December 2023 Effective Load Carrying Capability (ELCC) Report

For Public Use

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Contents

Introduction

PJM uses the Effective Load Carrying Capability (ELCC) methodology to calculate the ELCC Class Ratings for ELCC Classes and Accredited Unforced Capacity (AUCAP) values for ELCC Resources. This December 2023 ELCC Report provides background information on the calculation of the above parameters as well as the resulting values for the parameters. For the December 2023 ELCC Report, ELCC Class Ratings are calculated for each delivery year in the period 2024/2025 – 2033/2034 but only the 2024/2025 values are final (the results for the rest of the delivery years are preliminary). The ELCC methodology employed to perform the calculations is documented in PJM Manual 20 (Section 5) and PJM Manual 21A.

Note that throughout this document all references to a year are effectively references to a delivery year. For simplicity, the delivery years are labeled using the year corresponding to the summer season. Therefore, for example, delivery year 2024 refers to delivery year 2024/2025.

Assumptions

Table 1 provides a list of the assumptions used in the December 2023 ELCC calculations.

Table 1: December 2023 ELCC Study Assumptions

Parameter	December 2023 ELCC Study	Basis for Assumption
ELCC Classes (ELCC Classes for which ELCC Class Ratings are calculated)	Onshore Wind, Offshore Wind, Solar Fixed Panel, Solar Tracking Panel, 4-hr Energy Storage, 6-hr Energy Storage, 8-hr Energy Storage, 10-hr Energy Storage, Solar Hybrid Open Loop, Solar Hybrid Closed Loop, Intermittent Hydropower, Landfill Gas Intermittent, Hydro with Non-Pumped Storage	ELCC Classes with members that are expected to offer or provide capacity in the target year are determined based on a vendor's forecast and PJM Interconnection Queue information
ELCC Resources Deployment Forecast	December 2023 vintage	Most recently developed deployment forecast
Historical Weather Delivery Years	2012 – 2022	2012 was the first delivery year with a non-negligible amount of ELCC Resources; 2022 was the most recent delivery year for which ELCC resource performance and load data were available

Weight for each Historical Weather Year (for the calculation of LOLE and ultimately ELCC Class Ratings)	2012: 0.159 2013: 0.078 2014: 0.071 2015: 0.159 2016: 0.078 2017: 0.071 2018: 0.078 2019: 0.077 2020: 0.077 2021: 0.077 2022: 0.078	Analysis based on actual weather in each of the 11 delivery years and the weather scenarios considered in the 2024 PJM Load Forecast
Hourly Load Scenarios	11,000 (1,000 for each of the 11 Historical Weather Years)	Generate wide range of load scenarios based on the 12 monthly peaks corresponding to each weather scenario in the 2024 PJM Load Forecast
"Behind-the-meter" Solar Forecast	Consistent with 2024 PJM Load Forecast	Consistent with Reliability Requirement calculation
Thermal Unlimited Resources (Unit List)	Consistent with 2023 Reserve Requirement Study (RRS)	Consistent with Reliability Requirement calculation
Thermal Unlimited Resources (Performance: Forced Outages)	Modeled via Monte Carlo using forced outage metrics consistent with 2023 Reserve Requirement Study (RRS). Modeling of winter peak week generator performance and summer ambient derates is consistent with 2023 RRS.	Consistent with Reliability Requirement calculation

Thermal Unlimited Resources (Performance: Planned and Maintenance Outages)	Modeled via deterministic scheduling algorithm using metrics consistent with 2023 Reserve Requirement Study (RRS). Winter peak week modeling consistent with 2023 RRS.	Consistent with Reliability Requirement calculation
Variable Resources	Output shapes developed for each Historical Weather Year based on actual and backcasted output of existing and planned units. The same output shapes are used for the calculations in each year of the 2024 – 2033 period.	Consistent with Historical Weather Years as well as collection of existing and planned units
Solar Hybrid Resources (Open Loop and Closed Loop)	Configuration of these resources in ELCC Model: Storage component: 4-hr duration, 25% of solar hybrid Maximum Facility Output Solar component: tracking panel, 100% of solar hybrid Maximum Facility Output.	ELCC data submission process and PJM Interconnection Queue
Primary Reserves	2,450 MW	Consistent with PJM System Operations
Demand Resources	Consistent with 2024 PJM Load Forecast	Consistent with other planning models
Capping of Hourly Output	In all years except for 2024 the hourly output of ELCC Resources is capped in accordance with the CIRs for ELCC FERC filing documented in PJM M20 and M21A	Consistent with CIRs for ELCC FERC filing ER23-1067-000

2024 Results: ELCC Class Ratings and Accredited UCAP values

The ELCC Portfolio Rating i.e., the AUCAP value of the entire set of ELCC Resources as a share of the total nameplate, for 2024 is 51%.

