Capacity value of intermittent generators
Preliminary findings

Market Regulations

May 2018

Outline

1. Introduction
2. Capacity value assessment methods
3. Current method
4. Current issues in the SWIS

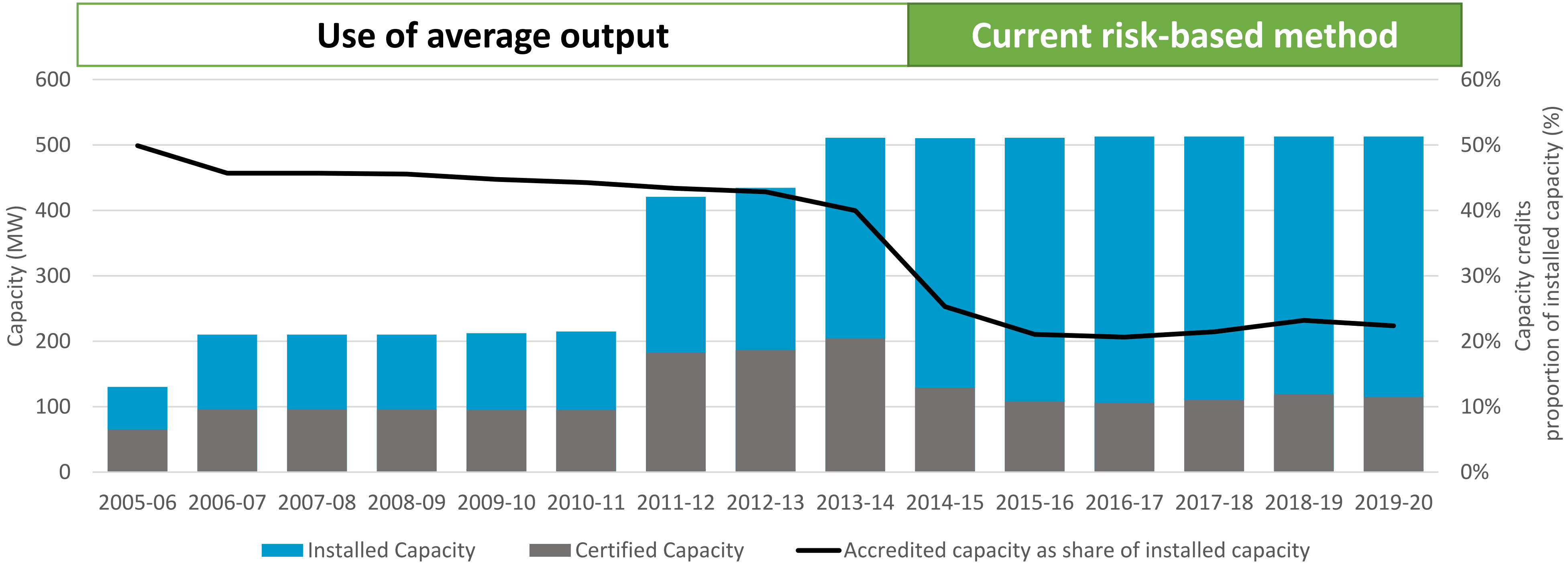
1.Introduction

Background

- Capacity value: the contribution a capacity makes to system adequacy
- Relevant Level Methodology – RLM
  - contribution of variable generation to system adequacy in the SWIS
- The ERA is currently required to review the method every three years
- IMO last reviewed the RLM in 2014

Capacity value outcomes

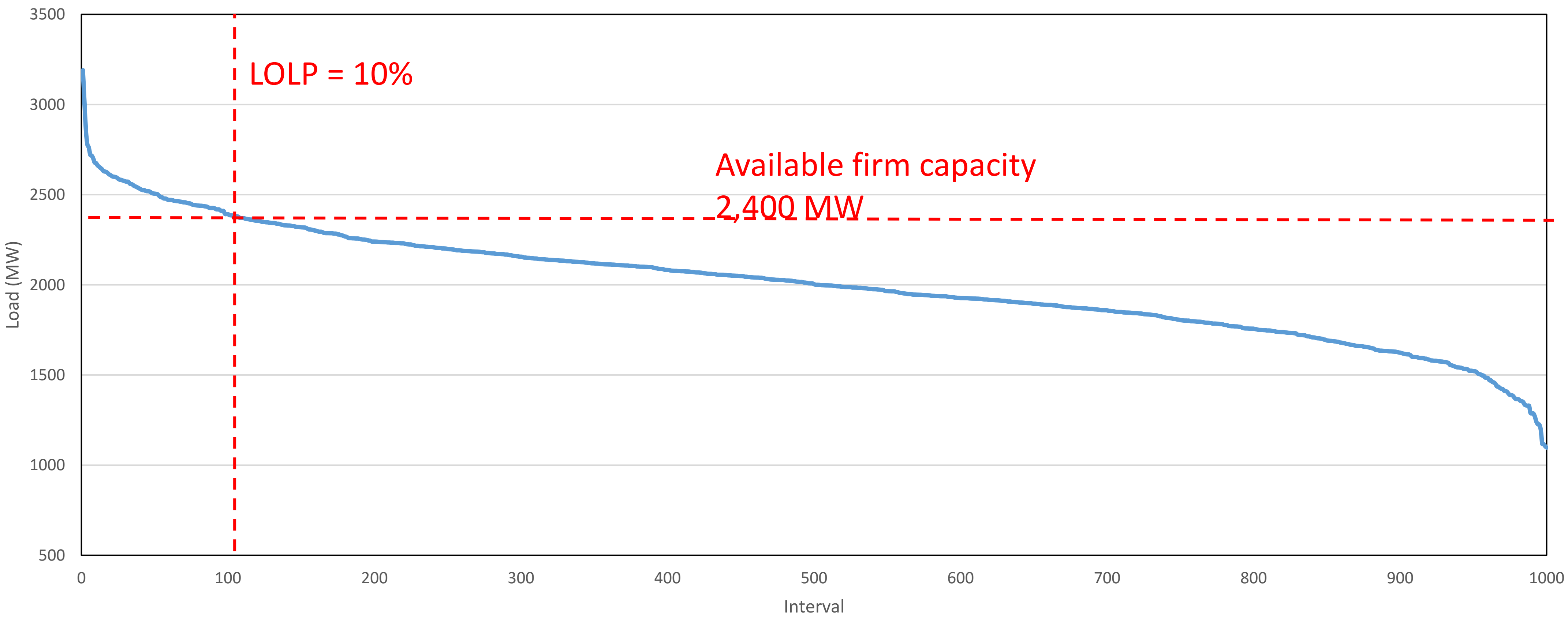
- Significant change in the RLM
  - Previous method: average output of IGs
  - Change in method transitioned over 3 years
  - Current method: average output during high-risk periods



