SESO 2016 International Thematic Week
"Smart Energy and Stochastic Optimization"
A Research Agenda for Optimization in the Energy Transition

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2 June 2016

Outline of the presentation

1. What is happening to power systems?
2. What new management problems do we see emerge?

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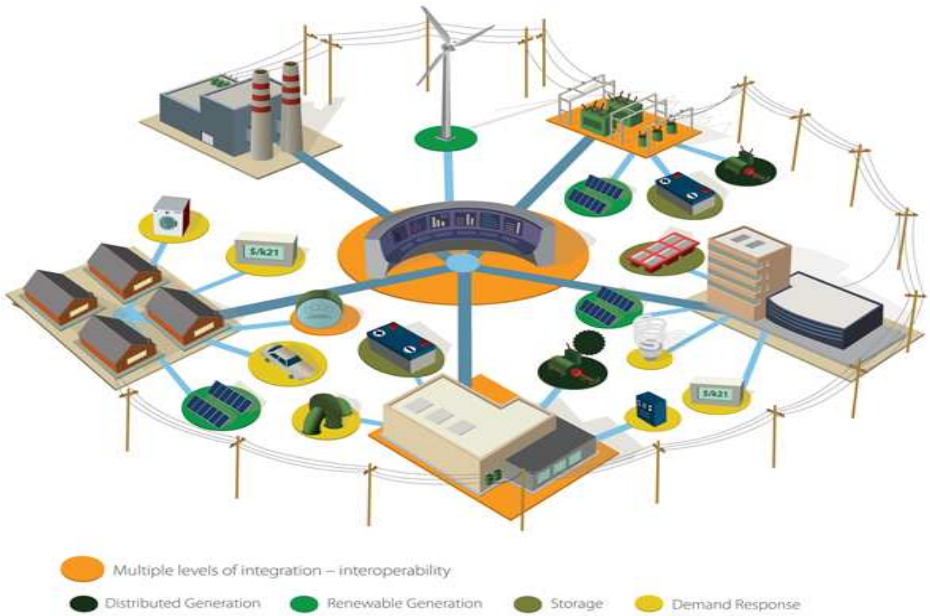
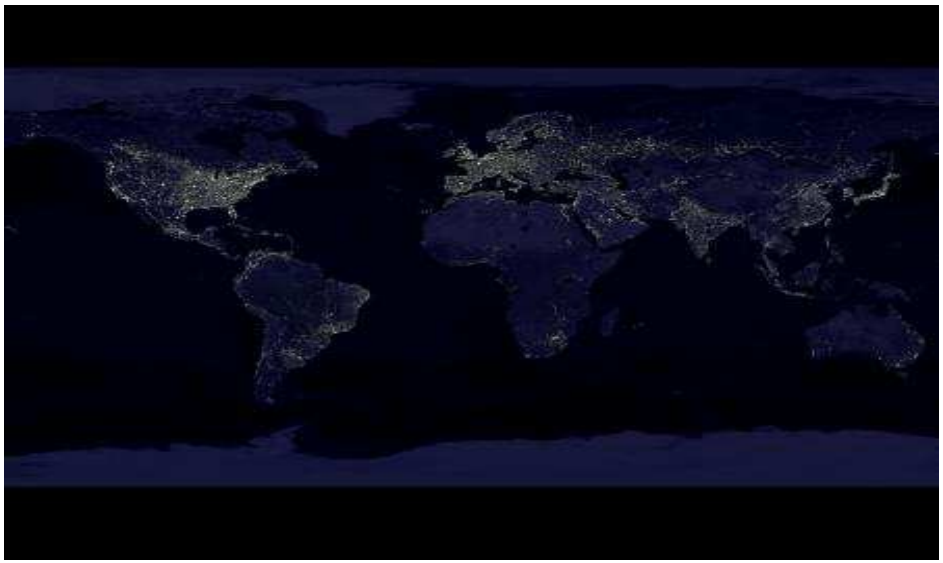
2. What new management problems do we see emerge?

