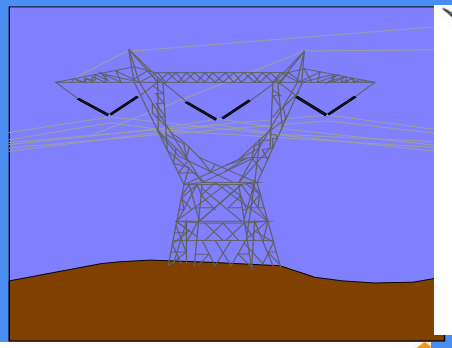
Diversity Challenges in Electricity Markets



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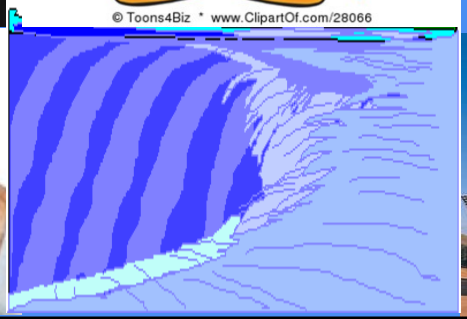
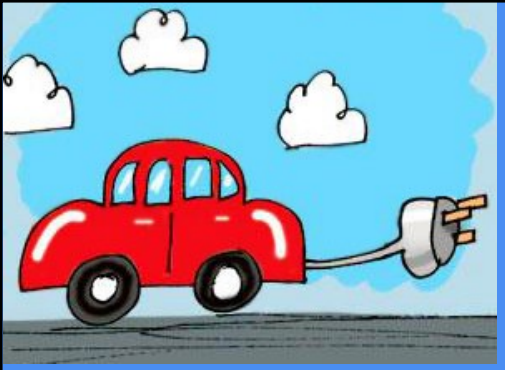
December 4, 2014

Views expressed are not necessarily those of the Commission





Give load a chance

- Current models assume value of 'lost load' at $3500/MWh or more
- Many would reduce consumption at less than $350/MWh
- Smart meters, smart appliances and 'low hanging fruit'
- Let demand speak for itself
- Price-responsive demand
  - is the most important missing element of market diversity and market efficiency
  - does not need to participate in the capacity market.

The Good Olde Days

HISTORICAL U.S. CONSTRUCTION COST EXPERIENCE

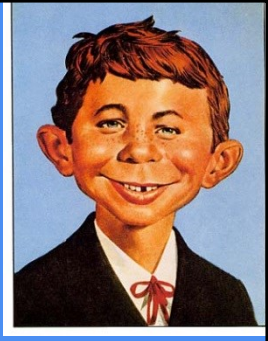
for nuclear plants under cost-of-service regulation

Construction Started	Estimated Overnight Cost	Actual Overnight Cost	% OVER
1966-67	$ 560/kWe	$1,170/kWe	209%
1968-69	$ 679	$2,000	294%
1970-71	$ 760	$2,650	348%
1972-73	$1,117	$3,555	318%
1974-75	$1,156	$4,410	381%
1976-77	$1,493	$4,008	269%

Source: U.S. EIA

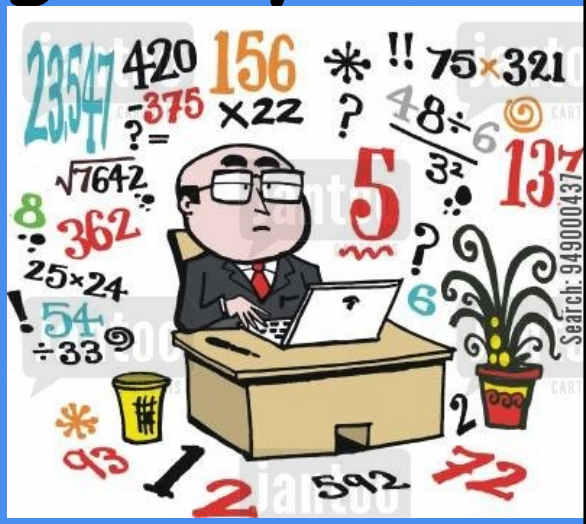
too cheap to too expensive

Financial Portfolio Selection



- 1952 Markowitz diversifies a portfolio to maximize expected returns for an investor's risk tolerance
- 1960s Capital Asset Pricing Model provides framework for risk/return tradeoffs
- 1973 Black Scholes Model used to price of a call option
- 1992 French and Fama find the CAPM measure of systematic risk was unreliable

Financial Portfolio theory is hard but we are whistling past the graveyard



- Mathematical and statistical finance assumes we know future probability distributions
  - copulas used for stress-tests
  - the martingale (doubling down) game
  - CAPM is widely taught because of the insights????
- Easy entry and exit

- S&P 500 is the gold standard
- Transactions costs: many snake oil salesman
- Should or could we do this for social security?

Energy Portfolio Design (Diversity) in 1978

- Oil running out
  - Subsidized imports!!!!!! and Strategic Petroleum Reserve
- Public Utility Regulatory Policies Act (PURPA)
  - Must buy wind, solar and cogen at avoided costs
- Power Plant And Industrial Fuel Use Act (FUA)
  - Outlaws natural gas in generators
  - Coal in electric generators
- Natural Gas Policy Act (NGPA) running out of natural gas
  - Ramsey pricing for for buyers and sellers and curtailment rules
- Natural Gas Act of 1938 (NGA) cradle to grave regulation
  - used rate design to encourage or discourage consumption
  - SFV, MFV, Seaboard, volumetric
- Gas certificates and reserves
  - Look at reserves backing the pipeline leads to overestimation of reserves
  - Contributes to the 'running out' panic of the 1970s

Integrated Resource Planning

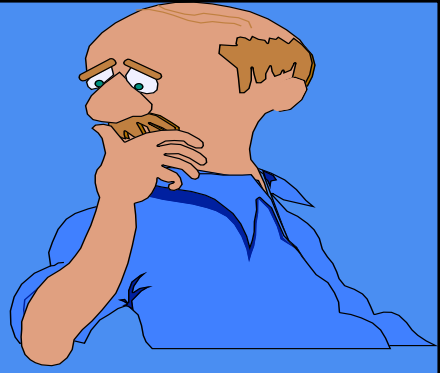
- a plan to meet forecasted peak plus a reserve margin.
- time- and resource-intensive.
- *Requires many forecasts*
  - *Weather*
  - *Fuel costs*
  - *Load*
  - *Technology innovation*
- Who should bear the risk of being wrong?

- 1980s IRP starts to address
  - oil price spikes
  - Nuclear cost overruns
- 1990s: IRP fades in restructured states
- 2000s: IRP revived for clean energy/climate change
- 'worst of central planning and due process'

Forecasting
Is the past prologue?