Basis of capacity valuation

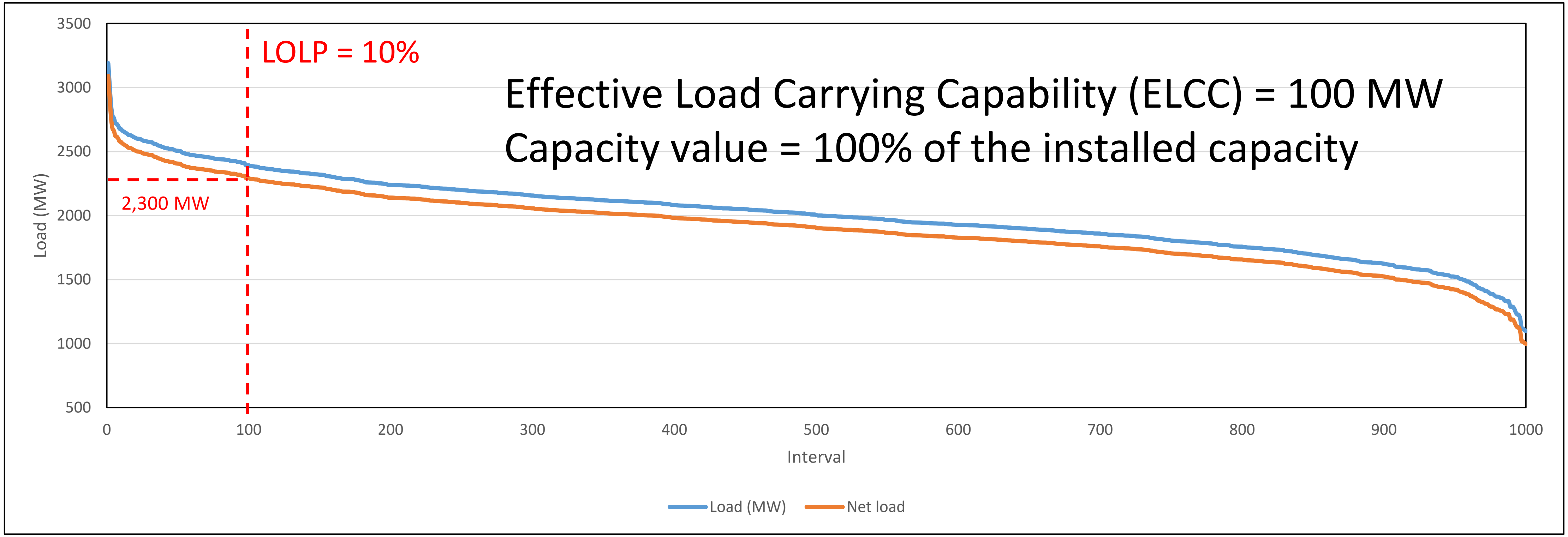
- **Effective load carrying capability (ELCC)**: the amount of incremental load that a resource can serve without a change in the system reliability
- ELCC considers:
  - probabilistic nature of generation output
  - random forced outages
  - Correlation between system random variables