Three key drivers are remolding power systems



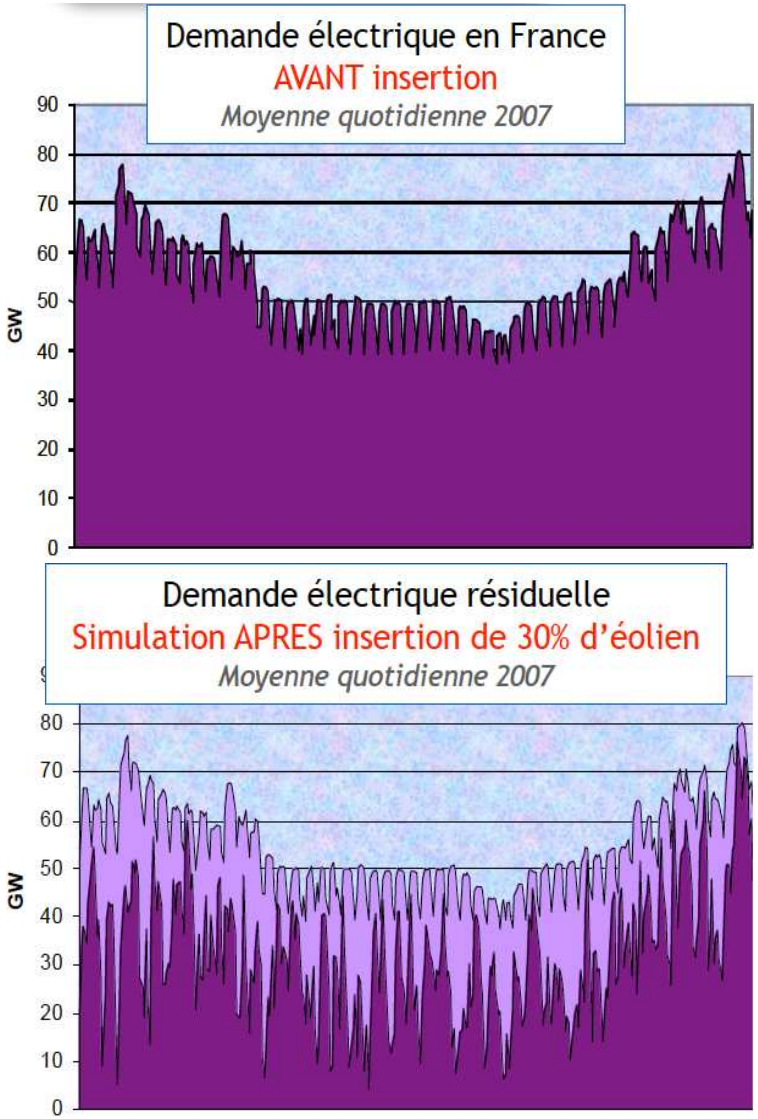
- Environment / Penetration of renewable energies
- Expansion of markets
- Penetration of Information Technology



Key driver: environmental concern

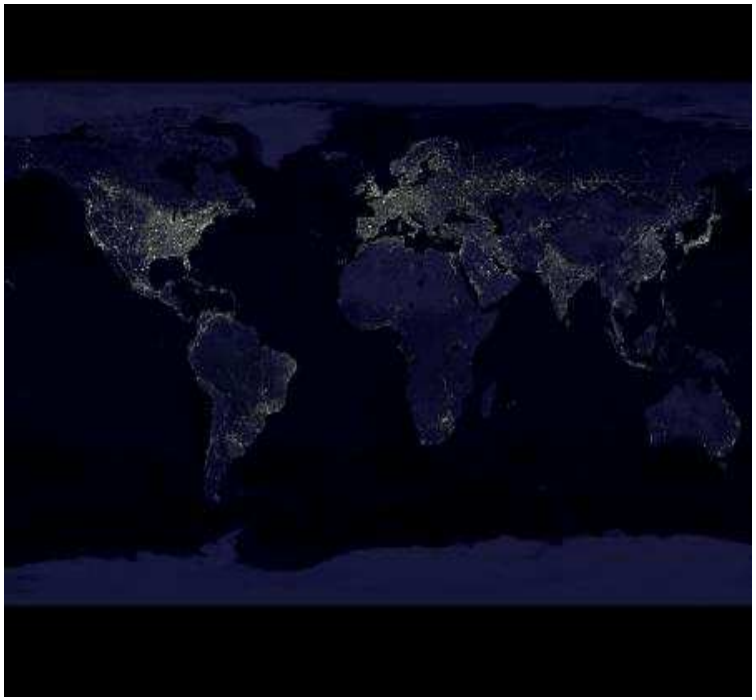
- The European Union climate and energy package materializes an environmental concern with three 20-20-20 objectives for 2020
  - a 20% improvement in the EU's energy efficiency
  - a 20% reduction in EU greenhouse gas emissions from 1990 levels
  - raising the share of EU energy consumption produced from renewable resources to 20%
- COP 21, Paris 2015

