Valuing Energy Security –

Quantifying the Benefits of Operational and Strategic Flexibility

Tom Parkinson

4 October 2013

THE LANTAU GROUP
strategy & economic consulting

We at The Lantau Group are experts in the economics of energy systems

THE LANTAU GROUP
strategy & economic consulting

- Asia Pacific Energy Experts
- Competition, Markets, Regulation
- Economic Consulting | Testimony
- Market Analysis | Asset Valuation
- Business & Regulatory Strategy

The founding partners of TLG first worked in the Asia Pacific region as part of Putnam, Hayes & Bartlett (PHB) and later with Charles River Associates

Overview

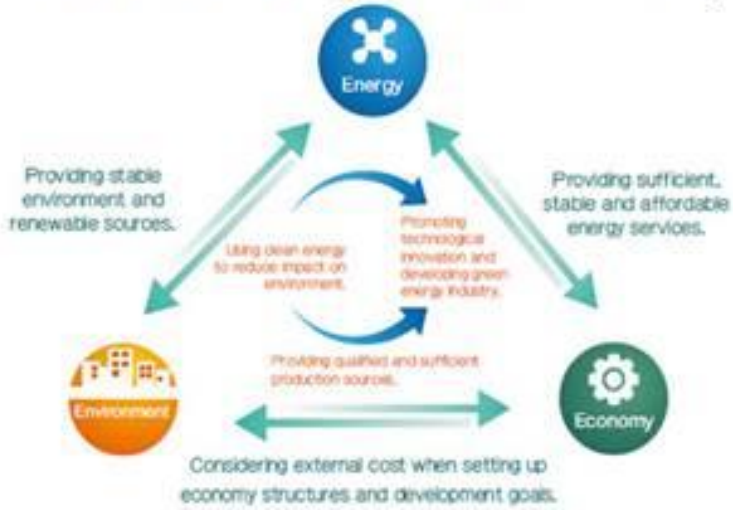
1. **What exactly is energy security?**
2. Is fuel diversity valuable?
3. Is strategic flexibility important?

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

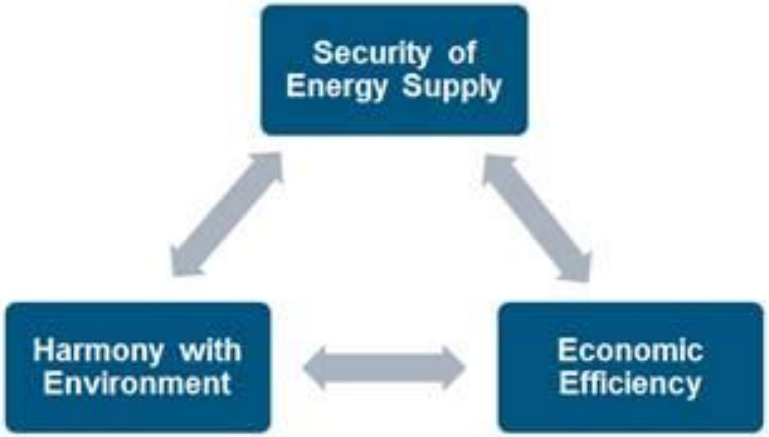
Malaysia's three principal energy objectives

Singapore's energy policy objectives

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



Japan's Energy Policies: 3Es



THE LANTAU GROUP
strategy & economic consulting

The concept of energy security is seemingly simple…

An electricity system that embodies a high degree of energy security will be resilient to exogenous physical and financial disruptions

But what can we do to increase energy security… and what is the value of doing so?

So much has been written on the topic of ‘energy security’ – but so little of it is useful policy guidance

10 percent

Attempts to provide useful policy guidance

10 percent

90 percent

90 percent

Attempts to quantify “energy security” so as to rank countries

THE LANTAU GROUP
strategy & economic consulting

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)
Short-Term	• Technical failure • Extreme weather events • Political disruption	• Supply disruption • Cartel production quota
Long-Term	• Resource depletion • Resource nationalization • Policy/regulatory failure	• Fuel price shifts • New technologies

THE LANTAU GROUP
strategy & economic consulting

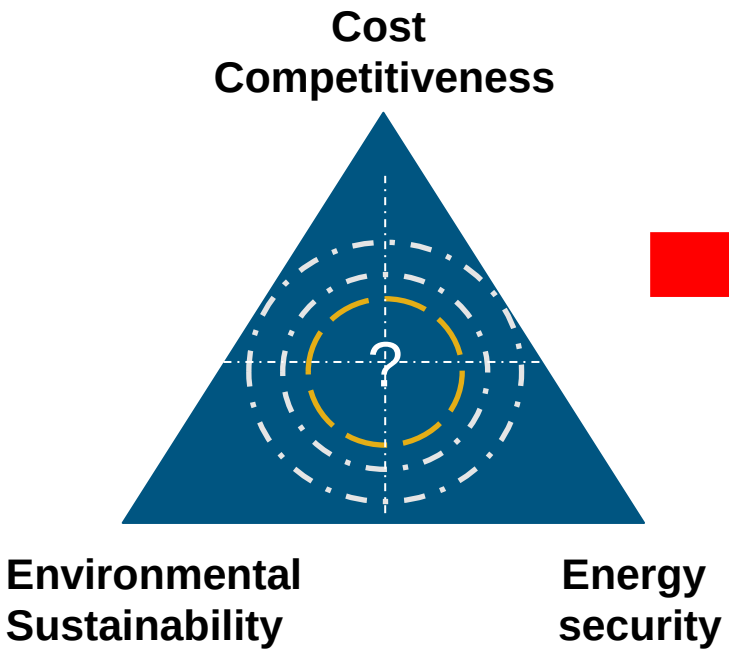
Each class of risk can best be managed via different strategies

Energy Security Risk Matrix	Physical (supply shortfall)	Financial (high prices)
Short-Term	• Physical redundancy • Supplier diversity	• Bilateral contracts • Hedging instruments
Long-Term	• Prudent planning • **Clear policy guidance**	• **Clear policy guidance** • **Strategic flexibility**

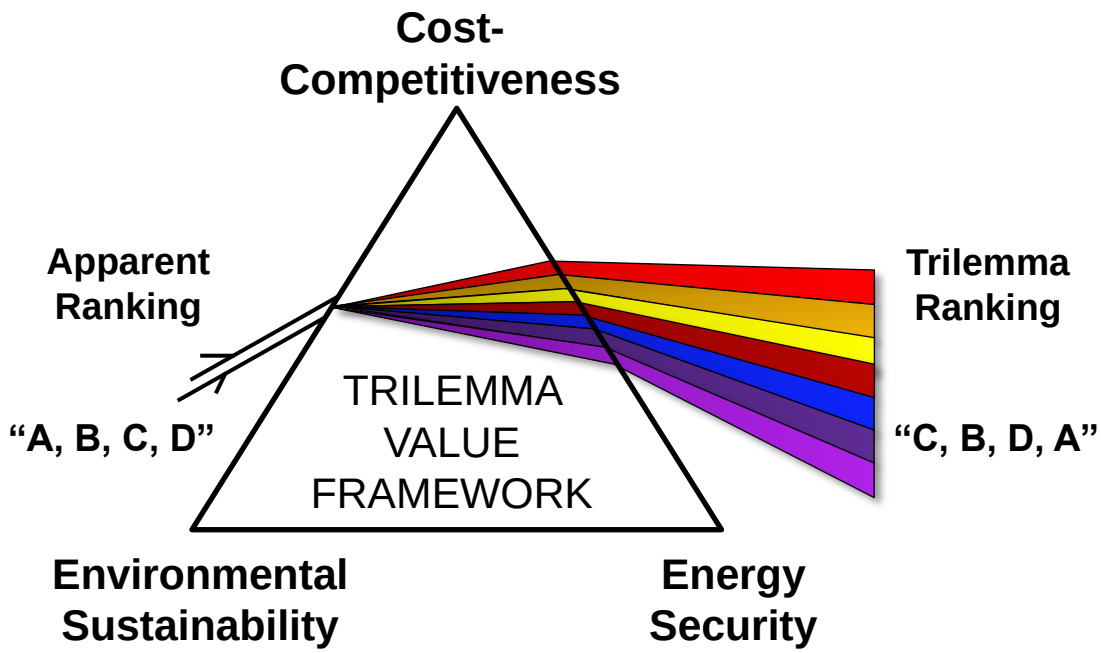
THE LANTAU GROUP
strategy & economic consulting

