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…

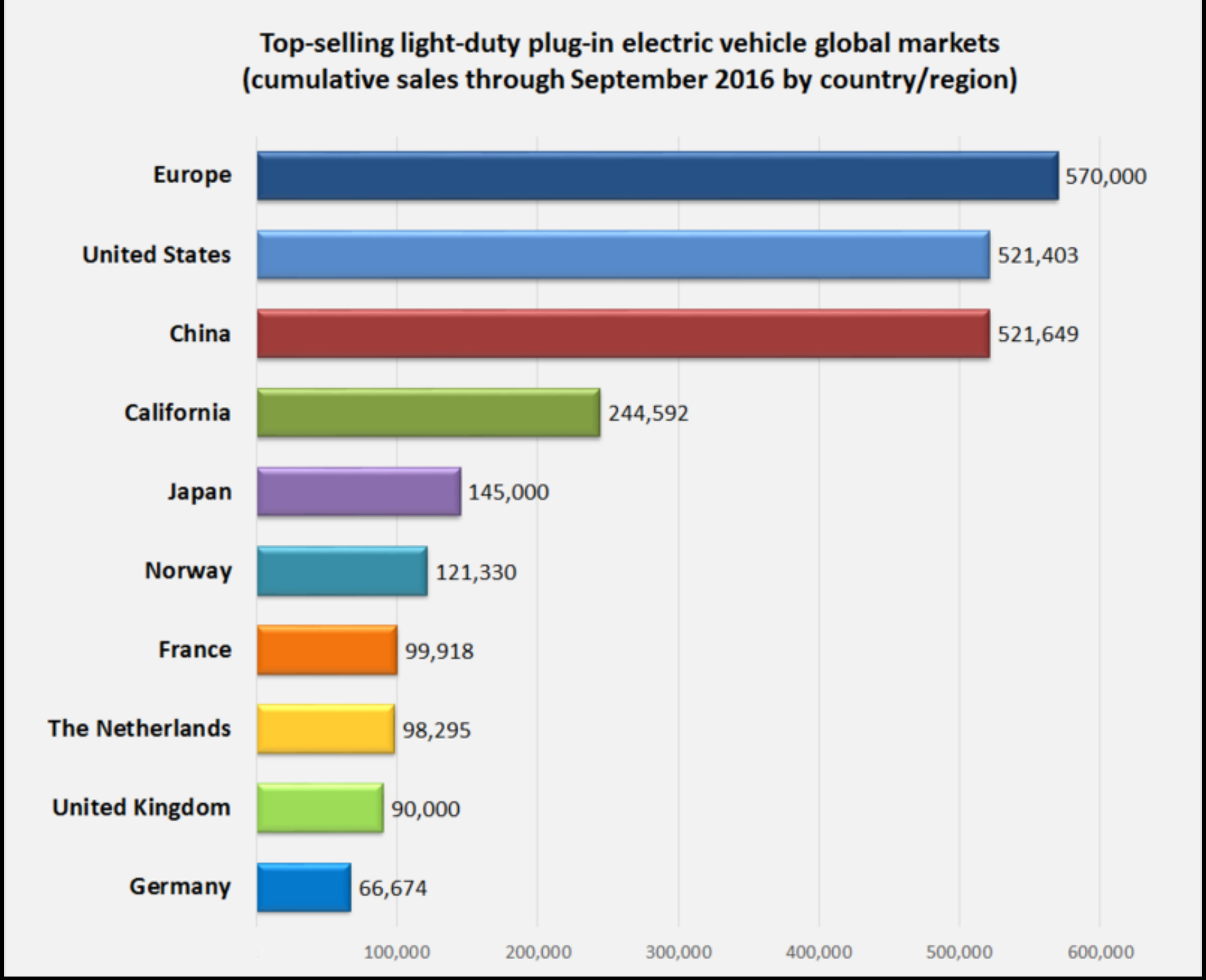
Introduction

Electric vehicle fleets are challenging

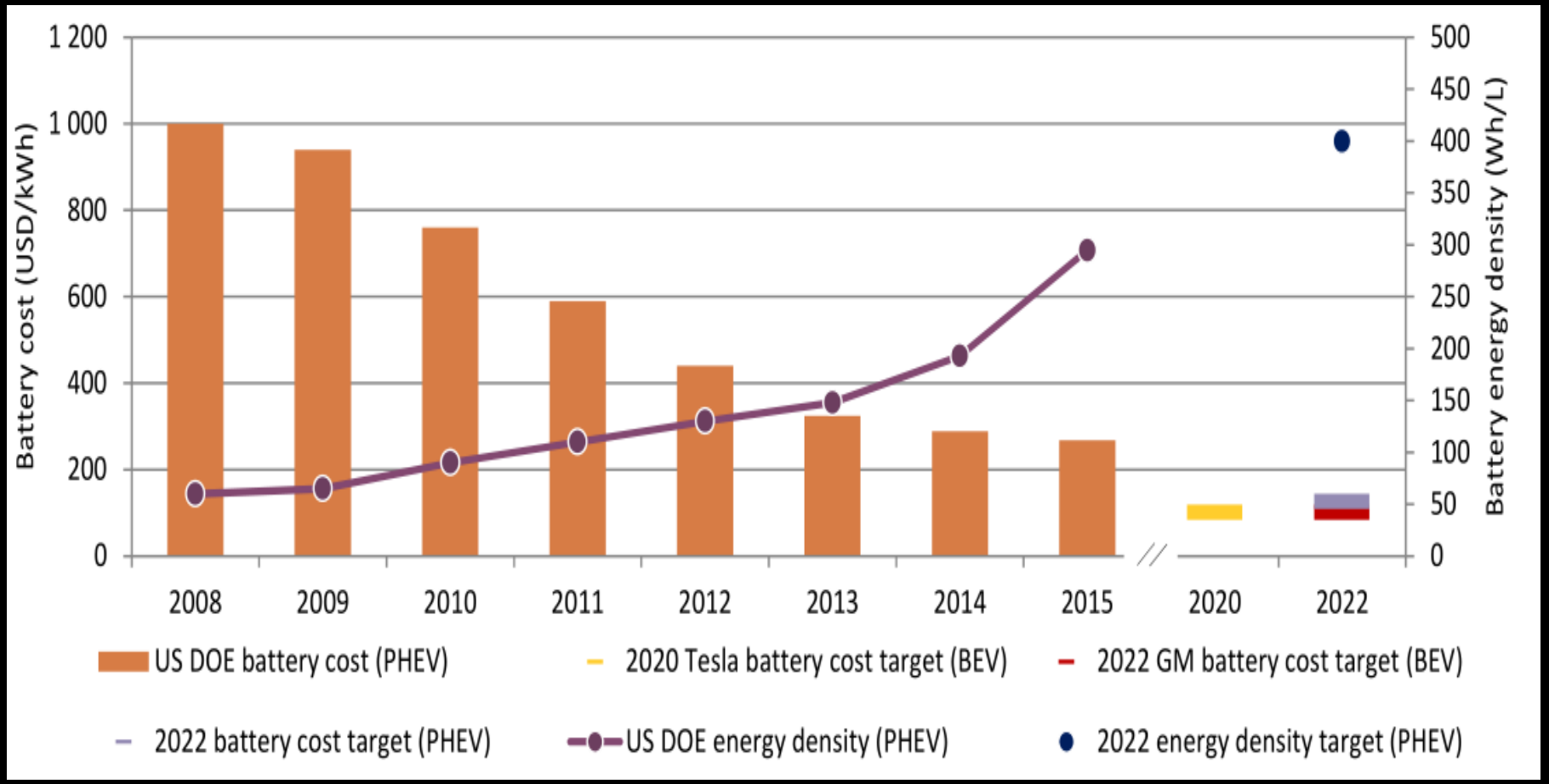
- Vehicle to Transmission grid = VtoG
- Vehicle to Distribution grid = VtoG
- Vehicle to buildings = VtoB
- Vehicle to Home = VtoH
- Vehicle to Load = VtoL

