RAP Energy solutions for a changing world

# Triggering Investment by Combining Capacity Revenues with Flexibility Revenues

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# Why can’t this poor man breathe?

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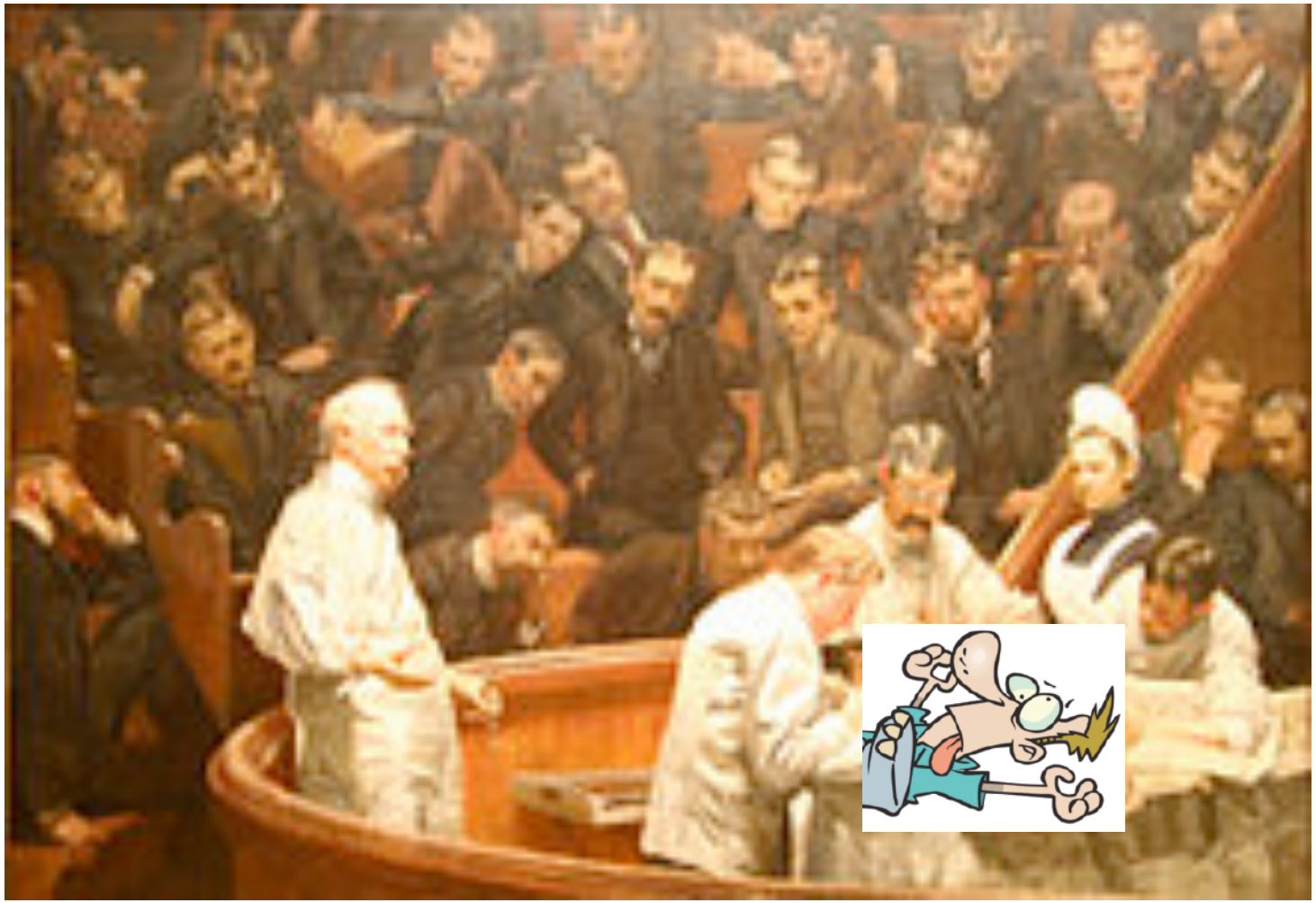
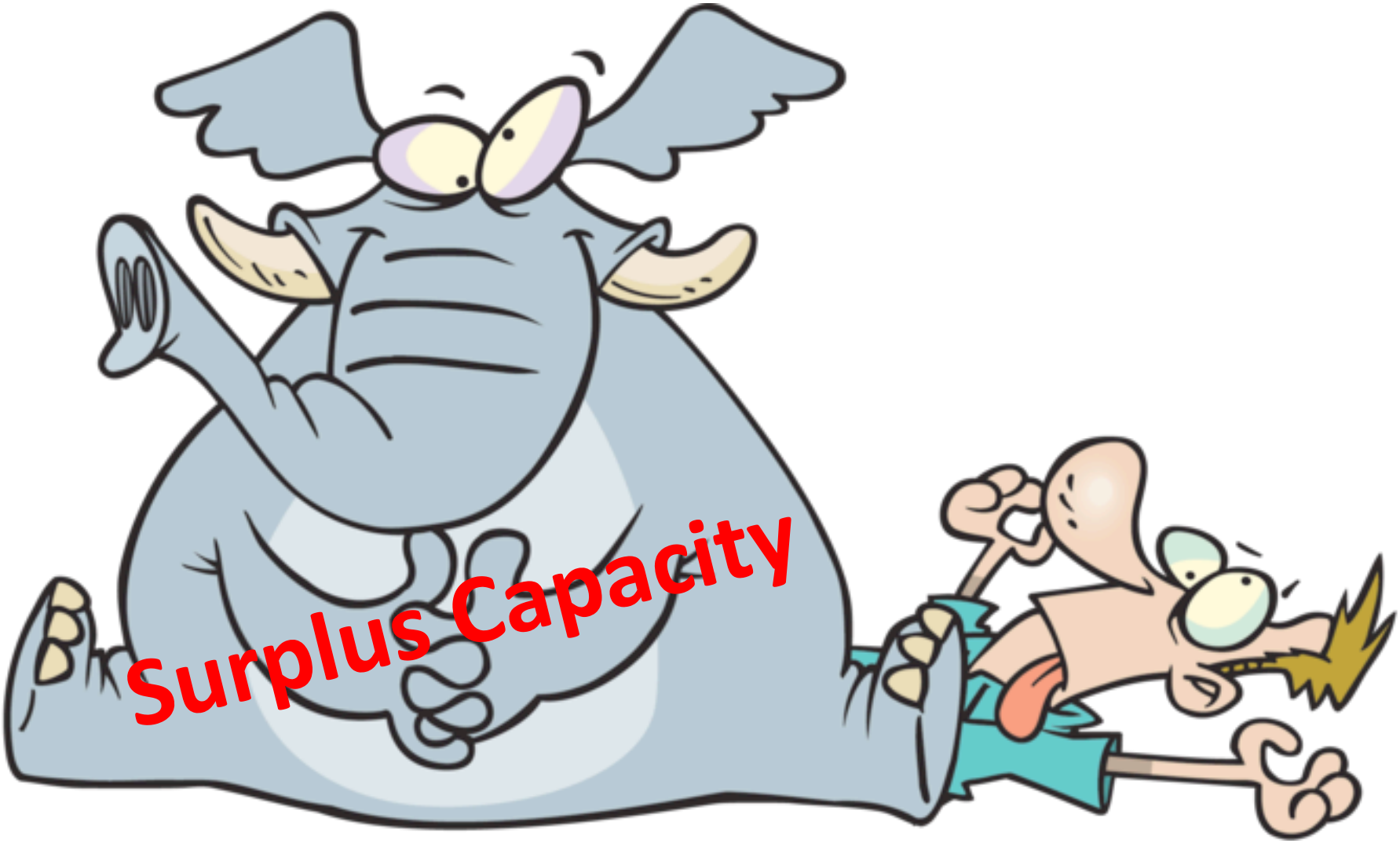
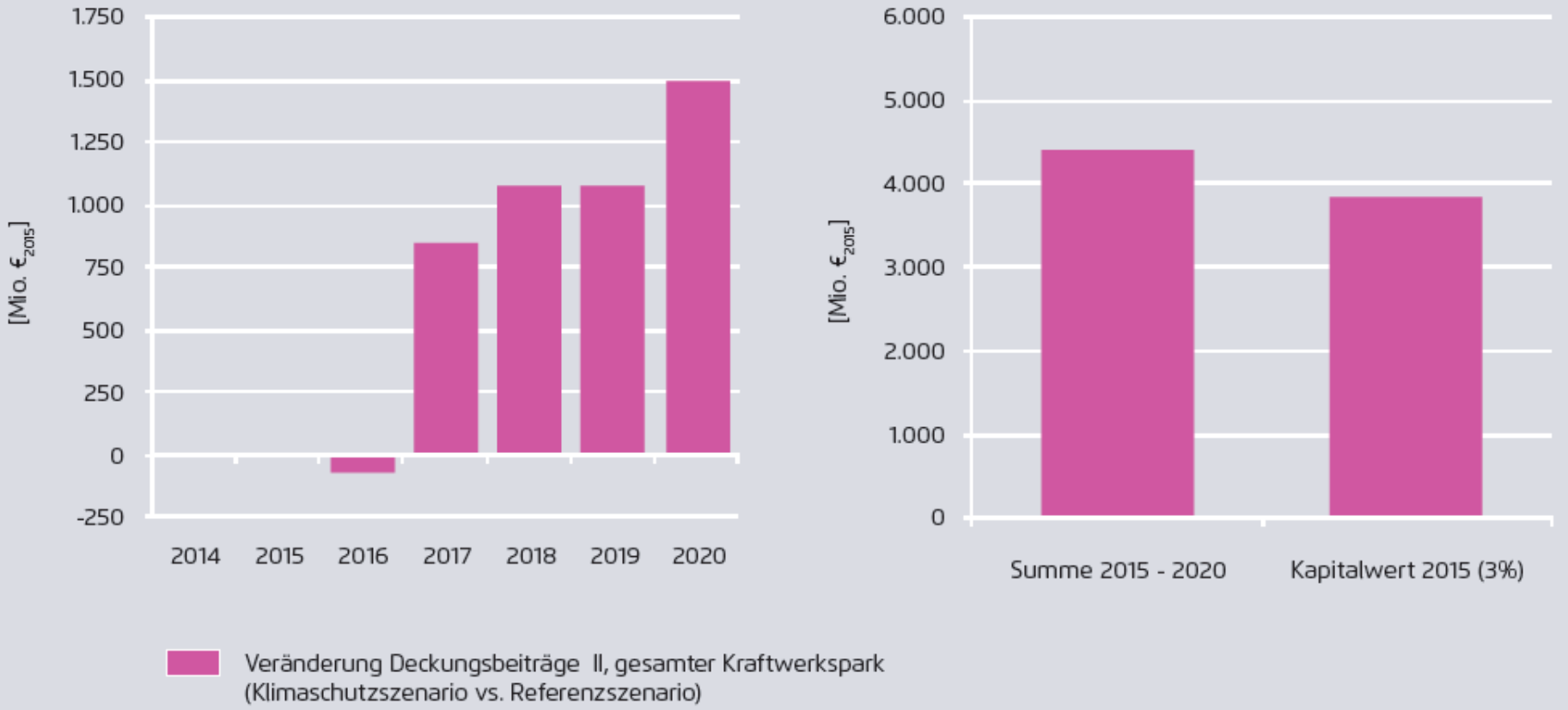



