Analayzing Effective Competition In Energy Market Using Multi Agent Modelling

Hamid Aghaie

Researcher at Energy Department, AIT Austrian Institute of Technology

PhD Student in EEG Group, TU Wien

Supervisors

Prof. Reinhard Haas, Dr. Peter Palensky

Introduction: Changing Landscape

Increasing the share of

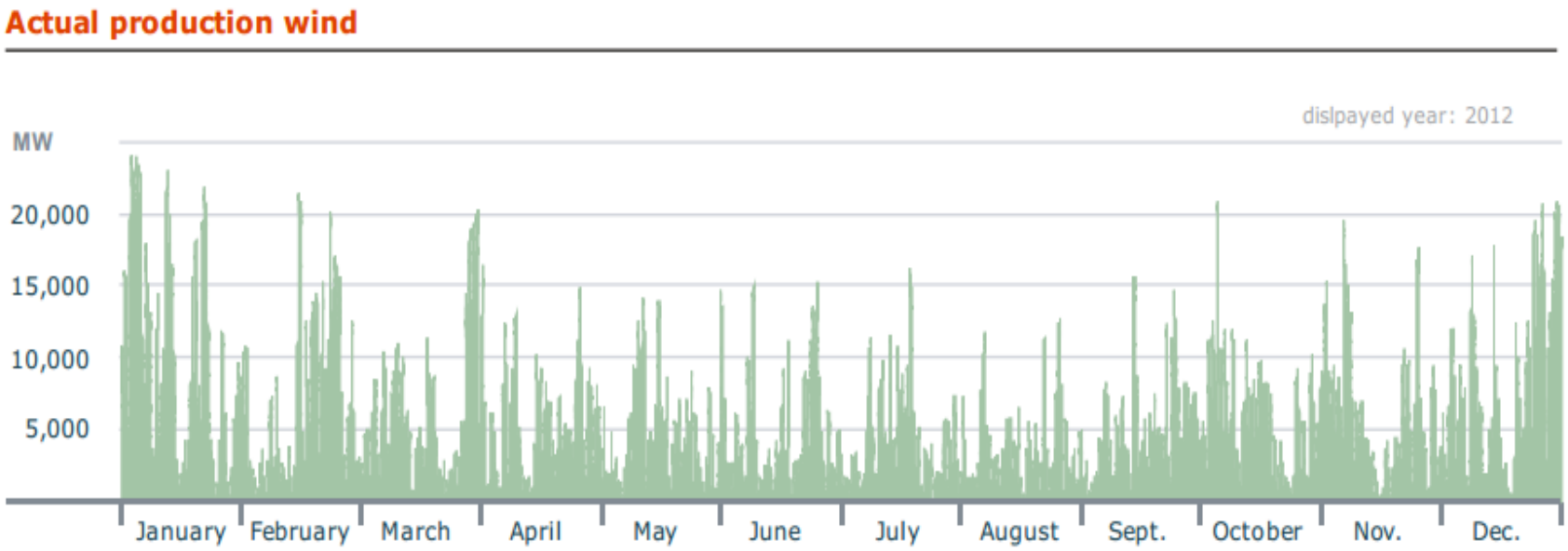
