

Due Diligence on The Economics and Business Risks of New Nuclear Power

Craig A. Severance CPA

Author, *Business Risks to Utilities as New Nuclear Power Costs Escalate*
(Electricity Journal, May 2009)

Co-Author, *The Economics of Nuclear and Coal Power* (Praeger, 1976)

Website Resources: www.EnergyEconomyOnline.com

March 4, 2010

Brookings Institution/Global Public Policy Institute Conference

"Towards a Nuclear Power Renaissance?

Challenges for Global Energy Governance"

Potsdam, Germany

Evaluating New Nuclear Power Economics and Business Risks

- Multiple studies & projections
- Levelized Cost of Energy primary focus
- Costs unproved, rely on *nuclear vendors*
- Promoter business plans always look competitive – yet most have serious weaknesses
- Due Diligence process asks questions that highlight strengths and weaknesses
- Trillions of dollars of energy investment now at stake
- Serious weaknesses exposed? Go slow.

“Who Stopped New Nuclear Power?”



- Not environmentalists – government policies always *favored* nuclear power



- Not Three Mile Island 1979 accident – cancellations already underway *before* accident



- Utility boards & Wall Street stopped nuclear expansion after true costs, business risks evident

Core Due Diligence Tests

1. Does proposal match customer needs?
2. Financial Ability/Financial Stress
3. Reliability of Cost Projections
4. Assessment of Competition
5. Reliability of Revenue Projections

Business Test #1: Does Proposal Match Customer Needs? – Current Utility Environment –

- Demand forecasts highly uncertain
- Energy efficiency efforts increasing
- Smart Grid to be implemented
- Distributed generation (PV, Central Heat & Power) growing
- Renewable energy increasingly large % of total MWhs
- Need to quickly reduce GHG emissions

Does Proposal Match Customer Needs?

– Ideal New Power Plant Now –

- Short lead time – can wait till demand better known
- Modular size – With only $\sim 1\%/yr$ growth, track demand curve with smaller additions
- Preserve capital needed now for Smart Grid, energy efficiency
- Load-following plant to work well with intermittent wind, solar
- Achieve lower carbon emissions

Does Proposal Match Customer Needs?

– New Nuclear Power Plant –

- Very long lead time -- major spending based on shaky 10 year forecast
- Added in huge chunks (1,100-1,600 MW) -- unable to track closely to growth curve
- Massive capital required– drains capital needed for efficiency, Smart Grid projects
- Unable to operate as load-following plant – incompatible with renewables
- Very slow to achieve low carbon emissions

Load-following plants meet utility needs best

- Cheaper: \$1,100 - \$4,000/KW
- Smaller units – track load curve closer
- Quicker to build – match load curve when needed, cut CO₂ emissions quicker
- Dispatchable plants that also run 24/7 when needed (i.e. can fill baseload needs)

Load-Following Plants Available Now



- Wind +/-or PV with Compressed Air Energy Storage



- Solar Thermal/Natural Gas Hybrid Steam Generators



- Geothermal (high or low-temperature)



- Hydro/Micro Hydro



- Combined Cycle Gas Turbines

Matching Customer Needs: Load-Following vs. Baseload Plants



"I think baseload capacity is going to become an anachronism....You don't need fossil fuel or nuclear [plants] that run all the time....We may not need any [more], ever."

—Jon Wellinghoff, Chairman
Federal Energy Regulatory Commission
22 April 2009

Business Test #2: Financial Stress

- Can utility *afford* project & maintain financial ratios?
- Six Wall Street Investment Banks (2007): No loans for new nuclear – too risky
- Government loan guarantees protect lender but *no protection for shareholders, ratepayers*
- Projects so large – cost overruns alone can exceed utility's entire Net Worth
- How will cost overruns be funded once government loan guarantee exceeded?

