Duke Energy Resource Adequacy Philosophy and Methods

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Mission

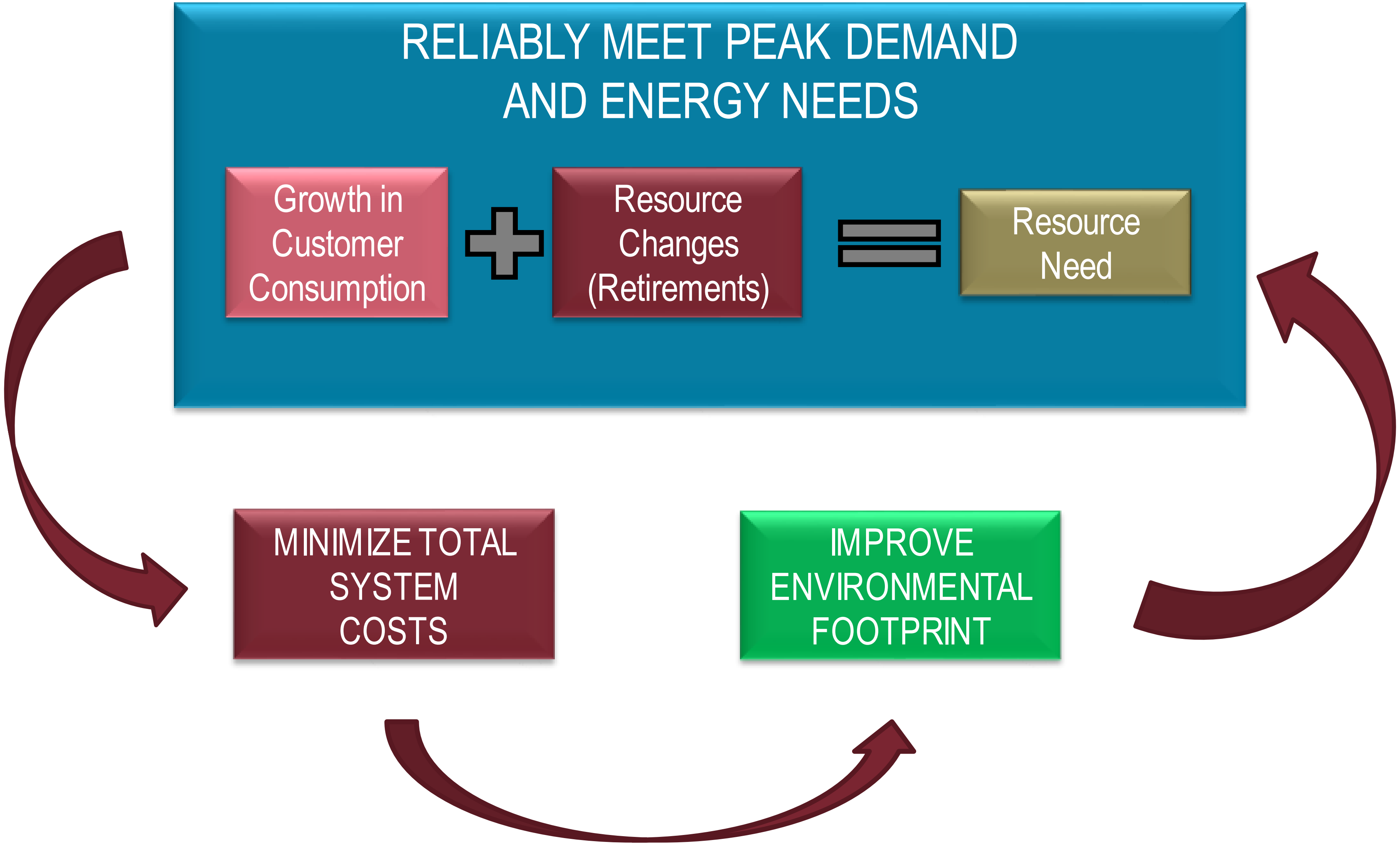
Integrated Utilities have a mission to provide:

Reliable, Affordable, Increasingly Clean Power

in a safe and environmentally compliant manner.

