Effective Load Carrying Capability (ELCC)

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How to measure the capacity value of a resource?

- Capacity adequacy of the PJM system is assessed using Loss of Load Expectation (LOLE)
- The main resource adequacy study in PJM is the Reserve Requirement Study (RRS)
- The RRS considers a fixed portfolio of resources P and varies load until LOLE is 0.1 days/year
  - At that point, PJM calculates the IRM (Total ICAP / Peak Load) and the FPR (Total UCAP / Peak Load)
- If a new resource X is added to portfolio P, what is the reliability benefit that such resource provides?

How to measure the capacity value of a resource?

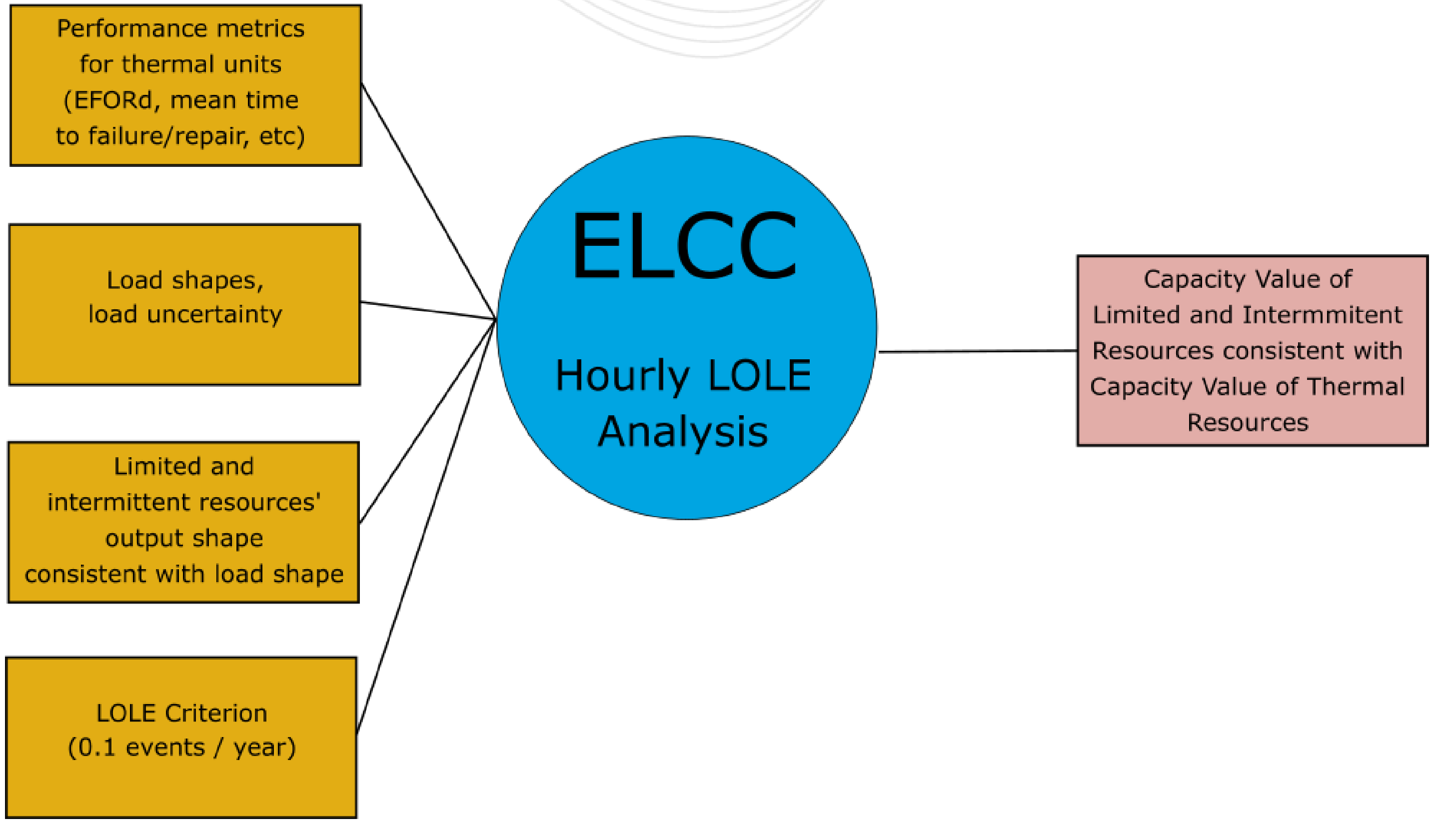
- One intuitive way to measure that benefit would be to run a new RRS, using the original portfolio P plus the new resource X
- Clearly, without any changes to the load, the reliability of the PJM system would be better than 0.1 events/year because there is an additional resource (X) in the system
- If the peak load is then increased by an amount L, the reliability of the PJM system will be back at 0.1 events/year.
- Arguably, the additional peak load L that PJM can now serve preserving the reliability of 0.1 events/year is the capacity value or reliability contribution of the new resource X

- Introduced by Garver in 1966, ELCC provides a way to assess the capacity value (or reliability contribution) of a resource (or a set of resources) that is tied to the loss-of-load probability concept
- Can be defined as a measure of the additional load that the system can supply with a particular generator of interest, with no net change in reliability.
  - ELCC can be based on any reliability metric (LOLE, LOLH, EUE)
  - Since PJM uses LOLE to set up the requirement in the capacity market, the rest of this presentation will use LOLE

