# Evaluation of demand response, DG-RES and storage technologies

**IEA Task XVII Workshop**

**Arnhem, 25 April 2012**

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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

# 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:

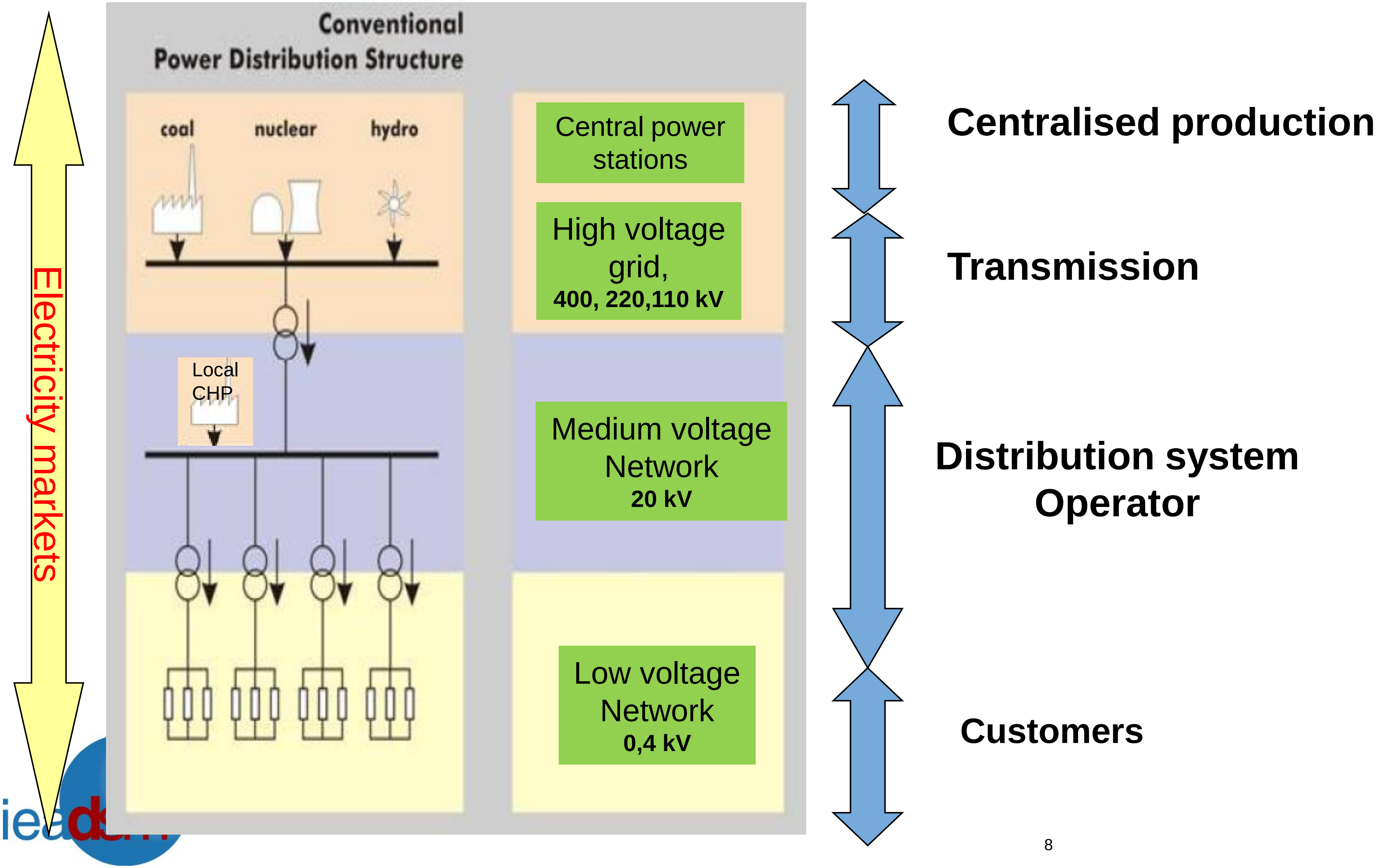
- national and local balances between supply and demand are more complicated to manage with high levels of variable-output generation, which can increase total financial electricity costs.

# Possible solutions

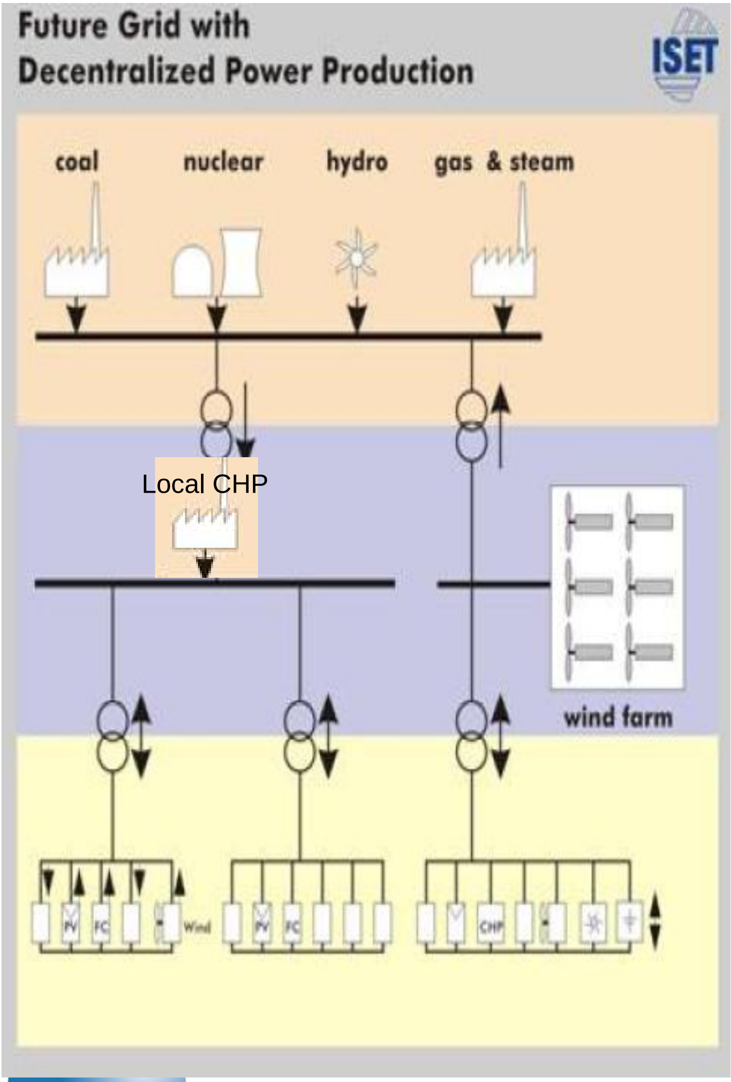
- One solution to decrease the problems caused by the variable output of some DG is to add energy storages into the systems (centralised or distributed energy storages DS).
- Another way is to use flexibility in electricity consumption (demand response DR).
- → Smart grids

