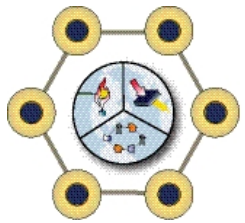
Air Quality and Public Health Benefits of the DRAFT Scoping Plan Scenarios



ADVANCED POWER & ENERGY PROGRAM
UNIVERSITY of CALIFORNIA · IRVINE

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Draft Scoping Plan Air Quality Workshop

April 20, 2022

Air Quality and Public Health Benefits

- **Provide a detailed assessment of the air quality and public health benefits in California that result from implementing the Scoping Plan**
  - Quantify and value health benefits from improvements in outdoor air pollution
  - Provide insight into health savings within socially and economically disadvantaged communities (DAC)

- **Draft Scoping Plan**
  - Utilize ***episodic air quality modeling*** to provide comparative results for the scenarios under consideration to support the Scoping Plan scenario selection process
  - Feasibly allows for the assessment of multiple scenarios
  - Provide air quality and public health metrics than can be used to compare the relative benefits of the scenarios under consideration

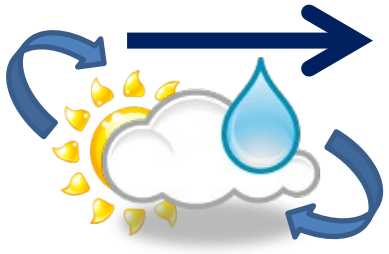
Assessing Air Quality

2.

Atmospheric Chemistry + **Transport** = **Air Pollution**

$NO_x + VOC + Sunlight \rightarrow Ozone$

$NO_x/SO_x/VOC \rightarrow PM_{2.5}$



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1.

Emissions

NO_x SO_2 VOC PM CO

Two kinds of pollutants in the atmosphere:

- **Primary (Emitted)**
- **Secondary (Formed)**

Secondary $PM_{2.5}$ is particularly important for health impacts

=

Health Impacts

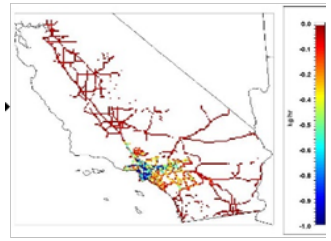
3.

Approach

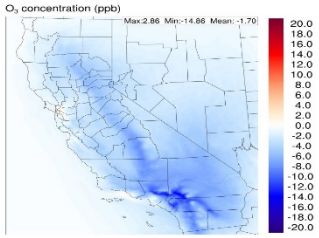
- **Develop and utilize an integrated modeling approach to comprehensively determine and spatially resolve impacts on pollutant emissions, air quality, and public health**
  - Scope and scale of the assessment requires regional-scale modeling

Scoping Plan Scenarios
- Project technologies and fuels via PATHWAYS

Pollutant Emissions
- Resolve direct emission changes

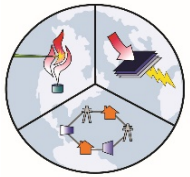


Air Quality Impacts
- Episodic differences in atmospheric pollution levels



Health Impacts
- Quantify and value the short-term health benefits

Disadvantaged Communities
- Insight into implications for environmental equity

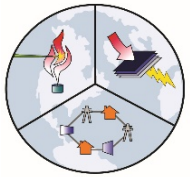


1. Emissions Modeling

- **Air quality modeling requires the development of a highly detailed pollutant emissions inventory representative of each Scoping Plan scenario in 2045**
  - CARB 2020 serves as a base year inventory* that is projected to 2045 for each scenario
  - Base year inventory contains highly detailed emissions data (total, spatial, temporal) for all sources in California

1. **Map energy shifts in end-use sectors to 2045 from PATHWAYS to base year inventory**
   - Utilize energy consumption, fuel, and technology stock data to project total emissions
   - Additional data sources used to account for other factors that impact emissions
     - Data from Onroad and Offroad EMFAC used to develop changes in emission rates
     - Air district rules controlling emissions from stationary sources
   - Reference scenario benchmarked against CEPAM 2019v1.03

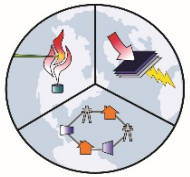
2. **Use Sparse Matrix Operator Kernel Emissions (SMOKE) model to account for locations and activity of emission sources**
   - E.g., traffic patterns and locations of roadways, locations and activity patterns of refineries



*For inventory details: https://ww2.arb.ca.gov/emission-inventory-documentation; https://ww2.arb.ca.gov/california-toxics-inventory

