



# Energy Security and the “Sustainability Trilemma”

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THE LANTAU GROUP  
strategy & economic consulting

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Testimony

Market Analysis

Asset Valuation

Business & Regulatory Strategy



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## Oil & Gas companies



## International Aid Agencies



## Leading utilities

## Financial Institutions



## Market and System Operators

## Government Ministries



## Regulatory Agencies

## Independent Power Producers



# Overview

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**1** What exactly IS energy security?

**2** Is fuel diversity valuable?

**3** Is strategic flexibility important?

# Energy security is one leg of the “sustainability trilemma” that appears in energy policy discussions for many countries

Malaysia's three principal energy objectives



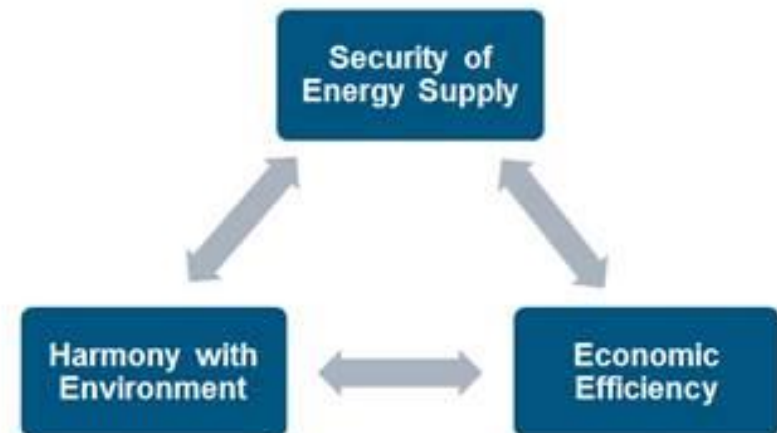
Singapore's energy policy objectives




Taiwan's Sustainable Energy Policy:  
Win-Win-Win Solution for Energy, Environment and Economy





Japan's Energy Policies: 3Es




# As part of a policy study, we did an exhaustive literature review – countless policy papers exist discussing energy security


 Academic papers for assessment criteria


 Australia

 Case studies


 Country specific

 EU


 General


 General Papers


 New York


 Quantitative modelling


 UK


 1. 200911axon\_presentation measuring energy security


 1. Australian Liquid Fuel Vulnerability Assessment


 1. axon\_presentation measuring energy security


 1. Saving\_Electricity in a hurry


 1. The Hidden Costs of Elecreport


 1. Electricity\_sector\_opportunities


 2. Externality of energy insecurity


 2. renewing\_energy\_security\_mitchell\_july\_2002


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 3. Lloyds\_360\_Energy\_Pages


 3. Measuring Energy Security-Trends in the diversification of oil and natural gas supplies


 4. Energy security - perceptions and reality, systemic and reductionist


 5. Cherp\_and\_Jewell 2011-three perspectives of energy security


 6. Lesson learned from energy security


 6. Lesson learned from the energy policies of IEA countries


 7. An overview of study of VOLL


 8. Australian Liquid Fuel Vulnerability Assessment


 8. Diversity of generation technologies-Costello


 9. International relations and security of energy supply


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 200911axon\_presentation measuring energy security


 200911gracceva\_presentation


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 an overview of study of VOLL


 ATSEHiddenCostsElecreport1262168477


 Cherp\_and\_Jewell 2011-three perspectives of energy security


 compendium lesson learned from energy security


 D\_05\_1 energy supply externalities update\_Dec\_07


 Diversity of generation technologies-Costello


 electricity\_sector\_opportunities


 Energy security - perceptions and reality, systemic and reductionist


 Energy Security in Four Asia countries


 ESWG emergency arrangements discussion paper - March 09


 EU Gas security


 externality of energy


 fuel\_diversity\_11202008 new york


 imf measuring energy security


 Learning from the blackouts 2005

 Liquid Fuel Vulnerability Assessment

 measuring energy security imf

 Meeting the energy challenge-White paper

 renewing\_energy\_security\_mitchell\_july\_2002

 Saving\_Electricity

# That's just the tip of the iceberg – for example, let's look inside the “Academic Papers” folder

## Academic papers for assessment criteria

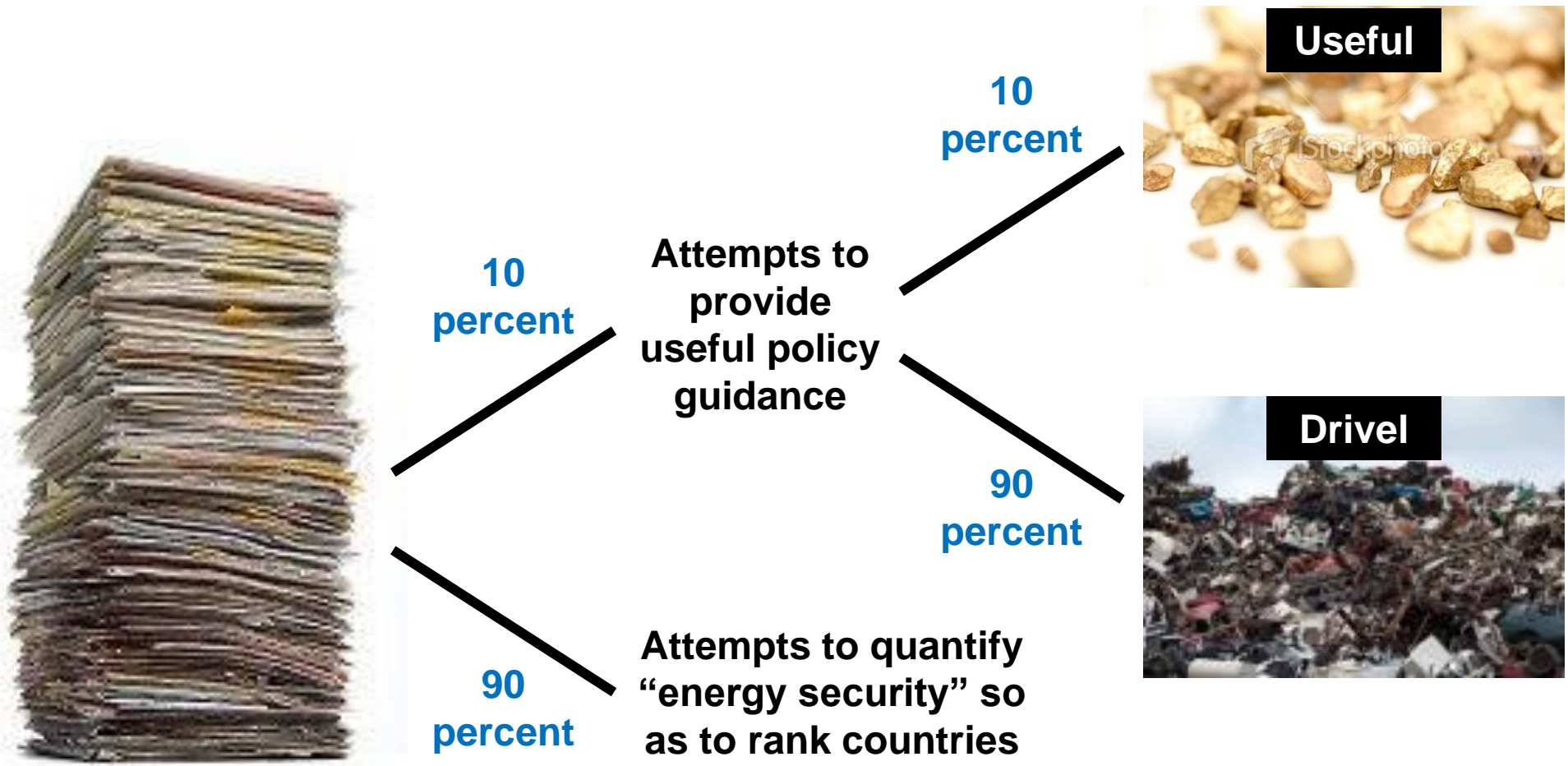
- Australia
- Case studies
- Country specific
- EU
- General
- General Papers
- New York
- Quantitative modelling
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- Meeting the energy challenge-White paper
- renewing\_energy\_security\_mitchell\_july\_2002
- Saving\_Electricity

# I couldn't even fit our entire directory of academic studies onto the slide!

- EPRG
- 1. Indicators for energy Security(Kruyt, March 2009)
- 2. An optimization Model for Long-term Planning of Energy(Jirutitijaroen;He)
- 2. Uganda\_Emission\_Factor\_Grid\_FINAL\_REPORT
- 3. Designing indicators of long-term energy supply security(Jansen, Jan 2004)
- 4. Competing dimensions of Energy Security(Sovacool; Brown Jan 2009)
- 5. Analytical Approaches to Quantify and Value Fuel Mix Diversity (FA Roques, Jul 2008)
- 6. GWS Discussion paper - More baskets (Ulrike Lehr)
- 7. On the Economics and Analysis of Diversity (Stirling, 1998)
- 8. Energy security - market oriented approach (Jenny, OECD 2007)
- 9. Conceptualizing Energy Security (Winzer, 2011)
- 10. Applying portfolio theory to EU electricity planning and policy-making (Awerbuch and Berger, Feb 2003)
- 10. Security of Energy Supply (Constantini and Vicini, June 2005)
- 11. Competing dimensions of Energy security (POLINARES workshop; Brown May 2011)
- 12. Competing dimentions of energy security
- 13. Accounting for Fuel Price Risk When Comparing Renewable to Gas-Fired Generation
- 13. ForfasElectricityBenchmarkingStudy
- 14. An integrated approach towards a secured energy system
- 15. Fuel mix diversification incentives in liberalised electricity markets (2006)
- 16. Indicators of energy security in industrialised countries
- 17. Energy Security in Energy Systems Modeling
- 18. The (non)sense of Energy security indicators
- 19. Energy Security Indicators, JRC Consulting
- accessing the cost of energy disruptions in APEC
- Accounting for Fuel Price Risk When Comparing Renewable to Gas-Fired Generation
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- analysis of energy security in the baltic region
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- APEC Strategic Framework Paper
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- assess the cost of energy disruption
- bazilian et al 2010 measuring energy access supporting a global target
- CEE-GLOBAL\_OIL\_MARKETS
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- Conceptualizing Energy Security (Winzer, 2011)
- data OECD country strategic assessment for environmental
- Designing indicators of long-term energy supply security(Jansen, Jan 2004)
- Energy and the Asian Security Nexus (Fereidun Fesharaki 1999)
- Energy Indices
- Energy security - market oriented approach (Jenny, OECD 2007)
- energy security lky
- FINAL\_Reliability Security Review (6 Apr 09)
- ForfasElectricityBenchmarkingStudy
- gupea\_2077\_26307\_3
- GWS Discussion paper - More baskets (Ulrike Lehr)
- Indicators for energy Security(Kruyt, March 2009)
- MIT-SMR-BCG-sustainability-the-embracers-seize-advantage-2011 (ideas on diagrams and charts)
- On the Economics and Analysis of Diversity (Stirling, 1998)
- Publications-2011-SOTR-Supplement-Transpacific-Energy cooperation
- REACCESS Book - Security of Supply & Risk of Energy Availability (June 2008)

# So much has been written – what have they said?



For example, note the indicators referenced in this “meta-study” of academic literature – how useful are these indicators really for decision-making?

| <b>Dimension</b>                      | <b>Explanation</b>  | <b>Indicators</b>   | <b>Percent of Articles</b> |
|---------------------------------------|---|---|----------------------------|
| <i>Availability</i>                   | Diversifying the fuels used to provide energy services as well as the location of facilities using those fuels, promoting energy systems that can recover quickly from attack or disruption, and minimizing dependence on foreign suppliers | –Oil import dependence;<br>–Natural gas import dependence;<br>–Dependence on petroleum transport fuels        | 82%                        |
| <i>Affordability</i>                  | Providing energy services that are affordable for consumers and minimizing price volatility   | –Retail electricity prices;<br>–Retail gasoline/petrol prices   | 51%                        |
| <i>Energy and Economic Efficiency</i> | Improving the performance of energy equipment and altering consumer attitudes to reduce energy price exposure and mitigate energy import dependency   | –Energy intensity (per GDP);<br>–Per capita electricity use;<br>–On-road fuel intensity of passenger vehicles | 34%                        |
| <i>Environmental Stewardship</i>      | Protecting the natural environment and future generations   | –Sulfur dioxide emissions;<br>–Carbon dioxide emissions   | 26%                        |

Source: *Competing dimensions of energy security* (Brown, May 2011)