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



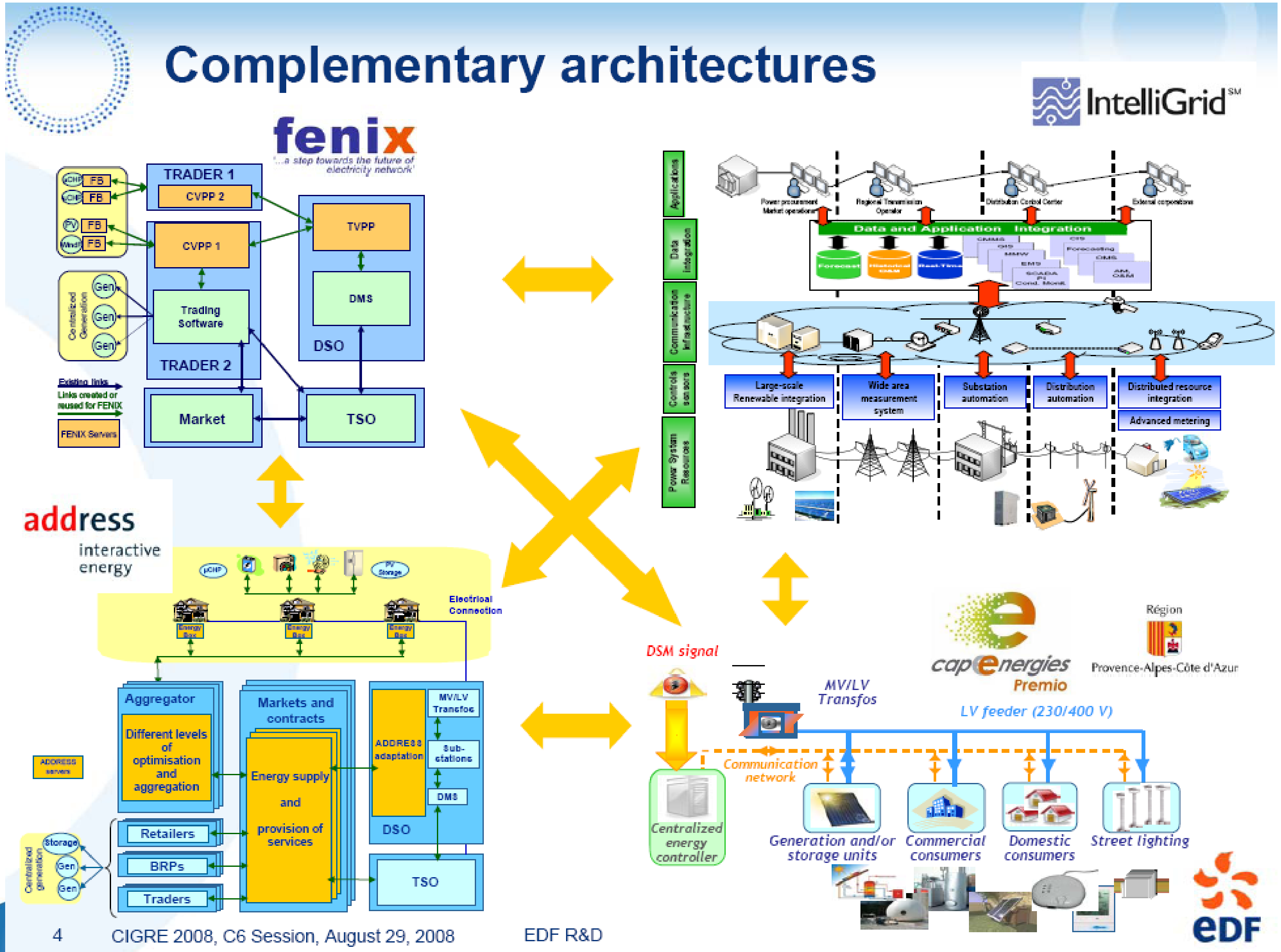

Characteristics:

- Decentralized power production in defferent part of network
- Energy storages
- Electricity flows in different directions
- new operators (producer, producer/cosumer)
- 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

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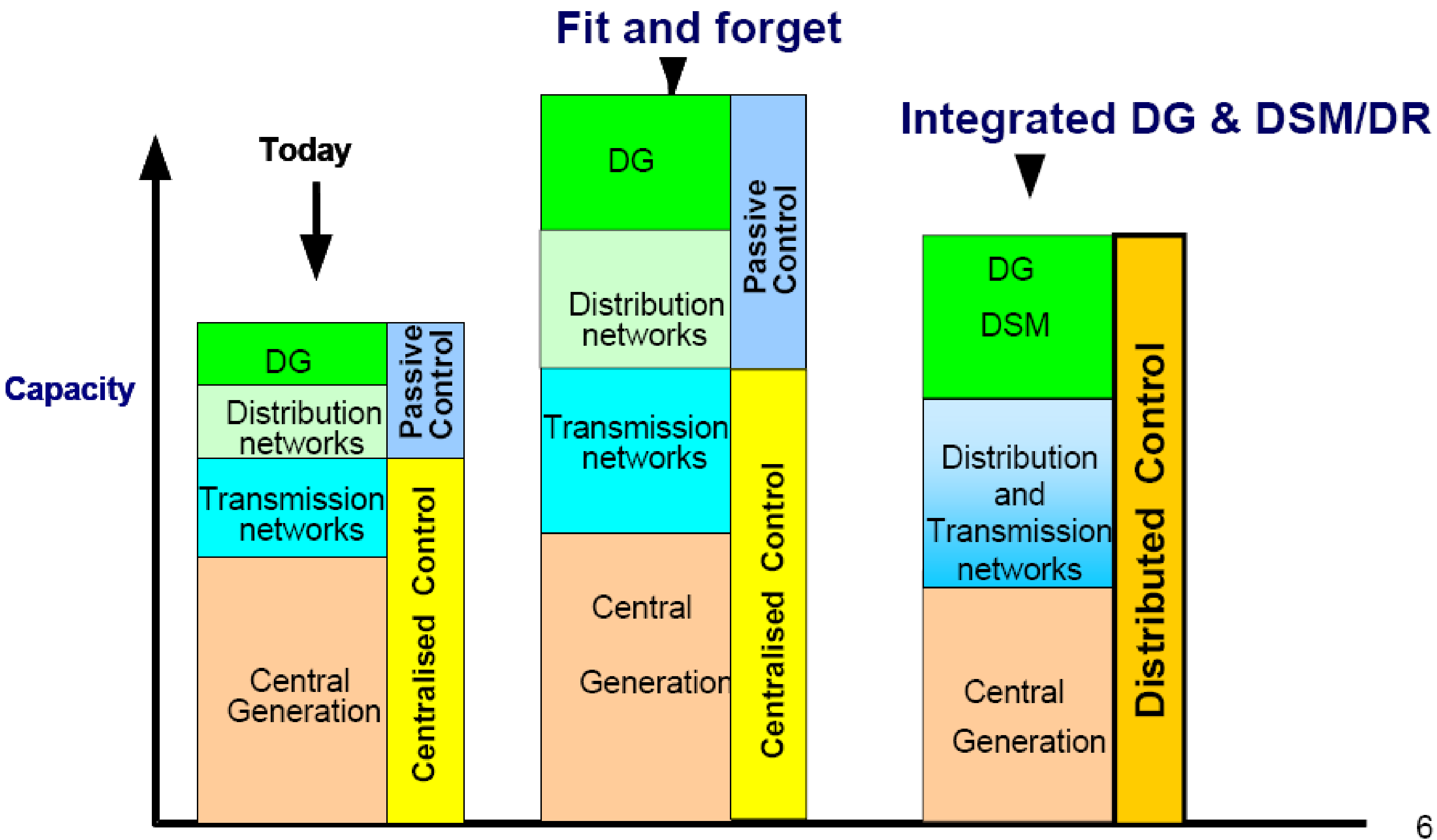
# Challences of SmartGrid concepts



