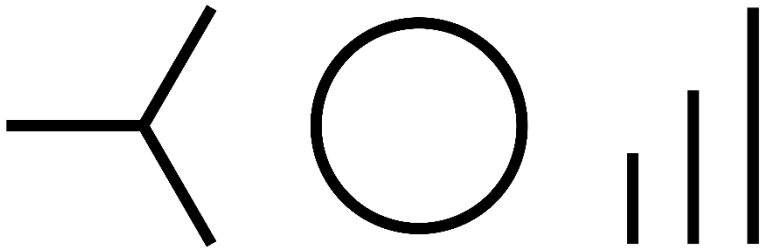
Nodal Pricing

Some Pros and Cons

Prof. Dr. Lion Hirth | Forum Energii | 30 Aug 2018



Neon: project references (1)

Neon is a Berlin-based boutique consulting firm for energy economics, directed by Lion Hirth. We combine expertise on economic theory with advanced modeling capabilities and extensive industry experience. Neon specializes in seven areas:

1. Market value of wind and solar energy
2. (Whole) system costs
3. Market design
4. Balancing energy
5. Power market modeling
6. Open data
7. Training seminars

Redispatch (BMWi). Assessment of alternative options to source redispatch resources, including redispatch markets and local markets for flexibility. The client is Germany's Federal Ministry of Economic Affairs and Energy, Berlin. Neon serves a project coordinator for a consortium of Consentec, Connect Energy Economics, Fraunhofer ISI, Ecofys, and SUER and is responsible for two work packages. 2017-20.

Open source power market modeling (BMWi). Study on open source energy system modeling and open data in the energy sector for BMWi. Neon leads a consortium of DIW Berlin, TU Berlin and ETH Zurich. 2018-20.

Electricity supply contract (European industrial company). Evaluation of a long-term electricity supply contract for a large-scale energy-intensive industrial consumer in the context of a court case. 2018.

TSO data quality (European Commissions. Assessment of data quality provided by European transmission system operators for DG Energy, Brussels. 2017. An article based on this study appeared in *Applied Energy*. More

Portfolio management costs (European utility). Regulatory assessment and quantitative cost benchmarks for portfolio management costs of renewable energy for the trading department of a major European utility. 2017.

Nodal pricing (BMWi). Consulting on locational price signals in wholesale markets. Along with Consentec, Neon was responsible to organize a series of workshop and write a project report. 2016-17.

Neon: project references (2)

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Market value of wind power (European utility). Evaluation of design options and operation strategies to improve the economics of wind power under market conditions. 2016-17.

Wind value in the Nordic region (Energiforsk). Model-based assessment of the market value of wind energy in the hydro-dominated power system of the Nordic region. Neon designed the study, developed the model, and wrote the report, which appeared in *Applied Energy.* 2016. More

EU electricity market design (BMWi). Policy advise on wholesale market and balancing market design in the development of the Clean Energy for all Europeans package. Neon was member of a consortium with Connect, Consentec, and others. 2016-18.

Reasons for the price drop (Swedish Energy). Swedish wholesale power prices declined by two thirds from 2010 to 2015. Neon conducted a model-based assessment of the reasons for this price drop. 2016. More

The benefits of hydropower flexibility (European utility). Model-based assessment of capture rates for a European utility. Neon provided a model-based assessment of the market value of wind energy and hydroelectricity. 2016.

Generation time series (European utility). Neon provided in-feed time series of wind and solar power from re-analysis models. 2016.

System-friendly wind and solar power (IEA). Model-based study for the International Energy Agency. Neon assessed the market and system benefits of low-wind speed wind turbines and east- and west-oriented PV. 2014-16. A summary report is published in *Energy Economics*. More

Neon: project references (3)

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Integration costs (Agora Energiewende). Qualitative study for Agora Energiewende. Neon advised Agora and helped implement workshops in Berlin and Paris. 2015. More

Model development (European utility). Neon supported the trading department of a major European utility in power market model development. 2015.

Whole system costs (DECC). Neon reviewed a report on whole system costs of wind and solar power for the UK Department of Energy and Climate Change, London. 2015.

Open Power System Data (BMWi). Construction of an online platform for European power system data. Neon coordinated a team of three research institutes. 2015-17. More

Electricity market design (IEA-RETD). Assessment of long-term wholesale and retail power market design under very high shares of variable renewables in cooperation with FTI CL Energy. 2015-16. More

Ad-hoc consulting. Neon regularly advises financial institutions and investment banks on renewable energy and power markets.

Power market trainings. Neon trained staff at BMWi, IRENA, BMEL, RP Global, ERRA, Vattenfall, JRC, EHA, 50 Hertz, GIZ, IASS Potsdam, UFZ, Swedenergy, Innogy, Clean Air Task Force, IG Windkraft, Hochschule Reutlingen, Axpo, Renac, Europe Beyond Coal, Agora Energiewende in topics such as power markets, energy economics, energy policy, and electricity market modeling. More