ELCC Inputs/Outputs

Inputs

Output



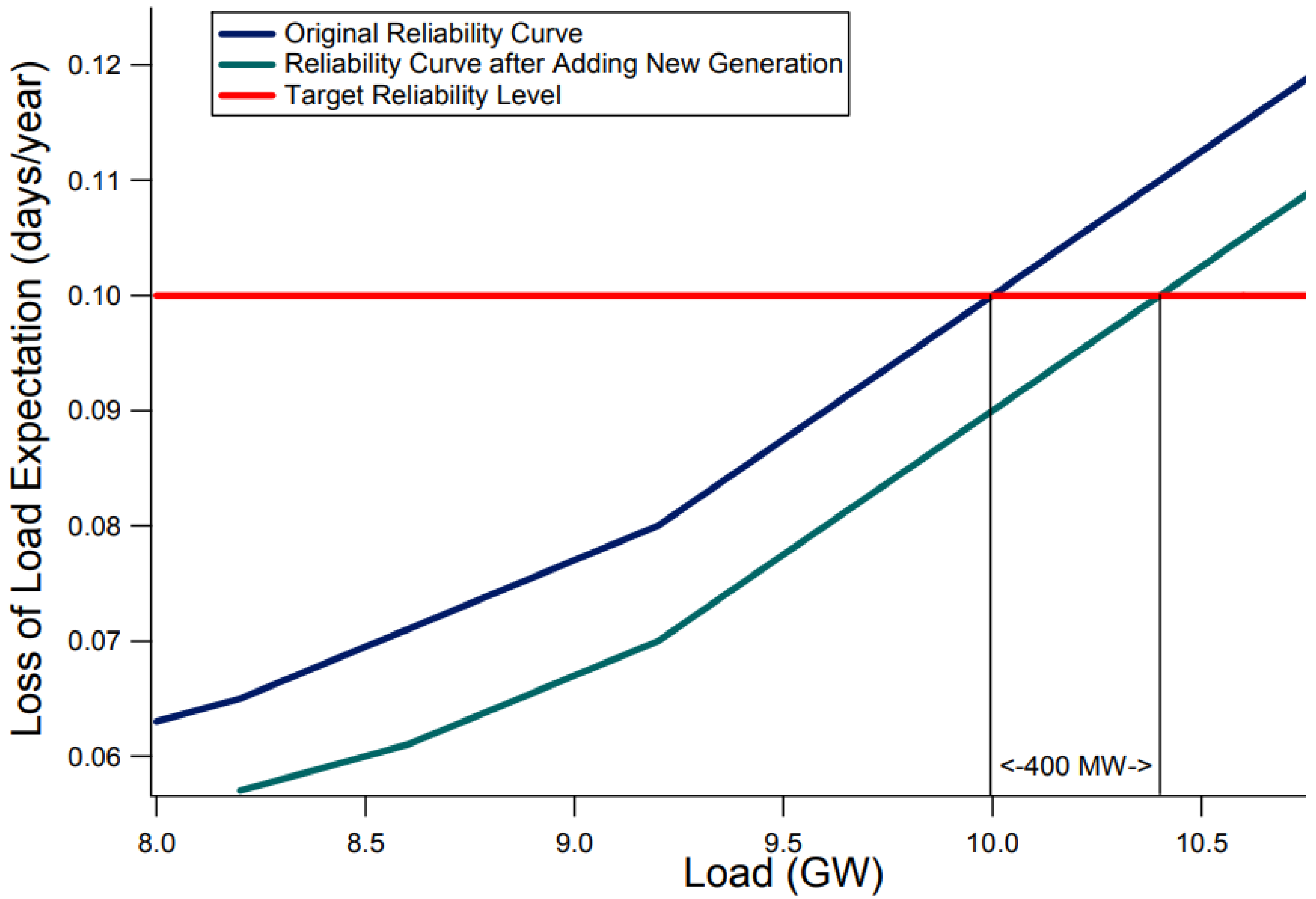


Figure 4. ELCC is the vertical distance between the reliability curves, measured at the target reliability level (400 MW at 1d/10y).

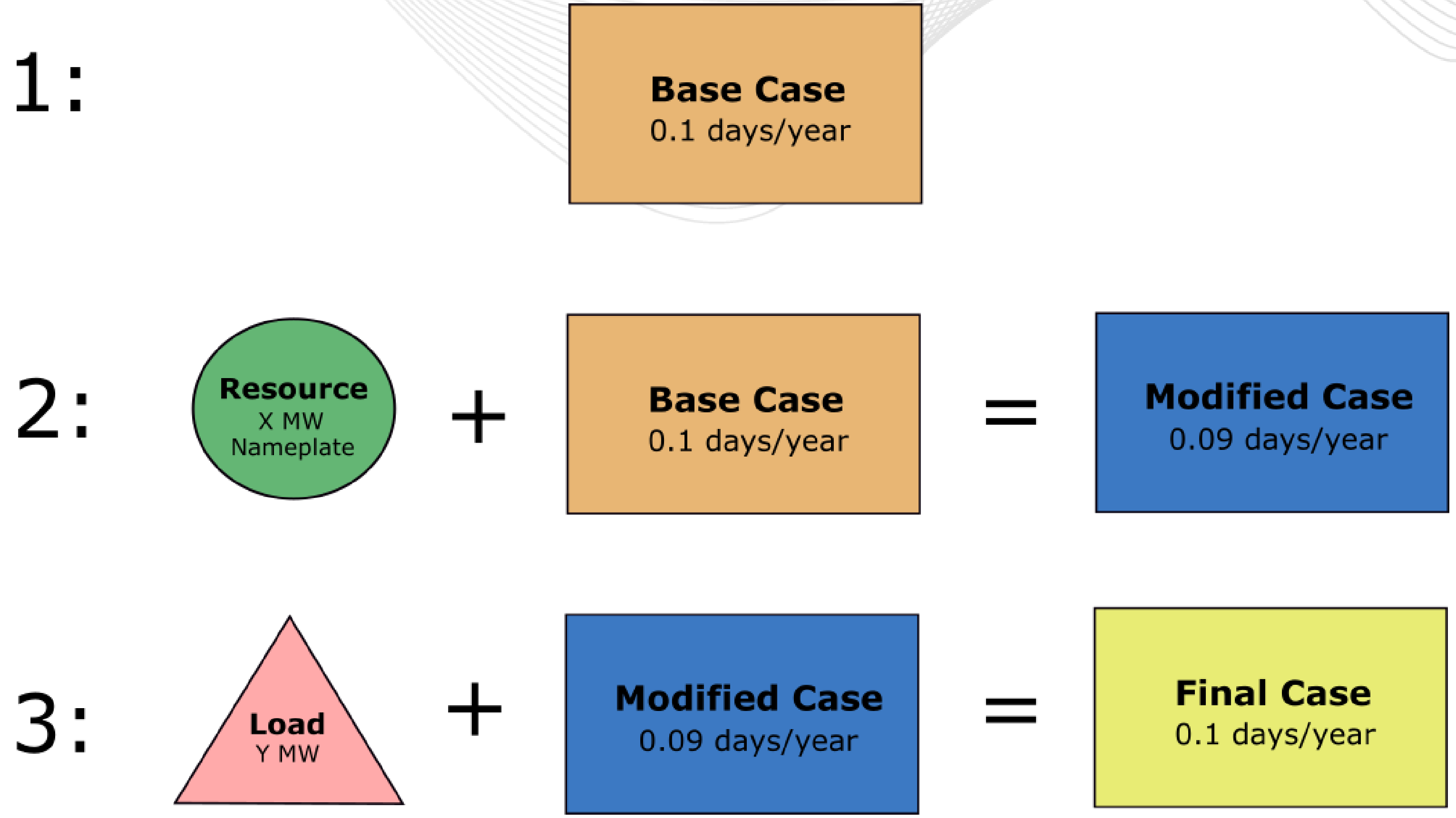
- Prospective analysis; based on inputs for a future target year
- LOLE is driven by the timing of high loss-of-load probability (LOLP) hours. Therefore, ELCC is driven by the timing of high LOLP hours
- A resource that contributes a significant level of capacity during high-risk hours will have a higher capacity value (ELCC) than a resource that delivers the same capacity only during low-risk hours