Surplus Capacity

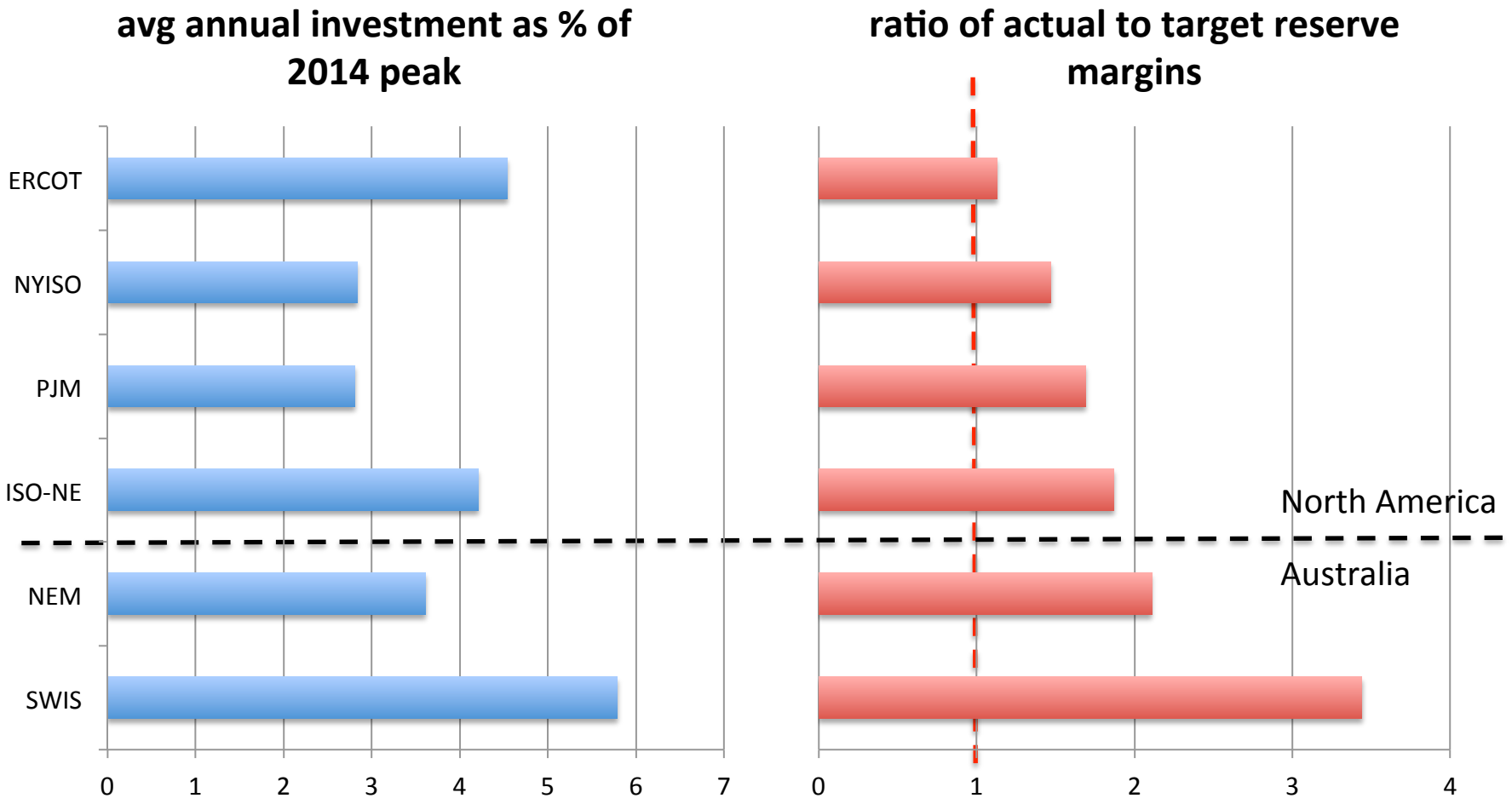
# What breathing looks like (in Germany)

