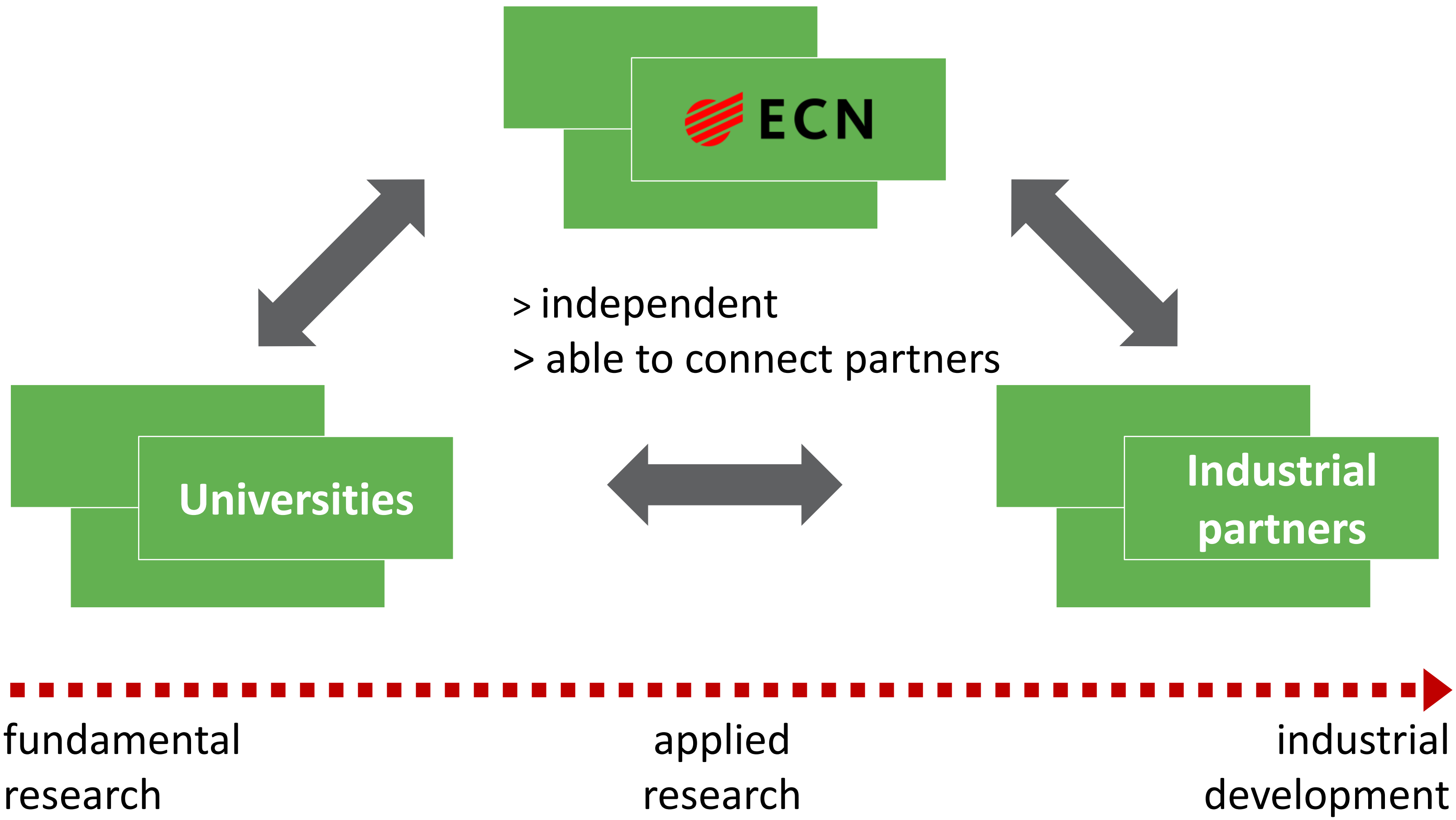
The impact of Electric Vehicles on European Energy Networks

Sytze Dijkstra
ECN Policy Studies

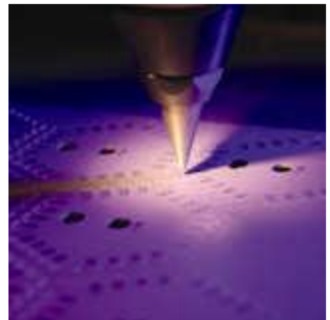
Grid Capacity and Stability Conference
London, 21 June 2012

Position


ECN
> independent
> able to connect partners
Universities
Industrial partners
fundamental research
applied research
industrial development

R&D fields

Policy Studies



Energy Engineering

Environment

Wind Energy

Solar Energy

Biomass

Energy Efficiency & CCS

What we do

- Problem solving
  Using our knowledge, technology, and facilities to solve our clients' issues
- Technology development
  Developing technology into prototypes and industrial application
- Studies & Policy support
  Creating insights in energy technology and policy

Overview

- Electric vehicles for reducing GHG emissions from transport
- Interaction with electricity networks
- Managing the threats, maximising the opportunities
- The way forward

Electric Vehicles for reducing GHG emissions from transport

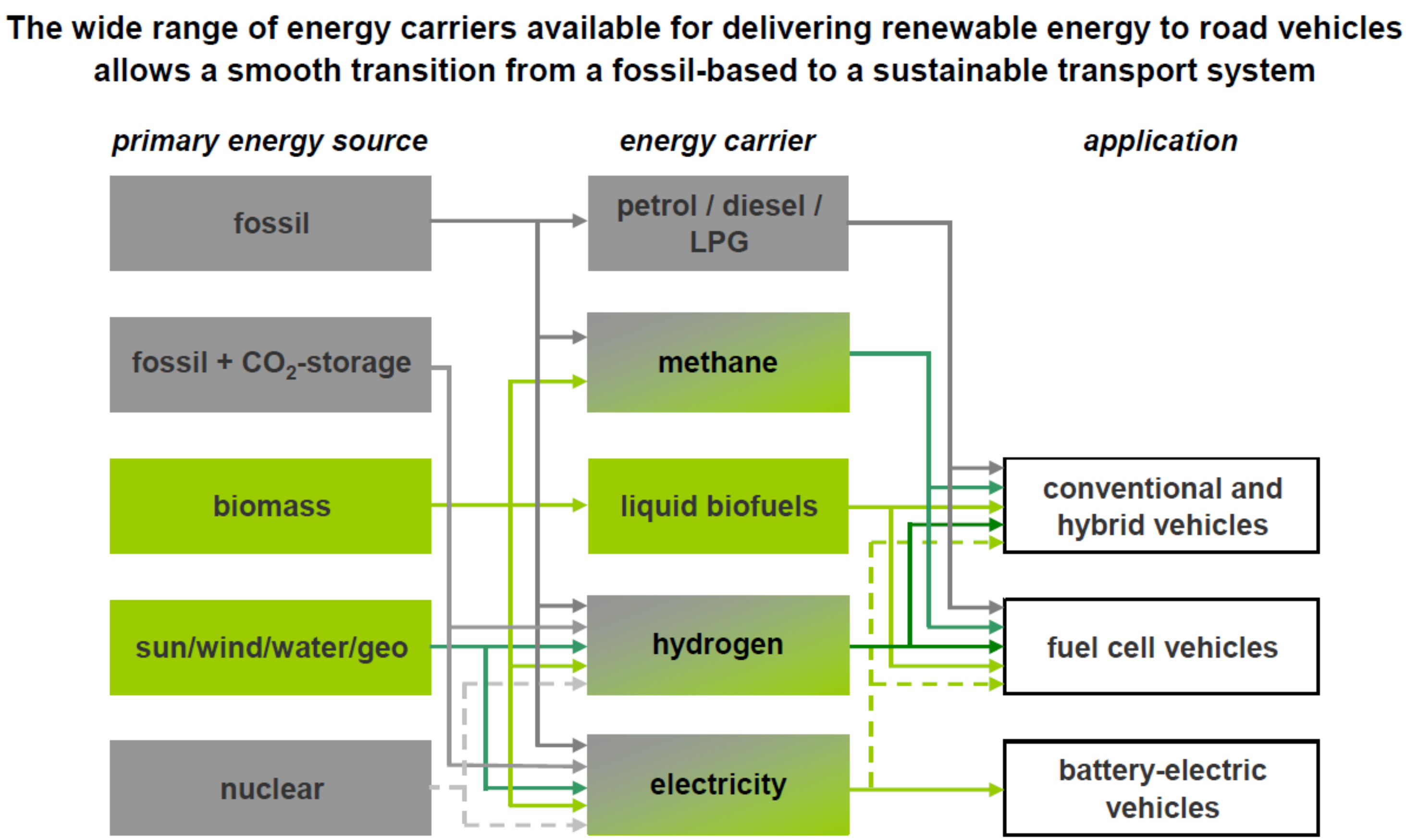
Reducing GHG emissions from transport

Technology

- Improving fuel efficiency of conventional vehicles
- Shift towards less carbon-intensive energy carriers
- Shift towards less carbon intensive modes of transport
- Curbing demand growth
  - Soft: taxation or price incentives
  - Hard: regulation

