MTEP19 Futures

Summary of definitions, uncertainty variables, resource forecasts, siting process, and siting results

MTEP19 Futures Key Takeaways

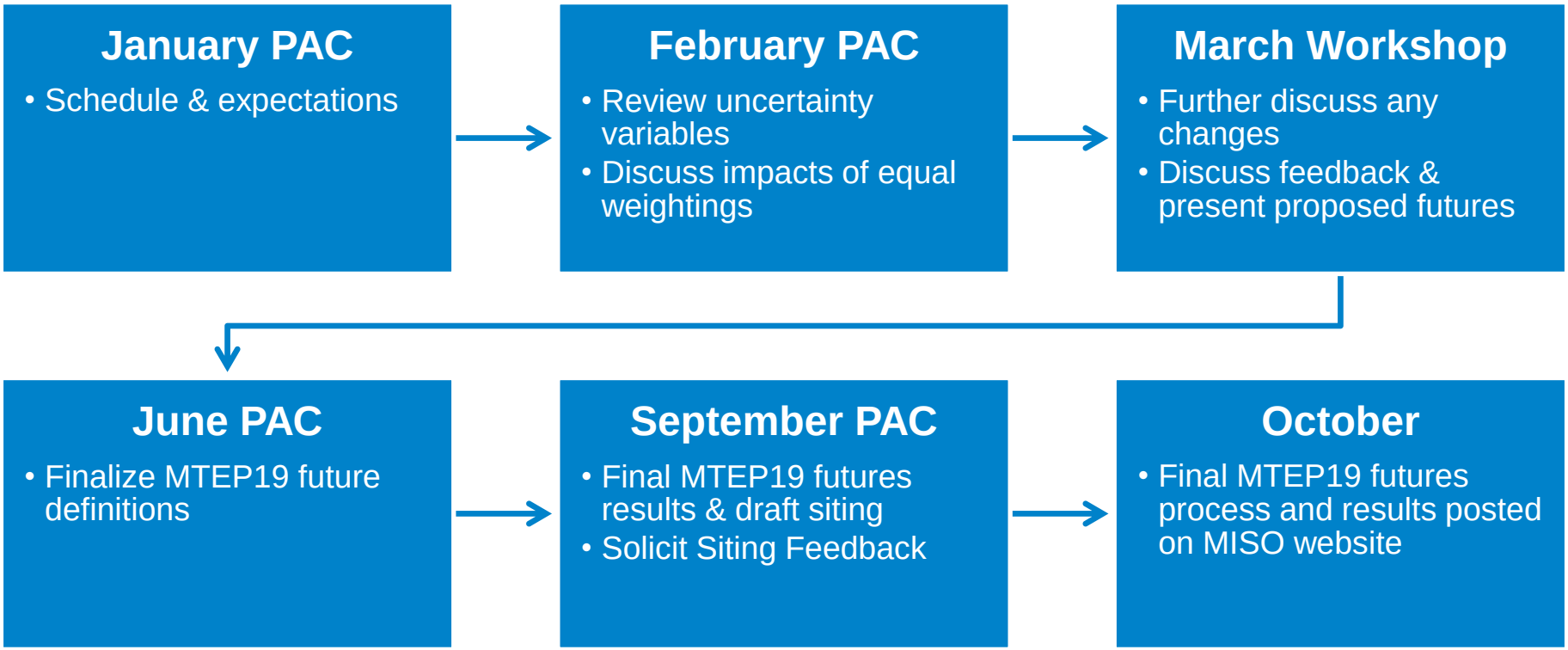
MTEP19 Future	Limited Fleet Change	Continued Fleet Change	Accelerated Fleet Change	Distributed & Emerging Technologies
Demand and Energy	Low (Demand: 0.0%, Energy 0.0%) High LRZ9 Industrial	Base (50/50) (Demand: 0.3%, Energy 0.4%)	High (Demand: 0.6%, Energy 0.9%) Low LRZ9 Industrial	Base + EV (Demand: 0.4%, Energy 1.0%)
Fuel Prices	Gas: Base -30% Coal: Base -3%	Base	Gas: Base +30% Coal: Base	Base
Supply Slide CC/CT/Wind/Solar (GW)	9.6 / 9.6 / 3.6 / 4.8	13.2 / 15.6 / 10.8 / 9.0	13.2 / 9.6 / 42 / 20.2	20.4 / 1.2 / 10.8 / 14.2
Demand Side Additions[1] ***By Year 2033***	EE: - GW DR: 0.6 GW DG PV: 2.4 GW	EE: 5.0 GW DR: 0.2 GW DG PV: 4.5 GW	EE: 6.8 GW DR: 0.5 GW DG PV: 10.1 GW	EE: 5.5 GW DR: 0.2 GW DG PV: 28.5 GW Storage: 2 GW
Renewable Penetration Level ***By Year 2033***	15%	20%	39%	25%
Generation Retirements[2] ***By Year 2033***	Coal: 9 GW Gas/Oil: 16 GW	Coal: 19 GW Gas/Oil: 16 GW	Coal: 19 GW+ Gas/Oil: 16 GW	Coal: 19 GW Gas/Oil: 16 GW Nuclear: 2 GW
CO_2 Reduction Constraint ***From Current Levels by 2030***	None	None	20%	None
Siting Methodology[3]	MTEP Standard	MTEP Standard	MTEP Standard	"Localized"

1. *Capacity of demand side additions from programs defined in Applied Energy Group study and economically selected in resource forecast. Energy storage in Distributed and Emerging Technology is additional assumption*
2. *In Accelerated Fleet Change Scenario 19 GW of coal retired. In addition, 12 GW of coal dispatched seasonally and must-run removed on all units.*
3. *"Localized" renewable siting assumes that at least 50% of incremental wind and solar energy will be sourced within each Local Resource Zone. 2/3 of solar sited as distributed.*

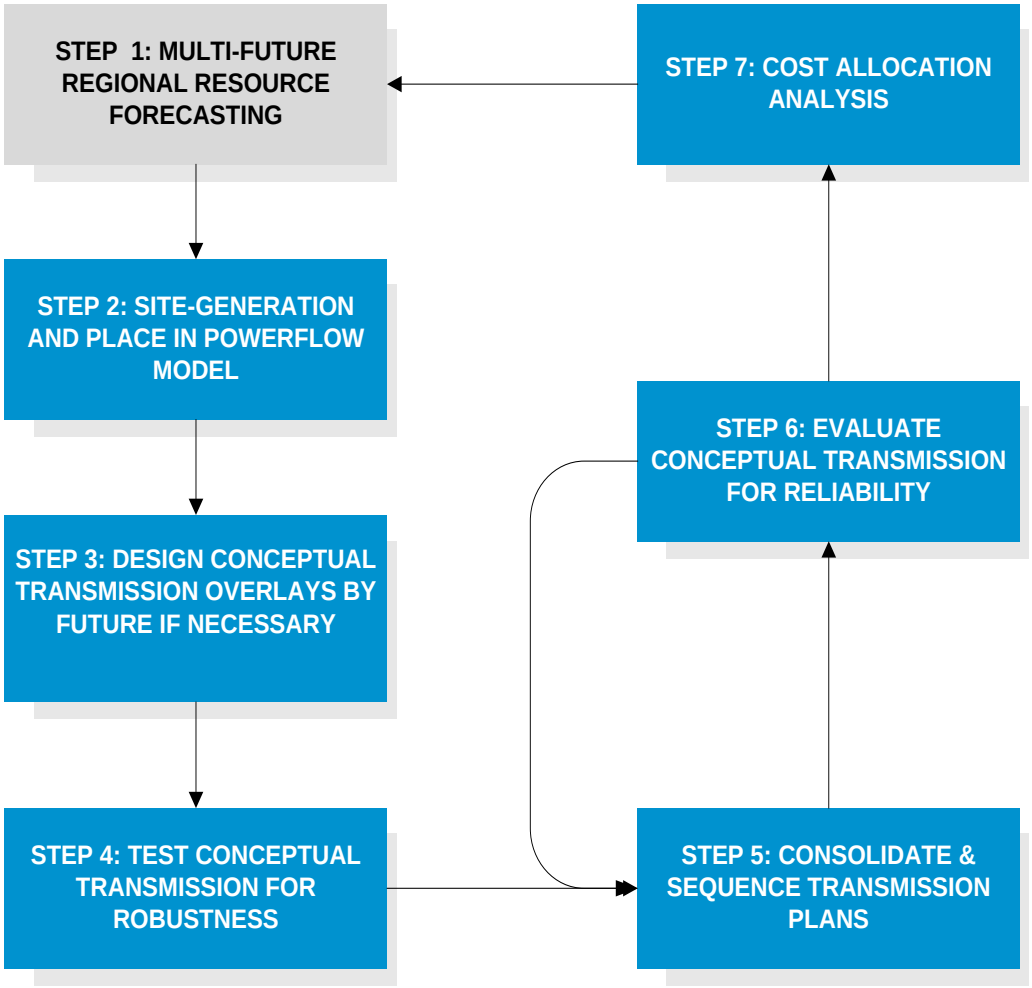
Contents

Background on MTEP19 Futures

MTEP19 Futures Development Timeline



Value-Based Planning



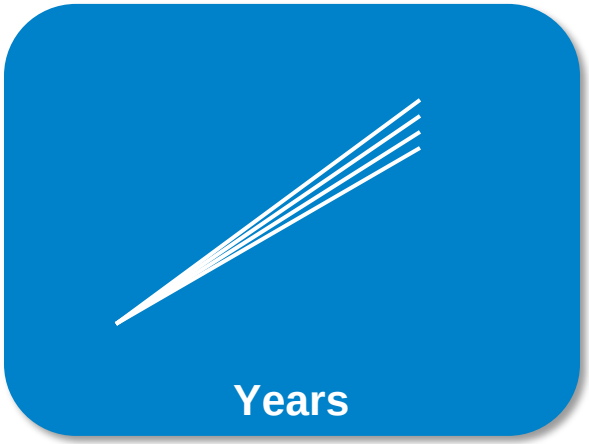
Objective of value-based planning is to develop the most robust plan under a variety of scenarios – not the least-cost plan under a single scenario

- The “best” transmission plan may be different in each policy-based future scenario
- The transmission plan that is the best-fit (most robust) against all these scenarios should offer the most future value in supporting the future resource mix

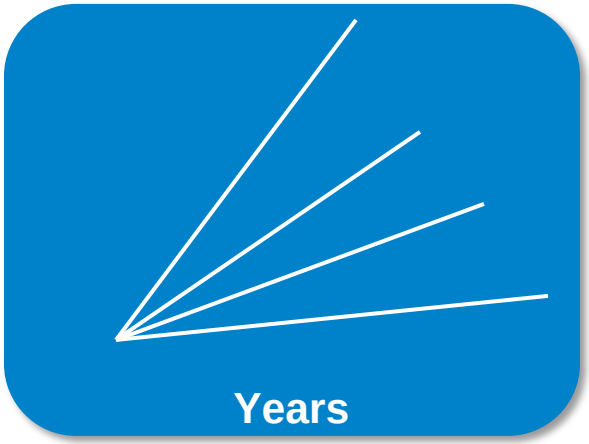
Long-Term Planning Requires Broad Futures

- Scenario analysis is needed to obtain multiple long term views of theoretical supply and demand resource availability given different policy and economic drivers
- Adequate bookends ensure that MISO continues to plan the system reliably and efficiently

Narrow and less useful



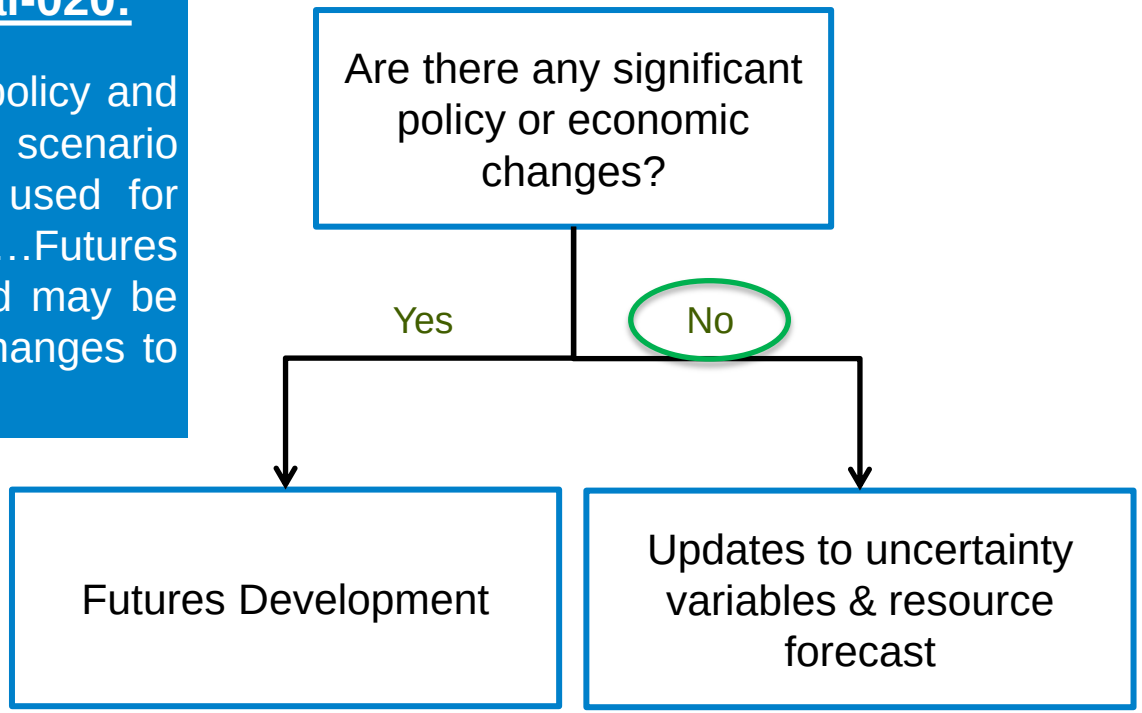
Broad and more useful



MTEP future definitions intended to be used for multiple cycles & may be updated annually

Business Practice Manual-020:

"Barring significant changes in policy and economic drivers, Future scenario definitions will continue to be used for multiple MTEP cycles…Futures definitions will be evaluated and may be updated annually for relevant changes to policy and economic drivers"



General policy, economic & industry trends continue from MTEP18 to MTEP19

→ Use updated MTEP18 futures in MTEP19

Stakeholders supported use & update of MTEP18 futures for MTEP19

- Stakeholder feedback received from three sectors on proposal to reuse and update MTEP18 futures for MTEP19
  - Environmental/Other, OMS, & TOs
- Each respondent believed the four MTEP18 futures still offered a reasonable set of bookends for the MTEP19 planning cycle
  - The Environmental/Other did propose a 5th "Carbon Regulation Future" as an alternative
  - Veriquest verbally requested a 5th future associated with more regionally distributed resource siting

MTEP19 Futures Enhancements

MTEP19 Futures Enhancements

1. Model/cost assumptions for new wind & solar
2. Capacity credit for new solar resources
3. Minimum renewable penetration assumptions
4. Inclusion of units having a CPCN or equivalent
5. Demand and energy growth rate bands

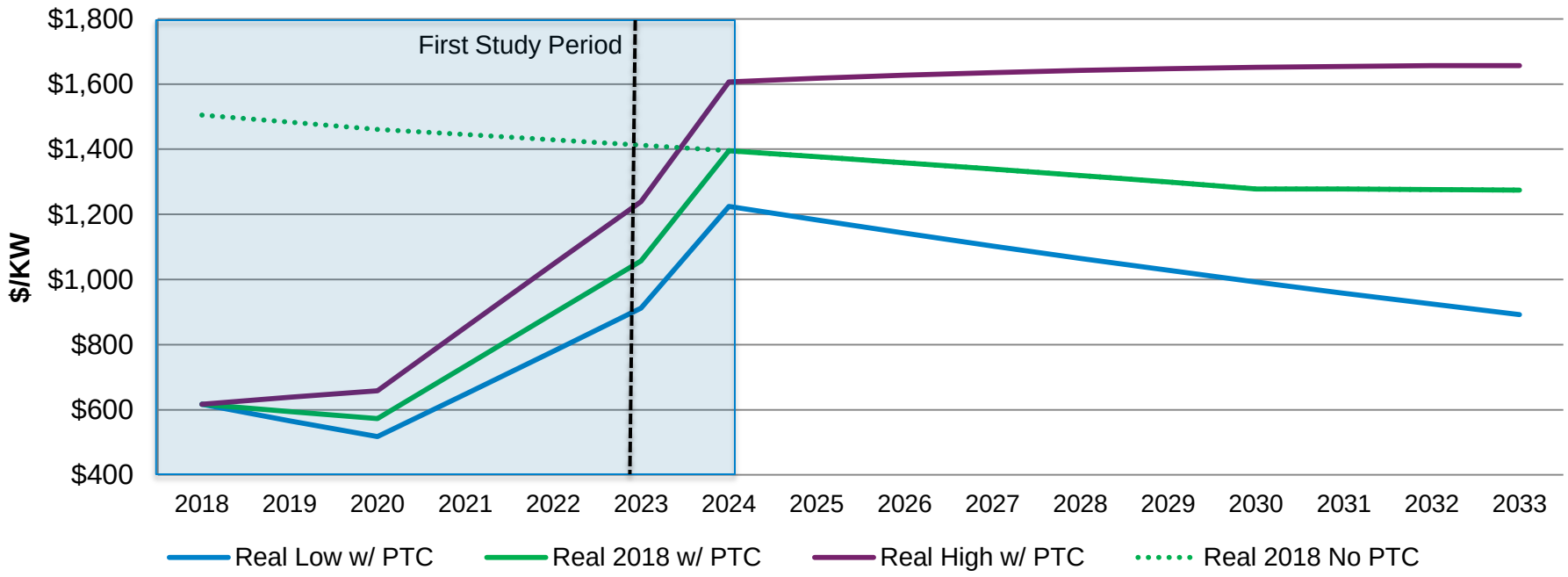
#1: EGEAS wind & solar capital cost and modeling assumptions updated

Enhancement	Previous Practice	MTEP19 Enhancement
Tax Depreciation	15-yr.	5-yr. for Utility Wind and Solar
Construction Schedule	Utility Solar: 2yr. 50/50 Utility Wind: 2yr. 50/50	Utility Solar: 2yr. 100/0 Utility Wind: 3yr. 80/10/10
Tax Credits	ITC: cost adjustment PTC: Variable O&M	ITC & PTC: Capital cost adjustment modeling credit & phase-out schedule

Benefits:

- More representative of recent project cost attributes
- Impacts of tax credits more accurately modeled

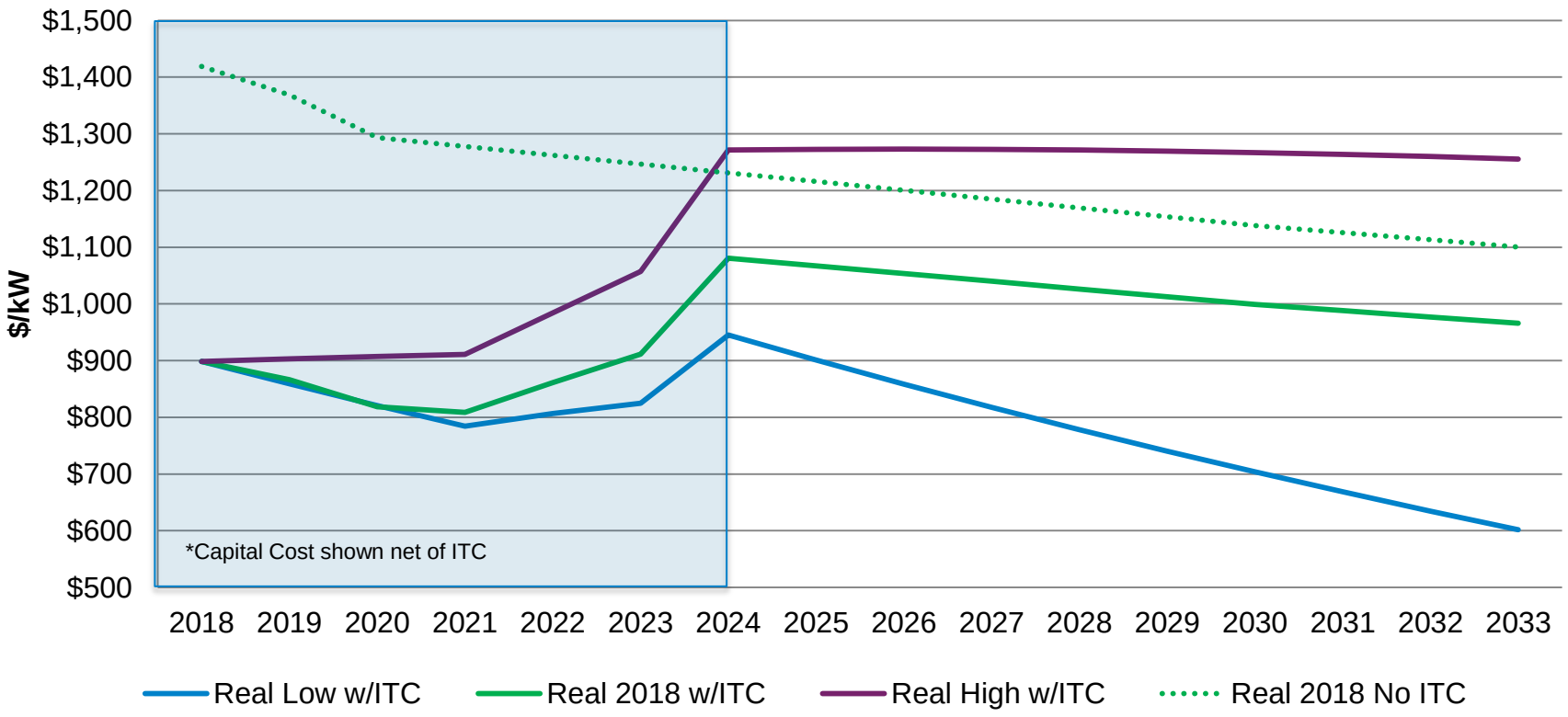
MTEP19 Wind Capital Cost



Model Representation	2018	2019	2020	2021	2022	2023	2024	2025
Utility Wind PTC	Full	Full	Full	80%	60%	40%	0%	0%
Utility Solar ITC	30%	30%	30%	30%	26%	22%	10%	10%

- *Mid ("Real 2017") maturity curve sourced from sourced NREL ATB 2017: http://www.nrel.gov/analysis/data_tech_baseline.html*
- *High and low maturity curves are +/- 30% in 2033 of mid maturity curve*

MTEP19 Solar Capital Cost



- *Mid ("Real 2017") maturity curve sourced from sourced NREL ATB 2017: http://www.nrel.gov/analysis/data_tech_baseline.html*
- *High and low maturity curves are +/- 30% in 2033 of mid maturity curve*

#2: Solar capacity credit updated across study period

- MISO modeled a decreasing PV capacity contribution as the amount of forecasted PV increases in and across the futures
  - This enhancement only impacts reserve contribution in the EGEAS model, not operating capacity
- Reserve contribution amount was informed by MISO's Renewable Integration Impact Assessment (RIIA) and stakeholder feedback
  - RIIA results related to the effective load carrying capability (ELCC) of PV were presented at the April PAC
    - As penetration levels increased, the reserve contribution needed to decrease, or risk too little capacity being constructed
    - Draft estimates ranged from 20-30% capacity credit within the penetration levels seen in MTEP18

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Solar Credit	**50%**	**50%**	**50%**	**50%**	**50%**	**50%**	**48%**	**46%**	**44%**	**42%**	**40%**	**38%**	**36%**	**34%**	**32%**	**30%**

#3: Based on industry trends and stakeholder feedback, minimum renewable energy levels increased across futures

Minimum % Renewable Energy in 15 Year Model	Limited Fleet Change	Continued Fleet Change	Accelerated Fleet Change	Distributed & Emerging Technologies	Rationale
MTEP18:	10%	15%	30%	20%	Stakeholders expressed concern that the low bookend was too low considering current renewable levels. Current power purchase agreement prices and capacity in MISO Interconnection Queue indicate future renewable levels will be higher than what was modeled as a minimum in MTEP18.
MTEP19:	***15%***	***20%***	***35%***	***25%***	

#4: Approved CPCN/CON units included in base model*

MTEP18 base model

- Existing active generating units
- Planned queue units with signed Generator Interconnection Agreement (GIA)

MTEP19 base model

- Existing active generating units
- Planned queue units with signed Generator Interconnection Agreement (GIA)
- Non-signed GIA units with approved CPCN/CON/CPN (or equivalent)
  - Included as a new unit with specific size, type, location, & timing of the approved unit
  - MISO requested state regulators or utilities to send MISO the approved unit-specific information

Units with **Certificate of Public Convenience and Necessity (CPCN)** have high level of certainty; ***stakeholder submissions of such approved units*** were included in the base model*

*Update only applied to MTEP Economic Model

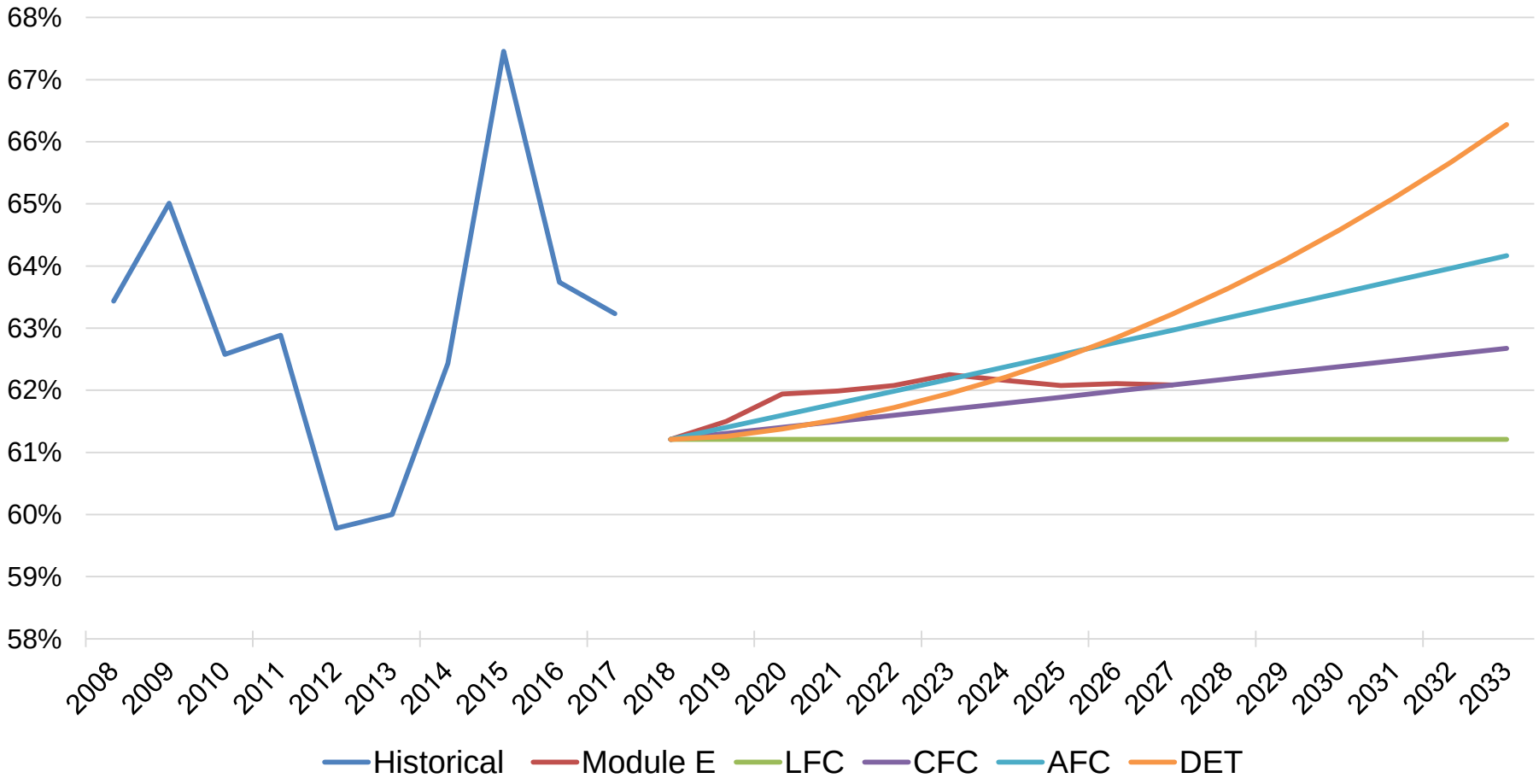
#5: Demand and energy growth rate assumptions broadened

	MTEP18 Method			MTEP19 Method		
	Low (10/90)	Mid (50/50)	High (90/10)	Low	Mid	High
Demand	0.23%	0.47%	0.70%	0.00%	0.29%	0.59%
Energy	0.25%	0.49%	0.74%	0.00%	0.43%	0.85%

MTEP Growth Rate %	50/50 growth rate has declined over time
MTEP16	Demand: 0.75% Energy: 0.82%
MTEP17	Demand: 0.64% Energy: 0.65%
MTEP18	Demand: 0.47% Energy: 0.49%
MTEP19	Demand: 0.29% Energy: 0.43%

- Due to declining 50/50 growth rates, MISO proposed and stakeholder feedback supported using 0 & 2 times base growth rate for low and high growth rate levels, respectively
- Prior MTEPs used .5 or 1.5 times the base growth rate for low & high, indicative of 10/90 and 90/10 forecasts

Load factor reasonable when modeling broadened growth rates in MTEP19



MTEP19 Siting Enhancements

Utility-Scale Renewables

**Additional details on updated methodology included in Siting Workshop #3 materials: https://www.misoenergy.org/events/mtep19-siting-workshop---march-22-2018/*

MTEP18 Methodology

- Site in wind and solar zones using tiers identified
- Zones and tiers created using 2015 Vibrant Clean Energy (VCE) study results and Generator Interconnection Queue locations

Limitations of Methodology Identified

- Scope of initial VCE analysis limited
  - Considered 1 wind and 1 solar technology type
  - Used 1 year of weather data
  - Cost maturity curves not fully considered

Updated MTEP19 Methodology*

- Site in updated wind and solar zones and tiers based on recommissioned VCE study and latest queue data
- Recommissioned VCE study includes:
  - More technology options
  - Increased granularity of weather data
  - More detailed representation of transmission

Distributed Energy Resources

**Additional details on updated methodology included in Siting Workshop #3 materials: https://www.misoenergy.org/events/mtep19-siting-workshop---march-22-2018/*

MTEP18 Methodology

- Site at top 20 load buses per PowerBase area, on a load ratio share
- Distributed solar currently modeled with this methodology

Limitations of Methodology Identified

- Additional characteristics not considered when identifying siting locations
  - Resource quality
  - Economics
  - State and local incentives

Updated MTEP19 Methodology*

- Use NREL's dGen model to account for additional variables in DER adoption
- Use dGen results to identify top 25 counties per Local Resource Zone
- Site at minimum of top 2 load buses per county (considering load at bus)
- Distribute county capacity using dGen results weighting

Energy Storage

**Additional details on updated methodology included in Siting Workshop #3 materials: https://www.misoenergy.org/events/mtep19-siting-workshop---march-22-2018/*

MTEP18 Methodology

- Site 50% at top load buses and 50% at top renewable buses per Local Resource Zone
- Distributed on a load ratio share and renewable ratio share, respectively

Limitations of Methodology Identified

- Methodology did not capture all potential benefits of energy storage
- Potential for greater geographic diversity within a Local Resource Zone

Updated MTEP19 Methodology*

- Site energy storage at top load bus per PowerBase area, considering load at bus
  - Top load bus captures multiple potential benefits
  - Adds additional geographic diversity
- Distribute capacity on a load ratio share

Electric Vehicles

**Additional details on updated methodology included in Siting Workshop #3 materials: https://www.misoenergy.org/events/mtep19-siting-workshop---march-22-2018/*

MTEP18 Methodology

- Demand and energy forecast adjusted for each PowerBase area across study period
- Electric vehicle (EV) load growth distributed across footprint on a load ratio share
- Assume 80% off-peak, 20% on-peak charging

Limitations of Methodology Identified

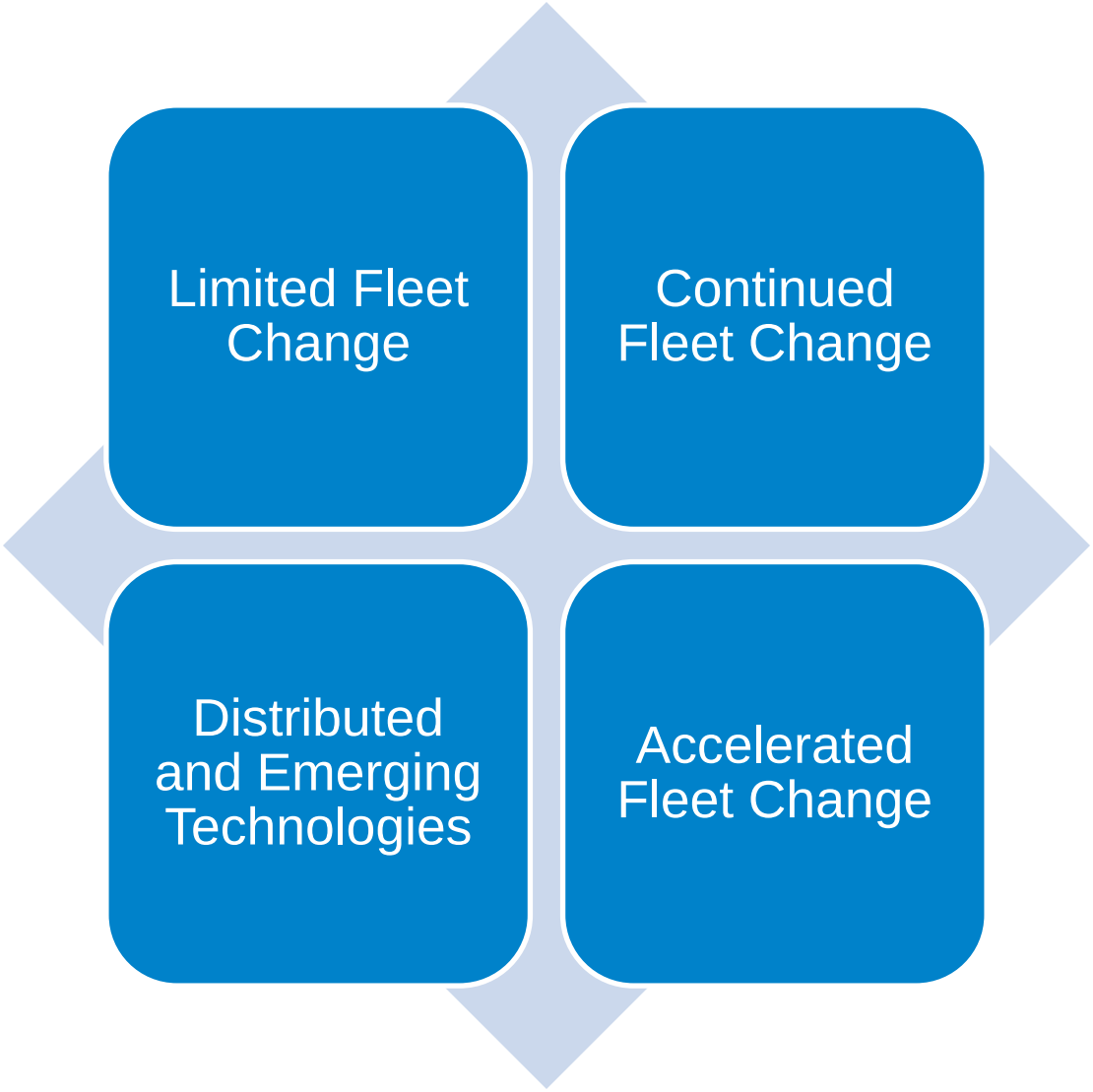
- Did not account for factors driving differences in adoption rates across footprint
  - Socioeconomics
  - Charging station availability
  - State and utility policies and incentives

Updated MTEP19 Methodology*

- Use indicators of EV potential to rank PowerBase areas
  - Urban population, median income, load factor, local incentives, charging infrastructure
- Create tiers to account for different adoption patterns over time
- Distribute load growth on an index of median income and urban population ratio share

MTEP19 Futures Definitions and Assumptions

MTEP19 Futures



Limited Fleet Change

Existing generation fleet remains relatively static without significant drivers of change. Some coal fleet reductions are expected as units reach the end of useful life. Renewable additions are driven primarily by current Renewable Portfolio Standards under low demand & energy growth rates.

