Managing Regret Risk:

Managing Downside Risk in Energy Procurement

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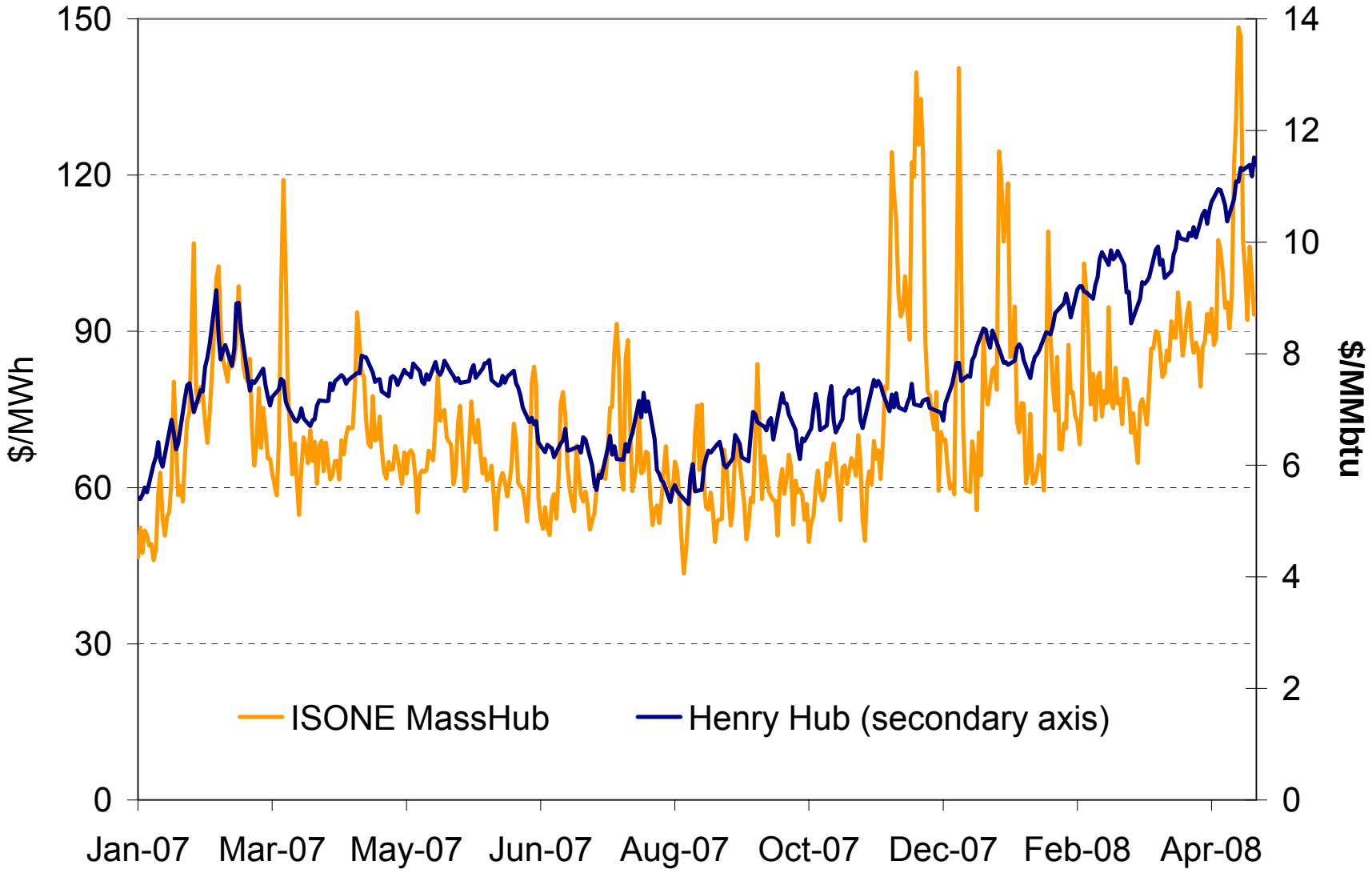
LEVITAN & ASSOCIATES, INC.
MARKET DESIGN, ECONOMICS AND POWER SYSTEMS

