2050 Transmission Study

Sensitivity Results and Solution Development Plans

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TRANSMISSION PLANNING

Overview

- Background
- Review of Preliminary Results
- Sensitivity Analysis Results
- Plans for Solution Development
- Next Steps

Background

- In accordance with a recommendation from NESCOE's October 2020 "*New England States' Vision for a Clean, Affordable, and Reliable 21st Century Regional Electric Grid*," ISO-NE is conducting the 2050 Transmission Study in order to determine:
  - Transmission needs in order to serve load while satisfying NERC, NPCC, and ISO-NE reliability criteria in 2035, 2040, and 2050
  - Transmission upgrade "roadmaps" to satisfy those needs considering both constructability and cost
- The ISO has coordinated with NESCOE throughout this study
  - In November 2021, ISO-NE introduced the 2050 Transmission Planning Study Scope of Work, preliminary assumptions, and methodology
  - In March 2022, ISO-NE presented preliminary N-1 and N-1-1 results showing the extent of the transmission system deficiencies observed
- Today, the ISO will review results of the sensitivity analysis proposed in March 2022, and discuss the high-level approach to development of transmission solutions and cost estimates

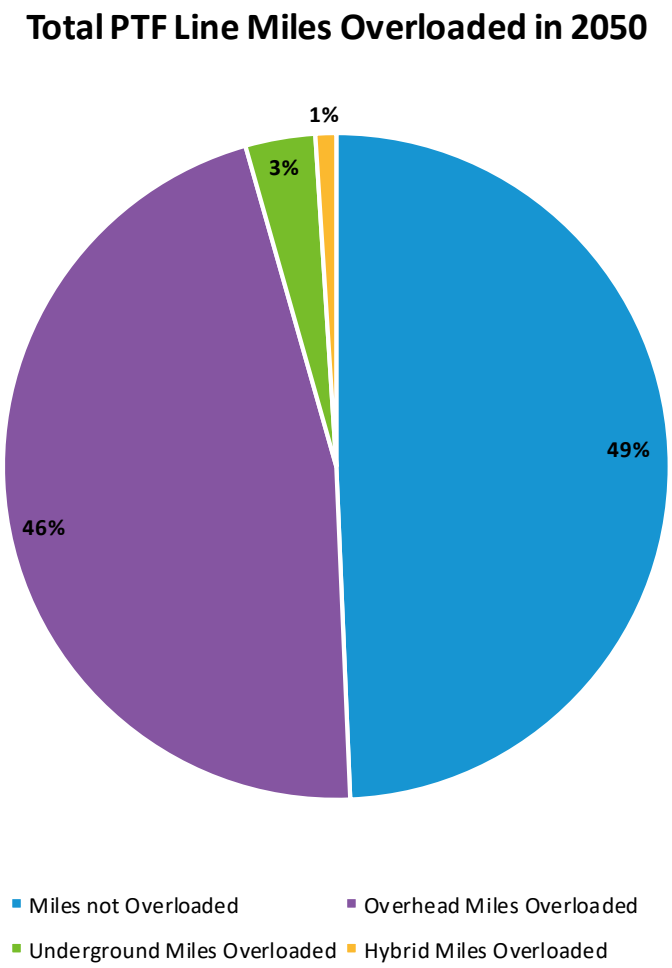
REVIEW OF PRELIMINARY RESULTS

Key Metrics

Capturing and Summarizing the Results

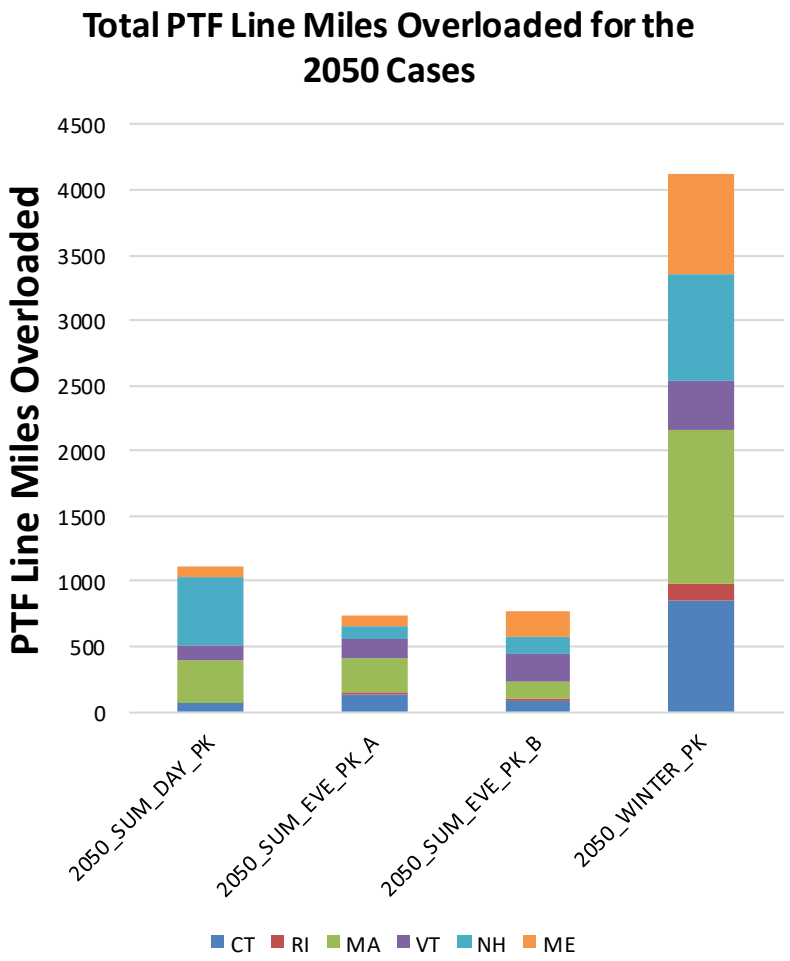
- A typical Needs Assessment presentation identifies criteria violations individually. However, the number of violations identified in the 2050 Transmission Study make this impractical
- Today's results are presented using circuit miles of overloaded Pool Transmission Facilities (PTF) lines (includes overhead lines and underground cables)