Clear policy guidance requires a value-based framework

From Ambiguous Triangle



To Clarifying Prism



But this requires an approach to valuing energy security

Overview

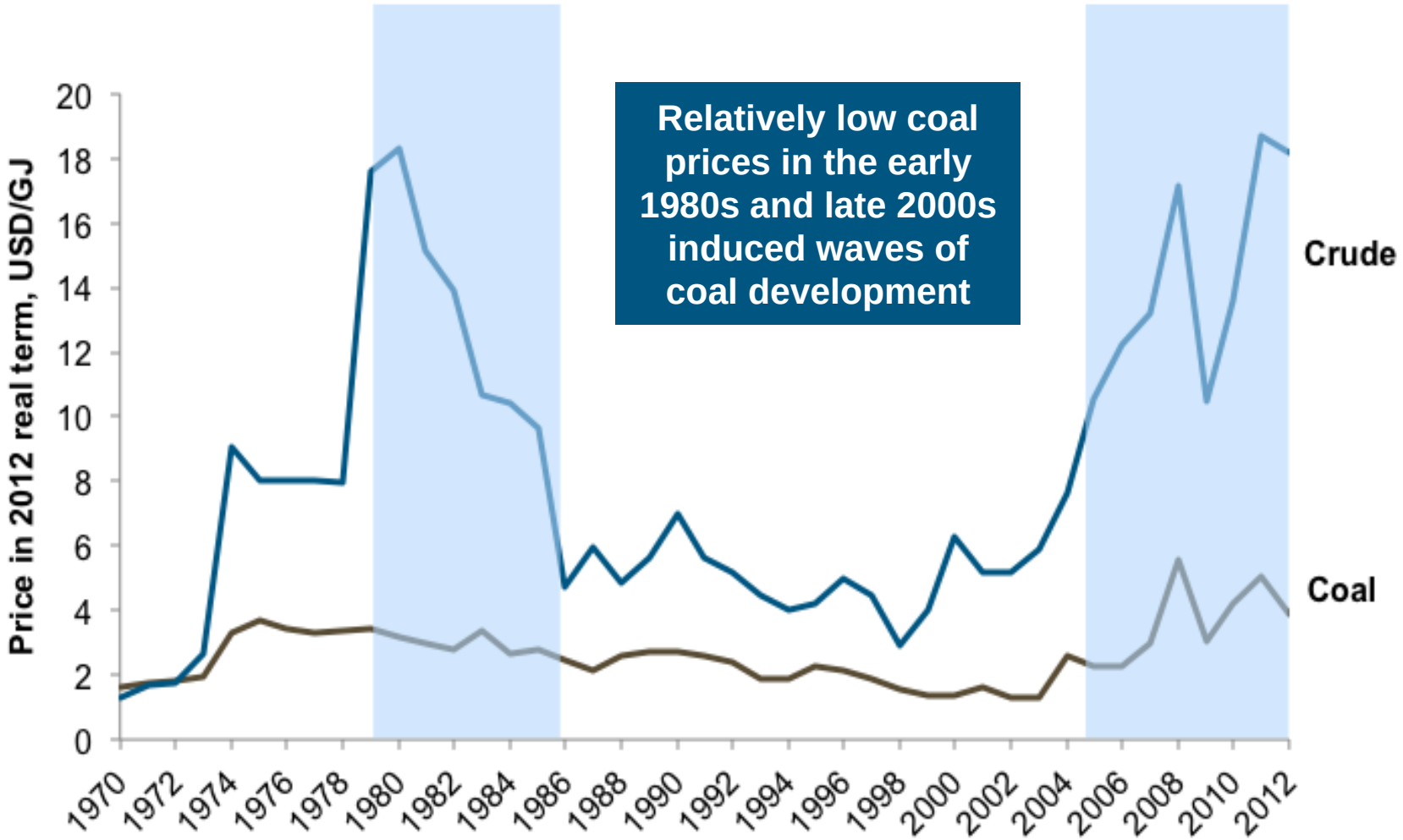
1. What exactly is energy security?
2. **Is fuel diversity valuable?**
3. Is strategic flexibility important?

THE LANTAU GROUP
strategy & economic consulting

Much of the energy security literature is intertwined with discussions of "diversity" – but diversity itself is not a source of value

- 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 operational (dispatch) flexibility – that is, the ability to burn the least expensive fuel at any time
  - Reaping operational flexibility benefits requires that fuel prices be free to float and quantities variable (that is, no binding take-or-pay constraint) 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
- Separately, physical redundancy or supplier diversity can offer value through lower probabilities of physical failure

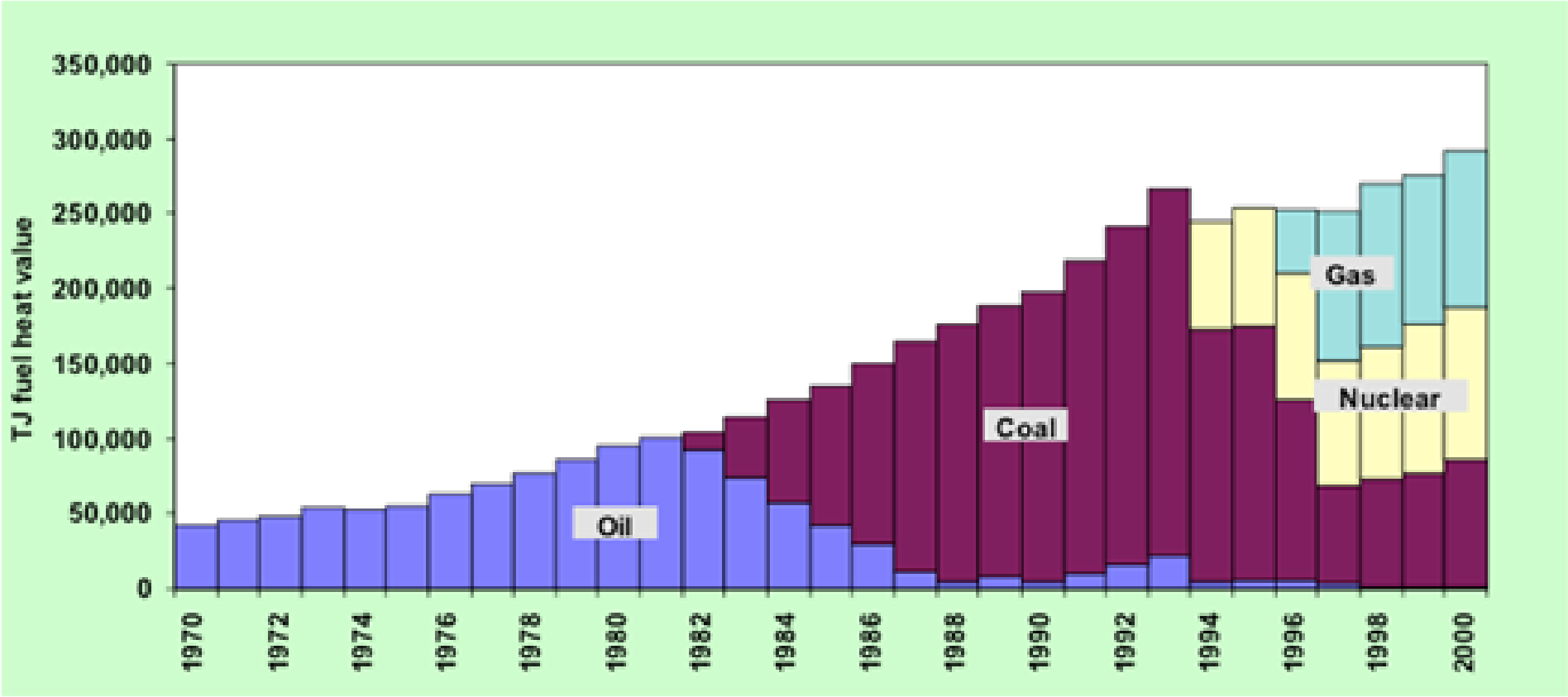
Diversity advocates point to fuel-diverse systems as examples of good public policy – but fail to recognize that diversity often results from strategic flexibility



Note: Crude price: 1970 - 1987:Arab Light Crude prices ; 1988 - 2012: Brent price (historical Brent price only starts from May 1987)
Coal price: 1970 - 1982: average coal prices in the US from EIA; 1983 - 2012: Newcastle FOB price