Financial Stress: Conclusions

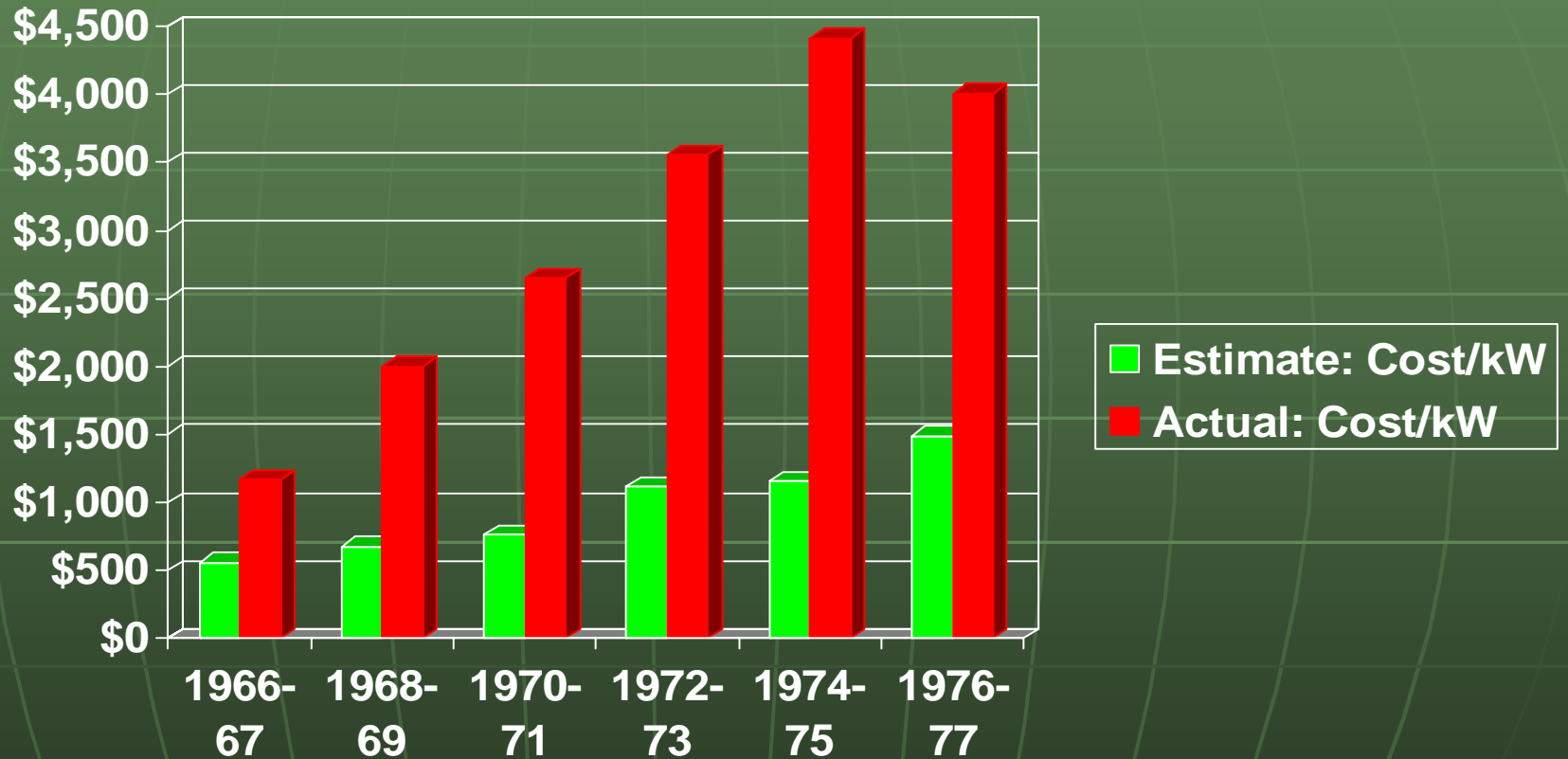
- Downgrade of Bond Ratings (*Moody's June 2009 Special Comment*)
- Everything being gambled on one project – “Nuclear’s Bet The Farm Risk” (*Moody's June 2009 Special Comment*)
- Nuclear projects easily “Corporate Killers” (*Citi's November 2009 analysis “New Nuclear – The Economics Say No”*)

Test #3: Reliability of Cost Projections

- Nuclear industry historical record: **2-4 X** original estimates (EIA)
- Cost escalations exposure over long period
- Vendors cannot/will not commit to price
- Nuclear cost estimates keep changing drastically. South Texas Project began at \$6 Billion estimate – now over \$13 Billion. Olkiluoto 75% > budget
- Delays are wild card – expose project to more years of ungovernable cost inflation

Nuclear Optimism Vs. Reality

Estimate v. Actual Cost/kW in 2002\$ - w/o Financing Costs
By Year When Construction Started



Source: U.S. Energy Information Administration, converted to 2002\$ by MIT Paul Joskow

Has Nuclear Industry Shown Cost Credibility?

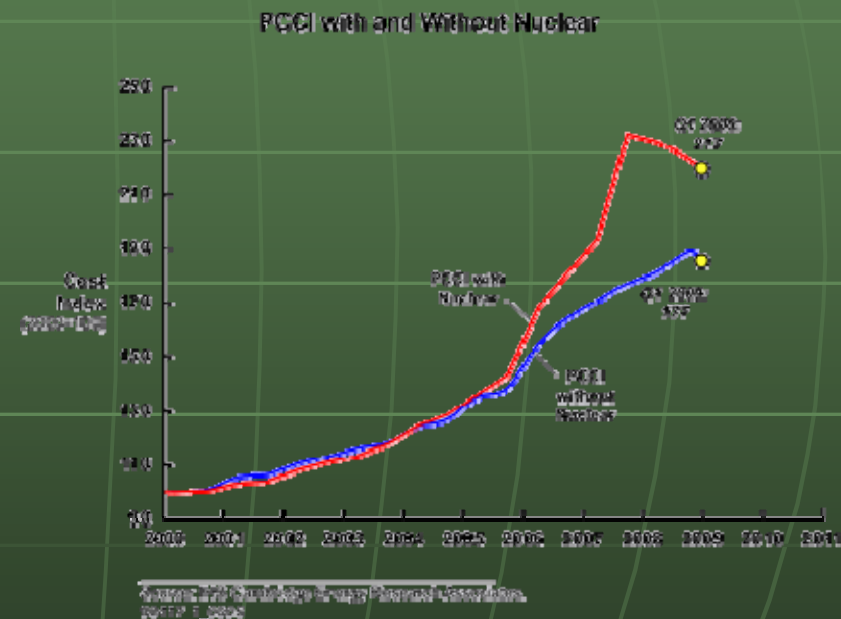
Have Real\$ Cost Escalations Stopped?

