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Quest Equity: A Tool for Assessing Powerplant Replacement with ES&PV

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Abstract

- Peaker plants provide power to the grid at peak times of the day and are often located in marginalized communities where their pollution has been linked with adverse health outcomes.
- A linear program is developed to optimally size a ES+PV to replace a given powerplant.
- This problem is of interest to utility resource planners wanting to weigh both economic and non-economic trade offs.

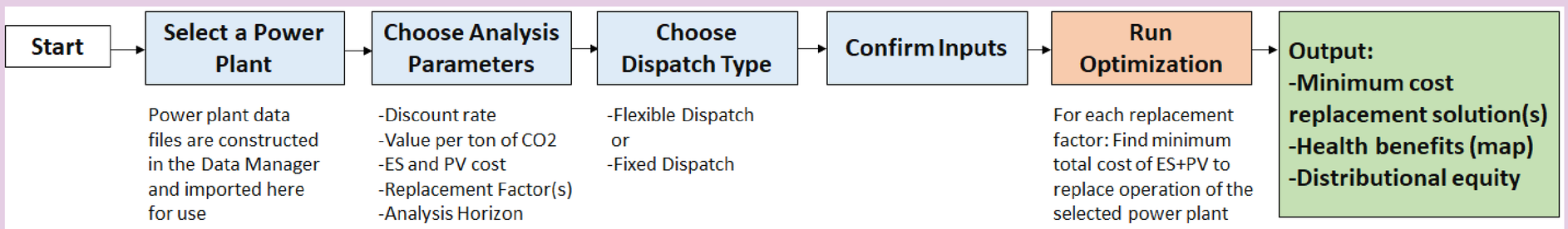
The user can select a power plant, download it's historical dispatch, calculate the ES and PV required to replace it, and estimate the potential health and climate benefits from doing so.

The tool provides an estimate of how much of the health benefits would go to disadvantaged and low-income communities.

Conclusion

QuESt Equity provides a user friendly tool to assess the costs, benefits, and distributional impact of powerplant replacement.

Methods



Powerplant Replacement Analysis Flowchart

Analysis Parameters

Discount Rate	3.0%
Cost per Ton of CO2	$93.0 / ton
Cost per MW PV system	$1.2M / MW
Fixed Cost of PV system	$0
Cost per MW ES	$3.2k / MW
Cost per MWh ES	$340.5k / MWh
Fixed Cost of the ES	-$31.4k
Round-trip efficiency	85.0%

Replacement Fractions (R.F.): % of the powerplant's yearly energy output to substitute with ES+PV

Optimization Problem Formulation (Flexible Dispatch Assumption)

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

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

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

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

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

$$\sum \mathbf{p}_{\mathrm{plant}}\mathbf{g} \geq \rho \sum \mathbf{p}_{\mathrm{plant}} \quad \forall i \in P_{peek}$$

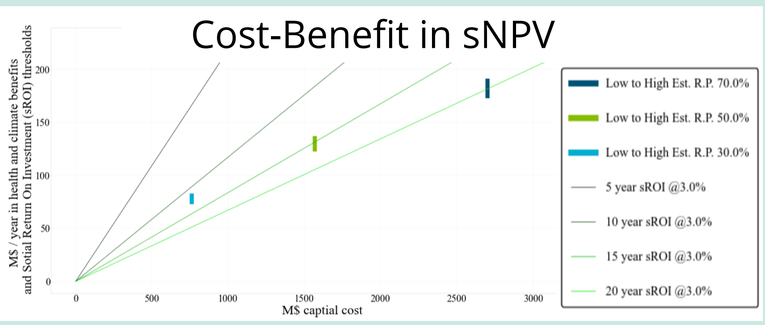
$$\mathbf{x} \in \{\boldsymbol{\varsigma}, \mathbf{p}^+, \mathbf{p}^-, \mathbf{g}, P_{BESS}, E_{BESS}\} \in \mathbb{R}^{3n+3} \times [0,1]^{n\prime}$$

Minimize capital cost, subject to: state-of-energy, powerplant replacement fraction, and es power / energy limits.