Intermittent Renewables

in the electricity market

Problem Statement

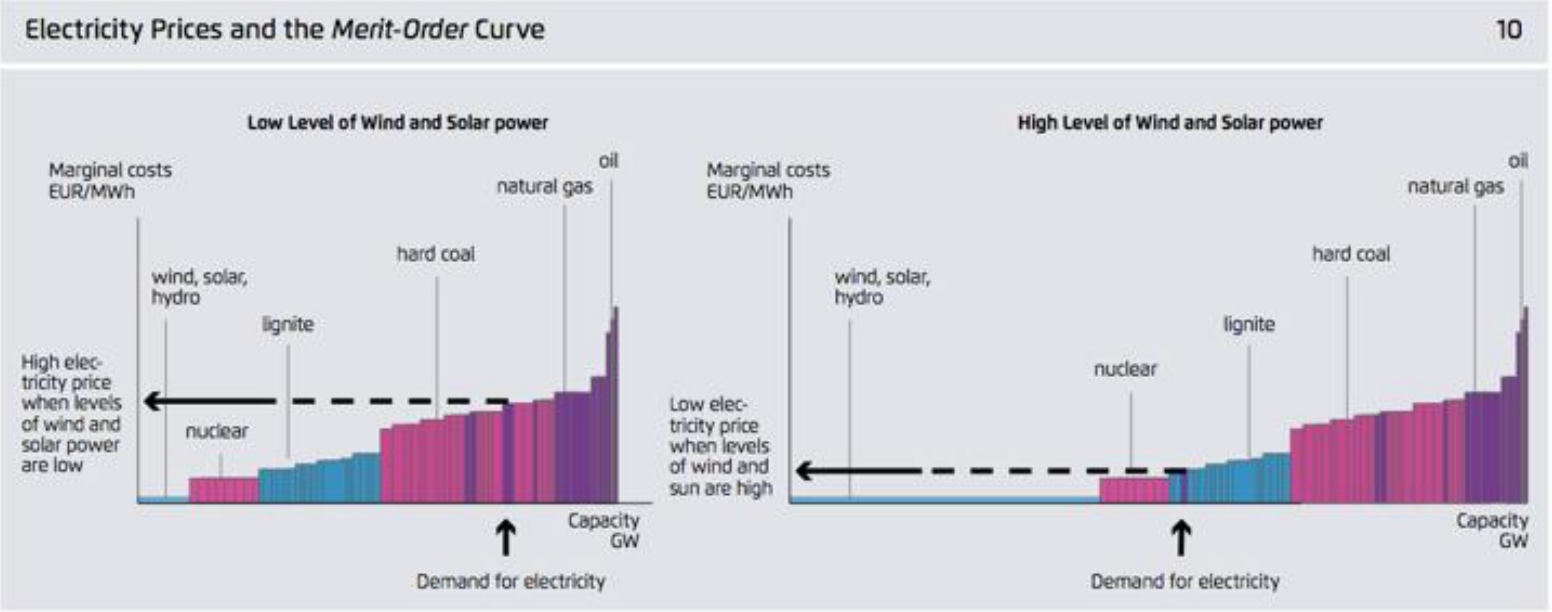
- Electricity produced by renewables:

  1) Highly fluctuating and intermittent



Problem Statement

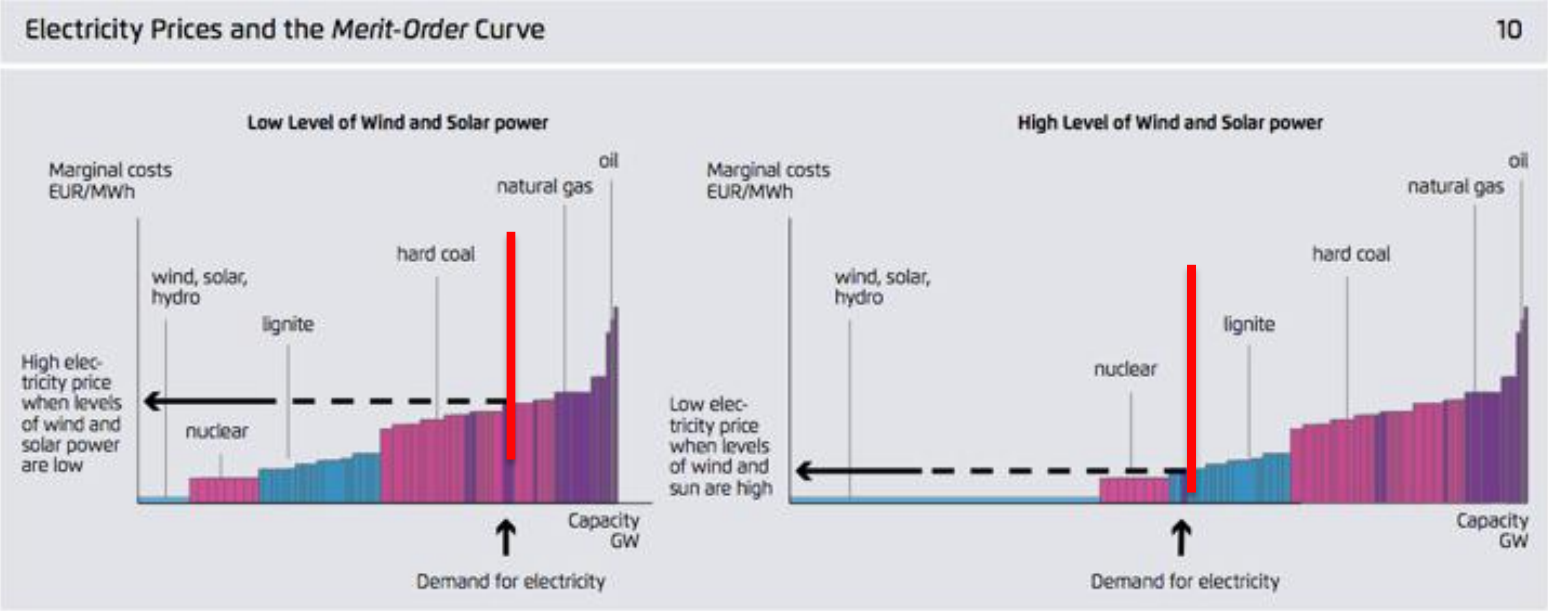
- Electricity produced by renewables:
  2) Less utilization of conventional generators



