MISO's Long Range Transmission Planning Process

March 8, 2024

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SUSTAINABLE FERC PROJECT

NRDC

“The goal of LRTP is to evaluate the system’s transmission needs through a variety of lenses, including both regional and project-specific assessments, with a goal of optimizing the total investment costs (inclusive of generation).”

https://cdn.misoenergy.org/20230717%20ERSC%20Item%2007%20Transmission%20Planning629604.pdf

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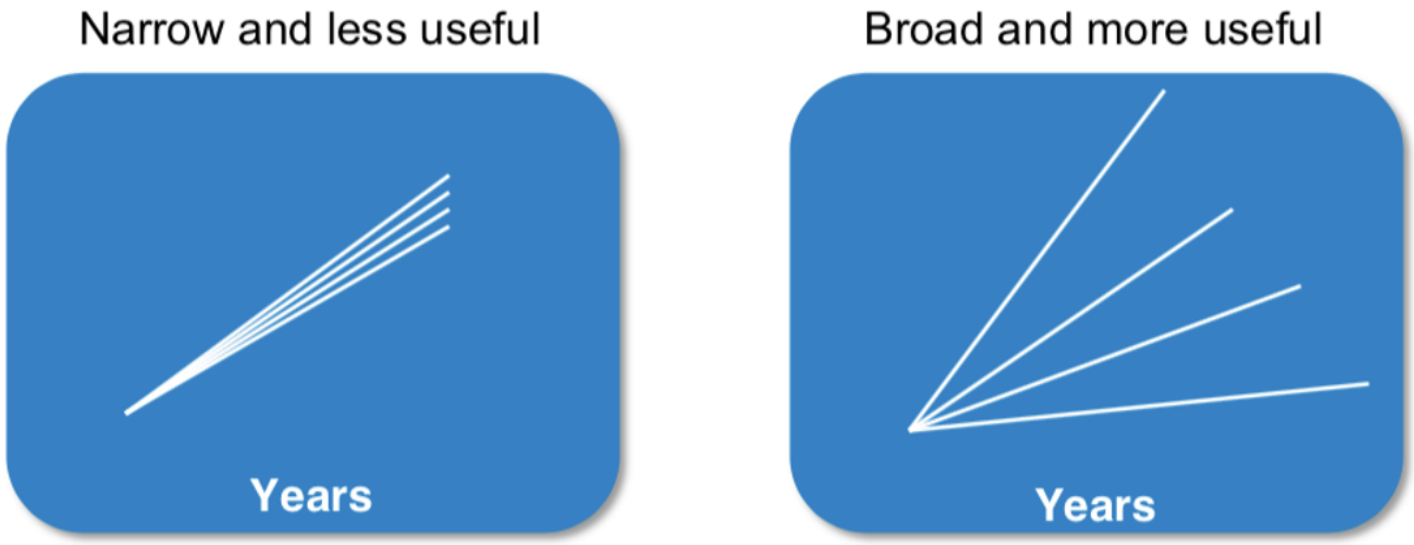
SCENARIO PLANNING

- The future is uncertain, but we cannot wait for the future to arrive to build the infrastructure that will be needed when it will take 10 to 15 years to build.

- Use multiple plausible future scenarios, and plan for a transmission grid that brings broad regional benefits under each of these scenarios.



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MISO's SCENARIO PLANNING FOLLOWS SEVEN STEPS

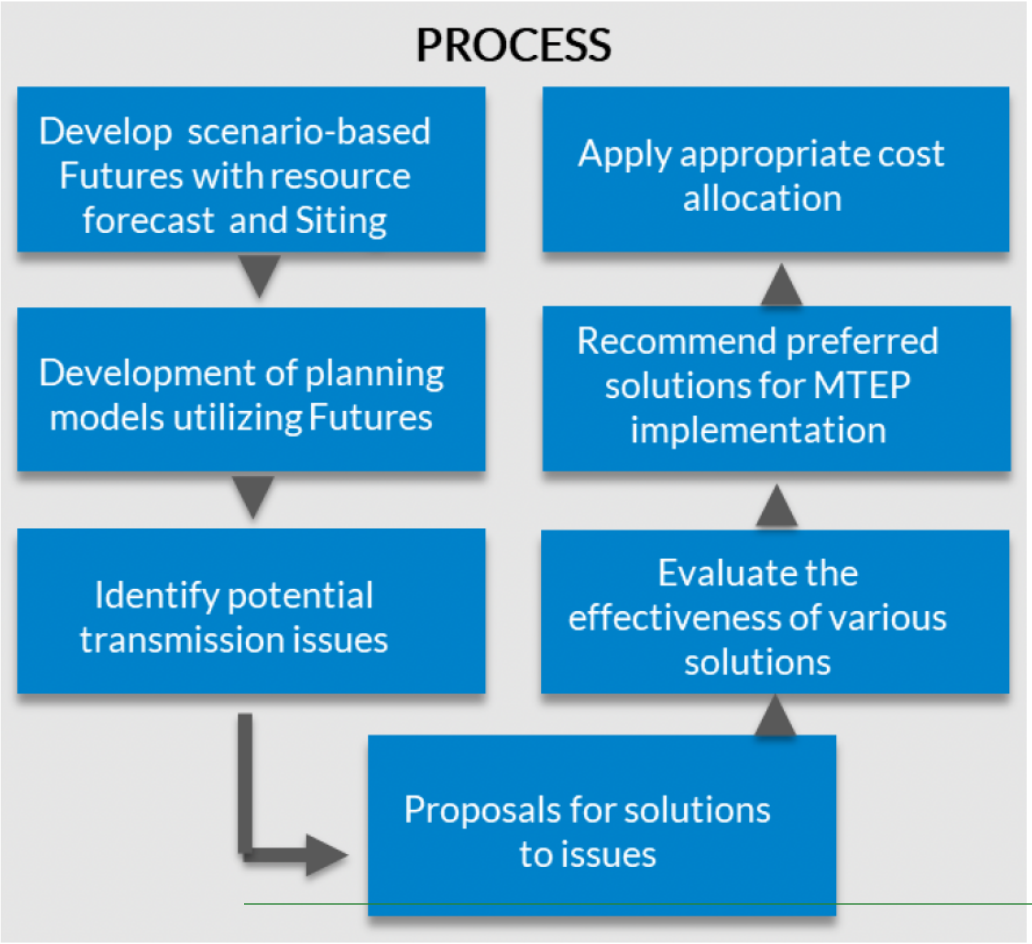

Figure 1.2-4: MISO's 7-step planning process

Source: MTEP22 Report

Step 1
Through a rigorous stakeholder process, update future scenario assumptions for resource mix and load in the 20-year horizon; key parameters = load + reserves, costs, emissions, utility plans, clean energy targets, etc.

Step 2
Develop reliability and economic models based on Futures to evaluate a variety of conditions

Step 3
Perform reliability and economic analysis to identify TX issues/needs

Step 4-5
Accept proposed and evaluate TX solutions identified by MISO and stakeholders

Step 6
Recommend preferred solutions to ensure reliability, cost-effectiveness over time based on evaluation of economic benefits with stakeholder review and input

Step 7
Apply appropriate tariff-based cost allocation based on project classification

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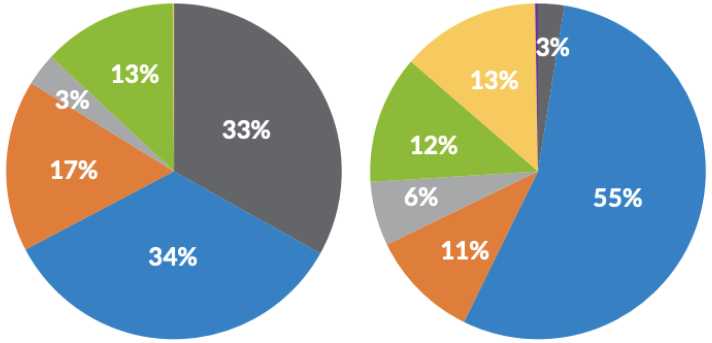
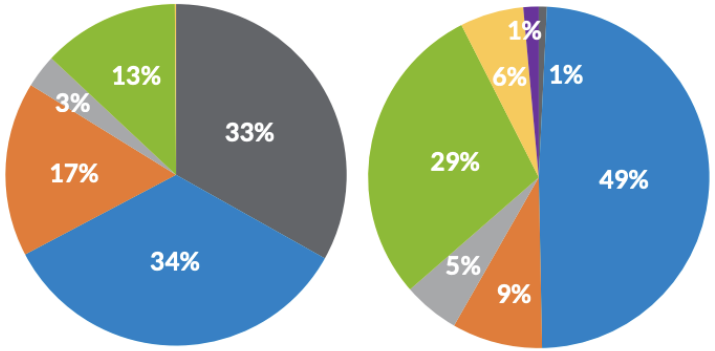
MISO FUTURES SERIES 1 - ENERGY GENERATION

FUTURE 1



2020 2039

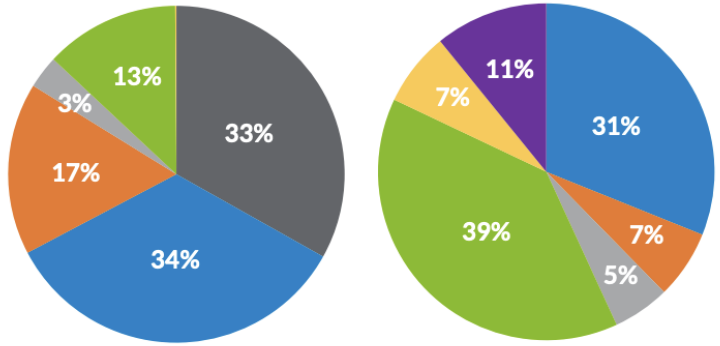
FUTURE 2



2020 2039

Coal
Gas
Nuclear
Other
Wind
Solar
Battery

FUTURE 3



2020 2039

Source: https://cdn.misoenergy.org/MISO%20Futures%20One%20Pager538214.pdf

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MISO LRTP Lessons Learned

- Support from MISO States is critical to moving MISO forward on comprehensive scenario-based planning.
- Transmission planning that uses a long planning horizon and considers all utility plans and state clean energy laws under a range of potential futures results in a cost-effective and durable transmission plan that can serve the region for a longer period of time.
- Evaluating a group or portfolio of projects using a range of benefit metrics helps to plan and gain support for transmission that brings broad benefits to all utilities and states.

