Improving Air Quality with Energy Storage: A New Deployment Strategy for Public Health and Environmental Equity

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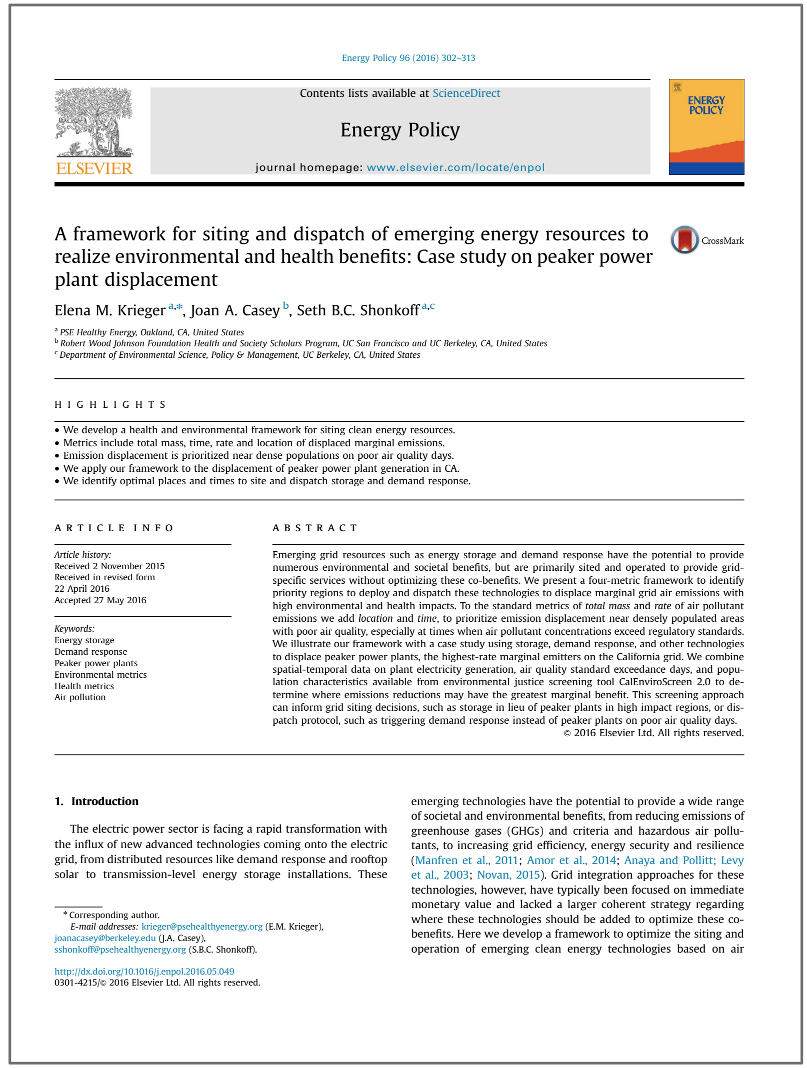
- We **conduct research** on clean energy transitions and on health and environmental impacts of energy resource production and use.
- We **translate** and **disseminate scientific research** so that policymakers, advocacy groups, and other stakeholders can understand and incorporate science into policy decision-making.

A framework for siting and dispatch of emerging energy resources to realize environmental and health benefits:

Case study on peaker power plant displacement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A framework for siting and dispatch of emerging energy resources to realize environmental and health benefits: Case study on peaker power plant displacement

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H I G H L I G H T S

- We develop a health and environmental framework for siting clean energy resources.
- Metrics include total mass, time, rate and location of displaced marginal emissions.
- Emission displacement is prioritized near dense populations on poor air quality days.
- We apply our framework to the displacement of peaker power plant generation in CA.
- We identify optimal places and times to site and dispatch storage and demand response.

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A B S T R A C T

Emerging grid resources such as energy storage and demand response have the potential to provide numerous environmental and societal benefits, but are primarily sited and operated to provide grid-specific services without optimizing these co-benefits. We present a four-metric framework to identify priority regions to deploy and dispatch these technologies to displace marginal grid air emissions with high environmental and health impacts. To the standard metrics of *total mass* and *rate* of air pollutant emissions we add *location* and *time*, to prioritize emission displacement near densely populated areas with poor air quality, especially at times when air pollutant concentrations exceed regulatory standards. We illustrate our framework with a case study using storage, demand response, and other technologies to displace peaker power plants, the highest-rate marginal emitters on the California grid. We combine spatial-temporal data on plant electricity generation, air quality standard exceedance days, and population characteristics available from environmental justice screening tool CalEnviroScreen 2.0 to determine where emissions reductions may have the greatest marginal benefit. This screening approach can inform grid siting decisions, such as storage in lieu of peaker plants in high impact regions, or dispatch protocol, such as triggering demand response instead of peaker plants on poor air quality days.