- As a reference point, New England has approximately 9,000 circuit miles of PTF lines (includes overhead lines and underground cables)

Lines and Transformers Overloaded in 2050



- Approximately half of the total Pool Transmission Facility (PTF) line miles in New England (~4,500 miles out of ~9,000 miles) are overloaded in 2050
- Approximately 90 PTF transformers (of about 150 total) are also overloaded in 2050

2050 Results by Snapshot



- The majority of overloads in 2050 occur in the Winter Peak snapshot
  - 2,705 miles of overloads appear only in this snapshot – Slide 40 of the March 2022 presentation
- The Summer Daytime Peak snapshot shows 1,120 miles of overloaded lines
  - 352 miles, primarily located in New Hampshire, are unique to the Summer Daytime Peak snapshot

Sensitivity Analyses Proposed in March 2022

- Two sensitivities were proposed to determine whether the severity and number of overloaded transmission lines could be reduced
- 2050 Winter Evening Peak: How will a reduction in load reduce the total mileage of overloaded lines only seen in winter?
  - Reduction in load could be due to measures such as energy efficiency, demand response, or use of alternate fuels in place of electrification of heating
- 2050 Summer Daytime Peak: Can resources be curtailed in order to reduce the total mileage of overloaded lines only seen in summer?
  - Surplus capacity is available in this snapshot, so reduction of power output on some resources is possible
  - Initial assumptions included extensive development of solar generation in New Hampshire, leading to many overloads in that state only for the Summer Daytime Peak snapshot