- Cost studies typically pick “Overnight Cost” and stick with it
- No *further* Real\$ cost escalations assumed during construction
- Examples: MIT 2009 Update; Florida Power & Light
- Reality: severe cost escalations have hit power plant construction, only recession broke trend
- Power plant construction costs escalated 12.75%/yr 2000-2007 (CERA) – avg. Real\$ cost escalation 10%/yr
- Is real\$ cost escalation *over*? Have China, others stopped their aggressive building programs?

Nuclear Needed *Lower* Construction Costs BUT Power Plant Construction Costs More than Doubled

- Driven by rapidly expanding economies e.g. China, India, Brazil
- MIT New Nuclear 2002\$ = \$2,000/kW "Overnight" Cost
- New Nuclear 2007\$ > \$4,000/kW "Overnight" cost (MIT, Florida Power & Light estimates)

Power Capital Costs Index 00-09 Q1



Source: Cambridge Energy
Research Assoc. Press Release
Jun 23, 2009

Example of “Counting The Costs” – To COMPLETE a Nuclear Mega-Project

- “Overnight” Cost: \$ 3,671/kW
- Escalations in Costs: \$ 2,505/KW
- Cost of Capital: \$ 2,256/kW
- “All-In” Costs \$ 8,432/kW*

Total Cost for 2,700 MW 2-Unit New Nuclear Facility
\$22.8 Billion

*Based on CPS STP “Overnight” Cost Estimate, CPS Avg. Weighted Cost of Capital, and nuclear cost escalations only ONE HALF 2002-2007 Average

Reliability of Nuclear Cost Projections : Conclusions

- “What is clear is that it is completely impossible to produce definitive estimates for new nuclear costs at this time...” Steve Kidd, Director of Strategy & Research, World Nuclear Association, *Nuclear Engineering International*, 22 August 2008
- “We see very little prospect of these costs falling and every likelihood of them rising further.” *Citi* analysis “New Nuclear – The Economics Say No”, 9 November 2009
- “We think the probability that things will go wrong with these large projects is greater than the probability that things will go right.” *Moody's* Senior V.P. Jim Hempstead, *WSJ*, 18 February 2010

Mega Project Sunk Costs vs. Modular Project Flexibility

Reactor Mega Project

- Long planning & construction period
- Costs can increase drastically while project still underway
- One project – ZERO kWh produced till complete
- Changing your mind results in abandoning enormous sunk costs (often billions)
- Specter of “Completely Wasted Money” if project abandoned
- “Boiling the Frog” – if facts had been known at beginning would have “jumped out” but “slow boil” keeps utility in
- Only nine U.S. nuclear projects in first wave abandoned once construction began, even though avg. 2-4 times original estimate



Mega Project Sunk Costs vs. Modular Project Flexibility



Modular Projects

- Smaller projects, shorter lead times
- Able to expand or shrink projects
- Flexible – can quickly change technologies
- If 1,000 MW planned but conditions change after 200 MW built – 200 MW *still generates electricity*
- No specter of massive sunk costs abandoned