- Assumptions, model adjustments and historical data have a huge influence on the results.
- Projection of the past into the future
- What are future paths?
- What is the probability of future path?
- What is the probability distribution of
  - Climate change impact on electric power
  - Extremely cold weather, e.g., polar vortex
  - Natural gas prices
  - Innovation
- Do we 'over react' to the last problem?
- Uncertainty of government intervention

Poor or bad incentives in IRP



- Limited individual choice
- Moral hazard: when one person takes more risks because someone else bears the risks.
- Principal-agent problem: when the "agent" makes decisions that impact the "principal".
- The benevolent enlightened social planner has a principal-agent problem and a moral hazard problem
- We play differently with house money

- Price-responsive demand should be the first choice
- If You (state) plan it, you own it (Pottery Barn rule?)
- Hedge for vertically integrated utilities
- Cost overruns without stranded costs

Wellhead Gas Price Forecasts from 1980 to 1990

(1995 $/Mcf)

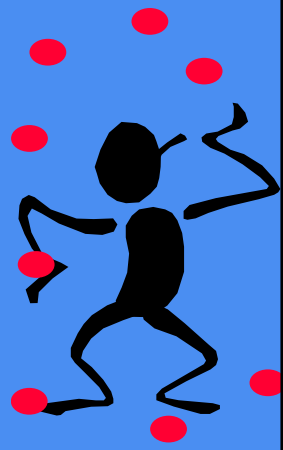
Forecast	Forecast 15 Years Out	Forecast 10 Years Out		Forecast 5 Years Out		
	for 1995	for 1990	for 1995	for 1985	for 1990	for 1995
	in 1980	in 1980	in 1985	in 1980	in 1985	in 1990
EIA	5.98	5.19	5.90	3.45	4.11	2.65
DOE	8.06	6.72	5.95	5.60	3.82	2.74
DRI	15.46	11.23	4.28	5.60	2.80	2.39
AGA	--	6.34	3.63	7.65	3.27	2.42
Average	9.84	7.37	4.94	5.57	3.50	2.67
Actual	1.59	1.96	1.59	3.44	1.96	1.59
Avg/Act	6.19	3.76	3.11	1.62	1.79	1.68

Sources: Energy Information Administration (EIA), Department of Energy (DOE), Data Resources Incorporated (DRI), American Gas Association (AGA) and Gas Resources Institute (GRI).

I am a recovering forecaster

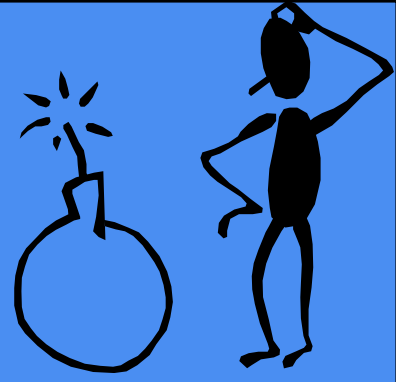
Who was the best econometrician of all time?

Successful Forecasters



- Timing is important. The most successful analysts know how to get the 'right' answer?
  - In 1980s, shale gas was a joke
  - In 2010s, shale gas was the central question
- Forecast early and often
- Be able to quickly and glibly explain why you were wrong
- Be able to defend your assumptions and model
- Get institutionalized
  - Old models (PROMOD)
  - accepted in litigation cases
  - Hammers looking for nails
  - The results are in the assumptions and massages

Energy Diversity in 2014



- Oil is a world wide market; price fluctuates
- PURPA
  - Must buy wind, solar and cogen at avoided costs
  - EPAct 2005 clarifies avoided costs in ISOs
- FUA repealed
- EPA puts hard federal limits on emissions
- NGPA repealed except section 3 combining markets
  - didn't run out; commodity deregulation
  - loaves and fishes story
- NGA pipeline open access
  - Pipelines get SFV and negotiated rates
  - Gas certificates with negotiated rates
- ISO markets: real-time, day-ahead and capacity

IRP (Electric Power Portfolio) is harder than Financial Portfolio

- Entry and exit: Life of a power asset is 40+ years
- Multiple political objectives:
  - jobs,
  - in-state resources
  - reliability
  - economics
- Transmission plan
  - If right generators show up
  - If wrong expensive capacitor
- What are the contingencies
  - Generator failure?
  - Single mode failure one event causes multiple systems to fail
- Market power

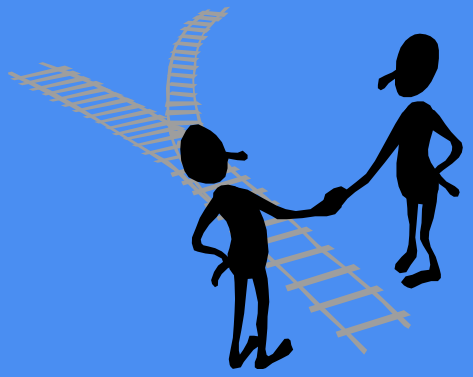
Are we whistling past the graveyard?

Reliability, IRP and Common (Single) mode failures

- Largest contingency is often weather
  - Hot and cold
  - Windless, cloudy and/or stormy
- Transmission capacity changes
- Hot weather
  - High Demand for power
  - Higher probability of generator failure
- Cold weather: winter is the new summer
  - high demand for electric power and natural gas
  - many generators have trouble starting up
  - Coal piles freeze
- Fukashima all nukes shutdown
- Solar generation and clouds
- Wind generators and wind
- What happens on a windless, cloudy, hot/cold hour?