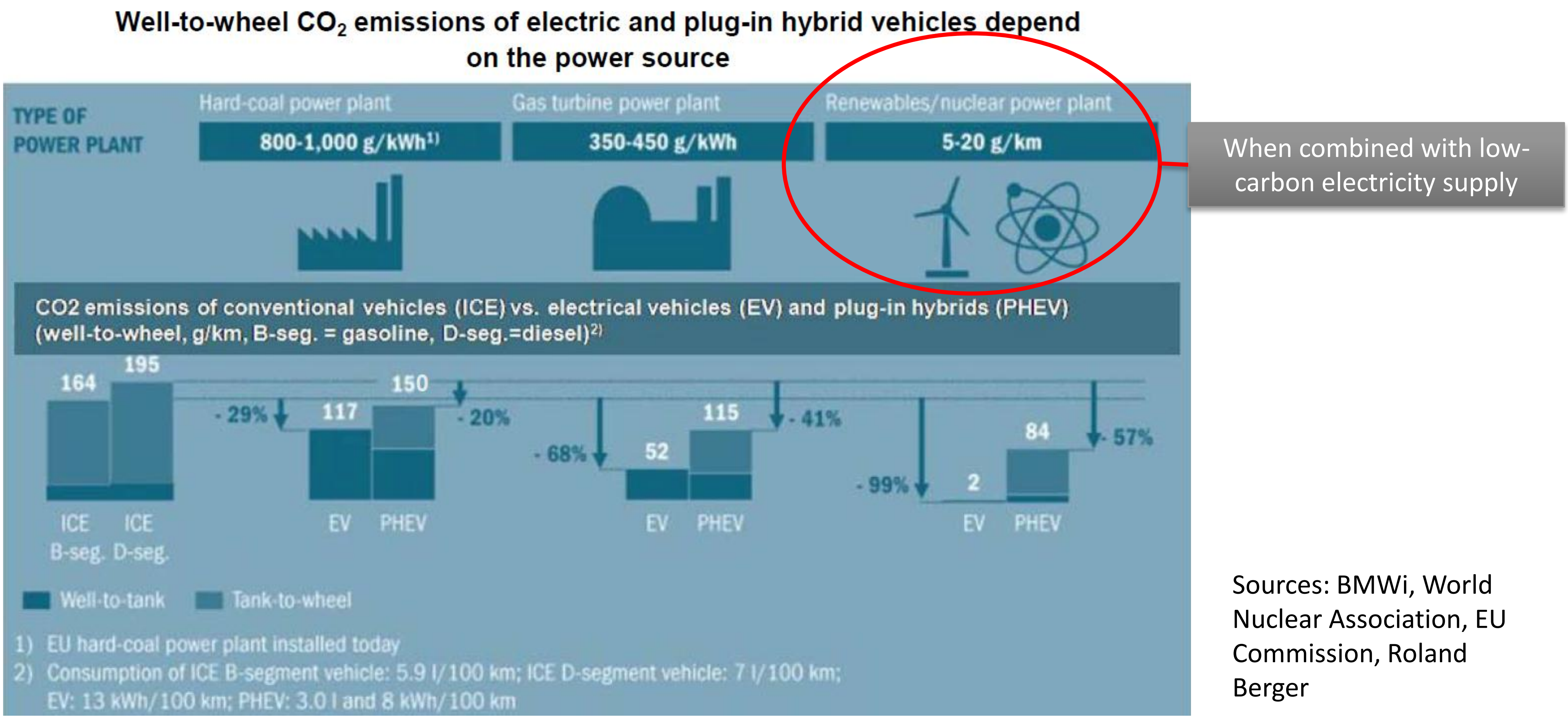
Lifestyle

Technology options



Source: IEA, RETRANS

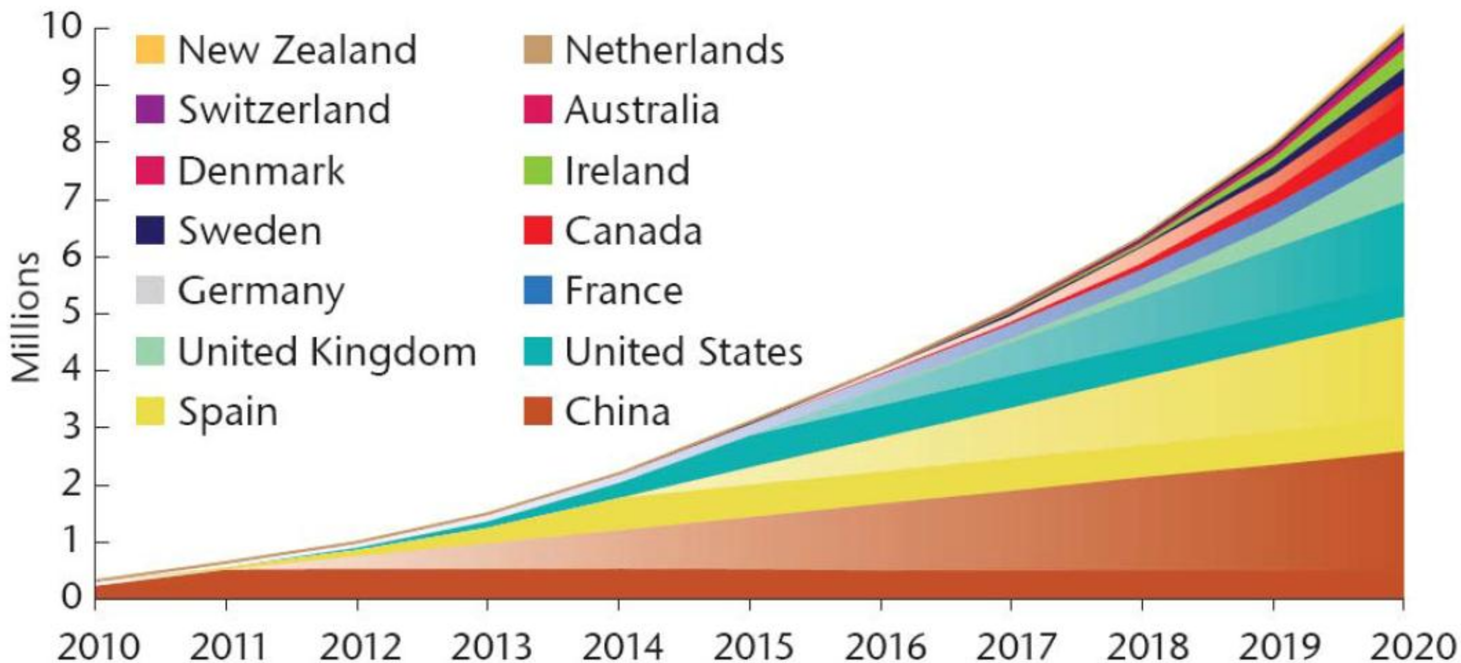
EVs allow for significant GHG emissions reductions



Sources: BMWi, World Nuclear Association, EU Commission, Roland Berger

Strong increase of number of EVs expected

ECN



Source: IEA, 2009

Your energy. Our passion.

