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

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Juan Pablo Carvallo – in collaboration with Natalie Mims Frick and Lisa Schwartz
jpcarvallo@lbl.gov

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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

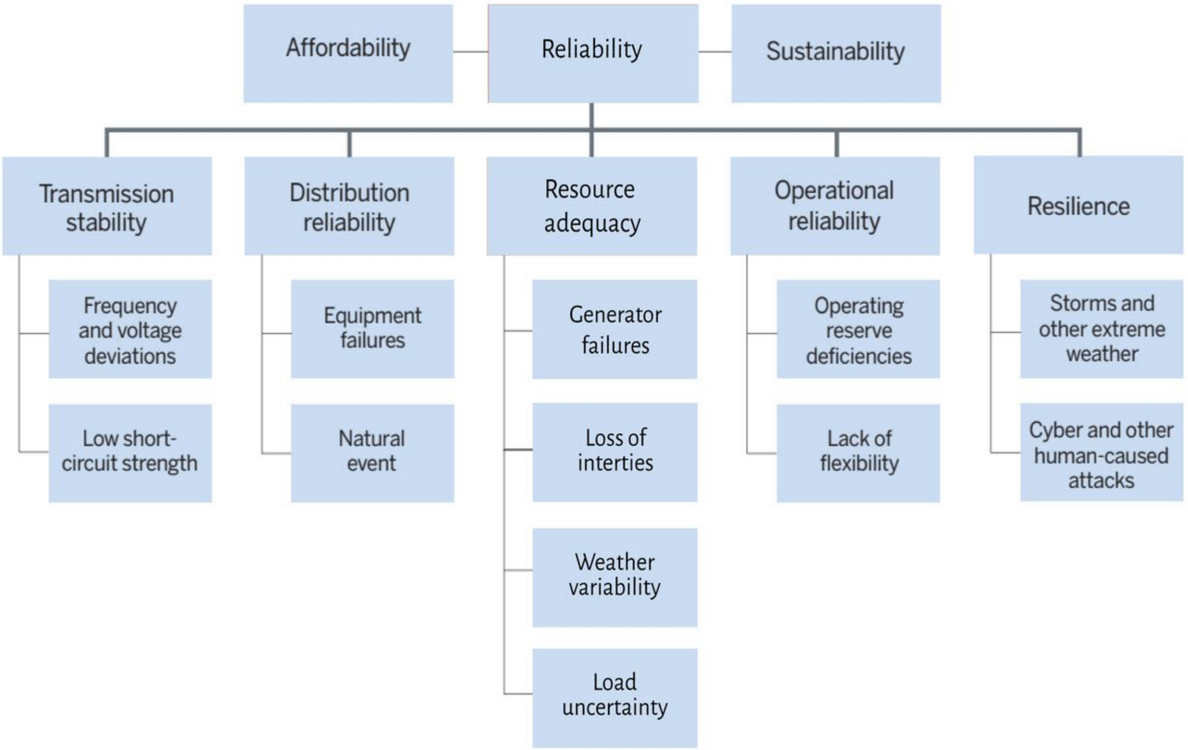
- **Electric system planning processes** are used to ensure that **future needs are reliably met** with cost-effective supply- and demand-side resources

- **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

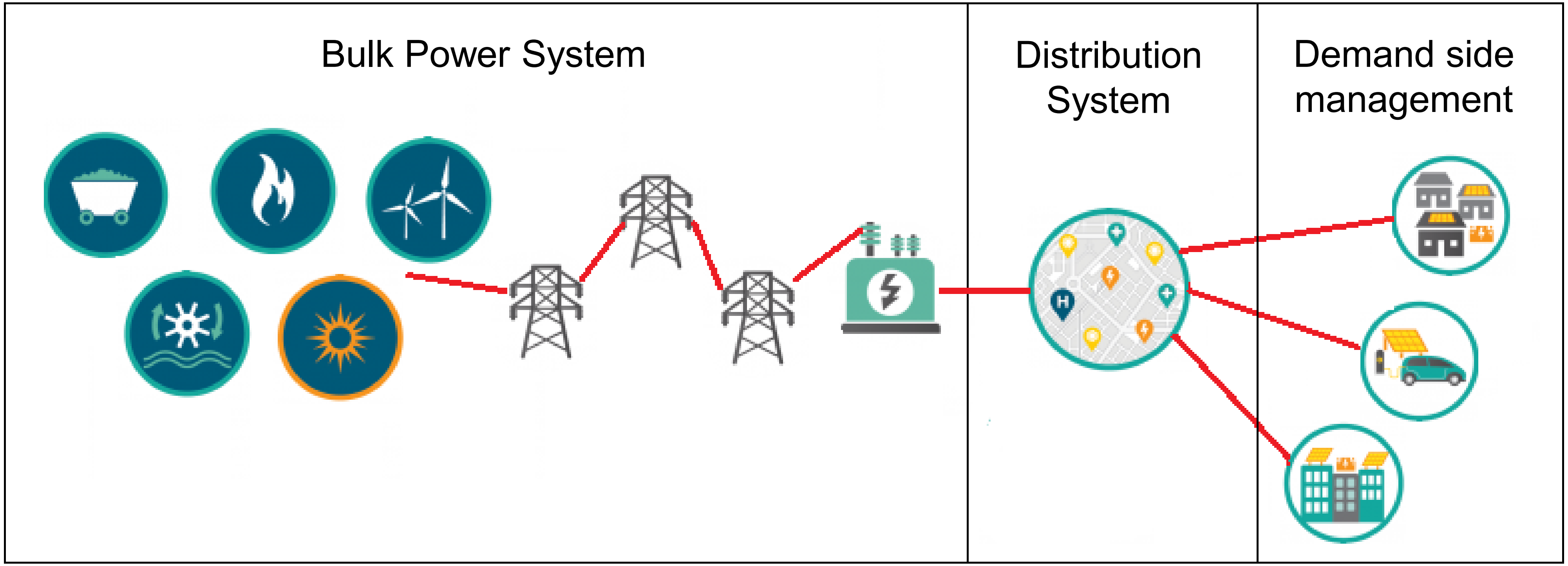
What are reliability and resilience?

- **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

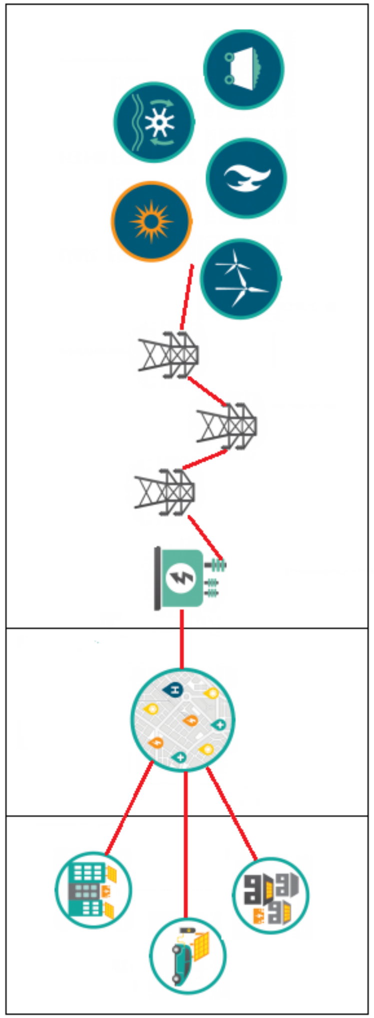


Long-term planning

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