Deregulating Electricity Markets: Naïve Hopes vs. Market Reality

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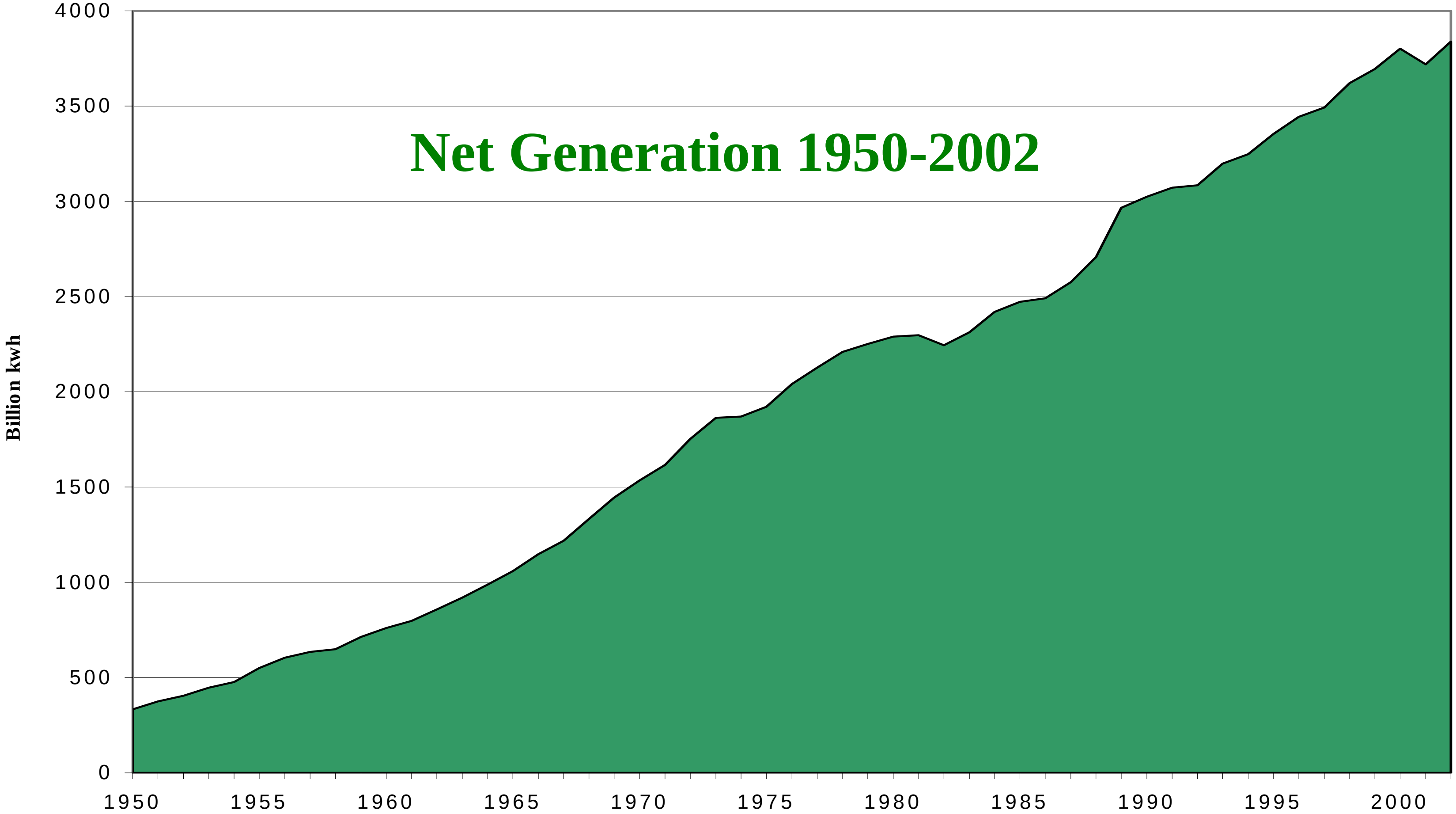
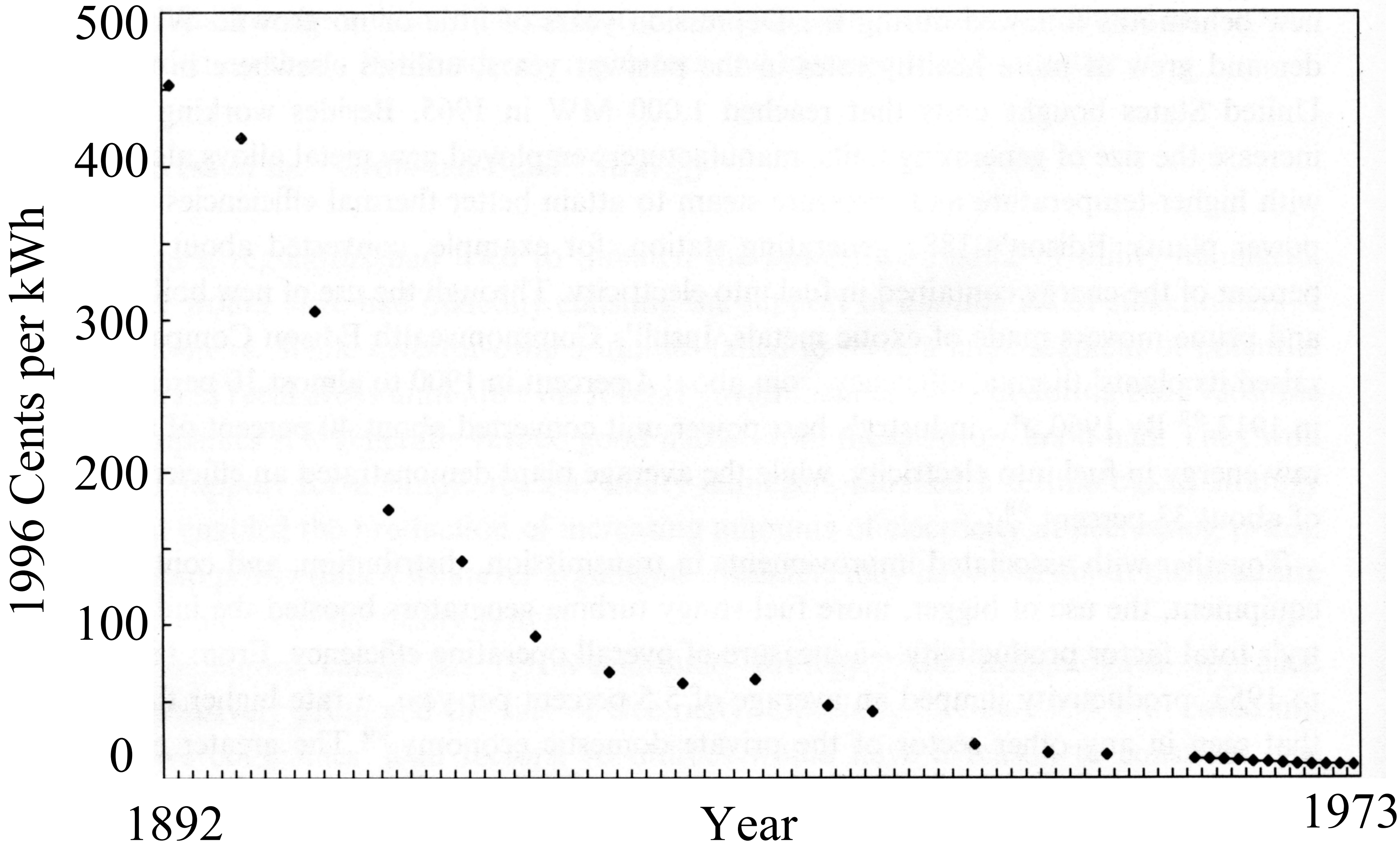
The U.S. Electricity Industry

$250 B in sales (2002)

