Operating Reserve Demand Curve, Scarcity Pricing and Intermittent Generation

Lessons from the Texas ERCOT Experience

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Introduction

Background

- 80's & 90's: privatization/liberalization of electricity sector
- But after the 2000s many markets faced reliability issues

Resource adequacy problem or "missing-money" problem

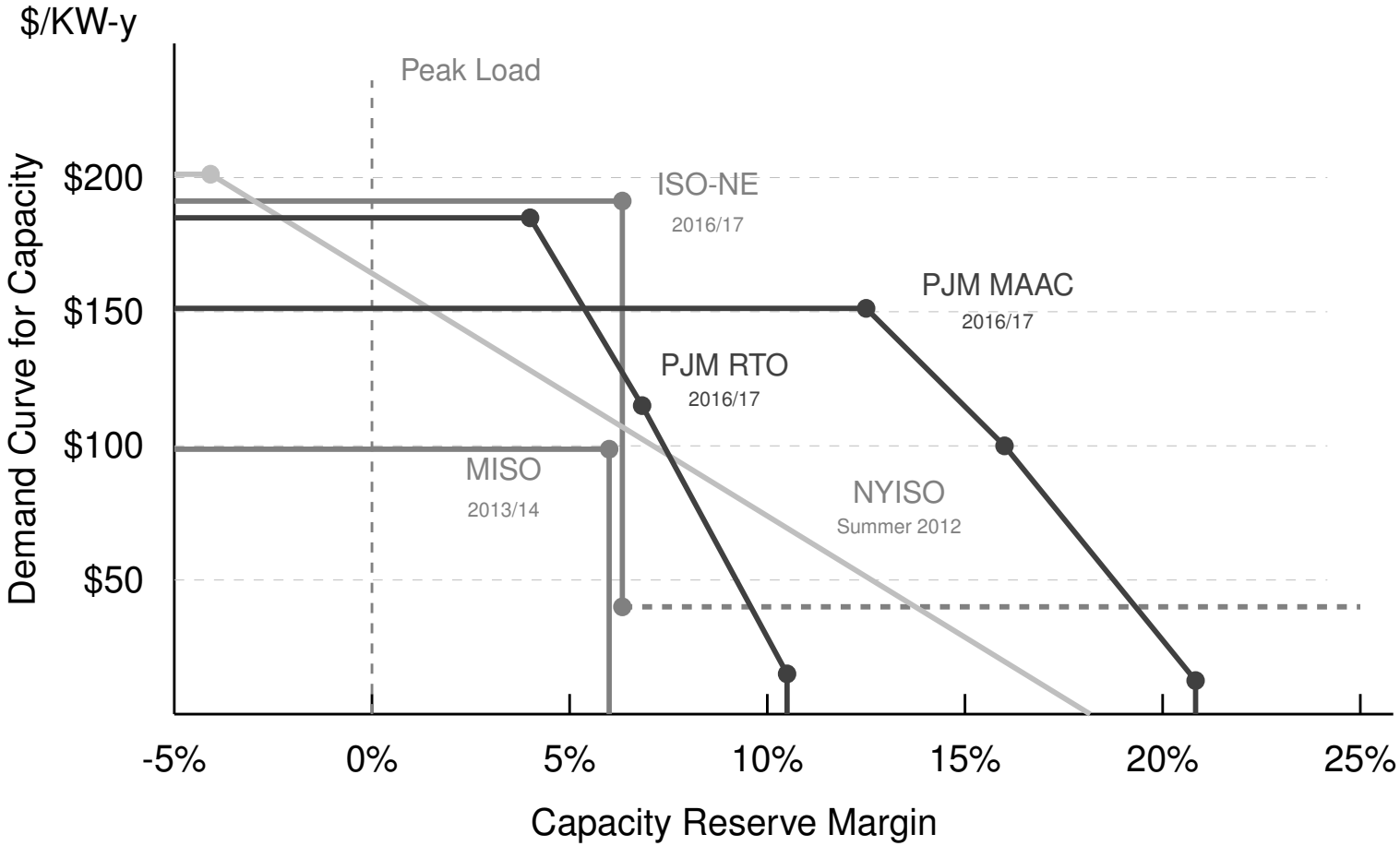
- Competitive electricity markets weren't providing right incentives to build adequate capacity to guarantee reliability
  - Price Caps
  - Negative prices (mostly due to wind subsidies)
  - Regulatory uncertainty

Background

- To solve the resource adequacy problem, many countries and regions implemented **Capacity Mechanisms**
  - Capacity Adequacy Requirements
  - Centralized Capacity Markets
- Where? ISO-NE, PJM, NYISO, etc.
- **Goal**: provide sufficient and clearly perceivable long-term price signals (lower investment risk)
  (Hoschle et al 2017, *EE*)

Background

Some examples of demand curves for capacity in the U.S.
(Spees et al. 2013, *EEEP*)



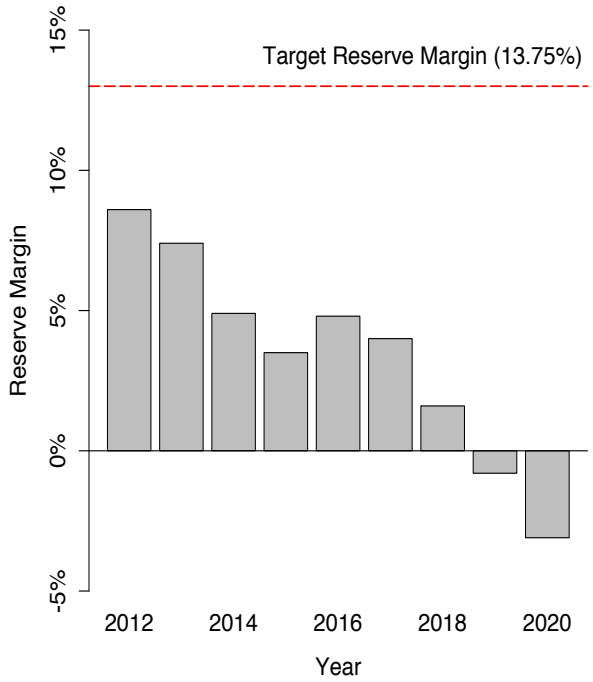
Background

- Another potential solution to the resource adequacy problem is to introduce a **futures market for wholesale electricity**
- Where? Singapore (since April 2015)
- **Goal**: lower the risk of investment in capacity (stable long-term price signals)
  (see Wolak 2017, *Working Paper*)

Meanwhile, in Texas...