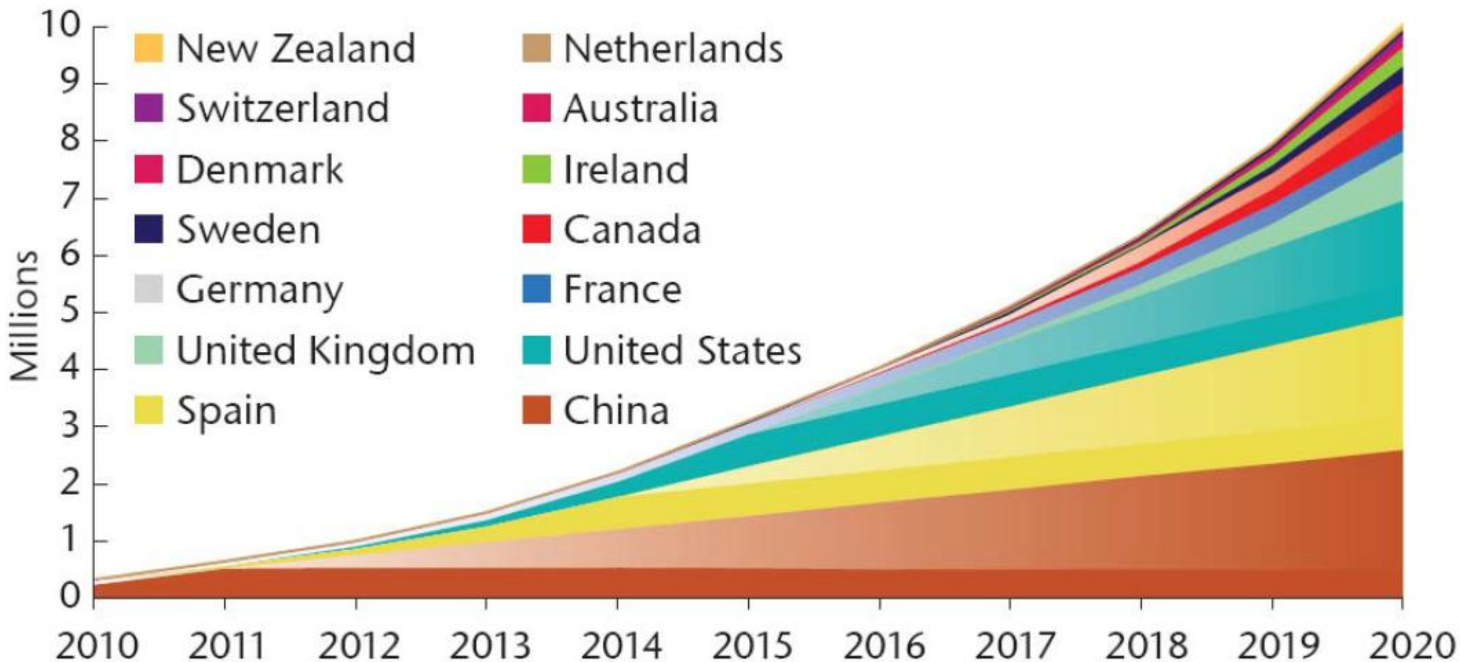
Interaction with electricity networks

www.ecn.nl

EVs and networks

	Treats	Opportunity
Volume	Additional load	Storage Capacity
Timing	Peak demand	Shaping the load curve

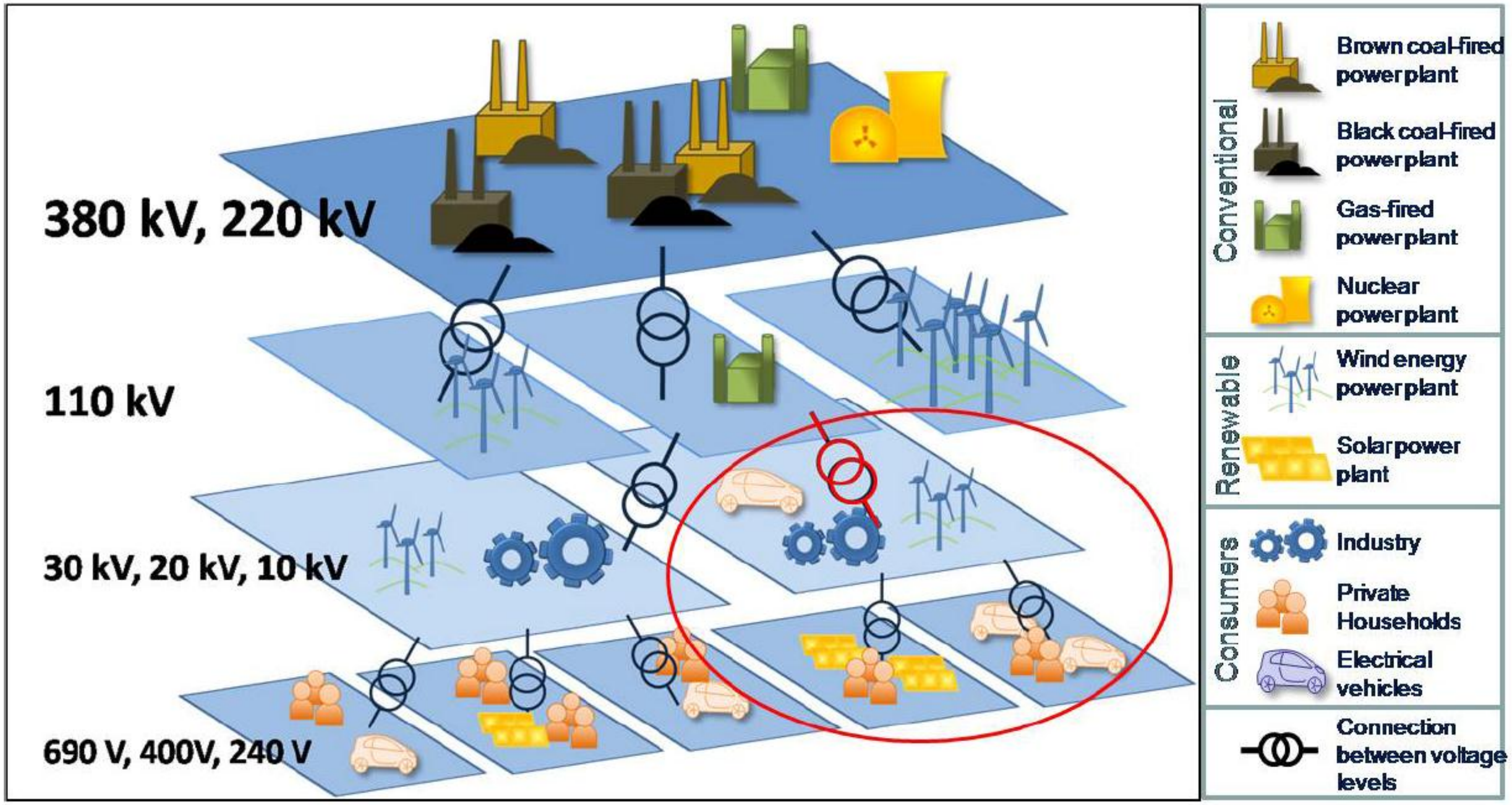
Strong increase of number of EVs expected



Source: IEA, 2009

Charging EVs and the network

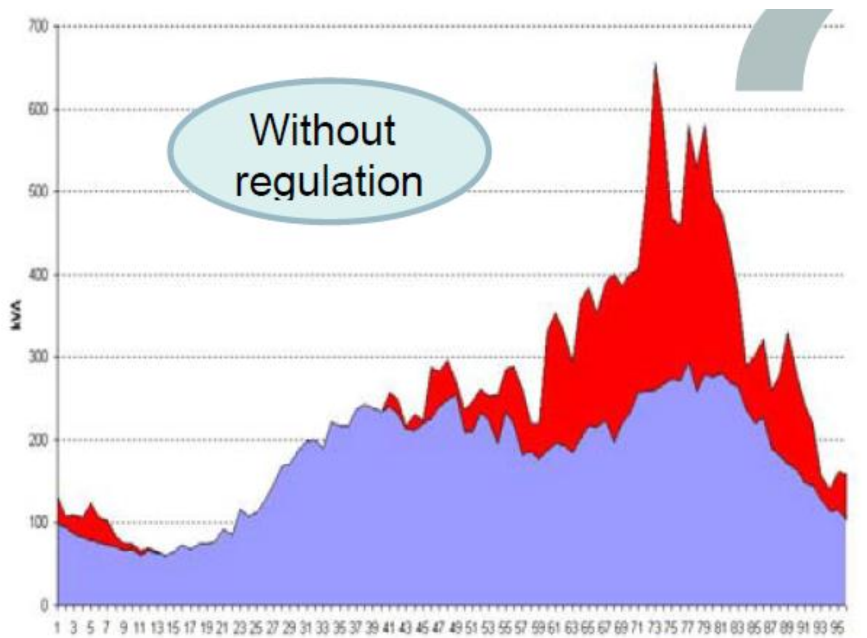
- Evs connected to medium and low-voltage electricity grids



Source: IFTH, RWTH Aachen

Strong increase of number of EVs expected

- Simultaneous charging of EVs
- Causes higher peak demand



Source: IEA, RETRANS

- Expensive under existing *Fit-and-Forget* network planning

Specific impacts on electricity networks

- Simultaneous charging of a large amount of Evs -> unacceptable **voltage drop** from the transformer to the end of the lines.
  - Compensate by reactive power, possibly provided by EVs
- Loss or surplus of power -> **deviation from nominal frequency**
  - Frequency-dependent charging
- Additional power flow -> **transformer overload** (overheating)
  - Control charging process
- Large feed-in of electricity from EVs -> **lack of short-circuit power**
  - Oversize converters / add short circuit power capacity
- Sudden simultaneous charging / discharging -> grid instability
  - Control charging process
- Impacts vary with quality of the grid locally
  - Rural ↔ urban
  - Developed country ↔ developing country