The allocation of the Portfolio ELCC to each of the ELCC Classes for each of the delivery years is performed in accordance with the procedure described in PJM Manual 20, Section 5.6. The resulting ELCC Class Ratings are shown in Table 2.

Table 2: ELCC Class Ratings for 2024/2025

ELCC Class	2024/2025
Onshore Wind	21%
Offshore Wind	47%
Solar Fixed Panel	33%
Solar Tracking Panel	50%
4-hr Storage	92%
6-hr Storage	100%
8-hr Storage	100%
10-hr Storage	100%
Solar Hybrid Open Loop - Storage Component	75%
Solar Hybrid Closed Loop - Storage Component	68%
Hydro Intermittent	36%
Landfill Gas Intermittent	61%
Hydro with Non-Pumped Storage*	95%

* PJM performs an ELCC analysis for each individual unit in this class. The value shown in the table is a representative value provided for informational purposes

To illustrate the differences in the December 2023 values relative to the December 2022 values, Table 3 shows a comparison between the 2024/2025 ELCC Class Ratings from the December 2023 report and those from the December 2022 report[1]. The major differences in 2024 ELCC Class Ratings are the decreases for the Solar Fixed, Solar Tracking, and Storage Component in Solar Hybrid classes and the increases for 4-hr Storage and wind classes. In the case of the Solar classes decreases, the changes are driven by more winter risk in the December 2023 study compared to the December 2022 study (in this year's study about 34% of the LOLE risk in 2024 is in the winter while in last year's study it was less than 1%); in the case of the decreases for the Storage Component in Solar Hybrid classes, the change is driven by the hybrid being output-constrained. In other words, the storage component cannot output enough megawatts because the solar component is using the majority of the hybrid's maximum facility output (please refer to Solar Hybrid Resources in the assumptions table. Also, in the case of the Closed Loop hybrid, the Class Rating is even lower for the Storage Component due to low solar output in the winter, which prevents the storage component of the resource from charging. In the case of the increases, the 4-hr Storage rating benefits from shorter duration events, even those in the winter, while the increases for the wind classes are driven by more winter risk.

Table 3: Comparison of 2024 ELCC Class Ratings between December 2023 and December 2022 Reports

ELCC Class	ELCC Class Rating for 2024/2025 (December 2023)	ELCC Class Rating for 2024/2025 (December 2022)	Difference (in percentage points)
Onshore Wind	21%	18%	+3
Offshore Wind	47%	43%	+4
Solar Fixed Panel	33%	45%	-12
Solar Tracking Panel	50%	56%	-6
4-hr Storage	92%	82%	+10
6-hr Storage	100%	98%	+2
8-hr Storage	100%	100%	0
10-hr Storage	100%	100%	0
Solar Hybrid Open Loop - Storage Component	75%	85%	-10
Solar Hybrid Closed Loop - Storage Component	68%	85%	-17
Hydro Intermittent	36%	40%	-4
Landfill Gas Intermittent	61%	63%	-2

[1] https://www.pjm.com/-/media/planning/res-adeq/elcc/elcc-report-december-2022.ashx

Hydro with Non-Pumped Storage*	95%	95%	0

* PJM performs an ELCC analysis for each individual unit in this class. The value shown in the table is a representative value provided for informational purposes

The Accredited UCAP (AUCAP) values for existing and planned resources for use in the 2024 3IA are calculated as the product of the respective ELCC Class Ratings from this report, the Performance Adjustment values calculated concurrent with this report and the Effective Nameplate values. AUCAP values and Performance Adjustment values cannot be made public, but are available in Capacity Exchange on a unit-specific basis to the applicable PJM Members.

