LEAST-COST PLANNING FOR 21ST CENTURY ELECTRICITY SUPPLY

MARK COOPER,
SENIOR FELLOW FOR ECONOMIC ANALYSIS
INSTITUTE FOR ENERGY AND THE ENVIRONMENT, VERMONT LAW SCHOOL
SENIOR ADJUNCT FELLOW,
SILICON FLATIRONS, UNIVERSITY OF COLORADO

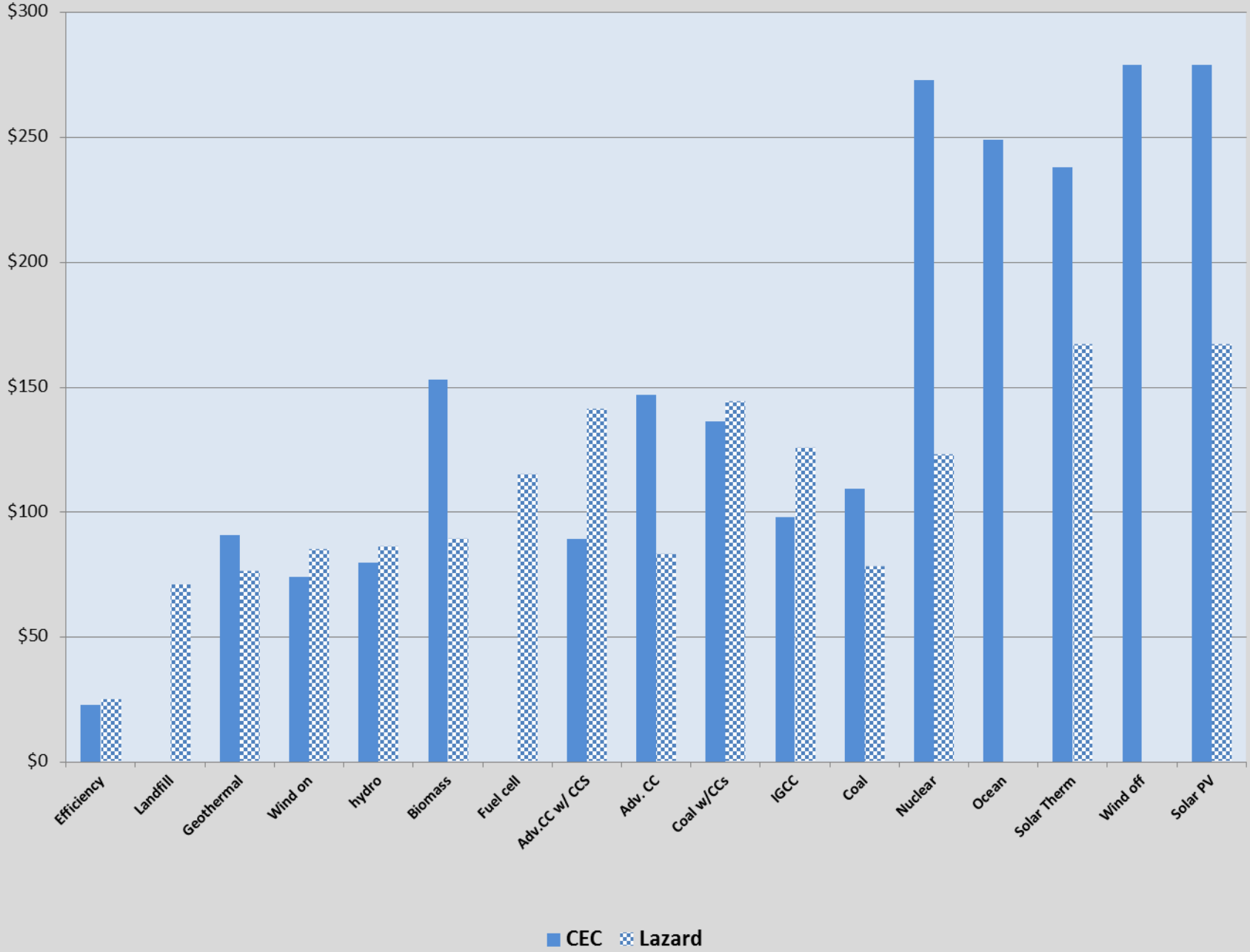
COMMISSIONER INFORMATION MEETING
COLORADO PUBLIC UTILITY COMMISSION
AUGUST 23, 2011

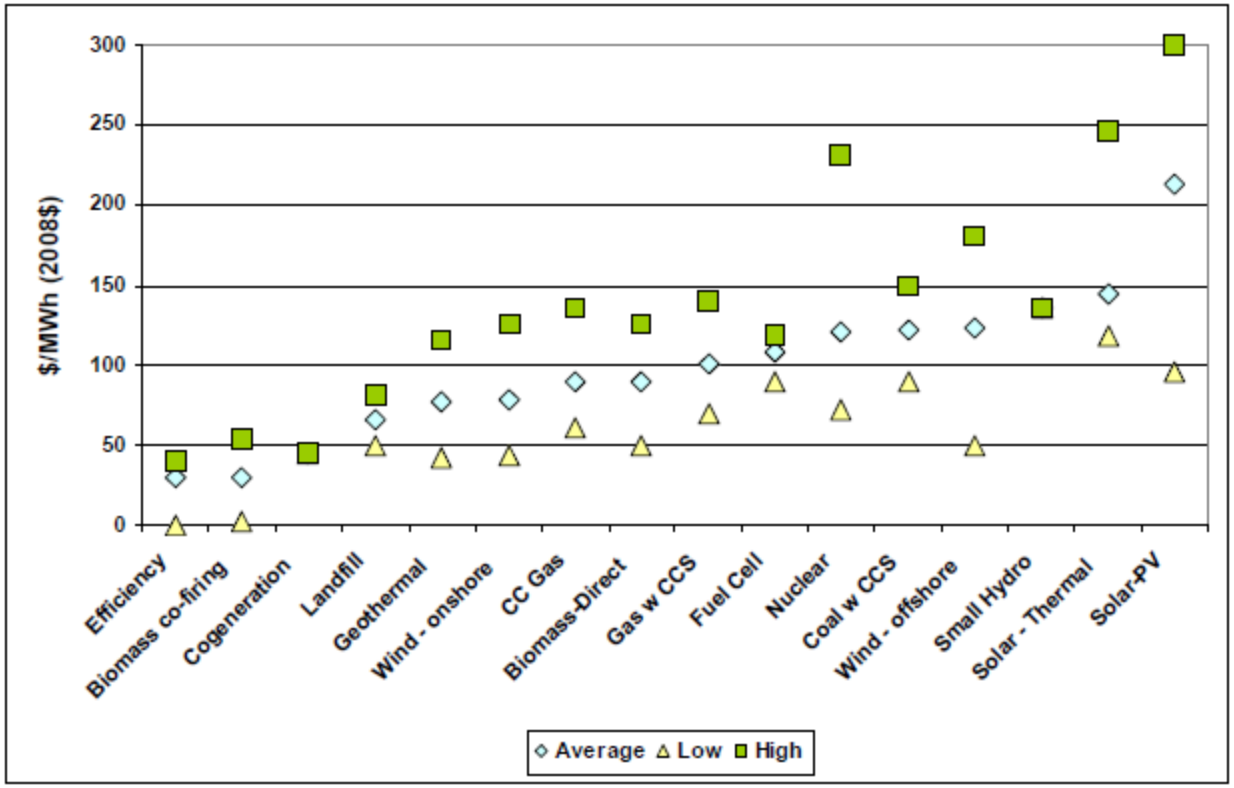
OUTLINE

- Resource Supply Curves
- Adapting Prudence to the 21 century
- The Four Regions of Knowledge
- A Road Map to the Future