Meanwhile, in Texas...

- The Texas ERCOT market was facing the Resource Adequacy Problem



- However, no capacity mechanisms were implemented, nor a futures market for wholesale electricity

Background

- Alternatively, the regulator implemented in June 2014...

Operating Reserve Demand Curve (ORDC) system

- Mechanism to provide adequate investment incentives through scarcity pricing system

Background

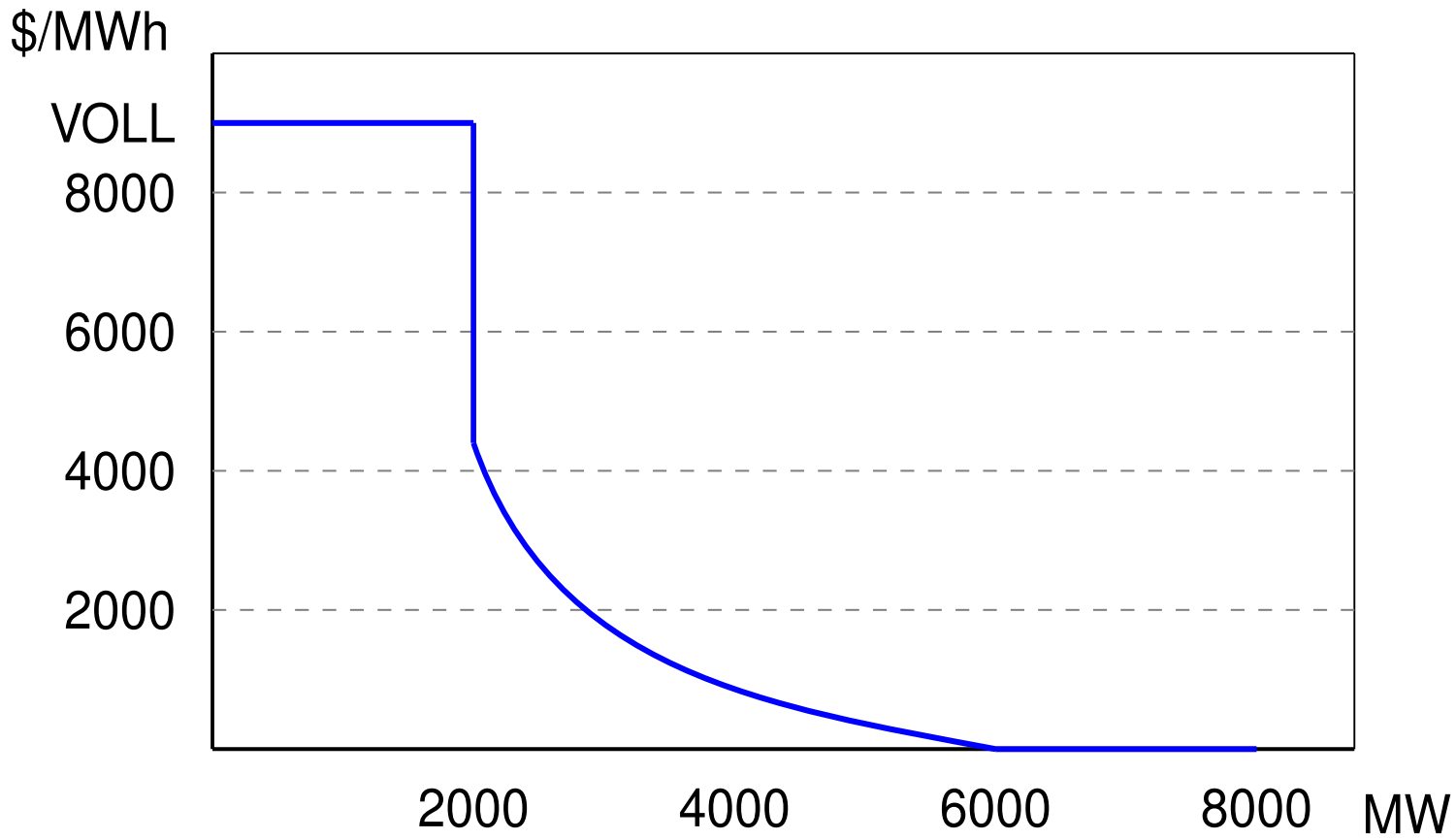
- Alternatively, the regulator implemented in June 2014...