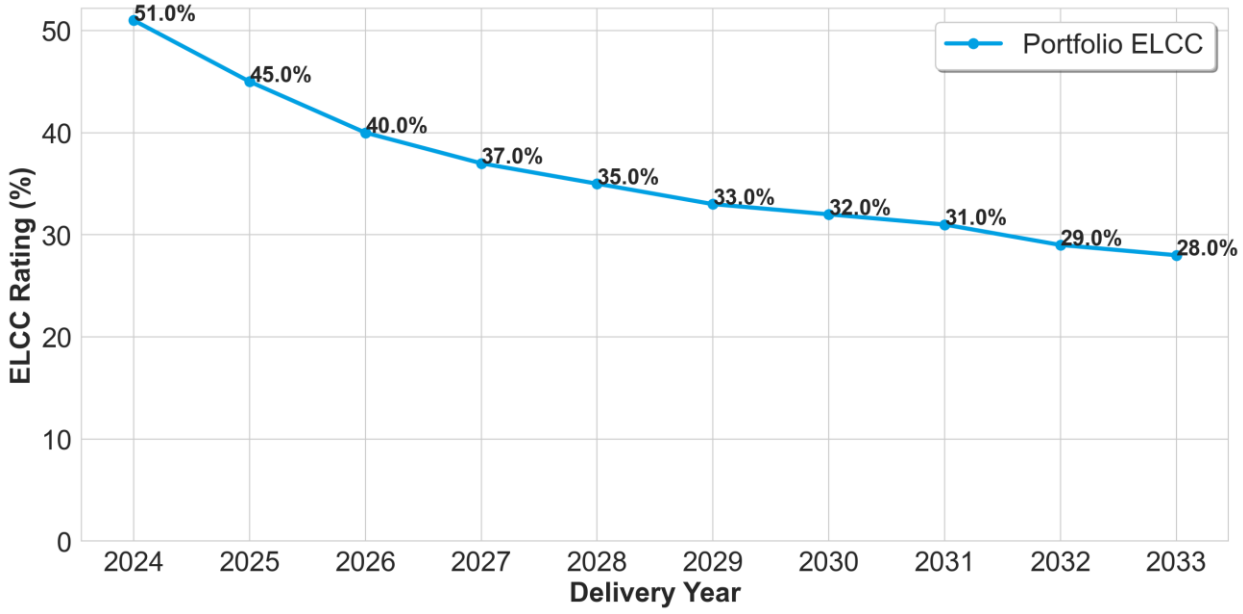
2024 - 2033 Results: ELCC Class Ratings

ELCC Class Ratings are provided for every delivery year in the period 2024 – 2033. Note that ELCC Class Ratings for delivery years other than 2024 are preliminary (for 2024, they are final).

Portfolio of ELCC Resources: 2024 – 2033 ELCC Rating

Figure 1 shows the ELCC Rating of the Portfolio of ELCC Resources (as a share of total nameplate of ELCC Resources) for the period 2024 – 2033. The rating exhibits a marked downward trend as the overall penetration of ELCC Resources increases. Any potential complementarity between some of the ELCC Classes is not sufficient to reverse the downward trend in the ELCC Rating of the Portfolio of ELCC Resources.