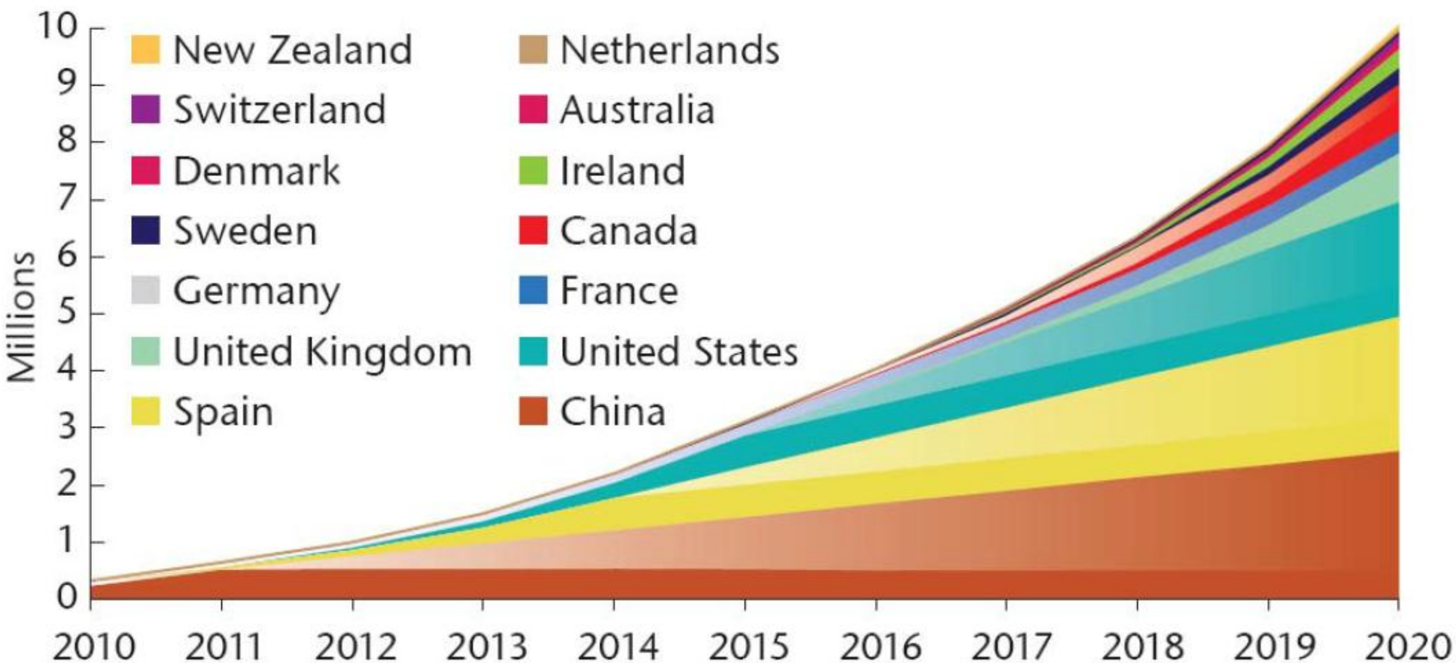
Managing the threats, maximising the opportunities

www.ecn.nl

EVs and networks

	Treats	Opportunity
Volume	Additional load	Storage Capacity
Timing	Peak demand	Shaping the load curve

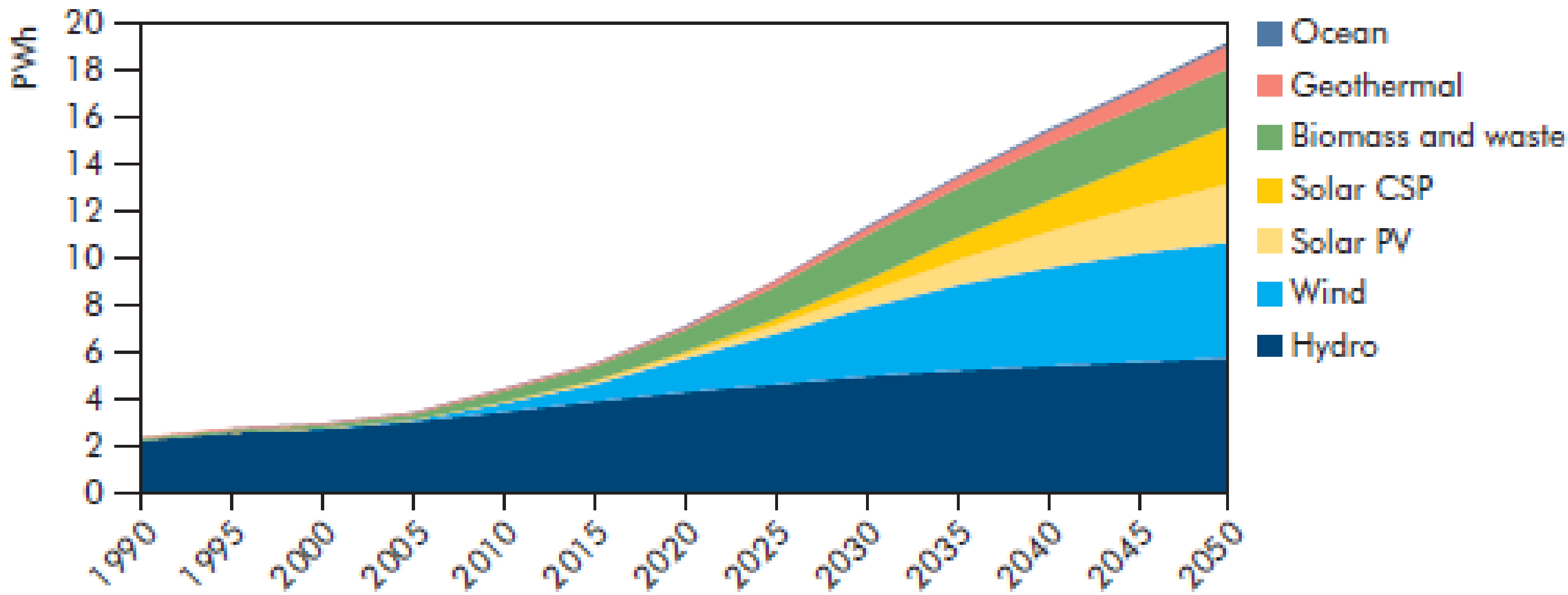
Strong increase of number of EVs expected



Source: IEA, 2009

Strong increase of number of EVs expected

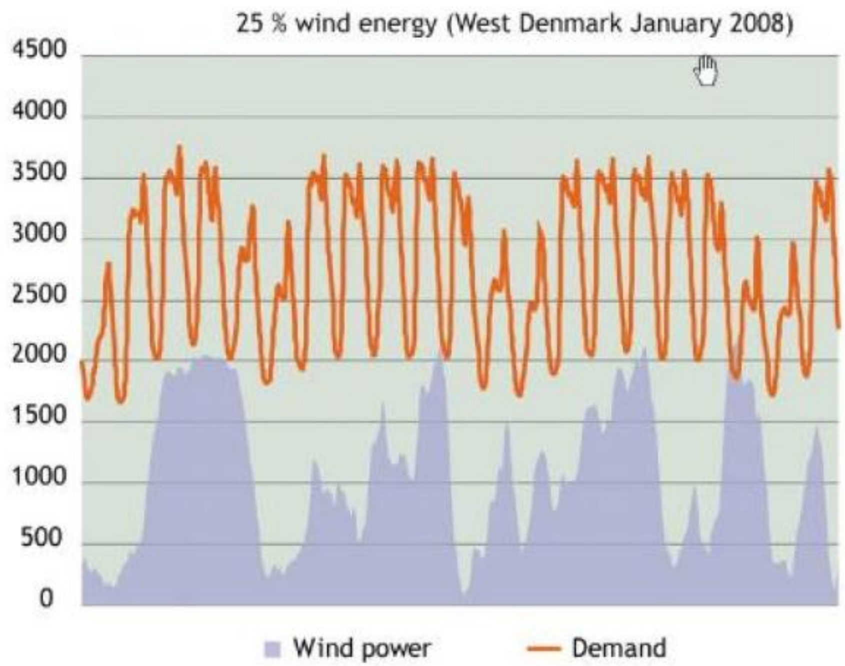
- Coinciding with rapid increase in renewable electricity generation

