National Association of Regulatory Commissioners:

Risk Workshop for Regulators

Presented by:

The Regulatory Assistance Project &
Synapse Energy Economics

Mid-Atlantic Conference of Regulatory Utility Commissioners

June 24, 2013

Overview of NARUC Risk Workshop

1) Introduction.
2) Risk Challenge to Audience.
3) Key Terms and Concepts.
4) Key Risks in the Electricity Industry.
5) General Strategies for Addressing Risk.
6) Robust Planning Practices.
7) Overview of Risk in Restructured Electricity Industries.
8) Addressing Risk in Specific Contexts.
9) Risk Challenge to Audience.
10) Synthesis and Discussion.

1. Introduction

- Purpose of the workshop.
- Introduce the audience to each other.
- Importance of risk to regulators.
- Emphasis of the workshop will be on risk in states with restructured electricity industries.

2. RISK CHALLENGE TO AUDIENCE

- It is late September. Hurricane Hannibal has just blown through town leaving in its wake extensive power outages of up to one week. Temperatures have plummeted. Residential customers are unhappy and cranky, many retreating to hotels or friends and family because it is too cold to stay home with no electricity. They've had to toss out freezers full of frozen foods. Businesses have had to close, impacting their profitability. Like it or not, affordable or not, everyone has to absorb these losses. Top it off with local TV and radio news featuring consumer advocates who are saying that these outages could have been avoided if the utility had maintained its system the way it was supposed to.

2. RISK CHALLENGE TO THE AUDIENCE

- The Governor has weighed in saying she wants power restored immediately and she wants an investigation into reliability. Now comes the utility filing for recovery of all the storm damage costs. They claim that the cost to repair and upgrade with state-of-the art equipment is imperative to prevent this kind of wide-spread outage from happening again. They claim this a force majeur situation and their shareholders should not bear the burden of this cost which was unpreventable. Without the upgrades and with the increasing frequency of severe weather (as Bloomberg Business called it – "It's Global Warming Stupid"), there is a risk this will happen again. They want $50 million and they want it now, in a surcharge. Meanwhile the public is in no mood to hear about increased rates and is clambering for their head!

2. RISK CHALLENGE TO THE AUDIENCE

- What are the risks?
- How do you evaluate the situation?
- What do you as a regulator do?

3. KEY TERMS AND CONCEPTS

3. Key Terms and Concepts

Volatility refers to near-term fluctuations in a security's value, e.g. fuel price. A higher volatility means that a security's value can potentially be spread out over a larger range of values. This means that the price of the security can change dramatically over a short time period in either direction. A lower volatility means that a security's value does not fluctuate dramatically, but changes in value at a steady pace over a period of time.

Uncertainty describes a situation where current and/or future conditions are unknown.

Risk is a consequence of uncertainty.

Defining Risk

"a low risk portfolio is one that is relatively stable under a variety of assumptions"

-*Duke 2013 IRP*

"If the returns the utility provides its shareholders have become more volatile, then the utility is riskier"

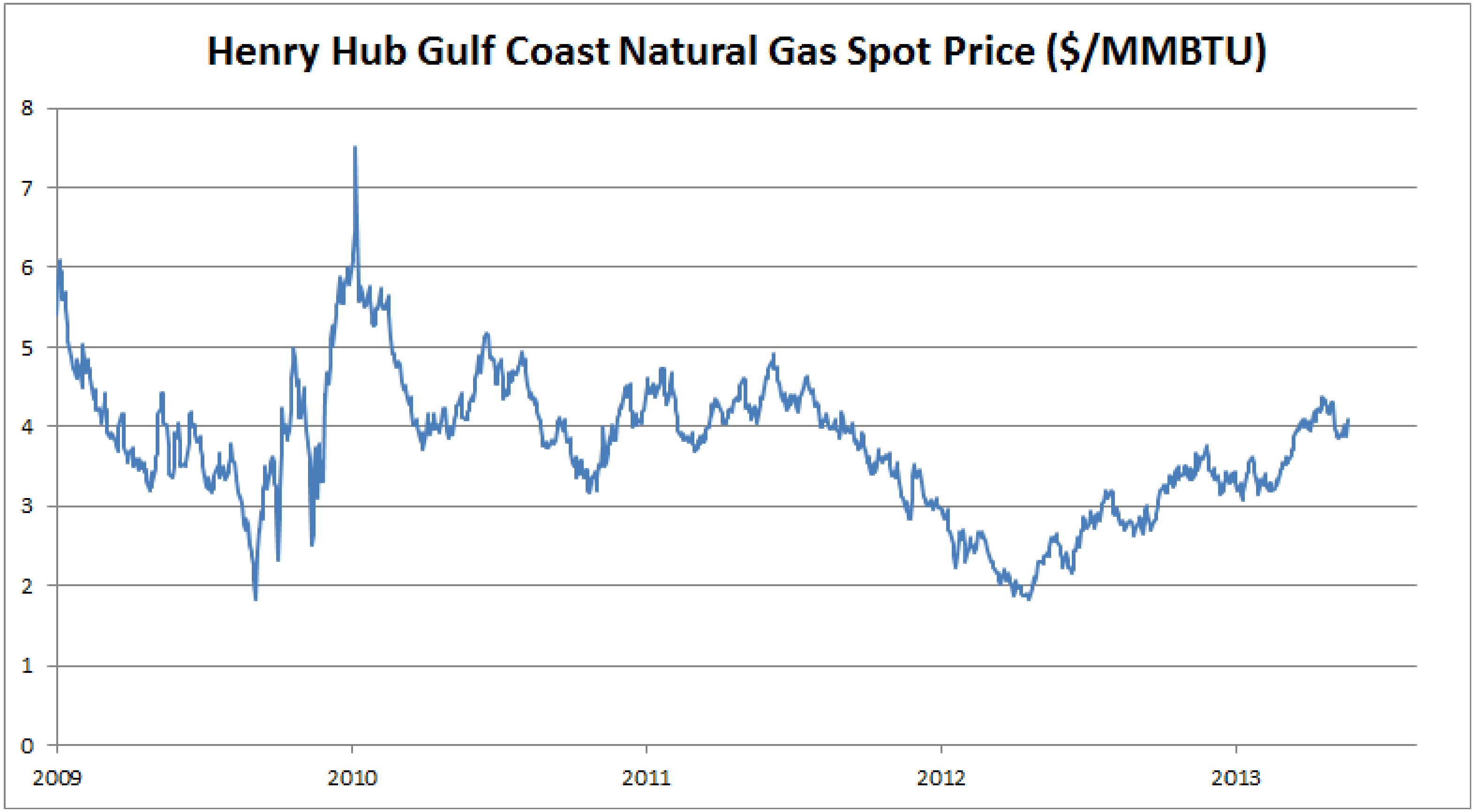
-*EEI (2006) "Electric Utilities and Risk Compensation"*

"Risk arises when there is potential harm from an adverse event that can occur with some degree of probability … Higher risk for a resource or portfolio means a larger expected value of a potential lost"

-*Ceres 2012*

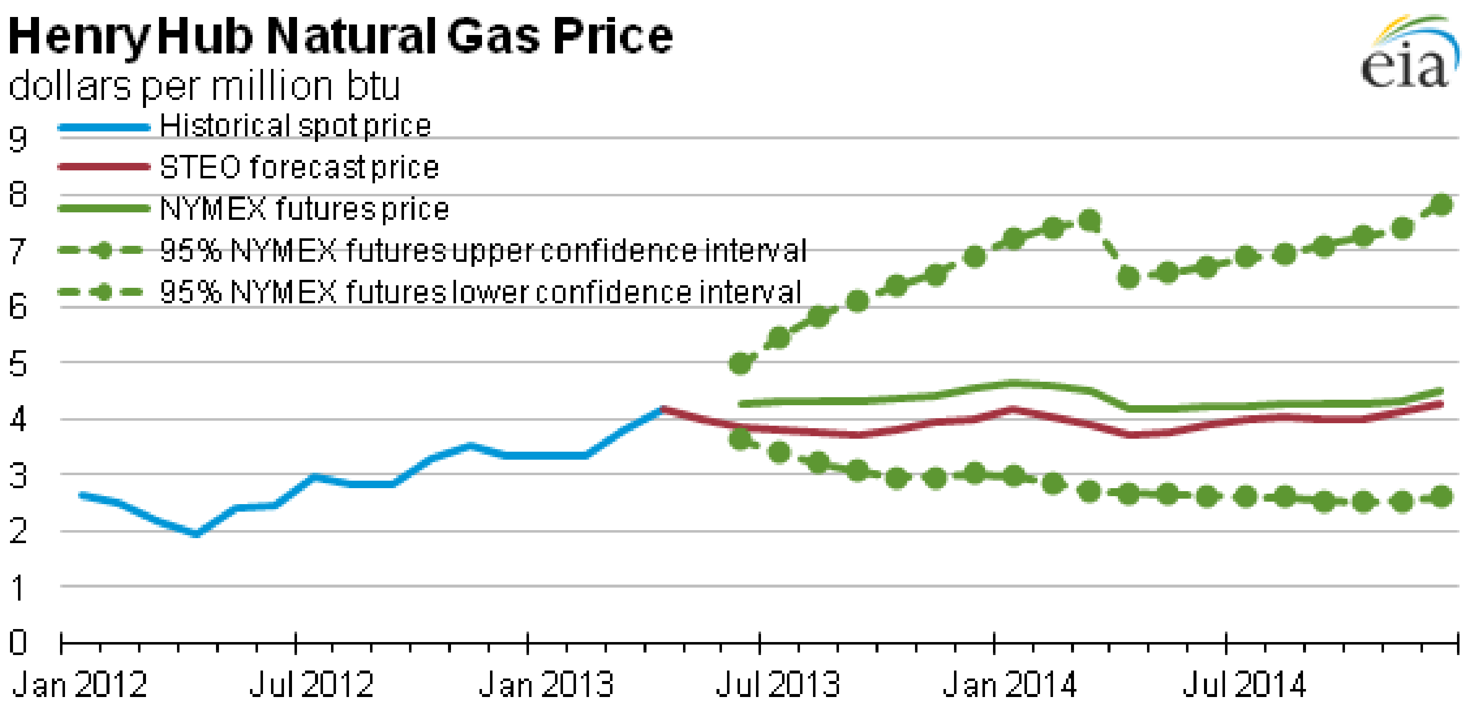
3. Key Terms and Concepts

- Never ZERO risk – goal is to manage
  - Example: Fixed price long term contracts vs market risk



3. Key Terms and Concepts

- Future confidence intervals are large

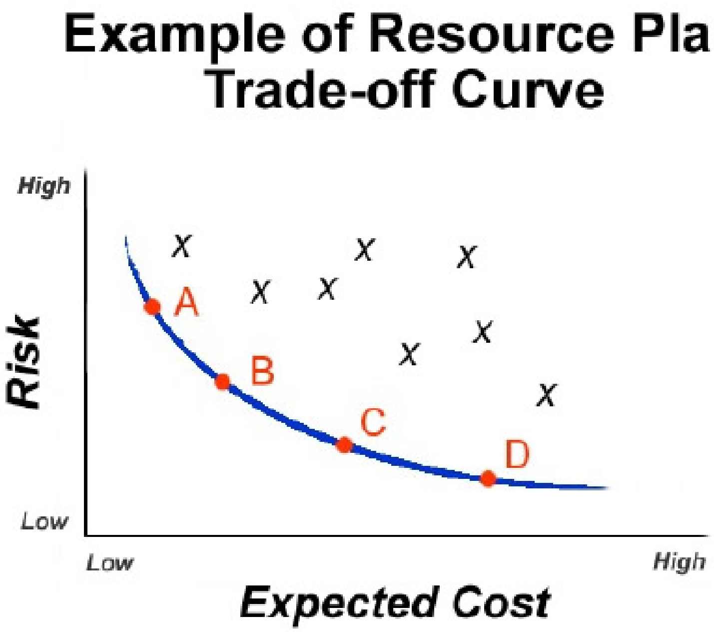


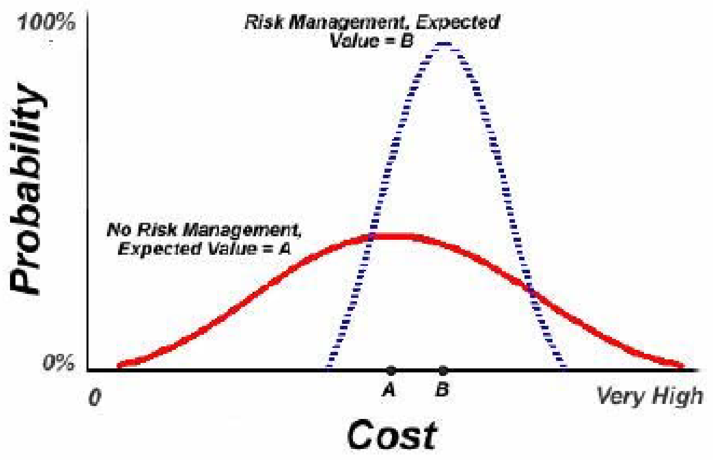
Note: Confidence interval derived from options market information for the 5 trading days ending May 2, 2013. Intervals not calculated for months with sparse trading in near-the-money options contracts.

Source: Short-Term Energy Outlook, May 2013

3. Key Terms and Concepts

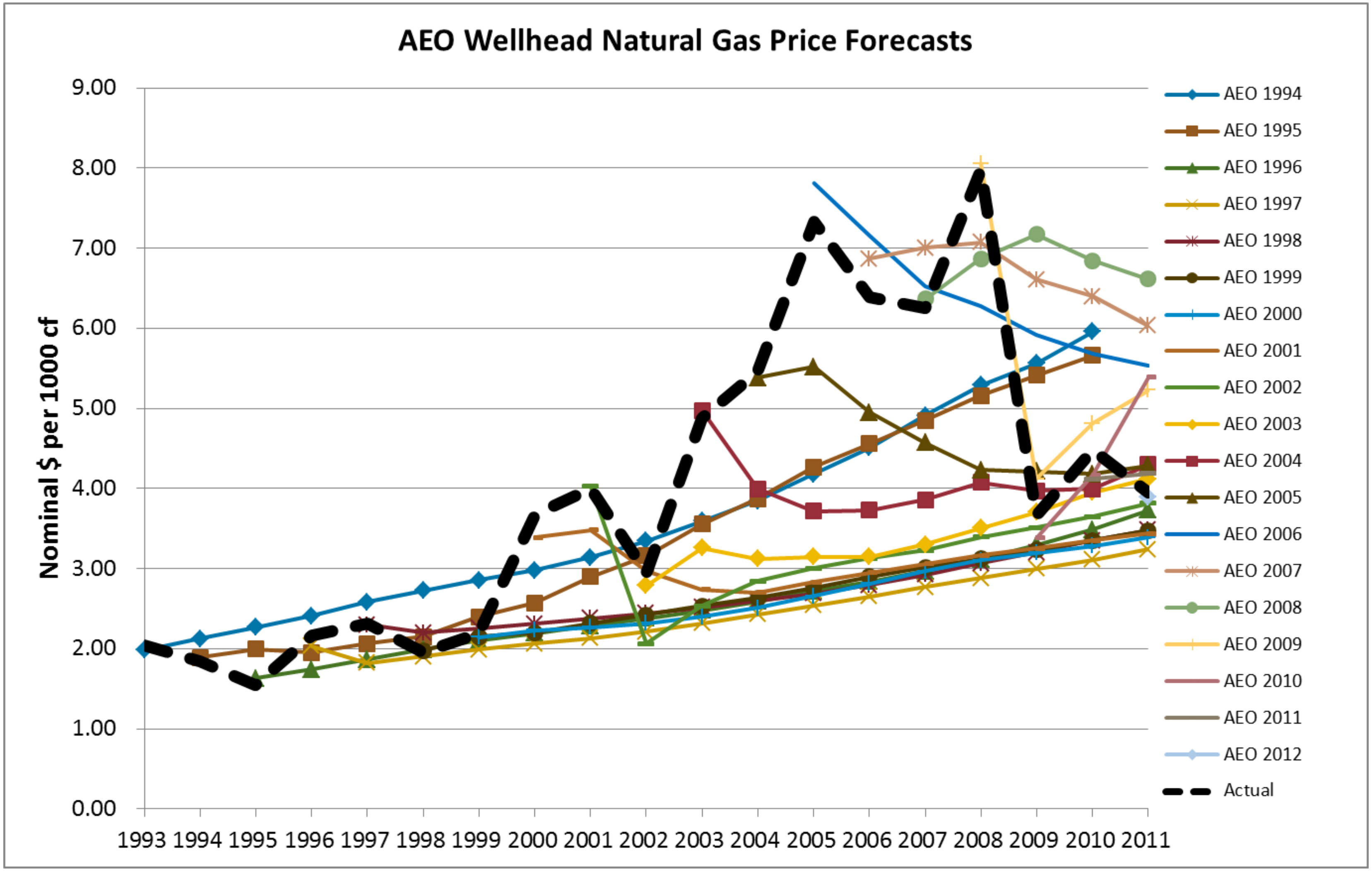
- Balance of cost versus risk
  - There are numerous "optimal" portfolios. Each has an optimal expect cost for a given risk level





3. Key Terms and Concepts

- How reliable are forecasts?



3. Key Terms and Concepts

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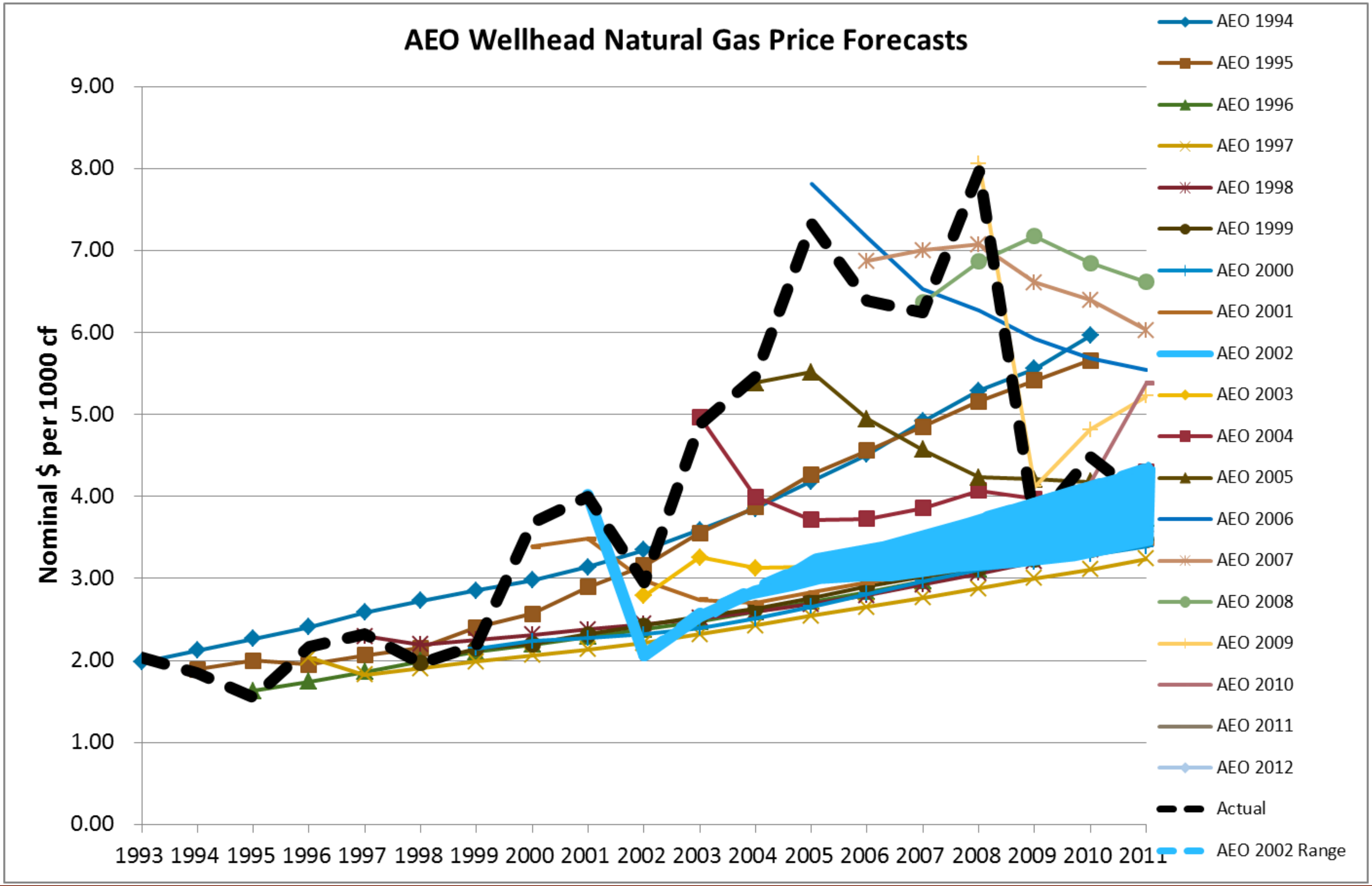
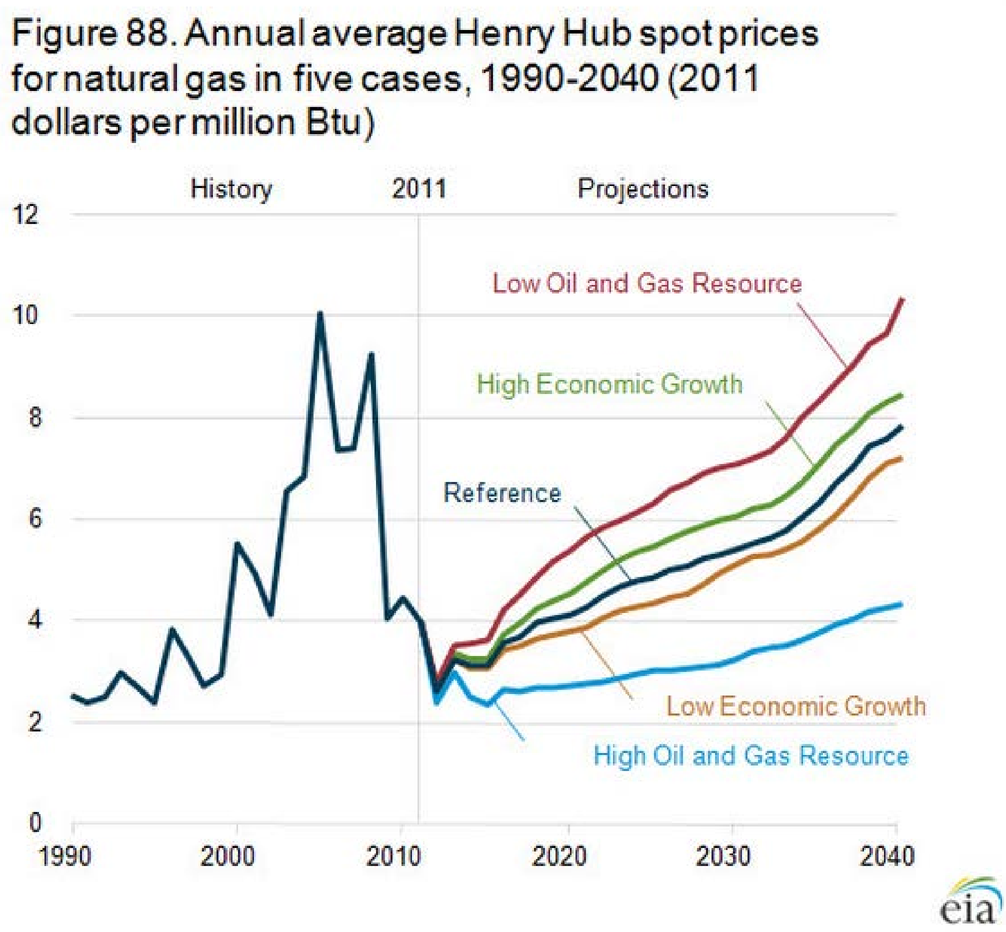


