



Overpowered

Connecting Energy to the Grid, Faster



The Team

UC Berkeley Masters of Information and Data Science



Paul Cooper



Hailee Schuele



Zhifei Dong



Adam Kreitzman

Our Mission

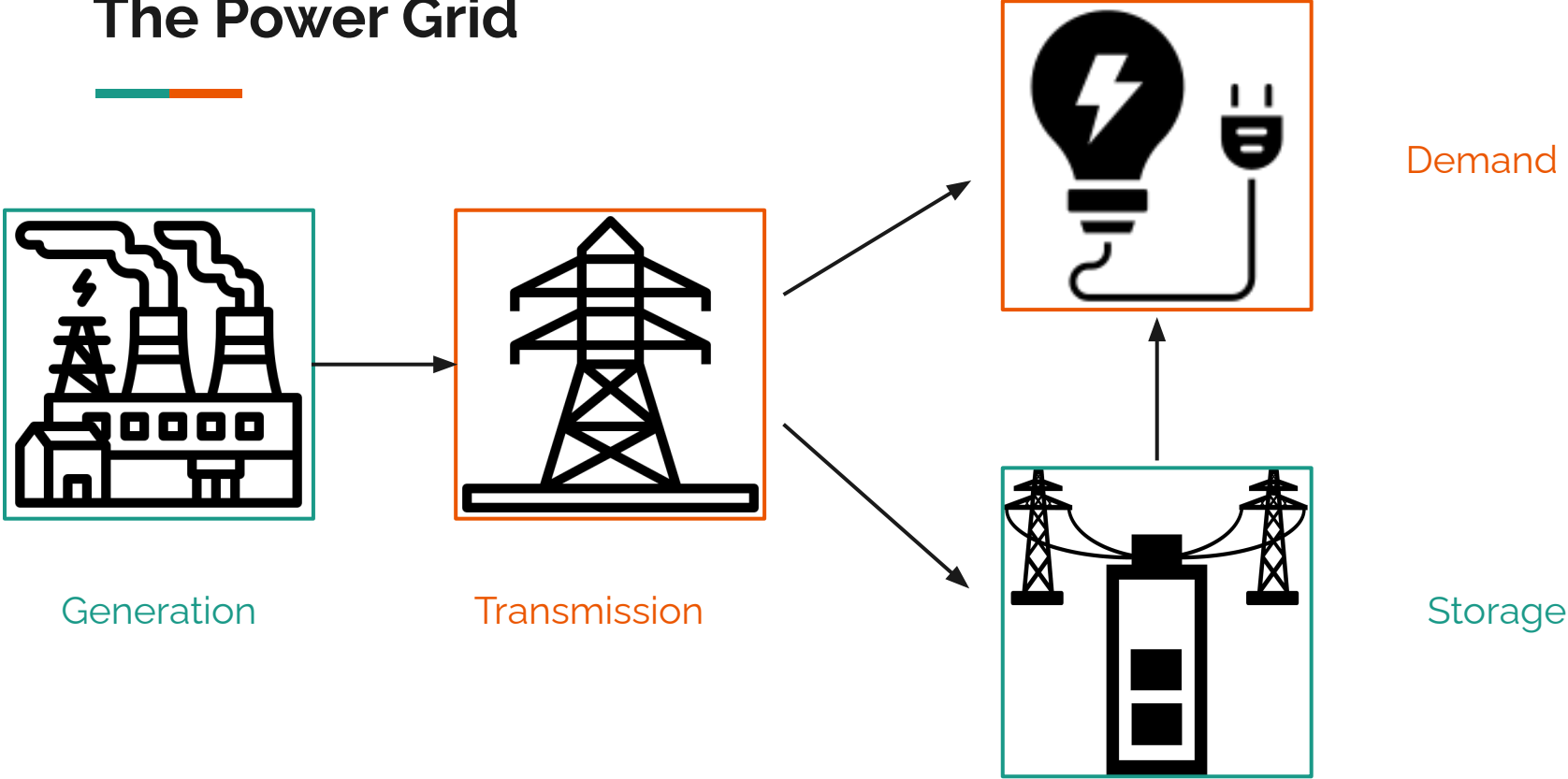


Provide a faster, more efficient way of connecting new energy sources to the power grid.

