PJM and the Clean Power Plan in New Jersey

March 9, 2016

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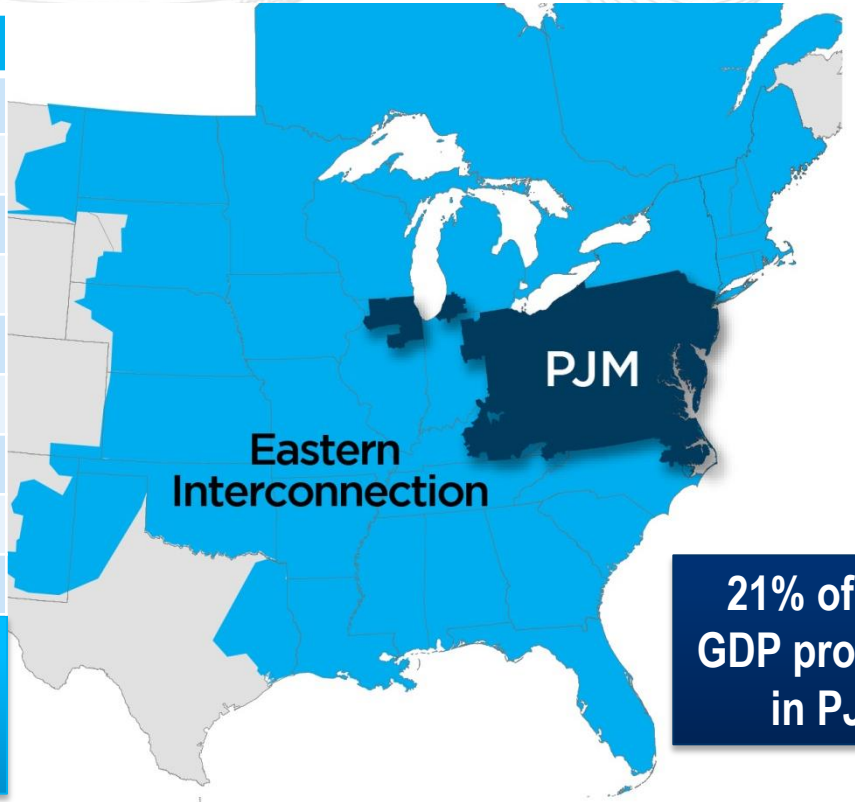
PJM Interconnection

PJM as Part of the Eastern Interconnection

Key Statistics	
Member companies	960+
Millions of people served	61
Peak load in megawatts	165,492
MW of generating capacity	171,648
Miles of transmission lines	72,075
2014 GWh of annual energy	792,580
Generation sources	1,304
Square miles of territory	243,417
States served	13 + DC

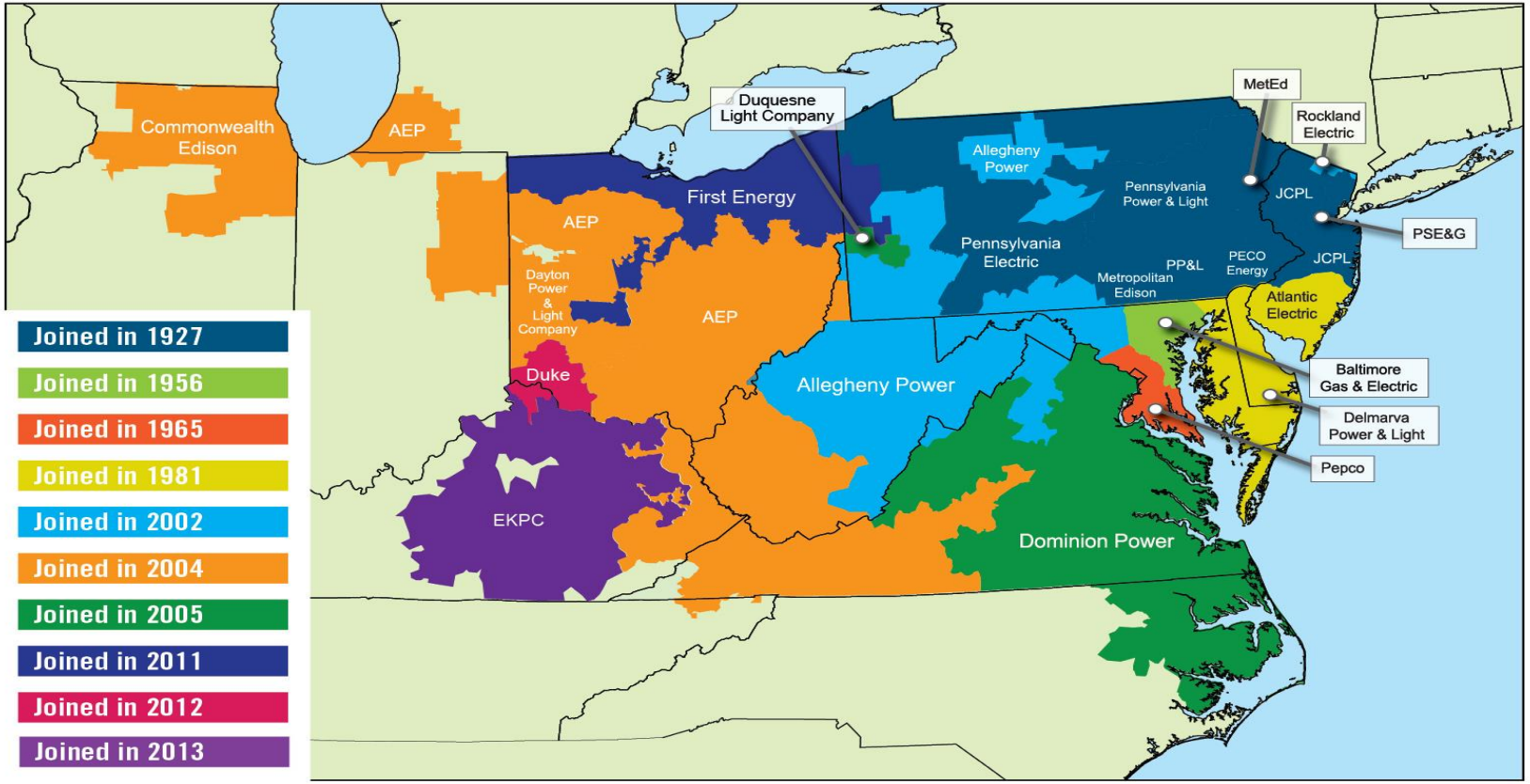
- 27% of generation in Eastern Interconnection
- 28% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection



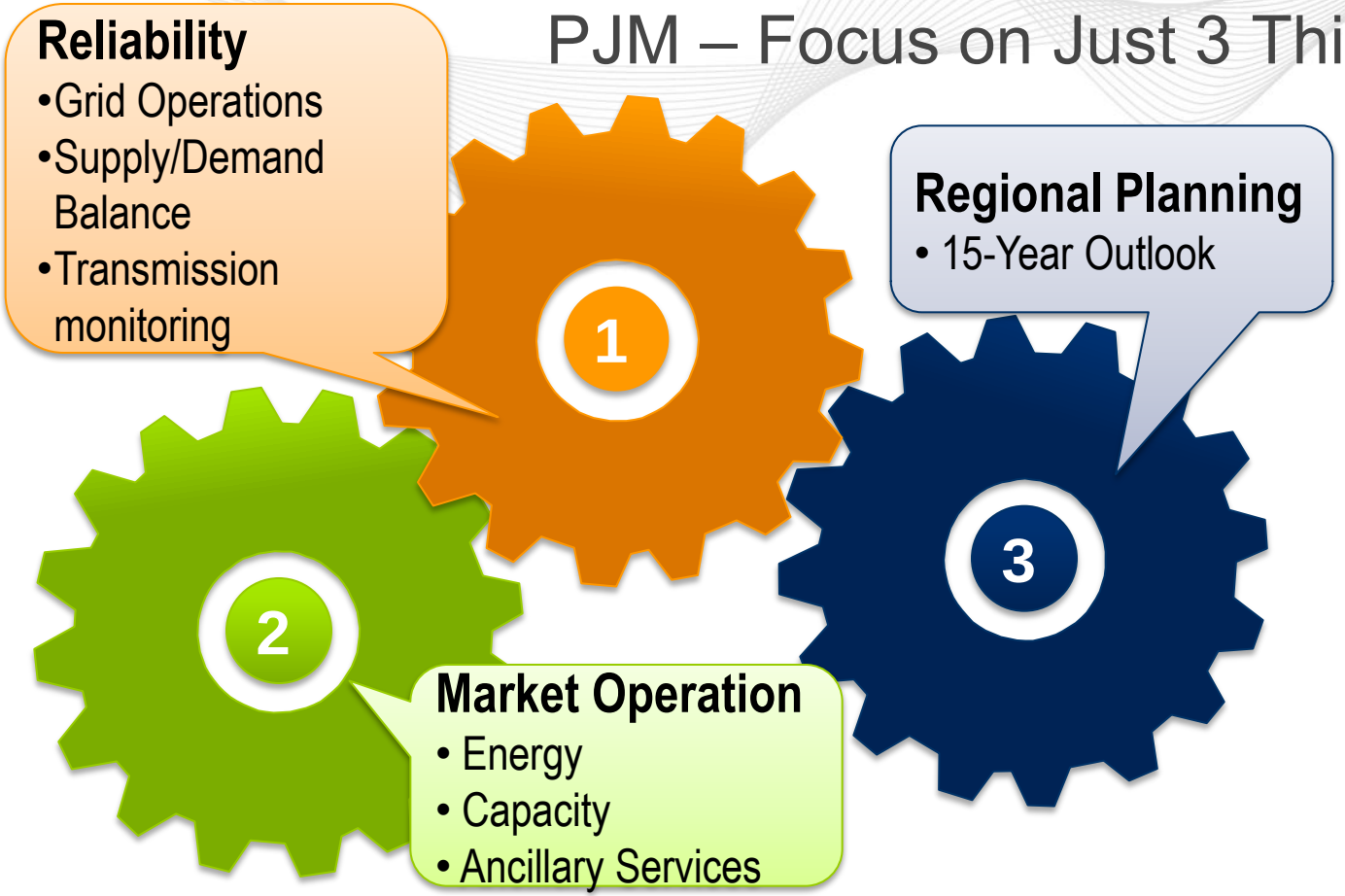
21% of U.S. GDP produced in PJM

As of 1/2016

PJM Evolution

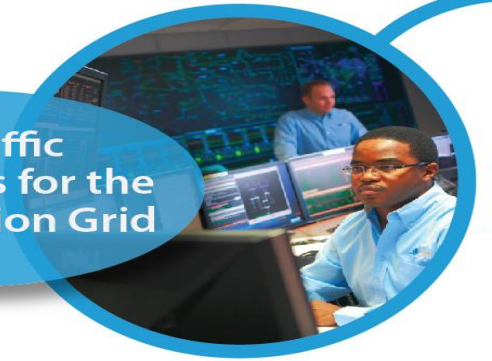


PJM – Focus on Just 3 Things



PJM's Role as a Regional Transmission Organization

Air Traffic Controllers for the Transmission Grid



Match Generation to Load

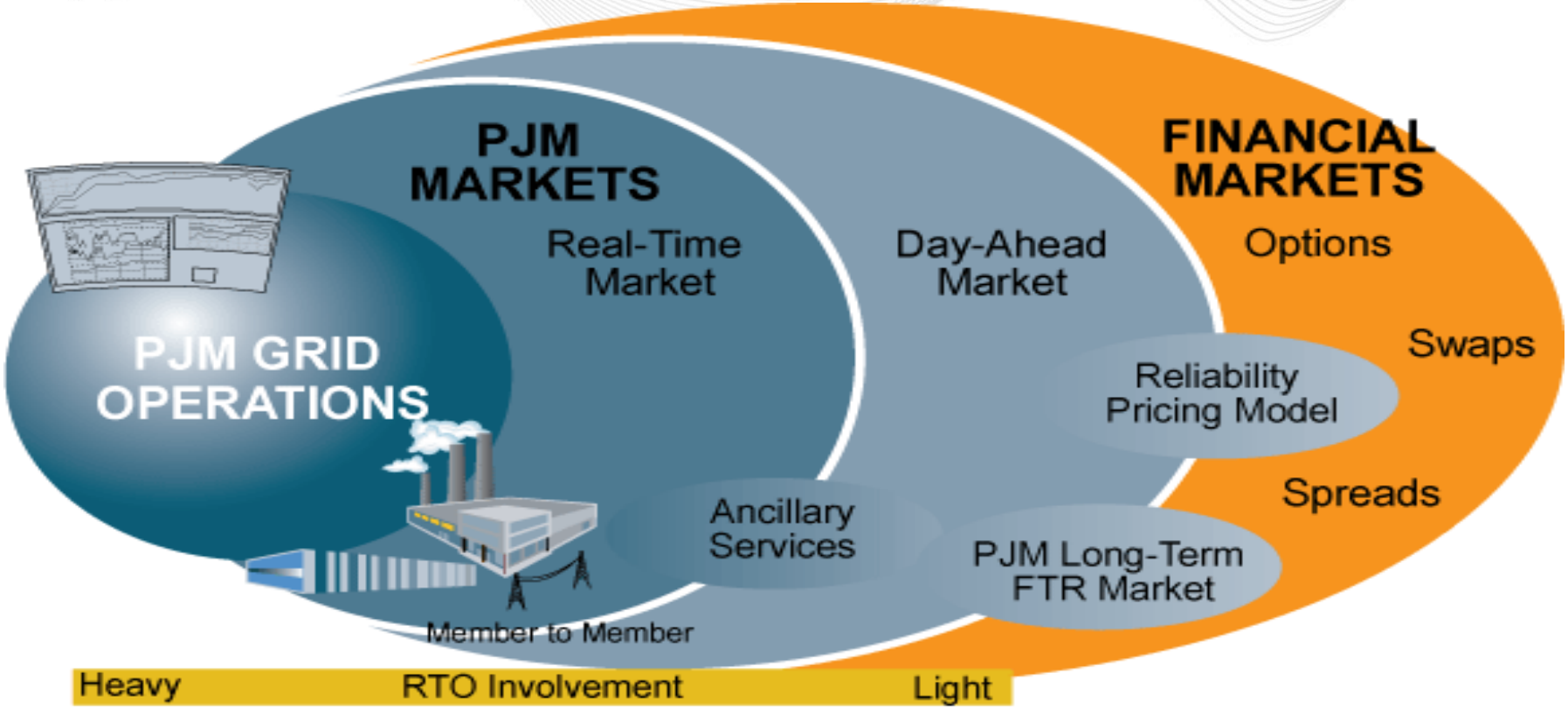
Stock Market for Electricity

Energy Market Pricing

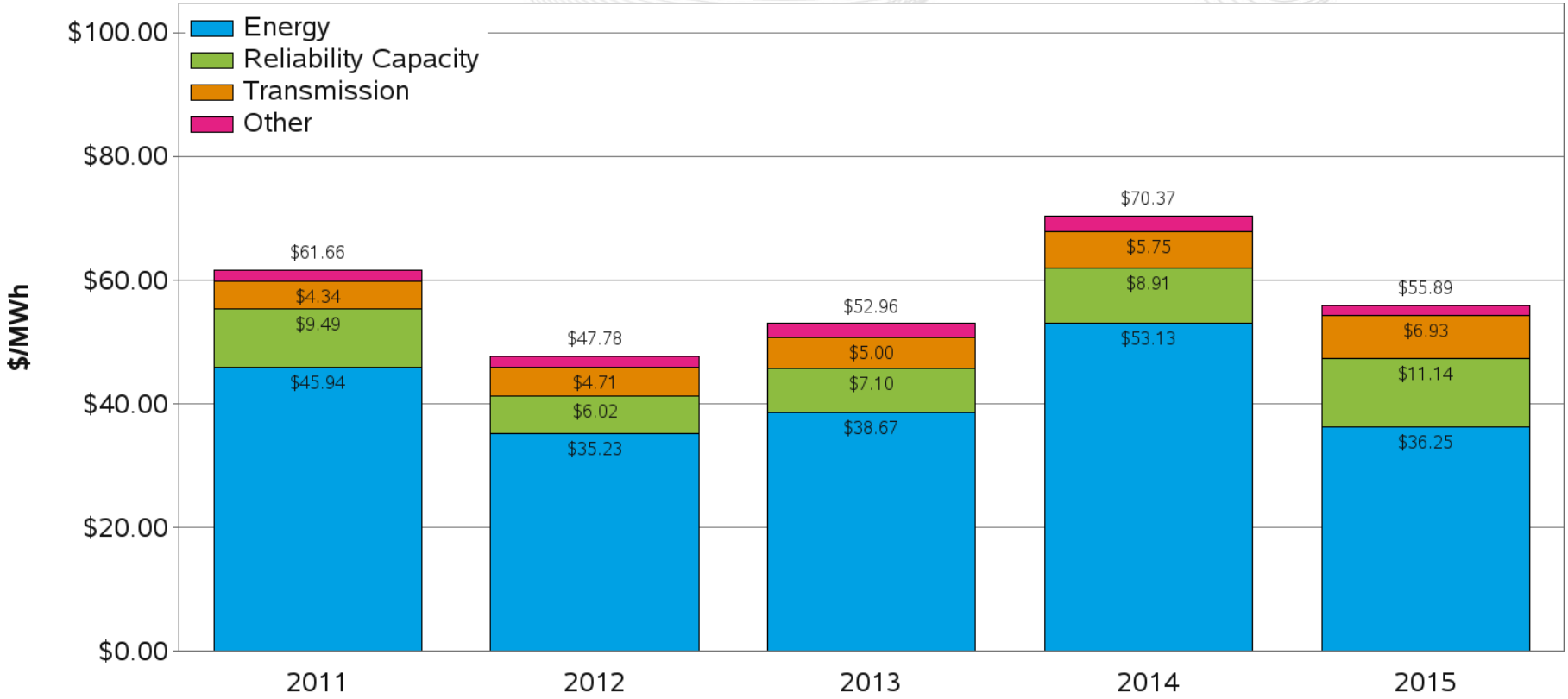
Market Design Philosophy

- Incentive-based
- Security constrained unit commitment and dispatch
- Bilateral transactions and self-supply properly form the bulk of trades
- Participants should have all available options to meet their needs
- Energy is the market focus
- Transparent pricing and customer confidence are critical to investment