1. Introduction

The electric power sector is facing a rapid transformation with the influx of new advanced technologies coming onto the electric grid, from distributed resources like demand response and rooftop solar to transmission-level energy storage installations. These emerging technologies have the potential to provide a wide range of societal and environmental benefits, from reducing emissions of greenhouse gases (GHGs) and criteria and hazardous air pollutants, to increasing grid efficiency, energy security and resilience (Manfren et al., 2011; Amor et al., 2014; Anaya and Pollitt; Levy et al., 2003; Novan, 2015). Grid integration approaches for these technologies, however, have typically been focused on immediate monetary value and lacked a larger coherent strategy regarding where these technologies should be added to optimize these co-benefits. Here we develop a framework to optimize the siting and operation of emerging clean energy technologies based on air

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Capturing co-benefits of emerging energy technologies

- Development and deployment of new energy technologies like **storage, demand response, and solar** are growing rapidly.

- These technologies have potential **environmental, health and equity benefits** that are not being fully realized.

- Current policy and regulatory objectives are trying to determine **how to value** these technologies, but focus on direct grid benefits (e.g. deferring upgrades).

Goal: develop approach to value and realize co-benefits

Power plants, air quality, and human health

- **Pollutant emissions:** power plants emit carbon dioxide (CO_2), criteria pollutants (PM, NO_x, SO_x), and toxic and hazardous air pollutants.
- **Criteria pollutants** can contribute to the formation of ozone and particulate matter, which have broad regional impacts.
- **Health impacts of ozone and particulate matter** include asthma exacerbations, increased risk of respiratory infections, and premature death, particularly in the elderly and those with existing heart and lung disease.
- **Plants tend to be disproportionately located in communities with low socioeconomic status and a high cumulative burden** of multiple social and environmental stressors. These communities are often more vulnerable to the impacts of environmental stressors.

Current policy approaches

Emission limits

- Technology emission standards
- Cap-and-trade
- Emission taxes and fees

Clean energy targets

- Renewable portfolio standards
- Energy storage targets
- Rooftop solar incentives

How do we realize co-benefits?

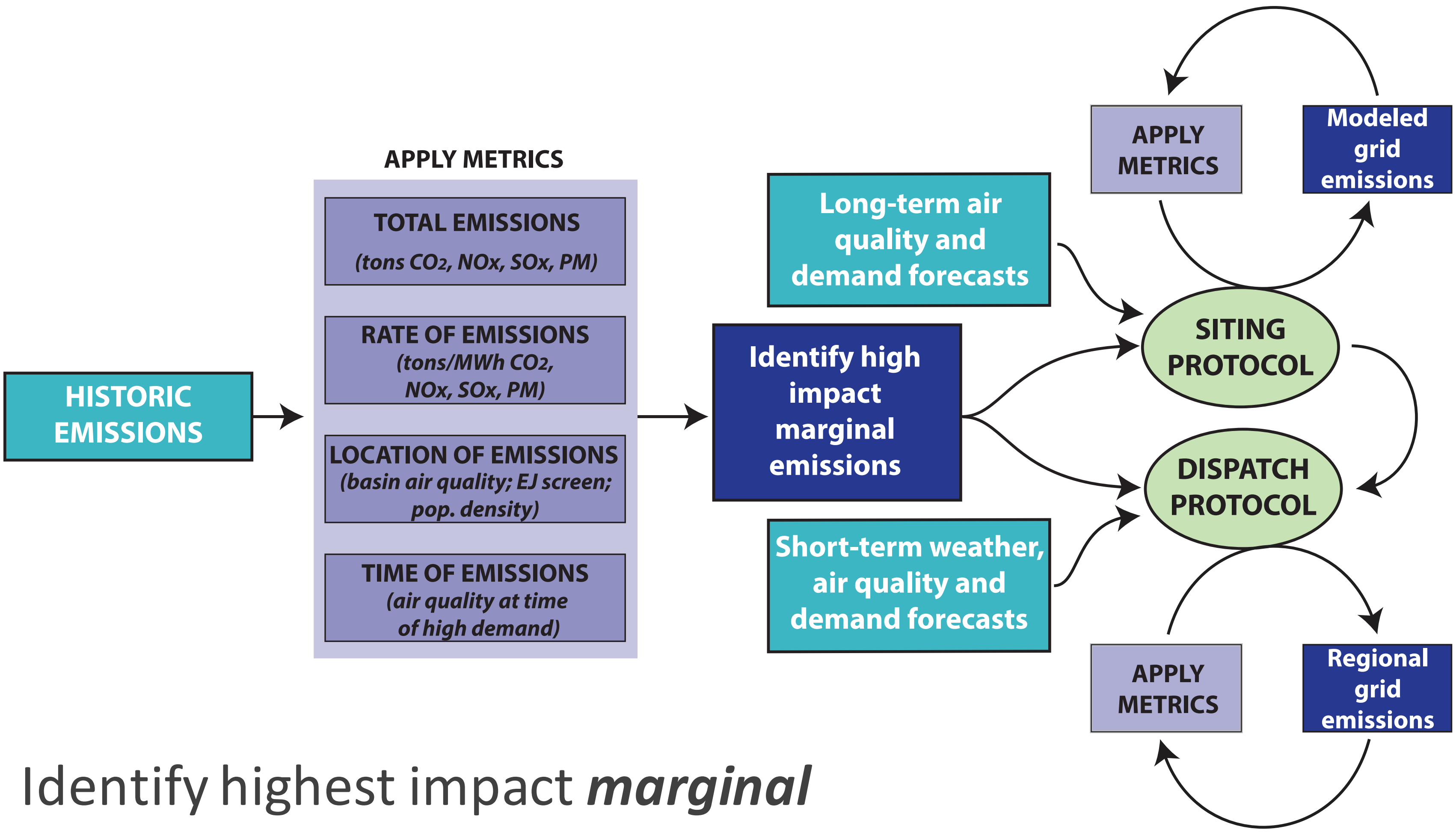
Add energy storage (solar, etc.) to the grid ***where*** and operate ***when*** it will have the greatest co-benefits.

