Challenges of Power Market Transition and Liberalization

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Key elements of reform

- Separate the industry into generation, transmission, distribution, and retailing and use an auction market to set a time-varying wholesale price of electricity
  - The IT revolution was a necessary pre-condition
- Encourage wholesale market competition between generators
  - Electricity *generation* is not a natural monopoly because short-run system-wide operating costs are increasing
  - Economies of scale in adding new capacity make the competitive investment path inefficient, but no worse than in many other industries run competitively
- Allow long-term contracts, with futures and options markets, to aid risk sharing
  - If generation < contracted amount, generator becomes a buyer and wants lower prices
  - Contracts for differences reconcile contract prices with formal spot market trading
    - A higher volume of spot trade makes the market more liquid, and reference to the spot price reveals the opportunity cost of a contract to both parties

What are the potential gains?

- Most significant gains are where government-owned firms are privatized
- Strong evidence, not just from electricity markets, shows that government-owned firms do not minimize costs or provide good service
  - Shareholder owned firms have much stronger incentives to minimize cost and find better ways of serving customers, including via technological innovation
  - More rapid technological change raises the benefits of decentralized decision making
  - Nominally, monitoring by politicians replaces monitoring by shareholders, but profitability is not a primary focus of political monitoring
  - Government firms also often face budgetary or political constraints on investments
- Government firms impose commercial risks on taxpayers involuntarily, whereas private investors are those most willing to voluntarily accept risks
- The many other uses for scarce public funds – such as education, health, public infrastructure – make it costly for government to do things firms would do
- After investments have been made, the return to capital becomes "rents" to be fought over by consumers and suppliers

Prices as signals

- Another key goal of electricity market reforms is to have market-determined prices direct resource use
  - Market prices convey information to consumers about production costs, and to producers about the benefits of satisfying consumer demand
- Individuals and firms have an incentive to respond to the price signals using information initially known only to themselves
  - In doing so, they can make the prices reflect their private information
  - Decentralized decision making can in principle utilize more, and more disparate, information than monopoly command and control structures
  - But the *structure* of prices needs to reflect the *structure* of costs and benefits, and decision makers need flexibility to respond to them
- If prices are distorted signals about marginal costs and benefits, markets allow incentivized agents to respond powerfully in the wrong ways

Most common error: Inadequate competition

- Liberalization is a means to the end of promoting more efficient resource use
  - Furthermore, the net gains have to be sufficient to offset the transition costs
- If the new market is uncompetitive, the outcome can be worse than before reform
- Reduced competition has been supported by claims there are economies of scale in electricity generation that mean costs would be higher if firms were smaller
  - While there are likely economies from keeping a single owner/operator of generating sets *within each power station*, these do not extend to multiple generating stations
  - Econometric studies reporting economies of scale estimate production functions including capital as an input
  - While there are economies of scale in investment, these do not justify aggregating existing firms since that does not lower operating costs
- Another argument is that it is "more risky" for firms to hold generators that serve only part of the load (base, intermediate or peak)
  - But investors can usually diversify risk more efficiently than firms

Problem: Asset sales price used as criterion

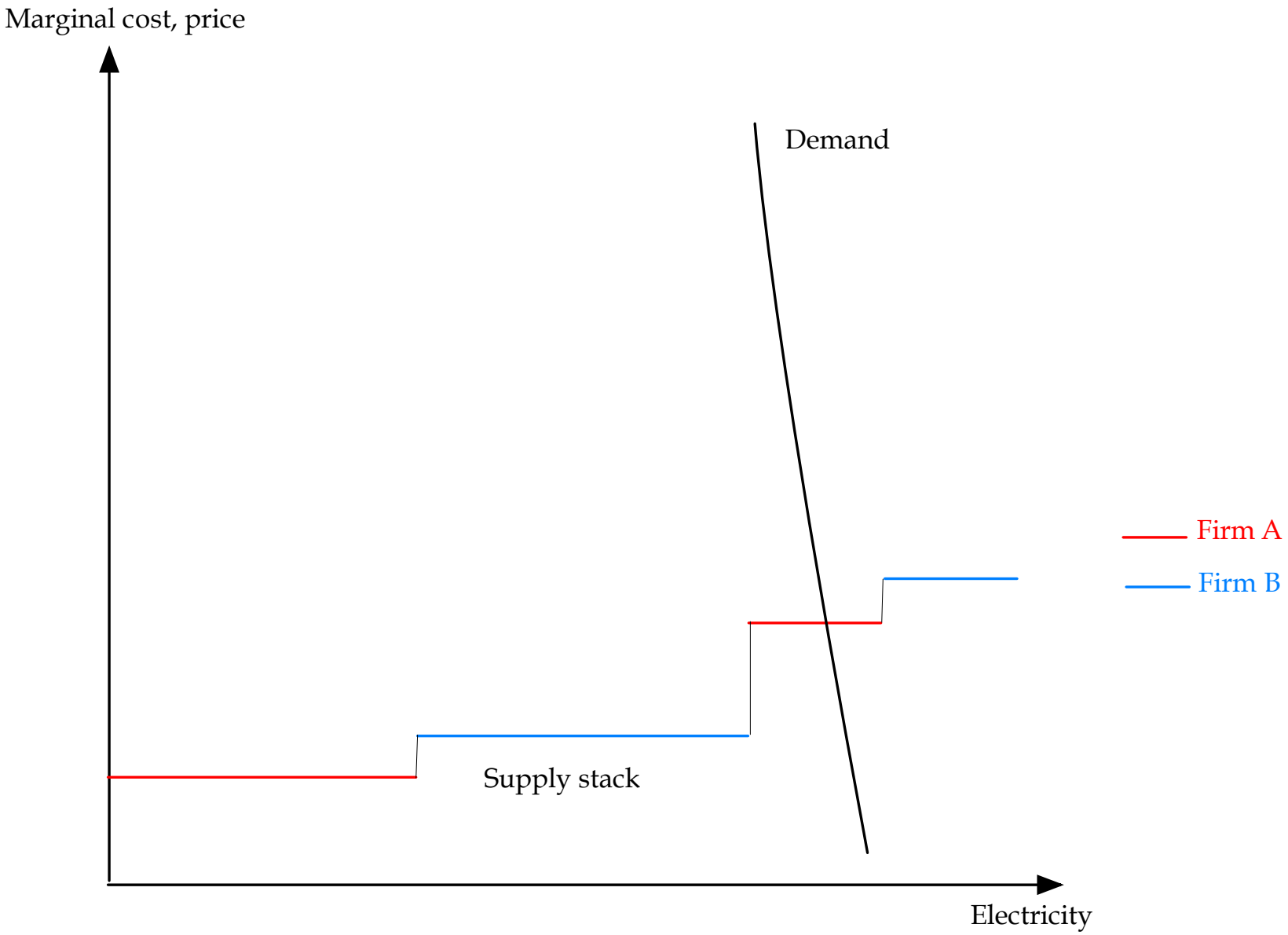
- Since governments are often privatizing to reduce a budget deficit, they want to raise as much money as possible
- Investment bankers advising the government on privatization also want the highest possible asset sales price since their fees typically depend on it
- Voters also may use the sale price to measure of the success of the policy
  - People selling their house, for example, want to get the highest possible price
  - So if privatization is seen as an asset sale, it is natural to regard a high sale price as better than a low sale price

