Grid in Transition Study: Phase 2 Analysis and Removing Negative Net Load Hours From the Phase 1 Analysis

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ICAP/MIWG

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Agenda

Today's Goals:

- Provide the results of the Phase 2 analysis
- Show the results of the Phase 1 analysis when eliminating negative net load hours

- **Background, 2022 study deliverable & plan**
- **Phase 2 Assumptions**
- **Phase 2 results**
  - Load shapes – winter peak, summer peak and shoulder
  - Distributions of hourly ramp needs over the year
  - Multi-hour ramp needs
- **Revisiting Phase 1 removing negative net load hours**
  - Phase 1 Assumptions
  - Phase 1 results when eliminating negative net load hours: leveraging the information in the Climate Change Phase 1 Study and the System and Resource Outlook Policy Case renewable buildouts
    - Load shapes – winter peak, summer peak and shoulder
    - Distributions of hourly ramp needs over the year
    - Multi-hour ramp needs
- **Next Steps**

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Background, 2022 study deliverable & plan

Grid in Transition

- **Background:**
  - A rapid transition is underway in New York State from a power grid where energy is largely produced by central-station fossil fuel generation, towards a grid with increased intermittent renewable resources and distributed generation.
  - A grid characterized by high levels of intermittent renewable resources and distributed generation will require new thinking. We approach potential market enhancement efforts with two guiding principles:
    - (1) all aspects of grid reliability must be maintained; and
    - (2) competitive markets should continue to maximize economic efficiency and minimize the cost of maintaining reliability while supporting the achievement of New York's climate policy codified in the CLCPA.
  - The study will inform the NYISO's planning, forecasting, and operations, as well as the development of wholesale market mechanisms to enhance grid resilience.

Excerpted from the August 27 2021 presentation of *2022 Market Project Candidates*
https://www.nyiso.com/documents/20142/24145498/02%20Proposed%202022%20Market%20Project%20Descriptionsl.pdf/1950d339-57d7-7e0d-dcc2-4ac1e6a738bc

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Grid in Transition

- **Deliverable: Q4 Study Complete**
- **Project Description:**
  - Using the work completed to date across various NYISO studies and initiatives, including the Reliability and Market Considerations for a Grid in Transition work and Climate Change Study work, the 2022 effort will identify and, if possible, quantify through a new study, the potential level of system flexibility and/or grid attributes needed to reliably maintain system balance.

Excerpted from the August 27 2021 presentation of *2022 Market Project Candidates*
https://www.nyiso.com/documents/20142/24145498/02%20Proposed%202022%20Market%20Project%20Descriptionsl.pdf/1950d339-57d7-7e0d-dcc2-4ac1e6a738bc

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Plan

- The study will look at the evolution of the variability that dispatchable generators will face over time to inform upcoming market design decisions: are changes to existing market products needed and/or are new products needed for the reliable operation of the grid?
- The study will
  - Look at evolution of load and net load shapes (load net of wind and solar) over time,
  - Look at the distribution of hourly ramps over time, and
  - Look at periods (multi day) with low wind and solar and what that implies for net energy and hourly ramps.
- Since load forecasts are constantly evolving and being reviewed and since different load forecasts have different implications, the study will leverage different forecasts and their underlying assumptions using data from previous studies.

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Multi phase study

- First phase – leverage the Climate Change Phase 1 "CLCPA Case" data to look at the questions
- Second phase – coordinate with 2022 planning studies
  - Leverage the upcoming Outlook study Policy Case (Scenario 1) and the NYSERDA Integration Analysis (Scenario 2) load forecast case
- See March 3 ICAP/MIWG presentation for additional details

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Multi phase study

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Phase 2 Assumptions

Climate Change Phase 2: Leveraging the Outlook study

- This phase of the study will be based on the 2021-2040 System and Resource Outlook study data.
- Just like in Phase 1, we are focused on the hourly variability from the Net Load defined as:
  - Load

    minus BTM output

    minus Front of the meter solar output

    minus Off Shore Wind Output

    minus Land Based Wind Output*
- We look at both Policy Case 1 and Policy Case 2 and use all the information (load, renewable output, curtailments, etc.) from those Outlook study cases. Please see the 2021-2040 System and Resource Outlook study presentations and report** for more information on the assumptions.

* The renewable output is net of curtailments.

** 2021-2040 System and Resource Outlook (The Outlook)

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Phase 2 results

Phase 2
Load Shapes – 2030 and 2040 (and actual 2021)

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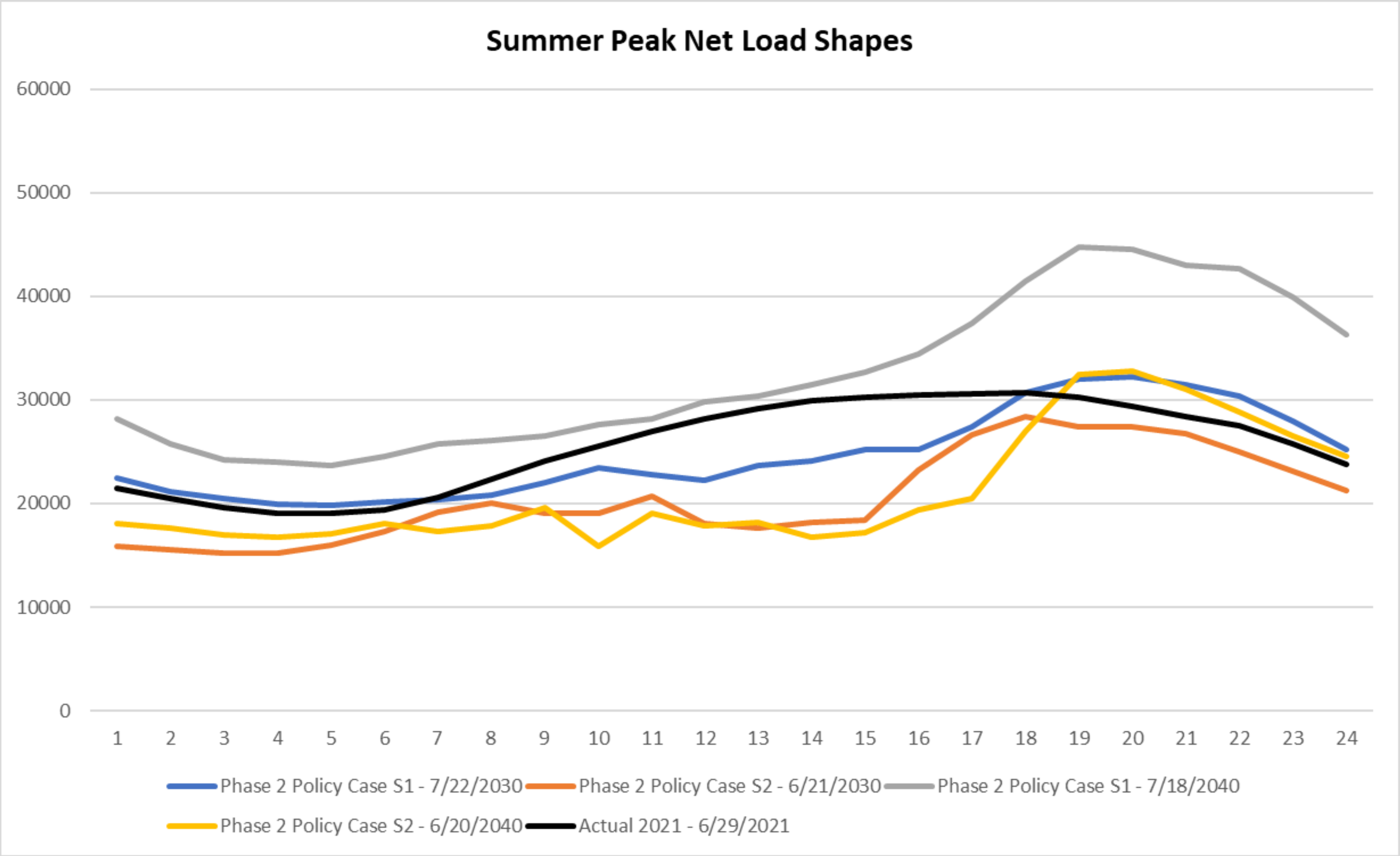
Summer Peak Net Load Shapes
60000
50000
40000
30000
20000
10000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Phase 2 Policy Case S1 - 7/22/2030
Phase 2 Policy Case S2 - 6/21/2030
Phase 2 Policy Case S1 - 7/18/2040
Phase 2 Policy Case S2 - 6/20/2040
Actual 2021 - 6/29/2021

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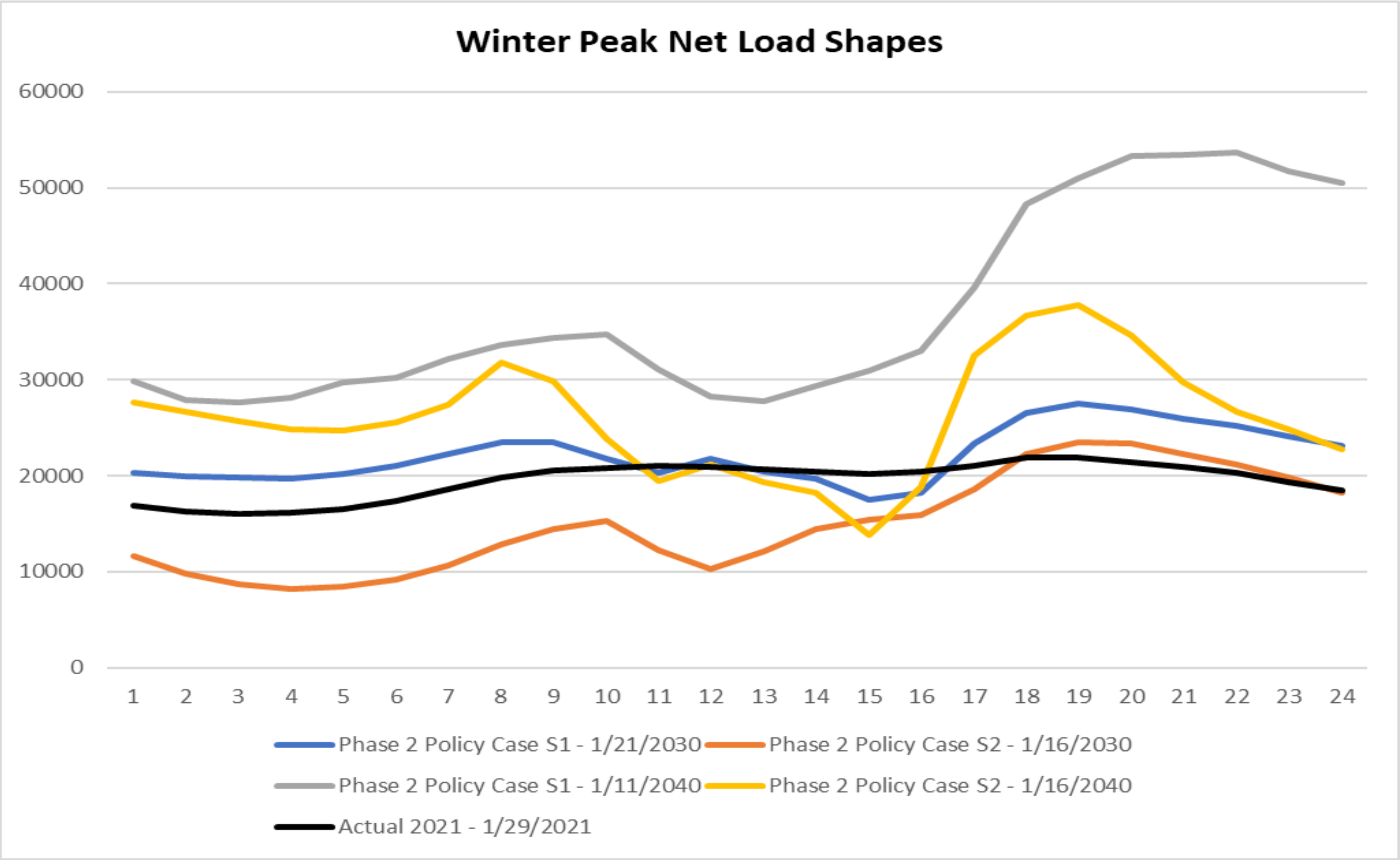
Winter Peak Net Load Shapes
60000
50000
40000
30000
20000
10000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Phase 2 Policy Case S1 - 1/21/2030
Phase 2 Policy Case S2 - 1/16/2030
Phase 2 Policy Case S1 - 1/11/2040
Phase 2 Policy Case S2 - 1/16/2040
Actual 2021 - 1/29/2021

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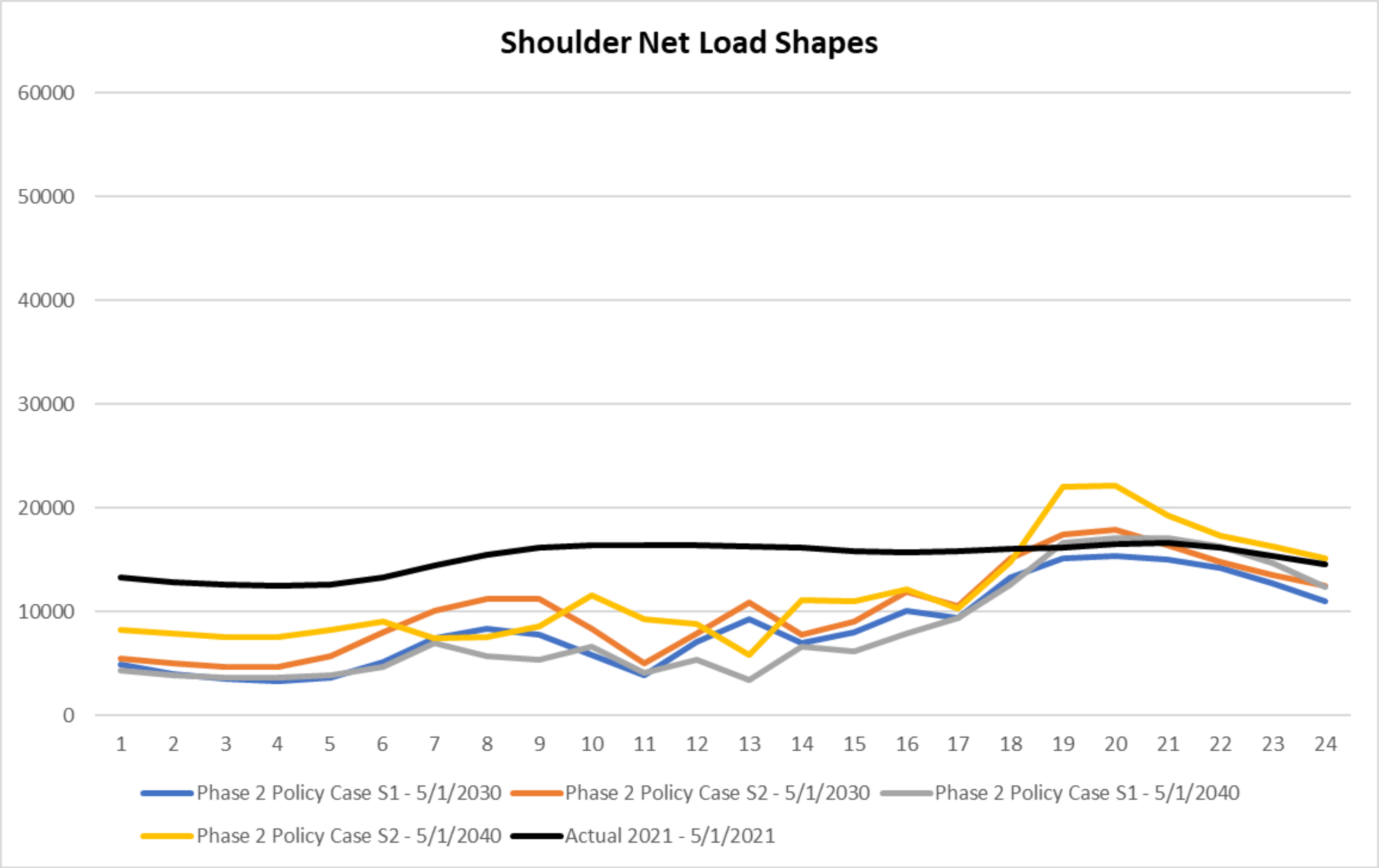

Shoulder Net Load Shapes
60000
50000
40000
30000
20000
10000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Phase 2 Policy Case S1 - 5/1/2030
Phase 2 Policy Case S2 - 5/1/2030
Phase 2 Policy Case S1 - 5/1/2040
Phase 2 Policy Case S2 - 5/1/2040
Actual 2021 - 5/1/2021