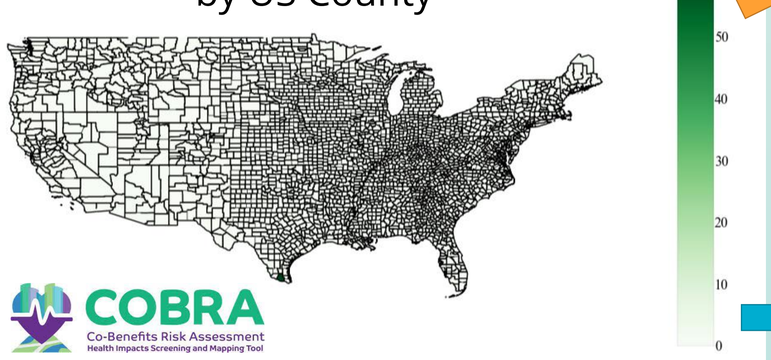
Results

Results for Calpine Hidalgo Energy Center

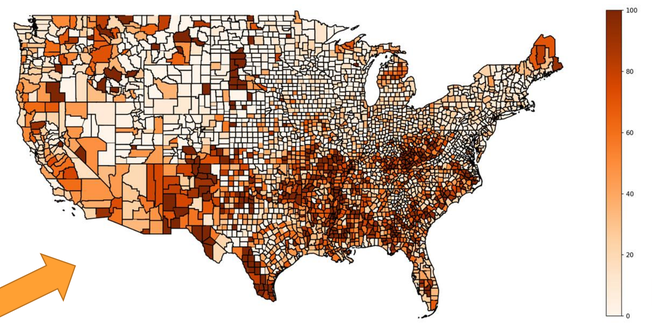
Cost-Benefit in sNPV



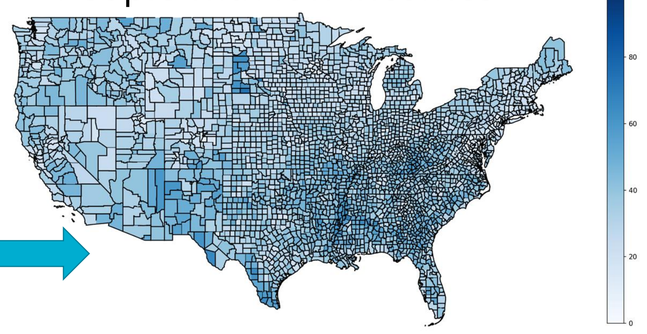
Distribution of Health Benefits by US County

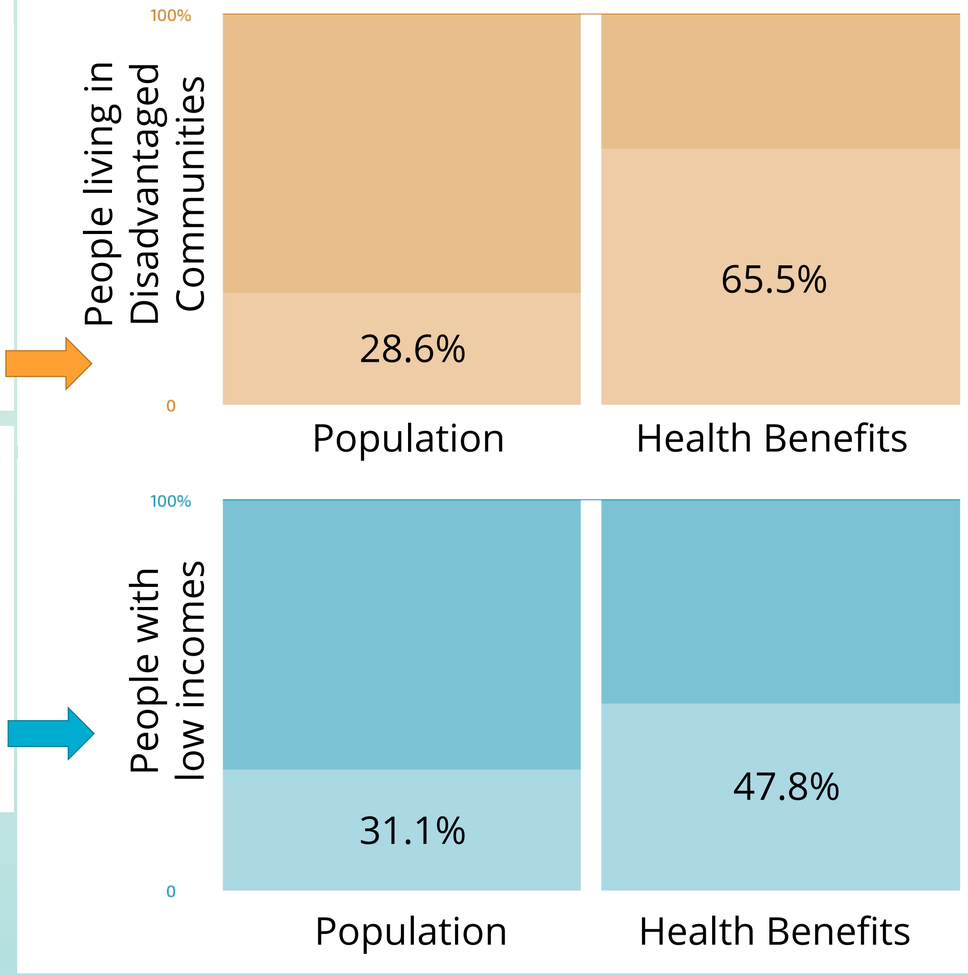


People living in disadvantaged communities



People with low incomes





References

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EPA CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA): www.epa.gov/cobra
EPA Field Audit Checklist Tool (FACT): www.epa.gov/airmarkets/field-audit-checklist-tool-fact
NREL PVWatts Calculator: pvwatts.nrel.gov/
Climate and Economic Justice Screening Tool (From Justice40): screeningtool.geoplatform.gov

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