



Principal and practical challenges with increasing complexity in the generation system through DSM integration

**Current issues in Demand Side Management
*(IEA-DSM) Programme – Enova 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, μ CHP, energy storages, smart metering and ICT
- Examples from the emerging technologies

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 to be completed shortly

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

The final workshop will be next week in Arnhem



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:

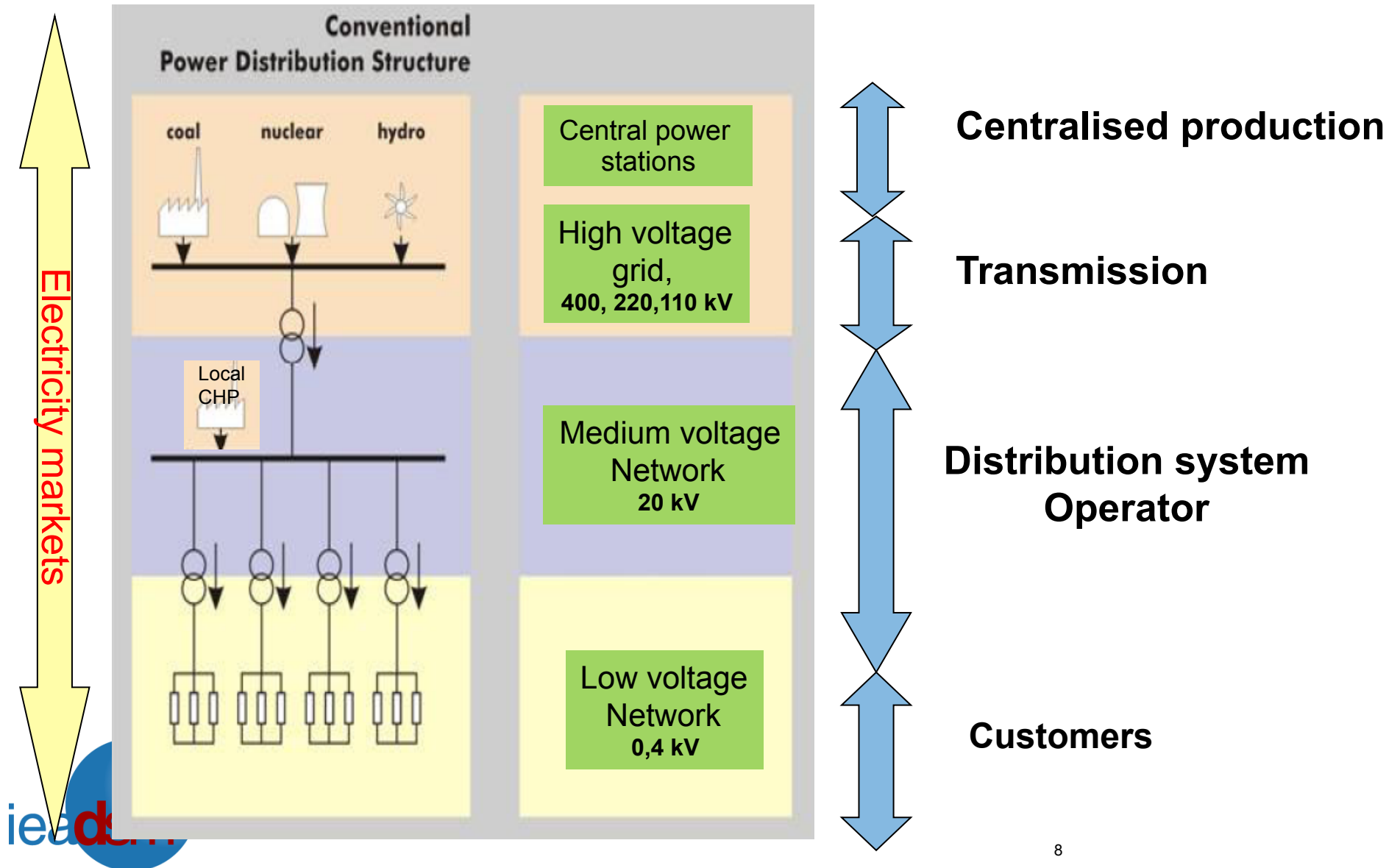
- ❑ national and local balances between supply and demand are more complicated to manage with high levels of variable-output generation, which can increase total financial electricity costs.

Possible solutions

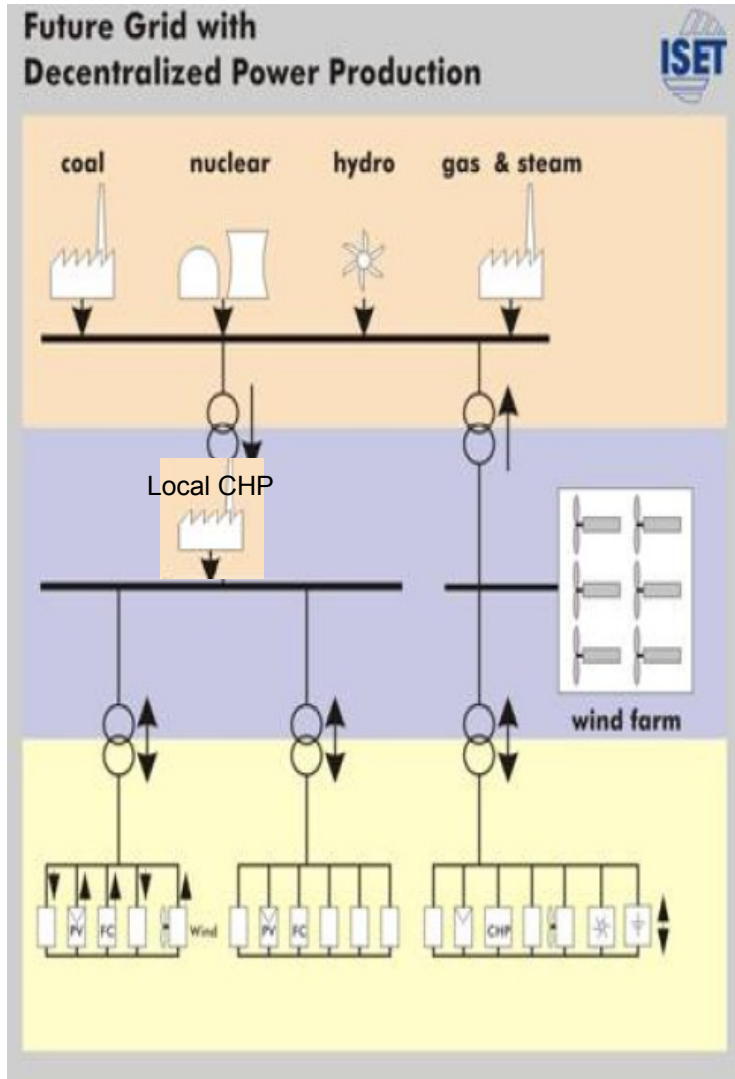
- ❑ One solution to decrease the problems caused by the variable output of some DG is to add energy storages into the systems (centralised or distributed energy storages DS).
- ❑ Another way is to use flexibility in electricity consumption (demand response DR).
- ❑  Smart grids

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.

