Moving Toward Integrated Planning

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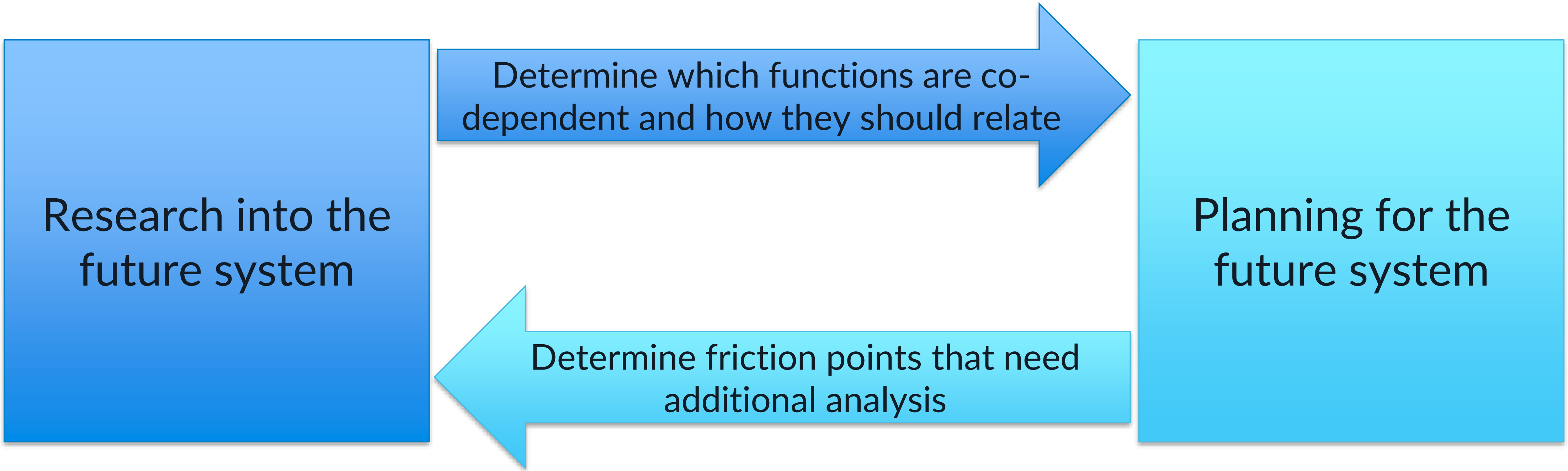
Integrated planning is complicated and shouldn't be pursued across all functions. Timely evaluation is needed to determine which functions should be integrated and how that integration can be simplified.

