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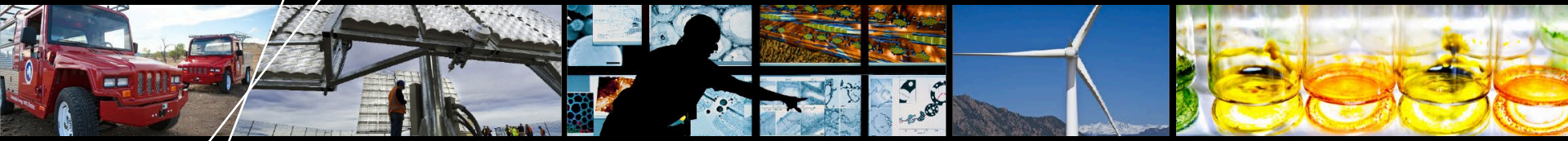
Impact of Market Behavior, Fleet Composition, and Ancillary Services on Revenue Sufficiency



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Bethany Frew

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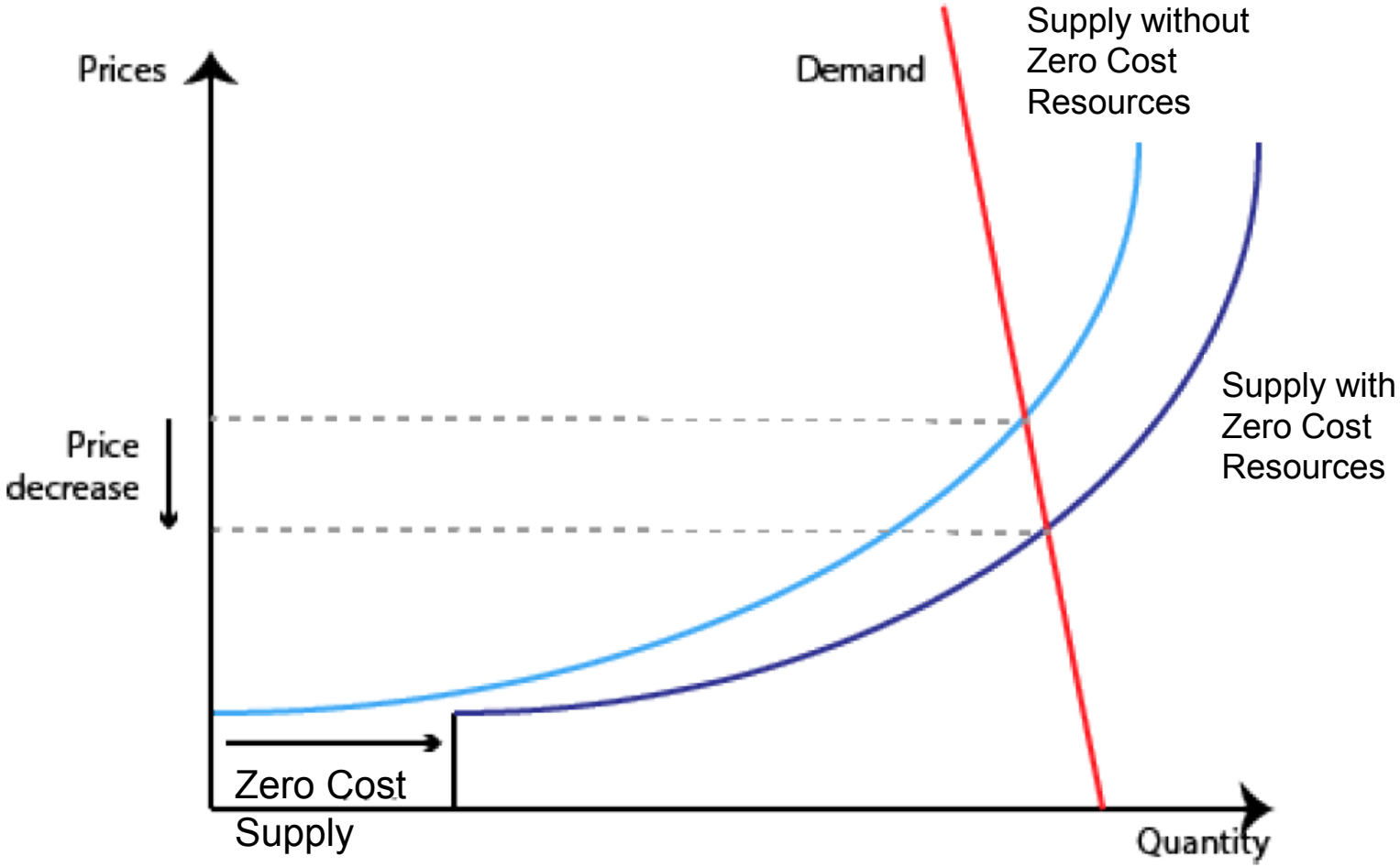
"There is growing world-wide concern over depressed energy prices and need for capacity adequacy…"