Dimensions of Diversity

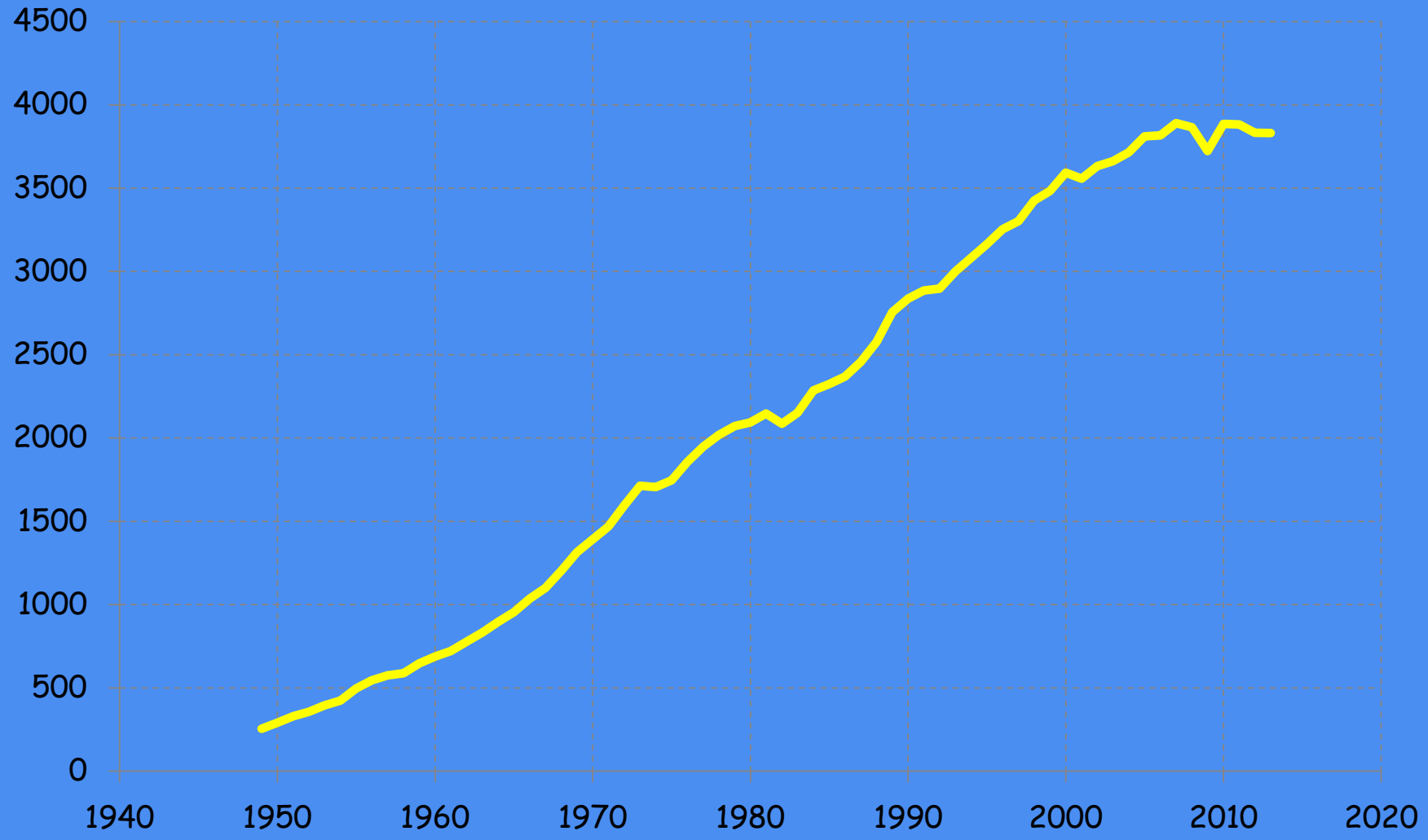
- Fuel supply failures
  - Natural gas pipeline failure
  - ISONE gas pipeline capacity
  - SPP Rail congestion for coal
  - Coal piles freeze
  - PJM dual fuel unit is the base unit
  - CAISO 'duck' curve and ramp rates



- Old clunker approach to reserves
  - Old clunkers are just that
  - Do not perform well
  - costly to maintain

Relapse

Total Electricity End Use
(Billion Kilowatthours)



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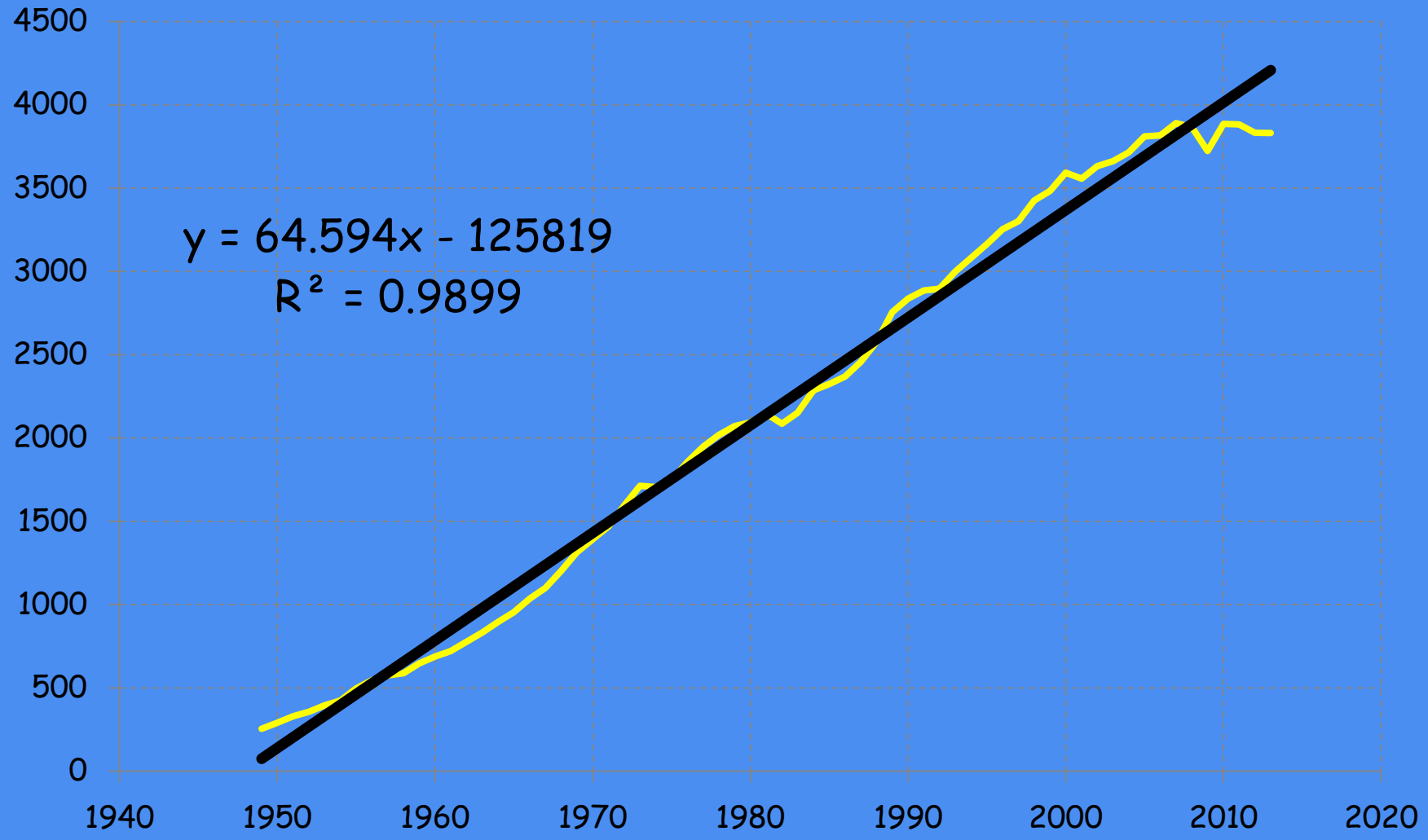