Passive distribution system: Electricity flows "downstream"



FUTURE ACTIVE DISTRIBUTION SYSTEM: Smart Grid



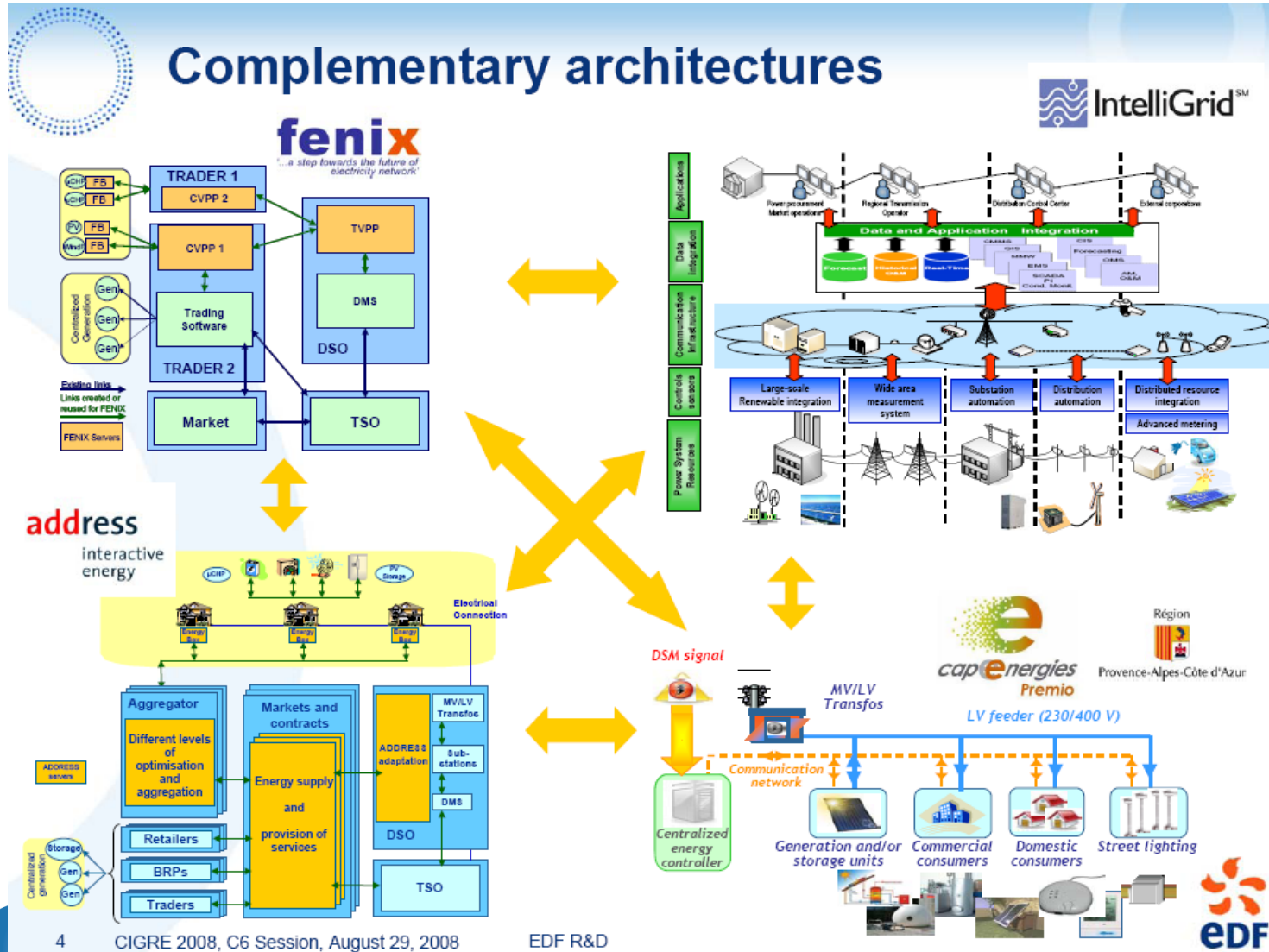
- Characteristics:**
- Decentralized power production in different part of network
 - Energy storages
 - Electricity flows in different directions
 - new operators (producer, producer/consumer)
 - Producer and consumers participate actively in markets