PJM Markets and Their Interaction

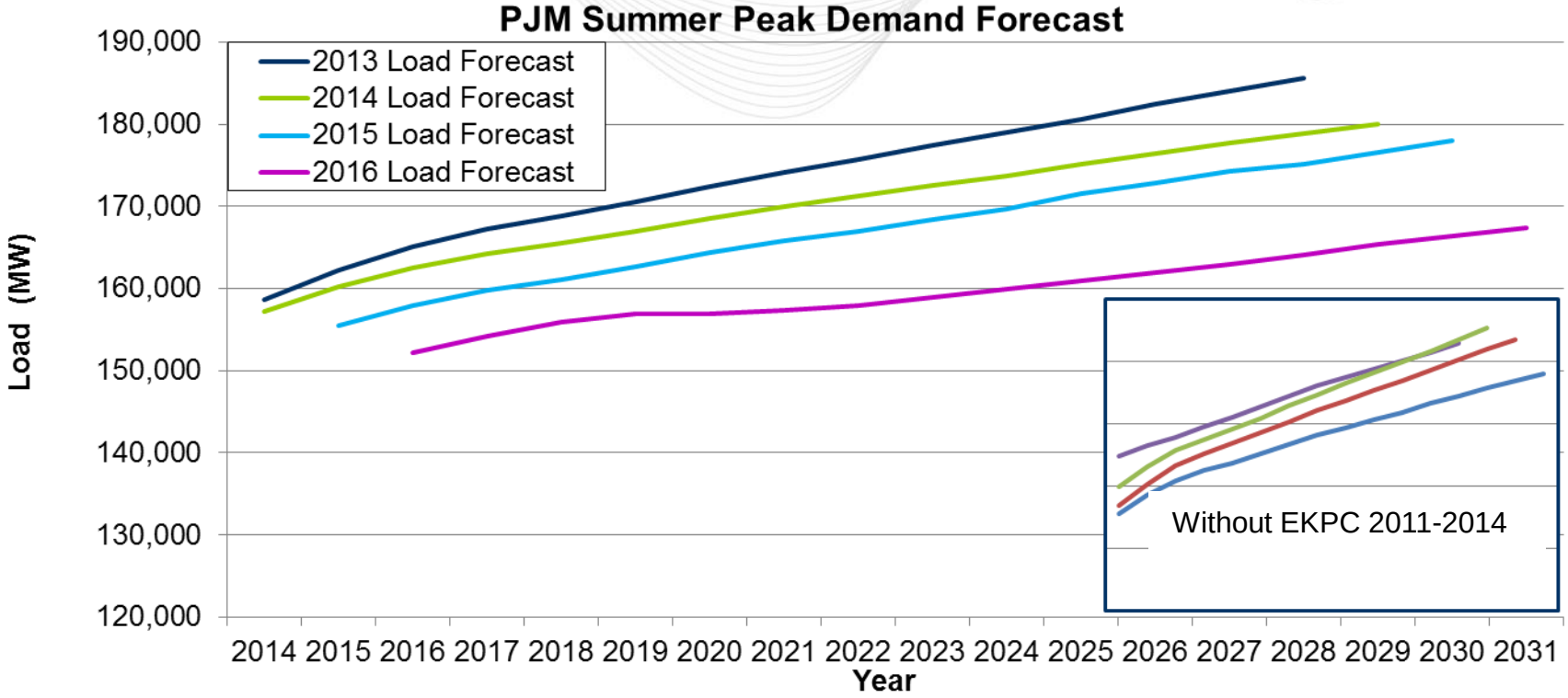


PJM Wholesale Cost

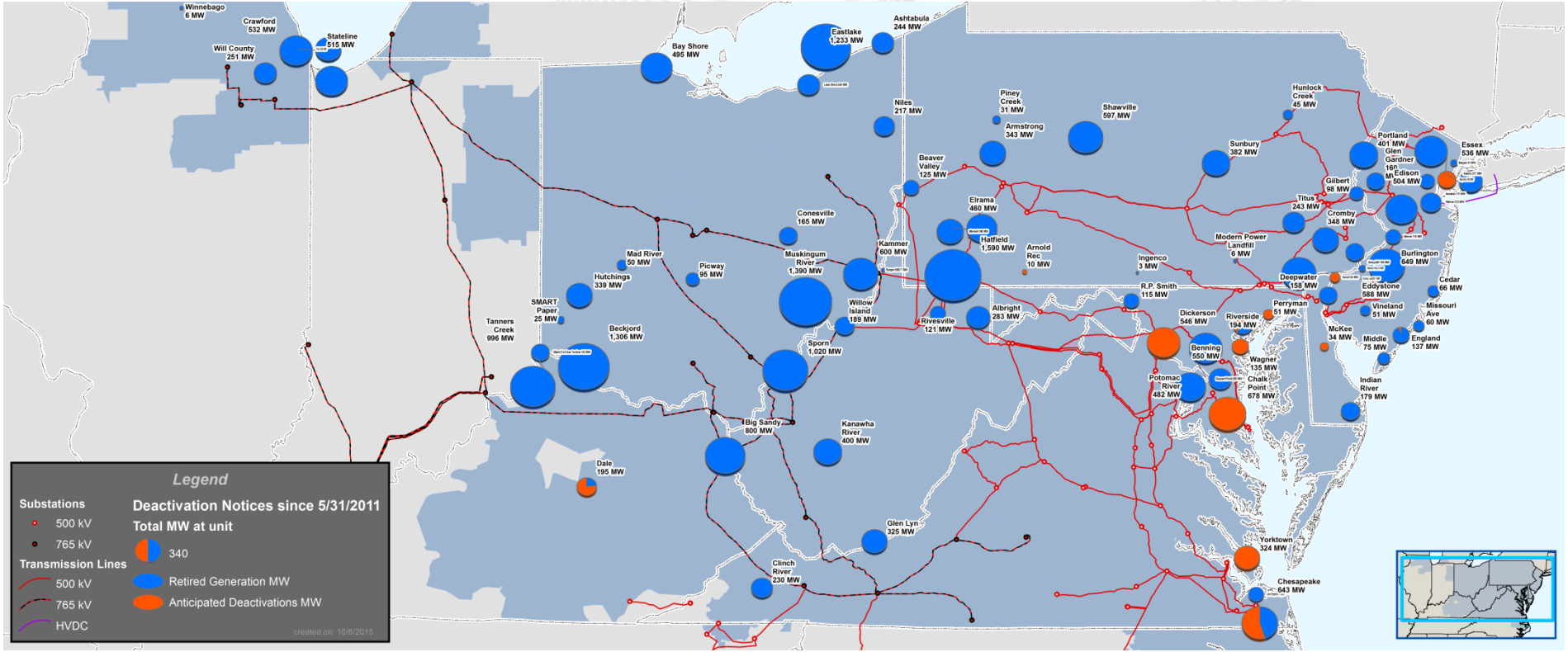


Recent Market Trends to Consider with Clean Power Plan Compliance

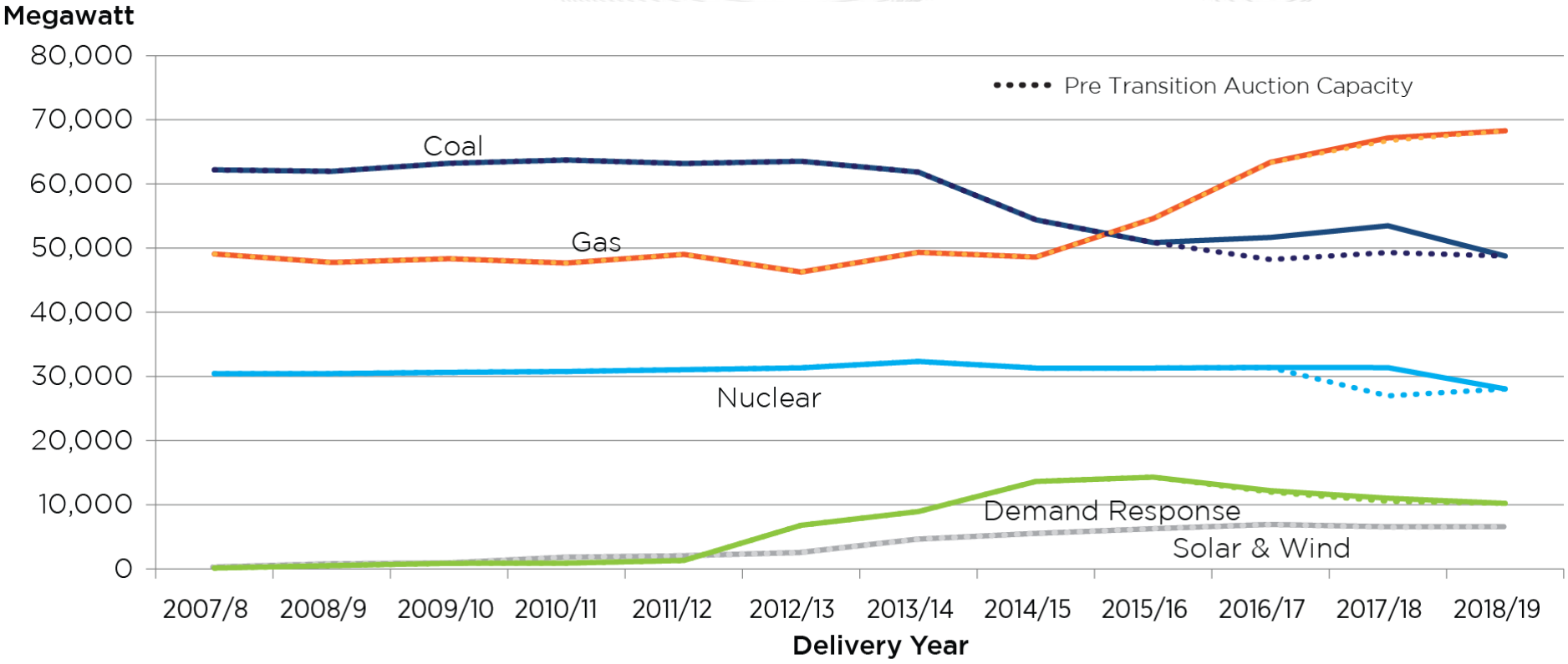
Declining Electricity Demand Growth



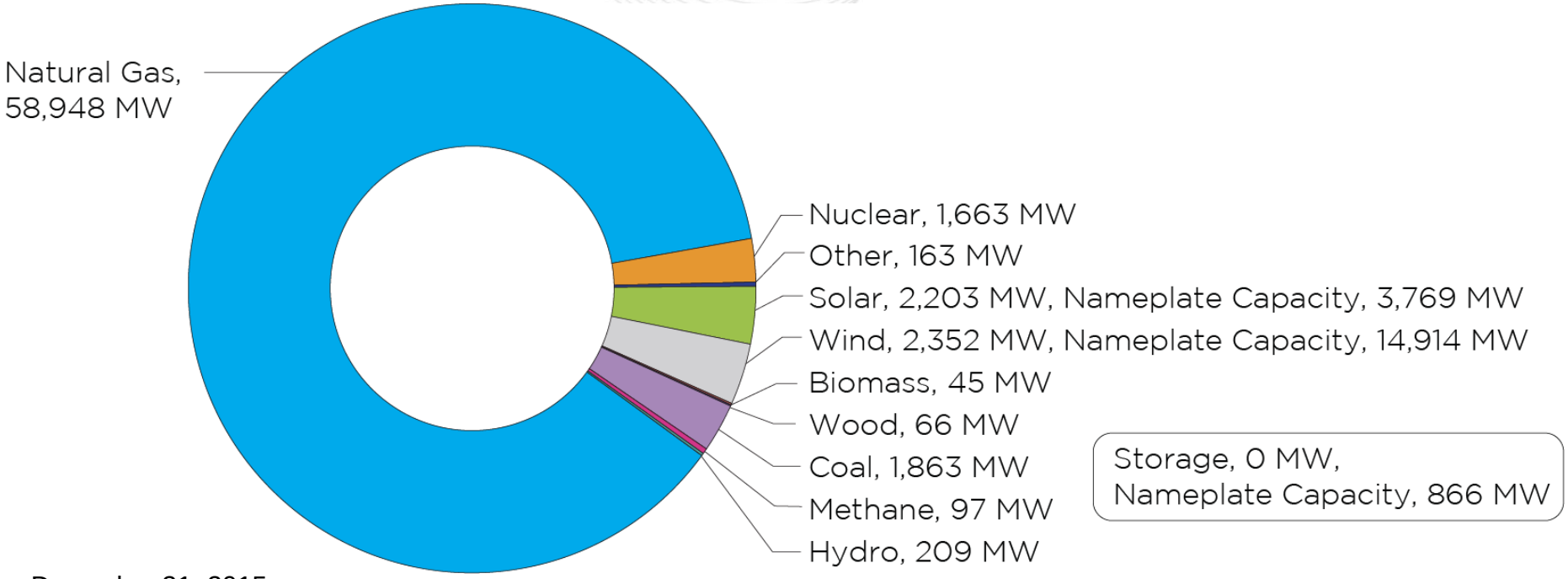
Resulting Generation Retirements



Responsiveness of Capacity Market

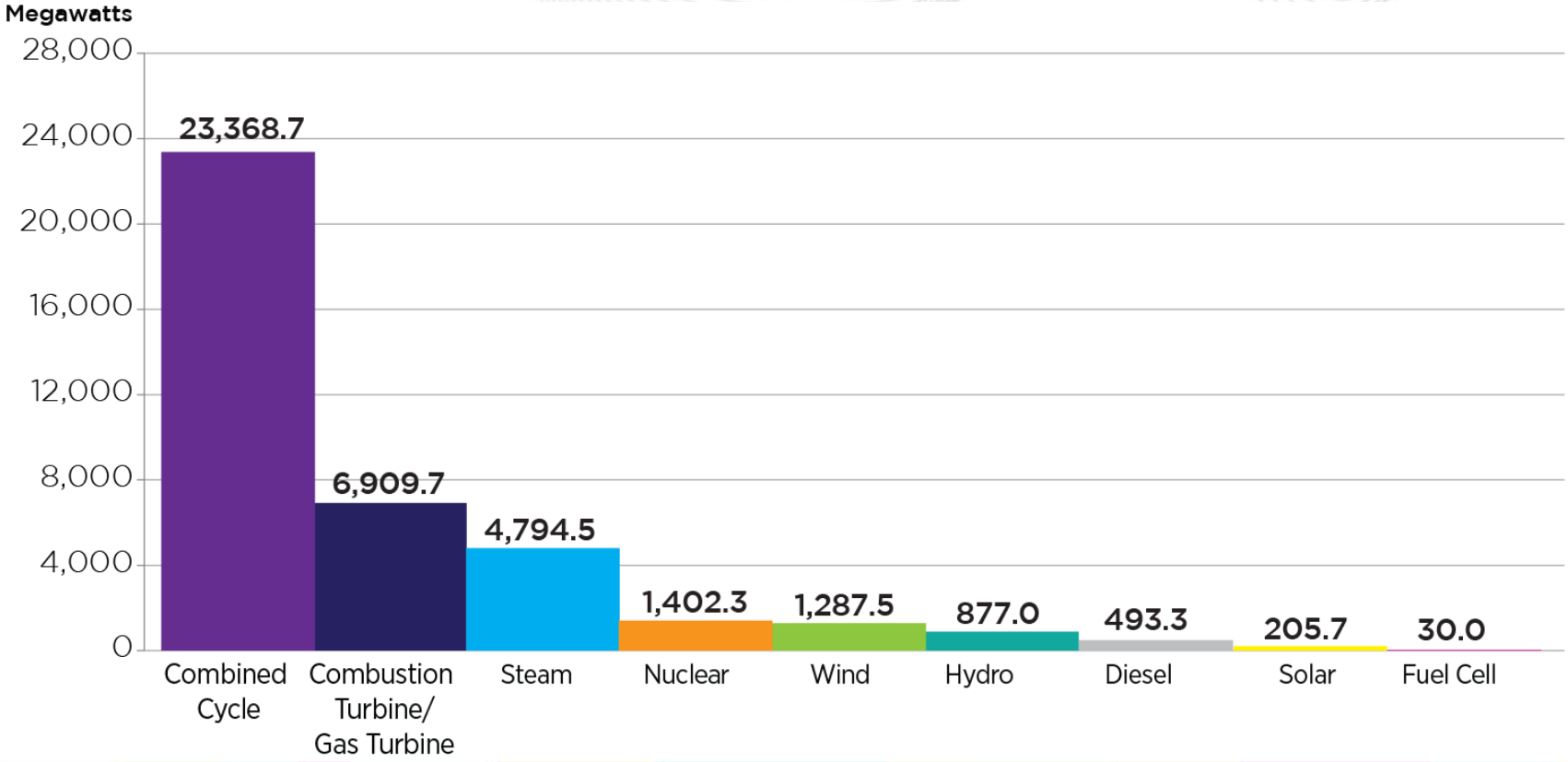


Queued Interconnection Requests



December 31, 2015

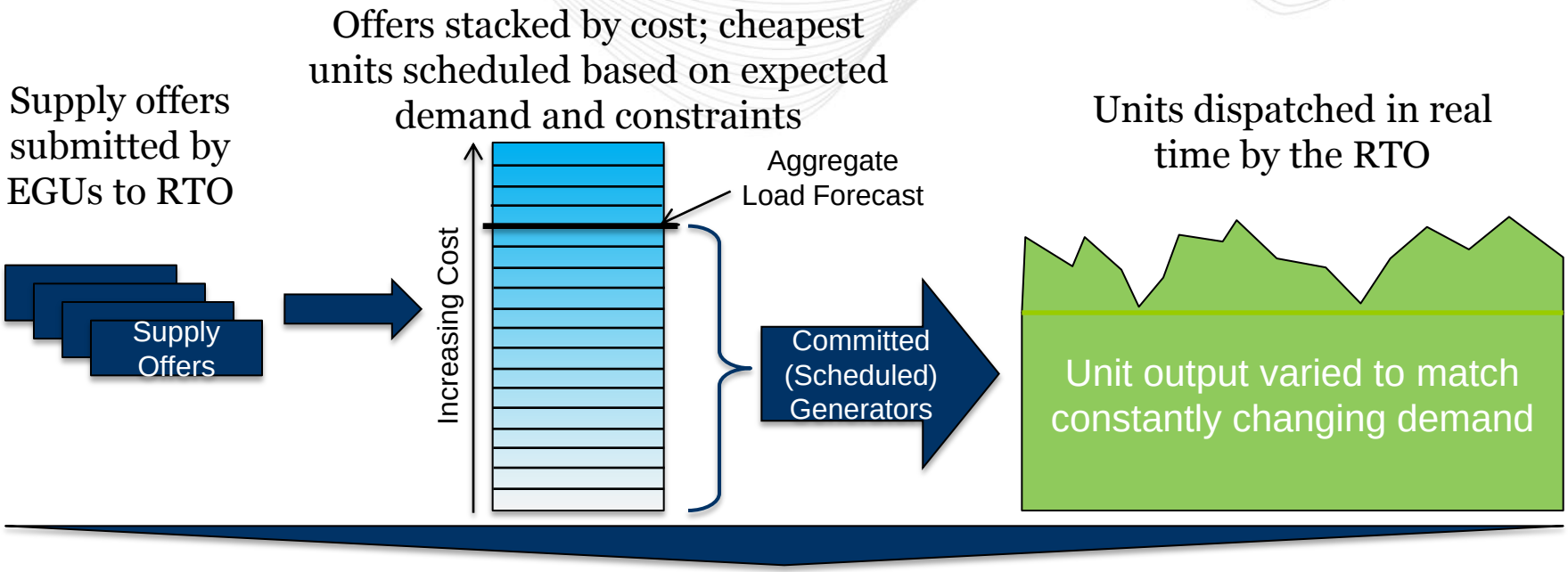
Cumulative Capacity Resource Additions



Least Cost Dispatch Subject to Constraints

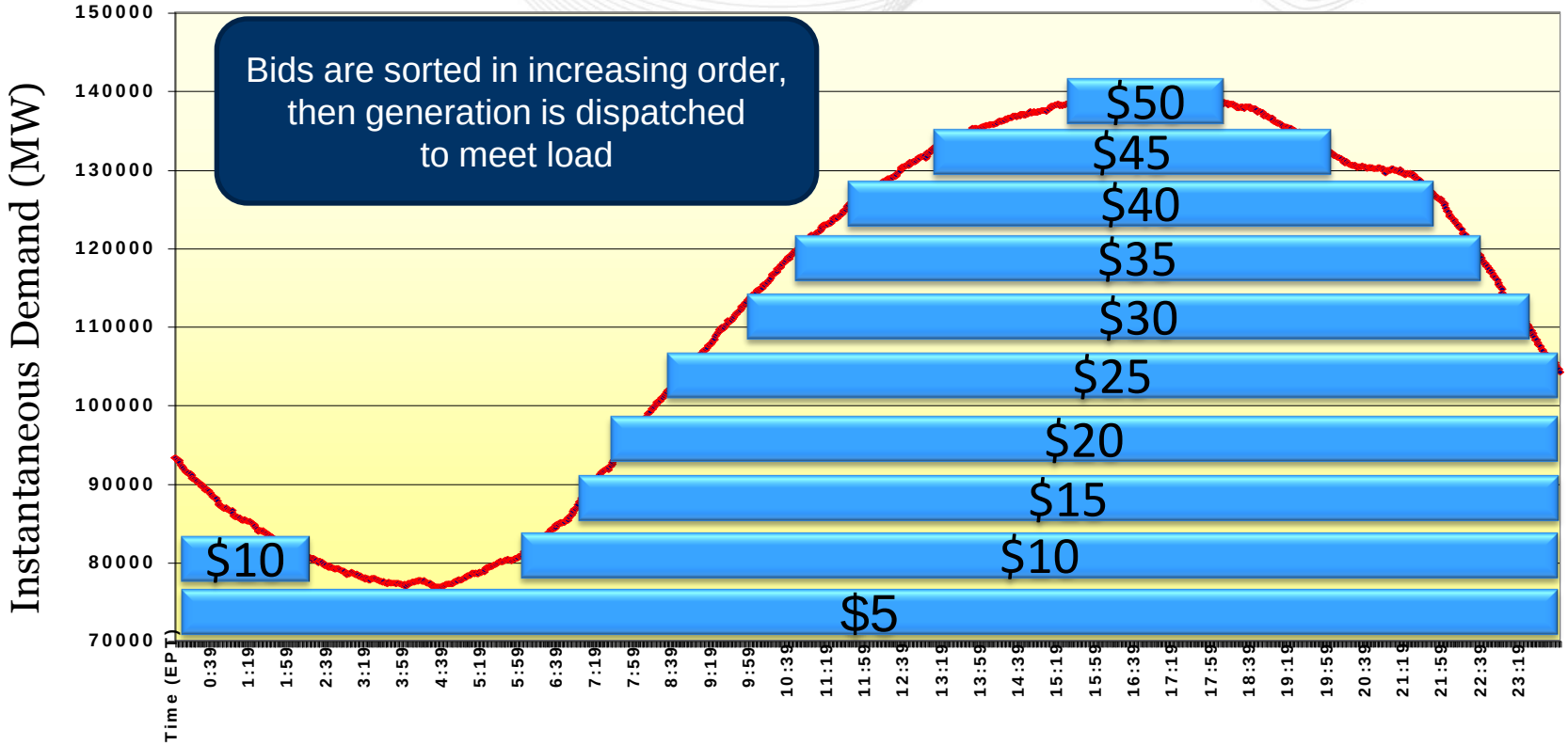
- System operations conducted through dispatch of generation that minimizes bid production cost while respecting generator and transmission or regulatory constraints:
  - Balance supply and demand
  - Physical limits of transmission facilities
  - Reserves and other reliability requirements
  - Power quality requirements (e.g., voltage levels, frequency)
  - Generators' schedules (e.g., maintenance outages)
  - Emissions limitations or hours-of-operation constraints
  - Other physical, regulatory, or market requirements

