LOCATING ENERGY EFFICIENCY IN A 21ST CENTURY LEAST COST PLANNING ENVIRONMENT

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ACEEE ENERGY EFFICIENCY CONFERENCE
DENVER COLORADO
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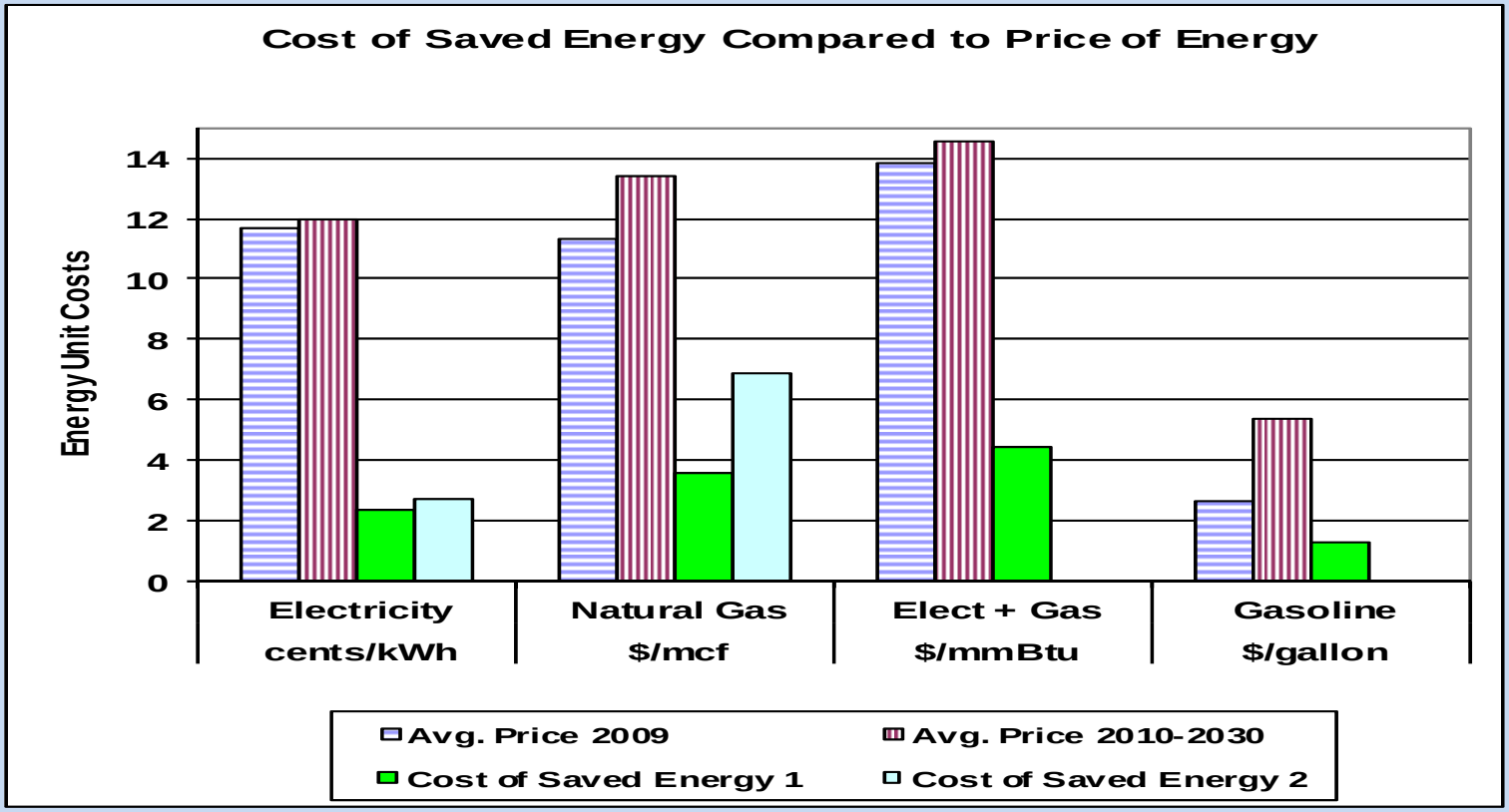


Sources and Notes:

Gold, Rachel, Laura, et. al., *Energy Efficiency in the American Clean Energy and Security Act of 2009: Impact of Current Provisions and Opportunities to Enhance the Legislation*, American Council for an Energy Efficient Economy, September 2009),

McKinsey Global Energy and Material, *Unlocking Energy Efficiency in the U.S. Economy* (McKinsey & Company, 2009).

