The role of emerging end-use and microgeneration technologies in smart grids – some findings from Task XVII

IEA DSM Workshop

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Presentation is mainly based on the work done inside the Task XVII of IEA DSM

Content of the presentation

- ☐ Overview of Task XVII
- ☐ Output of the Phase 1 (scope study)
- ☐ Phase 2. Emerging technologies at customers' premises: PE/PHEV, Heat pumps, photovoltaic, µCHP, energy storages, smart metering and ICT
- ☐ Examples from the emerging technologies
- ☐ Phase 3: proposal

Overview of Task XVII

IEA DSM Task 17: Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages

Phase one of Task XVII completed

Inside the IEA DSM Agreement a scope study was carried out in Task XVII in cooperation with seven countries: Austria, Finland, Italy, Korea, the Netherlands, Spain and USA.

The study was based on the information collected from the participating countries as well as from other countries concerning the state-of the art of market, DG/RES/storage technologies and their penetration as well as pilot case studies, research projects, etc.

Phase two will be completed officially tomorrow

Participant: Austria, Finland, France, the Netherlands, Spain

Phase three under discussions

Objectives of the Task XVII of IEA DSM

The main objective of the Task is to study how to achieve the optimal integration of flexible demand with Distributed Generation, energy storages and Smart Grids, and thus increase the value of Demand Response, Demand Side Management and Distributed Generation and decrease problems caused by variable output generation (mainly based on RES) both

- ☐ in the physical electricity systems and
- ☐ at the electricity market

The Task deals with distributed energy resources both

- ➢ at local (distribution network) level and
- ➢ at transmission system level where large wind farms are connected.

Problems caused by variable output generation

In electrical networks

❑ In some places, an increase in the network stresses are observed and needs for upgrades to provide greater capacity and flexibility to integrate the variable generation.

❑ It also increases the need for flexible, dispatchable, fast-ramping generation for balancing variations in load, generation and contingencies such as the loss of transmission or generation assets.

At market:

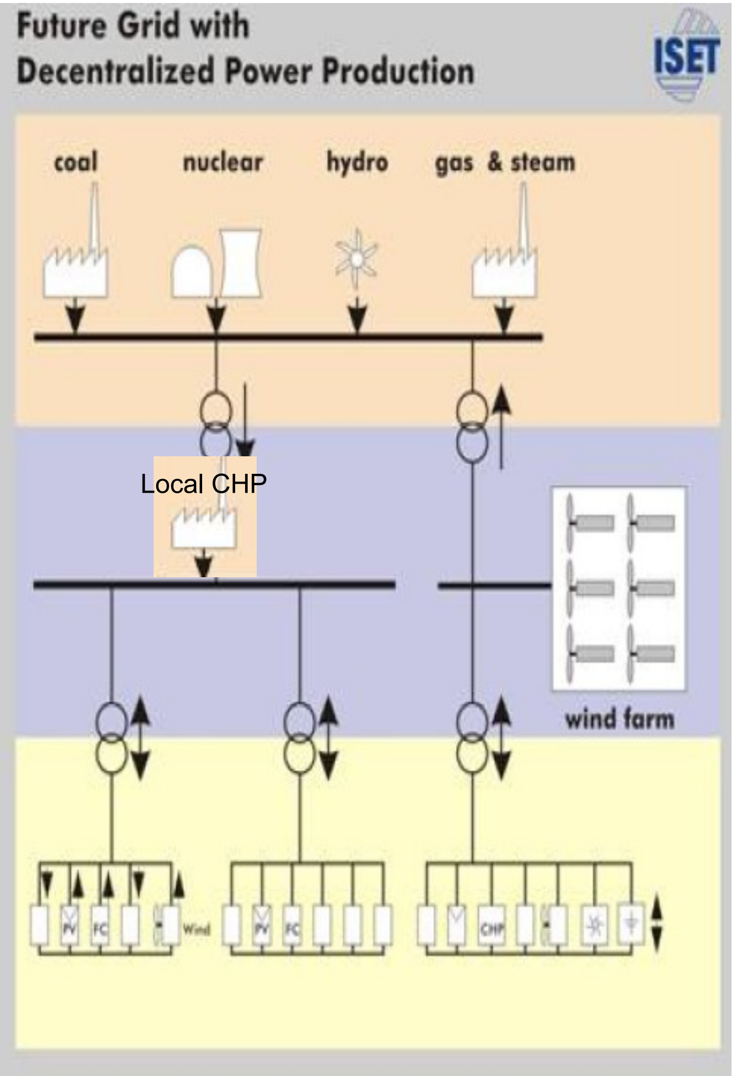
❑ national and local balances between supply and demand are more complicated to manage with high levels of variable-output generation, which can increase total financial electricity costs.