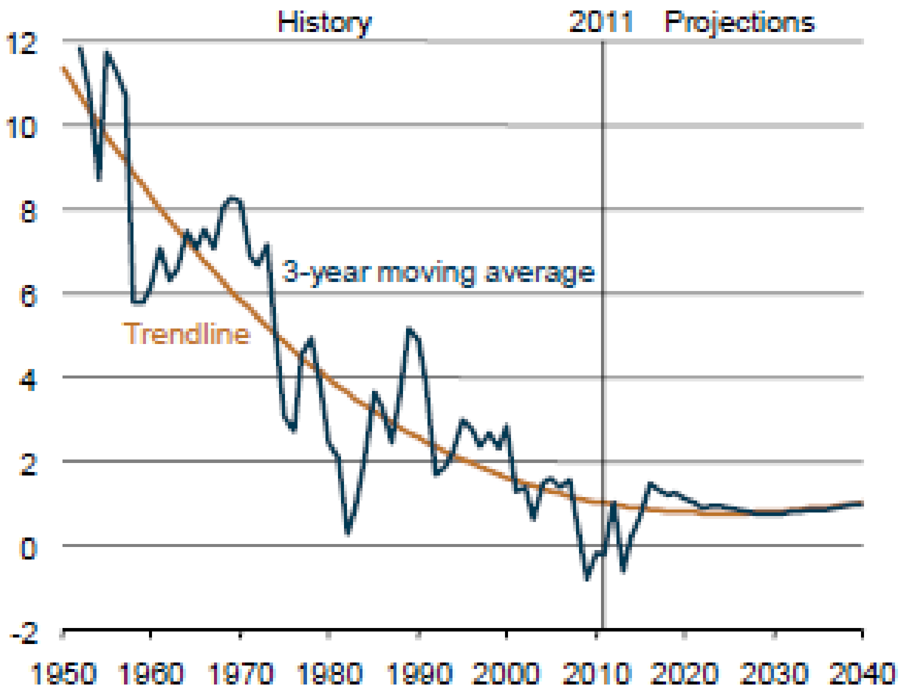
3. Key Terms and Concepts

- Volatility vs long term trends

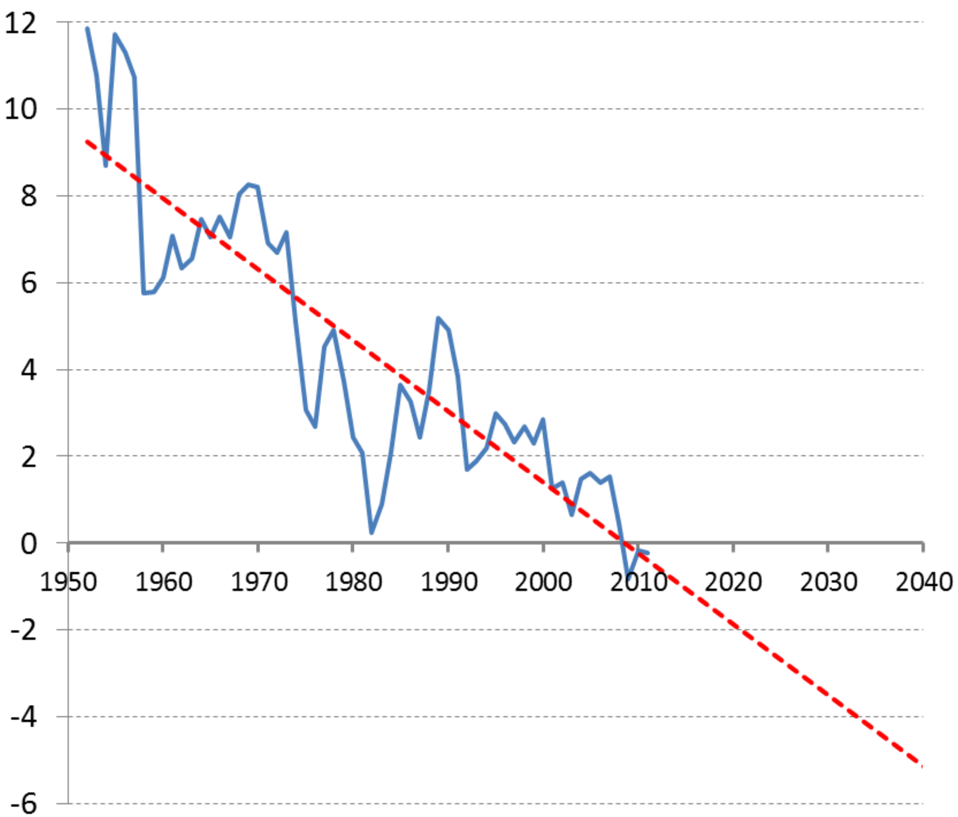


- How will national electricity demand change in the future?

Figure 75. U.S. electricity demand growth, 1950-2040 (percent, 3-year moving average)

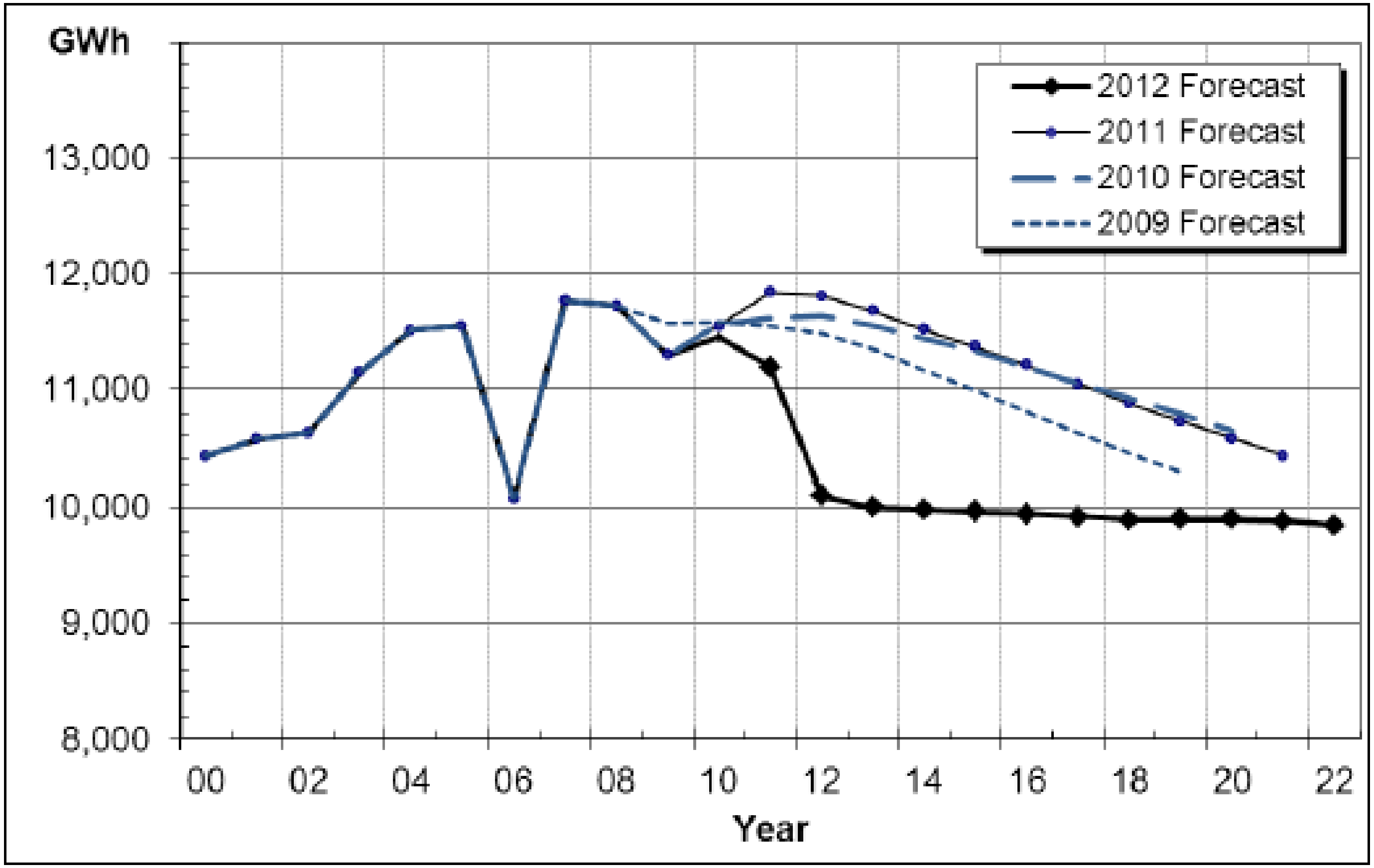


Linear trendline



3. Load Forecasting

- Is loss of a major customer a concern?
- Nova Scotia Energy Sales Forecasts



- Perception – how do human brains conceive and process risk?

Why buy insurance?

- The average U.S. house has a fire every 350 years
  - 0.3% probability per year of a residential fire
  - Almost all homeowners have fire insurance
- Annual probability of death is below 1% until age 61
  - Probability of death is under 0.2% until 40
  - Most young parents have life insurance

3. Key Terms and Concepts

- How much reliability do you need?
- How much are you willing to pay for it?

3. Key Terms and Concepts

- Perspectives on Risk (Ceres)

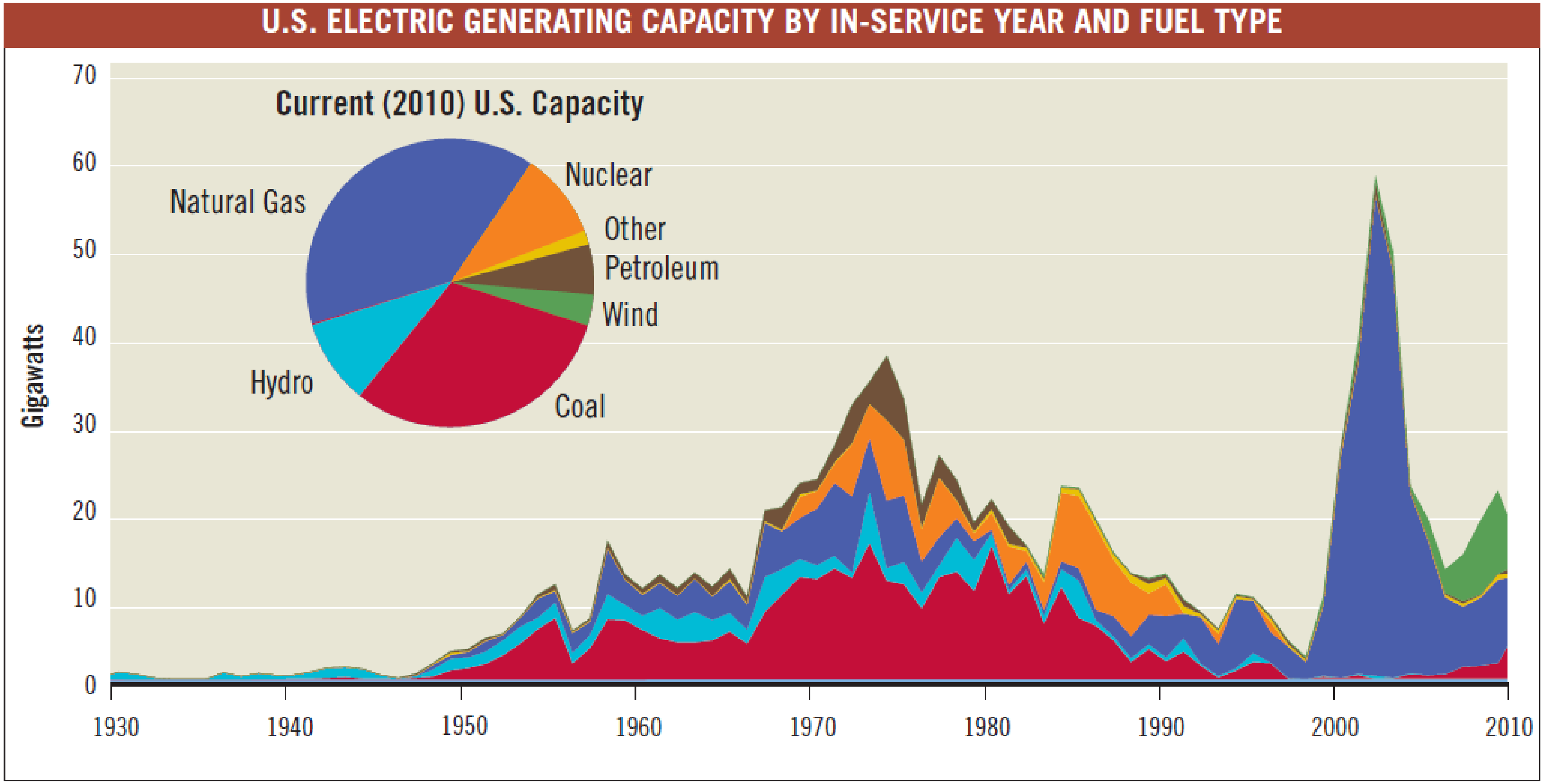
- Cost Risks: Construction cost, fuel cost, cost of capital
- Time Risks: Construction delays, env. rule changes

Perspectives on Risk

Risk means different things to different stakeholders. For example:

- For **utility management**, risks are a threat to the company's financial health, its growth, even its existence; a threat to the firm's competitiveness, to the firm's image, and to its legacy.
- For **customers**, risk threatens household disposable income, the profitability of businesses, the quality of energy service, and even comfort and entertainment.
- **Investors** focus on the safety of the income, value of the investment (stock or bond holders), or performance of the contract (counterparties). In addition, investors value utility investments based on their expectations of performance.
- **Employees** are uniquely connected to the utility. Their employment, safety and welfare is directly related to their company's ability to succeed and to avoid financial catastrophes.
- **Society generally** has expectations for utilities ranging from providing reliable, universal service, to aiding in economic development, to achieving satisfactory environmental and safety performance. Risk threatens these goals.

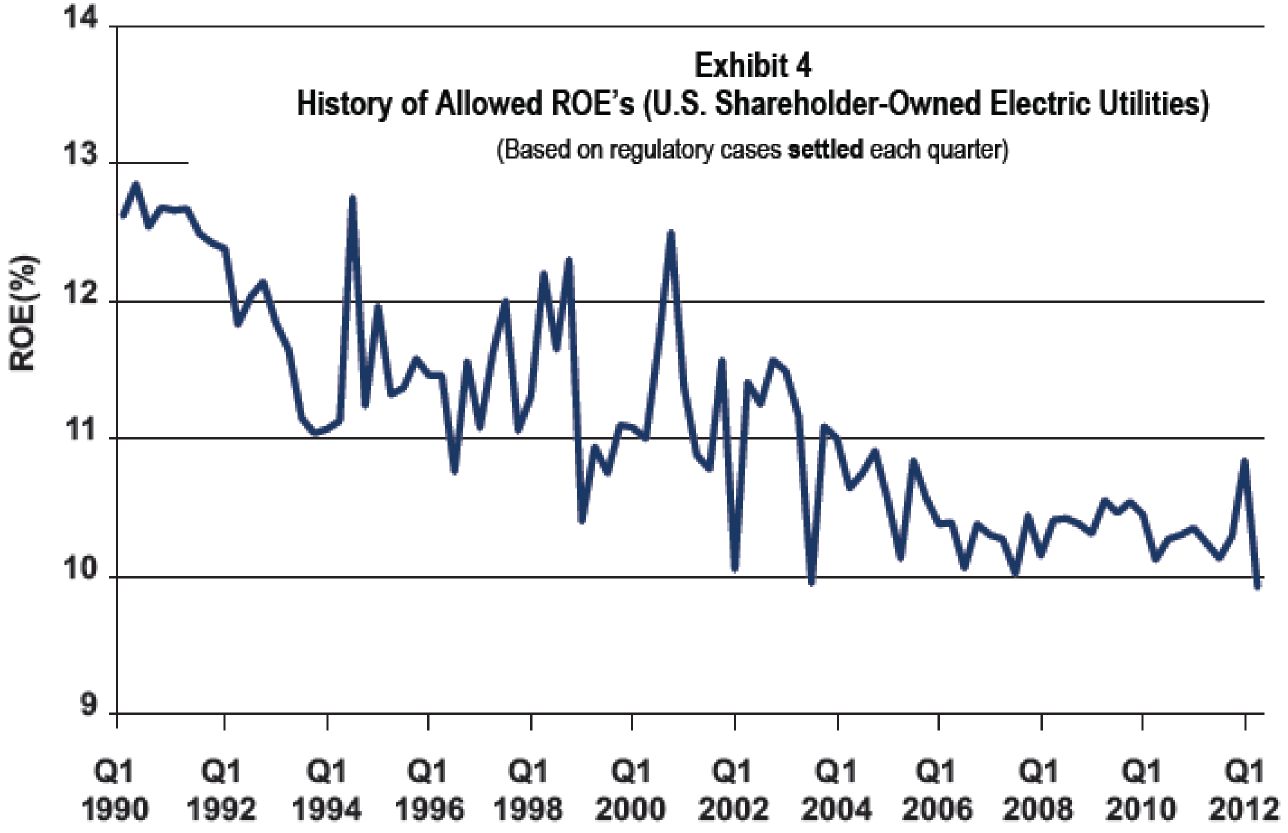
3. Key Terms and Concepts



Ceres 2012

3. Key Terms and Concepts

- Reducing vs Managing Risk
  - Utilities manage earnings per share, regulatory risk
    - ✓ "The new potential risk to utility investors from disruptive forces is the impact on future earnings growth expectations"



EEI 2013

Estimating capital costs for large projects

Edward Merrow

"Understanding the Outcomes of Megaprojects"

- **Scope**: Poor project definition is the source for most faulty cost estimates
- For long projects, **economic assumptions** are crucial; a small error in the assumed inflation rate can result in large changes in expenditures
- **Project execution**: can lead to higher costs than necessary, but rarely the primary source of cost growth

