# Nodal Pricing

## Some Pros and Cons

Lion Hirth | Strommarkttreffen | 18 Oct 2018

# About this talk

## Sources and acknowledgements

- Study "*Nodale und zonale Strompreissysteme im Vergleich*" for Germany's BMWi with three workshops and input from a dozen experts
- START project, various other studies

## Objectives of this talk

- Provide a brief introduction to nodal pricing
- Discuss the pros and cons of nodal pricing as compared to zonal pricing
- Outline alternative (or additional) instruments for locational incentive

## <u>Not</u> objectives of this talk

- Argue in favor or against nodal pricing
- Present the German government's position on nodal pricing
- Argue that introducing nodal pricing is (politically or legally) realistic – or not
- Draw final conclusions

# Relevant policy debates

- Difficulties and delays with transmission grid expansion
- Redispatch and curtailment costs
- Impacts on neighbors
  - Loop flows
- Bidding zone delimitation / market splitting
  - DE/AT split
  - Various studies on bidding zone delimitation, including ETNSO-E's Bidding Zone Review
  - Top level commitment to keep uniform German bidding zone
- Market based redispatch
  - Clean Energy Package proposal by the Commission

# Agenda

1. **An Introduction to Nodal Pricing**
2. Nodal Pricing: Pros and Cons
3. Locational Investment Incentives

# Nodal vs. zonal pricing in a nutshell

## Different approaches how to give electricity markets spatial granularity

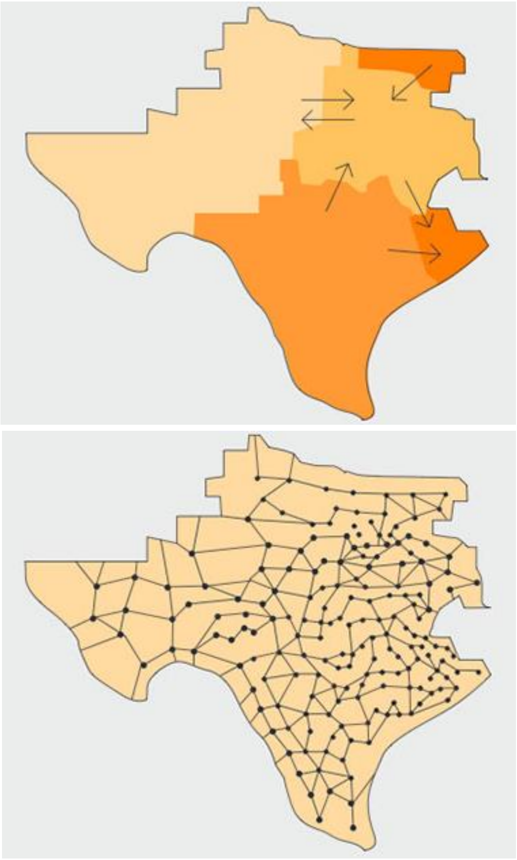
- Zonal: larger regions (e.g., countries)
- Nodal: individual network bus bars (“nodes”)

## Making sure transmission constraints are respected

- Zonal: congestion within zones are managed *after* dispatch
- Nodal: network restrictions are accounted for *during* the dispatch decision-making

## Institutional features of nodal pricing systems

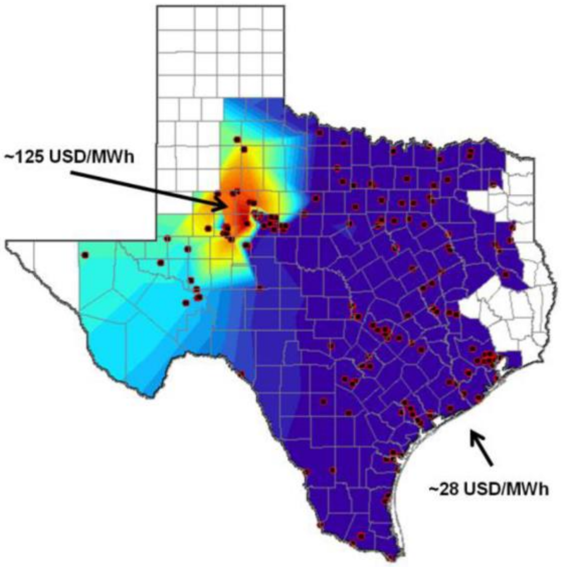
- One single trading platform: independent system operator
- Trading on hubs
- Base risk traded as financial transmission rights
- Price regulation, often with capacity mechanisms