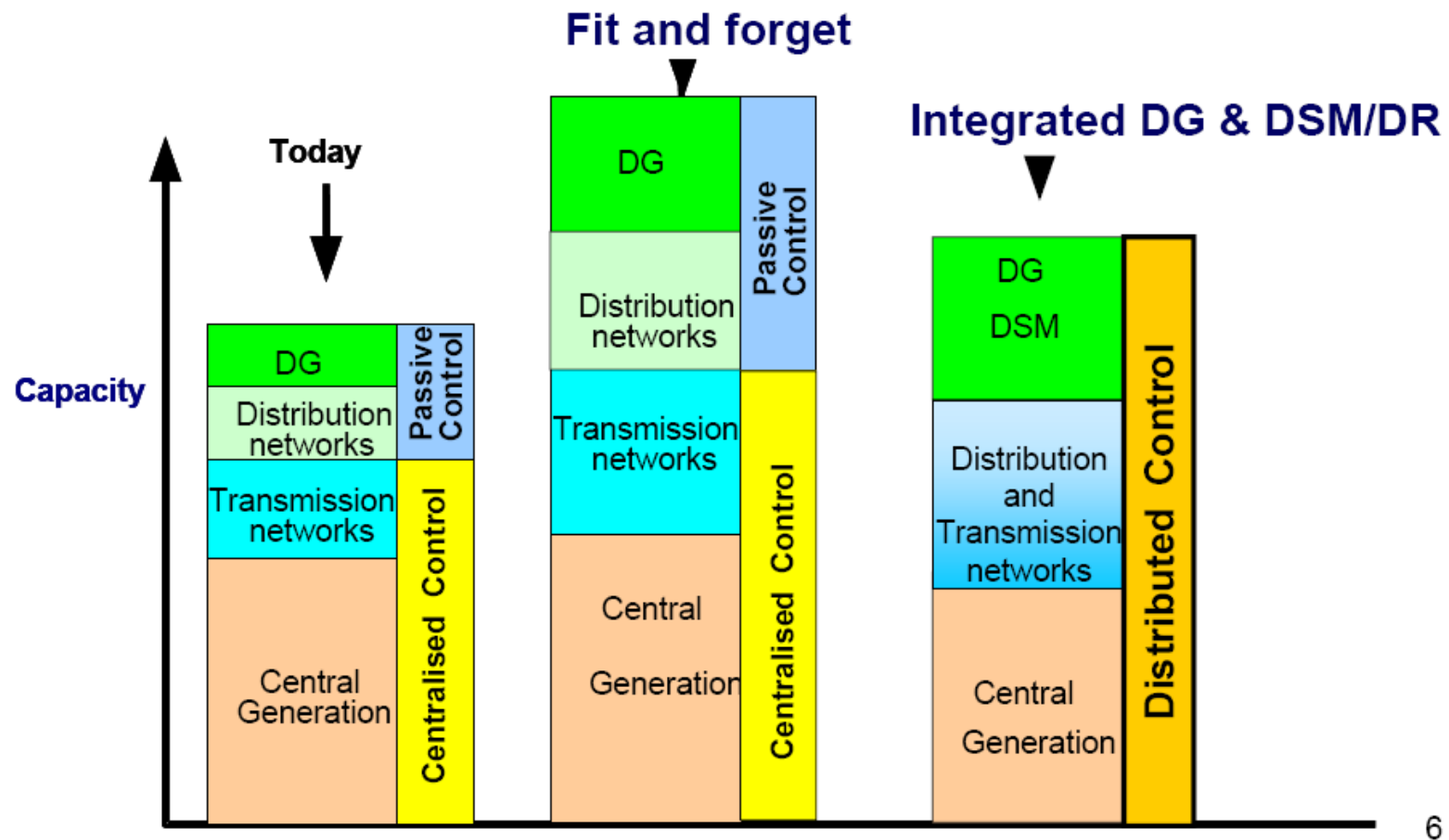
- functional markets
- smart grids
- smart DER management
- smart consumer

- Measurement
- Communication
- Automation
- Energy management

Examples on smart grid architectures



Challenges of SmartGrid concepts



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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 intermediary 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)

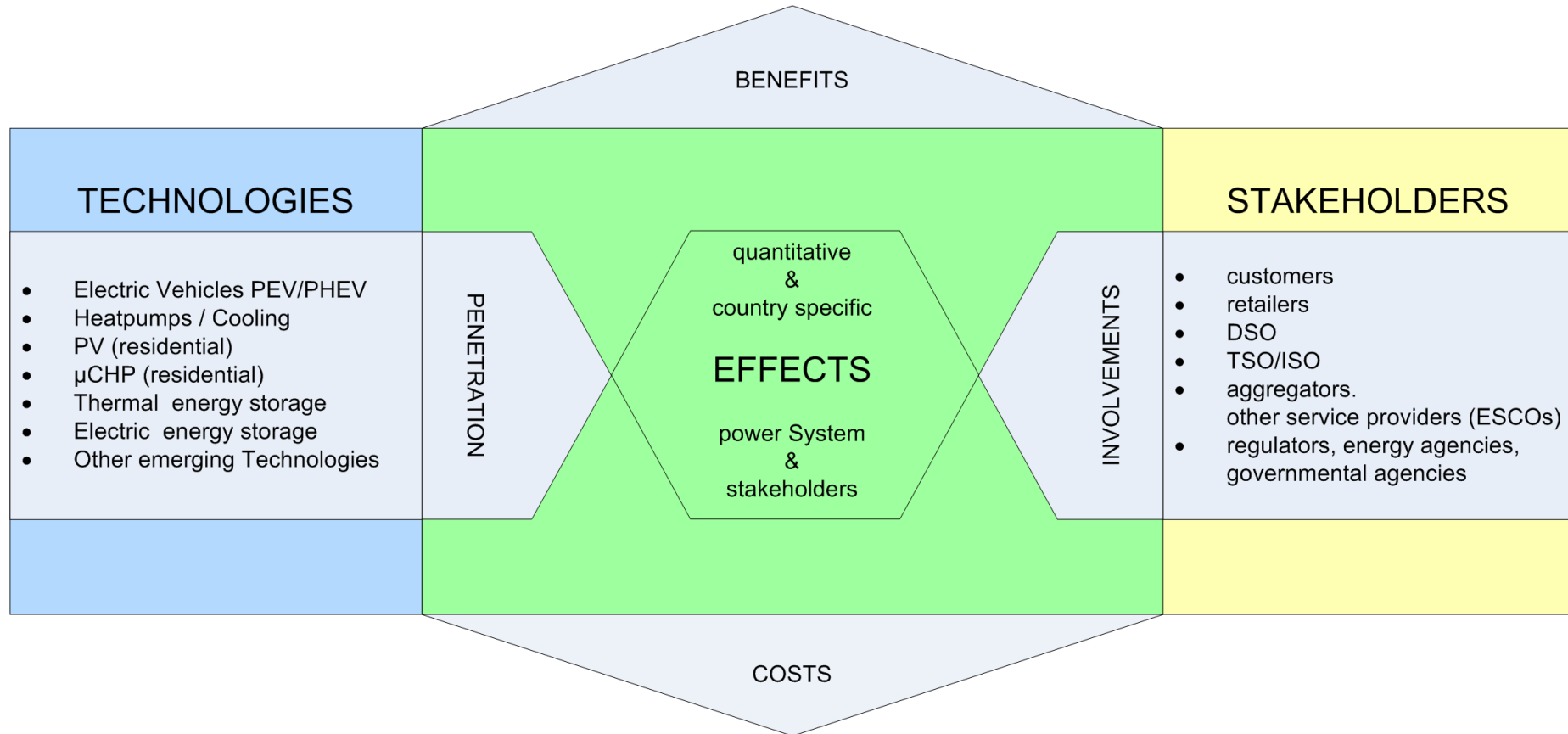
The main Subtasks in the Task extension are

