Summary and conclusions

Subtask 9 Report

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in co-operation with the country experts

International Energy Agency Demand-Side Management Programme

Task XVII: Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages

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EXECUTIVE SUMMARY – Summary and conclusions

TASK XVII: INTEGRATION OF DEMAND SIDE MANAGEMENT, DISTRIBUTED GENERATION, RENEWABLE ENERGY SOURCES AND ENERGY STORAGES

Task extension: The effects of the penetration of emerging DER technologies to different stakeholders and to the whole electricity system

Background Energy policies are promoting distributed energy resources such as energy efficiency, distributed generation (DG), energy storage devices, and renewable energy resources (RES), increasing the number of DG installations and especially variable output (only partly controllable) sources like wind power, solar, small hydro and combined heat and power.

Intermittent generation like wind can cause problems in grids, in physical balances and in adequacy of power.

Thus, there are two goals for integrating distributed energy resources locally and globally: network management point of view and energy market objectives.

Solutions to decrease the problems caused by the variable output of intermittent resources are to add energy storages into the system, create more flexibility on the supply side to mitigate supply intermittency and load variation, and to increase flexibility in electricity consumption. Combining the different characteristics of these resources is essential in increasing the value of distributed energy resources in the bulk power system and in the energy market.

This Task is focusing on the aspects of this integration.

Objectives The main objective of this Task is to study how to achieve a better integration of flexible demand (Demand Response, Demand Side Management) with Distributed Generation, energy storages and Smart Grids. This would lead to an increase of the value of Demand Response, Demand Side Management and Distributed Generation and a decrease of problems caused by intermittent distributed generation (mainly based on renewable energy sources) in the physical electricity systems and at the electricity market.

Approach

The first phase in the Task was to carry out a scope study collecting information from the existing IEA Agreements, participating countries with the help of country experts and from organized workshops and other sources (research programs, field experience etc), analyzing the information on the basis of the above mentioned objectives and synthesizing the information to define the more detailed needs for the further work. The main output of the first step was a state-of-the art report.

The second phase (Task extension) is dealing with the effects of the penetration of emerging DER technologies to different stakeholders and to the whole electricity system.

The main subtasks of the second phase are (in addition to Subtasks 1 – 4 of the phase one):

Subtask 5: Assessment of technologies and their penetration in participating countries

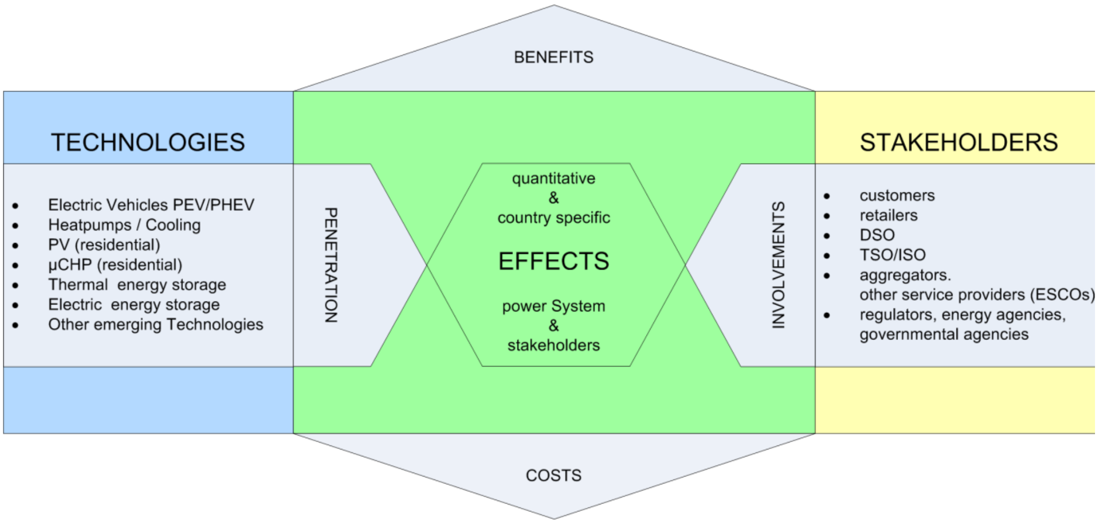
Subtask 6: Pilots and case studies

Subtask 7: Stakeholders involved in the penetration and effects on the stakeholders

Subtask 8: Assessment of the quantitative effects on the power systems and stakeholders

Subtask 9: Conclusions and recommendations

The figure below describes the concept of this extension.



Results

Technologies

Concerning the emerging end-use technologies it seems to be clear that electric vehicles will play important role in the future. Their penetration in different countries will increase in the next 10 – 20 years. Main obstacle is still the price of batteries which still seems to stay in quite high level although the benefits are high especially from the environmental point of view. Role of stakeholders is different in different countries as well as proposed business models. The role of some type of aggregator seems to be important in the future. Smart charging will be essential especially from the local networks' point of view. The services to the electricity system provided by EVs will be additional benefit in the future.

Heat pumps represent another emerging end-use technology in many countries. They are used for heating in countries with a cold climate and for cooling in countries with hot summers or for both purposes. In principle heat pumps are suitable for demand response for several reasons like they can be controlled similar way as electric heating and other air-conditioning systems: due to the natural (building mass) and artificial heat storages the heating/hot water production and cooling can be switched off for certain time periods. However, some obstacles exist for the use of heat pumps for demand response like

- there are not much experiences from the use of heat pumps for demand response and therefore also technical solutions have not been developed
- after the control period of heat pumps their load will be high and this "pay-back" has to be taken into account in the control strategy
- starting current of heat pumps after switch-off or blackouts can be high and problematic to the networks; this has to be taken into account

µ-CHP technologies generate both heat and power and can thus be considered in sites where a sufficient heat load is present. It has seen as a promising technology to produce electricity locally. DR is easily implemented with µ-CHP because thermal storages are becoming more commonplace. However, the penetration of µ-CHP is still low and much less than expected some years ago. The main reason for this is that the prices of the technology have not gone as expected.

PV in customers' premises is increasing rapidly in some countries. The rapid increase of PV capacity is related to the two main factors:

- PV technology and manufacturing capacity are increased rapidly which has resulted in the decrease of PV prices. In 2011 prices decreased even up to more than 50 % in some countries.
- Energy policies with incentives and feed-in tariffs have supported the PV development

Smart metering is a technology which is essential in the road to smart grids and to the integration of active customers to the electrical networks and to the market. The penetration is increasing quite rapidly in Europe due to the European legislation. At the moment countries are in different stage: some countries have already almost 100 % penetration and some are in the experimental phase. Cost-benefit analyses show in most cases that smart metering is in most cases economically feasible if the benefits to all stakeholders and to society are4 taken into account. It seems to be important to develop standardization and functional requirements to such a directions that all the benefits from DER can be obtained.

Stakeholder involvement and effects

Microgeneration and new end-use technologies can present significant effects to several stakeholders. Most importantly, the consumer himself, network companies and electricity supplier (retailer) are involved. Network companies may either benefit or suffer from the introduction of microgeneration, heat pumps and EV, depending on the specific technology and how it is used. The consumer can contract an aggregator to sell the microgeneration or reprofiled consumption to competitive energy market participants or network companies. Manufacturers strive to develop more affordable and more efficient generating units, normally with the help of subsidies provided by governments.

The stakeholders can effect on the penetration with differ ways. New market models and business models have been developed and should be develop further.

In each case the costs and benefits to each stakeholder depend on the details of technologies and their methods of control, on the details of contracts between stakeholders as well as on some other things like market rules, regulation and subsidies. For example, microgeneration may in some cases benefit DSO in the form of reduced peak load but the negative effect on revenue may be much larger. Thus the specific tariff applied has a crucial effect. Similarly, the financial incentives applied between an aggregator and consumer have a crucial effect on the benefits and behaviour of both parties.

It is important that in each case the key parties involved should find rules, tariffs and incentives, which allow all stakeholders to benefit, or at least not suffer, from the introduction of the new technologies. Otherwise it will be difficult to form successful business models on voluntary basis. To implement DR with the new technologies, manufacturers should add machine-to-machine communication ability using widespread standards.

The quantitative assessment of for ex. network effects of new technologies is very much dependent on the case to be studied (local network situation, customer mix, penetration scenarios, regulatory environment etc.). It is difficult to generalize results from one case to another.

Proposal for the future work

On the basis of the work carried out in Phase 1 and 2 it is proposed to continue the work in Phase 3.

Very preliminarily this phase includes four new subtasks:

- Subtask 10 – Role and potentials of flexible consumers (households and buildings)
- Subtask 11 – Changes and Impacts on the grid and market operation
- Subtask 12 – Sharing experiences and finding best practices
- Subtask 13 – Conclusions and Recommendations

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Table of content

1 Introduction

Energy policies are promoting distributed energy resources such as energy efficiency, distributed generation (DG), energy storage devices, and renewable energy resources (RES), increasing the number of DG installations and especially variable output (only partly controllable) sources like wind power, solar, small hydro and combined heat and power.

Intermittent generation like wind can cause problems in grids, in physical balances and in adequacy of power.

Thus, there are two goals for integrating distributed energy resources locally and globally: network management point of view and energy market objectives.

Solutions to decrease the problems caused by the variable output of intermittent resources are to add energy storages into the system, create more flexibility on the supply side to mitigate supply intermittency and load variation, and to increase flexibility in electricity consumption. Combining the different characteristics of these resources is essential in increasing the value of distributed energy resources in the bulk power system and in the energy market.

IEA has several Implementing Agreements dealing with distributed generation (DG) (such as wind, photovoltaic, CHP), energy storage and demand side management (DSM). However, the question of how to handle the integration of various distributed energy resources is not actually studied.