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

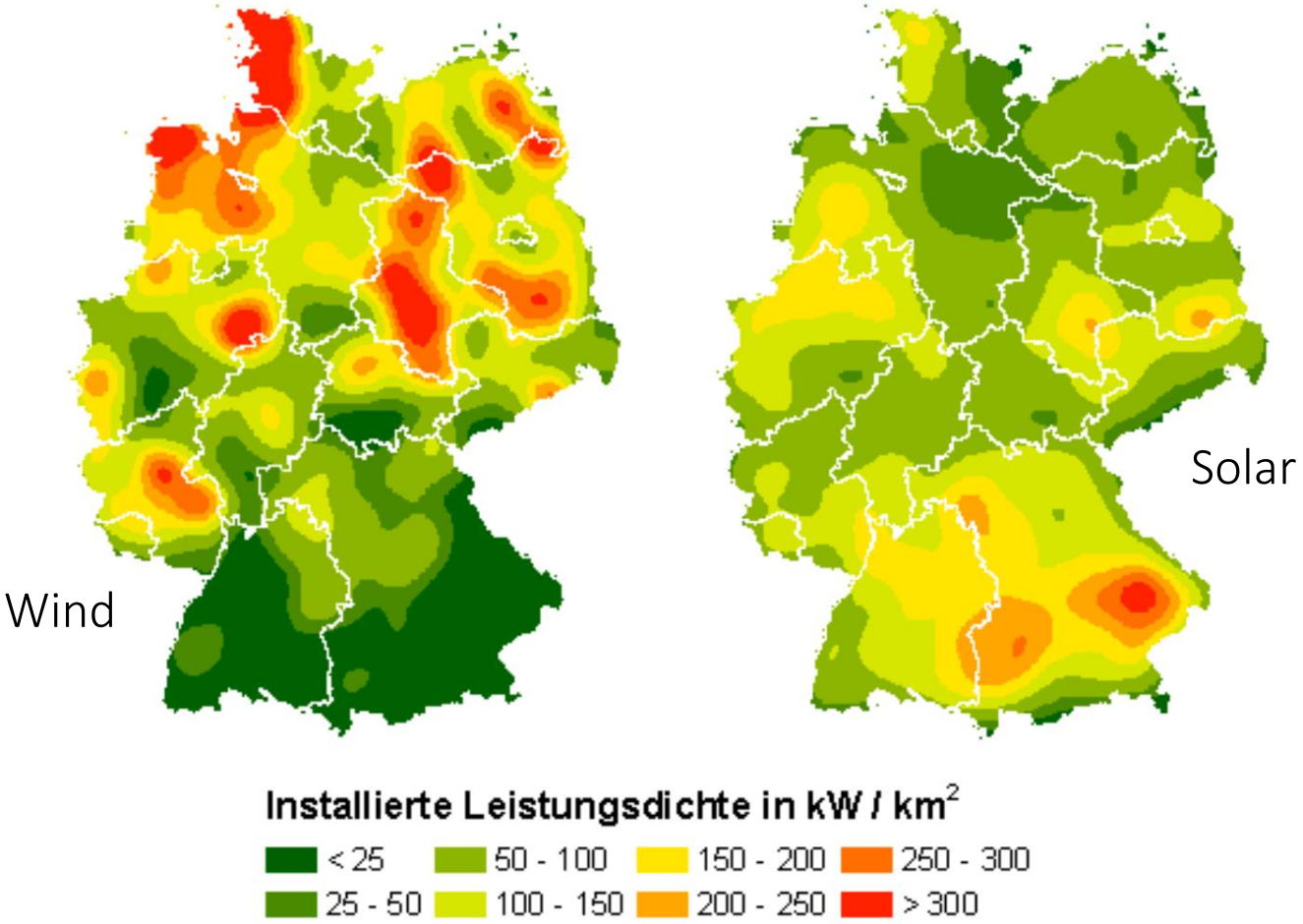
No objectives of this talk

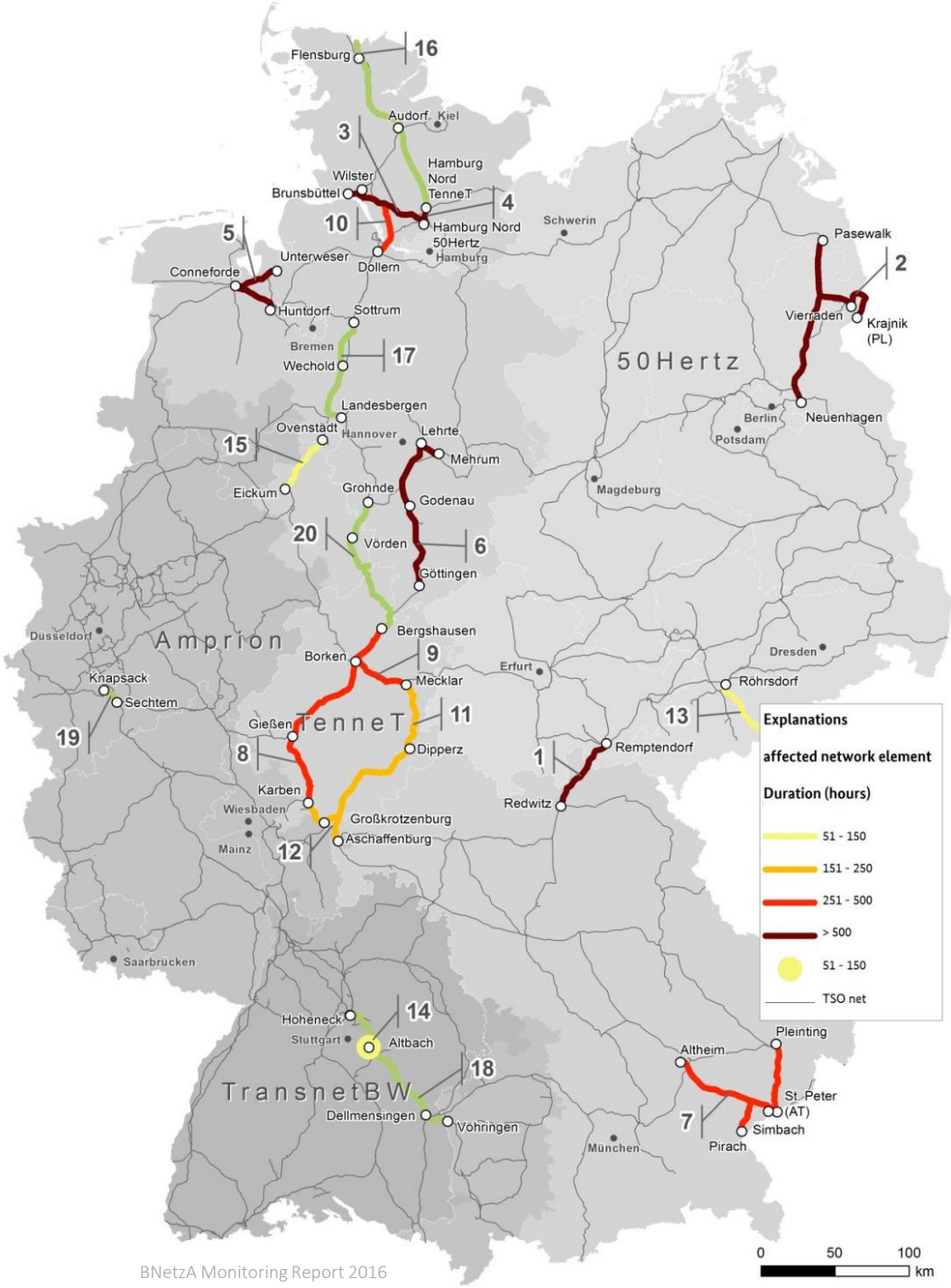
- Argue in favor or against nodal pricing
- Present the German government's position on nodal pricing
- Draw final conclusions

Agenda

1. **Germany's Grid Constraints**
2. An Introduction to Nodal Pricing
3. Concluding thoughts

Geographic distribution of wind and solar capacity in DE

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Hamburg
Schwerin
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Unterweser
Dollern
Conneforde
Huntdorf
Sottrum
Bremen
Wechold
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Pasewalk
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Vierraden
Krajnik (PL)