Possible solutions

- One solution to decrease the problems caused by the variable output of some DG is to add energy storages into the systems (centralised or distributed energy storages DS).
- Another way is to use flexibility in electricity consumption (demand response DR).
- → Smart grids

In this sense distributed generation (DG), distributed energy storages (DS) and demand response (DR) can be seen as an integrated distributed energy resource (DER). Combining the different characteristics of these resources is essential in increasing the value of variable output generation in the energy market.

FUTURE ACTIVE DISTRIBUTION SYSTEM: Smart Grid



Characteristics:

- Decentralized power production in different part of network
- Energy storages
- Electricity flows in different directions
- new operators (producer, producer/consumer)
- Producer and consumers participate actively in markets

☐ functional markets
☐ smart grids
☐ smart DER management
☐ smart consumer

- Measurement
- Communication
- Automation
- Energy management

Output of Phase 1

Outputs from Phase 1

- Task XVII - Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages - Final Synthesis Report vol 1. December 2008

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

Vol I. includes the main report and Vol 2. is the annex report with detailed country descriptions, analysis tools etc. These reports are available at the IEADSM-website (http://www.ieadsm.org/)

- Two public workshops were also arranged in Petten and in Seoul. The presentations can be found from web-site

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.

Concluding remarks from the Phase 1

As a conclusion of the analysis it can be said that the increased penetration of DG as well as the technology and market developments result in

- ❑ new roles of the different stakeholders meaning new business environment and possibilities; on the other hand new tools are also needed in this new business area,
- ❑ metering and ICT technologies are essential and developing rapidly,
- ❑ the above development will result in new products, services and pricing policies which can activate the more deep participation of final consumers in the market

Successful integration means that different technologies in supply and demand side as well as in ICT are developed to the level where their integration is feasible both technically and economically and that regulation, policy and market give the successful framework for the integration.

DER business opportunities: market access via aggregators

One obstacle in the promotion of Demand Side Integration is that small and medium size customers usually don’t have direct access to different types of market either due to the market rules or due to the high transaction costs in market entry. To decrease this kind of barriers a new type of service company, an aggregator, who acts as intermediator between distributed energy resources and energy markets, can emerge

Three main types of aggregators can be defined:

- Demand aggregators collecting demand response (DR) from different types of flexible customers and offering the aggregated DR to different market actors
- Generation aggregators collecting and using a group of dispersed generators in aggregation and offering that into market. This kind of aggregated generation is often called “Virtual power Plant (VPP)”.
- Combination of these.

Internationally, aggregators are most common in the USA market. Also in Australia and Europe some aggregators exist

Overview of the Phase 2

Task XVII extension: Phase 2 (1)

Assessment 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 heatpumps for heating and cooling
- ☐ photovoltaic at customer premises
- ☐ micro-CHP at customer premises
- ☐ energy storages (thermal/electricity) in the connection of previous technologies
- ☐ smart metering and ICT

Task XVII extension: Phase 2 (2)

The main Subtasks in the Task extension are

- Assessment of technologies and their penetration in participating countries
- Stakeholders involved in the penetration and qualitative effects on the stakeholders
- Assessment of the quantitative effects on the power systems and stakeholders
- Case studies and pilots
- Conclusions and recommendations

