

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

California Air Resources Board Scoping Plan

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Energy+Environmental Economics

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## + California PATHWAYS Model

- Scoping Plan 2022 Modeling Suite
- What is PATHWAYS?
- Capabilities

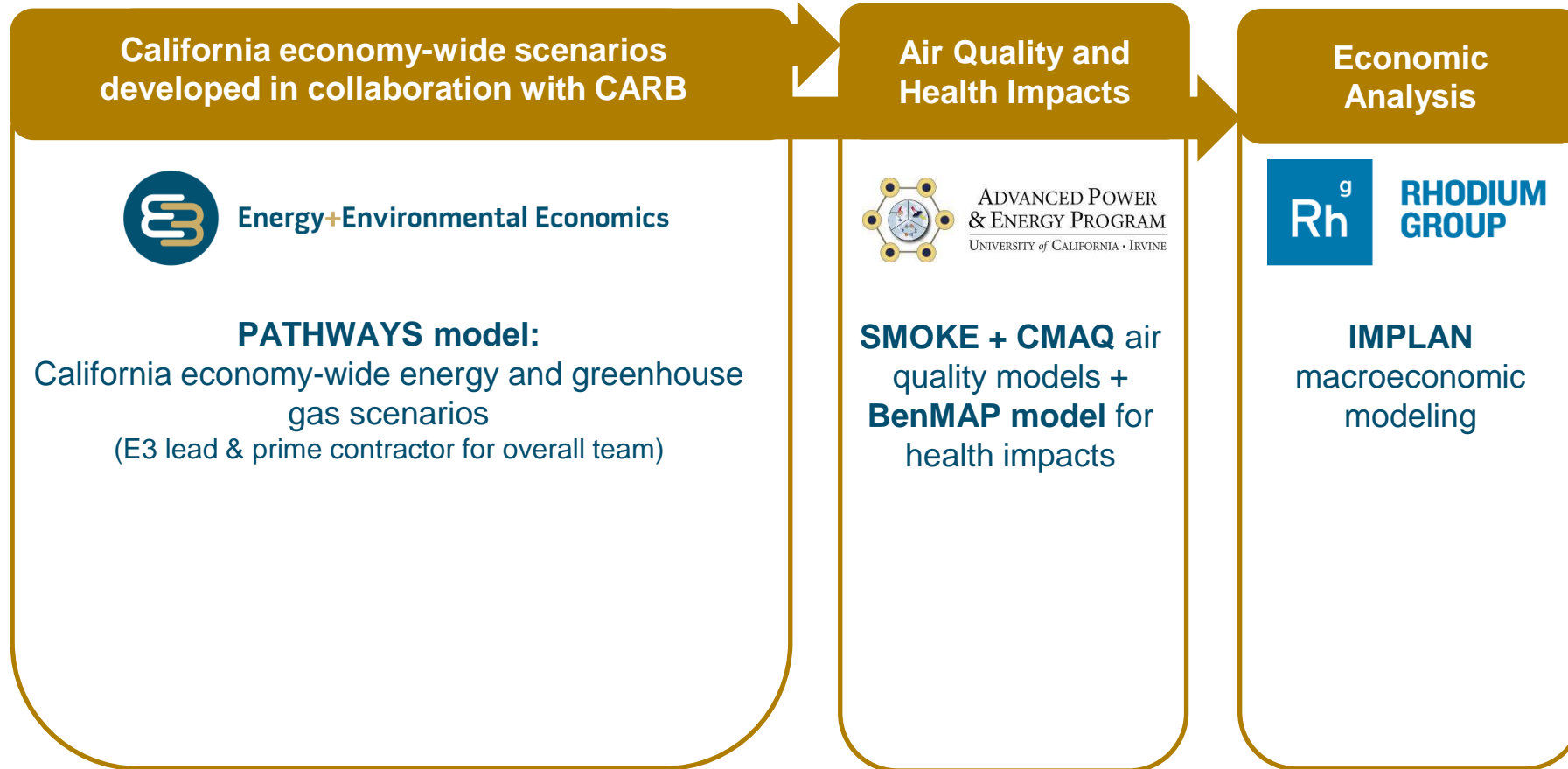
## + Scenario Design in CA PATHWAYS

- Inputs & Outputs
- Decarbonization Measure Examples



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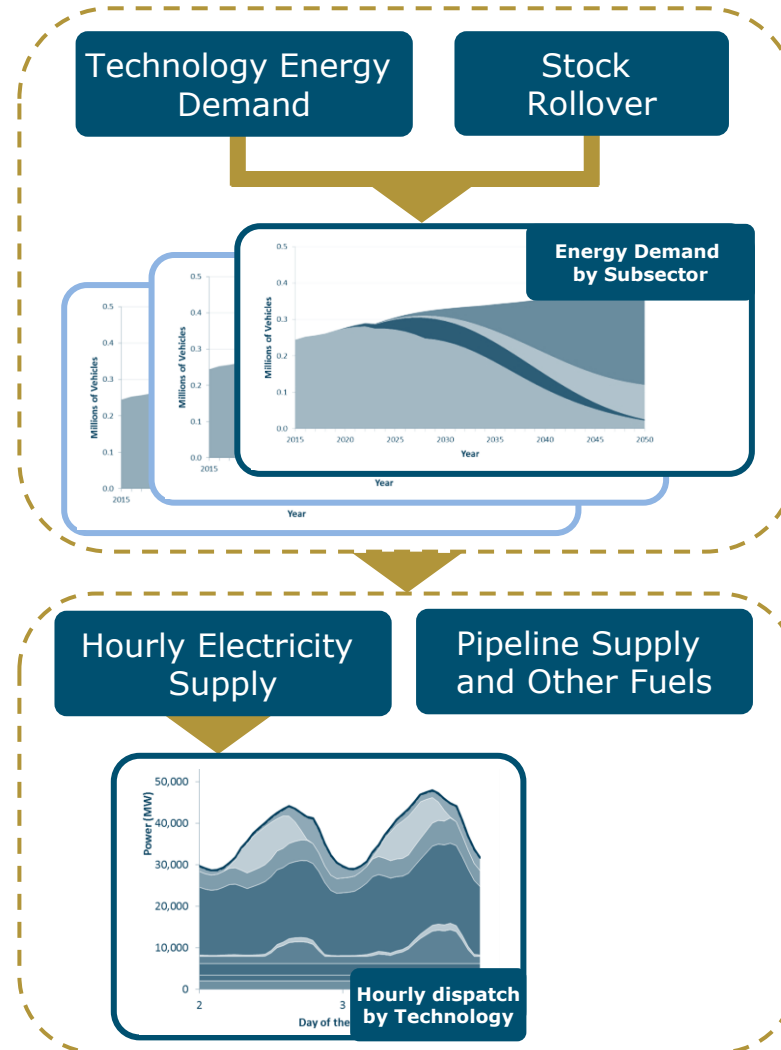
# California PATHWAYS Model



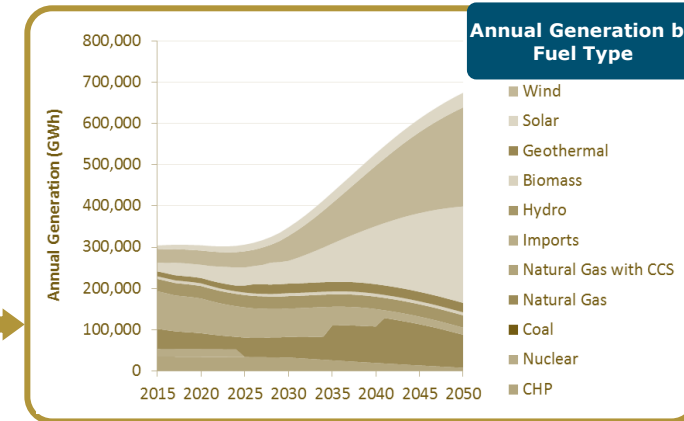
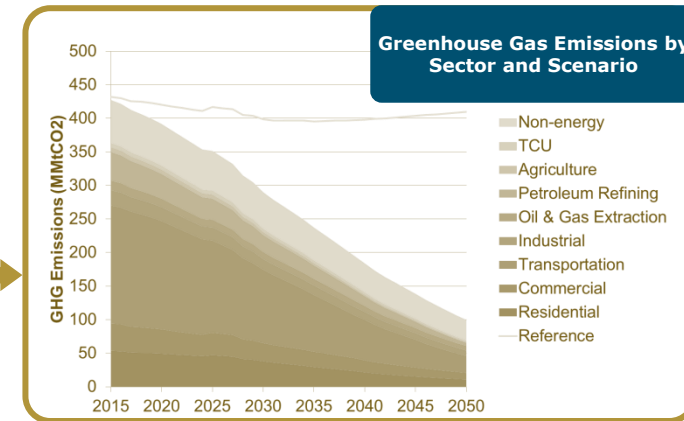