Overview of Generation Dispatch



- EGU availability (limits, retirement) affects the amount of supply offered to meet demand
- Changing EGU costs (and thus offers) affect frequency and magnitude of utilization in RTO
- Utilization of EGUs directly impacts fuel usage, and thus emissions produced by each EGU

Matching Supply to Demand Over the Day

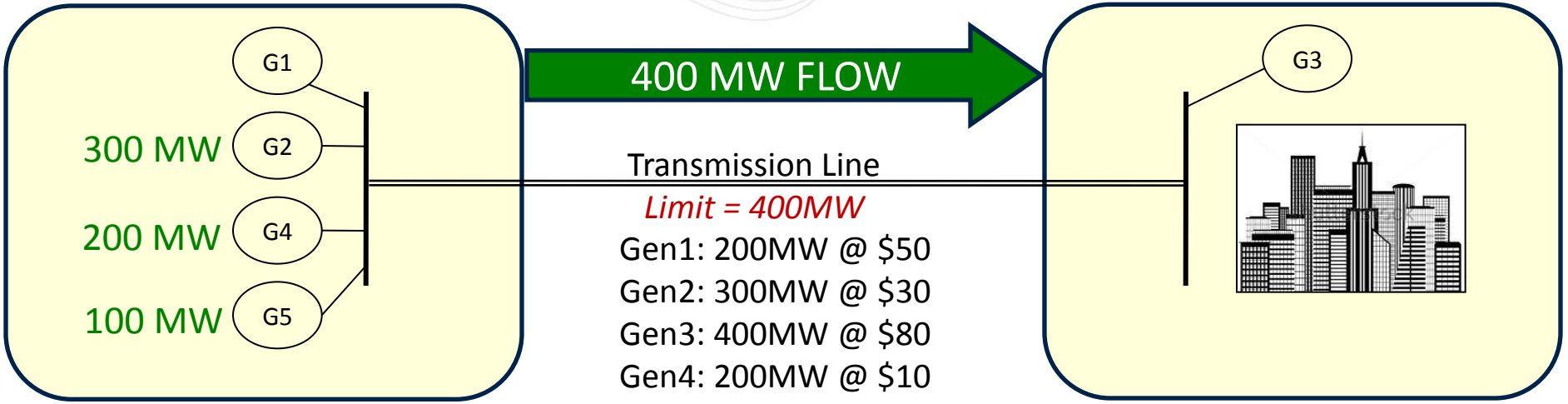


Generation Dispatch Over Multiple Areas (1)

(e.g., This could be two states in an RTO)

Area 1: Load = 200 MW

Area 2: Load = 400 MW



Area 1: Gen = 600 MW

Market Clearing Price in both areas is $40/MWh

Load Payment in Area 1 = $8,000

Load Payment in Area 2 = $16,000

Area 2: Gen = 0 MW @ $100

Gen 2 paid $12,000

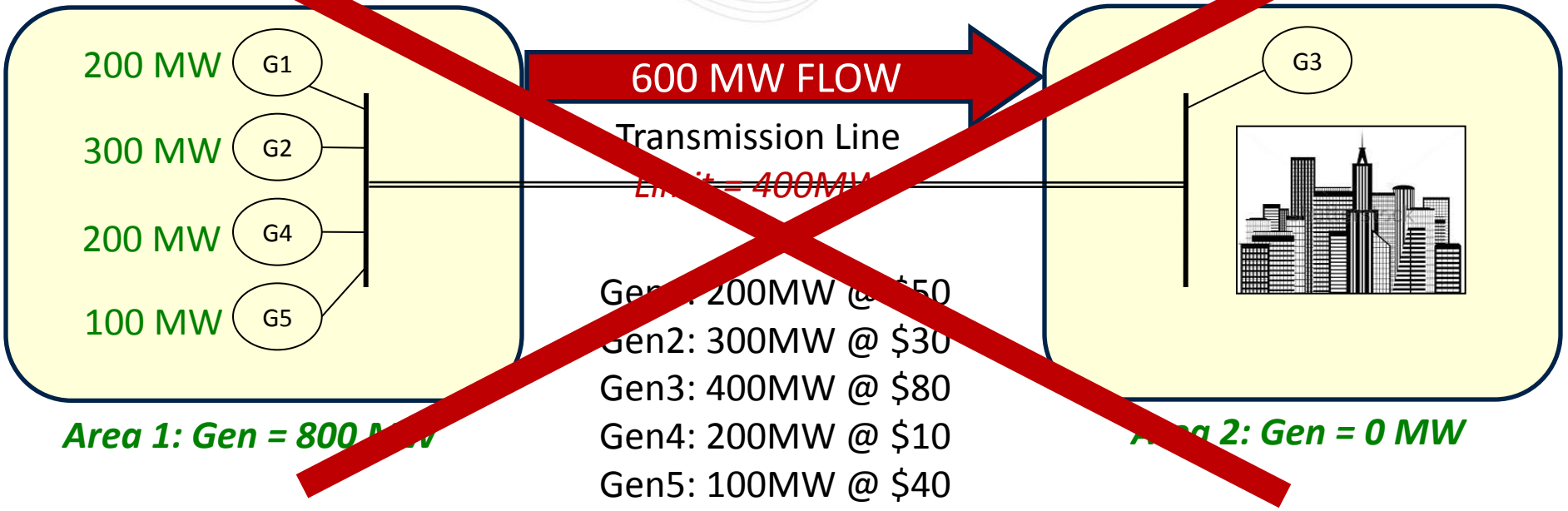
Gen 4 paid $8,000

Gen 5 paid $4,000

Generation Dispatch Over Multiple Areas (2)

Area 1: Load = 200 MW

Area 2: Load = 600 MW



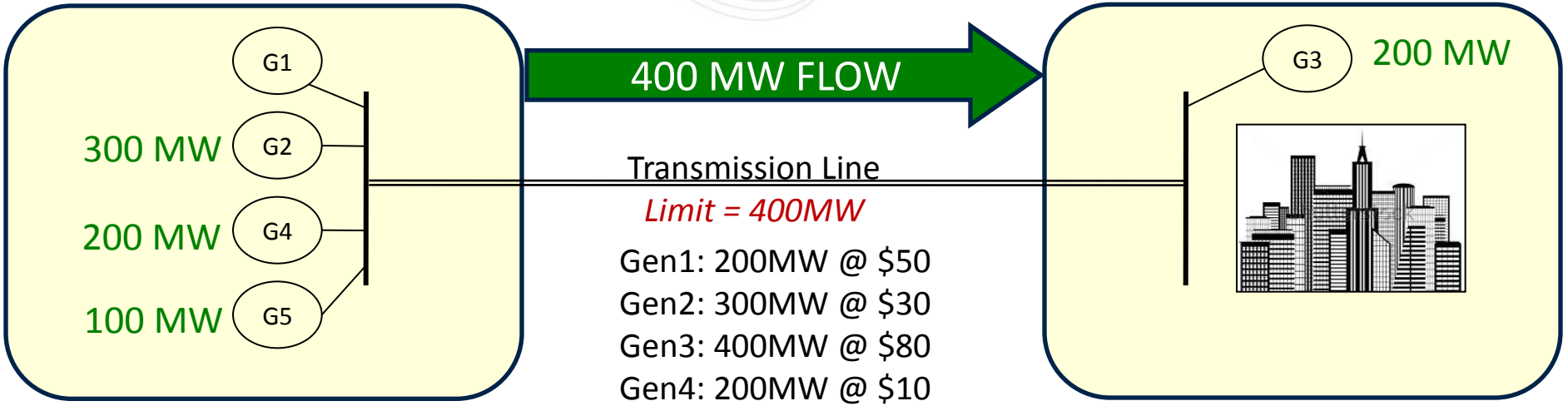
Area 1: Gen = 800 MW

Area 2: Gen = 0 MW

Generation Dispatch Over Multiple Areas (3)

Area 1: Load = 200 MW

Area 2: Load = 600 MW



Gen1: 200MW @ $50
Gen2: 300MW @ $30
Gen3: 400MW @ $80
Gen4: 200MW @ $10
Gen5: 100MW @ $40