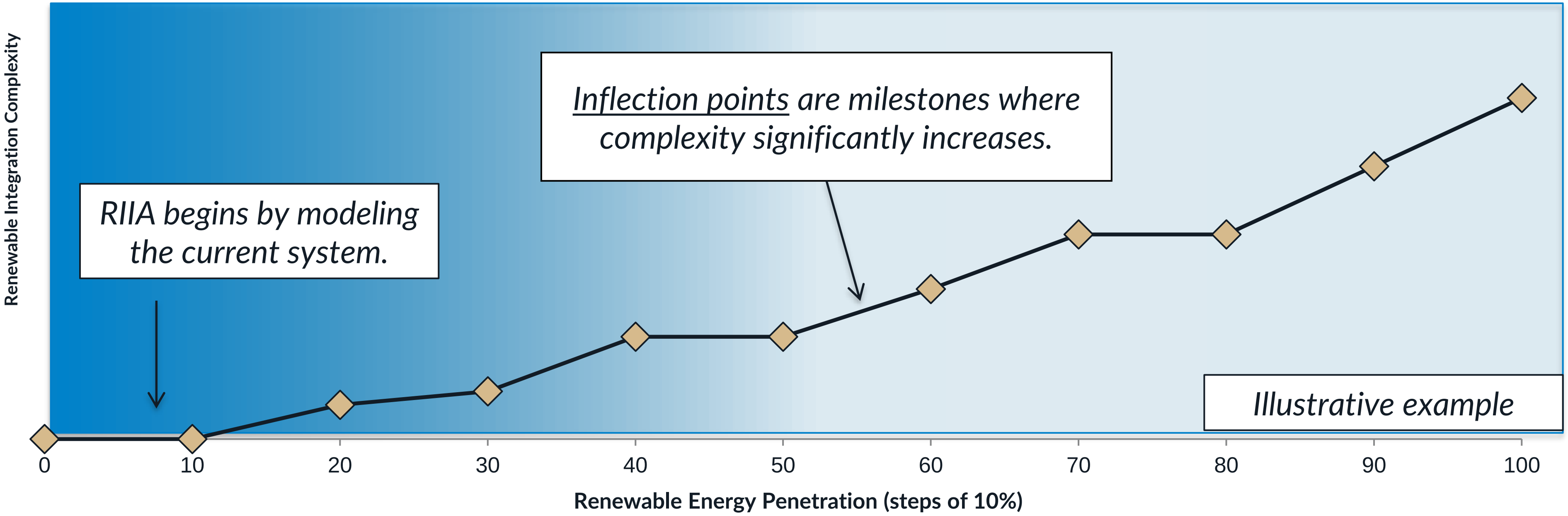


Example: Renewable Integration Impact Assessment

Example: Long Range Transmission Planning

What is the right balance of reliability and economic evaluation?

MISO's Renewable Integration Impact Assessment (RIIA) found inflection points of renewable integration complexity



Focus Areas

Resource Adequacy

Having the sufficient capacity of resources to reliably serve peak demand

Energy Adequacy

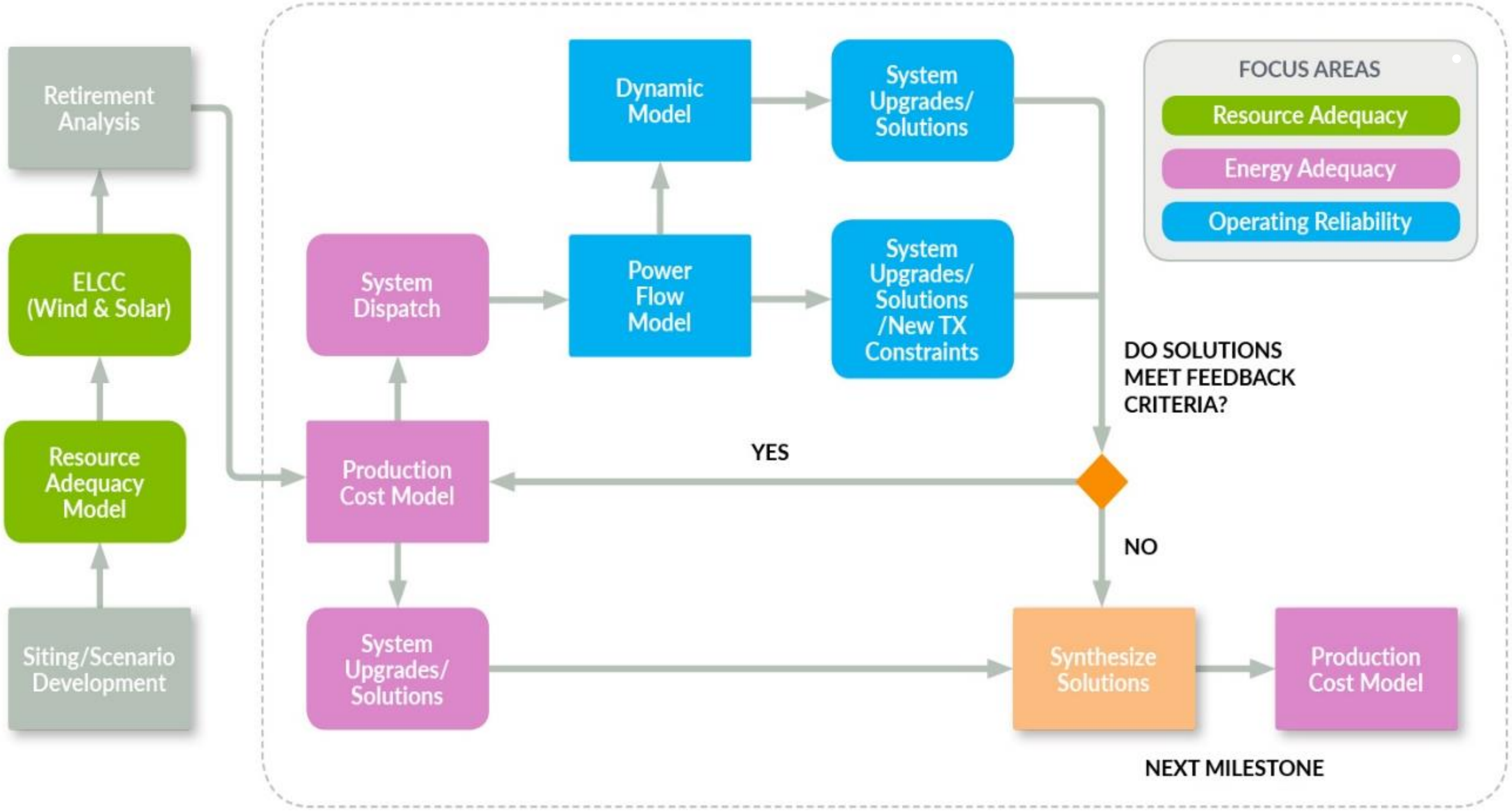
Ability to provide energy in all operating hours throughout the year