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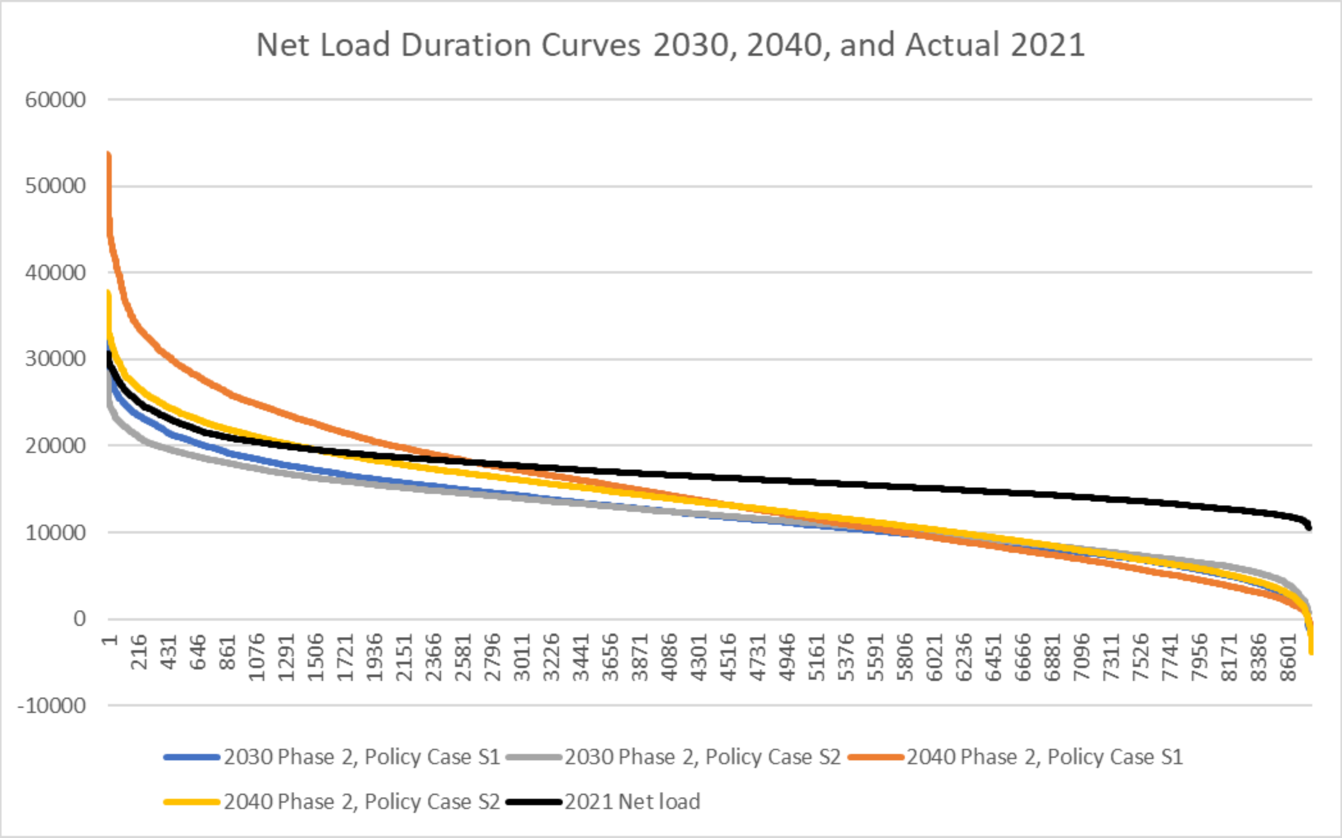
Phase 2
Net Load Duration Curves– 2030 and 2040 (and actual 2021)



Net Load Duration Curves 2030, 2040, and Actual 2021
60000
50000
40000
30000
20000
10000
0
-10000
1
216
431
646
861
1076
1291
1506
1721
1936
2151
2366
2581
2796
3011
3226
3441
3656
3871
4086
4301
4516
4731
4946
5161
5376
5591
5806
6021
6236
6451
6666
6881
7096
7311
7526
7741
7956
8171
8386
8601
2030 Phase 2, Policy Case S1
2030 Phase 2, Policy Case S2
2040 Phase 2, Policy Case S1
2040 Phase 2, Policy Case S2
2021 Net load

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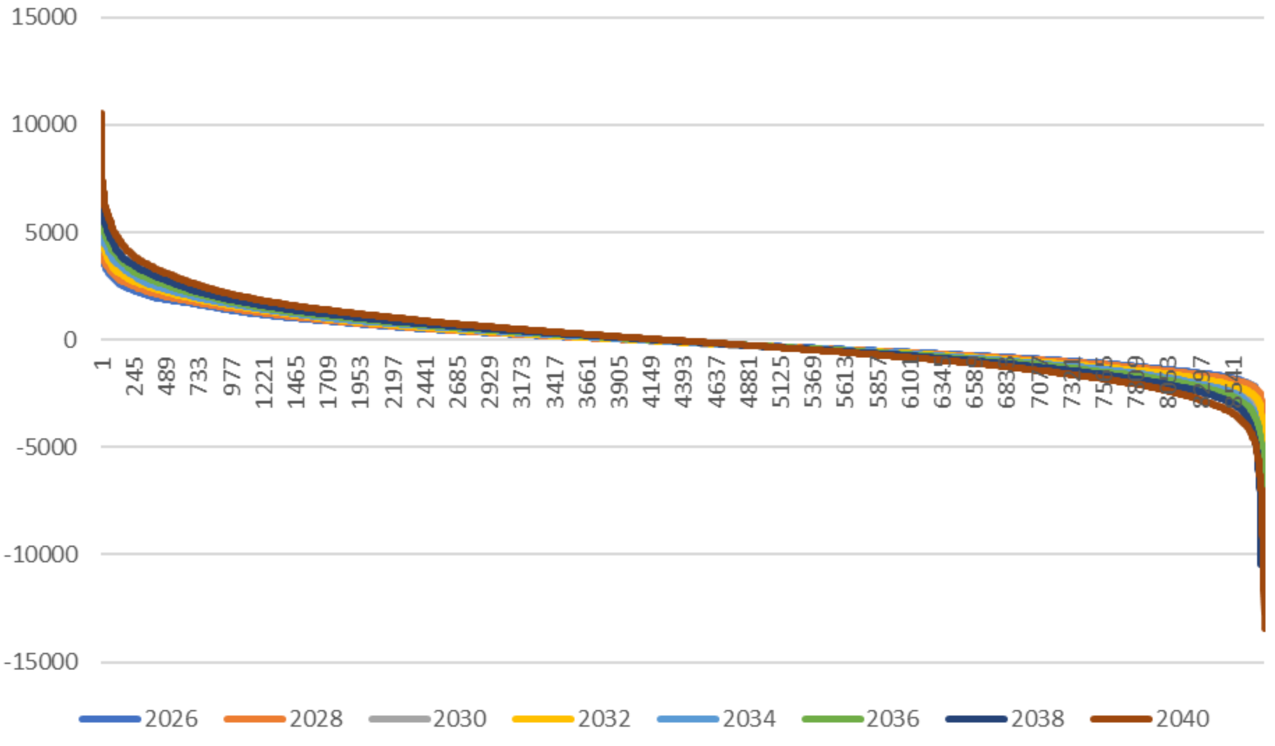
Phase 2 Ramp Distribution Curves

Looking at the hourly ramps over the entire year

Outlook Policy Case S1

Net Load Single Hour Ramp Distribution Curves (Including All Intermittent Resources) Phase 2 Policy Case S1



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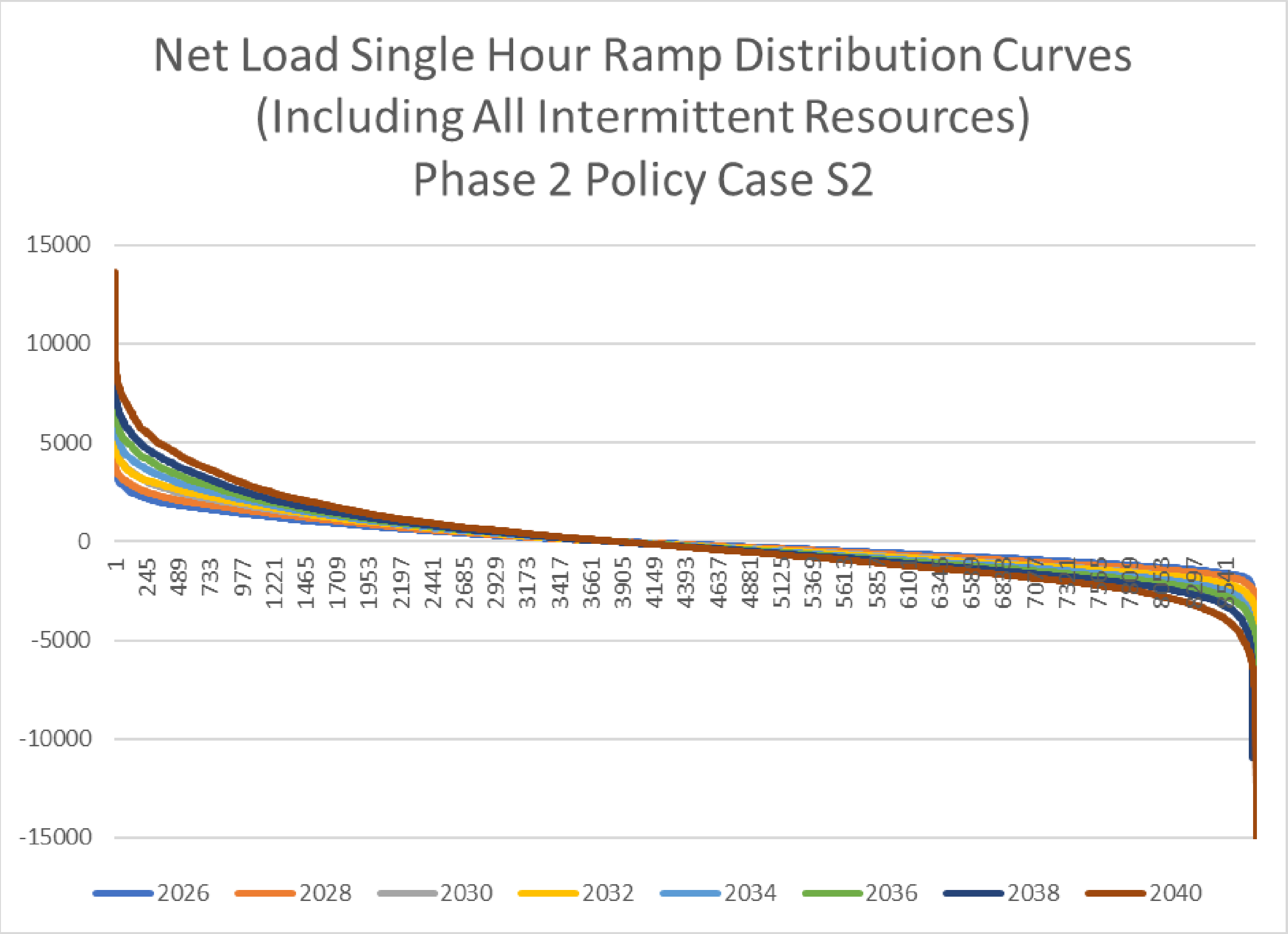
Outlook Policy Case S2


Net Load Single Hour Ramp Distribution Curves
(Including All Intermittent Resources)
Phase 2 Policy Case S2
15000
10000
5000
0
-5000
-10000
-15000
1
245
489
733
977
1221
1465
1709
1953
2197
2441
2685
2929
3173
3417
3661
3905
4149
4393
4637
4881
2026
2028
2030
2032
2034
2036
2038
2040

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Phase 2 Multi Hour Ramps

Looking at the total multi hour ramps over the entire year*

*Note: Does not include the over midnight ramps because of data discontinuities that produce phantom ramps

Multi Hour Ramps

- **Although looking at hourly ramps is very informative, the total ramp up is particularly useful to look at when considering the future needs of the grid**
- **We are looking at several different metrics**
  - The 3 and 5 hour ramping needs – a rolling metric that looks at the in-day net ramp (including all intermittent resources) over 3 and 5 hours.
  - The ramp needs over the entire up or down in-day ramp period
    - For example, if over a 24 hour period the net load ramps down for 6, up for 8 hours, down for 2 then up again for 5 and down for 3 that would be three down ramp events for 6, 2, and 3 hours and two up events for 8 and 5 hours.
    - This allows visibility of the full magnitude of ramp up events.

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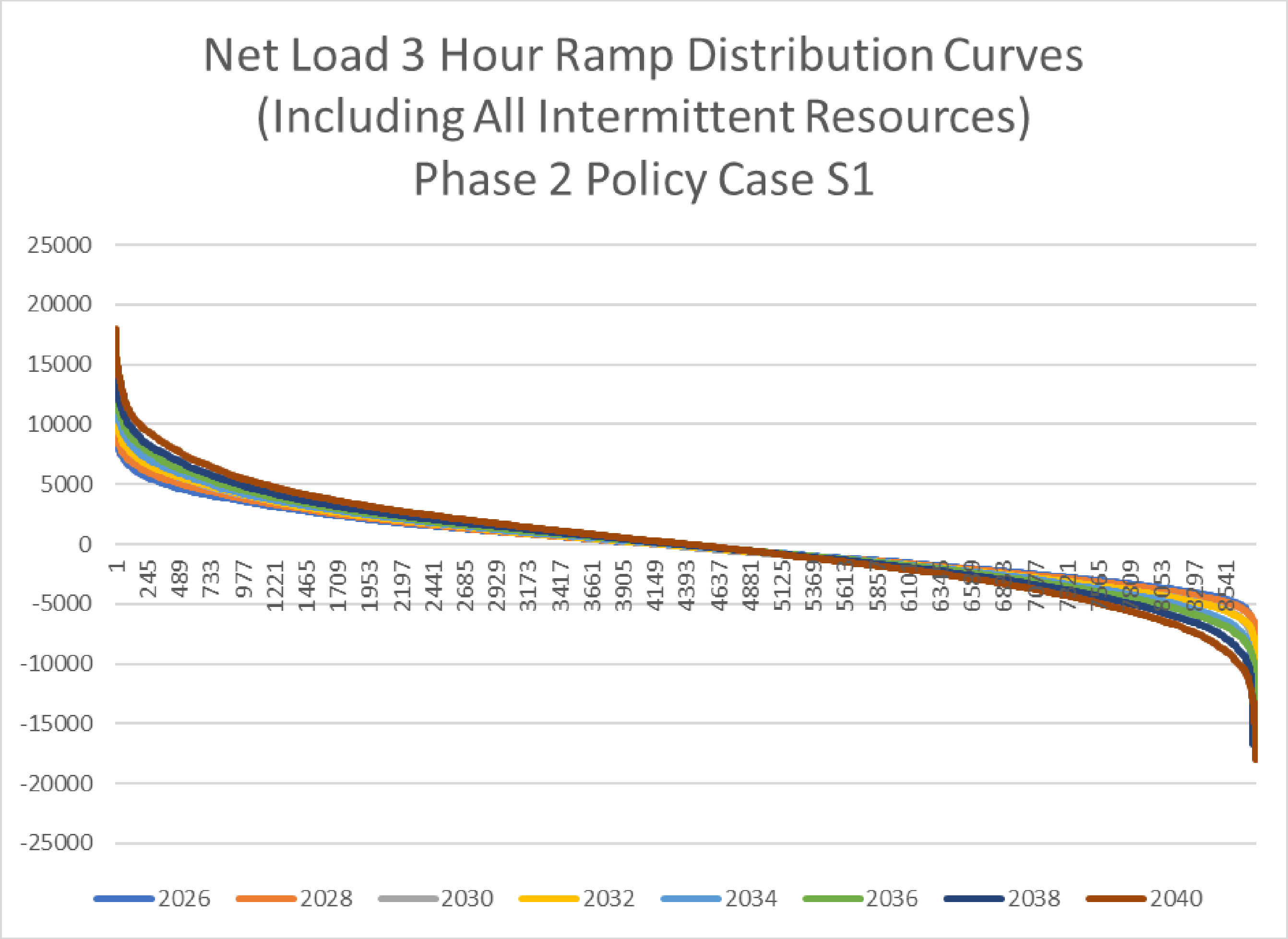
Outlook Policy Case S1



Net Load 3 Hour Ramp Distribution Curves
(Including All Intermittent Resources)
Phase 2 Policy Case S1
25000
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
1
245
489
733
977
1221
1465
1709
1953
2197
2441
2685
2929
3173
3417
3661
3905
4149
4393
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4881
5125
2026
2028
2030
2032
2034
2036
2038
2040

