

# Electromobility: Tacking Stock, Looking Ahead

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# What is the Armand Peugeot Chair?

- One Donor PSA Group
- Two leading institutions :
  - CentraleSupélec & ESSEC Business School
- A team :
  - In Management - J Lepoutre
  - In Engineering - M. Petit
  - In Economics – Y. Perez
  - 3 PhDs Students ( Y. Chen ; O. Borne : I. Freites)
- International Partners
  - Delaware University and DTU (W. Kempton) => Vehicle to Grid
  - Wharton School (J-P Mc Duffie) => Management studies
  - La Laguna University (F. Ramos-Real) => EV and Islands
- 2011 toward 2021...

# Introduction

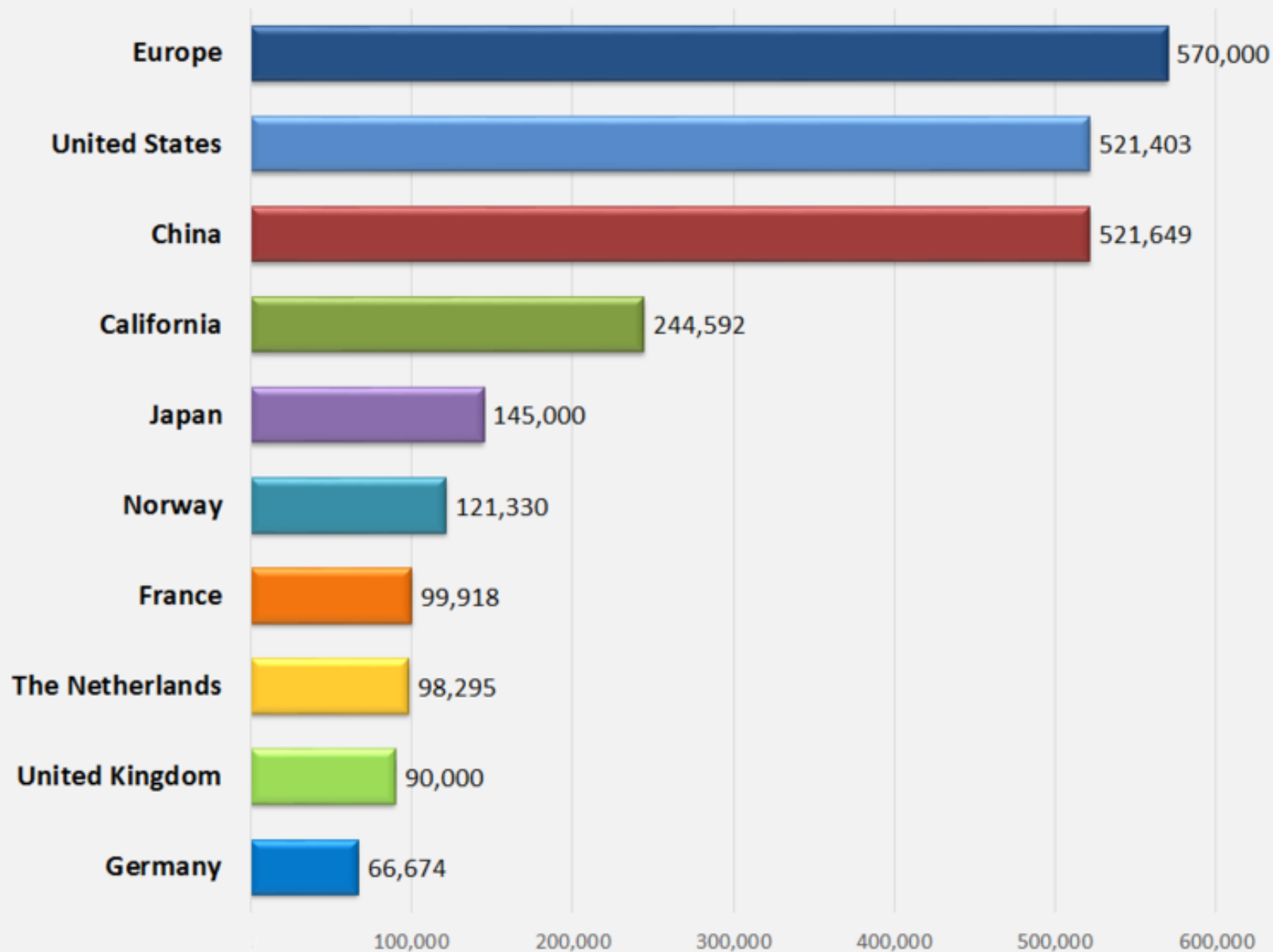
# Electric vehicle fleets are challenging