Why is this a mistake?

- The asset sale price does not reflect how efficiently resources are being used
- The government could maximize asset sale value by making the firm a monopoly
  - Investors would bid the discounted present value of the monopoly rents for the assets
  - But, the loss to the consumers would exceed the value of the monopoly rents
- Workers in the industry, and perhaps beneficiaries of politicized prices, also favor a market structure with lots of monopoly rents
  - With more rents, the politically powerful retain the opportunity to exploit privileges
  - But political action to capture rents wastes additional resources
- The best reform delivers maximum value to producers PLUS consumers, which amounts to maximizing *efficiency*

Problems with portfolios of generators

- A firm with generators using just one technology has an incentive to bid its full capacity into the market at marginal cost whenever market price $p \geq MC$
- But suppose a firm has 2 generators with different marginal costs $MC_1 < MC_2$
  - If $p = MC_2$, reducing 2 output cuts revenue and operating costs by the same amount
  - But if p rises as a result, rents to type 1 plant increase (see next slide)
- A firm with plants at several locations can also exploit exploit geographic price differentials by withholding capacity
- More generally, gaming the wholesale electricity market has repeatedly been a problem when firms hold multiple generators
- When firms can game the wholesale market, the prices will be a distorted signal of the true marginal costs of supply
  - Sending a "sharp signal" that is distorted could give a worse outcome than retaining the "blunt signals" of the old system of vertically integrated monopoly supply


Marginal cost, price
Demand
Firm A
Firm B
Supply stack
Electricity

Another common problem: Price Caps

- Low operating cost baseload plants earn revenue in excess of short-run operating costs in non-base periods to cover their capital costs
- Peak load plants are supposed to cover capital costs from:
  1. Providing ancillary services; but also
  2. Revenue in excess of short-run operating costs at peak periods when demand is capacity constrained
- But since electricity demand is quite inelastic, peak period prices needed to constrain demand can become very large
- Controls are often instituted to limit peak wholesale market prices
  - This leads to a "missing money problem"
- In many jurisdictions, capacity markets are being added to energy markets to ensure sufficient revenue to cover capital costs of plants
  - But these are difficult to design and often lead to too little or too much capacity

