Efficiency Evaluation and Improvement of Coordinated Transaction Scheduling

Liudong Chen[1,2], Feng Zhao[1]

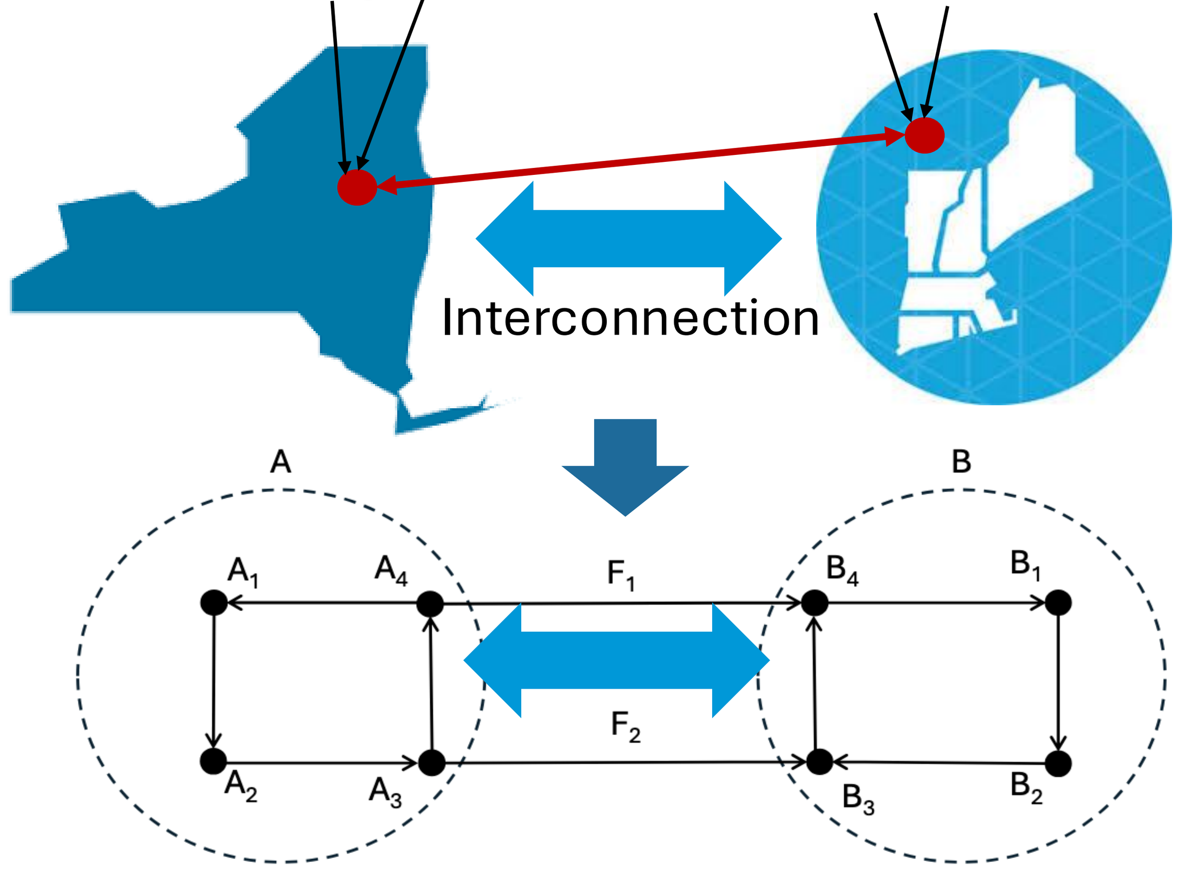
[1]Market and Optimization, Advanced Technology Solution, ISO-NE;
[2]Earth and Environmental Engineering, Columbia University