SENSITIVITY ANALYSIS RESULTS

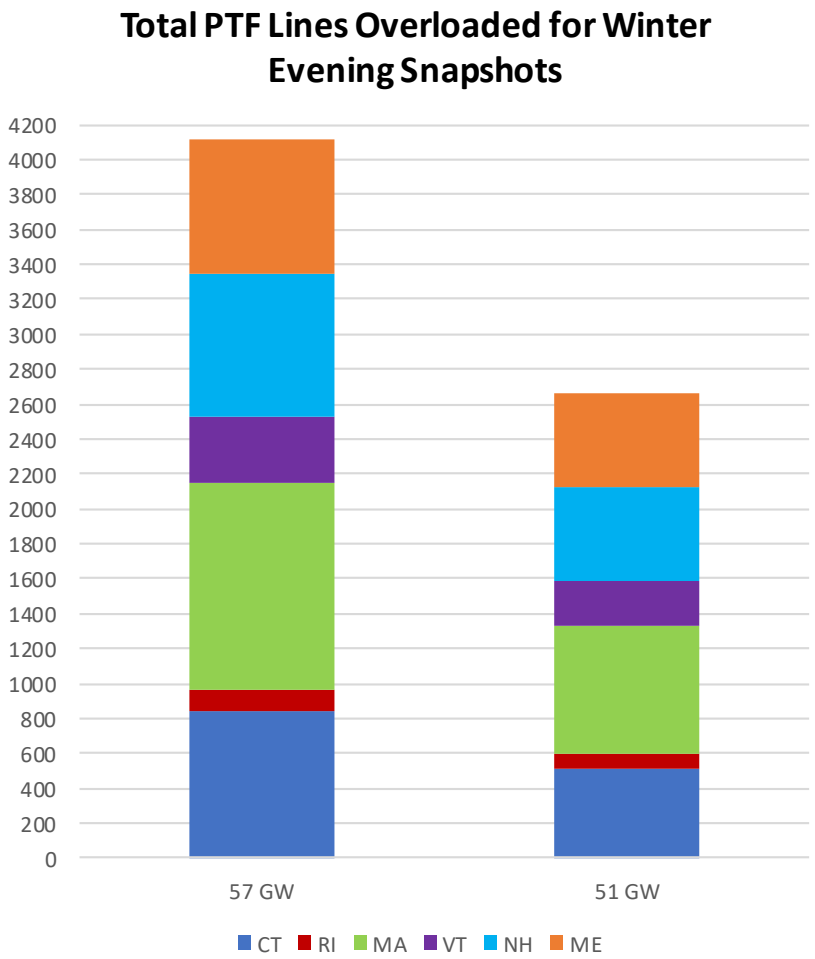
2050 WINTER EVENING PEAK SENSITIVITY

Load Reduction

2050 Winter Evening Peak Sensitivity: Development

- Load Reduction: A load reduction of approximately 6,000 MW, to 51,000 MW, was selected for this sensitivity
- Offshore Wind Reduction: To maintain energy balance, 6,800 MW of shortfall generation (modeled at offshore wind interconnection points) was reduced
  - All shortfall generation in ME and NH (3,600 MW) turned off
  - An additional 3,200 MW was reduced in SEMA/RI
- The 800 MW difference between load and generation changes is due to a reduction in transmission system losses

2050 Winter Evening Peak Sensitivity: Results



- 4,121 miles of PTF lines are overloaded in the original 57 GW 2050 Winter Evening Peak snapshot
- 2,665 miles of PTF lines are overloaded in the 51 GW 2050 Winter Evening Peak Sensitivity snapshot

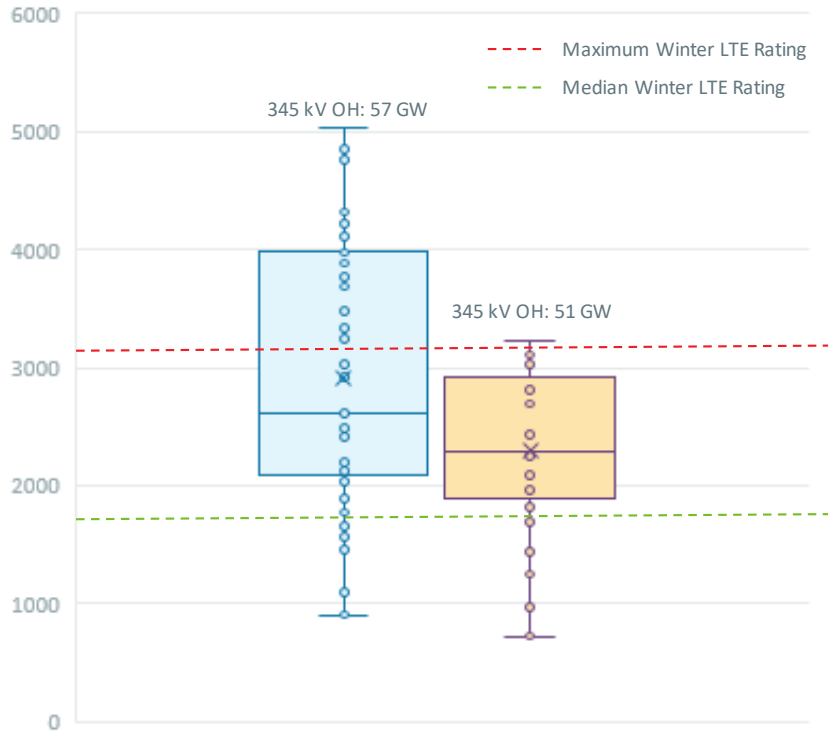
2050 Winter Evening Peak Sensitivity: Results