Well educated people tend to be overconfident in estimates

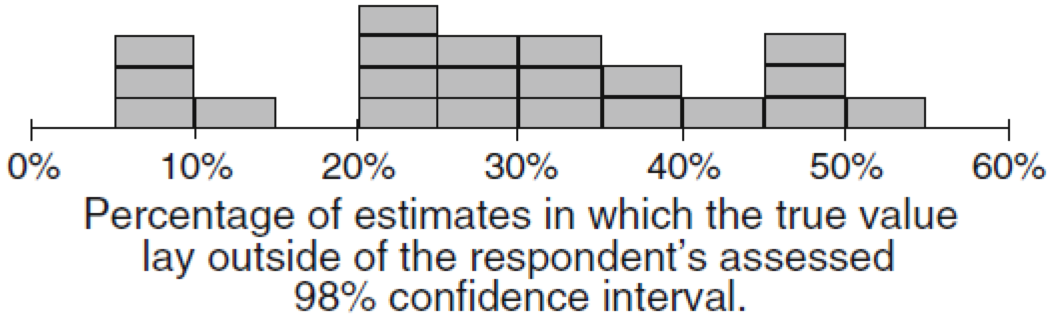


Fig. 6 Illustration of overconfidence in probabilistic judgments. In 21 separate studies, well-educated people were asked to make judgments about the value of a large number of known quantities (such as the length of the Panama canal). They were also asked to provide a 98% confidence interval on those judgments. The histogram reports the proportion of the time that the true answers lay outside the 98% confidence interval the respondents had given, which, of course, should have been 2% (each box in the histogram reports the results of a separate study, several of which had more than 1,000 participants). Histogram constructed from data summarized in Morgan and Henrion (1990)

Granger Morgan (2007) "Improving the way we think about projection future energy use and emissions of carbon dioxide"

3. Key Terms and Concepts

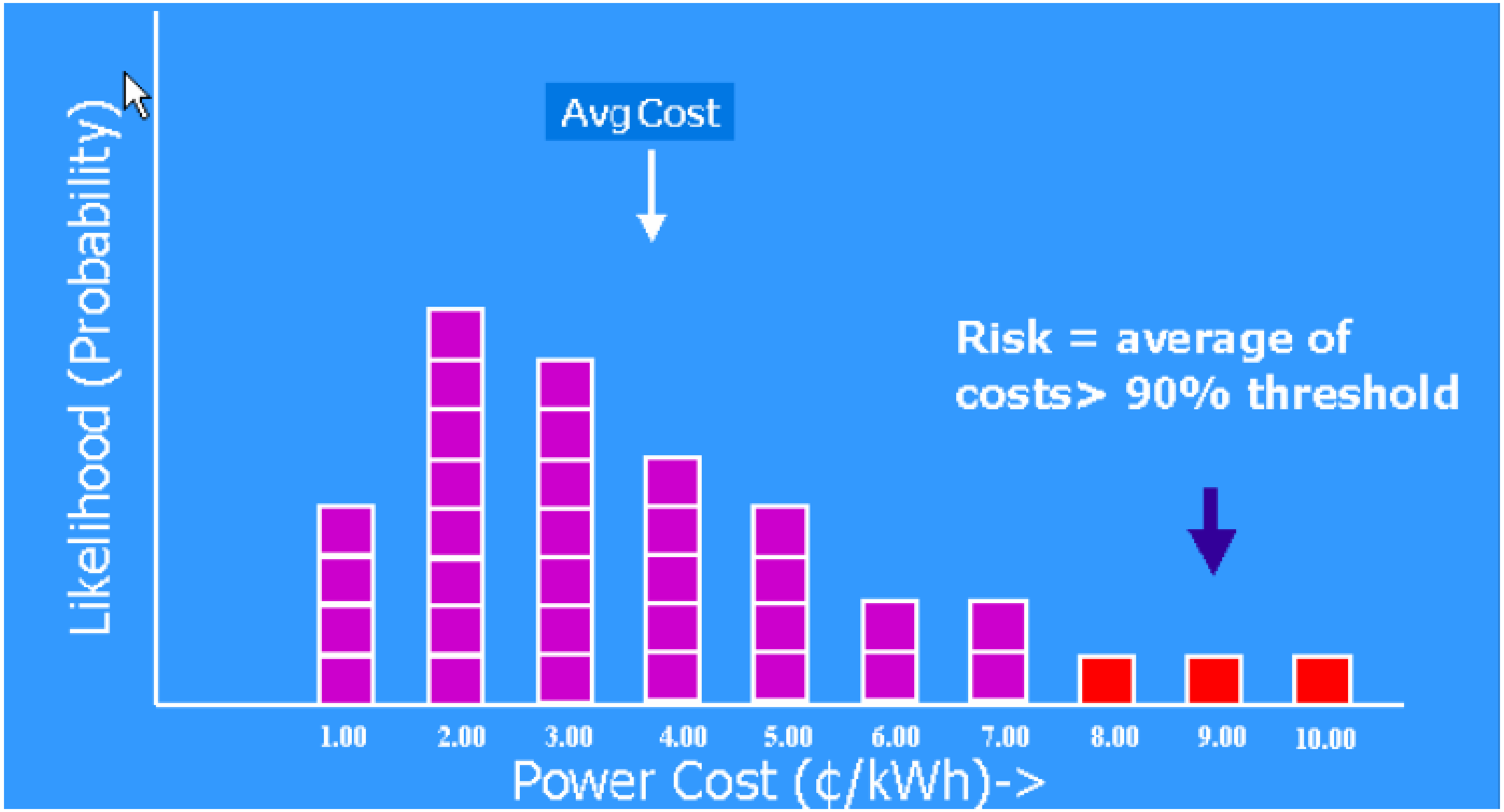
A Few of the Numerous Possible Measures of Risk	
Coefficient of Variation	Measures variation in price relative to mean price over a defined period. For example a fixed price would have a CV of 0.
Beta	Measures volatility of portfolio relative to volatility of an index. Does not capture risk of the portfolio independent of market risk.
Extreme Value	Measures the difference between expected cost and some estimate of worst-case cost.
Value at Risk	The maximum reduction in value (or increase in supply cost) that could occur over a specified period at a given confidence level.

3. Key Terms and Concepts

- VaR can be used to measure the cost increase that has a certain probability of occurring (risk level) during a certain time period
- For example the VaR for a 1 year horizon at the 85% level is the extra cost a portfolio has a 15% chance of incurring over the next year
- Inputs to calculation of VAR of a portfolio
  - Estimations of correlation and volatility
  - Probability distributions (Representative distributions can be created using Monte Carlo simulation and other methods).

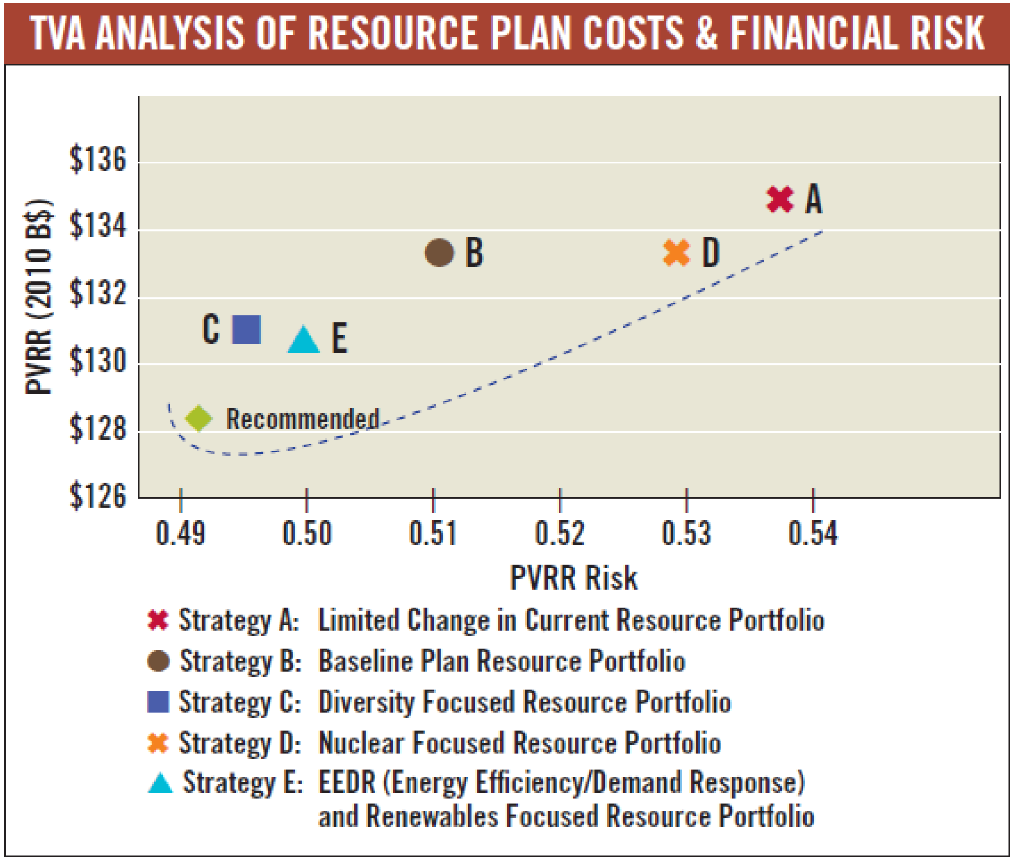
3. Key Terms and Concepts

TailVaR_{90} used in the Northwest



3. Risks versus Costs

- Efficient frontier of cost and risk analysis



Ceres 2012

3. Key Terms and Concepts

- Classifying Risks

"There are known knowns; there are things we know that we know. There are known unknowns; that is to say, there are things that we now know we don't know. But there are also unknown unknowns – there are things we do not know we don't know."

- Donald Rumsfeld

4. KEY RISKS IN THE ELECTRIC INDUSTRY

4. Key Risks in the Electric Industry

What do you see as the key risks you face as regulators?

4. Key Risks in the Electric Industry

- Every decision has risks because they impact future events, some of which are known and others which are unforeseen.
- These “decision risks” impact utilities, consumers, other stakeholders and the commission in the court of public opinion.
- Decisions involving risk affect costs, reliability and service adequacy and more.

4. Key Risks in the Electric Industry

Examples of Risk Include:

- Grid Reliability – Weather, Storms and Outages
- System Reliability and Generation Adequacy
- Fuel Price Volatility and Uncertainty
- Environmental Regulation Risk
- Load Uncertainty
- Technology Evolution and Obsolescence risk

4. Key Risks in the Electric Industry

More Examples of Risk Include:

- Market Risk
- Transmission Risk
- Construction of New Generation Risk
- Power Plant Operational Risk
- Economic and Demographic Swings
- Utility Credit Risk
- Regulatory Risk

5. GENERAL STRATEGIES FOR ADDRESSING RISK

5. General Strategies for Addressing Risk

1) Practice "Risk-Aware" regulation.
   - Explicitly acknowledge risks inherent in specific decisions.
   - Gather information relevant to understanding risk.
   - Conduct analyses to best understand risk and its implications.
   - Make informed decisions that reflect understanding of risk.
   - Recognized what is being balanced against what.
     - ✓(e.g., reliability versus cost).
2) Employ transparent ratemaking practices.
   - Recognize that regulatory decisions create utility incentives, which have risk implications.
   - Recognize ratemaking options that can reduce risks to all; shift risks from one party to another; or both.
   - Hold utilities accountable. Utilities are often in the best position to address risk.

5. General Strategies for Addressing Risk

3) Diversify utility supply portfolios.
   - Same concept as financial portfolio diversification.
   - Diversify across many factors: fuel types; generator types; generator sizes; generator ages; generator locations; ownership versus contracts; demand-side (efficiency, demand response, distributed generation); etc.
   - Include hedges, both physical and financial.

4) Utilize robust planning practices.
   - (See following slides).

6. ROBUST PLANNING PRACTICES

6. Robust Planning Practices

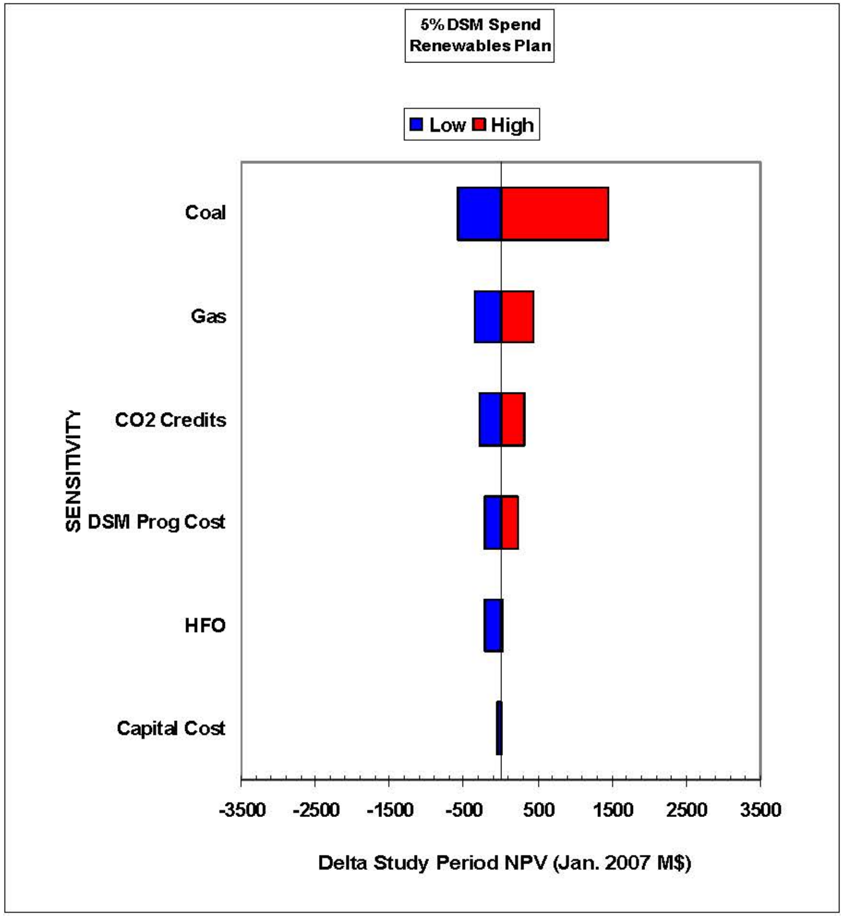
- Key tools for recognizing risk in planning
  - Sensitivity Analysis
  - Scenario Analysis
  - Probabilistic Simulations

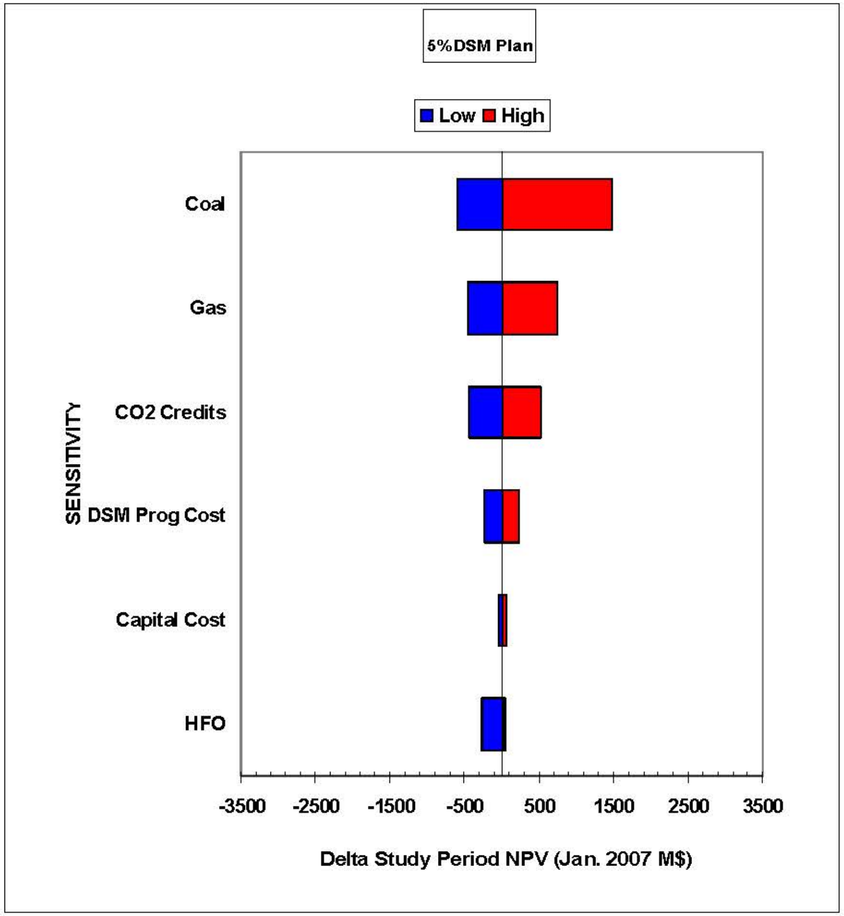
6. Addressing Risk - Sensitivity Analysis

- **Sensitivity Analysis**: Develop an optimal "resource plan" for "expected conditions", subject it to various exogenous drivers, and see how the plan performs in those scenarios
  - Drivers include high & low forecasts for uncertain projections such as demand, fuel prices, environmental regulations, and construction costs
  - Typically only one input assumption is altered at a time (sometimes two or three, but then planner must address ? of correlation
- *Strengths*: Straightforward to implement, provides considerable understanding to planners/decision makers
- *Weaknesses*: Doesn't typically allow for mid-course modifications of plan and thus can result in unrealistic scenarios.
- *Challenges*: Developing input assumptions for extreme cases, interpreting results

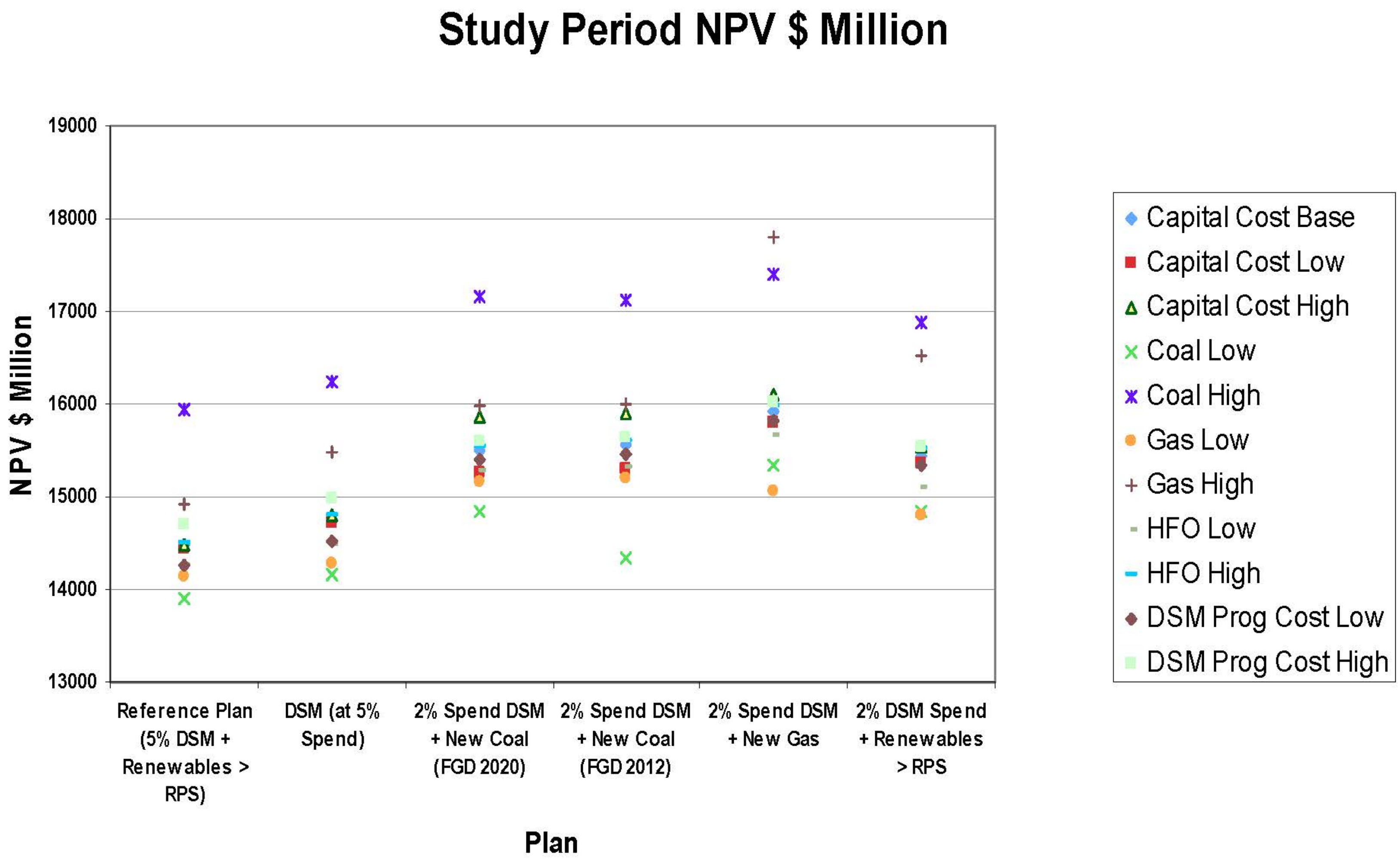
6. Addressing Risk - Sensitivity Analysis

