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TRACTEBEL
ENGIE

Response
ELECTRICITY MARKET DESIGN AND THE GREEN AGENDA

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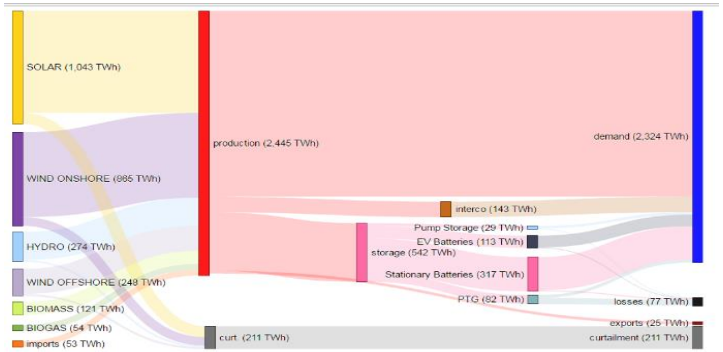
Disclaimer: The opinions expresed in the presentation are those of the author alone and might not reflect the views of Engie or Tractebel

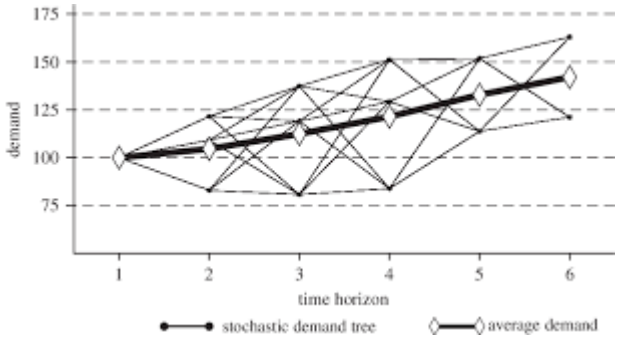
Based on joint work/ with Ibrahim Abada, Gauthier de MAERE d'AERTRYCKE and Yves SMEERS [2]

100% RES scenarios: The Green Agenda

Energy Mix: we know where we want to get

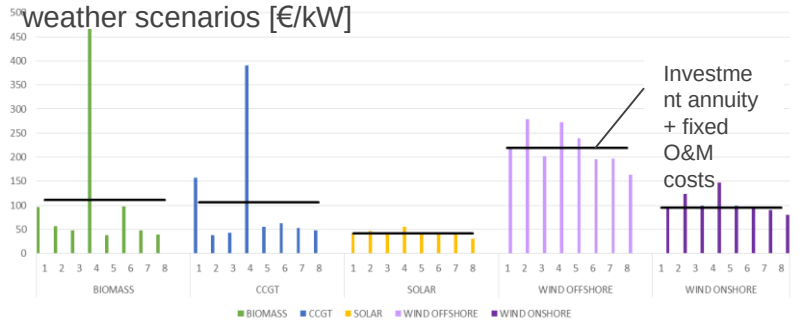


Long term
Pathway uncertainty

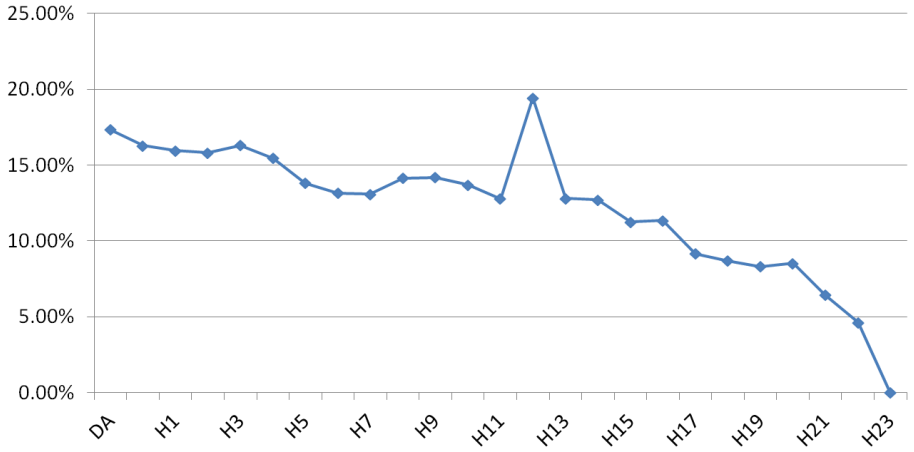


Mid term
Energy uncertainty (like in hydro systems)