$2009/MWH

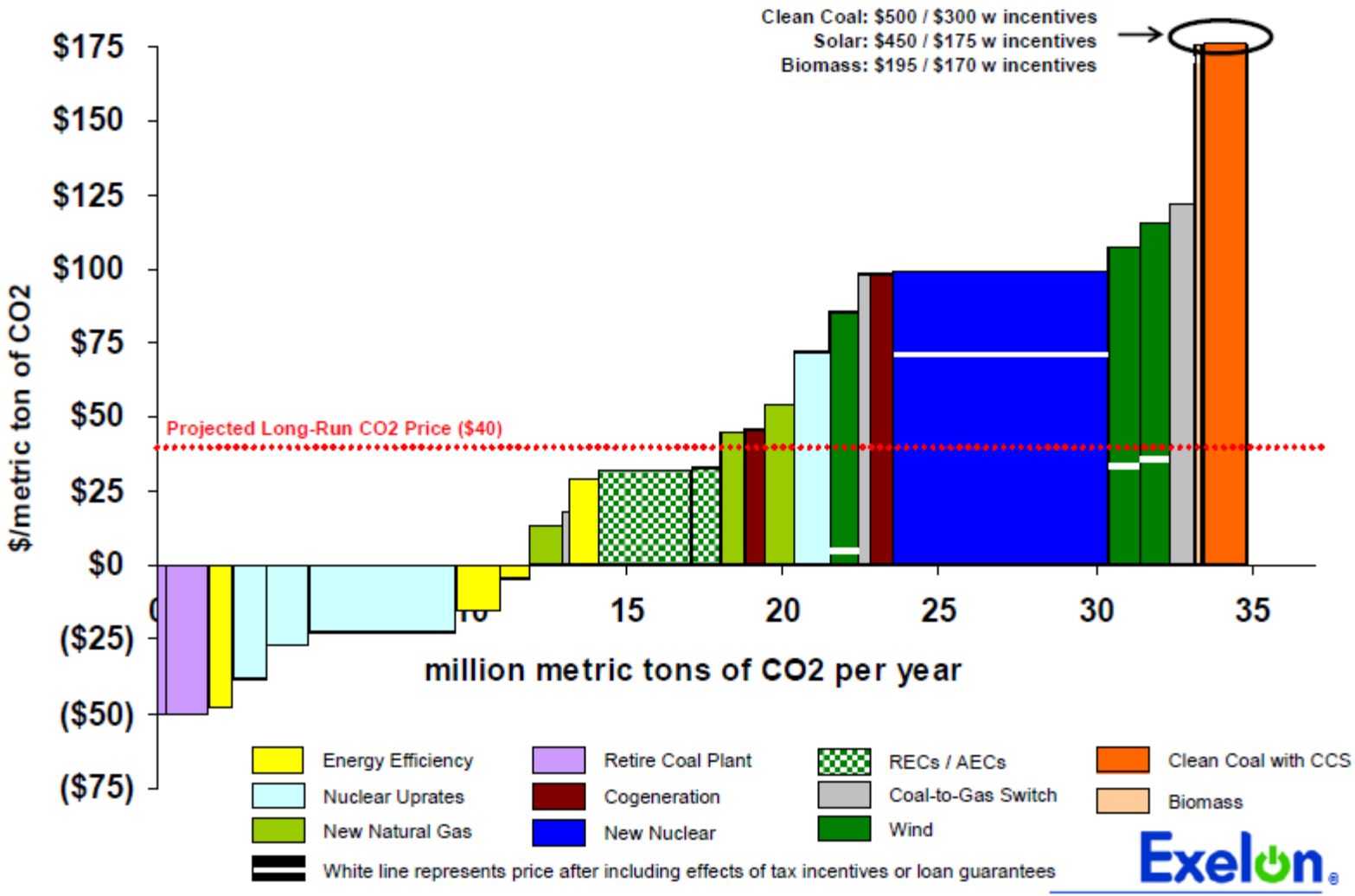
LEVELIZED COST OF ENERGY



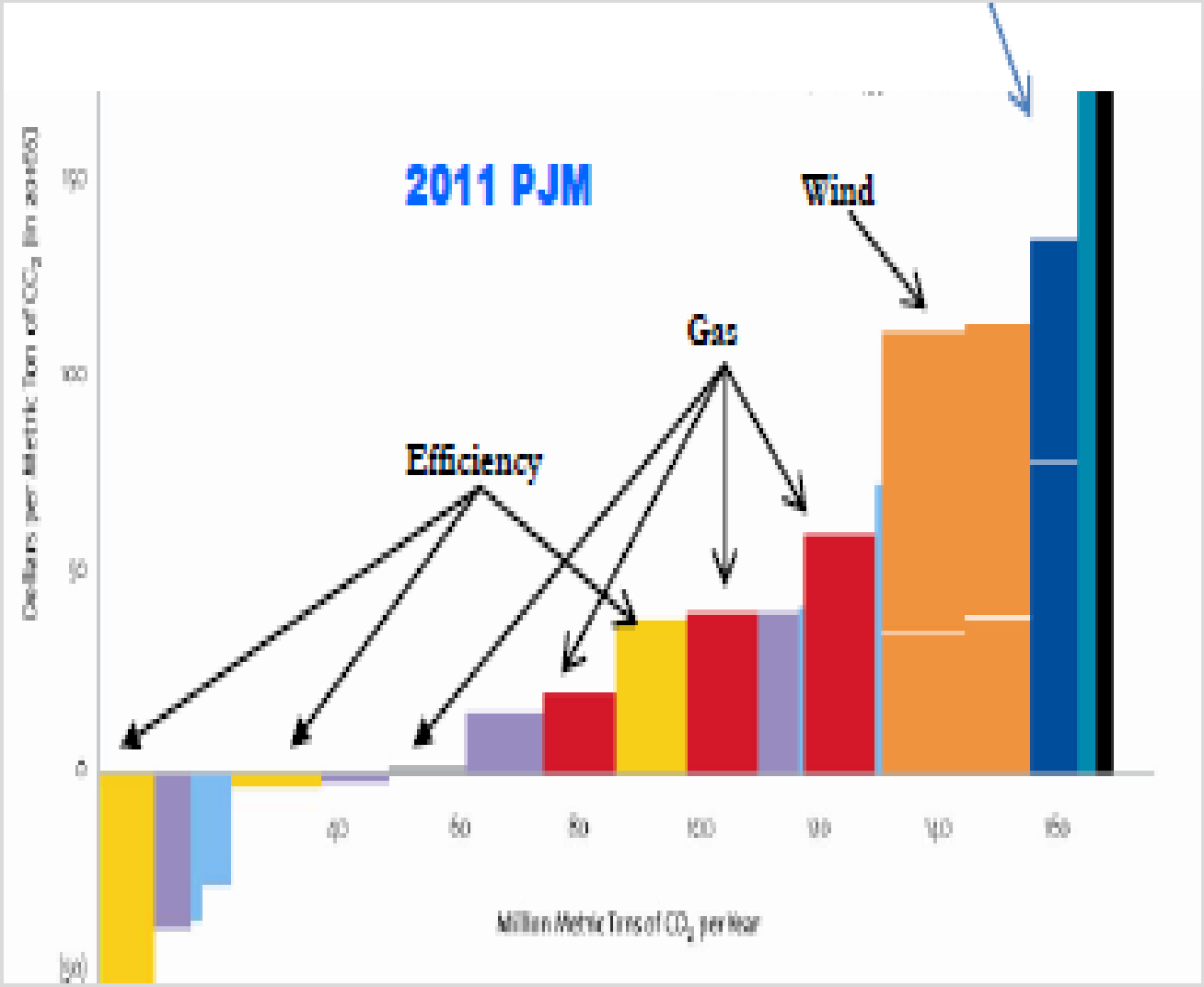


Sources: Congressional Budget Office, *Nuclear Power's Role in Generating Electricity*, May 2008, p.13; Stan Kaplan, *Power Plants: Characteristics and Costs,* Congressional Research Service, November 13, 2008, Appendix B; Staff draft, *Comparative Costs of California Central Station Electricity Generation Technologies Cost of Generation Model*, August 2009, p. 18; Lazard, *Levelized Cost of Energy Analysis—Version 2.0*, June 2008, p. 10; *Levelized Cost of Energy Analysis – Version 3.0,* for efficiency, onshore wind, biomass, natural gas, coal and nuclear and solar PV, as reported in World Resources Institute, *Renewable Energy Opportunities in Florida,* April 2009; Amory Lovins, and Imran Shiekh, and Alex Markevich, *Nuclear Power: Climate Fix or Folly?,* December 31, 2008, Draft, p. 2; Moody's, *New Nuclear Generating Capacity: Potential Credit Implications for U.S. Investor Owned Utilities*, May 2008, p. 15; National Research Council of the National Academies, *America's Energy Future: Technology and Transformation, Summary Edition*, 2009, p. 58; Renewable Energy Policy Network for the 21st Century, *Renewables 2007: Global Status Report*, 2008; Standard & Poor's, *Assessing the Credit Risk of Competing Technologies for New U.S. Nuclear Power Plants*, August 13, 2008, p. 11.

Exelon's View of Carbon Abatement Options – 2010



Exelon®


2011 PJM
Wind
Gas
Efficiency

- In the current environment the core principles of prudency and least cost planning should be reaffirmed, but a prudent, integrated resource plan must
- be hedged against **risk,**
- maximize options to reduce **uncertainty,**
- be flexible with respect to outcomes that are, at best, **vague** and
- be insulated against **ignorance** of the unknown

