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Decarbonizing China's Power Grid

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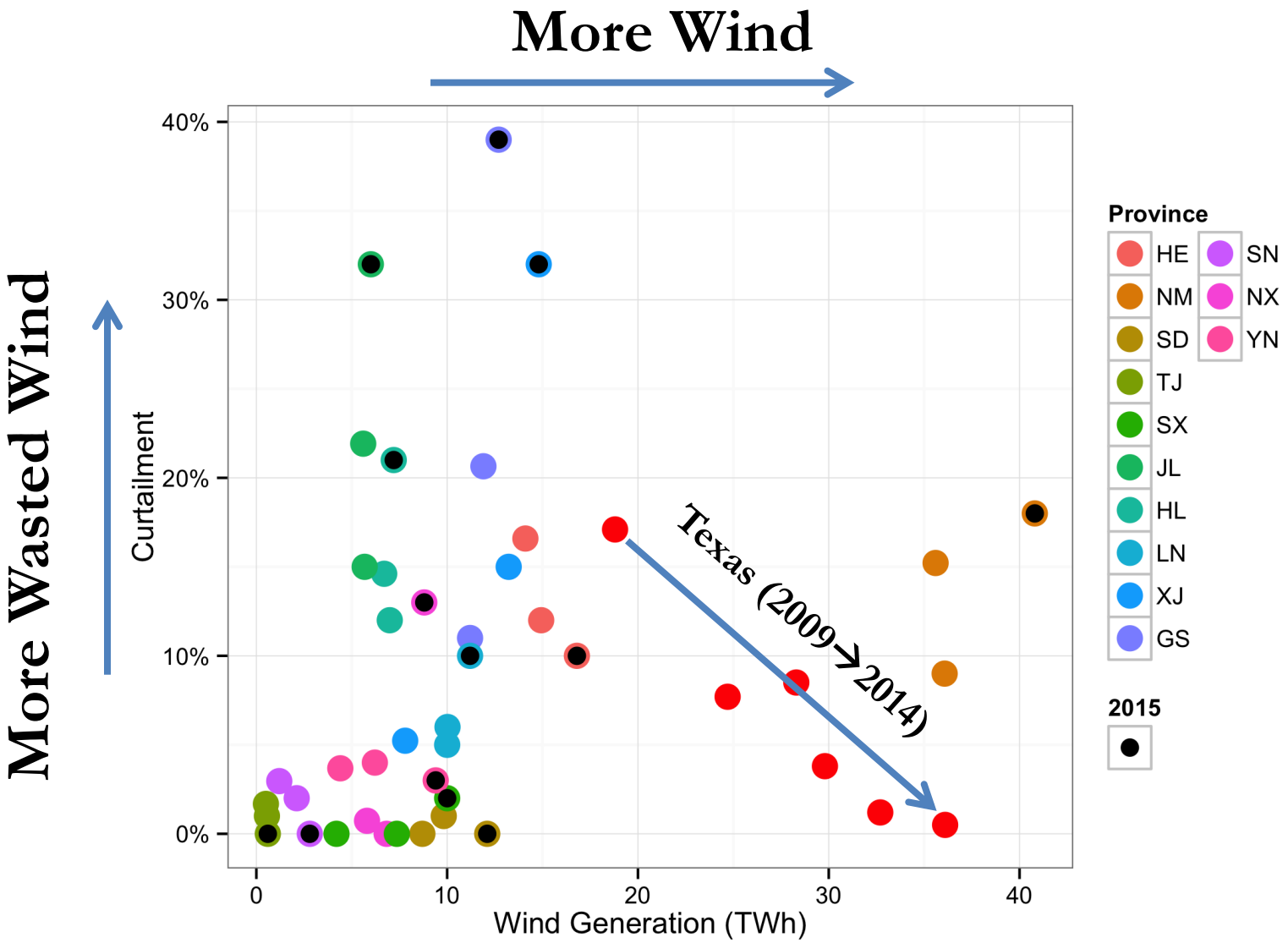
China's wind integration challenges

