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# Quest EQUITY

## A New Open Source Tool for ESS Equity Analysis

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NNSA

# QUEST EQUITY

Open source code published in July 2023:
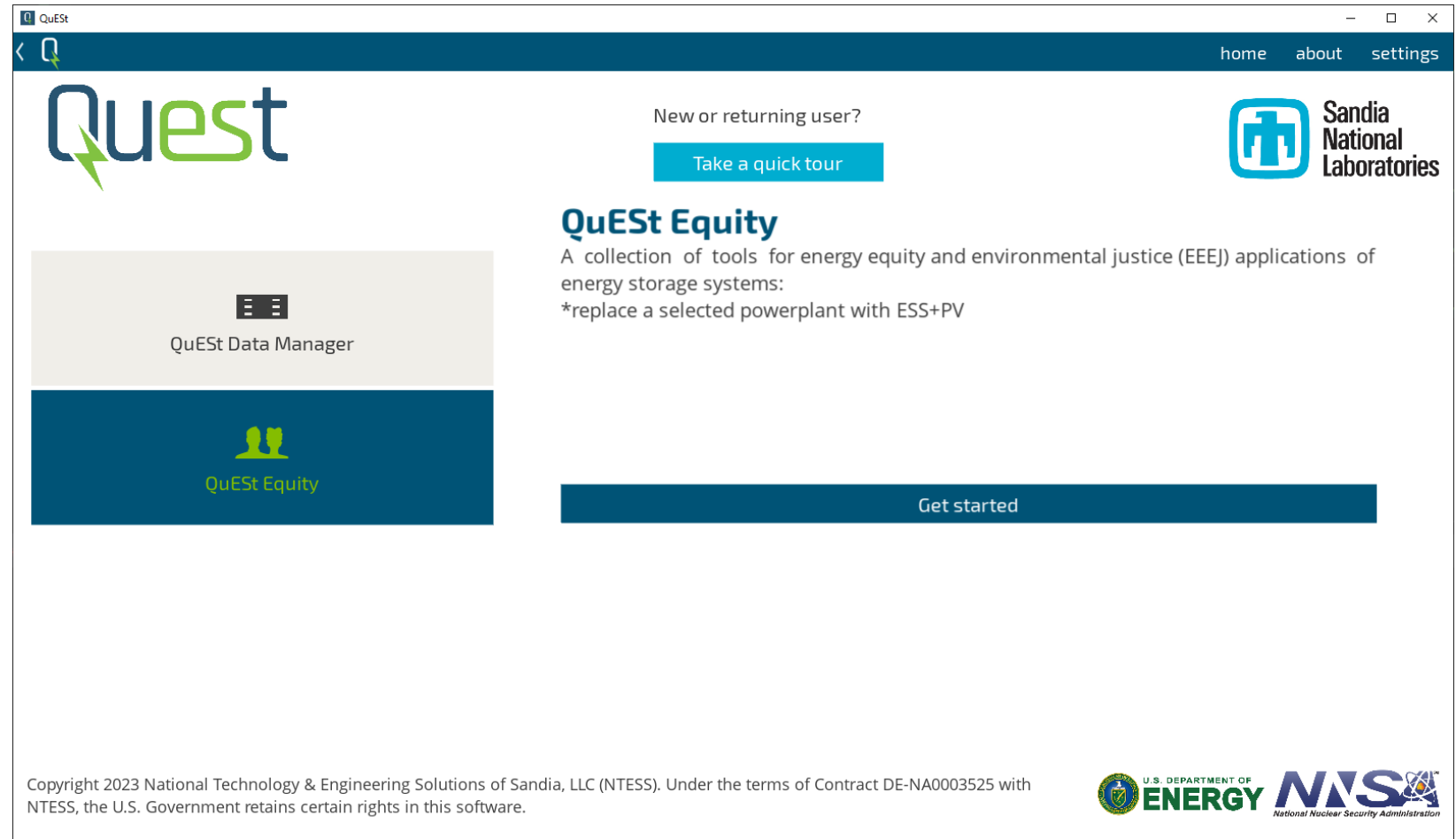
An application for assessing energy equity and environmental justice of energy storage projects. This application currently has the powerplant replacement wizard that estimates the health and climate benefits of substituting a powerplant with energy storage and PV. It then calculates the county level benefits to estimate how much the project would impact disadvantaged communities and people with low incomes.
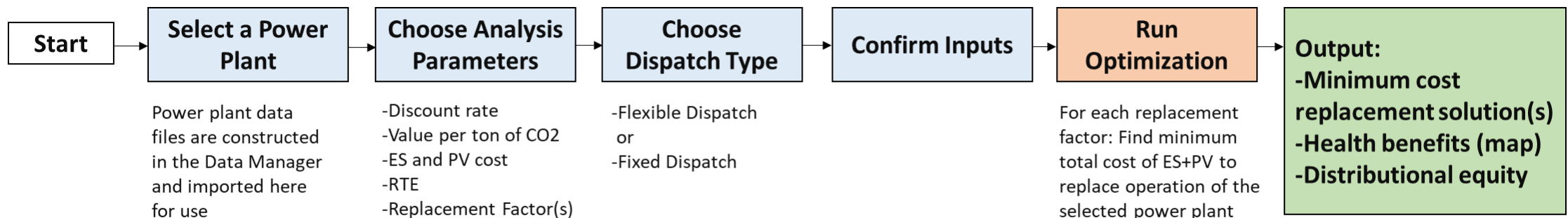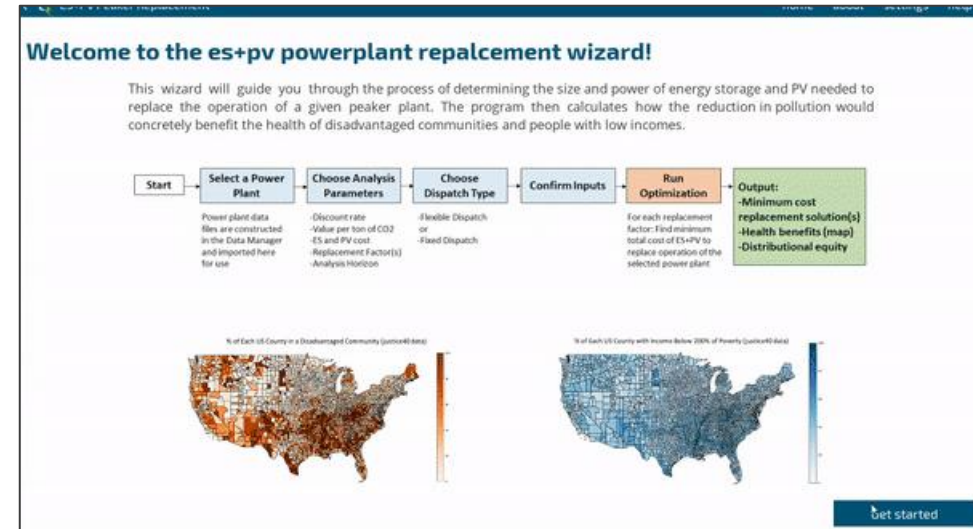
# POWERPLANT REPLACEMENT ANALYSIS