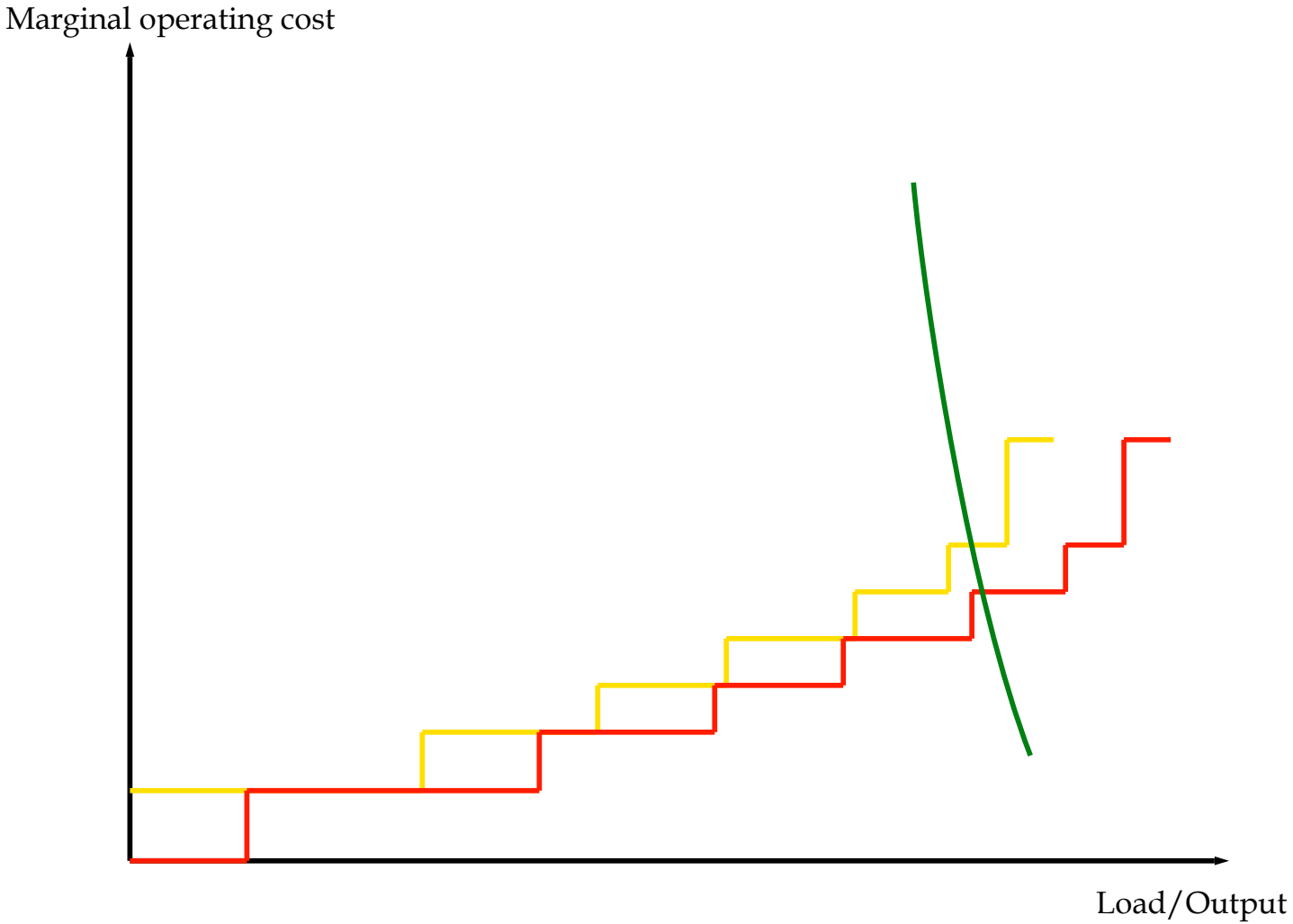
Mandated generating technologies

- Even after the most successful privatization and reform programs, governments have again intervened, now usually to pursue environmental objectives
  - Governments mandating technologies have become vulnerable to rent seeking
- The environmental policies most compatible with competitive markets are taxes or tradeable emission permits, not command & control
  - The economic approaches harness incentives to minimize pollution
    - Clean air or water becomes another "input" into production
    - Firms are incentivized to do R&D to improve emissions reduction technology
  - Emission reductions are allocated across firms in the least cost way
    - Firms with lower costs of reducing emissions cut back more
- Permits with a ceiling and floor price are generally best because they reduce risks and give firms a stronger incentive to truthfully reveal costs of control

Wind and solar mandates and subsidies

- Wind and solar PV now provide much of the new generating capacity in developed countries
  - Wind: mostly wholesale level, solar PV: mostly the retail level
- In many cases, their expansion has depended on supporting policies such as:
  - Investment or production tax credits or subsidies
  - Renewable energy (RE) mandates
  - Subsidized grid expansions and subsidized distribution system upgrades
  - Exemptions from planning, zoning, wildlife, site remediation and other laws
- But learning by doing and explicit R&D have also greatly reduced RE levelized costs of electricity (LCOE)
- Wind and solar generation were expected to lower power prices by displacing higher marginal cost generators in wholesale markets