50Hertz
Landesbergen
Berlin
Potsdam
Neuenhagen
Ovenstädt
Hannover
Lehrte
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Mehrum
Magdeburg
Eickum
Grohnde
Godenau
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Göttingen
Bergshausen
Amprion
Düsseldorf
Borken
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Dresden
Erfurt
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Großkrotzenburg
Mainz
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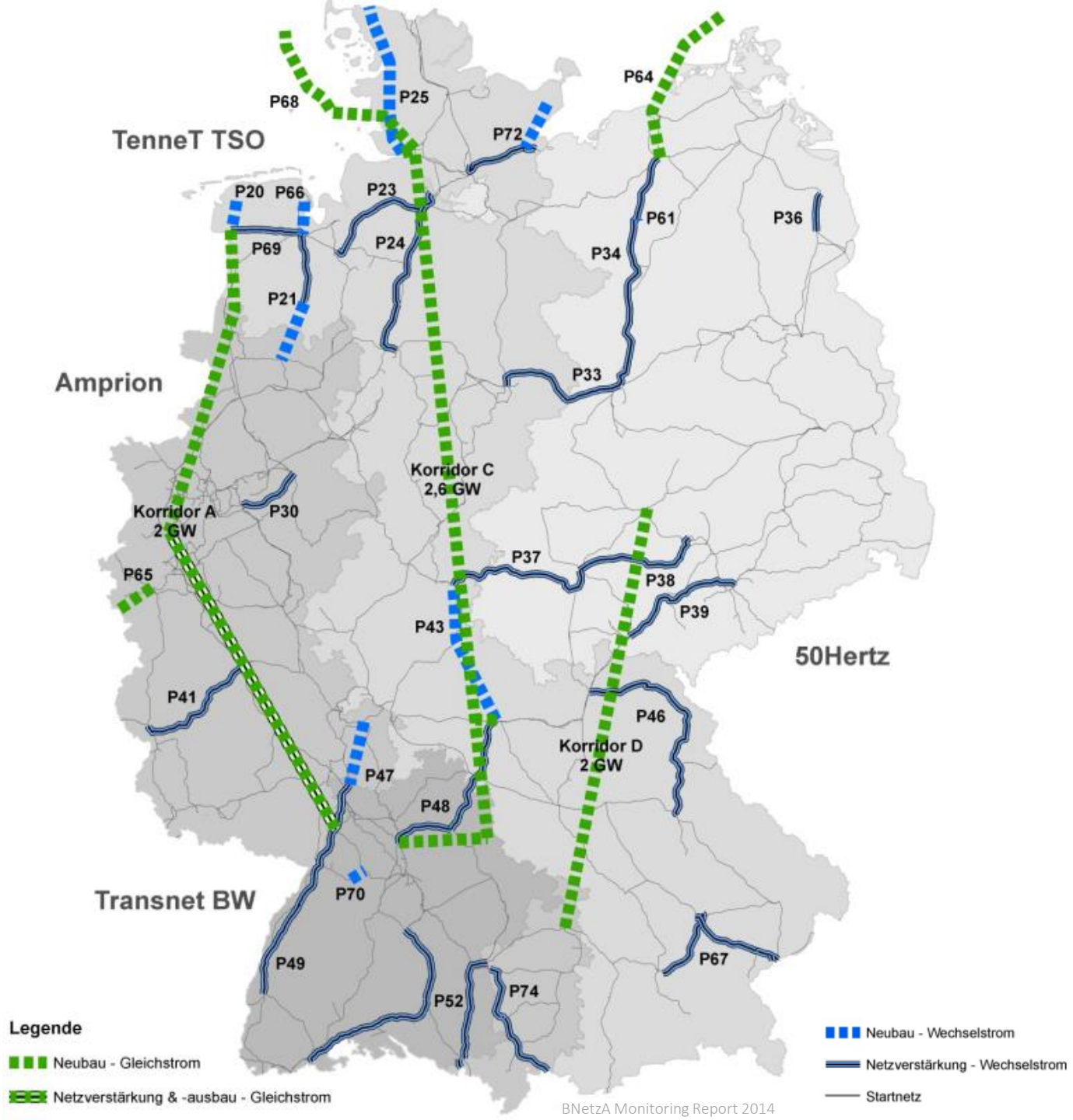
Aschaffenburg
Saarbrücken
Hoheneck
14
Stuttgart
Altbach
Pleinting
Altheim
18
TransnetBW
St. Peter (AT)
7
Dellmensingen
Vöhringen
Simbach
Pirach
München
Explanations
affected network element
Duration (hours)
51 - 150
151 - 250
251 - 500
> 500
51 - 150
TSO net
0
50
100
km