Operating Reliability

Ability to withstand unanticipated component losses or disturbances

https://cdn.misoenergy.org/RIIA%20Summary%20Report520051.pdf

MISO developed a robust process to understand how the seams between power system disciplines evolved as renewable penetration increased

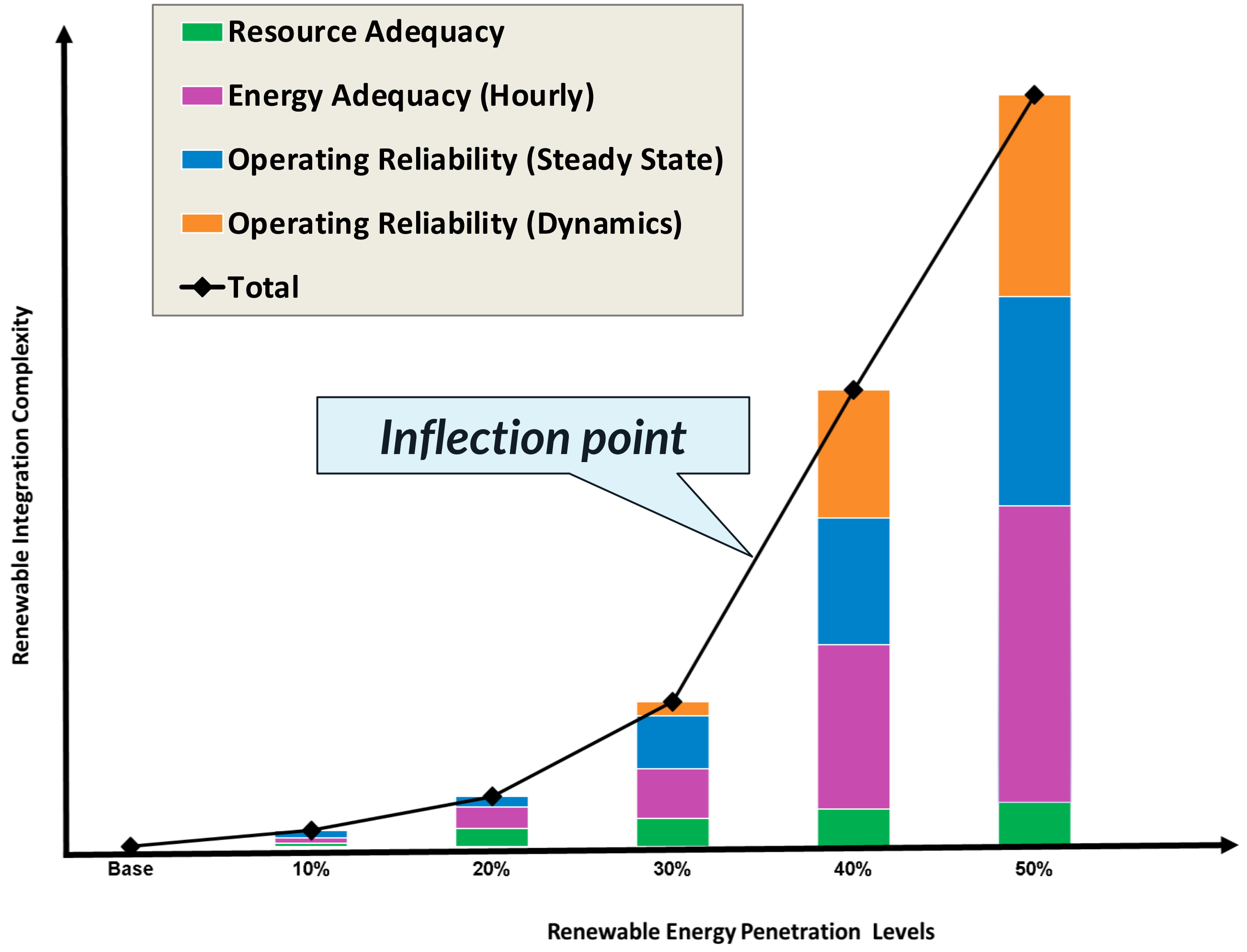


System dispatch results passed along from Energy Adequacy while keeping the retirement assumptions developed based on data received from Resource Adequacy;