1. Emissions Modeling

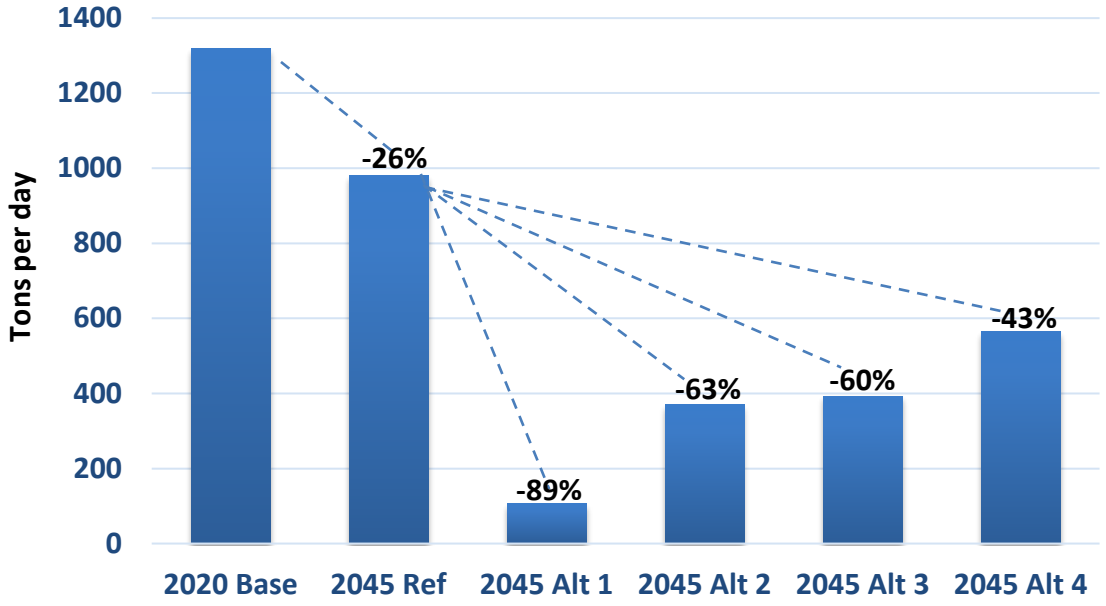
- **Emissions modeling caveats**
  - PATHWAYS provides statewide averages which do not allow for resolution at the regional or sub-regional level, although the base year inventory does account for those differences
  - Emissions are generated by many processes, including those not related to combustion in energy systems. For example, biogenic emissions, managed burning and disposal, etc. can contribute emissions of NO_x, PM, reactive organic gases (ROG) and others
  - Only existing facilities are included in the assessment due to the uncertainty of siting and locating novel emission sources and any major functional changes to existing sources are not considered



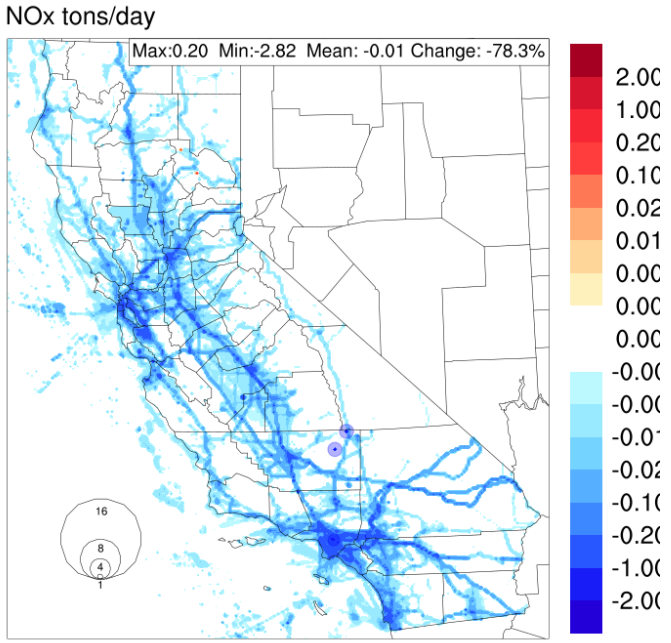
1. Emissions Modeling

- **Scenarios achieve large emission reductions in 2045 due to shifts to zero pollutant emission fuels and reductions in total energy consumption**
  - Reductions in total NO_x from the Reference scenario range from 89% in Alt 1 to 43% in Alt 4
  - Emission reductions are then applied to the locations of source activity