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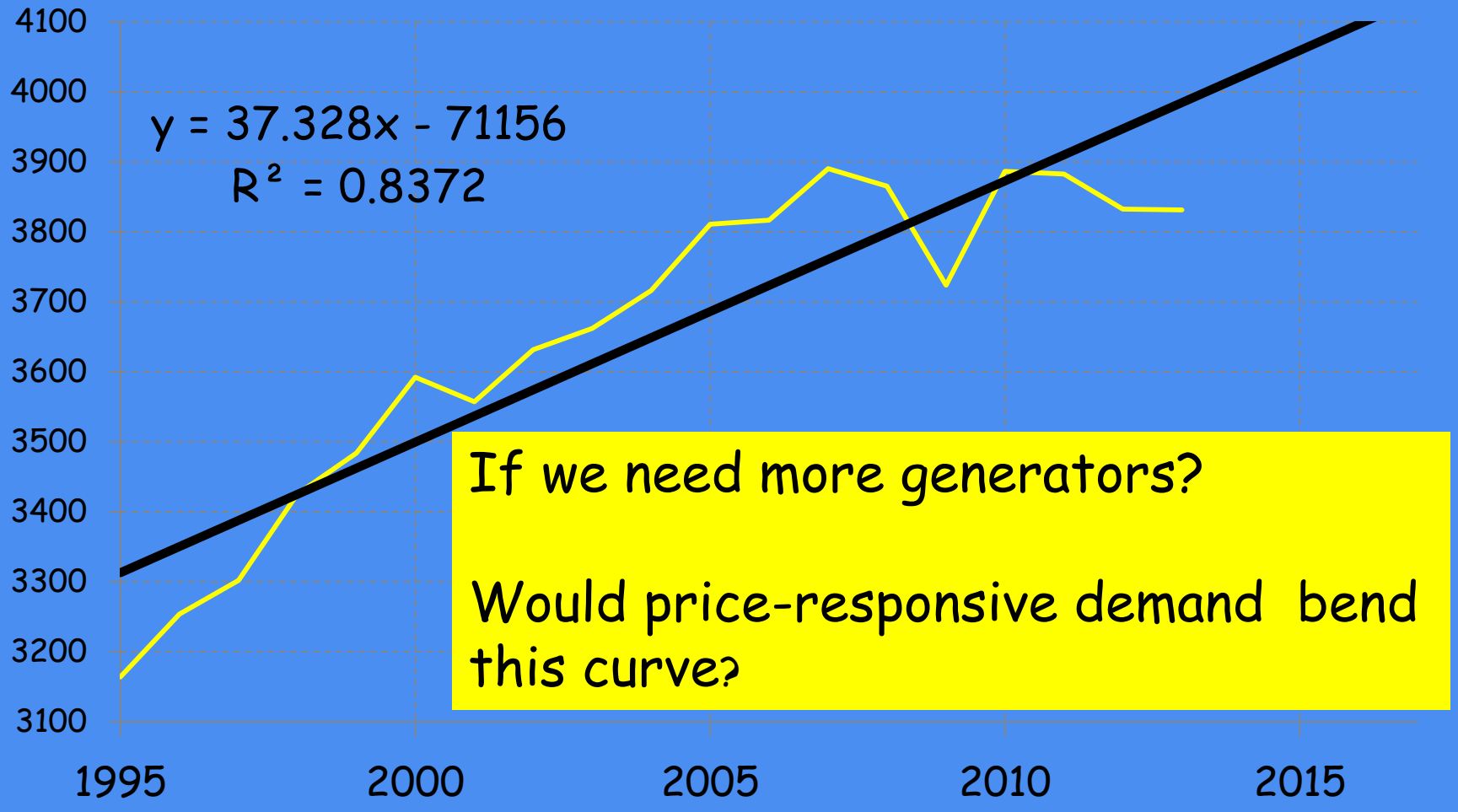
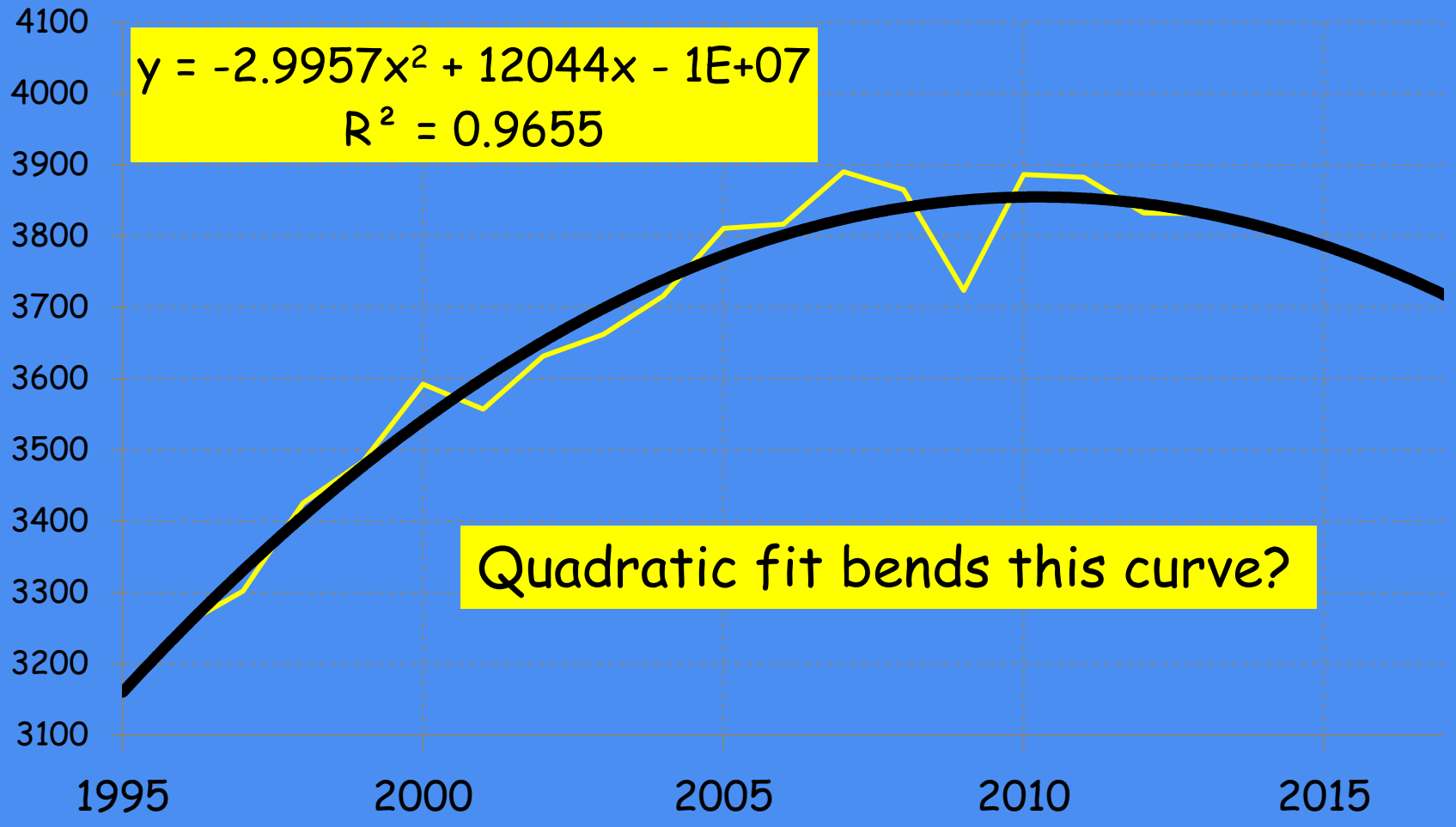