Revenues compared to fixed cost for 8 different weather scenarios [€/kW]



Short term
Wind error forecast (std. deviation) prior real time - RTE



Outline

The scope of the talk is about the details of an energy market design for green agenda.

1. Clarification for the US and EU design: Can the proposals easily transposed to Europe?
2. System services and ORDC: is a single signal enough?
3. Some computations: Are (efficient) short term markets enough?

(1) Focusing on risk management between real time operation and day-ahead

- Where are prices measured? EU centers around day ahead / US around RT markets
  - The French economists (Boiteux et al.): the short run marginal cost is equal to the long run marginal cost in an optimally developed system.
- ISO-based design differs from EU design by many aspects
  - Clearing / algorithm : ISO vs. power exchanges, central unit commitment vs. Euphemia, uplift vs. Paradoxically rejected bids
  - Reserve / ancillary services : joint (co-optimized) vs. separated procurement
  - Transmission : nodal vs. zonal, at all time vs. mainly in the DAM,…

 : Controversy about the role and performance of virtual bidding (Hogan,2016/PJM; FERC 2018)

- Virtual bidding is justified by risk (Hogan); does not work well and causes problems (FERC et al.)
- Need for a framework to analyse the overall cost and benefits of virtual transactions (Hogan)

 : Current focus on short-term price signal (EOM 2.0, shortage function) without much discussions on how that propagates forward

- Discussions with regulators on inclusion of intraday/real-time expectation in day-ahead bids
- Improvements for intraday (XBID)

(1) Two market designs to organize deregulated electricity market

: ISO performing central dispatch

Day-ahead market (DAM)
- Asset based offers
- Virtual bids
- Cleared by solving the unit commitment problem

Update plant conditions

Real-time market (RTM):
- Re-optimization of the dispatch to adapt to new conditions
- **Real time price**
- **ORDC**

: Power trading followed by a balancing market

Day-ahead market (DAM)
- Bid based offers (not *necessarily* linked to an asset)
- Voluntary participation
- BUT regulatory obligations: (mainly self-balance)

Intraday markets

Balancing market (?)
- Organized by TSO
- Ideally a market but Bids/Penalty/Clearing differ widely across countries

(1) Both EU and US system are not « first best » equilibrium

The theoretical notion of the complete market

- In both EU and US design, there is only limited possibility to hedge against real-time outcomes
  - In EU: day-ahead is a physical forward market, opportunity cost bidding
  - In US: day-ahead + virtual bids
- To increase market efficiency, one needs more hedging products (not necessarily based on physical operation)
- The optimal outcome is obtained when the market is complete : one financial contract by contingency
  - Impossibility to implement this in practice
  - But very easy to compute (cf. Ralph and Smeers, 2016)
- We find in a computational exercises that for Short Term markets both systems arbitrage the market reasonably well but not perfectly.