Total NO_x Emissions



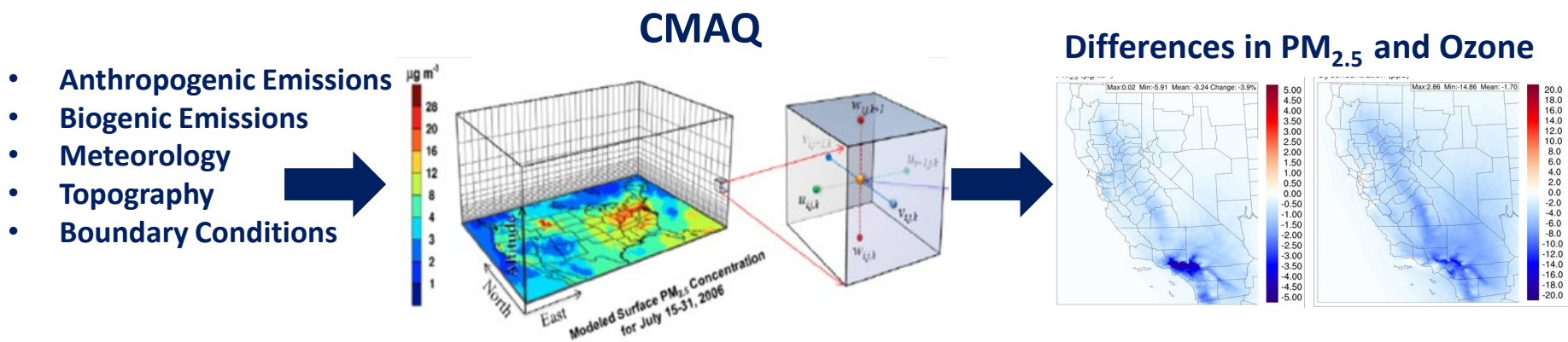
Reductions in 2045 NO_x for Alt 2



2. Air Quality Modeling

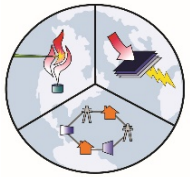
- **Community Multi-scale Air Quality Model (CMAQ) used to develop a comprehensive understanding of how atmospheric pollution changes in the Scoping Plan Scenarios**
  - 4 km x 4 km horizontal resolution across the entire state
  - Base year model performance has been statistically validated using observational data
  - CMAQ accounts for both primary (**emitted)** and secondary (**formed**) pollutants including ozone and $PM_{2.5}$

- **The months of July and January are modeled as they encompass the highest baseline concentrations of ozone and $PM_{2.5}$ due to meteorology and other factors**
  - Provides an estimation of the **maximum** impact on air pollution from the emission reductions associated with Scoping Plan measures
  - Does not provide a **comprehensive** understanding of the impacts experienced throughout the year on air quality



2. Air Quality Modeling

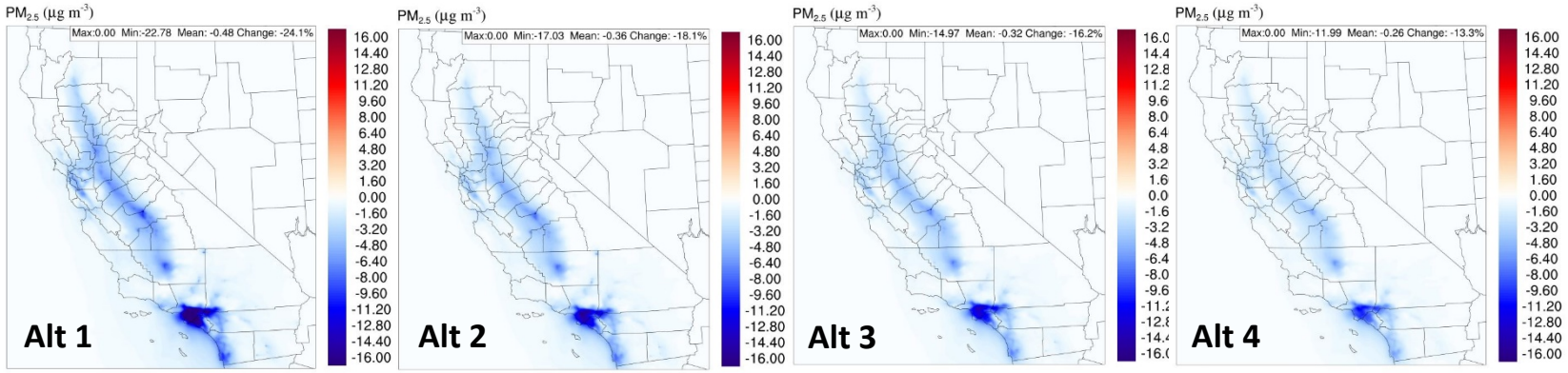
- **Air Quality Modeling Caveats**
  - Episodic modeling provides insight into the relative differences between scenarios but does not capture the comprehensive health benefits of the scenarios as it only allows for estimation of short-term exposure health benefits
  - Due to the selection of modeling periods coinciding with high pollutant formation periods, the pollutant differences and the health impacts estimated are also highest during those periods and may not be as large in other months.
    - **These results only represent two distinct months and cannot be used to estimate annual changes**
  - Meteorology and other factors including boundary conditions are held constant to the base year to ensure all impacts occur from changes in emissions from Scoping Plan measures
    - **Does not account for climate-impacted meteorology**