THE LANTAU GROUP
strategy & economic consulting

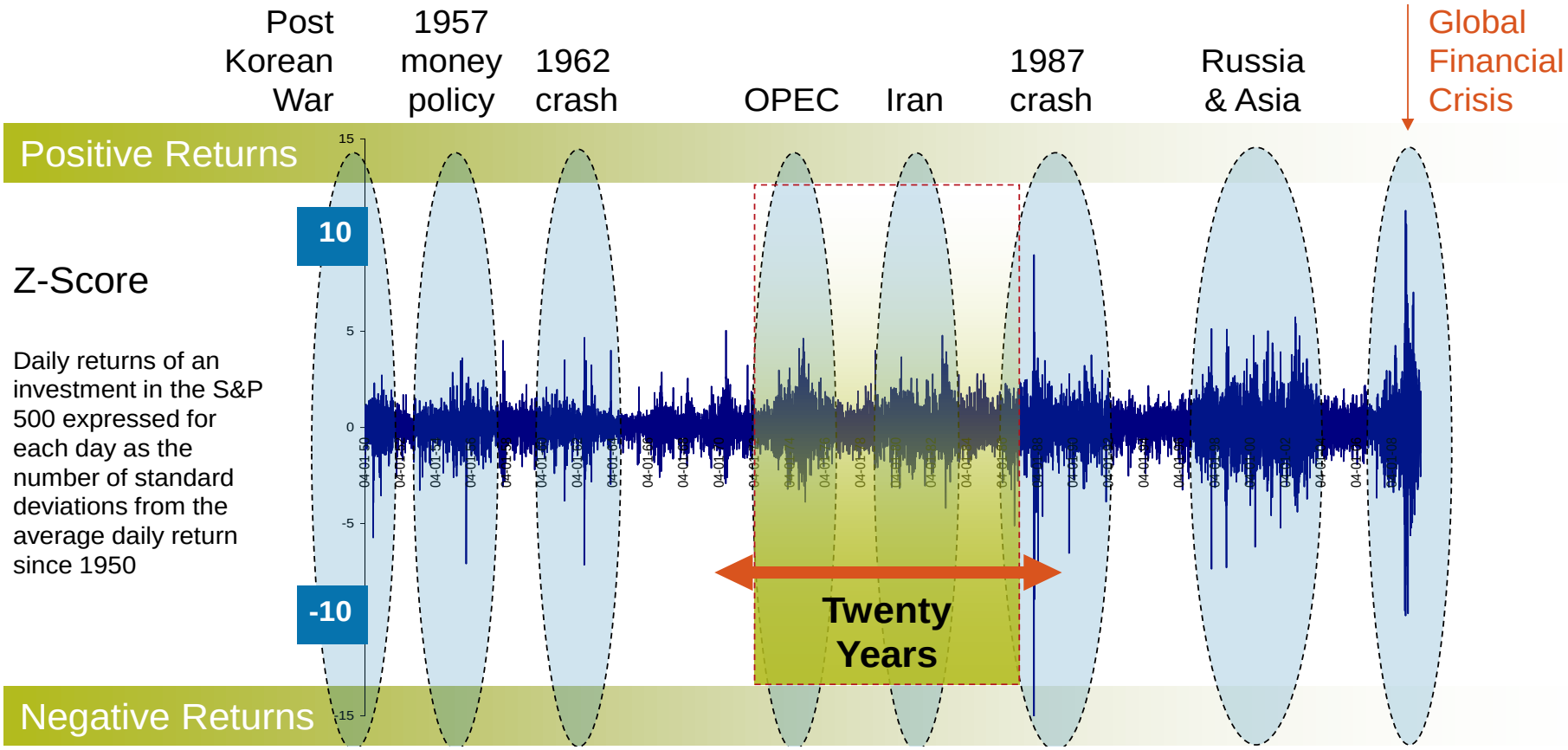
For example, CLP (Hong Kong) has a diverse fuel mix that resulted from a series of purely economic decisions made at various points in time



Fuel diversity could well be an outcome, it should not be a goal

THE LANTAU GROUP
strategy & economic consulting

The relative coal versus crude prices illustrate the impacts of commodity price uncertainty – and stock returns are another good example



Uncertainty is a reality in the market! Good decisions must account for uncertainty…

THE LANTAU GROUP
strategy & economic consulting

This uncertainty gives rise to the value of operational and strategic flexibility

Fuel price changes driven by uncertainty

Other cost changes driven by uncertainty

Changing dispatch decisions (such as merit order) *s.t. system constraints*

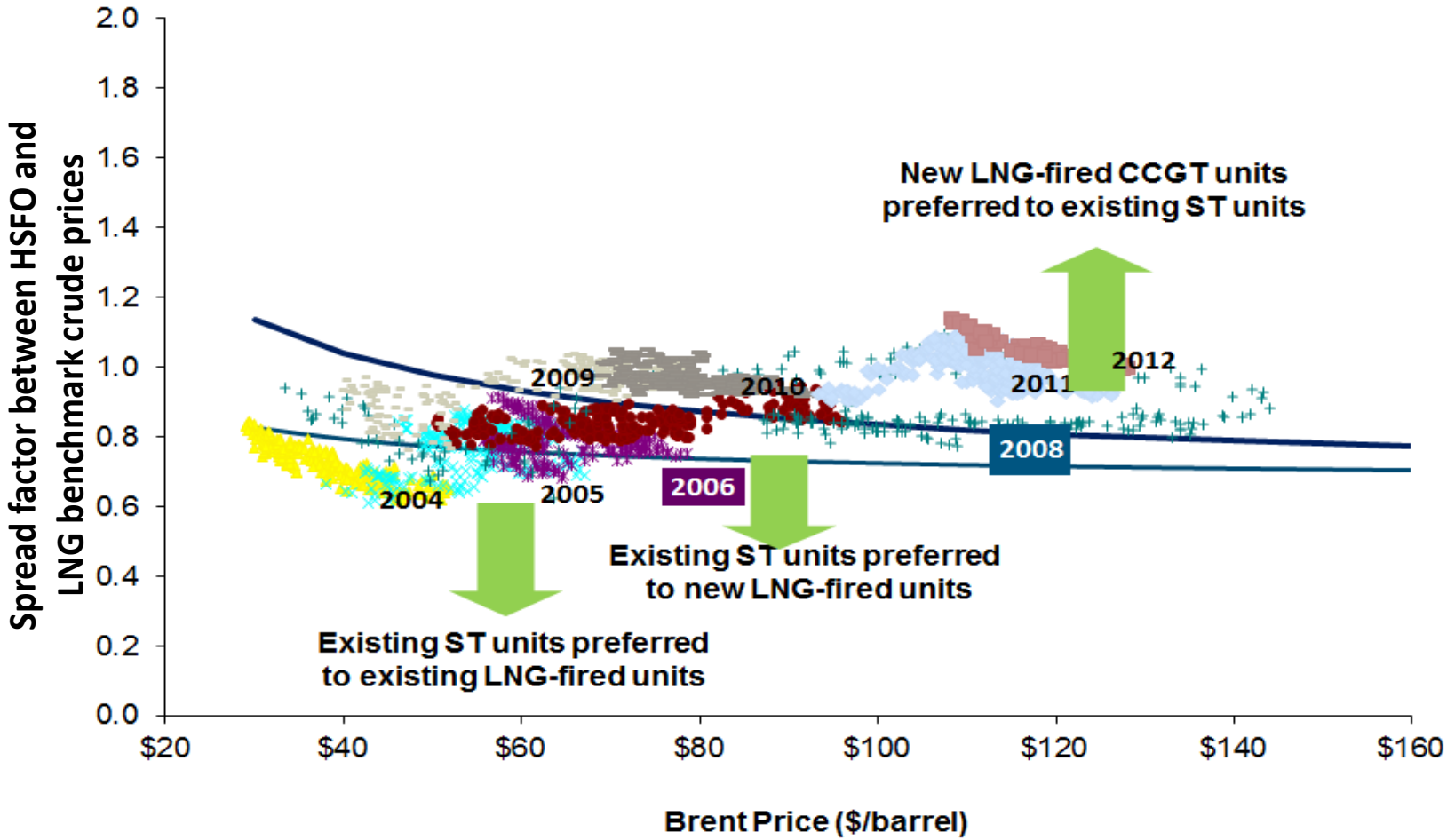
Changing optimal capacity expansion plan *s.t. system constraints*

Operational flexibility

Strategic flexibility

THE LANTAU GROUP
strategy & economic consulting

Strategic flexibility implies that entry decisions accommodate the dynamic fuel markets



THE LANTAU GROUP
strategy & economic consulting

Overview

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

THE LANTAU GROUP
strategy & economic consulting

We analyze the benefits of diversity using a value-based framework, driven by the consideration of system cost uncertainty

Total Cost

- **Expected System Cost**
  - **Expected Capital**
  - **Expected O&M**
  - **Expected Fuel**
  - **Expected Customer**
  - **Expected Externality**
- **Risk Premium**

Traditional System Costs

Customer Cost of Unserved Energy

Shadow Prices of Environmental Externalities

Risk is defined as the extent to which investment in a given technology increases (or decreases) the variance in cost relative to the least-cost system

