Decarbonization will lead to more equitable air quality in California

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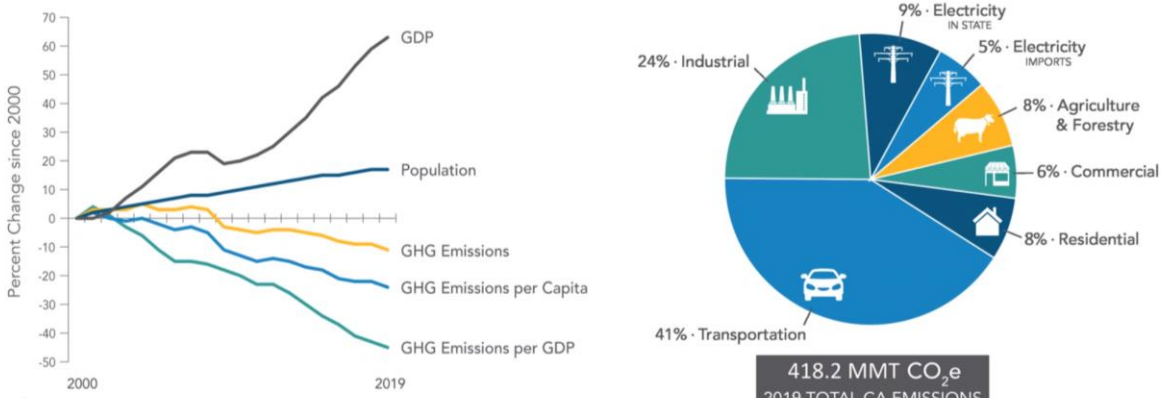
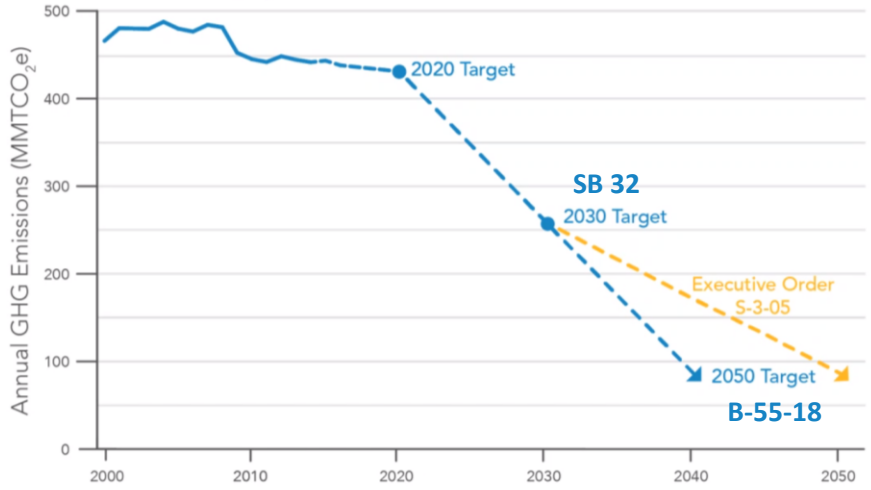
California's Decarbonization Efforts

- 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



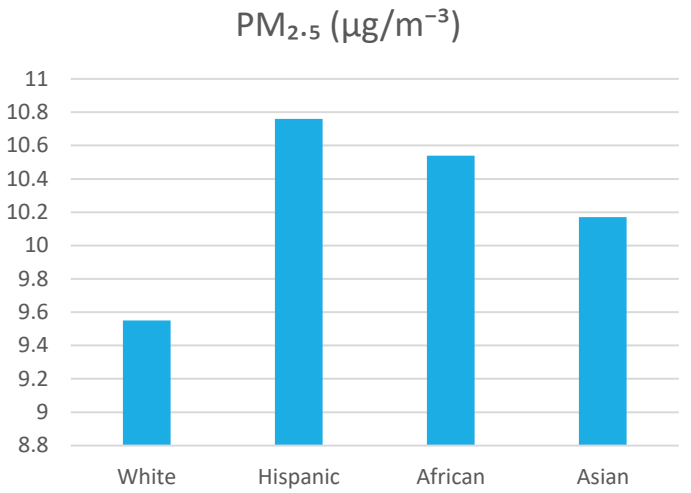
Source: 2021 Edition, California Greenhouse Gas Emission Inventory: 2000-2019



