Why underlying market structure matters for the implementation of cross-border financial transmission rights in Europe

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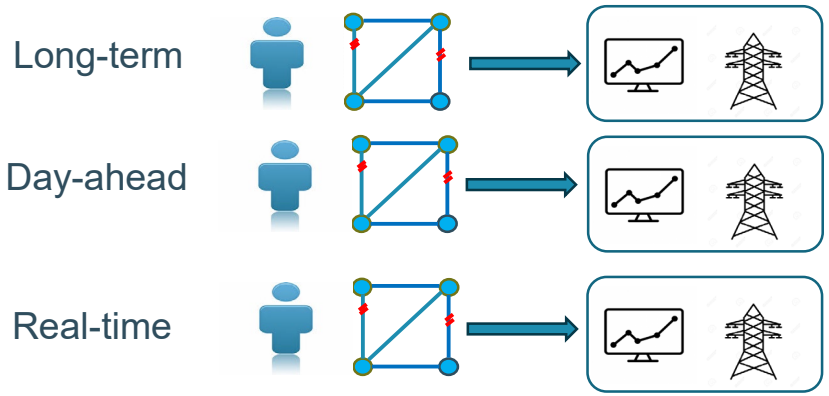
Diyun Huang, Geert Deconinck
Electa, KULeuven/Energyville

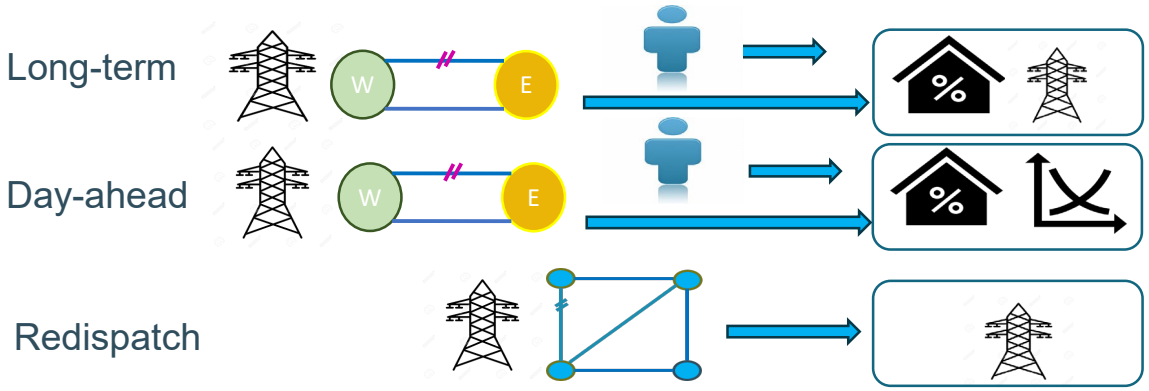
Table of content

Institutions, market process and FTR aspects

- Under nodal pricing, ISO can clear the FTR auctions based on detailed bid information and nodal network estimation (uncertainties in network configuration)
- Under zonal pricing, TSO first needs to build zonal network for FTR auction, with predictive parameters that depends on outcomes of market clearing. ➔ **Information asymmetry for TSO grid modeling**.
- FTR examination aspects: grid modeling accuracy, revenue adequacy and economic efficiency implication.



Centralized market structure cleared by ISO



Decentralized market structure

Flow-based market coupling under zonal pricing

- **Base case and GDSKs are predictive parameters under flow-based market coupling for zonal pricing**

•Base case: snapshot chosen by TSO as best estimate of system state

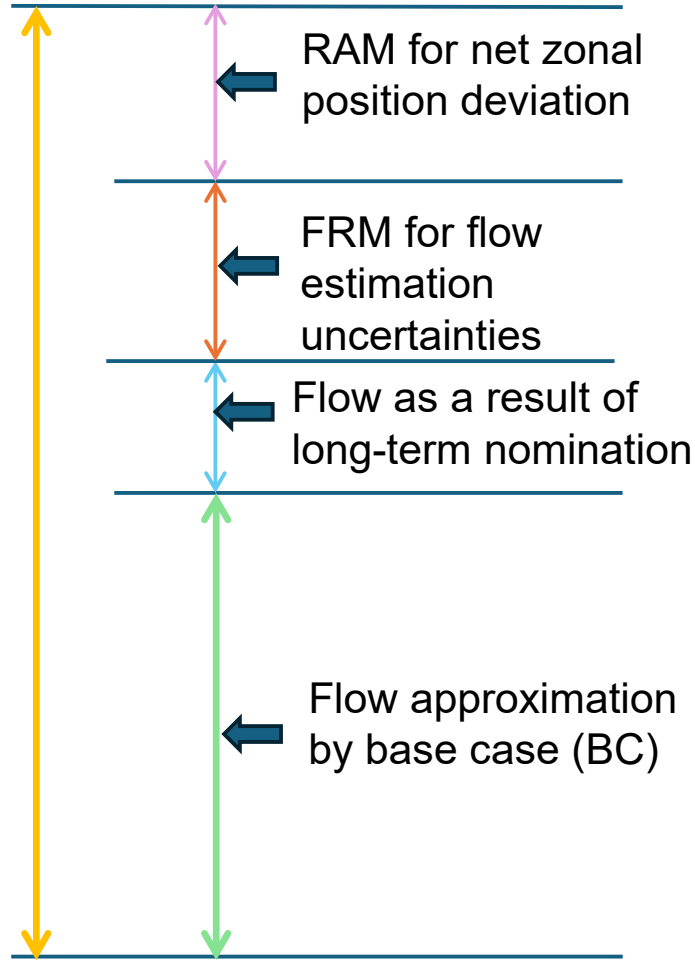
•GDSK: nodal change of generation or demand level in proportion to the zonal net injection/withdrawal change