Operating Reserve Demand Curve (ORDC) system

- Mechanism to provide adequate investment incentives through scarcity pricing system
- The basic idea
  - Generators holding additional reserves are compensated if reserves are low
  - The **compensation** is **added** to the **real-time** price

Background: Capacity Markets

The Operating Reserves Demand Curve (Hogan 2005)



Our research questions

- Does the ORDC provide clear long-term price signals (lower investment risk)?
  - Linked to the Real-Time market
  - Growing penetration of intermittent renewable generation
- Evaluate these issues based on the experience of the Texas ERCOT market over the past two years
- Why is this important?
  - Recently implemented in the Mexican reform
  - Some European markets are considering ORDC

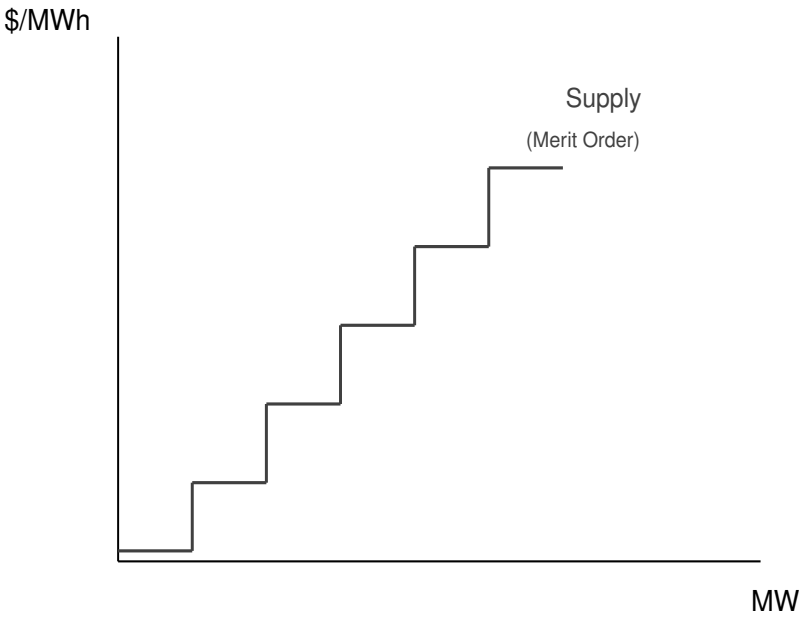
Stylized Model

Stylized model

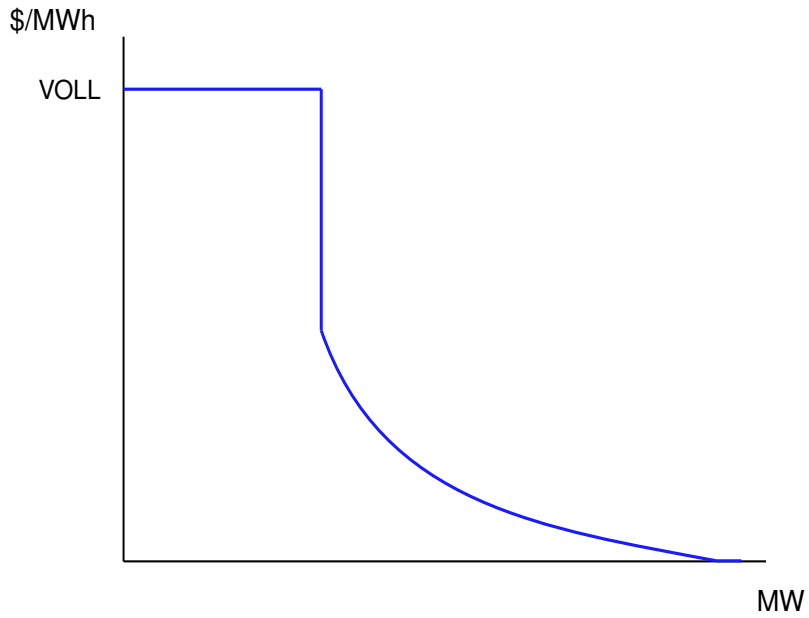
- In the presence of ORDC, generators have two options
  - Wholesale electricity market (RTM), or
  - ORDC