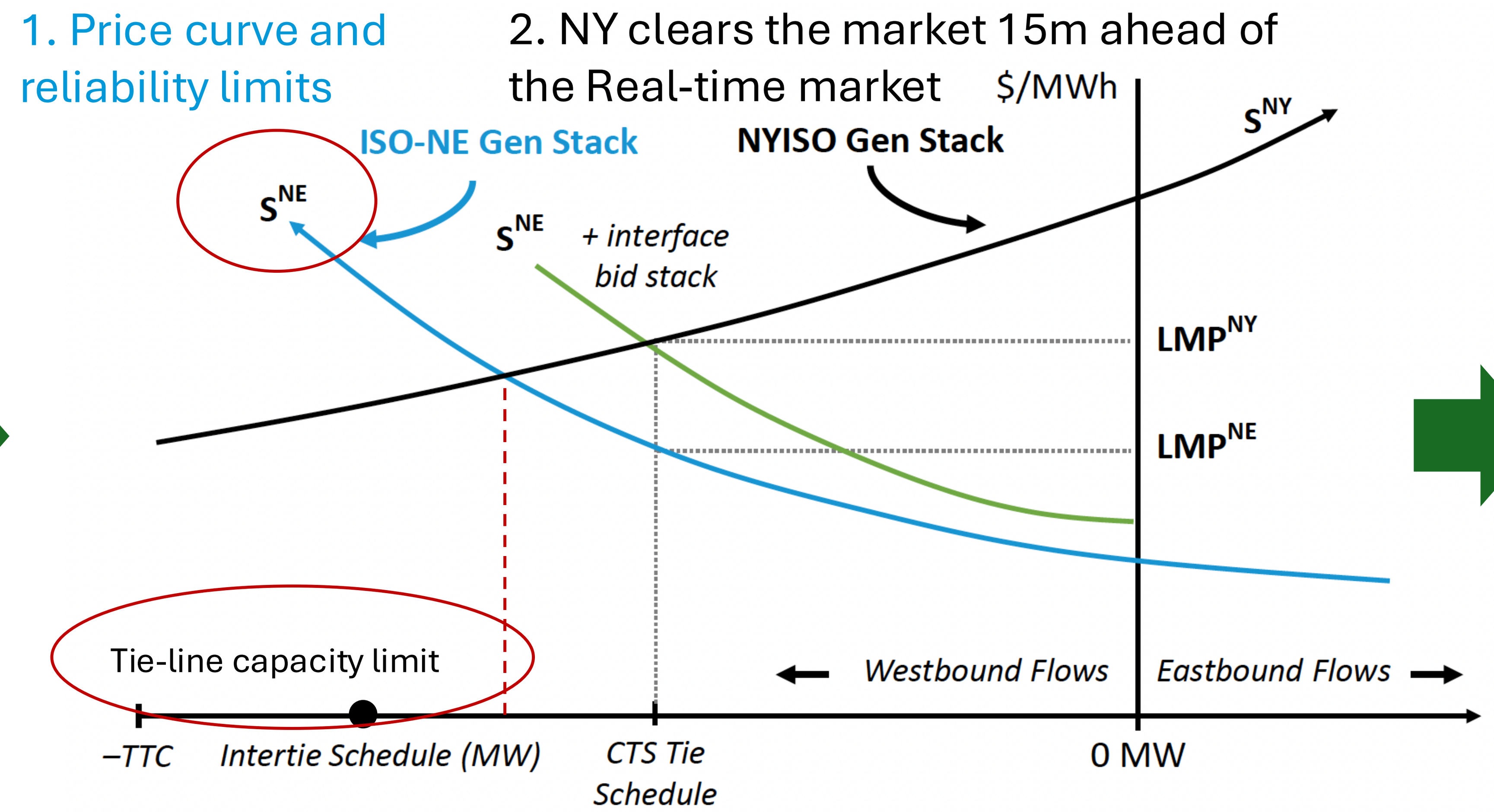
ISO new england

Personal website

Coordinated Transaction Scheduling

Bid: Trading quantity; Price spread; Direction





Research questions:

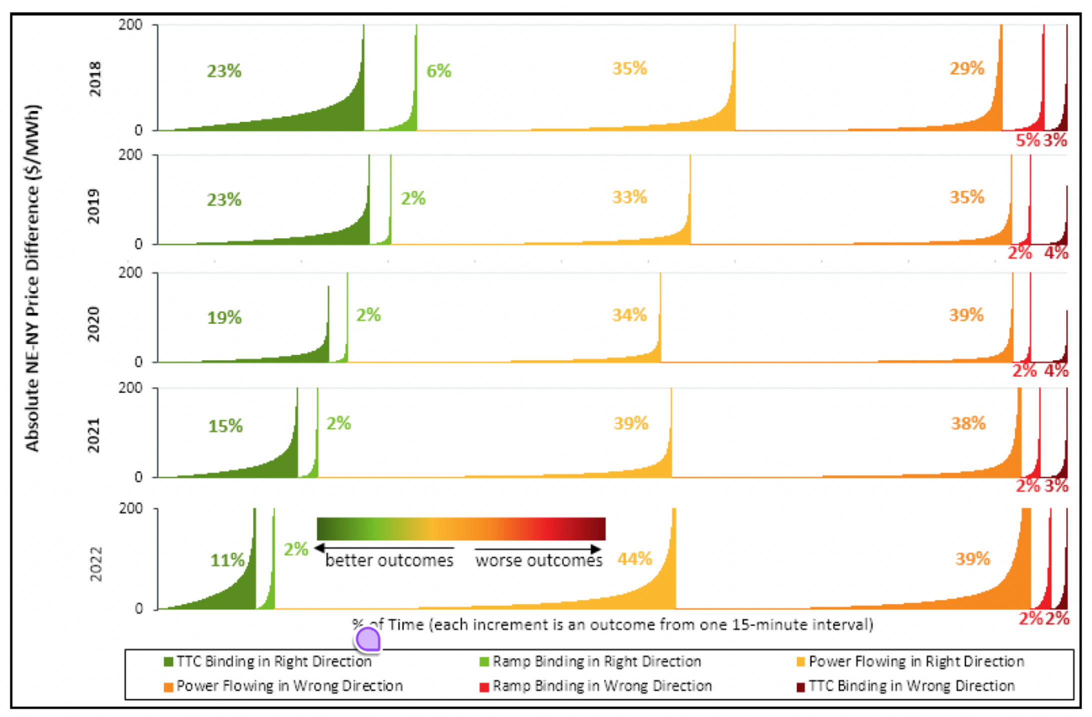
Find a proxy price reflects economic flow direction

Impact of hedging behavior on the CTS efficiency

Future work:

CTS settlement-focused LMP forecasting methods

Regional Proxy Price



Internal Market Monitor reports show CTS flow in a bad economic performance

Reason:

- The benchmark to evaluate economic performance is unsuitable
- CTS is really bad

Our way:

- Find a scalar function: Proxy Price = *f*(LMP)
- A static function about distributions on node

Theorem:

Except for three special cases, there is no scalar function mapping LMP π to proxy price λ independent to the operating conditions σ

Joint economic dispatch of two regions:

Primal variable:

- Generation g_i
- interface flow f_{tie}
- nodal power injection p_i

Focus on the shadow price of each constraints:

- Line congestion σ
- Nodal power balance (KCL) π
- Power balance in each area λ_A, λ_B
- Interface congestion μ

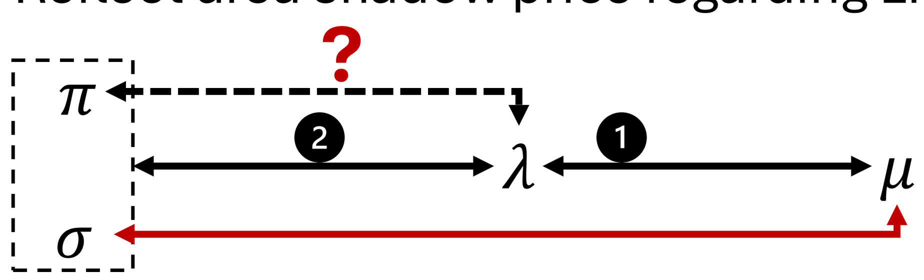
Stationarity:

f_{tie}: $\lambda_{\mathrm{A}} - (\lambda_{\mathrm{B}} - \gamma) - \mu^- + \mu^+ = 0.$ ❶