# What is PATHWAYS?

- + 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



## Sample Outputs:





## PATHWAYS does:

- + Compare input-driven technology adoption scenarios

## Included in model:

- + Accounting of energy use across all sectors of the economy
- + Incremental infrastructure and fuel costs and savings associated with decarbonization
- + Greenhouse gas emission accounting from energy use

## PATHWAYS does not:

- + Optimize for lowest cost solutions

## Not included in model:

- + Macroeconomic impacts
- + Social cost of carbon
- + Criteria and toxics pollutants
- + Geographic granularity
- + Policy design
- + Emission reduction or increase from land-use changes



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## **Scenario Design in CA PATHWAYS**



# Model Inputs and Outputs

## Raw Data Inputs (Constants)

Technology costs, population, commercial square footage, vehicle ownership per capita, etc.



## Scenario Input Assumptions

Clean energy share, sales of zero-emission vehicles, phase down of refinery operations, electric appliance sales, etc.



## Calculated Outputs

Greenhouse gas emissions, energy demand, energy supply, incremental cost of each decarbonization measure, etc.





# Buildings: Model Example

## Raw Data Inputs (Constants)

Device costs, device efficiencies, current device mix, space heating service demand, etc.

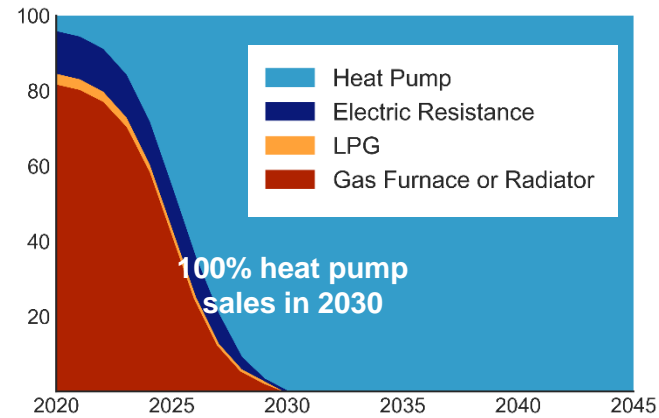
## Scenario Input Assumptions

Sales % of electric heat pumps, fossil energy efficiency, early retirement, etc.

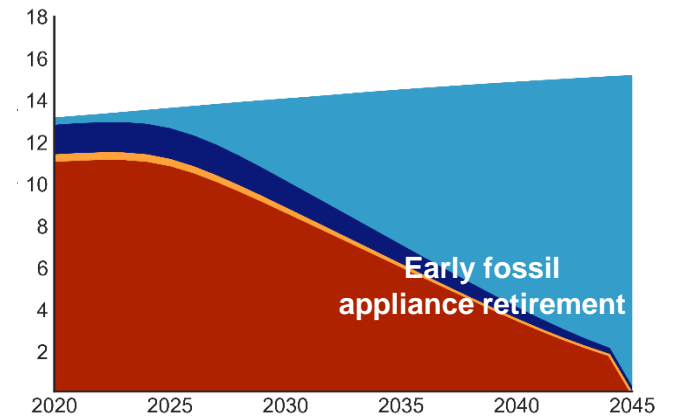
## Calculated Outputs

Device stocks, greenhouse gas emissions, energy demand, incremental cost of each decarbonization measure, etc.