- Example sensitivity analysis





6. Addressing Risk - Sensitivity Analysis



6. Addressing Risk – Scenario Analysis

- **Scenario Analysis**: Developing optimal resource plans for a set of different "futures", by selecting resource options based on what is best for each future
- *Strengths*: Allows for mid-course modifications, variables move together to tell a consistent story
- *Weaknesses*: A preferred resource plan (or set of resource options) may not emerge. Which "scenario" is the right one to use for planning?
- *Challenges*: Developing a reasonably consistent set of input assumptions for key drivers

6. Addressing Risk – Scenario Analysis

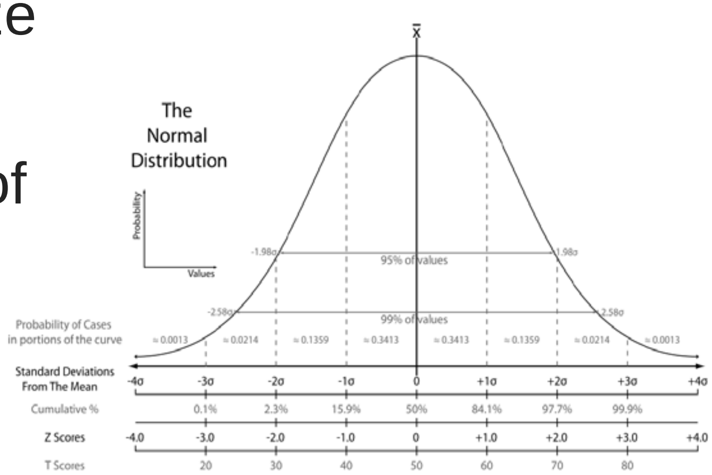
- HI IRP Example

Cost Driver	1. Blazing a Bold Frontier	2. Stuck in the Middle	3. No Burning Desire	4. Moved by Passion
Economic Conditions	Slow Growth	Moderate Growth	Strong Growth	Moderate Growth
Renewable Portfolio Standards (RPS) Energy Regulations	Raised: 2020 at 30% 2030 at 60%	Status Quo: 2020 at 25% 2030 at 40%	Lowered: 2020 at 20% 2030 at 30%	Status Quo: 2020 at 25% 2030 at 40%
Electricity Demand				
♦ *Underlying Economic Sales & Peak (pg 12)*	Low	Medium	High	Medium
♦ *Customer Renewable Self-Generation (pg 18)*	Very High	Medium	Low	High
♦ *Energy Efficiency Portfolio Standards–EEPS (pg 21)*	Exceeded 110% of Base	Partially Achieved 75% of Base	Partially Achieved 75% of Base	Achieved 100% of Base
♦ *Electric Vehicles (pg 25)*	High	Medium	Low	Medium
Construction Cost Escalation Rate (pg 28)	General: 3% Renewables: 0%	General: 3% Renewables: 3%	General: 3% Renewables: 3%	General: 3% Renewables: 2%
Fuel Supply & Prices (pg 29)				
♦ *Oil*	High Forecast	Reference Forecast	Low Forecast	Reference Forecast
♦ *Biofuels*	Low Forecast	High Forecast	High Forecast	High Forecast
♦ *LNG*	High Forecast (high forecast for neighbor islands)	Reference (high forecast for neighbor islands)	Reference (high forecast for neighbor islands)	Reference (high forecast for neighbor islands)
Energy Incentives	Continue	Gradually phased out by 2016	End 2014	Continue
Greenhouse Gas Regulations	CO_2: $100/ton	CO_2: $0	CO_2: $0	CO_2: $25/ton
Operating Costs	Escalate at 1.87%	Escalate at 1.87%	Escalate at 2%	Escalate at 1.87%

6. Addressing Risk – Probabilistic Simulations

- **Probabilistic Simulations**: Characterize input assumptions as distributions to recognize volatility and/or uncertainty. Could be low/med/high case forecasts of exogenous variables with probabilities attached

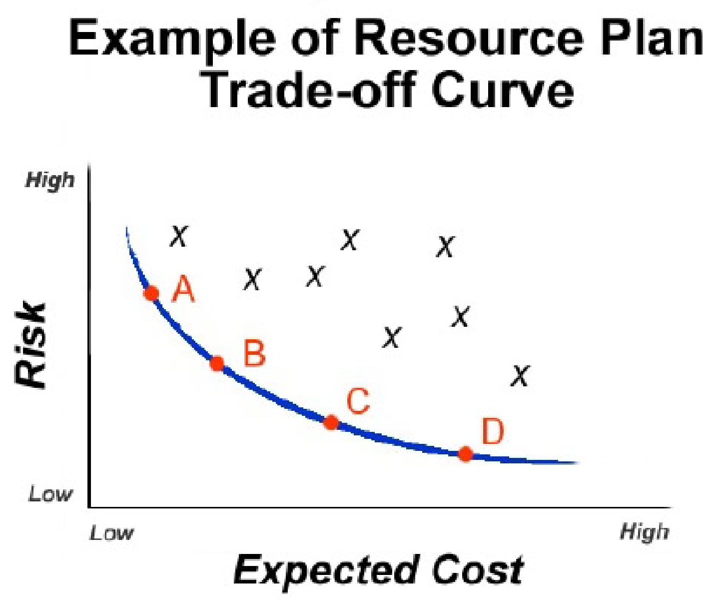
CO_2 Forecast	Low	Ref	High
Probability	30%	40%	30%

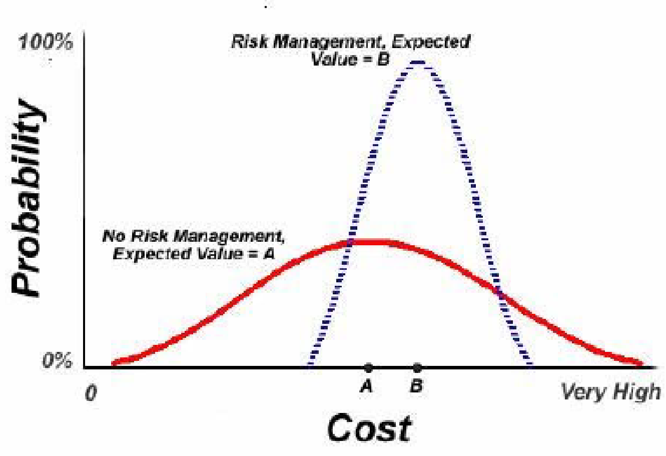


- *Strengths*: Can provide a quantitatively rigorous way of incorporating uncertainty, and can produce common statistical metrics (TVaR 90 etc)
- *Weaknesses*: Can be time consuming, requires planners to develop additional input assumptions for which there may be little quantitative basis, and results can be difficult to interpret

6. Addressing Risk – Probabilistic Simulations

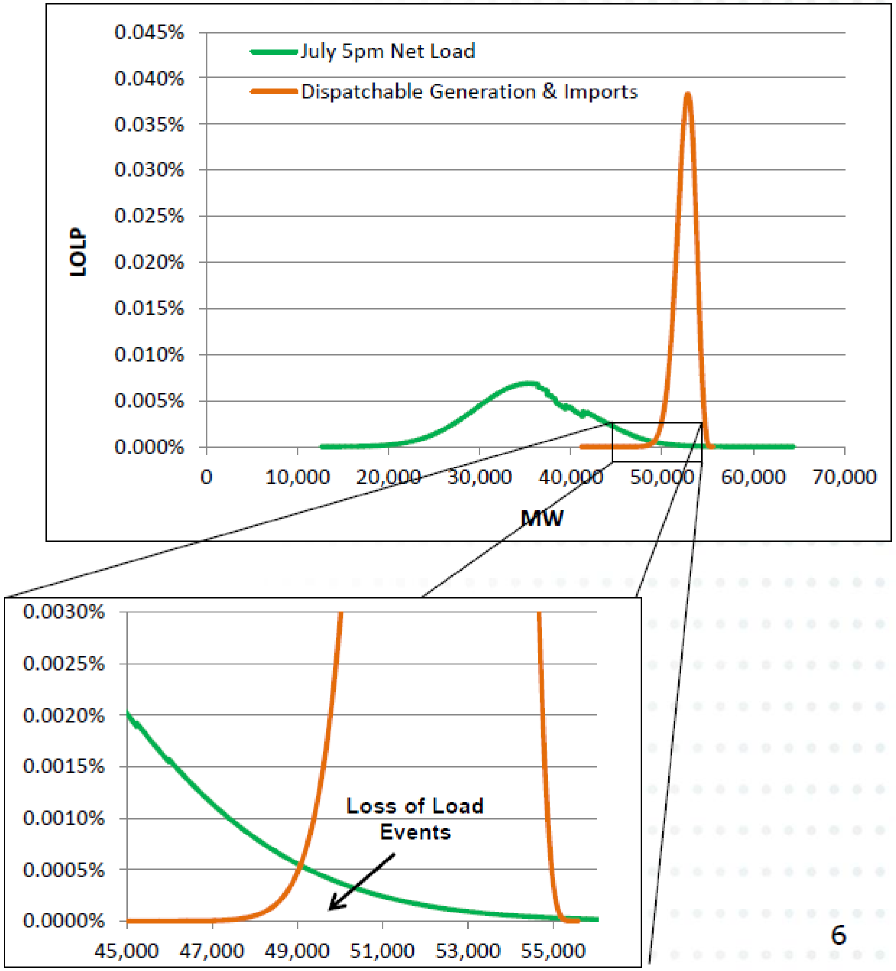
- There are numerous "optimal" portfolios. Each has an optimal expect cost for a given risk level





6. Addressing Risk – Probabilistic Simulations

- CA LTTP
  - LOLP is crossover of dispatchable generation and net load (after renewables)
  - Correlation among stochastic variables enforced



	Load	Load Ramp	Wind Gen	Solar Gen	Hydro Gen	RegU	LFU
Load	1	0.2884	-0.0947	-0.1997	0.4302	0.3801	0.0722
Load Ramp	0.2884	1	-0.3782	0.6156	0.0779	0.2064	-0.3193
Wind	-0.0947	-0.3782	1	-0.1618	0.2855	-0.0108	0.0609
Solar	-0.1997	0.6156	-0.1618	1	0.0254	-0.1101	-0.5064
Hydro	0.4302	0.0779	0.2855	0.0254	1	0.3094	-0.1283
RegU	0.3801	0.2064	-0.0108	-0.1101	0.3094	1	0.1415
LFU	0.0722	-0.3193	0.0609	-0.5064	-0.1283	0.1415	1

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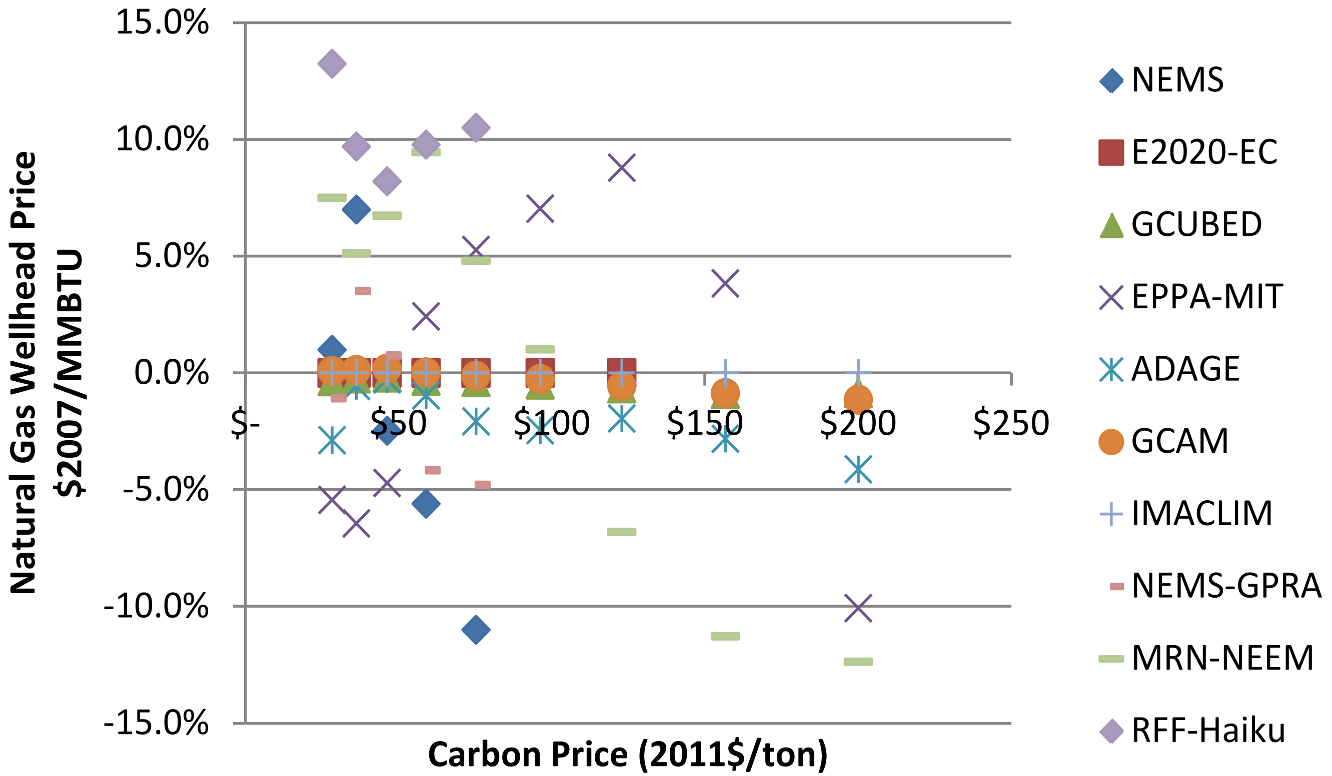
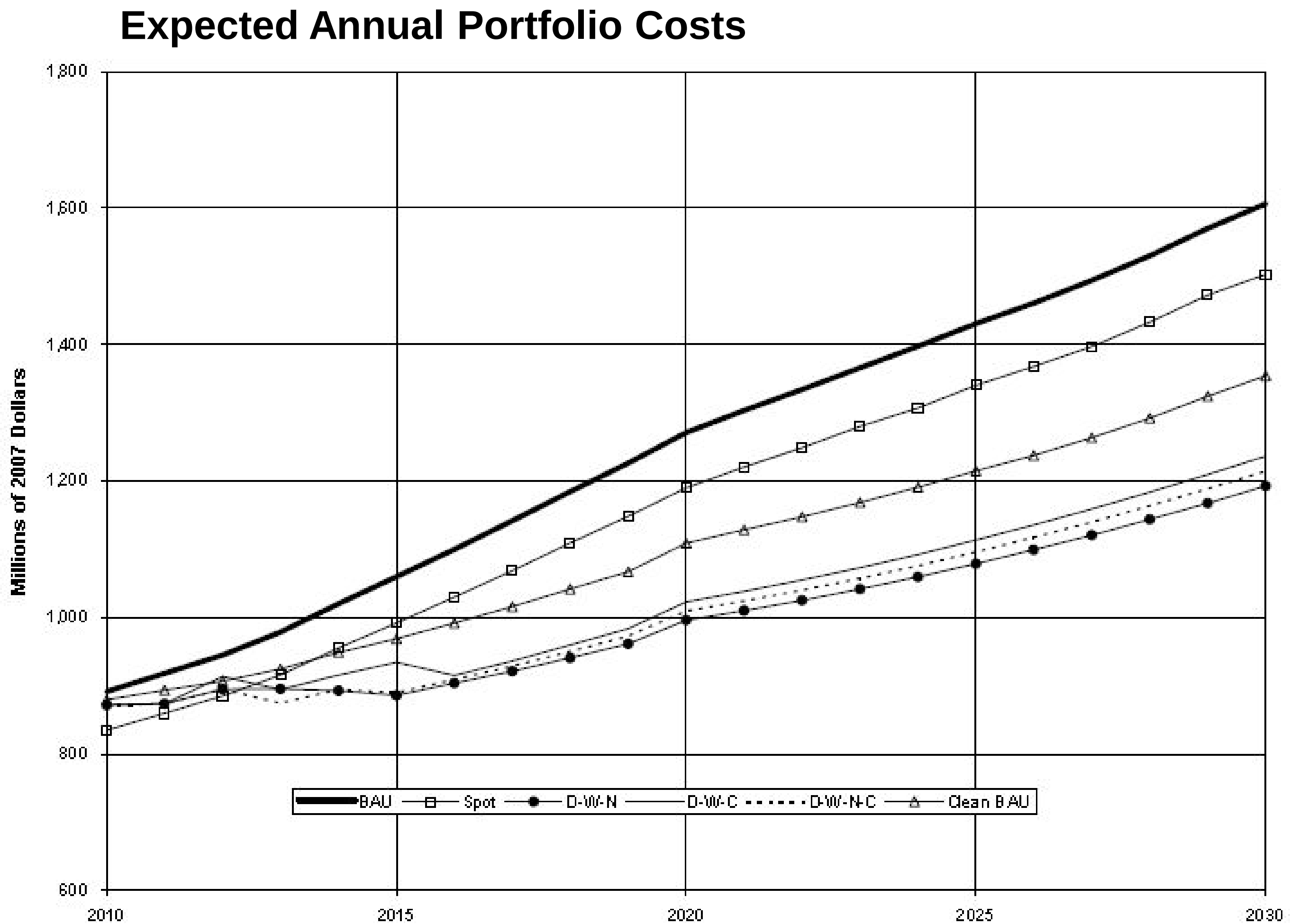
6. Addressing Risk – Probabilistic Simulations

- Correlations not always clear



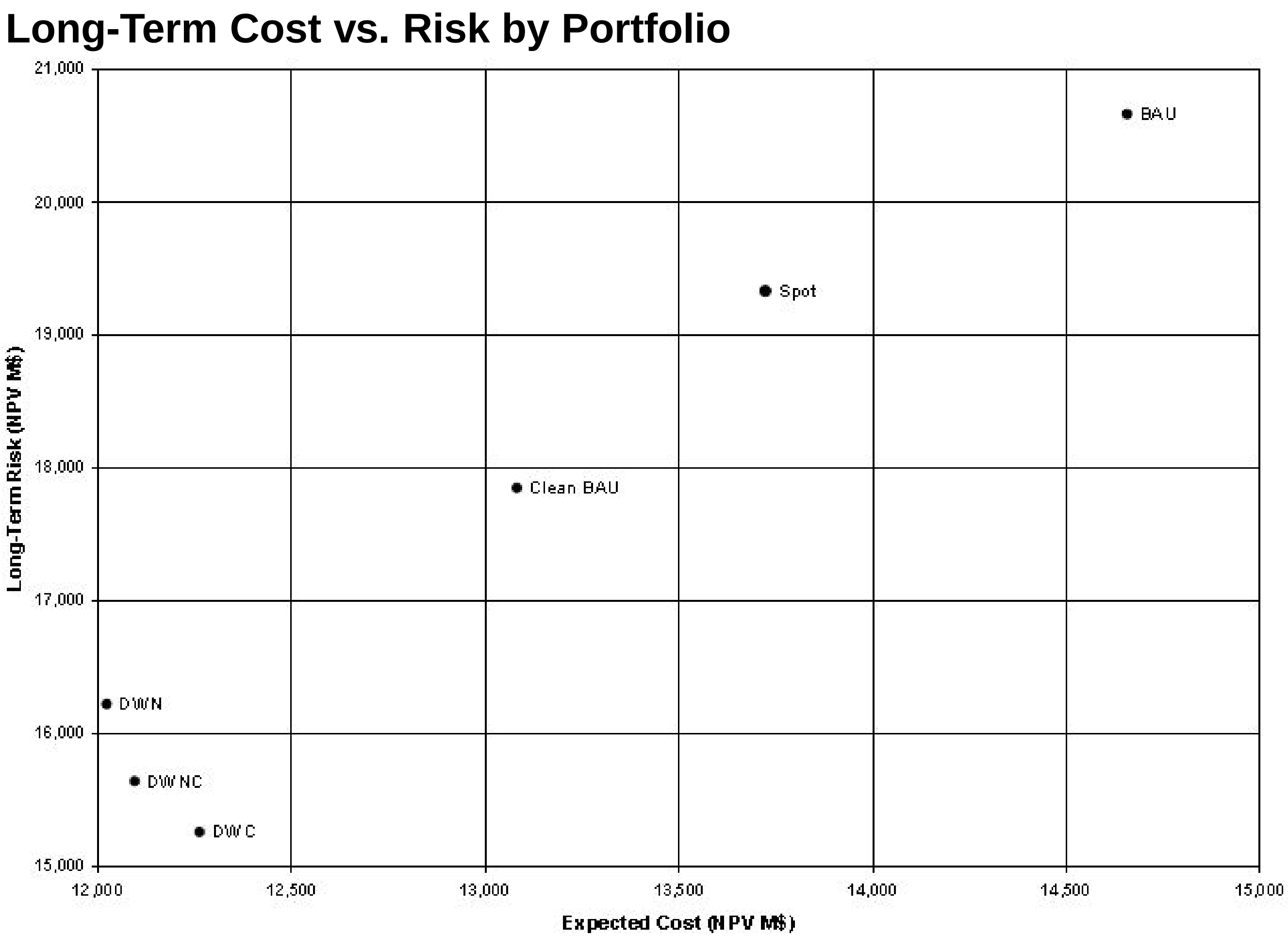
Fischer 2013, Testimony before Wisconsin PSC

