
IPF 2019 PARIS
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The paradox of negative prices

Circumstances and possible solutions

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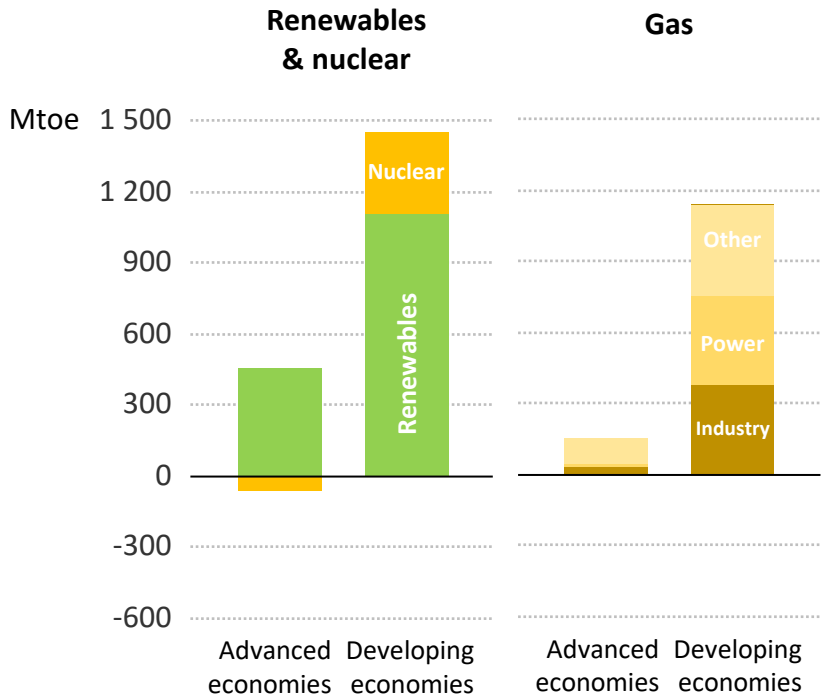
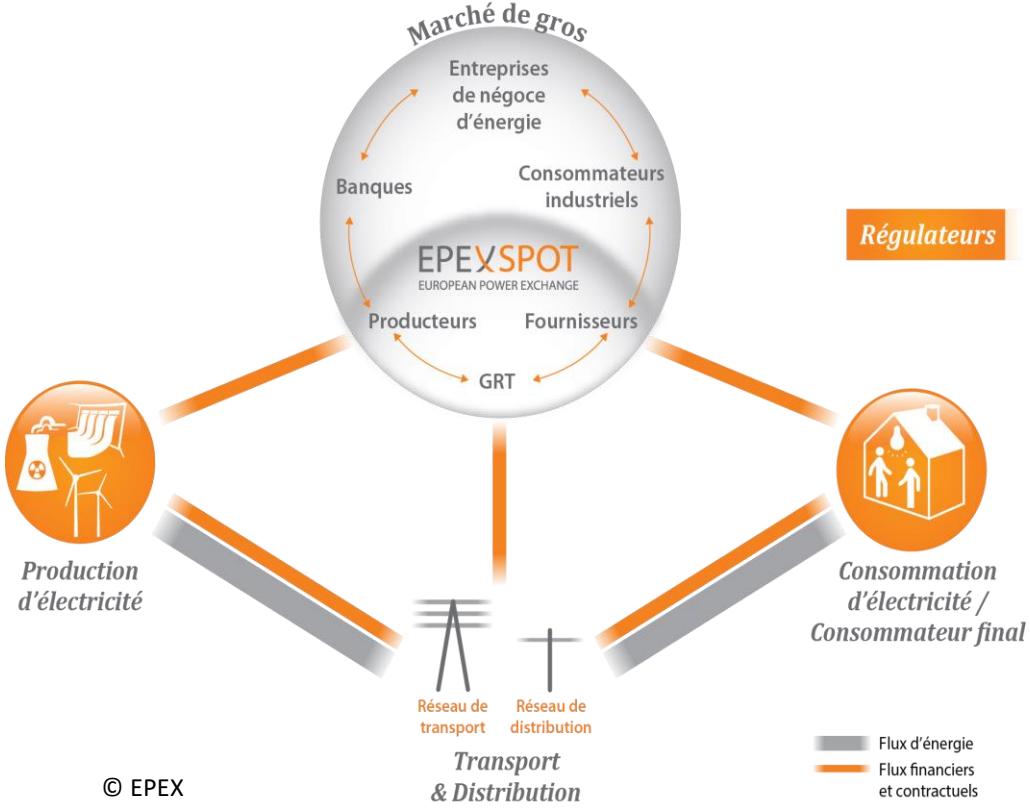
The future is electric !

