



# PJM Analysis of the EPA Clean Power Plan

PJM Interconnection  
October 6, 2016

Evaluate potential impacts to:

- Resource adequacy
- Transmission system operations
- PJM energy and capacity market prices

Determine compliance costs

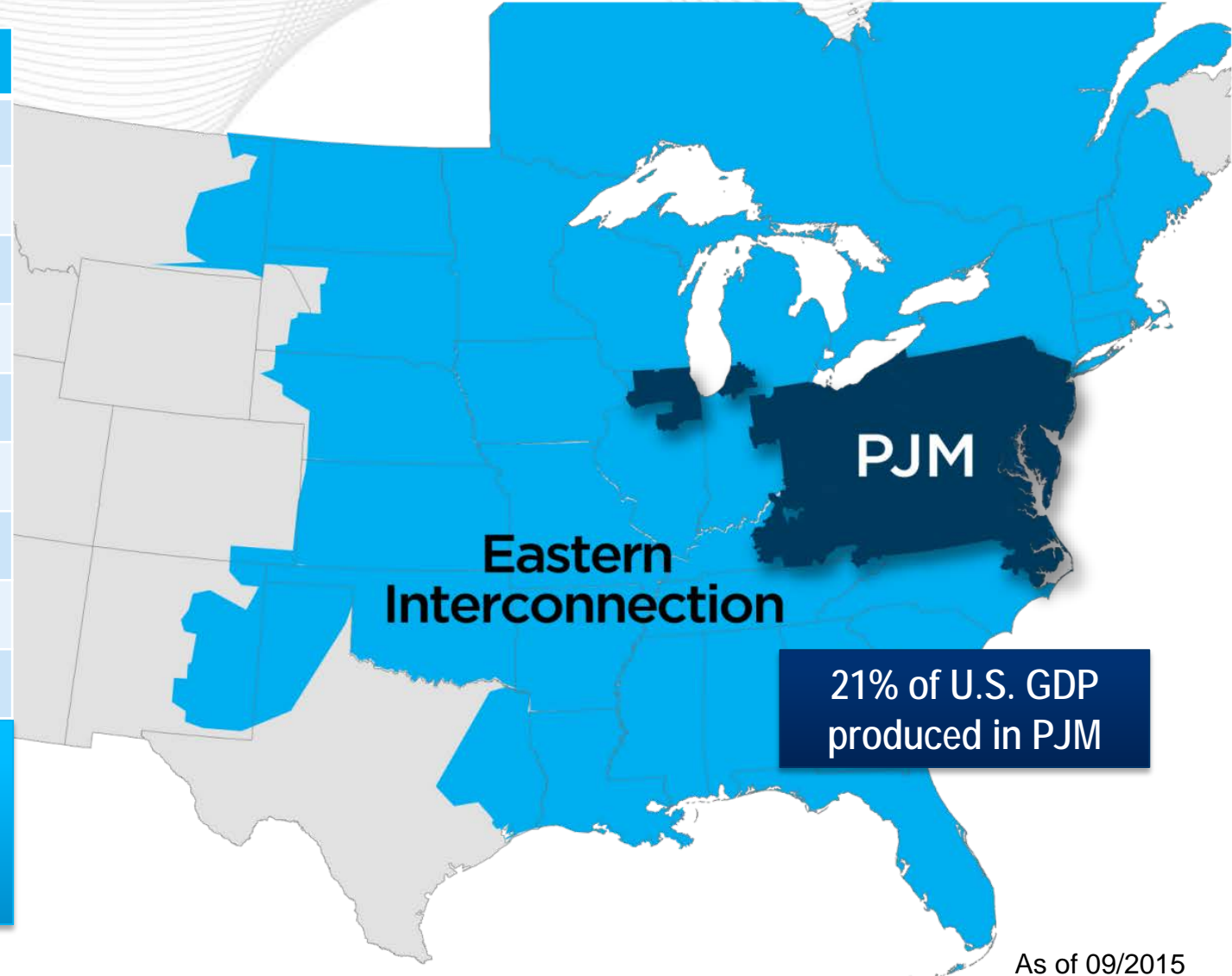
*The results are not a forecast, but are a function of assumptions*

# PJM as Part of the Eastern Interconnection

## Key Statistics

Member companies	940+
Millions of people served	61
Peak load in megawatts	165,492
MW of generating capacity	183,604
Miles of transmission lines	62,556
2014 GWh of annual energy	797,461
Generation sources	1,376
Square miles of territory	243,417
States served	13 + DC

- 27% of generation in Eastern Interconnection
- 28% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection



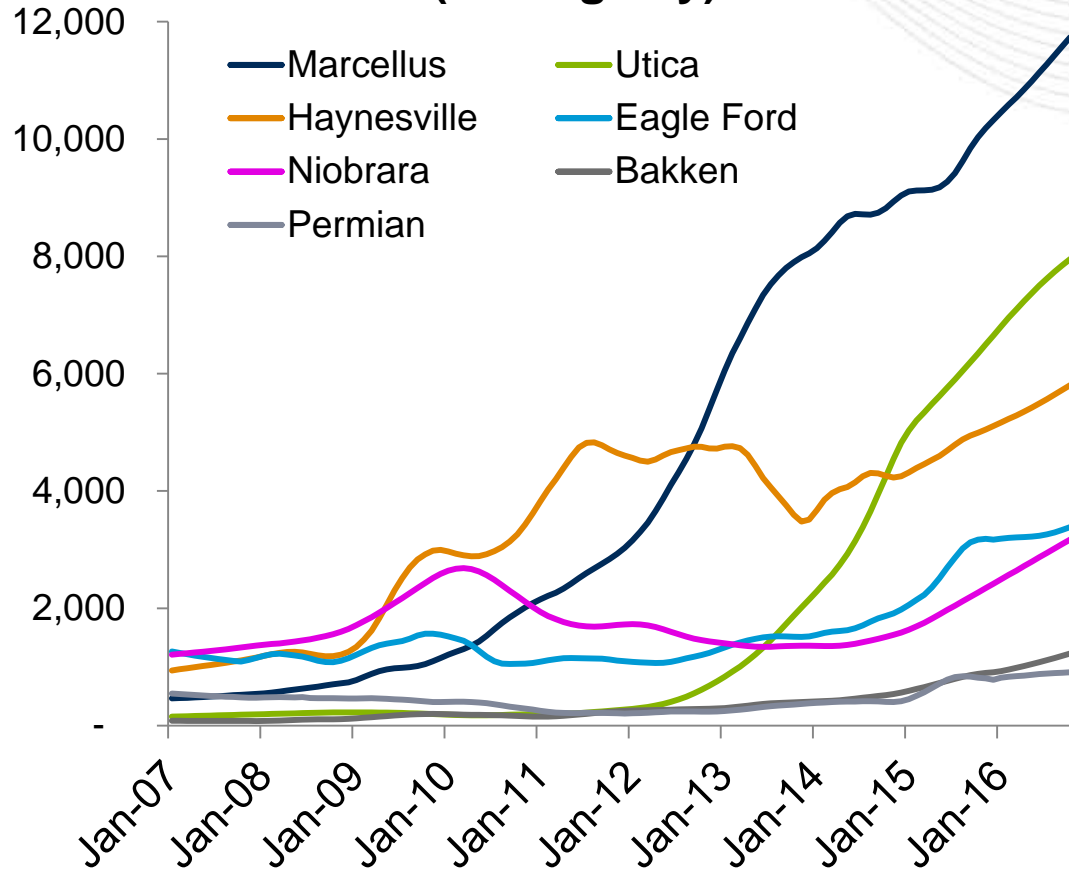
As of 09/2015



# Historic and Current Context for Understanding PJM's Analysis of the Clean Power Plan

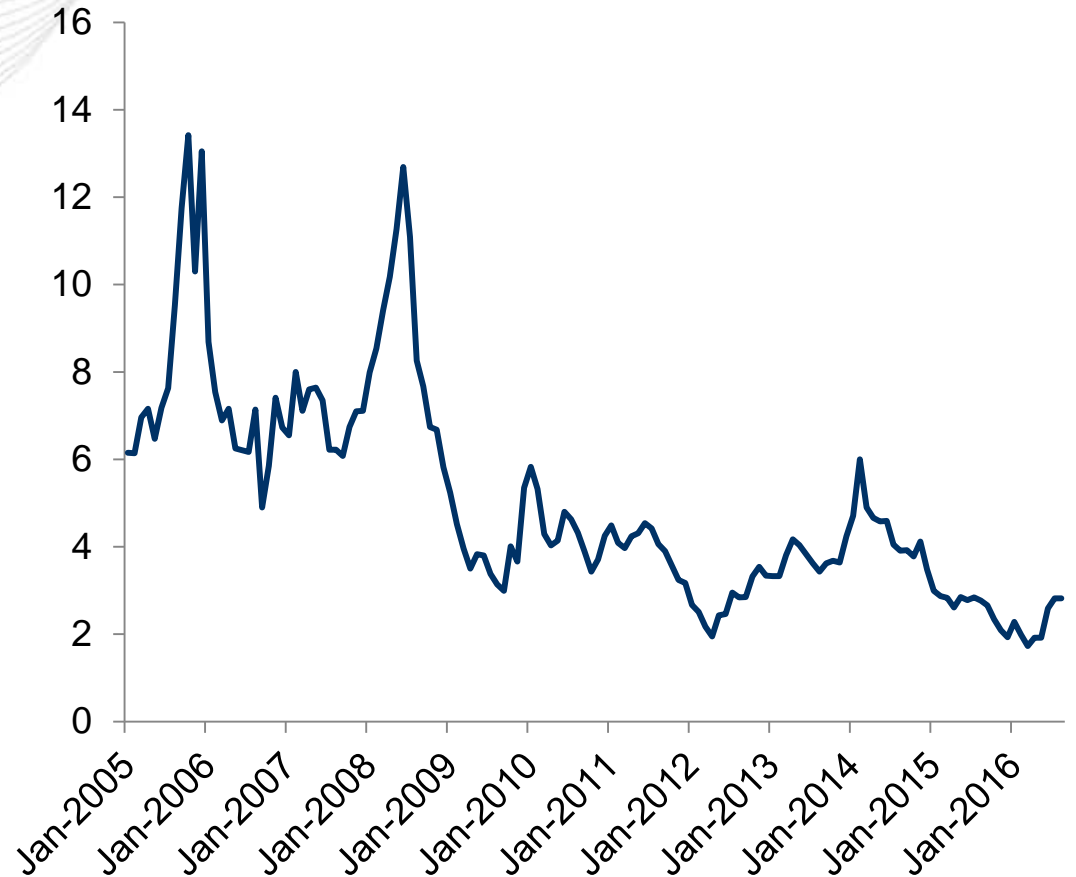
# Natural Gas Rig Productivity Rises and Prices Decline