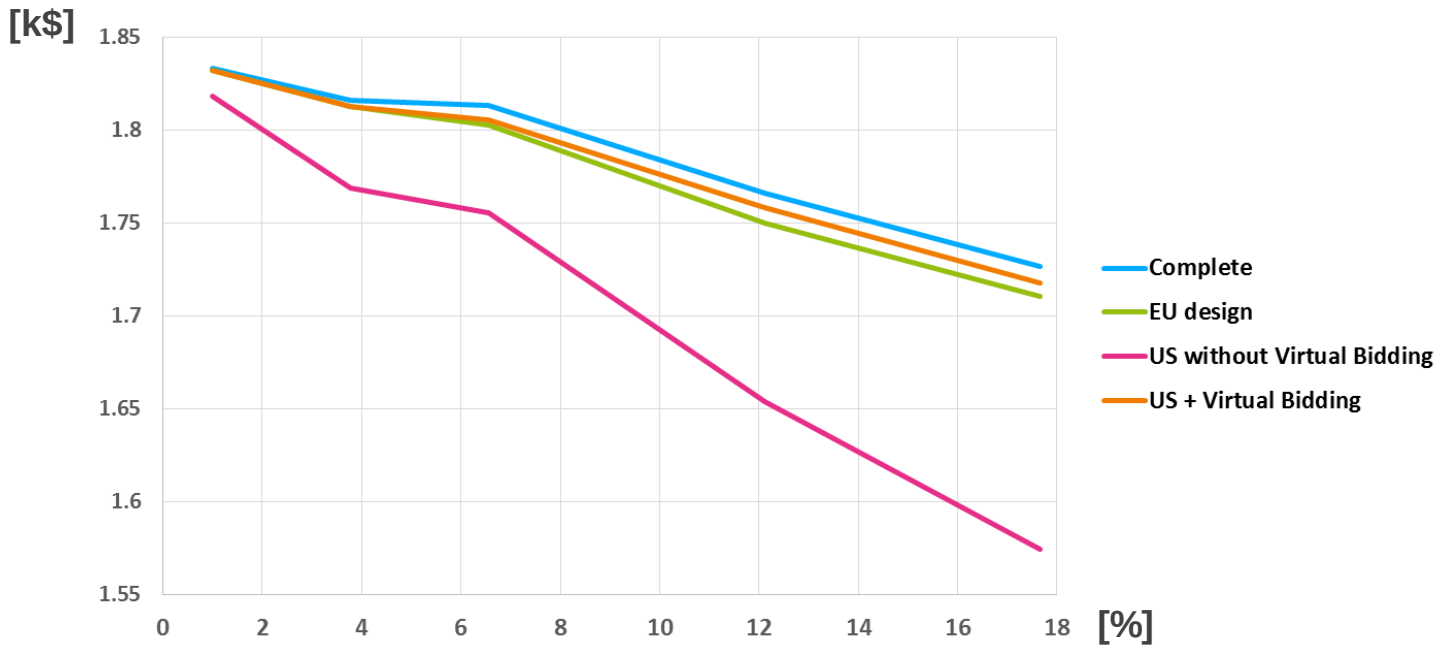
I only state the results here based on only the equilibrium models and numerical findings on an illustrative example. Theoretical results (equilbrium existence) exist under technical assumptions.

(1) Cost benefit analysis of the different designs

ONLY wrt risk management and opportunitines between DAM and RTM

- Welfare defined as the sum of agents risk-adjusted profit
  - Maximimum in the complete case
  - Virtual bidding improves greatly the market efficiency

Welfare as a function of RES uncertainty (std deviation)



(2) Energy only vs. Energy and Services: Virtual trading

- Power plants earn their living from energy and services
  - A pure energy system obeys a merit order rule: plants are ranked by order of cost
  - Services, when there are scarce may perturb the merit order.
- The energy transition will require more services (increased short term uncertainty due to e.g. wind predictions..): can things be different?
  - New ramping constraints in central dispatch models (CAISO)
  - New reserve products/markets (Ireland)
  - Flexibility IF scarce (no claim that this will happen, it will depend on the flexibility of new plants) can change the merit order just like congestion can.
  - For congestion virtual trading products exist for the difference between day ahead expectation and real time dispatch.
  - Will we also need virtual trading products for other services like ramping?

(2) Energy only vs. Energy and Services: ORDC

- ORDC acts as an “instantaneous” capacity market

  - ORDC integrates anything that could affect LOLP (reserve, ramping) into the energy demand. At higher prices reserve requirements are reduced.
  - Clearing prices can exceed supply bids without « scarcity ».
    - Value of (unused) reserve capacity is translated into an energy price for all
    - ERCOT (Texas) experience show some price adders → works as expected.