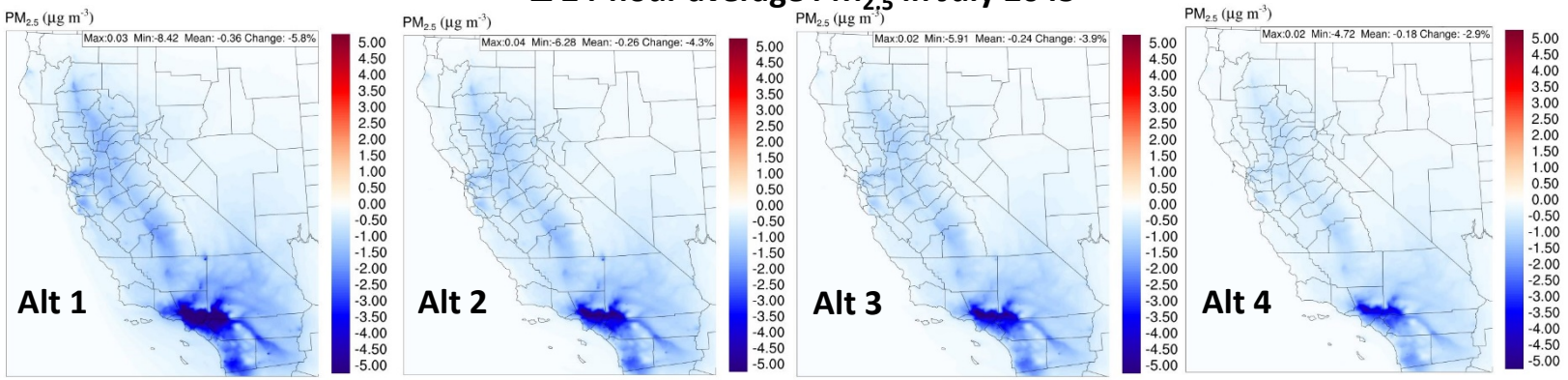
2. Air Quality Results – $PM_{2.5}$

- **Results present the difference in $PM_{2.5}$ in July and January 2045 relative to the Reference Scenario**

Δ 24-hour average $PM_{2.5}$ in January 2045



Δ 24-hour average $PM_{2.5}$ in July 2045



Peak Δ 24-hour average $PM_{2.5}$

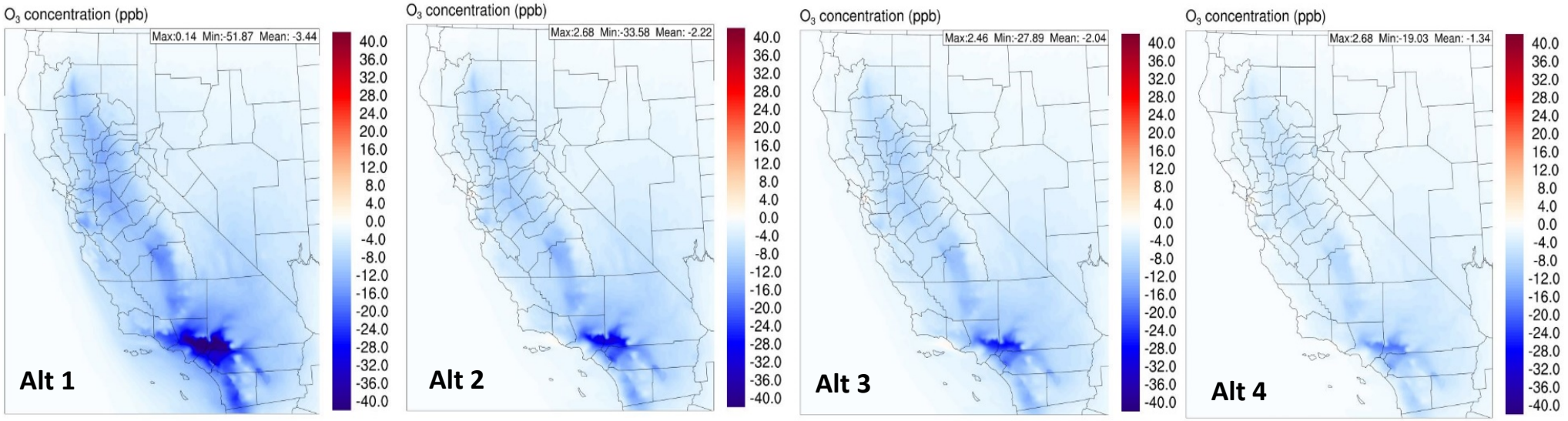
	Alt 1	Alt 2	Alt 3	Alt 4
January	-22.8	-17.0	-14.9	-11.9
July	-8.4	-6.3	-5.9	-4.3