$$PTDF_{l,z} = \sum_{n} PTDF_{l,n} * GDSK_{n,z}$$

$$PTDF_{l,z} * NEZ = F_l$$

•RAM: Remaining availability margin

$$-RAM \leq F_l \leq RAM$$

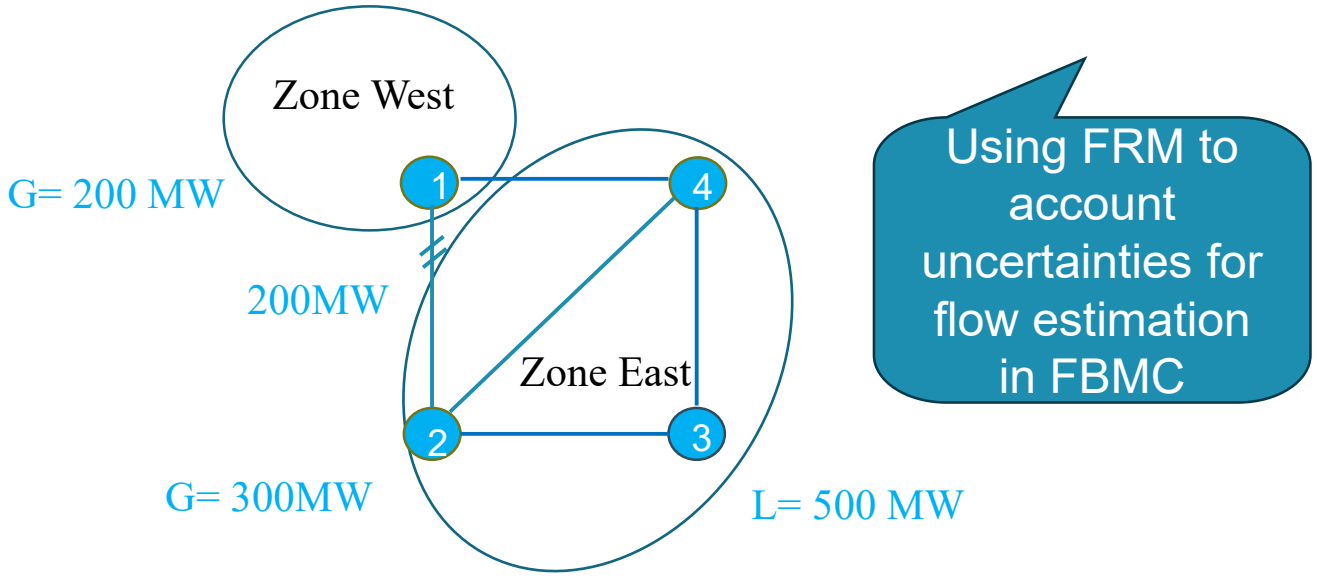


Base case challenges in long-term FTR auction

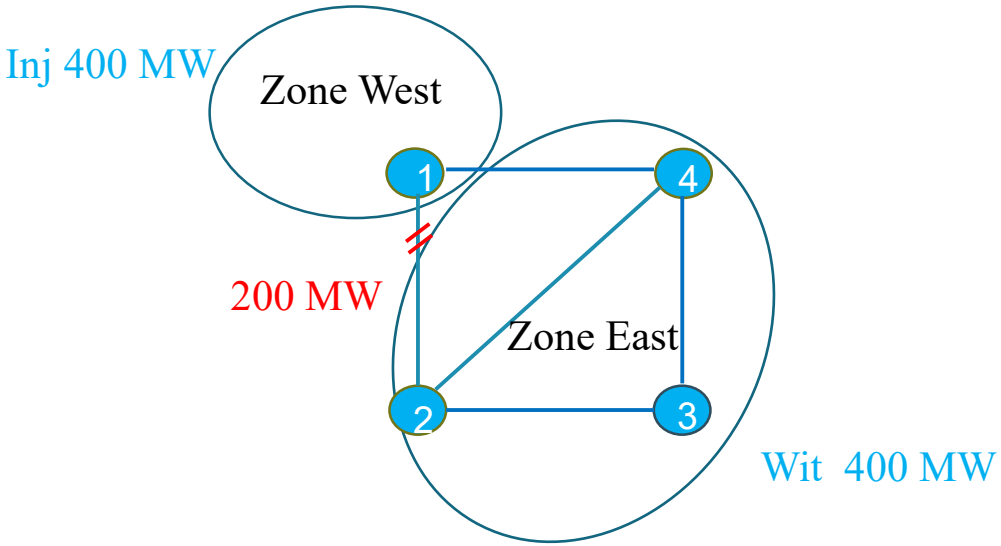
- Base case for day-ahead market, using reference day flows with updated renewable and load forecast at D-2 ➔ Lower uncertainties compared with BC in long-term
- Base case selection for long-term FTR: from multiple scenarios(seasons, peak/valley market time units) , with best estimate for generation and load.
- Base case challenges for long-term FTR auction (3 – 5 year prior to delivery) to predict energy injection and withdrawal patterns and resulting flows
  - Industry relocation ➔ Industry demand pattern change
  - Heat pump and EV integration ➔ Residential load increase
  - New generation investments ➔ Generation pattern change
  - Strategy for market players between hedging financial contract and physical contract in spot market ➔ Difference between FTR injection withdrawal and operating day physical injection and withdrawal

Intra-zonal transaction in base case for long-term FTR

- Under zonal pricing, intra-zonal trade are mainly described in base case ➔ Information asymmetry for TSO to obtain the bilateral contractual relationship between market players in the long-term auction ➔ Difficult to assess the impact of intra-zonal trade on interconnection capacity and the capacity left for inter-zonal trade



Using FRM to account uncertainties for flow estimation in FBMC



G at node 2 and load at node 3 have a long-term contract of 300 MWh, cross-border trade of 200 MWh.