High Prices and Volatility



Source: Bloomberg LP, ISO-NE

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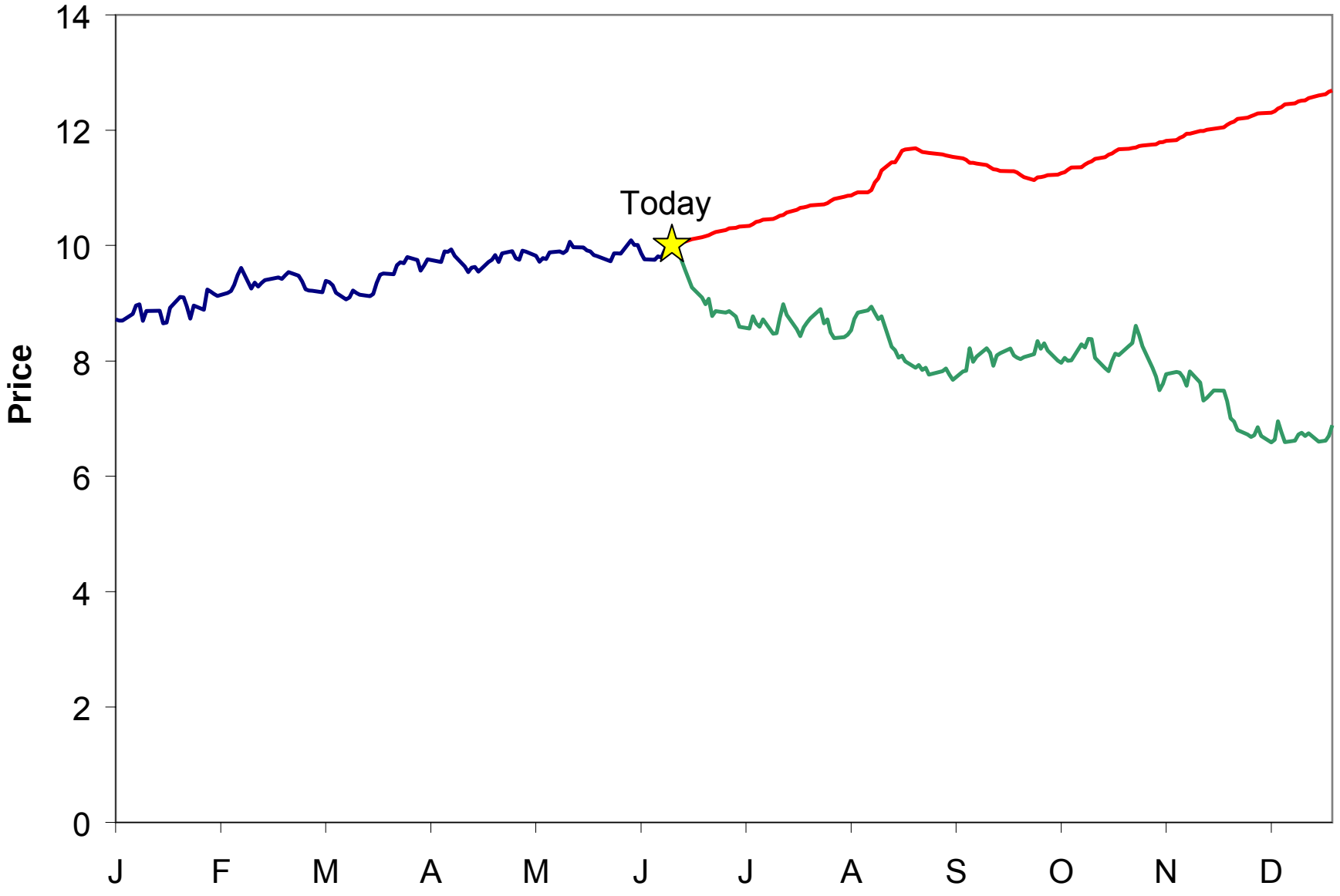
Prices in the Future are Highly Uncertain