- Vehicle to Transmission grid = VtoG
- Vehicle to Distribution grid = VtoG
- Vehicle to buildings = VtoB
- Vehicle to Home = VtoH
- Vehicle to Load = VtoL

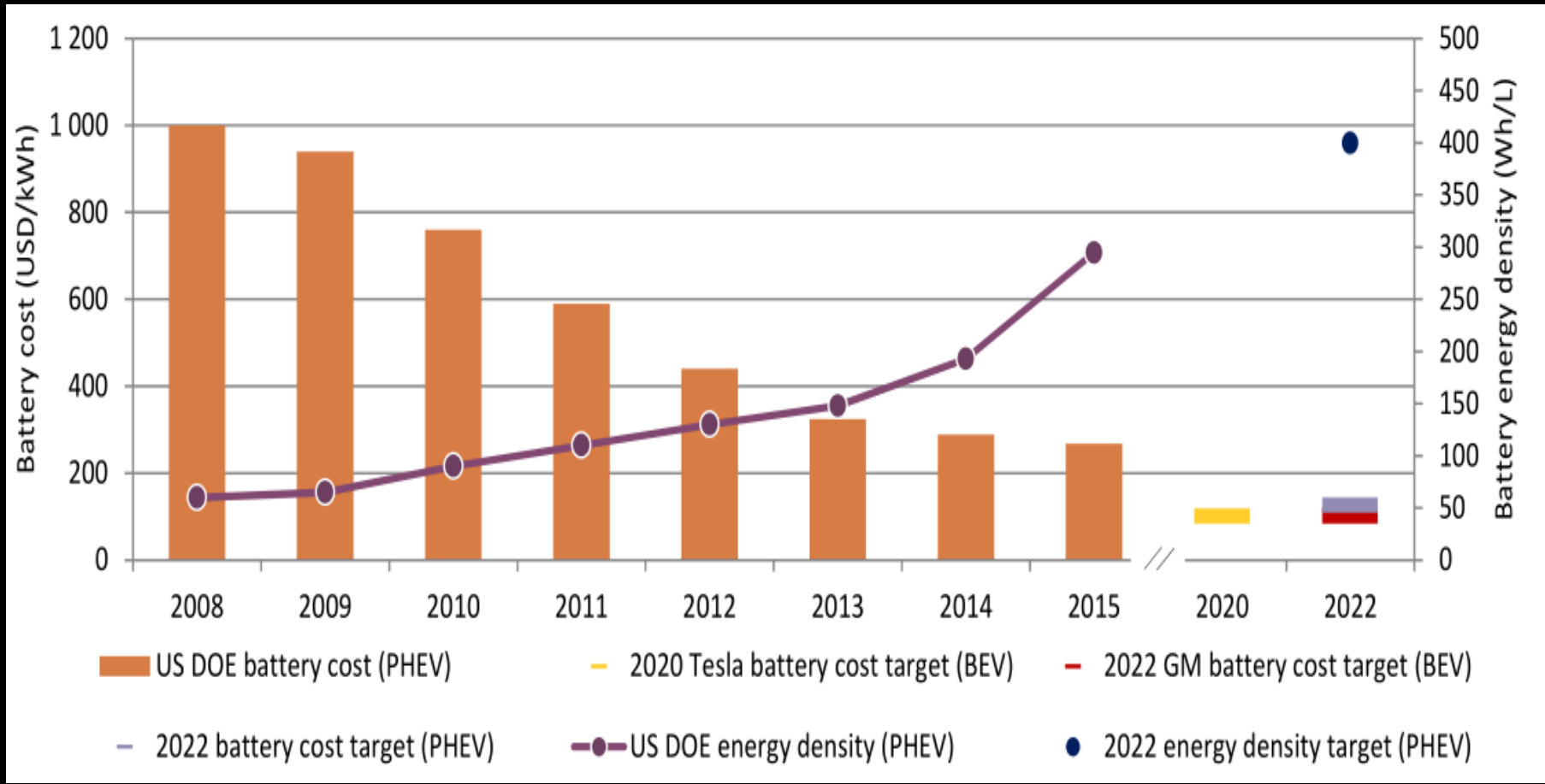
# Outline

1. The electromobility challenge
2. Solution by markets coordination
3. Solution by contracts
4. Conclusion

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

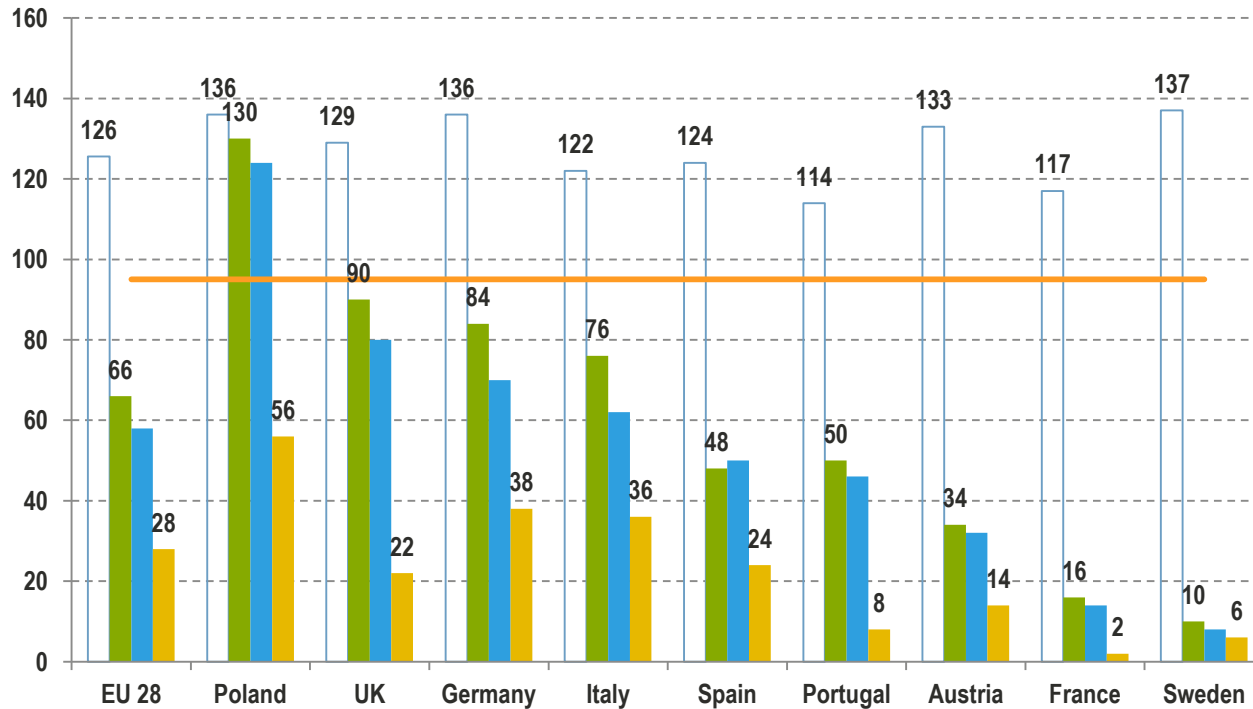


# EVs enjoy a Double dynamic: Increase in ENERGY DENSITY & decrease of COST



Source: IEA Global EV Outlook 2016

# EVs emit less CO<sub>2</sub> than conventional cars



□ Average of CO<sub>2</sub> of new cars

■ Average of CO<sub>2</sub> EVs (2015)

— 2021 Goal 95 gr

■ Average of CO<sub>2</sub> EVs (2010)

■ Average of CO<sub>2</sub> EVs (2035)Ref Scenario 2013

- With the 2010 carbon intensity, a typical EV emits about 66g CO<sub>2</sub>/km
- EVs will be even cleaner in the future as the power sector continues to decarbonise by 2050



# Electromobility : Energy or Capacity issue ?

## In energy (TWh)

- In France
- 2020 : 525 000 VE
  - = 1,3 TWh (source : RTE)
  - 0,2% of the total
  - => no energy problem

## In capacity (MW)

- Max peak consumption:
  - 100.5 GW (7 feb 2012, 19h)
  - 3% per year
  - + 28% in 10 years
- 2020 : 525 000 VE-VHR
  - No coordination with 3 kW → 1,5%
  - No coordination with 22 kW → 11,5%
  - Today Fast charger technologies are booming : 120 kW to 400 kW
  - + local issues with distribution grid / RES