- **OECD and IEA state in 2018 :**
  - Coverage of energy demand by electricity will rise from 19% today to 30% in 2040
  - Solar PV has the momentum
- **But to keep the lights on market designs need to deliver both electricity and flexibility**
  - The electricity sector is responsible for 40% of CO2 emissions (3/4 of which by coal fired powerplants)
- **Measures against global heating start with a clean electricity generation**

Response to change in global energy demand 2017-2040



Market organisation France

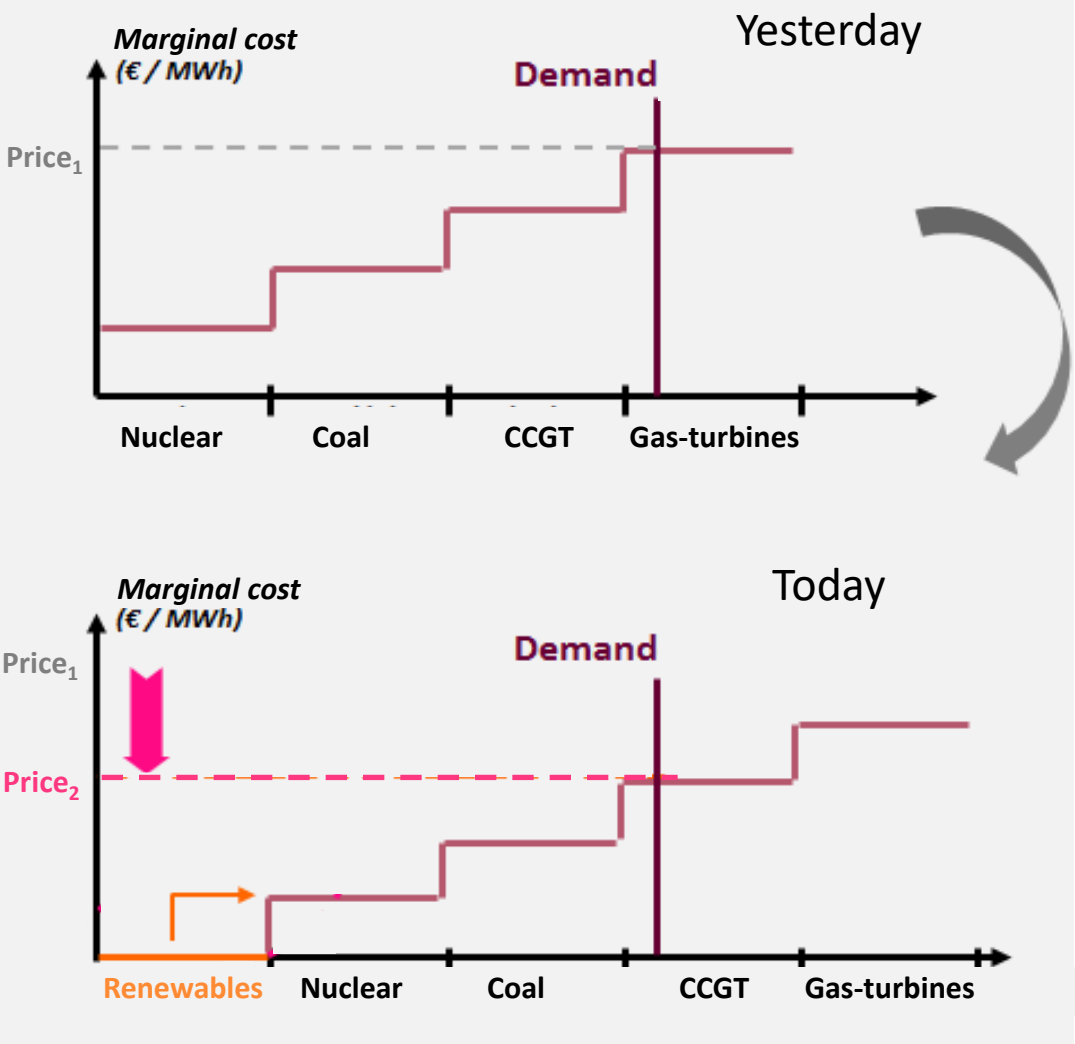


The world of electricity changes

- **Regulation changes structure of companies**
  - New interfaces between separated companies
  - Increased precision for cost calculation
- **Creation of the european power exchange EPEX**
- **Competition puts pressure on costs**
  - New technologies
  - Innovative new players
- **Technologies evolve**
  - Nuclear phase-out
  - Renewables become real alternatives
- **Subsidies for renewables begin to fade out**

