



# Flow-based Market-coupling

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# Overview

- 4 Market mechanisms
  - NTC market coupling
  - Flow-based market coupling
  - Ex-post market coupling
  - Nodal pricing
- Smaller topics
  - Internal congestion
  - Transparency and Risk
  - Market power
- Points for discussion

# Four Types of Market Mechanism

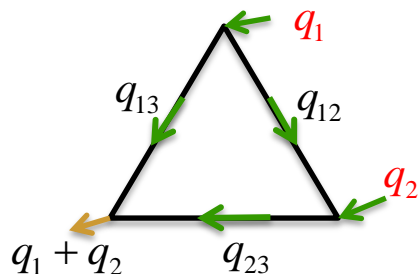
- We can consider the following types of market mechanisms
  - Regional prices
    - Ex-ante: Link-Based (NTC)
    - Ex-ante: Flow-Based (FB)
    - Ex-post: Physical Network
  - Nodal Pricing

Representation of the network improves



# NTC-based market coupling

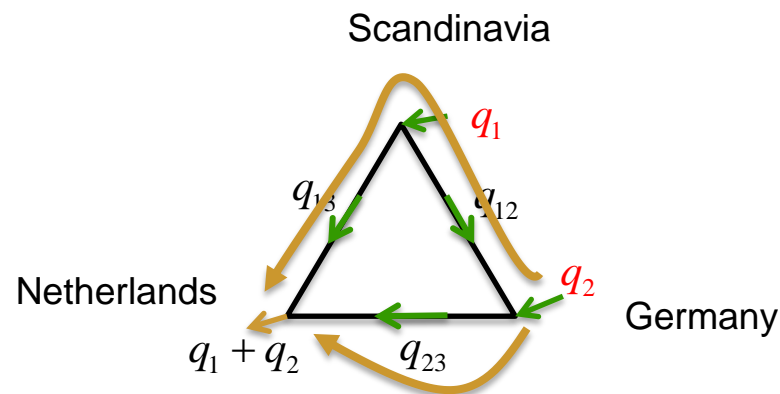
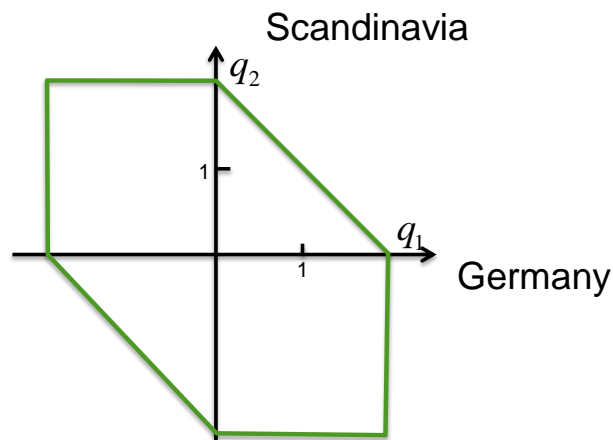
1. **Network operators** set cross-border transmission constraints (NTC values per pair of countries)
2. **Power Exchanges** maximize value of accepted bids ( $q_1, q_2$ )  
subject to: Cross-border transmission constraints (NTC)



$$\begin{array}{l} q_1 = q_{12} + q_{13} \\ q_2 = q_{23} - q_{12} \end{array} \left. \vphantom{\begin{array}{l} q_1 = q_{12} + q_{13} \\ q_2 = q_{23} - q_{12} \end{array}} \right\} \text{Regional Energy Balance}$$
$$\begin{array}{l} |q_{13}| \leq K_{13} \\ |q_{23}| \leq K_{23} \\ |q_{12}| \leq K_{12} \end{array} \left. \vphantom{\begin{array}{l} |q_{13}| \leq K_{13} \\ |q_{23}| \leq K_{23} \\ |q_{12}| \leq K_{12} \end{array}} \right\} \text{NTC Constraints}$$