Besserstellung des Gesamtportfolios aller Kraftwerke im Klimaschutzszenario vs. Referenzszenario — Abbildung Z4



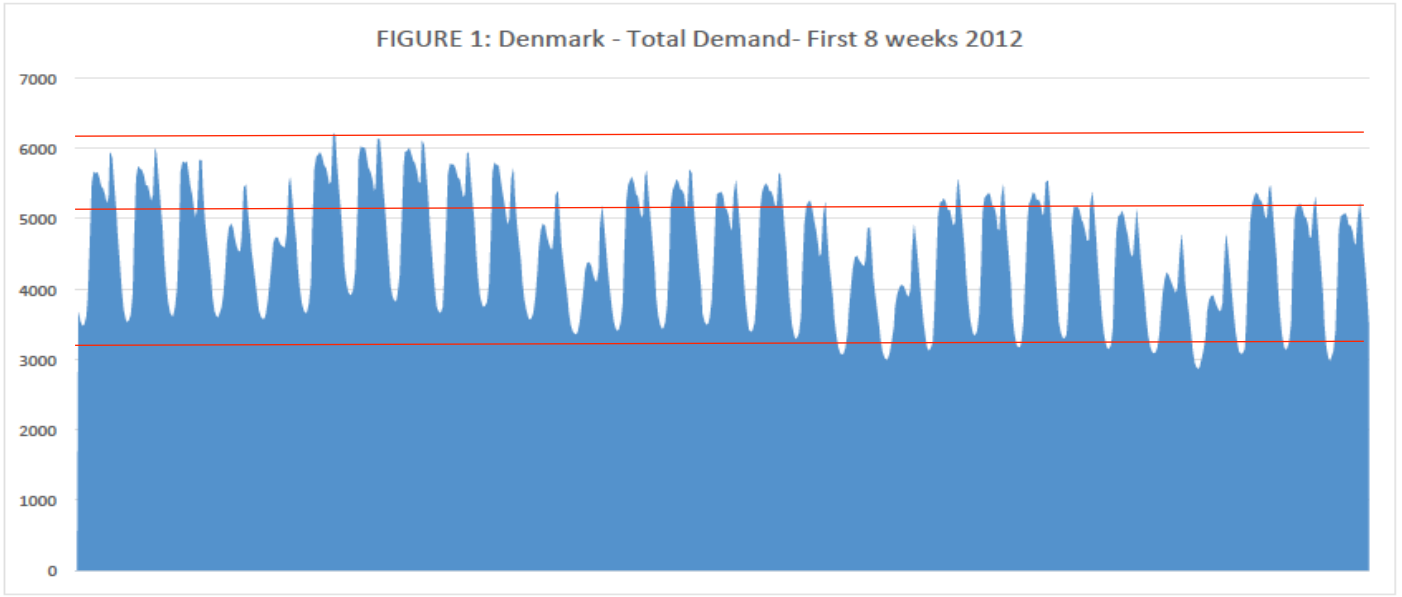

Source: Enervis (for Agora)