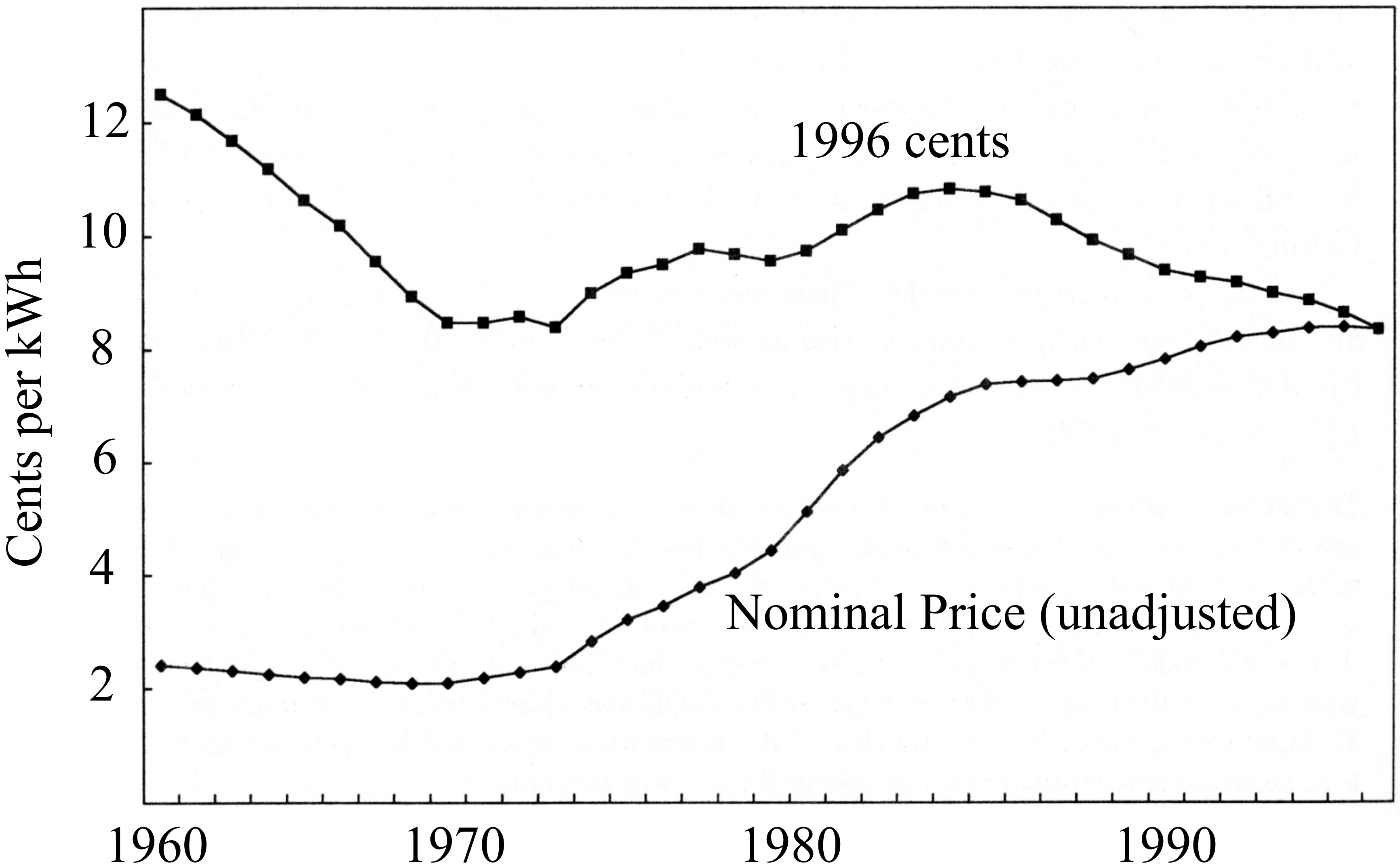




Source: R.F. Hirsh *Power Loss*, MIT Press 1999 Fig. 2.1

Pressures for Restructuring

- Rising cost, problems with reliability & nuclear plants, accident-environ record
- Success in deregulating airlines, rail, buses, trucks, barges; oil & natural gas, 1990 Clean Air Act: Allowance trading
- Ideology of incentives & free markets
- Dereg in UK, Australia, Argentina, etc.
- Unhappy customers: High prices
- Threat of industry to choose or walk
- 1995: Big utilities climb aboard



Source: R.F. Hirsh *Power Loss*, MIT Press 1999 Fig. 3.3

Deregulation Hurdles

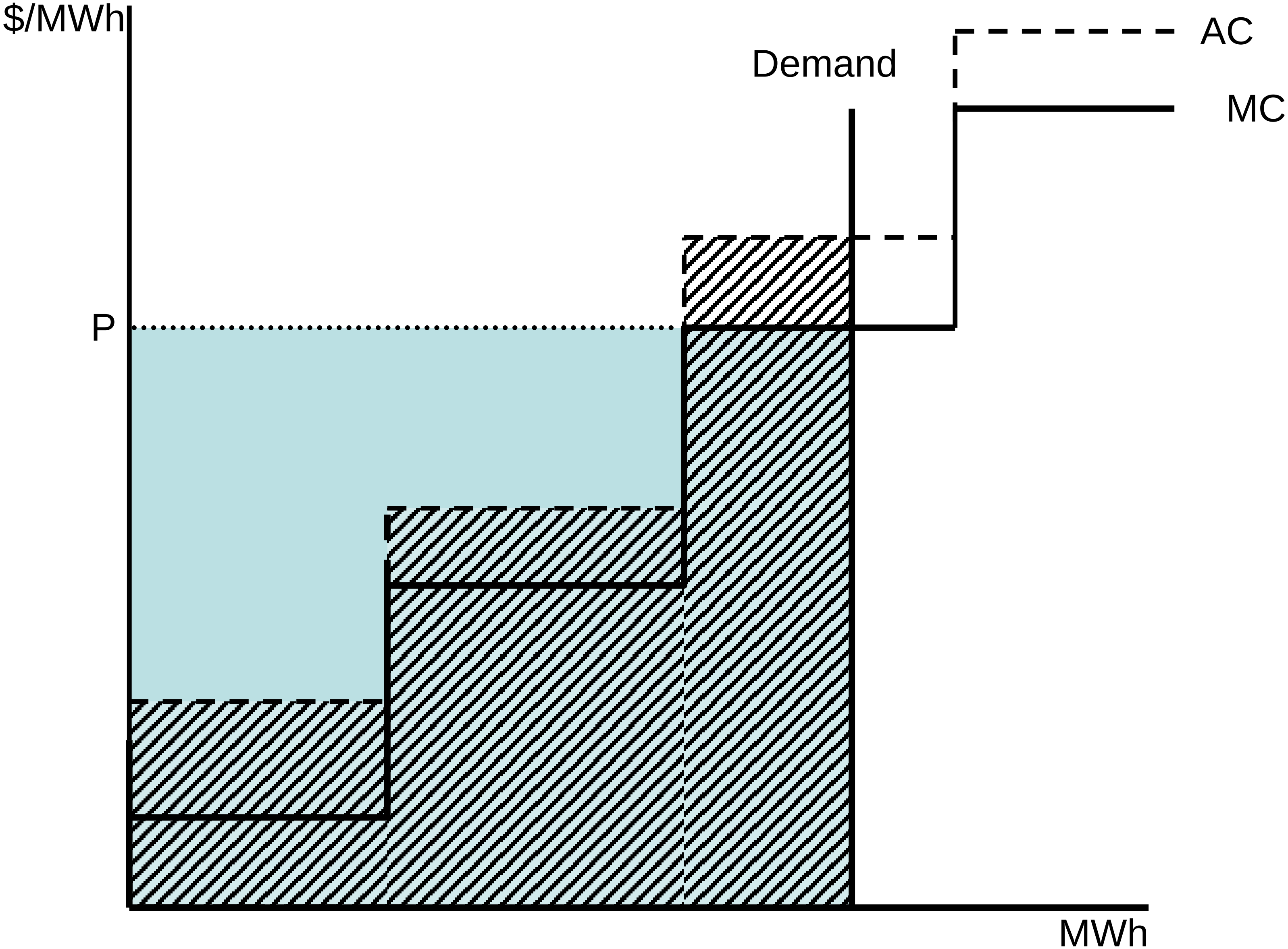
- Immediate effect of dereg is higher prices
  - Capital intensive industry with higher ROI
  - Pay market price, not AC of each unit
  - Utility management challenged & fails
  - Utility restructuring costs
  - New Regulatory costs – ISO, RTO, etc.
- Long term dynamics may bring down prices

Capital intensive industry with higher ROI

- For new coal plant, capital is 67-92% of total costs (number of operating hours/yr)
- Deregulation increases uncertainty => higher interest rates – 10 to 15% ROI => cost up 1-6 cents/KWh to 75-95% of TC
- Now, companies find it difficult to get new capital

Pay market price, not AC of each unit

- During regulation, each unit paid AC
- Now, one market clearing price paid to all
- Cost increase is potentially major