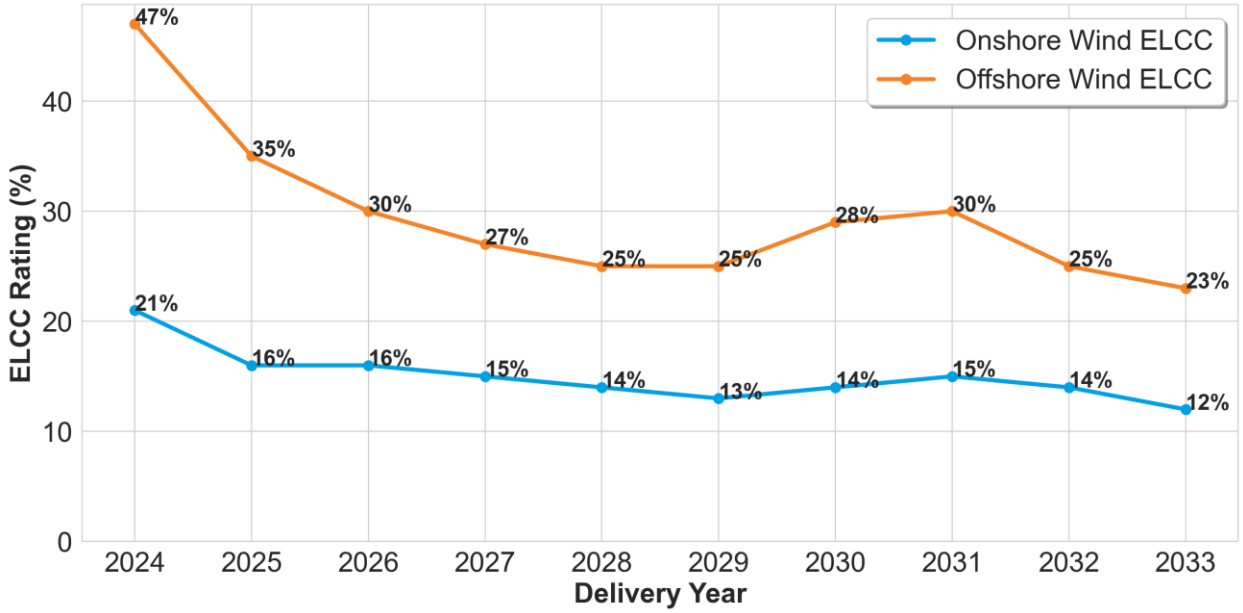
Figure 1: 2024 - 2033 ELCC Portfolio Rating



Onshore Wind & Offshore Wind: 2024 – 2033 ELCC Class Ratings

Figure 2 shows the 2024 – 2033 ELCC Class Ratings for Onshore Wind and Offshore Wind. The ratings for both classes exhibit a sharp decrease at the beginning of the period due to the capping of hourly output at assessed deliverability in 2025. After 2025, the ELCC Class Ratings are rather stable.

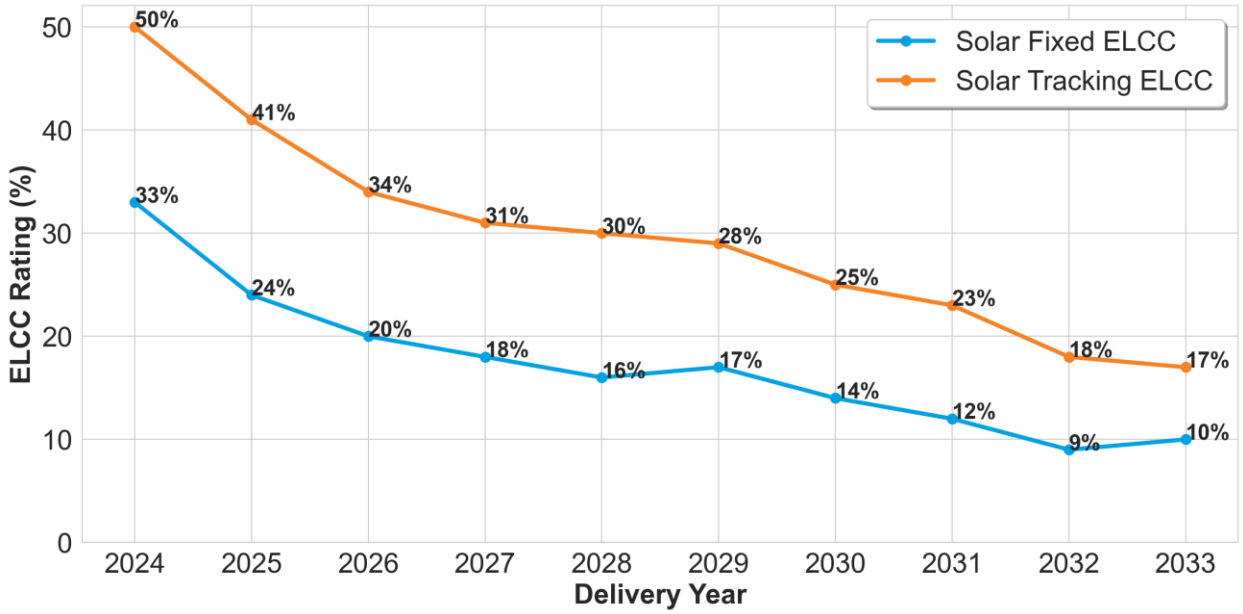
Figure 2: 2024 – 2033 ELCC Class Ratings for Onshore Wind & Offshore Wind



Solar Fixed Panel & Solar Tracking Panel: 2024 – 2033 ELCC Class Ratings

Figure 3 shows the 2024 – 2033 ELCC Class Ratings for Solar Fixed Panel and Solar Tracking Panel. The ratings for both classes exhibit a steep decline as the forecasted penetration level of each class increases.