Key driver: penetration of renewable energies



- Costs of wind and sun energies have dropped down
- Successfully integrating renewable energy sources has become critical
- But wind and sun energies are unpredictable and highly variable
- This triggers the use of local storage

Key driver: economic deregulation



- A power system (generation/transmission/distribution)
  - less and less vertical (deregulation of energy markets)
  - hence with many players with their own goals
- with some new players
  - industry (electric vehicle)
  - regional public authorities (autonomy, efficiency)
- with a network in horizontal expansion
- with more and more exchanges (trade of commodities)

$\Downarrow$

A change of paradigm for management
from centralized to more and more decentralized

Key driver: telecommunication technology

Linky

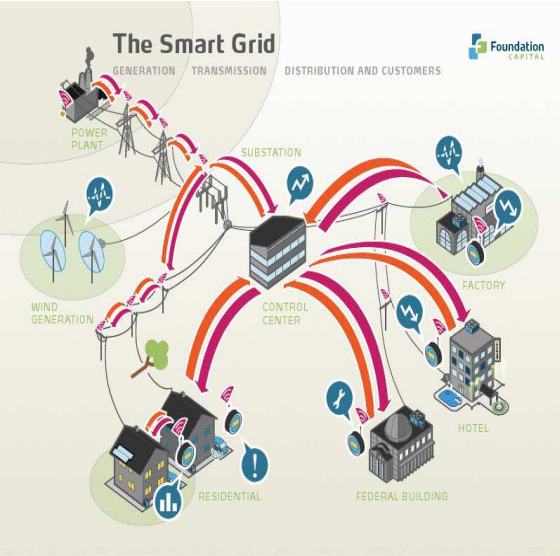
A power system with more and more technology due to evolutions in the fields of metering, computing and telecoms

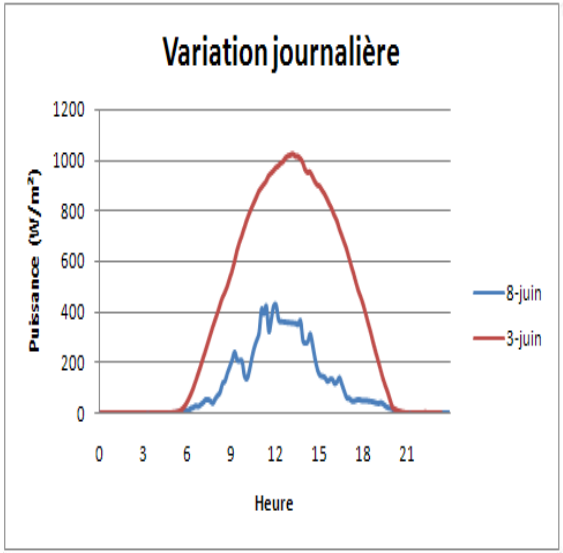
- smart meters
- sensors
- controllers
- grid communication devices...

$\Downarrow$

A huge amount of data which, one day, will be a new potential for optimized management

The "smart grid"? An infrastructure project with promises to be fulfilled by a "smart power system"





- Hardware / infrastructures / smart technologies
  - Renewable energies technologies
  - Smart metering
  - Storage
- Promises
  - Quality, tariffs
  - More safety
  - More renewables (environmentally friendly)
- Software / smart management
  (energy supply being less flexible,
  make the demand more flexible)

smart management, smart operation, smart meter management, smart distributed generation, load management, advanced distribution management systems, active demand management, diffuse effacement, distribution management systems, storage management, smart home, demand side management...