Approaches to Managing Regret Risk

- Laddering
- Vanilla Put Options
- Collars
- Exotic Options

Laddering

- For a single tranche (delivery period), make several purchases

Pros

- Simplicity
- Low upfront costs

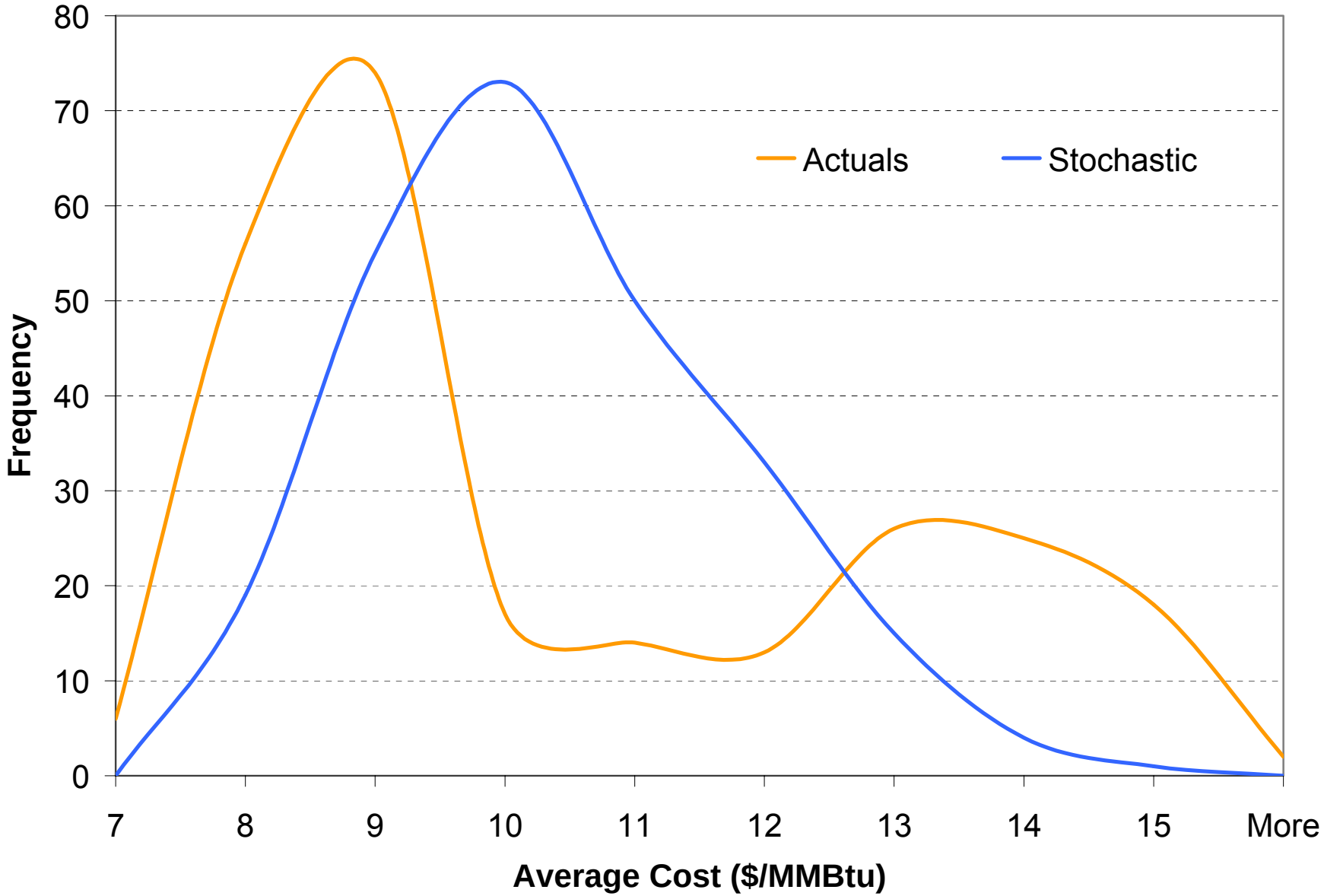
Cons

- Does not lock-in price protection, only reduces the probability of regret
- Multiple procurements increase administrative burden
- Threshold counterparty interest required – potential diseconomy of scale

Laddering Simulation

- Gas procurement at Henry Hub for calendar quarters (Q1 2006 and Q1 2007)
  - One-day purchase: Purchase gas on a single day in the preceding 12 months
  - Laddering: Purchase gas on four randomly selected days over the previous 12 months
- Laddering narrowed the distribution of results and the likelihood that gas was purchased at a high price
  - “Thinner tails” - both directions

Q1 2006 Simulation Results



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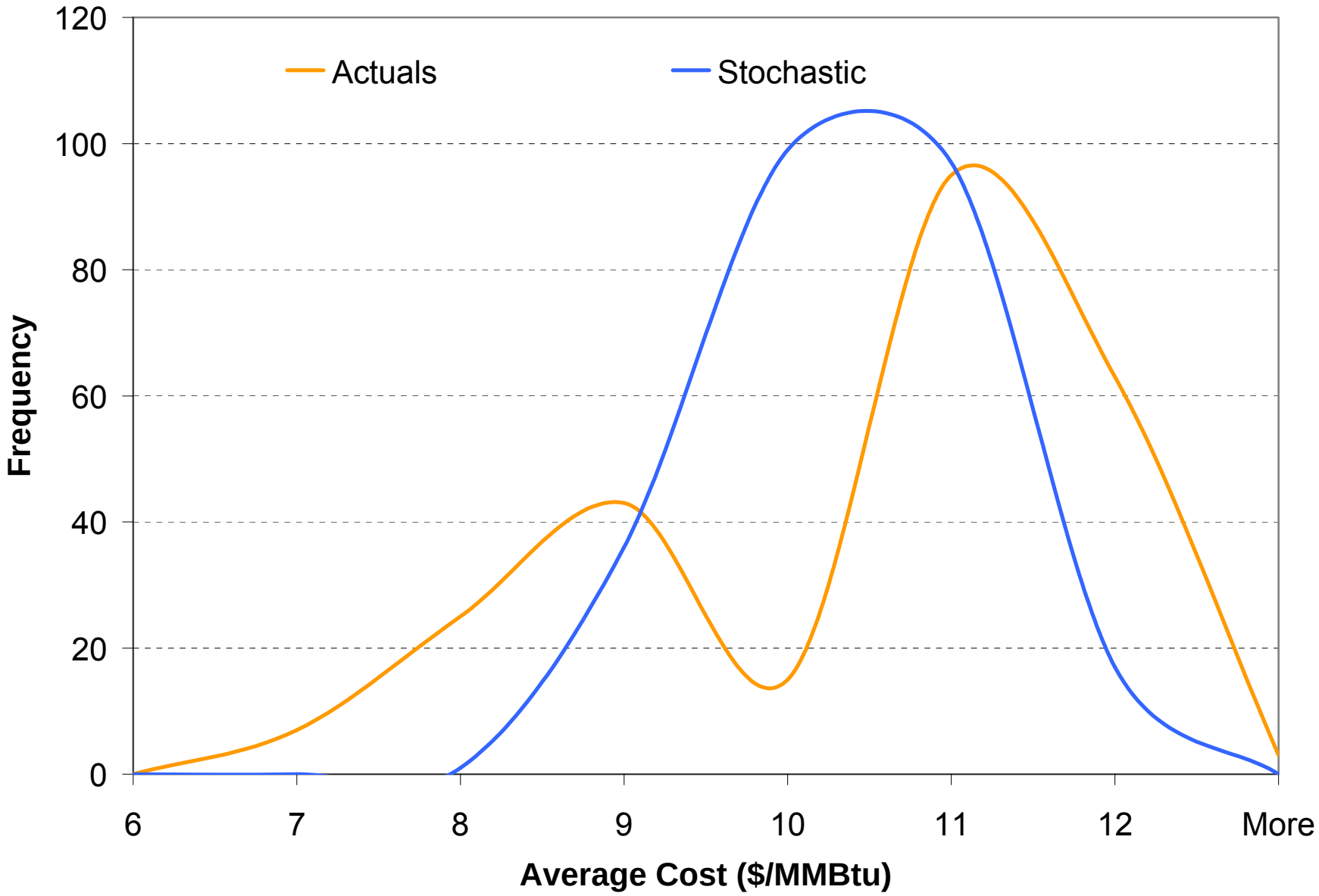
Q1 2007 Simulation Results



