARGES METHODOLOGY AND NORM MODELS FOR DISTRIBUTION SYSTEM INCLUDING DER", Dr J. Deuse et al. CIRED 2007 Conference, Vienna, Austria – "DER profitability, distribution network development and regulation", Dr. J. Deuse et al., CIRED 2009, Prague, Czech Republic
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Daniele Benintendi, FEEM, daniele.benintendi@feem.it
Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	N3
Title	**New tariffs for "Use of System" should lead to a long term reduction of system costs due to its "efficient" character.**
Context (50 words)	Energy policy objectives about CHP and RES could lead to an increase of network investments. However adequate signals to load and generation can help maintaining the costs of the system at acceptable level. These signals first oriented towards network can also have strong incidence on rational use of energy.
Challenge (1 question, max. 25 words)	How to decrease the costs of the system in the long term, while increasing the proportion of DER in this system?

Results (max. 6 results, max. 500 words for the whole section)	**Increasing the proportion of DER in the distribution network can have various impacts on the distribution network infrastructure, depending on the type of DG considered.** The impact of an increased number of DER on the cost of the system depends on the types of DER considered and on the system to which they are connected. The possible over cost due to DER depends on energy policy choices, including the associated operational rules that are imposed. As an example it is interesting to consider the case of PV, supposing the installation of PV in an already existing network designed considering 1.5 kW After Diversity Maximum Demand (ADMD), for the "mean" domestic customer. Installing 10 kW DG per client in this network without any possibility of power limitation in case of system overload supposes important system reinforcements, especially if all connection points eligible for PV along a feeder could be equipped. On the contrary, installing micro-CHP in the same system should not be harmful because the power output of micro-CHP is below the ADMD network design (1 kW versus 1.5 kW usually in EU) and most of the time it is operating in coincidence with load. **Increasing the proportion of DER in the distribution system can lead to an increase of distribution network cost.** The total cost of the distribution network can be seriously affected by DER introduction, depending of the type of DER, its operational behavior when compared to load, etc. Distribution network can be seriously affected by DER introduction, depending of the type of DER and its operational behavior when compared to load. The comparison of the consequences of the introduction of DG in distribution systems of various load densities showed that for conditions prevailing in the north-west of Europe, the cost of the system decreases in the presence of micro-CHP, whereas it increases in low load density regions for integrating PV. It is worthwhile to mention that a recent benchmarking of Transmission System Operators in Europe showed that the three main parameters explaining the transmission network costs are firstly the system size, secondly the load density in the country and finally the proportion of renewables (often decentralized) in the system, including large hydro. (Figure 1 and Figure 2.) **The new methodology for setting up tariff for UoS charges is sending strong signals to customers that should lead, all other things being equal, to a reduction of distribution network cost.** The proposed method, due to its intrinsic properties should lead to the reduction of the system costs, when compared to other, more classical, tariffs. The "intrinsic efficiency" of the new tariffs is resulting from the application of a marginal approach. It is important that this efficiency is preserved during the necessary simplification process leading to an applicable tariff. In the proposed scheme the tariff will impact load and generation independently during the peak loading periods whatever the moment this loading is taking place. A significant part of the cost of electricity depending on the footprint of generation and load, demand and generation response should be expected limiting the footprint. In the long run this will lead to a decrease of system costs. As a result, the responsibility of the DSO for acceptance of DER is increased as far as it can capture a part of the positive incidence of DER. It is not penalized if the presence of DER increases the costs of the system. The relation between DSO and regulator can be made simple using "normative" regulation.

Illustrations (1 or 2, with max. 30 words per legend)	 
Integration (no maximum)	– States of the Art –
References (max 3 references, max. 150 words)	– "Power System and Market Integration of DER, the EU-DEEP1 Approach", Dr J. Deuse et al. CIRED 2005 Conference, Turin, Italy – USE OF SYSTEM CHARGES METHODOLOGY AND NORM MODELS FOR DISTRIBUTION SYSTEM INCLUDING DER", Dr J. Deuse et al. CIRED 2007 Conference, Vienna, Austria – "DER profitability, distribution network development and regulation", Dr. J. Deuse et al., CIRED 2009, Prague, Czech Republic
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Daniele Benintendi, FEEM, daniele.benintendi@feem.it

Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	S1
Title	**In the present status of the electricity market, DER are already able to deliver services to the system.**
Context (50 words)	Reliable operation of the power system supposes the implementation of various controls that are often referred to as “system services”. Generally speaking, these services concern Transmission System Operators, Distribution System Operators and the considered player itself.
Challenge (1 question, max. 25 words)	In the present status what are the services that can be supplied by DER that are able to increase DER revenue?

Results (max. 6 results, max. 500 words for the whole section)	**The new organisation of the electrical supply industry has made the supply of system services more complex.** Fair integration supposes that the grid users contribute to the overall generation – consumption power balance. Simultaneously instruments must exist avoiding unnecessary control efforts. Market architecture proposes different instruments for smoothly solving such issues. Some are market based, but due to the specificity of the electrical power system some other are just activation of technical resources that have been selected beforehand. Balancing is essential for the overall security of the system, but the way it is implemented deeply depends on the context in relation with system state. In principle pure market based instrument are used for quasi steady-state control, while emergency control situations are treated using technical solutions with pre-selected resources (i.e. based on classified bids). Defense actions are based on automatically activated relays. **Balancing active power is presently an accessible service for DER installed in distribution.** One single service can be supplied by DER in the present market. It concerns active power balancing activities. This can take two main forms. The first one concerns the self balancing within the aggregator (supplier) perimeter for the sake of aggregator's activities, its benefit and for the benefit of its clients. The second one concerns supplying balancing power to different balancing markets. This service is presently significantly different depending on the market conditions, hence the country under consideration. Market architectures are indeed significantly different through out of Europe. Depending on the access conditions different possibilities are offered that can even concern system security in emergency conditions like for example "Short Term Operational Reserves (STOR)" in the U.K. **The operational security of the power system essentially depends on adequate system services that must be delivered on time.** Transmission System Operators are responsible for the operational security of the system. Generating companies supply balancing services to the system operator following specific contracts. Before the reform of the power industry, balancing activities were organized coherently from quasi steady-state operation up to defense countermeasures. Presently a gap exists between commercial activities of generating companies and the last resort security countermeasures implemented by TSO. A reconciliation of commercial and security balancing activities, including demand response, is necessary for increasing system security in emergency conditions. **Real-time balancing services, based on demand response, must be implemented under supervision of TSO.** In the present market organization demand response contracts are generally activated by electricity suppliers when the system is constrained for selling this power at a higher price on the spot market. However, this supposes that these resources will not be available for being activated for security reasons when the state of the system is further degraded. Last resort security should therefore remain close to TSO hands because this measure must avoid conflict of interest for the sake of system security. Displacing at least a part of the responsibility for system security to generating companies, under suitable contract with TSO, is a means allowing for reconciling the management of both types of balancing activities: commercial activities and real time balancing based on demand response.

Illustrations
(1 or 2, with max. 30 words per legend)

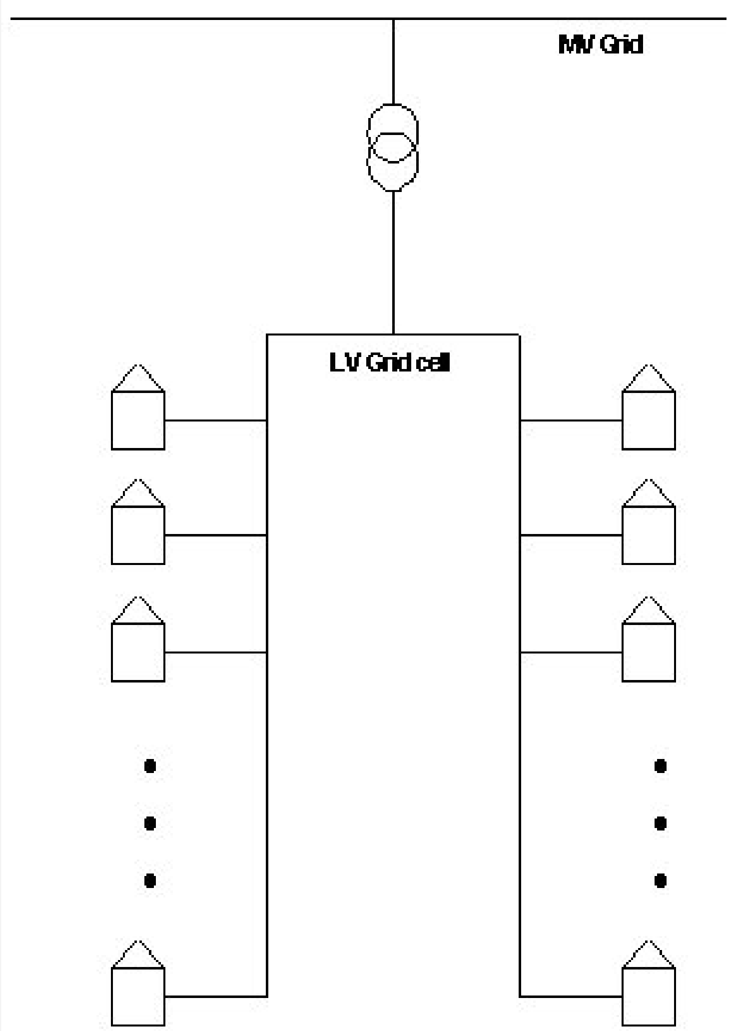


Figure - 2-5 Low Voltage distribution

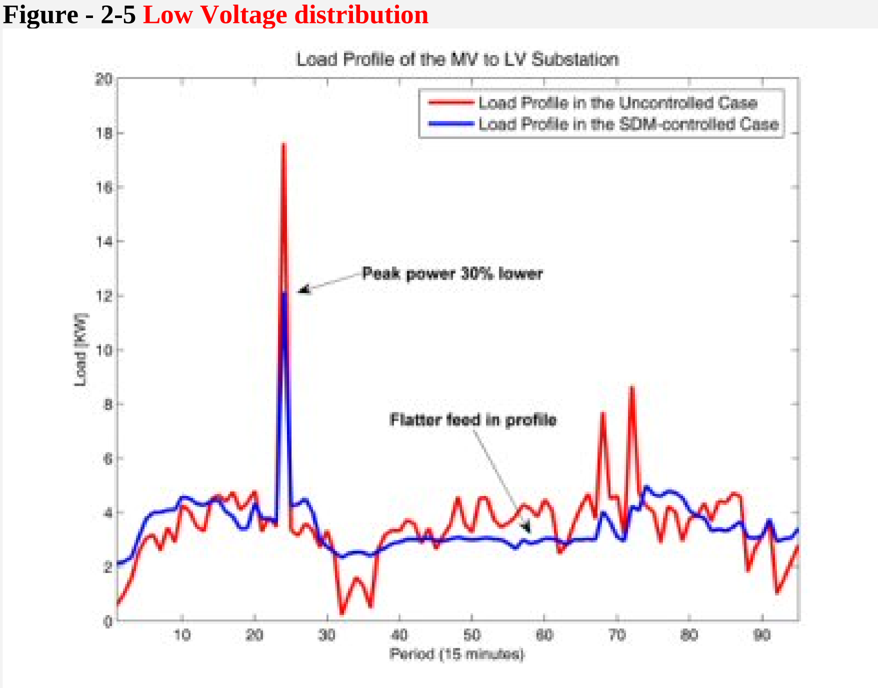


Figure -6 Power profiles : uncontrolled (red) and controlled (blue) using « PowerMatcher » (ECN) as a way for better use of infrastructure, an implicit form of services delivered to the distribution network (see www.powermatcher.net)

Integration (no maximum)	– T7 – TF2
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
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Pictures of the Contacts (max. 3 pictures)	  

Knowledge Block n°	S2
Title	**In the future additional services could be delivered by DER because distribution networks will no longer be designed following the “fit & forget” principle**
Context (50 words)	DER installed in medium and low voltage could today deliver some balancing services to Transmission System Operator. When “distribution” includes high voltage networks, other services can also be delivered, like for example voltage – var control. In the future additional services will become necessary in Medium Voltage and even in Low Voltage distribution networks.
Challenge (1 question, max. 25 words)	What type of services could be delivered to TSO and DSO in the future by DER installed in distribution?

Results (max. 6 results, max. 500 words for the whole section)	**For the sake of clarity it is important to distinguish “thick” from “thin” distribution networks.** Transmission and distribution are not organized similarly in the different countries. Roughly speaking two types of organizations concurrently exist. In the first one, TSO activities are limited to the upper layer of the system, which is respectively made of one layer like in England and Wales with 380 kV or 275 kV or made of two layers like in Germany with the 380 kV and the 225 kV networks; the rest is considered as distribution. In these systems, distribution is made of at least 3 layers (“thick” distribution) high, medium and low voltages. In the second type of organization, distribution is only made of medium and low voltage network (“thin” distribution), all other networks from high voltage up to ultra-high voltages being operate by TSO. **In “thick” distribution system the range of services that can be delivered today (or soon) is larger.** In the case of “thick” distribution system a larger range of services can be proposed because services can be delivered to DSO. Indeed DSO is operating high voltage networks, where big unit can be installed that are often also referred to as DER. Services from these units are, in decreasing order of importance, voltage control or reactive power compensation; contribution to security of supply; power flow management services and eventually quality of supply services. **In “thin” distribution system the range of services that can be delivered is limited to balancing active power.** In the case of “thin” distribution system, as considered within EU-DEEP, services are mainly supplied to TSO because the distribution services are presently built for being unconditionally “adequate”. This means that no congestions can take place in normal as well as in case of single contingency. **In the future the range of services deliverable by DER will increase because MV and LV distribution networks will loose their unconditional adequacy.** The proposed “UoS” tariffs tend to recognize the value of DER as “network replacement”. This wil lead to a progressive vanishing of the unconditional adequacy of distribution networks. One can expect distribution networks remaining adequate facing normal operation and subject to limitation following “N-1” contingencies. This means that, at least for certain circumstances and probably during “N-1” situations, contributions from DER could be required to maintain the operating point within acceptable limits. **In the longer term the number of services that could be delivered by DER to MV and LV distribution networks will increase.** Assuming a design based on security in “N”, depending on the loading conditions, the distribution network could be at risk in case of “N-1” contingency (note that these circumstances correspond to a low number of hours per year). The management of these cases could rely on services coming from local DER. This could correspond to two different services: those where no limitation of the active power is taking place and those where a reduction of active power injection is necessary. The first ones can be implemented using “light” contribution of voltage control or reactive power compensation for releasing the less demanding power flow management services. For the more critical constraints, like power flow management in “N-1” situations, the corrective action could correspond to sharp reduction of power injection (incidentally this is more a temporary constraint than a service brought to the system). Quality of supply services could also be developed if the use of power electronics in generation as well as on the load side is degrading Power Quality.

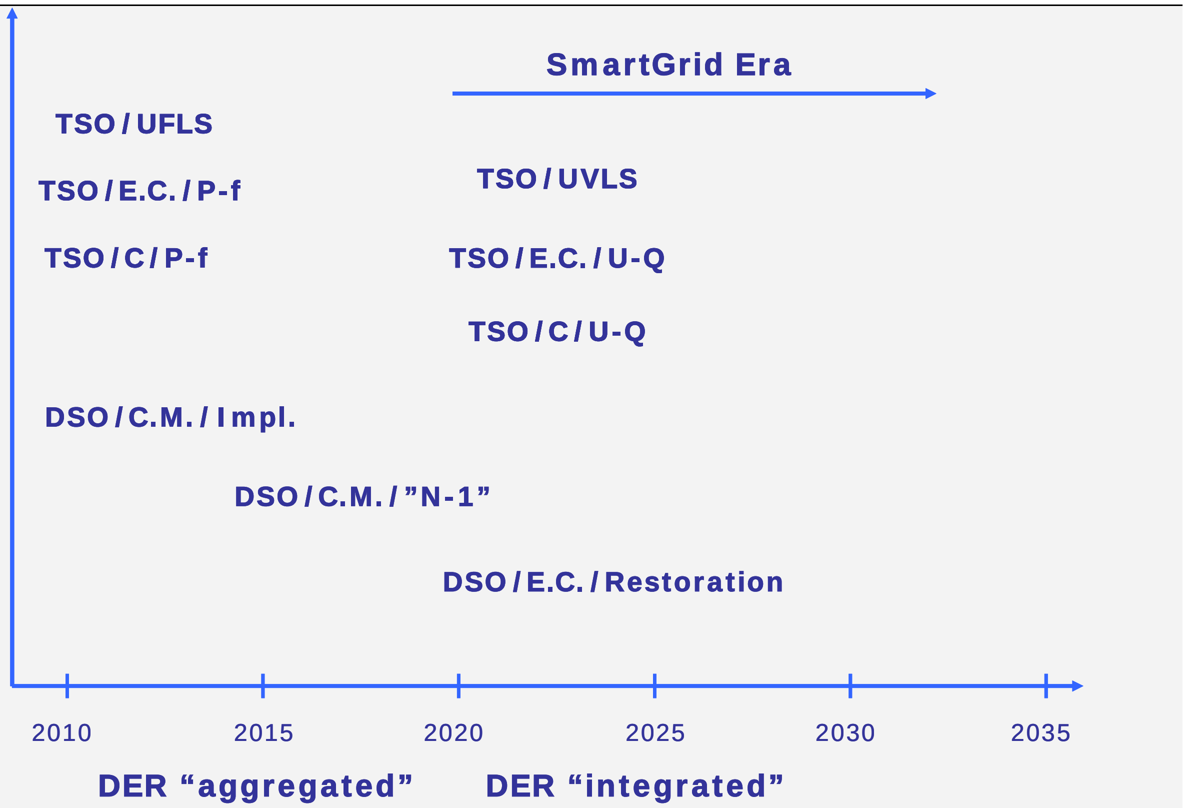
<table>
<tr><td>Illustrations
(1 or 2, with max. 30 words per legend)</td><td>

Figure – 1 Services will develop from “aggregated DER” to “integrated DER” as SmartGrid concept develops. Services are for TSO and DSO, concern control “C”, emergency control “E.C.”, congestion management “C.M” such implicit services like implanted via PowerMatcher, or during “N-1” conditions, DR during restoration phase</td></tr>
<tr><td>Integration
(no maximum)</td><td>– States of the Art
–</td></tr>
<tr><td>Stakeholders
(max. 8 stakeholders)</td><td>[Not to be filled for the moment]
– XXX</td></tr>
<tr><td>Contacts
(max. 3 contact names)</td><td>Jacques Deuse, Tractebel Engineering. jacques.deuse@tractebel.com
Christine Schwaegerl, Siemens, christine.schwaegerl@siemens.com
Vladimir Chuvychin, RTU, chuvychin@eef.rtu.lv</td></tr>
<tr><td>Pictures of the Contacts
(max. 3 pictures)</td><td>  </td></tr>
</table>

Knowledge Block no	A1
Title	**Typology of aggregators according to their offer**
Context (50 words)	
Challenge (1 question, 25 words)	What are the principles of aggregation and how can associated services be implemented?
Results (1 to 5 results, 500 words for the whole section)	see below

XXX

Aggregation is the process of organizing small groups, commercial or residential customers into a larger, more effective bargaining unit that strengthens their power to participate to trading. Aggregation can be based on demand (demand response, DR) and/or generation (distributed generation, DG) aggregation.

An aggregator is an entity that consolidates or aggregates a number of individual customers and/or small generators into a coherent group. Hence aggregators are aiming at optimizing both at economic and technical level energy supply and consumption.

2.

There are four main drivers for such businesses:
1) Aggregation is mainly decreasing market barriers: through aggregation also small customers and DG owners can access to electricity market. It gives additional economic benefits to customers and DG owners thus increasing the value of DG and its penetration.
2) It can also decrease technical barriers sharing the costs of ICT and smart metering which can increase the penetration of such technologies.
3) It also gives the possibility to optimize generation and consumption through the operation of a large number of units. This is particularly beneficial in terms of flexibility of overall portfolio.
4) The activity can also be combined with other energy related activities (ESCO, retailing) decreasing overall costs.

3. The description of their potential offer, leads to a typology of aggregators.

The aggregators can provide a series of services, which can be combined. A typology of various aggregators has been proposed. The roles according to their offer are:

Service offer	Profile of the aggregator
Energy (kWh sold / purchased)	- Purchaser from DR and DG owners, - Retailer to end users, - Wholesaler to and from power exchange and other market players
Ancillary and balancing services	- Ensures balancing of the units under his control and provides services to the system (TSOs and DSOs) and/or to other suppliers
Other energy related services	- Supplier of heat, fuel, operation and maintenance services to DER owners
Internal services that could be valorized	- Provider of forecasting, control, optimisation to be sold to other businesses

The aggregator can be a business per se or part of a larger company; under

<table>
<tr><td></td><td>current regulation Network Operators cannot be aggregators following the requirements of unbundling.

The aggregator must have well-defined contracts with all partners and especially with customers/DER-owners where liabilities of each partner are defined.</td></tr>
<tr><td>Illustrations
(1 or 2, with 30 words per legend)</td><td>

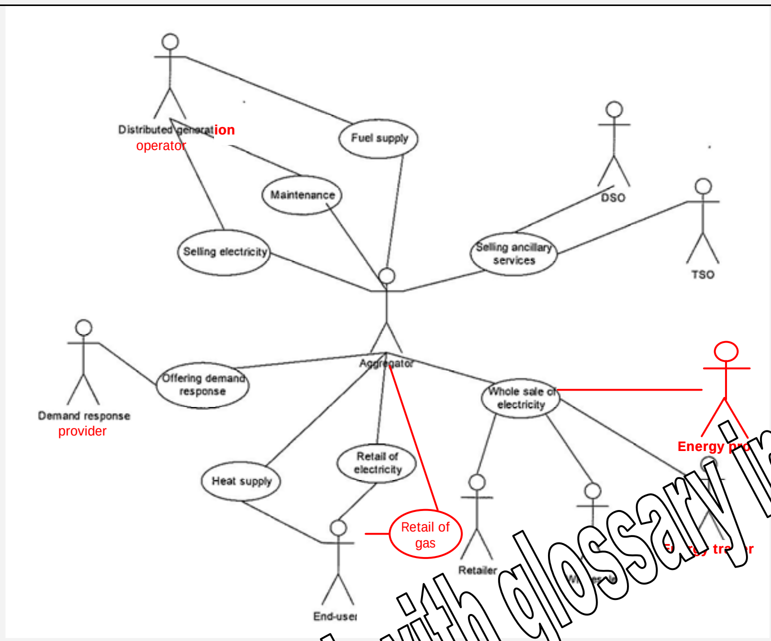


Figure 1: Typology of aggregators

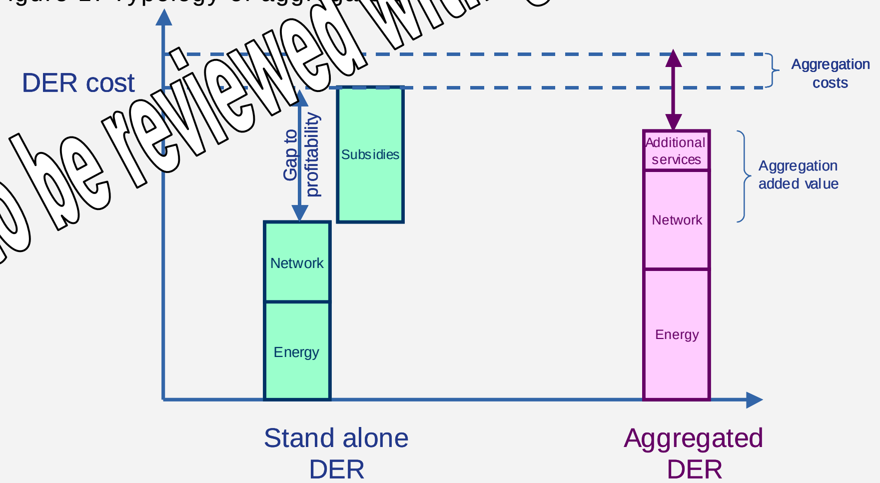


Figure 2: Aggregation decreases the gap to profitability and then the needs for subsidies
</td></tr>
<tr><td>Use of Knowledge
(no maximum)</td><td>– One-Year Test Campaign
– States of the Art
– Demand Analysis Tools
– Business Simulation Tools
– Demand Knowledge
– Cost Analysis
– Regulation Knowledge
– Standard Knowledge
– Network Knowledge
– Power System Knowledge
– Energy Market Knowledge
– Other (please precise)</td></tr>
<tr><td>References
(max 3 references, 100 words)</td><td>[Not to be filled for the moment?]
– "Local Trading Strategies. Seppo Kärkkäinen. First International Conference on the Integration of Renewable Energy Sources and Distributed Energy Resources, December 1 - 3. 2004, Brussels"</td></tr>
</table>

	– "Market Access of DER through Aggregation of Load and Generation. Seppo Kärkkäinen. 2nd International Conference on Integration of Renewable and Distributed Energy Resources, December 4 - 8, 2006, Napa, CA"
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	**Seppo Kärkkäinen, VTT, seppo.karkkainen@vtt.fi**
Pictures of the Contacts (1 to 3 pictures)	

Knowledge Block no	A2
Title	Four sources of values can already be captured by aggregation businesses
Context (50 words)	One of the objectives of EUDEEP was to identify promising DER business models. Practically, three examples of business model were studied. Regulatory conditions have a major impact on the value sources of aggregation businesses, so that they can even become barriers for such aggregation business models.
Challenge (1 question, 25 words)	Which are the key regulatory issues considered as barriers to aggregation?
Results (1 to 5 results, 500 words for the whole section)	The three business models aim at the same four sources of value. Separate qualitative analyses for each business case highlighted the fact that DER flexibility is used to maximise the same sources of value in all of them: • Reduction of imbalance costs (RIC): After the gate closure, energy cannot be traded in the market anymore. Without flexibility, inevitable errors in forecasting (consumption, wind production...) cannot be corrected. With flexibility, it is still possible to adapt the consumption or production level of DER units, to decrease imbalance charges. • Obtainment of best electricity prices in the market (OBPM): When the price of the spot market is high, it may be interesting to buy flexibility to DER units either to sell electricity bought for a consumer on the spot market, to avoid buying electricity on the spot market, or to increase the electricity sold by distributed generators. • Provision of frequency control services (PFCS) to the System Operator (SO): The flexibility of DER units can be offered to the SO to provide bids and offers in real-time balancing or in the market for reserves. While theoretically any size of consumer or generator could enter bids or offers into real-time balancing, larger contracts (tens of MWs) are far more likely to be accepted by the SO in many countries, because, in that way, the system operator has to communicate with fewer balancing providers, which results in an easier operation. Hence, aggregation allows smaller consumers to access this market. • Reduction of capacity-related grid fee (RCGF): Usually, T&D charges have a capacity-related component, who charges consumers for their maximum consumption in a given period (day, month, year…). If DER flexibility can be used to reduce consumer's maximum consumption (either increasing generation or reducing consumption), the payment linked to the maximum consumption will thus be reduced too. Figure 1 illustrates the timeframe of the decision-making process for these four sources of revenues in the case of the UK (for the first business model). **Different regulatory regimes create different barriers for aggregation** A detailed cross-country analysis provided by country experts showed that different regulations impose different barriers to the aggregation businesses: • No obligation for hourly metering & billing down to smallest consumers/generators: In order to provide flexibility, DER unit owners must see different prices in different periods of the day (ideally, as many prices as the market has), and they must be sure that they will be remunerated for all the flexibility that they provide (real metering, not profiles). • Prohibition of adjusting after gate closure: DER flexibility can only be used if some portfolio effect is allowed, i.e. if some units can compensate the output of others. Ideally, DER units should be able to compensate both generation and consumption errors. • DER units not fully integrated in the market: DER units must be incentivised not to sell their output without taking care of imbalances, so that they are able to modulate their output and provide flexibility to the system when needed. • Restricted access to provision of frequency control services: If properly aggregated, DER units, including Demand Response, can provide cheaper flexibility than some central generators to the SO; however, regulation does not always allow it. The Table 1 details the main barriers for three of the four sources of value

studied in the business models.

