

Course notes for EE394V Restructured Electricity Markets: Locational Marginal Pricing

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Recent History of Electricity Market Restructuring in Texas

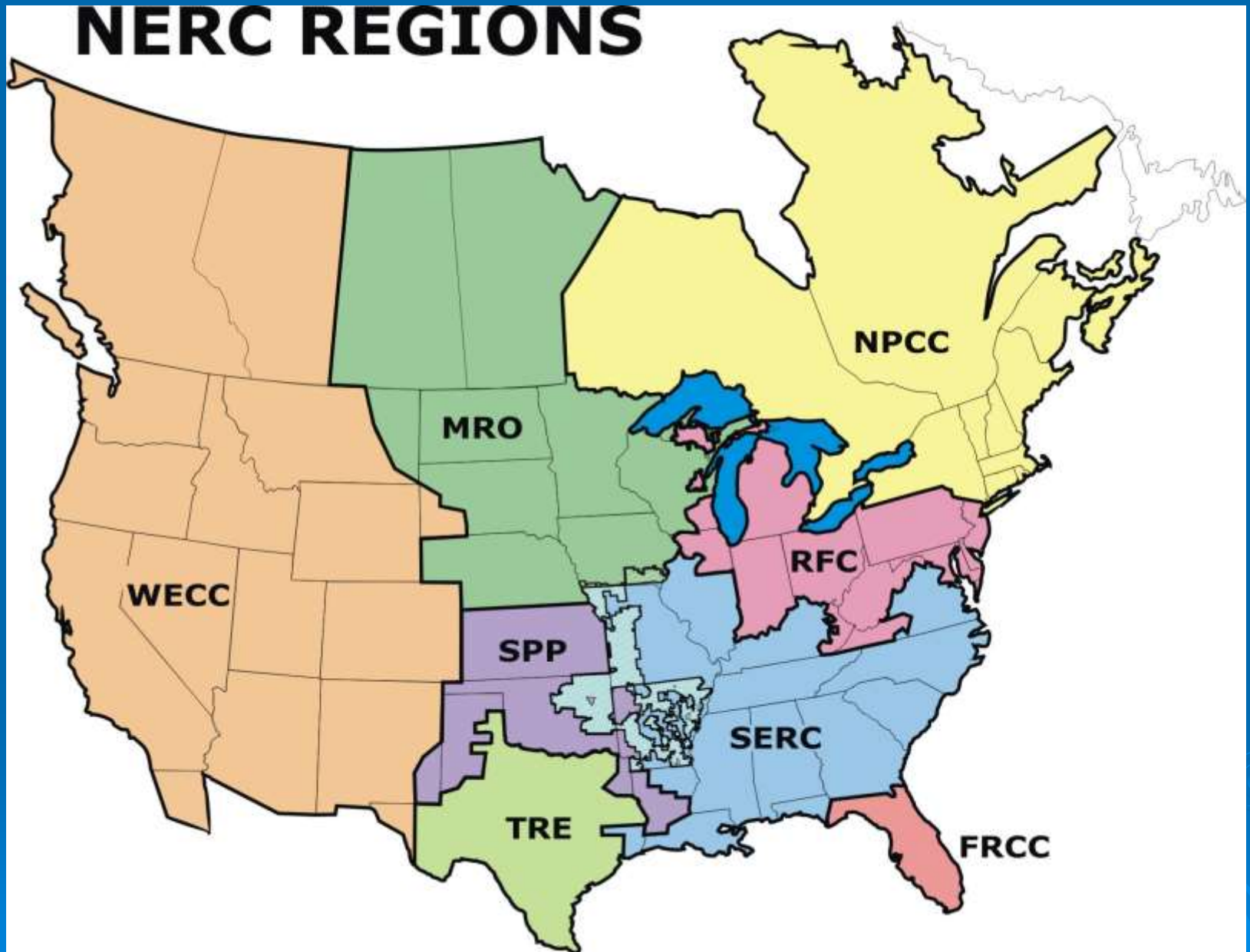
1. Regional entities,
2. Texas, the Electric Reliability Council of Texas (ERCOT), and the Texas Reliability Entity (TRE),
3. Regulatory jurisdiction,
4. Milestones in Texas electricity restructuring,
5. The locational marginal pricing or “nodal” market,
6. Capacity adequacy concerns,
7. Conclusions,
8. Homework Exercise.