The Road to the First Multi Value Project Portfolio

2003 MTEP03 Exploratory Study

2005 Board of Directors Guiding Principles

2006 MTEP 05 Exploratory Study

Value-Based Planning Process

2007 MTEP 06 Energy Market Planning Analysis

FERC Order 890

MISO Governors request Generation Interconnection Queue Reform

2008 6 States in MISO have Renewable Portfolio Standards

Joint Coordinated System Plan

Upper Midwest Transmission Development Initiative Created

2009 10 States in MISO have Renewable Portfolio Standards

Regional Generation Outlet Study I

OMS Cost Allocation and Regional Planning Work Group Created

Regional Generation Outlet Study II

Midwestern Governors Association supports Energy Zones Methodology

2010 Multi Value Project Tariff Development

Multi Value Project FERC Order

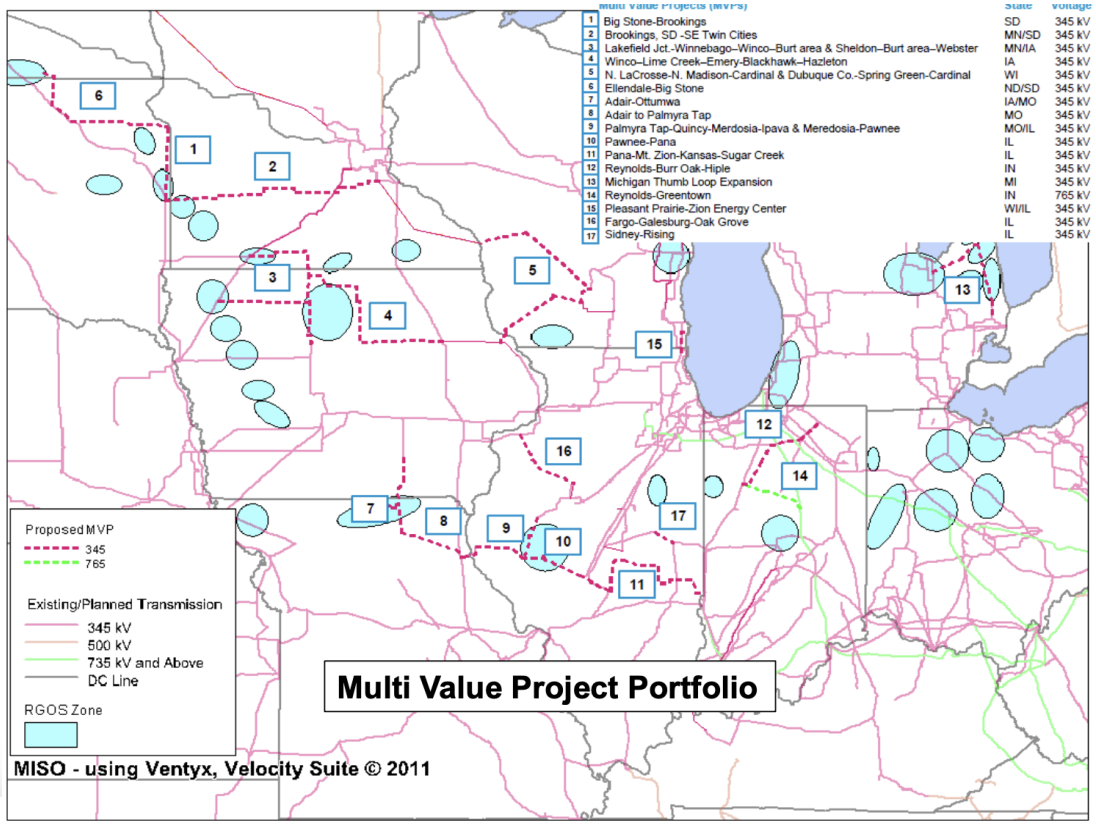
Candidate Multi Value Project Portfolio Analysis

2011 FERC Order 1000

First Multi Value Project Portfolio approved by BOD

MISO

Explorations of the policy, processes, and transmission solutions required to provide the best value for consumers began in 2003



https://cdn.misoenergy.org/2011%20MVP%20Portfolio%20Analysis%20Full%20Report117059.pdf

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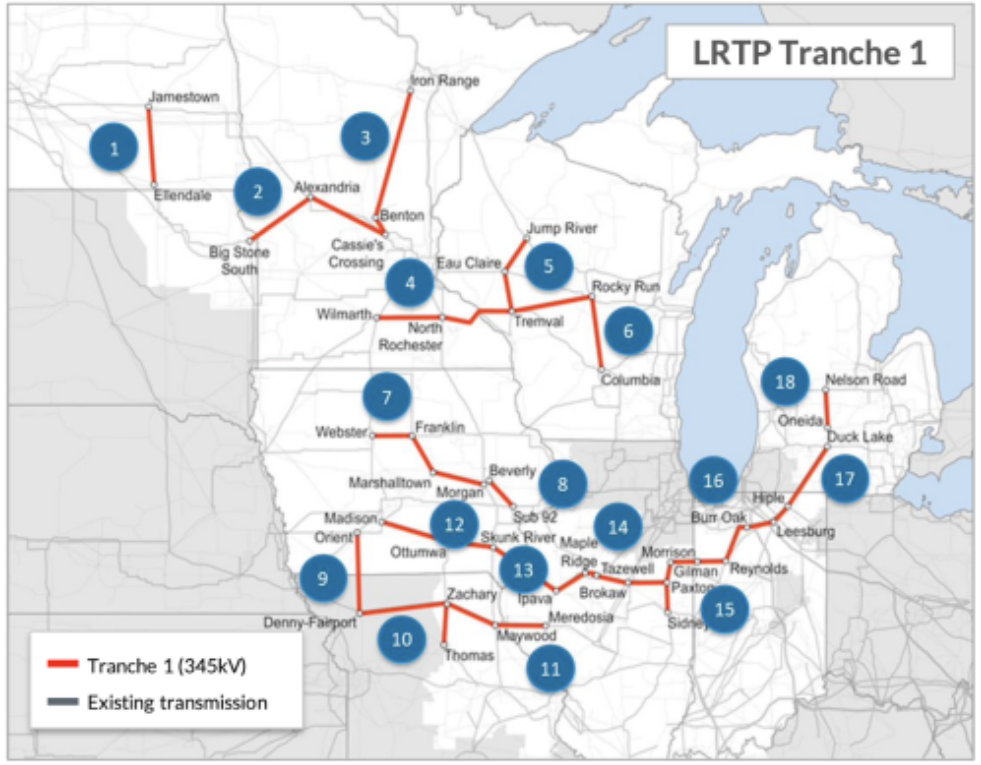
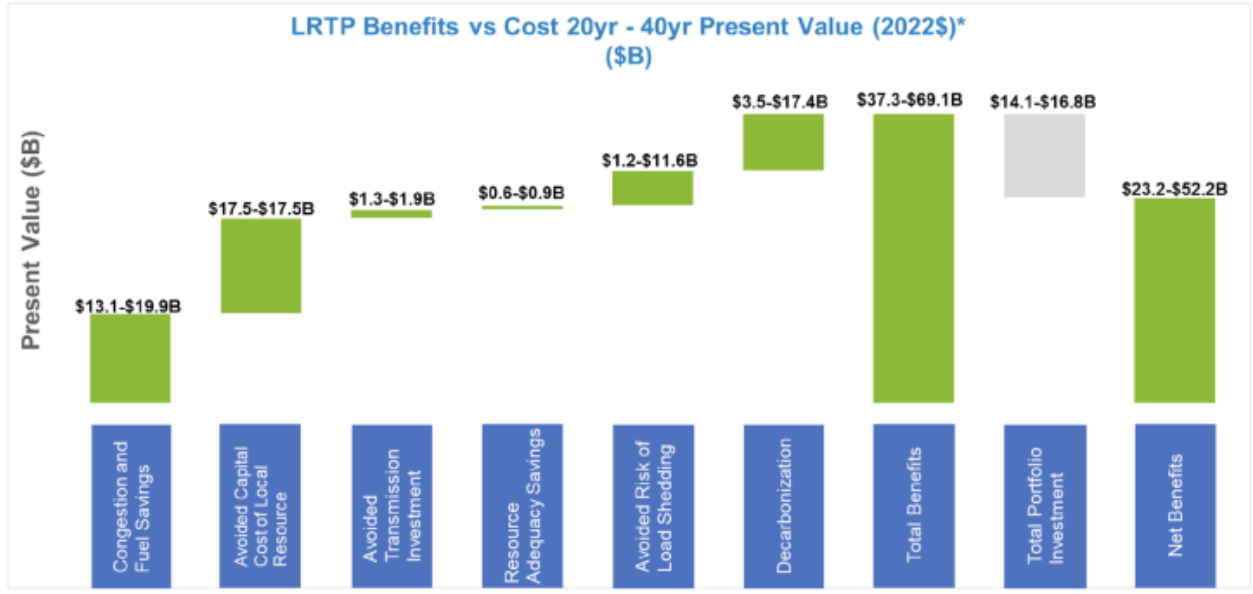
MISO's Tranche 1 Portfolio