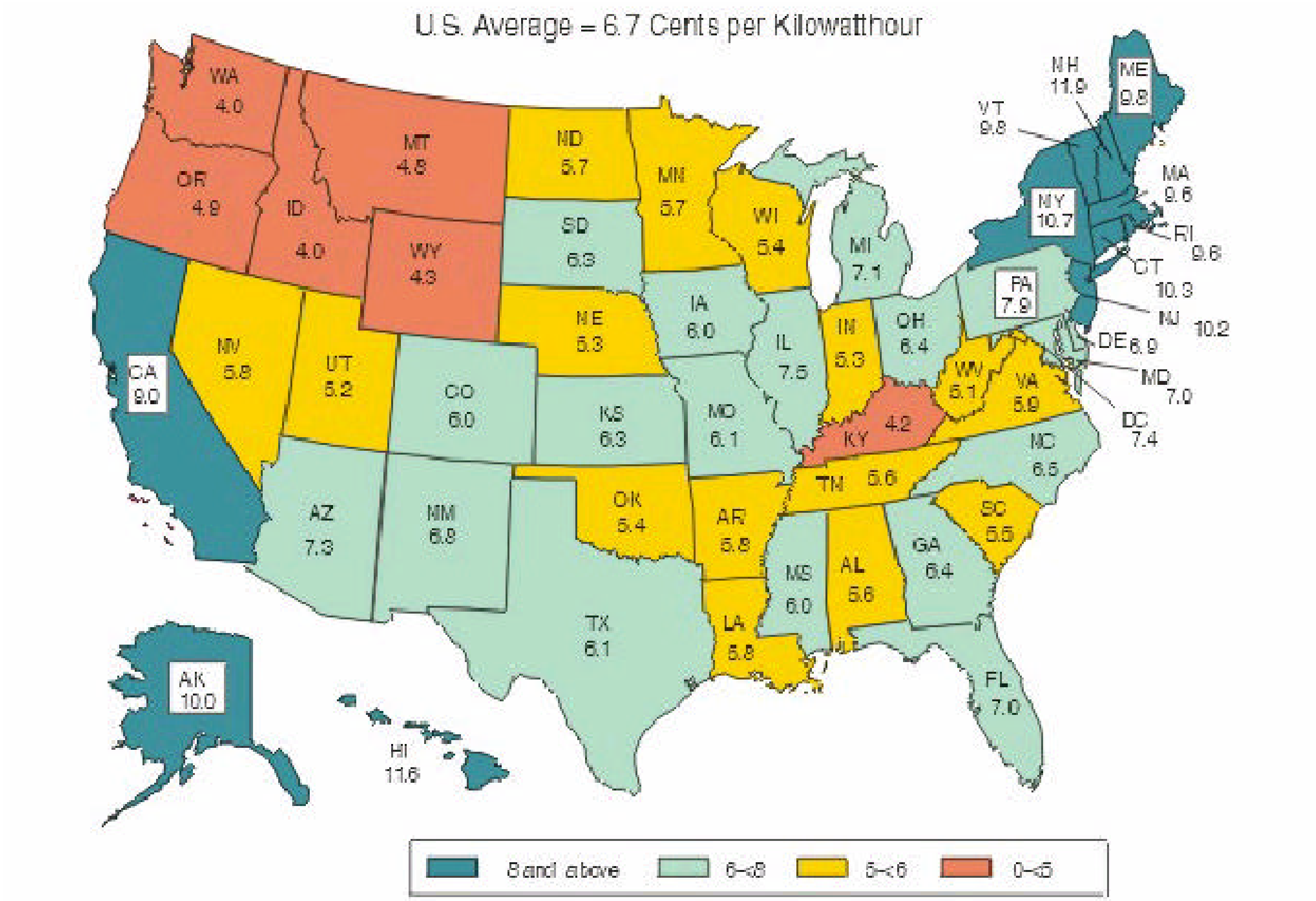

$/MWh
Demand
AC
MC
P
MWh

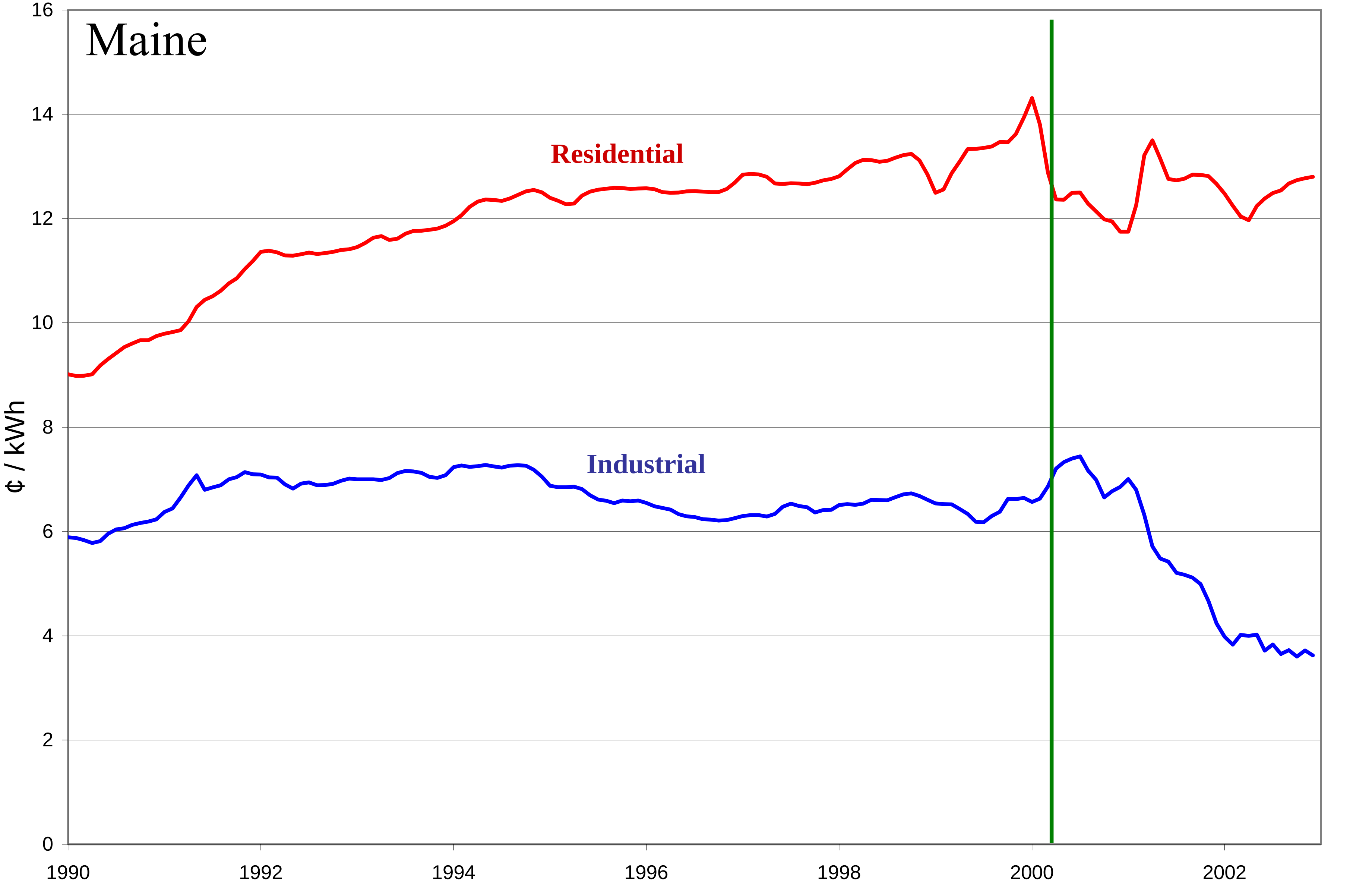
Deregulation Hurdles

- Utility management challenged & fails
  - Plethora of bad investment post deregulation
- Utility restructuring costs
  - Buying & selling assets, mergers
- New Regulatory costs – ISO, RTO, etc.
  - New Institutions set up & operations costs
- Long term dynamics may bring down prices – power of competition

Why Deregulate in California?

- Wholesale prices were low; annual averages between 1.3 and 2.0 cts/kWh in mid-1990's
- However, retail prices among the highest in U.S.





Maine
Residential
Industrial
¢ / kWh
16
14
12
10
8
6
4
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0
1990
1992
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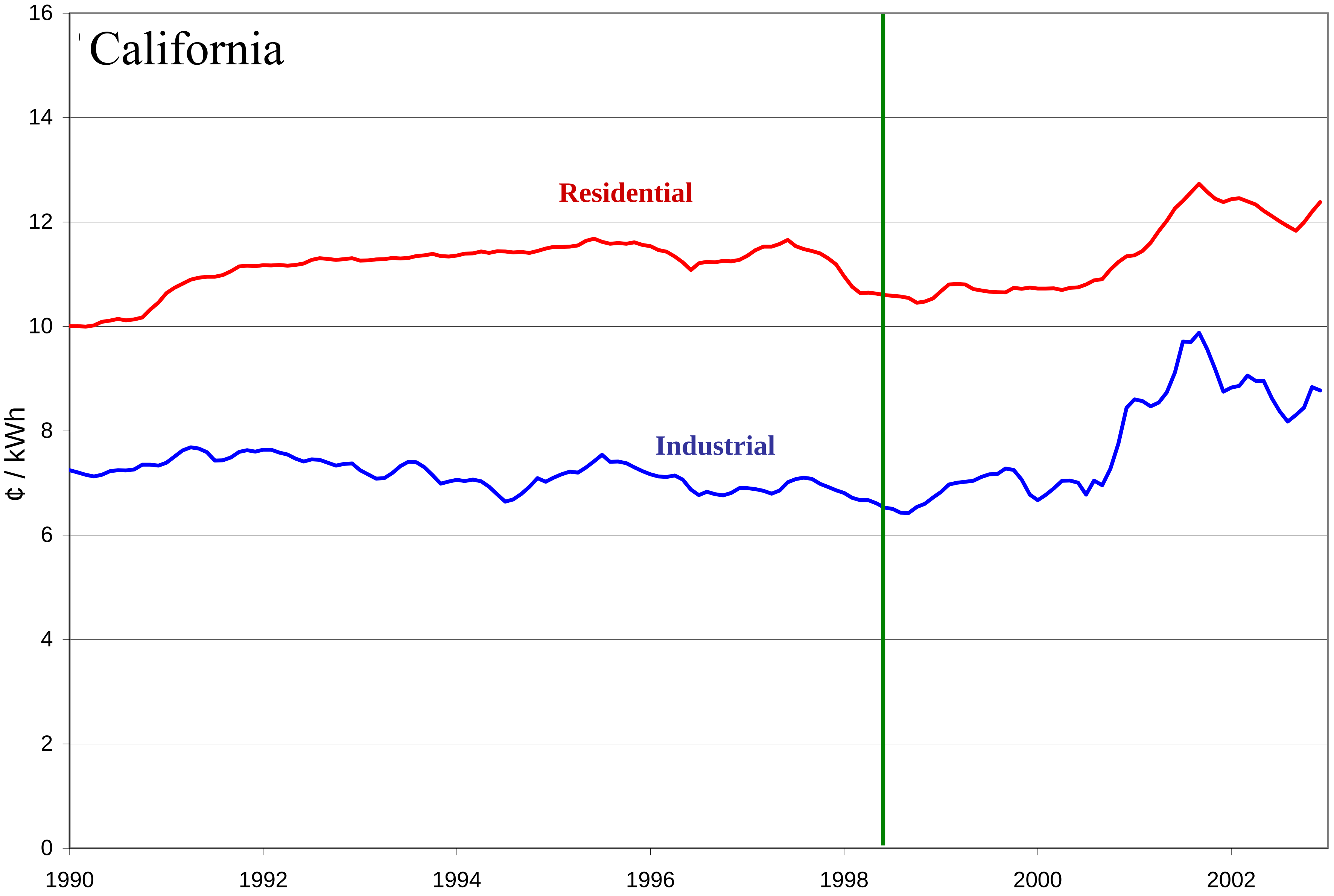
2002


