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

ECES Workshop: Energy Storage: Matching Supply and Demand in the Future

Bad Tölz, July 14 – 16, 2010

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IEA DSM PROGRAMME

Content of the presentation

- IEA DSM Agreement: status
- Background and introduction to Task XVII
- Phase 1: Overview of DER situation
- Incentives and subsidies
- DER business opportunities: aggregation business
- Concluding remarks
- Continuation of the Task (Phase 2)
- Examples on PEV/PHEV

The IEA DSM Programme (1)
http://ieadsm.org/

- Work begun in 1993, 4th 5 years period started in September 2008

- With 19 OECD Countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, India, Italy, Japan, Korea, The Netherlands, Norway, New Zealand, Spain, Sweden, United States, United Kingdom)

Programme Vision: In order to create more reliable and more sustainable energy systems and markets, demand side measures should be the first considered and actively incorporated into energy policies and business strategies.

Programme Mission: To deliver to our stakeholders useful information and effective guidance for crafting and implementing DSM policies and measures, as well as technologies and applications that facilitate energy system operations or needed market transformations

The IEA DSM Programme (2)

The Programme's work is organized into two clusters:

- The load shape cluster, and
- The load level cluster.

The 'load shape" cluster includes Tasks that seek to impact the shape of the load curve over very short (minutes-hours-day) to longer (days-week-season) time periods.

The "load level" cluster includes Tasks that seek to shift the load curve to lower demand levels or shift loads from one energy system to another.

A total of 21 Tasks have been initiated since the beginning of the DSM Program

Some completed tasks in load shape cluster related to demand flexibility

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

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

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

- Task 15: Network-Driven DSM, David Crossley, Energy Futures Australia Pty. Ltd, Australia, almost completed

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Ongoing tasks in load shape cluster related to demand flexibility

- Task 17: Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages, Seppo Kärkkäinen, Elektraflex, Finland, first phase completed

- Task 19: Micro Demand Response and Energy Saving, Linda Hull, EA Technology Ltd, United Kingdom, started in January 2009

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, 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 has just started and is still open to participation

Confirmed participant: Finland, France, Netherland, Spain
Near to confirm: Australia, Austria, Norway

First expert meeting in March in Madrid

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).

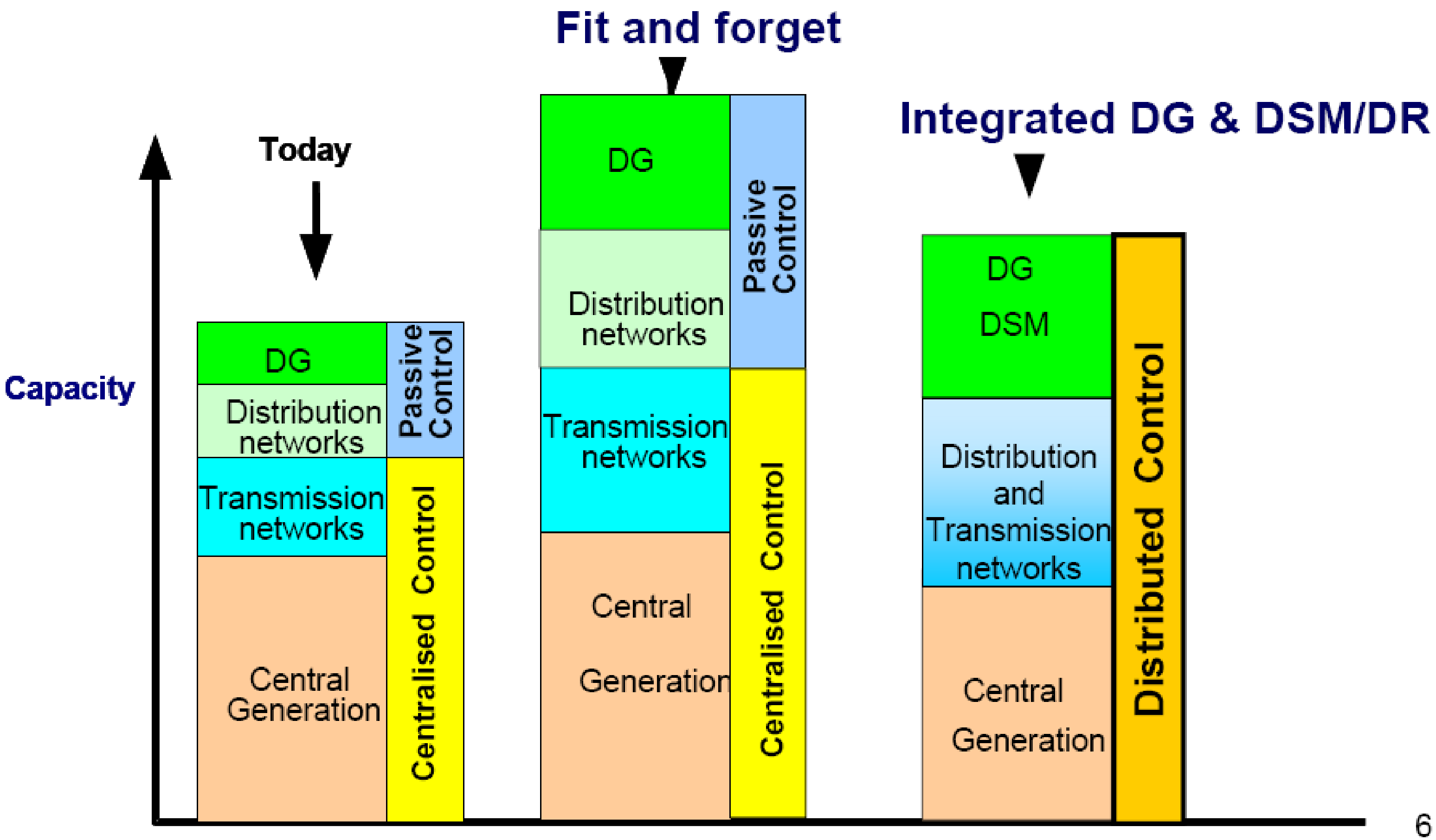
In this sense distributed generation (DG), distributed energy storages (DS) and demand response (DR) can be seen as an integrated distributed energy resource (DER). Combining the different characteristics of these resources is essential in increasing the value of variable output generfationm in the energy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