Operating Reliability analyzed the dispatch, identify thermal, voltage and dynamic issues;

System upgrades/solutions are developed for reliability issues identified in each milestone in Operating Reliability, including but not limit to reconductor, new circuit, adding dynamic devices, etc.

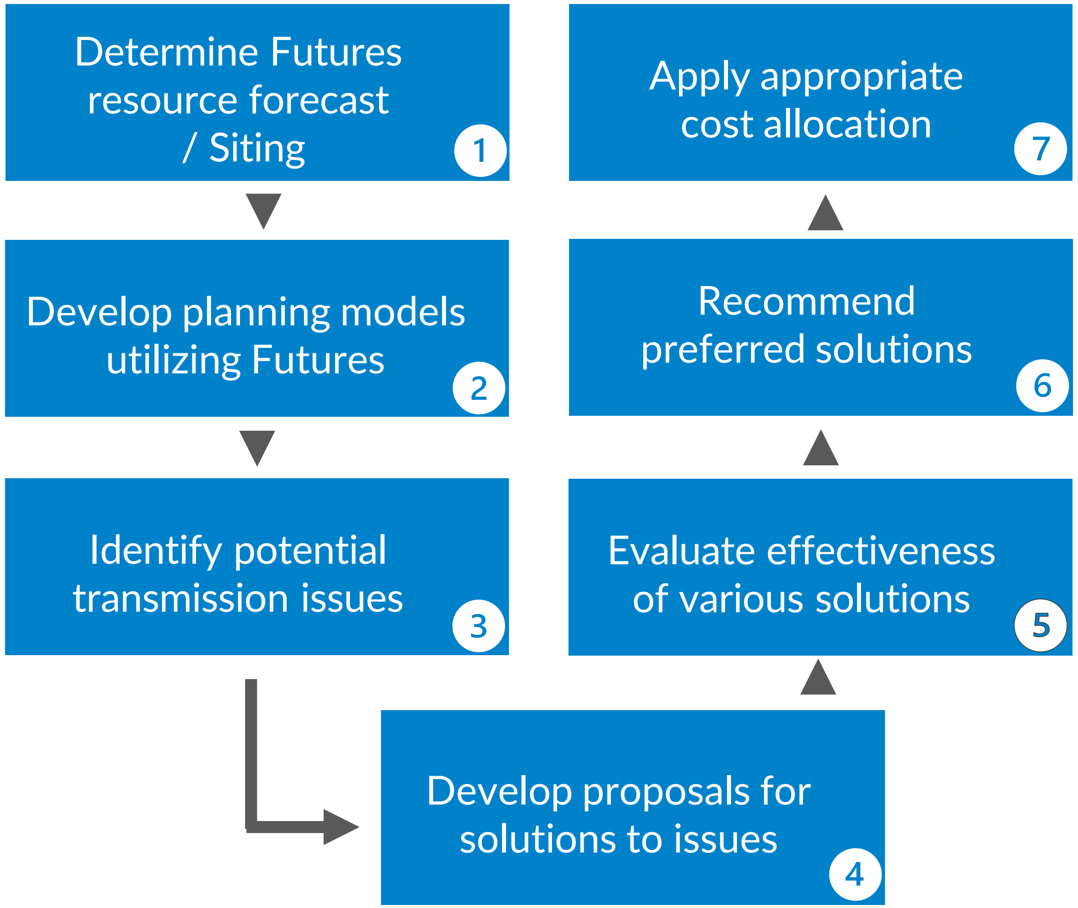
MISO's Renewable Integration Impact Assessment (RIIA) indicates integration complexity increasing sharply beyond 30% renewable penetration