# NTC-based market coupling: Discussion

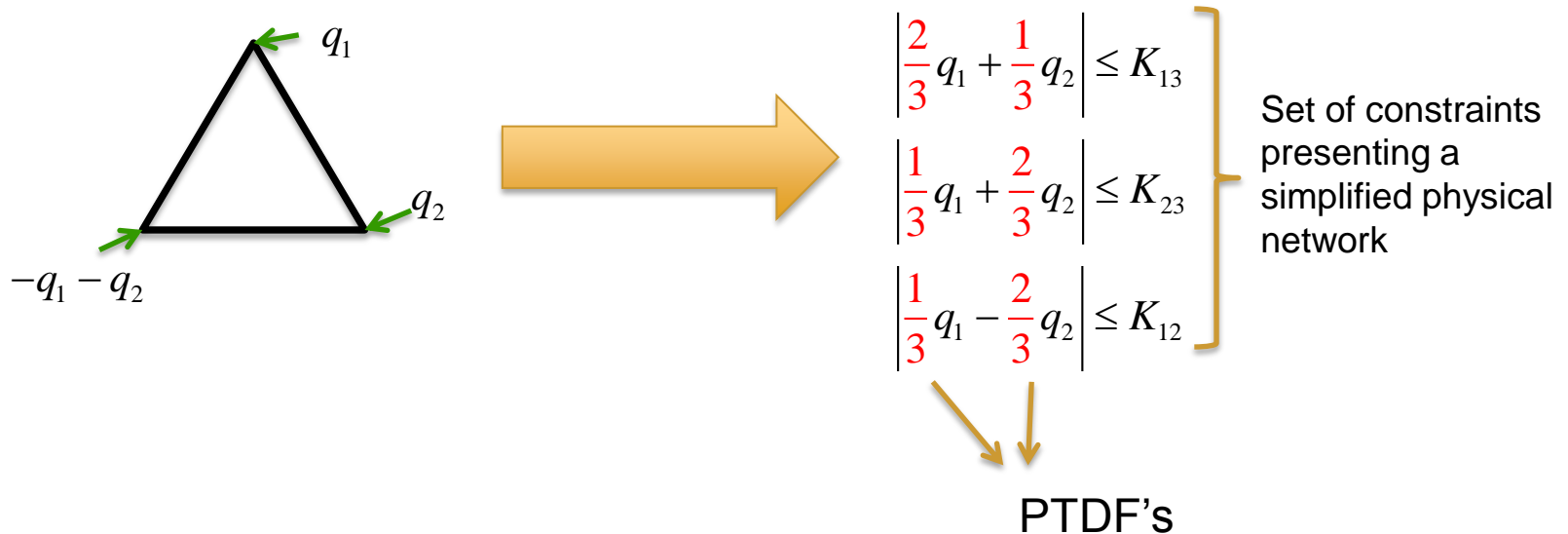
- Implicit assumption: **any contract-path is equivalent**
- **Example:** *Germany can transport 1 unit more to Netherlands, if net export from Scandinavia to Netherlands is reduced with 1 unit*  
*However, those transactions are clearly different physically*



- **Conjecture:** As the network becomes more meshed, and trade flows less predictable, the NTC approximation becomes unsustainable

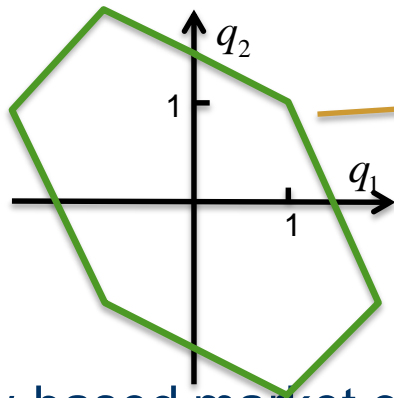
# Flow-Based market coupling

1. **Network operators** gives simplified network representation
2. **Power Exchanges** maximize value of accepted bids  $(q_1, q_2)$   
s.t. Simplified presentation of the network



# Flow-Based market coupling: Discussion

- It correctly represents the effect of different types of trade on congestion
  - By facing the right trade-offs efficiency is improved