(European) Put Options

- Price insurance
  - If the price of underlying forward goes down after procurement, option payout will (partially) compensate for buyer's regret

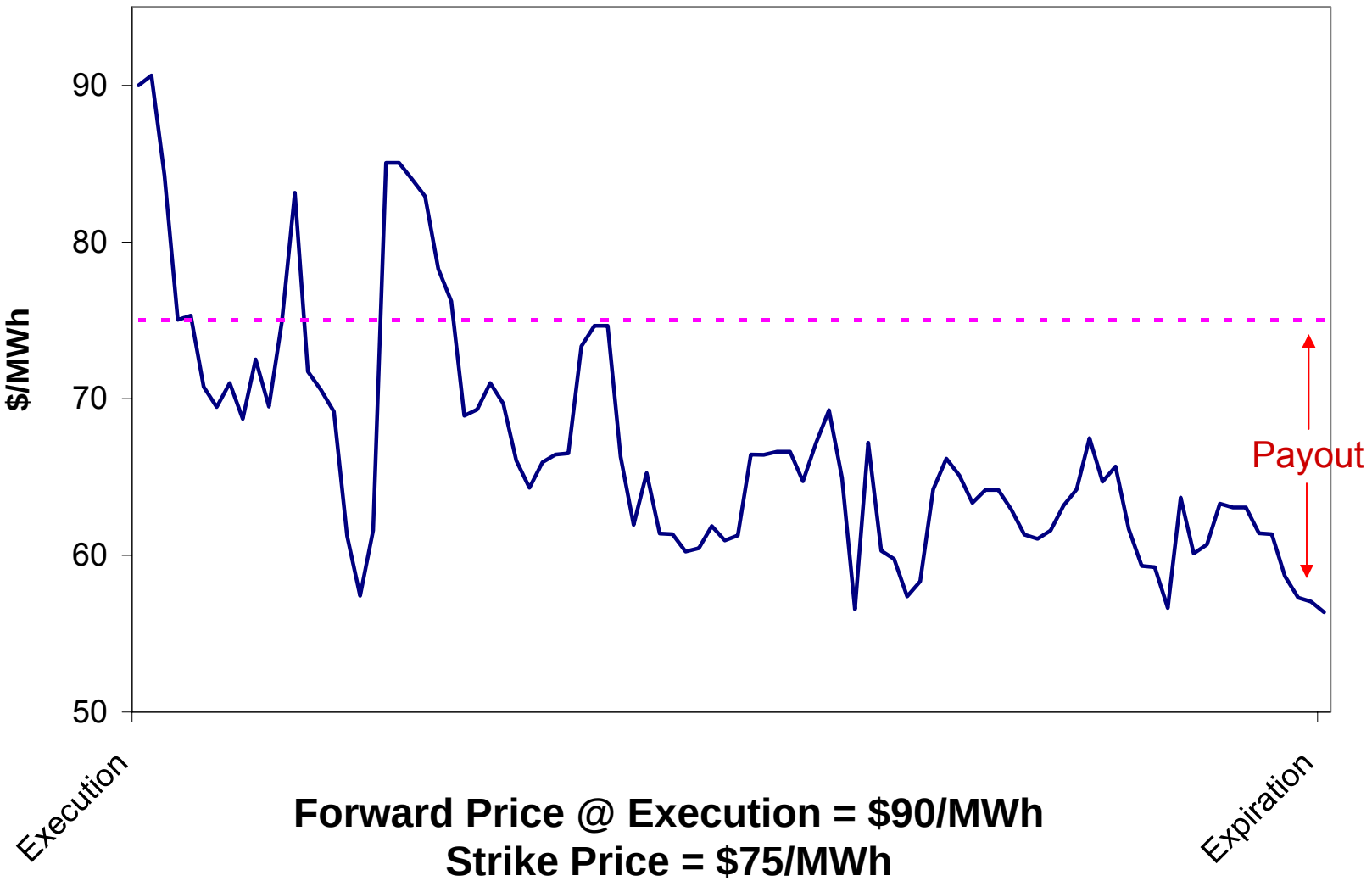
Pros

- Set a specified level of risk protection
- Liquid, offered on NYMEX and ICE

Cons

- Expensive
- May not pay out at settlement

Put Option Settlement



Forward Price @ Execution = $90/MWh
Strike Price = $75/MWh
Forward Price @ Expiration = $55/MWh
Payout = $20/MWh
Net Benefit = $15/MWh ($20 - $5 option cost)