Outline

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

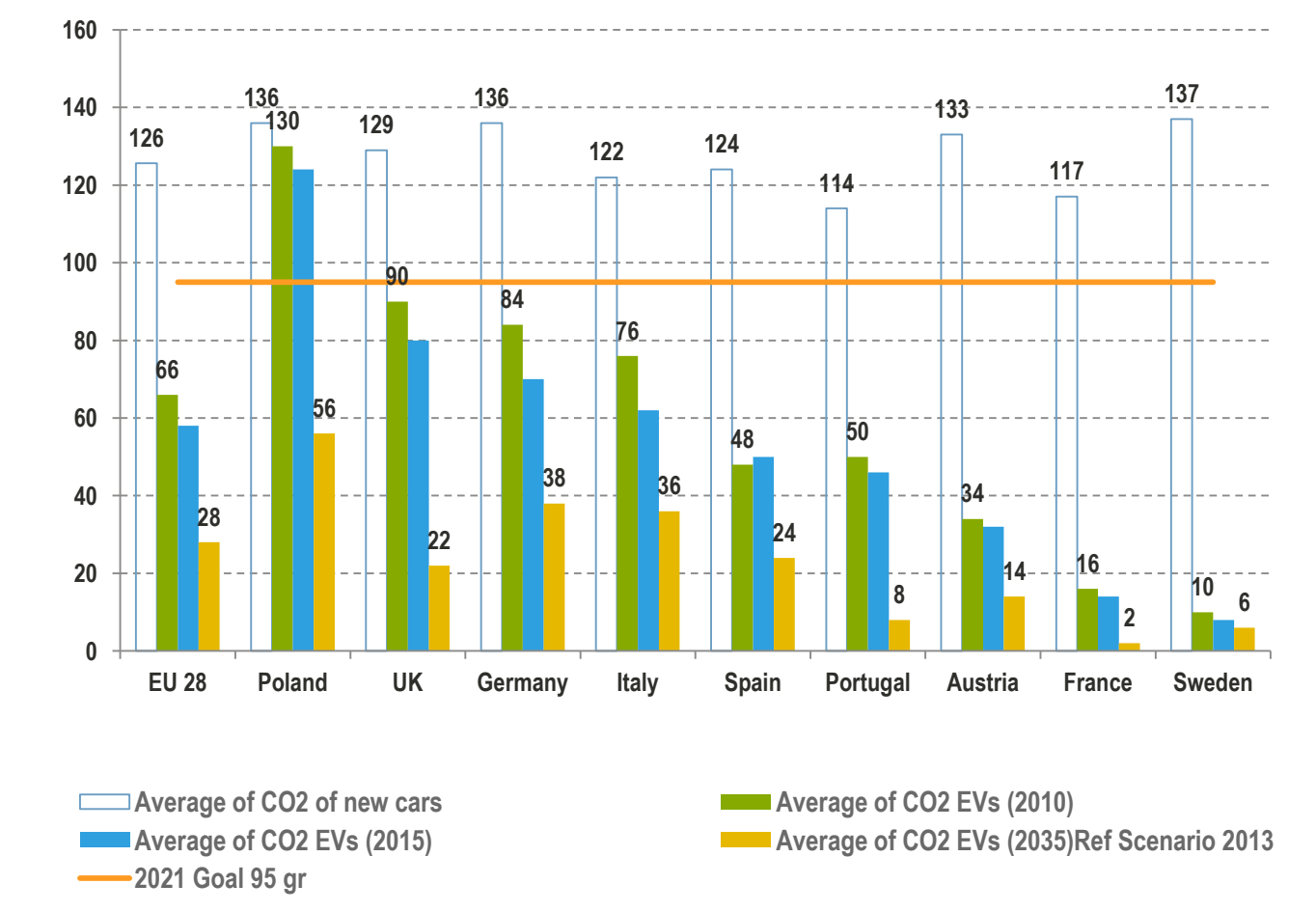

Top-selling light-duty plug-in electric vehicle global markets
(cumulative sales through September 2016 by country/region)
Europe
570,000
United States
521,403
China
521,649
California
244,592
Japan
145,000
Norway
121,330
France
99,918
The Netherlands
98,295
United Kingdom
90,000
Germany
66,674
100,000
200,000
300,000
400,000
500,000
600,000