California
Residential
Industrial
¢ / kWh
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14
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1990
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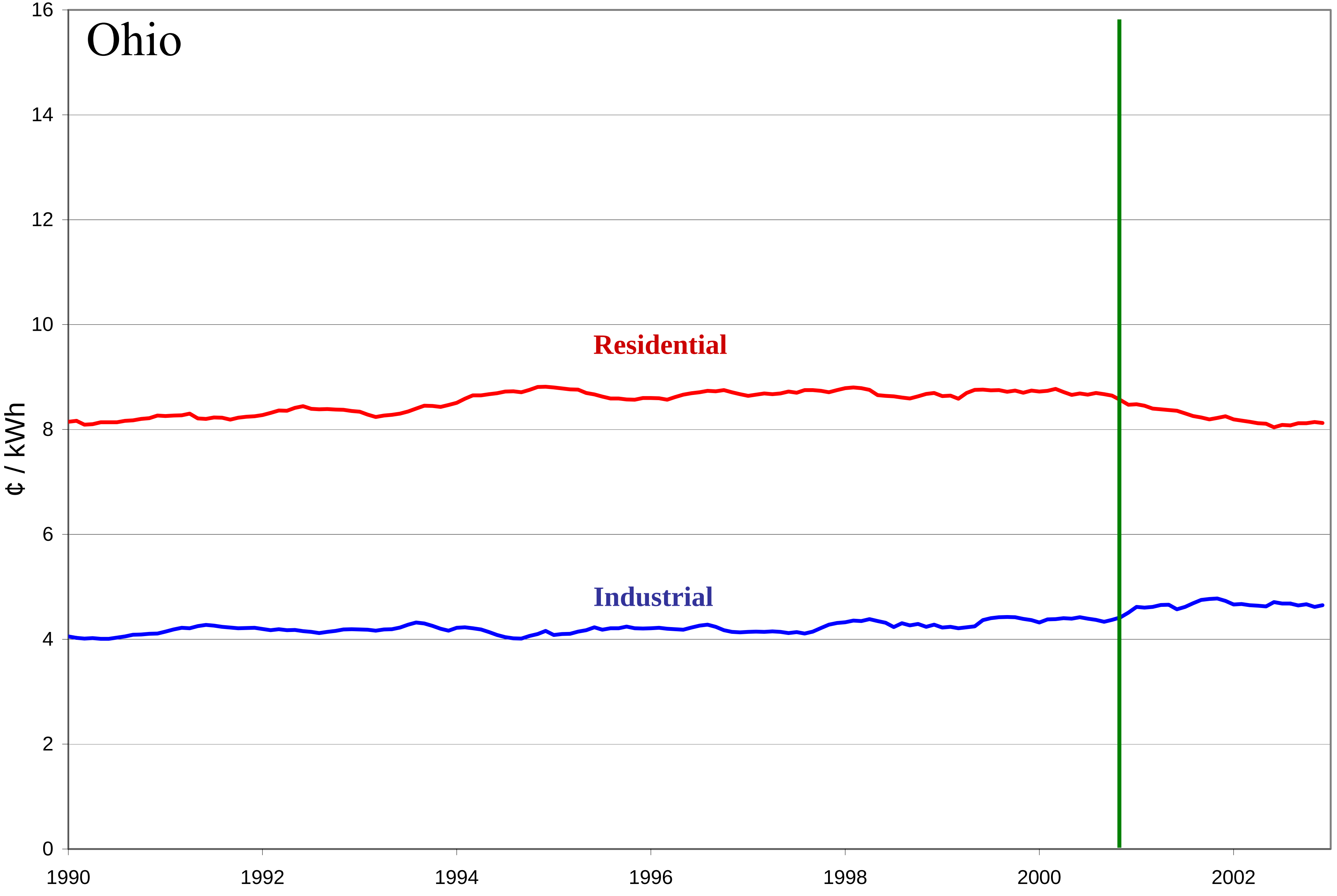
2002


Ohio
Residential
Industrial
¢ / kWh
16
14
12
10
8
6
4
2
0
1990
1992
1994
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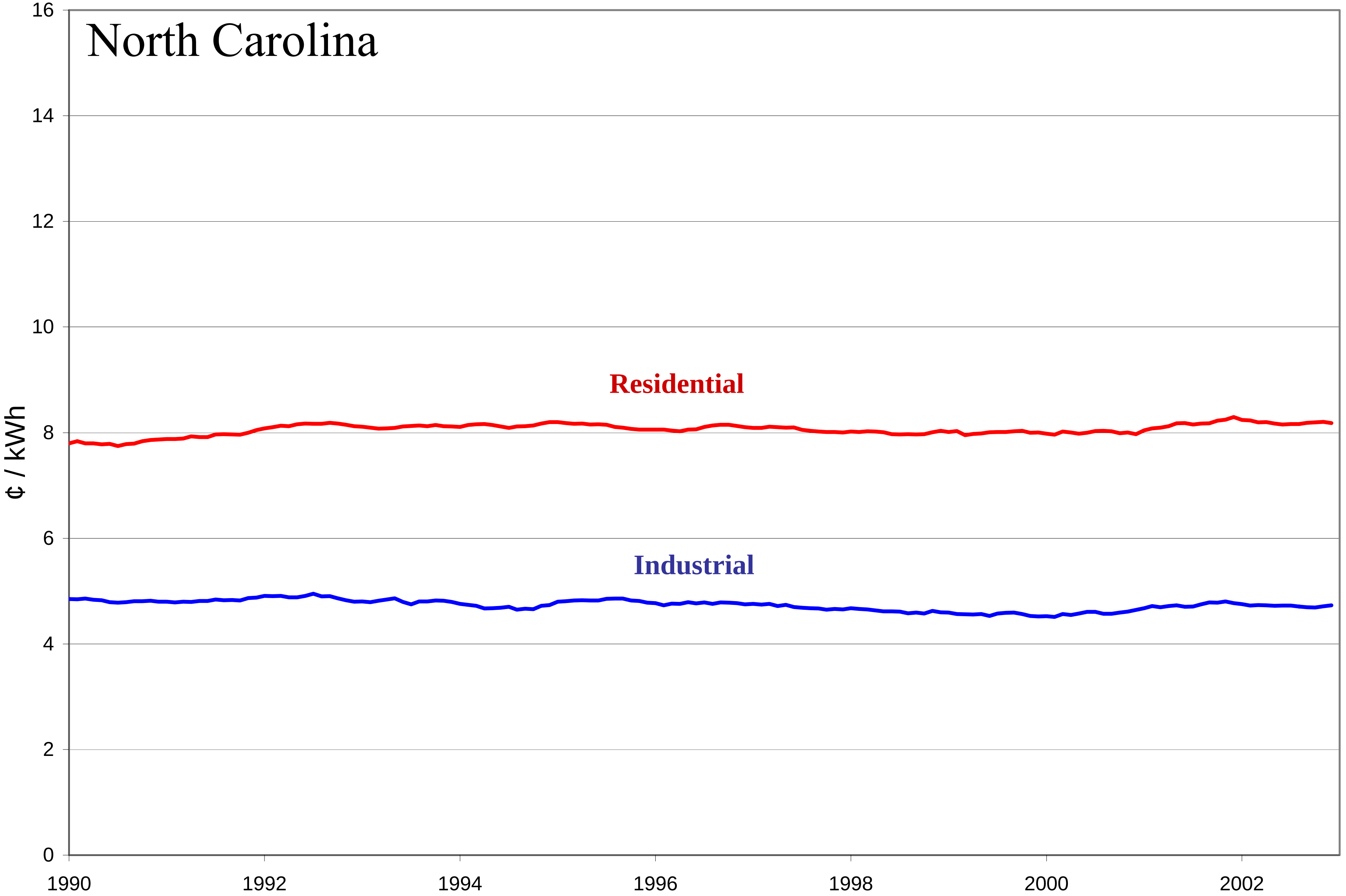
2002