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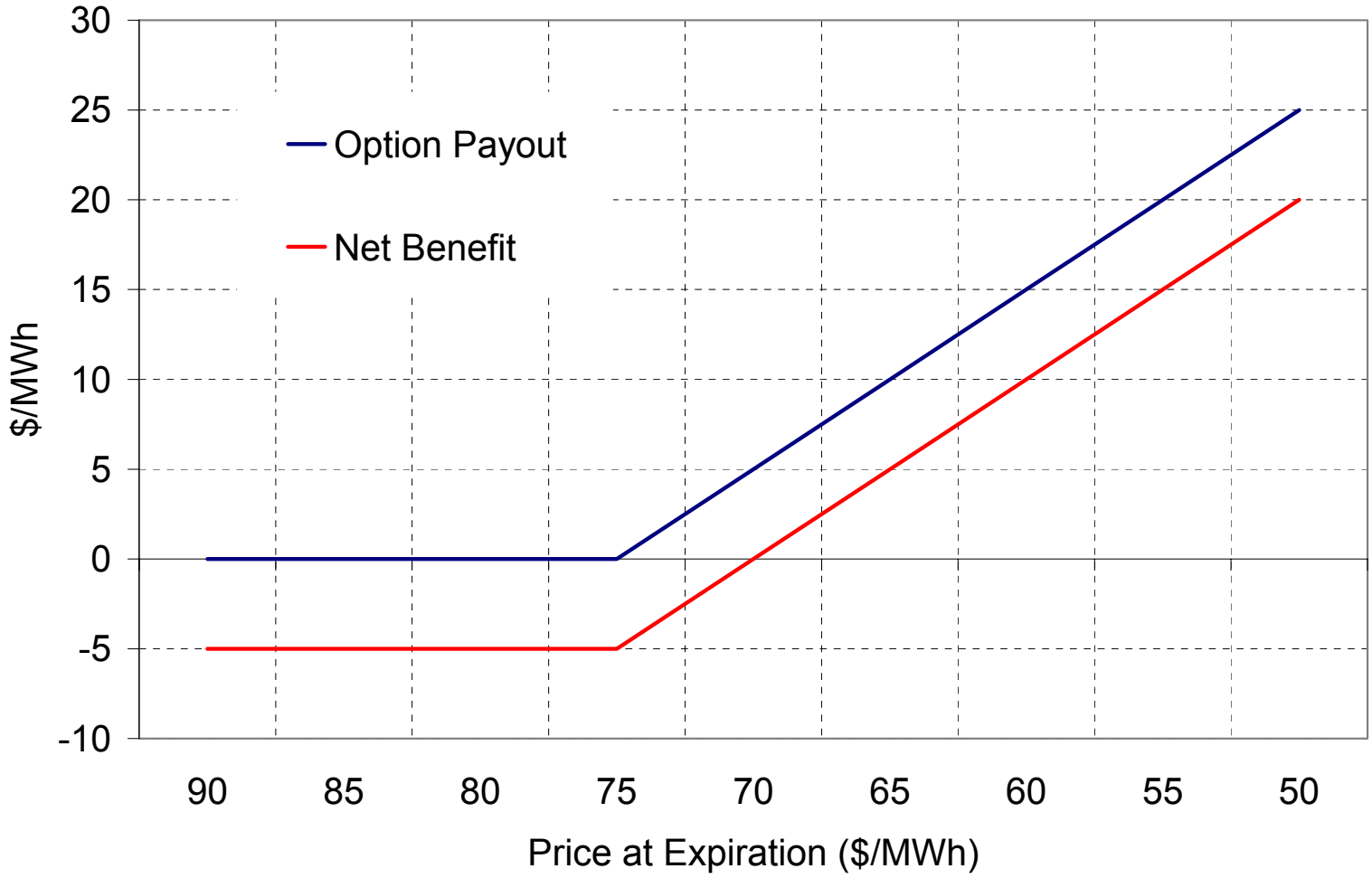
Put Option Settle Price vs. Payout



Option Price = $5/MWh
Strike Price = $75/MWh

Euro Option Pricing: The Black Model

$$V_{put}(t, F_{t,T}) = e^{-r(T-t)}[KN(d_1) - F_{t,T}N(d_2)]$$

where

$$d_1 = \frac{\ln(F_{t,T}/K) + \sigma^2(T-t)/2}{\sigma\sqrt{T-t}}$$

$$d_2 = \frac{\ln(F_{t,T}/K) - \sigma^2(T-t)/2}{\sigma\sqrt{T-t}}$$

F = Forward price of underlying
K = Strike Price
r = Risk-Free Rate
T,t = Time (execution vs. expiration)
N = Normal Cumulative Distribution Function
σ = Implied Volatility

Source: Eydeland, Wolyniec

Illustrative Pricing of Put Options

Settle Date	Forward Price ($/MWh)	Strike Price – 10% out of the money ($/MWh)	Option Premuim ($/MWh)	Strike Price – 25% out of the money ($/MWh)	Option Premuim ($/MWh)
Jan 2009	$87.94	$79.15	$8.77	$65.96	$3.82
Feb 2009	$87.94	$79.15	$9.57	$65.96	$4.41
Mar 2009	$74.31	$66.88	$8.66	$55.73	$4.16
Apr 2009	$74.31	$66.88	$9.26	$55.73	$4.62
May 2009	$66.75	$60.08	$8.81	$50.06	$4.54
June 2009	$78.25	$70.43	$10.90	$58.69	$5.78

Assumptions: 50% implied volatility, 2.5% risk free rate

Forward pricing at Cinergy Hub (on peak) from 5/27 NYMEX Clearport

Collars

- Lock in a range of prices by purchasing a call and selling a put
  - Proceeds of put offset the cost of the call (total or partial)