Merit order effect: Wind lowers wholesale prices when generating



Negative prices

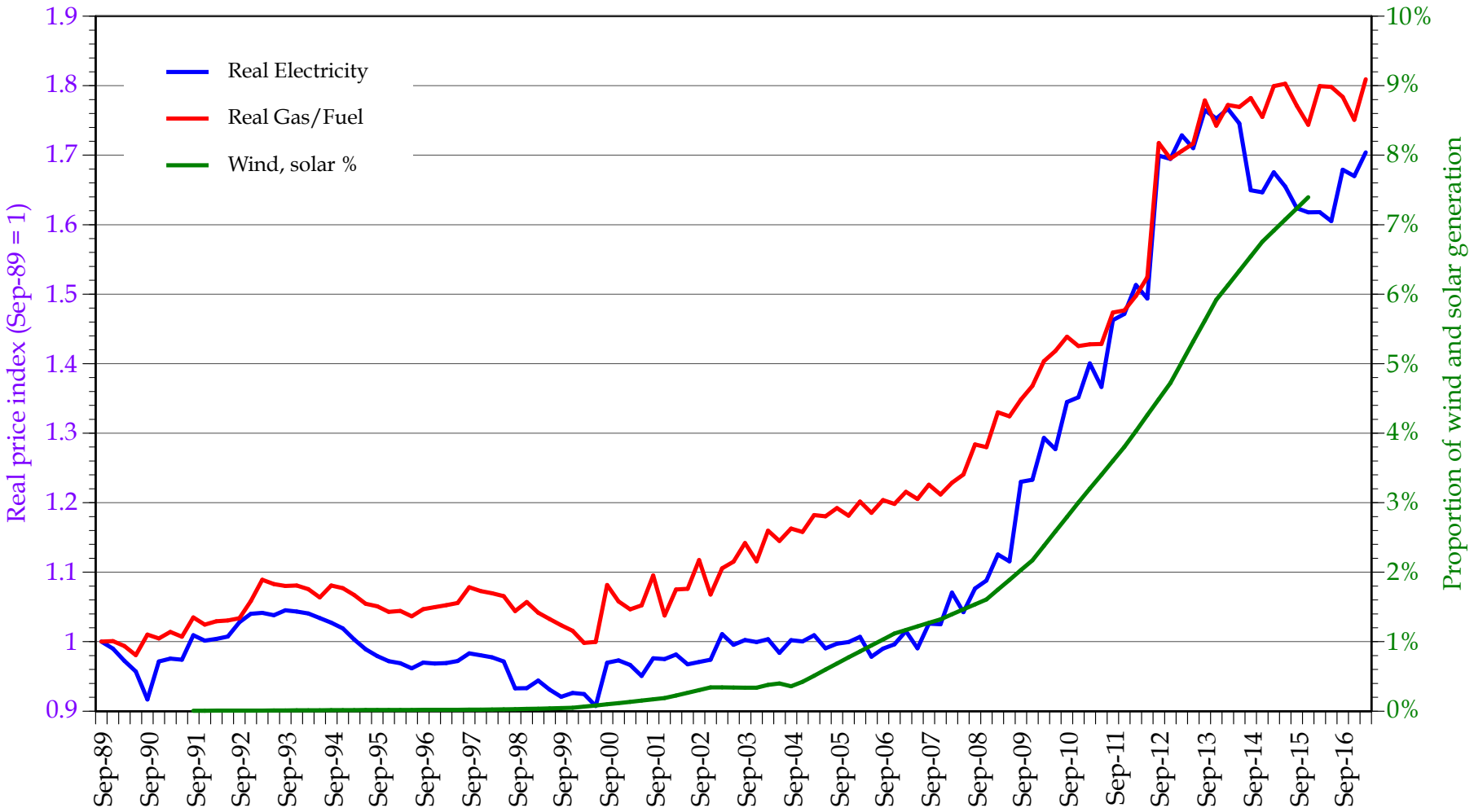
- Wind generation *production* subsidies can give negative wholesale prices
  - Generators will bid up to minus the subsidy to be allowed to generate
- Negative prices should also reduce average wholesale prices
- But negative prices also impose costs on thermal generators that have inflexible output or substantial ramping costs
- More generally, the merit order effect is a short-run phenomenon
  - Reduced revenue to thermal capacity leads to plant exit or discourages entry
  - Mandating renewables also exacerbates the "missing money" problem

European real household electricity prices 2007-2016

$$p = \underset{(0.013)}{0.158} - \underset{(0.035)}{0.156}\,N - \underset{(0.036)}{0.067}\,HL + \underset{(0.069)}{0.131}\,GT + \underset{(0.041)}{0.164}\,W + \underset{(0.035)}{0.253}\,S + \underset{(0.014)}{0.054}\,E$$