Source: CARB, 2017

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).**



Population weighted exposure
Source: CalEnviroScreen 3.0

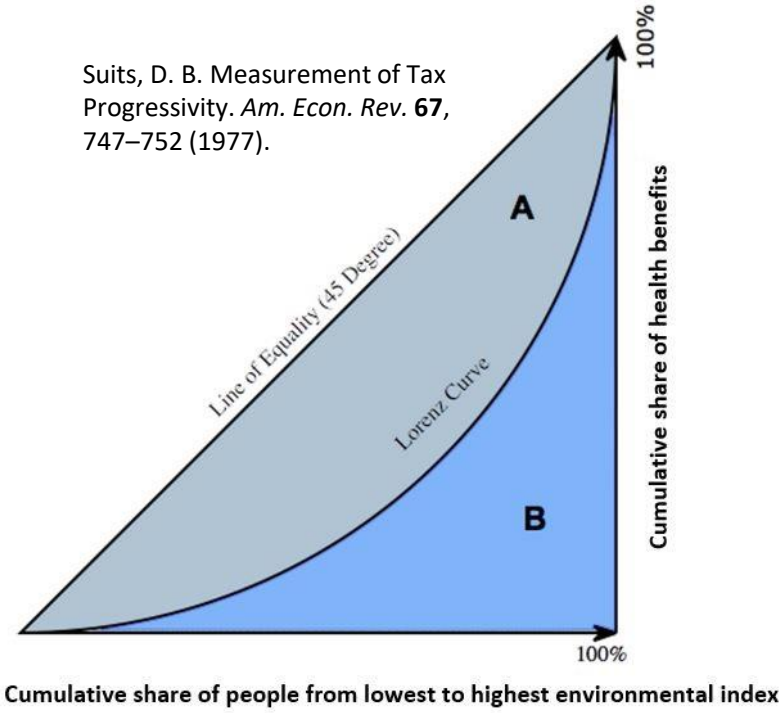
Pollution Burden		Population Characteristics	
Exposure Indicators	Environmental Effects Indicators*	Sensitive Population Indicators	Socioeconomic Factor Indicators

OEHHA
California Office of Environmental Health Hazard Assessment

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).