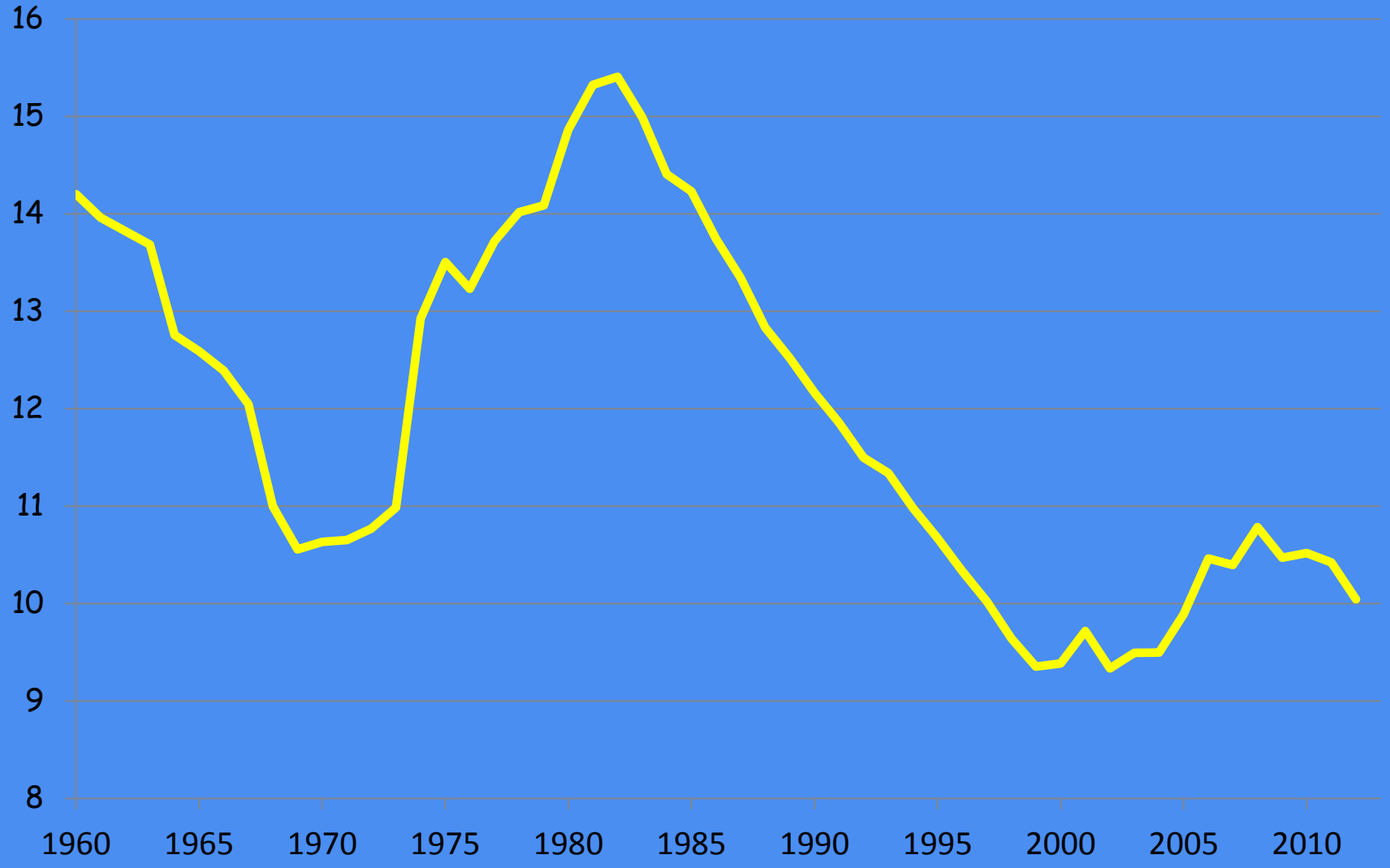
If we need more generators?

Would price-responsive demand bend this curve?

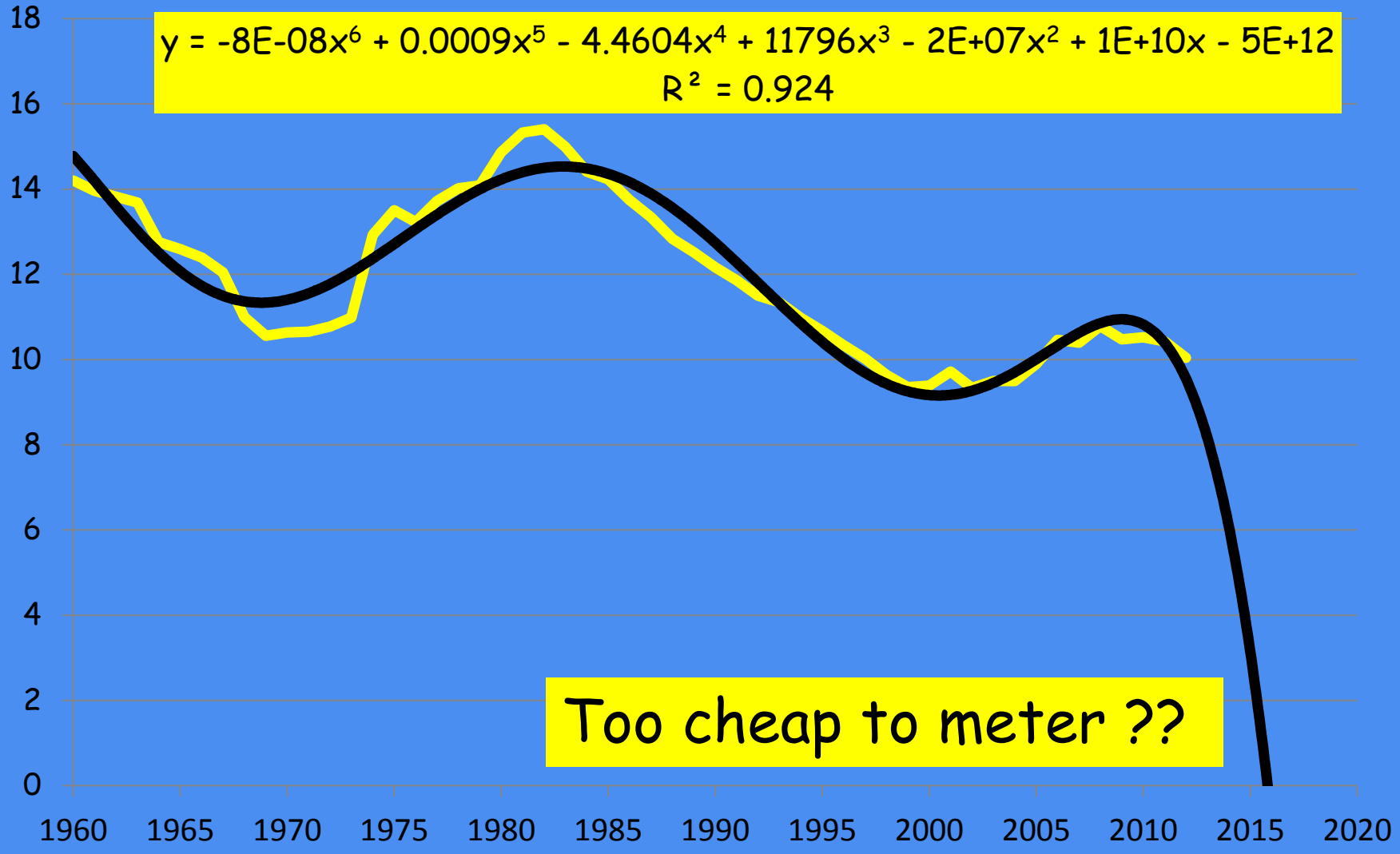
Total Electricity End Use (Billion Kilowatthours)