Time schedule: March 2010 – August 2012

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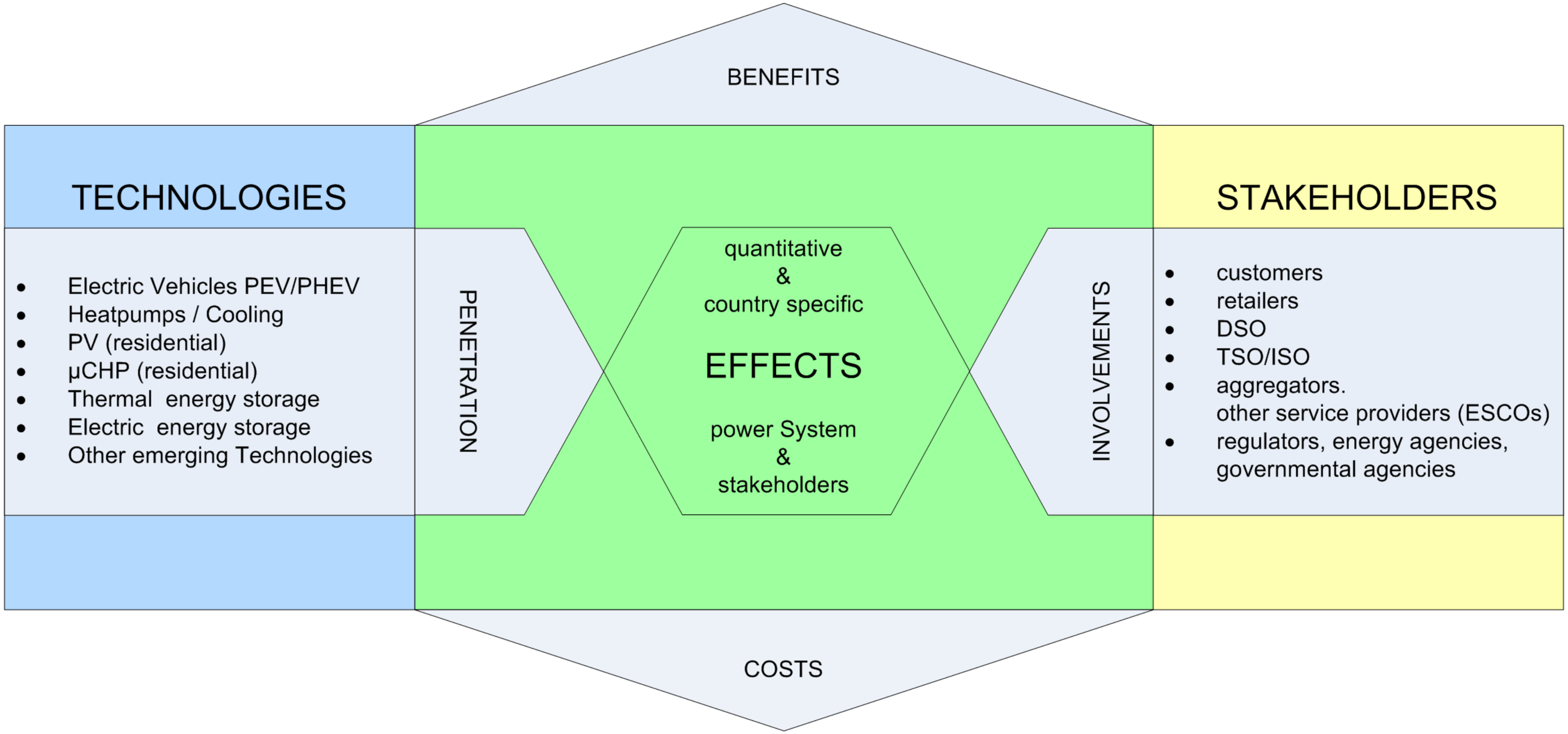
Task XVII extension: Phase 2 (3)



BENEFITS

TECHNOLOGIES

- Electric Vehicles PEV/PHEV
- Heatpumps / Cooling
- PV (residential)
- µCHP (residential)
- Thermal energy storage
- Electric energy storage
- Other emerging Technologies

PENETRATION

quantitative
&
country specific

EFFECTS

power System
&
stakeholders

INVOLVEMENTS

STAKEHOLDERS

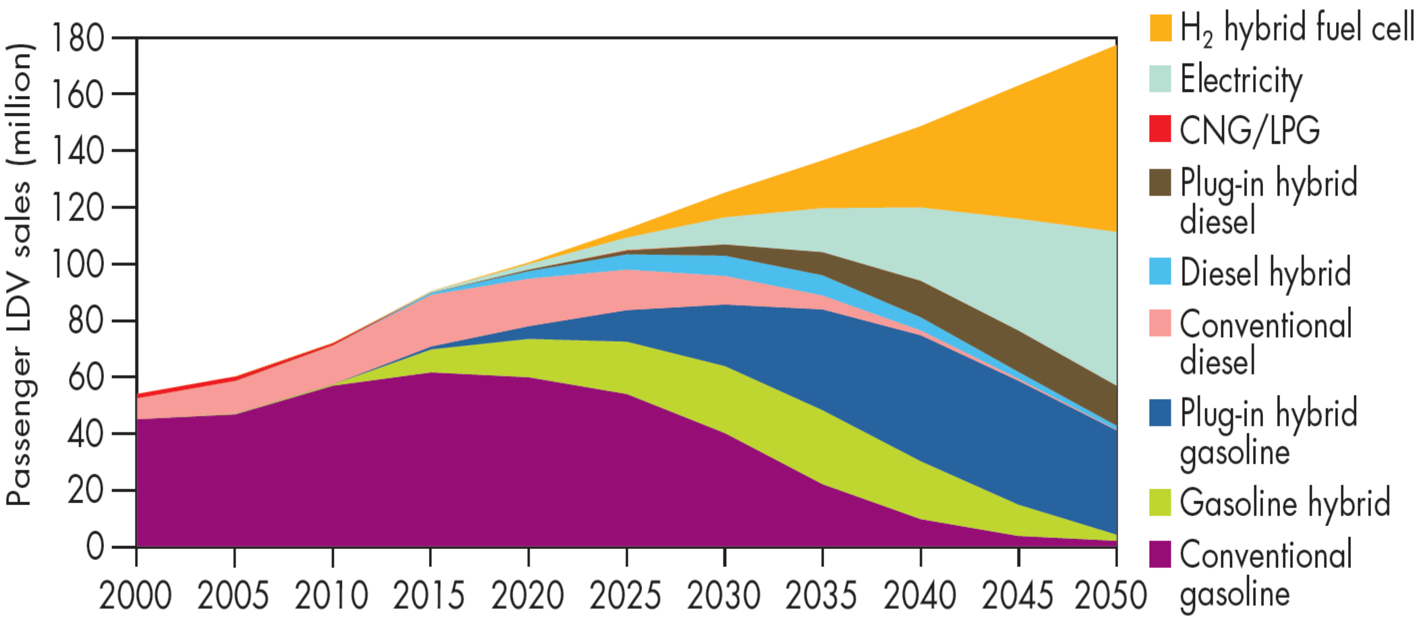
- customers
- retailers
- DSO
- TSO/ISO
- aggregators.
  other service providers (ESCOs)
- regulators, energy agencies, governmental agencies