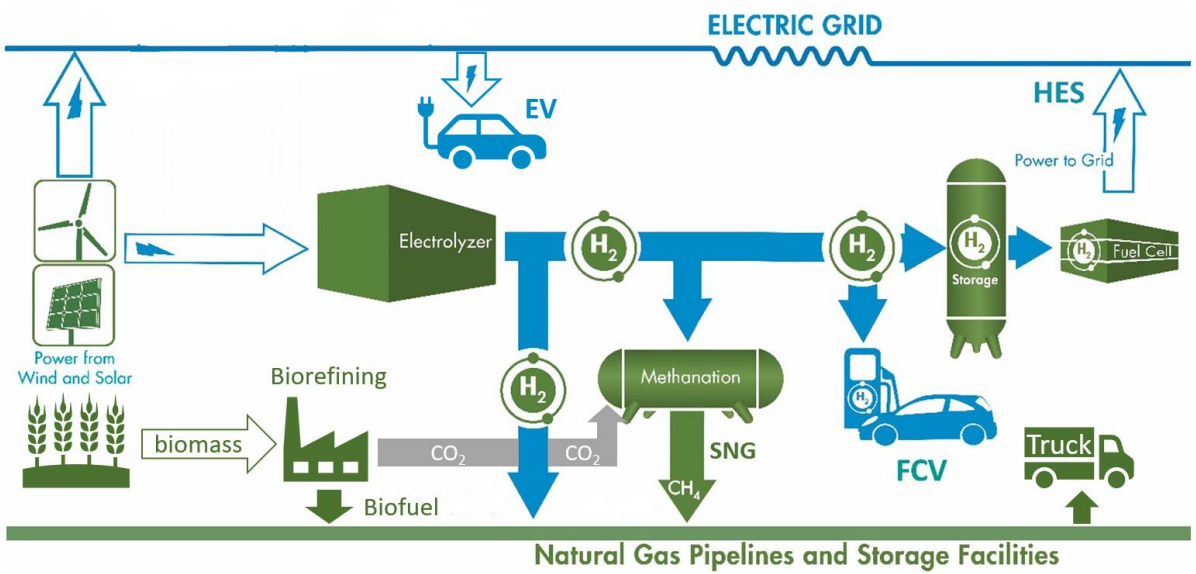
Decarbonization Pathways

- Pathway Modeling: E3 PATHWAYS model

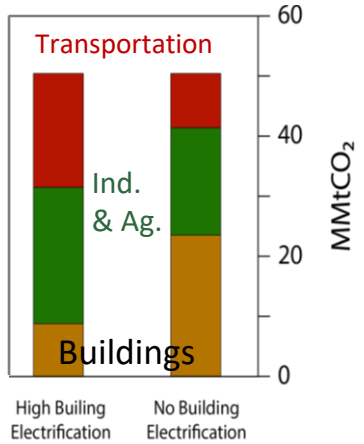
Key: Tradeoffs between the use of electrification and renewable gaseous fuels to decarbonize residential and commercial buildings.

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 H_2	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

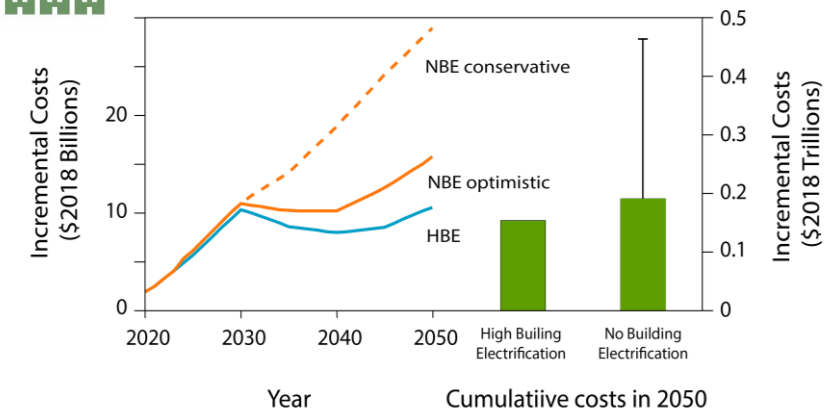


- More GHG in Buildings for NBE.
- Accumulate Cost:
  - HBE: 245 $billion
  - NBE: 304-464 $billion