# Patterns of investment (& over-investment) with increasing role for forward CRMs



# Low-carbon shift in system resource mix (ideal)

***Yesterday***

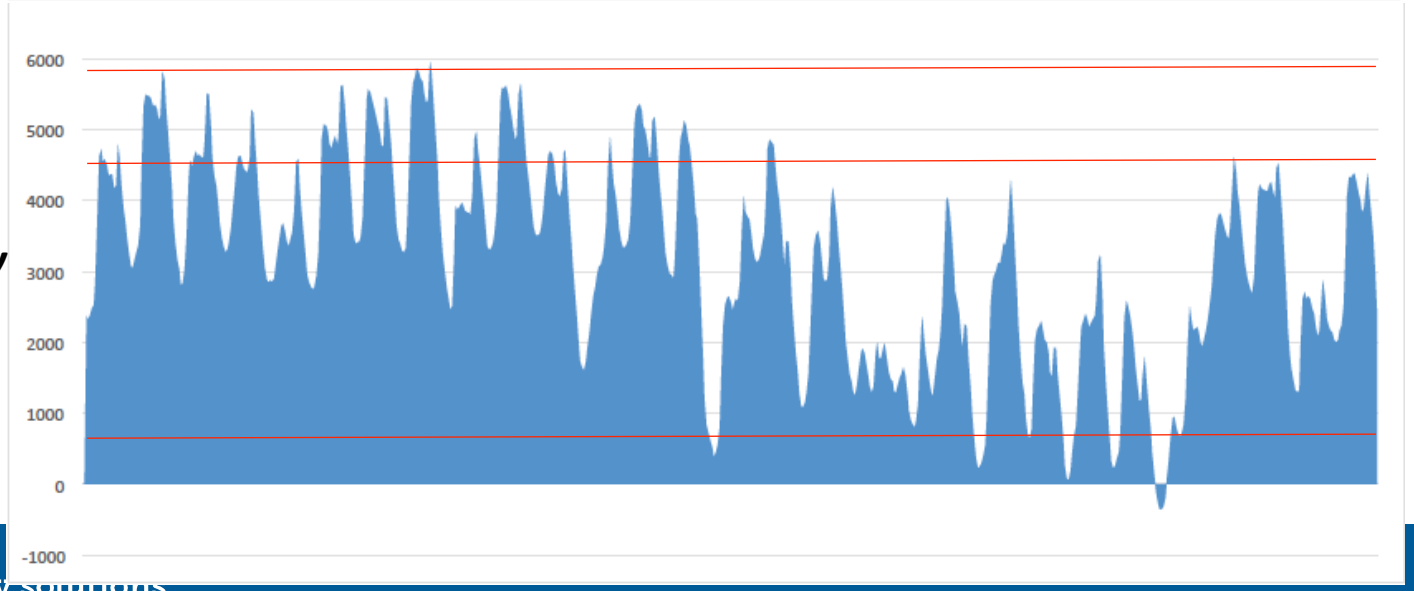



Peak

Mid-merit

Baseload

***Tomorrow***

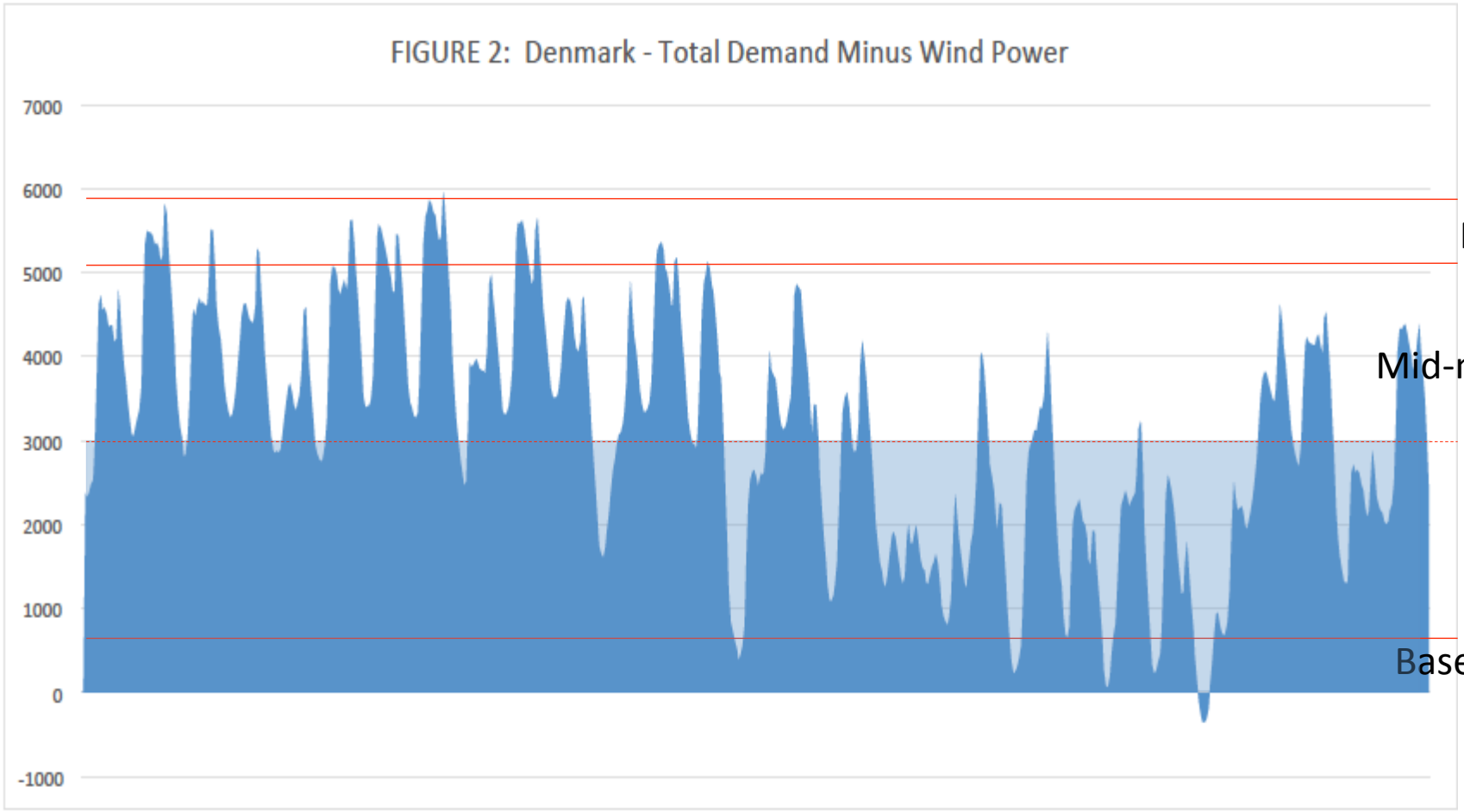


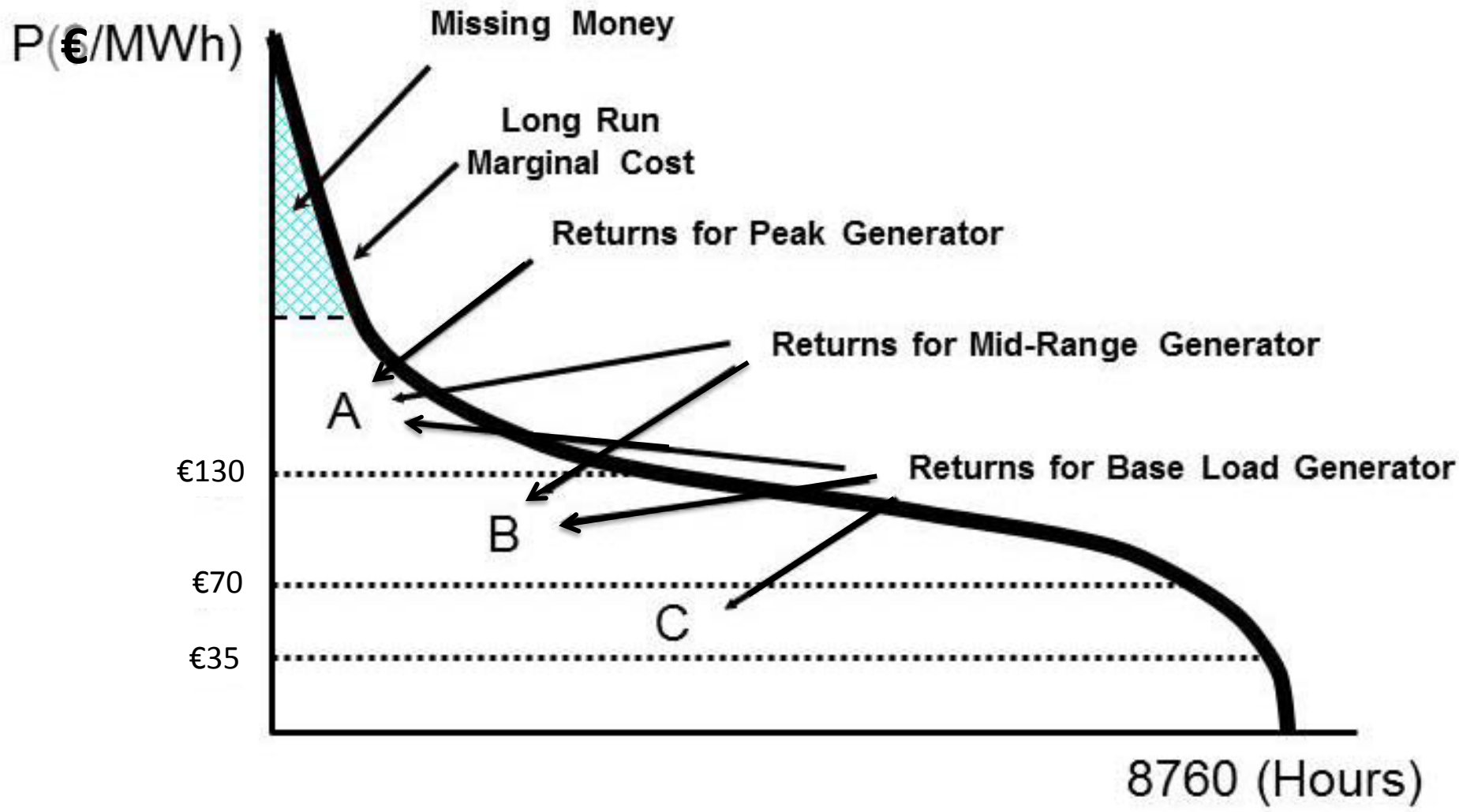

Peak