- 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 – May 2012



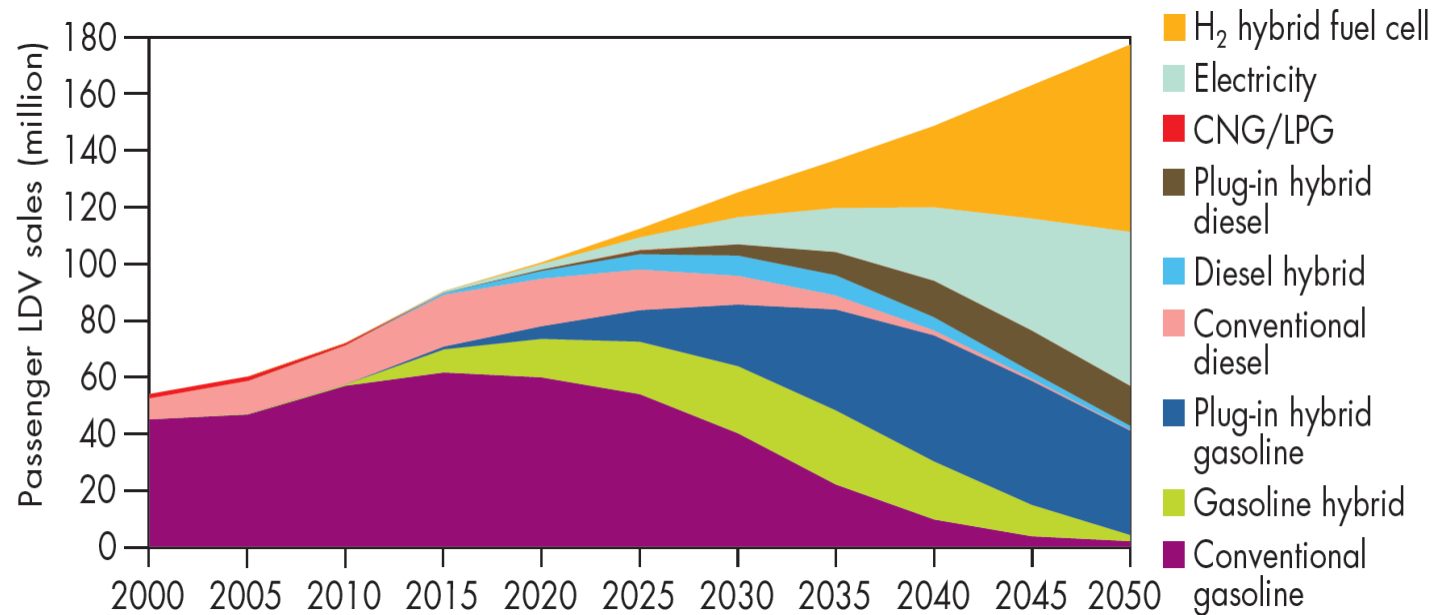
Task XVII extension: Phase 2 (3)



Examples from the integration of emerging technologies

- ❑ PEV/PHEV
- ❑ Heating and cooling – heat pumps

Electric vehicles (PEV/PHEV) (1)

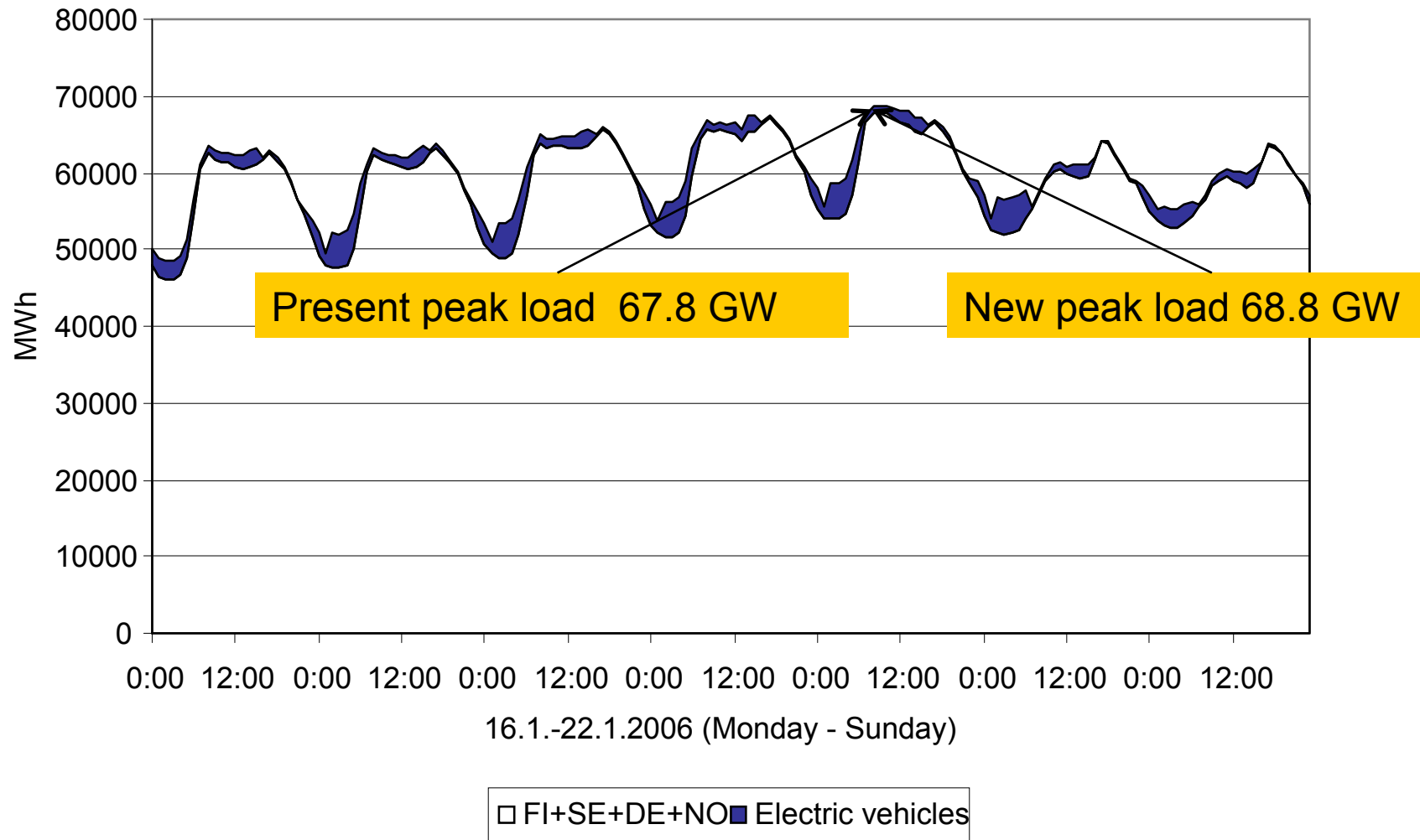


Sales of different vehicle types in the BLUE Map scenario (IEA 2009).