- Resource adequacy refers to the ability of the electric system to supply the aggregate electrical demand and energy requirements of customers at all times.

Planning Objectives



Alternative Resources

Balance of Sources

- Owned Generation
- QF
- DSM
- Other Purchases

Conventional Generation and Purchases

Renewables

Solar, Wind, Biomass, MSW

Energy Efficiency and Load Control

Characteristics

- Fuel Type and Supply
- Unit Performance
- Reliability / System Support

What is "Adequate"

- Adequacy requires Reserves.
- Reserve capacity must be available to account for
  - Capacity Variation
  - Load Variation
- A reserve margin target is utilized in the IRP process to ensure resource adequacy
  - The Reserve Margin is based on annual or seasonal peak load.
- The reserve margin target is established based on probabilistic analyses

Reliability Metrics and Costs

Metrics

- Loss of Load Expectation (LOLE)
- Industry utilized 1 day in 10 years standard = 0.1 LOLE

Objective:

- Meet the reliability standard at the lowest total system cost

Implication:

- High Impact Low Probability Analysis
- Requires a large number of scenarios
- 95% of all reliability events will occur in <10% of all scenarios simulated

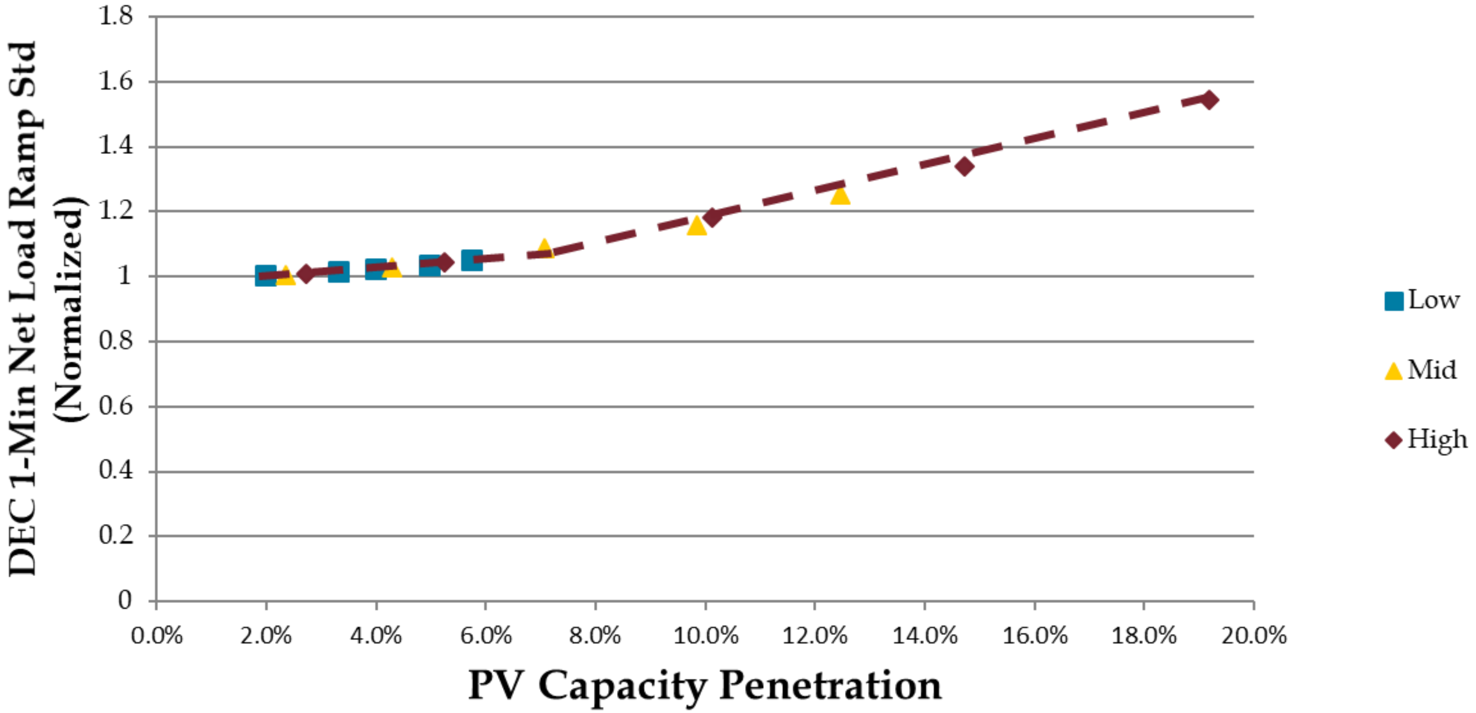