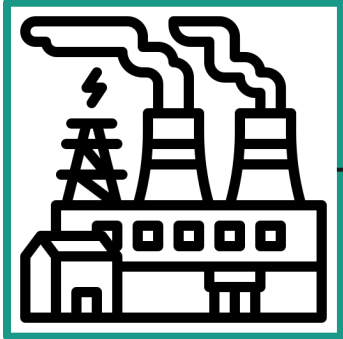


The Space

The Power Grid



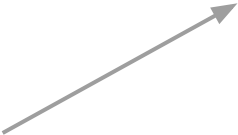
Our Focus: New Power Generation



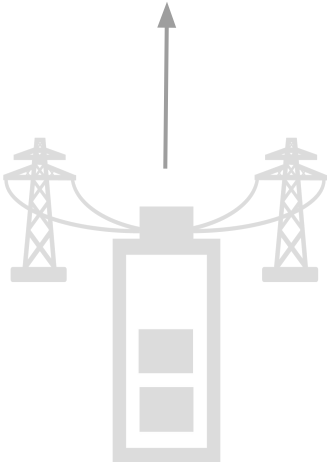
Generation



Transmission

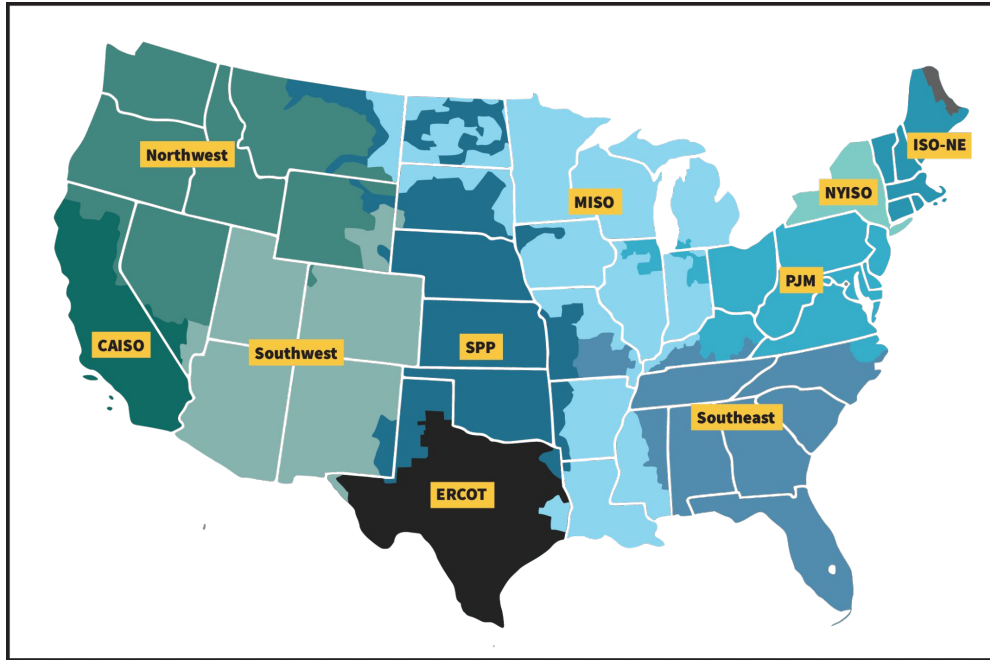


Demand



Storage

Regulatory Bodies



Geographic overview of RTOs and ISO. Source: FERC.gov

The Interconnection Queue



When a new power generation facility wants to come online, they submit an application to the **interconnection queue**



The Approval Process

- Each interconnection request is subject to **long, technical studies**
 - transmission capacity
 - market conditions
 - incident analysis
 - feasibility and impact
- One request may be **dependent** on other requests
- **Additional infrastructure investment** is often needed to accommodate a new power generation source





The Problem

Time, Money, and Dropout

1. 4+ year wait times
2. Unfeasible infrastructure costs
3. Wasted time and resources



