Electric Grid Reliability
&
BAAQMD Zero NOx Rules Electric Grid Infrastructure Impacts

C/CAG RMCP Committee Meeting

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Energy+Environmental Economics

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About Energy & Environmental Economics (E3)

Technical and Strategic Consulting for the Clean Energy Transition

~100 consultants across 4 offices with expertise in economics, mathematics, policy, modeling

San Francisco

New York

Boston

Calgary

Our parent company:

WILLDAN

Engineering and energy solutions

Recent E3 Projects

- BAAQMD Zero NOx Electric Infrastructure Impacts – E3 supported the air district by analyzing the potential electric infrastructure impacts associated with Zero NOx rule amendments
- CARB Scoping Plan – E3 supported the California Air Resource Board in using our PATHWAYS economywide decarbonization model to evaluate long-term scenarios aligned with California's climate targets

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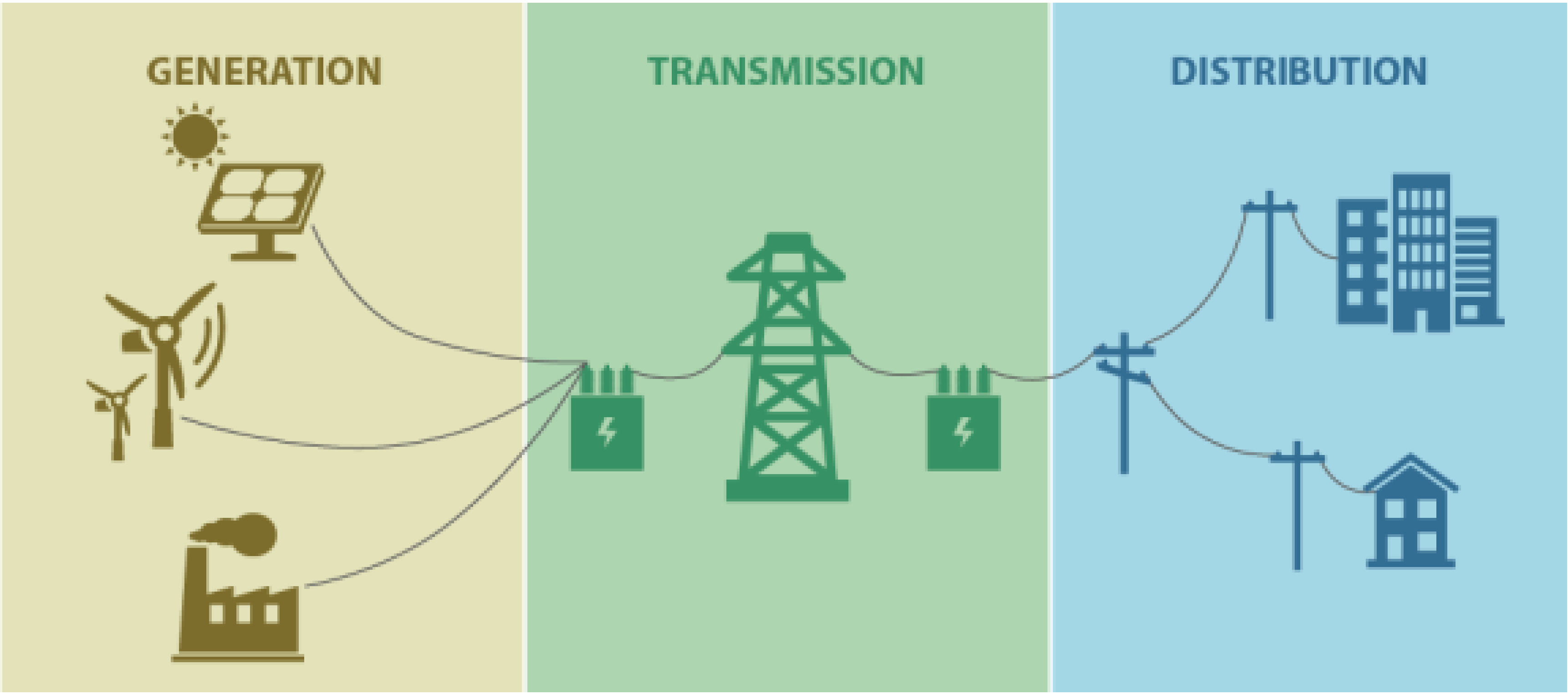
Electric Grid Reliability