National Highway Traffic Safety Administration, *Corporate Average Fuel Economy for MY2012-MY 2016 Passenger Cars and Light Trucks, Preliminary Regulatory Impact Analysis*, Tables 1b, and 10. The 7 percent discount rate scenario is used for the total benefit = total cost scenario..

National Research Council of the National Academies, *America's Energy Future: Technology and Transformation, Summary Edition* (Washington, D.C.: 2009). The NRC relies on a study by Lawrence Berkeley Laboratory for its assessment (Richard Brow, Sam Borgeson, Jon Koomey and Peter Biermayer, *U.S. Building-Sector Energy Efficiency Potential* (Lawrence Berkeley National Laboratory, September 2008).

2009 average prices are from the Energy Information Administration, Short-Term Outlook, while 2010-2030 Prices are from the *Annual Energy Outlook: 2009. Adjusted.*

Multivariate Comparison (Gas =1)

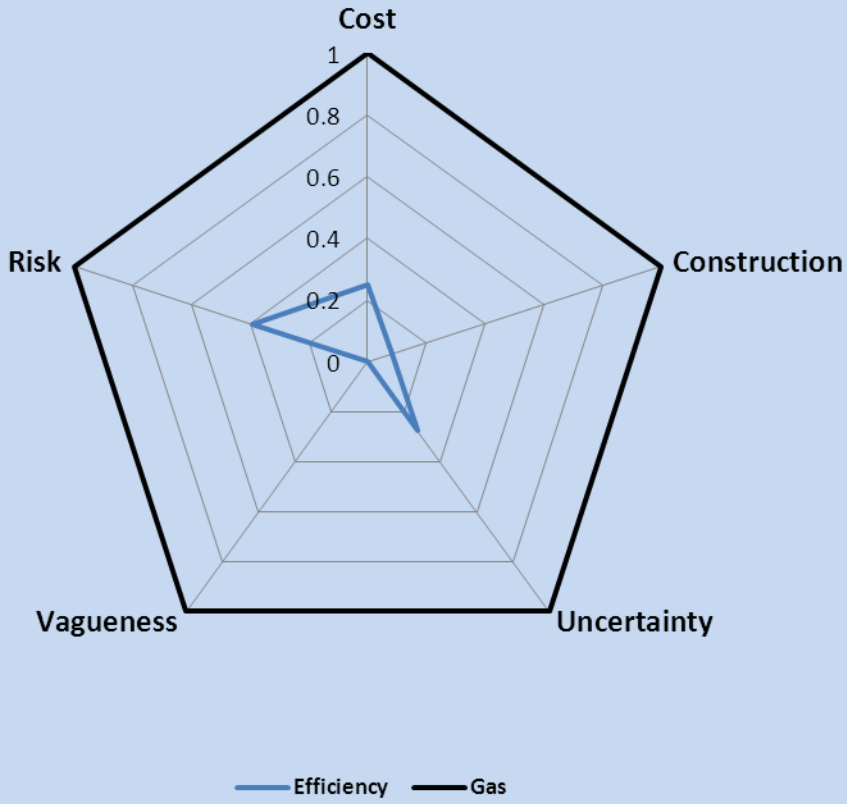


EXHIBIT I-2: COMPREHENSIVE LIST OF IMPERFECTIONS THAT CAUSE MARKETS TO FAIL (Citations to Lawrence Berkeley Laboratory & Resource for the Future)

TRADITIONAL NEOCLASSICAL & INDUSTRIAL BEHAVIORAL

NEW INSTITUTIONAL &

SOCIETAL FLAWS
- Traditional Externalities 1
  - Positive
  - Negative
  - Public Goods 22, a
  - Basic research B, b
  - Information
    - Learning-by-doing C, c
    - Learning-by-using D