The Power Grid's Big Bottleneck

The queue process is outdated, inefficient, and expensive

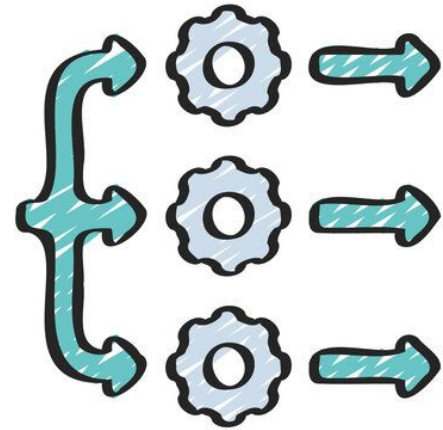




The Solution

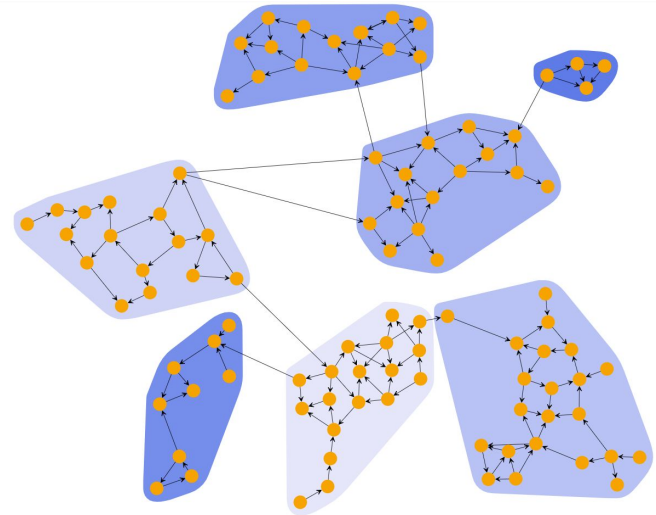
Cluster Processing

- New federal ruling allows for processing multiple applications together as a **cluster**
- Clusters allow:
 - Shared development investment
 - Reduced queue wait times
 - Fewer withdrawn applications



Improving Clusters

- If we can:
 - Identify efficient clusters
 - Understand how likely a given cluster is to be successful
- Then we can:
 - Speed up the queue
 - Reduce dropout
 - Save time and resources



Our Product

- Recommend **clusters of interconnection requests** to be studied together
- Provide **scoring mechanisms** to understand how strong the candidate batch is
- Provide tools for expert users to **customize their results**
- Provide an **integrated platform** for data querying, visualization and decision support

How to Use the Querying Map

Currently, the querying map only supports CAISO database.

1. To start with, choose a California county to zoom into. The county boundary is filled with "yellow" color.
2. Select a zoom-in scale to display the transmission lines in "blue" color.
3. Choose an extra data layer to display as "black dot". The available data layers are substations, power plants and retired generators.
4. This is optional. User can enter a location coordinate by latitude and longitude. The location will be added to plots as "red diamond"

Choose a County to View:

Alameda

Choose a Zoom-In Scale to Display:

17500

Add Additional Data to Display:

Substations

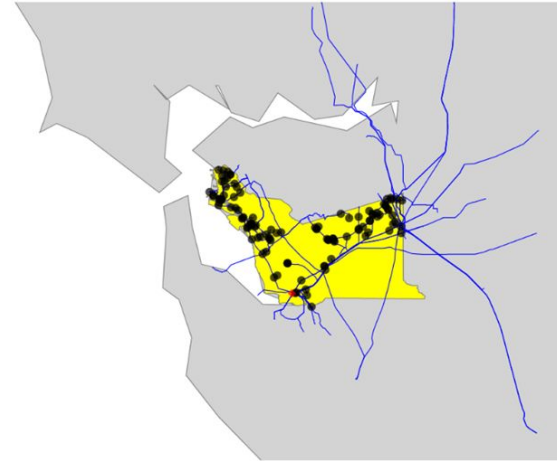
Enter a location:

Latitude:

37.50 - +

Longitude:

-122.00 - +





The Data

Piecing the Data Together

- CAISO interconnection queue data
- California substation GIS data
- California transmission line GIS data
- California power plant GIS data (including retired ones)
- CAISO future transmission projects
- *PowerWorld* - Power flow simulation software used by ISOs
- Simulated line capacity and load

