

Increasing Power System Reserve Capacities by changing the reserve market design: the case of Electric Vehicle fleets

Paul Codani*, Lesly Cassin**, Marc Petit*,
Yannick Perez*

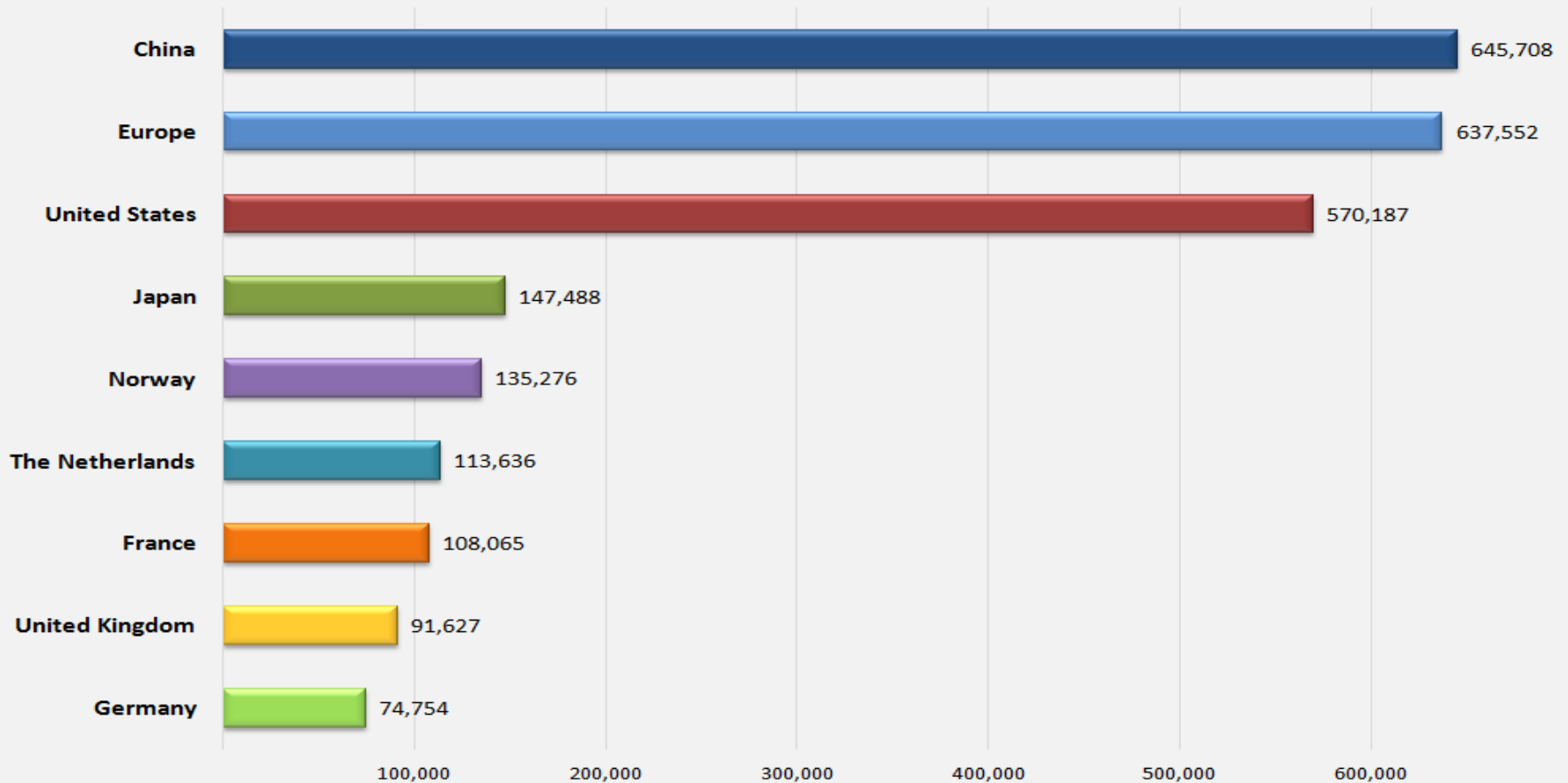
*Armand Peugeot Chair
CentraleSupélec – ESSEC Business School