Illustrations
(1 or 2, with 30 words per legend)

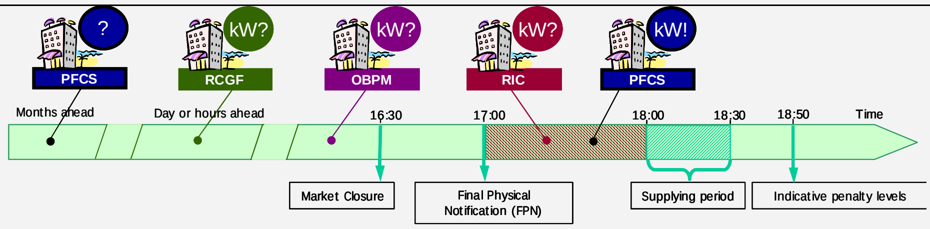


Figure 1: The aggregator's decision to use flexibility (for a dedicated revenue) is mainly linked to the opportunities provided by the markets and the balancing mechanism (here illustrated for the UK case)

	UK	Germany	Greece	Spain	France
BARRIERS FOR RIC					
Adjustment after gate closure?	Yes	Yes	No	Yes	Yes
CHP integrated in the market?	Yes	Partially	No	Yes	No
RES integrated in the market?	Yes	No	No	Yes	No
Aggregation of demand + generation?	Yes	Yes	No	No	Yes
BARRIERS FOR OBPM					
Number of sessions (FW, day-ahead...)	High	High	One	High	High
Is aggregation needed for spot market access?(*)	Yes	Yes	No	Yes	Yes
BARRIERS FOR PFCS					
Can be offered by demand?	Yes	Yes	No	No	Yes
Can be offered through an aggregator?	Partially	Yes	No	Yes	Yes
Can be offered by CHP?	Yes	Yes	No	Yes	No
Is aggregation needed for FCS market access?	Yes	Yes	No	Yes	Yes
Payment for capacity?	Yes	Yes	No	Yes	No
Payment for operation?	Yes	Yes	Yes	Yes	Yes

Table 1: List of the main barriers for 3 sources of revenue

Use of Knowledge
(no maximum)

–

References
(max 3 references, 100 words)

No references

Stakeholders
(max. 8 stakeholders)

[Not to be filled for the moment]

–

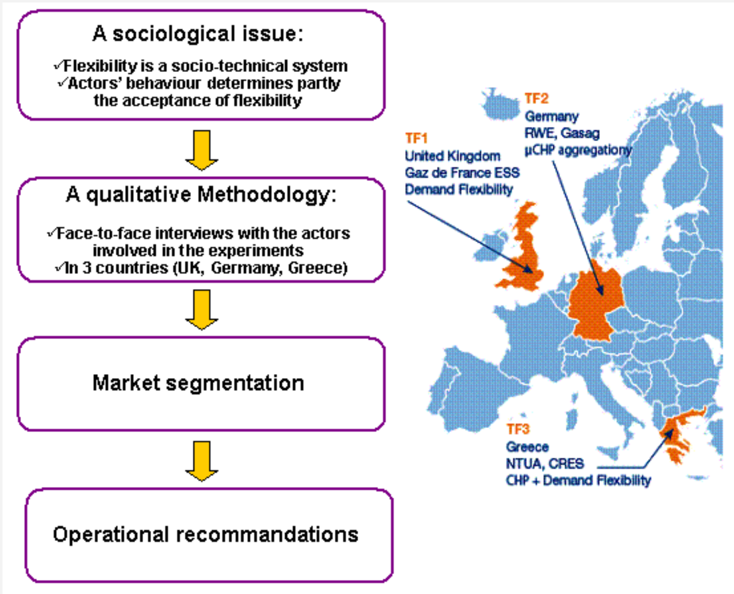
Contacts
(1 to 3 contact names)

– Carlos Madina, Labein-Tecnalia, cmadina@labein.es
– Gilles Bourgain, GDF SUEZ, gilles.bourgain@gdfsuez.com
– Athanase Vafeas, Technofi, avafeas@symple.eu

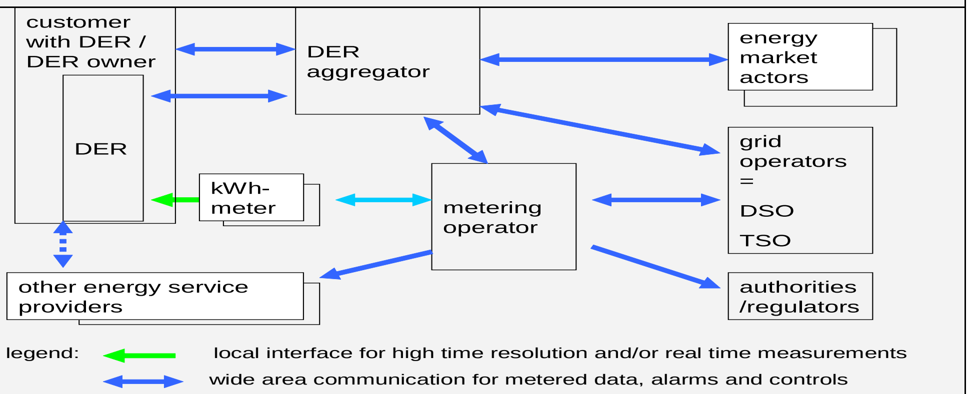
Pictures of the Contacts
(1 to 3 pictures)



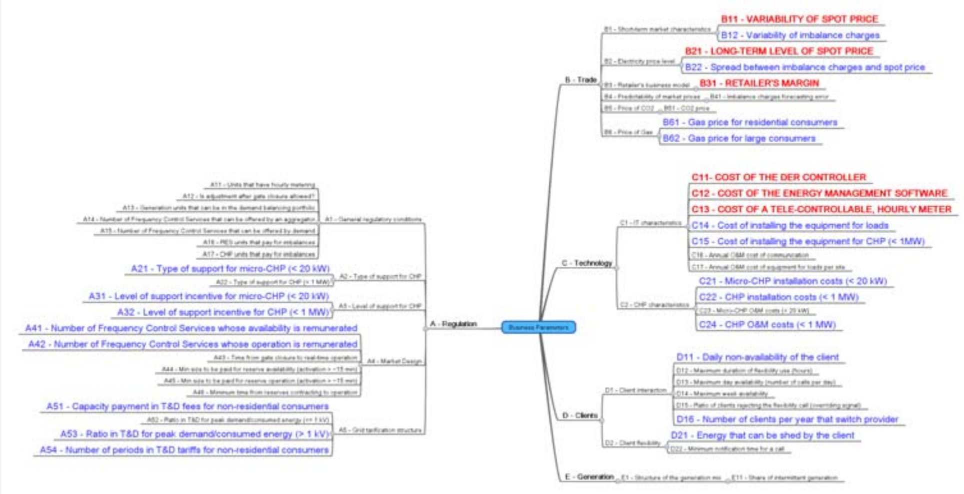
Knowledge Block no	A3
Title	Energy end user habits will change to benefit from innovative DER offers
Context (50 words)	High level of customer's acceptance is required to achieve commercial success of DER-based offers: setting up necessary flexibility in local sites puts constraints on the level of control of its own energy consumption. Energetic flexibility has to be compatible with the way people perceive and use energy and how they manage their technical equipment. A sociological study focusing on the social acceptance of flexibility was carried out in three test fields in the UK, Greece and Germany.
Challenge (1 question, 25 words)	What are the sociological conditions under which a commercial offer based on DER and flexibility can be accepted by end-users?
Results (1 to 5 results, 500 words for the whole section)	**Face to face interviews were carried out with different stakeholders involved in the field tests.** Semi-directive qualitative interviews were performed with the actors directly or indirectly involved in the project including utilities (project managers, technical experts), intermediaries (local authorities, associations), and partners (installers, equipment vendors, energy agencies) , consumers and providers of distributed energy. On the whole, 60 interviews were conducted. **Analysis of the customers expectations regarding innovative aggregation offers has unveiled a typology of profiles.** Customers (industrials, tertiary and residential customers) vary in their energy practices, environmental consciousness or comfort evaluation. - The **"Common good promoters"** who accept to be flexible in order to contribute to the reinforcement of the security of supply of their country; - The **"Friends of the Earth"** for whom the flexibility principle supports the environment protection; - The **"Energy savers"** for whom flexibility is mainly a means for reducing their energy bill; - The **"Profit makers"** who want to make money through the sell of their flexibility capacity; - The **"Early movers"** attracted by new technologies and energetic solutions. **On site technical preliminary studies stressing needs, uses and risks of customers are required before implementing DER and flexibility offers.** The preliminary studies will have to determine at the customers' sites: - The most profitable sources of flexibility from both the customer's and the aggregator's point of views; - The perceived risks and the expected benefits of the customers; - The conditions of acceptability of the remote management of flexibility and the potential requirement for an override system; - The flexibility availability according to the customers' own constraints; - The state of the installations and of the network infrastructures: industrial equipments, age of the buildings, thermal conditions, indoor electrical installations, voltage constraints, etc. **DER and flexibility offers implies a modification of the customers' status: customers become active energy co-producers and co-providers.** Providing flexibility implies necessarily a partnership between the aggregator and his customers. Customers consider themselves as energy co-producers and even as energetic services co-providers. As a consequence, they expect an "equitable share" of the flexibility costs and benefits between them and the aggregator. **Commercial contracts will have to specify each customer's needs and**

	requirements. For the companies as for the households, the flexibility exploitation raises the issue of the "private property" of the equipment use and it is clearly not acceptable for the customers that flexibility results in a kind of "dispossession" of their energetic tools. Customers have thus specific expectations referring to the contractual clarification of the flexibility exploitation and of the existence of protection clauses. The most important elements apply to: - Flexibility sources and availability; - Property of the equipment; - Responsibilities in case of incidents and in terms of maintenance, repairing; - Remuneration of the flexibility and share of the benefits; - Penalties; - Level of feedbacks requested by the customers (reporting tools, ...) - The possibility for the customer to keep a right for overriding.
Illustrations (1 or 2, with 30 words per legend)	 Figure 1: Description of the sociological method
Use of Knowledge (no maximum)	–
References (max 3 references, 100 words)	– Maud Minoustchin, Marc Berger, "Testing µ-CHP aggregation and social acceptance of flexibility in Germany", poster presented at IGRC Paris, 8-10th October, 2008. – Maud Minoustchin, C. Beslay, J-F. Barthe, R. Gournet, "Testing social acceptance of flexibility in the UK", poster presented at the 3rd International Conference on Integration of Renewable and Distributed Energy Resources, December 10-12th, 2008.
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	– Maud Minoustchin, GDF SUEZ, maud.Minoustchin@gdfsuez.com – Christophe Beslay, Bureau d'Etudes Sociologiques, beslay@univ-tlse2.fr
Pictures of the Contacts (1 to 3 pictures)	 PHOTO

Knowledge Block no	A4
Title	Expansion of DER aggregation needs minimum common requirements in ICT infrastructure
Context (50 words)	Smart metering refers to metering infrastructure rather than the properties of a meter. It includes automated metering and management of meters and data, provision of data and some communication for billing, energy retail, energy efficiency, demand response, distribution grid operation and management, energy services for the customer and aggregation of DER.
Challenge (1 question, 25 words)	To what extent enabling technologies such as smart metering and data communication will reduce costs and other barriers to profitable aggregation and penetration of small flexible Distributed Energy Resources (DER)?
Results (1 to 5 results, 500 words for the whole section)	**Mass rollouts of smart metering are on the way in several European countries, but common European requirements on functionalities, data availability and interfaces are still missing now**. The situation of smart metering in Europe was reviewed in ESMA JRC joint smart metering workshop 16-17 February 2009. Decisions made so far imply that by 2020 electricity smart metering has nearly full penetration in Sweden (2009), Italy(2011), Finland (2014), the Netherlands, Norway, Spain (2018), Portugal, France (2018), Ireland and the UK (2020). In the Netherlands and in the UK gas metering is included. In addition large implementations exist or are started in Denmark, Germany, etc. It is still unclear to what extent this development will be favourable to high penetration of aggregated small DER, because the needed common minimum requirements on smart metering functionality, related performance levels, open interfaces and data availability are still missing. **Smart metering system (or advanced metering infrastructure) is a promising way to meet many needs of metering, control and wide area data communication for aggregation of small DER.** Smart metering provides energy market actors, including DER aggregators, with measurement data on energy billing and possibly also to some extent on flows of active and reactive powers, voltage quality, etc. depending on how smart metering is implemented (see Figure 1). The functionality and performance of existing meter reading systems vary much and modern systems can typically collect measurement data from some minute to 1 h resolution. Availability and performance of instantaneous reading, spontaneous communication and sending control signals vary. Getting higher time resolution and more real time measurement data is usually possible at reasonable costs only locally and requires that the meters include a local data output for that purpose. The present wide area communication technologies applied for smart metering and small DER, such as GPRS, Power Line Carrier, narrow band radio and their combinations, have limitations regarding priorities, multicasting and availability that may cause some risks for large scale time critical control applications related to emergency control.. GPRS bandwidth is seldom a problem and average availability and transfer times are acceptable, but the near worst case performance can be inadequate. However the implementation of defence actions when developed following state of the art concept is normally decomposed into two layers. The co-ordinating layer needs communication for setting up the scheme and for controlling scheme response, which can be done asynchronously whereas the activation layer works based on local information only like locally sensed voltage or frequency. This allows for operating with limited data throughput. **EU legislation, its national implementations and regulation may have a key role in creating common minimum requirements**. Enabling the adequate development of such smart metering infrastructures and businesses at an acceptable costs serve also the needs of demand response, energy efficiency and DER aggregation. Lack of adequate common minimum requirements for smart metering functionality (e.g. what is measured), performance and data availability increases the costs and risks of aggregating small flexible DER.

	Deep analysis of communication and smart metering technologies was outside the scope of EU-DEEP. Research and development of requirements and related technical issues are still needed in order to develop smart metering systems and public communication infrastructures that more completely meet the requirements of high penetration of small distributed energy resources. This is an essential step towards SmartGrid infrastructure**.**
Illustrations (1 or 2, with 30 words per legend)	 Figure 1: DER related communication flows of smart metering
Use of Knowledge (no maximum)	–
References	– "P. Koponen, Smart metering and distributed energy resources, poster at the 3rd international conference on Integration of Renewable and Distributed Energy Resources, Nice, 10-12.12.2008" - "P. Koponen, Integration of metering with DER management?, Metering – Europe 2004, 29.09.2004" – Europe ESMA-JRC joint smart metering workshop 16-17 Feb 2009, available for free at http://sunbird.jrc.it/energyefficiency >events
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 names)	Pekka Koponen, VTT, pekka.koponen@vtt.fi
Pictures of the Contacts (1 to 3 pictures)	

Knowledge Block no	A5
Title	A 50-parameter analysis allows to assess DER aggregation business models in a given local context
Context (50 words)	The profitability of a business model on DER aggregation depends on some key parameters related to technology infrastructure and costs, customer behaviour, market and regulation. Identifying and quantifying them is critical to assess the robustness of a business model to different local contexts.
Challenge (1 question, 25 words)	How to compare qualitatively the opportunities brought by different national contexts for one given business model?
Results (1 to 5 results, 500 words for the whole section)	**EU-DEEP structured the key parameters that impact the profitability of aggregation businesses** In addition to the barriers identified in Card A2, EU-DEEP identified 50 parameters organized into 15 clusters that influence significantly the profitability of aggregation BM (as presented in Figure 1). In summary, those clusters can be further divided into five main groups: • <u>Regulation</u> the parameters of paramount importance that set up the framework where the three business cases will be implemented. They define the rules for trading electricity, and hence, for using aggregation of flexibility to increase the benefits potentially brought by DER. Regulation parameters are the only group that can completely remove one or several sources of value; • <u>Trade</u> parameters include the economic and market environment, which have a dramatic effect on the profitability of the business cases. • <u>Technology</u> parameters include the costs of the DER units, as well as the costs of the IT technologies to be used for monitoring and operating those DER in a flexible way. The costs of those IT technologies and the DER equipment have a big impact on the profitability of such aggregation businesses. • <u>Clients</u> parameters refer to the relationship between the aggregator and the clients, sometimes DER owners and some other DER users. This relationship is very important for the profitability of the business. • <u>Generation</u> parameters might also be important for certain business cases. For example, a high share of intermittent generation in total electricity generation is likely to result in high volatility prices in the spot price, or high requirements for balancing, which might increase the profitability of the business case under study. The developed framework provides a generic tool able to describe any DER-business context. It has been successfully tested for three different business models assessed with a wide range of situations (today for several European countries and in prospective scenarios). **A database is built with the status of the parameters characterizing aggregation business opportunities for six Member States.** By obtaining the present status of each parameter in a given country, a profitability analysis for that country can be carried out. With the help of country experts, the status of six Member States was compiled and included in a database. **A methodology ranking the current values of each critical parameter allows comparing different national contexts.** Starting from the description of present status, a qualitative comparison can be made between the six countries in terms of aggregation business opportunities. The maximum value in the qualitative scale is linked to the most favourable condition for aggregation business, either today or in the future. The methodology and the qualitative scale were validated by several project partners, including investors, utilities, academics, consultants, researchers…
Illustrations (1 or 2, with 30 words per legend)	



Legend	
BLACK	Key parameter with an impact on business profitability for at least one of the three business cases studied
BLUE	Critical parameters having a very significant impact for at least one of the three business cases studied
RED	Critical parameters for the three business cases studied

Figure (R5)-1: Spider diagram, showing the full list of parameters, clusters and groups

Use of Knowledge (no maximum)	–
References (max 3 references, 100 words)	– "Opportunities for balancing provision through the use of flexibility", Carlos Madina, Poster at the 3rd International Conference on DER integration, Nice, December 2008
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* –
Contacts (1 to 3 contact names)	– Carlos Madina, Labein-Tecnalia, cmadina@labein.es – Athanase Vafeas, Technofi, avafeas@symple.eu – Guillaume Brecq, GDF SUEZ, guillaume.brecq@gdfsuez.com – Roman Simcik, GDF SUEZ, roman.simcik@gdfsuez.com
Pictures of the Contacts (1 to 3 pictures)	   

Knowledge Block no	A6
Title	Four scenarios by 2020 picture different potential futures for DER aggregation businesses
Context (50 words)	The profitability of a business model on DER aggregation depends on some key parameters whose values evolve along the time. Trying to project their values in the future allows assessing the robustness of a business model with respect to different possible scenarios of evolution.
Challenge (1 question, 25 words)	How to confront the profitability of a present business model to various plausible evolution scenarios?
Results (1 to 5 results, 500 words for the whole section)	**Four scenarios are proposed to describe possible futures at 2020 of the European energy scene, involving three drivers: CO2 reduction, market trade, security of supply.** This is implemented by extending the methodology presented in A5. It aims at building different scenarios at 2020 horizon for one specific business model by fixing plausible values to each parameter according to a common 5 grade scale defined beforehand. Four distinct scenarios were designed to cover possible futures characterized using three tendencies: market opening, security of supply and environmental sustainability. The Figure (R6)-1 provides a chart of their relative position on these 3 axis. • Market trade: The scenario background is an increasing relevance of Competition Policy in the European agenda. The approach followed would be then based on Economic principles (competition and efficiency) rather than political, national or local interest. The first outcome would be a strictly centralized policy with a strong European Regulator closely working with DG Energy and DG Competition. This would imply a removal of regulatory differences across countries, allowing having similar Business Environments across Europe. • Smart Climate Change (CO2 reduction): this scenario indicates a situation where Environmental targets are a priority, the adjective smart is added in order to specify that they will be pursued implementing the most efficient initiatives. As a matter of fact there are clear similarities in terms of principles with the Market option. To summarize: “A policy-backed and innovation-driven approach to go beyond the 2020 climate change mitigation objectives, combining market forces (removal of regulation barriers, strong customer interaction) with technological and ecological measures (RES, energy efficiency)“. As in the previous case there is a strong centralization in terms of policies with especially RES support schemes coordinated at EU level • Security of Supply: this scenario is influenced by a strong institutional intervention in regulation and market design. It is possibly a less plausible outcome with respect to the previous ones. It is a fairly conservative approach to Energy Policy. • No direction: this scenario reflects a lack of coordinated European policy and leads to an intermediate situation where neither driver prevails. Scenarios were developed following two complementary approaches: - Bottom-up: giving values to elementary parameters, then aggregated into consistent scenarios - Top-down: using available information to build plausible scenario, then characterizing them with parameter values provided by experts. - **Each scenario has its own set of 50 parameter values for six Member States.** Beyond a qualitative description of the four scenarios by 2020, the synthetic result is a single table of values per scenario for three local business models, directly usable for a business developer. In the table shown in Figure R5-2, one can read how the main parameters have been tuned for each scenario.

Illustrations (1 or 2, with 30 words per legend)	See figures below

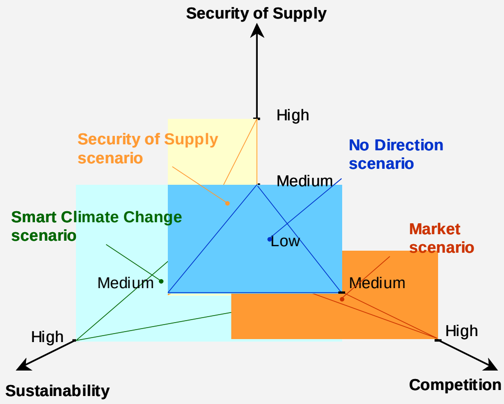


Figure (R6)-1: Relative positioning of the four scenarios by 2020

Security of Supply	*Smart Climate Change*	*Market*	*No direction*
D1 - Client interaction	A1 - Regulatory conditions	A1 - Regulatory conditions	B1 - Short-term market characteristics
D2 - Client flexibility	A2 - Type of support for CHP	A2 - Type of support for CHP	B2 - Electricity price level
B2 - Electricity price level	A3 - Level of support for CHP	A4 - Market design	B5 - Price of CO2
B4 - Predictability of market prices	B1 - Short-term market characteristics	A5 - Grid tariff structure	A1 - Regulatory conditions
C1 - IT characteristics	B2 - Electricity price level	B1 - Short-term market characteristics	A2 - Type of support for CHP
C2 - CHP characteristics	B3 - Retailer's business model	B4 - Predictability of market prices	A3 - Level of support for CHP
E1 - Structure of the generation mix	B5 - Price of CO2	B2 - Electricity price level	A4 - Market design
A1 - Regulatory conditions	B6 - Price of gas	B6 - Price of gas	A5 - Grid tariff structure
A3 - Level of support for CHP	C2 - CHP characteristics	D1 - Client interaction	B3 - Retailer's business model
A5 - Grid tariff structure	D1 - Client interaction	D2 - Client flexibility	B4 - Predictability of market prices
B1 - Short-term market characteristics	D2 - Client flexibility	B5 - Price of CO2	B6 - Price of gas
B3 - Retailer's business model	E1 - Structure of the generation mix	C1 - IT characteristics	C1 - IT characteristics
B6 - Price of gas	B4 - Predictability of market prices	C2 - CHP characteristics	C2 - CHP characteristics
A2 - Type of support for CHP	C1 - IT characteristics	B3 - Retailer's business model	E1 - Structure of the generation mix
A4 - Market design	A4 - Market design	E1 - Structure of the generation mix	D1 - Client interaction
B5 - Price of CO2	A5 - Grid tariff structure	A3 - Level of support for CHP	D2 - Client flexibility

Figure (R5)-2: Effect of the different scenarios in the clusters

Legend

- *Upward (red): Much better situation, in terms of aggregation business opportunities*
- *Up-rightward (yellow): Better situation*
- *Rightward (green): Unchanged situation*
- *Down-rightward (blue): Worse situation*
- *Downward (grey): Much worse situation*

Use of Knowledge (no maximum)	–
References (max 3 references, 100 words)	– "Opportunities for balancing provision through the use of flexibility", C. Madina, Poster at the 3rd International Conference on DER integration, Nice, December 2008
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* –
Contacts (1 to 3 contact names)	– Carlos Madina, Labein-Tecnalia, cmadina@labein.es – Athanase Vafeas, Technofi, avafeas@symple.eu – Guillaume Brecq, GDF SUEZ, guillaume.brecq@gdfsuez.com – Daniele Benintendi, FEEM, daniele.benintendi@feem.it

Pictures of the Contacts (1 to 3 pictures)	   

Knowledge Block no	A7
Title	A validated toolbox allows the economic evaluation and optimisation of DER-portfolio operation
Context (50 words)	In order to create maximum value through DER management (demand flexibility and decentralized energy production means) critical size of decentralized resources portfolio is required today. The practical implementation of such businesses relies on dedicated tools: a set of tools was designed or upgraded in EU-DEEP to that end. Market related and technical characteristics of the portfolio serve as an input to the optimization process that assesses the suitable trading strategies.
Challenge (1 question, 25 words)	How to operate locally an aggregated portfolio of loads, storage and generation units in order to capture the maximum values of DER?
Results (1 to 5 results, 500 words for the whole section)	Optimizing DER operation relies on aggregation of scattered flexible loads by an Aggregator. It brings expertise in terms of construction of profitable portfolios and best practices to take advantage of all identified income streams. Beyond their function of single DER unit optimization, the tools described in the knowledge card E3 also aid to decision making process: - long-term support for DER investment decisions, - real-time operation optimization and scheduling. **Optimisation and monitoring software DEMS developed and commercialised by SIEMENS PSE was upgraded and operated successfully in real-conditions** DEMS software allows command and control for optimized day-to-day operation of decentralized supply systems. It also provides help in investment decisions and profitable portfolio building process. The commercial software DEMS (Siemens PSE) range of functionality were widened and validated in real-life conditions. **OFFPEAK implemented by GDF SUEZ modelled the aggregator's activities to assess the profits brought by Demand Response.** Offpeak has been developed in GDF SUEZ for modelling the sources of revenues of an aggregator considering the client flexibility in a portfolio. It is a quick and efficient model that provides an evaluation of the expected revenues obtained from the customer flexibility over one year. **FLEXPROF implemented by VTT was developed and validated for profitability assessment of a demand response portfolio using a stochastic approach.** Using stochastic optimisation taking forecast error into account, Matlab-based Flexprof tool allows: - Assessment of profitability of all identified income sources in current conditions and different market evolution scenarios for an average portfolio - Study of the critical composition of the portfolio depending on market signals. - Impact of fixed and variable cost in the context of forward market studies. Simulations were validated by series of tests carried out for a portfolio of 10 customers in the UK excluding market operation. **Multi Agent Software, designed by NTUA, was successfully tested as an aggregation tool** The Multi-Agent System is a new control concept based on distributed artificial intelligence. An entity called *agent* can act autonomously and has the ability to communicate with other agents. The communication ability allows the agents to decide upon actions without the presence of a centralised controller. The system includes Distributed Generators and Loads via a load controller. The development is based on Java and Jade platform that allows the execution in different operating systems.

CleanPower software, developed by Tractebel Engineering, modelled the activities of a company aggregating cogeneration and demand response, estimating its potential profits.
CleanPower was used to choose optimal DER units for the chosen client portfolio, and then optimised the aggregation activities in order to gain insight into the potential of the studied business. Thanks to the flexibility of the tool, CleanPower was able to deal with all sources of revenue simultaneously, allowing tackling the interdependencies between the different revenue streams.

Illustrations
(1 or 2, with 30 words per legend)

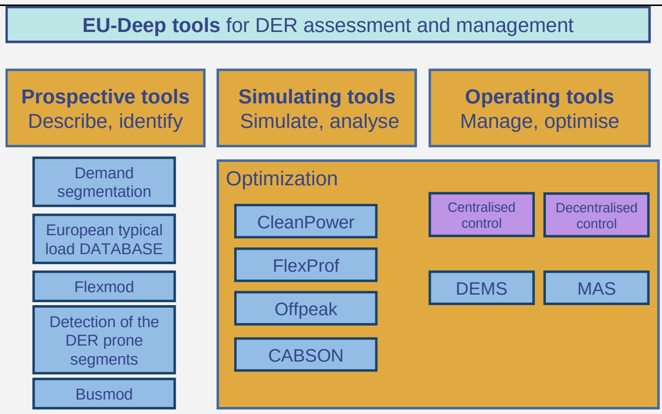


Table 1: Overview of the tools used per function

Tool	**Offpeak**	**Flexprof**	**DEMS**	**CleanPower**
Degree of industrialization	Internal tool	Intenal tool	Commercial tool	Internal tool
Model type	deterministic	stochastic	deterministic	deterministic
Field of analysis	Sensitivity analysis of business cases	Support investment decisions and customer selection	support investment decisions; live usage in online mode	support investment decisions, optimization of operation decisions and energy supply costs
Planning horizon	½ hours	normally 24 – 48 hours	Typically max 7 days ahead	User defined nr of periods (1, 6, 24 etc.)
Support for energy storages	no	yes	yes	yes
Computation time for one year simulation	10 s (5 customer types, ½ hour resolution)	15 min (5 customer types, ½ hour resolution)	45 min (with 5 contracts and 10 generator units)	1 h 20 min (50 end-uses, 10 generation units and 5 exchange contracts)

Table 2: Synthesis of the key features of the 5 optimisation tools developed in EU-DEEP

Use of Knowledge
(no maximum)

[The presented results have been produced from the following sources of knowledge. Please comply has much as possible with the proposed knowledge.]
–

References
(max 3

– No references

references, 100 words)	
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	– Erich Fuchs, SIEMENS PSE, erich.fuchs@siemens.com – Roch Drozdowski, GDF SUEZ, Roch.Drozdowski,gdfsuez.com – Konrad Purchala, Tractebel Engineering, konrad.purchala@tractebel.com – Jussi Ikaheimo, VTT, jussi.ikaheimo@vtt.fi – Aris Dimeas, NTUA, aris.dimeas@gmail.com – Antonis Tsikalakis, NTUA, atsikal@power.ece.ntua.gr
Pictures of the Contacts (1 to 3 pictures)	     

Knowledge Block no	Test 1
Title	Testing the integration of a composite CHP system for market interaction, office building segment, Grenoble France
Context (50 words)	The first test led within the EU-DEEP project, and focusing on a single DER system integration, had several objectives: • assess the potential of the "offices building" market segment in Northern Europe, identified as a most promising segment for DER • design a fully integrated system comprising all the different DER components • test and assess the corresponding cost of the automatic reconnection to the network after a grid failure
Challenges	How to operate a composite DER system as a single entity for easier interaction with the market?
Description	The system implemented in the office building integrates the following components: - a 12 kW-CHP engine from TEDOM (CZ) - a DER Controller developed by SIEMENS PSE (AT) - a "Local Trading Strategy Manager" developed by SIEMENS PSE (AT) to interact with external sources of information as electricity prices and weather forecast - a communication router from ANCO (Gr) - a UPS system provided by GDF SUEZ (FR) This test was led by GDF Suez from October 2006 to February 2008, within an office building of "Gaz et Electricité de Grenoble" (GEG, Grenoble's Local DSO) in France.
Key figures	CHP engine 12 kWe / 36kWth October 2006 – February 2008 90% of availability
Outputs	- The control technology for a single unit was validated - The "value of being connected" thanks to the CHP and the UPS was made explicit.

