Energy Technologies Area Lawrence Berkeley National Laboratory

Michigan Public Service Commission Integrated Resource Plan Stakeholder Group Meeting

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Presented by Tom Eckman on May 1, 2017

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Session 1 – Overview of IRP

- What's an IRP?
  - What questions does it address?
  - What are its essential elements?
- What are the major analytical steps in an IRP development process?
  - What types of models are used?
  - What role does each model type play in IRP development?
  - What are the critical inputs/assumptions?

What's in a IRP?
Illustrative Table of Contents

What's in a IRP? Illustrative List of Appendices

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Appendix B. Wholesale and Retail Electricity Price Forecast
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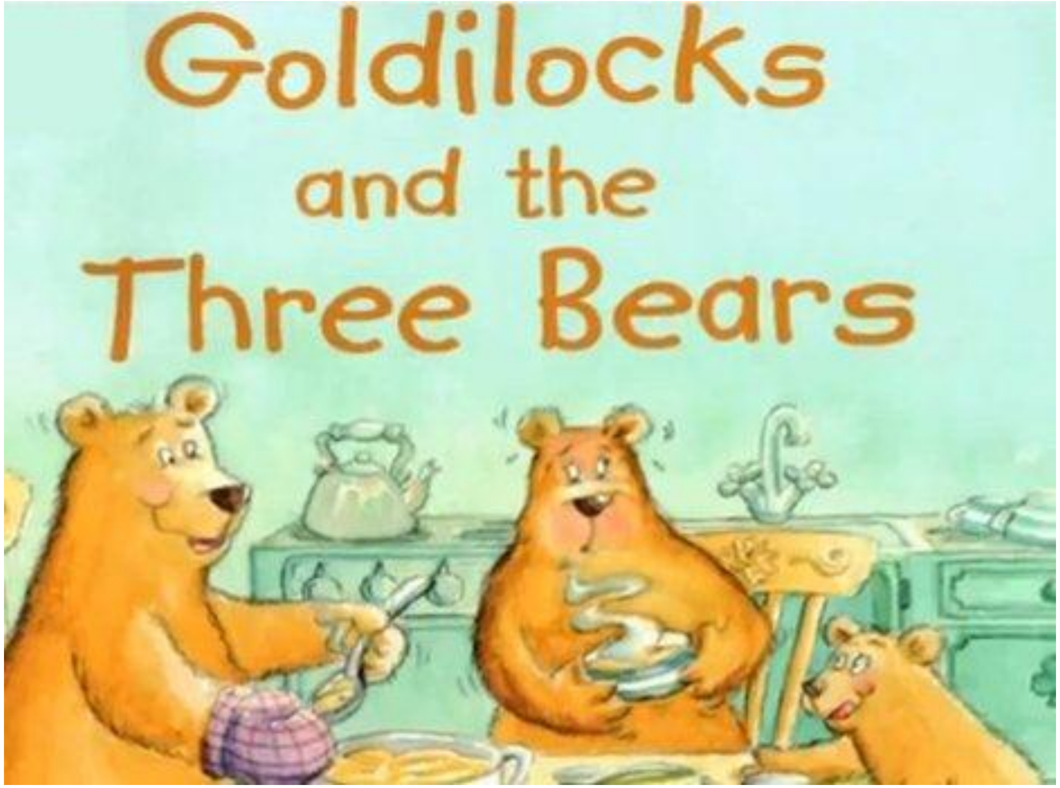
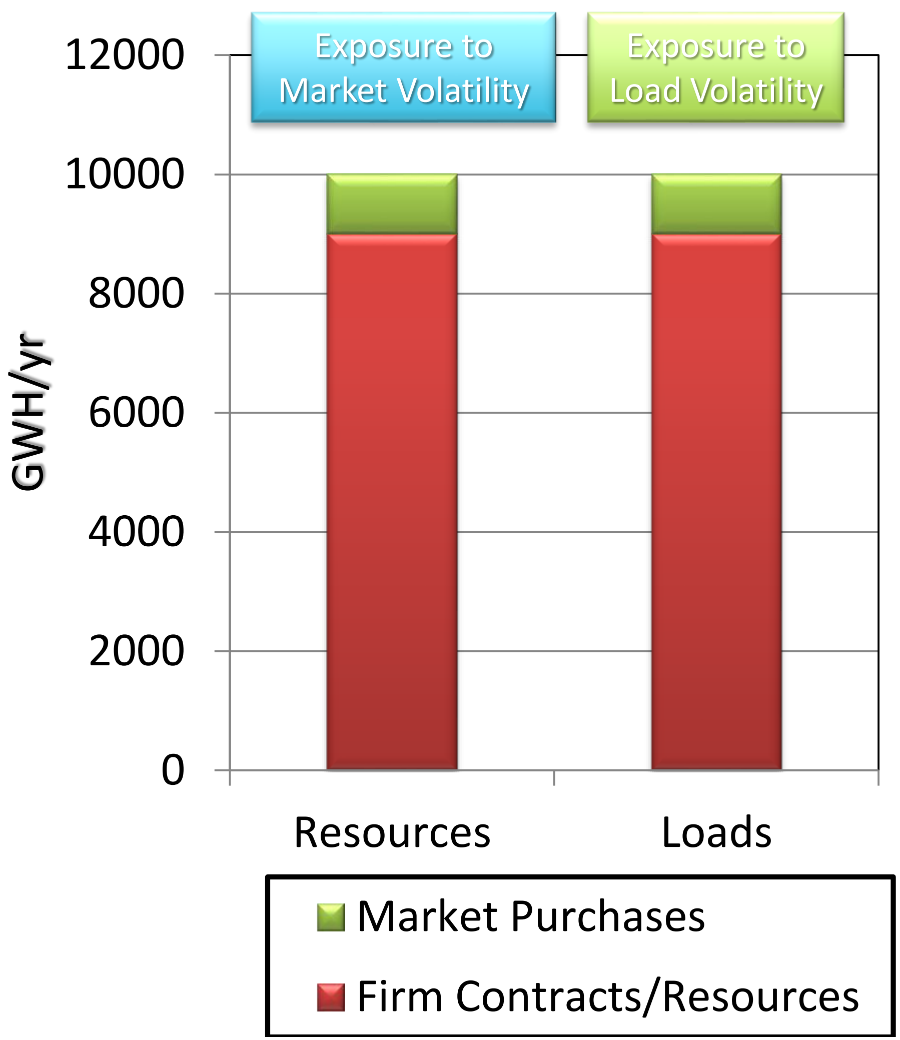
IRPs Are Intended to Address the Resource Planner's "Goldilocks Problem"

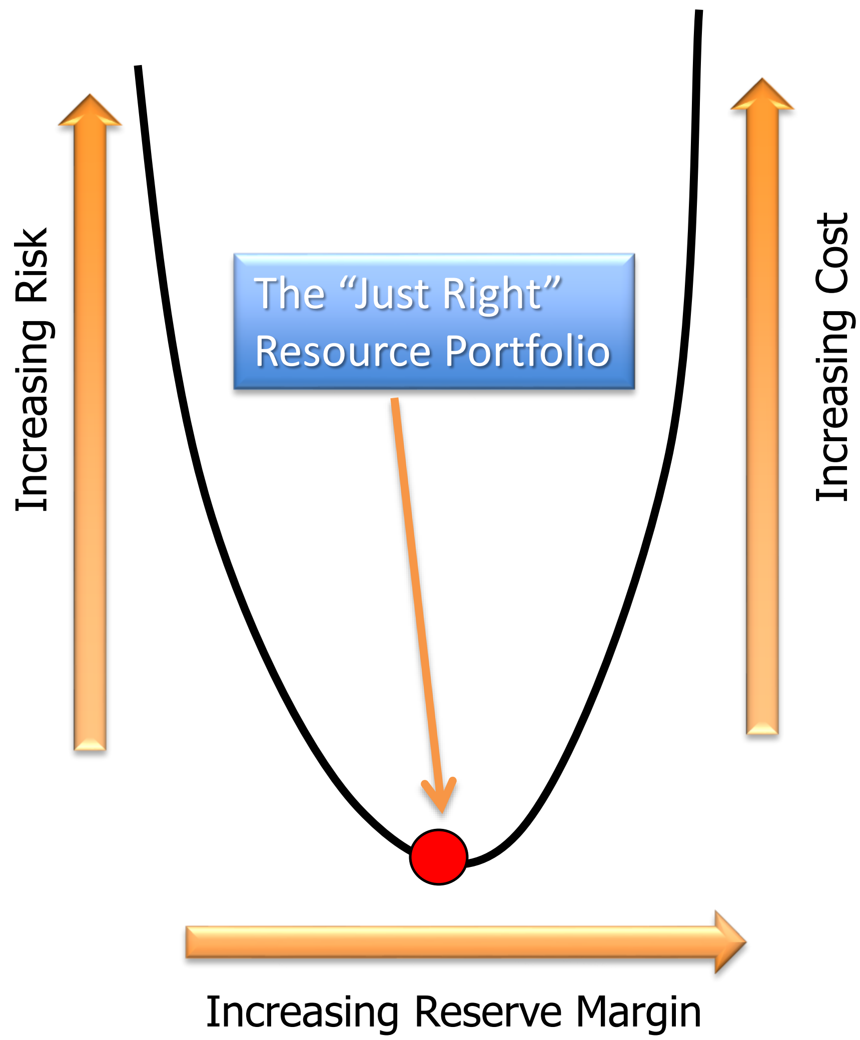
- Don't have too many resources
- Don't have too few resources
- Have "just the right amount" of resources*



*Resources include energy, capacity, flexibility and other ancillary services needed for system reliability.

Why "Just Right" Matters:
As A Utility's Resource Mix Changes So Does Its Cost and Risk

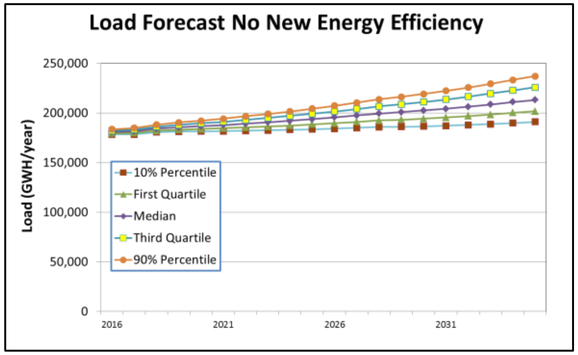




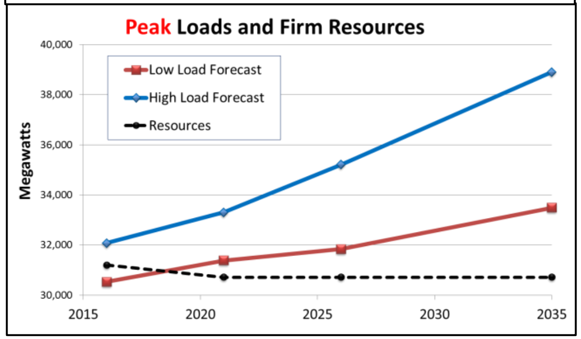
IRPs Attempt to Find the "Just Right" Resource Mix by Answering Six Simple Questions

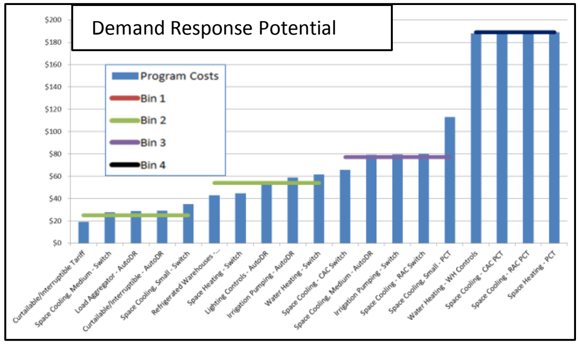
1. *When Will We Need Resources?*
2. *How Much Will We Need?*
3. *What Should We Build/Buy?*
4. *How Much Will It Cost?*
5. *What's the Risk?*
6. *Who Can We Blame If We Get It Wrong?*

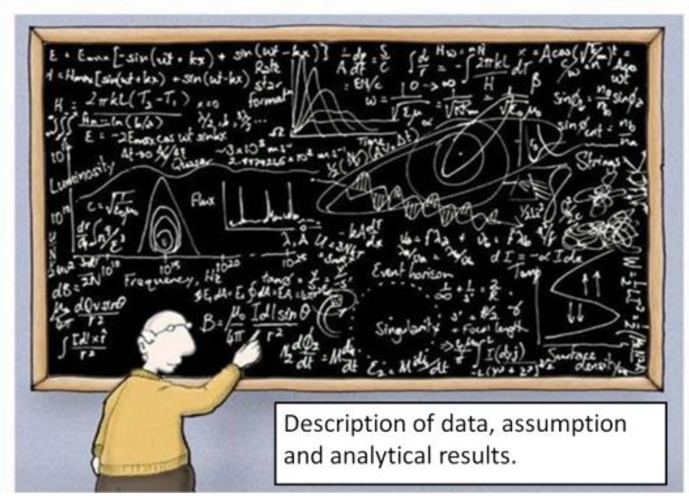
Key Components of IRPs

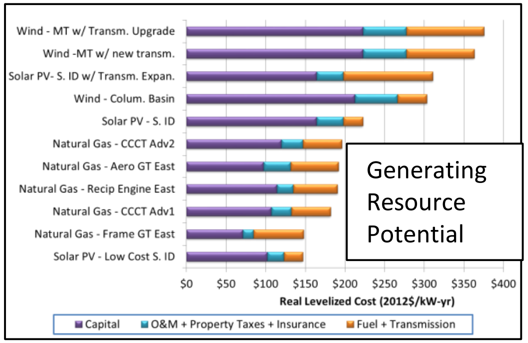


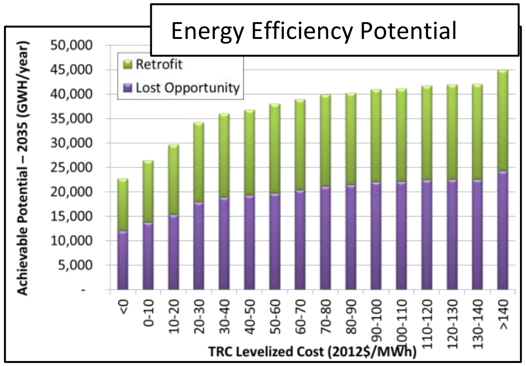
Resource Needs/Adequacy Assessment







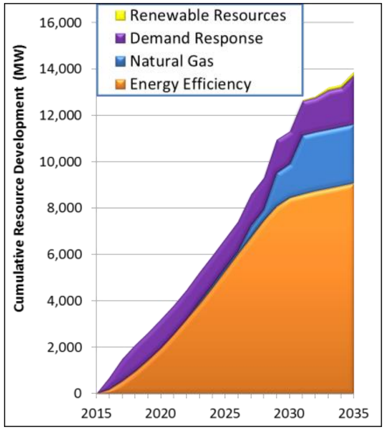


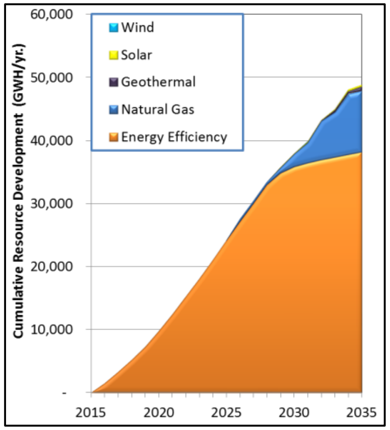


Resource Portfolio/ Strategy

Capacity Resources

Energy Resources

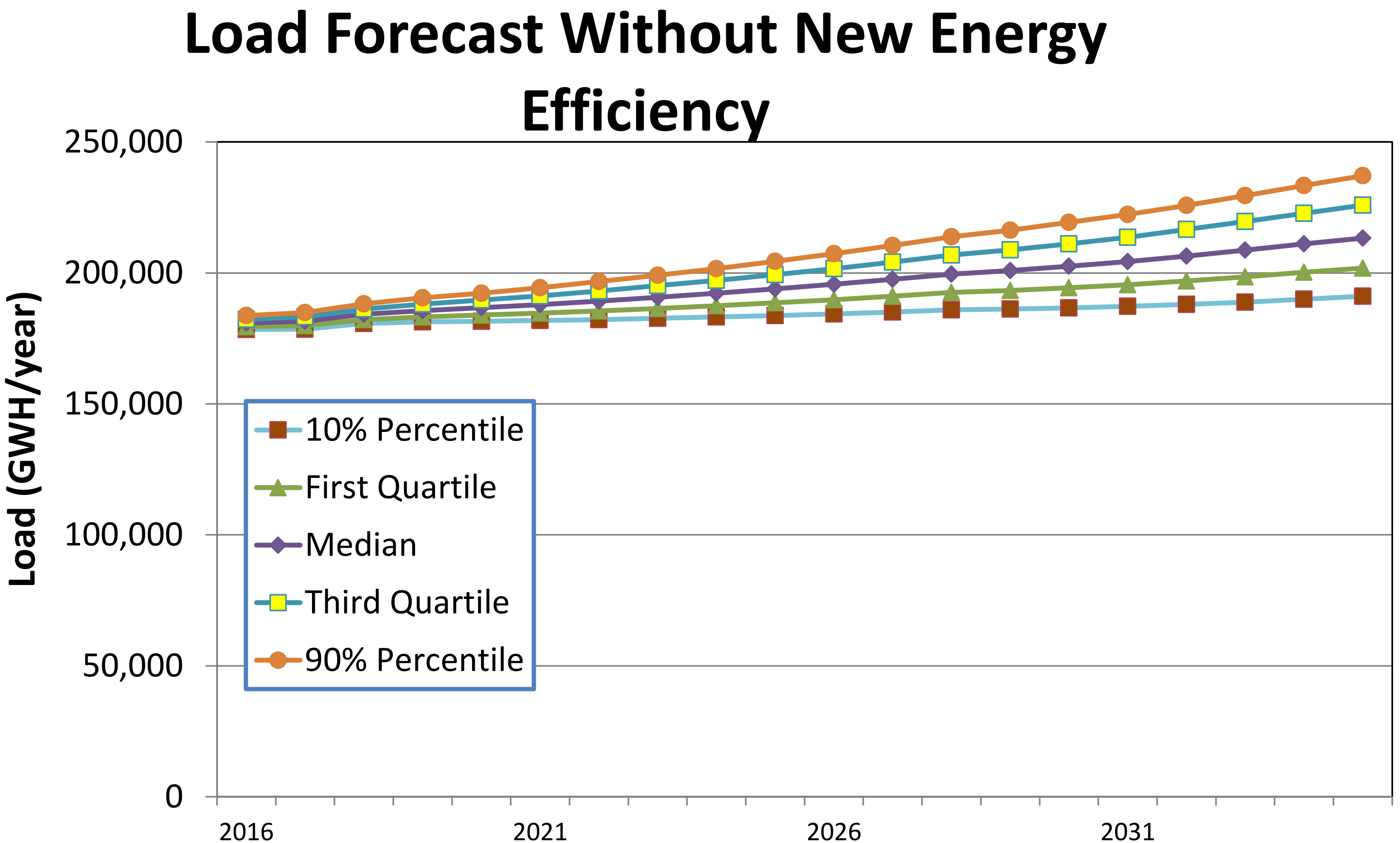




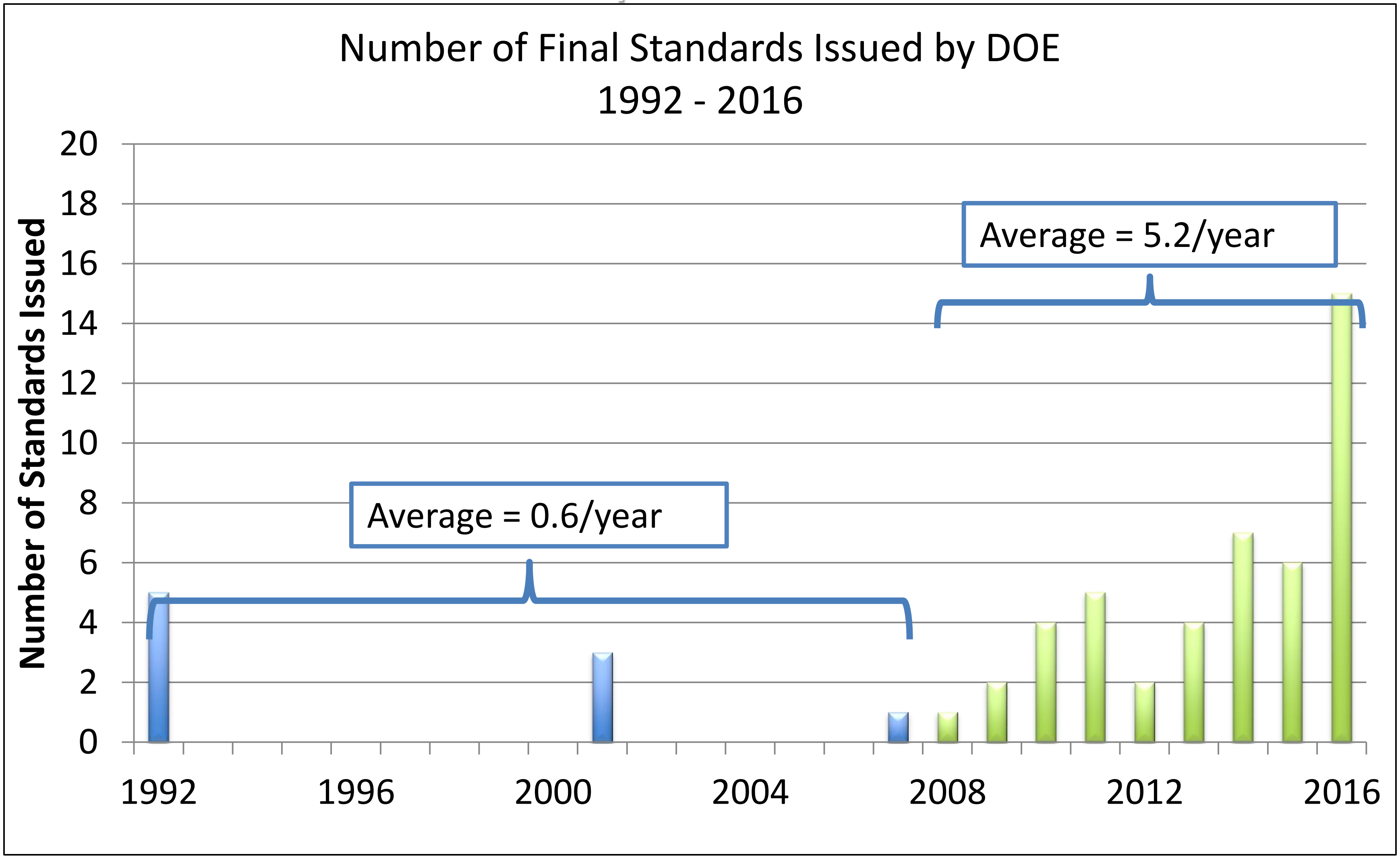
Action Plan

Load Forecast –

Typically provided as a range and without additional energy efficiency

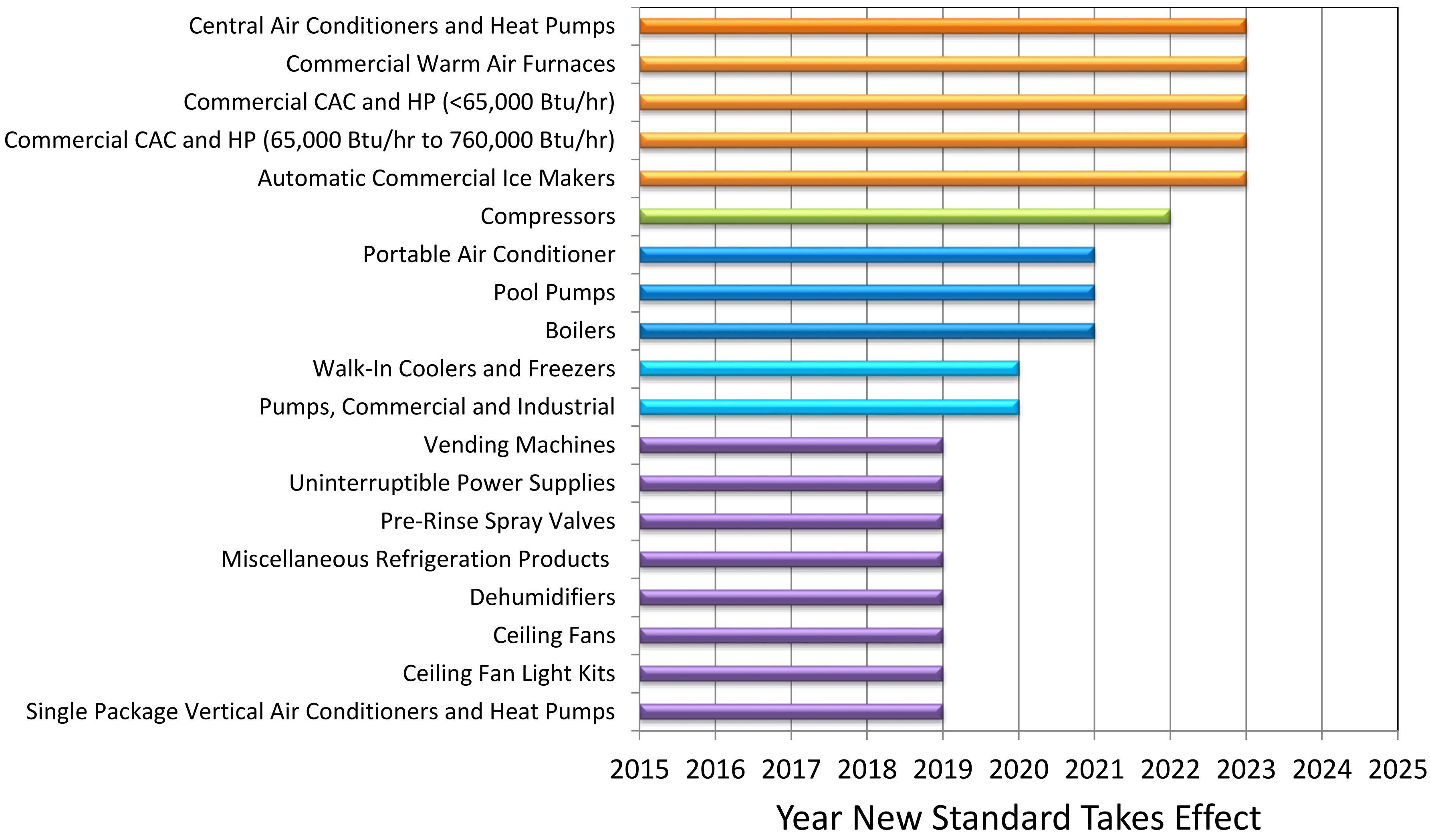


ALERT - Because the Recent Pace of DOE Appliance Standards Updates Is Unprecedented* Econometric Load Forecast May Not Fully Reflect Their Impact

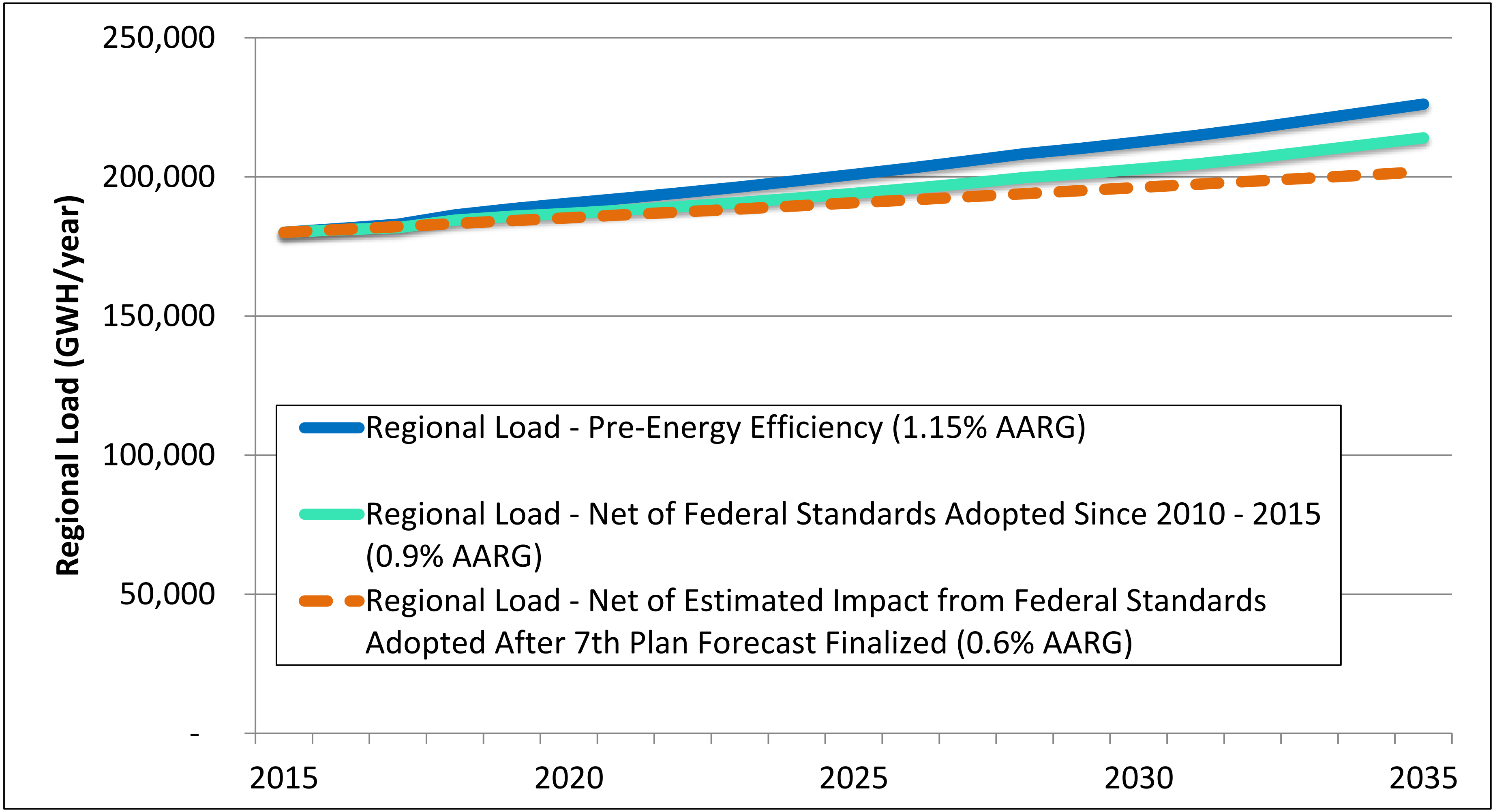


*As of January 3, 2017 Source: ASAP/ACEEE and US DOE

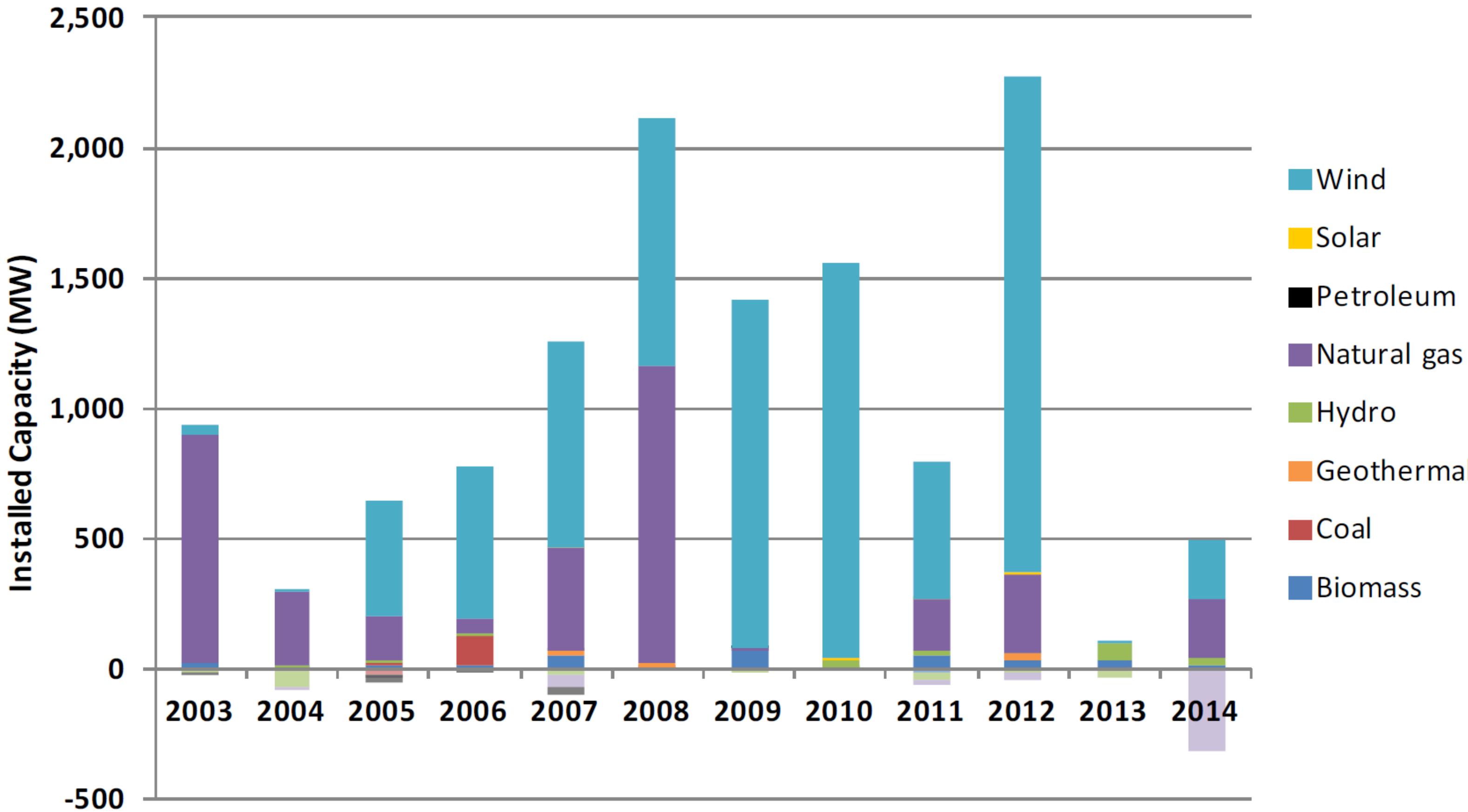
19 New Federal Efficiency Standards Issued Since 2015 Will Reduce Load Growth and Impact Assessments of Energy Efficiency Potential



