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ELECTRICITY MARKETS & POLICY

Training on Integrated Resource Planning for South Carolina Office of Regulatory Staff

Overview of the major components of an IRP and its development process

Portfolio Selection and Treatment of Risk and Uncertainty

Tom Eckman

March 1, 2021

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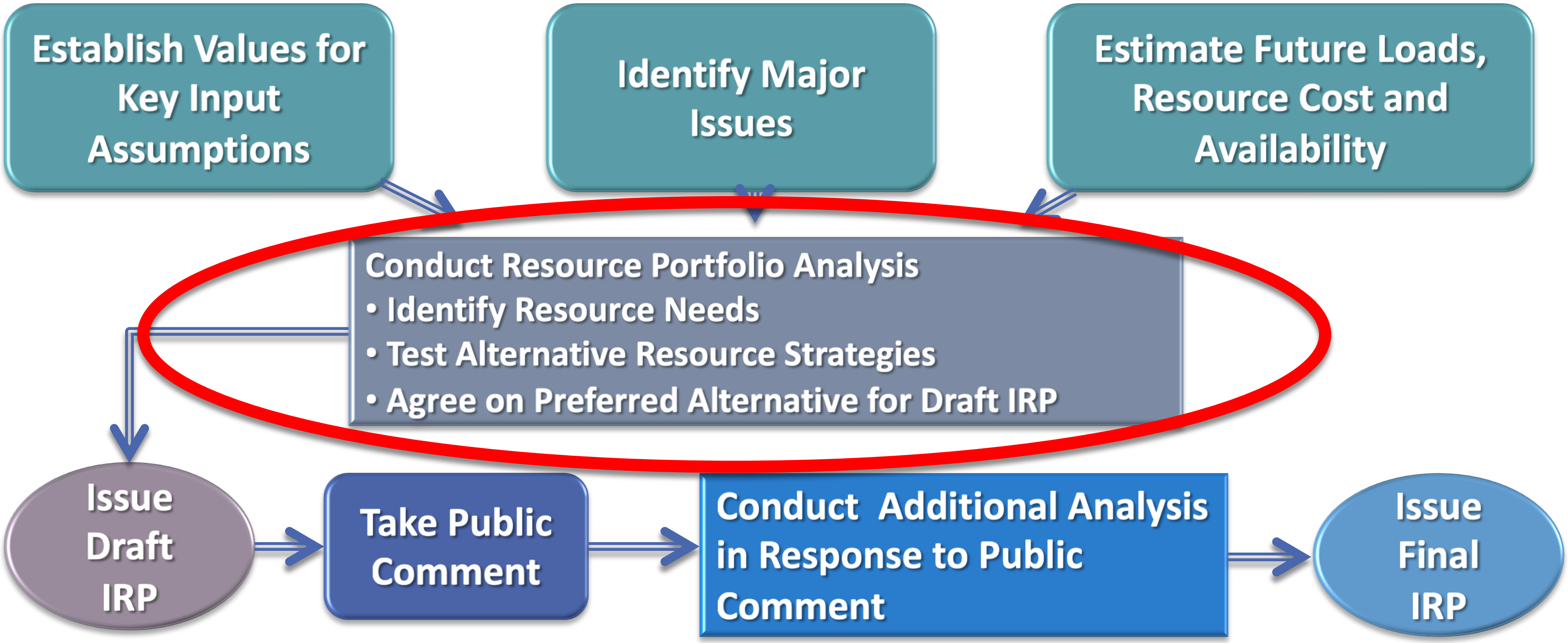
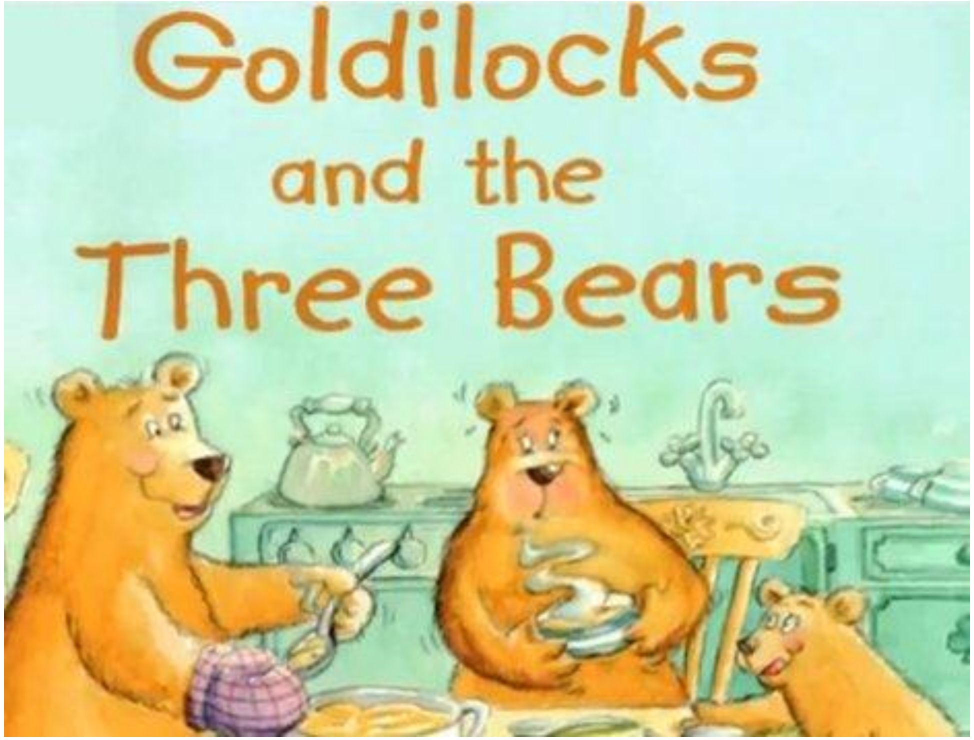
Overview of IRP Development Process



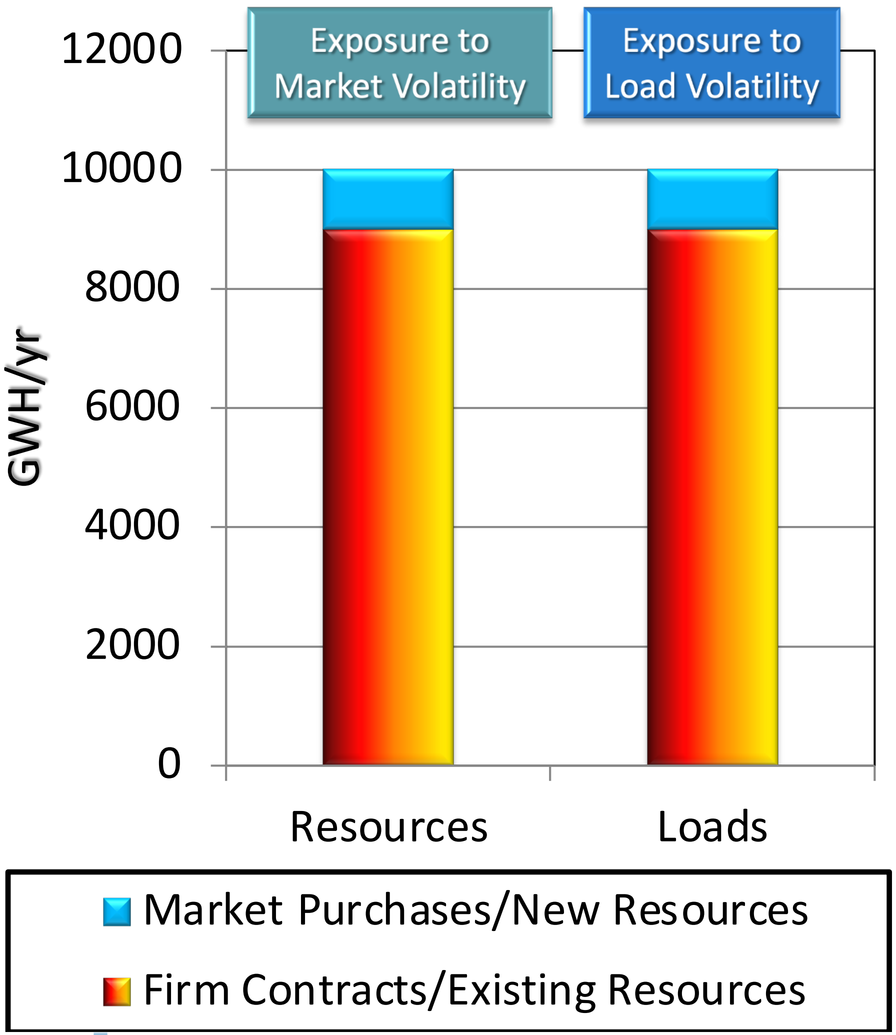
The Resource Planner's Problem

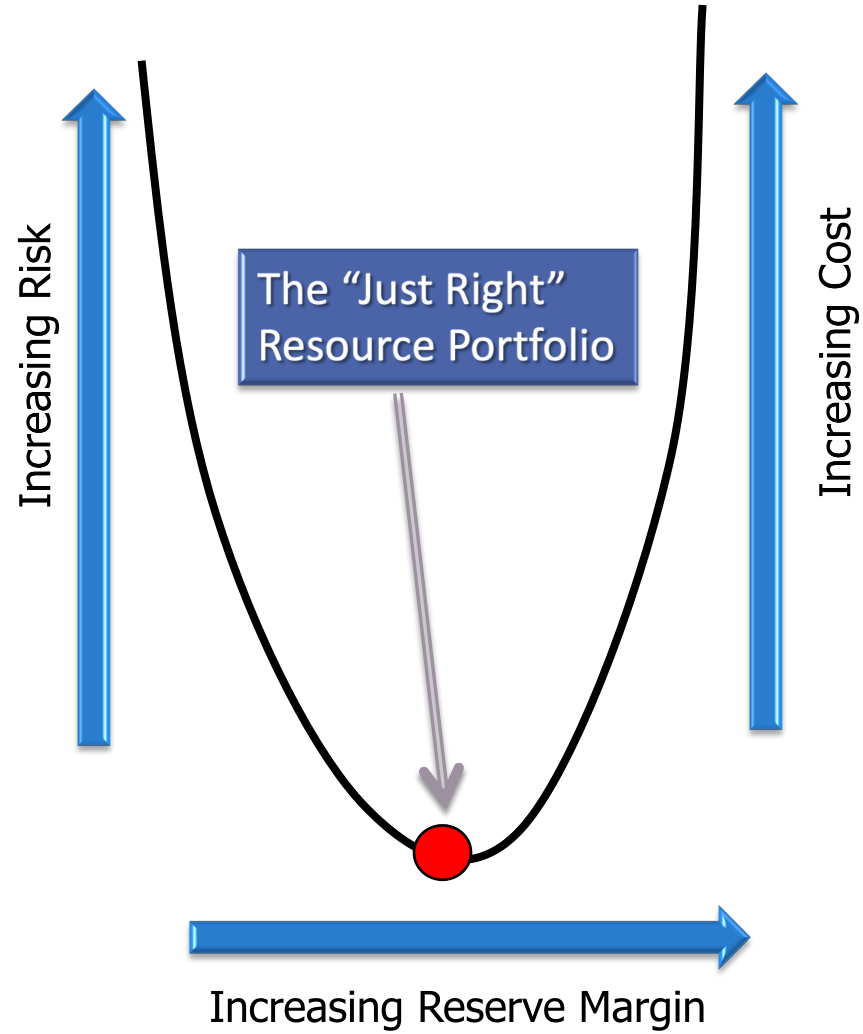


- Don't have too many resources
- Don't have too few resources
- Have "just the right amount" of resources*

**The "right amount" means not only the quantity developed, but the timing of their development and the mix (type) of resources required to provide energy, capacity, flexibility, and other ancillary services for system reliability, including risk management and resilience.*

Solving the "Goldilocks' Problem" Requires Analysis Comparing *Cost* and *Risk* of Alternative Resource Options





IRPs Attempt to Find the "Just Right" Resource *Timing*, *Type* and *Amount* by Answering Five Simple Questions

1. *When Will We Need Resources?*
2. *How Much Will We Need?*
3. *What Should We Build/Buy?*
4. *How Much Will It Cost?*
5. *What's the Risk?*

Answering These Questions Require Assumptions About the Future

Heisenberg

$$\Delta x \Delta \rho \geq \frac{\hbar}{2}$$

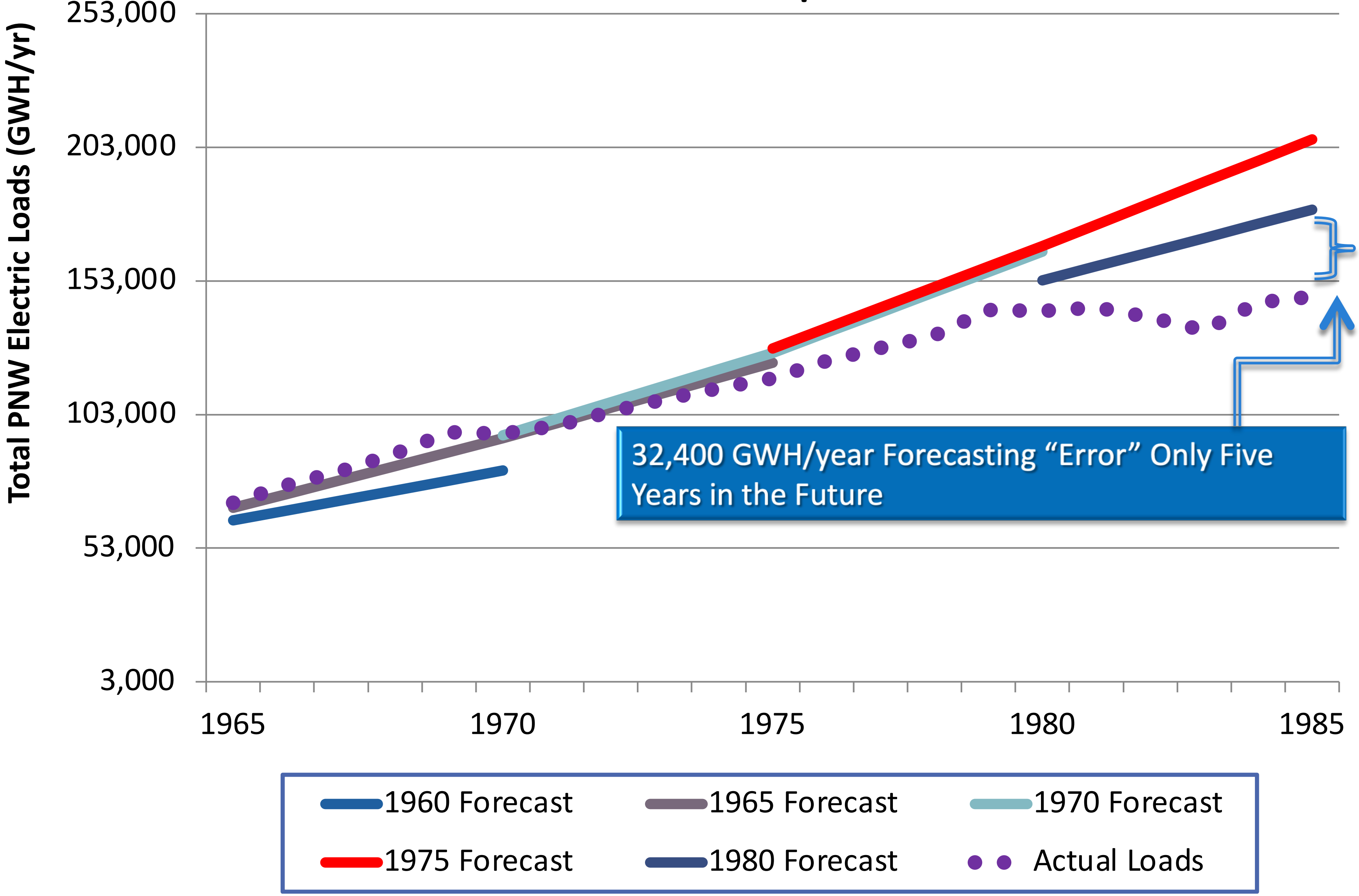
have been here.