**University Paris Nanterre

Motivations

2 challenges for electrical grids : EVs and Renewables

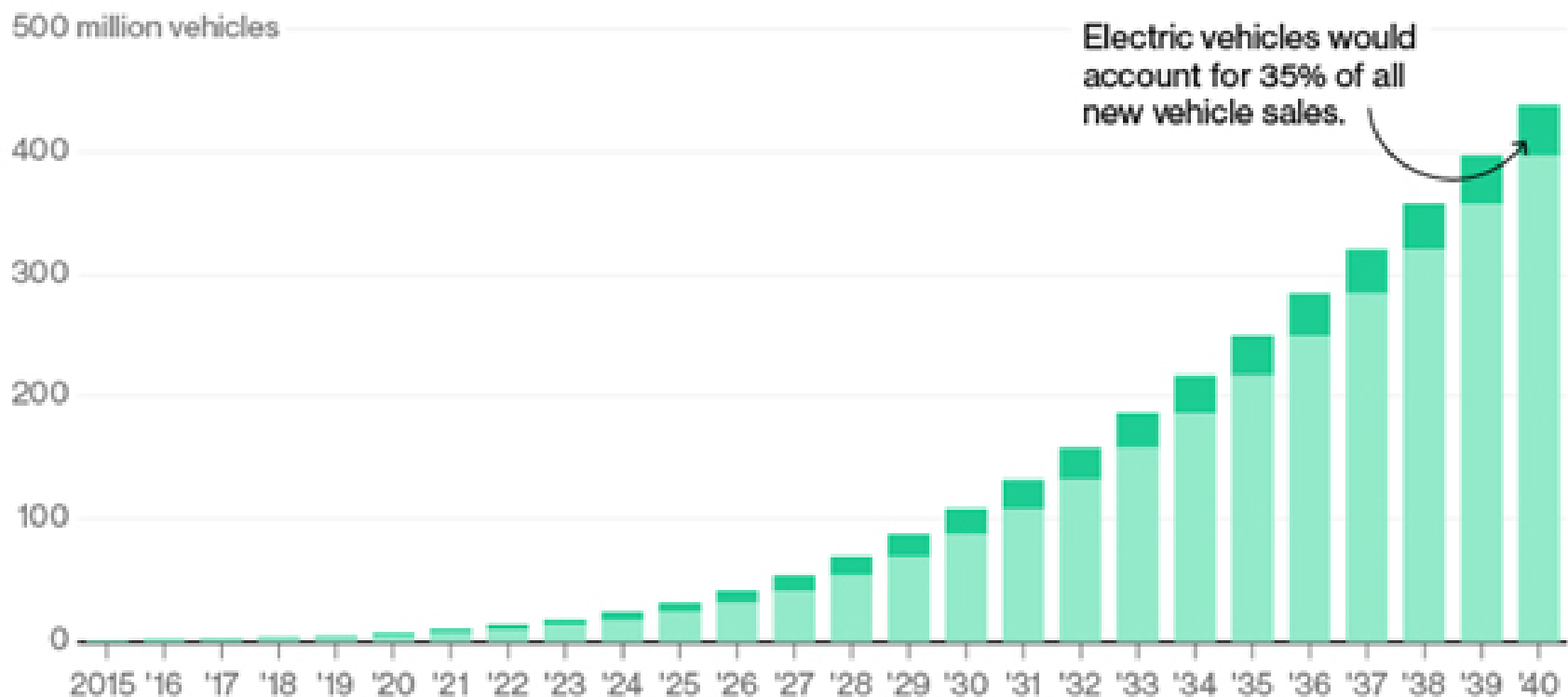
**Top-selling light-duty plug-in electric vehicle global markets
(cumulative sales through December 2016 by country/region)**



2 challenges for electrical grids : EVs and Renewables

The Rise Of Electric Cars

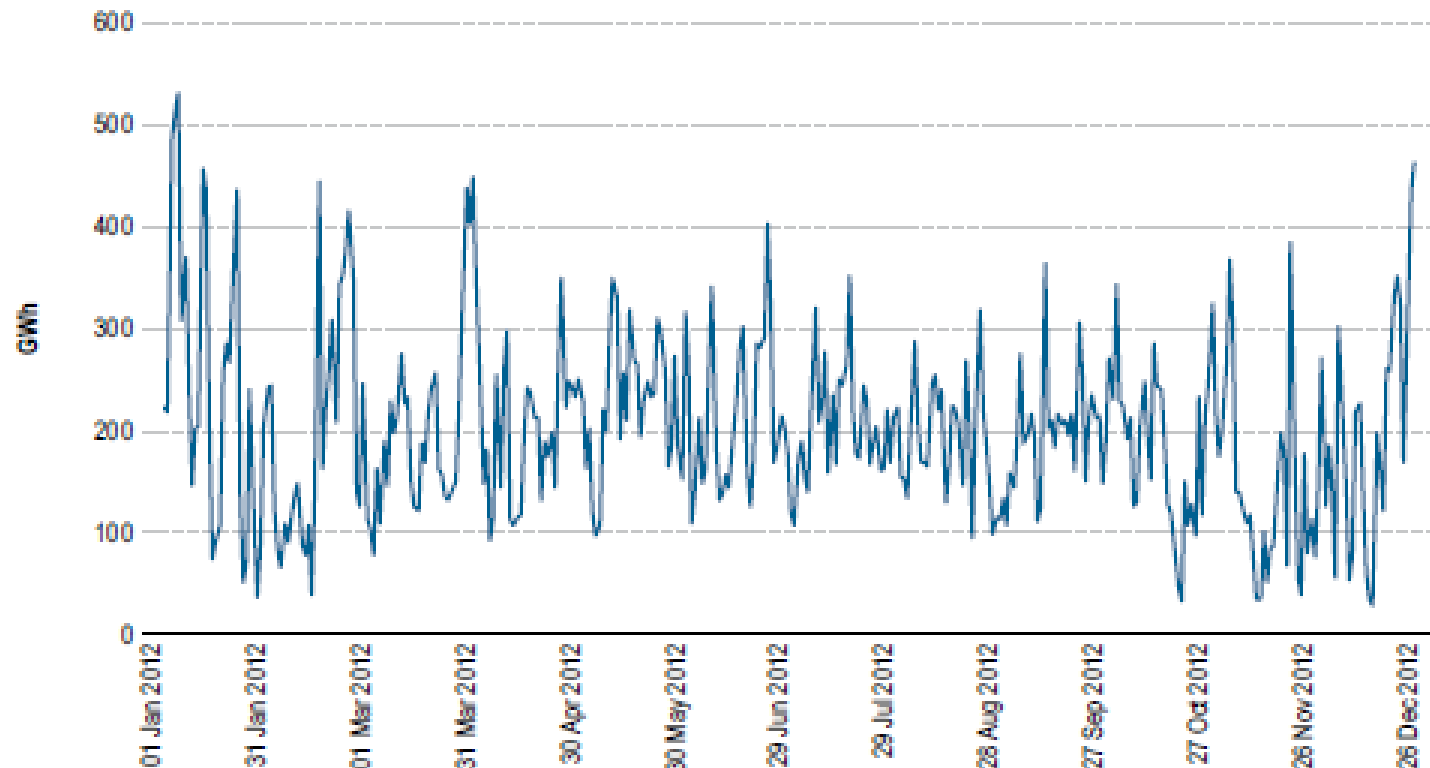
■ Projected Annual Sales ■ Cumulative Sales