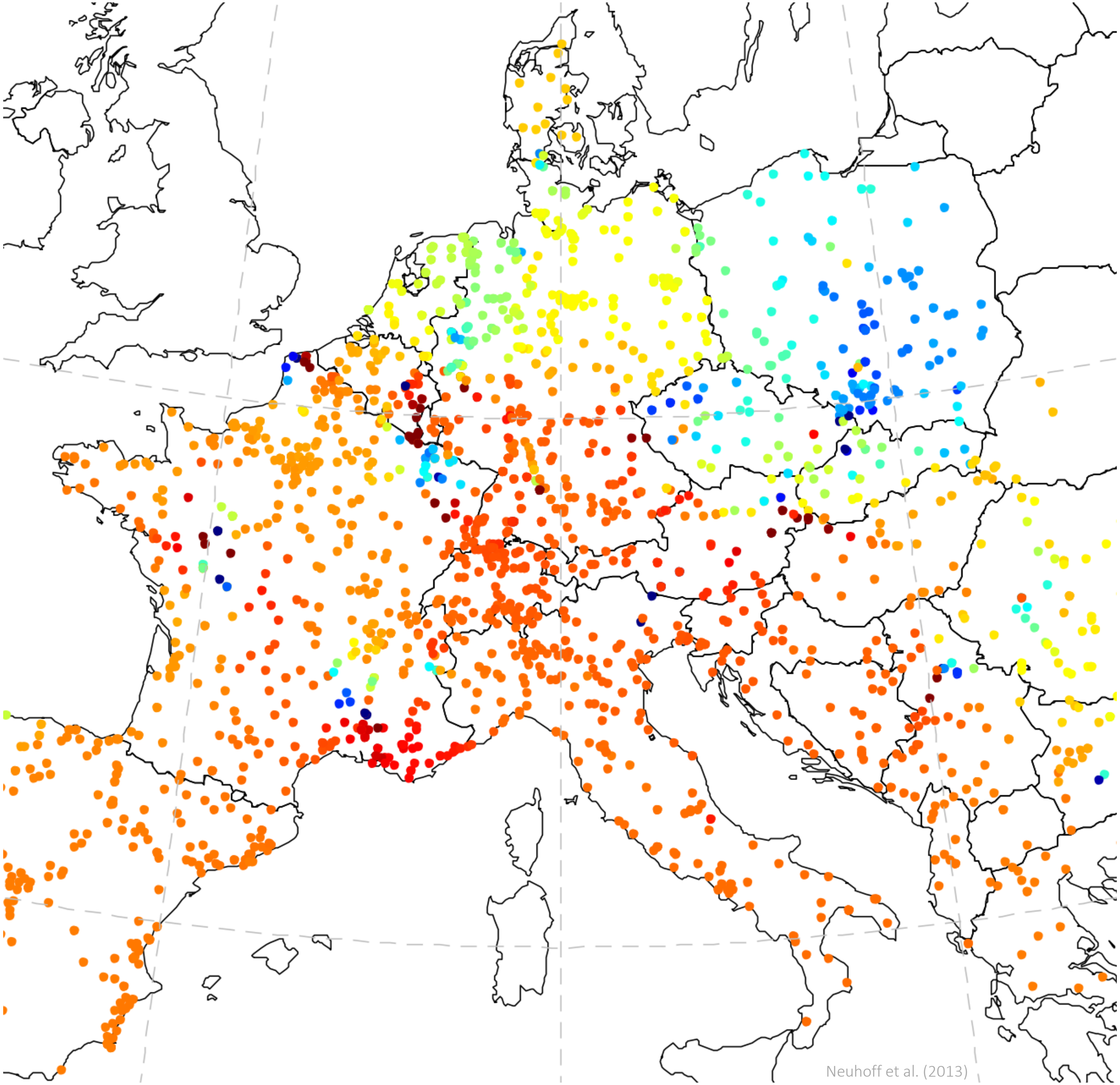
Texas was a single bidding zone 1999 - 2001, then 4-5 zones, before nodal pricing was introduced in 2010.

