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Parameterizing the variability and uncertainty of wind and solar in CEMs

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The big 3 variability and uncertainty parameters

1. Capacity Value (CV): a metric of the firm-power equivalent for a given installation

2. Curtailed Energy: generated power that exceeds load must be curtailed

3. Forecasting Error Reserve Requirement: additional operating reserves induced by uncertainty in supply from a generator

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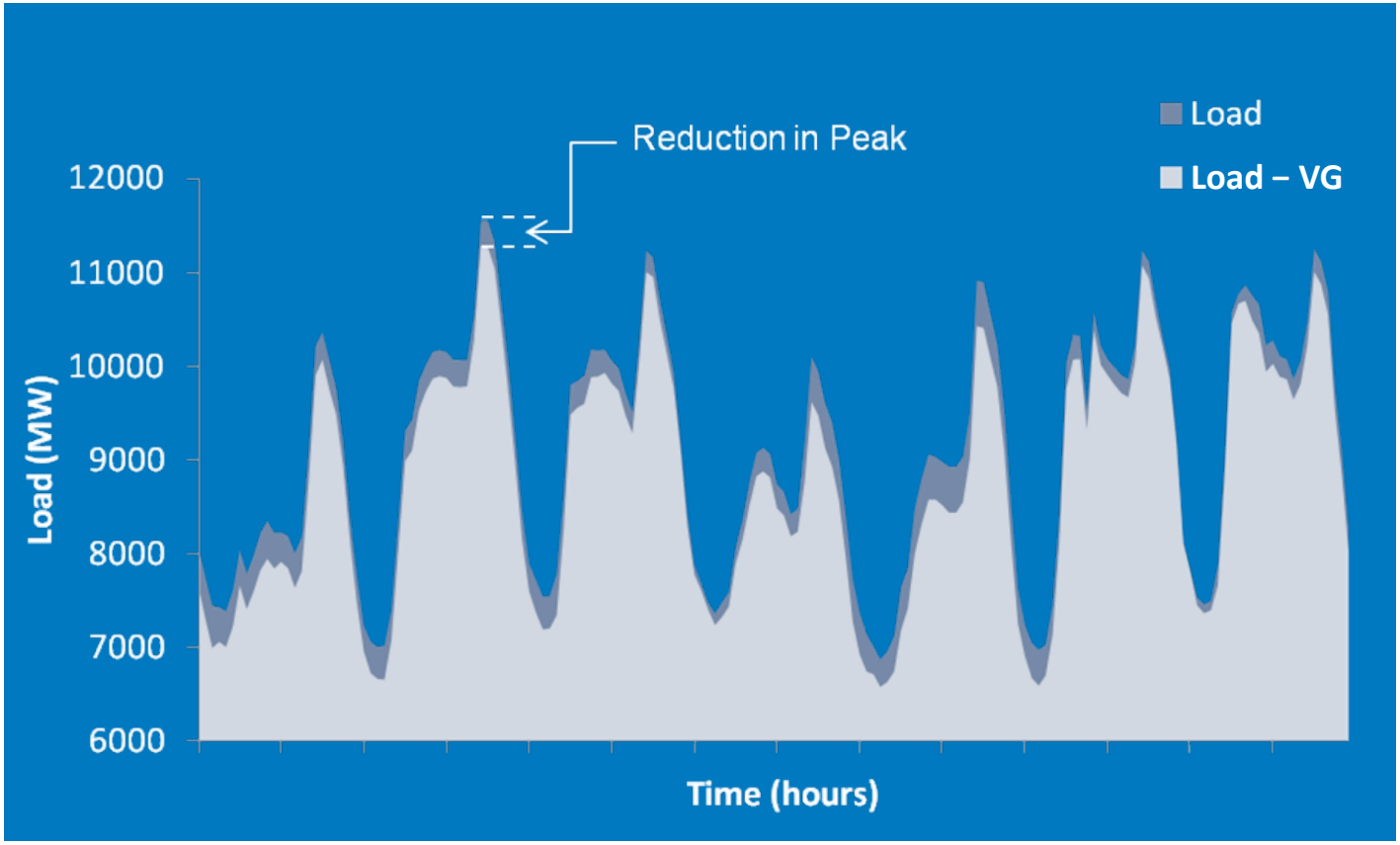
Modeling CV in CEMs – ideal treatment