Sources: Data compiled by Bloomberg New Energy Finance, Marklines

2 challenges for electrical grids : EVs and Renewables

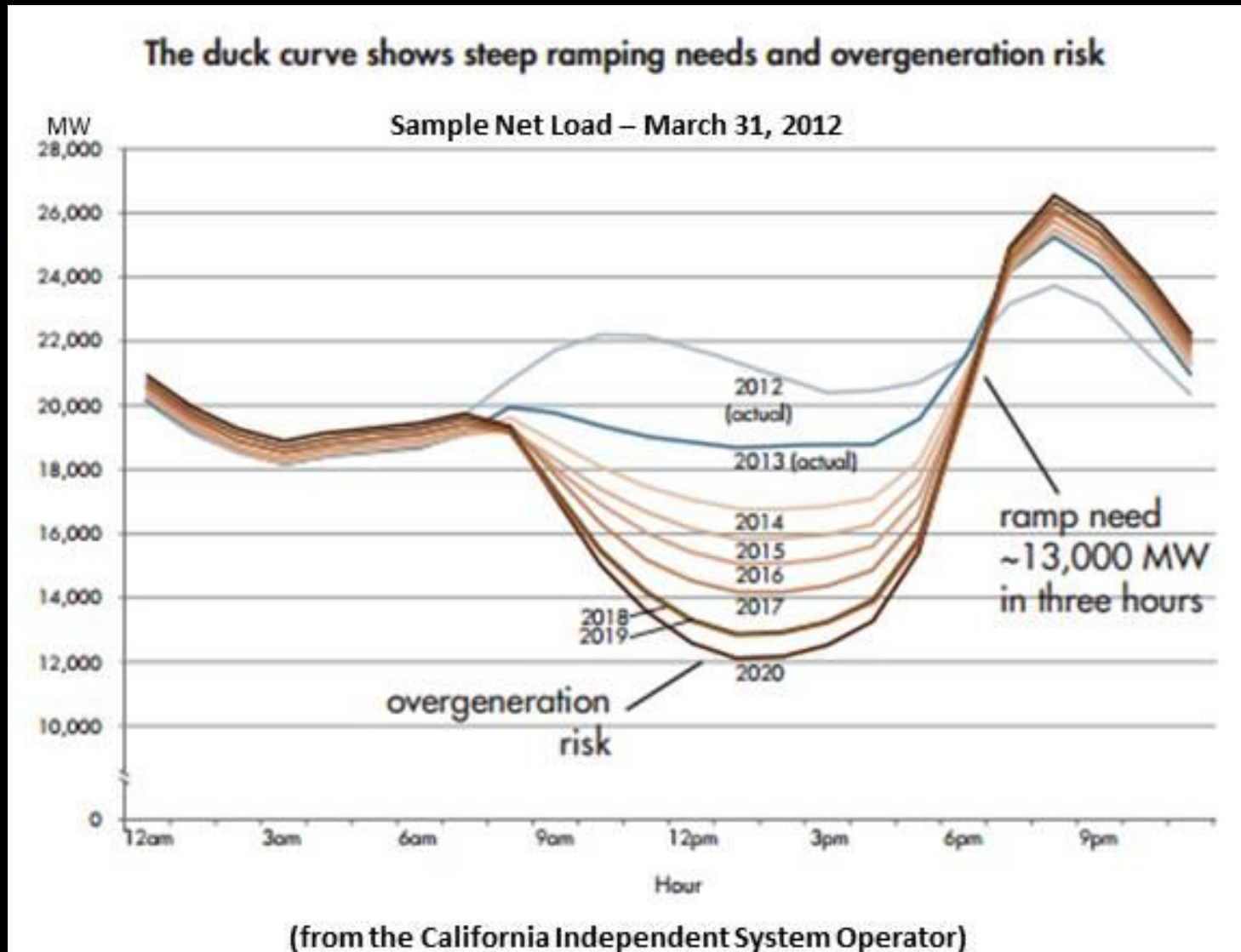
Figure 40: Aggregated daily wind and solar production in Germany – 2012 (GWh)