This Task is focusing on the aspects of this integration.

2 Objectives

The main objective of this Task is to study how to achieve a better integration of flexible demand (Demand Response, Demand Side Management) with Distributed Generation, energy storages and Smart Grids. This would lead to an increase of the value of Demand Response, Demand Side Management and Distributed Generation and a decrease of problems caused by intermittent distributed generation (mainly based on renewable energy sources) in the physical electricity systems and at the electricity market.

Thus the integration means in this connection

- how to optimally integrate and combine Demand Response and Energy Efficiency technologies with Distributed Generation, Storage and Smart Grids technologies, at different network levels (low, medium and high voltage)

- and how to combine the above mentioned technologies to ideally support the electricity networks and electricity market

The Task will provide the integration based solutions and examples on successful best practices to the problems defined above to the different stakeholders.

3 Approach

3.1 Phase 1

The first step in the Task was to carry out a scope study collecting information from the existing IEA Agreements, participating countries with the help of country experts and from organized workshops and other sources (research programs, field experience etc), analyzing the information on the basis of the above mentioned objectives and synthesizing the information to define the more detailed needs for the further work.

The final reports of the Phase 1 are published in the IEADSM web-site http://www.ieadsm.org/ as the key publications:

- Task XVII - Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages - Final Synthesis Report vol 1.
- Task XVII - Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages - Final Synthesis Report vol 2.

Vol l. includes the main report and Vol 2. is the annex report with country descriptions, analysis tools etc.

In spite of these public reports the secure web-site includes the answers to questionnaires of the experts and descriptions of about 50 case studies.

3.2 Phase 2: Task extension. The assessment the effects of the penetration of emerging DER technologies to different stakeholders and to the whole electricity system

The main topic of the Task extension is to assess the effects of the penetration of emerging DER technologies to different stakeholders and to the whole electricity system. The emerging DER technologies to be discussed include

- plug-in electric and hybrid electric vehicles (PEV/PHEV)
- different types of heat pumps for heating and cooling
- photovoltaic at customer premises
- micro-CHP at customer premises
- energy storages (thermal/electricity) in the connection of previous technologies.
- Other technologies seen feasible in 10 – 20 years period, especially by 2020. At the first expert meeting the following additions were agreed: smart metering, emerging ICT and possibly small wind at customer premises. Due to the practical limitations only smart metering is discussed in details.

The main Subtasks are (in addition to Subtasks 1 – 4 of the phase one):

Subtask 5: Assessment of technologies and their penetration in participating countries

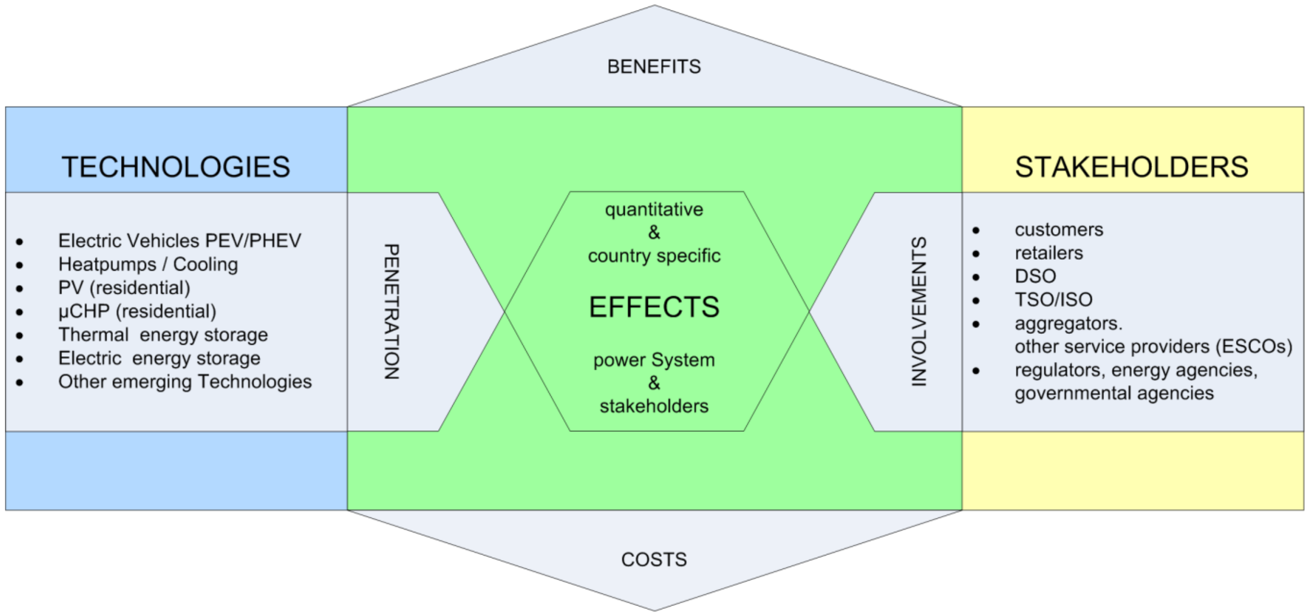
Subtask 6: The collection of new pilots and case studies

Subtask 7: Stakeholders involved in the penetration and effects on the stakeholders

Subtask 8: Assessment of the quantitative effects on the power systems and stakeholders

Subtask 9: Conclusions and recommendations

The figure below describes the concept of this extension. The more detailed descriptions of the subtasks is given below



4 Subtask 5: Assessment of technologies and their penetration in participating countries

Subtask 5 deals with the emerging generation, end-use and ICT technologies at customer premises. Five separate technology reports were produced:

- Subtask 5, Report n:o 1. Full electric and plug-in hybrid electric vehicles from the power system perspective [1]
- Subtask 5, Report n:o 2. Micro-CHP technologies for distributed generation [4]
- Subtask 5, Report n:o 3. Heat pumps for cooling and heating [5]
- Subtask 5, Report n:o 4, Photovoltaic at customer premises [6]
- Subtask 5, Report n:o 5, Smart metering [7]

These reports are shortly summarized in the following.

4.1 Full electric and plug-in hybrid electric vehicles from the power system perspective

The report briefly reviews current electric vehicle technology, presents some future prospects, and presents some possible consequences to the power system, and ways in which the harmful effects could be minimized. From the integration point of view the services offered by EV are interesting in the longer run

4.1.1 Services which can be offered by smart charging and V2G

Smart charging and V2G can provide the same types of services to the power system as DR and DG in general. In the present situation an aggregator company is needed, which takes care of contracting and selling the power output provided by EV. The role of the aggregator is discussed in more detail in Subtask 7 report.

Charging (or discharging in case of V2G) reprofiling, which the DR provided by EV, can easily be sold on the day-ahead and intra-day power markets. Naturally this requires that proper forecasts of EV charging in normal situation (in absence of control signals) and forecasts of charging responses to control signals are available and that control signals can be sent to EV chargers or HEMS reliably and quickly.

Smart charging EV’s could not only charge (or discharge) according to the organized day-ahead and intra-day power markets, but also offer ancillary services to the TSO. Ancillary services are support services, whose purpose is not directly to provide power for consumer but to ensure the reliability and security of the grid. They include operating reserves, which maintain the frequency of the grid within acceptable margins, reactive power support and black start capability services.

Balancing market is considered to lie in the grey area between electricity markets and ancillary services. EV with smart charging in principle can take part in balancing markets but the rules for participating vary from country to country.

Reserves are used to correct small deviations in frequency that occur throughout time and to provide backup power when large power plants or transmission lines unexpectedly trip off from the grid. Reserves can be in some cases profitably provided by smart charging, depending on e.g. the country in question. Pricing of reserves varies from country to another depending on e.g. electricity generation portfolios. For example, Anderson et al. [2] estimate that a modest EV (10 kWh battery and 3.5 kW charging power) could benefit 50 € per month by providing primary reserve on the German market. In Sweden the corresponding reserve type is called frequency-controlled normal reserve, and the benefit could be 20 € per month. These numbers are significantly higher than the profits for different types of flexible loads estimated in the EU-DEEP project, and also do not include costs such as communication between the EV and an aggregator. According to Rezania and Prüggler [3], in Austria the most profitable application would be providing downward regulation on the secondary control energy market (UCTE secondary reserve).

The value of V2G on the other hand is dependent on possible sources of income versus the costs from efficiency losses, battery degradation, and additional capital expenditure. Currently no sound business case can be presented: the costs far exceed the possible income generated. Also, if different kinds of demand side management and smart charging EVs will be increasingly available in the future, the possible revenues will diminish. Another trend in the opposite direction (increasing the need of short-term balancing) is that of increasing penetration of variable and partially predictable production such as wind and solar power.

4.1.2 Status and perspectives of EV in participating countries

The present situation and some prospects of EV in the participating countries, Finland, France, Austria, Netherlands and Spain are also presented. The following observations can be made:

Incentives

In Finland currently there are tax reductions for the registration tax and annual vehicle taxes. In France the government provides a direct 5,000 euro subsidy for the purchase of the electric vehicle (max 20 % of the purchase price). In Austria EV's are exempt from the registration tax, and there are direct subsidies (up to 5000 euro) in three of the nine provinces. In Spain some regional governments grant direct subsidies for the purchase of EV. In the Netherlands incentives include total exemption of the registration fee and road taxes, which result in savings of approximately 5,300 € for private car owners over four years (ACEA 2010). There are also parking spaces dedicated to EV.

In general, the incentives vary even inside the country and can change rapidly.

Future scenarios

It is very difficult to forecast the pace of growth in the number of electric vehicles. The scenarios prepared in different countries involve different assumptions, and thus are not directly comparable. If we neglect this problem and take the medium or target scenario from each country and avoid the low and high scenarios (if different scenarios have been presented), we end up with the results in table below. Unfortunately, in some cases the figures refer to FEV and in some cases also PHEV is included.