## Rig Productivity (mcf/rig/day)



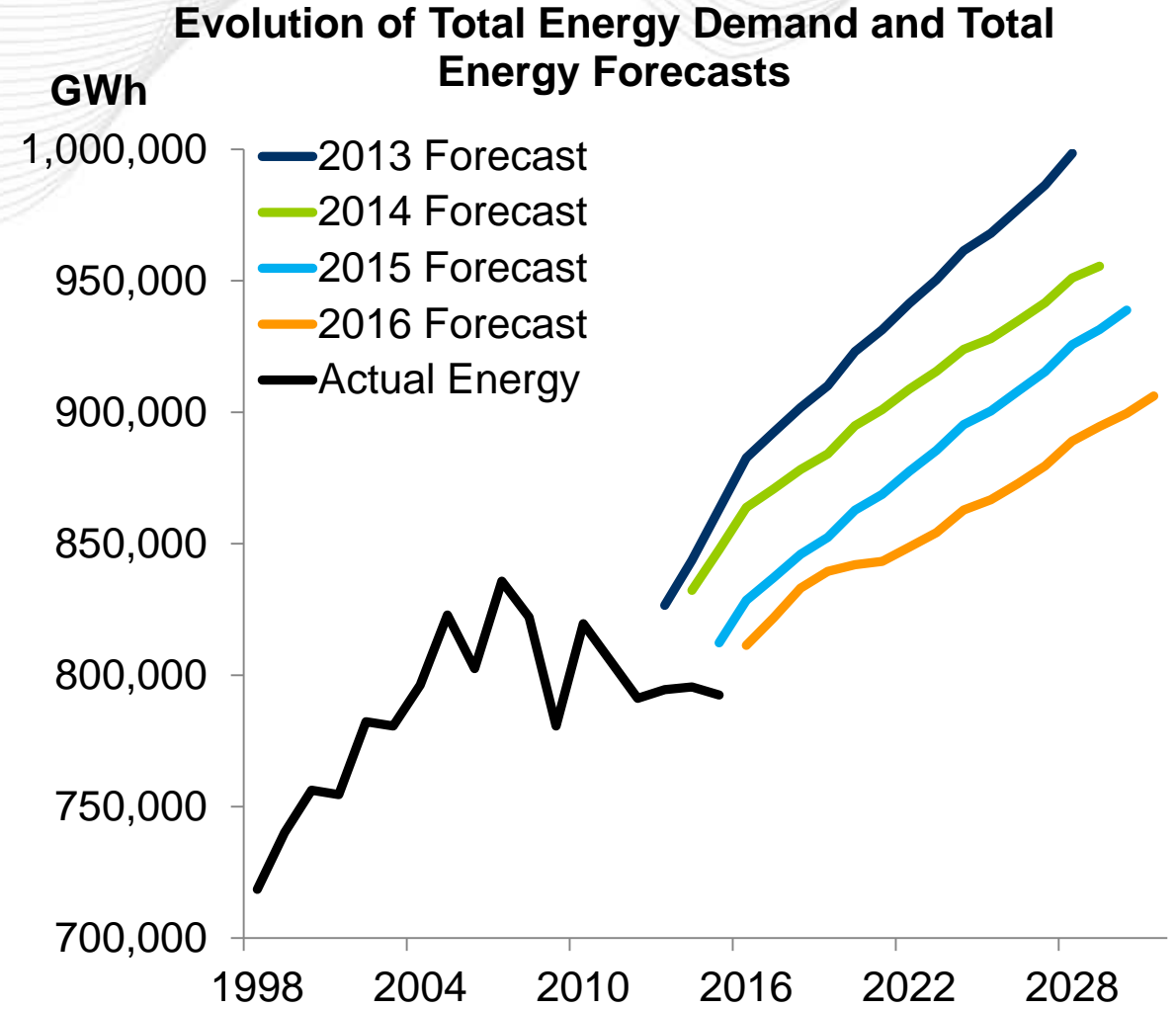
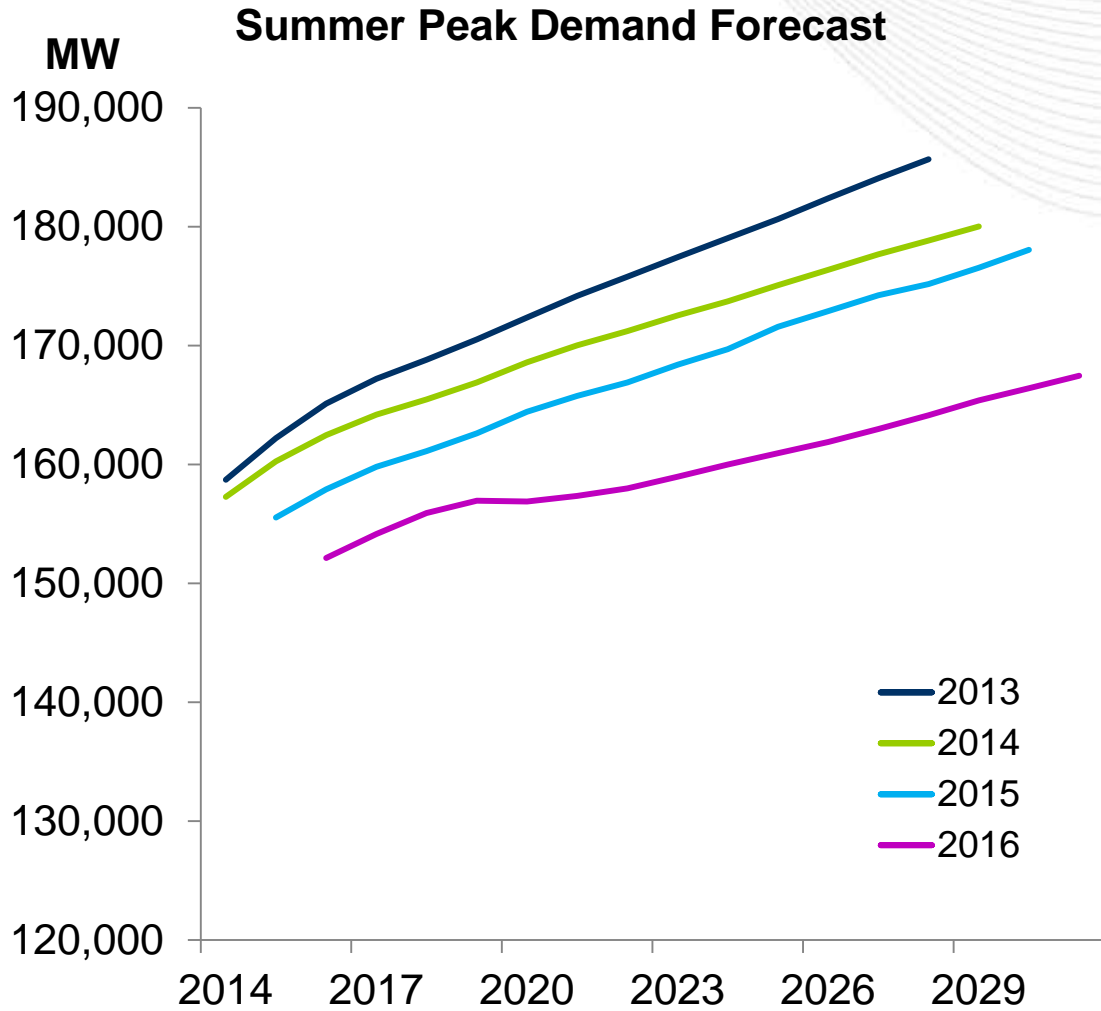
\* Source: EIA. *Drilling Productivity Report*. September 2016.

## Henry Hub Historic Monthly Price

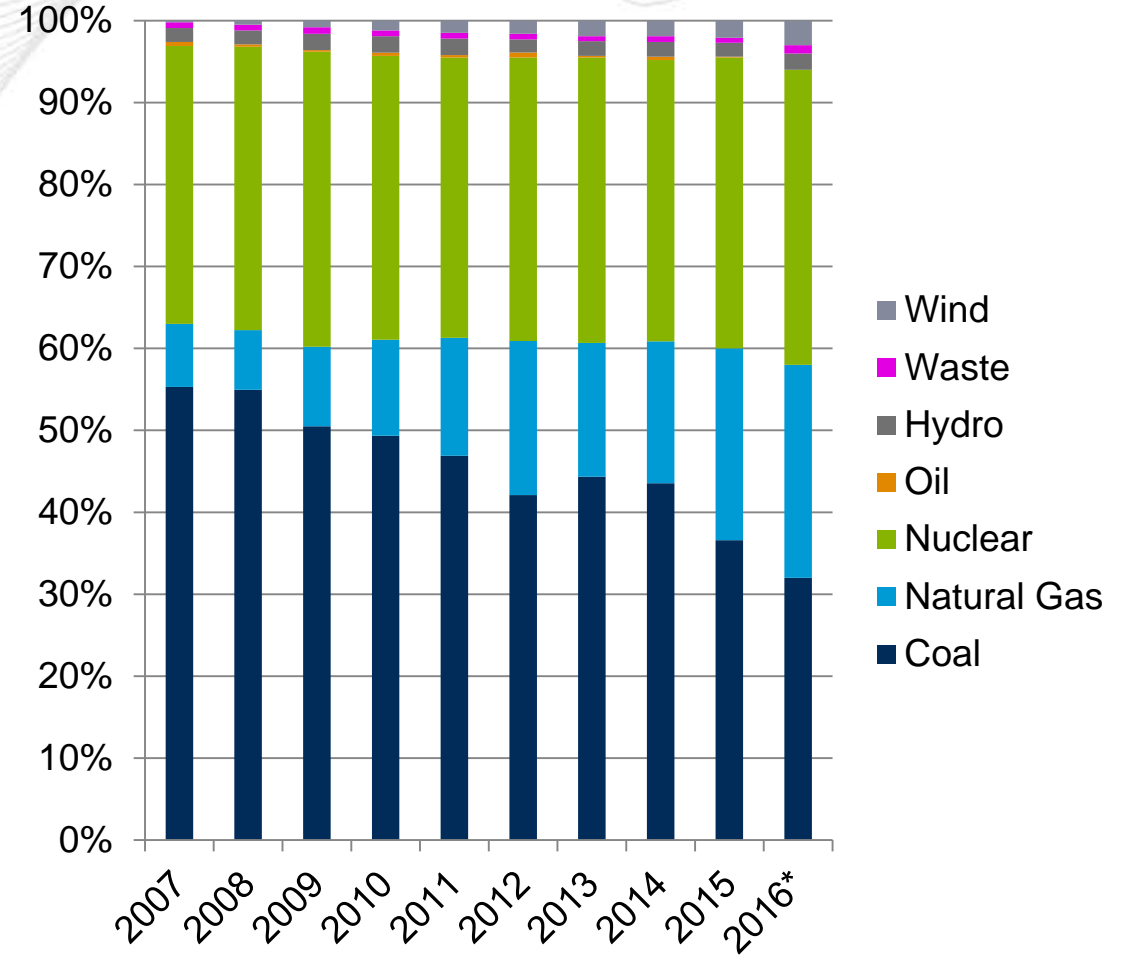
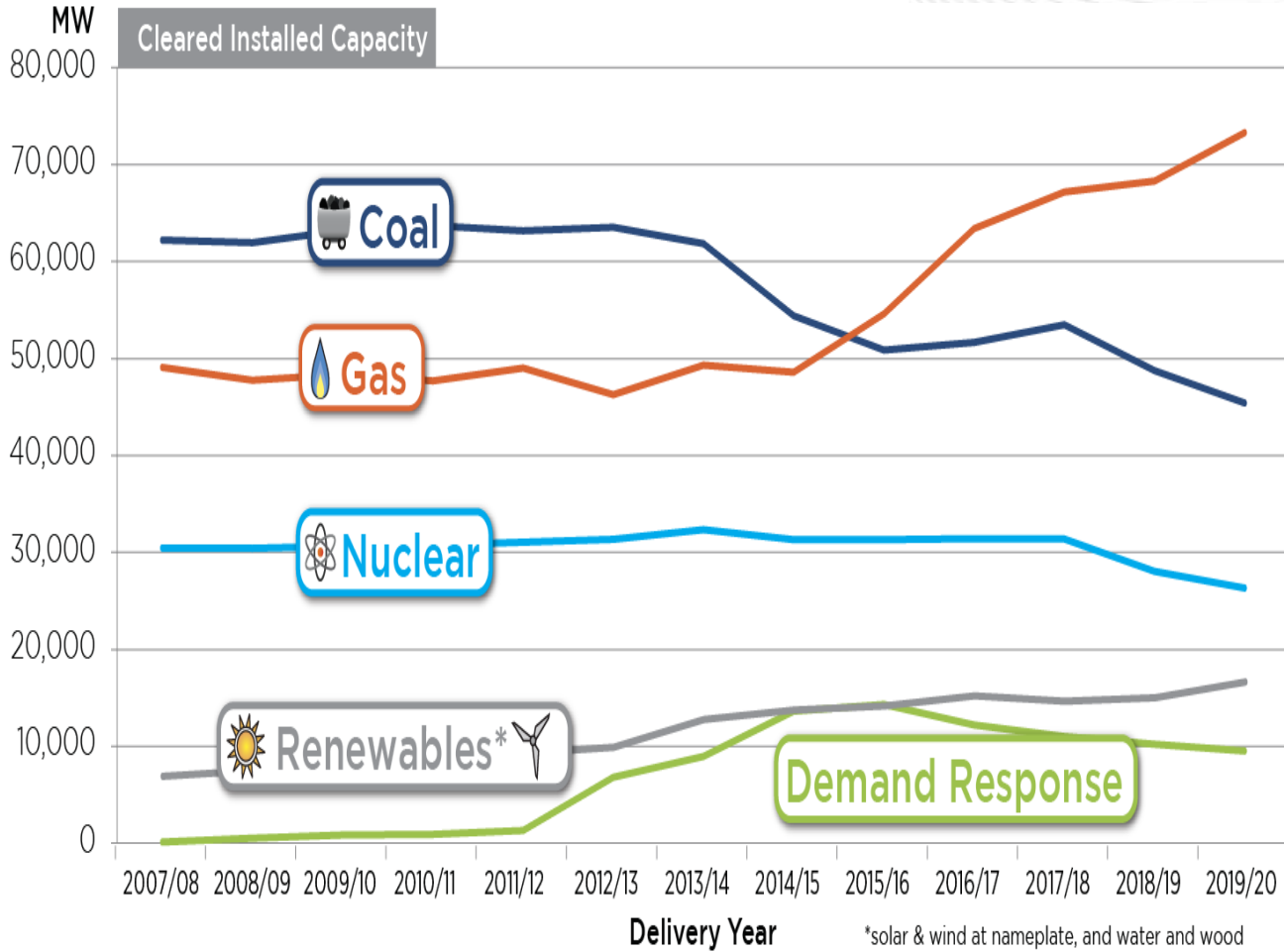


\* Source: EIA. *Henry Hub Monthly Spot Price Series*. September 25, 2016.

