Congestion management in electricity networks: Nodal, zonal and discriminatory pricing – Par Holmberg and Ewa Lazarczyk (University of Cambridge Electricity Policy Research Group)

**Abstract:**

The paper delves into how congestion in the transmission network is handled in the following market arrangements; nodal, zonal and discriminatory pricing. This is set in the context of networks which have transmission constraints and loop flows. Loop flows are ‘physical power flows in one bidding zone caused by internal commercial energy transactions with another bidding zone’ ([Loopflows and unscheduled energy flows – explaining the mystery – Euractiv](https://www.euractiv.com/section/energy-environment/opinion/loopflows-and-unscheduled-energy-flows-explaining-the-mystery/)). The paper concludes that when many producers/generators are allowed to participate in the real-time market, the three market designs result in the same efficient dispatch, however, zonal-pricing with counter-trading enabled, results in additional payments being made to generators at export constrained nodes. Power system dispatch refers to the optimisation problem that determines the operation pattern of the power system to fulfil demand ([Revisit power system dispatch: Concepts, models, and solutions | TUP Journals & Magazine | IEEE Xplore](https://ieeexplore.ieee.org/document/10144287)). Dispatch exists to achieve the most economically-lucrative operation schedule at a power plant ([Dispatch & Redispatch | Definition & Background Information (next-kraftwerke.com)](https://www.next-kraftwerke.com/knowledge/dispatch)). ‘Counter-trading’ describes a cross zonal exchange initiated by system operators between two bidding zones to relieve physical congestion (in the context of the UK this may not be relevant?) ([Countertrading - Emissions-EUETS.com](https://emissions-euets.com/internal-electricity-market-glossary/714-countertrading))

**Introduction:**

The most fundamental problem to solve for a system operator is ensuring that supply fulfils demand at all times – how this is managed with Tx constraints has a major influence on market clearing prices. The relevant regulatory body of a nation(s) (Ofgem for UK, ENTSO-E for EU I believe?) has to devise congestion management strategies in-line with policy.

In markets which utilise the LMP arrangement, the proximity to each node is reflected in the market clearing price – all accepted offers (when a generator is paid to increase generation) are paid a local-uniform price.

Under discriminatory pricing arrangements, there’s no uniform market prices – offers are paid as bid (bids are what the system operator pays a generator to reduce generation, offers are the price paid to generators to increase generation). As utilised by the UK’s SO, discriminatory pricing enables production in import-constrained nodes (the node cannot import supply due to Tx limitations – think of it as supply/demand – for the demand there is limited supply, hence the higher price) to be accepted at higher prices than production in export-constrained nodes (the zone cannot export supply due to Tx limitations).

Under zonal market arrangements, there are uniform prices within each zone, regardless of Tx constraints within the zone – in real-time inter-zonal congestion is factored into pricing. The US previously had this market arrangement in place but transitioned to a nodal pricing arrangement due to the need for SO’s to redispatch after real-time market clearing due to constrained Tx lines within the zone. This redispatch leads to an increase in supply in import-constrained nodes (could lead to oversupply) and decreases supply in export-constrained nodes (the zone already is limited in its ability to send electricity out of it – this could further exacerbate the problem). Additionally, in a zonal-market arrangement that enables counter-trading, the payoff for generators can be at the SOs expense if the producer has a strategy in-place for maximizing profits; when a generator at an export-constrained node is not generating any electricity, they can sell at the uniform zonal price and buy electricity back at the discriminatory equilibrium price in the countertrading stage which would be lower in price. The generator can further benefit from the 2-stage market clearing process by selling at the uniform zonal price or at the discriminatory equilibrium price in the second stage of market clearing depending on which price is higher.

In this paper the three market designs are compared by assuming that the demand is certain and inelastic (inelastic demand is an economic phenomena describing the behaviour of consumers – consumer spending is not affected by price changes, the consumer continues to buy the product/service [What Is Inelastic? Definition, Calculation, and Examples of Goods (investopedia.com)](https://www.investopedia.com/terms/e/inelastic.asp)).