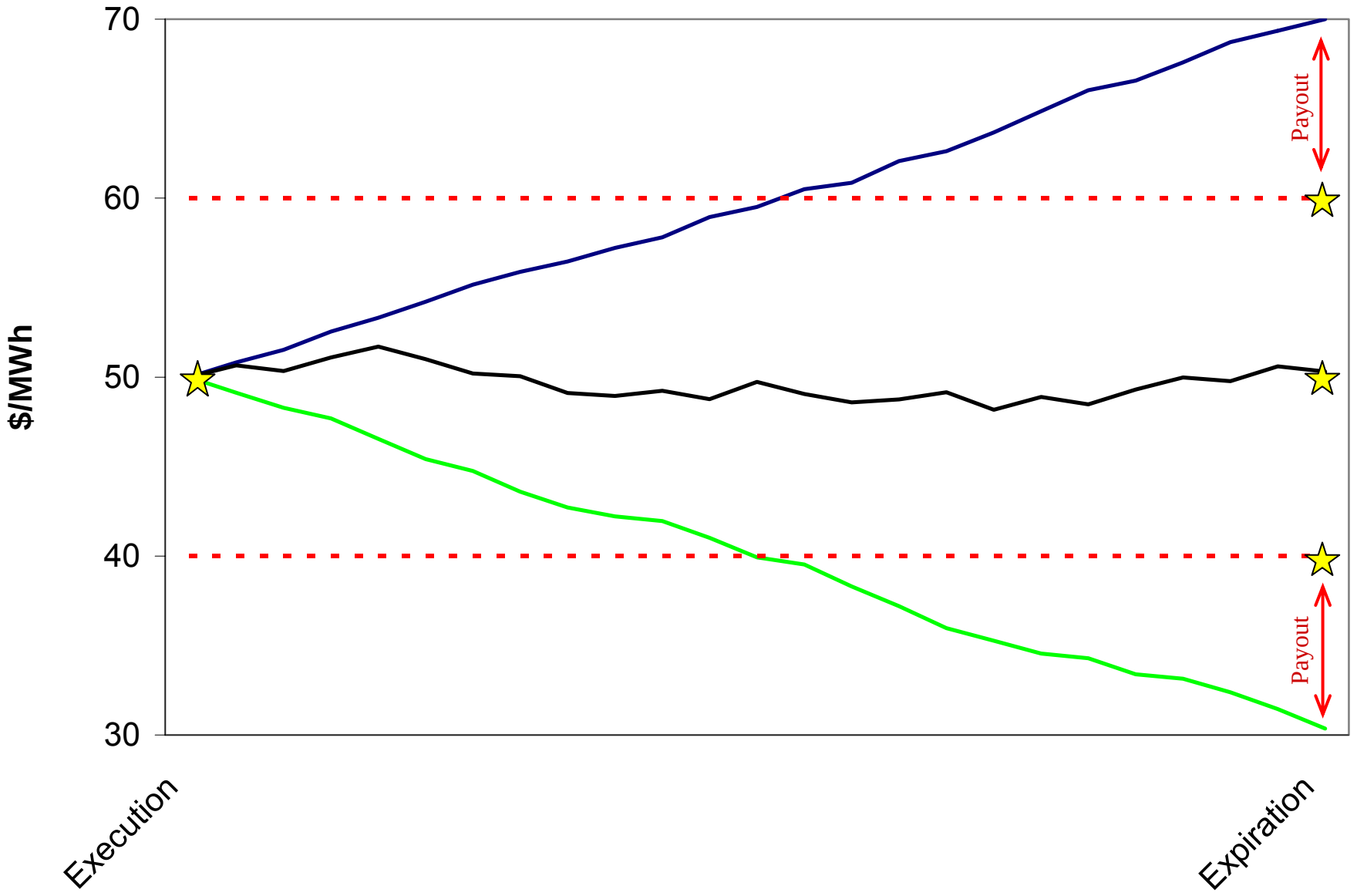
Pros

- Less expensive than buying a forward and hedging with a put option
- Comparatively liquid

Cons

- Doesn't lock in specific level of price protection, only a range
- Limits potential to participate in downward correction
- Prices may still increase

Collar Example



Exotic Options

- Wide variety available
- Can be custom designed
- Relatively new structures

Pros

- Able to tailor to meet needs
  - Can strike a good balance between price protection, potential upside, and cost considerations