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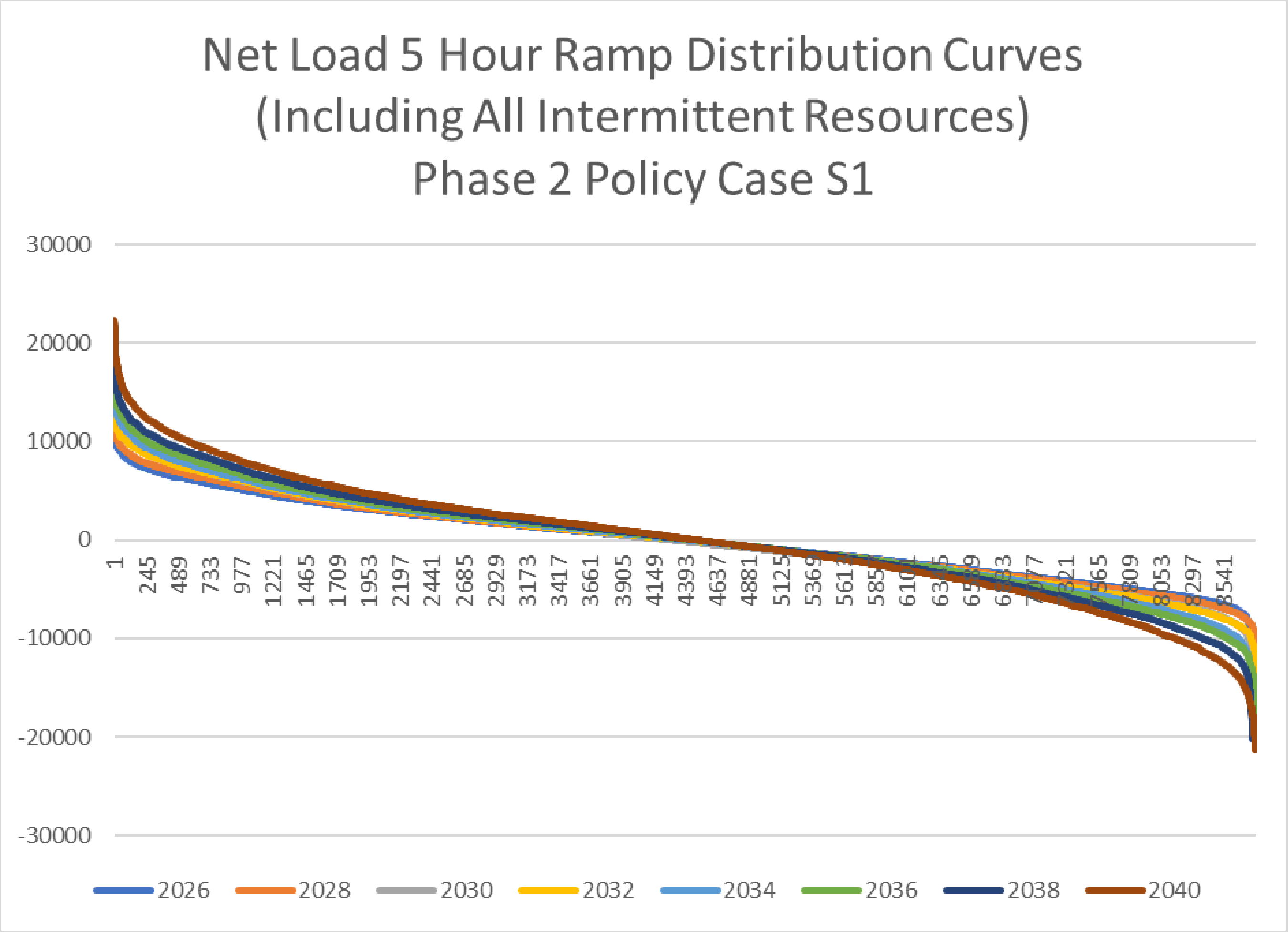
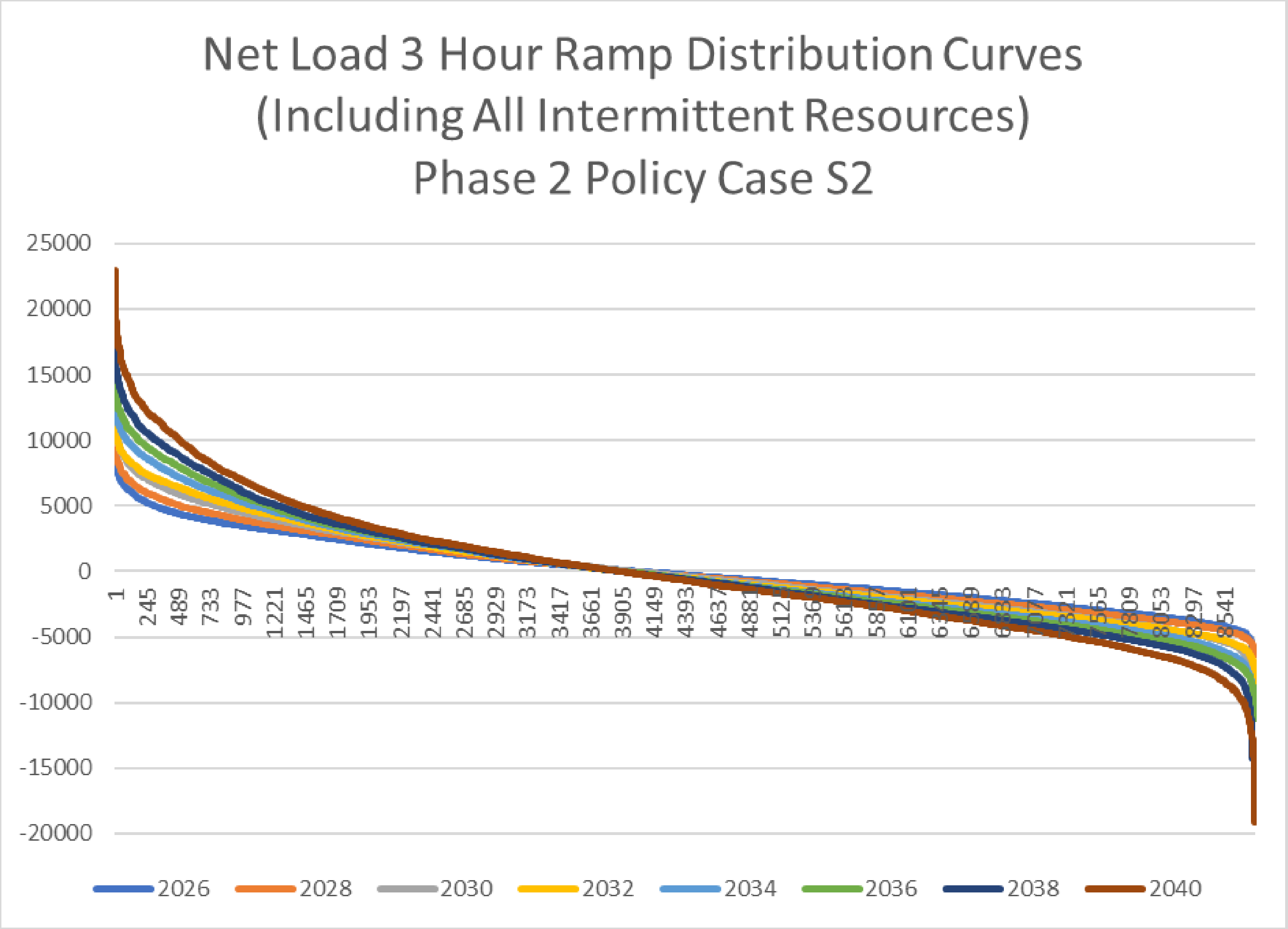
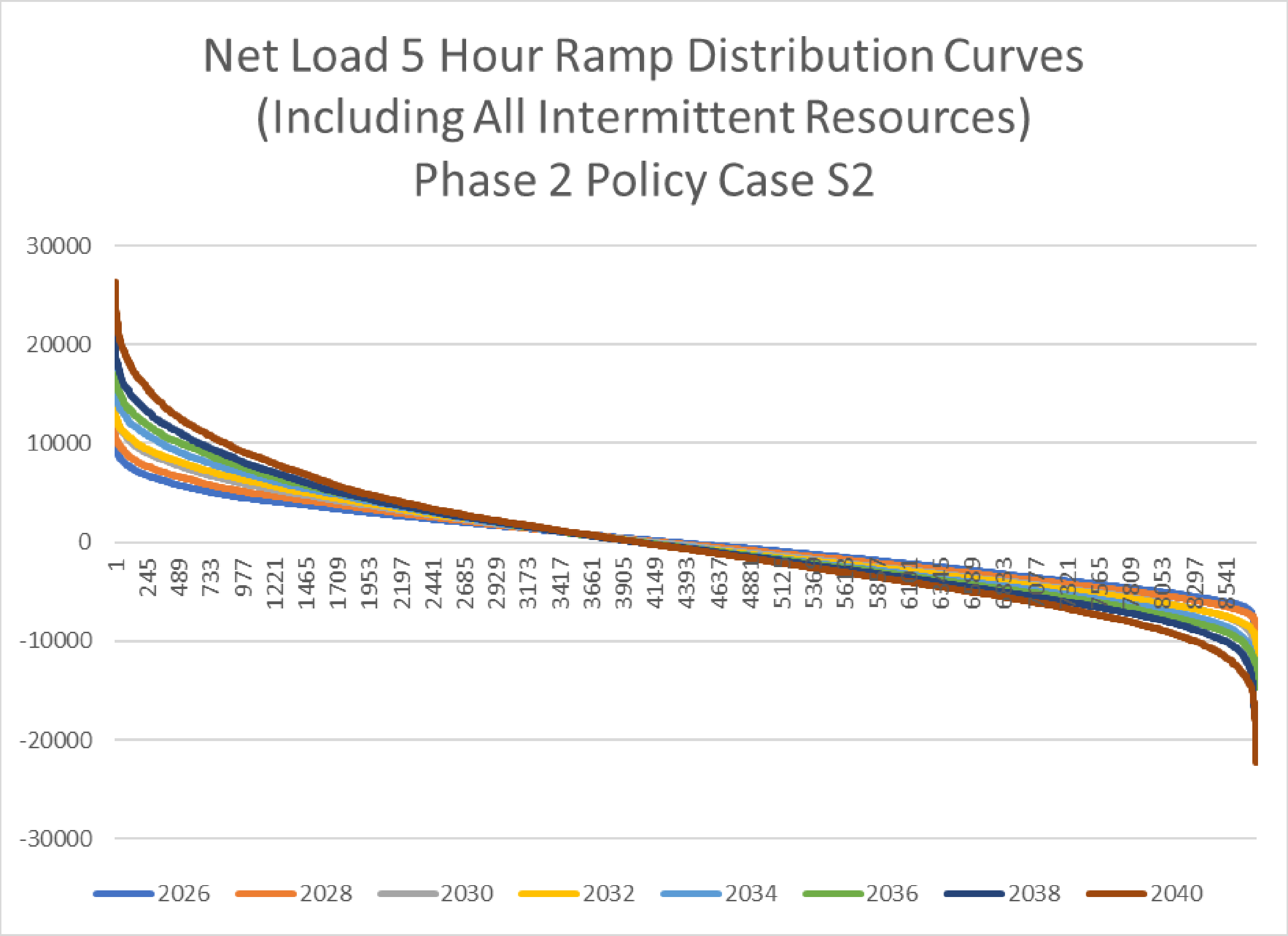

Net Load 5 Hour Ramp Distribution Curves
(Including All Intermittent Resources)
Phase 2 Policy Case S1
30000
20000
10000
0
-10000
-20000
-30000
1
245
489
733
977
1221
1465
1709
1953
2197
2441
2685
2929
3173
3417
3661
3905
4149
4393
4637
4881
5125
8541
2026
2028
2030
2032
2034
2036
2038
2040

Outlook Policy Case S2



DRAFT – FOR DISCUSSION PURPOSES ONLY


Net Load 5 Hour Ramp Distribution Curves
(Including All Intermittent Resources)
Phase 2 Policy Case S2
30000
20000
10000
0
-10000
-20000
-30000
1
245
489
733
977
1221
1465
1709
1953
2197
2441
2685
2929
3173
3417
3661
3905
4149
4393
2026
2028
2030
2032
2034
2036
2038
2040

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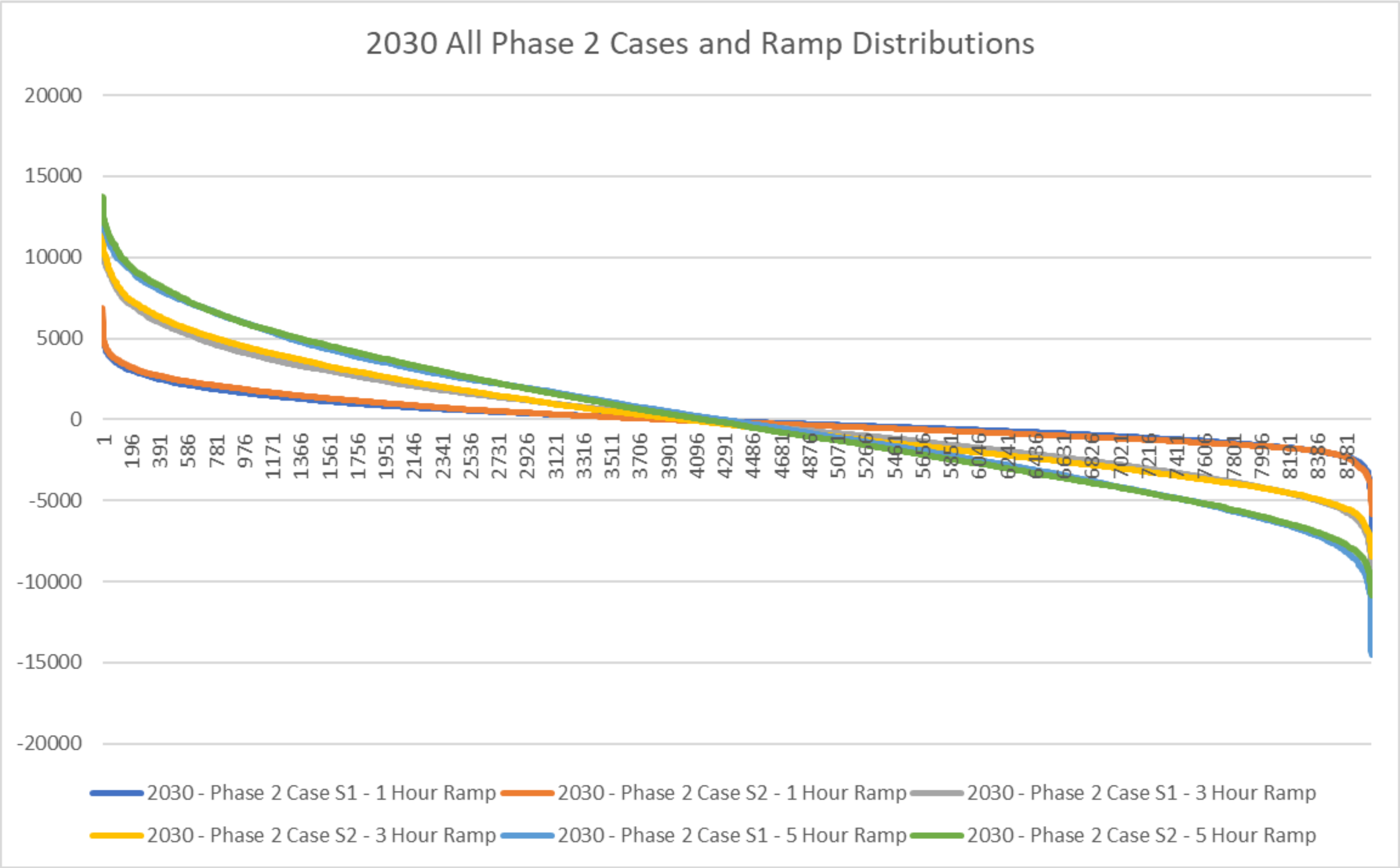
Looking at 2030



2030 All Phase 2 Cases and Ramp Distributions
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
1
196
391
586
781
976
1171
1366
1561
1756
1951
2146
2341
2536
2731
2926
3121
3316
3511
3706
3901
4096
4291
4486
4681
4876
5071
5266
5461
5656
5851
6046
6241
6436
6631
6826
7021
7216
7411
7606
7801
7996
8191
8386
8581
2030 - Phase 2 Case S1 - 1 Hour Ramp
2030 - Phase 2 Case S2 - 1 Hour Ramp
2030 - Phase 2 Case S1 - 3 Hour Ramp
2030 - Phase 2 Case S2 - 3 Hour Ramp
2030 - Phase 2 Case S1 - 5 Hour Ramp
2030 - Phase 2 Case S2 - 5 Hour Ramp

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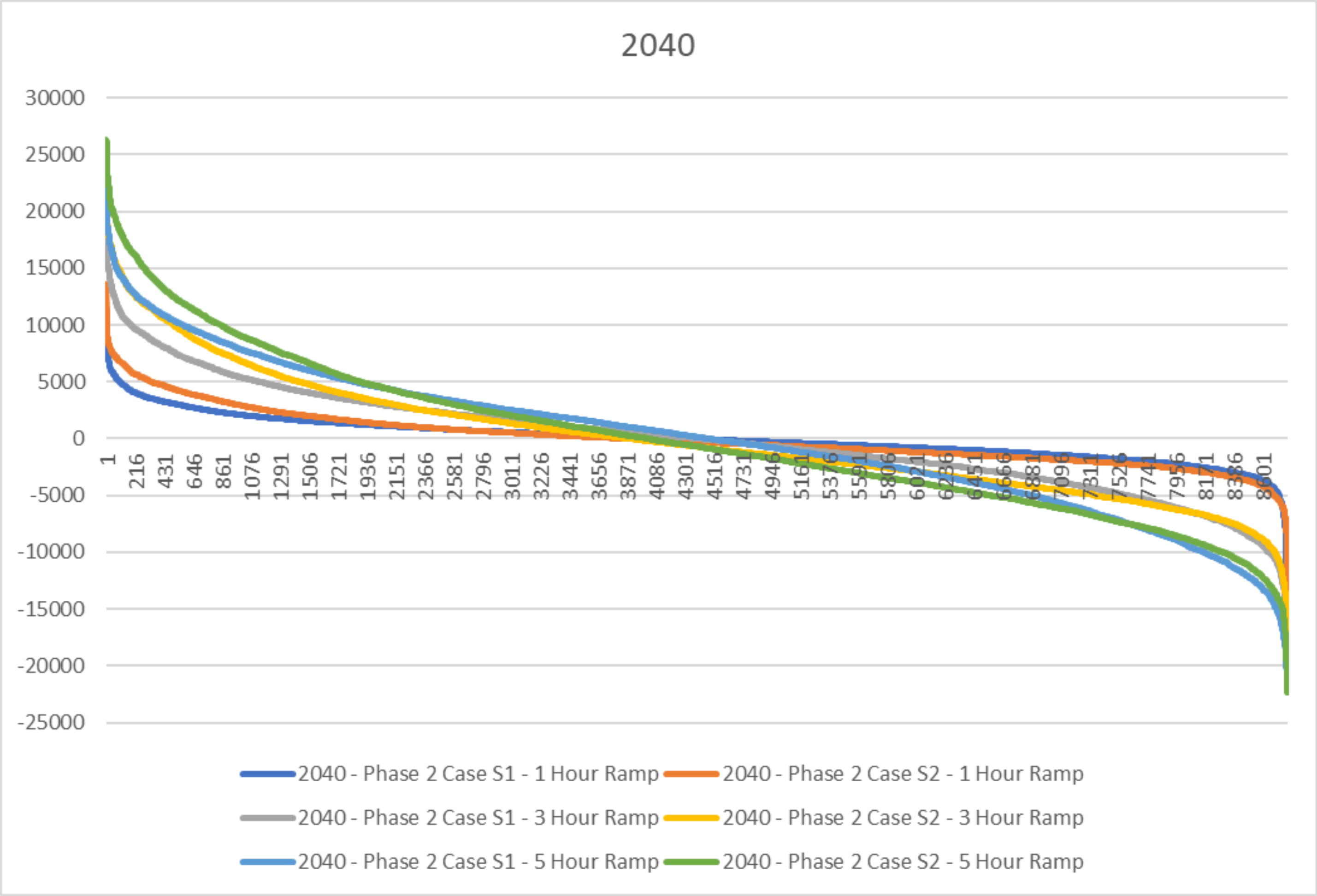
Looking at 2040