Smart-grid vision

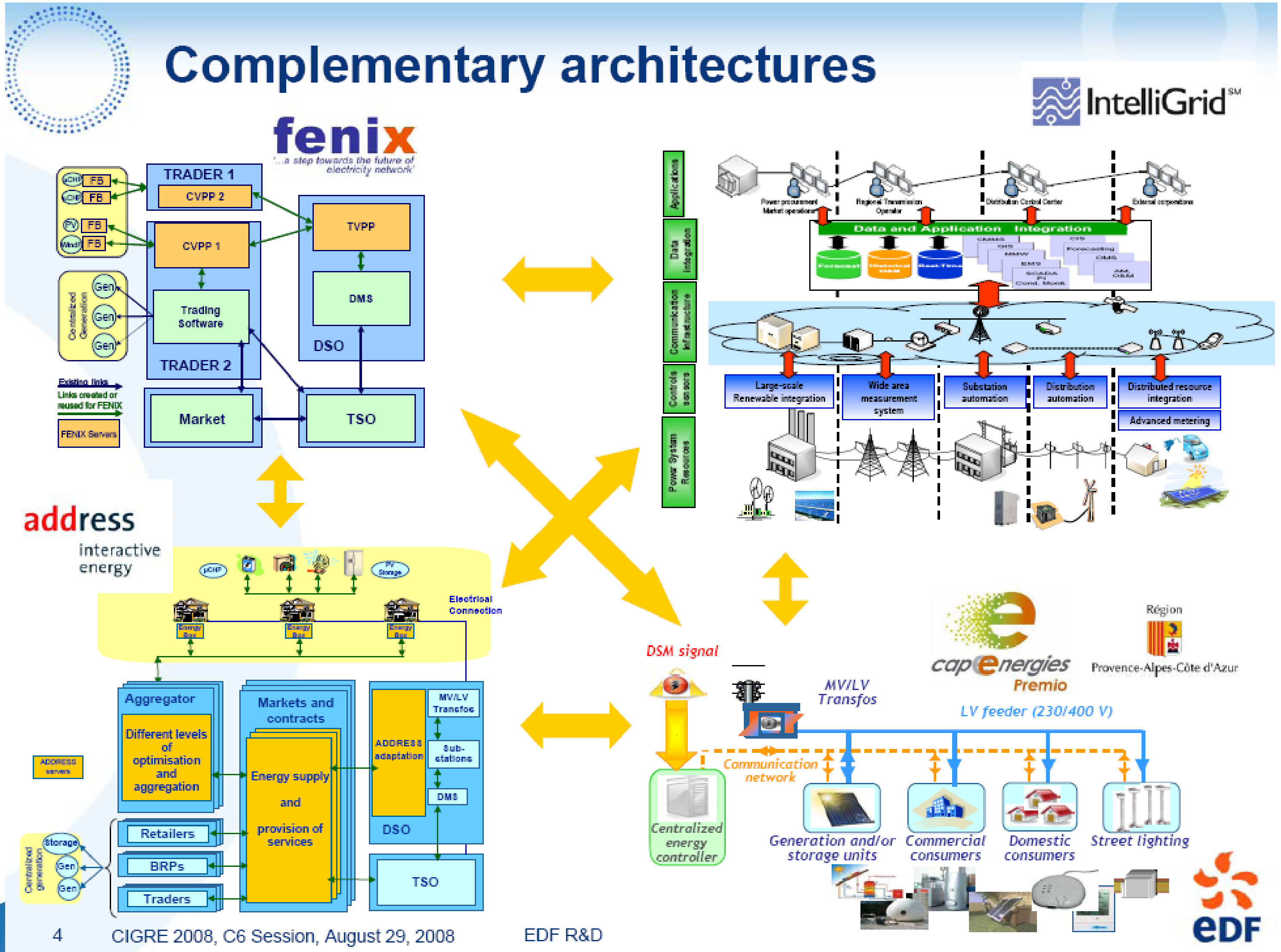
The vision for the integration of DER is a smart-grid platform that would link a web of diverse generation sources, including a variety of fossil fuels and renewable and distributed sources, across the grid to a large set of consumers with possibilities for improved energy efficiency, local generation, controllable loads or storage devices.