We actually use two different approaches to analyze the impacts of uncertainty

Probabilistic analysis

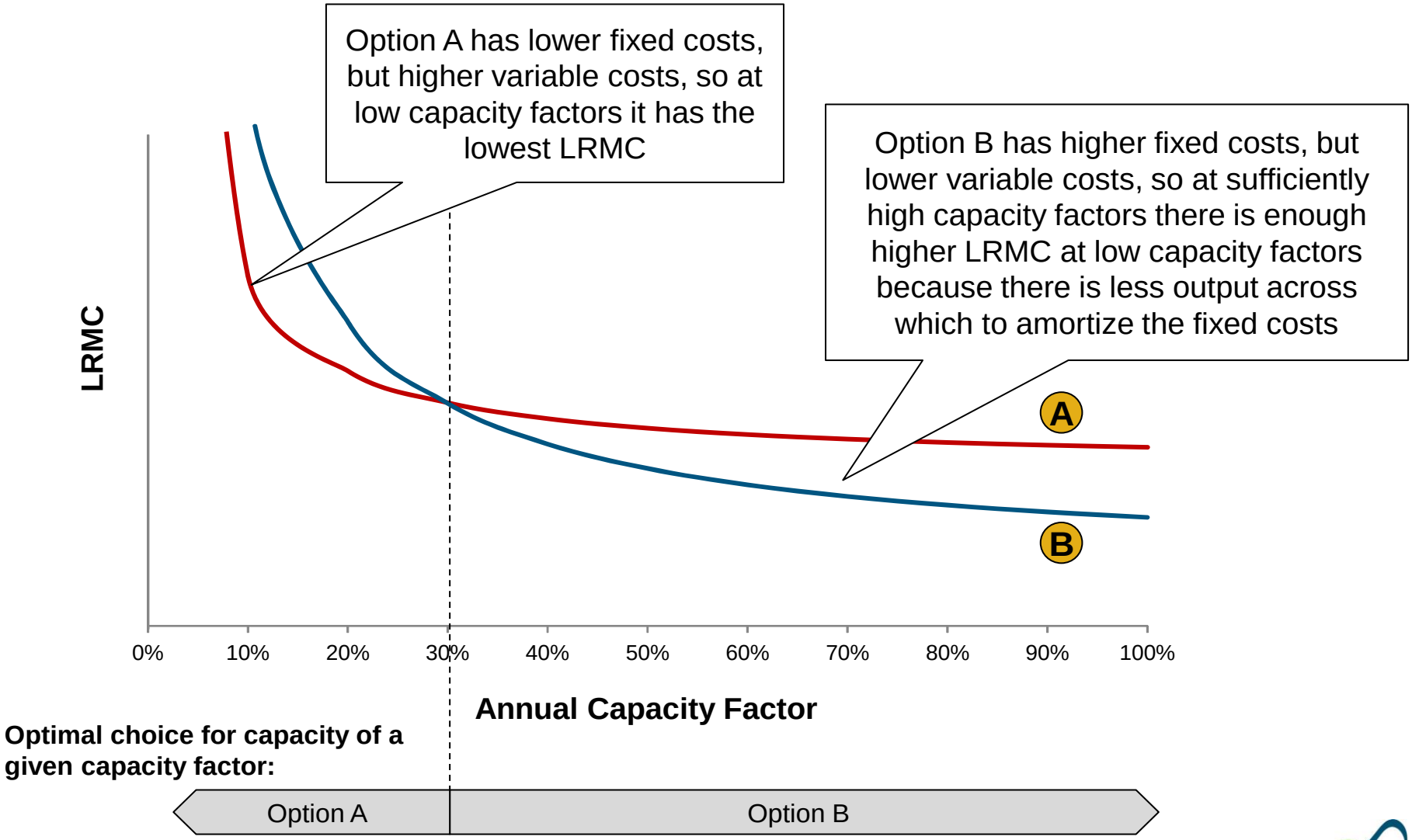
Screening curve analysis

- **Considers uncertainty at a point in time**
- **Easier to analyze and understand**
- **Does not account for existing system**
- **And fails to capture the impact of risk premium and investment "mistakes"**

Stochastic optimization

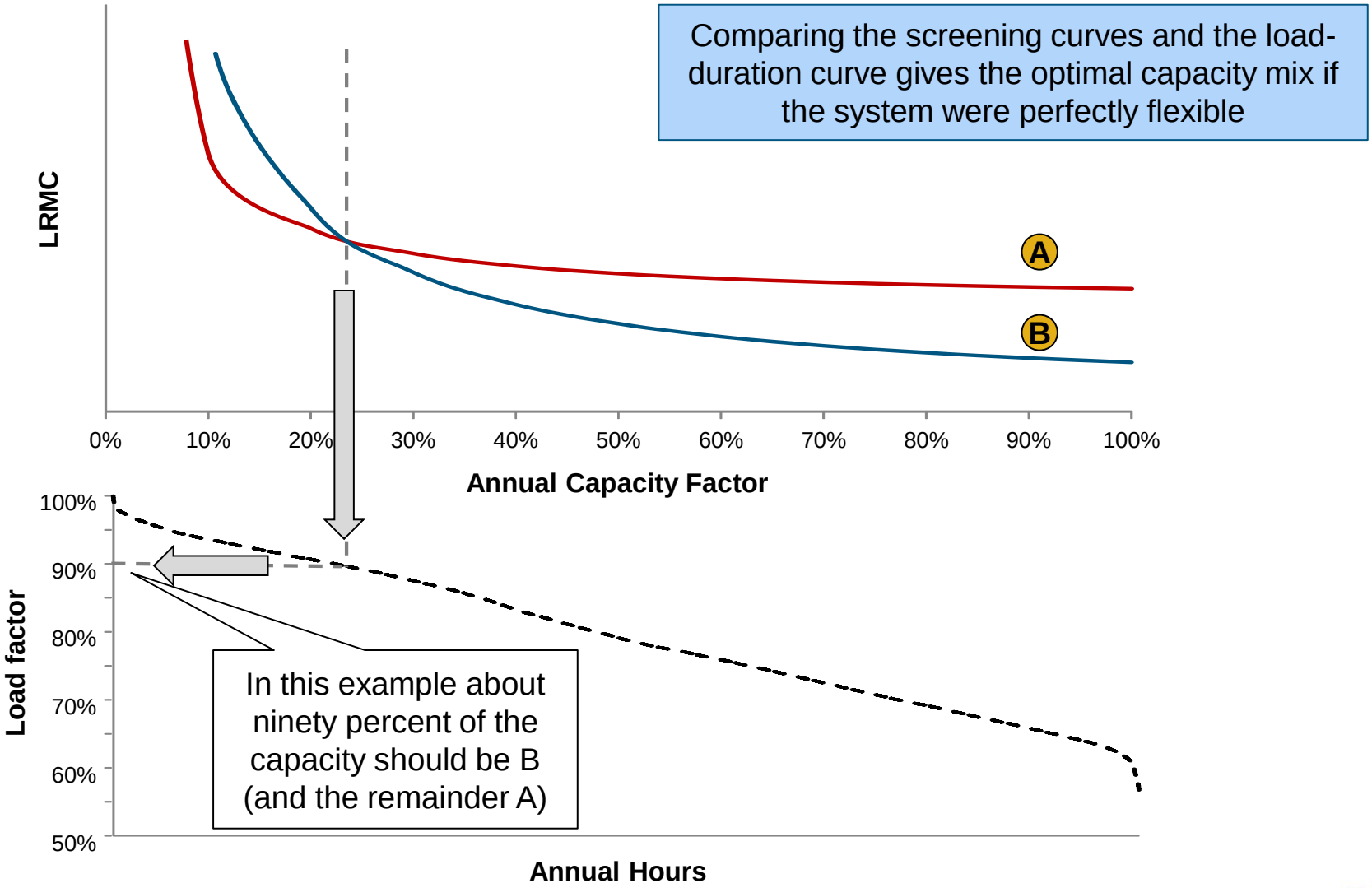
- **Models evolution of uncertainty over time**
- **Harder to analyze and understand**
- **Incorporates existing system effects**
- **Also captures the impact of risk premium and investment asymmetry**

Traditional screening curve analysis compares the costs of alternative technologies at different capacity factors to determine preferred technologies



THE LANTAU GROUP
strategy & economic consulting

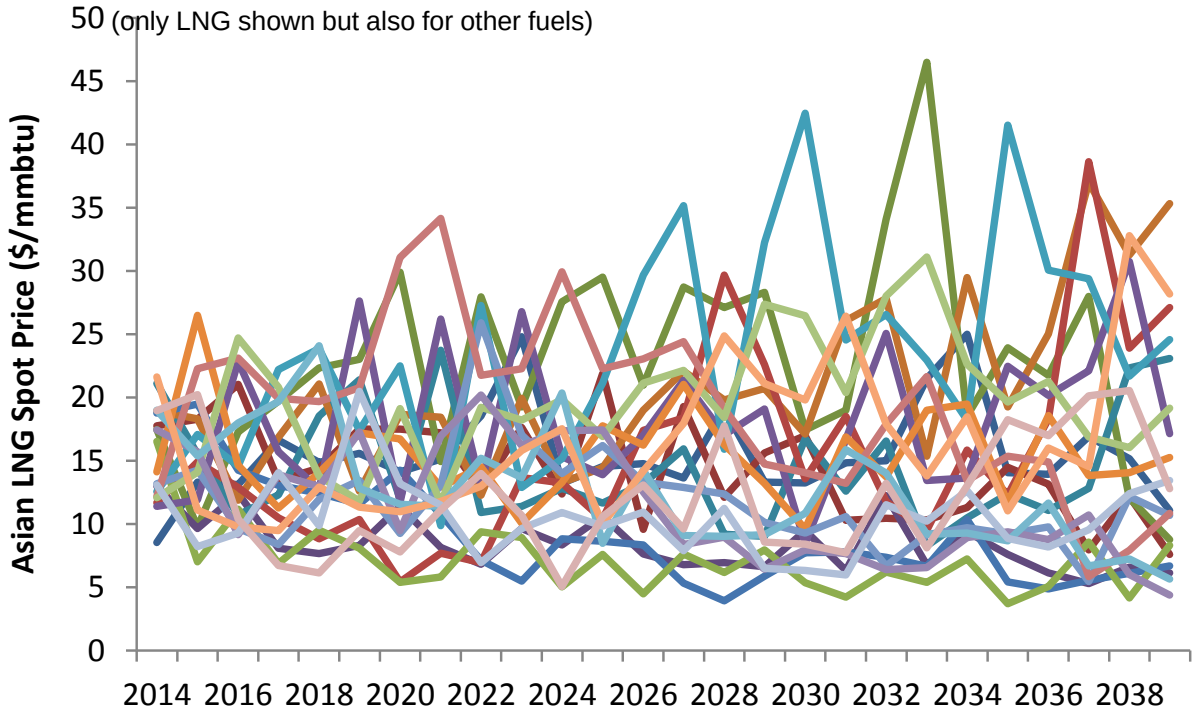
The cross-over in the screening curves determines the capacity factor at which one technology yields to another – and thereby the optimal mix