Business Test #4: Competition

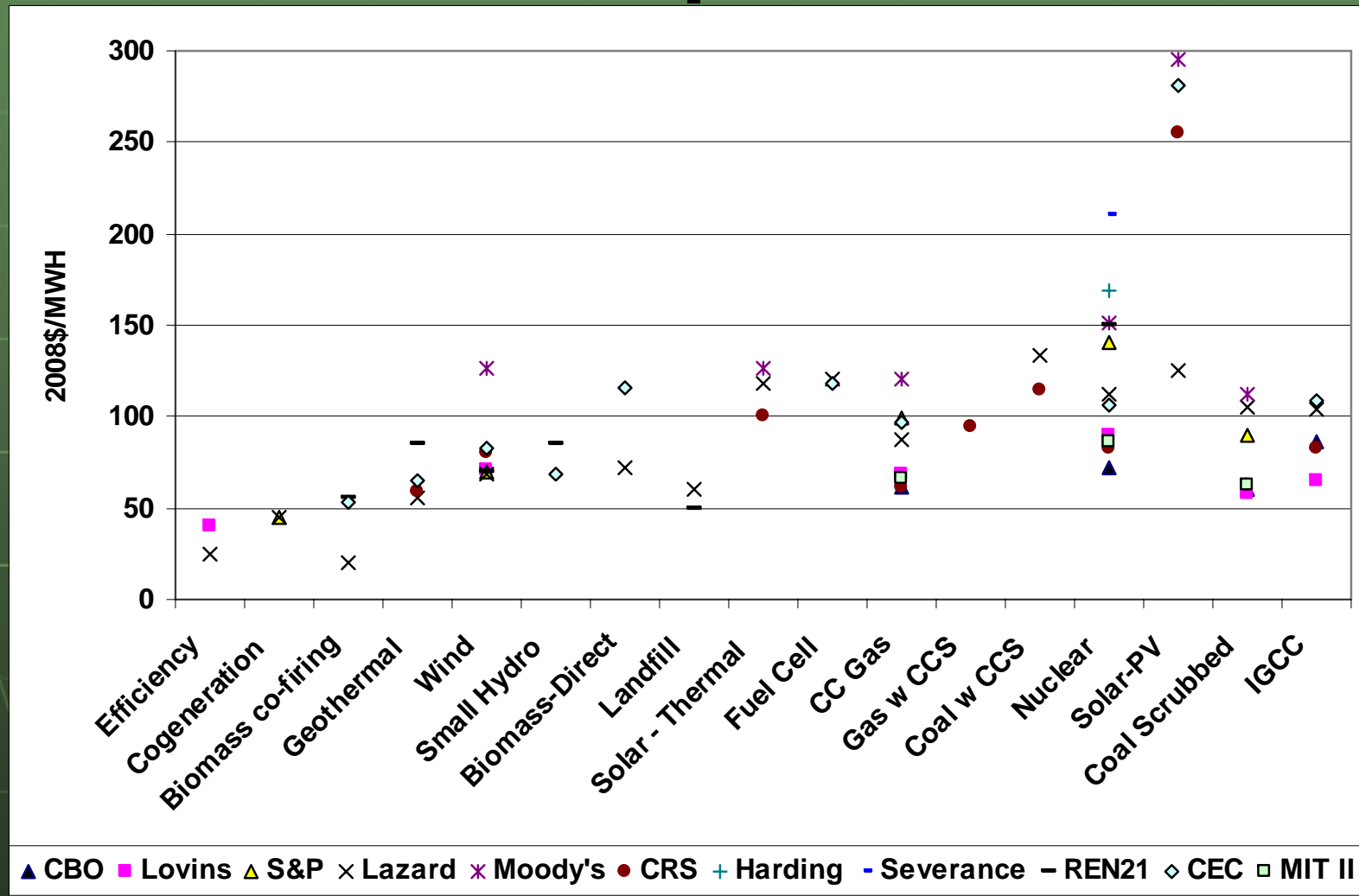
Three Types of Competition

- *KWh's not purchased*: Efficiency and Distributed Generation (e.g. PV, Combined Heat & Power, Bloombox)
- Other Types of Central Power Generation
- Society's other needs: should electricity drain so much capital?

Competition: Efficiency & Distributed Generation

- *McKinsey* 2009: efficiency can profitably save half of current U.S. coal-electric production by 2020
- Distributed Power: in 2006 delivered 1/6 of global electricity, 1/3 of new electricity, 1/6 to >1/2 of all electricity in a dozen industrial nations (Rocky Mountain Institute)
- Governance Issue: Efficiency & distributed most direct benefit to ordinary citizens, "democratization of power"

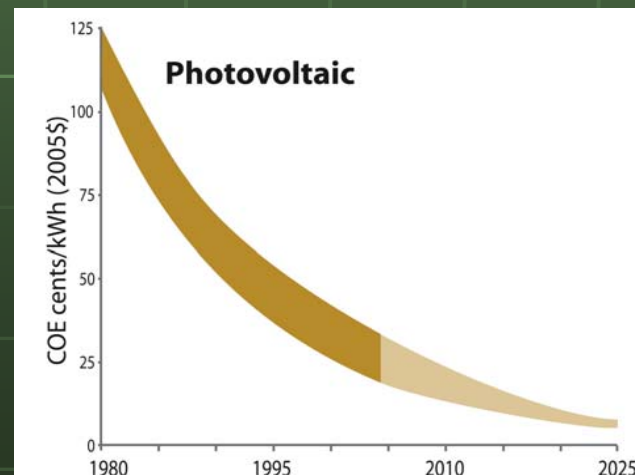
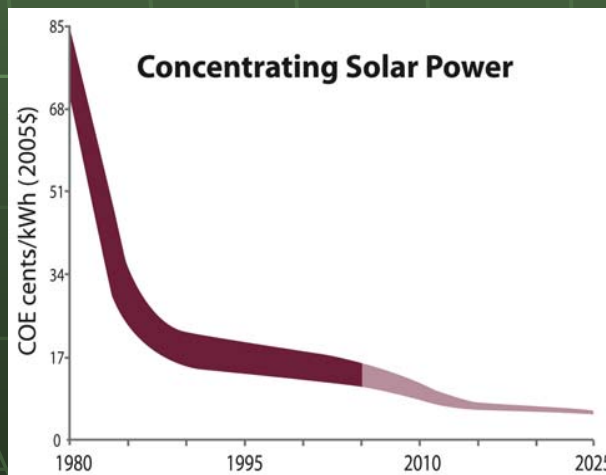
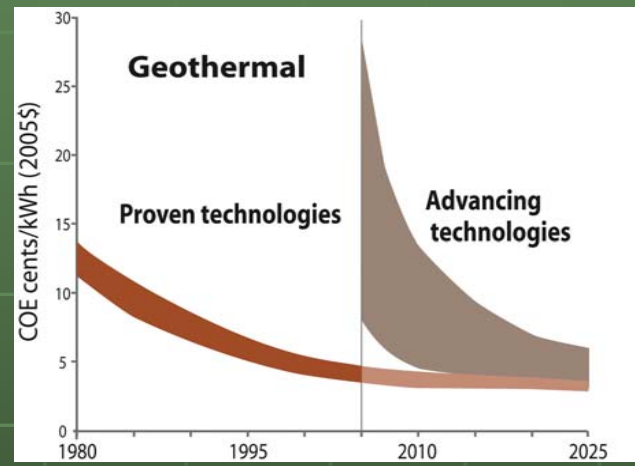
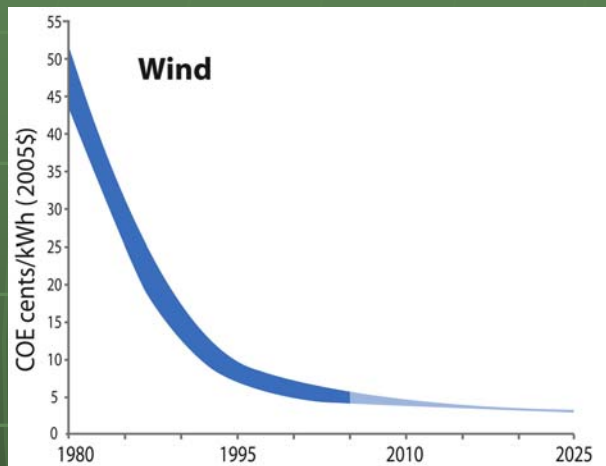
Competition: Other Types of Power – Comparative Costs