- Prices impact
  - For a given technology mix we can calculate the price adder
  - The price adder includes all the services that might be « binding »
  - But does the price adder reveal the marginal contribution to service requirement given the different characteristics of technologies ? → will we invest in the right technology?

(3) Are short term markets enough?

Economic discussions of policies often make the implicit assumption that it suffices to make the short run efficient to guarantee long run efficiency

But there is a long way between creating values in short-term markets and appraising this value in investment calculation.

Stiglitz and Newbery (1984) show that a market satisfying all assumptions of perfect competition in a deterministic world may become grossly inefficient in a risky environment if proper instruments for trading risk do not exist.

- See Newberry *Missing Money, Missing Markets Reliability, Capacity Auctions and Interconnectors , EPRG working paper 2015*

> *Missing markets* create problems if risks cannot be efficiently allocated with minimal transaction costs through futures and contract markets, or if important externalities such as CO_2 and other pollutants are not properly priced. The concept of missing markets can be usefully extended to cases in which politicians and/or regulators are not willing to offer hedges against future market interventions that could adversely affect generator profits. These arguments have been extensively covered in the literature,

(3) Methodology

Our work is based on computational models.

- We depart from optimization found in many modelling works and simulate interactions between agents (producers, merchants and final demand) on the market.
- These models used here are “two stages”:
  1. decisions to invest and contract are made in a first stage before uncertainty is revealed;
  2. short-term physical markets (hubs or PX) clear in the second stage.

The treatment of risk is through “coherent risk functions” (Artzner and Delbaen).

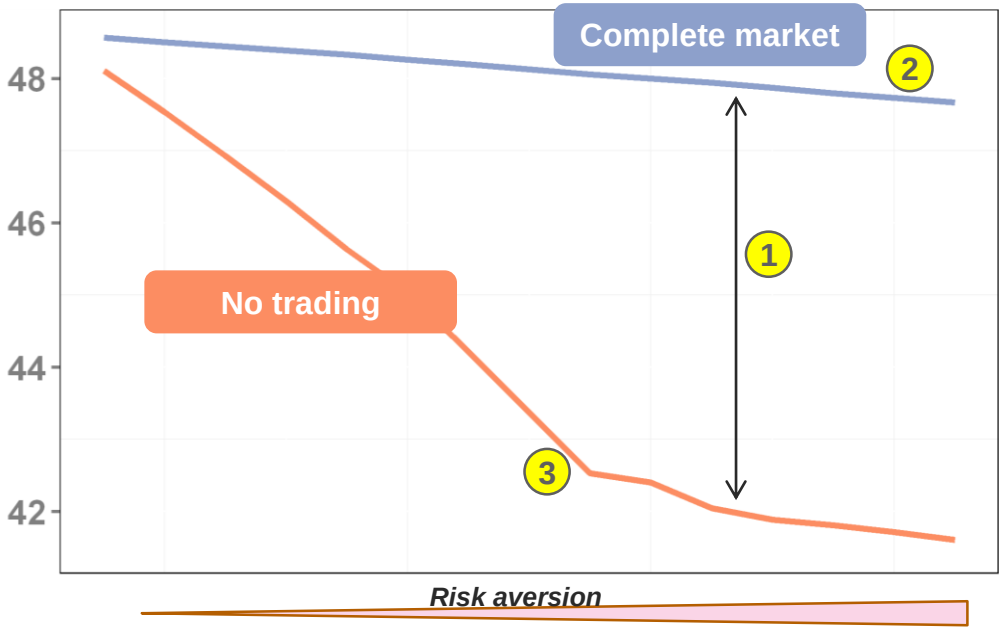
- risk-aversion progressively discounts higher profits, which decreases their value and reflects higher prudency in the presence of risk.
- Specifically an agent invests when the investment cost is covered by the risk adjusted value of the future payoffs.
- Details in: *Investment with incomplete markets for risk: The need for long-term contracts*, Gauthier de Maere d’Aertrycke, Andreas Ehrenmann, Yves Smeers Energy Policy 2018

(3) The two Reference cases

Risk-Adjusted Welfare

The reference cases are extreme cases: all mechanisms will stay in this range. (1)

Risk-adjusted Welfare – M€



Comments

(2) Welfare in the **complete market** is the highest possible.