Basis of capacity valuation



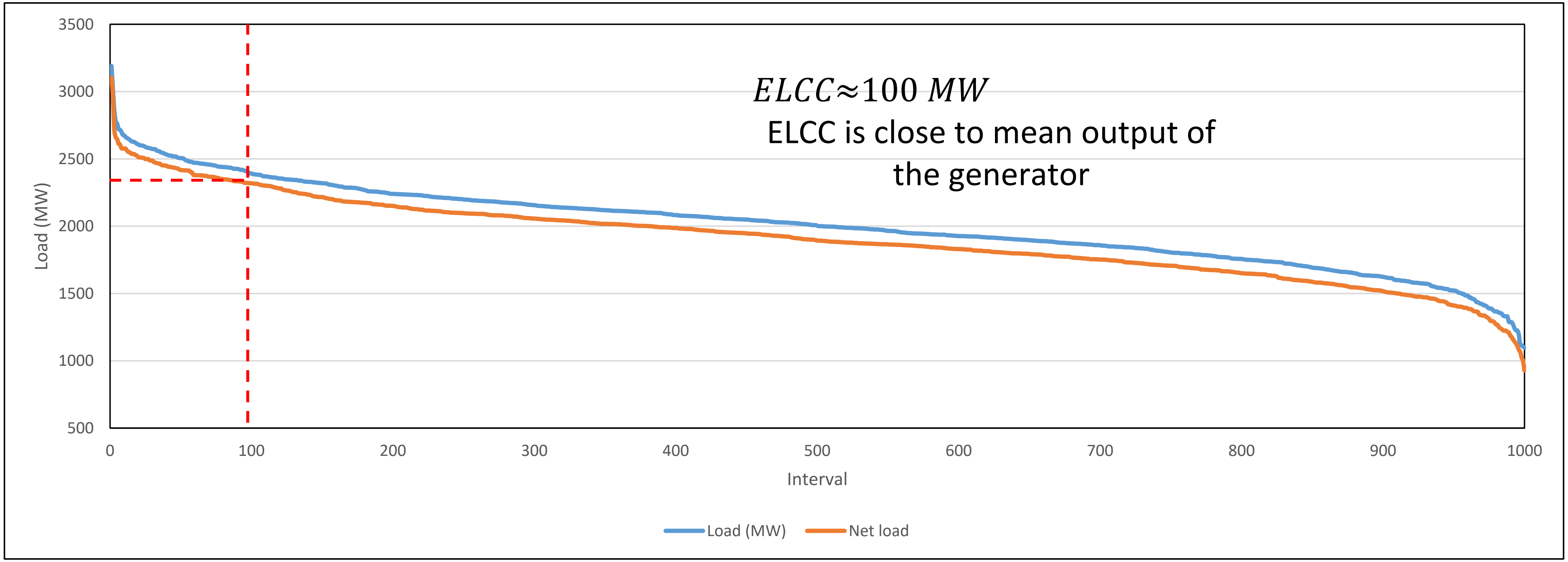
Capacity value of firm capacity - example

- Reliability target: LOLP=10%
- Additional generation: 100 MW installed capacity (firm)



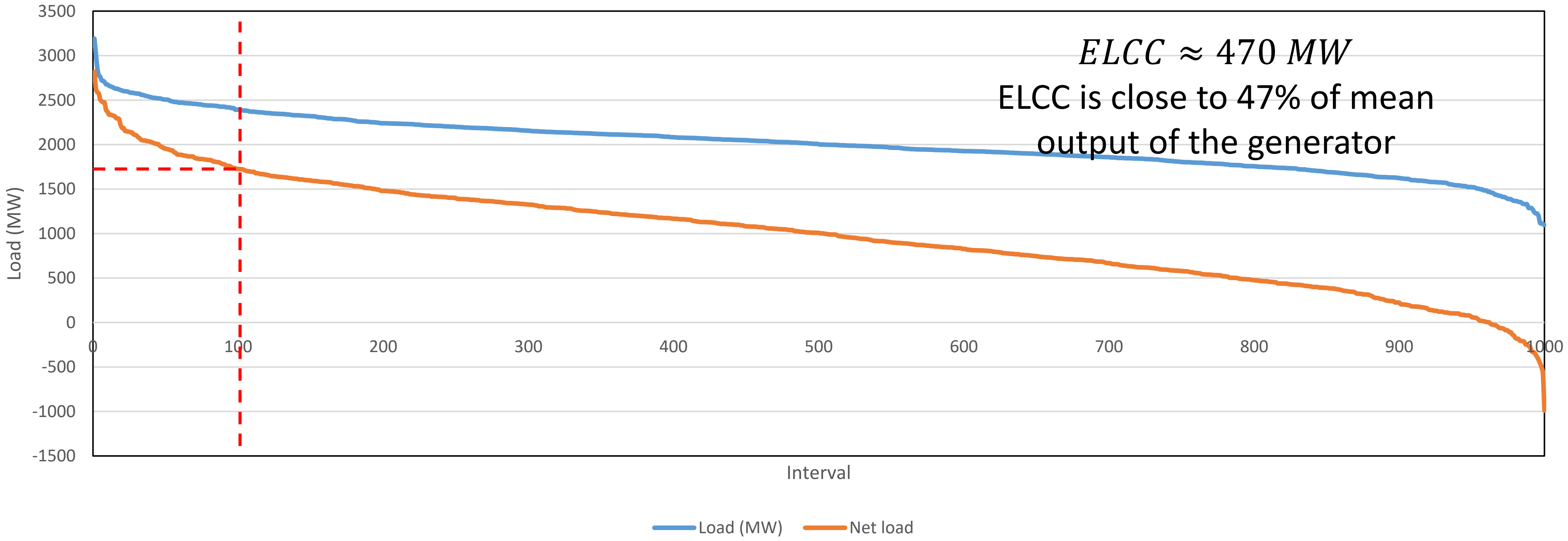
Addition of random capacity (low penetration)

- Generator: Normally distributed output, $m = 100\ MW, s = 50\ MW$
- Assume: generator output is independent of load distribution