- ELCC provides a consistent way to assess the capacity value of resources
  - ELCC of a thermal unit will approximately be its unforced capacity (UCAP) value
  - ELCC can be applied to wind, solar, storage, hybrid resources
- ELCC results are driven by hours with high LOLP. Such hours may vary as penetration of intermittent or limited availability resources increases
  - ELCC captures the “shifting of the net peak load” phenomenon

ELCC Challenges

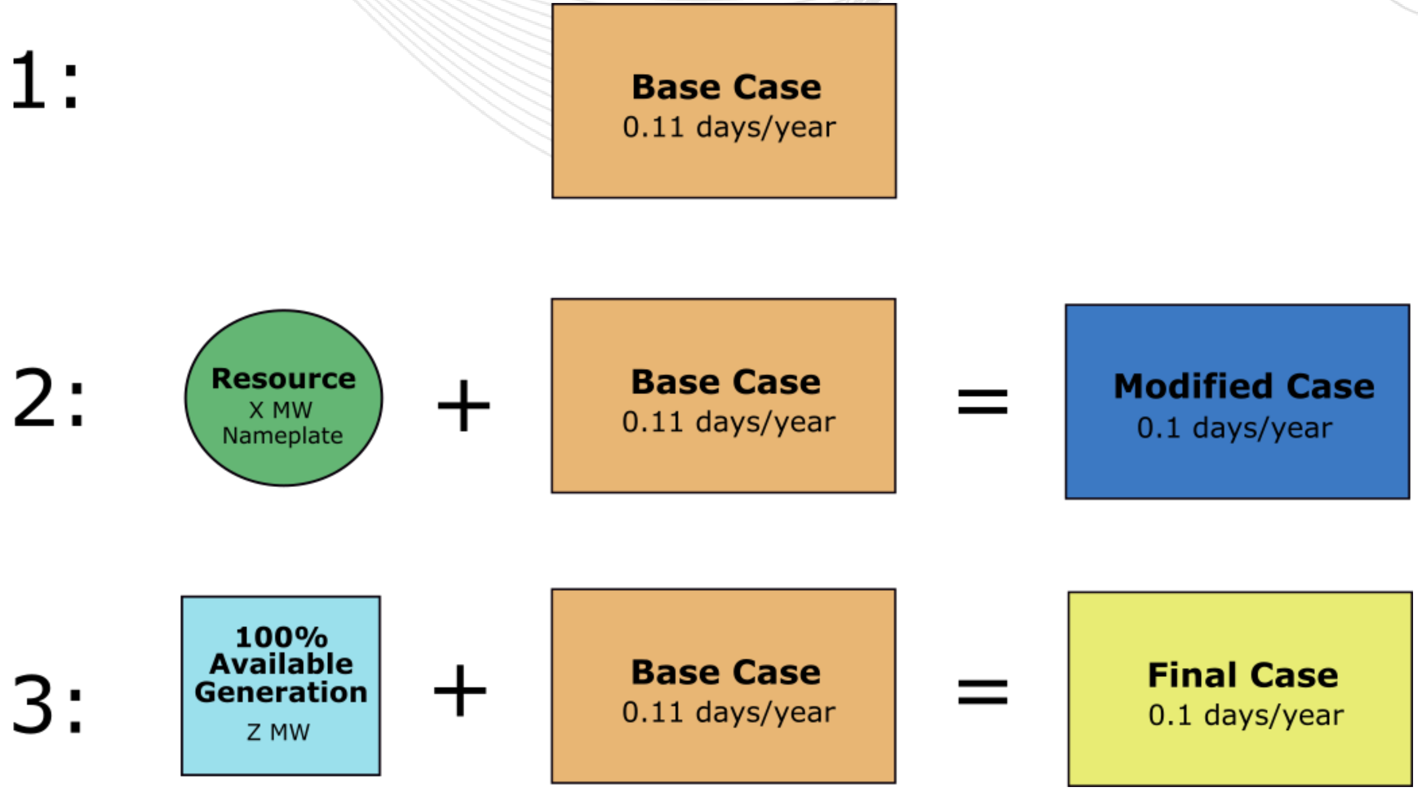
- ELCC requires data showing the performance of the generator of interest at the time of high LOLP hours
  - In the case of renewables, due to high weather variability, several years' worth of data are required
- For dispatchable or new resources, data may be limited or non-existent, so assumptions about the hourly performance of the resource of interest need to be made
- ELCC of an existing intermittent or limited availability resource is likely to decrease as penetration levels of similar resources increase as it is expected (this is also a feature)

ELCC Approaches – “Load Approach”



The ELCC of the Resource added in Step 2 is the amount of Load added in Step 3 (Y MW). It can be expressed as percent of the Resource’s nameplate (i.e., Y / X)

ELCC Approaches – “Generation Approach”



The ELCC of the Resource added in Step 2 is the amount of 100% Available Generation added in Step 3 (Z MW). It can be expressed as percent of the Resource’s nameplate (i.e., Z / X)