- "Grid shortcomings taking wind out of energy plan's sails" *China Daily* Feb 16, 2011

- "Nationwide wind curtailment worsens, rates climb to 79%" *Caijing Cankao* Nov 19, 2015

- "China struggles to use wind power to avert toxic, 'red alert' smog" *ClimateWire* Dec 23, 2015

In numbers



Sources: NEA (2013-2015), ERCOT (2009-2014)

Causes of curtailment

Technical

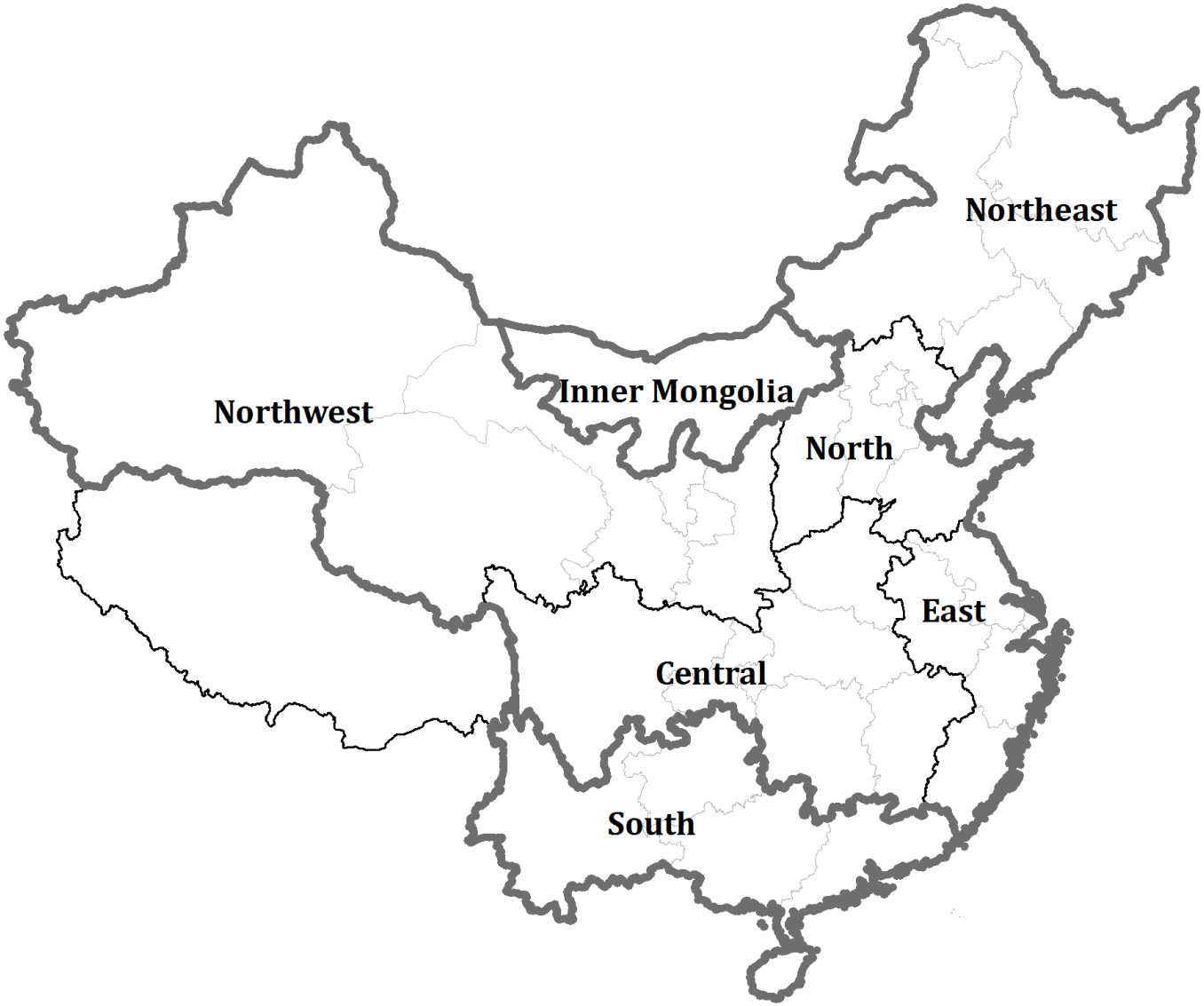
- Transmission bottlenecks
- Interactions with district heating systems
- Technical limitations of coal-predominant grid