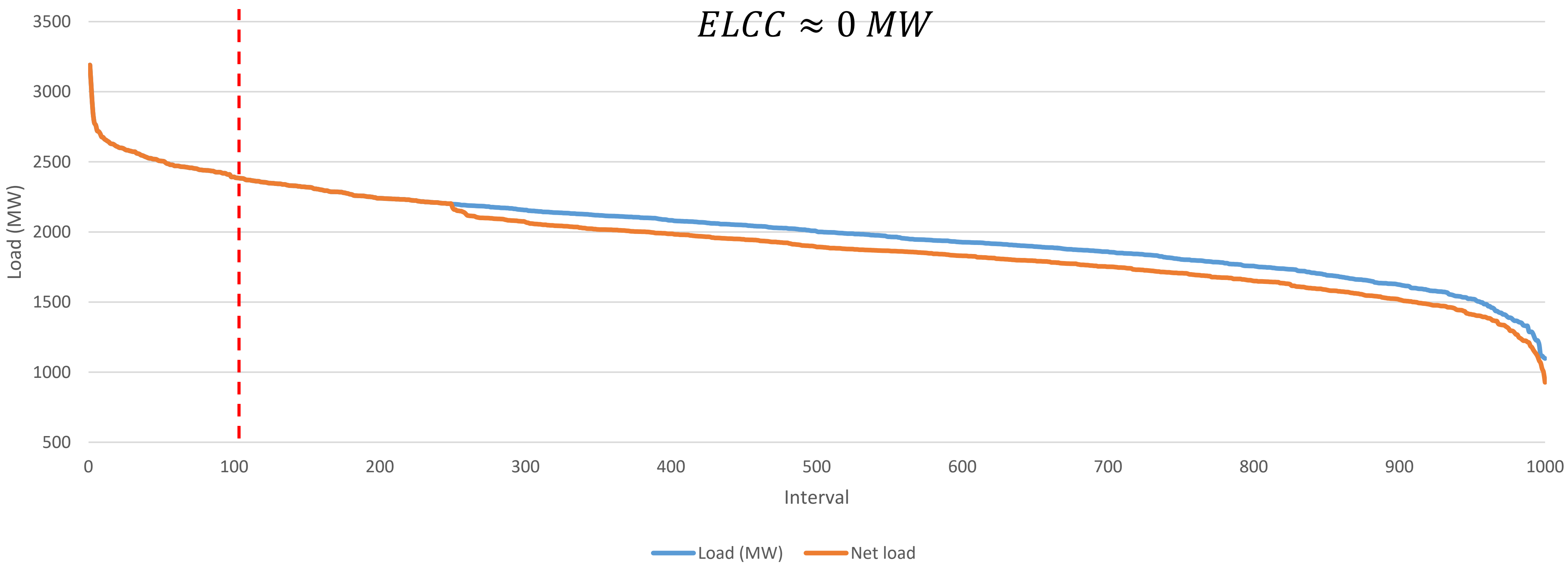
Addition of random capacity (high penetration)

- Generator: Normally distributed output, $m = 1000\ MW, s = 500\ MW$
- Assume: generator output is independent of load distribution

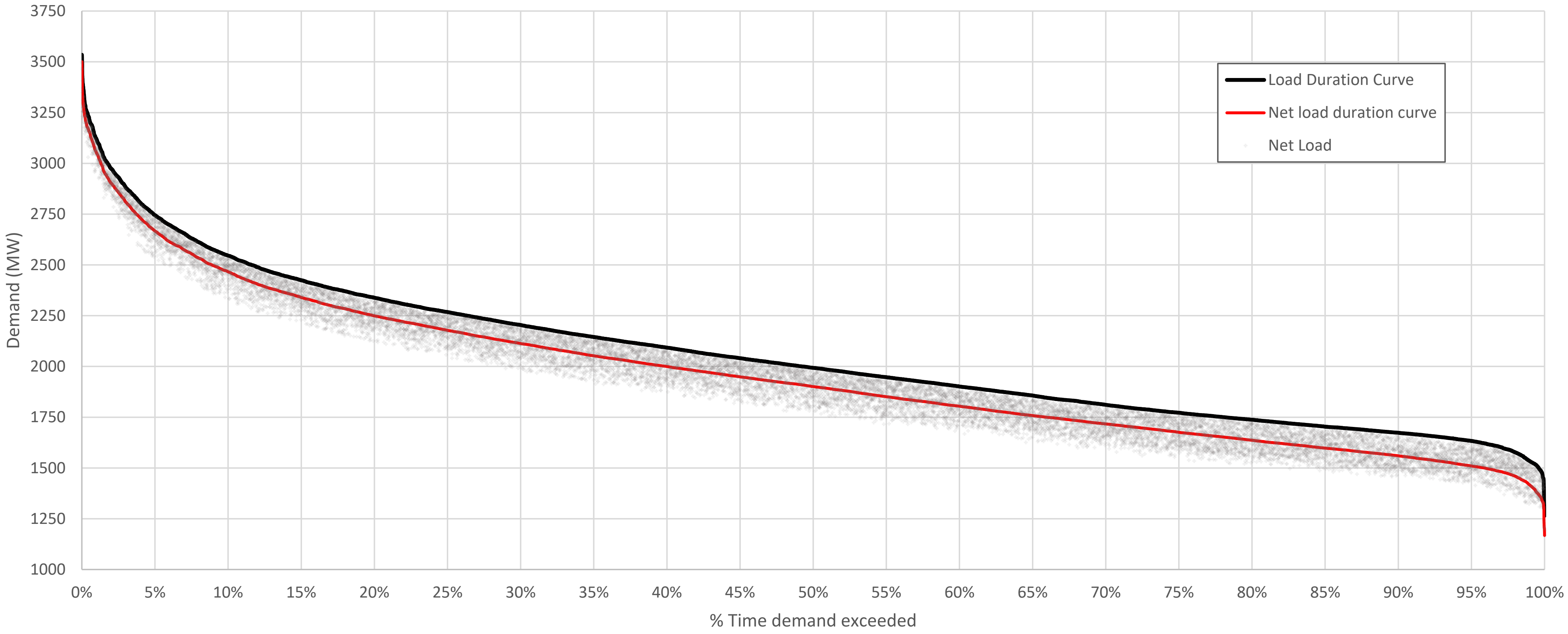


The effect of correlation (extreme example)