1. Risk of losing load compresses into a small number of hours and shifts into the evening
2. Existing infrastructure becomes inadequate for fully accessing the diverse resources across the MISO footprint
3. Regional energy transfer increases in magnitude and becomes more variable leading to a need for increased extra- high-voltage line thermal capabilities
4. Power delivery from low short circuit areas may need transmission technologies equipped with dynamic support capabilities
5. Frequency response is stable up to 60% instantaneous renewable penetration, but may require additional planned headroom beyond
6. Grid-technology-needs evolve as renewable penetration increases, leading to an increased need for integrated planning
7. Diversity of technologies and geography improves the ability of renewables to serve load

Long Range Transmission Planning (LRTP) is developed through a comprehensive planning process, to deliver a robust, least-regrets, regional solution that reliably and efficiently enable the goals and objectives of its members and states

7-Step Process



- Recognize member and state goals across the entire footprint
- Define a forward-looking resource expansion which conforms to member goals
- Identify a least-regrets transmission buildout that hedges uncertainty
- Focus on regional transmission solutions, rather than localized issues

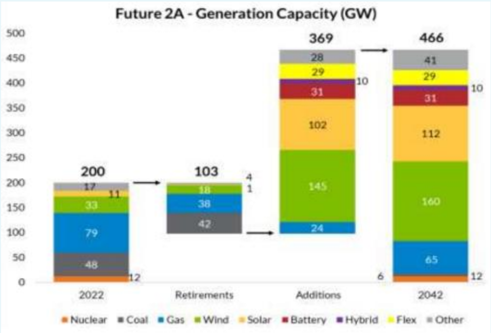
https://www.misoenergy.org/planning/long-range-transmission-planning/

This process began with the creation of Futures — critical planning scenarios to adequately bookend future uncertainties

Initial Model-Build/Resource Expansion

July 2022 – January 2023

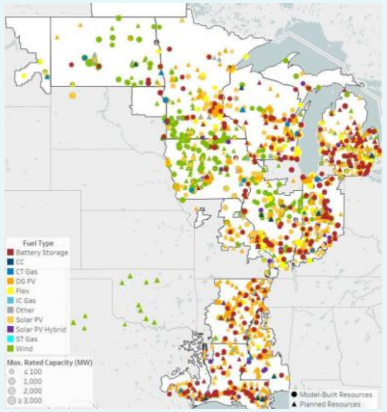
- Apply Futures assumptions
- Incorporate member plans – clean energy goals, resource additions, retirements
- Perform resource expansion to economically determine type, magnitude and timing of new resources



Siting

January – April 2023

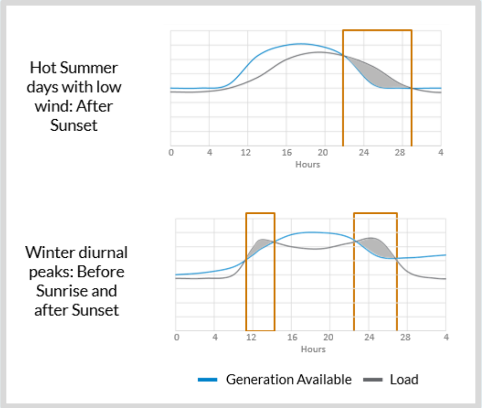
- Determine location to place each new resource in the transmission system
- Incorporate stakeholder feedback (500+ revisions) and update Siting



Energy Adequacy

January – April 2023

- Ensure all hours meet energy requirements
- Site 29 GW of resulting Flexible Attribute Unit capacity