Figure 3: 2024 - 2033 ELCC Class Ratings for Solar Fixed Panel & Solar Tracking Panel

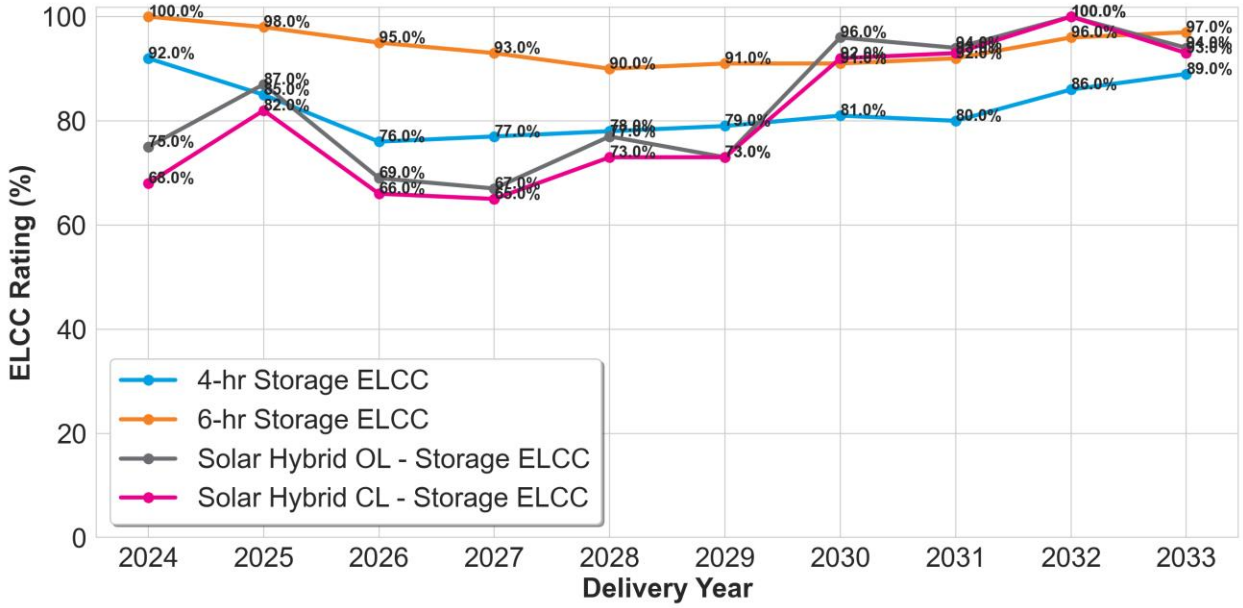


4-hr Storage, 6-hr Storage, Solar Hybrid Open Loop (OL) - Storage Component, Solar Hybrid Closed Loop (CL) - Storage Component: 2024 – 2033 ELCC Class Ratings

Figure 4 shows the 2024 – 2033 ELCC Class Ratings for 4-hr Storage, 6-hr Storage and the Storage Component of Solar Hybrids (for both, open and closed loop). The 6-hr Storage rating exhibits a mild decline until 2028 and then picks up again in 2031.

A similar pattern of decline and increase in class rating can be observed for 4-hr Storage, though the decline is more pronounced and the rating values are lower than for 6-hr Storage. The ratings for the storage component of open-loop and closed-loop solar hybrids are higher for the open-loop resource due to the ability of these resources to charge from the grid while the storage component in the closed-loop solar hybrid cannot fully charge from the solar component in the winter period (and, as noted earlier, a significant portion of the LOLE risk is in the winter).