Evolution of renewable energy pricing and its effect on the merit order

- **After 2000**
  - Fixed prices depending on size and type of renewables
  - Always first merit order
- **After 2010**
  - Market prices plus subsidy
  - First notions of disconnection in case of system needs
- **After 2015**
  - Inverted auctions
  - Maximum rates (energy and number of incidents per year) for disconnection of renewable generators in new power puchase agreements



Technical aspects of energy systems

- 20th century electricity system : dispatch generation to follow demand, electricity cannot be stored

$$G = D$$

- In order to insure frequency thus system stability !

$$G_{dispatchable} = D_{non-dispatchable}$$

- Modern system : assuring an equilibrium at all times is more complicated

$$G_{dispatchable} + G_{non-dispatchable} = D_{dispatchable} + D_{non-dispatchable}$$

The origin of negative prices

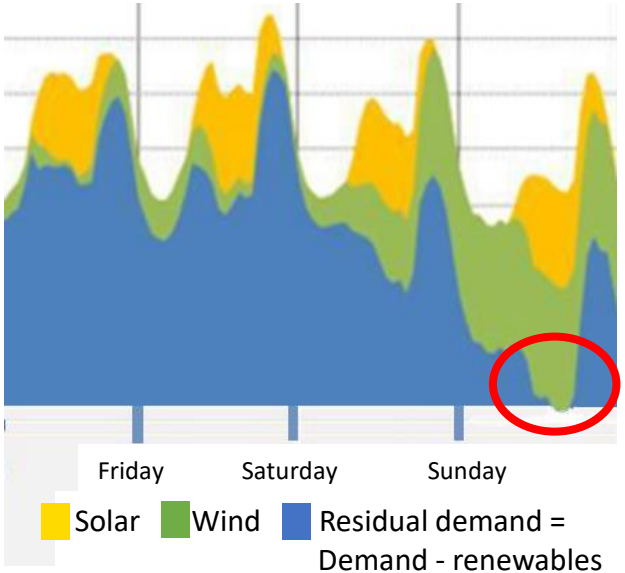
- **The world has changed : flexibility has to be able to cope with the variability induced by renewables and load !**

$$G_{dispatchable} - D_{dispatchable} = \underbrace{D_{non-dispatchable} - G_{non-dispatchable}}$$

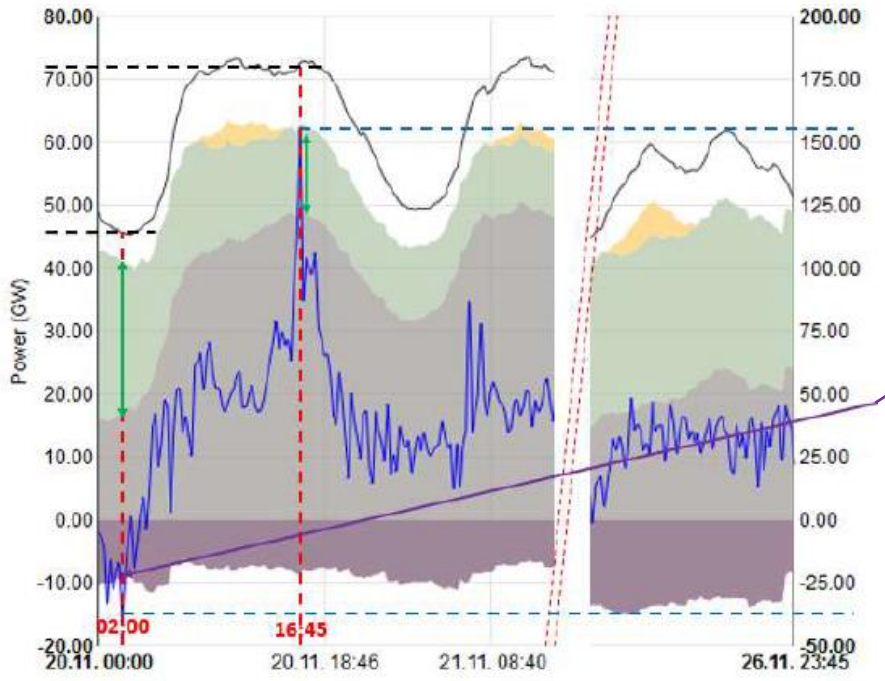
- **So we need more on the dispatchable side**
  - Make it interesting for customers to give away control of (a part of) their equipment
  - More flexible equipment at the customers' move non-dipatchable demand to dipatchable
  - Build more flexible power-plants with high ramping capabilities (CCGT, Gas-turbines, batteries)
  - Make renewable generation more predictable thus move it from non-dispatchable to dipatchable