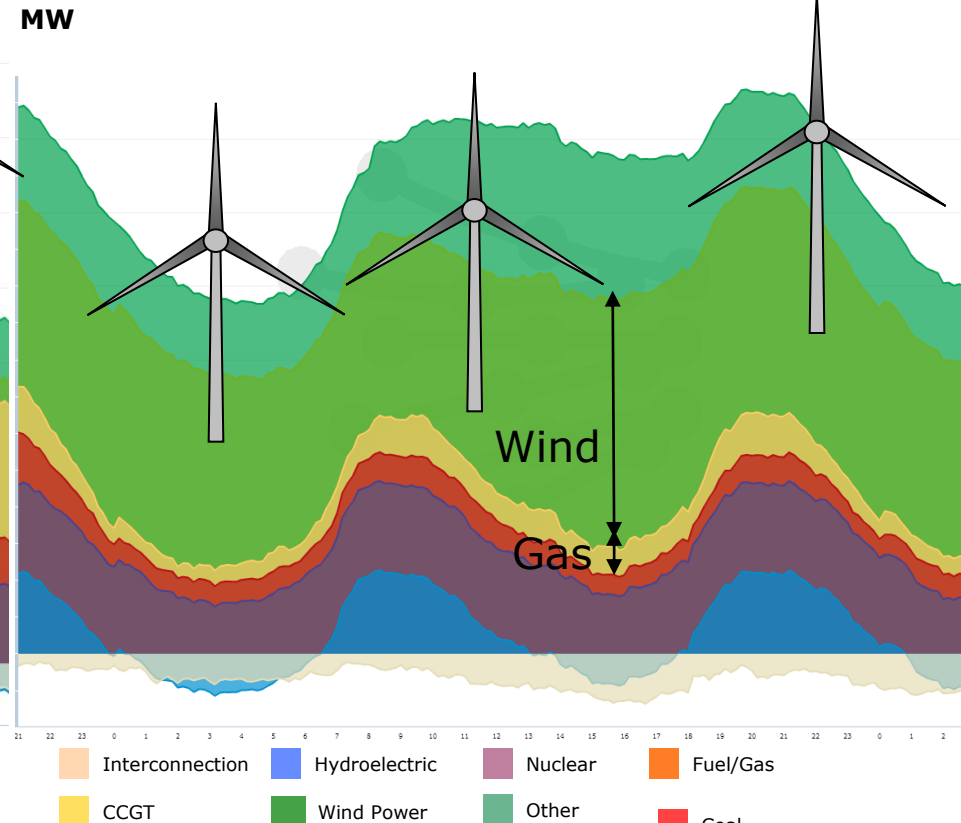
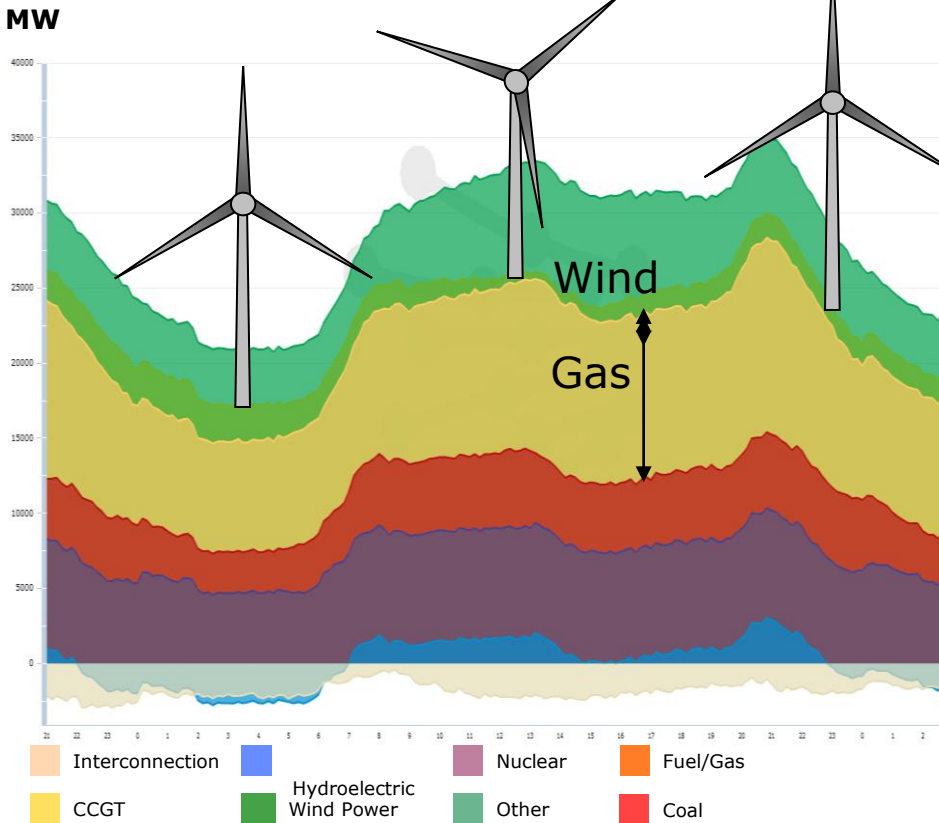
# More wind and solar = more flexibility needs