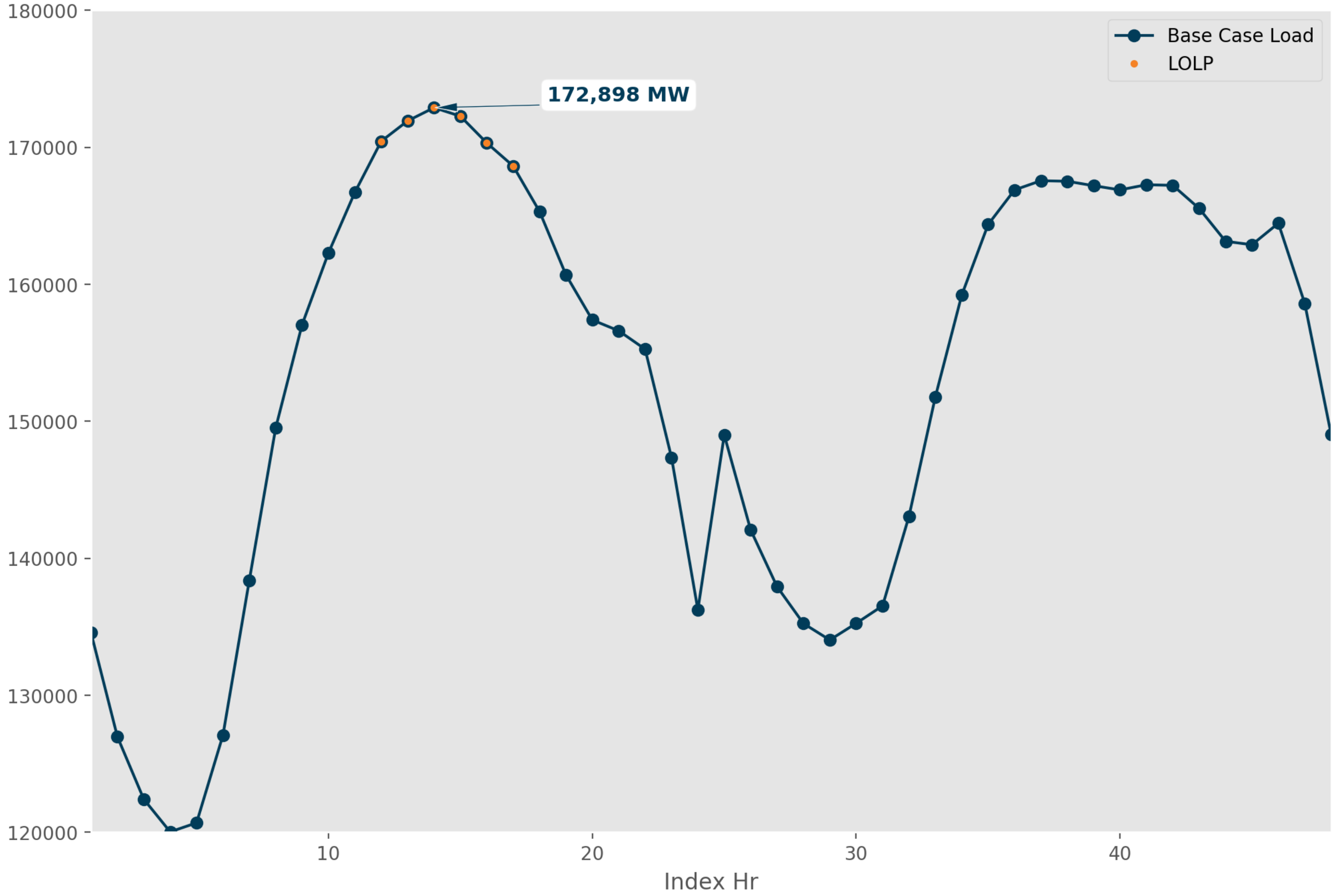
Comparison of ELCC Approaches

- A key difference between the approaches is the resulting ELCC of a 100% available resource (i.e., a resource that produces at its ICAP the 8,760 hours of a year)
  – Under the Load Approach, the resulting ELCC for such resource is ~93%
  – Under the Generation Approach, the resulting ELCC for such resource is 100%
- Under current RPM rules a 100% available resource is valued at 100% (i.e., its UCAP is equal to its ICAP)
- Therefore, the Generation Approach seems to be more consistent with current RPM rules.

Example

- Period to analyze: 48 hours (2 days)
- Peak occurs at Hour 14
- No load uncertainty (for ease of exposition)
- Performance uncertainty on thermal generation is modeled using Monte Carlo (included but not shown in slides)
  - This uncertainty is similar hour by hour
- Performance of limited resource:
  - From Hours 12 to 17 of Day 1, the resource provides 30% of Nameplate (NP)
  - Rest of the hours, the resource produces 0 MW
- Three nameplate penetration levels are examined: 1,000 MW, 10,000 MW and 30,000 MW
- For ease of exposition, the Load Approach is used to run ELCC