Potential Impact on Load Forecast of Known Codes and Federal Standards - 7th Northwest Power and Conservation Plan

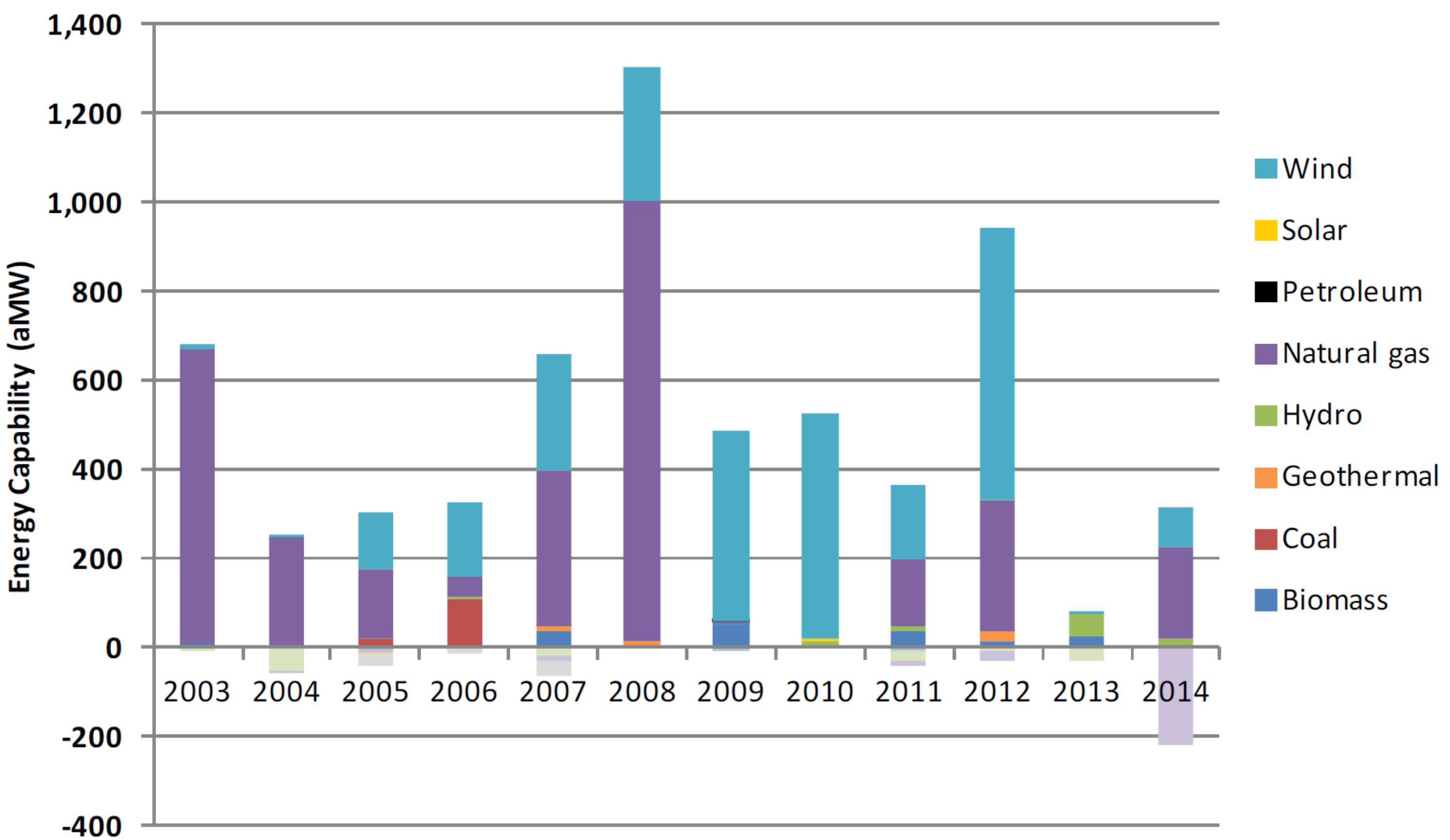


Generating Resource Additions and Retirements (Installed Capacity)



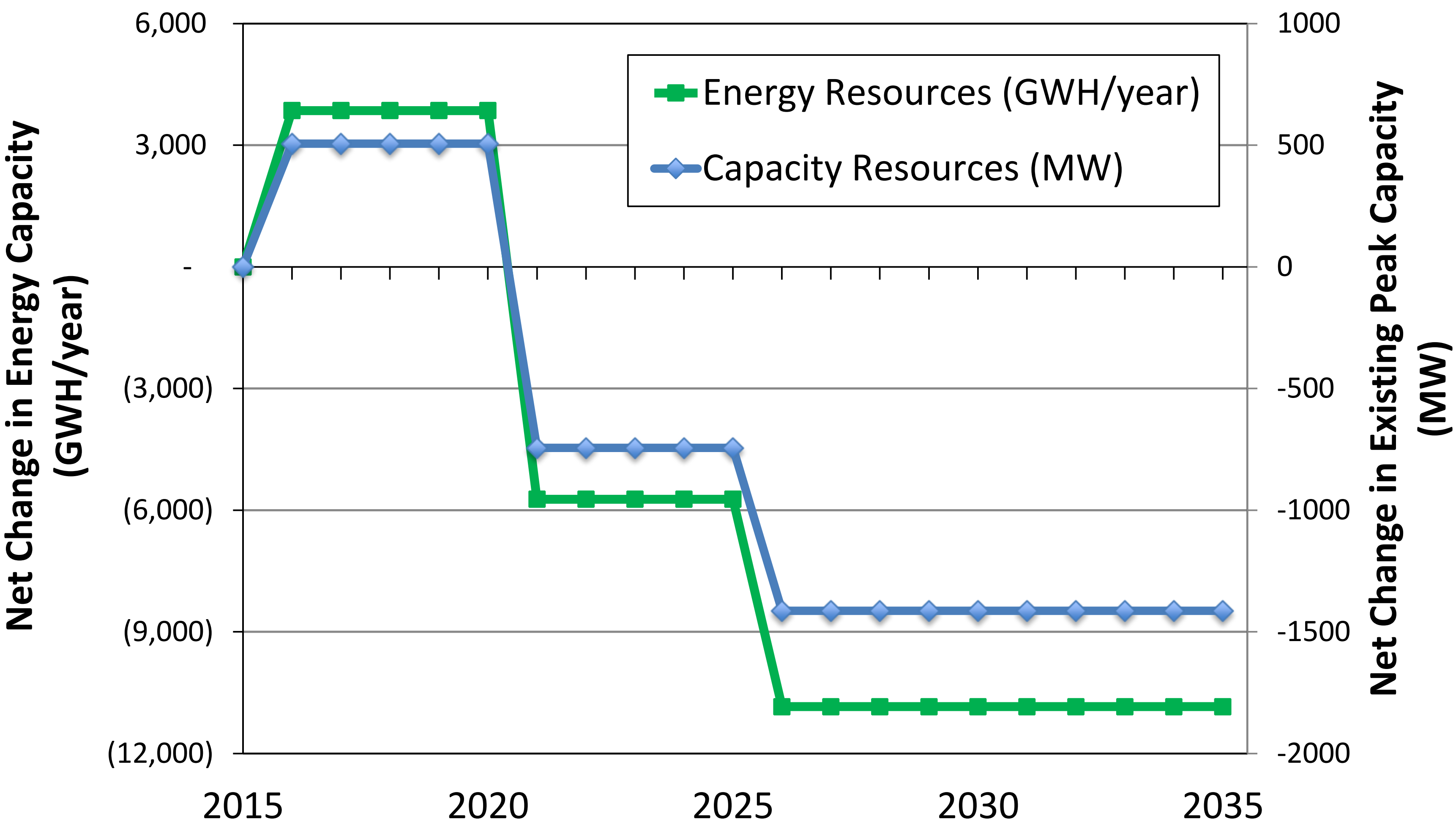
* Projects considered additions if in service or construction is near complete.
Retirements do not include plants that have been idled for potential future use.

Generating Resource Additions and Retirements (Energy Capability)

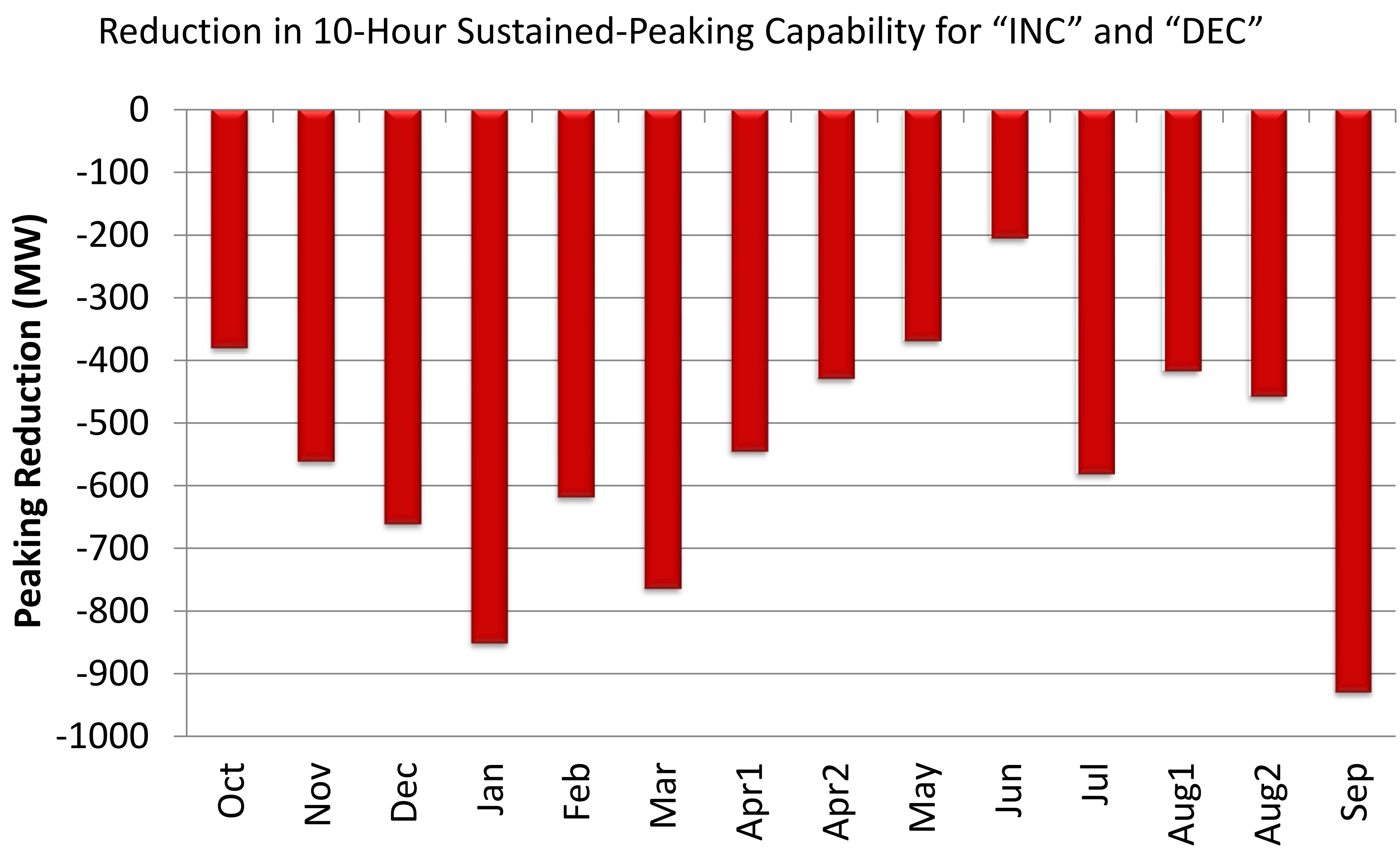


* Projects considered additions if in service or construction is near complete.
Retirements do not include plants that have been idled for potential future use.

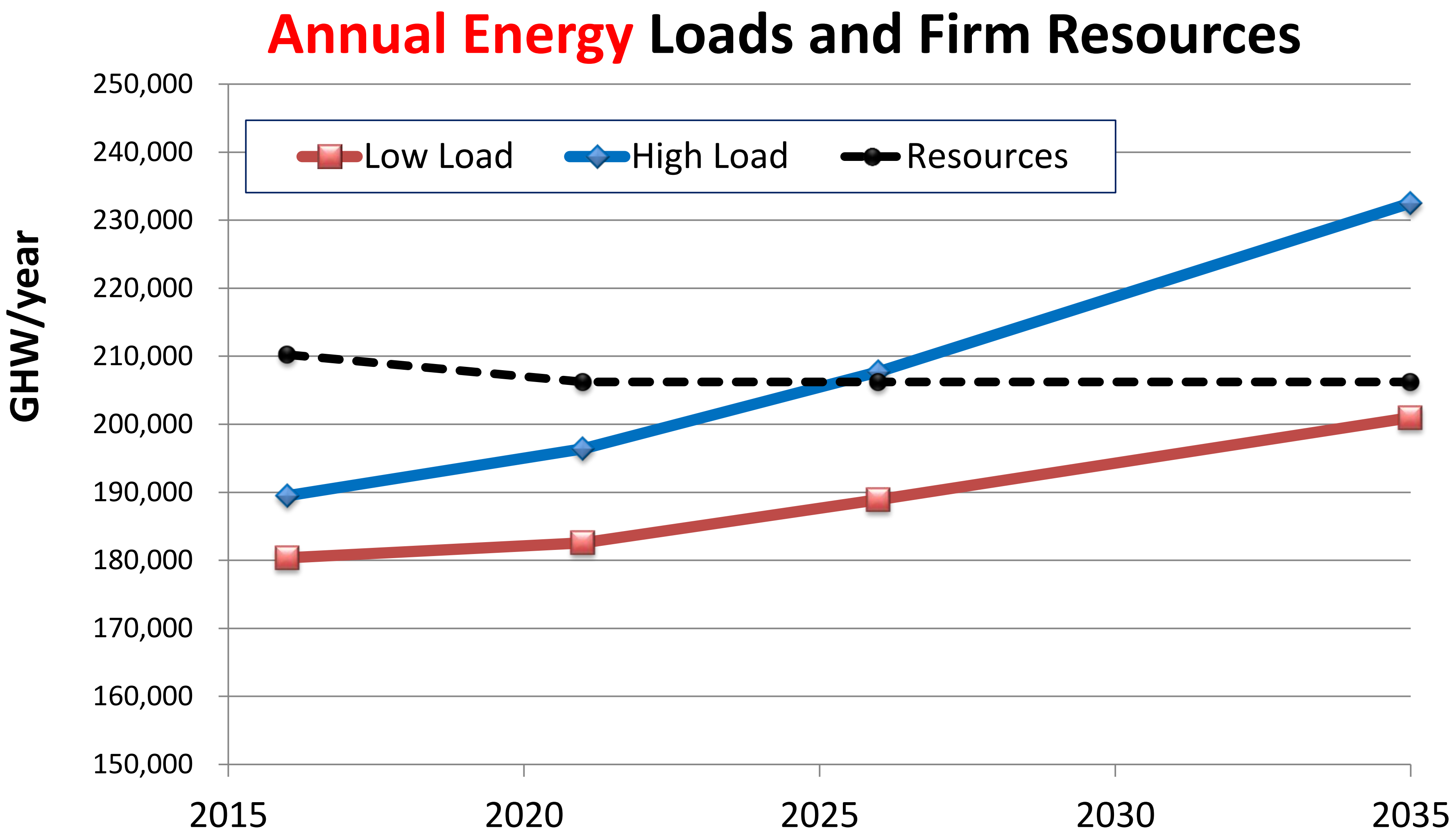
Forecast Changes in Existing Resources



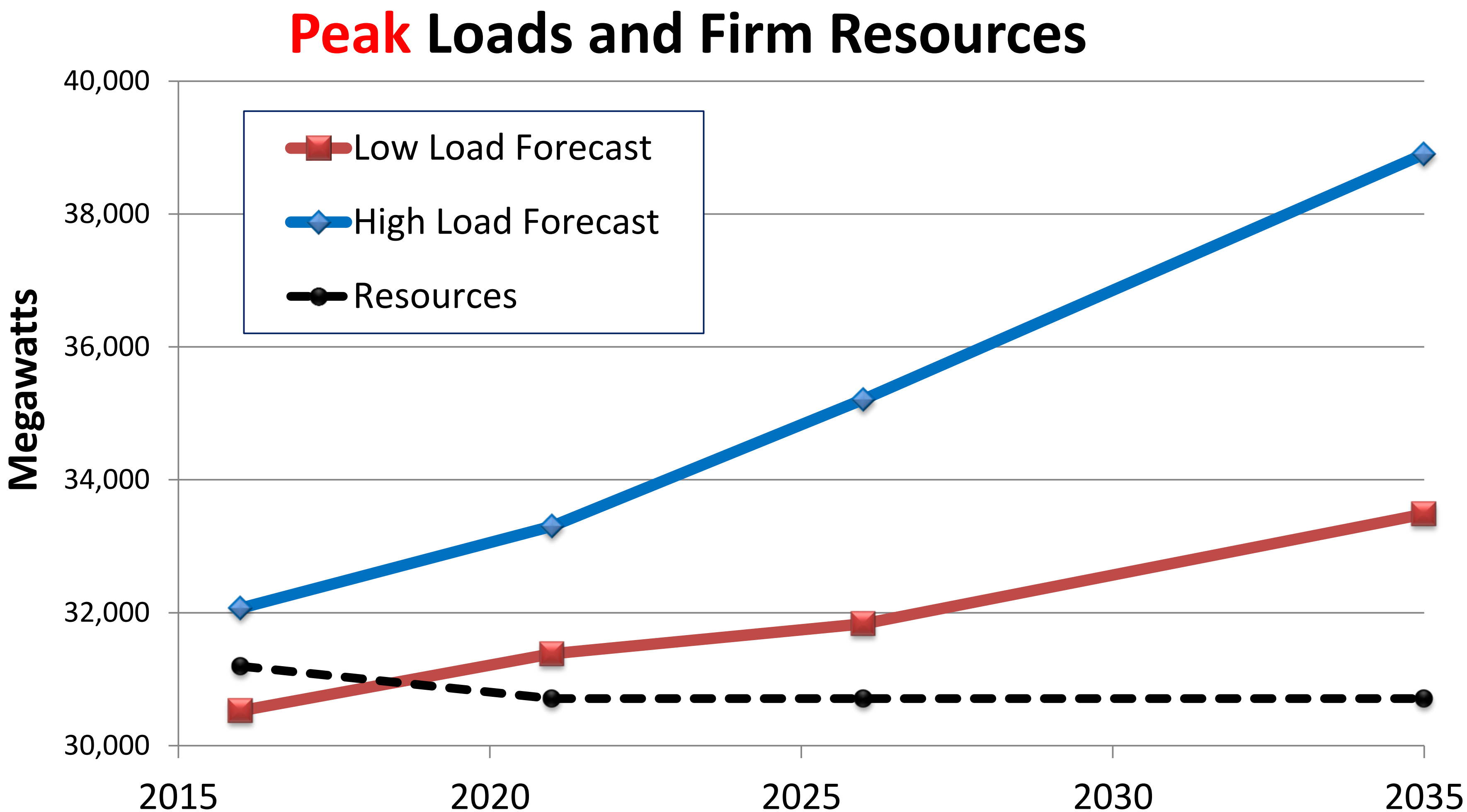
Resource Adjustments for Reserves/Ancillary Services, e.g., Balancing and Flexibility



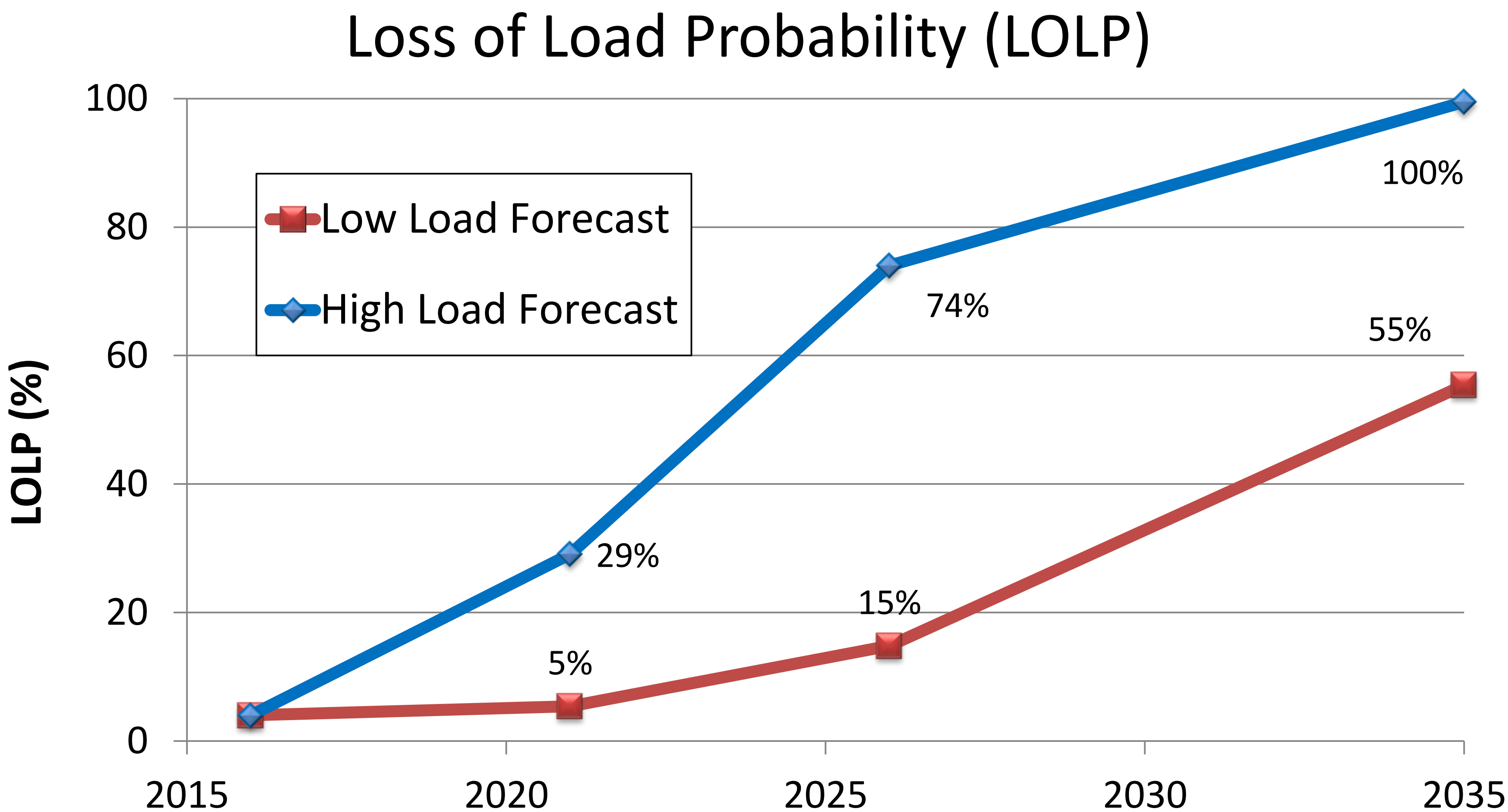
Resource Needs Assessment - Energy



Resource Needs Assessment - Capacity

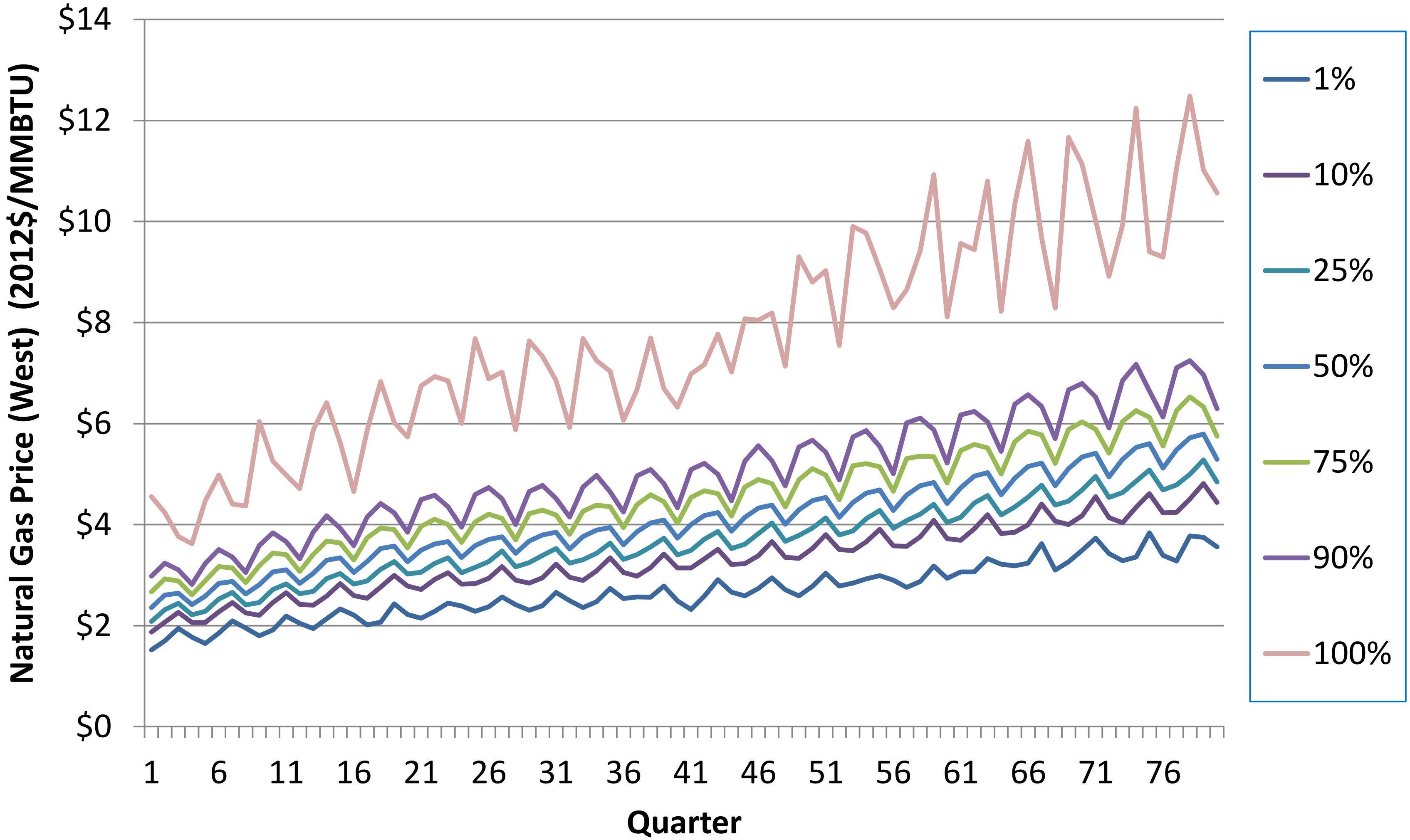


More Sophisticated Needs Assessments Employ Probabilistic Resource Adequacy Analysis*

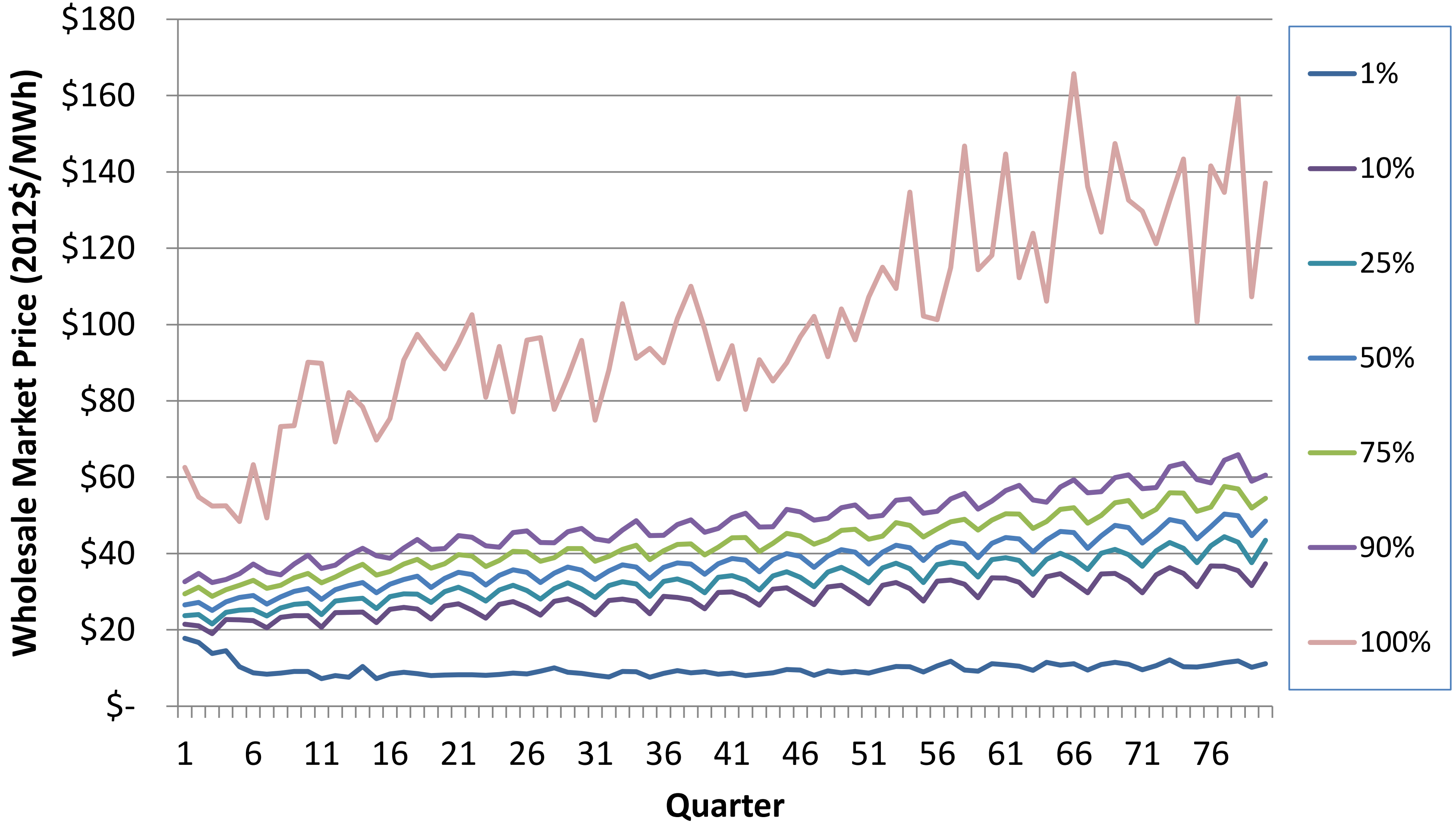


*Note: Resource Adequacy Assessments may be done independently of IRPs, but their results are used in an IRP, so data and assumptions used in both analysis should be internally consistent.