Data

Stylized model

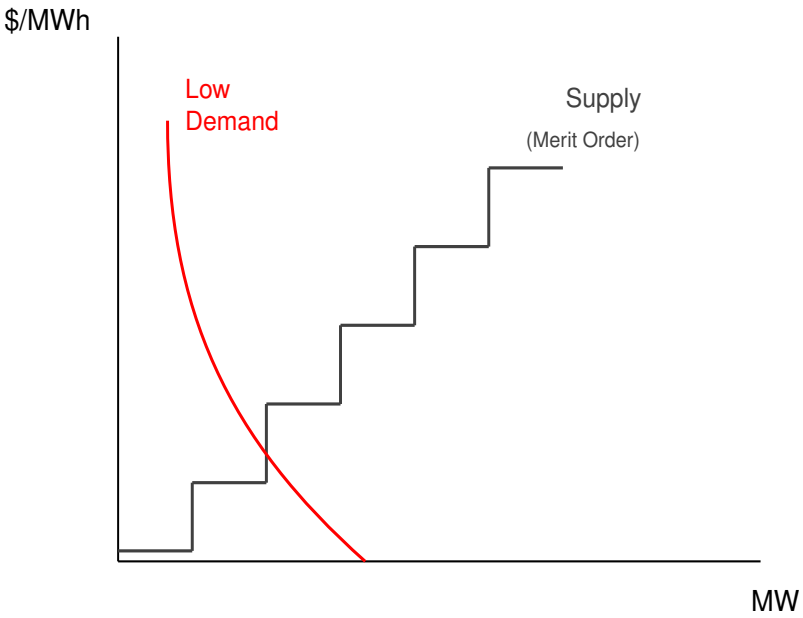


Wholesale market

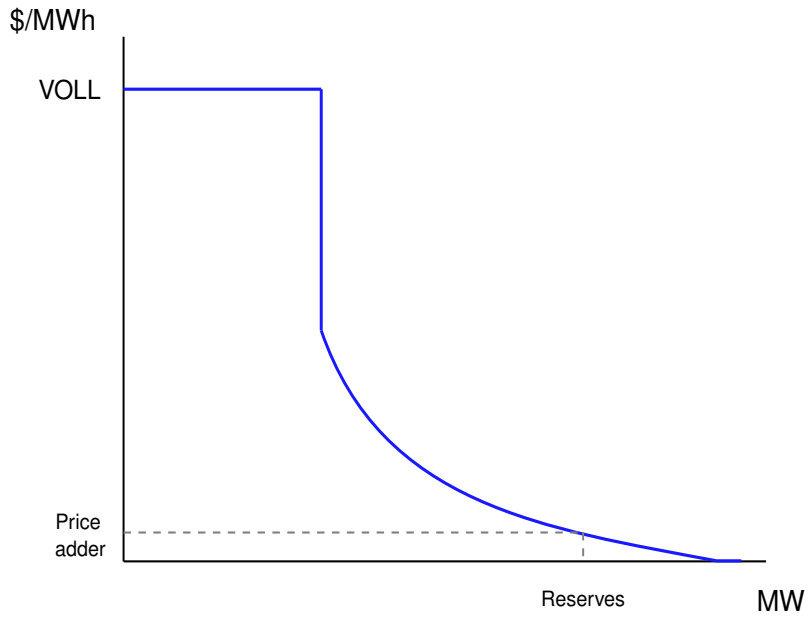


ORDC

Stylized model



Wholesale market



ORDC

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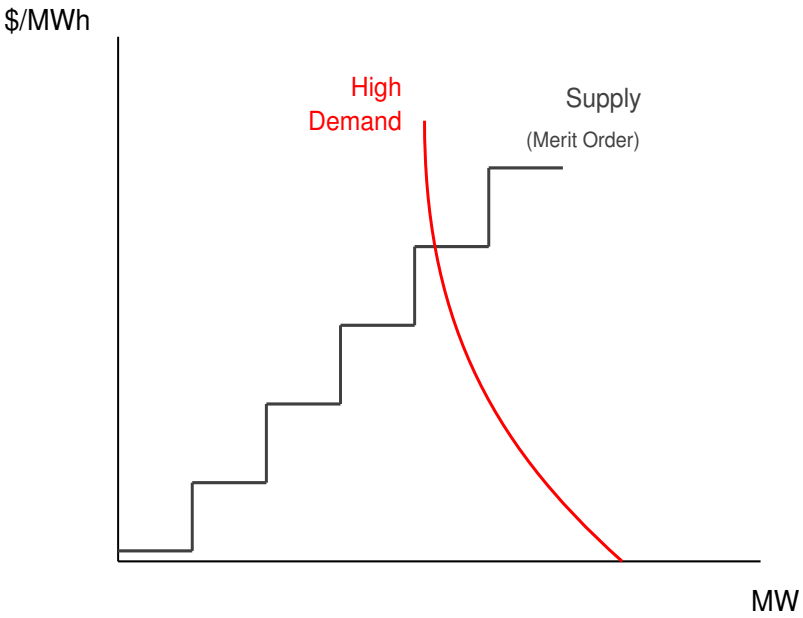

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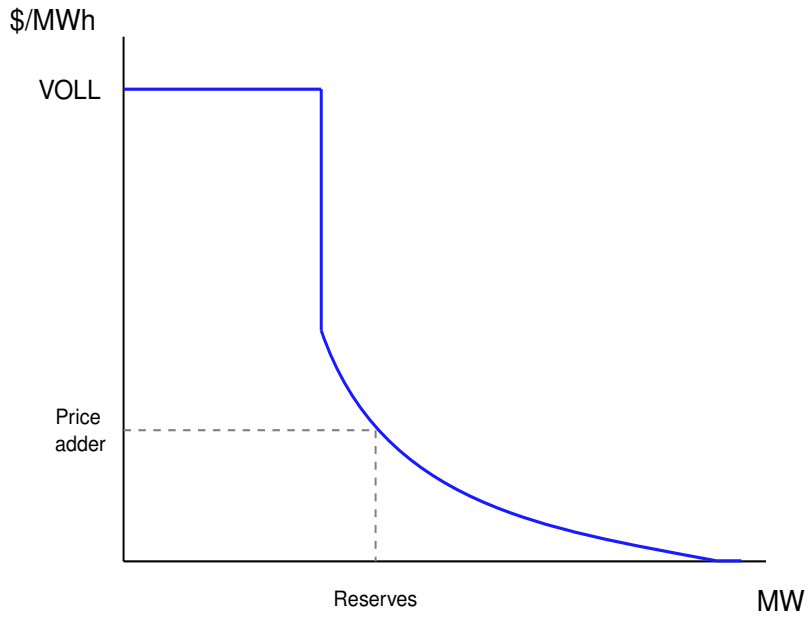

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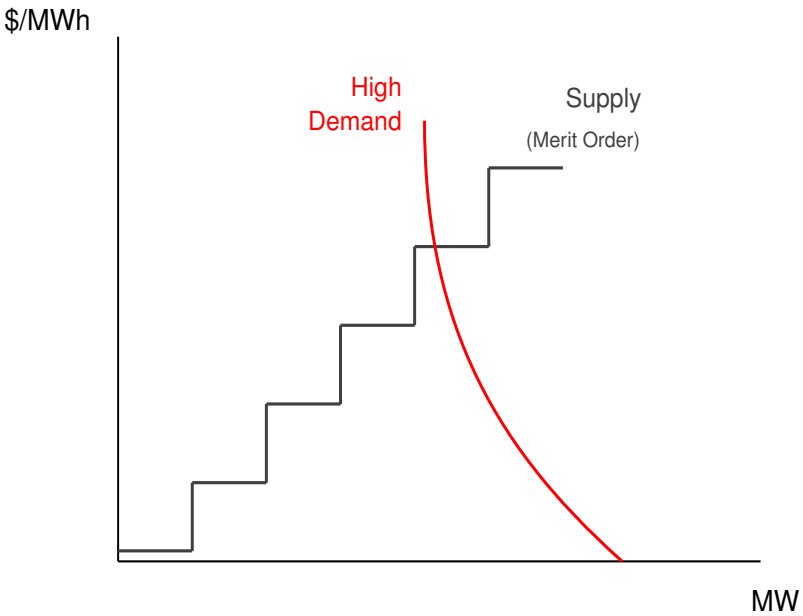