Reflect the economic flow direction regarding area shadow price

p_i: $0 = \pi_i - \lambda_{\mathrm{A}} + (H^T\sigma)_i - h^T_{\mathrm{tie},i}\gamma, \forall i \in N_{\mathrm{A}},$
$0 = \pi_i - \lambda_{\mathrm{B}} + (H^T\sigma)_i - h^T_{\mathrm{tie},i}\gamma, \forall i \in N_{\mathrm{B}}.$ ❷

Reflect area shadow price regarding LMP

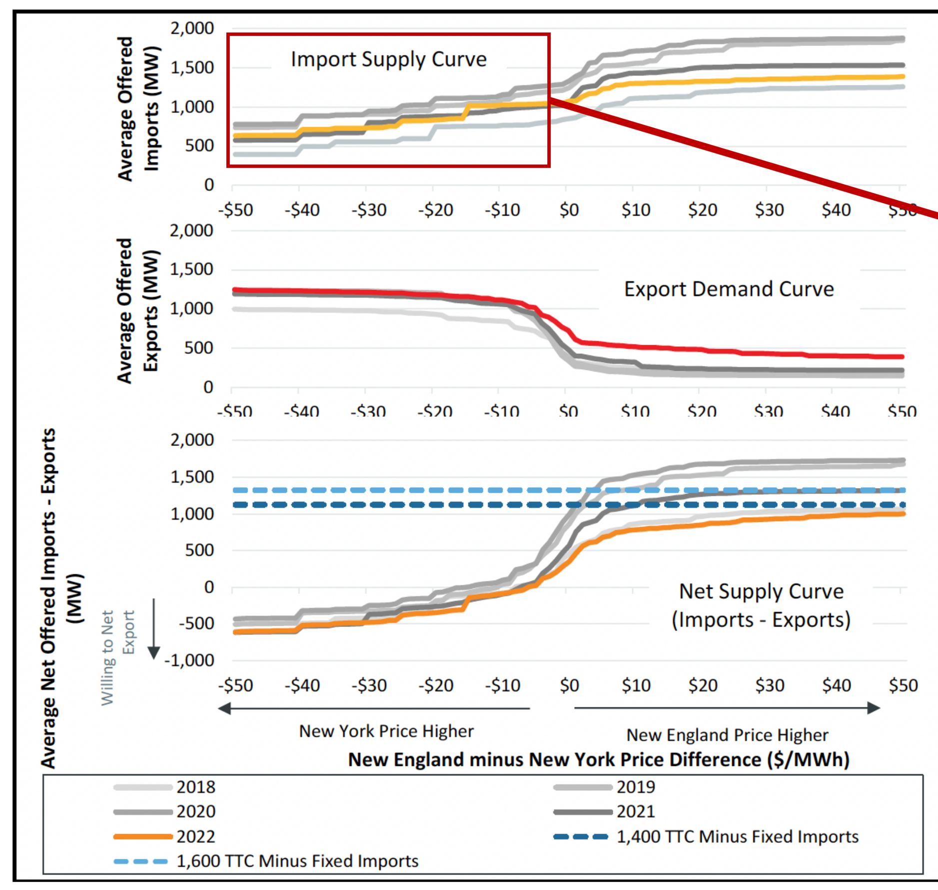


Special cases:

- Only interface binding, all lines are not
- Interface not binding
- Only one tie-line in the interface

2022 Annual Markets Report, ISONE Internal Market Monitor
Kirschen, D. S., & Strbac, G. (2018). Fundamentals of power system economics. John Wiley & Sons

