Cellular markets for distributed power grids: an exemplary study

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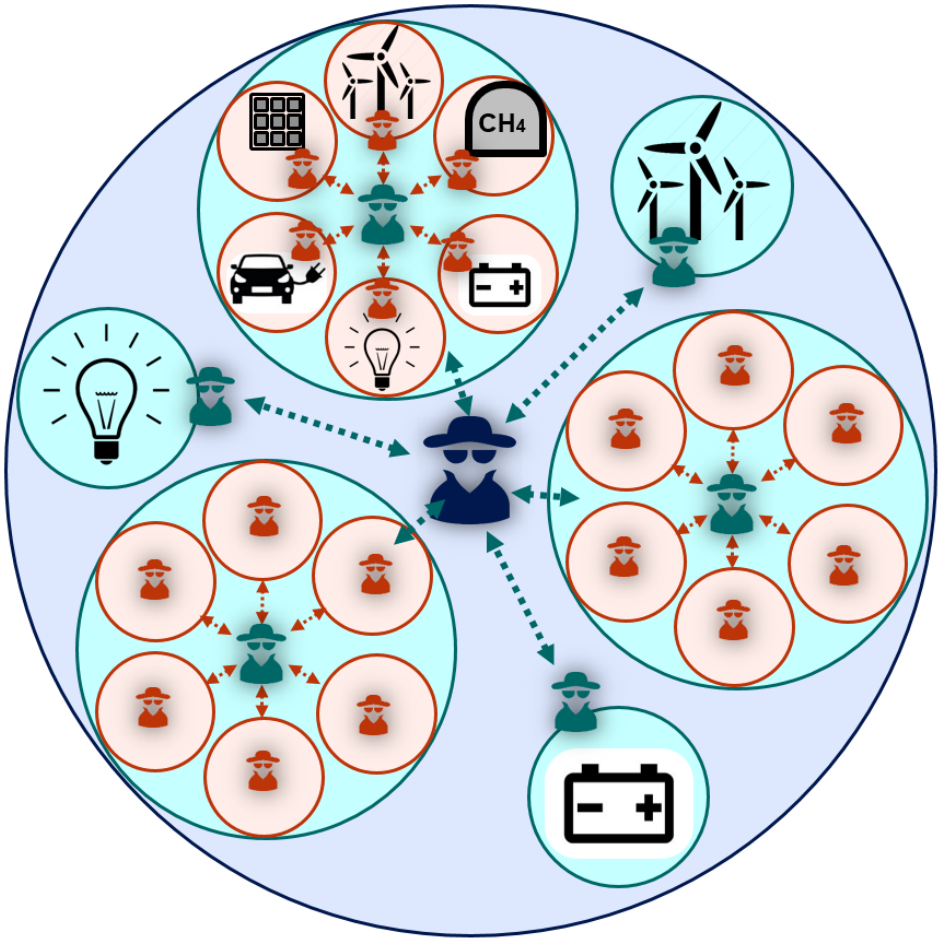
Challenge and Objective

- Increasing volatility between electricity generation and consumption induce more and more transmission bottlenecks
- Conventional approach:
  - Avoid them by building new transmission lines
- Our approach:
  - exploit distributed nature of renewables
  - Avoid and control transmission bottlenecks
    - primarily in the lowest grid level as possible in the distribution grid and
    - secondarily in the transmission grid
  - Create a resilient System based on stable subsystems

The cellular approach

- Distributed energy management systems (automation)
  - Design of an active distribution network
- Each cell
  - primarily supplies itself
  - secondarily use transmission to supply next higher cell level
- Open question:
  - How to orchestrate cells?



Market solution

- How could cellular energy markets work?
  - How can the cellular behaviour be illustrated?
  - Which market tools could affect which parameters?