AMBIGUITY AND THE REGIONS OF KNOWLEDGE

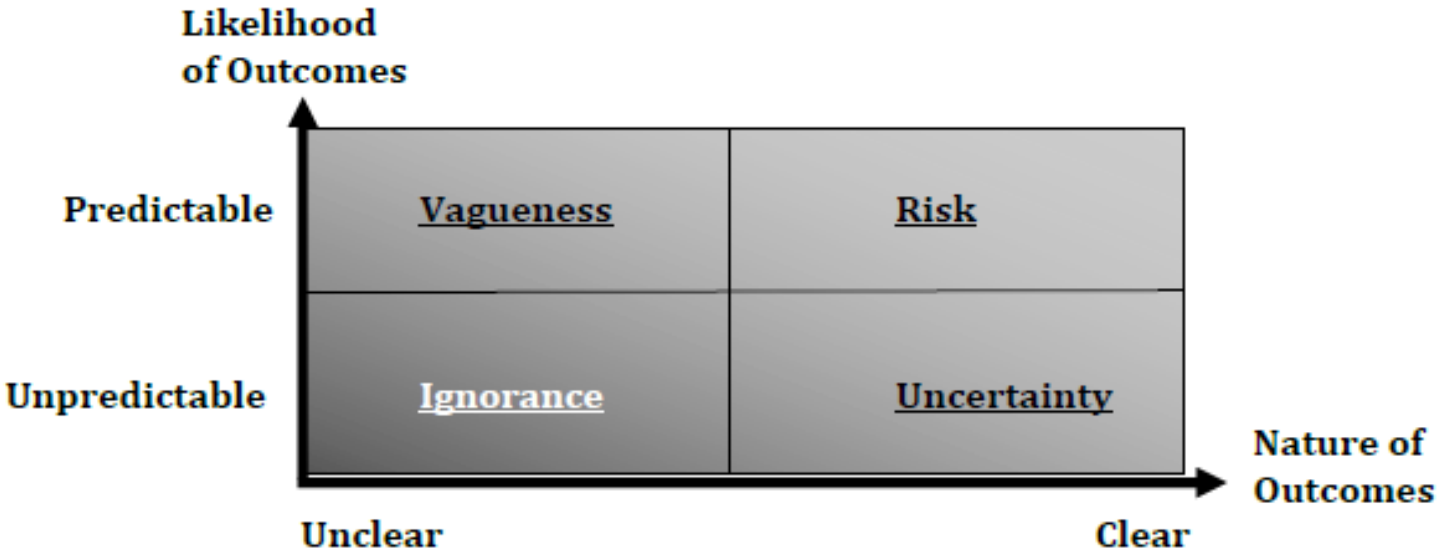


EXHIBIT ES-1: TOPOGRAPHY AND NAVIGATION TOOLS FOR THE REGIONS OF KNOWLEDGE

	REGIONS			
	IGNORANCE	VAGUENESS	UNCERTAINTY	RISK
TOPOGRAPHY				
Knowledge of				
Outcomes	Poorly defined	Poorly defined	Well defined	Well defined
Probabilities	Unknown	Known	Unknown	Known
Challenges	Unanticipated Effects	Contested Framing	Nonlinear Systems	Familiar systems
Conditions	*Black Swans*	*Sort of Safe*	*Safe*	*Extremely safe with (mild randomness)*
Distributions	*Fat tailed*	*Thin tailed*	*Fat tailed*	*Thin tailed*
Payoffs	*Complex*	*Complex*	*Simple*	*Simple*
CHARACTERIZATIONS				
Modern	Unknown/ Unknowns	Unknown/ knowns	Known/ unknowns	Known/knowns
Greek Mythology	Pandora, Pythia	Damocles, Cassandra	Cyclops	Medusa
Catholic	Hell	Limbo	Purgatory	Reality
ANALYSIS				
Approach	Multi-criteria analysis	Fuzzy Logic	Decision Heuristics	Statistics
Tools	Diversity assessment	Sensitivity analysis	Scenario analysis	Portfolio evaluation
POLICY TOOLS				
Instruments Rules	Insurance/ diversity	Monitor & Adjust	Optionality	Hedging
	TECHNOLOGY RISK ANALYSIS Precaution Buy insurance for system survival Accept non-optimization Diversity Variety Balance Disparity	***BLACK SWAN THEORY*** *Truncate Exposure* *Buy insurance for system survival* *Accept non-optimization* *Redundancy* *Numerical* *Functional* *Adaptive*	**TECHNOLOGY RISK ANALYSIS** Resilience Adaptability ***BLACK SWAN THEORY*** *Multi-functionality* *What Works*	**TECHNOLOGY RISK ANALYSIS** Flexibility Across Time Across Space ***BLACK SWAN THEORY*** *Optionality*	**TECHNOLOGY RISK ANALYSIS** Resilience Robustness Hedge ***BLACK SWAN THEORY*** *Robust to Error* *Small, Confined, Early Mistakes* *Incentive & disincentives* *Avoid Moral Hazard* *Hedge*