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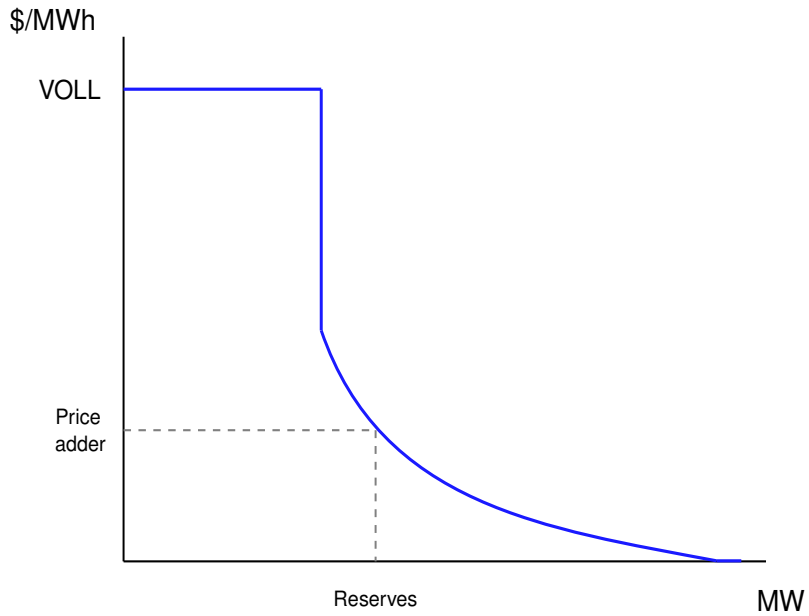
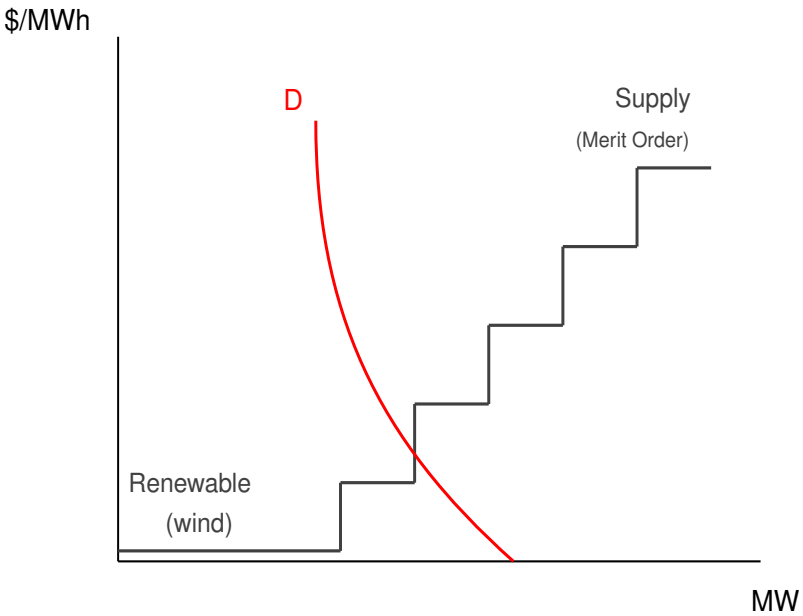


ORDC

Hypothesis #1: ORDC price increases as electricity demand increases (*ceteris paribus*)

Stylized model with renewable generation (wind)



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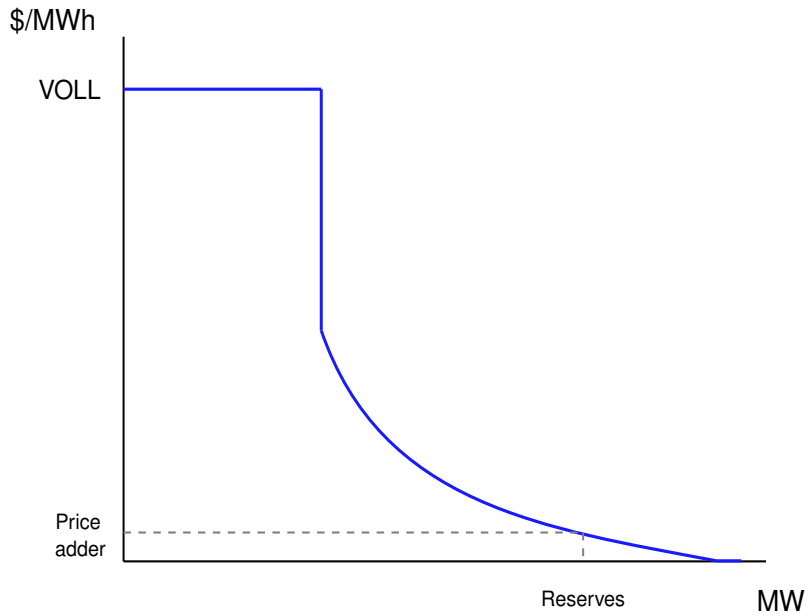

ORDC

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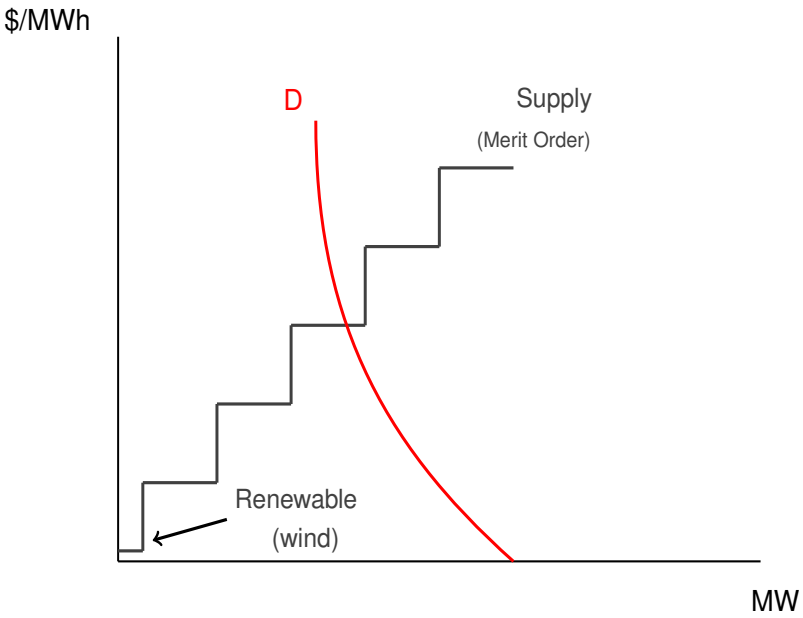