Results (1 to 5 results, 500 words for the whole section)	**- A fully integrated system was designed with the different DER components (generator using a gas engine, UPS, control systems) that make DER interactions with the power markets easier**. The integration allowed to consider the system as a single box of control, interacting with external sources of information: - Powernext (electricity prices) - Weather forecast **- A configuration of automatic reconnection was developed and tested with success:** the engine decoupling protection was controlled by the DER controller. In the event of a grid failure, the decoupling protection operated to bring the DER system in islanding mode. The DER controller switched off the interruptible loads and fed the critical loads. If the engine was off, the loads were fed by the UPS before the engine fully started up. The decoupling protection continuously checked the presence of grid voltage and frequency. When there was no more default on the grid, the DER controller resynchronized the engine with the grid. This automatic reconnection to the grid was only possible if the different DER system components (i.e. engine, decoupling protection, UPS, ...) were integrated with an appropriate communication strategy. **Thus the DER controller played the role of «integrator» and communicated with all components through the standard MODBUS protocol**. The DER controller took control of the engine control-command, switched the different loads and managed the decoupling protection. The DER controller was also the interface between the DER system and the power markets. The successful integration of the different components was **a necessary step for the control system** (Siemens DEMS®) to be tuned three other more complex experiments (see next cards).
Illustrations (1 or 2, with 30 words per legend)	GEG site TEDOM CHP engine

<table>
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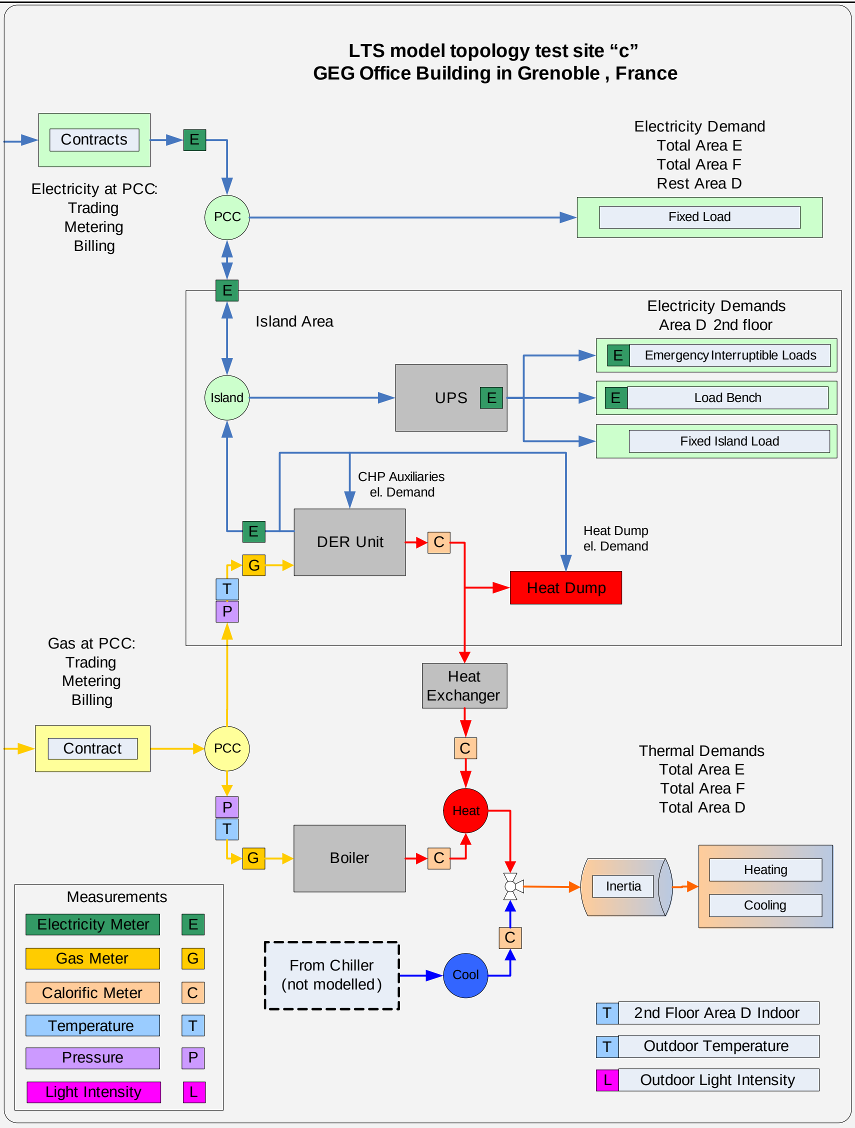


Siemens DEMS scheme of the experiment
</td></tr>
<tr><td>Use of Knowledge
(no maximum)</td><td>– One-Year Test Campaign
– Demand Knowledge
– Energy Market Knowledge</td></tr>
<tr><td>Stakeholders
(max. 8 stakeholders)</td><td>[Not to be filled for the moment]
– XXX</td></tr>
<tr><td>Contacts
(1 to 3 contact names)</td><td>– Marc BERGER, GDF SUEZ, marc-DR.berger@gdfsuez.com</td></tr>
<tr><td>Pictures of the Contacts
(1 to 3 pictures)</td><td>

Marc BERGER
</td></tr>
</table>

Knowledge Block no	Test 2
Title	Testing the integrating of a composite trigeneraion system for market interaction, Education building segment, Athens Greece
Context (50 words)	The second test of the project targeted the same objectives as the first one (see Test 1), however with an increased complexity in implementation, as addressing tri-generation and storage issues. This time, the market segment "educational buildings" was tested in southern Europe, as one of the most promising segments for DER expansion in Europe.
Challenges	How to operate a composite DER system as a single entity for easier interaction with the market?
Description	The installation, consisted of: - a gas microturbine of 80 kWe and 135 kWth - an absorption chiller which used exhaust gases thermal load, producing chilled water for air-conditioning during the summer season - Two Lithium-Ion Batteries (43 kWh each) and inverters - Controllers and control software (updated version from the first test site) with communication features Attiki Gas Supply Company was responsible for the set-up and operation from February to December 2008 of the experimental installation sited in the National Technical University of Athens
Key figures	Microturbine 80 kWe / 135 kWth February 2008 – December 2008
Outputs	- The control technology for a single unit was validated - The "value of being connected" thanks to the microturbine coupled with batteries was made explicit

Results
(1 to 5 results, 500 words for the whole section)

In Athens, the concepts developed at Grenoble's site were successfully applied to a more complex system: **a trigeneration producing heat / cold and electricity coupled with batteries was controlled as a single easy- to-operate unit**.

The following procedure was validated in case of black-out:
- The installed static switch automatically separated critical and non critical loads.
- The battery unit supplied power to critical loads.
- If the black-out outlasted the battery capacity, the CHP unit started operating in islanding mode supplying power to the critical loads.

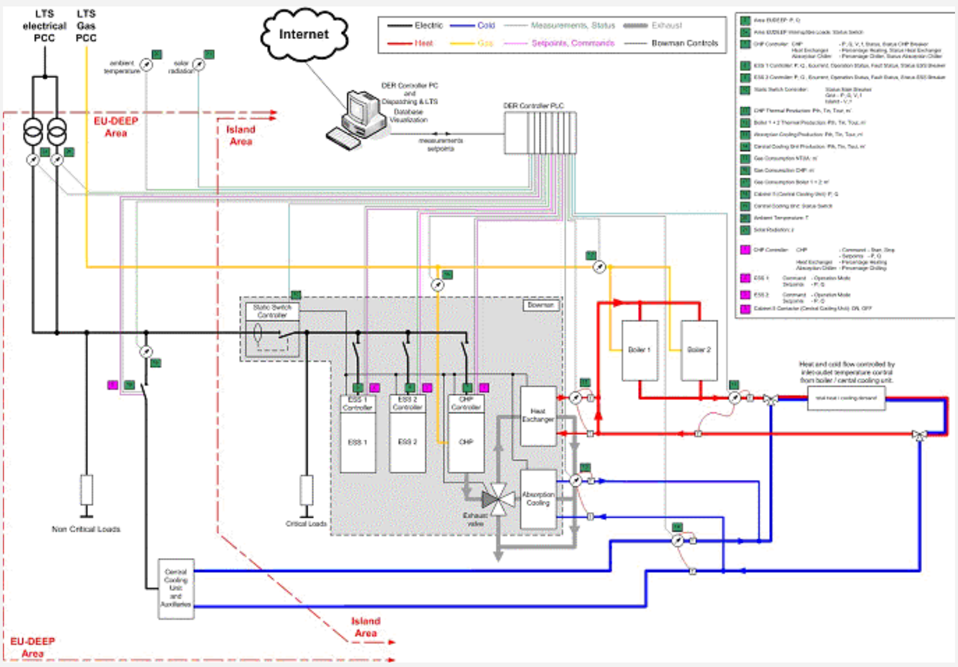
The control software was adapted to the specific installation and decided the operation of the unit according to the following:

Costs/ Prices	Forecasts	Technical characteristics
- Value of produced electricity - Value of produced thermal/ cooling energy - Cost of natural gas - Maintenance/ operation cost	- Energy demand based on meteorological forecasts - Electricity consumption based on historical data (working day, week-end, week-end, winter-summer seasons)	- Thermal characteristics of buildings - Outside temperature and solar radiation - Existing boilers and electrical chiller characteristics - Electrical energy storage in Lithium-Ion battery system - Technical characteristics of the CHP unit and the absorption chiller (efficiency and performance)

The Athens test site was included later on in the fifth experiment addressing aggregation, as part of the portfolio of end users tested, both as a generation source (microturbine) and a load (electric chiller). It contributed to the Multi-Agent Software experiments and flexibility tests (see Test 5).

Illustrations
(1 or 2, with 30 words per legend)

View of the site : microturbine on the left, chiller on the right

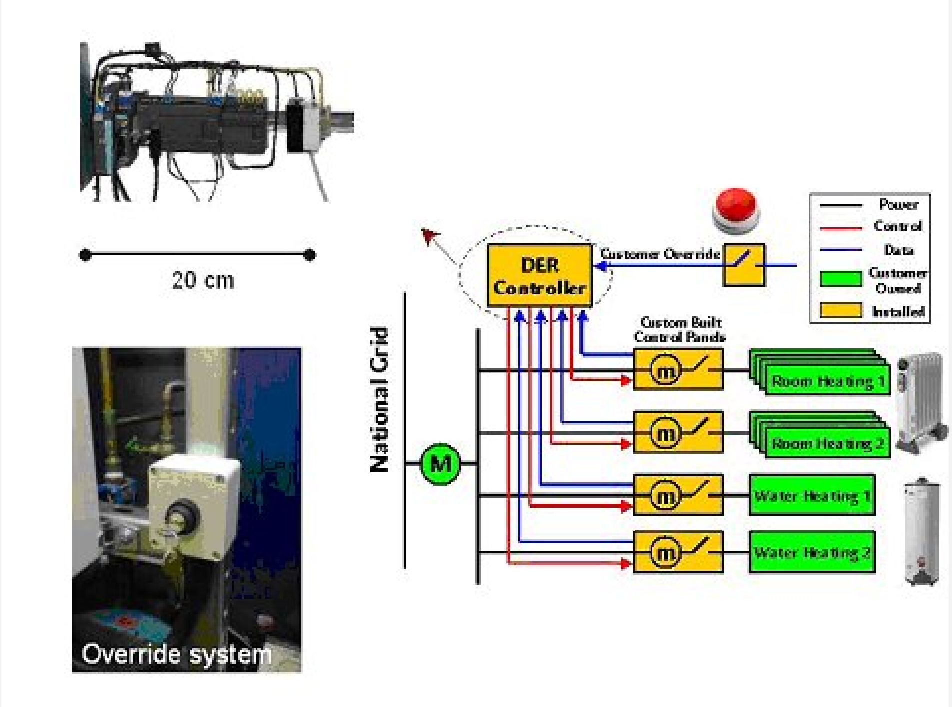


Siemens DEMS scheme of the experiment

Use of Knowledge (no maximum)	– One-Year Test Campaign – Demand Knowledge – Energy Market Knowledge
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	– Akis Koufis, EPA Attiki, a.koufis@aerioattikis.gr – Marc BERGER, GDF SUEZ, marc-DR.berger@gdfsuez.com
Pictures of the Contacts (1 to 3 pictures)	 *Akis Koufis*  *Marc BERGER*

Knowledge Block no	Test 3
Title	Testing the technical feasibility of aggregating10 kW to 1,5 MW scale DER in the UK commercial market segments.
Context	This test is related to Business model I investigated in EU-DEEP, which addresses the aggregation of flexible loads and generators. The experiment based on a set of such real loads and generators, aims at estimating the cost and value of small scale (10 kW to 1,5 MW) load management aggregated in UK industrial and commercial market segments. Load management refers, unless otherwise stated, to demand reduction and/or an increase in generation. These tests were characterized by flexible units having two main characteristics: - Availability: an expected ability to perform load reduction, when called. - Flexibility: the actual delivery of load reduction, when called.
Challenge	Is aggregation technically feasible today at a 10 kW to 1,5 MW load/generation scale in the UK context?
Description	The tests undertaken in this study were carried out in real client facilities. Two kinds of clients were distinguished hereafter regarding the energy resources that they could provide: - Standby generation: clients have generators that can provide power supply for the site demand, when the electrical network is unavailable. - Load flexibility: clients are able to adapt their electrical energy needs by interrupting or delaying: industrial processes, air-conditioning control, heat requirements, etc. The customer portfolio was made up of: - 8 small industrial and commercial sites from 20 to 1500 kW of flexible loads: offices (air conditioning, space heating), cold store (cold generation), factory (glass furnace), supermarket (HVAC, refrigeration), hotel (space and water heating) and shops (HVAC) - 2 controllable generators (500 kW diesel engines) - 1 wind farm (30 MW) All sites were equipped with local controllers (controllable circuit breakers and metering) (except the wind farm). GDF SUEZ Energy UK played the role of aggregator using a centralized control software (Siemens DEMS®).
Key figures	December 2007-December 2008 8 customers with 20 to 1500 kW of flexible power
Outputs	The control technology was validated for aggregation The value of being connected was highlighted

Results (1 to 5 results, 500 words for the whole section)	**Site selection requires market knowledge** Sites were selected for the experiment through a combination of modelling results suggesting suitable industries to focus on and the knowledge and experience of customer flexibility held within GDF SUEZ ENERGY UK. **Installation is a difficult stage** As each site in the experiment had a bespoke installation, a large amount of resource, both in terms of finance and time, went into developing the control and monitoring solutions. **Designed flexibility would be cheaper than retro-fitting** In many sites installations were carried out which integrated into current control systems, and required changes to those systems. If the use of flexibility had been considered when the system was initially designed, the cost of installation would have been reduced to almost nothing. This is an area where standards, and even regulation, would bring an ever growing volume of flexibility to the market as sites are built or refurbished. **Standardisation of equipment is vital** The cost of installations in the experiment was much higher than could be supported by the potential returns from the flexibility, as all installations involved site surveys, electrical planning and the purchase and installation of high level, customised electrical equipment. Going forward it should be possible to create a level of standardisation, both in the equipment itself and in the installation and interface requirements on site. This would dramatically lower the capital cost of installation, allowing far smaller loads to enter the flexible market. **Sites have poor knowledge of their flexibility levels** While most customers agreed that they did have interruptible loads, their estimates of the amount of flexibility they could deliver were generally inaccurate. In addition, identifying where loads could be controlled and monitored was often a difficult process, with the knowledge being spread out across the business. **Sites can generally manage more calls than they think** In general customers were initially quite conservative in estimating the amount of flexibility they would be able to provide, particularly in terms of number of calls. It was often felt that, while they were willing to participate, the actual interruptions would cause problems, particularly in the case of the air conditioning loads. In practice, many sites recorded no effect at all on staff and customers from regular 1 hours call, as many as two per day in some cases. **Flexible demand can be utilised now** The current 3MW limit for participation in Short Term Operating Reserves (STOR) can be reduced today. Even using the technology utilised in the experiment, sites as small as 500kW could be aggregated onto the scheme. When Triad avoidance is taken into account, and assuming that installing a standardised control system into multiple sites should lower the capital expenditure, this could be driven as low as 100kW. The main hurdles in this market now are regulatory, and should be easily overcome. **Participation in the markets needs more work, and more sites** The penalties for overselling flexibility into the commercial market are very severe (exposure to the imbalance cost), and underselling reduces the value. Therefore a very reliable view of the available flexibility is required. This is easier as site number increases, providing a portfolio effect. The development of contracts and pricing models to mitigate the risks involved will also be required before the business can really take off. However if, as expected, the volatility in the market continues to grow as more renewables are incorporated on the system then the value of this market will grow considerably.
Illustrations (1 or 2, with 30 words per legend)	

	 Example of a customer installation A customer : cold store in UK Location of the 10 sites of the experiment
Use of Knowledge (no maximum)	– One-Year Test Campaign – Sociological Survey – Demand Knowledge – Energy Market Knowledge
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	Mark Symes, GDF SUEZ ENERGY UK, Mark.Symes@gdfsuezuk.com Marc BERGER, GDF SUEZ, marc-DR.berger@gdfsuez.com
Pictures of the Contacts (1 to 3 pictures)	  *Mark Symes* *Marc BERGER*

Knowledge Block no	Test 4
Title	Testing the technical feasibility of aggregating micro CHPs in the German residential sector
Context	This test is related to Business model II investigated in EU-DEEP, which addresses the aggregation of micro CHP at residential clients in the German context. The aggregation of 10 Micro-CHP units installed in selected residential buildings was tested under real conditions to provide the necessary data and feedback to validate the business case of Micro-CHP aggregation.
Description	The test was conducted by RWE throughout 2008 in Berlin, in cooperation with GASAG, the major local gas supplier. The portfolio consisted in 10 residential customers of GASAG with the following characteristics (per customer): - approx. 120 m^2 living space - approx. 5000 kWh/yr electricity consumption - approx. 20000 kWh/yr gas consumption. All sites were equipped with a Micro-CHP (1 kWe) installed in the basement of each house. A large heating water storage allowed to decouple the use of heat and electricity. An aggregator could remotely manage the Micro-CHP via a controller communicating through a GPRS connection, in order to allow "on-demand" electricity production. All units were controlled remotely from the city of Dortmund via a control system developed by Siemens. RWE played the role of an aggregator using a centralized control software (Siemens DEMS®). During the test period different control strategies such as individual control, statistical control or scheduled control were been tested and evaluated.
Key figures	April 2008-December 2008 10 residential customers 10 sites remote controlled during the heating season
Outputs	Control technology for aggregation was validated **The** value of being connected to the network was highlighted.
Results	**Installed heat storage allowed a flexibility of 1 to 2 hours.** The field test confirmed that the flexibility regarding residential customers is limited to the size of the heat storage. Thus the maximum operation time of the Micro-CHP without having any instantaneous heat demand from the site was approximately 1 to 2 hours. Depending on the load profile of the heat demand it was possible to use this flexibility several times a day. During summer time when only hot water was needed by the customers the storage could be filled in many cases only once or twice a day. Contrasted control strategies were assessed during the field test and showed a limited usability of the flexibility. The heat supply of the customers had the highest priority during the field test: the acceptance of the external aggregator signal was limited to the period when the heat storage was half empty up to the point where the local heat controller started the Micro-CHP unit to reload the storage. **Eight Micro-CHP have to be called to offer 1 kW on the power market if self-consumption is promoted.** The results of the field test regarding the operation of Micro-CHP units and the

	generated revenues were compared with the theoretical calculations with Excel Tool and the DEMS Tool used for the calculation of the business plan and proved a good accordance. From an aggregator's point of view, the average availability of the Micro-CHP to start upon the aggregator's signal was approx. 50% of the time. The rest of the time the Micro-CHP was already running to answer to the heat demand of the dwelling. In a scenario where self-consumption is supported, an average of 23% of the produced electricity could be fed into the grid. The share of the electricity produced following an aggregator call that was injected into the grid was therefore approx 12% (50% x 23%) on average, meaning that 8 Micro-CHP have to be called to offer 1 kW on the power market if self-consumption is promoted. **Remote-control system using GPRS is reliable.** The field test proved that the selected communication system via GPRS is suitable for the business and extremely reliable with an availability over 99%. Even with data collecting every minute there were only few data points lost during the entire operation of the 10 systems. **The control strategy should be improved to increase the available power for the aggregator.** The performance of the Micro-CHP units was lower than expected. The electrical efficiency was in the range of 7 % compared to the specification of 12 %. The overall efficiency was approximately 85 % compared to 90 %. The low electrical efficiency is partly caused by the self consumption of the unit and the low average running time per start. Especially during the start up of the unit, which takes up to 15 minutes until full load is reached and the steady state efficiency is much lower compared to continuous operation at full load. Compared to the nominal electrical output of 1 kW the field test showed an average usable output of 0.75 kW. This means a loss of 25 % compared to the theoretical calculations. The control strategy should be improved in order to increase the running time per start which was approximately 70 minutes during autumn and winter time. In many cases especially during summer time the running time was less than 30 minutes. Here is a high potential to increase the general performance by optimizing the control strategy. The total availability of most units (for aggregator point of view and self-consumption) was 100 %. **A common standard for the control signal to run the Micro-CHP unit is a key issue.** Another key parameters identified in the field test was the technical performance of the system. The overall output and efficiency need to meet or better exceed the specifications in order to operate the Micro-CHP unit economically. The field test showed that it would be useful to determine a common standard for the control signal towards the Micro-CHP unit. The local heating controller should have a common interface to accept and process the start and stop signals coming from the local DER controller. In general the whole installation, measurement and control equipment should be optimized and standardized as much as possible in order to reduce initial investment costs as well as ongoing costs for maintenance and troubleshooting. A wider variety of Micro-CHP units suitable for use in residential applications would be helpful for the business. On one hand, competition might help to reduce investment costs and on the other hand, different Micro-CHP sizes might help to choose the right unit for a given site in order to optimize the performance of the system.
Illustrations (1 or 2, with 30 words per legend)	Micro-CHP installed in the cellar of the house

Use of Knowledge (no maximum)	– One-Year Test Campaign – Sociological Survey – Demand Knowledge – Energy Market Knowledge
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	Otto BERTHOLD, GASAG, OBerthold@gasag.de Uwe Dietze, RWE Energy, Uwe.Dietze@tbe.de Marc BERGER, GDF SUEZ, marc-DR.berger@gdfsuez.com
Pictures of the Contacts (1 to 3 pictures)	 Otto Berthold  Uwe Dietze  Marc Berger

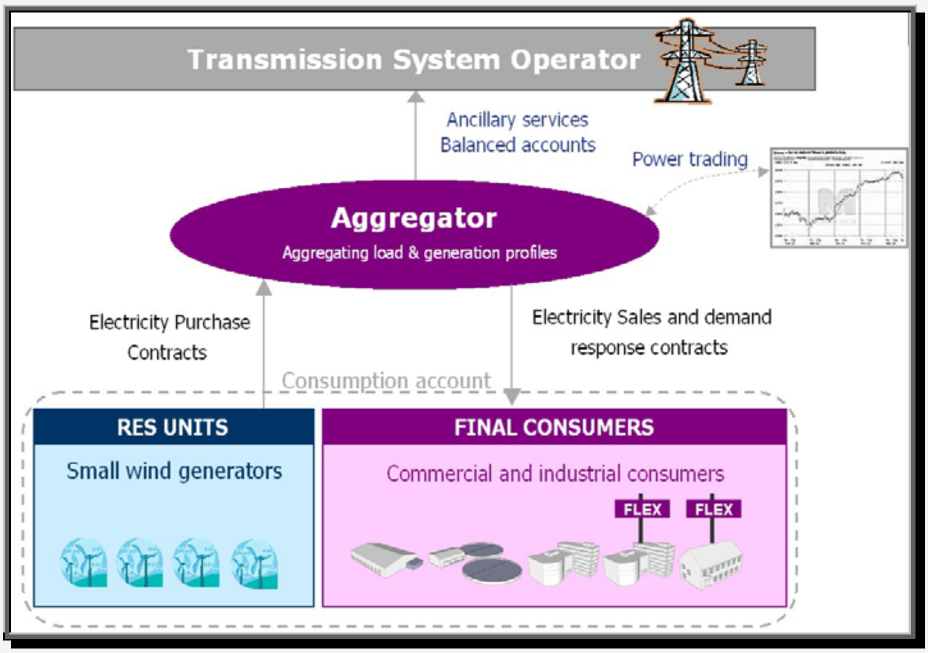
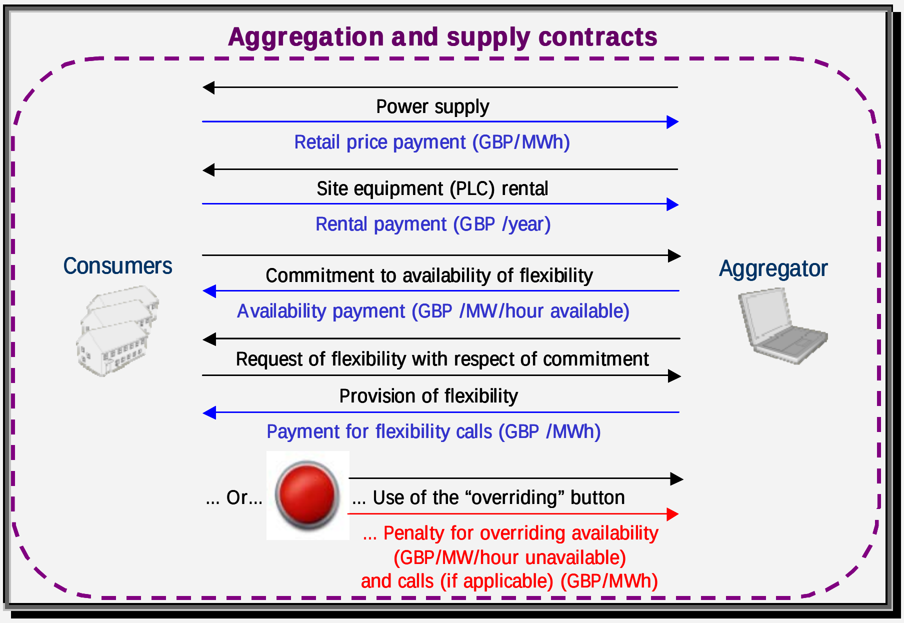
Knowledge Block no	Test 5
Title	Testing the technical feasibility of a decentralized control architecture for aggregaton of load and generation
Context	This last test was exploited for the sake of Business model III investigated within EU-DEEP, and focusing on CHP and demand response aggregation at small and medium customers' site. The experiment was more technology-oriented. The Multi-Agent Software technology, a decentralized control architecture for aggregation, was tested in real-time on a portfolio of real customers from Greece, including both demand response and generation.
Description	The customer portfolio was made up of: - A trigeneration system installed at the university premises of partner NTUA (see Test 2) - A Photovoltaics system and a flexible load issued from a heat pump, in partner's site Centre for Renewable Energy Sources (CRES) - A flexible load in the form of supermarket refrigerators in a holiday camp - A flexible load issed from the external lighting of a second university. -
Key figures	April 2008-December 2008 1st time MAS utilisation with real clients 200 calls for load interruptions
Outputs	The decentralized control technology was validated for aggregation **The value of being connected was highlighted**
Results	**Multi Agent System Experiments: Test and validation of Load controllers and MAS Software for the first time with real clients** The Intelligent Load Controller (ILC) designed and developed by the Power Systems Laboratory of NTUA in cooperation with ANCO S.A was tested for the first time in real clients environment in Greece. The MAS (Multi Agent System) software developed by NTUA was applied for the decentralized control of client loads and production units and further enhanced with more capabilities during the tests. Since there is no operational power market for LV customer in Greece, a virtual one was simulated. **Scalability issue: one of the most critical parts of MAS Technology** The technical goal in MAS experiments was the evaluation of various issues regarding the implementation of MAS system in a real market environment where normally several DG units and loads exist. The architecture designed for that purpose was validated: the agents can be organized in a hierarchical way and different actions could be performed in the different levels of organization. In this way, many control units (scalability) could be added in the control system, without increasing in a great extent the execution time of the algorithm. Furthermore, the agent-based algorithm has the ability of adding (or taking out of service) new production units without having to re-calibrate the whole control system from scratch (plug-and-play capability). **Reinforcement learning, an advanced algorithm** The operational goal of the experiments was to design a control system capable of correct scheduling of decisions in a given market environment to be proposed. For that purpose, the reinforcement learning algorithm developed by NTUA was tested for the first time in an environment with real clients. The experience gained from the tests led to improvements in the core algorithm. **The "Fair" load shedding** The "fair" load shedding prevailed during MAS experiments. It is obvious from the results that the agents can perform load shedding in a fair way since they are able to decide themselves, after a negotiation, which load should be shed, according to the consumption of each load and the total power available.

	The mobile technology seems to be a reliable solution for load interruptions In two of the four sites, the holiday camp and the second university, the load interruptions were performed remotely via mobile telephony system, while in CRES and NTUA they were done manually on site. The mobile telephony system that was used proved secure, cheap and easy-to-use system for remote load interruptions. **Possible alternatives to centralised DER control proved to be credible.** Decentralised MAS solutions present advantages in terms of better customer acceptance since the decisions are taken locally. The existence of open communication standards and their implementation to in-house appliances as well as other equipments would be a prerequisite for an extensive use of MAS.
Illustrations (1 or 2, with 30 words per legend)	Location of the 4 sites of the experiment MAS architecture in EU-DEEP project 
Use of Knowledge (no maximum)	– One-Year Test Campaign – Sociological Survey – Demand Knowledge – Energy Market Knowledge
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	Thomai Tomtsi, NTUA, ttomtsi@gmail.com Marc BERGER, GDF SUEZ, marc-DR.berger@gdfsuez.com
Pictures of the Contacts (1 to 3 pictures)	 *Thomai Tomtsi*  *Marc BERGER*

M 105

Knowledge Block no	i1
Title	A promising business based on balancing intermittent generation by aggregating demand response in the UK
Context (50 words)	The European Commission has recently reaffirmed its commitment to achieve the target of a 20% share of renewable energies in final energy consumption by 2020 in Europe. For many state members, this target implies integration of a massive amount of intermittent generation in the existing electrical system. Increasing constraints of the system, introduction of renewables will be associated with many business opportunities based on Demand Response.
Challenge (1 question, 25 words)	What is the rationale underlying the development of business models focusing on Demand Response in the UK?

Results (1 to 5 results, 500 words for the whole section)	**An electricity retailer can aggregate flexible demand of medium-sized industrial and commercial customers especially to balance RES generation.** An electricity retailer could develop a business based on the demand response of commercial and industrial customers in response to the increasing needs in reserve capacities. The business is supposed to be run by a supplier of electricity, called "Aggregator", who contracts a large number (from 1000 to 100,000 or more) of small to medium sized flexible clients. "Flexibility" is defined as the potential of a customer to rapidly modify the load as seen from the grid on request and to hold this modification over a certain period. The Aggregator manages this flexibility in order to generate profits, which are shared between him and the customers afterwards. In the UK, revenues from flexibility can be created in 4 different ways, by: – offering frequency control services to the TSO (Provision of Frequency Control Services – PFCS), – reducing T&D charges (Reduction of capacity-related grid fee, RCGF), enabled in the UK by a specific Use-of-System charges called Triad, – selling power on the wholesale electricity market during high price periods (Obtainment of the Best Price in the Market – OBPM) – improving the imbalance position during high penalty moments (Reduction of Imbalance Costs – RIC). The determination of the appropriate moment of using customers' flexibility and the revenue stream to be selected belong to the aggregator's responsibility. **Customers of the past will become active customers** By being simultaneously consumers and providers of flexibility (via the use of DER), the passive customers of the past are progressively replaced by a new type of agents: they become "active consumers". For a retailer, becoming in his turn an aggregator of Demand Response, this change implies major evolution in the relationship with his active customers. As stated by the sociological survey (A3), the customers expect transparent and efficient information about the profits they generate; in other words, they expect a close partnership with the aggregator. Besides, faced with the complexity of the electricity market, the active consumers need also simple transaction mechanisms. As a result, a possible remuneration system of customers can be based on payments for offering availability and providing flexible power when requested (see Figure 2). **This new business requires an in-depth knowledge of each individual customer's needs and habits** Next to a limited number of technical risks (mainly linked to the scalability of the load control architecture), the major risks for the aggregator are essentially associated with an emerging business: – The business introduces a change in the customer's relation to energy consumption and production. It must be fully accepted to allow a necessary involvement from the customers and to facilitate the new contract subscriptions; – It is also crucial to know in detail the customer's equipment to reduce the risks associated to their installation. This stage is critical and it can be very harmful to the image of the offer. The emergence of standard-based technology would enable to limit the risks and the associated financial impacts.

