AB 32 Scoping Plan Process – GHG Modeling Presentation for EJ Advisory Committee
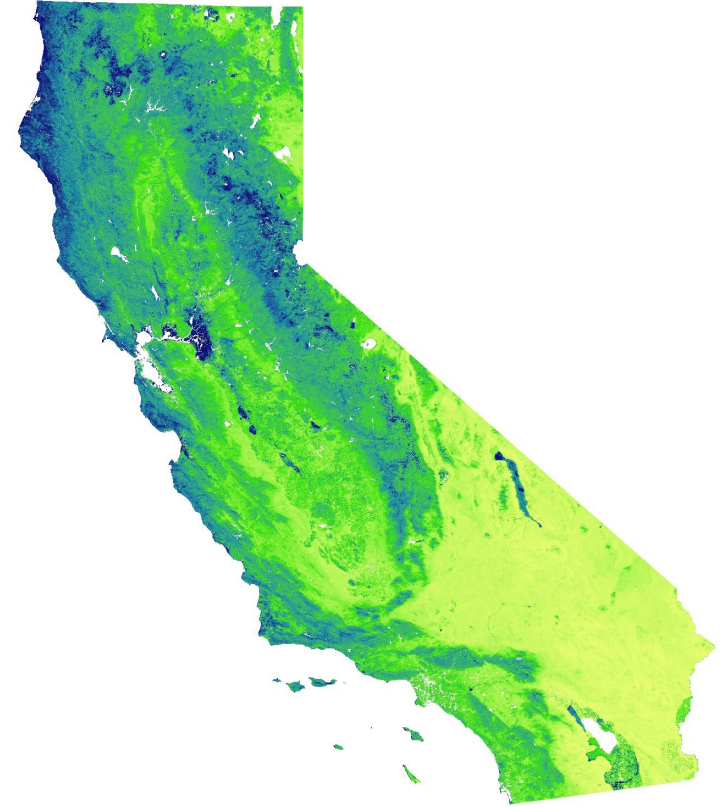
AUGUST 2021

Agenda for Today

- Describe GHG modeling approach for the Scoping Plan - what is PATHWAYS and how does it work?

Before We Start – GHG Modeling Notes

- GHG modeling is an important step in the Scoping Plan, it informs:

    - Path of California's future GHG emissions and fuel use both in the absence of action and under various scenarios

    - Subsequent analyses on public health and economic impacts

- Modeling does <u>not</u> identify mechanisms (e.g. specific regulations)

- CARB has not yet conducted any modeling for this Scoping Plan

California PATHWAYS:
A Tool to Examine Long-Term Greenhouse Gas Reduction Scenarios

California Air Resources Board Scoping Plan

08/03/2021

Confidential and Deliberative Draft

Energy+Environmental Economics

Amber Mahone, Partner
Jessie Knapstein, Managing Consultant
Gabe Mantegna, Senior Consultant
Vivan Malkani, Consultant