Problem Statement

- Electricity produced by renewables:

  3) Lower market price



Problem Statement

- 1, 2, 3 brings:
- Less utilization and less revenue for conventional generators
- Less incentive to investment in conventional generators
- Less reliable backup in the market

- **Supply Security Problem**

- Missing Money ~ Resource Adequacy ~ Revenue Sufficiency
- ISO needs a way to repay this “missing money” to keep enough generation on hand
- **Research Question:**
  - How an effective competition in energy market can solve this problem?

Market Structure: Effective Competition

- Effective competition in new market design

4 elements

- **1) Effcient Scarcity Prices**

  NOW

  - Scacity situation ocurrs rarely
  - Price cap

  To Do

  - Increase the frequency and duration of scarcity situations
  - High price caps
  - e.g. ERCOT,
    - maintain energy-only market (2012)
    - $4500 per MWh in 2012 to $9000 per MWh in 2015

Market Structure: Effective Competition

- **2) Active demand side participation**
  - Add flexibility to the market
  - e.g. Interruptible loads
  - e.g. PJM market, 2000 MW in 2007 to 16000 MW in 2015 (10% of total capacity cleared in capacity auctions)

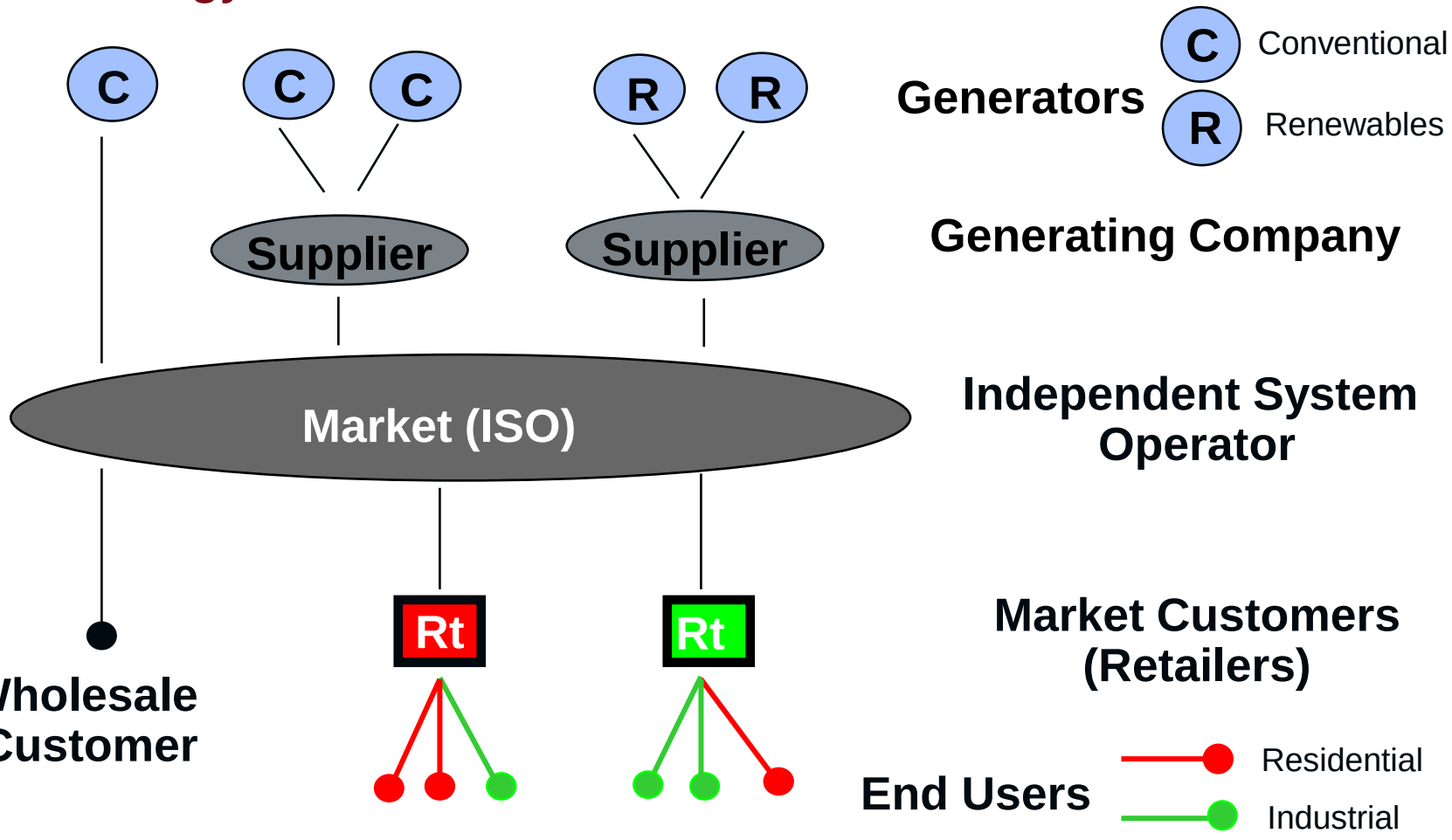
- **3) Utilization of storage facilities**
  - Add more flexibility to the market