2040
30000
25000
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
1
216
431
646
861
1076
1291
1506
1721
1936
2151
2366
2581
2796
3011
3226
3441
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4086
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4516
4731
4946
5161
5376
5591
5806
6021
6236
6451
6666
6881
7096
7311
7526
7741
7956
8171
8386
8601
2040 - Phase 2 Case S1 - 1 Hour Ramp
2040 - Phase 2 Case S2 - 1 Hour Ramp
2040 - Phase 2 Case S1 - 3 Hour Ramp
2040 - Phase 2 Case S2 - 3 Hour Ramp
2040 - Phase 2 Case S1 - 5 Hour Ramp
2040 - Phase 2 Case S2 - 5 Hour Ramp

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Multi Hour Ramping Needs

- This metric looks at the entirety of the ramp up and ramp down events
- The next slides show both the Phase 2 statistics and the Phase 1 statistics previously presented
- There are a number of differences, however, overall the two Phases of the study are quite similar
  - The S1 and S2 cases continue to show somewhat different ramps but the differences between them are somewhat smaller in the Phase 2 analysis.
  - The higher amounts of solar resources in Policy Case S2 along with the different loads lead to larger ramp needs in the extremes of the distribution (both ramps up and ramps down) especially in the later years. This is consistent with the load shapes and hourly ramp distributions seen earlier.
  - The most notable difference between Phase 1 and Phase 2 are that in Phase 2 the mean and median of the ramping needs are both near zero

Multi Hour Ramping Needs

Summary Statistics- Phase 2 of Study (2025-2040)

Scenario	Year	No. of Instances	Average number of Ramp up hours	Average ramp MWs	25 %ile Ramp MWs	50 %ile / Median Ramp MWs	75 %ile Ramp MWs	Max Ramp	Max Ramp	Max number of hours	Min number of ramp hours
Policy Case S1	Overall	33431	4.2	0.2	-3127	0	3270	25863	-25906	17	1
Policy Case S2	Overall	34807	4.0	-0.2	-4316	0	3924	27920	-27032	18	1

Summary Statistics- Phase 1 of Study (2022-2040)

	Year	No. of Instances	Average number of Ramp up hours	Average ramp MWs	25 %ile Ramp MWs	50 %ile / Median Ramp MWs	75 %ile Ramp MWs	Max Ramp Up	Max Ramp Down	Max number of hours	Min number of ramp hours
Policy Case S1	Overall (2022-2040)	46077	3.5	331	-2401	-257	2845	24388	-23631	19	1
Policy Case S2	Overall (2022-2040)	45383	3.5	337	-2635	-287	2505	36692	-36308	17	1

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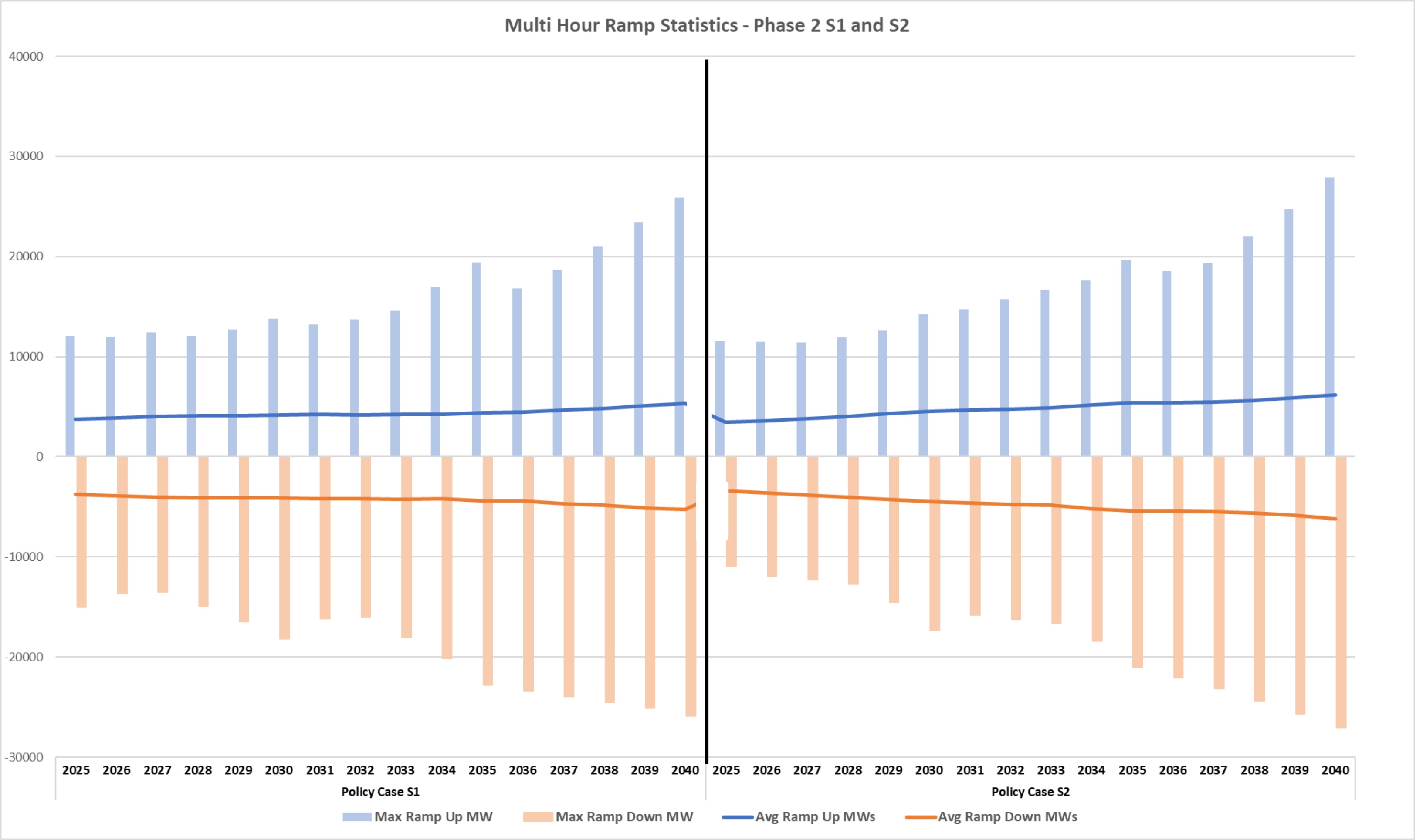
Multi Hour Ramp Statistics - Phase 2 S1 and S2
40000
30000
20000
10000
0
-10000
-20000
-30000
2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Policy Case S1
2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Policy Case S2
Max Ramp Up MW
Max Ramp Down MW
Avg Ramp Up MWs
Avg Ramp Down MWs

Ramp up needs

- Focusing on instances when the multi-hour ramp up is greater than 5,000MW and when it is greater than 10,000 MW
  - Ramp up needs are larger in 2040 than 2030
  - Ramp up needs greater under Policy Case S2 than S1 because of the larger amounts of assumed intermittent resources

Scenario	Year	No. of Instances	Ramp MWs	Average number of Ramp up hours	Average ramp MWs	Shoulder % (6 months)	Winter %	Summer %	25 %ile Ramp MWs	50 %ile / Median Ramp MWs	75 %ile Ramp MWs
Policy Case S1	2030	364	>5000	6.1	8428	48%	29%	24%	6763	8392	9920
Policy Case S1	2040	461	>5000	6.0	10613	47%	29%	24%	7287	10161	13420
Policy Case S2	2030	441	>5000	5.2	8081	50%	28%	22%	6144	7773	9691
Policy Case S2	2040	550	>5000	4.5	11828	49%	29%	21%	7471	11219	15195
Policy Case S1	2030	86	>10000	7.2	11266	42%	30%	28%	10569	11077	11767
Policy Case S1	2040	239	>10000	6.9	13729	37%	33%	30%	11489	13306	15402
Policy Case S2	2030	94	>10000	5.8	11263	54%	31%	15%	10398	11051	11923
Policy Case S2	2040	314	>10000	5.1	15323	48%	28%	24%	12180	14391	17597

Revisiting Phase 1 Results without negative net load hours

Phase 1 Assumptions

Climate Change Phase 1 “CLCPA Case”

- **As discussed in the prior presentations, this phase of the study will be based on the Climate Change Phase 1 CLCPA Case load forecast data. ***
- **Today’s presentation is focused on the hourly variability from:**
  - Climate Change Phase 1 load forecast (adjusted for the new 10 GW BTM PV in 2030)
    minus Front of the meter solar output
    minus Off Shore Wind Output
    minus Land Based Wind Output
- **Note that this can result in negative Net Load which may lead to larger than expected ramps. <u>This section of the presentation focuses on ramps when Net Load is non-negative</u>.**
  - This replicates what would happen if renewables were curtailed or additional load were to come online
  - In other words, when the prior analysis would have had a negative net load, the load has been set to zero

* Climate Change Phase 1 report;

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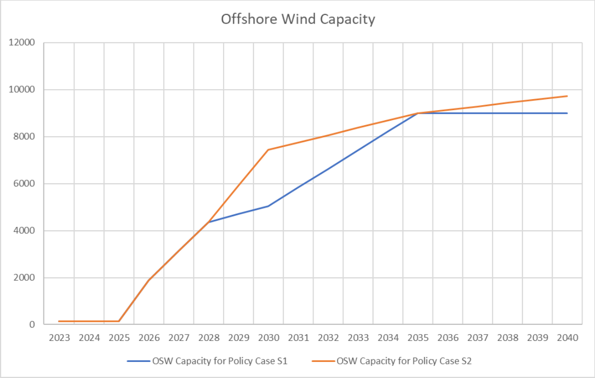
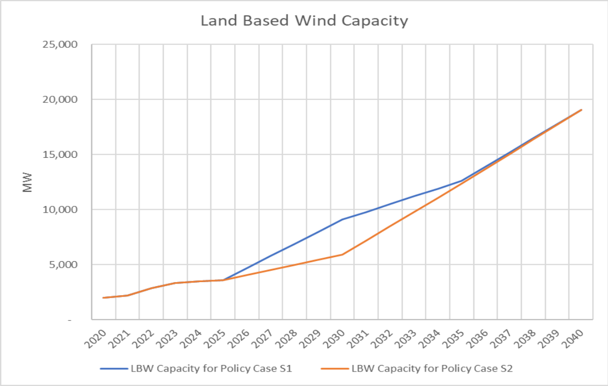
Assumptions – Wind (LBW and OSW)

- **Land Based Wind (LBW) & Off Shore Wind (OSW) Capacity**
  - Existing LBW capacity based on the 2021 Gold Book
  - Capacity additions for both Land Based Wind and Offshore Wind were taken from
    - Facilities that have completed Class Year Facilities Study (2021 Gold Book)
    - Facilities that have completed CRIS Request (2021 Gold Book)
    - Future and Non-Class Year Facilities reported to NYSERDA ((https://data.ny.gov/Energy-Environment/Large-scale-Renewable-Projects-Reported-by-NYSERDA/dprp-55ye)
  - Beyond the years reported for entry of these facilities, subsequent additions were determined using linear trends based on System and Resource Outlook Policy Cases S1 and S2 (see the April 26 ESPWG presentation)
- **LBW Shapes - Based on the 2009 Land Based Wind Hourly NREL Data**
- **OSW Shapes - Based on the 2009 Offshore Wind Annual Hourly NREL Data**





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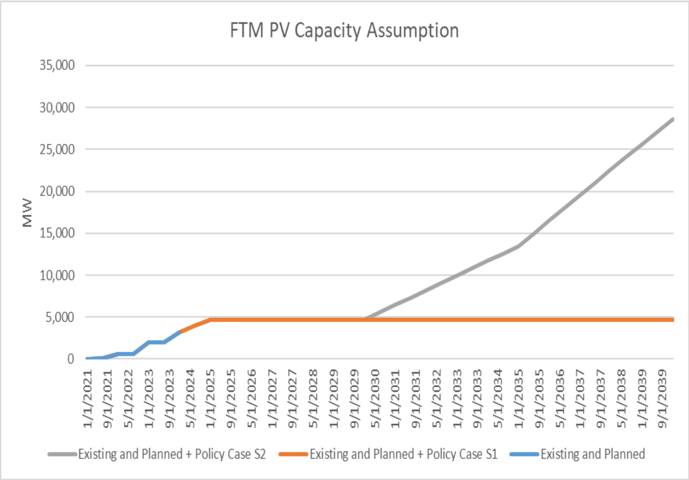
Assumptions- Solar (BTM and FTM)

- **BTM PV– increased the Climate Change Phase 1 CLCPA case assumption of 6GW to 10GW consistent with current policy**
  - The existing shape and path of adoption assumed in the Climate Change Phase 1 CLCPA Case maintained until 2025 then scaled to reach 10 GW from 2026 until 2030*
- **FTM PV**
  - Existing and planned capacity based on the installed in-service date provided in the 2021 Gold Book. Approximately 30 MW of existing and planned FTM Solar:
    - Facilities that have completed Class Year Facilities Study (2021 Gold Book)
    - Facilities that have completed CRIS Request (2021 Gold Book)
    - Future and Non-Class Year Facilities Reported to NYSERDA (https://data.ny.gov/Energy-Environment/Large-scale-Renewable-Projects-Reported-by-NYSERDA/dprp-55ye)
  - Beyond 2023 adjusted the assumed MW to be in line with the System and Resource Outlook Study Policy Cases S1 and S2 grid scale solar resources (see the April 26 ESPWG presentation)
  - Using the 2006 Solar Planning Shape for upstate zones and the actual 2019 production data shape for zone K



* Updated from last presentation

Phase 1 results without negative net load periods

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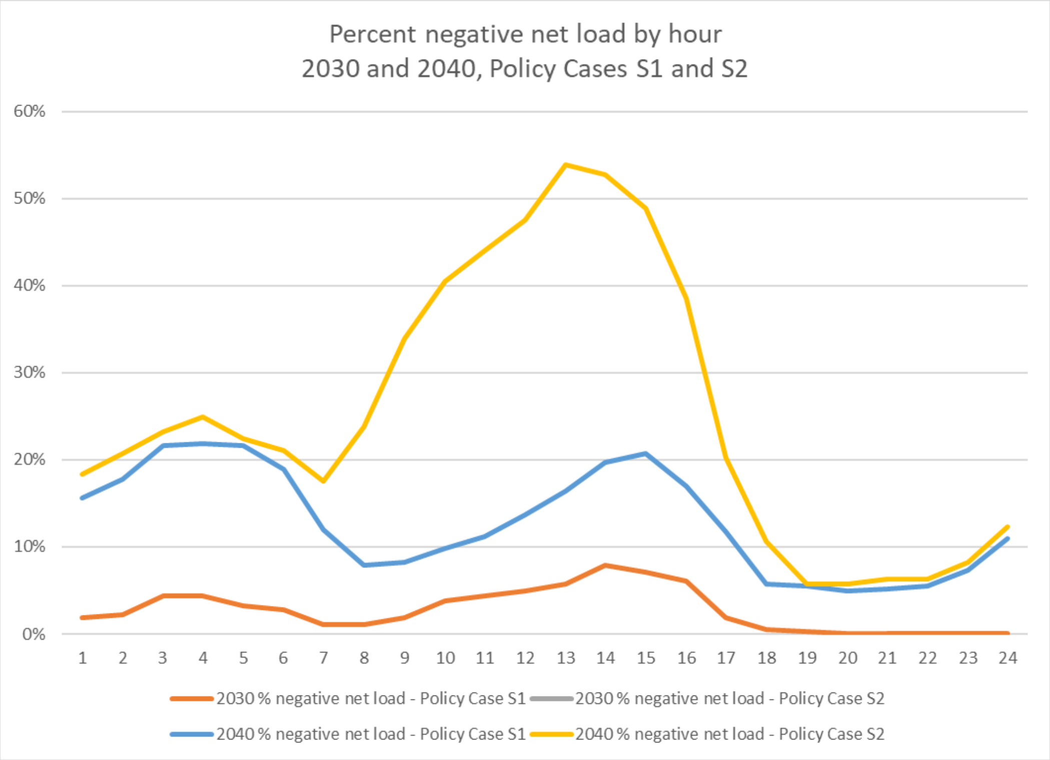
Hours with negative net load

- **The hours with negative net load account for approximately 9% of hours over all of the years of the study however that changes over time from 3% in 2030 to 13% to 25% in 2040**
  - The chart shows the percent of negative load hours by hour, year and Policy Case buildout.
  - In 2030 there is almost no difference between the two Policy Cases
  - The 2040 difference between the two Policy Case buildouts is primarily because of the additional PV in Policy Case S2



