Missing Money for EVs

Economics impacts of TSO market designs

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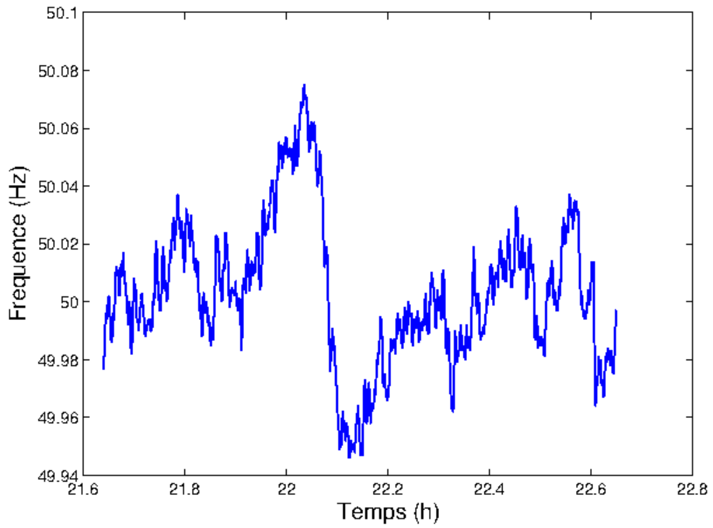
Motivations

- University of Delaware demo project
  - $1500/year /EV by participating in the frequency regulation market

- Wide diversity of TSO market designs for frequency control
- Consequence :
  - « Missing money » for EVs depending on the TSO market designs for frequency control

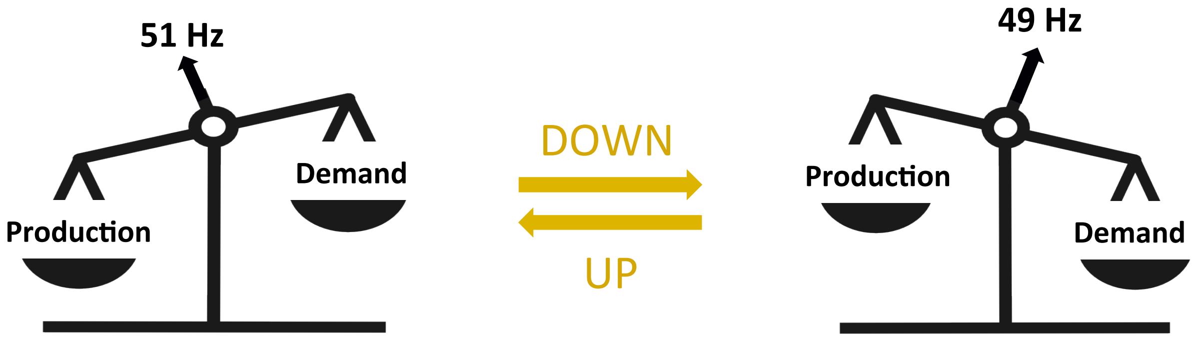
The basics of frequency control mechanisms

- Frequency is a common characteristic within an interconnected network



- Its value fluctuates on a second basis
- TSOs implement control mechanisms to limit these fluctuations

- Controlling the frequency ↔ ensuring P = C continuously



Outline

- Introduction
- TSO rules survey
- Simulation Model
- Results and Discussions
- Conclusions

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Introduction

- Solution intensively studied in scientific literature:
  - Using EVs as distributed storage units to reduce their TCO
- A Grid Integrated Vehicle (GIV):
  - Communication means
  - Controllable charging rate
  - V2G capabilities
- Objectives:
  - Assessing the economics impacts of local market designs on expected revenues of a GIV fleet providing frequency regulation
- Approach:
  1. Identification of the most crucial frequency control market rules
  2. Implementation of a model for the provision of frequency regulation by GIVs
  3. Selection of 2 combinations of rules, comparison of the expected revenues