The useful literature recognizes that energy security risks take different forms – and must be analyzed and addressed separately

| Energy Security Risk Matrix | Physical (supply shortfall)   | Financial (high prices)                      |
|-----------------------------|---|--|
| <b>Short-Term</b>           | Technical failure<br>Extreme weather events<br>Political disruption         | Supply disruption<br>Cartel production quota |
| <b>Long-Term</b>            | Resource depletion<br>Resource nationalization<br>Policy/regulatory failure | Fuel price shifts<br>New technologies        |

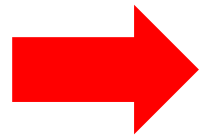
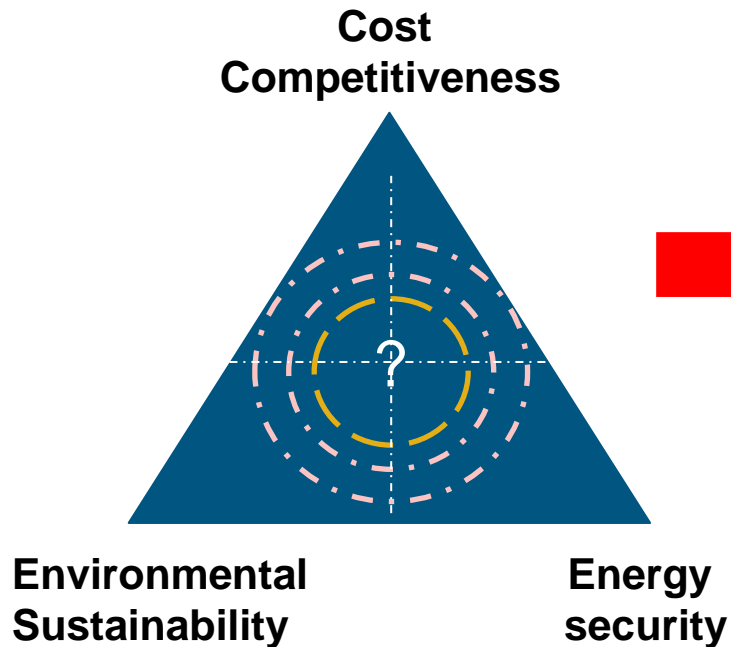
Furthermore, each class of risk can best be managed via different strategies

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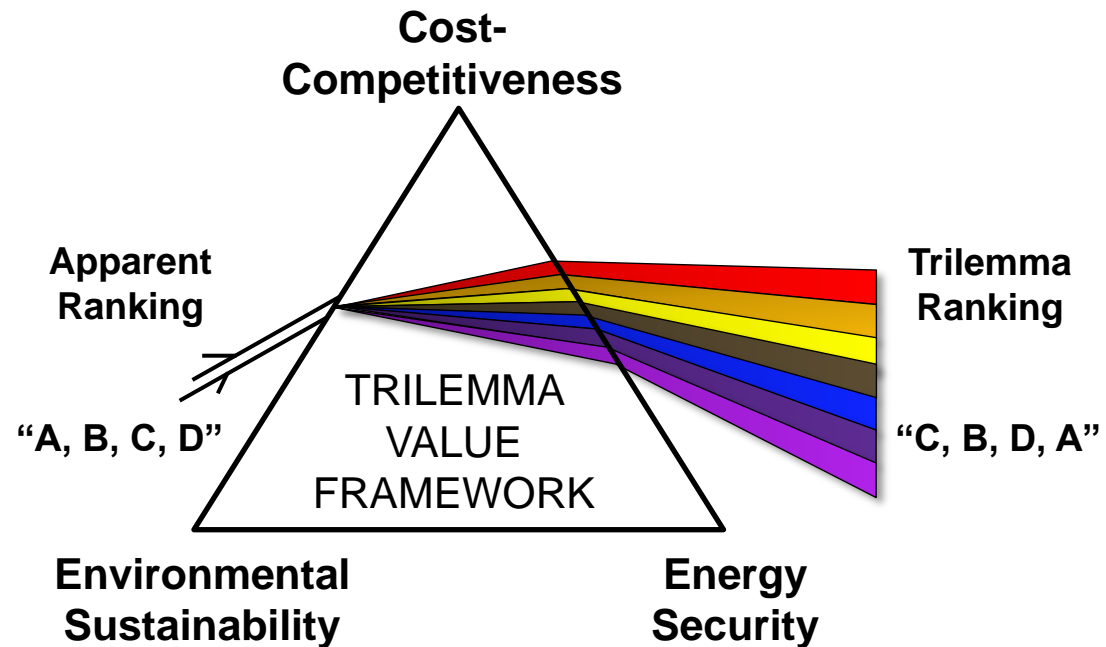
| <b>Energy Security<br/>Risk Matrix</b> | <b>Physical<br/>(supply shortfall)</b>           | <b>Financial<br/>(high prices)</b>                           |
|--|--|--|
| <b>Short-Term</b>                      | Physical redundancy<br>Supplier diversity        | Bilateral contracts<br>Hedging instruments                   |
| <b>Long-Term</b>                       | Prudent planning<br><b>Clear policy guidance</b> | <b>Clear policy guidance</b><br><b>Strategic flexibility</b> |

# Clear policy guidance requires a value-based framework

## From Ambiguous Triangle



## To Clarifying Prism



We must also dispel a “sacred cow” of energy security policy – “energy independence” does NOT imply appropriate energy security

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**“Notions of “energy independence” are not only obsolete, they can be dangerous.”**

*INTERNATIONAL RELATIONS AND SECURITY OF ENERGY SUPPLY:  
RISKS TO CONTINUITY AND GEOPOLITICAL RISKS*

Jan Horst Keppler

Professor of Economics, University of Paris–Dauphine

Director of the Energy Program of the French Institute for International Relations

- International fuel markets exist because there are mutual benefits to trade; developing national resources in preference to imports necessarily incurs higher costs
- International fuel markets are actually highly secure and robust – there is no more liquid market than crude oil
- International fuel markets offer hedging mechanisms to mitigate spot price risks
- “Energy independence” implies an implies a self-centered, inward-looking attitude willing to invest politically (or even militarily) in securing scarce resources – such a race for resources would be mutually destructive for all.

# Overview

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1 What exactly IS energy security?

2 **Is fuel diversity valuable?**

3 Is strategic flexibility important?

## Diversity – and the related issue of fuel mix – is a timely topic due to several issues facing SE Asian economies

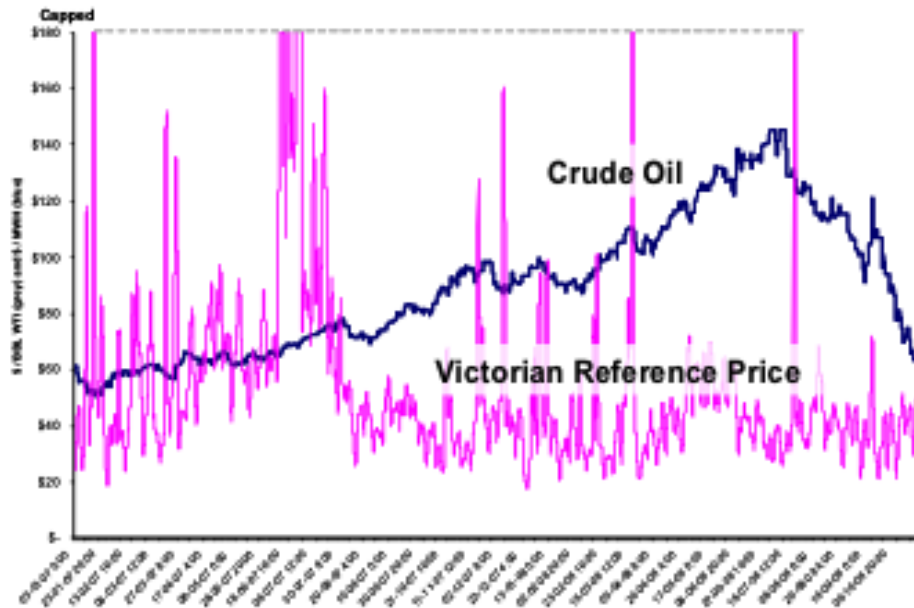
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- Many are grappling with the transition from a largely domestically-fueled electricity system to one tied to fuels traded in international markets
- A second challenge is the dramatic increase in the price of natural gas – which is now (or will soon be) the marginal fuel for many SE Asian economies
- The desire to reduce carbon emissions by substituting gas for coal runs counter to the push for greater energy affordability and cost-competitiveness.