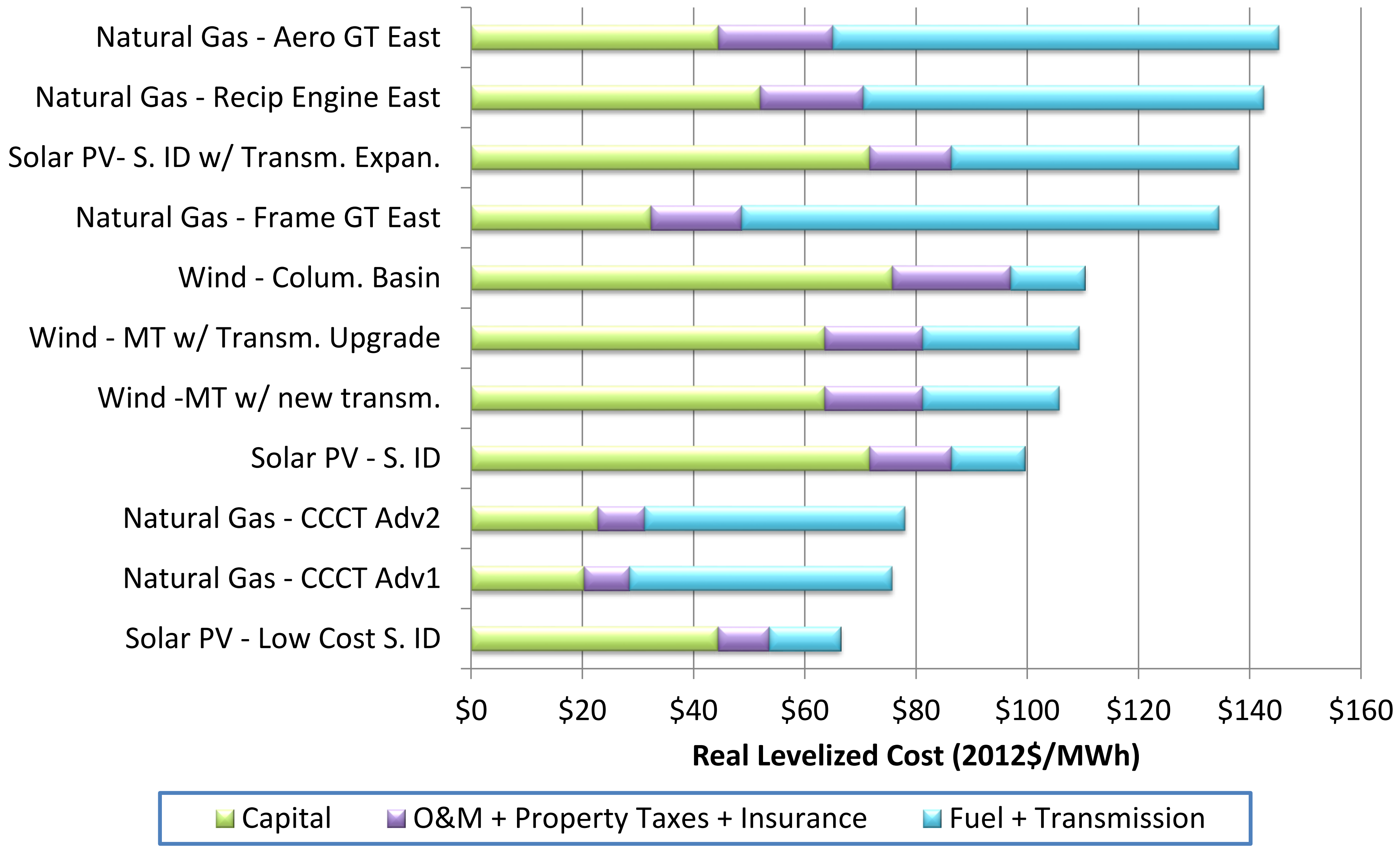
Natural Gas (and other fuel) Price Forecast Range



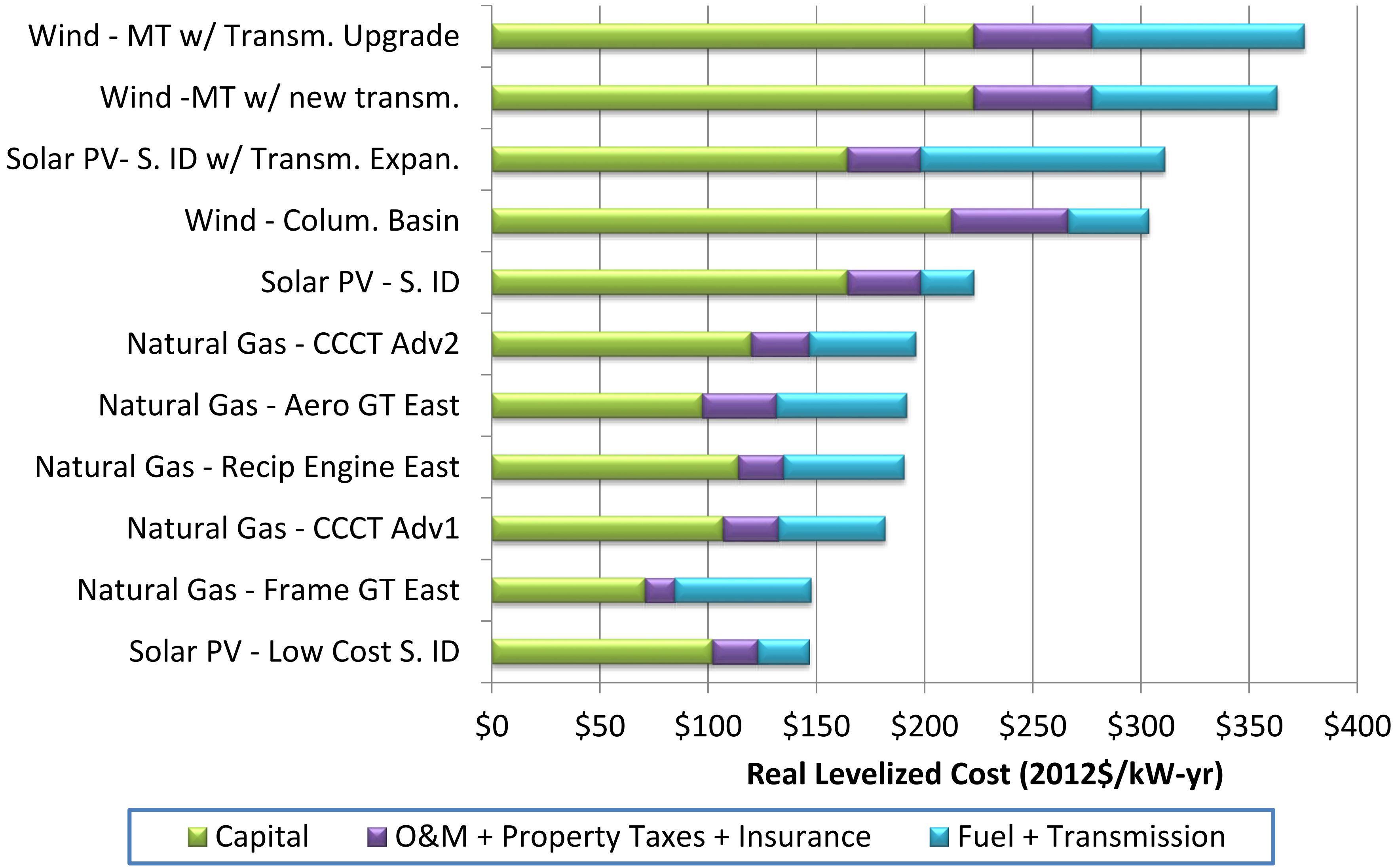
Wholesale Electricity Price Forecast Range



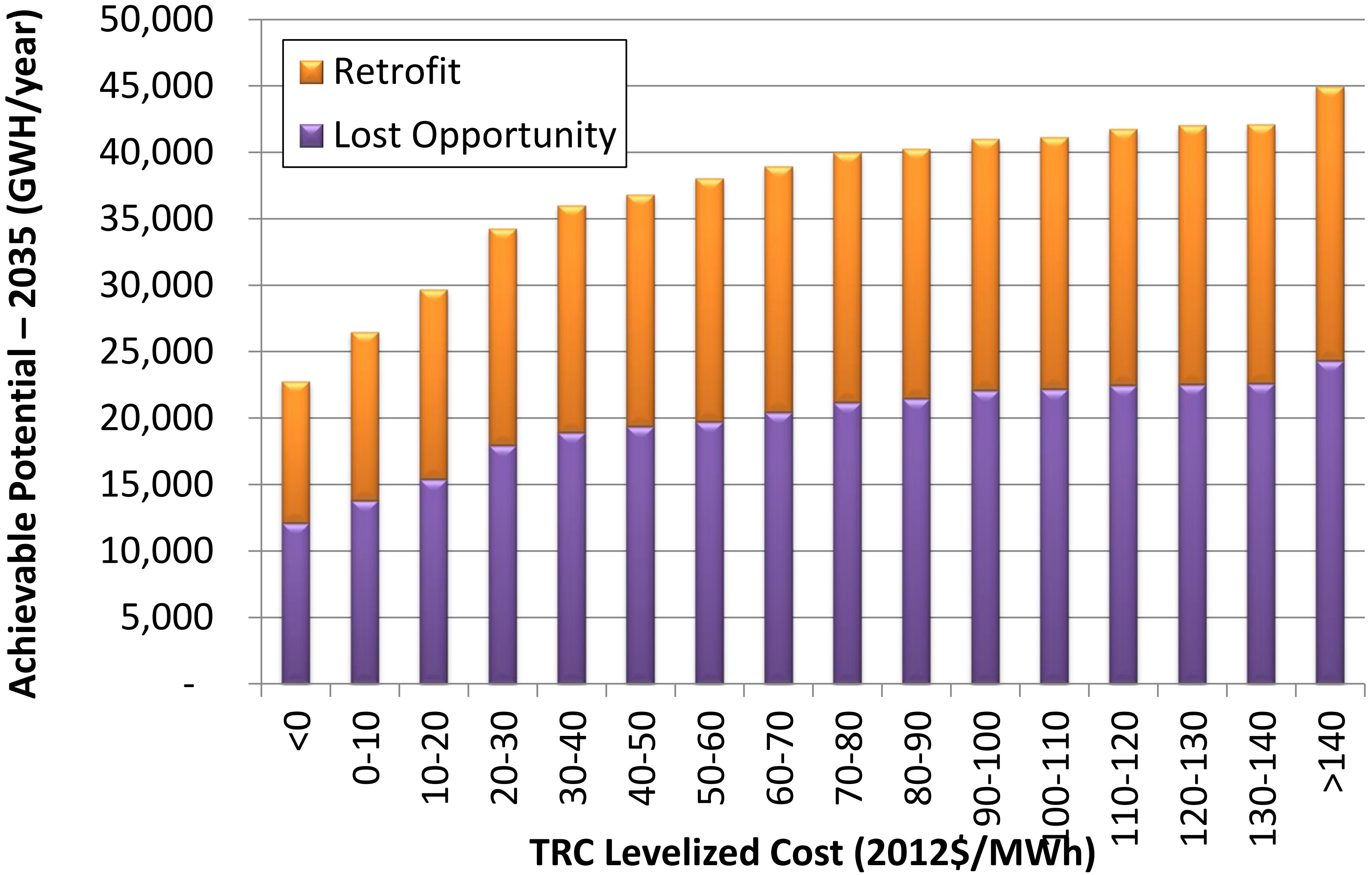
Generating Resource Cost Estimates – Energy Capability, Operating Characteristics and Cost



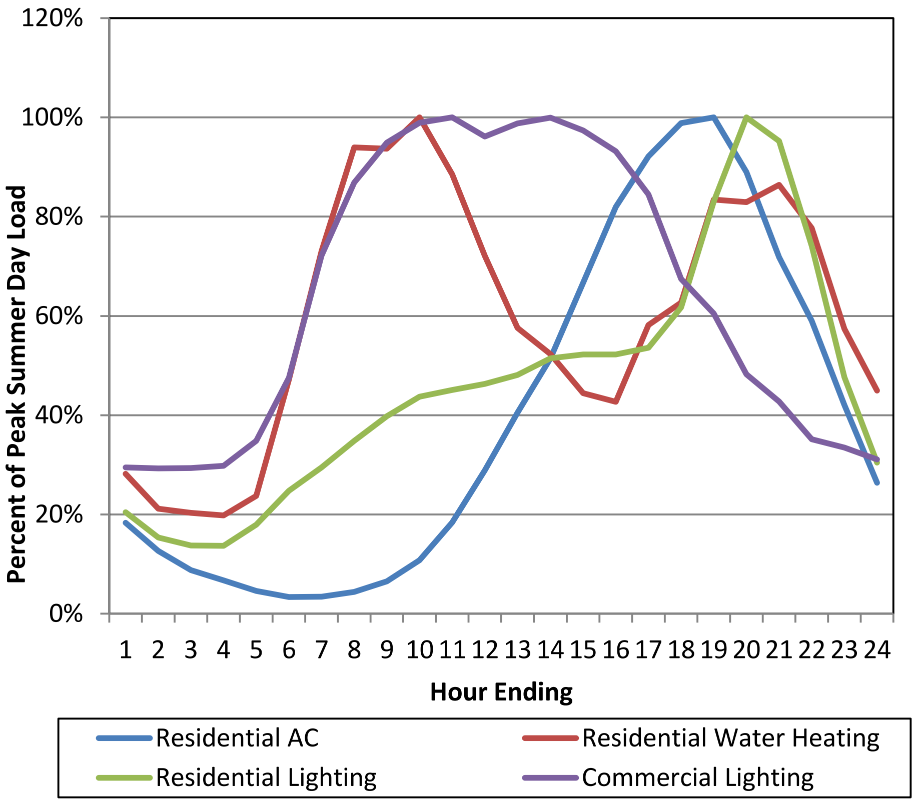
Generating Resource Cost Estimates – Peak Capacity, Operating Characteristics and Cost

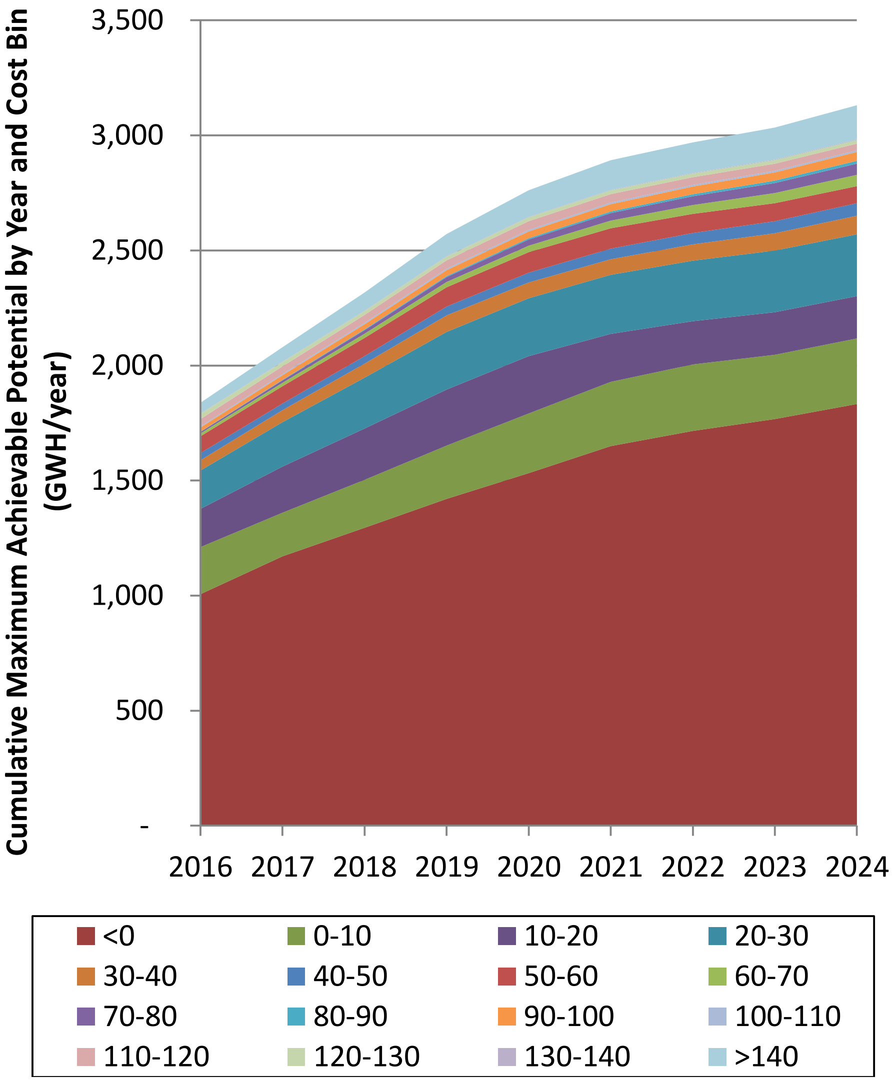


Energy Efficiency Resource Assessment:
Technical, Economic and Achievable Potential

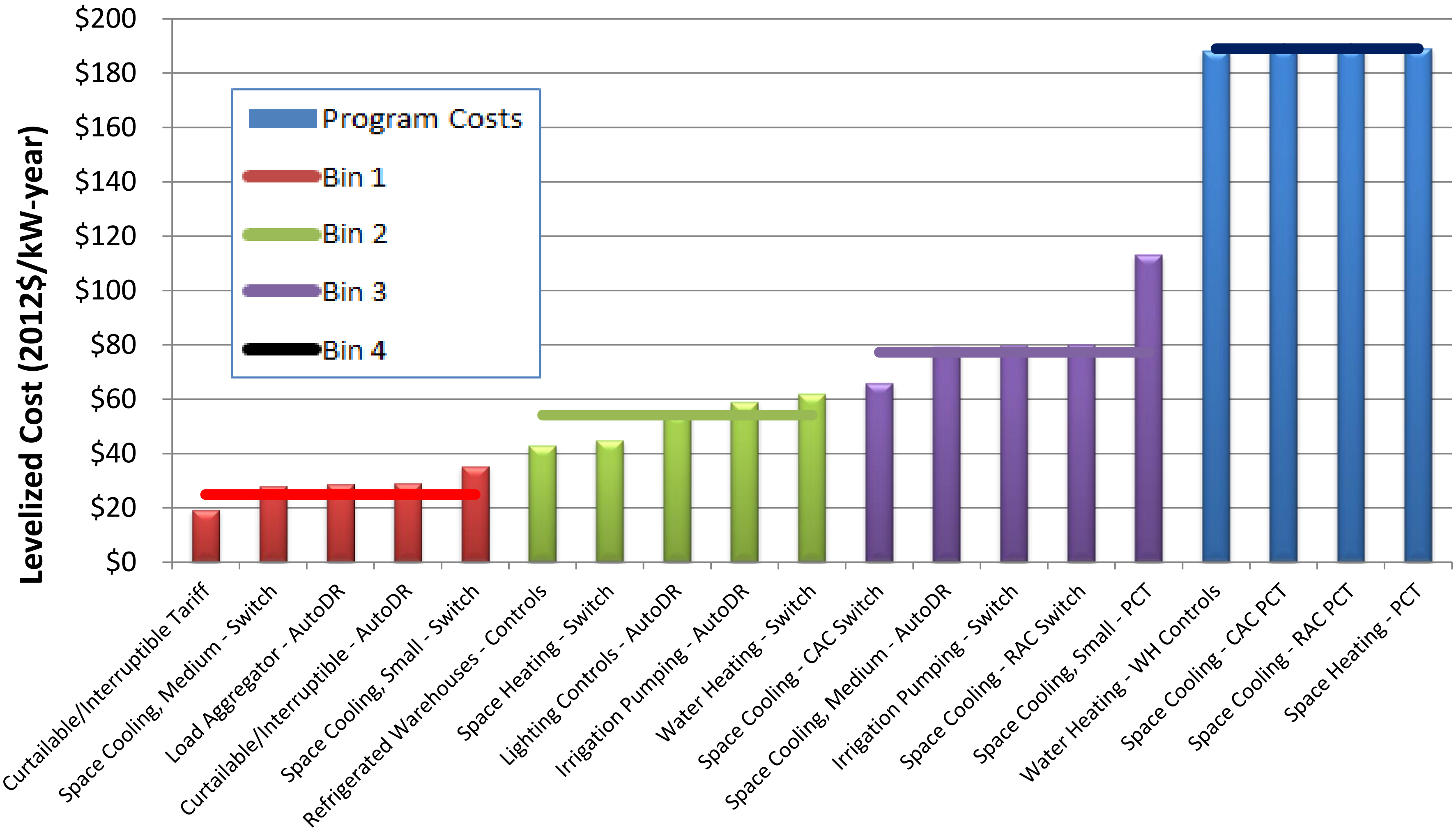


Energy Efficiency Resource Assessment:
Load Shape and Deployment Limits

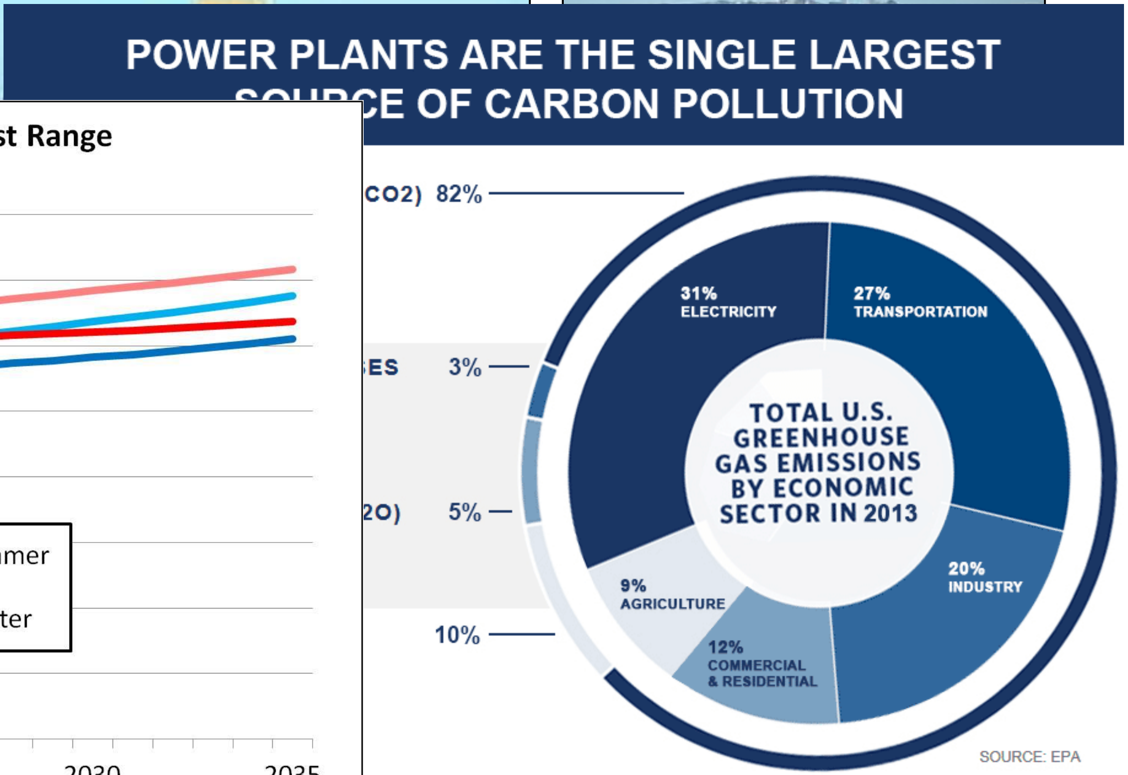


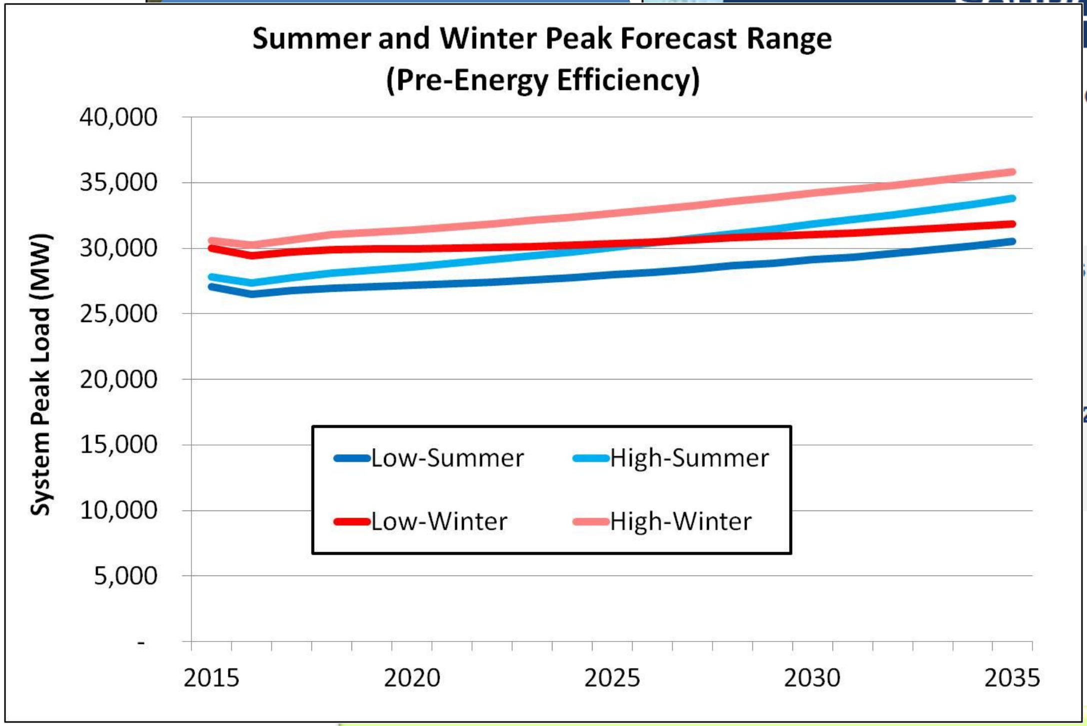


Demand Response Resource Assessment: Technical, Economic and Achievable Potential



Description of Major Issues Potentially Impacting Resource Planning Environment





Implications of and options for addressing EPA's Clean Power Plan

How to best meet regional need for capacity (i.e., peaking) resources

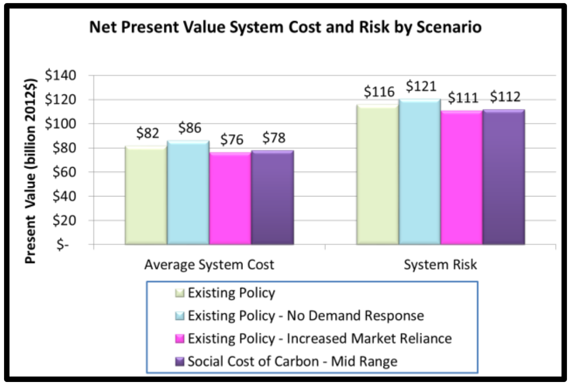
Description of the Scenarios Tested

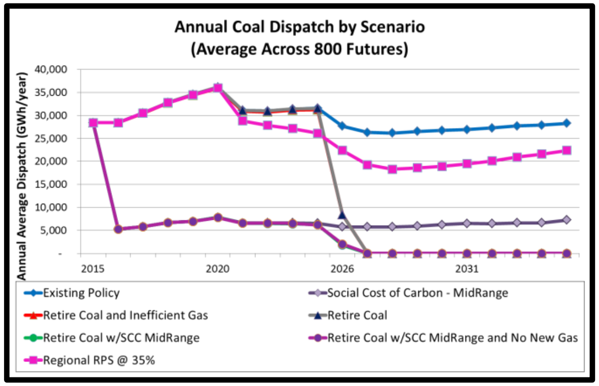
Example: Over Two Dozen Scenarios Were Tested As Part of the Development of the Council's Seventh Power Plan

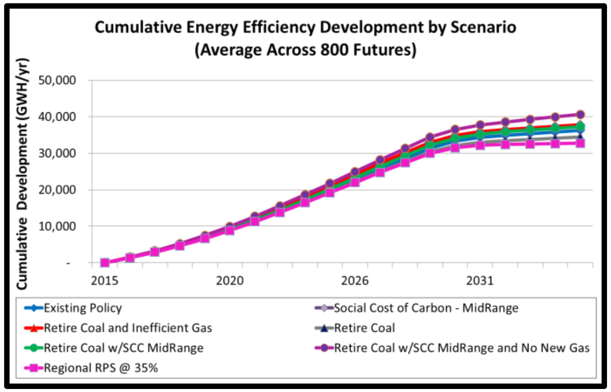
- Existing Policy
- Social Cost of Carbon
- Retire Coal
- Retire Coal and Inefficient Gas
- Retire Coal & Impose Social Cost of Carbon
- Retire Coal & Impose Social Cost of Carbon & No New Gas
- Regional RPS @ 35%
- No Demand Response
- Increase Market Reliance
- Limit Energy Efficiency Acquisitions to Market Price

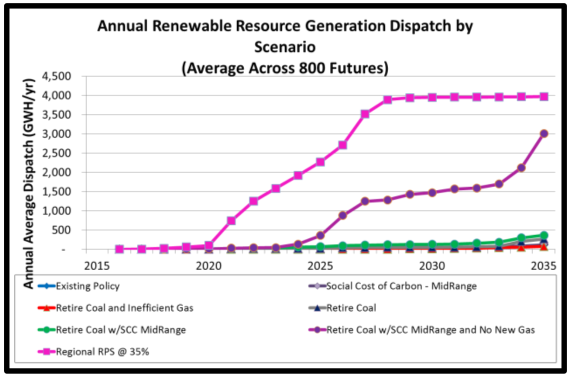
Description of Resource Analysis Methods

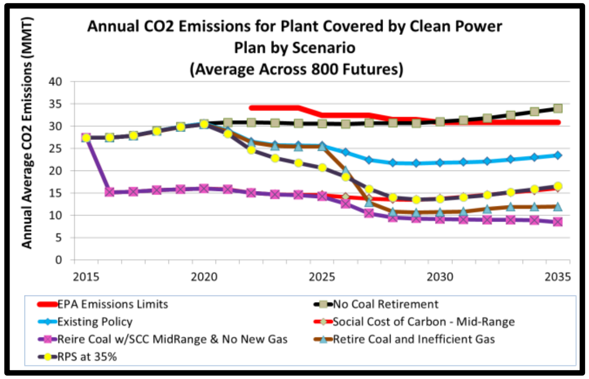
Analytical Findings:
Example – 7th Northwest Power and Conservation Plan

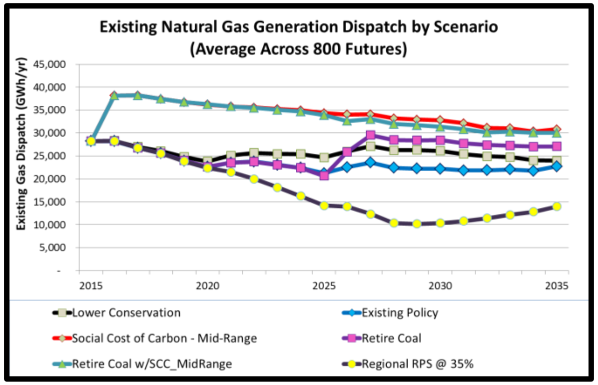


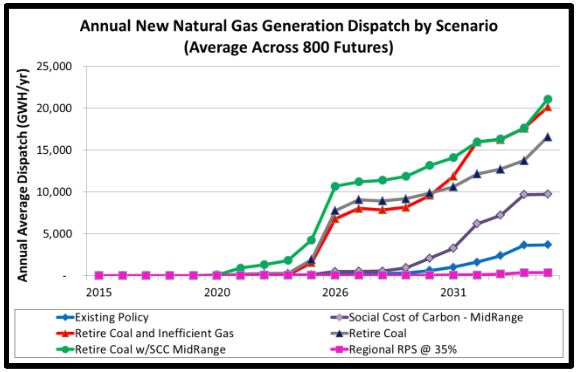


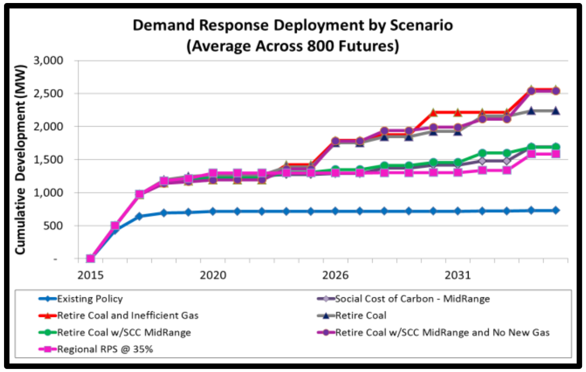


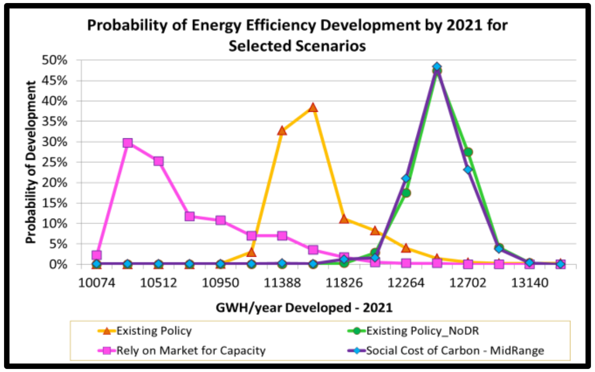




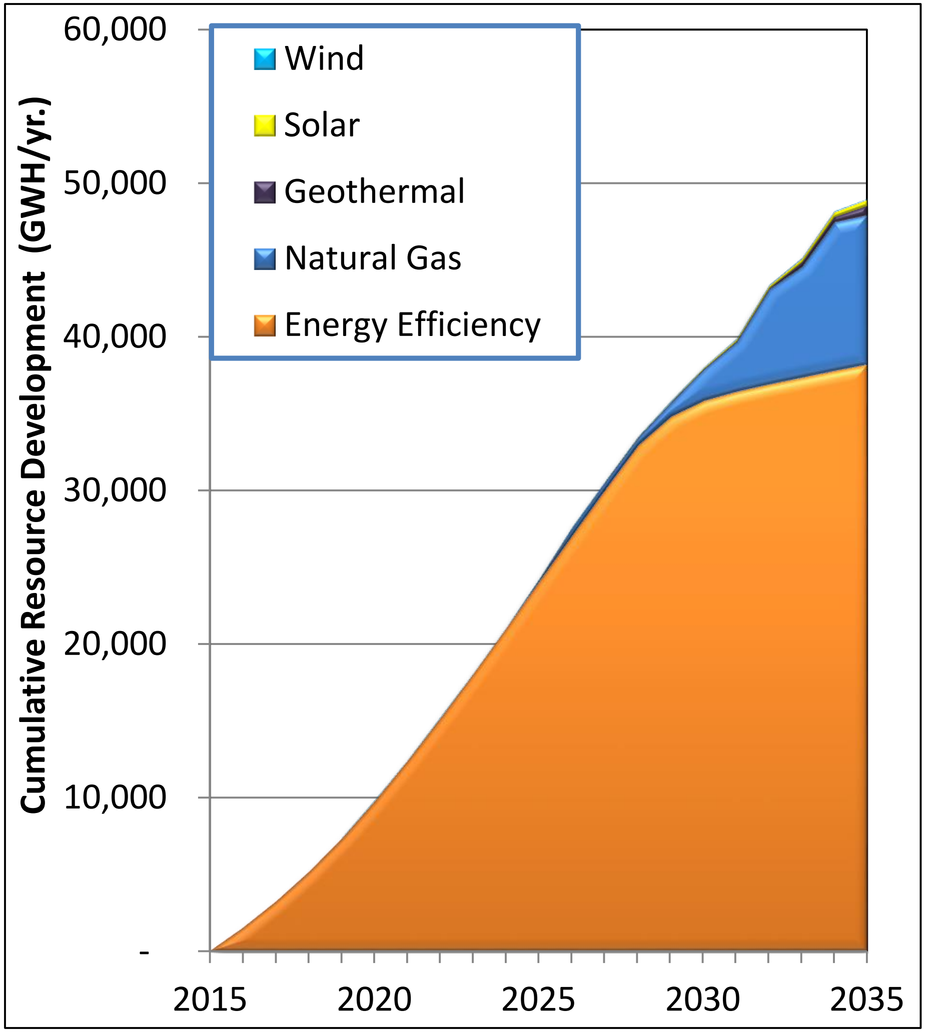


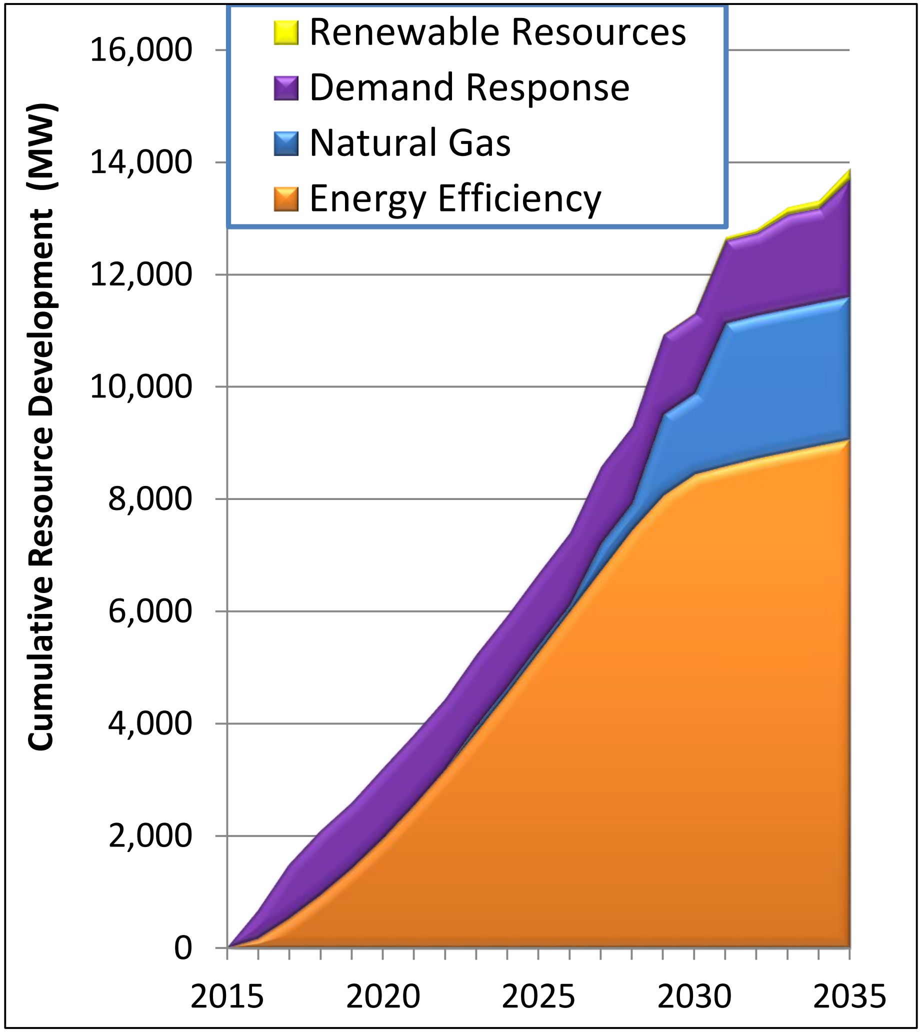






Preferred Resource Strategies for Meeting Forecast Energy and Capacity Needs Over Planning Period