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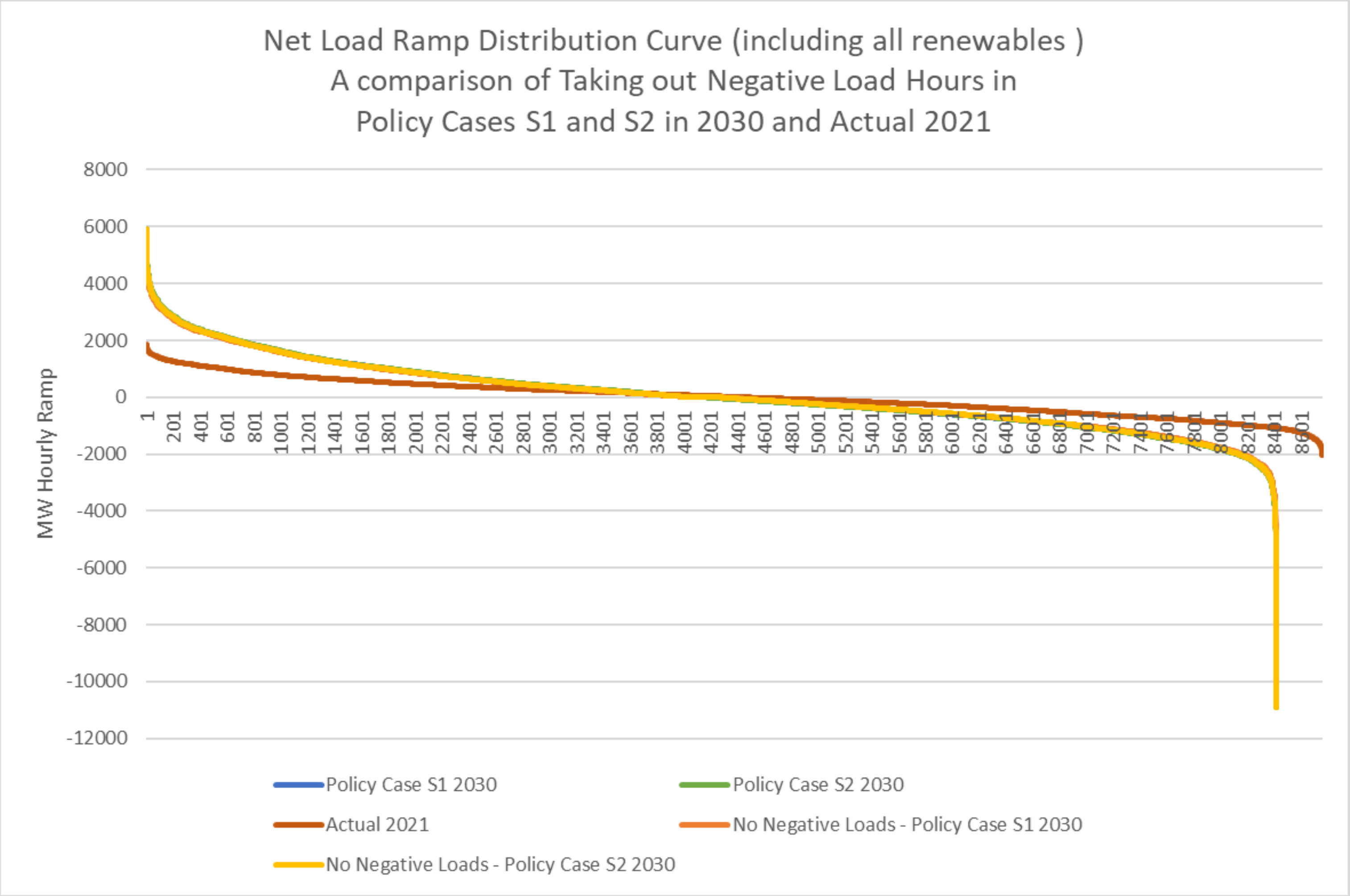
Phase 1 Net Load Duration Curves– 2030 and 2040 (and actual 2021) without negative net load hours



Net Load Ramp Distribution Curve (including all renewables)
A comparison of Taking out Negative Load Hours in
Policy Cases S1 and S2 in 2030 and Actual 2021
MW Hourly Ramp
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
-12000
1
201
401
601
801
1001
1201
1401
1601
1801
2001
2201
2401
2601
2801
3001
3201
3401
3601
3801
4001
4201
4401
4601
4801
5001
5201
5401
5601
5801
6001
6201
6401
6601
6801
7001
7201
7401
7601
7801
8001
8201
8401
8601
Policy Case S1 2030
Policy Case S2 2030
Actual 2021
No Negative Loads - Policy Case S1 2030
No Negative Loads - Policy Case S2 2030

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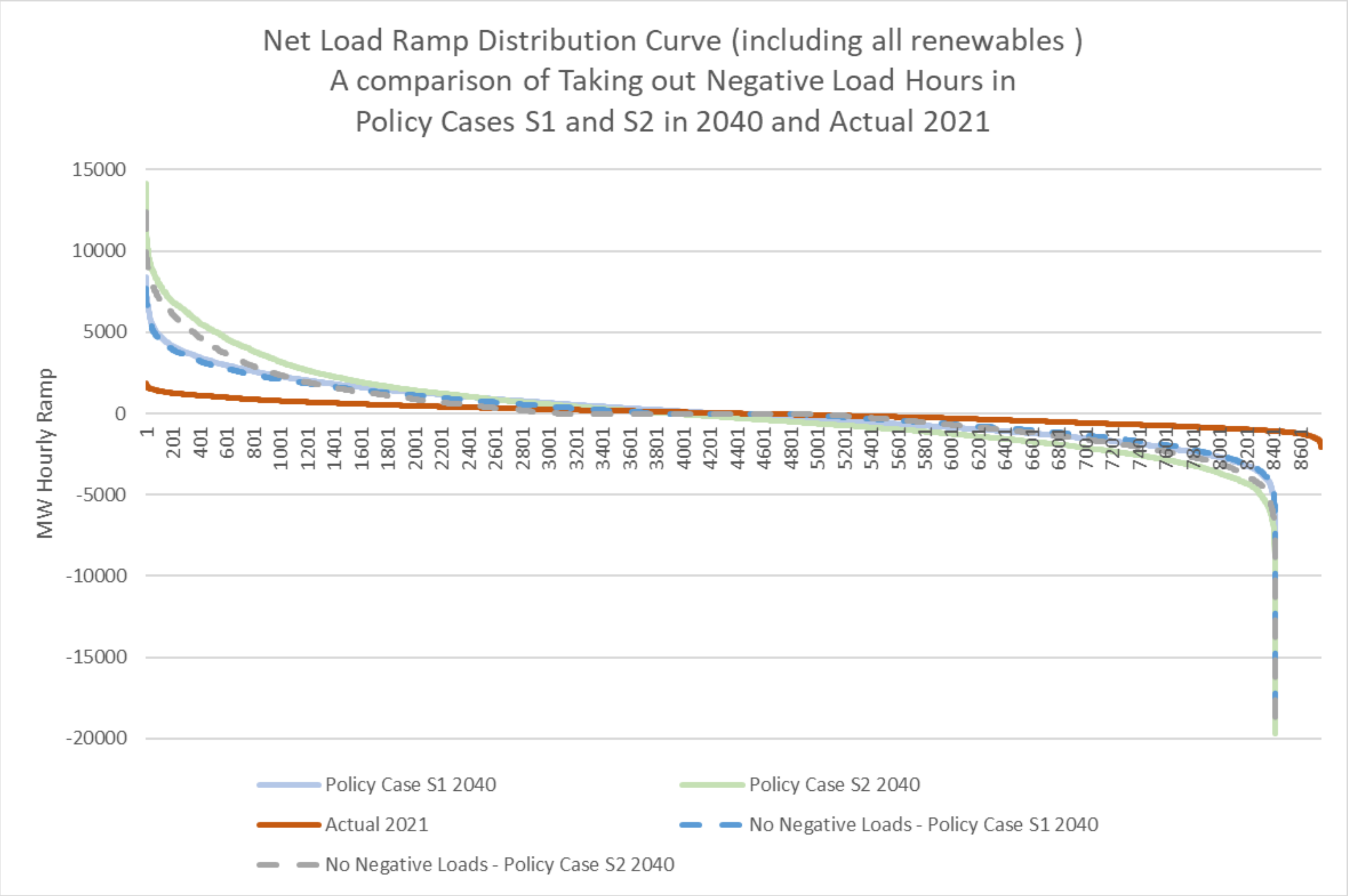
Net Load Ramp Distribution Curve (including all renewables)
A comparison of Taking out Negative Load Hours in
Policy Cases S1 and S2 in 2040 and Actual 2021
15000
10000
5000
0
-5000
-10000
-15000
-20000
MW Hourly Ramp
1
201
401
601
801
1001
1201
1401
1601
1801
2001
2201
2401
2601
2801
3001
3201
3401
3601
3801
4001
4201
4401
4601
4801
5001
5201
5401
5601
5801
6001
6201
6401
6601
6801
7001
7201
7401
7601
7801
8001
8201
8401
8601
Policy Case S1 2040
Policy Case S2 2040
Actual 2021
No Negative Loads - Policy Case S1 2040
No Negative Loads - Policy Case S2 2040

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Phase 1 Multi Hour Ramps without negative net load hours

Looking at the total multi hour ramps over the entire year*

*Note: Does not include the over midnight ramps because of data discontinuities that produce phantom ramps

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Comparing 3 and 5 hour ramps

- **The following two slides compare the distributions of the 3 and 5 hour metrics between the original net loads and the net loads without negative loads for 2030 and 2040 and for the Policy Case S1 and S2 buildouts.**
  - The Policy Case S1 shows almost no difference between the two net loads
  - The Policy Case S2 shows a little difference in 2040 for the two different net loads

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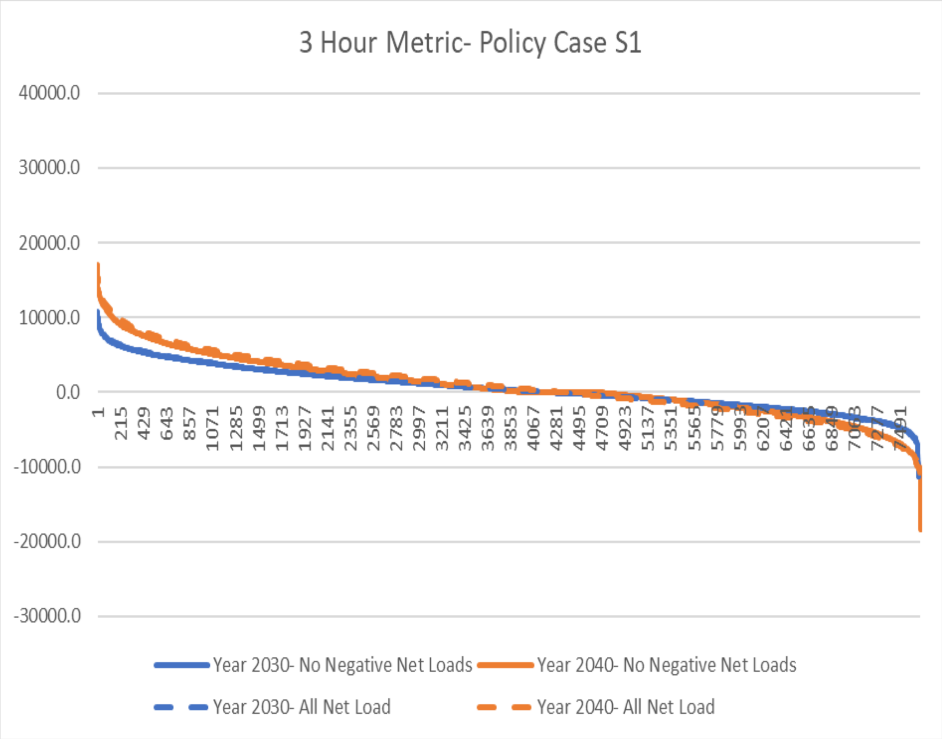
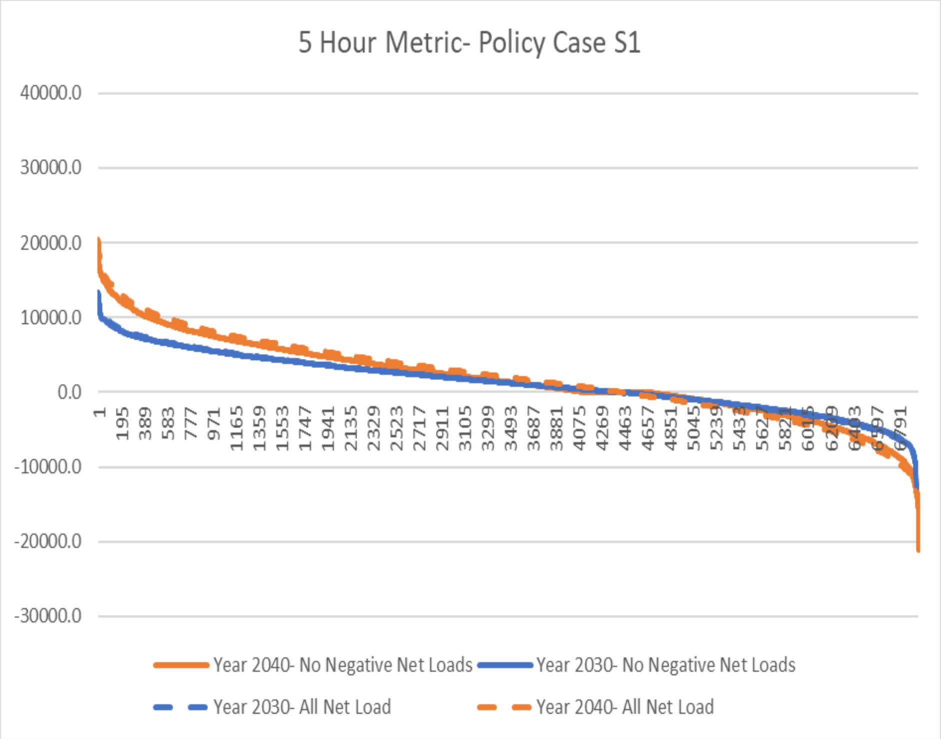
Policy Case S1





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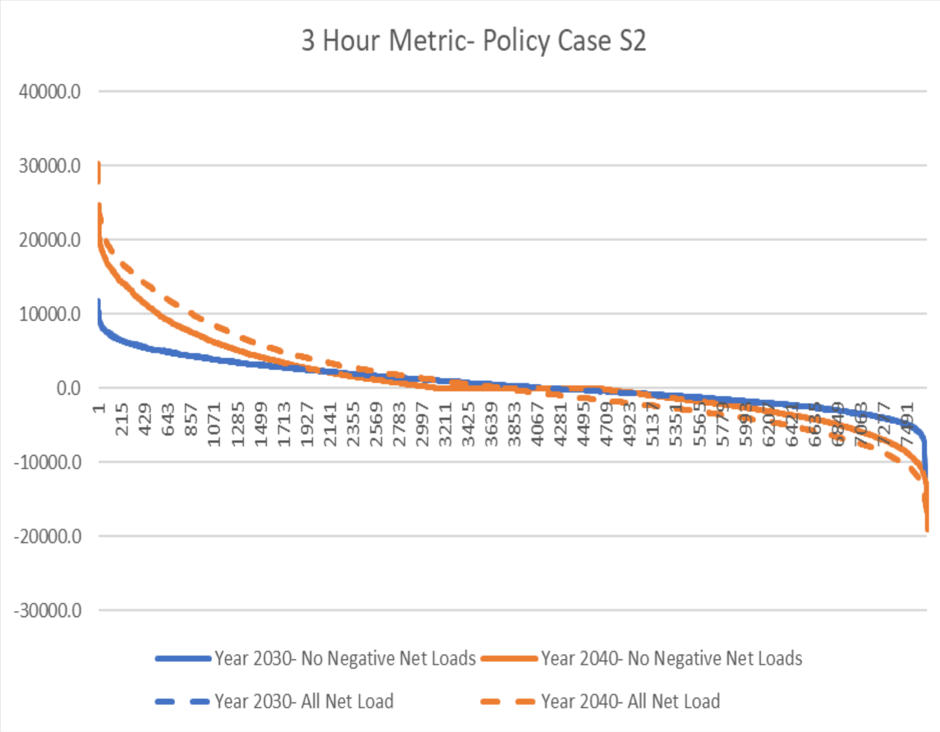
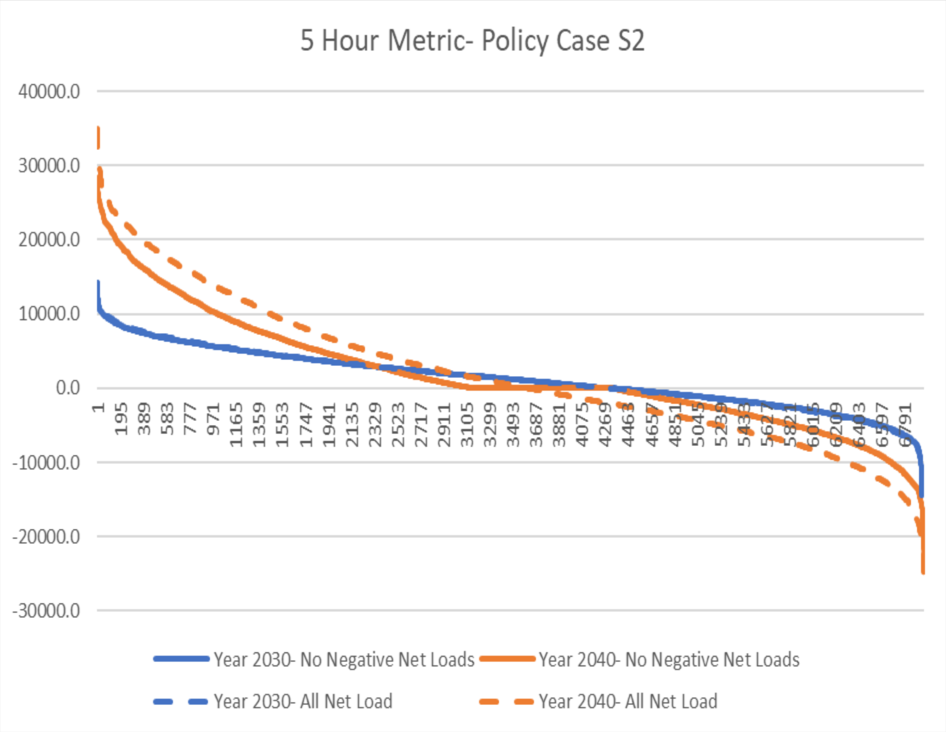
Policy Case S2





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Ramp up needs with negative net load periods (from prior presentation)

- **Focusing on instances when the multi-hour ramp up is greater than 5,000MW and when it is greater than 10,000 MW**
  - Ramp up needs are larger in 2040 than 2030
  - Ramp up needs greater under Policy Case S2 than S1 because of the larger amounts of assumed intermittent resources

Scenario	Year	No. of Instances	Ramp MWs	Average number of Ramp up hours	Average ramp MWs	Shoulder % (6 months)	Winter %	Summer %	25 %ile Ramp MWs	50 %ile / Median Ramp MWs	75 %ile Ramp MWs
Policy Case S1	2030	398	>5000	5.9	7692	48%	28%	24%	6235	7460	8791
Policy Case S1	2040	558	>5000	5.6	10032	49%	26%	25%	6985	9380	12335
Policy Case S2	2030	407	>5000	6.0	7905	49%	28%	23%	6355	7771	9052
Policy Case S2	2040	466	>5000	6.0	17019	50%	28%	21%	10055	17542	22968
Policy Case S1	2030	46	>10000	6.8	11149	59%	37%	4%	10321	10979	11773
Policy Case S1	2040	245	>10000	6.5	13371	45%	32%	23%	11130	12694	15009
Policy Case S2	2030	58	>10000	7.0	11394	59%	29%	12%	10426	10865	11973
Policy Case S2	2040	351	>10000	6.5	20274	50%	25%	25%	15340	20166	24528

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Ramp up needs with no negative net loads

- **Not a great deal of differences**
  - Somewhat shorter ramps and fewer instances which is consistent with the 3 and 5 hour ramps

Scenario	Year	No. of Instances	Ramp MWs	Average number of Ramp up hours	Average ramp MWs	Shoulder % (6 months)	Winter %	Summer %	25 %ile Ramp MWs	50 %ile / Median Ramp MWs	75 %ile Ramp MWs
Policy Case S1	2030	389	>5000	5.8	7533	47%	29%	25%	6124	7298	8581
Policy Case S1	2040	498	>5000	5.5	9638	44%	28%	28%	6833	9003	11745
Policy Case S2	2030	397	>5000	5.9	7769	48%	28%	24%	6280	7649	8915
Policy Case S2	2040	407	>5000	5.3	14079	45%	31%	24%	8167	13147	18973
Policy Case S1	2030	37	>10000	6.7	10887	54%	41%	5%	10270	10514	11182
Policy Case S1	2040	200	>10000	6.4	13061	35%	38%	28%	10953	12584	14523
Policy Case S2	2030	49	>10000	7.0	11266	55%	31%	14%	10399	10680	11557
Policy Case S2	2040	264	>10000	5.9	17772	37%	30%	33%	13455	17180	21541

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The bottom line

- **As expected, taking out the negative net load periods does change the results somewhat. It generally decreases the ramp periods**
  - For the period of the study, the maximum ramp up and down MWs have reduced by an average of 11% while the average ramp up and down MWs have reduced by 6%.
  - The table below shows summary statistics of the 2021 Actuals along with the 2030 and 2040 cases, with and without the negative net loads.