Perfect Foresight is Not Possible,
So IRP's Must Address Uncertainty and Risk

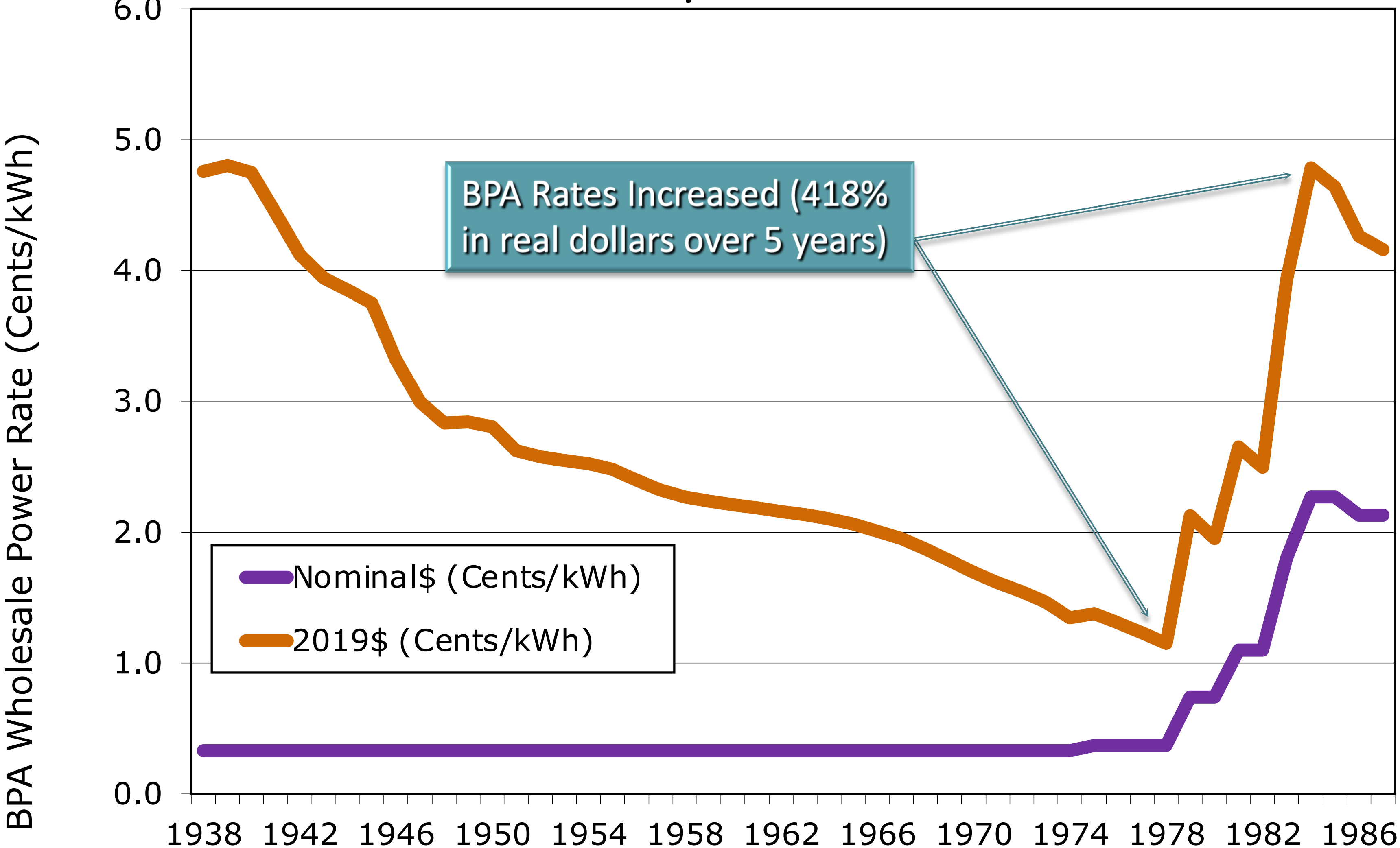
Major Sources of Uncertainty

- Load Uncertainty
  - Business cycles (e.g., post-2008 recession, COVID-19)
  - Technology "shifts" (e.g., electrification of transportation, distributed generation)
- Resource Uncertainty
  - Output (e.g., prolonged outages due to terrorist action, storms)
  - Cost
  - Construction lead times (e.g., pumped storage, transmission expansion)
  - Technology change (e.g., declining cost of renewables, batteries)
- Wholesale Electricity Market Price Uncertainty
- Regulatory Uncertainty (e.g., required reductions in GHG emissions)

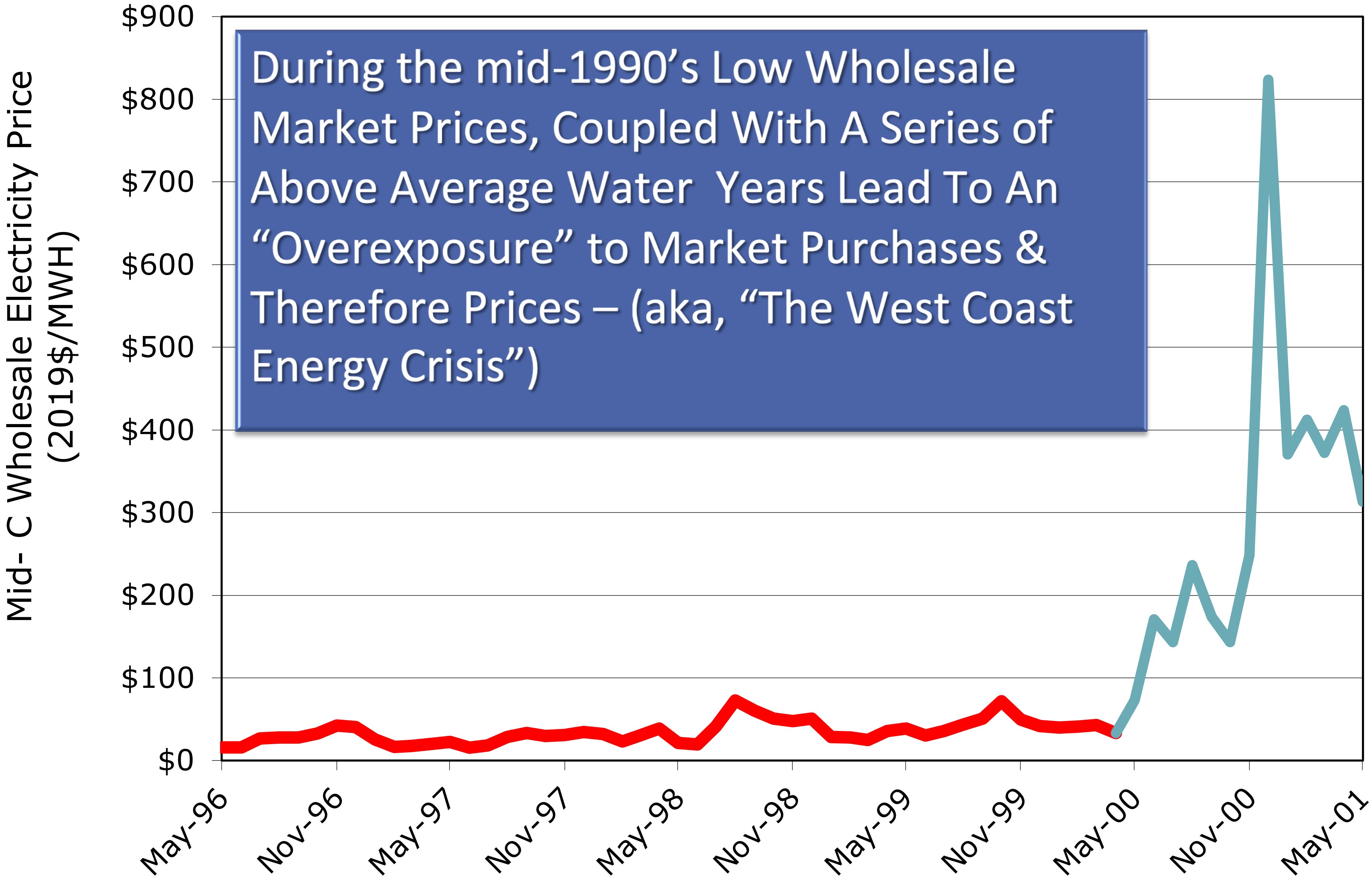
Perfect Foresight Can Lead to Overbuilding: PNW Example



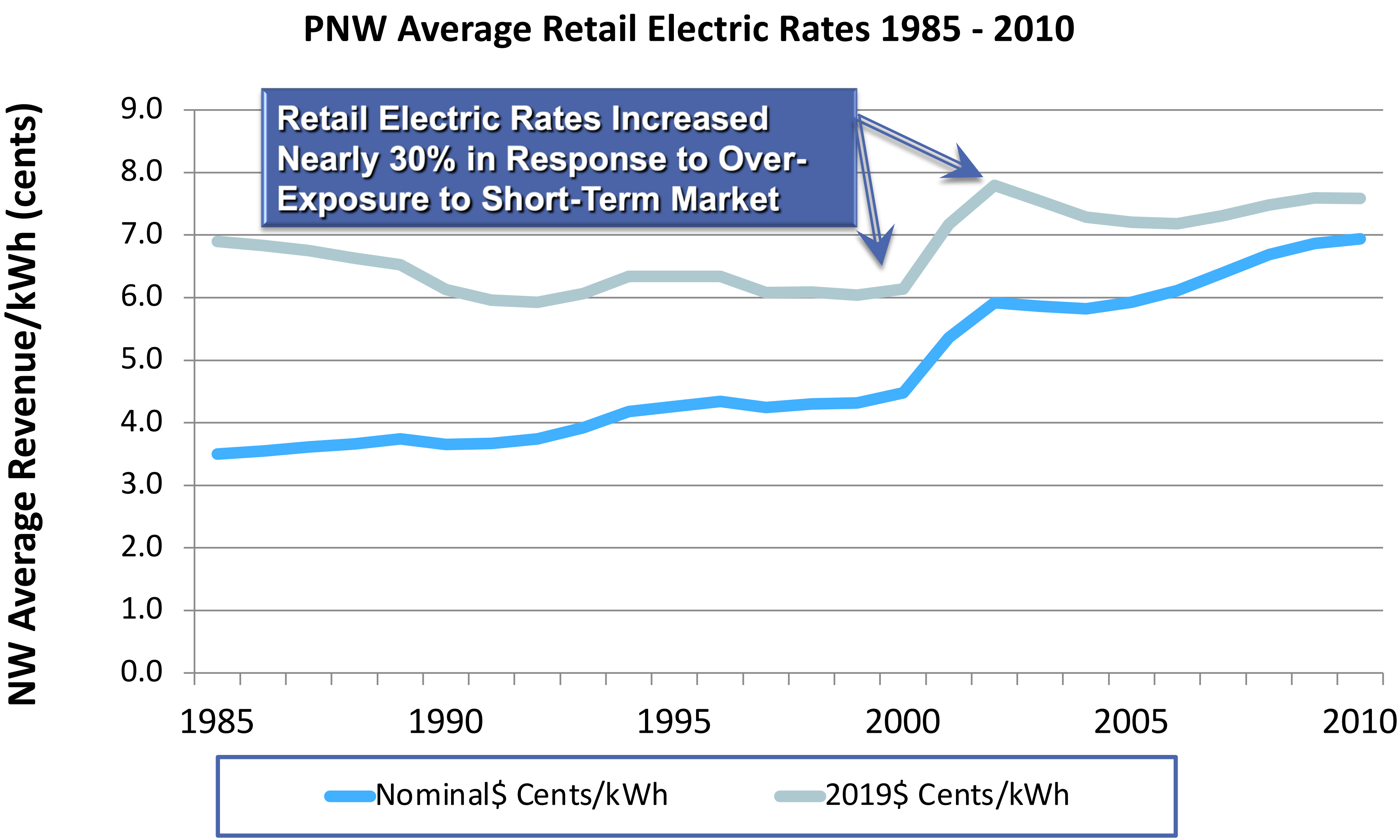
Real World Example of the Cost of "Too Many Resources"



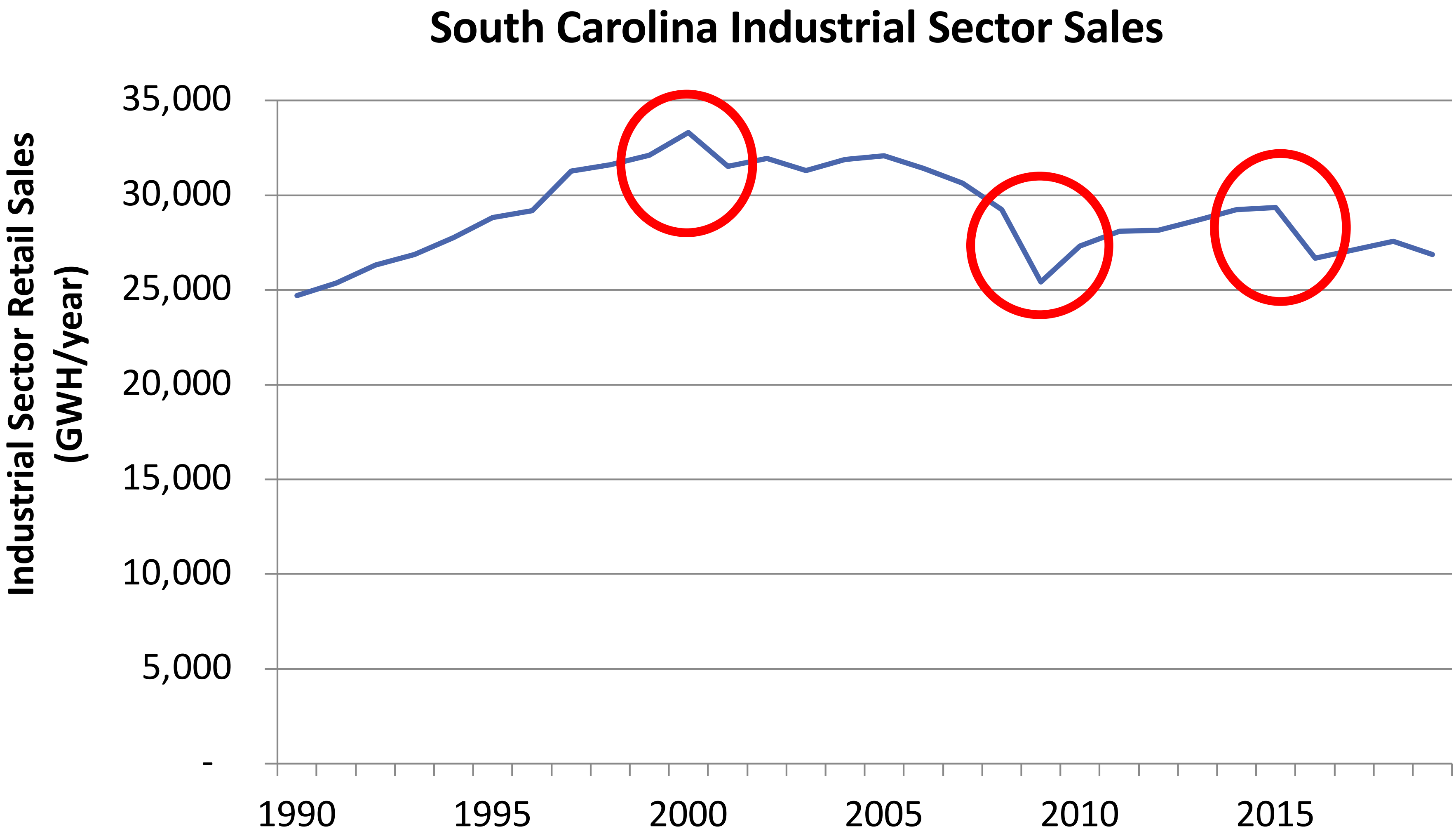
Perfect Foresight can also lead to underbuilding: PNW Example



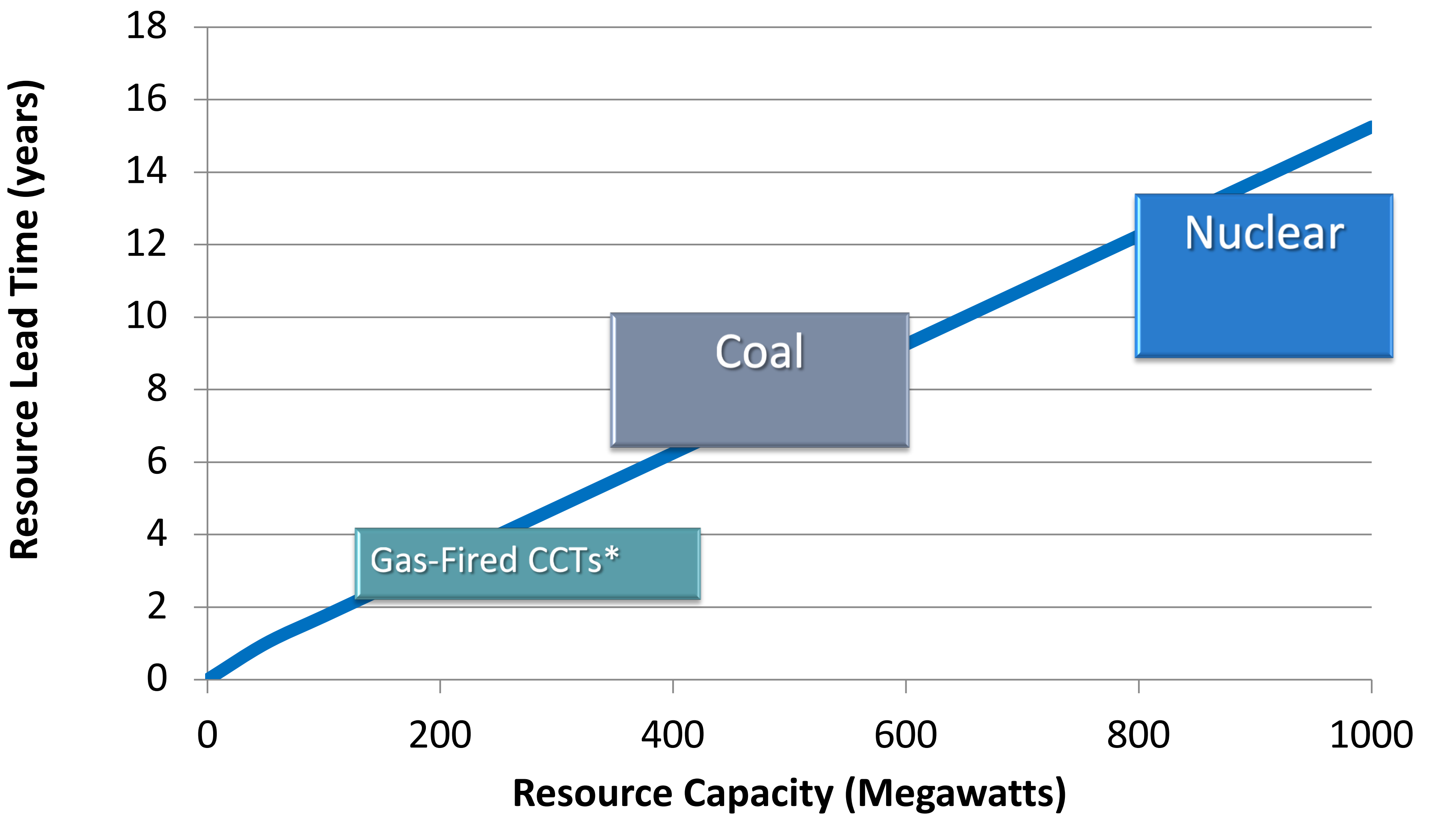
Real World Example of the Cost of "Too Few Resources:" PNW Example