TenneT TSO
Amprion
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P61
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P24
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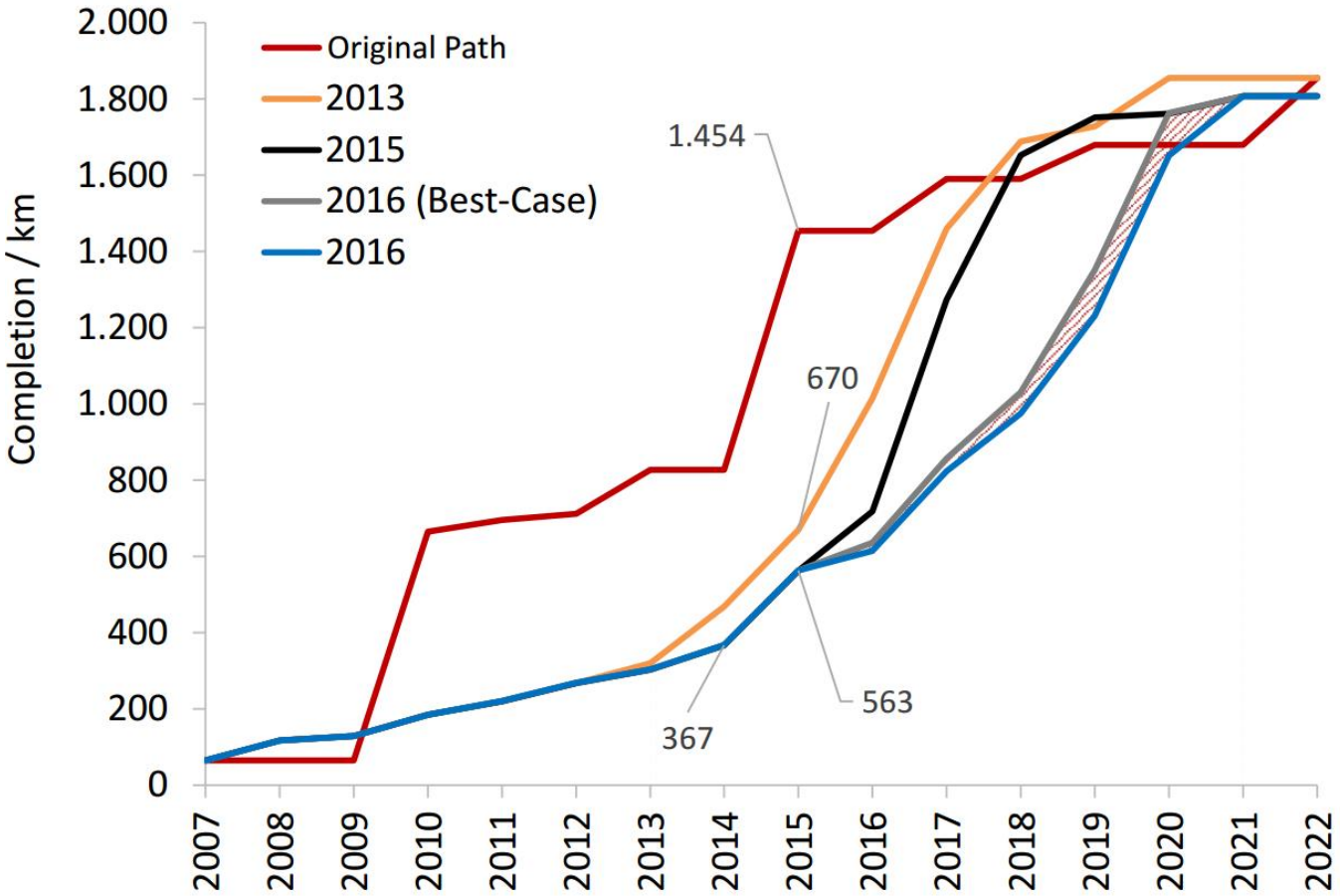
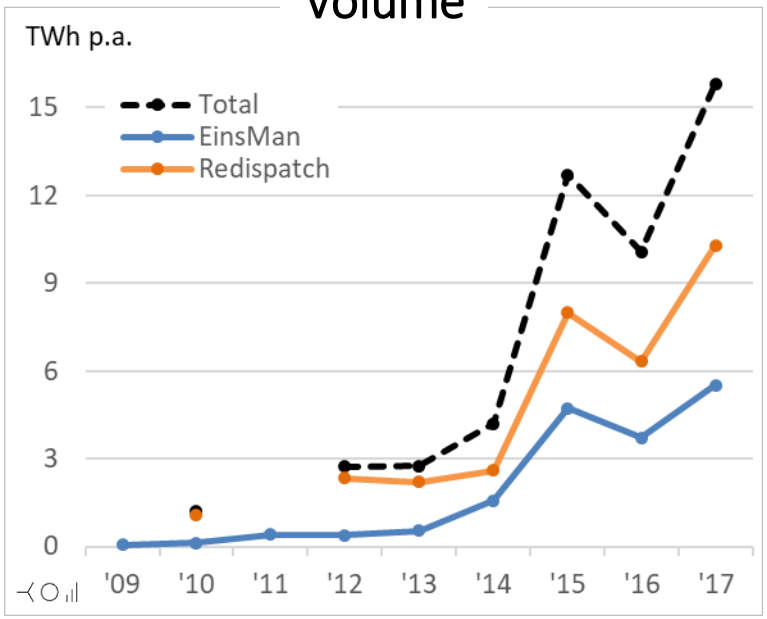
P21
P33
Korridor C
2,6 GW
Korridor A
2 GW
P30
P37
P65
P38
P39
P43
P41
P46
Korridor D
2 GW
P47
P48
P70
P49
P67
P52
P74
Legende
Neubau - Gleichstrom
Netzverstärkung & -ausbau - Gleichstrom
Neubau - Wechselstrom
Netzverstärkung - Wechselstrom
Startnetz