**Inputs**

- Powerplant Data File
- Battery and Analysis Parameters
- Dispatch Type Assumption

**Outputs**

- Minimum capital cost solution(s)
- Health Benefits
- Distributional Impacts



Welcome to the es+pv powerplant repalcement wizard!

This wizard will guide you through the process of determining the size and power of energy storage and PV needed to replace the operation of a given peaker plant. The program then calculates how the reduction in pollution would concretely benefit the health of disadvantaged communities and people with low incomes.



| Start | Select a Power Plant | Choose Analysis Parameters | Choose Dispatch Type | Confirm Inputs | Run Optimization | Output: |
|---|---|---|---|---|---|---|
| | Power plant data files are constructed in the Data Manager and imported here for use | -Discount rate<br>-Value per ton of CO2<br>-ES and PV cost<br>-RTE<br>-Replacement Factor(s) | -Flexible Dispatch<br> or<br>-Fixed Dispatch | | For each replacement factor: Find minimum total cost of ES+PV to replace operation of the selected power plant | -Minimum cost replacement solution(s)<br>-Health benefits (map)<br>-Distributional equity |

# ANALYSIS ASSUMPTIONS

- Health impacts based on the EPA's COBRA tool
- County level resolution for health impact magnitude
  - Undervalues health impact in direct proximity to powerplant
  - Ignores health impact outside US boarders
  - No analysis for Alaska, Hawaii, or US territories
- Powerplant pollution data from calendar year 2019 and 2022
- COBRA API uses 2023 forecast baseline pollution
- Justice40 designation of Disadvantaged Communities (DAC) from 2010 census with overall population numbers from Alaska, Hawaii, or US territories subtracted
  - Population for census tracts are averaged by county to match health impact data.