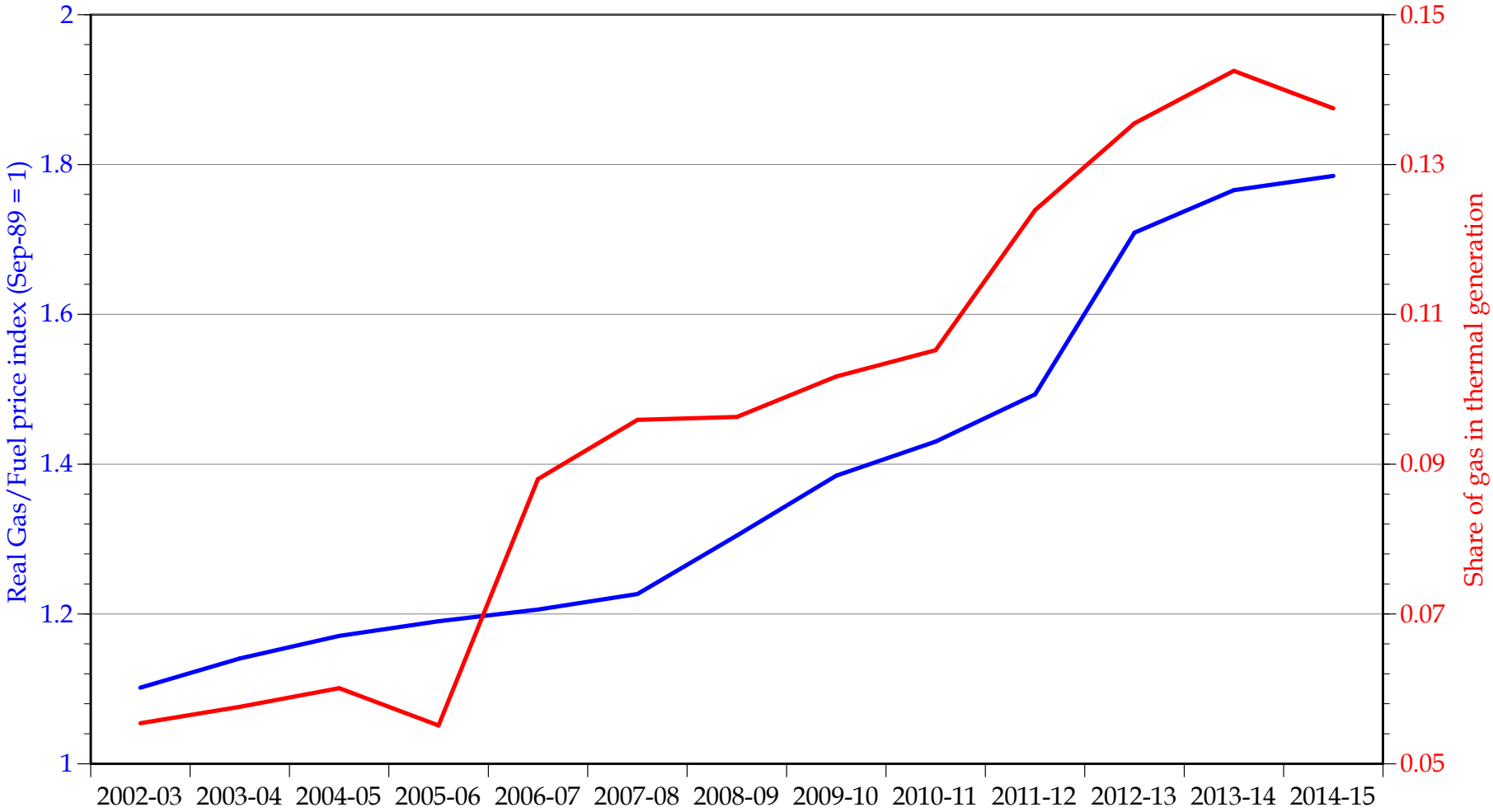
- p = Real household electricity price per kWh for households consuming 5–15MWh pa
  N = nuclear capacity as fraction of total
  HL = large hydro (>10MW) capacity as fraction of total
  GT = gas turbine capacity as fraction of total
  W = wind capacity as fraction of total
  S = solar (thermal + PV) capacity as fraction of total
  E = 1 if former east European country, 0 otherwise
- R^2 (overall) = 0.5335, R^2 (within) = 0.4996, R^2 (between) = 0.5414
  Fraction of variance due to country effects = 0.7654
  Joint test of significance of coefficients $\chi^2(6)$ = 224.23
- 23 countries in sample: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

Australian retail electricity, gas prices



Source: Australian Bureau of Statistics, and Department of Environment and Energy

Australian gas price and gas use in electricity generation



Source: Australian Bureau of Statistics, and Department of Environment and Energy

Systemic issues with wind generation

- Time of day correlation with load
- Seasonal correlation with load
- The need to control short-term frequency and voltage instability
  - South Australian episodes following both high and low wind speeds
- Remoteness of RE sources leads to long transmission links operated at low capacity factors
  - CREZ zones in Texas – $7 billion transmission upgrade
  - These links have also proven fragile as in Australia

Systemic issues with solar PV

- Wholesale versus retail competition with natural gas in NW Australia
- Economics of wholesale versus retail competition
  - Why isn't it like growing your own food rather than buying retail?
  - In electricity, fixed costs mostly are rolled into the marginal charge
  - Equity aspect and why high demand customers install PV
  - An alternative: A fixed plus a variable charge is common for club goods
- Exacerbated by net metering
- Costs of network upgrades to accommodate solar
- In some parts of Australia:
  - No more solar PV is allowed as the "duck belly" is about to hit the ground
  - Excessive voltages from solar power are raising costs for some non-PV customers and have damaged their appliances

"But LCOE show wind and solar are now competitive"

- If so, why are subsidies, mandates, tax benefits etc. still needed to support them?
- Comparing technologies via LCOE implicitly assumes that the *value* of the generated power is irrelevant to the competitiveness of the different sources
  - But as Joskow has noted, the critical issue is *value of output minus cost*
- Hirth and others have shown that the wholesale prices RE generators receive decline as RE generators using the same energy source are added to a system
  - Renewable generation "fouls its own nest"
  - Green and Léautier (2018) show subsidies can rise dramatically if baseload exits and stops setting marginal prices at the time renewable generators are operating
- In addition, as the share of wind in particular rises, short-run variability of its output imposes ancillary service costs that are not part of the LCOE calculation