Sources: Nassim Nicholas Taleb, *The Black Swan* (New York: Random House, 2010), p.365; Andrew Stirling, *On Science and Precaution in the Management of Technological Risk* (European Science and Technology Observatory, May 1999), p. 17, *On the Economics and Analysis of Diversity* (Science Policy Research Unit, University of Sussex, 2000), Chapter 2; "Risk, Precaution and Science; Toward a More Constructive Policy Debate," *EMBO Reports*, 8:4, 2007.

PRACTICAL ADVICE

1. Identify the trade-offs between cost and risk and lower risk through hedging.
2. Reduce exposure to uncertainty by buying time.
3. Keep options open by acquiring small assets that can be added quickly.
4. Minimize surprises by avoiding assets that have unknown or uncontrollable effects.
5. Create systems that monitor conditions and can adapt to change to maintain system performance.
6. Build resilience with diversified assets by increasing variety, creating balance, and adding disparity.
7. Buy insurance where possible and recognize that diversity is the best insurance against ignorance.

LIFELONG FINANCIAL STRATEGIES TIP SHEET

TIP #1: Seek assistance from a CERTIFIED FINANCIAL PLANNER

TIP #2: Buy long-term care insurance now, when it's less expensive

TIP #3: Have and follow an investment roadmap

TIP #4: Diversify your assets

TIP #5: Prepare properly for the years to come

LONG TERM FINANCIAL PLANNING: SECURING YOUR FINANCIAL FUTURE

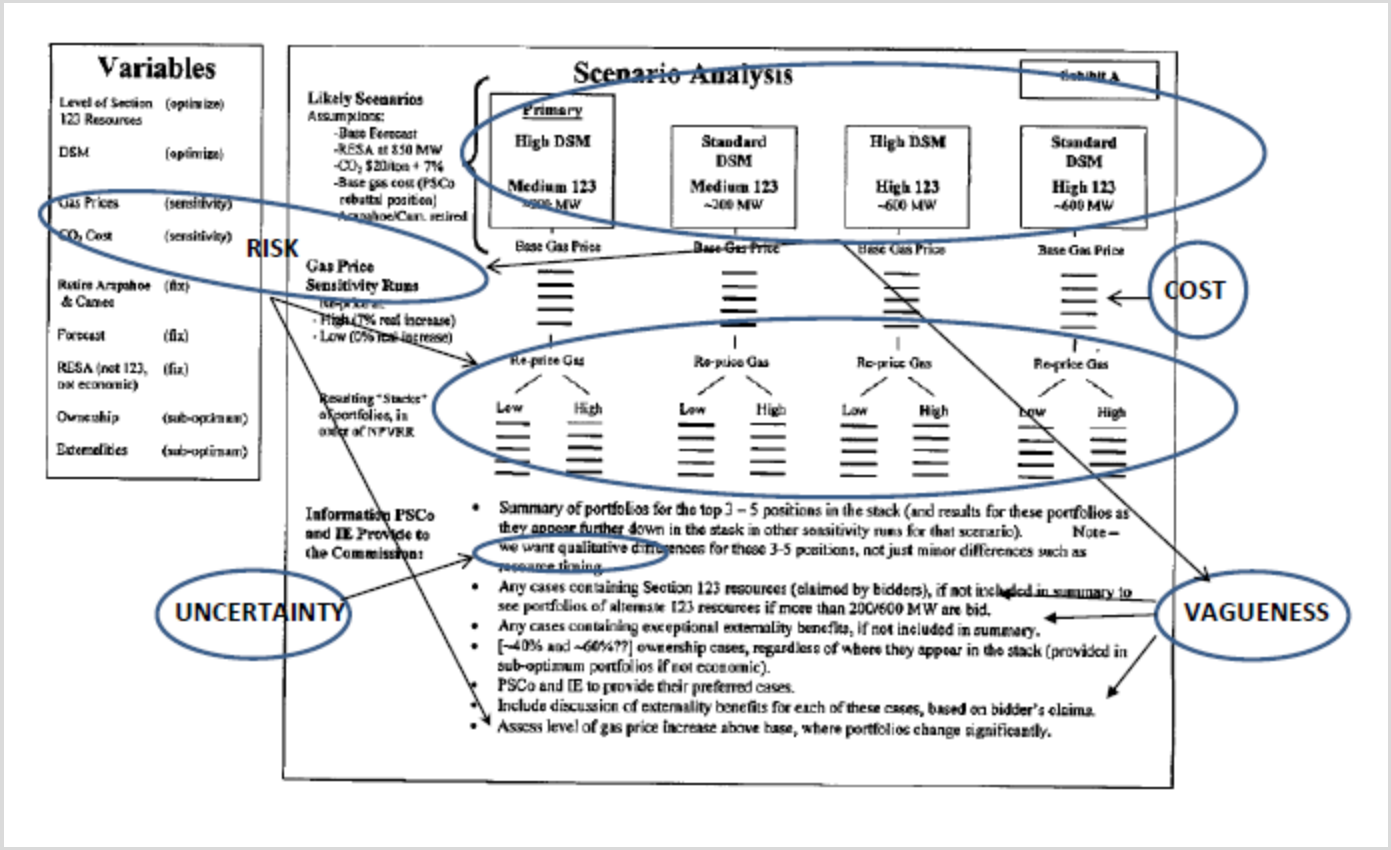
What concepts do I need to understand to make sure the money I invest continues to grow?

