Supporting California's Electric Grid with Rooftop Solar

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INTRODUCTION

23% ↑ Major Power Outage Events [1]

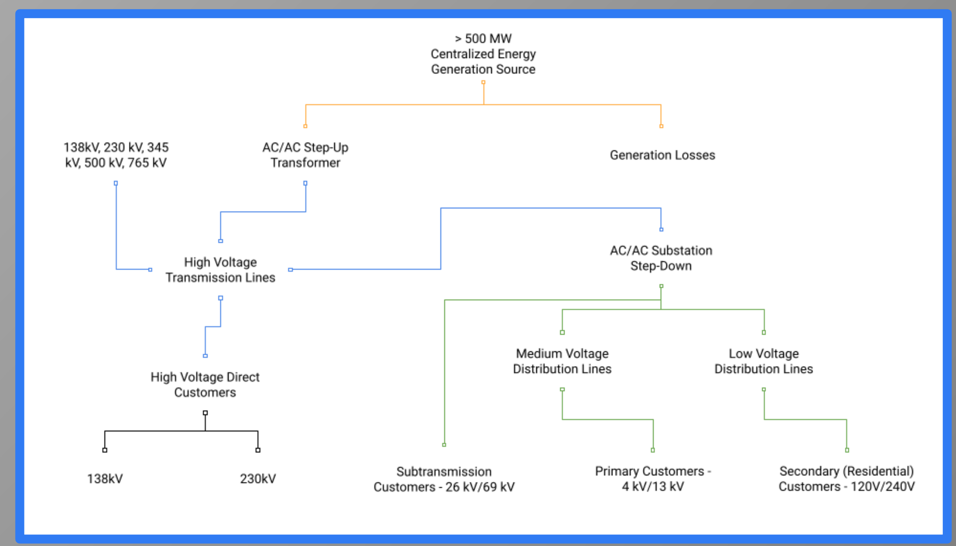
51% ↑ Customers Impacted [1]

From 2018 to 2019 in California

Household Solar + Battery Systems can be used to stabilize and support the grid in the event of **outages** and **high loads**

Goal: Find optimal percentage of Distributed Energy Resource (DER) Saturation

Generalized Grid Layout



California's grid is designed in a **"cascading line"** fashion, which means a single point of failure in the primary system can have **massive adverse effects** on customers.

RESEARCH METHODOLOGIES

Model created in GridLAB-D; made in conjunction with **PG&E** → A Degree of **Realism** + Usability of Results

12 Feeder Models (Up to **Individual Distribution Transformers**) → Primary, **most common** model used

Paired with Model of **Secondary Distribution System Design** (up to Individual *Households*)

dist_gen_battery_solar used to model a **Solar + Battery System** → **Excess Energy** given back to Grid

volt_var_control used with all constants at Predefined Defaults (necessary with many Generation Sources) [2]

event_gen used (*random line-line* faults) + 1 Very Large Outage (Simulating a Public Safety Power Shutoff) [3]

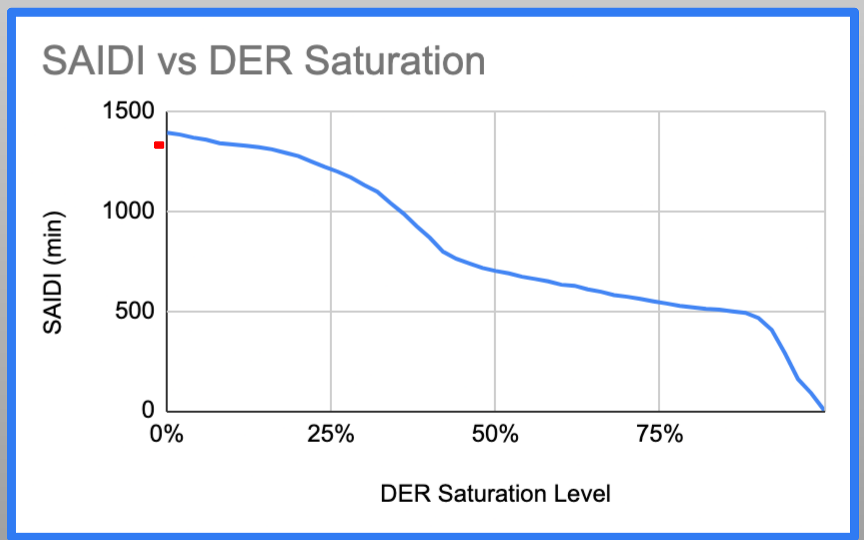
power_metrics object called with *metrics* module → *customer_group* defines each house as a "customer"