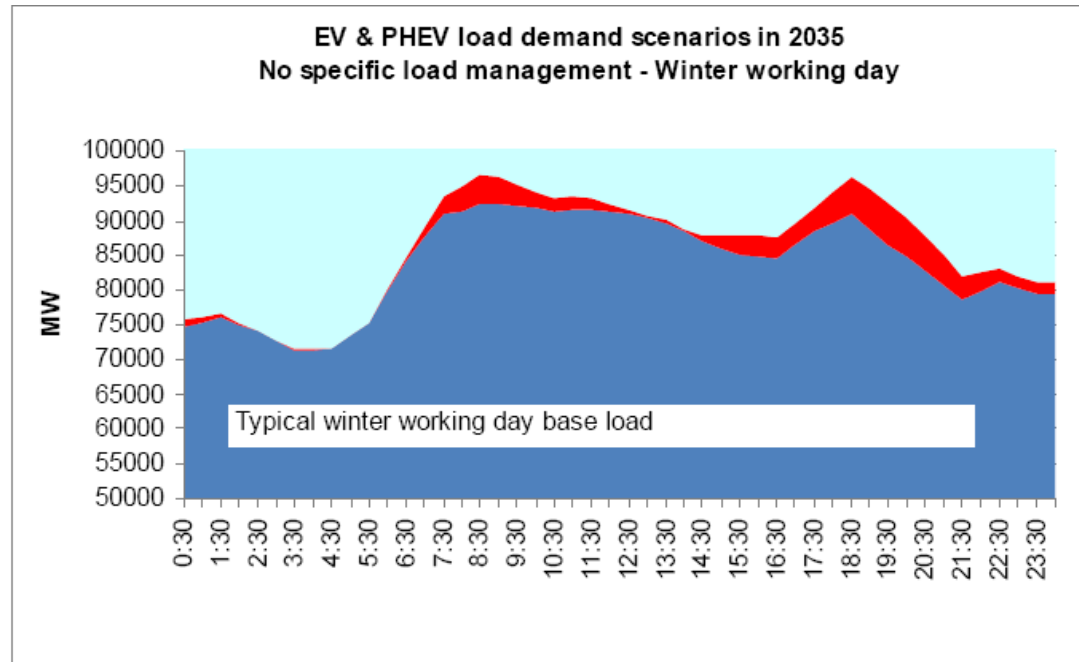
Penetration scenarios vary, but anyway

- 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)

System level impacts (3): 5 million PEV/PHEV in Nordic system: intelligent charging



System level impacts: France, Spain (4)



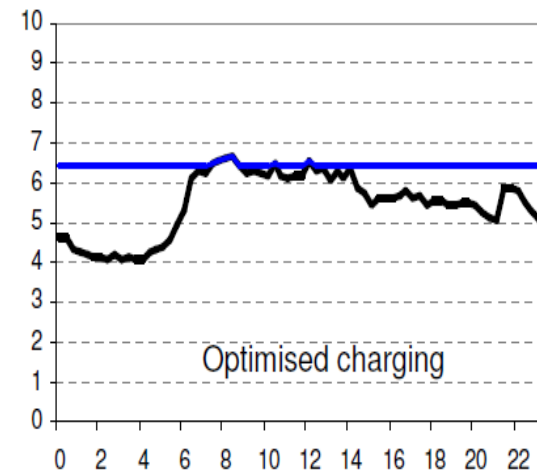
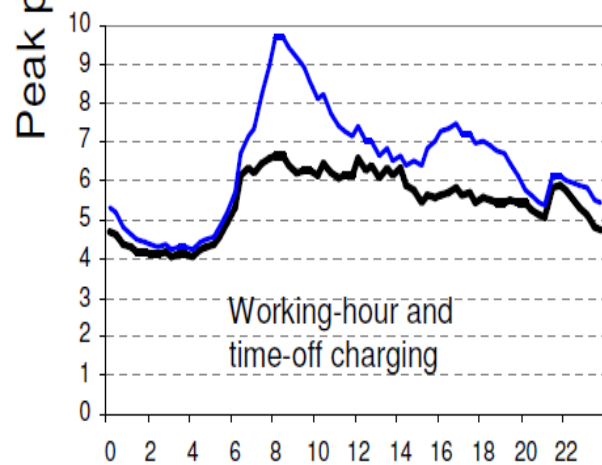
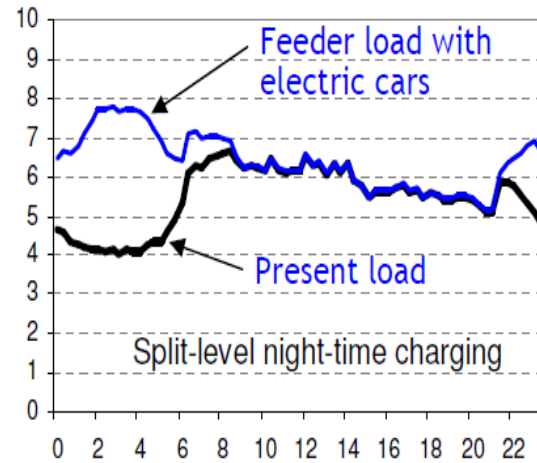
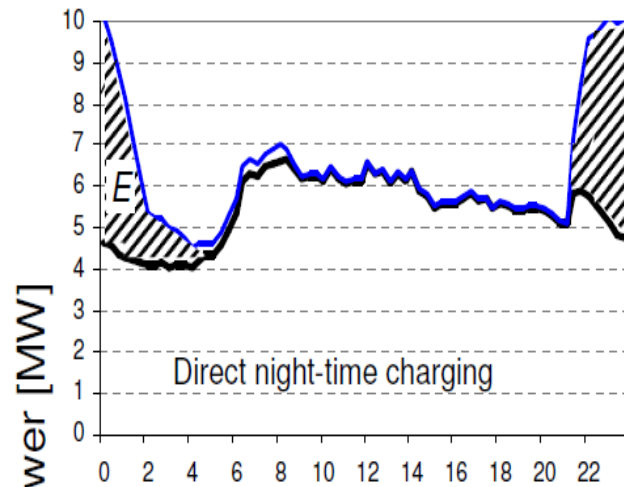
Free charge generates peaks at the beginning of the work period and in late afternoon till early evening