# Demand has Been Declining in the PJM Region



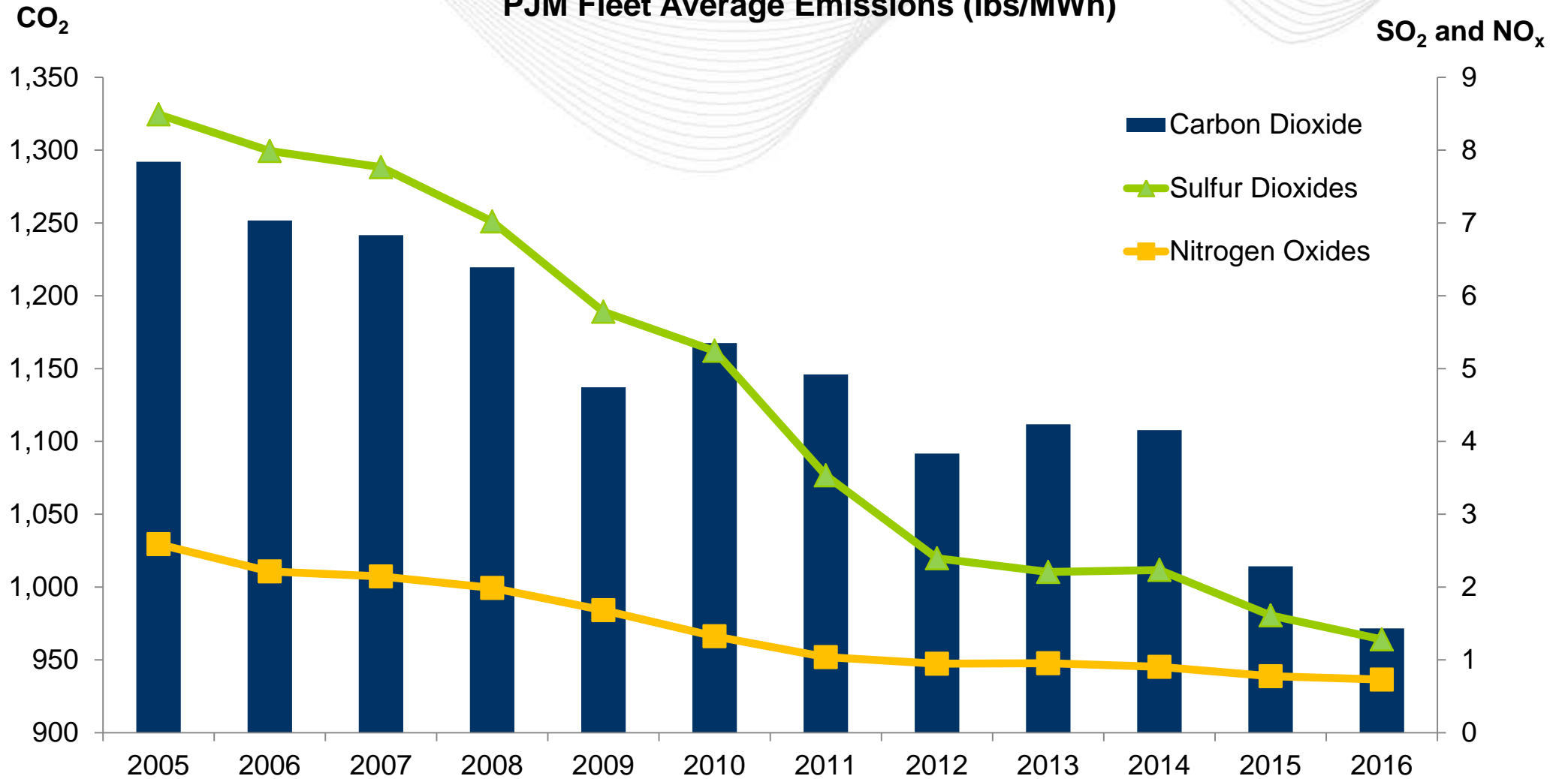
# Gas is Gaining Prominence in the Energy Mix



\* Source: Monitoring Analytics, LLC. 2016 State of the Market Report for PJM. August 11, 2016.



## PJM Fleet Average Emissions (lbs/MWh)



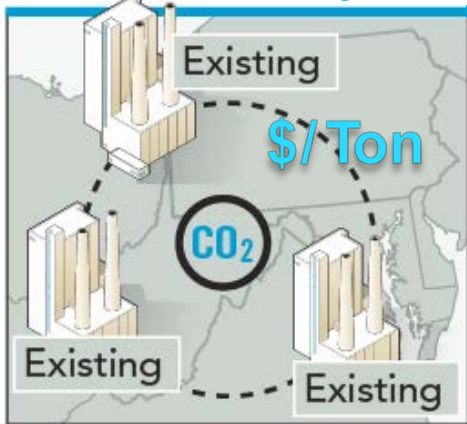
Source: PJM Generation Attributes Tracking System. 2016 data is through July.



# PJM's Analysis of the Clean Power Plan:

## Key Model Features

## Trade-Ready



Single CO<sub>2</sub> limit applied to the PJM region for 111(d) existing resources

## State Mass



Each state applies a CO<sub>2</sub> limit covering all 111(d) existing resources

## New Source Complement



Single CO<sub>2</sub> limit applied to the PJM region for 111(d) existing and 111(b) new sources

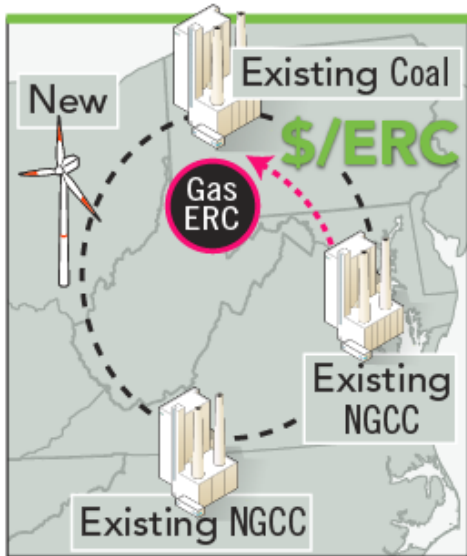
## State Mass New Source Complement



Each state applies a CO<sub>2</sub> limit covering all 111(d) existing resources and 111(b) new sources

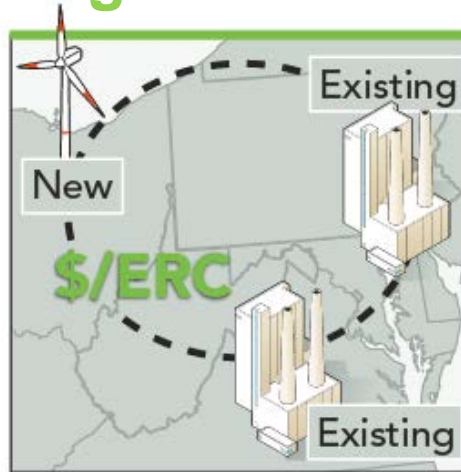
[1] [Proposed Federal Plan for the Clean Power Plan \(PDF\)](http://www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22848.pdf) - <http://www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22848.pdf>

## Trade-Ready Rate



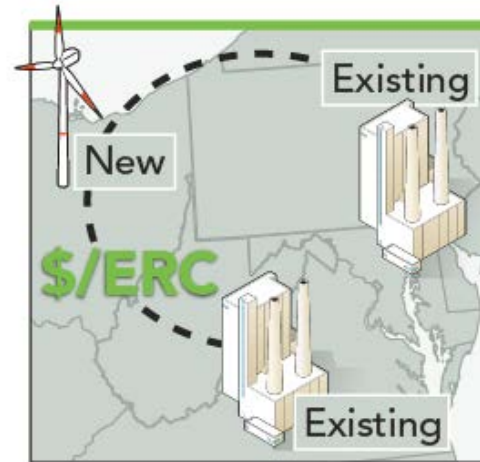
Emissions performance measured against the sub-category CO<sub>2</sub> emission rate targets for combined cycle and steam turbine resources

## Regional Blended Rate



Emissions performance measured against a weighted average of PJM states' CO<sub>2</sub> emissions rate targets

## State Blended Rate



Emissions performance measured against the state CO<sub>2</sub> emissions rate target

[1] [Proposed Federal Plan for the Clean Power Plan \(PDF\)](http://www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22848.pdf) - <http://www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22848.pdf>