COSTS

Examples from the integration of emerging technologies

- ☐ PEV/PHEV
- ☐ Heating and cooling – heat pumps
- ☐ Micro-chp
- ☐ Photovoltaic at customer’s premises

Electric vehicles (PEV/PHEV) (1)



Sales of different vehicle types in the BLUE Map scenario (IEA 2009).

Penetration scenarios vary, but anyway

- The share will be considerable in 15 – 25 years
- The battery costs are gradually decreasing
- Many countries have incentives for EVs
- Smart charging is essential from the electricity system point of view
- EVs can in the future provide ancillary and balancing services (V2G)

Electric vehicles (PEV/PHEV) (2)

Some penetration estimates for participating countries:

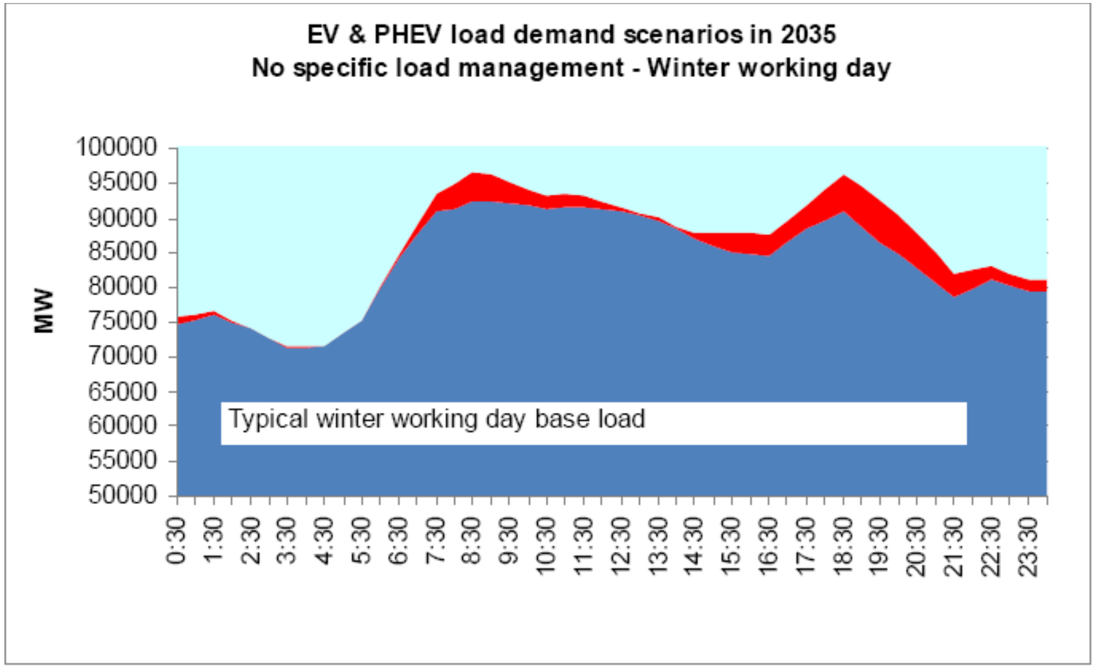
	number of EV		per 1000 people	
	2020	2025	2020	2025
Finland	79,000		15	
France	2,000,000	4,500,000	31	69
Spain	1,000,000		22	
NL	200,000	1,000,000	12	59

Electric vehicles (PEV/PHEV) (3)

Incentives for EV vary and can change rapidly. Some examples from the participating countries:

- ☐ 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.