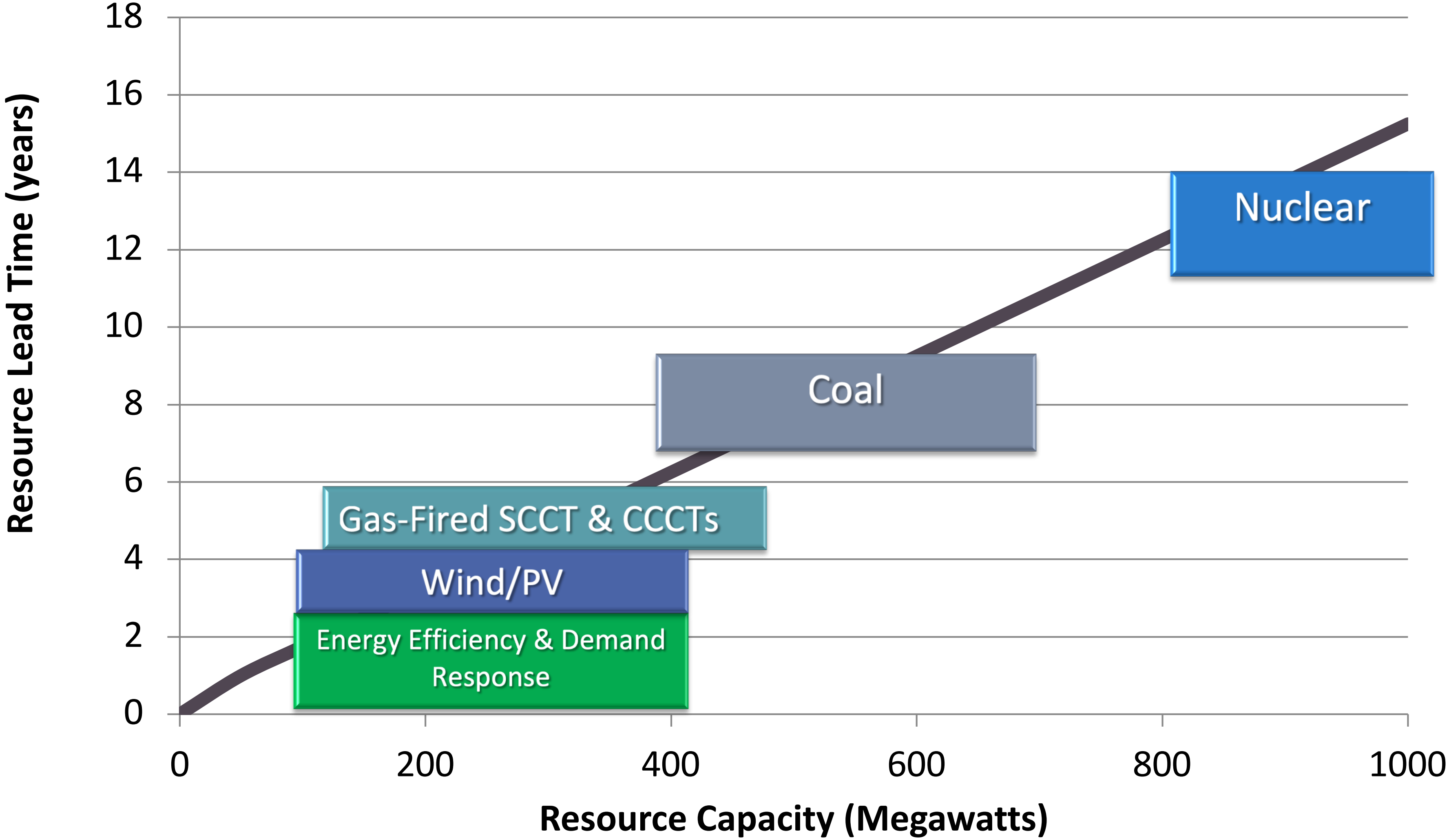
Load Uncertainty Is Often Driven by Large Industrial Loads



Load Uncertainty Is Particularly A Problem For Resources With Long Lead Times and Large Sizes



Energy Efficiency, Demand Response and Shortened Lead Times and Smaller Sizes For Some Generating Resources Has Reduced Exposure to Load Uncertainty



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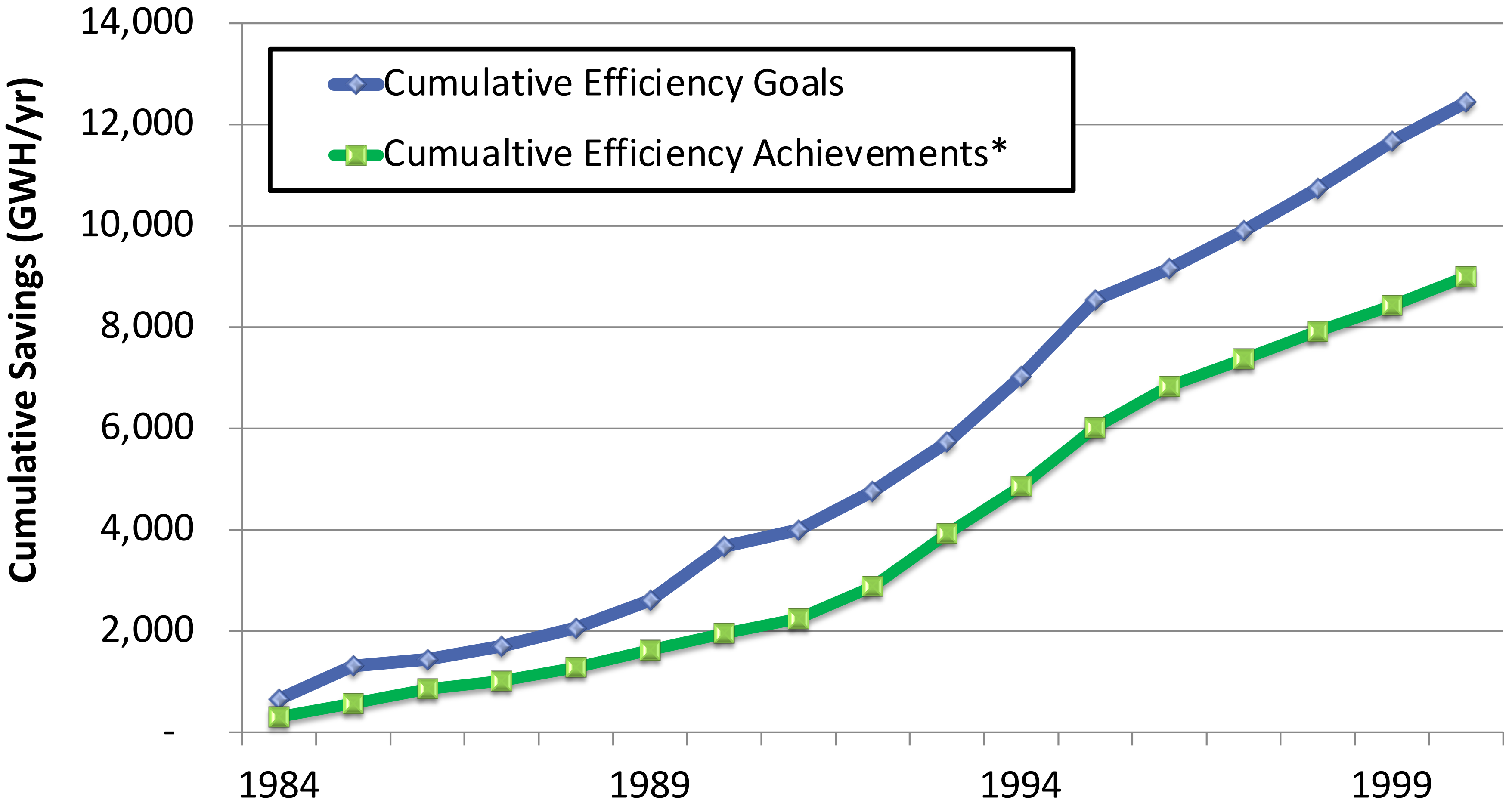
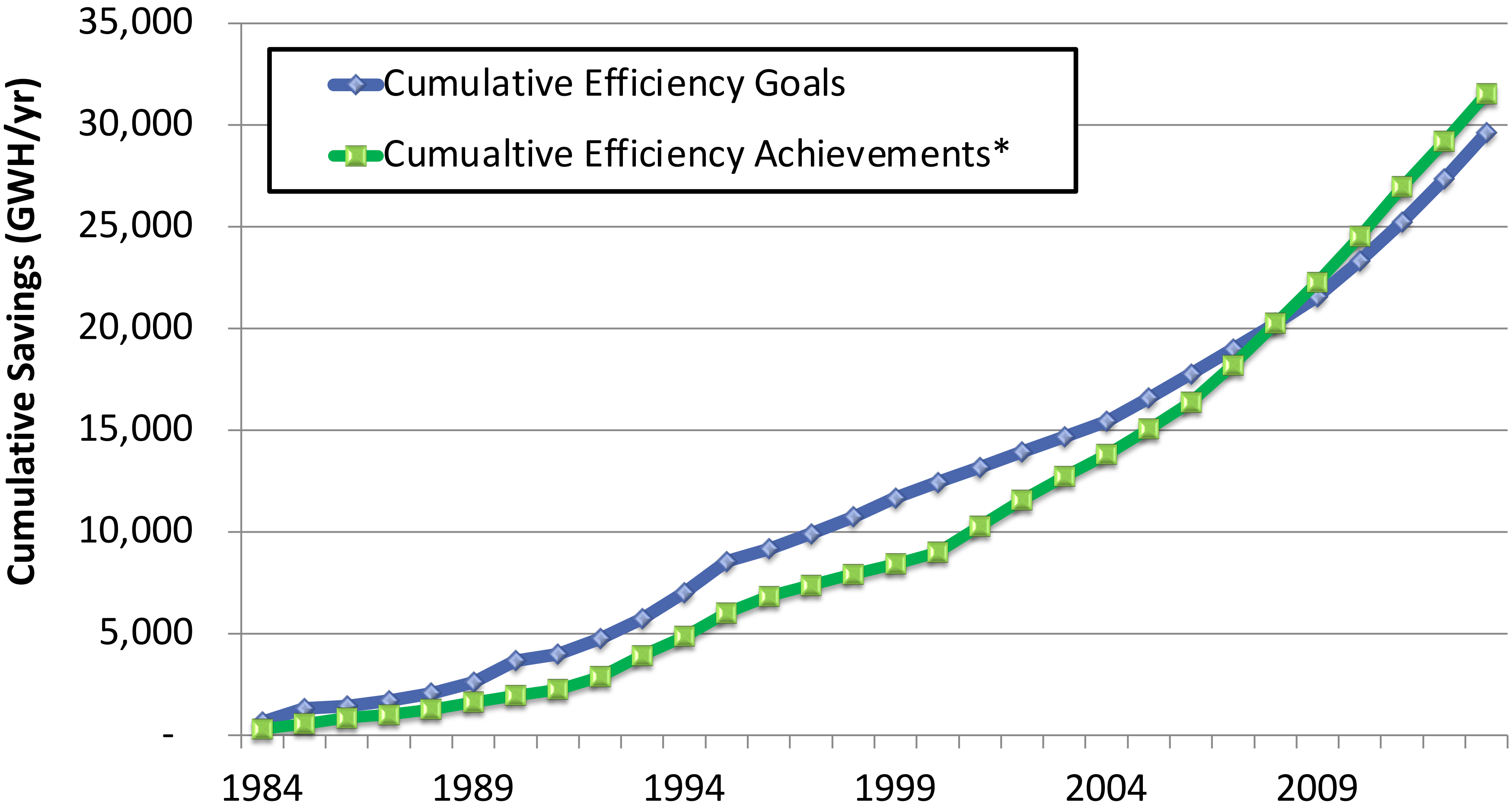
Energy Efficiency Resource Uncertainty Stems from Delays in Deployment (i.e. construction) Schedule



*Achievements reflect utility funded savings only. Savings from codes and standards are included as baseline adjustments in each IRP's baseline load forecast

Since the West Coast Energy Crisis Energy Efficiency Resource Development Delays in Deployment Have Been Less Uncertain



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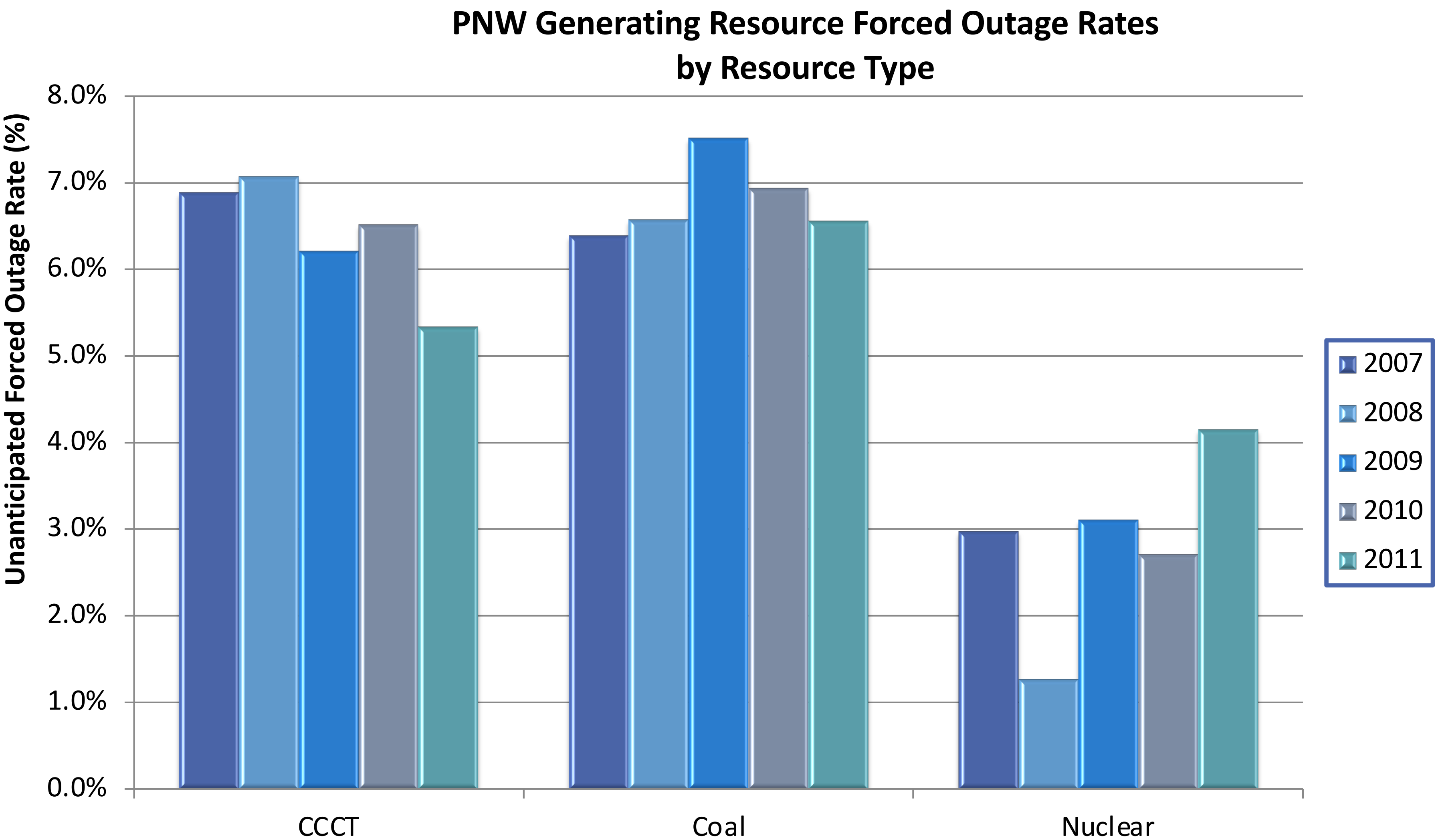
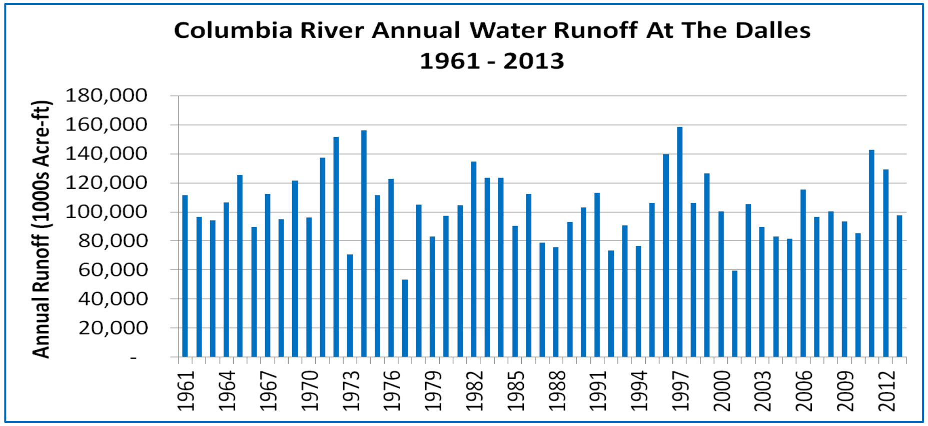
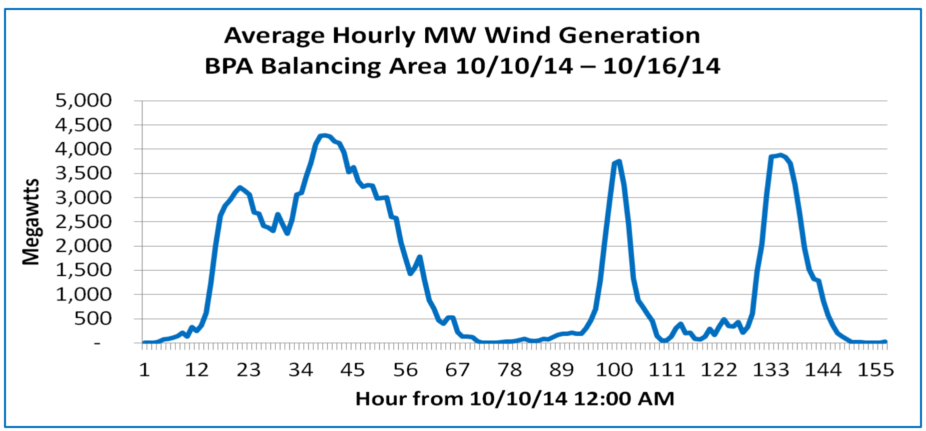
Generating Resource Uncertainty Results from *Unanticipated* (i.e., "forced") Outages Which Reduces Their Availability