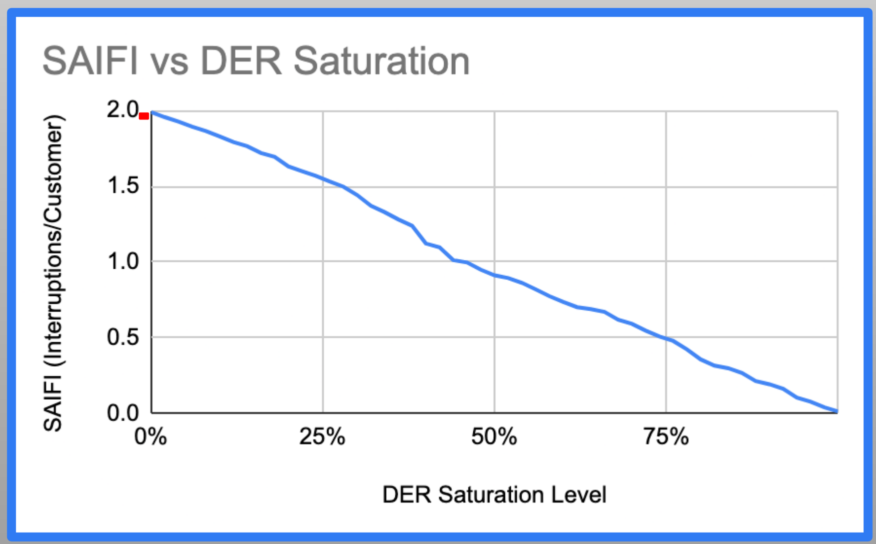
reliability module used with *powerflow module* → calculate SAIDI, SAIFI, CAIDI, and MAIFI

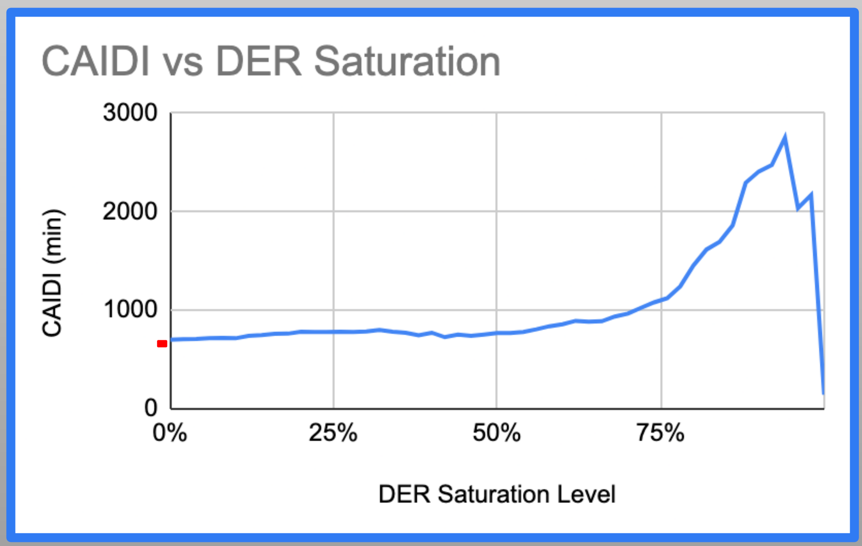
Note: Trial-and-Error was initially used to model a combination of outage events similar to those experienced by PG&E customers throughout 2019[3]