Framework of metrics to value emission reductions

- **Total mass** of emissions (CO_2, NO_x, SO_x)
- **Rate** of emissions (tons per MWh)
- **Time** of emissions (poor air quality days)
- **Location** of emissions (near vulnerable populations)

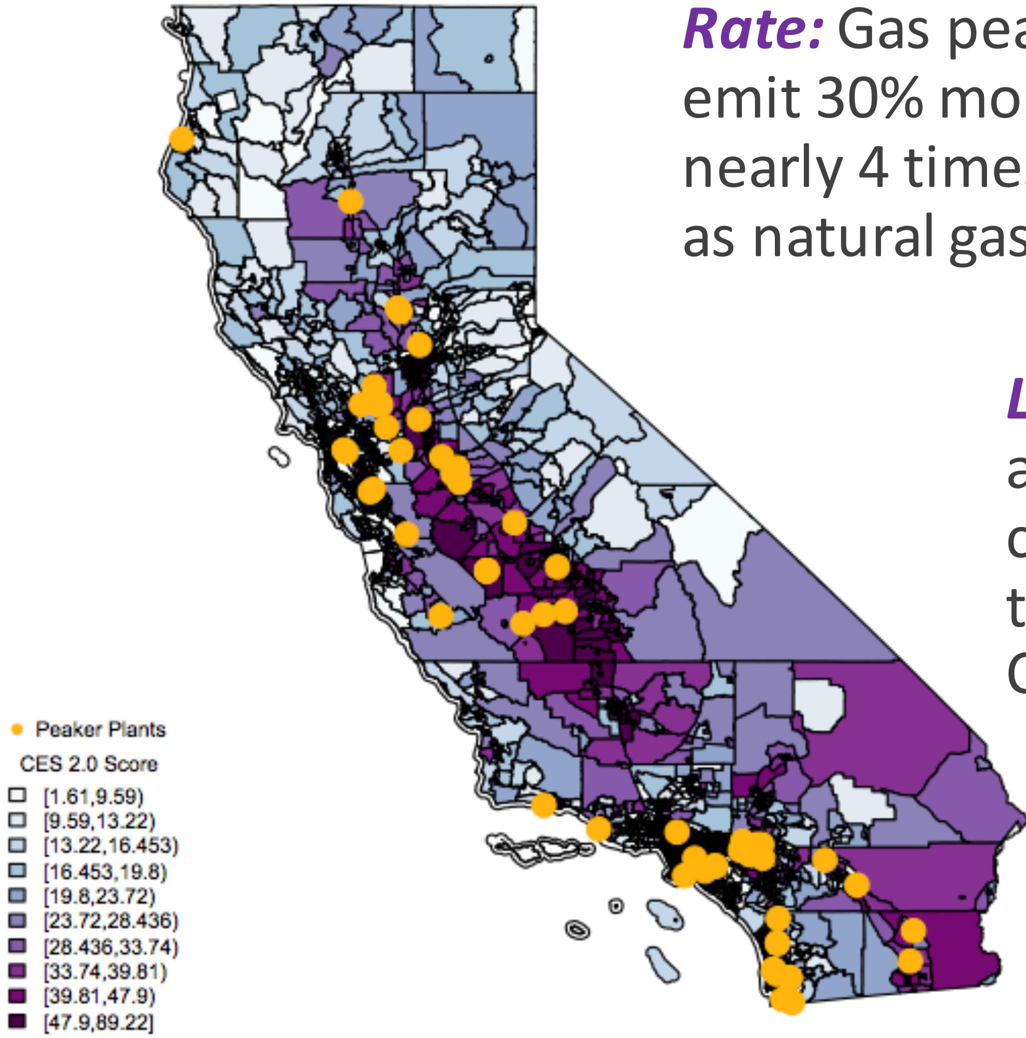
Example
• Dispatch ***demand response*** on poor air quality days to reduce emissions from the most polluting power plants near disadvantaged and vulnerable communities.

Using metrics for siting, dispatch



Identify highest impact ***marginal emissions*** and reduce them through siting and dispatch of clean technologies.