- Lower load leads to different outcomes in different states
  - Smaller decreases in overloads in northern New England
  - 345 kV overloads in Rhode Island and Connecticut virtually eliminated

State	kV Level	Total Overloaded Miles	
		57 GW Winter Peak Base Snapshot	51 GW Winter Peak Sensitivity Snapshot
ME	345 kV	352	258
	115 kV	421	278
NH	345 and 230 kV	236	173
	115 kV	584	375
VT	345 kV	0	0
	115 and 69 kV	372	258
MA	345 and 230 kV	323	162
	115 and 69 kV	859	567
CT	345 kV	181	6
	138, 115, and 69 kV	662	508
RI	345 kV	9	0
	115 kV	117	81

2050 Winter Evening Peak Sensitivity: Results

345 kV Overhead Line Flows (MVA) Winter Peak Base and Sensitivity Snapshots



- The severity of line overloads on 345 kV overhead lines drops significantly due to the reduced load level
- Overload severity on 345 kV underground lines drops as well, but not as much as overhead lines
- In addition to the overall reduction in line miles overloaded, most 345 kV overloads are expected to be able to be fixed with a rebuild at 51 GW of load

ADDITIONAL 2050 WINTER EVENING PEAK SENSITIVITY

Load Reduction + Offshore Wind Relocation

Additional 2050 Winter Evening Peak Sensitivity

- An additional 2050 Winter Evening Peak sensitivity snapshot was analyzed, based on comments received from Anbaric
  - Same 51 GW load level, and shortfall generation reduction, as in the previously-described 2050 Winter Evening Peak Sensitivity
  - 530 MW (nameplate) offshore wind farm moved from SEMA to CT
  - Two 1,200 MW (nameplate) offshore wind farms moved from ME to CT
- By modifying the interconnection locations of offshore wind, overloaded mileage was reduced to 2,248 miles
  - Approximately a 400 mile reduction, as compared to the previous sensitivity snapshot
- The average 345 kV overload decreased to 111%
  - Average 345 kV overload in the previous sensitivity snapshot was 122%
- Most of the reductions in overloads occurred in Maine