ENDEMIC IMPERFECTIONS
- Asymmetric Information H, 9
  - Agency L, 4
  - Moral Hazard
  - Adverse Selection H
- Perverse Incentives 1
- Conflict of Interest
- Inequality
  - Physical Capital E, e, 8
    - Maldistribution
  - Human Capital
    - Health
    - Education
- Macroeconomic Imbalances
  - Income/
  - Demand
  - Insufficiency
  - Investment
  - Instability
- Network Effects
  - Direct
    - User
    - Nonuser
  - Indirect
  - Cross platform
- Innovation Economics
  - General Purpose Tech.
  - Producer surplus
  - Consumer surplus
  - Prosumers
  - Productivity
  - Applications

INDUSTRY STRUCTURE
- Imperfect Competition 28
  - Concentration
  - Barriers to Entry
  - Scale f
  - Vertical Leverage
  - Collusion
- ICE problems
  - Price discrimination
  - Entry barrier
  - Bargaining
- Technology B, b
  - R&D
  - Investment
- Marketing
  - Bundling: Multi-attribute 13
  - Product Differentiation
  - Gold Plating
  - Inseparability
  - Purchase Method
  - Advertising
- Cost-Price
  - Level
  - Structure
    - Product cycle
    - Disaggregated/ fragmented Mkt. 15
  - Ownership
    - Control
    - Transfer
      - Limited payback g
      - Lack of premium
- Elasticity
  - Own-price
  - Cross-price
  - Income
- Availability
  - Backward bending supply
  - Lack
  - Emergency replacement
  - Poor Quality
- Regulation h, k, 14
  - Price Distortion Avg-cost 20, j
  - Permitting
  - Other Distortions

TRANSACTION COST 2
- Search and Information E
  - Imperfect Information G, 10
  - Availability
  - Accuracy 12
  - Search Cost 12
- Bargaining
  - Risk & Uncertainty 6, 7
  - Technology
  - Marketplace
  - Policy
  - Financial
  - Liability h, i
- Enforcement
  - Switching costs j
  - Sunk costs g, k, 3
  - Monitoring Costs

POWER
- Legal Framework
  - Property
  - Contract
- Policy
  - Taxation
  - Subsidies
  - Protectionism
  - Trade
- Antitrust Enforcement
  - Toward Mergers
  - Toward Behavior
  - Market Dominance
- Regulatory Capture

BEHAVIORAL
- BASICS K
- Motivation Values & Commitment 19
  - Bounded Selfishness/wants
    - Morality
    - Fairness/reciprocity
    - Altruism
    - Preference
    - Custom 17
    - Social group & status
- Perception
  - Bounded Vision/Attention
    - Prospect L, 24
      - Framing
      - Loss Avoidance
      - Status Quo
      - Salience
    - Self-fulfilling Prophesy
    - Social Influence
      - Awareness
      - Attention
      - Low priority
- Calculation
  - Bounded rationality M, 26
    - Ability to process info 27
    - Limited understanding
    - Heuristic Decision Making N
      - Rules of thumb
      - Information O
    - Discounting
      - Low Probability Events
      - Long-Term
      - Small Outcomes
- Execution
  - Bounded Willpower
    - Improper use
    - Improper maintenance

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	Insurance/ diversity	Monitor & Adjust	Optionality	Hedging
Rules				