Tranche 1 represents the first iteration and includes 18 projects across the MISO Midwest subregion estimated at $10.3 billion



Assumption on all in-service dates is by 2030

The business case analysis indicates total economic benefits significantly exceed cost of the Tranche 1 LRTP portfolio



Source: https://cdn.misoenergy.org/LRTP%20Tranche%201%20Detailed%20Business%20Case625789.pdf

Source: MTEP21 Report Addendum on Long Range Transmission Planning Tranche 1 retrieved at https://cdn.misoenergy.org/MTEP21%20Addendum-LRTP%20Tranche%201%20Report%20with%20Executive%20Summary625790.pdf

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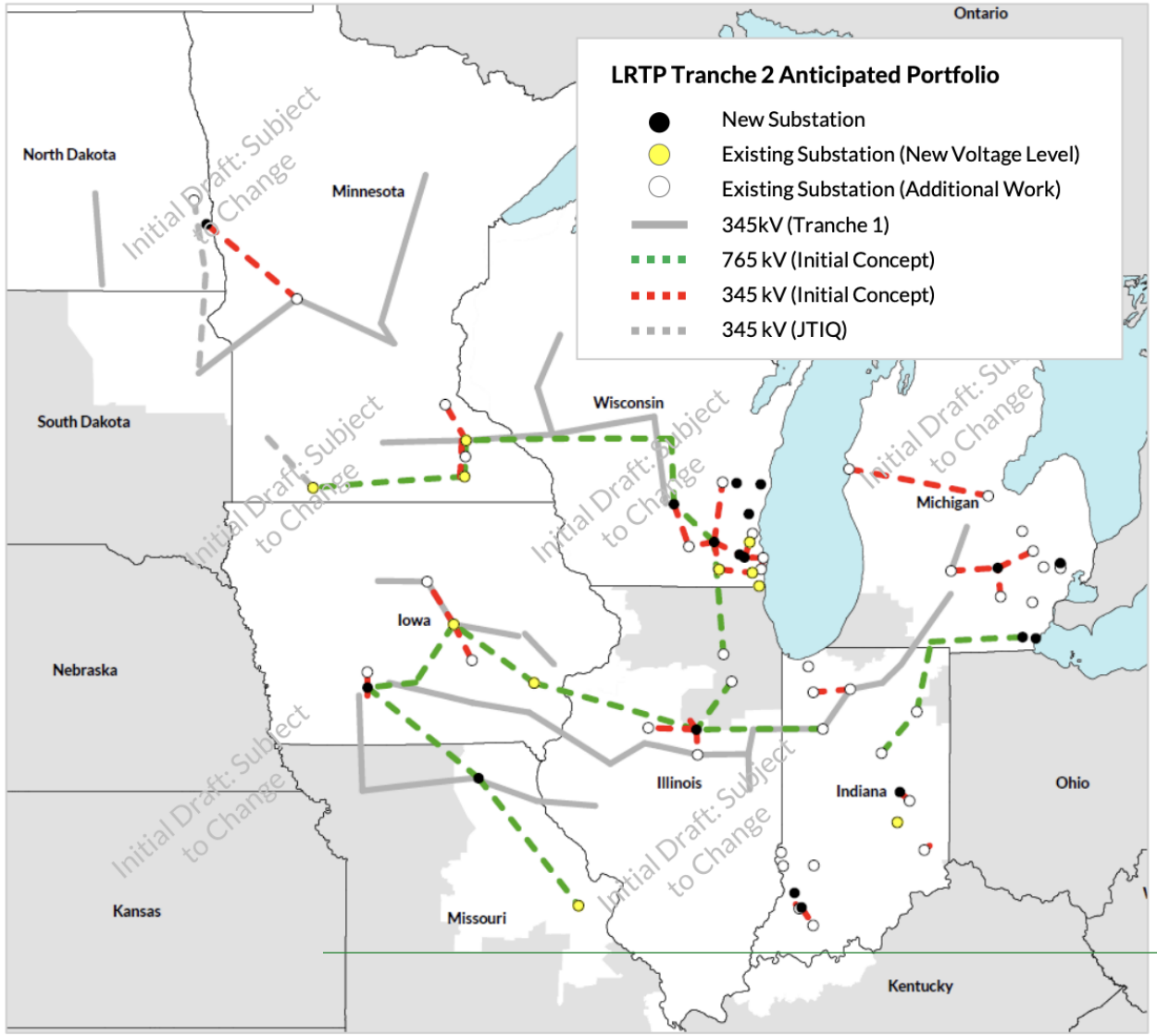
Tranche 2 Hypothesis Lines - shared March 2024



Note: This map may be adjusted, based on stakeholder feedback.

Source - https://cdn.misoenergy.org/20240315%20LRTP%20Workshop%20Tranche%202%20Anticipated%20Portfolio632013.pdf

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Questions?

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APPENDIX

TRANCHE 1 TIMELINE

Note: Stakeholder Process for Tranche 1 timeline does not include development of the future planning scenarios ("Futures") that began in 2019

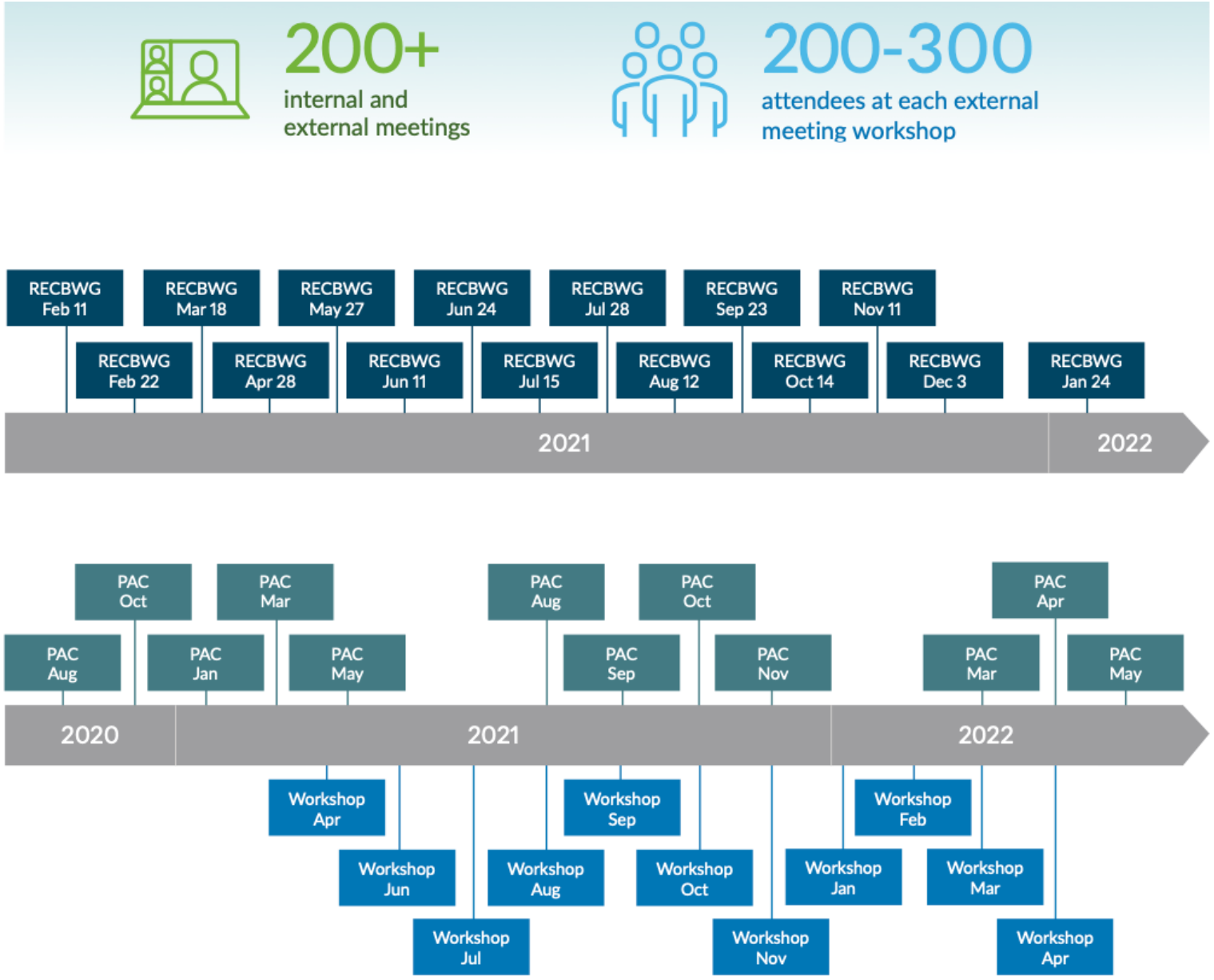


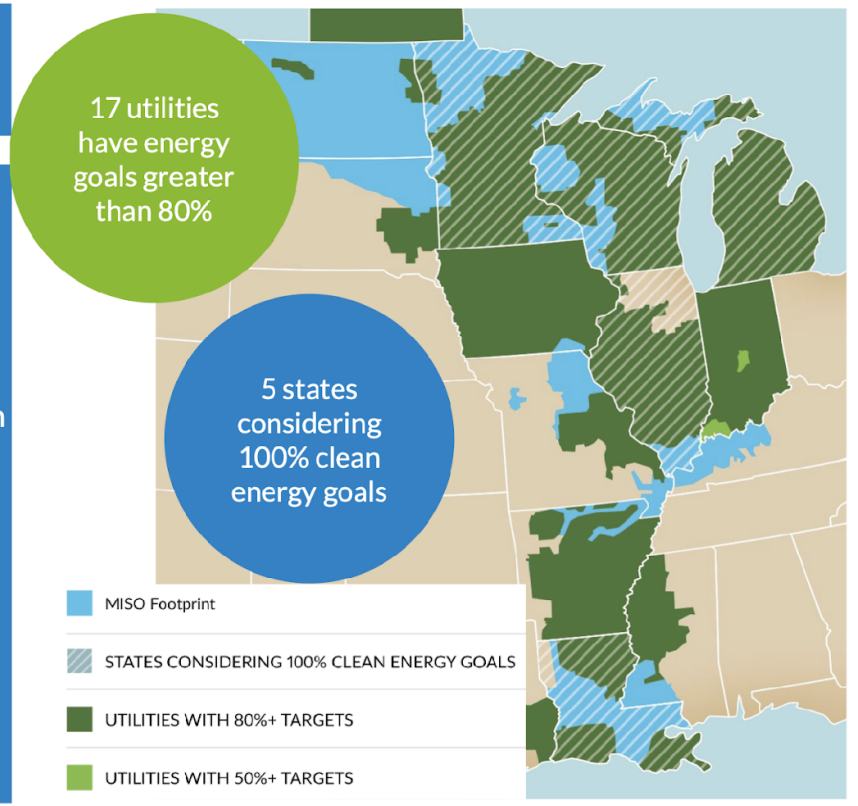
Figure 6: MISO's Long Range Transmission Plan Tranche 1 followed an extensive stakeholder process