Delays, delays, delays



Congestion management in Germany

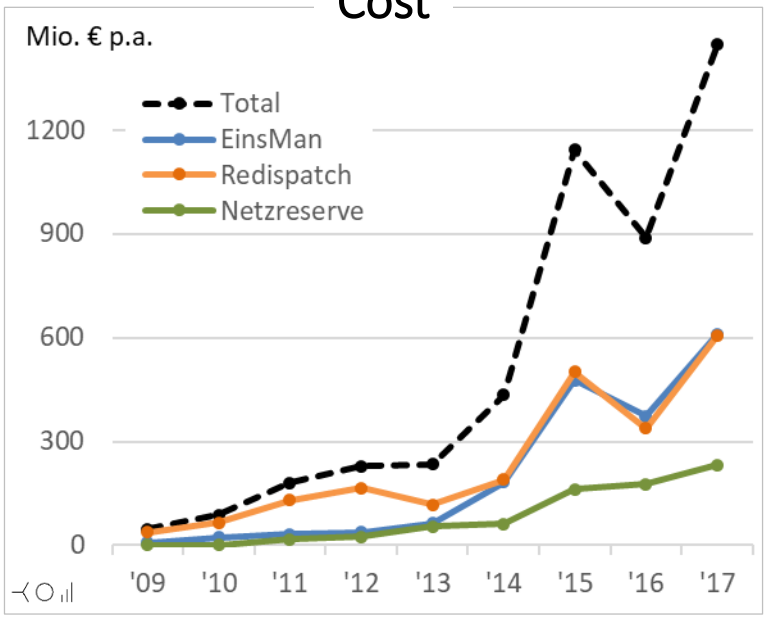
Volume



Neon analysis. Data sources: Various BNetzA publications. Redispatch includes the activation of Netzreserve. Updated July 2018.

The volume of congestion management increased 5-fold since 2012.

Cost



Neon analysis. Data sources: Various BNetzA publications. Redispatch includes the activation of Netzreserve. Netzreserve is the cost of holding the reserve only. Updated July 2018.

The costs for congestion management increased similarly.