6. Addressing Risk – Probabilistic Simulations (Ohio)



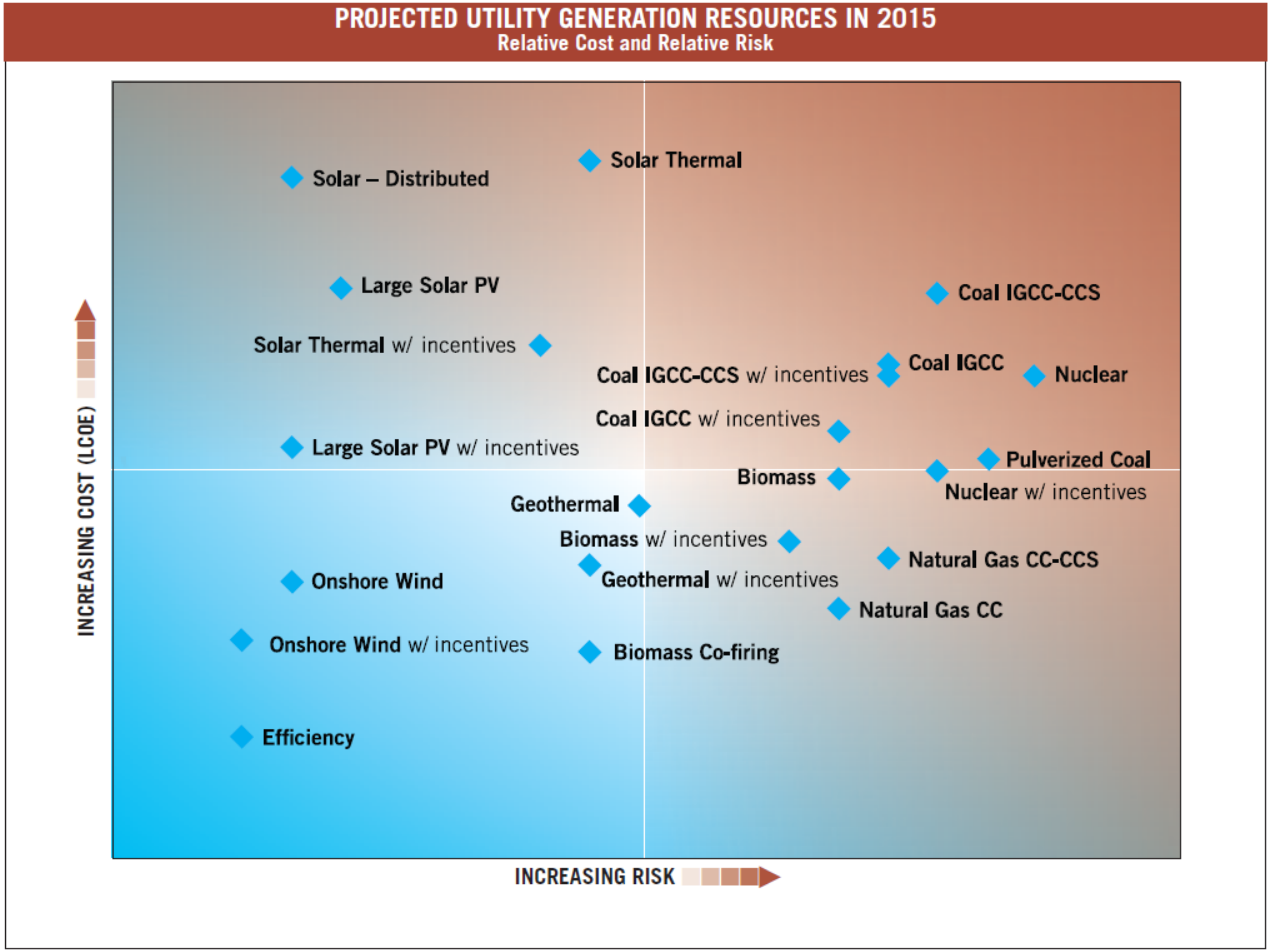
Source: Chernick, et al. 2008

6. Addressing Risk – Probabilistic Simulations (Ohio)



Source: Chernick, et al. 2008

6. Risk Associated With Different Resource Types



Ceres 2012

7. OVERVIEW OF RISK IN RESTRUCTURED ELECTRICITY INDUSTRIES

7. Risks in Restructured Electricity Industries

Restructured electricity markets result in a different landscape of risks, relative to a vertically integrated system.

- Some of the risk associated with generation plants are shifted from customers and utilities to the generation companies.
  - Construction costs, capital expenditures, financial risk, siting, permitting, environmental regulations…
- Generation companies are well equipped to address risks.
  - Perhaps better equipped than utilities.
- However, generation companies only account for their own individual risks; they are not concerned with electricity system-wide risks, e.g., system reliability, system fuel diversity.

7. Risks in Restructured Electricity Industries

- Many risks to utilities and their customers remain in restructured industries:
  - Reliability, fuel price volatility, load uncertainty, environmental regulations, transmission needs, technological evolution and obsolescence.
- Wholesale electricity markets create new risks to utilities and their customers:
  - Jurisdictional Authority. Increased FERC role and reduced state role.
  - Reliability. Will the capacity market deliver sufficient resources in time to meet demand?
  - Volatility.
    - ✓ Short-term: peak vs. off-peak.
    - ✓ Long-term: boom and bust cycles.
  - Cost. Will the market outcomes result in lowest cost?
  - Regulatory risk. Uncertainty created by changes to market design over time.
  - Accountability. Between the different market actors, the ISO, the FERC and state regulators - will all of the elements of the market be adequately addressed?

7. Risks in Restructured Electricity Industries

- Meanwhile, planning-based approaches to addressing risk are less relevant and effective.
  - Many states abandoned IRP practices upon restructuring.
  - ISOs are typically resistant to applying IRP practices.
- Regulators may have less control over key issues:
  - Planning in general.
  - Technology choice.
  - Fuel choice and fuel diversity.
  - Physical or financial hedges.
  - Regulators become advocates, not decision-makers.
- Other mechanisms, practices, policies may be needed to address risk in specific contexts.
  - Some of these mechanisms may be more important in restructured electricity systems, relative to traditional systems.

8. ADDRESSING RISKS IN SPECIFIC CONTEXTS

8.1 REGULATION AND RESTRUCTURING

RATEMAKING

8.1 Regulation and restructuring: Ratemaking

- **Rate Design**:
- Rate Design is an indicator of policy
- Risk of miscalculating rate design can cause unintended consequences:
  - Inter or Intra-class subsidies
  - Rate shock and customer backlash
  - Failure to send appropriate price signals causing reliability concerns at peak periods and increasing system costs
  - Failure to address the circumstance of low use and low-income customers

8.1 Regulation and restructuring: Ratemaking

- **Future v. Historic Test Years**
- Importance of balancing and weighing risks associated with regulatory circumstances:
  - Future Test Year – Risk regarding accuracy of data used to set rates
  - Historical Test Year – Risk that data will not be reflective of actual costs resulting in the need for more frequent rate cases or riders between cases

8.1 Regulation and restructuring: Ratemaking

- **Riders:**
- Riders present utilities with the opportunity to recover costs with minimal delay. Doing so reduces potential carrying costs.
- Riders prevent the opportunity to net cost decreases with the increases requested resulting in the risk of customers over-paying.
- Risks include transparency and accuracy/verification of costs, customer confusion with bills and reduced accountability

8.1 Regulation and restructuring: Ratemaking

- **Decoupling:**
- Decreases utility risk for insufficient revenues due to energy efficiency and renewable energy
- Issue of whether to reduce pro-actively the utility's ROE due to reduced risk is sometimes raised by consumer groups
- Failing to address the through-put incentive can thwart EE policy objectives.

8.1 Regulation and restructuring: Ratemaking

- **ROE Implications:**
- The establishment of the ROE sends an important message as the Commission's assessment of the utility's performance and the fairness of the profit level that customers should pay to compensate the utility.
- The ROE is carefully reviewed by rating agencies and can impact the bond rating of a utility. The better the rating the better the interest rate for borrowing.
- Customers view the ROE as an equity issue to reward or penalize a utility based on performance or changes in utility risk.
- The risk conundrum is that if regulators lower the return due to poor performance it could increase the cost of borrowing. Regulators need to assess how much of that cost should be covered by customers.
- Conversely, failure to penalize the utility sends the wrong message that there is not penalty for poor performance and that customers will continue to be required to pay.

CUSTOMER EXIT

8.1 Customers Leaving the Grid

- As customers engage in EE or install generation in response to forecasted long-run prices for energy and/or for environmental reasons, the utility is at risk of not recovering sufficient revenues to meets its cost plus a return to pay for existing and future service and policy commitments
- Thus, utilities then file to increase rates to the remaining customers to cover these costs.
- As rates go up, the incentives to reduce reliance on utilities goes up as well risking a death spiral as more customers reduce their exposure to increased rates by reducing their reliance on the utility system.

- **Risks that regulators must balance:**
- Ensuring that the utility has sufficient revenues to operate the system reliably
- Providing price incentives for customers to install RE and participate in EE as part of a long-term IRP strategy
- Protecting the “have-not” customers who cannot afford the cost of RE from bearing the burden of the covering utility revenue requirements through increased rates

RETAIL MARKETS

8.1 Retail Markets

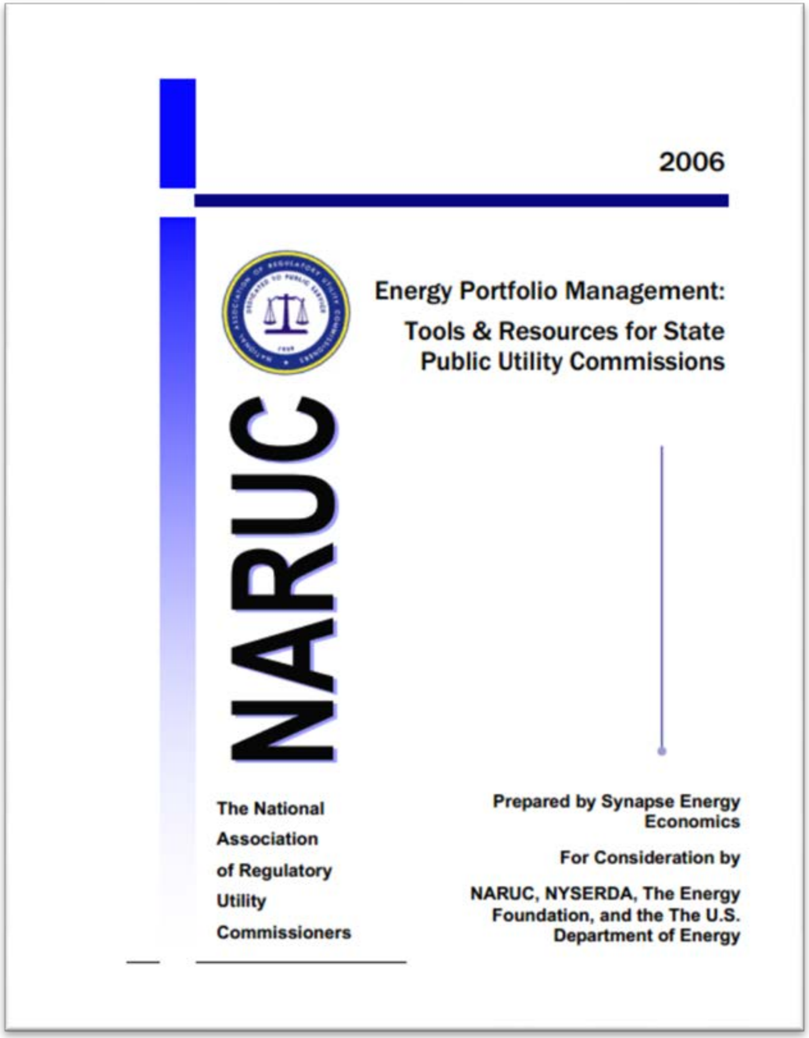
- Creating the right market structure is imperative to avoid the risk of having deregulated monopolies in an environment where regulators can no longer control prices.
- While not regulating prices, regulators can still exercise authority over the terms and conditions of service to ensure a fair competitive market with fluid access between suppliers and customers.
- Regulators can also regulate the conduct of suppliers without regulating price to avoid the risks of public discontent caused by bad marketer practices.
- If the structure and rules are not established correctly, there is a risk that customers will not get the best prices that they should.

8.1 Retail Markets

- Examples of Issues that can create barriers to competition:
- Lack of comprehensive codes of conduct and enforcement
- Market Power
- Operational Rules
- Customer Switching Rules
- Surety bonds, letters of credit, collateral
- Customer Nonpayment issues
- Customer Protections from Bad Actors – Regulation of the terms and conditions of service

BASIC SERVICE

- Conclusions from 2006 NARUC Energy Portfolio Management Report
  - Common approach to managing risk for default service is through defining and overseeing procurement process
  - Purchased power is a combination of
    - “legacy hedges”
    - Short term contracts
    - Spot purchases
    - Financial hedges
    - RFP’s
    - Auctions



2006

NARUC

Energy Portfolio Management:
Tools & Resources for State Public Utility Commissions

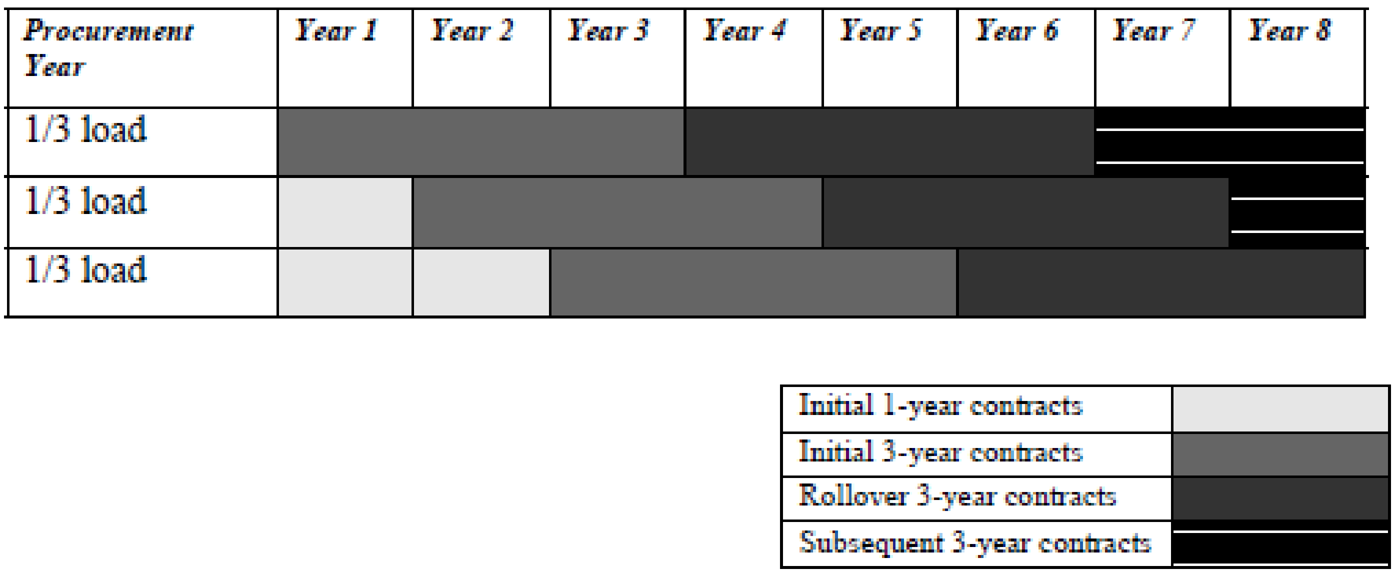
The National Association of Regulatory Utility Commissioners

Prepared by Synapse Energy Economics

For Consideration by

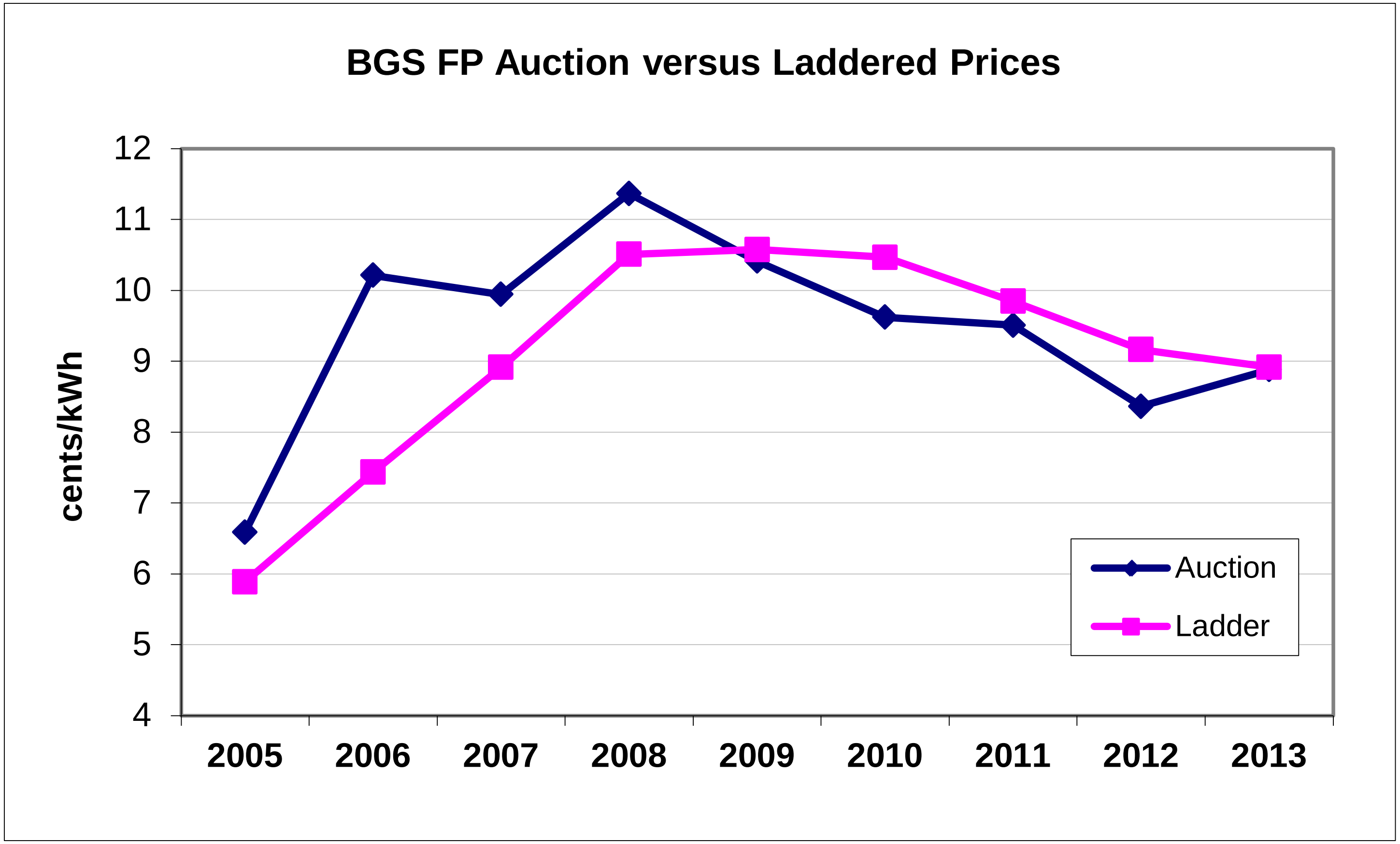
NARUC, NYSERDA, The Energy Foundation, and the The U.S. Department of Energy

- Portfolio management practices allow regulators to mitigate risks associated with basic service.
  - Laddering
    - ✓ Contract lengths vary from one to several years, with overlapping procurement up to every few months

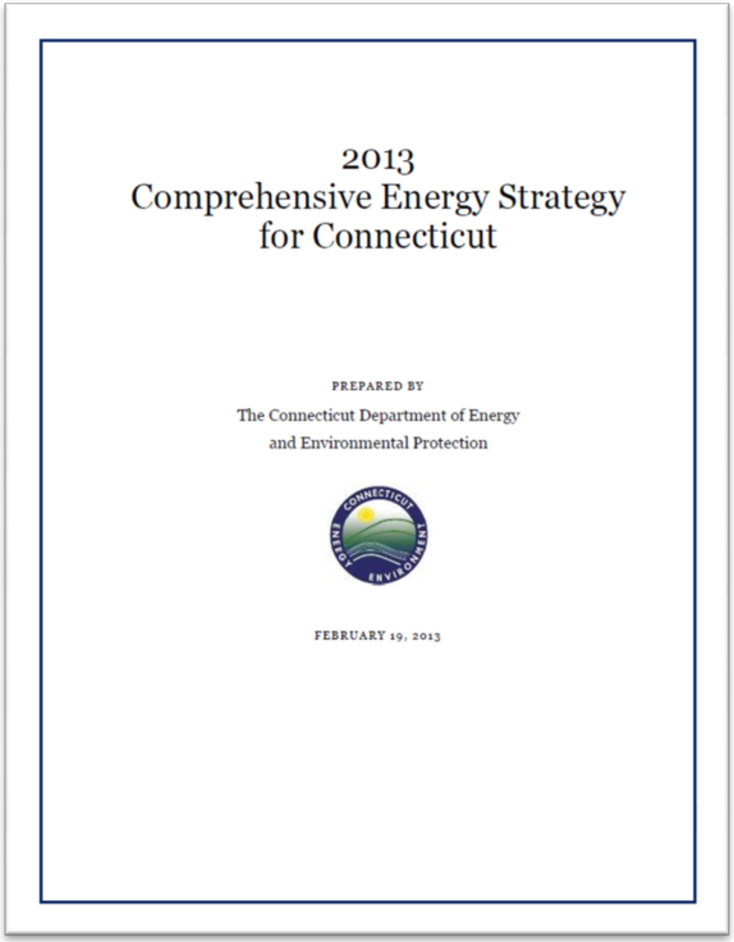


NARUC 2006 PM Report

- New Jersey Basic Service



- Beyond Laddering
  - Long term contracting as a hedge
  - Statewide energy planning (IRP)
  - Fuel diversity