Source: https://cdn.misoenergy.org/MTEP21%20Addendum-LRTP%20Tranche%201%20Report%20with%20Executive%20Summary625790.pdf

FUTURES PROCESS BEGINS WITH NARRATIVES

Three Futures incorporate & bookend uncertainty with members' plans

Future 1	Future 2	Future 3
• The footprint develops in line with 100% of utility IRPs and 85% of utility announcements, state mandates, goals, or preferences. • Emissions decline as an outcome of utility plans. • Load growth consistent with current trends.	• Companies/states meet their goals, mandates and announcements. • Changing federal and state policies support footprint-wide carbon emissions reduction of 60% by 2040. • Energy increases 30% footprint-wide by 2040 driven by electrification	• Changing federal and state policies support footprint-wide carbon emissions reduction of 80% by 2040. • Increased electrification drives a footprint-wide 50% increase in energy by 2040.



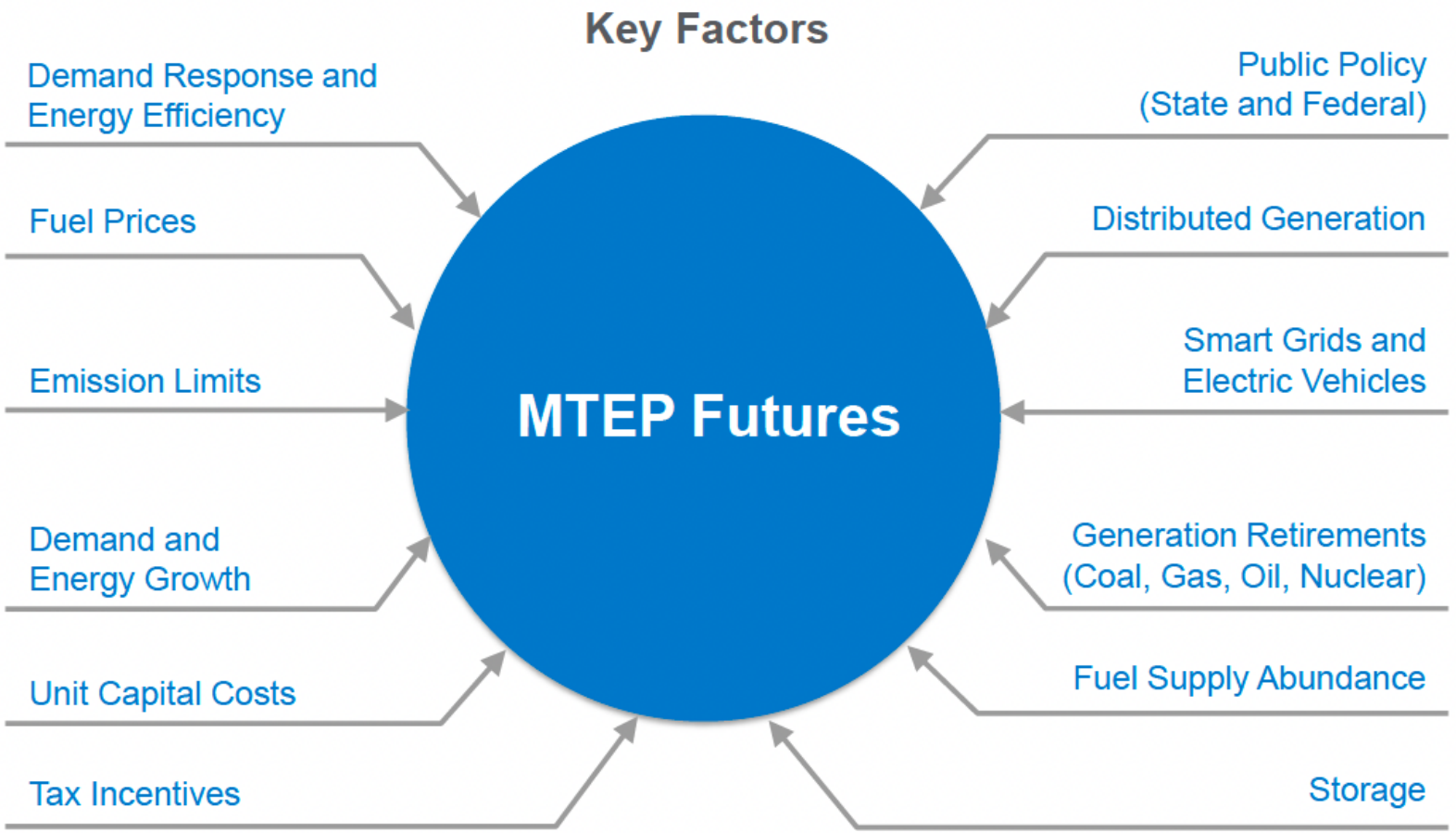
April 2021; changing rapidly.

MISO

MISO Futures Report for Tranche 1 ("SERIES 1") can be found here: https://cdn.misoenergy.org/MISO%20Futures%20Report538224.pdf

Source: https://cdn.misoenergy.org/MISO%20Futures%20Summary%20Presentation538220.pdf

Multiple factors are considered when developing MTEP Futures



Source: MISO BOD System Planning 20191210

SUMMARY OF SERIES 1 FUTURES - FINAL

Variables / Futures	Future 1	Future 2	Future 3
EGEAS Ready Gross Load^ Energy Demand	Low-Base EV growth 0.63% CAGR growth rate 0.59% CAGR growth rate	30% energy growth 1.23% CAGR growth rate 1.09% CAGR growth rate	50% energy growth 1.91% CAGR growth rate 1.94% CAGR growth rate
Potential Load Modifiers^^ *(Technical Potential by 2040)* DR EE DG	Technical Potential Offered 5.2 GW 13.3 GW 14.7 GW	Technical Potential Offered 5.9 GW 14.5 GW 14.7 GW	Technical Potential Offered 5.9 GW 14.5 GW 21.8 GW
Carbon Reduction* *(2005 baseline)* MISO Footprint currently at 22%**	40%	60%	80%
Min. Wind & Solar Penetration	No minimum	No minimum	50%
Utility Announced Plans	85% goals met 100% IRPs met	100% goals met 100% IRPs met	100% goals met 100% IRPs met
Retirement Age-Based Criteria Coal Natural Gas-CC Natural Gas-Other	46 years 50 years 46 years	36 years 45 years 36 years	30 years 35 years 30 years

* Entire footprint in aggregate
** 2005-2017; MISO calculation from EIA Form 860 data
^ Compound annual growth rate (CAGR); does not include impact from DERs, DSM, or Wind/Solar
^^ Distributed Energy Resources (DER); Demand Response (DR); Energy Efficiency (EE); Distributed Generation (DG): Capacity technical potential offered into EGEAS as resources; final amounts selected to be determined by EGEAS simulations.

Source MTEP21 Report, p. 42

SERIES 1 FUTURES ASSUMPTIONS

MISO Futures Assumptions (1 of 2)

Variables / Futures	Future I	Future II	Future III
Percent of Goals Met	≥ 85% goals met ≥ 100% IRPs met	≥ 100% goals met ≥ 100% IRPs met	≥ 100% goals met ≥ 100% IRPs met
Carbon Emissions Reduction* *(2005 baseline)*	≥ 40% (currently at 22%)**	≥ 60%	≥ 80%
Retirements–Coal **Retirements–Natural Gas-CC** **Retirements–Natural Gas-Other**	46 years 50 years 46 years	36 years 45 years 36 years	30 years 35 years 30 years
Wind & Solar Penetration	No minimum	No minimum	≥ 50%
Electrification *(gas to electric appliances/heating /cooling)*	None	39% of technical potential realized representing a 30% energy growth	77% of technical potential realized representing a 60% energy growth
Demand & Energy Growth	Future-dependent (based on "Merged" ILF forecast); Awaiting Future-specific forecast from AEG	Future-dependent (based on "Merged" ILF forecast); Awaiting Future-specific forecast from AEG	Future-dependent (based on "Merged" ILF forecast); Awaiting Future-specific forecast from AEG

* Entire footprint in aggregate
** 2005-2017; MISO calculation from EIA Form 860 data

Source: PAC Futures Update 3/11/2020

SERIES 1 FUTURES ASSUMPTIONS

MISO Futures Assumptions (2 of 2)