Why is "risk" an important concept to investors?

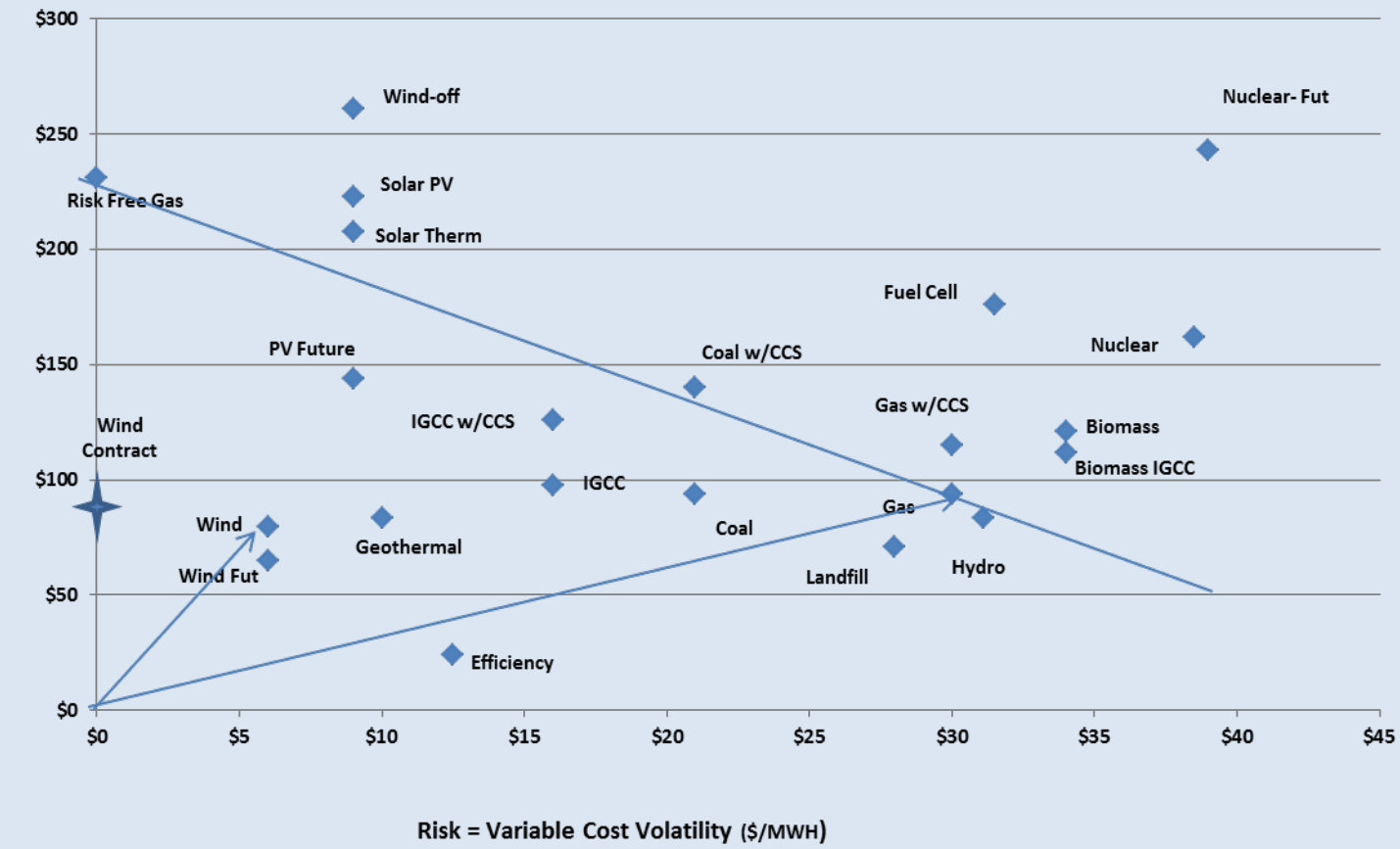
What is meant by "diversification"?

"Volatility" is a term that I have heard used, but what is it?

Why is insurance important and how do I determine whether I need it?