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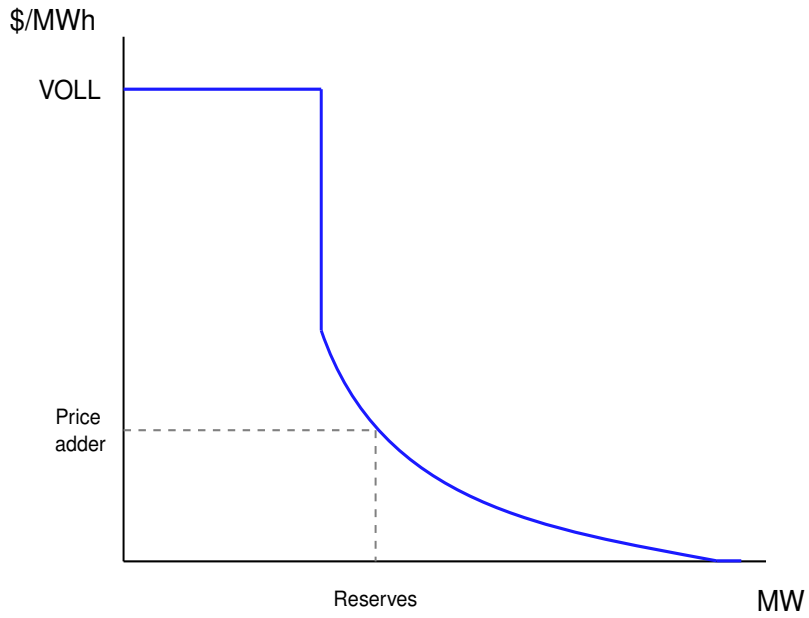

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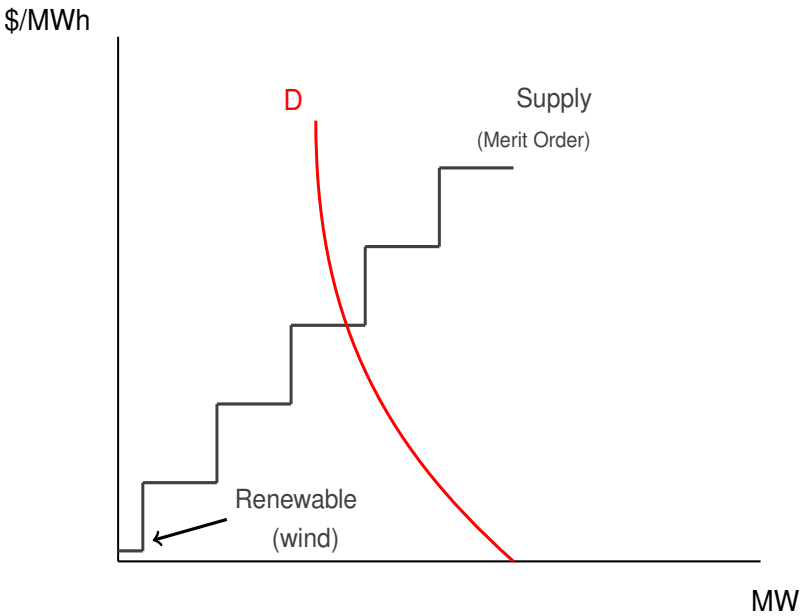

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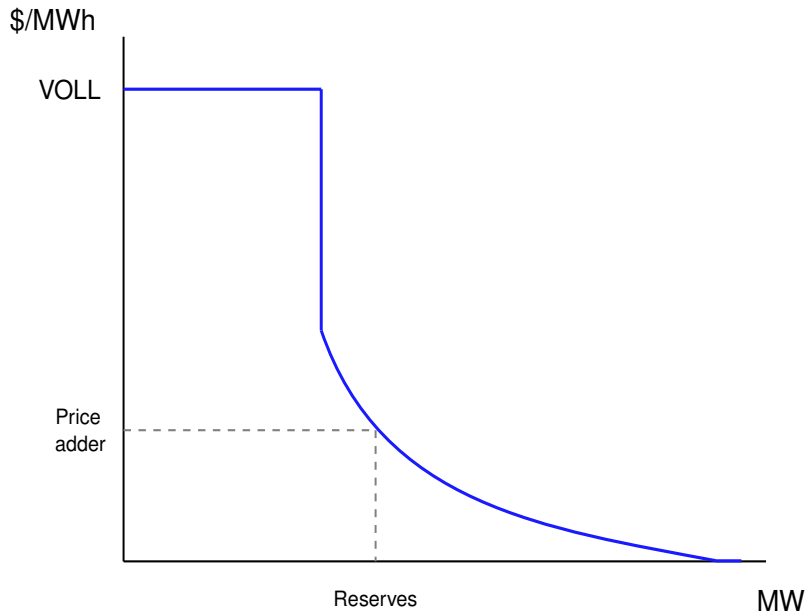

ORDC

Hypothesis #2: ORDC price decreases as wind generation increases (*ceteris paribus*)

Empirical model and results

Baseline model

- Unit of observation: an hour (t)

$$\log(RTORPA)_t = \alpha_1 \log(Load)_t + \alpha_2 \log(Wind)_t + \lambda_t + \varepsilon_t$$