Year	Scenario	Ramp Up Instances	Ramp Down Instances	Average Ramp Up Hours	Average Ramp Down Hours	Average Ramp Up MWs	Average Ramp Down MWs	Max Ramp Up MWs	Max Ramp Down MWs
2021	Actual	856	1,147	5.2	3.5	3,171	(1,852)	13,138	(7,115)
2030	Policy Case S1- with negative net loads	1,141	1,403	3.6	3.0	3,853	(2,617)	15,046	(14,528)
	Policy Case S2- with negative net loads	1,132	1,399	3.7	3.0	3,946	(2,671)	16,247	(14,425)
	Policy Case S1- no negative net loads	1,129	1,384	3.6	3.0	3,788	(2,570)	15,046	(14,375)
	Policy Case S2- no negative net loads	1,120	1,381	3.6	3.0	3,883	(2,623)	15,739	(14,425)
2040	Policy Case S1- with negative net loads	1,134	1,395	3.8	3.0	5,779	(3,838)	24,388	(19,000)
	Policy Case S2- with negative net loads	1,080	1,338	3.6	3.4	8,178	(5,706)	36,692	(29,637)
	Policy Case S1- no negative net loads	1,049	1,271	3.6	2.9	5,466	(3,651)	21,367	(19,000)
	Policy Case S2- no negative net loads	917	1,130	3.3	3.0	7,085	(4,794)	30,466	(29,637)

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Conclusion

- **Taking out the negative net load periods does change the results somewhat. It generally decreases the ramp periods, especially ramp up periods.**
- **When looking at the ramp metrics overall, the change is generally small and does not change the general conclusions**
  - For the Policy Case S1 buildout, when taking out the negative net loads, the maximum ramp up goes down by 9% while the maximum ramp down does not change for both 3 hour and 5 hour ramps
  - For Policy Case S2, the larger solar buildout leads to more negative net load hours and more of a change when excluding negative net loads from the ramps.
    - When taking out the negative net loads, the maximum ramp up decreases by an average of 20% for both the 3 hour and 5 hour ramps while the maximum ramp down decreases by 10% for the 5 hour ramps and is unchanged for the 3 hour ramps.
- **We are considering including both cases in the report**
  - Results without negative net load periods to provide operational insight
  - Results with negative net load periods to provide insight on the curtailment of renewables and for the additional loads that might consider to coming online in those periods

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Next Steps

Planned Next Steps

- September - Finalize study and prepare report incorporating stakeholder feedback
- Expect to return late September/early October with the draft report

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Our Mission & Vision

Mission

Ensure power system reliability and competitive markets for New York in a clean energy future

Vision

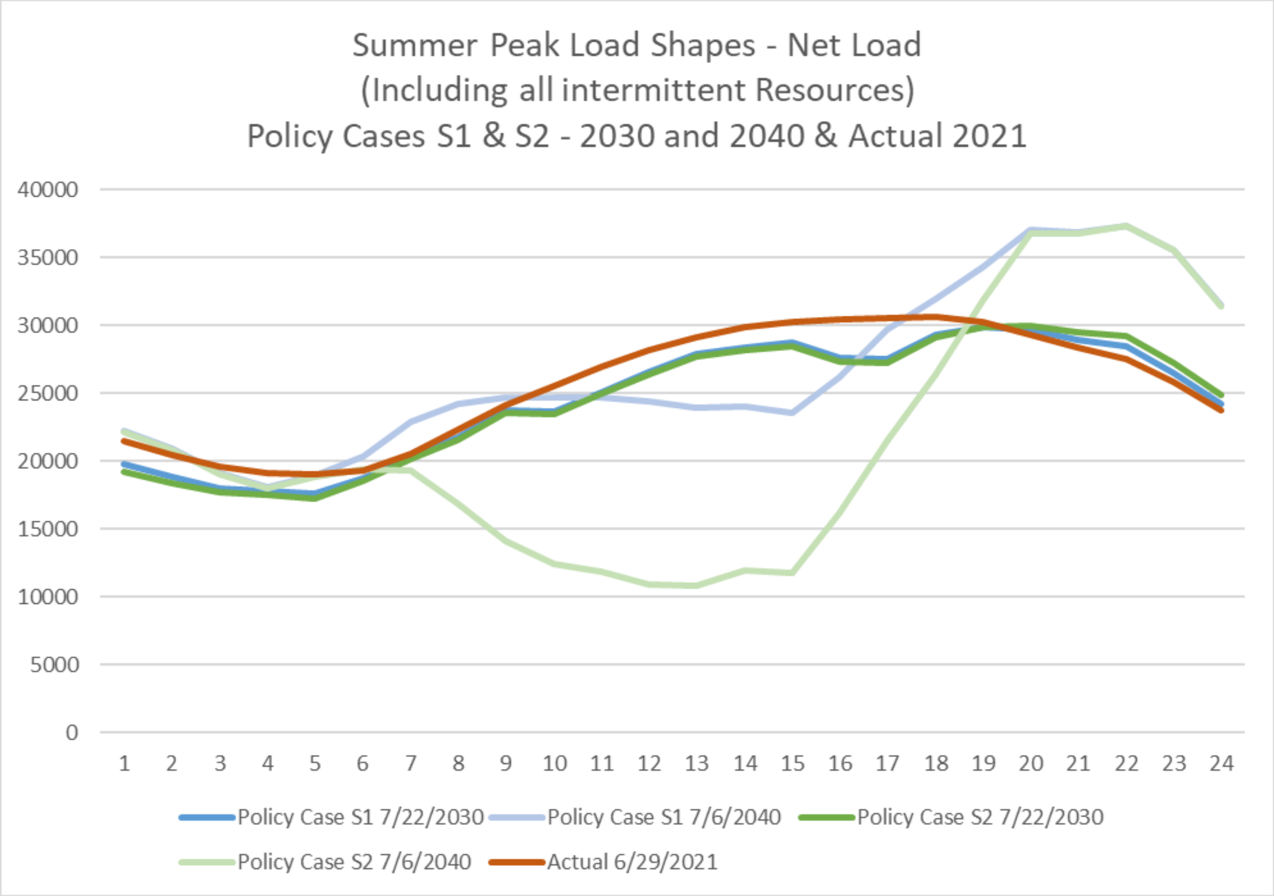
Working together with stakeholders to build the cleanest, most reliable electric system in the nation

Questions?

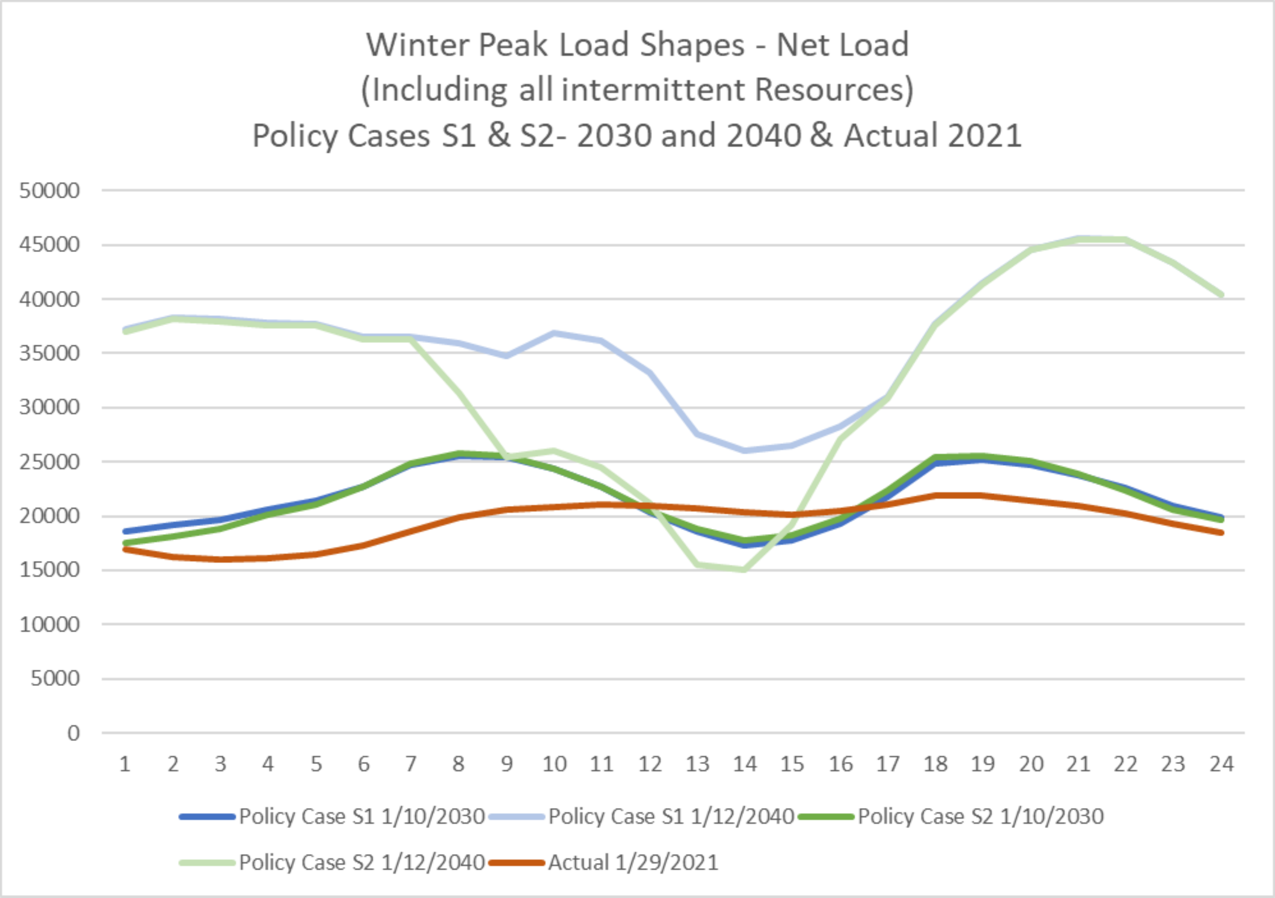
Appendix- Slides presented at the Jun 29 ICAP/MIWG:

Phase 1 results with negative net load periods

Load Shapes – 2030 and 2040 (and actual 2021)



Summer Peak Load Shapes - Net Load
(Including all intermittent Resources)
Policy Cases S1 & S2 - 2030 and 2040 & Actual 2021
40000
35000
30000
25000
20000
15000
10000
5000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Policy Case S1 7/22/2030
Policy Case S1 7/6/2040
Policy Case S2 7/22/2030
Policy Case S2 7/6/2040
Actual 6/29/2021



Winter Peak Load Shapes - Net Load
(Including all intermittent Resources)
Policy Cases S1 & S2- 2030 and 2040 & Actual 2021
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Policy Case S1 1/10/2030
Policy Case S1 1/12/2040
Policy Case S2 1/10/2030
Policy Case S2 1/12/2040
Actual 1/29/2021

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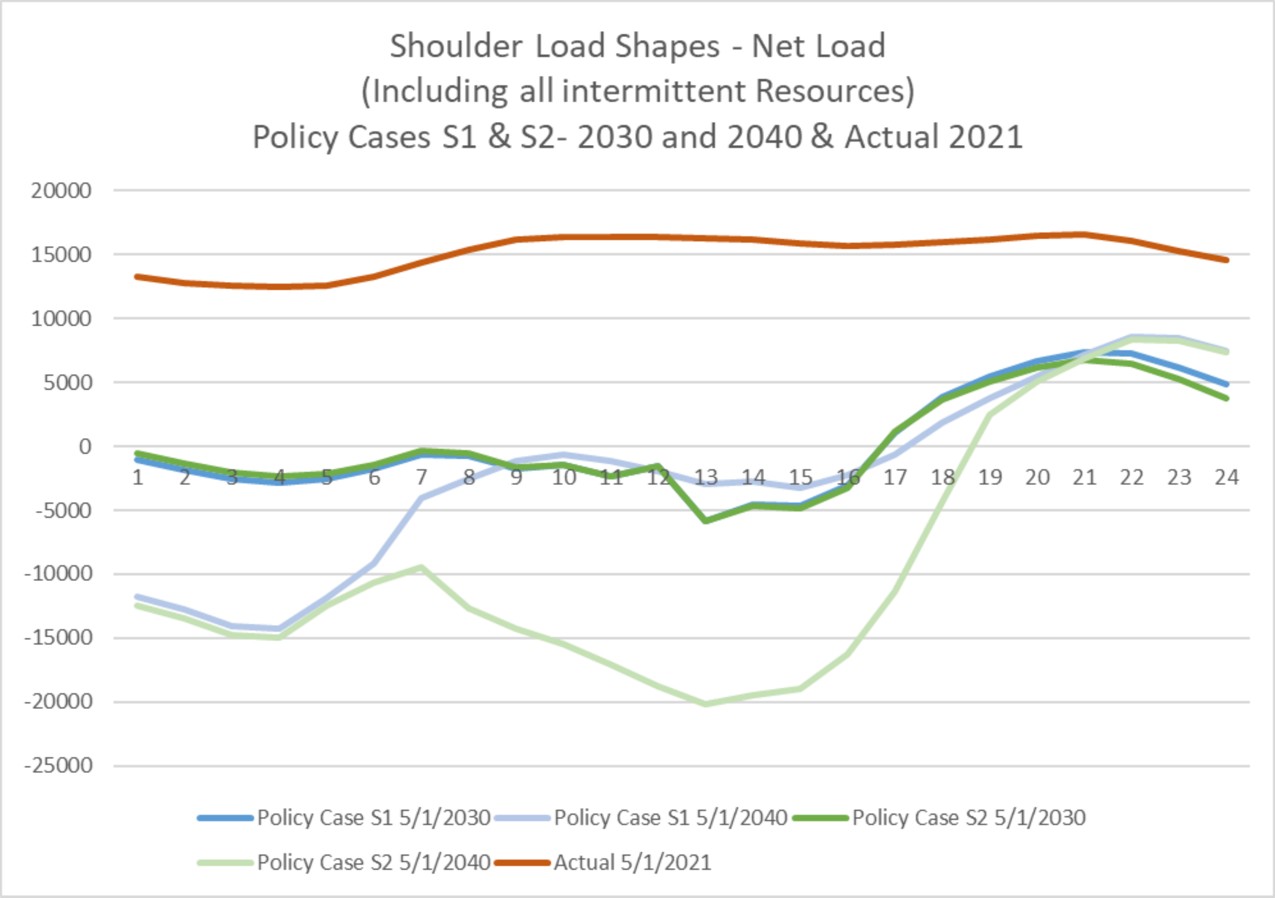
Shoulder Load Shapes - Net Load
(Including all intermittent Resources)
Policy Cases S1 & S2- 2030 and 2040 & Actual 2021
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Policy Case S1 5/1/2030
Policy Case S1 5/1/2040
Policy Case S2 5/1/2030
Policy Case S2 5/1/2040
Actual 5/1/2021