System level impacts: France, Spain (4)

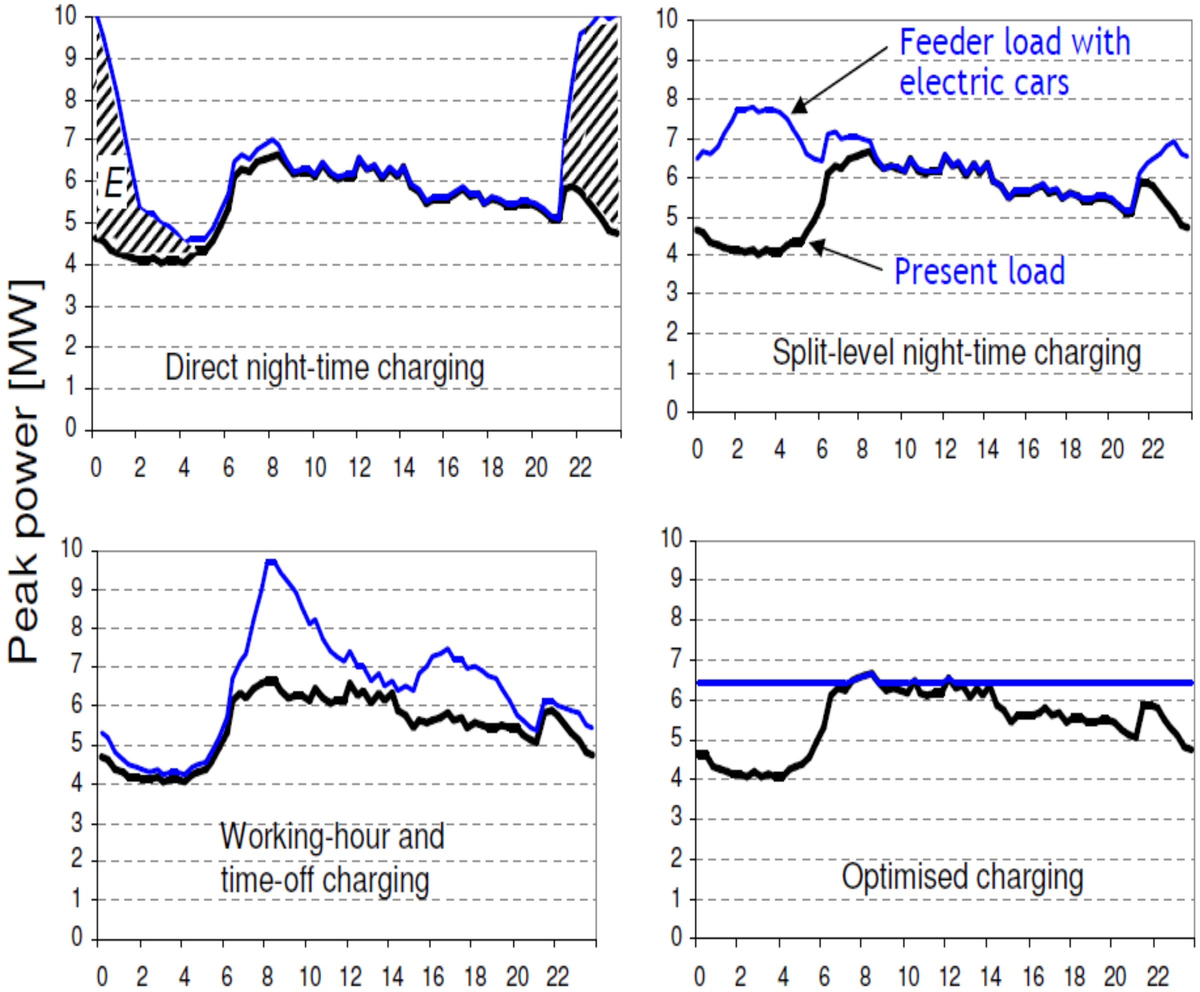


Free charge generates peaks at the beginning of the work period
and in late afternoon till early evening

The simulations in several countries like France (above), Spain and Finland indicate the effects of smart charging in system level:

- in the worst case peak load increase 6000 – 7000 MW
- but with smart charging 6.5 million PEV can be connected without additional investmenst

Example: effect of the charging method on the local network: Finland (5)



City area feeder:

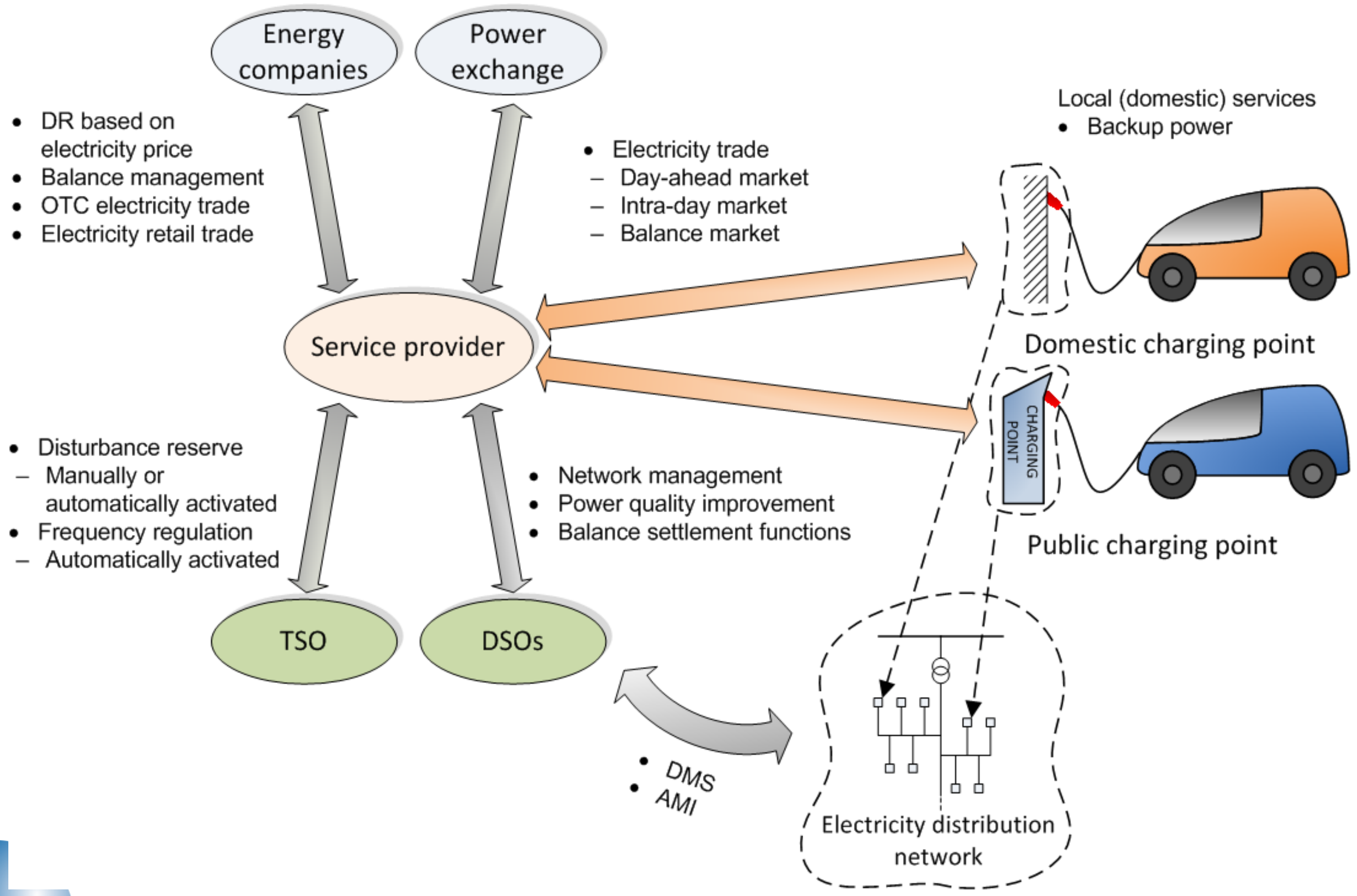
- Peak load of the day: 6.6 MW
- Minimum load of the day: 4.0 MW

- **Number of electric cars: 2000**
- Driving distance: 57 km/car,day
- Energy consumption: 0.2 kWh/km
- Charging energy: 11.5 kWh/car,day
  → **22.9 MWh/day for all cars**

- Charging power: 3.6 kW/car
- **Additional power: 0 – 3.5 MW**
  (depending on charging method)

- Charging energy (E) is equal in each charging alternative

New services and business models needed (6)



- DR based on electricity price
- Balance management
- OTC electricity trade
- Electricity retail trade

- Electricity trade
  - Day-ahead market
  - Intra-day market
  - Balance market

Local (domestic) services

- Backup power

- Disturbance reserve
  - Manually or automatically activated
- Frequency regulation
  - Automatically activated

- Network management
- Power quality improvement
- Balance settlement functions

- DMS
- AMI

Heating and cooling – heat pumps (1)

- ➢ Heating and cooling loads are very suitable for DSM services
- ➢ They can utilise both natural storing capacity of buildings and artificial heat and cool storages
- ➢ The share of different types of heat pumps is increasing in buildings

Heat pumps for heating and cooling buildings can be divided into four main categories:

☐ **Heating-only heat pumps, providing space heating and/or water heating.**

☐ **Heating and cooling heat pumps, providing both space heating and cooling.** The most common type is the reversible air-to-air heat pump, which either operates in heating or cooling mode. Large heat pumps in commercial/institutional buildings use water loops for heat and cold distribution, so they can provide heating and cooling simultaneously.

☐ **Integrated heat pump systems, providing space heating, cooling, water heating and sometimes exhaust air heat recovery.**

☐ **Heat pump water heaters, fully dedicated to water heating.** They often use air from the immediate surroundings as heat source, but can also be exhaust-air heat pumps, or desuperheaters on air-to-air and water-to-air heat pumps.