- Peak January reductions occur in the South Coast Air Basin (SoCAB) and Central Valley
- Peak July reductions occur in the South Coast Air Basin (SoCAB)

2. Air Quality Results – Ozone

- **Results present the difference in ground-level ozone in 2045 relative to the Reference Scenario**
  - Improvements in all scenarios are large due to 1) large reductions in precursor emissions and 2) the selection of the July modeling period due to meteorology conducive to ozone formation which maximizes the reductions
  - Peak reductions occur in the South Coast Air Basin

Δ MD8H average Ozone in July 2045

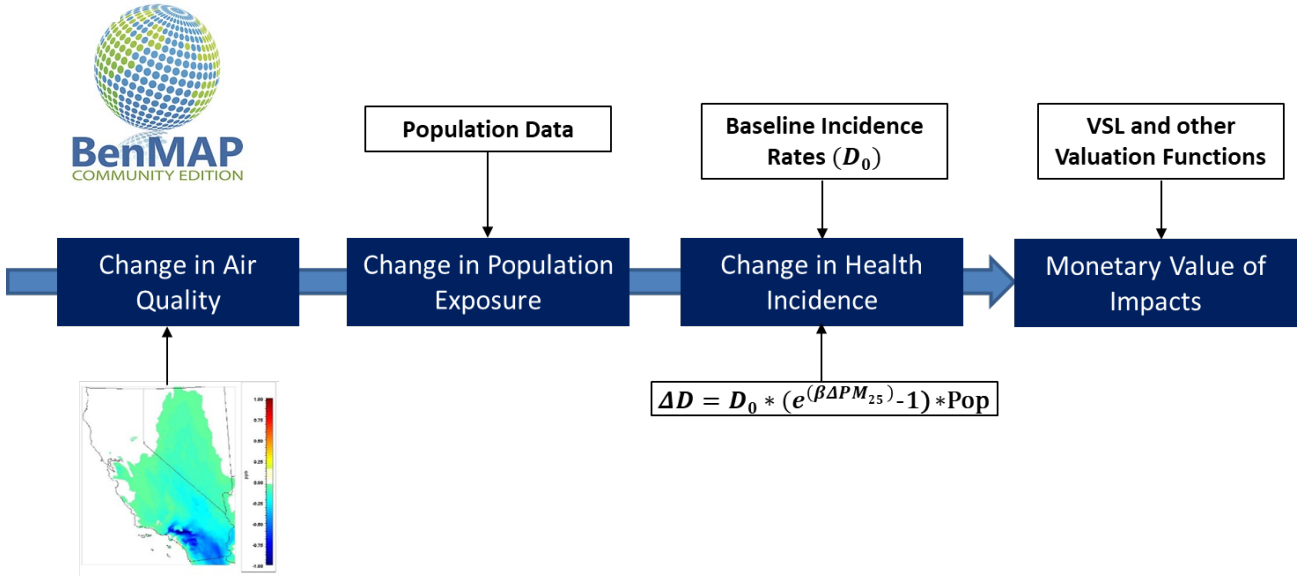


	Alt 1	Alt 2	Alt 3	Alt 4
Peak Max Daily 8-hr Avg. Reduction	-51 ppb	-33 ppb	-28 ppb	-19 ppb

3. Health Impact Assessment

- **EPA's BenMAP v1.5.8 used to translate pollutant changes from CMAQ into health impacts**
  - Total benefits that accrue during July and January in 2045
  - Health impacts estimated for short-term exposure only as appropriate for the episodic modeling
  - Selection of health impact functions generally represent the core functions in BenMAP v1.5.8