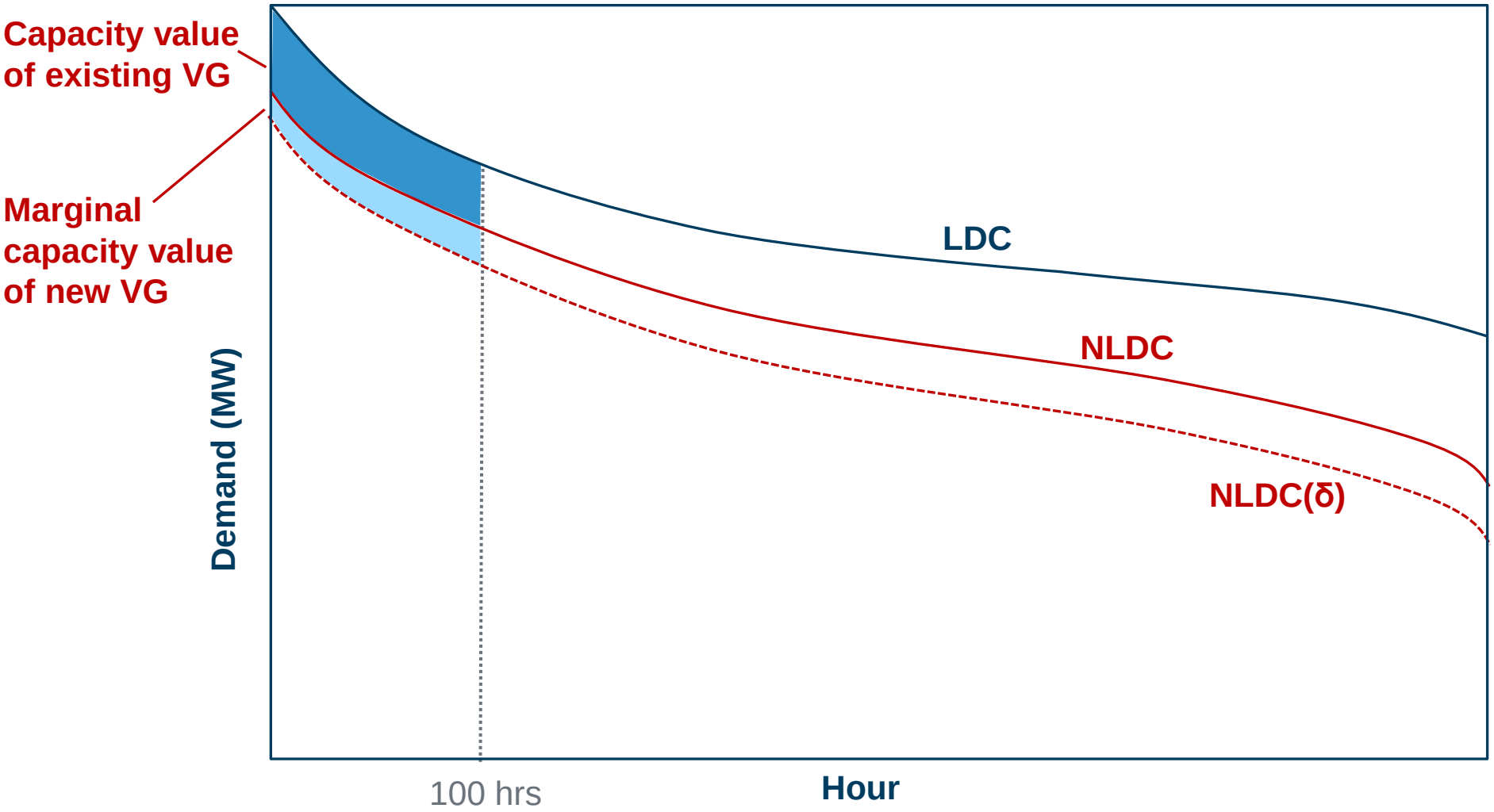


- We care about Effective Load Carrying Capability (ELCC) in highest Loss of Load Probability (LOLP) hours
- See Hasche et al. (2011) for inter-annual variability