# Globalization exposes these markets to volatile prices – at least at the margin

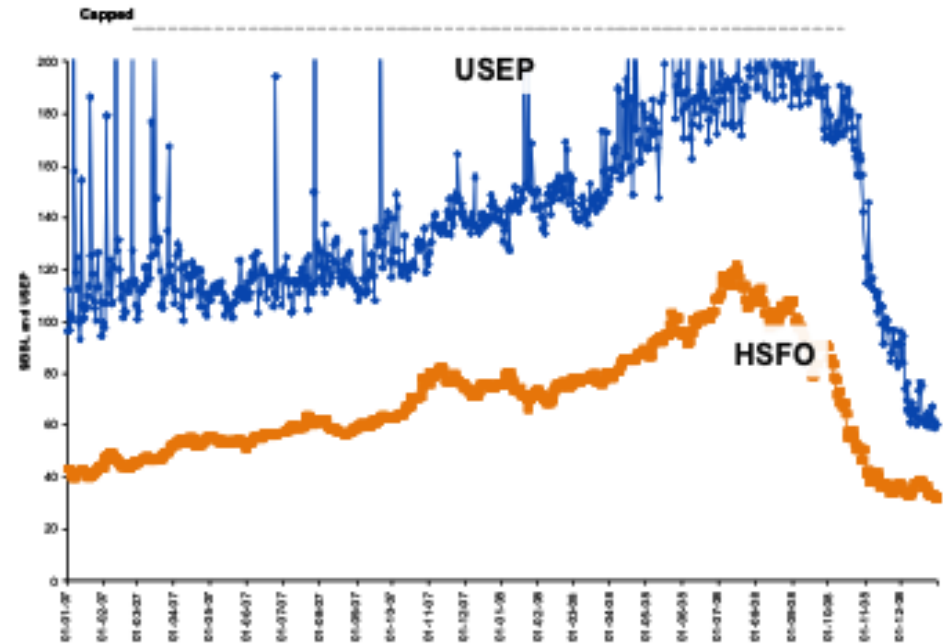
## DOMESTIC MARKET

Victoria, Australia

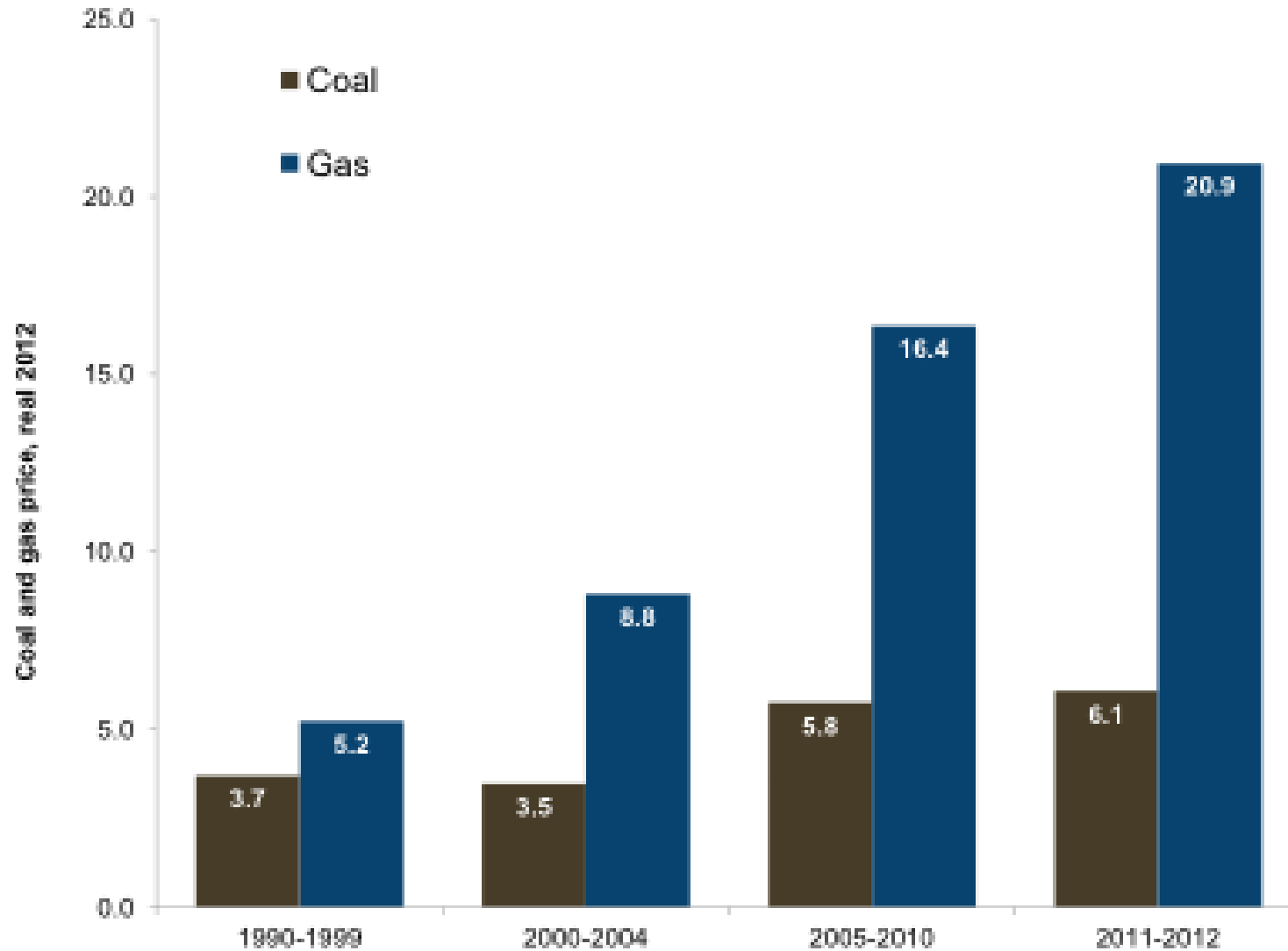


## STRONG LINKAGE

Singapore



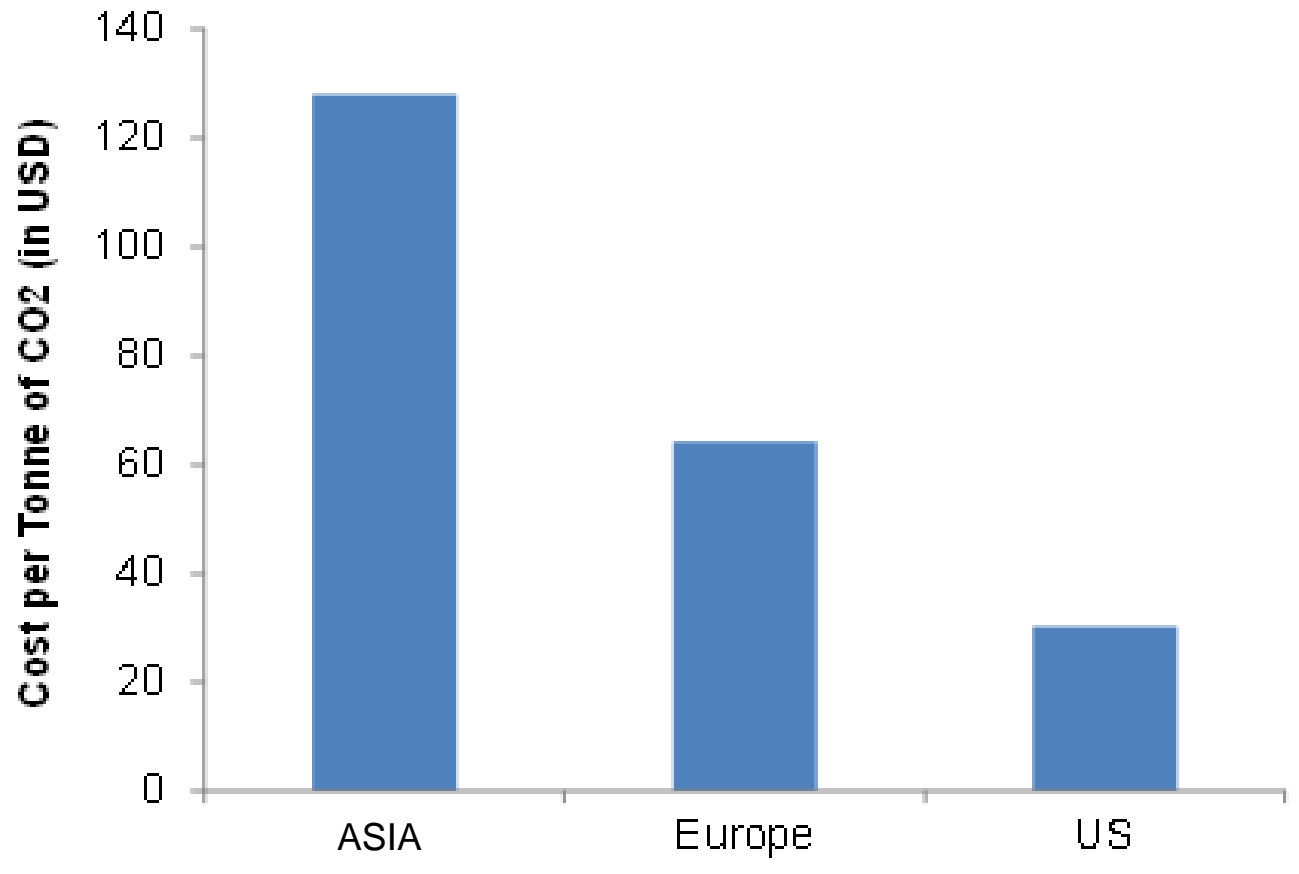
Since the mid 90s, gas in Asia has moved from being 40 percent more expensive than coal to 240 percent more expensive



As a result, the cost of carbon compliance is much higher than in the US or Europe – which highlights the opportunities in international carbon trading

### Carbon price required to induce switch from coal to gas

US\$/mt CO<sub>2</sub>



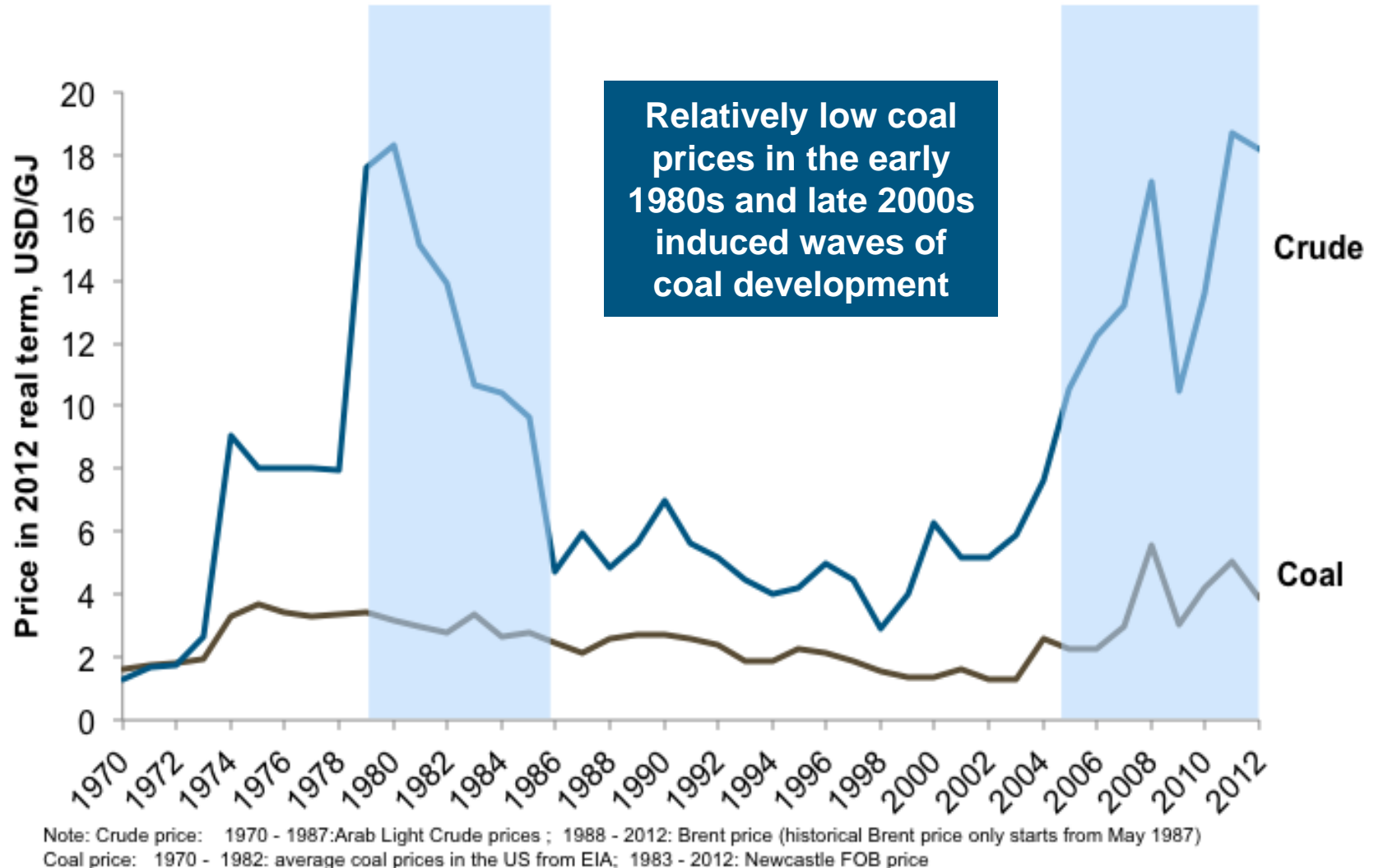
***Fuel Mix is a euphemism for... We don't like our choices!***

## Fuel diversity (as distinguished from physical redundancy or supplier diversity) is unquestionably valuable – but how valuable?

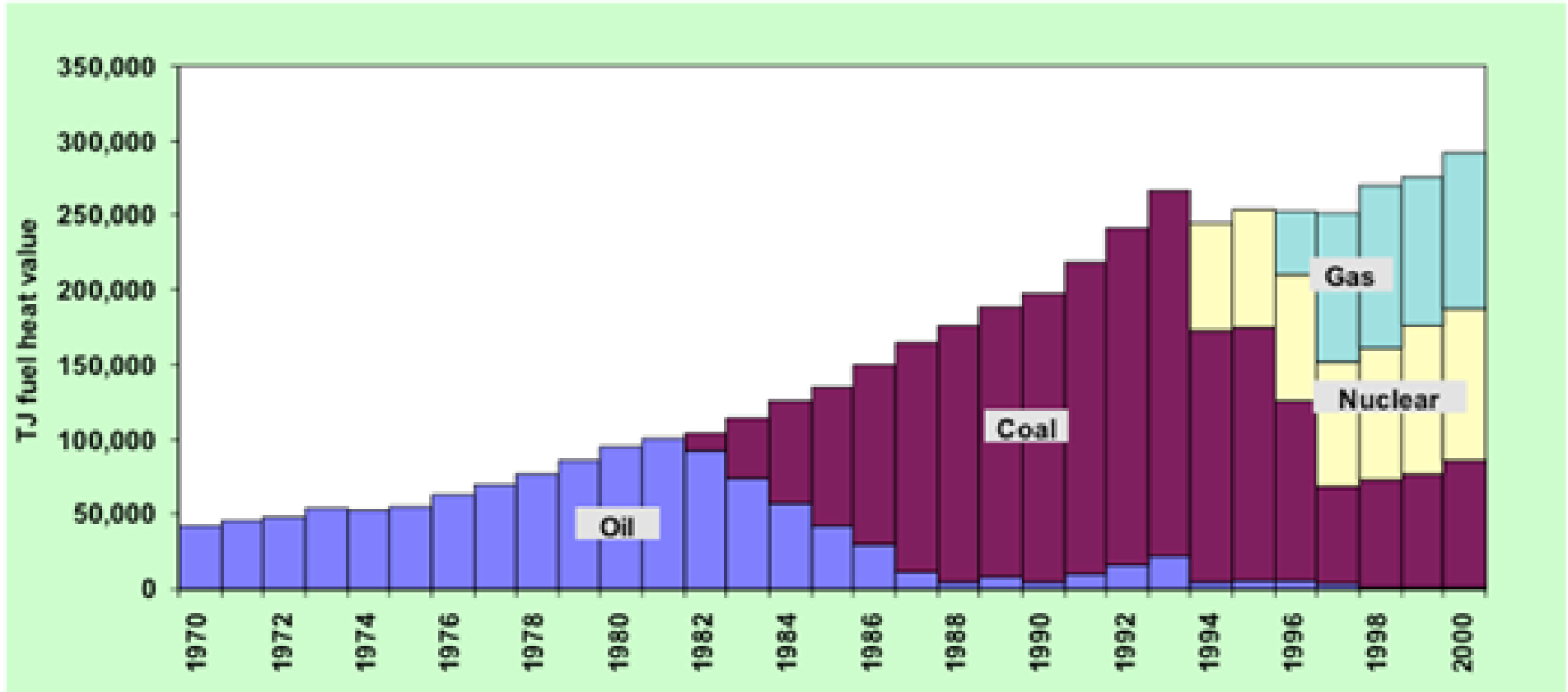
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- Fuel diversity lowers risk via the “portfolio effect” – a basket of fuels will have lower overall price risk than a single fuel
  - But contracts and hedging instruments already exist to mitigate short-term volatility
  - Long-term correlation between fuel prices in international markets is very high
  - What long-term risks are we worried about anyway – since it is virtually impossible (and probably not desirable) to decouple from international energy prices in the long run?
- An electricity system incorporating fuel diversity can reap the benefits of dispatch flexibility – that is, the ability to burn the least expensive fuel at any time
  - Reaping dispatch flexibility benefits requires that fuel prices be free to float so that such dispatch opportunities arise
  - The primary fuel competition today in Asia is between gas and coal – whose prices are so far apart as to create relatively few opportunities to realize the benefits of dispatch flexibility
  - Strategic flexibility can reap the benefits of long-term relative shifts in fuel prices.