### Device Sales (%)



### Device Stocks (million households)



Stock Turnover

Energy Demand by Fuel (exajoules)

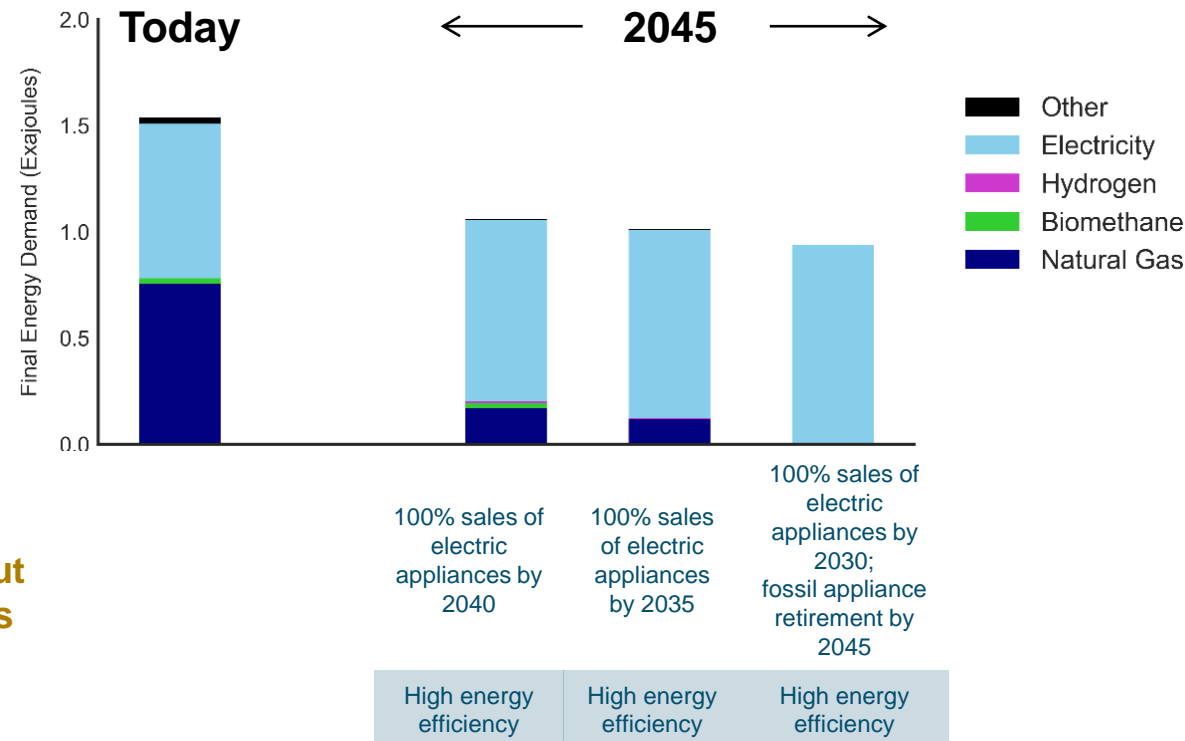
GHG Emissions (tons CO2e)



# Buildings: Final Energy Demand Three Examples

- + Differences in building energy demand and fuel types are driven by differing scenario input assumptions for **electric appliance sales trajectories** and assumptions about **early retirement of fossil appliances** before the end of their useful life
- + Building final energy demand includes assumptions for commercial and residential buildings

### Building Final Energy Demand





# Transportation Light Duty Vehicles (LDV): Model Example

## Raw Data Inputs (Constants)

Vehicle costs, vehicle efficiencies, vehicle ownership per capita, current vehicle mix, etc.

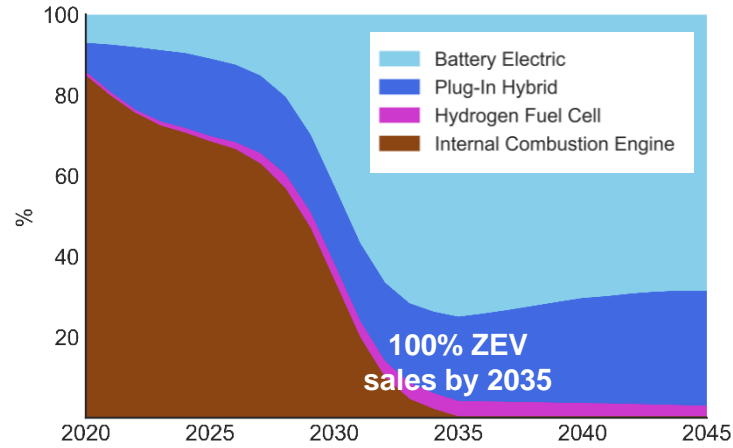
## Scenario Input Assumptions

Sales % of zero-emission vehicles, early retirement, vehicle miles traveled (VMT), etc.