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- Introduction
- TSO rules survey
  - Approach
  - Module 1 : aggregation rules
  - Module 2 : payment scheme for grid services
  - Conclusion
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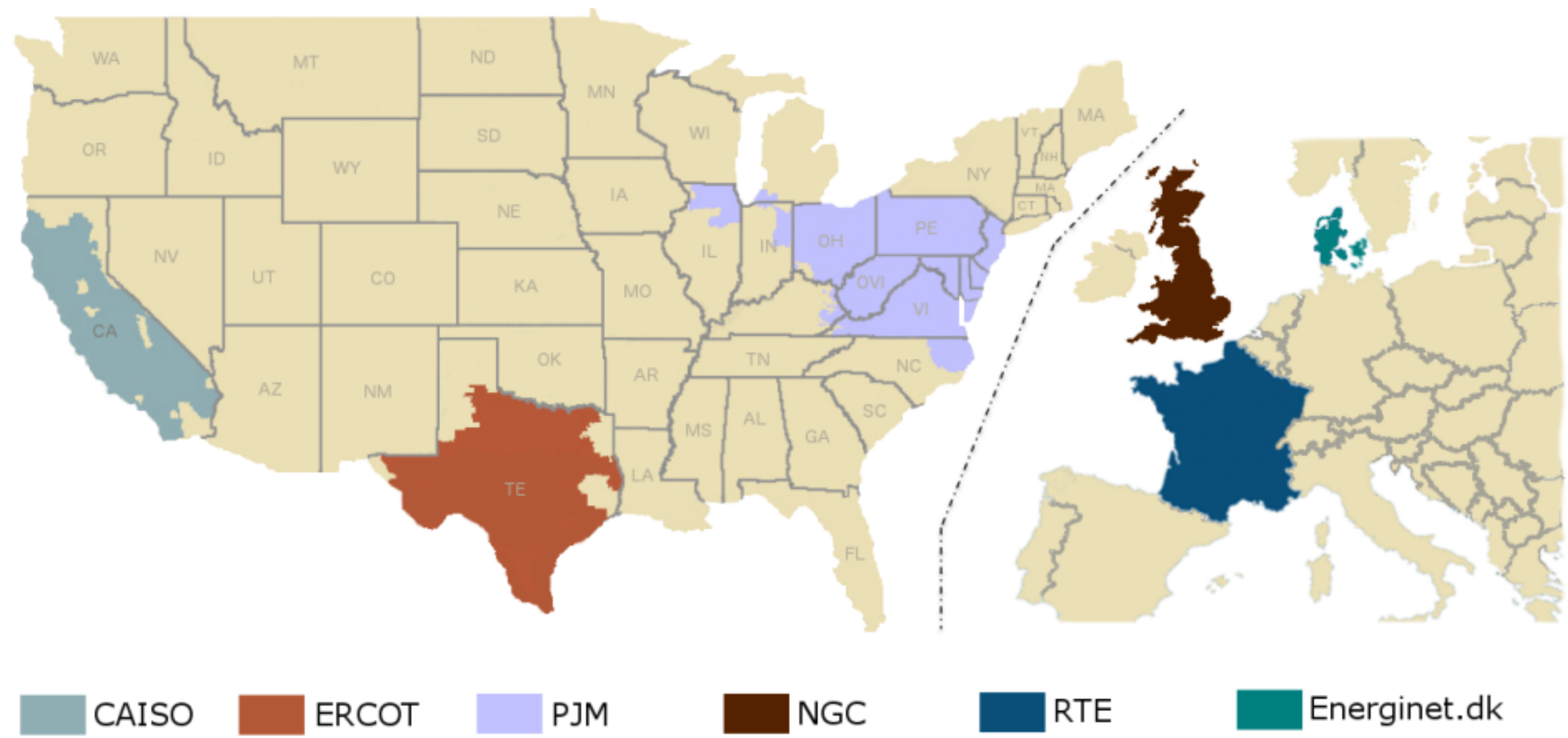
TSO rules survey – Approach

- Survey of 6 representative TSO rules for frequency control
- Experience from Nikolai and eV2G demonstration projects



Module 1 : Aggregation rules

- Aggregators have fundamental roles in GIV architectures
- The three criteria of this module are:
  - Minimum rated power to be included in the market
  - Possibility to aggregate units across various DSO technical zones
  - Possibility to aggregate power flows and not only financial products

Aggregation rules	Organization	
	Best option	**Conservative Option**
R1 : Minimum Size	100 kW	10 MW
R2 : Interoperability among DSOs	Possible	Impossible
R3 : Aggregation level	Telemetry & Financial	Financial only

Module 2 : payment scheme of grid services

- GIV, V2G → A mean to reduce the TCO of EVs
- The three criteria of this module are:
  - Nature of the payment scheme (regulated, contract-based or market-based)
  - Incompleteness of the payment scheme
  - Extra bonus for intense flexibility