2013
Comprehensive Energy Strategy
for Connecticut

PREPARED BY

The Connecticut Department of Energy
and Environmental Protection

FEBRUARY 19, 2013

8.2 FRONT-PAGE ISSUES

RELIABILITY AND OUTAGES

8.2 Reliability and Outages

- Value of lost load (VOLL) can range from $1,000/MWh for residential to >$10,000 for commercial and industrial

8.2 Reliability and Outages

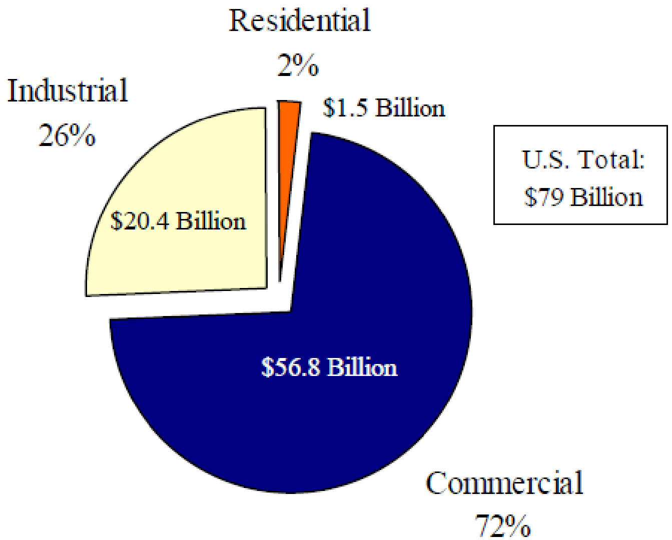
- Reliability of:
  - Generation
  - Transmission
  - Distribution

PGE SAIDI by event type

	Transmission	Distribution	Generation
2001	22	240	0.0
2002	42	358	0.6
2003	20	188	0.0
2004	23	182	0.3
2005	38	211	0.1
2006	30	251	0.0
2007	21	139	0.0
2008	38	378	0.3
2009	15	193	0.0
2010	26	220	0.0

PGE 2010 Annual Electric Distribution Reliability Report

8.2 Reliability/Outages

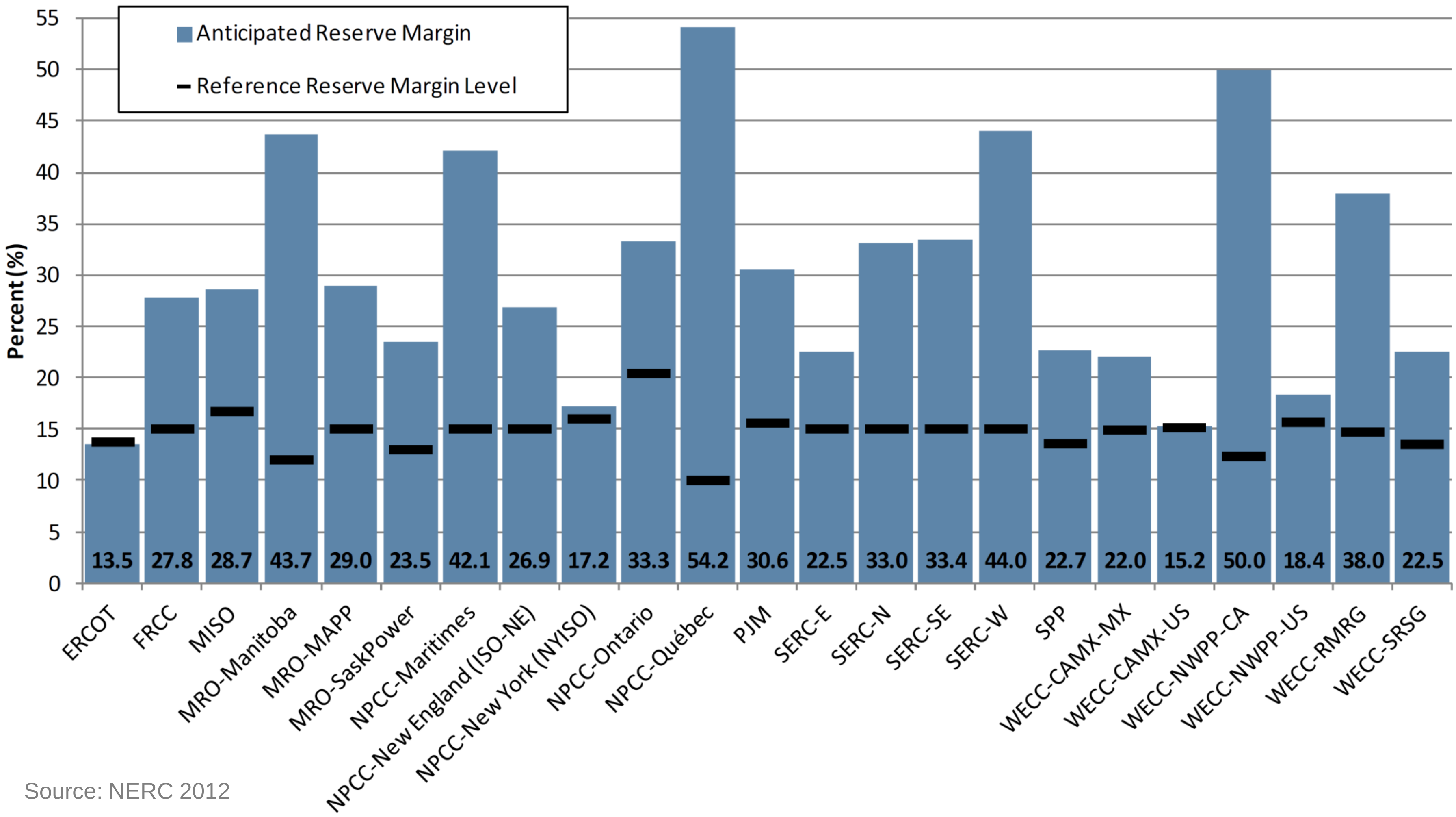


[1]Costs shown in U.S. 2002 CPI-weighted dollars

Figure 1. Base-Case Estimate of the Cost of Power Interruptions by Customer Class[1]

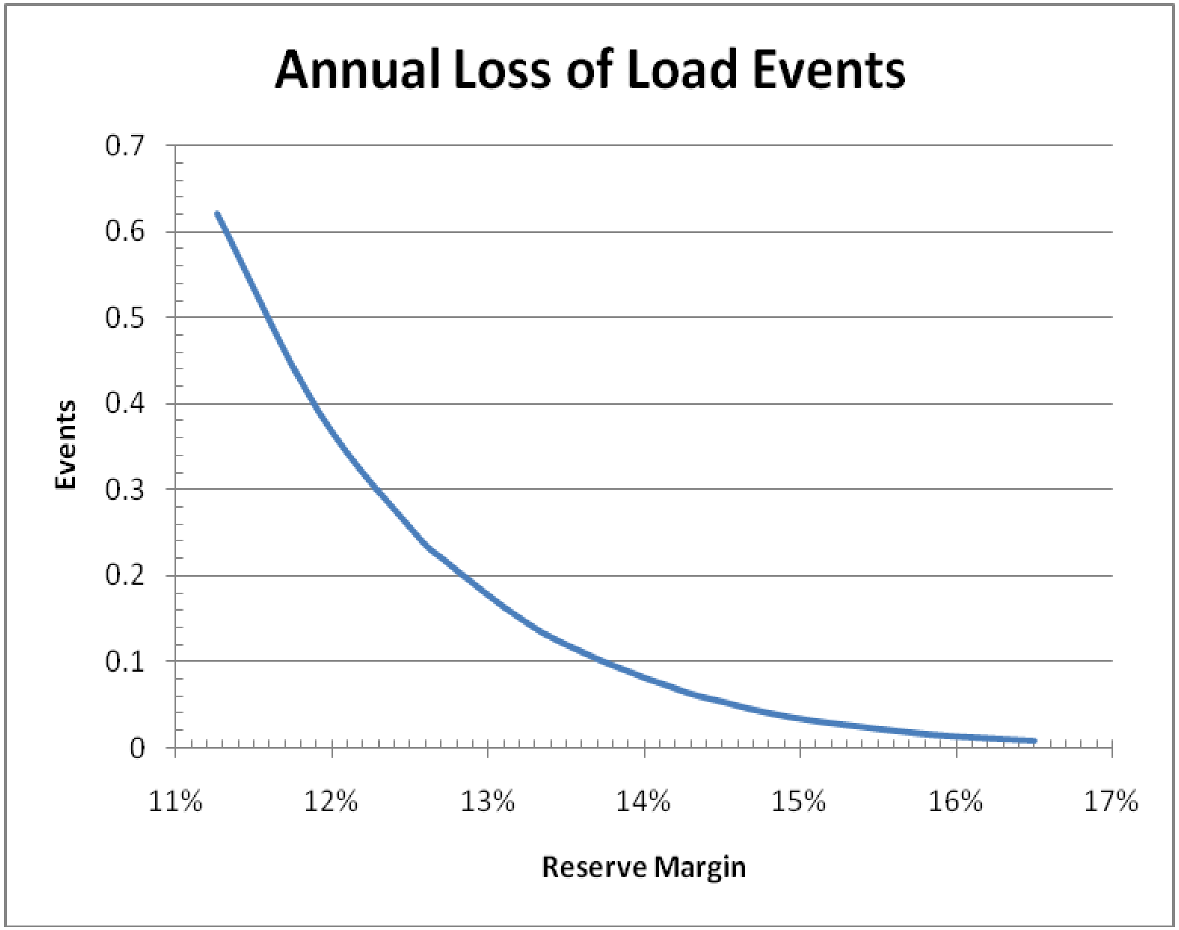
LaCommare and Eto (2006) *Cost of Power Interruptions to Electricity Customers in the US*

8.2 NERC Anticipated Reserve Margins for Summer 2012



Source: NERC 2012

8.2 LOLE and Reserve Margin



Source: ERCOT 2010

8.2 Reliability and Outages

"The fraction of time… will be called the *loss of load duration*… expressed in terms of "so many days upon which loss of load may be expected to occur during a given number of years," say 10 or 100.

This number of days provides a first index for measuring and comparing service reliabilities."

- Giuseppe Calabrese, 1947

8.2 Reliability and Outages

- Metrics: IEEE Standard 1366-2003
  - SAIDI (System Average Interruption Duration Index)
  - SAIFI (System Average Interruption Duration Index)
  - MAIFI (Momentary Average Interruption Frequency Index)

$$\text{SAIDI} = \frac{\sum \text{Customer Interruption Durations}}{\text{Total Number of Customers Served}}$$

$$\text{SAIFI} = \frac{\sum \text{Total Number of Customers Interrupted}}{\text{Total Number of Customers Served}}$$

$$\text{CAIDI} = \frac{\text{SAIDI}}{\text{SAIFI}}$$

$$\text{MAIFI} = \frac{\sum \text{Total Number of Customer Momentary Interruptions}}{\text{Total Number of Customers Served}}$$

8.2 Reliability and Outages

- Metrics and data collection on reliability represent a success – need to repeat with economics, rates, etc

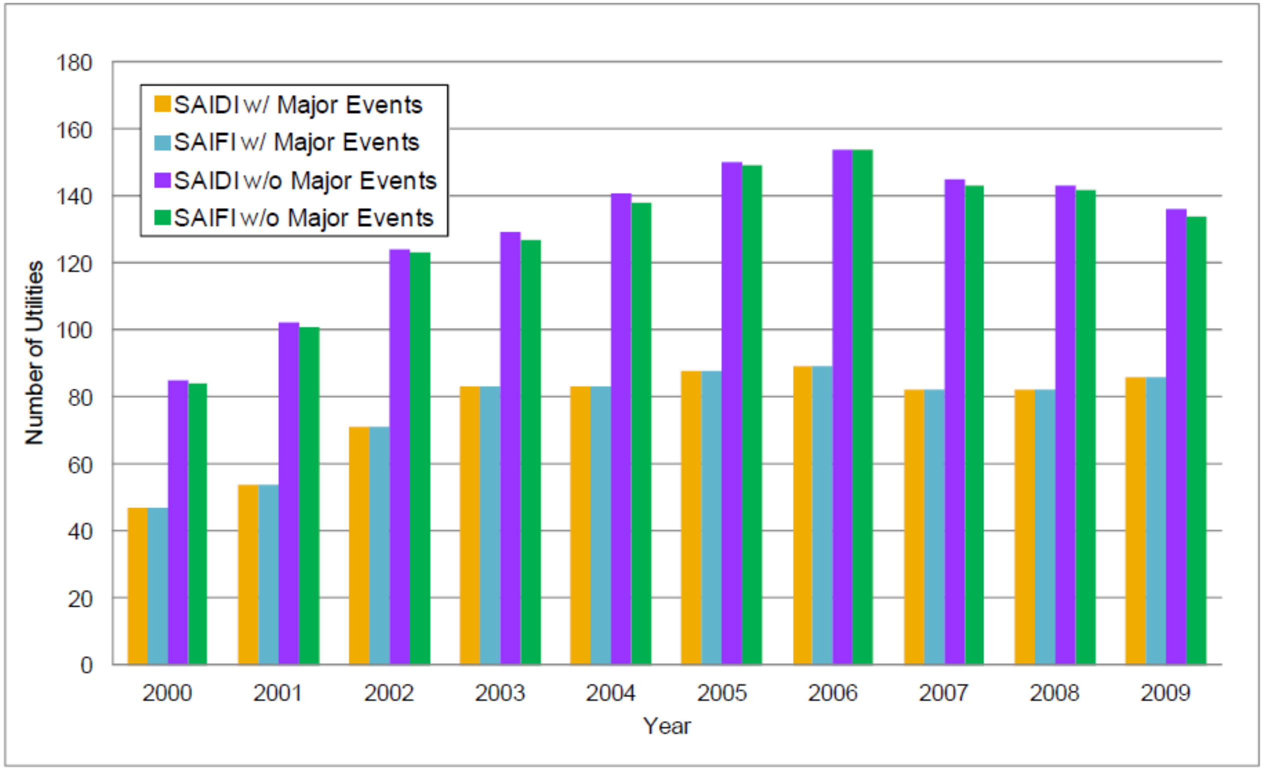
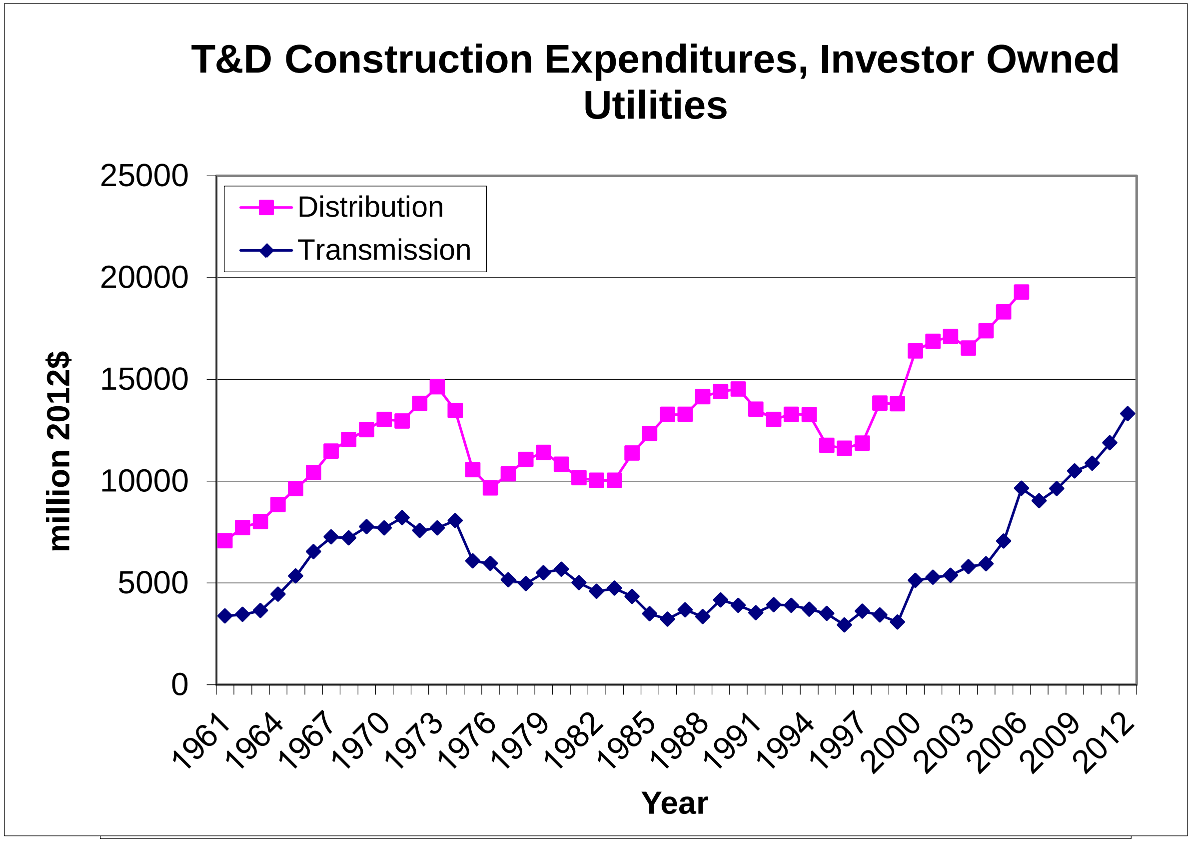


Figure 2. Number of Utilities with SAIDI and SAIFI Data

LBNL, 2012

Transmission and Distribution Investments



Compiled from EEI Statistical Yearbooks

ENVIRONMENTAL ISSUES

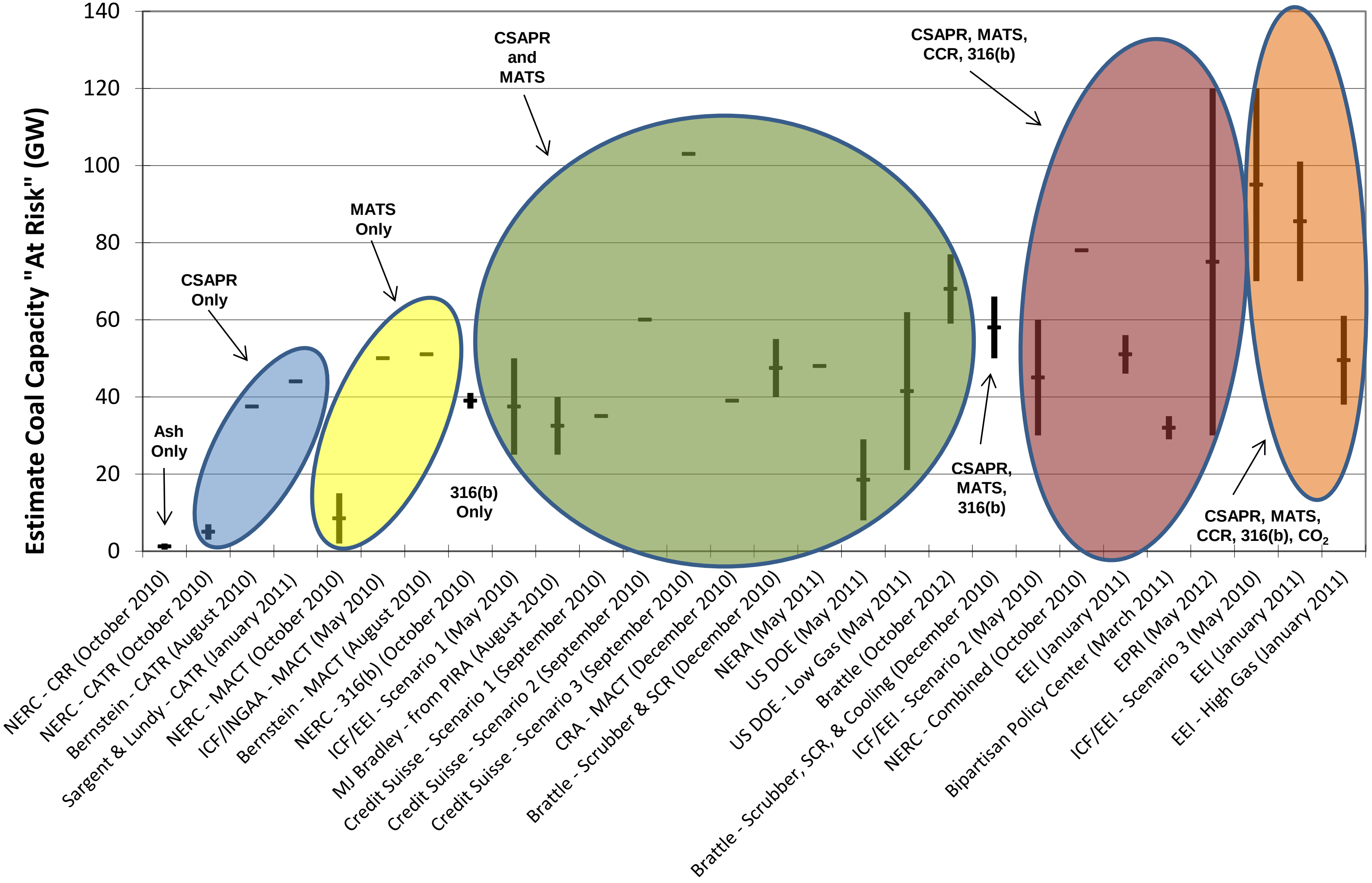
8.2 Environmental Issues

- Regulatory risks to existing generation assets
  - CAIR/CSAPR
  - RCRA
  - 316(b)
  - MATS
  - CO_2
  - Others?