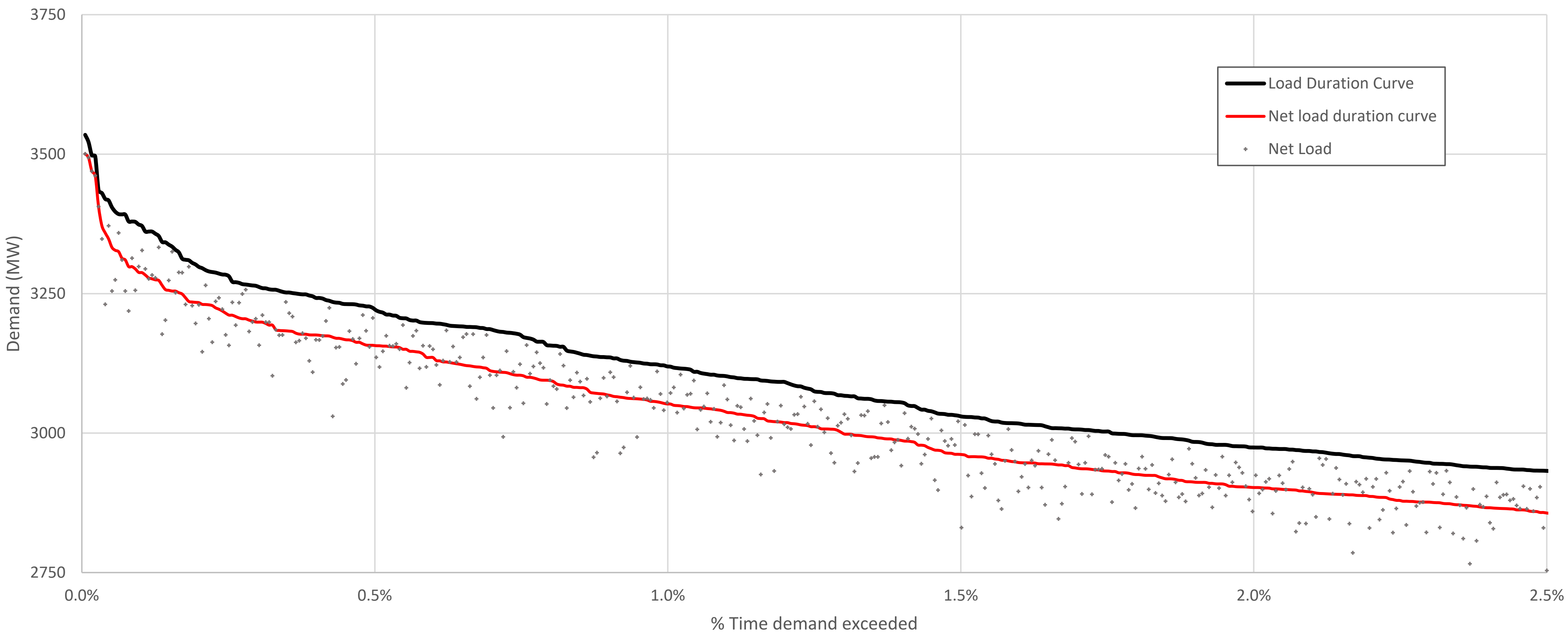
- Assume the generator with 100 MW mean output and 50 MW std. dev. is not available during extreme demand periods (above 2,200 MW)