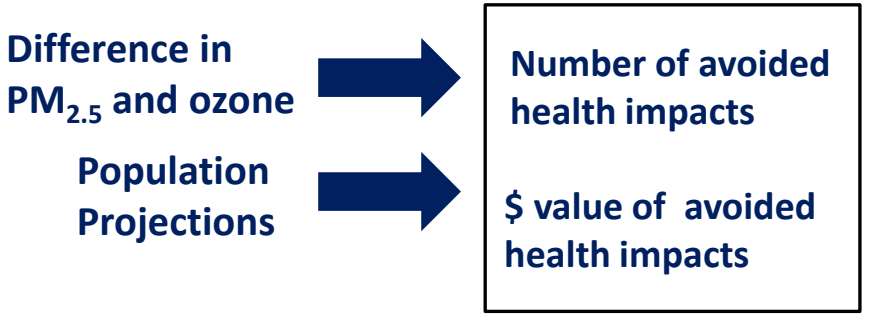
- **Health impacts estimated for $PM_{2.5}$ and ground-level ozone in July and $PM_{2.5}$ in January**
  - Ozone concentrations are below health-based standards in winter and have an inverse relationship with precursor emissions

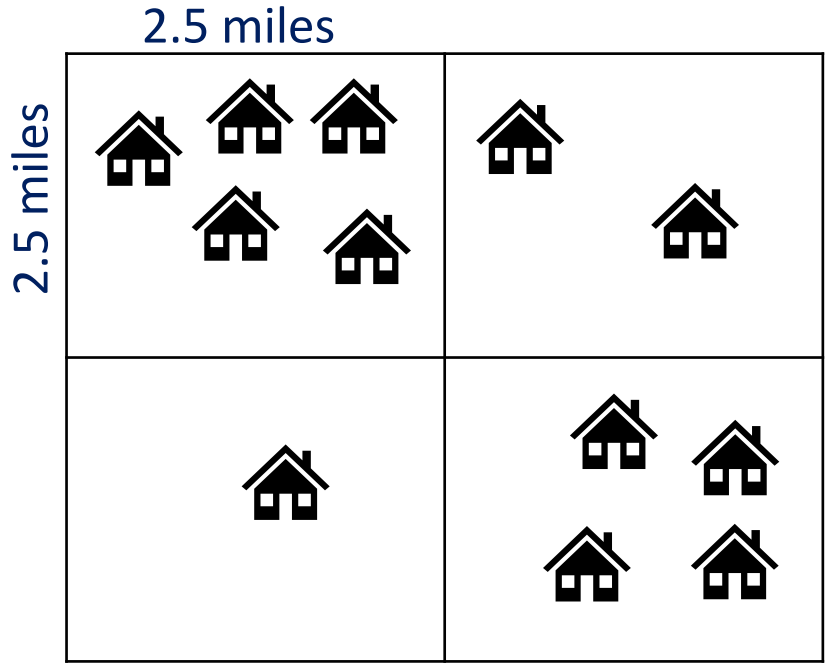


$PM_{2.5}$ Health Endpoints	Ozone Health Endpoints
• Avoided Mortality	• Avoided Mortality
• Hospital Admissions, Alzheimer's Disease	• Emergency Room Visits, Respiratory
• Hospital Admissions, Parkinson's Disease	• Hospital Admissions, Respiratory
• Incidence, Lung Cancer	• Asthma Symptoms
• Incidence, Asthma Onset	• Incidence, Asthma Onset
• Acute Myocardial Infarction, Nonfatal	
• Asthma Symptoms	
• Hospital Admissions, Cardiovascular	
• Emergency Room Visits, Cardiovascular	
• Hospital Admissions, Respiratory	
• Emergency Room Visits, Respiratory	
• Work Loss Days	

3. Health Impact Results

- **Health Impact Assessment Caveats**
  - Benefits are estimated for the two months in 2045 and do not account for those that would accrue over the entire period of the Scoping Plan implementation
  - Health savings are calculated with the same resolution as the air quality and can be reasonably downscaled to the census tract level
    - **Does not allow for individual source impacts to be resolved**
    - **Does not allow for neighborhood level impacts to be resolved**



