Quantifying reliability and resilience impacts of energy efficiency: Examples and opportunities

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Agenda

- Motivation
- Reliability and resilience
- EE and reliability in three planning domains
  - Long-term planning in bulk-power systems (BPS)
  - Distribution system planning
  - Demand-side management planning
- Challenges
- Opportunities

Motivation

- Energy efficiency (EE) has **reliability and resilience benefits** for the power system

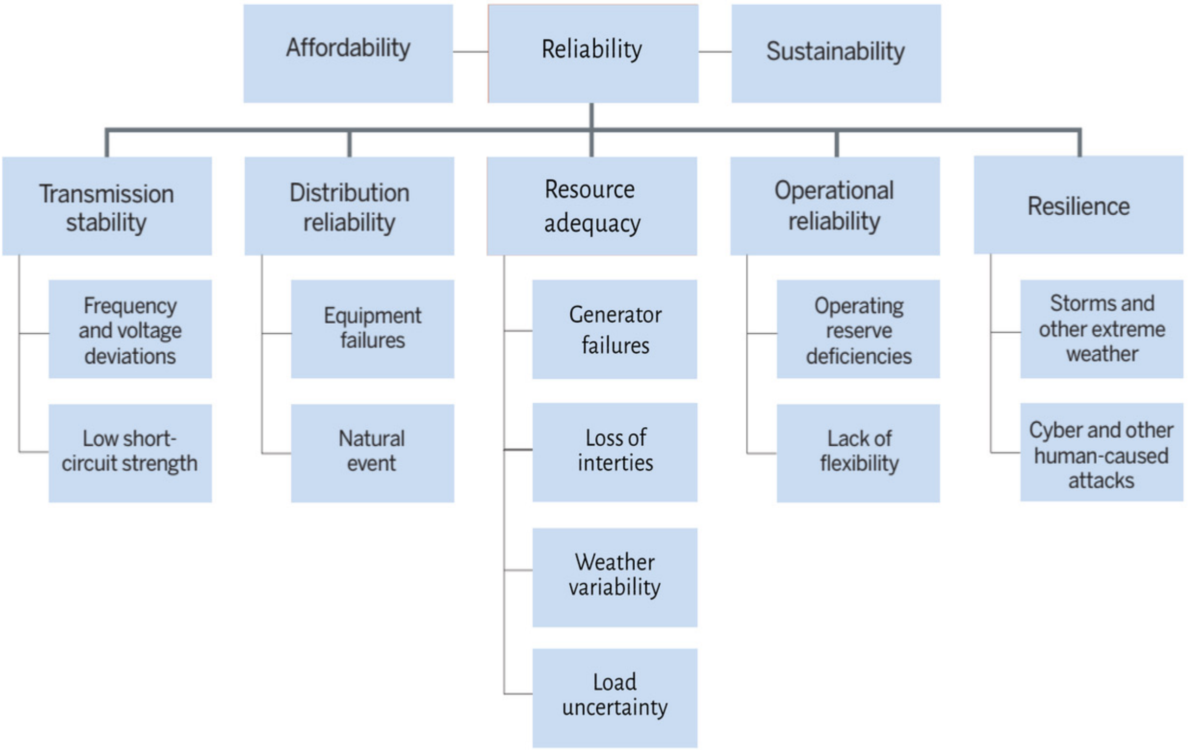
- **Electric system planning processes** are used to ensure that **future needs are reliably met** with cost-effective supply- and demand-side resources

- **Traditional reliability metrics and planning methods** and **emerging resilience metrics** may not fully capture the benefits from distributed energy resources (DER), in particular EE

- Our work seeks to:
  - **Understand** how (1) current planning processes, (2) and reliability/resilience assessment methods and metrics capture the reliability and resilience benefits of EE
  - **Identify challenges** to capture reliability and resilience benefits of EE
  - **Propose opportunities** to address these challenges