Example - Base Case



LOLE = 0.1 days/year

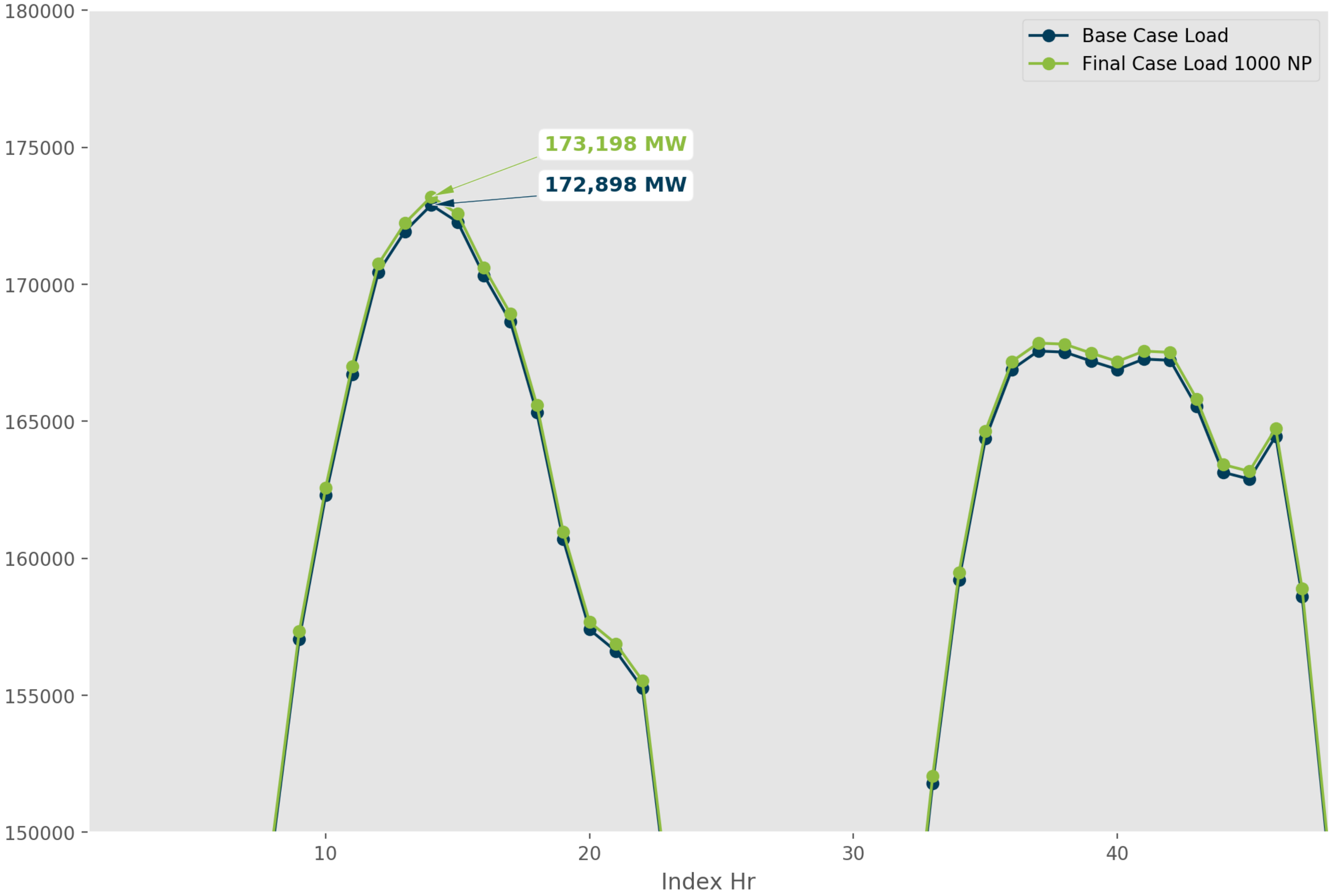
A peak of 172,898 MW can be served

Hours 12-17 are the only hours with LOLP greater than 0.

Only thermal resources

Limited resource is not included

Example – Final Case - 1,000 MW Limited Resource



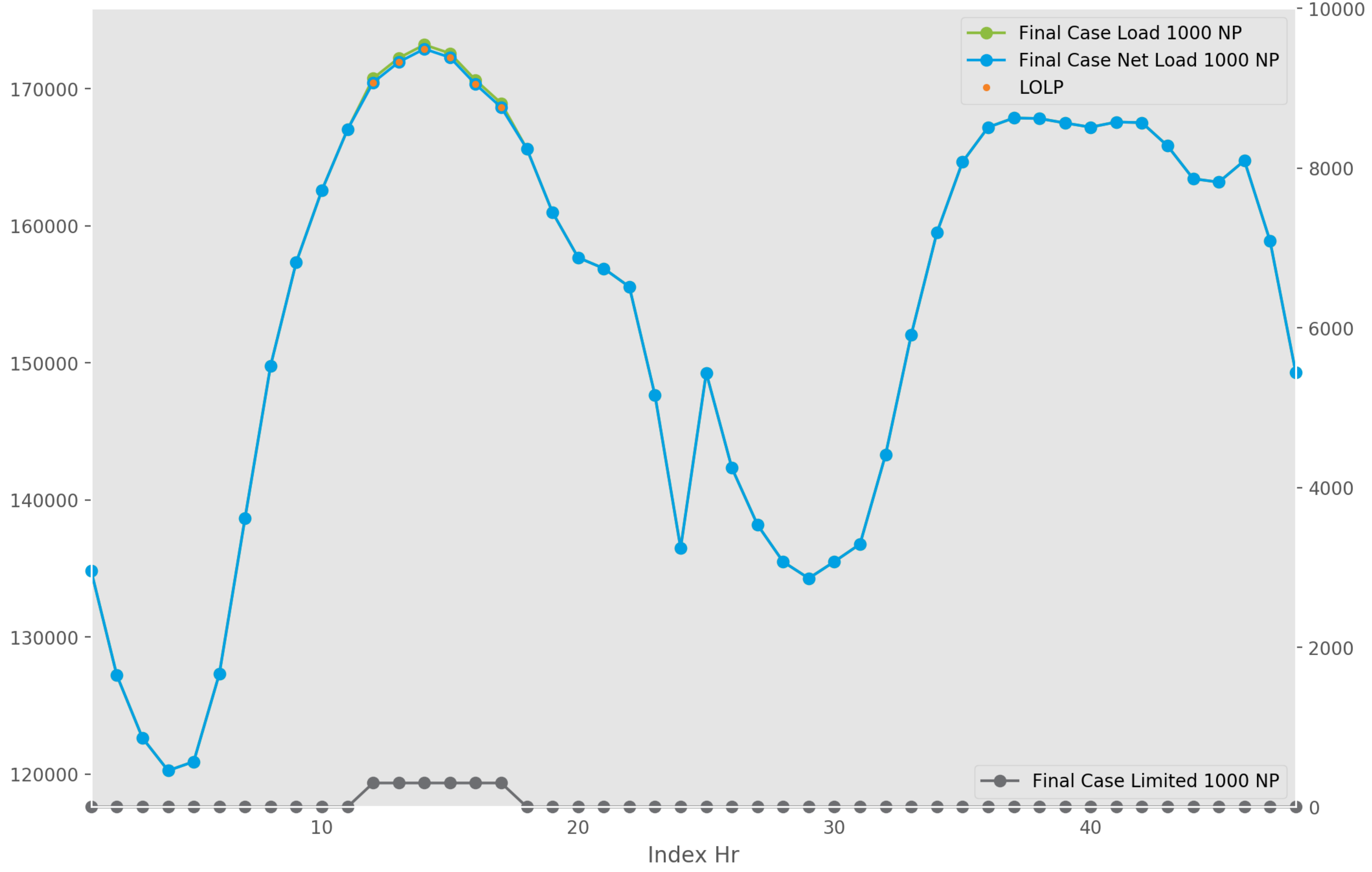
LOLE = 0.1 days/year

By adding the Limited Resource, which performs at 30% of NP during hours 12-17, the system can now serve a peak of 173,198 MW maintaining the same reliability