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



Source: IEA Global EV Outlook 2016

EVs emit less CO_2 than conventional cars



- With the 2010 carbon intensity, a typical EV emits about 66g CO_2/km
- EVs will be even cleaner in the future as the power sector continues to decarbonise by 2050

EURELECTRIC smart charging paper, 2015

Electromobility : Energy or Capacity issue ?

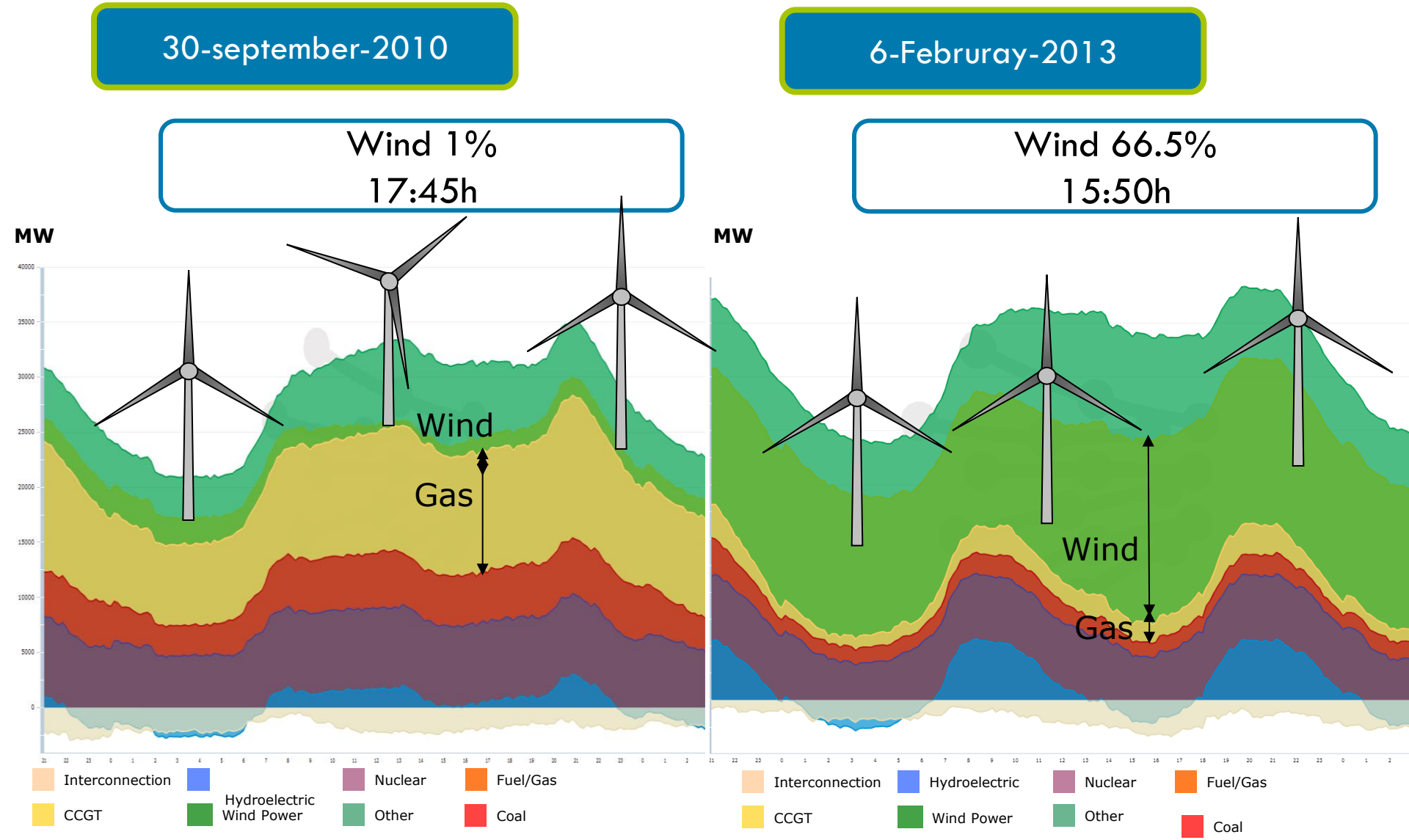
In energy (TWh)