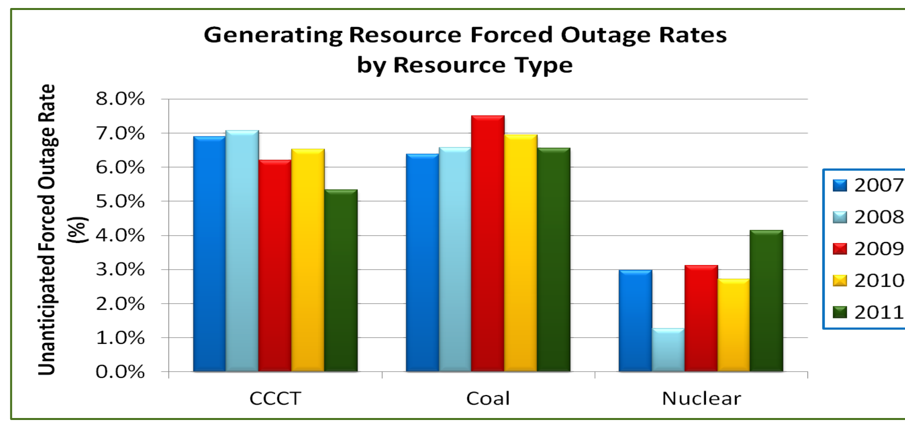


Resource *Variability* Differs from Resource *Uncertainty - But Planning for Both Is Important*

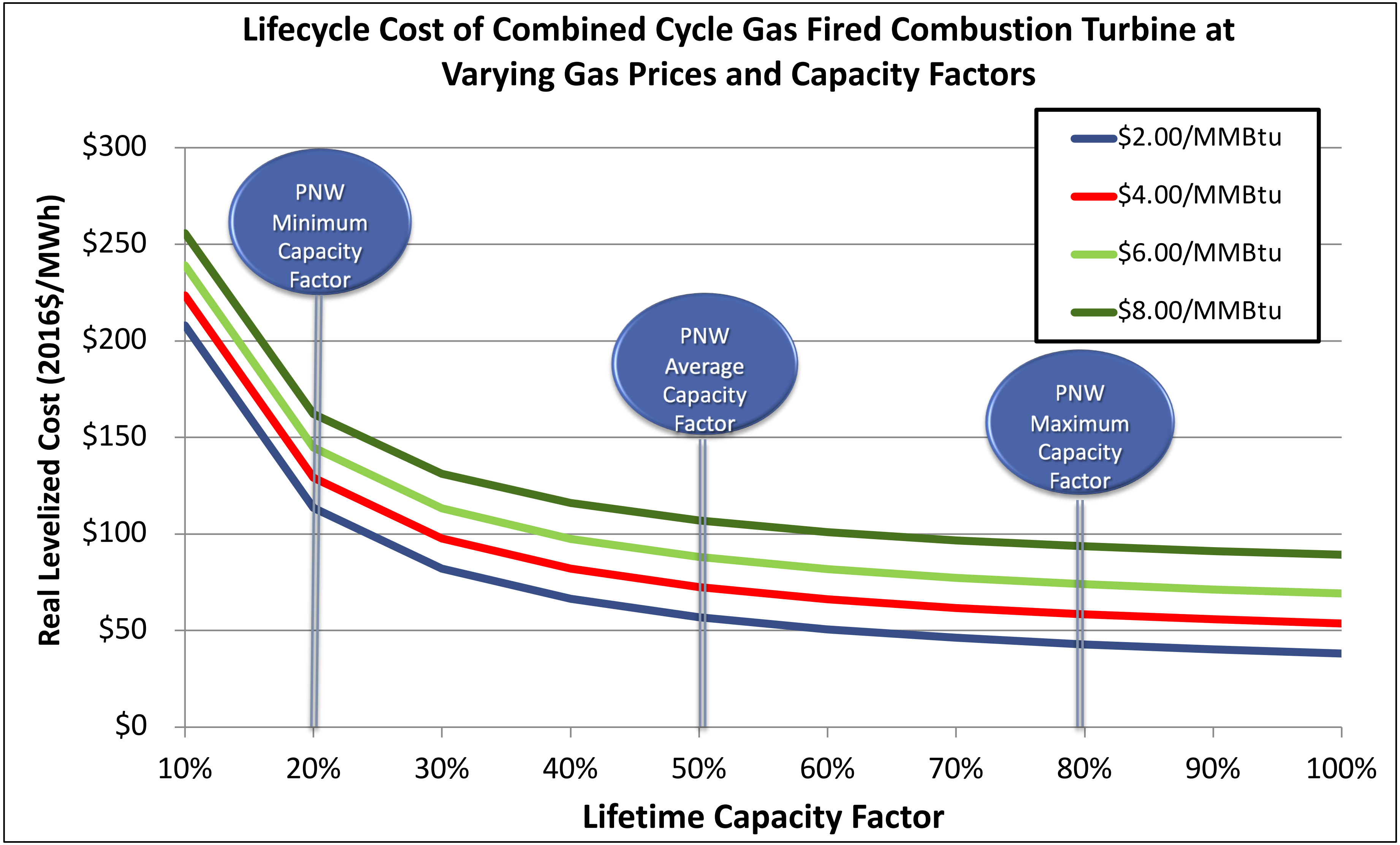


While probabilities can be assigned to predict the output of variable resources and adjust for forced outage rates, this does not eliminate <u>*cost*</u> uncertainty

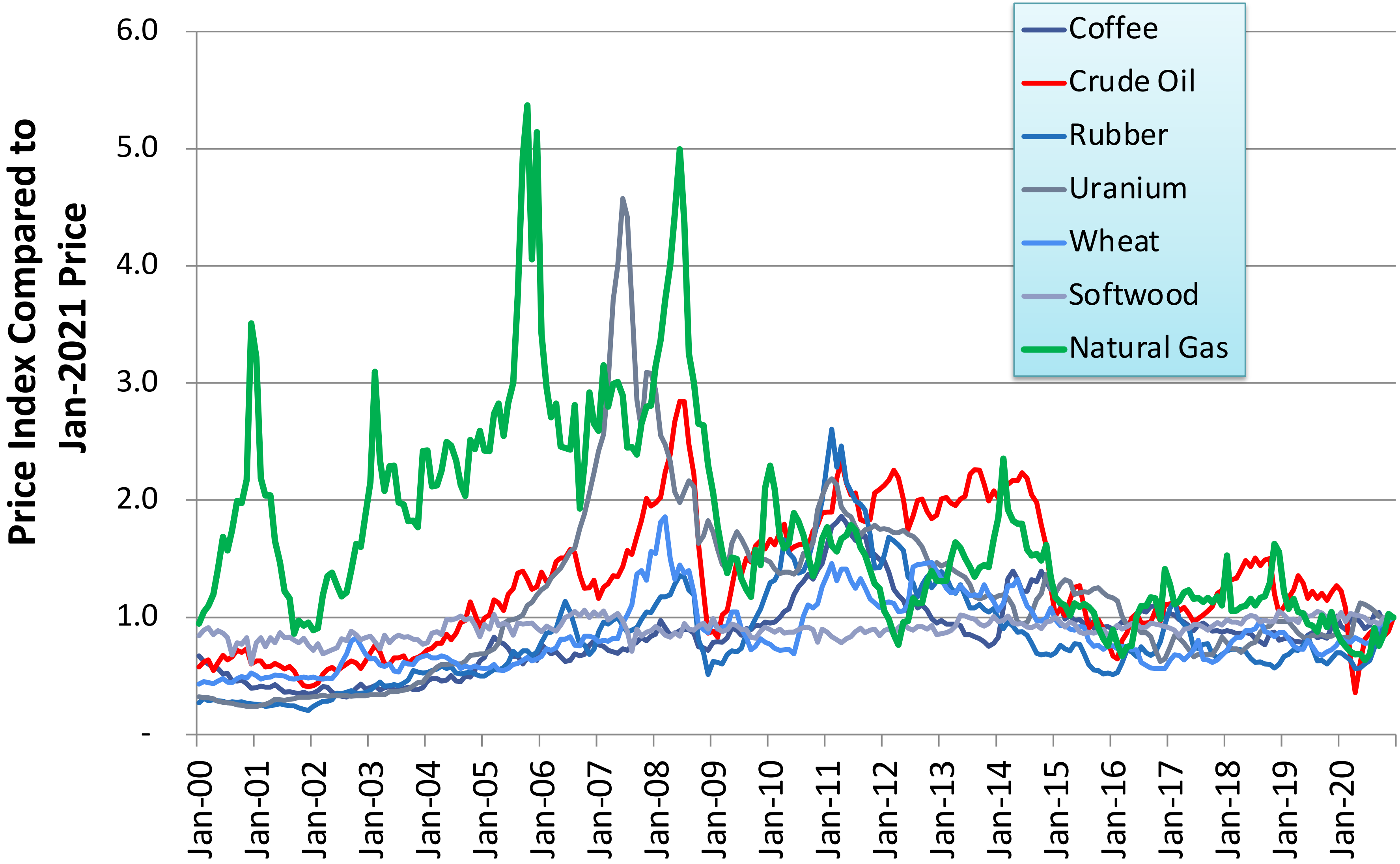




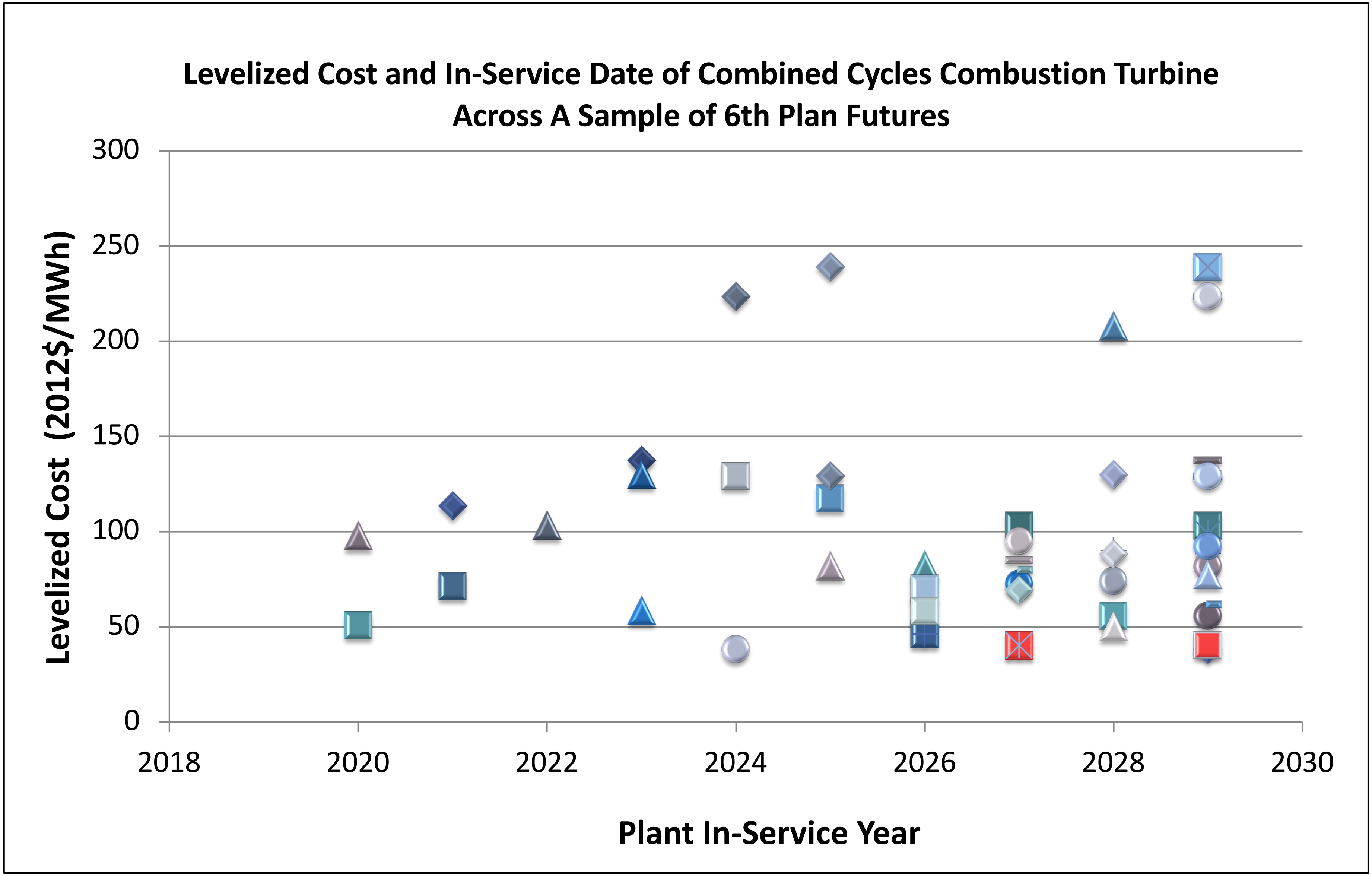
Resource Cost Uncertainty Is Primarily Driven by Input Fuel Prices and Utilization (i.e., "capacity factors”)



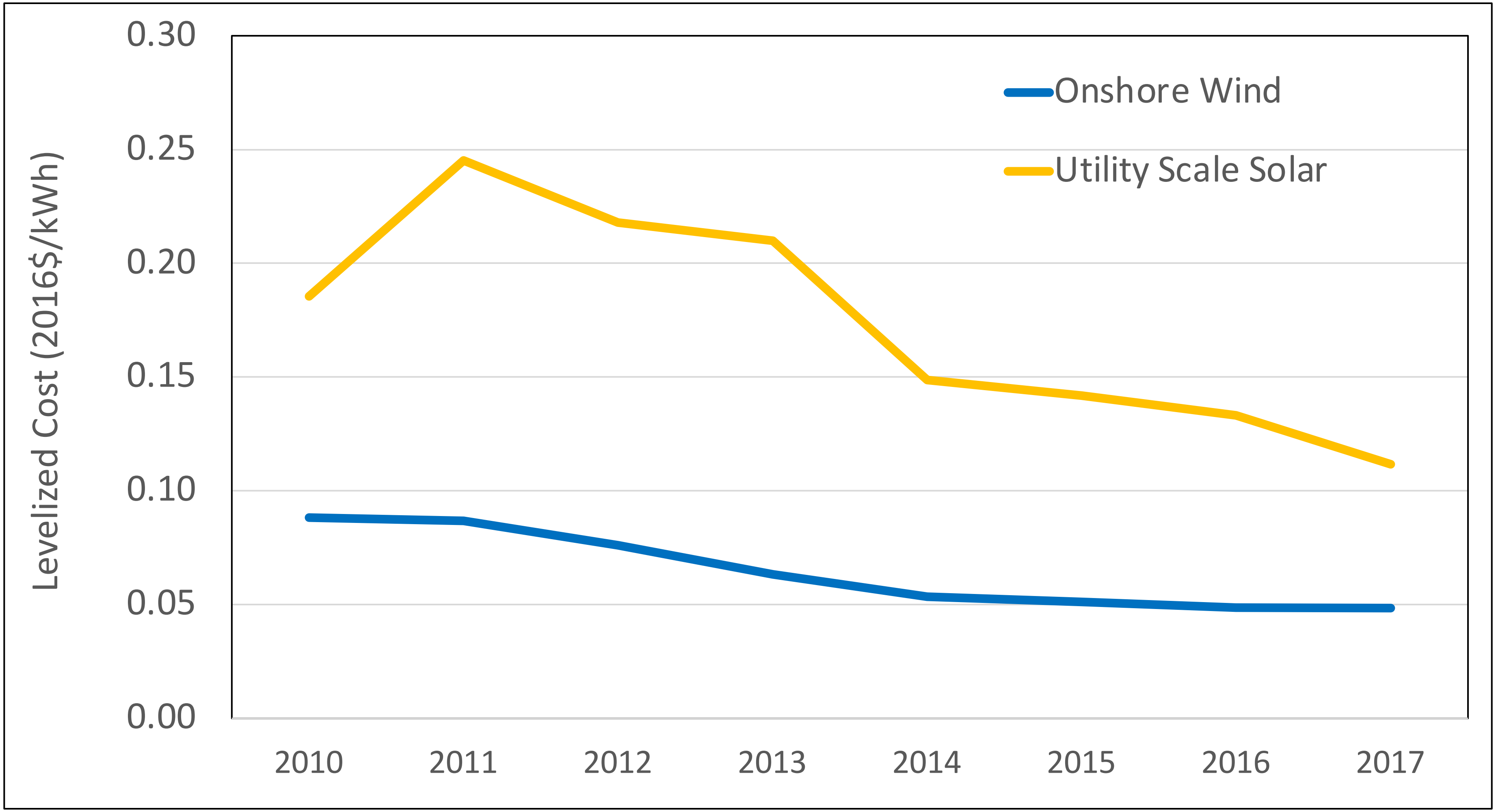
Forecasting Natural Gas Prices Is Equivalent to Engaging in Commodity Trading