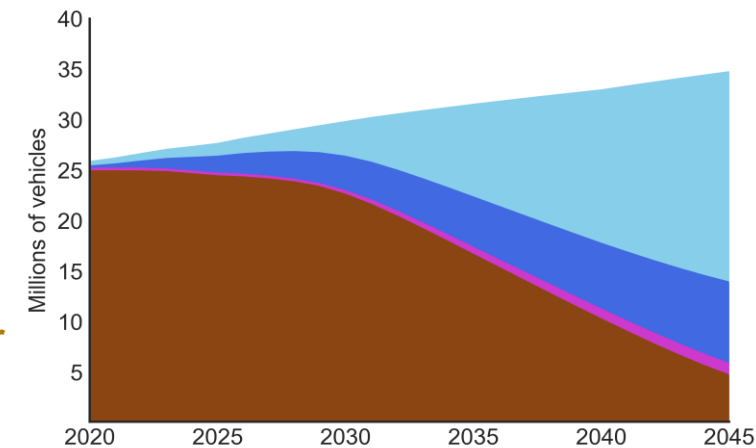
## Calculated Outputs

Vehicle stocks, greenhouse gas emissions, energy demand, incremental cost of each decarbonization measure, etc.

### LDV Sales (%)



### LDV Stocks (million vehicles)



**Stock Turnover**

**Energy Demand by Fuel (exajoules)**

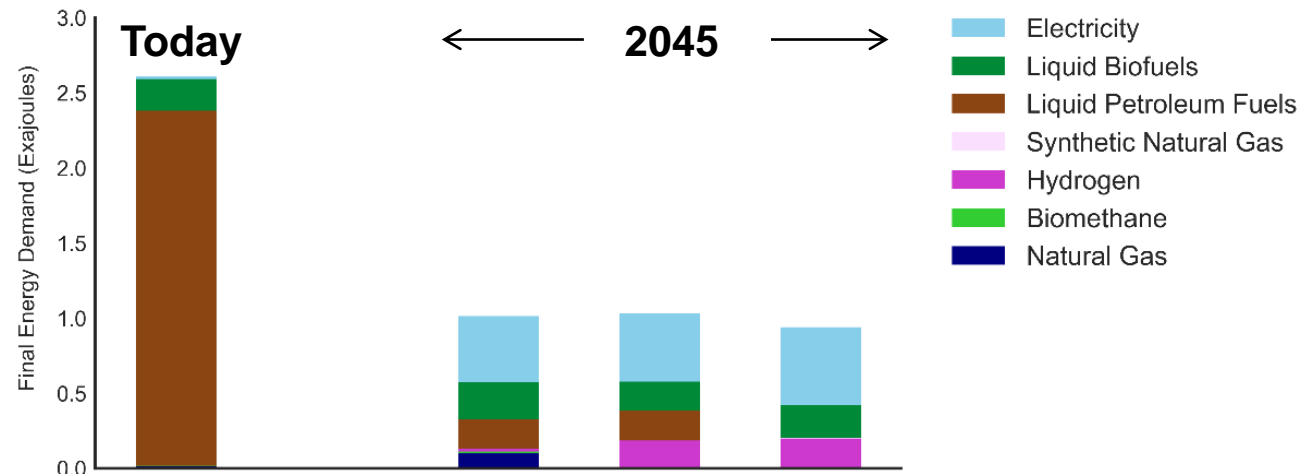
**GHG Emissions (tons CO2e)**



# Transportation: Final Energy Demand Three Examples

- + Differences in transportation energy demand and fuel types are driven by differing scenario input assumptions for sales trajectories of zero emissions vehicle (ZEV) vehicle types including battery electric vehicles (BEVs) and hydrogen fuel cell vehicles
- + Transportation final energy demand includes assumptions for light-duty vehicles, medium duty vehicles and heavy-duty vehicles, along with assumptions for rail and aviation