Table: medium or target scenarios of EV penetration in different countries.

	number of EV		per 1000 people	
	2020	2025	2020	2025
Finland	79,000		15	
France	2,000,000	4,500,000	31	69
Spain	1,000,000		22	
NL	200,000	1,000,000	12	59

Impacts on the electricity grid

Results from all countries were not available and the parameters used in charging studies vary from case to case. Generally the findings seem to indicate that the effect of charging intelligence is considerable. In Finland and NL a significant portion of the vehicle fleet can consist of full electric vehicles without causing problems to the local grid, if smart charging has been implemented. In other countries, such as Italy, the distribution grid has been dimensioned differently, with very small power allocated to each connection point. In France, 7.5 million EV's and PHEV's (portions not defined) would not cause significant peaks in the transmission grid, if smart charging has been implemented.

If smart charging is insufficient to alleviate the load caused by charging, problems can be alleviated by encouraging local generation (such as µ-CHP's) to supply part of the charging power, and finally by expanding grid capacity.

4.2 Micro-CHP technologies for distributed generation

4.2.1 General

µ-CHP technologies generate both heat and power and can thus be considered in sites where a sufficient heat load is present. µ-CCHP (micro combined cooling, heating and power), which produces cooling by absorption chiller, is being studied but not widely available commercially. Energy saving with µ-CCHP compared to compression chiller is not evident in all cases.

In this report different µ-CHP technologies were reviewed. Typical features of µ-CHP units based on internal combustion engine are: low costs, high efficiency, wide power range and ability to run on different fuels. Internal combustion engine power plants are modular, i.e. standardized units can easily be combined. Their weak points include noise, high emissions and high maintenance costs. Advantage of gas turbines is small size. Disadvantages include poor efficiency at part load and high investment cost. Advantages of Stirling engine, when compared with internal combustion engines, include stable combustion, low noise and emissions and longer maintenance intervals. Advantages of fuel cells are: high electrical efficiency (also at part load), low noise and emissions. Disadvantages are very high costs and fuel quality requirements.

Besides natural gas and heating oil, wood chips or other biomass may be used in ICE, Stirling engines or microturbines. Gasification stage and gas purification is required with ICE and microturbine. The benefit is the wide availability, renewability and often low cost of biomass.

Finally, µ-CHP can use solar radiation as energy source. The disadvantage will be that output cannot be modulated according to user and system needs.

4.2.2 Status and perspectives of µ-CHP in the participating countries

The appendices describe the current status, policies and projects related to µ-CHP in the Netherlands, Austria and France. The following conclusions can be made.

In Finland, the penetration of µ-CHP's is very low, with only few units operational. The natural gas distribution network is very limited, which restricts the use of gas-consuming µ CHP units. Also the size of these units is on the high end of the µ-CHP power range, and household-sized units do not exist. Also there is no support for µ-CHP's in Finland. For this reason there is no separate report from Finland. In Spain there is a similar situation.

In France the penetration of μ-CHP's is very low, with only few dozen units operational. There are no household-sized units but the units have been installed in hospitals, sport centers, research centers, etc. There is a purchase obligation, according to which EdF must purchase the produced electricity for 80 €/MWh. The future success of μ-CHP depends on incentives and competitiveness of other heating technologies. According to low scenario, there would be 200 MWe μ-CHP's in France by 2020.

In Austria there are a few hundred μ-CHP's operational and most of them are residential-sized gas engines. All but the smallest μ-CHP's using gas are applicable for subsidies of up to 25% of environmentally related investment costs. However, there are restrictions to the subsidy, for example private citizens are ruled out, the applicants have to run a business. The experience in Austria is that from the point of view of distribution grids, μ-CHP's produce far more revenue losses to the DSO than what they can create savings by reducing peak loads. In other words, from the perspective of a grid operator, μ-CHP's reduce revenues in low voltage grids disproportionately.

In the Netherlands the expectations for the introduction of μ-CHP were high a few years ago. It was expected that the traditional high-efficiency boilers could be replaced by μ-CHP . However, the prices of the technology have not gone as expected and also discontinuation of investment subsidies has had the effect that the real penetration of the technology is lagging behind. There used to be an investment support of about 5000 € for domestic μ-CHP units but at the moment this has been discontinued.

Horticultural sector is quite important in the Netherlands with regard to μ-CHP and some units were already installed in the 1990's. Currently there are about 1500 μ-CHP units installed in NL. The total market, if prices could be lowered, is several million units. In NL, as opposed to Finland, the gas distribution network is extensive, thus gas-based μ-CHP can be installed almost anywhere.

DR is easily implemented with μ-CHP because thermal storages are becoming more commonplace. In the horticultural sector they have existed for years. In the residential sector the thermal storage can be used either to store hot tap water or hot water for heating.

4.3 Heat pumps for cooling and heating

The report summarizes the heat pump technologies and their prospective for demand response purposes. In addition to that the situation of heat pumps in participated countries are described.

4.3.1 Heat pumps and demand response

In principle heat pumps are suitable for demand response for several reasons:

- the penetration rates of different types of heat pumps for heating and cooling are high and increasing in most countries
- in the control strategy demand response needs during the system peaks fits well with the high use of heat pumps either for cooling in summer peak or heating in winter peak situations, similarly local peaks at network level can be decreased; on the other hand, in very low temperatures the COPs of heat pumps are low and in very low temperatures (typically below - 20 to - 25 C^{o}) they have to be stopped and additional heating systems are in use (electricity or gas)
- from the customer's comfort point of view heat pumps can be controlled similar way as electric heating and other air-conditioning systems: due to the natural (building mass) and artificial heat storages the heating/hot water production and cooling can be switched off for certain time periods

- from the technical point of view the total switching-off the heat pumps or the thermostat set-point adjustments are possible in short term because heat pumps usually have remote control capabilities

However, some obstacles exist for the use of heat pumps for demand response like

- because technical requirements and solutions such as open interoperable interfaces and functionalities are still missing, there are not much experience from the use of heat pumps for demand response; therefore it may take long time before mature technical solutions are available
- after the control period of heat pumps their load will be high and this “pay-back” has to be taken into account in the control strategy
- starting current of heat pumps after switch-off or blackouts can be high and problematic to the networks; this has to be taken into account

4.3.2 Summary on situation in participating countries

The table below shows roughly the penetration of heat pumps at the moment and in 2020 and/or 2030 in participating countries.

	2010		2020		2030	
	number	total electric power (MW)	number	total electric power (MW)	number	total electric power (MW)
Austria	175 000	350	250000	508	343000	696
Finland	390 000	> 2000	1 000 000			
France	950 000		2 000 000			
Netherlands	?		1 500 000			
Spain	6.3 % of houses in 2008	share of summer peak 2.24 %	9 300 000			

The shares of different types of heat pumps are different in different countries:

- In Finland roughly 20 % were ground source based in 2010, but the air/air heat pumps have been very popular during the recent years
- In France the share of geothermal (ground source) is recently about 40 %
- In Spain in practice all heat pumps are air-based

The penetration of heat pumps are partly related to the energy policies, regulations and incentives related to heat pumps: in many countries heat pumps are seen as a way to increase energy efficiency and to reduce CO2-releases:

- In Finland there is financial support (max 20 %) for the renovation investments as well as income tax reduction for labor costs
- In France an income-tax credit permits to deduce from one’s tax return a percentage of the investments made in different sustainable development installations. For geothermal heat pump, the tax credit was of 40% in 2010, and is of 36% in 2011. For air/water heat pump,

the tax credit was of 40% in 2009, 25% in 2010, and is of 22% in 2011. The government also allows “eco”-loans at 0% interest for ecological installations. In the case of heat pumps, construction work such as drilling for geothermal heat pump for example can benefit from this loan. Renovation work can also benefit from the loan but only if there is a substantial energy saving with the new equipment. Also the VAT is reduced to 5.5% instead of 19.6% for heat pumps installations.

- In the Netherlands applying heat pump systems in homes and utility buildings is taken up in the design time energy performance index (EPC), to which newly built homes in the Netherlands have to comply. This makes it easy to compare heat pumps to other measures to conserve energy. Heat pumps in the Netherlands in existing homes are also subsidized on a per investment basis. For home owners the amount of money is approximately 5000 euro for water/water heat pumps and 2000 euro for air/water heat pumps. Allocated budgets change in time depending on the policy.
- In Spain there are trend to increase the share of geothermal heat pumps. At the moment this market is still very small in Spain. However Spanish regions are subsiding up to 20% of the total cost of geothermal heat pumps.

4.4 Photovoltaic at customer premises

The report describes the present PV technologies and the future development trends in technologies. It also discusses on the penetration of PV in European countries and especially in participating countries. Also the price development of PV modules and systems is discussed.

The following table shows the recent cumulative development of the grid-connected PV penetration in participating countries (in MWp):

	2009	2010	2011
Austria	49	99	187
France	306	1025	2831
Netherlands	62.5	91.9	130
Spain	3418	3787	4260

In Finland the grid-connected PV penetration is nil.