North Carolina
Residential
Industrial
¢ / kWh
0
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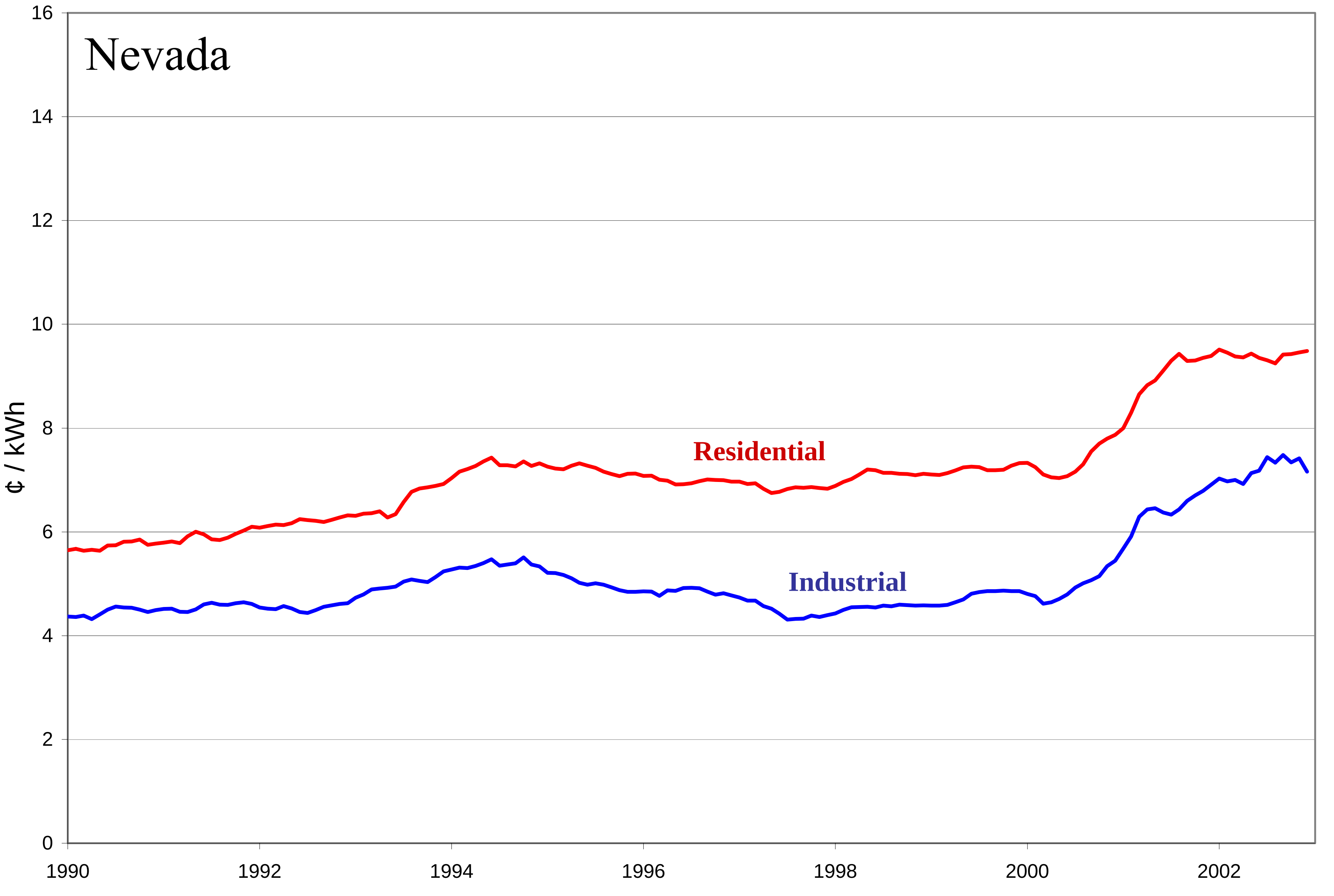

Nevada
Residential
Industrial
¢ / kWh
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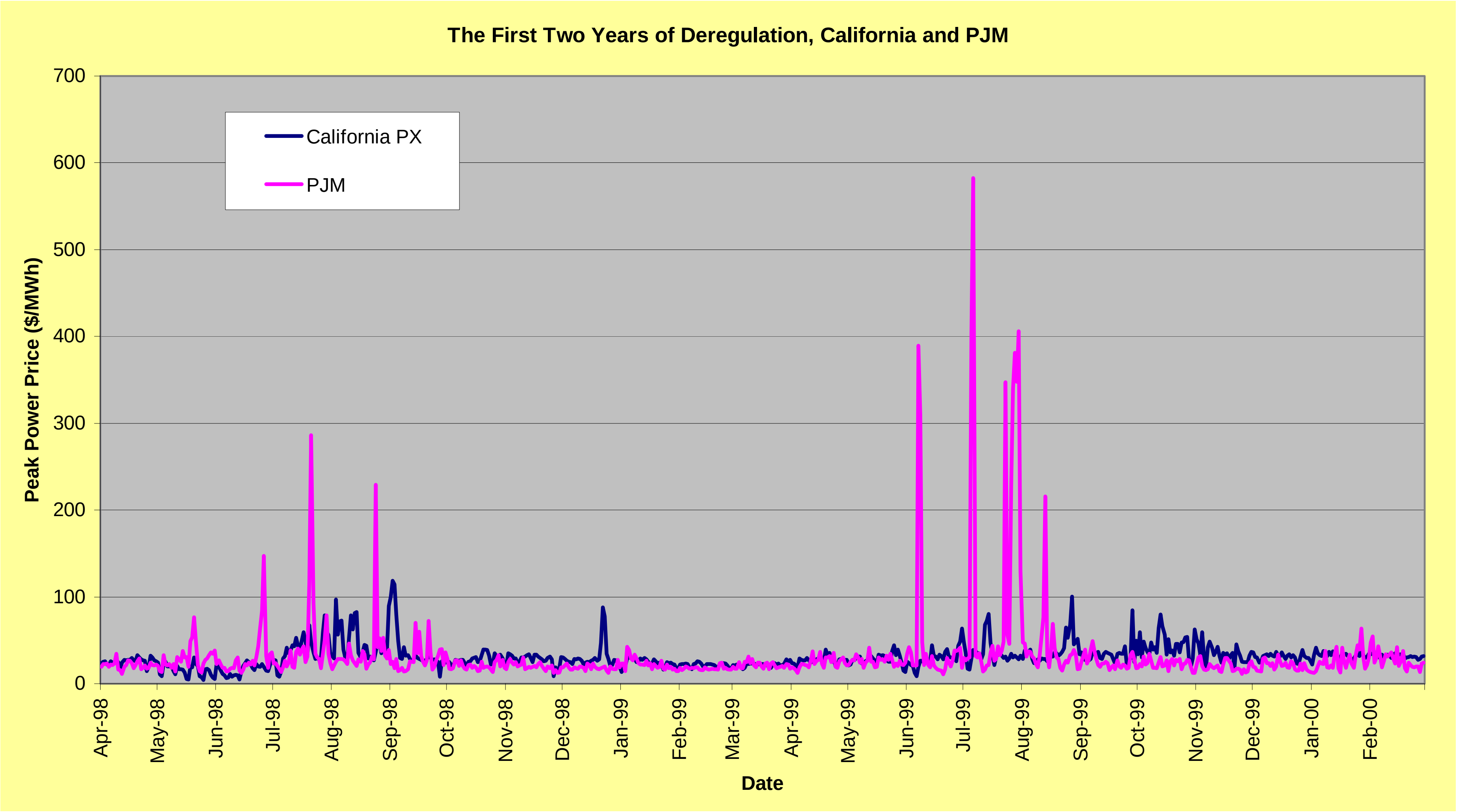
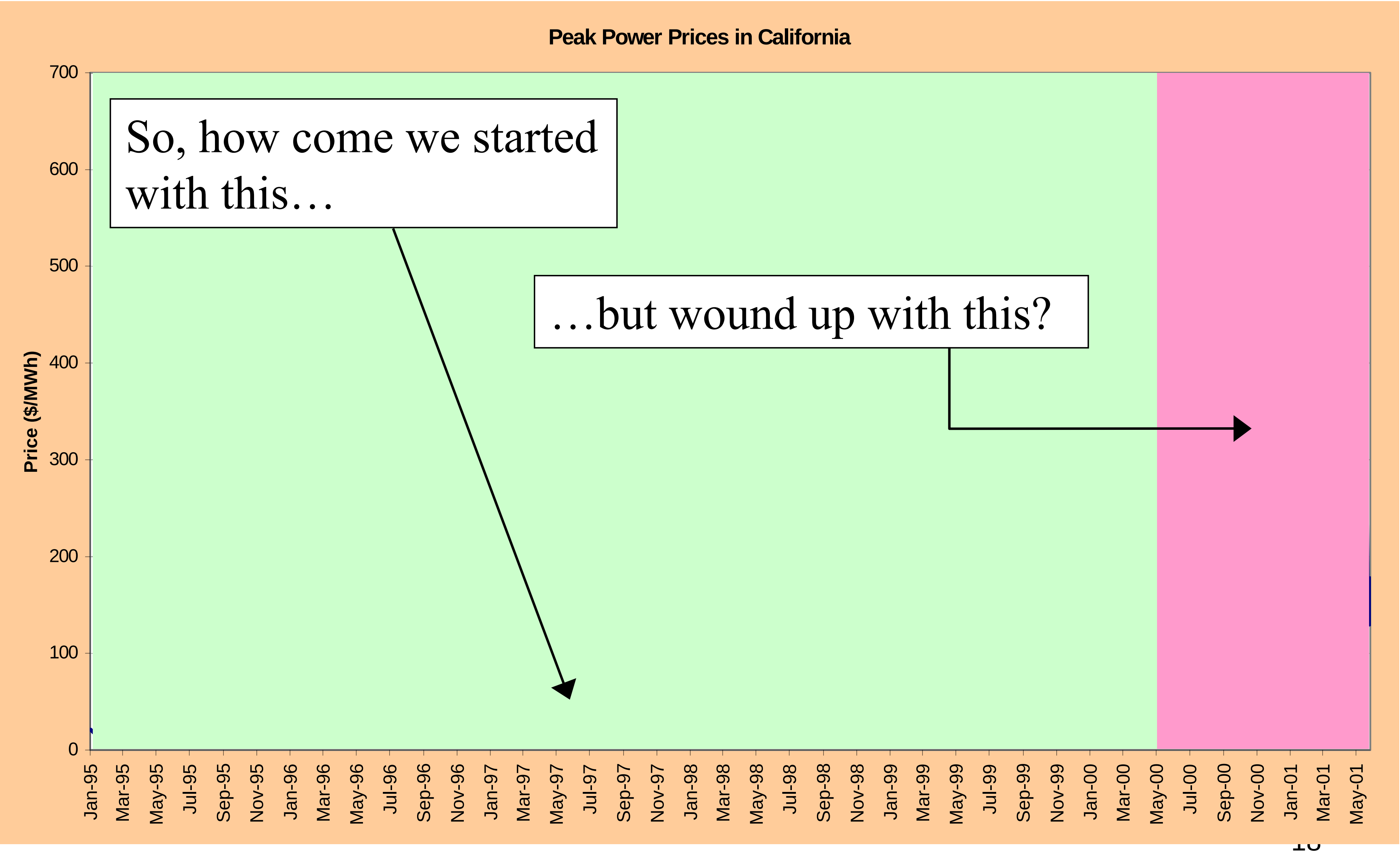