Charlie Smith, UVIG

New and ongoing NREL research aims to improve our understanding of reliability and **revenue sufficiency** challenges through modeling tools within a markets framework

VG amplifies revenue sufficiency problem



Merit order effect

modified from
(Gallo, 2016)

Current market designs to ensure revenue sufficiency

1) Scarcity (shortage) pricing

2) Forward capacity markets

3) Reserve products/pricing

Strategies to deal with this problem depend on existing market designs, and it remains unclear if/which of these can provide proper incentives to ensure longer-term reliability

NREL using models to assess evolving grid

Goal: Examine impact of evolving electric systems on revenue sufficiency and reliability.

We examined:

- Increasing penetration of VG
- New ancillary service requirement
- Changing fleet composition

NREL using models to assess evolving grid

Goal: Examine impact of evolving electric systems on revenue sufficiency and reliability.

We found:

- Increasing penetration of VG ***amplifies revenue sufficiency challenges***
- New ancillary service requirement ***marginally abates revenue sufficiency challenges***
- Changing fleet composition ***drives greater concern over resource adequacy***

NREL using models to assess evolving grid

Future Work:

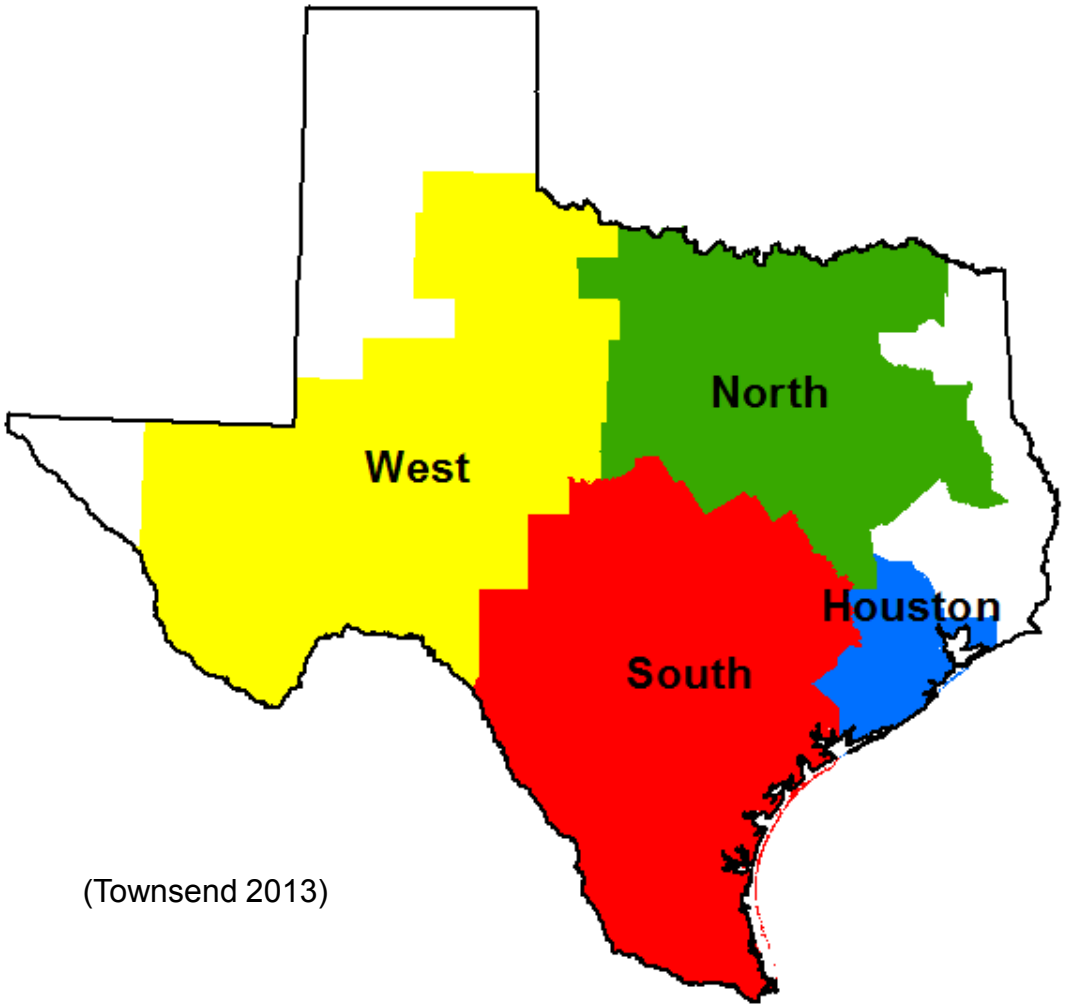
Develop more comprehensive framework to assess **reliability** and **revenue sufficiency** challenges.