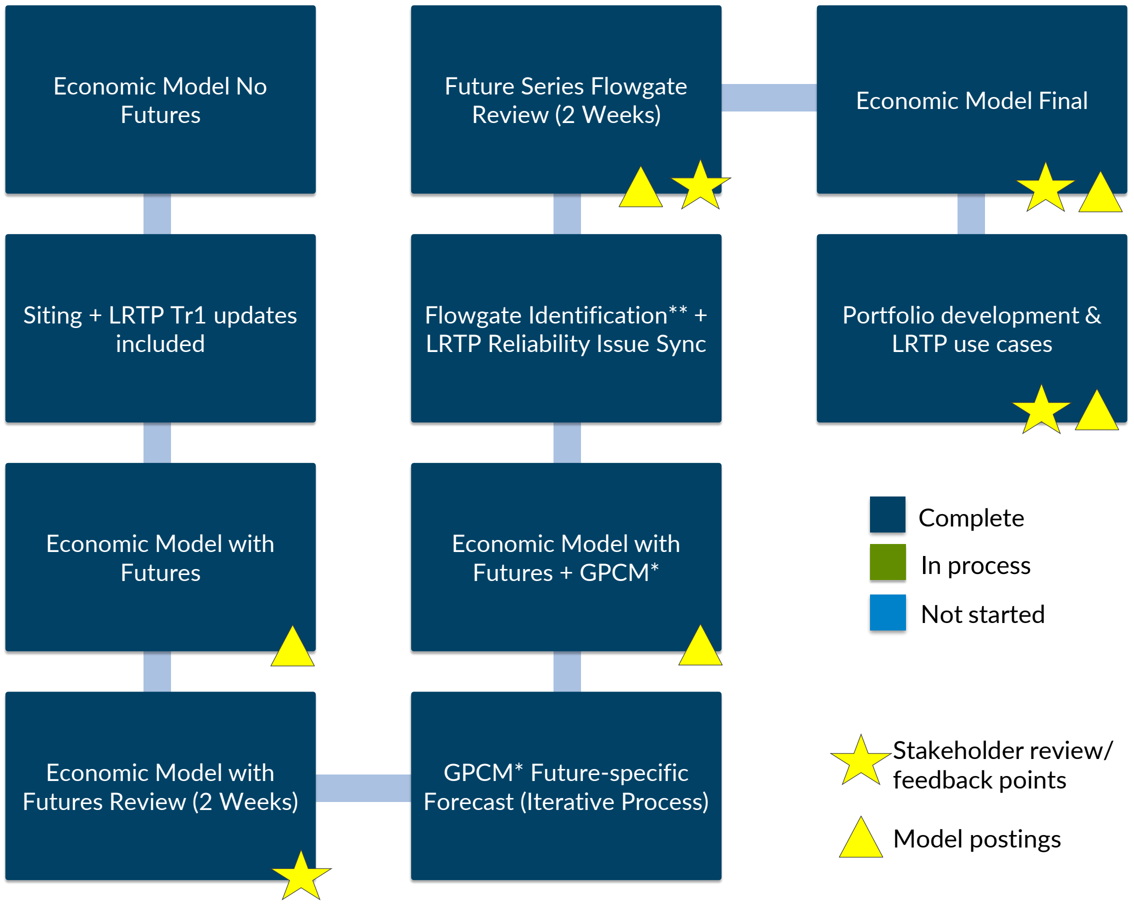


Futures help account for resource gaps and highlight focus areas for planning throughout MISO

Long-term planning analyses require sufficient resources throughout the study period, which can exceed what's currently known or publicly planned by members

Resource Expansion and Siting graphics: examples only (Series 1A).

The economic production cost models included Series 1A Future 2A assumptions, consisting of three study years



Economic Model Development Overview

- MISO's production cost models utilize PROMOD
  - Provides hourly (8760) chronological security constrained unit commitment and economic dispatch – adhering to a wide variety of operating constraints
- Three study years (2032, 2037, 2042)
- Future and year-specific gas prices
- Future and year-specific flowgates
- Used to develop the portfolio development and in business case analysis

*Mar '23 LRTP Workshop - Gas Pipeline Competition Model (GPCM)
**Dec '23 LRTP Workshop - Flowgate Identification

The reliability analysis included core models representing key future resource and load supplemented with transfer scenarios, dynamic stability and safe loading limits

10-year out models

2032

- Core models
- Potential solutions

→ Summer peak, Winter peak, Light load, Average load

20-year out models

2042

- Core models
- Potential solutions

→ Summer peak, Winter peak, Light load, Average load

20-year out models

Stability 2042

- Core models
- Potential solutions

→ Summer peak, Average load

20-year out models

Transfer scenarios 2042

- Core models
- Potential solutions

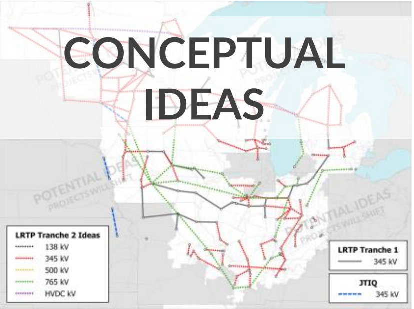
→ Twilight summer, Winter low renewable, Average East to West, Avg lowers to uppers