The electric grid: overview

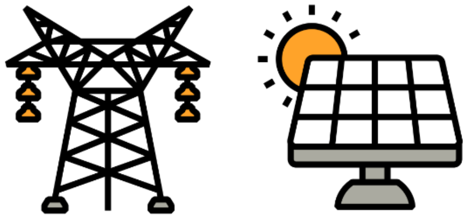


Congressional research service
https://sgp.fas.org/crs/misc/R45764.pdf

What is “electric grid reliability”

- **Reliability = maintaining electricity service for customers, “keeping the lights on”**
- **Broadly speaking: two kinds of reliability that describe different types of power outages**

	Distribution system reliability	**“Bulk system” reliability, a.k.a. “Resource Adequacy”**
Type of outage	• Local outage on part of the distribution system	• System-wide blackout • Rolling blackouts
Overall outage drivers	• Weather • Equipment failures or maintenance	• Not enough generation (and/or transmission) to meet peak load
Direct causes of outages	• Tree falling on power line • Public Safety Power Shutoff (PSPS) due to fire risk • Planned maintenance projects	• Inadequate generation to meet peak load • Peak load exceeding forecast • Generator or transmission outage



Distribution system outages

+ Distribution system outages are the most common outages

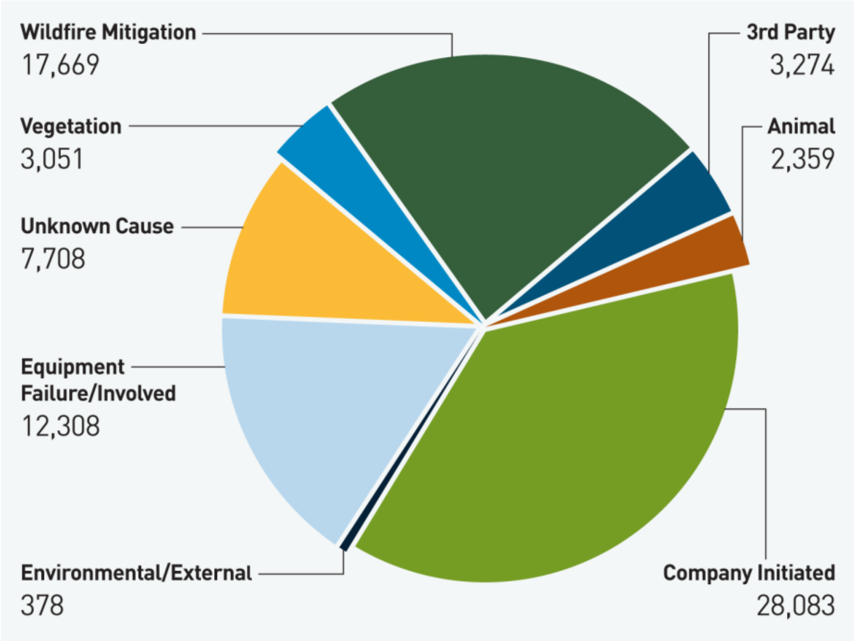
- Only one *bulk system outage* since CA Energy Crisis: August 2020 rolling blackouts
- There were tens or hundreds of thousands of smaller distribution-system outages over this time period

+ Distribution system outages are driven by factors including *weather* and *maintenance*

+ Distribution system outages are generally not driven by *customer load*

- New loads may require distribution system upgrades, leading to costs
- But loads are generally not associated with distribution system reliability