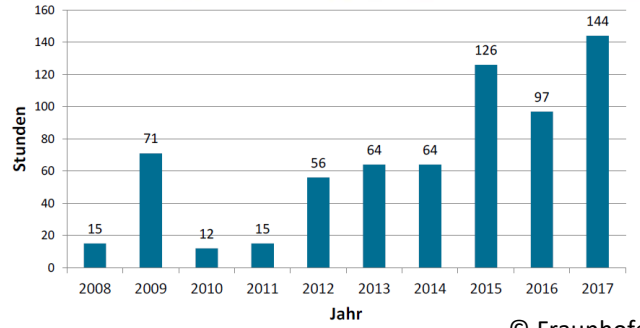
- **Because if the renewables ($G_{non-dispatchable}$) generate more than your demand asks for (= your « residual demand » is negative)**
  - You need to disconnect renewable power generators or
  - be connected to a neighboring country that needs electricity in that very moment or
  - pay somebody to consume the power overflow !

this is called « residual demand »



Occurrence of negative prices





Grafik: B. Burger, Fraunhofer ISE; Daten: EPEX

- **Germany's electricity system is prone to continuing periods with negative prices on its spot market**
  - On Monday 20th of November 2017 prices went from -40€/MWh at 2 am to 155€/MWh at 5 pm
  - Power of installed renewables rises every year and with it the number of hours with negative prices
  - Electricity demand is stable (at best)
  - Still : estimates for the overall cost of negative prices periods is about 200M€ / year
- **In Spain the number of negativ hours is comparable**
  - It is also caused by a huge amount of installed renewable power
  - the overall cost is lower
- **The biggest incident in France (June 2013, -200€/MWh) was caused by nuclear power-plants that couldn't be shut off**
- **As almost all European countries are interconnected, negative prices in one country « swap over »**

Solutions for the occurrence of negative prices exist

- **The initial problem was variability…**

… which is tantamount to fatality

something unchangeable

and not forecasted

… and to lack of flexibility !

The solutions are:

Means for weather forecast (clouding, wind)

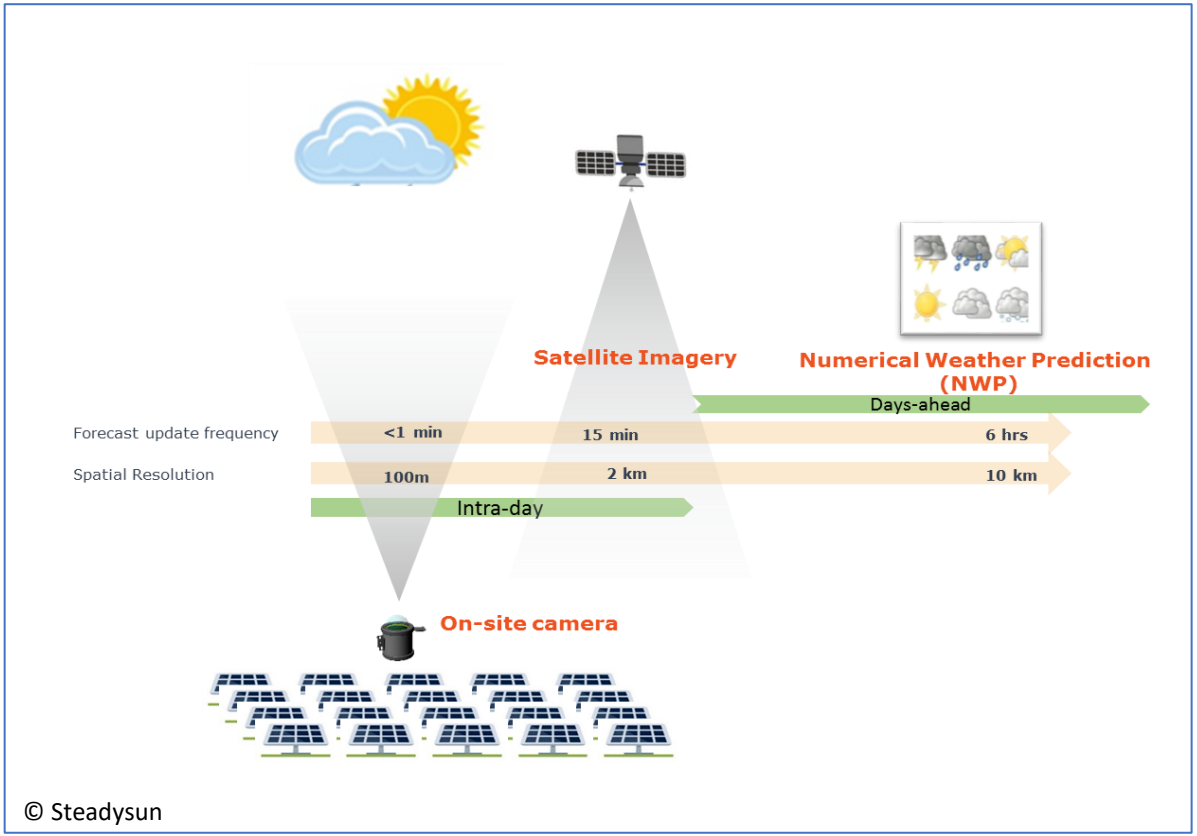
Market integration to smooth variability (demand as much as weather influences)