Source: The German TSOs (2013)

Range of Wind and solar generation variability : 20-520 GWh

More PV => more « Duck » issues



RES uncertainties + EV Dumb charging

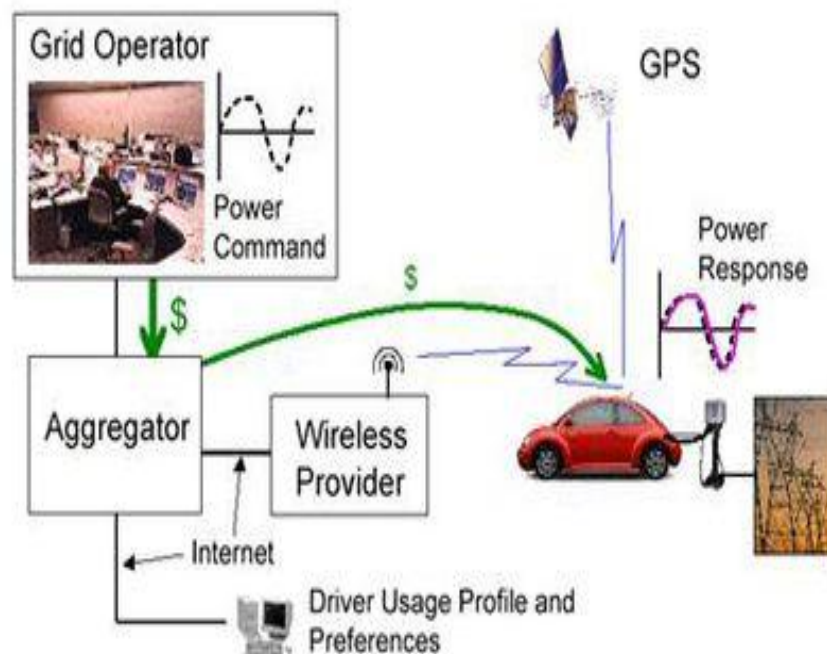
=>

Electricity systems need more
reserves to manage these new
sources of uncertainties

One option: Making EV smart by Vehicle to grid technology = potential reserve provider

- Developed by Willett Kempton from University of Delaware
- **Goal:** real time management of EV batteries to provide flexibility
- Money for users
- In PJM : 1500 \$ per car and per year