- 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



Source REE, ENAGAS

The electricity sector needs more flexibility provision

Connected EV Fleets are potentialy very flexible ressources…

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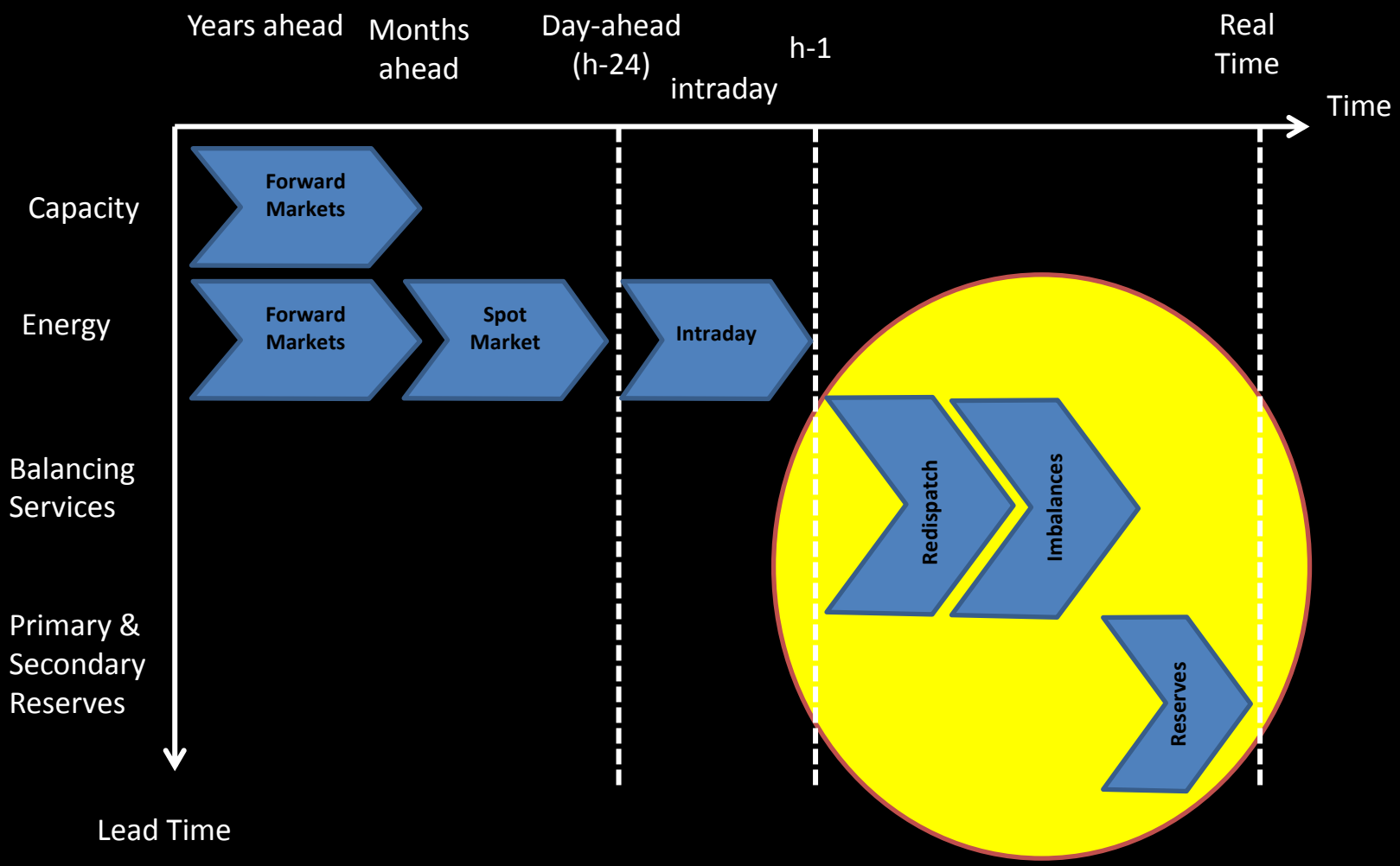
GENERIC ELECTRICITY MARKETS ORGANIZATION and EV Fleet