Outline of the presentation

1 What is happening to power systems?

2 What new management problems do we see emerge?

The energy system is becoming more and more complex: Supply

- Energy resources are blossoming:
  photovoltaic (individual, solarfarms), solar heating, heatpumps, wind power (onshore and offshore), hydraulic power, combined heat and power generators
- Energy resources are more and more spatially scattered
- Wind and solar energies are highly variable and intermittent

The energy system is becoming more and more complex: Demand

- Demand may also become more intermittent: electrical vehicles
- Part of the demand may become controlable (sheddable): hot water tanks, electrical vehicles, etc.

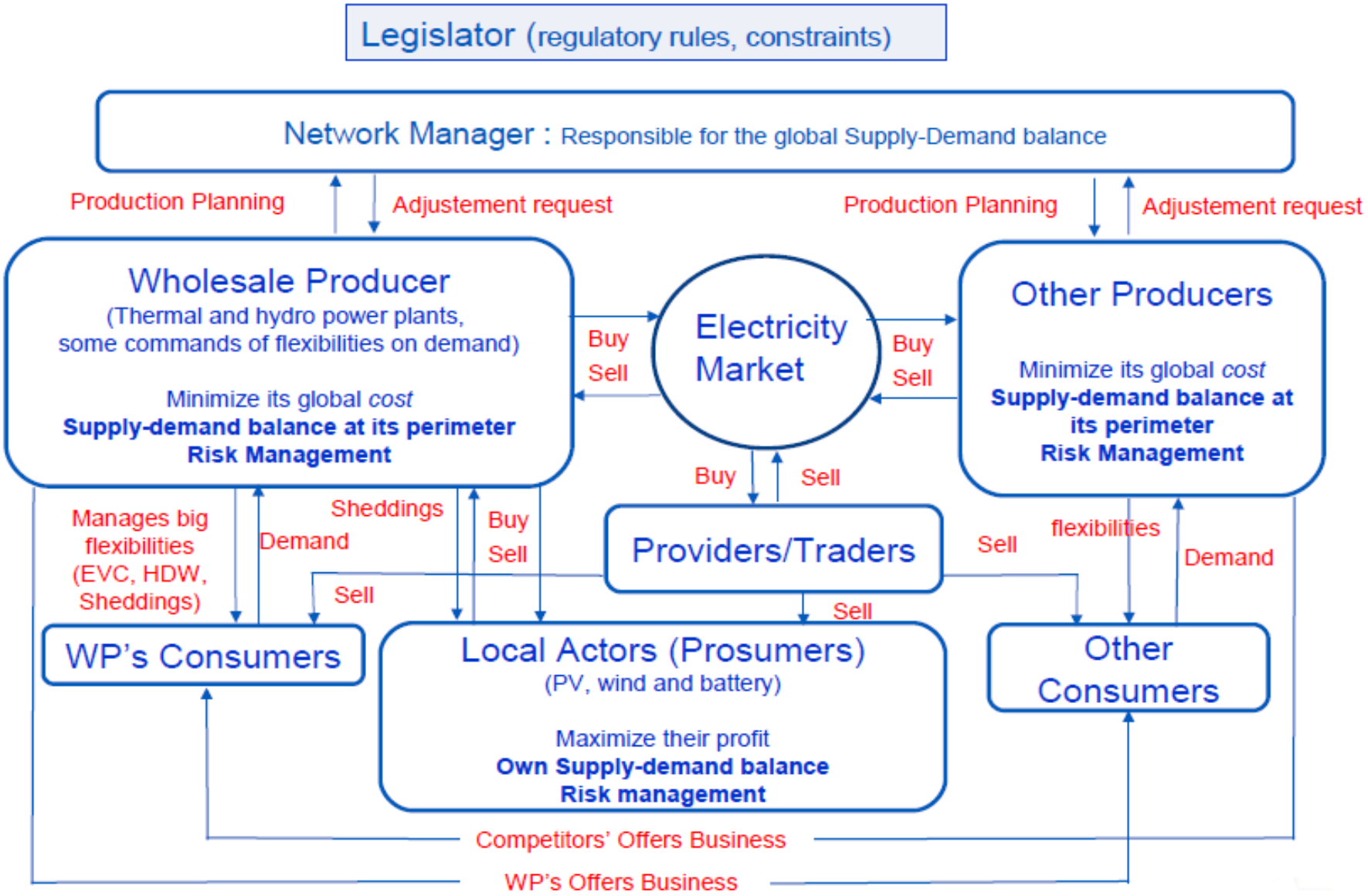
The energy system is becoming more and more complex: Supply = Demand