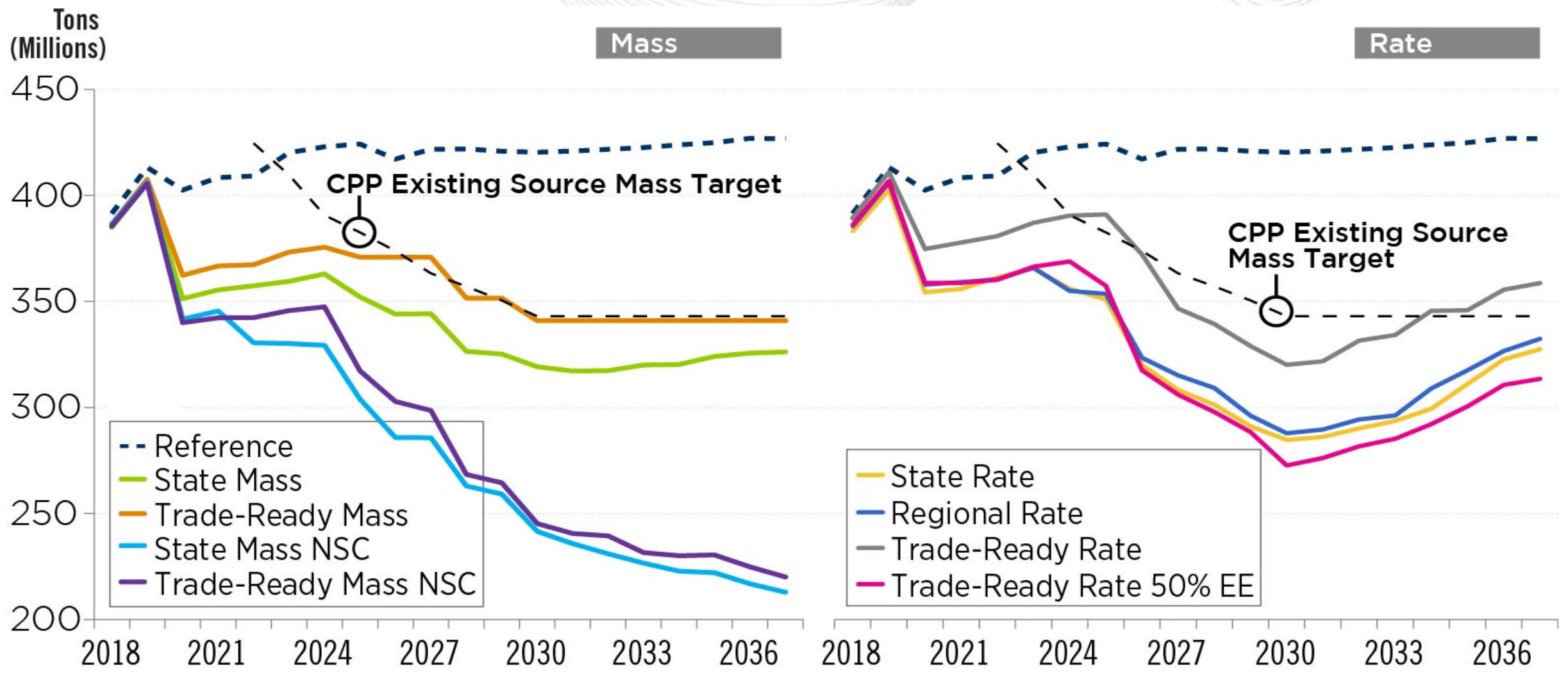


# PJM's Analysis of the Clean Power Plan: Key Findings from Reference Gas Scenario



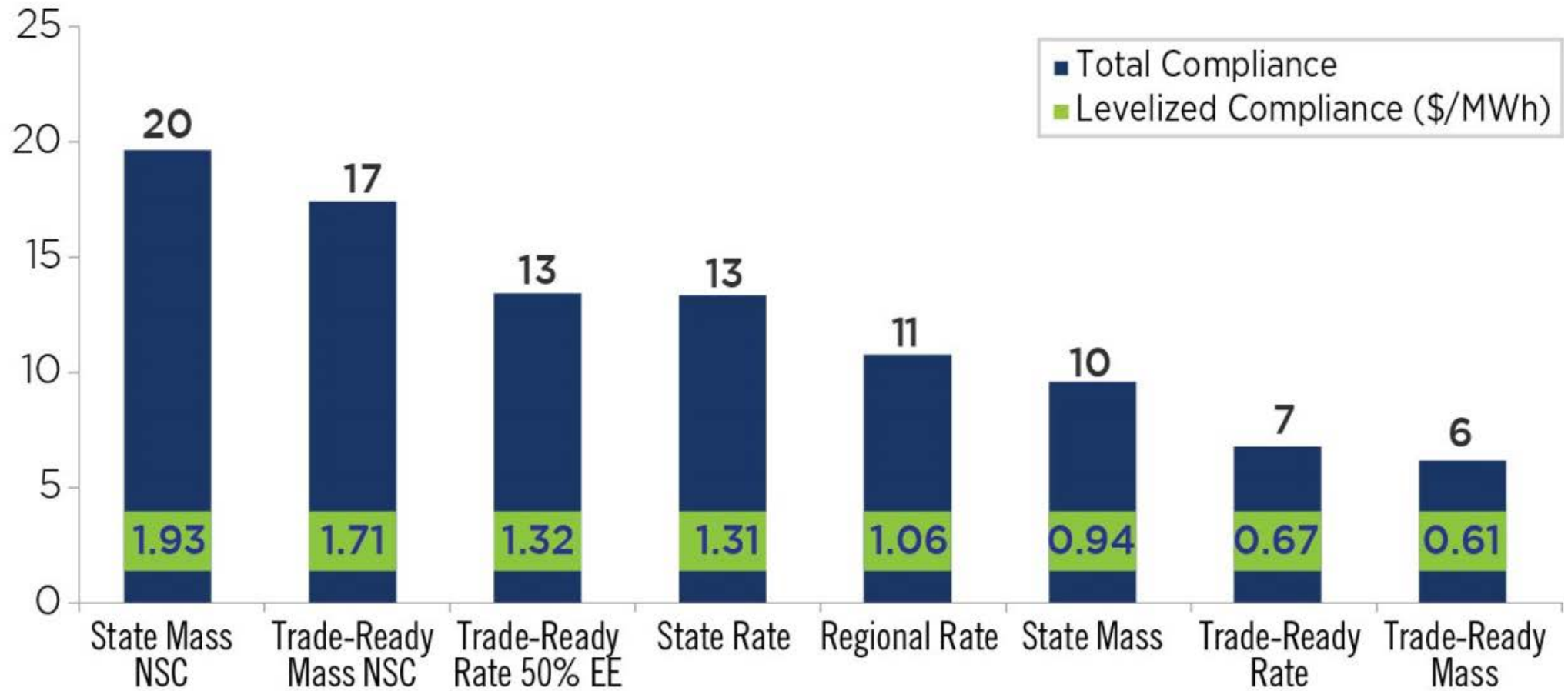


# It is Feasible for PJM States to Achieve CO<sub>2</sub> Emissions Targets...

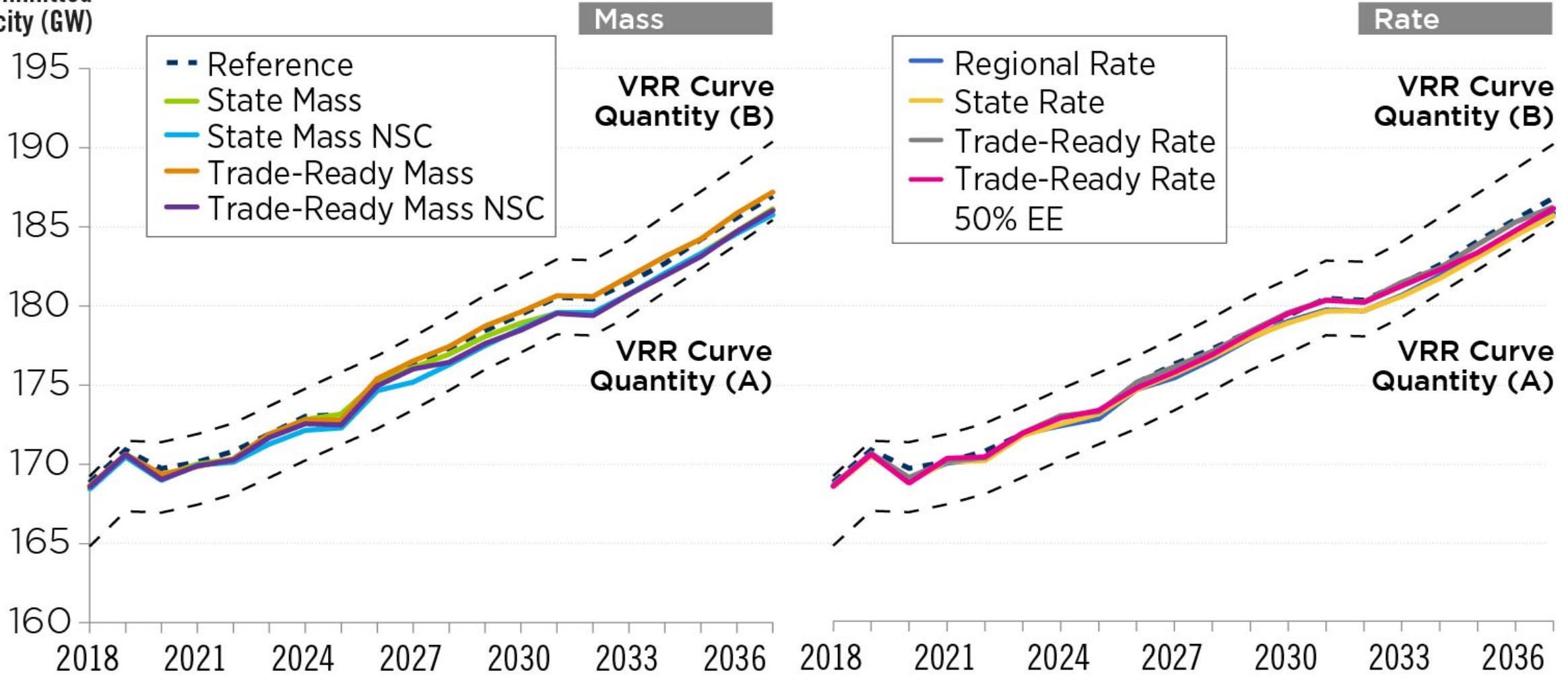


# ...Compliance Costs are 1% to 3% of recent Wholesale Market Costs to Load

Net Present Value  
Compliance (\$Billions)



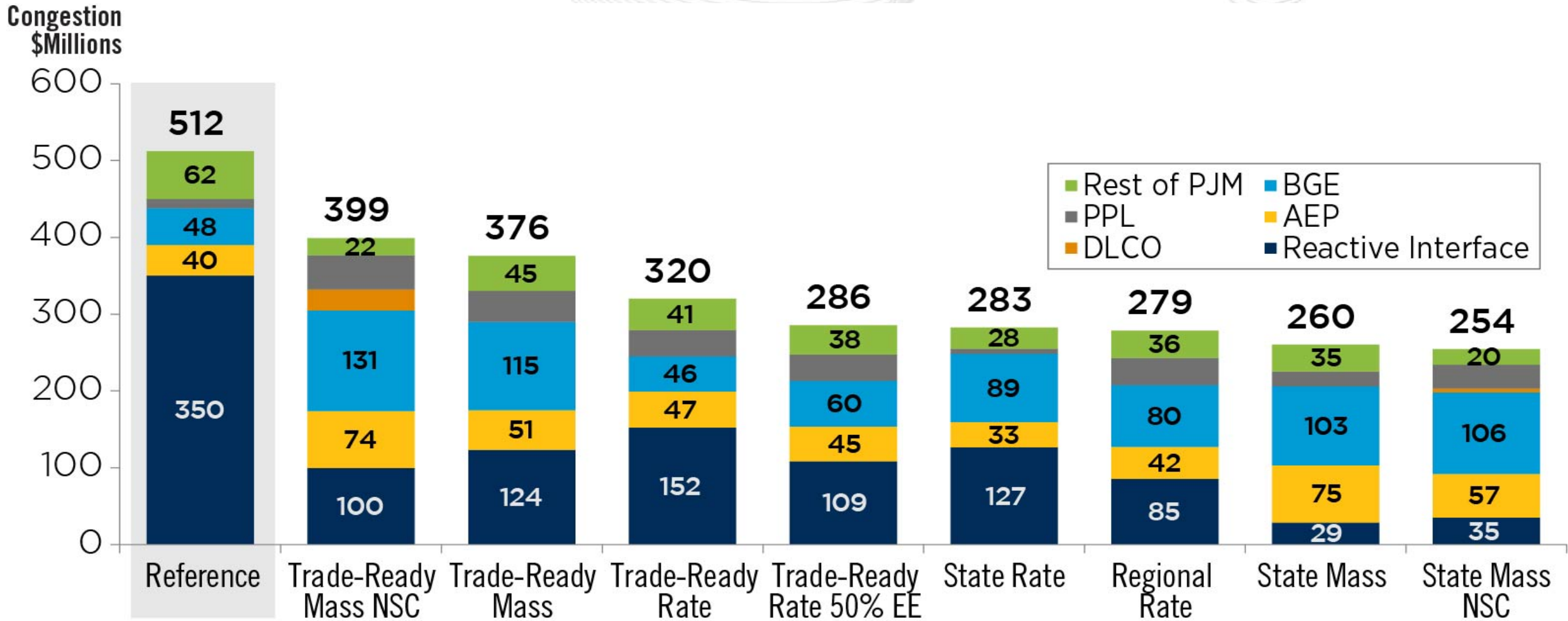
Committed Capacity (GW)







# The High Voltage Transmission System is Utilized Less Transmission Congestion in 2025

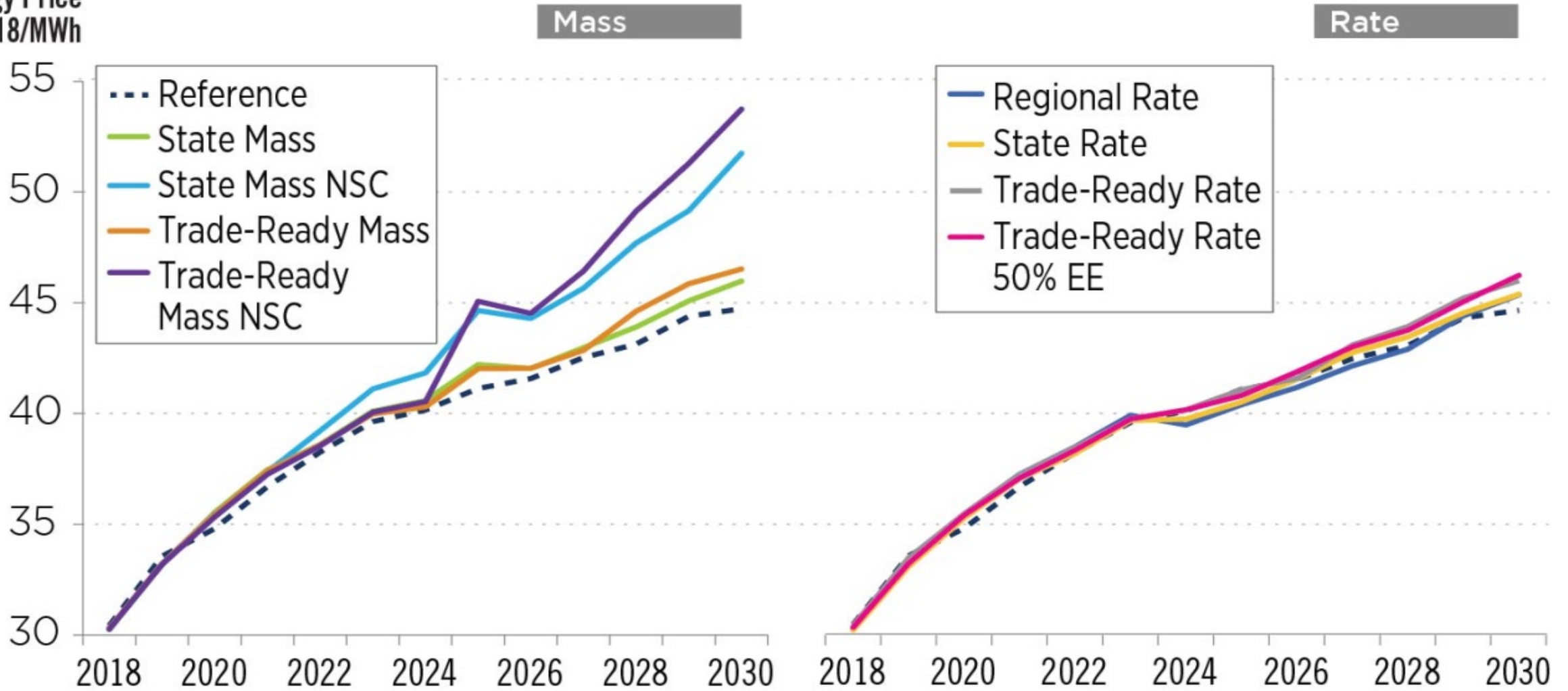


\*Analysis focused on transmission limitations in 2025 at the 230 kV system and up. Limited set of 138 kV or below constraints evaluated.