# 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

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# 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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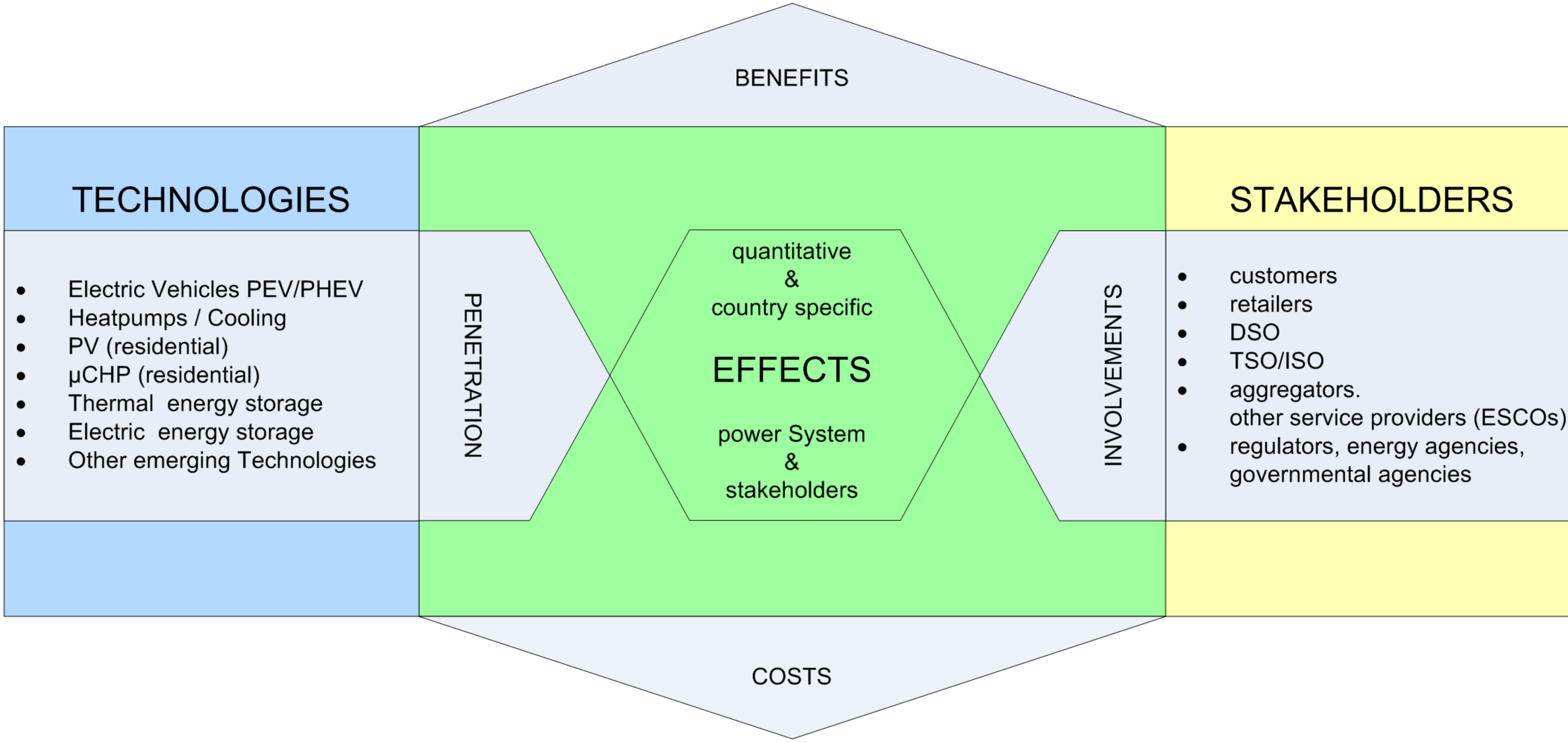
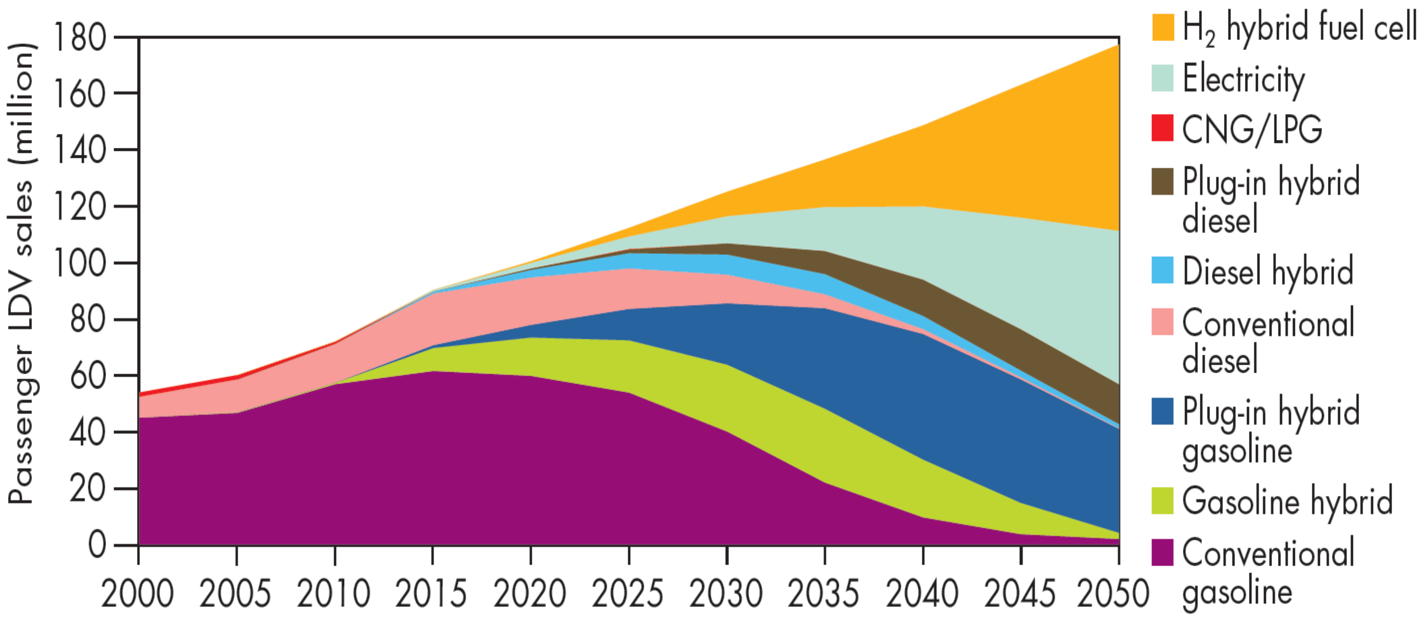
# Task XVII extension: Phase 2 (3)



# Examples from the integration of emerging technologies

- PEV/PHEV
- Heating and cooling – heat pumps

# Electric vehicles (PEV/PHEV)




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
- Charging infrastructure has to be built
- Smart charging is essential from the electricity system point of view
- EVs can in the future provide ancillary and balancing services (V2G)

# Examples on national scenarios

## Finland

| | year | Proportion of new cars | | Cumulative amount of the sold cars | | Proportion of annually driven distance | |
|---|---|---|---|---|---|---|---|
| | | PHEV | EV | PHEV | EV | PHEV | EV |
| **Basic scenario** | 2020 | 10 % | 3 % | 66 000 | 13 000 | 3 % | 0,6 % |
| | 2030 | 50 % | 20 % | 480 000 | 160 000 | 19 % | 7 % |
| **Rapid scenario** | 2020 | 40 % | 6 % | 190 000 | 26 000 | 8 % | 1 % |
| | 2030 | 60 % | 40 % | 960 000 | 450 000 | 38 % | 19 % |
| **Slow scenario** | 2020 | 5 % | 2 % | 38 000 | 12 000 | 2 % | 0,5 % |
| | 2030 | 20 % | 10 % | 207 000 | 92 000 | 8 % | 4 % |

# Examples on national scenarios

## France


| Number of terminals | 2015 | 2020 | 2025 |
|---|---|---|---|
| Private or company terminals | 900 000 | 4 000 000 | 9 000 000 |
| Public space terminals - normal charging | 60 000 | 340 000 | 750 000 |
| Public space terminals - fast charging | 15 000 | 60 000 | 150 000 |
| TOTAL | 975 000 | 4 400 000 | 9 900 000 |

The number of terminals which need to be installed

Estimation of the number of EVs/PHEVs
in the national fleet of vehicle

# Support schemes/mechanisms

## Austria:

- Tax reductions (no ownership tax, no tax of acquasitions (up to 16 %))
- Three of nine federal states have subsidies (750 -5000 €)
- Municipal and city subsidies
- Nationwide subsidy to commercial fleet up to 10 cars (2500 – 5000 €)

## Finland:

- CO2-dependent purchase tax (12.2 – 48.8 %), minimum at 60 g/km or less
- CO2-dependent annual tax from 43.07 €/a (0 g$CO_2$/km) to 260 €/a
- An annual fuel-tax for the vehicles, which use other fuels than gasoline. This is mainly because gasoline fuel has higher taxation (from 1.1.2013)

| Energy source | Tax (cents/day/100 kg) |
|---|---|
| Diesel | 5.5 |
| Electricity | 1.5 |
| Electricity and gasoline | 0.5 |
| Electricity and diesel | 4.9 |
| Methane | 3.1 |

# Support schemes/mechanisms

## ❑ France

The guidelines for the deployment of EVs (and PHEVs) are now written down in a “national plan” which proposes 14 concrete actions. As a beginning the government took two concrete measures:

- ❖ A public order, made together with enterprises, city community organizations and state representatives, for 100 000 EVs until 2015
- ❖ A 5 000 € bonus for the order of a vehicle emitting less than 60 $gCO_2/km$

# Support schemes/mechanisms

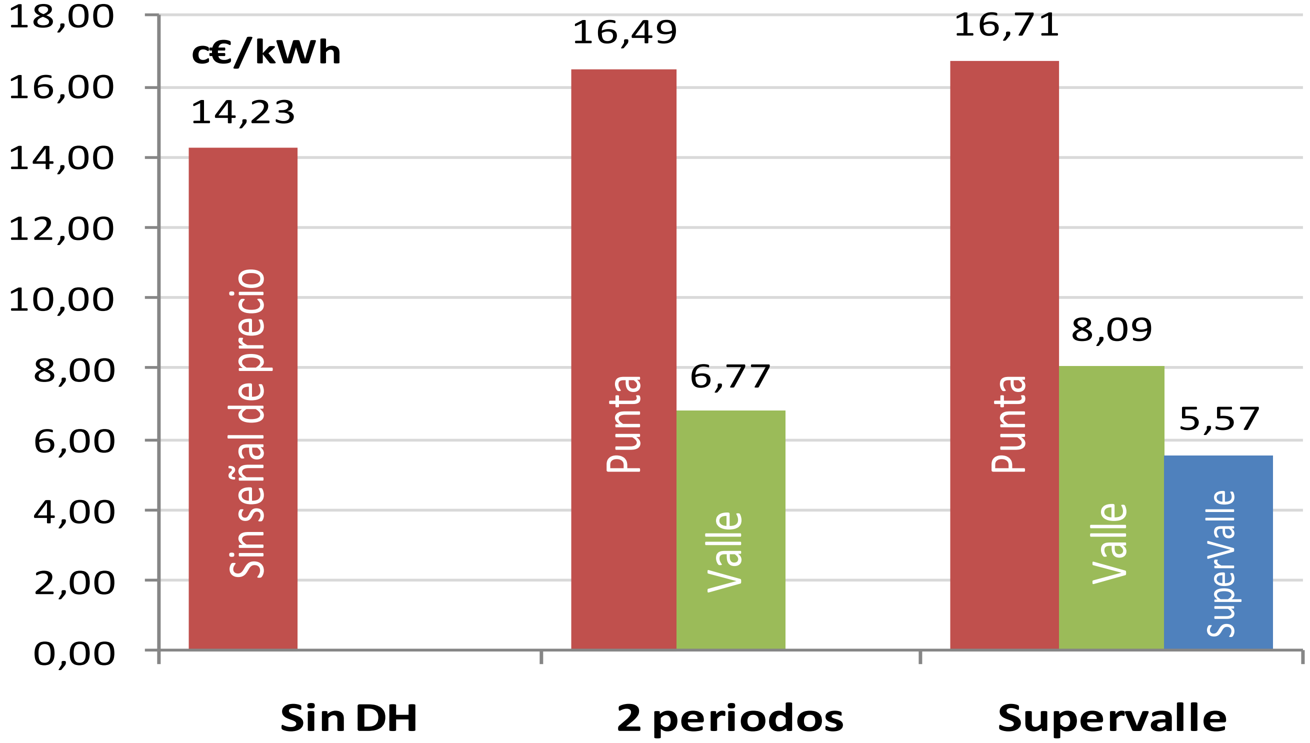
## ❑ Spain

Goals for 2014 in the whole country: 252.000 electric vehicles and more than 300.000 charging points. Four working areas have been defined in order to fulfil this objective:

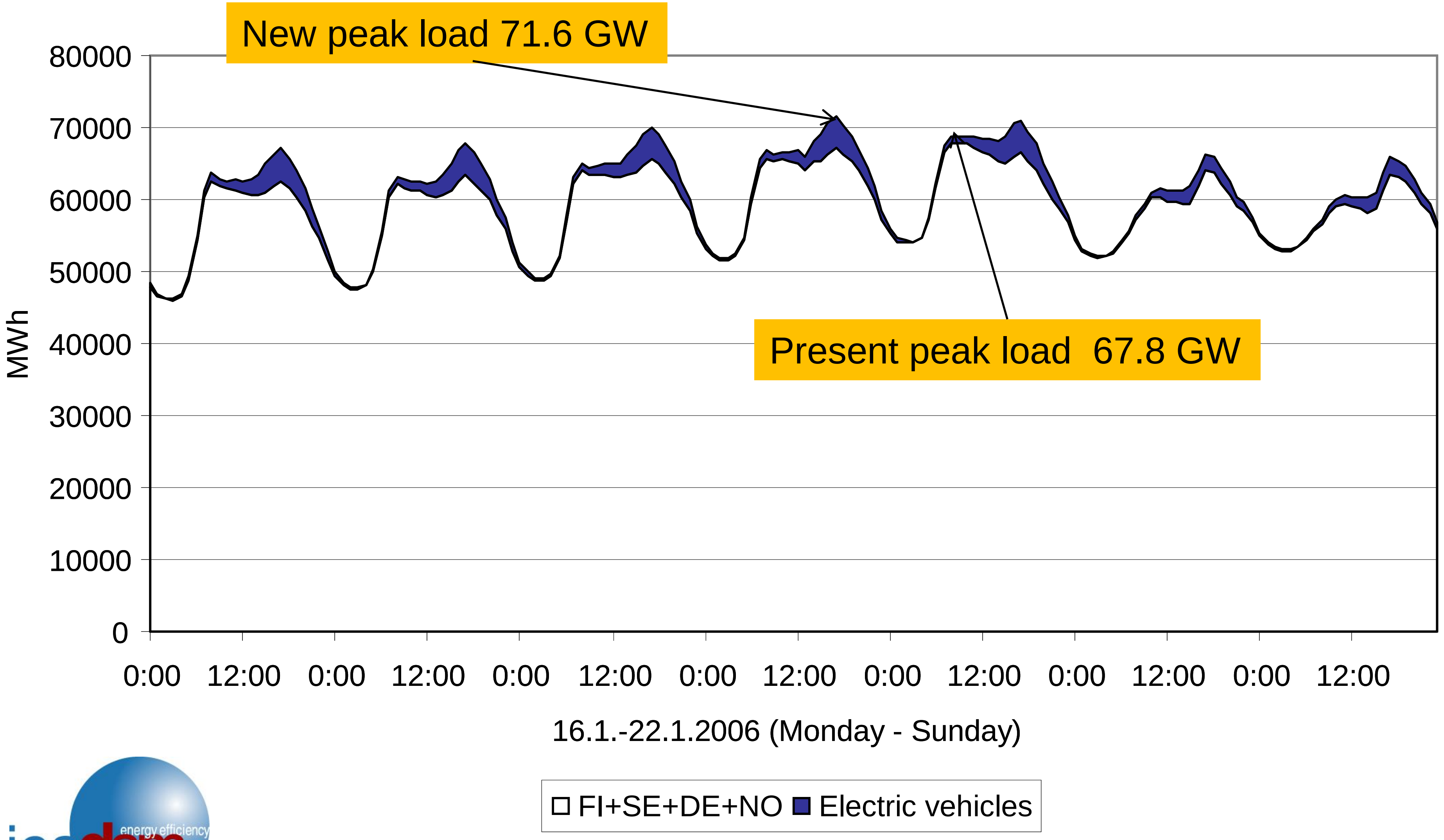
- Promotion of EV sales: monetary incentives for EV purchase and infrastructure development have been established (% of the EV cost up to 6.000€).
- Industrialization and R&D: companies can benefit of financial resources in order to support the industrialization and EV development by means of national industry.
- Promotion of charging infrastructure and side management services:
- Horizontal programs: regulatory framework and legal barriers suppression, communication programs, promotion and training of new specialized jobs, etc.
- The Electricity Sector Act (ley 54/1997) has been modified in order to include a new actor, the “Load manager” (therefore the regulatory framework for the aggregator has been created), and a consumer with the capability to resell energy for charging EVs, and a new activity, the “Charging services”

# Support schemes/mechanisms

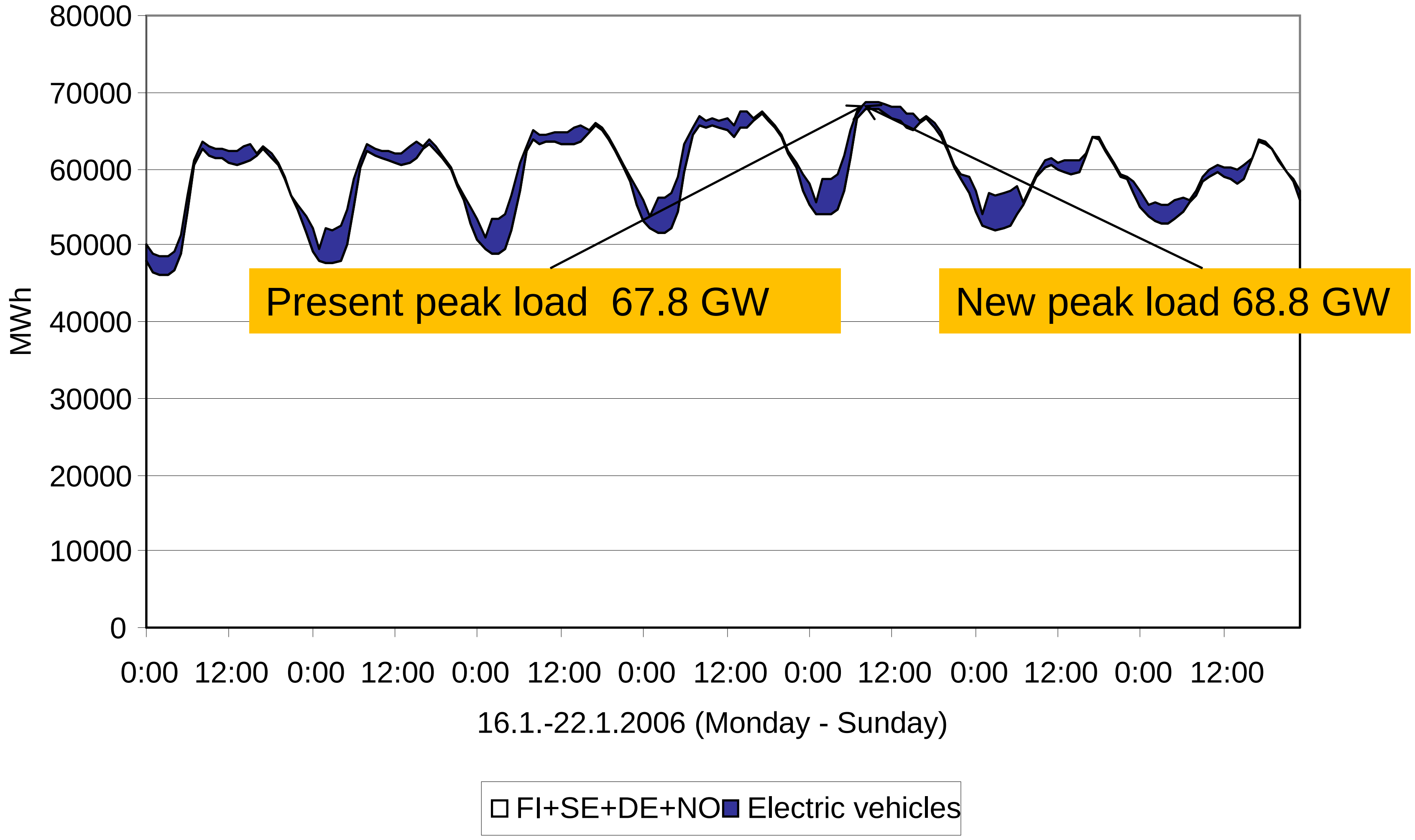
- New super off-peak tariff has been designed for EV consumption.