Illustrations (1 or 2, with 30 words per legend)	 Figure 1 : Graphical representation of the main stakeholders and basic activities in the business model  Figure 2: Main interactions considered in the business occurring between the aggregator and its customers
Use of Knowledge (no maximum)	
References (max 3 references, 100 words)	- "G. Brecq, R. Simcik, M. Dillig, R. Drozdowski, A promising business based on adapting customer demand to the needs of the UK electrical system, 3d International Conference on Integration of Renewable and Distributed Energy Sources, Nice (France), December 10-12th, 2008"
Stakeholders (max. 8 stakeholders)	[Not to be filled for the moment] – XXX
Contacts (1 to 3 contact names)	– Guillaume Brecq, GDF SUEZ, guillaume.brecq@gdfsuez.com – Roman Simcik, GDF SUEZ, roman.simcik@gdfsuez.com – Roch Drozdowski, GDF SUEZ, roch.drozdowski@gdfsuez.com – Gilles Bourgain, GDF SUEZ, gilles.bourgain@gdfsuez.com –

Pictures of the Contacts (1 to 3 pictures)	   

Knowledge Block no	i2
Title	Aggregating demand response can be profitable in the UK under current regulation
Context (50 words)	Integration of intermittent renewable energies (wind & solar) within the European power system implies an increase in costly and CO_2-emitting reserve capacity to balance the variability of power output. However, an alternative does exist: balancing can be achieved by using demand-side flexibility in a much greater extent than it is the case today (i1).
Challenge (1 question, max. 25 words)	– What is today in the UK the minimum threshold of customer's flexibility to enable a profitable business on Demand Response aggregation?

Results (1 to 5 results, max. 500 words for the whole section)	**A profitable business can be achieved in the UK with the current regulations and available technologies.** Based on field results, simulations running over a 10-year period show that, taking expected customer constraints into consideration, Demand Response aggregation business can be profitable for both the aggregator (with an IRR expected to cover the cost of capital) and the customer (average earnings representing up to 4% of the electricity bill). As shown in Figure 1, the total revenues increase with customer's involvement in the business. For an annual interruption duration of 100 hours, the revenue can reach 30 GBP/kW of average flexibility. Ancillary services (Provision of Frequency Control Services, PFCS) turn out to generate most of these revenues. This revenue stream allows exploiting availability of the customers, with potentially few actual calls for flexibility actions. Reduction of Transmission charges (Reduction of Capacity-related Grid Fee, RCGF) also brings in significant revenues due to important savings on Use-of-System charges with a rather small number of calls per year (~20 hours). Last, incomes from energy trading (OBPM) and internal balancing (RIC) are reduced in their potential by partly overlapping with PFCS and RCGF (and with one another). This point contributes to explain their smaller part in the total benefits. **The bottom threshold for a profitable load management is considerably lower than the current limit imposed by the TSO for ancillary services.** Customers' profitability varies significantly with their size, their capacity to offer flexibility when the system needs it (mainly in winter and during the morning and evening peak hours), their constraints and the level of flexible power. As a result the absolute profitability limit varies from one customer to another and has been determined by simulations (as seen in Figure 2). It comes out that 40 to 140 kW of offered flexibility per customer is needed to justify their involvement in the aggregation business. This threshold is significantly lower than the limit set today by the TSO (at 3 MW of flexible power in the UK). Cold storage, due to its high level of flexible power and its full availability over the year, is seen as the most profitable customer segment. For this type of customer, the minimum flexibility that can be targeted is 50 kW, accounting for around 20 % of the real flexibility provided during the tests. Nevertheless, some shops (installed in a trading area and equipped with a heat pump) can also be of interest to the business if the provided flexibility is doubled compared to the customer actually involved in the field tests. **The tests have demonstrated that a major reserve of flexibility exists in customers' sites.** Customers have a poor knowledge of their flexibility potential. This point leads them to underestimate their ability to provide flexibility. On average over the one-year test program, an annual interruption duration of 100 hours is expected for customers whose activity can be potentially impacted by the use of their flexibility. For very little impacted customers like the Cold Stores, a very high number of interruptions can be achieved. **Aggregating Demand Response is of benefit for stakeholders involved in the electric system.** Demand Response aggregation exhibit positive impacts for customers who take part in commercial offers, energy retailers who manage aggregation of DR, manufacturers and installers who produce and install the equipments. But, since it enables to reduce capacity requirements in balancing reserve with positive effects on CO_2 emissions (by around 350 gram of CO_2 per kWh of flexible energy provided today in the UK) and network investments, it should also be well perceived by TSOs, DSOs and policy makers.

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<tr><td>Illustrations
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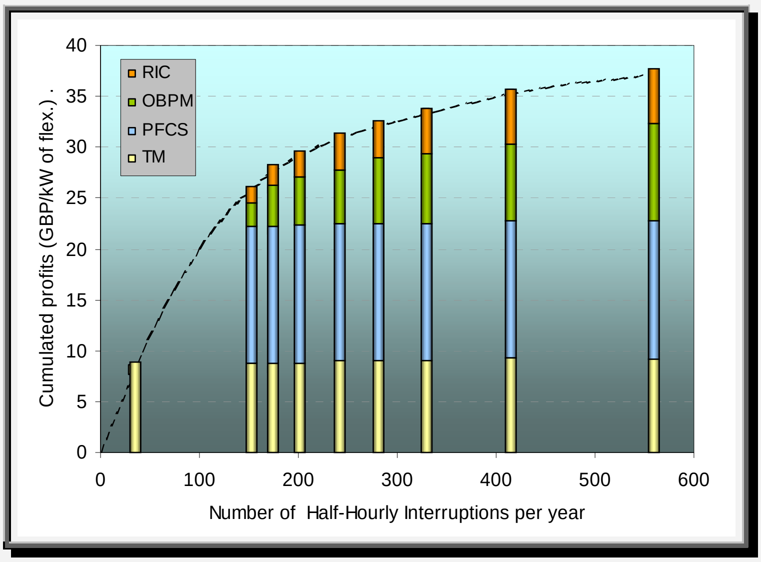


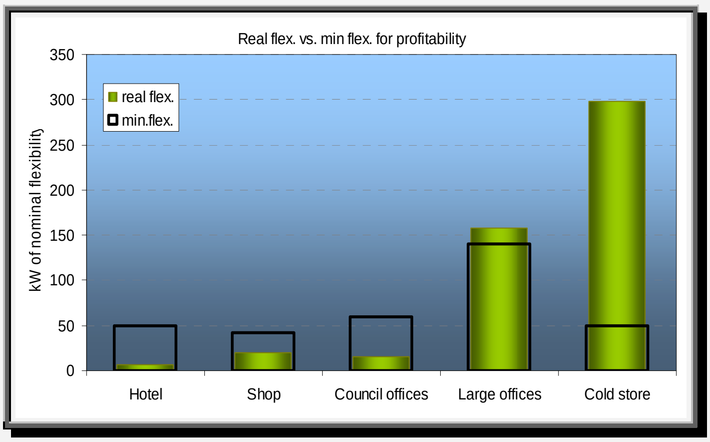
Figure 1: The profits generated by the flexibility increase with the annual availability of the customers. Network value (RCGF) and ancillary Services (PFCS) have been chosen to ensure the bulk of the revenue streams.


Figure 2: The customers' minimum flexibility varies between 40 and 140 kW. Only "Large Offices" show a high level because of their flexibility not being available in winter time (air-conditioning)
</td></tr>
<tr><td>Use of Knowledge
(no maximum)</td><td>–</td></tr>
<tr><td>EU-DEEP Public References
(max 3 references, max. 100 words)</td><td>– ""The UK Aggregation Experiment Combining Wind and Demand Response"Gilles Bourgain, GDF SUEZ; Franck Neel, GDF SUEZ ESS, UK, 3d International Conference on Integration of Renewable and Distributed Energy Sources, Nice (France), December 10-12th, 2008"</td></tr>
<tr><td>Stakeholders
(max. 8 stakeholders)</td><td>[Not to be filled for the moment]
– XXX</td></tr>
<tr><td>Contacts
(max. 3 contact names)</td><td>– Mark Symes, GDF SUEZ ENERGY UK, Mark.Symes@gdfsuezuk.com
– Guillaume Brecq, GDF SUEZ, guillaume.brecq@gdfsuez.com
– Roman Simcik, GDF SUEZ, roman.simcik@gdfsuez.com
– Gilles Bourgain, GDF SUEZ, gilles.bourgain@gdfsuez.com</td></tr>
</table>

Pictures of the Contacts (max. 3 pictures)	   

Knowledge Block no	i3
Title	Demand Response aggregation business strongly relies on customer portfolio characteristics and market conditions
Context (50 words)	Aggregation of demand response provided by small customers can lead to a new kind of business managed by electricity retailers (i1). The environment of this business has been described by 60 key parameters whose impact on the business profitability has been studied (A5). The criticality of each parameter has been assessed by making it vary independently of the other parameters in a probable range of values.
Challenge (1 question, 25	– What are the most impacting parameters for a business on the aggregation of Demand Response in the UK?

Results (1 to 5 results, 500 words for the whole section)	**The degree of involvement of the customers has a critical impact on business profitability.** Among the 9 parameters required to describe the involvement of the customer in the business, 4 of them have been identified as key parameters: 1. Availability windows (40% of the incomes depend on the peak hours of the customer, i.e. on only 20% of the customer's availability window) 2. Annual interruption duration (40% of incomes rely on 50 hours of interruption, i.e. on 50% of the total interruption duration) 3. Level of flexible power (a loss of 30% of the flexible power will result in a similar decrease of the earnings) 4. Portfolio size (similarly to the flexible power, it has a directly proportional effect on the earnings level, however the impact is largely reduced for the aggregator as the cost requirement is also decreased) In practice, any disengagement of the customers will impact simultaneously all these parameters amplifying their effect. For this reason and more than in any other business, a special care must be taken of customers' satisfaction. **The levels of the ancillary services payments and of the transmission charges can change significantly the profitability of the business** Several parameters associated with the revenue streams impact heavily the business profitability. Their impact is even more important if the associated risks are not directly shared with the customers. 1. Provision of Frequency Control Services (PFCS) remuneration level (60% of the IRR rely on 30% of the payment level for ancillary services) 2. T&D fees (40% of the IRR depend on 30% of the avoided costs of the Triad system via the Reduction of Capacity-related Grid Fee, RCGF) **The higher the market price volatility, the more value can be created by using optimisation tools with accurate forecasting** Because of the current low level of energy trading, the wholesale market price level and volatility can only impact the revenues if they increase. In that case, a 30% increase for any of these two parameters can result in a 60% increase of the profitability. When price level and volatility are higher, the internal balancing and the energy trading generate very profitable revenues (of the same order of magnitude than ancillary services or avoided T&D fees). This has been confirmed by deterministic as well as stochastic optimisation models. **The arbitrage between the different revenue streams is a key expertise of the aggregator.** The aggregator's task not only consists in determining the optimal timing of flexibility use, but also requires selecting the source of revenue that will bring the maximum benefits at this moment. The competition between the value streams is a difficult task to handle as it involves very different time scales with complex interdependencies. For this reason, the recourse to a full optimisation tool is far from obvious and a global strategy is more likely to bring fruitful results (at least in a short run). As a matter of example, a strategy privileging ancillary services and reduction of T&D fees has been proposed by EU-DEEP. The impact of PFCS periods that must be contracted with the TSO has shown a relatively small impact on the revenues expected if ancillary services prevent from using RCGF (see Figure 2). A full loss of profit for the aggregator has been observed in that case.
Illustrations (1 or 2, with 30 words per legend)	

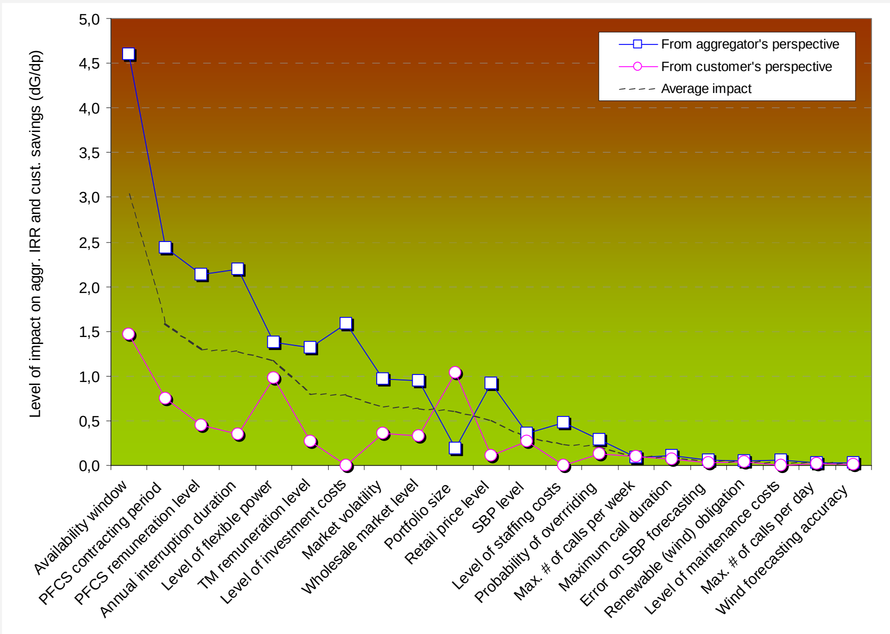


Figure 1: Because of the exposure to the market, the aggregator activity is submitted to a large number of impacting parameters

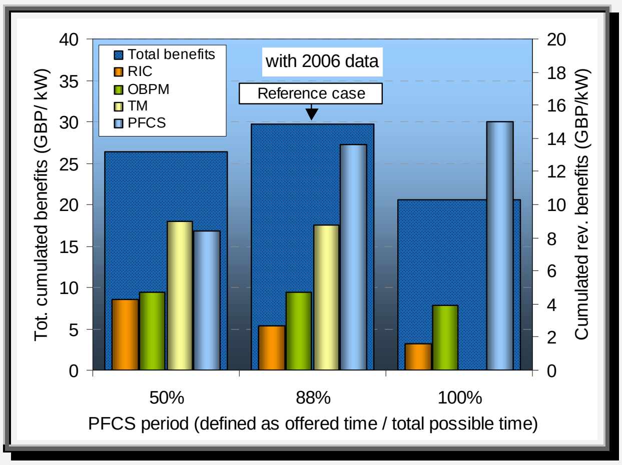


Figure 2: The way to determine the selection of the revenue streams can have a strong impact on the business incomes, especially if RCGF value (avoided T&D fees) is lost

Use of Knowledge (no maximum)	–
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	– Guillaume Brecq, GDF SUEZ, guillaume.brecq@gdfsuez.com – Roman Simcik, GDF SUEZ, roman.simcik@gdfsuez.com – Jussi Ikaheimo, VTT, jussi.ikaheimo@vtt.fi
Pictures of the Contacts (1 to 3 pictures)	  

Knowledge Block no	i4
Title	Germany and France could become two interesting countries for businesses based on aggregation of Demand Response
Context (50 words)	In spite of the actions pursued by the EC, the current European electricity system is a patchwork of national markets differing in their mix, policy and regulation. This heterogeneity makes necessary the transposition of the analysis of a business based on aggregated DR in the UK (i2) to other country contexts. 3 other national contexts have been studied: Germany, France and Spain.
Challenge (1 question, 25 words)	– Is there any other country than the UK where a business focusing on the aggregation of Demand Response can be profitable?

Results (1 to 5 results, 500 words for the whole section)	**Among the different European countries, the United Kingdom appears as an interesting country to start with** Three facts explain why the UK is particularly interesting for starting a business on aggregating Demand Response: – The open and transparent English regulation is probably the most favourable one in Europe to express the value brought by the DER (short gate closure time, DER and Renewable fully integrated within the system, etc.); – The value for the network (Reduction of Capacity-related Grid Fee, RCGF) can be explicitly expressed in the business via savings on the specific Use-of-System charge mechanism used in the UK, called Triad. – The UK could meet a difficult 2020 context due to the balancing of a high amount of wind with the important presence of non-flexible nuclear within its generation mix; **A high level of profits is expected in Germany if single pre-qualification can be obtained by the aggregator for the full portfolio** In Germany, incomes are almost exclusively produced by ancillary services (Provision of Frequency Control Services, PFCS). The level reached is equivalent to the cumulated revenue sources obtained in Great Britain. Thanks to PFCS, a German aggregator can expect to achieve similar profits to those expected in the UK (with a simplified decision-making process as only one revenue is used). However, this situation is today clouded by very high pre-qualification costs required by the German TSOs for each controlled site. These costs could likely be transferred to the aggregator's level who would then be responsible for the service provided to the TSOs. The German system based on a single level of price for imbalance penalties does not enable to generate sufficient revenue from internal balancing. **A business based on energy trading and ancillary services could start in France with lower profitability than in the UK** In France, the assessment of the profitability level yields a lower income (half the UK value). In France the profit is mainly based on two revenue streams: energy trading (Obtainment of Best electricity Prices in the Market, OBPM) and PFCS. The PFCS revenues can only be obtained from operation and not from capacities, unlike in the UK or Germany. This is opposed to a DR business since it would require a high frequency of utilisation (which is generally not permitted by the flexible customers). However, this result must be tempered as the assumptions that have been considered are conservative on the ancillary services mechanism. The strong synergies existing today in France between the wholesale market and the ancillary services could not be assessed at their full potential. The result is an underestimation of the ancillary services incomes. A simple correction method applied on PFCS leads to a 30% increase of the cumulated incomes (see Figure 1). The value that can be obtained from the balancing of intermittent renewable is inexistent, as they are not integrated to the market. The value expressed by the internal balancing only relies on the errors made on the demand forecasts. **In Spain, two major barriers prevent the provision of services to TSO and impede the development of such a business** In Spain, no profitable business has been found. Indeed, Spanish rules for curtailment services show two major barriers preventing the access to PFCS, whereas OBPM and Reduction of Imbalance Costs (RIC) display low performances. These barriers are: – No offer can be made by aggregation of flexible loads; – Only the customers connected to transmission network can provide ancillary services.

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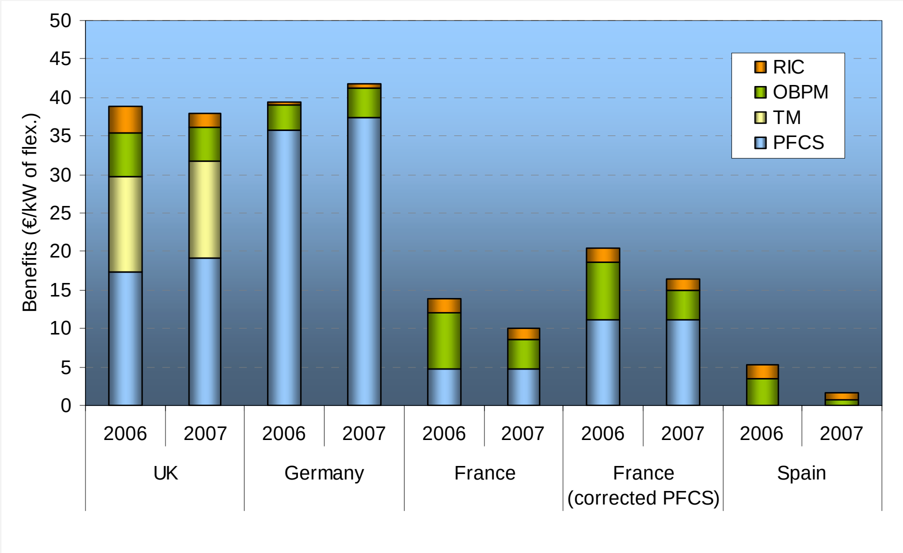

Figure 1: In the current market conditions, Germany generates the highest profits (in € per kW of flexible power) due to its highly remunerated ancillary services (PFCS).</td></tr>
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<tr><td>Stakeholders
(max. 8 stakeholders)</td><td>[Not to be filled for the moment]
– XXX</td></tr>
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– Roman Simcik, GDF SUEZ, roman.simcik@gdfsuez.com</td></tr>
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Knowledge Block no	i5
Title	Extrapolation to 2020 time horizon shows that aggregation of Demand Response looks even more promising in future
Context (50 words)	In the UK, a profitable business can be started today from the aggregation of Demand Response with the current environment and regulation (i2). Four contrasted scenarios have been used to frame possible futures for the 2020 time horizon. The business has been simulated in each of these scenarios by adapting 60 key parameters (A5, i3).
Challenge (1 question, 25 words)	– How will the possible future changes in the economic and regulatory context affect a business focusing on the aggregation of Demand Response?

Results (1 to 5 results, 500 words for the whole section)	**Four scenarios have been built to describe the 2020 energy context in the UK.** The “Security of Supply” scenario is characterized by a strong public support to infrastructure investments to maintain reasonable level of energy price and volatility. In this context, the network value (Reduction of Capacity-related Grid Fee, RCGF) is lost, the volatility and long-term energy prices are limited, and promotion programmes for Demand Response are set up. The “Smart Climate Change” scenario is driven by the EU willing to comply with the 2020 targets using markets as a major lever. Like in “Security of Supply”, the customers pushed by promotion programs are keen to get involved in Demand Response offers. However, the energy price and its volatility are much higher because of the large integration of intermittent renewables. In the “Market” scenario, the impulse of development of the energy system is shifted to markets that are supposedly fully transparent, efficient and liberalized. In opposition to the previous scenarios, the cost of the technology is only slightly reduced compared to today’s situation. Only economic aspects can prompt customers to subscribe to DR businesses. The price level and volatility are relatively high. Last, the “No Direction” scenario can be seen as an intermediate situation where none of these visions could impose itself. It is mainly based on a business-as-usual approach in which no particular drivers have been fostered. This scenario is characterized by a low involvement of the customers. The energy price and volatility are as high as in “Market” but the costs of equipments have not decreased at all. **In all the investigated 2020 scenarios the profitability of the business increases.** By exploring these contrasted market, policy and consumption scenarios, it can be expected that, even the least favourable case for value extraction from the aggregation of flexibility (“No Direction”) turns out to be more profitable than the (current) reference situation, as shown in Figure 1. The equivalent savings achieved for the customer are then twice as high as in the reference case and equal to 9% of the energy bill. Besides, a probable underestimation of two of the revenues (internal balancing RIC and energy trading OBPM) is expected. **Even in the most optimistic scenario and without major changes in the infrastructure, Demand Response aggregation could not target the residential sector.** The context evolutions that have been considered result in a profitability threshold that can be decreased at most by 70% (down to 20 kW, see Figure 2) for “Smart Climate Change” scenario. Such a decrease will naturally enlarge the potential market targeted by this business, but will not enable to bring the households into the business. Open smart metering devices are then a crucial element to enable a deep decrease of the required investment costs. **In 2020, capturing the network value is not anymore essential for Demand-Response aggregation businesses** The “Security of Supply” scenario is characterized by the fact that it describes a UK market without Triad mechanism. The scenario analysis shows that in future, the business has the potential to remain profitable even in the event of absence of revenues generated by Triad management, i.e. without reducing overall Transmission Network Use of System charges by decreasing consumption during system peaks. Indeed, the value generated by the internal balancing and energy trading will increase significantly, enabling the aggregator to change his revenue mix. This feature can be used for prospecting countries other than Great Britain where Triad-like systems will probably not be available, even by 2020.

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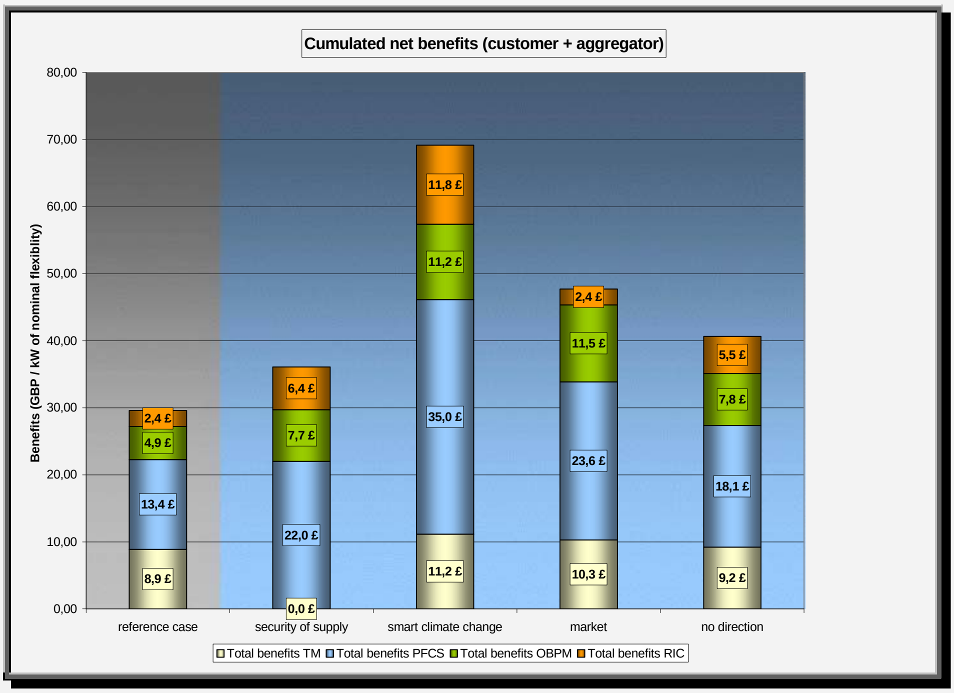

Figure 1: In all the studied scenarios, the total incomes to be shared between customers and the aggregator will increase by 2020

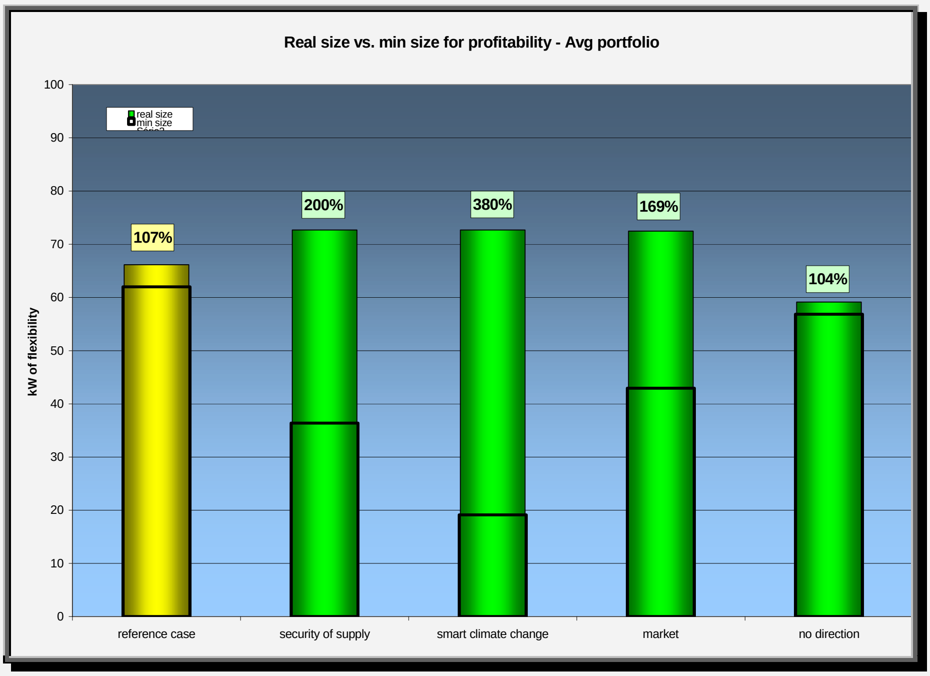

Figure 2: The minimum flexible power beyond which DR aggregation is not profitable is expected to be significantly lower in 2020
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<td>Contacts
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<td>– Guillaume Brecq, GDF SUEZ, guillaume.brecq@gdfsuez.com
– Roch Drozdowski, GDF SUEZ, roch.drozdowski@gdfsuez.com</td>
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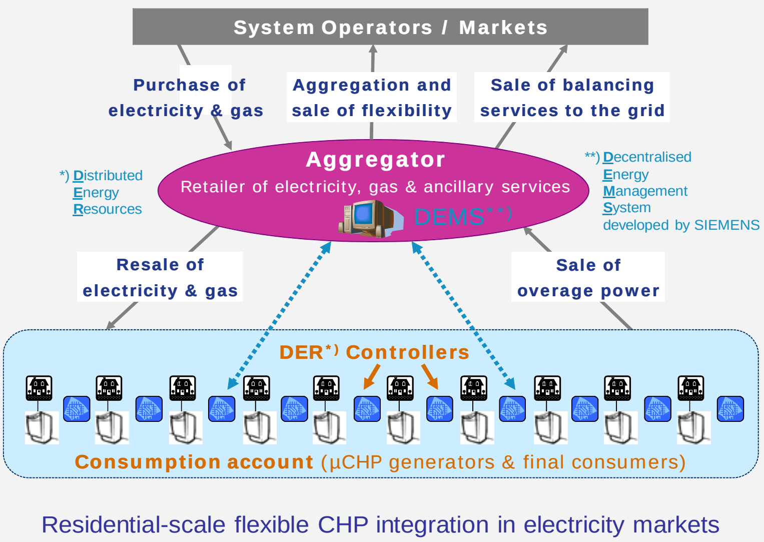
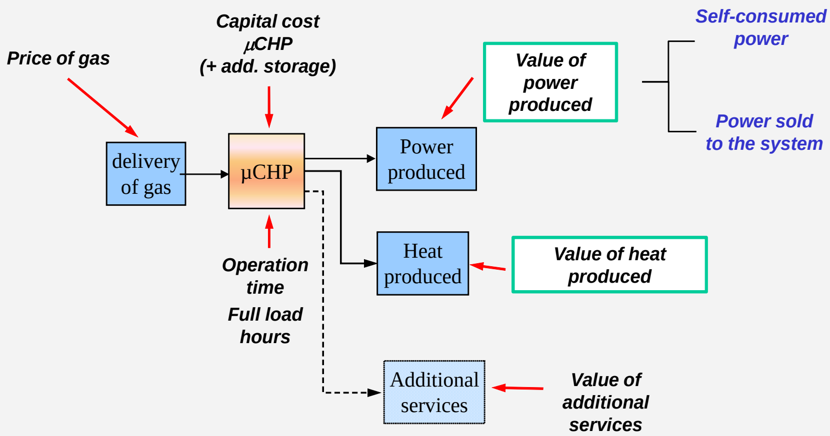
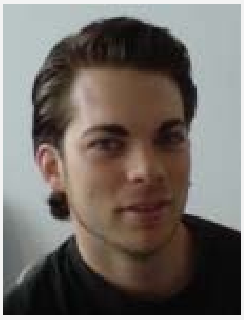
</table>

Pictures of the Contacts (1 to 3 pictures)	 