- **4) Optimized guaranteed policies**
  - Reduce the investment risk
  - e.g. renewables support policies, introducing price caps

Methodology

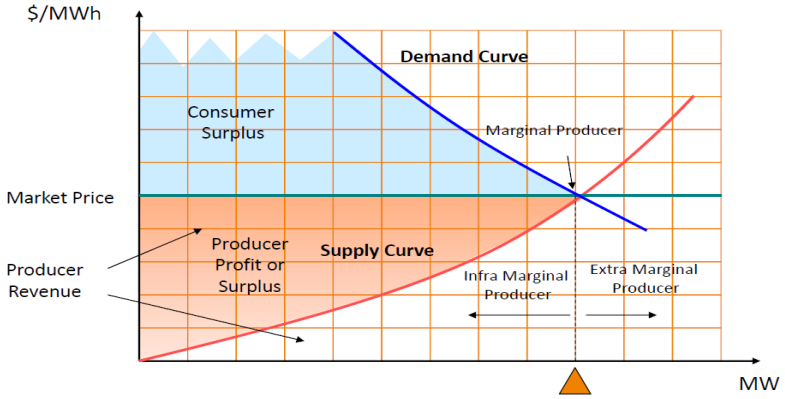
- Multi-Agent Systems (MAS)
  - Agent: an entity that acts upon the environment it inhabits
    - rationality
    - Autonomy
    - Proactiveness
    - Reactivity
- Game Theory (GT): analyze the interplay between parties that may have similar, opposed, or mixed interests
- Difference between GT and MAS : Strategic Decision Making
- Hybrid Model (MAS + GT)

Methodology: Market Model



Methodology

- Agents‘ strategies (actions): {Bidding price, Bidding quantity}
- Agent‘s goal: maximize its own individual surplus



- Strategy selection: ϵ-Greedy

P (Probability of selection)

$$1 - \epsilon + \epsilon/n \quad \text{Action with best payoff}$$

$$\epsilon/n \quad \text{Other actions}$$

Methodology

- Reward Function

$$R_{a_i} = MPC - q_{a_i} * c_{a_i} \quad \text{for Generator Agent}$$

$$R_{a_i} = q_{a_i} * d_{a_i} - MPC \quad \text{for Consumer Agent}$$

  - $\boldsymbol{MPC}$: Market Clearing Price
  - $\boldsymbol{q_{a_i}}$: Bidding Quantity
  - $\boldsymbol{c_{a_i}}$,$\boldsymbol{d_{a_i}}$: Bidding Prices

- Update Q-values : $Q_{a_i}^{new} = (1-\alpha) * Q_{a_i}^{old} + \alpha * R_{a_i}$

α: Learning Parameter

Conclusion

- **Purpose:**
  - Solve supply security problem using characteristics of market competition instead of administratively determined capacity requirements
- **Effective Competition:**
  - Efficient Scarcity Prices
  - Active Demand Side Participation
  - Storage Facilities
  - Optimized Guaranteed Policies
- **Method:**
  - Multi Agent Modeling
    - Adaptive learning
    - Strategic decision making

Thank You!