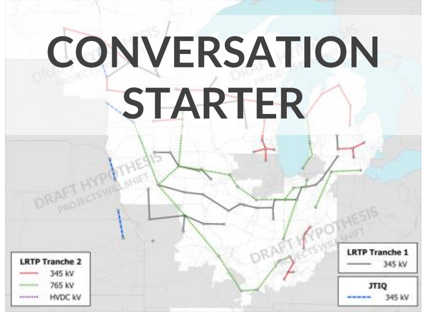
Contingencies: P0, P1, P2, P4, P5, and P7 – generally system intact, single element and single right of way outages P3 and P6 (within close proximity) – generally multiple outages in parallel

Safe Loading Limits
(>345 KV, > 50 mi)

Monitored facilities: MISO Bulk Electric System (BES) elements including tie-lines to neighboring systems & First Tier non-MISO

This analysis drove transmission plans, building from conceptual ideas to an initial draft



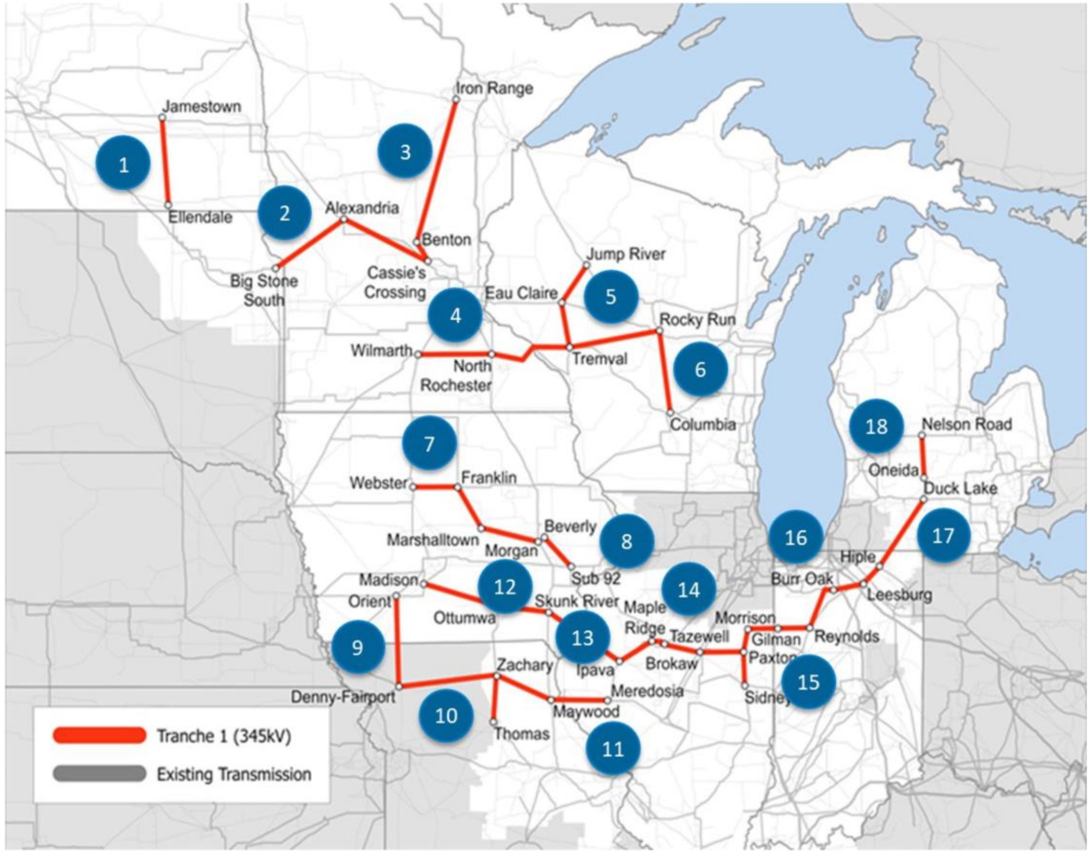


- How do assumptions impact the future resource mix?
- Under what conditions do lines provide value?
- What blend of 345 kV, 765 kV and HVDC* is best?
- Will the projects in the Tranche 2.1 provide robust solutions?
- Does the portfolio provide benefits consistent with the Tariff?
- What are the impacts of other late-stage transmission projects?

* HVDC – High Voltage Direct Current

Two phases on new backbone transmission have been designed to enable the evolution of the system and mitigate against the risks previously explored

Final LRTP Tranche 1 Design



Final LRTP Tranche 2.1 Design