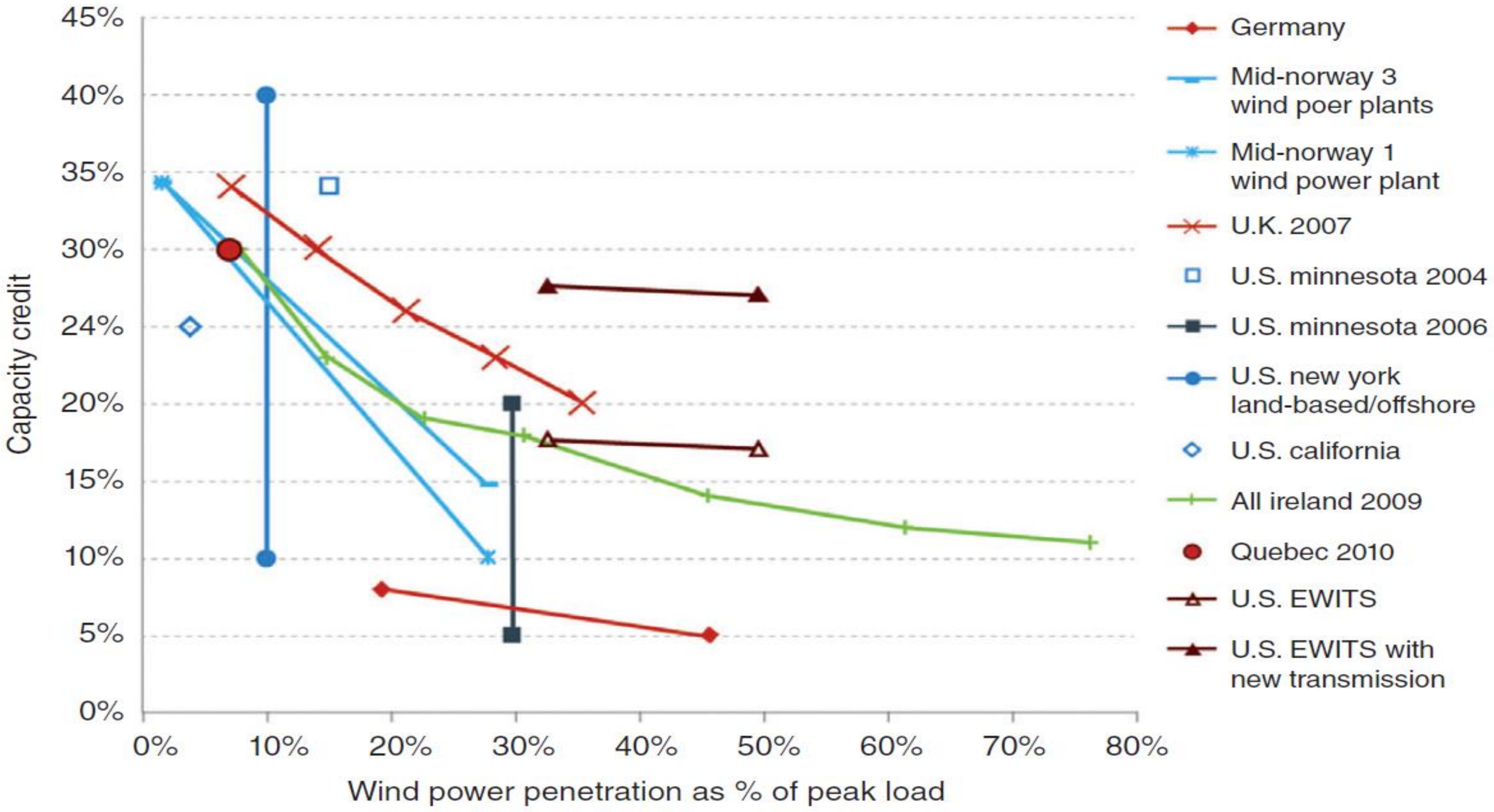
2017 WEM distribution



2017 WEM distribution



Wind capacity value in other jurisdictions



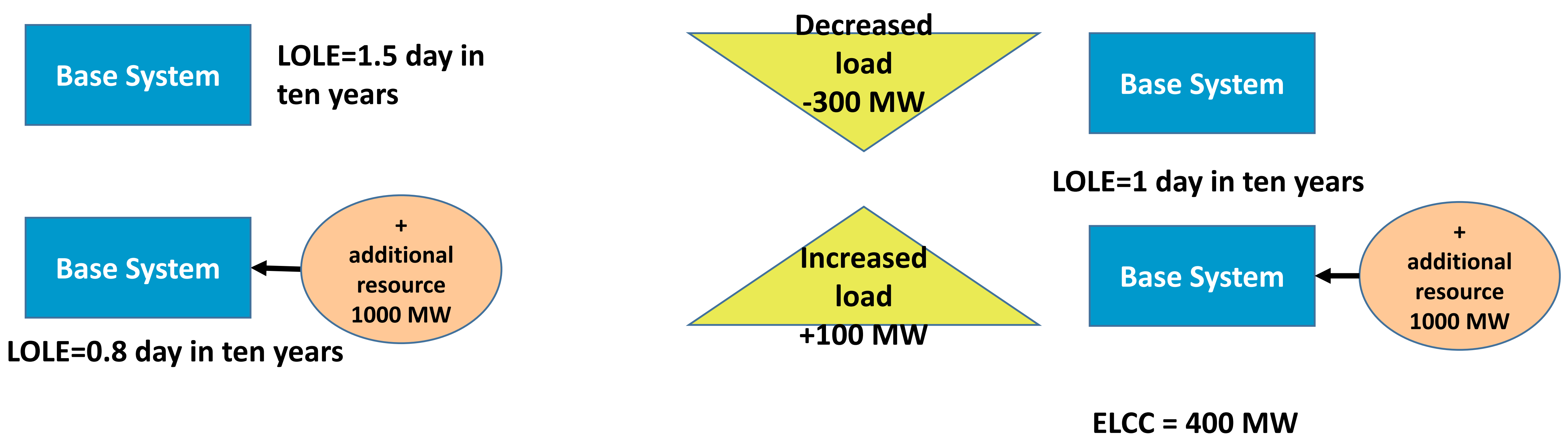
Source: Milligan et al. 2017, Capacity value assessments of wind power

2. Capacity value assessment methods

Assessment methods in practice

- Two approaches for ELCC calculation:
  - Fundamental analysis (reliability model)
  - Approximation method: to approximate the outcomes of fundamental analysis
- Data required for calculation
  - Coincident data during high LOLP/peak intervals:
    - Output of intermittent generators
    - Output of conventional generators
    - System load

Fundamental analysis (ELCC)



ELCC calculation challenges

- Historical data is usually not sufficient (for rare events in the system)
- Eg. In the SWIS (between 2006 and 2012) we never experienced a peak load above the one in ten year peak forecast
- We need a model to forecast how IGs perform during extreme demand/high-risk periods

3. Current method in the SWIS

Current method

- Approximation method to estimate (individual) ELCCs
- Mean output during peak LSG (net load) intervals
  - Less:
    - K factor (define)
      - To account for variability of IGs
      - Previously was 0.003 (international experience) but in 2014, Sapere estimated it for the SWIS (set to 0.000)
    - U-Factor
      - To account for the (negative) correlation of IGs with load during high-risk periods