What **market designs** best enable the system to move from the current state to future target?

The price is right…right?

- **Getting the prices right is critical for properly assessing revenue sufficiency challenges**
- **Lesson learned: production cost models (PCMs) out-of-box need to be tuned**
- **Capturing generator behaviors is one key factor**
  - We use bid offer markups as proxy for for strategic behavior in generator bid offers

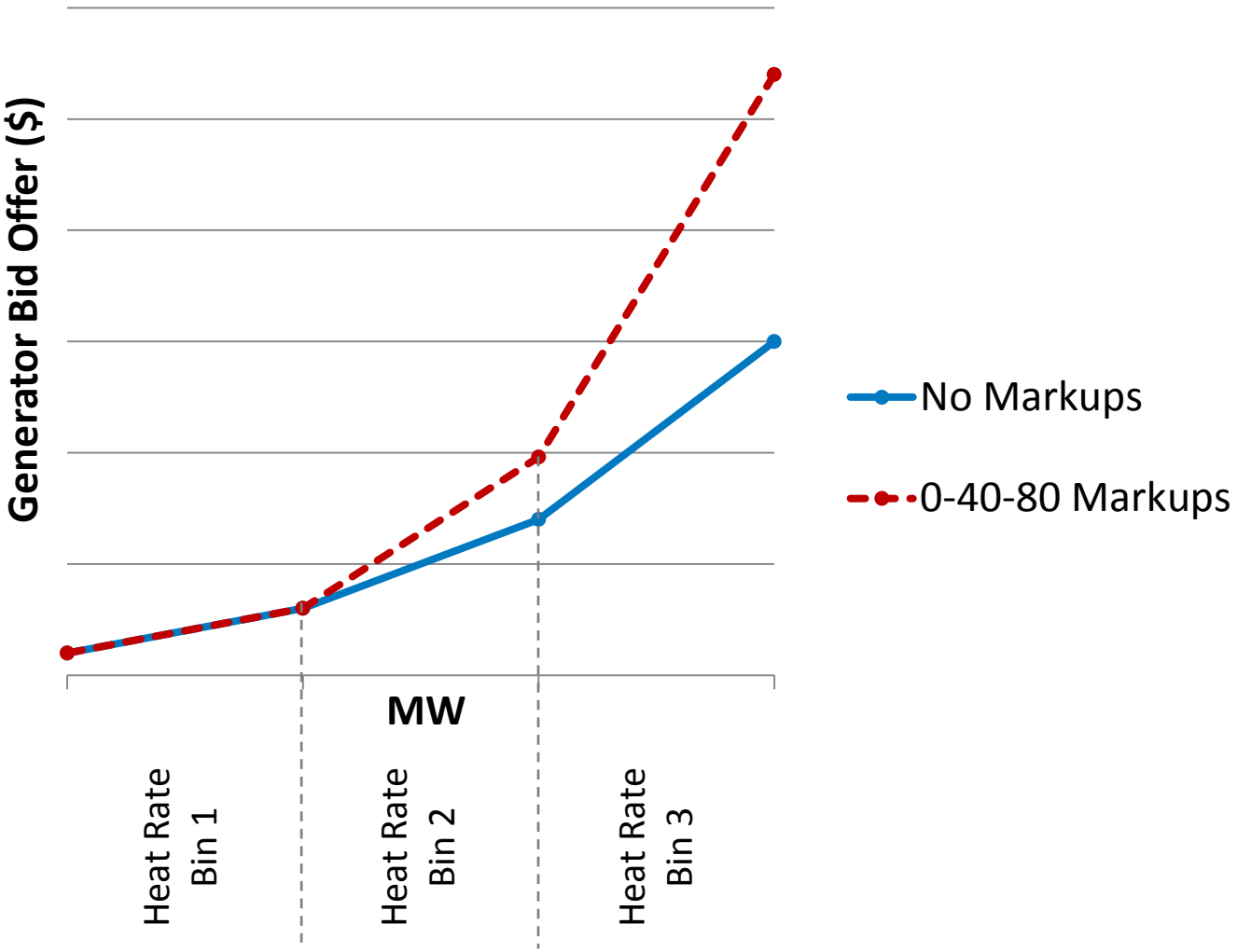
Proof of concept: ERCOT-like PCM



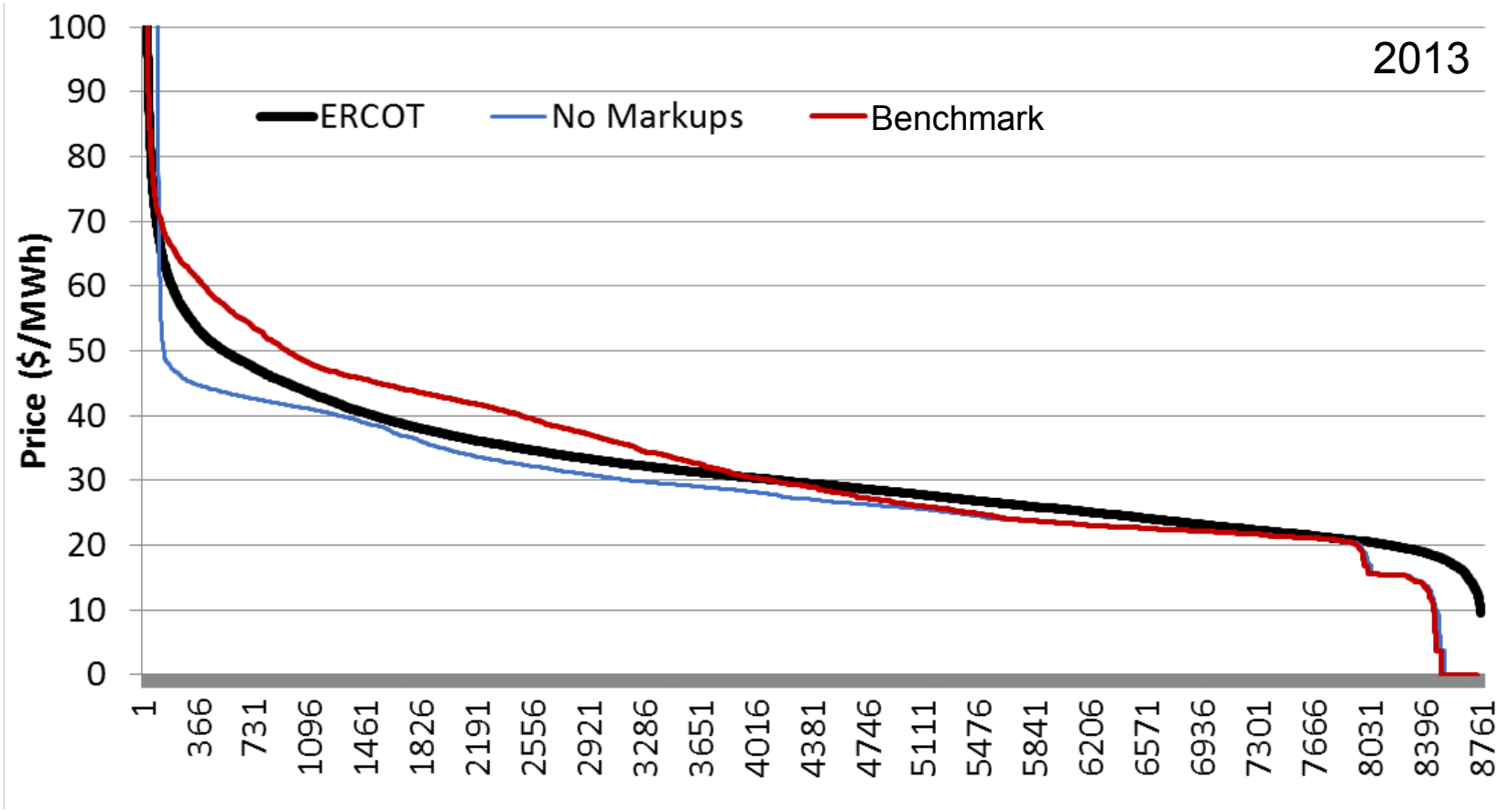
(Townsend 2013)