Key Input Examples

- Weather Uncertainty: 36 Weather Years Modeled
- Load Growth Uncertainty: 5 Economic Growth Multipliers
- Unit Performance Uncertainty: Monte Carlo Draws for Unit Outages, 20 Draws
- Total iterations at each reserve margin scenario
  - 36 weather years x 5 load forecast error multipliers x 20 unit outage draws = 3,600 iterations

Physical Reliability Metric Results

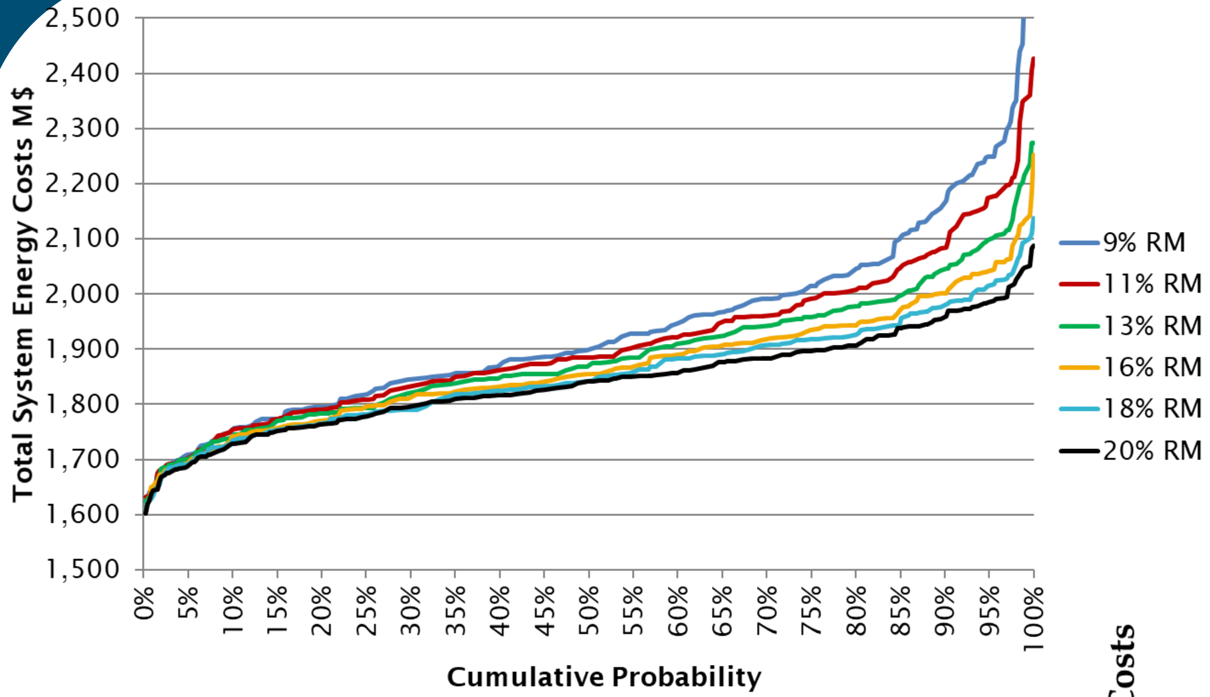
Winter Reserve Margin	13.0%	14.0%	15.0%	16.0%	16.5%	17.0%	18.0%
January	0.104	0.090	0.077	0.066	0.061	0.056	0.047
February	0.020	0.016	0.013	0.009	0.008	0.007	0.005
March	0.018	0.016	0.013	0.011	0.010	0.009	0.007
April	0.000	0.000	0.000	0.000	0.000	0.000	0.000
May	0.000	0.000	0.000	0.000	0.000	0.000	0.000
June	0.000	0.000	0.000	0.000	0.000	0.000	0.000
July	0.028	0.020	0.015	0.012	0.011	0.011	0.009
August	0.028	0.020	0.014	0.010	0.009	0.008	0.006
September	0.000	0.000	0.000	0.000	0.000	0.000	0.000
October	0.000	0.000	0.000	0.000	0.000	0.000	0.000
November	0.000	0.000	0.000	0.000	0.000	0.000	0.000
December	0.005	0.004	0.003	0.002	0.001	0.001	0.001
Summer LOLE	0.056	0.040	0.029	0.023	0.020	0.018	0.015
Winter LOLE	0.148	0.126	0.106	0.088	0.080	0.072	0.059
Total LOLE	0.204	0.166	0.135	0.111	0.100	0.091	0.075