Heating and cooling – heat pumps (2)

Some estimates for the penetration of heat pumps 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 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 and different types of incentives are applied

Heating and cooling – heat pumps and DR (3)

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 often well with the high use of heat pumps either for cooling in summer peak or heating in winter peak situations; on the other hand, in 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: the heating/hot water production and cooling can be switched off for certain time periods

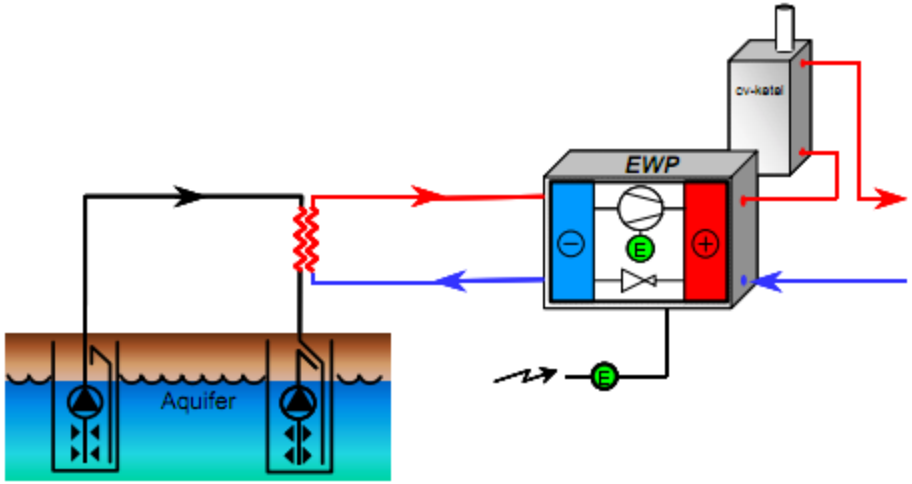
❑ from the technical point of view the total switching-off the heat pumps or the thermostat set-point adjustments are possible in short term because heat pumps usually have remote control capabilities

Heating and cooling – heat pumps and DR (4)

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

Heat pumps and energy storages in the Netherlands.
Example: aquifers as a seasonal heat storage (5)



In the Netherlands, there is a large installed base of heat pumps, based on aquifer storage of heat, especially in large buildings. The opportunities of these types of heat storage depend on the absence of long term local subsurface flows of water in geological strata at a certain suitable depth. In the Netherlands, generally, the possibilities at most locations are good.

The challenges in operating these devices is maintaining the heat/cold balance during a year to guarantee operation at the optimal COP and to comply to municipality license conditions and in configuring in relation to the other heat/cold generating devices and the realized user comfort. Aquifers allow comfort control by delivering cooling capacity in summer and heating capacity in winter.

Example on the integration: residential load shifting in the Netherlands in the future (6)

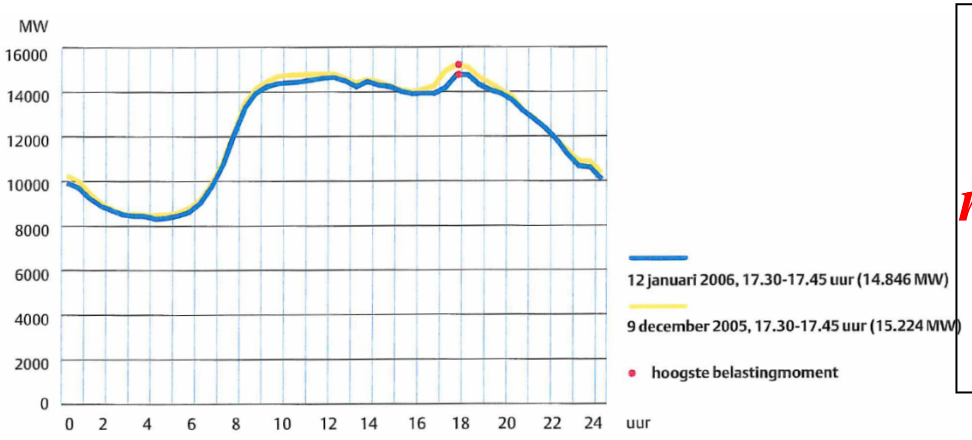
Electric appliances with a large future potential for load shifting:

- Plug-in hybrid electric vehicles
- Electric heat pumps
- Air conditioning

Contribution of PHEV and heat pumps to flatten day-night patterns (7)

Table 9. Share of plug-in vehicle and heat pump electricity demand as percentage of final electricity demand in SE scenario, and their contribution to filling the ‘night trough’

	2020	2040
Final electricity demand in SE scenario (TWh/a)	137	161
Electricity demand heat pumps + EV (TWh/a)	5.8	24.3
Heat pumps and EV as percentage of SE: (%)	4.2	15.1
Annual electricity demand to create a flat load curve (at load factor of 0.8) (TWh/a)	27	32
Heat pump and EV contribution to a flat load curve (%)	21	76



Conclusion: if heat pumps and electric vehicles become popular, residential load shifting can almost completely flatten the total electricity load in the Netherlands

Conclusions from the integration possibilities in the Netherlands (8)