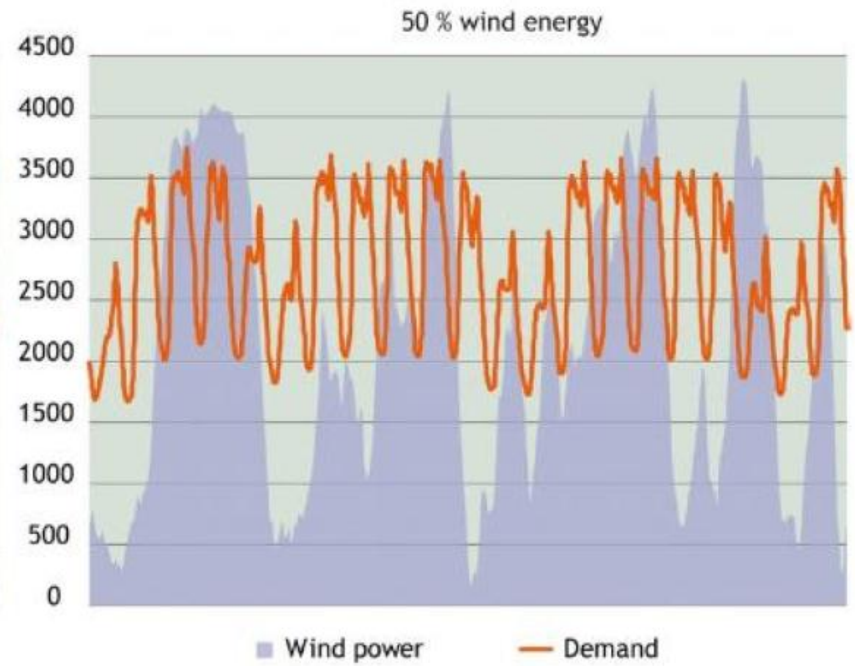


Source: IEA, Energy Technology Perspectives 2010, Blue Map Scenario

Strong increase of number of EVs expected

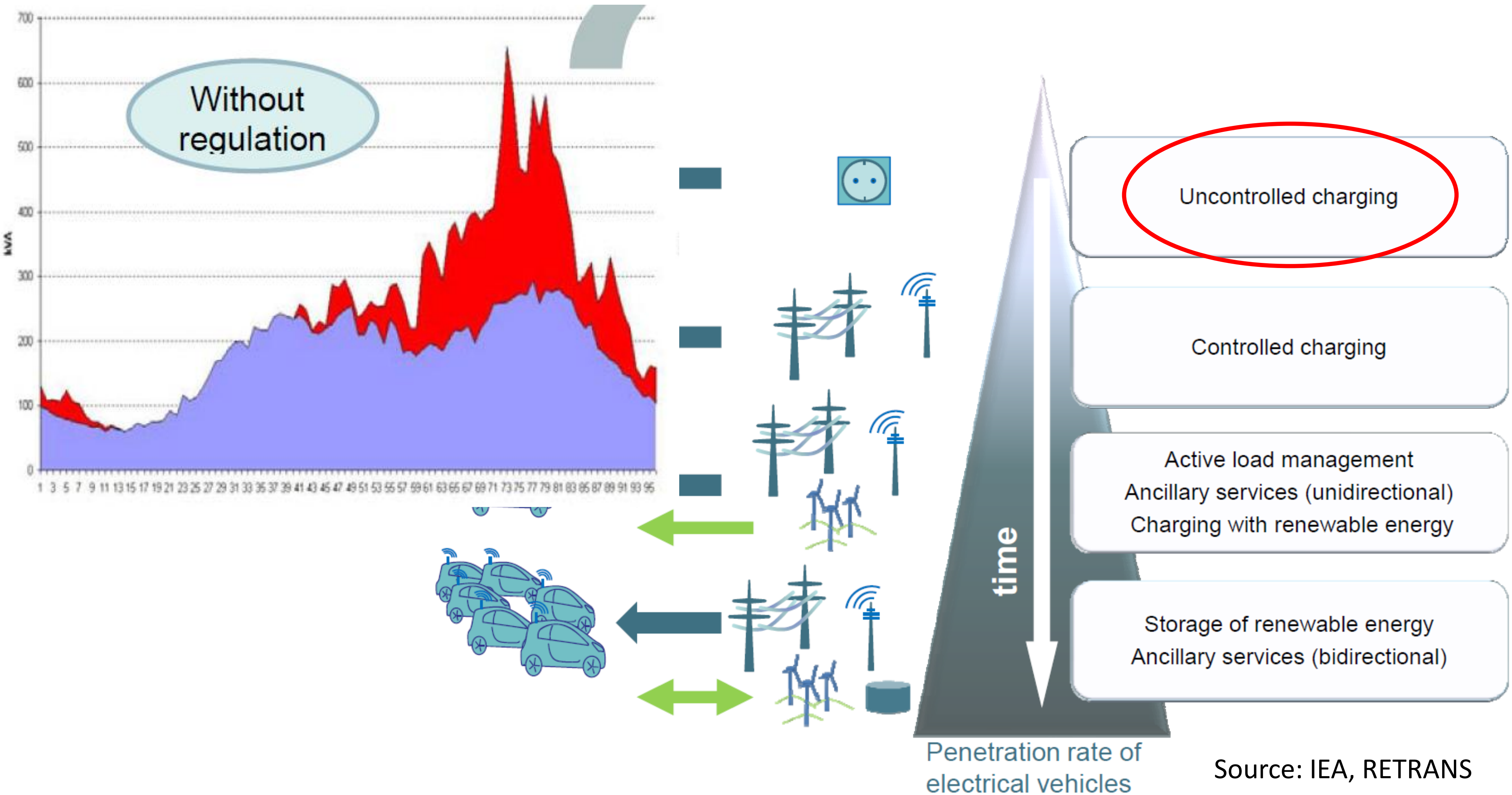
- Coinciding with rapid increase in renewable electricity generation
- Leading to higher variability of supply
  - Wind energy production and electricity demand in Denmark