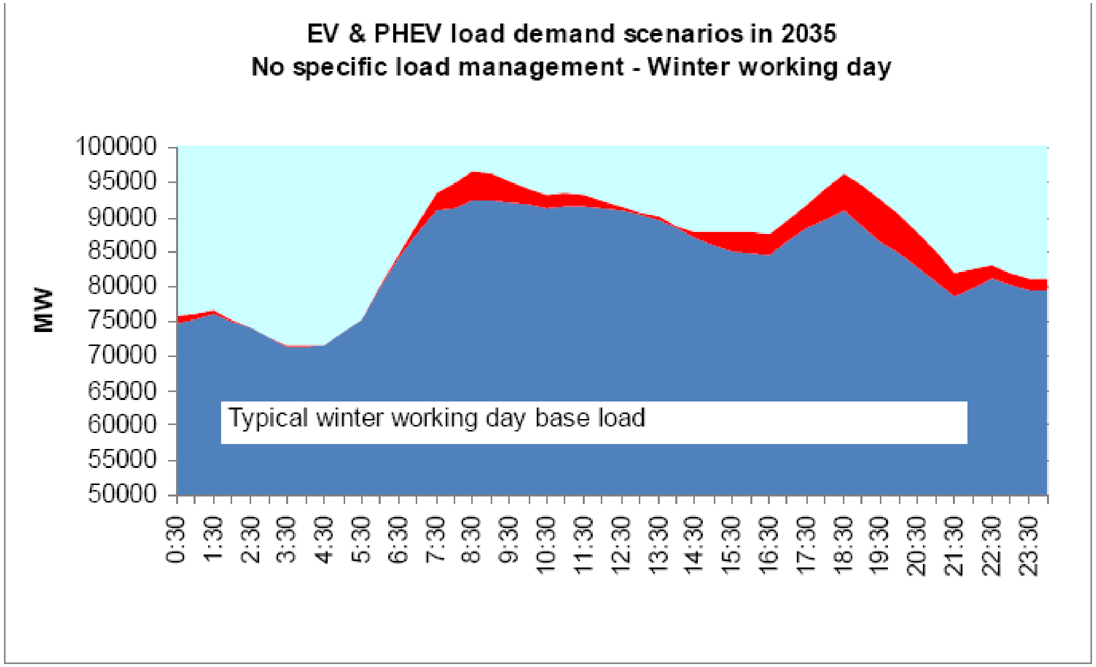
# System level impacts: Simulation case 1: 5 million PEV/PHEV in Nordic system: normal charging



# System level impacts:
# 5 million PEV/PHEV in Nordic system: intelligent charging



# System level impacts: France, Spain

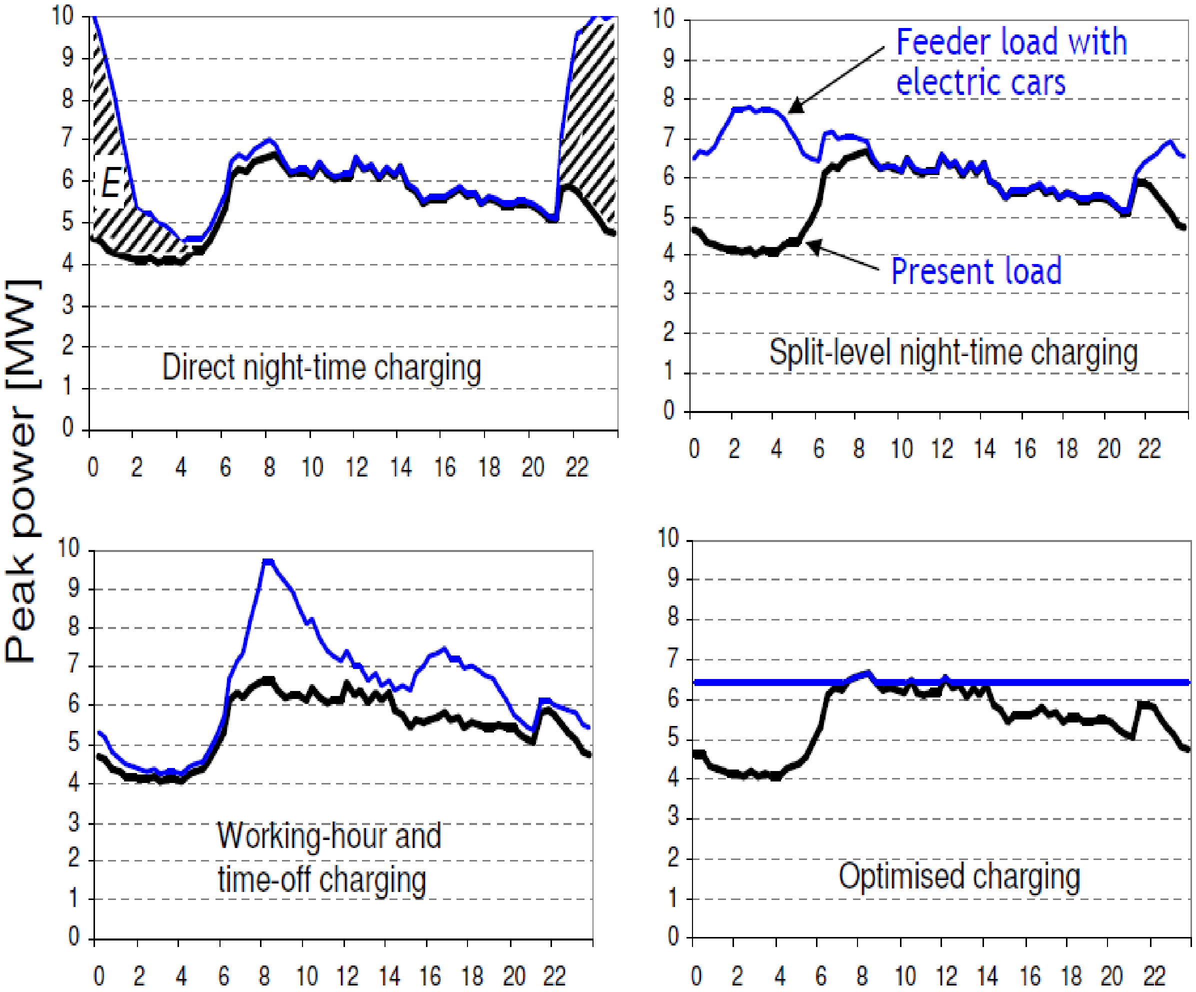



Free charge generates peaks at the beginning of the work period
and in late afternoon till early evening

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 without additional investmenst