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
Second	MW	- **Frequency regulation** - Voltage regulation - Quality of delivery
Hour	MW Or MWh	- Terciary reserve market - Demand response - Balancing services - Congestion management - Intraday-market - Coupling With RES - ...
Block orders	MWh	- Day head market - Time of Use - Coupling with RES - ...

Frequency remunerations for EV :

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

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

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 €

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

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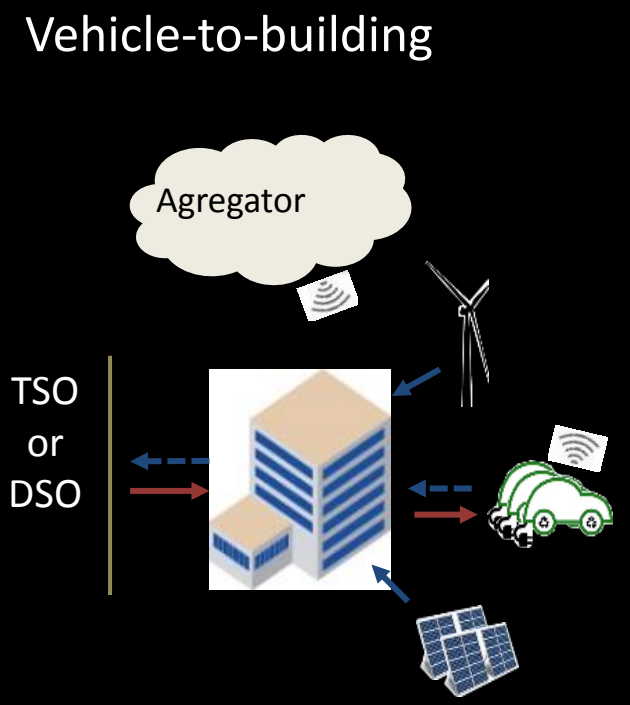
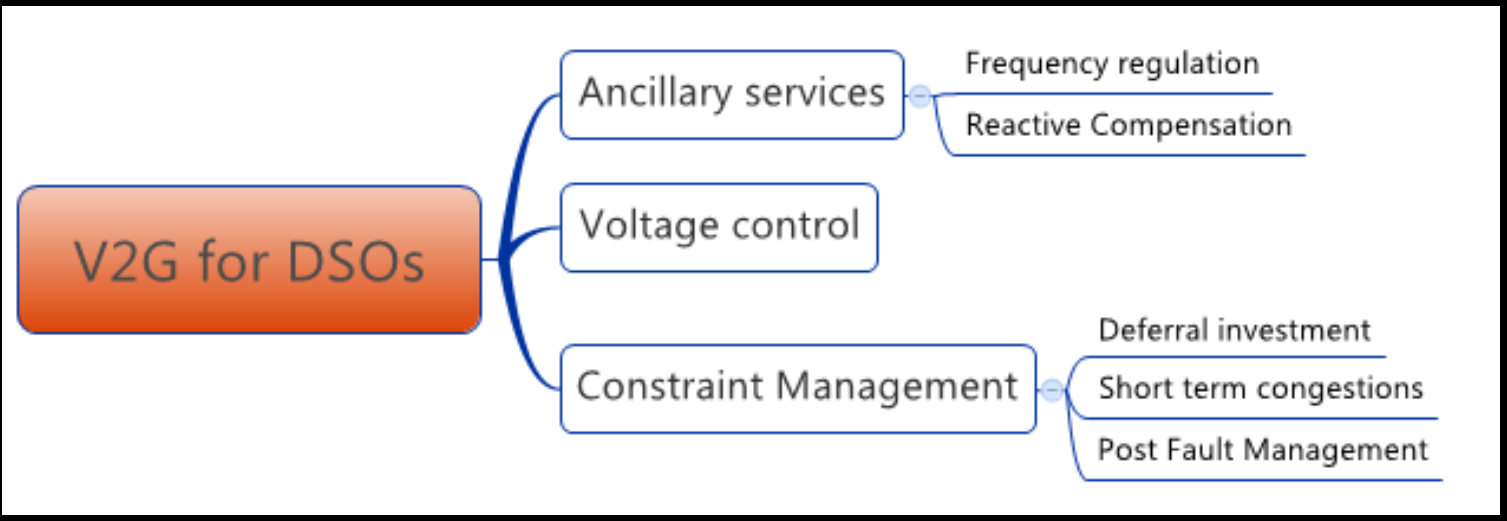
Contractual solution (s) for VtoB