(3) In the **no trading** case, the producer and the consumer cannot share their risk. The risk-adjusted welfare is significantly destroyed as they become more and more risk averse.

Risk-adjusted Welfare – M€

What: The risk-adjusted welfare is the sum of the risk-adjusted (E-CVaR) profits of the consumer and the producer. We show its variation with the risk aversion of the consumer and the producer.

(3) The two Reference cases

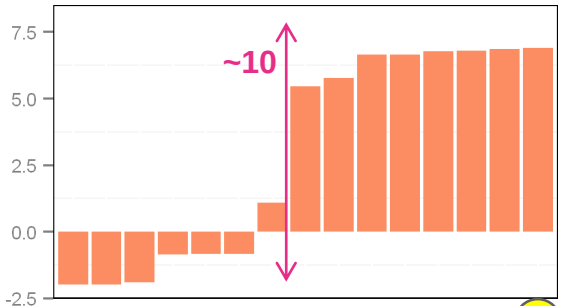
Profit distribution

Both the producer and the consumer benefit to trade in a complete market. (1)

B **Profit distribution – M€**

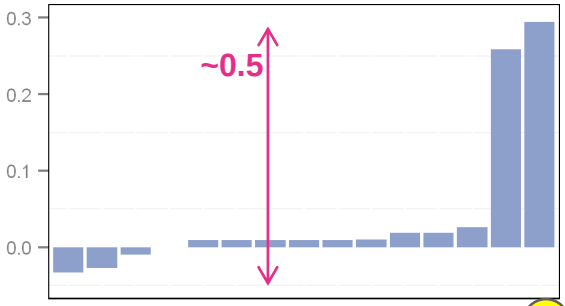
Producer

No trading



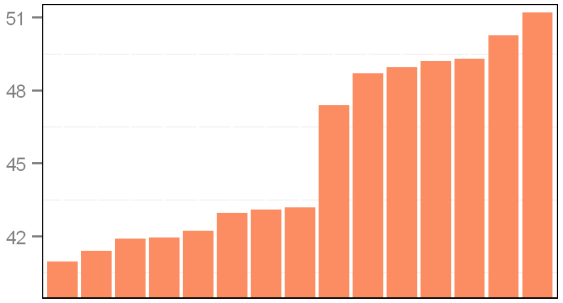
$\mathbb{E}[\Pi] = 4.23$ $\text{vol}[\Pi] = 135\%$ (2)

Complete market

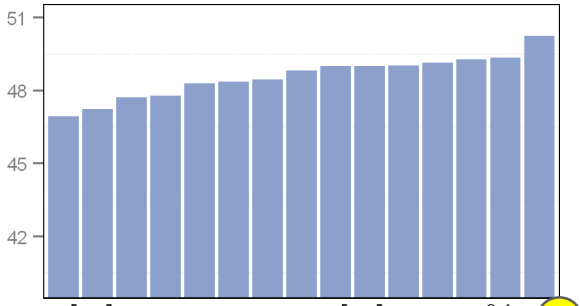


$\mathbb{E}[\Pi] = 0.04$ $\text{vol}[\Pi] = 3.8\%$ (1)

Consumer



$\mathbb{E}[\Pi] = 43.9$ $\text{vol}[\Pi] = 6.7\%$



$\mathbb{E}[\Pi] = 48.6$ $\text{vol}[\Pi] = 1.7\%$ (1)

Comments

(2) When there is **no trading** possibilities, the profit of the producer is particularly volatile.

Profit distribution – M€

What: The profit distribution shows the agent's profit in each scenarios.
The average ($\mathbb{E}[\Pi]$) and the volatility ($\text{vol}[\Pi]$) of the distributions are also printed.

Why: Illustrate the risks behind the 15 scenarios.