- *Footprint wide, demand & energy growth rates are low; however, as a result of low natural gas prices, industrial production along the Gulf Coast increases.*
- *Natural gas prices are low due to increased well productivity and supply chain efficiencies along with low demand & energy.*
- *Low demand & energy and natural gas prices reduce the demand for and economic viability of new generation technologies.*
- *Thermal generation retirements are driven by unit useful life limits. Nuclear units are assumed to have license renewals granted and remain online.*
- *Lower levels of demand-side management programs are assumed due to low demand & energy.*

Continued Fleet Change

The fleet evolution trends of the past decade continue. Coal retirements reflect historical retirement levels based on average age of retirement. Renewable additions continue to exceed current Renewable Portfolio Standard Requirements as a result of economics, public appeal, and the potential for future policy changes. Natural gas reliance increases as a result of new capacity needed to replace retired coal capacity.

- *Demand and energy growth rates are modeled at a level equivalent to a 50/50 forecast.*
- *Natural gas prices are consistent with industry long-term reference forecasts.*
- *Renewable additions continue along current trends. Wind & solar serve 20% of MISO energy by 2033.*
- *Maturity cost curves for renewable resources reflect some advancement in technology and supply chain efficiencies.*
- *Oil and gas generators retired at the useful life limit age. Coal units will be retired reflecting age and historical retirement trends beyond age limits. Nuclear units are assumed to have license renewals granted and remain online.*
- *Demand-side management programs modeled to reflect growth and technical potential of current programs.*

Accelerated Fleet Change

A robust economy with increased demand & energy drives higher natural gas prices. Carbon regulations targeting a 20% reduction from current levels are enacted in response to increased demand & energy, driving coal to both retirement and decreased production. Increased renewable additions are driven beyond Renewable Portfolio Standards by need for new generation, technological advancement, and carbon regulation. Natural gas reliance increases as a result of new capacity needs driven by the need to replace retired capacity and provide flexibility to support the integration of intermittent renewable resources.

- *Demand & energy grows at a high rate due to a robust economy; however, as a result of high natural gas prices, industrial production along the Gulf Coast decreases.*
- *Natural gas prices are high due to increased demand.*
- *Retirements, economics, and potential regulations drive renewable additions. Maturity cost curves for renewable technologies applied reflecting advancement in technologies.*
- *Oil and gas generators will be retired in the year the age limit is reached. Coal units will be retired reflecting age and economics. Nuclear units are assumed to have license renewals granted and remain online.*
- *A 20% carbon reduction for current levels is modeled to reflect future national or state-level carbon regulation.*
- *High demand & energy levels and carbon regulation drive greater potential for demand-side management programs.*

Distributed and Emerging Technologies

Fleet evolution trends continue, primarily driven by local policies and emerging technology adoption. State level policies reflect desires for local reliability and optionality. Mid-level coal retirements reflect economics and age limits. Increased renewable additions are driven by favorable economics resulting from technological advancements and state-level Renewable Portfolio Standards and goals with targeted increases in distributed solar. Natural gas reliance increases as a result of new capacity needs driven by load growth from electric vehicles, the need to replace retired capacity, and the need to provide flexibility to support the integration of intermittent renewable resources.

- *Demand and energy forecast begins at level equivalent to a 50/50 forecast and has high growth rate to reflect adoption of electric vehicle technology on a broader scale. Energy grows faster than demand reflecting smart charging.*
- *Natural gas prices are consistent with industry long-term reference forecasts.*
- *Generation siting shows a strong preference for localized energy and capacity self-sufficiency within state jurisdictions.*
- *Maturity cost curves for renewable technologies applied reflecting advancement in technologies and supply-chain efficiencies. Renewable additions reach 25% of MISO energy by 2033, the increase from 20% as defined in Continued Fleet Change future comes primarily from solar.*
- *Increased deployment of energy storage devices is driven by economies of scale resulting from commercial mass production of lithium ion batteries and other viable technologies.*
- *Oil and gas generators will be retired in the year the age limit is reached. Coal units will be retired reflecting age and economics. Nuclear units are assumed to retire when current licenses expire unless there has been a recent significant investment.*
- *Demand-side management programs grow in scale and scope due to technological advancement and load growth.*

MTEP19 Futures Matrix

Future	Uncertainties																		
	Maturity Cost Curve		Demand and Energy					Fuel Cost (Starting Price)			Fuel Escalations			Emission Costs			Other Variables		
	Wind Onshore	Photovoltaic	Demand Response Level	Energy Efficiency Level	Demand Growth Rate	Energy Growth Rate	Natural Gas Forecast	Oil	Coal	Uranium	Oil	Coal	Uranium	SO_2	NO_x	CO_2	Inflation	Retirements	Renewable Portfolio Standards
Limited Fleet Change	H	H	L	L	L	L	L	M	L	M	M	M	M	-	M	-	M	L	L
Continued Fleet Change	M	M	M	M	M	M	M	M	M	M	M	M	M	-	M	-	M	M	M
Distributed and Emerging	M	L	M	M	M^{+}	H^{+}	M	M	M	M	M	M	M	-	M	-	M	M	M^{+}
Accelerated Fleet Change	L	L	H	H	H	H	H	M	M	M	M	M	M	-	M	H	M	H	H

MTEP19 Uncertainty Variables

MTEP19 UNCERTAINTY VARIABLES				
Uncertainty	**Unit**	**Low (L)**	**Mid (M)**	**High (H)**
New Generation Capital Costs[1]				
Coal	($/KW)		**3,674**	
CC	($/KW)		**1,048**	
CT	($/KW)		**899**	
Nuclear	($/KW)		**5,609**	
Wind-Onshore[1]	($/KW)		**1,505**	
IGCC	($/KW)		**3,941**	
IGCC w/ CCS	($/KW)		**5,092**	
CC w/ CCS	($/KW)		**2,179**	
Pumped Storage Hydro	($/KW)		**5,458**	
Battery Storage (Lithium Ion)[1,4]	($/KW)		**1,542**	
Compressed Air Energy Storage	($/KW)		**1,313**	
$Photovoltaic_{AC}$[1]	($/KW)		**1,419**	
Biomass	($/KW)		**3,860**	
Conventional Hydro	($/KW)		**3,830**	

[1] *All costs are overnight construction costs in 2018 dollars; sourced from NREL Annual Technology Baseline 2017; MTEP19 varies cost maturity over time versus having high and low starting points at the front of the study period.*

[2] *Mid values for years 1 - 10 of demand growth are derived from Module-E; Years 11-20 are extrapolated; H & L values are derived using updated demand growth assumption*

[3] *Energy values are calculated using Module E, the corresponding demand forecast and historical load factors. Add .5% EV growth for DET future*

[4] *Lazard used for Li Ion battery costs*

MTEP19 Uncertainty Variables, cont.

MTEP19 UNCERTAINTY VARIABLES				
Uncertainty	**Unit**	**Low (L)**	**Mid (M)**	**High (H)**
Demand and Energy				
Baseline 20-Year Demand Growth Rate[2]	%	0.0%	0.29% (.41% in DET)	0.59%
Baseline 20-Year Energy Growth Rate[3]	%	0.0%	0.43%	0.85% (0.92% in DET)
Demand Response & Energy Efficiency Levels - EE trimmed by estimated Mandates & Goals	%	AEG Limited Fleet Change	CFC: AEG Reference Case (Mid Growth) DET: AEG Distributed and Emerging Technologies	AEG Accelerated Fleet Change
Natural Gas				
Natural Gas	($/MMBtu)	Forecast-30%	Combined NYMEX, EIA, and Wood Mackenzie	Forecast +30%
Fuel Prices (Starting Values)				
Oil	($/MMBtu)		Powerbase default	
Coal	($/MMBtu)	Powerbase default -3%	Powerbase default	
Uranium	($/MMBtu)		Powerbase default	

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MTEP19 Uncertainty Variables, cont.

MTEP19 UNCERTAINTY VARIABLES				
Uncertainty	**Unit**	**Low (L)**	**Mid (M)**	**High (H)**
Fuel Prices (Escalation Rates)				
Oil	%		2.5%	
Coal	%		2.5%	
Uranium	%		2.5%	
Emissions Costs/Constraints				
NO_x	($/ton)		Annual $155 Seasonal $300	
CO_2	(Tons)			20% by 2030
Other Variables				
Inflation	%		2.5	
Retirements	MW	Age-related oil/gas (55 years) & coal (65 years)	Age-related oil/gas (55 years) & coal (60 years), nuclear in DET	Age-related oil/gas (55 years) & coal (60 years, reduced operation)
Renewable Energy Level	%	15%	20% energy from wind and solar (25% in DET, emphasis on solar	35% energy from wind and solar
Cost Maturity Curves	%	More aggressive than NREL ATB, achieving -30% by 2033	Based on NREL ATB	Less aggressive than NREL ATB, achieving +30% by 2033

[1] All costs are overnight construction costs in 2018 dollars; sourced from NREL Annual Technology Baseline 2017; MTEP19 varies cost maturity over time versus having high and low starting points at the front of the study period.

[2] Mid values for years 1 - 10 of demand growth are derived from Module-E; Years 11-20 are extrapolated; H & L values are derived using updated demand growth assumption

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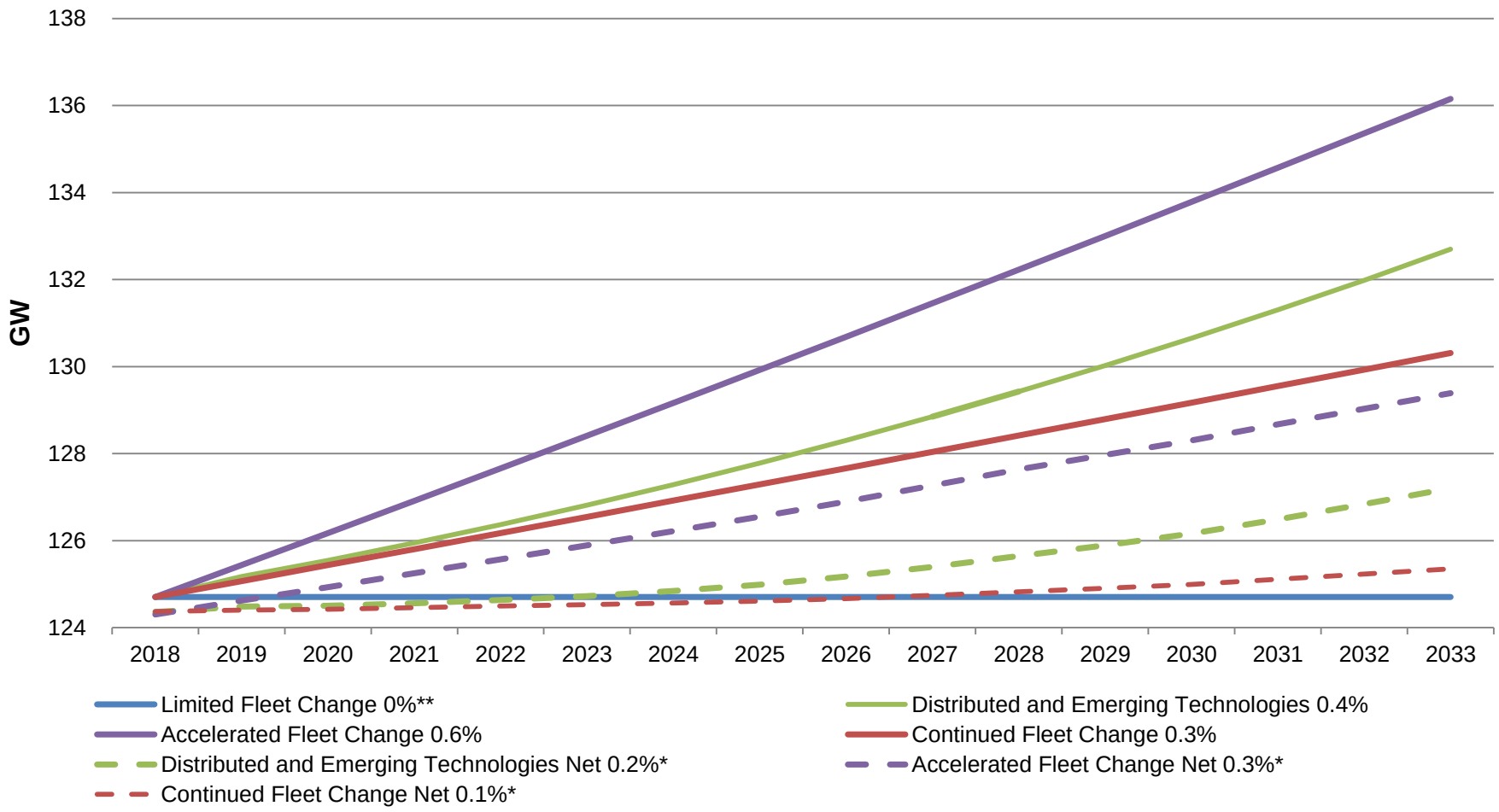
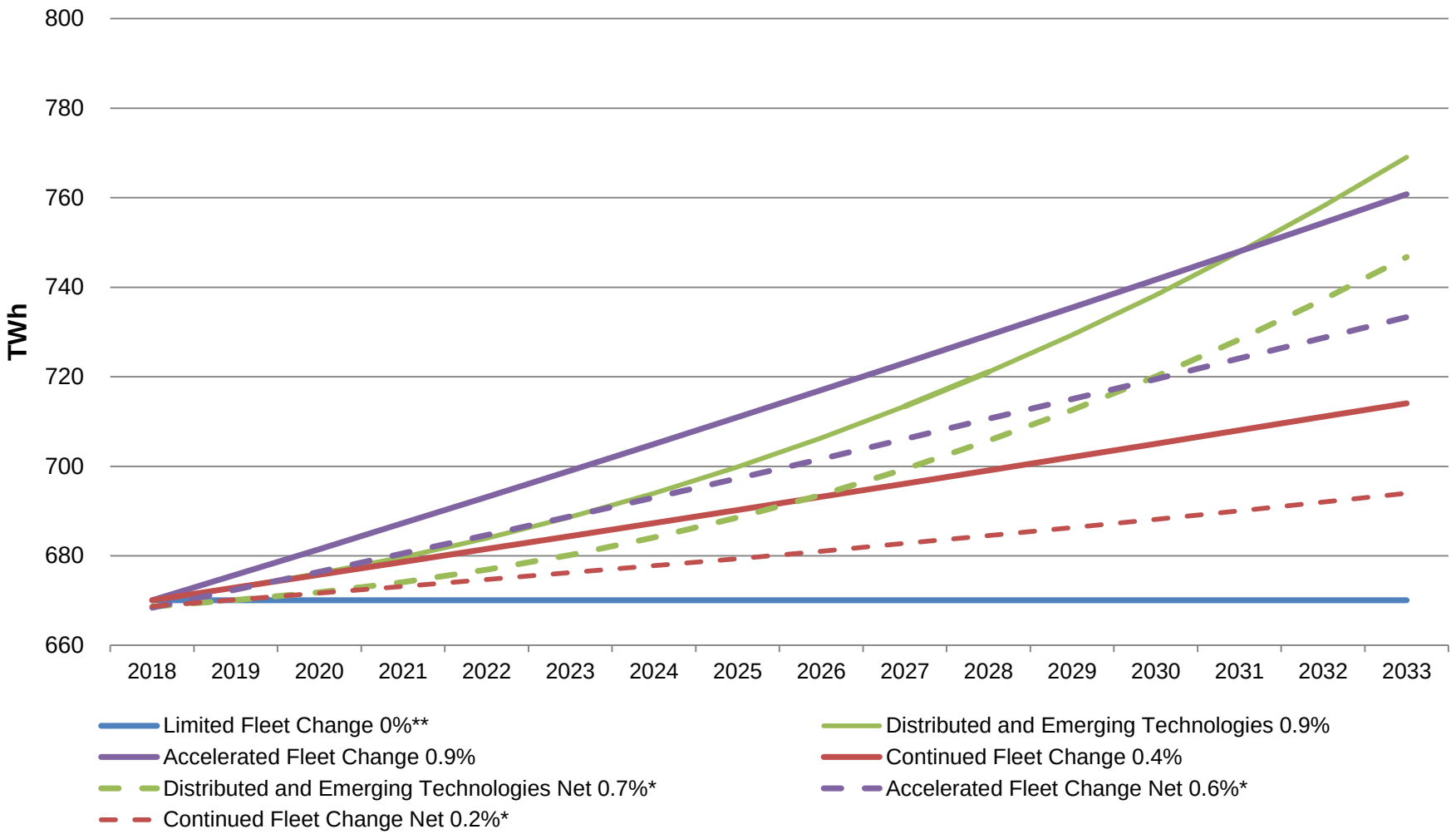
MTEP19 Gross and Net Peak Demand Forecasts*



* *Net Forecasts* are the *Gross Forecasts* less economically selected energy efficiency programs

** No energy efficiency programs selected in low scenarios

MTEP19 Gross and Net Energy Forecasts



* *Net Forecasts* are the *Gross Forecasts* less economically selected energy efficiency programs

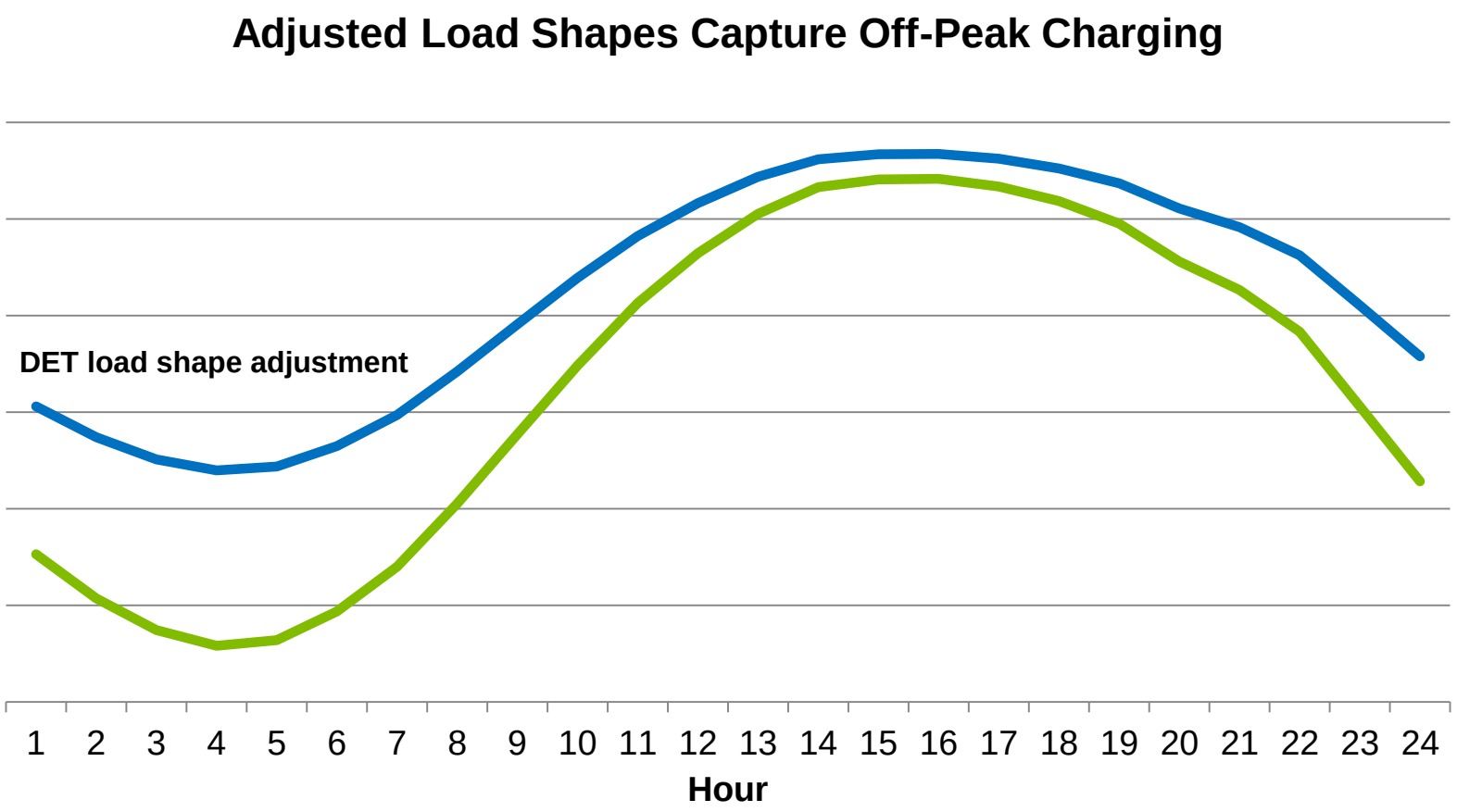
** No energy efficiency programs selected in low scenarios

Regional variations modeled within MTEP demand and energy forecasts*

**All growth rates represent a 10-year compound annual growth rate, beginning in 2018.*

Electric vehicle load impacts modeling in Distributed & Emerging Technologies future

- Assume 80% off-peak, 20% on-peak charging



New Applied Energy Group demand-side management programs for MTEP19

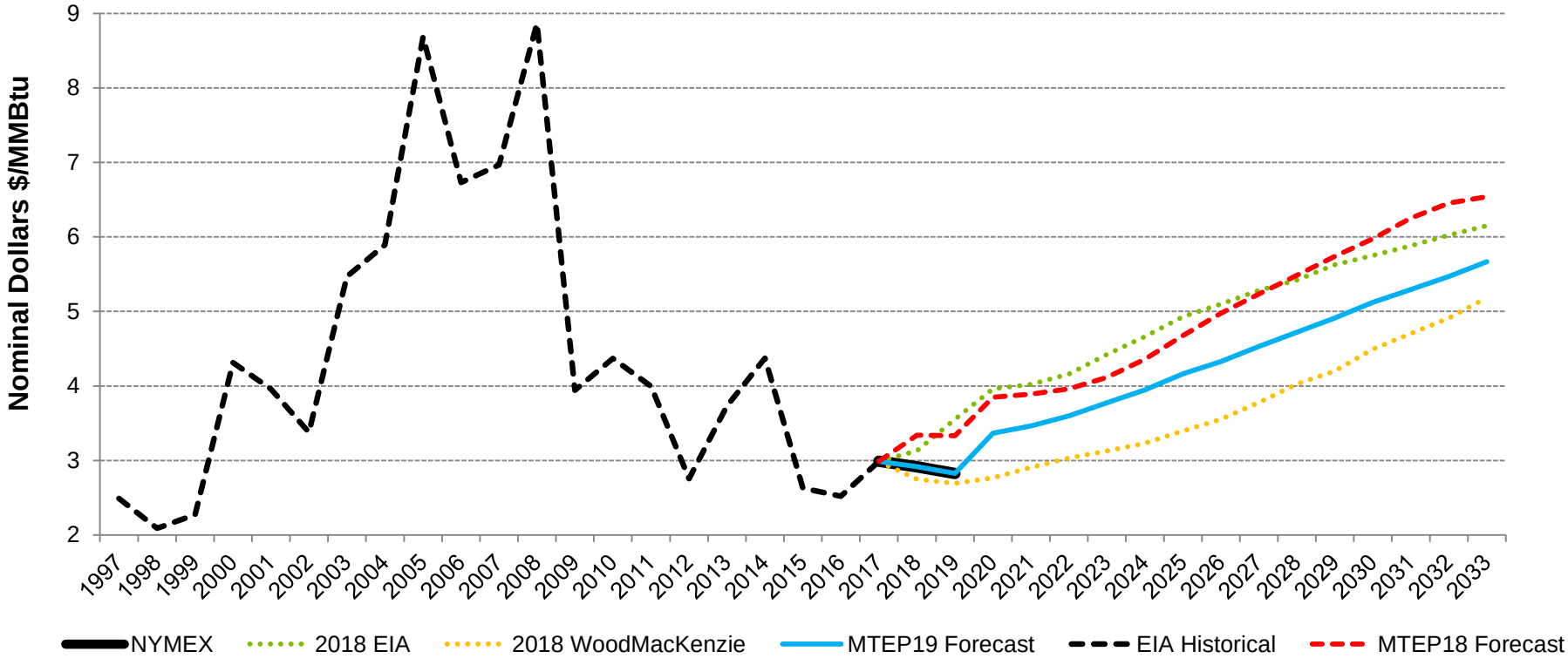
MTEP19 Programs		Limited Fleet Change		Continued Fleet Change		Accelerated Fleet Change		Distributed and Emerging Technologies	
		Capacity (GW)	Energy (GWh)	Capacity (GW)	Energy (GWh)	Capacity (GW)	Energy (GWh)	Capacity (GW)	Energy (GWh)
15 Year Technical Potential*	Demand Response (DR)	6.4	470	6.9	505	8.2	595	7.5	547
	Energy Efficiency (EE)	8.1	49,253	9.5	56,809	10.7	64,361	9.5	58,245
	Distributed Generation (DG)	1.9	3,774	2.2	4,308	2.4	4,773	6.0	9,435

State mandates & goals met in all MTEP19 futures, additional DR/EE/DG up to listed potential allowed to be economically selected.

Technical Potential represents the maximum feasible potential under each scenario. Existing DR not yet deducted from technical potential. Only economically viable programs will be implemented in the MTEP19 models (each program will be offered against supply-side alternatives). AEG discussed at March 22, 2018 workshop: https://www.misoenergy.org/events/mtep19-siting-workshop-2---january-18-2018222/

* *Existing DR programs will be modeled as base assumptions*

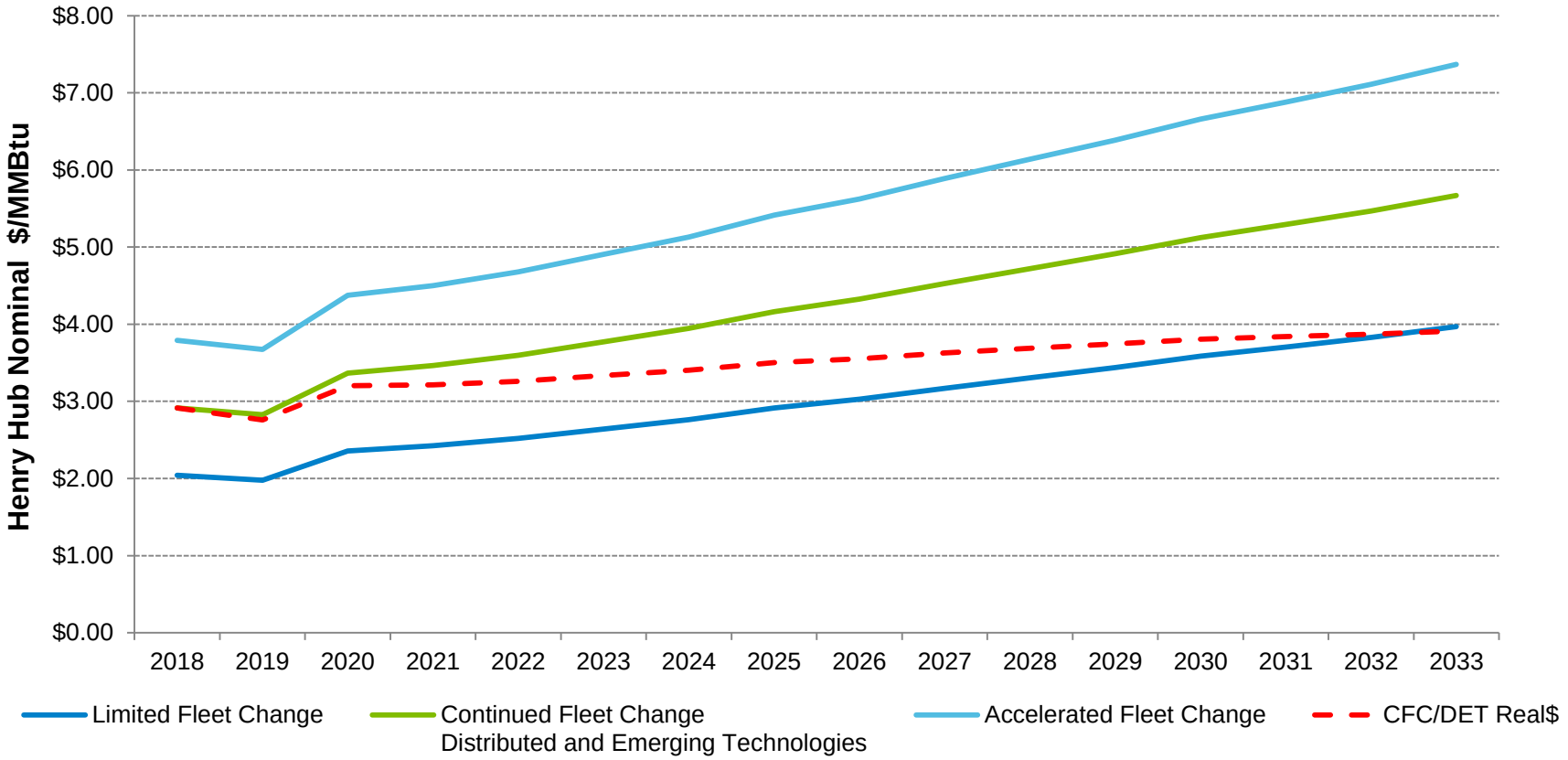
MTEP19 Natural Gas Price Forecast
(Annual Average Values Henry Hub in Nominal 2018 $)



Using the same methodology as MTEP18 with updated data, NYMEX was used for the first two years and an average of the EIA and Wood Mackenzie forecasts for the out years.