Area 1: Gen = 600 MW

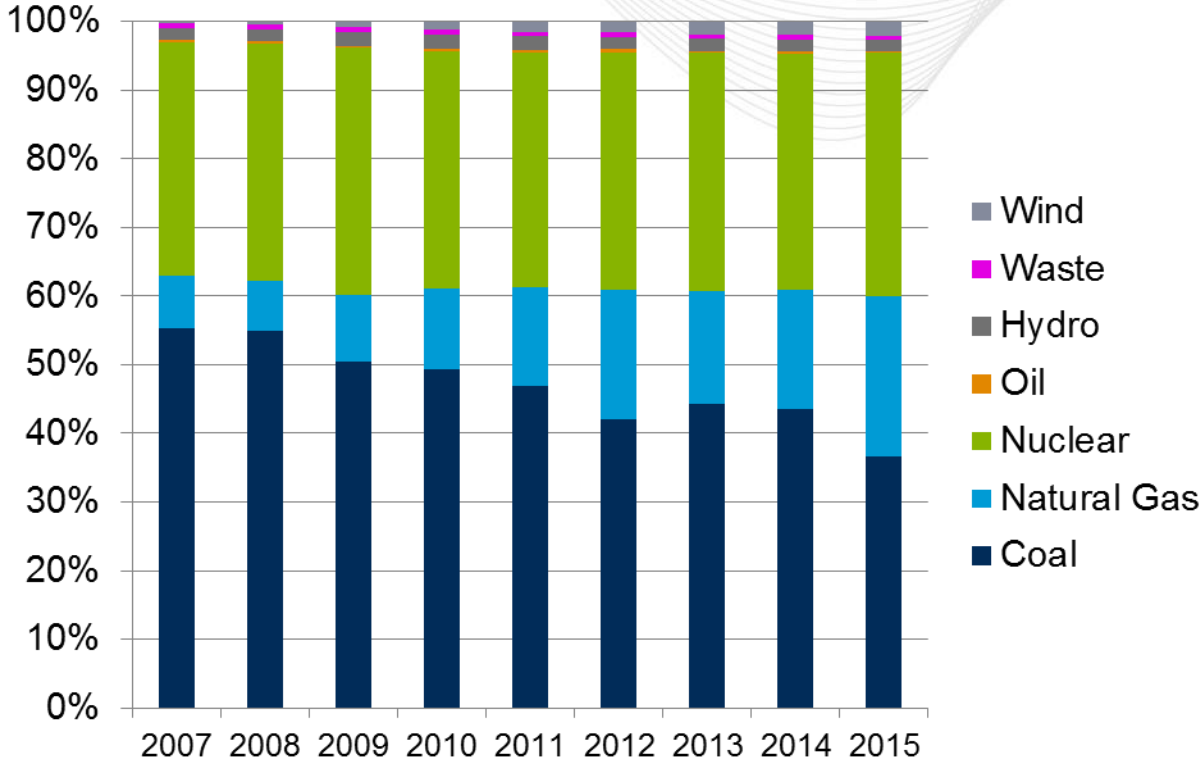
Area 2: Gen = 200 MW @ 100

Market Clearing Price Area 1 = $40/MWh
Market Clearing Price Area 2 = $80/MWh
Load Payment in Area 1 = $8000, Area 2 = $48,000

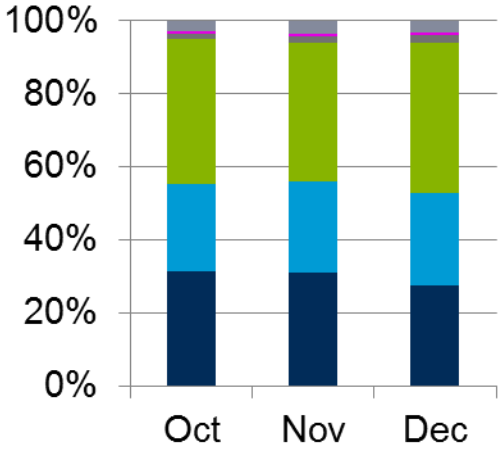
Gen 2 paid $12,000
Gen 4 paid $8,000
Gen 5 paid $4,000

Area 2 Gen
Paid $20,000

Changing Energy Market Trends

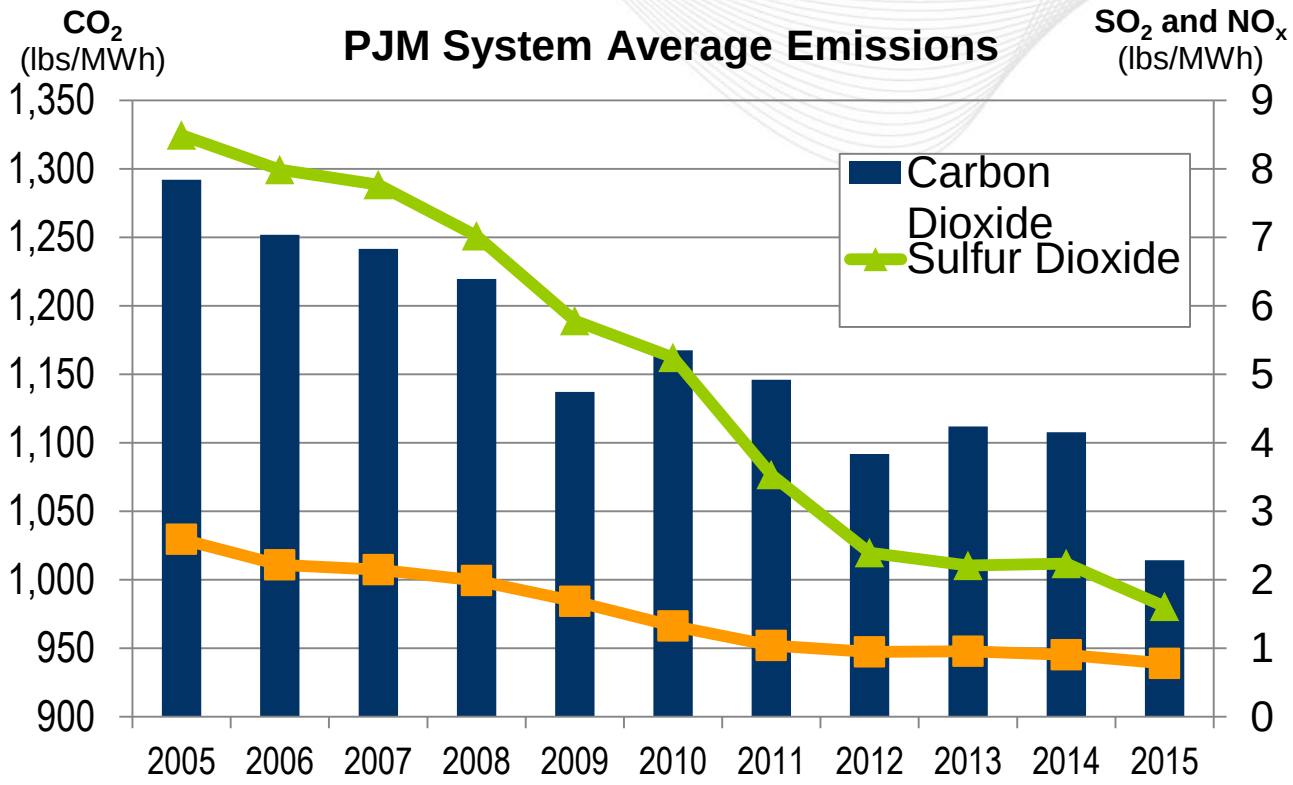


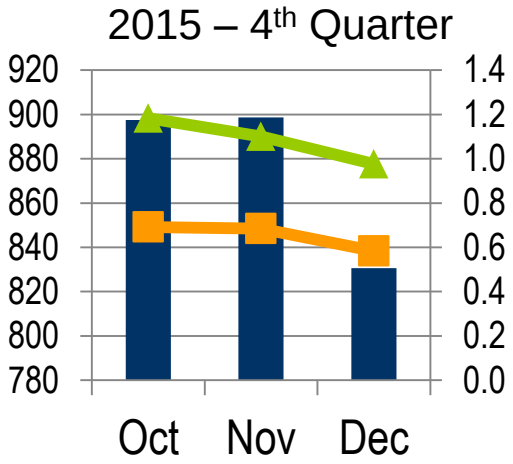
2015 – 4th Quarter



* Source: Monitoring Analytics, LLC. *2015 State of the Market Report for PJM*. March 10, 2016.

Declining Emission Rates





Implications for CPP Planning

- Regional markets dispatch EGUs on the basis of cost, providing economic and reliability benefits
- The Clean Power Plan will internalize carbon costs; this will affect a regional market's "economic merit order" (EGU dispatch order):
  - Generally, EGUs with higher emissions will be more costly to use
- Modifications to dispatch order may cause electricity generation and emissions to:
  - Occur in different amounts
  - Occur in different geographic locations (sometimes in different states)
- Decision-makers will need to determine:
  - Relative advantage of compliance plan structure & path (mass or rate)
  - Benefits of coordinating compliance plans with neighboring states
  - Multi-pollutant ramifications

Implications for NJ:
Observations from the PJM Analysis of the Proposed Clean Power Plan
March 2015

More Information and Scenario Results

PJM Economic Analysis of the EPA Clean Power Plan Proposal:

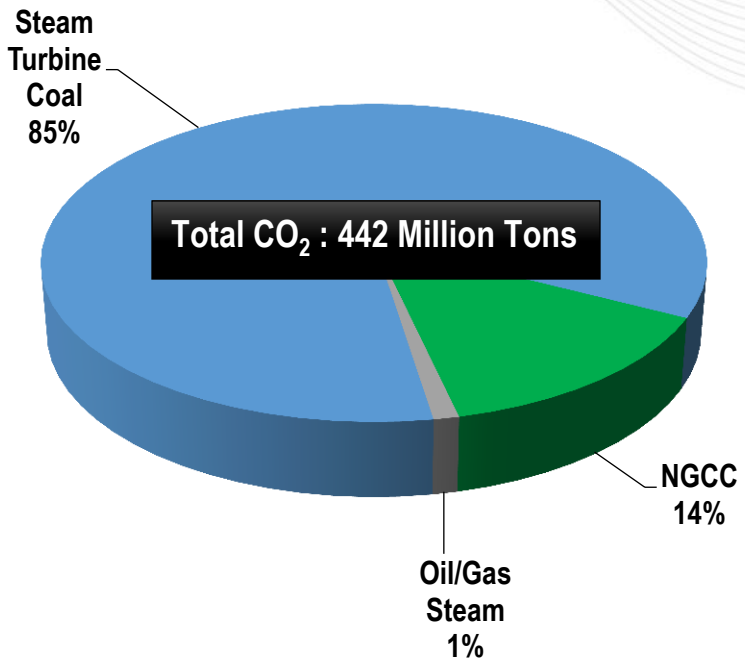
- http://www.pjm.com/~/media/documents/reports/20150302-pjm-interconnection-economic-analysis-of-the-epa-clean-power-plan-proposal.ashx

State-Level Detail:

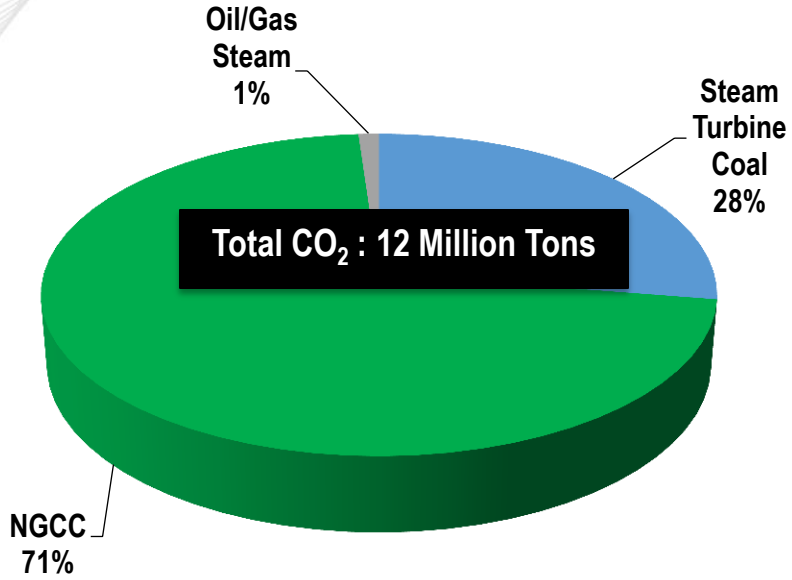
- http://www.pjm.com/~/media/documents/reports/20150302-state-level-detail-pjm-economic-analysis-of-epas-proposed-clean-power-plan.ashx

Sources of CO_2 Emissions

2012 PJM CPP Covered Sources

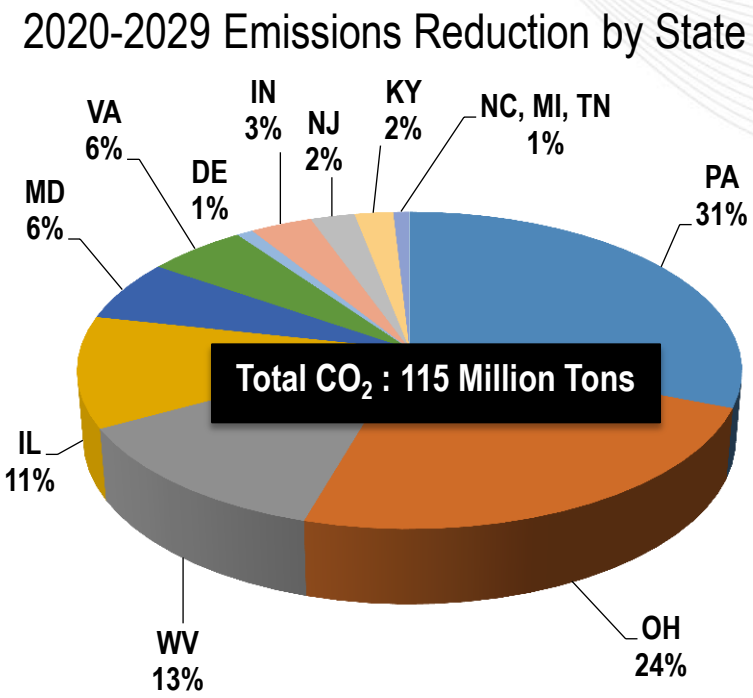


2012 New Jersey CPP Covered Sources



Source: EPA Emissions Goal Computation TSD

Interim Compliance Period Reductions

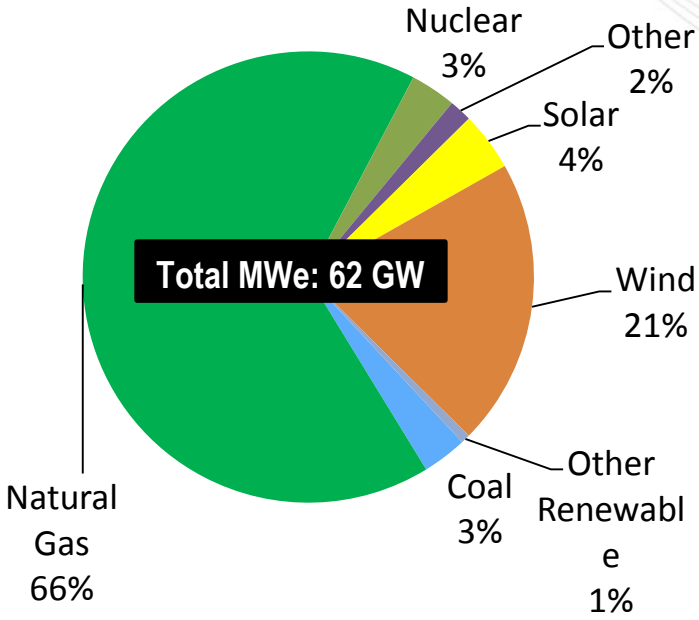


*DC does not have a compliance obligation. The portion of Tennessee in PJM does not have any sources covered by the proposed rule.