Similar impacts can be found also from the simulations in other countries like France (above) or Spain:

- ❑ in the worst case peak load increase 6000 – 7000 MW
- ❑ but with smart charging 6.5 million PEV can be connected

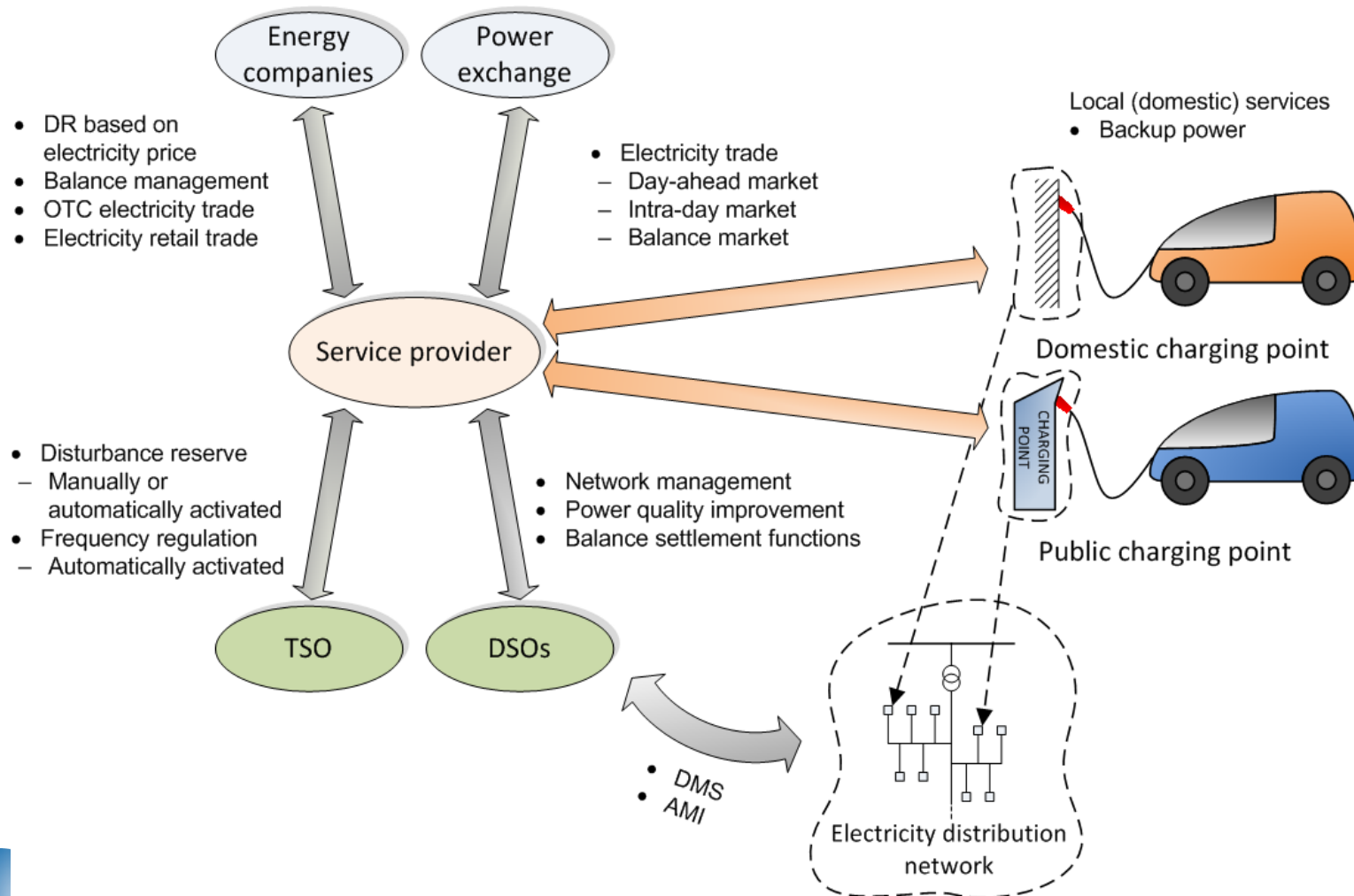
Example: effect of the charging method on the local network: Finland (5)



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)



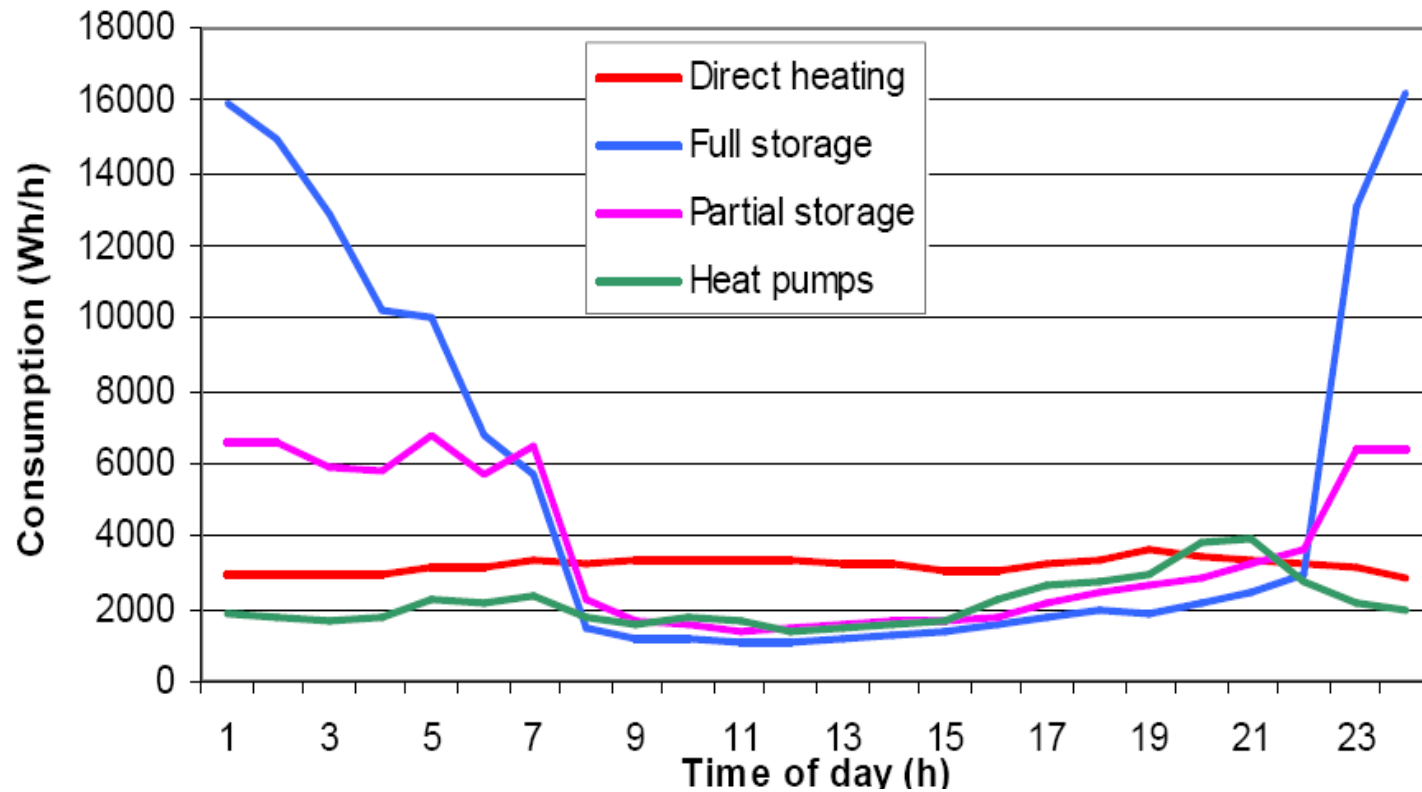
Heating and cooling – heat pumps (1)