ELCC = 173,198 – 172,898
= 300 MW

ELCC (%) = 300 / 1,000 = 30%

Example – Final Case - 1,000 MW Limited Resource

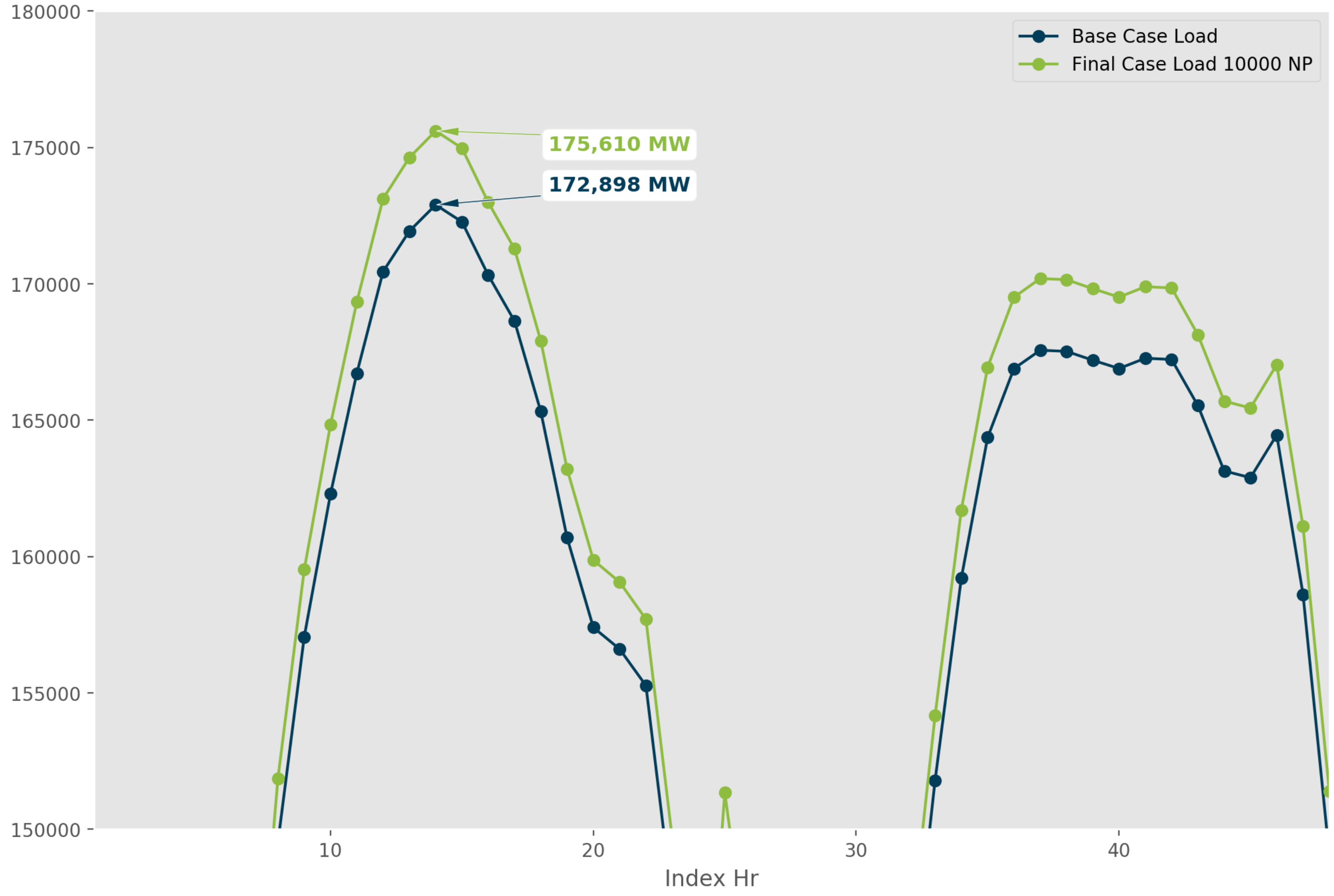


All lines except for the gray line (performance of Limited Resource) are drawn based on the left y-axis

The Load Shape and the Net Load Shape in the Final Case almost overlap, except between hours 12-17 where the Limited Resource produces energy.

As in the Base Case, hours 12-17 continue to be the only hours with LOLP greater than 0. These hours coincide with the hours where the Limited Resource performs