1.1 Regional Entities:

Responsible for reliability of the bulk transmission system

- Texas Regional Entity, (TRE),
- Florida Reliability Coordinating Council (FRCC),
- Midwest Reliability Organization (MRO),
- Northeast Power Coordinating Council (NPCC),
- ReliabilityFirst Corporation (RFC),
- SERC Reliability Corporation (SERC),
- Southwest Power Pool, Inc. (SPP),
- Western Electricity Coordinating Council (WECC).

NERC REGIONS



Source: North American Electric Reliability Corporation. Available from:

www.nerc.com/fileUploads/File/AboutNERC/maps/NERC_Regions_Color_072512.jpg.

1.2 Texas, ERCOT, and TRE

➤ The Electric Reliability Council of Texas (ERCOT) Region:

- Encompasses 75% of area of Texas, shown as TRE on previous slide,
- Accounts for approximately 80% of the electric load in Texas,
- approximately 6400 buses and 7800 lines,
- will not discuss the rest of Texas in detail.

Texas, ERCOT, and TRE

- The Electric Reliability Council of Texas (ERCOT) Independent System Operator (ISO):
 - responsible for maintaining “reliability” in ERCOT region,
 - Operates “centralized” market,
- Antecedent organization of ERCOT ISO was formed in 1970.

Texas, ERCOT, and TRE

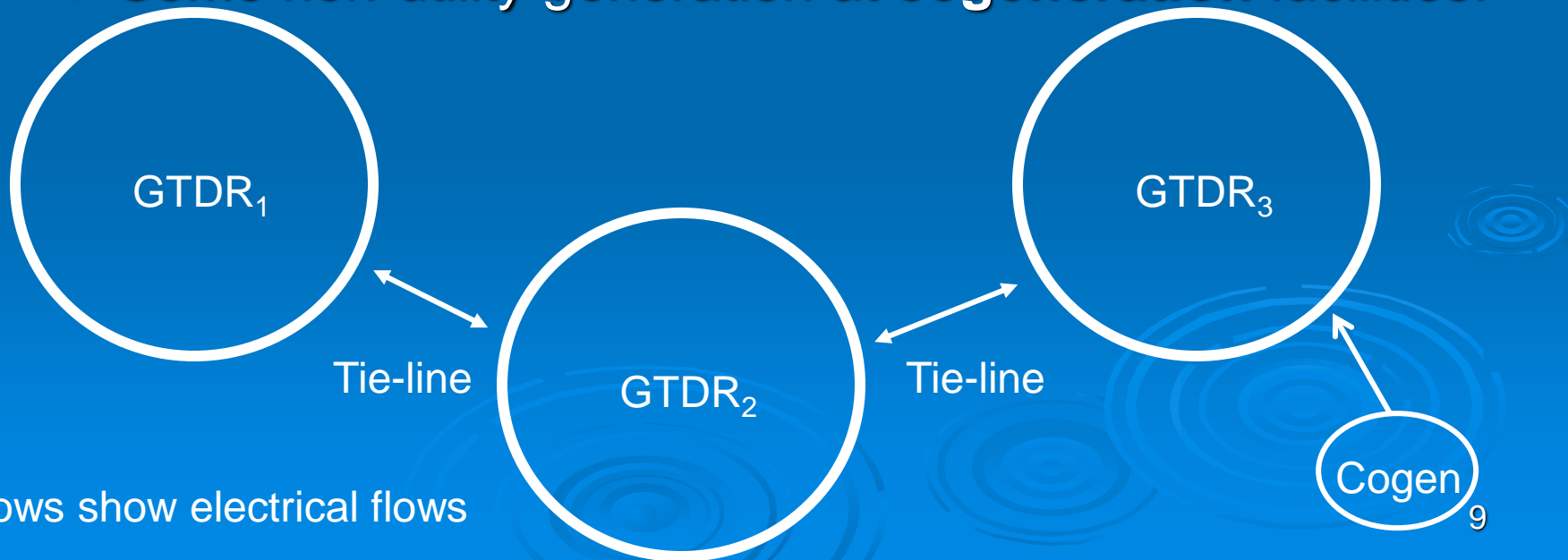
- TRE is one of eight regional entities (formerly “reliability councils”) in North America:
 - regional entities under authority of “North American Electric Reliability Corporation” (NERC) for purposes of “reliability”
 - TRE develops, monitors, assesses, and enforces compliance with NERC reliability standards.