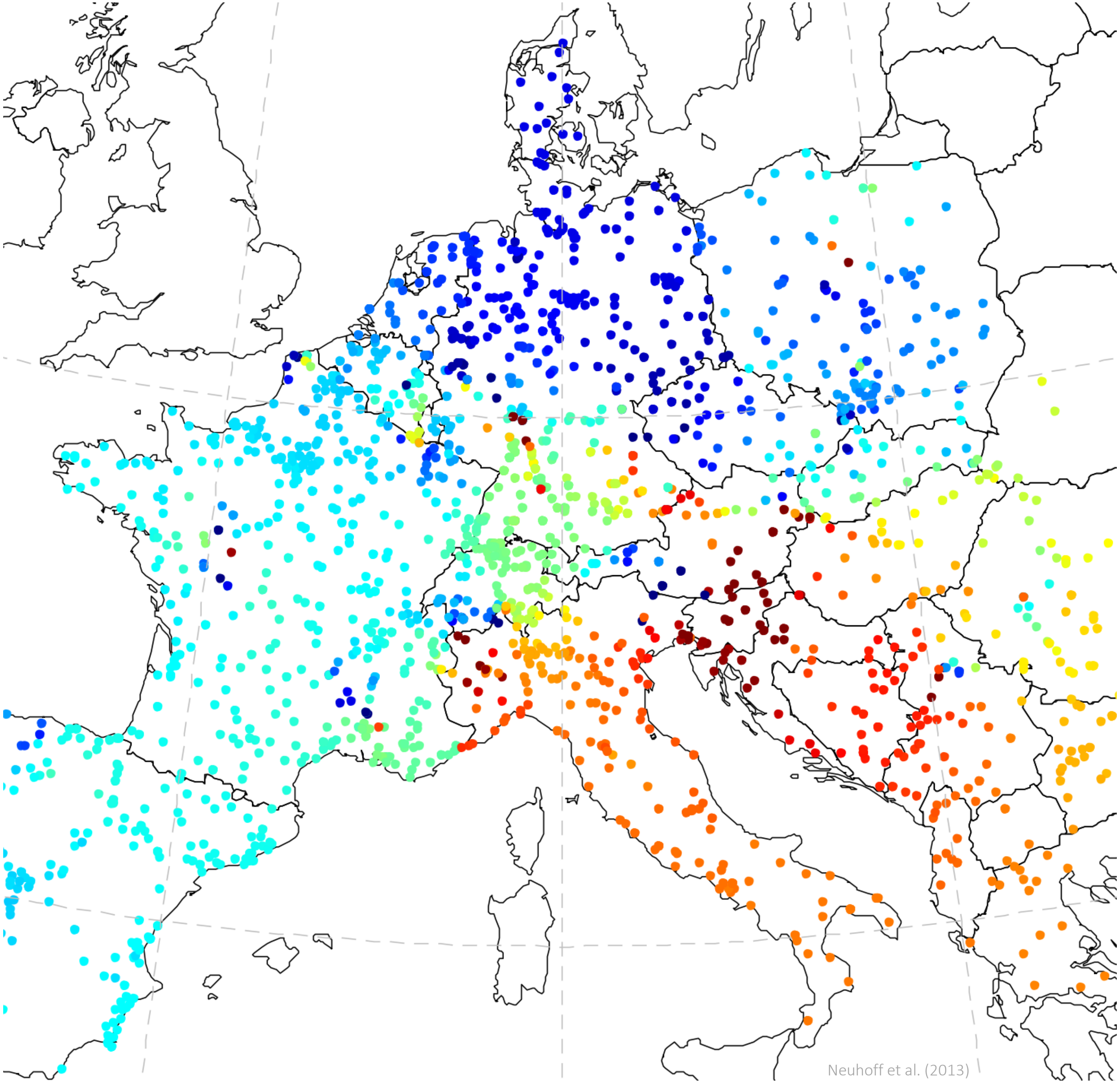
# Nodal pricing: price determination

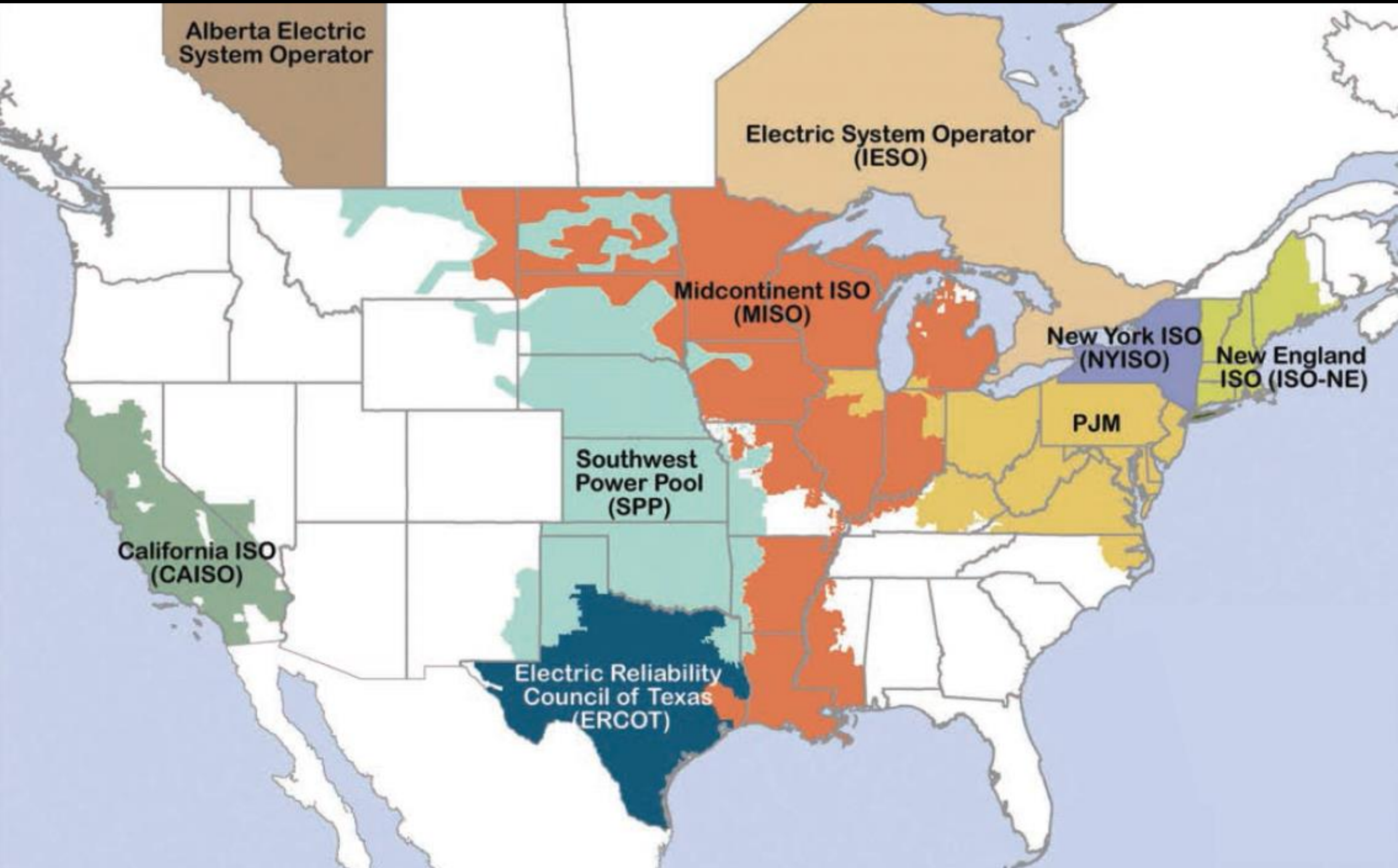
- Line capacity between nodes is not fully used → prices converge
- Congested lines → prices diverge
- Price at node X is determined as ”marginal benefit for total system if an additional MWh is fed into this node, accounting for all network constraints“
- Example
  - In-feed at X relaxes constraint
  - As a consequence, it is possible to ramp up cheap generation elsewhere
  - Consequence: price at X is very high to reflect the high value of generation here




- Load flow follows Kirchhoff‘s rules: calculations are complex, require computer model
- Theory established by Schweppe et al. (1988) and others


Neuhoff et al. (2013)


Neuhoff et al. (2013)


Alberta Electric System Operator
Electric System Operator (IESO)
Midcontinent ISO (MISO)
New York ISO (NYISO)
New England ISO (ISO-NE)
PJM
Southwest Power Pool (SPP)
California ISO (CAISO)
Electric Reliability Council of Texas (ERCOT)