30-september-2010

Wind 1%  
17:45h

6-Februray-2013

Wind 66.5%  
15:50h



Source REE, ENAGAS

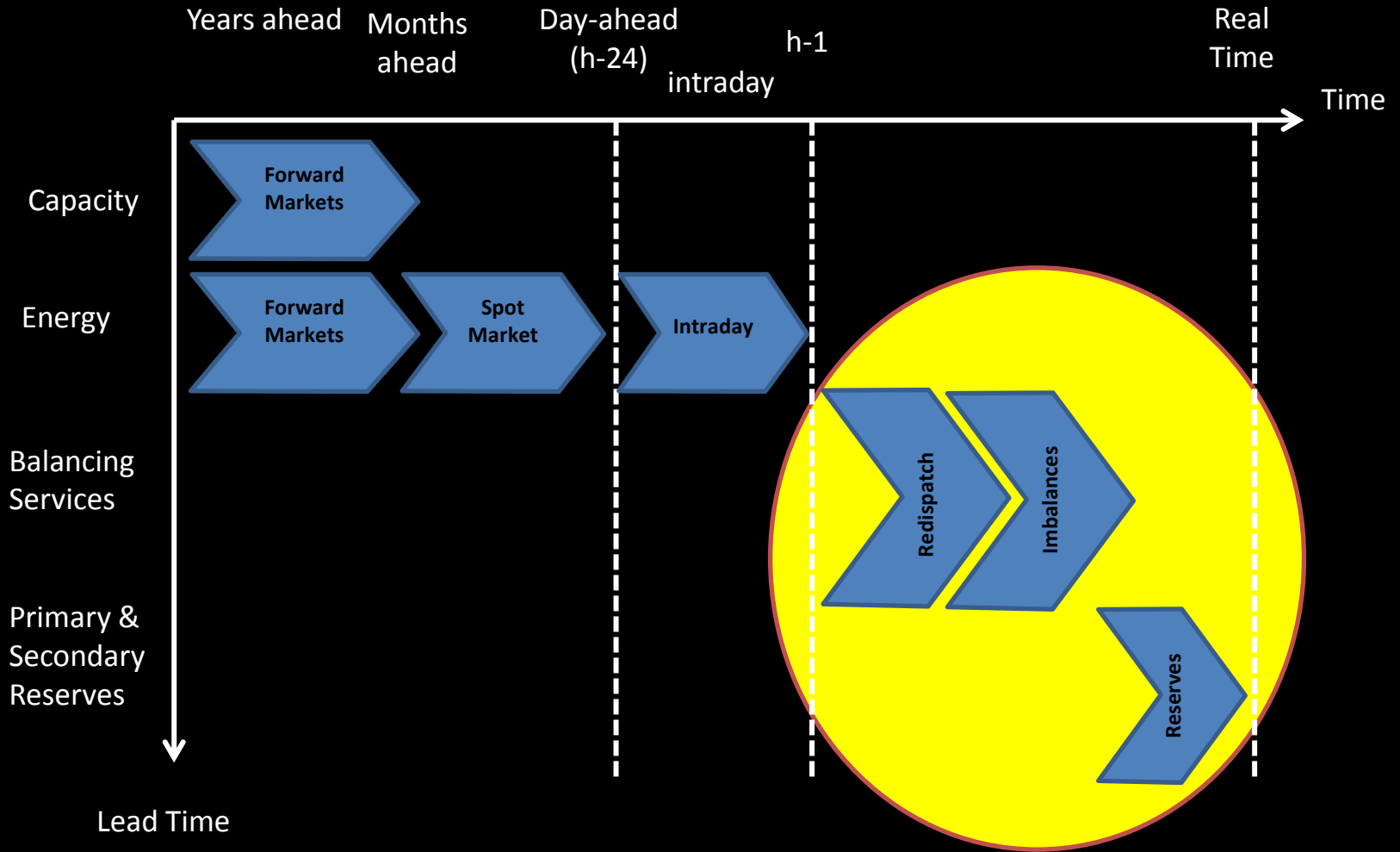
# The electricity sector needs more flexibility provision

Connected EV Fleets are potentially very flexible resources...