1.3 Regulatory jurisdiction

- Most electricity entities in ERCOT are under “economic” regulatory jurisdiction of the Public Utility Commission of Texas (PUCT).
- In other states, and in the non-ERCOT part of Texas, economic regulation is typically through both:
 - The Federal Energy Regulatory Commission (wholesale trade), and
 - The relevant state Public Utility Commission (retail).
- Split of jurisdiction complicates restructuring.

1.4 Milestones in Texas electricity restructuring 1995-2010

- Prior to 1996, most electricity supplied by partially or fully vertically-integrated utilities:
 - Generation (G), transmission (T), distribution (D), and retail (R) function combined in one company,
 - Some wholesale trade on “tie-lines” between them,
 - Some non-utility generation at **cogeneration** facilities.



Milestones in Texas electricity restructuring 1995-2010

- Vertical integration and variations typical in North America (and worldwide) prior to restructuring:
 - In principle, vertical integration is the most effective arrangement if industry is “natural monopoly:”
 - Economies of scale of construction or operation large enough that one company in a region can construct and operate the system more cheaply than two or more.
- Some variations such as:
 - Generation (G) and transmission (T) in one company (eg, Lower Colorado River Authority),
 - Distribution (D) and retail (R) in one company (eg, rural cooperatives).

Milestones in Texas electricity restructuring 1995-2010

- Larger vertically-integrated companies mostly investor-owned; also some vertically-integrated municipal utilities such as Austin Energy.
- Retailer had exclusive franchise to sell to retail customers in franchise area:
 - Retail tariffs set by regulator to recover **cost-of-service** to utility including operating costs, capital costs plus regulator-approved return on equity,
 - Limited incentive to utility to minimize costs, particularly capital costs, or to innovate,
 - “Averch-Johnson” bias to over-invest in capital compared to optimal.

Milestones in Texas electricity restructuring 1995-2010

- By 1990s, change in perception about regulated monopolies due to:
 - Successful restructuring of other industries,
 - high costs of nuclear generation,
 - new, smaller combined-cycle generators.
- Realization that G, T, D, R could be separated:
 - Generation sector not necessarily natural monopoly, so potential for competition,
 - Transmission and distribution still understood to be natural monopoly, and could remain regulated.