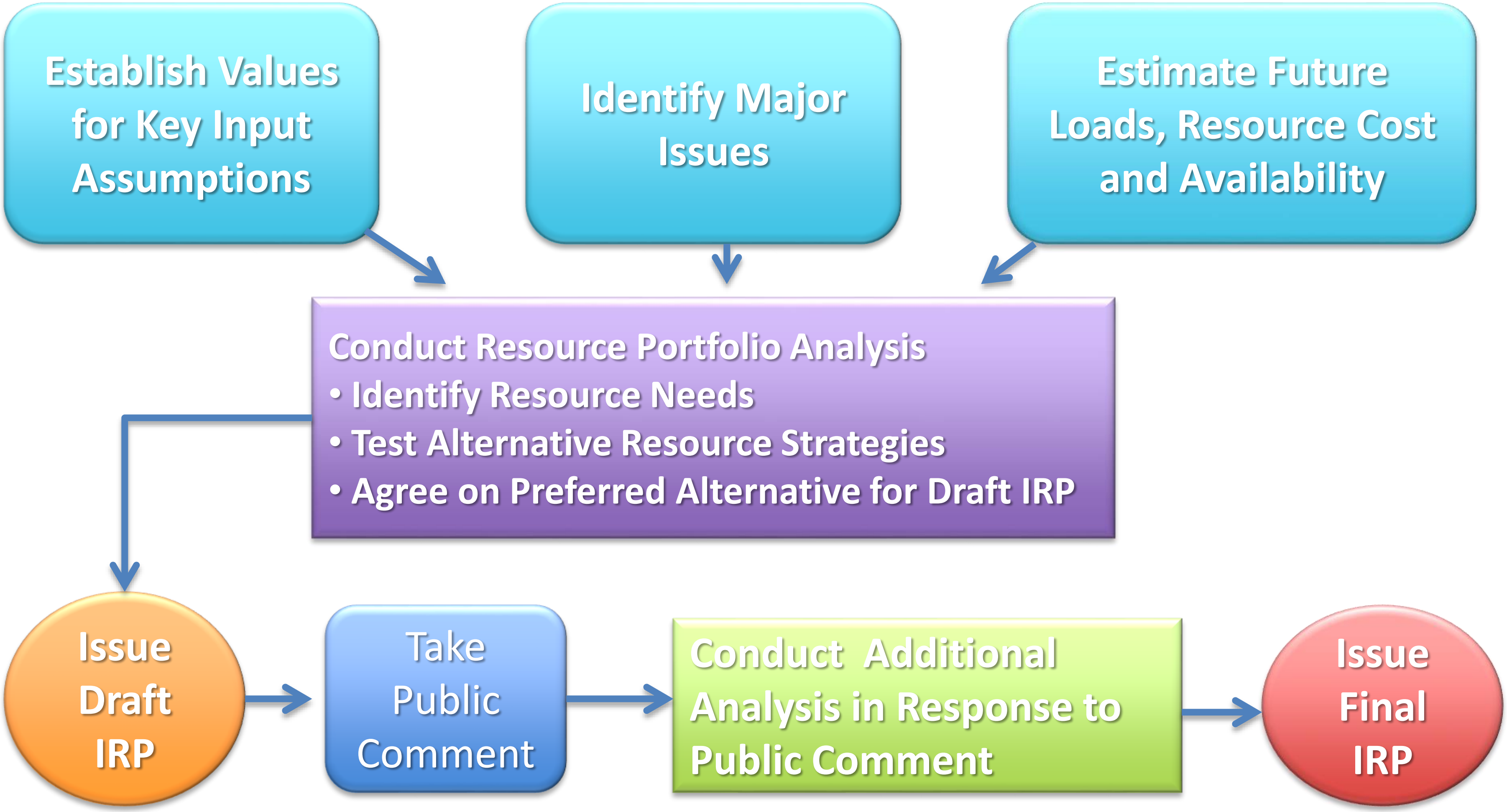




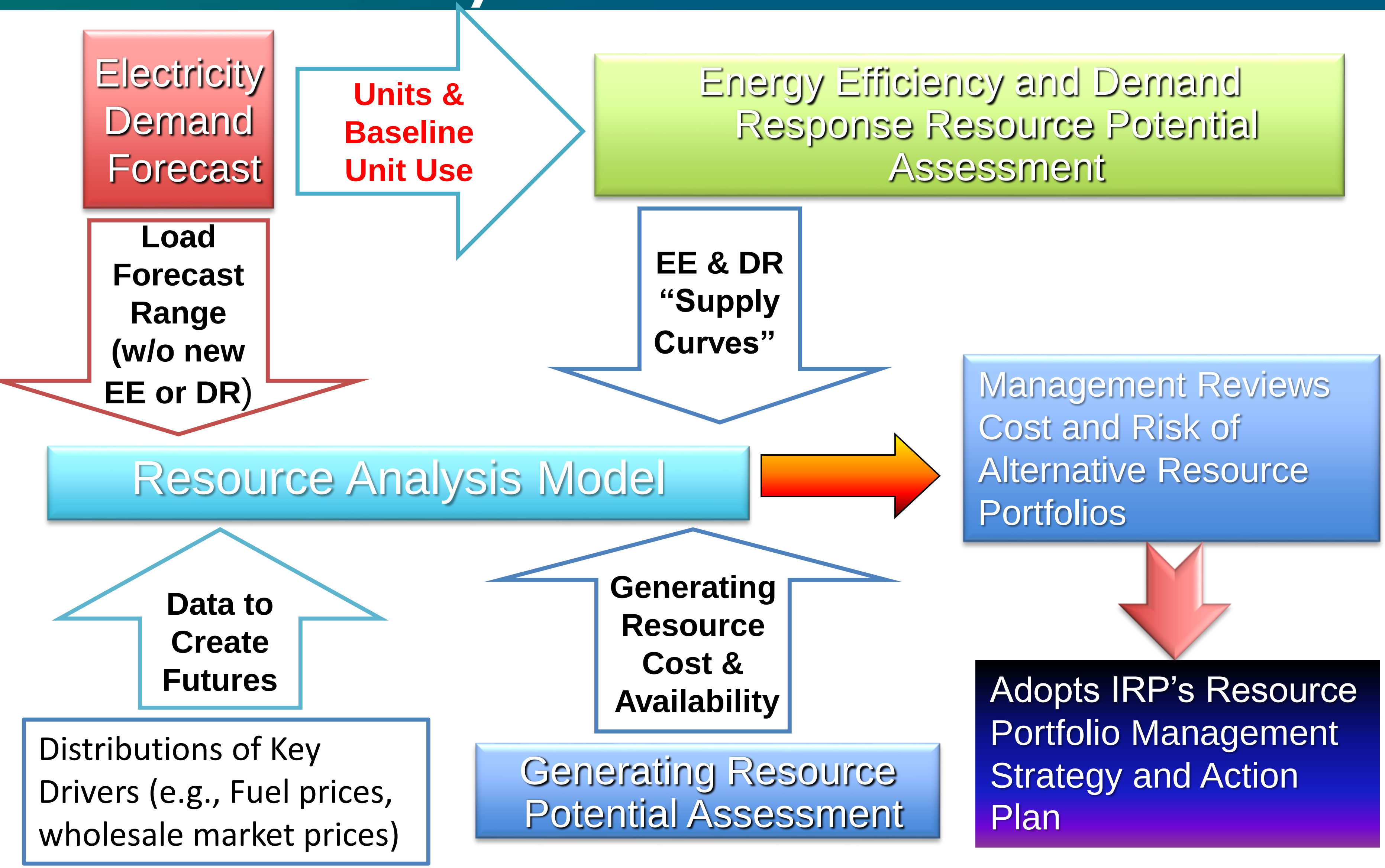
An Action Plan:

- Preferred Resource development/management actions
  - EE & DR goals
  - Generation, including ancillary services/reserves
  - Transmission and Distribution
  - Risk management
- Non-resource development actions
  - Analytical capability enhancement
  - Data development
  - Research on emerging technologies

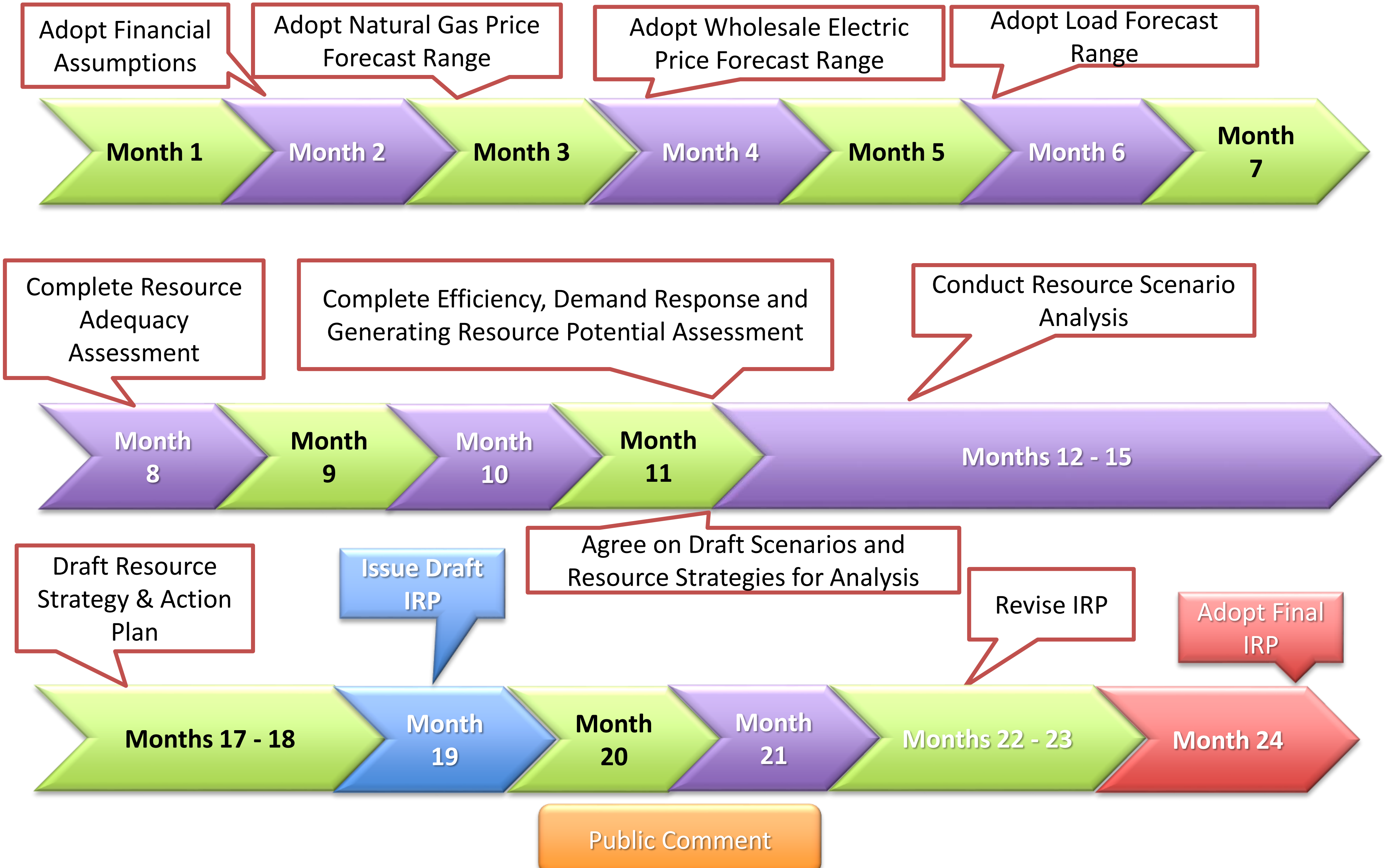
Overview of IRP Development Process



Best Practice IRP Development Analytical Process Flow



IRP Development – Typical Timeline and Major Milestones



Models Used in IRP Development

- Load Forecasting
  - Econometric
  - End Use Econmetric
  - Statistically Adjusted Engineering
- Capacity/Resource Expansion Models –
  - These models simulate generation and transmission capacity investment, given assumptions about future electricity demand, fuel prices, technology cost and performance, and policy and regulation
  - Examples - Aurora, System Optimizer, Strategist, PLEXOS, the Council's Regional Portfolio Model, and NREL's Resource Planning Model
  - Key differences between models
    - Treatment of uncertainty (i.e., does the model optimize for a single future or scenario or does it optimize across a range of future conditions)
    - Time resolution (i.e., many do not have chronological unit commitment (i.e., every hour of the year chronologically) and some use aggregate (model) plants for dispatch). This can limit there ability to model DR.
    - Transmission and power flow are a stylized representation (pipe flow or DC)

Role of Capacity Expansion/Resource Analysis Models

What They Do Do

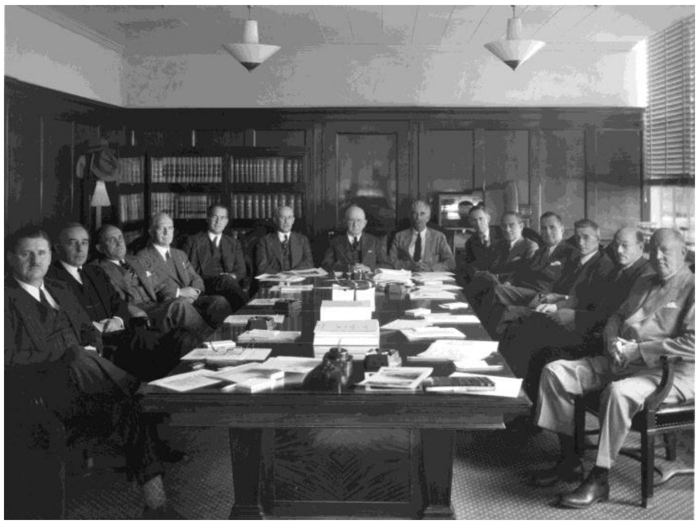
- Test alternative resource mixes and development timing (aka, *Resource Strategies*) against a range of future conditions (e.g., load growth, natural gas prices, emissions costs/limits, etc.)
- Identify the "least cost" *Resource Strategy* <u>and may</u> account for "risk"

What They Don't Do

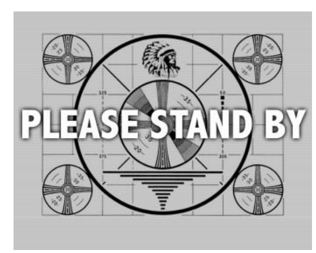
- Determine what is an acceptable level of "cost"
- Determine what is an acceptable level of "risk"
- Decide which *Resource Strategy* is "Preferred"

Finally – A Brief Comment on Public/Stakeholder Engagement in IRP Development

Best Practices Integrated Resource Planning actively and openly engages stakeholders in development – all parties benefit.



Stay tuned to the next workshop for more on this topic



Questions?

BREAK

Session 2 – Modeling Energy Efficiency and Demand Response

- Modeling Options
  - Best Practice: EE and DR compete directly with supply side alternatives in resource optimization
  - Frequent Practice: EE (and DR) are treated as a load reduction prior to supply side resource optimization
- Analytical Issues
  - Load forecast baseline calibration
  - Characterization of EE (and DR)
    - Derating for Achievable vs. Economic Potential
    - Accounting for both energy and capacity impacts
    - Ramp rates and maximum annual deployment assumptions
    - Issues with modeling retrofit vs. lost-opportunity resources

Understanding Why the Difference in Approach to Modeling EE and DR Matters Requires A Discussion of Planning Under Uncertainty

All IRP's Require Assumptions About the Future

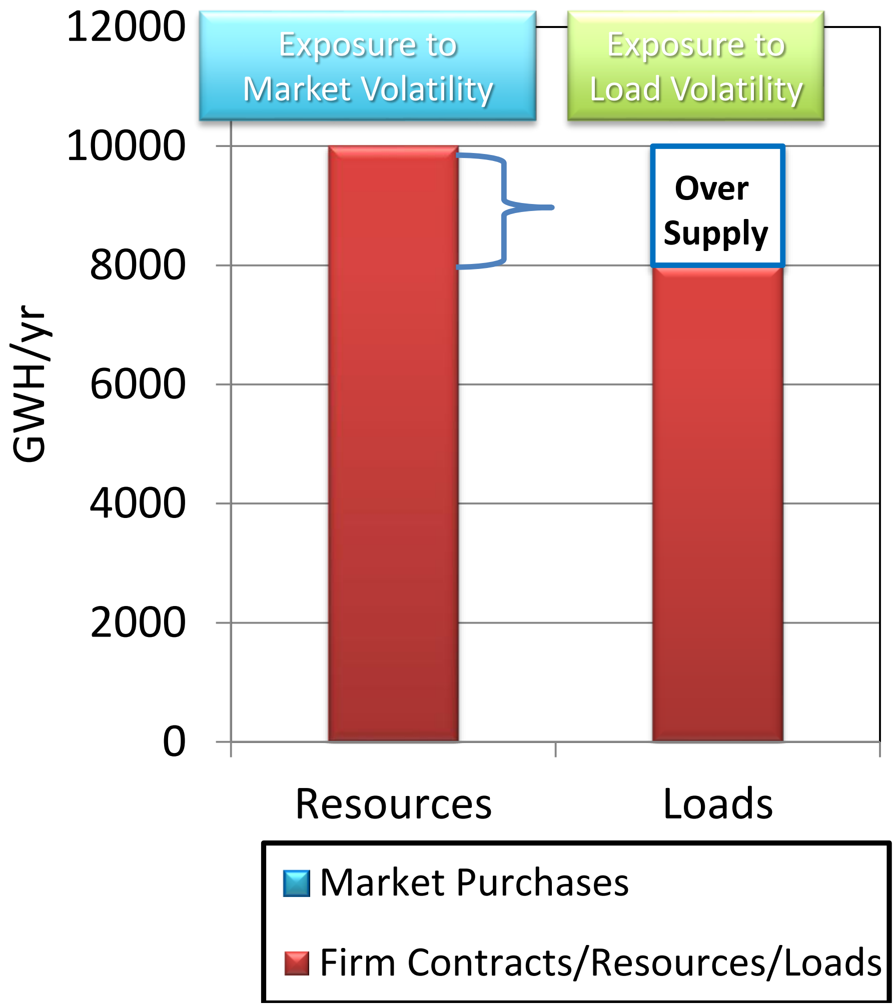
Perfect Foresight (i.e., *prescience)* is <u>not</u> possible.

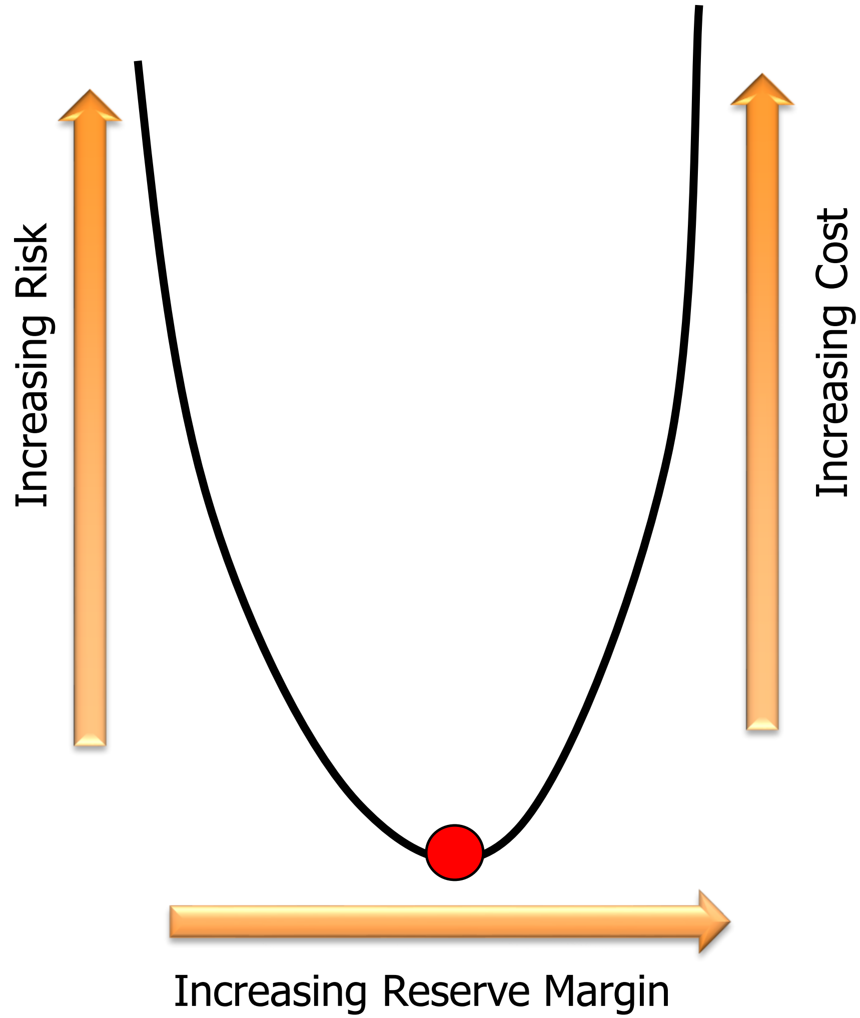
However, it is an occupational hazard of planners!

IRPs Must Address Three Major Sources of Uncertainty

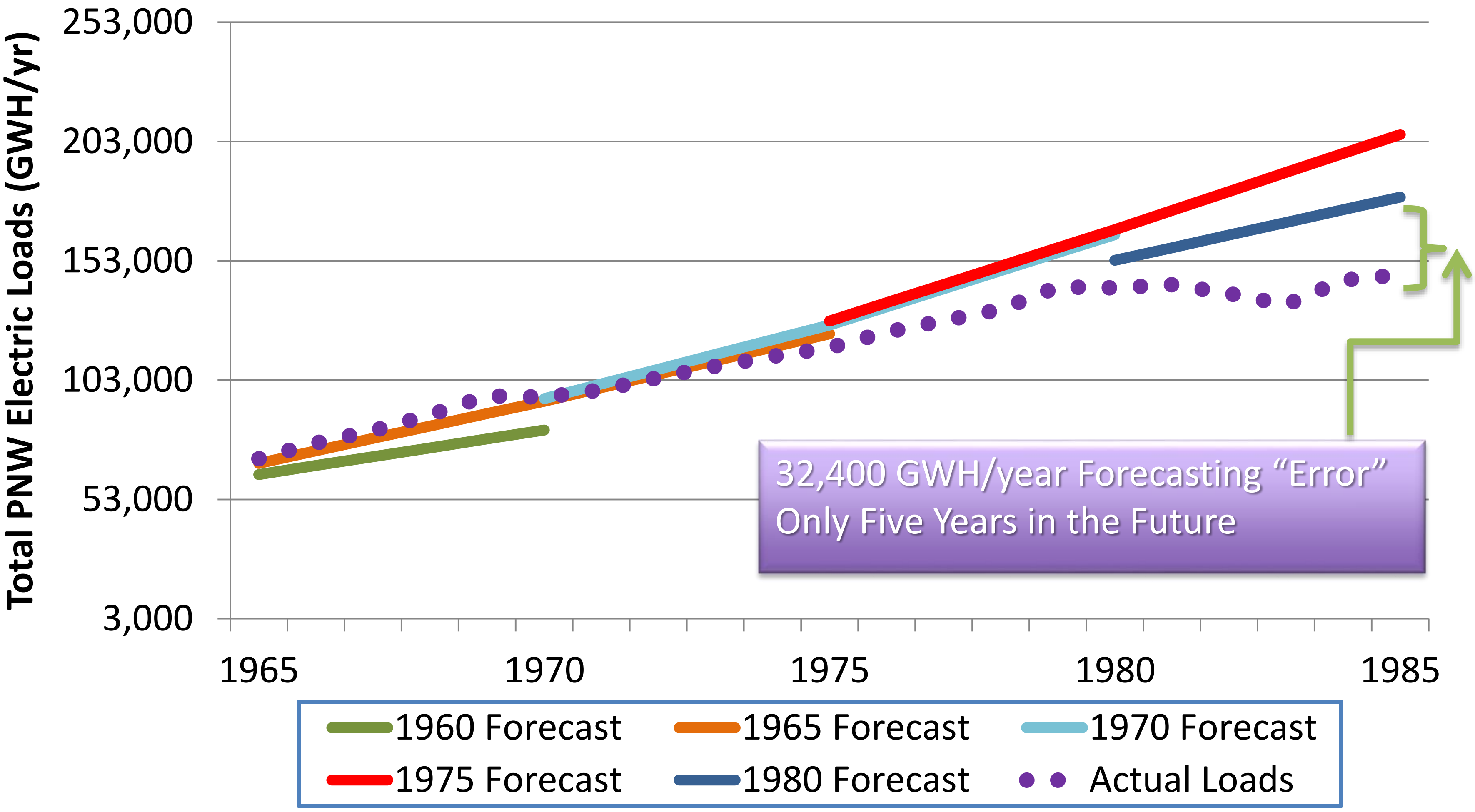
- Load Uncertainty
- Resource Uncertainty
  - Output
  - Cost
  - Construction Lead Times
  - Technology Change
- Wholesale Electricity Market Price Uncertainty

Why "Just Right" Matters: Increasing Firm Contracts/Resources Increases Exposure to Load Volatility Risk

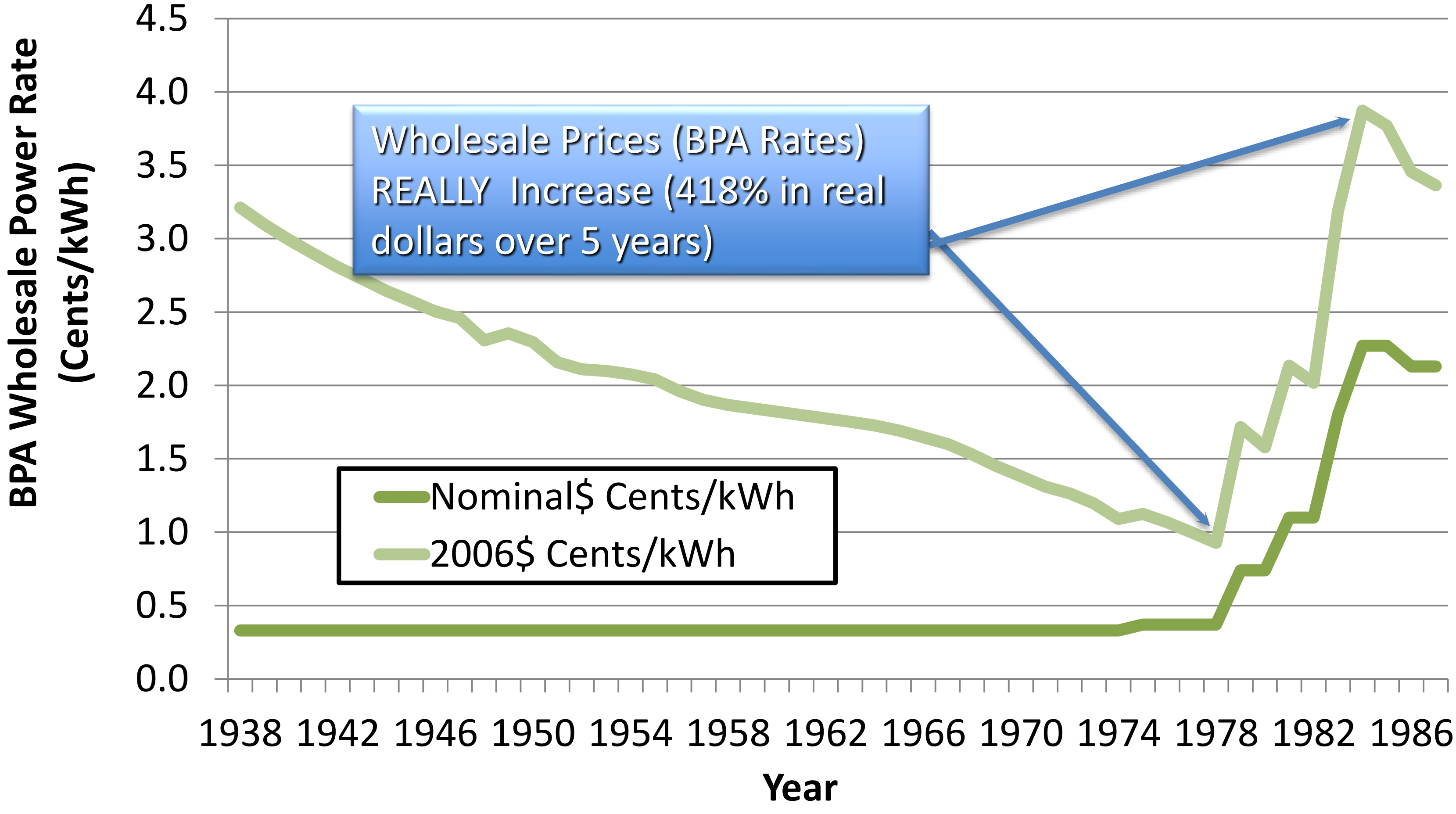




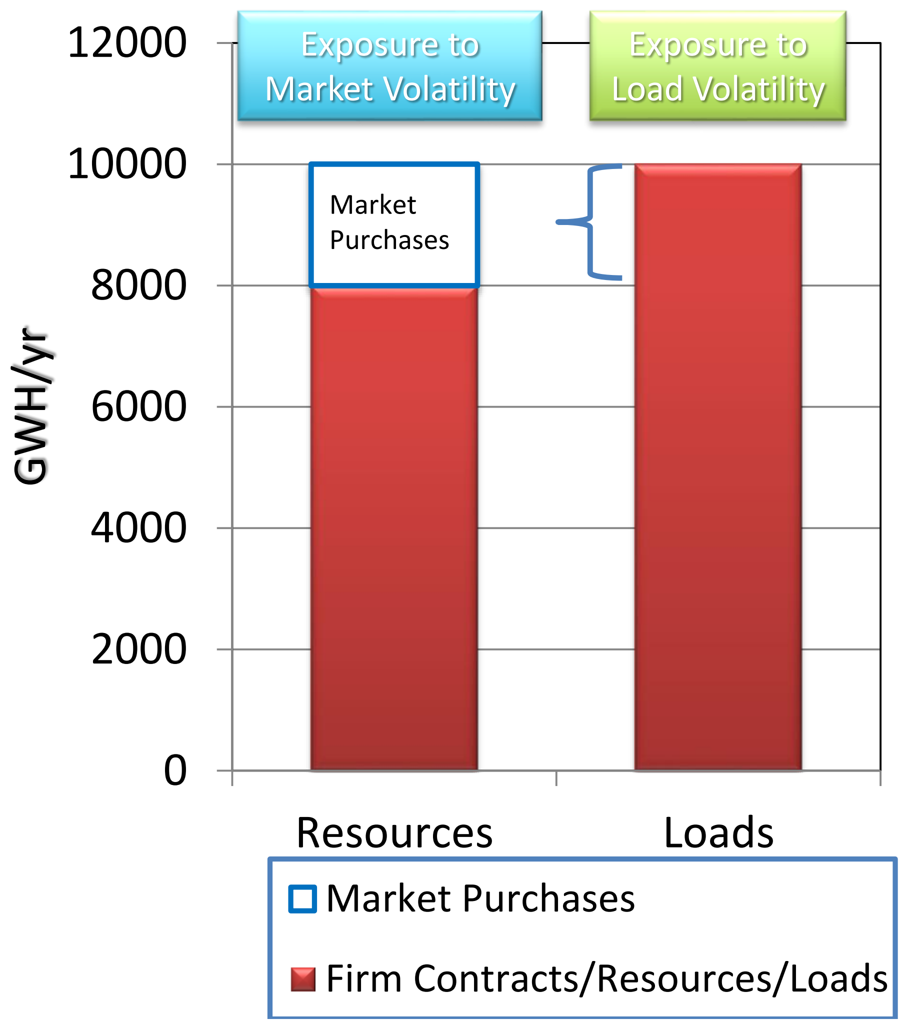
Perfect Foresight can lead to overbuilding: Example – PNW