Variables / Futures	Future I	Future II	Future III
EV Adoption & Charging Technology	Low-Base EV growth Uncontrolled charging	Base-High EV growth Uncontrolled 2020-2035 & V2G 2035 and beyond	Extra-High EV growth Uncontrolled 2020-2030 & V2G 2030 and beyond
DER Technical Potential by 2040 (GW)^	DR: 5.2 EE: 13.3 DG: 14.7	DR: 5.9 EE: 14.5 DG: 14.7	DR: 5.9 EE: 14.5 DG: 21.8
Natural Gas Prices	Base starting price determined by GPCM; Future-specific price input to PROMOD	Base starting price determined by GPCM; Future-specific price input to PROMOD	Base starting price determined by GPCM; Future-specific price input to PROMOD
External Modeling	Pick "more aligned" SPP Future and single PJM	Apply our assumptions to external areas (take their sites though)	Apply our assumptions to external areas (take their sites though)

Source: PAC Futures Update 3/11/2020

TRANCHE 1: UTILITY GOALS DRIVING RESULTS

State Clean Energy Goals & RPS[6] (source linked)	State	Utility	Utility Carbon Reduction Goals (2005 Baseline)[7]	Utility Renewable Energy Goals
RPS: 15% RE by 2021 (IOUs)	Missouri	Ameren	Net Zero by 2050*	100% by 2050
100% Clean Energy by 2050 (Governor) RPS: 25% by 2025-2026	Illinois	MidAmerican Energy	-	100% by 2021
RPS: 105 MW (completed 2007)	Iowa	Alliant Energy	Carbon Free by 2050	30% by 2030*
		Dairyland Power	-	29% by 2029
Carbon Free by 2050 (Governor) RPS: 10% by 2020	Wisconsin	WEC Energy Group	Carbon Neutral by 2050	-
		Madison Gas & Electric	Net Zero by 2050*	30% by 2030
Carbon Neutral by 2050* RPS: 15% by 2021 (standard), 35% by 2025 (goal, including EE & DR)	Michigan	Consumers Energy	Net Zero by 2040	56% by 2040
		DTE Energy	Net Zero by 2050	25% by 2030
		Upper Peninsula Power	-	50% by 2025
Voluntary clean energy PS, 10% RE by 2025	Indiana	Duke Energy	Net Zero by 2050	16,000 MW by 2025
		Hoosier Energy	80% by 2040	10% by 2025
		Vectren	75% by 2035*	62% by 2025
		NIPSCO	90% by 2028	65% by 2028
Carbon Free by 2050 (Governor) RPS: 26.5% by 2025 (IOUs), 25% by 2025 (other utilities)	Minnesota	Xcel Energy	Carbon Free by 2050	100% by 2050
		SMMPA	90% by 2030	75% by 2030
		Minnesota Power	100% Clean Energy by 2050*	50% by 2021
		Great River Energy	95% by 2023	50% by 2030
Net Zero GHG by 2050 (Governor)	Louisiana	Entergy	Net Zero by 2050 (2000 baseline)	12% by 2030*

Table 1: State & Utility Goals – Service Area Overlay

Source: https://cdn.misoenergy.org/MISO%20Futures%20Report538224.pdf

DER ASSUMPTIONS FOR TRANCHE 1

"As in previous Futures cycles, MISO commissioned Applied Energy Group (AEG) to develop new DER technical potential. AEG developed estimates of DER impacts through survey of load-serving entities (LSE) and secondary research. Based on analysis for MTEP20, with updated utility information and Futures narratives for this cycle, technical potential represents feasible potential under each scenario."

MTEP21 DERs Capacity (GW) Technical Potential & Added	Future 1		Future 2		Future 3	
	Potential	Added	Potential	Added	Potential	Added
Demand Response (DR)	5.2	0.9	5.9	0.9	5.9	0.9
Energy Efficiency (EE)	13.3	7.8	14.5	8.1	14.5	11.7
Distributed Generation (DG)	14.7	3.5	14.7	3.5	21.8	6.2

Table 3: DER Capacity (GW): 20-Year Technical Potential & Additions in MISO

MTEP21 DERs Energy (GWh) Technical Potential & Added	Future 1		Future 2		Future 3	
	Potential	Added	Potential	Added	Potential	Added
Demand Response (DR)	442	118	498	118	498	118
Energy Efficiency (EE)	86,886	30,801	94,313	31,393	94,313	49,145
Distributed Generation (DG)	26,119	5,709	26,119	5,709	36,934	9,837

Table 4: DER Energy (GWh): 20-Year Technical Potential & Additions in MISO

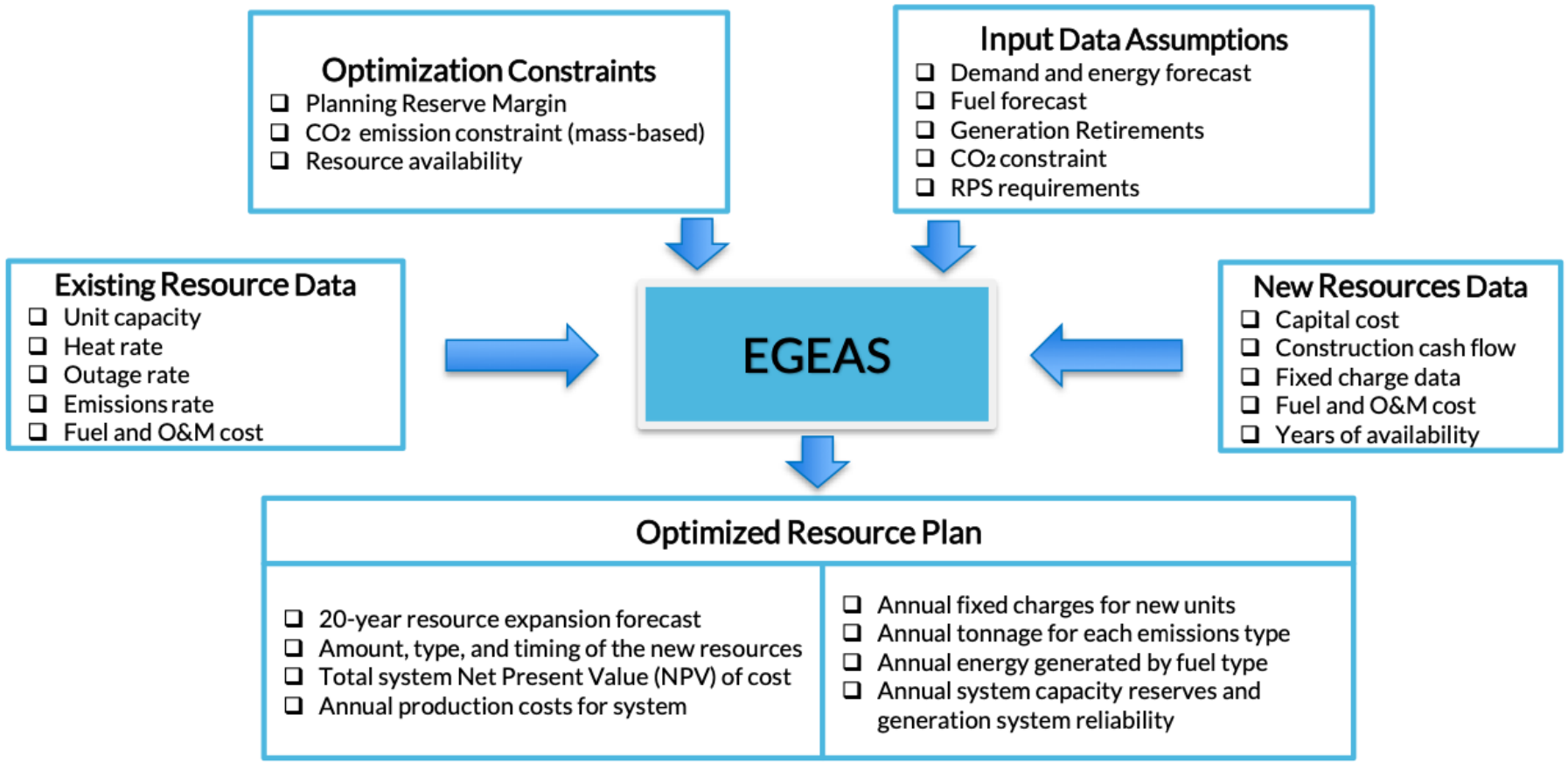
Source: https://cdn.misoenergy.org/MISO%20Futures%20Report538224.pdf

LOAD ASSUMPTIONS FOR TRANCHE 1 – INCLUDING ELECTRIFICATION

- Future 1 - assumed a load growth consistent with recent trends; **0.48%**, including currently low electric vehicle adoption as modeled by Lawrence Berkeley National Laboratory's (LBNL) 'Low' scenario projection.
- Future 2 - assumed an annual energy growth rate of **1.09%** to reach a targeted 30% energy increase by 2040, largely driven by electrification.
- Future 3 - assumed an annual energy growth rate of **1.71%** to reach a targeted 50% energy increase by 2040, driven by additional electrification.
- A primary driver of load growth in Futures 2 and 3 is electrification.