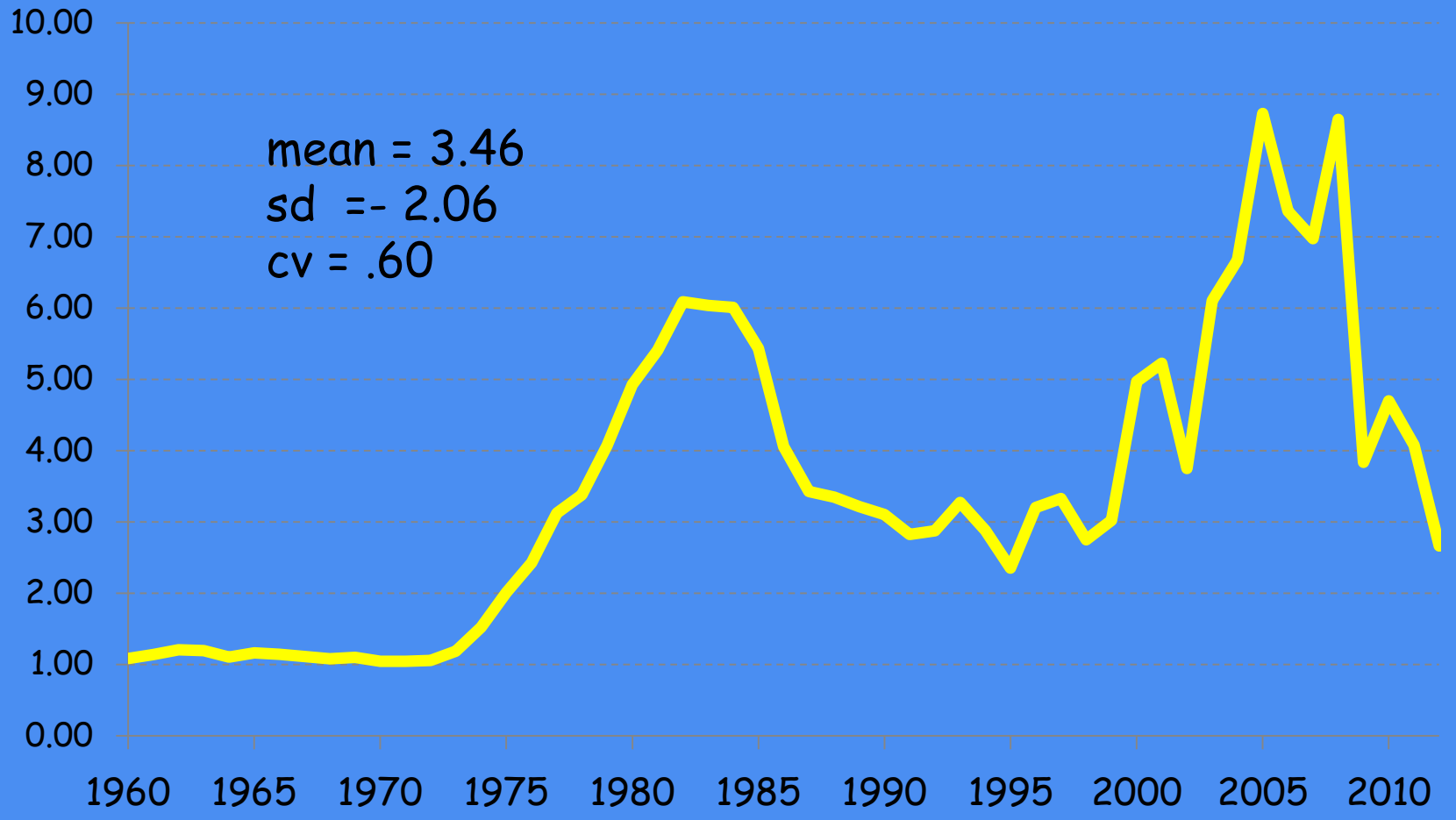
Average Retail Price of Electricity



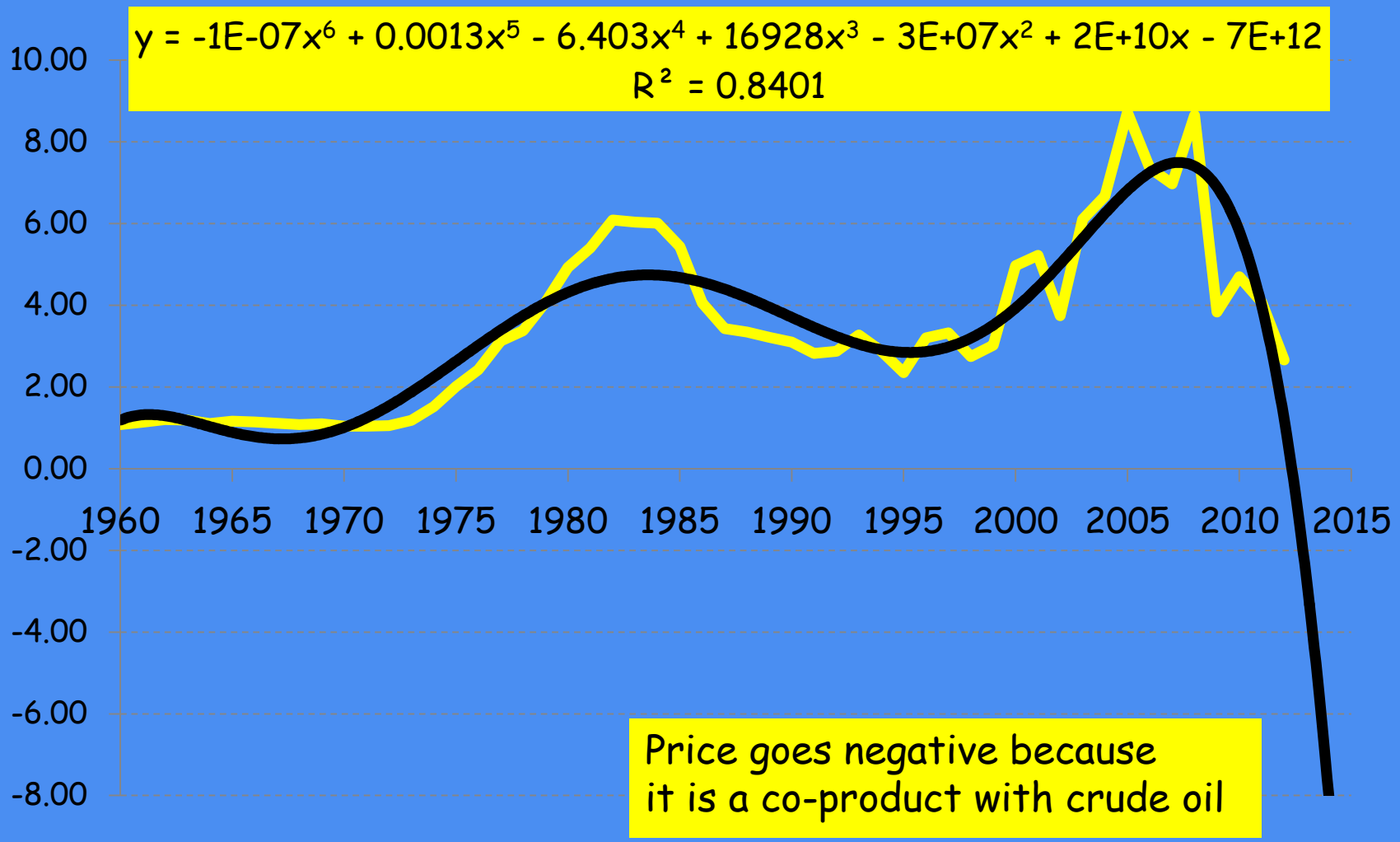
Average Retail Price of Electricity forecast



