Decarbonization will lead to more equitable air quality in California

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California’s Decarbonization Efforts

- California is facing climate change (drought & wildfire), and air pollution
- Significant GHG reduction since 2000
- S-3-05: 80% below 1990 level by 2050 (2005)
- SB 32: 40% below 1990 level by 2030 (2016)
- B-55-18: Carbon neutrality by 2045
- GHG are often co-emitted with various pollutant species
- Co-benefits could be achieved for GHG and air pollution mitigation
Disproportionate pollution burden

• Environmental Justice (Since 1970s): siting of hazardous waste facilities in low-income minority communities.

• Now: disproportionate burden of persistent environmental harms from air pollution in low-income minority communities.

• Statewide PM$_{2.5}$ exposure: Hispanic (13%), African (10%), Asian (6%) higher than White population.

• CalEnviroScreen is a mapping tool that helps identify California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects.

• Communities with the highest 25% environmental index is considered as environmental disadvantages communities (DAC).
Policy effectiveness in addressing Environmental Justice

- Policy evaluation matrix is needed to optimize mitigation pathways.
- Per capita benefits for DAC vs. overall average.

**Suits Index**: \[ \frac{A}{A + B} \]
  - The original Suits index of a public policy is a measure of tax progressiveness.
  - Captures the overall distribution of policy impacts across the entire spectrum of communities.
  - Normalized index for different polices regardless of the absolute total value.
  - Larger Suits Index indicates more benefits towards DAC.

- Accumulative policy cost saving analysis for long-term climate pathways at community (census tract) level.

Suits, D. B. Measurement of Tax Progressivity. *Am. Econ. Rev.* 67, 747–752 (1977).
Decarbonization Pathways

**Pathway Modeling:** E3 PATHWAYS model

Key: Tradeoffs between the use of electrification and renewable gaseous fuels to decarbonize residential and commercial buildings.

| Category                        | Reference (REF)                  | High Building Electrification (HBE) | No Building Electrification (NBE) |
|---------------------------------|----------------------------------|-------------------------------------|----------------------------------|
| GHG Emissions Reduction         | Does not meet state climate goals| 40% by 2030 80% by 2050            | 40% by 2030 80% by 2050          |
| Building Electrification        | None                             | 100% equipment sales by 2040        | None                             |
| Pipeline Biomethane             | None                             | 25%                                 | 16%                              |
| Pipeline H₂                     | None                             | None                                | 7%                               |
| Pipeline SNG                    | None                             | None                                | 21%                              |
| Electric and Fuel Cell Trucks   | Low                              | Medium                              | High                             |
| Advanced Biofuels               | 71 TBTU                          | 478 TBTU                            | 533 TBTU                         |
| Light-Duty Vehicle Electrification | Medium                         | High: 100% Sales by 2035            | High: 100% Sales by 2035          |
| CNG Trucks                      | Displace some diesel trucks      | Displace most non-electrified diesel trucks | Displace most non-electrified diesel trucks |
Decarbonization Pathways

- More GHG in Buildings for NBE.
- Accumulate Cost:
  - HBE: 245 $billion
  - NBE: 304-464 $billion

| Industry Learning     | Conservative | Optimistic           |
|-----------------------|--------------|----------------------|
| Electrolysis Technology (Hydrogen) | Upgrade between 2030-2040 | Upgrade between 2020-2030 |
| CO₂ Source (Methanation) | Limited bio-CO₂ coproduct | Entirely bio-CO₂ coproduct |
| Energy Source         | California Solar ($26/MWh) | Midwest Wind ($40/MWh) |
Impact on air quality

- PATHWAY emissions projection: SMOKEv4.7 (CARB 2012 Inventory)
  - HBE results to larger emission reductions except for NH$_3$

- Air quality modeling: CMAQv5.2 (SAPRC07 & 2012 meteorology)
  - Largest reduction in SoCAB and San Joaquin Valley
Health benefits

- Exposure Assessment: BenMAP-CEv1.5
  - Similar distribution
  - HBE has more health benefits
  - Linear interoperation is used for cumulative health benefits estimation.
- VSL: $10.1 million (2020$)

![Projected incidence graph]

- High-Building Electrification: $920 billion
- No-Building Electrification: $723 billion
Impact on equality

- HBE: 28.9% for DACs & NBE: 29.3% for DACs
- Suits index: HBE < NBE
- More benefit for disadvantages communities in NBE than HBE.
- Income distribution highly correlated with environmental justice distribution.
Cost saving assessment

• For 2021-2050: Net Benefits for HBE is $675 billion and for NBE at $259~$419 billion

|                        | HBE scenario | NBE optimistic scenario | NBE conservative scenario |
|------------------------|--------------|-------------------------|---------------------------|
| Population with net benefit | 78%          | 66%                     | 49%                       |
| Census tracts with net benefit | 83%          | 72%                     | 58%                       |
| DAC with net benefit     | 91%          | 87%                     | 75%                       |

[Graphs showing cumulative population and mitigation costs per life saved for different scenarios]
Conclusion

- Air quality co-benefits alone is sufficient to offset the substantial mitigation costs to achieve a low carbon future in California.

- More air quality co-benefits from the HBE (-0.68 μg/m³) than the NBE (-0.59 μg/m³).

- 78% population received a net benefit from the HBE, compares to 49%~66% net benefit from the NBE.

- The NBE outperforms the HBE pathway in environmental justice evaluation, with a suits index of 0.090 (NBE) against 0.084 (HBE).

- Such conflicting results signified the importance of including environmental justice analysis when evaluating climate mitigation policies. The suits index adopted in this study proves to be a good indicator when evaluating the progressiveness in environmental justice related policies.
Thank you!

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