Modeling CV in CEMs – simplifications

- **ELCC estimations**
  - Approximate the relationship between capacity additions and LOLP
  - e.g., Z-method (Dragoon and Dvortsov 2006), Garver's method (Garver 1966), and Garver's method extended to multistate generators (D'Annunzio and Santoso 2008)
- **Capacity factor proxy**
  - Applied to "high risk" hours (e.g., Milligan and Parsons 1999 for wind, Madaeni et al. 2013 for solar)
  - Applied to top load hours in load duration curve (LDC)
    - RPM and future ReEDS (Hale et al. 2016)

RPM and future ReEDS LDC approach: CV



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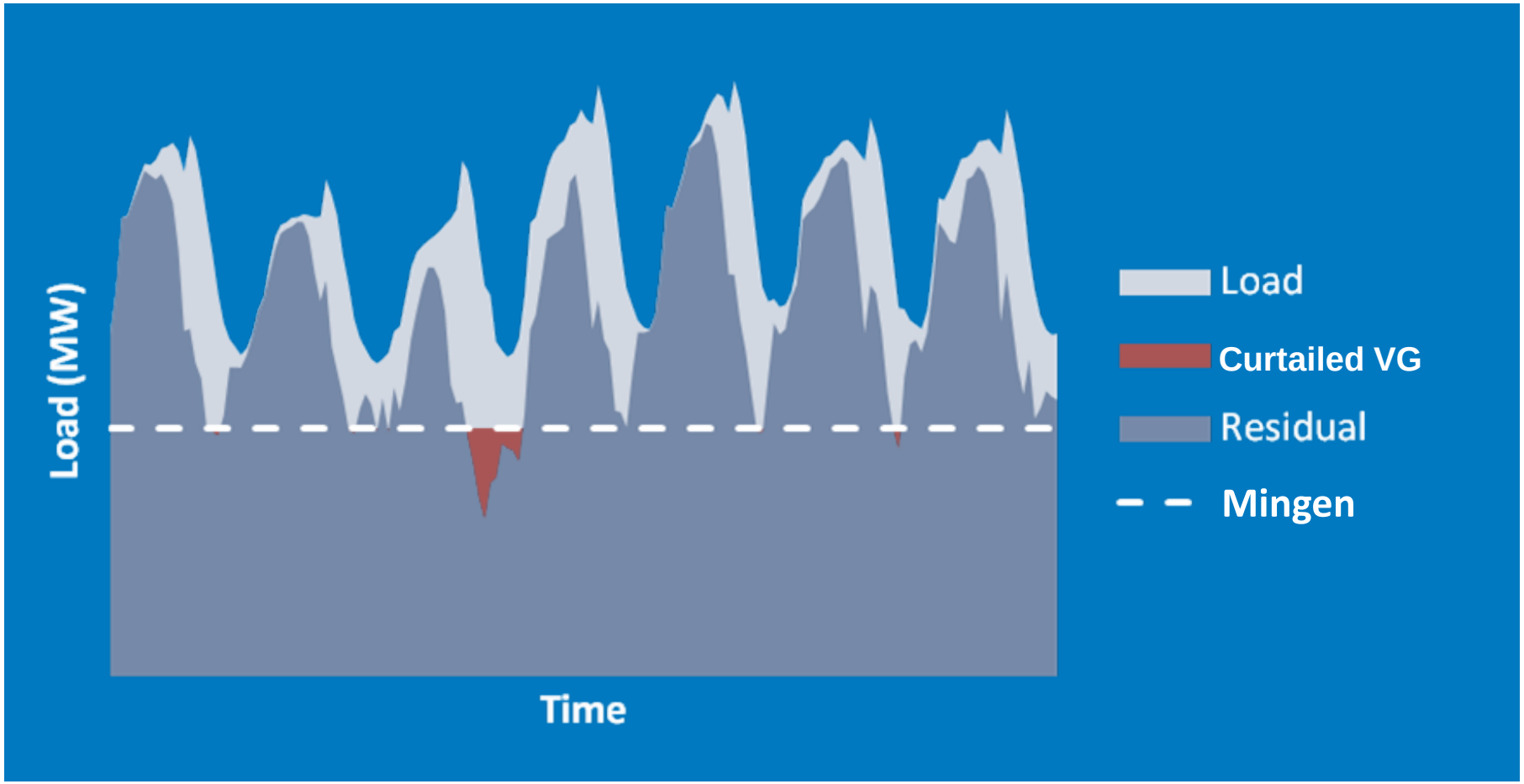
Modeling curtailment (surplus) in CEMs – ideal