Economywide annual net costs relative to the current policy reference scenario

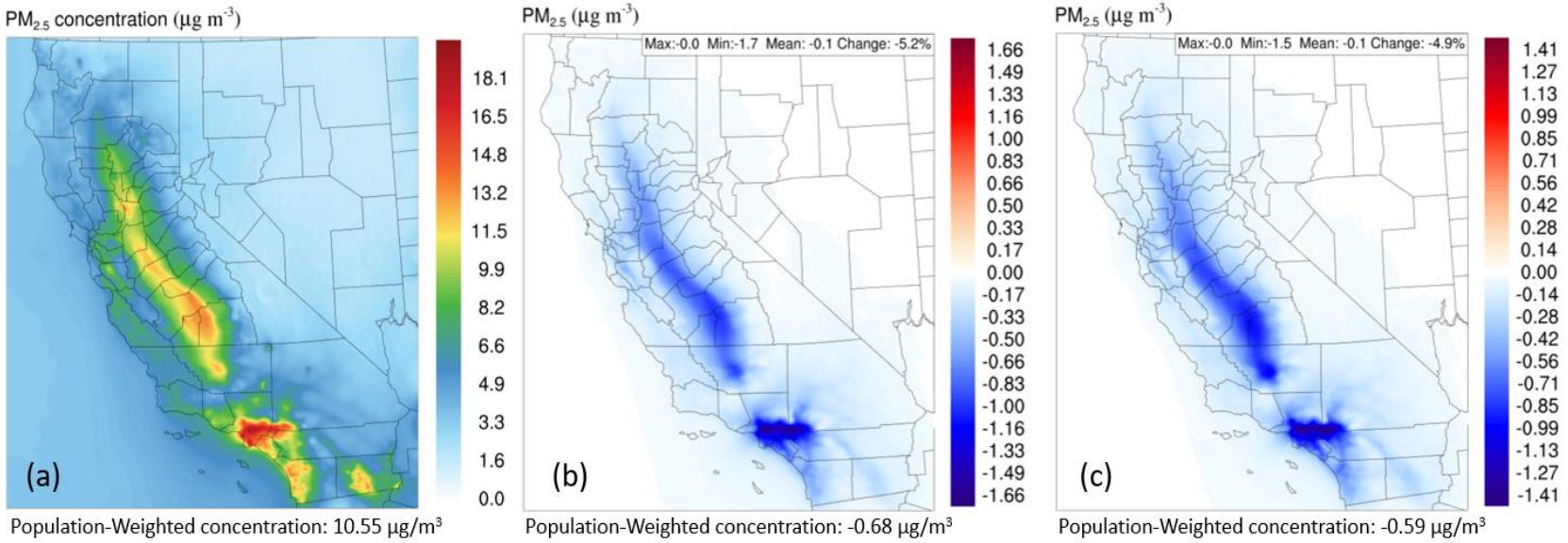
Scenario in 2050

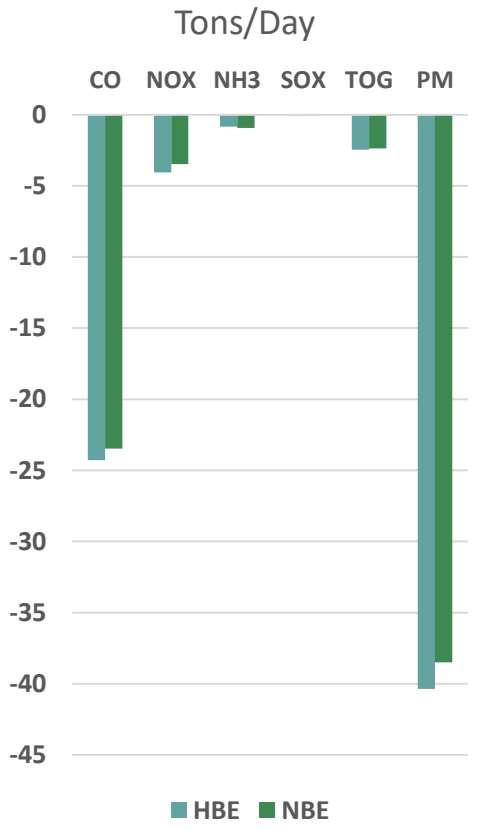


Industry Learning	Conservative	Optimistic
Electrolysis Technology (Hydrogen)	Upgrade between 2030-2040	Upgrade between 2020-2030
CO_2 Source (Methanation)	Limited bio-CO_2 coproduct	Entirely bio-CO_2 coproduct
Energy Source	California Solar ($26/MWh)	Midwest Wind ($40/MWh)