- 1.5 million heat pumps (2040) can provide the equivalent of 250 MW regulating power and 1.5 GWh storage
- 6.5 million PHEV can provide 26 GWh of storage
- Together this is sufficient to compensate most of the short term differences between predicted versus realized output of 10 GW wind farms

Residential load shifting (with plug-in hybrid electric vehicles and heat pumps) can contribute substantially to integration of intermittent renewables

Micro-CHP - some conclusions

- Several technologies have been developed like internal cumbustion machines, micro gas turbines, stirling engines and fuel cells; different types of fuels can be utilized
- However, the prices of the technologies have not gone as expected and no actual breakthrough has happened
- 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
- DR is often easily implemented with µ-CHP because thermal storages are becoming more commonplace

Photovoltaic at customer premises - some conclusions

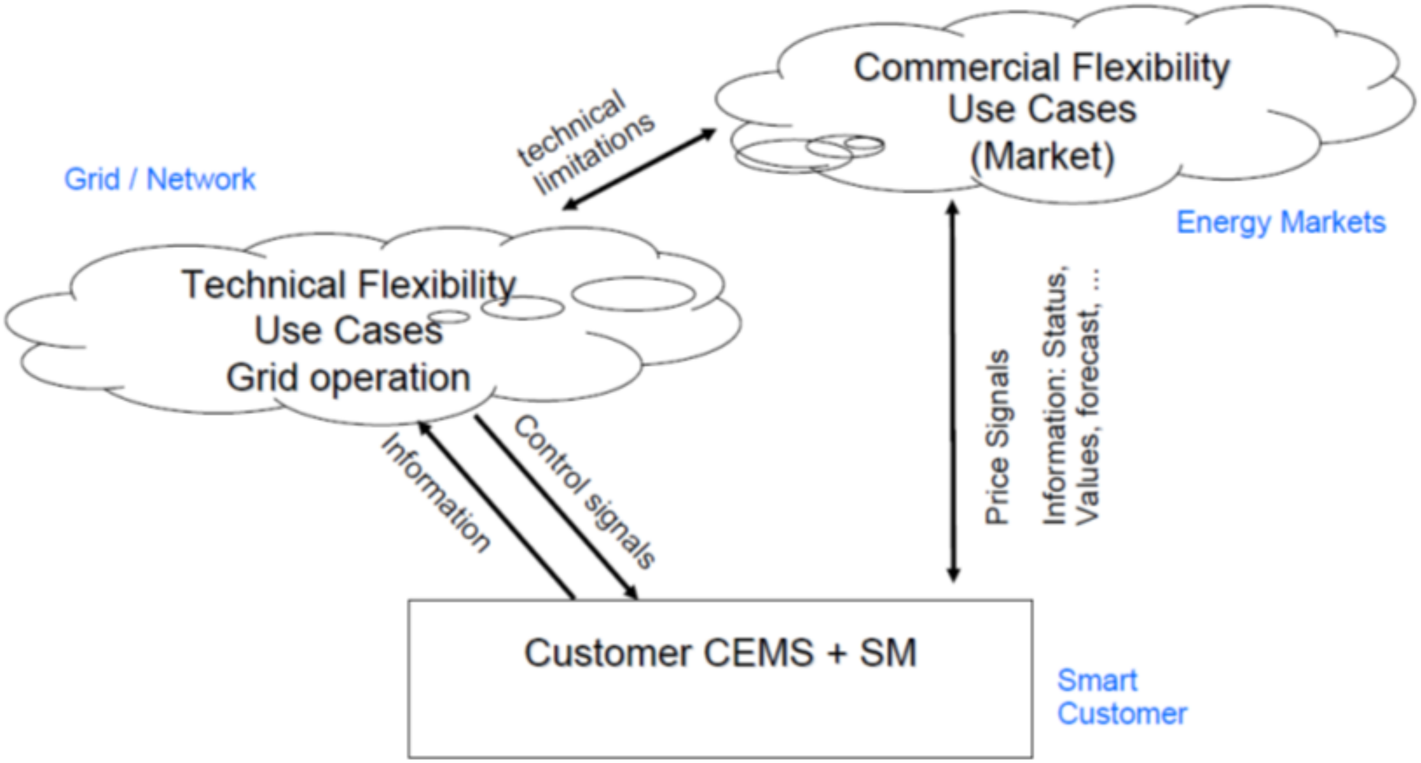
The following table shows the recent cumulative development of the grid-connected PV penetration in participating countries (in MWp) (In Finland nil):

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

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. 35–50 % price reduction can be expected by 2020
- ☐ Energy policies with incentives and feed-in tariffs have supported the PV development

Task extension, Phase 3:
Proposal for the future work (1)



Proposal for the future work (2)

Very preliminarily this phase includes four new subtasks:

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.

Proposal for the future work (3)

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 (like 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

Proposal for the future work (4)

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

Subtask 13 – Conclusions and Recommendations

Thank you

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