Set can be adjusted to reflect all physical constraints, security etc.  
e.g. N-1 constraints: add some extra set of constraints  
Any convex set will do

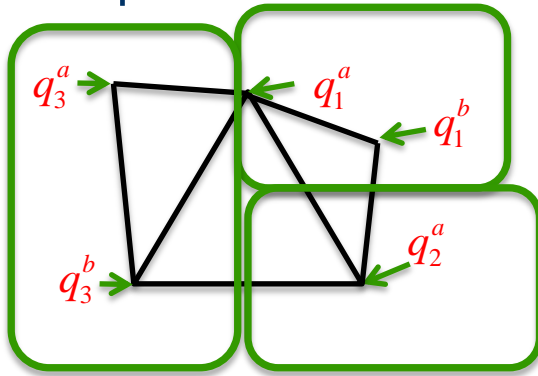
- Flow-based market coupling is not more complex
  - The optimization problem of the auctioneer has not fundamentally changed

# Ex-post market coupling

1. **Power Exchanges** maximize the value of accepted bids

$$q_1^a, q_1^b, \dots, q_2^a, q_2^b, \dots, q_3^a, q_3^b$$

s.t. Complete set of transmission constraints



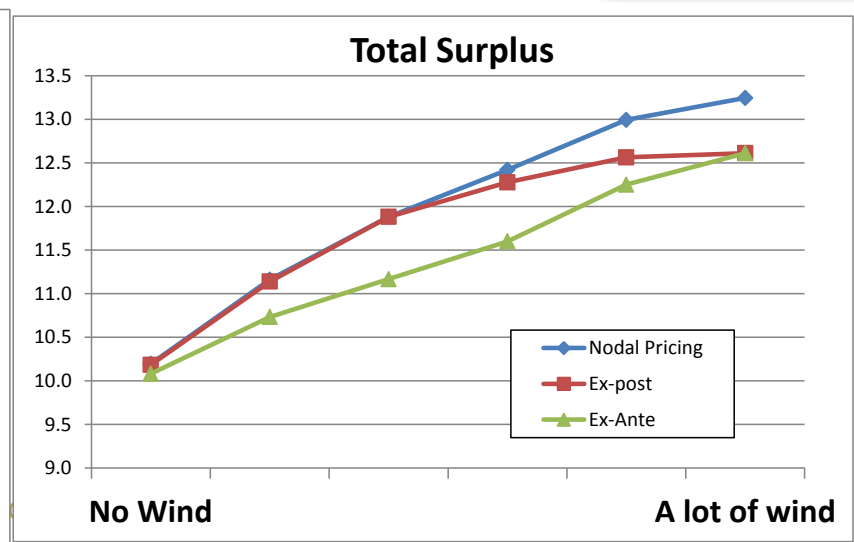
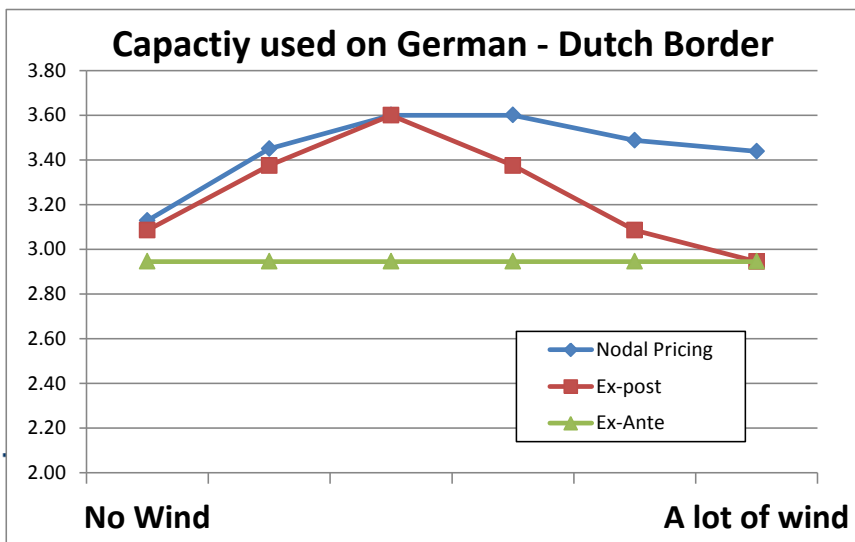
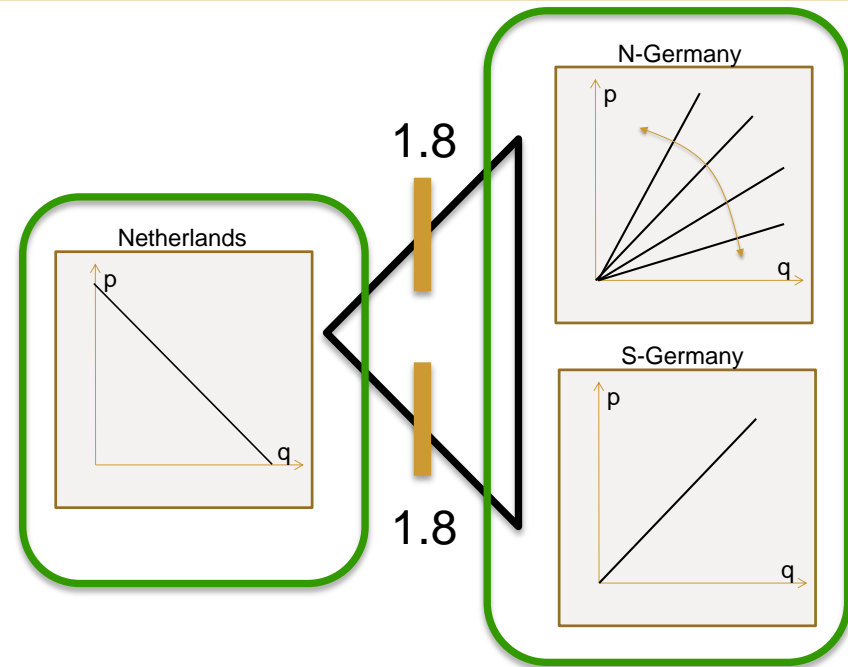
Zonal prices are uniform