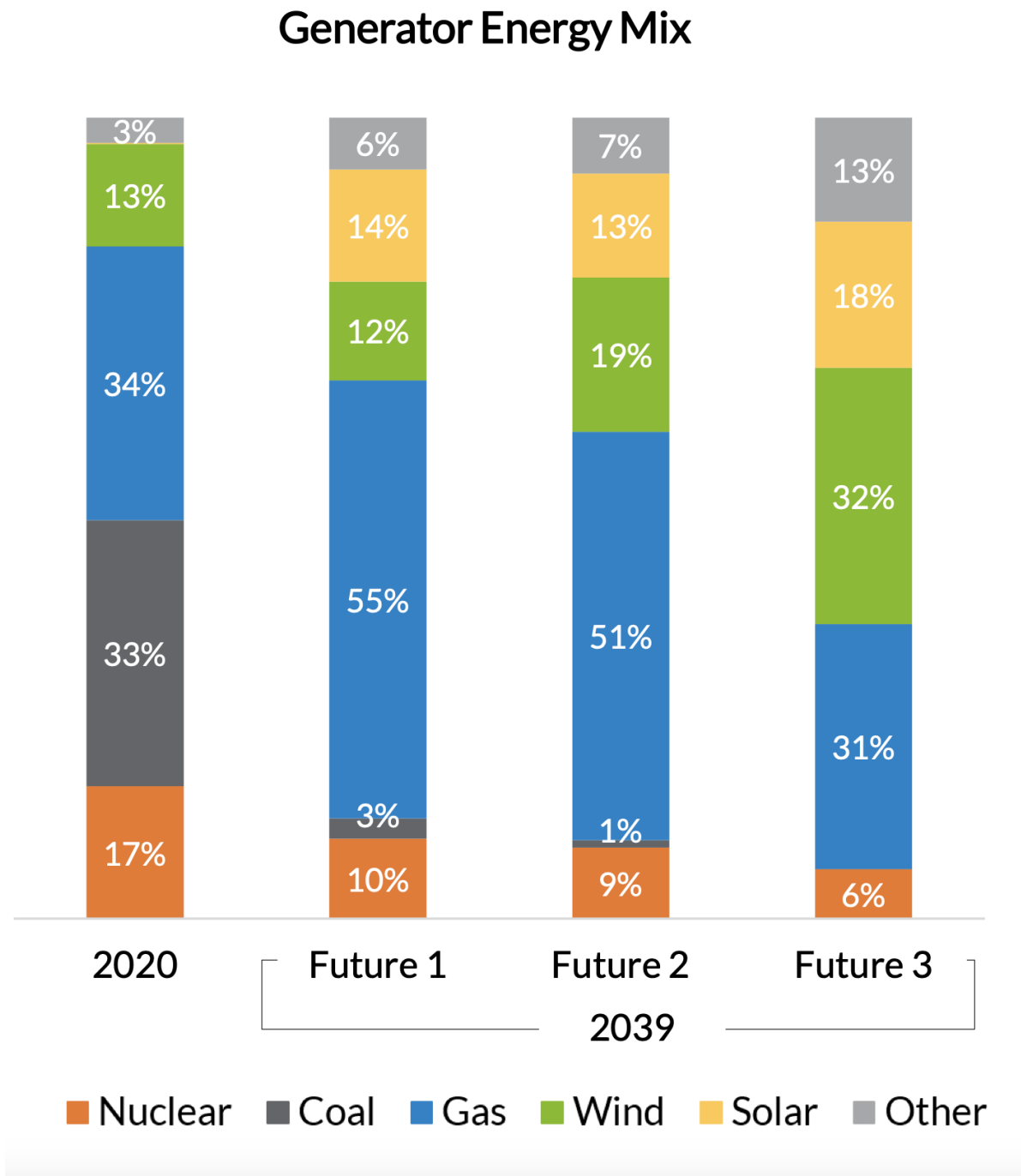
Source: https://cdn.misoenergy.org/MISO%20Futures%20Report538224.pdf

EGEAS Inputs and Outputs



Total System Costs = Sum of Production Costs + Fixed O&M Cost + Capital Carrying Costs

Series 1 – Generation Energy Mix: Tranche 1 primarily relied on Future 1



Source:
https://cdn.misoenergy.org/20210615%20System%20Planning%20Committee%20of%20the%20BOD%20Item%2006%20Long%20Range%20Transmission%20Planning%20Strategy558584.pdf

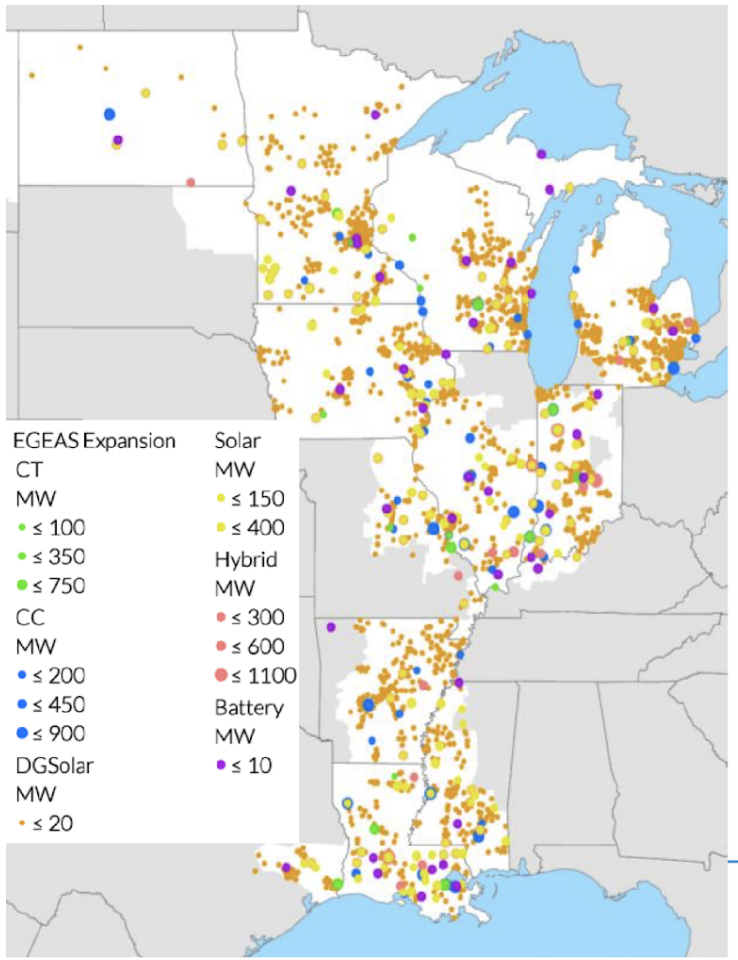
MISO Future Generation-Siting Process

- Unknown wind and solar PV Resources were modeled as a collector system, representing an aggregated capacity potential that can be installed within 10-30 miles of each site. These collector sites were identified by two methods:
  1. **80%** of Future-determined capacity was distributed to **Generation Interconnection (GI) queue sites**, and
  2. **20%** of Future-determined capacity was identified using the **Vibrant Clean Energy* (VCE) results**.
- The same sites were used for each Future and site differences only occurred due to Future-specific renewable capacity needs (increase or decreased MW).

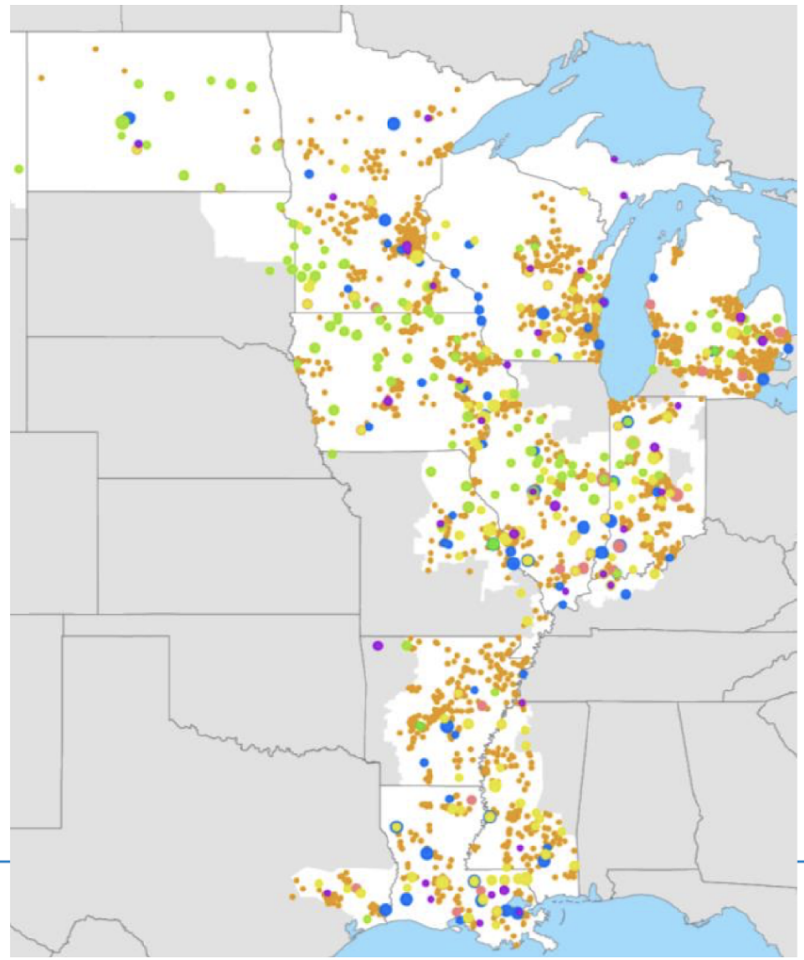
* - https://cdn.misoenergy.org/2018%20VCE%20Study_Results536959.pdf