Net Load Variability Increases With PV Penetration Rate



The normalized standard deviation of ramps is the ratio between net load and load without PV

Total System Energy Costs by Reserve Margin

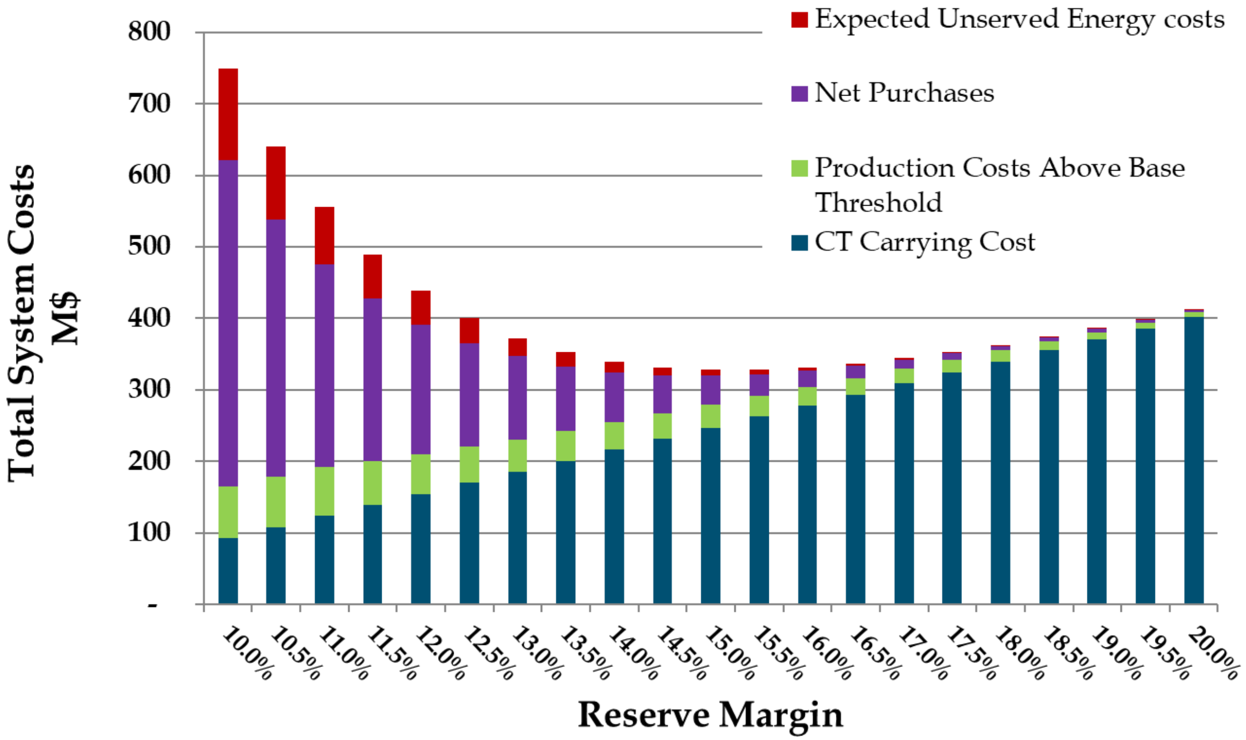


Includes EUE Cost

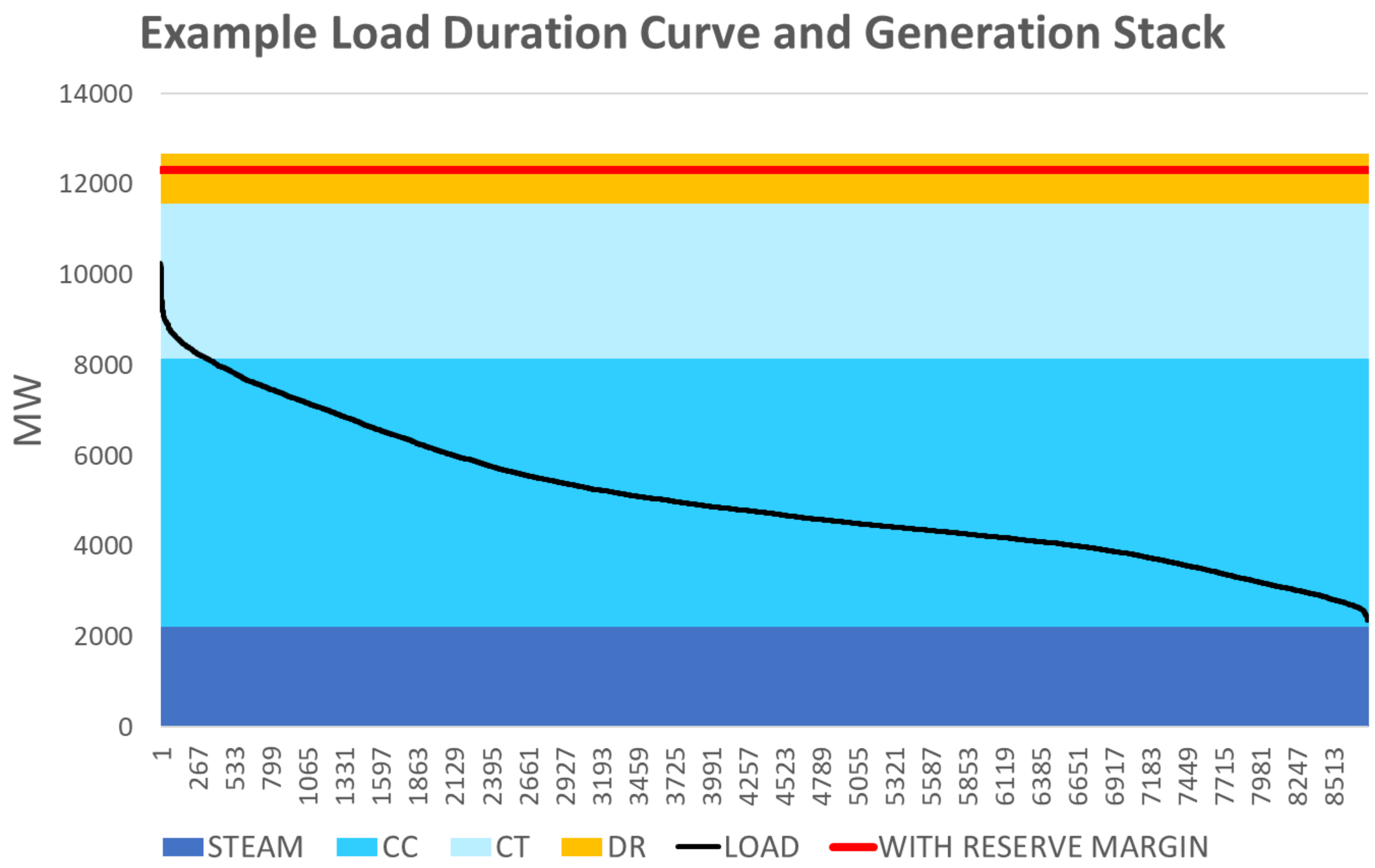
- Production costs
- Cost of available power for purchase/import
- Societal cost of Unserved Energy

vs.