# Institutional features of real-world nodal pricing systems

- Bidding, scheduling and clearing has to be done for each node
- Independent system operator (ISO) operates the power grid and spot market in an integrated way
- ISO does not own the grid
- Dispatch (schedule) is determined by sophisticated unit commitment computer model operated by ISO (“central dispatch”)
- Minimize total system costs subject to network constraints: “security-constrained economic dispatch”
- A single mandatory trading platform (ISO)
- Complex bids and high time resolution (5 min for real-time markets)
- Usually: price caps and capacity mechanisms

# Financial markets in nodal pricing systems

- Spot markets: dispatch decisions
- Financial markets: hedging
- Zonal pricing: one financial market per zone
- Nodal pricing: one financial market per node would lead to low (or zero) liquidity → pool liquidity at "hubs"
- Risk of price deviations between hub and node (base risk) → financial transmission rights (FTRs)
- Financial Transmission Rights: contract between two parties with obligation (or option) to pay hour-by-hour price differences between two locations

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# Comparing nodal pricing … to what? Three prototypes

Pros and cons of nodal pricing can also be discussed relative to a benchmark

Compare to “zonal pricing” – but zones can be small or large

We compared three prototypes: “Status Quo”, “CACM bidding zones” and “Nodal Pricing”

| | Status Quo (1) | CACM Bidding Zones (2) | Nodal Pricing (3) |
|---|---|---|---|
| **Bidding zone delimitation determined by** | National borders (mostly) | Structural congestion | - |
| **Revision of zone delimitations** | No (stable zones) | Yes, every 5 years | - |
| **# of zones in GER** | 1 | 2-10 | 100s |
| **Congestion management** | After dispatch, cost-based (except at zonal border) | Between (1) and (2) | Integrated with dispatch, incentive-based |
| **Institutional framework** | Network operation (TSO) separated from wholesale trading (PX) | (1) | Integrated optimization of network operation with dispatch (ISO) |

# Criteria

We have collected more than 40 criteria, grouped into 10 clusters

| |
|---|
| 1. Impact on dispatch decisions (static efficiency) and flexibility |
| 2. Impact on investment decisions in power plants and flexibility resources (dynamic efficiency) |
| 3. Impact on network investments (dynamic efficiency) |
| 4. Impact on other electricity markets |
| 5. Need for regulatory interventions |
| 6. Impact on renewable energy sources |
| 7. “Political” criteria |
| 8. Security of supply |
| 9. Impact on neighboring systems |
| 10. Cost of system transformation |

| | Status Quo (1) | CACM zones (2) | Nodal Pricing (3) |
|---|---|---|---|
| 1. Impact on dispatch decisions (static efficiency) and flexibility | | | |
| **Use existing grid efficiently** | Moderate to high (depending on quality of redispatch process) | Moderate to high (depending on quality of redispatch, # of zones) | High (if well implemented an regulated) |
| **Incentives for efficient plant and flex-resource dispatch** | Locational efficiency within zones missing | Between (1) and (3), depending on # of zones | Locational precise, but central dispatch can stifle innovation |
| **Support short gate closure and scheduling intervals** | - | See (1) | Possibly: reduced manual interventions allow shorter GC |
| **Support intraday markets** | Continuous trading or sequence of auctions | See (1) | Sequence of auctions |
| **Redispatch volume** | High if network expansion remains delayed | Reduced compared to (1) | No redispatch |
| **Technical network operations (e.g. switching operations)** | | | [Disagreement] |
| **Potential for market power abuse (spot)** | Limited, because rare scarcity | Moderate | High, because frequent local scarcity |
| **Potential for market power abuse (redispatch)** | High (depends on regulatory regime) | Moderate | - |
| **Options to mitigate market power** | Cost-based redispatch | Between (1) and (3), depending on # of zones | Price regulation of spot bids |
| *Conclusions* | *If both systems are implemented optimally, differences in dispatch efficiency are small: the dispatch algorithm then resembles the nodal pricing algorithm. In reality, differences due to imperfect redispatch and market power abuse (and regulation) are likely.* | | |