- Identify Parameters that indicate the utility of certain measures

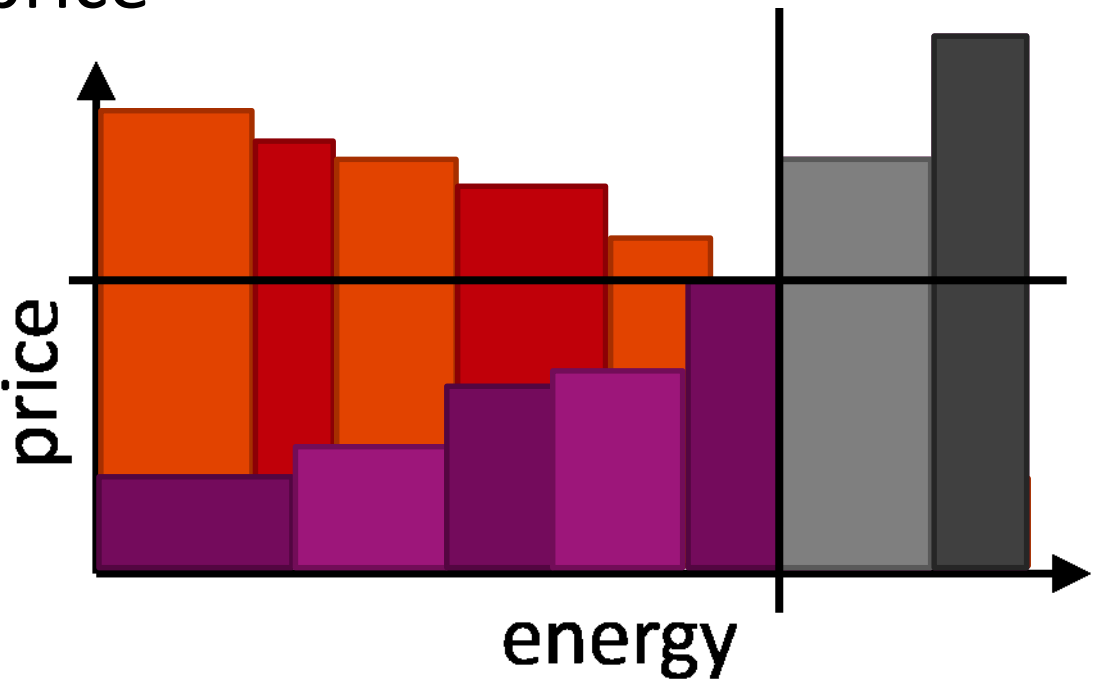
Market solution

- Organize and control via free market
  - How could such market look like?

- Ideas:
  - Automated pricing by a merit order
  - Differentiation of transmission distance
    - Transmission fee or local bonus