- 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



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



If V2G avoids investments, at least the value of V2G has to equals 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

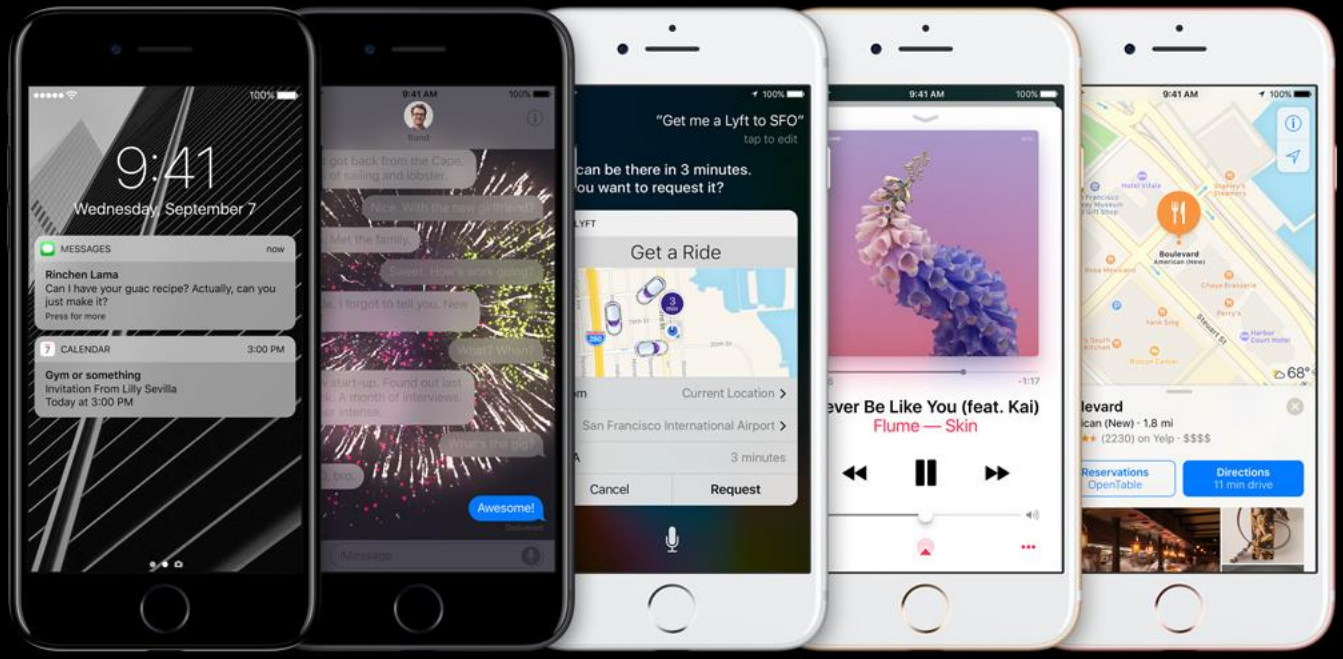
Flexibility provision with EV fleets

- 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 by clarify
  - 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?