It is expected that the costs of a system with a better DER integration would be reduced compared to the present situation, because of higher energy efficiency and the inclusion of more renewables, but also of a lesser use of expensive peaking power and a better use of the transmission and distribution assets.

Challences of SmartGrid concepts



Examples on smart grid architectures



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.

Overview of the situation

The main topics discussed in the main report are:

- DER and electricity supply
- Flexibility in electricity demand
- Communications and IT
- Integration analytics
- Regulation, policy and business models

Overview of the DER situation

Next tables give a short overview of the DER situation in participating countries in 2008 including

- DG and RES-E
- Energy storages and
- Demand response

Installed capacity (in MW) for DG and renewables

Country	**Wind** (MW)	**Solar** (MW)	**CHP** (MW)	**µCHP** (MW)	**Small hydro** (MW)	**Others** (MW)	**Estimated Total DG** (MW)
Finland	122	marginal	294	N/A	270 *(<10 MW)*	< 20	800
Italy	1500	120	3242 *(<25 MW)*	N/A	4138	672*	9700
Netherlands	1560	53	8500	N/A	marginal		10200
Spain *(<25 MW)*	3705	413	4214	0.788	1702	538**	10600
USA	1078	810	***	minimal	minimal		2000
Austria	1032	36	402	****	1559 (<20 MW)	1	5000
Korea	178	36	3455	148	60 (<5 MW)	81	4000

Notes
* : In Italy, others are biogas (347 MW) and heat & enthalpy recovery (325 MW)
**: In Spain, others are biomass, biogas and municipal solid waste fired units
***: In USA, total capacity almost 50 000 MW, most over 20 MW units
****: In Austria, total µCHP generation 6165 MWh, 1172 MW of small hydro capacity <10MW

Energy storages in participating countries

	Pumped hydro	Heat storage (large scale)	Heat storage (consumer's level)
Austria	6.5 GW / 11.2 TWh		Yes
Finland	No	About 17 GWh and 900 MW_h (non-coincident)	Yes
Italy	7.6 GW/5 TWh (2007)	N/A	rare
Korea	3.9 GW	699Gcal/h	649 MW (ice storage)
Netherlands	No	Yes	Not really
Spain	2.7 GW	No	No

Existing DR options in the participating countries

Type of DR	Country	Note
Time of use tariffs	Finland	Retail and network ToU, usually for customers over 10 to 15MWh per year
	Italy	Night&Day tariffs for residential customers
	Spain	Compulsory above 50kW, otherwise optional
	Austria	exist
	Netherlands	exist
	USA	exist
	Korea	Industrial and commercial consumers
Real-time pricing	Finland	Some suppliers are offering this form of pricing for small customers if customer has an hourly meter [4]
	Italy	For large and medium consumers
	Spain	For large consumers
	Netherlands	For large consumers
	USA	Exists and is viewed to increase
Curtailment and direct load control programs *	Italy	Interruptible load deals with VHV grid large customers (by 7% of country peak load)
	USA	Most of the DR programs are of this type
	Austria	exist

* : Does not include emergency curtailment programs that exist in all the participating countries

Incentives and subsidies

- RES-E usually has incentives
- DR has also incentive based programs

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Renewable energy incentives

	Country	Note
Investment support	Finland	30% (40% for wind power)
	Korea	30% ~ 80% (depend on the types)
Tax reduction	Finland	Certain generation forms do not pay electricity tax
	Korea	10 % of investment in renewable energy can be deducted from corporate income tax
Feed-in tariffs	Italy	CIP6 scheme with frozen eligibility; all-inclusive scheme for devices less than 1MW
	Spain	Optional if under 50MW
	Austria	
	Korea	
Fixed premium	Italy	PV solar
	Netherlands	
	Spain	Optional if under 50MW
Green certificates	Italy	Quotas up to 6.8% (2012) of fossil generation & imports
Quota	Austria	For balancing areas

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Incentive based DR

These programs give customers load reduction incentives that are separate from, or additional to, their retail electricity rate, which may be fixed (based on average costs) or time-varying.

The load reductions are needed and requested either when the grid operator thinks reliability conditions are compromised or when prices are too high (reliability or economy based DR).

Most demand response programs specify a method for establishing customers' baseline energy consumption level. Hence, observers can measure and verify the magnitude of their load response. Some demand response programs penalize customers that enrol but fail to respond or fulfil their contractual commitments when events are declared.