Components of the V2G system

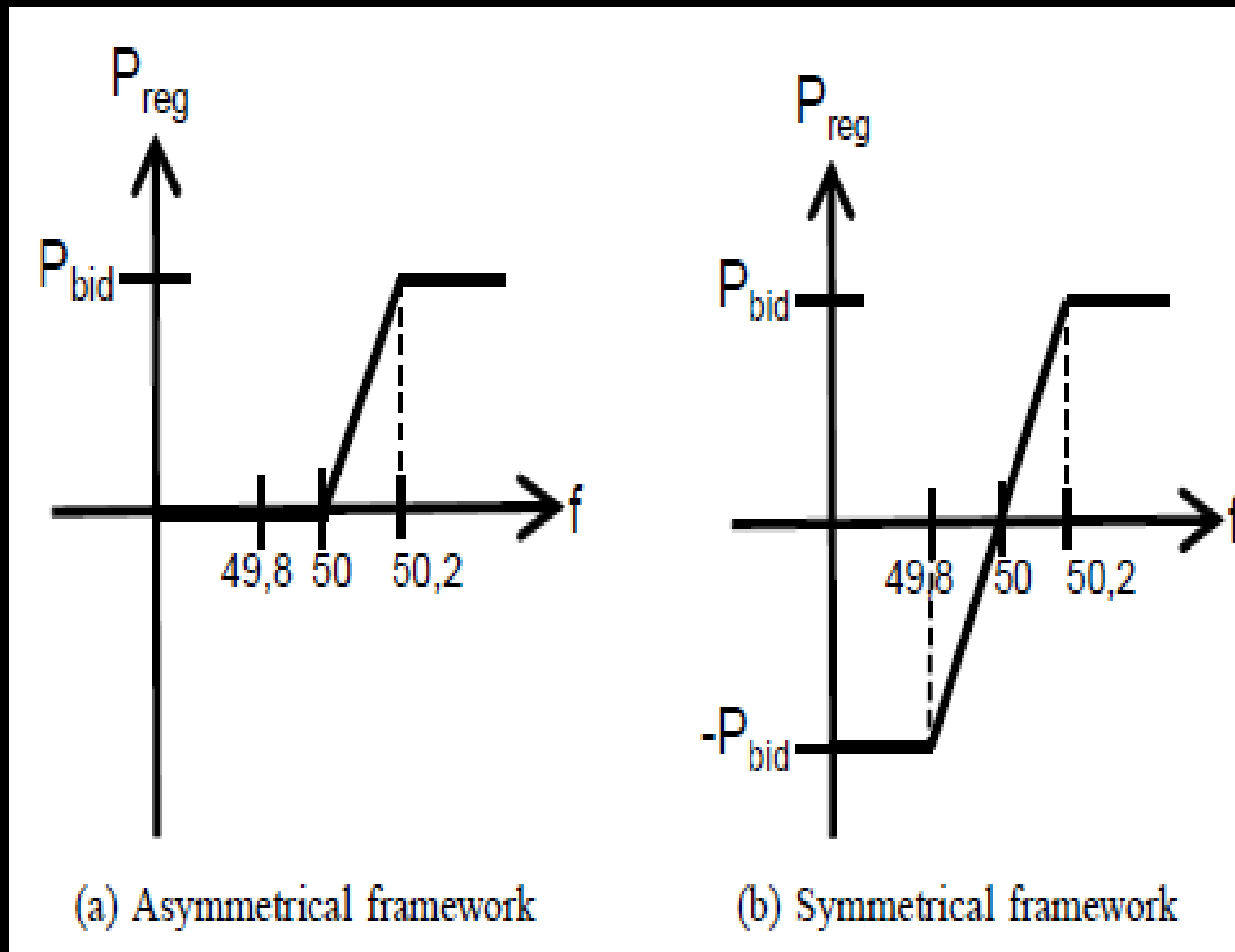


This paper

- Codani Perez & Petit (2016): Market is better than annual « Annual Flat regulated tariff » for organising reserve provisions
 - So what changes are needed in the electricity market rules for reserve provision?
- This paper explores precise market design options:
 - Symetrical (PJM) or asymetrical (= Danemark) market designs?
 - Impact of clearing period time : short time periode (1 heure= PJM) or (4h = Danemark) long ?

Symmetrical vs. Asymmetrical markets designs?

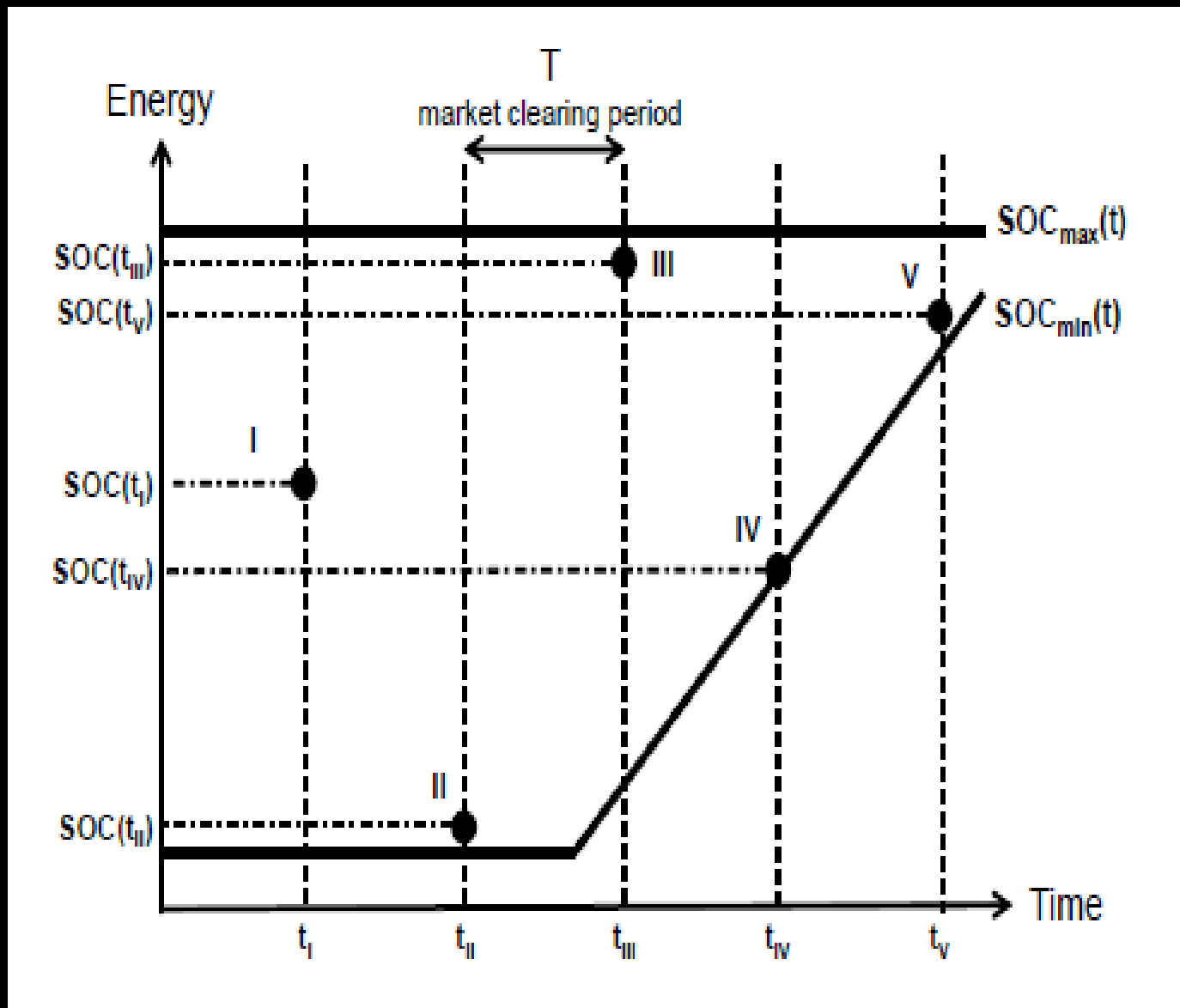
- **Symmetrical**: EV has to provide as much down as up reserves
- **Asymmetrical**: Markets are separate one for up ; other for down