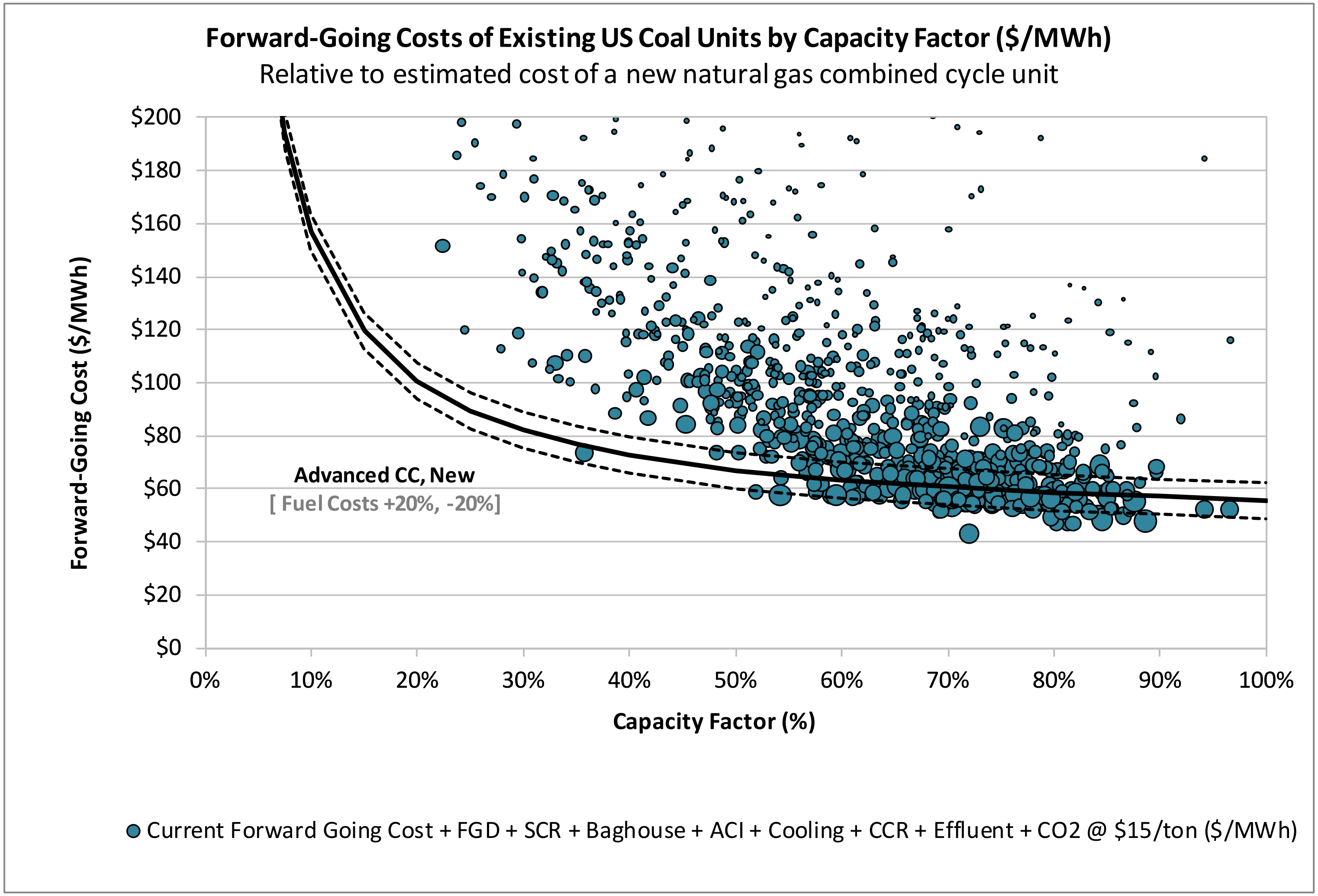
8.2 Environmental Issues

- Several of the issues discussed above (EE, RE, GM) help address the risks associated with climate change.
- There are other mechanisms that can also help address the risks associated with climate change, e.g.
  - Carbon cap and trade mechanisms.
  - Coordinated energy and environmental planning.
  - New ratemaking approaches to support the utility of the future…
- Increased risks associated with climate change practices:
  - Increased costs to customers from over-compliance, or from over-estimating future compliance requirements.
- Reduced risks associated with climate change practices:
  - Reduced costs of compliance with future environmental regulations.

8.2 Studies of Coal Capacity at Risk

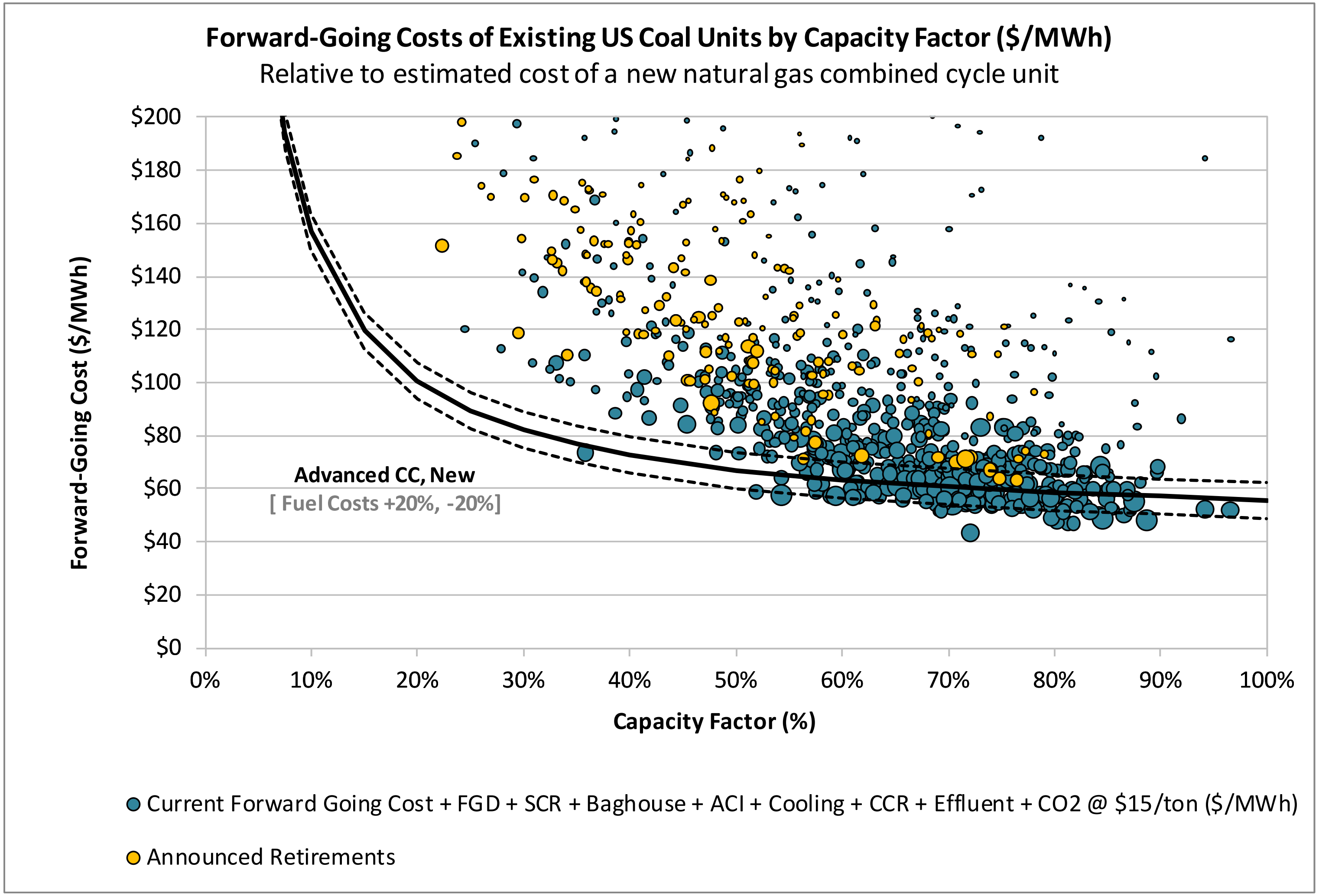


8.2 Existing US Coal Fleet Forward-Going Costs



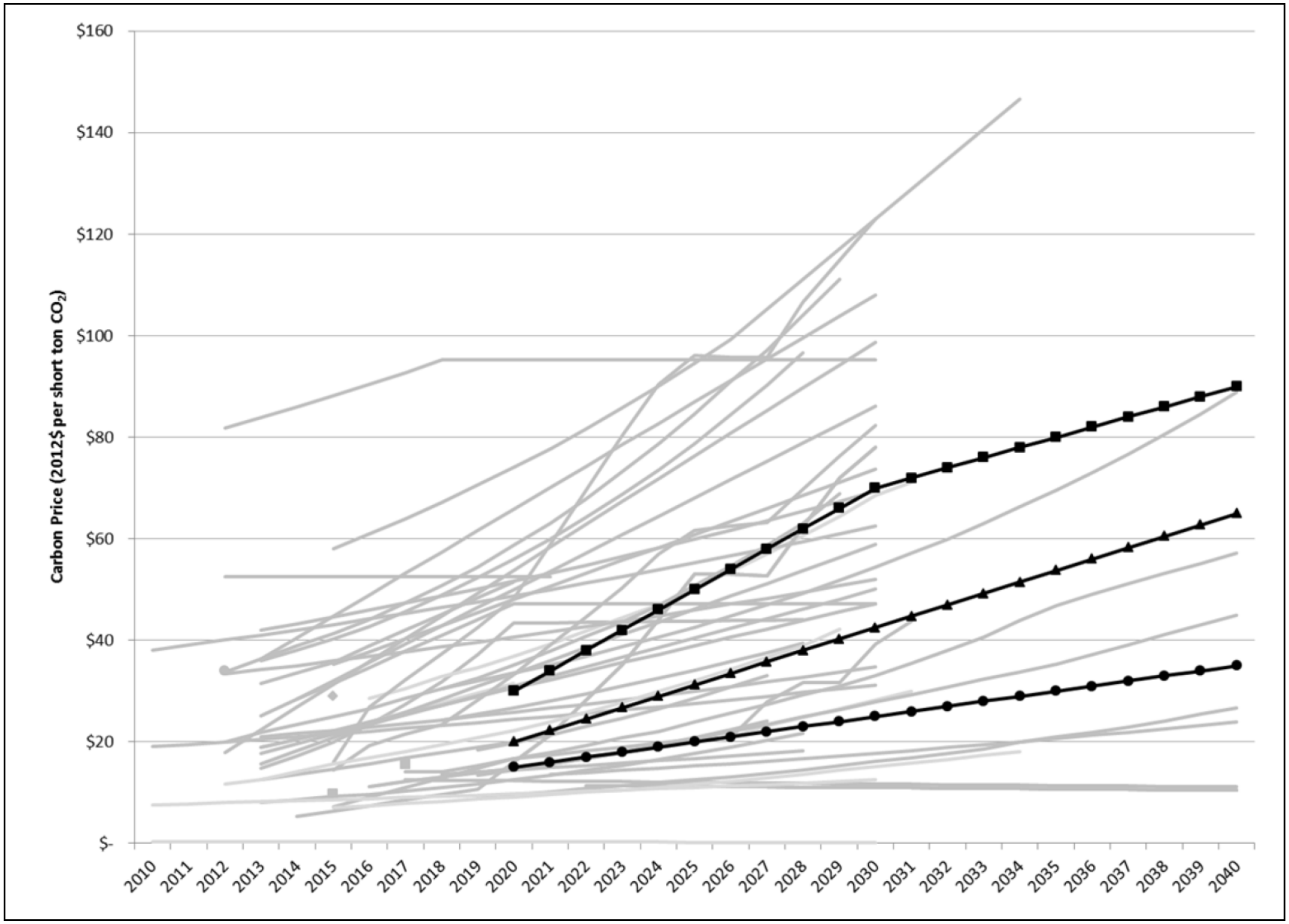
Note: Area of circles indicate MW capacity of units

8.2 Announced Retirements of US Coal Fleet



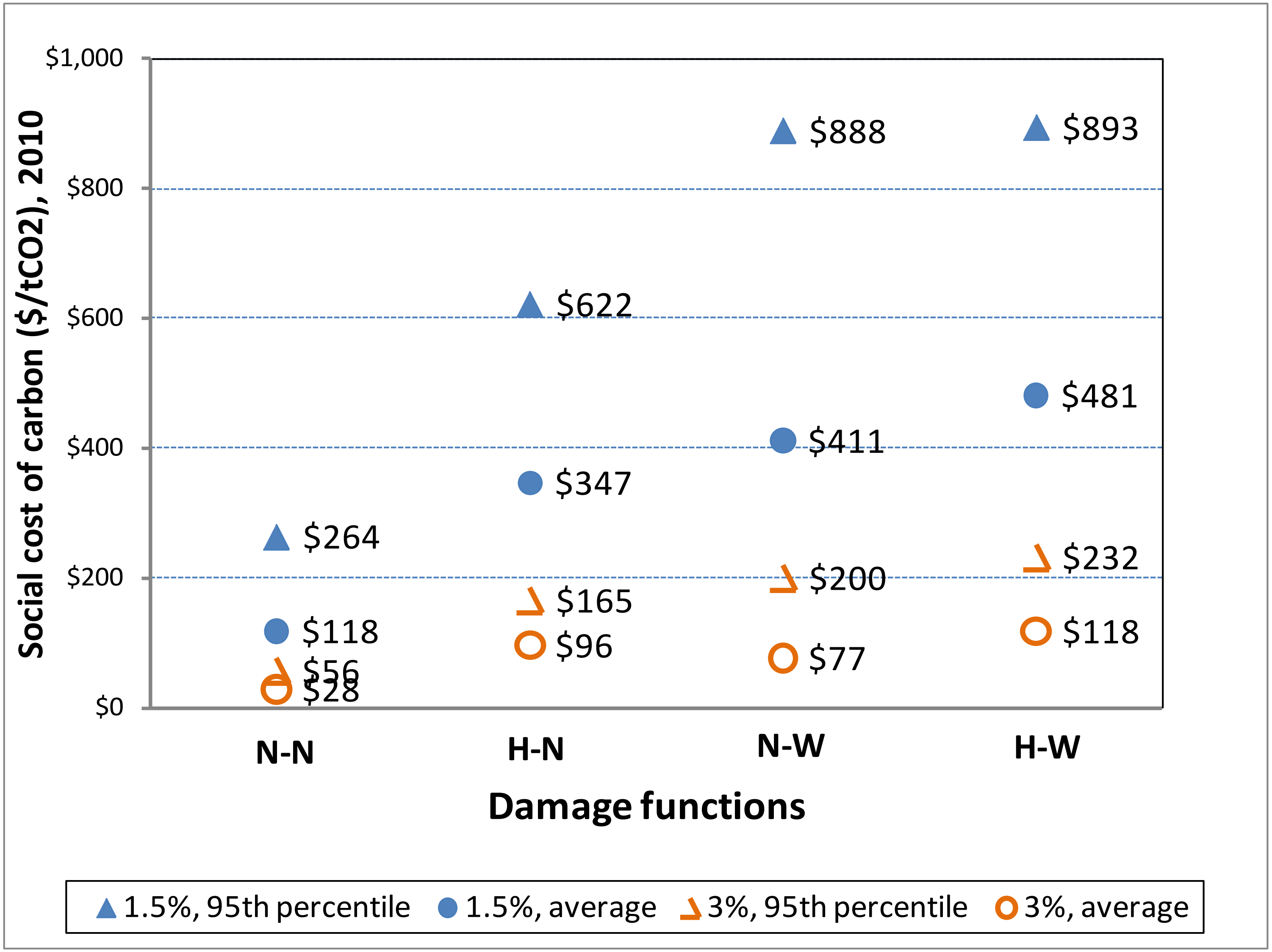
Note: Area of circles indicate MW capacity of units

8.2 CO_2 Price Forecast

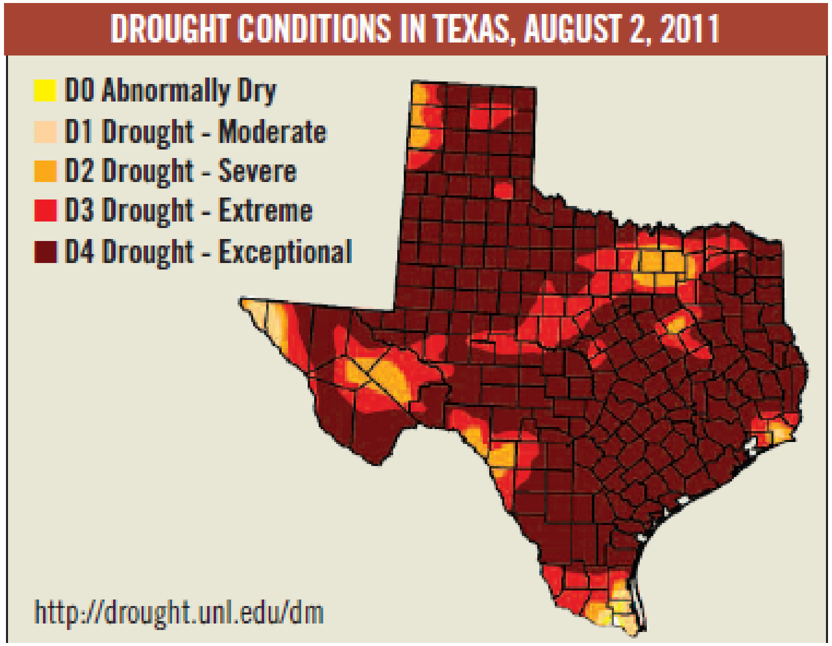


Source: Wilson, et al. 2012

8.2 Social Cost of Carbon



- Location specific
- High degree of uncertainty, but potentially large effects (see next slide)



Ceres 2012

Overview of Climate impacts on electricity demand and supply

	Demand	Thermal supply	Renewable supply	Transmission
Change in temperature	Change in heating and cooling degree days (comparatively well studied for some regions)	Increased water and air temperature decreases the efficiency of thermal cooling (some research for some regions)	Decreased icing increases efficiency of wind power (little research)	Increased transmission losses due to higher temperatures (little or no research) Negative impact of thawing permafrost (little research) Underground cable de-rating due to higher temperatures and drier soils (little or no research)
Changes in precipitation	Fuel choice (very little research)	Change in river flow affects cooling in thermal power plants (little or no research)	Hydropower potential affected by changes in river flow and evaporation (some research for some regions)	(no research in this review)
Extreme weather events	(no research in this review)	(no research in this review)	Dam safety affected by frequency of erratic river flow (little research)	Potentially costly interruption of supply (little research)
Changes in wind speed	(no research in this review)	(no research in this review)	Potentially large change to wind power potential (comparatively well studied for some regions, though not for extreme wind speeds)	(no research in this review)
Sea level rise, subsidence and other effects	(no research in this review)	Damages due to inundation and subsidence (little or no research)	Damages due to inundation and subsidence (little or no research)	(no research in this review)

Mideksa and Kallbekken (2010) *The impact of climate change on the electricity market: A review*

8.2 Dimensions of climate impacts

- Fairly soon, and fairly certain
  - Heat waves, drought, storms, some sea-level rise
  - Agricultural and coastal property losses
  - Bad, but not enough to cause a global crisis?
- Far future
  - Worst impacts will be 100+ years from now
  - Outcomes uncertain due to time span
  - Is discounting meaningful beyond one lifetime?
- Extreme risks
  - We know that we don't know the exact tipping points
  - "Black swans," fat-tailed probabilities
  - More research may not resolve uncertainties

8.2 Environmental Concerns

Coordinate with Environmental Regulators

- The US EPA is under instruction from federal courts to update air quality and water rules – there is experience in this area
- EPA has also indicated its intent to address greenhouse gases, the courts have reinforced this intent, and there is little experience
- These areas are integral to power generation
- Environmental regulation and utility regulation have operated primarily in parallel