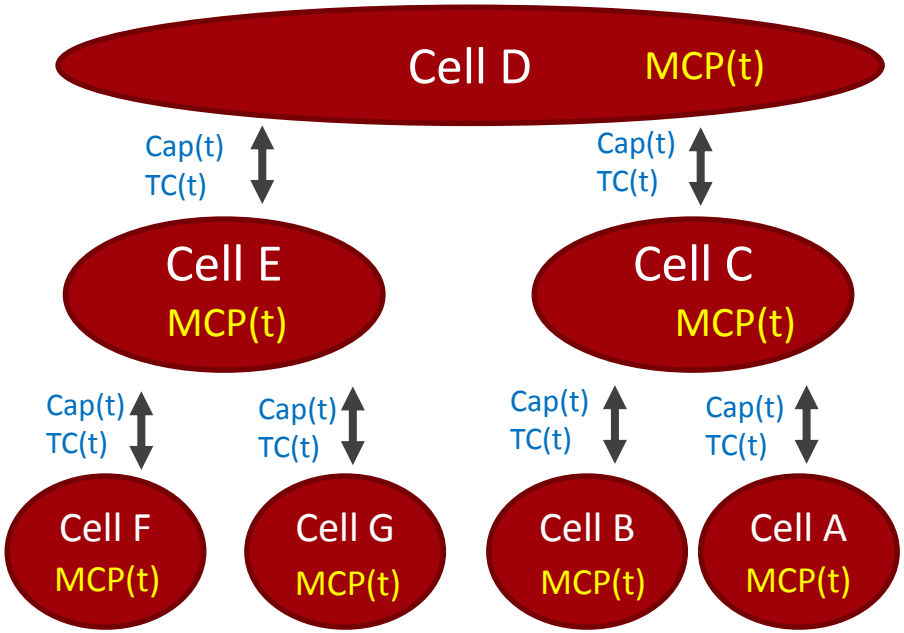
Merit Order

- Increasing Supply list
- Decreasing demand list
- Market clearing price

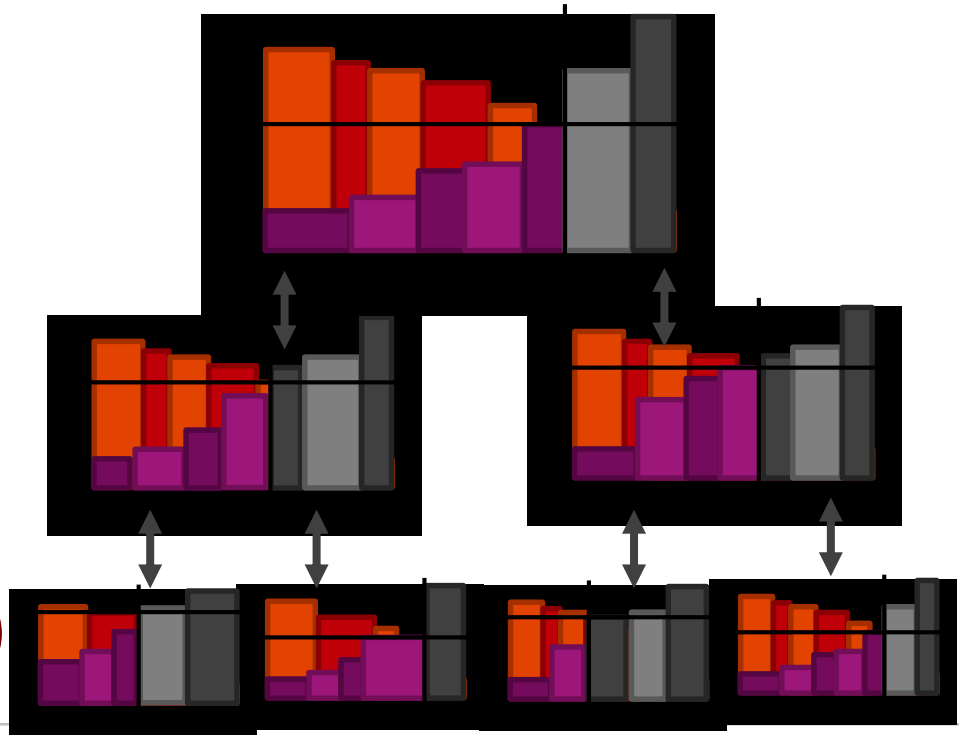


Cellular Merit Order markets

- Cells are vertically linked
- Merit Order is linked to its upper and lower Merit Orders
  - Transmission Capacities Cap(t)
  - Transmission Costs/Fees TC(t)
  - Market clearing prices MCP(t)