# Energy Market Prices Increase Over-Time in Response to Higher Fuel Cost, Load Growth and Emissions Market Prices

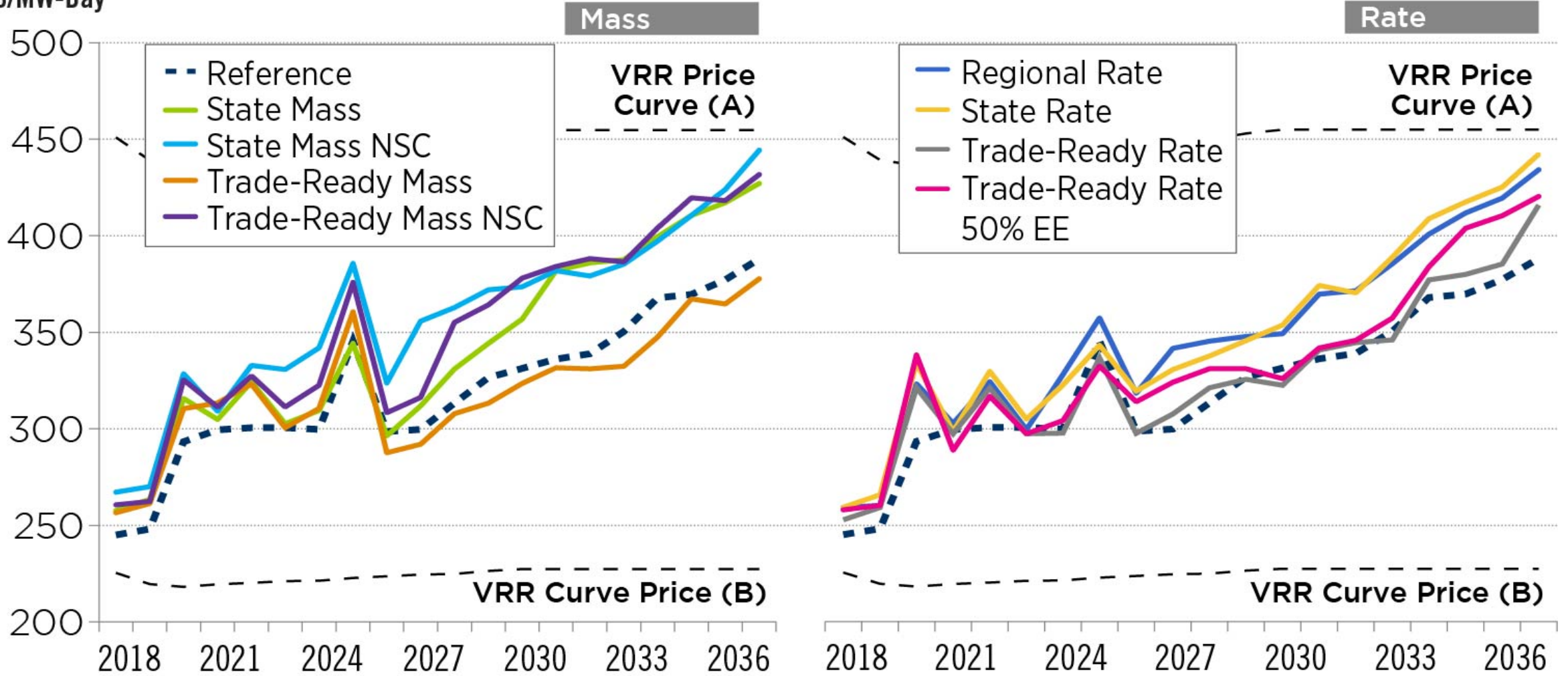
Energy Price  
\$2018/MWh





# Capacity Market Prices Increase to Offset Resource Retirements and Load Growth

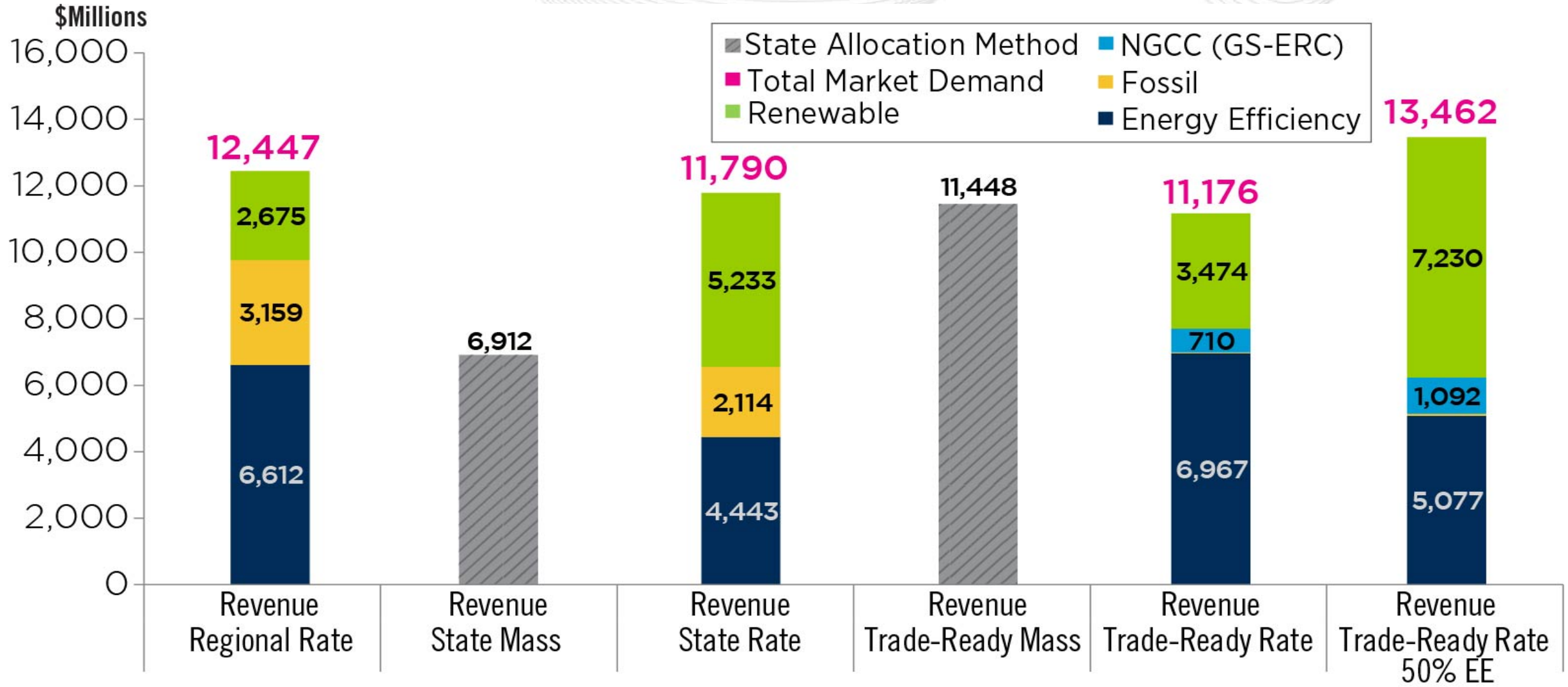
\$2018/MW-Day







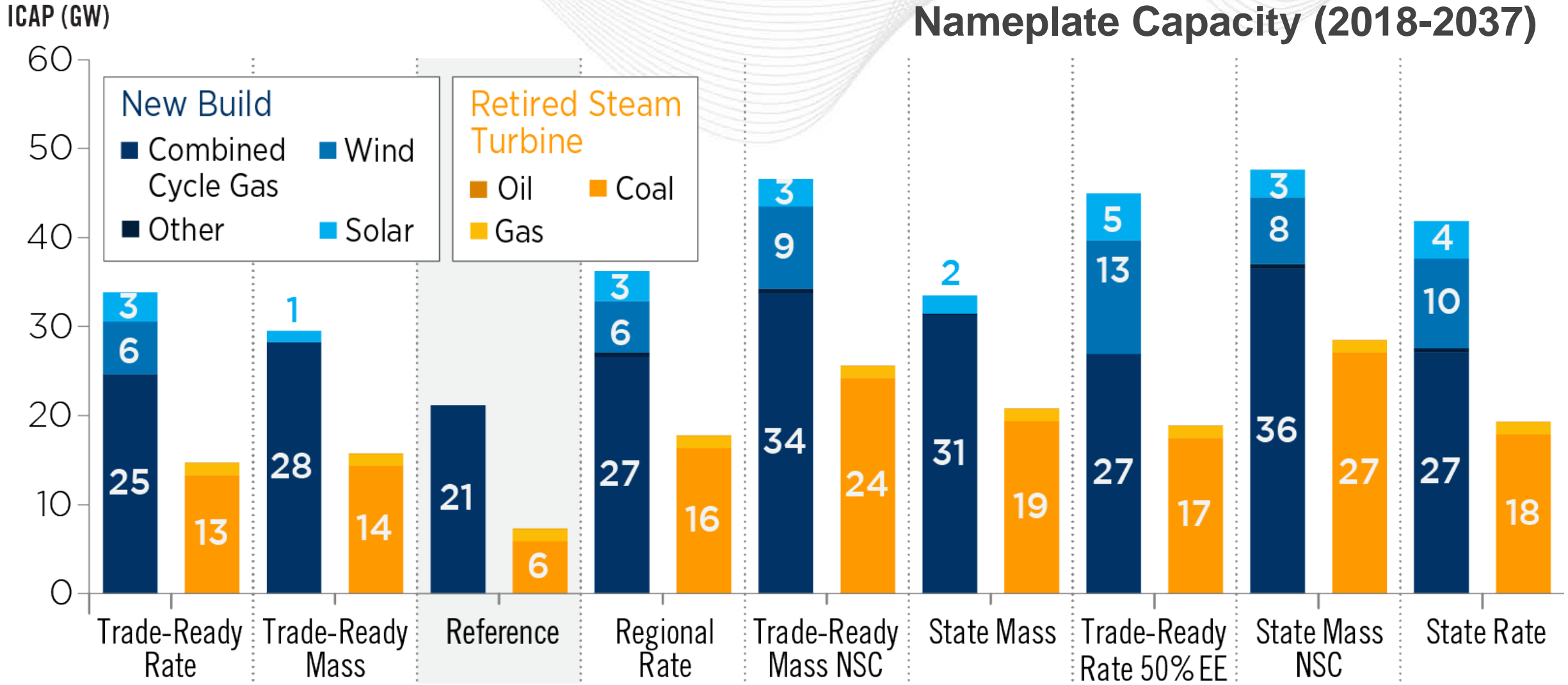
# Rate- and Mass-based Trading Implies Differing Allocations of Money, Flexibility, and Affects Resource Development Incentives