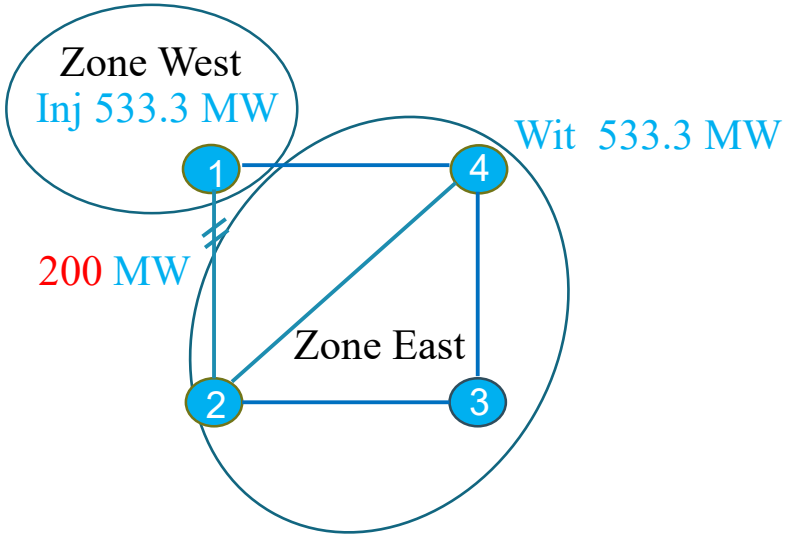
Cross-border FTR cleared is 400 MWh for FTR between node 3 and node 1.

GDSK under nodal and zonal pricing

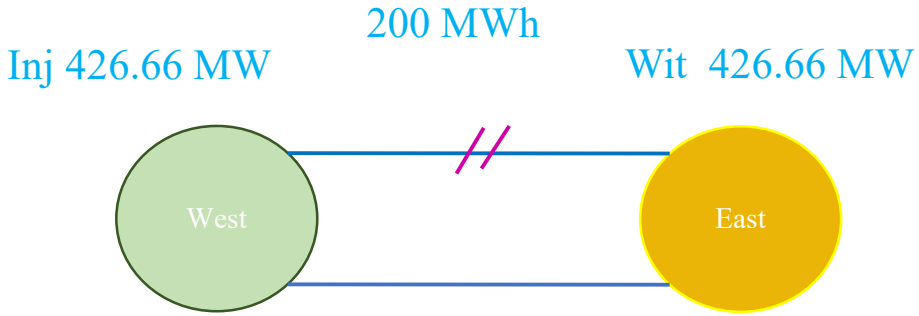
- Under nodal pricing, each FTR bid can be assigned a separate nodal PTDF
- FTR bids that are physically feasible in long-term auction are revenue adequate for SO in spot market, which has the same network configuration (Hogan 1992).
- Under zonal pricing, only one inter-zonal PTDF to account for flow distribution of aggregated inter-zonal transactions ➔ Approximated load flow constraints
- No congestion consideration in current GDSK methodology to guarantee physical feasibility of long-term FTR

Revenue inadequacy for inaccurate grid modeling

- **Suppose FRM=20%, GDSK in zone east (0, 0, 1), zonal PTDF 0.375**
- **Base case left , FTR auction outcome right**
- **426.66MWh of FTR from zone west to east cleared ➔ Physically infeasible when the FTR withdrawal at node 3**



Base case for long-term auction



Clearing outcome for long-term FTR

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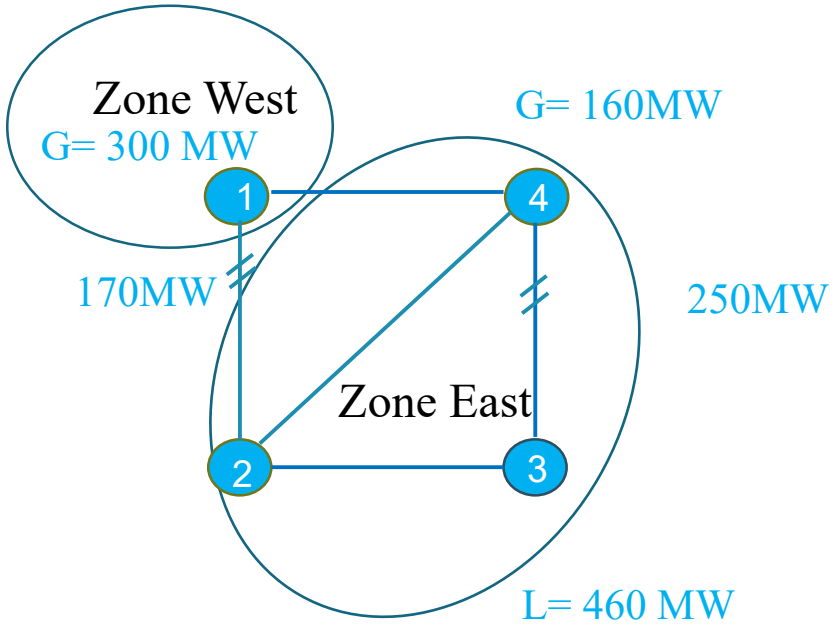
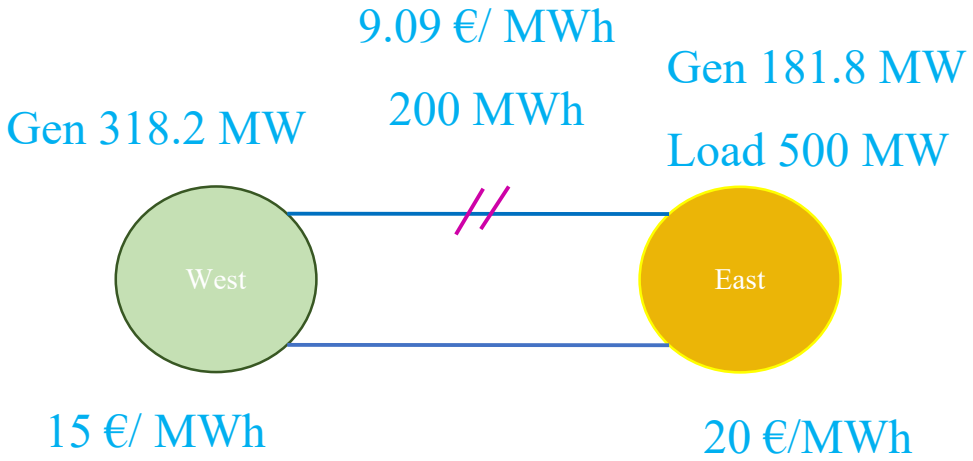
Day-ahead energy market

- Base case in left, FRM = 10% in day-ahead energy market
- GDSK among node 2, 3 and 4 (0.4, 0.6, 0), zonal PTDF 0.55
- Market clearing outcome right



Base case for day-ahead market



Day-ahead market clearing

Revenue inadequacy

- Day-ahead market, surplus from load generation payment € 1591
- Day-ahead market, price difference between zone west and east is €5/MWh. SO needs to pay long-term FTR holders €2133.3.
- Revenue inadequacy for the SO in day-ahead market!