System	Mean Price (1st Two Years)	Std. Dev. Price (1st Two Years)
PX	30.83 $/MWh	13.67 $/MWh
PJM	31.31 $/MWh	46.5 $/MWh

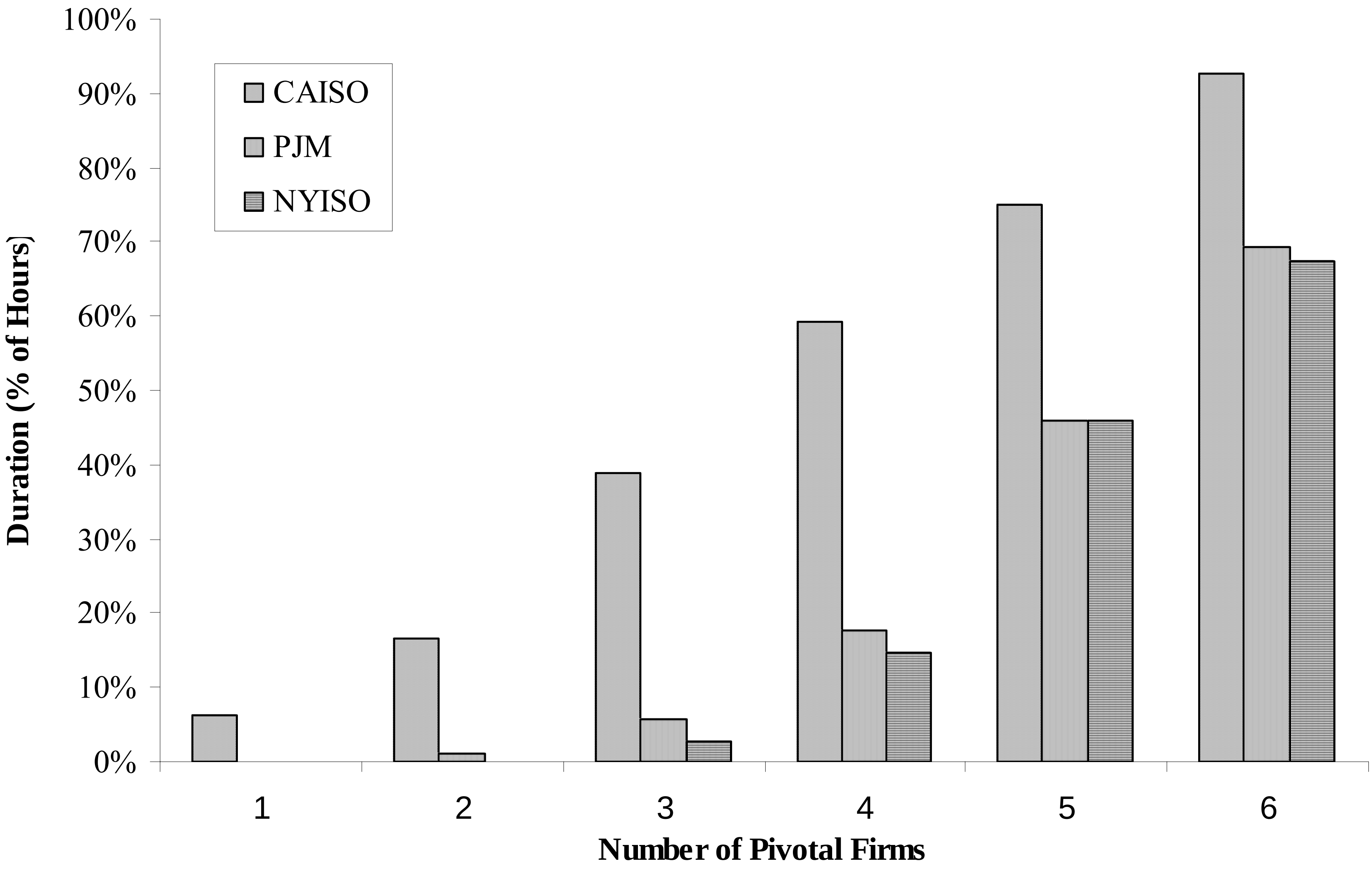
Wholesale Price Escalation



Structuring a Competitive Market

- Local distribution a natural monopoly
- Transmission must be centrally controlled
- Generation could be competitive if:
  - No firms have power to raise price & profit
  - Complete Markets : All products are priced competitively: Power, reactive power, standby
  - Markets have correct lead time
  - System operator represents demand, controls supply and transmission, can stop fraud

Pivotal Supplier Duration Curves for California, PJM, and New York



Curtailing Market Power

Eliminate the power to raise price & profit by withholding capacity:

- Regulate price during high demand
- Increase generation capacity
- Increase transmission capacity
- Increase demand response
- Lower firm size: Divest assets
- Long-Term contracts

Regulate price when demand high

FERC proposal: Set price caps & force suppliers to offer generation at variable cost when pivotal

Pivotal firm must offer at cost – cannot bid – determined by one hour in a month or year

BUT paying variable cost doesn't allow recovery of fixed costs – no investment – system dies

Paying fixed costs requires cost audits, approval of new capacity, personnel audits – it is re-regulation

Increase Generation Capacity

Building generation not needed for reserve is expensive

Building gas turbines ($600/KW) to curtail duopoly pivotal power costs:

CA: Need 8.4 GW (16% of hours): $5 billion, 10.7¢/KWh for 1400 hours in 2000

Offset some of the costs with reserve benefit?