Typical incentive based programs

- Direct load control: a program by which the program operator remotely shuts down or cycles a customer's electrical equipment (e.g. air conditioner, water heater, space heating) on short notice.
- Interruptible/curtailable (I/C) service: curtailment options integrated into retail tariffs that provide a rate discount or bill credit for agreeing to reduce load during system contingencies.
- Demand Bidding/Buyback Programs: customers offer bids to curtail based on wholesale electricity market prices or an equivalent.
- Emergency Demand Response Programs: programs that provide incentive payments to customers for load reductions during periods when reserve shortfalls arise.
- Capacity Market Programs: customers offer load curtailments as system capacity to replace conventional generation or delivery resources.
- Ancillary Services Market Programs: customers bid load curtailments in ISO markets as operating reserves.

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DER business opportunities: market based DER

Typical examples for DG/RES are market price based feed-in tariffs and green certificates and for energy efficiency white certificates.

Correspondingly price-based demand response refers to changes in usage by customers in response to changes in the prices they pay:

- Time-of-use (ToU): a rate with different unit prices for usage during different blocks of time, usually defined for a 24 hour day. ToU rates reflect the average cost of generating and delivering power during those time periods.
- Real-time pricing (RTP): a rate in which the price for electricity typically fluctuates hourly reflecting changes in the wholesale price of electricity. Customers are typically notified of RTP prices on a day-ahead or hour-ahead basis.
- Critical Peak Pricing (CPP): CPP rates are a hybrid of the ToU and RTP design. The basic rate structure is TOU. However, provision is made for replacing the normal peak price with a much higher CPP event price under specified trigger conditions (e.g., when system reliability is compromised or supply prices are very high).

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

Pilot case studies

Case studies, experiments and research projects in the participating and some other countries have been collected and categorized:

- Autonomous grids, Microgrids
- Balancing DG units;
- Aggregation of units and virtual power plant
- Traditional DR/DSM
- Delay network investments

Concluding remarks from the IEA Task XVII Phase 1 (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 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.

Concluding remarks (2)

The summary on the situation of integration was developed on the basis of analysis and expert group opinions. The status of each item was assessed among the following:

Early:	R&D
Young:	Pilots / Field tests
Existing:	Available, at least one vendor or early adopters involved
Mature:	Widespread commercial

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Status of integration (1)

Electricity supply	**Fossil fuel based technologies** ▪ fuel cells ▪ micro chp ▪ conventional chp	Young Existing Mature
Electricity supply	**Renewables** ▪ Wind ▪ pv ▪ small hydro ▪ waves, tidal ▪ biomass	Mature Existing/Mature Mature Young/Mature Young/Mature
Electricity supply	**Renewable production forecasting**	Young/Existing
Electricity supply	**Electrical energy storage** ▪ energy management ▪ bridging power ▪ power quality	Young/Mature Existing/Mature Early/Existing
Electricity supply	**Economic dispatch, SCUC software**	Mature
Electricity supply	**Resource planning techniques, tools**	Mature
Electricity supply	**Real-time grid operation tools**	Mature

Status of integration (2)

Electricity demand	**Many DSM techniques**	Mature
	Automated DR devices	Young
	Pricing granularity (smart rates) ▪ Small customers ▪ Large customers	 Early Existing
	Consumer response and production	Early
Communication, control and monitoring	**Communication networks**	Mature
	High-speed digital monitoring ▪ Generation ▪ Transmission (EU) ▪ Transmission (USA) ▪ Distribution	 Mature Mature Young Early
	Smart meters deployment	Young/Existing
	Cyber-security	Young/Existing
	Interoperability	Existing
	Functional Automation/Monitoring ▪ for large assets ▪ for DER	 Mature Young
	Intelligence/Smart behaviour	Young
	User/primary process feedback	Young/Existing
	Intelligent agents and distributed controllers	Young
	Communication semantic and content	Young/Existing

Status of integration (3)

Integration analytics	**Modelling electricity system impacts**	Young/Existing
	Understanding relative costs and benefits	Existing
	Controlling and coordinating parts	Young
	Good, real data	Early / Young
Regulation, policy and business	**How to capture benefits**	
	Incentives and subsidies	
	How to pay for everything	
	Taxation	
	Aggregator business	Young/Existing

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
- Other technologies (small wind at customer premises, smart metering, emerging ICT) seen feasible in 10 – 20 years period, especially by 2020.