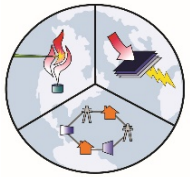


3. Health Impact Results

- **Air pollution improvements reduce incidence of harmful health outcomes**

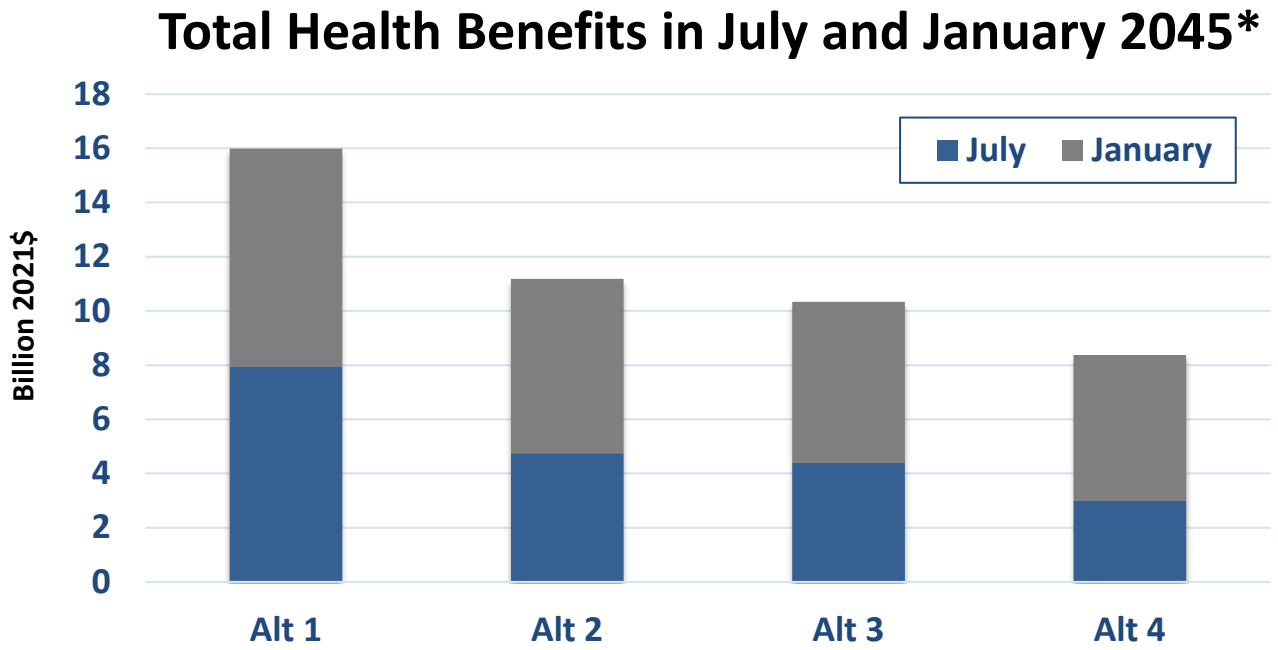
Avoided Incidence of Health Effects in California during the July Modeling Period

Endpoint	Pollutant	Alt 1	Alt 2	Alt 3	Alt 4
Avoided Mortality, All Cause	$PM_{2.5}$	268	188	177	132
Hospital Admissions, Alzheimers Disease	$PM_{2.5}$	3,597	2,706	2,584	2,046
Hospital Admissions, Parkinsons Disease	$PM_{2.5}$	325	238	226	176
Incidence, Lung Cancer	$PM_{2.5}$	536	386	364	280
Incidence, Asthma Onset	$PM_{2.5}$	12,773	9,349	8,778	6,784
Acute Myocardial Infarction, Nonfatal	$PM_{2.5}$	62	43	41	31
Asthma Symptoms	$PM_{2.5}$	138,729	99,356	92,699	69,869
Hospital Admissions, Cardiovascular	$PM_{2.5}$	101	71	66	50
Emergency Room Visits, Cardiovascular	$PM_{2.5}$	159	112	105	79
Hospital Admissions, Respiratory	$PM_{2.5}$	16	11	10	8
Emergency Room Visits, Respiratory	$PM_{2.5}$	229	163	153	115
Work Loss Days	$PM_{2.5}$	49,428	35,188	32,911	24,738
Avoided Mortality, Respiratory	Ozone	360	171	155	87
Incidence, Asthma Onset	Ozone	2,865	1,526	1,364	821
Emergency Room Visits, Respiratory	Ozone	1,937	1018	909	542
Asthma Symptoms	Ozone	1,201,704	654,334	587,897	356,922
Hospital Admissions, Respiratory	Ozone	169	79	71	40