- Dependent variable
  - RTORPA$_t$: ORDC real time price adder at t ($/MWh)
- Explanatory variables
  - Load$_t$: ERCOT's load at t (MW)
  - Wind$_t$: ERCOT's wind generation at t (MW)
  - λ_t: seasonal dummies

Data and summary statistics (highlights)

- Unit of observation: an hour (t)
  - Time: January 2015 to December 2016
    - Data is missing for the last week of 2016
  - Source: Texas ERCOT data
- The variables are all stationary Tests
  - ADF test performed with and without trend and drift

The determinants of ORDC prices

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
log Load	0.283***	0.274***	0.279***	0.279***	0.564***
	(0.0202)	(0.0232)	(0.0234)	(0.0232)	(0.0348)
log Wind	-0.0859***	-0.0812***	-0.0814***	-0.0805***	-0.0829***
	(0.00494)	(0.00492)	(0.00493)	(0.00473)	(0.00472)
Hour dummy		✓	✓	✓	✓
Day of Week dummy			✓	✓	✓
Day of month dummy				✓	✓
Month dummy					✓
r2	0.0731	0.105	0.107	0.111	0.134
N	17373	17373	17373	17373	17373
vce	robust	robust	robust	robust	robust

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Robustness Checks (I)

- Potential endogeneity between prices and demand
  - Solution: IV regression
- We use weather as an instrument for ERCOT load
  - Daily data on the (squared) deviation from average temperatures
  - Data from the three major metropolitan areas in TX (Houston, Dallas and SA)
  - Extreme weather (hot and cold) highly correlated with load

The determinants of ORDC prices (IV)

	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
log Load	0.568***	0.544***	0.920***	0.830***	0.989***	0.856***
	(0.139)	(0.127)	(0.211)	(0.217)	(0.250)	(0.234)
log Wind	-0.149***	-0.149***	-0.153***	-0.153***	-0.143***	-0.143***
	(0.0335)	(0.0335)	(0.0345)	(0.0346)	(0.0334)	(0.0336)
Day of Week dummy					✓	✓
Day of month dummy					✓	✓
Month dummy			✓	✓	✓	✓
r2	0.0840	0.0839	0.139	0.139	0.184	0.184
N	724	724	724	724	724	724
vce	jackknife	jackknife	jackknife	jackknife	jackknife	jackknife

Standard errors in parentheses

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Robustness Checks (II)

- Persistence of the effect of the some variables on ORDC prices
  - Solution: autoregressive distributed lag (ARDL) model
- Alternative model

$$\log(RTORPA)_t = \sum_{i=1}^{l} \alpha_i \log(RTORPA)_{t-i} + \sum_{j=0}^{n} \beta_j \log(Load)_t +$$

$$+\sum_{j=0}^{n} \gamma_j \log(Wind)_t + \lambda_t + \varepsilon_t$$

The determinants of ORDC prices (ARDL)

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS
log Load	0.390***	0.848***	0.249***	0.499***	0.252***	0.505***
	(0.0292)	(0.0587)	(0.0518)	(0.0697)	(0.0521)	(0.0706)
log Wind	-0.0662***	-0.0764***	-0.0489***	-0.0549***	-0.0489***	-0.0550***
	(0.0129)	(0.0140)	(0.0166)	(0.0170)	(0.0166)	(0.0170)
(T-1) log RTORPA	0.756***	0.750***	0.990***	0.970***	0.986***	0.965***
	(0.0264)	(0.0258)	(0.0336)	(0.0331)	(0.0356)	(0.0351)
(T-1) log Load	-0.332***	-0.720***	-0.127	-0.253**	-0.136	-0.275**
	(0.0253)	(0.0551)	(0.0930)	(0.126)	(0.0933)	(0.128)
(T-1) log Wind	0.0440***	0.0547***	0.0458	0.0450	0.0469	0.0465
	(0.0132)	(0.0143)	(0.0300)	(0.0300)	(0.0300)	(0.0300)
(T-2) log RTORPA			-0.310***	-0.295***	-0.297***	-0.279***
			(0.0292)	(0.0287)	(0.0418)	(0.0411)
(T-2) log Load			-0.0474	-0.0918	-0.0407	-0.0735
			(0.0480)	(0.0734)	(0.0480)	(0.0749)
(T-2) log Wind			-0.0246	-0.0170	-0.0259	-0.0188
			(0.0167)	(0.0167)	(0.0167)	(0.0167)
(T-3) log RTORPA					-0.0131	-0.0163
					(0.0245)	(0.0242)
Full set of dummies		✓		✓		✓
r2	0.604	0.621	0.642	0.654	0.642	0.654
N	17372	17372	17371	17371	17370	17370
vce	robust	robust	robust	robust	robust	robust

Standard errors in parentheses

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The determinants of ORDC prices (ARDL) (IV)