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

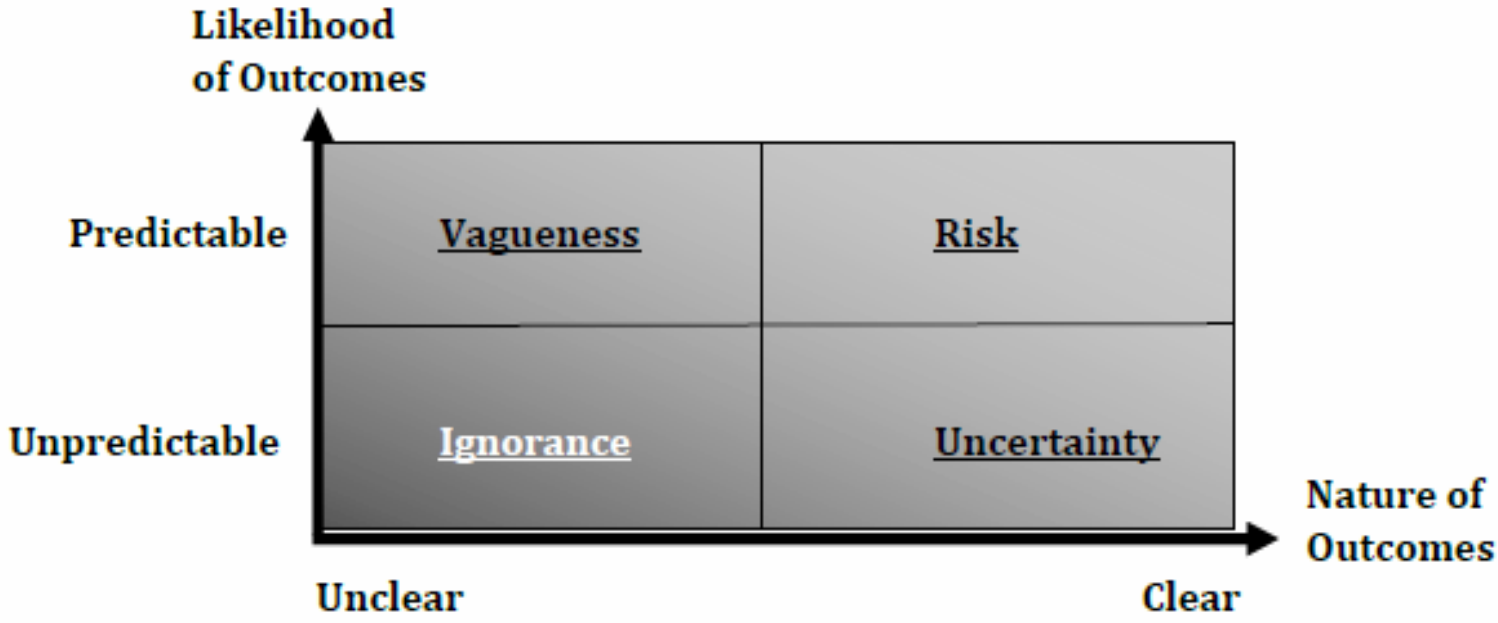
BLACK SWAN THEORY
Optionality

TECHNOLOGY RISK ANALYSIS
Resilience
Robustness
Hedge

BLACK SWAN THEORY
Robust to Error
Small, Confined, Early Mistakes
Incentive & disincentives
Avoid Moral Hazard
Hedge

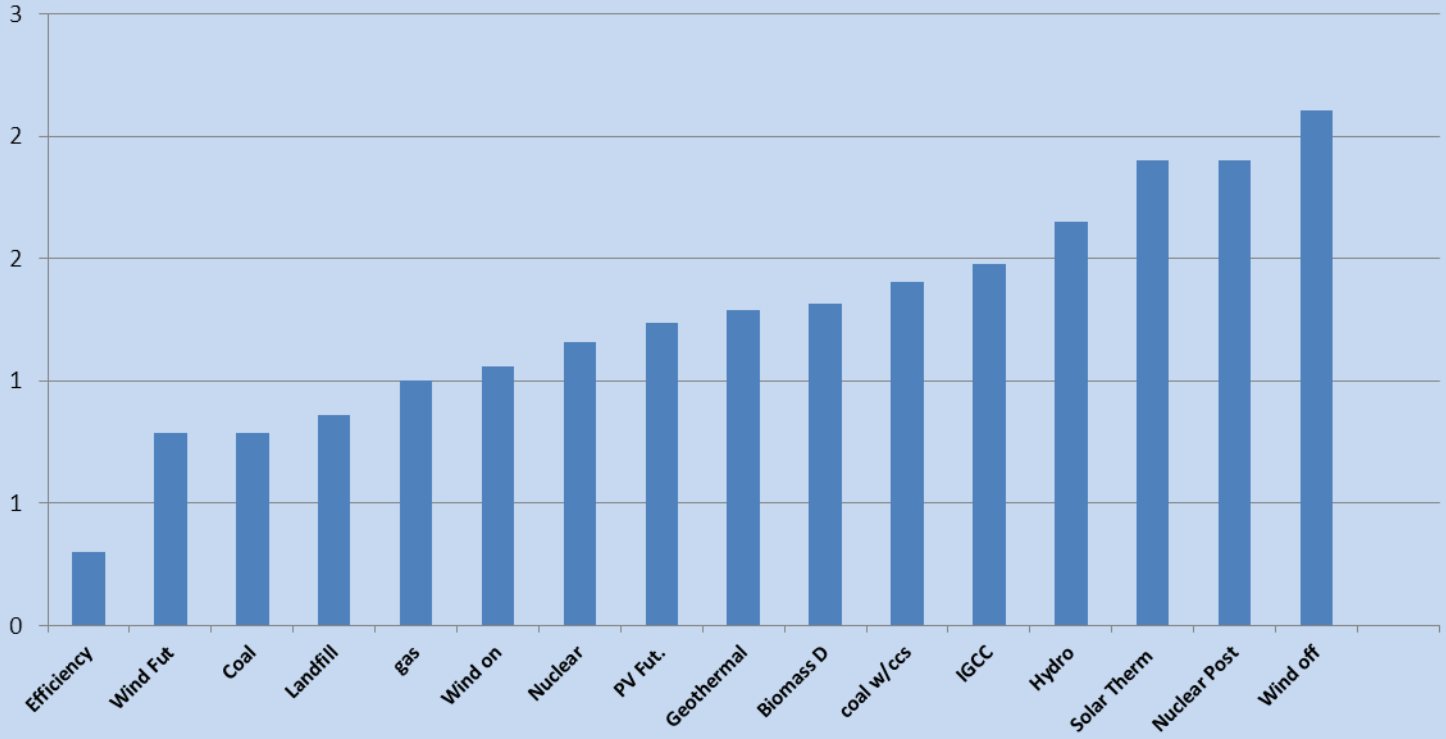
Sources: Nassim Nicholas Taleb, *The Black Swan* (New York: Random House, 2010), p.365; Andrew Stirling, *On Science and Precaution in the Management of Technological Risk* (European Science and Technology Observatory, May 1999), p. 17, *On the Economics and Analysis of Diversity* (Science Policy Research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