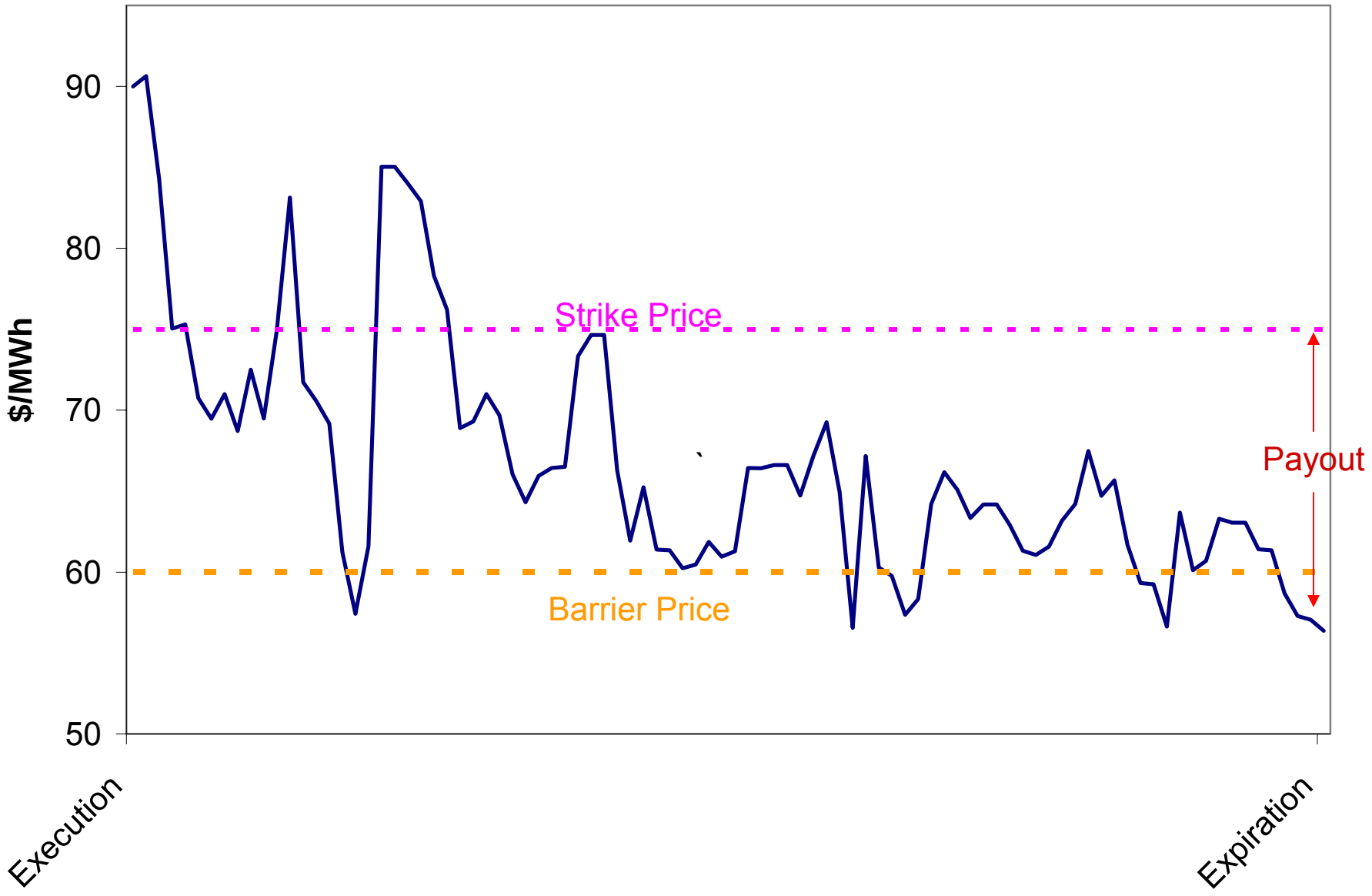
Cons

- Opaque, difficult to price
- Illiquid, can be difficult to unwind at good value
- High upfront costs

Barrier Options

- Sometimes called “knock-in” or “knock-out” options
- If barrier is exceeded, option settles against the strike price
  - Reduces both the cost and the probability of payout
- Multiple designs
  - Settlement of strike price vs. either the barrier or forward price
  - “One touch” or specified time (# of trading days) above/below the barrier
- Difficult to Price
  - Closed form solutions provide approximation only