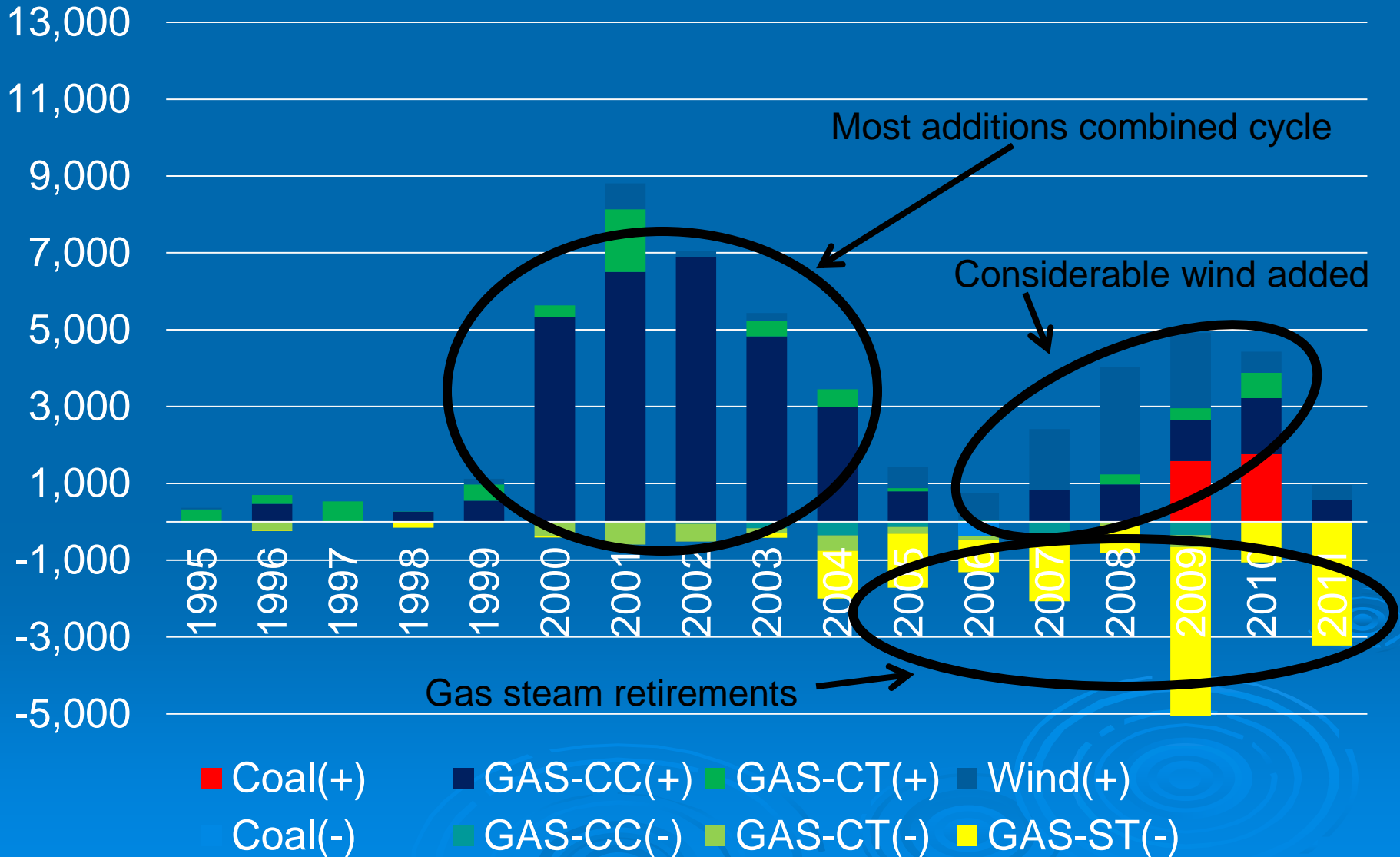
Milestones in Texas electricity restructuring 1995-2010

- 1995, amended Public Utility Regulatory Act provided for wholesale competition involving non-utilities, principally **Independent Power Producers** (IPPs)—independently owned generators,
- Consistent with world-wide trend to harness competition in generation sector.
- 1996, ERCOT **Independent System Operator** (ISO) formed and wholesale competition involving non-utilities began:
 - Most new entry in next several years was gas.

Milestones in Texas electricity restructuring 1995-2010

- 1999, Senate Bill 7 enabled retail competition:
 - Integrated investor-owned utilities required to “functionally unbundle” into:
 - generation, sells energy at wholesale,
 - transmission and distribution, cost-of-service regulated by Public Utility Commission,
 - Retailer, sells to consumer of energy.
 - Generation resources competing in wholesale market:
 - Many new power stations built over subsequent years, including combined cycle gas turbines and then wind.
 - New retailers competing in retail market to serve customer load.
 - Transmission and distribution remain as regulated entities receiving cost-of-service and return on equity.

ERCOT Capacity Expansion (+) and Retirement (-) by Fuel Type [MW]