Figure 4: 2024 – 2033 ELCC Class Ratings for 4-hr Storage, 6-hr Storage, Solar Hybrid Open Loop (OL) - Storage Component, Solar Hybrid Closed Loop (CL) - Storage Component

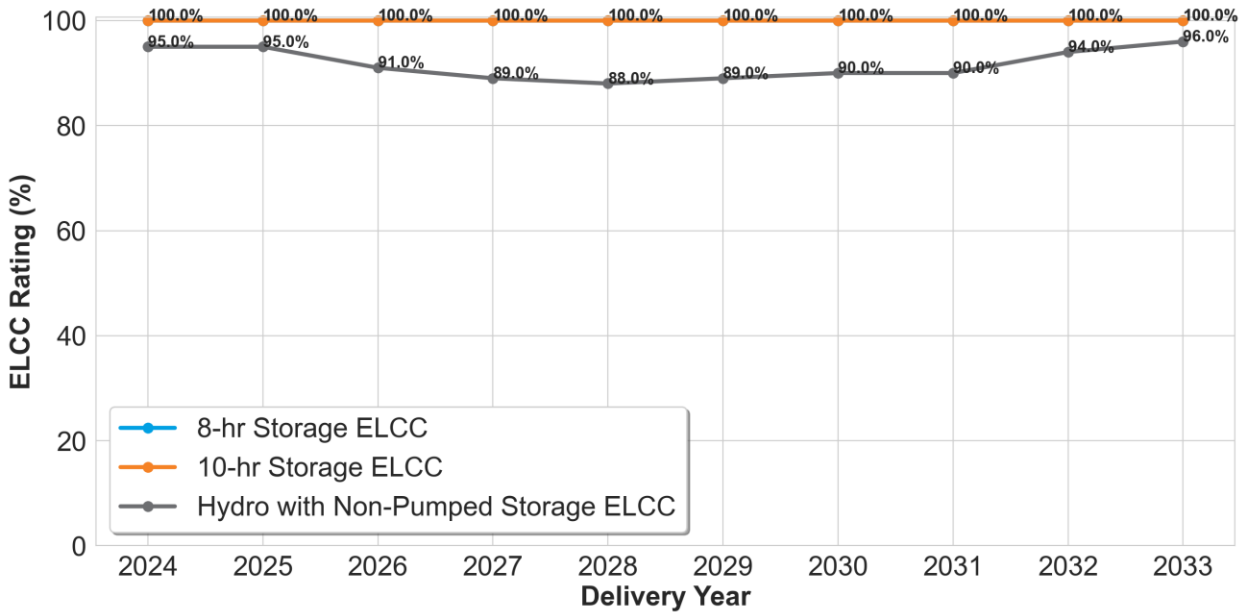


8-hr Storage, 10-hr Storage, Hydro with Non-Pumped Storage: 2024 – 2033 ELCC Class Ratings

Figure 5 shows the 2024 – 2033 ELCC Class Ratings for 8-hr Storage, 10-hr Storage and Hydro with Non-Pumped Storage. The ratings for 8-hr Storage and 10-hr Storage remain constant at 100% for the entire period.

Figure 5 also shows an aggregate rating for the Hydro with Non-Pumped Storage class, notwithstanding the fact that PJM performs an ELCC analysis for each individual unit in this class. The trend for the aggregate rating of this class follows the same pattern as that observed for the classes in Figure 4.