Source: Mark Cooper, Sr. Fellow for Economic Analysis, Institute for Energy and the Environment, Vermont Law School, July 2009

Renewable Energy Cost Trends

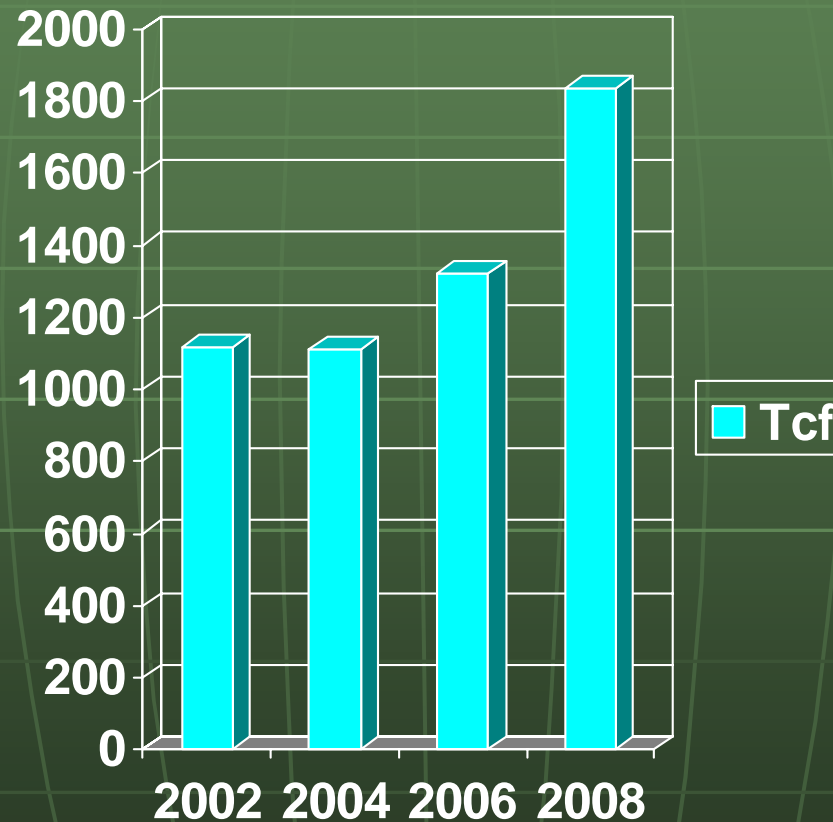
Advantage of FACTORY MADE Mass Production Cost Curves
– Renewable Portfolio Standards Achieve Desired Goal –



Source: NREL Energy Analysis Office (www.nrel.gov/analysis/docs/cost_curves_2005.ppt)