### Transportation Final Energy Demand

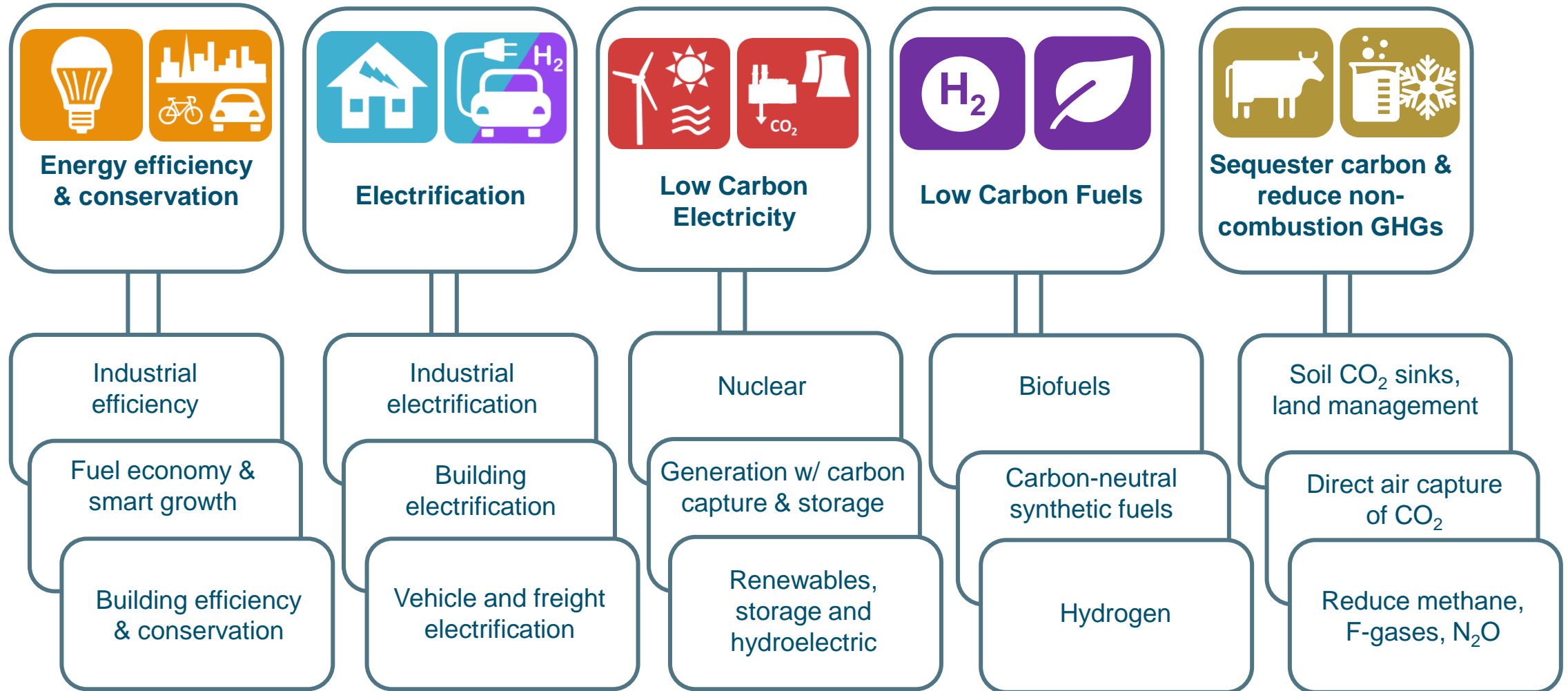


### Scenario Input Assumptions

Light Duty Vehicle (BEV)	100% sales by 2035;	100% sales 2035;	100% sales 2030;
Med Duty Vehicle (BEV)	100% sales by 2040;	100% sales 2035;	100% sales 2030;
Heavy-Duty Vehicle (50/50 Hydrogen/BEV)	45% sales 2035	93% sales 2035	100% sales 2030