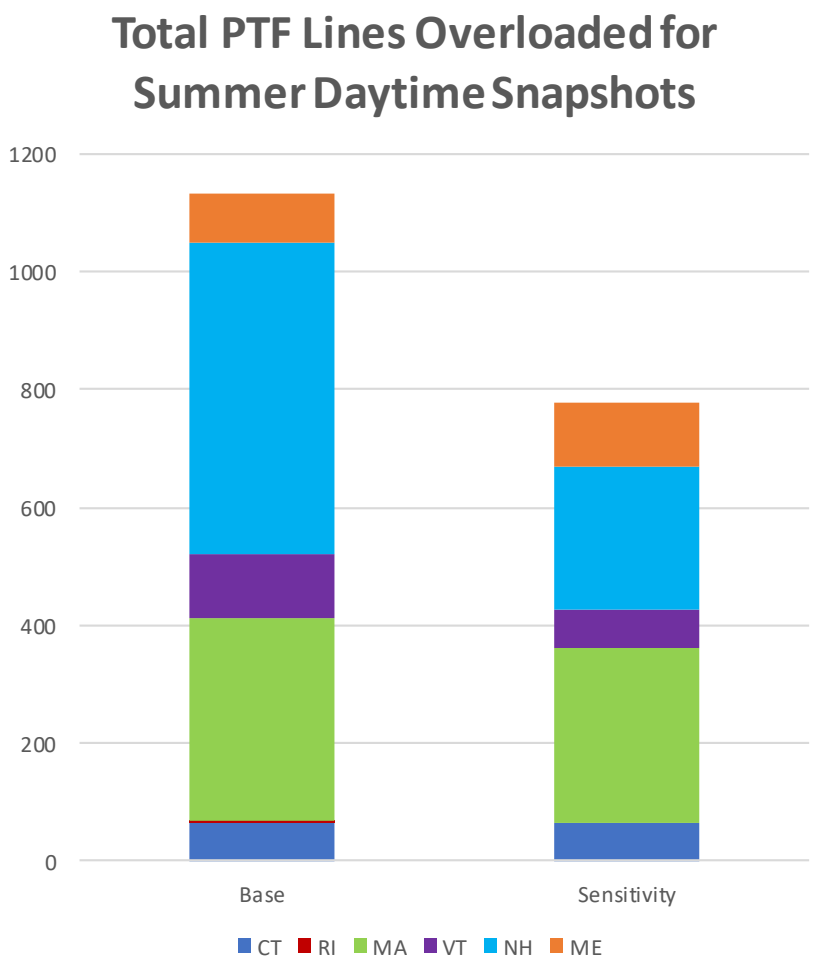
2050 SUMMER DAYTIME PEAK SENSITIVITY

Resource Curtailments

2050 Summer Daytime Peak Sensitivity: Development

- This sensitivity focused on resource curtailments to address overloads only seen in the 2050 Summer Daytime Peak snapshot
  - Overloads unique to this snapshot were primarily located in NH
- Curtailments were selected to optimally reduce overloads
- Approximately 1,200 MW of natural gas (1,070 MW in NH) and 750 MW of solar (610 MW in NH) were reduced
- The reductions were offset by approximately 1,950 MW of natural gas in SEMA/RI
  - Additionally, 80 MW shifted from one RI natural gas unit to another

2050 Summer Daytime Peak Sensitivity: Results



- 1,132 miles of PTF lines are overloaded in the original 2050 Summer Daytime Peak snapshot
- 788 miles of PTF lines are overloaded in the 2050 Summer Daytime Peak Sensitivity snapshot

2050 Summer Daytime Peak Sensitivity: Results

- Decreases in overloads in most areas of New England, although some new 115 kV overloads do appear

State	kV Level	Total Overloaded Miles	
		Summer Daytime Peak Base Snapshot	Summer Daytime Peak Sensitivity Snapshot
ME	345 kV	31	0
	115 kV	52	109
NH	345 and 230 kV	429	207
	115 kV	100	33
VT	345 kV	0	0
	115 and 69 kV	107	68
MA	345 and 230 kV	115	103
	115 and 69 kV	231	191
CT	345 kV	0	0
	115 kV	66	66
RI	345 kV	0	0
	115 kV	1	0

2050 Summer Daytime Peak Sensitivity: Results

- Overall, overloaded PTF mileage in the 2050 Summer Daytime Peak snapshot is reduced by over 30%
- Some new 115 kV overloads appear in these sensitivity results but not in the 51 GW 2050 Winter Evening Peak Sensitivity snapshot
  - 52 miles of newly-overloaded lines in ME, driven by generation reductions in western Maine to reduce North-South transfers
  - 27 miles of newly-overloaded lines in MA, due to load serving in Boston with increased SEMA/RI exports
- Overloads on 345 kV lines have been reduced in all states
- The 2050 Summer Daytime Peak Sensitivity snapshot still has some unique overloads that do not appear in the 2050 Summer Evening or 51 GW 2050 Winter Evening Peak Sensitivity snapshots
  - 22 miles in MA, 150 miles in NH, 75 miles in ME