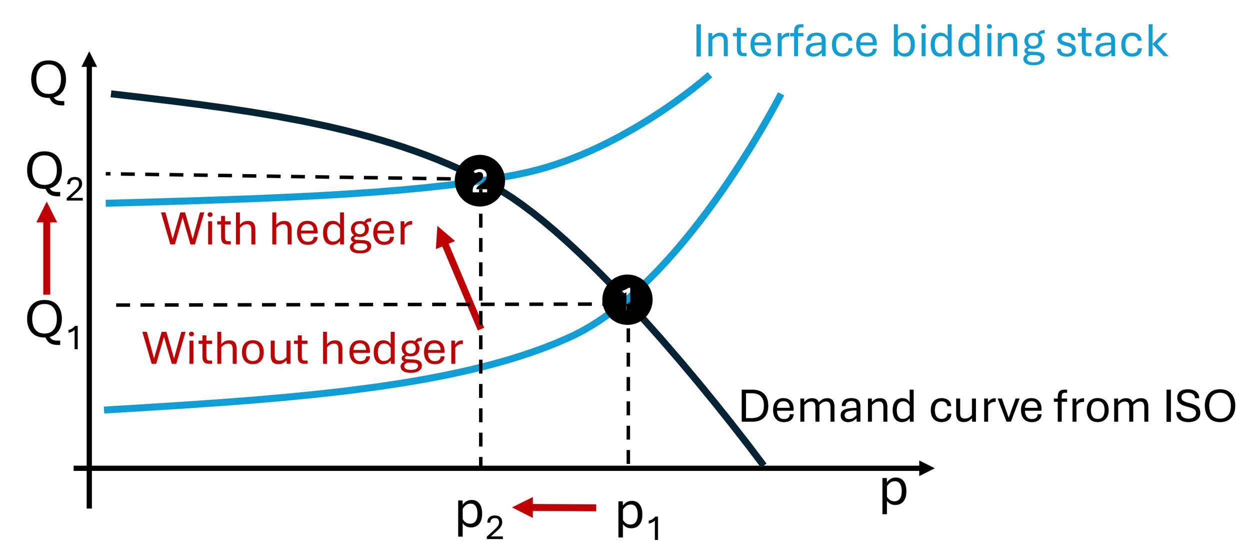
Hedging Behavior



Internal Market Monitor reports show aggressive CTS bidding behavior

Explanations:

- Some participants accept a negative price to trade power inter-regional.
- Define hedger and arbitrager. Hedger have day-ahead positions, and CTS only clears in the real-time market.
- Understand the impact of hedging behavior on the CTS operation efficiency.



Phenomenon:

- Clearing price reduced, so more likely to have reverse prices in real-time settlement
- Clearing amount increases, possibly resulting in greater social welfare

Metrics:

- Reversal cost
- Social welfare
- Forecast-error robustness

Supply function bidding and game formulation: Let the linear bidding function as $q_i = C_i(P)$

- Hedger, $C_j(0) = B_j, C_j'(q_i) \approx 0$
- Arbitrager, $C_j(0) \approx 0, C_j'(q_i) > 0$

Payoff:
$\pi_i = q_i P(Q) - \int_0^{q_i} C_i^{-1}(s)ds,$

- Nash game exists unique Nash equilibrium
- Three regions with hedgers

With forecast error

- Demand curve $P = \alpha - \beta Q$ with $\alpha_r = \alpha_f + \varepsilon_\alpha, \beta_r = \beta_f + \varepsilon_\beta$, the imbalance flow is $Q = \left|Q_f - \frac{\alpha_r}{\beta_r}\right|$

M. Ndrio, S. Bose, L. Tong and Y. Guo, "Coordinated Transaction Scheduling in Multi-Area Electricity Markets: Equilibrium and Learning," in IEEE Transactions on Power Systems, vol. 38, no. 2, pp. 996-1008, March 2023

lc3671@columbia.edu