Replace 12,000 Btu/KWh plant with 8,000 Btu plant – For $5/MCF gas, saves $26/1400 hours but costs $60 : offsets 1/3 of costs

The cost of mitigating market power through generation capacity expansion

Pivotal Group Size		California		PJM		NYISO	
	System Capacity (GW)	**54**		**60**		**38**	
	Average Retail Price ($/kWh)	**$0.12**		**$0.07**		**$0.11**	
	Capital Cost ($/kW)	**$600**	**$1,200**	**$600**	**$1,200**	**$600**	**$1,200**
1	Additional Capacity Needed (GW)	4.9		0.0		0.0	
	Average Mitigation Cost (cts/kWh)	48.36	96.71	0.00	0.00	0.00	0.00
	Cost Increase (%)	*403.0%*	*805.9%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2	Additional Capacity Needed (GW)	8.4		15.7		0.0	
	Average Mitigation Cost (cts/kWh)	10.67	21.34	83.36	166.72	0.00	0.00
	Cost Increase (%)	*88.9%*	*177.8%*	*1190.9%*	*2381.7%*	*0.0%*	*0.0%*
3	Additional Capacity Needed (GW)	11.7		21.1		14.7	
	Average Mitigation Cost (cts/kWh)	3.24	6.48	12.23	24.46	37.83	75.66
	Cost Increase (%)	*27.0%*	*54.0%*	*174.7%*	*349.4%*	*343.9%*	*687.8%*
4	Additional Capacity Needed (GW)	14.9		25.2		17.6	
	Average Mitigation Cost (cts/kWh)	1.67	3.35	3.33	6.65	5.72	11.44
	Cost Increase (%)	*14.0%*	*27.9%*	*47.5%*	*95.1%*	*52.0%*	*104.0%*
5	Additional Capacity Needed (GW)	17.8		28.8		20.1	
	Average Mitigation Cost (cts/kWh)	1.10	2.21	1.12	2.23	1.60	3.19
	Cost Increase (%)	*9.2%*	*18.4%*	*16.0%*	*31.9%*	*14.5%*	*29.0%*
6	Additional Capacity Needed (GW)	20.7		32.4		22.4	
	Average Mitigation Cost (cts/kWh)	0.77	1.54	0.66	1.32	0.98	1.95
	Cost Increase (%)	*6.4%*	*12.8%*	*9.4%*	*18.8%*	*8.9%*	*17.8%*

Increase Transmission Capacity

- Surplus generation capacity available elsewhere when needed?
- Cost of building new lines high
- Intense political opposition to siting new lines - NIMBY

	AZ	CA	NM	OR	WA
AZ	1				
CA	0.90	1			
NM	0.93	0.80	1		
OR	-0.10	**-0.04**	0.10	1	
WA	-0.48	**-0.41**	-0.33	0.77	1

Demand correlation matrix – Western States

	PJM	NYISO	ECAR	SERC	NEPOOL
PJM	1				
NYISO	**0.92**	1			
ECAR	**0.90**	0.78	1		
SERC	0.87	0.83	0.88	1	
NEPOOL	0.91	0.86	0.84	0.74	1

Demand correlation matrix – Eastern Interconnect

Increase demand response

- Short-run price elasticity is low: a 10% price increase => 1-2% fall in quantity
- Does not stop monopoly profit
- Wholesale price from $30 to $120 => retail price 9 to 18 cents/KWh => 10-20% fall in quantity – this large a consumer response would lessen market power

Table 5: Demand response required to mitigate against pivotal suppliers in California and PJM

Pivotal Group	CA Demand Response		PJM Demand Response	
Size	MW	%	MW	%
1	4,840	12%	5,395	15%
2	3,534	10%	5,395	15%
3	3,296	10%	5,381	18%
4	3,165	12%	4,030	16%
5	2,951	12%	3,617	16%
6	2,877	13%	3,611	19%

Note: The MW column represents the maximum amount of demand response necessary to mitigate against a given pivotal oligopoly. The % column is the MW column as a percent of load.

Estimate price elasticity of demand needed to mitigate pivotal suppliers in California through demand response (demands are in MW, prices in cts/kWh)

Pivotal Group Size	Price Cap In Effect	Demand Response	New Demand	Price Increase	New Price	Estimated Elasticity
1	$750	4,840	34,492	61.5	73.5	-0.17
2	$150	3,534	30,529	5.25	17.25	-0.38
3	$250	3,296	29,069	6.25	18.25	-0.33
4	$250	3,165	24,279	5.00	17	-0.44
5	$150	2,951	22,593	3.3	15.3	-0.61
6	$250	2,877	19,718	1.25	13.25	-1.55

Lower firm size: Divest assets

- Economies of Scale in management
- 1 large generation plant only
- What would happen to generating costs, availability, and safety?

Consolidation and performance in the nuclear generation industry, 1993 – 2002

1993

# of Plants	Number of Firms	Mean Capacity Factor	Median Capacity Factor	Standard Deviation
1	35	0.669	0.713	0.166
2	9	0.644	0.710	0.212
3	2	0.660	0.660	0.096
More than 3	1	0.635	0.635	0.000

1997

# of Plants	Number of Firms	Mean Capacity Factor	Median Capacity Factor	Standard Deviation
1	35	0.673	0.748	0.240
2	8	0.733	0.829	0.181
3	3	0.758	0.768	0.065
More than 3	1	0.540	0.540	0.000

2000

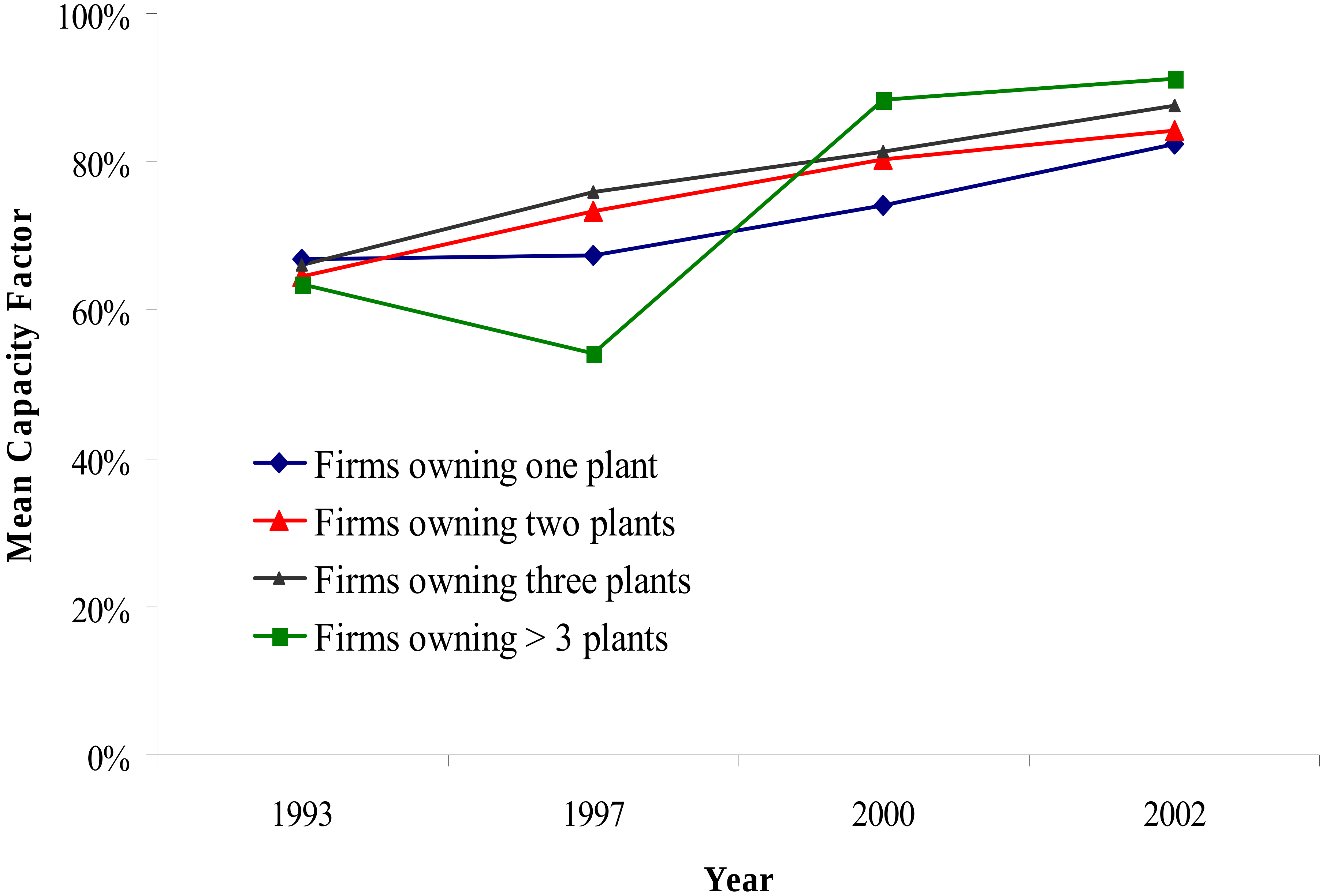
# of Plants	Number of Firms	Mean Capacity Factor	Median Capacity Factor	Standard Deviation
1	33	0.742	0.824	0.221
2	9	0.802	0.841	0.131
3	3	0.814	0.861	0.096
More than 3	1	0.883	0.883	0.000

2002

# of Plants	Number of Firms	Mean Capacity Factor	Median Capacity Factor	Standard Deviation
1	29	0.823	0.863	0.166
2	8	0.842	0.852	0.085
3	3	0.875	0.884	0.017
More than 3	1	0.911	0.911	0.000

Note: Capacity factors are estimated using the total and potential output of each plant, as measured by the plant’s nameplate capacity. Data is from the EIA.