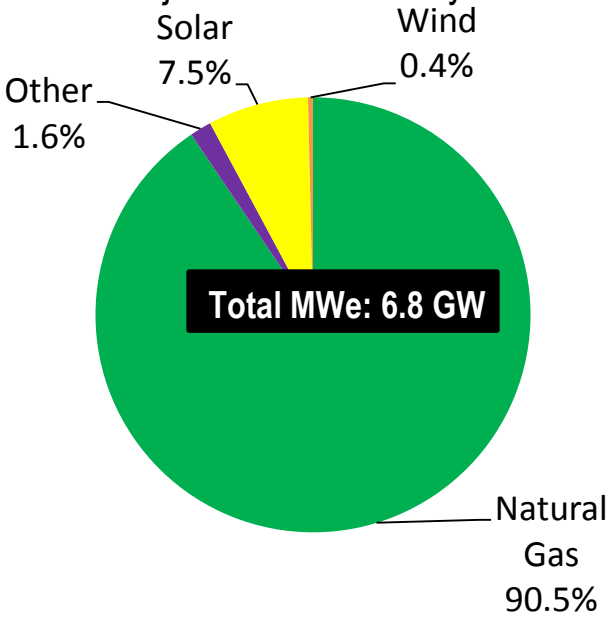
- New Jersey accounts for about 2.8 million short tons of CO_2 reductions by 2029 or 2.5 percent of the total required reductions in PJM
- Of the total 115 millions tons of required PJM reductions nearly 50 million tons are from resources that have either announced retirement or planned to convert from coal to gas since 2012
- Within New Jersey 0.25 million short tons are attributed to resources that will have retired before 2020
- Retirements announced prior to EPA's guidance provide an implicit credit and significantly reduce the burden of compliance since load will be served by a mixture of existing and new sources.

PJM Interconnection Queue Statistics

PJM Active Queue Projects by Energy Capability



Active* Queue Projects in New Jersey



PJM included queue project W4-009 (Woodbridge Energy Center) and W4-015 (West Deptford Power Project) in the emissions rate goal computation resulting in a more conservative rate and mass target

*New Projects identified based on having an FEAS\SIS\FSA\ISA, not currently suspended, and that result in an increase in output at the point of interconnection.

Existing Source vs. New Source Standards

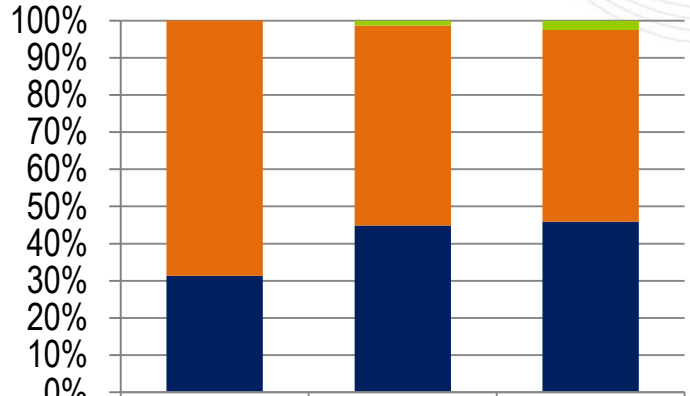
	111(d)	111(b)
Relevant dates	Interim compliance 2020-2029. Final compliance 2030 and beyond	Scheduled promulgation January 2015
Units impacted	• Existing and Under-construction: ST Coal, NGCC, ST Gas/Oil, High-utilization CT Gas/Oil, IGCC and some CHP • Units under 111(b) not subject to 111(d) but could be included at a state's discretion	• New Gas-Fired CT, fossil-fired utility boilers and IGCC units • CTs running under a 33% capacity factor are exempt

Standard	• State-based compliance with a CO_2 emissions rate target or converted to a mass-based target
	• Options for regional compliance
		Federal compliance (NSPS):
		• Large CT - 1,000 lbs/MWh
		• Steam Turbine and IGCC:
		  • 1,100 lbs/MWh (12 mos.)
		  • 1,000-1,050 lbs/MWh (84 mos.)

Impact on units	Reduced net energy market revenues Potentially CO_2 allowance price or restrictions on unit operation	New gas/dual fuel CCs meet limit New coal units require partial carbon capture and sequestration or similar to meet limits

Emissions Reductions from RE & EE

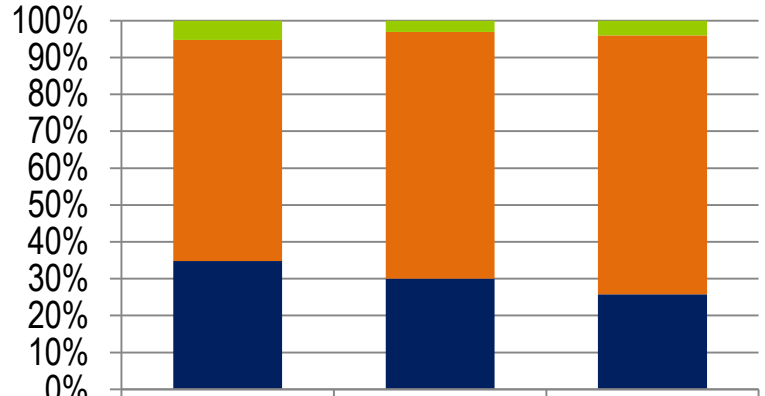
Energy Displacement due to Wind Resources



	2020	2025	2029
Other	0.0%	1.3%	2.5%
Natural Gas	68.7%	53.8%	51.6%
Coal	31.3%	44.9%	45.9%

OPSI 2b.1 and OPSI 2a used to calculate displacement percentage

Energy Displacement due to Energy Efficiency



	2020	2025	2029
Other	5.2%	3.1%	4.0%
NGCC	60.0%	66.9%	70.2%
Coal	34.8%	30.1%	25.8%

OPSI 2b.2 and OPSI 2a used to calculate displacement percentage

2020 State by State Compliance Scenario: Resource Summary

Driver	OPSI 2a/2c	PJM 4/9	PJM 7/11
Renewables Modeled	88.8 GWh (Thousands)	46.5 GWh (Thousands)	46.5 GWh (Thousands)
111(b) NGCC	14.5 GW	14.5 GW	2.8 GW
Nuclear	33.4 GW	33.4 GW	33.4 GW
Natural Gas Price	Economic Forecast	Economic Forecast	Economic Forecast
Energy Efficiency Modeled	26.3 GWh (Thousands)	7.9 GWh (Thousands)	7.9 GWh (Thousands)
Description	**Achieve State RPS and EPA EE Targets**	**Low Growth in Renewables and EE**	**Limited New Resources**

State compliance was only evaluated for compliance with the 2020 interim target

Modeling the Proposed Rule

Used PROMOD for simulation modeling

- PROMOD models hourly security constrained economic generation commitment and dispatch
- Assumptions consistent with 2014 RTEP Market Efficiency Analysis
- Regional Dispatch of PJM Generators to serve PJM load

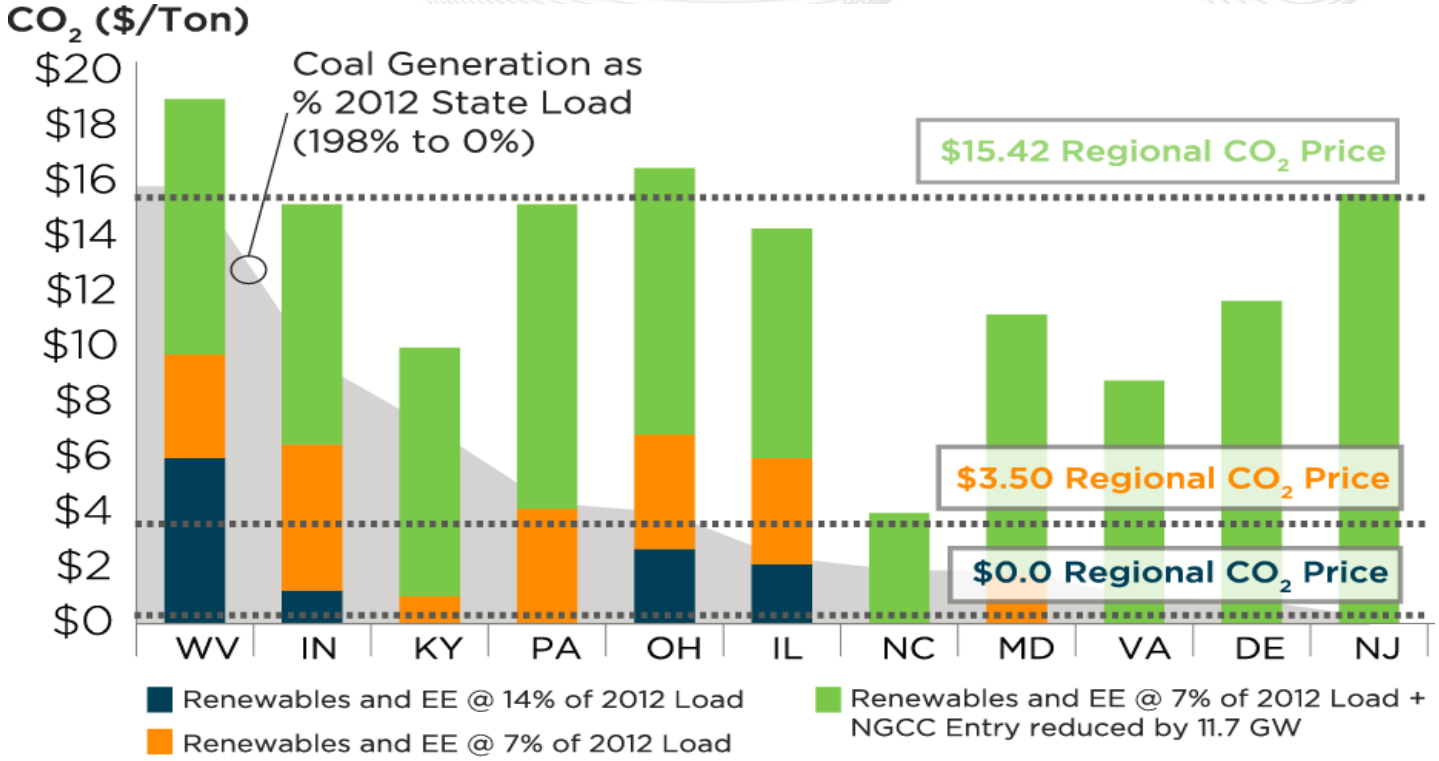
Regional Compliance

- No one state needs to comply in isolation, but in aggregate the region cannot exceed the regional mass- or rate-target
- Iterate on a single PJM-wide CO_2 price until the region is in compliance