8.2 Environmental Concerns

- Uncertainty about the nature of future regulation will persist yet early action has benefits
- Coordination between utility and environmental regulators can identify lower cost and higher cost effective compliance strategies and adapt regulatory practices to prefer and credit the former, while guiding those who make investments
  - Energy efficiency is increasingly seen as the first rank of lower cost effective compliance strategies

8.2 Environmental Concerns

- State utility regulators can help regulated generation owners subject to EPA regulation manage risk by engaging in scenario planning and, after due consideration, offering a path to address likely regulatory demands including cost recovery assurances to support the path
- Tough one: managing disconnect between state regulation and compliance and regional market and transport effect

8.3 EVOLVING RESOURCE OPTIONS

ENERGY EFFICIENCY

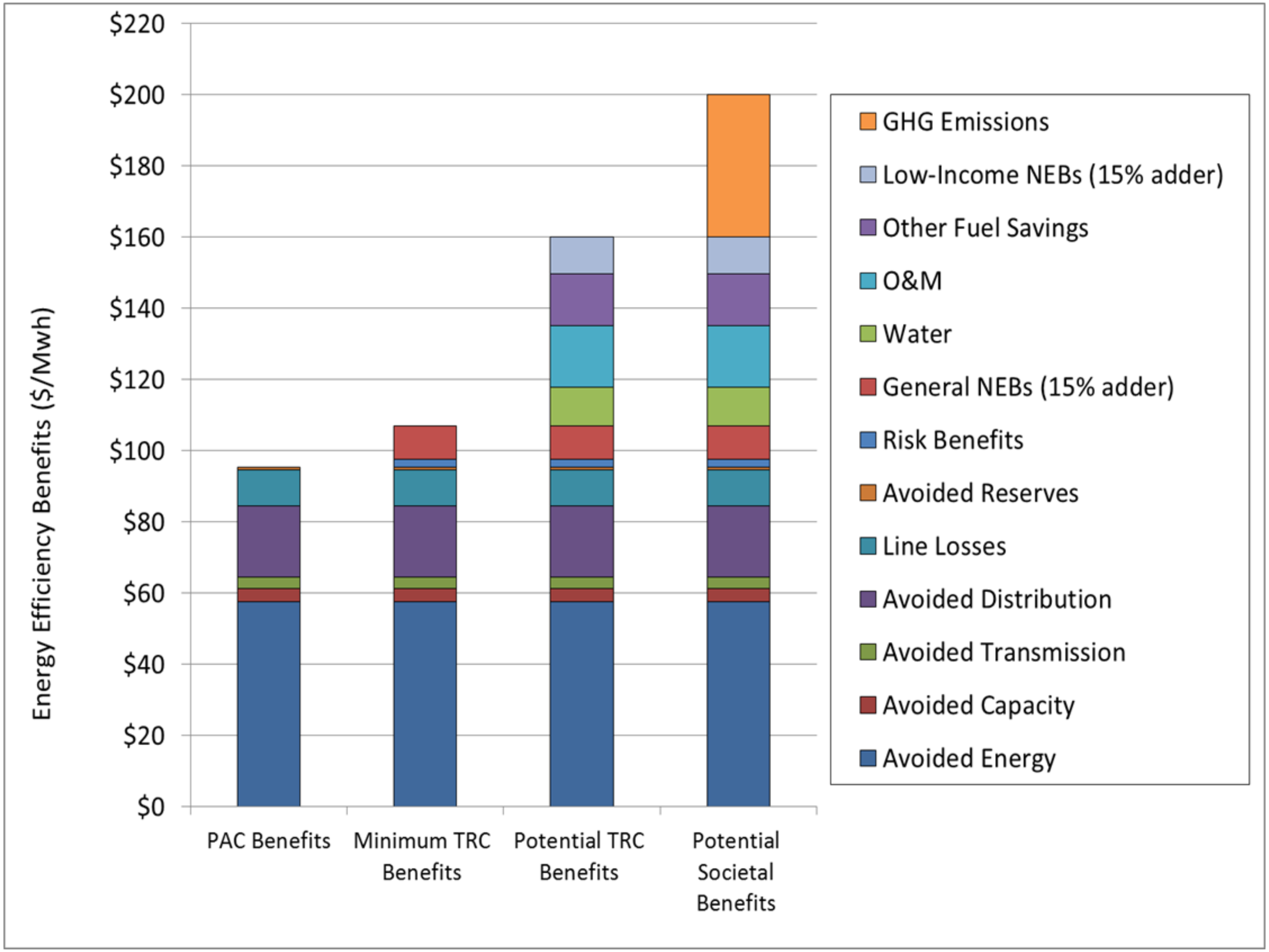
8. 3 Policies Supporting Energy Efficiency - I

- Risk concerns regarding energy efficiency:
  - Customer adoption rates.
  - Technology performance.
  - Overpaying (e.g., free-riders).
- Risk benefits from energy efficiency:
  - Increased reliability.
  - Increased fuel diversity.
  - Reduced customer bill volatility.
  - Reduced risk associated with generation construction costs.
  - Reduced risks associated with transmission and distribution.
  - Reduce risk associated with environmental regulations.
  - Reduced risk associated with water constraints.

8. 3 Policies Supporting Energy Efficiency - II

- Addressing risk when establishing energy efficiency policies (planning, cost recovery, recovery of lost revenues, shareholder incentives):
  - In establishing and refining these policies over time, regulators can recognize energy efficiency's potential to reduce risk.
- Addressing risk when screening energy efficiency programs for cost-effectiveness:
  - Through long-term planning practices (e.g., NWPCC).
  - By including quantitative estimates of risk benefits (e.g., Oregon assumes $5/MWh to $10/MWh hedge value, based on NWPCC modeling analyses).
  - By including qualitative estimates where quantitative estimates are not available. (e.g., VT reduces cost by 10% – see next slide).

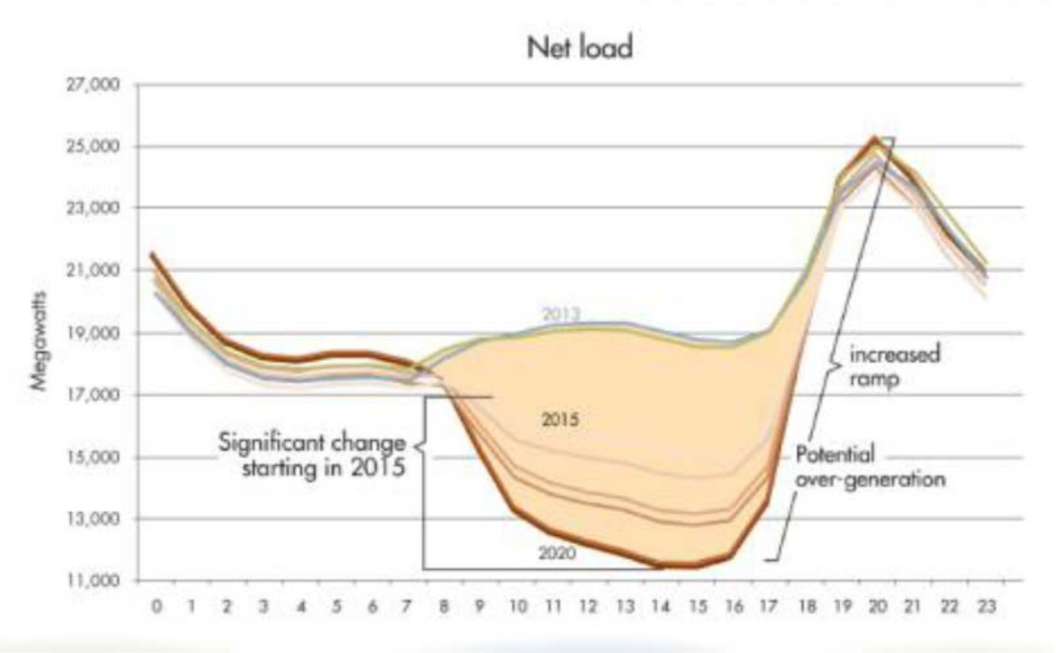
8.3 One Example of Accounting for EE Risk Benefits



RENEWABLE RESOURCES

8.3 Renewable Resources

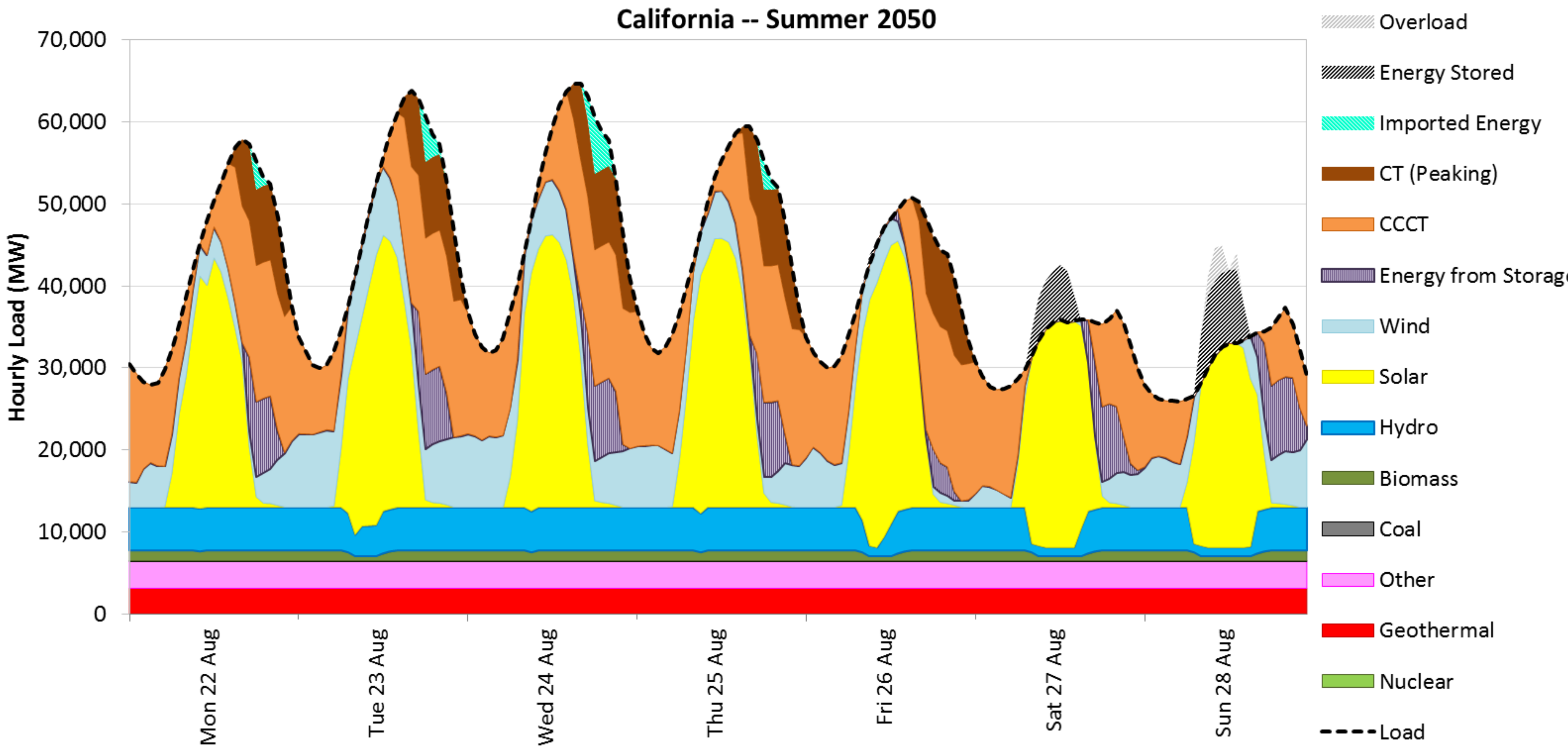
- Risk concerns associated with renewable resources.
  - Technology uncertainty.
  - Operational issues.
  - Stability of grid.
  - Integration into the grid.
  - Transmission costs and risks.



California LTTP

Changing net load shape, ramp requirements

Beyond Business as Usual – Shortages, surplus renewable power, changing “peak” times (fatback)



8.3 Renewable Resources

- Potential risk benefits from renewable resources.
  - Fuel diversity.
  - Technological diversity.
  - Reduced price volatility.
  - Cost stability.
  - Reduced risk associated with generation construction costs.
  - Reduce risk associated with environmental regulations.
  - Reduced risk associated with water constraints.

- Renewables as a hedge

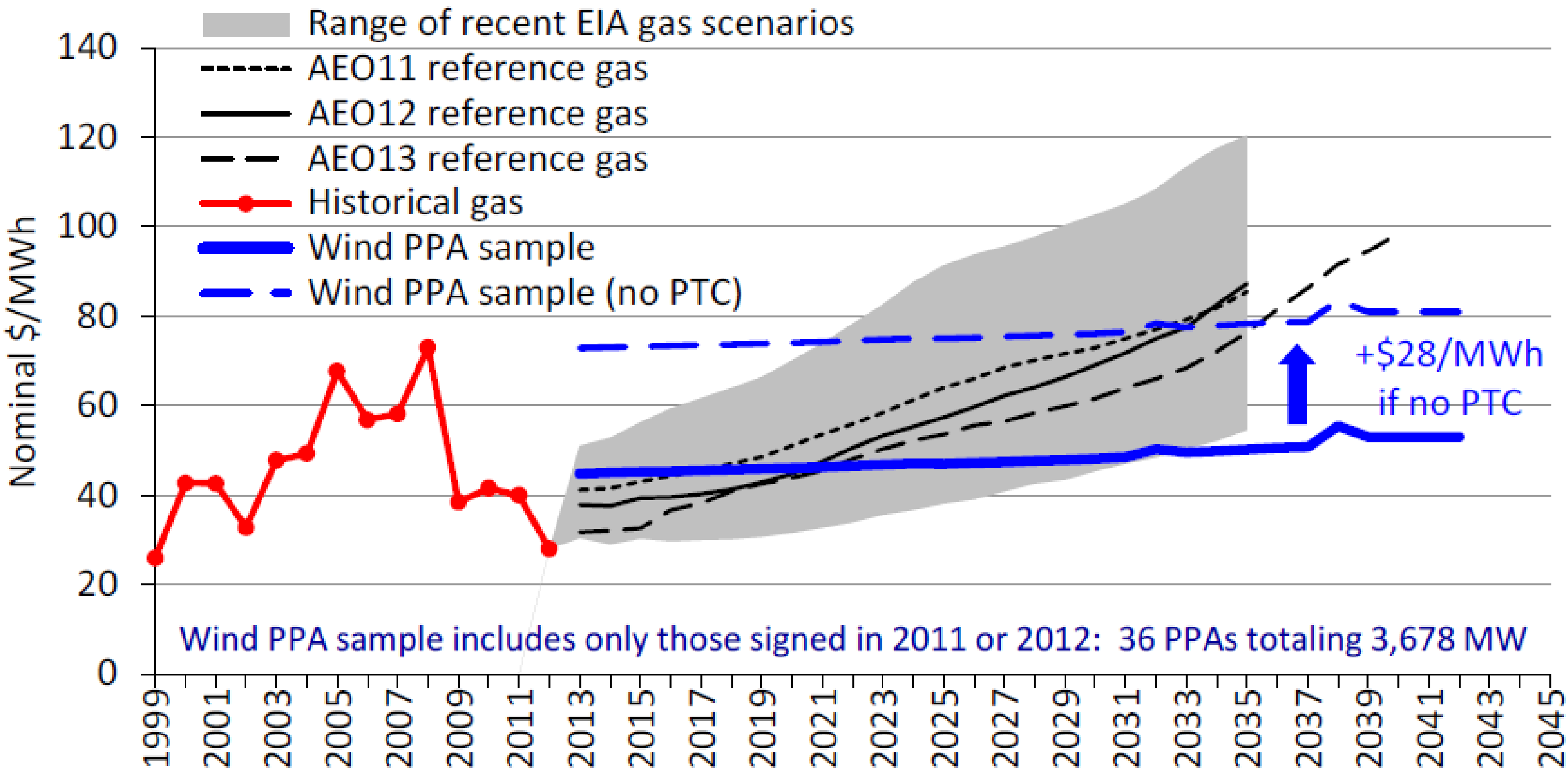


Figure 9. Comparison of Recent Wind PPA Sub-Sample to Projected Range of Natural Gas Prices

Bolinger, 2013

8.3 Renewable Resources

- Risks can be explicitly addressed when establishing renewable resource policies and practices:
  - renewable portfolio standards, feed-in tariffs, long-term contracts, net metering, distributed generation.
- Risks can be addressed through:
  - Long-term planning practices (see Part 6).
  - Terms and conditions for long-term contracts.
  - Terms and conditions for purchases of renewable energy credits.
  - Determination of feed-in tariff prices and conditions.
  - Wholesale market designs:
    - ✓ Operational issues.
    - ✓ Grid stability issues.
    - ✓ Integration issues.

GRID MODERNIZATION

a/k/a Smart Grid

8.3 Grid Modernization

- Risk concerns associated with grid modernization:
  - Rapid technological evolution.
  - Technological obsolescence and potential for stranded costs.
  - Cost uncertainty.
  - Customer adoption (short-term and long-term persistence):
    - ✓ of time-varying rates.
    - ✓ of demand response programs.
    - ✓ of new and evolving enabling technologies.
  - Multiple private parties offering services to customers.
  - Customer exit from the system, especially associated with DG.
  - Lost revenues to the distribution utility as a result of reduced consumption and customer exit. Can lead to increased rates, and further customer exit.
  - Integration with the grid, especially associated with DG.

8.3 Grid Modernization

- Risk benefits from grid modernization:
  - Distributed generation: generation sited closer to load can reduce transmission and distribution risks.
  - Distributed generation: can contribute to fuel diversity, geographic diversity, technology diversity.
  - Reduced peak demand can reduce risks associated with generation, transmission and distribution costs.
  - Many aspects of grid modernization might reduce risks associated with reliability:
    - ✓ Demand response, time-varying rates, distributed generation, distribution automation, grid hardening.
  - Some grid modernization applications might reduce risks associated with environmental regulations.

8.3 Grid Modernization

- Risk can be addressed when establishing grid modernization policies and practices:
  - demand response, time-varying rates, advanced meters, distributed generation, grid-facing investments, etc.
- Risk benefits can be addressed by:
  - Explicitly acknowledging the risks associated with GM.
  - Identifying the risks.
  - Assessing the risks: using the best information available, using information from states with more experience, using information from pilot projects, analyzing with sensitivity analyses.
  - Managing the risks:
    - ✓ Use of pilot programs.
    - ✓ Gradual phase-in and transition approaches.
    - ✓ Careful allocation of costs and risks between utilities, customers, and third parties.

9. RISK CHALLENGE EXERCISE

- Renard Utilities is concerned that the market price for power for default customers is too high and customers are complaining to them – like it's their fault. They want to hedge against the short-term market prices. They propose to enter into a long-term power contract to buy 20% of the power needs to serve the default customers. They argue that while the price is higher than the market price at the moment, this is a hedge against market prices that are expected to go higher and exceed the contract price.

- There is a concern that since this is a forecast, there is a certain level of unpredictability. Moreover, if the default rate rises due to the impact of this more expensive power, more default customers may choose to switch to a lower-priced retail generation rate, thereby increasing the cost for the remaining customers and creating a death spiral. On the other hand, if market prices start to rise, without this hedge, there could be significant economic impacts for customers.

- As a Regulator, do you let the market take its course or do you allow the utility to intercede?
- How do you weigh and value the policy goals of creating a competitive market and regulatory action to maybe keep rates down (or keep them from rising too much)?
- What are your long and short-term strategies?
- How does the decision you make potentially impact those strategies?

10. SYNTHESIS

10. Synthesis – General Concepts

- Risk affects many decisions made by regulators – whether explicitly addressed or not.
- There are many factors causing increased risks in the industry. Some factors causing risk are less obvious.
- It is rare that risk can be eliminated – the goal for regulators is to actively manage risk.
- Management of risk often means balancing competing interests (e.g., cost versus reliability).
- Restructured electric industries create a different landscape of risk, but risk must still be actively managed by regulators.

10. Synthesis – General Strategies

1) Practice "Risk-Aware" regulation.
   - Explicitly acknowledge risks inherent in specific decisions.
   - Gather information relevant to understanding risk.
   - Conduct analyses to best understand risk and its implications.
   - Make informed decisions that reflect understanding of risk.
   - Recognized what is being balanced against what.
2) Utilize robust planning practices, and diversify resource portfolios.
3) Employ transparent ratemaking practices.
   - Recognize that regulatory decisions create utility incentives, which have risk implications.
   - Recognize ratemaking options that can reduce risks to all; shift risks from one party to another; or both.
   - Hold utilities accountable. Utilities are often in the best position to address risk.

10. Synthesis – Moderated Discussion

- Have we missed anything important to you?
- Of the risks discussed above, what do you see as the key risk issues for your state / region?
- Have you attempted to use some of the recommendations provided here?
  - What was the result?
  - What more needs to be done?
- What risk issues and topics need additional attention, to best meet the needs of your state / region?

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