Relevant policy debates

- Bidding zone delimitation / market splitting
- Redispatch markets
- Redispatch and curtailment costs
- Loop flows / impacts on neighbors

Agenda

1. Germany’s Grid Constraints
2. **An Introduction to Nodal Pricing**
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Nodal vs. zonal pricing in a nutshell

Different approaches how to give electricity markets spatial granularity

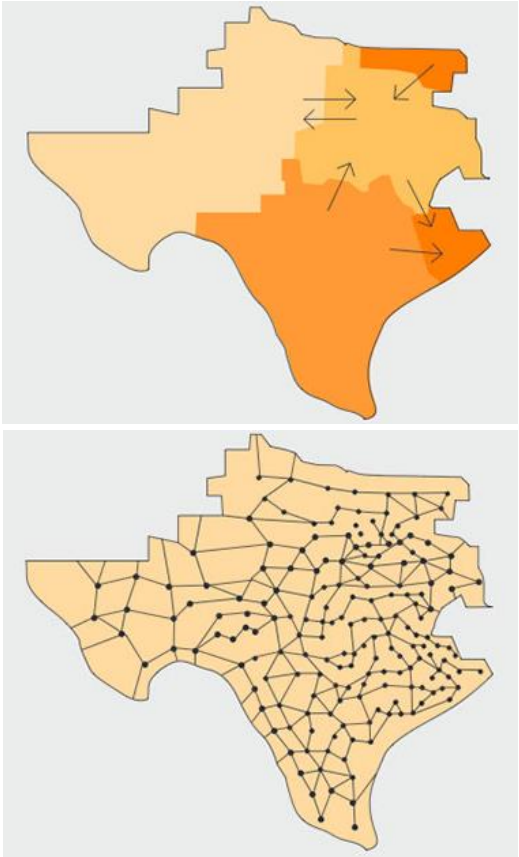
- Zonal: larger regions (e.g., countries)
- Nodal: individual network busbars (“nodes”)

Congestion management

- 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

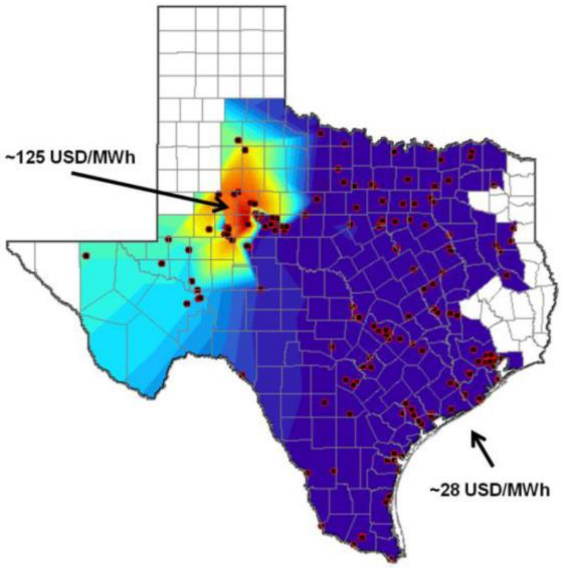
- One single trading platform: independent system operator
- Trading on hubs
- Base risk traded as financial transmission rights
- Price regulation, often with capacity mechanisms