Diversity advocates point to fuel-diverse systems as examples of good public policy – but fail to recognize that diversity often results from strategic flexibility

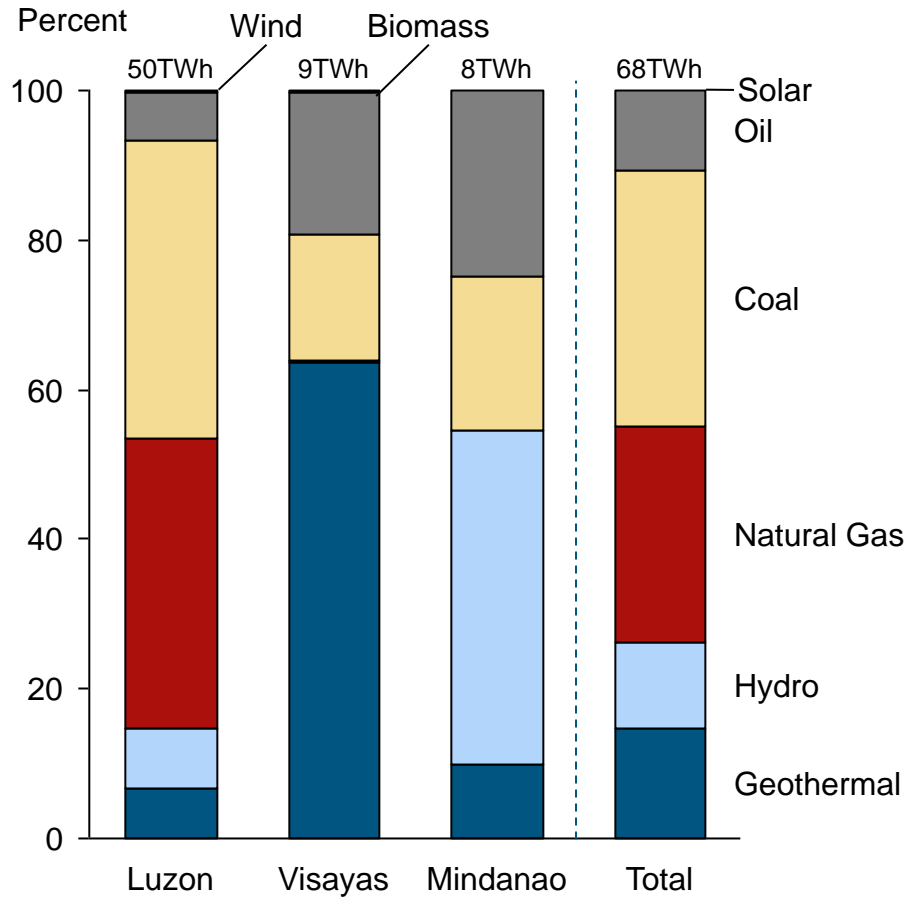


For example, CLP (Hong Kong) has a diverse fuel mix that resulted from a series of purely economic decisions made at various points in time

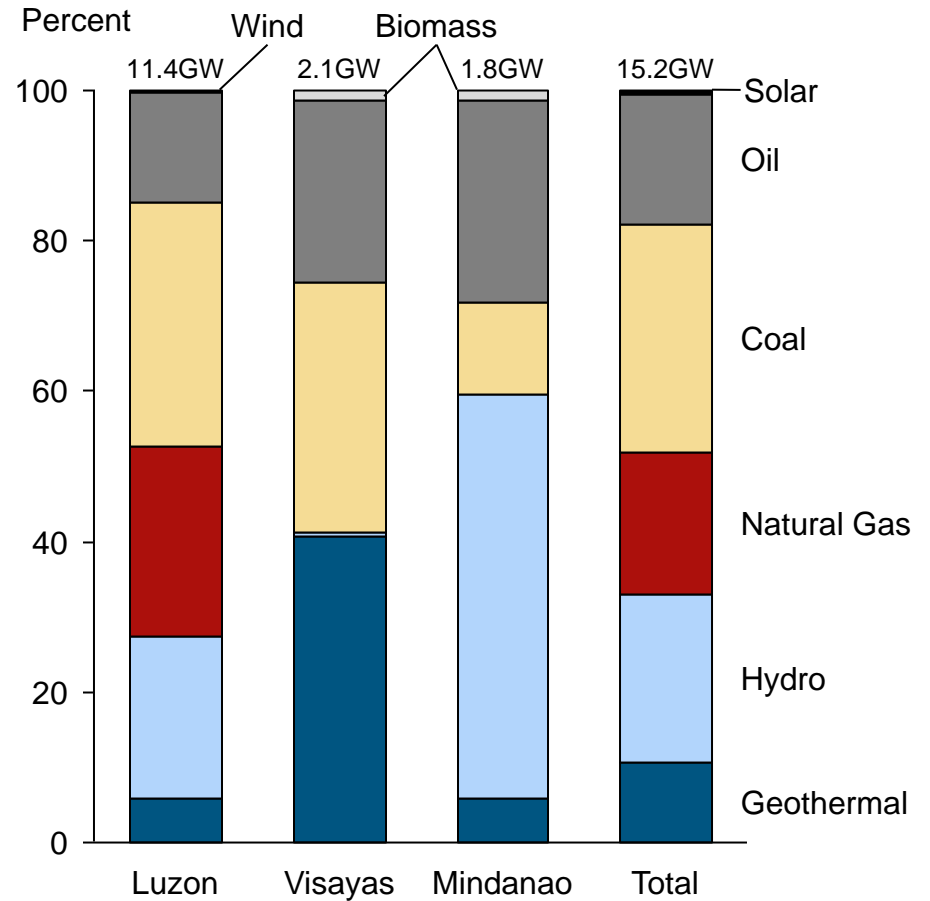


# By contrast, the Philippines has fuel diversity that arose by virtue of its regional energy endowments

## Generation mix in the Philippines (2010)



## Installed capacity mix in the Philippines (2012)

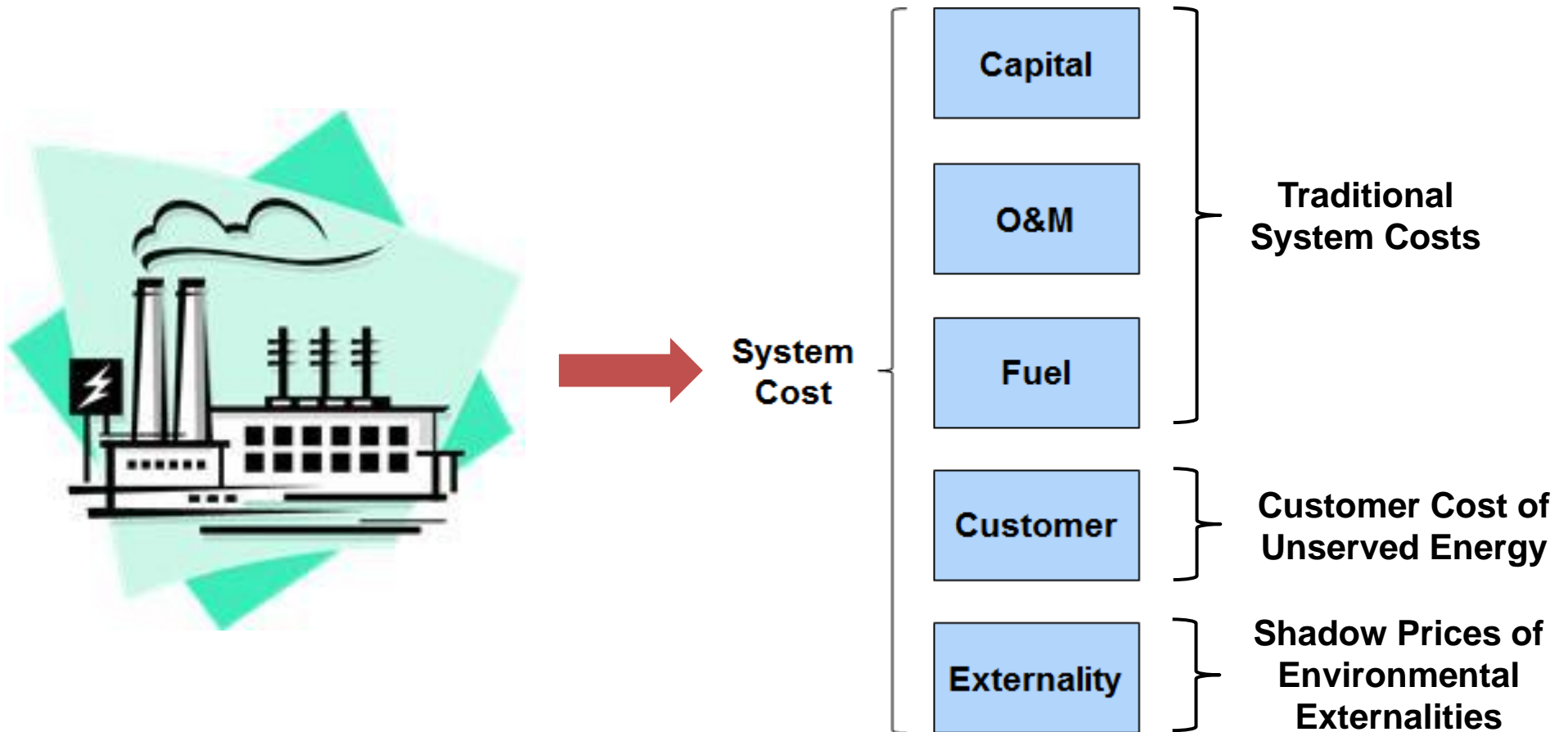


# Overview

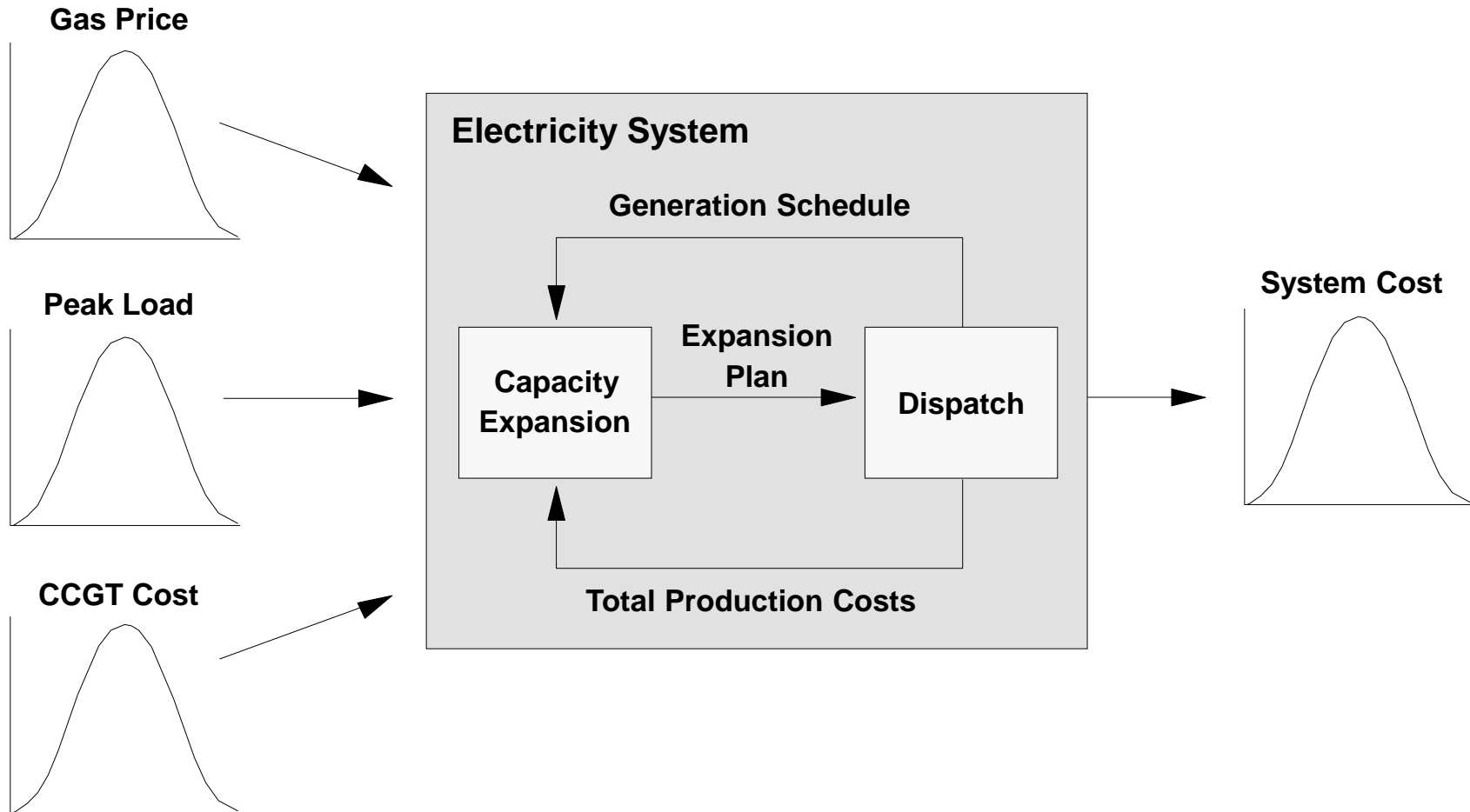
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- 1 What exactly IS energy security?
- 2 Is fuel diversity valuable?
- 3 Is strategic flexibility important?**