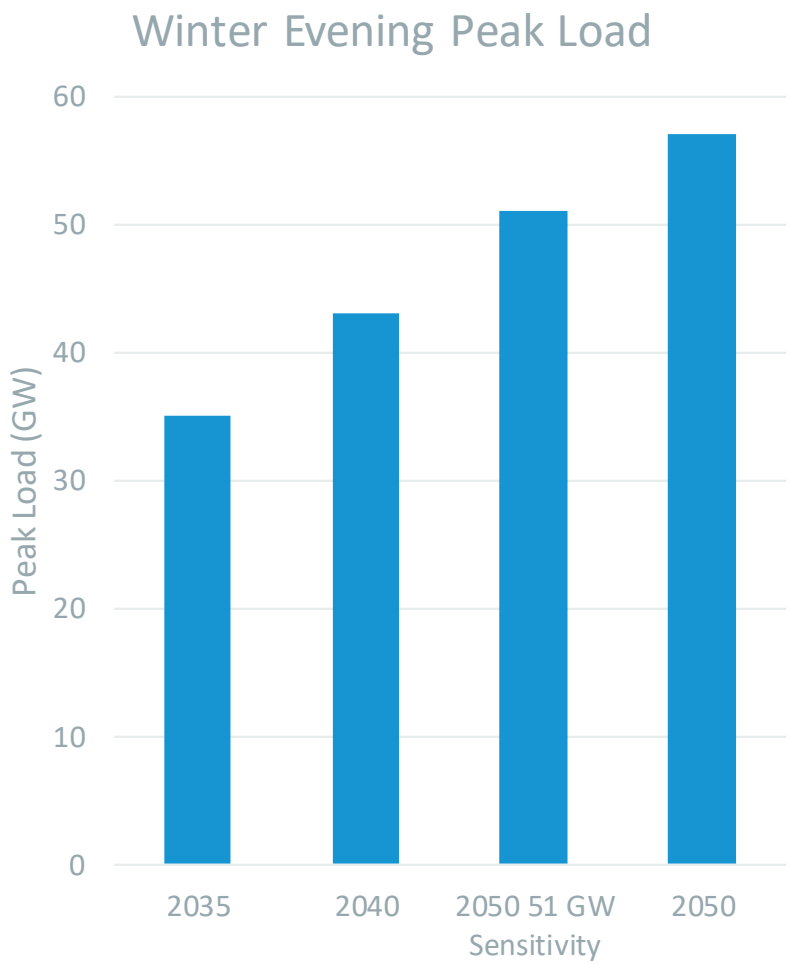
PLANS FOR SOLUTION DEVELOPMENT

Plans for Solution Development

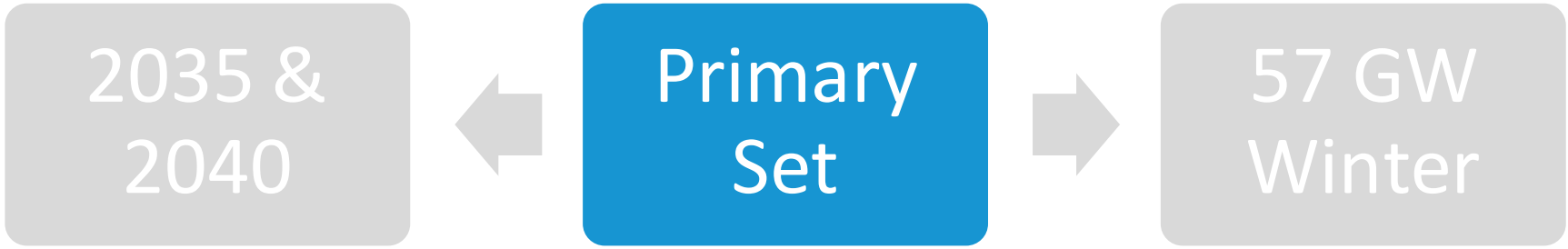
- One of the goals of the 2050 Transmission Study is to address observed transmission system overloads in a coordinated, long-term-oriented way
- Optimizing a solution for one set of snapshots may lead to a sub-optimal solution for other snapshots
  - For example: addressing issues seen in 2035 might lead to some relatively minor upgrades, but major transmission additions in 2040 or 2050 could later make these upgrades unnecessary
- The ISO is considering the following approach to solution development, but waiting for feedback from NESCOE before proceeding