Impact on air quality

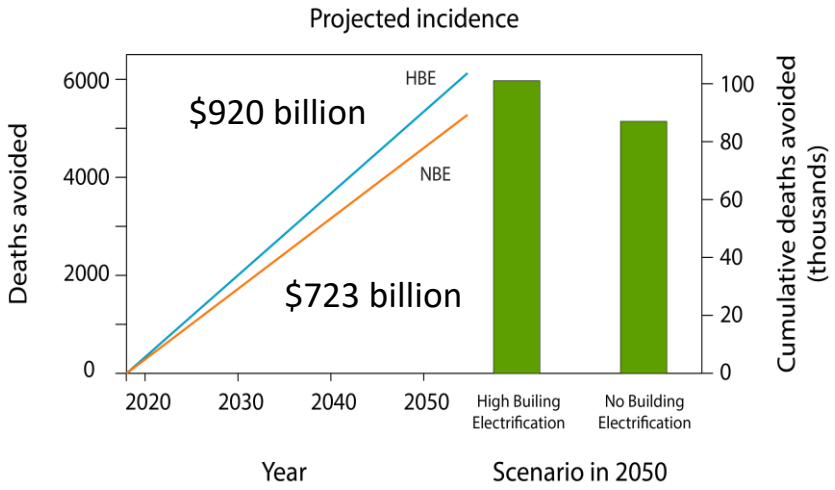
- PATHWAY emissions projection: SMOKEv4.7 (CARB 2012 Inventory)
  - HBE results to larger emission reductions except for NH_3
- Air quality modeling: CMAQv5.2 (SAPRC07 & 2012 meteorology)
  - Largest reduction in SoCAB and San Joaquin Valley