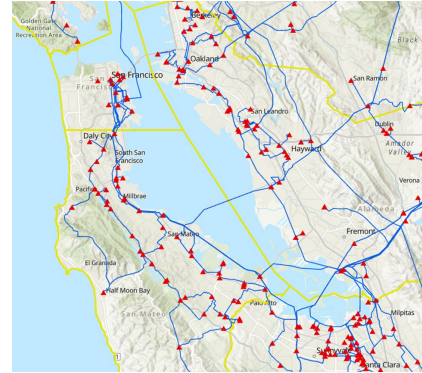
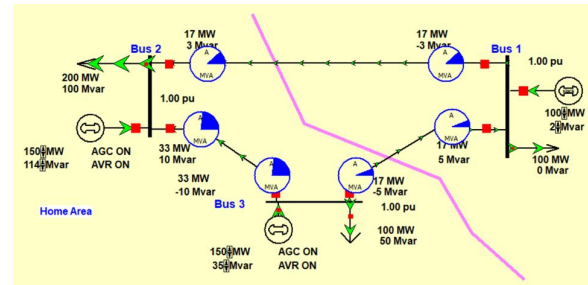
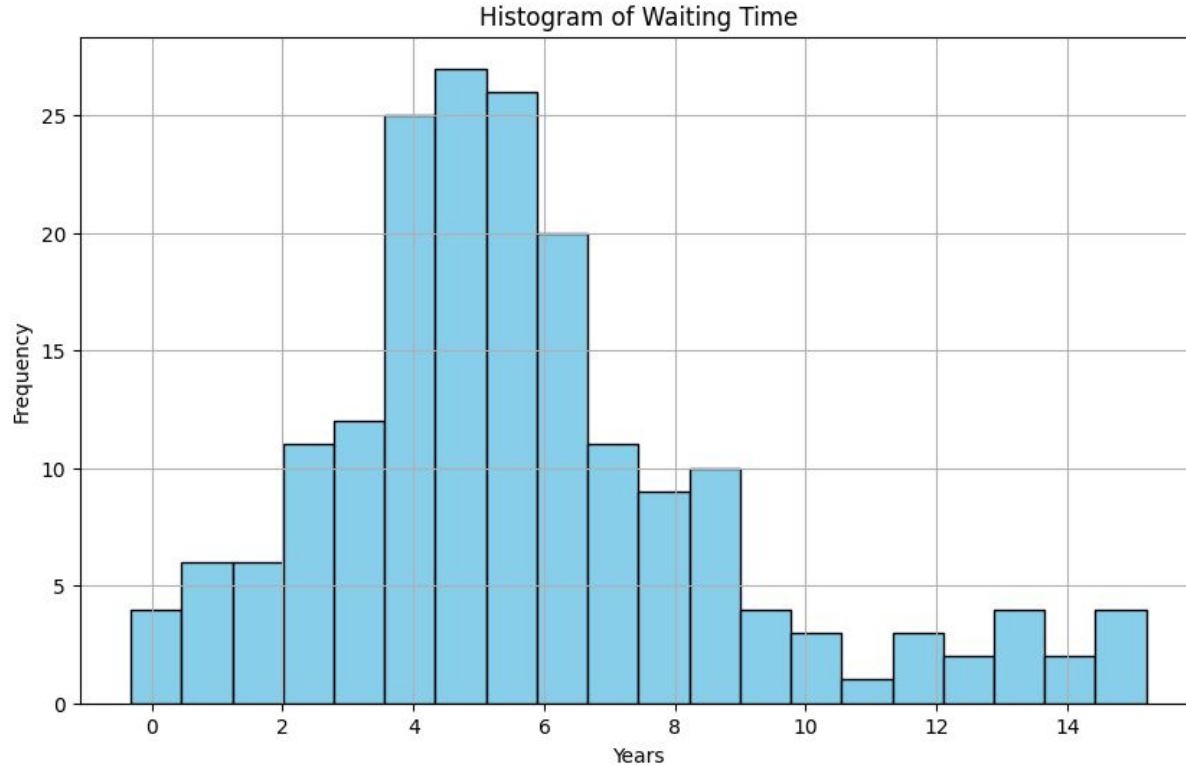