# Outline

1. The electromobility challenge
2. **Solution by market coordination**
3. Solution by contracts
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# GENERIC ELECTRICITY MARKETS ORGANIZATION and EV Fleet



And best adapted grid services for ev fleets

# Managing data to create “bundle of valuable flexible resources” for potential markets

Times	MW or MWh	Services on market base if exist
<b>Second</b>	MW	<ul style="list-style-type: none"> <li>- <b>Frequency regulation</b></li> <li>- Voltage regulation</li> <li>- Quality of delivery</li> </ul>
<b>Hour</b>	MW Or MWh	<ul style="list-style-type: none"> <li>- Tertiary reserve market</li> <li>- Demand response</li> <li>- Balancing services</li> <li>- Congestion management</li> <li>- Intraday-market</li> <li>- Coupling With RES</li> <li>- ...</li> </ul>
<b>Block orders</b>	MWh	<ul style="list-style-type: none"> <li>- Day head market</li> <li>- Time of Use</li> <li>- Coupling with RES</li> <li>14 ...</li> </ul>

# Frequency remunerations for EV :

PJM real case / France exploration/ Netherlands / Denmark and  
France under construction

Charging point capacity (kW)		Revenus /VE/ year
Primary	Secondary	
3	0	179,4 €
3	3	310,7 €
3	7	505,7 €
3	22	1346,8 €
7	0	474,5 €
7	3	543,4 €
7	7	780 €
7	22	1448,2 €

**1500 €/ year and per car  
in PJM Zone  
for only « frequency  
regulation market base  
Provision »  
Kempton (2016)**

Sources: Codani, Petit & Perez (2016)

# Remarks on frequency regulation

Rules of the game are created for previous  
generation technologies

and

They can act as barrier to entry for new tech



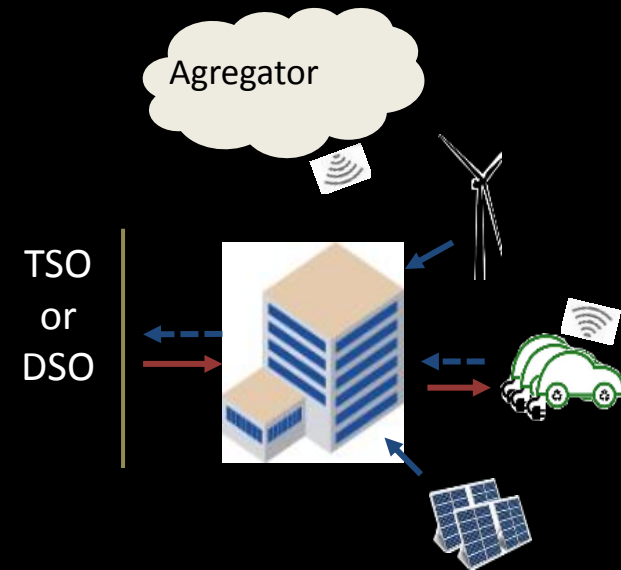
# Outline

1. The electromobility challenge in energy markets
2. Solution by markets coordination
3. **Solution by contracts**
4. Conclusion