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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
- Pilots and case studies
- Stakeholders involved in the penetration and effects on the stakeholders
- Assessment of the quantitative effects on the power systems and stakeholders
- Conclusions and recommendations

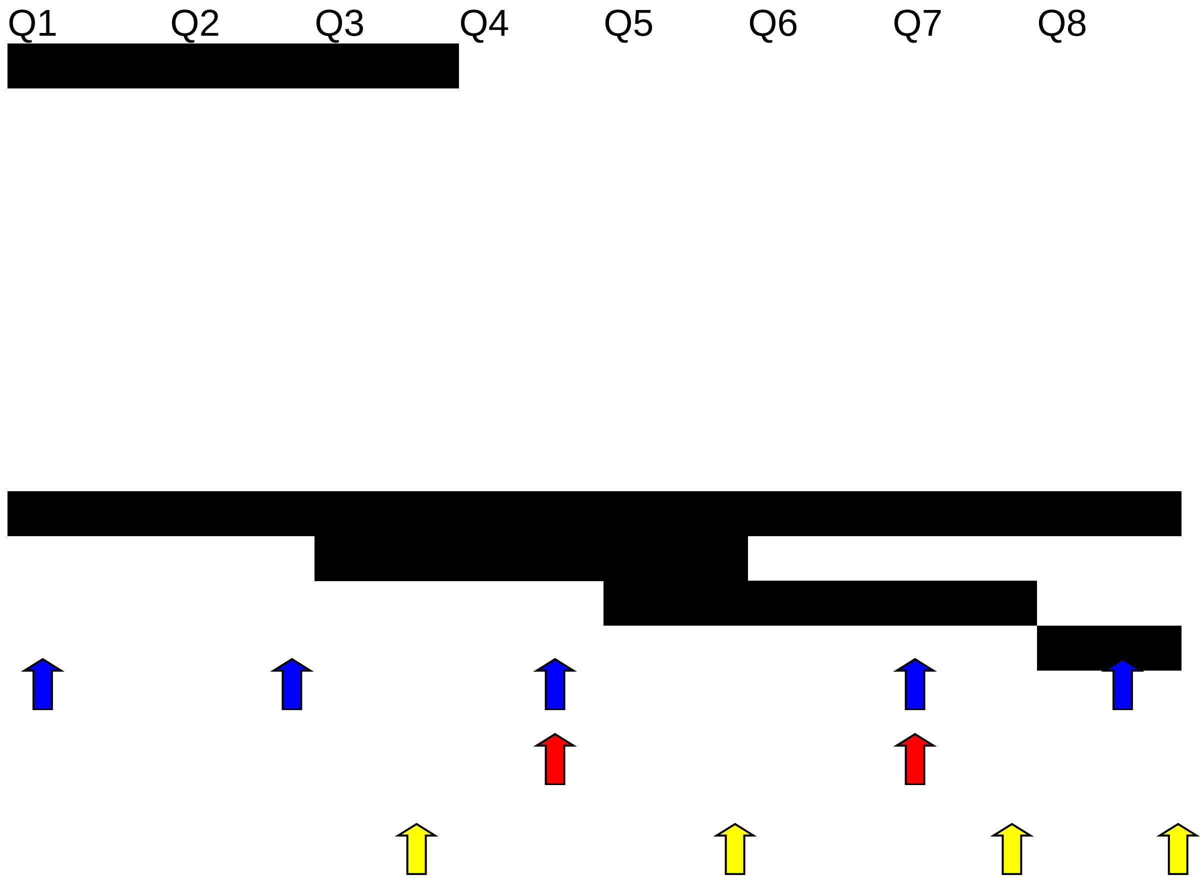
Time schedule: 2 years, started 1st of March 2010
New participants still wellcome

Task XVII extension: Phase 2. Deliverables (3)

- 4 subtask reports
  - technologies including state-of the art in participating countries (present situation) and future penetration scenarios
  - stakeholder involvement and effects (including regulation, business opportunities etc.),
  - assessment of the effects on the system and stakeholders including methodologies and cost-benefit analysis
  - Summary, conclusions and recommendations
- 2 workshops
- Case studies and pilots data base + summary report
- Country descriptions
- Conference presentations
- 2 updated Task flyers (in the beginning and end of the Task extension)

Time schedule of Phase 2: the total length is 2 years starting 1st of March 2010 (4)