Type	Generation at node 1	Generation at node 4	Load at node 3
Zone	Zone west	Zone east	Zone east
Price (€/MWh)	15	20	20
Cleared quantity (MWh)	318.2	181.8	500
Payment to SO (€)	4773	3636	10000

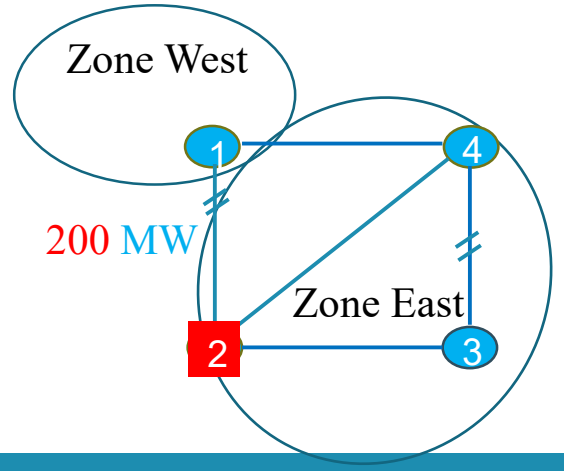
GDSK rules with congestion consideration

- Inaccurate base case and too relaxed GDSK lead to FTRs cleared that are physically infeasible for the grid
- Generation load net payment is not sufficient to pay for FTR holders ➔Revenue inadequacy for the SO
- Remedy action not allowed for FTR auctions by regulation

➔GDSK with congestion considerations

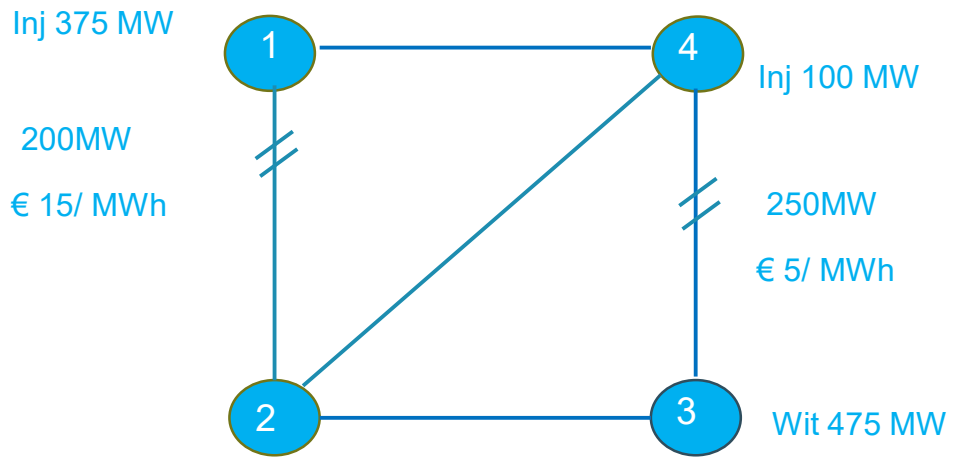
- GDSK rule: 1) Dispatchable generations; 2) Higher weight on the nodes associated with the most critical cross-zonal transactions.

The longer-term FTR auction is, higher the uncertainties, the higher GDSK weight for the nodes associated with critical transactions

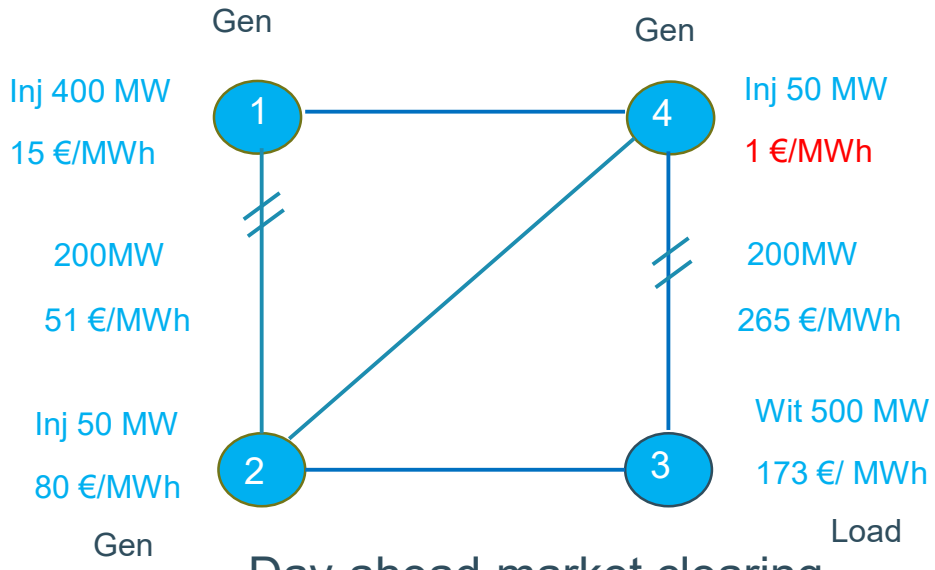


Nodal pricing long-term FTR and day-ahead market

- Bids in long-term FTR auction: 1) 500 MWh of FTR bids from node 1 to node 3 at 10€/MWh; 2) 300 MWh of FTR bids from node 4 to node 3 at 5€ / MWh.
- FTR auction clearing: 375 MWh of FTR awarded from node 1 to node 3 at price of €10/MWh, 100 MWh FTR from node 4 to node 3 at €5 /MWh.
- Total payment to SO from FTR bidders is € 4250.