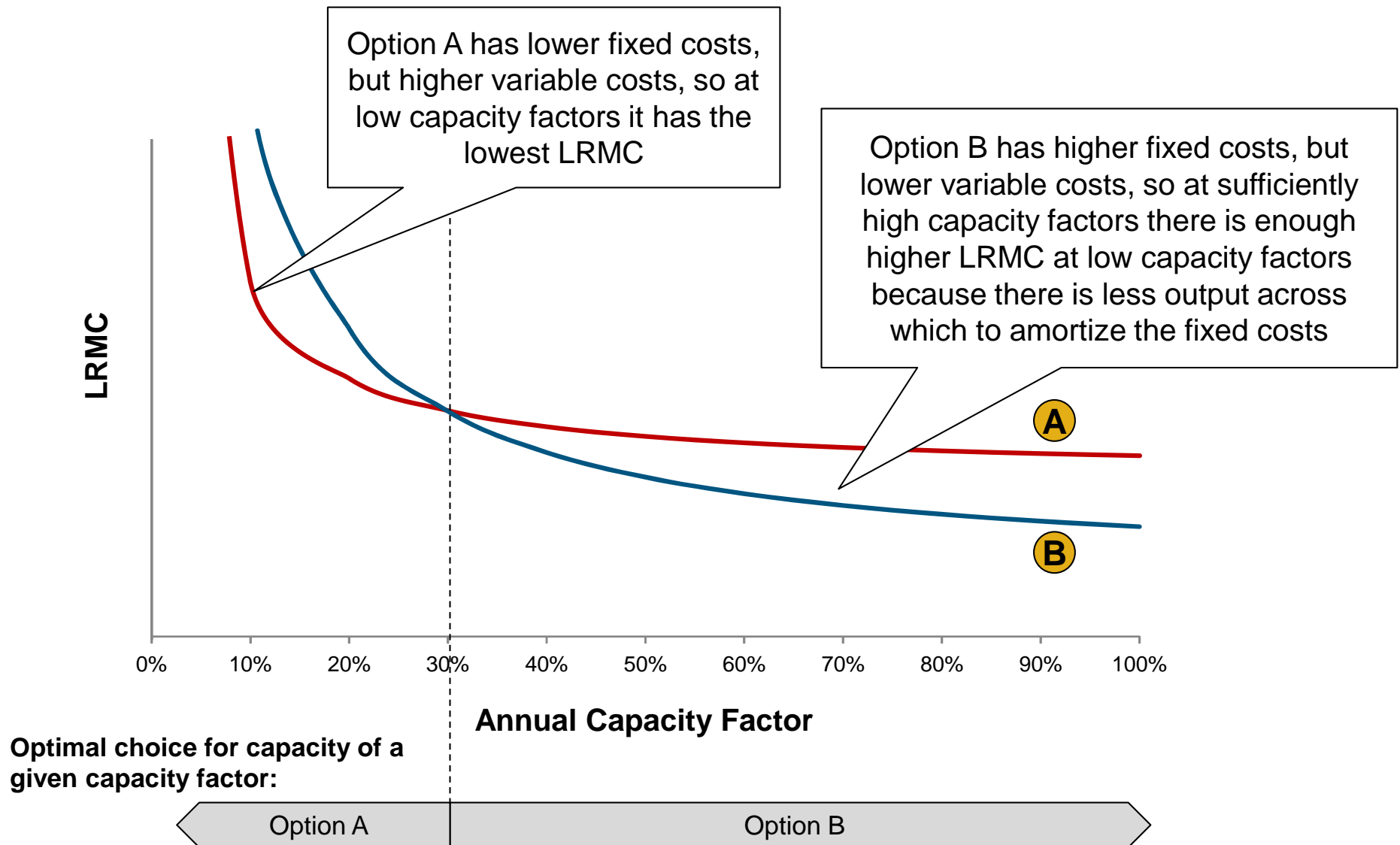
# We analyze the benefits of diversity using a value-based framework



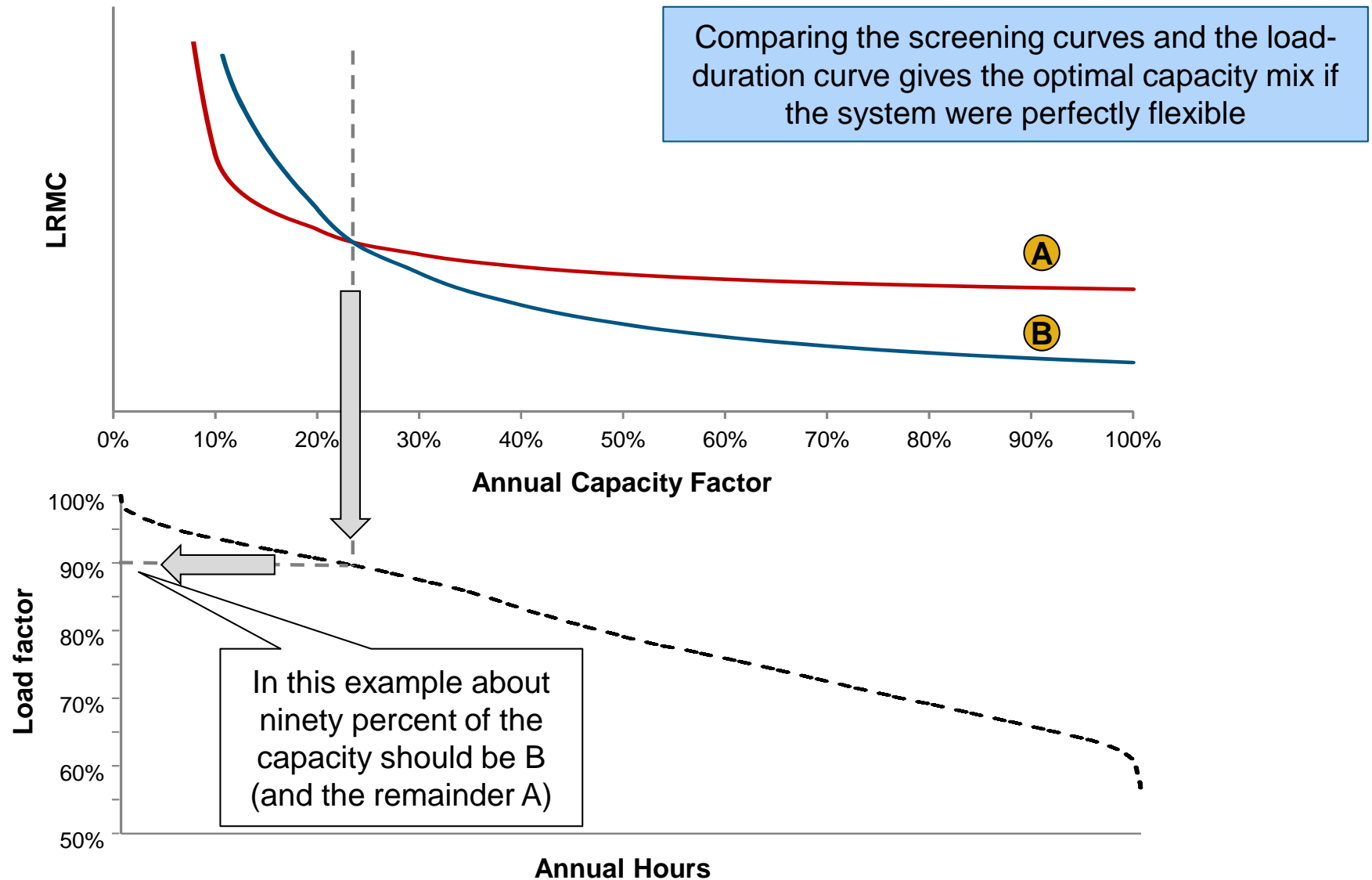
# The benefits of diversity arise from risk reduction – and valuing risk reduction demands an underlying uncertainty framework



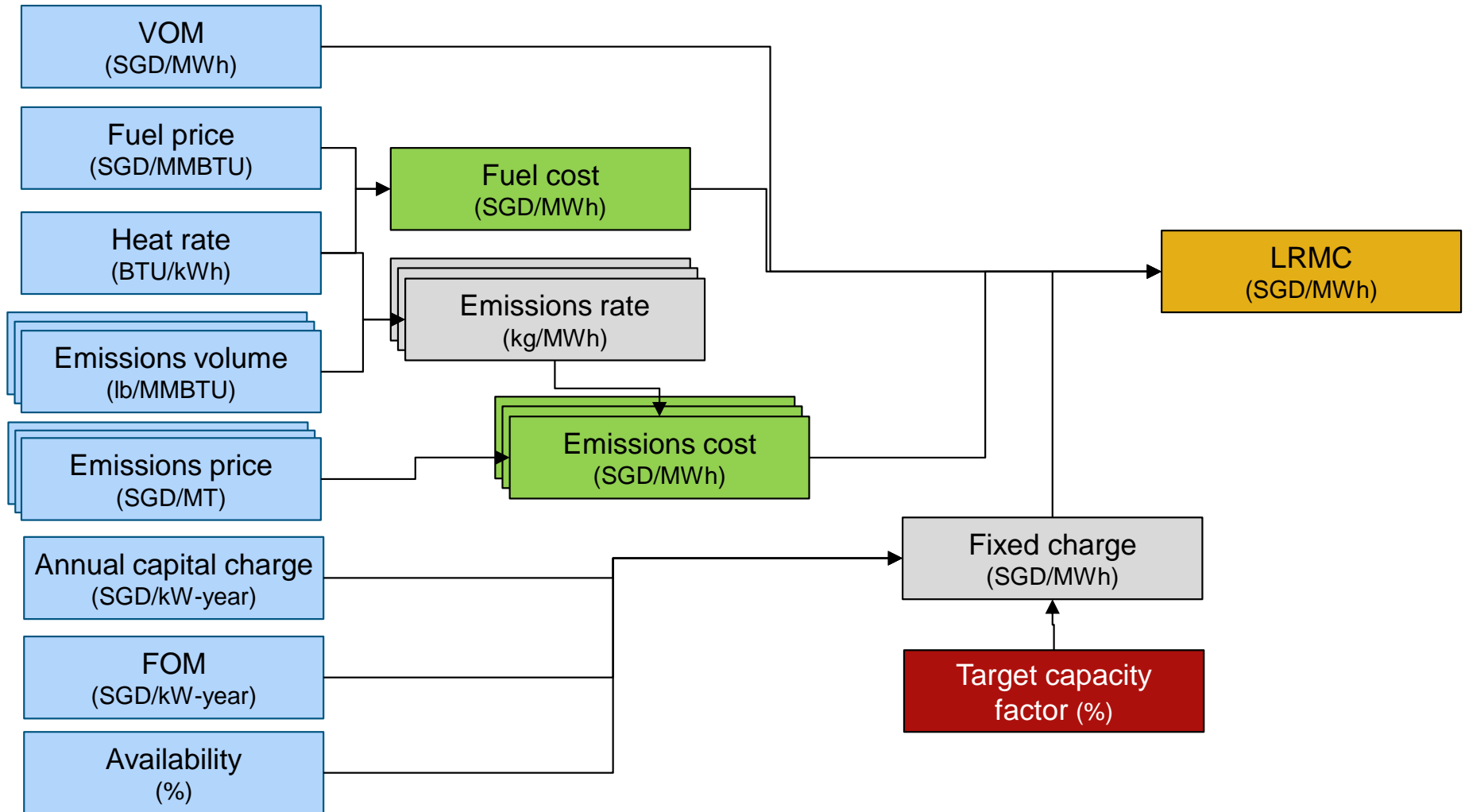
# We can analyze the impact of uncertainty on future technology choice via a “probabilistic screening curve” analysis