Kodak

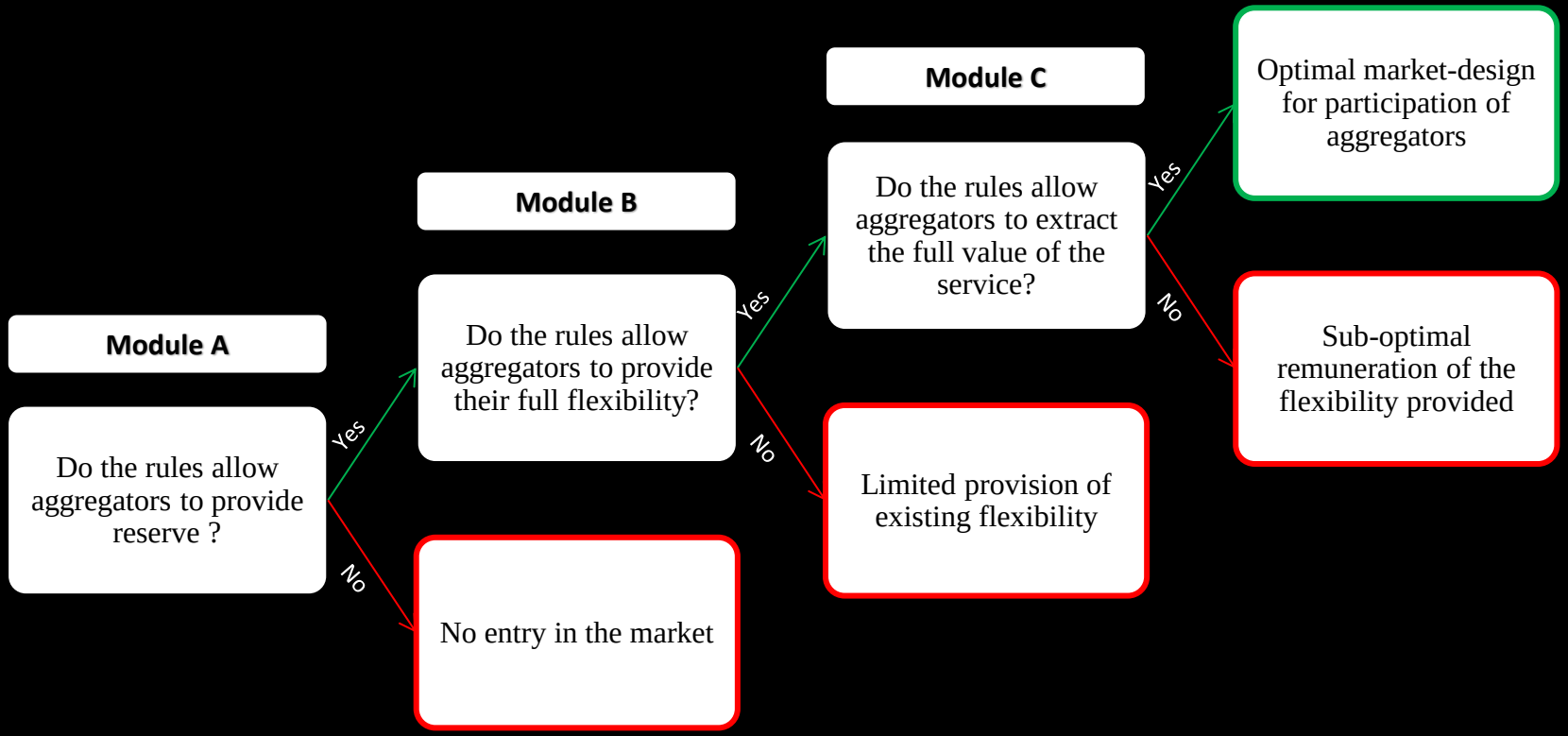
Additional material

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 **Renevable 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[2] 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