PG&E 2021 – number of distribution outages by cause

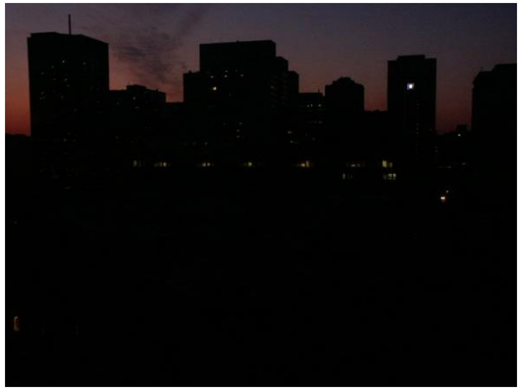


https://www.pge.com/en_US/residential/outages/planning-and-preparedness/safety-and-preparedness/grid-reliability/electric-reliability-reports/electric-reliability-reports.page

Bulk system outages

- **Bulk system outages are much less common, but can be very disruptive when they occur, e.g.:**
  - CA rolling blackouts during 2000-2001 energy crisis
  - Northeast blackout of 2003
  - Texas blackouts during 2021 Winter Storm Uri

2003 Northeast Blackout



- **Bulk system outages are caused by inadequate generation to meet load during peak hours**
- **Proximate causes may include operational errors, high loads, generator outages, or transmission outages, if these occur during system peak hours**
- **Root cause would generally be issues in system planning, *e.g.*, issues associated with:**
  - Forecasting of load growth
  - Modeling of severe weather
  - Capturing correlations in generator and/or transmission outages
  - Reflecting capacity value of variable and energy-limited resources

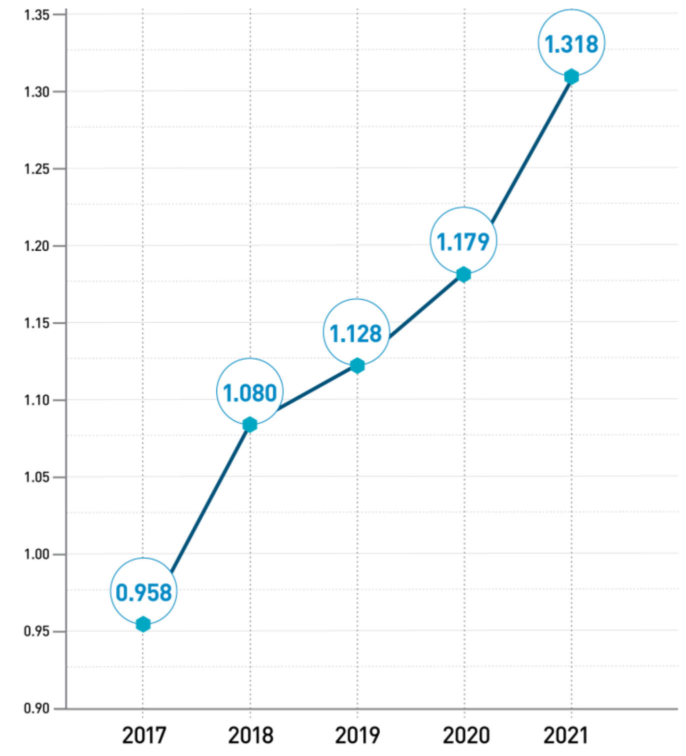
Photo: Camerafiend at English Wikipedia., CC BY-SA 3.0 http://creativecommons.org/licenses/by-sa/3.0/

No system is perfectly reliable

+ **All engineered systems have a tradeoff between cost and risk**
  - E.g., stormwater systems may be built for a “10-year flood” or a “100-year flood”
    - Building for the 10-year flood is *cheaper* but the system will flood every 10 years
    - Building for the 100-year flood is *more expensive* but the system would only flood every 100 years
+ **Bulk power systems are generally designed to a “1-in-10-year” standard**
  - Empirically, CA’s bulk system has met this standard since the CA energy crisis
+ **Distribution outages are more frequent**
  - PG&E customers experience 1.3 distribution outages per year on average (see figure)

PG&E Average Number of Outages Per Year

SAIFI = System Average Interruption Frequency Index



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What does this all mean for electrification?