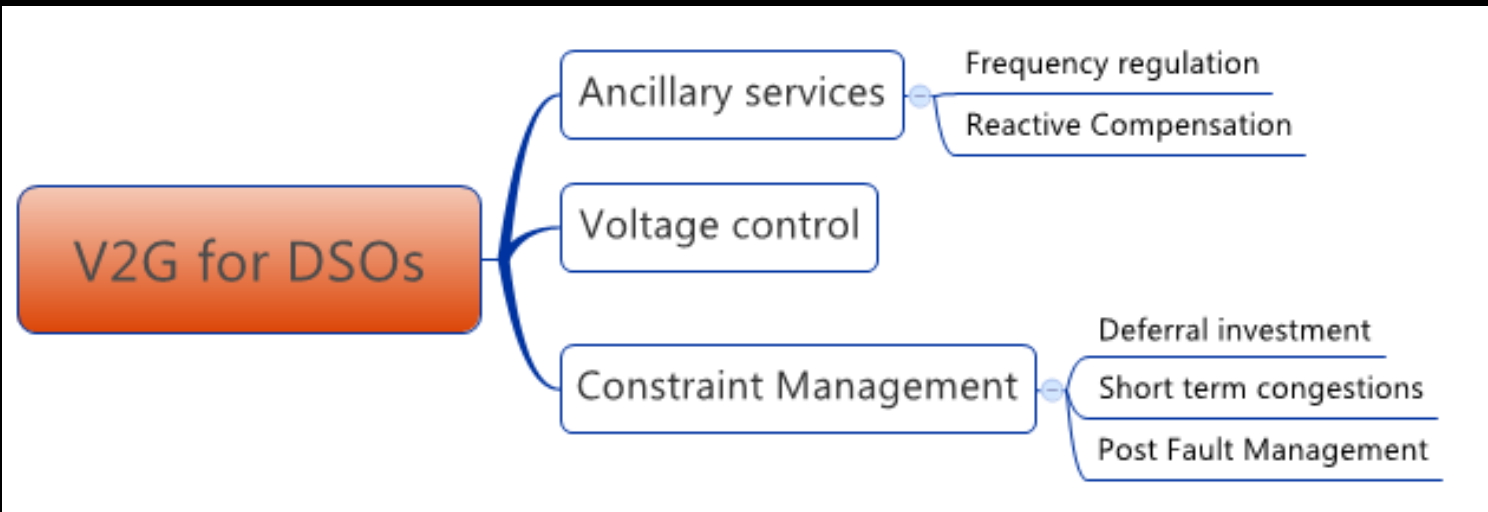
# Contractual solution (s) for VtoB

- Objectives of the site manager
  - Minimizing energy cost over time
  - Maximizing self-consumption of local renewable energies
  - Minimizing the peak demand toward networks
  - Reducing the network connexion fee
- Sharing potential benefits with the consumers and / or DSO

## Vehicle-to-building



# Contractual solution (s) with the Distribution Service Operator (DSO)



If V2G avoids investments, at least the value of V2G has to equal CAPEX and OPEX of the avoided reinforcement.

# Contractual solution (s) for VtoH

- Objectives of the House manager
  - Minimizing energy cost over time
  - Maximizing self-consumption of local renewable energies if incentives are aligned
  - Providing Distribution grid services (optional)



# And the off-grid « solution » VtoL

- New companies propose “off grid green” solution
  - Home Storage + Solar Roof + EV (100kWh) < Energy + networks + taxes + sunkcosts



# Conclusions

# Flexibility provision with EV fleets

- **Not perfectly done yet...**
  - VtoG experiment around the world (US / Denmark...)
  - Majors success with regulation power : mainly frequency
  - New projects are starting
- **3 Main problems to overcome**
  - Rules and Market regulation are barrier to entry for EV Fleets in most VtoG services or markets
  - Communication standards (15118 / CHAdeMO...) need to be clarified
  - Engaging cooperation between Electricity and automotive industries for optimal charging infrastructure deployment

# Predicting the future of EV is hard

If you were asked in the 1980s about having a camera in your phone...

what would you have imagined?