Review: Load Levels in Snapshots Studied

- Highest loads occur in the Winter Evening Peak snapshots in all three study years
- Original 57 GW peak for 2050 is far higher than any other snapshot studied
- 51 GW sensitivity snapshot represents an alternate future with lower peak load growth, and shows fewer transmission deficiencies at peak loads

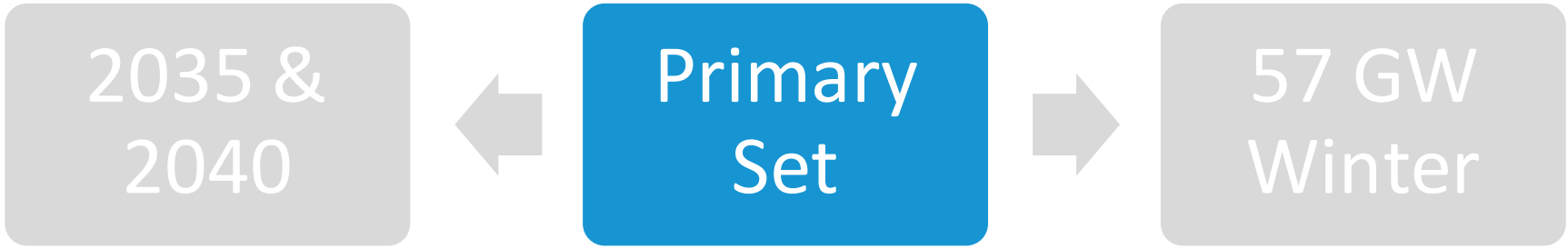


Development of Primary Solution Set



- The ISO would develop a primary set of transmission solutions that would address all transmission overloads in the following snapshots:
  - 2050 Winter Evening Peak – Either original 51 GW load sensitivity or 51 GW load sensitivity with relocated offshore wind
  - 2050 Summer Evening Peaks A & B
  - 2050 Summer Daytime Peak – Generation Curtailment sensitivity
- This will optimize transmission solutions for the concerns identified at all but the highest winter peak load levels

Development of Primary Solution Set, cont.



- The following process would be used to develop the primary solution set:
  - Add new transmission lines (either AC or DC) to address any overloads that are too severe to be solved through conductor size increases
  - Add/replace transformers to address any transformer overloads
  - In areas with many remaining overloads, determine whether a small number of new elements could efficiently address many needs
  - Fix any remaining overloads by rebuilding existing lines

Development of 2035 and 2040 Solution Sets

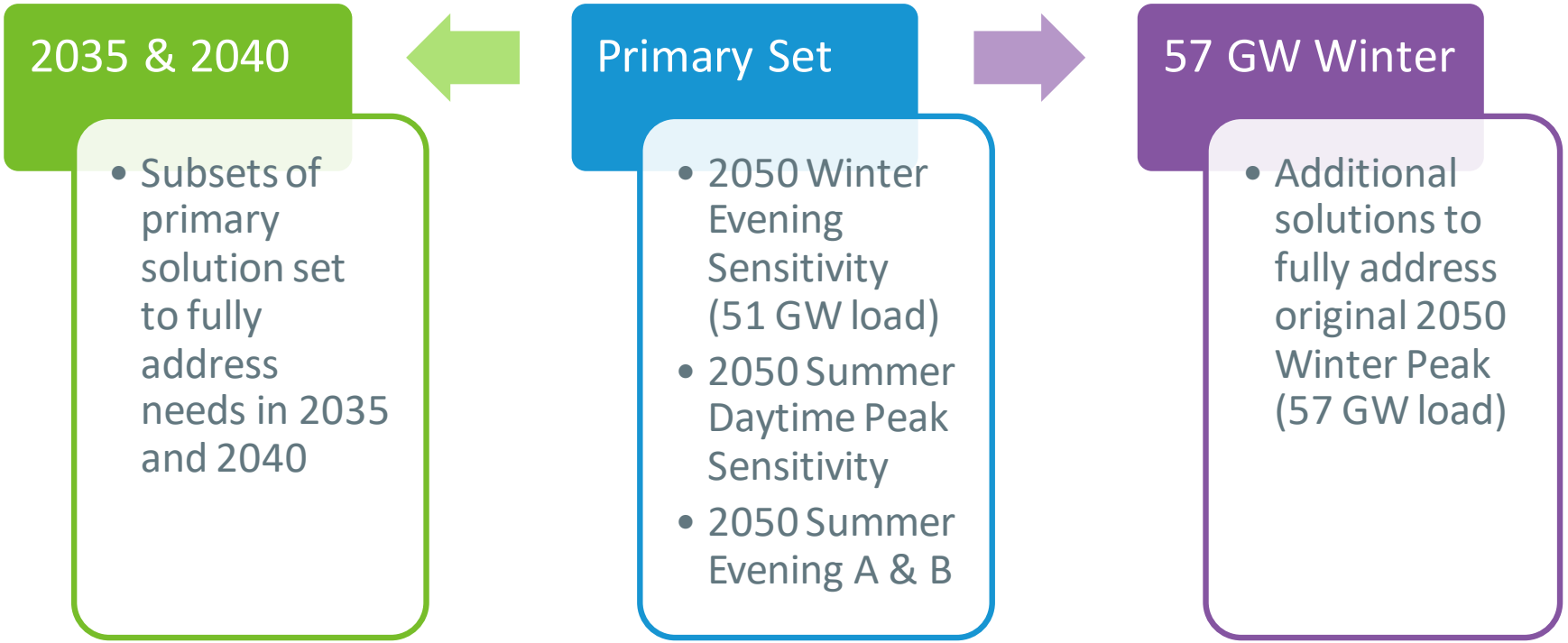
- Subsets of the primary solution set would be chosen in order to fully address needs found in 2035 and 2040 snapshots
- Beginning from the list of upgrades required for 2050 will ensure that short-term fixes designed around 2035 or 2040 do not become insufficient due to more severe reliability concerns in later years