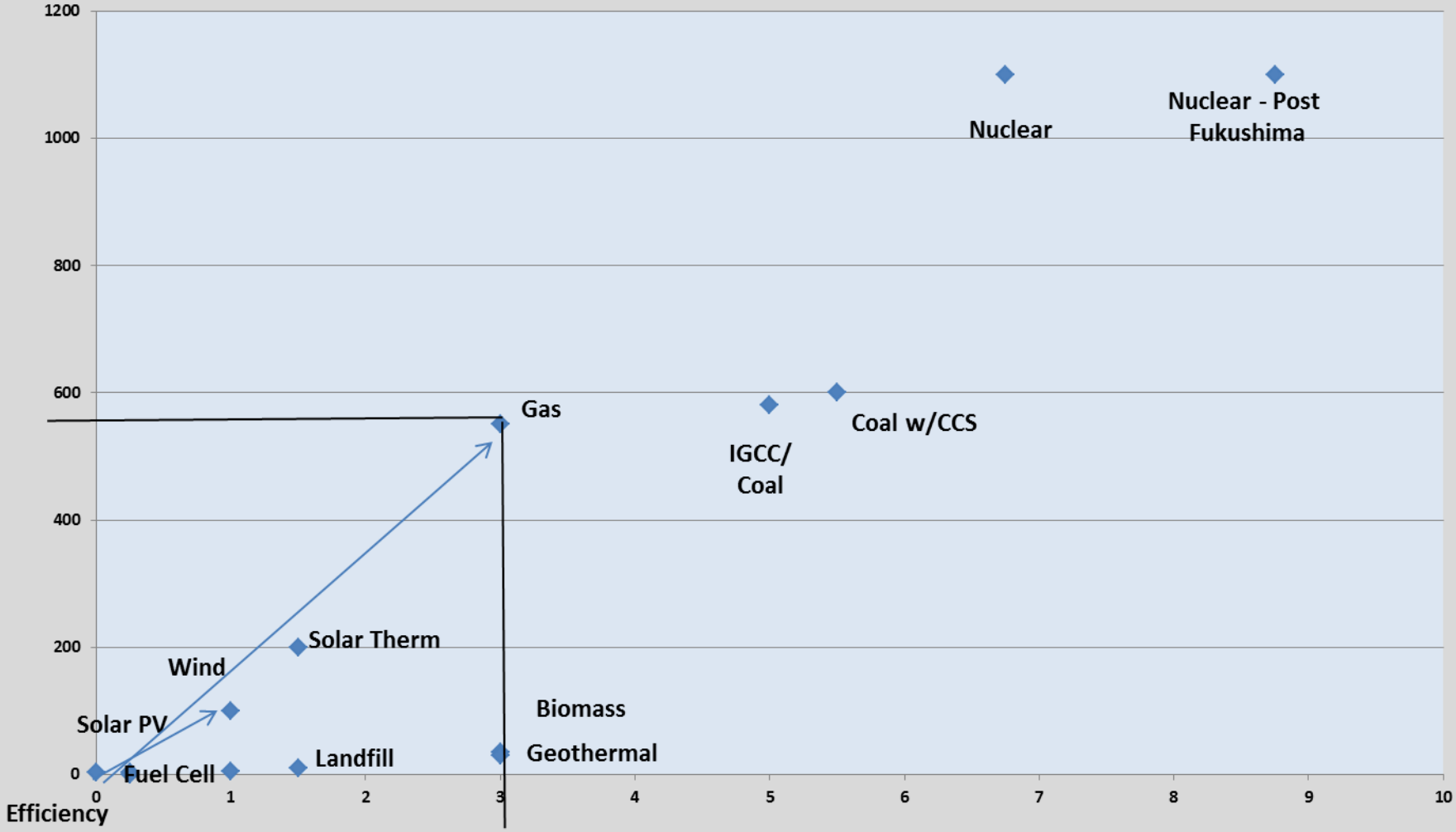

Variables
Level of Section 123 Resources (optimize)
DSM (optimize)
Gas Prices (sensitivity)
CO_2 Cost (sensitivity)
Retire Arapahoe & Cameo (fix)
Forecast (fix)
RESA (not 123, not economic) (fix)
Ownership (sub-optimum)
Externalities (sub-optimum)
Scenario Analysis
Exhibit A
Likely Scenarios
Assumptions:
-Base Forecast
-RESA at 850 MW
-CO_2 $20/ton + 7%
-Base gas cost (PSCo rebuttal position)
Arapahoe/Cam. retired
Primary
High DSM
Medium 123
~200 MW
Standard DSM
Medium 123
~200 MW
High DSM
High 123
~600 MW
Standard DSM
High 123
~600 MW
Base Gas Price
Base Gas Price
Base Gas Price
Base Gas Price
RISK
Gas Price Sensitivity Runs
Re-price as:
- High (7% real increase)
- Low (0% real increase)
COST
Re-price Gas
Re-price Gas
Re-price Gas
Re-price Gas
Low
High
Low
High
Low
High
Low
High
Resulting "Stacks" of portfolios, in order of NPVRR
Information PSCo and IE Provide to the Commission:
UNCERTAINTY
VAGUENESS
Summary of portfolios for the top 3 – 5 positions in the stack (and results for these portfolios as they appear further down in the stack in other sensitivity runs for that scenario). Note – we want qualitative differences for these 3-5 positions, not just minor differences such as resource timing.
Any cases containing Section 123 resources (claimed by bidders), if not included in summary to see portfolios of alternate 123 resources if more than 200/600 MW are bid.
Any cases containing exceptional externality benefits, if not included in summary.
[~40% and ~60%??] ownership cases, regardless of where they appear in the stack (provided in sub-optimum portfolios if not economic).
PSCo and IE to provide their preferred cases.
Include discussion of externality benefits for each of these cases, based on bidder's claims.
Assess level of gas price increase above base, where portfolios change significantly.

Risk Analysis:
Avg. CEC/Lazard 2010 cost, Lazard risk



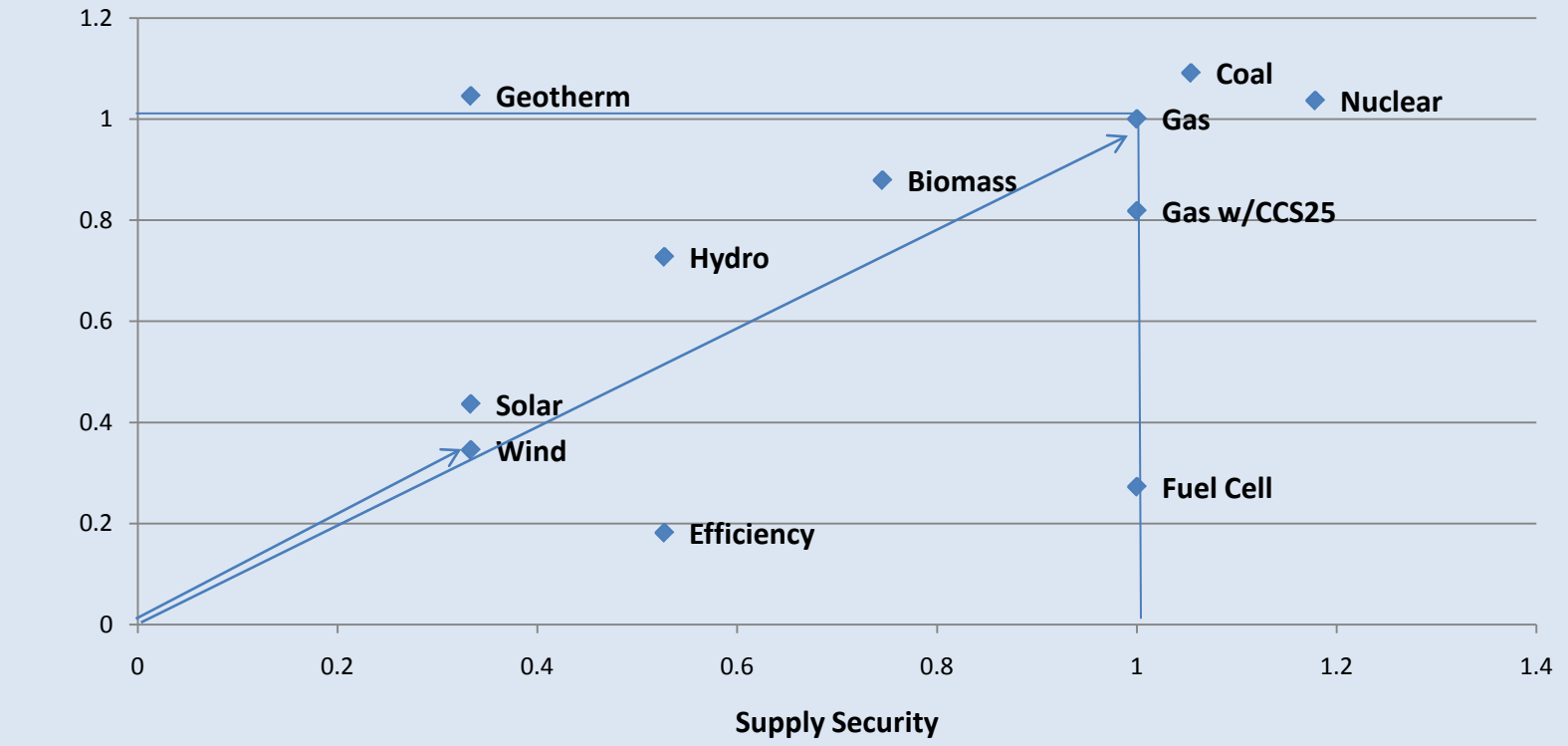
EXPOSURE TO UNCERTAINTY: LAZARD (2009) DATA