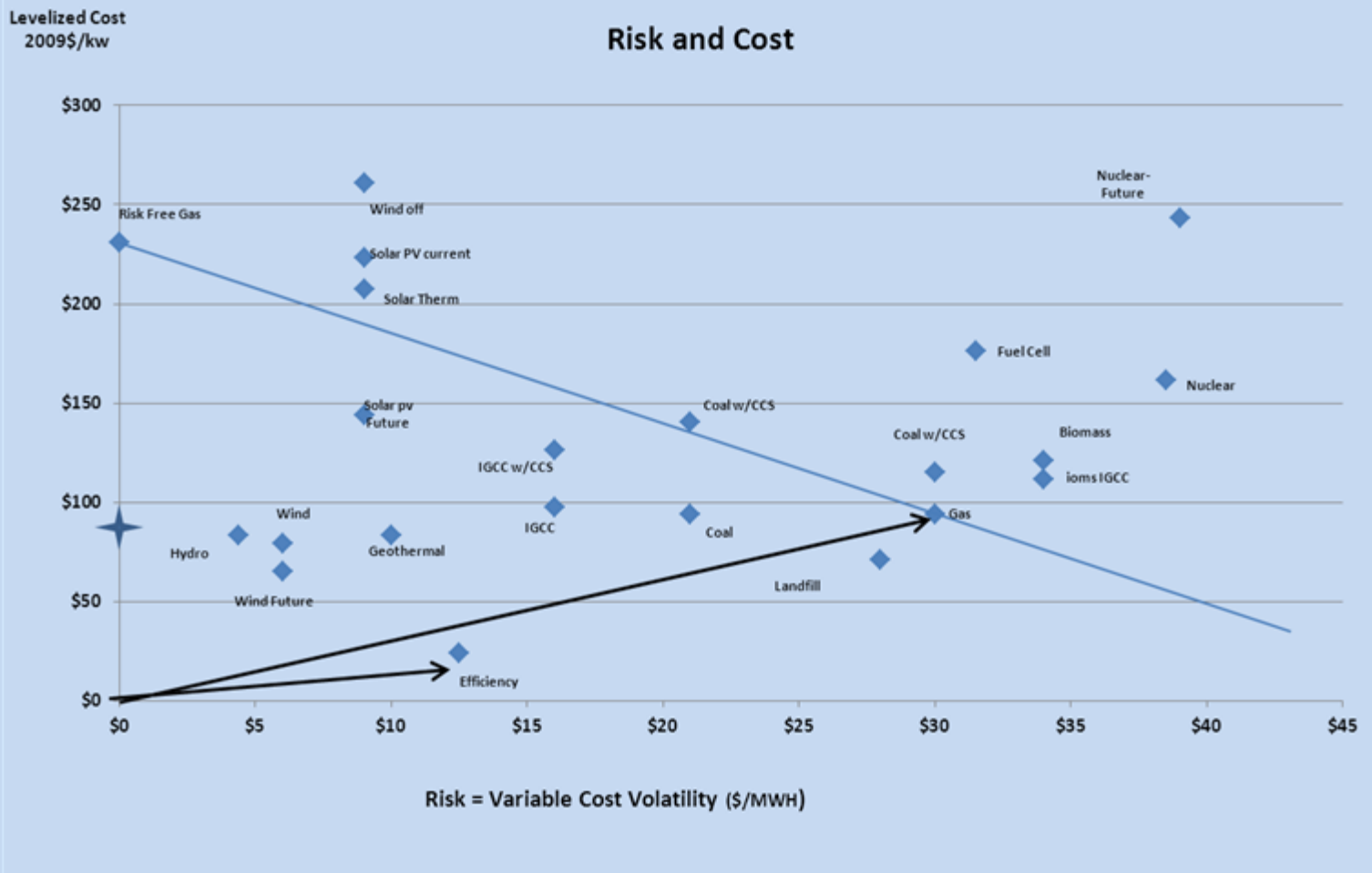
AMBIGUITY AND THE REGIONS OF KNOWLEDGE

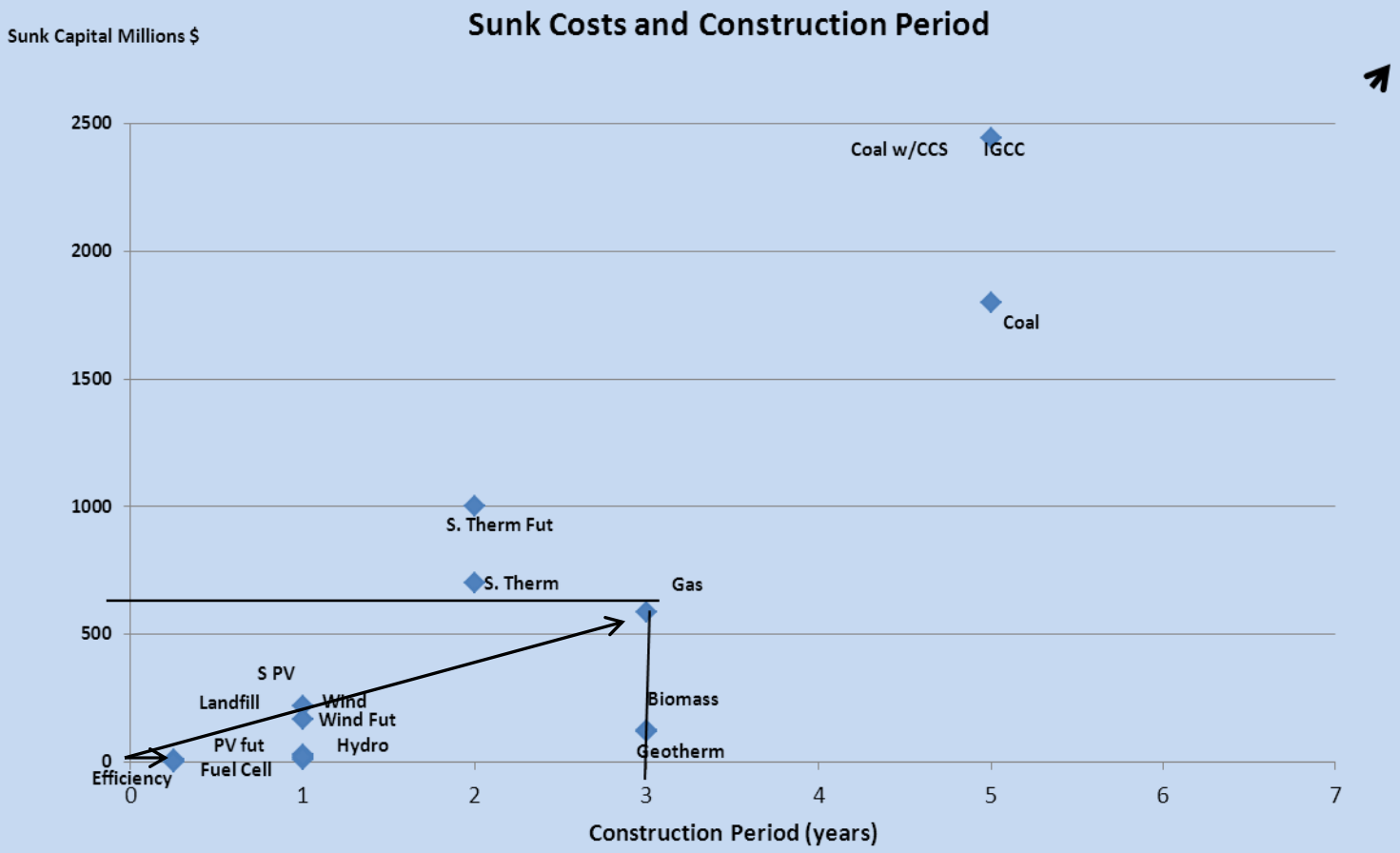