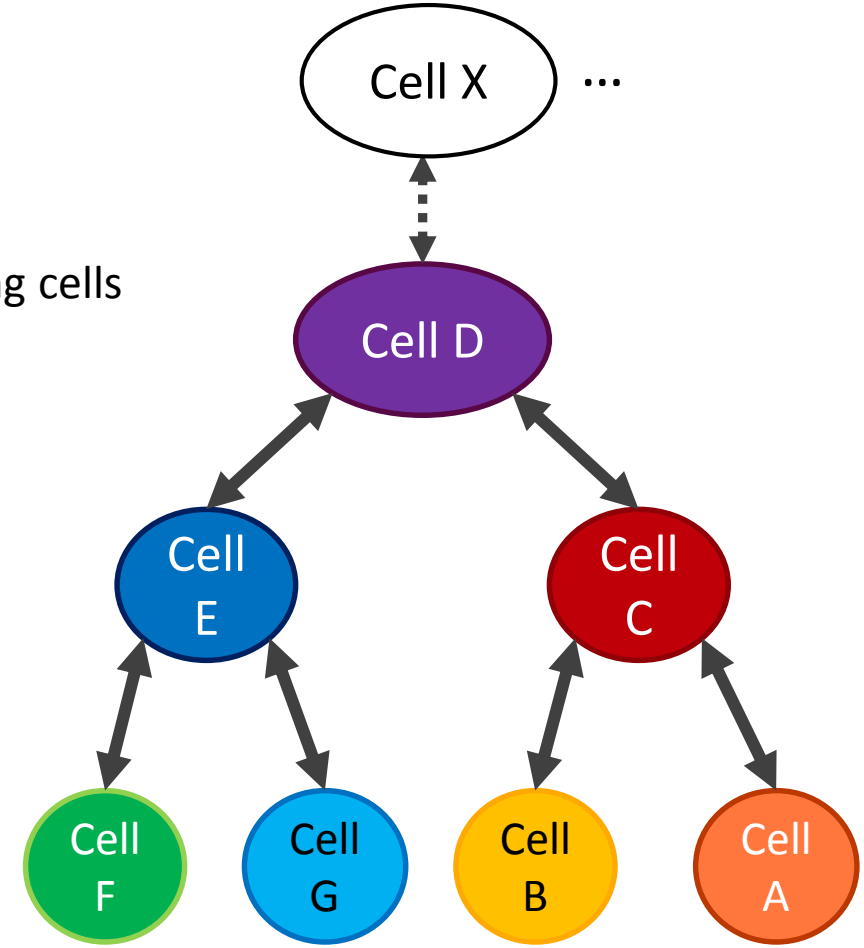


Each Cell has its own market clearing price



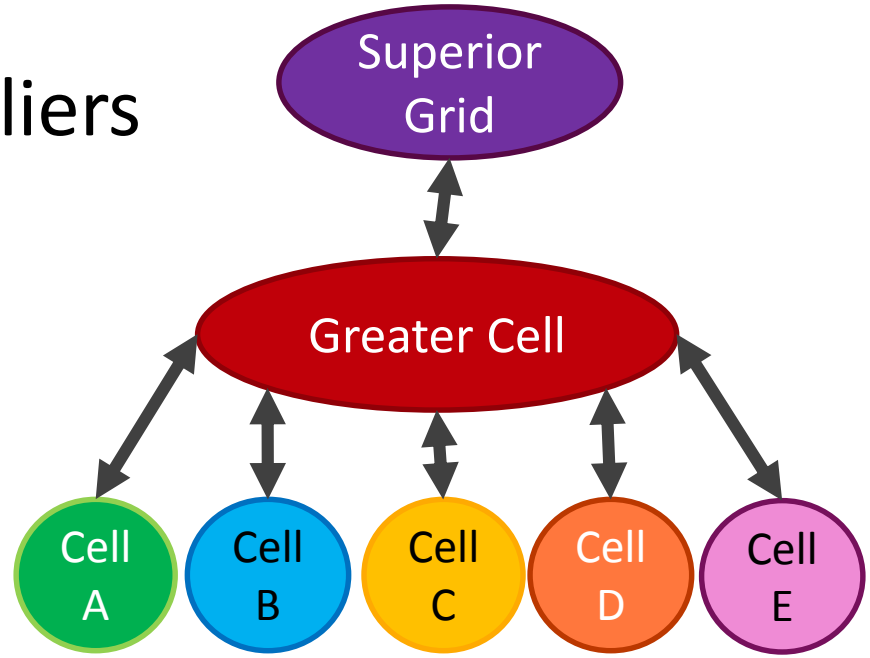
Simulation Tool

- Class „Cell“
  - Properties:
    - Transmission capacity to neighboring cells
    - Own market price
  - Functions:
    - Create Merit order
    - Calculate market clearing price
- Cells only vertically linked
  - Hierarchy can be enhanced as far as desired
- Inputs: load and price profiles