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) est7	(8) est8
log Load	0.706***	1.022***	1.028***	1.221***	0.734***	1.000***	1.170***	1.322***
	(0.226)	(0.367)	(0.271)	(0.397)	(0.240)	(0.363)	(0.286)	(0.415)
log Wind	-0.154***	-0.158***	-0.144***	-0.151***	-0.155***	-0.157***	-0.146***	-0.149***
	(0.0345)	(0.0313)	(0.0332)	(0.0311)	(0.0343)	(0.0318)	(0.0335)	(0.0315)
(T-1) log RTORPA	0.413***	0.418***	0.398***	0.408***	0.411***	0.417***	0.404***	0.410***
	(0.104)	(0.0342)	(0.102)	(0.0346)	(0.101)	(0.0376)	(0.0986)	(0.0373)
(T-1) log Load	-0.388*	-0.754**	-0.450*	-0.908**	-0.523	-1.243**	-0.929**	-1.509**
	(0.216)	(0.376)	(0.270)	(0.418)	(0.368)	(0.596)	(0.425)	(0.640)
(T-1) log Wind	0.0690**	0.0690**	0.0534*	0.0567*	0.0475	0.0519	0.0432	0.0475
	(0.0303)	(0.0311)	(0.0296)	(0.0311)	(0.0343)	(0.0377)	(0.0339)	(0.0369)
(T-2) log RTORPA					0.000387	-0.00186	-0.0150	-0.0145
					(0.0606)	(0.0377)	(0.0628)	(0.0377)
(T-2) log Load					0.117	0.585	0.450	0.802*
					(0.245)	(0.397)	(0.285)	(0.456)
(T-2) log Wind					0.0324	0.0336	0.0216	0.0239
					(0.0279)	(0.0315)	(0.0277)	(0.0314)
Full set of dummies			✓	✓			✓	✓
r2	0.242	0.239	0.314	0.311	0.244	0.240	0.317	0.315
N	723	723	723	723	722	722	722	722
vce	robust	unadjusted	robust	unadjusted	robust	unadjusted	robust	unadjusted

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Conclusions

Conclusions & policy implications

- Many regions solved the “resource adequacy” problem using Capacity Mechanisms/Future Markets
  - Solve the “missing money” problem
  - Provide a stable framework for investors
  - Guarantee reliability thru long-term capacity commitments
- However, in the Texas ERCOT market, implemented an alternative mechanism to solve the “resource adequacy” problem

Conclusions & policy implications

- ORDC: alternative mechanism to provide investment incentives thru scarcity pricing
  - Implemented in ERCOT in June 2014
- We show that ORDC prices mostly depend on:
  - Load shocks/weather shocks
  - Wind speed

Conclusions & policy implications

- ORDC: alternative mechanism to provide investment incentives thru scarcity pricing
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- We show that ORDC prices mostly depend on:
  - Load shocks/weather shocks
  - Wind speed

Does the ORDC provide sufficient and clearly perceivable long-term price signals (lower investment risk)?

Thanks! Questions?

Your feedback is much appretiated: rbajo@unav.es

Extra slides

Extra Slides

Stationarity tests

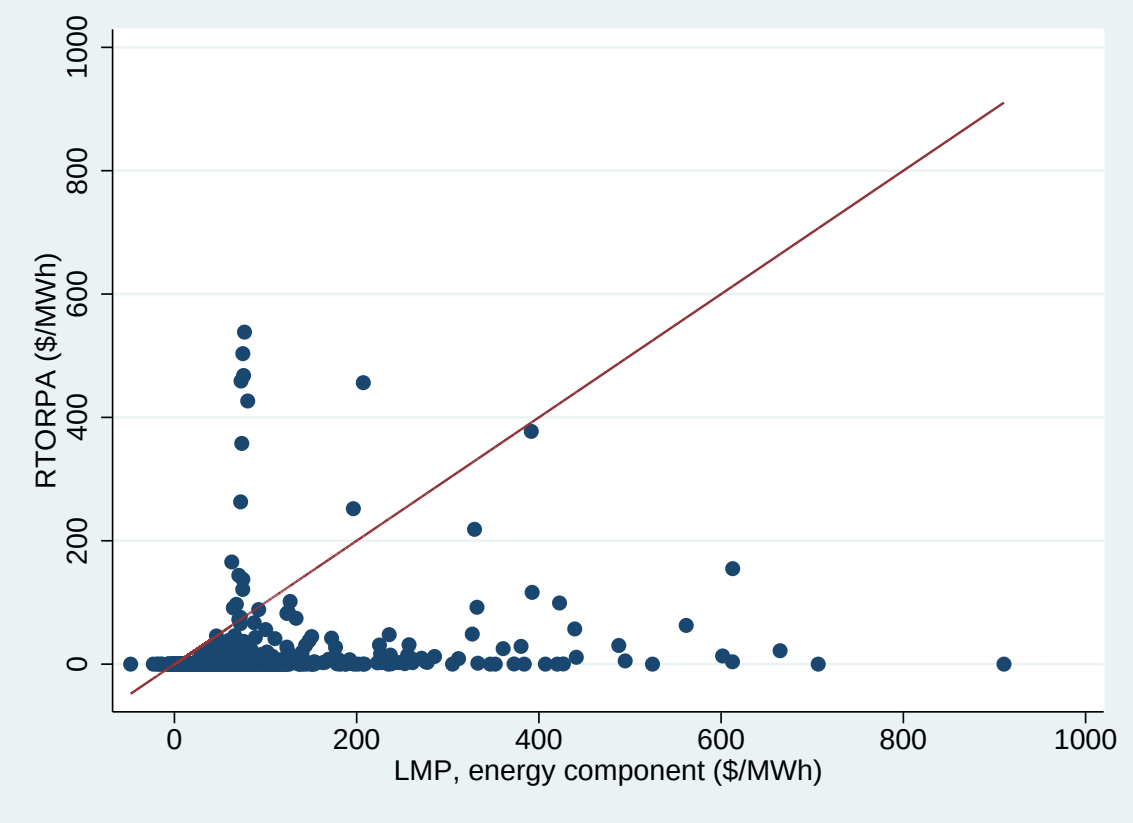
Variable	D-F test		D-F test (trend)		D-F test (drift)	
	t-statistic	p-value	t-statistic	p-value	t-statistic	p-value
log RTORPA	-15.114	0.000	-16.725	0.000	-16.593	0.000
log Wind output	-13.979	0.000	-14.522	0.000	-13.979	0.000
log ERCOT load	-5.007	0.000	-5.025	0.000	-5.007	0.000

Note: Critical values for rejection of hypothesis of unit root at the 1% confidence level are -3.430 for the “no drift/no trend” case, -3.960 for the trend case, and -2.332 for the drift case.

Return

Electricity market prices versus ORDC prices

Figure: LMP versus Price adder ($/MWh)



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