Backup for renewables is the key issue

- Example: The Danish success?
  - Large scale hydro ("the Scandinavian battery") provided critical support
  - Shows again that trade can be an alternative to "domestic backup"
  - Even so, Denmark often sells when the price is low, buys when its high
- Pumped storage
  - Currently 99% of bulk electricity storage
  - Approximately 80% round-trip efficiency
  - Topography is a critical limitation
- Batteries
  - 50% higher LCOE than pumped storage under generous assumptions
  - Some problems: Leakage, deterioration over time
  - More suited to provide ancillary services than seasonal storage
  - Expanded battery use would also increase the need for, and price of, material inputs

Natural gas as backup

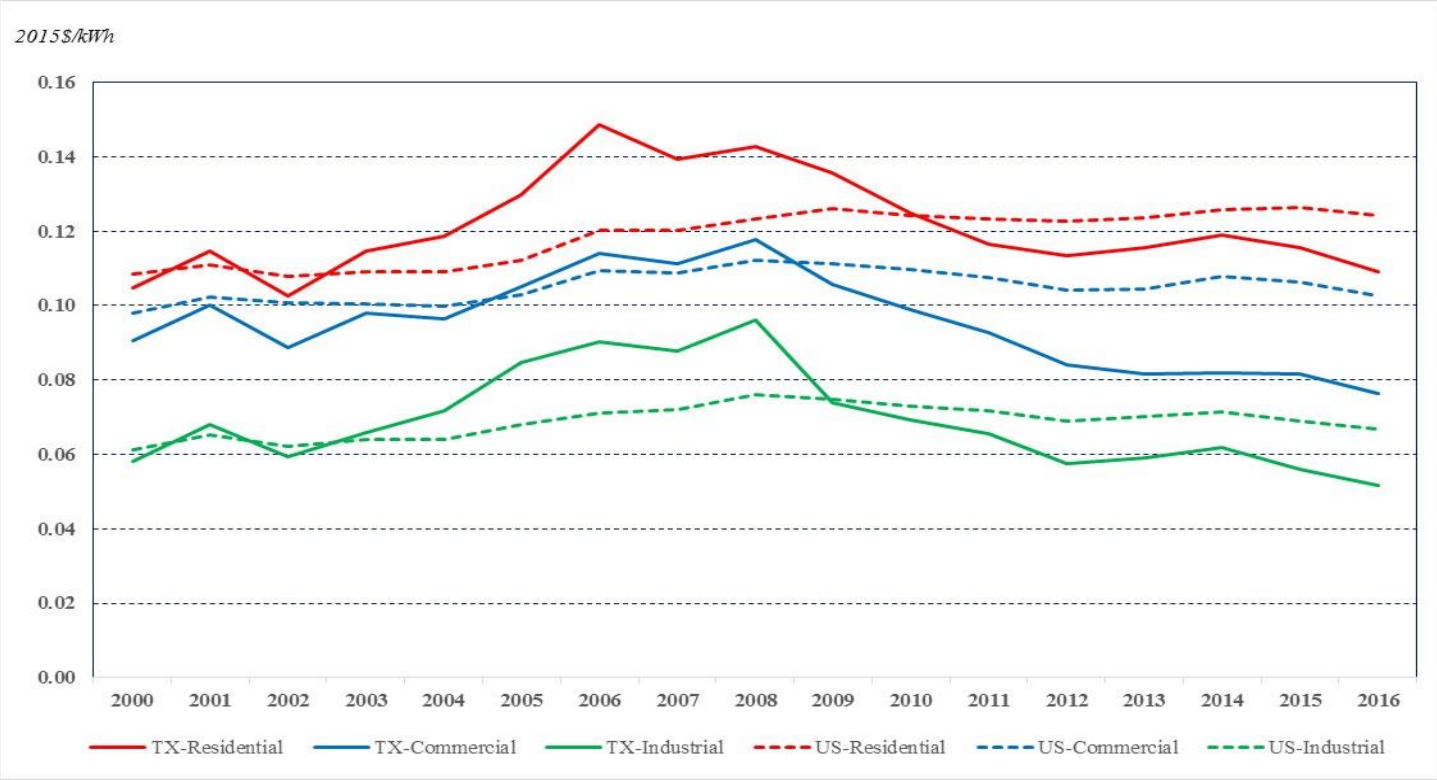
- Texas (ERCOT) experience with wind has been more favorable than the European and Australian experiences discussed earlier
  - More than 22GW wind; 0.46GW non-dispatchable and only 0.09GW dispatchable hydro; 1.75GW of solar; less than 0.09GW of battery storage
  - About 66.5GW of thermal; of which 5.06 is nuclear; 14.25 is coal; remainder mostly natural gas
- Critical supporting factor: Low cost natural gas
- Australian expansion of RE coincided with opening to LNG exports and simultaneous bans on onshore natural gas E&P in much of SE Australia
- In Europe, natural gas prices from LNG and Russian imports are also high

Texas electricity market reform

- The Texas electricity market featured vertically integrated utilities until the passage of Senate Bill 7 in 1999, which allowed competition in the market
- Utilities were "unbundled" into retail energy providers, generators, and distribution and transmission utility companies
- Consumer choice of retailer commenced in January 2002
- In the five years that followed, transitory provisions such as mandated price caps or "price-to-beat" were established to incentivize market entry
- Zarnikau (2008): "ERCOT market is generally considered to be the most successful of the restructured electricity markets in North America"
  - More retail competition than any other market in the U.S. or Canada
  - According to the Public Utility Commission of Texas (PUCT, 2017), as of March 2016, 92% of all customers have exercised their right to choose an electricity supplier
  - ERCOT (2016) notes that 75% of electricity is sold to retail choice consumers

