PRACTICAL INFORMATION

THE 40th IAEE INTERNATIONAL CONFERENCE
Meeting the Energy Demands of Emerging Economies
Implications for Energy and Environmental Markets
18-21 JUNE 2017 SINGAPORE

CALL FOR PAPERS

IMPORTANT DATES

About Singapore:
The Republic of Singapore is a sovereign, island city state that lies off the southern tip of the Malay Peninsula, about 140 kilometers south of Singapore. Singapore is the last of the British colonies to gain independence and is now home to more than 5 million people. Singapore's economy is driven by exports of electronics and information technology products, as well as financial services and tourism.
On how to integrate large quantities of variable renewables into electricity systems

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1. Introduction: Motivation
2. How variable renewables impact prices in electricity markets
3. The core problem of capacity payments
4. Flexibility and sector coupling
5. Balancing groups: A future market design
6. Conclusions
Motivation:

* Climate change → Paris agreements
* European targets for renewables → „Clean energy“ winter package
* Competition & democracy
* It is not possible to squeeze variable renewables into the system by violence
Electricity generation EU-28

- Solid Fuels
- Petroleum
- Gases
- Nuclear
- Renewables
Core objective

... to identify the major boundary conditions to integrate even larger amounts of variable renewables into the electricity system

Very important:

Our reflections apply in principle to every electricity system world-wide;

.... are based on electricity economic point-of-view
Old thinking

- Generation
- Grid
- Supply
- Demand

Flexibility options
Day-ahead electricity markets

Expectation of

prices = \text{Short-term marginal costs}

(Short-term marginal costs = fuel costs)

due to huge depreciated excess capacities at the beginning of liberalisation!
2 HOW VARIABLE RENEWABLES IMPACT PRICES IN ELECTRICITY MARKETS
Example: prices without and with PV

Price = System marginal costs

Supply curve w/o PV

Price with PV!

Supply curve w/ PV

Demand $D_t$
Supply and Demand

RES Production > Demand

RES Production < Demand

Demand

Supply and Demand

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Hours per week

GW

1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101 105 109 113 117 121 125 129 133 137 141 145 149 153 157 161 165 169

- of-river hydro
- PV
- Wind
- Load
Key term of the future: Residual load (base load is "dead")

Residual load = Load – non-flexible generation
Deviation from STMC-pricing in spot markets

Scarcity prices!

Electricity price spot market

Low average price (3 cents/kWh)

Negative prices!

→ These price spreads provide incentives for new flexible solutions!!!!
Classified residual load

Graph showing the relationship between MW and Stunden/Jahr.
There are two extreme positions:

By a regulated capacity „market“ with STMC pricing?

or

By competition between supply-side and demand-side technologies and behaviour (incl. Storages, grid and other flexibility options) with correct scarcity pricing signals??
Given a price pattern, showing excess and scarcity prices it would be attractive for a sufficient number of flexible power plant operators to stay in the market!

REVISED ENERGY-ONLY MARKET
3 THE CORE PROBLEM
OF CAPACITY PAYMENTS

Strategic reserves as well as capacity payments for power plants destroy the EOM by providing misleading price signals!

Price peaks at times of scarce resource should revive the markets and lead to the correct quantities from comp markets point-of-view!
4. FLEXIBILITY AND SECTOR COUPLING

Flexible power plants

Storages

Very high prices (2000 EUR/MWh!)

Load reduction due to Demand response to prices

Load reduction due to Demand-side management technical (e.g. cycling)

Transmission grid

Extention
Demand for long-term storage

Long-term storage needed

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GWh/mo

Monat

1 2 3 4 5 6 7 8 9 10 11 12

Laufwasser  Solar  Wind  Last/Nachfrage
Sector coupling hydrogen: Storage and fuel in transport?

- Electrolyser
  - Electricity → H₂
  - Efficiency: η=60-70%

- H₂-Storage
  - H₂ → F-CELL
  - Efficiency: η≈90%

- Combined cycle
  - H₂ → Electricity
  - Efficiency: η=50-60%

- Electricity
  - Flow direction:
    - From wind turbines
    - To electrolyser
    - From H₂-storage
    - To combined cycle
    - To fuel cell vehicles

η=27-38%
**Problems of Sector coupling**

* In times of surplus generation: How to use excess electricity in a meaningful way?

- Heating/Cooling
- Transport

* Vague simplified suggestions, no convincing long-term solutions

* Central (Ptx approaches, e.g. H2) vs decentral (end user level, e.g. EVs, heat pumps for heating) applications

* How to fit use with time of surplus, e.g of PV for heating?
Elements of electricity markets

Quantity (TWh) vs. Time of delivery

Long-term:
- Bilateral contracts
- Futures

Short-term:
- day-ahead and
- Intraday markets

Control power, Balancing energy

Days, hours vs. ¼ hours
5. THE CORE ROLE OF BALANCING GROUPS

Balancing group: entity in a control area of an electricity system; it has to ensure that at every moment demand and supply is balanced.

E.g. municipal utility of Vienna, Singapour, Shanghai
To meet this target: own generation, storage, flexibility, Trading in long-term, day-ahead and intraday market

Every difference → high costs!
New Thinking: Making the electricity system more democratic

Grid

Balancing Group/Supplier

Prosu-mers

Storage

Flexibility options

G1

G2

G3

G4
Grid parity: PV-costs and household electricity prices

- Costs
- Household electricity price Germany

Grid parity

Cent/kWh


Kosten Strompreis
Share of own consumption
6. CONCLUSIONS

- **Sustainable electric. system** → integrating many technologies & demand-side options!
- **Larger market areas** favourable
- **Very important**: correct price signals (incl. CO2)
- **most urgent**: exhaust full creativity of all market participants incl. decentralised PV systems
- **The key**: Flexibility (incl. dispatchable var RES)!
  - Currently low economic incentives but activities started → very promising!
- **Capacity payments**: Any CP will distort the system towards more conv. and less RES capacity
- **New key player**: Balancing group (Supplier), no more the generator