**Data**
- 3477 powerplants in the PPNC database
- 3,142 counties in the continental US
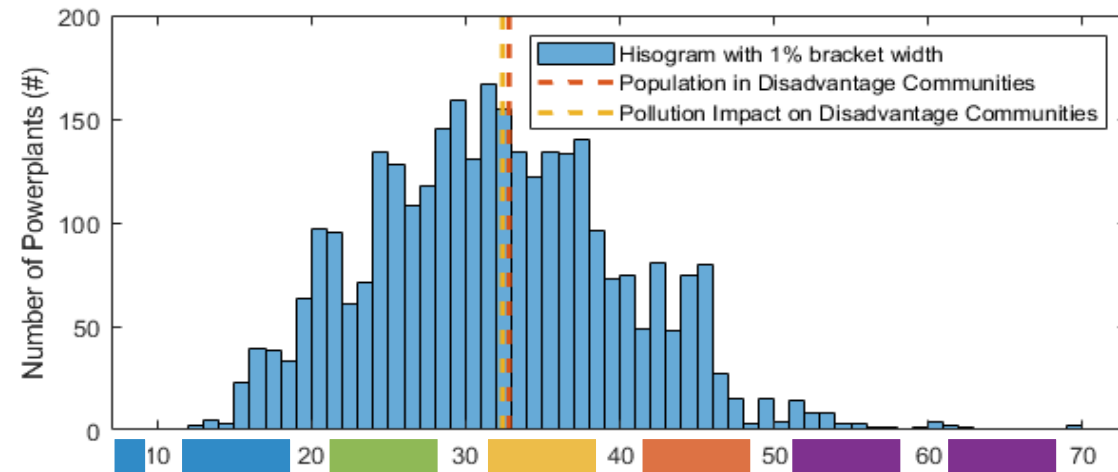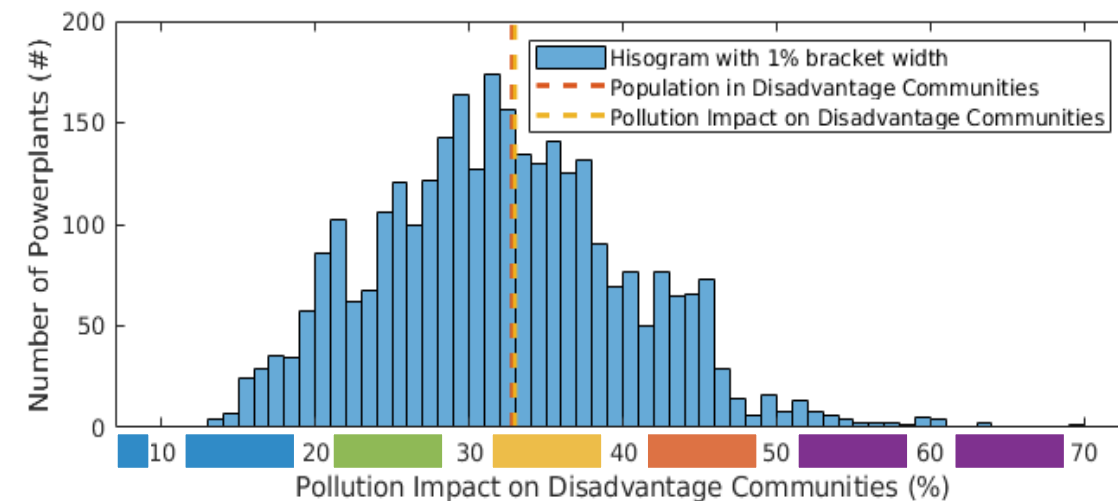- 84,414 census tracts identified as DAC or not by justice40
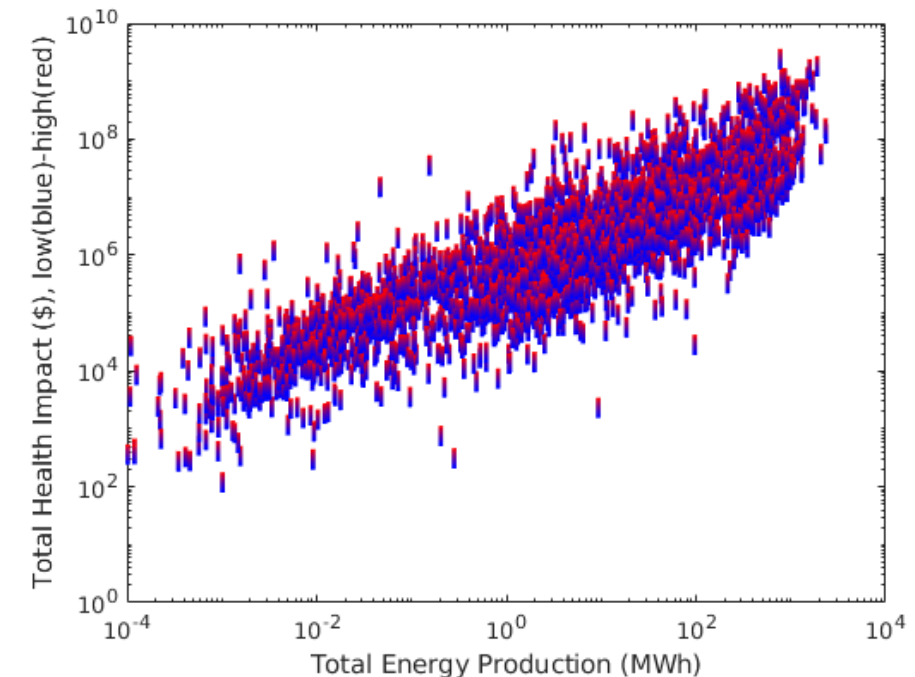
# AVERAGE IMPACT AND DISTRIBUTION