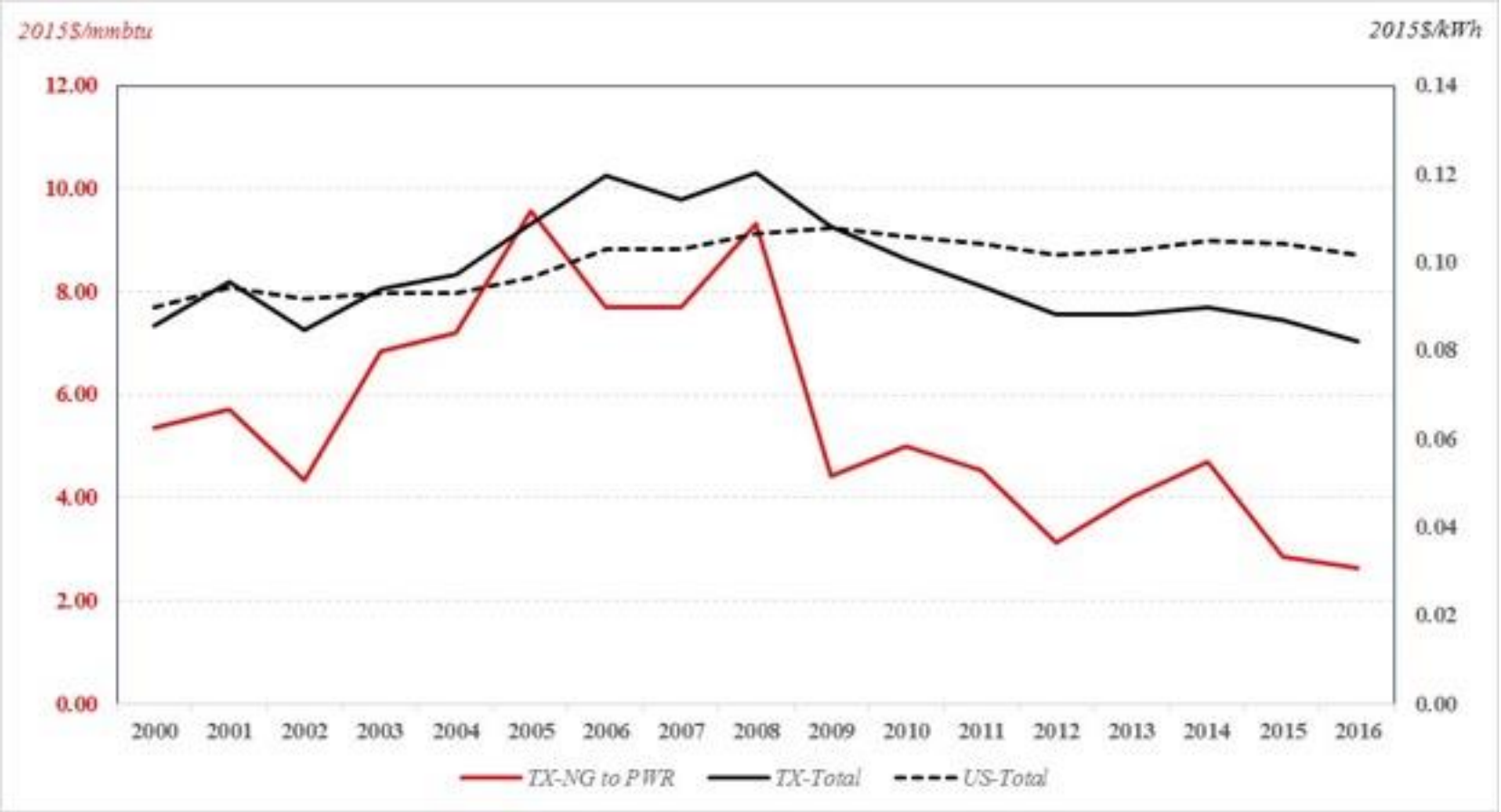
Texas versus US electricity rates

- By contrast, a Texas Coalition for Affordable Power study (TCAP, 2016) claimed the Texas reform was ineffective
- In the decade prior to deregulation average residential rates in Texas were 6.4 percent *below* the national average, but in the decade following it they were 8.5 percent *above*