- ERCOT is energy-only market
- 4 zones, hourly resolution with historic wind and load data, DAM only
- Simulate prices, costs, revenues for 2012-2014, focus on 2013

Markup scenarios to calibrate model



Validate against historic ERCOT DAM prices



- **Modeling captures mid-section of price duration curve, but misses tails**
- **Using default pricing (*No Markups*) would overestimate the extent of any revenue sufficiency challenges**
- **Markups result in overall larger revenues, production costs, and net revenues**

Sensitivity scenarios to assess revenue sufficiency

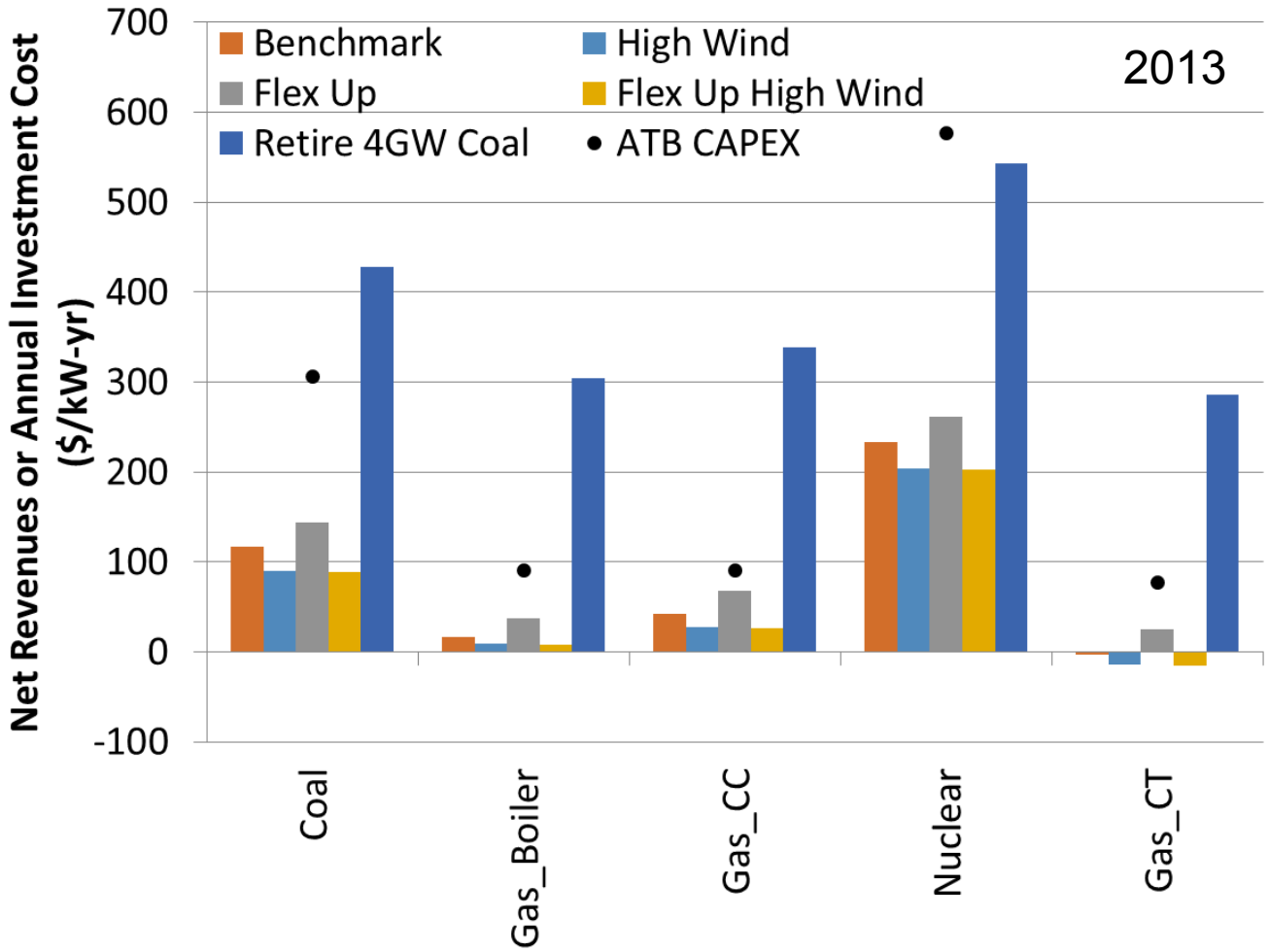
Sensitivity Scenario	Wind Capacity	Flexible Reserve	Coal Retirement
High Wind	High Wind	Benchmark	Benchmark
Flex Up	Benchmark	Flex Up Reserve Requirement	Benchmark
Flex Up High Wind	High Wind	Flex Up Reserve Requirement	Benchmark
Retire 4GW Coal	Benchmark	Benchmark	Retire 4GW coal from North and South zones