3. Health Impact Results

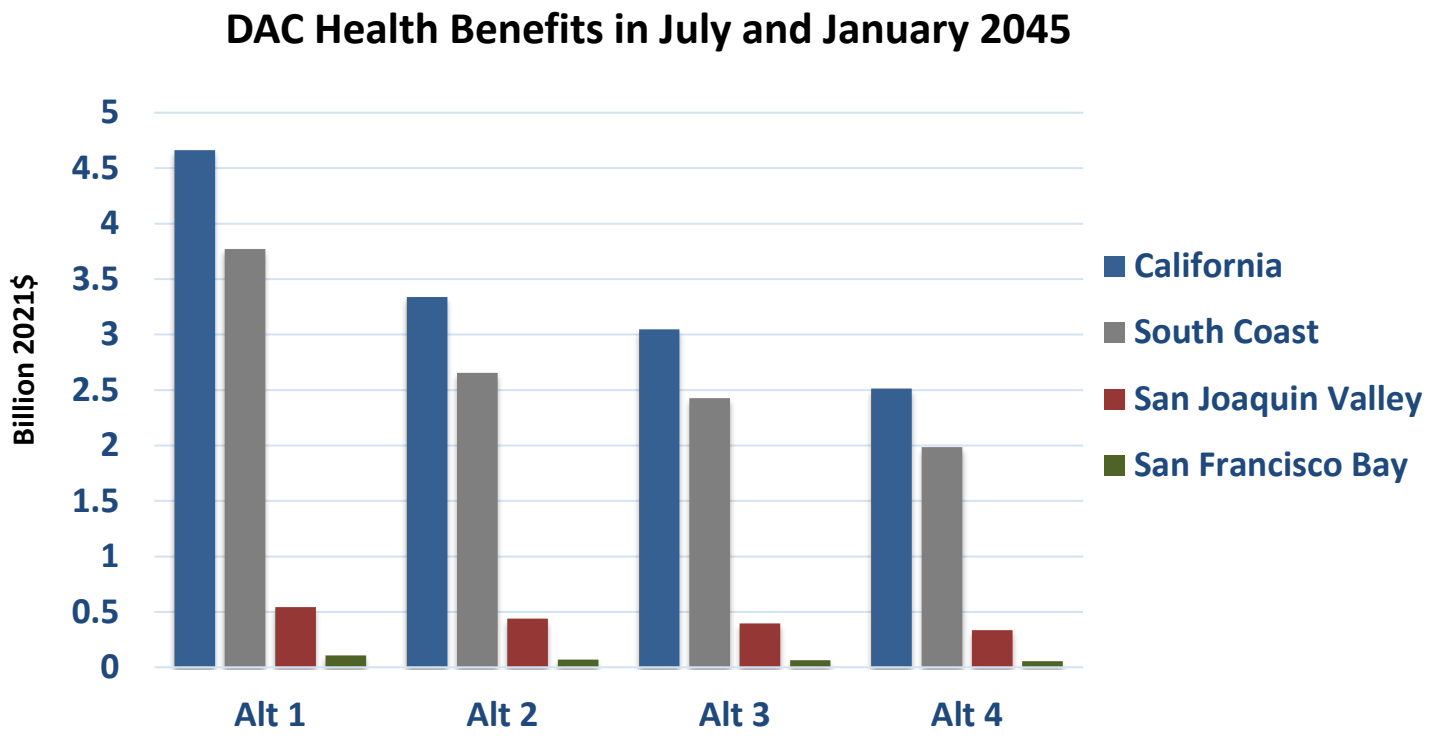
- **The implementation of the Scoping Plan scenarios achieves notable public health benefits relative to the Reference Scenario**
  - Total combined benefits range from $8.3 billion in Alt 4 to $15.9 billion in Alt 1 in July and January 2045
  - Improvements in winter $PM_{2.5}$ provide significant health benefits



*Represents the mean value reported by BenMAP

3. DAC Impacts

- **CalEnviroScreen 4.0 used to quantify health benefits within census tracts identified as socially and economically disadvantaged communities (DAC)**
  - Scenarios attain benefits within DAC ranging from $2.5 billion to $4.7 billion combined
  - Communities in the SoCAB benefit more due to pre-existing air quality challenges, significant emission sources and activity, and large, dense populations



Conclusions

- **Episodic evaluation of the air quality and health benefits demonstrates that all proposed Scoping Plan Scenarios achieve important benefits**
  - All four scenarios significantly reduce air pollution and incidence of pollution-related mortality and morbidity

- **Health benefits approximately scale with scenario aggressiveness**
  - Alt 1 attains the highest benefits due to the elimination of combustion emissions
  - In 2045, Alt 2 and Alt 3 attain similar benefits
  - Comparatively, Alt 4 achieves the lowest benefits, but they are still significant in total

- **Health benefits are most pronounced in the South Coast Air Basin due to pre-existing air quality challenges, the presence of significant emission sources, and the large, dense urban population**

- **Scenarios attain important benefits within socially and economically disadvantaged communities that are most impacted by, and vulnerable to, degraded air quality**
  - Benefits within DAC are most pronounced within impacted communities in the South Coast Air Basin