Source: Ecogrid, 2007

Uncontrolled charging: a headache



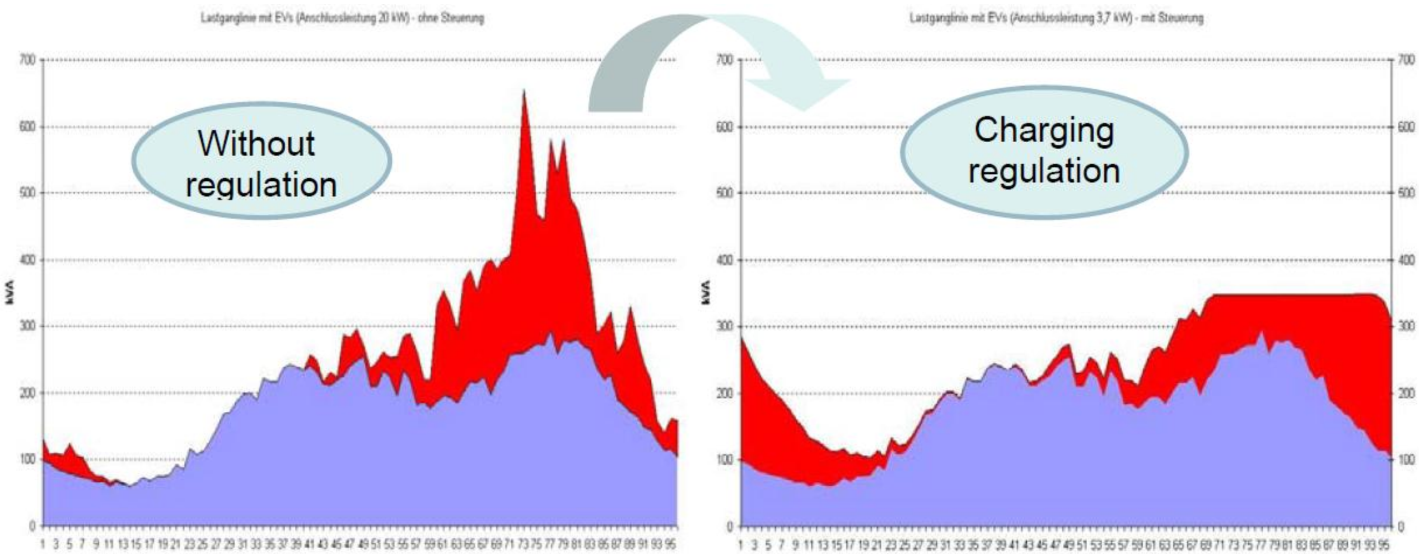
Source: IEA, RETRANS

ECN

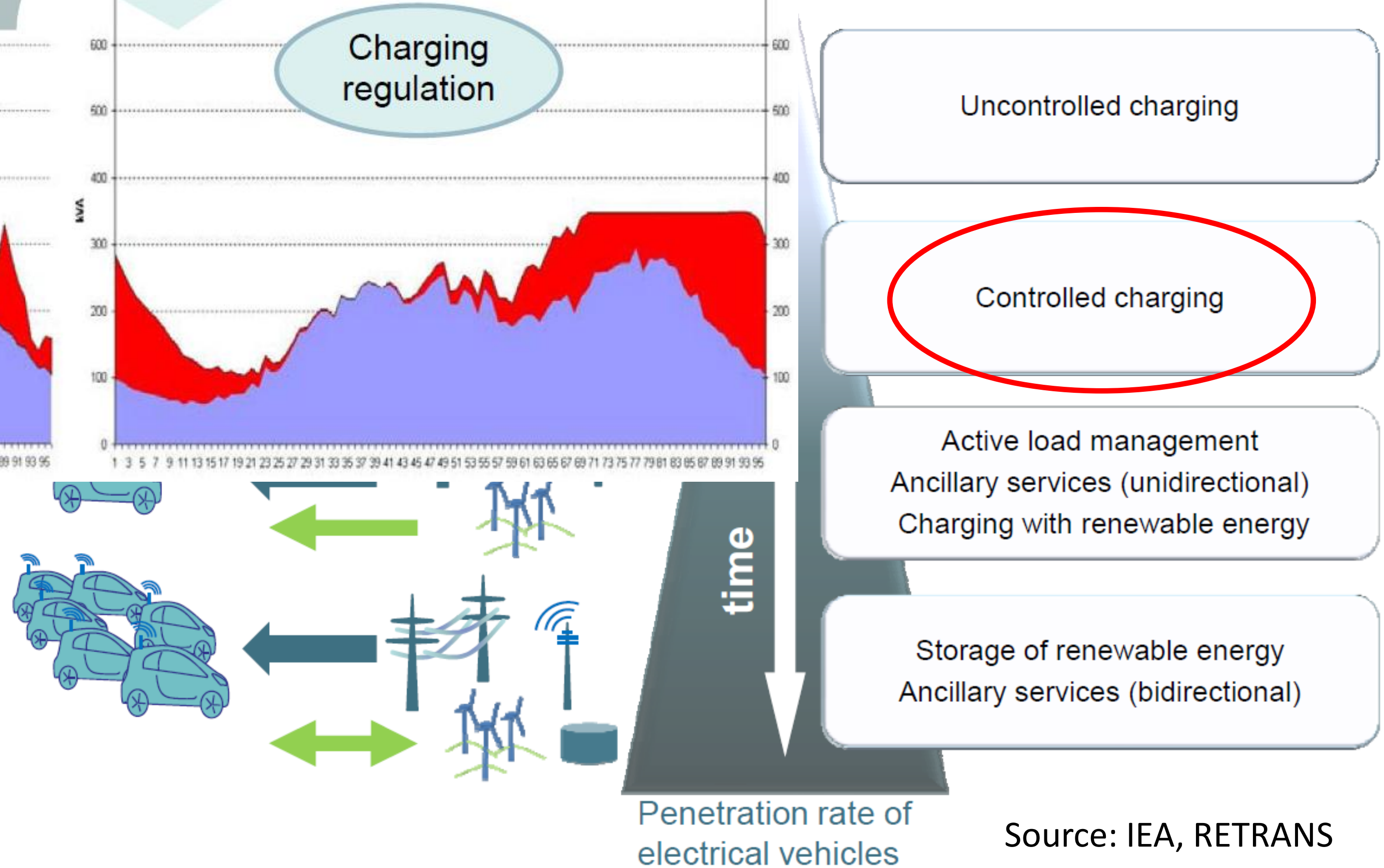
EVs and networks

	Treats	Opportunity
Volume	Additional load	Storage Capacity
Timing	Peak demand	Shaping the load curve

Controlled charging: using demand-side flexibility



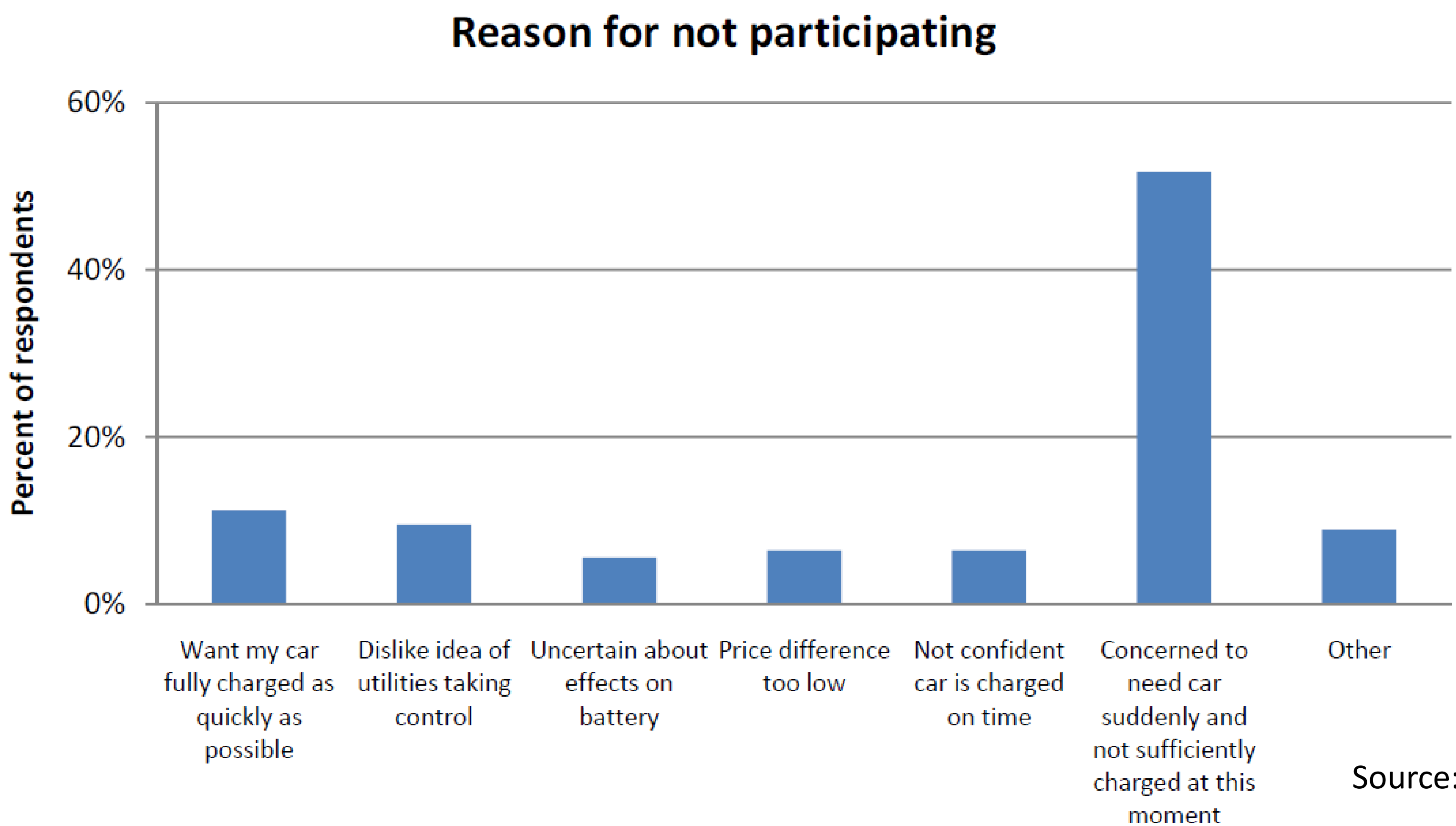
- Price signals



Source: IEA, RETRANS

Are people happy to get on board?