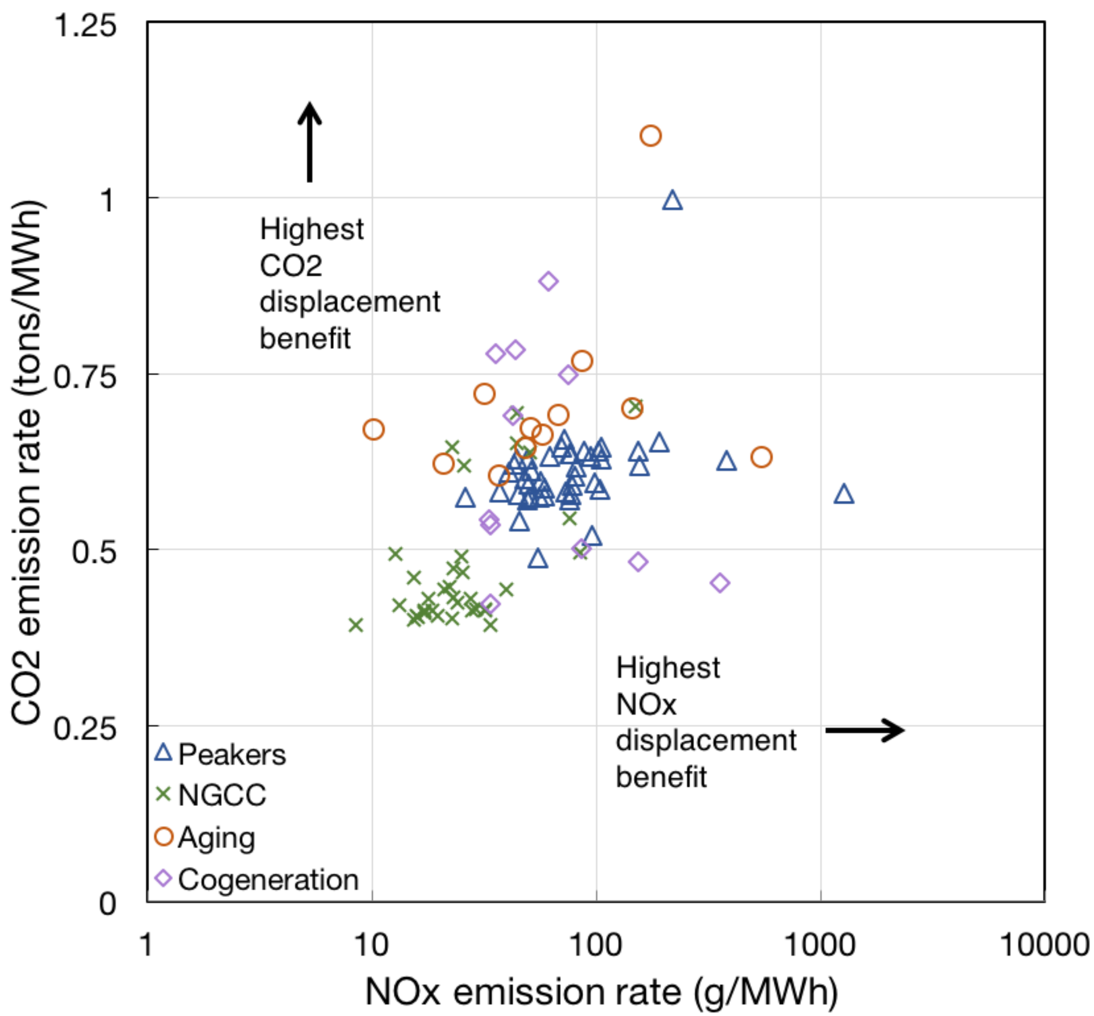
Case study: CA peaker plants



Rate: Gas peaker plants in California emit 30% more CO_2 per MWh and nearly 4 times as much NO_x per MWh as natural gas combined cycle plants.

Location: 84% of peakers are located in areas considered more vulnerable than the median (using CalEnviroScreen).