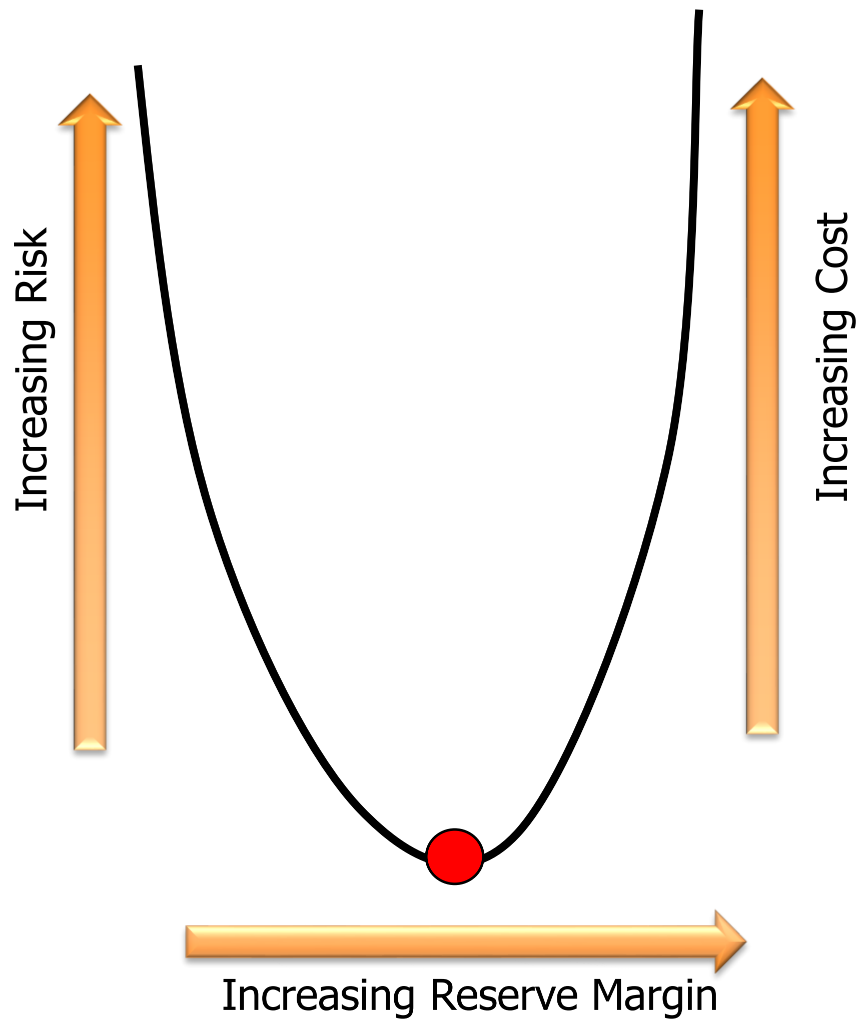


Real World Example of the Cost of "Too Many Resources"

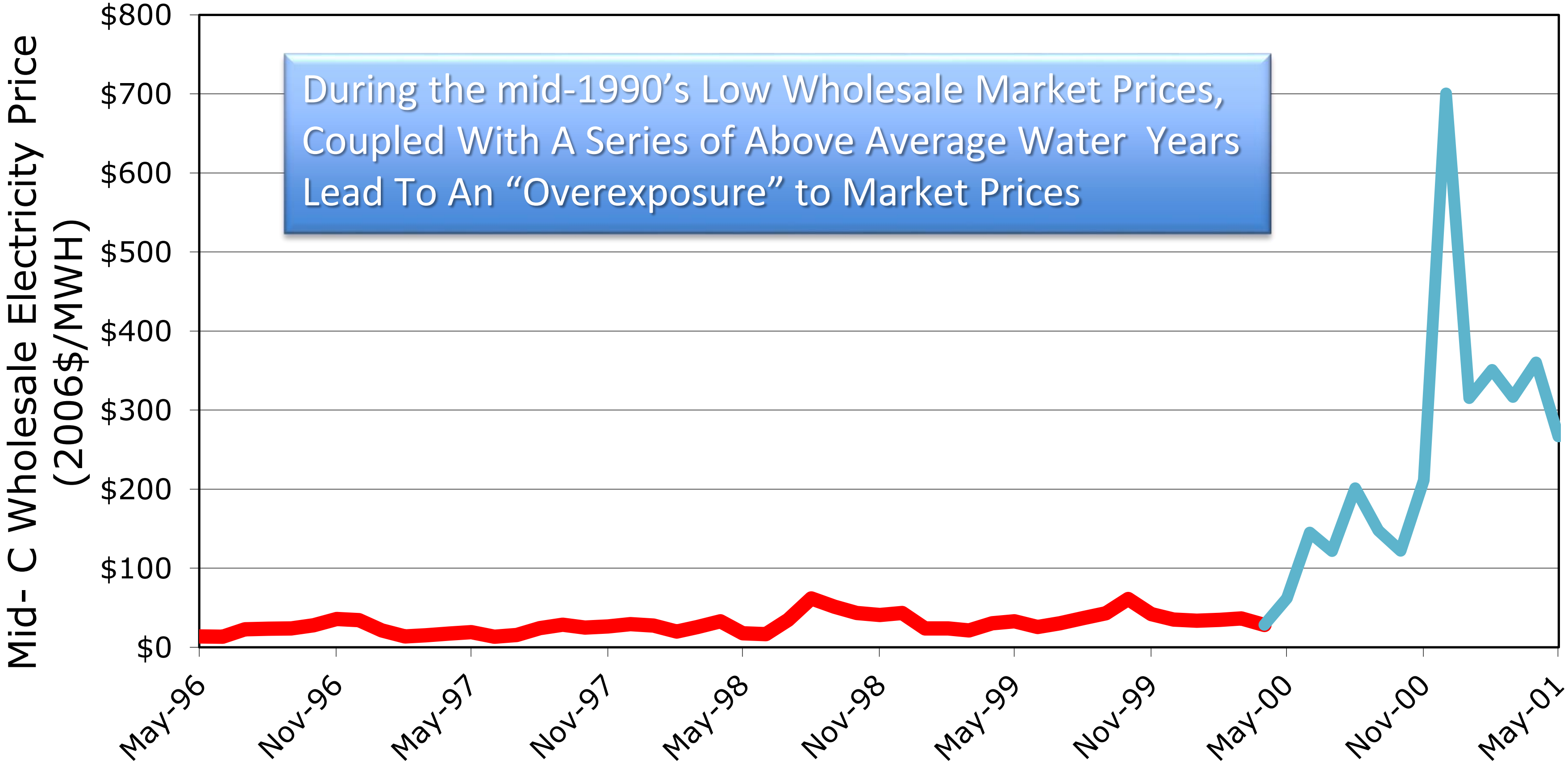


Why "Just Right" Matters: Decreasing Firm Contracts/Resources Increases Market Risk Exposure

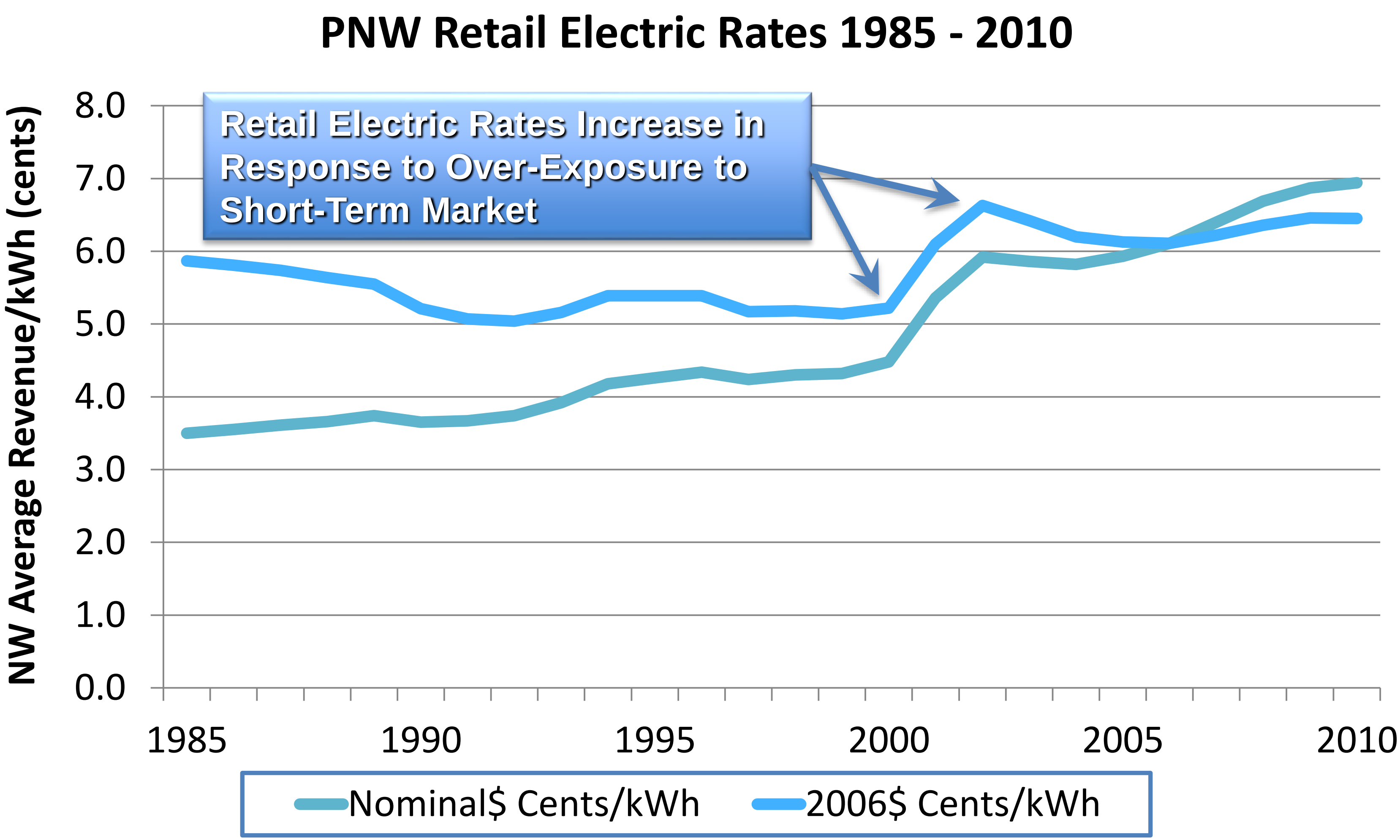




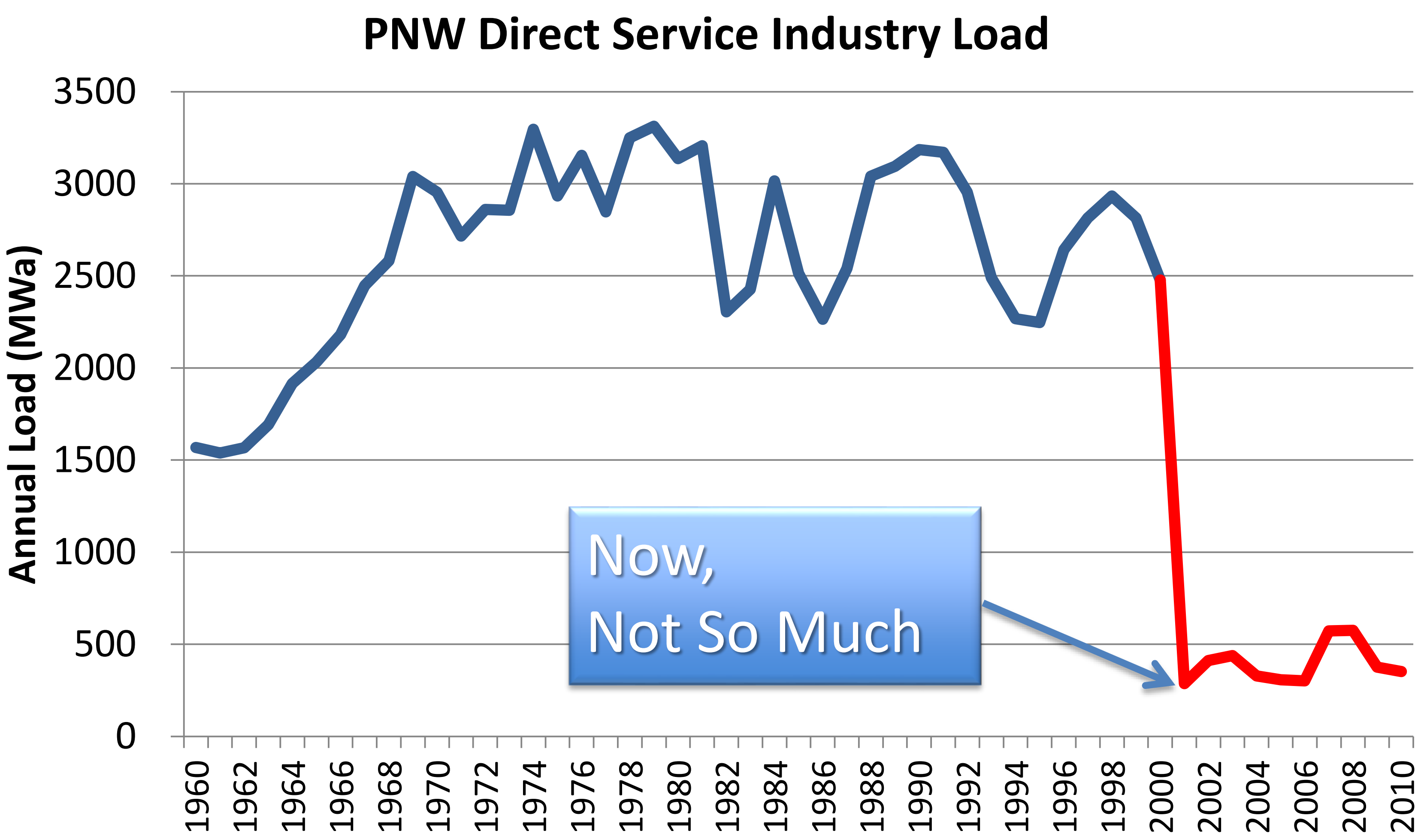
Perfect Foresight can also lead to underbuilding: Example – PNW



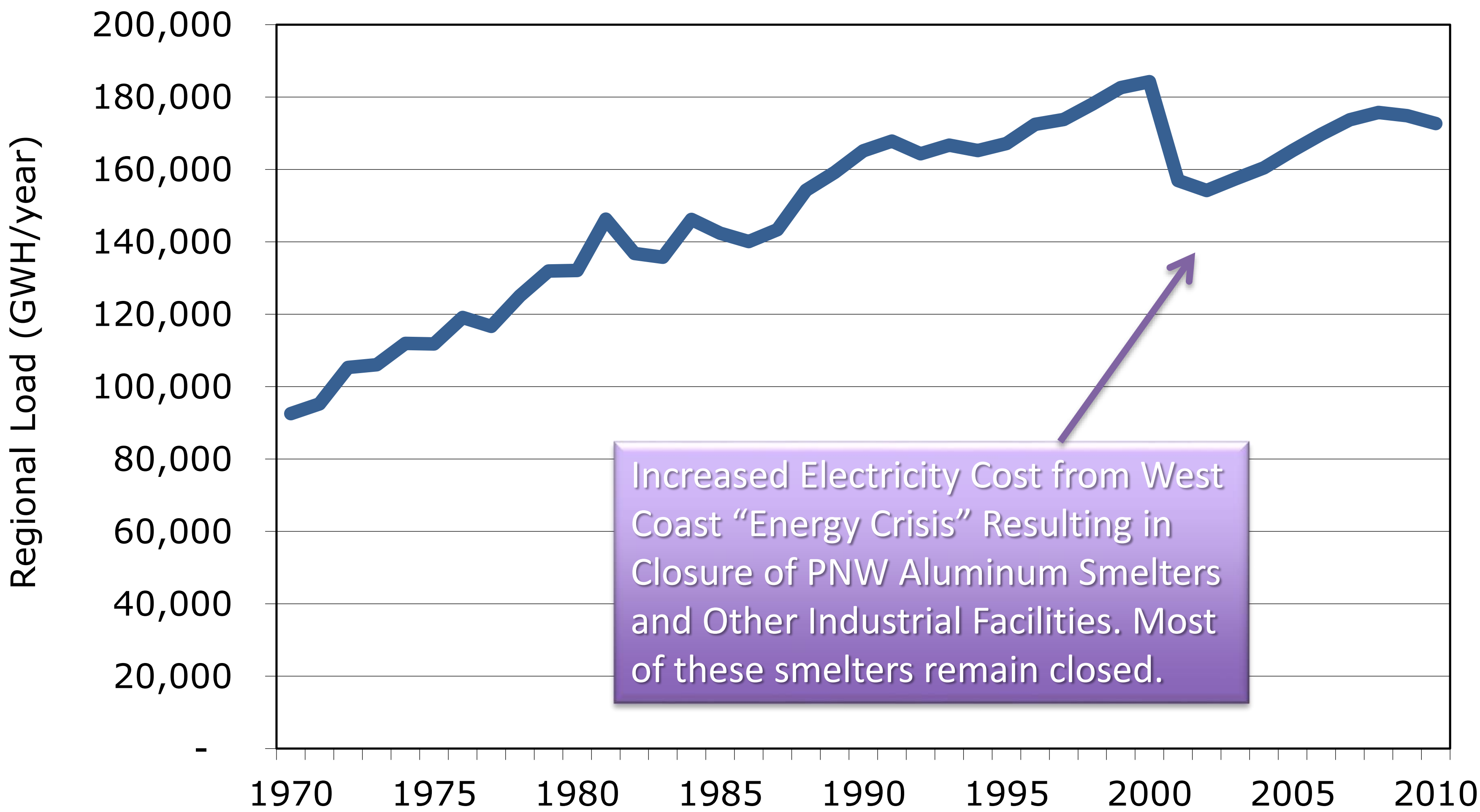
Real World Example of the Cost of "Too Few Resources" - PNW



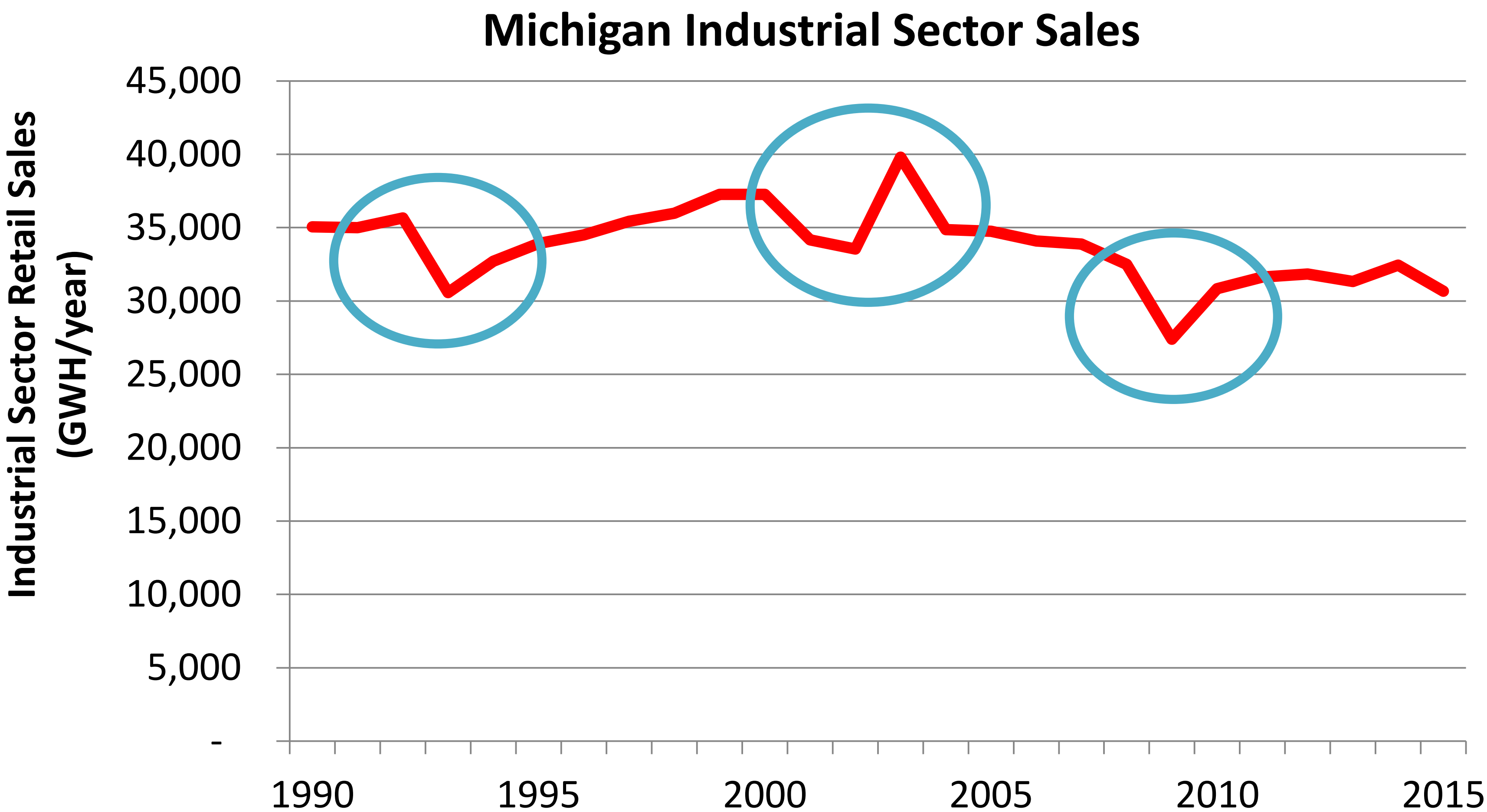
Historical Levels of Load Uncertainty Were Often Driven by Large Industrial Loads



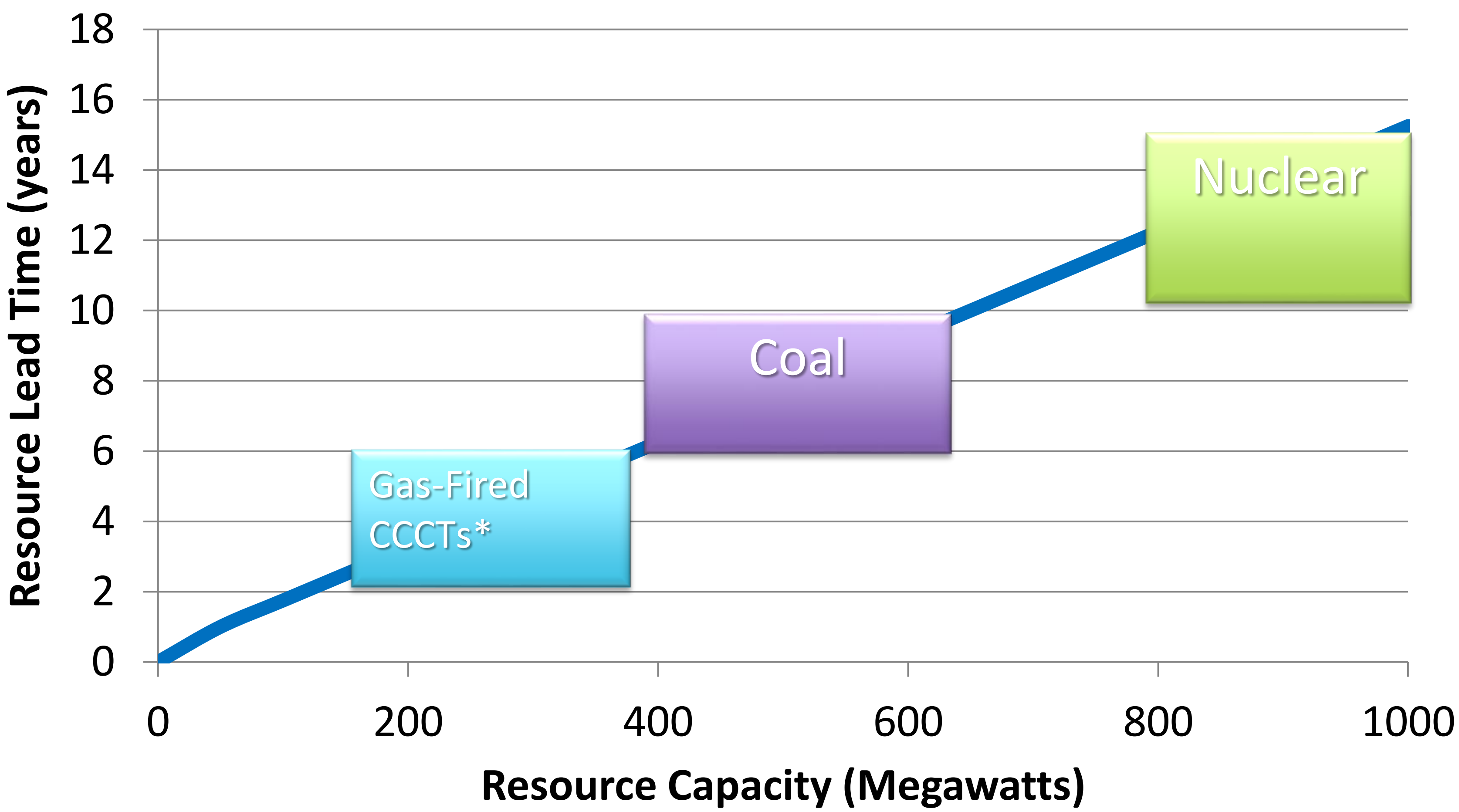
As A Result, Load Uncertainty Still Exists, But Near Term Volatility Is Less



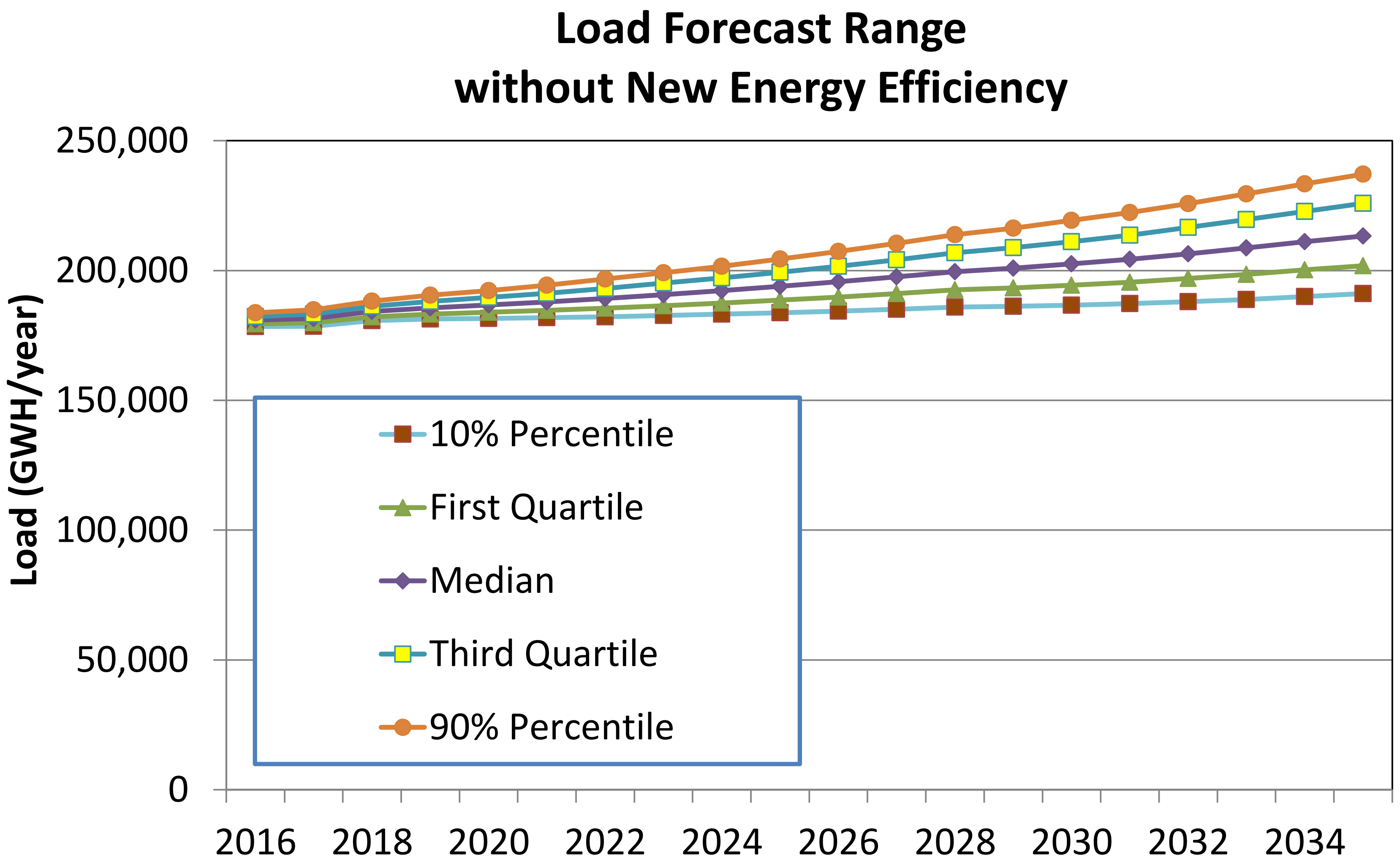
It Appears that Historical Levels of Load Uncertainty in Michigan Were Often Driven by Large Industrial Loads



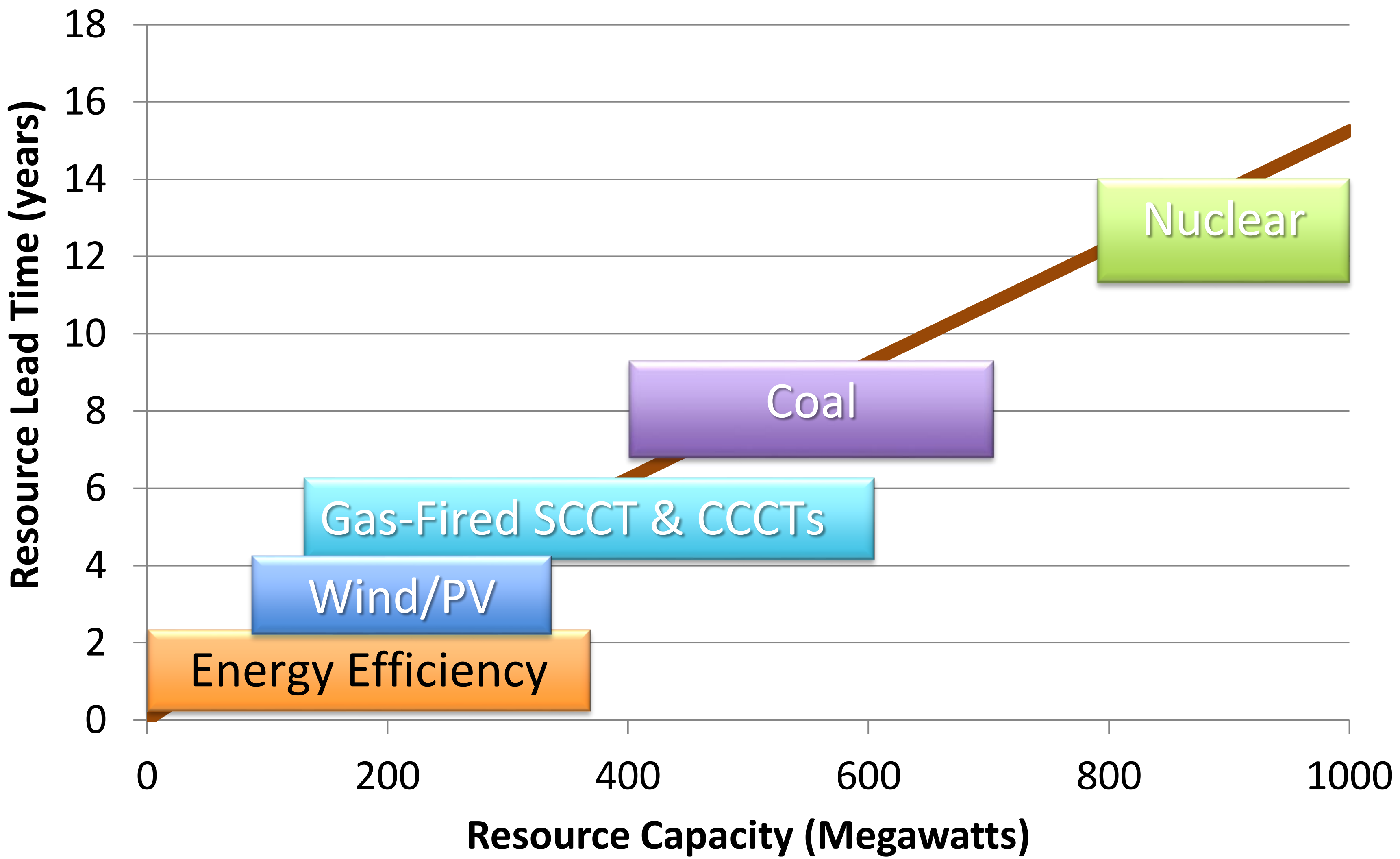
Load Uncertainty Is Particularly A Problem For Resources With Long Lead Times and Large Sizes