- 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:

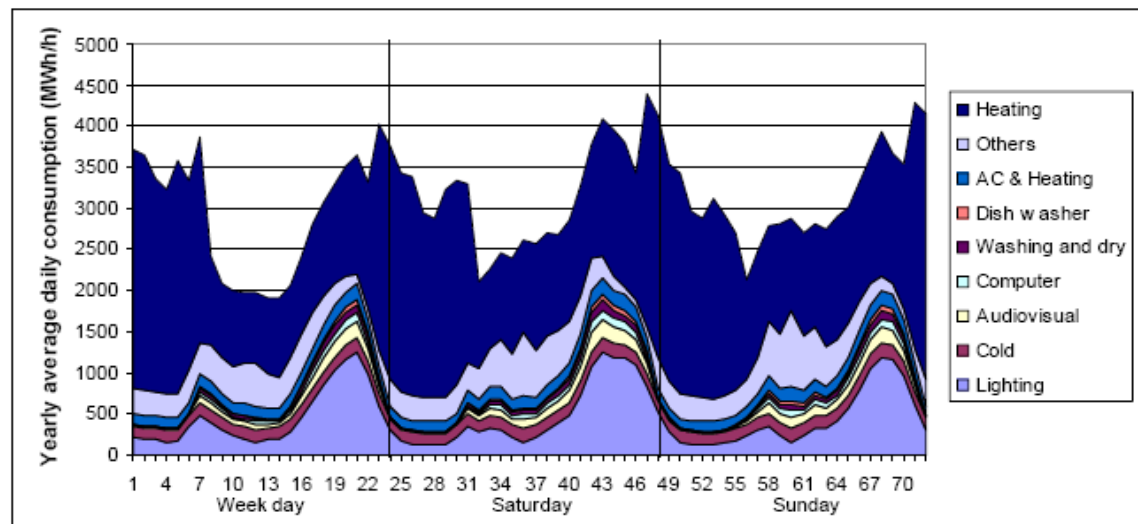
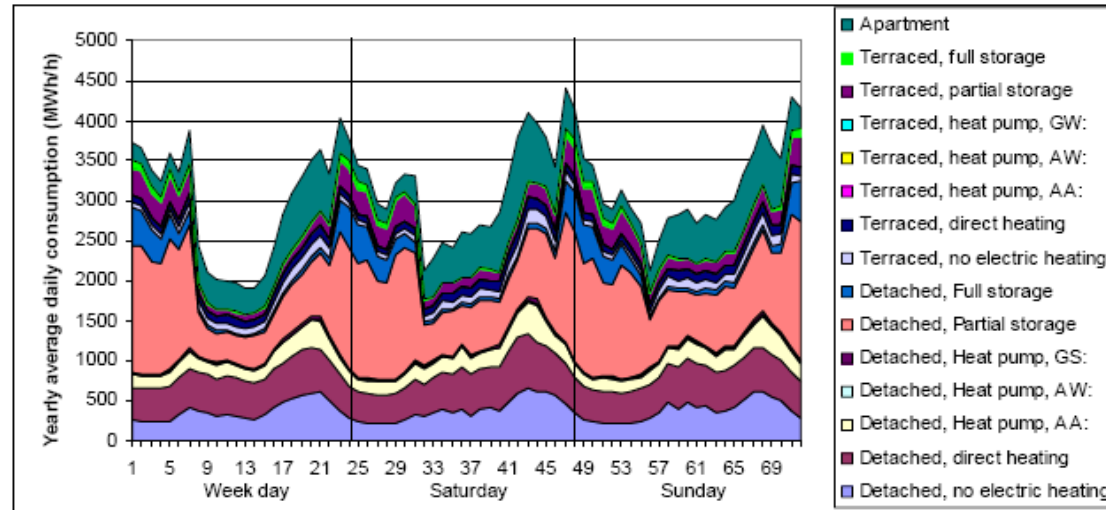
- ❖ **Heating-only heat pumps, providing space heating and/or water heating.**
- ❖ **Heating and cooling heat pumps, providing both space heating and cooling.**
The most common type is the reversible air-to-air heat pump, which either operates in heating or cooling mode. Large heat pumps in commercial/institutional 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.