- **New loads may require new investment**
  - Distribution system capacity investments driven by “connected load” or by local peaks
  - Transmission and generation capacity investments are driven by system peaks
  - Any new loads may need new electric generation resources to serve them
- **New loads should not directly impact reliability as long as utilities (e.g., PG&E) and load serving entities (e.g., Peninsula Clean Energy) are planning for them**

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- **New loads may require new investment**
  - Distribution system capacity investments driven by “connected load” or by local peaks
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  - Any new loads may need new electric generation resources to serve them
- **New loads should not directly impact reliability as long as utilities (e.g., PG&E) and load serving entities (e.g., Peninsula Clean Energy) are planning for them**
- **If higher loads meant worse reliability…**
  - …then larger electric systems would have worse reliability ✗
  - There is no evidence to support this!
- **Instead, higher loads require more resources to serve them…**
  - …but can be served reliability with good planning ✓

Grid impacts vs. customer impacts

- **E3 study for BAAQMD did not evaluate customer impacts**
  - Customer costs were considered in a separate part of the BAAQMD rule amendment materials

E3 perspective on customer costs

- **Customer costs of building electrification will be very heterogeneous**
- **In addition to equipment and installation costs, some customers may need electric panel and/or service upgrades to support building electrification**
  - These costs are real and may be expensive!
- **However, these upgrades would likely be needed to support other home upgrades such as electric vehicle charging or air conditioning**
  - Thus, these costs should not be attributed solely to building electrification

Questions?

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BAAQMD Zero NOx Rules
Electric Grid Infrastructure Impacts

Study overview

- **BAAQMD proposed Zero NOx standards for residential and commercial space and water heaters**
  - These rule amendments were adopted in March 2023

- **To support an environmental impact review of the proposed rules, E3 analyzed the potential for electric load increases and electric infrastructure impacts**
  - To estimate conservative (upper-end) impacts, the study assumed that heat pump devices are used to comply with the zero NOx standards
  - If gas-fired technologies are developed that meet the proposed standards and these devices are adopted by customers, the overall impacts on electric infrastructure would be smaller

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Key Finding #1

- **The potential electric grid impacts of the zero NOx standards are highly dependent on the other policies California enacts around building electrification to meet the state's climate goals**
  - In other words, the answer depends on *how much building electrification would occur in the region absent the rule amendments*
- **E3 developed two different reference scenarios ("counterfactuals") in which the rule amendments are not implemented**
  - Low Policy Reference: assumes no major state policy changes in support of building electrification
  - High Policy Reference: assumes major state policy support for building electrification aligned with the California Air Resource Board 2022 Scoping Plan
- **Relative to the Low Policy Reference:**
  - Zero NOx standards would result in incremental load impacts, capacity impacts, and infrastructure needs by 2050.
- **Relative to the High Policy Reference:**
  - Zero NOx standards would result in electric grid impacts occurring *earlier than would otherwise be expected*, but there would be *very small net impacts by 2050*.