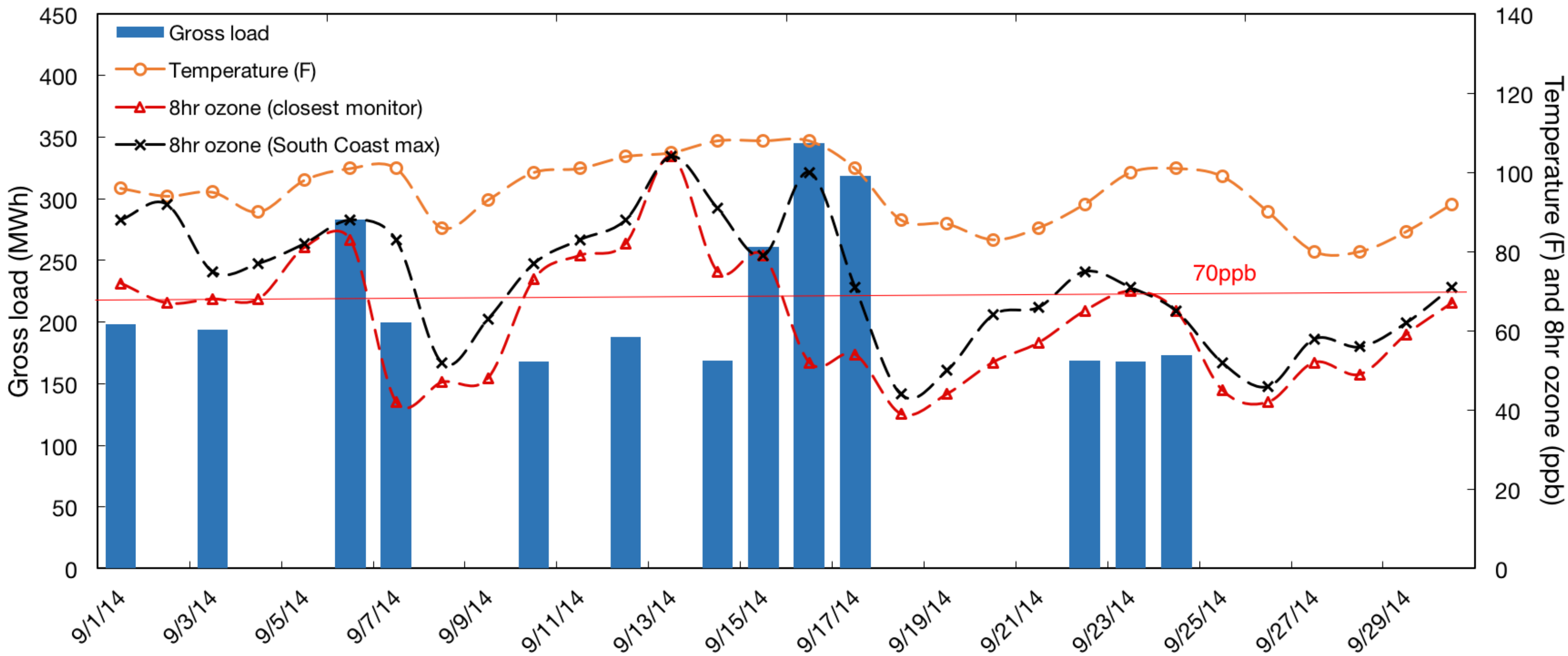
Emission **rate** and plant type



Of CA power plants:

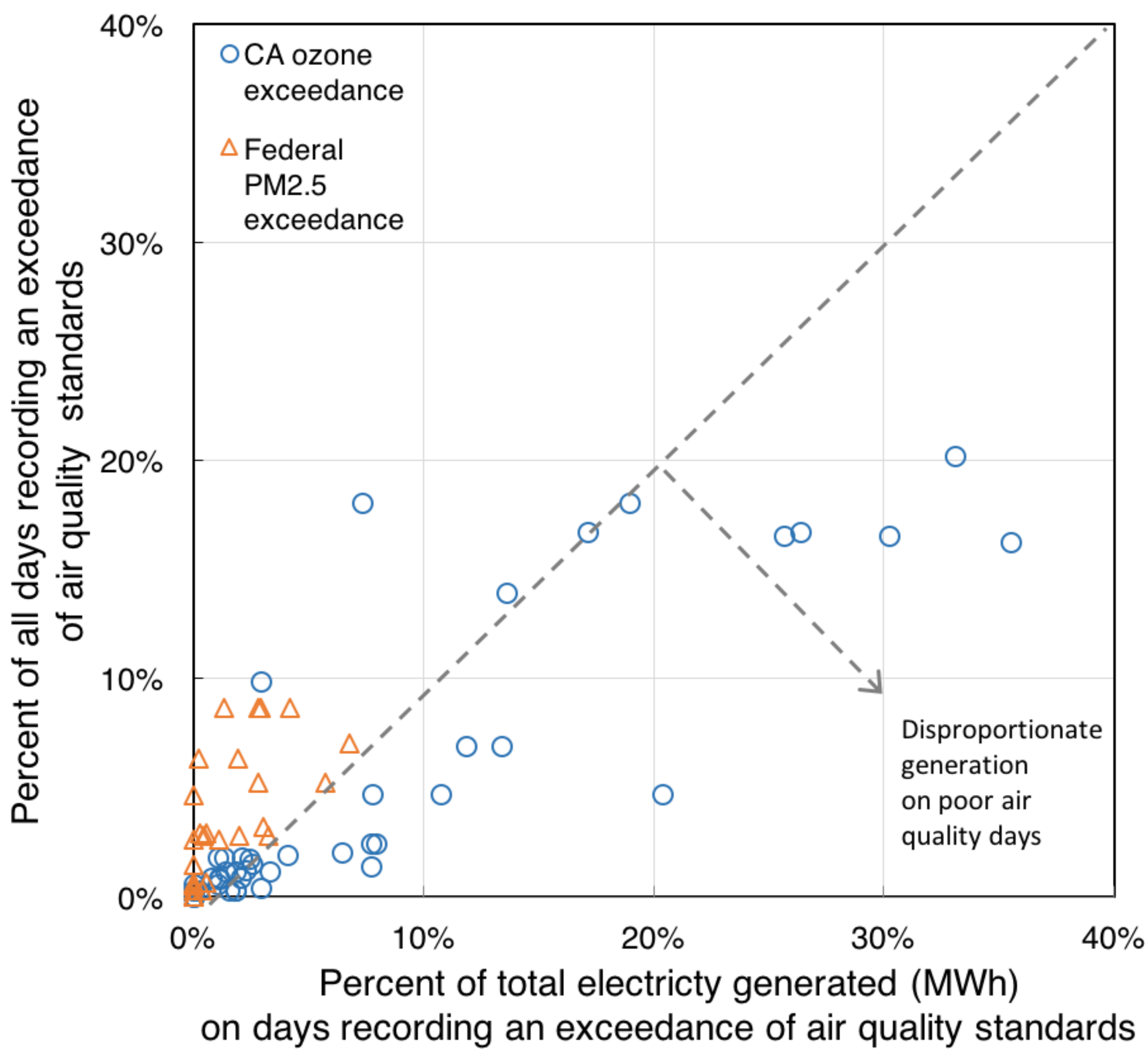
- **NGCC** have lowest emission rates
- **Cogen** have wide range of emission rates, but heat value is not reflected here
- **Aging** gas steam plants have high emission rates, but are being phased out
- **Peaker** power plants have high emission rates