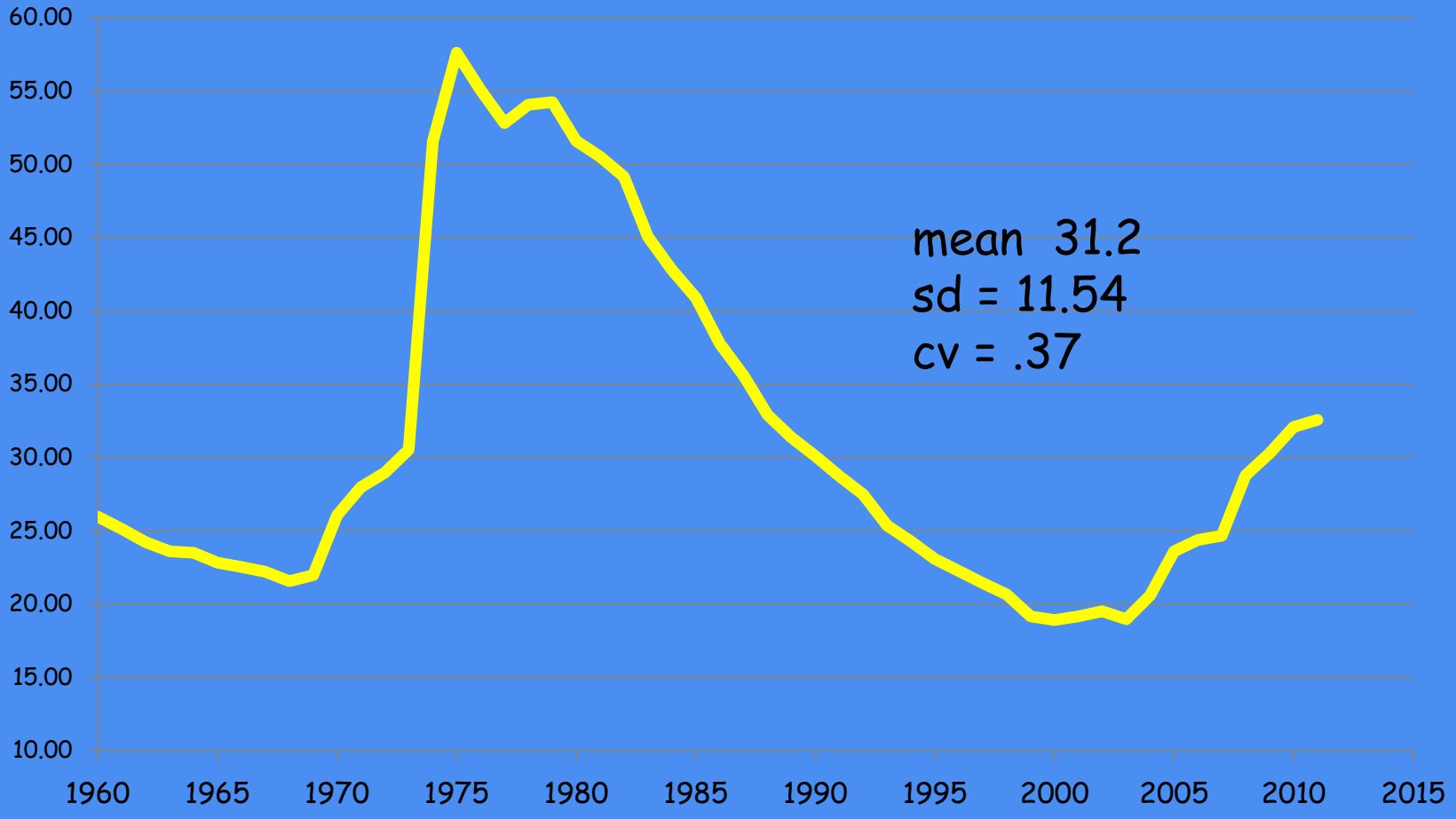
Natural Gas Wellhead Price



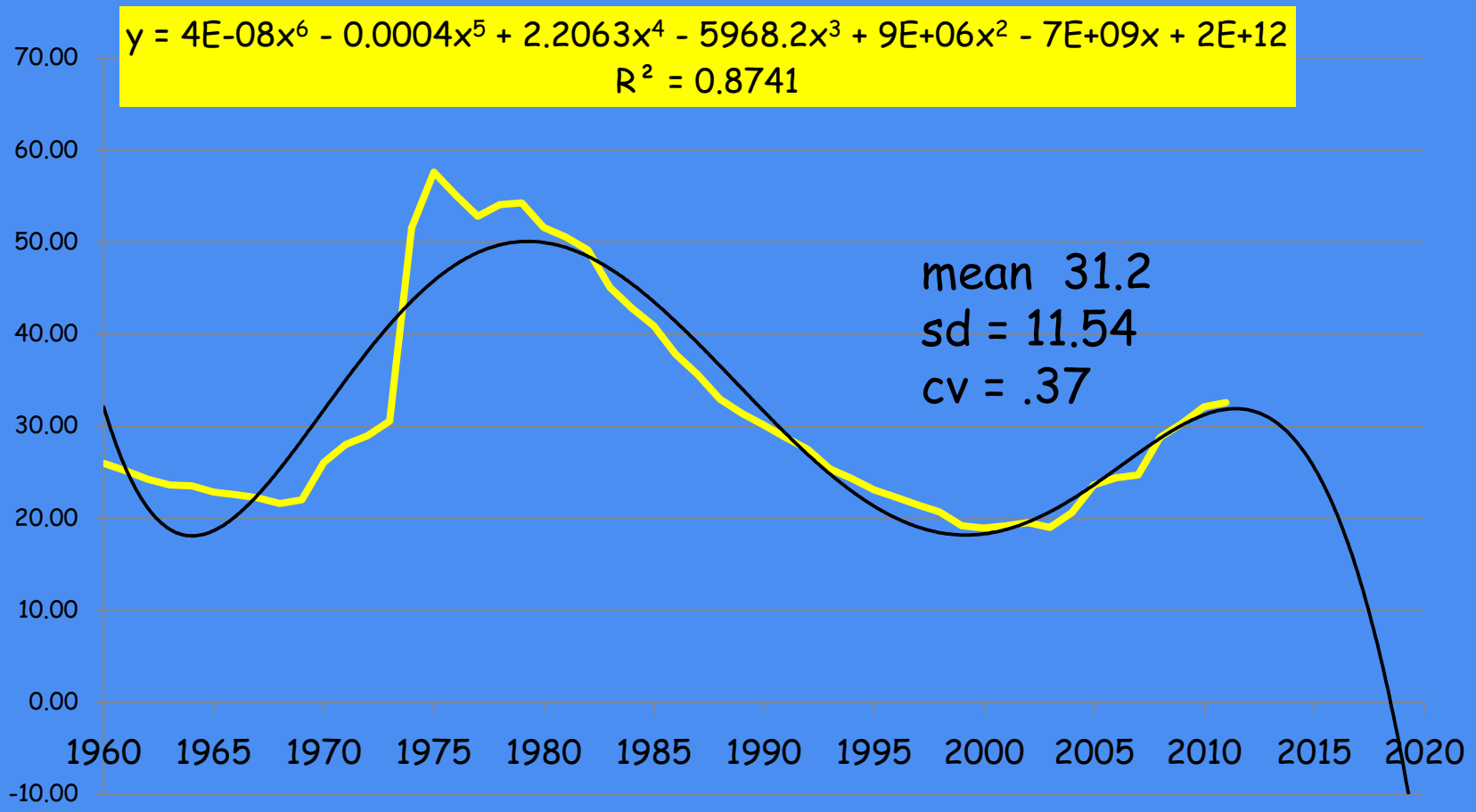
Natural Gas Wellhead Price forecast



Coal Prices


60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
mean 31.2
sd = 11.54
cv = .37

Coal Price forecast



Reverse Portfolio Theory

- Germany and Japan
  - Price of fossil fuel is high
  - Security of supply: fossil is imported
  - Portfolio theory tells us to find indigenous sources of energy, that is, wind and solar
  - Stimulate exports
- China and India:
  - Poverty/living standards
  - 'All of the above' strategy
- US and Canada: cheap fossil fuels mostly North American
  - Political coalition for wind and solar PTCs
- Does climate change change this strategy? Very little

Well Developed Hedging for generators and load

- ⇨ Bilateral contracts and state procurement hedge the prices for customers and generators.
- ⇨ Hedging more important since LMPs can be more volatile (not necessarily higher)
- ⇨ Contracts should have good price-responsive incentives

Wholesale v. Retail Market

'In my family, it was a sin to buy retail'
Woody Allen

- Federal EPA defines the climate agenda
- State have individual agendas that affect other states
- MOPR: Are some state programs a 'taking' ?

- National diversity
  - PTC for wind and solar
  - EPA Environmental limits
- State diversity
  - Renewable portfolios
  - CO2 markets

Future Capacity Market?

- Minimum Tranches purchases mean a price for each
  - Old clunkers keep them around as insurance
  - Wind not yet economic; only few more years
  - Solar not yet economic; only few more years
  - Batteries not yet economic; change the market design
  - Natural gas and CTs needed for balancing
  - Oil need for diversity
  - Coal ????
  - Nuclear radiation

Capacity Market Reforms