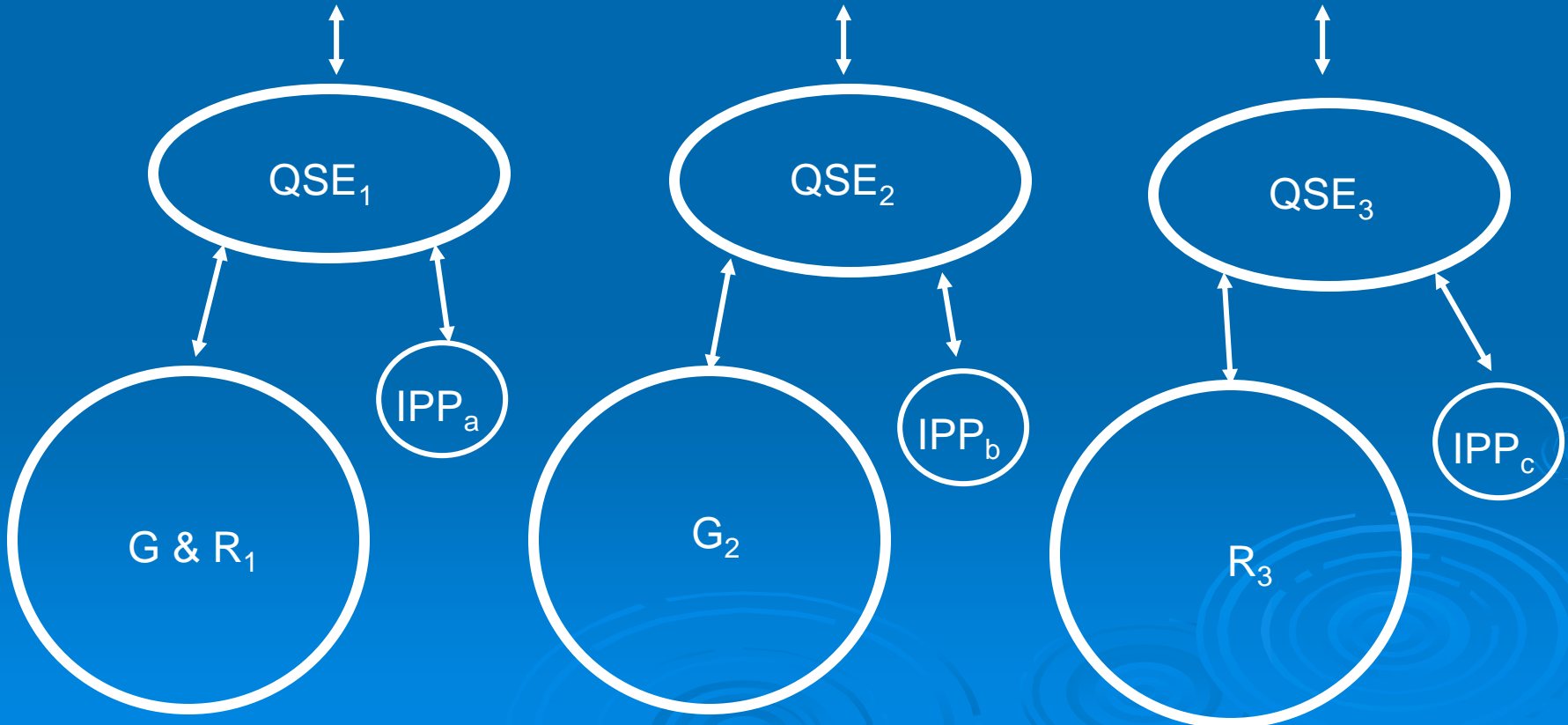


Milestones in Texas electricity restructuring 1995-2010

- 2001, ERCOT ISO became the single **control area operator (balancing authority)**:
 - Day-ahead scheduling process established,
 - Qualified Scheduling Entities (QSEs) representing generators and/or retailer submitted balanced specification of generation to meet specified demand, the **schedule**,
 - **Balancing market** established to cope with deviations of actual from scheduled generation and demand.

Milestones in Texas electricity restructuring 1995-2010

ERCOT ISO validates schedules and operates balancing market



Arrows show information flows

Milestones in Texas electricity restructuring 1995-2010

➤ Transmission issues:

- If result of schedule would overload the transmission system, then **re-dispatch** of generation necessary compared to schedule,
- Individual generators re-dispatched and QSEs compensated for cost of re-dispatch,
- All costs of re-dispatch to relieve transmission constraints due to initial schedule were **uplifted** (charged) to retail customers,
- Predictable result was that QSEs submitted schedules that would have overloaded transmission constraints and were then compensated for relieving the overloads that their schedules would have caused.

Milestones in Texas electricity restructuring 1995-2010

- 2002, retail market began.
- 2002, effects of inter-zonal transmission constraints represented in zonal wholesale prices so that only re-dispatch costs due to “local” transmission constraints were then uplifted.
- 2002-2005, hundreds of millions of dollars of local re-dispatch costs uplifted.
- 2005, decision to change to a nodal wholesale market.
- Nodal market opened December 2010.

1.5 The nodal market from December 2010

- Centrally dispatched real-time market, similar role to the previous balancing market, but with nodal representation of transmission.
- Centrally dispatched day-ahead market:
 - Each generator can offer its capacity to be used to generate energy, or provide for ancillary services, or a mixture of energy and ancillary services (or can schedule),
 - Energy and related ancillary services acquired in a single day-ahead auction run by ERCOT ISO,
 - Determines short-term forward prices.