These Uncertainties Mean There's No Single "Avoided Cost" for New Resources – Hence No Single Avoided Cost for Energy Efficiency (or Demand Response)



The Pace of Technology Change Introduces Additional Uncertainty Into the Determination of Avoided Cost



Source: Renewable Power Generation Costs in 2017 from the International Renewable Energy Agency (IRENA)

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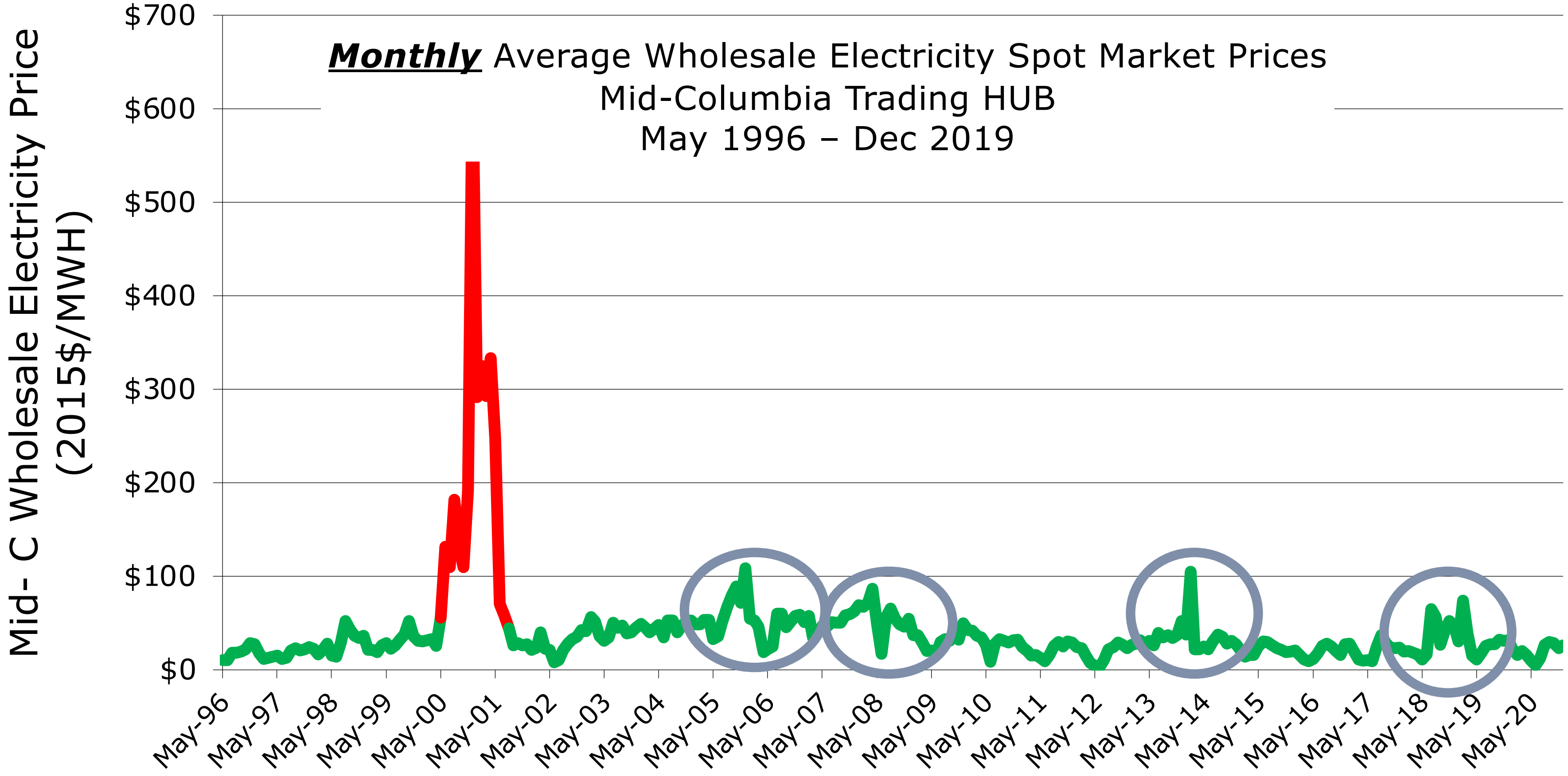
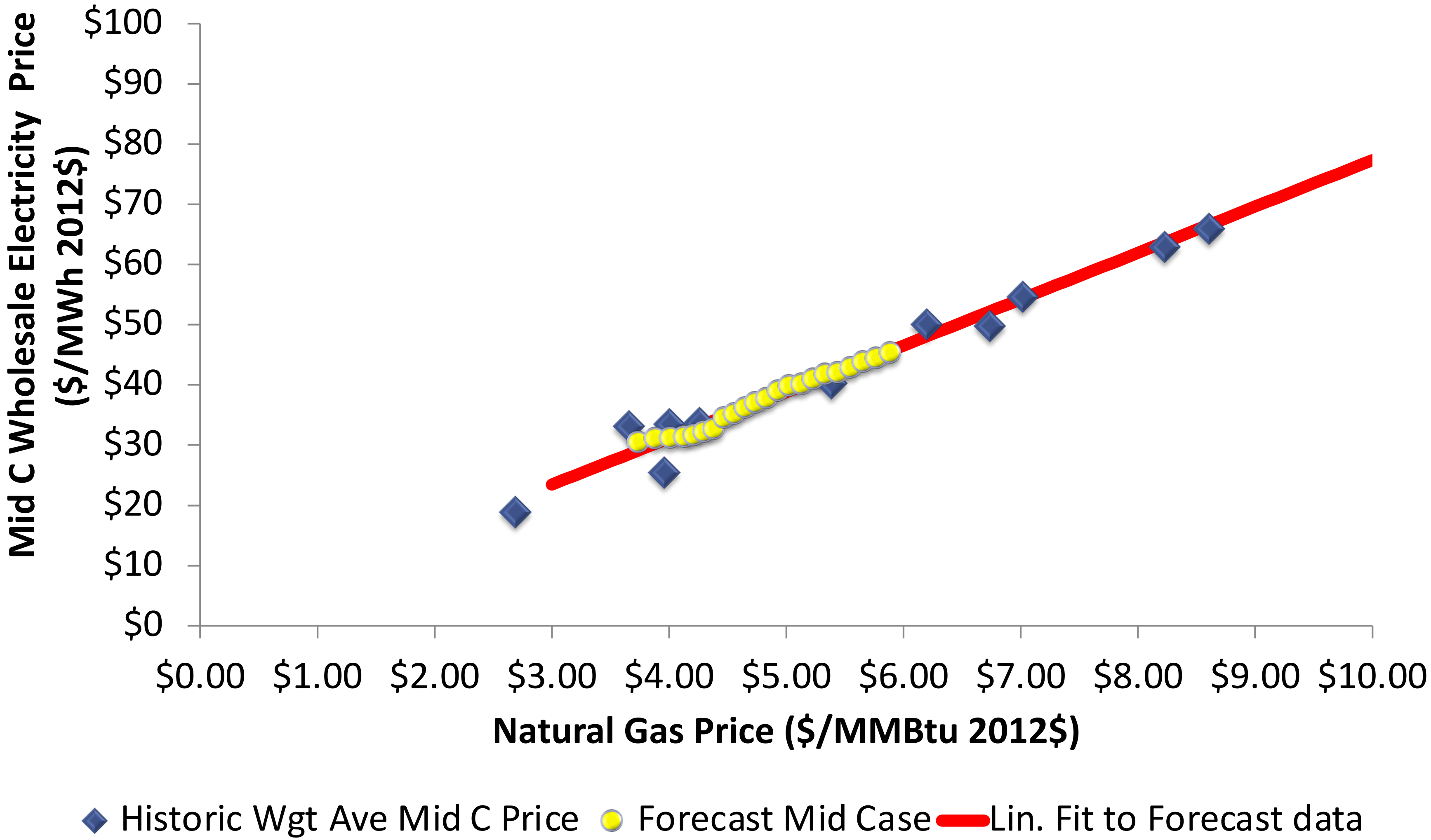
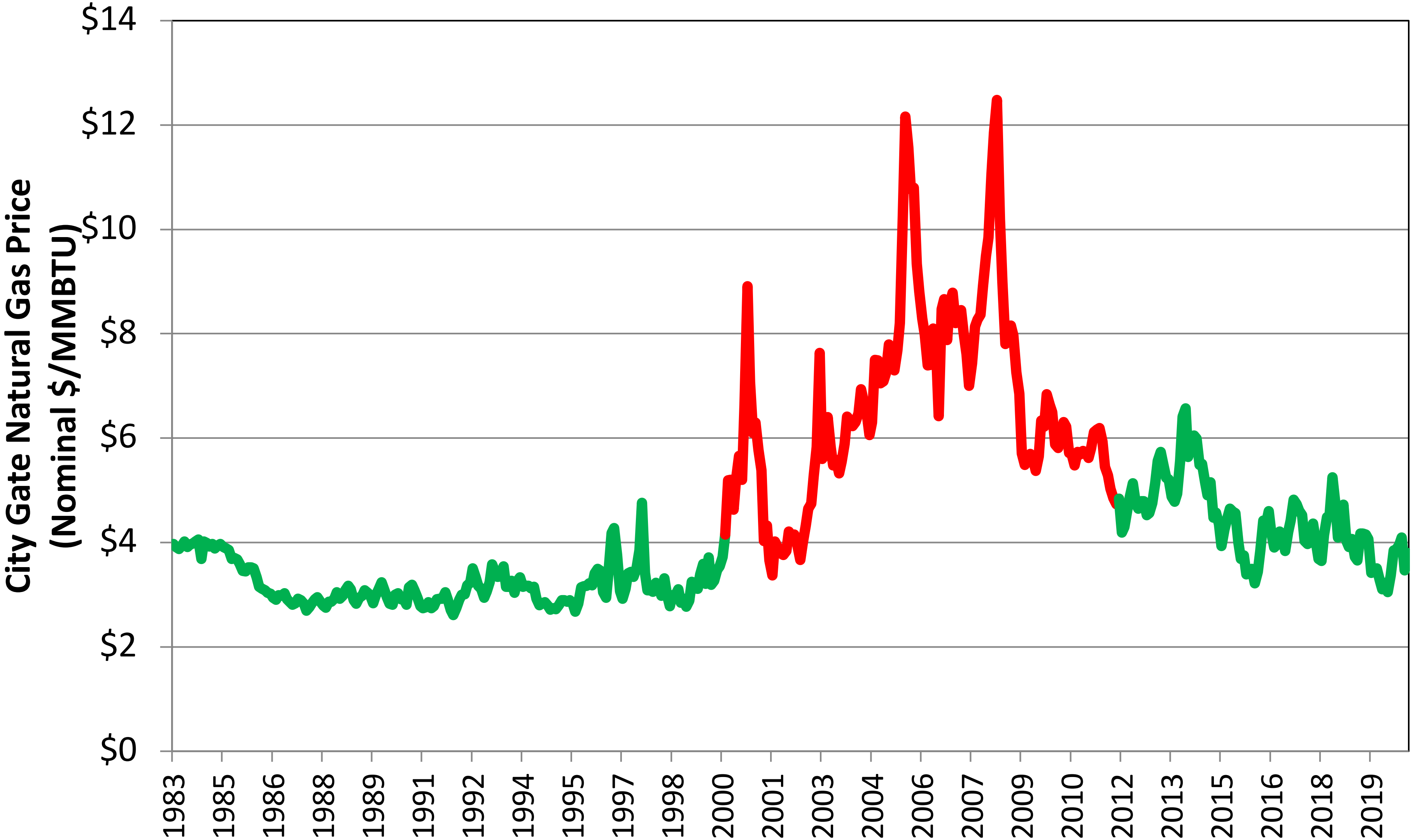
Market Prices Establish the Value of Marginal Resources – But They Are Full of Surprises



Wholesale Electricity Market Prices Are Strongly Correlated to Natural Gas Prices



When Natural Gas Market Prices Provide *Surprises*, They Pass Along That *Gift* To Wholesale Electricity Prices



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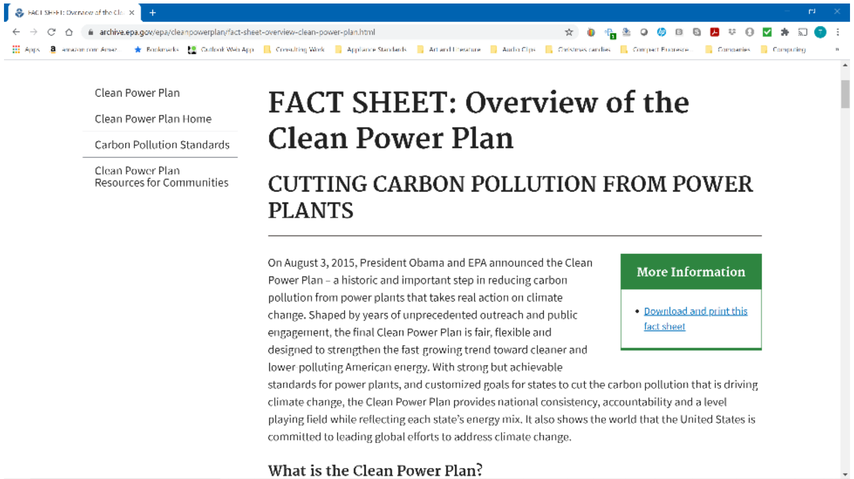
Climate Change Regulation – Yes, No, Maybe?


Clean Power Plan
Clean Power Plan Home
Carbon Pollution Standards
Clean Power Plan Resources for Communities

FACT SHEET: Overview of the Clean Power Plan

CUTTING CARBON POLLUTION FROM POWER PLANTS

On August 3, 2015, President Obama and EPA announced the Clean Power Plan – a historic and important step in reducing carbon pollution from power plants that takes real action on climate change. Shaped by years of unprecedented outreach and public engagement, the final Clean Power Plan is fair, flexible and designed to strengthen the fast growing trend toward cleaner and lower polluting American energy. With strong but achievable standards for power plants, and customized goals for states to cut the carbon pollution that is driving climate change, the Clean Power Plan provides national consistency, accountability and a level playing field while reflecting each state's energy mix. It also shows the world that the United States is committed to leading global efforts to address climate change.