Regulatory

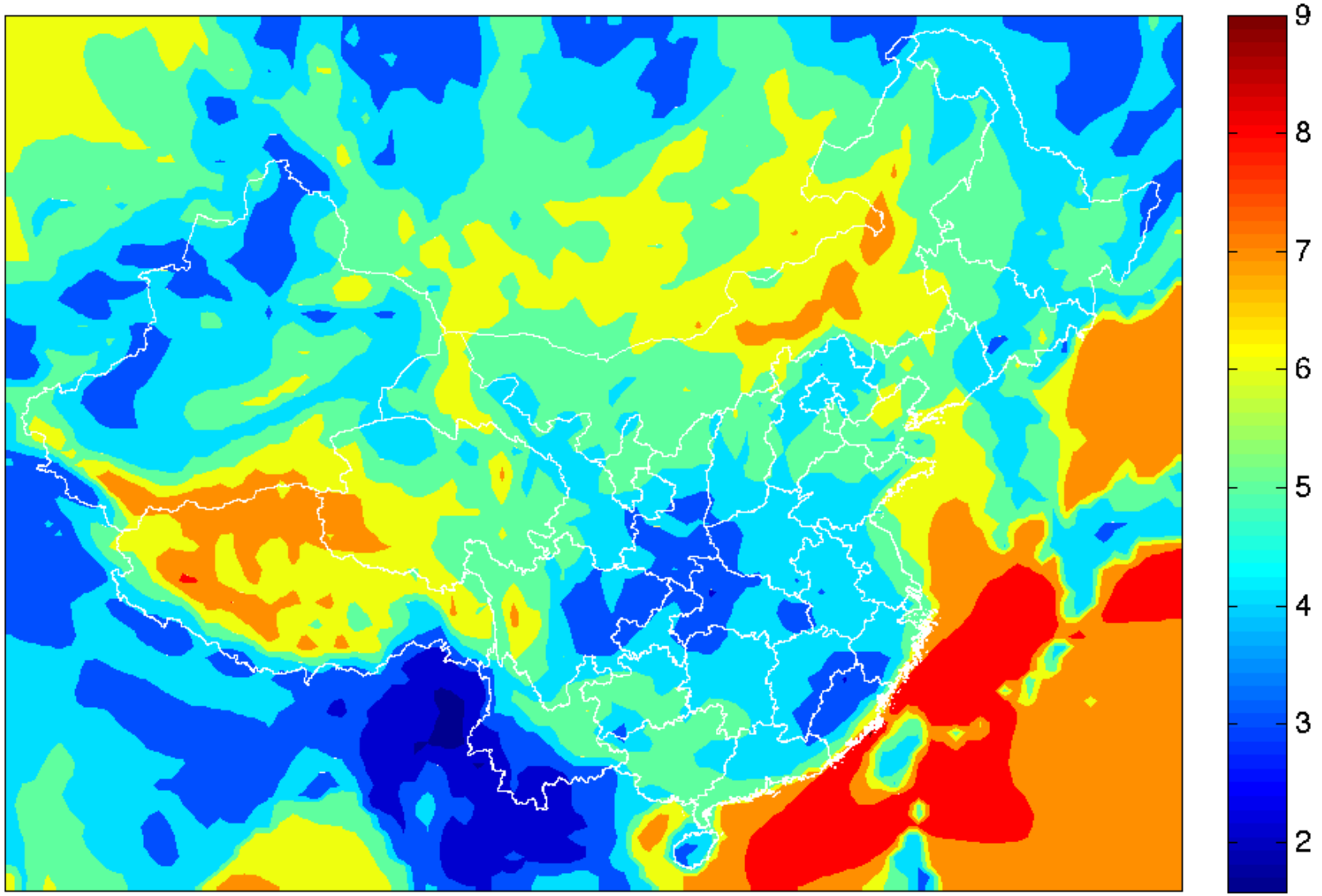
- Inadequate enforcement of existing regulations
- Centralized generation planning
- Lack of incentives for flexible operation