| | Status Quo (1) | CACM zones (2) | Nodal Pricing (3) |
|---|---|---|---|
| 2. Impact on investment decisions in power plants and flexibility resources (dynamic efficiency) | | | |
| **Incentives for spatially efficient investments into plants and flex-resources** | None based on market price signals (except across zones) | Moderate, at bidding zone level; Effectiveness depends on credibility and stability zonal price signals | Stronger incentives; effectiveness depends on credibility and stability of local price signals – may still be significantly too low |
| **Incentives for investments into system-wide flexibility options** | High due to possibility of competitive and efficient price signals at system level | Between (1) and (3), depending on # of zones | Possibly dominated by local effects and uncertainties; development of new flex options only within specified bidding types – thus flexible bidding options are important (multi-part bid etc.) |
| **Credibility of prices as incentives for investments** | High due to more stable prices (Individual decisions hardly affect prices)<br>Low if investors do not consider price system as sustainable | Between (1) and (3), depending on # of zones | Reduced when local prices are difficult to predict and strongly influenced by individual (line extension) decisions |
| **Market entry of new actors** | Hypothesis: New entries are easier due to pooling, particularly small flex options may be easily aggregated and jointly marketed.<br>Antithesis: Difficult, as different flex options need to be pooled in order to model standardized products. | Similar to (1), but smaller pools, higher transaction costs | Hypothesis: Inter-nodal pooling of flex impossible, high transaction cost impedes efficient development of unconventional flex options<br>Antithesis: Simple, since pooling unnecessary, due to (i) possibility of multi-part bids, (ii) No discrimination against small actors in case of deviations |
| **Incentives for spatially efficient investments into RES** | Depends only on the RES support scheme | Interaction with RES-support scheme | Interaction with RES-support scheme |
| ***Conclusions*** | *Strength of local investment signal rises from (1) to (3). However, its effectiveness is fundamentally dependent on predictability and credibility. Strength of systemwide investment signal rises from (3) to (1). Other local investment signals (spatially differentiated grid usage and connection fees, RES support, tenders) can be combined with all price systems.* | | |

# Crucial aspects: market power and investment incentive

## Market power abuse and regulatory response

- Locational market power is much more pervasive than zonal market power
- Most regulators have responded with price caps …
- … resulting in missing money and under-investments …
- … triggering capacity payments
- Not a great option (in my view)

## Locational investment incentives

- Do nodal prices provide the right incentives to invest at the right location?
- Doubts: locational prices have little long-term credibility
- Main reason: a single (political) network investment will drastically reduce local prices

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# Market design elements with locational incentive

Grid reserve

Market splitting

RE zones

Nodal Pricing

Market-based redispatch

Using balancing for congestion

Regulatory redispatch

**Policy instruments and market design elements with locational dispatch or investment incentives (selection)**

Locational-specific RE support schemes

Deep connection charges

Curtailment

Local flex markets

Procurement of local generation capacity

Locational-specific grid usage fees

→ How to make sense of this myriads of proposals?

# Clustering instruments

**The instruments can be grouped by their economic principles into 5 clusters**

| | |
|---|---|
| 1 | Large bidding zone with cost-based redispatch |
| 2 | Small bidding zones with cost-based redispatch |
| 3 | Locational prices |
| A | Locational procurement of capacity |
| B | Locational administrative price signals |

# Market-based redispatch: zonal *plus* local “extra” market

## Keep zonal spot market, add local ”extra“ market

- Market based redispatch (Article 14 of the proposed Electricity Market Regulation)
- Can come in various forms: dedicated “redispatch market”; market(s) for local flexibility; local intraday order book; balancing market with local information