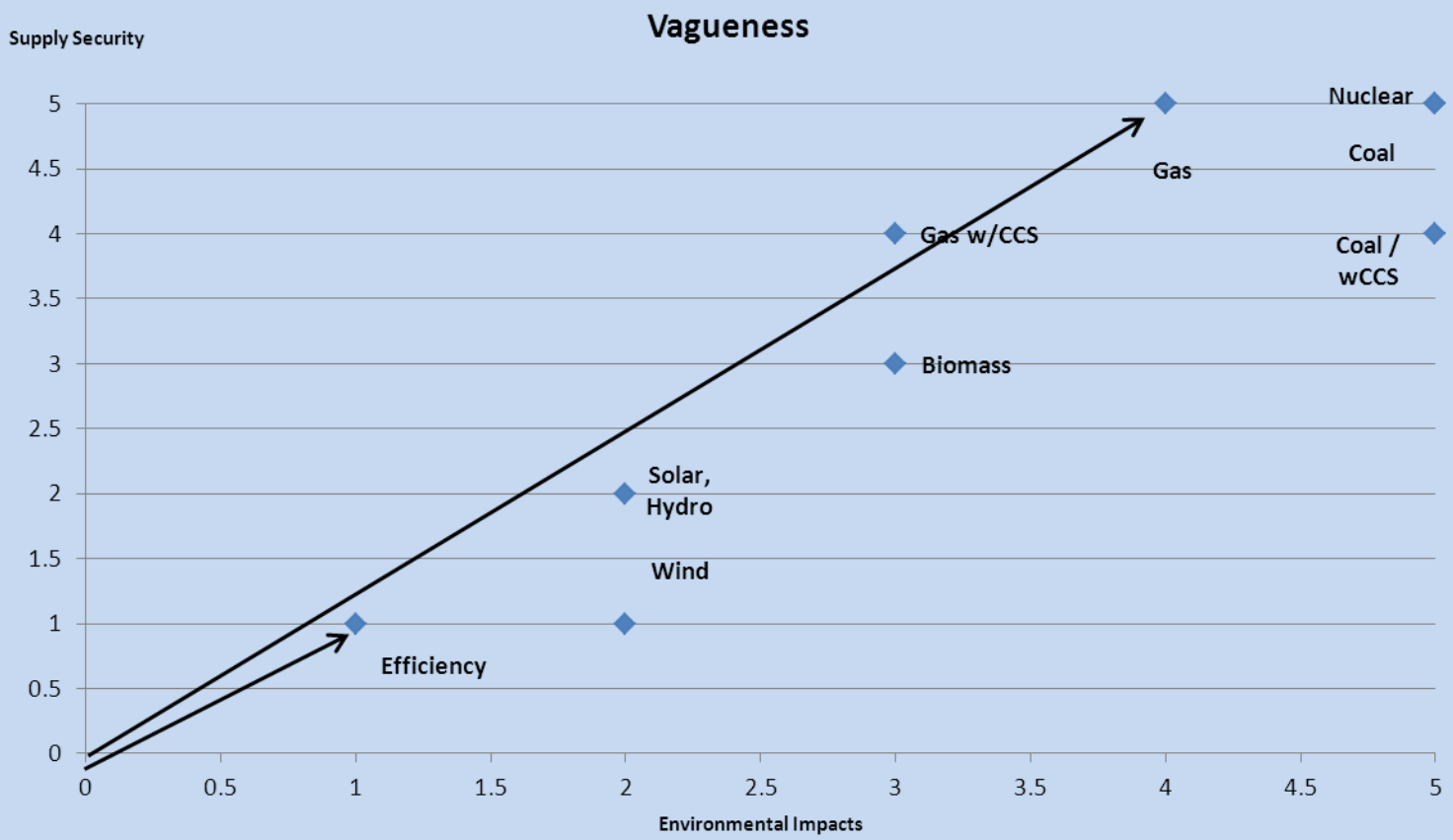
- be hedged against **risk**,
- maximize options to reduce **uncertainty**,
- be flexible with respect to outcomes that are, at best, **vague** and
- be insulated against **ignorance** of the unknown.