Table B-2-1: New Reliability Projects Found to be needed

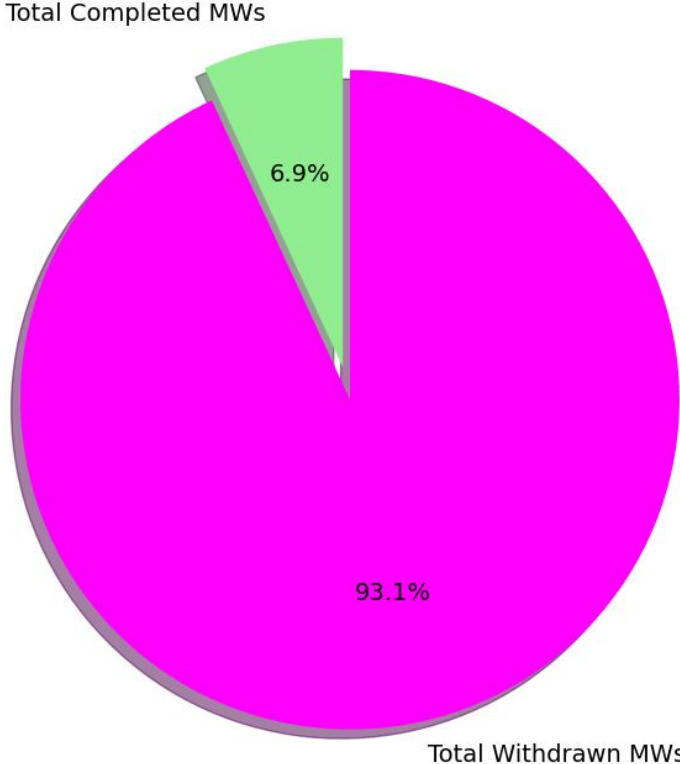
No.	Project Name	Service Area	Expected In-Service Date	Project Cost (in millions of dollars)
1	Garberville area reinforcement project	Humboldt	2022	204
2	Tulucay-Napa #2 65 kV line Reconstructing project	MCMB	2028	4.6
3	Santa Rosa 115 kV line Reconstructing project	MCMB	2028	74
4	Texia 115 kV Bus Reconfiguration Project	CHLY	2030	55
5	Santa 60 kV Bus Voltage Conversion	CHLY	2024	17.5
6	Metal 220 115 kV Transformers Circuit Breaker Addition	GBA	2026	15
7	South Bay Area Limiting Elements Upgrade	GBA	2027	11
8	Redwood City Area 115 kV System Reinforcement	GBA	2020	110.8
9	Lone Tree - Cayetano - Newark Corridor Series Compensation	GBA	2027	25
10	Pittsburg 115 kV Bus Reactor project	GBA	2032	25
11	Equipment Upgrade at CCSF Owned Wimmerville 220 kV Substation	Fresno	2024	1.6
12	Los Banos 70 kV Area Reinforcement Project	Fresno	2029	60
13	Los Banos 220 kV Circuit Breaker Replacement	Fresno	2032	66
14	Panache 115 kV Circuit Breaker Replacement and 220 kV Bus Upgrade project	Fresno	2032	184
15	North East Kern 115 kV Line Reconstructing Project	Kern	2032	295
16	Mesa 220 115 kV spare transformer	COLP	2032	50.48