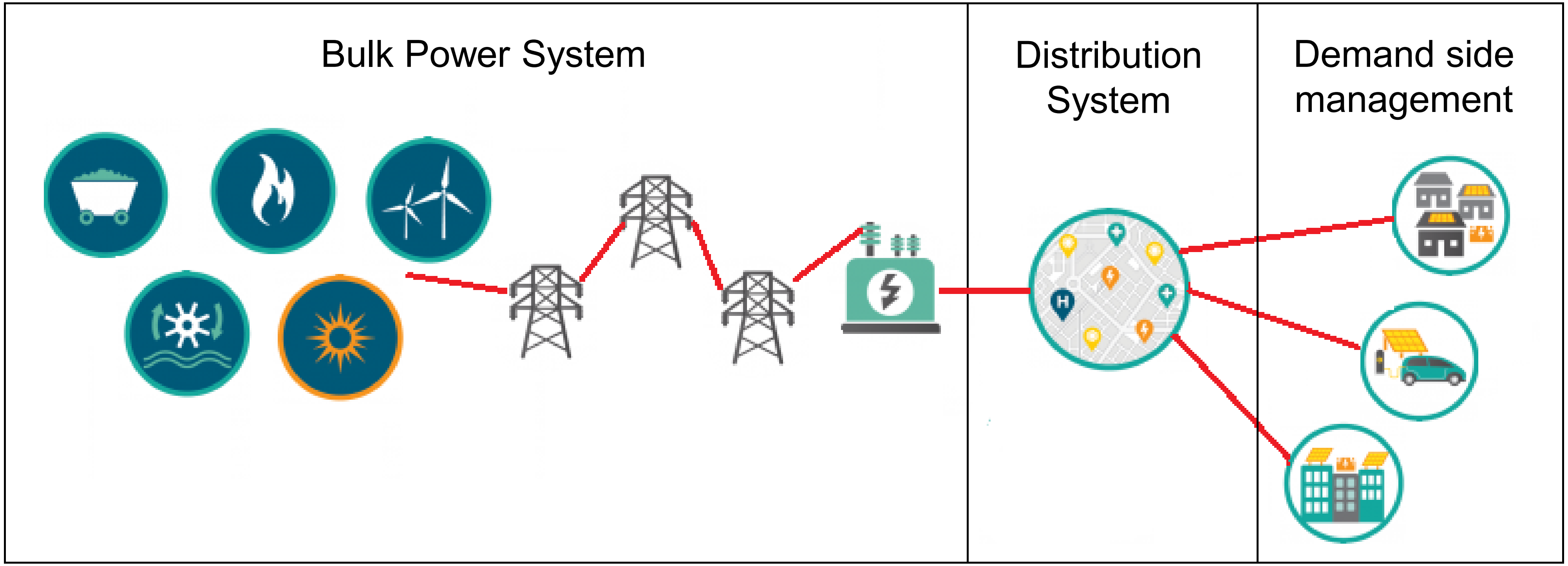
What are reliability and resilience?

- **Reliability**
  - "The ability of the system to deliver power in the face of routine uncertainty in operation conditions" (Eto et al. 2020)
  - Metrics and methods are standardized and widely accepted
  - Different metrics and methods depending on domain:
    - Resource adequacy and operational reliability (Generation)
    - Transmission stability (Transmission)
    - Distribution reliability (Distribution)
- **Resilience**
  - "Ability to prepare, adapt, withstand, and recover rapidly from disruptions" (PPD 21, 2013)
  - No widely accepted metrics or methods yet
  - Focused on high impact, low frequency events
  - Proposed metrics at the customer, community, grid, and economy-wide levels



Source: ESIG 2021 "Redefining Resource Adequacy for Modern Power Systems"