Source: Energy Information Administration

Real electricity rates and natural gas prices

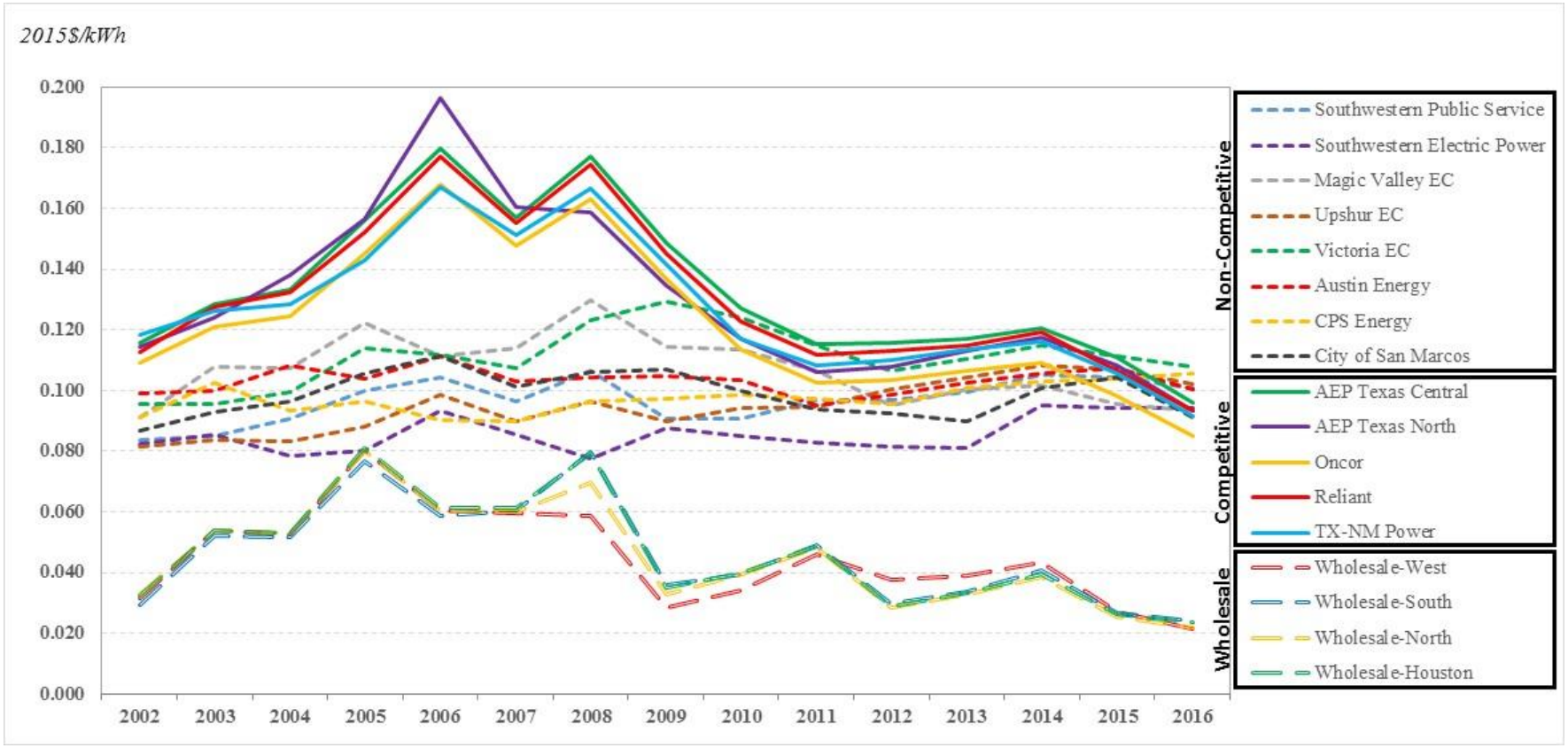


Source: Energy Information Administration

Competitive and non-competitive retailers

- Utilities owned/regulated by municipal governments and co-operatives were allowed to retain their pre-reform status
- Non-competitive retail areas:
  - Municipally owned – Austin Energy, CPS Energy, City of San Marcos
  - Investor-owned – SW Electric Power, SW Public Service
  - Co-operatives – Magic Valley EC, Upshur EC, Victoria EC
  - Some included limited generation capacity, but they all still purchased wholesale power
- Competitive retail areas: AEP Texas Central, AEP Texas North, Oncor, Reliant CPT, TX-NM Power
- TCAP study found that, after restructuring, residential customers in non-competitive areas enjoyed lower rates on average than those in competitive areas

Annual average residential rates (1000kWh) and wholesale prices ($2015)



Sources: Public Utilities Commission Texas, ERCOT, US Federal Reserve

Some key observations from the Texas case

- Residential prices closely track wholesale prices in the competitive, but not in the non-competitive, areas
- Competitive area residential price volatility also better mirrored wholesale price volatility, and hence exceeded non-competitive area price volatility
- A declining gap between competitive area retail and wholesale rates suggests that competition is reducing costs in competitive areas
  - The gap has generally widened in non-competitive areas
  - As reported by TCAP (2016), the post-reform average residential rate was higher in competitive than in non-competitive areas, but the gap disappeared by 2015
- Consistent with political interference, we found cross-subsidization from commercial to residential customers in the non-competitive areas

Challenges in power market transition and liberalization

- We have identified five key issues that need to be addressed when liberalizing power supply:
  1. Markets need to be sufficiently *competitive*
  2. The *structure* of prices has to reflect the *structure* of costs – especially with regard to the fixed and variable components of costs
  3. Price caps cause a "missing money problem" and insufficient capacity, exacerbated by mandating zero marginal operating cost renewable plants
  4. *Privatization* enhances the benefits of using markets, prices and decentralized information to achieve efficient outcomes
  5. Other policies, such as environmental ones, need to *use neutral market mechanisms* that do not favor particular technologies