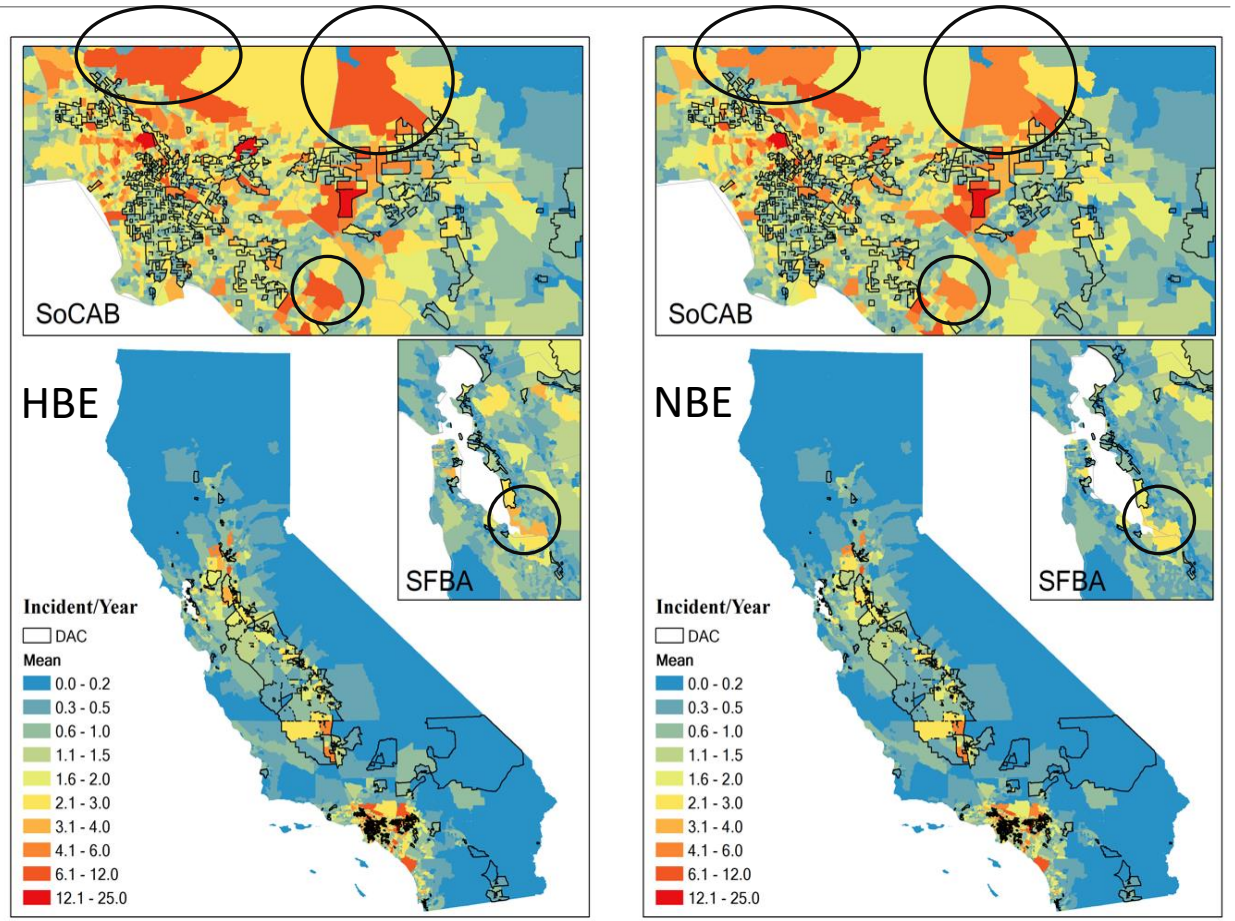




Health benefits

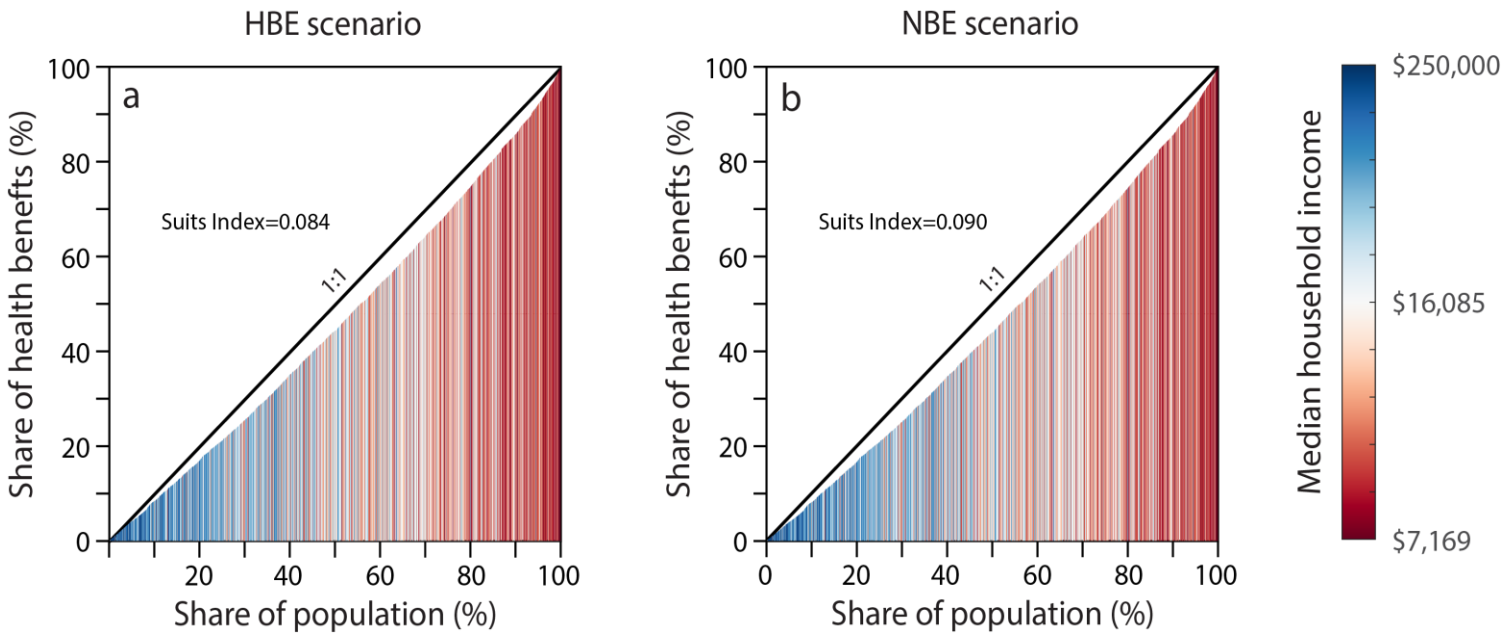
- Exposure Assessment: BenMAP-CEv1.5
  - Similar distribution
  - HBE has more health benefits
  - Linear interoperation is used for cumulative health benefits estimation.
  - VSL: $10.1 million (2020$)