Time schedule :
1st of March 2010 - 28th of February 2012



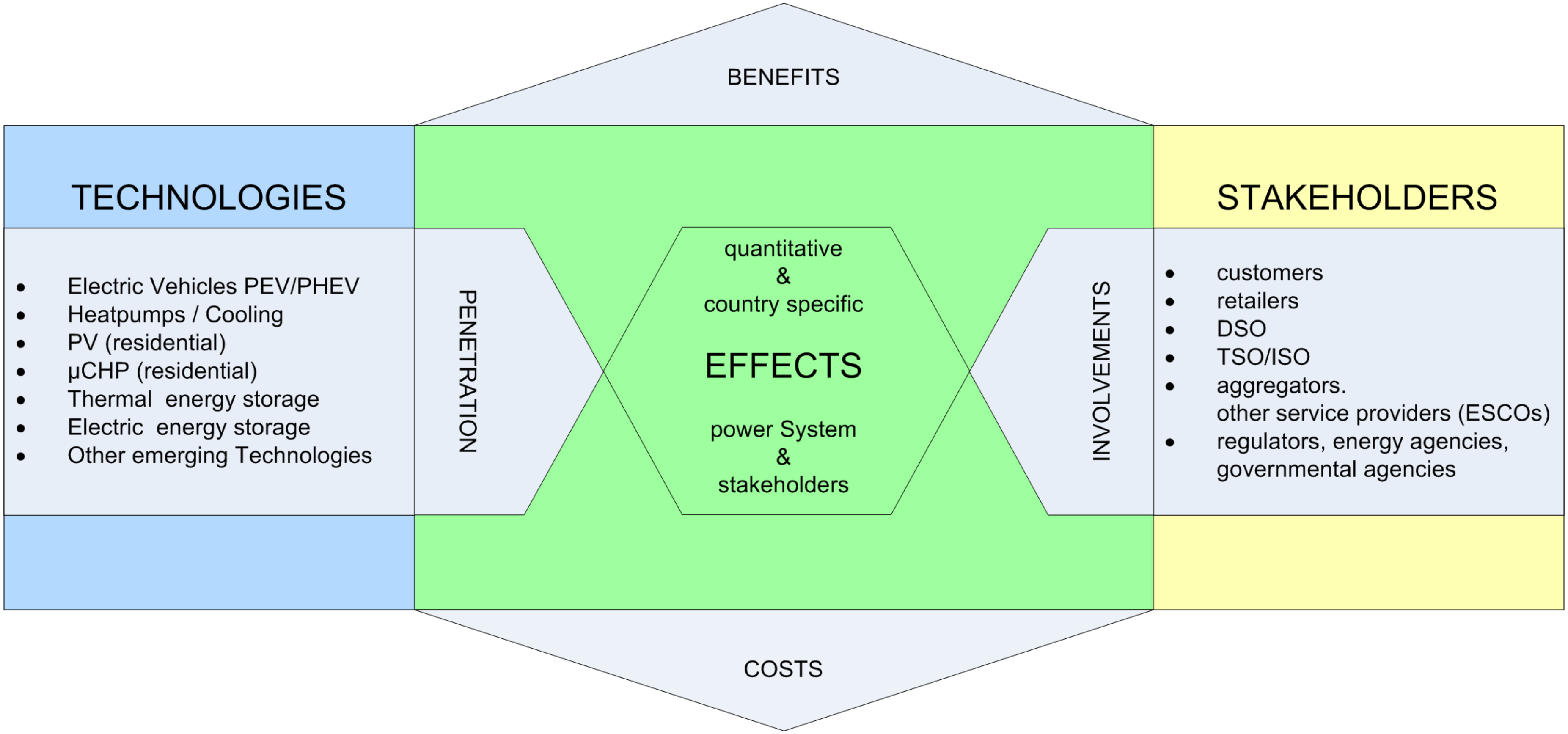
Subtask 5
  PHEV/PEV
  Heat pumps
  Photovoltaic
  Micro CHP
  Energy storage
  Smart metering
  Emerging ICT
  Wind power at customers?
Subtask 6
Subtask 7
Subtask 8
Subtask 9