Source: EIA Annual Energy Outlook 2018; Wood Mackenzie North America Power & Renewables Long-Term Outlook 2017, NYMEX, retrieved from SNL

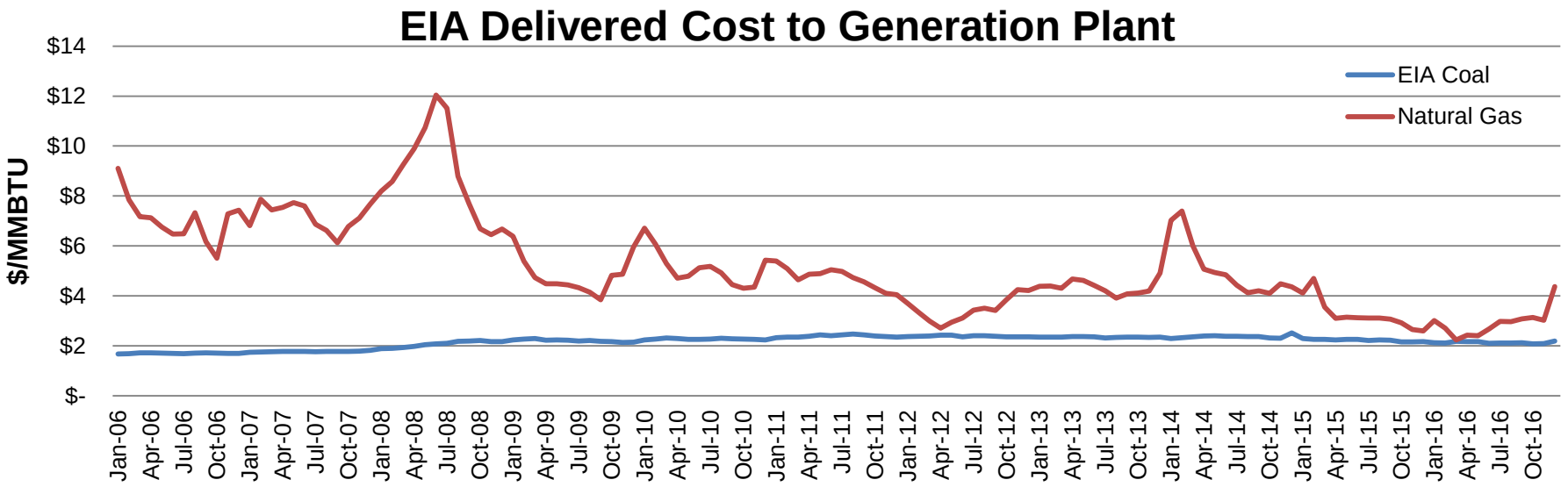
MTEP19 Fuel Forecast Bands
(Annual Average Values Henry Hub in Nominal 2018 $)



Source: EIA Annual Energy Outlook 2018; Wood Mackenzie North America Power & Renewables Long-Term Outlook 2017, NYMEX, retrieved from SNL

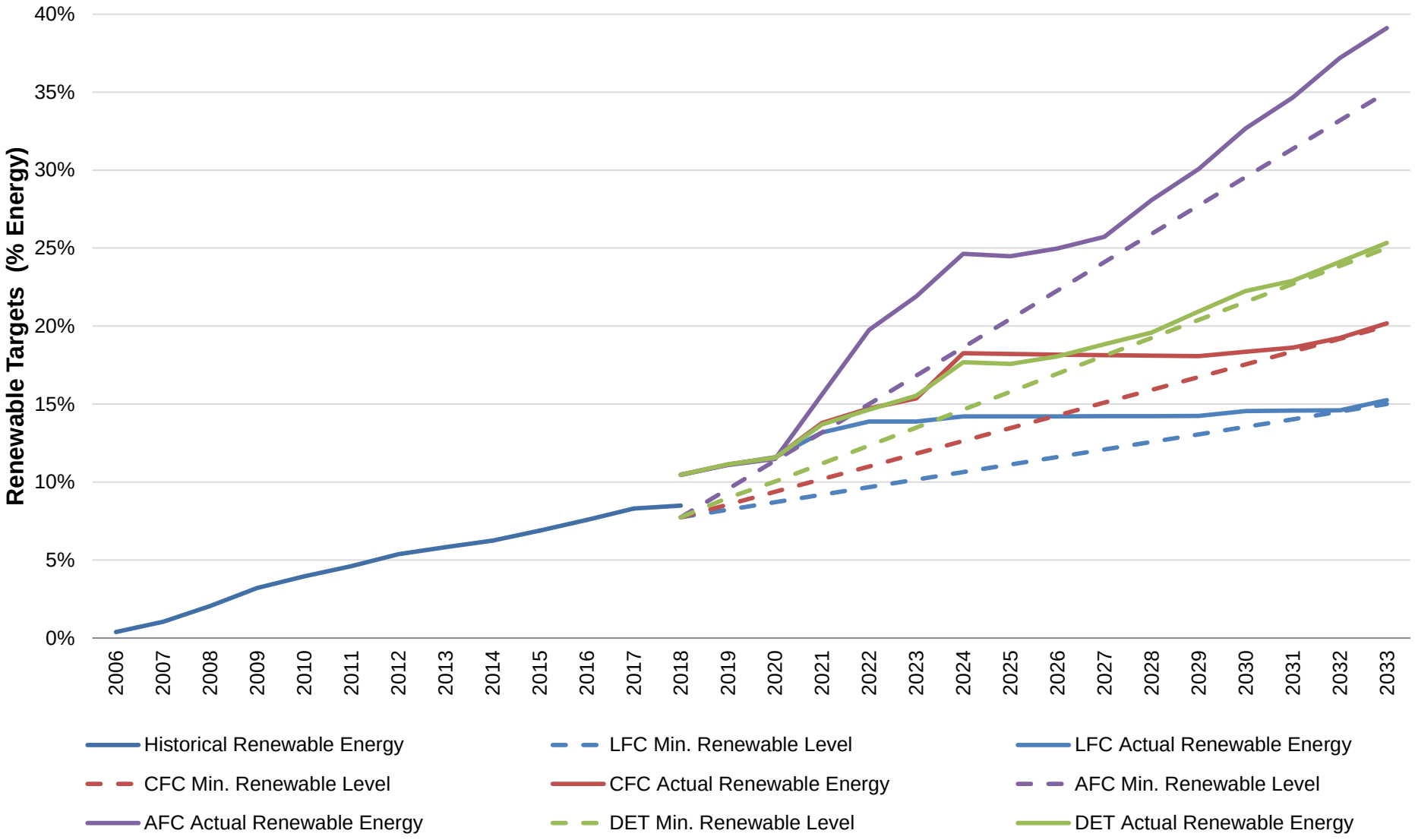
Modeling of lower coal prices with lower gas prices in LFC future continued from MTEP18

- Delivered coal prices stable compared to natural gas
  - Limited low gas & coal price correlation will be captured
  - Per EIA, about 10-1: 30% drop in natural gas prices = 3% drop in coal prices
  - No correlation for gas/coal price increases



Sources: http://www.eia.gov/outlooks/steo/query/
https://www.eia.gov/analysis/studies/fuelelasticities/pdf/eia-fuelelasticities.pdf

Minimum renewable energy levels and results by future

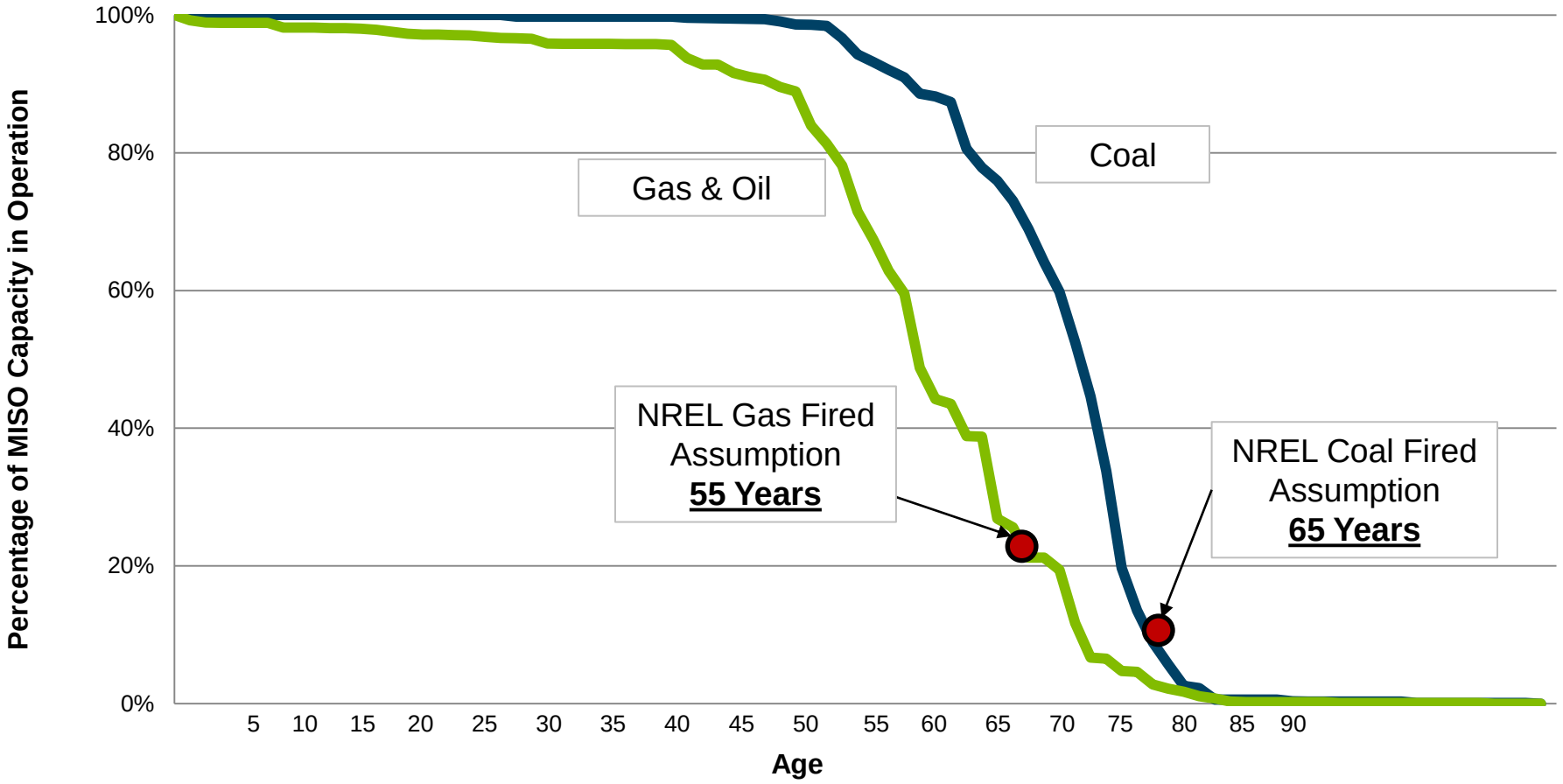


PTC/ITC modeling drives renewable additions forward in time

MTEP19 Retirement Methodology

- Thermal unit age-related retirements occur in the year the useful life is reached unless planned retirement is sooner
  - Oil & gas units retire at 55 years of age in all futures
  - Coal retires at 65 years of age in the Limited Fleet Change future
  - In the Continued Fleet Change, Accelerated Fleet Change and Distributed and Emerging Technologies futures, coal retires at 60 years of age reflecting historical trends
  - The Accelerated Fleet Change future had units cycle seasonally to better meet CO_2 reduction targets without steeper retirement levels
- Nuclear units assumed to have license renewals granted and remain online, except in the Distributed and Emerging Technology future - unless significant upgrade or maintenance (>$500M)
- Publically announced retirements supported by approved attachment Y or officially committed retirements (e.g. IRP) that are submitted to MISO included

Retirement age assumption based on historical analysis of MISO generation fleet

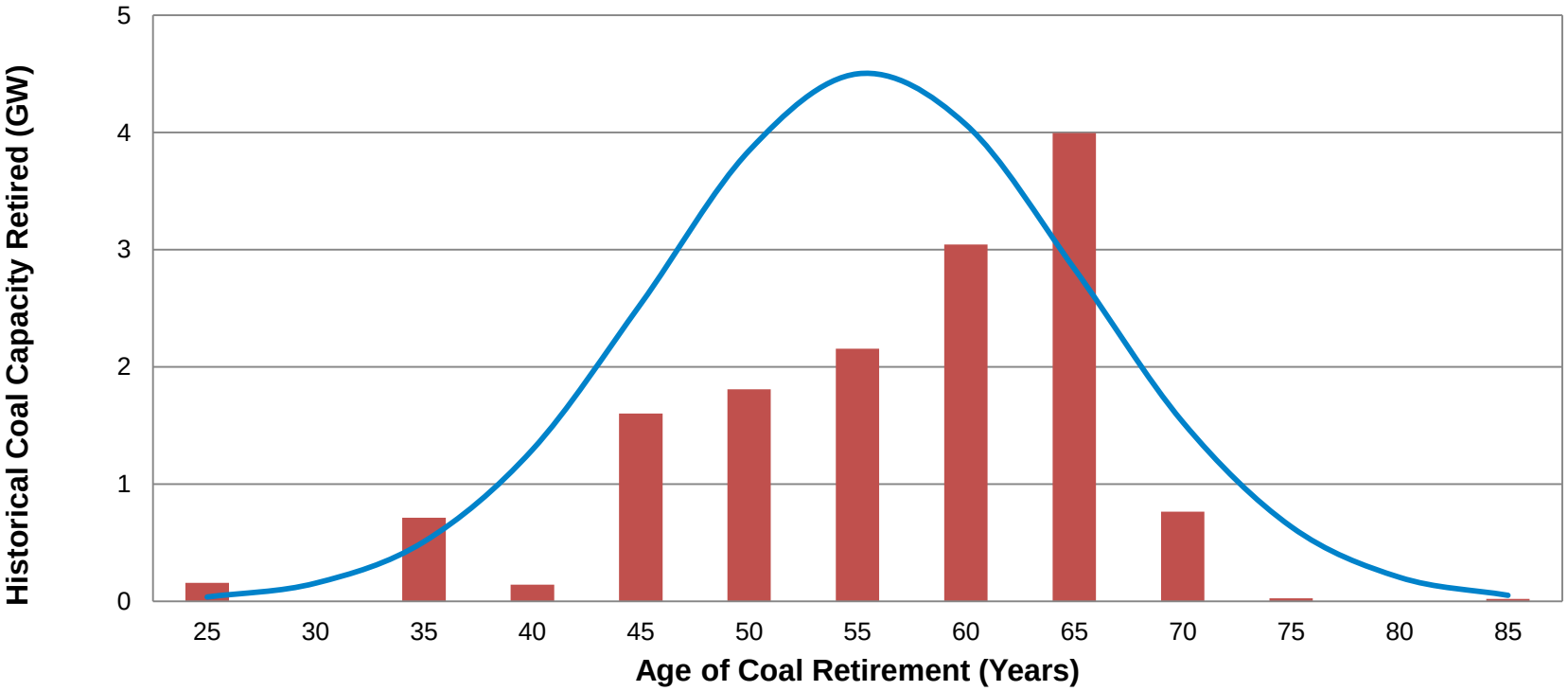


MISO assumes all non-coal fossil units retire by 55 years and coal units by 65 years, at the latest, based on historical analysis with support from NREL analysis.

NREL age-related assumptions: http://www.nrel.gov/analysis/reeds/pdfs/reeds_documentation.pdf (*Page 24)*

Mid-level coal retirements based on recent retirement trends

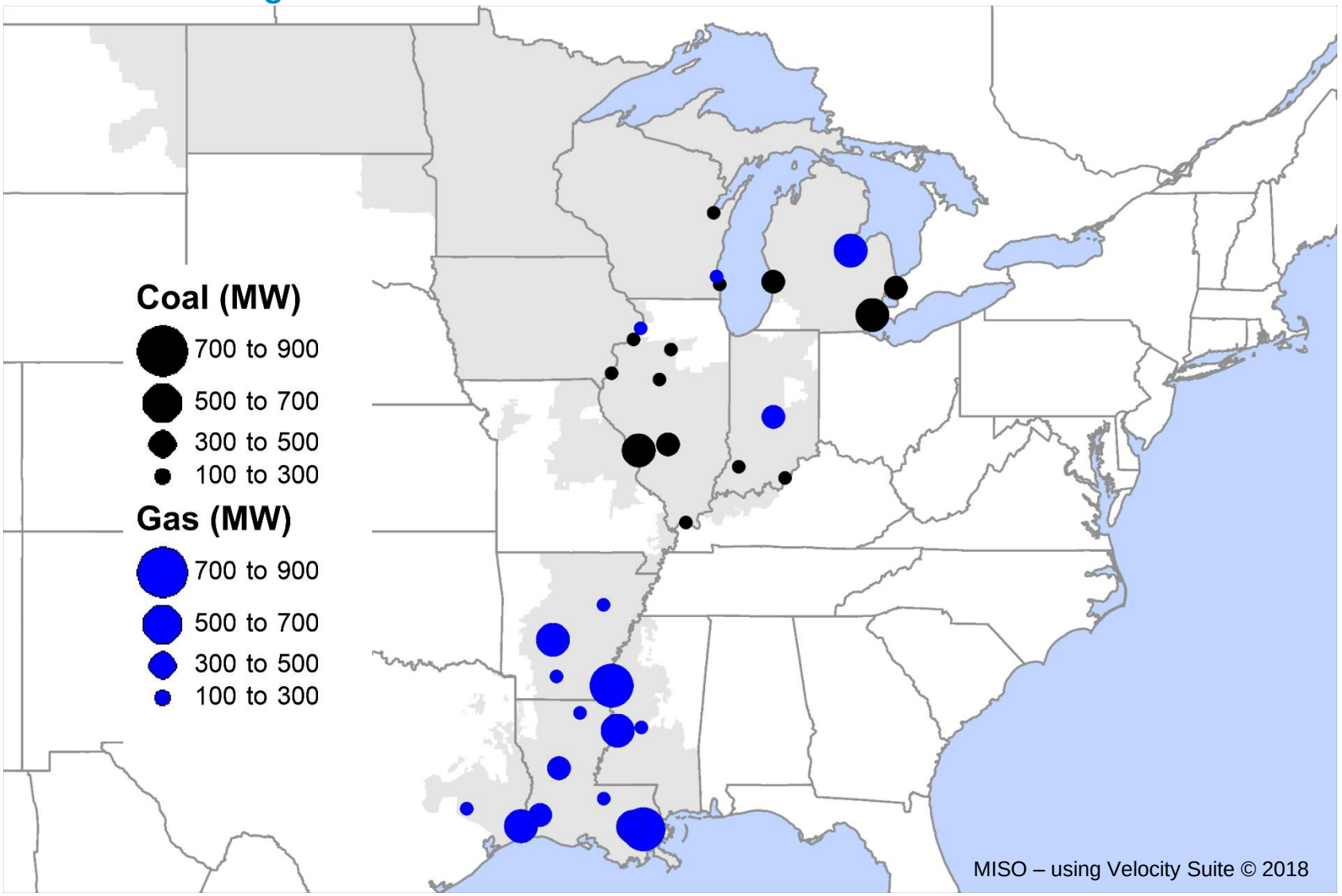
- 91% of MISO's retired coal capacity did not achieve its assumed 65 year useful life; 48% retired prior to age 60.
- Common trend is members are moving to a "balanced" fleet



As a mid-level coal retirement assumption, MISO will retire all units at 60 years of age

MISO Assumed Retirements

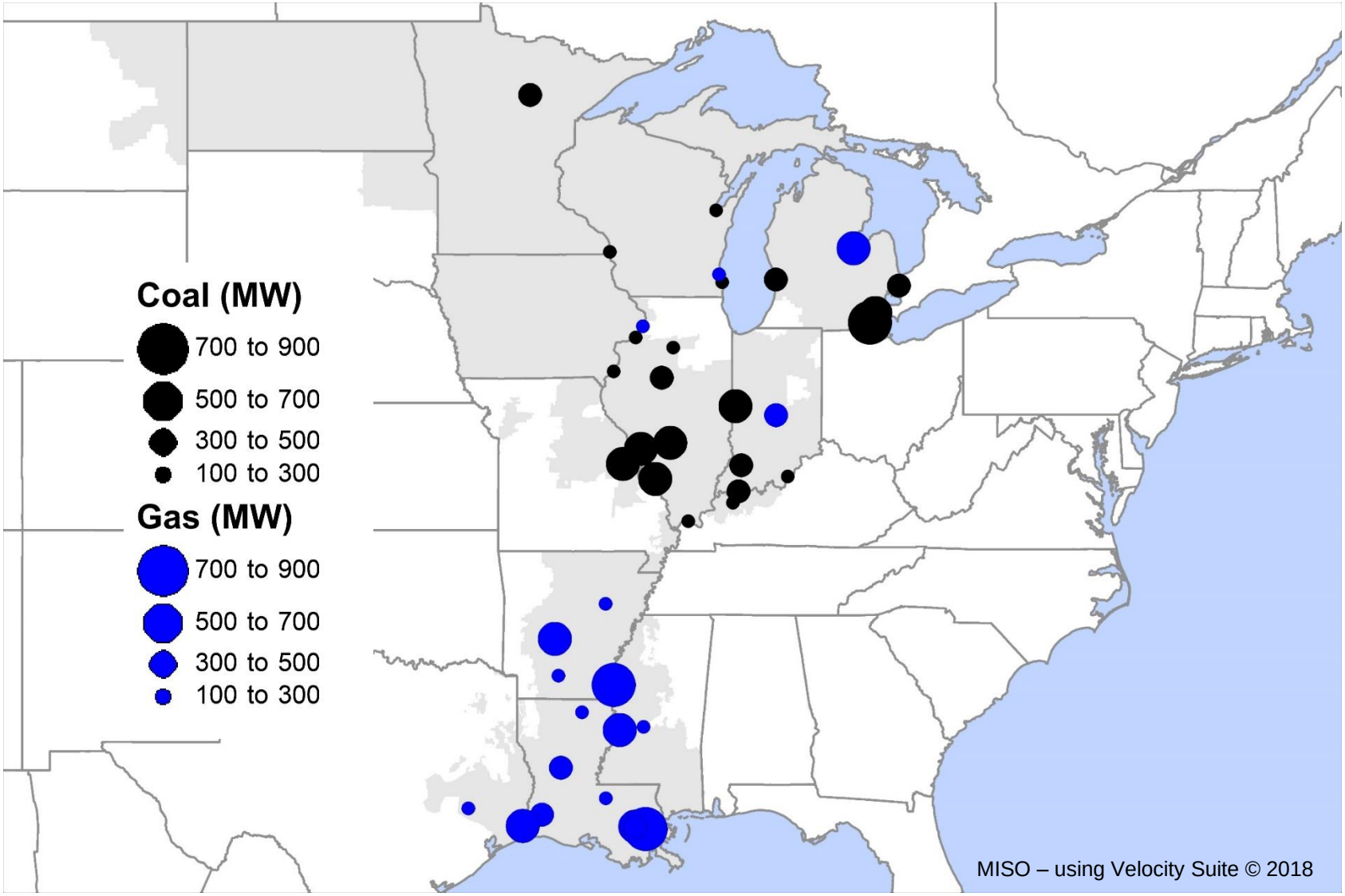
Limited Fleet Change



Map shows retirements >100 MW

MISO Assumed Retirements

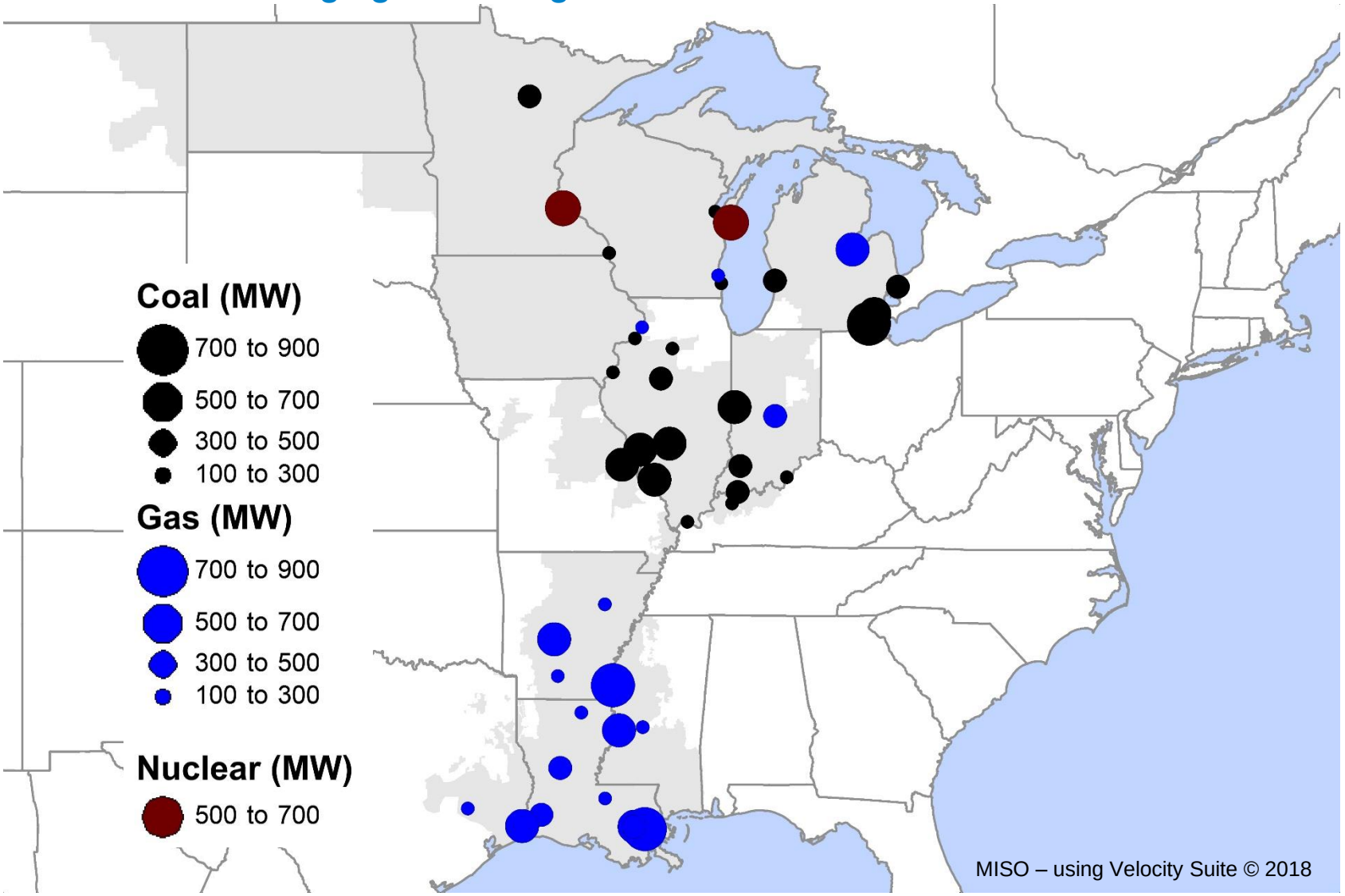
Continued & Accelerated Fleet Change



Map shows retirements >100 MW

MISO Assumed Retirements

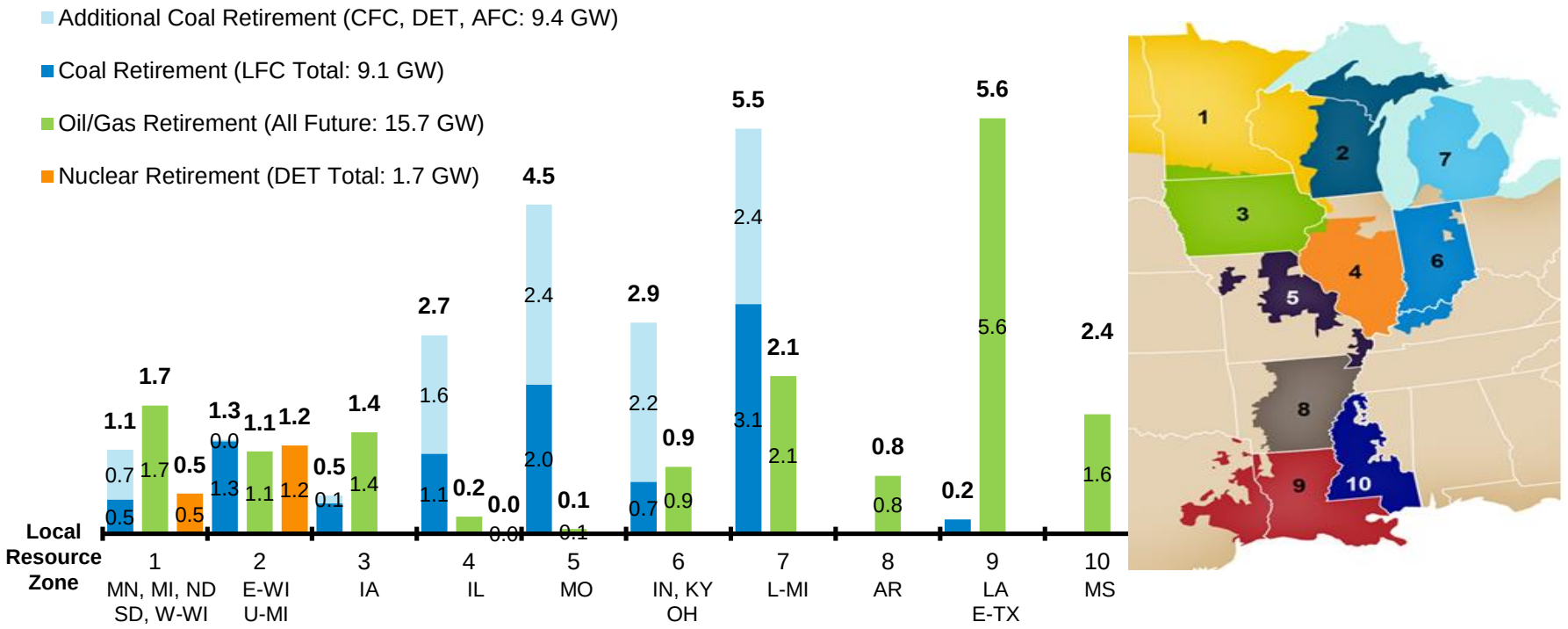
Distributed and Emerging Technologies



Map shows retirements >100 MW

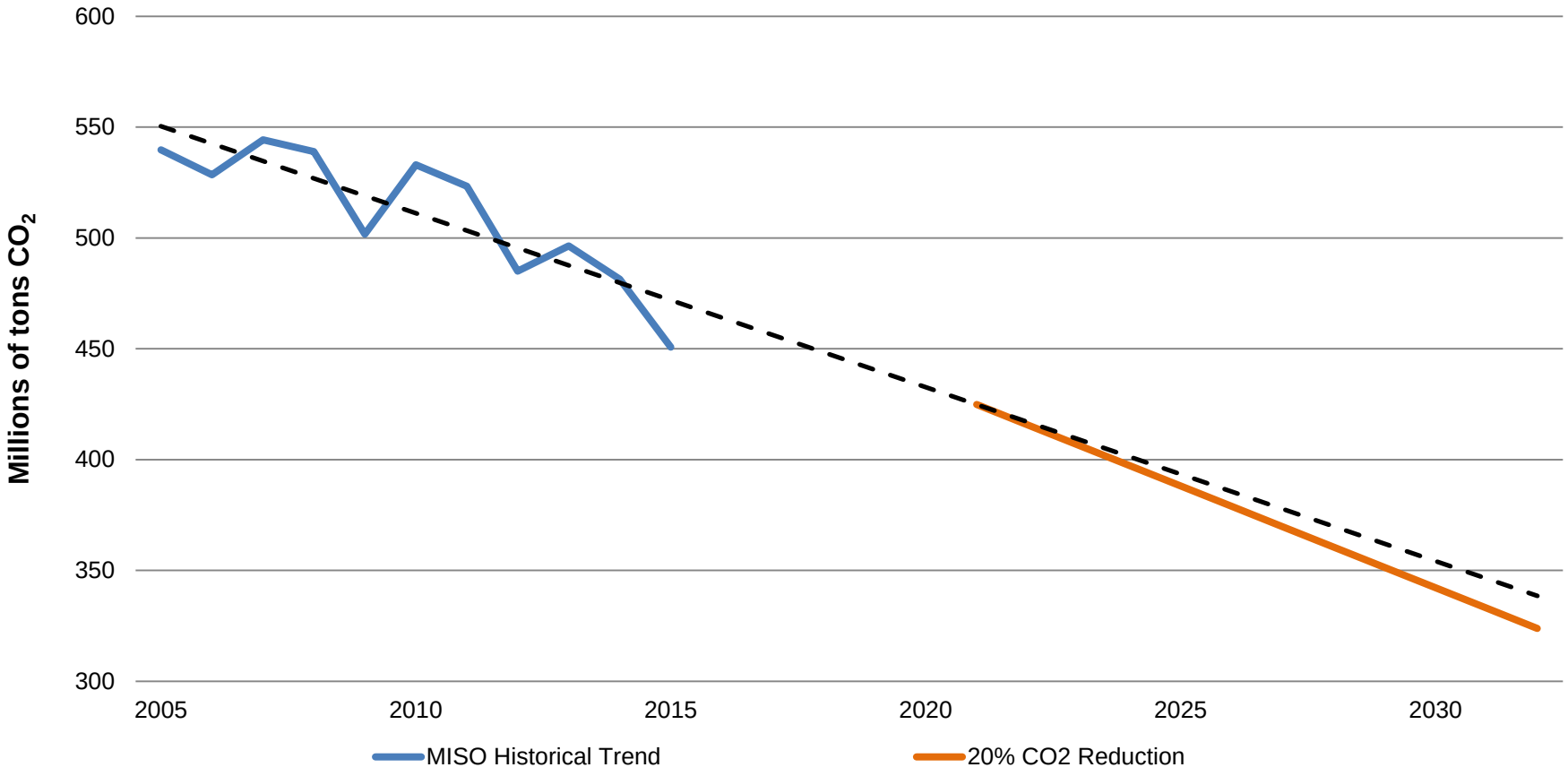
Assumed coal & natural gas/oil retirement capacity per Local Resource Zone by 2033

Age limits based on historical analysis*
Nuclear license expiration assumption used for DET



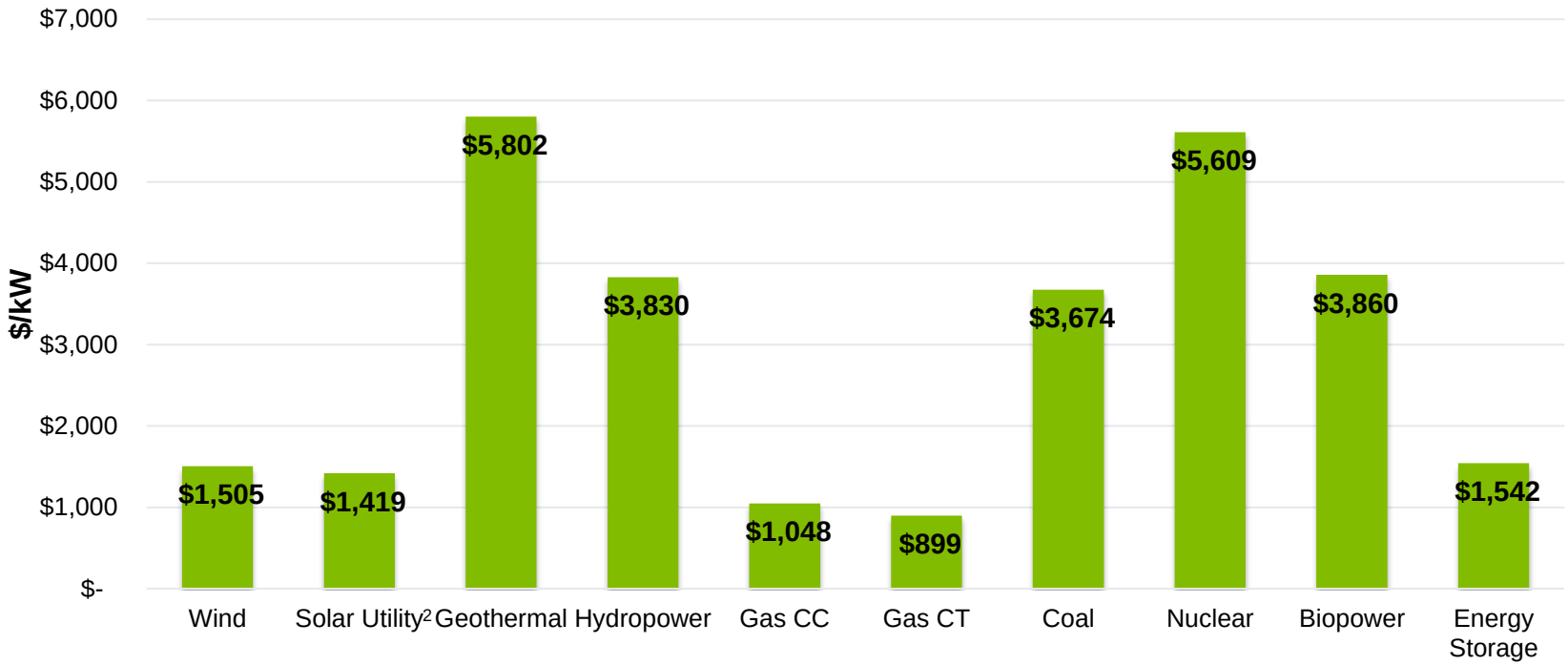
*Based on statistical analysis of historical MISO generation fleet with support from industry analysis (NREL)

CO_2 constraint applied only in Accelerated Fleet Change Future



A CO_2 constraint is applied in the Accelerated Fleet Change future targeting 20% emissions reductions by 2030 & continuing on into the future.