The nodal market from December 2010

- Generators exposed to locational prices.
- As we will see in rest of course, transmission constraints generally result in:
 - Lower locational prices on “export” side of constraint,
 - Higher locational prices on “import” side constraint.
- No longer a mechanism for QSEs to benefit from congestion.

The nodal market from December 2010

- Uplift of only a much smaller fraction of overall market value compared to previous zonal market, including costs of:
 - Ancillary services,
 - Cost of losses,
 - Re-dispatch costs due to transmission constraints not represented in nodal market,
 - Reliability unit commitment.
- Consumption exposed to zonal averages, with zones based on previous zones.

The nodal market from December 2010

- In addition to centralized real-time and day-ahead markets run by ERCOT ISO there are:
 - Centralized markets run by ERCOT ISO for “congestion revenue rights” to hedge fluctuations in locational price differences between, eg, generation and load,
 - Longer term products traded bilaterally and through exchanges.

The nodal market from December 2010

- Locational pricing map for real-time prices available from:
<http://www.ercot.com/content/cdr/contours/rtmLmpHg.html>
- Do you have retail choice for your retail electricity purchases?

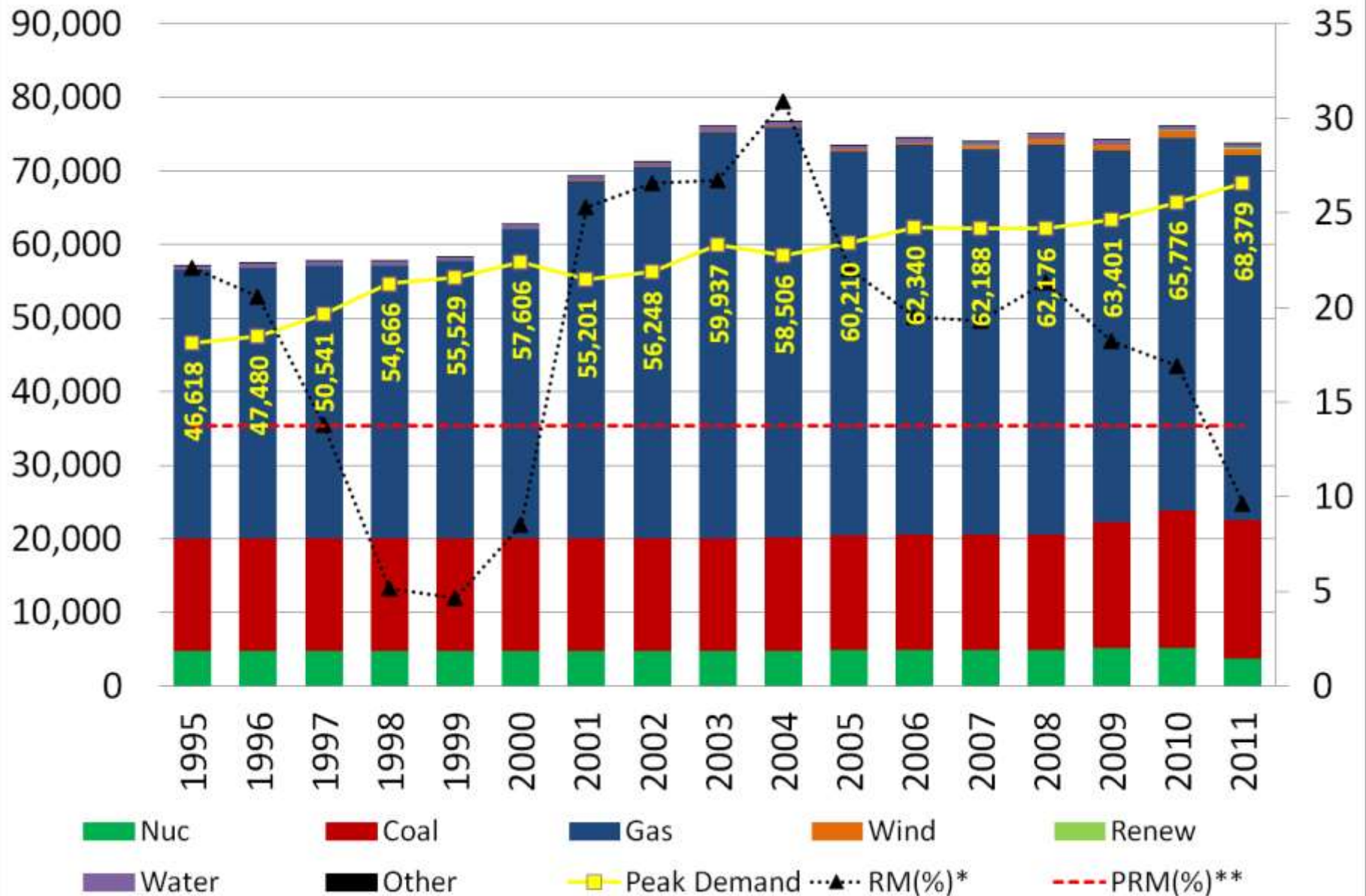
Similar designs in other restructured markets in North America.