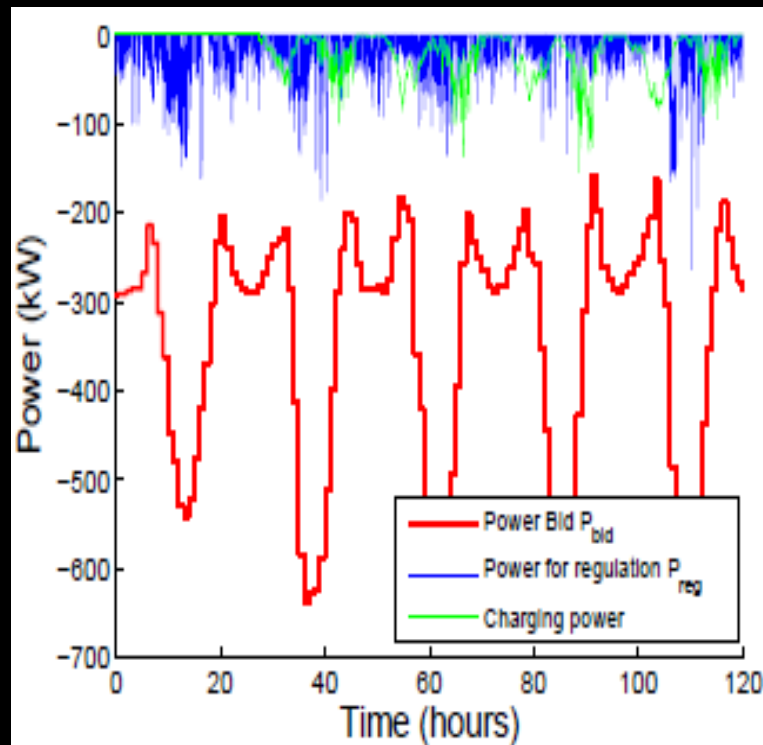
Simulation model

- **A stochastic and dynamic simulation model with:**
 - ❑ **Electric vehicles fleet design: 1 EV=1 agent**
 - 22 kWh battery capacity
 - No extreme States of Charge allowed
 - French Charging stations power data
 - ❑ **Real Driving patterns**
 - French National Transport and Travel Survey (35,803 car trips made by 9,630 drivers) from 2008 (last)
 - Commuting trips only (« representative »)
 - Under 100 km/day (« in accordance with capacity »)
 - ❑ **Benevolent Aggregator** = estimate the real reserves available per car
 - ❑ **Real Frequency data for demand** = 45 000 observations
 - ❑ **Montecarlo simulations** of 100 times 100 Evs fleet