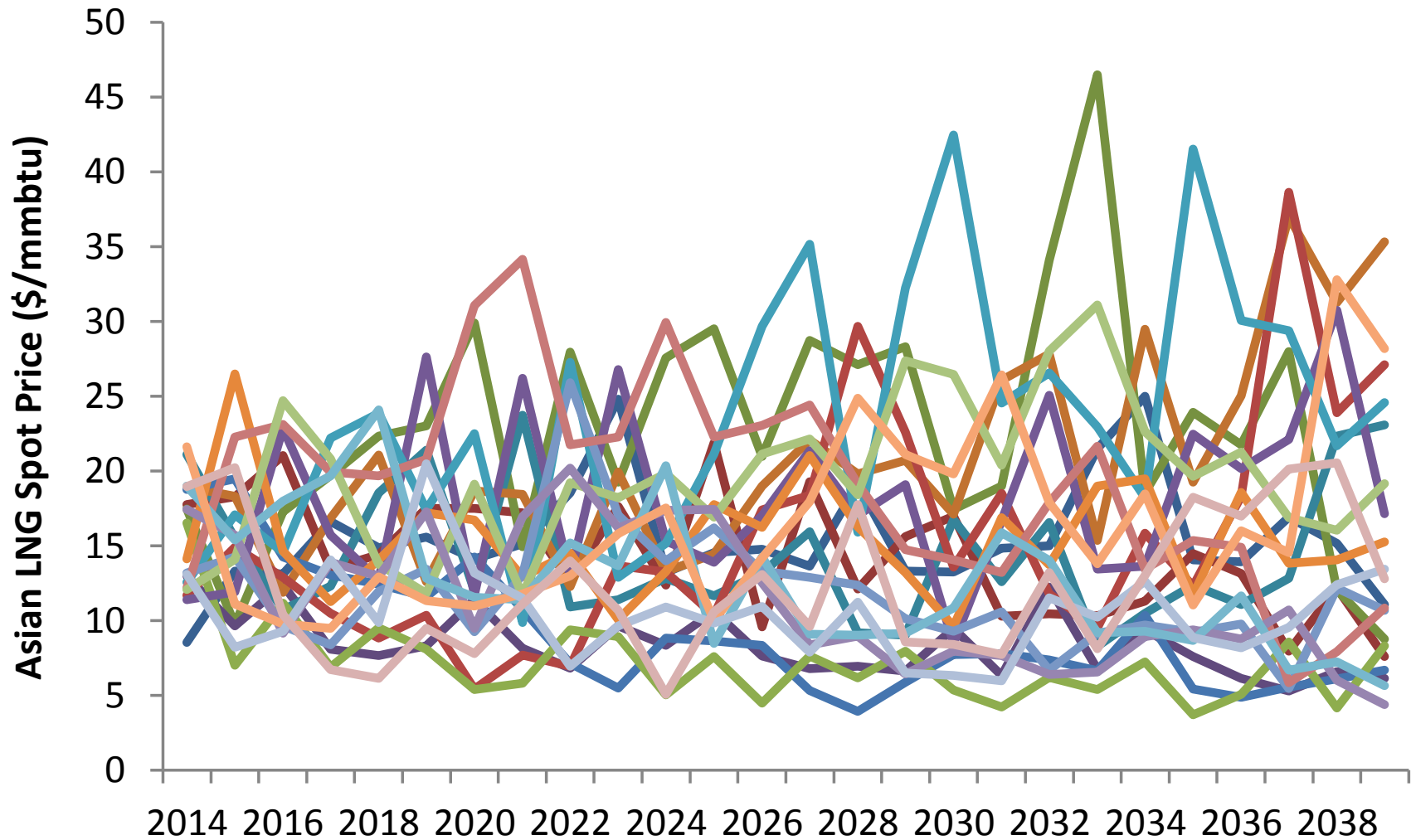
The cross-over in the screening curves determines the capacity factor at which one technology will yield to another – and thereby the optimal capacity mix



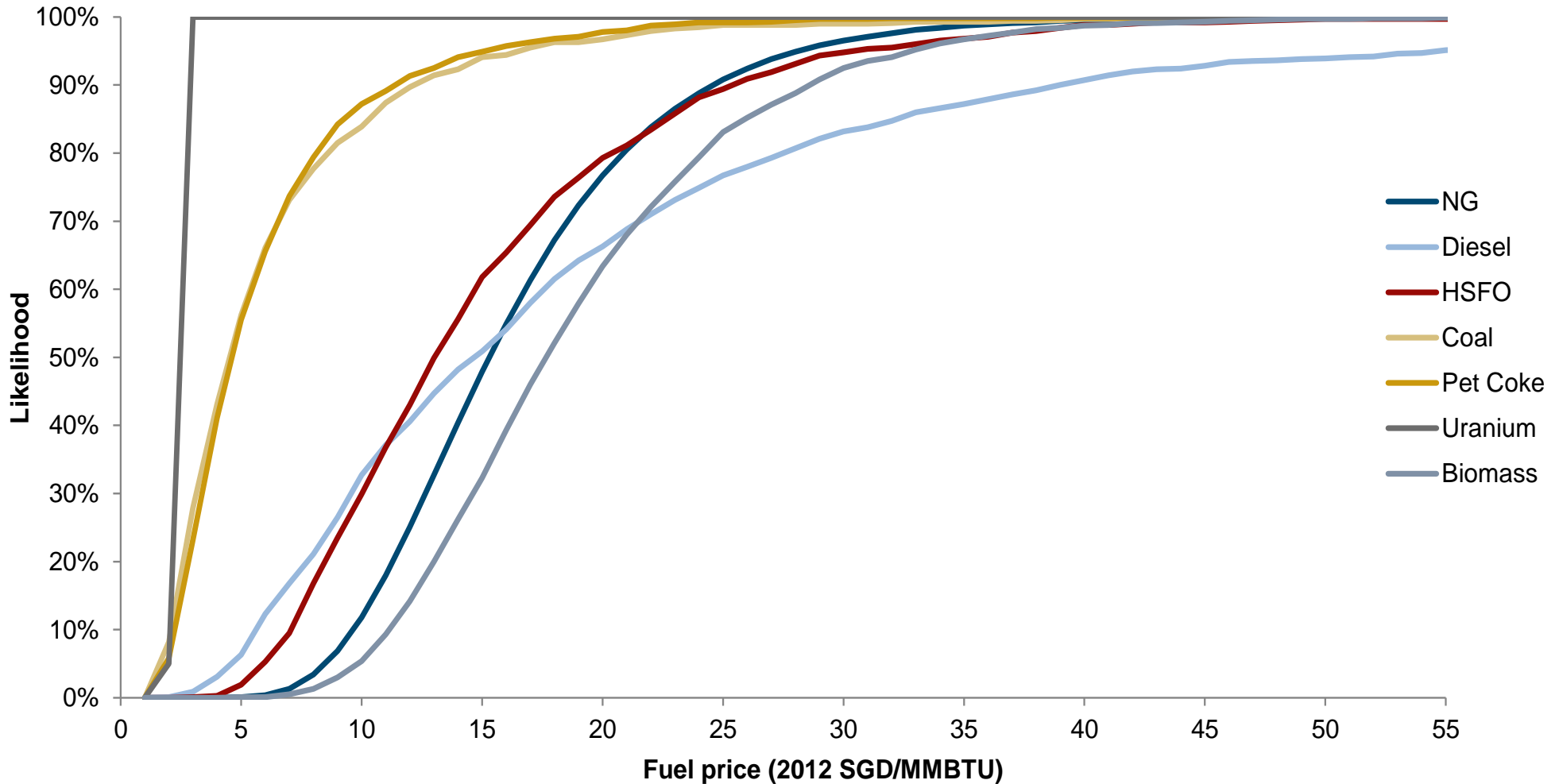
Since the screening curve is looking at capacity expansion, the economic choice between technologies is based on long-run marginal cost



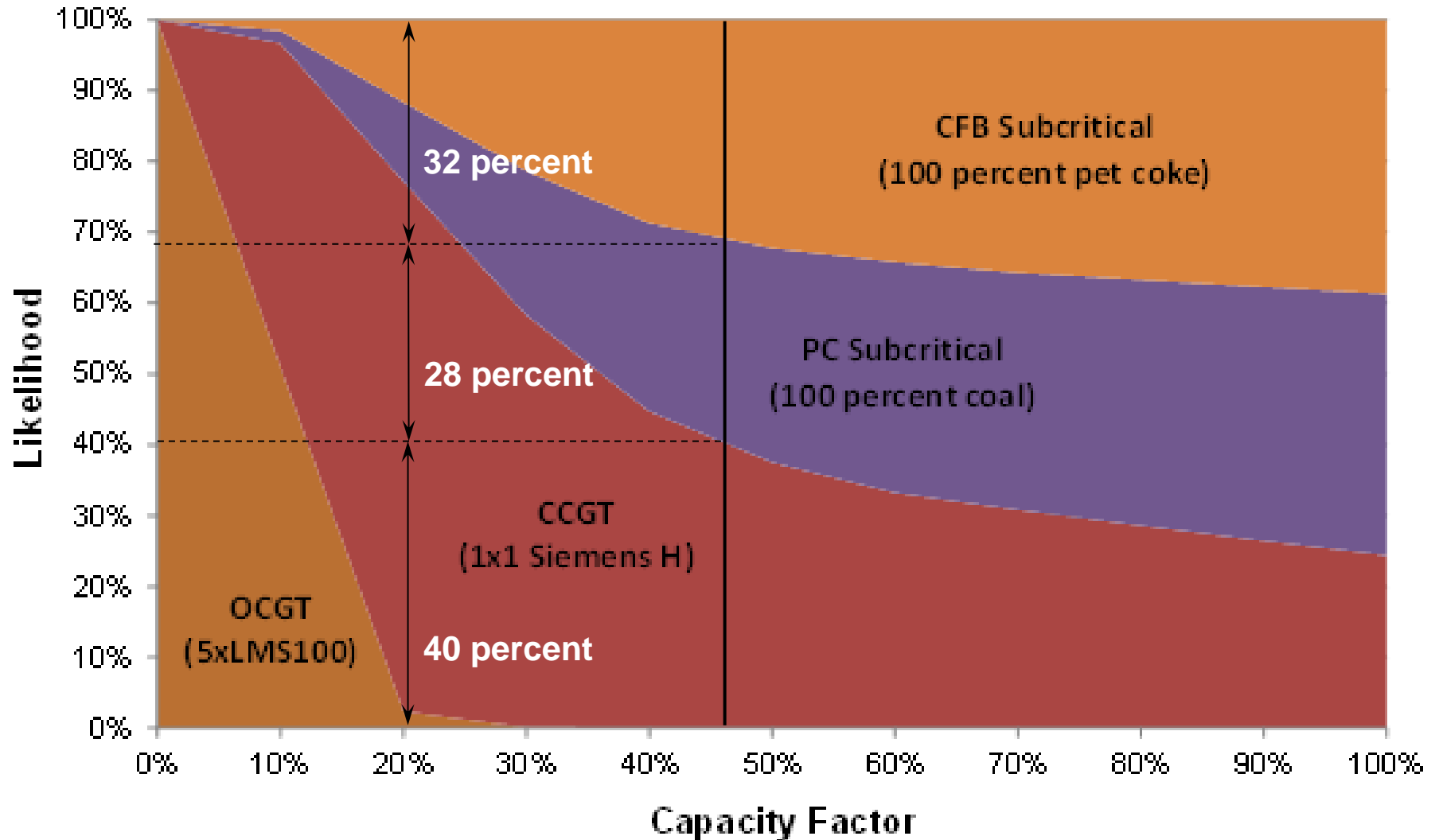
We then “drive” the screening curve analysis with representative fuel price and technology cost/performance scenarios that span the range of possibilities