Overall, at the county level, pollution impacts of powerplants on DAC are aligned with population fraction of DAC.

**2019** Power plant pollution data

**2022** Power plant pollution data

# SPATIAL IMPACT EQUITY CLUSTERING (2022 DATA)

2022 Power Plant Data
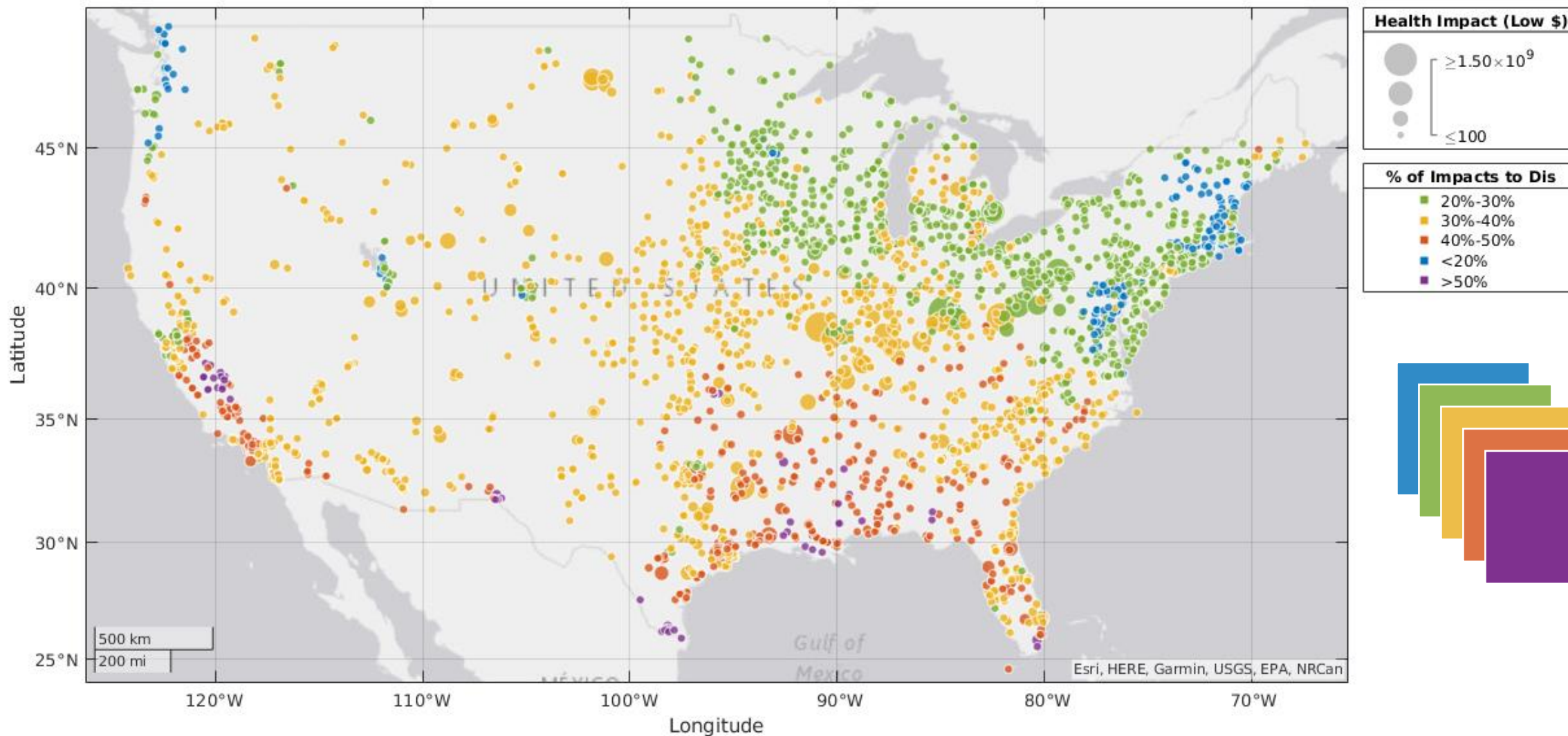
# A TALE OF TWO COUNTIES

Health impacts per-capita from powerplant pollution

2019 Power Plant Data
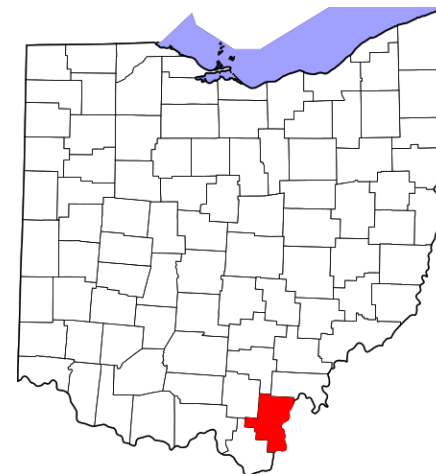
**Mono County CA**
Total = $184,260 (2019)
14,310 people (17% DAC)
$12.87 per-person

**Gallia County OH**
Total = $90,289,000 (2019)
30,088 people (65% DAC)
$3,000.83 per-person

Image credit: Wikipedia Commons

# POWERPLANT REPLACEMENT

# TOP TWENTY POWERPLANTS BY IMPACT ON DISADVANTAGED POPULATION (2019)

| ORIS_id | Name | State | Capacity (MW) | CF | Total Health Benefits (low) | Total Health Benefits (high) | impact on disadvantaged |
|---|---|---|---|---|---|---|---|
| 3559 | Silas Ray | TX | 170.4 | 4.42% | 423988.3105 | 954701.4617 | 72.07% |
| 55123 | Magic Valley Generating Station | TX | 801 | 40.62% | 6669382.568 | 14999965.13 | 71.20% |
| 50660 | Covanta Tulsa Renewable Energy LLC | OK | 16.8 | 8.33% | 710538.7144 | 1601016.229 | 69.57% |
| 7762 | Calpine Hidalgo Energy Center | TX | 551.3 | 56.37% | 8671792.455 | 19505900.96 | 69.06% |
| 55146 | Green Country Energy, LLC | OK | 903.9 | 59.68% | 6464173.105 | 14567228.51 | 62.46% |
| 3439 | Laredo | TX | 450.8 | 2.83% | 102222.5183 | 230221.6667 | 61.43% |