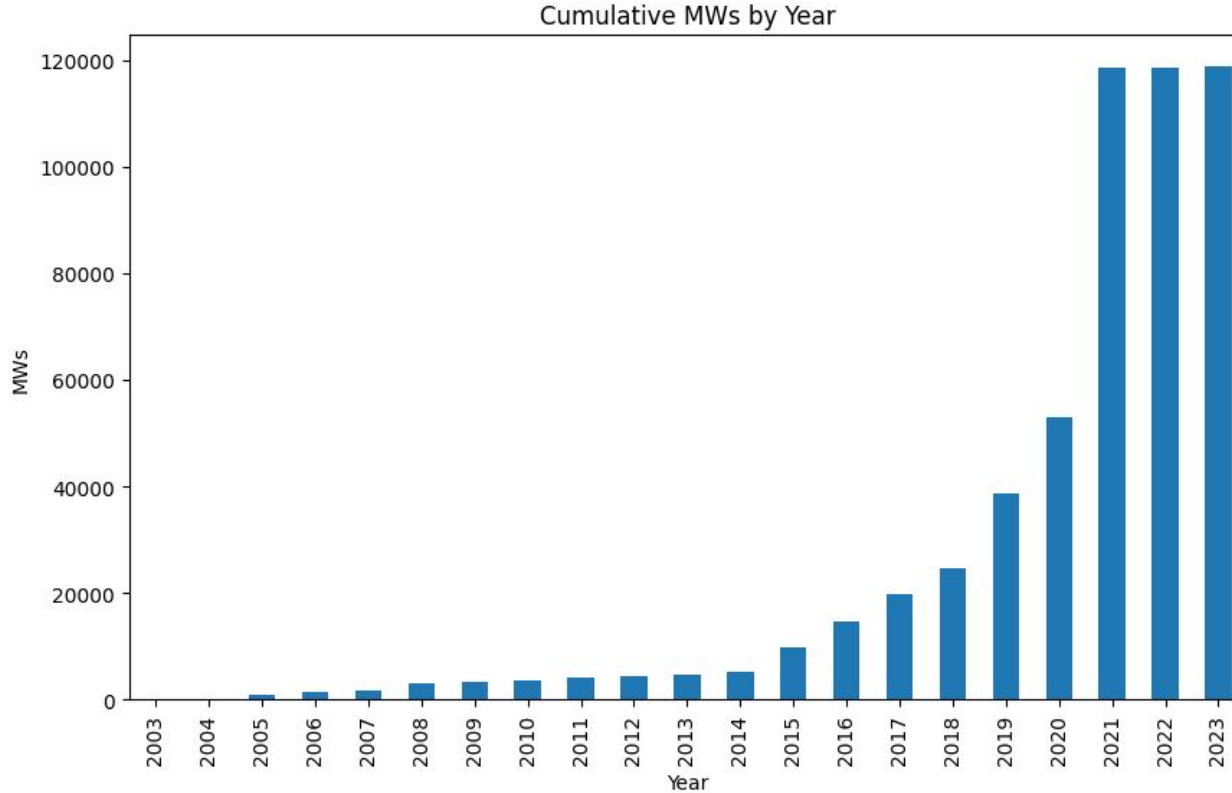
Key Data Takeaways - Completed Queues



Key Data Takeaways - Completed vs. Withdrawn



Key Data Takeaways - Current Queue



The Technical Approach

Concept Abstraction & Operationalization



Concept	Variables
Location	<ul style="list-style-type: none">● Geolocation of Interconnection Point● Proximity to Existing Infrastructure (retired plants)● Proximity to Planned Infrastructure
Infrastructure	<ul style="list-style-type: none">● Included Storage● Transmission Availability● Generator Type(s)● Amount of Energy Output
Process	<ul style="list-style-type: none">● Permit Status● Expected On-line Date● Queue Position● Utility company

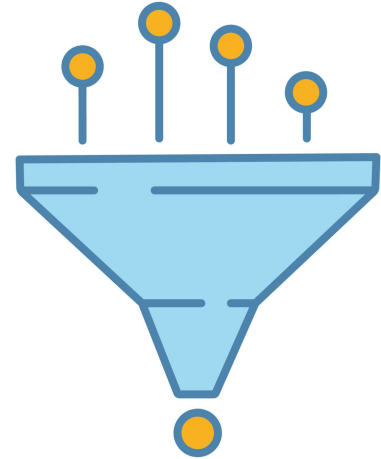
Output Variables



Measurement	Meaning
Likelihood Scores	<ul style="list-style-type: none">● Likelihood of success based on features learned from historical data
Cluster Strength	<ul style="list-style-type: none">● The strength of the recommended cluster as a whole using aggregated similarity calculations
Total MegaWatts	<ul style="list-style-type: none">● The total MWs provided to the grid by the cluster minus the current available transmission capacity

Data Pipeline

- Databricks & Blob Storage
- Feature Selection/Engineering
 - SME feedback
 - Inference from past interconnection requests
- Preprocessing for Machine Learning:
 - VectorAssembler + Scalers
 - Generating a numeric representation



Likelihood of Approval



- A method of judging the strength of an application based on supervised learning past data and future grid infrastructure development.
- Combines coefficients from supervised learning with proximity to retired power plants and future transmission projects to gauge relative strength of a grid applicant.
- Allows a decision maker to consider the probability of application success in cluster-building process.

Custom Clustering Algorithm



- Crafting a similarity algorithm that involves group subsets + process subtleties – not a simple or intuitive process to create.
- Variable-centric similarity inspired by Cosine Similarity.
- Custom similarity algorithms built to handle all variables.
- Only considering projects downstream for each project (i.e in a FIFO approach, what projects could be added to this one to form a cluster, maintains fair process)

Sample Results

MONTEZUMA (HIGH WINDS III) Suggested Cluster

Set Parameters

0.653 Cluster Strength	-18942.0 Net Transmission Capacity	0.6073 Likelihood of Approval
----------------------------------	--	---

Project	Net MWs to Grid	Likelihood of Appr...	Location	Process	Infrastructure	Overall
SOLANO 4 WIND	90.8	0.7049	0.7832	0.8736	0.75	0.7779
RECLAIMED WIND	90.7	0.8176	0.5267	0.8737	0.75	0.742
MULQUEENEY RAN...	20	0.7431	0.5349	0.8987	0.75	0.7317
SANDSTORM WIND ...	150	0.4227	0.135	0.9989	1	0.6391
SALOON ENERGY S...	150	0.7041	0.4655	0.8788	0.5	0.6371
GONZAGA WIND FA...	76.35	0.254	0.3939	0.881	1	0.6322
WINDWALKER OFF...	1000	0.6646	0.2721	0.8399	0.75	0.6317
PROXIMA SOLAR	300	0.6592	0.4394	0.9015	0.5	0.625
MONTEZUMA II	78	0.6128	0.802	0.0798	1	0.6237
SEAGLASS OFFSHO...	606.1024	0.6639	0.2709	0.8032	0.75	0.622
KEYHOLE WIND	100	0.6906	0.2025	0.8361	0.75	0.6198
CUERNO GRANDE ...	150	0.7289	0.1569	0.782	0.75	0.6044
WINDSTAR I ALTER...	120	0.2285	0.1829	0.9989	1	0.6026

Cluster Metrics

Component Scores

Aggregate Score



The Demo

Demo - Clustering Tool

Overpowered - Connecting Renewable Energy to the Grid Faster

Home Clustering Power Grid Map Details

Let's get to clustering!