The rapid increase of PV capacity in most of the countries is related to the two main factors:

- PV technology and manufacturing capacity have been increased rapidly which has resulted in the decrease of PV prices. In 2011 prices decreased even up to more than 50 % in some countries.
- Energy policies with incentives and feed-in tariffs have supported the PV development

In 2010 the support policies in participating countries included

- In Austria the revised Green Electricity Act (GEA) forms the framework for national PV implementation in Austria. The nationwide feed-in tariff system for electricity introduced under the GEA is financed by all consumers of electricity via supplements on the electricity price and an obligatory purchase price for Green Electricity that is paid by electricity dealers. Besides the federal feed-in tariff scheme, an initiative launched in 2008 – the national Fund for Climate and Energy – provided rebates for newly installed private PV systems up to 5 kW installed capacity. In 2010 17,8 million EUR were granted under this funding scheme, leading to an installed capacity of over 11 MW. Each Austrian province is also running regional PV rebate programs, aimed at overcoming the limitations of federal incentives. In most cases the support is subject to limited budgets and is linked to further requirements. Generally, the regional support is only granted where the installation is not supported by the federal feed-in tariff scheme. In 2010 the regional funding initiatives amounted to about 39,6 million EUR and helped to install a total PV capacity of about 22,6 MW.

- In France public initiatives structured and supported the expansion of the PV market during 2010: these included the feed-in tariff with a highly specific orientation towards building integration, the income tax credit of 25 % of the amount of the investment in PV system goods (this was 50 % until 29 September 2010) up to a cap of 8 000 EUR per taxpayer (16 000 EUR for a couple), the ADEME-FACE contracts for off-grid systems and various regional and local government support measures. In order to control the development of the market the French government set up in 2011 a new method of evolution of the purchase obligation prices. Since March 10th, 2011, the prices of the purchase obligation are reviewed every trimester (July 1st, 2011, October 1st, 2011, January 1st, 2012, etc). These prices depend on the number of installations demanded.
- In the Netherlands the market increase in 2010 compared to previous years is partly due to the release of a backlog of grants following the start of the new subsidy scheme (SDE) in 2008. Grants from previous years still remain in the pipeline. The subsidy scheme has now been revised and systems below 15 kW are no longer supported.
- In Spain Royal Decree 1565/2010 has amended the economic regime contained in Royal Decree 1578/2008 for photovoltaic installations in operation, putting electricity into the grid and registered in the Administrative Registry of Producers after 30 September 2008. Feed-in tariffs have been amended as follows: 45 % reduction for ground-based PV installations, 25 % reduction for large rooftop installations (> 20 kW), and 5 % reduction for smaller roof-top systems. With regard to PV systems in operation, putting electricity into the grid and registered before 30 September 2008, their economic regime has also been amended by cancelling the feed-in tariff after 25 years of operation. Other amendments include a definition of a ‹substantial change› in installations whereby the plant may become ineligible to continue to receive the feed-in tariff set in the previous economic regime. The feed-in tariff paid to Spanish PV installations was also reduced through limiting the operational hours, via Royal Decree Law 14/2010. Operational hours are limited to 1250 hours per year for fixed systems, 1644 hours per year for single-axis tracking systems and 1707 hours per year for two-axis tracking systems. Surplus generation outside these hours is purchased at regular wholesale electricity market prices. The limitation applies for the next three years; however, to compensate, the total period for which the feed-in tariff can be obtained has been extended three years. In addition, a network toll has been introduced, applicable to all electricity generation plants, with PV plants being exempt for the first three years.

4.5 Smart metering

The report analyzes the technologies, regulation, costs and benefits as well as experiences of smart metering. It also describes the current situation of smart metering in the participating countries. Short summary of this is as follows.

4.5.1 Austria

According to the new Electricity Act (ElWOG 2010), the Minister of Economy may introduce smart metering per decree, following a cost-benefit-analysis. The regulator may define functionalities and data requirements of a smart metering system. Current situation in Austria is that approx. 40.000 smart meters are installed, and it is planned that 80% of the customers will be equipped in 2020 according to the EU rules..

4.5.2 Finland

Currently, the number of the AMR meters is increasing rapidly in Finland, because almost all DSOs have AMR meter installation work ongoing. This is mostly due to the "Government Decree on settlement and measurement of electricity transactions (66/2009)". Based on the decree, at least 80 % of the customers have to be measured with AMR meters by 31^{st} of December 2013. However, it is assumable that penetration will be almost 100 %, since most of the DSOs are installing AMR meters for all customers during their AMR installation programs. More than one million meters have been installed

4.5.3 France

ERDF was asked by the CRE (Energy Regulation Committee) to experiment an advanced smart meter counting system, based on recommendations made in the CRE's declaration of the 6th of June 2007. This LINKY pilot project consisted 300 000 meters and ended in March 2011. The CRE validated this experimentation. The deployment objective of smart meters is 35 million smart meters installed in 2020.

The results being positive, this project prefigures the national deployment of smart meter systems in France, though some points are still being discussed as, for instance, what kind of information and services suppliers should provide to their clients in order to help them reduce their consumption and at what price? By the end of 2011, there are still political discussions concerning who shall finance the system and who will own the meter (ERDF or local distribution managers).

4.5.4 The Netherlands

The Dutch Government plans to roll out smart meters following Electricity Directive 2006/32 EC. The bill concerning the rollout was adopted in February 2011 and was followed by an Order in Council ("Algemene Maatregel van Bestuur" or "AMvB") which came into effect on January 1^{st} 2012. This Order determines the functions of the Smart Meter on which the final standard should be based. The Grid Operators (GO's) in the Netherlands are responsible for the roll-out of smart meters, for both gas and electricity

There are currently about 8 million electricity meters and 7.1 million gas meters in the Netherlands. In a period starting in 2012 up to 2020, 80 percent of these meters will be replaced by smart meters

From the first of January 2012 the GO's will start with the small-scale rollout. During a two year period the GO's will be placing smart meters:

- In new domestic houses
- As part of regular replacements of old meters
- In case a customer requests a smart meter.

The GO's plan to install smart meters at 450.000 households in these 2 years. As most Dutch households are dual fuel consumers, this amounts to almost double that number in terms of actual meters. The large scale rollout is planned to start on January 1^{st} 2014.

Spain

In 2007, since the publication of the "*Reglamento Unificado de Puntos de Medida"* (RD 1110/2007) and of the "*Orden Ministerial por la que se regula el control metrológico del estado"*

(ITC/3022/2007), the regulatory framework for smart meters in the residential sector establish new functionalities to be implemented in the meters.

At the end of 2007, Spain approved the National Plan for Meters Substitution which involved the obligation for distribution companies to change 26 millions of meters in the residential sector in Spain for 2018. In addition consumers will pay around 15 % more each month for the smart meter rent since the moment that they have a new meter.

However the delay in the implementation of this plan has motivated a revision of milestones in the Orden IET/290/2012 maintaining the target of 26 millions of meters for 2018 but rescheduling the milestones.

In Finland the minimum functional requirements for the smart meters are defined, in other countries they are still under discussion and the requirements seem to be varying depending on the local circumstances and market regulations.

5 Subtask 6: pilot case studies

In the Phase 1 an internal data base for pilot and case studies was established and about 50 cases were collected into the data base.

This work has continued during this Phase 2 (Task extension). The template for the data collection was modified a little bit related to the technologies studied.

The following cases are included in the database:

5.1 Austria

Building 2 Grid

Utilizing of the building's demand shifting potential for the support of the distribution network.

To determine the potential to store thermal energy on one hand and to operate the building within these constraints on the other hand.

The case describes how electro-thermal processes in buildings can be used for demand response and how such intelligent behavior can be enabled via communication technology.

Experiments and simulations on typical mid-European buildings were done to estimate the potential time constants.

DG DemoNet: SmartLVGrid

Integration of high PV and EV penetration into rural low voltage distribution grids by voltage control with a LV on load tap changer and with reactive power of the PV inverters, controlled charging of EV, load shedding of electric heat devices

5.2 Finland

Green Campus

The objectives of the case are to implement smart grid technology with distributed generation, energy storages, and load control, in the existing network, to realize a research platform for further development and analysis and to demonstrate operation of versatile smart grid functionalities

Market price based control of electrical heating

The objective of the case is to develop a new dynamic load control method to replace the traditional static time of use tariffs and controls. The messages and the operating model were developed for the purpose and were implemented to two smart metering systems including the meters, the systems of a DSO and two retailers are completing the needed changes, too. The extra investments needed for changing ToU to dynamic are very small compared to the other present possibilities to large scale dynamic small customer DR in Finland..

Home Energy Management System (HEMS)

Objective of the case was to learn more about the possibilities and requirements of the HEMS (Home Energy Management System) by piloting. Furthermore, most potential functionalities of such system were evaluated.

Low-Voltage DC (LVDC) real-network research platform

Realisation and verification of the operation of the research platform for LVDC distribution in actual application environment. Gathering experiences and feedback from customers and DSO. Providing platform for further development of the technology, working methods, inspection processes and standardization

5.3 The Netherlands

De Teuge/ Zutphen and Aqua Vicus in Alphen aan den Rijn

Evaluate the operation of heat pumps for delivery of heat and cold and tapwater in 201 homes in two Dutch distribution areas. Verify dimensioning of the distribution assets calculations.

PowerMatchingCity/ Hoogkerk

8 use cases were considered:

1. Reduce wind imbalance
2. Integrate PV-production locally
3. Reduce imbalance from PRP perspective
4. Tailoring of portfolio profile
5. Ramp-up/ramp-down assistance
6. Integrate charging pattern of EV fleet
7. Dual objective optimization (commercial and grid management)
8. Provide user/usage feedback via Web-portal

SPCA Apeldoorn and Intelligent distribution station

Evaluate the operation of 172 micro-CHP installations homes in a Dutch distribution area in Apeldoorn. Verify dimensioning of the distribution assets calculations

5.4 Spain

GAD Project

The objective was to develop solutions aiming at the optimization of electric demand in residential sector. GAD Project (2007/2010) proved that it is possible to do DSM in Spanish houses through interaction with smart electric appliances and smart meters

PRICE Project

This Project has a wide scope including all the aspects related to integration of distributed resources. Regarding DSM the goal is to developed a monitoring and management system (for DSO, TSO and retailer) that take into account consumers with smart meters (installed within the context of the National Smart meters substitution Plan)

VERDE Project

VERDE Project aims at developing a SEAT EV and its efficient integration in the grid. (49 M€ 2009/2012)

5.5 Other projects

In addition to the above mentioned projects in the database the reports of Subtask 5 and 7 include description of some other ongoing activities.