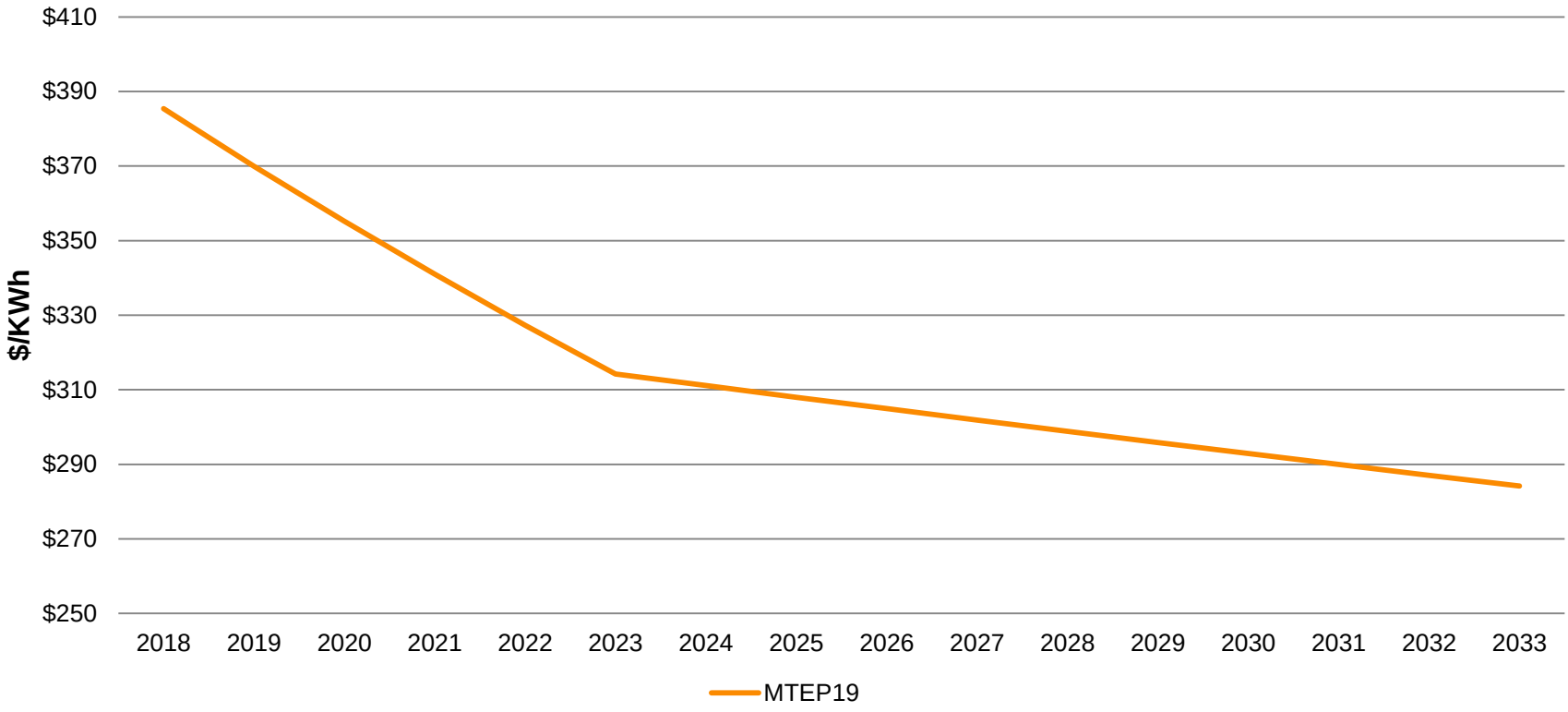
MTEP19 Capital Costs[1]
(Capital costs of unit technology types in 2018 $/kW)



[1]Capital costs from the NREL Annual Technology Baseline Report; Energy storage costs from Lazard Levelized Cost of Storage Report
[2]Solar values reflect a 20% adder for DC to AC conversion

Source: 2017 NREL ATB using updated inflation rate (1.42% actual) https://data.nrel.gov/files/71/2017-ATB-data.xlsm
Energy Storage Source: https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf

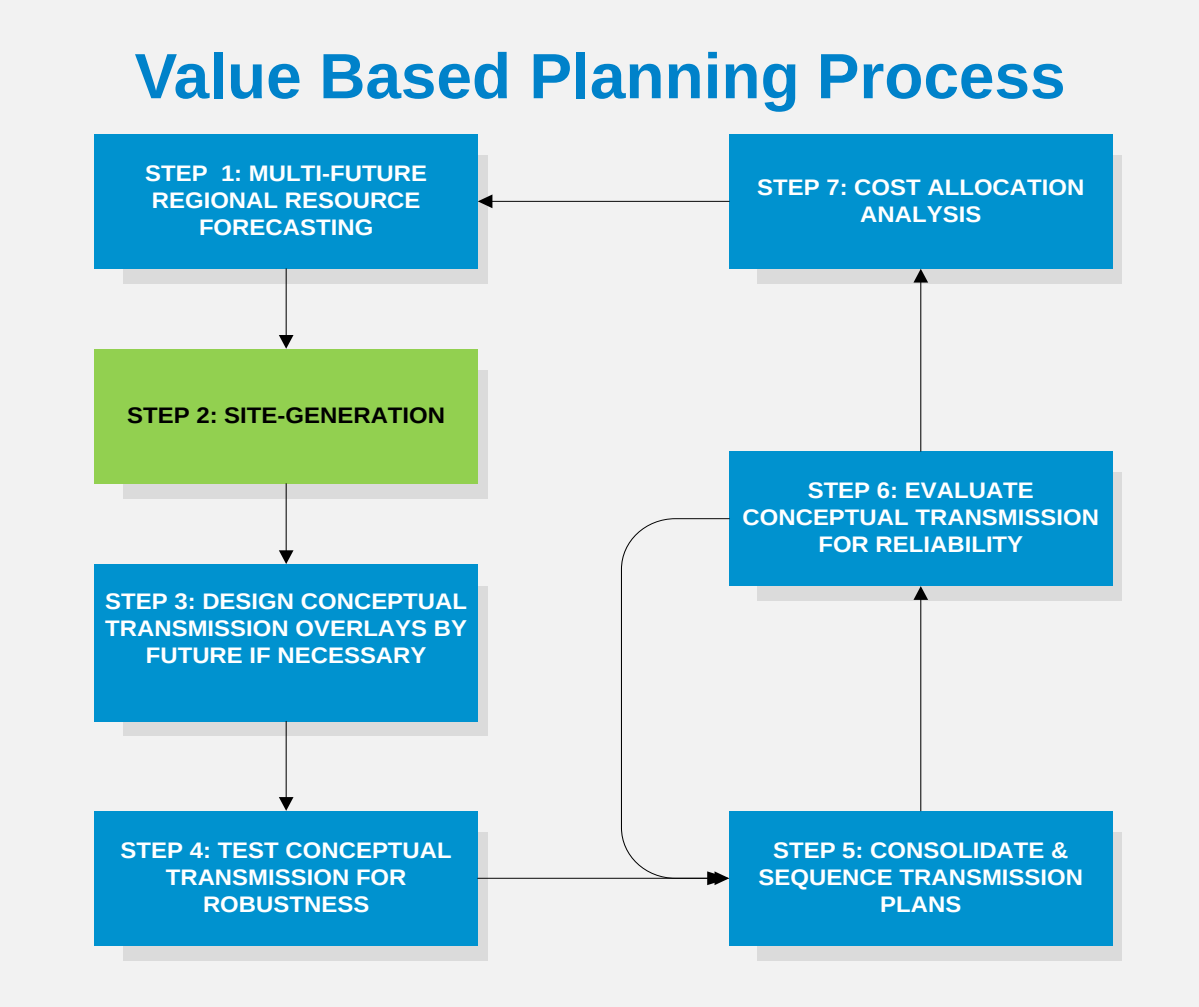
MTEP19 Storage (Li Ion) Capital Cost Maturity Curve



- Maturity curve based on LAZARD's Levelized Cost of Storage Report Version 2.0: *https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf*
- Technology assumes an average of Energy and Power – which results in 4% cost reduction for the first 5 years, followed by a 1% cost reduction thereon

MTEP19 Siting Methodology

Generation siting process is used to predict where future generation units would likely be located



General MTEP Siting Methodology

- Different siting process for different types of units – thermal, renewable, demand-side resources
- Siting process designed to reasonably predict proximal location of future units
  - Siting done at 230kV or higher voltage level where possible unless at retired site
- Siting process is unique for each future
- Stakeholder review is utilized to identify if a site is not a feasible location

Generation Unit Sizes for Siting

Unit Type	Size*
CC	600 MW/Matched to Site
CT	300 MW/Matched to Site
Solar	Matched to Site
Nuclear	1,200 MW
Wind	Matched to Site

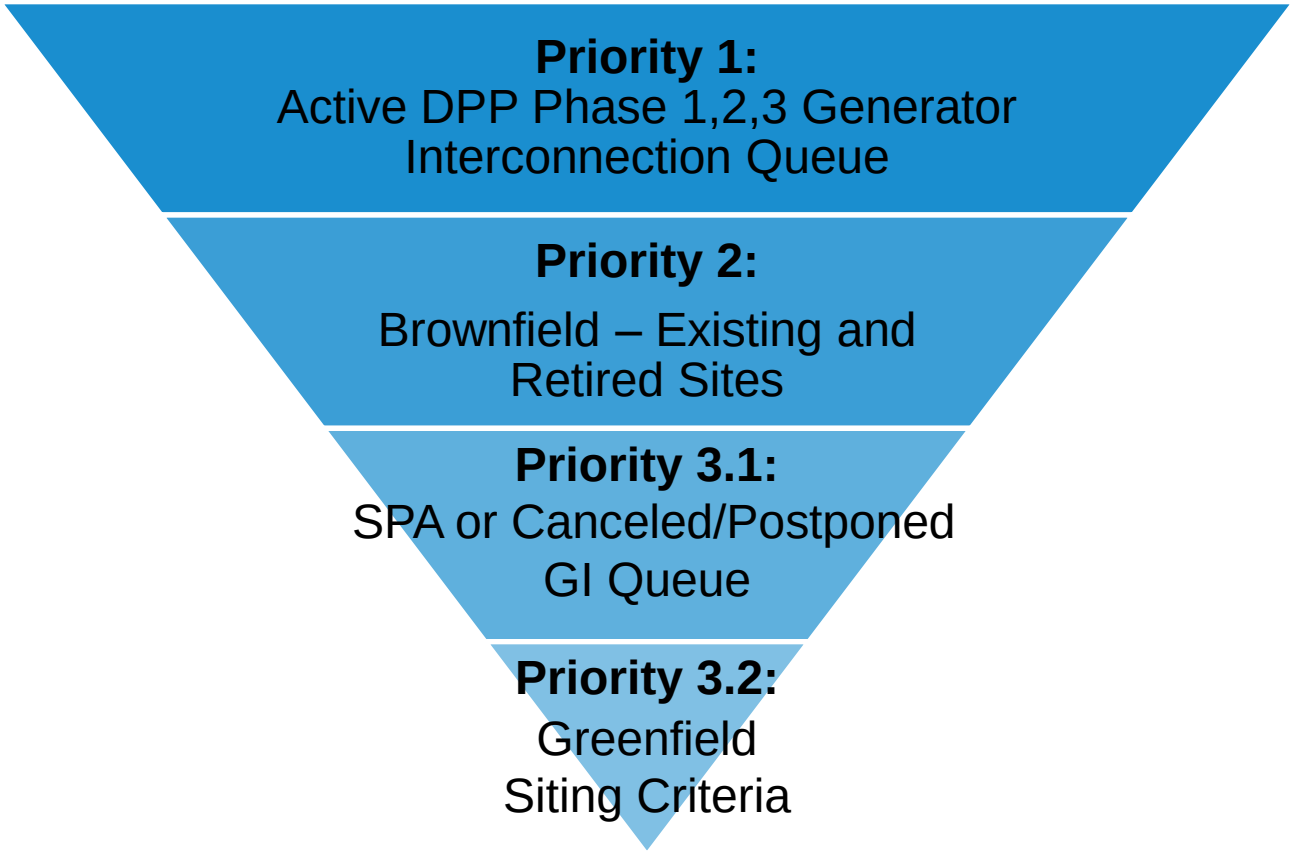
**Sizes based on typical size in GI Queue as well as stakeholder feedback*

- When possible, forecast units will match size of existing site or queued capacity
  - For simplicity, MISO will round up to nearest 100 MW
- Restrict total site capacity to 1,200 MW, unless justified

Thermal Generation Siting Methodology

(Coal, Gas, Oil, & Nuclear)

Thermal Siting Methodology



- Diversity in siting across futures encourages robust solution development
- Stakeholder review was used to identify if a site is not a feasible location

Brownfield Siting Guidelines

- Targeting newer sites that may be able to expand:
  - **CC**
    - Use 200MW+ sites built since 2000
  - **CT**
    - Use 100MW+ sites built since 1990
    - Prefer sites near urban areas
  - **Coal**
    - Only consider Existing/Planned sites 200 MW+
    - Only consider sites outside the 25 miles buffer of a major urban area
  - **Nuclear**
    - Expand an existing site twice – 1,200 MW intervals

Greenfield Siting Guidelines

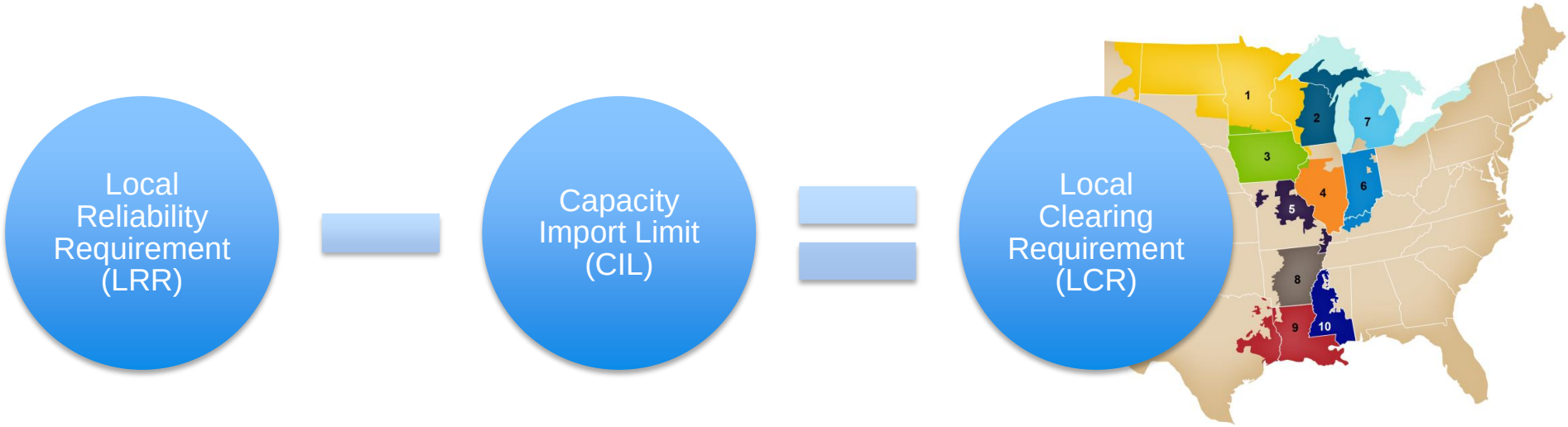
Fuel Type / Criteria	Railroad/Navigable Waterway	Class I Lands	Urban Area	Major River/ Lake	Gas Pipeline	Coal Mine/ Dock
Coal	Within 1 mile (Prefer multiple)	Outside 20 miles	Outside 25 miles	Within half a mile	Prefer Access	Within 20 miles
Biomass	Within 1 mile (Prefer multiple)	Outside 20 miles	Outside 25 miles	Within half a mile	Prefer Access	-
CC	-	Outside 20 miles	(Prefer near load)	Within 2 miles	Within 10 miles	-
CT	-	Outside 20 miles		-	Within 5 miles	-

National Ambient Air Quality Standards & Transmission Considerations

- New thermal generation will not be sited in latest identified NAAQS nonattainment areas (except lead)
  - Large coal retirement could be replaced by natural gas
- Where all things are equal, transmission and/or deliverability will be considered for sites
  - Consider the number of lines/ratings of a substation
  - Export congested areas and load pockets would be a lower priority

Zonal Resource Adequacy Requirements

- Siting in 5, 10, and 15[1] year cases will meet both Local Clearing Requirements and North/South transfer limits in each future
- Local Reliability Requirements (LRR) and Capacity Import Limits referenced from the latest LOLE Report[2]
- North/South transfer limit of 1,000 MW used in MTEP siting process



1. 15 year case will assume same Local Clearing Requirements as the 10 year case
2. 2017 Loss of Load Expectation Report, see https://www.misoenergy.org/Library/Repository/Study/LOLE/2017%20LOLE%20Study%20Report.pdf

Renewable Generation Siting Methodology
(Wind and Solar)

MTEP Wind Siting Tier Development

- Siting tiers are created based on combination of Vibrant Clean Energy (VCE) study results and MISO's Interconnection Queue data
- Capacity is sited in tiers based on priority
- Sites filled evenly within tier until total tier capacity filled

Tier 1**	Tier 2	Tier 3	Tier 4	Tier 5*	Tiers 6+
Remaining MVP-enabled capacity in RGOS Zones	VCE Zones 30% / ***Phase 3 and Phase 2 Queue Sites***	VCE Zones 30% / ***Phase 1 Queue Sites***	VCE Zones 30% / ***Pre-Queue and Withdrawn Queue Sites***	VCE Zones 50%	VCE Zones 90%

Existing Zones *Planned/likely areas for wind expansion* *Potential areas for future wind expansion*

- *VCE results (location, MW) are used as an indication of potential wind growth zones*
- *MISO will continue to monitor developing trends; should there be a shift in concentrations of wind developments, MISO will adjust zones/tiers accordingly*

* "50% VCE" refers to results from the 50% penetration case

** Multi-Value Project (MVP)-Enabled capacity, see https://www.misoenergy.org/Planning/TransmissionExpansionPlanning/Pages/MVPAnalysis.aspx

MTEP Utility-Scale Solar Siting Tier Development

- Siting tiers are created based on combination of Vibrant Clean Energy (VCE) study results and MISO's Interconnection Queue data
- Capacity is sited in tiers based on priority
- Sites filled evenly within tier until total tier capacity filled

Tier 1	Tier 2	Tier 3	Tier 4*	Tiers 5
VCE Zones 30% / ***Phase 3 and Phase 2 Queue Sites***	VCE Zones 30% / ***Phase 1 Queue Sites***	VCE Zones 30% / ***Pre-Queue and Withdrawn Queue Sites***	VCE Zones 50%	VCE Zones 90%

- *VCE results (location, MW) are used as an indication of potential solar growth zones*
- *MISO will continue to monitor developing trends; should there be a shift in concentrations of wind developments, MISO will adjust zones/tiers accordingly*

MISO will continue to update renewable zones in future MTEP cycles as needed based on new developments

- New developments include:
  - Queue activity
  - Emerging trends
  - Additional analysis
- In MTEP18 and MTEP19, wind sited in all LRZs in Distributed & Emerging Technologies future
- In each cycle, wind & solar siting tier priority is adjusted based on most recent Interconnection Queue data

Alternative Technologies Siting Methodology

	MTEP19 Siting Methodology	
MTEP 2019 Future	**Limited Fleet Change Continued Fleet Change Accelerated Fleet Change**	**Distributed & Emerging Technologies**
Distributed Solar[1]	1/3 of Solar Capacity Expansion: Distributed (Top 20 Load Buses per county identified by dGen)	2/3 of Solar Capacity Expansion: Distributed (Top 20 Load Buses per county identified by dGen)
Demand Response[1]	Residential: Top 10 Non-Industrial Load Buses per LBA Commercial & Industrial: Top 10 Industrial Load Buses per LBA	
Battery Storage[2]	Top load bus per LBA	

MISO requested stakeholder feedback on potential distributed siting buses at June PAC to incorporate in MTEP19

1. Bus level siting (magnitude and location) reviewed through MTEP19 process; sites commented as infeasible were replaced
2. 2 GW of battery storage by 2033 included in the Distributed & Emerging Technologies future; storage offered as a resource option in all futures

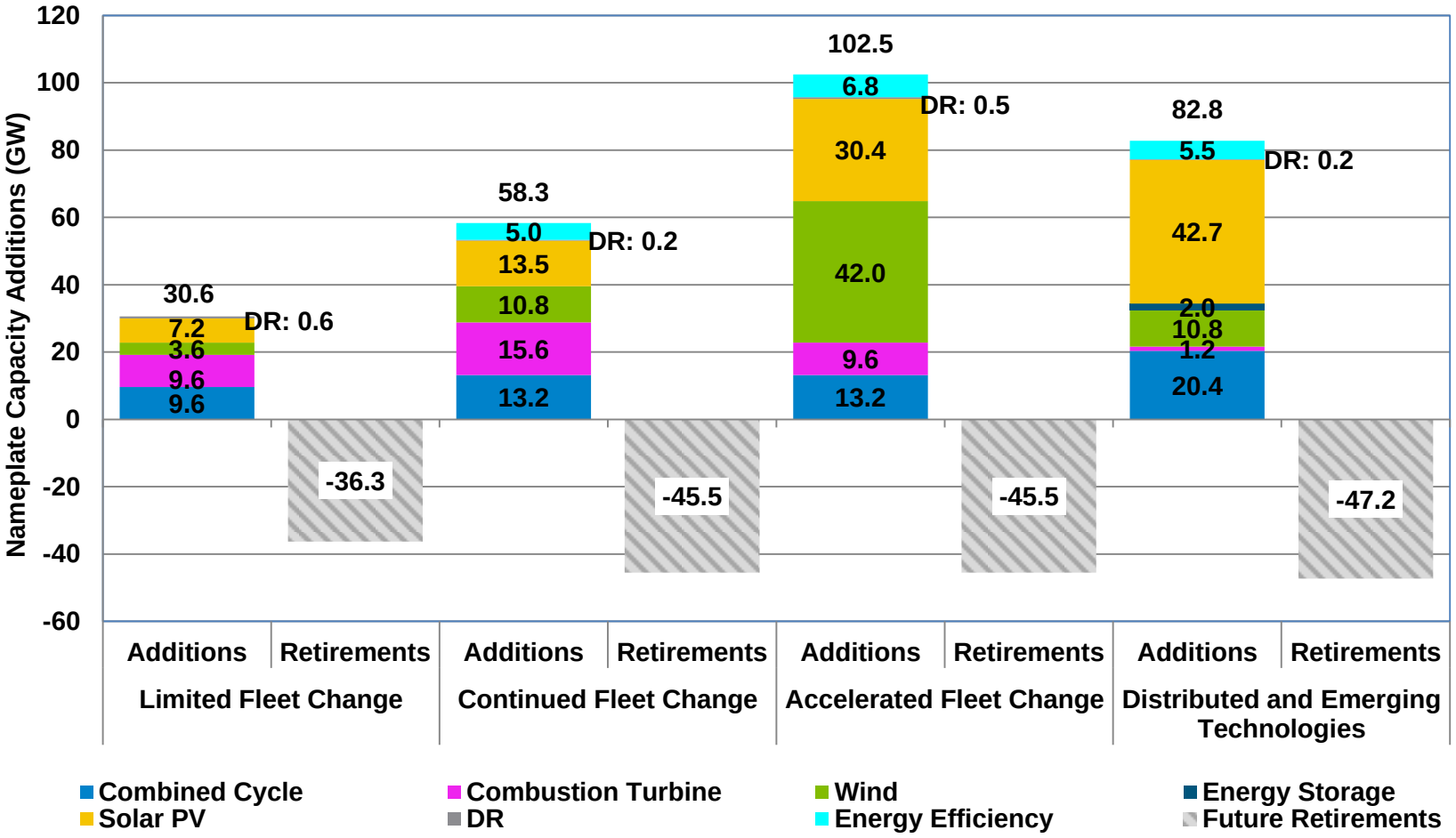
External Resources Siting Methodology

Siting of External Resources

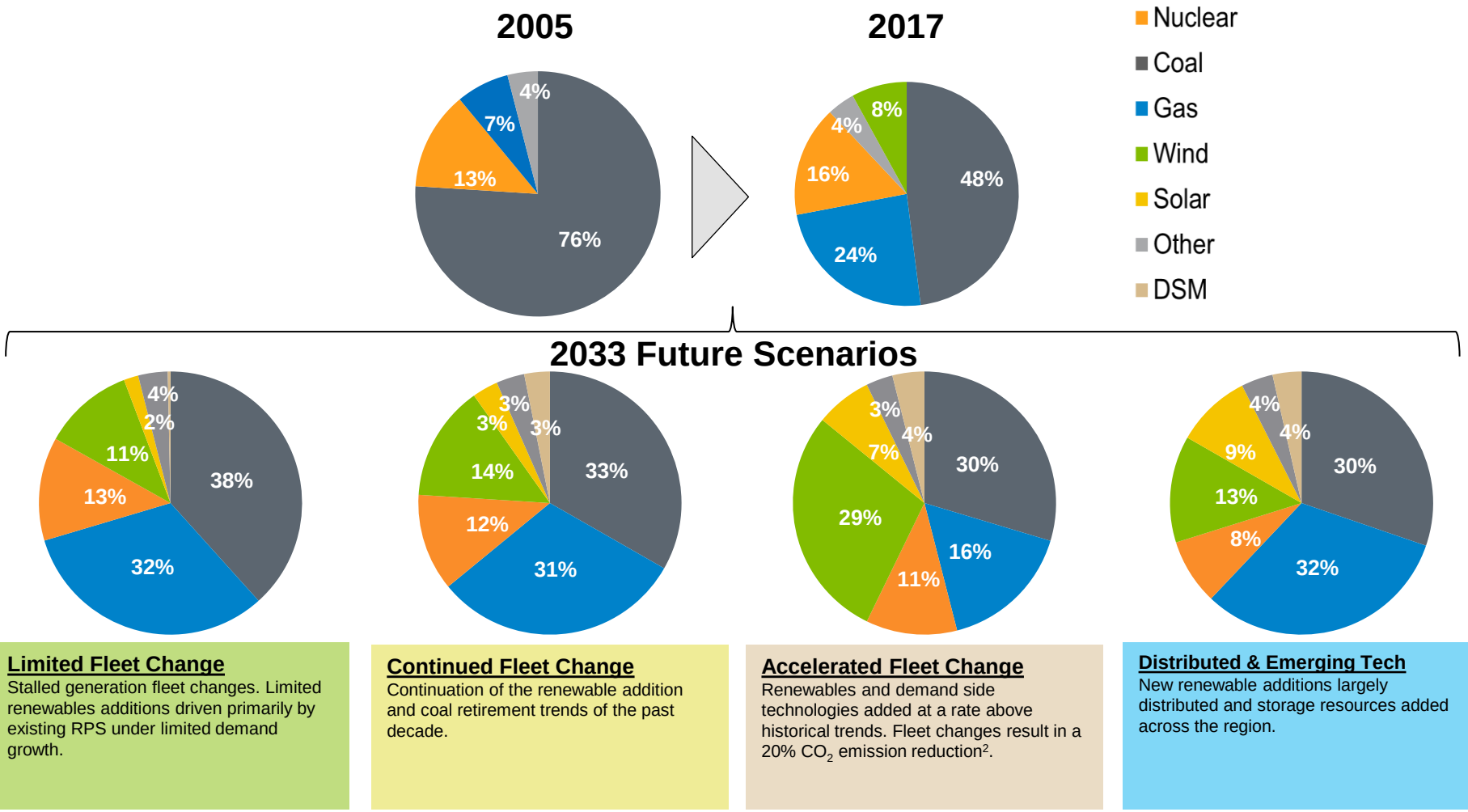
- Goal is consistent siting assumptions between RTOs
- Each model development, MISO will request latest siting information from neighboring regions
- Exhausting neighbors list and methodology, priority-based approach used for all supply-side unit types
  - Priority 1: Queue Generators
  - Priority 2: Brownfield sites + retired sites
  - Priority 3: Greenfield Sites

MTEP19 Resource Expansion and Siting Results

MTEP19 Nameplate Capacity Additions
(2018 through 2033)



MTEP19 Energy Projections by Future
(through 2033)[1]



Limited Fleet Change
Stalled generation fleet changes. Limited renewables additions driven primarily by existing RPS under limited demand growth.

Continued Fleet Change
Continuation of the renewable addition and coal retirement trends of the past decade.

Accelerated Fleet Change
Renewables and demand side technologies added at a rate above historical trends. Fleet changes result in a 20% CO_2 emission reduction[2].

Distributed & Emerging Tech
New renewable additions largely distributed and storage resources added across the region.

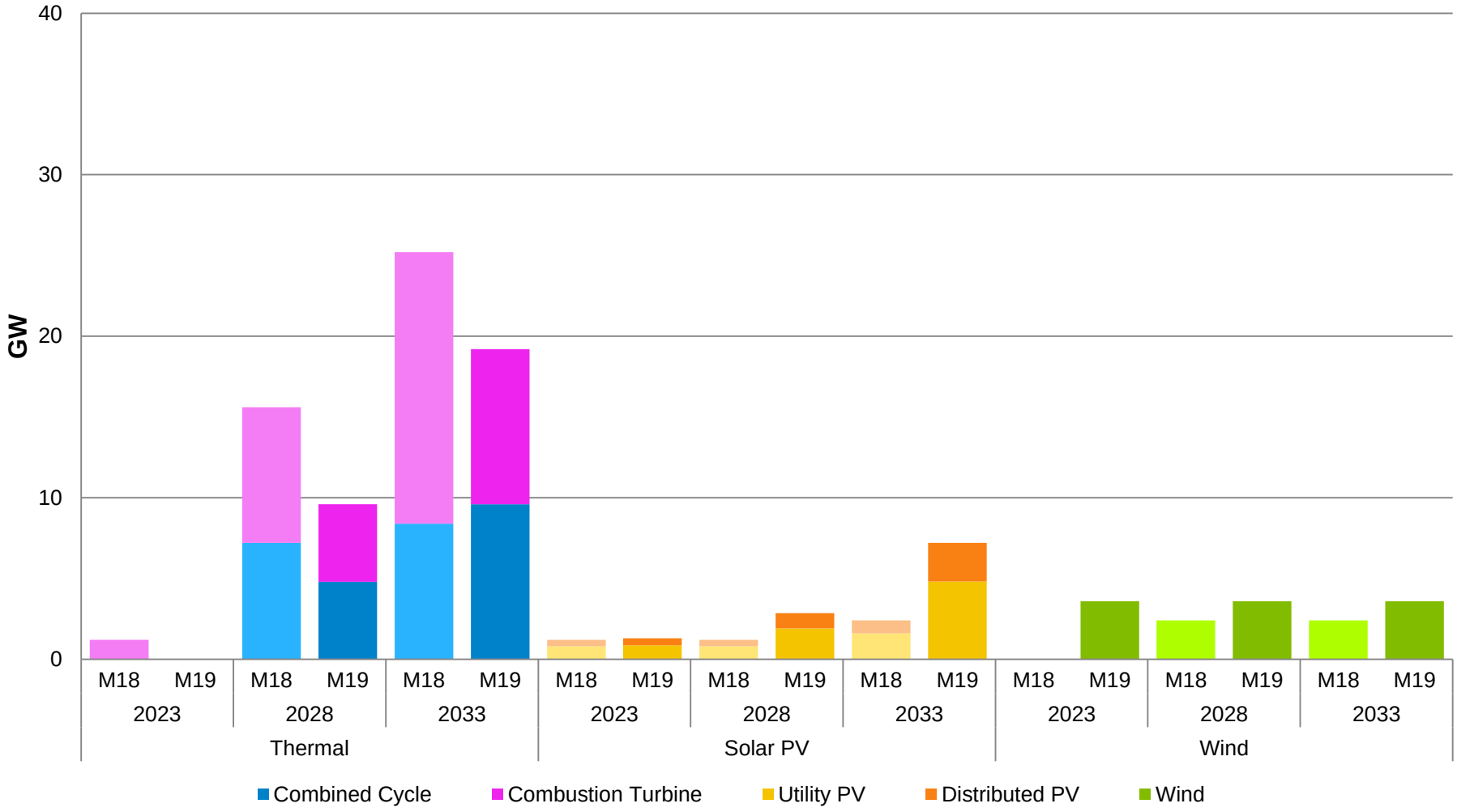
1. *Energy mix outputs from EGEAS do not consider transmission constraints*
2. *Emission reductions from current levels by year 2031*

Demand Side Programs Selected

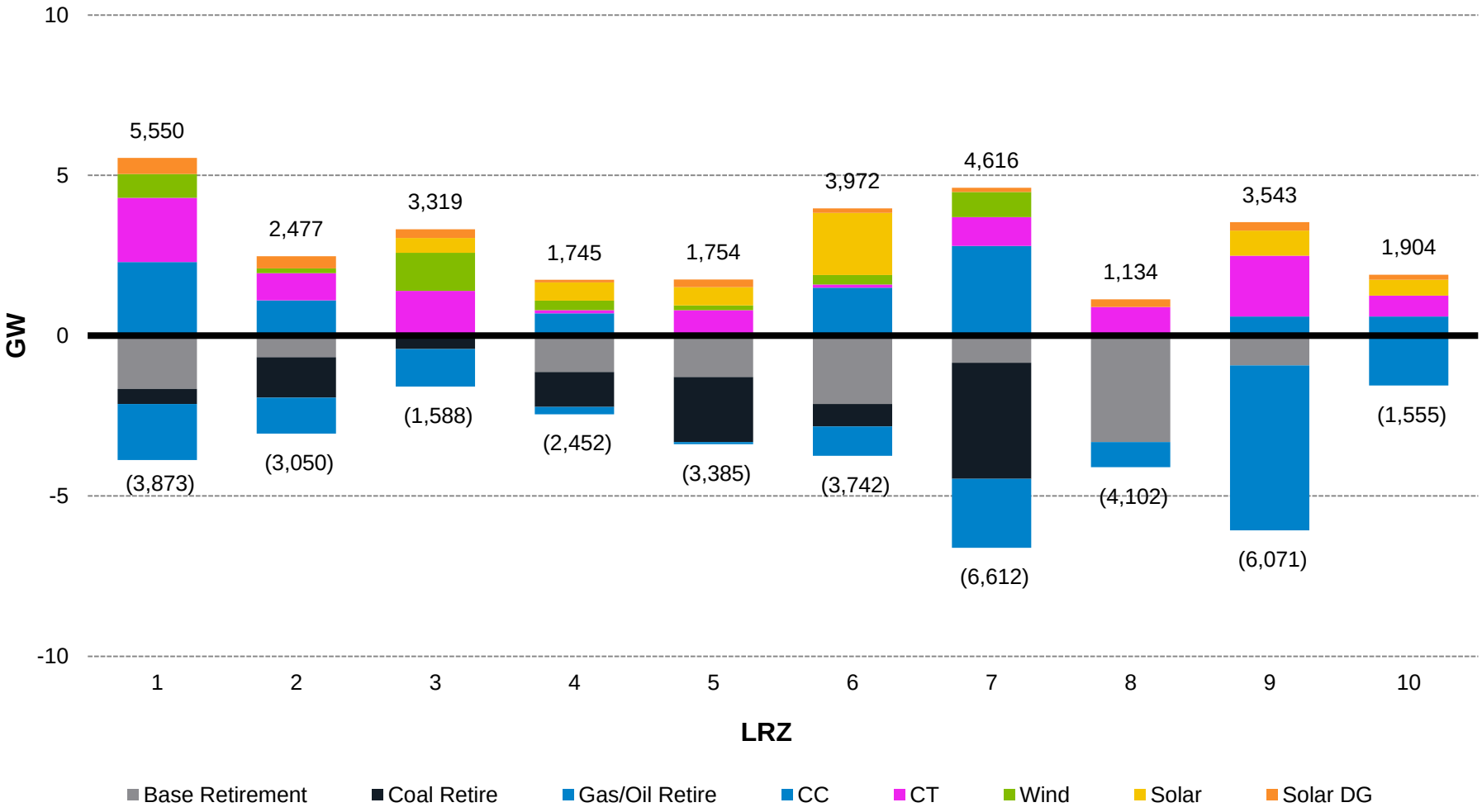
MTEP19 Programs		Limited Fleet Change		Continued Fleet Change		Accelerated Fleet Change		Distributed and Emerging Technologies	
15 Year Potential**	C&I vs Residential	Capacity (GW)	Energy (GWh)	Capacity (GW)	Energy (GWh)	Capacity (GW)	Energy (GWh)	Capacity (GW)	Energy (GWh)
Direct Load Control	C/I	0.213	14	-	-	0.265	17.5	-	-
Price-Responsive Demand	C/I	0.202	32.6	-	-	0.253	40.6	-	-
	R	0.162	62.6	0.172	66.2	-	-	0.202	78.1
High-cost Energy Efficiency	C/I	-	-	-	-	1.285	5,249.2	-	-
	R	-	-	1.12	4,383.9	1.289	5,024.7	1.305	5,087.2
Mid-cost Energy Efficiency	C/I	-	-	3.84	15,732.4	4.191	17,187	4.187	17,168.7
DG PV	C/I	1.214	2,182	1.456	2,617.2	1.557	2,797.7	3.095	5,562.3

Notes: Low cost EE were assumed to be part of base forecast.
Existing DR within MISO is greater than AEG programs. Hence, the AEG C/I DR program removed from all futures.
No DG besides DGPV was selected in any future.