# PJM Markets and Emissions Markets Drive Varied Resource Outcomes

## Nameplate Capacity (2018-2037)

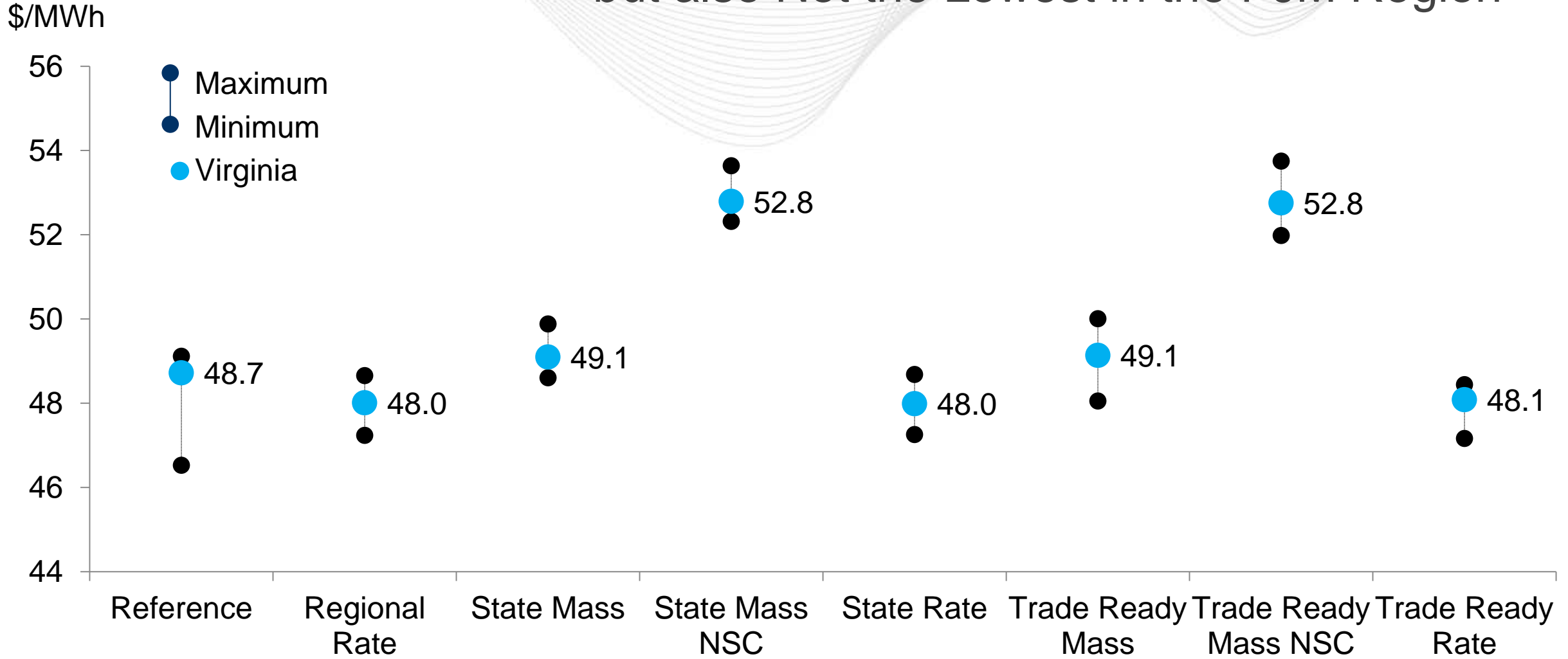




# PJM's Analysis of the Clean Power Plan: Security Constrained Economic Dispatch Virginia 2025



# Virginia's 2025 Energy Costs (LMP) are Not the Highest but also Not the Lowest in the PJM Region

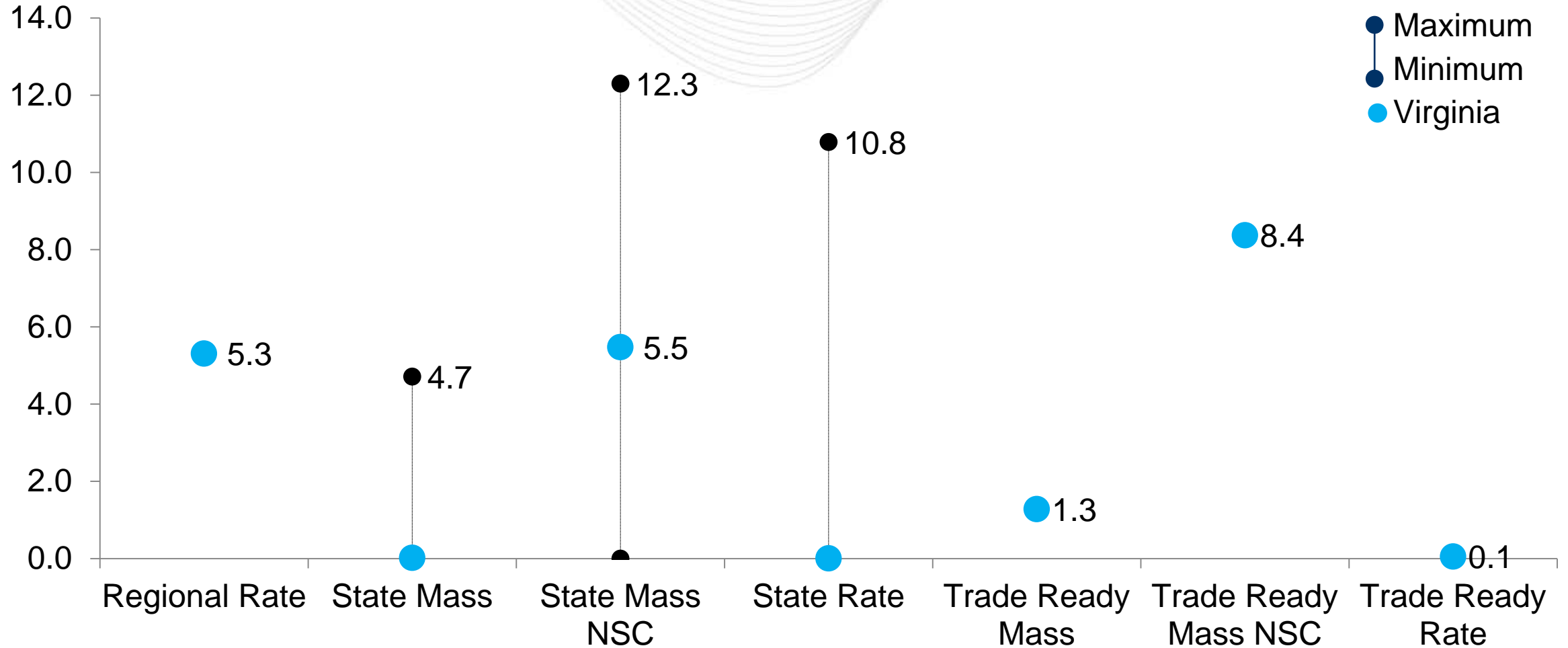






# Virginia 2025 CO<sub>2</sub> Prices Under State-Compliance are Lower than Other States in the PJM Region

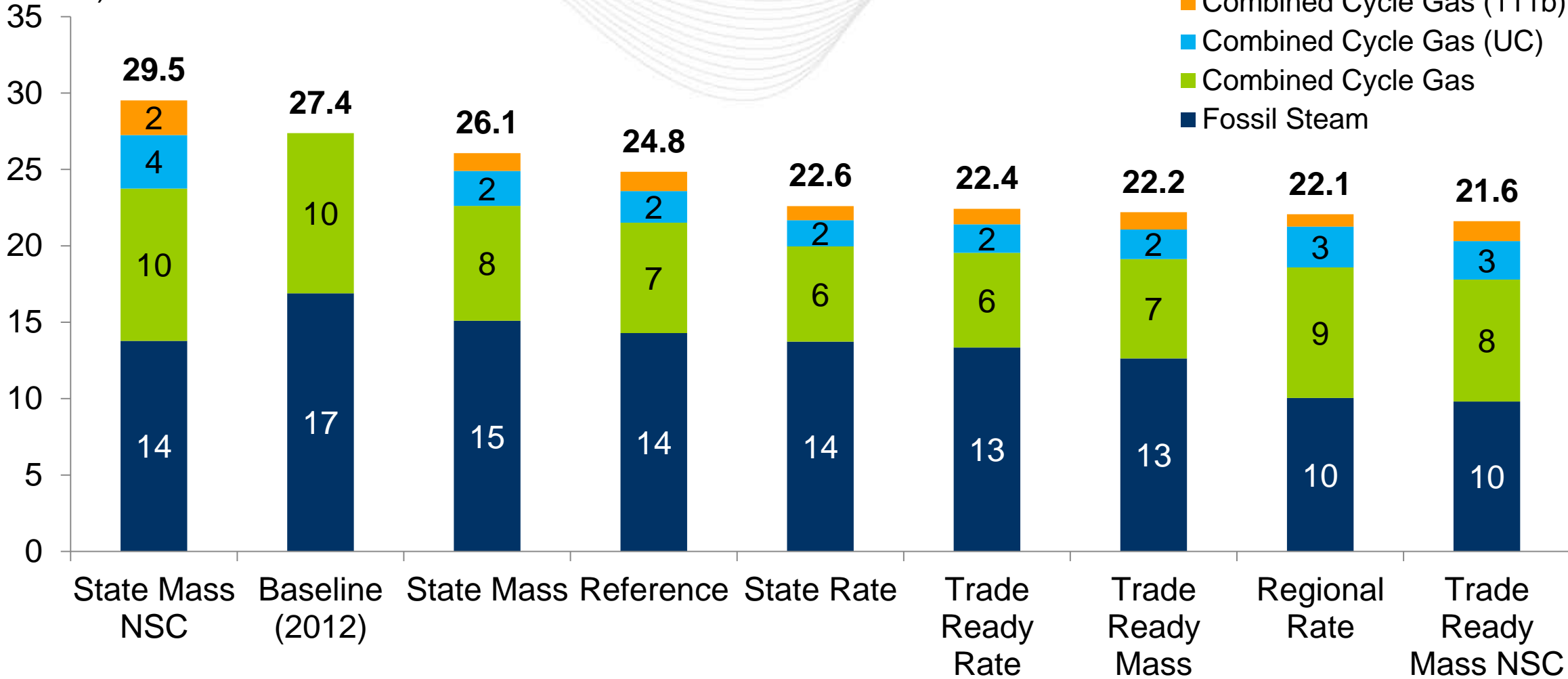
\$/ERC or \$/Ton





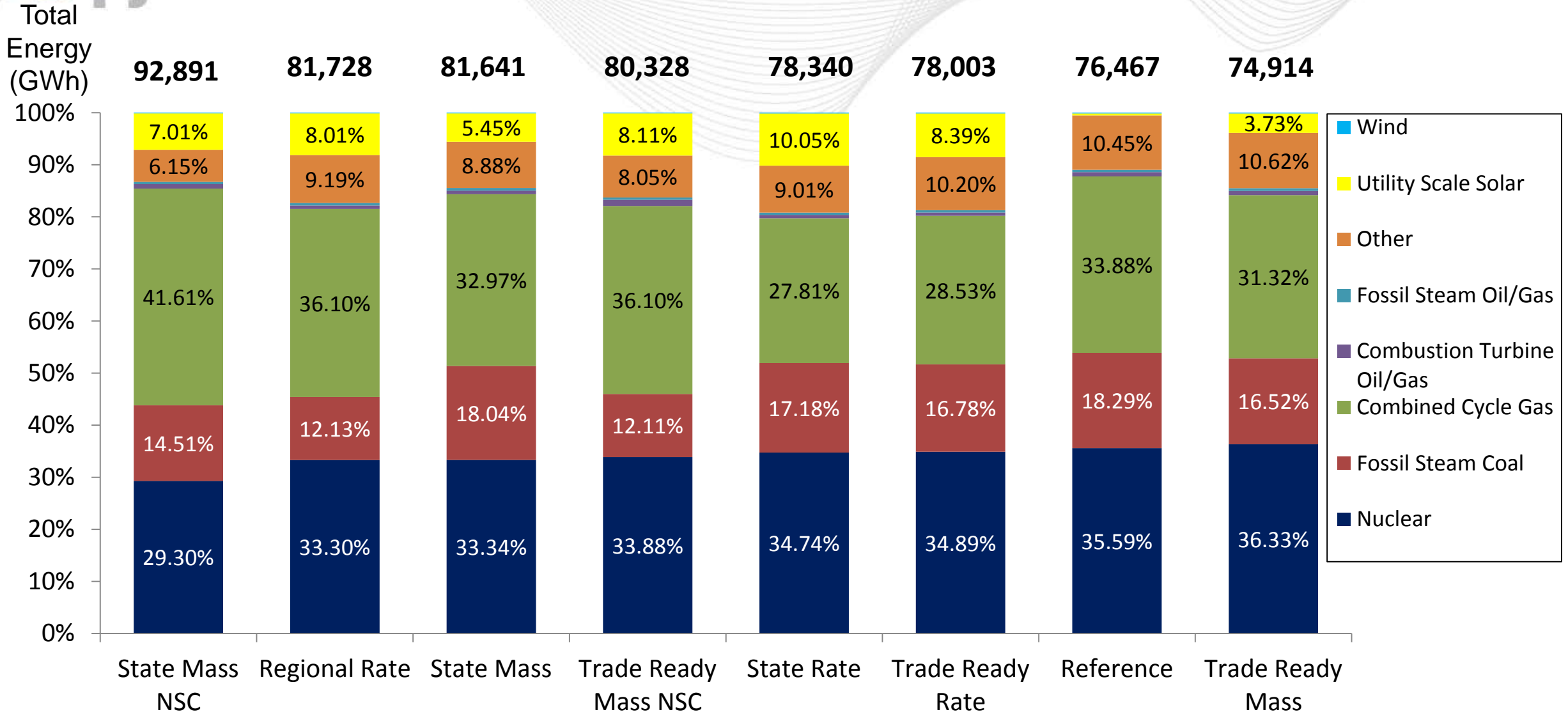
# State Compliance Leads to Higher In-State CO<sub>2</sub> Emissions by 2025

Tons  
(Millions)