6 Subtask 7: Stakeholders involved in the penetration and effects on the stakeholders

6.1 Summary of the stakeholders' involvement

In the Subtask 7 the following report has been produced:

– Stakeholders involved in the deployment of microgeneration and new end-use technologies. Subtask 7 Report [8]

The report discusses different stakeholders involved in the penetration of microgeneration and new end-use technologies, as well as effects on the stakeholders. Microgeneration includes e.g. solar power (photovoltaics and concentrated solar power), small wind turbines and micro-CHP; new end-use technologies include heat pumps and electric vehicles with smart charging. The characteristic for these technologies is that they are installed at the consumer's premises and generate power mainly for the consumer himself. We also considered the rough power limit for microgeneration to be 50 kW_e.

We identify a number of stakeholders to whom microgeneration and new end-use technologies can present significant effects. Most importantly, the consumer himself, network companies and electricity supplier (retailer) are involved. Network companies may either benefit or suffer from the introduction of microgeneration, heat pumps and EV, depending on the specific technology and how it is used. The consumer can contract an aggregator to sell the microgeneration or reprofiled consumption to competitive energy market participants or network companies. Manufacturers strive to develop more affordable and more efficient generating units, normally with the help of subsidies provided by governments.

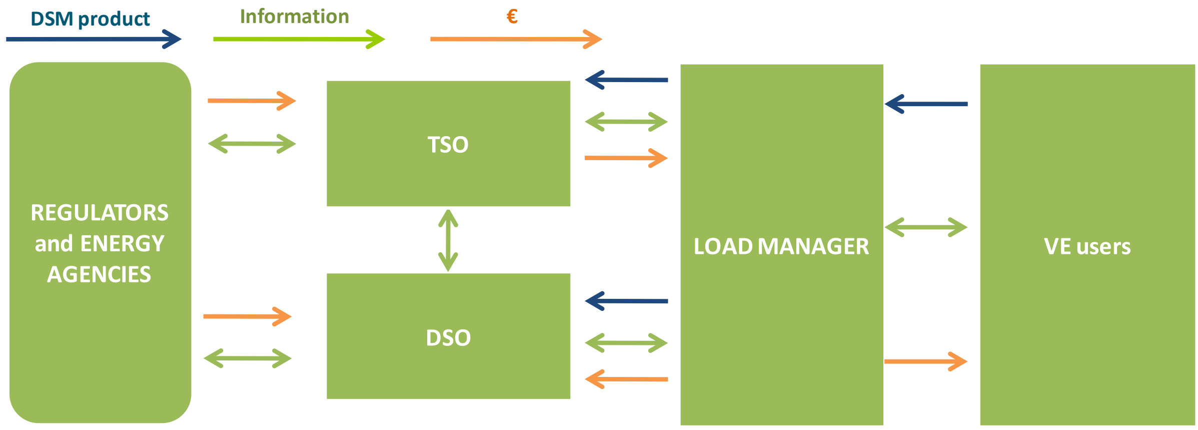
The scope of this report is indeed wide. The report reviews the various questions the stakeholders have to consider related to the introduction of the new generation and end-use technologies. Examples include operation of the microgenerators and EV charging systems, communication, effects on power quality, network stability and network capacity, emissions, energy efficiency, etc. In some cases, the questions can turn out to be serious barriers.

It is difficult to draw general conclusions about the costs and benefits to each stakeholder. In each case they depend on the details of technologies and their methods of control, as well as on the stakeholders themselves and the details of contracts between them.

The appendices provide some examples of stakeholder involvement from four different countries:

6.2 Spanish business cases for EV and smart meters

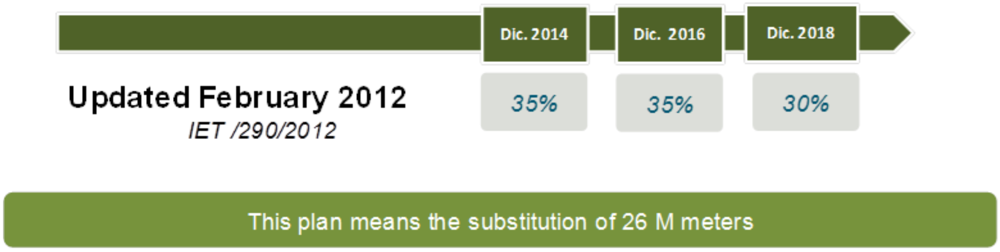
In the case of EV, an aggregator of electric vehicles is the commercial middleman between a collection of PEVs and electric system agents (TSO, DSO, retailers). From the TSO perspective, the aggregator is seen as a large source of generation or load, which can provide ancillary services and can also participate in the electricity market with supply and demand energy bids, as indicates in the following market model.



Market model for Spanish DSM provided by EV users

In Spain there is a National Plan for Meters Substitution which involved the obligation for distribution companies to change 26 millions of meters in the residential sector for 2018. Figure below shows the percentage of additional (not cumulative) metering points to be installed by 2014, 2016 and 2018.

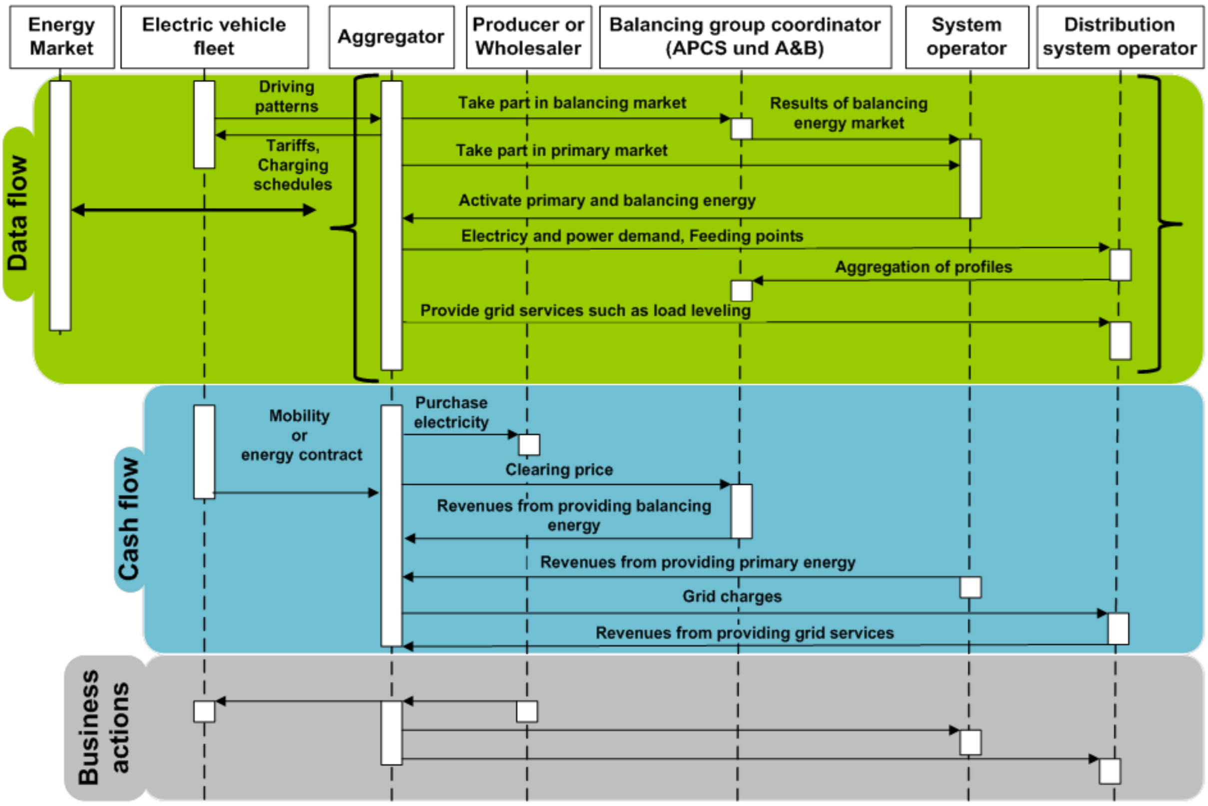
Consumers can choose between buying the meter or pay a rent (most used option) which implies to pay around 15 % more each month for the smart meter rent since the moment that they have a new meter.



Spanish Smart Meters Substitution Plan

6.3 Stakeholders for integration of electric vehicles into the Austrian energy system

The figure below shows the involved stakeholders for integration of EVs. Figure shows a possible integration of the new stakeholder -Aggregator- in the Austrian electricity sector. The figure shows that the electric vehicle users or owners will have only a contract with the Aggregator (e-mobility provider / service provider).



Involved Stakeholder for integration of EVs in the Austrian energy system

The integration of the mentioned agent with the responsibilities of an aggregator could be realized with:

1. The extension of a current stakeholder such as an advanced retailer with added responsibilities like managing the EVs charging/ discharging strategies and diffusion/development of charging points in certain areas (except public areas). The advanced retailer would act with his fleet and the mentioned strategies as an energy consumer and as a producer/ power provider for different ancillary services, simultaneously. Thus, the charging/discharging strategies of EVs could fulfill different target functions of DSM. Due to a high penetration of EVs, the charging/ discharging strategies could take the security of the grid into account (load management). This can be accomplished by considering of coming needs from the DSOs. Therefore, the cooperation between aggregators and DSOs in conjunction with DSM-application and grid security (controlled charging/ discharging strategies) will be needed.
2. The establishment of new actors in an enhanced regulatory framework: This way leads to the integration of a new stakeholder with the defined responsibilities for an advanced retailer. This way may result in a change of each stakeholder's framework conditions.