Levelized cost of energy in constant 2005\$

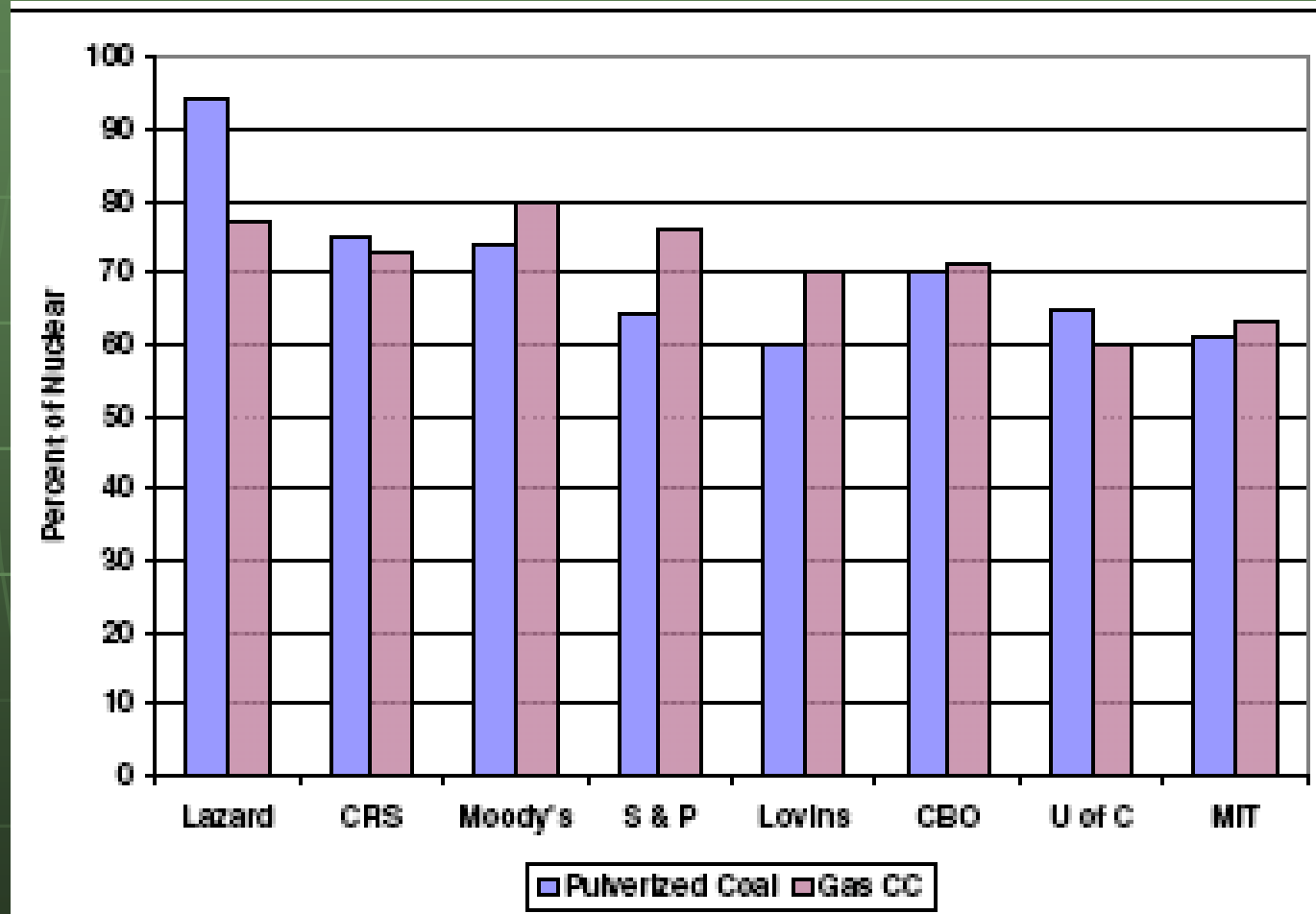
“Game Changer” - U.S. Natural Gas Supply Greater than Expected



Source: Potential Gas Committee/CO School of Mines
(Shale Gas Exploration Now Also Underway in Europe, China)

New Nuclear Still Loses Against Coal and Natural Gas

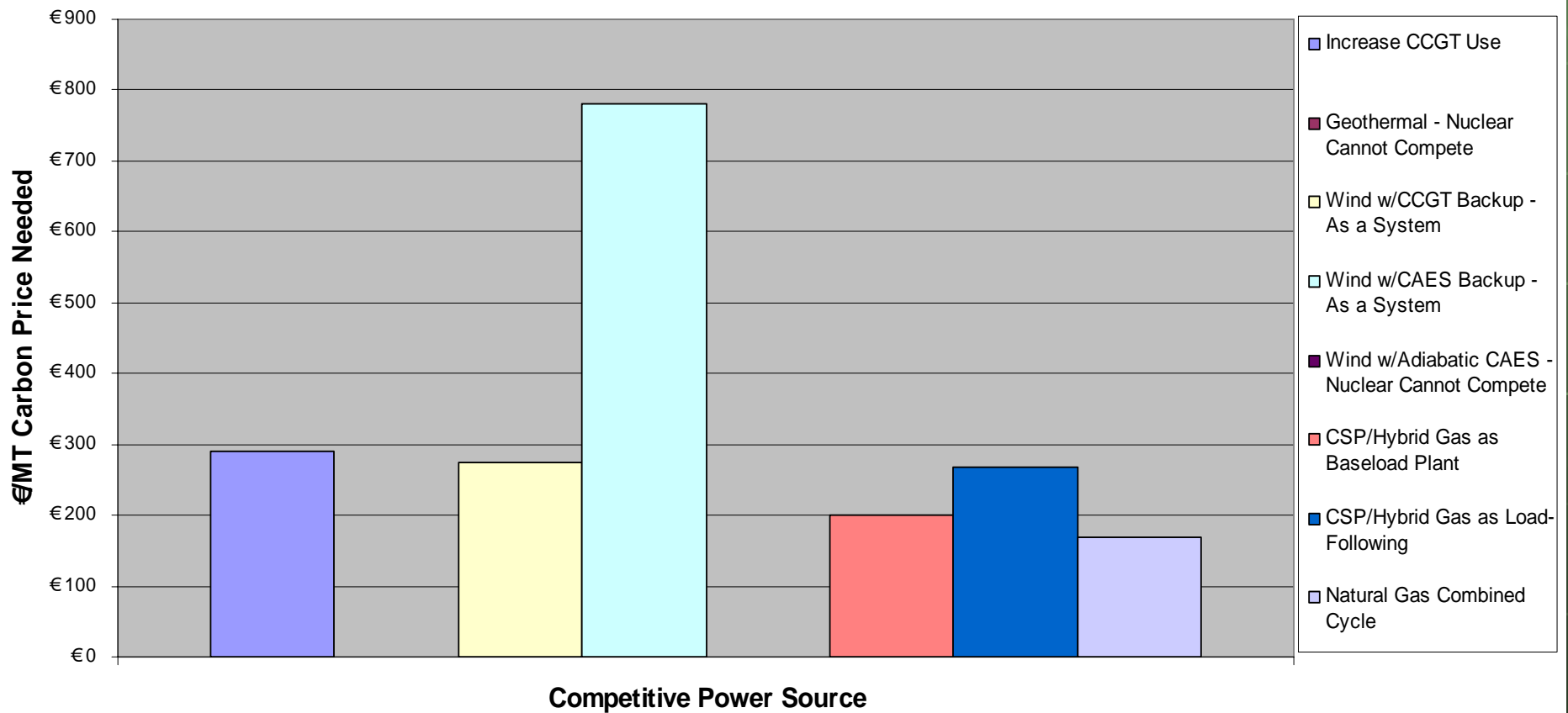
Coal & Natural Gas Costs as % of Nuclear Cost