Impact on equality

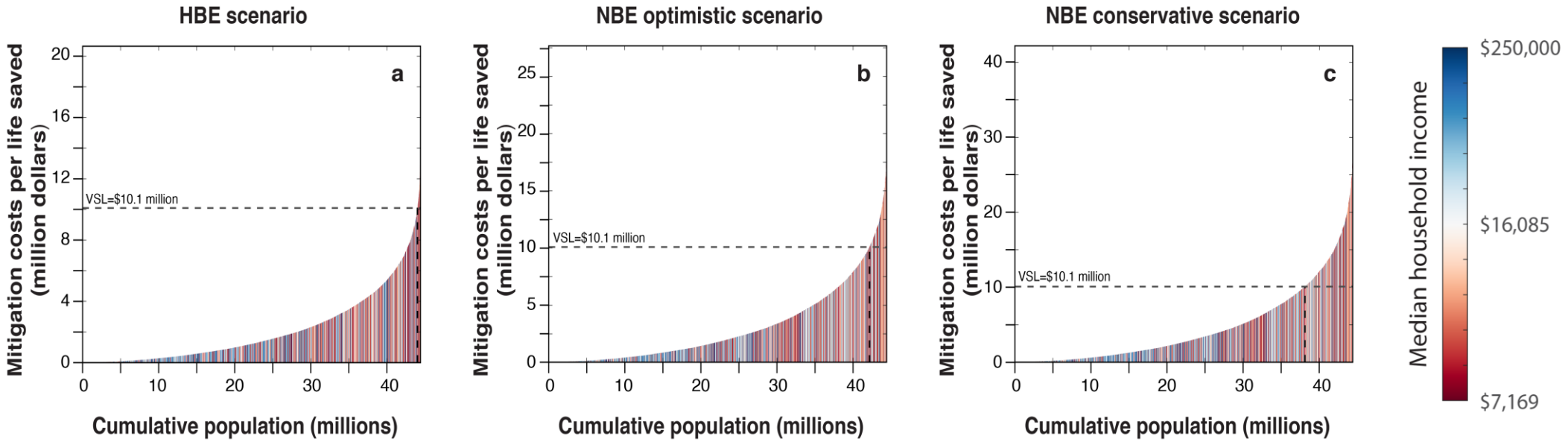
- HBE: 28.9% for DACs & NBE: 29.3% for DACs
- Suits index: HBE < NBE
- More benefit for disadvantages communities in NBE than HBE.
- Income distribution highly correlated with environmental justice distribution.



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 %



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 $\mu g/m^3$) than the NBE (-0.59 $\mu g/m^3$).
- 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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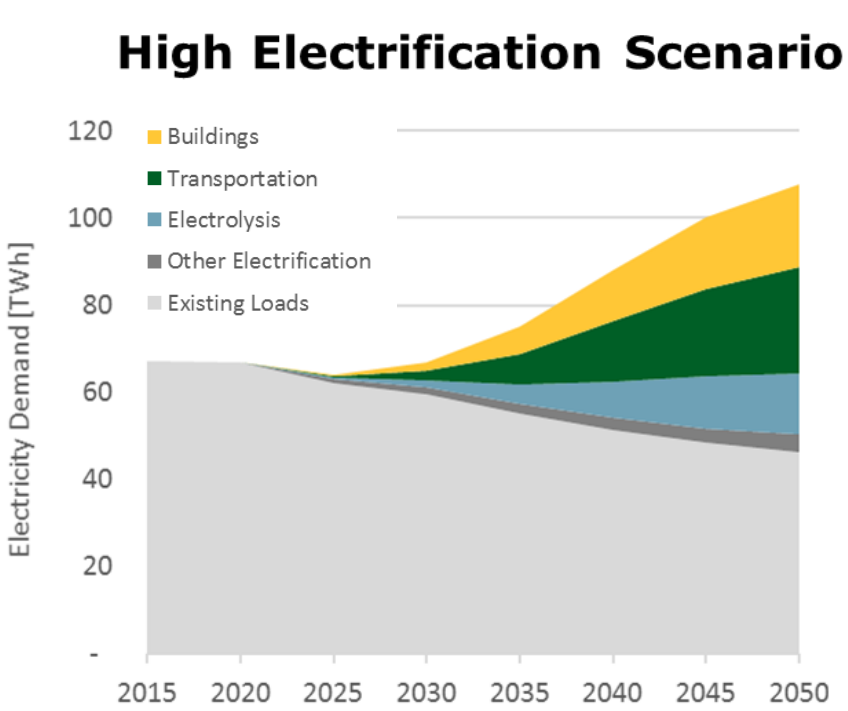