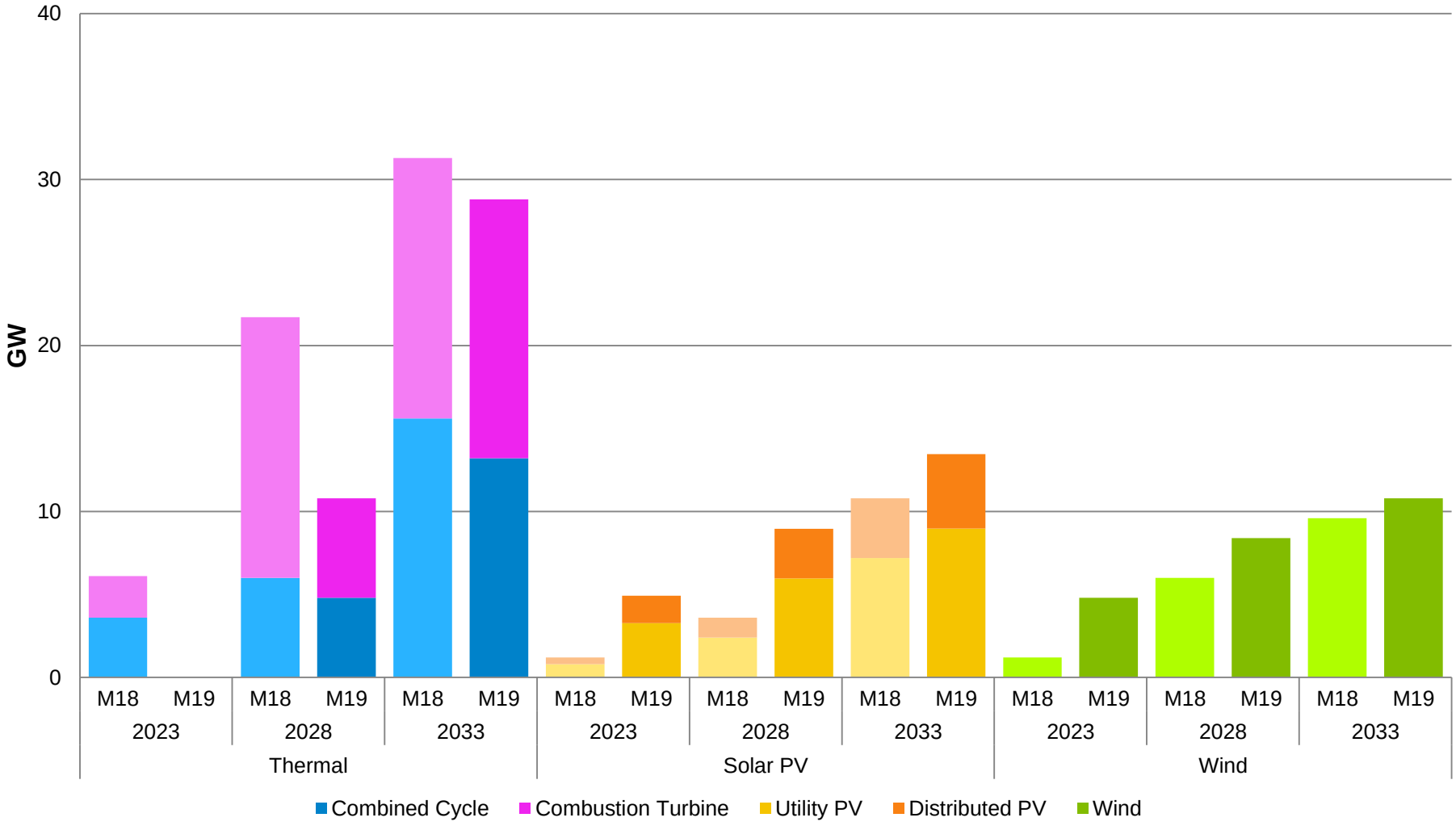
Limited Fleet Change Capacity Expansion
(Comparison between MTEP18 and MTEP19)



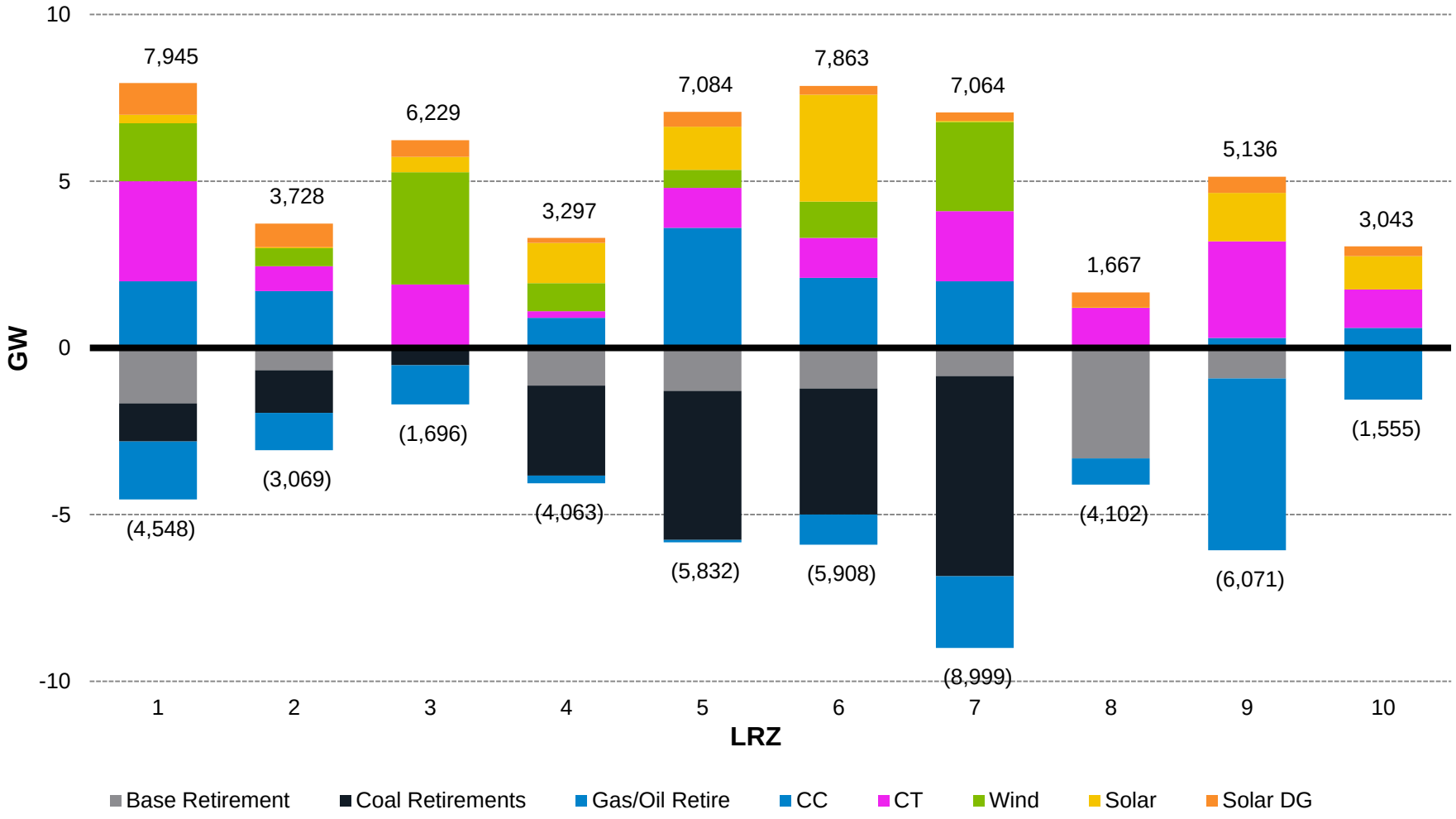
Retirements and Additions by LRZ
(Limited Fleet Change Future)



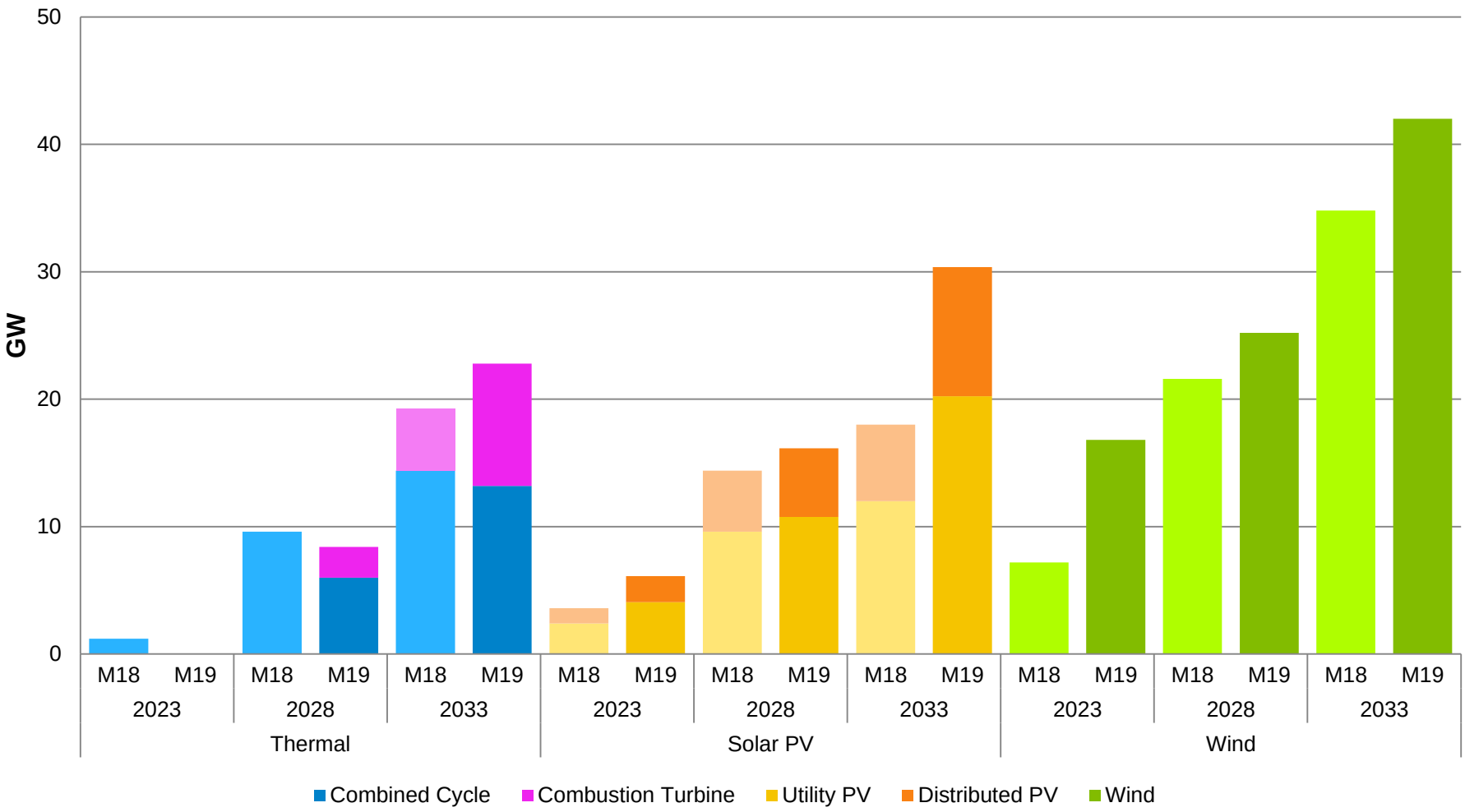
Continuous Fleet Change Capacity Expansion
(Comparison between MTEP18 and MTEP19)



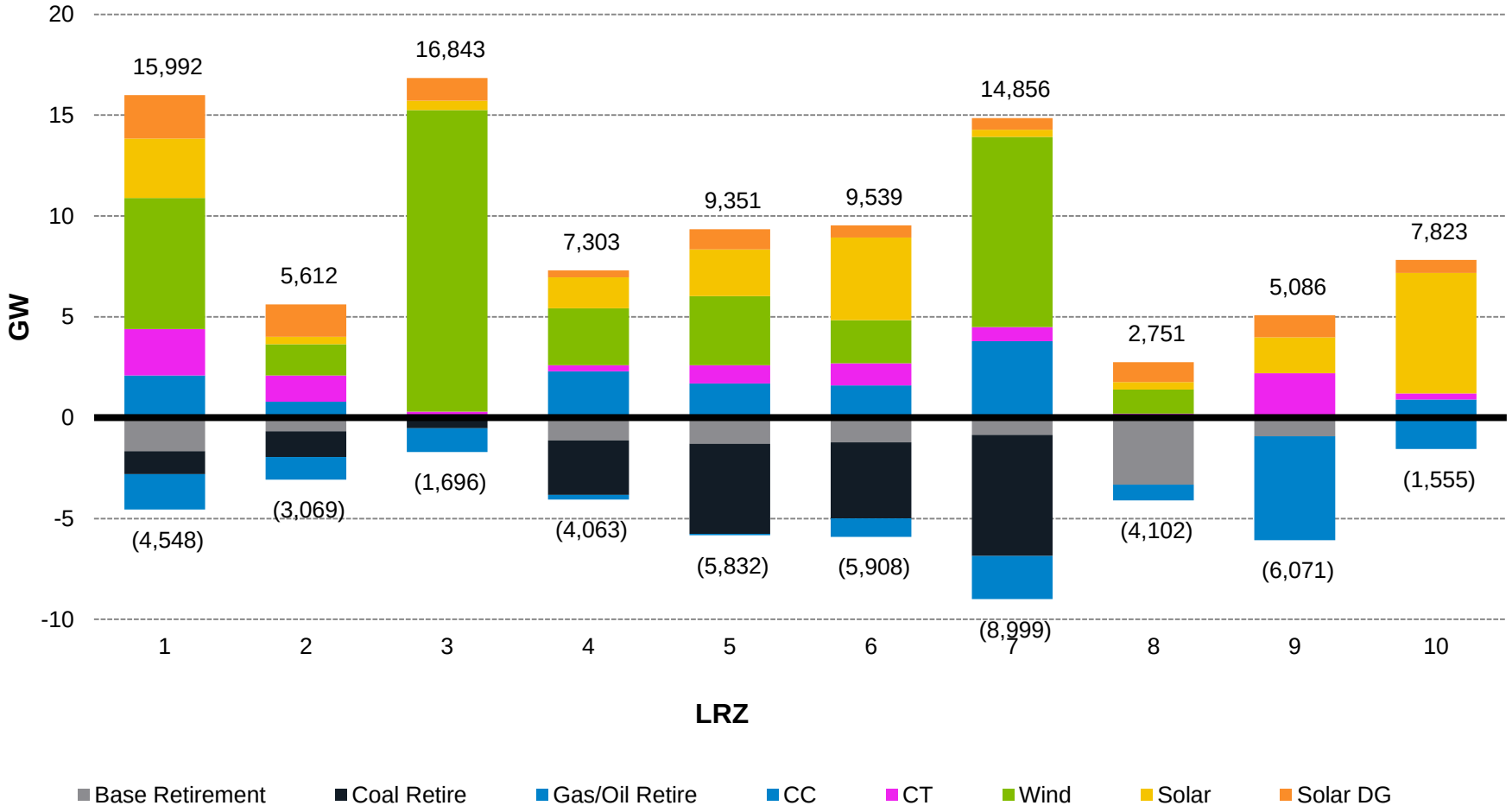
Retirements and Additions by LRZ
(Continuous Fleet Change Future)



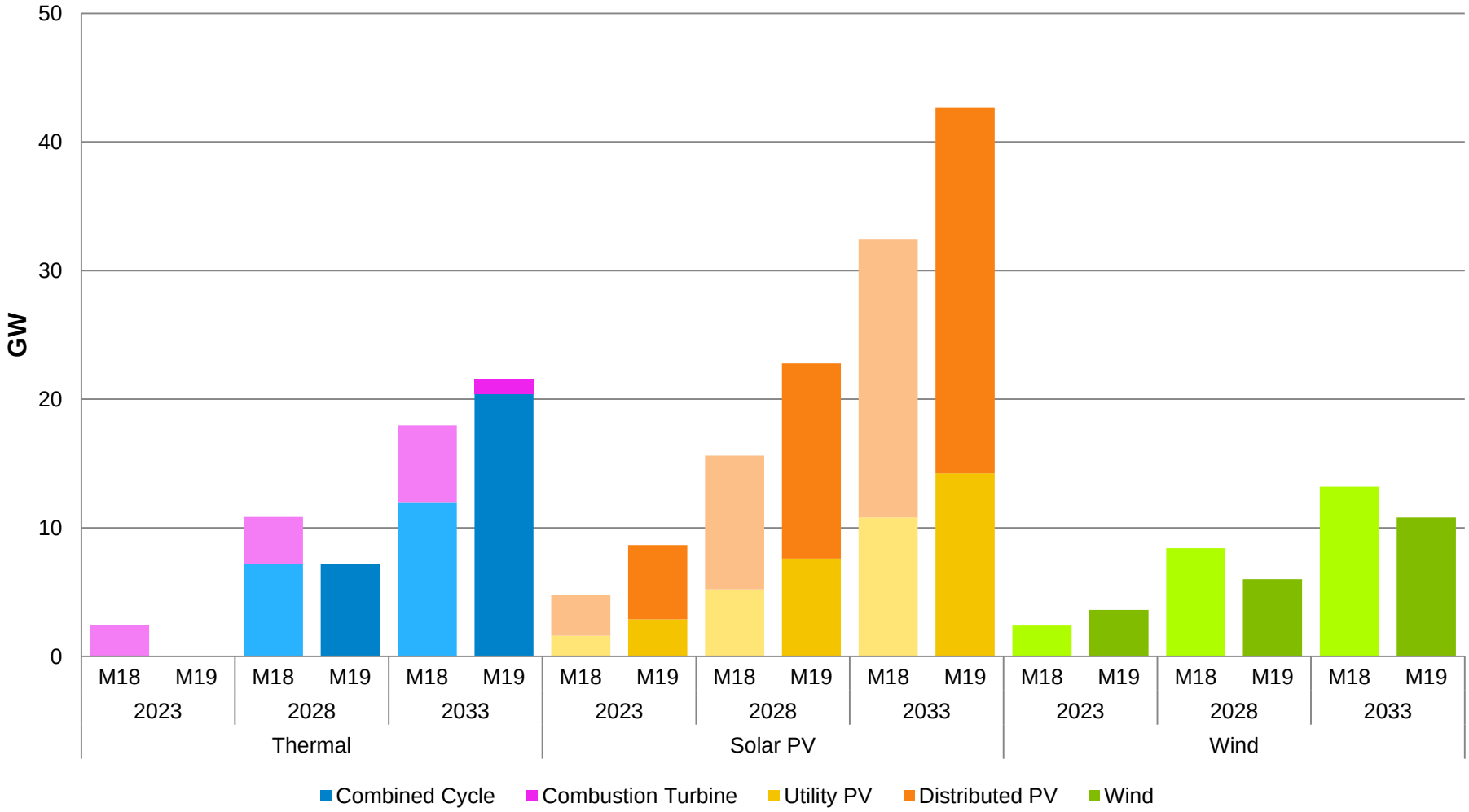
Accelerated Fleet Change Capacity Expansion
(Comparison between MTEP18 and MTEP19)



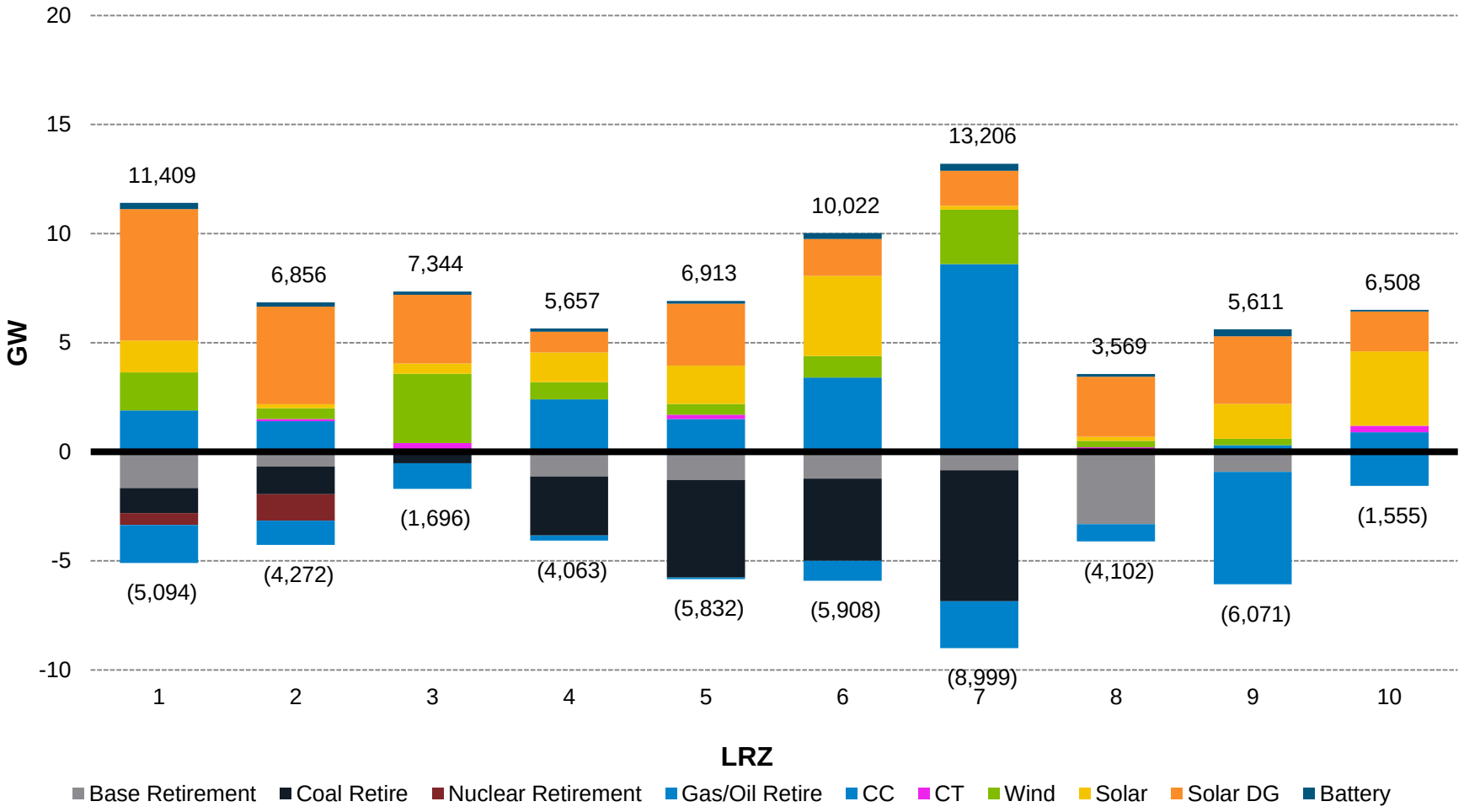
Retirements and Additions by LRZ
(Accelerated Fleet Change Future)



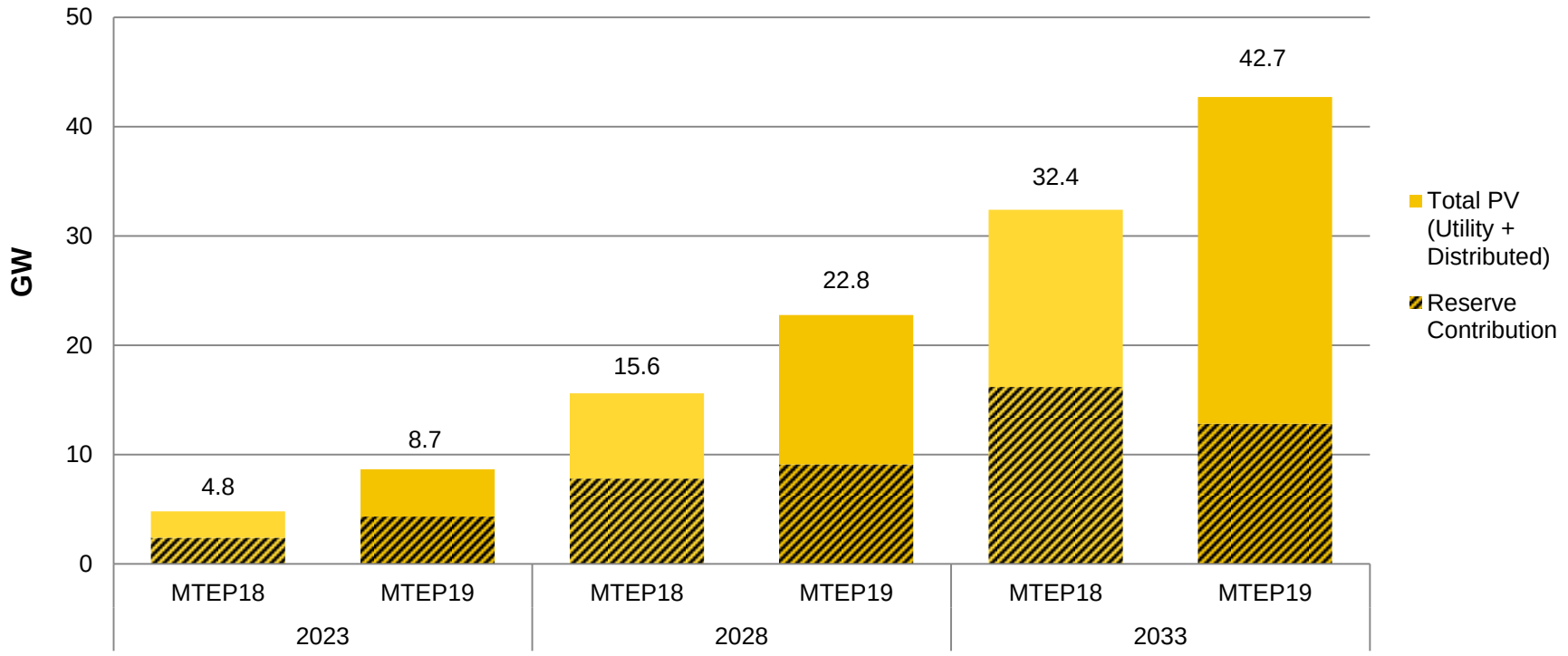
Distributed & Emerging Technology Capacity Expansion
(Comparison between MTEP18 and MTEP19)



Retirements and Additions by LRZ
(Distributed & Emerging Technology Future)



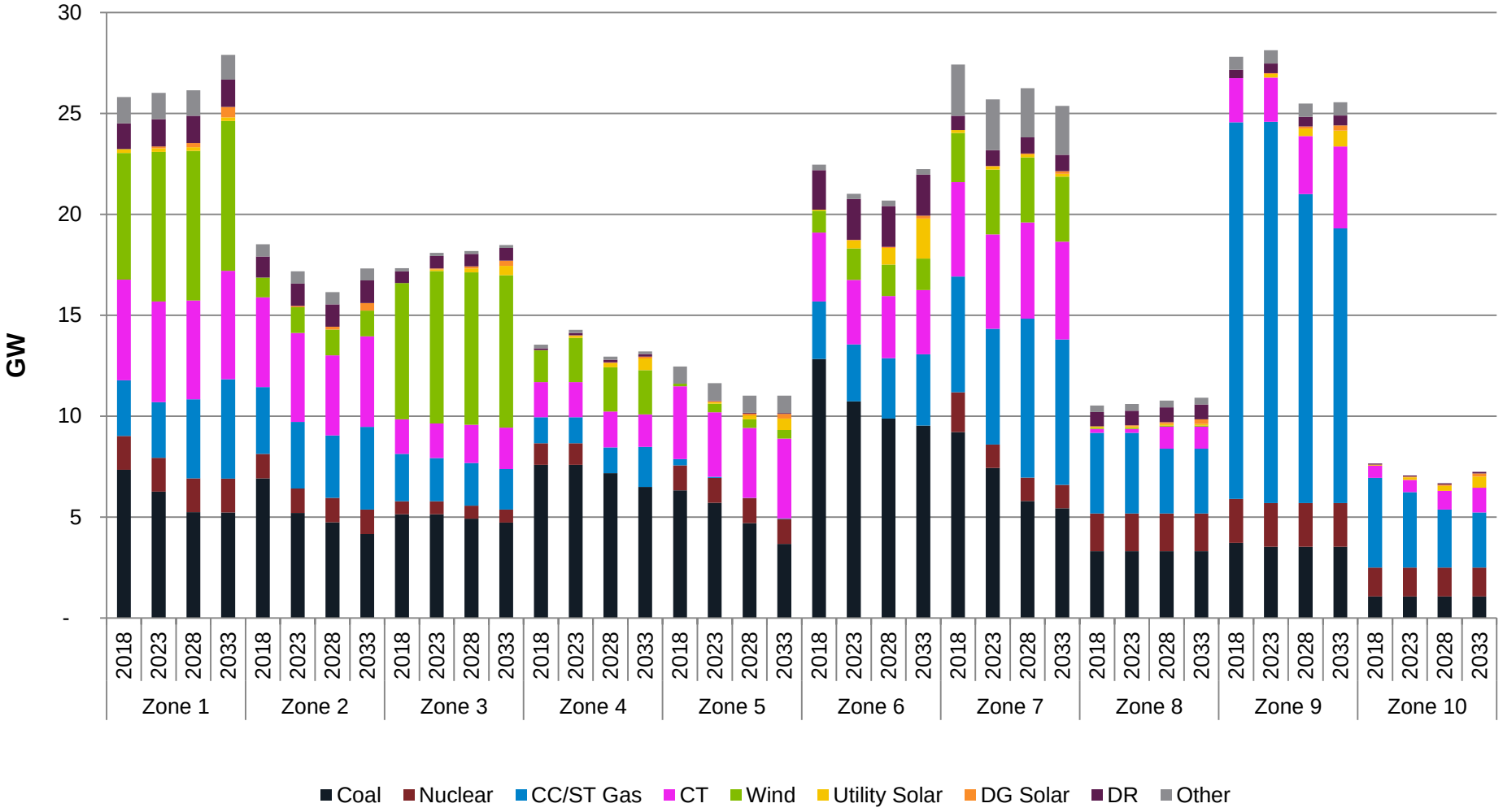
Effective Load Carrying Capacity of Distributed & Emerging Technologies Future



Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Solar Capacity Credit	**50%**	**50%**	**50%**	**50%**	**50%**	**50%**	**48%**	**46%**	**44%**	**42%**	**40%**	**38%**	**36%**	**34%**	**32%**	**30%**

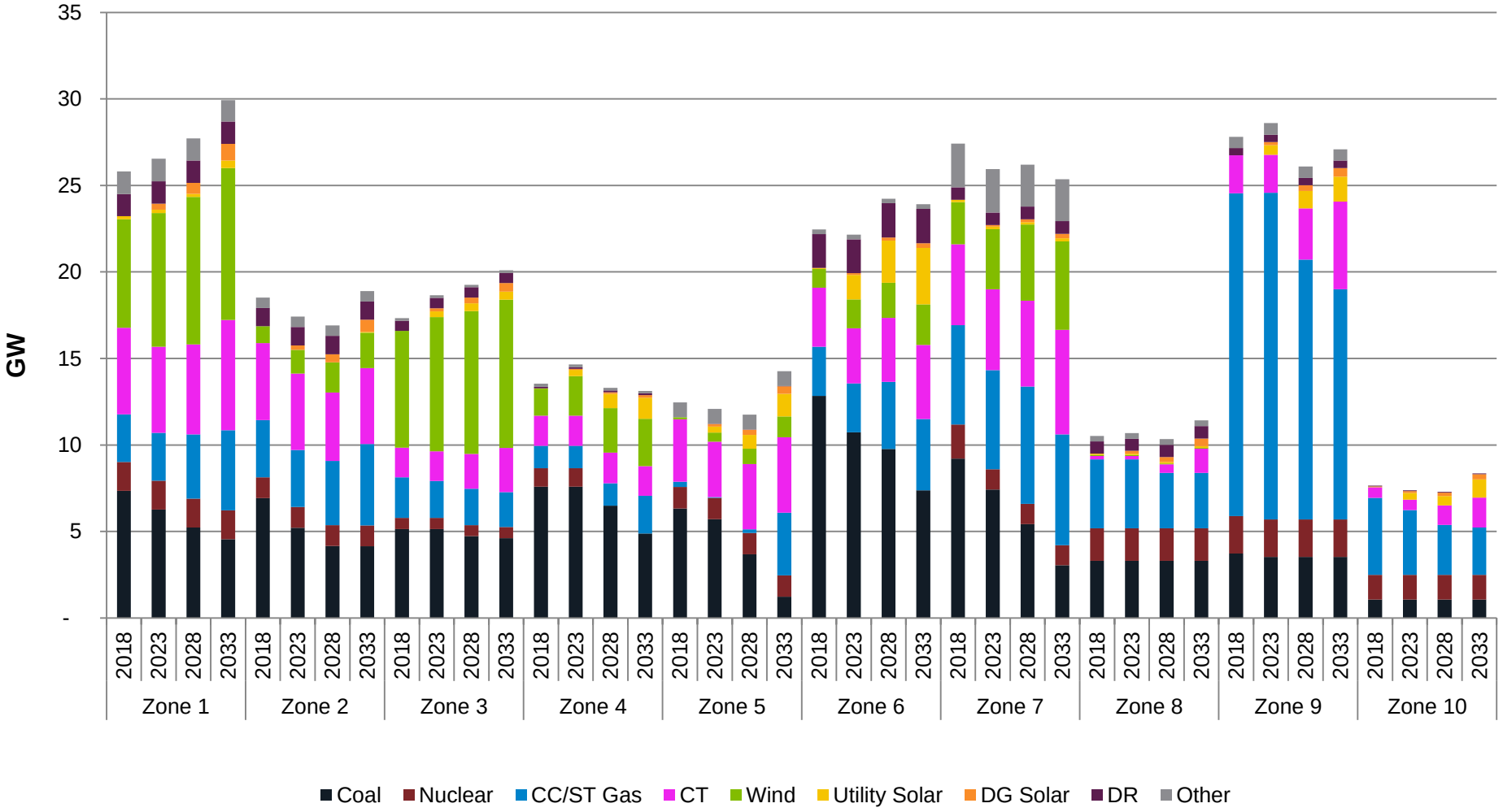
Zonal Nameplate Capacity by Fuel

Limited Fleet Change



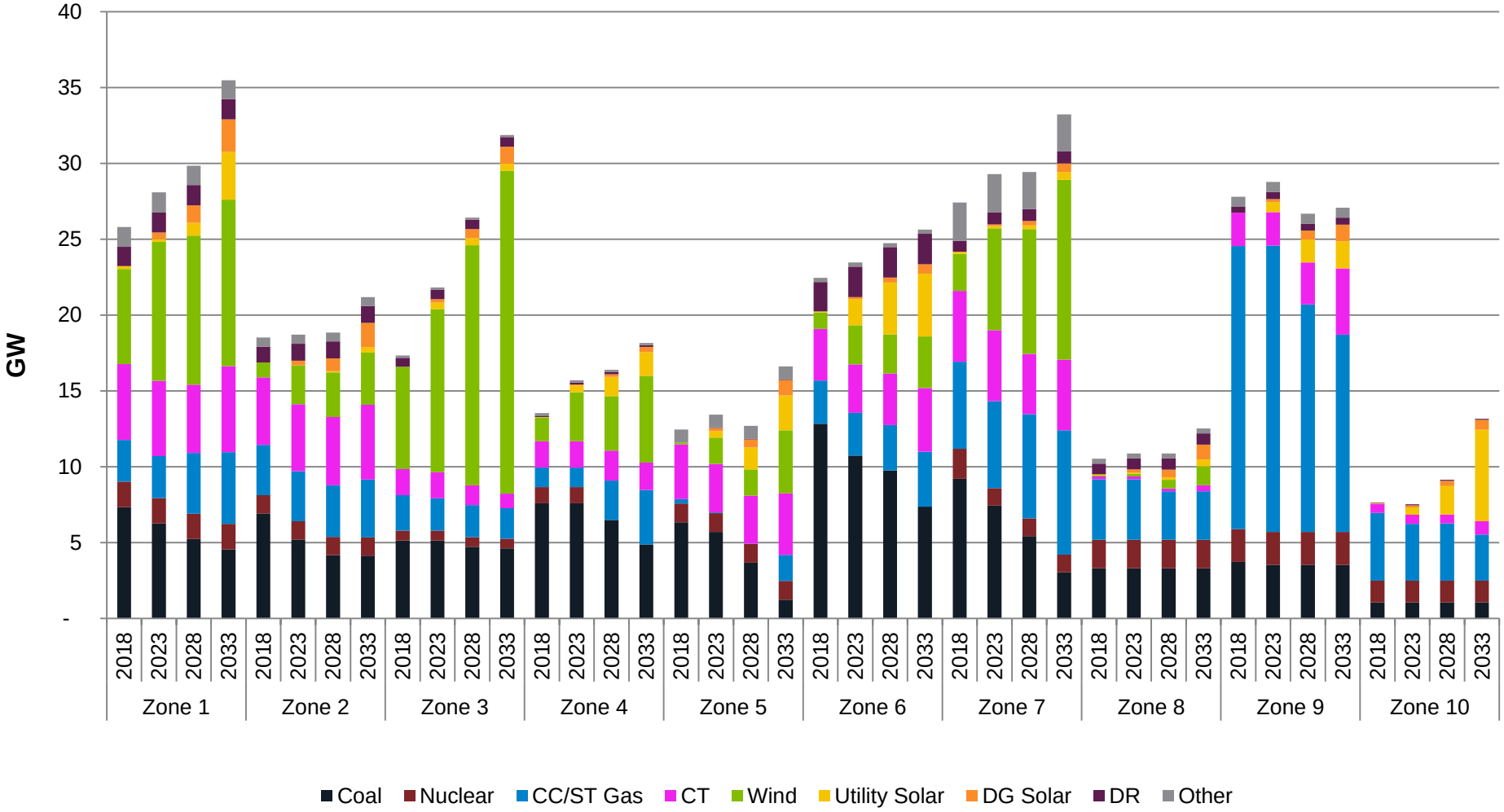
Zonal Nameplate Capacity by Fuel

Continued Fleet Change



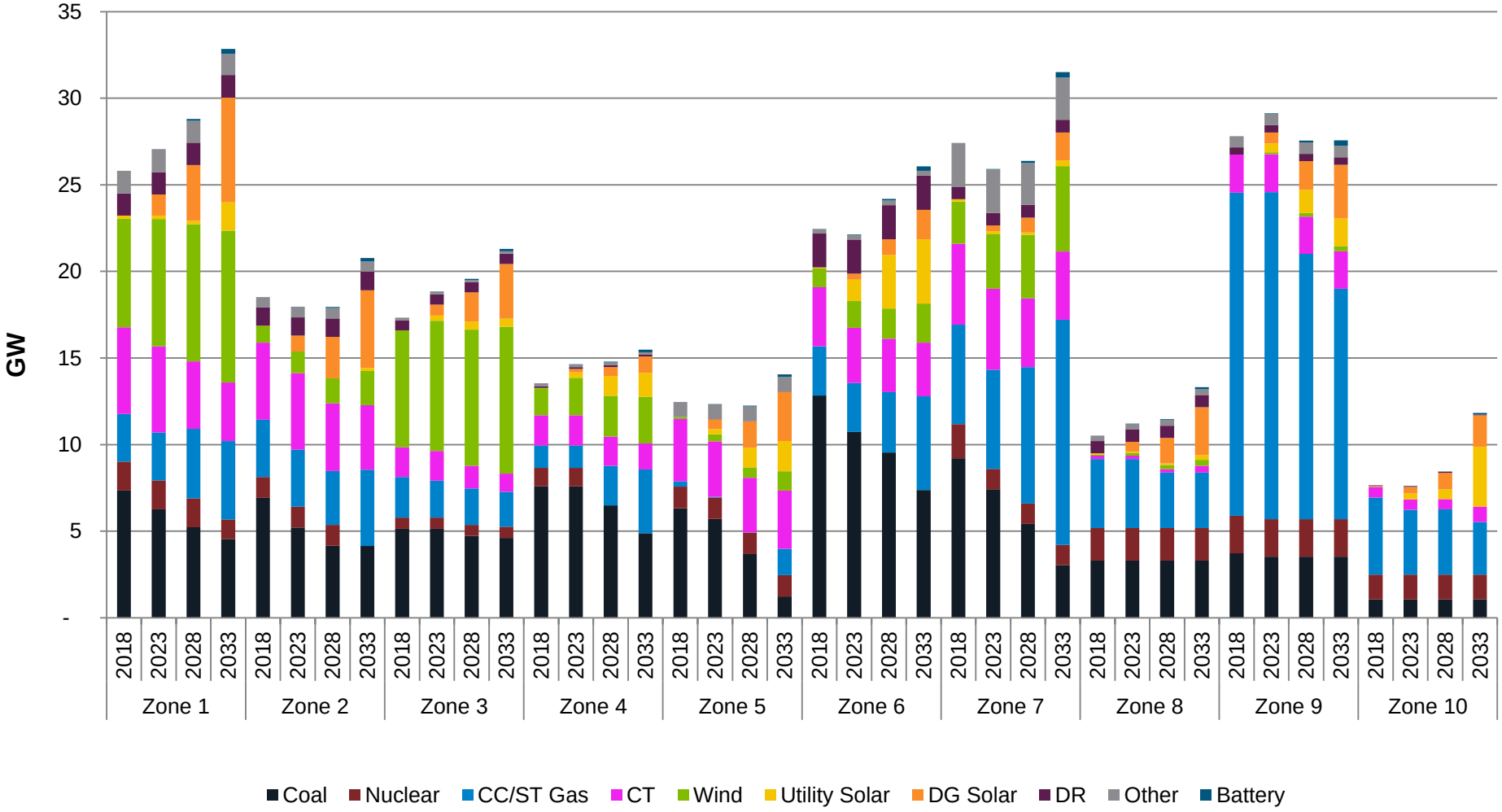
Zonal Nameplate Capacity by Fuel

Accelerated Fleet Change



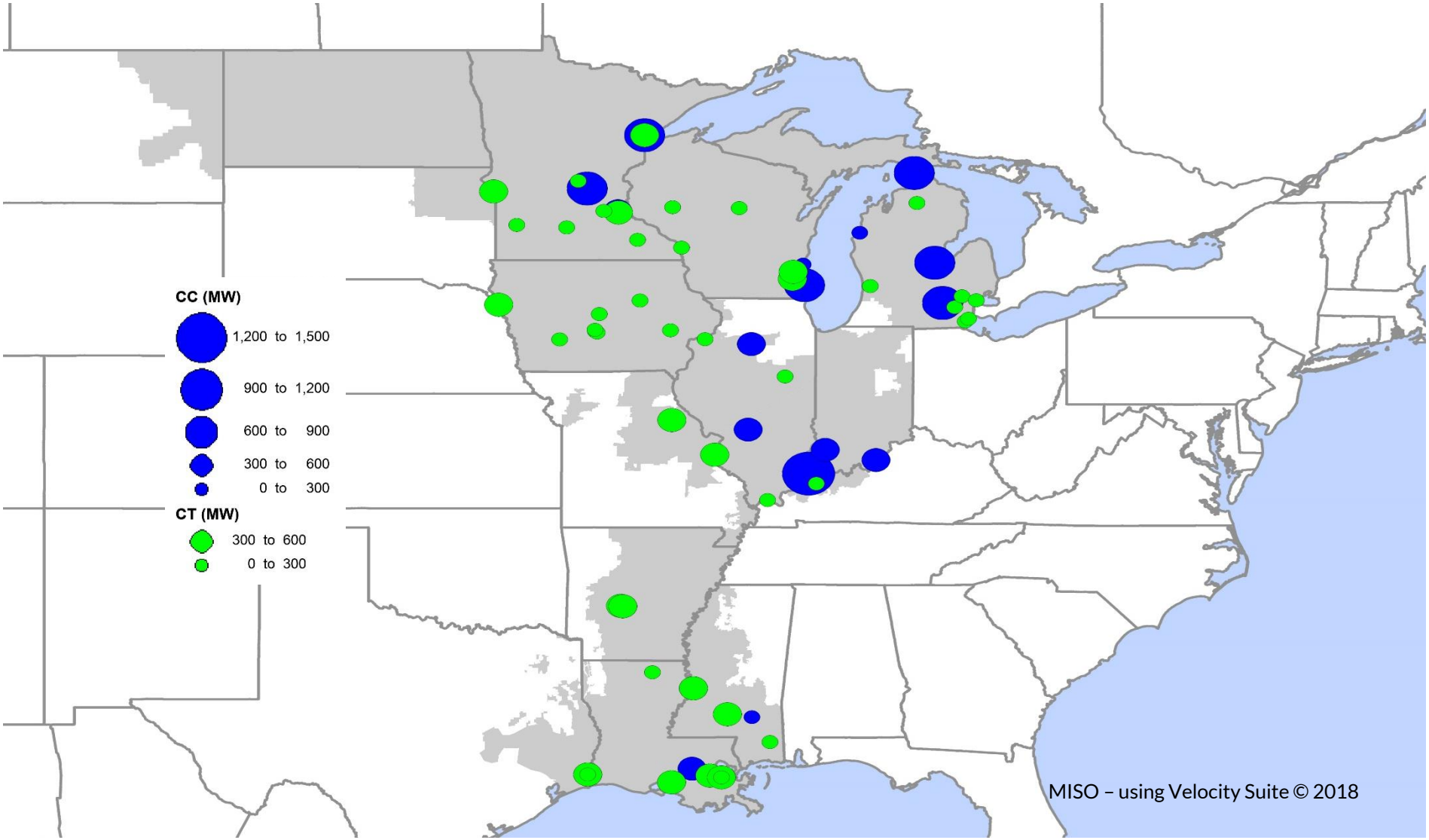
Zonal Nameplate Capacity by Fuel

Distributed & Emerging Technologies



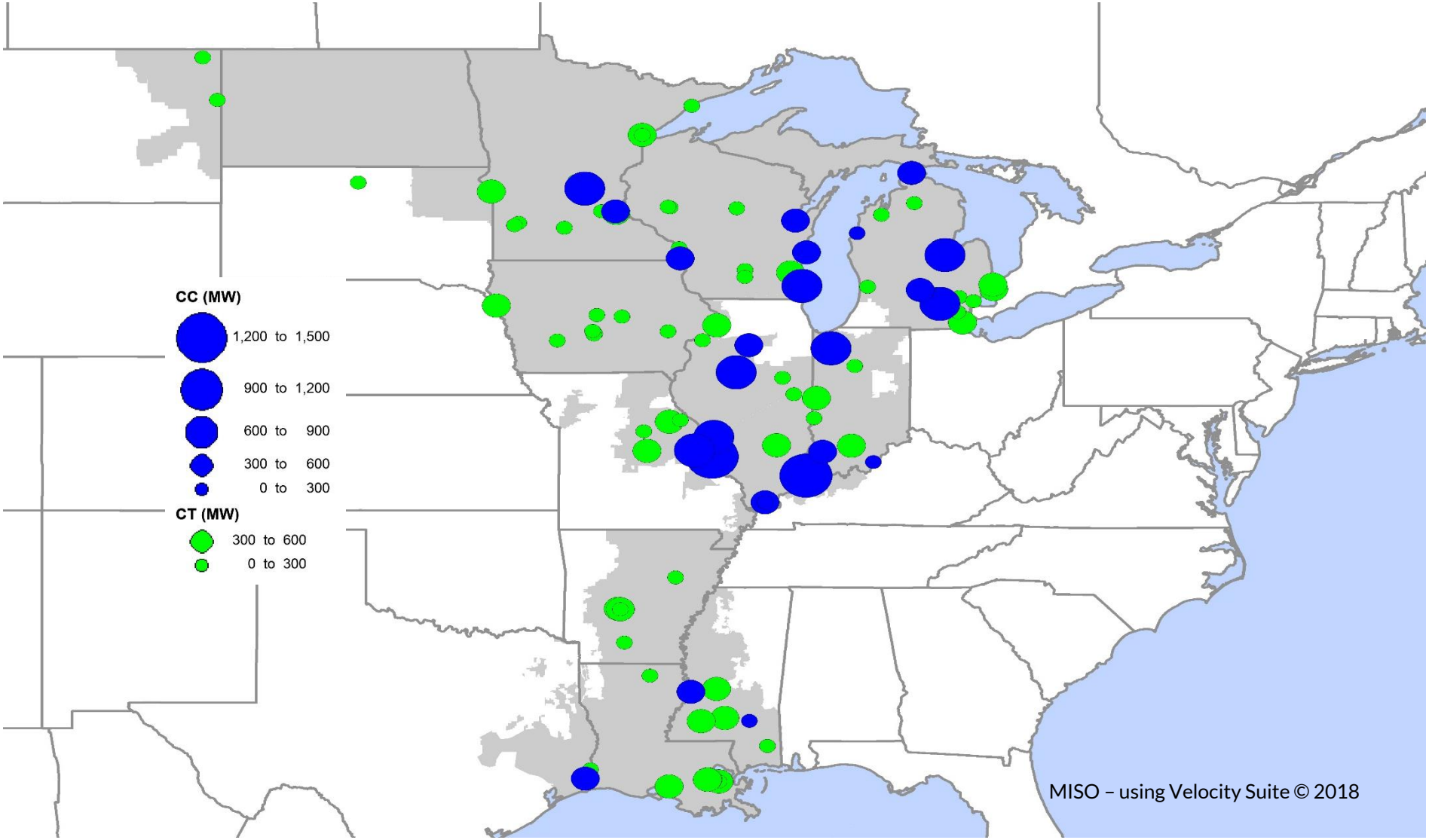
MISO Thermal Regional Resource Forecast Units

Limited Fleet Change Future



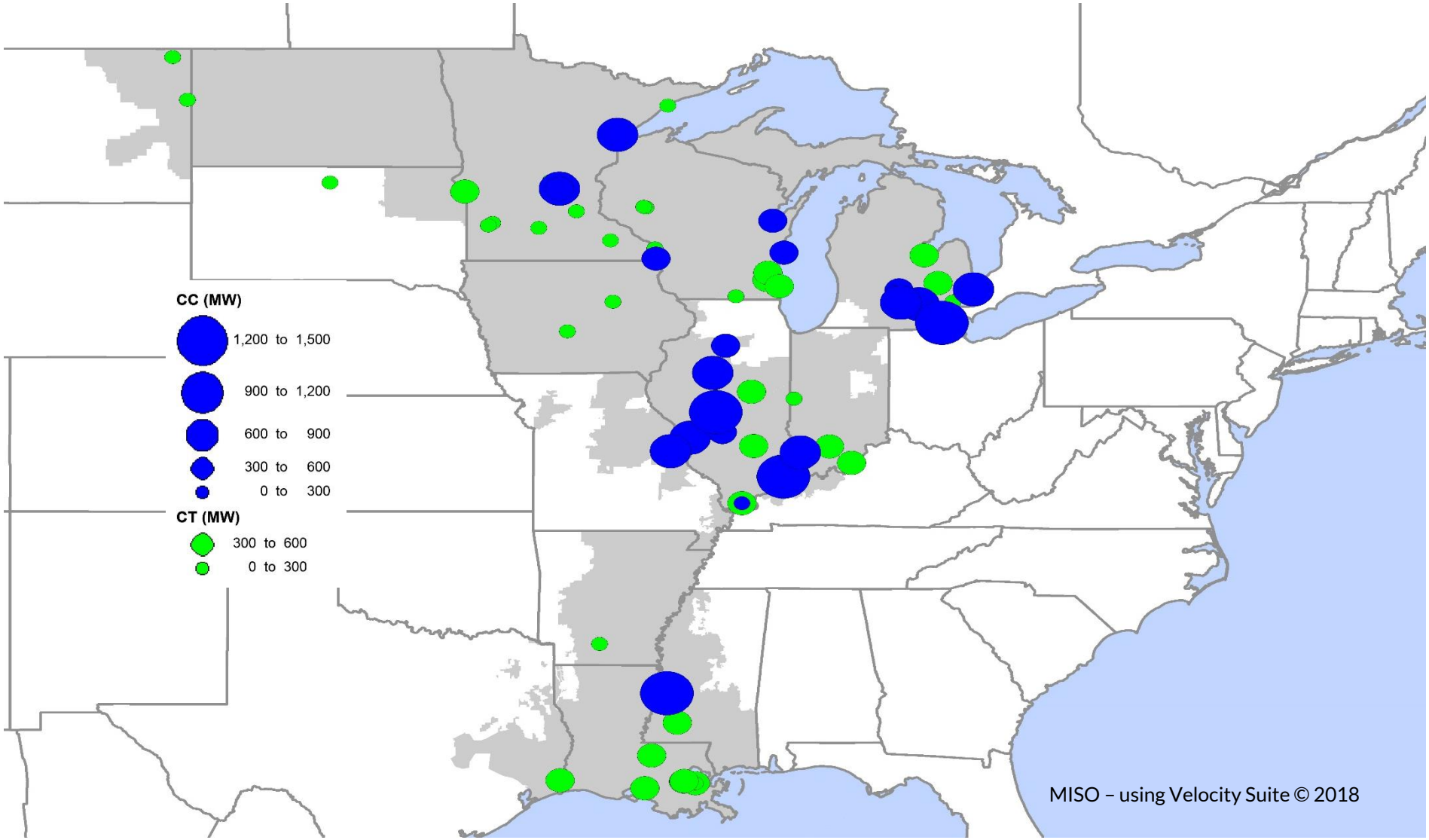
MISO Thermal Regional Resource Forecast Units

Continued Fleet Change Future



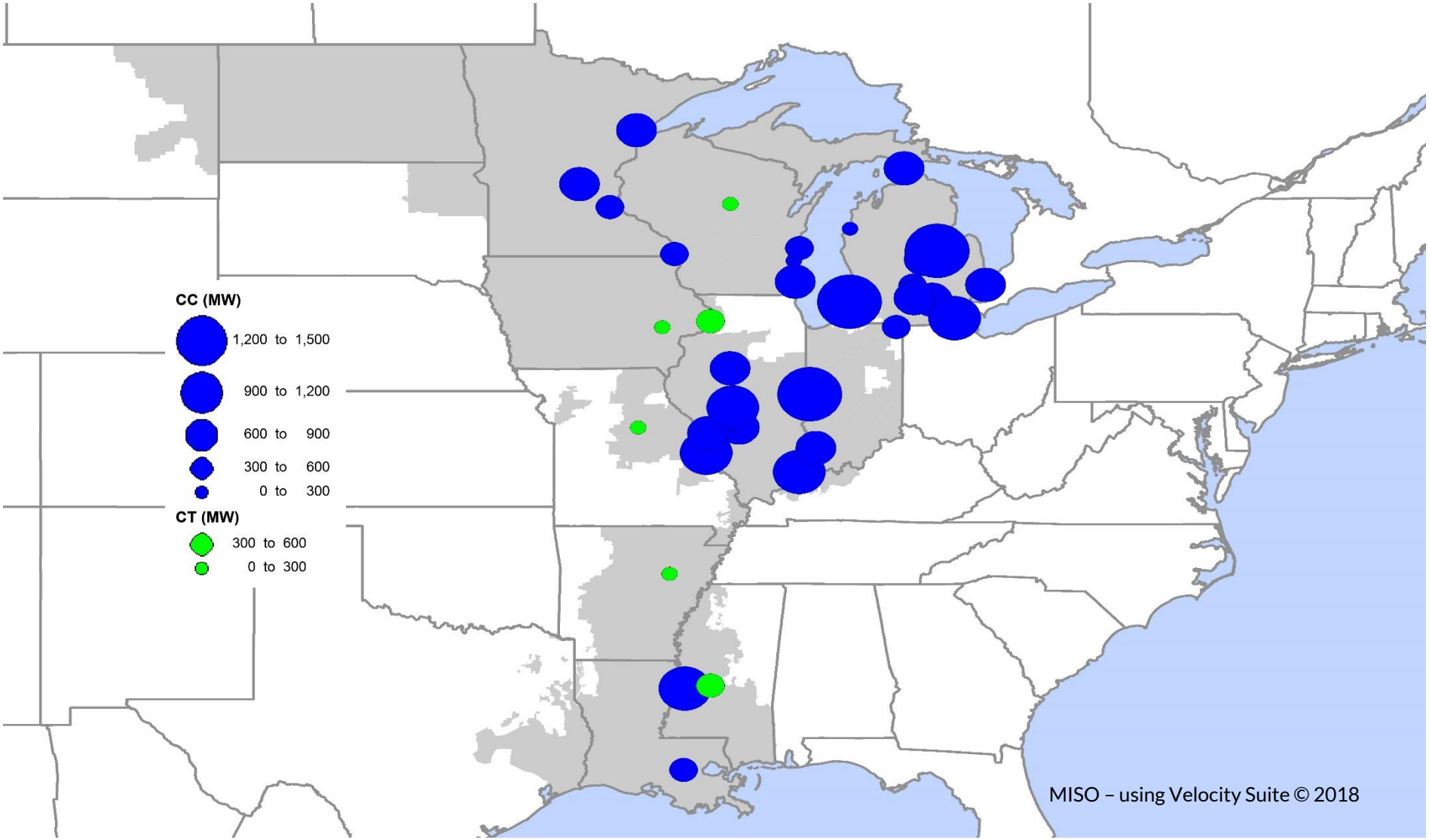
MISO Thermal Regional Resource Forecast Units

Accelerated Fleet Change Future

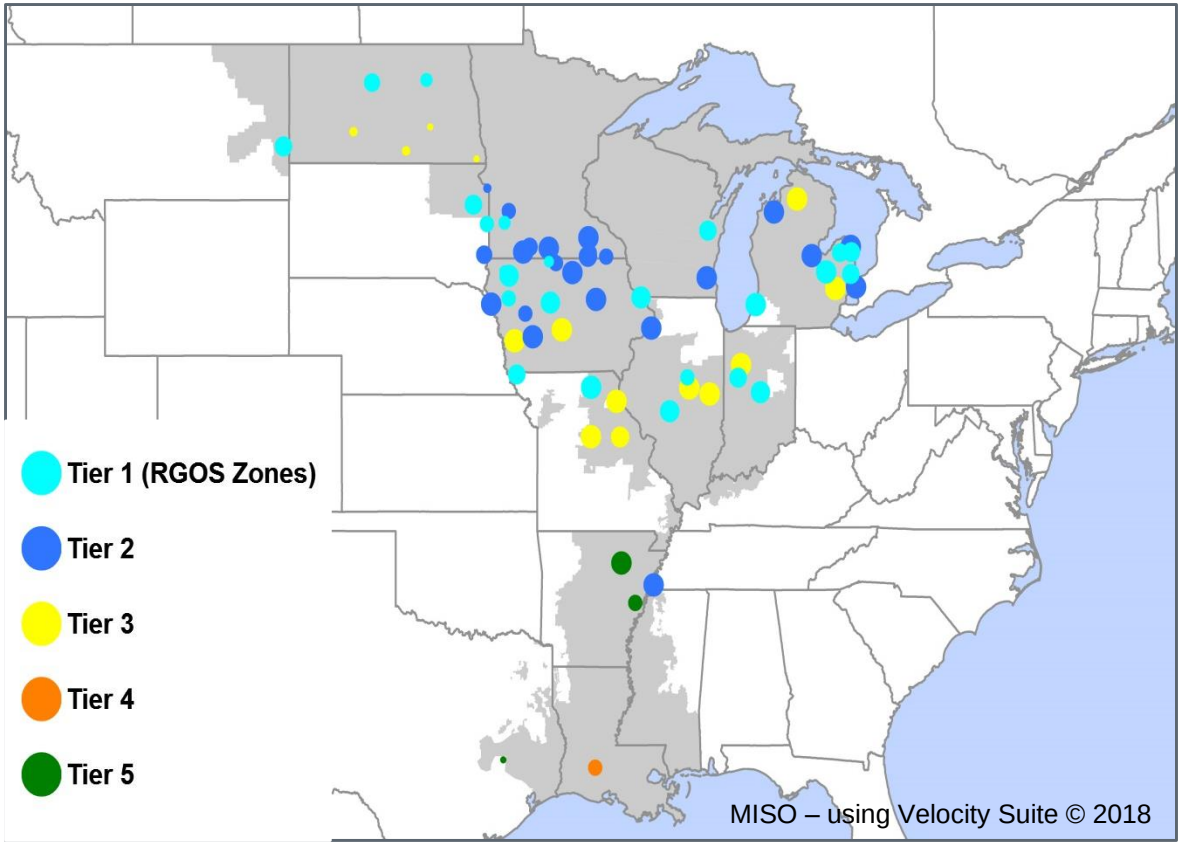


MISO Thermal Regional Resource Forecast Units

Distributed and Emerging Technologies

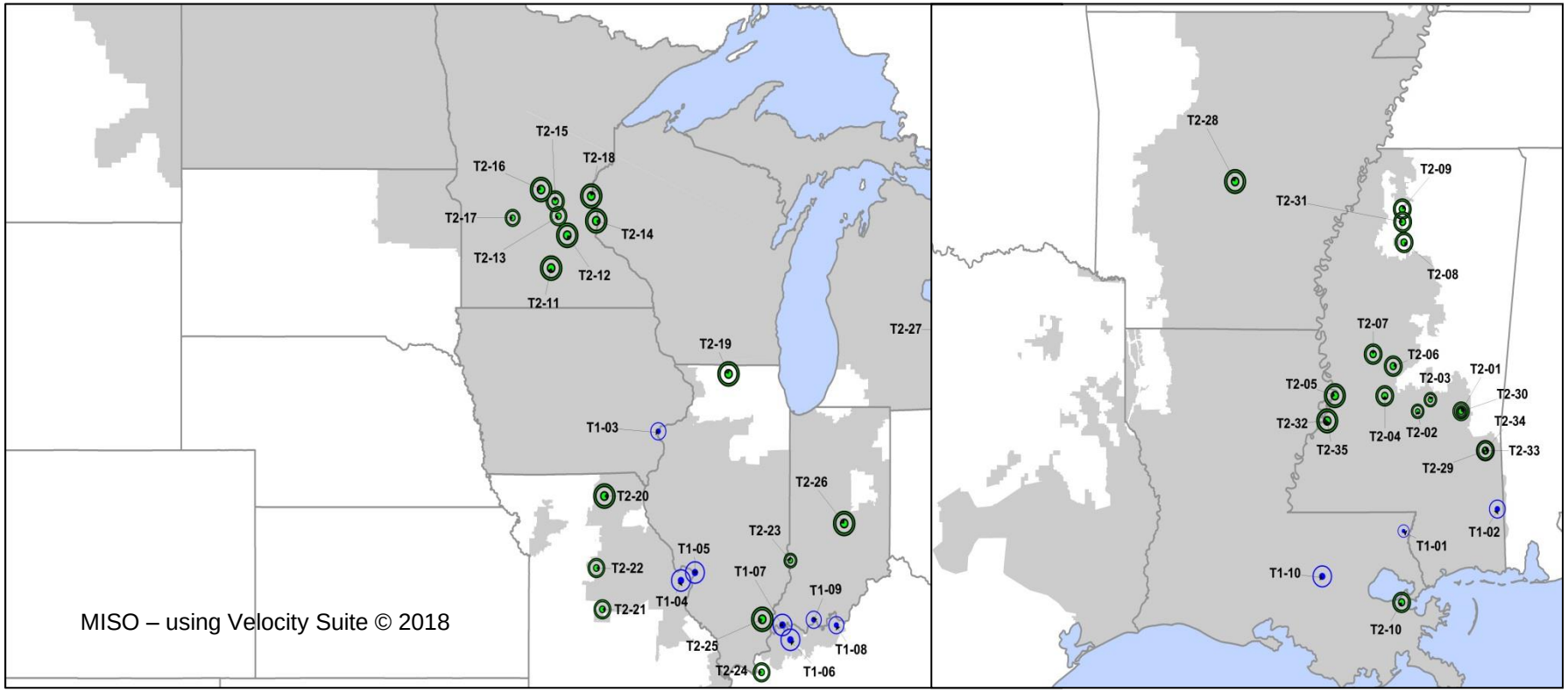


Wind Regional Resource Forecast Unit Siting



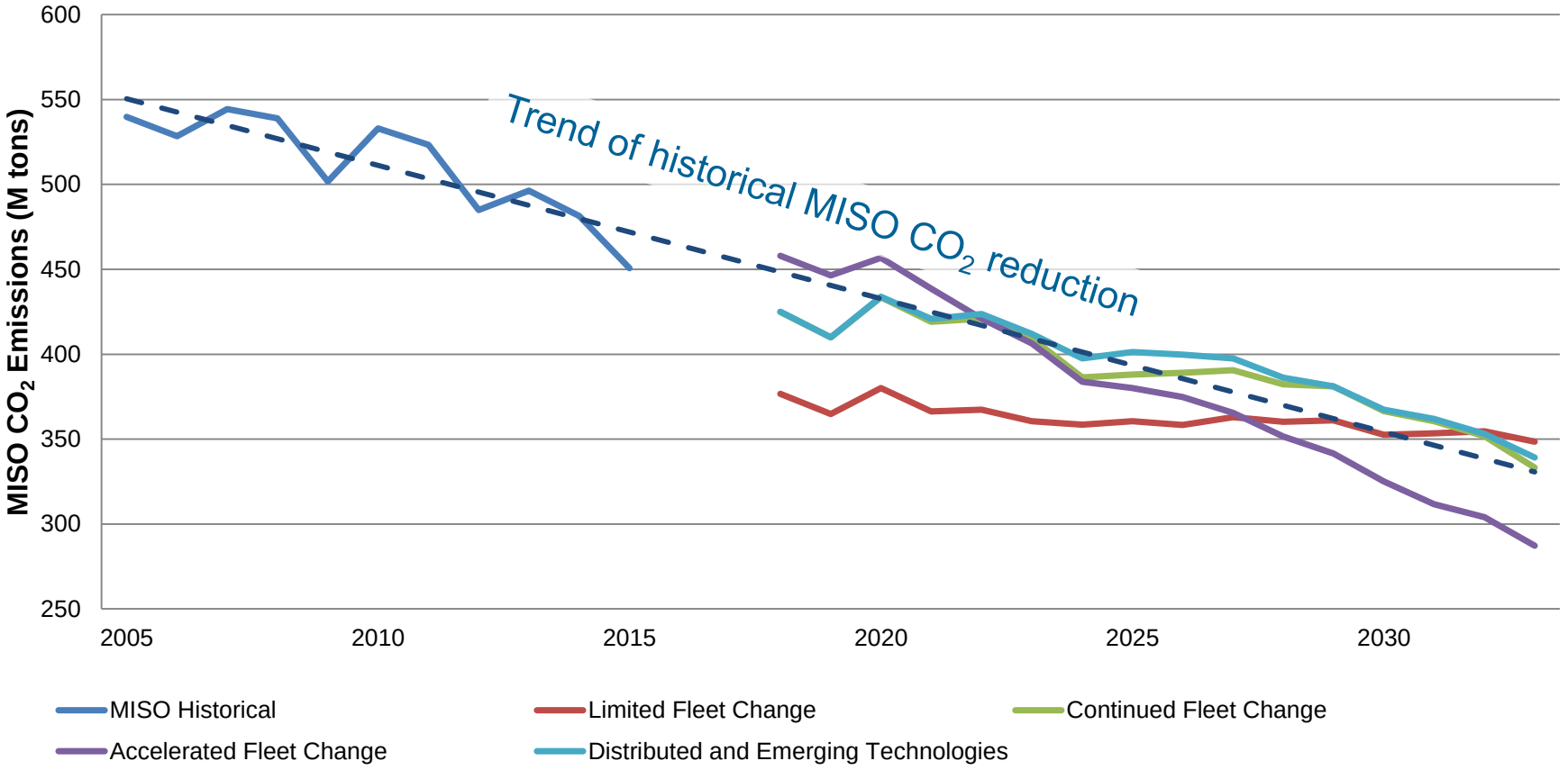
Wind Tier (MW)	Total Available Capacity	Limited Fleet Change	Continued Fleet Change	Accelerated Fleet Change	Distributed and Emerging Technology
Tier- 1 / RGOS	13,837	3,600	10,800	13,837	10,200
Tier- 2	19,400	-	-	19,400	100
Tier- 3	10,550	-	-	8,763	-
Tier- 4	20,350	-	-	-	200
Tier- 5	6,950	-	-	-	300
Total	**71,087**	**3,600**	**10,800**	**42,000**	**10,800**