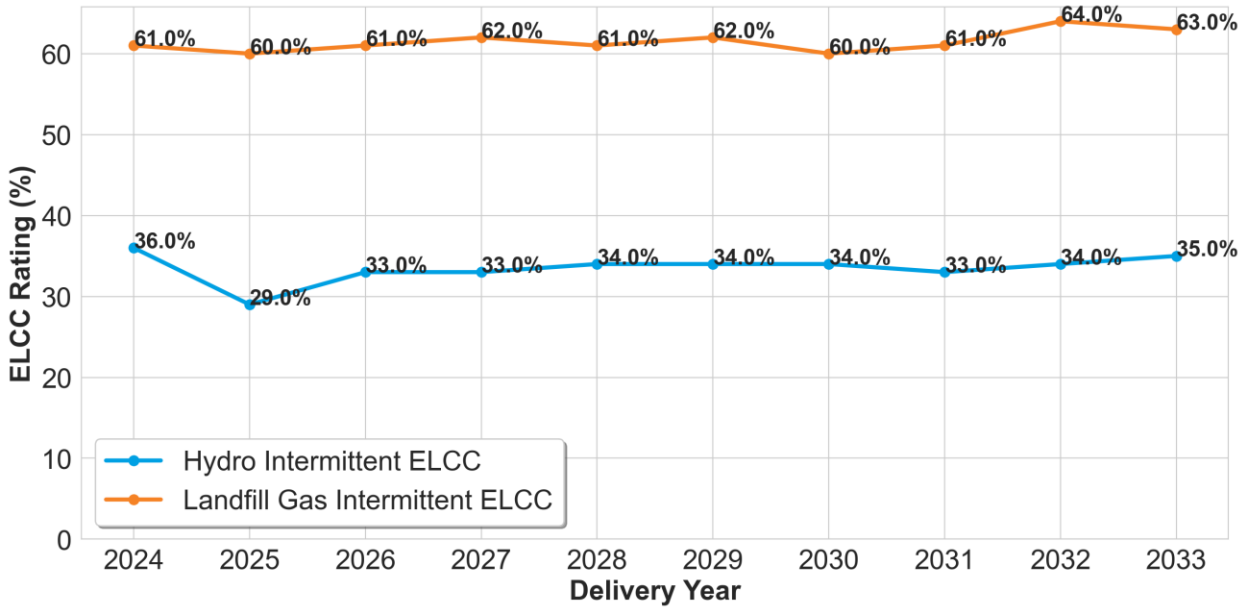
Figure 5: 2024 – 2033 ELCC Class Ratings for 8-hr Storage, 10-hr Storage, Hydro with Non-Pumped Storage



Hydro Intermittent & Landfill Gas Intermittent: 2024 – 2033 ELCC Class Ratings

Figure 6 shows the 2024 – 2033 ELCC Class Ratings for Hydro Intermittent and Landfill Gas Intermittent resources. In general, the ratings for both classes exhibit a slight upward trend.

Figure 6: 2024 – 2033 ELCC Class Ratings for Hydro Intermittent & Landfill Gas Intermittent



Portfolio and All ELCC Classes: 2024 – 2033 ELCC Class Ratings

Table 4 summarizes all the information provided in the above Figures.

Table 4: 2024 - 2033 ELCC Class Ratings and ELCC Portfolio Rating

ELCC Class	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Onshore Wind	21%	16%	16%	15%	14%	13%	14%	15%	14%	12%
Offshore Wind	47%	35%	30%	27%	25%	25%	29%	30%	25%	23%
Solar Fixed	33%	24%	20%	18%	16%	17%	14%	12%	9%	10%
Solar Tracking	50%	41%	34%	31%	30%	29%	25%	23%	18%	17%
4-hr Storage	92%	85%	76%	77%	78%	79%	81%	80%	86%	89%
6-hr Storage	100%	98%	95%	93%	90%	91%	91%	92%	96%	97%
8-hr Storage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
10-hr Storage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Solar Hybrid Open Loop - Storage Component	75%	87%	69%	67%	77%	73%	96%	94%	100%	94%
Solar Hybrid Closed Loop - Storage Component	68%	82%	66%	65%	73%	73%	92%	93%	100%	93%
Hydro Intermittent	36%	29%	33%	33%	34%	34%	34%	33%	34%	35%
Landfill Gas	61%	60%	61%	62%	61%	62%	60%	61%	64%	63%
Hydro Non-Pumped Storage	95%	95%	91%	89%	88%	89%	90%	90%	94%	96%
Portfolio	51%	45%	40%	37%	35%	33%	32%	31%	29%	28%

* PJM performs an ELCC analysis for each individual unit in this class. The value shown in the table is a representative value provided for informational purposes

Description of Posted Files

PJM has posted the following files as background information for the calculation of 2024 ELCC Class Rating and Accredited UCAP values. Note that the data contained in these files is *simulated data* whose only purpose is to calculate ELCC Class Rating and Accredited UCAP values. **The simulated data is not intended to be a prediction of how the system will perform in future years**.