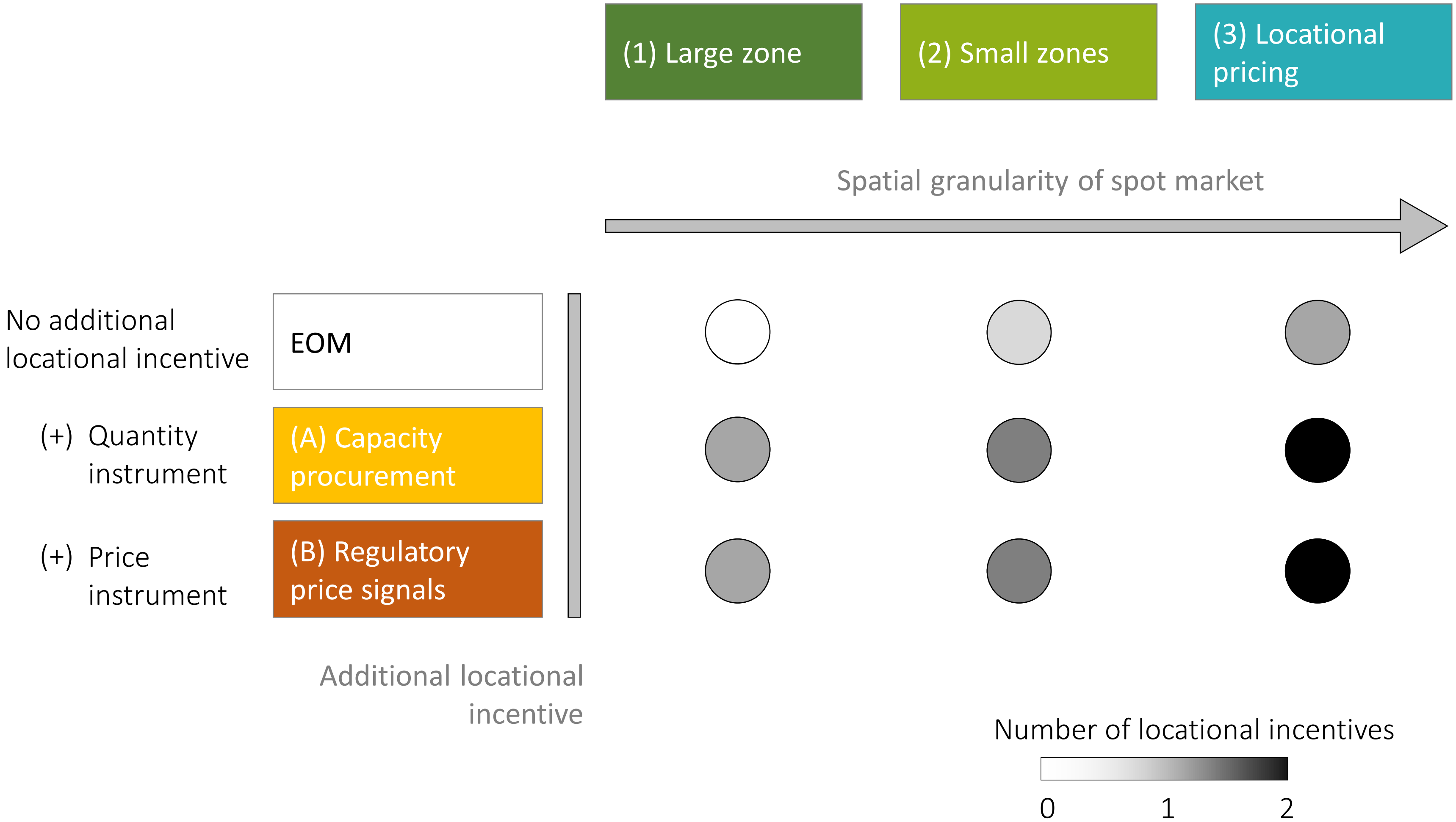
## Feedback to spot via strategic bidding: the “INC/DEC game”

- Generators and loads have an incentives to hold back capacity on the spot market if they expect better prices on “extra” market
- The spot loses incentive compatibility: agents stop bidding true marginal costs
- In effect, the “extra” market can quickly become the “lead market”
- Requirement: constraints can be anticipated

## Local “extra” markets converge to nodal pricing

- But lack important features like FTRs
- → “If you want nodal pricing, implement it properly”

# Combining spot design with investment incentives



# Concluding thoughts

## Textbook economics emphasizes static efficiency of nodal pricing

- This is largely undisputed, but probably reduces system costs by not more than few %pt
- Other arguments are likely to be more important (we studied 40+)

## Crucial aspects are (in my view)

- Market power, how to mitigate it, and how to avoid regulatory overreaction
- Investment incentives and credibility of price signals

## No market design performs best in all criteria: trade-offs have to be made

- Weighting criteria are subjective – decision is (to some degree) political

## Reconfiguring zones add significant regulatory risk

- Possibly worse than both stable zones and nodal pricing

## Market-based redispatch (or other local "extra" markets) can converge quickly to *de facto* nodal pricing

- If you want nodal pricing, better implement it properly – not through the back door

# Nodal Pricing

## Some Pros and Cons

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