THE LANTAU GROUP
strategy & economic consulting

Representative fuel price and technology cost/performance scenarios that span the range of possibilities are then used to drive the model

Fuel price uncertainty



+ **Carbon cost uncertainty**

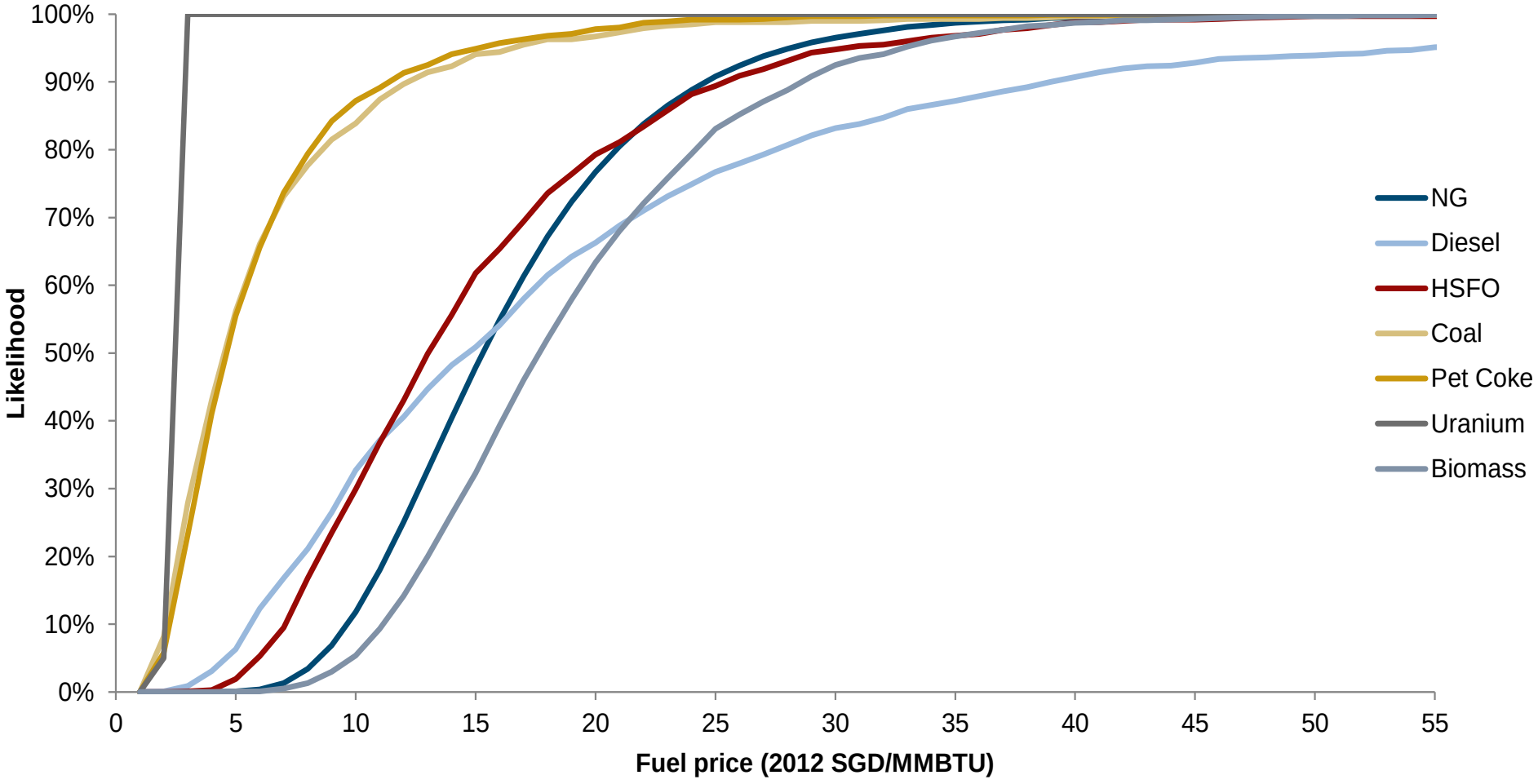
+ **Overnight project cost uncertainty**

+ **Technological improvement (heat rate) uncertainty**

+ **Load uncertainty**

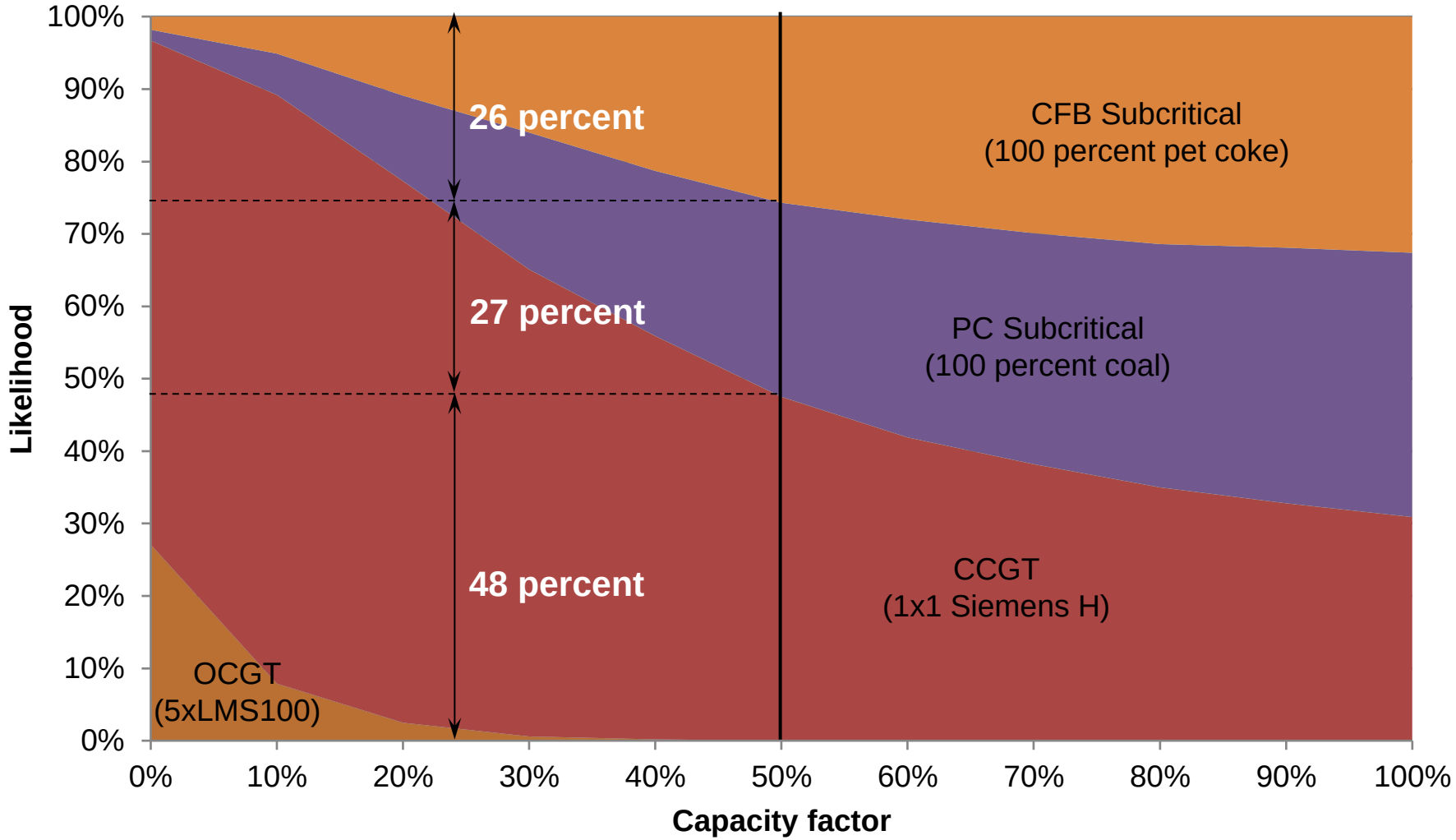
THE LANTAU GROUP
strategy & economic consulting