$$p_1^a = p_1^b = p_1^c \quad p_2^a = p_2^b, \dots,$$



# Ex-post market coupling: Illustration

- Transmission capacity NL-D depends on wind production in Germany
- Ex-ante: Capacity is determined by worst-case scenario
- Ex-post: Clear market while using network and bid data



# Ex-post market coupling: Discussion

- Use all information at the time of market clearing
  - Location of power plants + price of bids
- Can be implemented gradually within optimization program of flow-based market coupling
- Requires
  - Close coordination between Network Operator and Power Exchanges
  - Information on location of plants has to be transferred to the power exchange

**Note:** If there is congestion **within** a country, the optimization model has to allow for counter-trading within a country. Otherwise there is no feasible solution.

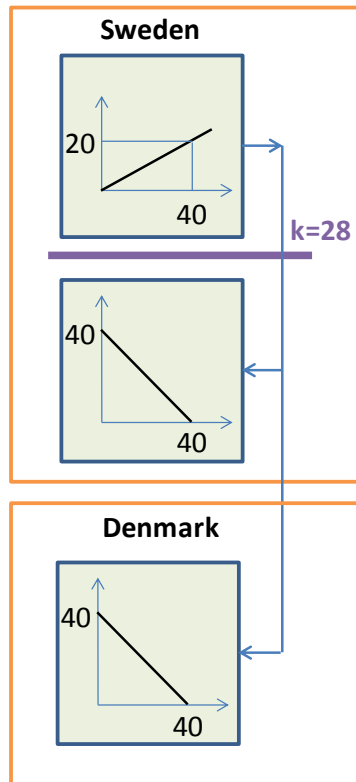
Instead of a strict transmission constraint, the optimization model will impose a “penalty” if the constraint is broken which is equal to the cost of counter-trading