# Example: effect of the charging method on the local network: Finland




**City area feeder:**

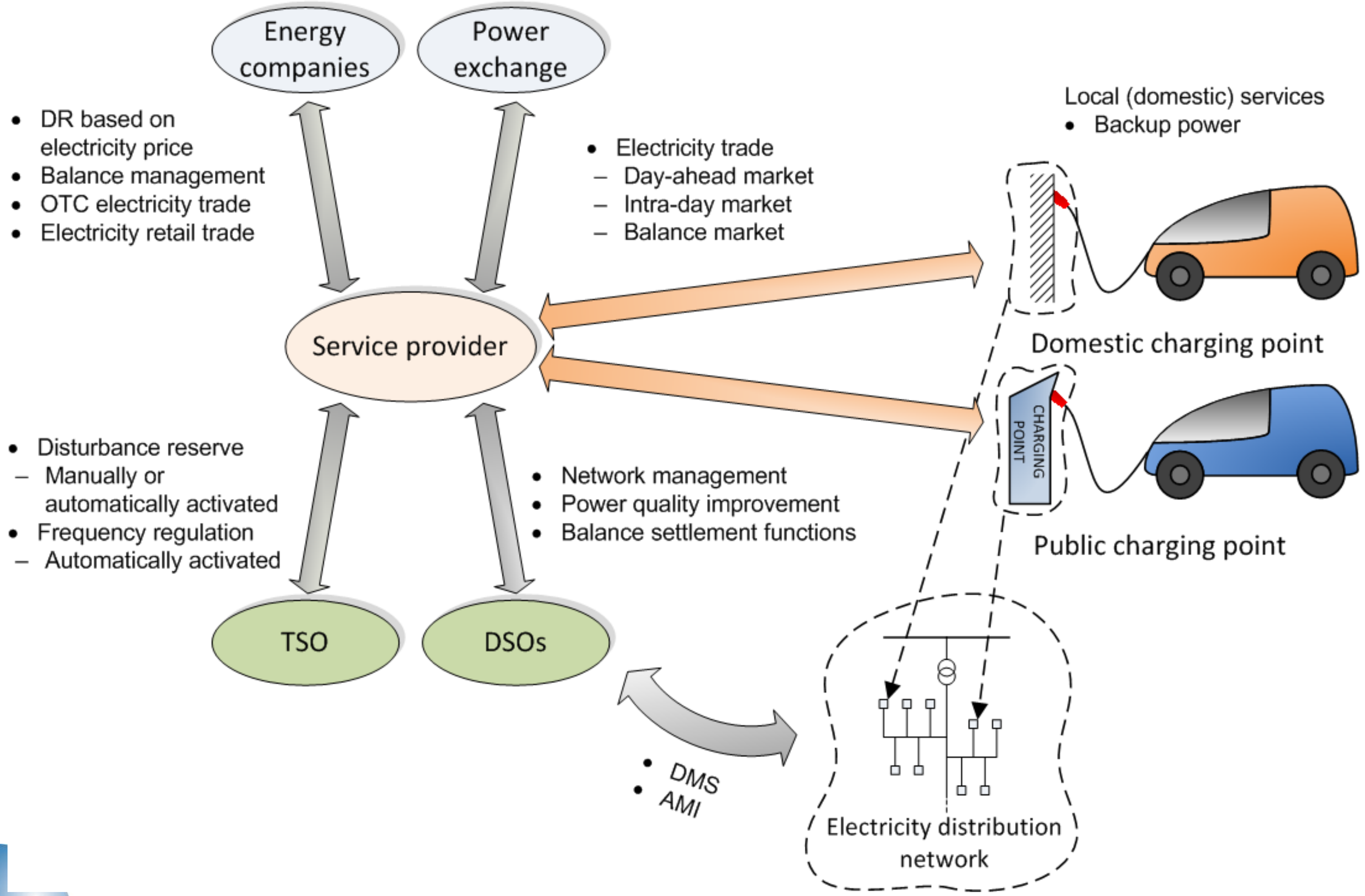
- Peak load of the day: 6.6 MW
- Minimum load of the day: 4.0 MW

- **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

- 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.

# Heat sources of heat pumps

| Heat Source | Temperature Range (°C) |
| --- | --- |
| ambient air | -20 – 15 |
| exhaust air | 15 – 25 |
| ground water | 4 – 10 |
| lake water | 0 – 10 |
| river water | 0 – 10 |
| sea water | 3 – 8 |
| rock | 0 – 5 |
| ground | 0 – 10 |
| waste water and effluent | >10 |

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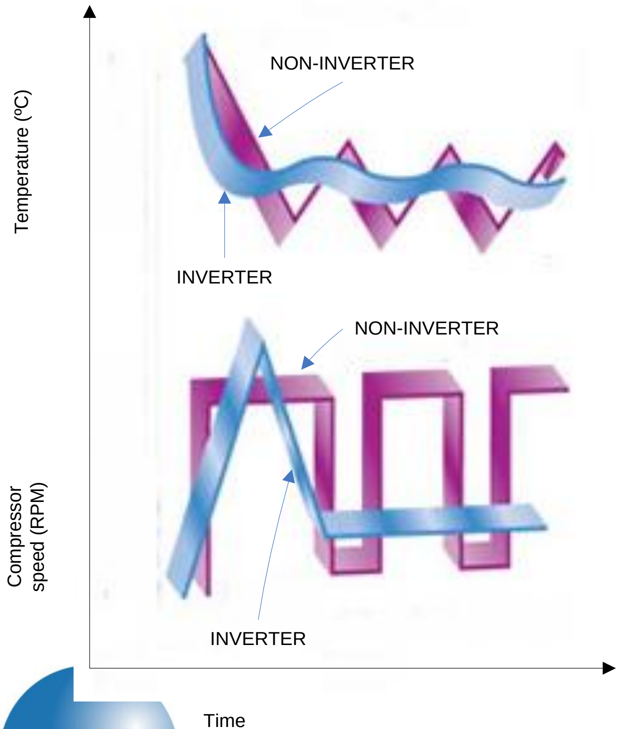
# Control of heating and cooling heat pumps

Heating and cooling systems do not have a pre-determined consumption profile. In contrast, the electrical consumption is related to the thermal demand of the room. In addition, the consumption profile depends on the type of technology employed for regulating




DSM-alternatives:

- **Air-conditioning system disconnection**

Has been the basis of many direct load control initiatives.Technical implementation of these control actions could be performed in a short-term because the required technology already exists in the market

- **Temperature set-point modification**

Technical implementation of these control actions would be also possible in the short-term because most air-conditioners sold nowadays are equipped with a digital thermostat that would allow a remote control of the temperature setting without a significant investment

- **Compressor capacity limitation**

These control actions are only applicable to air-conditioning systems equipped with an inverter power control. This control option could represent a good alternative for being implemented in the long-term because important changes on the air-conditioning systems are required

# Example: Status quo for electrical power consumption of HP in Austria and scenarios

| HP power classification | Percentage on the total share [%] | 2009 [MWel] Status quo | 2020 [MWel] Baseline scenario | 2020 [MWel] Accelerated scenario | 2030 [MWel] Base scenario | 2030 [MWel] Accelerated scenario |
|---|---|---|---|---|---|---|
| Installed HP | | 164.000 | 250.000 | 233.000 | 343.000 | 455.000 |
| < 20kW | 90% | 300 | 457 | 426 | 627 | 831 |
| 20kW-80kW | 9% | 30 | 46 | 43 | 63 | 83 |
| > 80 kW | 1% | 3 | 5 | 5 | 7 | 9 |
| Total | 100% | 333 | 508 | 473 | 696 | 924 |

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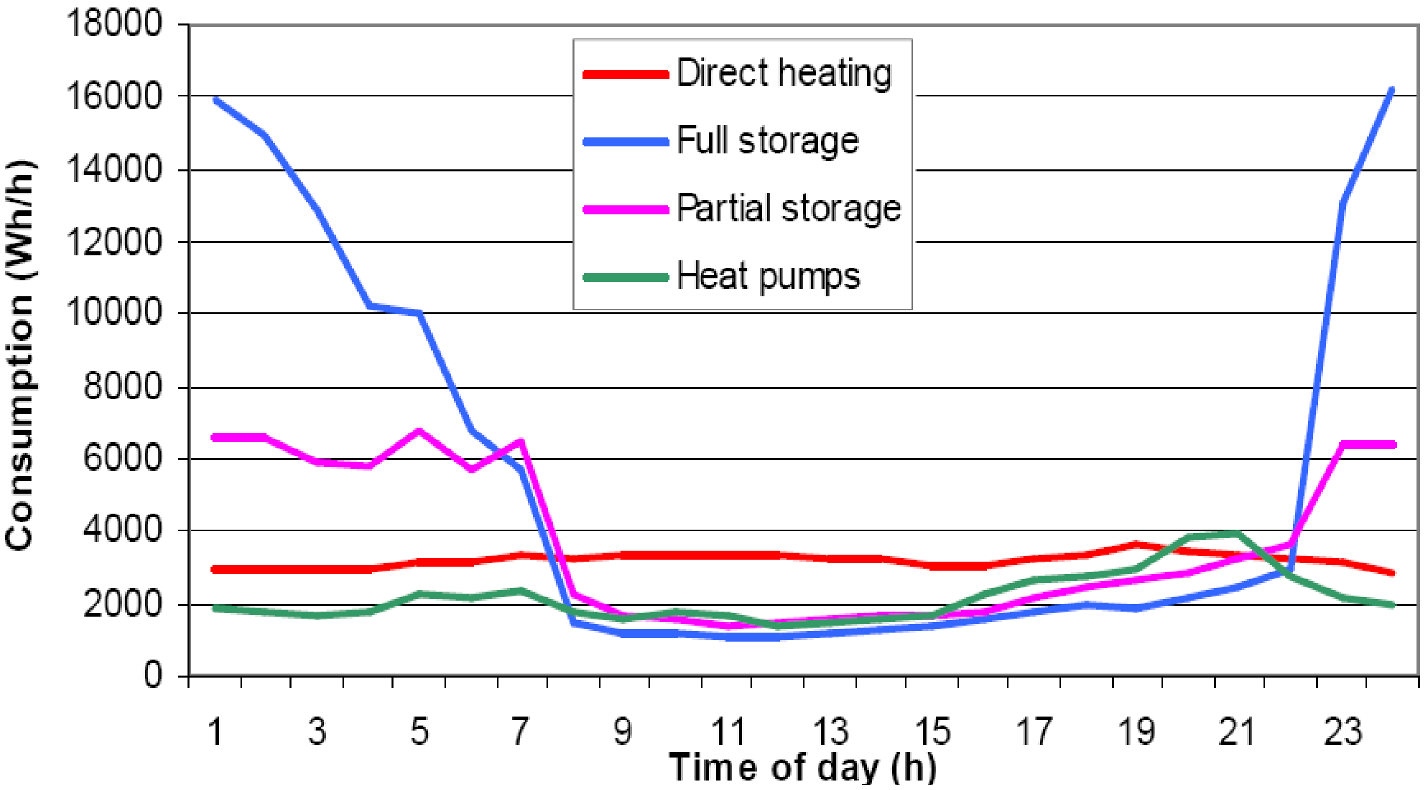
# Example: The amount of the annually installed heat pumps and the estimate of the total amount of the heat pumps in Finland

| Type | 2009 | 2010 | 2011 | 2015 | 2020 |
|---|---|---|---|---|---|
| Ground source | 6 137 | 8 091 | 11 000 | 15 000 | 20 000 |
| Exhaust air | 1 819 | 1 988 | 2 000 | 3 000 | 4 000 |
| Air-to-water | 1 819 | 1 150 | 3 000 | 5 000 | 6 000 |
| Air-to-Air | 57 977 | 53 821 | 60 000 | 50 000 | 40 000 |
| Total amount of annually installed heat pumps | 67 752 | 65 050 | 76 000 | 73 000 | 70 000 |