Payment scheme rules	Organization	
	Best Option	**Conservative Option**
R4 : Nature of the payment	Market based	Regulated
R5 : Incompleteness of the payment	All AS should be paid	Incomplete payment scheme
R6 : Extra bonus	Set at the efficient level, or separate market created	Not existing

TSO rules – partial conclusions

- We have identified two sets of crucial rules
  - leading to different organizational forms
- Possibility to define a best and a worst case
- To go a step further:
  - Evaluate and number the missing money of having ”bad” rules
- → Need for a simulation model

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  - EV fleet modeling
  - Aggregator modeling
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Electric Vehicles' characteristics

- General characteristics
  - N_{VE} = 200,000 EVs in 2020
  - Battery capacity: 22kWh
  - Battery constraint: $0,2 < SOC/SOC_{max} < 0,9$
- Trip patterns:
  - Data used: CROME project results; internal PSA data; ministerial reports
  - Only daily working commuting trips modeled
  - Ongoing work: survey of other fleet types (such as postal mail services fleet, company fleets…)

Characterization of charging stations (1)

- EVSE modeling:
  - Home charging at the « primary EVSE »
    - « One EV, one EVSE »
  - Work charging at the « secondary EVSE »

Scenario	Secondary EVSE penetration rate
Scenario 1	0%
Scenario 2	25%
Scenario 3	50%
Scenario 4	75%

Characterization of charging stations (2)

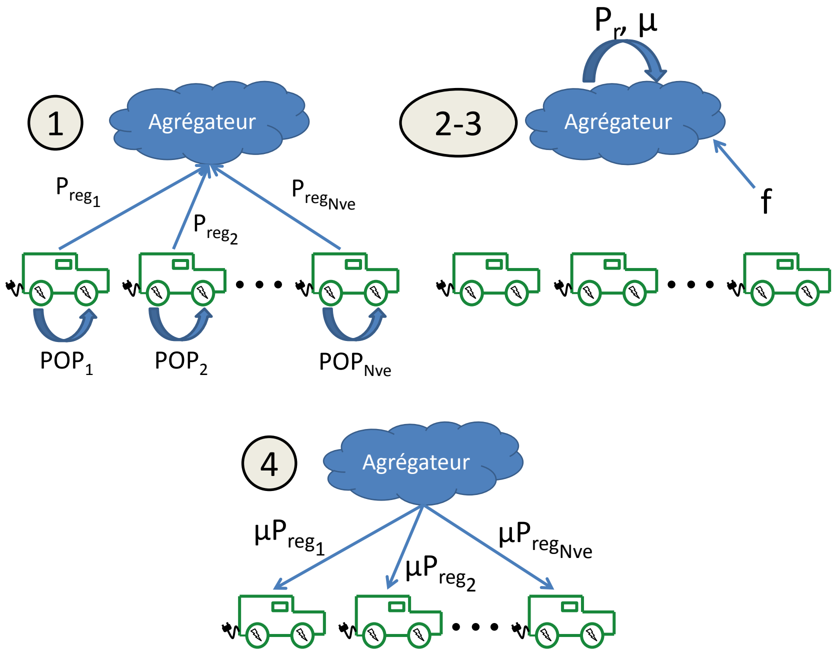
- EVSE charging power repartition depending on the charging location[1] :

Charging Power	Primary EVSE	Secondary EVSE
Slow A – 3kW	95%	35%
Slow B – 7kW	5%	34%
Intermediate – 22kW	0%	29%
Fast – 43kW	0%	2%

[1]Commissariat General au Développement Durable, Livre Vert sur les infrastructures de recharge ouvertes au public pour les véhicules décarbonés, pp. 1–198, 2013

Aggregator modeling

- Aggregator roles :
  - presenting the EV fleet as a single entity to the TSO
  - scheduling algorithm (here, supposed to be efficient)
  - dispatch algorithm
    → mimics the one from the UD demo project[2]