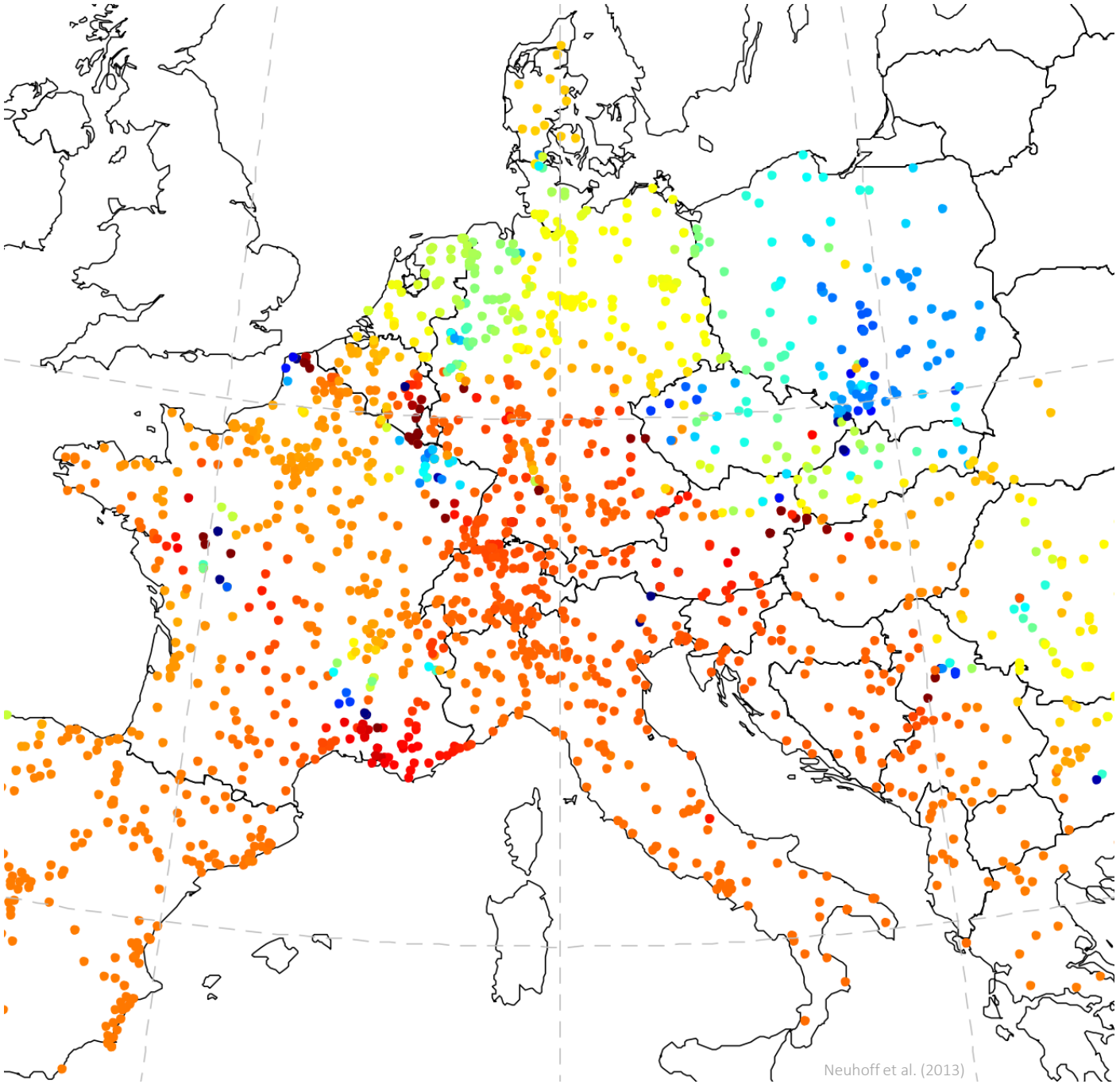


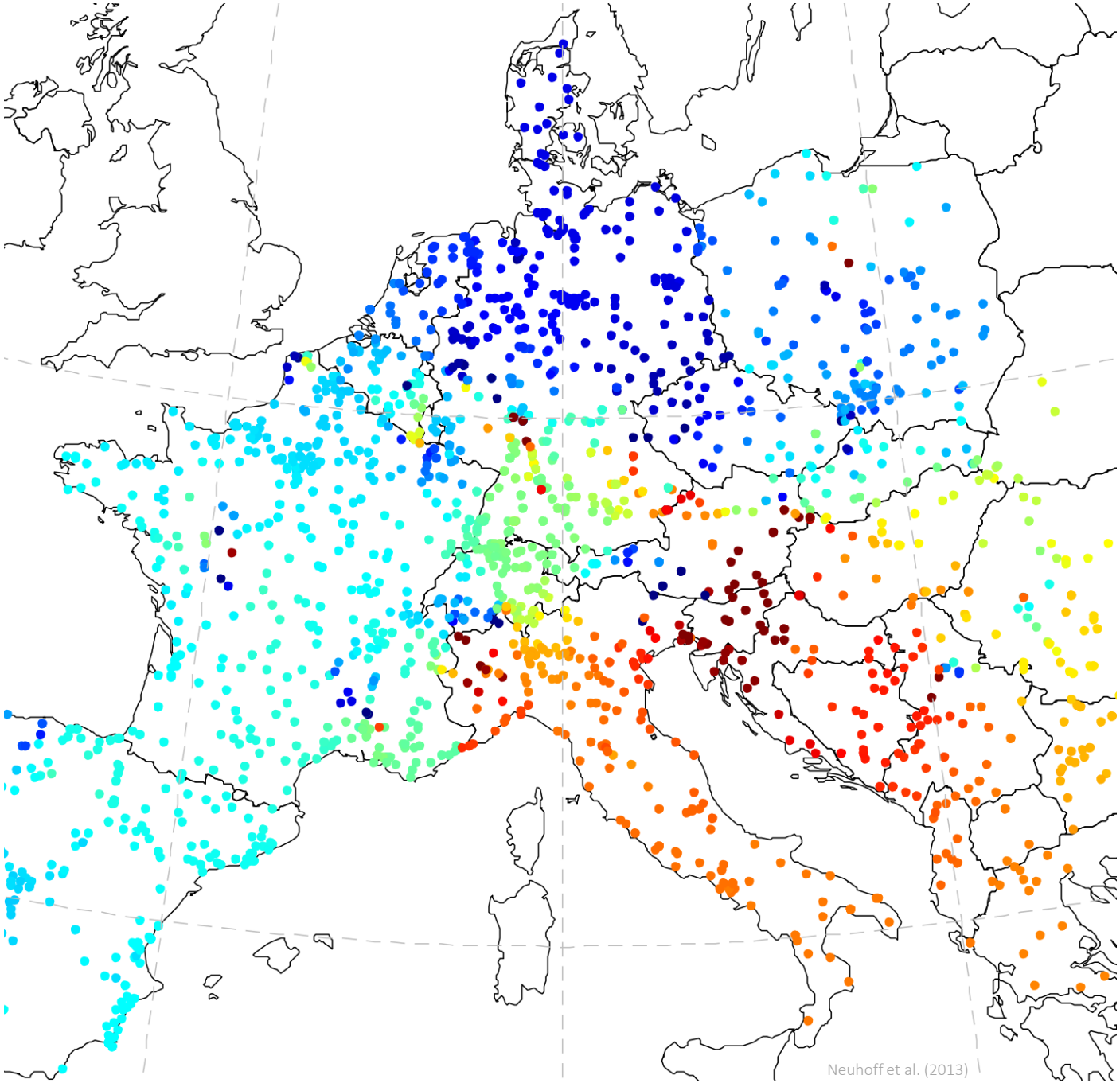
Texas was a single bidding zone 1999 - 2001, then 4-5 zones, before nodal pricing was introduced in 2010.