| 621 | Turkey Point | TX | 3678.7 | 59.80% | 33715677.27 | 75954281.7 | 61.11% |
| 54624 | South District Wastewater Treatment Plt | FL | 10.7 | 15.83% | 3022030.852 | 6808113.717 | 60.71% |
| 54623 | Central District Wastewater Treat Plant | FL | 9.6 | 5.29% | 93279.67093 | 210142.083 | 60.71% |
| 10062 | Miami Dade County Resource Recovery Fac | FL | 77 | 43.58% | 55912567.74 | 125973004 | 60.60% |
| 54338 | Rio Grande Valley Sugar Growers | TX | 24.9 | 0.33% | 3873.026077 | 8715.47457 | 60.44% |
| 59391 | Red Gate Power Plant | TX | 224.4 | 22.11% | 41803081.41 | 94083950.17 | 59.35% |
| 58562 | Montana Power Station | TX | 527.2 | 22.77% | 6810147.226 | 15350376.44 | 57.48% |
| 7988 | Silver Creek Generating Plant | MS | 250.5 | 2.08% | 126652.0546 | 285875.7069 | 56.45% |
| 4940 | Riverside (4940) | OK | 1121.7 | 6.04% | 8118836.862 | 18298235.14 | 55.49% |
| 56707 | El Nido Facility | CA | 12.5 | 42.55% | 2243331.289 | 5047056.19 | 55.44% |
| 55419 | Plaquemine Cogen Facility | LA | 987 | 61.78% | 8693682.045 | 19610169.13 | 55.33% |
| 2965 | Tulsa | OK | 443.2 | 8.58% | 5850960.252 | 13187007.53 | 54.86% |
| 55404 | Carville Energy Center | LA | 555 | 61.10% | 3229834.697 | 7285403.935 | 54.59% |
| 58478 | LEPA Unit No. 1 | LA | 74.1 | 24.37% | 266287.9958 | 600507.9219 | 54.33% |

# CALPINE HIDALGO ENERGY CENTER (TX)

Capacity: 551.3 MW

Capacity Factor: 56.36%

Health Impacts:

$9M -$20M / year

Impact on disadvantaged population: 69.06%



Image credit: google street view



Open Example Quest Equity Report
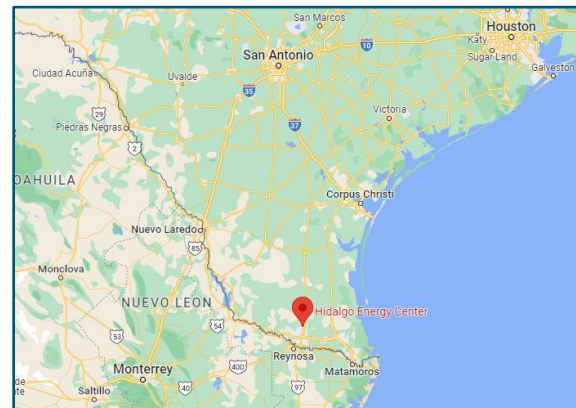
# RIVERSIDE (OK) POWER STATION

Capacity: 1121.7 MW

Capacity Factor: 6.04%

Health Impacts:

$8.1M -$18.3M / year

Impact on disadvantaged population: 55.5%

**Open Example Quest Equity Report**
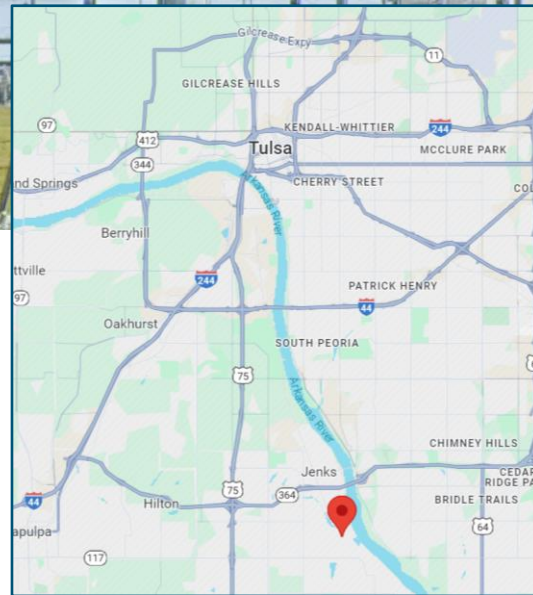
Image credit: google street view

# KEY CONCLUSIONS FROM ANALYSIS

2019 Power Plant Data

- 531 powerplants in the continental US (~15.3% of 3477) are located where >40% of the impact of their pollution go to people in DACs

- 161 powerplants in the continental US (~4.6% of 3477) cause at least $0.50 / kWh in health impacts.

- 15 powerplants fall in both categories and can be prioritized for early retirement