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



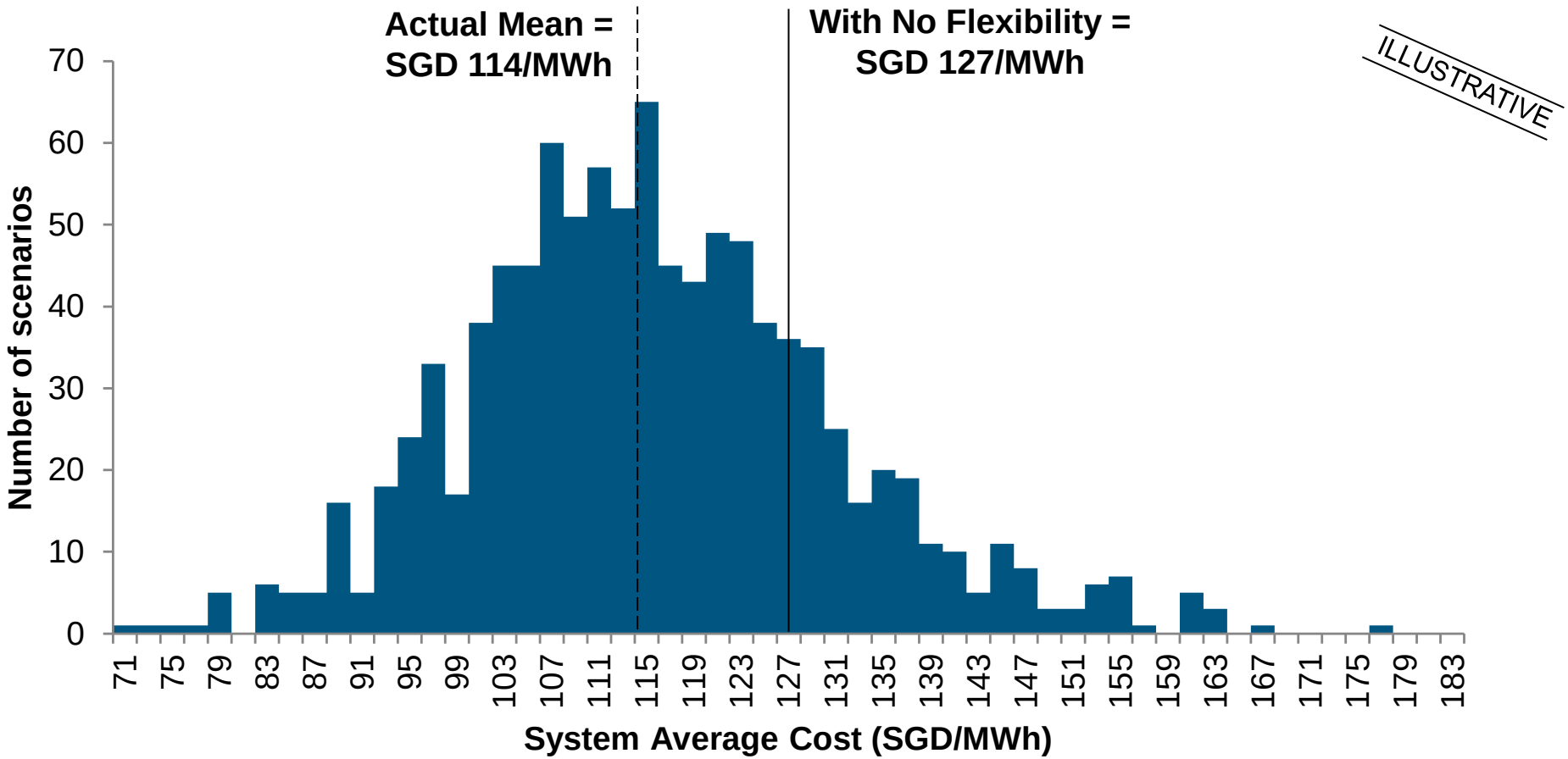
THE LANTAU GROUP
strategy & economic consulting

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 LANTAU GROUP
strategy & economic consulting

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

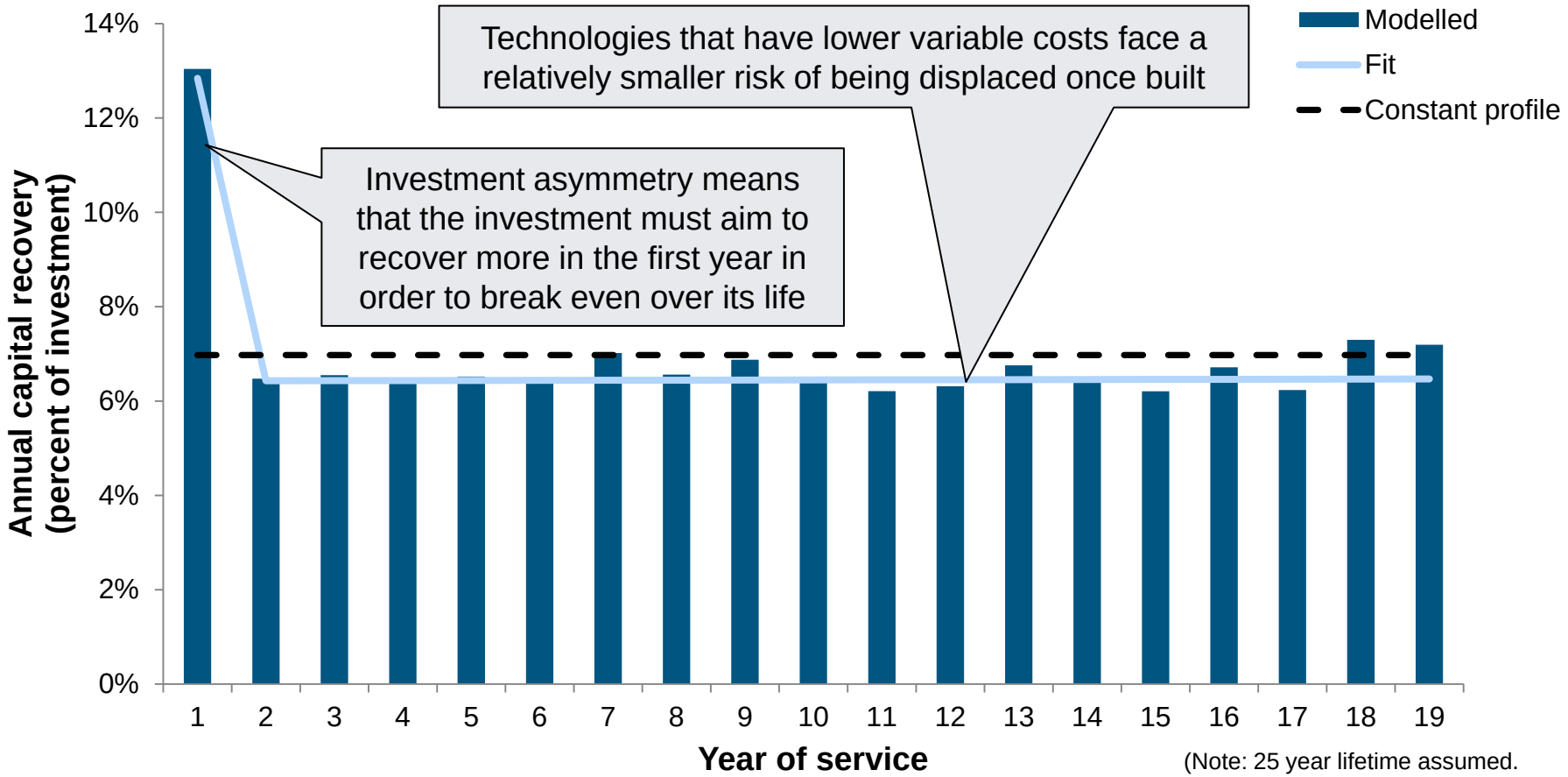


But this analysis assumes perfect strategic flexibility – which overstates the realistic value

THE LANTAU GROUP
strategy & economic consulting

This stochastic optimization accounts for the impact of "investment asymmetry" and "out-of-the-money technology options"