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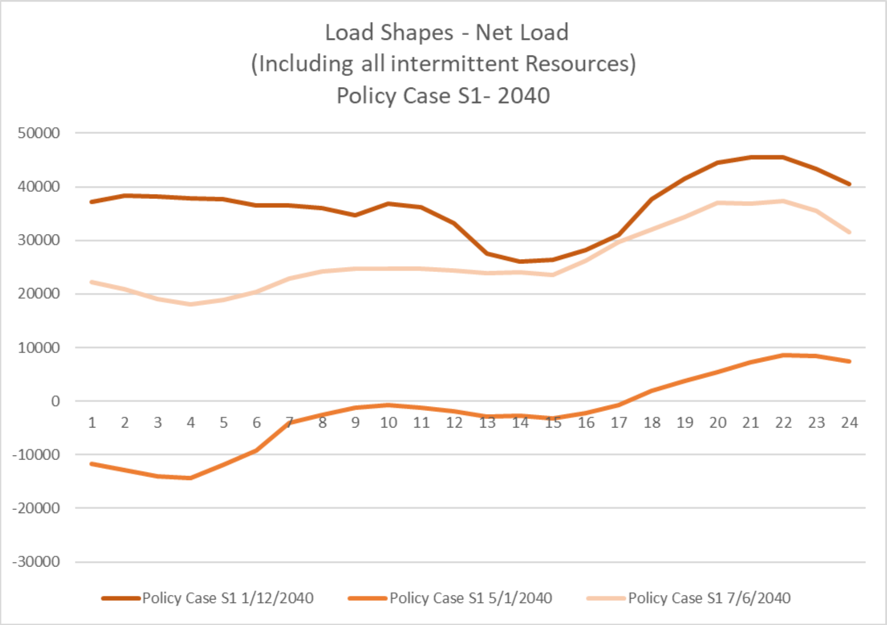
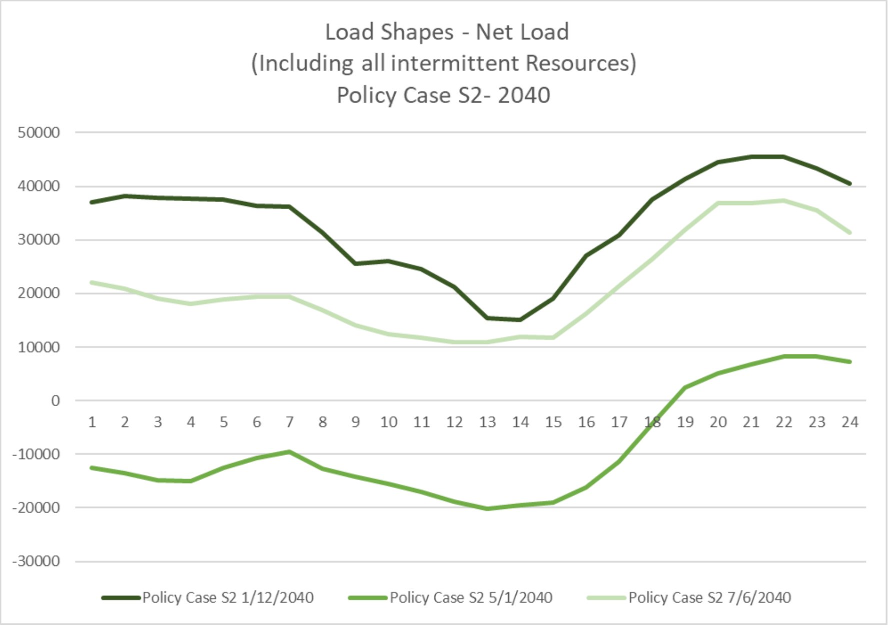


Load Shapes - Net Load
(Including all intermittent Resources)
Policy Case S1- 2040
50000
40000
30000
20000
10000
0
-10000
-20000
-30000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Policy Case S1 1/12/2040
Policy Case S1 5/1/2040
Policy Case S1 7/6/2040



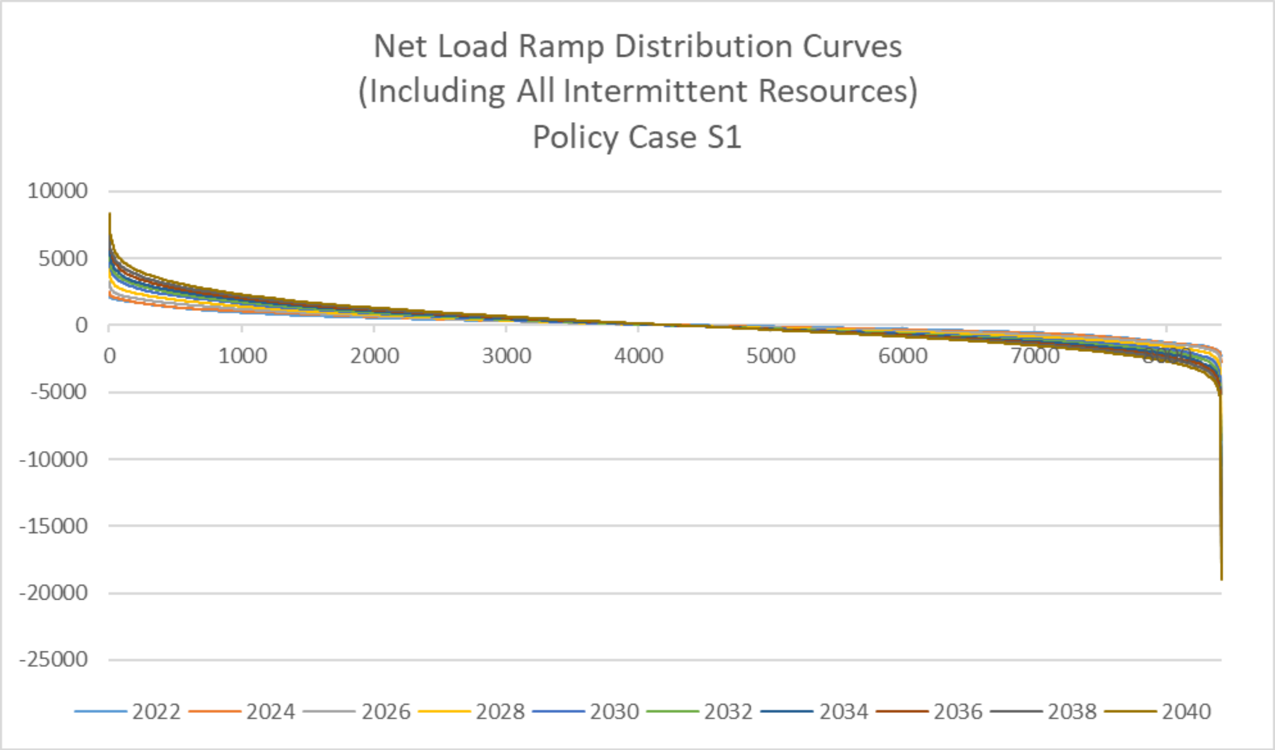
Load Shapes - Net Load
(Including all intermittent Resources)
Policy Case S2- 2040
50000
40000
30000
20000
10000
0
-10000
-20000
-30000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Policy Case S2 1/12/2040
Policy Case S2 5/1/2040
Policy Case S2 7/6/2040

Ramp Distribution Curves

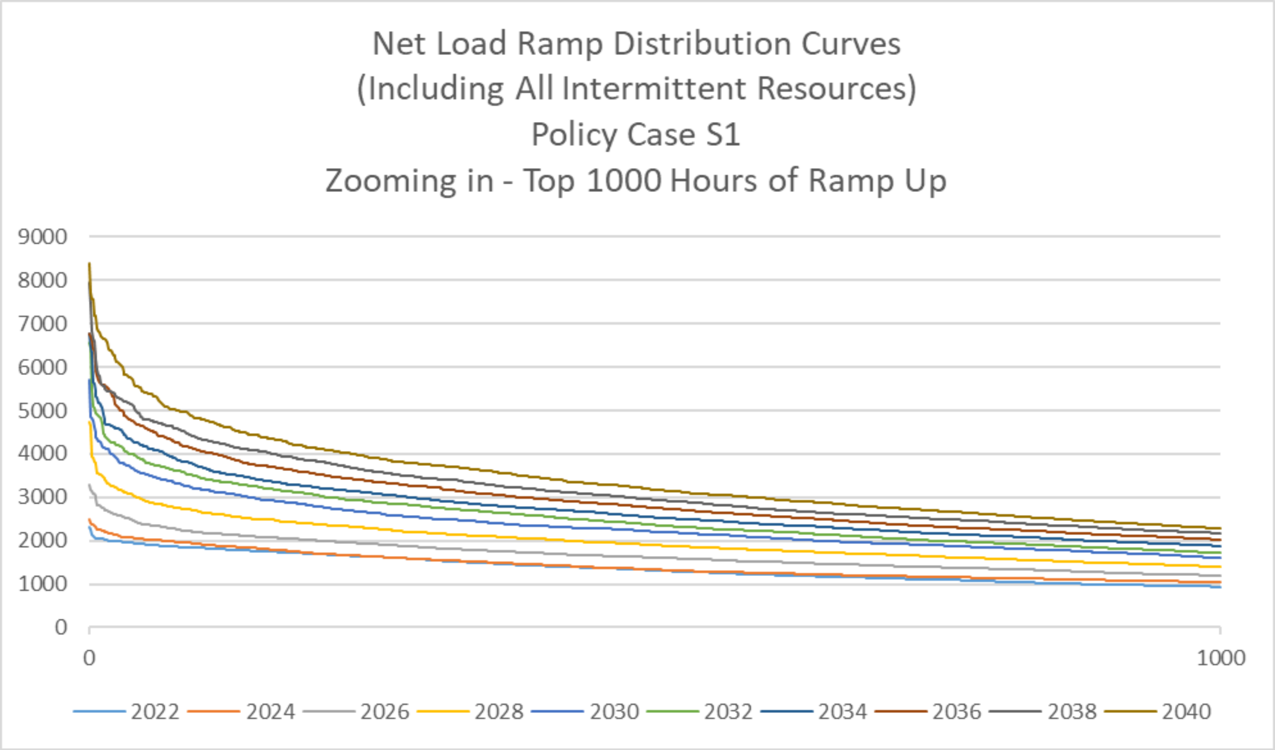
Looking at the hourly ramps over the entire year*

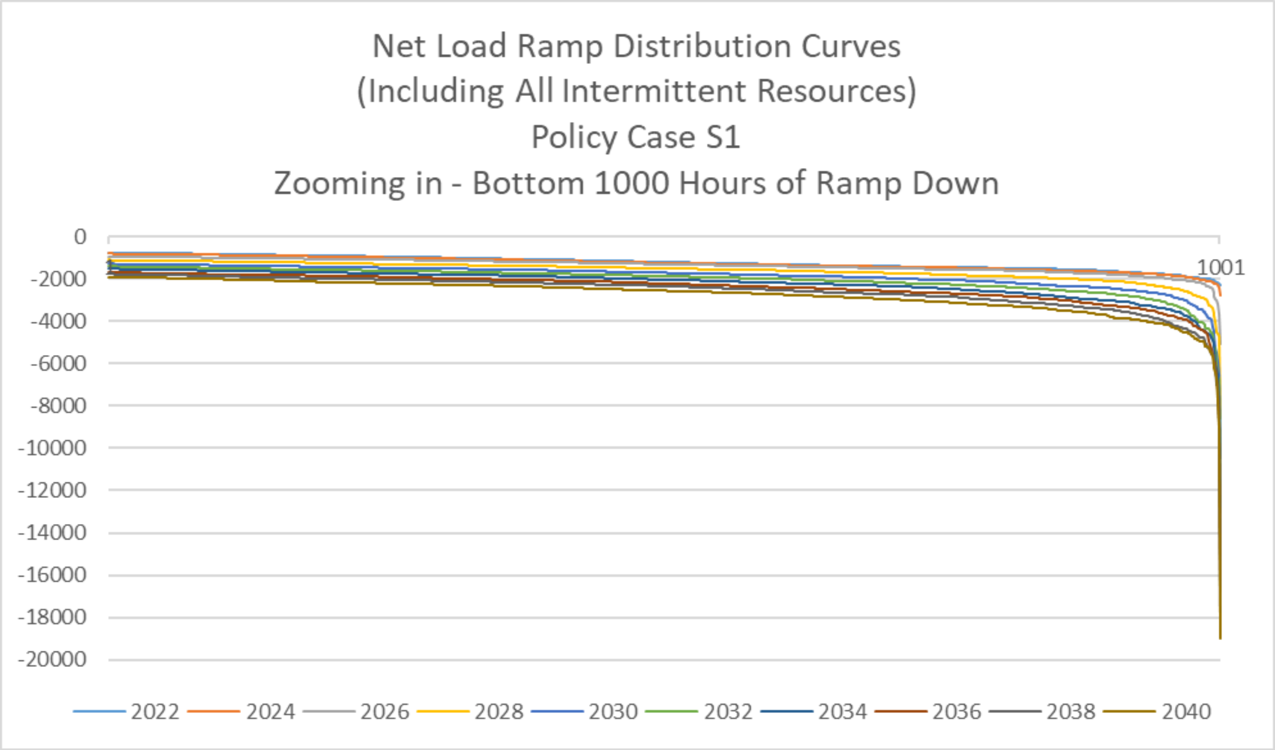
*Note: Does not include the over midnight ramps because of data discontinuities that produce phantom ramps

Policy Case S1



Net Load Ramp Distribution Curves
(Including All Intermittent Resources)
Policy Case S1
10000
5000
0
-5000
-10000
-15000
-20000
-25000
0
1000
2000
3000
4000
5000
6000
7000
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040


Net Load Ramp Distribution Curves
(Including All Intermittent Resources)
Policy Case S1
Zooming in - Top 1000 Hours of Ramp Up
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1000
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040



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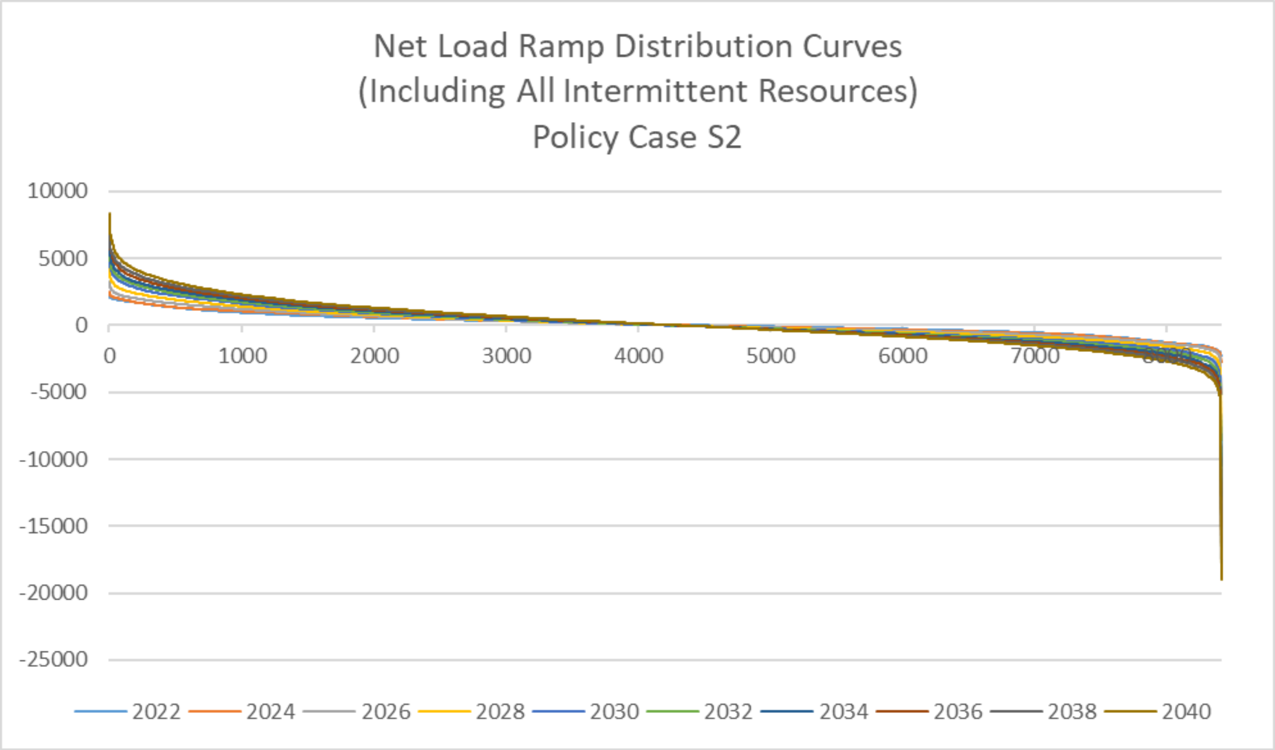
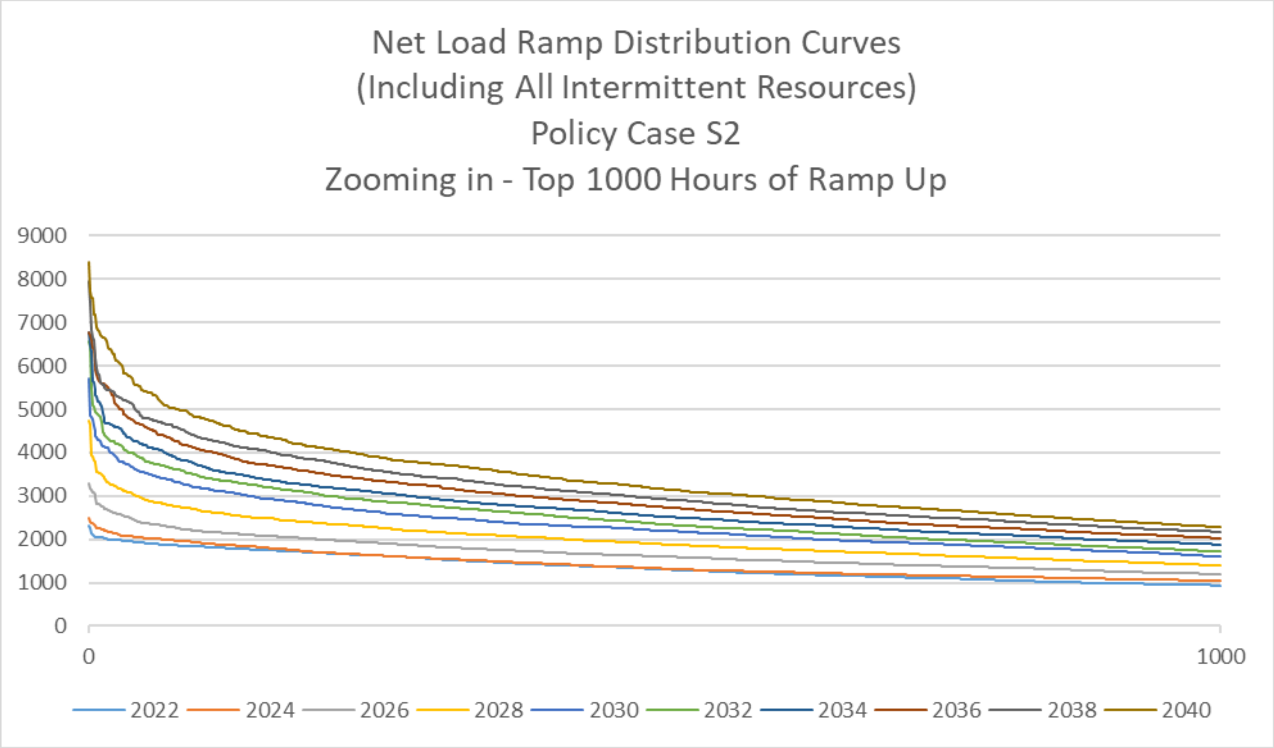
Policy Case S2