Studying a single application at a time makes for a slow going. Overpowered's clustering tool helps you determine which projects make sense to study together. This tool focuses on the California grid operator (CAISO) Interconnection Queue.

Set Custom Weights

Overpowered provides a structured scoring mechanism to determine the best groups of applicants to study together. We also recognize that expert energy users have insights into how Queue applications are successful in their unique operating regions. Feel free to start with the default equal split, or configure the weighting parameters as you see fit!

Set Parameters

Pick a Project

Now that you've set your weights, click a base project in the CAISO Queue below to generate cluster recommendations.

Project Name	Queue Position	Interconnection Request Re...	Type-1	Type-2	Fuel-1	Net MWs to Grid	Full Capacity, Partial or Ener...	County
MONTEZUMA (HIGH WINDS III)	22	11/18/2003	Wind Turbine	Storage	Wind Turbine	38	Partial Capacity	solano
TULE WIND	32	5/12/2004	Wind Turbine		Wind Turbine	193.8	Partial Capacity	san diego
FRESNO COGENERATION EX...	61	3/28/2005	Steam Turbine	Storage	Natural Gas	73.27		fresno
LAKE ELSINORE ADVANCED ...	72	4/26/2005	Storage		Pumped-Storage hydro	500	Full Capacity	riverside
BOTTLE ROCK POWER	81	9/13/2005	Steam Turbine	Storage	Geothermal	52.01	Energy Only	lake
WINDSTAR I (ALTERNATE)	100	4/5/2006	Wind Turbine	Storage	Wind Turbine	120		kern
SANDSTORM WIND POWER	138	10/23/2006	Wind Turbine	Storage	Wind Turbine	150	Partial Capacity	riverside
DESERT SUNLIGHT PV I	146	11/16/2006	Photovoltaic	Storage	Solar	250	Partial Capacity	riverside



Demo - Interactive Map

Overpowered - Connecting Renewable Energy to the Grid Faster

[Home](#) [Clustering](#) [Power Grid Map](#) [Details](#)

Interactive Map

Each application in the queue data indicates the county where the project is to be built. The application also briefly describes the station or transmission line it plans to connect to. Therefore, the interactive map allows the user to explore the available datasets (transmission lines, substations, retired power plants, and future infrastructure projects) by California counties.

Here are some examples of using the interactive map:

- **Scenario 1:** The application indicates the transmission line it plans to connect to. The user can load the current queue and quickly find the shortest distance to the nearby transmission line. Additionally, the user can compare the proposed power with the remaining line capacity to determine if the transmission line has enough capacity for the application.
- **Scenario 2:** The application includes a power storage unit. The user can load the current queue and the retired power plants to check the availability of the nearby plants as ideal storage units.
- **Scenario 3:** The project location of the application is far away from the existing infrastructure. The user can load the current queue and the future infrastructure to determine if an infrastructure project is to be built near the site.

Currently, the querying map only supports California database.

Available Datasets

- **US state boundaries:** base map filled in gray color
- **California county boundaries:** base map filled in yellow color
- **California transmission lines:** base map lines in blue color. The transmission lines are labeled by their names and simulated remaining capacity. Hover over a transmission line to view.
- **Additional datasets**
 - **California substations:** add-on points in "red triangle". The substations are labeled by their names. Hover over a substation to view.
 - **Retired power plants:** add-on points in "black cross". The retired power plants are labeled by their names and dates of retirement. Hover over a plant to view.
 - **Current queue:** add-on points in "green diamond". The queue applications are labeled by their names and station/transmission line to connect to. Hover over an application to view.