1.6 Capacity adequacy concerns.

- After 2006, most new generation additions have been wind:
 - West Texas wind mostly generates off-peak,
 - Wind capacity does not contribute much to meeting peak demand:
 - “ERCOT Capacity” on next slide shows estimate of contribution of wind to meeting demand at peak.

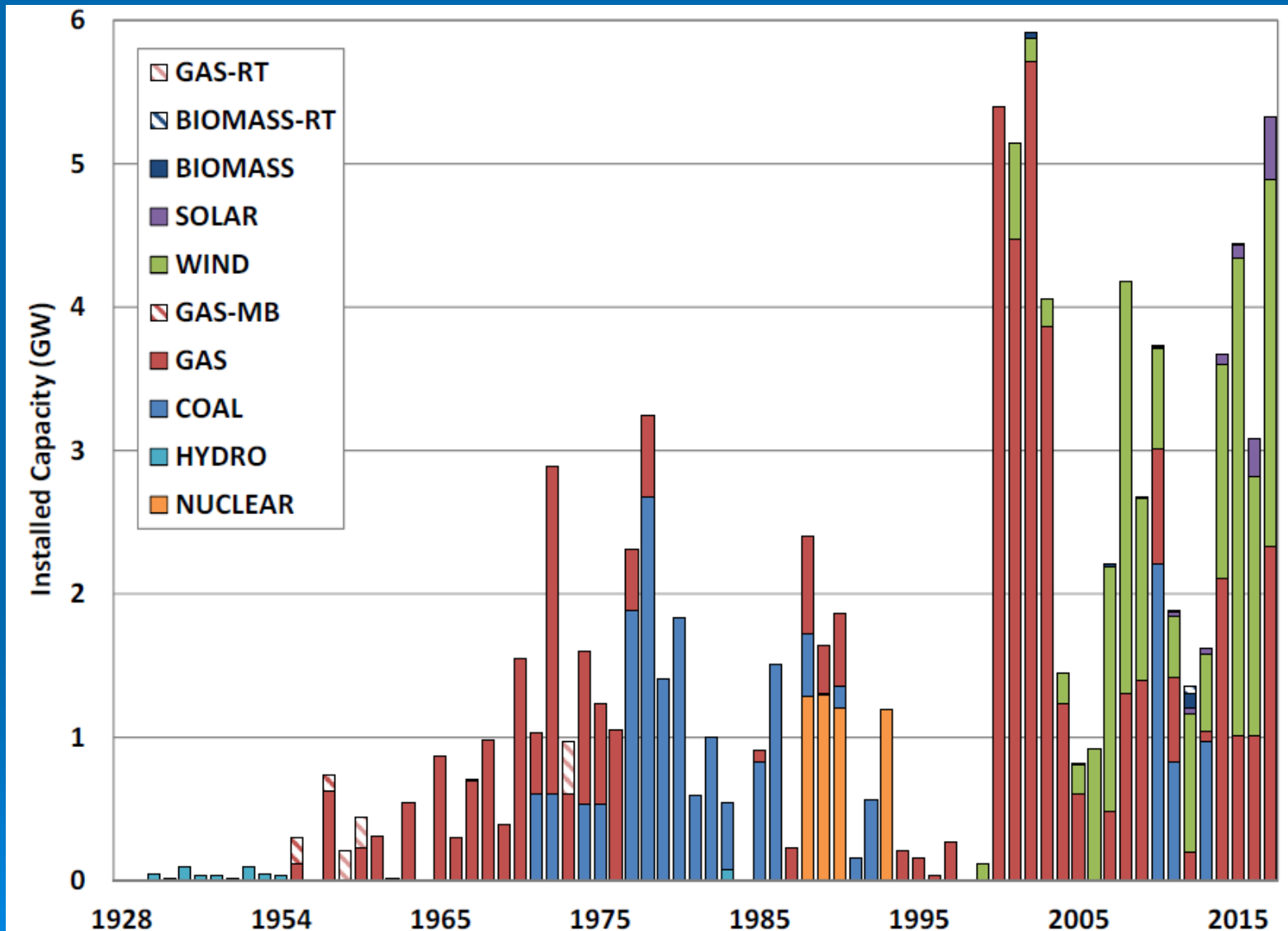
ERCOT Capacity, Peak Demand [MW], and Reserve Margin[%]