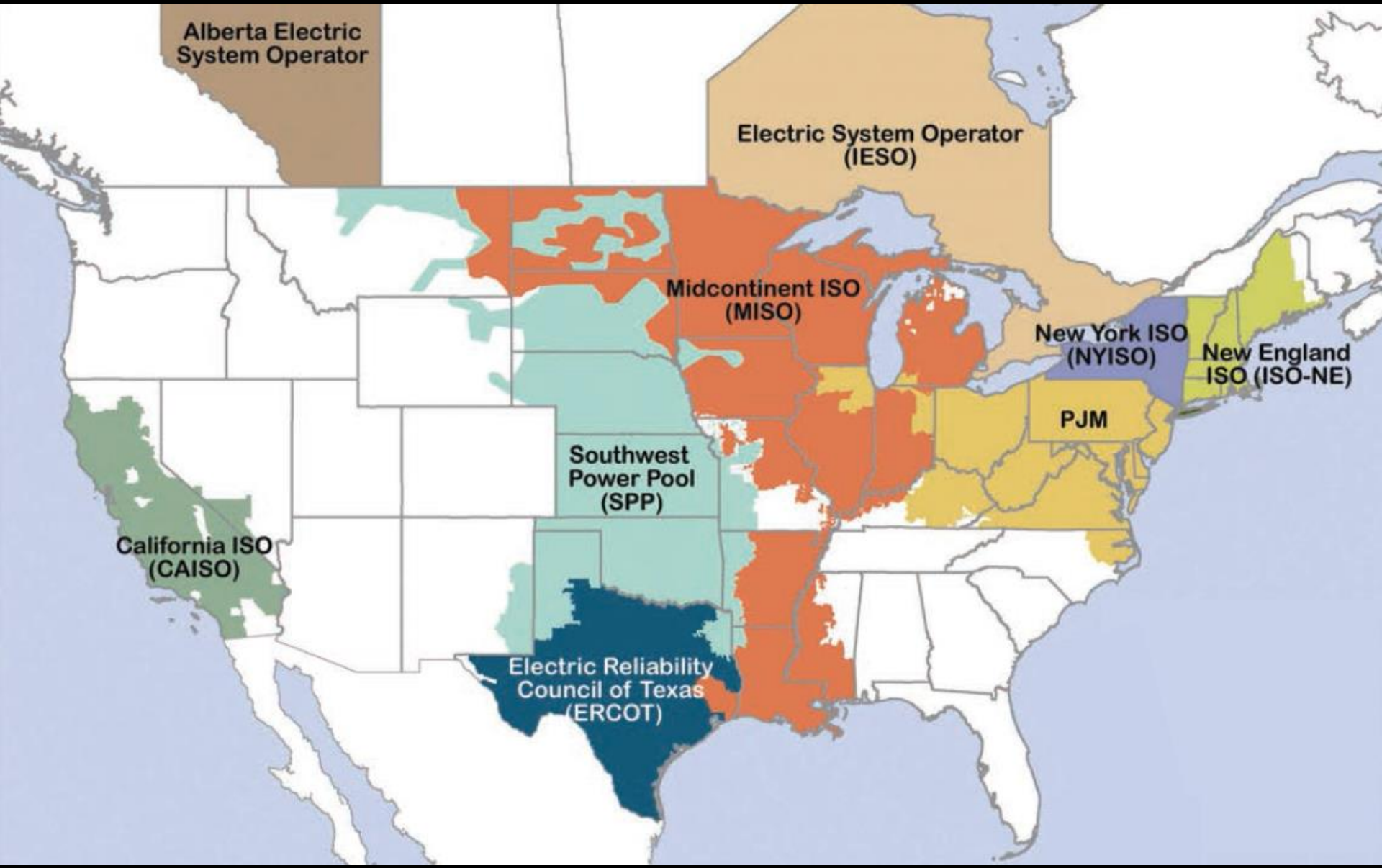
Nodal pricing: price determination

- 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




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"
- Complex bids and high time resolution (5 min for real-time markets)
- Usually: price caps and capacity mechanisms

Self-dispatch vs. central dispatch

	Self-dispatch	Central dispatch
Institutions	TSO owns and operates grid PX facilitates bilateral trading Parties determine dispatch	ISO operates grid, provides bidding platform, determines dispatch Another entity owns the grid
Trading platform	Various (multiple power exchanges, brokers, bilateral)	One central trading platform
Dispatch decision	Taken by plant owner; schedules submitted to TSO	Taken by ISO
Trading	Bilateral	Via ISO
Incentives	Balancing responsibility with imbalance charges	Direct dispatch decision by ISO

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

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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1. Germany's Grid Constraints
2. An Introduction to Nodal Pricing
3. **Concluding thoughts**

Core issues

- Textbooks emphasize the good performance in determining efficient plant dispatch – this is largely undisputed
- But the reality is complex – there are many more arguments for and against nodal pricing: we compiled more than 40 criteria
- No market design performs best in all criteria: trade-offs have to be made
- Weighting criteria are subjective – decision is (to some degree) political
- Crucial aspects (in my view) are
  - Market power (and how to mitigate it)
  - Investment incentives

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