- Electricity flows in two-ways in the grid
- Local storage is expected to increase
- With so much variability, in time and in space, tackling with risk is critical (peak placement)
- Players are multiplying on the energy market — producers, prosumers, aggregators, cities and regions — calling for new economic regulation

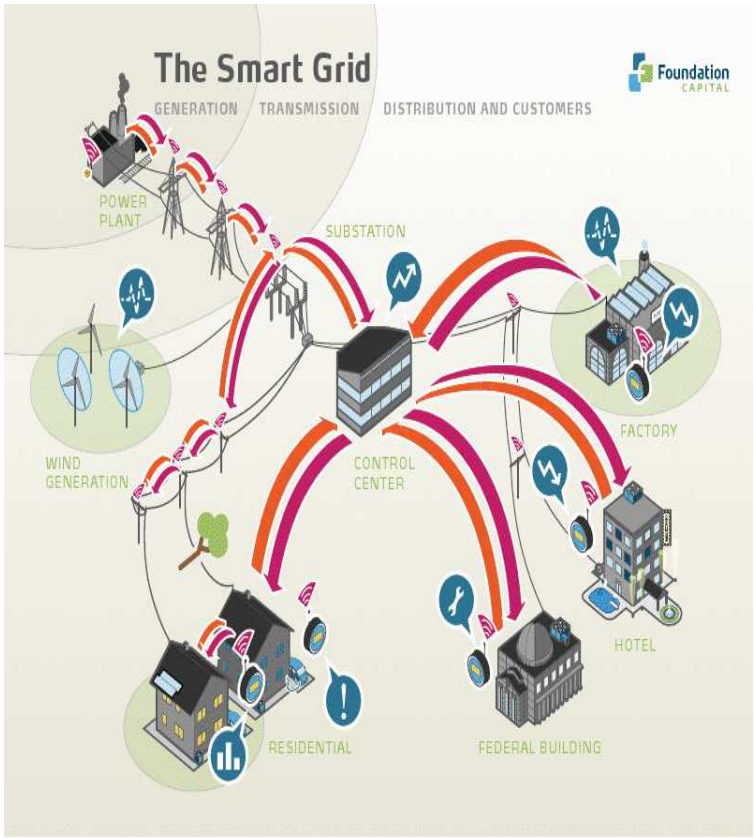
What demand for applied mathematics?

- More telecom technology
  $\hookrightarrow$ more data
- More data and more unpredicability
  $\hookrightarrow$ more statistics
- More unpredictability
  $\hookrightarrow$ more storage $\hookrightarrow$ more dynamic optimization
- More unpredictability
  $\hookrightarrow$ more stochastic dynamic optimization
- More computer technology and more decision centers
  $\hookrightarrow$ more decentralized optimization
- More players with their own agendas
  $\hookrightarrow$ more game theory
- More players with their own information
  $\hookrightarrow$ more game theory with information
- More players to coordinate
  $\hookrightarrow$ more mechanism design

The Centralized/Decentralized General Problem



OGRE: optimization, game and renewable energies



- Tackling large scale stochastic optimization problems:
  spatial, temporal and scenario decompositions
- Handling risk in a dynamic setting, and designing adapted algorithms
- Coping with multiple players with their own objectives and with decentralized (private) information:
  - team optimization
  - bi-level optimization
  - game theory
  - stochastic equilibrium
- Proposing new rules:
  mechanism design