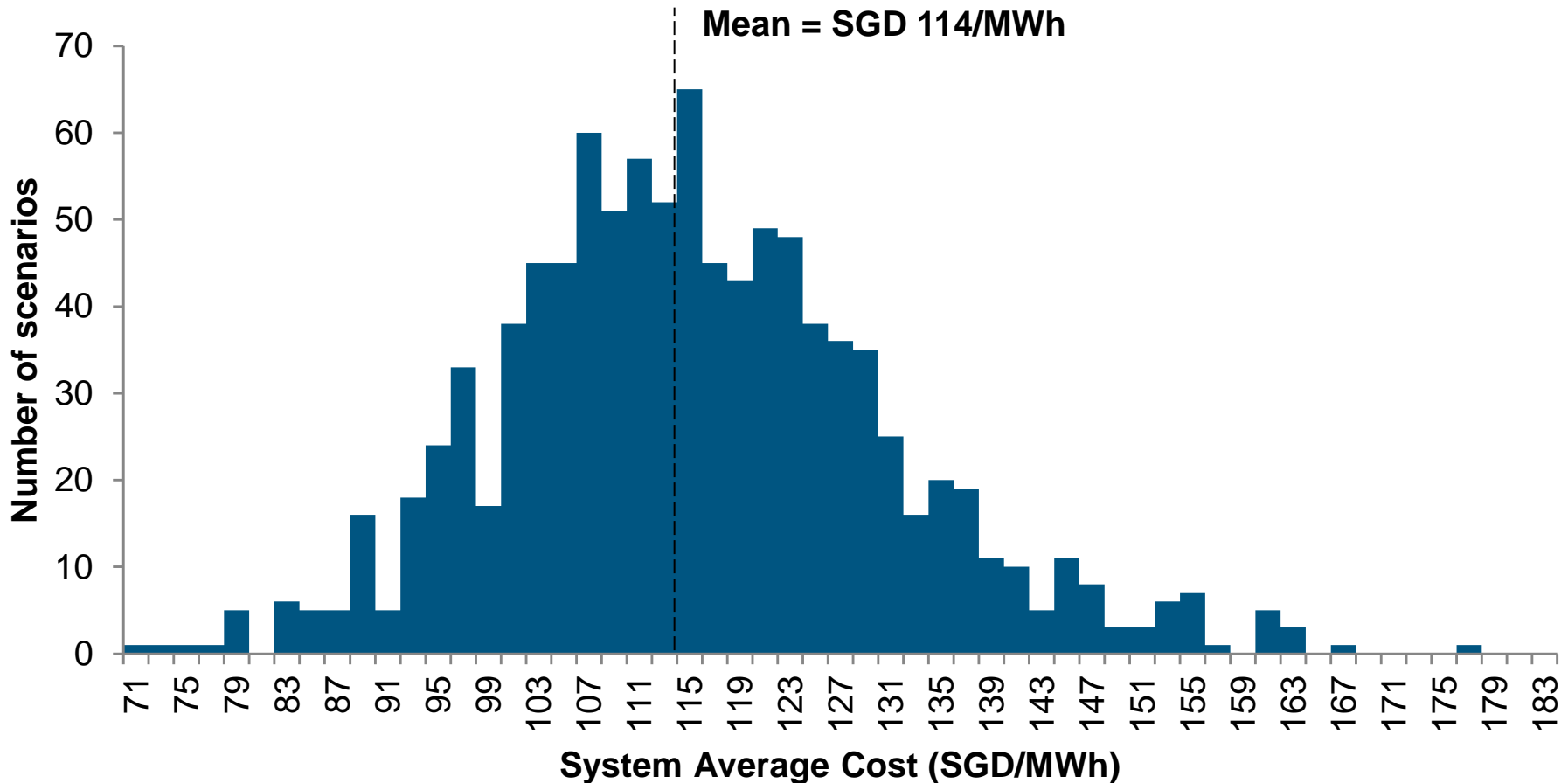
If we look at a “time slice”, these scenarios imply cumulative distributions on the various fuel prices



This structure yields a probabilistic optimal mix in which each technology has some likelihood of being the least-cost unit (at a given capacity factor)

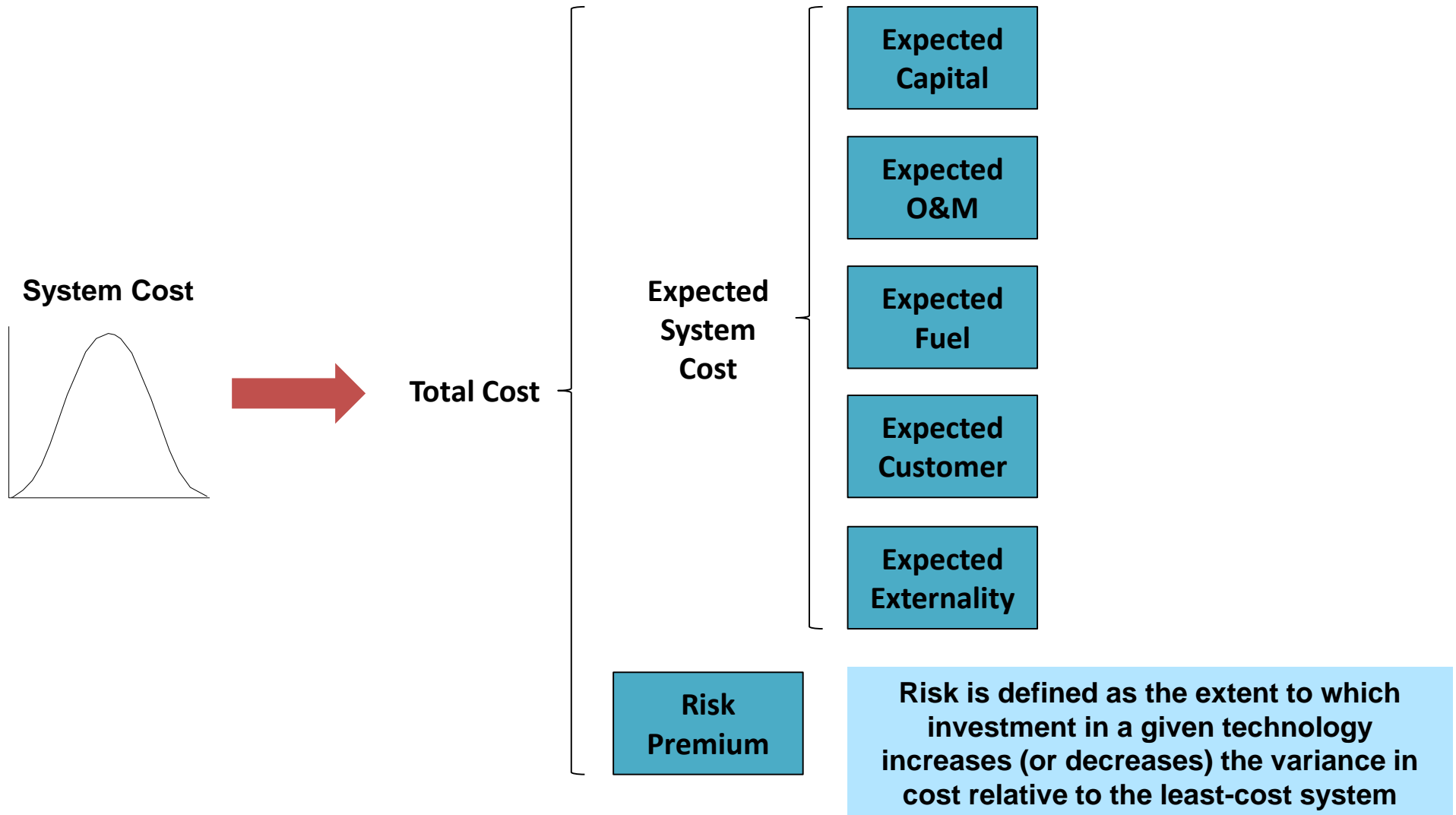


The system average cost for the incremental capacity is lowered by strategic flexibility – the opportunity to harness the least-cost mix of technologies/fuels

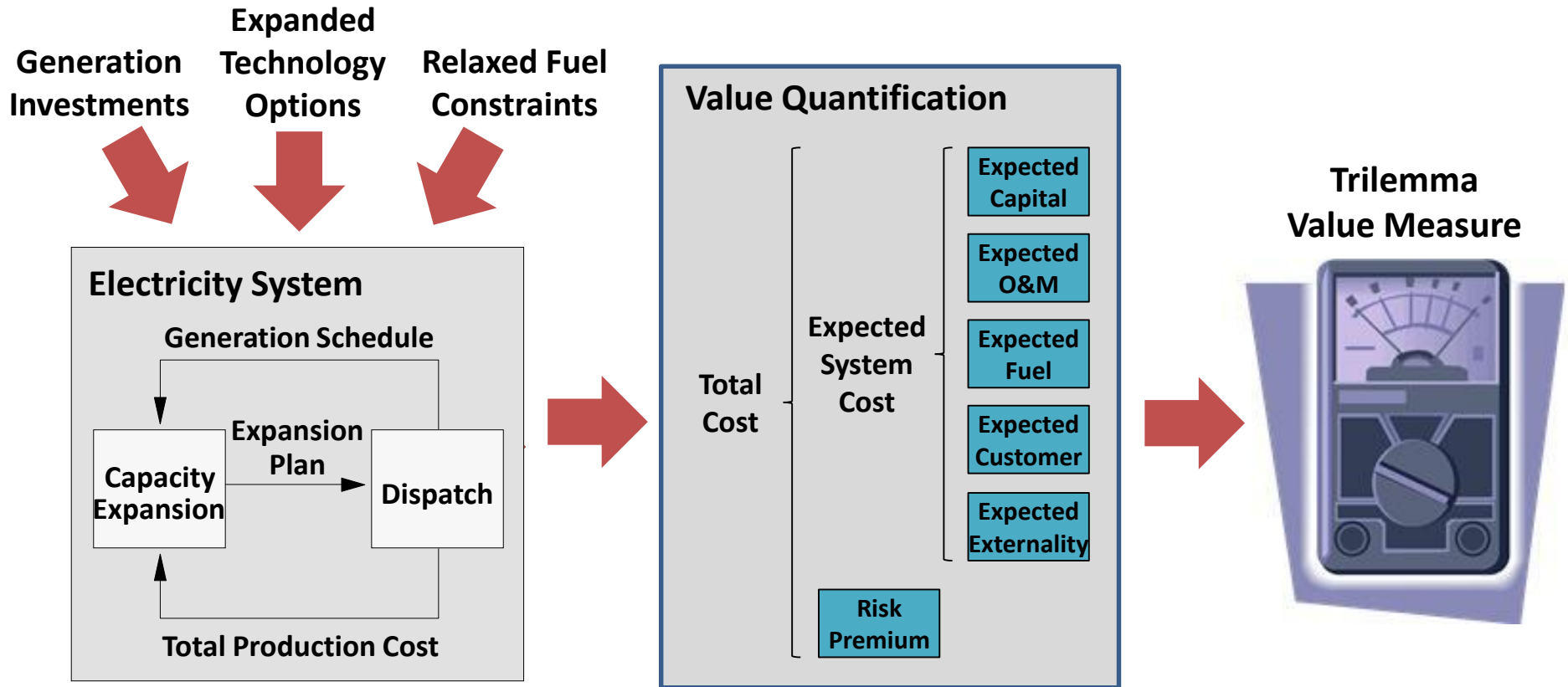


*The next step is to integrate this probabilistic capacity expansion with the existing system*