Key Finding #2

+ **The largest infrastructure impacts would be from increased electric loads and the associated need for zero-carbon generation to meet these loads**
  - Relative to the Low Policy Reference, the zero NOx standards could result in 6.2 terawatt-hours per year of additional electric load by 2050, which represents 2.2% of 2020 statewide electric loads.
  - If this load was met by new utility-scale solar, this would require 2180 MW of new solar capacity, with an estimated direct land impact of 19,500 acres
    - New utility-scale solar would likely be sited in the Central Valley, Inland Empire, and/or Mojave Desert, with little to no utility-scale solar development within the Bay Area

+ **While there would also be potential impacts on generation capacity, transmission capacity, and distribution capacity, these capacity-related impacts would be small relative to potential impacts on electric generation**

Summary of potential infrastructure impacts

Table 1: Summary of potential 2050 electric grid impacts of proposed zero NOx standards

	Impact relative to Low Policy Reference	Impact relative to High Policy Reference
Utility-scale solar *to serve electric loads*	2,180 MW new solar by 2050	70 MW new solar by 2050 *+ accelerated build in 2030s & 2040s*
4-hour battery storage *for generation capacity*	680 MW new batteries by 2050	< 10 MW new batteries by 2050 *+ accelerated build in 2030s & 2040s*
Transmission Capacity	460 MW impact by 2050	< 10 MW impact by 2050 *+ accelerated build in 2030s & 2040s*
Distribution Capacity	420 MW impact by 2050	< 10 MW impact by 2050 *+ accelerated build in 2030s & 2040s*

Questions?

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Appendix
BAAQMD Electric Infrastructure Impacts

Utility-scale solar

Table 4: Potential utility-scale solar impacts from proposed standards

	2050 impact relative to Low Policy Reference	2050 impact relative to High Policy Reference
Utility-Scale Solar (MW)	2180 MW	70 MW impact by 2050 *Accelerated impact in 2030s, 2040s*
Cumulative Cost (Real $2021 Million)	$1,860	$390 *Due to accelerated build*
Land Use (acres)	19,500	700

Battery storage

Table 5: Potential generation capacity impacts from proposed standards

	2050 impact relative to Low Policy Reference	2050 impact relative to High Policy Reference
Generation Capacity (MW)	410 MW	< 10 MW impact by 2050 *Accelerated impact in 2030s, 2040s*
4-Hour Battery Storage (MW)	680 MW	< 10 MW impact by 2050 *Accelerated impact in 2030s, 2040s*
Cumulative Cost (Real $2021 Million)	$90	$30 *Due to accelerated build*
Land Use (acres)	8	< 0.1

Transmission capacity

Table 6: Potential transmission capacity impacts from proposed standards

	2050 impact relative to Low Policy Reference	2050 impact relative to High Policy Reference
Transmission Capacity (MW)	460 MW	< 1 MW impact by 2050 *Accelerated impact in 2030s, 2040s*
Cumulative Cost (Real $2021 Million)	$100	$25 *Due to accelerated build*
Associated infrastructure	Costs reflect one transformer upgrade **or** 10-20% of a 100-mile transmission project	Negligible impact by 2050 *Accelerated impact in 2030s, 2040s*

Distribution capacity

Table 7: Potential distribution capacity impacts from proposed standards

	2050 impact relative to Low Policy Reference	2050 impact relative to High Policy Reference
Distribution Capacity (MW)	420 MW	< 10 MW impact by 2050 *Accelerated impact in 2030s, 2040s*
Cumulative Cost (Real $2021 Million)	$380	$100 *Due to accelerated build*
Estimated Banks (New, by 2050)	6 New Banks	Negligible impact by 2050 *Accelerated impact in 2030s, 2040s*
Estimated Feeders (New, by 2050)	45 New Feeders	Negligible impact by 2050 *Accelerated impact in 2030s, 2040s*
Estimated Line Sections (New, by 2050)	10 New Line Section	Negligible impact by 2050 *Accelerated impact in 2030s, 2040s*
Estimated Banks (Upgrades, by 2050)	31 Bank Upgrades	Negligible impact by 2050 *Accelerated impact in 2030s, 2040s*
Estimated Feeders (Upgrades, by 2050)	42 Feeder Upgrades	Negligible impact by 2050 *Accelerated impact in 2030s, 2040s*
Estimated Line Sections (Upgrades, by 2050)	35 Line Section Upgrades	Negligible impact by 2050 *Accelerated impact in 2030s, 2040s*