DRAFT – FOR DISCUSSION PURPOSES ONLY


Net Load Ramp Distribution Curves
(Including All Intermittent Resources)
Policy Case S2
Zooming in - Top 1000 Hours of Ramp Up
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1000
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040

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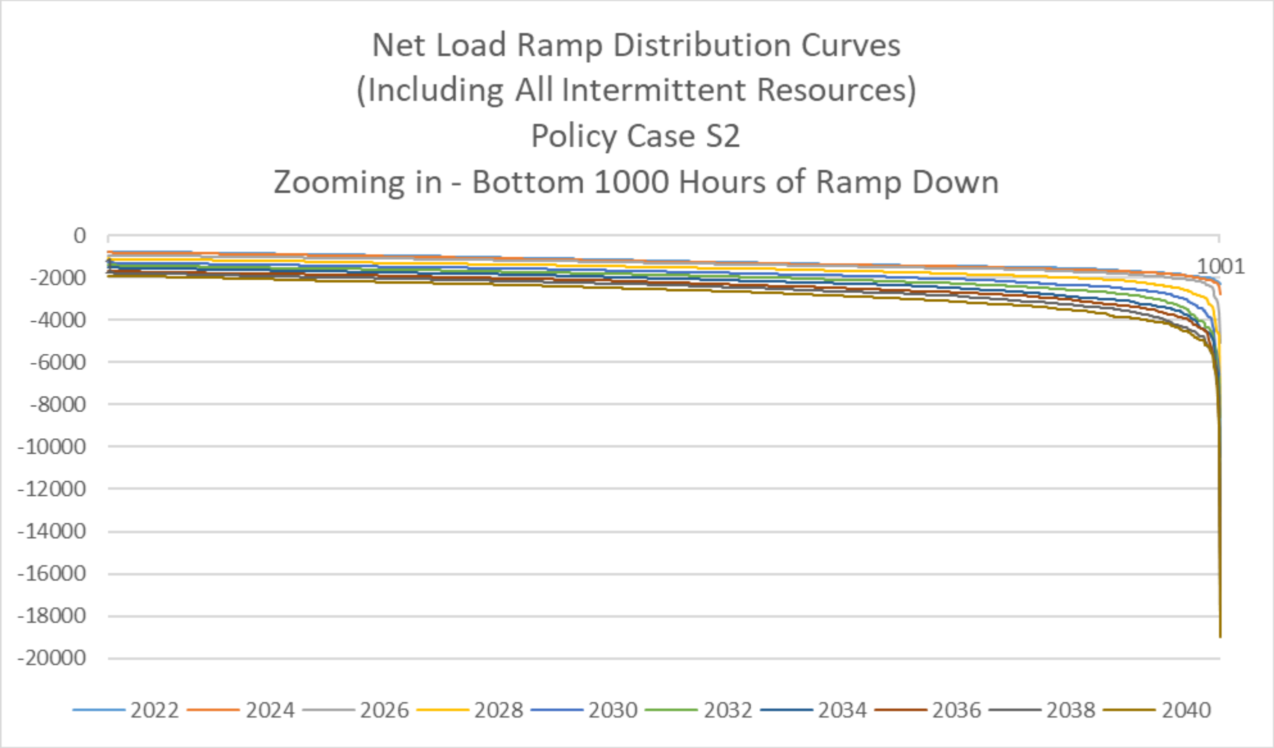
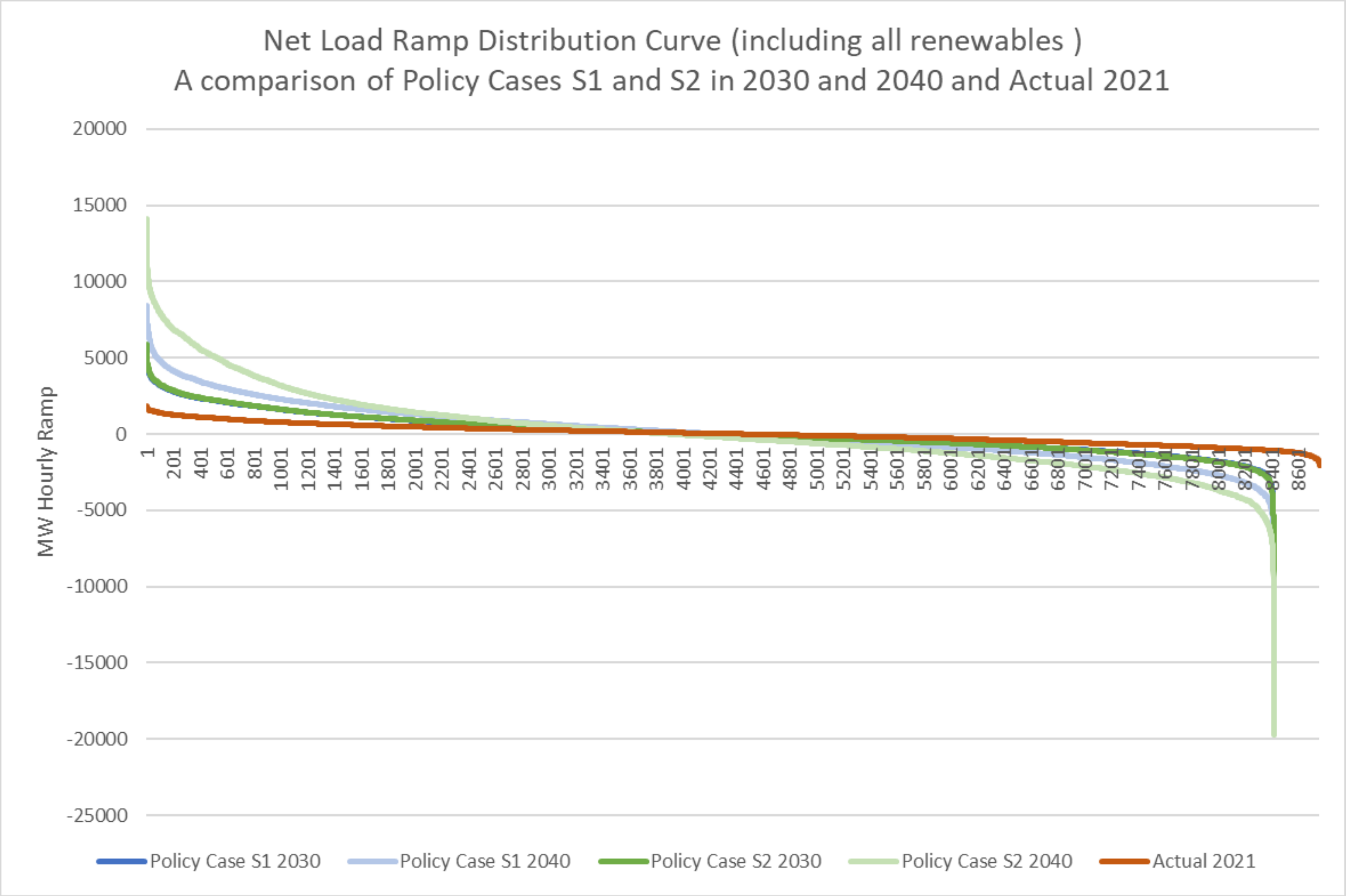

Net Load Ramp Distribution Curves
(Including All Intermittent Resources)
Policy Case S2
Zooming in - Bottom 1000 Hours of Ramp Down
0
-2000
-4000
-6000
-8000
-10000
-12000
-14000
-16000
-18000
-20000
1
1001
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040

A comparison of Policy Cases S1 & S2


Net Load Ramp Distribution Curve (including all renewables)
A comparison of Policy Cases S1 and S2 in 2030 and 2040 and Actual 2021
MW Hourly Ramp
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
1
201
401
601
801
1001
1201
1401
1601
1801
2001
2201
2401
2601
2801
3001
3201
3401
3601
3801
4001
4201
4401
4601
4801
5001
5201
5401
5601
5801
6001
6201
6401
6601
6801
7001
7201
7401
7601
7801
8001
8201
8401
8601
Policy Case S1 2030
Policy Case S1 2040
Policy Case S2 2030
Policy Case S2 2040
Actual 2021

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Multi Hour Ramps

Looking at the total multi hour ramps over the entire year*

*Note: Does not include the over midnight ramps because of data discontinuities that produce phantom ramps

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Multi Hour Ramps

- **Although looking at hourly ramps is very informative, the total ramp up is particularly useful to look at when considering the future needs of the grid**
- **We are looking at several different metrics**
  - The 3 and 5 hour ramping needs – a rolling metric that looks at the in-day net ramp (including all intermittent resources) over 3 and 5 hours.
  - The ramp needs over the entire up or down in-day ramp period
    - For example, if over a 24 hour period the net load ramps down for 6, up for 8 hours, down for 2 then up again for 5 and down for 3 that would be three down ramp events for 6,2, and 3 hours and two up events for 8 and 5 hours.
    - This allows visibility of the full magnitude of ramp up events.

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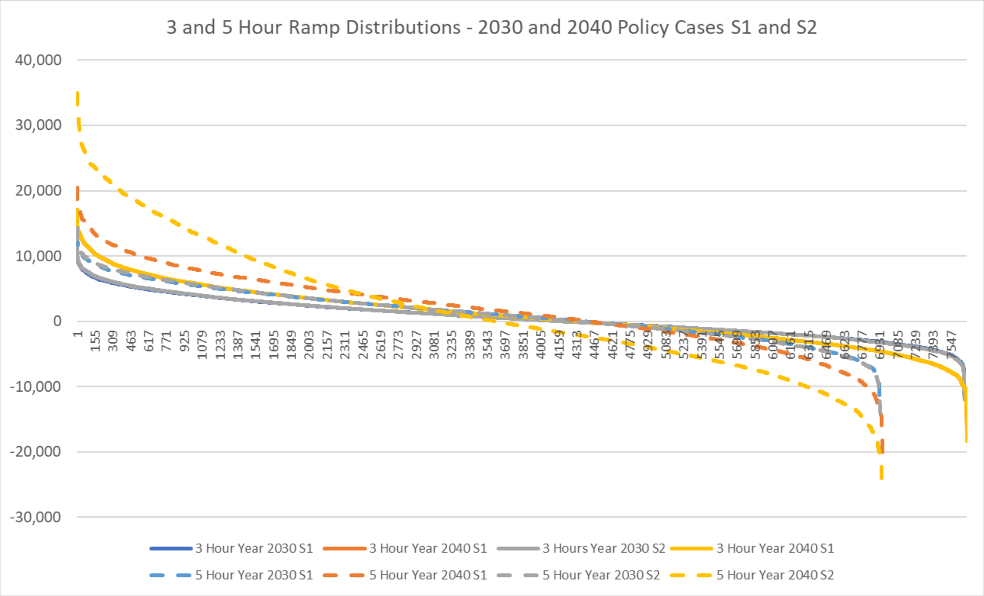
Three and Five Hour Ramps: 2030 and 2040



Ramp	Case	Year	Mean	Median	Standard Deviation	Max Ramp Up	Max Ramp Down
3 Hour	Policy Case S1	2030	552	350	2,915	10,741	-11,330
	Policy Case S2	2030	557	345	2,978	11,788	-11,962
5 Hour	Policy Case S1	2030	1,291	1,261	3,826	13,389	-13,648
	Policy Case S2	2030	1,300	1,274	3,933	14,252	-14,425
3 Hour	Policy Case S1	2040	860	661	4,349	17,036	-18,309
	Policy Case S2	2040	906	-180	6,795	30,315	-15,207
5 Hour	Policy Case S1	2040	1,989	1,970	5,668	20,448	-13,449
	Policy Case S2	2040	2,002	449	9,781	34,903	-20,434

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Multi Hour Ramping Needs

- This metric looks at the entirety of the ramp up and ramp down events
- Looking at the years 2022-2040, the averages of the Policy Cases S1 and S2 are fairly close (average ramps of 328MW and 333MW respectively) however the higher amounts of solar resources in Policy Case S2 lead to larger ramp needs in the extremes of the distribution (both ramps up and ramps down). This is consistent with the load shapes and hourly ramp distributions seen earlier.

Summary Statistics- 2022 through 2040

	Year	No. of Instances	Average number of Ramp up hours	Average ramp MWs	25 %ile Ramp MWs	50 %ile / Median Ramp MWs	75 %ile Ramp MWs	Max Ramp Up	Max Ramp Down	Max number of hours	Min number of ramp hours
Policy Case S1	Overall (2022-2040)	46077	3.5	331	-2401	-257	2845	24388	-23631	19	1
Policy Case S2	Overall (2022-2040)	45383	3.5	337	-2635	-287	2505	36692	-36308	17	1

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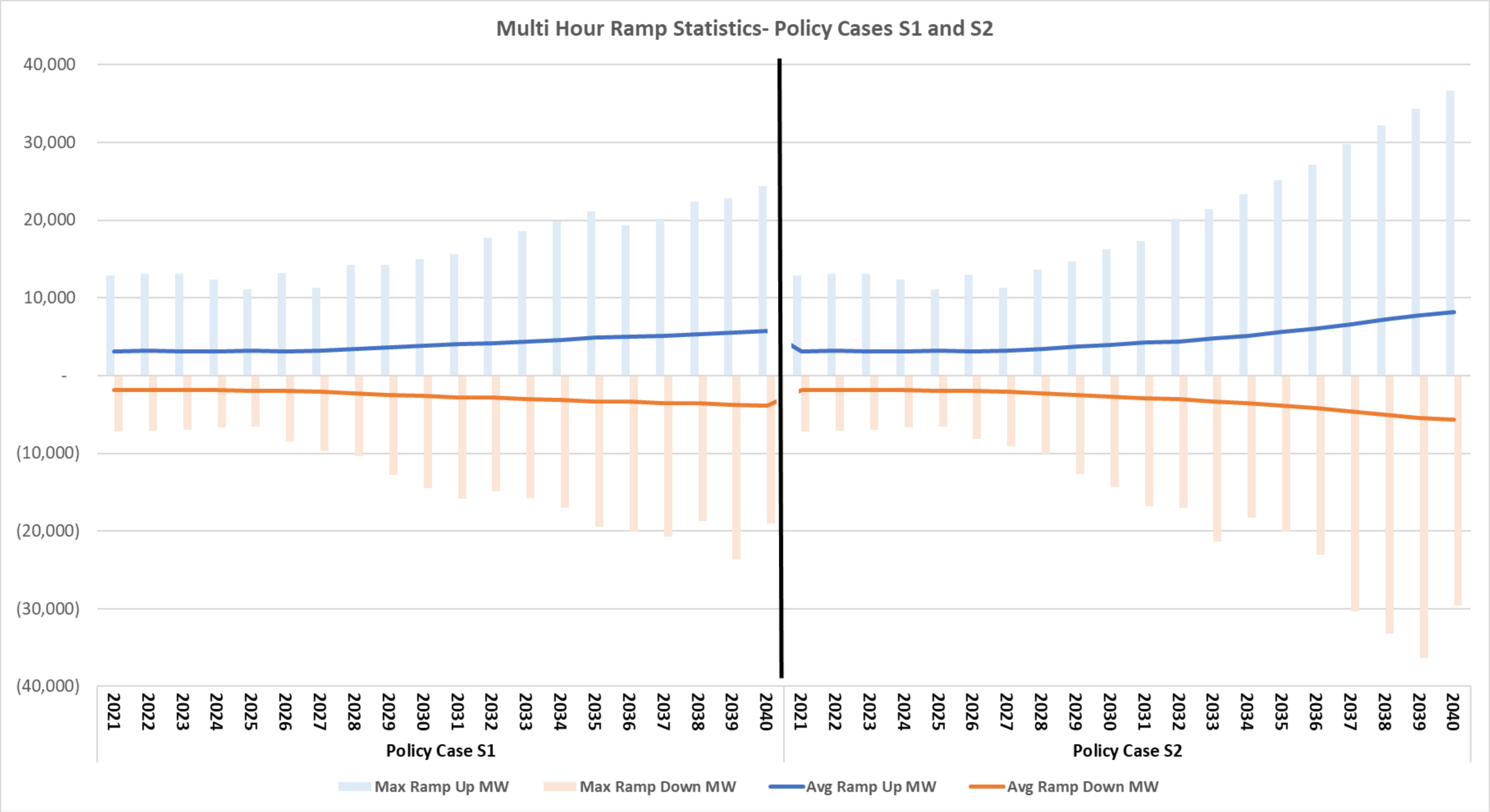

Multi Hour Ramp Statistics- Policy Cases S1 and S2
40,000
30,000
20,000
10,000
-
(10,000)
(20,000)
(30,000)
(40,000)
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Policy Case S1
Policy Case S2
Max Ramp Up MW
Max Ramp Down MW
Avg Ramp Up MW
Avg Ramp Down MW

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Ramp up needs

- **Focusing on instances when the multi-hour ramp up is greater than 5,000MW and when it is greater than 10,000 MW**
  - Ramp up needs are larger in 2040 than 2030
  - Ramp up needs greater under Policy Case S2 than S1 because of the larger amounts of assumed intermittent resources

Scenario	Year	No. of Instances	Ramp MWs	Average number of Ramp up hours	Average ramp MWs	Shoulder % (6 months)	Winter %	Summer %	25 %ile Ramp MWs	50 %ile / Median Ramp MWs	75 %ile Ramp MWs
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