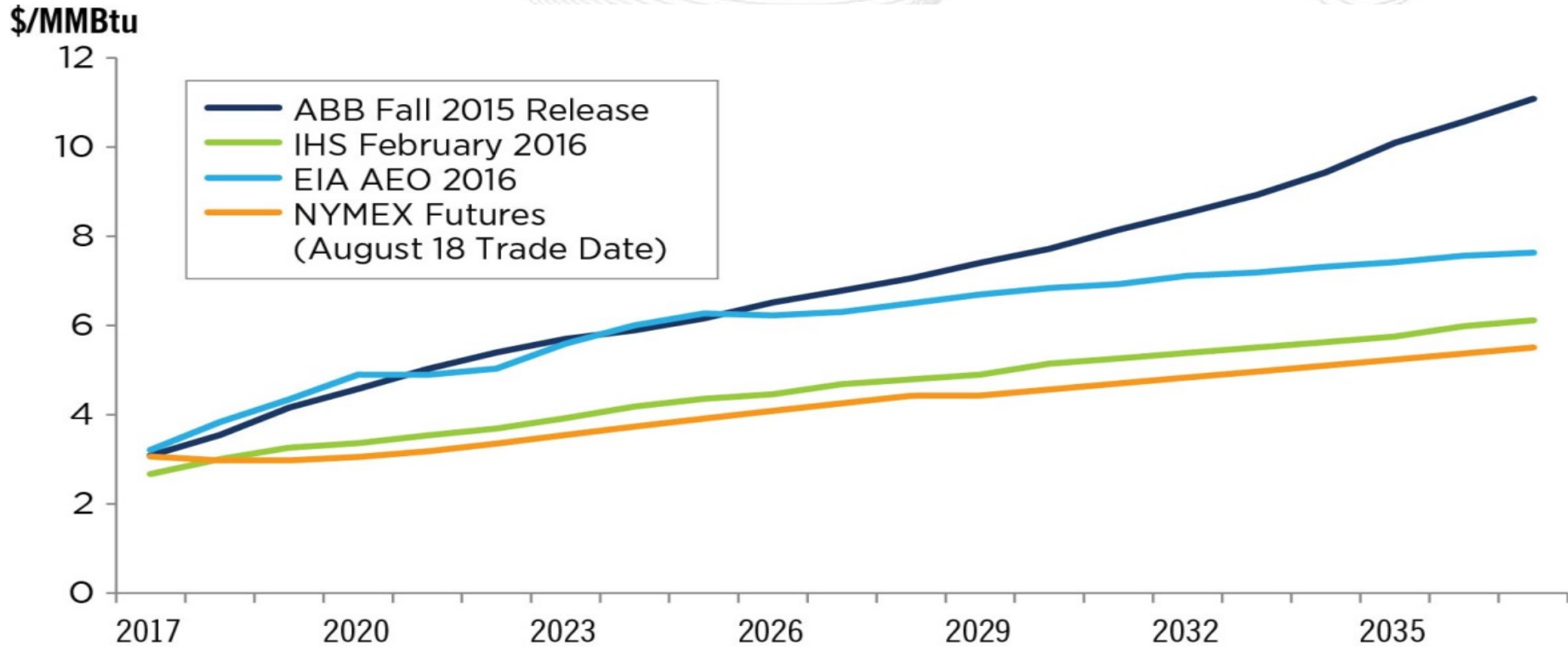


# Virginia's Energy Mix in 2025



# PJM's Sensitivity Analysis:

## Low Gas Price Sensitivity Short-Term Retirement Decision Sensitivity

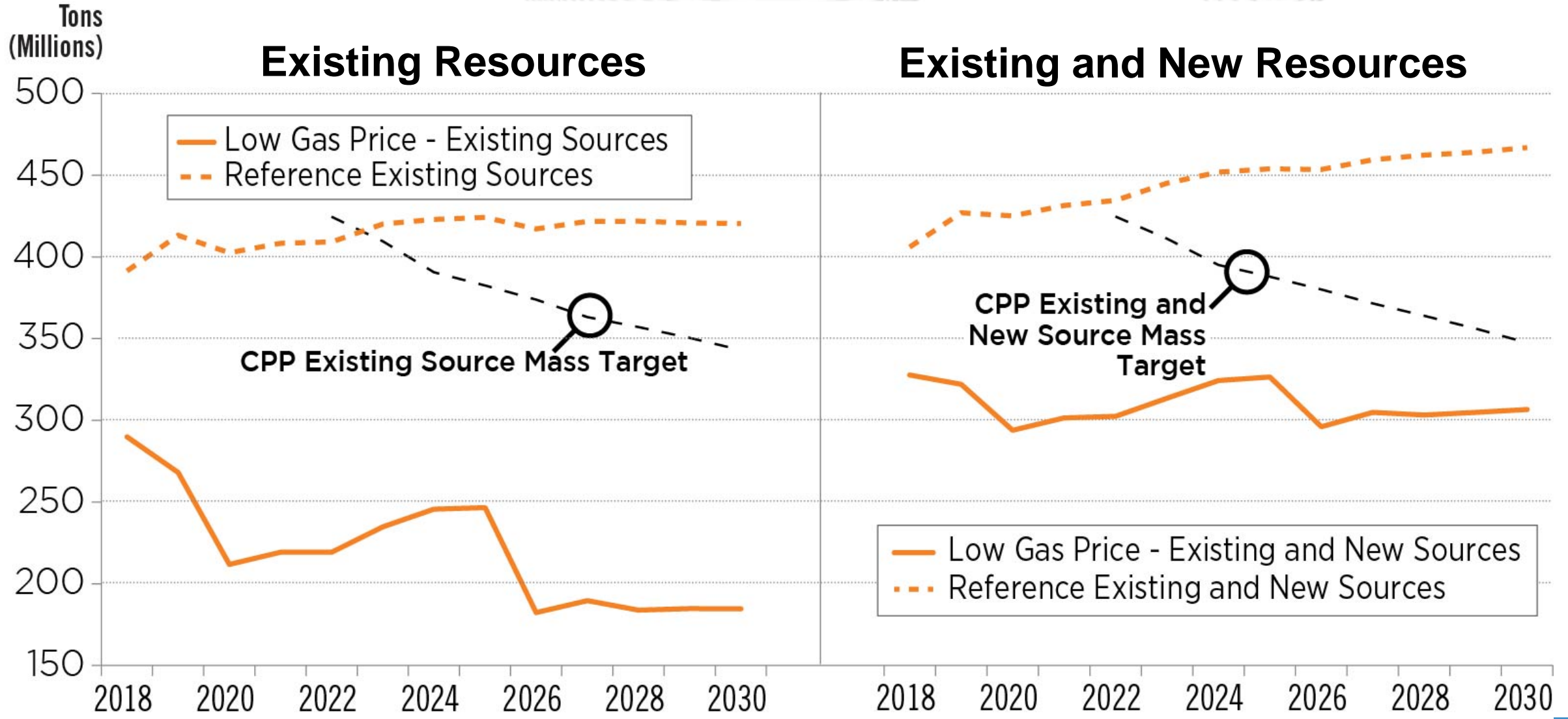


**Source: IHS Inc.**

The use of this content was authorized in advance by IHS. Any further use or redistribution of this content is strictly prohibited without written permission by IHS. All rights reserved.