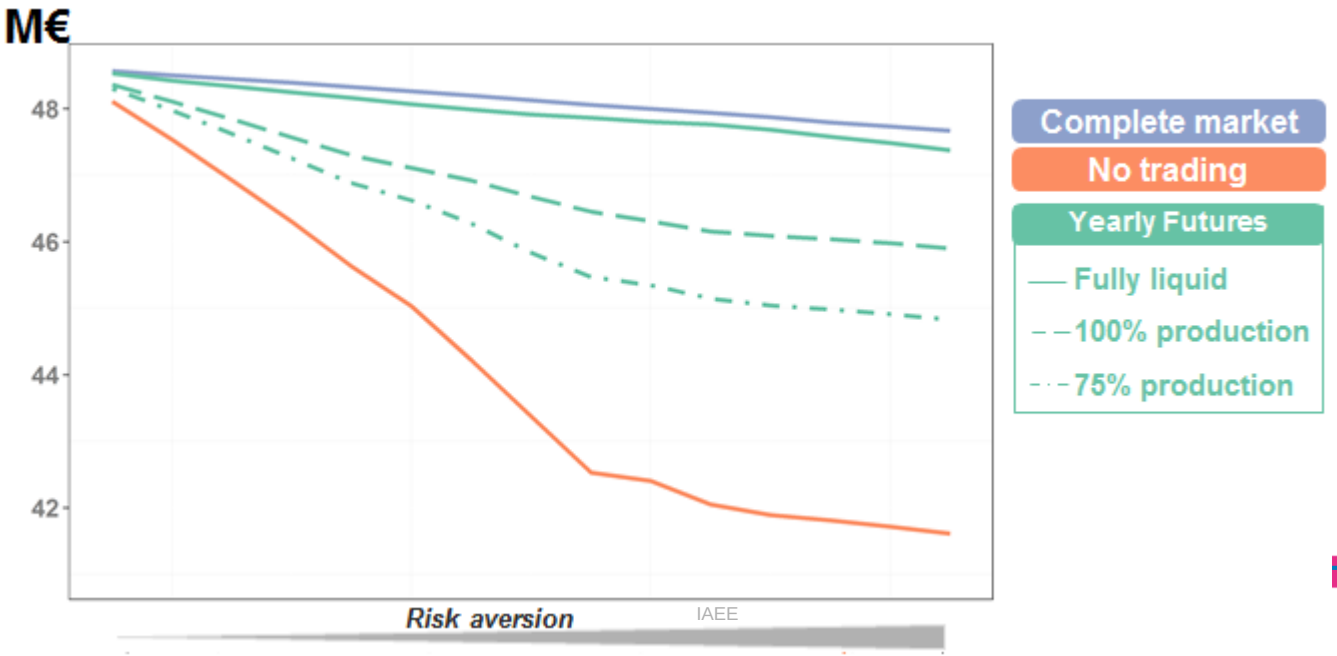
(1) *volatility: standard deviation divided by the average*

(3) No intervention: forward contracts

Limited liquidity destroys the benefits of classical contracts

- The important risk reduction implied by classical contracts requires a level of trading far above today's experience: Baseload FUTURES the total volume exchange represents more than **150%** of the expected power consumption
- Financial markets for power do not have such liquidity.
  - Producers cannot find counterparties to hedge fully their production
  - The liquidity limit on the futures contracts leads to a drastic reduction of the welfare
  - Assumption: the consumer only hedges 75% - 100% of its expected consumption

Risk-adjusted Welfare



Conclusion

Economists have pointed out the importance of risk trading. This directly applies to restructured markets in need of investments for the energy transition.

For the short term virtual trading can be a solution:

- But the FERC ruling of February 2018 that drastically reduced the number of nodes where VT was allowed in PJM (at the request of PJM) raises doubts if we can get to a complete market.

Europe proposes new products that will require complicated auctions to mimic « co-optimization ». Producers have to price a range of opportunity costs to arbitrage all sub-products. This will be more and more difficult.

Whatever the efficiently achieved in the short-term, these benefit may not be conveyed to the investment stage if risk is too high and risk trading not in place.

- The development of efficient risk trading, should not be taken for granted. The reason is practical: the market will probably not develop the required liquidity.