- Delayed charging for €2 instead of €3 for full charge
- 19% skeptical

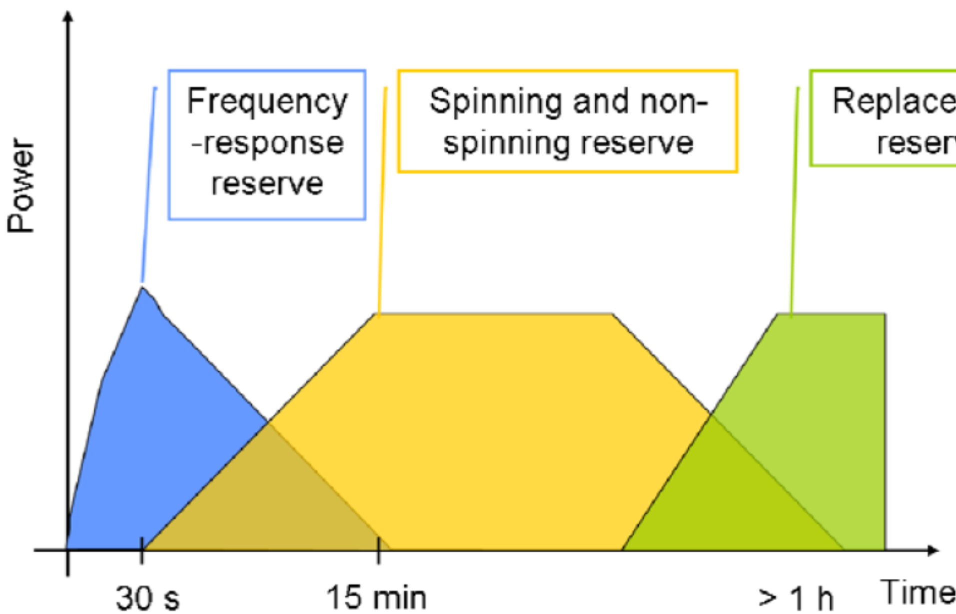


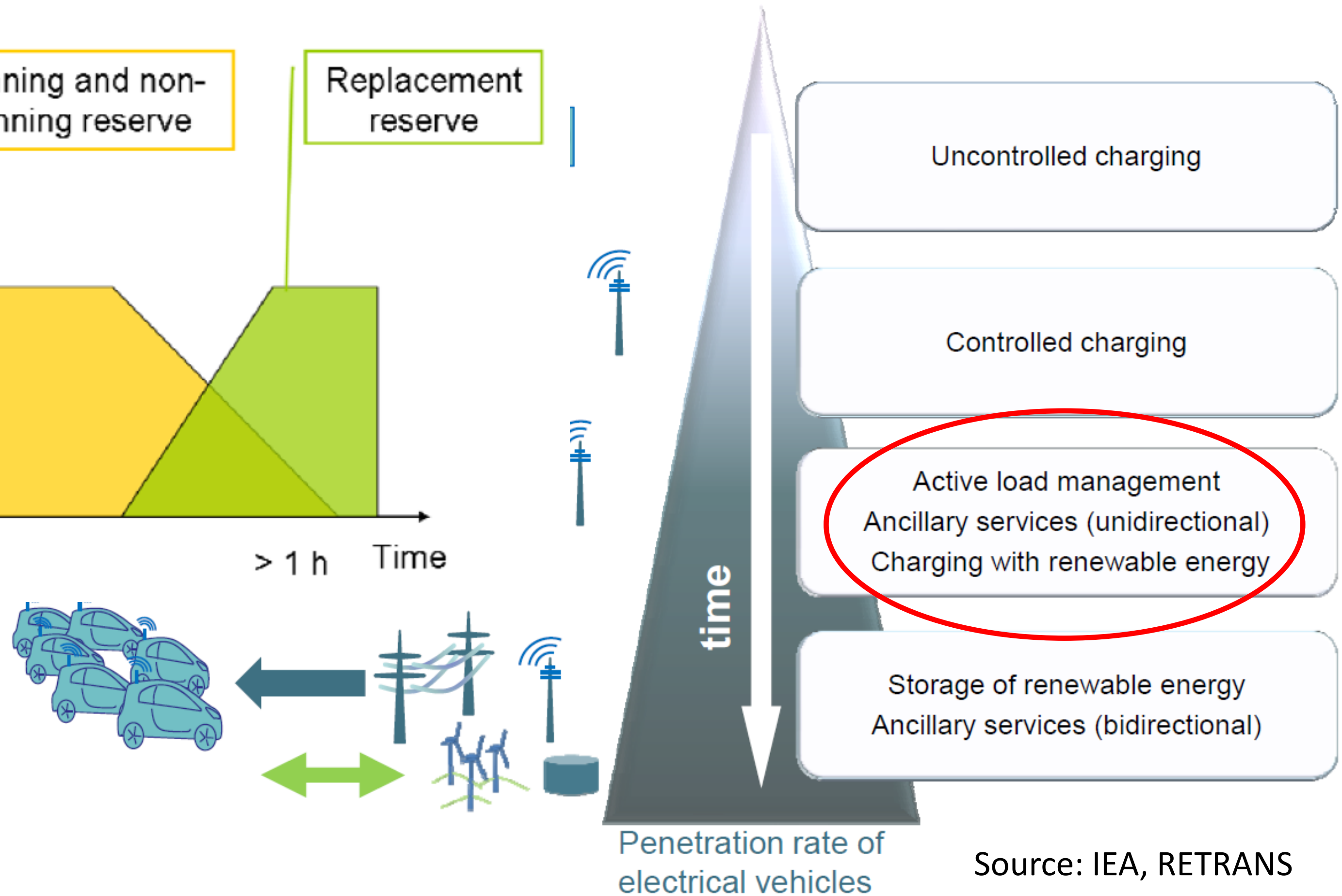
Source: Grids4Vehicles

Vehicle-to-grid options

- Aggregation of EVs
- Communication systems
- Potential:
  - Number of EVs
  - Charging behaviour
- Impact on battery lifetime
- Medium-term

Ancillary services: balancing renewables





- Providing balancing services

Source: IEA, RETRANS

Storage: optimising renewable electricity supply

Table 1 Available power from electric vehicles connected to the grid depending on the power of the charging connection

Vehicles	Power Connection	Power	Energy	Duration
10,000	3.7 kW	37 MW	262.5 MWh	7.1 h
10,000	11 kW	110 MW	262.5 MWh	2.4 h
10,000	22 kW	220 MW	262.5 MWh	1.2 h

that can be provided by 1 million electric vehicles during a day in Germany

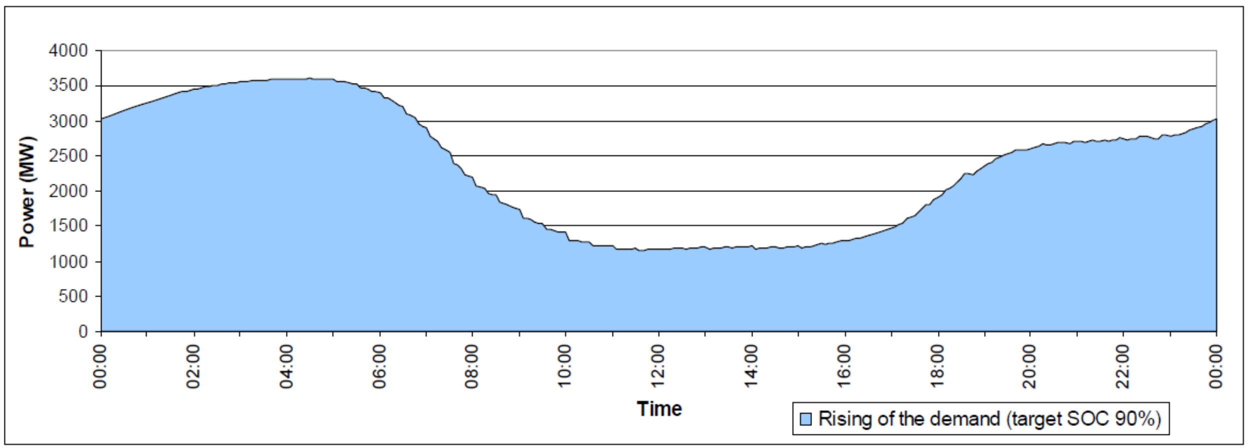
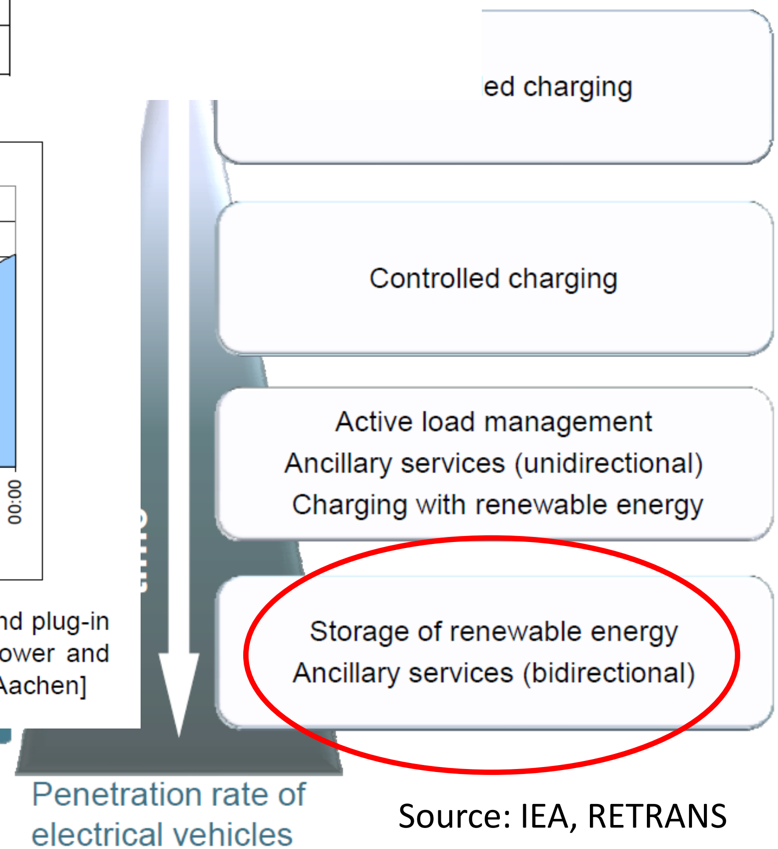