Example – Final Case - 10,000 MW Limited Resource



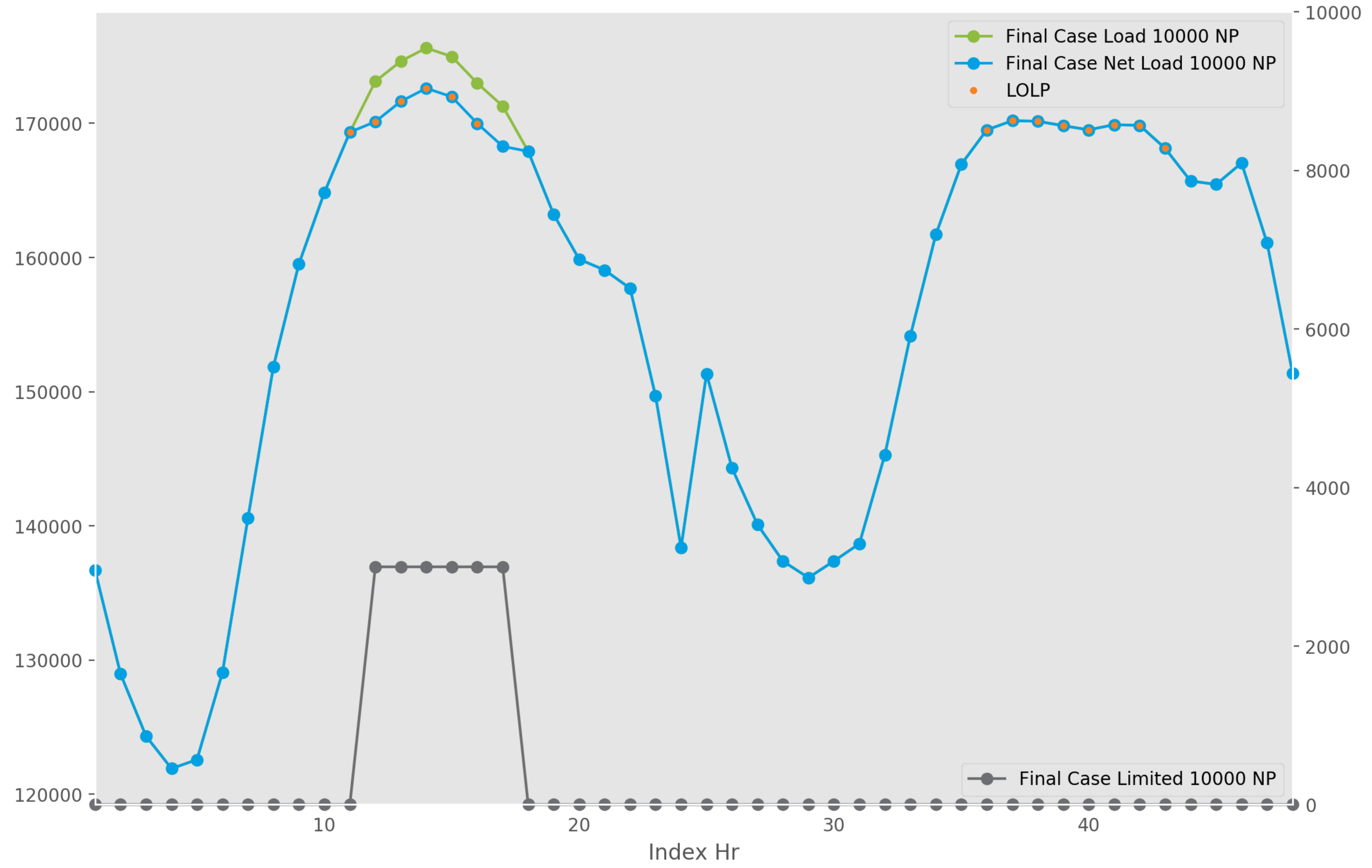
LOLE = 0.1 days/year

By adding the Limited Resource, which performs at 30% of NP during hours 12-17, the system can now serve a peak of 175,610 MW maintaining the same reliability

ELCC = 175,610 – 172,898
= 2,712 MW

ELCC (%) = 2,712 / 10,000
= 27.12%

Example – Final Case - 10,000 MW Limited Resource



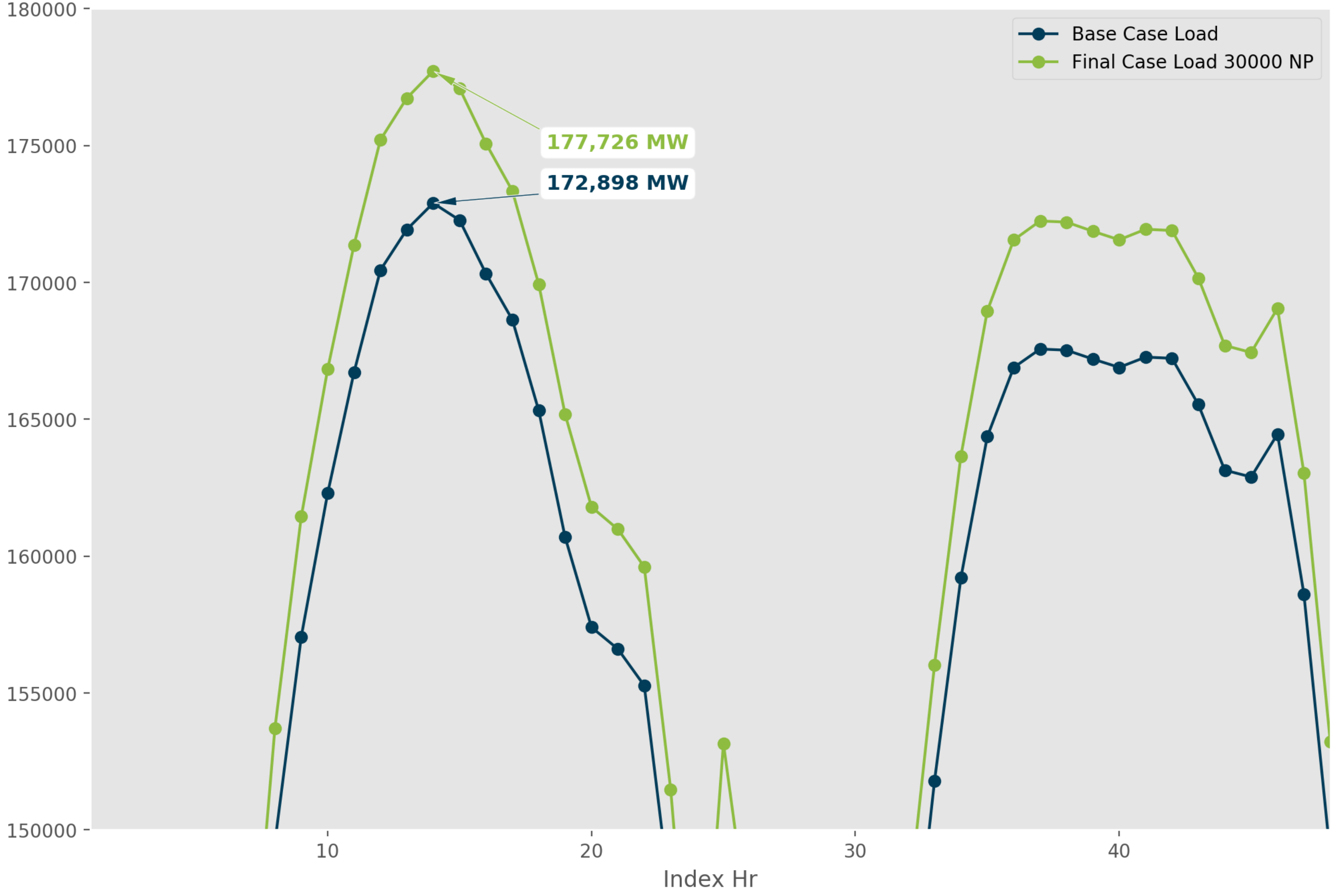
All lines except for the gray line (performance of Limited Resource) are drawn based on the left y-axis

The Load Shape and the Net Load Shape in the Final Case almost overlap, except between hours 12-17 where the Limited Resource produces energy.