State-by-State Compliance

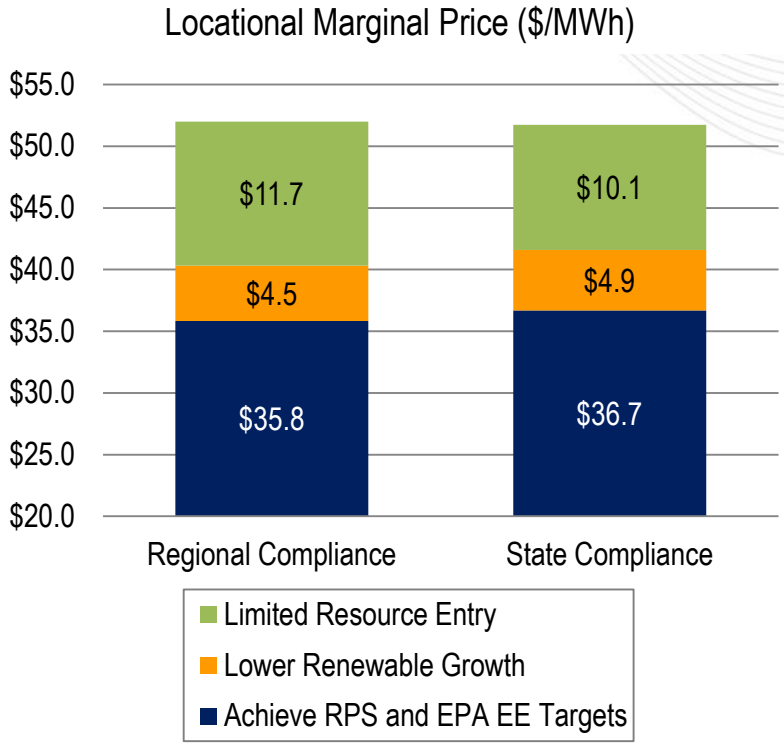
- Each state (12 states in the simulation) has its own unique CO_2 price
- Simultaneously iterate on individual state CO_2 prices until all states are in compliance

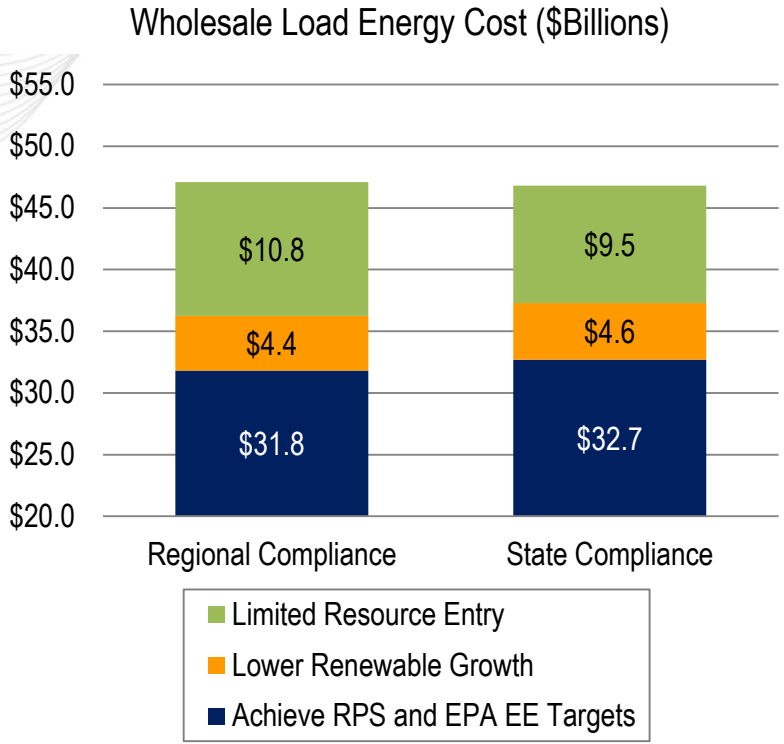
State-By-State vs Regional Compliance



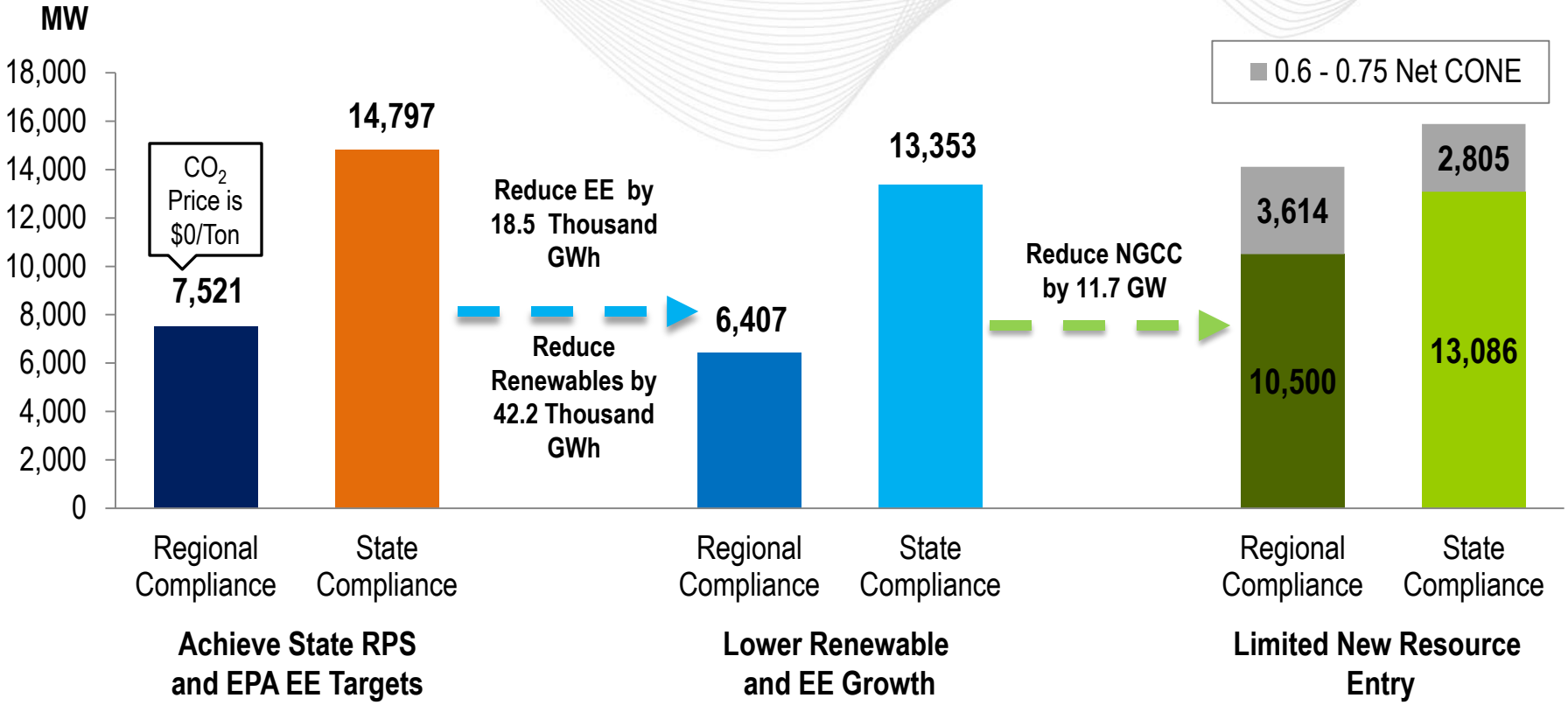
*DC does not have a compliance obligation. The portion of Tennessee in PJM does not have any sources covered by the proposed rule. The portion of Michigan in PJM has a single covered source (Covert Generating Station) and was not studied for state-by-state compliance.

Sensitivity of Costs Due to RE, EE & NGCC



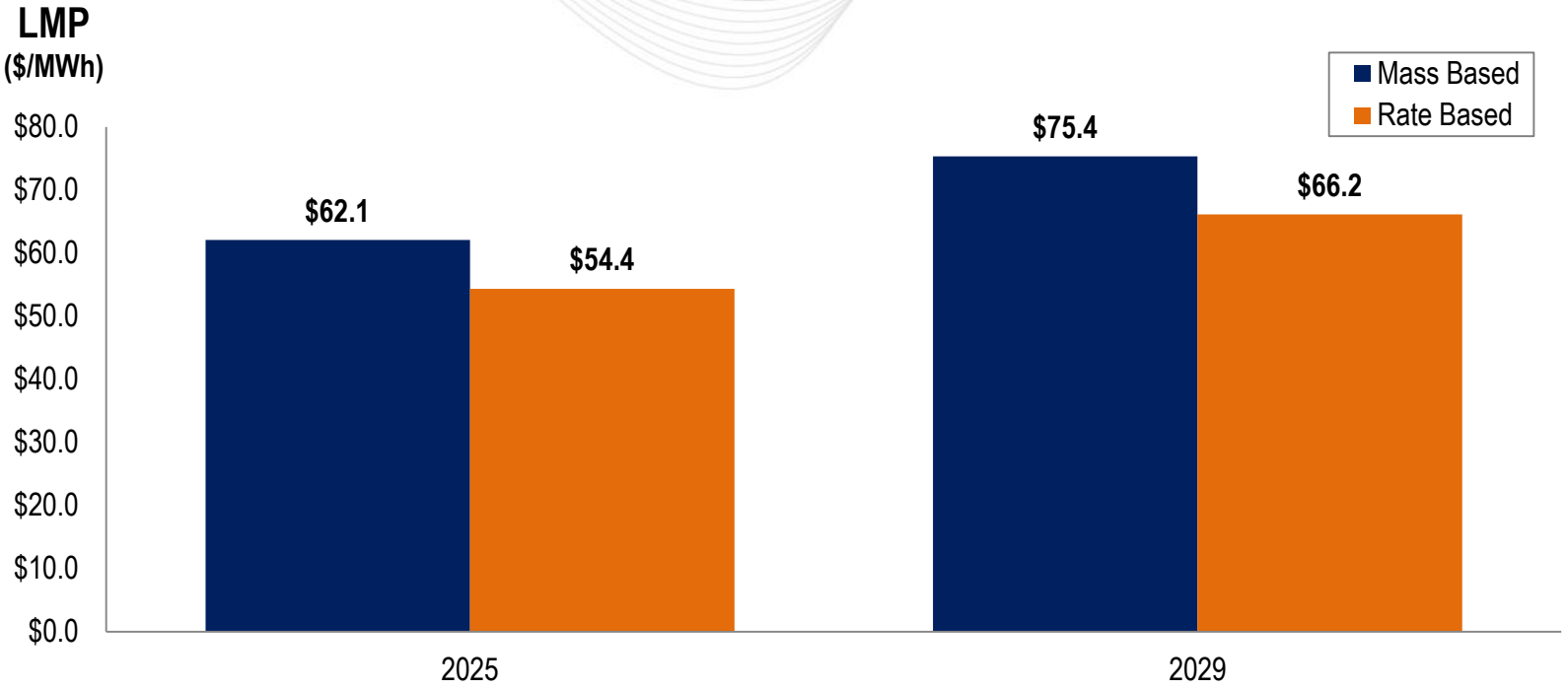


At-Risk Generation

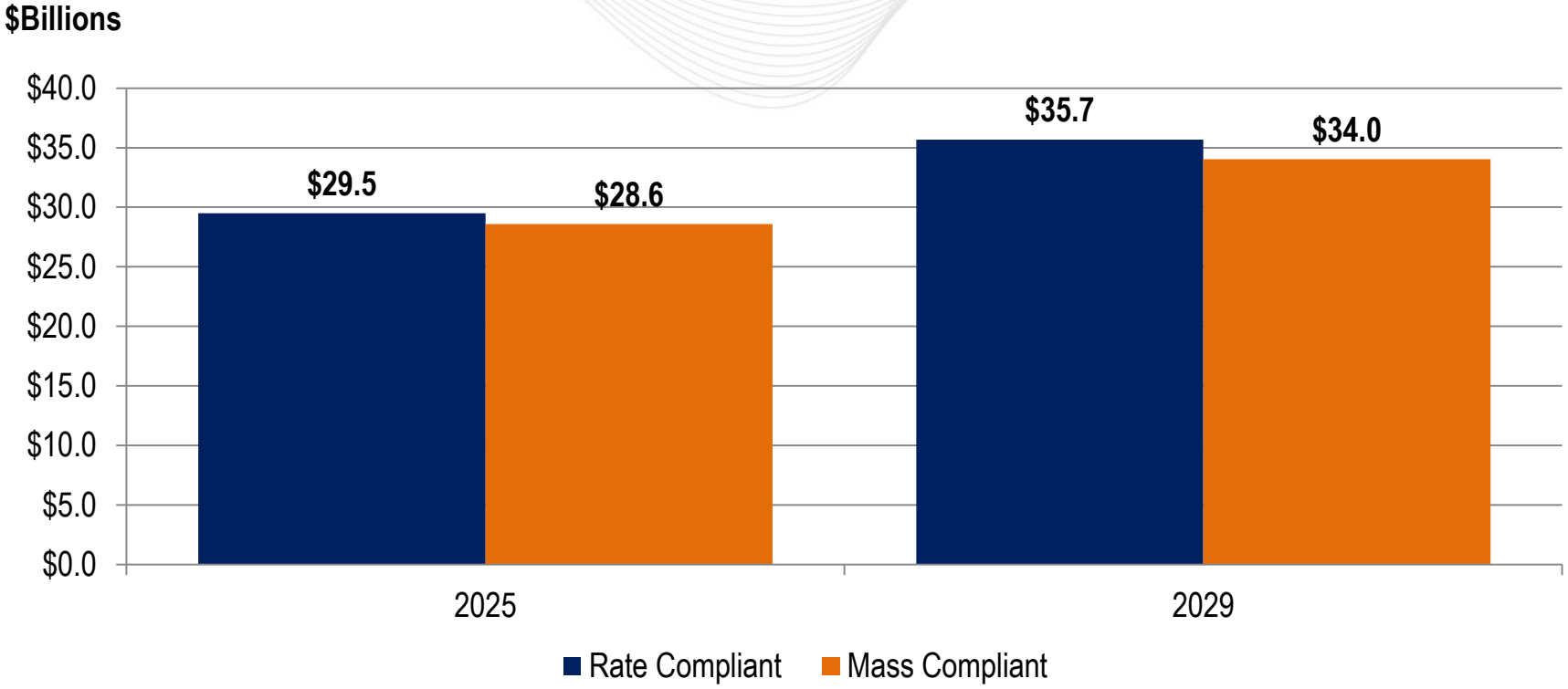


Regional Compliance Approaches:
Emissions Rate Based (PJM 10)
vs.
Mass-Based (PJM 4)
(Note: The Final CPP models rate a bit differently)