Roughly double the ERCOT-wide wind penetration from Benchmark

Additional reserve requirement to capture uncertainty burden from wind

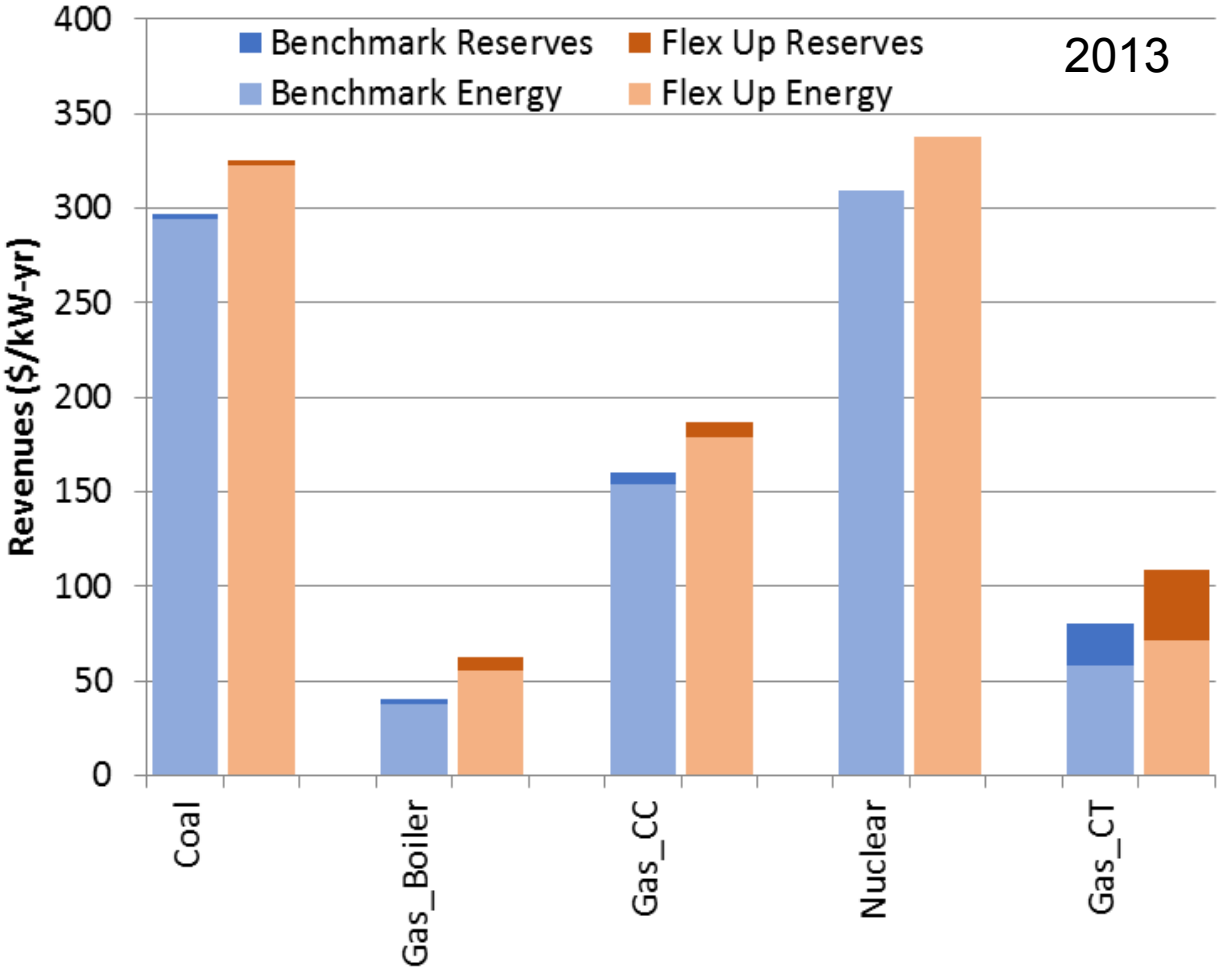
Retire about 23% of base coal fleet

Revenue sufficiency challenges are present



Revenue sufficiency challenges are implied if annual investment cost for new unit (dot) is greater than observed net revenues (bar)

Flex reserve = small (but linked) revenue impact



But presence of additional reserve requirement in the *Flex Up* scenario increased total revenue relative to the Benchmark scenario in 2013

- **Reserve revenues by 44%, energy revenues by 13%**

Key Conclusions

- **Getting the prices right is critical for estimating revenue sufficiency challenges, and out-of-box PCMs may need "tuned" to accurately replicate electricity market prices**
  - Markups can help, but other methods for capturing strategic behaviors may be needed
- **Markups increase overall production costs, revenues, and net revenues; at generator-level, net revenues may decrease**