Solar Regional Resource Forecast Unit Siting



Solar Tier (MW)	Total Available Capacity	Limited Fleet Change	Continued Fleet Change	Accelerated Fleet Change	Distributed and Emerging Technology
Tier- 1	7,870	4,809	7,869	7,869	7,869
Tier- 2	25,234	-	1,102	12,369	6,363
Distributed	N/A	2,405	4,485	10,119	28,463
Total	**33,103**	**7,214**	**13,456**	**30,357**	**42,695**

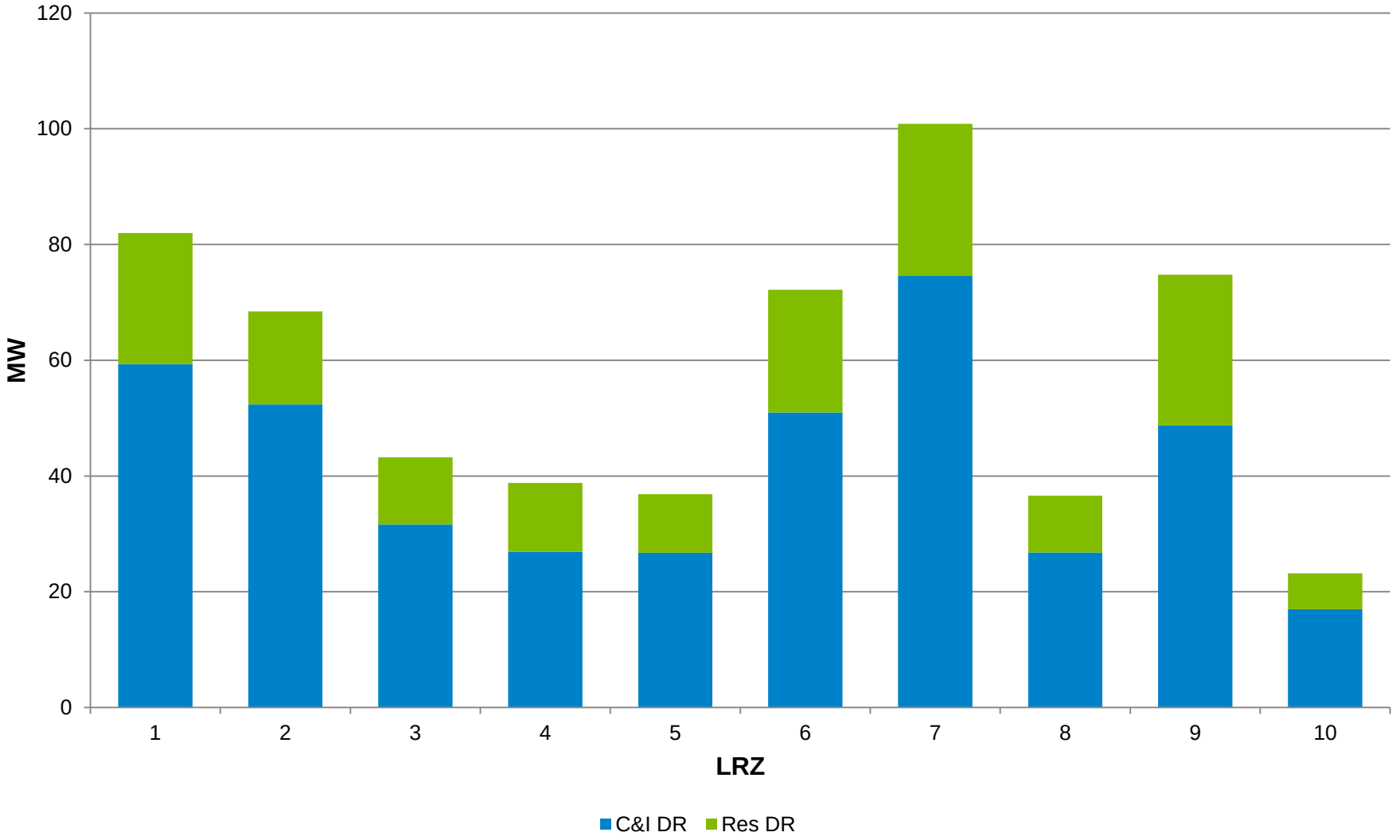
CO2 Emissions - constraint applied only in Accelerated Fleet Change Future



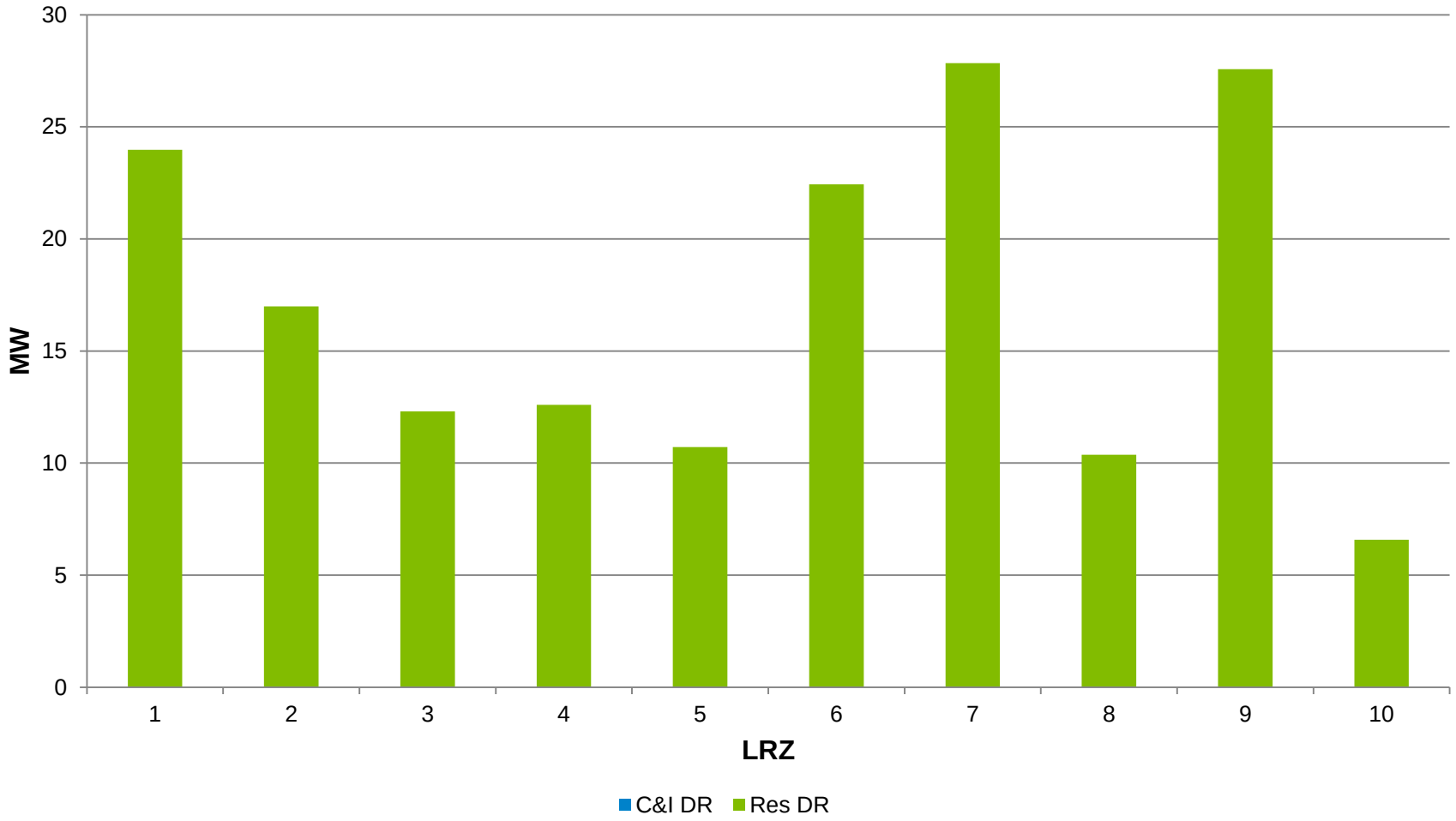
A CO_2 constraint is applied in the Accelerated Fleet Change future targeting 20% emissions reductions by 2030 & continuing on into the future.

Demand Response Additions by LRZ – 2033

Limited Fleet Change

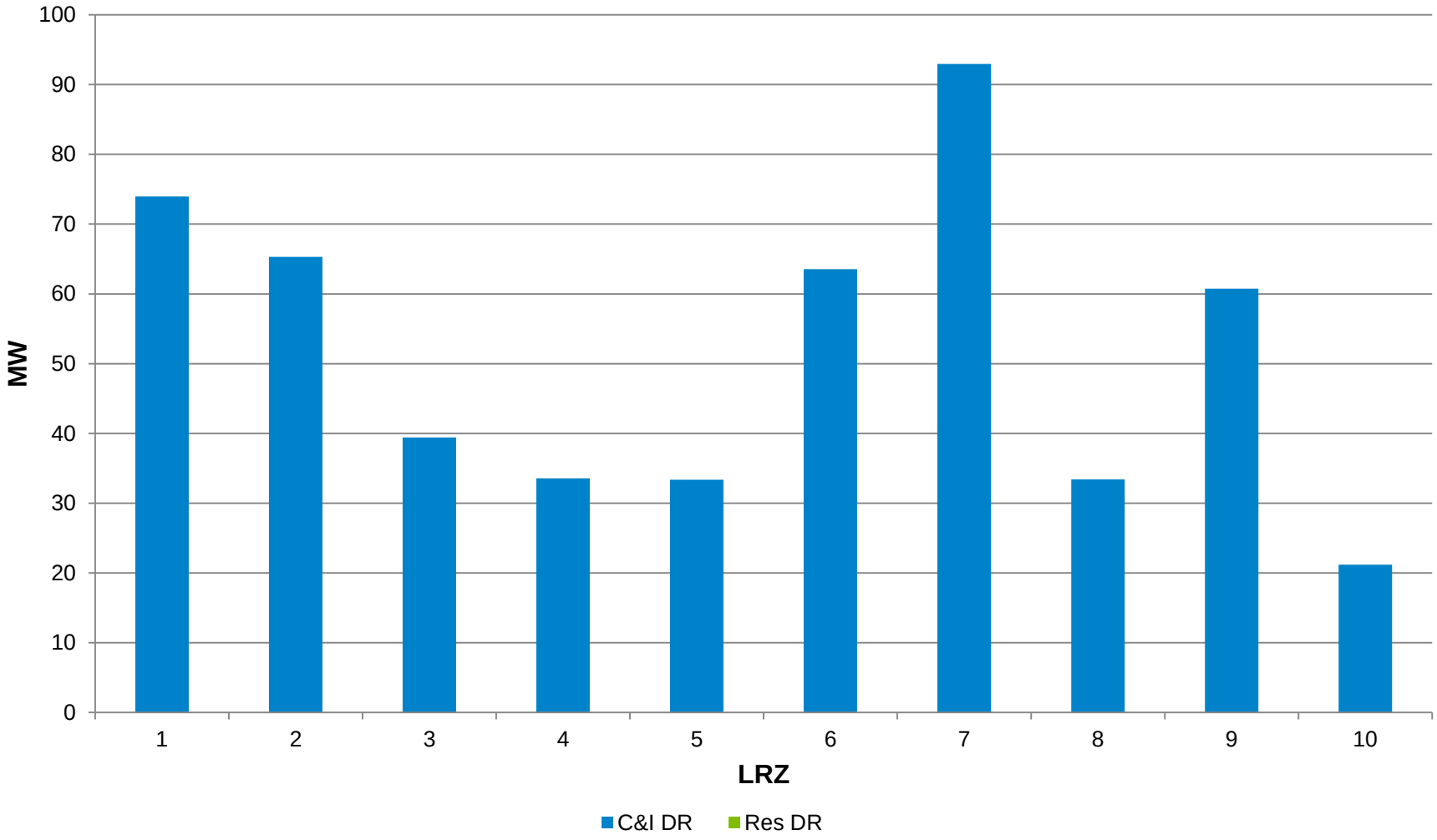


Demand Response Siting by LRZ – 2033
Continued Fleet Change- No C&I DR selected



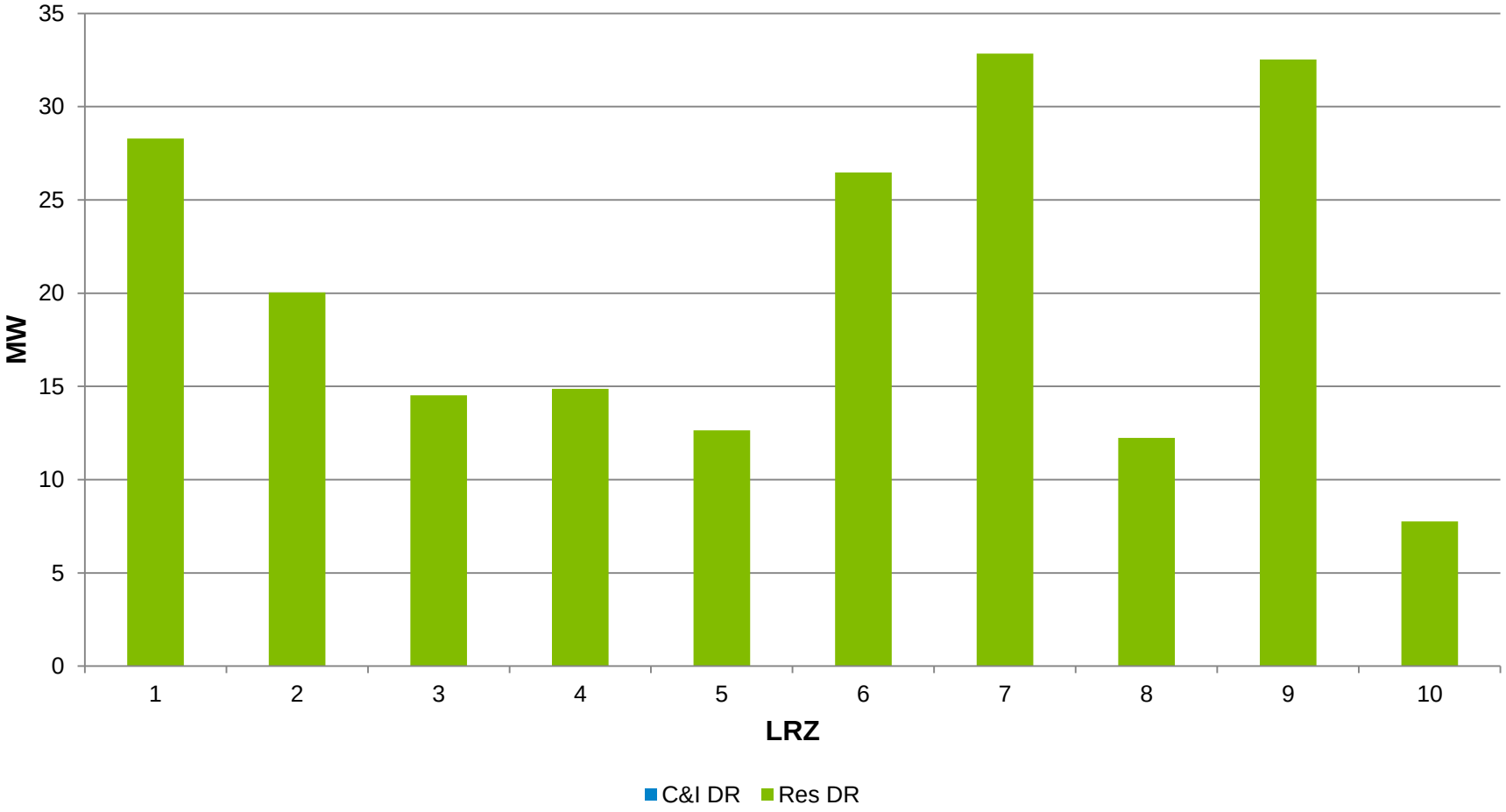
Demand Response Additions by LRZ – 2033

Accelerated Fleet Change- No C&I DR selected



Demand Response Additions by LRZ – 2033

Distributed and Emerging Technologies- No Res DR selected



MTEP19 siting results meet Zonal Resource Adequacy Requirements – 2023

Percentage over zonal Local Clearing Requirement in 2023										
	LRZ 1	**LRZ 2**	**LRZ 3**	**LRZ 4**	**LRZ 5**	**LRZ 6**	**LRZ 7**	**LRZ 8**	**LRZ 9**	**LRZ 10**
LFC	129%	125%	139%	236%	174%	166%	113%	219%	152%	158%
CFC	129%	127%	147%	246%	176%	168%	112%	224%	151%	158%
DET	125%	122%	135%	229%	171%	164%	110%	210%	149%	153%
AFC	126%	121%	142%	225%	169%	164%	111%	205%	147%	153%

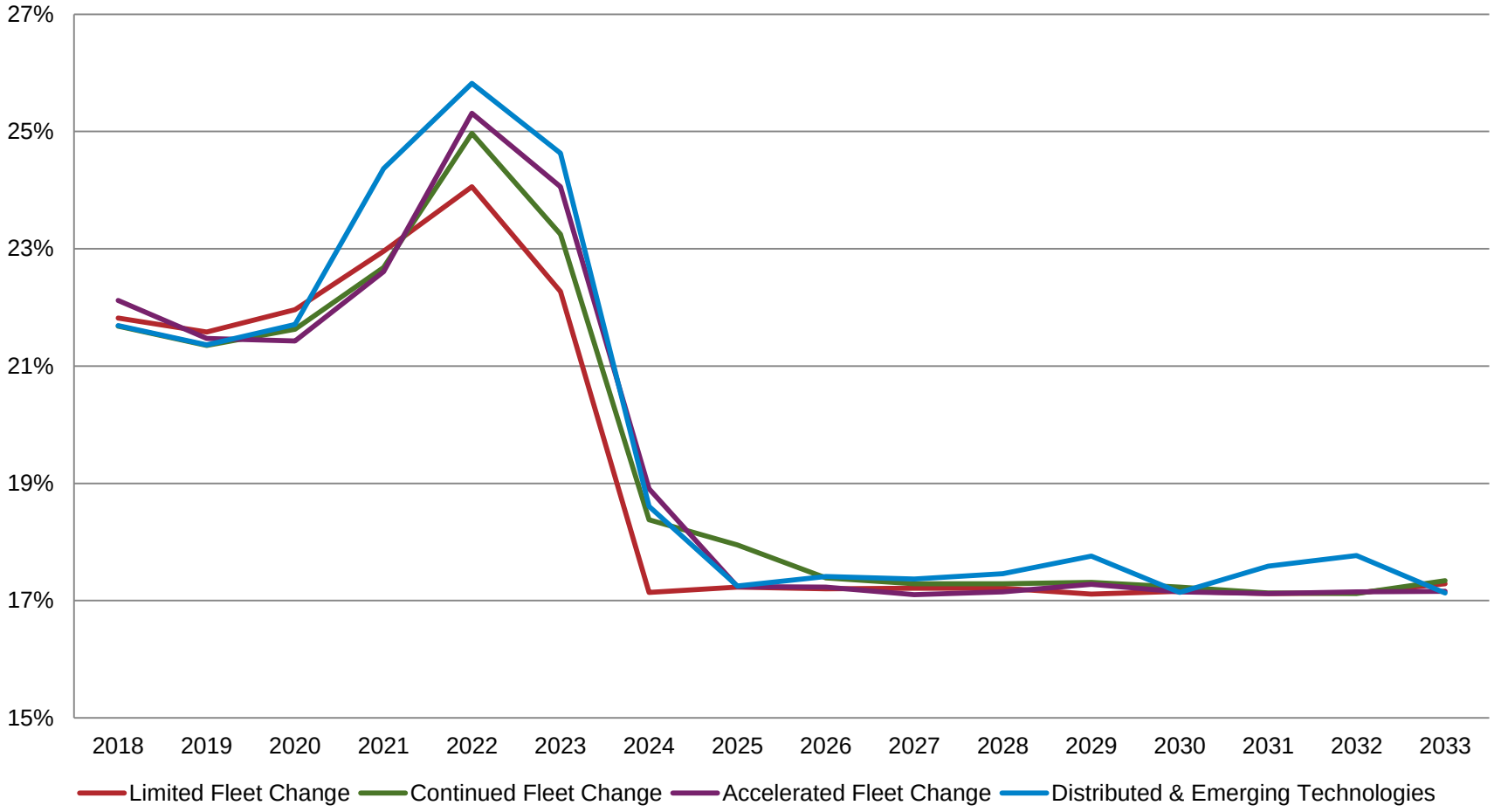
MTEP19 siting results meet Zonal Resource Adequacy Requirements – 2028

Percentage over zonal Local Clearing Requirement in 2028										
	LRZ 1	**LRZ 2**	**LRZ 3**	**LRZ 4**	**LRZ 5**	**LRZ 6**	**LRZ 7**	**LRZ 8**	**LRZ 9**	**LRZ 10**
LFC	129%	118%	140%	215%	166%	152%	116%	222%	143%	148%
CFC	129%	121%	154%	217%	167%	167%	110%	217%	138%	148%
DET	116%	107%	124%	206%	144%	151%	106%	186%	126%	149%
AFC	122%	112%	136%	210%	143%	150%	102%	180%	131%	158%

MTEP19 siting results meet Zonal Resource Adequacy Requirements – 2033

Percentage over zonal Local Clearing Requirement in 2033										
	LRZ 1	**LRZ 2**	**LRZ 3**	**LRZ 4**	**LRZ 5**	**LRZ 6**	**LRZ 7**	**LRZ 8**	**LRZ 9**	**LRZ 10**
LFC	138%	123%	147%	218%	168%	153%	112%	154%	137%	154%
CFC	140%	129%	167%	211%	190%	151%	109%	167%	134%	158%
DET	113%	105%	119%	200%	131%	143%	122%	122%	109%	153%
AFC	131%	113%	137%	198%	151%	135%	106%	120%	121%	164%

MISO Forecasted Planning Reserve Margin from EGEAS Results by MTEP Future



MTEP19 External Region Resource Forecasts

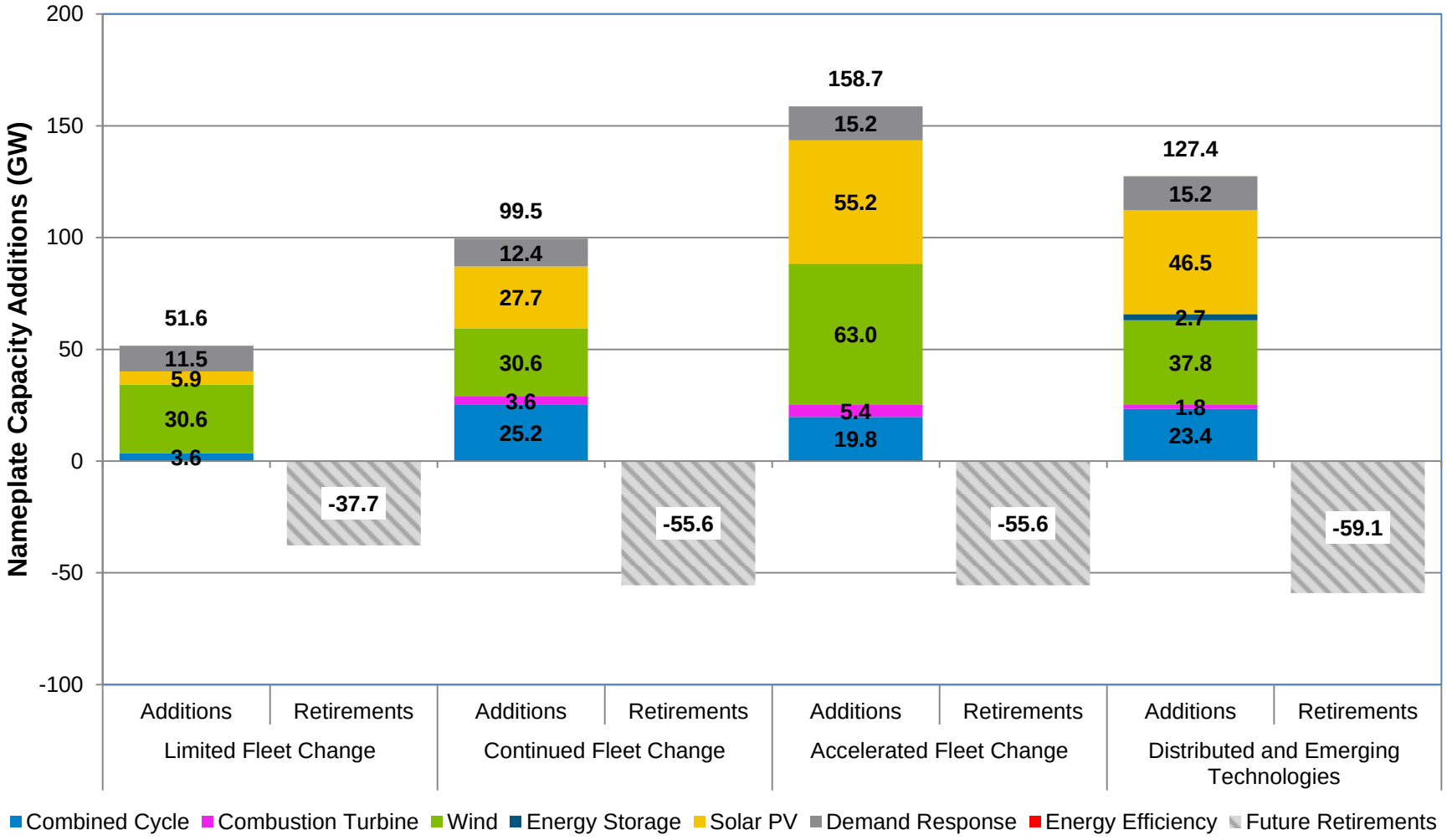
MTEP Modeling of External Regions

- MISO's regional economic models include most of the Eastern Interconnection
- Consistent assumptions are applied to all regions to prevent biases driven solely from differing assumptions
- Regional differences modeled when available and appropriate (e.g. demand and energy forecasts, natural gas transportation adders, site-specific wind and solar profiles)
- In MTEP19 futures, carbon reduction assumptions consistent with MISO's were applied to all regions in the Accelerated Fleet Change future
  - Assumed historical trend coal retirements for external regions modeled at the same age threshold as MISO coal fleet
  - Age-based retirements use consistent age limits from MISO fleet analysis
- MISO regularly coordinates with neighboring regions to update base data and information

MTEP Resource Forecast Regional Definitions

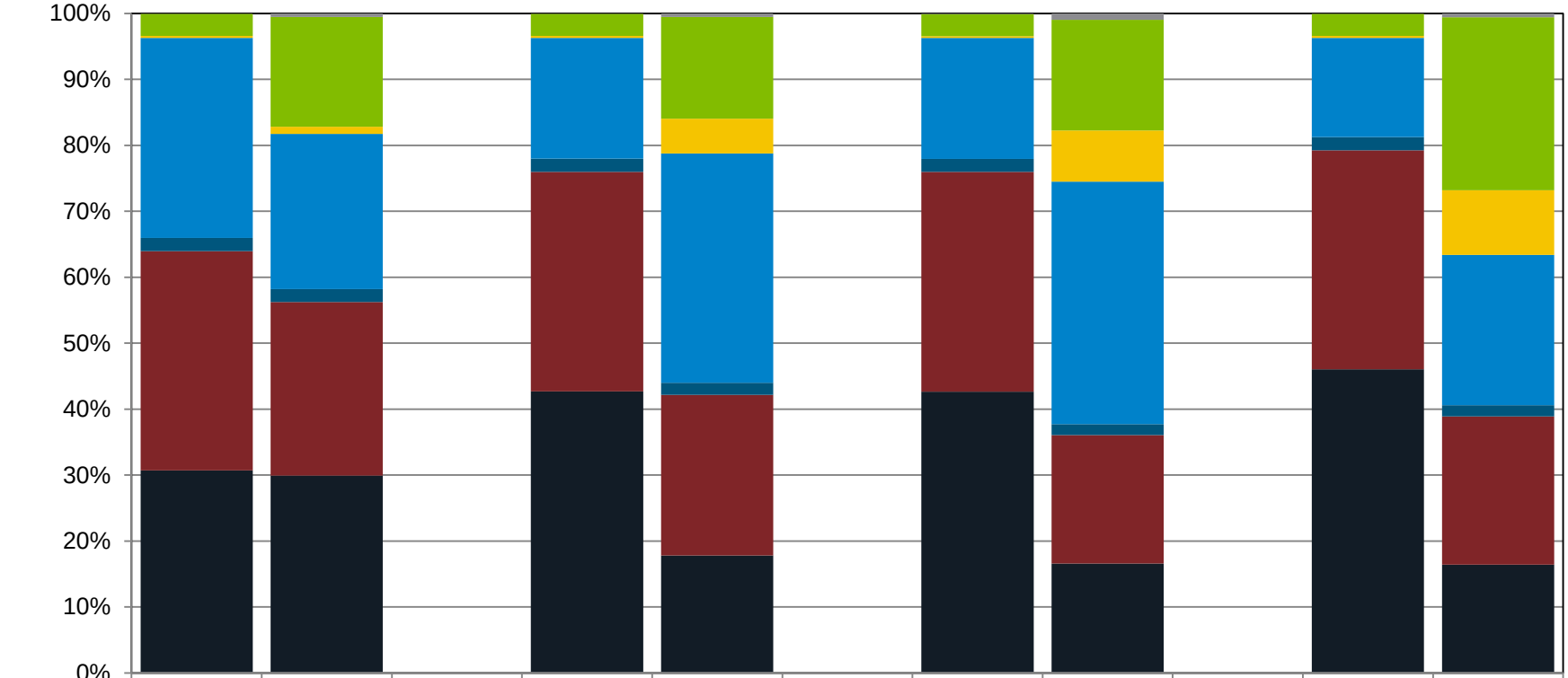
- MISO
- PJM
- SPP (Includes Integrated System)
- NYISO
- Southeastern Regional Transmission Planning Region
  - **SERC**
    - SOCO
    - Duke
    - AEC
    - CPL
    - SC
    - SCEG
  - **TVA Region**
    - TVA
    - AECI
    - LG&E