More Information
- Download and print this fact sheet

What is the Clean Power Plan?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An unusual 5–4 decision halts the federal effort to curb carbon dioxide emissions from power plants while the court battle continues

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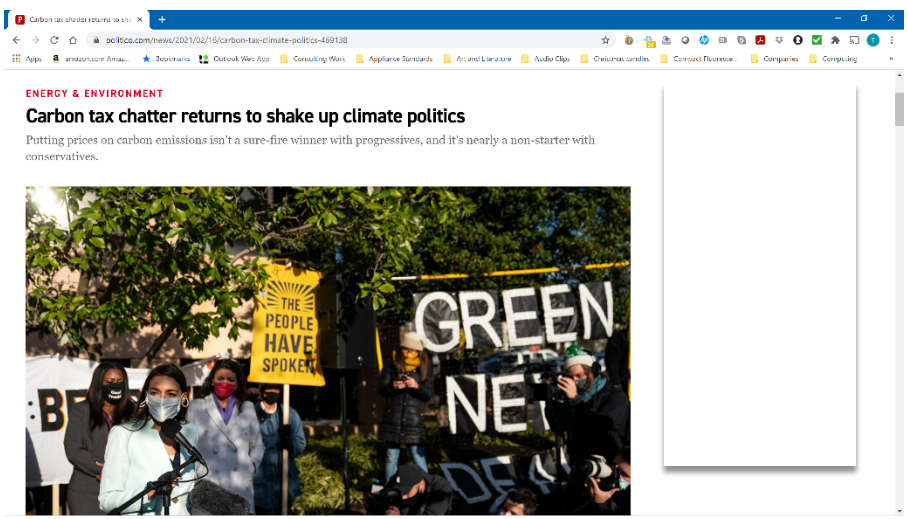
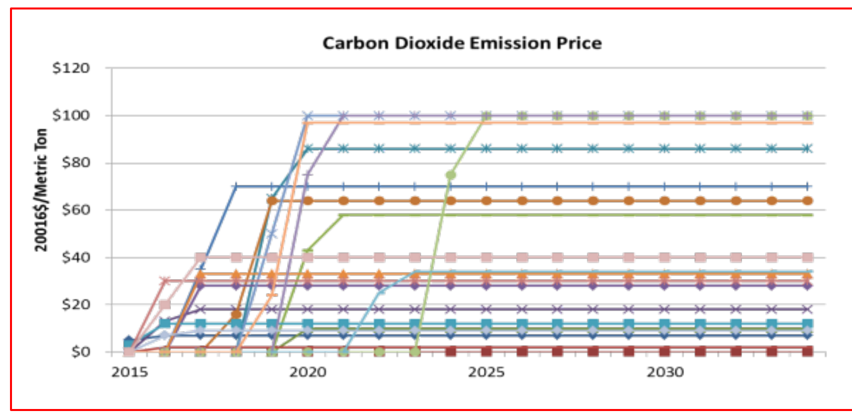

ENERGY & ENVIRONMENT

Carbon tax chatter returns to shake up climate politics

Putting prices on carbon emissions isn't a sure-fire winner with progressives, and it's nearly a non-starter with conservatives.



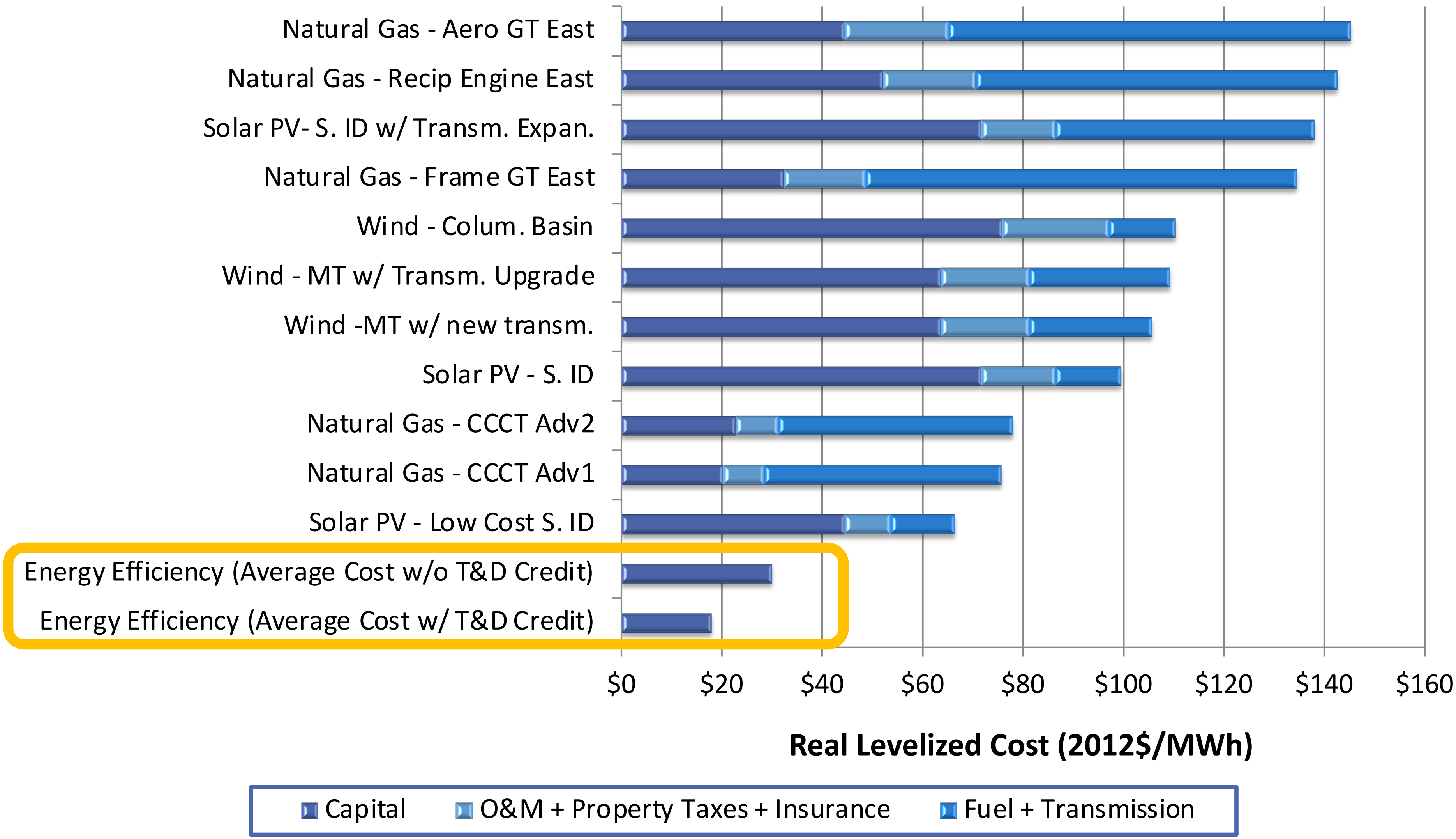
Agree or Disagree, It's Still a "Known Unknown"

So With All These Uncertainties, How Does An IRP Answer Those Simple Questions?

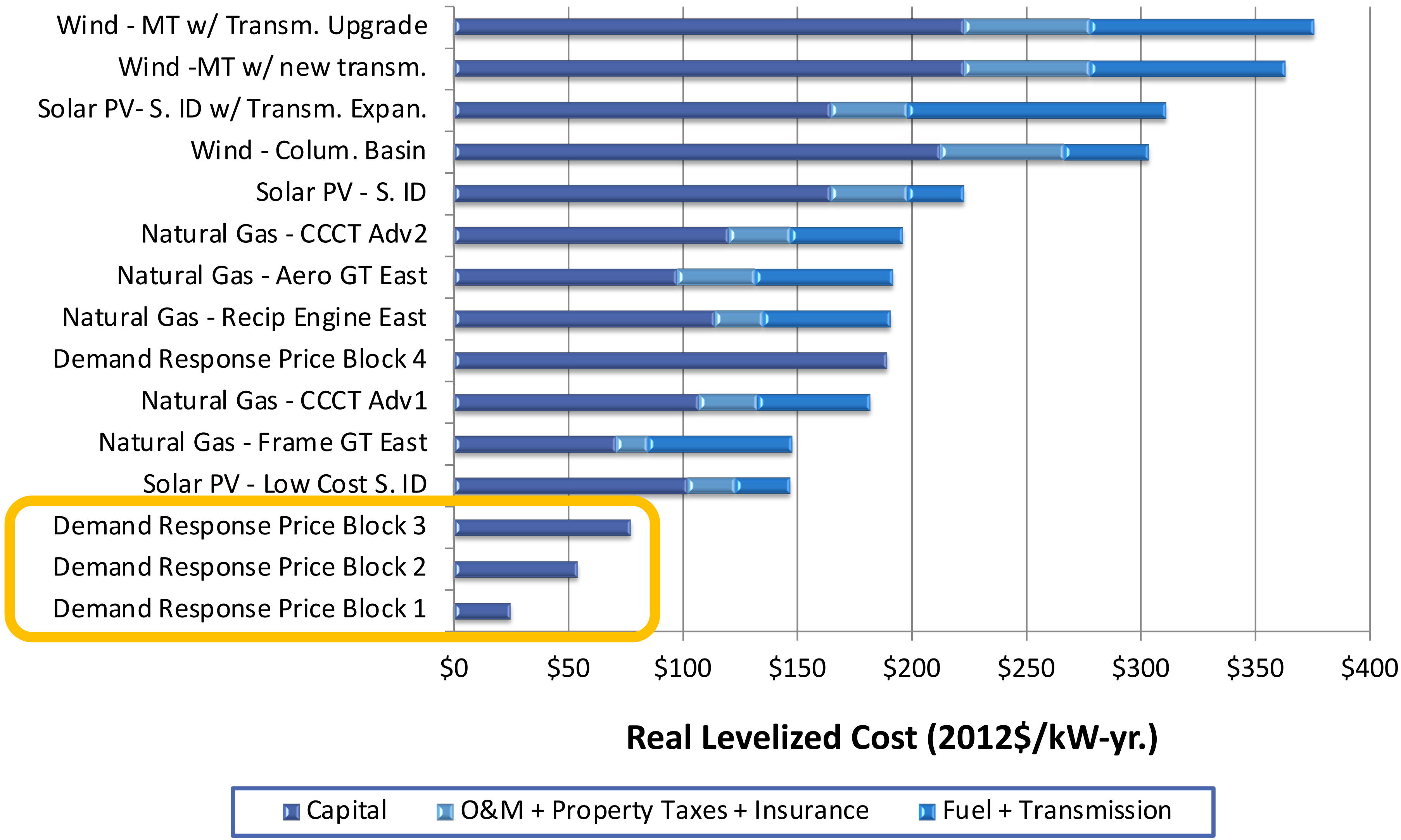
1. *When Will We Need Resources?*
2. *How Much Will We Need?*
3. *What Should We Build/Buy?*
4. *How Much Will It Cost?*
5. *What's the Risk?*

The Answer Seems Obvious: The Lowest Cost and Lowest Risk Resources

All Resource Cost – Energy

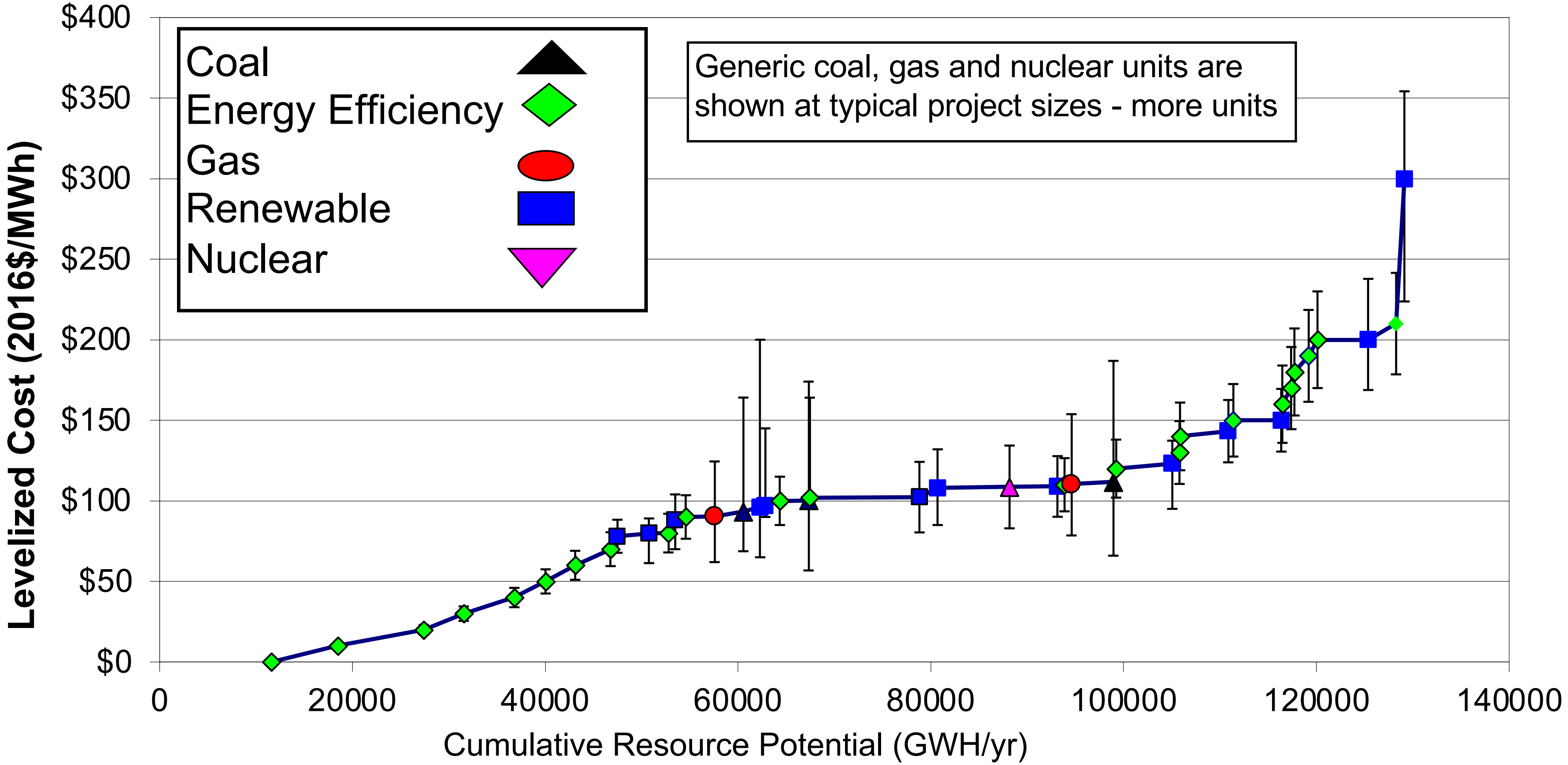


All Resource Cost – Peak Capacity



Creating and All Resource Supply Curve Permits Resource Portfolio Analysis on One Slide

Almost



While the "All Resource Supply Curve" tells use what to acquire, it doesn't tell us *how much, when or the costs and risks* of acquisition!

Uncertainty and Risk Means Managing the Unknowns

As we know,

There are known knowns.

There are things we know we know.

We also know

There are known unknowns.

That is to say

We know there are some things

We do not know.

But there are also unknown unknowns,

The ones we don't know

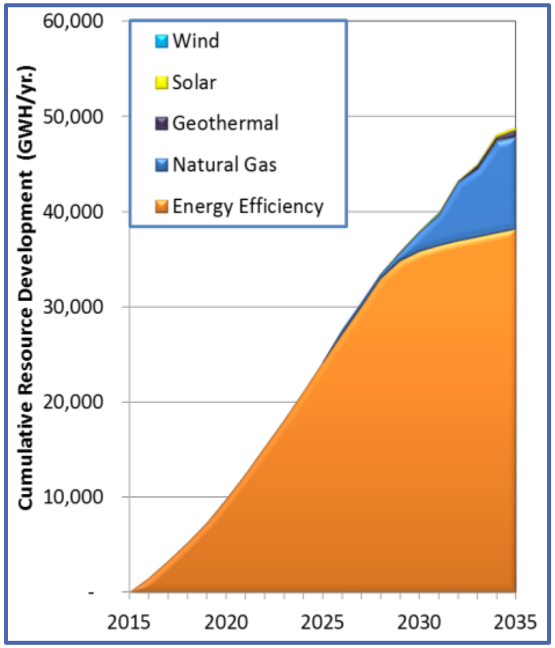
We don't know.