Wind forecast errors likely do *not* explain current integration challenges

Orienting ourselves

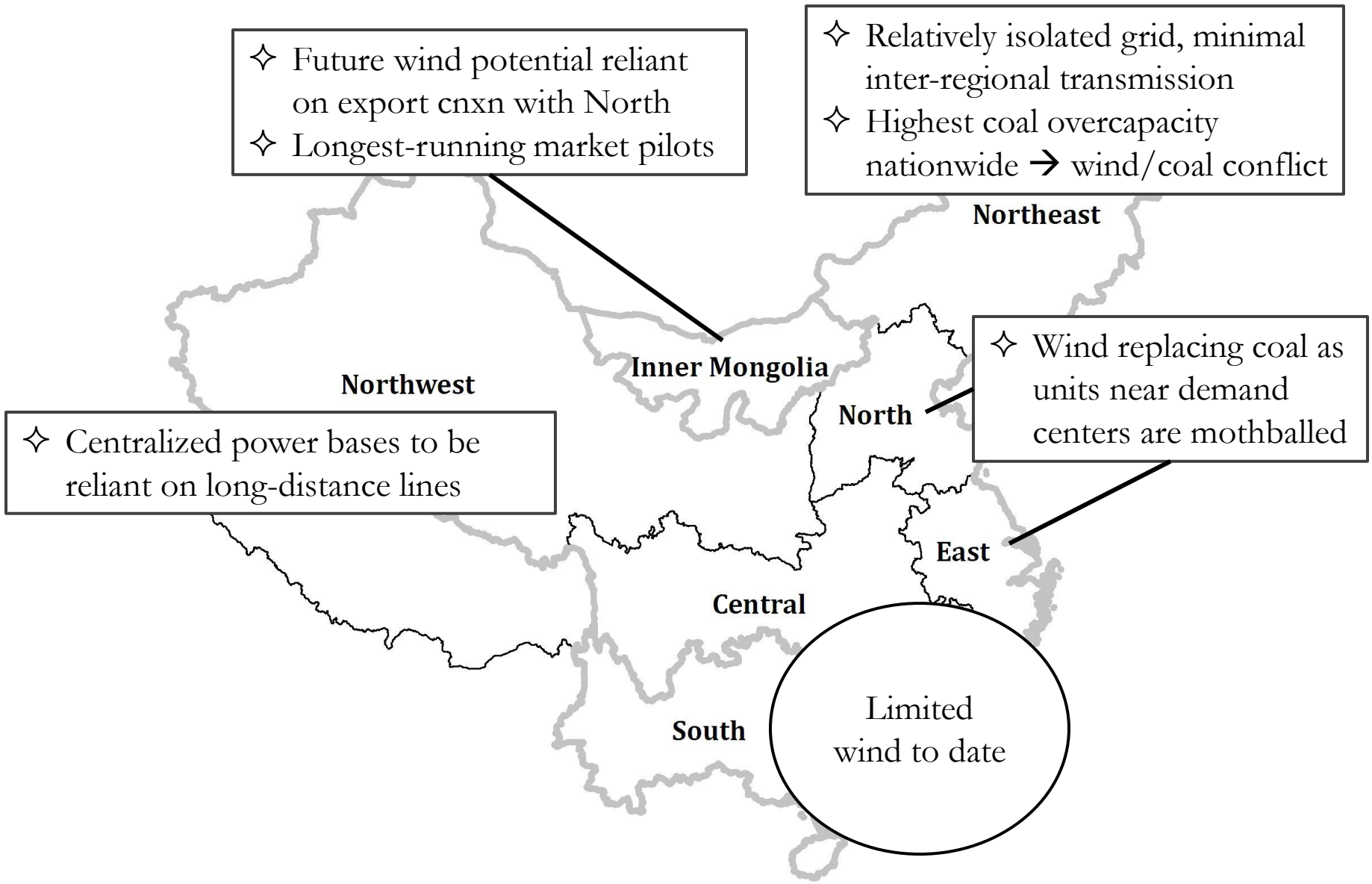