+ Scoping Plan 2022

+ The California PATHWAYS model

- Inputs & Outputs
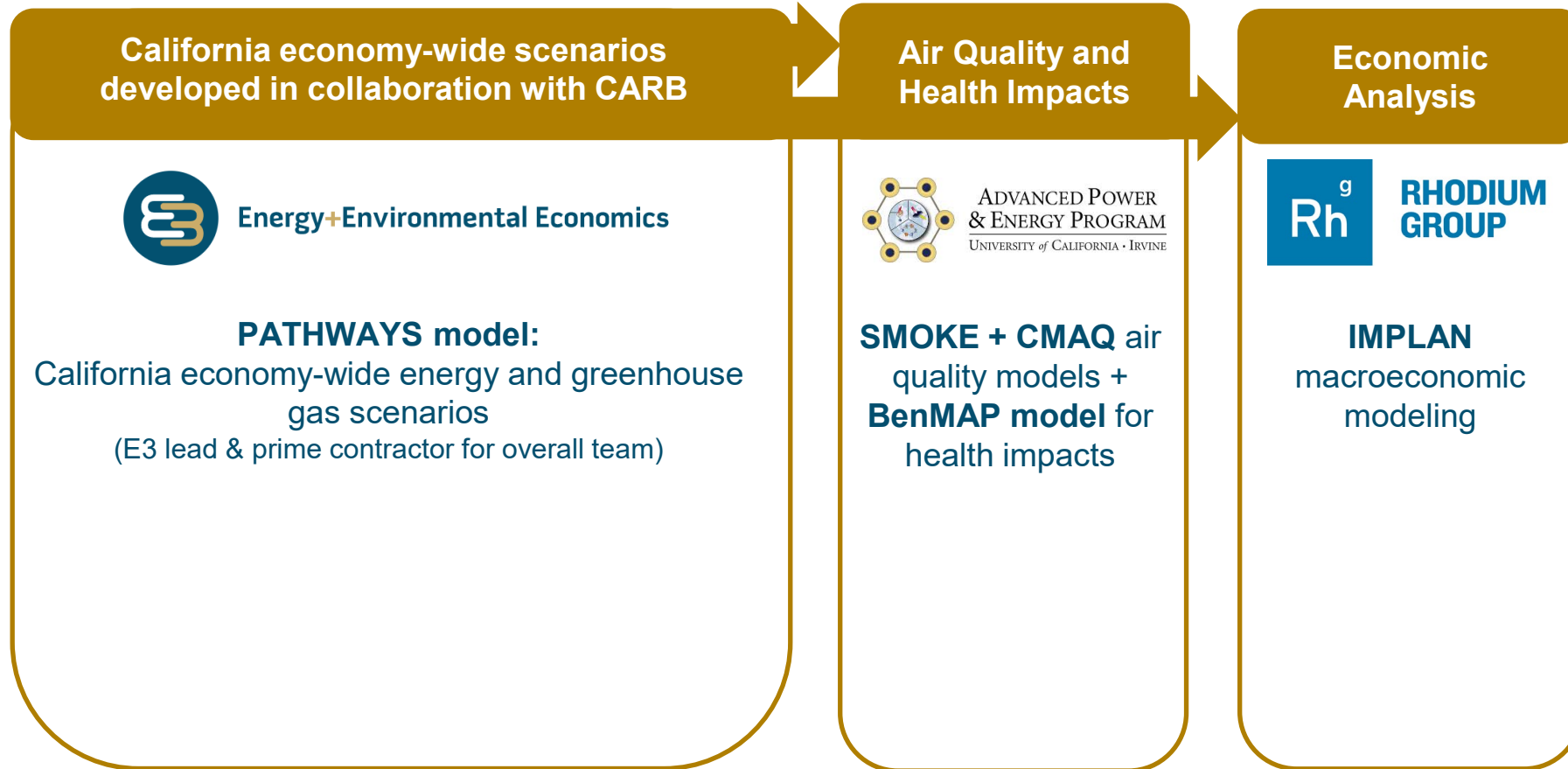- Example Inputs & Outputs: 2017 Scoping Plan

Scoping Plan 2022

Scoping Plan 2022

California economy-wide scenarios developed in collaboration with CARB

Energy+Environmental Economics

PATHWAYS model:
California economy-wide energy and greenhouse gas scenarios
(E3 lead & prime contractor for overall team)