Donald Rumsfeld. Feb. 12, 2002, Department *of Defense news briefing*

Answering the *Timing, Amount, Type, Cost* and *Risk* Questions Requires Capacity Expansion Modeling and Risk Analysis

Resource Strategies – actions and policies over which the decision maker *has control* that will affect the outcome of decisions (i.e., "***the knowns***")

Futures – circumstances over which the decision maker *has no control* that will affect the outcome of decisions (i.e., "**the unknowns**")



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=

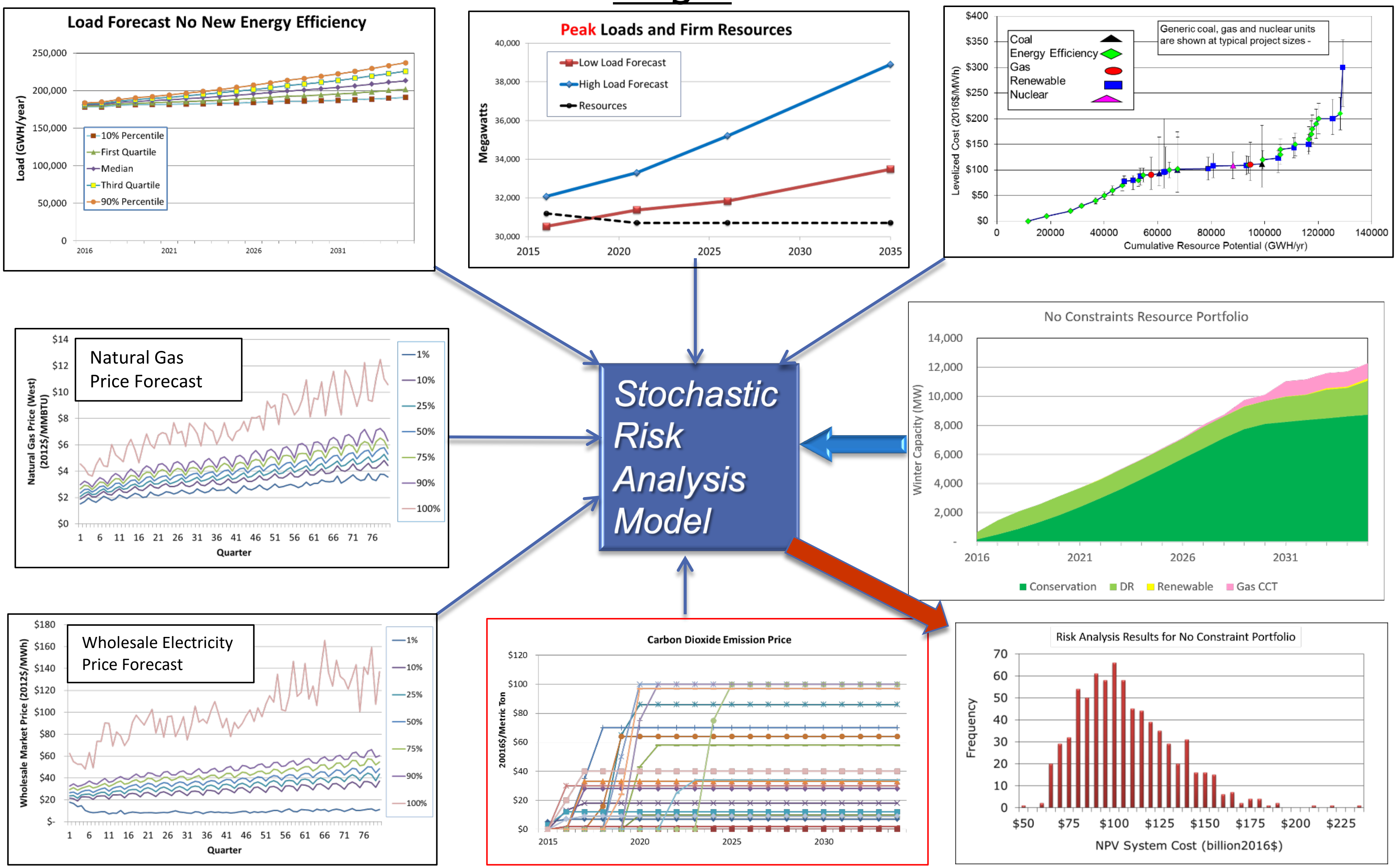
Scenarios – Combinations of *Resource Strategies* and *Futures* used to "stress test" how well what we control performs in a world we don't control

Resource Portfolio Optimization & Risk Assessment Methods

- *Users** of Capacity Expansion Models (CEMs) employ different methods to optimize resource development plans and assess risk
  - ***Most prevalent*** - Deterministic modeling, followed by stochastic risk analysis
    - Optimization is done for a *single* future
    - Optimization produces a "resource portfolio" specifying the type, amount and schedule of resource development over a planning period.
    - Risk is quantified by stress testing the optimized resource portfolio against a wide range of alternative futures.
  - ***Less prevalent*** – Stochastic optimization (scenario analysis on steroids)
    - Optimization is done across *multiple* (100s) of futures using decision criteria for capacity expansion.
    - Optimization results in a "resource strategy" of options and decision criteria managing the type and schedule of resource development over planning periods as future conditions evolve over a planning period.
    - Risk is quantified based on the cost of "worst outcomes" across all futures tested.

*Commercially available CEMs can be run in "multiple modes." Users determine which modes are used for optimization and whether other models and analyses are used in conjunction with the CEM to select their preferred resource plan.

Stochastic Risk Analysis of Resource Strategies Optimized for a *Single* Future



Limitation of Deterministically Optimized Resource Portfolio Stochastic Risk Assessment

- Capacity expansion modeling that optimizes resource portfolios for a *single* future.
  - Assumes control of not only all “known knowns,” but also the “known unknowns” and the “unknown unknowns”
  - This systematically likely *understates* risk, and therefore the value of risk mitigation and resilience
- Adding stochastic risk assessment permits testing resource portfolios optimized for a single future against a stochastically derived range of alternative future conditions
  - Replication of this process is required to compare the risk of many (1000s) of resource portfolios optimized for different single futures against stochastically derived range of many (100s) of alternative future conditions to identify the most robust portfolio
  - This approach likely *overstates* risk, because these *resource portfolios are not altered in response to future conditions* for which they are not optimized

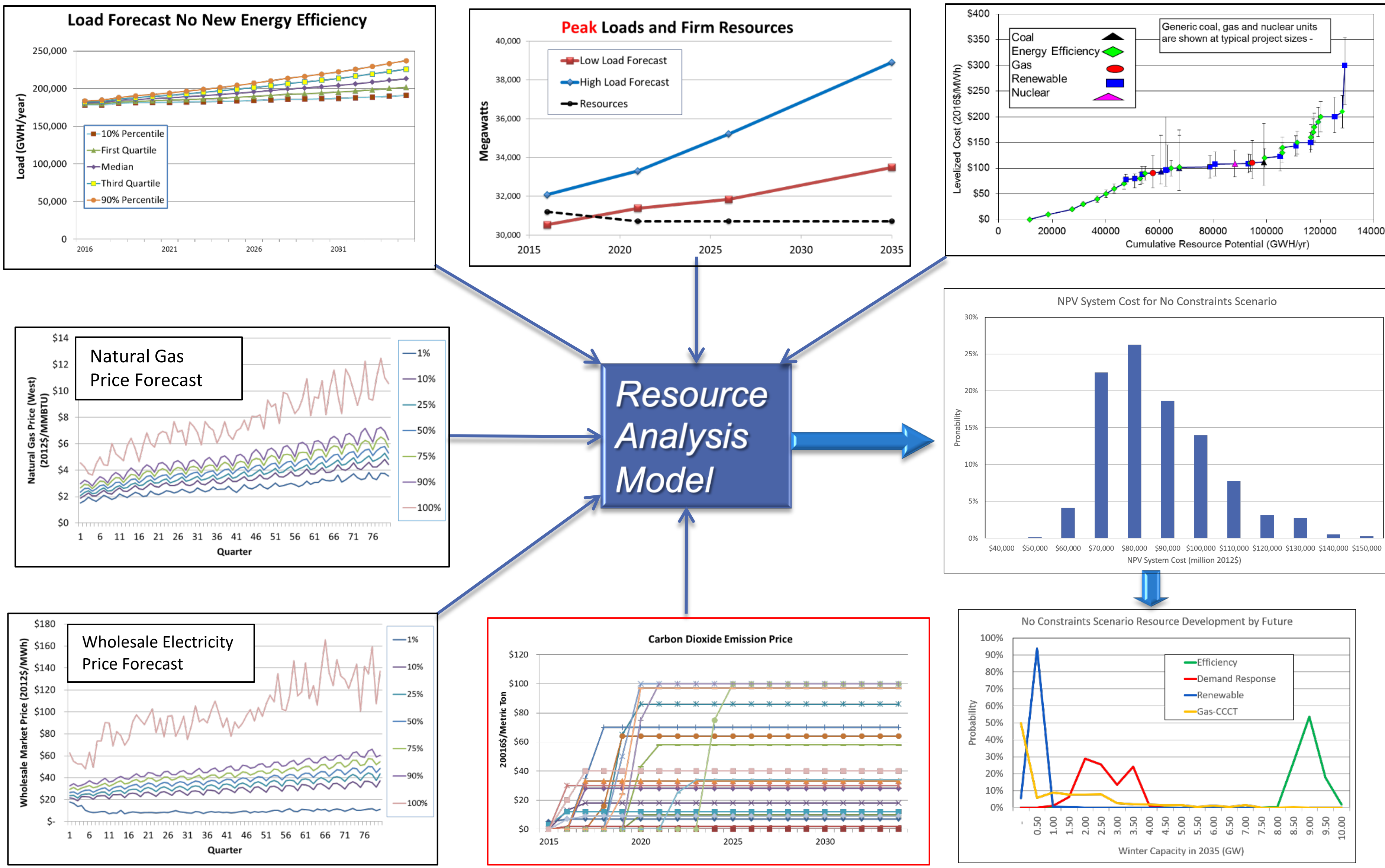
This method of risk analysis assumes that even though you can see the bridge is out, you would drive into the river because you continue to follow Google Map’s “Quickest Route.”

Best Practice IRPs Follow the "Gump" Resource Strategy Risk Analysis Method

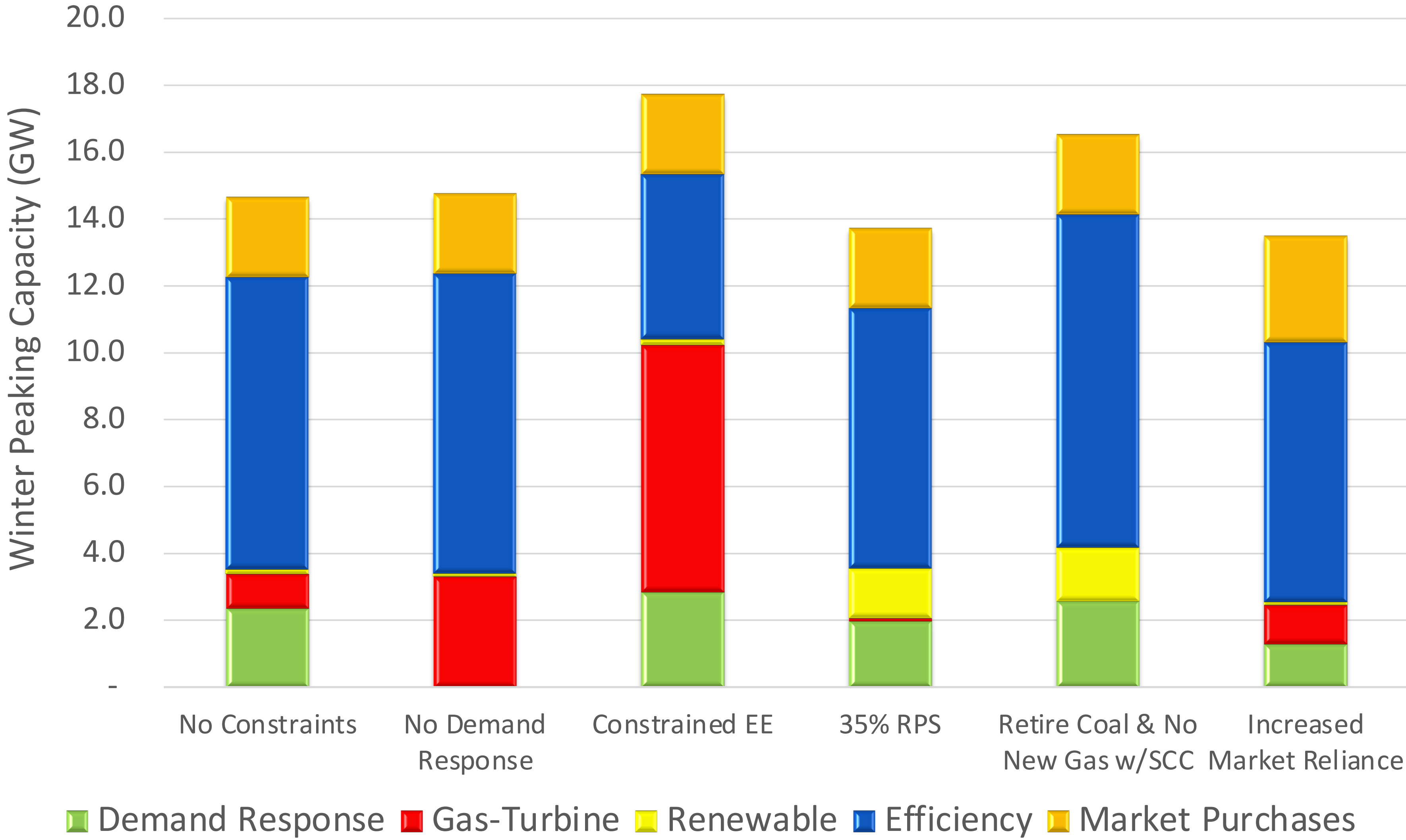
The Future's Like A Box of Chocolates.

You Never Know What You're Gonna Get.

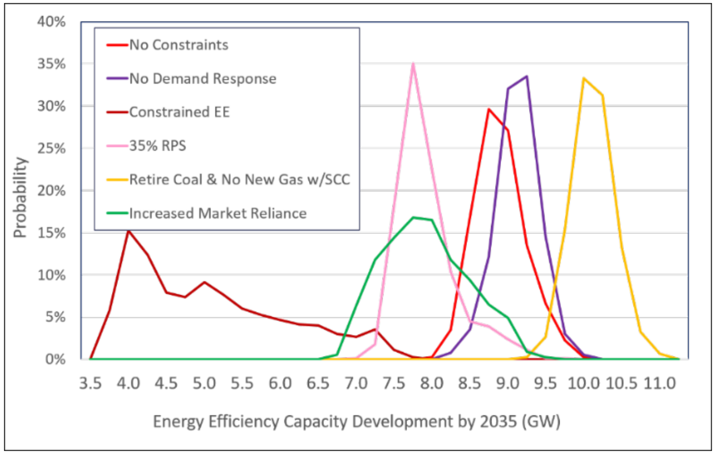
Stochastic Risk Analysis for Resource Strategies Optimized *Across A Range* of Future Conditions

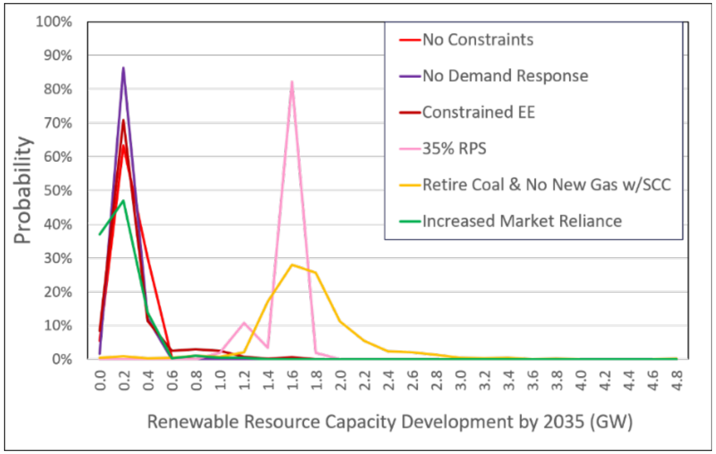


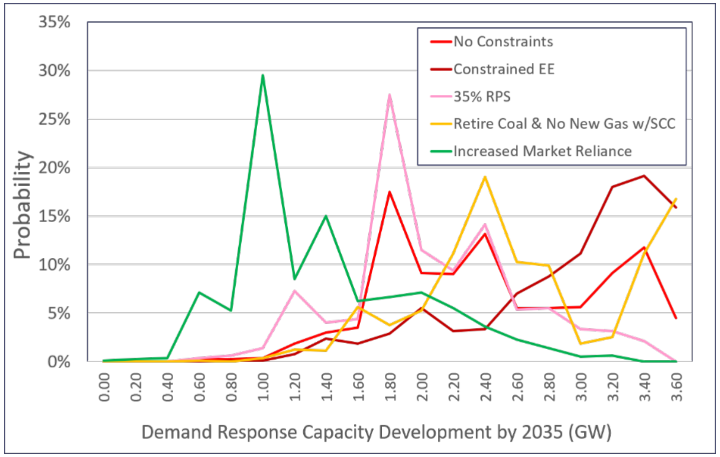
Multiple Scenarios Are Tested
Each Scenario Has an "Expected Value" Resource Portfolio

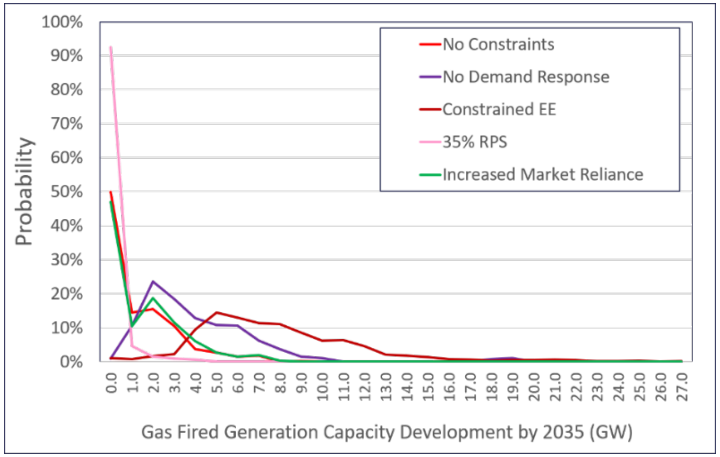


However, Each Scenario Varies Resource Development by Future Assumes *Adaptive Management** by Utilities