Wind resource

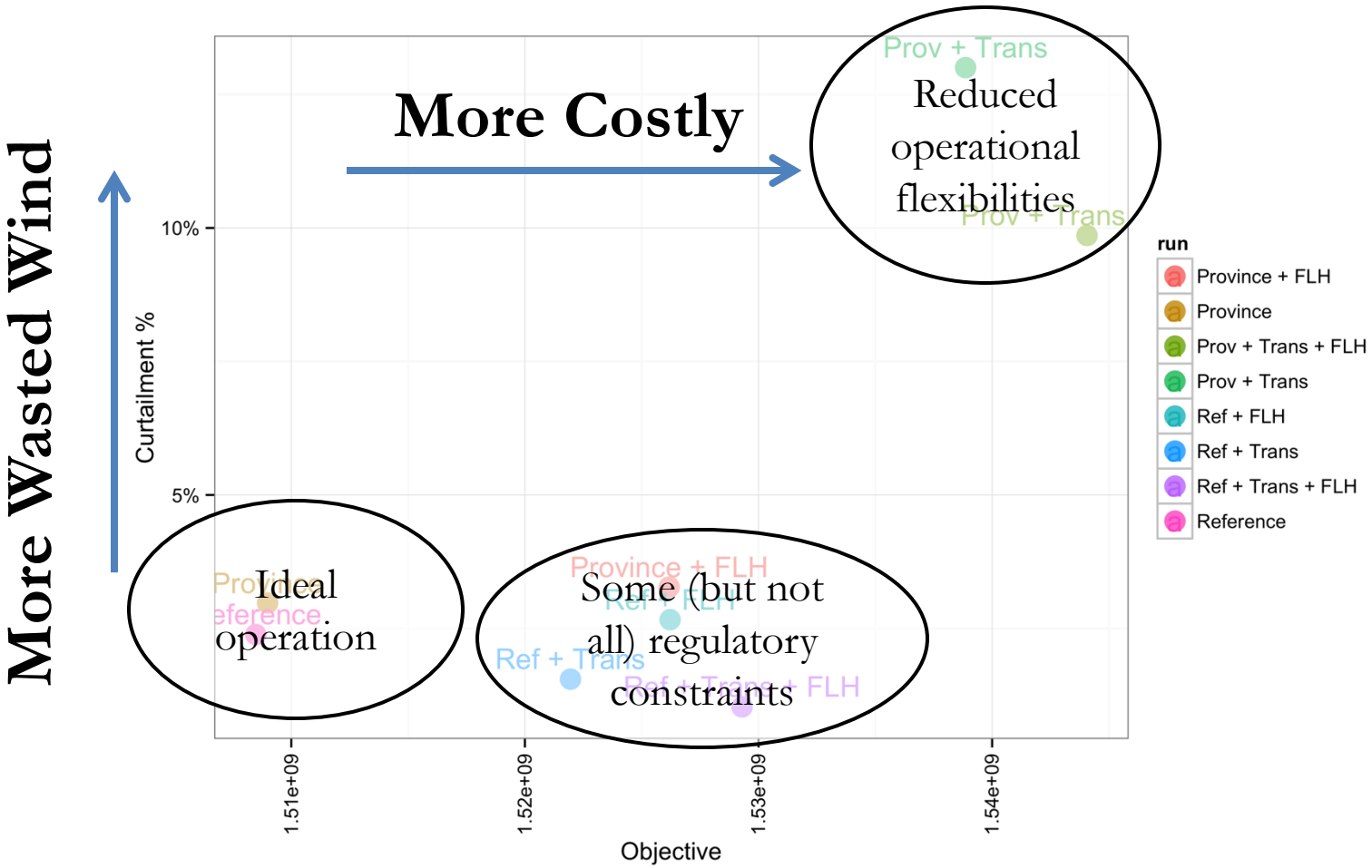


Average wind speed at 80m (1979-2010). Source: MERRA (NASA).