# BACKUP SLIDES

# DATA COLLECTION

Inputs

- Input 1: ORIS ID, Location ID (use 0 for all locations), and Year for selected powerplant
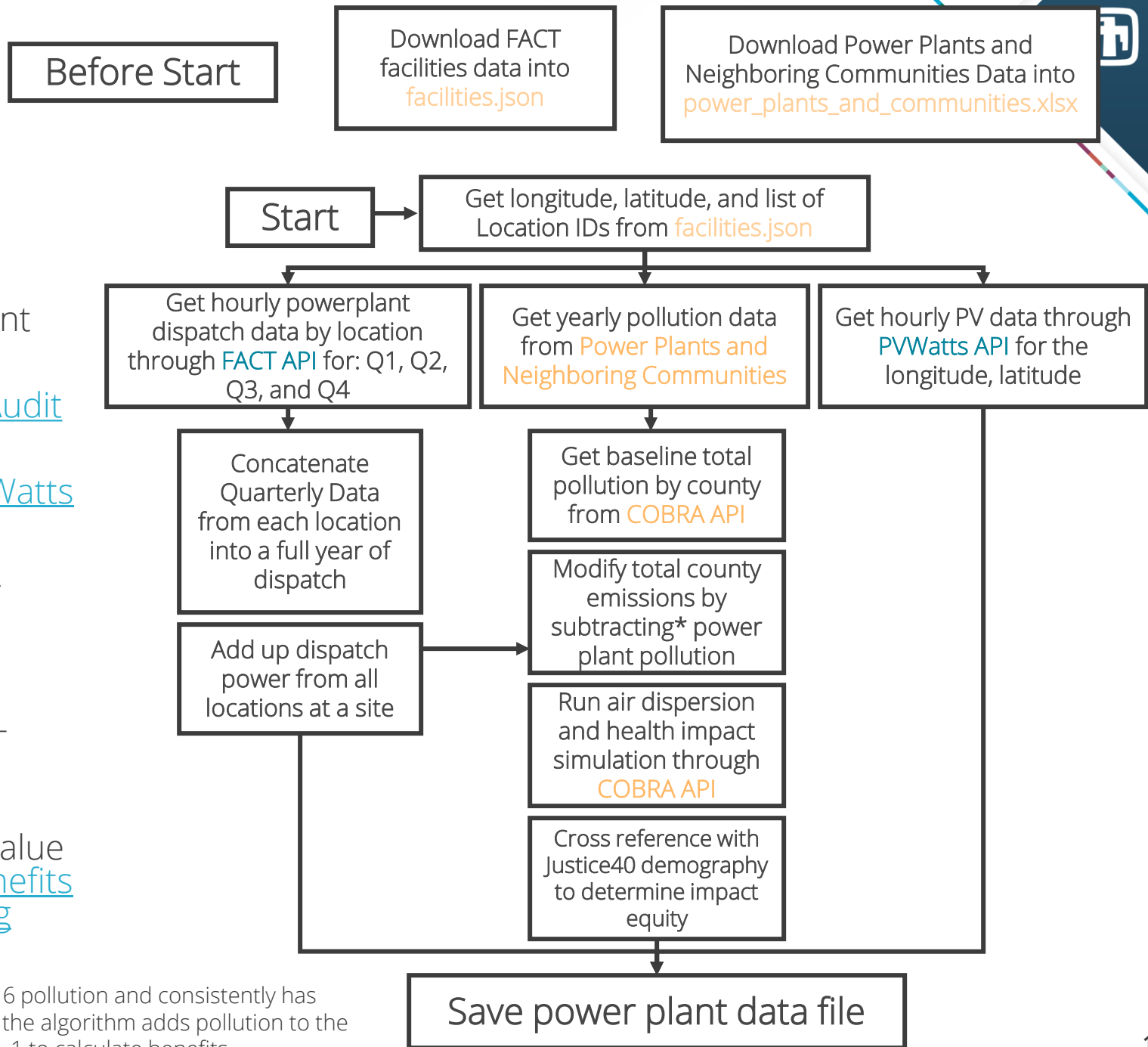- Input 2: Database with powerplant units, locations, and hourly dispatch: EPA Field Audit Checklist Tool (FACT)
- Input 3: Database with hourly PV Data PVWatts
- Input 4: Database with 2019 powerplant pollution mass tons/MWh, ORIS ID: PM2.5, NOX, SO2: Power Plants and Neighboring Communities
- Input 5: Database with county level demography for "disadvantaged" and "low-income" status: Justice40 Climate and Economic Justice Screening Tool
- Input 6: Modeling tool for estimating the value of pollution reductions per county CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)

*COBRA baseline is a 2023 forecast from 2016 pollution and consistently has insufficient pollution to subtract from. Hence the algorithm adds pollution to the baseline and multiplies the resulting costs by -1 to calculate benefits.

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Before Start

**Download FACT facilities data into** facilities.json

**Download Power Plants and Neighboring Communities Data into** power_plants_and_communities.xlsx

Start → Get longitude, latitude, and list of Location IDs from facilities.json

Get hourly powerplant dispatch data by location through FACT API for: Q1, Q2, Q3, and Q4

Get yearly pollution data from Power Plants and Neighboring Communities

Get hourly PV data through PVWatts API for the longitude, latitude

Concatenate Quarterly Data from each location into a full year of dispatch

Get baseline total pollution by county from COBRA API

Add up dispatch power from all locations at a site

Modify total county emissions by subtracting* power plant pollution

Run air dispersion and health impact simulation through COBRA API

Cross reference with Justice40 demography to determine impact equity

Save power plant data file

Inputs

- Input 1: power plant data file

- Input 2: Cost of PV per MW (with 0MW cost)

- Input 3: Cost per MW and MWh of BESS (with 0MW/0MWh cost)

- Input 4: BESS Round Trip Efficiency

- Input 5: Replacement Fraction $\rho$ [0.5, 1]

$$\min_{\mathbf{x} \in \mathbb{R}^{3n+3}} C_{PV}^{MW} P_{PV} + C_{ES}^{MW} P_{ES} + C_{ES}^{MWh} E_{ES} + \Pi |\mathbf{g}|_1$$

$$D\boldsymbol{\varsigma} = \eta \mathbf{p}^+ + \mathbf{p}^-$$

$$\mathbf{p}^+ + \mathbf{p}^- + P_{PV} \mathbf{p}_{\mathrm{pv}} \geq \mathbf{p}_{\mathrm{plant}} \mathbf{g} \quad \forall i \in P_{peek}$$

$$\mathbf{p}^+ - \mathbf{p}^- \leq P_{ES}$$

$$0 \leq \boldsymbol{\varsigma} \leq E_{ES}$$

$$\mathbf{p}_{\mathrm{plant}}^{\top} \mathbf{g} \geq \rho \sum \mathbf{p}_{\mathrm{plant}}^{\top}$$

$$\mathbf{x} \in \{\boldsymbol{\varsigma}, \mathbf{p}^+, \mathbf{p}^-, \mathbf{g}, P_{PV}, P_{ES}, E_{ES}\} \in \mathbb{R}^{3n+3} \times [0,1]^n$$