Time of generation and air quality



What percent of the time that the plant is generating electricity does local or basin-wide air quality exceed EPA National Ambient Air Quality Standards for ozone or particulate matter pollutant concentrations?

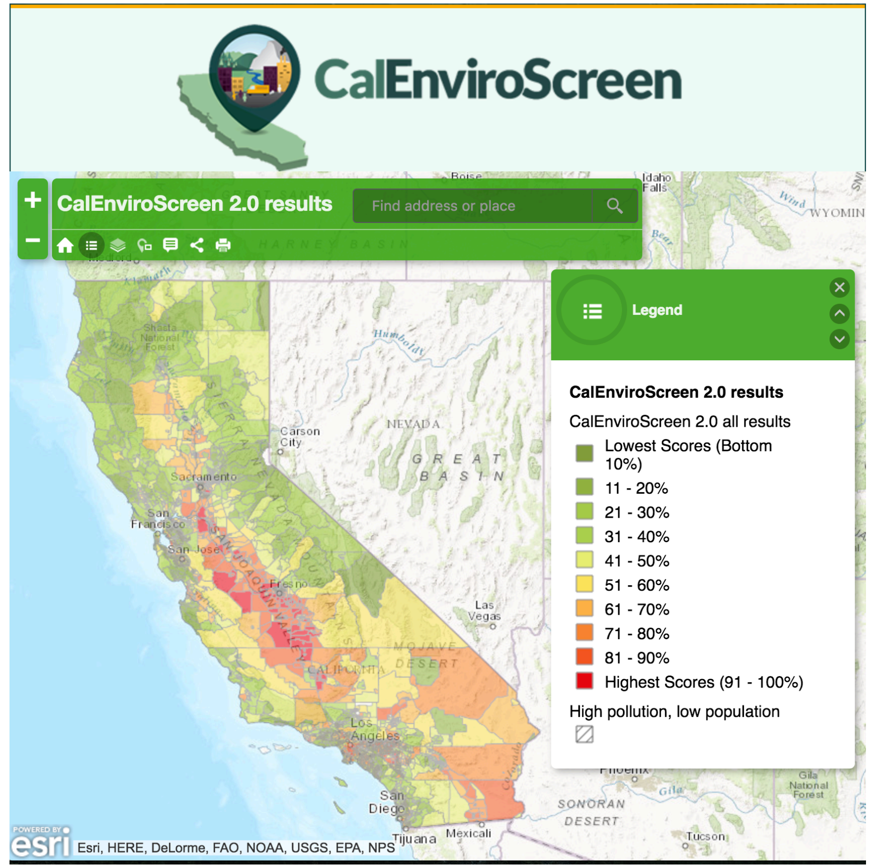
Time of generation and air quality



Many peaker plants in California generate electricity disproportionately on days that exceed National Ambient Air Quality Standards.

EJ screening tools

- Environmental justice (EJ) screening tools integrate demographic data with cumulative environmental burden to yield a score for each census tract.
- California, when siting power plants, has historically looked at demographic information for populations within **six miles** of plants.
- The EPA, for the Clean Power Plan, assessed populations within **three miles** of plants using EJSCREEN.
- **Here, we use CA OEHHA's CalEnviroScreen 2.0 tool to assess populations within six miles of power plants.**