If charging stations are available and they could be controlled by an aggregator depending on penetration of EVs, there would be a corresponding and significant load control potential, respectively.

6.4 Tariff scheme options for distribution system operators in Finnish conditions

Based on the analyses of DER penetration in the Finnish conditions, there will be drastically changes in the end use of electricity, which will affect the costs and incomes of the network companies. Currently, DSO tariffs in Finland are based on the energy fee and fixed monthly fee, of which latter one is typically based on the size of the main fuse. The proportion of the energy based fee varies between the companies and customer types; typically it is 40–75 % of the total distribution fee. Hence, the incomes of the DSOs are based on the amount of the delivered energy, while the majority of the costs of the DSOs are based on power demand. As illustrated above, for instance heat pumps, in Finnish climate, will decrease the amount of the delivered energy, while peak load remains the same. Thus, with present tariff structure, the income of the distribution company will decrease, while costs remain same, which could jeopardize the business of the DSO, or lead to unfair distribution of network tariffs among customers. To avoid such development, the possibilities of the development of the tariff structure of the DSOs have been studied.

Several different tariff structures have been considered, and the most promising option seems to be power band tariff, where billing is based on the amount of the network capacity (power limit) subscribed by the customer, similarly as in the broadband internet connections. In that solution, customer will pay the fixed monthly fee for the power limit (€/kW) to DSO. The assumption was that the customer is allowed to exceed the power limit a certain number of times per year. Incentives for decreasing the energy consumption are based on the energy based sales tariff and energy based taxes. The quantitative and qualitative impacts of such tariff system for the customers and DSOs, as well as for the other stakeholders of the electricity markets, have been analysed. Quantitative analyses have been made based on the hourly load data of 1 500 customers from several years' period. Customers belong to different customer groups (households, agriculture, services etc.) and they are located in the area of two DSOs.

Major outcomes of the analysis are that such tariff structure is in line with the general demands of the DSO tariff structure and it enables market based demand response. Furthermore, for DSO, such tariff structure is cost reflective, and ensures predictable revenues. For customers, tariffs provide incentives to decrease peak power (e.g. by optimal dimensioning of DER) and to optimize energy usage against the demands of the distribution network also. Thus, in long run, it should increase capacity utilization rate in distribution network, which will decrease the costs of the electricity distribution. Furthermore, quantitative analysis of the customers' load data indicates that five years transition period could be appropriate to avoid the oversized changes in the distribution fees paid by individual customers. Moreover, analyses have proven out that distribution fee will increase, if a customer has short peak time, and it will decrease, if peak time is long. This can be justified because customers with longer peak time use distribution network capacity more efficiently than customers with shorter peak time.

6.5 Analysis of the stakeholders involved in the penetration of the new technologies in France

In the French analysis the roles of stakeholders are discussed in the case of PEV/PHEV, smart meters and PVs. Conclusions from these analyses are as follows:

6.5.1 PEV/PHEV

Nowadays electrical vehicles are not enough developed to have a real impact on the grid. For the moment two major problems impede the deployment of EVs: the battery and the development of the reload infrastructures. In fact, even if some car manufacturers are trying to reduce the cost for the customer, it is still high. More of that, even if the batteries' autonomy has increased, today is difficult to drive more than 150 km with one reload. As a consequence, for the daily rides the EV is a good solution but not to travel for long distance. This will incite the customer to keep his thermal vehicle or to have two cars: one for the short trips, one for the long one. So the battery is a decisive issue for the EV deployment. In order to succeed a perennial deployment, the objective is to reach in 2020 the number of 2 million of electric vehicles .

One important unknown is the charge management: how the users are going to employ their vehicles, when will they charge their batteries, the kind of charge they are going to use, etc. That is why some demonstration projects are devoted to analyse the users' behaviour to prepare the grid to a more significant insertion of EVs and to know what are the issues that need to be reviewed. Nevertheless there is a quasi-consensus on the fact that the batteries' charge needs to be smart, which means that the charge does not have to amplify the peak of the load profile or to exert stress on the grid. As it is shown on the examples of charge profiles above, the proper load and charge controls allow the reduction between 500 MW to 2 000 MW (depending on the control strategy) the morning peak and between 4 000 MW and 5 000 MW the evening peak.

Thus the debate is more on the Vehicle to Grid, the fact to use the car as storage mean or as a production mean (depending on the moment of the day and the needs of the network). Today such use is not yet considered, but this model is one of the options for the deployment of electric vehicles.

Today the use of EVs is a real opportunity for the utilities but at the same time a huge challenge. It is essential to require a harmonized standardization and policies in order to have a better impact at the European level. For the business models it is necessary for the moment that the technical solutions remain simple and the cost optimal.

On one hand, the deployment of the EVs reinforces and encourages the development of the energetic efficiency on all the kind of vehicles (thermals, hybrids or electrics).These improvements of the energetic efficiency should be in competition with the development of the electric vehicles and so the transition to the electricity will be very progressive. The panorama of the car manufacturers should be totally changed.

But on the other hand it is also a good accelerator of thinking for city planning. The problem of the public reload stations should help to reorganize the scheme of the cities, in order to better welcome the smart-grids.

Today the deployment of the EVs seems to be directly linked with the evolution of the customer mind. The demand of electric vehicles and of reload devices should help to the deployment of electric vehicles.

6.5.2 Smart meters

Nowadays, the experimentation made possible the installation of around 250 000 smart meters. This development has been possible thanks to the force of the DSO ERDF, who has an important action power. Thanks to the Linky experimentation, the goal of 35 million smart meters installed seems to be accessible. This project is enriched by the fact that other DSOs can create their own smart-meters and so, by the fact launching the competition. If the deployment of the smart-metering could be resumed in 3 different steps – technological, economic and social – they would not be all at the same stage of development.

In fact, the technological success on the basic functionalities of the Linky meter has been proved and today a lot of manufactures are working on the research and development for other functionalities like Sagemcom, Atos, Landis & Gyr, Iton, Iskramenko and Schneider Electric.

The business model of the energy market will be modified and today the final future model is not known yet, but it needs to finish launching the economy of the smart-metering.

Most probably the most unpredictable step of the deployment is the behavior of the end-users. In fact, to make interesting the smart-meters project, end-users need to play their role by being involved in their electricity consumption and production. But this requires a change in the every day habits. However the results of the Linky experimentation are encouraging: 72% of the interviewed persons have a positive opinion on their new meter

6.5.3 Photovoltaic panels

The 31st March 2012 France counted 238 312 installations of photovoltaic panels all over the territory. This number confirms that the Government efforts bared its fruit: French people have well accepted the integration of those panels even if the gross investment is very significant.

The figure below shows an example on the involvement of different stakeholders in the PV integration.

Today in France the deployment of the photovoltaic panels seems to be in good track in order to reach the 2020 objective of 5.4 GW of installed capacity. This development is notably made through the regulation of the feed-in tariffs according the quarterly number of connection requests. Furthermore the regulations are well established. The technologies for the building integration and the ways to install the photovoltaic panels are domesticated. Also it is necessary to integrate the photovoltaic aspect since the construction of the building. So now the real challenge is to decrease the module prices as much as possible, without compromising their quality and to validate the business model of the photovoltaic. According to the ADEME, the business model should allow the reduction of the dependence of the field on the feed-in tariffs after 2015 and promote the self-consumption.

Nowadays the major constraint for the deployment of photovoltaic panels is the business model: in fact to launch the photovoltaic market the French Government gives grant-in-aids and put in place attractive feed-in tariffs. But today the technical part is mature and so the feed-in tariffs are decreasing. The existing model has not favoured the self-consumption of the electricity produced. The feed-in tariffs are only set for a period of transition between the launch and the maturity of the photovoltaic market. But today the producers largely prefer the business model of the feed in tariff instead of the self-consumption.