Additional Solutions for 57 GW Winter Peak

- From the primary set, add transmission elements as necessary to serve the original 57 GW 2050 Winter Peak snapshot
  - This snapshot represents nearly 100% electrification of heating assuming existing technology
  - A 57 GW peak would not be likely to occur until well after 2040
  - Deferring these upgrades will avoid over-building the system in the event that more energy efficiency, distributed storage, demand response, alternate fuels for heating, or other technology keeps load below the original 57 GW assumption
- If desired, another additional solution set can be assembled for the original 2050 Summer Daytime Peak snapshot

Summary – All Solution Packages

The ISO is considering the following approach to solution development, but waiting for feedback from NESCOE before proceeding.



Cost Estimates

- Due to the large number of overloads, developing detailed cost estimates for each component could be very costly and time-consuming
- 2050 Transmission Study results already have a certain degree of uncertainty for many reasons:
  - Load distribution among substations is based on today's system; loads may grow more quickly at some substations than at others
  - The location of additional load-serving substations to address growing loads is not yet known
  - Future generation locations are assumed and may not match the decisions ultimately made by generation developers
  - Final transmission solutions may vary due to future detailed engineering, study work, and the exact Request for Proposal responses if the competitive transmission development process is utilized
- Precise cost estimates would provide "false precision" given these existing unknown factors

Cost Estimates, cont.

- The ISO proposes to develop more detailed cost estimates for major new solution components, such as:
  - HVDC transmission
  - Major 345 kV (or higher-voltage) additions
  - New overhead transmission on new rights-of-way
  - New transmission with major underground or submarine components
- For rebuilds or voltage conversions of existing lines, the ISO proposes to use typical ranges of per-mile cost assumptions
  - Conditions causing higher or lower costs for a given line could change by 2050, and estimating based on today's conditions may not be reflective of the actual costs when a project finally proceeds
  - Using typical costs may overestimate some costs and underestimate others; total result for all overloads will still be a reasonable assumption
- Discussions with NESCOE on approach to costs are ongoing

FEEDBACK AND NEXT STEPS

Feedback and Next Steps

- Any feedback may be submitted to pacmatters@iso-ne.com by May 13, 2022
- The ISO is continuing discussions on the approach to solution development and cost assumptions/estimates with NESCOE
- Following agreement with NESCOE regarding these open items, the ISO will continue with development of transmission solutions and associated costs for the identified deficiencies. This effort will continue throughout the rest of 2022, and may extend into early 2023