Long-term FTR clearing



Day-ahead market clearing

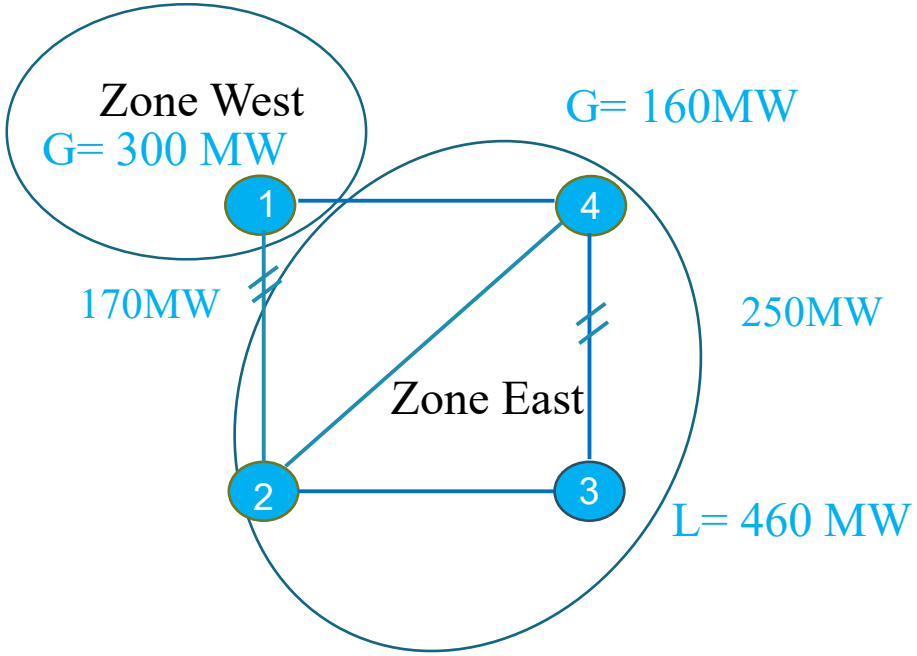
Revenue adequacy at day-ahead market

- 375 MWh FTR holders from node 1 and node 4 is paid € 59250. 100 MWh FTR holders from node 4 and node 3 is paid €17200.
- In total, the SO payment to FTR holders is € 76450.
- The net payment from load generation to SO is €76450.
- Revenue adequacy for SO in day-ahead market

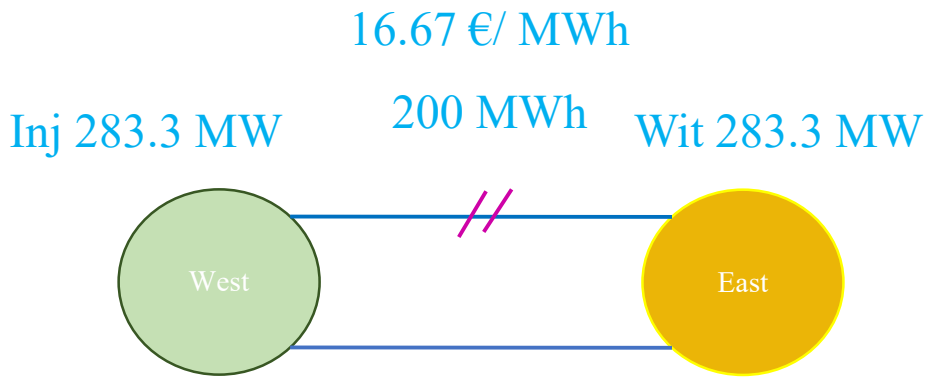
Type	Generation at node 1	Generation at node 2	Generation at node 4	Load at node 3
Price (€/MWh)	15	80	1	173
Cleared quantity (MWh)	400	50	50	500
Payment to SO (€)	6000	4000	50	86500

Long-term FTR auction

- GDSK among node 2, 3 and 4 (0.8, 0.2, 0)
- Base case in Figure 5, FRM = 20% in long-term FTR auction
- 500MWh FTR bids from zone west to east, 283.3 MWh of FTR cleared at €10/MWh