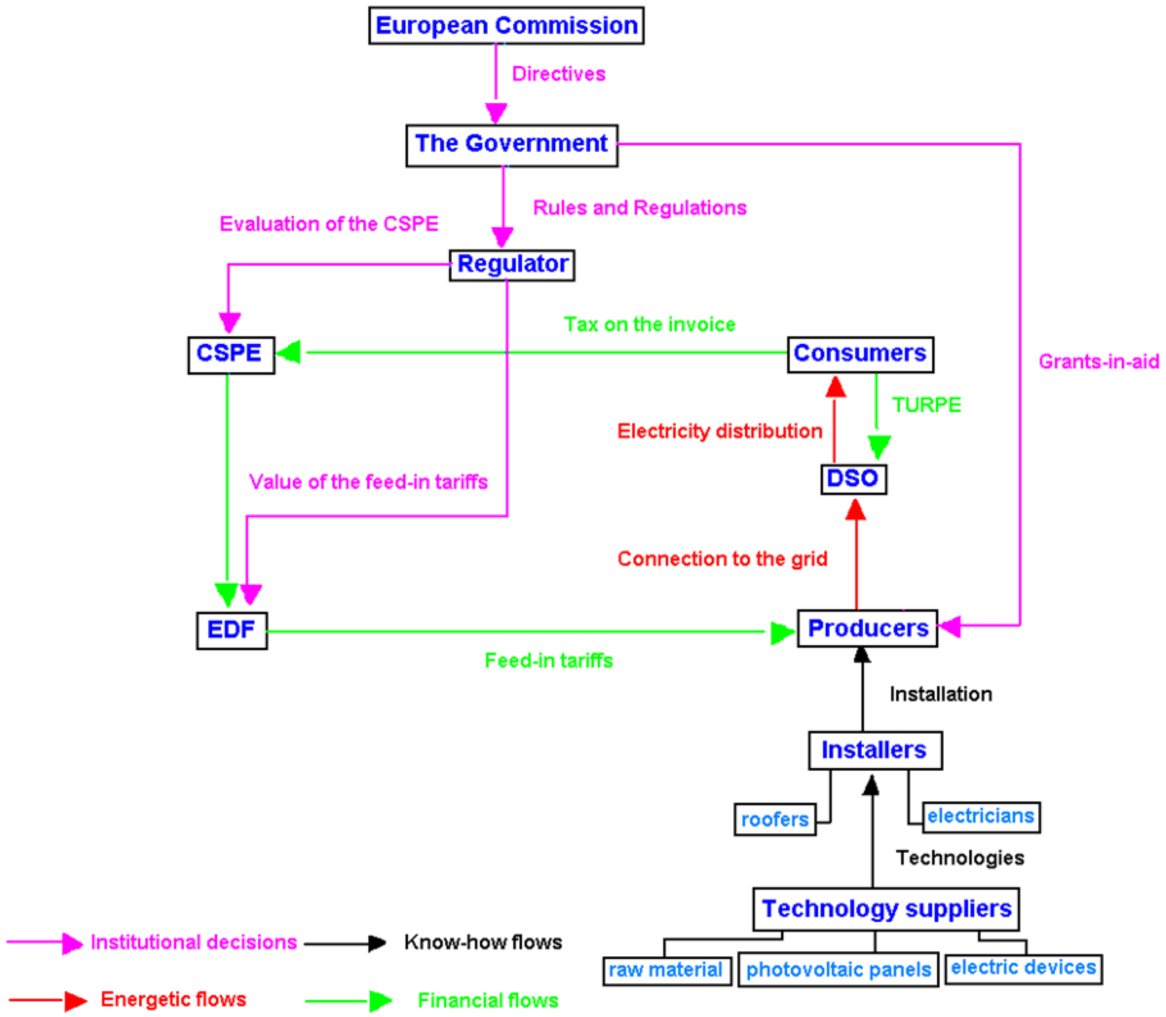


Diagram of the different interactions between the different stakeholders of the PV

7 Subtask 8: Assessment of the quantitative effects on the power systems and stakeholders

In the Subtask 8 the following report has been produced:

- Assessment of the quantitative effects on the power systems and stakeholders - case studies from Austria and Finland. Subtask 8 Report.

Quantitative assessment of the penetration of new customer-side generation and end-use technologies to the electricity system and stakeholders is a difficult task. The methodology to be used was discussed by the country experts and a proposal was prepared by Austrian experts. However, it was noted that this kind of generic methodology needs much more time and resources to be developed further and applied than what was available in this Task extension.

The quantitative assessment of e.g. network effects of new technologies is very much dependent on the case to be studied (local network situation, customer mix, penetration scenarios, regulatory environment etc.). It is difficult to generalize results from one case to another. Therefore it was decided by the experts that some specific case studies should be presented including the descriptions of local situation, assumptions etc.

This report describes shortly the following case studies from Austria and Finland:

- PV penetration and network effects in Austria
- EV penetration and impact on LV networks in Austria
- Heat Pump penetration, potential and impact on power system in Austria
- Network impacts of electric vehicles in Finland
- Impacts of heat pumps to DSOs and
- Development of the DSO tariff structures to stabilize the penetration effects of the above technologies

8 Conclusions

8.1 Technologies

Concerning the emerging end-use technologies it seems to be clear that electric vehicles will play important role in the future. Their penetration in different countries will increase in the next 10–20 years. Main obstacle is still the price of batteries which still seems to remain in quite a high level although there is potential for decrease during the next 10 years. Role of stakeholders is different in different countries as well as proposed business models. The role of some type of aggregator seems to be important in the future. Smart charging will be essential especially from the local networks' point of view. The services to the electricity system provided by EVs will be additional benefit in the future. Standardization of the charging connector is on-going. It is not sure if a single connector type can be established in Europe.

Heat pumps represent another emerging end-use technology in many countries. They are used for heating in countries with a cold climate and for cooling in countries with hot summers or for both purposes. In principle heat pumps are suitable for demand response for several reasons like they can be controlled similar way as electric heating and other air-conditioning systems: due to the natural (building mass) and artificial heat storages the heating/hot water production and cooling can be switched off for certain time periods. However, some obstacles exist for the use of heat pumps for demand response like

- there are not much experiences from the use of heat pumps for demand response and therefore also technical solutions have not been developed;
- after the control period of heat pumps their load will be high and this "pay-back" has to be taken into account in the control strategy;
- starting current of heat pumps after switch-off or blackouts can be high and problematic to the networks; this has to be taken into account;
- heat pumps should have the technical ability to receive a standardized signal to charge the thermostat setting.

One issue which can be highlighted is the lack of standardization in the field of Home Area Networks (HAN). Often the available market solutions are incompatible. Therefore, the market needs full HAN standardization and regulations in order to facilitate the the future provisions of small customer DER solutions [11].

µ-CHP technologies generate both heat and power and can thus be considered in sites where a sufficient heat load is present. It has seen as a promising technology to produce electricity locally. DR is easily implemented with µ-CHP because the shut-down and start-up costs are relatively small, the heating process includes some thermal storage capacity and thermal storages are becoming more commonplace. However, the penetration of µ-CHP is still low and much less than expected some years ago. The main reason for this is that the prices of the technology have not gone as expected. µ-CCHP units, which combine an absorption chiller, are also available commercially but are not affordable without subsidies.

PV in customers' premises is increasing rapidly in some countries. The rapid increase of PV capacity is related to the two main factors:

- PV technology and manufacturing capacity have been increased rapidly which has resulted in the decrease of PV prices. 35–50 % price reduction can be expected by 2020.
- Energy policies with incentives and feed-in tariffs have supported the PV development

Smart metering is a technology which is essential in the road to smart grids and to the integration of active customers to the electrical networks and to the market. The penetration is increasing quite rapidly in Europe due to the European legislation. At the moment countries are in different stage: some countries have already almost 100 % penetration and some are in the experimental phase. Cost-benefit analyses show in most cases that smart metering is in most cases economically feasible if the benefits to all stakeholders and to society is taken into account. It seems to be important to develop standardization and functional requirements to such a directions that all the benefits from DER can be obtained. Some smart meters can already be used for simple control of DR resources.

8.2 Stakeholder involvement and effects

Microgeneration and new end-use technologies can present significant effects to several stakeholders. Most importantly, the consumer himself, network companies and electricity supplier (retailer) are involved. Network companies may either benefit or suffer from the introduction of microgeneration, heat pumps and EV, depending on the specific technology and how it is used. The consumer can contract an aggregator to sell the microgeneration or load flexibility to competitive energy market participants or network companies. Manufacturers strive to develop more affordable and more efficient generating units, normally with the help of subsidies provided by governments.

The stakeholders can effect on the penetration with differ ways. New market models and business models have been developed and should be develop further.

In each case the costs and benefits to each stakeholder depend on the details of technologies and their methods of control, as well as on the details of contracts between stakeholders. For example, microgeneration may in some cases benefit DSO in the form of reduced peak load but the negative effect on revenue may be much larger. Thus the specific tariff applied has a crucial effect. Similarly, the financial incentives applied between an aggregator and consumer have a crucial effect on the benefits and behaviour of both parties.

It is important that in each case the key parties involved should find rules, tariffs and incentives, which in spite of common benefits also allow all stakeholders to benefit, or at least not suffer, from the introduction of the new technologies. Otherwise it will be difficult to form successful business models on voluntary basis. To implement DR with the new technologies, appliance manufacturers should add machine-to-machine communication ability using widespread open standards.

The quantitative assessment of e.g. network effects of new technologies is very much dependent on the case to be studied (local network situation and architecture, customer mix, penetration scenarios, regulatory environment etc.). It is difficult to generalize results from one case to another.

8.3 Proposal for the future work

On the basis of the work carried out in Phase 1 and 2 it is proposed to continue the work in Phase 3.

Very preliminarily this phase includes four new subtasks:

8.3.1 Subtask 10 – Role and potentials of flexible consumers (households and buildings)

Objectives

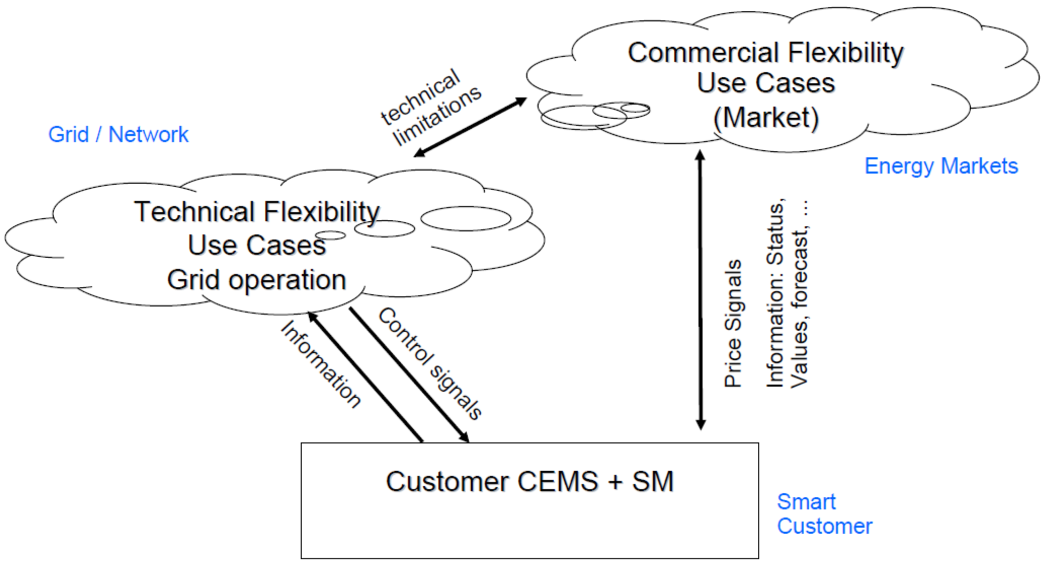
Assessing the concepts and implementations of customer energy management systems (CEMS) in different (participating) countries:

- Comparing specific requirements in households vs. functional (office) buildings
- Energy balancing possibilities and potentials
- Role of Smart Meters (SM) and (CEMS) – in the terms of technical concepts

Technologies:

In order to enable DSM, existing functionality and requirements of SM and CEMS according to the specifications (M/441, country specific) will be analyzed as following:

- Local balancing / local markets of the generated power/energy with the consumption
- Controlled charging and discharging of EV
- Integrating electrical storages
- Support aggregation to participate in markets and grid operation.