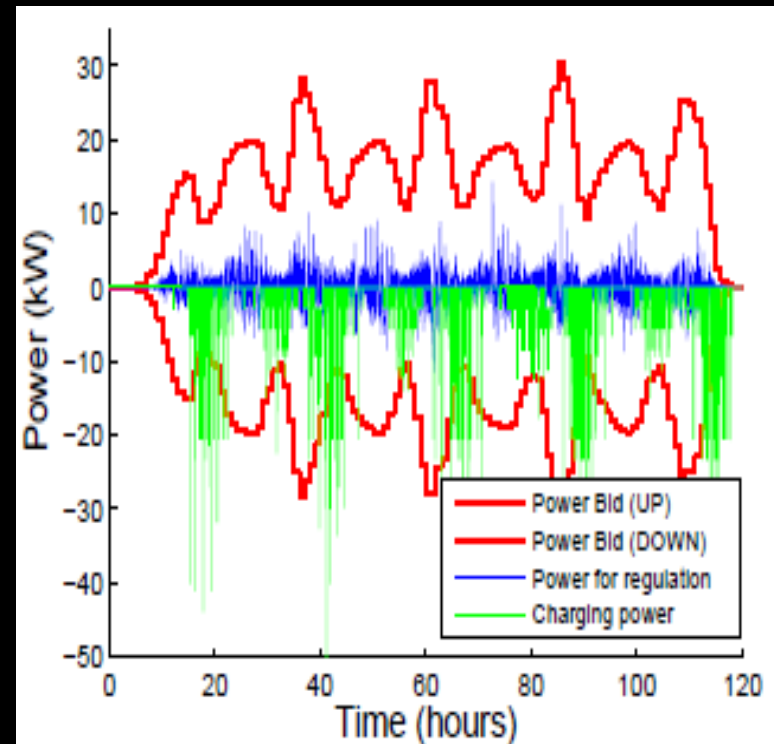
Overview on Algorithm design



Result 1: Asymmetrical > symmetrical



(a) Asymmetrical framework



(b) Symmetrical framework

Pbid values: 9 times as high on average

Result 2: The shorter the market clearing period the better

Market clearing period	Min (kW)	Max(kW)	1st quartile (kW)
1 hour	125	675	243
4 hours	19	271	70

With a one-hour time stamp, 75% of the offers made in the market by the aggregator exceed 243kW, while they only exceed 70kW with a four-hour market clearing period.

Conclusion:

What an efficient regulator could do?

- Help integration of EV fleets: efficient and cost-effective reserve providers
- Separate downward and upward reserve markets (asymmetrical markets)
- Reduce the market clearing period to one hour or less

Breaking news !

1 January 2017

French regulated tariff move to market for Reserve procurements

French Market Design until 01/01/2017

- Mandatory provision for every large generation units
- RTE allocates reserve to generation units pro-rata their generation for every half-hour time-step on D-1
- Regulated tariff
- Other prequalified actors can sell reserves through bilateral negotiation
- Amount of reserve which can be provided by aggregators limited to 40 MW

ADMINISTRATIVE MECHANISM

Common EU market

- Common market between Germany, Austria, Switzerland, Belgium and Netherlands
- Each prequalified actor can offer reserve on a **symmetrical market**
- Product duration of **one entire week**, from Monday 0am to Sunday 12pm
- TSOs select offers with lowest price. Pay-as-bid remuneration
- Minimum bid of 1 MW, bid increment of 1 MW

MARKET MECHANISM

Thanks !