Example: DSM potential for residential sector in Finland (2)

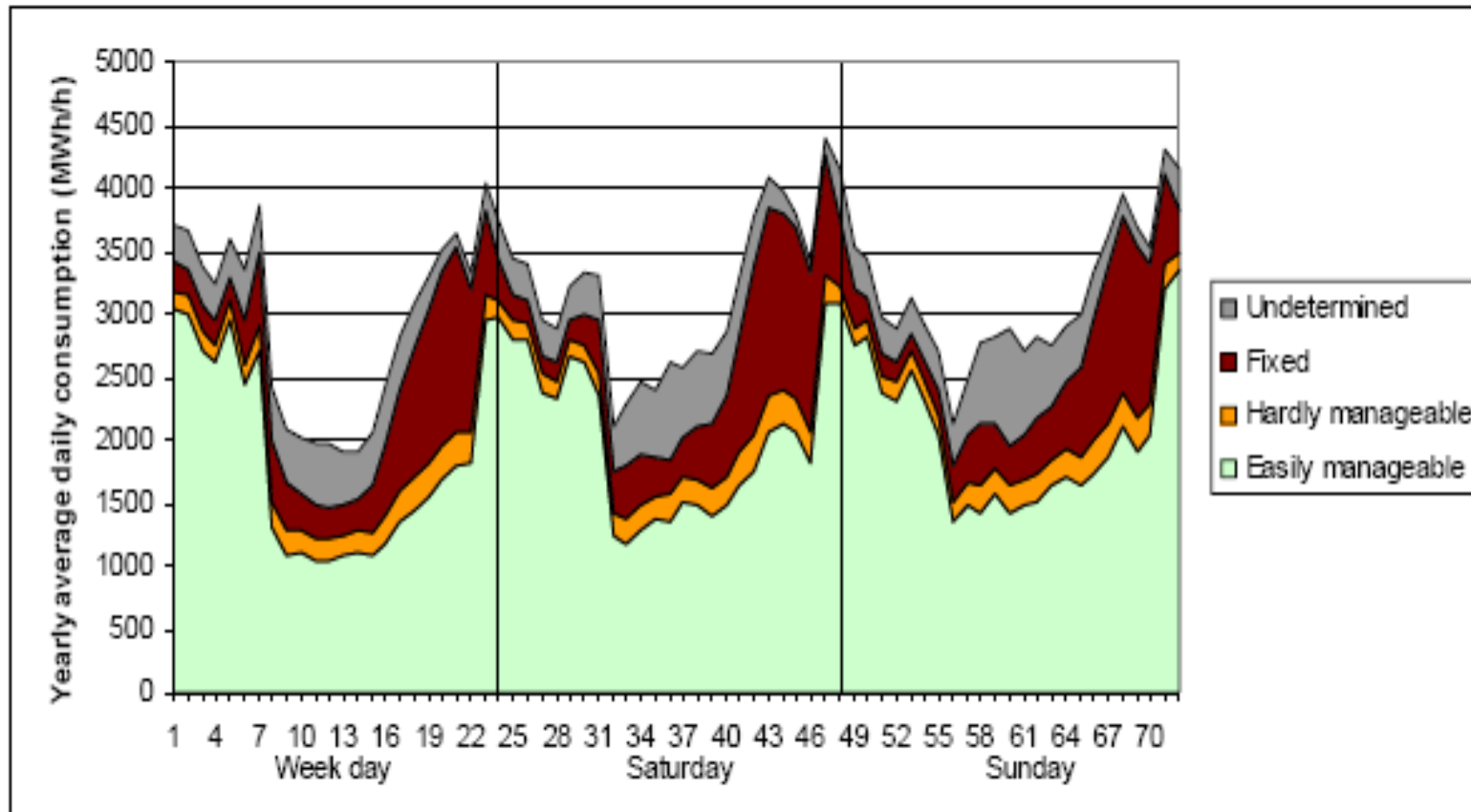


Load curves for different heating types during a typically January weekday in Finland

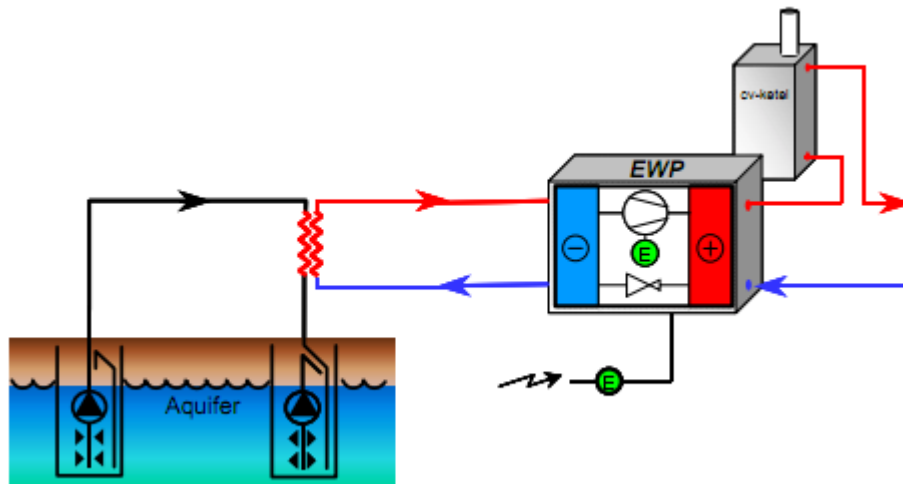
Aggregated winter load curve for residential sector in Finland (3)



Estimated flexibility potential in the residential sector during an average winter week (4)



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 (1)

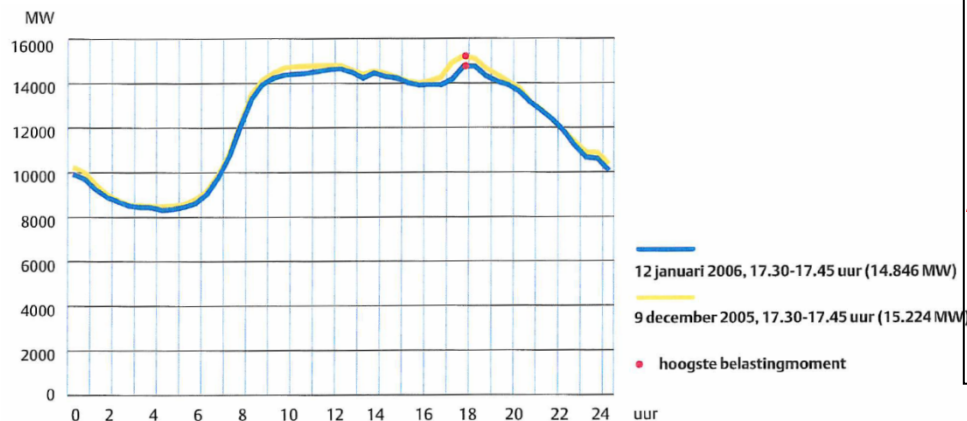
Electric appliances with a large future potential for load shifting:

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

Contribution of PHEV and heat pumps to flatten day-night patterns (2)

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 (3)

- 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 realised 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

Thank you