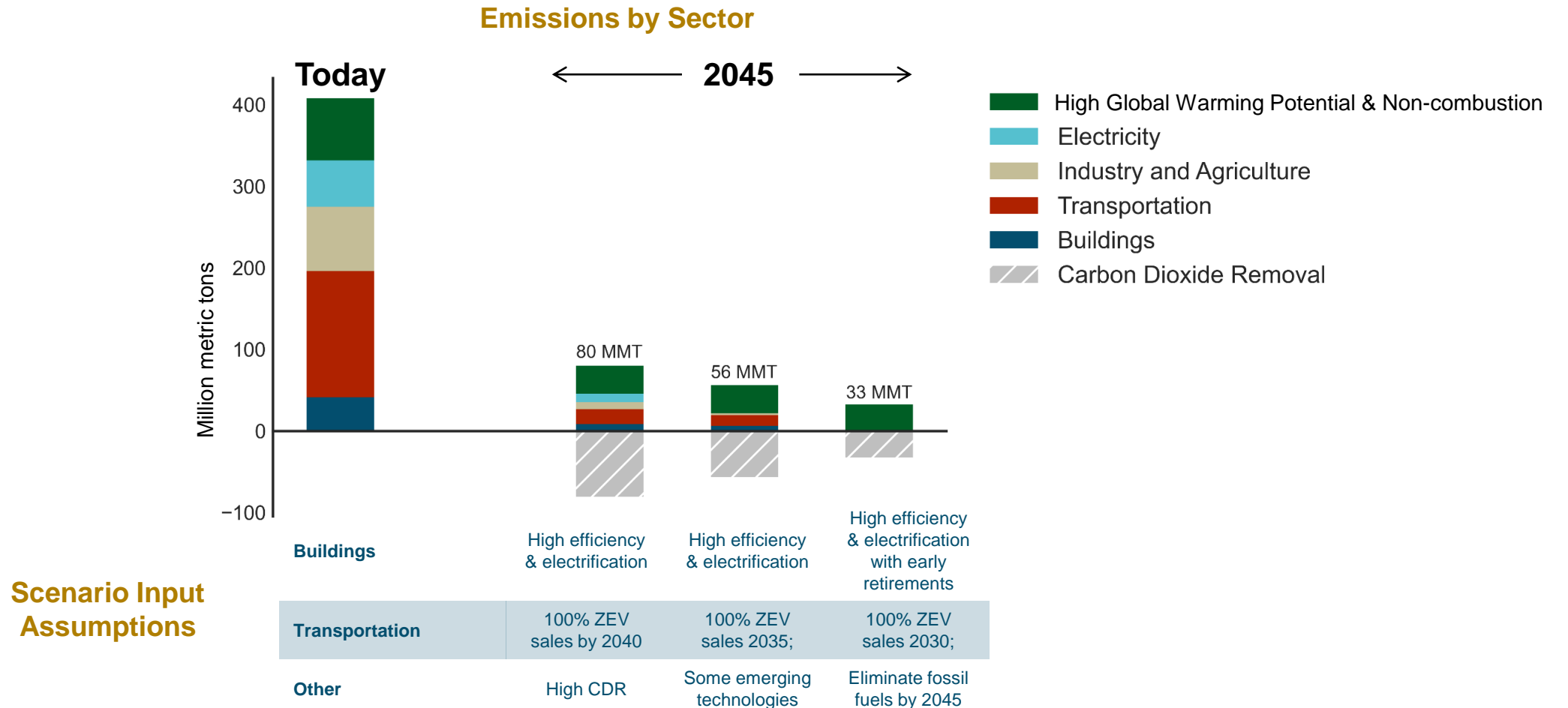
# Five “Pillars” of GHG reductions





# Example: Different Strategies to CA Goal of Carbon Neutrality by 2045

- + Each scenario meets the same goal of Carbon Neutrality by 2045 with differing levels of reliance on building and transportation electrification, carbon dioxide removal (CDR), low-carbon fuels, hydrogen, and emerging technologies like synthetic natural gas in the pipeline, electric aviation, and fuel-cell trains, etc.



# Thank You

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