Expert meetings

Workshops

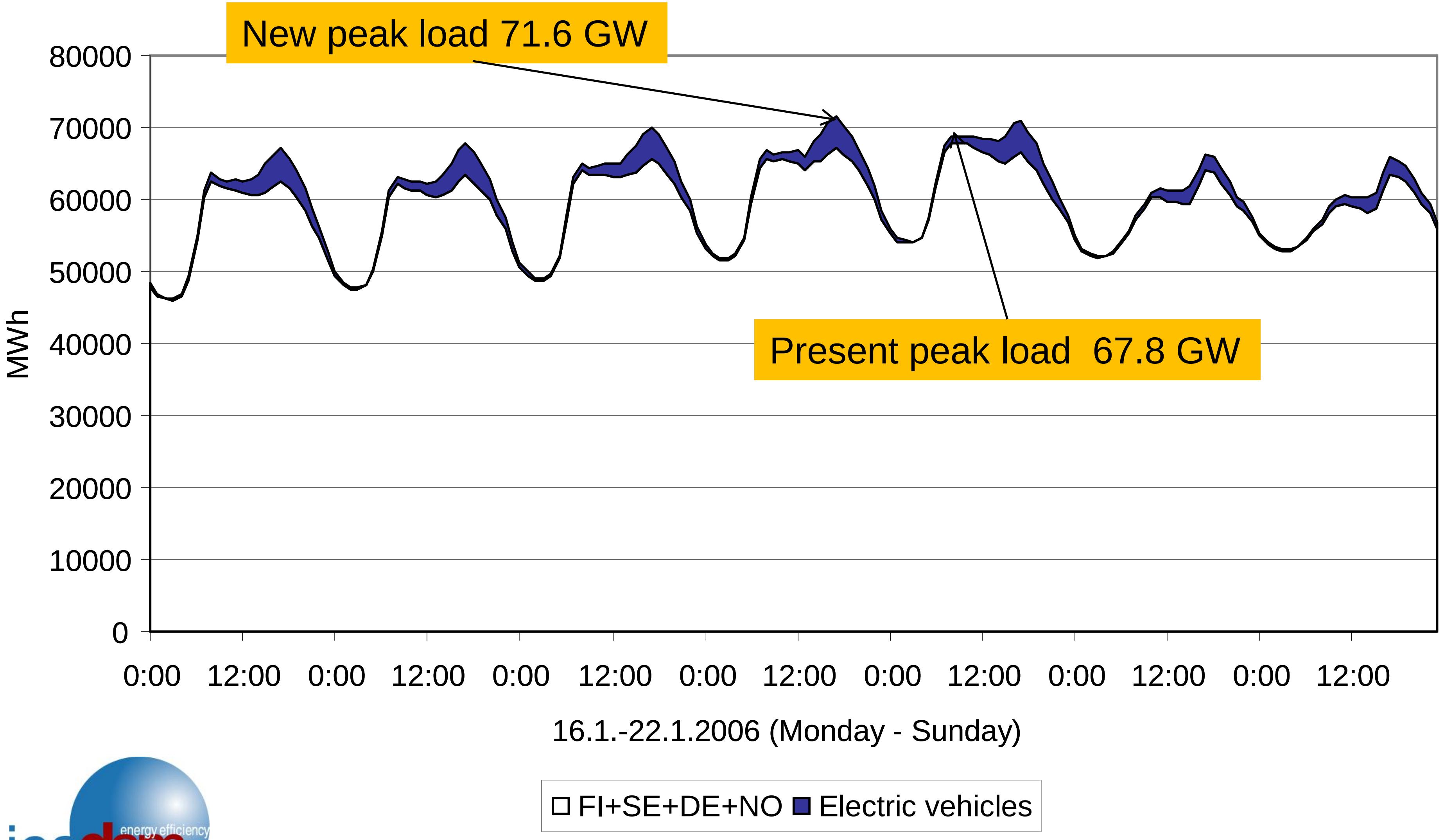
Reports

Task XVII extension: Phase 2 (5)