MTEP19 PJM Nameplate Capacity Forecast
(Year 2018 – 2033)



MTEP19 PJM Energy Comparisons by Future

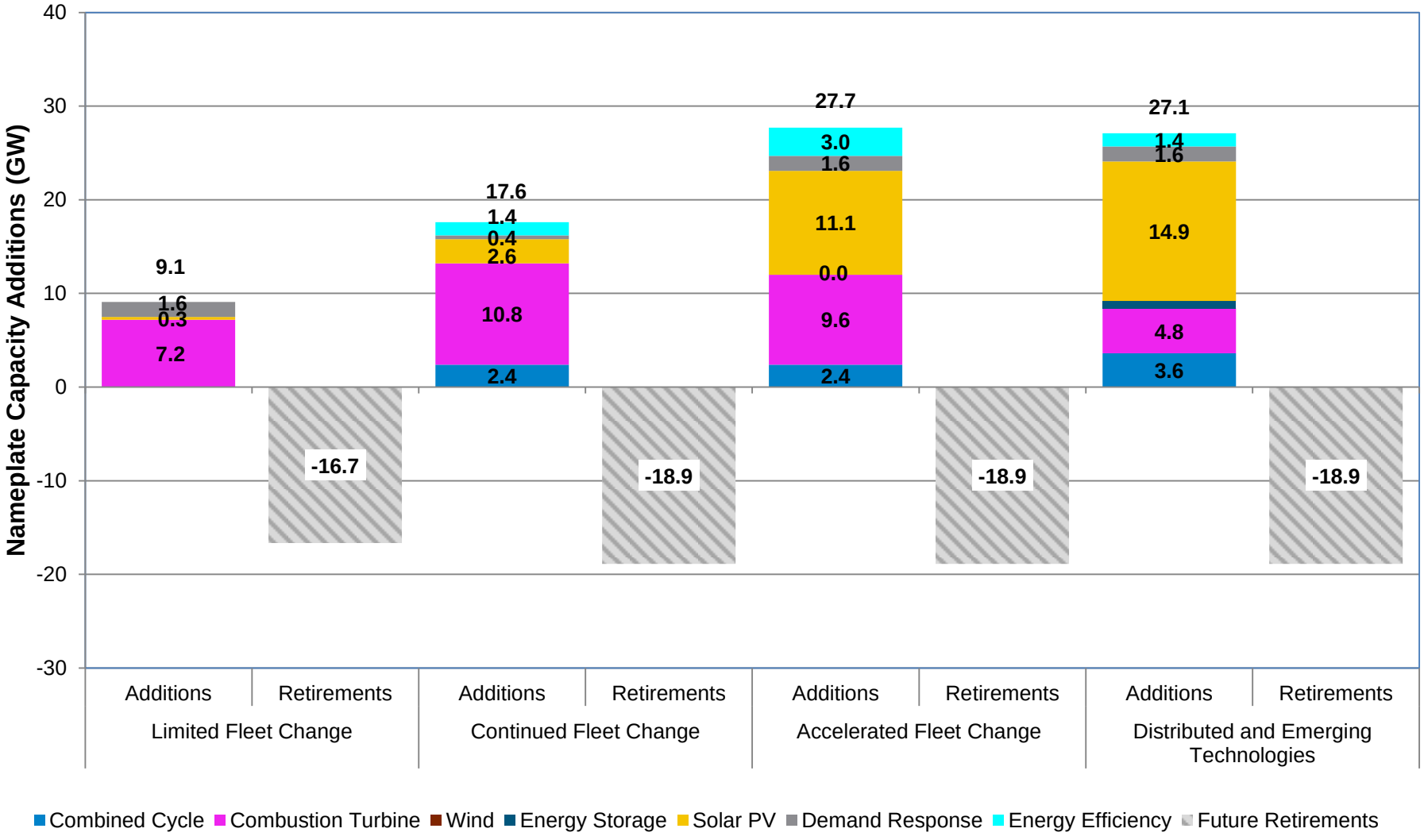
(Year 2018 vs 2033)



	LFC 2018	LFC 2033		CFC 2018	CFC 2033		DET 2018	DET 2033		AFC 2018	AFC 2033
DSM	0%	1%		0%	1%		0%	1%		0%	1%
Wind	3%	17%		3%	15%		3%	17%		3%	26%
Solar PV	0%	1%		0%	5%		0%	8%		0%	10%
Gas	30%	23%		18%	35%		18%	37%		15%	23%
Hydro	2%	2%		2%	2%		2%	2%		2%	2%
Nuclear	33%	26%		33%	24%		33%	19%		33%	22%
Coal	31%	30%		43%	18%		43%	17%		46%	16%

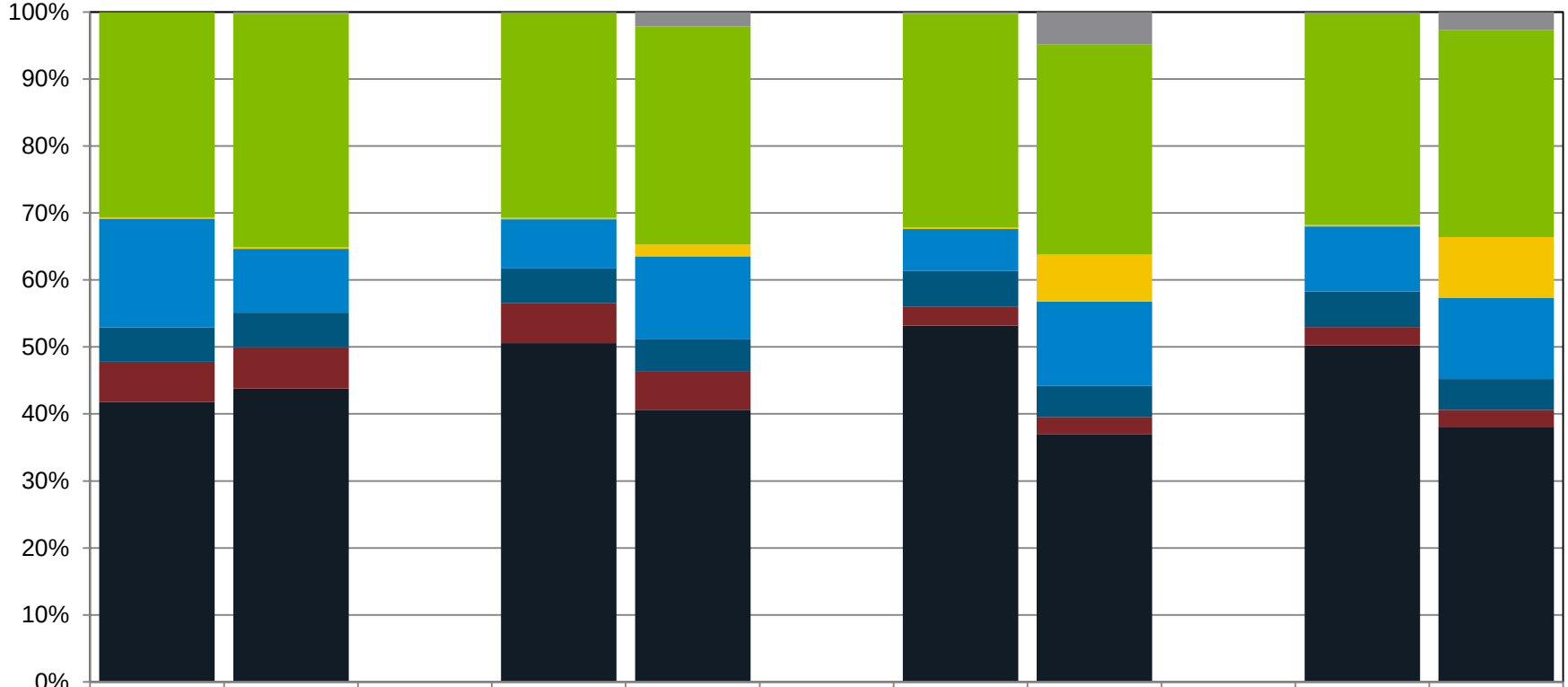
MTEP19 SPP Nameplate Capacity Forecast

(Year 2018 – 2033)



MTEP19 SPP Energy Comparisons by Future

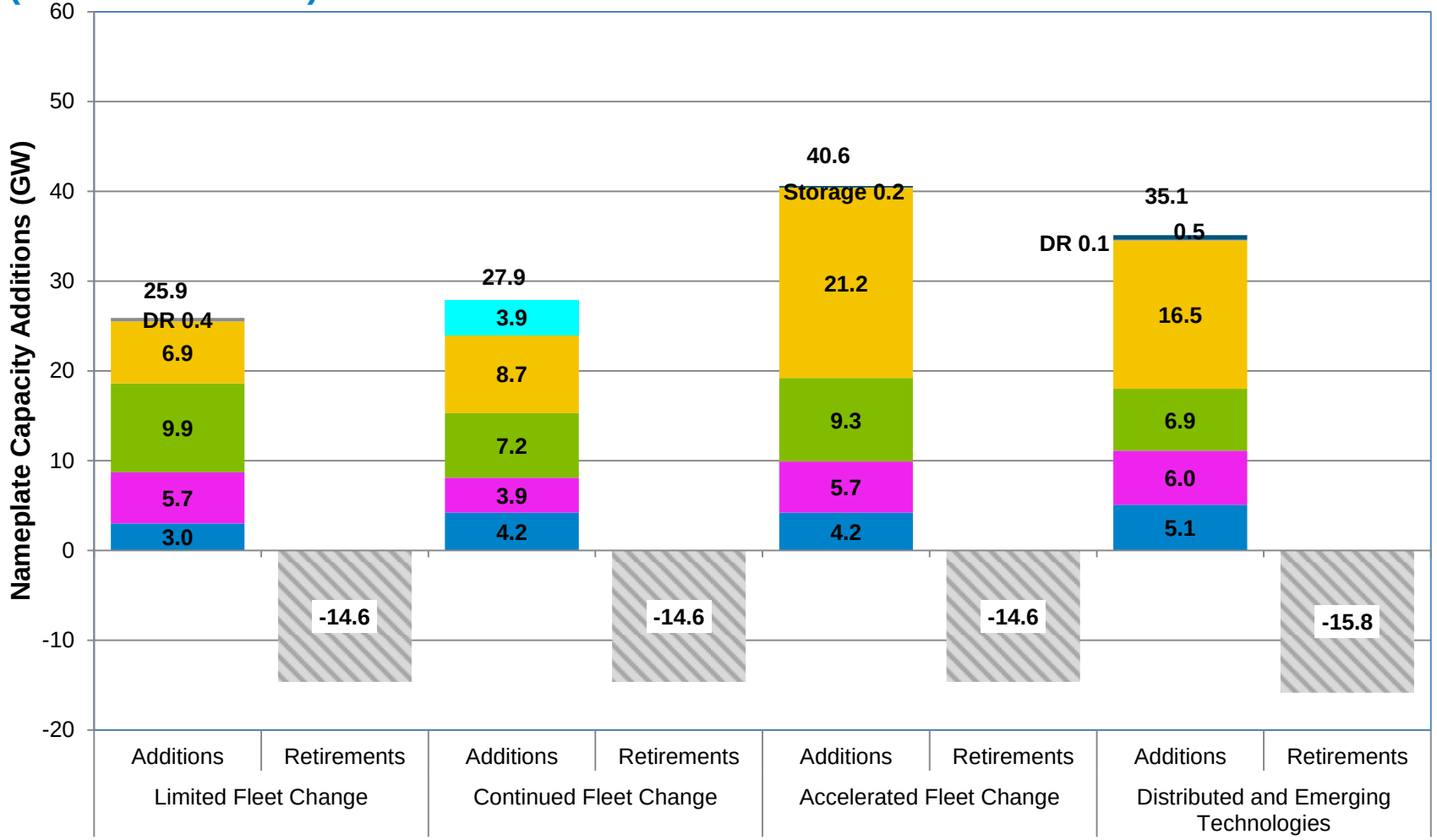
(Year 2018 vs 2033)



	LFC 2018	LFC 2033		CFC 2018	CFC 2033		AFC 2018	AFC 2033		DET 2018	DET 2033
DSM	0%	0%		0%	2%		0%	5%		0%	3%
Wind	30%	35%		30%	32%		32%	31%		31%	31%
Solar PV	0%	0%		0%	2%		0%	7%		0%	9%
Gas	16%	9%		7%	12%		6%	13%		10%	12%
Hydro	5%	5%		5%	5%		5%	5%		5%	5%
Nuclear	6%	6%		6%	6%		3%	3%		3%	3%
Coal	41%	44%		50%	40%		53%	37%		50%	38%

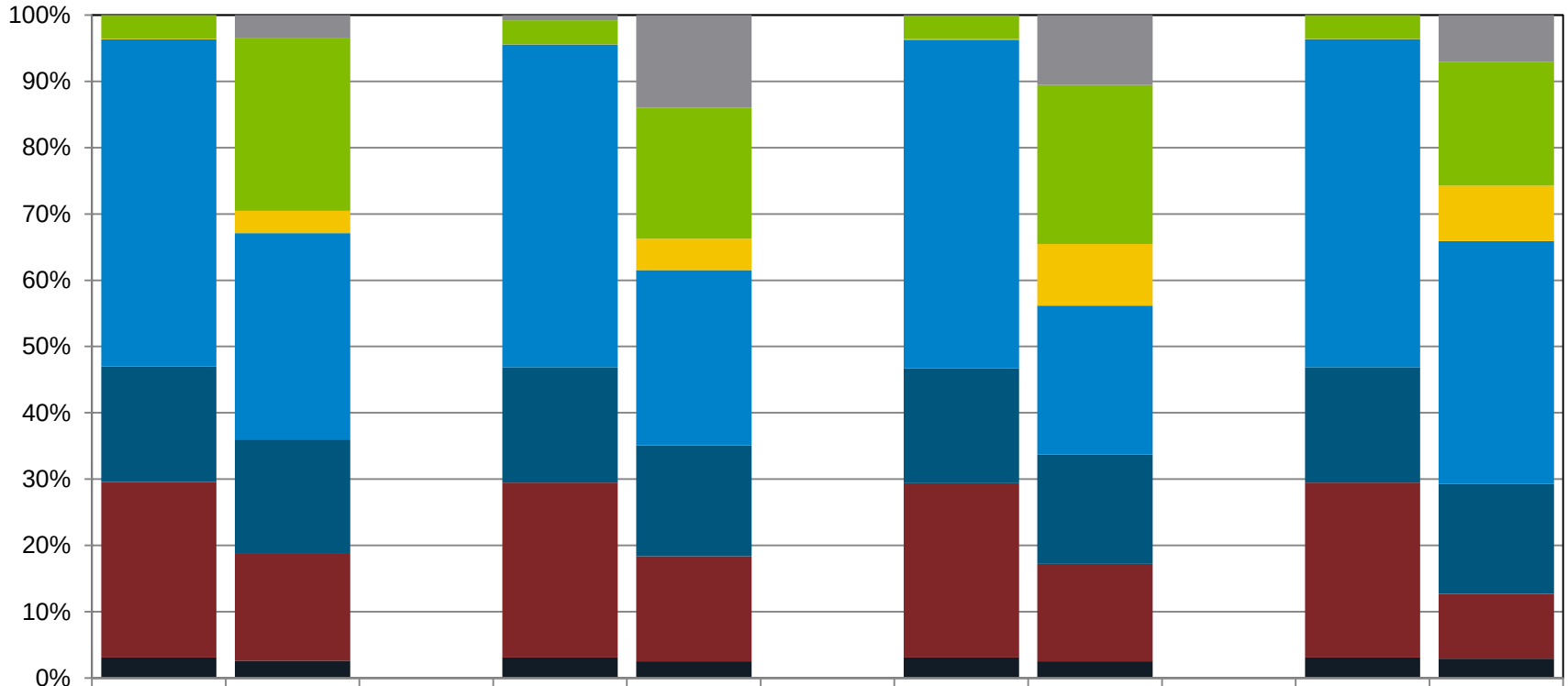
MTEP19 NYISO Nameplate Capacity Forecast

(Year 2018 – 2033)



MTEP19 NYISO Energy Comparisons by Future

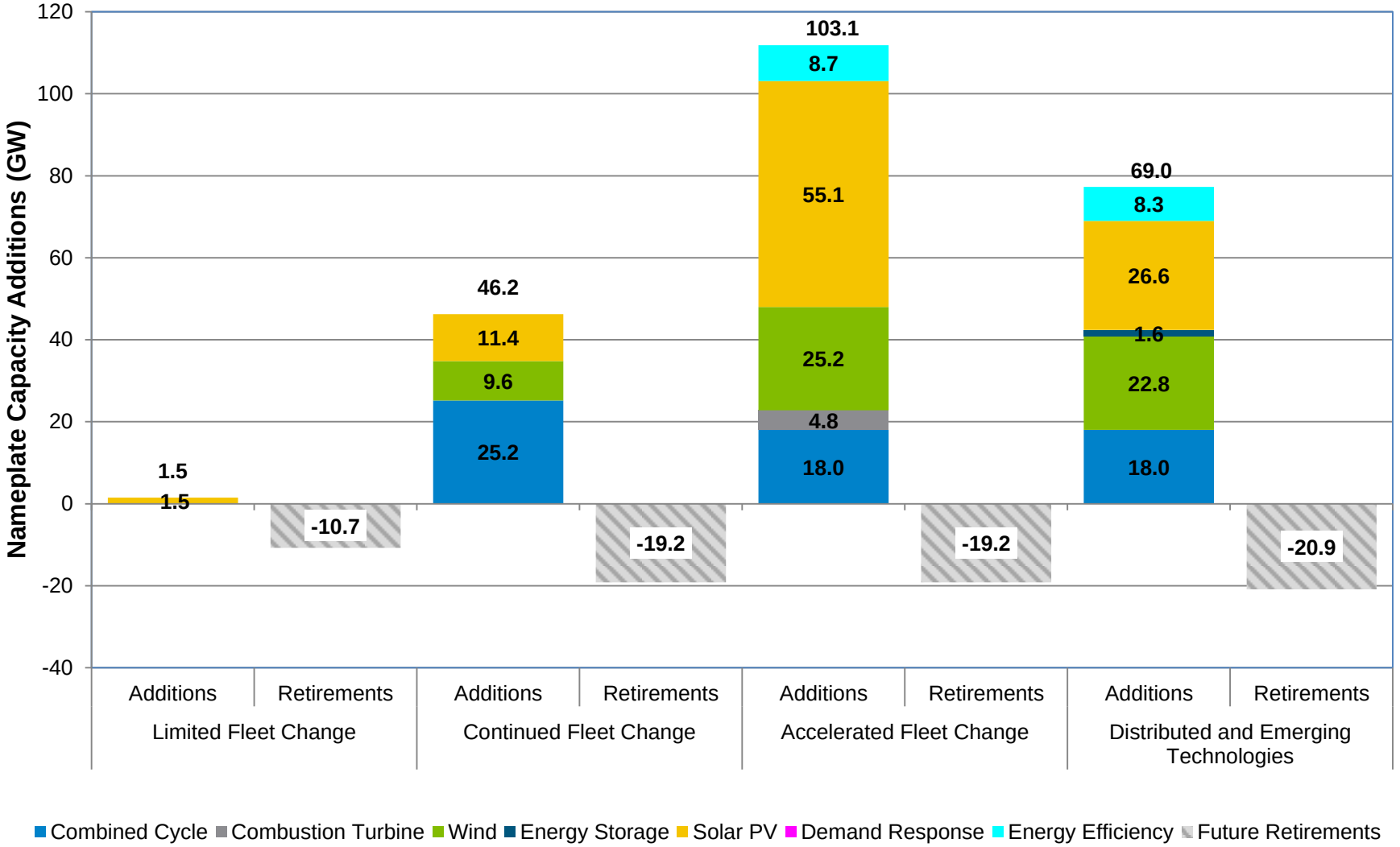
(Year 2018 vs 2033)



	LFC 2018	LFC 2033		CFC 2018	CFC 2033		AFC 2018	AFC 2033		DET 2018	DET 2033
DSM	0%	3%		1%	14%		0%	11%		0%	7%
Wind	4%	26%		4%	20%		4%	24%		4%	19%
Solar PV	0%	3%		0%	5%		0%	9%		0%	8%
Gas	49%	31%		49%	26%		50%	22%		49%	37%
Hydro	17%	17%		17%	17%		17%	17%		17%	17%
Nuclear	26%	16%		26%	16%		26%	15%		26%	10%
Coal	3%	3%		3%	3%		3%	3%		3%	3%

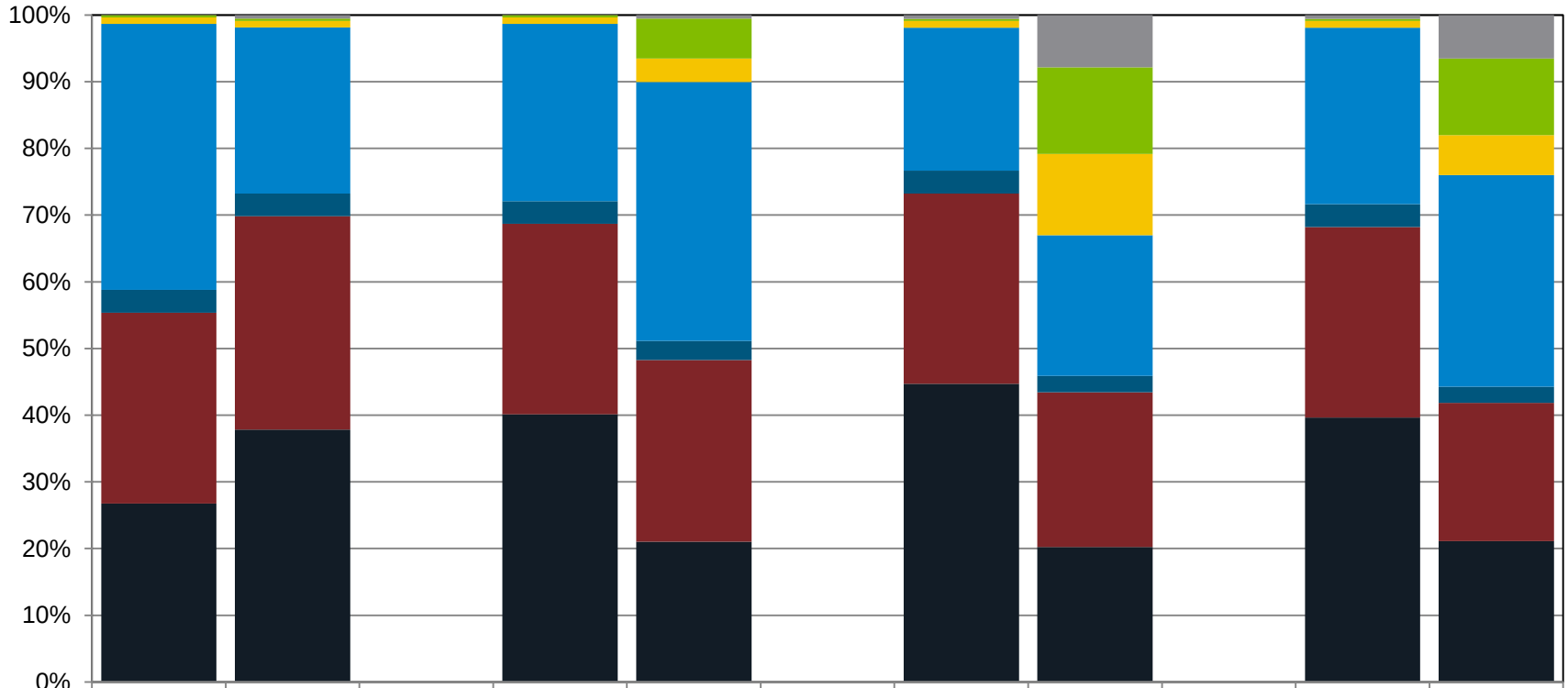
MTEP19 SERC Nameplate Capacity Forecast

(Year 2018 – 2033)



MTEP19 SERC Energy Comparisons by Future

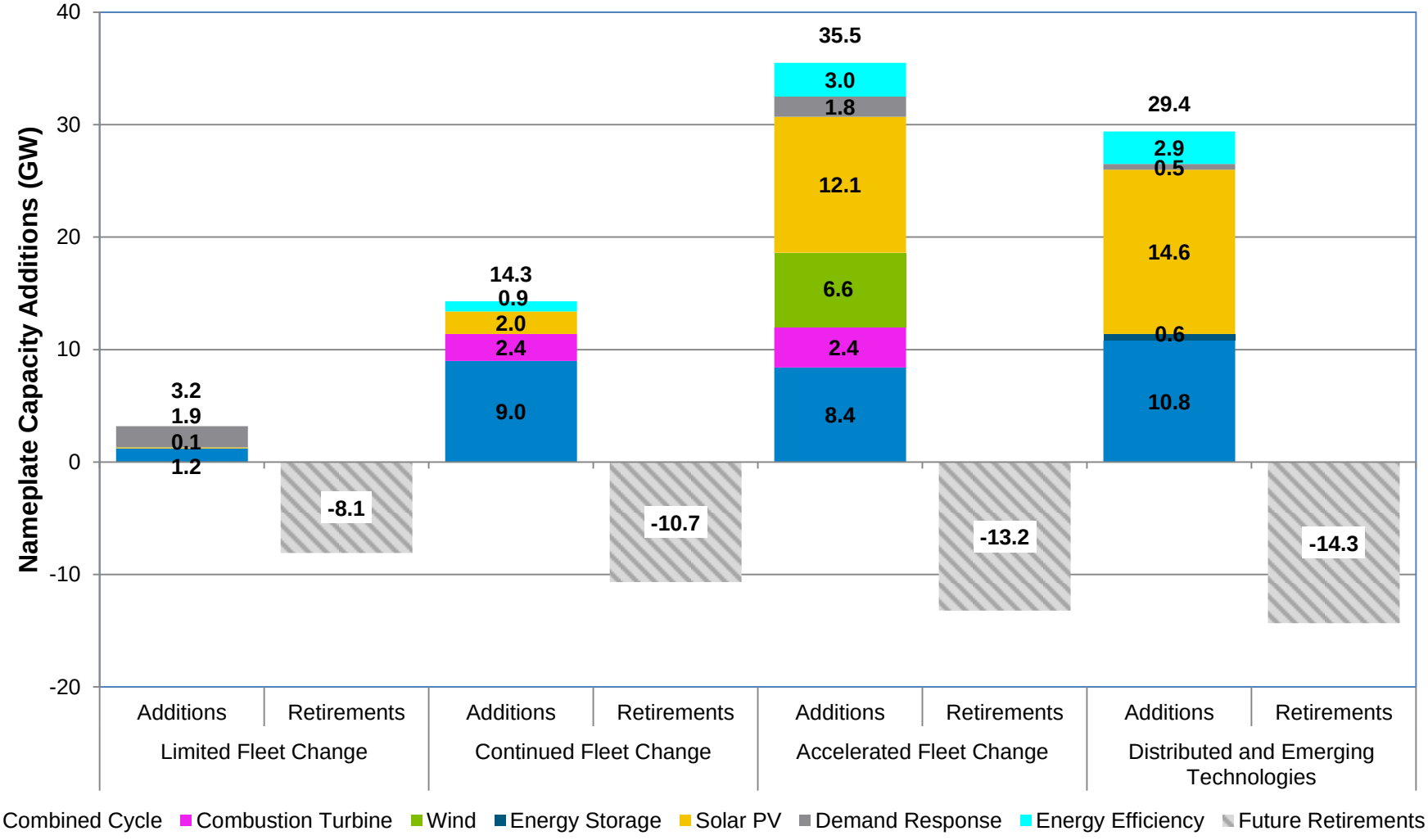
(Year 2018 vs 2033)



	LFC 2018	LFC 2033		CFC 2018	CFC 2033		AFC 2018	AFC 2033		DET 2018	DET 2033
DSM	0%	1%		0%	1%		1%	8%		1%	7%
Wind	0%	0%		0%	6%		0%	13%		0%	11%
Solar PV	1%	1%		1%	4%		1%	12%		1%	6%
Gas	40%	25%		27%	39%		21%	21%		26%	32%
Hydro	3%	3%		3%	3%		3%	2%		3%	2%
Nuclear	29%	32%		29%	27%		29%	23%		29%	21%
Coal	27%	38%		40%	21%		45%	20%		40%	21%

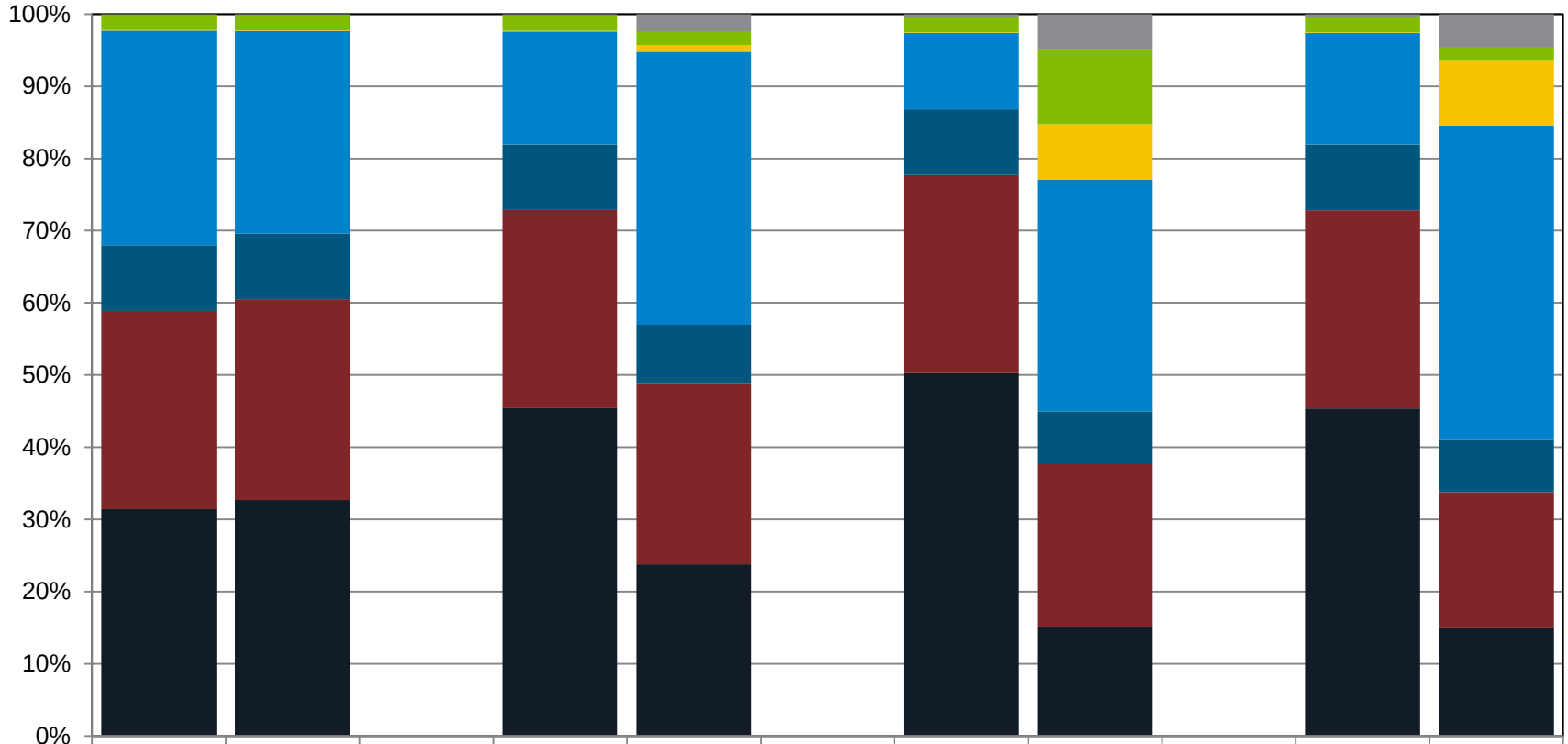
MTEP19 TVA Region Nameplate Capacity Forecast

(Year 2018 – 2033)



MTEP19 TVA Region Energy Comparisons by Future

(Year 2018 vs 2033)



	LFC 2018	LFC 2033		CFC 2018	CFC 2033		AFC 2018	AFC 2033		DET 2018	DET 2033
DSM	0%	0%		0%	2%		0%	5%		0%	5%
Wind	2%	2%		2%	2%		2%	10%		2%	2%
Solar PV	0%	0%		0%	1%		0%	8%		0%	9%
Gas	30%	28%		16%	38%		11%	32%		15%	44%
Hydro	9%	9%		9%	8%		9%	7%		9%	7%
Nuclear	27%	28%		27%	25%		27%	22%		27%	19%
Coal	31%	33%		45%	24%		50%	15%		45%	15%

References

Additional information on the MTEP19 Futures can be found in the following meeting materials:

- January 17 Planning Advisory Committee – MTEP19 Futures Development Schedule & Expectations
  - https://www.misoenergy.org/events/planning-advisory-committee-pac-2018/
- February 14 Planning Advisory Committee – MTEP19 Futures Development
  - https://www.misoenergy.org/events/planning-advisory-committee-pac---february-14-2018/
- March 20 Futures Development Workshop
  - https://www.misoenergy.org/events/mtep19-futures-development-workshop---march-20-2018/
- March 22 Siting Workshop
  - https://www.misoenergy.org/events/mtep19-siting-workshop---march-22-2018/
- March 22 Applied Energy Group Workshop
  - https://www.misoenergy.org/events/mtep19-siting-workshop-2---january-18-2018222/
- April 18 Planning Advisory Committee – MTEP19 Futures Presentation
  - https://www.misoenergy.org/events/planning-advisory-committee-pac---april-18-2018/
- June 13 Planning Advisory Committee – MTEP19 Futures Definitions
  - https://www.misoenergy.org/events/planning-advisory-committee-pac---june-13-2018/
- September 26 Planning Advisory Committee – MTEP19 Futures Review & Draft Siting
  - https://www.misoenergy.org/events/planning-advisory-committee-pac---september-26-2018/