Compared to the Base Case, there are many more hours with LOLP greater than 0. In fact, there are some hours in Day 2 with LOLP > 0 (hours 36-43).

However, 81% of the risk is still concentrated during hours 12-17. This is why the ELCC is still close to 30% (27%)

Example – Final Case - 30,000 MW Limited Resource



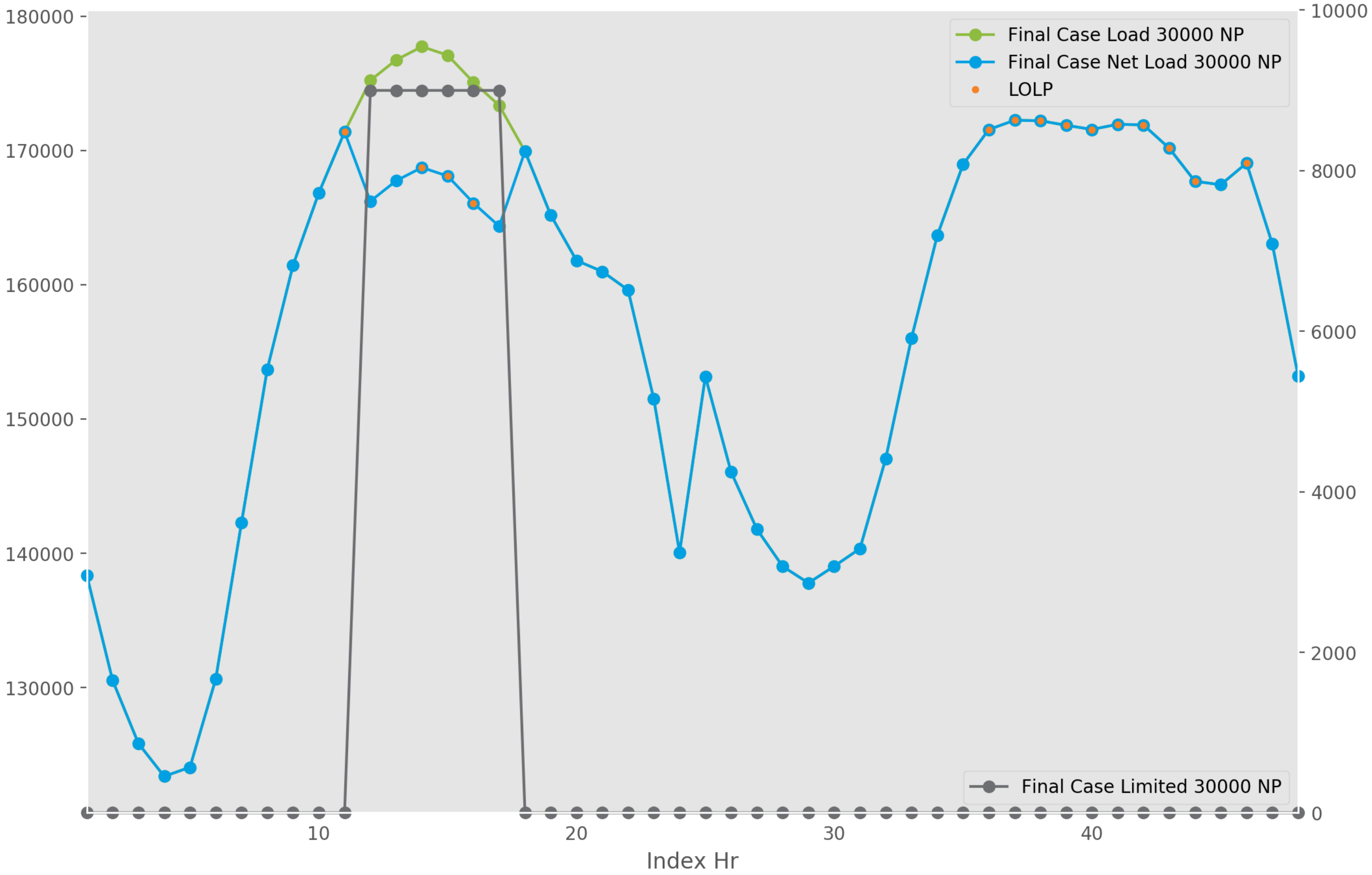
LOLE = 0.1 days/year

By adding the Limited Resource, which performs at 30% of NP during hours 12-17, the system can now serve a peak of 177,726 MW maintaining the same reliability

ELCC = 177,726 – 172,898
= 4,828 MW

ELCC (%) = 4,828 / 30,000
= 16.09%

Example – Final Case - 30,000 MW Limited Resource



All lines except for the gray line (performance of Limited Resource) are drawn based on the left y-axis

The Load Shape and the Net Load Shape in the Final Case almost overlap, except between hours 12-17 where the Limited Resource produces energy.

Compared to the Base Case, the hours with LOLP greater than 0 have mostly shifted. There are several hours in Day 2 with LOLP > 0 (hours 36-44 and 46).

Most of the risk is now in Day 2 (74%). This is why the ELCC drops significantly to 16%

Example - Conclusions

- The ELCC value is determined by the difference between the peaks in the Final and Base cases
  - However, the peak values are impacted by the LOLP during **all hours**
- At the lowest analyzed penetration level (1,000 MW nameplate), the limited resource does not get its capability capability (i.e., capacity credit) further reduced
  - The ELCC is 30% which corresponds to the output of the resource during the hours that is able to perform
  - This is the case because the hours with risk in the Final Case (as shown in slide 16) are the same as those in the Base Case (shown in slide 14). There is no “shifting of the risk” to hours where the limited resource cannot perform

- As the penetration level increases, the risk in the Final Case is shifted to hours where the limited resource cannot perform, which results in a lower capacity capability for the limited resource
  - Under 10,000 MW nameplate, there is some risk shifted to hours in Day 1 and Day 2 (shown in Slide 18). However, the majority of the risk (81%) is still concentrated during the hours where the limited resource performs (12-17 in Day 1). This is why the ELCC is still close to 30% (27%)
  - Under 30,000 MW nameplate, most of the risk has been shifted to Day 2 (shown in Slide 20) where the limited resource cannot perform. The ELCC is reduced to 16%.