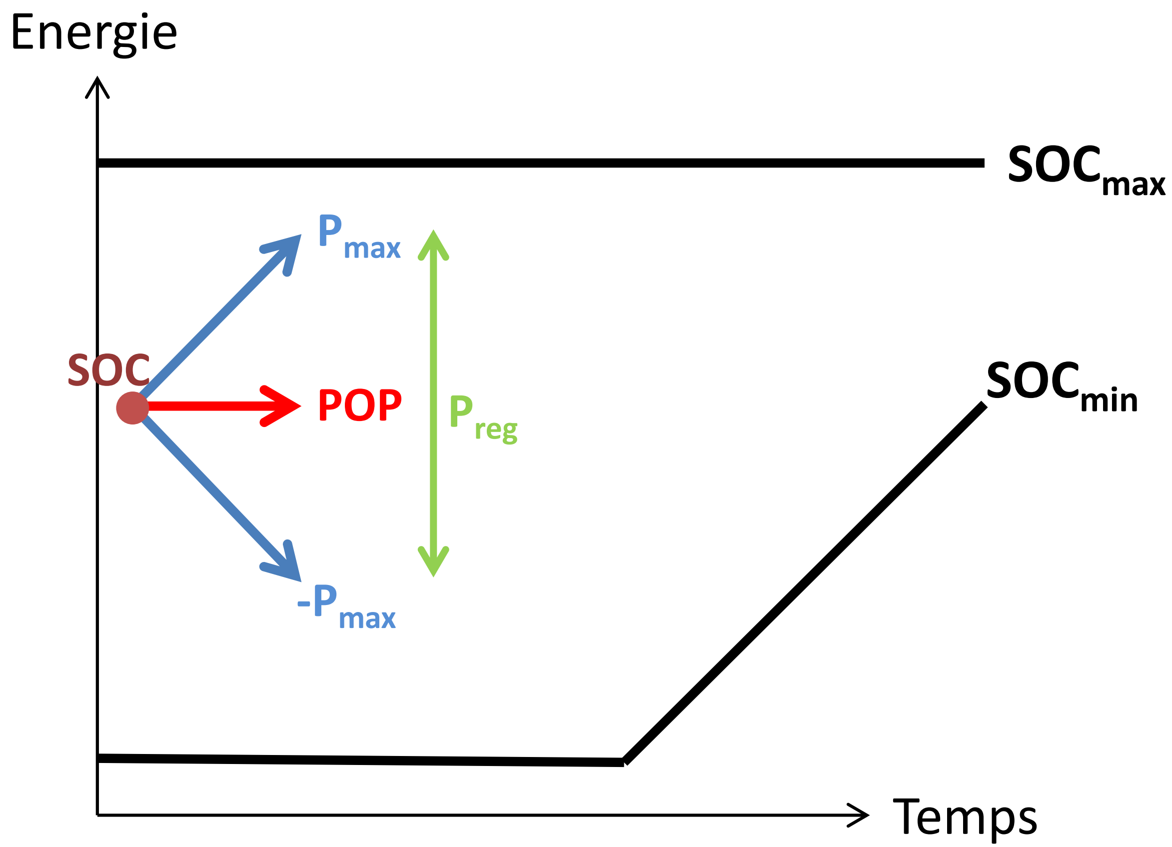


- Algorithm :
  - decentralized
  - Implemented in a real-life operational project

[2] S. Kamboj, N. Pearre, W. Kempton, K. Decker, K. Trnka, and C. Kern, "Exploring the formation of Electric Vehicle Coalitions for Vehicle-To Grid Power Regulation" in 2010 AAMAS workshop on Agent Technologies for Energy Systems, 2010