Mid-merit

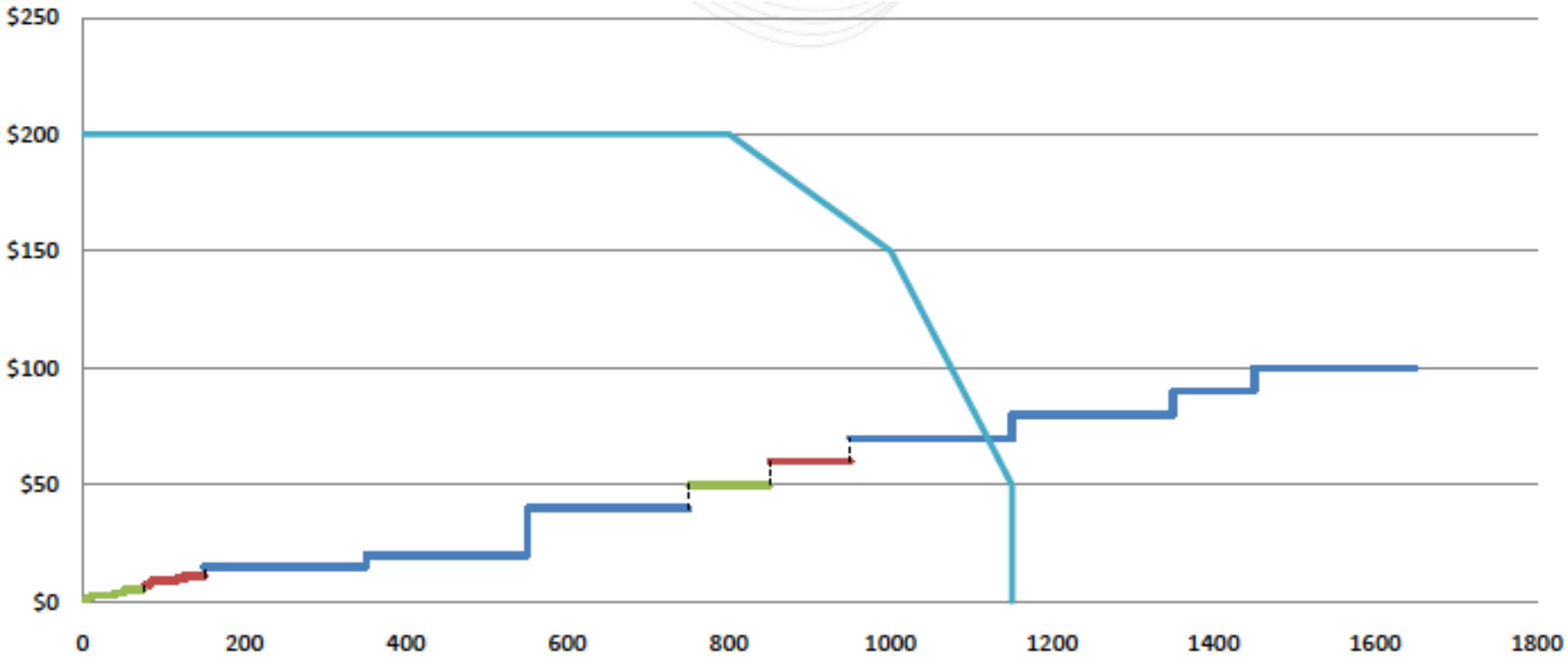
Baseload

# Residual mix, distorted market: *everyone* suffers

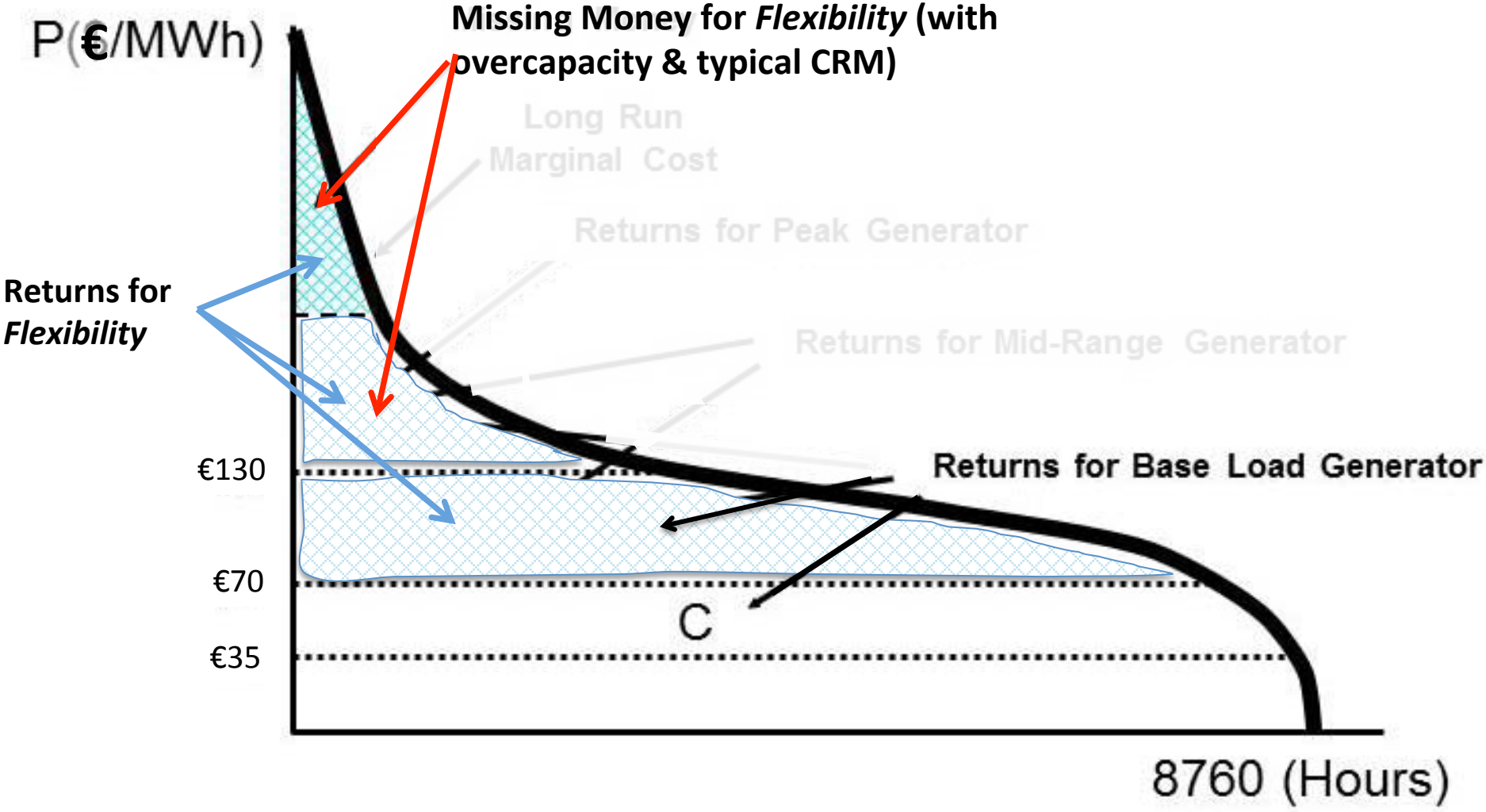



P(€/MWh)
Missing Money
Long Run
Marginal Cost
Returns for Peak Generator
Returns for Mid-Range Generator
A
€130
Returns for Base Load Generator
B
€70
C
€35
8760 (Hours)