# Nodal pricing: Discussion

- Not on the table yet
- Two arguments against nodal pricing
  - Nodal pricing reduces liquidity
    - Not a lot of empirical evidence
    - Theory: firms already have market power in counter-trading
  - Nodal pricing is more complex
    - Nodal pricing = one optimization
    - Zonal pricing = complexity is setting transmission constraints, real-time determination of zones

# Smaller Topics

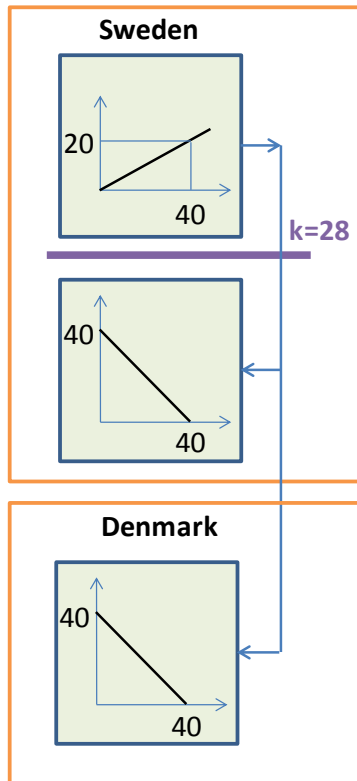
# EU Fallacy: How to treat internal congestion?



- Congestion between N and S-Sweden
- Internal congestion is dealt with by counter-trading
- Q: How much capacity should be allocated at the Swedish-Danish border?
  - A. no constraint
  - B. 14 Units
  - C. 2 Units

***Discussion is based on joint work with Małgorzata Sadowska. We hope to finish a working paper version soon.***

# EU Fallacy: How to treat internal congestion?



- Congestion between N and S-Sweden
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- Q: How much capacity should be allocated at the Swedish-Danish border?
  - A. no constraint
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- Efficiency requires that congestion is shifted partially to the border
- Efficient calculation of capacity requires price information (See also previous example)
- EU pretends that internal and external congestion is something different
- Inclusion of N-1 rules makes it even harder to define what is internal and what is external

# Transparency and Risk

- A small change in the amount of congestion
  - Has a small effect on overall surplus
  - But can have large price effects on individual countries or firms
- Clear rules and transparent process is important
  - Predictability of future congestion for producers/retailers
  - Network operators might want to avoid legal scrutiny as in Sweden
- Potential problems with transparency
  - Firms try to exploit network constraints and create congestion
    - Make potentially sensitive information public with a delay of 6 months

**Reformulated:** I am in favor of transparency, but could imagine cases where not all information is made public.

# Transparency and Risk

- Network operators should provide firms with tools to hedge transmission risks
- Evolve from longer term NTC transmission rights to point-to-point transmission rights (Injection, take-off & volume)
- In liquid market the difference between a physical contract and a financial contract is small
  - In case you cannot produce
    - Receive money via the financial contract
    - Or receive money via counter-trading
  - In case you produce
    - Money you receive via the financial contract = payment for transmission
    - You have the right to inject and take-off with the physical right



# Market power and Flow-based Market Splitting

- Benefit of extra transmission capacity is cost arbitrage
  - Market integration, reduction of market power, choice for consumers → minor effects
- Strategic manipulation of bids to affect congestion or receive payments in counter-trading market is possible
  - Opportunities are highest if the market does not reflect the physical dimensions of the system

# Points for Discussion

# Statements for discussion

1. Flow-based market coupling is **necessary**  
(wind input, larger and more meshed networks)
2. Flow-based market coupling is **not more complex** than NTC mechanism  
(same optimization problem but with a different convex set, constraints reflect physics better)
3. The main **benefit is cost arbitrage** (not market-power)
4. Determination of efficient transmission constraints **requires production cost data** (pure engineering models are insufficient)
5. EU is wrong to consider **internal congestion** as something entirely different
6. It is possible to have **uniform prices within a zone** and take a full network model into account.
7. Firms should be offered **tools to hedge** location risks