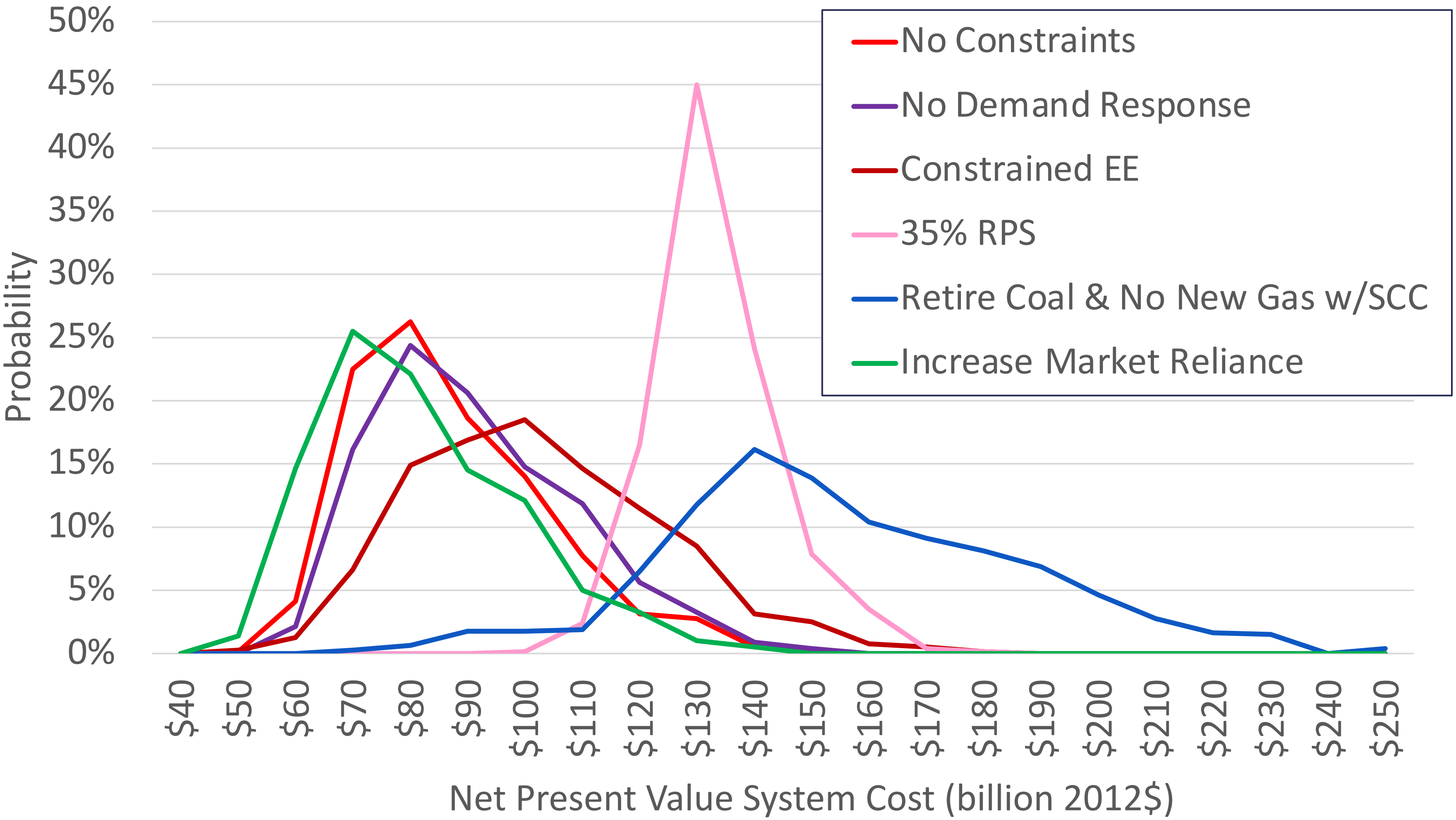




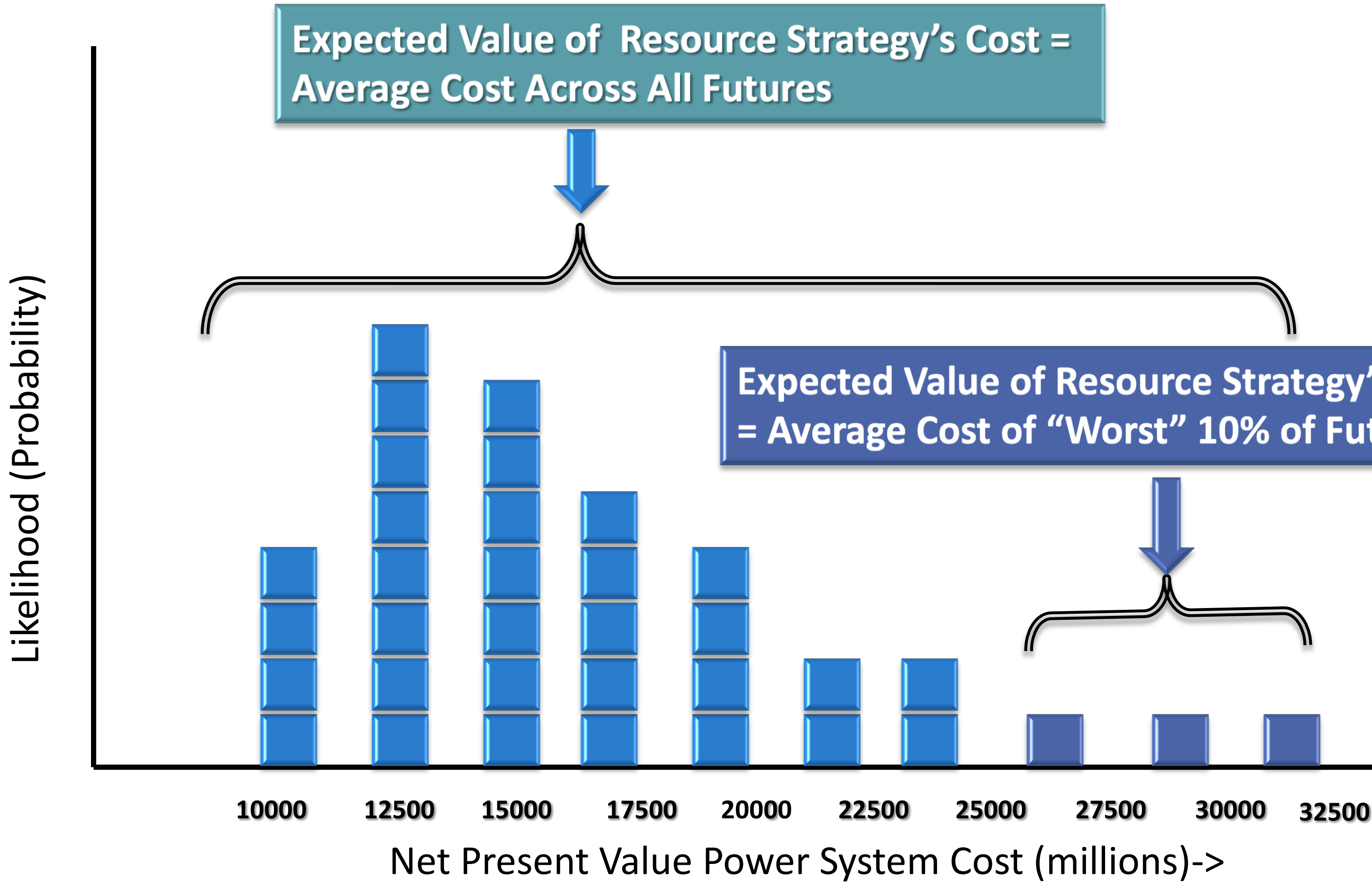


Avoids driving into the river when you can see the bridge is out!

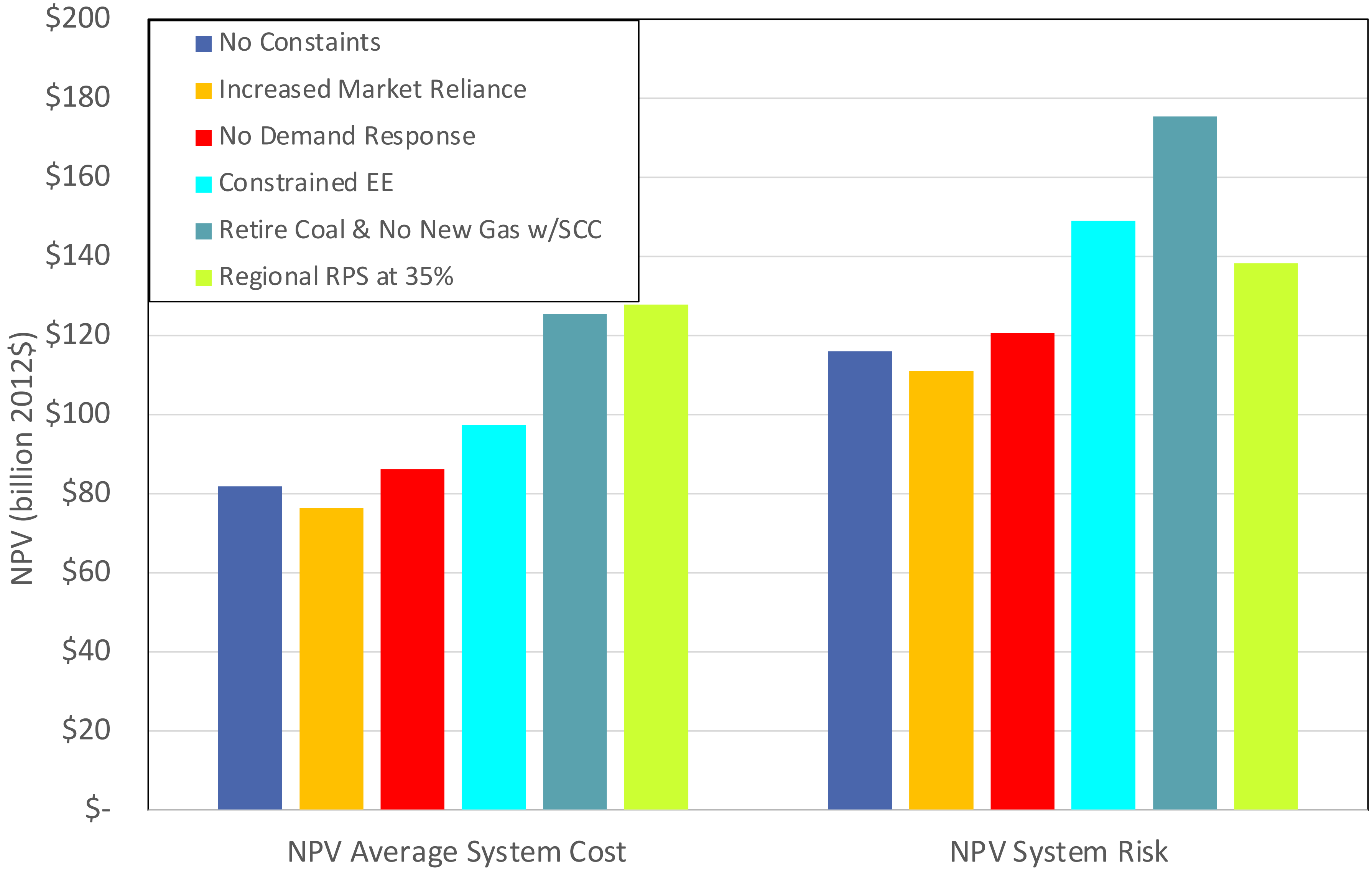
The Distribution of Net Present Value System Cost for a Resource Strategy Across All Futures Permits Comparison of Their Relative Cost and Risks



Expected Cost and Risk Metrics Characterize Each Resource Strategy

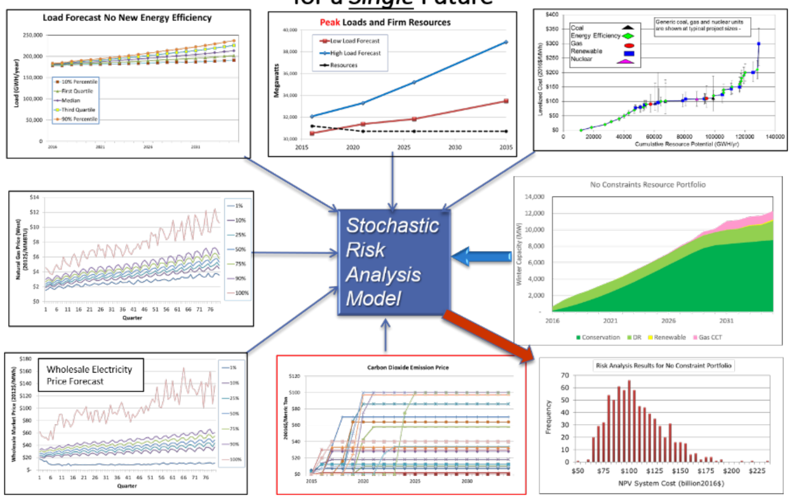


This Permits Comparison of Both System Cost and Risk



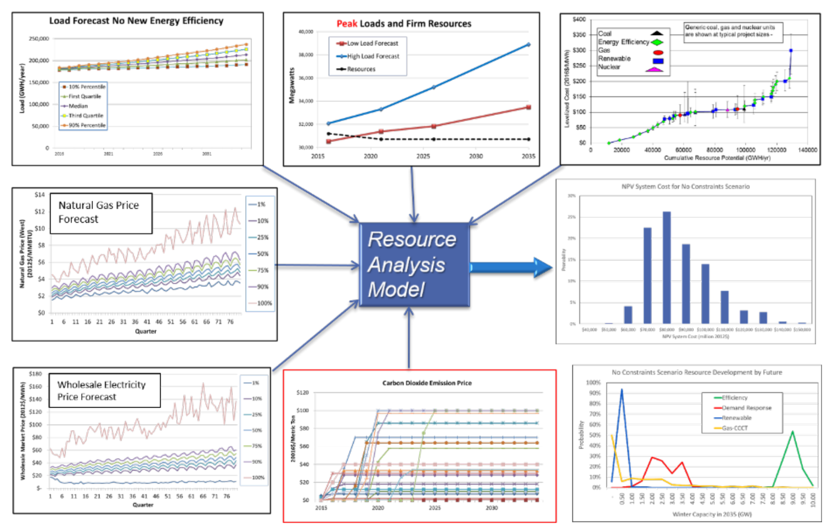
Average of the Inverse ≠ Inverse of the Average

Stochastic Risk Analysis of Resource Strategies Optimized for a *Single* Future



Deterministically optimized Resource Portfolio's likely *understate* risk relative to stochastically optimized Resource Portfolios

Stochastic Risk Analysis for Resource Strategies Optimized *Across A Range* of Future Conditions



Stochastic risk assessments of deterministically optimized Resource Portfolio's likely *overstate* risk relative to stochastically optimized Resource Portfolios

What Does a Stochastic Risk Analysis Model Do?

- It test ***thousands*** of alternative resource strategies (those things we control)
  - Varying the amount and timing of utility controlled *resource* development
    - Energy Efficiency (retrofit, lost-opportunity)
    - Demand Response
    - Natural gas fired CCCT and SCCT
    - Wind and Utility Scale Solar
    - Utility scale storage
    - Distributed Generation and stroage
  - Varying the amount and timing *market purchases* in lieu of resource development

- Against *hundreds* of different futures (those things we don't control)
  - Fuel Price Uncertainty
  - Regulatory/Carbon Risk Uncertainty
  - Load Uncertainty
  - Resource Uncertainty
  - Wholesale Market Price Uncertainty
  - Regulatory Uncertainty

- It "sorts" through all of the resource strategies to find those with the *lowest cost for each level of risk.*

The "Optimization Objective" of Best Practice IRPs - Find the Lowest Cost Insurance for the Same Risk Coverage

	LOW DEDUCTIBLE	MIDRANGE DEDUCTIBLE	HIGHER DEDUCTIBLE
Policy year claim is filed	$250 deductible $1,000 premium	$500 deductible $900 premium	$1,000 deductible $800 premium
1	$1,250	$1,400	$1,800
2	2,280	2,327	2,624
3	3,341	3,282	3,473
4	4,434	4,266	4,347
5	5,560	5,280	5,248
6	6,720		
7	7,915		
8	9,146		

Source: CR Money Lab. Premiums are hypothe

Auto Insurance

INSURER	PRICE	RATING	
Liberty Mutual	300.00	A++	CHOOSE
State Farm	395.00	B	CHOOSE
Geico	300.00	A++	CHOOSE
Progressive	395.00	B	CHOOSE
			CHOOSE

blem? Report a price as incorrect

Customize »

My Car Insurance	My Car Insurance Quotes		
My Insurance Provider Springfield, CA	Insurance Provider 1 Springfield, CA	Insurance Provider 2 Cupertino, CA	Insurance Provider 3 Modesto, CA
Current Auto Insurance Payment: $154/mo.	$132/mo.	$154/mo.	$180/mo.
Insurance Type: Full Coverage	Insurance Type: ✓ Full Coverage	Insurance Type: ✓ Full Coverage	Insurance Type: ✓ Full Coverage
Coverage Type: Standard $100K/$300K Injury, $50K property	Coverage Type: ✓ Standard $100K/$300K Injury, $50K property	Coverage Type: Basic $50K/$150K injury, $30K property	Coverage Type: Liability $50K/$150K injury, $30K property
Preferred Deductible: $500.00	Comprehensive Deductible: ✓ $500.00	Comprehensive Deductible: $1,000.00	Comprehensive Deductible: $1,000.00
Preferred Collision Deductible: $500.00	Collision Deductible: ✓ $500.00	Collision Deductible: ✓ $500.00	Collision Deductible: ✓ $500.00
Preferred Medical Coverage: $10,000.00	Medical Coverage: ✓ $10,000.00	Medical Coverage: ✓ $10,000.00	Medical Coverage: $5,000.00
Emergency Roadside Assistence: Yes	Emergency Roadside Assistence: ✓ Yes	Emergency Roadside Assistence: ✓ Yes	Emergency Roadside Assistence: ✓ Yes
Safe Driver Discount: Yes	Safe Driver Discount: ✓ Yes	Safe Driver Discount: ✓ Yes	Safe Driver Discount: ✓ Yes

This image is for illustration purposes only, and do not necessarily represent the exact products, services, or ideas in the context they are found in.

In Summary, a Resource Strategy's Benefits Should Always Outweigh Its Risks