Source: Cooper, Mark "The Economics of Nuclear Reactors: Renaissance or Relapse", June 2009

Could Carbon Price Help New Nuclear Close the Gap?

**Carbon Price Needed for New Nuclear to Compete
(if Nuclear at €0.13/kWh & Nuclear is Zero Carbon)**



Competition for Capital: Society's Other Needs

- Annual World Development Assistance and Aid – All Purposes **\$106 Billion** (2005 Data, World Resources Institute, *World Resources 2008*)
- Annual Cost to Curtail Species Extinctions Worldwide **\$46 Billion** (“The Price of Survival”, Spiegel Online Intl, 23 May 2008)
- Cost to Save Rainforests **\$22-\$36 Billion**
U.N. Negotiations on REDD: Reducing Emissions from Deforestation and Forest Degradation proposal (NY Times 24 Sep 2009)
- Annual Cost to End World Hunger **\$30 Billion** U.N. Food and Agricultural Organization, 2008
- Cost to Build just 100 new Nuclear Reactors **\$1,100 Billion**

Business Test #5: Sufficient Revenues?

Three Threats to Revenue Adequacy

- Rate increases, efficiency may destroy customer demand for kWh's
- Inadequate Prices Received for kWh's Sold
- Lower than Projected Generation Output (# of kWh's)

Could Demand Go Flat?

What Happens to Revenue if Customers Save?