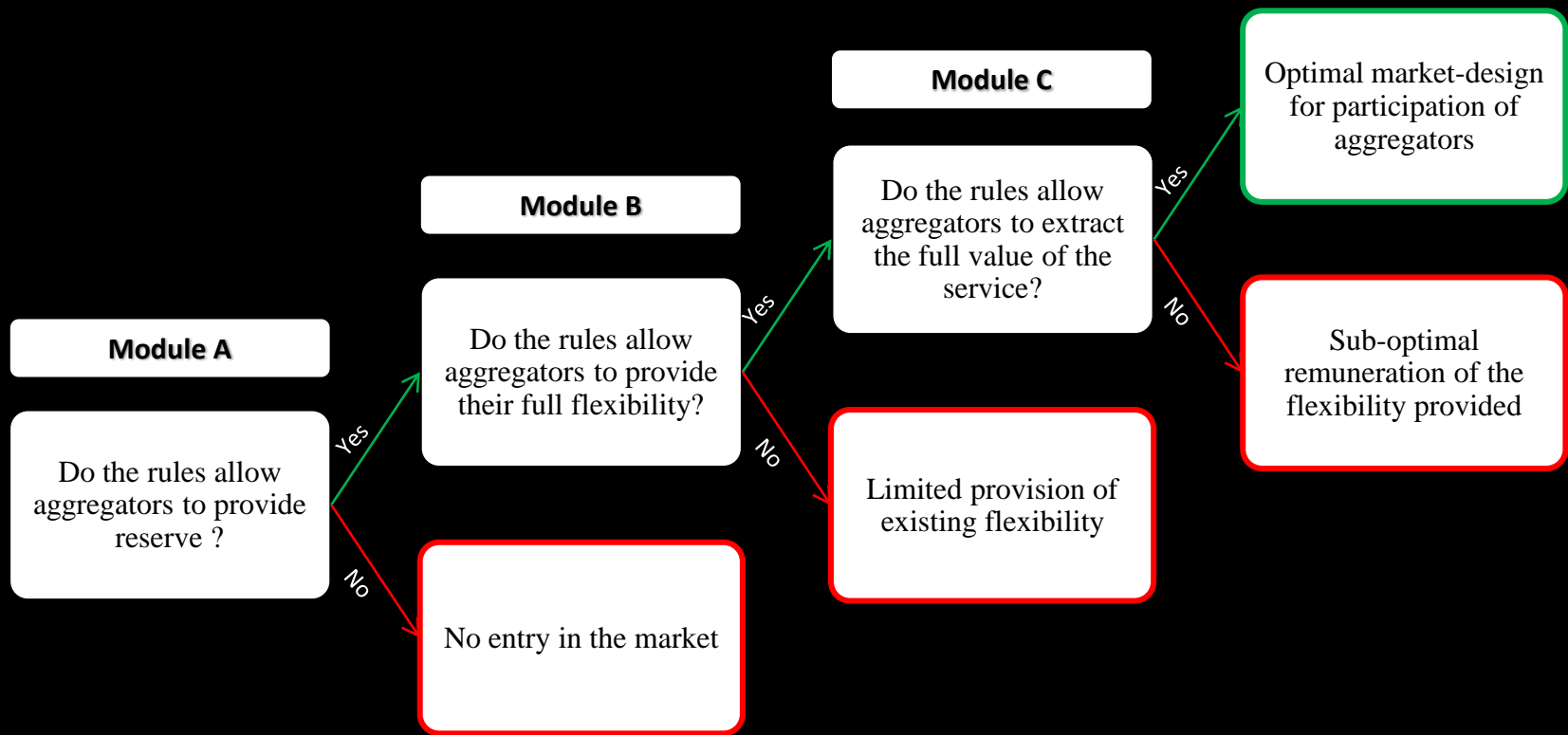
Additional material

# Selected Literature of the Armand Peugeot Chair

- Olivier Borne, Yannick Perez and Marc Petit (2017) Market Integration VS Temporal Granularity: How to provide needed flexibility resources, EEM conference 2017.
- Olivier Borne, Klaas Korte, Yannick Perez, Marc Petit and Alexandra Purkus 2016 *Barriers to entry in Frequency-Regulation Services Markets: Review of the status quo and options for improvements*, Forthcoming in **Renewable and Sustainable Energy Review**.
- Codani Paul, Perez Yannick and Petit Marc 2016, *Financial Shortfall for Electric Vehicles: economic impacts of Transmission System Operators market designs*, **Energy**, Volume 113, pp 422-431.
- Eid Cherrelle, Codani Paul, Perez Yannick, Reneses Javier, Hakvoort Rudi, 2016, *Managing electric flexibility from Distributed Energy Resources: A review of incentives for market design*, **Renewable and Sustainable Energy Reviews**, 64 (2016) pp 237–247.
- Donada Carole et Perez Yannick (eds) 2015, *Electromobility : Challenging Issues*. **International Journal of Automotive Technology and Management**. Vol. 15, No. 2.
- Codani Paul, Petit Marc and Perez Yannick, 2015, *Participation of an Electric Vehicle fleet to primary frequency control in France*, **International Journal of Electric and Hybrid Vehicles**, Vol 7, N°3, pp 233-249.
- Kempton Willett, Perez Yannick, and Petit Marc, 2014, *Public Policy Strategies for Electric Vehicles and for Vehicle to Grid Power*. **Revue d'Economie Industrielle**. N° 148, pp 263-291.

# Borne , Korte , Perez, Petit and Purkus (2016)

- We built a framework in order to understand where the barriers are, and to rank them for different countries: France, Germany, UK and Denmark.



2017

## Modifications of French market design for FCR procurement

### 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

### FCR Cooperation

- Common market between Germany, Austria, Switzerland, Belgium and Netherlands
- Each prequalified actor can offer reserve on a 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

## Borne, Perez & Petit (2017)

- With the actual settings of rules in the FCR Cooperation, entry of aggregators is virtually impossible
- Changing time granularity (Week => Second), but also volume granularity (MW to kW), could allow entry of these actors.
- It would also allow to have a more flexible procurement of reserve, which appears to be important when generation patterns are becoming more volatiles
- Or other solutions must be explored for EV fleets...

# 2017: Gridmotion project

- **Project partners are looking for volunteers to start the experiment.**
- Participants should be based in France and own a Peugeot or Citroën electric vehicle produced from January 2015 onwards.
- The role of each partner is detailed below:
  - Groupe PSA is in charge of recruiting customers and managing the project;
  - Direct Energie will act as an aggregator towards RTE<sup>2</sup> and will make bids in the electricity and reserve markets by taking advantage of EV battery flexibility;
  - Nuvve will be in charge of controlling the charging/discharging patterns of electric vehicles;
  - Enel will provide the bidirectional charging stations and its expertise in smart grids;
  - Proxiserve will install the B2C and B2B charging stations;
  - DTU will provide academic support and testing systems.
- <http://media.groupe-psa.com/en/gridmotion-project-reducing-electric-vehicle-usage-cost-thanks-smart-charging-process>