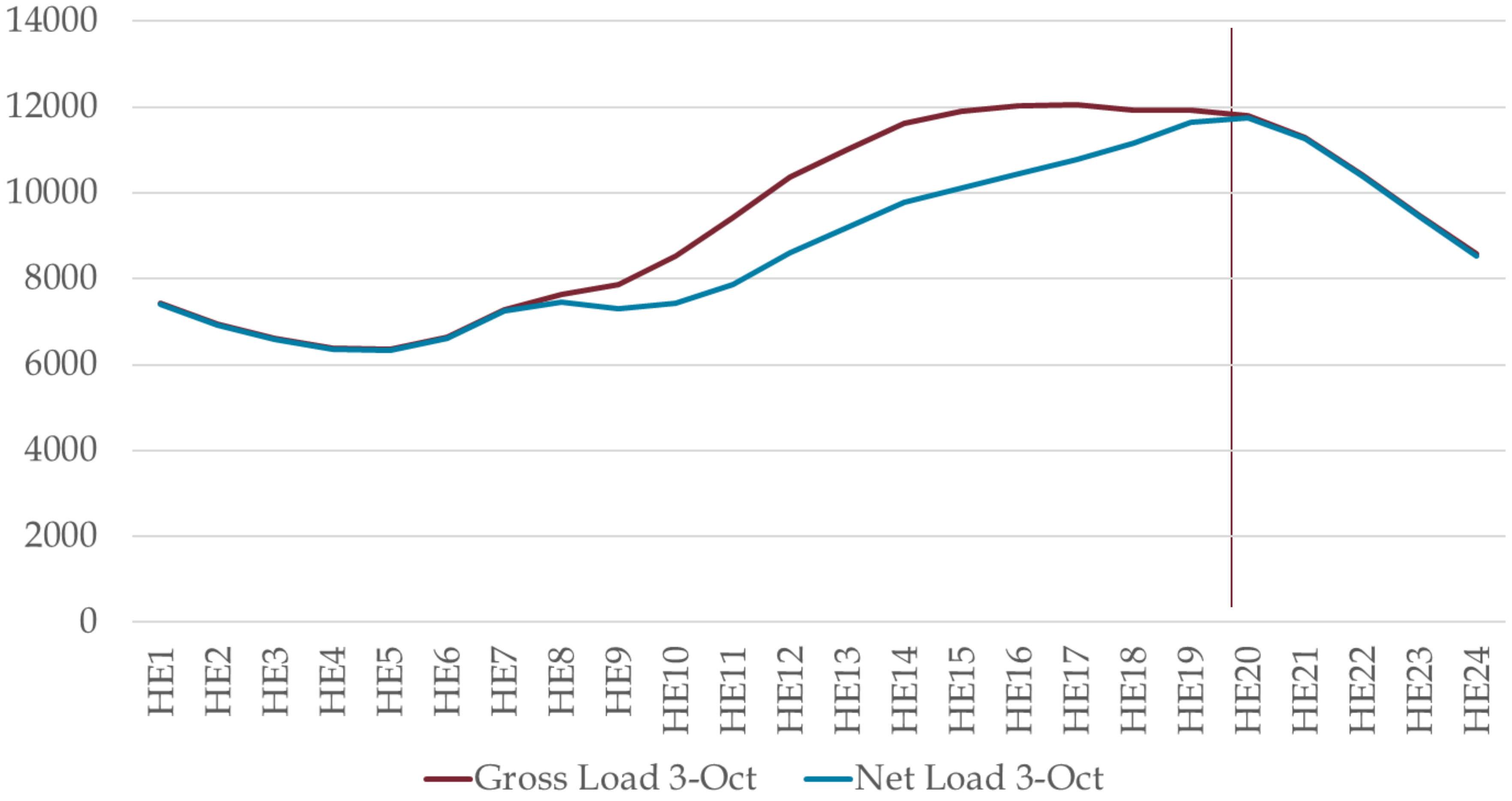
- Marginal Cost of New Resources



Reserve Margin Planning

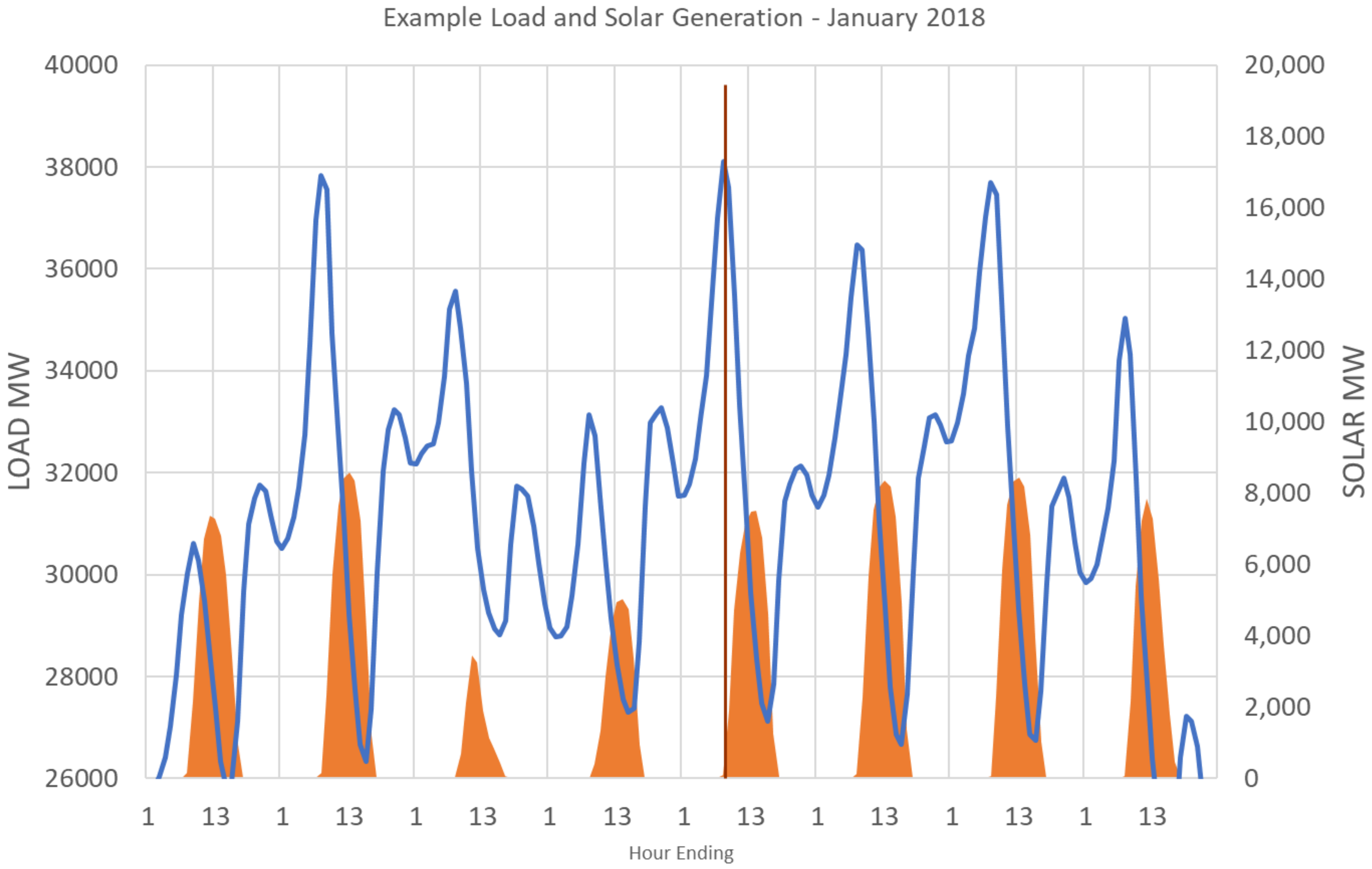


Summer Load Shape – Solar Effect



	HE14	HE15	HE16	HE17	HE18	HE19	HE20	HE21	HE22	HE23	HE24
Gross Load	11,607	11,890	12,040	12,047	11,934	11,932	11,801	11,281	10,413	9,471	8,568
Solar Output	1,831	1,773	**1,596**	1266	769	278	**61**	30	28	28	27
Net Load	9,776	10,117	10,444	10,781	11,165	11,654	11,740	11,251	10,385	9,443	8,541

Winter Load Shape – Solar Effect



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