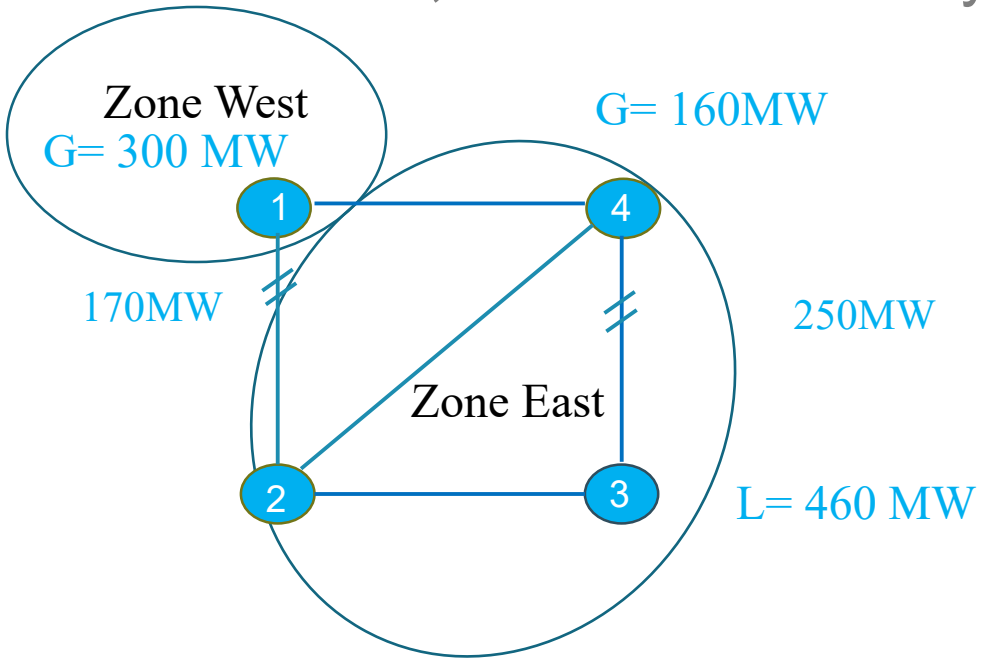
Base case for long-term FTR



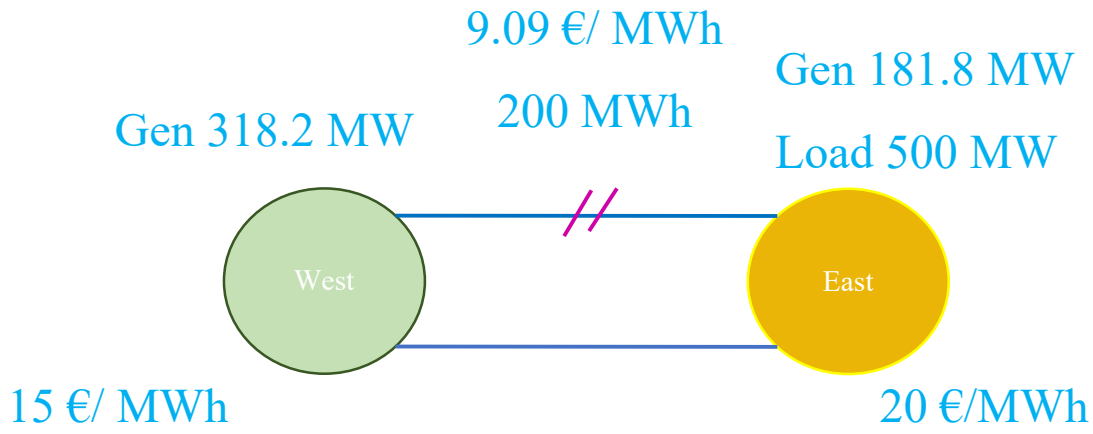
Long-term FTR clearing outcome

Day-ahead energy market

- GDSK among node 2, 3 and 4 (0.4, 0.6, 0)
- Base case left, FRM = 10% in day-ahead energy market



Base case for day-ahead market



Day-ahead market clearing outcome

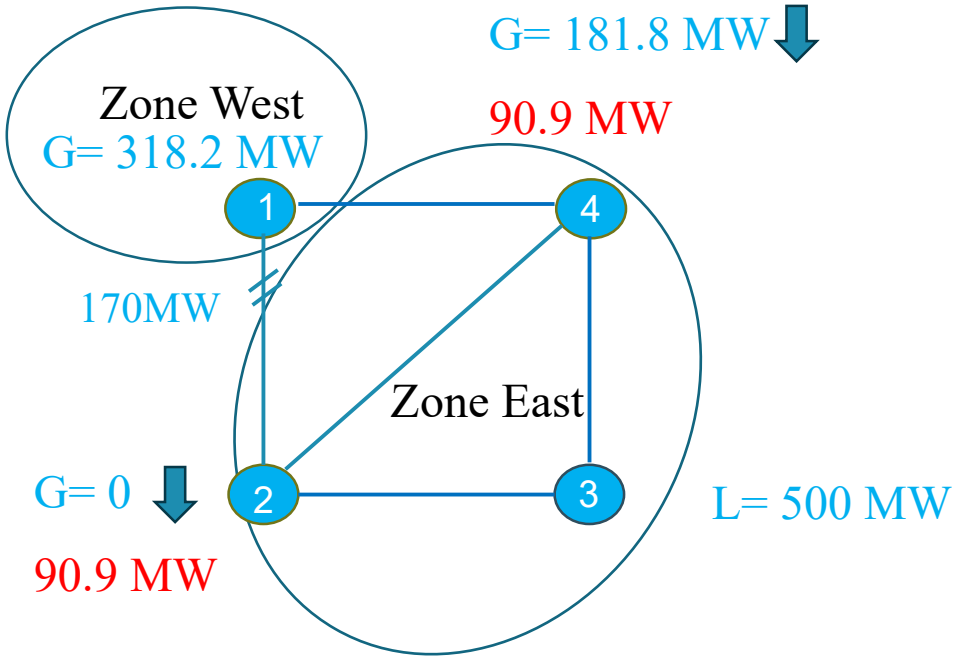
Revenue adequacy

- In long-term market, FTR holders procure 283.33 MWh FTR at the price of 10€/MWh and pays 2833. 3€
- In the day-ahead market, SO pays back the FTR at 5 €/MWh totaling 1416.65 €.
- Generation load net payment €1591.
- Revenue adequacy for SO at day-ahead market

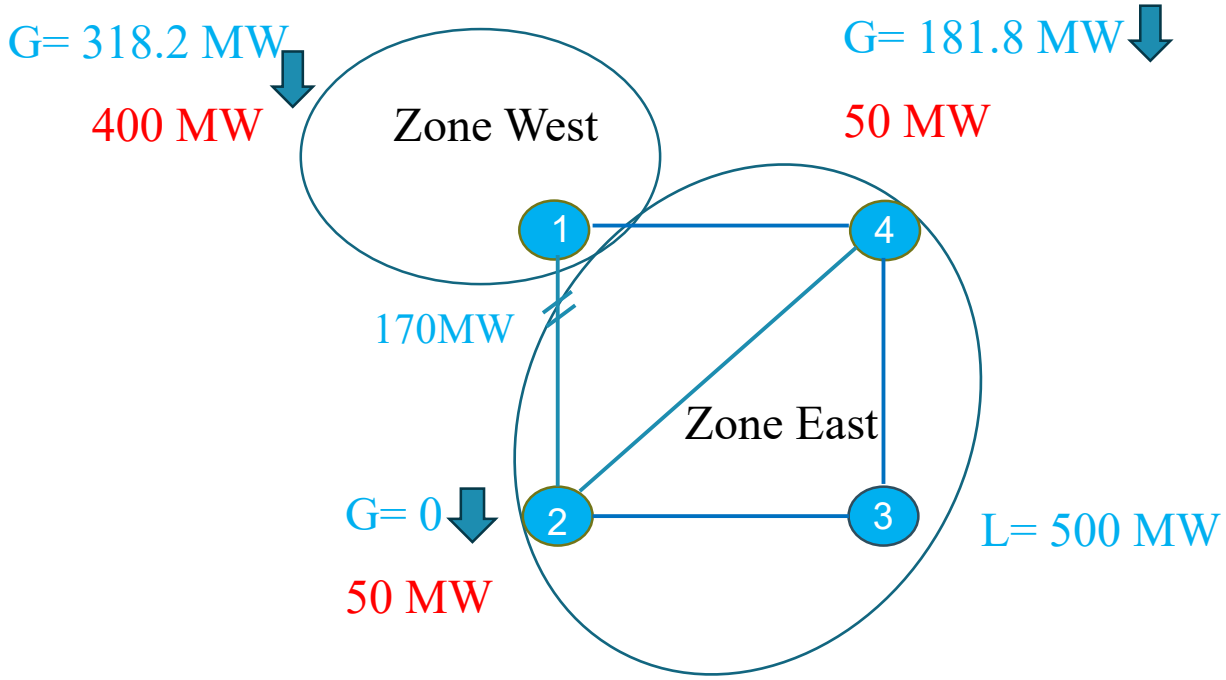
Type	Generation at node 1	Generation at node 4	Load at node 3
Zone	Zone west	Zone east	Zone east
Price (€/MWh)	15	20	20
Cleared quantity (MWh)	318.2	181.8	500
Payment to SO (€)	4773	3636	10000