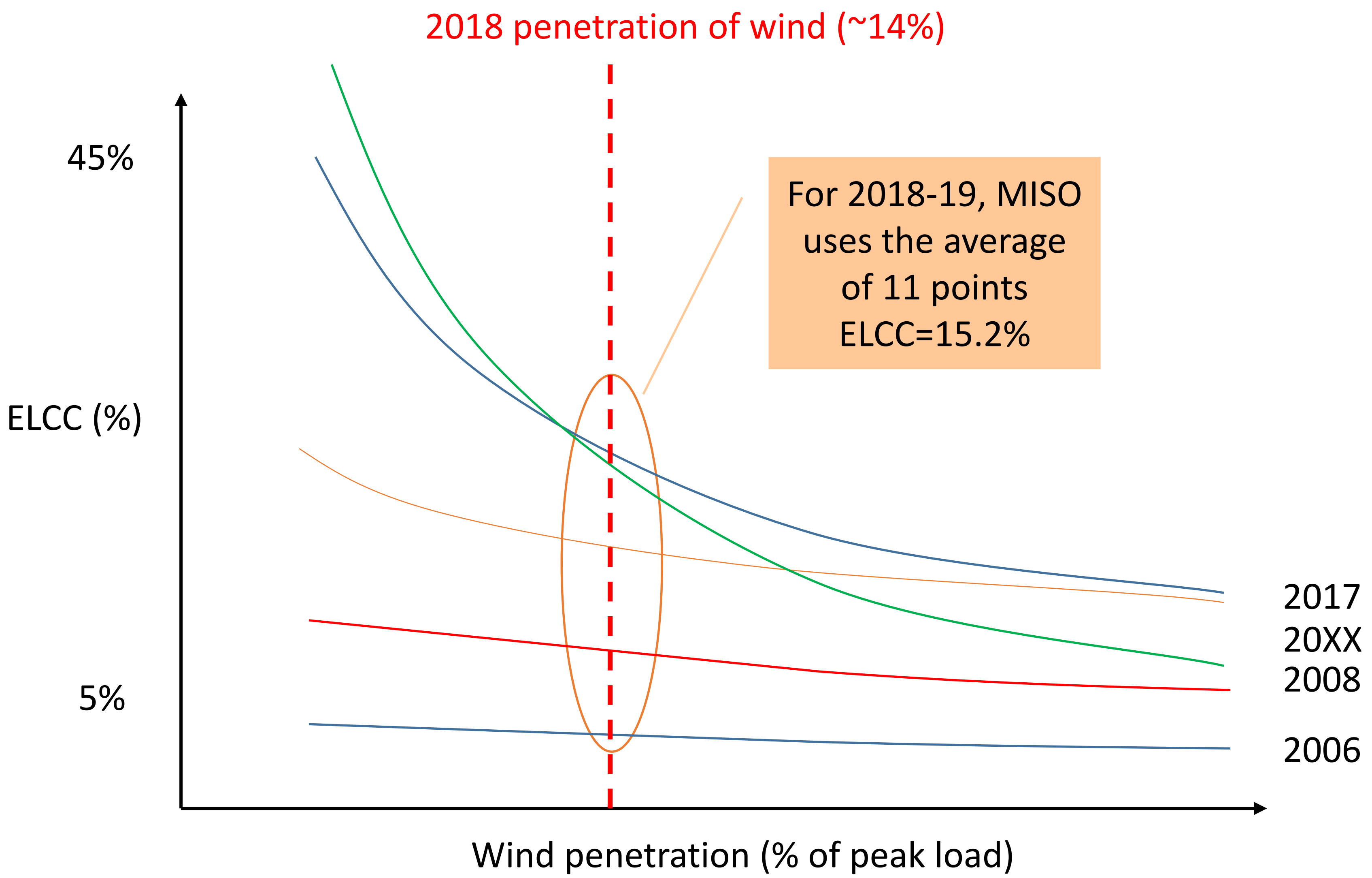
Capacity valuation in other jurisdictions

- Approximation methods
  - average output of IGs
    - Time-based approaches: specified (peak/high-risk) intervals
    - Risk-based approaches: when the system is under the highest reliability risk

- Fundamental analysis:
  - Mid-continent ISO (MISO)
    - System-wide ELCC calculation (wind resources)
    - Deterministic allocation of ELCC to individual IGs (based on historical performance)

Jurisdiction	Reliability criteria	Method
PJM	1 in 10 year LOLE	Approximate Time-based Mean output during peak periods
SWISS	Hybrid: • 1 in 10 year peak demand LOLE • <0.002% USE	Approximate Risk-based Adjusted mean output during peak net load (LSG)
NYISO	1 in 10 year LOLE	Approximate Time-based Mean output during peak intervals
ISO-NE	1 in 10 year LOLE	Approximate Time-based, also allows for intervals with system-wide shortages
California ISO	1 in 10 year LOLE	Approximate Time-based Mean capacity during peak intervals (70% exceedance factor)
MISO	1 in 10 year LOLE	Fundamental analysis Calculation of system-wide ELCC Allocation of ELCC to individual wind farms based on historical data

Does fundamental analysis provide an exact capacity value number?