Univariate Approach: Levelized Cost (Gas = 1)

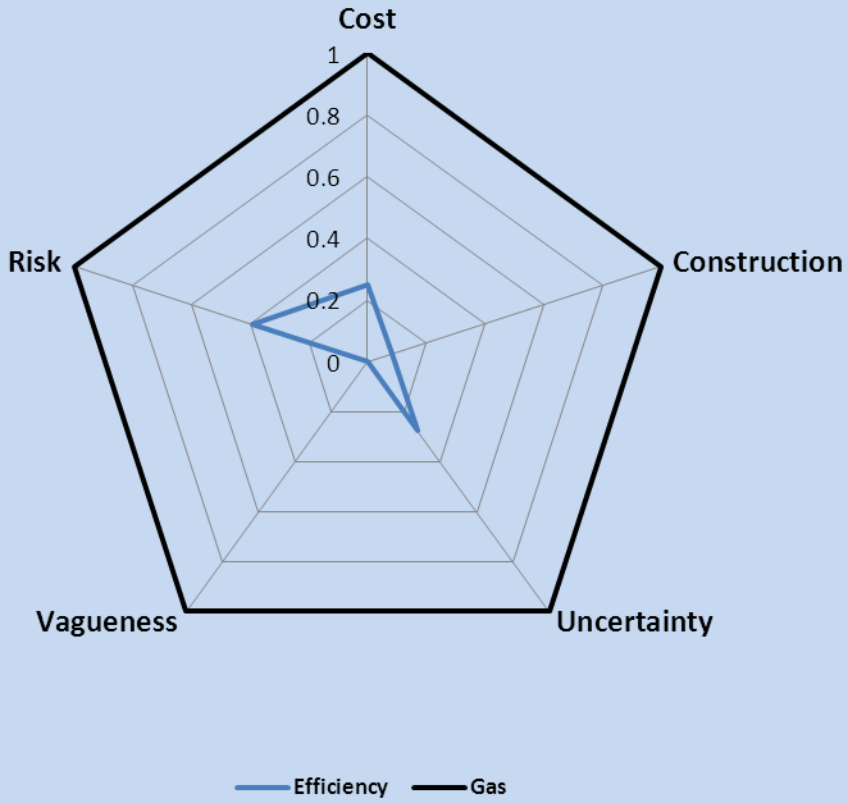



Levelized Cost
2009$/kw
Risk and Cost
$300
$250
$200
$150
$100
$50
$0
$0
$5
$10
$15
$20
$25
$30
$35
$40
$45
Risk Free Gas
Wind off
Solar PV current
Solar Therm
Solar pv Future
Nuclear-Future
Fuel Cell
Nuclear
Coal w/CCS
Coal w/CCS
Biomass
Ioms IGCC
IGCC w/CCS
IGCC
Coal
Gas
Wind
Hydro
Geothermal
Wind Future
Landfill
Efficiency
Risk = Variable Cost Volatility ($/MWH)


Sunk Costs and Construction Period
Sunk Capital Millions $
2500
2000
1500
1000
500
0
Coal w/CCS
IGCC
Coal
S. Therm Fut
S. Therm
Gas
S PV
Landfill
Wind
Wind Fut
PV fut
Hydro
Fuel Cell
Efficiency
Biomass
Geotherm
0
1
2
3
4
5
6
7
Construction Period (years)


Vagueness
Supply Security
Environmental Impacts
Nuclear
Coal
Gas
Gas w/CCS
Coal / wCCS
Biomass
Solar, Hydro
Wind
Efficiency
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Multivariate Comparison (Gas =1)



Colorado PUC ERP