Best Practice Load Forecasts for IRPs Do Not Assume *Perfect Foresight*



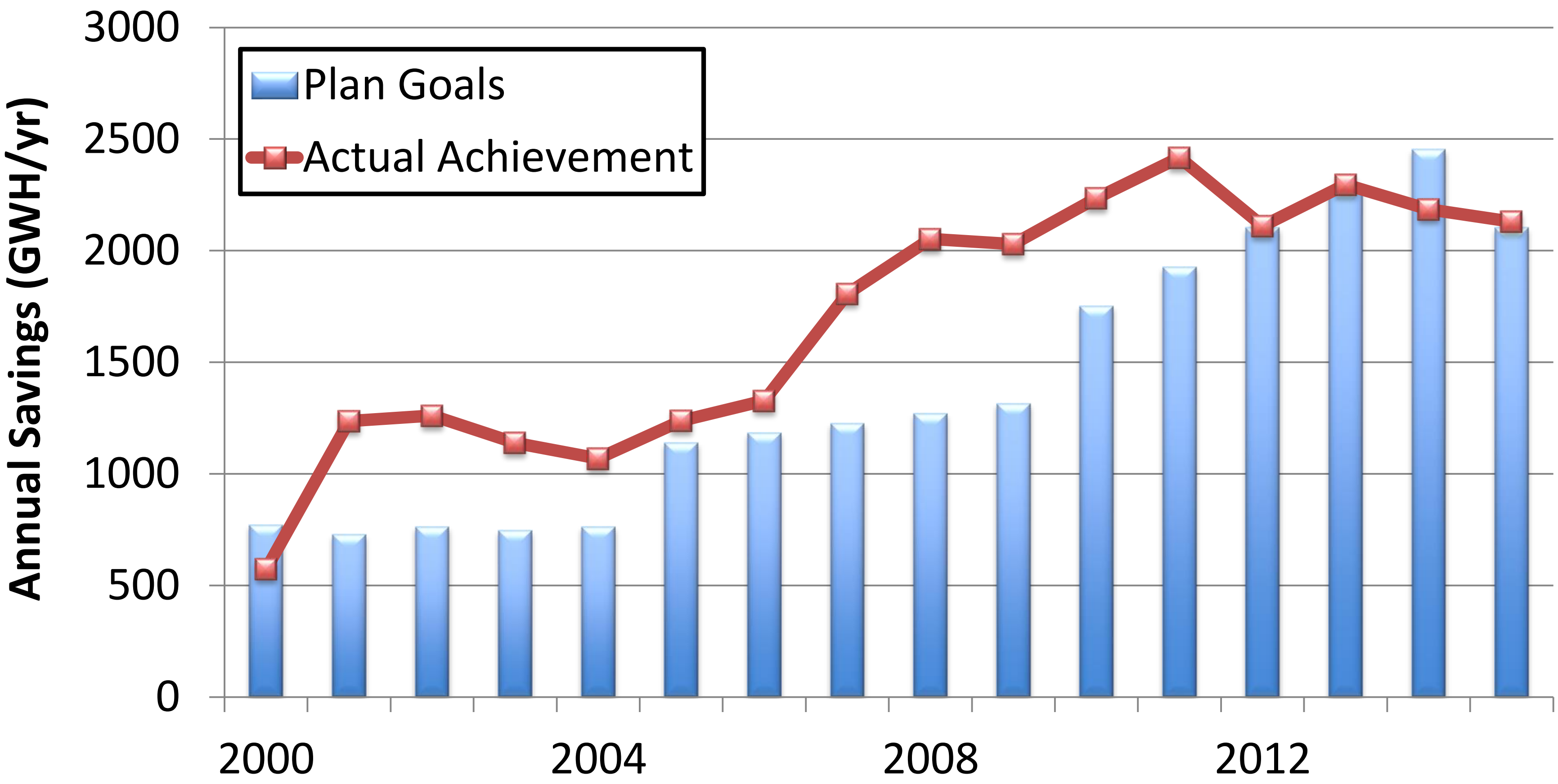
Energy Efficiency, Demand Response and Shortened Lead Times and Smaller Sizes For Some Generating Resources Reduce Exposure to Load Uncertainty



IRPs Must Address Three Major Sources of Uncertainty – Resource Uncertainty

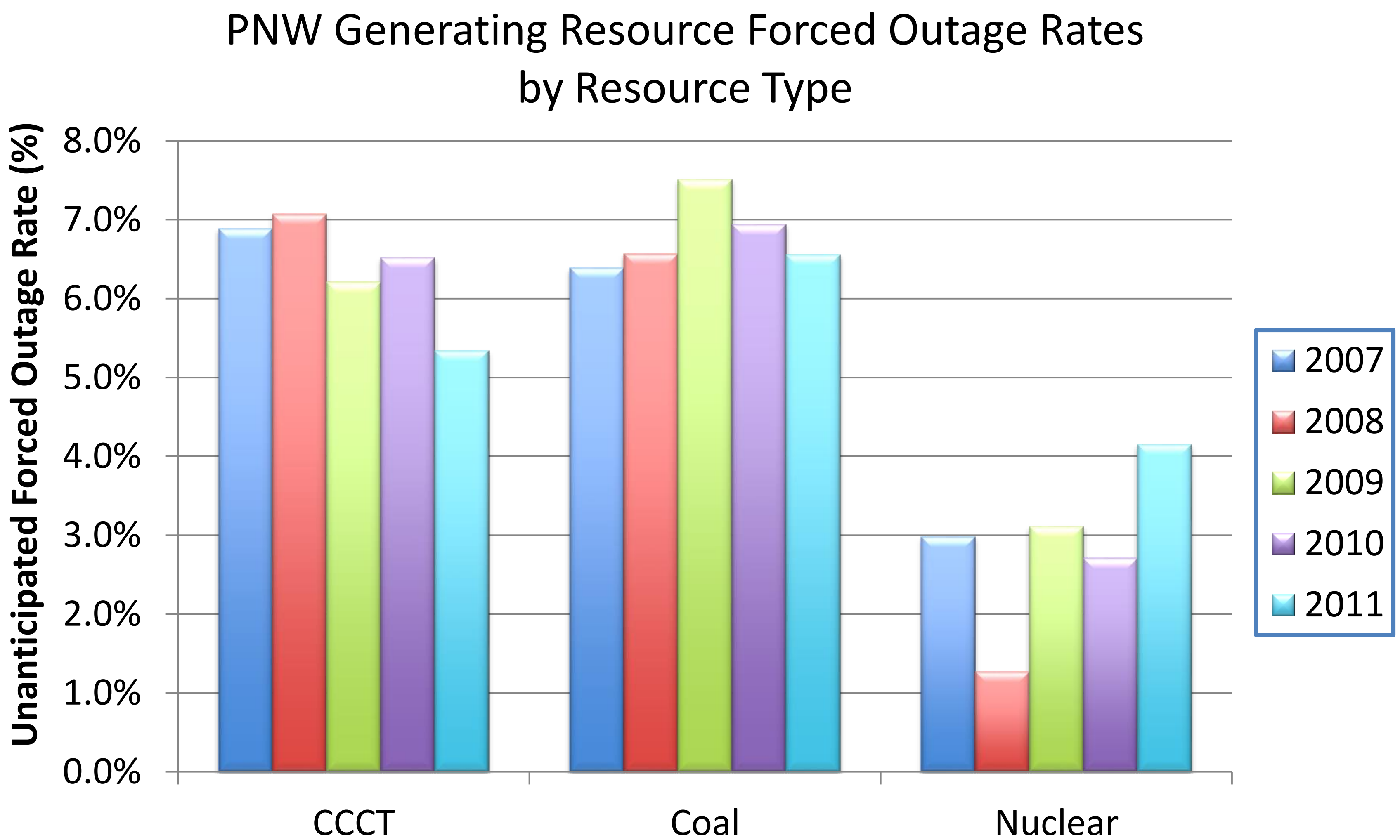
- Load Uncertainty
- Resource Uncertainty
  - Output
  - Cost
  - Construction Lead Times
  - Technology Change
- Wholesale Electricity Market Price Uncertainty

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

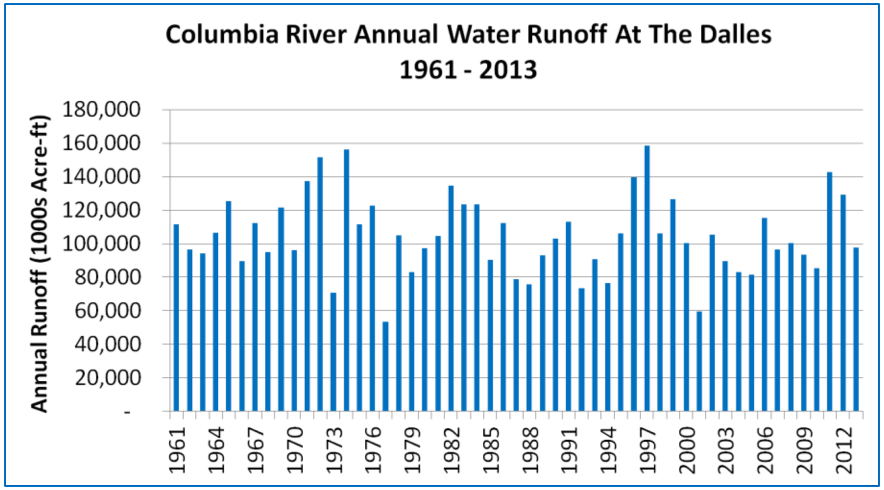


*Achievements reflect utility and NEEA savings only. Savings from codes and standards are included as baseline adjustments in each plan's baseline load forecast

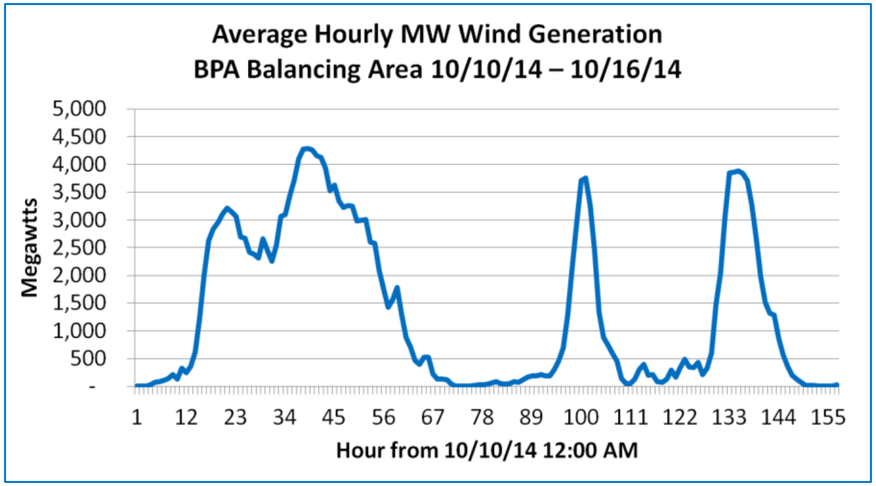
Generating Resource Uncertainty Results from *Unanticipated* (i.e., "forced") Outages Which Reduces Their Availability

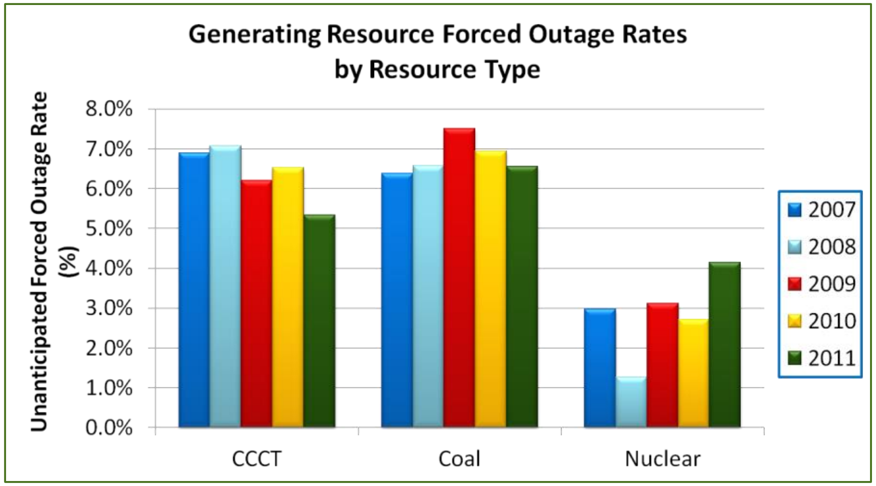


Resource *Variability* Differs from Resource *Uncertainty* - *But Planning for Both Is Important*

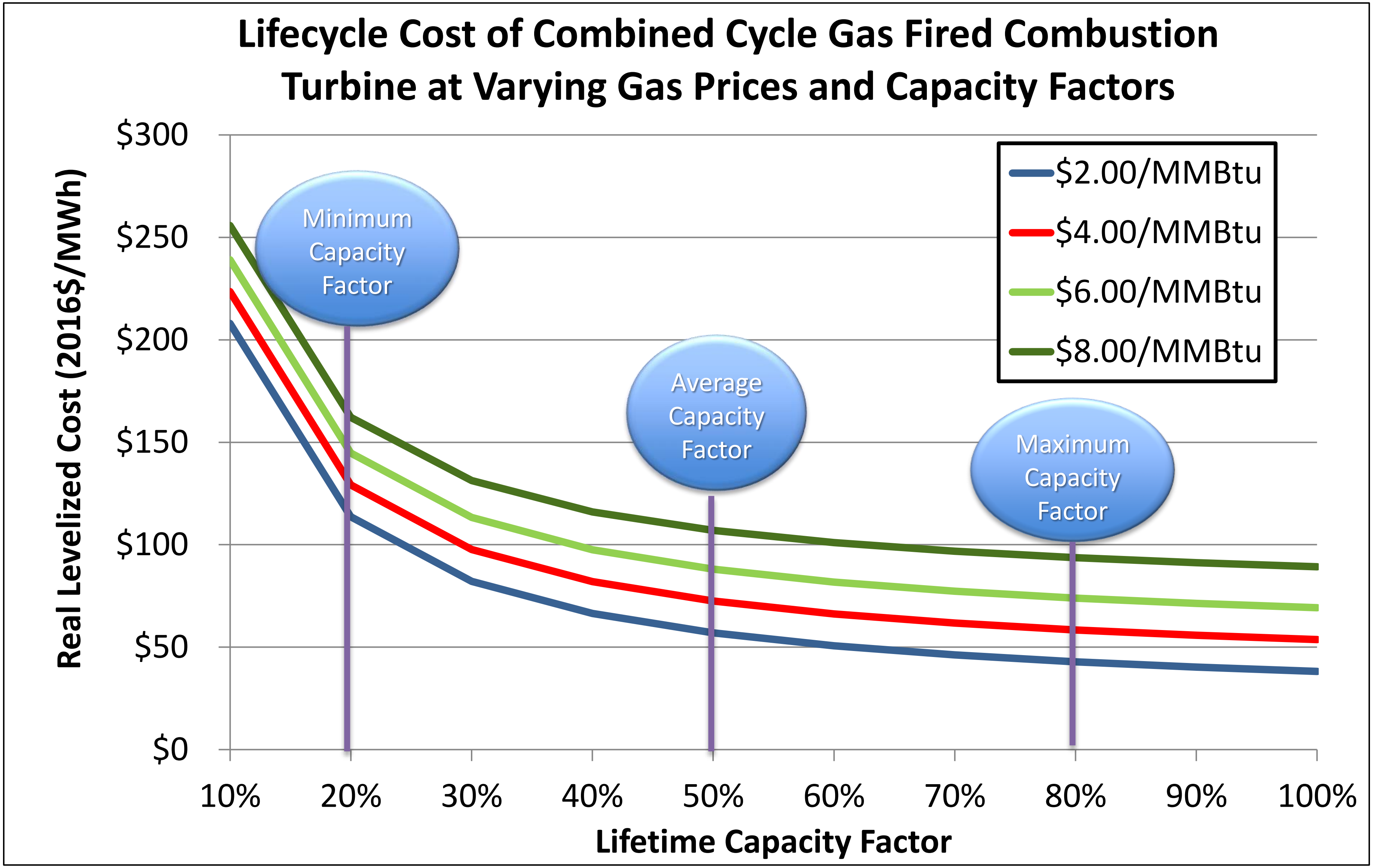


While probabilities can be assigned to predict the output of variable resources and adjust for forced outage rates, this does not eliminate *cost* uncertainty

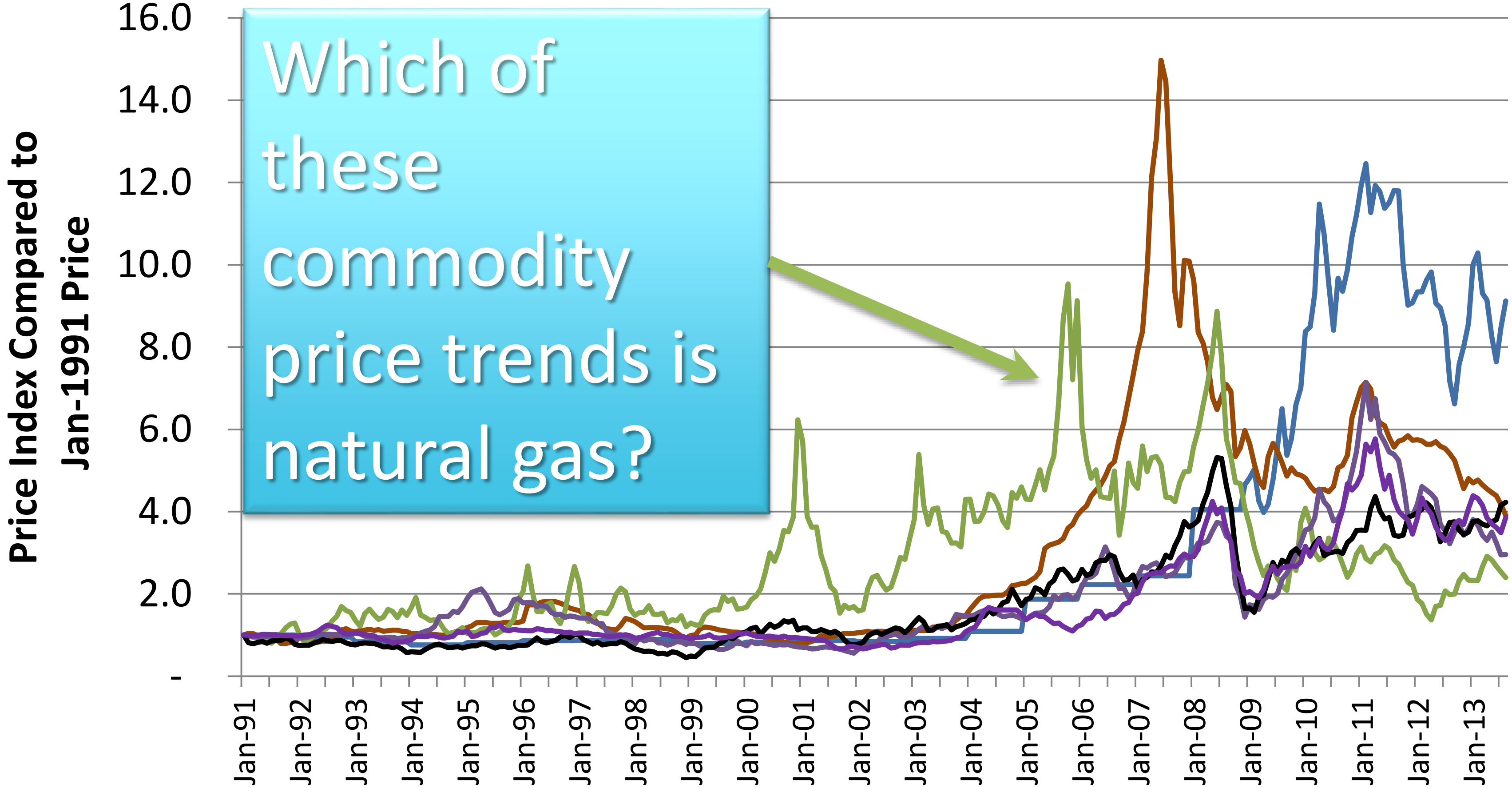




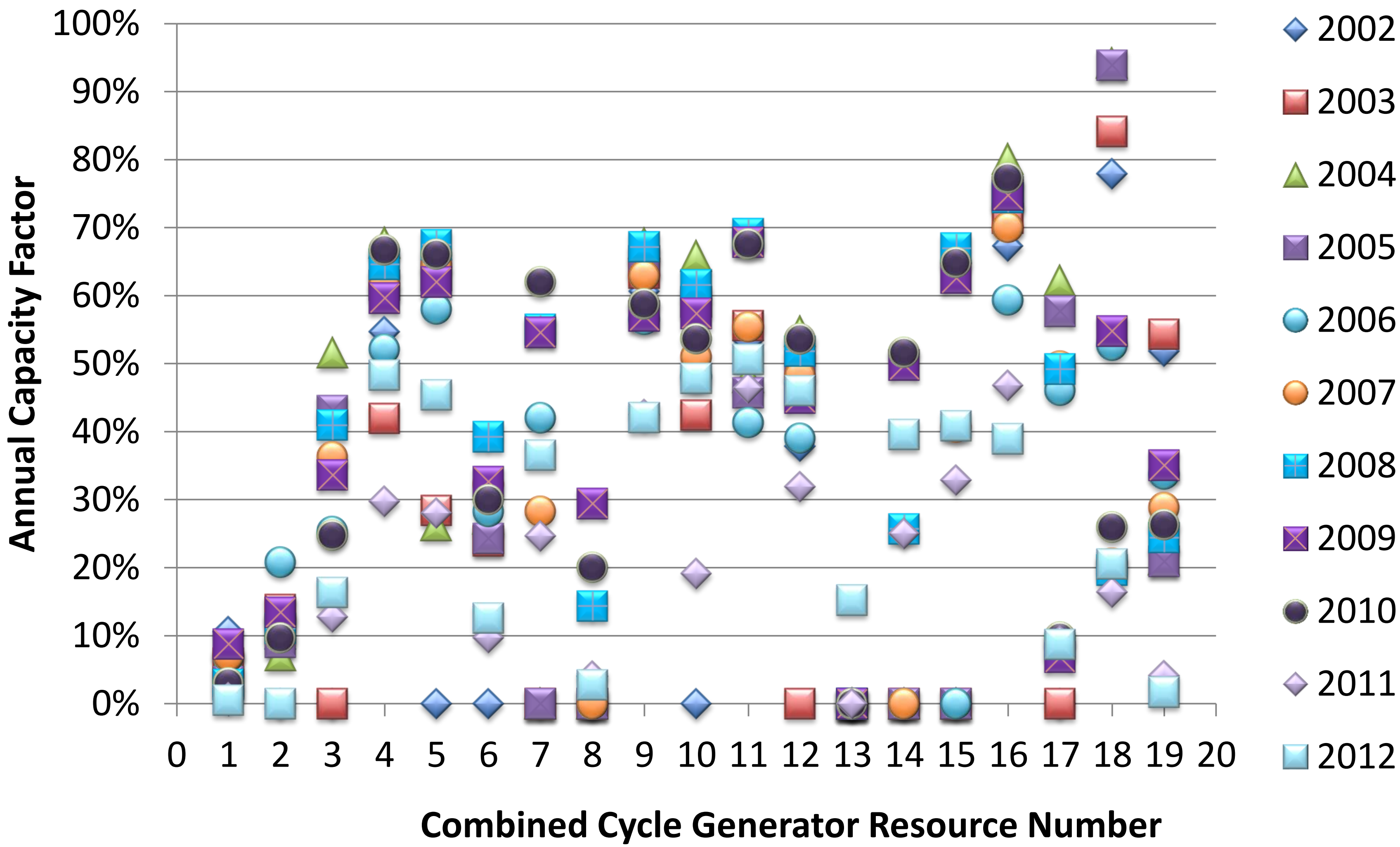
However, Resource Cost Uncertainty Is Primarily Driven by Input Fuel Prices and Utilization (i.e., "capacity factors")



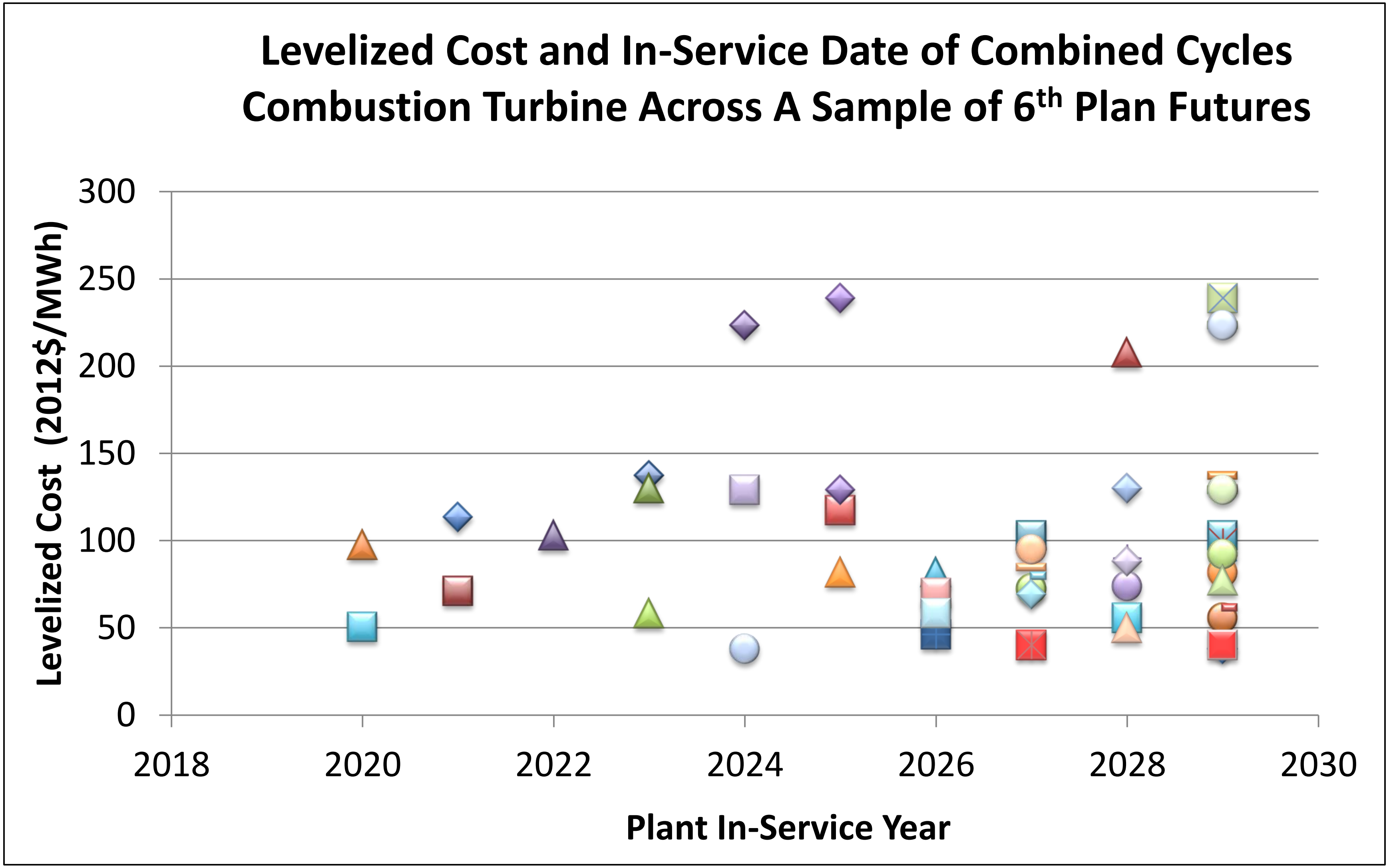
Forecasting Natural Gas Prices Is Equivalent to Engaging in Commodity Trading



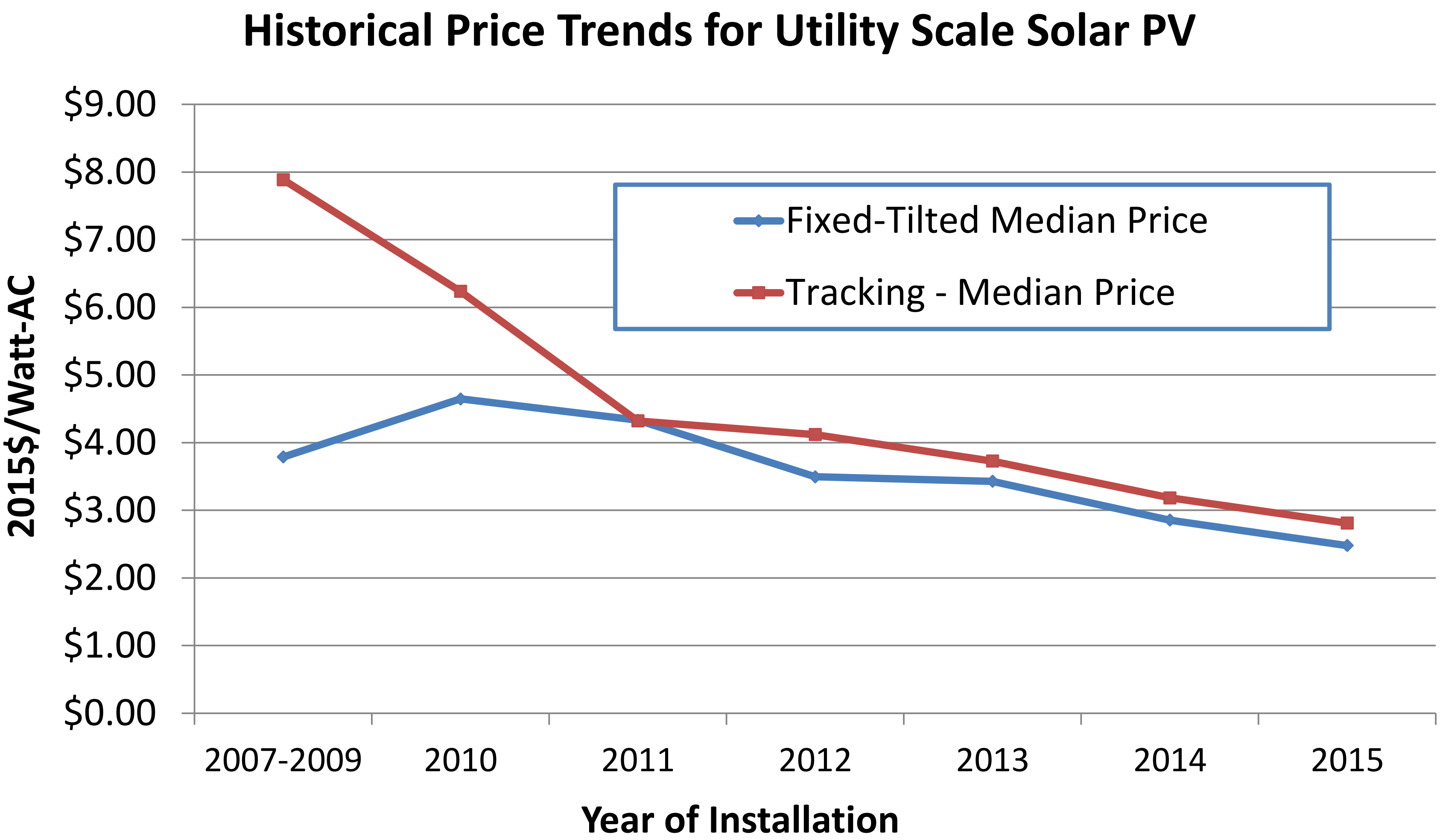
Combined Cycle Generation Resource Capacity Factors Can Vary Significantly From Year-to-Year