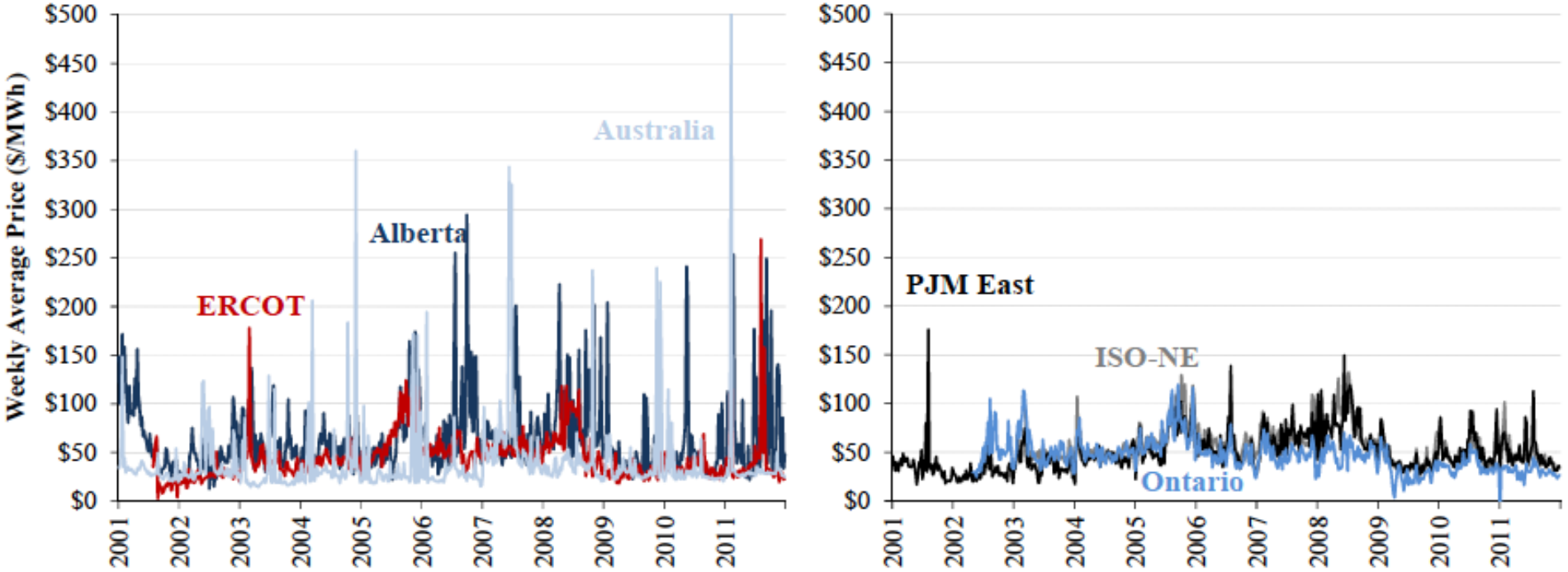
# Fixing “missing money”: typical single-product CRM




Source: PJM


P(€/MWh)
Missing Money for *Flexibility* (with overcapacity & typical CRM)
Long Run Marginal Cost
Returns for Peak Generator
Returns for Mid-Range Generator
Returns for *Flexibility*
€130
Returns for Base Load Generator
€70
C
€35
8760 (Hours)

## Prices in Energy Only Markets (Left) and Markets with a Reliability Requirement (Right)

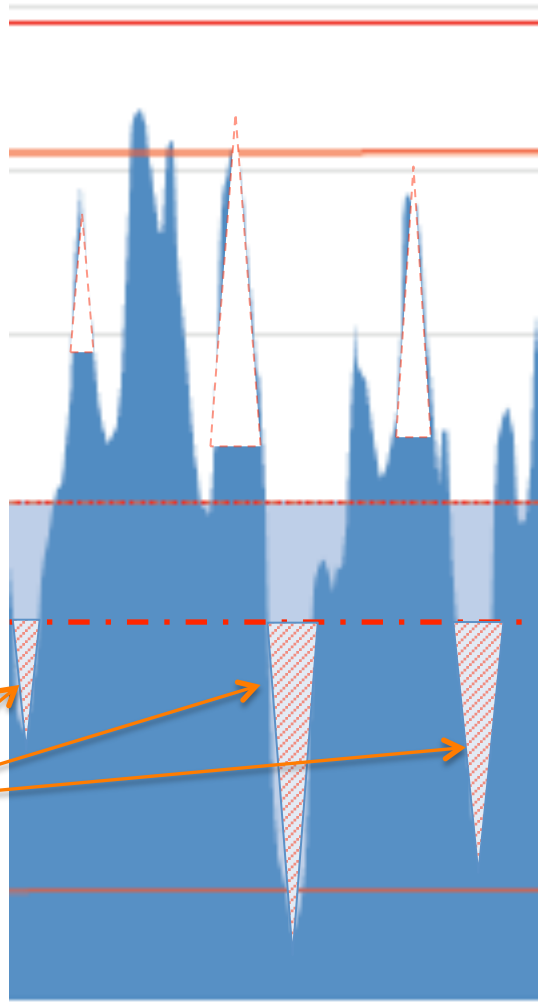



*Sources and Notes:*

Weekly average prices from Ventyx (2012); Weekly average prices for Australia from AEMO (2012).

Historical prices shown for ERCOT are at the North Hub; Australia prices are at New South Wales; PJM prices are at the Eastern Hub; and ISO-NE prices are at the System Hub.