Three planning domains

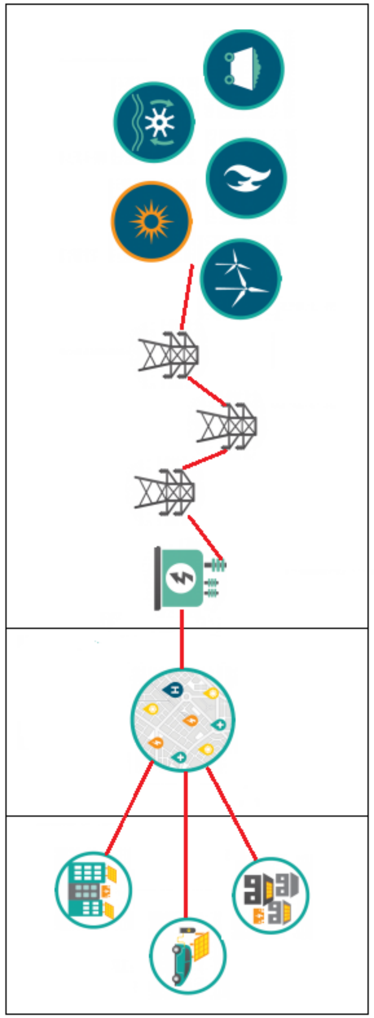


Long-term planning

Distribution System Planning

DSM Planning

Three planning frameworks



- BPS planning
  - Resource adequacy assessments
  - The impact of EE on the reserve margin
  - Examples of NERC and NWPCC assessments
- Distribution planning
  - EE can be used to defer grid upgrades in non-wires alternative (NWA) projects
  - Examples of Xcel Energy, ConEdison, and NV Energy performing NWA
- Demand side management planning
  - Benefit-cost analysis of EE that include reliability benefits
  - Uses the value of lost load (VOLL) to monetize impacts
  - Examples of the five states that require consideration of EE reliability benefits (Arizona, Connecticut, Massachusetts, New York, and Rhode Island)

Challenges – Reliability metrics

- In distribution planning and NWS, **traditional reliability metrics** (e.g. SAIDI, SAIFI) are really *availability* metrics. They **do not reflect**:
  - The **actual impact of interruptions** on the consumption or fulfillment of end-use services
  - The reliability experienced by **each individual customer**

- IEEE Standard 1366-2012 introduced **two customer-centric metrics**: Customers Experiencing Long Interruption Durations (CELID) and Customers Experiencing Multiple Interruptions (CEMI)
  - These standards ***count* customers suffering certain types of interruptions**
  - Standards **do not reflect the reliability experience** of each customer

- **Customer-level** metrics would:
  - Identify **highly-valued or critical** end-uses
  - Ensure that these **end-uses can be consumed** at least at minimum sustainable levels
  - Ensure that service for each customer meets a **minimum reliability standard** with recognition of their level of vulnerability and adaptability.

Challenges – The Value Of Lost Load in BCA

- The VOLL typically reflects the **cost of energy not served** to customers, instead of **costs of the consequences that accrue to customers** during interruptions. It is needed to monetize the reliability benefits of EE due to energy reductions.

- VOLL is limited to a **single value** per customer segment using traditional segments of residential, commercial, and industrial, which does not capture **heterogeneity across customers** and interruption types.

- Current VOLL approaches are generally **not time sensitive**, assigning the same value to load lost at any time of day and season.

- The calculation of VOLL is often based on **short-duration** interruption data, limiting its application to resilience that studies long duration interruptions.

Opportunities

- Performance metrics
  - Develop and use customer-level metrics to measure reliability and resilience
  - Measure and value voluntary energy efficiency and conservation (e.g., load shedding) as a resilience strategy and compensate it accordingly
  - Track improvement in restoration time as a reliability benefit of energy efficiency and potentially other DER

- Monetary metrics: VOLL
  - Use better data and methods to monetize reliability
  - Improve traditional VOLL approaches through development and use of a framework to quantify DER resilience benefits to the Bulk Power System

- Methods
  - Strengthen BCA frameworks and expand their application
  - Treat energy efficiency as a resource, and consider its time-sensitive value, in long-term BPS planning
  - Integrate energy efficiency with other DERs

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Examples of EE reliability and resilience benefits

	Power system planning processes		
	Bulk power system	Distribution system	Demand-side management
Reliability	Energy efficiency contributes to meeting reliability needs at least cost and risk. In wholesale capacity markets, energy efficiency lowers capacity auction prices.	During power interruptions, lower loads due to energy efficiency measures allow more customers to be switched across feeders for faster restoration times.	Efficient equipment extends the duration of storage backup during interruptions.
Resilience	System operator calls for emergency conservation can prevent large-scale blackouts.	Lower loads reduce equipment overloading and thermal wear and tear, reducing the likelihood of equipment failure.	Efficient buildings maintain habitable indoor conditions for longer periods of time during power interruptions.