Computation of the available power for regulation

- Based on the value of the operating point POP



Computation of the available power for regulation

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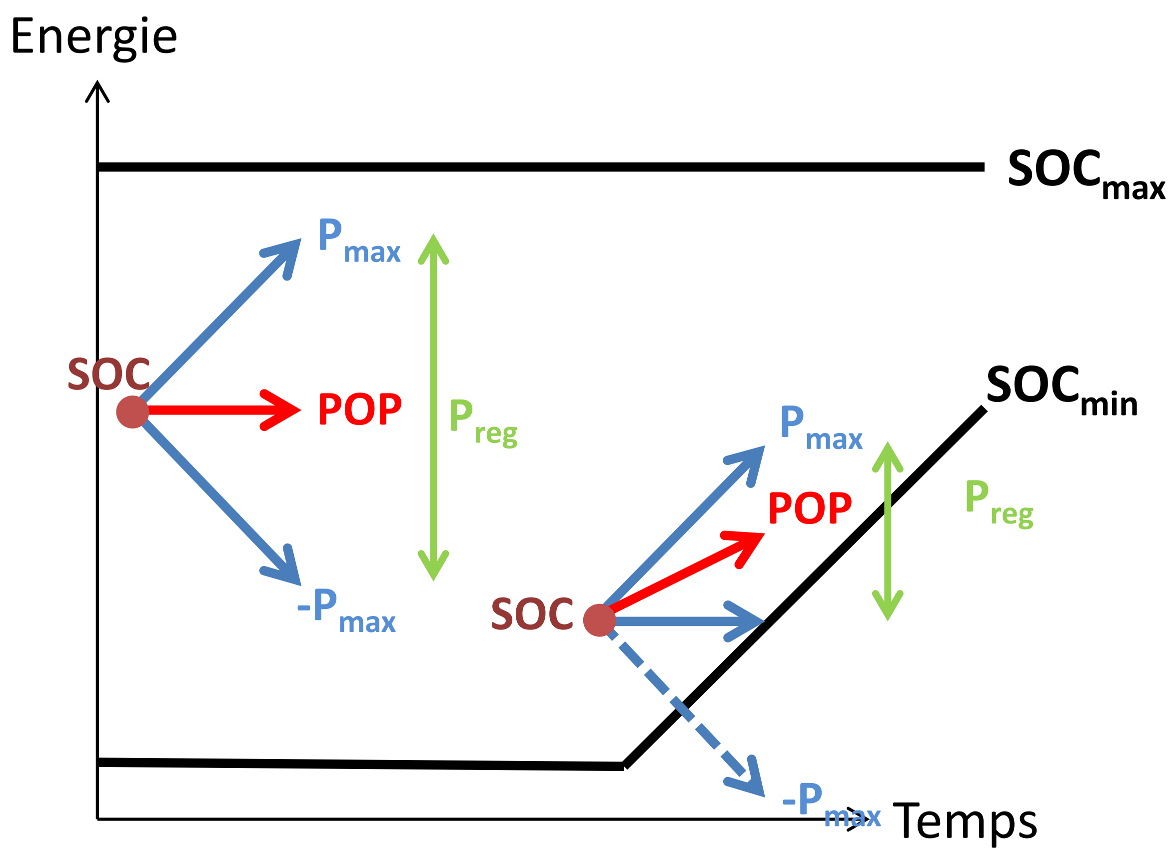

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- TSO rules survey
- Simulation model
- Results and Discussions
  - Simulation scenario
  - Combinations of rules A: results
  - Combinations of rules B: results
- Conclusions

Combination of rules understudy

- We select two combinations of rules:

Rules	Combination A : Current RTE rules	Combination B : Ideal settings
R1 : Minimum Size	1 MW	100 kW
R2 : Interoperability among DSOs	Possible	Possible
R3 : Aggregation level	Impossible	Telemetry and Financial
R4 : Nature of the payment	Regulated	Market-based
R5 : Incompleteness of the payment	All AS remunerated	All AS remunerated
R6 : Extra bonus	Not existing	Set at the efficient level

Combination of rules A – results

- Under this combination of rule:
  - EVs are not allowed to participate in primary frequency control
  - Even if they were, they would have a very low remuneration
    - RTE dispatches the reserve according to the ”historical load share” of the units
    - Regulated tariff
  - A substantial number of EVs would be required

- Results:

Under the combination of rules A, EVs can not participate, their revenues amount to 0€

Combination of rules B – results

- We use prices from Energinet.dk primary control market, raised by 30% to represent the extra-bonus[3]
- We weight individual revenues per charging station power based on the EVSE repartition
- We assume all EVs to be remunerated evenly

Scenario (secondary EVSE % rate)	Revenues / EV / year
Scenario 1 (0%)	193 €
Scenario 2 (25%)	326 €
Scenario 3 (50%)	459 €
Scenario 4 (75%)	593 €

[3]This value was observed in the UD demo project

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Conclusion

- Work completed:
  - Identification of the most important TSO rules for GIVs
  - Modeling of an EV fleet participating to primary frequency control
  - Comparison of tow combinations of rules on the expected revenues of a GIV fleet
- Results:
  - Current French rules: revenues = 0€
  - Ideal rules: revenues from 193€ to 593 € / EV/ year
- Policy considerations:
  - ENTSO-E network codes are paving the way for enabling these technologies
  - National/local TSOs and regulators should made all efforts to improve their rules

Questions? Remarks? Don't hesitate: paul.codani@mpsa.com

THANK YOU VERY MUCH FOR YOUR ATTENTION