**Capital Cost**

RF Regularization

Energy Reservoir Model

Peaker Power Matching

Battery Management System Limits

Replacement Fraction
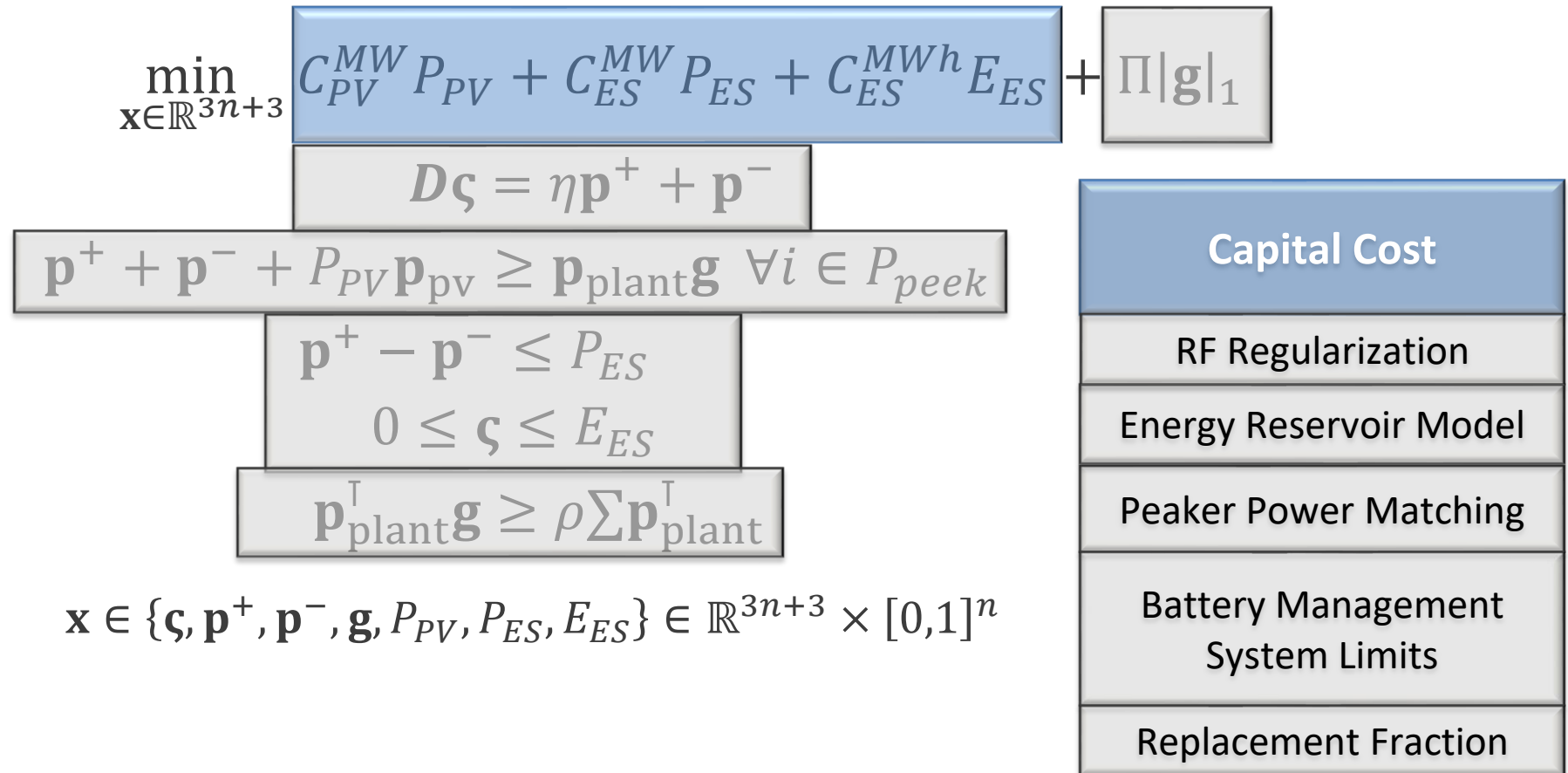
# PUBLIC INVESTMENT DRIVEN BY DISTRIBUTED BENEFITS

This plot illustrates the distributed benefits verses concentrated costs of candidate projects.

A local, state, or federal entity can select a replacement fraction, and desired ROI, and this plot will tell them the level of cost share that will present a positive social NPV.



Calpine Hidalgo Energy Center