Key Takeaways

TULE WIND Suggested Cluster

Set Parameters ^

Assign relative weights

Location: 4 - + Infrastructure: 2 - +

Process: 1 - + Likelihood of Approval: 3 - +

Rerun

0.6676
Cluster Strength

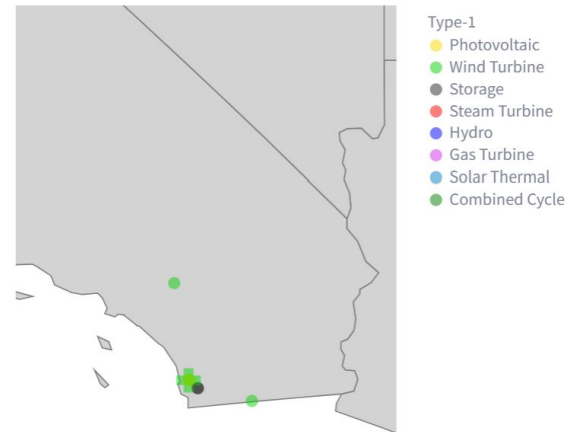
-18709.1
Net Transmission Capacity

0.7159
Likelihood of Approval

Project	Net MWs to Grid	Likelihood of Approval	Location	Pro
MOUNT LAGUNA WIND 2	400	0.7134	0.8203	0.6
RUGGED SOLAR FARM	71.88	0.718	0.8368	0.3
STARLIGHT SOLAR	20	0.6611	0.837	0.6

Choose a Zoom-In Scale to Display:

3000 ^





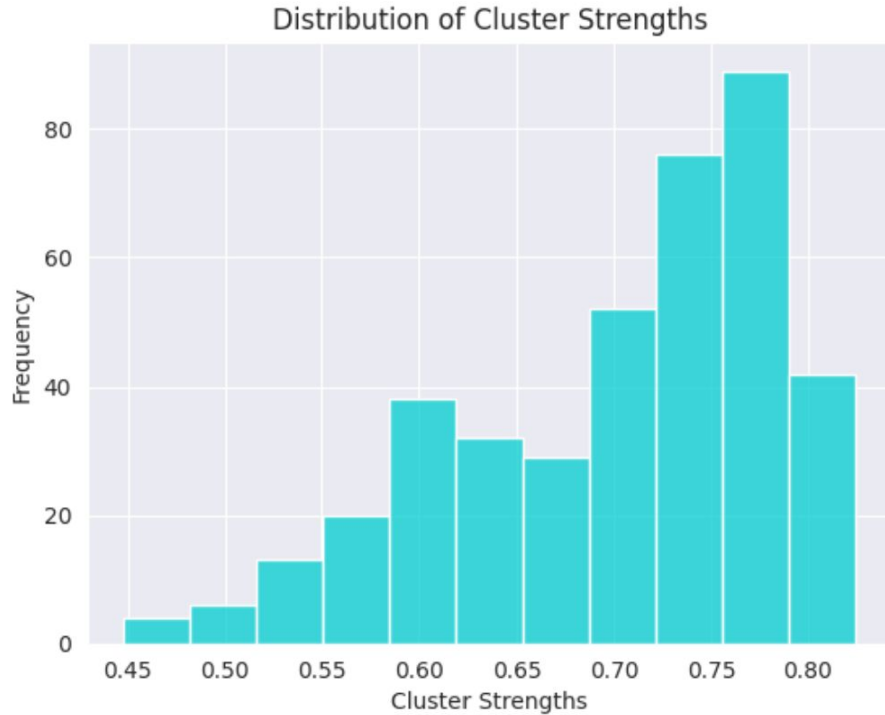
The Evaluation

Measuring Impact



- Our ultimate goal is to **improve queue efficiency**
- We want to measure:
 - Cluster strength
 - How compatible are the projects within a cluster?
 - How likely is the cluster to be approved?
 - Improved wait times
 - Are we speeding up the queue?

The Tool's "Goodness"



SME Feedback



“The old way has its limitations and everyone complains about it”

“When we’re trying to advise clients, they want to know where the best place to connect would be... and we really don’t know”

“Having historical data boiled down is the value of your tool. You don’t have to rerun the study every time (you assess a new applicant)”



The Overpowered Value

Breaking Down a Complex Problem



- Technical Challenges
 - Piecing together various data sources of different types
 - Calculating unknown variables such as transmission line capacity and usage load
- Human-Centric Challenges
 - Abstracting technical and human-centric process considerations
 - How to allow tool flexibility in an inexact problem-space
 - Machine learning expertise in an antiquated system

Roadmap



- Extend the application to developers
- Incorporate additional data points that grid operators use
- More SME feedback
- Additional data outside of California
- Incorporate outcomes from initial cluster studies
- More supervised ML-focused approaches to grid expansion built on top



The Mission

Impact



Provide a faster, more efficient way of connecting new energy sources to the power grid.

Acknowledgements



- Damian Berger (SME at Atwell Group)
- Annie Polakowski (SME at Atwell Group)
- Dr. Roy McCann (Principal Investigator at GRAPES)
- Thomas Dempsey (SME at MYNO Carbon)
- CAISO Customer Support
- UC Berkeley MIDS Capstone class and professors

"Striking a balance between a slow and certain approach and considering all-comers fairly is really the heart of the solution."

- Damian Berger (SME at Atwell Group)