Simulation example

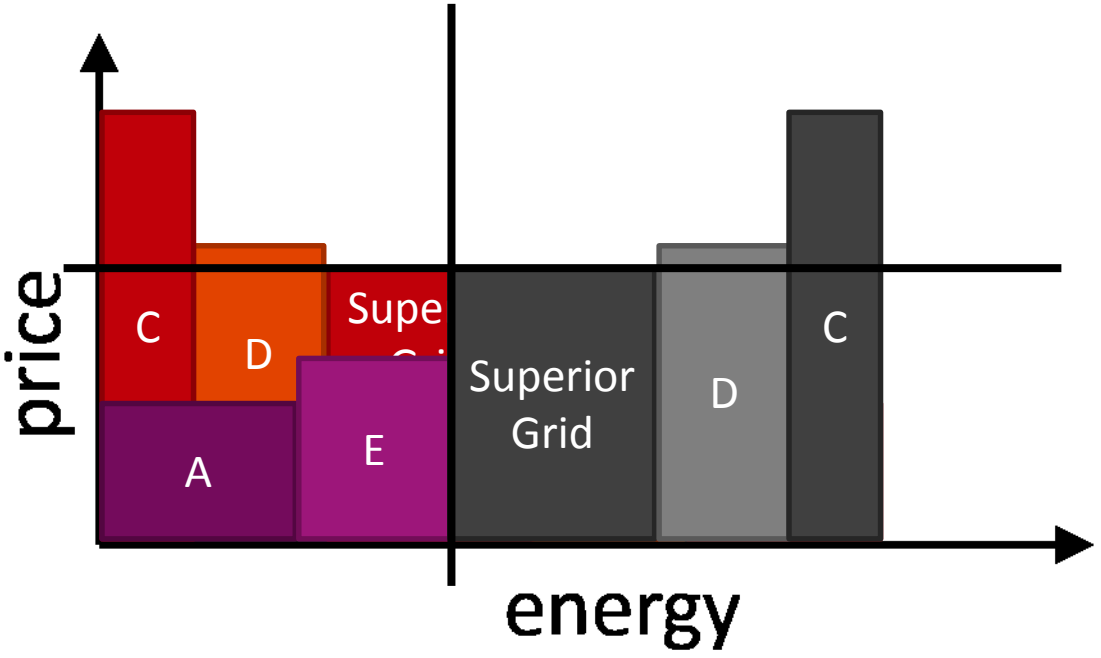
- Greater Cell which comprise of 5 small cells A, B, C, D, E
- All Cells contain suppliers and consumers, e.g.:
  - Wind park + storage
  - City + CHP plant
  - Industry + biogas plant
  - Village + PV plants



Merit Order of Greater Cell

Case 1: supply surplus

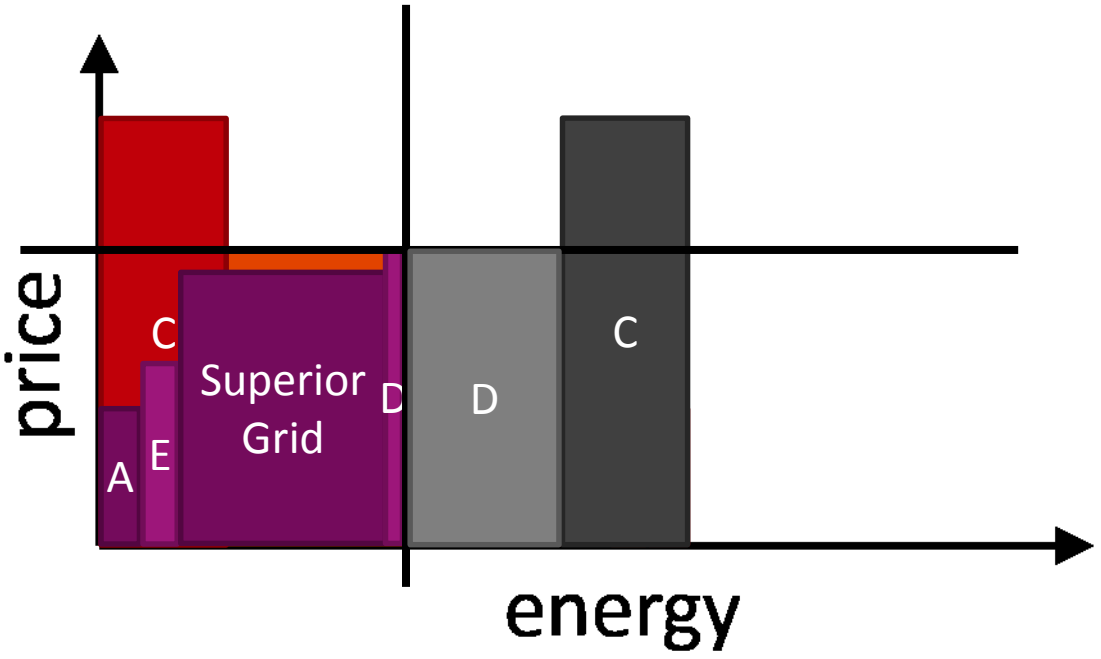
- Cells C & D (e.g. Cities) and the superior grid are supplied by Cell A & E (e.g. Wind & PV park)