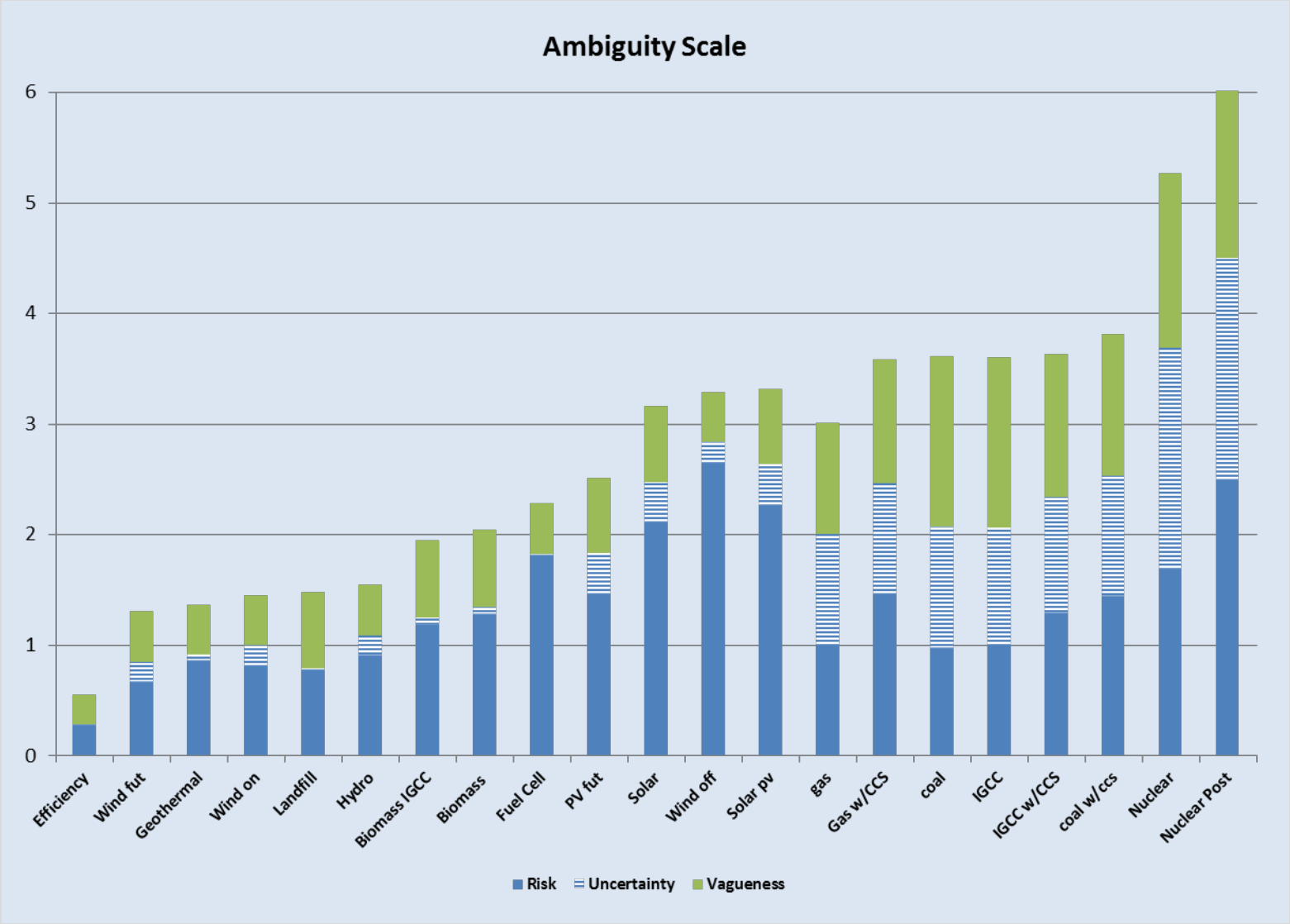
Size = MW



Duration Years = Construction Period

Vagueness: Supply Security and Environmental Impact




Ambiguity Scale
6
5
4
3
2
1
0
Efficiency
Wind fut
Geothermal
Wind on
Landfill
Hydro
Biomass IGCC
Biomass
Fuel Cell
PV fut
Solar
Wind off
Solar pv
gas
Gas w/CCS
coal
IGCC
IGCC w/CCS
coal w/ccs
Nuclear
Nuclear Post
Risk
Uncertainty
Vagueness

The Region of Ignorance

Search for Swans:

- **Consistency**
- **Unintended Consequences**
- **Additional Externalities**

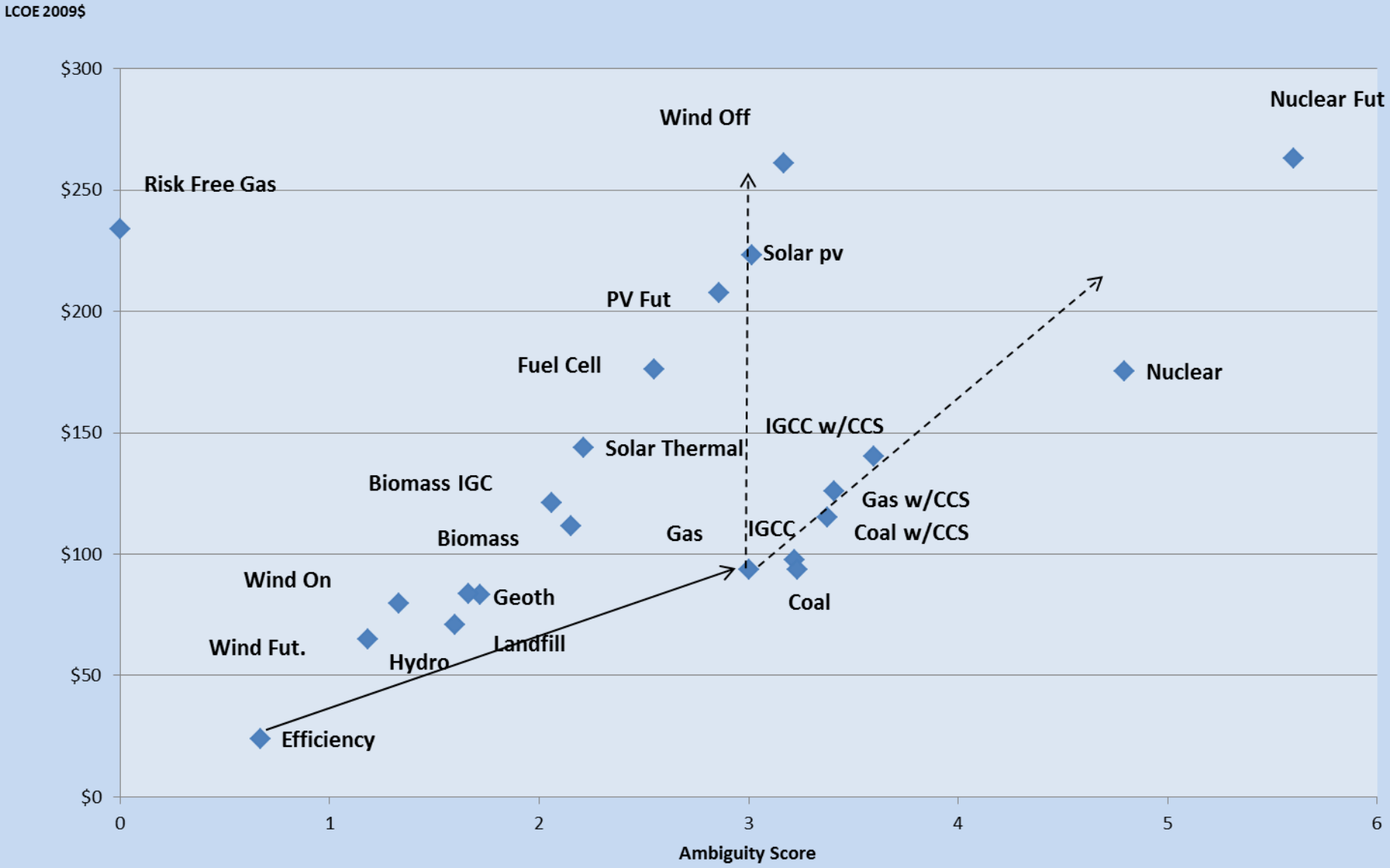
Diversity:

- **Structural - resources that are**
  - **varied,**
  - **balanced and**
  - **disparate**
- **Alternative Instruments**

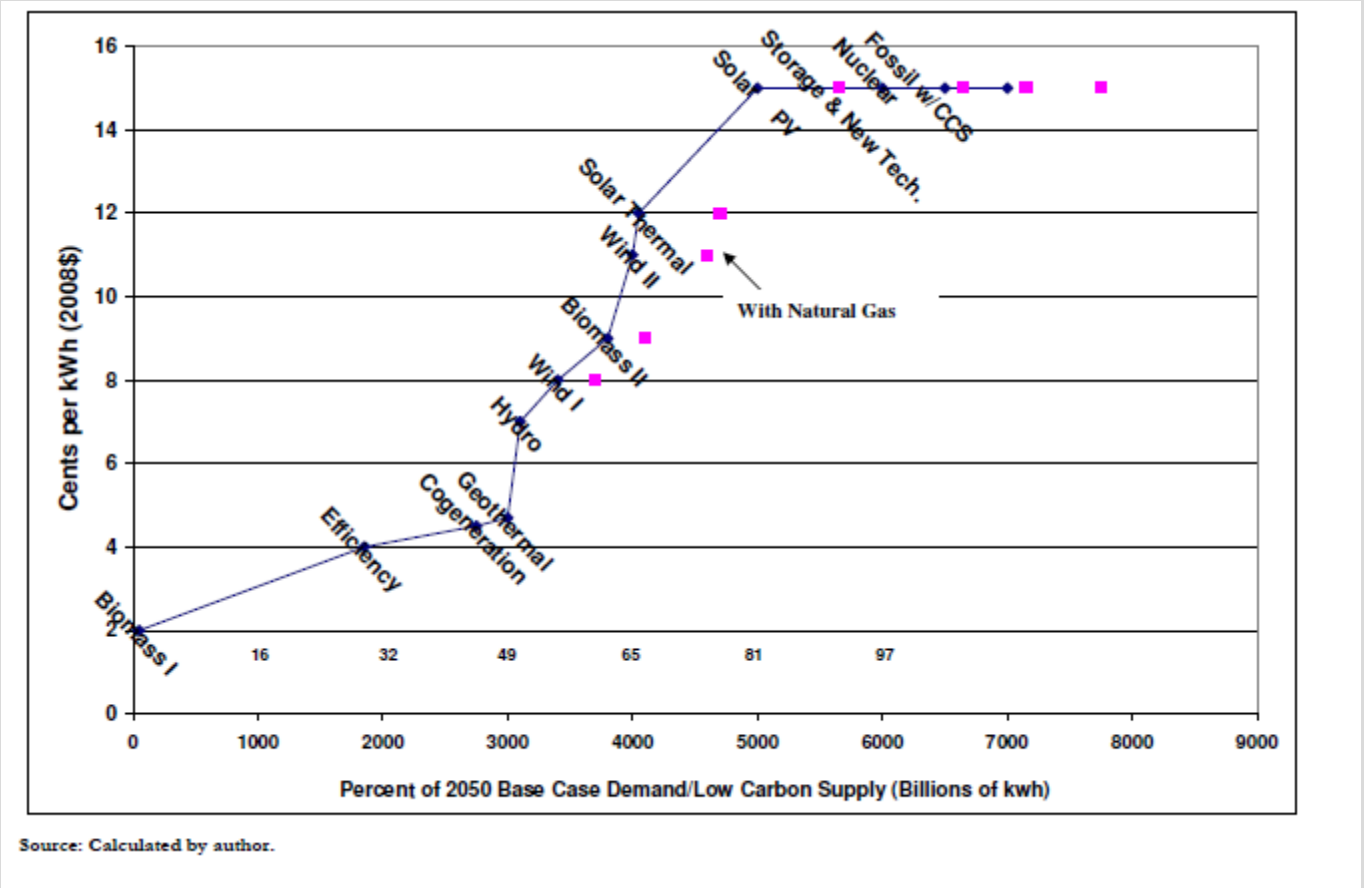
Sufficiency:

- **Adequacy**
- **Sequence**

Ambiguity and Levelized Cost: A Road Map for Resource Acquisition



SUFFICIENCY – KEEPING THE LIGHTS ON IN A LOW CARBON ENVIRONMENT



Source: Calculated by author.

MAJOR IMPLICATIONS

1. Acquisition of central station facilities, particularly nuclear, makes long-term commitments in exactly the wrong way for the current decision making environment.
2. The dash to gas that is developing is being significantly overdone because it exposes ratepayers to volatility risks and unnecessary uncertainty.
3. A balanced approach that begins with a great deal more efficiency and locally abundant renewables that can be acquired more quickly and in much smaller increments, combined with natural gas, yields lower expected costs.
4. Long-term contracts for smaller increments of the more attractive resources are a form of insurance that public utility commissions should require utilities to acquire.