Some Evidence for Management Economies in Nuclear Generation



The Effect of Divestiture on Pivotal Suppliers

California

Number of Pivotal Firms	PFDC Under Capacity Ownership Limit (% Hrs.)				
	No Limit	4 GW	3 GW	2 GW	1 GW
1	6%	5%	4%	3%	3%
2	16%	13%	8%	5%	3%
3	39%	32%	20%	8%	4%
4	59%	55%	41%	14%	5%
5	75%	70%	60%	26%	6%
6	93%	88%	75%	41%	8%

PJM

Number of Pivotal Firms	PFDC Under Capacity Ownership Limit (% Hrs.)				
	No Limit	10 GW	6 GW	4 GW	3 GW
1	0%	0%	0%	0%	0%
2	1%	1%	0%	0%	0%
3	6%	6%	2%	0%	0%
4	18%	17%	6%	1%	0%
5	46%	45%	16%	4%	1%
6	69%	69%	42%	10%	2%

Long-Term contracts

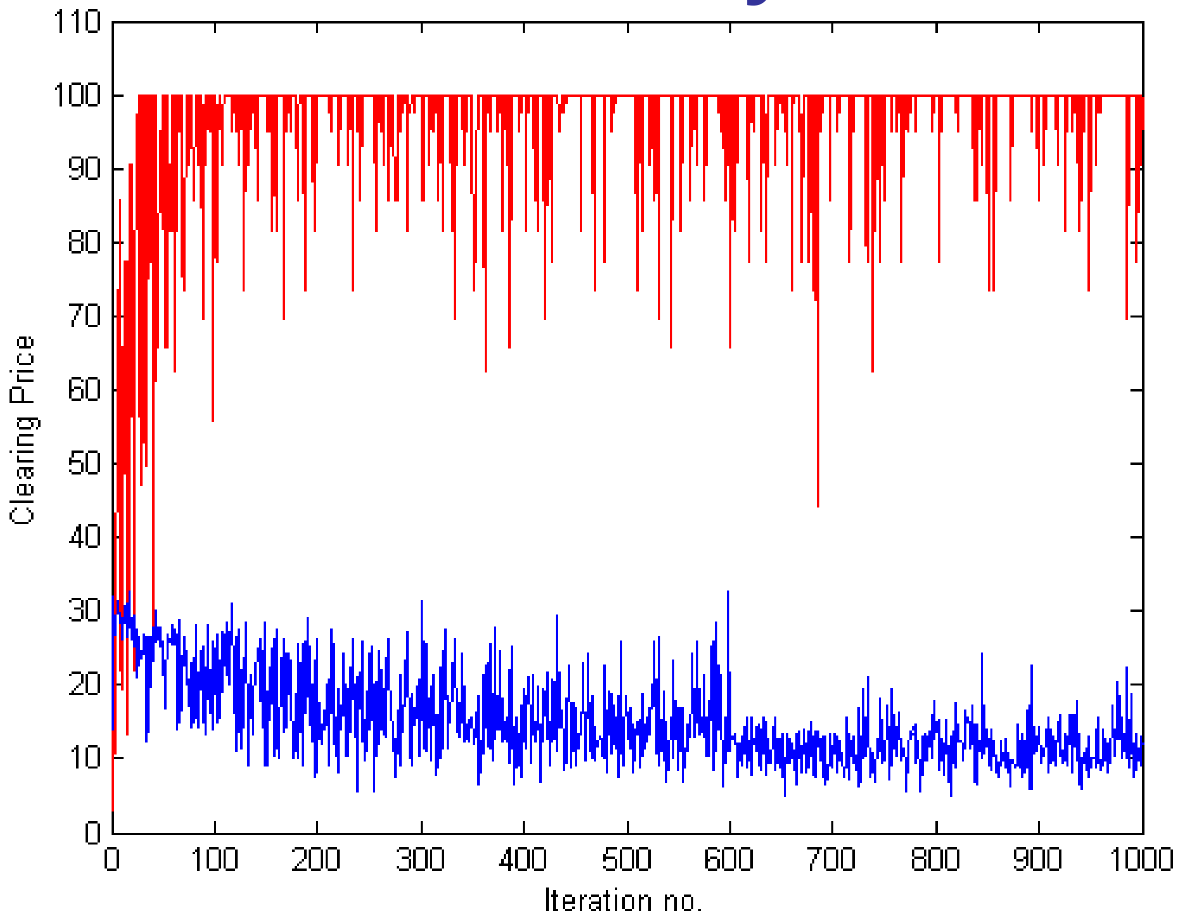
- California: Contracts limited to 1 hr or 1 day
- When longer contracts permitted, prices were \$150/MWh – far above costs
- ISO bargaining power comes from life of plant contracts
- LT contracts involve risk bearing & fuel price change – Who should bear the risk? What is an efficient contract?

Eliminate Hourly Auctions

- Sarosh Talukdar has simulated markets that have 10 suppliers or 10 demanders, each with 10% of capacity
- "Stupid" agents – evolutionary – remember 10 most profitable moves from the past
- Suppliers trying to raise price as well as profit
- Top curve: ISO fixed demand, suppliers bid
- Bottom: Suppliers and demanders both active

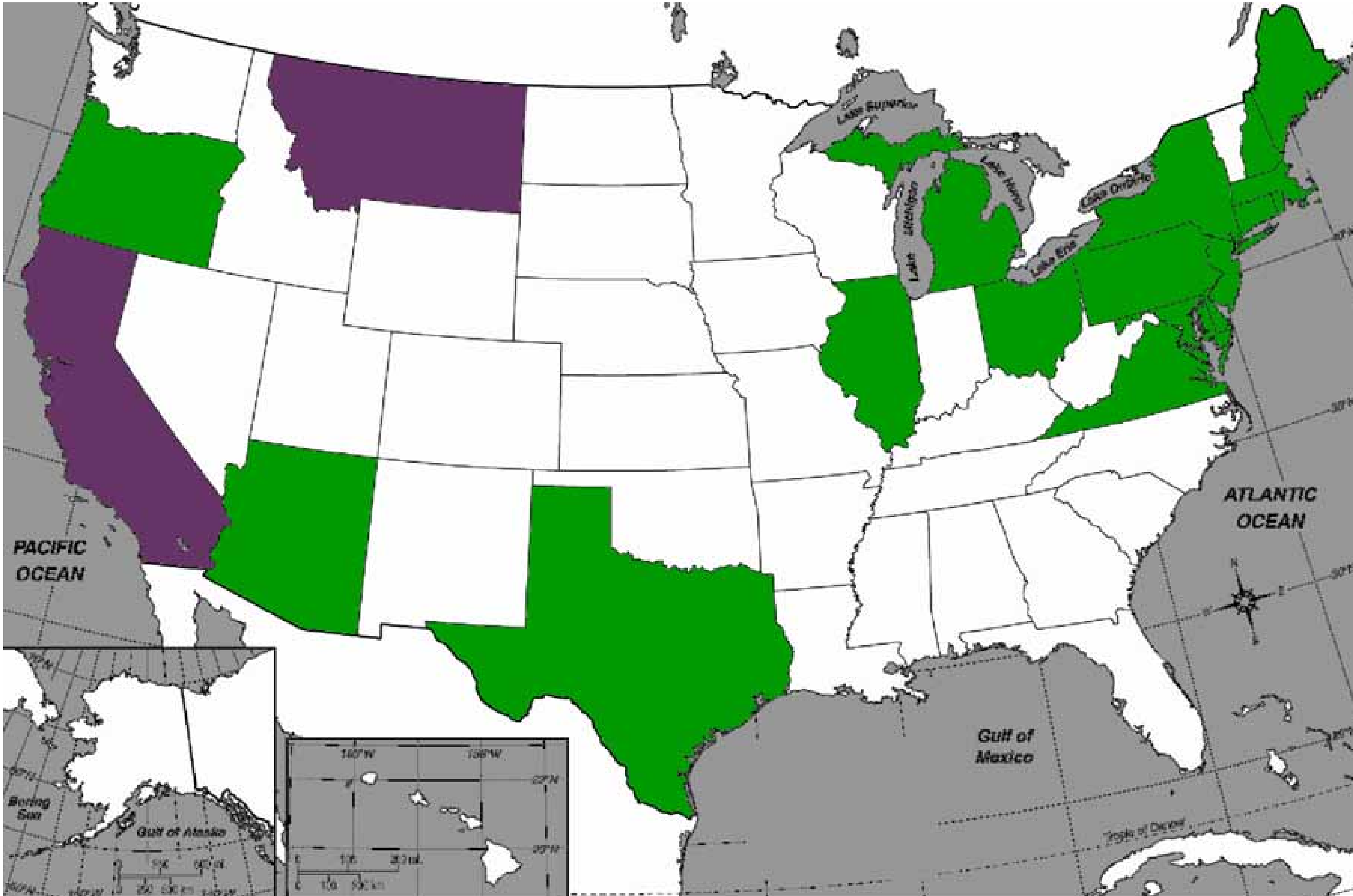
Red: Active Sellers Only

Blue: Active Buyers & Sellers



Sellers: Maximize profit & price for $P \leq 100$

Buyers: Min price & buy 50 units


PACIFIC OCEAN
ATLANTIC OCEAN
Gulf of Mexico
Lake Superior
Lake Michigan
Lake Huron
Lake Ontario
Lake Erie
Bering Sea
Gulf of Alaska