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



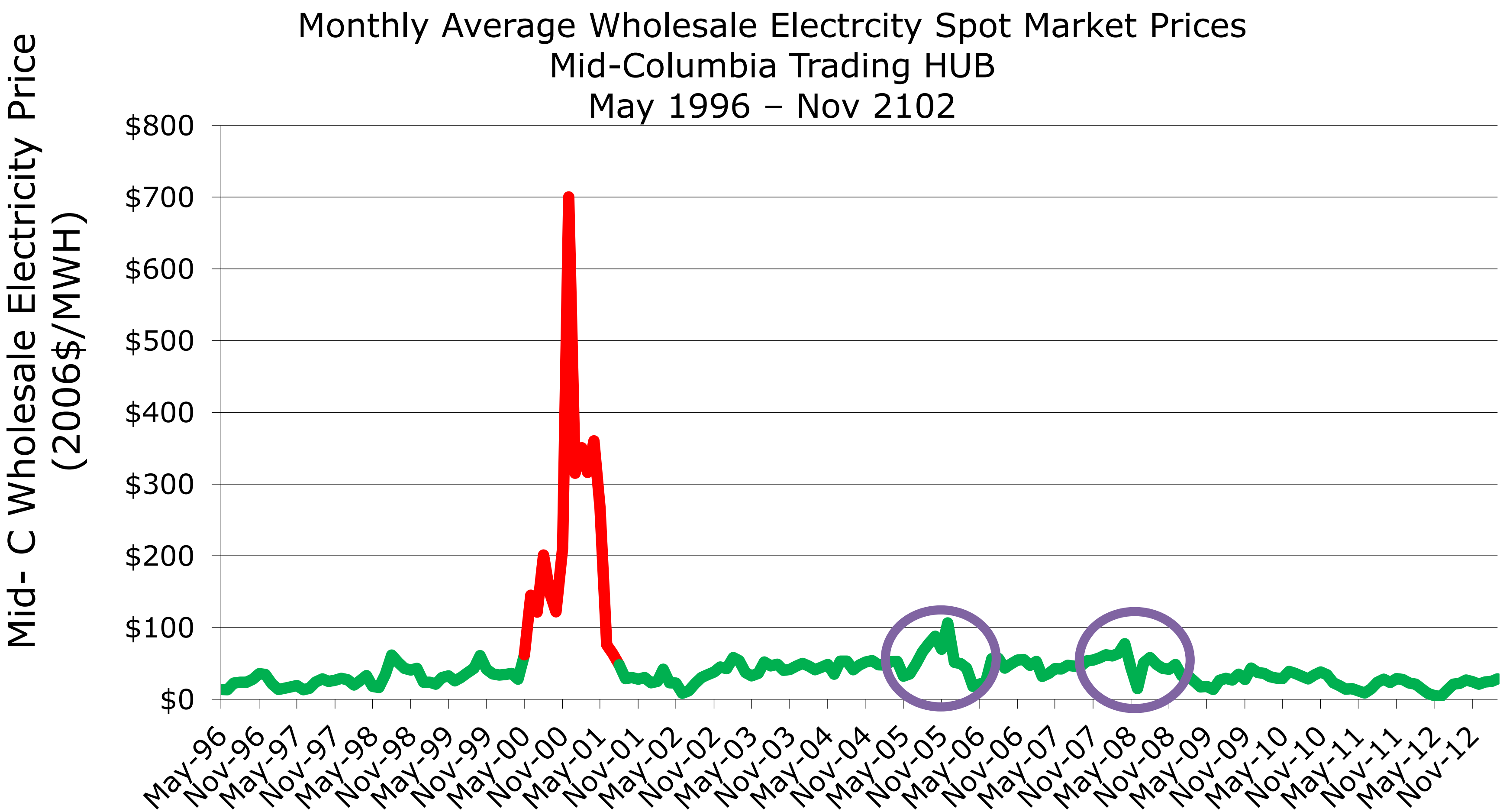
The Pace of Technology Change Introduces Additional Uncertainty Into the Determination of Avoided Cost



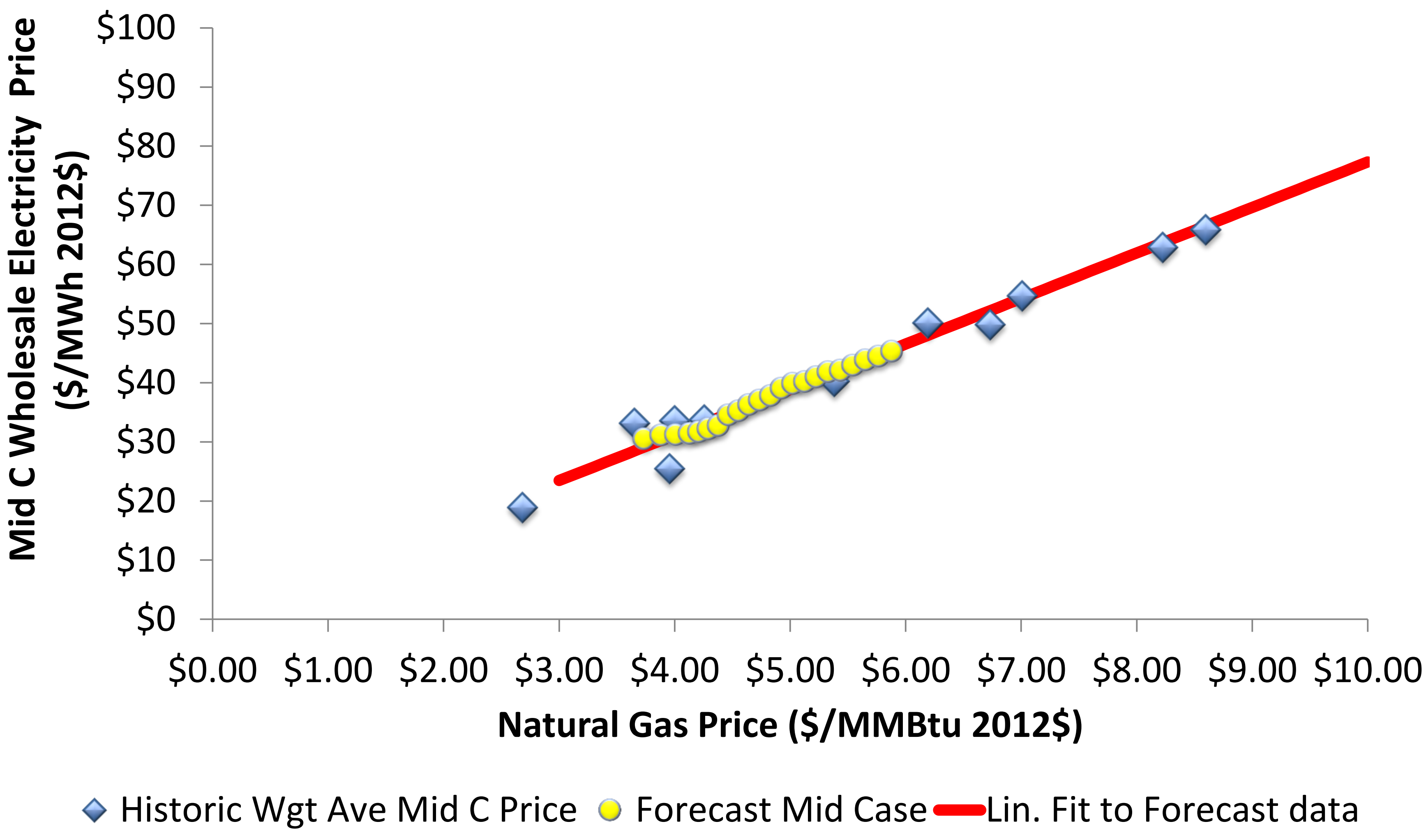
IRPs Must Address Three Major Sources of Uncertainty – Wholesale Market Prices

- Load Uncertainty
- Resource Uncertainty
  - Output
  - Cost
  - Construction Lead Times
  - Technology Change
- Wholesale Electricity Market Price Uncertainty

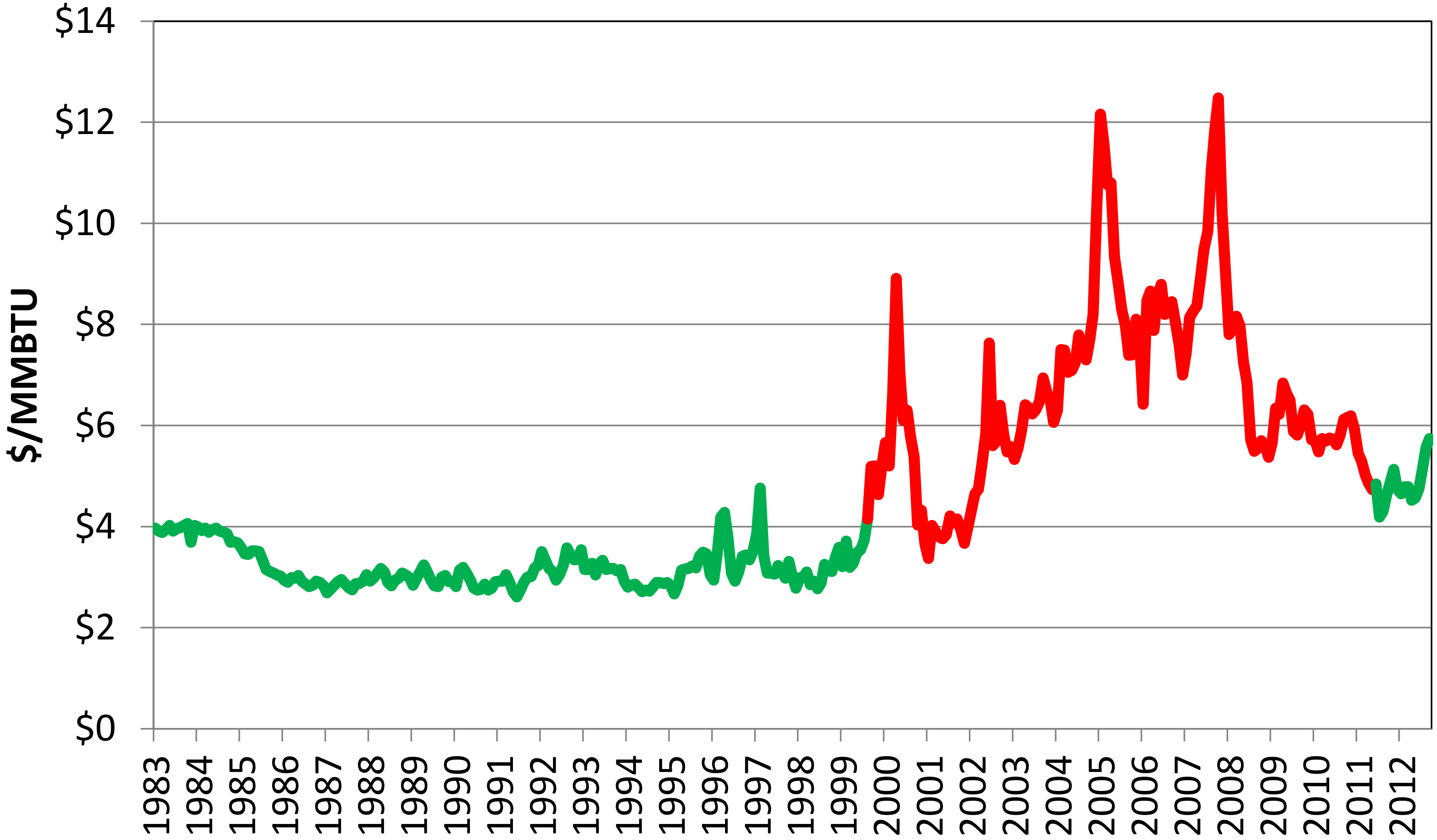
Market Price Establish the Value of Marginal Supply – But They Are Full of Surprises



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

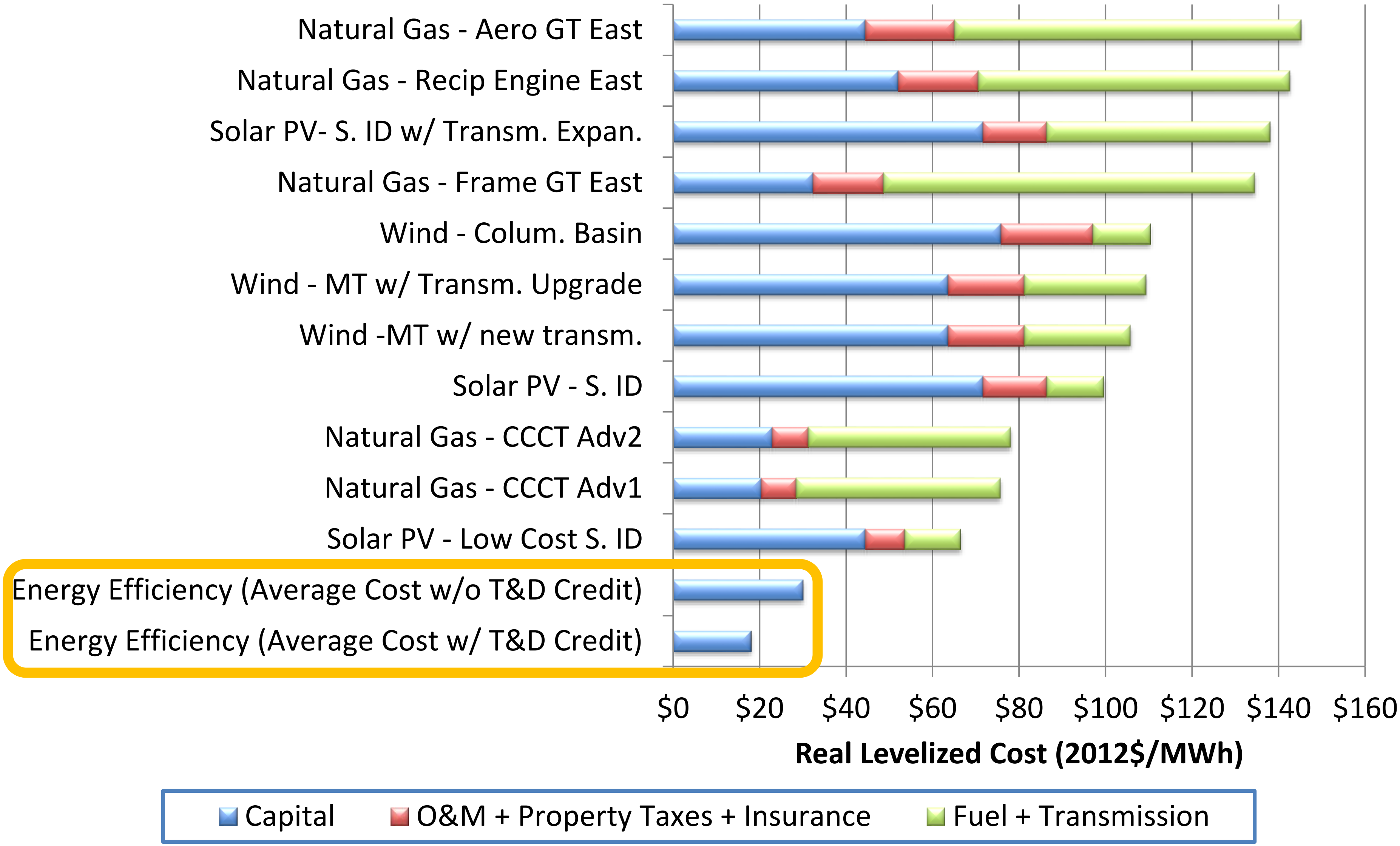


So With All These Uncertainties, How Does The An IRP Answer Those Simple Questions?

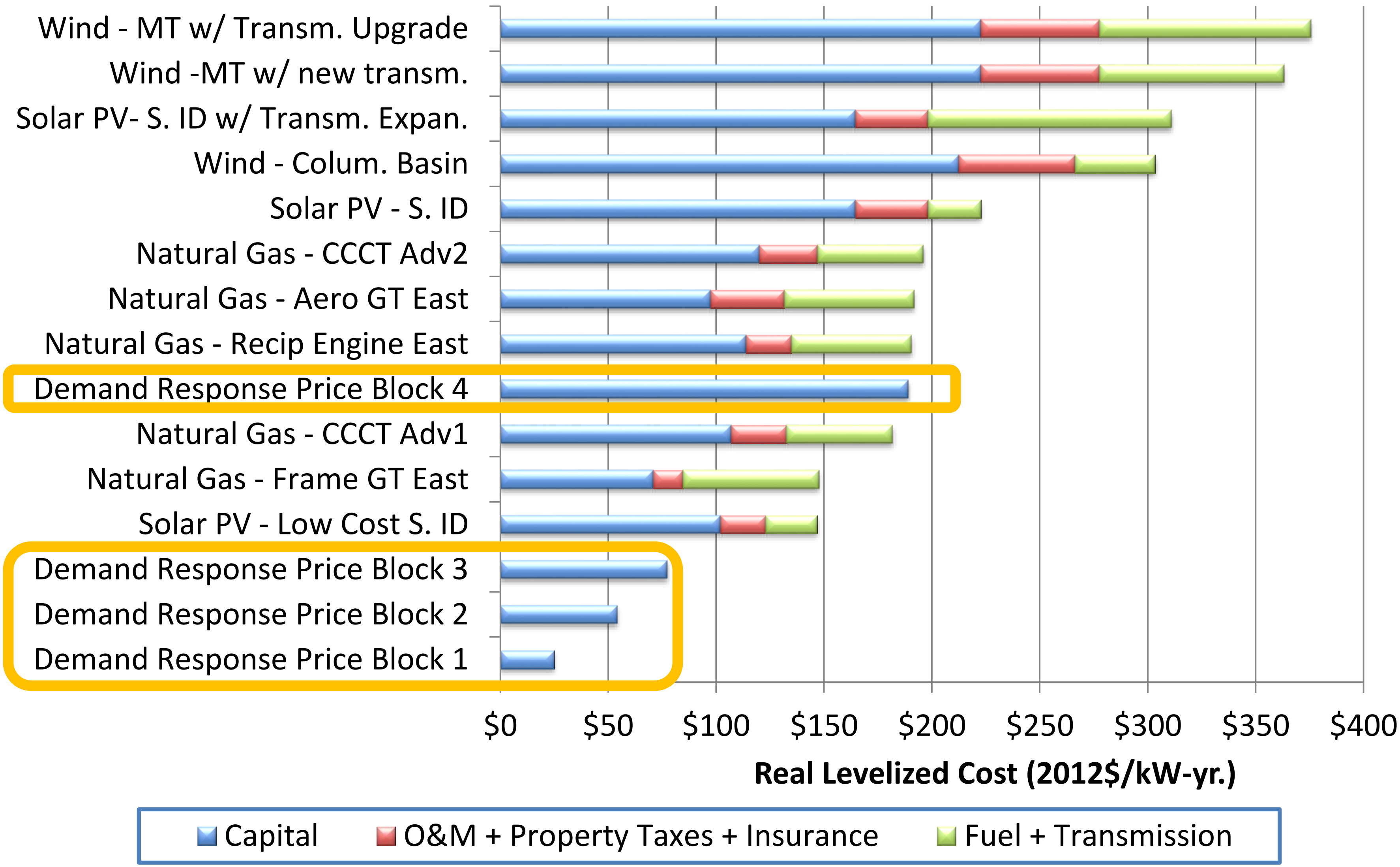
1. *When Will We Need Resources?*
2. *How Much Will We Need?*
3. *What Should We Build/Buy?*
4. *How Much Will It Cost?*
5. *What's the Risk?*

The lowest cost, lowest risks resources first.

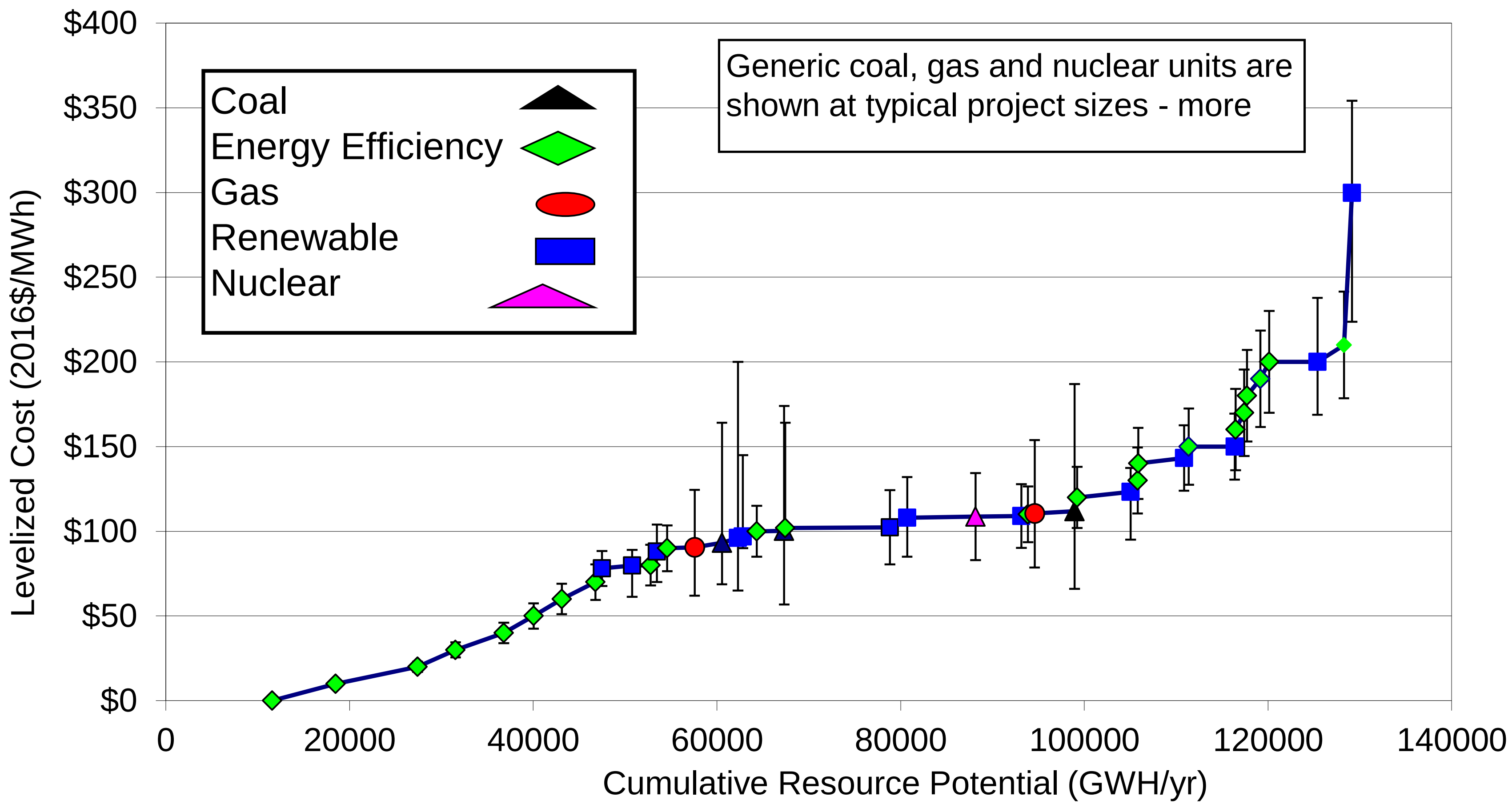
All Resource Cost – Energy



All Resource Cost – Peak Capacity



Resource Portfolio Almost Analysis on One Slide

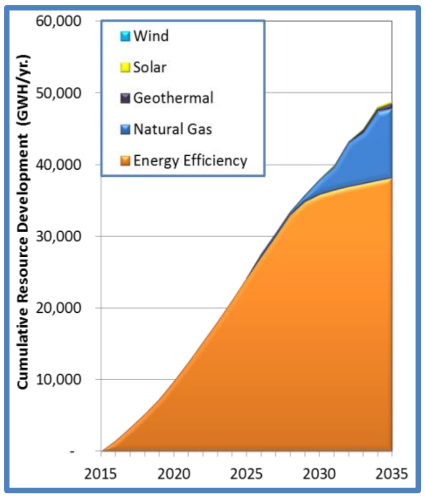


While the “All Resource Supply Curve” tells use what to acquire, it doesn’t tell us *how much, when or the costs and risks* of acquisition!

Answering to the *Amount, Timing, Cost and Risk* Questions Requires Modeling and Analysis of Uncertainty

Resource Strategies – actions and policies over which the decision maker *has control* that will affect the outcome of decisions

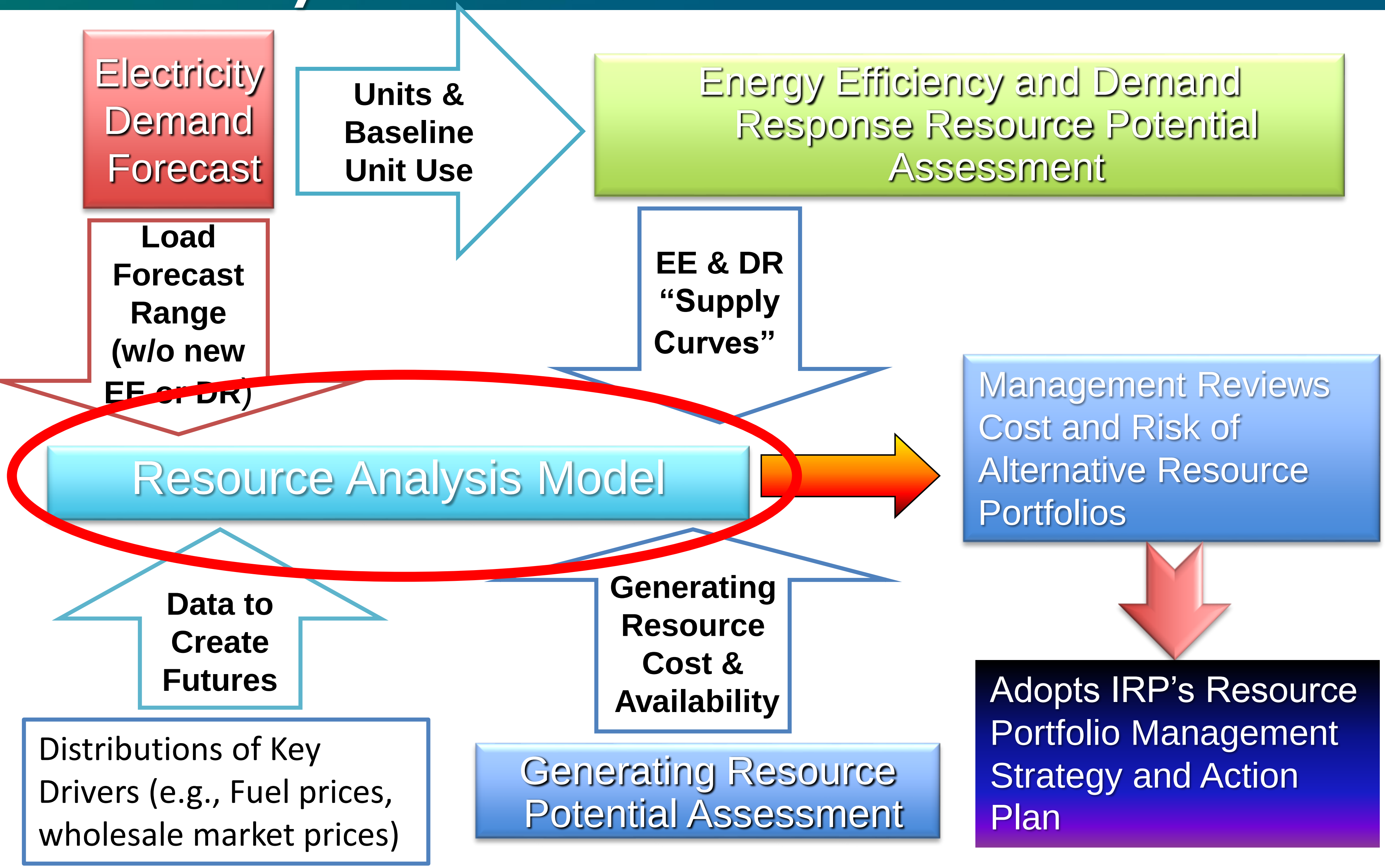
Futures – circumstances over which the decision maker *has no control* that will affect the outcome of decisions



- Load Uncertainty
- Resource Uncertainty
  - Output
  - Cost
  - Construction Lead Times
  - Technology Change
- Wholesale Electricity Market Price Uncertainty

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

Best Practice Capacity Expansion/Resource Analysis Models Used in IRPs Do This

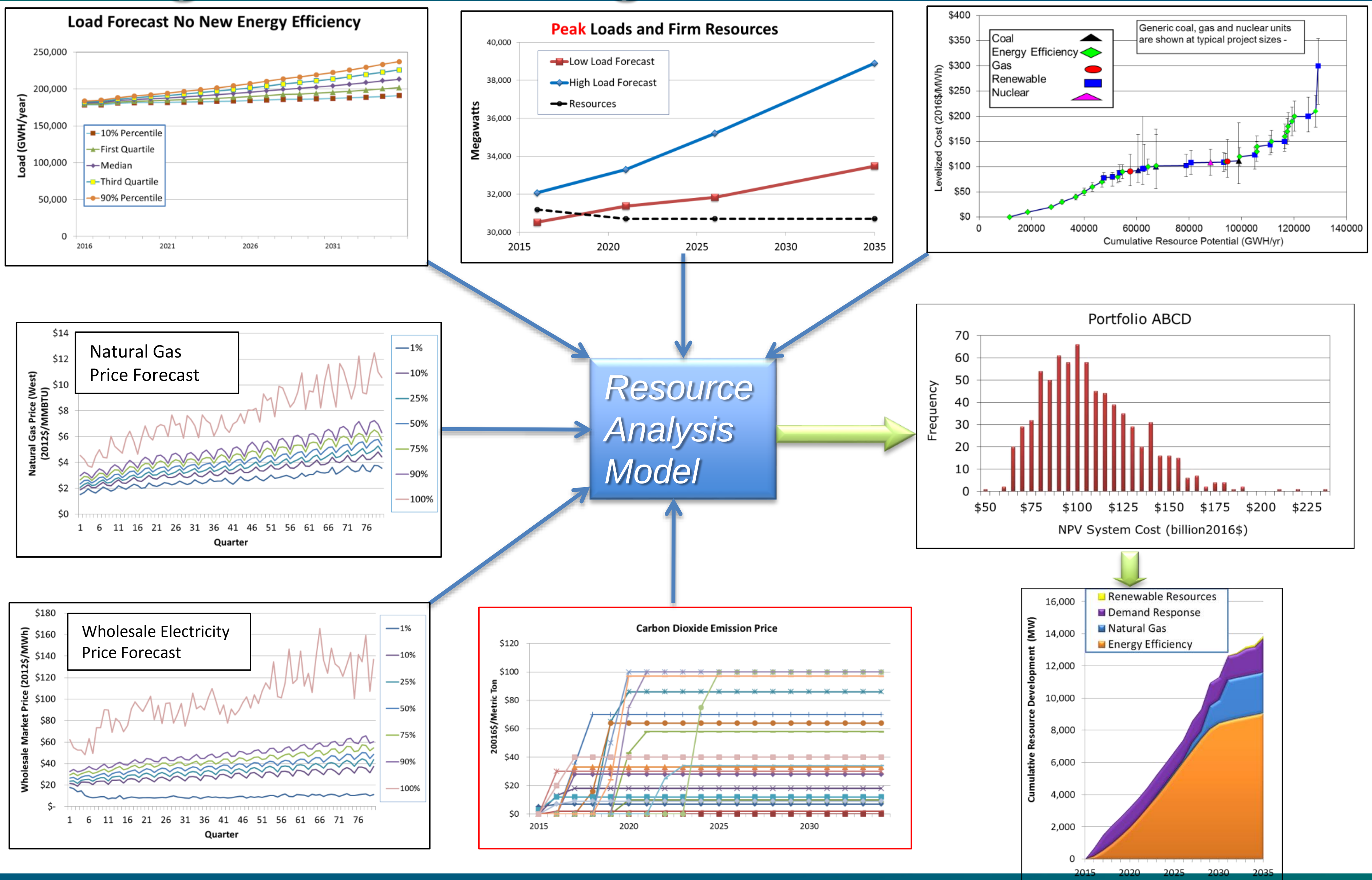


Best Practice IRPs Follow the “Gump” Resource Strategy Testing Model

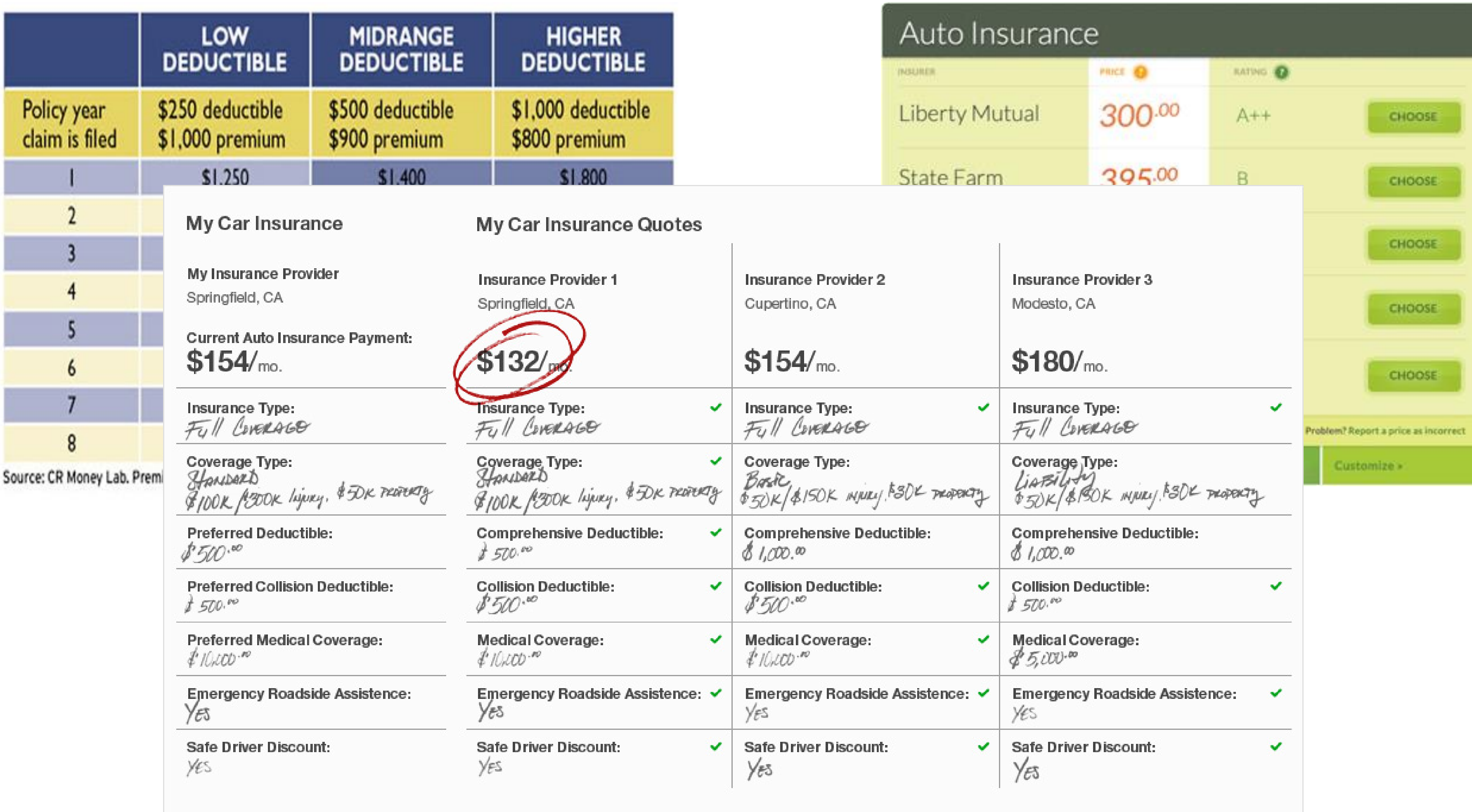
The Future’s Like A Box of Chocolates.