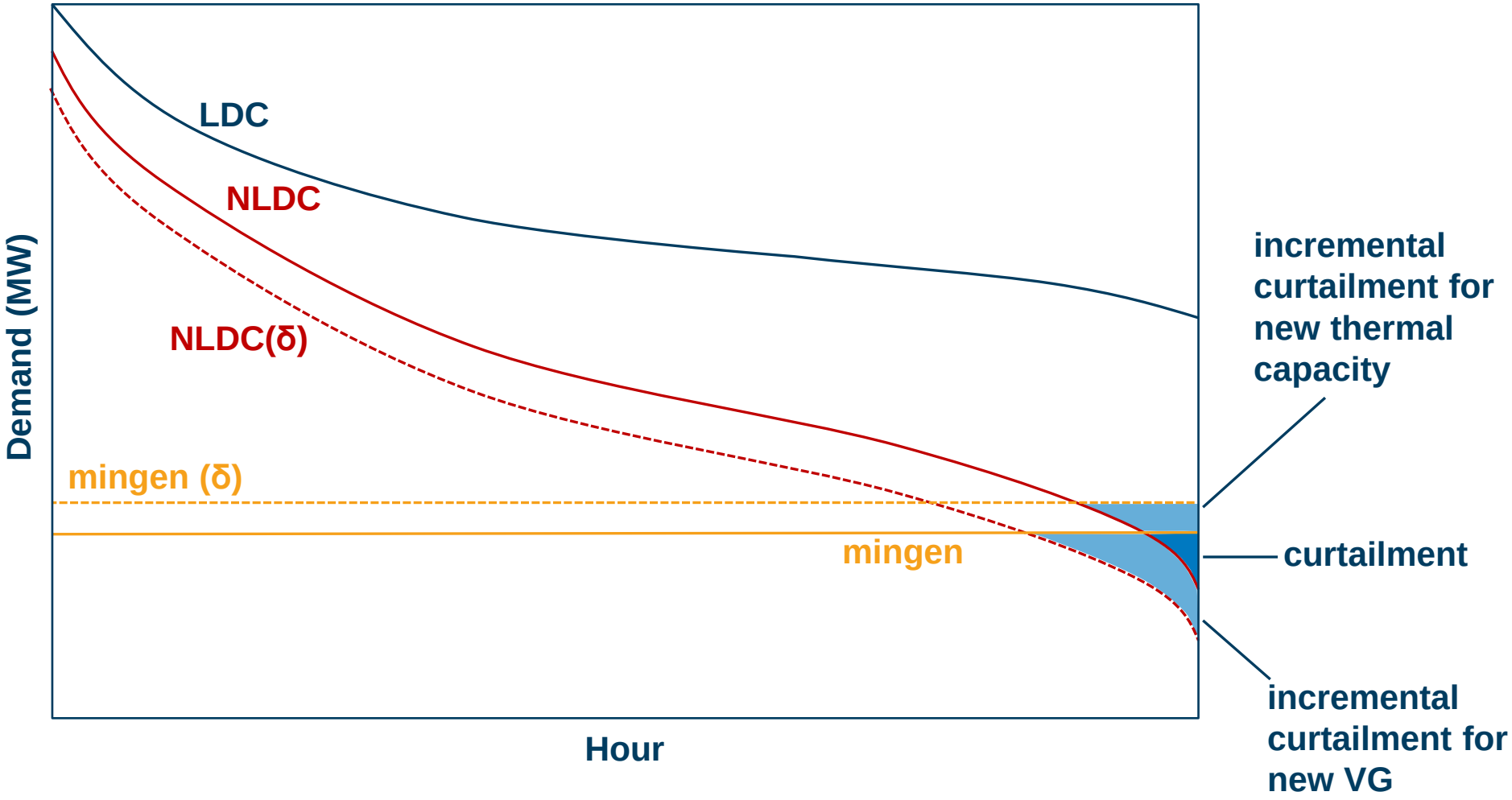


Modeling curtailment – simplifications

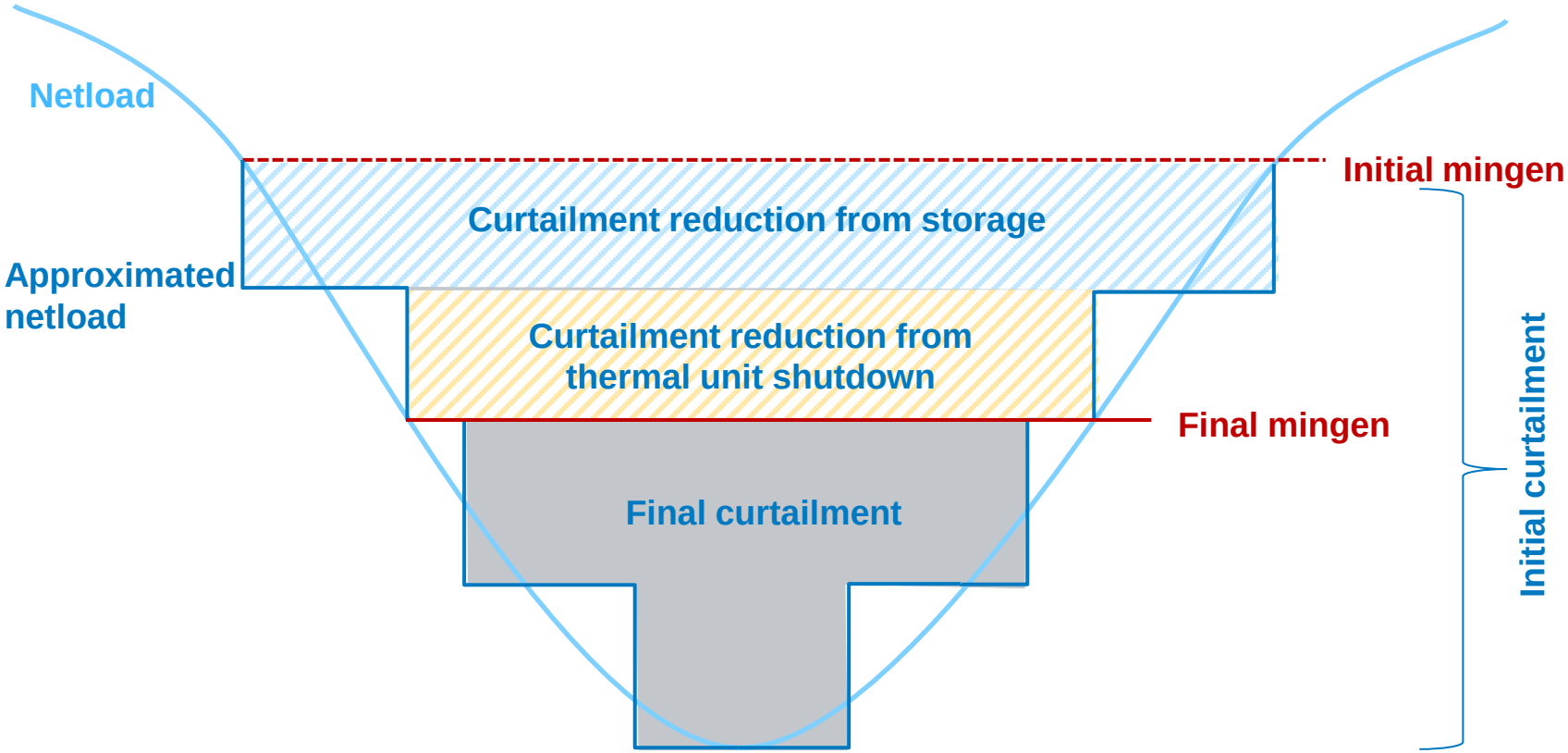
- **Implicit integration cost function**
  - e.g., WITCH
- **Step-wise marginal curtailment function**
  - e.g., MESSAGE
- **Statistical parameterization**
  - e.g., current ReEDS
- **LDC approach**
  - REMIND-D (Ueckerdt et al. 2015)
  - RPM (Hale et al. 2016)
- **Simplified 8760 dispatch**
  - Future ReEDS

RPM LDC approach: curtailments

- Curtailment based on interplay of NLDC and mingen



Future ReEDS curtailment and storage via dispatcher



Summary

- Improving the representation of VG variability and uncertainty in CEMs is increasingly important as VG penetration levels grow
- There are different ways to model CV and curtailment, with varying computational and data requirements
- RPM and ReEDS are working toward 8760 exogenous methods

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