Knowledge Block n°	ii1
Title	**Residential-scale flexible CHP integration in electricity markets** *A business case for residential-scale flexible CHP integration in electricity markets is elaborated.*
Context (50 words)	Micro CHP (µCHP) are gaining interest in the domestic sector, their energy efficiency inducing economic savings. Taken individually, their small size prevents them from the participation to electricity markets that could generate additional revenues. The aggregation of µCHP units is an option to allow market participation, but inducing IT costs that question the potential profitability of such an activity.
Challenge (1 question, max. 25 words)	- What sources of revenues could bring µCHP aggregation, and who could bear the investment and unit operation?
Results (max. 6 results, max. 500 words for the whole section)	**1. The business idea investigated consists in an energy retailer of electricity and gas that aggregates a large number of flexible standardized µCHP units owned by either end users/prosumers or by the energy retailer (called aggregator).** *(The business principle is shown in Figure 1)* Four sources of revenues are identified when aggregating µCHPS: The scaling effect of aggregation allows to gain access to electricity and gas markets and capture revenues from the following sources: - Selling energy to end users (gas if the unit is owned by the end user; heat and electricity if the aggregator is the owner) - Selling surplus power (produced beyond consumption) to the market or at Feed-In tariff. Selling at best moment on the market (at highest prices) will require a flexible operation* of the CHP-Park. On the contrary flexibility in operation is not necessary when selling under a flat Feed in tariff– which is constant over time - Reducing the penalties related to imbalances in the portfolio (compared to the locally scheduled load) through optimal use of DG - Selling balancing services: active provision of reserves provided to the grid operator *(The key drivers for the business are shown in Figure 2)* **2. *Flexibility of µCHP-units is realized through a decoupling of heat and electricity demand by using heat storage capacities.** **3. According to a sociological study, remotely controlled units need to be controllable last resort by the inhabitants through a thermostat.** Some people remain strongly opposed to any external intervention through the remote control of the apparatuses on their heating system. **4. Four configurations are considered for this business idea, depending on the investor, the operator, and the operation mode:**

Configuration	*Investor*	*Operator*	*Operation mode*
1) End user owner (BASIC)	*End user*	*End user*	*Heat-driven*
2) End-user contracting energy (CONTRACTOR)	*Energy retailer*	*Energy retailer*	*Heat-driven*
3) End user owner rewarded for flexibility (Virtual Power Plant OPERATOR)	*End user*	*Aggregator*	*Flexible*
4) End-user contracting energy and flexibility reward	*Aggregator*	*Aggregator*	*Flexible*

	(VPP OPERATOR & INVESTOR) | | | Only the last two configurations deal with aggregation in the EU-DEEP sense. The value of aggregation consists in the difference of profits between configurations (3 vs. 1 and 4 vs. 2). **5. Beyond the investment cost for DG, initial and operational aggregation costs need to be covered:** On the one hand, the installation of a controller, management software and communication devices is needed at the customers' sites - a key driver in the business case is therefore the communication cost between aggregator and end-users. The economical challenge lies in the level of standardisation that is possible to reach when implementing the service at multiple customer sites. On the other hand, the operating costs of the aggregator (staff, facilities etc.) to optimize operation and maintenance over time need to be taken into account.
Illustrations (1 or 2, with max. 30 words per legend)	 **Figure 1: Aggregation of µCHP units in domestic applications**  **Figure 2: Key drivers for µCHP-units**
Use of knowledge (no maximum)	- States of the Art - Technology and Country Database - Demand Knowledge - Regulation Knowledge - Standard Knowledge - Network Knowledge - Power System Knowledge - Energy Market Knowledge
References (max 3 references, max. 150 words)	- *M. Laskowski, U. Dietze, P. Himmes (2008): Aggregation of aCHP units for domestic applications, 3rd IRED, Nice* - *P. Himmes et. al (2008): Geschäftsmodelle für eine effiziente Nutzung von µKWK-Anlagen, uwf UmweltWirtschaftsForum, Volume 16, Number 3, September 2008 , pp. 143-147(5) Heidelberg* - *C. Weber, P. Vogel (2008): Assessing the benefits of a provision of*

	system services by distributed generation; International Journal of Global Energy Issues 2008 - Vol. 29, No.1/2 pp. 162 - 180 DOI 10.1504/IJGEI.2008.016347
Stakeholders (max. 8 stakeholders)	-
Contacts (max. 3 contact names)	Patrick Himmes, University of Duisburg-Essen, Patrick.himmes@ibes.uni-due.de Michael Laskowski, RWE, Michael.laskwoski@rwe.de Uwe Dietze, RWE,Uwe.dietze@tbe.de
Pictures of the Contacts (max. 3 pictures)	 **P. Himmes**  **M. Laskowski**  **U. Dietze**

Knowledge Block n°	ii2
Title	**An application case in Germany validated with experiments** *The business model is difficult to implement under the current German regulatory regime.*
Context (50 words)	The Germany context regarding CHP can be favourable to µCHP aggregation businesses as can be seen from the calculations. To validate these computations, business cases must be tested by real tests.
Challenge (1 question, max. 25 words)	- Is the aggregation of µCHP-units profitable in Germany?
Results (max. 6 results, max. 500 words for the whole section)	**1. Germany presents high heat demand with well implemented domestic CHP.** A µCHP aggregation business case was investigated within the German context, presenting a promising market for µCHP, as one of the most populated European countries with significant heat demand and where CHP for domestic customers is quite well implemented. Furthermore German regulation favours the operation of CHP-units. For CHP-units up to 50kWel, the German CHP-Law from June 2008 (KWKModG) foresees a bonus payment for every kWh_{el} produced of 5.11 ct on-top of a base price negotiated with the DSO for the fed-in electricity. The economic analysis of the business idea was performed with different tools (mentioned in card A2) on a portfolio of single family dwellings. The end-user loads considered for computation include typical loads for several days along the year, for single family and multifamily housing. The load profiles are issued from German standards (VDI guidelines 4655). **2. Five scenarios are designed taking into account CHP ownership, heat driven or flexible operation mode and electricity sell back options.** Three options exist for selling back the surplus electricity: to the grid at feed-in tariff (KWKModG 2009) or to the German wholesale market EEX or both combined. The market sale option is only open to the aggregation configurations allowing for flexible operation (see ii1). The table below sums up the different scenarios considered. <table><tr><td>*Individual vs aggregated configurations*</td><td>*Sell back at FIT (KWK law)*</td><td>*Sell back to market (EEX)*</td><td>*Combined*</td></tr><tr><td>*Individual CHPs in heat driven mode, whatever ownership*</td><td>0_{KWK}</td><td>0_{EEX} *(theoretical)*</td><td>*N/A*</td></tr><tr><td>*Aggregated CHPs with flexible operation, whatever ownership*</td><td>2_{KWK}</td><td>1_{EEX}</td><td>$3_{EEX/KWK}$</td></tr></table> *The estimation of benefits is simulated for these five scenarios, and for both individual and aggregated configurations (for each, ownership by retailer and by end user are considered).* **3. When comparing a standard heat driven operation of single units and the flexible operation of aggregated units, the profit for the former reaches 645€ per year and unit compared to 685€ for the latter.** The CHP investment and maintenance costs per kW being controversial and questioning the business profitability, only operational cash flows (EBITDA) are displayed on the following example comparing a basic case (0_{KWK}) and an aggregation case (2_{KWK}). *(The results of the computations are shown in Figure 3)* **4. The 40€ surplus (+6%) correspond to the value of**

aggregation.

This sets an upper limit to the aggregation costs (ii1). Such low aggregation costs can only be achieved through a high degree of standardisation and maturity of IT technologies.
All in all, the aggregation business is only interesting if the operation of the CHP itself, with investment and maintenance costs, is profitable.

5. **A Field test with 10 WhisperGen Stirling engines over year 2008 in Berlin proved the general usability of the µCHPs and the control system via GPRS signals, with reliability above 99%.**

10 µCHPs installed at GASAG residential customer sites were remotely controlled from RWE head office using the DEMS system developped by Siemens. A heat storage was used to enable decoupling heat and electricity demand to provide significant flexibility. Next to the identification of real investment, installation and maintenance costs the field test proved the general usability of the µCHPs and the control system via GPRS signals (reliability of the control system above 99%). Regarding the aggregation business, the field test indicates that the DEMS signal was successful in 50% of the time and that on average 8 units were necessary to sell 1 kWh_{el} to the market. Due to the fact that higher-level restrictions limited the actual access to control the µCHP, these numbers could be improved by allowing an unrestricted control.
In course of the field test, different control strategies such as scheduled, individual and statistical control have been tested and compared to each other showing that the statistical approach could be a practical solution.
Furthermore, different comparison calculations have been performed (see the cards on tests):

- The standardized load profiles used for the theoretical calculations have been compared to the real load profiles obtained from the field test.
- The theoretical possible revenues by using the real load profiles and the theoretical efficiency of the unit have been compared to the real production and the real measured efficiency.
- The modelling tools have been validated by comparing the real production with the modeling results (based on real load profiles and measured thermal, electric and overall efficiencies).

6. **Annual savings reach 1.4 t CO2 per unit, 170€ avoided grid charges and potentially 40€ reserve contribution.**

On the one hand, the impact on the CO2-emissions and on the other hand the impact on the grid and the reserve contribution. Generating heat and electricity with a µCHP unit compared to standard generation (using a merit order model for the purchase of electricity from the grid and producing heat with a conventional gas-fired boiler) saves about 1.4 t CO2 per unit and year. The avoided grid charges for one unit correspond to roundabout 170€ per year and if a reserve contribution would be possible, this would add about 40€ to the yearly profit.

Illustrations
(1 or 2, with max. 30 words per legend)

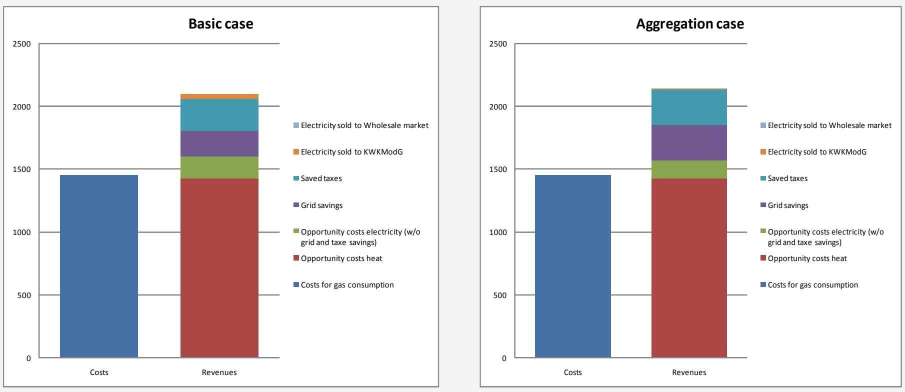
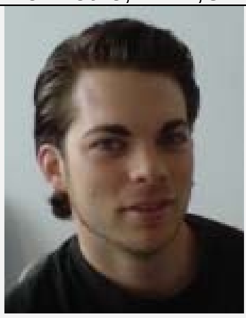


Figure 3: Operational results Basic case (left) and Aggregation case (right)

Use of knowledge
(no maximum)

- One-Year Test Campaign
- Power Quality Testing
- Sociological Survey

	- States of the Art - Demand Analysis Tools - Business Simulation Tools - Technology and Country Database - Demand Knowledge - Cost Analysis - Regulation Knowledge - Standard Knowledge - Network Knowledge - Power System Knowledge - Energy Market Knowledge
References (max 3 references, max. 150 words)	- *C. Weber, P. Vogel (2005): Decentralized energy production and electricity market structures; Fourth Conference on Applied Infrastructure Research,http://www.infraday.tu-berlin.de/fileadmin/documents/infraday/2005/papers/Vogel_weber_Decentralized_Energy_Production_and_Electricity_Market_Structures.pdf* - *"Deuse, J. et al (2007): Use of system charges methodology and norm models for distribution system including DER, C I R E D. 19th International Conference on Electricity Distribution. Vienna, 21-24 May 2007. Paper 76. CIRED2007 Session 6. Paper No 76. Page 1 / 4, www.cired.be/CIRED07/pdfs/CIRED2007_0076_paper.pdf "*
Stakeholders (max. 8 stakeholders)	-
Contacts (max. 3 contact names)	Patrick Himmes, University of Duisburg-Essen, Patrick.himmes@ibes.uni-due.de Michael Laskowski, RWE, Michael.laskwoski@rwe.de Uwe Dietze, RWE,Uwe.dietze@tbe.de
Pictures of the Contacts (max. 3 pictures)	   **P. Himmes** **M. Laskowski** **U. Dietze**

Knowledge Block n°	ii3
Title	**Sensitivity analyses on the local business case** *Under some conditions as lower investment cost per kW_{el} the business starts to be promising*
Context (50 words)	Aggregating µCHP in the German Context is not yet profitable. Barriers to profitability must be identified, and the gap to profitability must be quantified. Different sensitivity analyses to identify the barriers to remove for an economic business are computed: - Larger unit with better heat-to-power ratio in a larger dwelling - Target costs (investment costs) - Lower amortization period - Electrical storage - Subsidy amount
Challenge (1 question, max. 25 words)	- What are the target investment costs and subsidy amount to reach profitability in aggregating µCHP in the German Context?
Results (max. 6 results, max. 500 words for the whole section)	**1. A market price-based scheme remunerating additionally the CHP flexibility increases the value of aggregation.** The flat feed-in tariffs in the current German regulation don't allow benefitting from the flexibility of µCHP as the electricity is sold at a fixed price whenever it is produced. The issue is therefore to assess the value that could be created for the system if the subsidiary scheme would be more flexible. Beside only selling the electricity to the wholesale market as done in some cases (described in card ii1 and calculated in card ii2), a new kind of regulatory regime is implemented: the produced electricity is always sold to the wholesale market, being remunerated with the hourly price plus a fixed incentive (5,11, corresponding to the current bonus payment) on top without self-consumption of the produced electricity. Hence, the operator of the unit has to buy the electricity to cover the energy demand at the wholesale market. This implements a full integration of the units in the market with higher value for aggregation. However the overall business case (including investment costs) is not profitable in that case compared to the current context cases due to lower revenues caused by decreasing subsidies (no incentives for investment costs and no indirect subsidies by the self consumed electricity as all produced power is remunerated with the hourly price plus a fixed incentive and not partly valued by the retail price including grid costs and taxes). The target incentive to reach break-even in those cases would be at about 75 ct/kWh. **2. Profitability can be reached when targeting larger customers with higher heat to power ratio.** In this analysis, the unit is substituted by a larger unit (higher electric efficiency and larger overall capacity) operated in a multi family dwelling with 6 apartments in order to show the impact of a better heat-to-power ratio. The same cases as in ii2 are calculated and the results show, that this ratio together with the lower investment costs per kWel significantly impacts the business due to the decreased costs on the one hand and increased revenues on the other hand (more opportunity costs for avoided purchase and more sold electricity). *(The results of these computations are shown in Figure 4)* **3. Electrical storage costs must target a 80% reduction by 2020.** Heat and power demand can be decoupled by using either heat storage or electricity storage. This issue is studied by modelling some cases with electricity storage and comparing the performance of those cases with the comparable non-storage case. As costs for investing in such electricity storage are very high, the main focus of this analysis is the target cost for the storage. Compared to the "standard" case (without storage) about 80€ of additional receipts can be made by using electricity storage (EBITDA). In conclusion, to reach the same annual profit as for the non-storage case (= 1103€ including

annual maintenance and annualized investment costs), the investment costs for the electricity storage need to be at most 850€, which involves a decrease of about 80% of the total investment costs.

4. **Target cost analyses allow inferring the level of optimal subsidy to reach break-even.**

(subsidy level, investment costs and payback/amortization period)
In this section, 3 analyses on costs are performed: target costs for investment in the unit; target costs of the unit at a lower amortization time (7 years instead of 15); and the optimal subsidy level for break-even. In the table below, the target costs (to reach break-even under given regulation) are listed for the small µCHP engine in every calculated case: it ranges from €4,000 to €7,500.
(The target investment costs for each case are shown in Figure 5)

Illustrations
(1 or 2, with max. 30 words per legend)

	Scenario					
	Current Context					Market Integration
Configuration	0_{KWK}	0_{EEX}	1_{EEX}	2_{KWK}	$3_{EEX/KWK}$	
Basic	A: 1485	C: 901	X	X	X	X
Contractor	B: 1316	D: 1283	X	X	X	K: -974
VPP Operator	X	X	E: 979	G: 1012	I: 1103	L: -1089
VPP Operator & Investor	X	X	F: 1362	H: 1395	J: 1485	M: -845

Figure 4: multi-family house results (annual profit/loss in € per unit)
In the Market Integration cases, no further subsidies (direct investment grant, indirect subsidies by valuating the self-consumed electricity with the retail price including grid costs and taxes as in the current context as all produced electricity is sold to the market) are considered which results in lower overall profitability but higher aggregation value (case M - case K).

	Scenario					
	Current Context					Market Integration
Configuration	0_{KWK}	0_{EEX}	1_{EEX}	2_{KWK}	$3_{EEX/KWK}$	
Basic	A: 9617	C: 8407	X	X	X	X
Contractor	B: 7201	D: 7231	X	X	X	K: 4229
VPP Operator	X	X	E: 7380	G: 7442	I: 7520	L: 4682
VPP Operator & Investor	X	X	F: 5339	H: 6436	J: 6500	M: 4160

Figure 5: Target investment costs for the single family house (in €)
As no further subsidies (direct investment grant, indirect subsidies by valuating the self-consumed electricity with the retail price including grid costs and taxes as in the current context as all produced electricity is sold to the market) are considered in the Market Integration cases, the overall profitability in these cases is lower and therefore the target costs are lower as well compared to the current context cases.

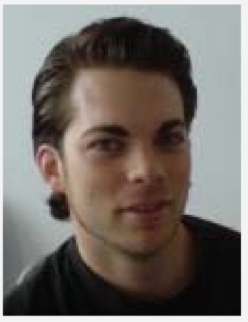
Use of knowledge
(no maximum)

- Business Simulation Tools
- Technology and Country Database
- Cost Analysis
- Regulation Knowledge
- Standard Knowledge
- Network Knowledge
- Power System Knowledge
- Energy Market Knowledge

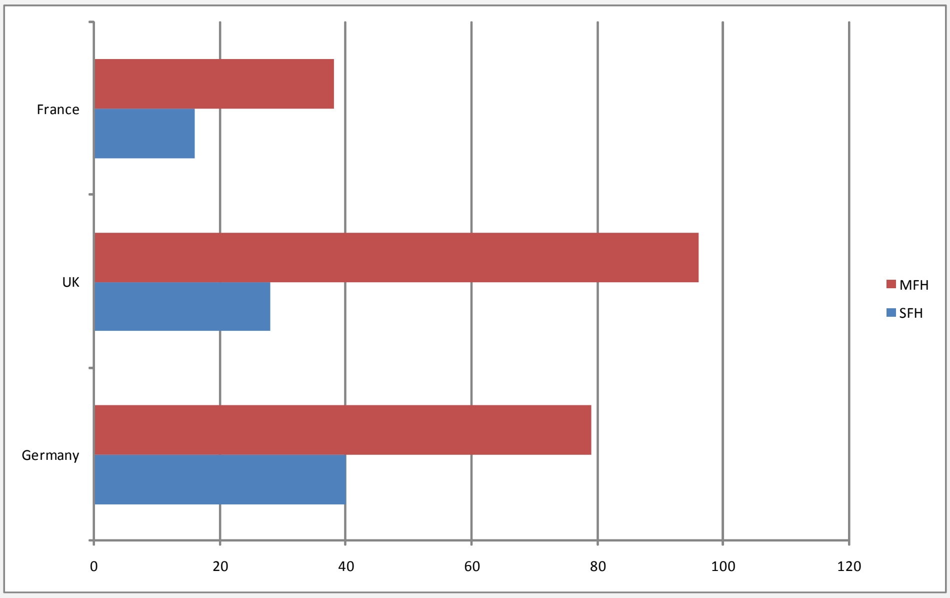
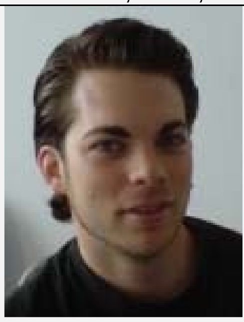
Stakeholders
(max. 8 stakeholders)

-

Contacts
Patrick Himmes, University of Duisburg-Essen,

(max. 3 contact names)	Patrick.himmes@ibes.uni-due.de Michael Laskowski, RWE, Michael.laskwoski@rwe.de Uwe Dietze, RWE,Uwe.dietze@tbe.de
Pictures of the Contacts (max. 3 pictures)	 **P. Himmes**  **M. Laskowski**  **U. Dietze**

Knowledge Block n°	ii4
Title	**Extending the business model to other countries** *Aggregation is interesting in the UK but operating a µCHP unit profitable is still very difficult due to high investment costs*
Context (50 words)	The German context to the profitability of µCHP aggregation is compared to other Member States (UK and France) with country-specific assumptions, notably assumptions on prices and regulations, such as subsidies for µCHP-units and investments grants for example.
Challenge (1 question, max. 25 words)	- Is the µCHP aggregation business model more efficient in France, in the United Kingdom (UK) or in Germany?
Results (max. 6 results, max. 500 words for the whole section)	Calculations for two different cases (basic operation and aggregation mode) each for a single family house and a multi family dwelling are done. A value for aggregation is calculated by comparing both cases and the impacts on CO2 are extracted. **1. µCHP-units are more profitable in Germany than in the UK and in France in the heat driven cases.** The German case seems to be, due to the high remuneration and support by the KWKModG combined with the relatively high electricity prices and therewith high opportunity costs for avoided purchase, the "best" country even for a normal, heat-driven configuration. Besides, the gas prices for the gas burnt in the boiler and in the CHP-unit and the spread between those prices and the gas-electricity price have an impact on the comparison of the different countries. Compared to the German case, the UK seems to be the second best option and close to profitability, followed by France where the market structure (e.g.: electricity and gas prices) is less favourable for the implementation of CHP units, even if there is a feed-in tariff, although rather low. The main difference besides the retail prices is the existence of investment cost subsidies as the Enhanced Capital Allowances (ECA: http://www.eca.gov.uk/) in the UK and the "Impulse Program" included in the KWKModG in Germany. **2. In the aggregation cases, µCHP units in Germany are more profitable than in the UK and in France.** Due to the high remuneration and support by the KWKModG and the relatively high electricity prices and therewith high opportunity costs for avoided purchase, Germany is seen as the "best" country. Furthermore, the spread between the gas price for the gas burnt in the boiler and in the CHP-unit has an impact on the comparison of the different countries. The UK seems to be the second best option followed by France were electricity and gas prices do not favour the implementation of CHP units, even if a, rather low, feed-in tariff exists. The main difference besides the retail prices is the existence of investment cost subsidies as the ECA in the UK and the "Impulse Program" in Germany. In these cases the different wholesale market prices and the flexibility of the remuneration scheme (feed-in or flexible scheme) affect the amount of electricity that is sold to the market by using flexibility and the remuneration for this electricity. **3. The aggregation value is the highest in UK followed by France and Germany.** As stated in ii3, the existing German feed-in tariff (Reference case with selling the surplus electricity to the grid, being remunerated only by the CHP-law) does not privilege flexibility. Hence the value for aggregation is the highest in the UK, at least for the MFH (in the SFH cases, the produced electricity is mostly used for covering the own demand and not much surplus can be sold) due to the extremely flexible support scheme (electricity sold at wholesale market plus an incentive, comparable to the Market integration scenario of ii3 but with investment grant). The UK is followed by France and Germany. In the graph of Figure 8, the aggregation value of the different countries is compared. *(The aggregation value is displayed in Figure 6)*

Illustrations (1 or 2, with max. 30 words per legend)	 **Figure 6: Comparison of the values of aggregation in different countries**
Use of knowledge (no maximum)	- State of the Art - Demand Analysis Tools - Business Simulation Tools - Technology and Country Database - Demand Knowledge - Cost Analysis - Regulation Knowledge - Standard Knowledge - Network Knowledge - Power System Knowledge - Energy Market Knowledge
Stakeholders (max. 8 stakeholders)	-
Contacts (max. 3 contact names)	Patrick Himmes, University of Duisburg-Essen, Patrick.himmes@ibes.uni-due.de Michael Laskowski, RWE, Michael.laskwoski@rwe.de Uwe Dietze, RWE,Uwe.dietze@tbe.de
Pictures of the Contacts (max. 3 pictures)	 **P. Himmes**  **M. Laskowski**  **U. Dietze**

Knowledge Block n°	ii5
Title	**Projections of the business model in different futures** *Changing some assumptions as investment costs and flexible support scheme, the business becomes very promising in a 2020 horizon*
Context (50 words)	The profitability of µCHP aggregation relies on certain parameters that are largely influenced by political decisions. Forecasting the possible evolutions of the energy framework can help assess the best conditions of profitability for the µCHP aggregation businesses in the future. -
Challenge (1 question, max. 25 words)	- How could the profitability of a business model on µCHP aggregation change in the future?
Results (max. 6 results, max. 500 words for the whole section)	**All configurations simulated in the business model are tested against four different scenarios for 2020.** Three extreme scenarios are respectively driven by liberalized Market trade (M=market); strong policy towards CO2 reduction (SCC=smart climate change); and concern for security of supply (=SoS). An intermediate scenario reflects a lack of coordinated European policy in these drivers (ND=No Direction). The critical changes for the business case in the different scenarios are changes in the assumptions on - Investment costs - Maintenance costs - Subsidies - Electricity and gas retail prices - Spot prices (See card R5) In each and every possible future described above, two cases are modelled, one basic operation mode case and one aggregation mode case in order to assess the benefits of aggregation. In each scenario, different key drivers are changed (remuneration scheme, retail prices for electricity and gas, spot market level, spot market volatility, investment and maintenance costs etc) in line with the orientation of each scenario. Those parameters significantly influence the business case. The assumed retail prices influence the costs on the one hand (costs for gas consumption) and the revenues (for heat generation and avoided electricity purchases) on the other hand as also the opportunity costs depend on the retail prices. On the revenue side, there are intra-scenario differences based on the operation mode: the aggregation mode always produces more revenues, mainly from sold electricity, than the basic operation mode. **The Smart climate change scenario is the most promising one for µCHP aggregation.** All in all, the smart climate change scenario is the most interesting one for µCHP implementation and for the aggregation business. Due to an attractive and highly flexible remuneration scheme, flexibility is very interesting and due to the market structure (retail price level and spread towards gas), the operation of µCHP units itself is highly profitable. In this scenario, the aggregation operation mode totally changes the structure of the incomes from opportunity costs of avoided purchase as main source of revenue in the basic scenario to incomes by exploiting the advantages of the flexible support scheme. This also holds for the market oriented scenario that shares the second place with the no direction scenario. The aggregation business is more valorised in the market scenario due to the more flexible support scheme, but the operation itself is, due to the higher electricity prices, more interesting in the no direction scenario. In the security of supply scenario, µCHP and their aggregation are not a very profitable business due to fixed feed-in tariffs and an all in all not very interesting market environment. *(The single family results for each scenario are shown in Figure 7)* For the multifamily dwelling, the same observations as for the single family

dwelling can be made; but due to the better power-to-heat-ratio of the unit and the demand, the differences in the revenues are considerably higher. Another aspect is that storage capacities can be used in a more efficient way and are used more frequently than for the single family house .
(The multi family results for each scenario are shown in Figure 7Figure 8)
In the graph below, the different aggregation values are illustrated.
(The aggregation values are shown in Figure 9)

Illustrations
(1 or 2, with max. 30 words per legend)

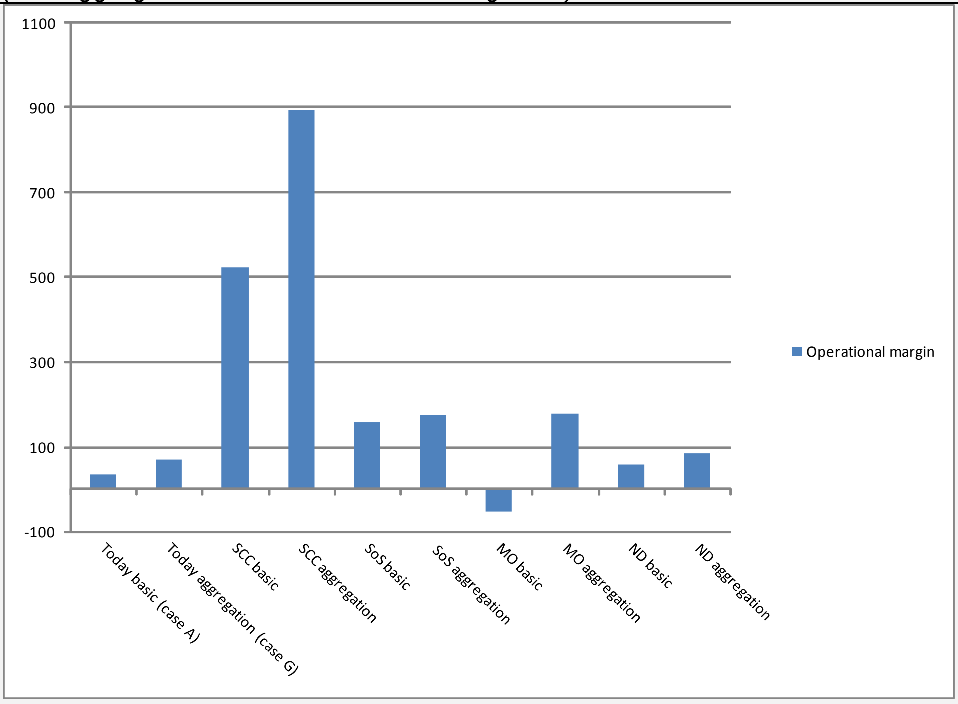


Figure 7: Profitability of the different scenarios (single family house)