MISO EGEAS Resource Siting

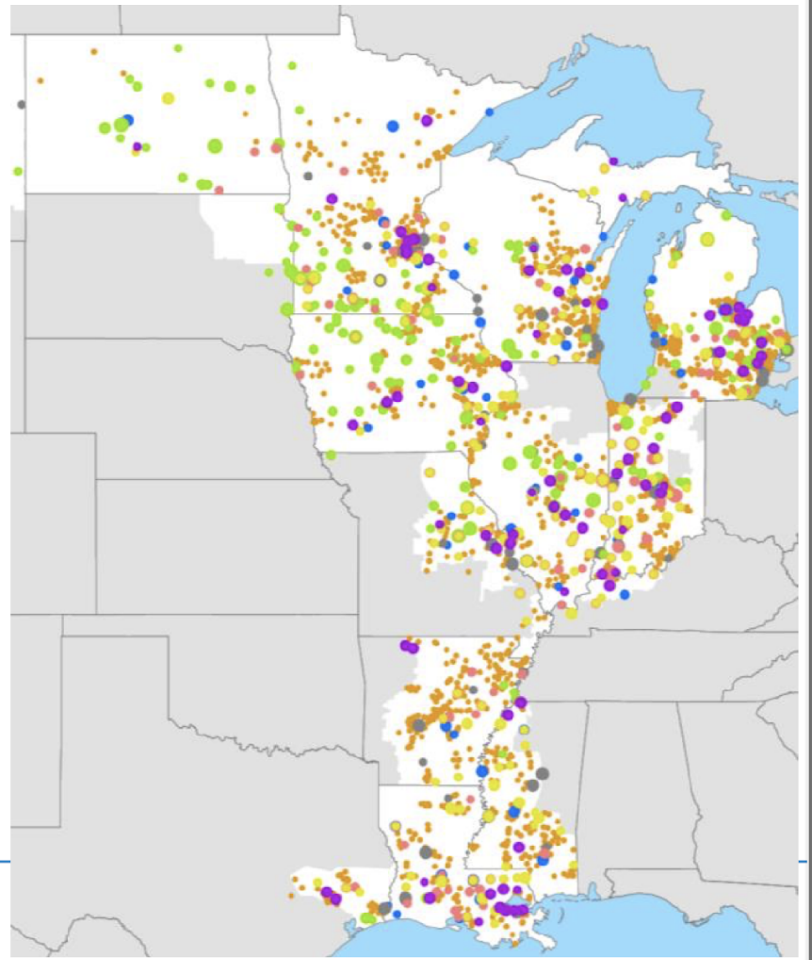
Future 1



Future 2



Future 3

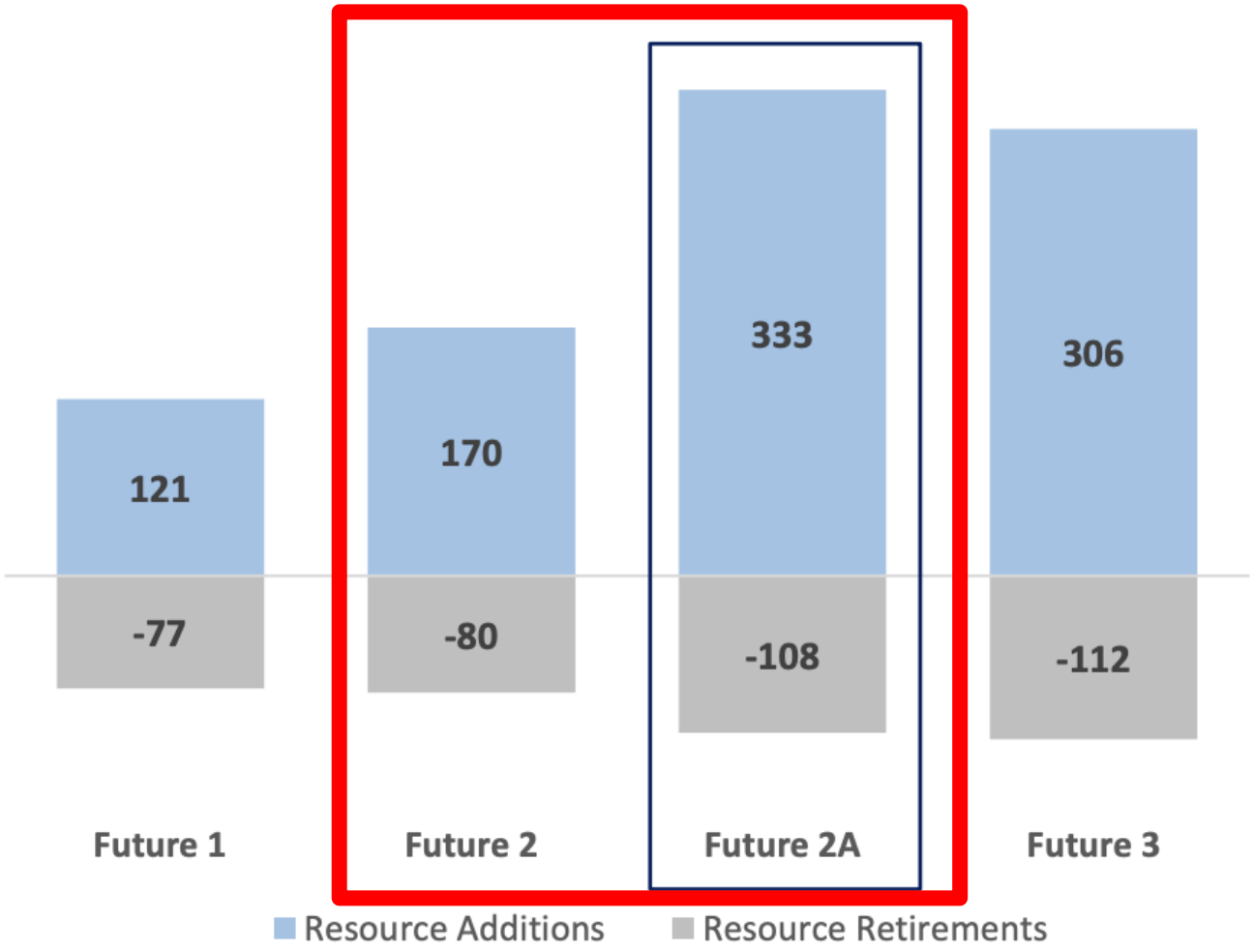


Source: https://cdn.misoenergy.org/20201111%20PAC%20Item%2003a%20Futures%20Resource%20Expansion%20&%20Siting%20Results491495.pdf

REFRESHING THE FUTURES – SERIES 1A

Data that will be updated in Futures refresh

- State & member plans
  - Announced additions
  - Announced retirements
  - Announced carbon goals
  - Announced renewable targets
  - Integrated Resource Plans
- Capital, operating, & fuel costs
- Planning Reserve Auction data
- Additions & retirements from the GI queue & Attachment Y process

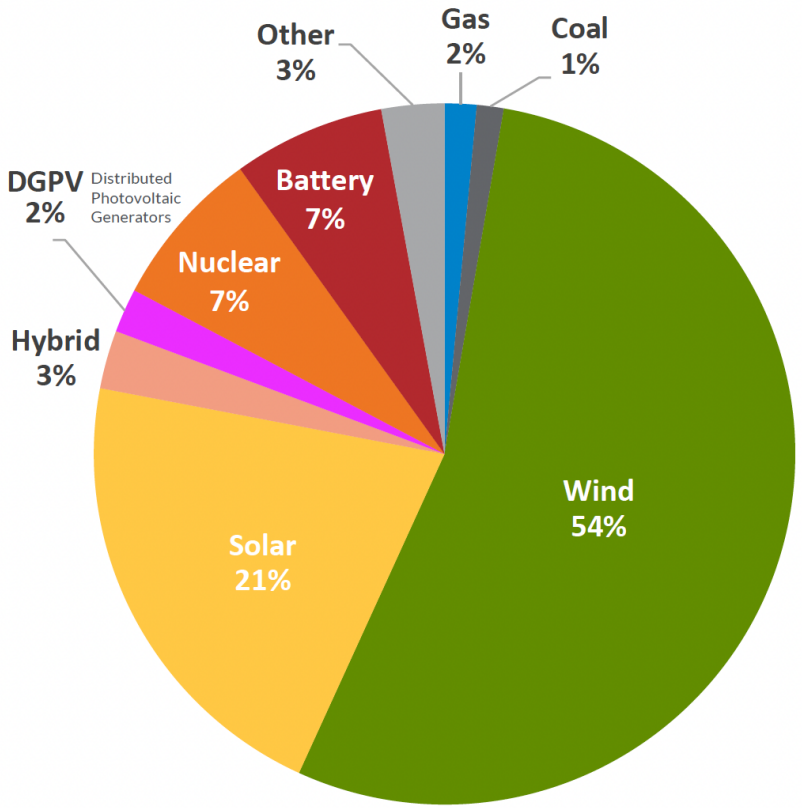


Source:
https://cdn.misoenergy.org/20230310%20LRTP%20Workshop%20Item%2002%20MISO%20Future%202A%20Expansion%20and%20Preliminary%20Siting628178.pdf