Wind


✧ Future wind potential reliant on export cnxn with North
✧ Longest-running market pilots
✧ Relatively isolated grid, minimal inter-regional transmission
✧ Highest coal overcapacity nationwide → wind/coal conflict
Northeast
Inner Mongolia
Northwest
North
✧ Wind replacing coal as units near demand centers are mothballed
✧ Centralized power bases to be reliant on long-distance lines
East
Central
South
Limited wind to date

Modeling Northeast Operations



- All regulatory constraints make electricity production more costly
- Quota has negligible *direct* impact on wind curtailment
- Key challenge to wind integration is *grid flexibility* (short- and long-term)

Model described in Davidson (2014)

Three steps to decarbonize more generally

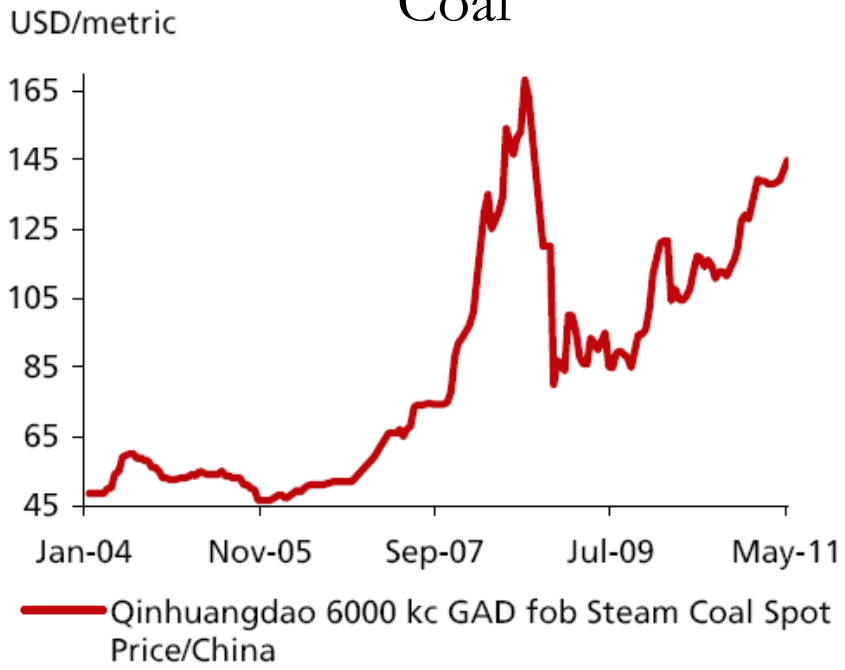
- ✧ Getting prices right
- ✧ Coordinating generation and transmission expansion
- ✧ Improving system operation

Getting prices right

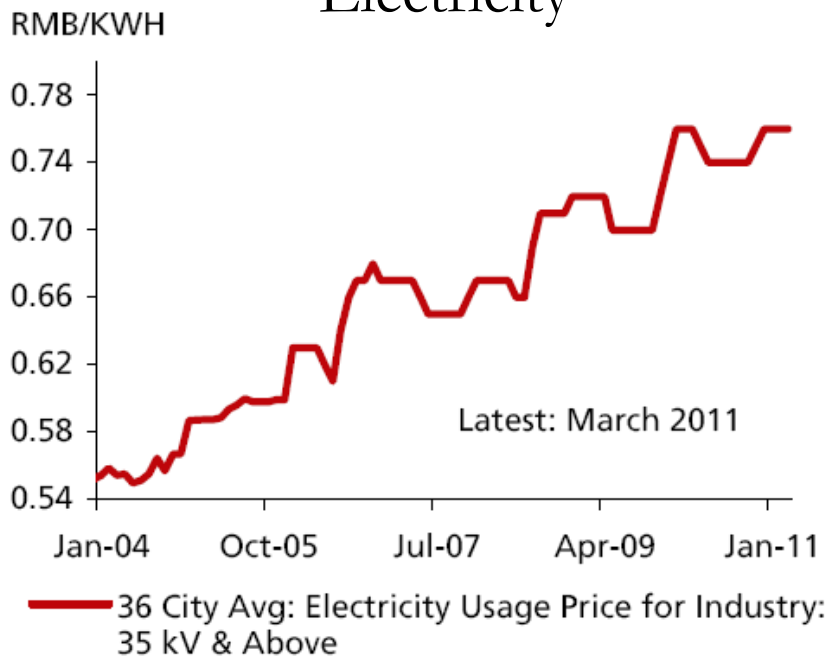
Example of poor incentives:

- Prices for coal liberalized in 2002, electricity still planned

Coal



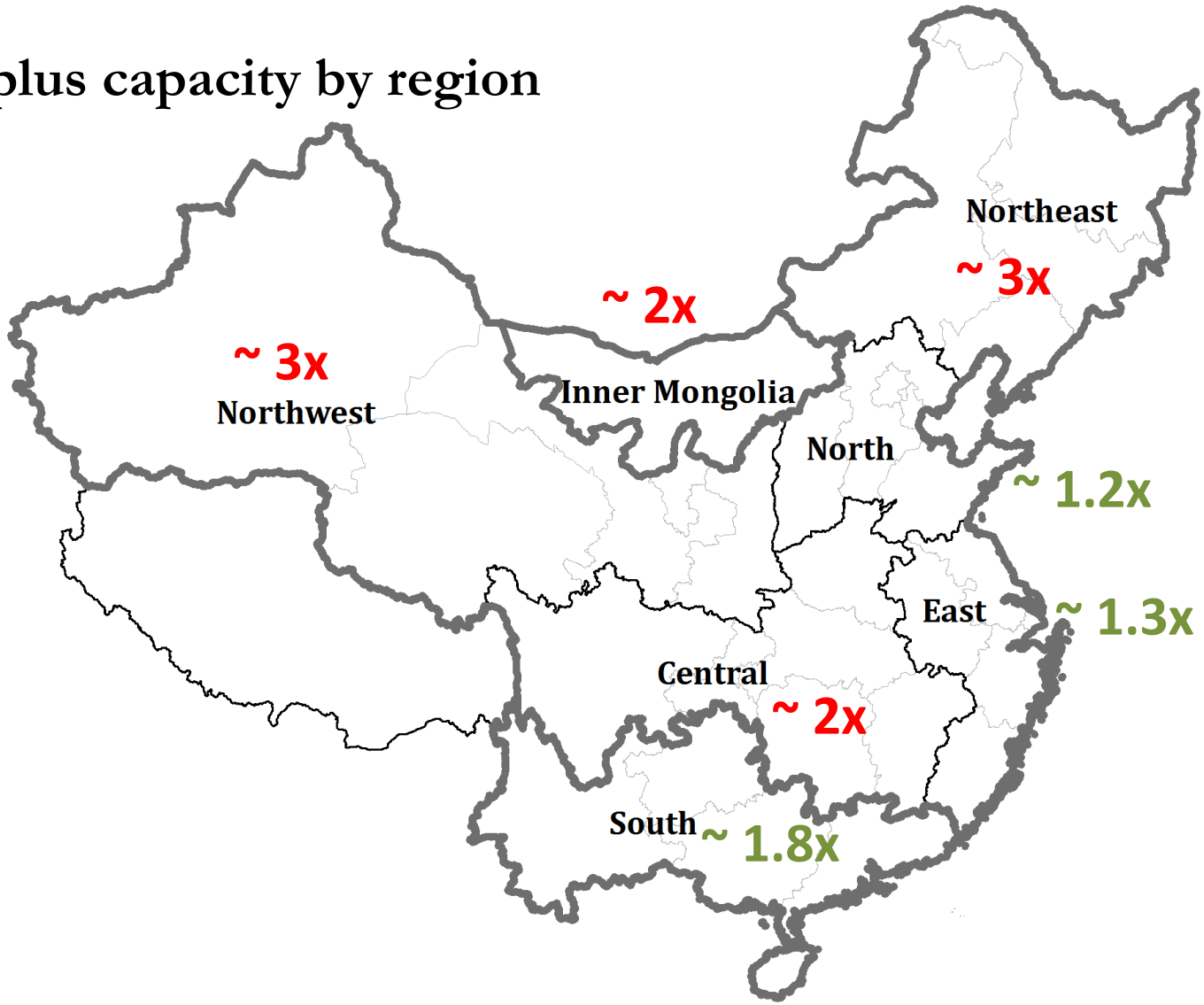
Electricity



Source: Leung, C. (2011). *China: A case study of price control on electricity*. DBS Group Research.

Coordinating generation and transmission

Surplus capacity by region



Ratio of peak demand to installed capacity (2012)

Sources: State Grid, Southern Grid, Inner Mongolia Grid

System operation

System operation

Multiple priorities for dispatch leading to potential conflicts / unintended consequences during operation

Equitable dispatch (三公调度)

- Plants should share "equitably" the benefits (& costs) for providing electricity and meeting policy goals

Energy-efficient dispatch (节能调度)

- Prioritize renewable energy ← high efficiency coal ← low effic coal

…and most recently:

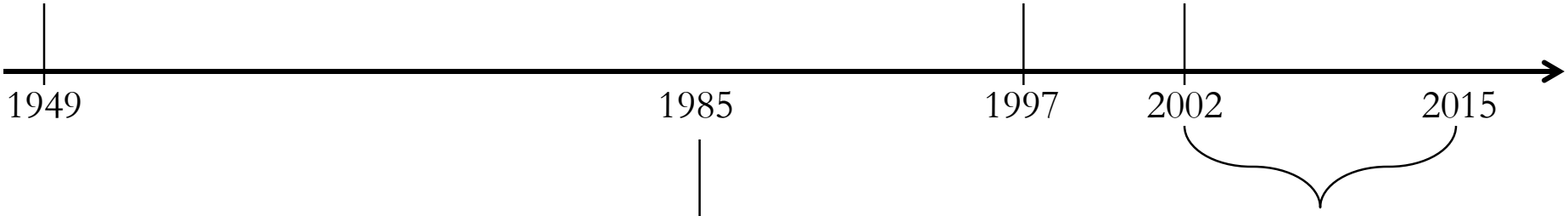
Green power dispatch (绿色调度)

(Brief) History of China's electricity reforms

Vertically-integrated state-run utility

✧ Provincial development-focused

✧ State finances limited



(Reform 1): Open investments to local gov't and private firms

✧ "Competed" with ministry

✧ Inefficient plan allocation

(Reform 2): Corporatization, unbundling generation & grid

✧ Gov't plans and pricing remain

✧ Uneven implementation of energy efficiency directives

✧ Cyclical shortage/overcapacity

✧ Renewable energy integration challenges

Current round (2015~)

- State Council [No. 9], March 2015:
  - Grid co revenue cap based on cost estimates
  - “Slowly” open up retail competition
  - “Relatively independent" market exchange organization
  - “Slowly” shift electricity away from plans (primarily, thru bilateral contracts)
- NDRC and NEA [No. 518], March 2015:
  - Prioritize hydro, wind, solar in plans
  - Thermal generator flexibility regulation and compensation
- Several implementing regulations throughout 2015

Thoughts on making this round of reforms work

- Focus on *operation* of assets, not solely on *investment* and ownership
- Address *short-term* flexibility (daily and real-time), not just *long-term* competition (bilateral contracts)
- Prioritize wholesale before retail…important half of the market
- Address potential conflicts of interest in system operation
- Economic signals for flexibility have a much better track record than administrative fixes

Thank you

谢谢!

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Studies on potential and opportunities:

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