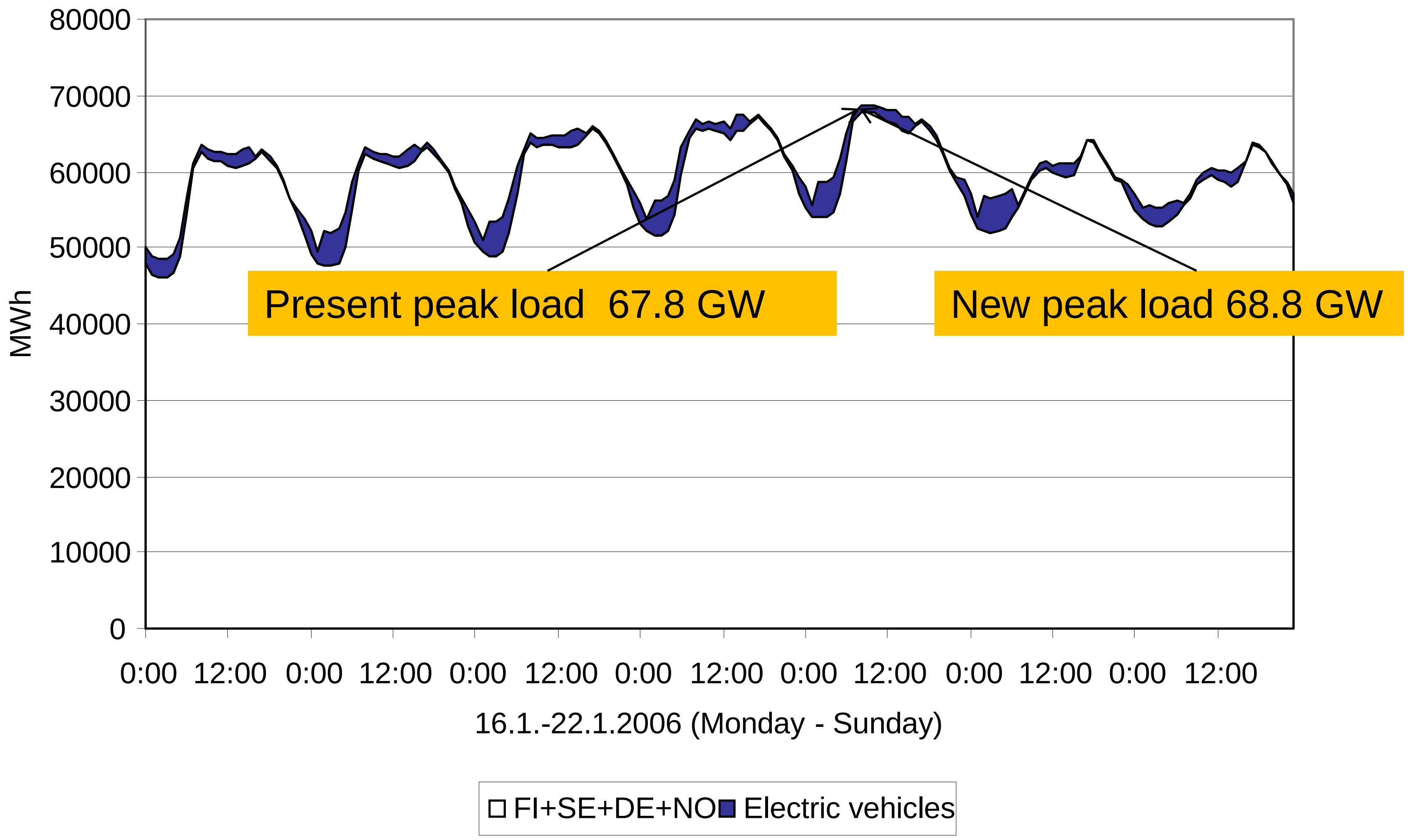


If you are interested in this work, please contact
seppo.karkkainen@elektraflex.com

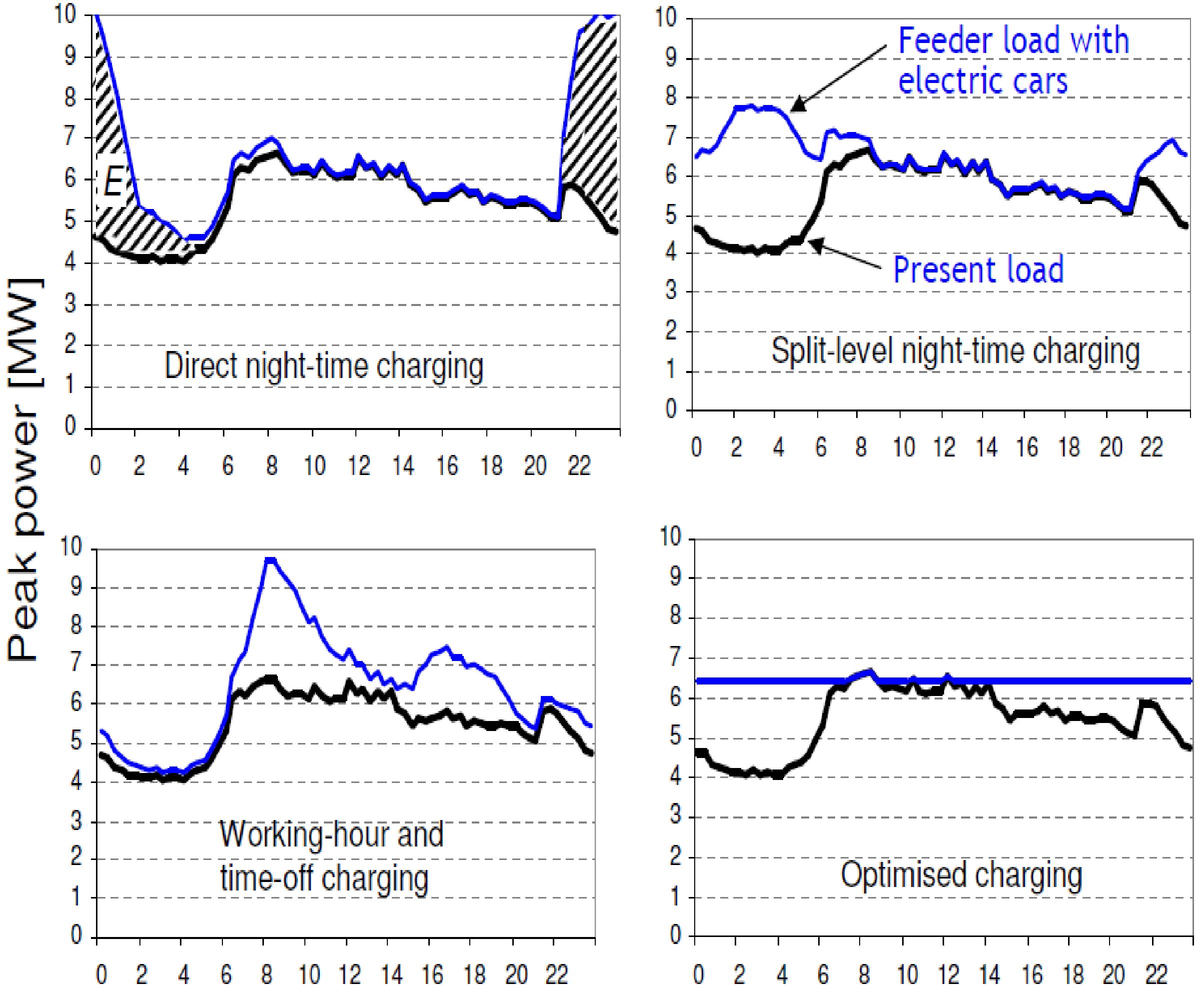
Simulation case 1: 5 million EV/PHEV in Nordic system: normal charging



5 million EV/PHEV in Nordic system: intelligent charging



Simulation case 2: effect of the charging method on the local network



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