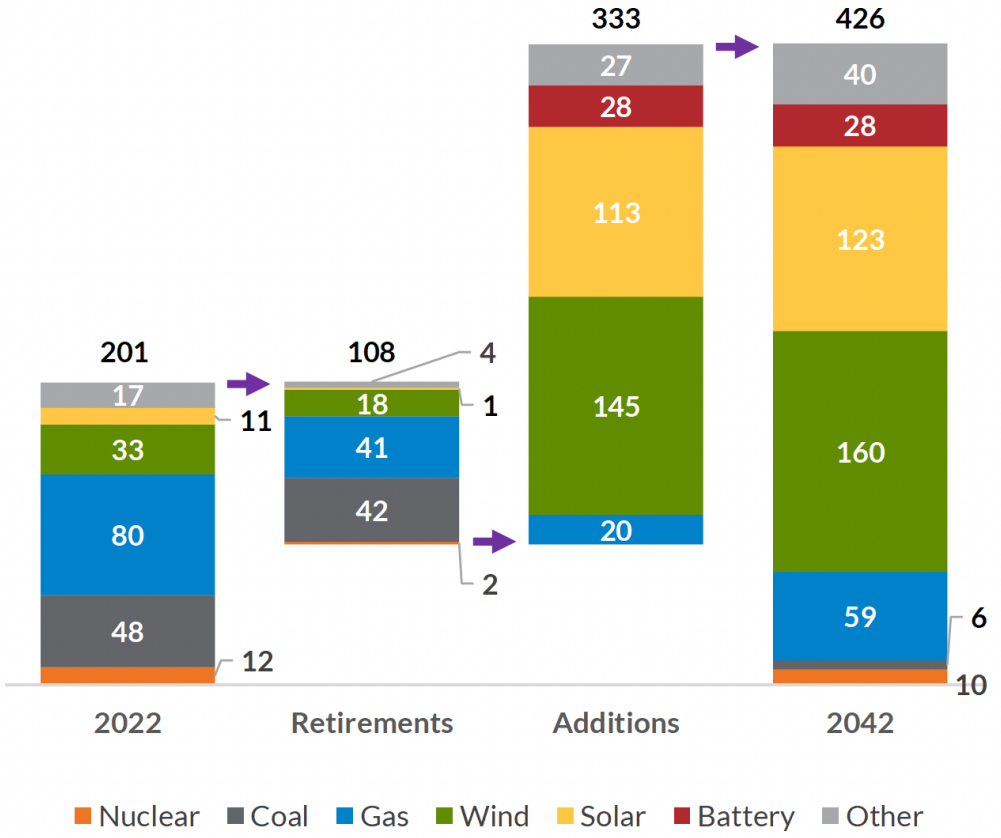
Updated member resource plans and goals result in a Future 2A that's closer to the prior Future 3 and introducing new system reliability needs

TRANCHE 2: STEP 2 RESOURCE MIX (RESULTS OF EGEAS)

Future 2A – 2042 Energy*

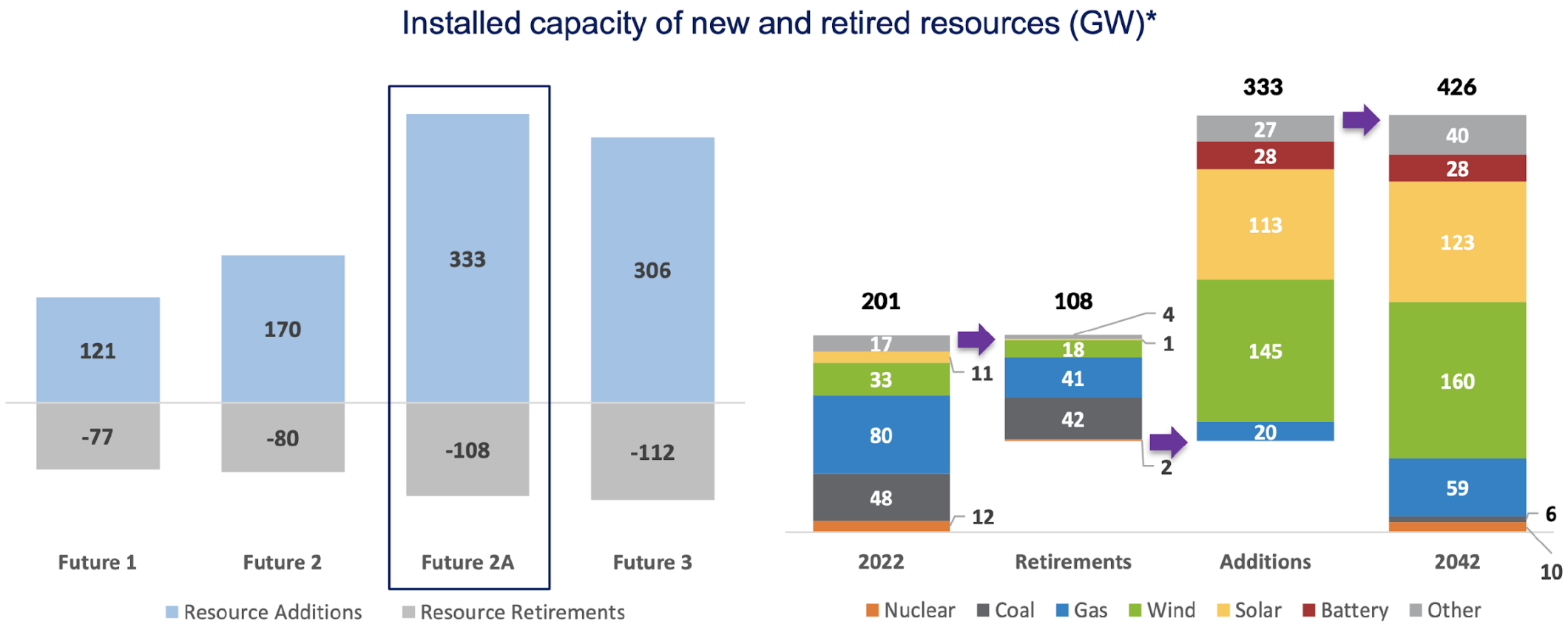


Future 2A – 2042 Installed Capacity (GW)*



* Data as of March 7, 2023. Futures do not account for all operational level reliability needs and attributes that may require different levels of dispatchable resources. Resource additions may be subject to adjustment based on new accreditation rules.

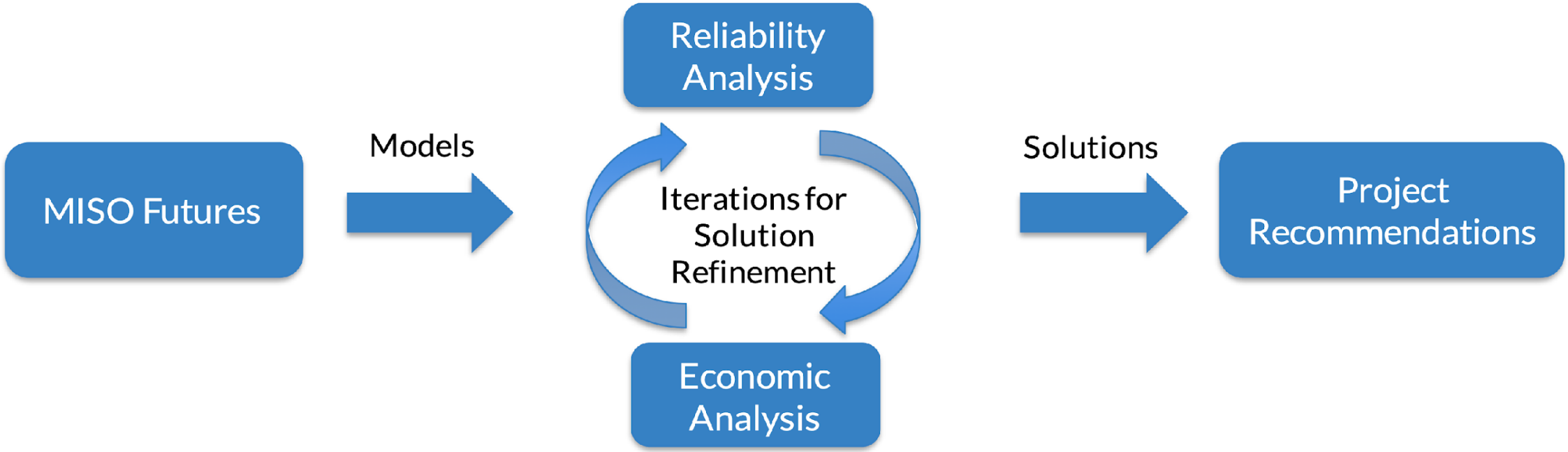
Future 2A's expansion and retirements approaches/surpasses levels seen in Future 3, which will transform our current resource fleet



* Data as of March 7, 2023. Futures do not account for all operational level reliability needs and attributes that may require different levels of dispatchable resources. Resource additions may be subject to adjustment based on new accreditation rules.

Source:
https://cdn.misoenergy.org/20230310%20LRTP%20Workshop%20Item%2002%20MISO%20Future%202A%20Expansion%20and%20Preliminary%20Siting628178.pdf

LRTP involves reliability and economic analyses to identify projects that meet system needs due to changing generation fleet



Within iterations solution ideas and issues from respective processes will be exchanged

Source:
https://cdn.misoenergy.org/20210924%20LRTP%20Item%2002%20Economic%20Analysis%20Overview591889.pdf

LRTP TRANCHE 1 QUANTITATIVE BENEFIT METRICS

Purpose of the LRTP business case analysis is to quantify across multiple benefit metrics the value of the LRTP Tranche 1 Portfolio meeting the needs identified in MISO's Future 1

No.	Business Case Metric	What value is the metric trying to capture?
1	Congestion and Fuel Savings	Benefit of having lower-cost F1 resources to dispatch plus the benefit of reducing congestion (i.e., the typical adjusted production cost economic benefit)
2	Avoided Capital Costs of Local Resource Investment	Reduced resource capital costs through a more regional versus local siting of resources by leveraging higher resource production areas and the benefits of a larger footprint
3	Avoided Transmission Investment	Savings associated with transmission upgrades or age/condition replacements that would be avoided with the LRTP Tranche 1 Portfolio
4	Resource Adequacy Savings	Value of increased transfer capability between MISO's Local Resource Zones, and the resulting savings from lower Resource Adequacy requirements
5	Avoided Risk of Load Shedding	Benefit of a resilient transmission system to avoid load shed during weather-related events through increased transfer capability
6	Decarbonization	Value of reduced carbon emissions with the additional F1 renewable resources

- In addition to the quantified benefits the business case does identify the reliability issues resolved by the Tranche 1 portfolio but does not put a dollar value on resolving those issues