- ⇨Reliability has a cost; price it in the day-ahead market and real-time market
- ⇨Price-responsive demand is key
- ⇨Let the day-ahead market and real-time market work, prices should clear the market
- ⇨Price-responsive demand does not need to be in the capacity market

Long-term Forecast for 1950 Interesting Predictions

- 'When you come to fork in the road take it' Y Berra

- 1894 The Times of London... "In 50 years, every street in London will be buried under nine feet of manure."
- Samuel Morse was convinced that no one would use the telephone (Millennials prefer texting)
- 1899 ''Radio has no future. Heavier-than-air flying machines are impossible. X-rays will prove to be a hoax.' *Lord Kelvin*
- 1929 'Stocks have reached what looks like a permanently high plateau.' *Irving Fisher, Yale Economics Professor*
- 1932 'There is not the slightest indication that nuclear energy will ever be obtainable.' *Albert Einstein,*

Long-term Forecast for 2000 Interesting Predictions

- Insanity: doing the same thing over and over again and expecting different results. Albert Einstein

- 1943 'market for maybe five computers' *Thomas Watson, IBM,*
- 1977 'There is no reason anyone would want a computer in their home' *Ken Olson, Digital Equipment Corp.,*
- 'The concept is interesting and well-formed, but in order to earn better than a 'C', the idea must be feasible.' *Yale professor on Fred Smith's Federal Express proposal)*
- 1972 Limits to Growth projects all known oil reserves would be consumed in 31 years.

Long term forecasting for 2100

⇨How good are we tech forecasting??

Discount factor	years 20	50	100
0.99	0.82	0.61	0.37
0.98	0.67	0.36	0.13
0.95	0.36	0.08	0.01
0.90	0.12	0.01	0.00

Answer: Ptolemy

Thank you

Does human nature need an end times story?

The magical mystery tour is hoping to take you away