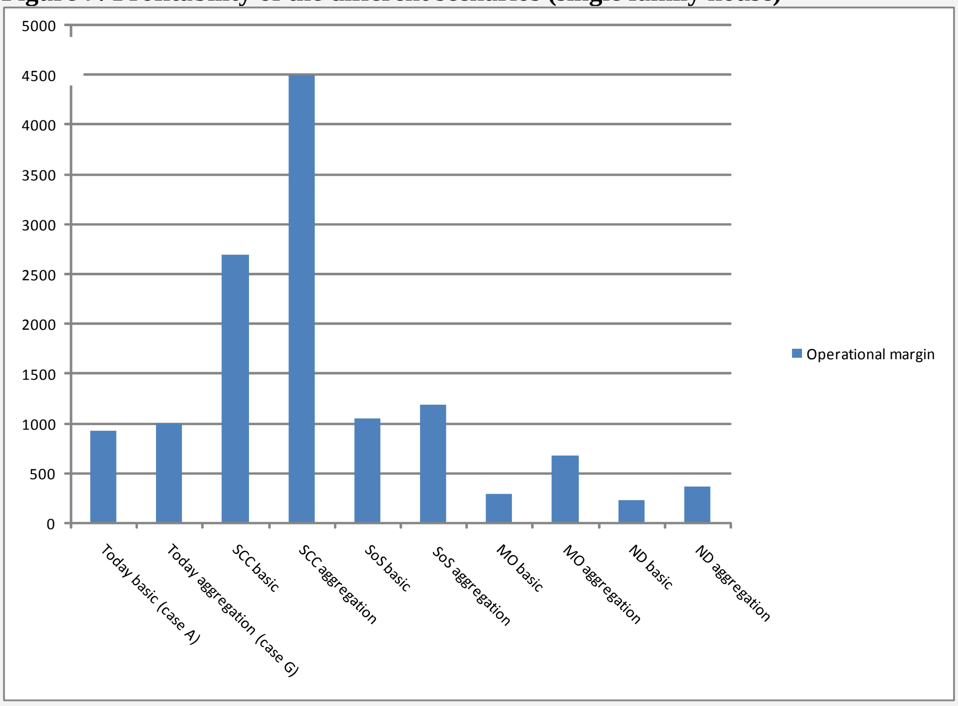
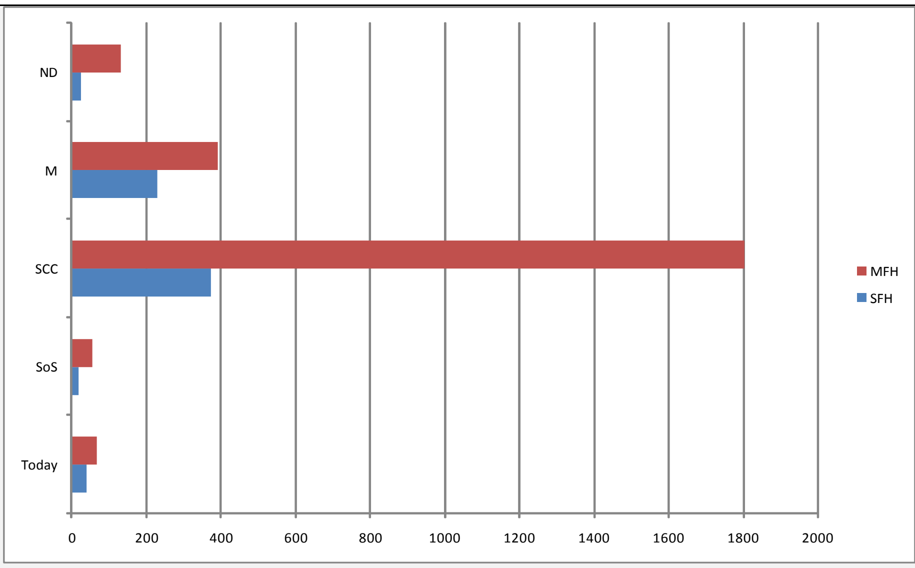
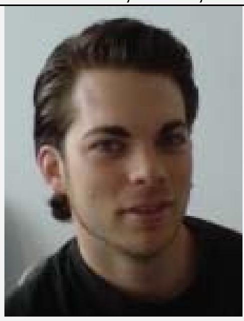
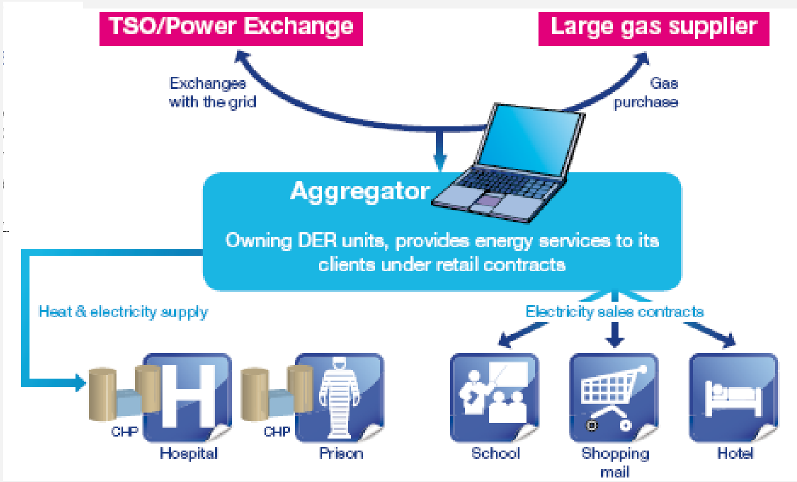
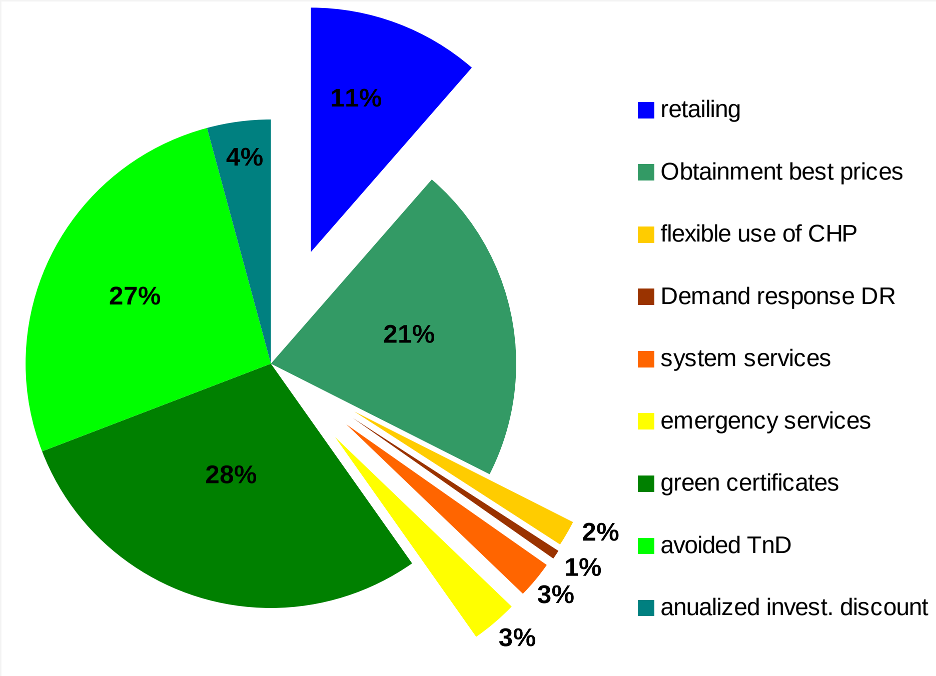


Figure 8: Profitability of the different scenarios (multi family house)

	 **Figure 9: Aggregation value of the different scenarios** *ND: Scenario No Direction* *M: Scenario Market* *SCC: Scenario Smart Climate Change* *SoS: Scenario Security of Supply*
Use of knowledge (no maximum)	- Business Simulation Tools - Cost Analysis - Regulation Knowledge - Standard Knowledge - Network Knowledge - Power System Knowledge - Energy Market Knowledge
Stakeholders (max. 8 stakeholders)	-
Contacts (max. 3 contact names)	Patrick Himmes, University of Duisburg-Essen, Patrick.himmes@ibes.uni-due.de Michael Laskowski, RWE, Michael.laskwoski@rwe.de Uwe Dietze, RWE,Uwe.dietze@tbe.de
Pictures of the Contacts (max. 3 pictures)	 **P. Himmes**  **M. Laskowski**  **U. Dietze**

Knowledge Block n°	iii 1
	Aggregation of high efficiency CHP units and Demand Flexibility can allow extending the ESCO business model by reaching new markets and improving CHP economics
Context (50 words)	Distributed generation based on high efficiency CHP units can help tackling climate change challenges. However profitability of such installations is not obvious. Aggregating flexibility of CHP units and loads can help reach new markets and improve the CHP economics.
Challenge (1 question, max. 25 words)	– What sources of revenues are available in the business of aggregating small and medium size CHP units?

Results (max. 6 results, max. 500 words for the whole section)	**The investigated business idea concerns the activities of a new type of Energy Service Company (ESCO) that aggregates small and medium-size consumers for which it invests in CHP units and proposes demand response contracts.** This company makes its business on delivering energy services to commercial and tertiary sector consumers, and trying to access new markets with enhanced flexibility of its portfolio (figure 1). The business as described consists of three strongly inter-related levels: retailing of energy to final consumers, investing in CHP units to lower energy supply costs and taking measures to enhance the flexibility of the generation-load portfolio. Each of these three levels can be profitable, but combined together they offer important synergies. **The first level of the aggregation business is retailing defined as making profit supplying the energy to final consumers.** The basis for this profit is a price mark-up between the wholesale and retail electricity prices. This revenue stream is highly dependent on the trading, energy and risk management abilities of the aggregator. As retailing business is generally quite competitive in Europe, the opportunities lie in reduction of energy purchase costs that can be realized thanks to utilizing the two remaining levels of the flexible ESCO aggregation business. **Energy supply costs of the aggregator can be reduced thanks to investment in CHP units, leading thus to higher retailing profits**. By replacing conventional boilers with adequately chosen CHP units one is able to significantly reduce the energy supply costs. Even if the CHP units are run in base-load heat following mode (i.e. at full load whenever there is heat demand), the energy efficiency gains (see *obtainment of best prices* on figure 2) complemented with dedicated support schemes (see *green certificates* and *avoided T&D charges* on figure 2) is enough to offset the investment costs. Note that in case of aggregation, the purchasing power related to large quantities of equipment allows to reduce the costs of CHP installations as compared to individual investors (see *annualized investment discount* on figure 2). **Energy supply costs can, as the third level, be further reduced by extracting the flexibility of the generation-load portfolio using both the flexibility of CHP units and demand response**. CHP investment can give more benefits by dispatching the units in a flexible way driven by optimization of the complete energy portfolio. The opportunities enabled by this, range from increased efficiency of energy purchases (flexible use of CHP) to the ability to deliver system services to transmission system operators (e.g. system services, emergency services). Moreover, a flexible portfolio is able to deal with uncertainties more effectively, limiting the exposure to high market prices or imbalance positions on the balancing market.

Illustrations (1 or 2, with max. 30 words per legend)	 **Figure 1. Graphical representation of the main stakeholders and flows in the business model**  [KP72] **Figure 2. Split of gross revenues of the aggregators into different value streams: *retailing* (blue), *CHP investment* (green) and *portfolio flexibility* (other)**
Integration (no maximum)	**[These results integrate outputs from:]** – Business Case 3: Aggregation of small and medium size CHP units and demand response – Grenoble Test Campaign – Athens Test Campaign – Sociological Survey – 3 States of the Art – Tools
References (max 3 references, max. 150 words)	– *Konrad Purchala,""Aggregation of small and medium size CHPs", 3rd International Conference on Renewables and DER integration, Nice 2008.*
Stakeholders (max. 8 stakeholders)	**[The following stakeholders can be interested by this Knowledge Block]** – Energy producers and Retailers – Energy Managers of End Users – Regulators and Policy Makers – Scientific Community – Manufacturers – Investors

	– DSO – TSO –
Contacts (max. 3 contact names)	Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Jacques Deuse, Tractebel Engineering, jacques.deuse@tractebel.com Antonio Pereira, Tractebel Engineering, antonio.pereira@tractebel.com
Pictures of the Contacts (max. 3 pictures)	 **K. Purchala**  **J. Deuse**  **A. Pereira**

Knowledge Block n°	iii 2
Title	**ESCO aggregation business can be profitable today in Belgium**
Context (50 words)	The Belgium context regarding CHP can be favourable to CHP aggregation businesses. To validate this assumption, business cases with several configurations have been tested.
Challenge (1 question, max. 25 words)	– What profitability increase can be gained by making use of the flexibility from the CHP units in the Belgian energy context?

Results (max. 6 results, max. 500 words for the whole section)	The business case has been investigated in the Belgian context, characterized by a sufficient heat demand and more importantly a flexible CHP support. The CHPs are effectively integrated in the portfolio of the grid user (i.e. the aggregator) making their dispatch subject to balancing obligations. **ESCO business of aggregating CHP units and delivering energy to end-clients can be profitable in Belgium today.** Analysis based on 2006 market prices and a portfolio of typical clients from the commercial segment yields Internal Rate of Return (IRR) values of about 10%, obtained thanks to retailing and CHP investment. The largest share of profitability is related to CHP investment (Figure 1). By consuming the locally generated energy one is able to avoid paying Transmission & Distribution Use of System charges (T&D charges) and other non-energy components of the final electricity price. On top of that, high efficiency CHP installations are liable for green certificates. **The obtained profitability can be further increased with about 1.5-2 percentage points by making use of the flexibility of the generation-load portfolio**. By employing a flexible dispatch of the CHP units one is able not only to increase the arbitrage efficiency between different energy markets (gas vs wholesale electricity), but also to enter new markets such as ancillary services. The revenue streams related to enhanced flexibility should generate sufficient added value to cover the associated costs such as increased aggregation costs (more advanced control equipment, higher personnel costs) and lower income from support schemes (less running hours). In Belgium 2006 the net result proved to be positive rendering 0.62% reduction of the portfolio annual energy supply costs (see Figure 2). The critical point here is the income from system services as without considering this revenue stream it is difficult to reach a profitable case (see Figure 2). **Enhanced portfolio flexibility improves risk-hedging abilities of the flexible ESCO.** Thanks to flexible DER units, demand response and other flexibility enhancing means, ESCO is able to secure the margins created on supplying the retail energy to end-clients by hedging against both the price risks (high wholesale prices) and quantity risks (improved self-balancing ability leading to lower imbalance payments). As a result, a flexible ESCO will see 10-20% less imbalance costs than an inflexible one. **Command and control architecture of the aggregation business has been validated by real-life experiments carried out in the project.** Both centralized and decentralized approaches have been successfully tested on-site. A centralized control using DEMS software was tested in the UK, where demand response capabilities of different clients were aggregated and valorised. Decentralized approach based on Multi-Agent System (MAS) was tested in Greece, where agents controlling generation and flexible demand of the clients were interacting in a multi-layer structure to reach an optimal decision for each time frame. **Clients of the flexible ESCO are able to benefit from some 2-6% energy bill reduction.** These savings strongly depend on the consumption profile of the client. The basis is the sharing of avoided T&D charges and other DER benefits between the client and the ESCO. Given that the CHP investment is carried out by the ESCO with no financial participation of the clients, this reduction of the energy bill is quite significant and most importantly comes at practically no costs. **Flexible ESCO business can offer significant benefits for the TSO**. As ESCO assumes the responsibility for forecasting and balancing of their CHP generation, the TSOs will have less system balancing costs. This is especially important in the presence of significant share of small resources dispersed beyond the system operator observability. Moreover, flexible ESCOs making use of distributed resources extend the number of system services providers.

Illustrations
(1 or 2, with max. 30 words per legend)

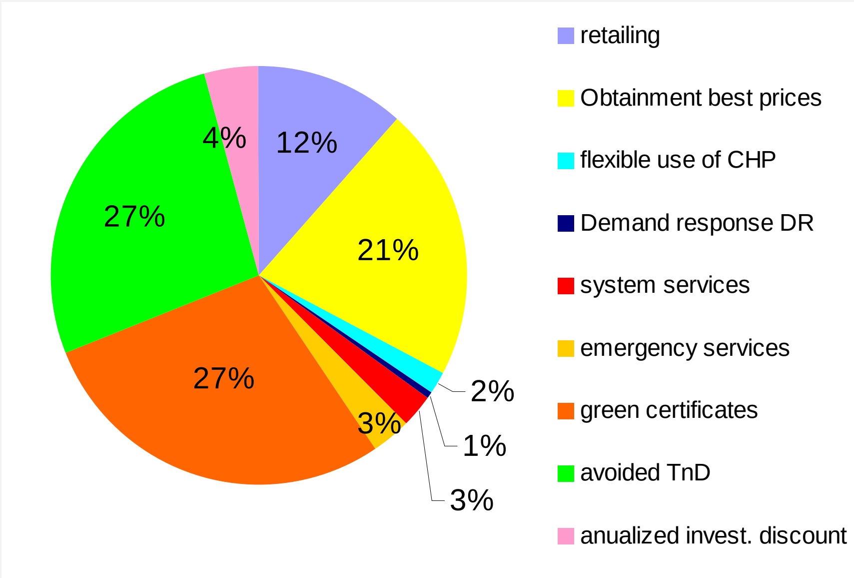


Figure 1. Split of the gross revenues of the flexible ESCO in different value streams.

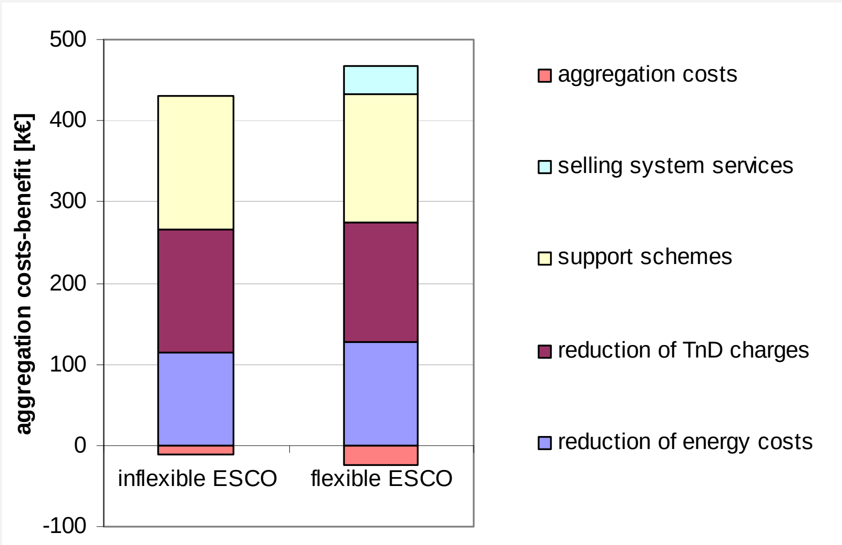


Figure 2. Cost-benefits analysis of aggregation

Integration
(no maximum)

[These results integrate outputs from:]

– Business Case 3: Aggregation of small and medium size CHP units and demand response
– Grenoble Test Campaign
– Athens Test Campaign
– Sociological Survey
– 3 States of the Art
– Tools

References
(max 3 references, max. 150 words)

– *Konrad Purchala, Jacques Deuse, "Distributed Generation as a Hedging Instrument in Energy Retailing Business", CEPSI 2008, Macau*

Stakeholders
(max. 8 stakeholders)

[The following stakeholders can be interested by this Knowledge Block]

– Energy producers and Retailers
– Energy Managers of End Users
– Regulators and Policy Makers
– Scientific Community
– Manufacturers
– Investors
– DSO
– TSO
–

Contacts (max. 3 contact names)	Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Jacques Deuse, Tractebel Engineering, jacques.deuse@tractebel.com Antonio Pereira, Tractebel Engineering, antonio.pereira@tractebel.com
Pictures of the Contacts (max. 3 pictures)	 **K. Purchala**  **J. Deuse**  **A. Pereira**

Knowledge Block n°	iii 3
	DER can offer risk hedging abilities for the portfolio management
Context (50 words)	Distributed generation based on high efficiency CHP units can offer risk hedging abilities for the portfolio management. Thanks to innovative flexible operation mode and the use of demand response, one is able to limit the exposure to imbalance penalties, and the impact of high wholesale prices
Challenge (1 question, max. 25 words)	– What is the impact of the main economic parameters on the profitability of the aggregation business?

Results (max. 6 results, max. 500 words for the whole section)	This analysis looked at the impact of key economic parameters on the profitability of the aggregation business. The main parameters analyzed were the CHP investment and installation costs, support schemes for high efficiency CHP, treatment of T&D charges and demand forecast errors. **CHP investment costs remain a critical point of the aggregation business, as each 10% discount can be translated into about 1 percentage point increase in Internal Rate of Return IRR.** (Figure 1). The similar effect can be found for installation costs as lowering these by 10% yields IRR values increased by about 0.5-0.6 percentage points. The reason for the above is that the cost related to CHP investment are the main fixed cost of the aggregation business. Note that the share of the benefits offered by reduced installation and investment costs depends on the size of the unit. Installation costs can amount up to 60% of the total costs for small machines and some 20% in case of larger ones. **The magnitude of CHP support schemes has a significant impact on the aggregation business as for each 10% increase of the green certificate price the business profitability increases by about 1.2 percentage points.** However, the reverse trend is also visible as lower bonus paid for energy produced using high efficiency CHP implies immediately lower business profitability. If the green certificate is worth a half of its current value (i.e. 35 EUR instead of 70 EUR), the business will lose 5% percentage points of IRR. This shows that the impact of support schemes is quite significant. **Lower transmission and distribution charges are the second most important revenue stream needed to justify the CHP investment.** In a regulatory framework where end-users benefit from the ability to auto-consume locally generated energy, avoided T&D charges can *make or break* the aggregation business. If these benefits could not be captured in the business case evaluation, the expected IRR would drop to 6.8%, being below the expected rate of 9%. **Increased portfolio flexibility improves the ability to deal with portfolio imbalances resulting from the incorrect demand forecast.** Thanks to its ability to flexibly change the energy generated by the portfolio by shifting heat production between CHP units and boilers, the aggregator is able to reduce its exposure to imbalance settlement payments. Comparing flexible and inflexible aggregators, one can see a difference of 10-20% in the ability to limit imbalance charges (figure 2). **Revenue coming from system services market is critical for the success of the flexible aggregation business.** Extracting flexibility from CHP units can imply less running hours, which is in turn detrimental to the incomes collected from the support schemes. Flexible CHP units that are switched on only when it is economically optimal run less full-load hours than the base-load non-flexible ones. Hence, in order to offset the possible loss on support schemes and to cover the increased aggregation costs, the direct value created by increased portfolio flexibility (*obtainment of best prices on the market*) must be complemented by the revenue stream related to the sale of system services.

Illustrations
(1 or 2, with max. 30 words per legend)

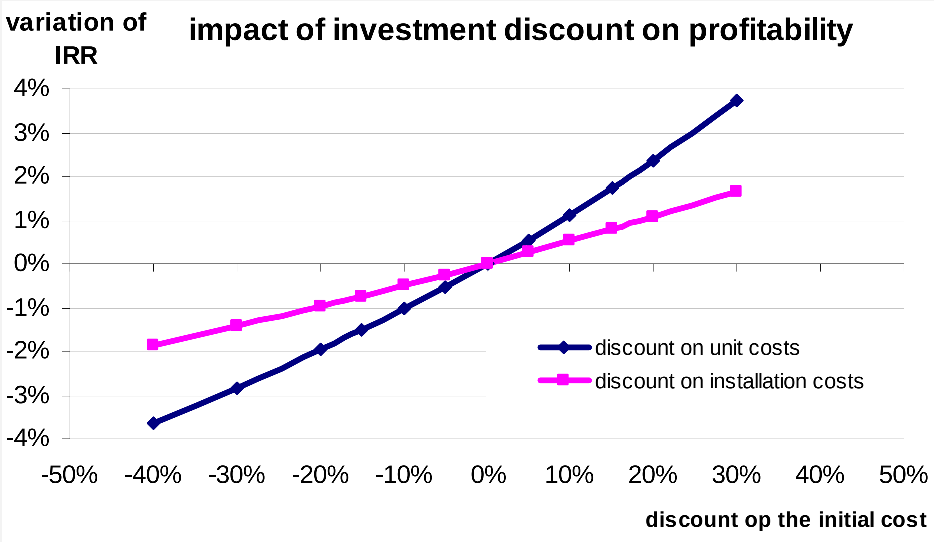


Figure 1. impact of investment and installation discount on business profitability

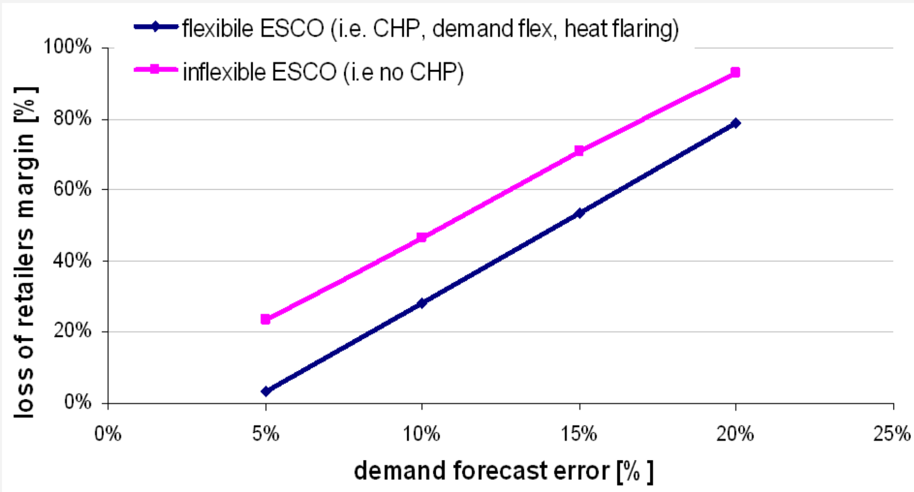


Figure 2. Benefits offered by flexibility (CHP, demand, etc). Inflexible ESCO vs flexible ESCO.

Integration
(no maximum)

[These results integrate outputs from:]

- Business Case 3: Aggregation of small and medium size CHP units and demand response
- Grenoble Test Campaign
- Athens Test Campaign
- Sociological Survey
- 3 States of the Art
- Tools

Stakeholders
(max. 8 stakeholders)

[The following stakeholders can be interested by this Knowledge Block]

- Energy producers and Retailers
- Energy Managers of End Users
- Regulators and Policy Makers
- Scientific Community
- Manufacturers
- Investors
-

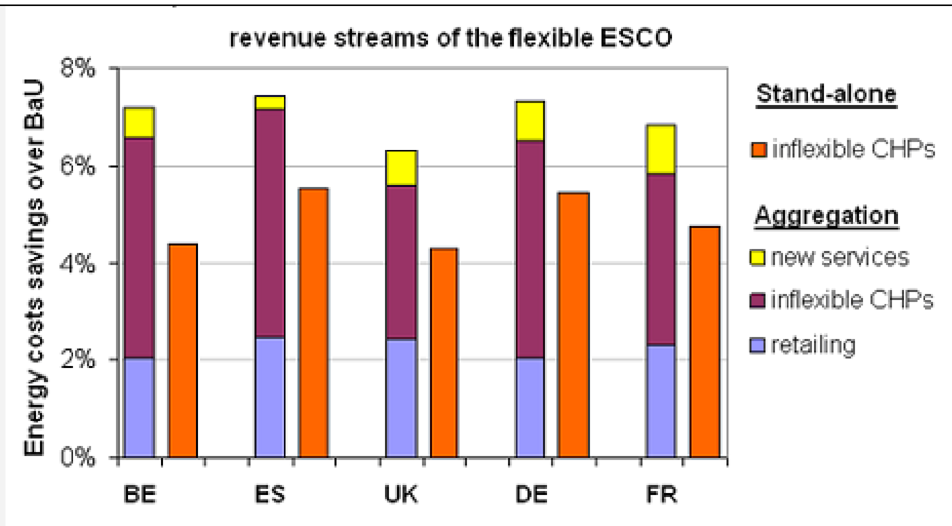
Contacts
(max. 3 contact names)

Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com
Jacques Deuse, Tractebel Engineering, jacques.deuse@tractebel.com
Antonio Pereira, Tractebel Engineering, antonio.pereira@tractebel.com

Pictures of the Contacts (max. 3 pictures)	 **K. Purchala**	 **J. Deuse**	 **A. Pereira**

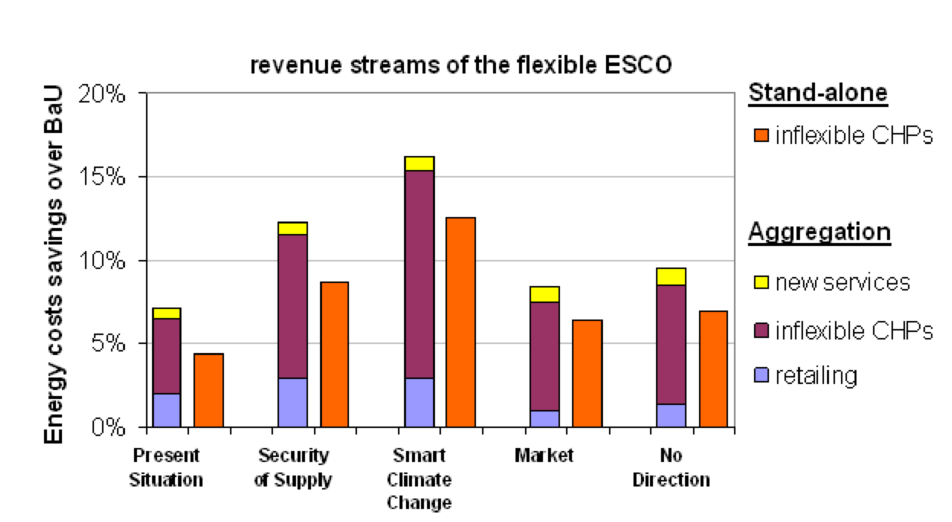
Knowledge Block n°	iii 4
	Belgium, UK and Germany are suitable for the aggregation business, while the presence of feed-in tariffs for all generated electrical energy makes such business infeasible in France and Spain.
Context (50 words)	Profitability of the aggregation business strongly depends on the regulatory regimes, especially on the absence of barriers limiting the access to certain markets for distributed energy resources. Moreover, in order to trigger the interest in flexibility of the DER one needs support schemes that offer the right incentives
Challenge (1 question, max. 25 words)	– What is the potential of CHP and demand response aggregation business in Germany, France, UK and Spain as compared to the native country of the business case, Belgium?

Results (max. 6 results, max. 500 words for the whole section)	In order to investigate the potential of the CHP and demand response aggregation business and quantify the impact of different regulatory schemes on business profitability, the business initially organized in Belgium has been extrapolated to Germany, France, UK and Spain. **In current regulatory conditions, Belgium, UK and Germany are suitable for the aggregation business, while the presence of feed-in tariffs for all generated electrical energy makes such business infeasible in France and Spain.** Business based on aggregation of flexible CHP units and demand response can be triggered only by adequate support schemes providing incentives for being flexible. In the presence of flat feed-in tariffs there is no interest in aggregation of DER units as all generated energy is sold at a predefined price. There is simply no new value that could be created to offset the increased aggregation costs. **Provided adequate CHP support schemes are put in place, offering equivalent level of support as compared to feed-in tariffs *but* allowing for additional benefits to be captured in case of smarter behaviour (i.e. green certificate system), the business made on enhancing portfolio flexibility has a potential in all studied countries.** The analysis performed in the studied countries shows that the flexibility of the CHP units and demand response can have sufficient value to make the flexible ESCO aggregation business profitable. Flexible support scheme allows the DER unit to be included in the portfolio optimization of the aggregator (retailer) improving the efficiency of energy purchase decisions. Further, this can be complemented with revenues from provision of system services. However, if no adequate support schemes are put in place, the owners and operators of the DER have no incentives to employ flexible dispatch. **Portfolio flexibility has the highest value in France, followed by Germany, UK and Belgium.** The benefits of flexible portfolio over the inflexible one are however quite limited, as the all-in energy supply costs can be reduced by some 1 percentage point in France, about 0.8 point in Germany, and around 0.6-0.7 in Belgium and UK. On the other hand, only 0.3 points can be expected in Spain. Though these numbers looks quite unimpressive, 1 percentage point of energy cost savings can correspond to some 1.5-2 percentage points of additional IRR that can be obtained by extracting value from portfolio flexibility. **Valorisation of the CHP units within the flexible ESCO aggregation business is significantly higher than for an inflexible stand-alone installation.** Flexible ESCO enables complementing the CHP investment value with revenue streams related to retailing ("becoming small scale utility") and increased flexibility of the portfolio (more efficient arbitrage between gas and wholesale prices, sale of system services, etc.). Moreover, the flexibility is also a risk hedging means that limits the exposure of the flexible ESCO to imbalance penalties. All in all, the comparison of IRR values between the stand-alone CHP and flexible aggregated one yields a difference in the range of one third to the benefit of aggregation.