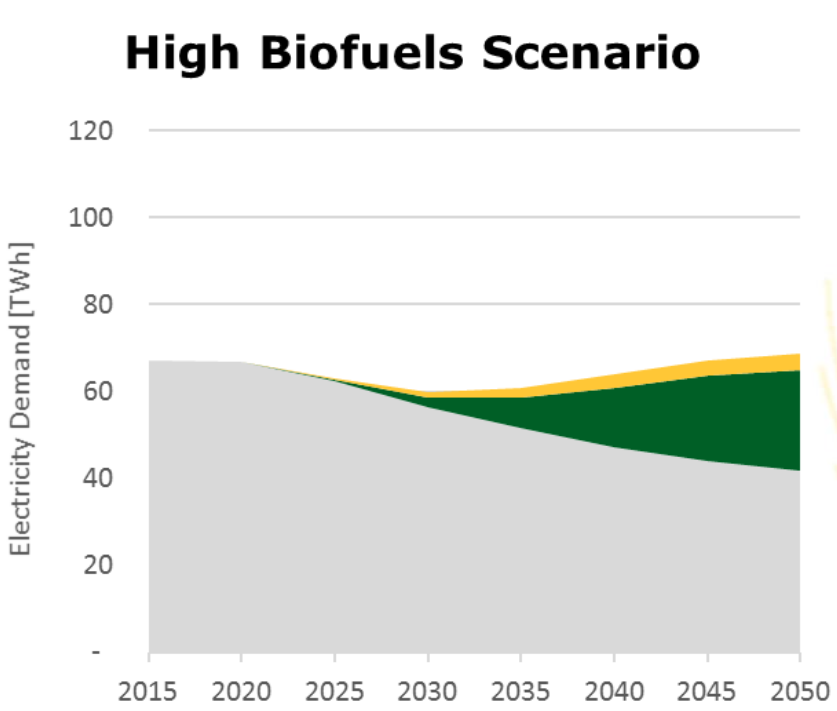

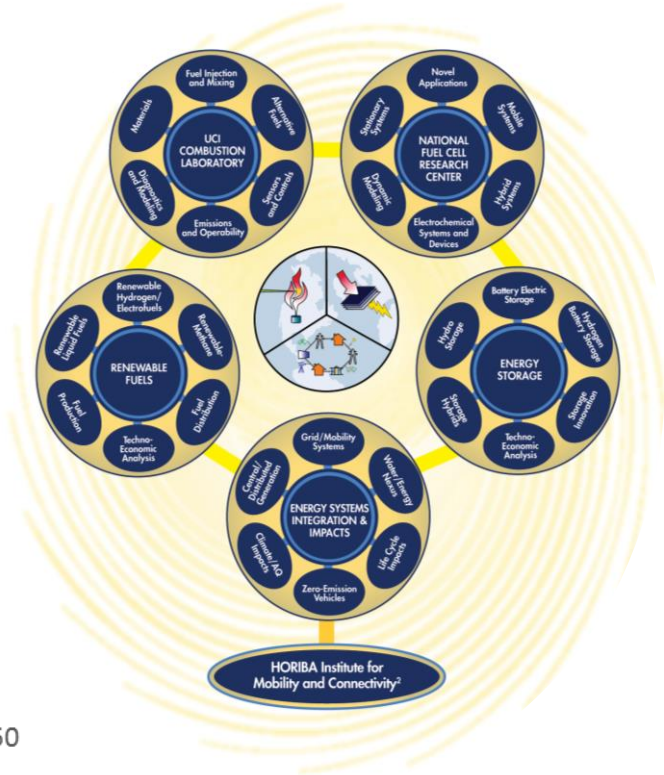

Source: E3