Providing network user's flexibilities [10]

8.3.2 Subtask 11 – Changes and Impacts on the grid and market operation

Objectives:

Quantification of impact on grid and market operation based on technology penetration scenarios developed in subtask 5.

- Improvement on grid operation
- Customer benefits
- Optimization potentials
- Methodology to estimate potential and to cost effective activation.
- Regulation issues for grid and (local) market operations

Interaction:

How do CEMS interact with flexibility operators (aka. aggregators)?

- Impact on the grid operation (technical flexibility)
- Impact on the market (market flexibility)
- Technical feasible but optimization necessary:
- Requirements for establishing this grid operating and market mechanisms? – regulatory and legislative
- Installation and operation costs vs. delayed network investments.

8.3.3 Subtask 12 – Sharing experiences and finding best practices

Objectives:

Based on the collected pilots and case studies from the previous subtasks the results and findings of the finished projects in term of successful implementations, barriers and effectiveness will be analyzed.

- Lessons learned from existing pilots: Workshops (E-Energy, EcoGridEU, …)
- Comparisons and analysis of country specific differences in the implementation
- Assessment and development of a methodology to apply different DSM mechanism to individual countries.
- Extrapolation of the results from previous collected projects on applicability.

Knowledge sharing (Country experts and operating agent):

- Successful DSM projects in International context and EU context.
- Knowledge and exchange of experience – best practices

8.3.4 Subtask 13 – Conclusions and Recommendations

Recommendations will be based on the experts' opinion and will at least provide a priorisation based on impacts, costs and likely future penetration of the technologies.

9 References

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5. Kärkkäinen, S., Heat pumps for cooling and heating. Subtask 5, Report n:o 3, 66 p.

6. Kärkkäinen, S., Photovoltaic at customer premises, Subtask 5, Report n:o 4, 38 p.

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8. Jussi Ikäheimo, Göran Koreneff, Stakeholders involved in the deployment of microgeneration and new end-use technologies, 168 p.

9. Kärkkäinen, S., Assessment of the quantitative effects on the power systems and stakeholders - case studies from Austria and Finland. Subtask 8 Report. 60 p.

10. Mandate on Smart Grids, M/490, *Smart Grid Standardization and Practice,* CEN/CENELEC, DKE, VDE

11. Rodriguez-Mondejar J.A., Santodomingo R., Brown C., The ADDRESS Energy Box: Design and implementation. 2nd IEEE ENERGYCON Conference & Exhibition, 2012 /Future Energy Grids and Systems Symposium.

Appendix 1 Template for data collection of integrated pilots/demonstrations/field tests/existing practices

Description of integrated pilots/demonstrations/field tests/existing practices

1. Name of the case
2. What is integrated with DSM

New end-use technologies ☐

heat pumps ☐

electric vehicles ☐

others ☐

- specify

DG ☐

Photovoltaic ☐

micro-chp ☐

small wind ☐

Others ☐

- specify

Energy storage ☐

- specify

Smart grid technologies ☐

smart metering ☐

emerging ICT ☐

- specify

3. Energy supply chain

- Customer site ☐
- Metering system ☐
- Network site ☐

4. What is the level of progress

- Proof of principle/concept/feasibility ☐
- Existing practice ☐

5. Stakeholders involved

- Customers ☐
- DSO/DNO ☐
- Retailer/supplier ☐
- TSO ☐
- Market operator ☐
- Manufacturer ☐
- Aggregators ☐
- Service providers ☐
- Regulators ☐
- Energy Agencies/governmental org. ☐
- Associations ☐
- Universities and Research organization ☐
- Telecom companies ☐
- IT system integrator ☐
- Others ☐
  - specify

6. Where to find more information?
    - Contact person
    - Company
    - web-site
    - references

7. Objectives of the case

8. Technologies used

9. Short description of the case

10. Achieved/expected results (operational savings, CO_2, efficiency enhancement)

11. Lessons learnt

Appendix 2 Overview of the IEA Demand-Side Management Programme

IEA Demand Side Management Programme

The Demand-Side Management (DSM) Programme is one of more than 40 co-operative energy technology programmes within the framework of the International Energy Agency (IEA).The Demand-Side Management (DSM) Programme, which was initiated in 1993, deals with a variety of strategies to reduce energy demand. The following 16 member countries and the European Commission have been working to identify and promote opportunities for DSM:

Austria	Netherlands
Belgium	Norway
Canada	New Zealand
Finland	Spain
France	Sweden
India	Switzerland
Italy	United Kingdom
Republic of Korea	United States

Sponsors: RAP

Programme Vision during the period 2008 - 2012: Demand side activities should be active elements and the first choice in all energy policy decisions designed to create more reliable and more sustainable energy systems

Programme Mission: Deliver to its stakeholders, materials that are readily applicable for them in crafting and implementing policies and measures. The Programme should also deliver technology and applications that either facilitate operations of energy systems or facilitate necessary market transformations

The Programme's work is organized into two clusters:
- The load shape cluster, and
- The load level cluster.

The 'load shape" cluster will include Tasks that seek to impact the shape of the load curve over very short (minutes-hours-day) to longer (days-week-season) time periods. Work within this cluster primarily increases the reliability of systems. The "load level" will include Tasks that seek to shift the load curve to lower demand levels or shift between loads from one energy system to another. Work within this cluster primarily targets the reduction of emissions.

A total of 24 projects or "Tasks" have been initiated since the beginning of the DSM Programme. The overall program is monitored by an Executive Committee consisting of representatives from each contracting party to the Implementing Agreement. The leadership and management of the individual Tasks are the responsibility of Operating Agents. These Tasks and their respective Operating Agents are:

Task 1 International Database on Demand-Side Management & Evaluation Guidebook on the Impact of DSM and EE for Kyoto's GHG Targets - *Completed*
Harry Vreuls, NOVEM, the Netherlands

Task 2 Communications Technologies for Demand-Side Management - *Completed*
Richard Formby, EA Technology, United Kingdom

Task 3 Cooperative Procurement of Innovative Technologies for Demand-Side Management – *Completed*
Dr. Hans Westling, Promandat AB, Sweden

Task 4 Development of Improved Methods for Integrating Demand-Side Management into Resource Planning - *Completed*
Grayson Heffner, EPRI, United States

Task 5 Techniques for Implementation of Demand-Side Management Technology in the Marketplace - *Completed*
Juan Comas, FECSA, Spain

Task 6 DSM and Energy Efficiency in Changing Electricity Business Environments – *Completed*
David Crossley, Energy Futures, Australia Pty. Ltd., Australia

Task 7 International Collaboration on Market Transformation - *Completed*
Verney Ryan, BRE, United Kingdom

Task 8 Demand-Side Bidding in a Competitive Electricity Market - *Completed*
Linda Hull, EA Technology Ltd, United Kingdom

Task 9 The Role of Municipalities in a Liberalised System - *Completed*
Martin Cahn, Energie Cites, France

Task 10 Performance Contracting - *Completed*
Dr. Hans Westling, Promandat AB, Sweden

Task 11 Time of Use Pricing and Energy Use for Demand Management Delivery- *Completed*
Richard Formby, EA Technology Ltd, United Kingdom

Task 12 Energy Standards
To be determined

Task 13 Demand Response Resources - *Completed*
Ross Malme, RETX, United States

Task 14 White Certificates – *Completed*
Antonio Capozza, CESI, Italy

Task 15 Network-Driven DSM - *Completed*
David Crossley, Energy Futures Australia Pty. Ltd, Australia

Task 16 Competitive Energy Services
Jan W. Bleyl, Graz Energy Agency, Austria
Seppo Silvonen/Pertti Koski, Motiva, Finland

Task 17 Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages
Seppo Kärkkäinen, Elektraflex Oy, Finland

Task 18 Demand Side Management and Climate Change - *Completed*
David Crossley, Energy Futures Australia Pty. Ltd, Australia

Task 19 Micro Demand Response and Energy Saving - *Completed*
Barry Watson, EA Technology Ltd, United Kingdom

Task 20 Branding of Energy Efficiency
Balawant Joshi, ABPS Infrastructure Private Limited, India

Task 21 Standardisation of Energy Savings Calculations
Harry Vreuls, SenterNovem, Netherlands

Task 22 Energy Efficiency Portfolio Standards
Balawant Joshi, ABPS Infrastructure Private Limited, India

Task 23 The Role of Customers in Delivering Effective Smart Grids
Linda Hull. EA Technology Ltd, United Kingdom

Task 24 Closing the loop - Behaviour change in DSM, from theory to policies and practice
Sea Rotmann, SEA, New Zealand and Ruth Mourik DuneWorks, Netherlands

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Also, visit the IEA DSM website: http://www.ieadsm.org