Air Quality and Health Impacts

ADVANCED POWER & ENERGY PROGRAM
UNIVERSITY of CALIFORNIA · IRVINE

SMOKE + CMAQ air quality models + **BenMAP model** for health impacts

Economic Analysis

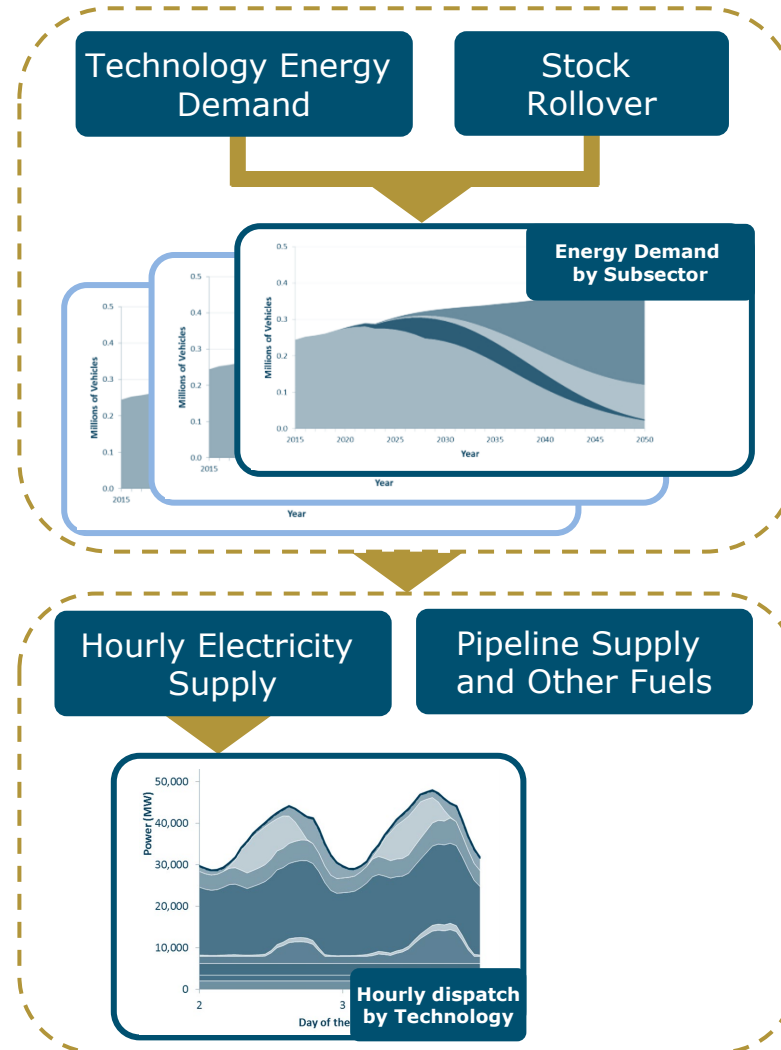**Rh**g **RHODIUM GROUP**

IMPLAN macroeconomic modeling
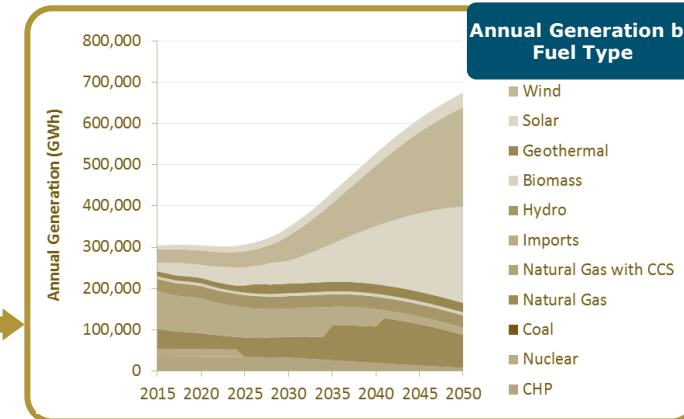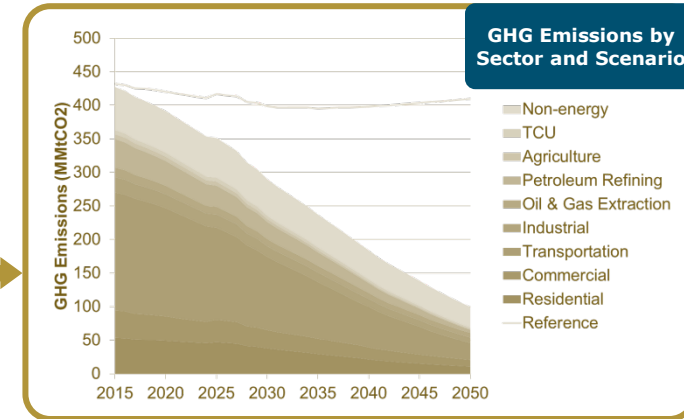
About the California PATHWAYS Model

What is PATHWAYS?