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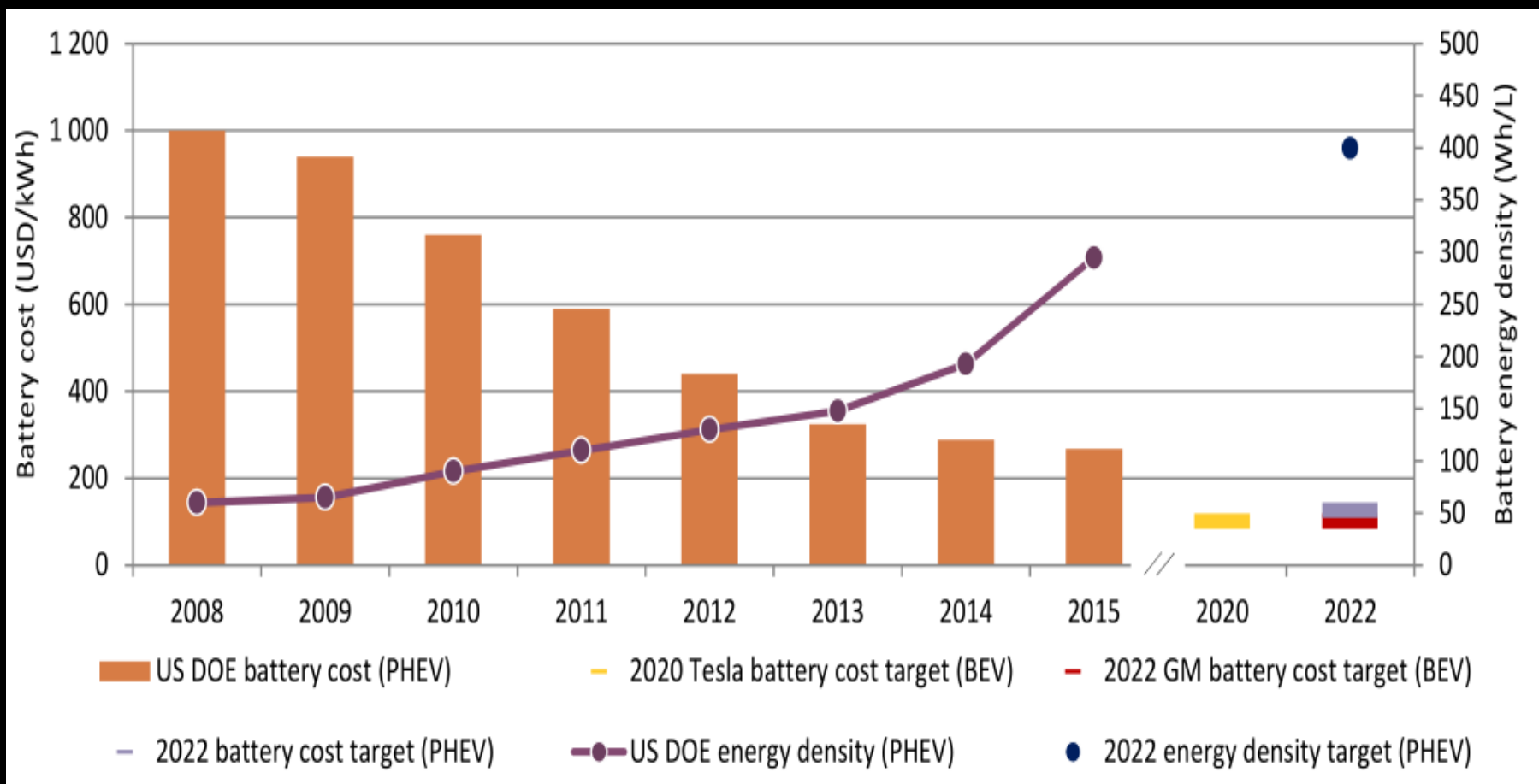
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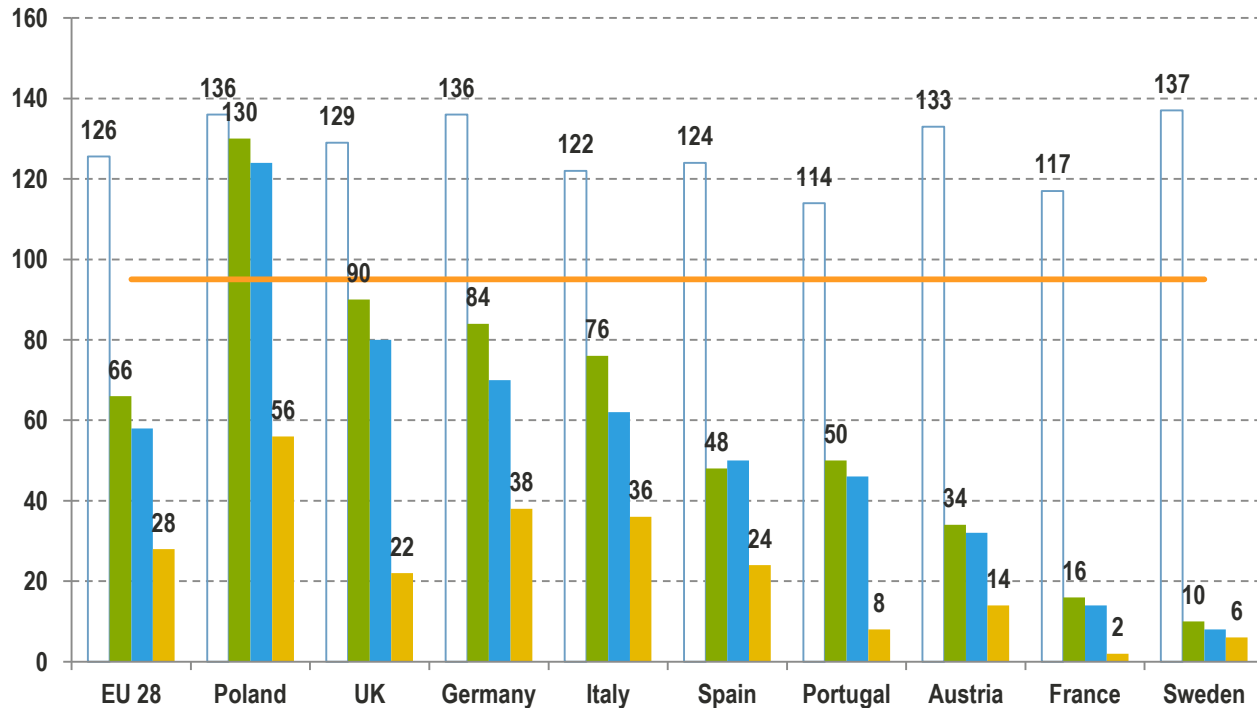
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2 challenges for electrical grids : EVs and Renewables

EVs enjoy a Double dynamic:
Increase in ENERGY DENSITY & decrease of COST



EVs emit less CO₂ than conventional cars in Europe



□ Average of CO₂ of new cars

■ Average of CO₂ EVs (2015)

— 2021 Goal 95 gr

■ Average of CO₂ EVs (2010)

■ Average of CO₂ EVs (2035)Ref Scenario 2013

- With the 2010 carbon intensity, a typical EV emits about 66g CO₂/km
- EVs will be even cleaner in the future as the power sector continues to decarbonise by 2050