Fundamental vs approximation methods

- Fundamental analysis entails building a reliability model:
  - Can a Plexos model be ready in time?
  - Constraints on the use of data collected (eg SRMC data) to use for purposes other than 2.16
- Do the results of such analysis provide a significantly different estimate of ELCC (than approx. methods)?
- Fundamental analysis is more complex and less transparent
- Approximation methods:
  - Relatively simple
  - More transparent
  - However, underlying assumptions may no longer be valid

4. Current issues in the SWIS

Valuation of capacity in a security constrained network

- The PUO's consultation paper:
  - the valuation of capacity in a security constrained network design
- Resources to receive capacity credits subject to network constraints
- Current RLM does not consider capacity constraints
- Timing of PUO's review:
  - Capacity valuation method review after outcomes of network access review
- PUO is exploring design of different mechanisms to provide for system adequacy and security

Collgar’s rule change proposal

- **Collgar**: use of mean output at peak LSG periods is discriminatory
  - Does not reflect the contribution of IGs to peak demand periods
- AEMO argued that contribution towards high-risk periods is more relevant (noting the increased penetration of IGs)
- Some (including the PUO) supported Collgar’s argument
- Others noted the upcoming review of the capacity valuation method by the ERA

Collgar’s rule change proposal…

- Hybrid reliability criteria defined in the market rules
- With increased penetration of IGs the likelihood of energy shortfall during not highest peak periods increases
- If most of energy shortfall events happen during highest peak periods:
  - Use of peak LSG and peak demand interval would provide similar results (in theory)
- If energy shortfall events and highest peak do not coincide:
  - Peak LSG (net-load) can be relevant for the calculation of ELCC

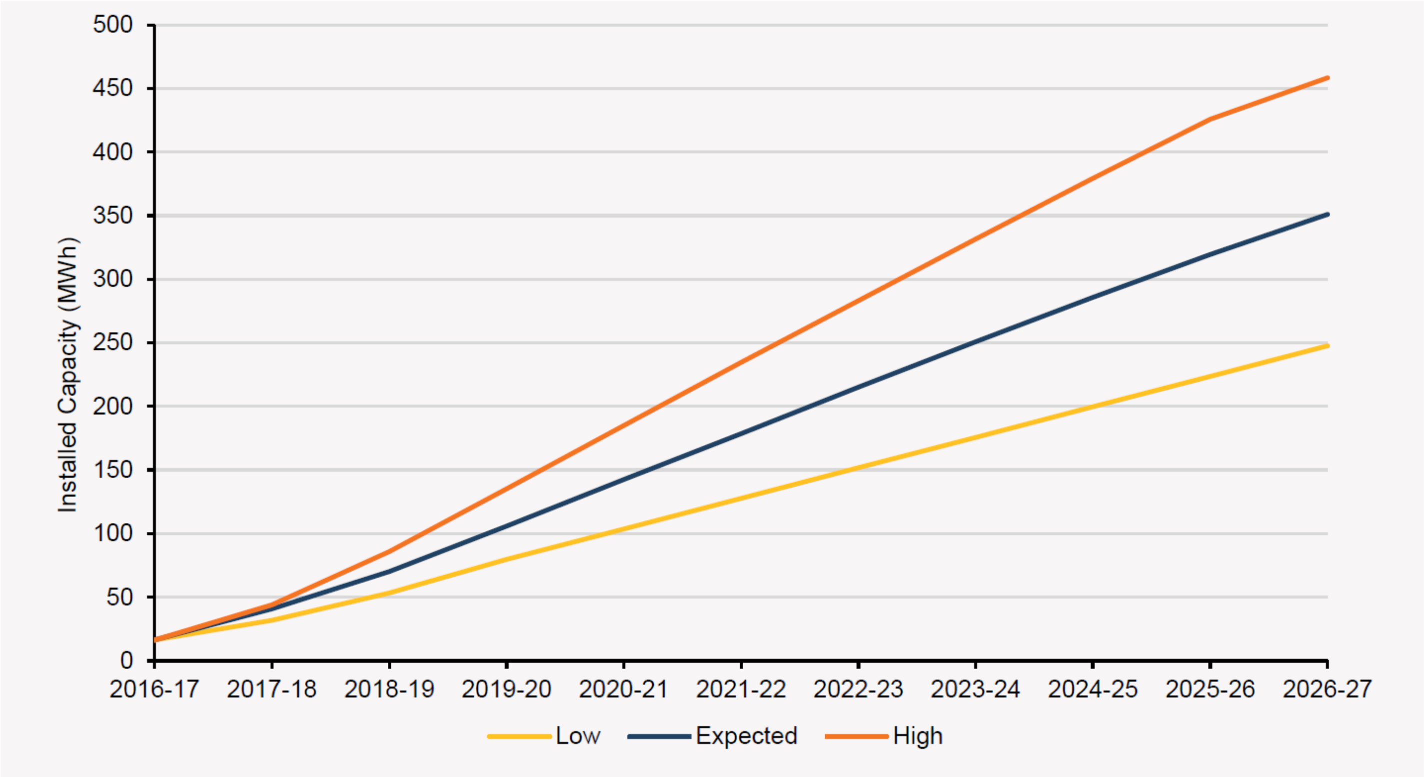
Technology differences

- Emergence of behind the meter technologies.
- Differences in operational characteristics (solar, wind)
- Battery storage installed with intermittent generators
- Battery combined with intermittent capacity : firm capacity
  - How to value such capacity?
  - MISO uses a system wide ELCC and allocates that to individual IGs based on historical performance
  - In the SWIS, ELCC is calculated individually (with a common adj. factors)

SWIS characteristics

- What has happened since last review
  - facilities retired or slated for retirement,
  - addition of wind/solar/ emerging technologies

Figure 24 Installed capacity of battery systems, 2016–17 to 2026–27 financial years



Source: Jacobs

Timing and market reforms

- ERA's draft report published end Oct 2018 plus 6 weeks consultation
- Final report and recommendations due 1 April 2019
  - Any associated rule change proposal, is unlikely to be progressed before next one or two capacity cycles (beginning Oct 2019 or Oct 2020), so will need to calculate K&U values in the interim.
- Market reform activity:
  - Mid-2018 – compensation for unconstrained generators - partial or fully constrained network access, plus ancillary service review findings
  - Sep 2018 – recommendations on capacity pricing