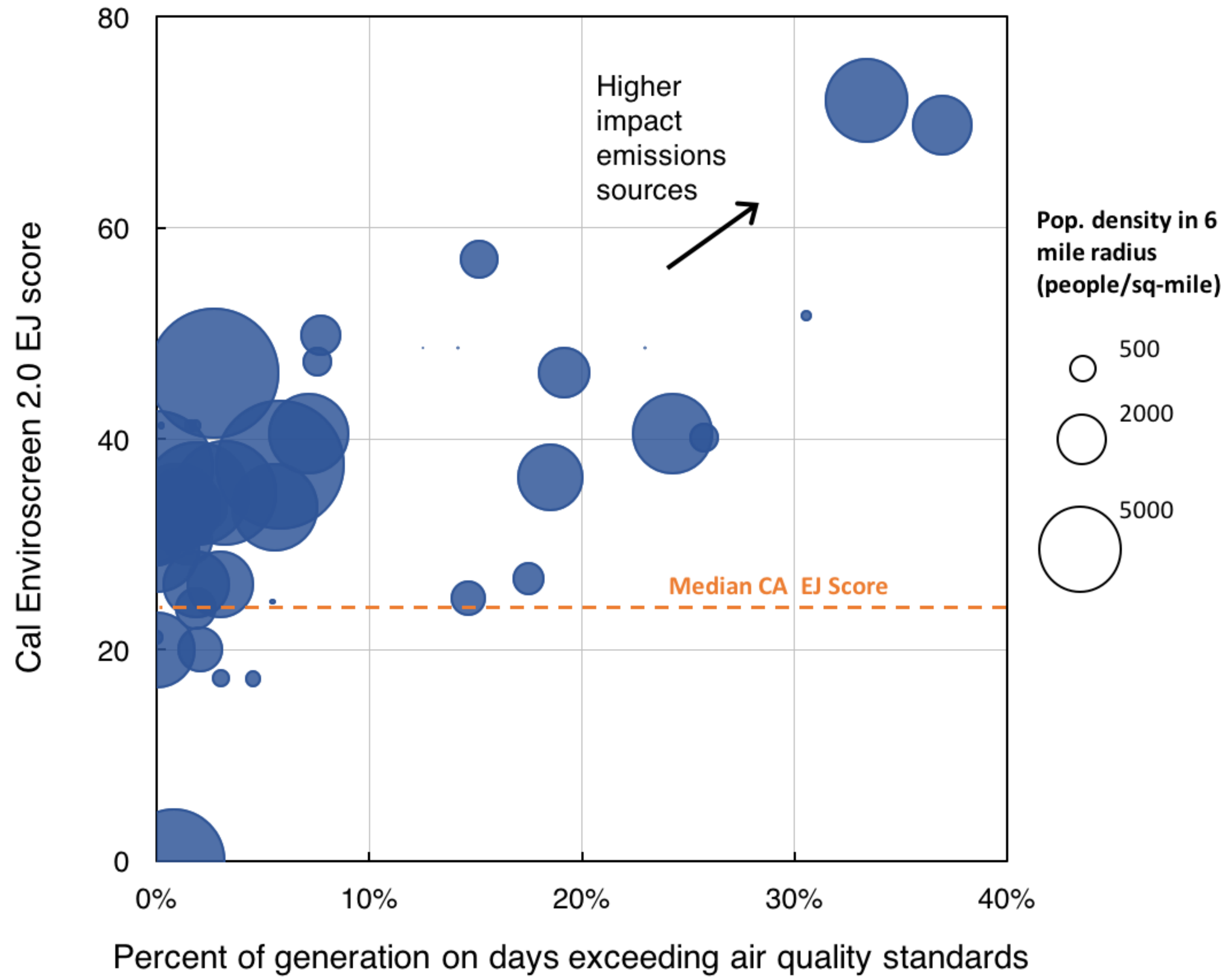
http://oehha.ca.gov/calenviroscreen

EPA EJSCREEN

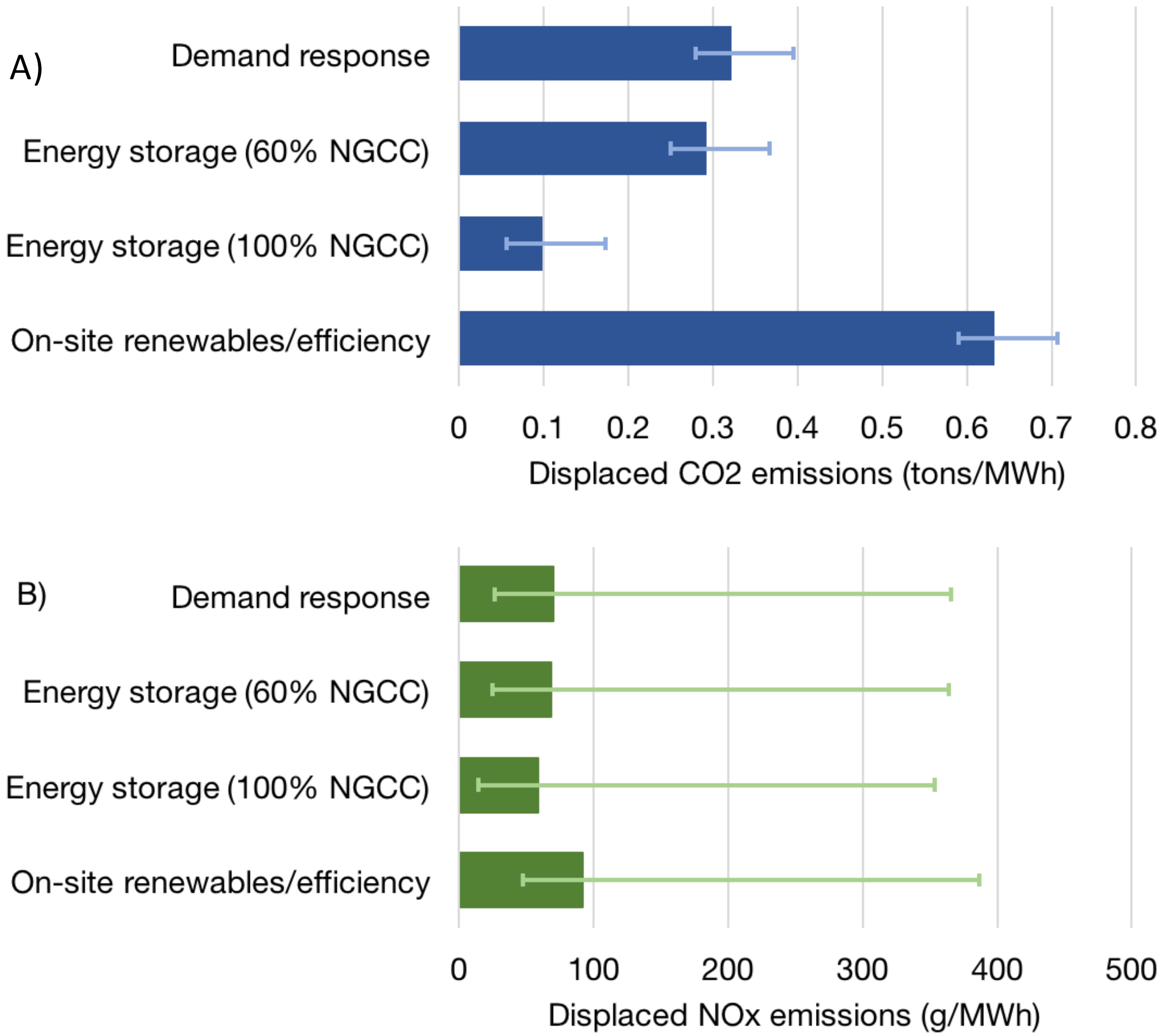
https://www.epa.gov/ejscreen

Location: EJ and air quality

Site clean energy technologies in the same substation footprint as high-impact power plants – or in lieu of new plants modeled to have a high impact.



Emission reductions by tech



Range bar represents 5th to 95th percentile of CA peaker plant emission rates.

Wide range in NO_x emission rates; greatest reductions from displacing emissions at plants near 95th percentile.

Extending the framework

- Our case study is constrained to the displacement of emissions from a single class of power plants in California. Full application would include **power sector modeling across all plants** in a region or state.
- We only analyzed emissions, but full **air quality dispersion modeling** would provide greater detail on emission impacts.
- Peaker plants likely generate at the same time as other plants, meaning there may be a benefit to analyzing the **combined impact of multiple emitters** in the same area.
- This approach can extend to **the generation used to charge energy storage** or meet displaced demand response loads.
- Additional benefits from addressing **chronic air quality impacts** in addition to acute pollutant concentrations**.**

Applying the framework

- **In California:** potential for storage or demand response to be **sited** or **dispatched** in the same substation footprint as peakers with high marginal emissions.
- **Outside of California:** may be **even higher benefit to displacing coal or oil emissions** – but may need a different mix of technologies that operate at the same time as these plants.