Redispatch

- National based redispatch costs €7272 (90.9 MWh* € 80/ MWh).
- Cross-border redispatch costs €5227

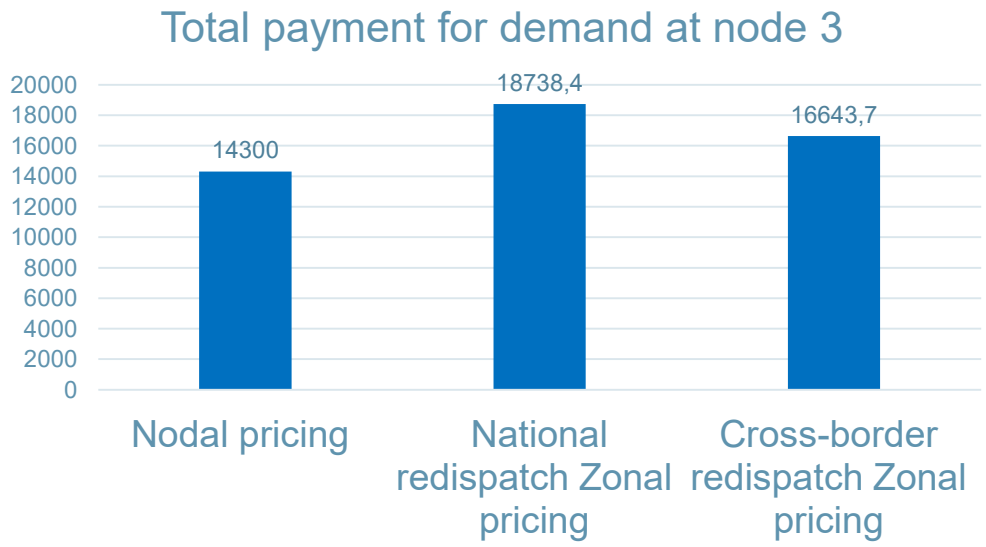


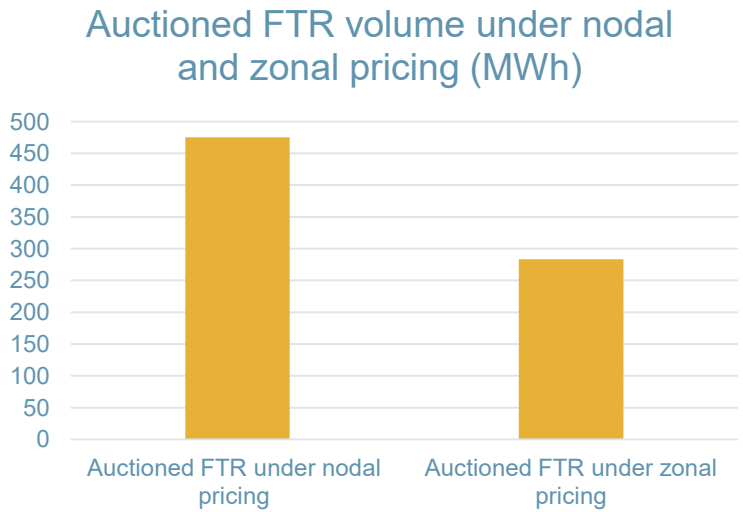
National-based redispatch



Cross-border redispatch

Total payment for demand and network utilization





Inter-zonal line 1-2 utilization	Long-term FTR	Day-ahead
Nodal pricing	100%	100%
Zonal pricing	70.8%	79.55%

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Results comparison

- ❑ Case study is not exhaustive scenario simulation, rather reflection of typical situation
- ❑ FTR holders under zonal pricing could not effectively hedge zonal price differences with procured FTR as under nodal pricing, because:
  - Total amount of FTR allocated is much lower, 283.3 MW under zonal pricing compared with 475 MWh under nodal pricing ➔ Base case and GDSK selection
  - Only cross-border FTR can be procured, high redispatch costs that can not be hedged ➔ Zonal pricing design issue
  - The zonal price difference (5€/MWh between zone west and east) is lower in zonal pricing compared with nodal pricing (158€/MWh between node 1 and node3) ➔ Intra-zonal congestion not reflected in price formulation, FTR payback not fully representing congestion cost