- **Revenue sufficiency challenges are implied in base case, when increase wind, and when add new reserve product; resource adequacy becomes greater concern when retire large amounts of coal**
- **A/S (Flex Up reserve) contributes small amount to total revenues, but increases both energy and reserve revenues**

Full report available soon: NREL.gov/Analysis

Next steps: market test bed

- Use more **robust model**: UC, RTM, nodal representation, outages, DR, and forecast error
- Better capture **reliability** linkage
- Improve representation of **bidding strategies**: physical withholding, self-scheduling, bilateral agreements, and dynamic behavior
- Include other **market mechanisms**: uplift payments, congestion charges, redispatch, and other A/S components (e.g., ORDC)

We welcome suggestions for data/methods/expertise regarding reserve calculation options

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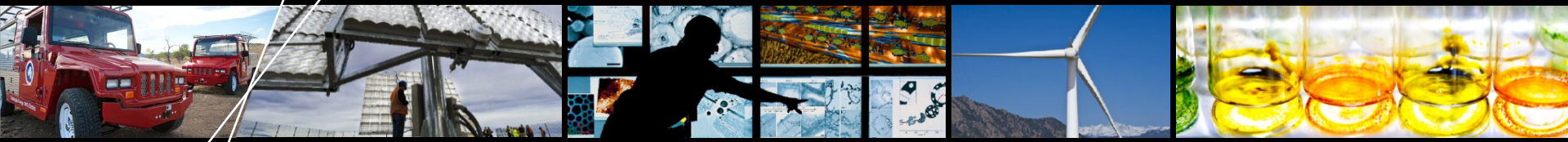

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