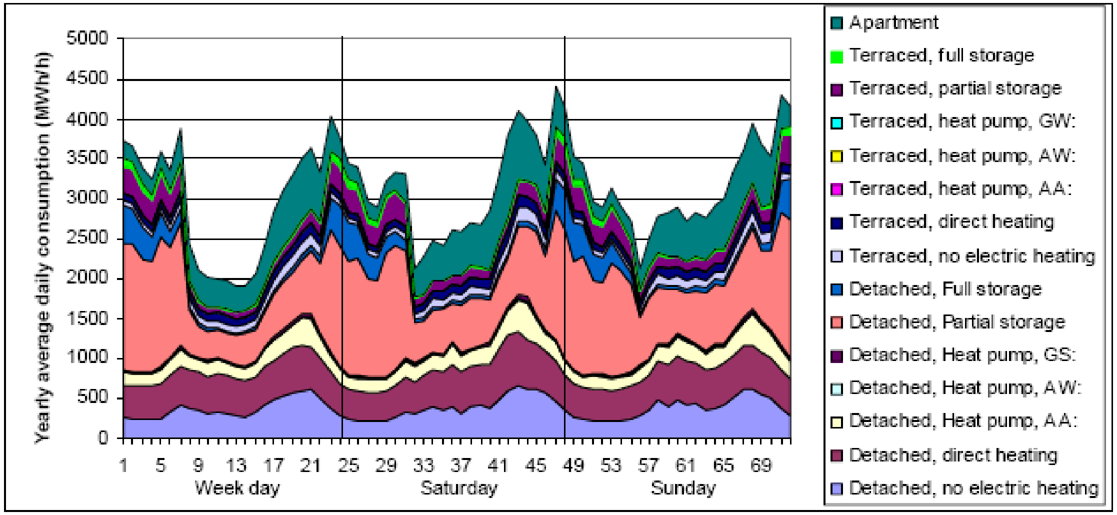
| | 2009 | 2010 | 2011 | 2015 | 2020 |
|---|---|---|---|---|---|
| Total amount of heat pumps | 340 000 | 390 000 | 465 000 | 750 000 | 1 000 000 |

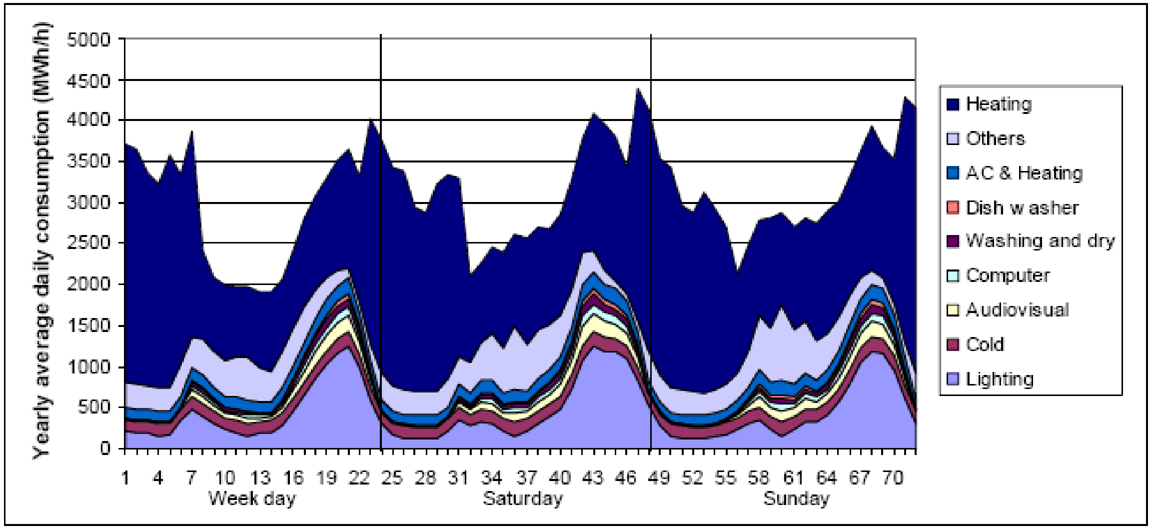
# Example: DSM potential for residential sector in Finland (1)



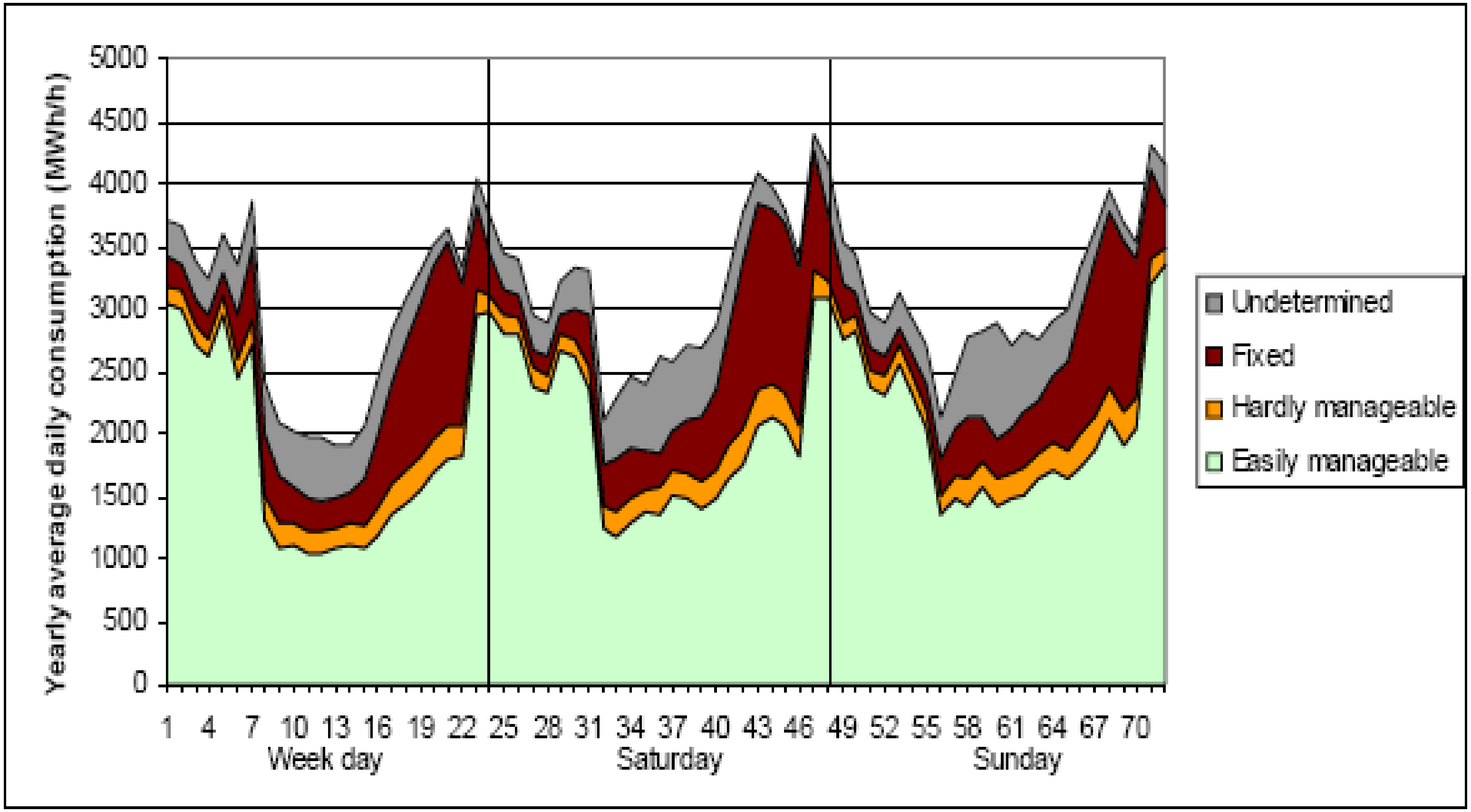

Load curves for different heating types during a typically January weekday in Finland