GDSK comparison

❑Perfect GDSK with a good base case

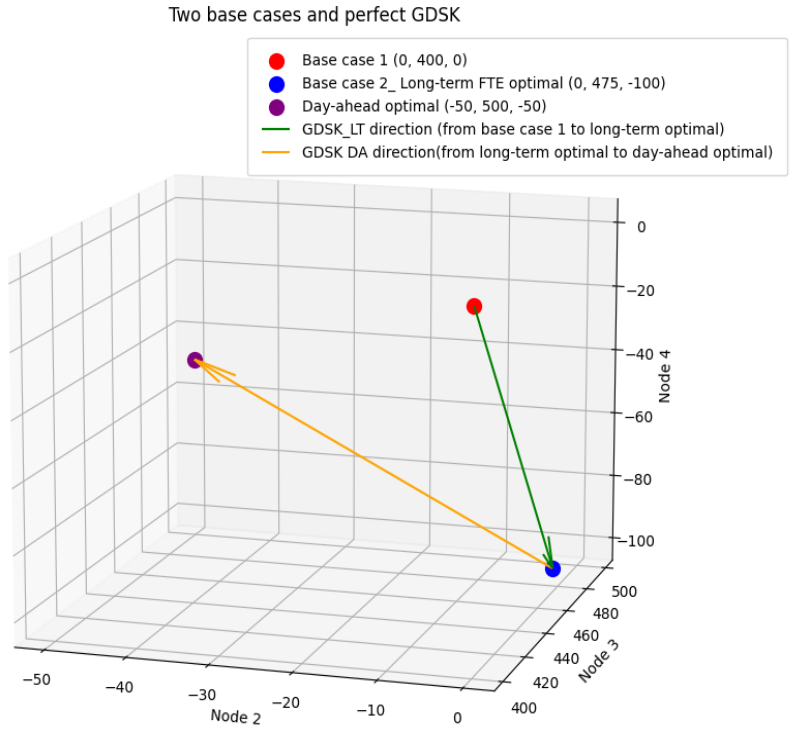
- Non-linearity for GDSK (D' Aertrycke and Smeers 2013)
- Perfect GDSK with fixed value (required by regulation) within a range; GDSK (0, -3, 4) from point red to blue; GDSK (-2, 1, 2) from point blue to purple

❑Ex-post optimal GDSK for zonal pricing

- Nodal pricing dispatch compared with applied base case ➔ GDSK to compensate for base case inaccuracy

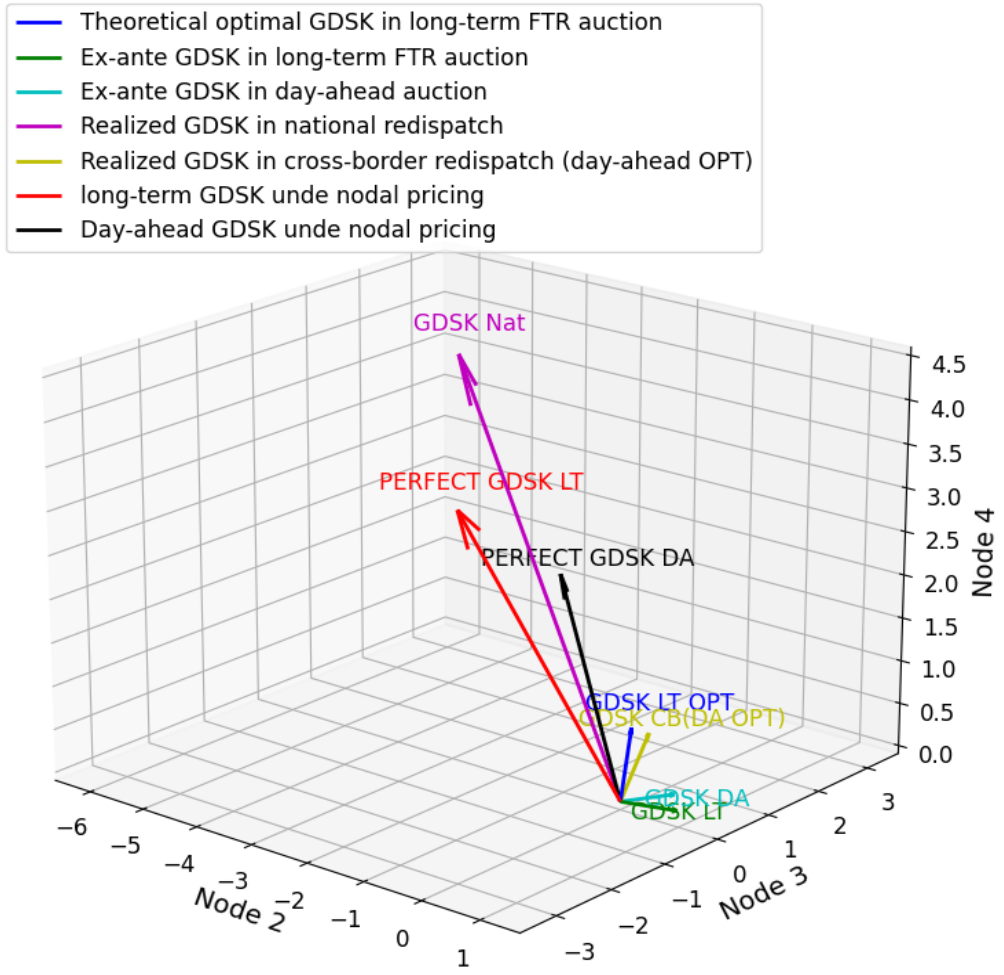
❑Realized GDSK for redispatch

- Redispatch outcome compared with day-ahead base case



Perfect GDSK from nodal pricing dispatch

GDSK comparisons



- GDSK with congestion consideration under zonal pricing can take congestion management into account to help make auctioned FTRs physically feasible, but it can not at the same time optimize the system due to information asymmetry (maximize bid values, optimize network utilization).

Conclusion

- ❑Information asymmetry brings uncertainties for FTR network modeling under decentralized market compared with centralized market structure
- ❑ Revenue adequacy issue for inaccurate base case and relaxed GDSKs
- ❑ GDSKs with congestion consideration results in restrictive grid modeling under zonal pricing
  - Inter-zonal network underutilized
  - Non optimal dispatch pattern
  - Payback for FTR less efficient, less reflective of network congestion cost
  - High redispatch costs
- ❑FTR as hedging instruments can be less effective under decentralized market structure due to the grid modeling challenges

Future work

- Restriction of FTR options on the grid modeling;
- Bidding zone configuration for long-term FTR auction
- FTR comparison with other instruments forward energy and joint energy and transmission right auction.