Capacity adequacy concerns.

- Since 2006, in addition to wind, some natural gas, and a small amount of coal capacity has been added.
- Increasing amounts of solar anticipated in coming years.
- But gas steam and (recently) coal has been retired:
 - Much of remaining coal capacity is old.
- Ongoing concerns as to whether generation capacity will be adequate in future as peak demand continues to grow.²⁸

Capacity adequacy concerns.



Years of installation of capacity in ERCOT. Source: Potomac Economics.

Capacity adequacy concerns.

- In US restructured wholesale electricity markets other than ERCOT, there are either:
 - Obligations on (typically regulated) “load serving entities” (retailers) to purchase or contract with sufficient capacity to meet forecast load, or
 - A “capacity market” designed to ensure that sufficient capacity will be built for forecast load.
- ERCOT does not have these mechanisms, but introduced an “operating reserves demand curve” in 2014 to incentivize new capacity by increasing prices under reserve scarcity.

Capacity adequacy concerns.

- Significant wind in ERCOT has benefitted from Federal tax subsidies and development of large-scale “competitive renewable energy zone” transmission to enable expanded West Texas wind development.
- Wind (and solar) tend to lower average wholesale price because marginal cost of production is zero.
- Low natural gas prices since 2006 have also contributed to low wholesale prices.

Capacity adequacy concerns.

- Renewables and low gas prices continue to result in low wholesale prices in ERCOT.
- Recently, there have been several closures of coal plants in ERCOT:
 - Low wholesale prices,
 - Also closures of nuclear and coal units throughout the US.
- Concern about capacity adequacy remains.

Capacity adequacy concerns.

- Extreme cold weather event in February 2021 resulted in localized blackouts of well over 10GW over three days:
 - Common mode outages due to cold of electricity, gas, and water infrastructure.
- Previous cold event in February 2011 also resulted in blackouts, but was less severe
 - Weatherization recommendations from FERC/NERC 2011 report not made mandatory.
- May result in changes to ERCOT market.

1.7 Conclusions

- Regional entities,
- Texas and the Electric Reliability Council of Texas (ERCOT),
- Regulatory jurisdiction,
- Milestones in Texas electricity restructuring,
- The locational marginal pricing or nodal market,
- Capacity adequacy concerns.

References

- This is an updated version of parts of “Lessons Learned: The Texas Experience,” Ross Baldick and Hui Niu, presented at the Bush School Conference on *Electricity Deregulation: Where to from here?* April 4, 2003, and appearing as Chapter 4 of Griffin and Puller, Editors, *Electricity Deregulation: Choices and Challenges*, The University of Chicago Press, 2005.

References

- Harvey Averch and Leland L. Johnson, “Behavior of the Firm Under Regulatory Constraint,” *The American Economic Review*, 52(5):1052—1069, December 1962.
- Potomac Economics, “2017 State of the Market Report for the ERCOT Electricity Markets,” Available from www.potomaceconomics.com
- Federal Energy Regulatory Commission, www.ferc.com

Homework Exercise

1.1

- i. Print out and turn in a copy of the ERCOT real-time locational pricing map from:
<http://www.ercot.com/content/cdr/contours/rtmLmpHg.html> for any time interval of your choice.
- ii. For this time interval, specify the highest price in ERCOT, the lowest price in ERCOT, and the difference between the highest and lowest price.
- iii. Find the ERCOT “offer cap;” that is, the highest price allowed in any market offer.