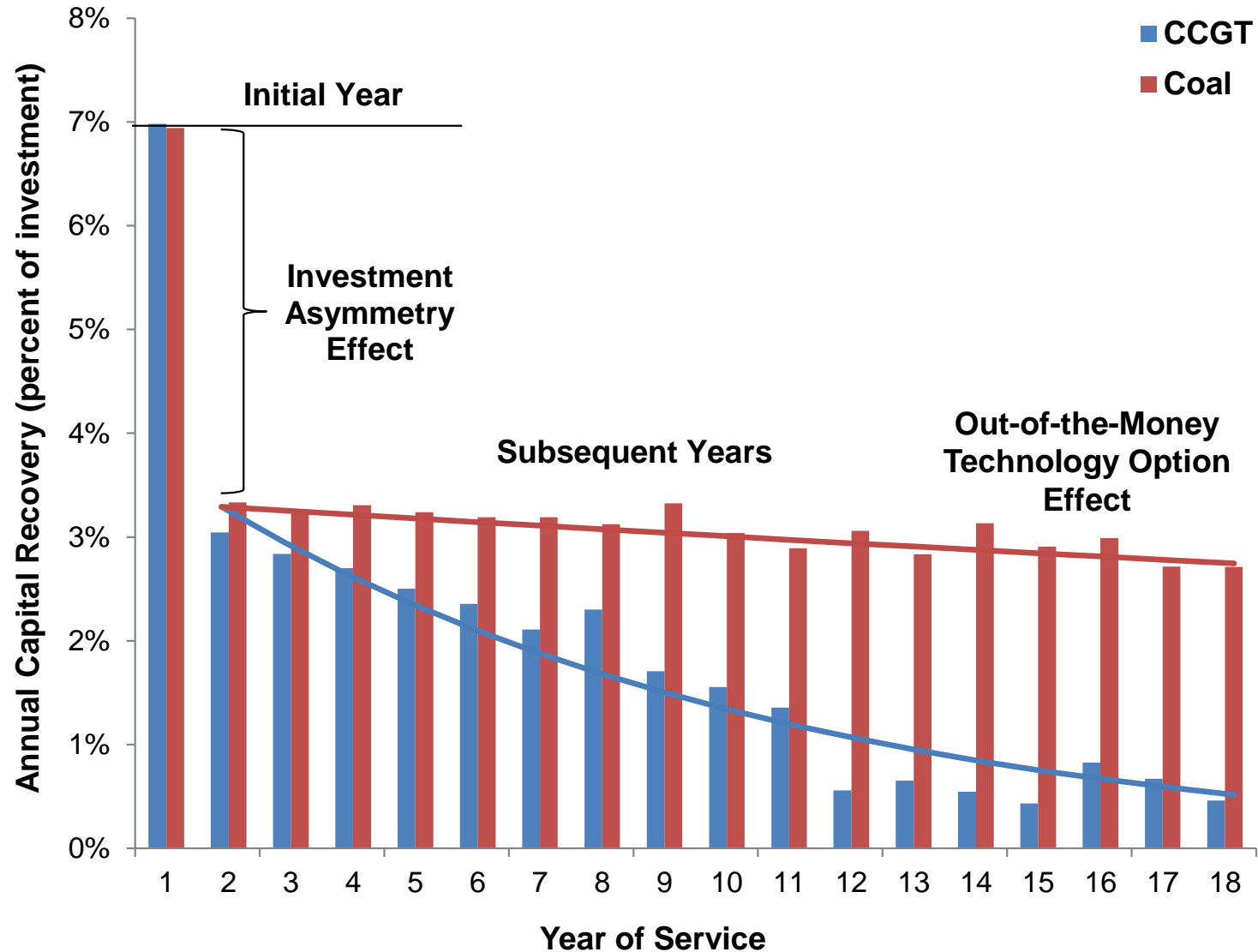
The consideration of system cost uncertainty adds an additional component to the total cost measure – the risk premium, or willingness to pay to avoid risk



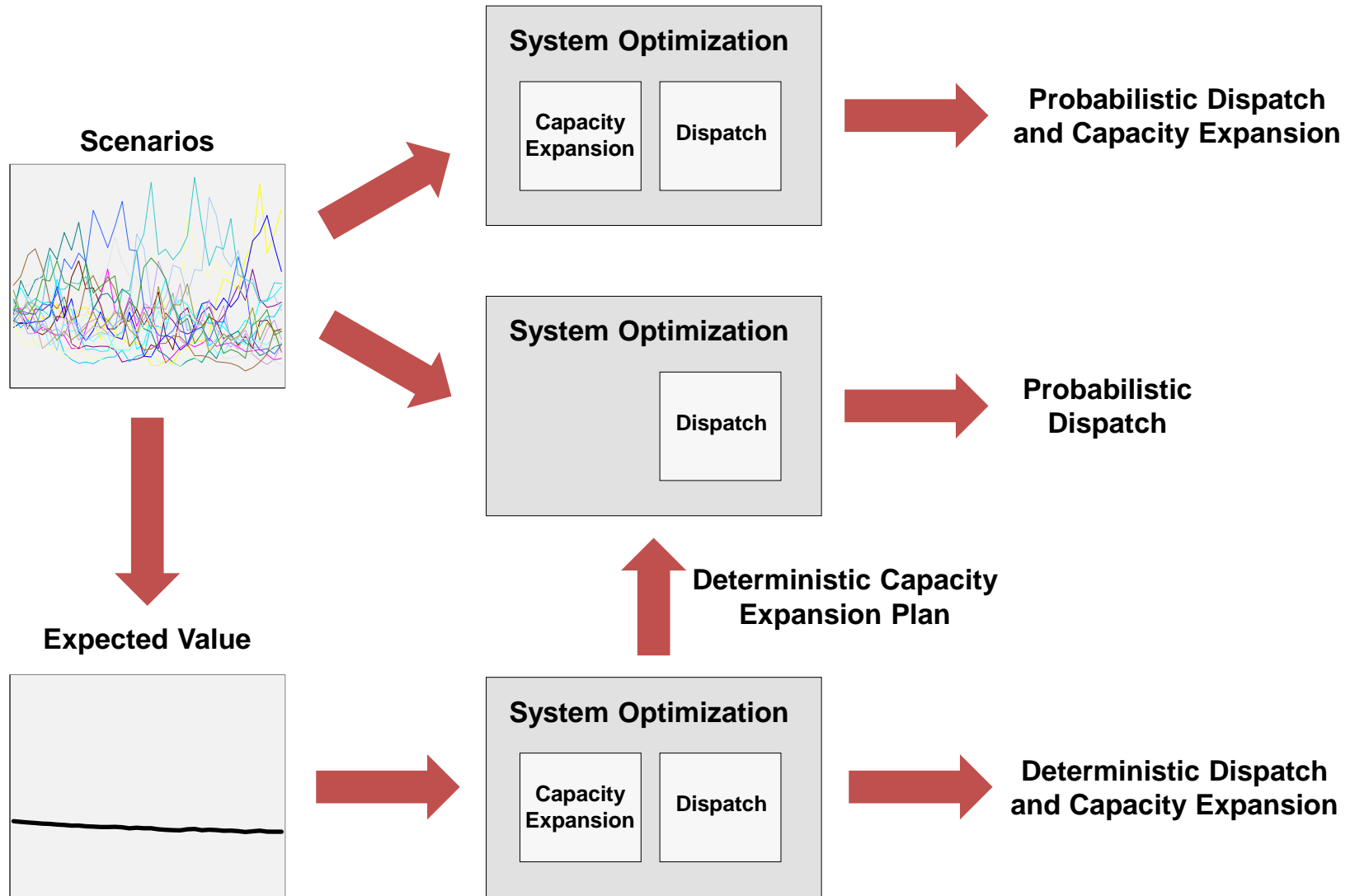
The available technology options and existence of fuel constraints affects the extent of future strategic flexibility – and thereby the expected total system cost



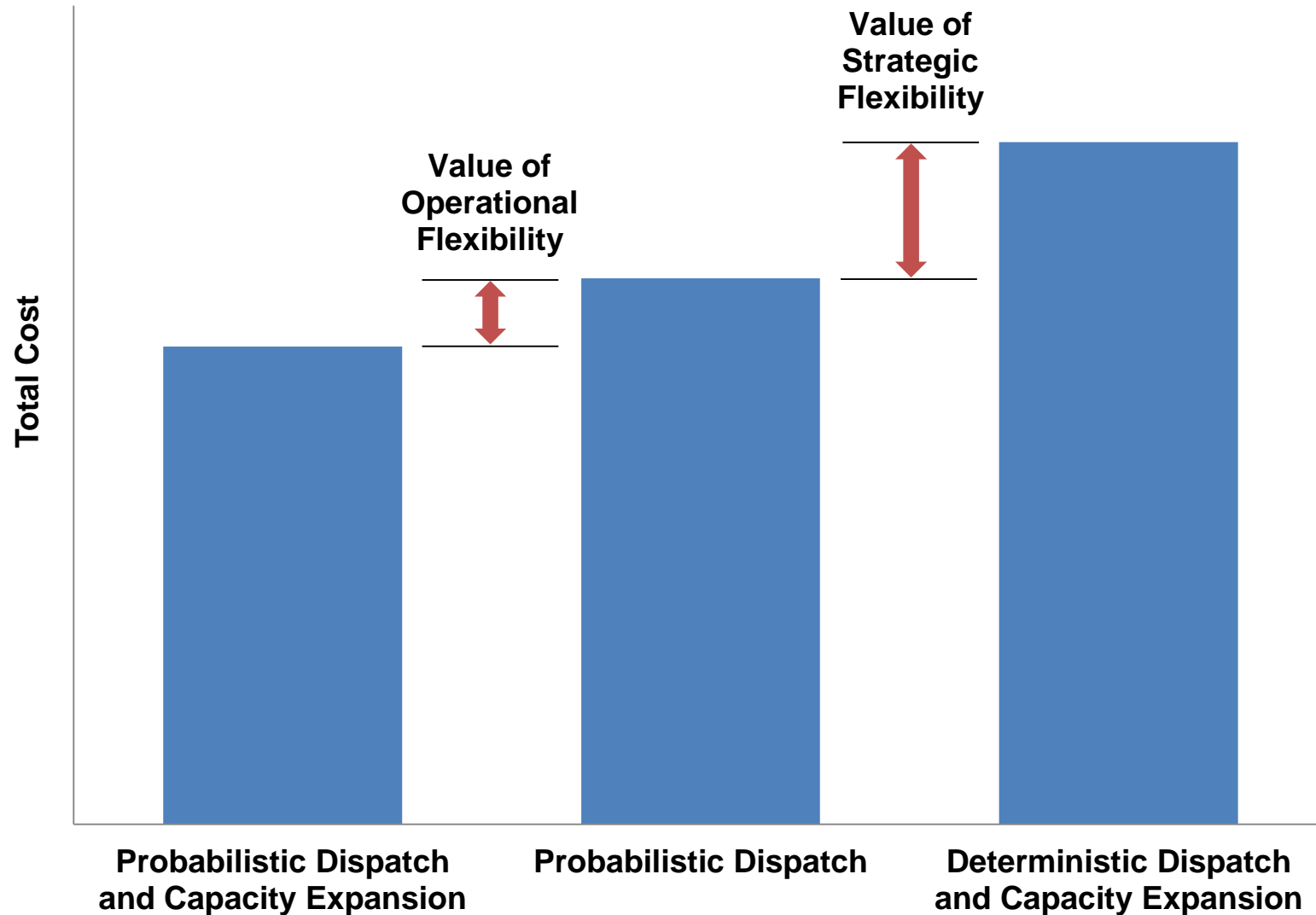
This probabilistic capacity expansion must account for the impact of “investment asymmetry” and “out-of-the-money technology options”



Given this probabilistic engine, we can determine the value of dispatch and strategic flexibility



In general, strategic flexibility has far more value to an electricity system than dispatch flexibility

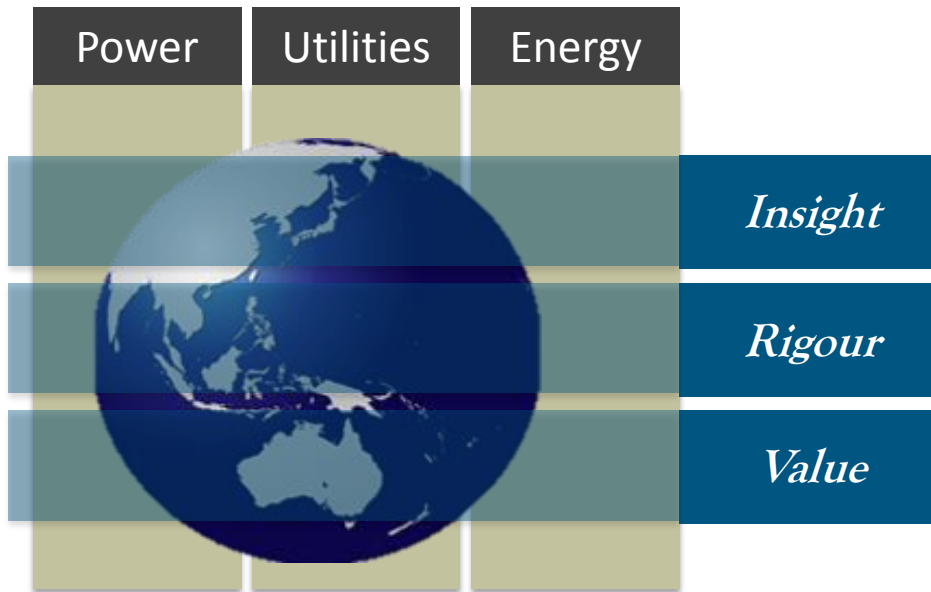


## Implications of Trilemma value framework

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- Expanding the opportunity to profit from strategic flexibility has great value
  - Investments in infrastructure that expand the scope of technology/fuel options are valuable
  - But long-term take-or-pay contracts that force utilization of such infrastructure reduces strategic flexibility
  - Policies that create non-market constraints – such as carbon caps that preclude the use of international offsets – limit strategic flexibility
  - High-capital, low-variable cost investments offer fewer opportunities for the overall system to gain from strategic flexibility
- By itself, diversity has relatively little value
  - Incremental dispatch flexibility associated with diversity has relatively little value given existing fuel price expectations in SE Asia
  - Strategic flexibility can capture much of the long-term potential dispatch flexibility
  - The value of “portfolio diversification” appears to be small (on the order of a few percent of capital cost) relative to differences in long-run marginal costs
  - Hedging mechanisms exist that do not require investment in diverse resources..

# Thank You!



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