Barrier Settlement with Payout

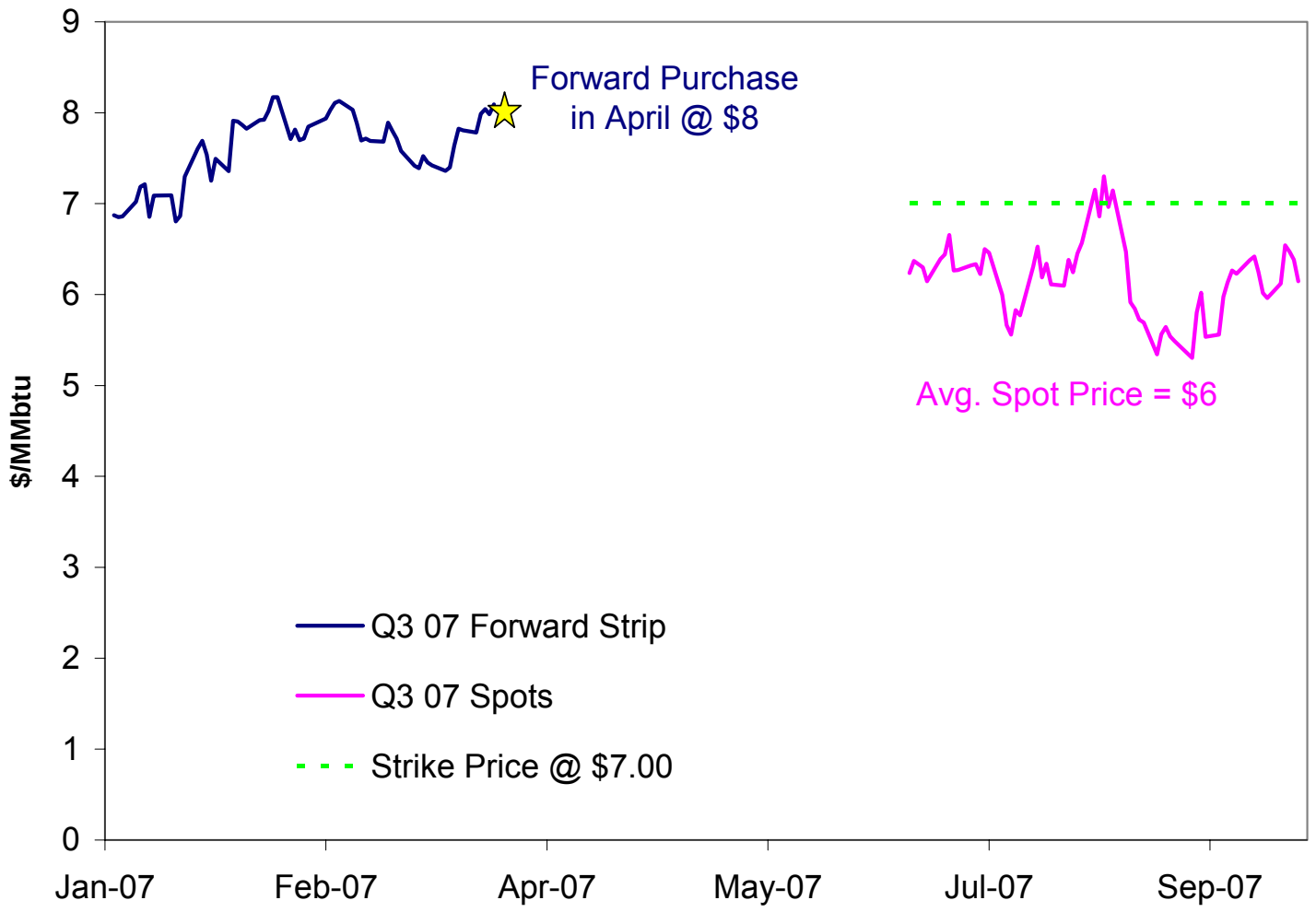


Barrier Settlement, no Payout

Asian Options

- Management of forward v. spot risk
  - Settlement of average spot prices against a strike price
  - Generally the strike price is either the forward price at the beginning of the delivery period or when prices locked in via forward purchase
- Difficult to price
  - No closed form solution, requires simulation to estimate
- Two Structures: Cash settlement or delivery at strike price
  - Cash settlement most common for energy risk management

Asian Put Option Knock In



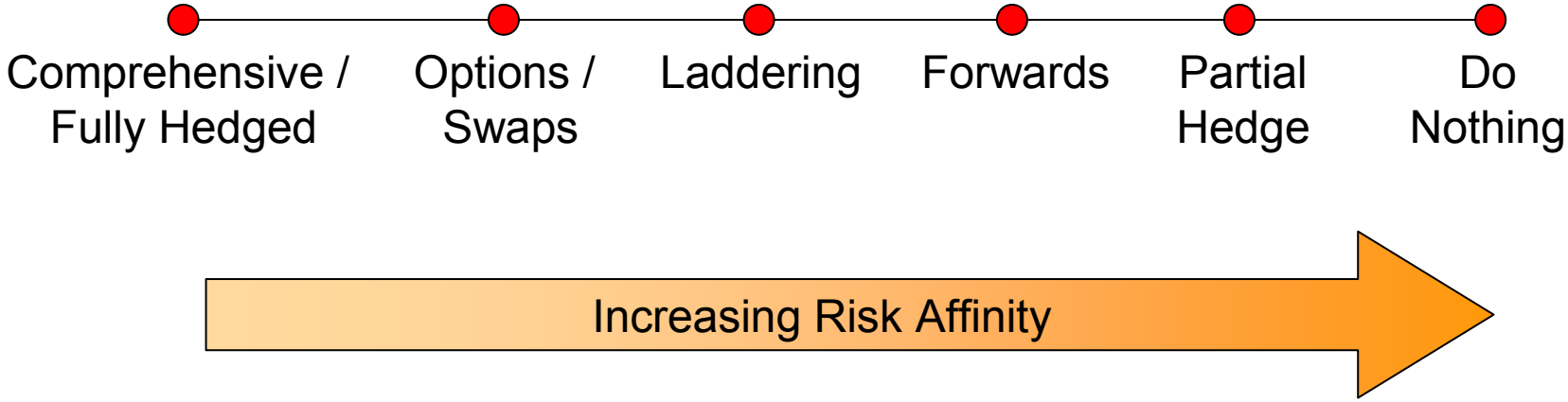
Strike Price = $7/MMbtu
Average Spot Price Q3 2007 = $6/MMbtu
Payout = $1/MMbtu

Other Exotics/Structures/Strategies

- Lots and lots of structures in the market
  - American v. European v. Asian v. Parisian *et al*
  - Bull/bear spreads, game options, Russian options *et al*
  - Cross-commodity hedges
  - Combinations of various structures
- Most deal-specific and won't be available to small or mid size users
- Use exotics selectively; may not be suitable for many institutional users

Risk Continuum

- Important to tailor risk management approach to individual risk tolerance and price sensitivity



- More risk protection usually means higher upfront costs

Pros and Cons

Approach	Upfront Cost	Protection Provided	Liquidity/ Availability
Laddering	Low	Low	High
Vanilla Option	High	High	High
Collar	Varies	Medium	Medium (multiple transactions)
Barrier Option	Medium	Medium	Low
Asian Option	High	High/Varies	Low

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