- **Example:** Kerl *et al.* (2015) modeled that selectively dispatching natural gas in lieu of coal in Georgia at times when particulate matter formation was expected to be most rapid would have outsized public health benefits. **Emerging resources could achieve similar or greater benefits.**
- **Caveat:** storage could have a negative impact if charged with coal generation, hence the need to carefully measure and assess which marginal emissions will be displaced.

General policy applications

- **Require measurements and reporting** of emission impacts from solar, storage targets, demo projects, and long-term procurement modeling, and **model air quality impacts.**
- Prioritize **clean technologies in lieu of new fossil-fired plants** in long-term procurement planning, particularly in areas that rank high on metrics (e.g. extend "preferred resources pilot" to these areas), and prioritize them in the resource loading order.
- Use **environmental conditions to dispatch** storage, demand response (e.g. extend "spare the air" days to generation).
- Invest cap-and-trade funding in **emerging technologies that benefit vulnerable communities** both directly and indirectly through displacing emissions.
- **Price criteria pollutants higher in specific locations/at specific times** rather than permitting the current broad trading mechanisms.

Example policy applications

- **CA AB32/SB 535:** investment of cap-and-trade funding for the benefit of disadvantaged communities
- **CPUC locational net benefits analysis (LNBA):** integrated planning and valuation for distributed resources
- **NY Reforming the Energy Vision:** extend upon the "social cost of carbon" analysis
- **Clean Power Plan/Clean Energy Incentive Program (CEIP):** incorporate into multi-pollutant approaches to emission reductions or in CEIP targets
- **Aliso Canyon:** use energy storage to reduce reliance on/shift away from natural gas storage

Thank you!

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