- **PATHWAYS is a transparent and in-depth approach to economy-wide emissions accounting**

- **Bottom-up, user-defined, non-optimized scenarios test "what if" questions**

- **Economy-wide model captures interactions between sectors & path-dependencies**

- **Annual time steps for infrastructure-based accounting simulates realistic stock roll over**

- **Tracks capital investments and fuel costs over time**

Technology Energy Demand

Stock Rollover

Energy Demand by Subsector

Hourly Electricity Supply

Pipeline Supply and Other Fuels

Hourly dispatch by Technology

Sample Outputs:

GHG Emissions by Sector and Scenario
- Non-energy
- TCU
- Agriculture
- Petroleum Refining
- Oil & Gas Extraction
- Industrial
- Transportation
- Commercial
- Residential
- Reference

Annual Generation by Fuel Type
- Wind
- Solar
- Geothermal
- Biomass
- Hydro
- Imports
- Natural Gas with CCS
- Natural Gas
- Coal
- Nuclear
- CHP

PATHWAYS Detail

PATHWAYS does:

+ **Compare input-driven technology adoption scenarios**

Included in model:

+ **Physical accounting of energy flows within all sectors of the economy**

+ **Cost accounting, including energy infrastructure and fuel costs**

+ **GHG accounting**

PATHWAYS does not:

+ **Optimize for lowest cost solutions**

Not included in model:

+ **Structural/macroeconomic impacts**

+ **Societal cost impacts (avoided damages)**

+ **Criteria and toxics pollutants**

+ **Geographic granularity (CA-wide)**

+ **Policy design modeling**

Data Inputs and Outputs

All Inputs and Outputs Tracked by: Sector, Subsector, Technology, and Fuel

Residential	Commercial	Transportation	Industrial	Agriculture
16 subsectors, including: • Water Heating • Air Conditioning • Cooking	**9** subsectors, including: • Refrigeration • Ventilation • Office Equipment	**9** modes of transport, including: • Cars, Trucks, Buses • Passenger Rail • Aviation	**7** subsectors, including: • Conventional boiler use • Machine drive • Process heating	**7** subsectors, including: • Lighting • Motors • Refrigeration

Petroleum refining	Oil & gas extraction	Water Demand	Non-Energy GHGs	Forestry & LUC
• Sector-Level Energy Demand Only	• Sector-Level Energy Demand Only	• Energy use from procurement, treatment, conveyance and wastewater-treatment of water	• Sector-Level GHGs Only, with reduction measures by GHG type consistent with CARB inventory categories	• Not currently explicitly modeled

Electricity		CHP	Pipeline Gas	Liquid fuels	Other fossil fuels
• Uranium • Hydro • Coal • Geothermal • Wind • Solar PV • Solar thermal	• Natural Gas • Biomass • Biogas • Specified imports • Unspecified imports • CCS	• Waste heat	• Natural Gas • Hydrogen • Power to Gas • Biogas	• Diesel • Gasoline • Biodiesel • Bio-gasoline • Hydrogen • Kerosene-Jet Fuel	• Coke • Refinery and Process Gas • Fuel Oil • Kerosene • LPG

Model Inputs and Outputs

Raw Data Inputs (Constants)

Technology costs, Average number of people per household, Population…

Scenario Input Assumptions (Selected by Users)

Percent of annual clean energy, Sales of zero-emission vehicles, Phase down of refinery operations, Electric appliance sales…

Calculated Outputs

Greenhouse gas emissions, Energy demand, Energy supply, Technology stocks & sales, & Cost

Thank You

Amber Mahone

Amber@ethree.com

Energy+Environmental Economics