Illustrations (1 or 2, with max. 30 words per legend)	 **Figure 1. Cross-country comparison of the impact of regulation arrangements on the business case results, values relative to the business as usual case [in%].**[AV73] **BaU:** Business as Usual. **Stand-alone inflexible CHP:** a single inflexible CHP unit owned and operated by the client, covering a part of the heat and electricity demand **Aggregation** (ESCO case) **Retailing**: revenues made on the difference between the wholesale and retail prices **Inflexible CHP**: revenues related purely to the CHP running in base-load heat following more, i.e. at full load whenever there is heat demand. **New services:** additional revenue that can be realized by flexible dispatch of the CHPs according to aggregator's energy optimization decisions, complemented with demand response and the sale of system services.
Integration (no maximum)	**[These results integrate outputs from:]** – Business Case 3: Aggregation of small and medium size CHP units and demand response – Grenoble Test Campaign – Athens Test Campaign – Sociological Survey – 3 States of the Art – Tools
Stakeholders (max. 8 stakeholders)	**[The following stakeholders can be interested by this Knowledge Block]** – Energy producers and Retailers – Energy Managers of End Users – Regulators and Policy Makers – Scientific Community – Manufacturers – Investors –
Contacts (max. 3 contact names)	Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Jacques Deuse, Tractebel Engineering, jacques.deuse@tractebel.com Antonio Pereira, Tractebel Engineering, antonio.pereira@tractebel.com

Pictures of the Contacts (max. 3 pictures)	 **K. Purchala**	 **J. Deuse**	 **A. Pereira**

Knowledge Block n°	iii 5
	Flexible ESCO business will experience more profitability in the future.
Context (50 words)	The profitability of CHP aggregation is highly dependant on energy policy choices, as well as on long term evolution of market prices and technology costs. The opening of several futures requires to investigate to which extent the aggregation business can be impacted by the future evolution of regulatory context, as well as mutual positions of different market segments.
Challenge (1 question, max. 25 words)	– What is the expected evolution of this aggregation business profitability in the future?
Results (max. 6 results, max. 500 words for the whole section)	All configurations simulated in the business model are tested against four different scenarios by 2020. Three extreme scenarios are respectively driven by increased market liberalization ("Market" scenario); strong policy towards CO_2 emissions reduction ("Smart Climate Change"); and concerns for security of supply ("Security of Supply"). This is complemented with an intermediate scenario reflecting a lack of coordinated European energy policy ("No Direction"). See card A6 for the scenario description. **Flexible ESCO business will experience more profitability in the future.** When extrapolating the business located in Belgium to future scenarios, one finds that the value of aggregation is to increase in all considered futures. This finding results from the fact that the future energy markets are characterized by increased volatility and price levels, two factors that increase the value of flexibility (i.e. better risk hedging capabilities). For this reason, the expected energy supply savings for the studied portfolio can be estimated at about 0.6% for the "Security of Supply" scenario to 0.9-1% for other scenarios. This suggests that aggregation has a potential to become a profitable business in the future. **Enhanced portfolio flexibility has the highest value in scenarios "No Direction", "Smart Climate Change" and "Market", indicting business potential in the flexible ESCO aggregation activities.** The main reason is that these scenarios are characterized by high volatility of both the wholesale prices and imbalance penalties. As volatility tends to reward flexibility, flexible ESCO is able to take profit of it by continuous optimization of its processes with respect to prices at different markets. For other scenarios characterized by more stable prices the value of flexibility is noticeably lower. **As far as the CHP investment is concerned, scenario "Smart Climate Change" steps forward with the highest profitability, while scenario "Market" is as expected the least interesting.** The main reasons are the height of support schemes and CHP investment costs. Scenario "Smart Climate Change" assuming low CHP investment costs accompanied by high support schemes yield best valorisation of the CHP unit. On the contrary, CHP investment benefits captured in the scenario "Market" are the lowest of all future scenarios as the revenues available on a free and competitive market are lower than the ones coming from support schemes imposed by national regulation. Note however, that the CHP remuneration in the scenario "Market" is higher than in the "Present Situation", suggesting that generally speaking market is able to deliver at least similar levels of profitability than non-market-based support schemes.

Illustrations (1 or 2, with max. 30 words per legend)	 **Figure 1. Cross-scenario overview of the benefits of the flexible ESCO vs the stand alone installation.** **BaU:** Business as Usual. **Stand-alone inflexible CHP:** a single inflexible CHP unit owned and operated by the client, covering a part of the heat and electricity demand **Aggregation** (ESCO case) **Retailing**: revenues made on the difference between the wholesale and retail prices **Inflexible CHP**: revenues related purely to the CHP running in base-load heat following more, i.e. at full load whenever there is heat demand. **New services:** additional revenue that can be realized by flexible dispatch of the CHPs according to aggregator's energy optimization decisions, complemented with demand response and the sale of system services.
Integration (no maximum)	**[These results integrate outputs from:]** – Business Case 3: Aggregation of small and medium size CHP units and demand response – Grenoble Test Campaign – Athens Test Campaign – Sociological Survey – 3 States of the Art – Tools
Stakeholders (max. 8 stakeholders)	**[The following stakeholders can be interested by this Knowledge Block]** – Energy producers and Retailers – Energy Managers of End Users – Regulators and Policy Makers – Scientific Community – Manufacturers – Investors –
Contacts (max. 3 contact names)	Konrad Purchala, Tractebel Engineering. konrad.purchala@tractebel.com Jacques Deuse, Tractebel Engineering, jacques.deuse@tractebel.com Antonio Pereira, Tractebel Engineering, antonio.pereira@tractebel.com

Pictures of the Contacts (max. 3 pictures)	 **K. Purchala**  **J. Deuse**  **A. Pereira**

Knowledge Block no	R1
Title	Recommendations for future large scale experiments
Context (50 words)	Several research and demonstration projects at national and EU level have looked after DER integration into the electricity grid at distribution level. The scale of the work appears to be too small to infer answers about issues such as future customer behaviour, technology reliability, influence of regulatory regimes, replication of the observed results. Integrated experiments (10.000 and beyond) customers over long periods of time and large areas are needed in a way similar to what was implemented by ENEL Distribuzione to launch smart metering in Italy.
Challenge (1 question, 25 words)	– What are the scaling rules required to size the demonstration projects? – How replicable are the experimental results obtained in such large projects?

Results (1 to 5 results, 500 words for the whole section)	EU-DEEP like many other projects has already pinpointed the immediate larger scale experiments which are required to validate the technical (such as control strategies or ICT improvements), or economic part of the foundations (like further validation of demand simulation tools). However, the real challenge is to reach a scale of integrated experiments where: • all the stakeholders are involved (TSO, DSO, generators, retailers, clients, regulators and equipment manufacturers) • various geographical implementation for the Distribution Network are studied (rural, semi-rural, urban) • technologies are deployed at a number of sites where real life behaviour of customers can be studied in order to converge on stable standards meeting the largest possible functional requirements of the involved technologies (leading to cost abatement when deployed at European scales) • market behaviours of large sets of clients can be monitored and/or tested with energy price signals that mimic what the future ones would be, and socio-economic studies are run in parallel to understand the resulting measured consumption / load. EU-DEEP proposes to segment the approach for large scale experiments into three main steps: **<u>Step 1</u>: secure "up to the meter" experimental infrastructures which will guarantee that the right level of smart metering is implemented to validate market designs and regulatory options** This requires the deployment of a full metering system with the appropriate regulatory authorisation and insurances to perform experiments with real life clients. **<u>Step 2</u>: secure "beyond the meter" samples of real clients that will experiment coupled DER and DSM approaches, within, whenever possible, aggregation business models** This requires the selection of groups of clients which are representative of the regional markets which will be under full scale scrutiny. **<u>Step 3</u>: secure "system" experiments which involve the system contribution to the DER <u>and</u> the DER/DSM** Contributions to the system (system services, balancing, behaviour under faulty conditions) can then be part of the experiments, and manageable at DSO level while "visible" at TSO level. These large scale experiments should be addressing one main issue at a time, and should be located in several regions of Europe to include the influence of system boundary conditions (interaction with the TSO, regulatory regimes) and customer habits. There are several directions of investigation: o DER management in rural networks o DER/DSM management in urban networks o DER/DSM in new eco districts with low energy buildings and electricity storage system. The results obtained will involve simulation to validate scalability and replicability in EU27.

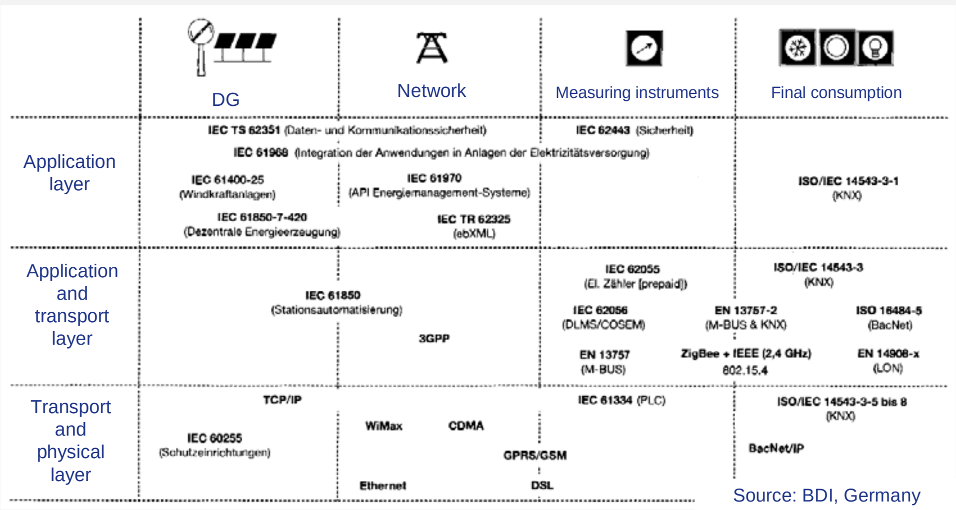
Use of Knowledge (no maximum)	*[The presented results have been produced from the following sources of knowledge. Please comply has much as possible with the proposed knowledge.]* – One-Year Test Campaign – Power Quality Testing – States of the Art – Demand Knowledge – Cost Analysis – Regulation Knowledge – Standard Knowledge – Network Knowledge – Power System Knowledge – Energy Market Knowledge
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (1 to 3 contact names)	Raúl Rodríguez, LABEIN TECNALIA, rsergio@labein.es Gilles Bourgain, GDF SUEZ, gilles.bourgain@gdfsuez.com
Pictures of the Contacts (1 to 3 pictures)	 

Recommendation°	R2
Title	**Distribution regulation and network design represent key parameters for the integration of Distributed Energy Resources**
Context (50 words)	The integration of DER poses a valid challenge to both industry and regulators. The regulatory model behind the Internal Energy Market (IEM) is based on a strict separation between the generation, transport and distribution of energy, where the tasks, rights and obligations of the two latter are defined by Directives implemented as national laws. For central generation, economic network regulation may be seen as a side constraint. For decentralized energy resources, however, economic regulation of both DER and the distribution network operators is an integral part of the business model. DER is promoted not only by externalities offered to other stakeholders and national environmental targets but also by network arguments such as deferred reinforcements. DER can be seen as a competitive [generation] or a regulated [network] activity and the delicate interaction between direct support and network charges will set the pace for the deployment.
Challenge (1 question, max. 25 words)	Which regulatory environment for coordinating DG and DSO activities, for promoting “efficient” use of network and for driving the right design towards a flexible distribution network?

Results (max. 6 results, max. 500 words for the whole section)	**DER can be both a complement and a substitute to network; the regulatory structure must reflect this, further the harmonization of the DER-DSO regulation interface is important to reduce regulatory risk and to promote investments.** DER that lead to deferred network investments may be promoted adequately by DSOs provided that their regulatory regime is based on total expenditure for a gross load output, not on markups on grid investments. As the substitution is highly location and time dependent, DSO participation is vital for full welfare effects. DER investments may also be complements, such as remotely controlled units provide value-added services on the network. In this case, the optimal regulation incentivizes joint investments from DER investors and networks to maximize impact. In this respect, traditional models using delegation or contingent investments perform poorly, whereas coordinated direct mechanisms give better results in terms of investment level and benefit. Since DER is both relatively new and “odd” under the EU-type network regulation, regulators have implemented a range of different rules for their interaction with DSOs and the DSOs service conditions towards them. In combination with parallel unsustainable support schemes of investments, energy or network charges, the resulting effect of diversity is regulatory risk that lowers investment incentives, impedes economies of scale in DER deployment, commercialization and increases operating costs for DSOs. DER penetration can be promoted at lower social costs and with a higher efficiency by harmonizing the DER-DSO regulations to a common set of rules and by clarifying what elements are sustainable. **Upgraded “Use of System” tariffs must be deployed for an “efficient” and sustainable integration of DER in the system.** DER located in medium and in low voltage networks can represent an additional value for the system. Principles for unveiling the value DG or load represents for the network can be derived from a “marginal” approach that considers the footprint of load or of generation on distribution network. For being applicable down to low voltage networks, the method requires large scale interval metering systems as well as *ex post* data management. Different stages of simplifications are possible in terms of metering. Equality of treatment principles must also be integrated when adjusting customers’ charges in function of location in the network. Further “Use of System” tariffs must be made stable enough from one year to the next. Regulatory bodies must be the catalyser for setting up these new “Use of System” tariffs, but they must be discussed with representative of all stakeholders. Incidentally, the large scale data gathering necessary for UoS tariffs represents an opportunity for the development of new services based on demand response. These data sets could be made available under anonymous individual load curves. **Integrating more DG means change in operation and design for the distribution system. Upgrading the design criteria for distribution networks to higher flexibly asks for new requirements that must be exogenously defined.** The impact of an increased number of DER on the cost of the system depends on the types of DER considered and on the network where they are connected. The additional investment costs due to DER integration depend on energy policy choices, including the associated operational rules that are imposed, amongst others the possibility to control power injection in case of contingencies. Increasing the “DER hosting capacity” of the network using or not active management requires the set up of new design criteria for developing and exploiting distribution networks. This is necessary because margins are needed if limitation on power injection must be avoided in case of network constraints. “Exogenous” objectives, often in close connection with objectives of energy policies, are necessary for fixing these targets: limitation of generation power per connection, objective in terms of penetration for RES, limits set for generation control in normal and abnormal conditions, etc. New design criteria for distribution networks can easily be developed as soon as clear objectives are defined. These objectives should be defined outside of the electrical supply industry, but with its participation. The definition of the respective roles of design and active management is an integral part of the process.

Illustrations (1 or 2, with max. 30 words per legend)	
Integration (no maximum)	–
Stakeholders (max. 8 stakeholders)	*[Not to be filled for the moment]* – XXX
Contacts (max. 3 contact names)	NO contact
Pictures of the Contacts (max. 3 pictures)	

Knowledge Block no	R3
Title	Beyond EU-DEEP: Recommendations to standardisation bodies
Context (50 words)	Future distribution networks will become more active to allow for the deployment and large scale integration of Distributed Generation units. An increased number of participants on the energy market, i.e. as aggregators or ESCOs, together with the increased involvement of smaller generation units, consumers and possibly storage, require a cost efficient and reliable data exchange between the different players through all the voltage levels. It is necessary to set up an affordable communication environment based on standardized protocols. However, today, ICT is applied only in transmission and subtransmission networks down to 110 kV, but not in medium/ low voltage distribution networks for cost reasons. Different standard and partly proprietary protocols for various levels and for different kinds of equipment are used to-day. The statements given here based on the experiences of the project consortium – although triggered by EU-DEEP – are of general importance and thus hold beyond the project as a framework condition for DER expansion.
Challenge (1 question, max. 25 words)	What are the key areas within which standardisation bodies should work to accelerate DER penetration in European grids, based on increased automation and demand integration (thus leading to promising business cases)?

Results (1 to 5 results, max. 500 words for the whole section)	**Recommendations are made to standardisation bodies to work on overall communication standards and protocols for seamless exchange of data: continuation of TC57 work on interoperability and worldwide marketing of the developed standard series** Overall communication standards and protocols for seamless exchange of data are still missing and must be developed. Within IEC TC 57 several parts are already addressed (IEC 61968 DMS; IEC 61850-7-420 DER, IEC 61970 EMS; IEC TS 62351 Security, see illustration). Interoperability between such protocols needs to be further developed, with some parts already being dealt with IEC 61850 & 61970. **Recommendations are made to standardisation bodies for smart metering requirements: the development of a harmonized Smart meter standard in Europe and its extension at international level via IEC is proposed.** The requirements for Smart metering needs to be harmonised: a draft mandate by the European Commission has been issued to develop a European standard for measuring instruments - standard for communication, protocols and functions. The standardization work can be expected to be done in Cenelec TC 13 and CEN TC 205, since gas, heat and water shall be included. **Recommendations are made to implement and ensure coordination at international level at IEC and Cenelec levels (and CEN if appropriate) when dealing with DER integration into electric networks** Standardization needs to be performed in a coordinated way at international level. Overlapping activities and proprietary standards must be avoided. It is recommended to concentrate work at international level via IEC and at European level via Cenelec (and where appropriate CEN). IEC TC 57 takes a central role in providing standards for a Smart Grid environment. Furthermore IEC decided to establish a Strategic Group on Smart Grid, which is supposed to coordinate the standardization work between the involved committees and parties (TC 8, TC 13, TC 57, TC 88 etc.).
Illustrations (1 or 2, with max. 30 words per legend)	 Current landscape of standardisation
Use of Knowledge (no maximum)	– One-Year Test Campaign – States of the Art – Energy Market Knowledge – Business Experience
Stakeholders	*[Not to be filled for the moment]*

(max. 8 stakeholders)	– XXX
Contacts (max. 3 contact names)	– Christine Schwaegerl, Siemens, christine.schwaegerl@siemens.com – Erich Fuchs, Siemens, erich.fuchs@siemens.com
Pictures of the Contacts (max. 3 pictures)	 

GLOSSARY on DER concepts

RIGHT SIDE

MESSAGES TO THE STAKEHOLDERS

9 executive summaries to cater for a wide variety of point of views

Stakeholder	Messages to policy makers
Title	Key messages coming from EU-DEEP
Context (150 words)	The 2008 IEA study for Europe quotes investments in excess of 1 Trillion € over the next 20 years to make the European electric systems meet a unique goal: decarbonising electricity production. The investments will include a large share of decentralised electricity production, both from renewable energy and combined heat and power facilities. They will also address the transmission and distribution networks in order to increase their capacity to accommodate DER connection onto the distribution network, without compromising system reliability and power quality.
Challenges (1 to 5 questions, 50 words)	– Can distribution networks accept large amounts of DER by 2010 and beyond? – How to increase the share of DER-based generation?
Results (1 to 5 results, 700 words for the whole section)	**EU-DEEP demonstrates that existing networks can already host large amount of Distributed Generation** Electrical power systems have been designed to meet the demand from centralised generating units. As long as the present network design criteria are complied with, it is possible to host a significant amount of Distributed Generation. This hosting capacity is site and technology dependent. For instance, the integration of 1 kW of combined heat and power units in the residential market of northern – western Europe is quite easy, which is just the opposite for 5 to 10 kW peak power PV units in the same area. **The hosting capacity of present distribution networks can be further increased by upgrading network management.** A loss of voltage control is probably the main technical concern when increasing DER penetration levels in distribution networks. Indeed, voltage profiles can increase and decrease along the various feeders depending on the load and generation locations. Adjusting the operational voltage as a function of network conditions allows for connecting larger amounts of DER units without requiring network reinforcement and abandoning previous design principles. **New design criteria should be developed in agreement with energy policy requirements.** Further increasing the "DER hosting capacity" of distribution networks requires network reinforcements based on new network design criteria. They can easily be developed whenever clear objectives for DER integration are agreed upon. These objectives should be defined outside of the electrical supply industry, but should be implemented with its participation to make sure that all the technical requirements are taken into account. This will require "exogenous" deployment objectives, closely connected to energy policies. For instance, limits could be put on deployment plans such as limited generation capacity per connection, minimum level of DER penetration in distribution, generation curtailment into specific operating conditions. **Reducing public subsidies for near to market DER is possible if they can access all the values they represent for the system.** Distributed Generation installed in medium and low voltage networks represent immediate value above energy delivery (network replacement) and, in the longer term, through the supply of system services. The absence of adequate metering at customer site makes net tariffs a provisional solution. Yet, in the longer term, DER integration must be based on the network replacement value. This will require cost reflective "use of

system” tariffs based on generalised internal metering systems.

EU-DEEP proposes new business approaches based on the commercial aggregation of DER units which will enhance their profitable integration

The novel way of regulating the electric power sector in Europe leads naturally to the aggregation of DER units. It allows bringing small generation units into electricity markets while maximising their overall value brought to the system. For instance, the intermittency of renewable-based DER can be compensated by the flexibility of other clients belonging to an aggregation portfolio.

EU-DEEP proposes lines of regulatory harmonization to help DER expand further at minimum costs

Today’s, national regulatory regimes in use within EU-27 define the performances of Transmission and Distribution Operators. These existing rules play against DER expansion:

- Their diversity leads to specific market implementations of technologies and standards that augment DER integration costs;
- It counterbalances the public innovation funding of DER technologies, whose aim is to reduce manufacturing costs and increase working efficiency;
- The way network connections are charged cannot take into account the new charges which networks face as DER expands.

EU-DEEP proposes new design criteria for upgrading distribution networks and cost reflective charging tariffs that decouple DSO revenues from the sharing of network costs between customers. Harmonization of the regulatory regimes regarding such features will favour DER expansion in the future.

Connection to the Temple
(1 to 6 “X” to be filled in the table)

[Not to be filled. This information has already been provided end of December]

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Aggregation layer (A)			
Business case 1 (Pillar 1)			
Business case 2 (Pillar 2)			
Business case 3 (Pillar 3)			
Recommendations (R)			

Challenges not covered by EU-DEEP
(1 to 5 questions, max. 50 words)

[What are the key issues that the stakeholders could expect and that are not covered by EU-DEEP?]

– Local employment generated by DER expansion, including services

What comes next?
(max 1 or 2 interviews, max. 100 words)

[Not to be filled for the moment.
For information, direct interviews will be performed on practical exploitations of results.]

– XXX

Stakeholder	Messages to investors
Title	Key messages coming from EU-DEEP
Context (150 words)	Investments in excess of 1 Trillion € in the European electricity system will be needed in the next 20 years to cover electricity consumption growth, replacement of ageing infrastructures and a strengthened integration of the national electricity systems. Before the 2008 financial crisis, the investor community had changed its mind when investing into renewable technologies and, overall Distributed Energy Resources. 45 clean-energy companies were already listed on US stock exchanges by the end of 2008. This development is built on grounds more robust than the ones which fired the dotcom boom. A political consensus exists in the EU27 to keep Europe as the world leading continent on new energy technologies. The Venture Source Institute published early 2008 an EU rise in equity towards clean energy of 27 %, reaching 266 millions Euros. Opportunities exist in technology development, both at Transmission and Distribution levels, leading to a grid supporting the intermittency of renewables, the volatility of customers that can switch on or off depending upon price signals, but also capable of more reliable operations at reduced costs and emissions based on Demand Side Management approaches.
Challenges (1 to 5 questions, 50 words)	– Are EU directives and subsequent regulations favouring DER investments? – Are there business models that are free from public subsidies, thus involving long term energy demand shifts? – Can DER compete one day with fossil fuel electricity? – What are the critical technologies that can become blockbusters? – What are the most promising business models for DER development?

Results (1 to 5 results, 700 words for the whole section)	**The EU directives are favouring DER investments within a positive political climate** A larger portion of electricity will come from renewable sources in 2020: care must be taken for an increased access to the networks by third parties. EU-DEEP recommends simpler regulatory regimes in support of DER expansion for the distribution system operators. A political consensus exists in the EU27 to keep Europe as the world leading continent on new energy technologies. The Strategic Energy Technology Plan is foreseeing 450 Billion Euros of investments in network infrastructures over the next 30 years (25 % transmission, 75 % distribution) with 70 % of private investment. **Future business models based on aggregation linked with demand response are quite free from public subsidies** EU-DEEP has developed demand models for segments prone to DER expansion, thus showing the natural demand from **pro-sumers**, a new type of client that both **pro**duces and con**sumes** electricity. Moreover, Demand Response does not require government intervention in the form of feed-in tariffs. The latter leads to re-allocating profits from incumbent players to new entrants in the market, which may provoke inertia, resentment or outright obstruction from the incumbents. Demand response does not need new legislative or economic instruments. It relies on savvy marketing and good customer relations, is not coercitive, and is therefore very adapted to markets where customers are open to business innovation. **DER will compete one day with fossil fuel electricity provided that the whole value of DER to the electricity system is accounted for** Electricity produced by DER will beat fossil fuel generated electricity, provided that both value chains are compared on a fair basis by consumers. Moreover, generation comes from extremely diverse generation technologies, insulating the industry from downturns if one technology stumbles, but also creating opportunities for multi-disciplinary solutions. **EU-DEEP has pinpointed the critical technologies that could become blockbusters** EU-DEEP has identified several critical technologies that will need investor money to support DER expansion. These are: • *Smart metering, when coupled with demand side energy participation measures, will help optimise energy consumption while making the load more responsive and flexible.* • *ICT to monitor and improve the control of selected distribution network areas is expected to make the grid more secure and reliable with the advent of Renewable Energy Sources and CHP units,* • *Technologies to ensure active control of distribution networks, where Europe can reinforce its leadership combining large groups (SIEMENS, ABB, AREVA, SCHNEIDER) and very innovative SMEs and start-ups* • *Storage of heat, cold and electricity appears to be critical when one wants to cope with the intermittency of renewables or the decoupling between generation and use of electricity.* **EU-DEEP has pinpointed commercial aggregation linked with demand response as one of the most promising business models for DER development** The business model dealing with demand response aggregation is the most interesting opportunity for non utility players in order to enter the energy sector with a rather low entry barrier. The arrival of prosumers will change the relationship between customers and energy suppliers. Key parameters for business model validation have been modelled and validated experimentally.

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– The challenges you consider as not covered by EU-DEEP</td></tr>
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Stakeholder	Messages to the research community and research funders
Title	Key messages coming from EU-DEEP
Context (150 words)	Distribution systems will evolve progressively from passive to active networks providing adequate protection systems and to enable power flow control. They will involve: ➢ The large scale deployment of smart meters, ➢ The further automation of distribution substations that will expand thanks to the existing automation and communication equipment already installed ➢ The automation of feeders and DER control that will grow to facilitate their commercial aggregation ➢ The integration of active demand solutions, involving smart appliances or other customers owned systems This evolution catalyzes new DER business models, which will augment the value of DER brought to the whole electric system. These evolutions will benefit from parallel progresses in the ICT sector (telecom networks, , sensors, automation, automatic control…). R&D at EU level is needed along three complementary directions (technology-based, market-based, regulation and standard-based research activities) which will in turn allow addressing standards and regulatory issues in a harmonised way.
Challenges (1 to 5 questions, 50 words)	– *What are the most critical technology-based research topics to launch?* – *What are the most critical market-based research topics to launch?* – *What are the most critical regulation/standard -based research topics to launch?*

Results
(1 to 5 results, 700 words for the whole section)

The research topics will benefit from large scale experiments to be performed in the coming years at national and EU level. They encourage any initiative trying to influence the electricity consumption curve.

Technology-based research topics

EU-DEEP proposes a systemic framework to face the major issues raised by DER integration into existing electricity networks. Research activities have covered technology, market and regulatory aspect with accessible results:

- 180 scientific publications
- 150 delivered outputs accessible within a dedicated descriptive knowledge scheme
- three business cases described through a set of 50+ parameters and confronted to full scale experiments
- a conference held in Nice on December 2008 to favour international exchanges amongst 300 participants.

Yet, new research topics arise to accompany large scale demonstrations needed to validate massive DER integration:

- How to make the EU 2020 energy targets with affordable investments on networks?
- How to operate the resulting networks with reduced stability margins?
- How to favour more customer participation thanks to real time price signals?

The topics will continue covering new technology, market and regulatory issues.

- Controllable energy sources where loads and storage devices contribute to system services and energy balance.
- Electricity, heat and cooling storage
- The role of electric and hybrid vehicles as storage and as flexible loads
- Advanced power electronics equipment
- Real-time monitoring and accurate prediction of consumption, generation and electricity prices, which enable more stable network operation.
- DER and network planning based on probabilistic approaches considering bidirectional power flows.
- integration of varied DER technologies into standard network analysis procedures.
- Active control options and standardization.
- Energy storage management, cost of storage device drops to make storage viable alternative to other network management options
- Novel architecture of distribution networks where DER can support the network
- Centralised versus decentralised control strategies (intelligent agents on board DER units)

Market-based research topics

Market-based research focuses on initiatives to improve the utilisation of the flexibility at customer level.

- Innovative investment mechanisms in support of DER investors..
- Techniques to enhance the elasticity of demand by incentivising customers (public and/or private support)
- Novel aggregation techniques of small customers to enhance their impact onto the electricity market and system
- Smart metering to enhance load flexibility and energy efficiency
- Charging electricity costs with tariffs reflecting the marginal cost of electricity.
- Development of accessible and understandable information for participants
- New data standards to make them more accessible to market participants
- Management of the costs of ownership for DER units (extension of current ESCO business)
- Evaluation of DER contribution to reduction of CO_2 emissions, especially in peak load replacement.

Five regulation / standard -based research topics

- Reliability- and quality of supply- based regulations: impact on DER deployment with harmonization over EU-27 for DSOs and TSOs
- Quality and safety issues induced by large scale deployment of DER
- Regulatory options to encourage the combined use of electricity storage and distributed energy resources
- Coupling of electricity and transport regulations (plug-in hybrid cars)
- Development of standards for DER (distributed generation and storage systems) interconnection to the network.