Merit Order of Greater Cell

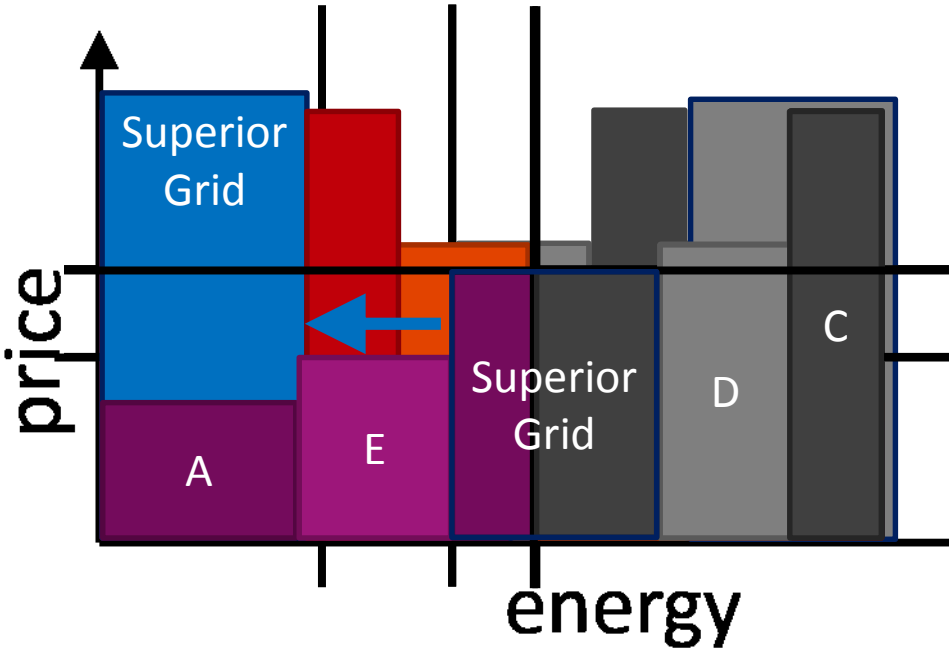
Different dates: supply deficit

- Cells C & D (e.g. Cities) are supplied by Cell A & E (e.g. Wind & PV park), the superior grid and Cell D partly by itself (CHP plant)



Fee or bonus on foreign cell trade

- Greater Cell:
  - Own subcells: A, B, C, D, E
  - Foreign trade with superior grid
- Fee on supply
- Bonus on supply
- Fee on demand
- Bonus on demand



Conclusion

- Target: Cell gets more dependent on its own resources
  - Introduce fees on foreign trade
    - Storages, flexible generators, demand response are utilized
    - Renewable supply is used directly
    - Superior cells get less stressed
- Target: Cell gets more dependent on external resources
  - Introduce bonus on foreign trade
    - Supply surpluses can be exported
    - Supply deficits can be covered
    - Superior cells get more stressed
- Cellular markets could foster the appropriate installation of
  - renewable power plants,
  - storages and
  - grid extensions

Thank you for listening

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