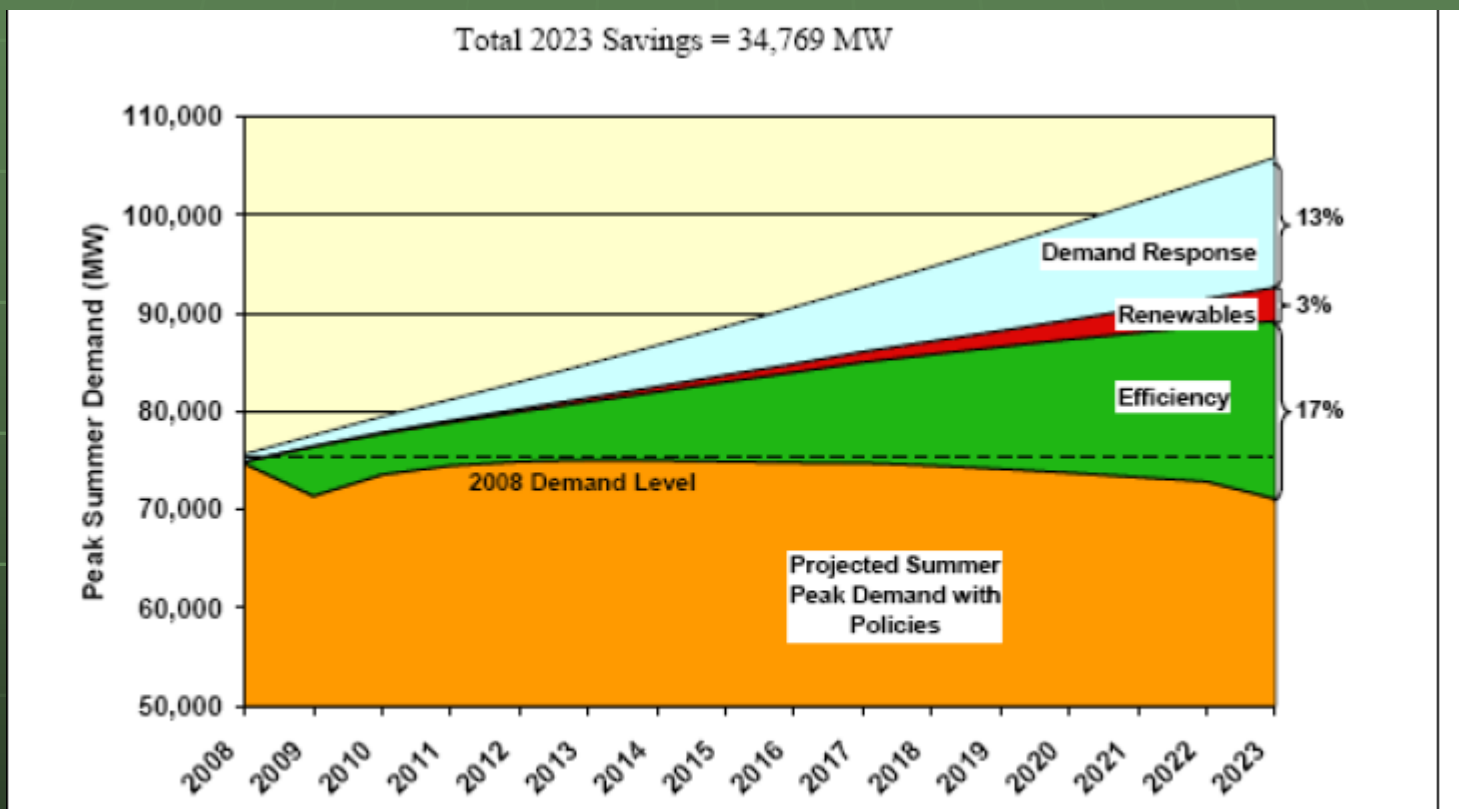


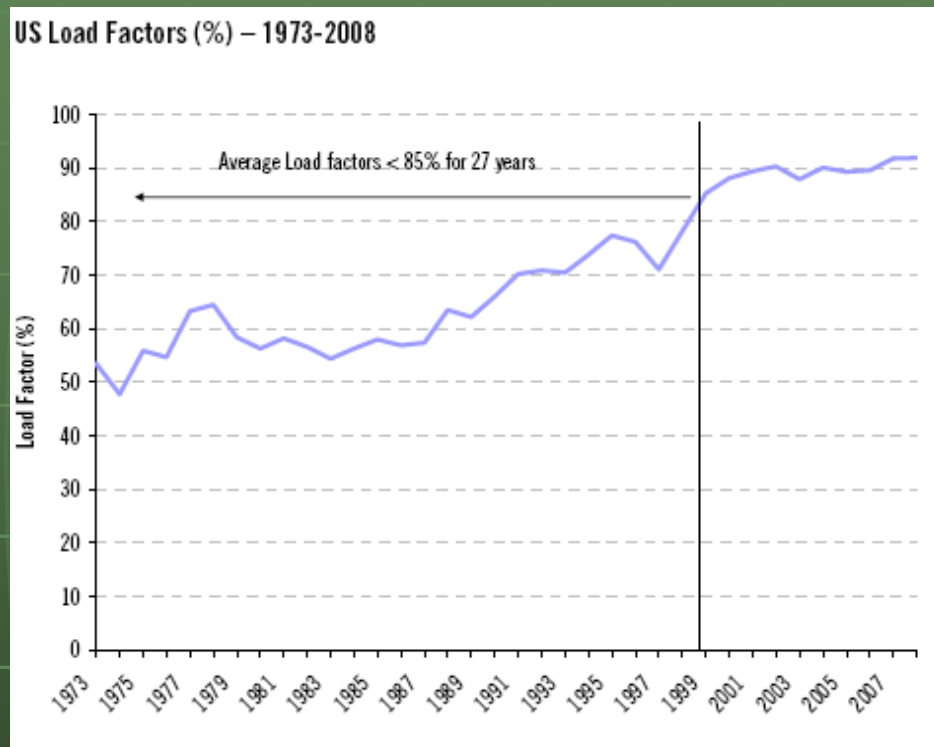
Figure 11: Overall Impact of Efficiency, Demand Response, and Renewable Measures Recommended by ACEEE for Texas

Source: American Council for Energy Efficient Economy 2007 Report

Threat to Revenue: Prices Received

- *Citi*: UK electric market would have paid *too little revenue > 80% of time* - *Citi Nov 2009*
- *U.S. Congressional Budget Office*: loan default well over 50% likely as prices received unlikely to cover new nuclear costs - *CBO 2003 Report*
- *Simmons & Company*: "The economics of nuclear power in a low priced gas environment are not very compelling." Also, "wind power may not compliment nuclear... given that wind power can be produced in the off-peak periods thereby threatening nuclear power at the baseload."
"Simmons Energy Briefing: Nuclear Energy Update" 25 February 2010

Threat to Revenue: Lower than Projected Output



Source: EIA as used in Citi Nov 2009 Report

- Radically New Nuclear Plant Designs
- Lifetime Capacity Factor of US, other nuclear fleets low on average
- Early years most important for ROE
- Existing workforce retiring, shortages of trained nuclear personnel expected

Summary of Tests of New Nuclear as Business Proposal

- | | |
|----------------------|---------------------|
| 1. Customer Needs: | <i>Poor Fit</i> |
| 2. Financial Stress: | <i>Extreme</i> |
| 3. Costs: | <i>Ungovernable</i> |
| 4. Competition: | <i>Cannot Beat</i> |
| 5. Revenue: | <i>Inadequate</i> |

Conclusion: *Severe Weaknesses*

Prudent Path for Utilities Now

- Adopt “least cost” strategies - \$500 rebate could save \$10,000 new plant construction
- With economy and demand uncertain, use shorter-lead-time plants – track demand curve closer, wait longer to commit.
- Use load-following and peak plants to guarantee *capacity* so lights stay on (kW)
- Use intermittent (e.g. wind, solar PV) to generate carbon free *energy* (kWh) and cut fossil fuel use