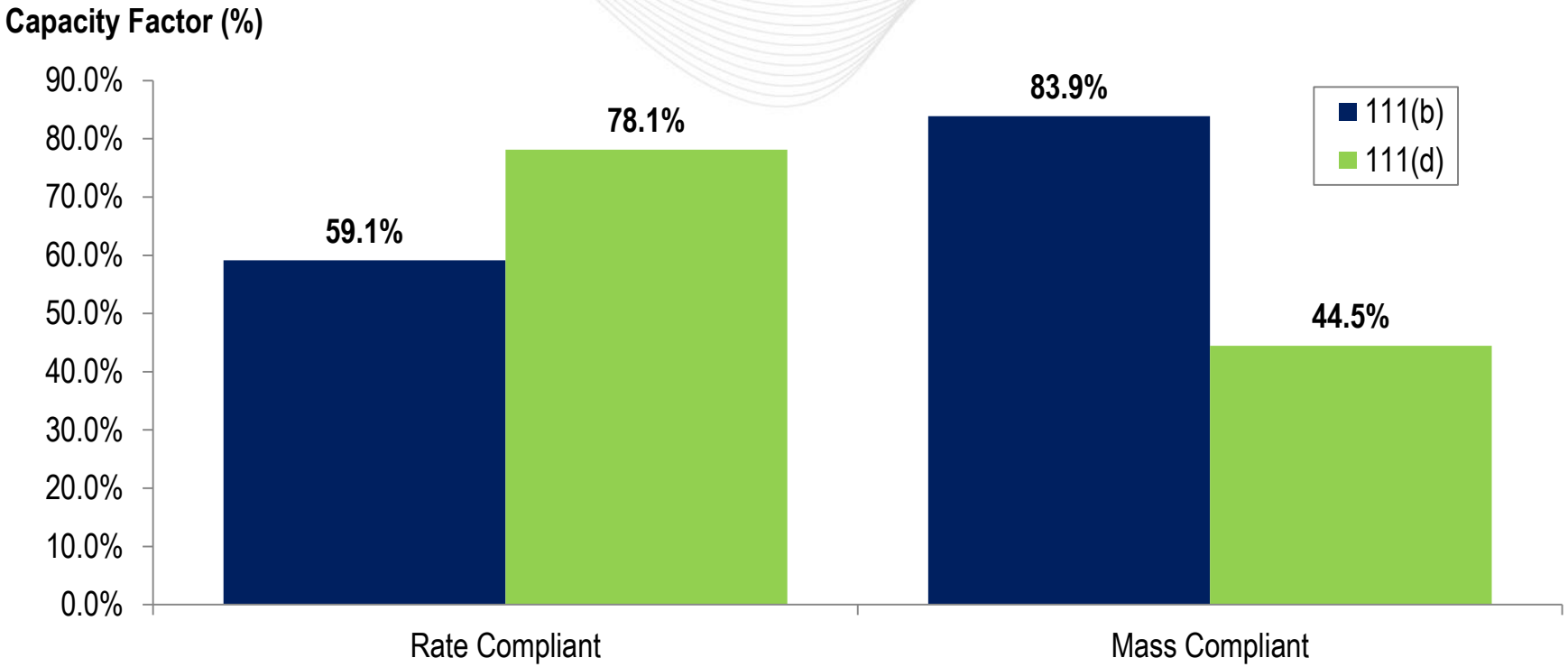
Rate-Based vs Mass-Based Compliance Impact on Locational Marginal Prices



Rate-Based vs Mass-Based Compliance Impact to Fuel and O&M Expense



Rate-Based vs Mass-Based Compliance Impact on NGCC Unit Operation



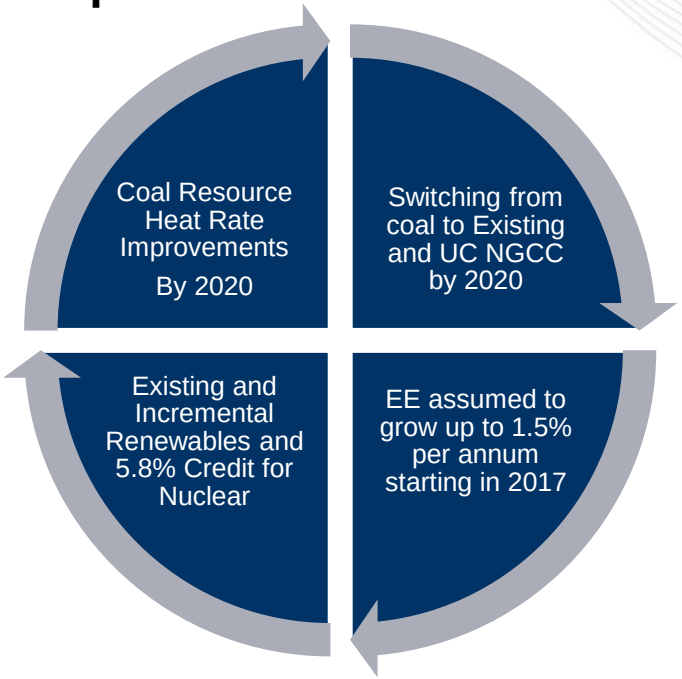
Clean Power Plan
Proposed Rule Versus Final Rule
Key Differences and how PJM's Economic Analysis is Impacted

Proposed Rule vs Final Rule

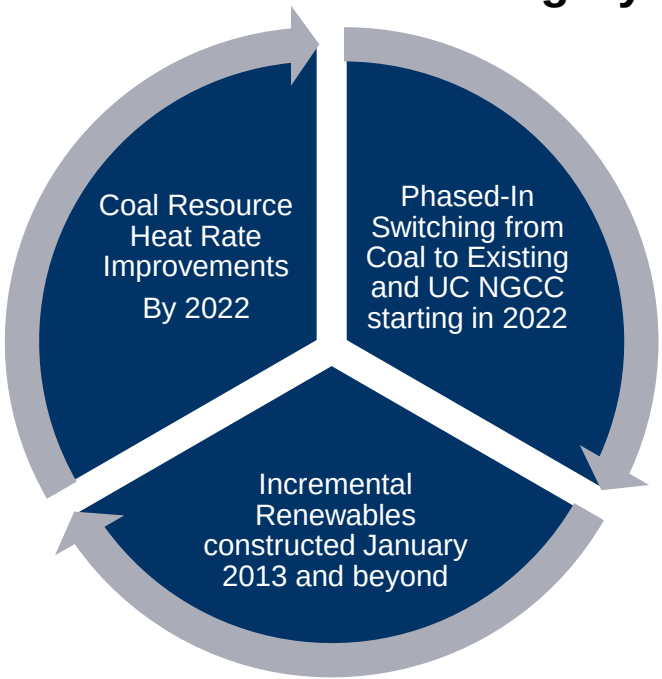
	Proposed Rule	Final Rule
Relevant dates	Interim compliance 2020-2029. Final Compliance 2030 and beyond	Interim compliance 2022-2029. Final Compliance 2030 and beyond
Units impacted	Existing and Under-construction: ST Coal, NGCC, ST Gas/Oil, High-utilization SCT Gas/Oil, IGCC and some CHP.	Existing and Under-construction: ST Coal, NGCC, ST Gas/Oil, some IGCC and CHP units
Standard and compliance	• Individual state-based compliance with emissions rate or mass targets • Multi-state based compliance with emissions rate or mass targets	• Individual state-based compliance with emissions rate or mass targets • Multi-State compliance with emissions rate or mass targets • Trading or state-measures (mass-based) • Trade-ready (Individual state plan) • Federally enforceable rate targets • State enforced operational limitations on specific units

Target Setting: Proposed Rule vs Final Rule

Proposed Rule: State Portfolio Rate



Final Rule: EGU Sub-category Rates



Final Rule Target Setting Procedure

Sub-category rate

- EPA building blocks used to set national sub-category emissions rate targets for natural gas combined cycles and fossil (Oil, Gas, Coal) steam resources

State Rate

- State goal rates based on average of national sub-category rates weighted by in-state 2012 fossil steam and NGCC generation

State Mass

- State mass targets based on product of state goal rate and 2012 baseline generation + MWh credit for assumed over-build of renewables in sub-regions

Clean Power Plan Analysis Update

What Are we Being Asked

What will be the economic and reliability impacts to states

What is my state's bottom line due to trading versus not using a trading option

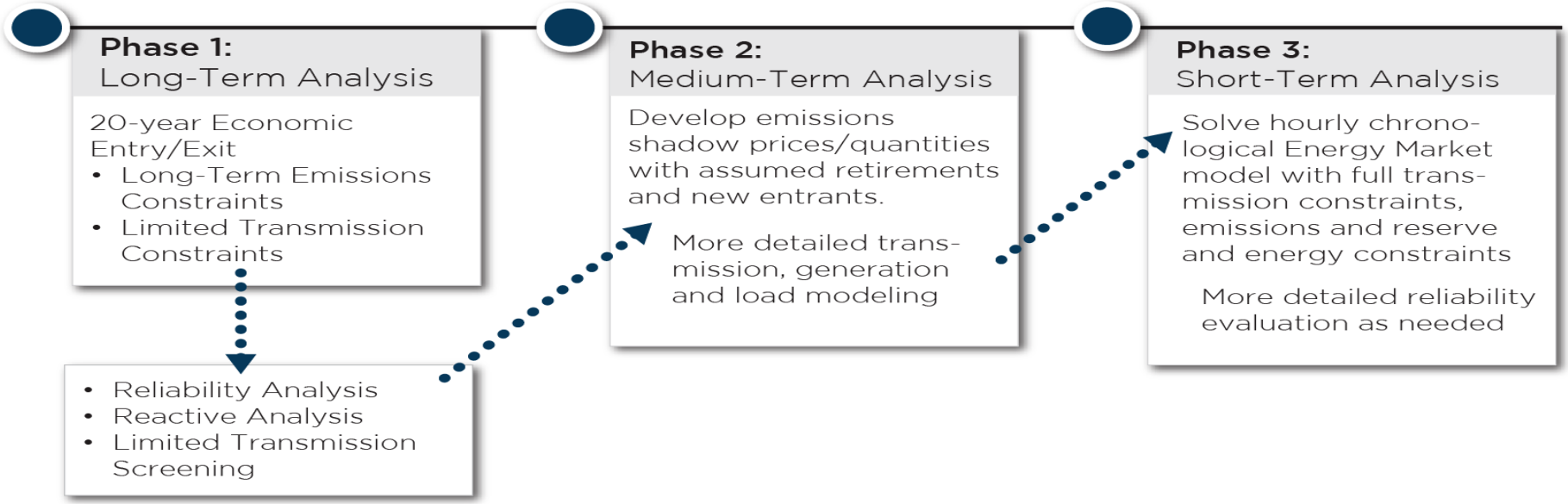
What happens to resource diversity and what does it mean for baseload resources

What is the difference between an emissions market trading seam and an electric market seam

What happens if my plan diverges from what most of the other PJM states submit in their compliance plans

Alright, trading makes sense but rate or mass

How is PJM Identifying Answers



What Information will Answer these Questions

Detailed Results by Individual State and/or PJM region

Reliability

- Capacity added /retired by LDA and RTO region
- Transfer capability for reactive interfaces
- Generation and Load Deliverability tests results

Electric Market

- Locational marginal prices and energy market load payments
- Facility level transmission congestion
- Percentage of generation by prime mover and fuel type

Environmental

- Carbon dioxide prices, total allowance supply/demand
- Resource entry capital costs
- Emission rate credit production and consumption

Final Rule Analysis Timeline