# If Gas Prices Remain Low... Compliance with CPP Mass Targets are not Binding

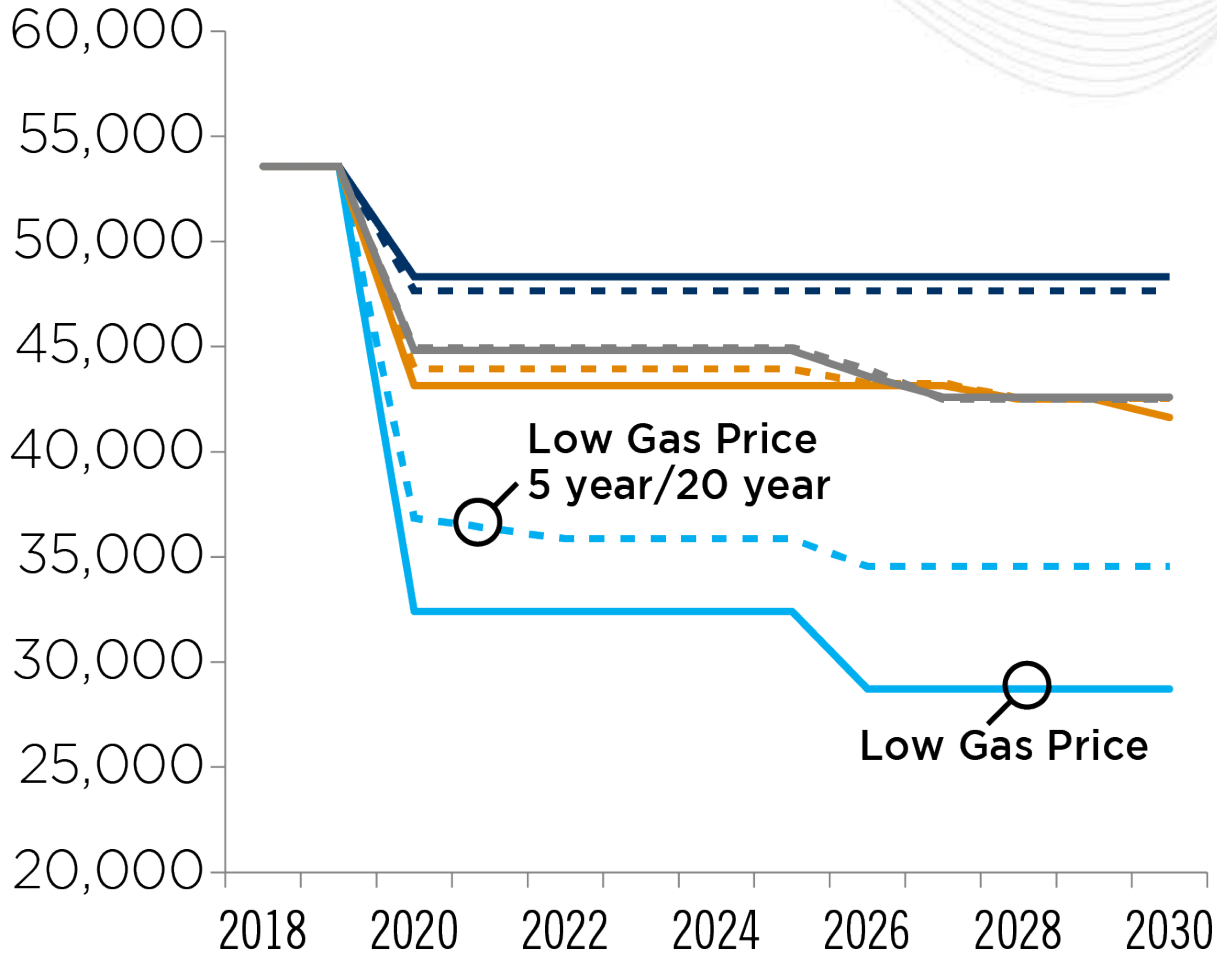




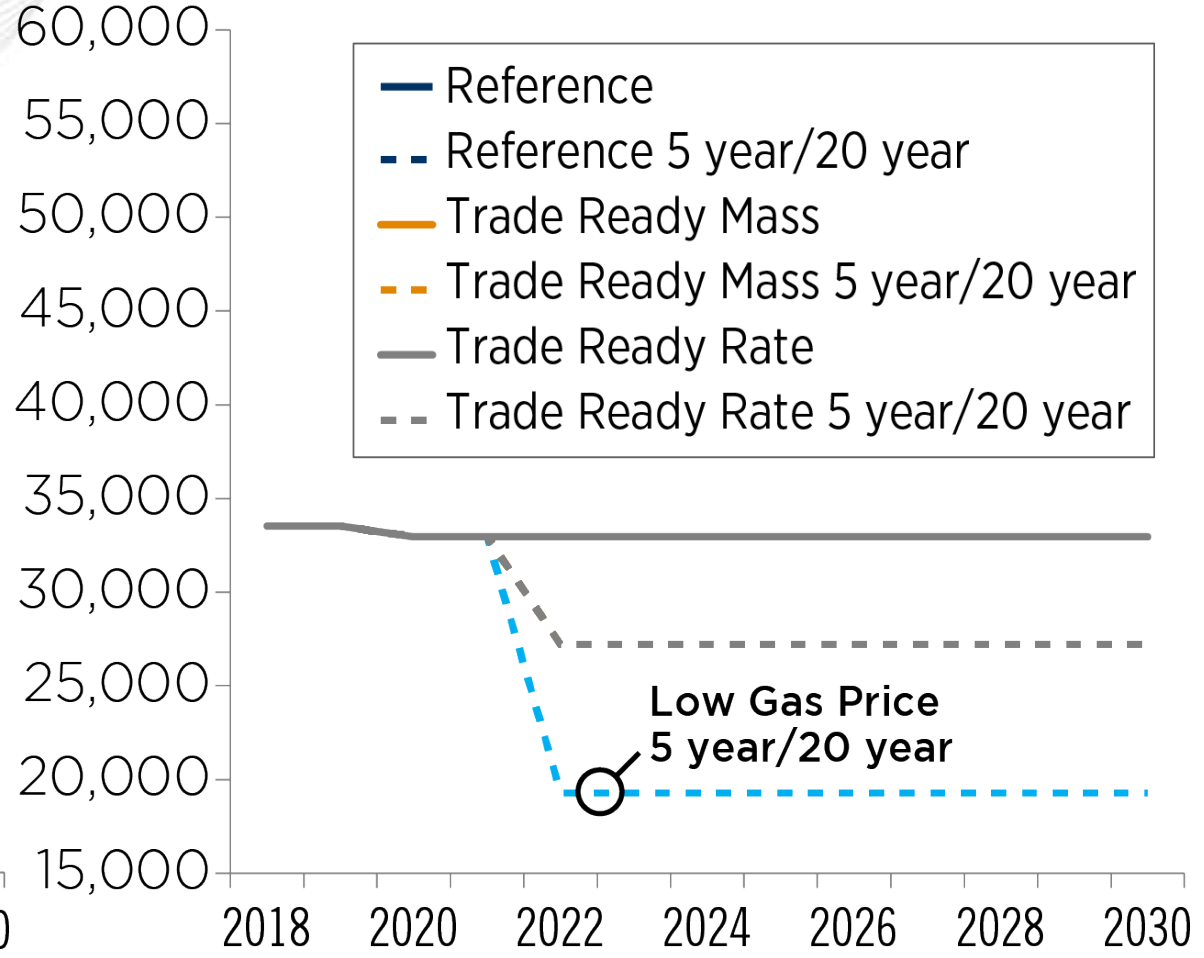


# Low Gas Price and Short-term View Impact on Coal and Nuclear

### Steam Turbine Coal Unforced Capacity (MW)



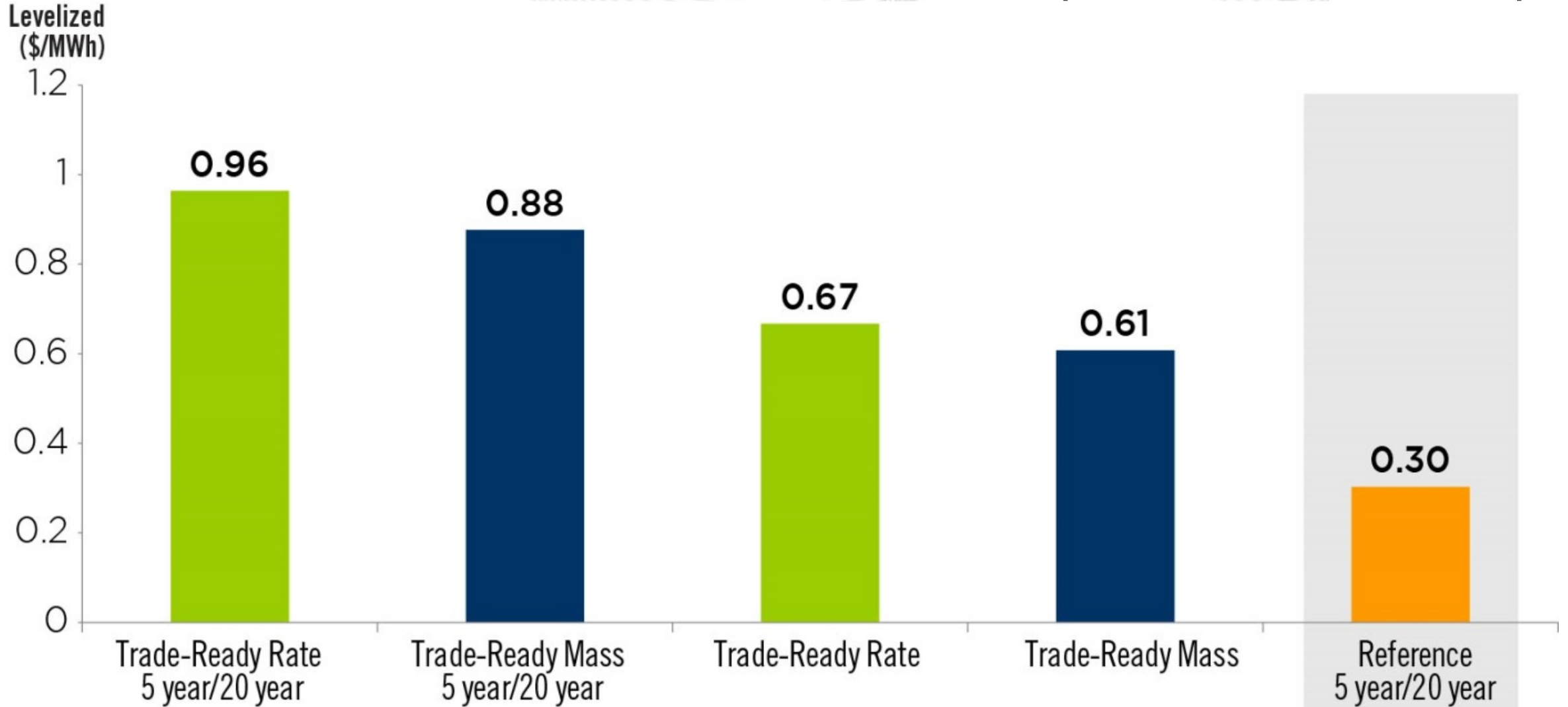
### Nuclear Unforced Capacity (MW)



- Reference
- - Reference 5 year/20 year
- Trade Ready Mass
- - Trade Ready Mass 5 year/20 year
- Trade Ready Rate
- - Trade Ready Rate 5 year/20 year

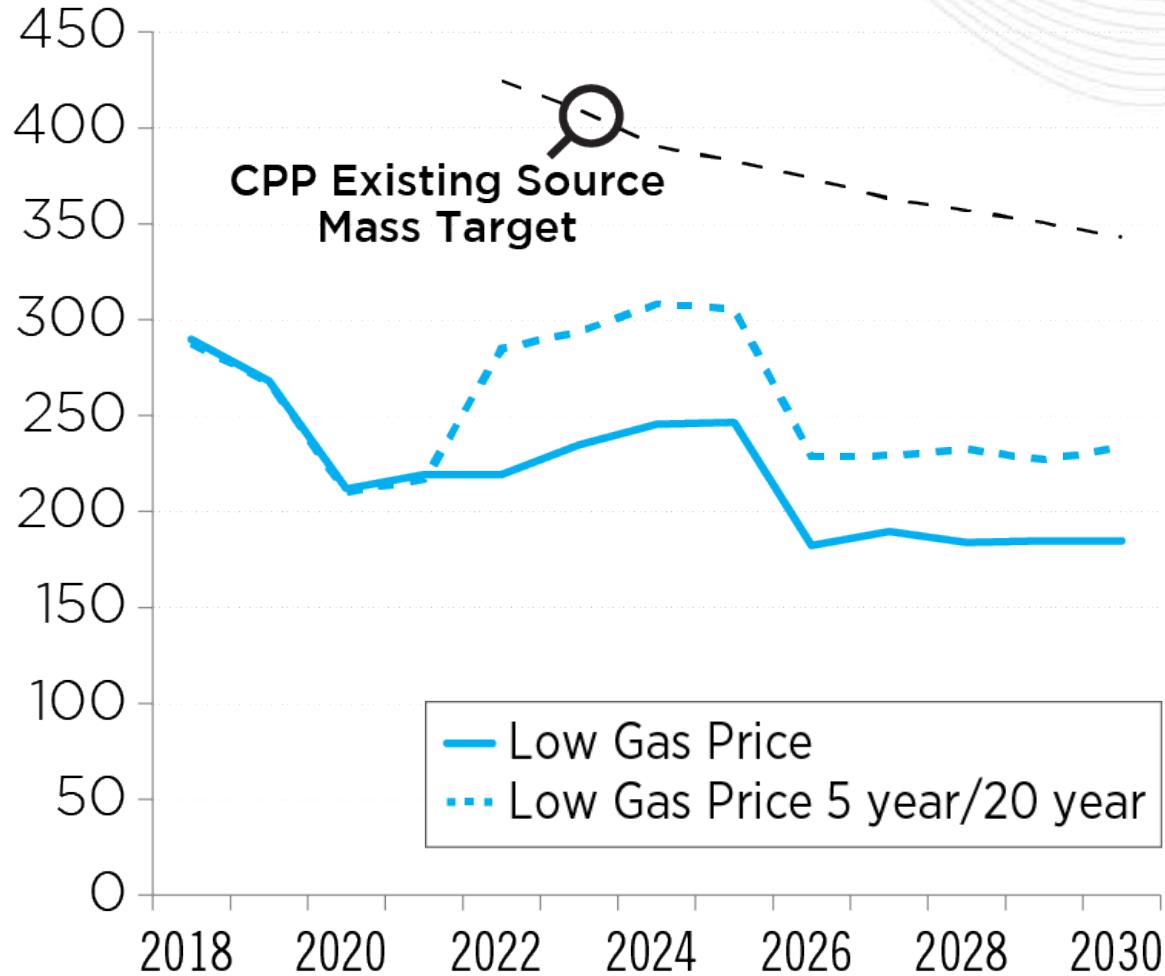


# If Generation Takes a Short-Term View... Compliance Cost Goes Up

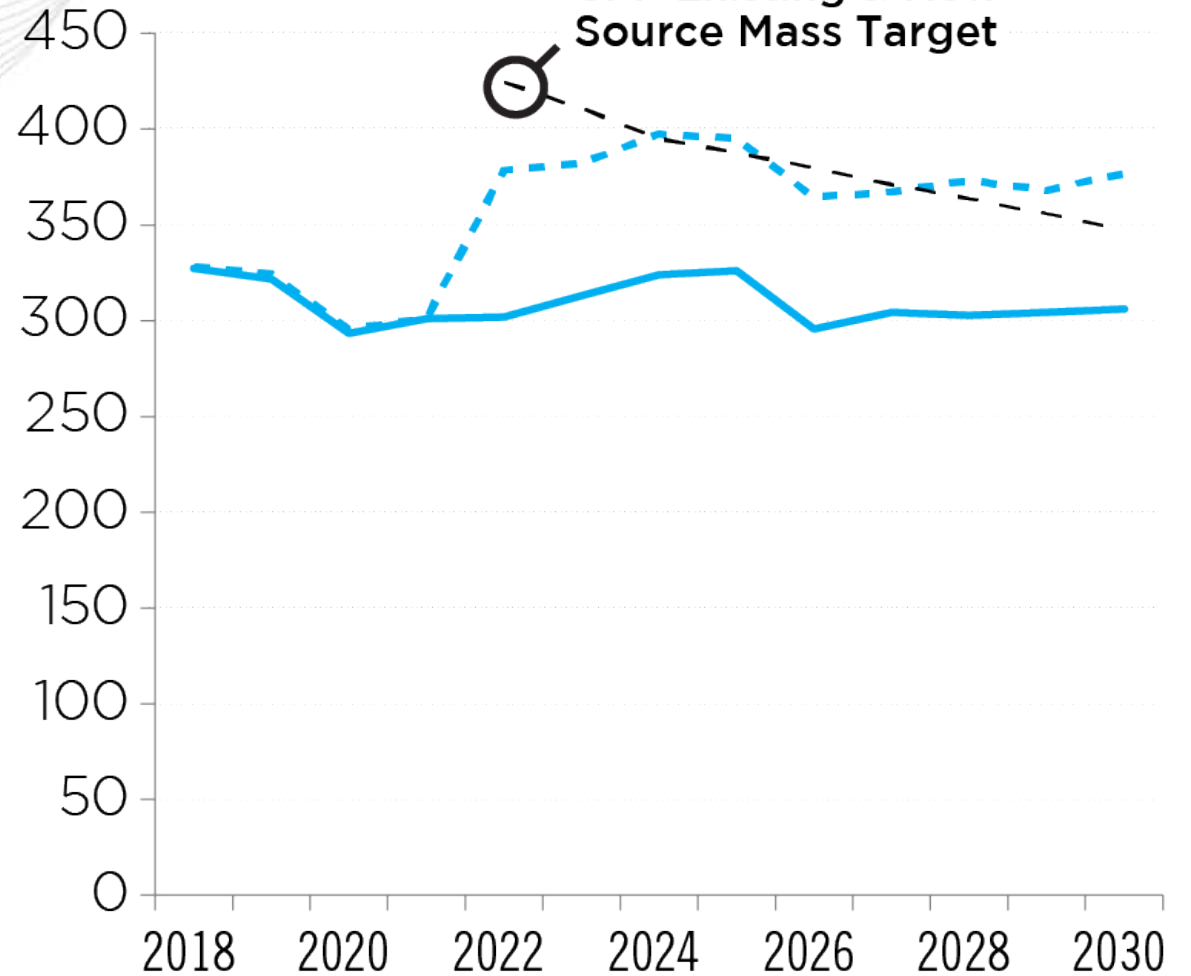


# Low Gas Price and Short-term View Impact on CO<sub>2</sub> Emissions

Existing Source CO<sub>2</sub>  
Millions of Tons



Existing and New Source CO<sub>2</sub>  
Millions of Tons



1. It is feasible for the PJM states to comply with the CPP and do so with compliance costs between 1.1%-3.3% of current total wholesale costs.
2. Resource adequacy is maintained, but with a shift from coal and other fossil steam generation to new combined cycle natural gas and renewable generation.
3. Compliance with the Clean Power Plan leads to lower transmission congestion overall and shifting of congestion patterns relative to the reference case but transmission reliability studies are ongoing.
4. Mass-based, trade-ready compliance leads to the lowest compliance costs.

5. If natural gas prices remain low as they have been in the past several years, the PJM states would achieve or exceed the EPA mass-based emission reduction goals even in the absence of the Clean Power Plan
  
6. Shortening the retirement decision horizon to a 5 year window leads to nuclear retirements and an increase in compliance costs with reference case gas prices, with compliance costs remaining below 2% of current total wholesale costs for the model scenarios examined.