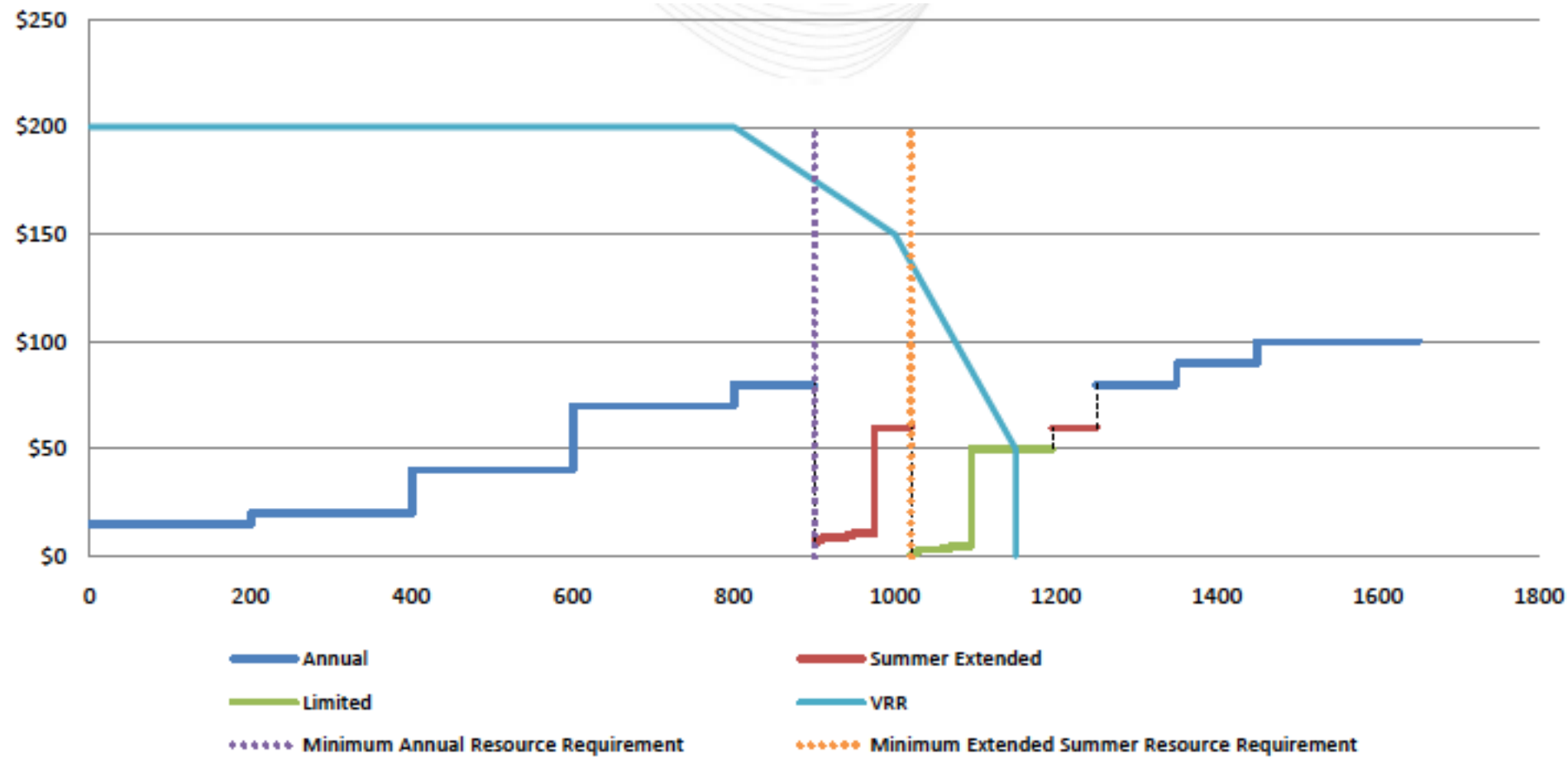
Source: Brattle Group



Increased generator flexibility

Demand response

# Real-life example of a tranched CRM



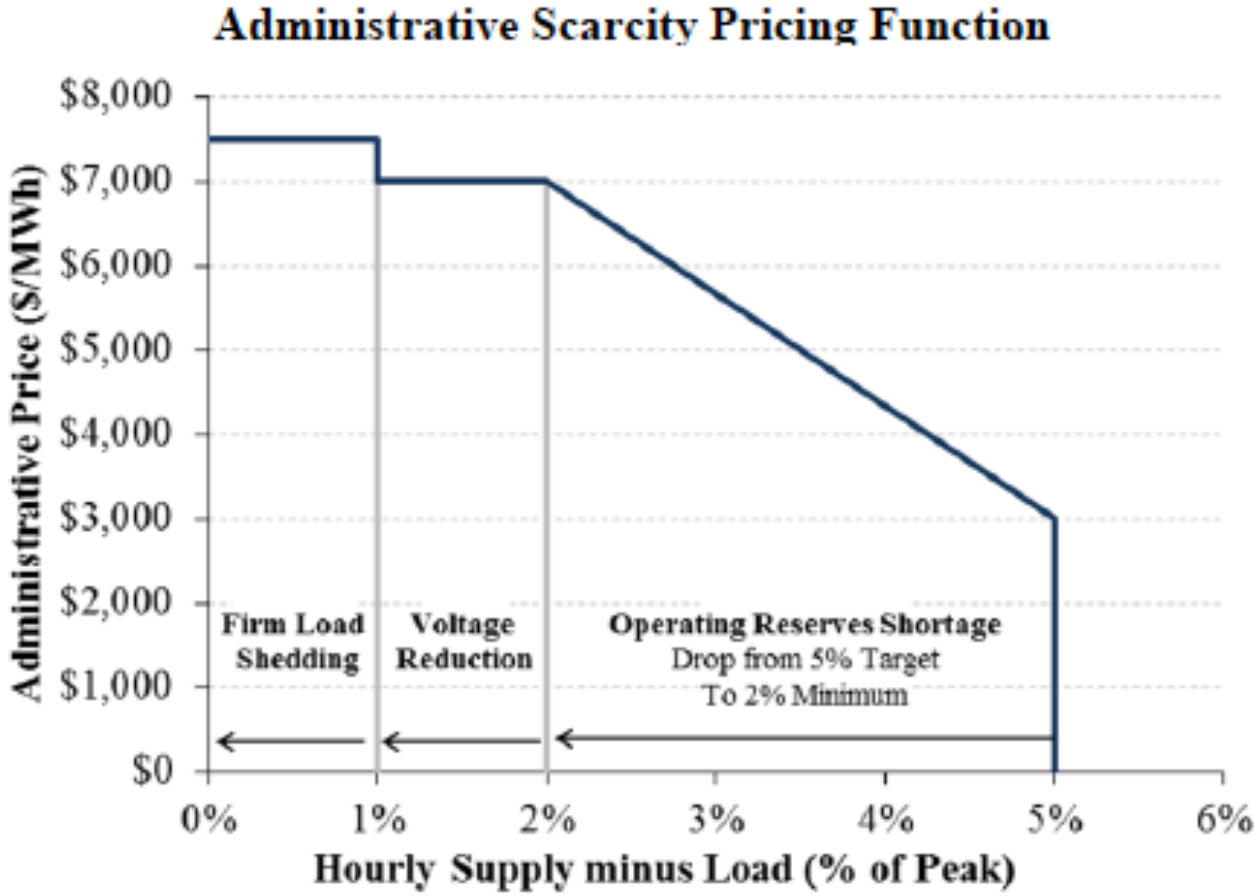

Source: PJM

# Example of *actual* marginal resources and costs

| Emergency Level | Marginal Resource | Trigger | Price | Marginal System Cost |
|---|---|---|---|---|
| n/a | Generation | Price | Approximately $20-$250 | Same |
| n/a | Imports | Price | Approximately $20-$250<br>Up to $1,000 during load shed | Same |
| n/a | Non-Spin Shortage | Price | Marginal Energy +<br>Non-Spin ORDC w/ X = 2,000 | Marginal Energy +<br>Non-Spin ORDC w/ X = 1,150 |
| n/a | Emergency Generation | Price | $500 | Same |
| n/a | Price-Responsive Demand | Price | $250-$9000 | Same |
| n/a | Spin Shortage | Price | Marginal Energy + Non-Spin +<br>Spin ORDC w/ X = 2,000 | Marginal Energy + Non-Spin +<br>Spin ORDC w/ X = 1,150 |
| n/a | Regulation Shortage | Price | Power Balance Penalty Curve | Same |
| EEA 1 | 30-Minute ERS | Spin ORDC x-axis<br>= 2,300 MW | $3,239 at Summer Peak<br>(from ORDC) | $1,405 |
| EEA 1 | TDSP Load Curtailments | Spin ORDC x-axis<br>= 1,750 MW | $9,000 (from ORDC) | $2,450 |
| EEA 2 | Load Resources in RRS | Spin ORDC x-axis<br>= 1,700 MW | $9,000 (from ORDC) | $2,569 |
| EEA 2 | 10-Minute ERS | Spin ORDC x-axis<br>= 1,300 MW | $9,000 (from ORDC) | $3,681 |
| EEA 3 | Load Shed | Spin ORDC x-axis<br>= 1,150 MW | VOLL = $9,000 | Same |