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Challenges not covered by EU-DEEP
(1 to 5 questions, max. 50 words)

[What are the key issues that the stakeholders could expect and that are not covered by EU-DEEP?]

The development of the more detailed modelling methodologies like

– the use of probabilistic methods to quantify the performance of the network,
– the stochastic modelling of demand and of the impact of DER and pricing on demand

What comes next?
(max 1 or 2 interviews, max. 100 words)

[Not to be filled for the moment.
For information, direct interviews will be performed on practical exploitations of results.]

– XXX

Stakeholder	Distribution System Operators (DSO)
Title	**Key messages from EU-DEEP for DSOs**
Context (150 words)	During the next decade, DSO will face a significant increase in the number of small generation units dispersed in the medium and low voltage networks. The ambitious 20-20-20 plan of the EU will naturally increase the demand for renewable energy sources, often small and distributed in low and medium voltage networks. Further, increase in fossil fuel prices will enhance the attractiveness of demand efficiency measures, for example small CHP units. Design and operation of existing transmission and distribution networks, together with the associated regulatory and market rules, were decided on the basis of a centralized system, thus leading to unidirectional power flows in the distribution network. Given the quick developments of Distributed Energy Resources (DER), these assumptions do not hold true any more. Due to the technical and economic changes induced by DER and its location in the electricity supply chain, DER integration sets new challenges on network players, particularly distribution and transmission networks operators, but also on electricity retailers, market operators and regulators. Being responsible of distribution network development and operation, DSOs are on the frontline of the DER integration process.
Challenges (1 to 5 questions, 50 words)	– Are the existing distribution networks capable of hosting significant amounts of Distributed Generation? – What impact will DER have on technical aspects of DSO operations? – How will the DSO business be affected by Distributed Generation? – How can DSOs benefit from Distributed Generation?
Results (1 to 5 results, 700 words for the whole section)	**Most distribution networks exhibit margins in terms of voltage, flow, fault current… allowing them for accepting a significant proportion of DG.** Voltage issues are probably the main technical concern when increasing DER penetration. Since loads cause the voltage to drop along feeders, the voltage set point is traditionally adjusted near the upper limit, as at the same time this reduces system losses. In presence of local generation the voltage profiles can increase and decrease along the various feeders depending on load and generation. A large proportion of distribution networks are characterised by sufficient margins such as they are able to operate satisfactorily in presence of a significant amount of DER. Sometimes this requires the adjustment of the voltage set point downwards but without abandoning the traditional “fit and forget” approach. This extension of the “fit & forget” principle supposes sufficient homogeneity between feeders and regularity in terms of behaviour of the load and generation. **Active management allows for further increasing DG proportion.** Without sufficient voltage margin a fixed voltage set point that gives acceptable voltage at all points at all times cannot be found. In such case, dynamically changing the voltage control settings in the HV-MV substation may be a solution. This however supposes that the load shapes of the different feeders exhibit similar voltage characteristics. Occasional generation curtailment could further increase the acceptable DER penetration ratio. **Upgraded design criteria for distribution network lead to more flexible DER deployment** Increasing the “DER hosting capacity” of the network requires new design criteria for developing distribution networks. This is necessary because margins are needed if reduction on power injection, i.e., “curtailing”, must be

<table>
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This means that “exogenous” objectives are necessary for fixing limits: maximum generating capacity per connection, maximum level of penetration for DER or possibilities for generation control, etc.
The basic principle is to adjust the design of the system for making active management possible. Voltage control issues that cannot be solved using active management are most often resulting from the existence of non homogeneous feeders (different proportion of load and DER along the different feeders), the non-coincidence of load and generation, and further the lack of physical room for implementing additional voltage control device on feeders. EU-DEEP proposed as an example the “flexible – symmetric” design that equally shares the voltage range between generation and consumption.

Technical issues with small DER (DG) in most cases are not materialised.
Operation of protection schemes is dominated by the short circuit power supplied by the HV network and small DER units installed in low voltage generally do not supply short-circuit power. Hence, they cannot disturb protection operation as long as the networkarea is connected to HV network.

Cost reflective “Use of System” charges tariffs must be promoted.
Present “Use of System tariffs” for distribution networks are not cost reflective. When introducing local generation it is most straightforward to connect it behind the energy meter and to use a net tariff. This gives an incentive to investors for installing distributed generation. However it reduces DSO income, which does not necessarily reflect the benefits that these DG units bring to the DSO, e.g. reduced losses as these can only be true if the consumption and production coincide exactly in time. Instead of considering the net impact over a long time window, for example 1 year, consumption and production must be considered separately using short time frame. EU-DEEP proposed a methodology for determining the impact they have on the distribution network. Such implementation requires large scale deployment of smart interval metering with automatic meter reading and ex-post data treatment.

In the long run, when integrated, DER will be able to deliver services even to DSO.
It is expected that these opportunities shall increase in the future when MV and LV distribution networks will loose their present unconditional adequacy. Future services that could be delivered by DER in MV and LV distribution networks are mostly related to limited contribution to voltage control or reactive power compensation, and less to power flow management.
For the more critical constraints, like voltage control in “N-1” situations of a reconfigured radial operated network, the “service” corresponds to generation curtailment.</td></tr>
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<tr><td>Challenges not covered by EU-DEEP
(1 to 5 questions, max. 50 words)</td><td>[What are the key issues that the stakeholders could expect and that are not covered by EU-DEEP?]
– Architecture of the local markets organized within aggregation. EU DEEP assumes that the aggregators will find the most effective way to manage their portfolios in order to participate in the wholesale energy markets, provide system services or avoid imbalance positions.
– Detailed set up of the proposed “Use of System” charges scheme because such new scheme must be based on consensus through moderated by regulators and discussed with all stakeholders.
– The protection against temporary islanded operation of a portion of the distribution network has been evaluated, but no recommendation has been proposed due to the large diversity of situations within EU.</td></tr>
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What comes next? (max 1 or 2 interviews, max. 100 words)	*[Not to be filled for the moment.* *For information, direct interviews will be performed on practical exploitations of results.]* – XXX

Stakeholder	Transmission System Operators (TSO)
Title	Key messages from EU-DEEP for TSOs
Context (150 words)	The ambitious 20-20-20 target set by the EC will naturally push for more renewable energy sources and distributed high efficiency CHP units. Combined with the demand flexibility these trends will introduce breakthrough changes in the way electricity will be generated, transported and used. Design and operations of the existing transmission and distribution networks, together with the associated regulatory and market rules were decided on the basis of a "centralized system", thus leading to unidirectional power flows in the distribution network –since only demand was connected to the distribution network. Currently these assumptions do not hold true any more due to Distributed Energy Resources (DER) developments. Location of DER in the electricity supply chain and the associated techno-economic consequences introduce new challenges on grid operators, utilities, market operators and regulators. In order to capitalize on the potential benefits offered by the distributed resources these challenges need to be adequately met. Being responsible of system operational security, TSOs are on the front line of the DER integration process.
Challenges (1 to 5 questions, 50 words)	– How the TSO business will be affected by Distributed Generation? – How[OS74] to maintain security with increasing penetration of DG units replacing large centralized power plants – How can *"DER Aggregators"* help TSOs in the task of balancing the system? – How the TSO-DSO relations will be affected with raising penetration of DER? – How can TSO benefit from Distributed Generation?[LG75] (KP: this challenge is somehow mentioned in the last paragraph, but the link is not straightforward.)

Results (1 to 5 results, 700 words for the whole section)	**EU-DEEP demonstrated that basic principles of power systems control remain valid in presence of large amount of DER.** DER will impact the system as a whole as well as transmission and distribution networks. However, the fundamental principles behind power systems operation remain valid. Preventive security margins, voltage and frequency controls are the cornerstone of design and operation of electrical power systems. This ensures the robustness against a predefined list of contingencies. Built initially for rotating generators, these practices remain compatible for both generation connected using power electronic interfaces and demand response. The structure of control as it has been used since the initial developments of power systems can be prolonged. **Increasing penetration of DER in the power system asks for their "integration", especially for the management of system security.** Maintaining continuous balance between generation and consumption is one of the tasks of a TSO. It requires however sufficient amount of control capacities, that with increasing penetration of DER need to be transferred from conventional generators towards DER. If they reach significant penetration levels covering substantial amount of the demand, they need to be fully integrated in system security management. They have to participate in system control and in provision of reserves similarly to large conventional power stations. TSOs serve as the entity responsible for system security, and need to consider the impact of DER on the system, especially during critical moments. This requires that next to the demand and its evolution, the TSO must also collect information about amount of DER on-line, estimating the power injections at the boundaries between the TSO and DSO grids. Yet, given the possible changing behavior of the DSO grid from passive (i.e. only consuming) to active (i.e. injecting into the TSO grid), monitoring of the net injection will not be enough, as the TSO will need to get the information about generation. **Aggregation of multiple small customers can be the provisional interface needed tomorrow between DER market and TSO.** Due to its typically small size, individual DER cannot directly interact with market and TSO. DER aggregation becomes the lacking provisional interface between the dispersed resources and the TSO prefiguring SmartGrid solutions. Aggregators can provide balancing power and power-frequency control as an alternative to large centralized power plants increasing the competitiveness of reserve markets. Good integration of DER in the system can only be ensured when information necessary for guaranteeing system security is available. Aggregation will make DER more visible to TSOs at acceptable costs, aiding TSOs in their task of managing the system balancing and helping them to improve the coordination of defense schemes in the DSO and TSO grids.

For the stability of power system operation, coordination of frequency ranges between TSO and DSO is mandatory and sufficient “low voltage ride through capability” for DER must be ensured.

For normal operation system frequency remains near to its nominal setting, within a range of about ± 200 mHz around 50 Hz for UCTE system. At a “secured event” (standard assumed loss of 3000 MW) the frequency can transiently decrease down to 49.25 Hz, and in case of contingencies beyond the “secured event” even to 47.5 Hz probably within a sub-network. It is then mandatory that generation of whatever type remains connected to the system to avoid further deterioration of the system state. The September 2003 and November 2006 incidents demonstrated this necessity empirically.
High proportion of DER means a reduced number of large generators on-line, which reduces short-circuit power leading to higher system voltage sensitivity during transient conditions. Faults in transmission network will lead to dips deeper in voltage and geographically more wide-spread. DER must therefore present sufficient robustness and low voltage ride through capability facing normally cleared faults.

In systems with large proportion of DER mature control concepts must be extended in particular load shedding schemes must be adjusted and in the mid-term replaced by load shedding implemented locally in LV.

Load Shedding schemes are implemented at HV – MV substations by tripping MV feeders. With high penetration of DER units, this practice is not anymore optimal as feeder tripping also means disconnection of generation. In the mid term, this could be tackled by adequate selection of feeders for implementing the load shedding schemes. In the long-term however, the best solution is to include emergency demand response and load shedding within the smart system–customer interface (i.e. upgraded smart meter).

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Business case 3 (Pillar 3)			
Recommendations (R)			X

Challenges not covered by EU-DEEP
(1 to 5 questions, max. 50 words)

[What are the key issues that the stakeholders could expect and that are not covered by EU-DEEP?]

- Change of the system services markets when increasing integration between different control zones (i.e. cross-border balancing and its impact on system security, provision of cross-border transfer capacity, etc)
- Architecture of the local markets organized within the “aggregation”. EU-DEEP assumes that aggregator bodies will find the most effective way to manage their portfolios in order either to participate in the wholesale energy markets, provide system services or to manage imbalance positions.

What comes next?
(max 1 or 2 interviews, max. 100 words)

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For information, direct interviews will be performed on practical exploitations of results.]

- XXX

Stakeholder	Regulator
Title	Key messages from EU-DEEP for regulatory bodies
Context (150 words)	The integration of DER poses a valid challenge to both industry and regulators. The regulatory model behind the Internal Energy Market (IEM) is based on a strict separation between the generation, transport and distribution of energy, where the tasks, rights and obligations of the two latter are defined by Directives implemented as national laws. For central generation, economic network regulation may be seen as a side constraint. For decentralized energy resources, however, economic regulation of both DER and the distribution network operators is an integral part of the business model. DER is promoted not only by network arguments such as deferred reinforcements, but also by externalities offered to other stakeholders and national environmental targets. The regulator is facing a dilemma. DER can be seen as a competitive [generation] or a regulated [network] activity and the delicate interaction between direct support and network charges will set the pace for the deployment.
Challenges (1 to 5 questions, 50 words)	• What structure of network regulation will create a sound, robust and credible commitment to DER integration in distribution networks? • What are the *prerequisites* of sustainable and efficient “Use of System” charges tariffs for distribution? • How to build “Use of System” tariffs that are able to unveil the value of DER as “network replacement”? • What is “hosting capacity” for DER of the present distribution networks? • What are the rational bases for the upgrade of the design criteria allowing for more flexible DER integration?

Results (1 to 5 results, 700 words for the whole section)	**DER can be both a complement and substitute to network services; the regulatory structure must reflect this.** DER investments that lead to deferred network investments may be promoted adequately by DSOs provided that their regulatory regime is based on total expenditure for a gross load output, not on markups on grid investments. As the substitution is highly location and time dependent, DSO participation is vital for full welfare effects. DER investments may also be complements, such as remotely controlled units performing value-added services on the network. In this case, the optimal regulation incentivizes joint investments from DER investors and networks to maximize impact. In this respect, traditional models using delegation or contingent investments perform poorly, whereas coordinated direct mechanisms give better results in terms of investment level and benefit. **Harmonization of the DER-DSO regulation interface is important to reduce regulatory risk and promote investments** Since DER is both relatively new and "odd" under the EU-type network regulation, regulators have implemented a range of different rules for their interaction with DSOs and the DSOs service conditions towards them. In combination with parallel unsustainable support schemes of investments, energy or network charges, the resulting effect of diversity is regulatory risk that lowers investment incentives, impedes economies of scale in DER deployment, commercialization and increases operating costs for DSOs. By harmonizing the DER-DSO regulations to a common set of rules and clarifying what elements are sustainable, penetration can be promoted at lower social costs and higher efficiency. ***Prerequisites* have been defined for sustainable and efficient "Use of System" charges tariffs for distribution.** Bills of customer are generally mixing the different parameters of electricity delivery *via* kW and kWh components. The supply contract separates components from the supplier of energy, the transmission company, the distribution company as well as additional components like contribution for the regulation task, for renewable energy, etc. Getting "efficient" tariffs supposes a clear separation of UoS tariff from incentives; for sites equipped with DER, load and generation cannot be treated as a single component. **A new "Use of System" tariffs methodology has been proposed that is able to unveil the value of DER as "network replacement"** DER located in medium and in low voltage networks represent an additional value for the system. A new methodology has been proposed allowing for unveiling the footprint of load and generation in distribution. For being applicable down to low voltage networks, the method requires large scale metering systems as well as ex post data management. Different stages of simplifications are possible in terms of metering. Equality of treatment principles must also be integrated to avoid penalising customers due to their location in the network. Further UoS tariffs must be made stable enough from one year to the next. **The "hosting capacity" for DER of the present distribution networks is significant.** Present distribution networks are most often characterised by margins that permit integrating a significant proportion of DER. This "hosting capacity" that must be calculated based on design criteria of distribution network, is function of the type of considered DER. The important issues of system loading and voltage control depend on a series of parameters: the coincidence of consumption and generation, the homogeneity of the HV – MV substation feeders in terms of location of load and generation, the voltage control margin, etc. This leads to two control options: limitation of the risk of flow inversion along a feeder, or possibility of implementing active management for setting the medium voltage.

Rational bases have been proposed for upgrading the design criteria of distribution networks able to flexibly integrate more DER.

The impact of an increased number of DER on the cost of the system depends on the types of DER considered and on the network where they are connected. The additional investment costs due to DER integration depend on energy policy choices, including the associated operational rules that are imposed, amongst others the possibility to control power injection in case of contingencies.

Increasing the "DER hosting capacity" of the network using or not active management requires the set up of new design criteria for developing and exploiting distribution networks. This is necessary because margins are needed if reduction on power injection must be avoided as much as possible. "Exogenous" objectives, in close connection with objectives of energy policies, are necessary for fixing these targets: limitation of generation power per connection, objective in terms of penetration for DER, limits set for generation control in normal and abnormal conditions, etc.

New design criteria for distribution networks can easily be developed as soon as clear objectives are defined. These objectives should be defined outside of the electrical supply industry, but with its participation. The exact sharing between design and active management is an integral part of the process.

Connection to the Temple
(1 to 6 "X" to be filled in the table)

	For information	For further development	For short term implementation
Technical knowledge (T)			X
Energy value (E)	X		
Network value (N)			X
Services value (S)		X	
Aggregation layer (A)			X
Business case 1 (Pillar 1)			
Business case 2 (Pillar 2)			
Business case 3 (Pillar 3)			
Recommendations (R)			X

Challenges not covered by EU-DEEP
(1 to 5 questions, max. 50 words)

[What are the key issues that the stakeholders could expect and that are not covered by EU-DEEP?]

What comes next?
(max 1 or 2 interviews, max. 100 words)

[Not to be filled for the moment.
For information, direct interviews will be performed on practical exploitations of results.]

- XXX

Stakeholder	Energy producers and retailers
Title	Under current technology and regulation, DER aggregation provides promising business opportunities to energy producers and retailers

In recent years, the development of Distributed Energy Resources (DER) has already started. The ambitious objectives set by the EC (3x20) in 2007 and the broadening scope of industrial activities subject to the Emissions Trading Scheme will undoubtedly contribute to higher DER penetration and to its extension to new market players in the years to come.

Since the liberalisation of the European energy sector, utilities have had to deal with number of changes including energy markets integration, tightening environmental regulation and increasing volatility of commodity prices, prompting them to adapt their business models to the changes in the environment and to take on new roles, like for instance multi-utility model, use of renewable generation, etc.

DER may be seen as a threat to conventional business models but also as a tremendous opportunity where power producers are in a privileged position to build new DER and retailers may provide innovative energy-related services to their customers.

- What are the promising business models for DER?
- What are the conditions to run successfully such business models?

Aggregation business models will appear to facilitate the technical and commercial integration of DER

A comprehensive assessment of the technical impact of DER on the different layers of the power system concluded that even if the DER "hosting capacity" of existing networks is significant, non-integrated DER could undermine system integrity in the long run. Furthermore, the economic analysis of DER showed that non-integrated DER can not access the different streams of revenue. In particular, the small size of the DER prevents them from participating directly to energy markets. Aggregation of DER will play a key role to include these local resources into the global dynamics of the market. The role of aggregators is to use the flexibility of DER units and to provide Demand Response (DR) solutions, so as to gain a sufficient size to enter energy markets and to provide services to the network operators. **Energy retailers may want to expand their businesses by acting as aggregators.** Indeed, they hold most of the aces in this game including an existing customer base and the know-how to interact with customers. In the tightening competitive race that will take place in the future energy retailing business, aggregation gives the retailers the opportunity to differentiate themselves from their peers. By entering DR solutions contracts with energy consumers and operating DER on their premises, energy retailers may attempt at improving customer loyalty. [TE76]

Three EU-DEEP prototype businesses proved that it is already possible to launch profitable aggregation commercial offers in given regulatory contexts

Among the various promising business opportunities arising with the emergence of DER, EU-DEEP carried out an **in-depth assessment of three contrasted business models set in three different European countries**, focusing respectively on intermittent renewable generation & demand response, micro-CHP and cogeneration. The assessment aimed at:

- **evaluating the proposed technical solutions** to each business model and testing them in **field experiments**;
- **appraising the economic viability of the business models** in a given country-specific context and performing a similar analysis in different contexts (other countries or for near future conditions).

The assessment shows that **some business models of aggregation could earn a fair rate of return** in given current regulatory contexts. However, the diversities of balancing mechanisms, use-of-system tariffs, "renewables" balancing obligations and support schemes are important barriers to readily adapting the business models to different country contexts. The business models' viability by 2020 was also assessed according to **four different scenarios**. In all the scenarios, the attractiveness of the aggregation business models is expected to increase. Running DER aggregation in an economically efficient way requires good knowledge of energy market mechanisms and forecasts of future market outcomes. **EU-DEEP explored and gave rise to several computing tools suitable for evaluating business potential and for managing a DER portfolio in a real world.** Some of these tools have a large scope of applications and can be used on a commercial basis.

These new business opportunities require a deeper knowledge of the energy consumers that become active

EU-DEEP developed a Europe-wide database on power consumption and a methodology to identify the most promising segments for DER. The project also developed tools to analyse the load profiles of these segments: simulation of load curves for an in-depth assessment of the flexible part of the different end uses. energy consumers may fear a loss of control over their equipment when the operation is delegated to an aggregator, **a sociological study carried out within EU-DEEP showed a strong adhesion to the principles of demand response and aggregation** among the flexible consumers involved in field experiments. It also allowed for building a typology of customers according to their reasons for involvement and risk perceptions. In all cases, transparency will be a condition for sustainable relationship with the customers.

EU-DEEP recommends large-scale demonstrations as a next step to industrialise the project results

Aggregation is a promising business in the long run and can be profitable in some environments today. It is still a risky business with technical, market and regulatory uncertainties. As a next step, it would therefore be desirable to **launch a large-scale demonstration of the aggregation business** that would prove its commercial feasibility regardless of a particular country context, provide a learning process to the involved parties and encourage participation of DER units. Only demonstration projects involving a significant number of sites would allow validating the technical results of the project and testing the scalability of the concepts and technologies explored within EU-DEEP.

	For information	For Recommendation	For ST implementation
Technical knowledge (T)			
Energy value (E)		X	
Network value (N)			
Services value (S)		X	
Aggregation layer (A)			X
Business case 1 (Pillar 1)			X
Business case 2 (Pillar 2)	X		
Business case 3 (Pillar 3)		X	
Recommendations (R)			

- What are the market segment's value and growth potential?
- What are the detailed incentives schemes in the different European Member States and how to take advantage of these existing incentives?

[Not to be filled for the moment.
For information, direct interviews will be performed on practical exploitations of results.]

- XXX

Stakeholder	Messages to consumers and energy facility managers
Title	Key messages coming from EU-DEEP
Context (150 words)	The agreements that have been reached in December 2008 on the Climate and Energy Package proposed by the European Commission set up **new challenges** that energy managers will have to cope with. The 3 X 20 targets for 2020 – 20% of reduction of EU greenhouse gas emissions compared to 1990 levels, 20% share of renewable energy sources in EU energy consumption and 20% energy efficiency increase – require unprecedented measures to meet new requirements, and optimize energy-related costs. **Optimization of consumption and generation takes on a crucial importance** under new constraints and strategic adaptation and energy management will support **profitability** and **compliance with those new standards**. Starting today, energy managers have the opportunity to consider use of the two levers they have at their disposal: **distributed generation** for decentralized energy production, and **demand response** for power consumption optimization process.
Challenges (1 to 5 questions, 50 words)	▪ How to assess the pertinence to launch a DER project for a given site? ▪ Will DER open new ways to manage energy and new offers from the energy suppliers?

Results
(1 to 5 results, 700 words for the whole section)
	Detailed analysis of energy end-uses is crucial to design appropriate DER project and to reveal the flexibility potential of a given customer.
	The EU-DEEP project developed a European demand database shared within several major utilities and a methodology to identify the most interesting customers for DER integration. By extending pre-existing segmentations with specific additional criteria, 250 market segments have been identified and specific customer assessment has been elaborated. EU-DEEP tools simulating customer's loads and local DER management, and the segments ranking according to the DER potential index (distributed generation, storage and demand response) allows for analysing installations, and assess opportunity and profitability of DER integration. Besides, while in-depth analysis is required to optimize energy management for local sites, a sociological survey pointed out that the customer's knowledge is even more critical to run DER aggregation business models. Building win-win business models require indeed a detailed analysis of the end-uses to quantify the technical flexibility potential but also a clear understanding of the client expectations to build strong and transparent contractual partnerships.
	
	New DER-based offers will be developed for the customer, resulting in a change of the relationship between the customer and the energy supplier.
	The 20-20-20 objectives will lead to a significant development of DER. The integration of these local resources into the dynamics of the market will be critical for their sustainable development. EU-DEEP developed and tested innovative DER aggregation models that enable this integration within the today system. New energy players, referred to as "aggregators", propose to their customers to operate their "flexible" DER units and to provide Demand Response (DR) solutions, so as to take advantage of portfolio effects, to gain a sufficient size to enter energy markets and to provide services to the network operators. Development of those enabling structures and technologies such as smart metering should foster the emergence of new partnerships where the customer turns sometimes into a supplier. Those new commercial relationships are a valuable opportunity for energy managers to unveil value that lies in the generation capacities and load flexibility of their local sites. The tested business models confirmed that it is possible for some market conditions to run aggregation business that can be rolled out and spare up to 3 % of the yearly electricity bill today.
	
	EU-DEEP developed training for energy managers aiming at delivering energy managers with the key tools for decision making in DER investment.
	Management of distributed generation and demand response require specific expertise which is included in a specific training program developed within EU-DEEP. A series of trainings have been designed within the ISO framework as change-management tools aiming at:
	➢ providing any organization with a framework for integrating DER with respect of energy efficiency and in coherence with ISO like management practices;
	➢ providing organizations which are operating in more than one EU country with a thorough and synthetic view of DER integration impacts and the ISO standards suited for DER implementation across the organization, provided that DER brings the expected benefits in energy savings;
	➢ providing a integrated and consistent methodology for identifying improvement opportunities and to carry out implementation of recommendations using DER solutions that may support continuous increase of energy efficiency across facilities;
	➢ helping organizations operating existing DER solutions to set up best practices for DER use and cost-killing;
	➢ sketching guidance rules:
	    ▪ on benchmarking, measuring, and reporting energy intensity improvements and their projected impact on reductions in GHG emissions with the help of DER units;
	    ▪ in evaluating and prioritizing implementation of new energy-efficient technologies based on DER solutions;
	➢ providing frameworks for organizations in support of ESCO and/or aggregators in order to optimize energy systems management.

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– How to decrease the costs of DER technologies?</td>
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Stakeholder	Messages to manufacturers
Title	Key messages coming from EU-DEEP
Context (150 words)	While DER equipment costs follow a traditional learning curve, manufacturers of the different DER technologies still need to reduce manufacturing costs and increase energy conversion efficiencies. Meanwhile, public support is required to alleviate the high initial costs incurred at the beginning of such learning curves. DER development within the distribution network (i.e. medium and low voltage network) can follow two complementary routes: • Initially "passive" integration of DER units is expected. distribution networks are still following the "fit and forget" principle: DER units are allowed operating on their own, as long as the impact on network operation remains limited once connected. • In a second step "active" integration of DER is required. This assumes metering, telecommunication and last but not least remote control. The 20-20-20 objectives increase the interest for active management concepts which should be assessed on a case by case analysis as it is essentially network dependant. The transition from "passive" to "active" integration requires starting technical developments from now that will impact both existing DER and newly-introduced DER.
Challenges (1 to 5 questions, 50 words)	– What are the new services that can be delivered with DER when they are integrated? – What is the hosting capacity of the today electric system and when will active management become mandatory? – What are the critical technologies and standards to smooth transition from passive to active grid control? – What could be a rational generating cost target?

Results (1 to 5 results, 700 words for the whole section)	**EU-DEEP has tested integrated DER systems optimising the energy management at consumer level and enabling new functionalities and services.** Today DER controllers, based on present technologies, already allow the complete integration of DER into a single system. Two one year experiments showed that additional integration costs for innovative control strategies represent around 10 % of the total DER installation cost (for DER unit size of around 100 kW), a level that it is acceptable for some business models. **On the basis of the 1 year aggregation experiments, EU-DEEP has upgraded today software, and DER control technologies to operate innovative aggregation businesses.** Local DER Controllers and central Aggregator technologies - connected via e.g. GPRS based telecommunication – allow the setup of aggregation systems up to a certain number of aggregated sites based on today's ICT technology (e.g. 200 sites). To include a larger number of (smaller sized) sites, standardization of interfaces, parallelization and/or stochastic control with hierarchical ICT system infrastructures (or local agent based ICT solutions) as well as reuse of existing or upcoming telecommunication possibilities will be necessary. The cost / benefit analysis performed with the 3 tested business models of aggregation defined the target costs for DER and ICT equipment with respect to today's market environments. **A large amount of DER can be "hosted" by the today's system, but integration of DER is mandatory in the long run.** In depth analysis of the technical impact of DER at the different layers of the system proved that margins exist in today distribution network, particularly if DG unit size is under design criteria. For instance 1 kW micro CHP are more easily "hosted" by the network than 5 to 10 kW PV. Two complementary steps are needed to go beyond the today hosting capacity of the network. The first is based on active management within present deign criteria and the second one requires upgrade network design. The technical analysis also showed that DER must be integrated for preserving system integrity. In a first step, this integration can be "**passive"**: the system operator should have a detailed cadastre of DG. In a second step, in particular when network relies on Distributed Generation as "network replacement", an **active integration** will be required: DER will need to be controlled during specific system conditions. **EU-DEEP has identified the key technologies and standards to be developed to facilitate interoperability and foster DER integration.** Several technologies play a key role for the integration of DER into the system, especially Smart metering and ICT to monitor and improve the control of selected distribution network areas. Component technologies to ensure active control of distribution networks should be further developed. The EU-DEEP project specifically addressed energy management challenges, via aggregation techniques of multiple units through energy management systems or dispatch technologies of active power outputs from multiple DER units. Recommendations have been made to standardisation bodies to work on • overall communication standards and protocols for seamless exchange of data (continuation of TC57 work on interoperability and worldwide marketing of the developed standard series); • smart metering requirements (harmonized Smart meter standard in Europe and its extension to international level via IEC); • coordination at the European level when dealing with DER integration into electric networks.

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<td>The MV or LV retailing price of electricity is not necessarily the target for DER generation costs.
The economic value of DG - DER units for the system and for the network depends on the technology, the way it is used, the system & network specificities, and the regulatory environment. An important aspect concerns the value of DG as “network replacement”. The eligibility of a particular DER to this value leads to different target generation costs. For example the value of PV for the network can be high in a network where peak demand is due to air conditioning (often running when PV is operating). On the contrary this value can be low , even negative in a system where PV generates during summer and peak consumption takes place in winter. In this latter case, the targeted costs for PV should be lower than the retail price, transmission and distribution tariffs included.

EUDEEP recommends large-scale demonstrations as a next step to industrializing the solutions developed.
EU-DEEP proposes demonstration experiments in urban and rural grids to prove the scalability and reliability of technical/market/regulation solutions proposed by the EU-DEEP project. The Third International Conference on DER and RES integration organised in 2008 by the EU-DEEP project outlined the convergence between the North American, Japanese and European experiences for RES and DER integration and the urgency to industrialise the corresponding solutions.</td>
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