Coal: Capital intensive



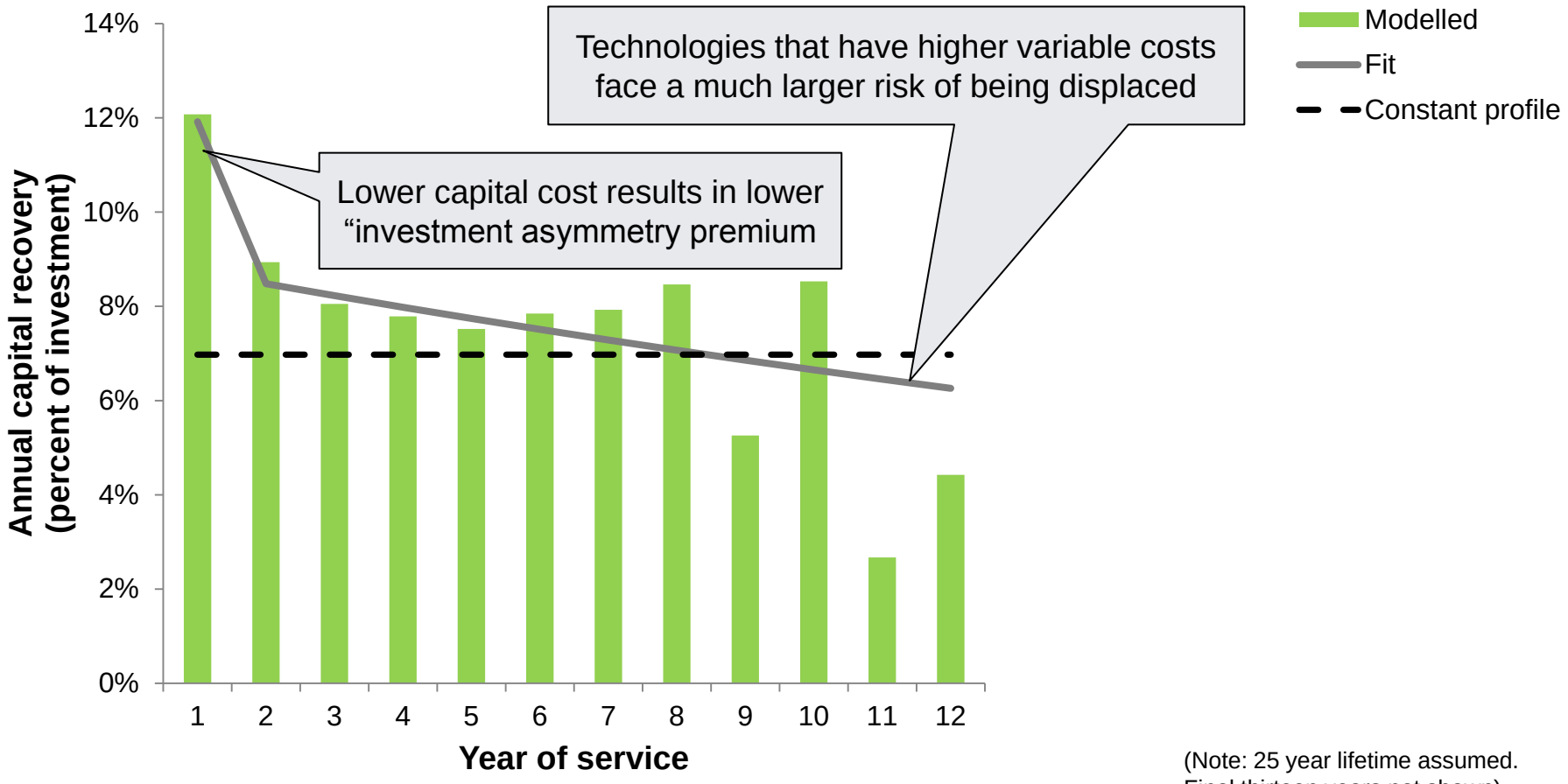
(Note: 25 year lifetime assumed. Final six years not shown)

Source: TLG analysis

THE LANTAU GROUP
strategy & economic consulting

“Investment asymmetry” and “out-of-the-money technology options” have differential effects on alternative technologies

Gas: Higher variable cost

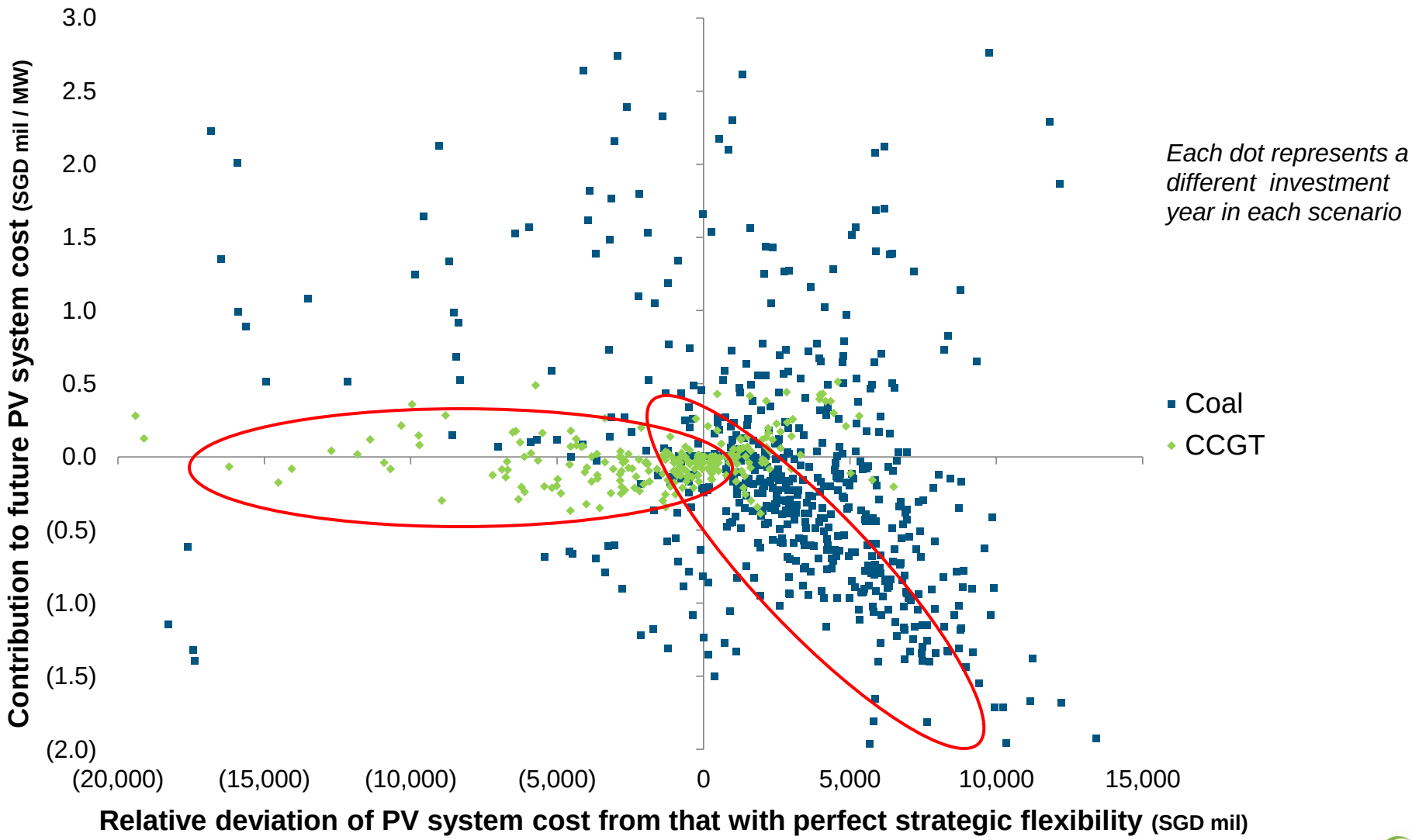


(Note: 25 year lifetime assumed. Final thirteen years not shown)