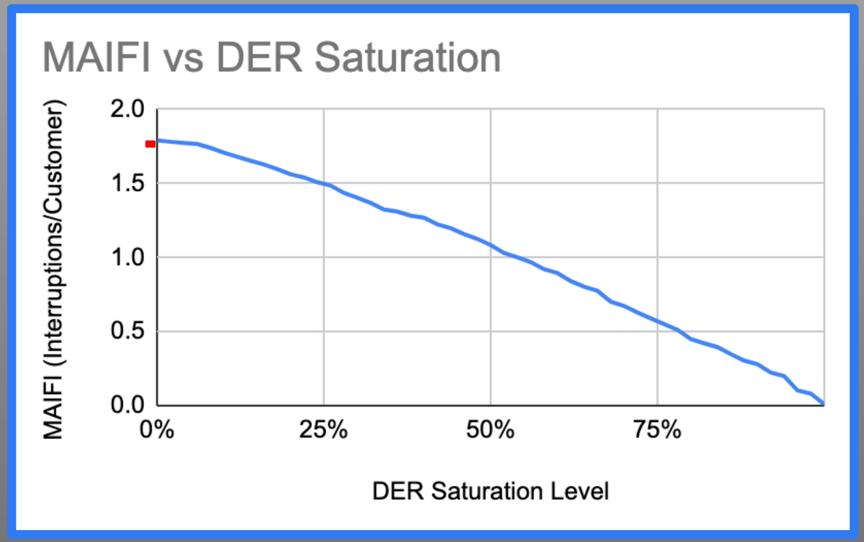
DATA AND FINDINGS

All Data Collected by **Amol Tandon**









System Average Interruption Duration Index = Sum of All Customer Interruption Durations / Total Number of Customers Served

System Average Interruption Frequency Index = Total Number of Customer Interruptions / Total Number of Customers Served

Customer Average Interruption Duration Index = Sum of All Customer Interruption Durations / Total Number of Customer Interruptions = SAIDI / SAIFI

Momentary Average Interruption Frequency Index → Total Number of Customer Interruptions Less Than 5 Minutes ÷ Total Number of Customers Served

CONCLUSIONS AND ANALYSIS

Graphical Analysis

SAIDI	~ Parabolic *(0% - 40%)*	Inverted, Origin @ 0%
	~ Linear *(40% - 85%)*	Mild Negative Slope
	~ Linear *(85% - 100%)*	Strong Negative Slope
SAIFI	~ Linear *(0% - 100%)*	Mild Negative Slope
CAIDI	~ Exponential *(50% - 90%)*	~ y = 2^{0.5x}
	~ Linear *(90% - 100%)*	Severe Negative Slope
MAIFI	~ Linear *(0% - 100%)*	Mild Negative Slope

Notable Info

SAIFI Decreases at a (Avg) Faster Rate than SAIDI

↳ Causes CAIDI to **Increase** in Some Scenarios

Gives the False Impression of Worsening Performance[4]

MAIFI and SAIFI Display Similar Linear Trends

↳ Logical → Frequency Metrics are *Directly Correlated* with Percentage of Houses with PV/Battery Systems

Momentary Interruptions may be **Completely Eliminated** with Such Systems

Optimal DER Saturation Level

~ 40% - 45%

SAIDI shows Substantial Decrease at a Reasonable Saturation Level

CAIDI shows No Negative Effects

SAIFI and MAIFI See Similar Results with Improved System Performance

Image sourced from *tesla.com/solarpanels*

IMPLICATIONS AND NEXT STEPS

Continuation of Research

Deep Technical Research into Realistic Values for Model of Volt-VAR-Regulation

Implementation of a native MATLAB script for Realistic Variable Loads from Houses

Can Model Charging Electric Vehicles, Heat Pumps for Air Conditioning, etc.

Implement Methodology on Other Feeder Models with Wide Range of Attributes

Application of Research

Discuss Results (Optimal Saturation Level) with CPAU Staff → Future Goals

Work to Create a GridLAB-D Model for the City of Palo Alto Specifically

Note: **PG&E DOES NOT supply electricity to the City of Palo Alto, although it DOES to surrounding cities**

ACKNOWLEDGEMENTS / REFERENCES

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[3] Pacific Gas & Electric Company. (2021, July 15). *2020 Annual Electric Reliability Report*. https://www.pge.com/pge_global/common/pdfs/outages/planning-and-preparedness/safety-and-preparedness/grid-reliability/electric-reliability-reports/CPUC-2020-Annual-Electric-Reliability-Report.pdf

[4] S&C Electric Company. (2020, July 20). *Moving Beyond Average Reliability Metrics* [PDF].https://www.sandc.com/globalassets/sac-electric/documents/sharepoint/documents---all-documents/technical-paper-100-t128.pdf?dt=637686135722062170