Figure 22 Additional power capacity to store a surplus of renewable energy from 1 million electric and plug-in hybrid vehicles in Germany, based on unidirectional power supply, 3.7 kW charging power and nominal charging op to a target State-Of-Charge of 90% [own calculations, IFHT, RWTH Aachen]

services



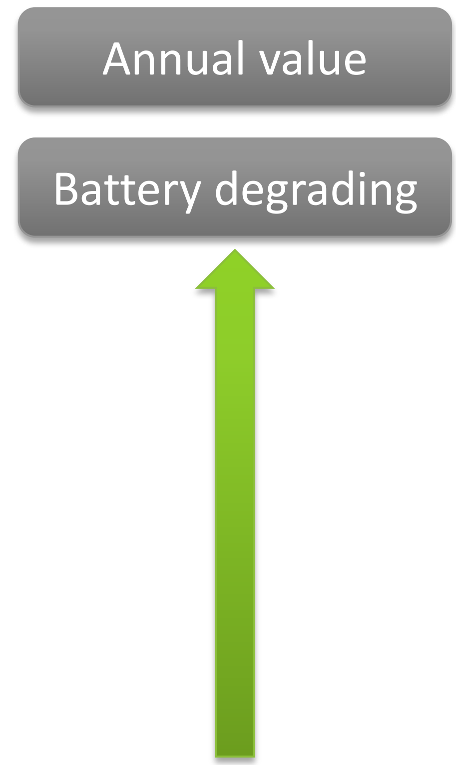
Source: IEA, RETRANS

The business case

- Largest opportunity for providing primary reserve

(Analysis for each country necessary because of different grid codes and legal requirements)
(50% availability of EV and PHEV, a=year, based on prices in 2009 in Germany reserve energy market.)

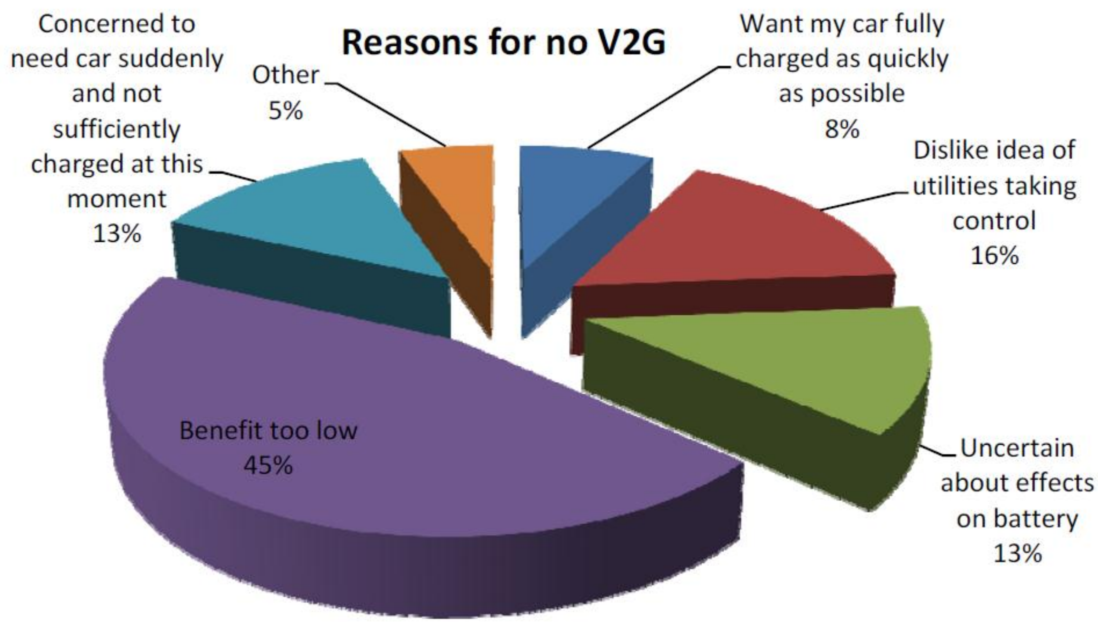
Ancillary services	*IN GERMANY*			Negative spinning reserve (unidirectional/bidirectional)		Positive spinning reserve (bidirectional)	
		Power / time	Vehicles needed (pooling)	Attributes	Possible revenue	Attributes	Possible revenue
	Primary reserve	~2 MW, t < 30 s	3.7 kW: > 1000 EV 11 kW: > 400 EV	Only for a bidirectional power connection, legal permission necessary, frequent service			3.7 kW: 300-400 €/a 11 kW: 700-800 €/a
	Secondary reserve	>10 MW 5s< t <15 min	3.7 kW: > 5500 EV 11 kW: > 2000 EV	Pooling of EV legal possible	Demand rate: 3.7 kW: 10-130 €/a 11 kW: 40-380 €/a free charging possible	Pooling of EV legal possible	Demand rate: 3.7 kW: 60-100 €/a 11 kW: 180-300 €/a Plus 0.10 €/kWh
	Tertiary reserve	>15 MW t ≥ 15 min	3.7 kW: > 8000 EV 11 kW: > 3000 EV	Pooling of EV legal possible, rare service	Demand rate: 3.7 kW: < 15 €/a 11 kW: < 35 €/a free charging possible	Pooling of EV legal possible, rare service	Demand rate: 3.7 kW: < 15 €/a 11 kW: 20-60 €/a Plus ~350 €/kWh



Source: IEA, RETRANS

Are people happy to get on board?

- Interest to participate in vehicle-to-grid scheme (out of 7):
  - 3.88 (France) to
  - 4.94 (UK)

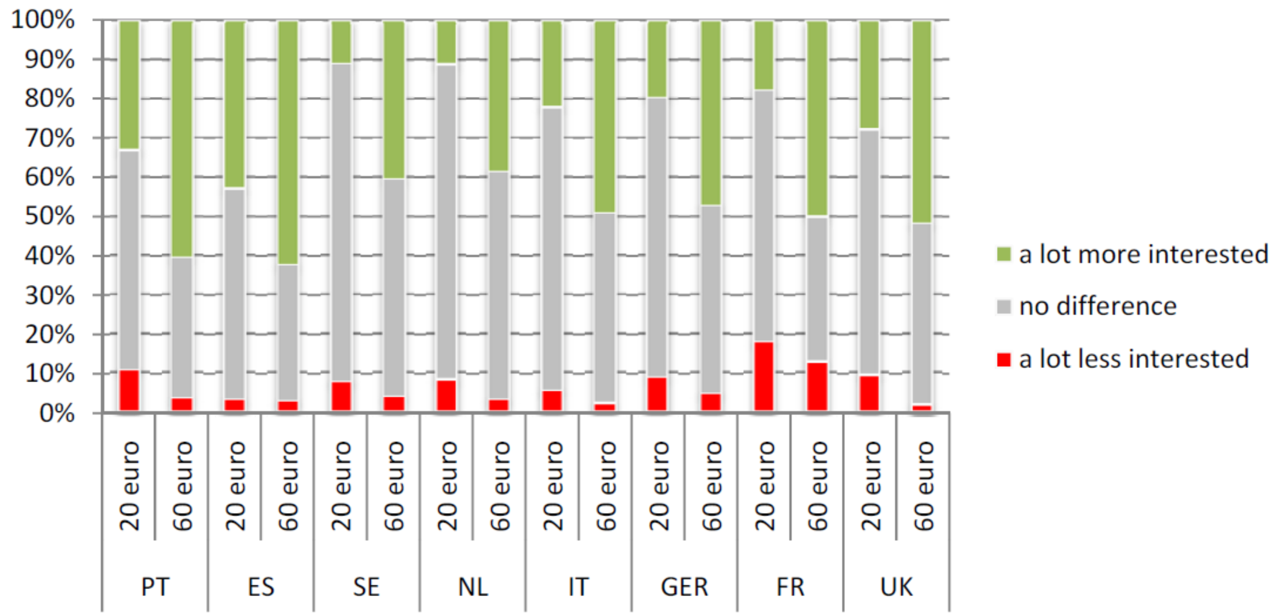


- Benefit primary concern

Source: Grids4Vehicles

Price incentives help

- Price incentives are needed to stimulate consumers to take part in vehicle-to-grid schemes
  - With €60 p.a. about 50% more interested than with €20 p.a.



Source: Grids4Vehicles

The way forward

- EVs & renewable electricity: the beginning of a beautiful friendship?
- It's complicated
  - Combination of EVs & variable renewable electricity: complex grid management
  - Uncontrolled charging not feasible in long run
  - Controlled charging can mitigate problems
  - EVs can facilitate grid management by providing ancillary services
  - Balance revenue & impact on battery ageing
  - Get end-users on board

Thank you for your attention

ECN

Westerduinweg 3	P.O. Box 1
1755 LE Petten	1755 ZG Petten
The Netherlands	The Netherlands
T +31 224 56 49 49	info@ecn.nl
F +31 224 56 44 80	**www.ecn.nl**