Source: TLG analysis

THE LANTAU GROUP
strategy & economic consulting

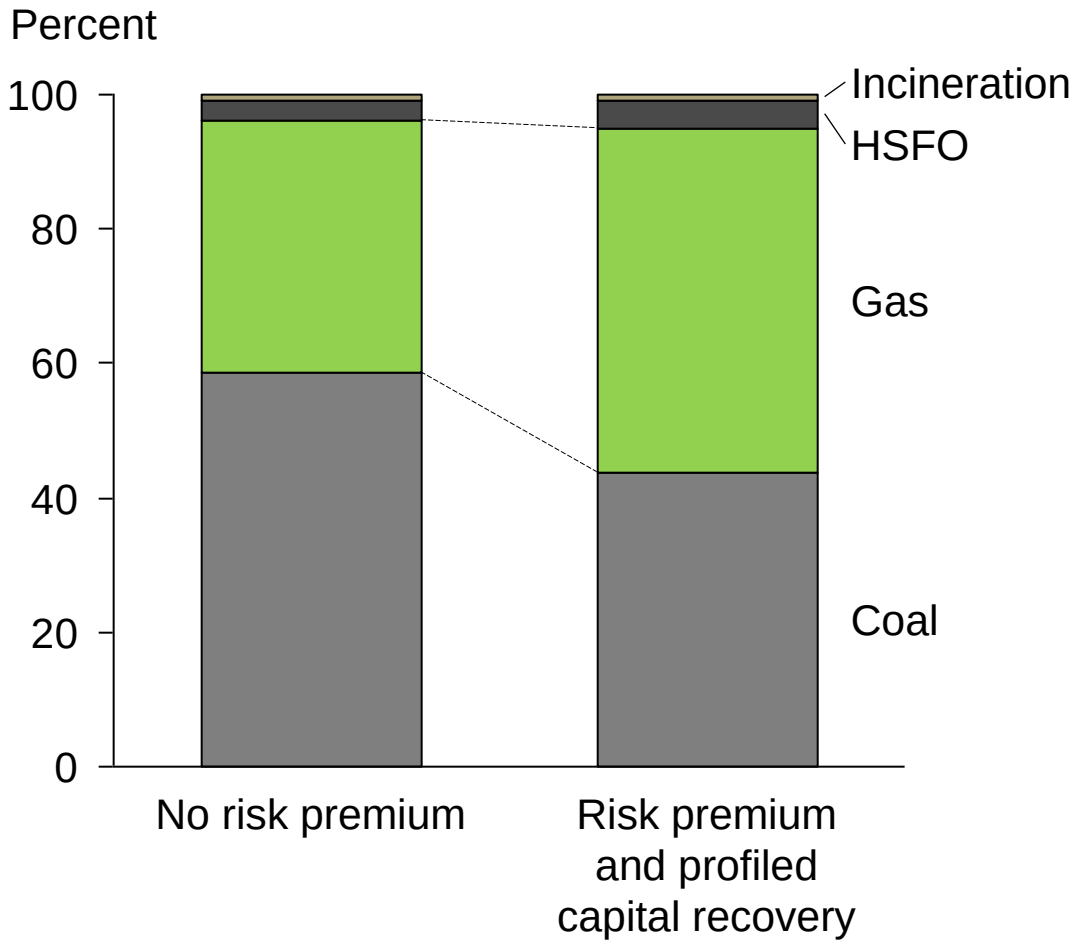
In our example, coal investments tend to reduce system costs but increase the deviation from a perfectly flexible system – thereby increasing risk



THE LANTAU GROUP
strategy & economic consulting

The net effect is a preferential shift towards less capital-intensive technologies

Least-cost average generation fuel mix

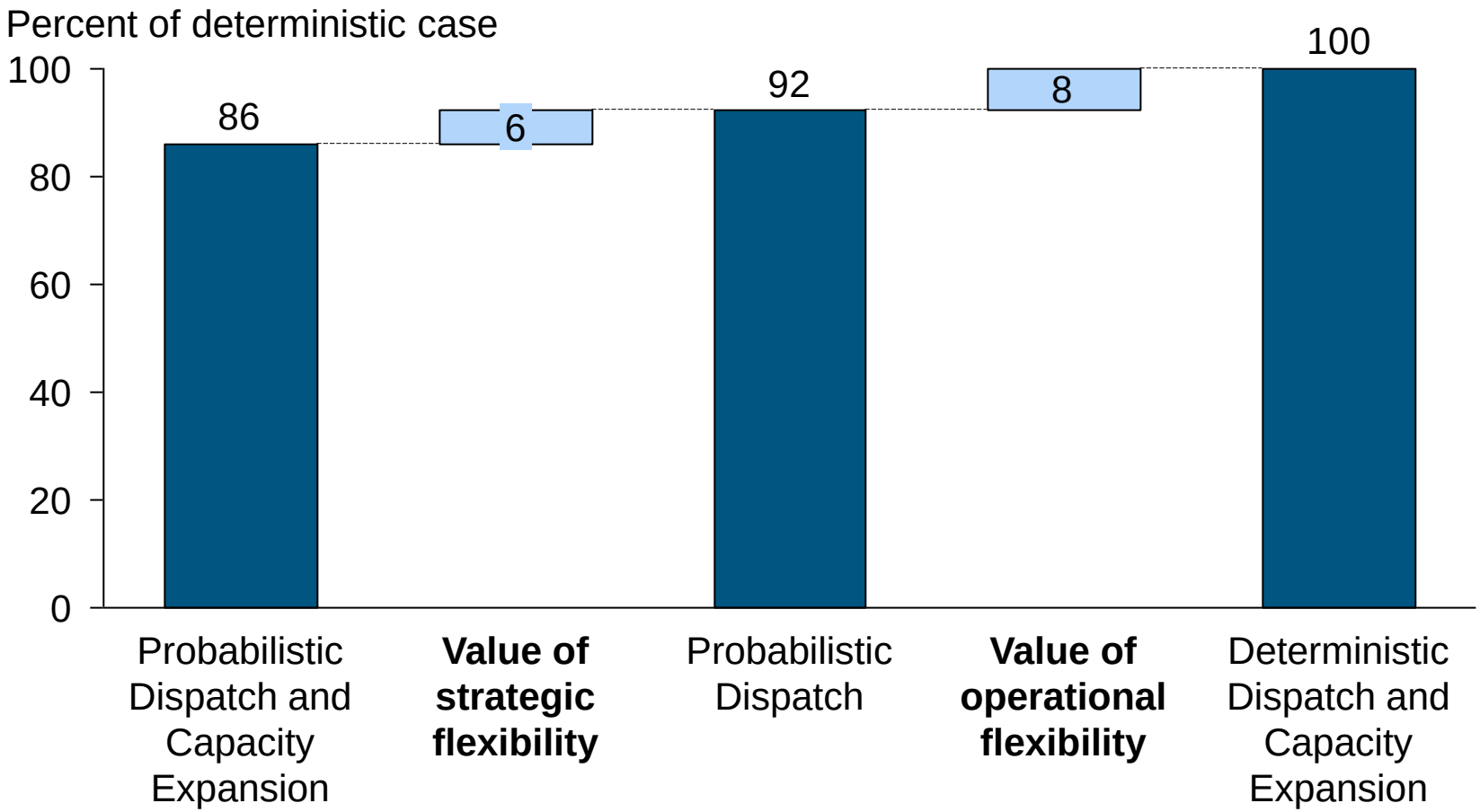


- Increased capital recovery requirements in earlier years means that less coal capacity tends to be built
- Lower capital intensive technology options tend to offer greater strategic flexibility to change the future capacity expansion plan

THE LANTAU GROUP
strategy & economic consulting

Using this framework, we can value flexibility – the value of strategic flexibility is comparable to that of operational flexibility

Illustrative example: Expected PV of system costs

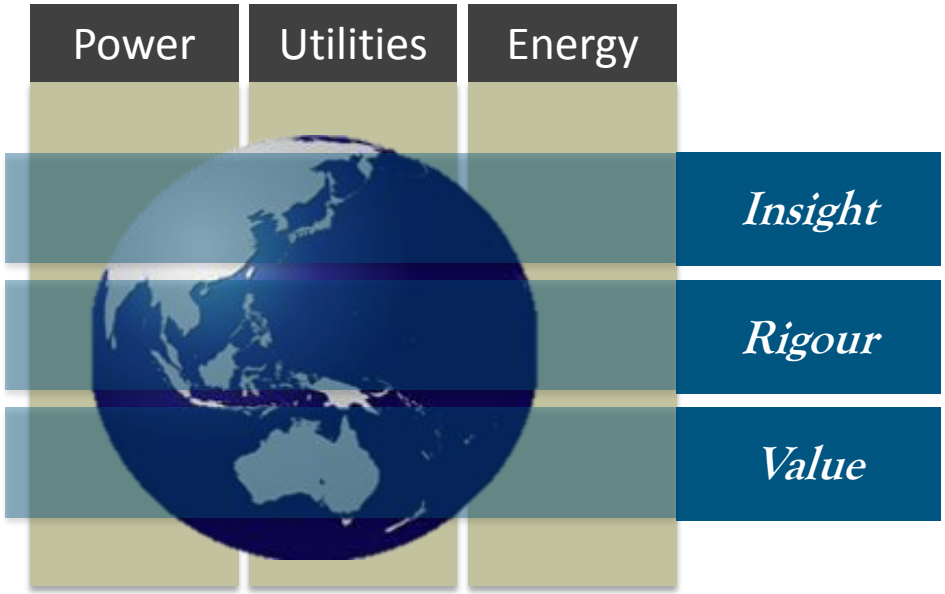


THE LANTAU GROUP
strategy & economic consulting

Implications of “trilemma” value framework

- 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 operational 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!



For more information please contact us:

By email
General Capabilities Inquiries
projects@lantaugroup.com

Direct Communications
mthomas@lantaugroup.com
sfairhurst@lantaugroup.com
tparkinson@lantaugroup.com
nsemple@lantaugroup.com

By phone
+852 2521 5501 (office)

By mail
4602-4606 Tower 1, Metroplaza
223 Hing Fong Road,
Kwai Fong, Hong Kong

Online
www.lantaugroup.com

THE LANTAU GROUP
strategy & economic consulting