Source: Brattle Group report to Texas PUCT

# Example: Integrating reserve constraints into energy pricing

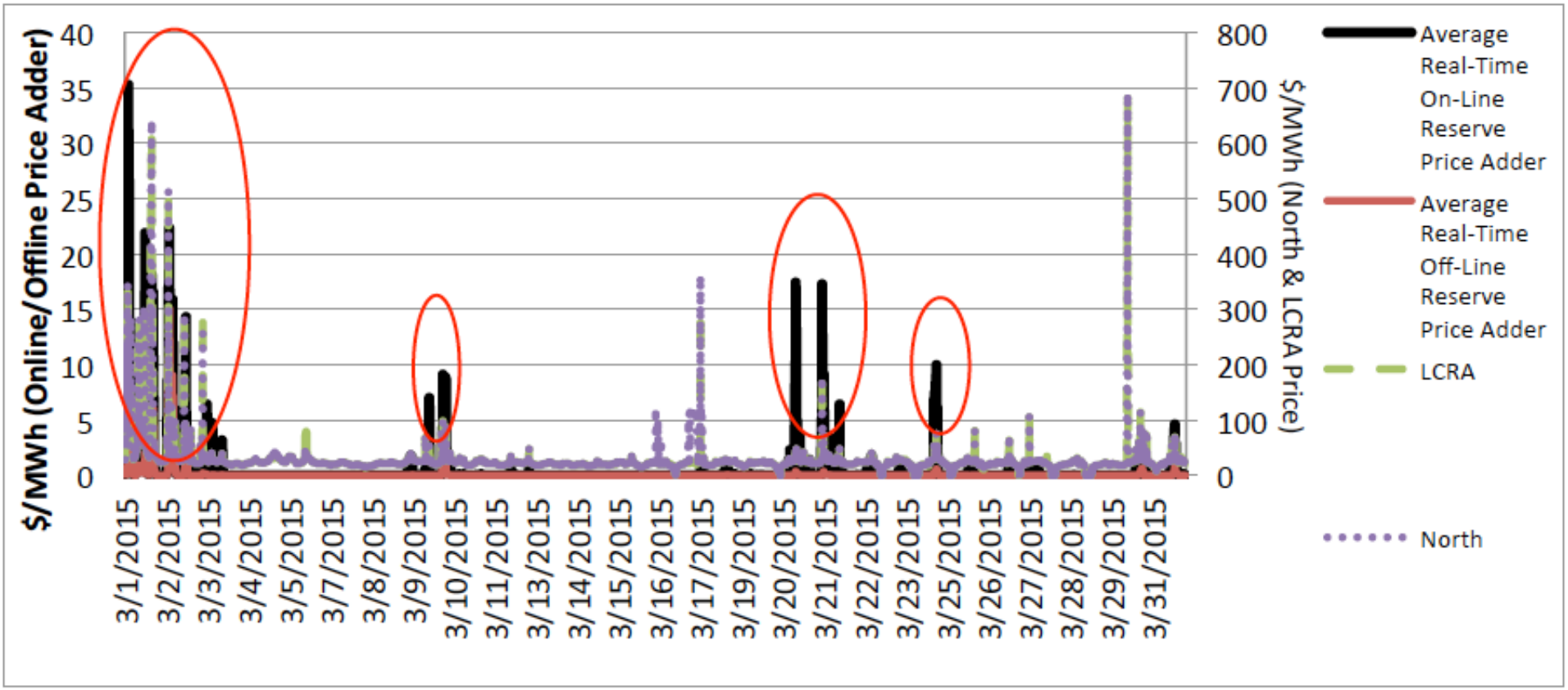



*Notes:*

Horizontal axis of the administrative pricing curve is calculated as a percent of peak load and does not vary with system conditions.

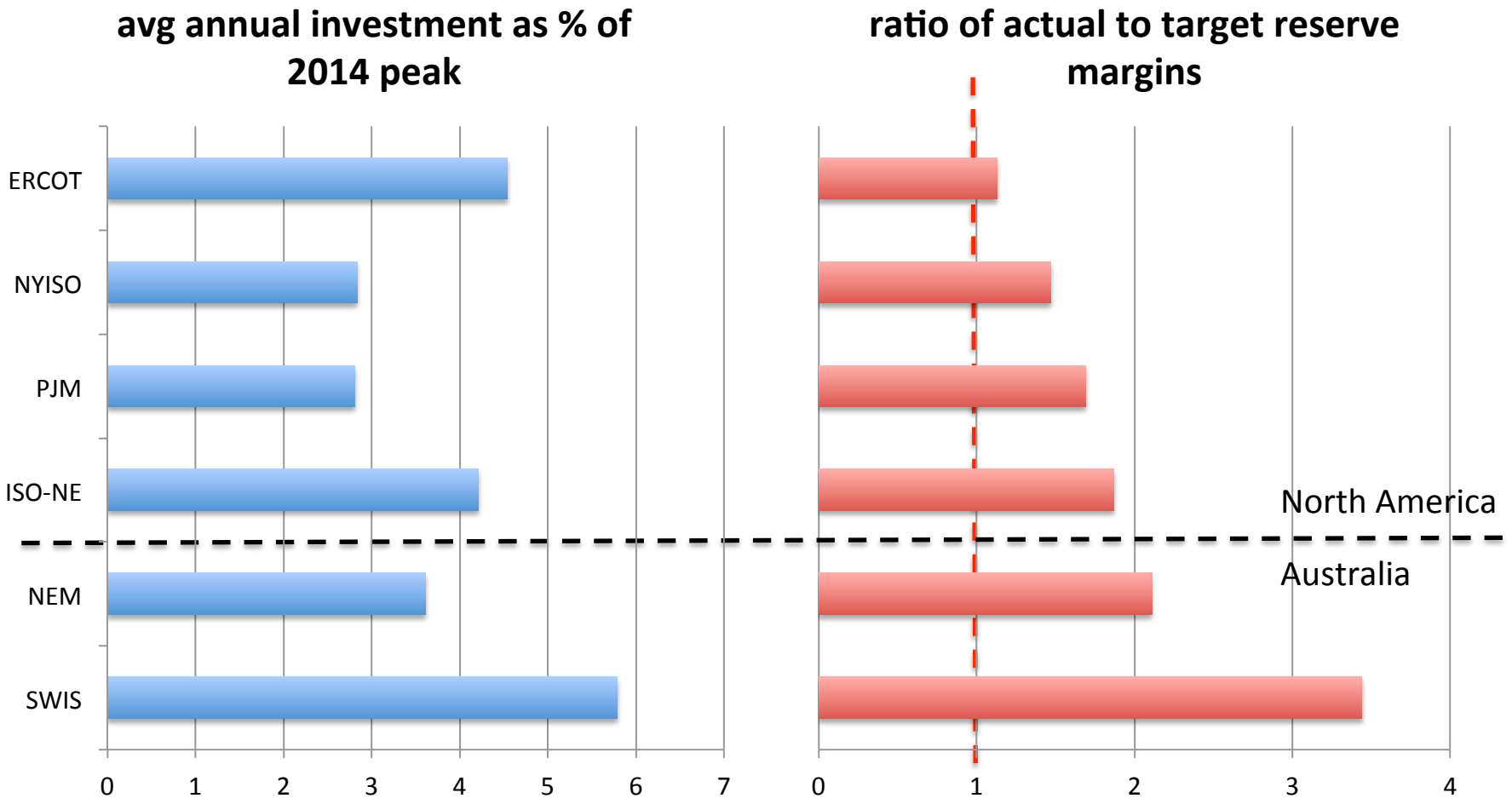
Source: Brattle Group

# ERCOT EOM Pricing – March 2015




Source: Jay Zarnikau, Univ. or Texas & Frontier Associates

# Patterns of investment (& over-investment) with increasing role for forward CRMs



# About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

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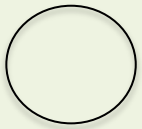
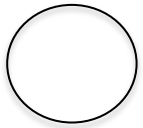
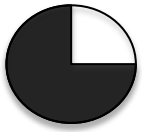
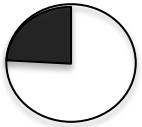
**www.raponline.org**

| | Consumer VOLL | Resource Adequacy Std. | Values flexibility | Liquidity |
|---|---|---|---|---|
| "Simple" EOM |  |  |  |  |
| "Simple" CRM |  |  |  |  |
| Tranched CRM |  |  |  |  |
| EOM w/ full demand part. |  |  |  |  |
| Co-optimized EOM w/ DR |  |  |  |  |
| Co-opt. EOM w/ simple CRM |  |  |  |  |