# Aggregated winter load curve for residential sector in Finland (2)



# Estimated flexibility potential in the residential sector during an average winter week (3)



# Example: heat pumps in France

Estimation: The total number of heat pumps installed in the residential sector in France was estimated to be around 550 000 at the end of 2010, plus 400 000 air/air type heat pumps. The penetration rate of heat pumps in the residential sector is therefore about 3.4% (950 000 heat pumps for 27.5 millions possible installations). The scenario considered by the Program of Investments in Heat Production is for a total of 2 millions of housing equipped with a heat pump unit. This scenario also predicts a share of 20% of heat pump being geothermal, the rest being air/water heat pump

Incentives:

- **Sustainable development income-tax credit**

  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
- **Eco"-loan at 0% interest**

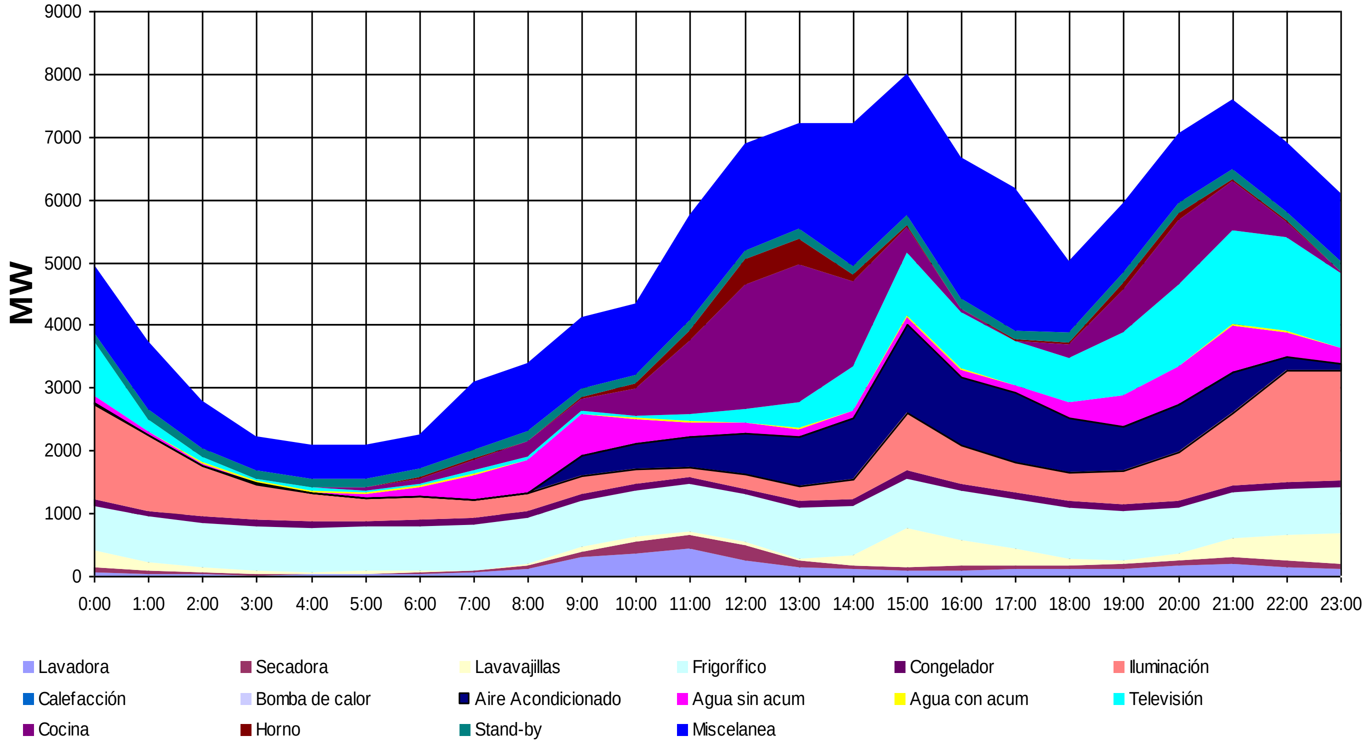
  There are of course some specific criteria to fulfil in order to benefit from this eco-loan. In the case of heat pumps, construction work such as drilling for geothermal heat pump for example can benefit from this loan.
- **VAT of 5.5%**

  The VAT is reduced to 5.5% instead of 19.6% for heat pumps installations.

# Example: heat pumps in Spain

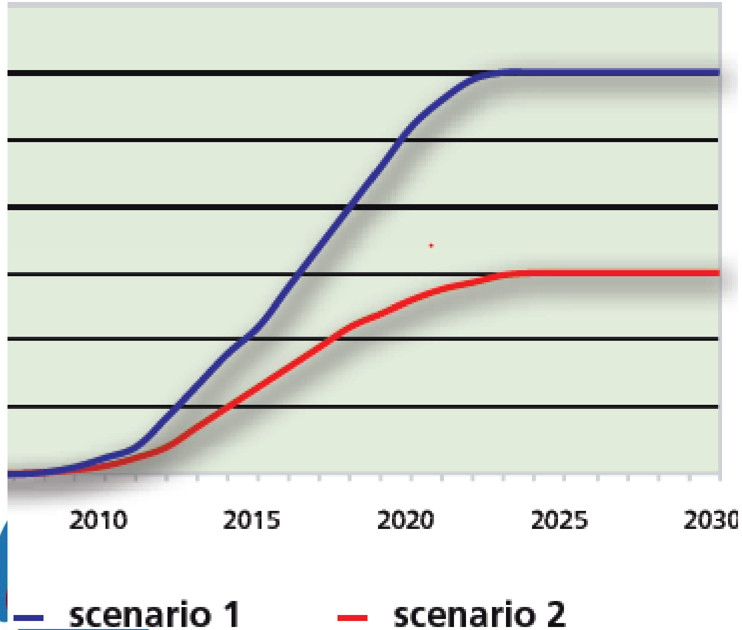
According to the Spanish National Institute of Statistics, in 2008 6,3% of houses in Spain have a heat pump installed. Internal REE studies forecast that, taking into account the efficient scenario for 2020 it could imply 9,3 M of heat pumps in Spain.

Regarding its impact in the daily load shape of residential sector, next figure shows the different uses of electricity and its weight in a working day in summer.



# Example: heat pump development in the Netherlands

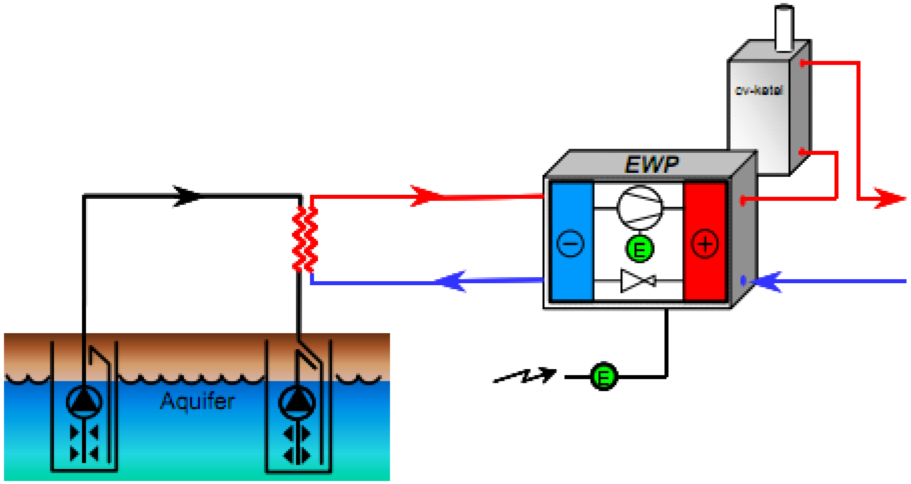
Applying heat pump systems in homes and utility buildings is taken up in the design time energy performance index (EPC), to which newly built homes in the Netherlands have to comply. This makes it easy to compare heat pumps to other measures to conserve energy.
Heat pumps in the Netherlands in existing homes are 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.




Hybrid systems are now most close to the market. These entail electricity or gas based heat pumps for the base load and gas fired high-efficiency boilers as add-ons to generate tap water. The most recent projection is from 2009. The scenario is for hybrid air-water heat pumps.

| | | |
|---|---|---|
| 2011-2015 | 340.000 | 182.000 |
| 2016-2020 | 1.000.000 | 535.000 |
| 2021-2030 | 2.980.000 | 1.479.400 |

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




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.

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# 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

# Conclusions (2)

- 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***

# Other technologies assessed

In spite of the PEV/PHEV and heat pumps also

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

were discussed in the Task. Due to the time limit they are not discussed in this connection. Separate reports will be published (except energy storages).

# Integrated pilots/demonstrations/field tests/existing practices

The Task collects information on the existing pilots etc. related to the integration of technologies mainly in participating countries.

- ❑ In the Phase One about 50 cases were collected

- ❑ In the Phase Two a little bit modified template has been produced. The data collection is still going on aiming to have minimum 5 cases per country + some international projects

# Thank you