Replications_LOLE_2024.zip: this zip file contains a collection of several CSV files, one for each of the scenarios with LOLE in each of the 10 historical weather years (scenarios without LOLE are not posted). The files correspond to the ELCC run that result in the ELCC Class Rating values shown in Table 2 (for 2024). The LOLE of the case is 0.1 days per year. The columns in each file are as follows:

- Unnamed Column: 0-8760(8784). Hour number of the delivery year. The delivery years begin on June 1st.
- Load: In MW. Load at the given hour.
- ThCap: In MW. Unlimited Thermal Capacity available at the given hour (after Forced, Planned and Maintenance outages)
- ThOutageRate: As fraction between 0 and 1. Unlimited Thermal Capacity outage rate at given hour (includes Forced, Planned and Maintenance outages)
- OnshoreWind: In MW. Total onshore wind output at given hour.
- OffshoreWind: In MW. Total offshore wind output at given hour.
- SolarFixed: In MW. Total solar fixed panel output at given hour.
- SolarTracking: In MW. Total solar tracking panel output at given hour.
- HydroInt: In MW. Total hydro intermittent output at given hour.
- LandfillInt: In MW. Total landfill gas intermittent output at given hour.
- 6hrStorage: In MW. Total 6-hr Storage dispatched at given hour.
- HydroNPS: In MW. Total Hydro with Non-Pumped Storage dispatched at given hour.
- OL_Hybrid: In MW. Total Solar Hybrid Open Loop dispatched at given hour (includes solar and storage output)
- CL_Hybrid: In MW. Total Solar Hybrid Closed Loop dispatched at given hour (includes solar and storage output)
- 4hrStorage: In MW. Total 4-hr Storage dispatched at given hour.
- DRDispatched: In MW. Total amount of DR dispatched at given hour.
- Ambient: In MW. Hourly ambient derates during peak weeks of summer. A total of 2,500 MW are modeled as not available to be consistent with Reserve Requirement Study (these derates are not included in ThCap and ThOutageRate columns).

- AddPlannedOutages: In MW. Additional planned outages modeled during winter peak week to be consistent with Reserve Requirement Study (these additional planned outages are not included in ThCap and ThOutageRate columns).
- SolarHyOL: In MW. Total solar component output in Solar Hybrid Open Loop.
- SolarHyCL: In MW. Total solar component output in Solar Hybrid Closed Loop.
- MarginBeforeDR: in MW. Margin before dispatching DR calculated as total available resources minus load.
- MarginAfterDR: in MW. Margin after dispatching DR. This is the margin value used to determine if there is LOLE or not. LOLE is declared if MarginAfterDR is less than -0.1 MW (the model has a tolerance of 0.1 MW).
- LOLE: 0 or 1. If 1, there is loss of load in the given hour; if 0, there is no loss of load.
- Day: 1-365(366). Day number of the year
- Hour Beginning: 0-23. Eastern Prevailing Time Hour beginning.

Load_Scenarios_2024.zip: this zip file contains 11 CSV files, one for each of the 11 historical weather years. Each CSV file has either 8,760 or 8,784 rows (one for each hour of the year) and 1,000 columns (one for each of the 1,000 replications; the columns are named from 0 to 999). All values in the files are in MW and represent hourly loads in each scenario.

Available_Unlimited_Thermal_Scenarios_2024.zip: this zip file contains 11 CSV files, one for each of the 11 historical weather years. Each CSV file has either 8,760 or 8,784 rows (one for each hour of the year) and 1,000 columns (one for each of the 1,000 replications; the columns are named from 0 to 999). All values in the files are in MW and represent available hourly unlimited thermal capacity available in each scenario. Note that ambient derates and additional planned outages (columns Ambient and AddPlannedOutages in the Replications files) during winter peak weeks are not accounted for in these files.

200_CPX2_2024.xlsx: this file contains the hours included in the 200 CPX2 metric used to calculate the Performance Adjustment for Variable Resources and Variable Resources components in Combination Resources. The file has two sheets: the sheet “Gross” has the top 200 gross load hours; the sheet “Net” has the top 200 net load hours where net load is defined as gross load minus the potential output of Variable Resources. Note that the hourly load values in this file should be interpreted as the potential hourly load values (gross and net) in 2024 if the same pattern of historical weather that occurred on the past hours listed in the file were to repeat themselves in that year.