You Never Know What You’re Gonna Get.

Scenario Analysis "Stress Test" Resource Strategies Across A Range of Future Conditions



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



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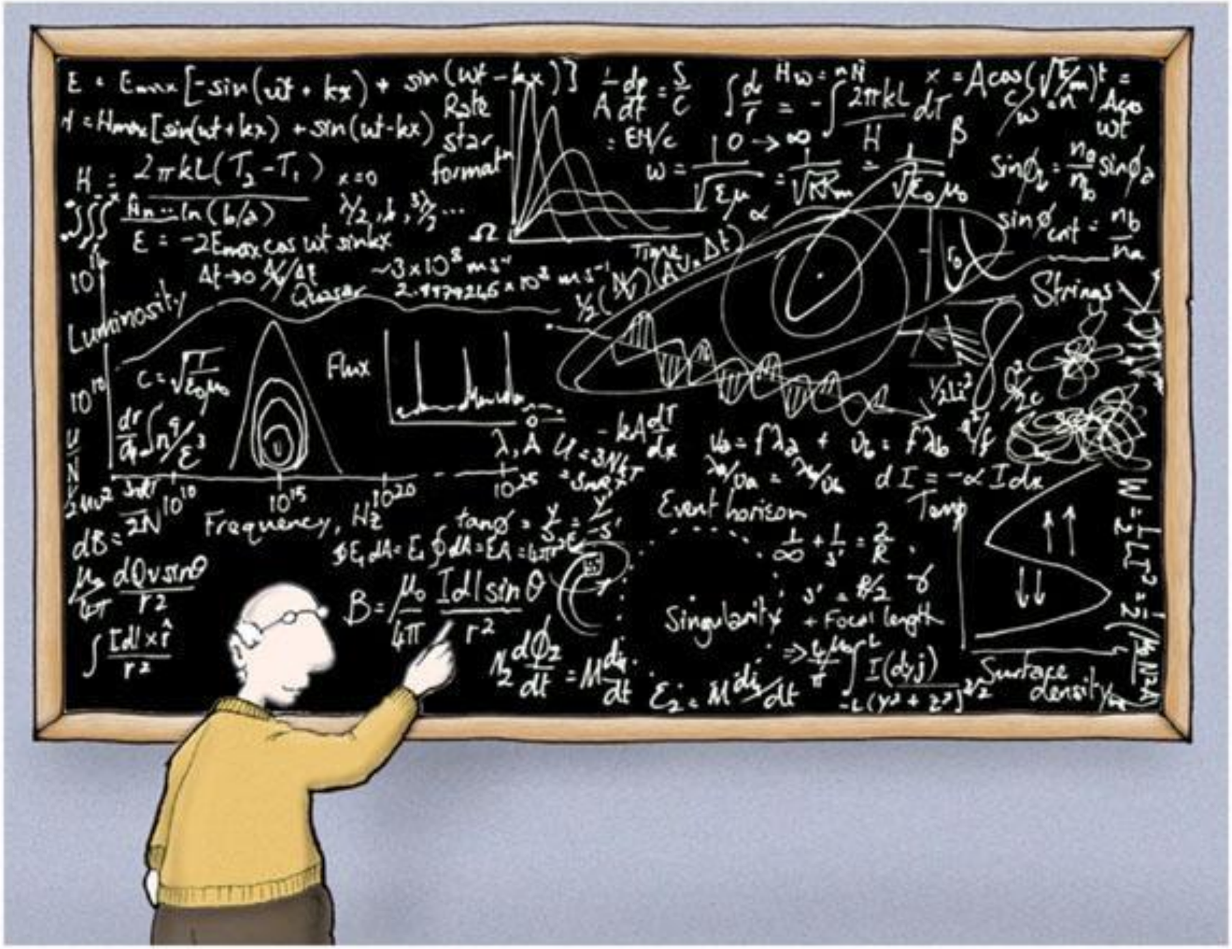
A Resource Strategy's Benefits Should Always Outweigh Its Risks

Determining The Amount and Pace of EE and DR Development in an IRP



Efficiency Potential in Michigan

I'm Feeling Lucky

Google Search

The Basic Formula for Estimating Savings Potential

Achievable Potential **=**
Number Units * Savings per Unit * Achievable Market Penetration

Fraction of units realistically achievable over time

Examples:
- Number Homes
- Floor Area of Office Buildings
- Number of TVs
- Acres Irrigated
- Pounds of Paper

Use per Unit at Current Efficiency – Use per at Improved Efficiency) = Savings (kWh/yr)

Current Efficiency is adjusted for adopted codes & standards and stock turnover (Frozen Efficiency)

We're Now Heading In To the Weeds . . .

In Best Practice IRPs the Amount of EE is Determined in a Five Step Process

- *Step 1 -* Estimate *Technical Potential* on a *per application* basis (i.e. savings per unit)
- Step 2 - Estimate *number of applicable units* (account for physical limits, retirements, new construction, etc.)
- Step 3 – Estimate *Technical Potential* for *all applicab*le units
- Step 4 – Estimate *Achievable* Potential for *all realistically achievable* units
- Step 5 – Estimate *Economic Potential* for *all realistically achievable* units by competing EE against supply side resources in capacity expansion modeling

In Many IRPs the Amount of EE is also Determined in a Five Step Process – But the Order is Different

- *Step 1* - Estimate *Technical Potential* on a <u>*per application*</u> basis (i.e. savings per unit)
- Step 2 – Estimate *Economic Potential* on a <u>*per application*</u> basis (i.e., levelized cost per unit) based on “avoided cost” of “proxy” resource or capacity expansion model marginal resource analysis
- Step 3 - Estimate <u>*number of applicable units*</u> (account for physical limits, retirements, new construction, etc.)
- Step 4 – Estimate *Technical Potential* for <u>*all applicab*</u>le units
- Step 5 – Estimate *Achievable* Potential for <u>*all realistically achievable*</u> units

The amount of “economically achievable” savings resulting from Step 5 are then used to reduce the load forecast provided to the capacity expansion model before that model is used to “optimize” the supply side resources.

Establishing the Amount and Timing of EE and DR Development Through Direct Completion

- Allows *optimization* across all resources based on their cost, load shape/load following characteristics and risk
- Requires capacity expansion models that are capable of accepting "acquisition decision and development rules" for EE and DR (specifics later on this)
- Is less useful when deterministic (versus probabilistic) capacity expansion models are used
  - Because there's no uncertainty regarding the answers to the planner's five simple questions

Important Concepts/Principles for Both Methods
Input Assumptions Regarding *Annual* and *Cumulative Achievability*

- **Maximum Achievability Over Planning Period**
  - Reflect *gross* savings from all mechanism (e.g., programs, codes, standards, market transformation, etc.).
    - Free-ridership (i.e., the share of the population that is already adopting measure) should be captured in load forecast model
  - Treating EE is a resource means that acquisition payments to consumers up to the value of avoided utility system cost can be legitimately (i.e. are cost-effective) assumed so that economic barriers to participation are not a constraint
  - Limits to achievability should reflect continuous program operation across the entire planning period (10 - 20 years)
  - Limits on lost opportunity resource achievability should reflect potential adoption of codes and standards as well as other market transformation activities
- **Maximum Annual Achievability for Lost-Opportunity Measures**
  - Limits are based on the fraction of annual new or replacement units subject to program/codes/standards influence
  - Typically assume increasing penetration over time up to maximum, which for measures subject to codes and standards can be 90-100%.
- **Lost Opportunity "Found Again" Decision Rule**
  - If lost-opportunity unit savings is not "acquired" first opportunity, then measure is placed back in resource inventory for acquisition at next opportunity, if it occurs within planning period.

Both Methods

Interaction with Load Forecast

- Internal consistency between load forecast and energy efficiency assessment is necessary to avoid potential for *over* or *under* estimating remaining EE potential
  - Baseline use/efficiency assumptions should be equivalent
  - “Units” (e.g. houses, commercial floor space, appliance counts) should be identical
  - Internal consistency is most readily achieved when end-use and SAE load forecasting models are used
  - When econometric load forecasting models are used “calibration” between load forecast and EE potential assessments is typically done at the sector (i.e., residential, commercial) level.
    - Example – Baseline use assumptions for all of the residential sector EE measures are aggregated to sector levels to ensure that they total the load forecast estimate of that sectors current loads.

Special Considerations for Direct Competition Method – Interaction with Load Forecast and Resource Cost

When “direct competition” method is used to determine EE and DR development

- All potential EE and DR improvements are treated as resource options that compete against generating resources in supply expansion model and characterization includes both energy and capacity impacts
- Load forecast are not decremented with assumed level of EE and DR*
- Baseline load forecast used in capacity expansion/resource optimization model assume “frozen efficiency” (i.e., no price responsive improvements occur) only efficiency improvements from stock turnover and known codes and standards
- EE and DR costs should reflect all utility system impacts not accounted for in capacity expansion resource optimization process
  - Example – Capacity expansion model does not estimate value of deferred transmission and distribution, therefore EE levelized cost input into model should be “net” of deferred T&D.
  - Example – If non-energy benefits, such as the value of water savings, are to be included in the valuation of energy efficiency, the levelized cost input into the model should be “net” of the value of such benefits.

*Note: Where EERS requirements exist, they are modeled as “must build” resources and only additional increments above EE “compete”.

Special Considerations for Direct Competition Method Modeling "Acquisition Logic"

- Acquisition Logic:
  - Capacity expansion models require decision rules that determine when a resource is acquired
  - Unlike supply side resources EE and DR can be acquired across a wide range of costs (i.e., it has a nearly continuous supply curve)
  - EE and DR supply curves can be represented as "continuous" or as "discrete cost bin"
    - If "price bins" are used, care should be taken to avoid the "binning game"
  - A capacity expansion model must be able to compare the cost and load impacts of EE and DR with the cost and load following capability of supply side generation to determine which resource meets forecast needs for energy and capacity at the lowest cost

Special Considerations for Direct Competition Method
Input Assumptions Regarding Pace of Acquisition

- Maximum Retrofit Pace Constraint:
  - Resource optimization models will "build" (i.e., replace all existing lamps in a single year) all retrofit EE and DR resources with cost below the marginal dispatch of existing generating resources at first opportunity – unless constrained
  - Real-world infrastructure limits maximum annual retrofit development Constraints on the annual acquisition of retrofit EE and DR resources must be set in the model. Limits may be fixed or grow through time fixed for 20-yrs, i.e., assumes infrastructure never grows)
- Acquisition Logic:
  - Modeling supply curve, whether continuous or in cost "bins" can result in acquisition lowest to highest cost measures through time
  - Real world programs don't acquire <u>only</u> the lowest cost measures first
  - Acquisitions must be modeled so EE resources are selected across entire supply curve since program costs meld low and higher cost measures

Any Questions?

Resources

- Northwest Power and Conservation Council's Seventh Power Plan

  (https://www.nwcouncil.org/energy/powerplan/7/plan)

- Using Integrated Resource Planning to Encourage Investment on Cost-Effective Energy

  (https://www4.eere.energy.gov/seeaction/publication/using-integrated-resource-planning-encourage-investment-cost-effective-energy-efficiency)

- Best Practices in Electric Utility Integrated Resource Planning - Examples of State Regulations and Recent Utility Plans (http://www.raponline.org/wp-content/uploads/2016/05/rapsynapse-wilsonbiewald-bestpracticesinirp-2013-jun-21.pdf)

- Practicing Risk-Aware Electricity Regulation: What Every State Regulator Needs to Know

  (http://www.raponline.org/knowledge-center/practicing-risk-aware-electricity-regulation-what-every-state-regulator-needs-to-know/?sf_action=get_results&_sft_topic=energy-resource-planning+integrated-resource-planning)

- LBNL – Resources on Integrated Resource Planning (https://emp.lbl.gov/projects/utility-resource-planning)

Lunch Break

Session 3 - Agenda

- Analytical approaches used to represent energy efficiency and demand response in recent electric utility Integrated Resource Plans
  - Summary of Survey of Recent Utility IRPS
  - Policy Context Driving Consideration of EE and DR
  - How EE and DR Resources are characterized
  - Treatment in Load Forecast
  - Treatment in Resource Comparisons
  - Elements of Better/Best Practice

Analytical Approaches Used to Represent Energy Efficiency Resources in Recent Electric Utility Integrated Resource Plans

Prepared by

Natalie Mims

Presented by Tom Eckman

Policy Background

Policy	Utility and State			
	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority (TN, AL, MS, VA, NC, GA, KY)	PacifiCorp (CA, OR, UT, WA, ID, WY)
Energy efficiency resource standard or target	No	1.5% annual savings (as percent of retail sales)	No	CA: Acquire 2,864 GWh in 2016; must pursue EE as first resource OR: Energy Trust of Oregon Strategic Plan set goal of 240 average MW of electric efficiency over five years UT: Non-binding energy savings goals of 1% per year WA: RPS requires utility to pursue all cost-effective EE, using methodology consistent with Northwest Power and Conservation Council
IRP require-ments	Yes	Yes (see RAP paper for citation)	Yes (see Berkeley Lab paper for citation)	CA: IRP rulemaking underway OR, UT, WA: Yes (see RAP paper for citations)
Renewable portfolio standard	Voluntary goal of 10% by 2025 (baseline year 2010)	25% of electric generation from renewable energy by 2025	NC: 12.5% by 2021 VA: Goal of 15% by 2025	CA: 40% by 2024; 50% by 2030 OR: 27% by 2025; 50% by 2040 WA: 15% by 2020 UT: Goal of 20% by 2025
Greenhouse gas reduction goal	No	30% reduction by 2025	Federal requirement (by Exec. Order) that was included in 2015 IRP	CA: 40% reduction from 1990 baseline by 2030 OR: 75% reduction from 1990 baseline by 2050 WA: 1990 levels by 2020

IRP Characteristics

Characteristics	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
Most recent IRP released	2015	2016	2015	2017
20-year IRP planning period	Yes	Yes	Yes	Yes
Stakeholder engagement requirement	Yes, state regulation	Yes, Commission order	Yes, Federal law	Yes, commission order (OR, UT)
Model used for demand side resources	PLEXOS	Strategist	System Optimizer	System Optimizer

Stakeholder Engagement

- I&M is required to include consideration of stakeholder input in developing the IRP.
- One of TVA's IRP objectives was to "integrate stakeholder perspectives throughout the study." In the 2015 IRP, TVA created an overarching IRP working group, and subgroups to focus on energy efficiency and renewable energy. Public meetings and working group meetings were held throughout the IRP process.
- The Minnesota Commission continues to required Xcel Energy to share information with stakeholders via order in IRP proceedings.
- Oregon and Utah require IRP stakeholder engagement.
    - Oregon Public Utility Commission Order 89-507 and Order 07-002 (see Guideline 2: Procedural Requirements; Utah Report and Order in Docket No. 90-2035-01 (1992) created public participation requirements in IRP
    - During 2017 IRP cycle, PacifiCorp held public meetings in of the five states it operates in, and seven general meetings to discuss the development of the IRP.

Energy Efficiency Potential Studies

Criteria	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
Potential identified	Technical, economic, achievable and high achievable potential	Technical, economic, net economic, high achievable, mid achievable and low achievable potential	Technical, economic, high achievable and low achievable potential	Technical and achievable technical potential
Potential used in IRP	Achievable and high achievable potential	High, mid and low achievable potential	Used potential study to craft DSM programs which are basis of IRP efficiency	Achievable technical potential

- Energy efficiency potential studies are used by all four entities to identify the amount of future efficiency that is available to be used in the IRP process.
- Energy efficiency potential studies, like all forecasts about the future, may not account for all energy efficiency that will be available over the 20 year IRP planning period due to the emergence of new technology.
- Some of the concern about accounting for all available efficiency can be mitigated if IRPs are updated on regular cycles and generating resources with shorter lead time are used
- Energy efficiency potential studies not only provide essential input into IRPs but their results serve as a guide to energy efficiency program administrators regarding where to focus their implementation efforts.

Load Forecast

Criteria	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
Load forecasting method	Econometric, statistically adjusted end-use, and analyses of time series data	Econometric	Econometric	Econometric, except for residential sector where statistically adjusted end-use model is used
Load forecast scenarios	Three scenarios: Low-case, base-case and high-case forecasts of summer and winter peak demands and total internal energy requirements	Three sensitivities: Based, high and low load sensitivities	Three scenarios: Highest growth (1.1% energy growth); current outlook (1.0% energy growth); and lowest growth (0% energy growth)	Six scenarios: 1-in-20 weather; high, base case, and low case; high and low private generation

- Load forecast scenarios are important because they provide alternative views of future electric needs
- At minimum, it is useful to look at low, mid and high growth scenarios

Load Forecast and Resource Analysis

Criteria	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
DSM load shapes	Mentioned but not discussed in IRP; "I&M system load shapes can vary from those load shapes used to estimate DSM program demand savings."	Little mention and no discussion; "Collect and calculate historical and current effects of DSM on observed sales"	Mentioned but not discussed in IRP; "[EE] Blocks are a blend of measures with different lifespans and each with a different underlying load shape."	Mentioned in IRP, but not discussed; "Attributes specific to demand-side supply curves include: the hourly load shape of the resource."

- DSM load shapes provide information on energy (kWh) and demand (kW) reductions. Depending on how DSM is integrated into the IRP, inaccurate load shapes can
  - (1) improperly increase or decrease a utility's energy and peak demand forecast,
  - (2) result in the under/over selection of DSM resources by a capacity expansion model and/or,
  - (3) under or over estimate the cost-effectiveness of DSM resources.

Integrating DSM into the IRP

Criteria	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
Integrating DSM into IRP	Load forecast adjustment for current programs and DSM supply curves can be selected by the planning model for future resources	Load forecast adjustment	Load forecast adjustment through 2018 and DSM supply curves can be selected by the planning model	DSM supply curves can be selected by the planning model
	◕	◑	◕	●

- I&M modeled all existing programs as a load forecast adjustment, then created DSM supply curves for incremental energy efficiency and allows the IRP model to select the supply curves as a resource.
- TVA forced its IRP model to put in a prescribed amount of energy efficiency until 2018 and then allowed the model to select DSM supply curves as a resource.
- Xcel Energy reduces load forecast for historical DSM, all planned DSM, and impact of codes and standards. In 2015/2016 IRP, exogenous changes were made to forecast to address lighting impacts from codes and standards.
- PacifiCorp does not account for existing or new energy efficiency measures in load forecast, but does account for class 3 DSM (e.g., TOU rates). Existing and new energy efficiency is used to create supply curves, which are then available to the IRP model as a resource.

DSM Supply Curves

Criteria	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
Size of selectable resource	For each end-use, “achievable” and “high-achievable” potential are available. The model may select all or a portion of the bundle, but the resource is only available at one cost.	N/A	For each class, 10MW blocks are available. Cap on number of blocks that can be selected each year.	All technical potential efficiency identified is available in 27 bundles ranging from from <$10/MWh to >$1000/MWh.
	◔	○	◑	●
Load shape of selectable resource	Mentioned in IRP but not discussed; “Demand-side power plants that produce energy according to their end-use shape”	N/A	Load shape for energy efficiency blocks is weighted average of class program shape	Hourly load shape of measure used to create DSM supply curve
	◔	○	◑	●

- I&M modeled five residential end-uses (thermal shell, water heating, appliances, heating/cooling and lighting) and four commercial end-uses (heating, cooling, office equipment, and indoor lighting).
- TVA capped the amount of blocks that are available to be selected by the model each year based on what the utility thought was a reasonable growth rate. Residential, commercial and industrial classes have separate supply curves.
- PacifiCorp energy efficiency bundles are split by $10/MWh groups (e.g., <$10/MWh, $10-20/MWh, $20-30/MWh, etc).

Accounting for DSM Risk in IRP

Criteria	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
Accounting for Risk	Potential study constrains efficiency through market acceptance ratios and program implementation factors; these constraints flow into efficiency bundles	Constrained efficiency target to 1.5% of sales to address utility-identified risks	Planning adjustment factor (i.e., cost adder) to account for utility-identified risks associated with efficiency	T&D deferral credit, stochastic risk reduction credit, Northwest Power Act credit
	◔	◔	◑	●

- I&M relied on the 2014 national Electric Power Research Institute potential study to create its energy efficiency bundles, and applied the constraints identified in the potential study to the energy efficiency bundles used in the IRP.
- Xcel identified declining avoided energy and capacity costs, increasing rate impacts, increases in efficiency impacts from codes and standards, and an increase in naturally occurring conservation as risks that constrain the company from implementing more efficiency.
- TVA identified three design risks and three delivery risks for efficiency. TVA applied a 10% cost adder to its efficiency bundles to account for delivery risk in the first five years of implementation. The other risks grow over time and at the end of the IRP period, the planning adjustment factor is a 30% cost adder.
- PacifiCorp applies three credits to its energy efficiency bundles to account for the reduced risk associated with energy efficiency.

Modeling RPS in IRP

Criteria	I&M (IN)	Xcel Energy (MN)	Tennessee Valley Authority	PacifiCorp
RPS compliance level	N/A	Due to banked Renewable Energy Credits, and annually generated RECs of existing resources, Xcel does not need new renewable energy resources through 2030 to comply with RPS, including solar requirement	N/A	Renewable energy is optimized in all scenarios
Alternative levels of renewable energy	Preferred portfolio accelerates renewable energy adoption	Preferred plan adds 800 MW of wind by 2020; seven different levels of renewable energy evaluated in IRP.	Additional renewables are added into one scenario evaluated	Additional renewables are added in to comply with projected RPS requirements in certain scenarios evaluated

- Xcel did not include any new renewable resource additions in base case, but did add 3200 MW of large solar and wind to preferred plan.
- I&M preferred plan accelerates the adoption of renewable energy into the generation mix, although it is more expensive than the base case.
- PacifiCorp optimized renewable energy resources in all of the scenarios it analyzed, and the model selected enough renewable energy to meet all RPS requirements cost-effectively. Additional renewable were evaluated in scenarios for future RPS compliance.

Any Questions?

Analytical Approaches Used to Represent Demand Response Resources in Recent Electric Utility Integrated Resource Plans

Prepared by

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Presented by Tom Eckman

Policy and Regulatory Drivers for Considering Demand Response (DR) in Resource Planning

- Many utilities are obligated by state regulatory or legislative requirements to consider DR in resource planning
  - Implicitly – e.g., least-cost planning requirement
  - Explicitly – e.g., consider all cost-effective demand-side resources
- FERC Order 1000 established the consideration of “non-wires alternatives” and required regional planners to consider public policy goals
- DR may be cost-effective resource to integrate the variability and declining capacity value of distributed generation

Use of Demand Response Is Increasing

RTO/ISO	2014 Potential Peak Reduction (MW)	2014 Percent of Peak Demand [8]	2015 Potential Peak Reduction (MW)	2015 Percent of Peak Demand [8]
California ISO (CAISO)	2,316 [1]	5.1%	2,160 [9]	4.4%
Electric Reliability Council of Texas (ERCOT)	2,100 [2]	3.2%	2,100 [10]	3.0%
ISO New England, Inc. (ISO-NE)	2,487 [3]	10.2%	2,696 [11]	11.0%
Midcontinent Independent System Operator (MISO)	10,356 [4]	9.0%	10,563 [12]	8.8 %
New York Independent System Operator (NYISO)	1,211 [5]	4.1%	1,325 [13]	4.3%
PJM Interconnection, LLC (PJM)	10,416 [6]	7.4%	12,910 [14]	9.0%
Southwest Power Pool, Inc. (SPP)	48 [7]	0.1%	0 [15]	0%
Total ISO/RTO	**28,934**	**6.2%**	**31,754**	**6.6%**

- Potential peak demand reduction from DR in ISO/RTO regions increased 10% from 2014 to 2015 and outpacing demand growth of 4% over the same time period
- MISO region has one of largest DR potentials

Source: FERC (2016). Assessment of demand response and advanced metering. Available at: https://www.ferc.gov/industries/electric/indus-act/demand-response.asp

Treatment of DR in Recent Utility IRPs

- Reviewed 25 electric utility integrated resource plans (IRPs)
- Identified whether and how DR was accounted for in load forecast and resource portfolios

Utility	State	Year IRP published
Green Mountain Power	VT	2014
Eversource	NH	2015
Liberty Utilities	NH	2016
Unitil	NH	2016
Delmarva	DE	2016
Kentucky Power Company (AEP)	KY	2016
East Kentucky Power Coop	KY	2015
Duke Energy Kentucky	KY	2014
Big Rivers	KY	2014
Louisville Gas and Electric	KY	2014
Public Service Colorado	CO	2016
Indianapolis Power and Light	IN	2016
Vectren	IN	2016
NIPSCO	IN	2016
I&M (AEP)	IN	2015
Duke Energy Indiana	IN	2015
Xcel Minnesota	MN	2015/2016
Idaho Power	ID	2015
El Paso Electric	NM	2015
PNM	NM	2014
Sierra Pacific Power	NV	2016
Nevada Power	NV	2015
Arizona Public Service	AZ	2017
Entergy Arkansas	AR	2015
PacifiCorp	CA, WA, OR, ID, WY, & UT	2017

Observations from Review of Recent IRPs

- Approaches to construct portfolio of DR programs varies widely among utilities

DR resources are not incorporated or assumed in resource plan (or IRP is unclear about approach)

(5 out of 25)

Green Mountain Power, El Paso Electric, Sierra Pacific Power, Entergy Arkansas, and Big Rivers

Existing DR resources accounted for in IRP in load forecast and/or loads and resources table

(11 out of 25)

Eversource, Liberty Utilities, Unitil, Delmarva, East Kentucky Power Coop, Duke Energy Kentucky, Louisville Gas & Electric, Public Service Colorado, Indiana Michigan Power, Duke Energy Indiana, Public Service New Mexico

IRP considers potential incremental DR resources

(9 out of 25)

Kentucky Power, Indianapolis Power & Light, Vectren, NIPSCO, Xcel Minnesota, Idaho Power, Nevada Power, Arizona Public Service, and PacifiCorp

- Utilities typically assumed amount of DR based on what was approved in most recent DR or DSM program filings
- Seven (7) of the 25 utilities considered incremental DR in the resource optimization allowing DR to “compete” against supply-side resources

Two Common Approaches Are Used to Analyze DR Resources in IRPs

DR as a peak load reduction

- DR resources are assumed at 100% capacity and deducted from resource plan forecasts
- Assumes DR resources are perfectly coincident with utility annual peak and does not capture patterns in DR resource availability

DR competing against supply-side resources

- Supply curves of DR resources compete with supply-side resources
- DR resources are used by LSEs in a different manner than supply-side resources and subject to program rules limiting their operations

Examples of Better DR Analysis Practice
Kentucky Power Company (KY)

IRP forecast period	15 years (2017 to 2031)
How was existing DR accounted for?	Included load forecast and loads and resources table
How was incremental DR considered?	Blocks of DR were represented and model was allowed to select up to four blocks of each DR resource type in any year
What types of DR were modeled?	Residential and commercial direct load control (A/C)
What resource characteristics of DR were captured?	Annual demand and energy savings, upfront installation cost, and annual administrative and incentive costs (values derived from DSM potential study)

Table 16. Incremental Demand Response (DR) Resource Blocks

Sector	Participants	Demand Savings (kW)	Energy Savings (kWh)	Installation Cost	Annual Cost	Total First Year Cost
Residential	495	445	19,780	$ 152,471	$ 43,351	$ 195,822
Commercial	112	101	9,815	$ 35,223	$ 9,983	$ 45,206

Examples of Better DR Analysis Practice
Indianapolis Power and Light (IN)

IRP forecast period	20 years (2017 to 2036)
How was existing DR accounted for?	Historic savings from DSM programs were embedded in load forecast
How was incremental DR considered?	DR for 2017 based on approved DSM plan and DR for 2018 to 2036 was modeled via six "program input bundles" with two distinct periods of installation (2018-2020 and 2021-2036) Not all blocks were cost-effective in DSM potential study but considered for strategic reasons
What types of DR were modeled?	Residential and commercial direct load control (A/C, water heater, space heating, smart appliances, electric vehicle charging, and smart thermostats), residential and commercial & industrial (C&I) battery energy storage, and C&I load curtailment
What resource characteristics of DR were captured?	Installed cost, hourly load shape, ramp rate, and timing for implementation

Examples of Better DR Analysis Practice

NIPSCO (IN)

IRP forecast period	20 years (2017 to 2036)
How was existing DR accounted for?	Historic savings from DSM programs were embedded in load forecast
How was incremental DR considered?	Six DR program types were screened for cost-effectiveness and grouped into four DR programs for modeling
What types of DR were modeled?	Residential and small/medium commercial direct load control (A/C and water heater), large C&I interruptible tariffs (with and without 3rd party aggregator)
What resource characteristics of DR were captured?	Hourly savings (converted into "typical week" for modeling parameters) and measure cost

Examples of Better DR Analysis Practice
PacifiCorp (CA, WA, OR, ID, WY, & UT)

IRP forecast period	20 years (2017 to 2036)
How was existing DR accounted for?	Existing load control and interruptible programs included in loads and resources table as capacity resource (i.e., not decrement to annual peak demand) Historic savings from pricing programs embedded in load forecast
How was incremental DR considered?	Resource supply curve for nine DR program types
What types of DR were modeled?	Residential and commercial direct load control (A/C, water heater, space conditioning, smart thermostats, smart appliances, electric vehicle charging), C&I curtailment, irrigation load control and ice energy storage
What resource characteristics of DR were captured?	State-level peak demand impacts across summer and winter seasons, and levelized costs

Improving the Analysis of DR Resources In Integrated Resource Planning

Recognize the 'option value' of DR

- Capture the ability for DR resources to respond to extreme and highly uncertain events through probabilistic uncertainty analysis (e.g., Monte Carlo simulations)

Account for load building immediately before or after DR event periods

- Capture the hourly impacts of DR before/after DR event

Assess the optimal dispatch of the DR portfolio

- Identify more 'flexible' dispatch approaches

Account for the geographical distribution of DR participants

- Address transmission- and distribution-level reliability

Account for the relationship between incentives and participation

- Capture the correlation between DR program participation and incentive levels

Improving the Analysis of DR Resources In Integrated Resource Planning

Account for the operational constraints of DR resources

- Capacity value of DR can be limited by tariff rules on maximum hours of dispatch per event and maximum events per year

Account for potential environmental impacts

- DR resources can defer highly inefficient fossil fuel generation and integrate renewable energy resources

Consider other 'hard-to-quantify' benefits of DR

- DR can provide system and customer benefits when compared to other resource options (e.g., improved post-outage restoration)

Takeaways and Considerations

Understand the limitations of planning models

- Consider the important characteristics of DR program types that should be represented in IRPs (e.g., minimum dispatch amount, dispatch over multi-hour blocks, dispatch during high load vs high price events)

Identify disparate processes for screening DR and resource planning

- Consider whether only DR deemed cost-effective in program filings should be included in resource plans or whether IRP process will be used to identify additional DR resources
- Also consider any misalignment of factors taken into account when screening DR vs. resource planning (e.g., scenario analysis in resource planning but no sc, environmental benefits)

Resource planning context is key

- Consider whether DR resources may be able to meet utility operational needs and requirements beyond what is considered in IRP

Resources

- Berkeley Lab Resource Planning Practices and Trends webpage, with links to over 20 years of research on resource planning
- Indiana Utility Regulatory Commission Electricity Division's IRP Contemporary Issues Technical Conferences. Current and past year's agendas and presentations here: http://www.in.gov/iurc/2340.htm
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Any Questions?