Market design to cope with this new world

Technology (e.g. storage)

Forecast

- Increasing the quality of forecast will reduce variability of intermittent power sources
- Learning algorithms integrate regional and local as well as day ahead and short term forecast
- Advantages are : less operational margins, less reserves and thus less costs !



Market integration

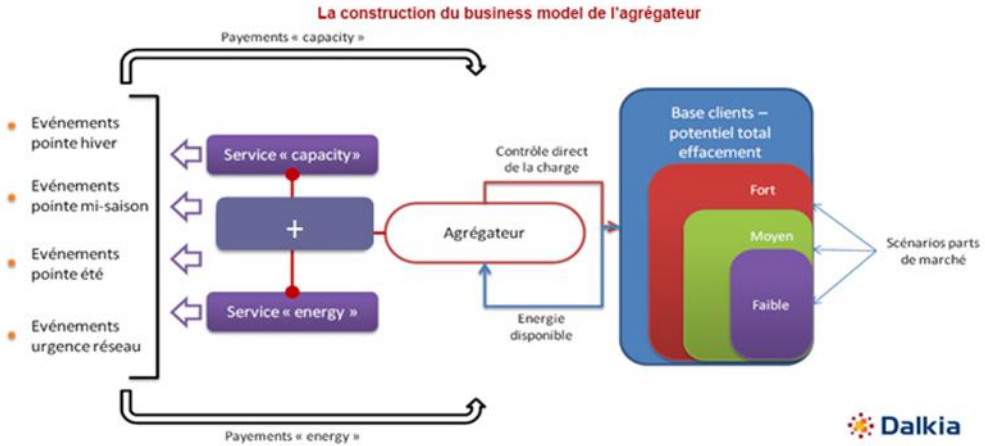
CORESO

TSCNET

- Smoothing of variability by interconnecting markets (ENTSO-E)
  - Joint planning of grids
  - Joint forecast
- Joint operation, especially for constraint situations (CORESO, TSCNET…)
- And most important a common market : the EPEX power exchange

Market design

- **New players, new rules**
  - Creation of a capacity market (versus the energy only market) in order to ensure presence of power in scarce wind and solar power situations
  - Rules for renewable power sources operators limiting their negative impact in tense market situations
    - In Germany after 6h of negative prices on EPEX, renewables (of a certain size) have to lower infeed of power
  - Tarifs that fit renewable generation pattern (solar maximum between 10am and 3pm)
  - Demand side management
    - In order to offer positive and negative power adjustment on the spot market, **agregators** can either remotely control a huge number of small customers or some big industrial loads
    - The good old EJP tarif put in place in the nineties by EDF (max 22 very high tarif rate days in winter in case of tense generation situations)



Technology

Tesla Battery in Australia

Ambri System

500 kW / 1 MWh

5 Ambri Cores

Integrated with grid-tied power electronics

- **Storage today**
  - Centralized : add batteries to existing powerplants for higher ramping rates thus better grid stability
  - Centralized : grid stability for weak grids
  - Decentralized : wallboxes for solar power, EV charging and household peakshaving
- **Electricity-to-heat, -to-cold, -to-hydrogen or every other transformation linked to storage that can help to shift load for several hours**
- **Storage in future**
  - peak-shaving for industry and services, but only for very specific use cases
  - Max load in France above 100 GW about 30h a year; thus a need for 150 GWh or 150 million kWh; at a target price (after 2023) of 100 $/kWh
    - That would amount to about 25 billion $ (as opposed to a comparable investment in gas-turbines of 5 billion $ and a double life-time)
  - So **disruptive** storage technology is needed for large scale arbitrage


Turn
off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