

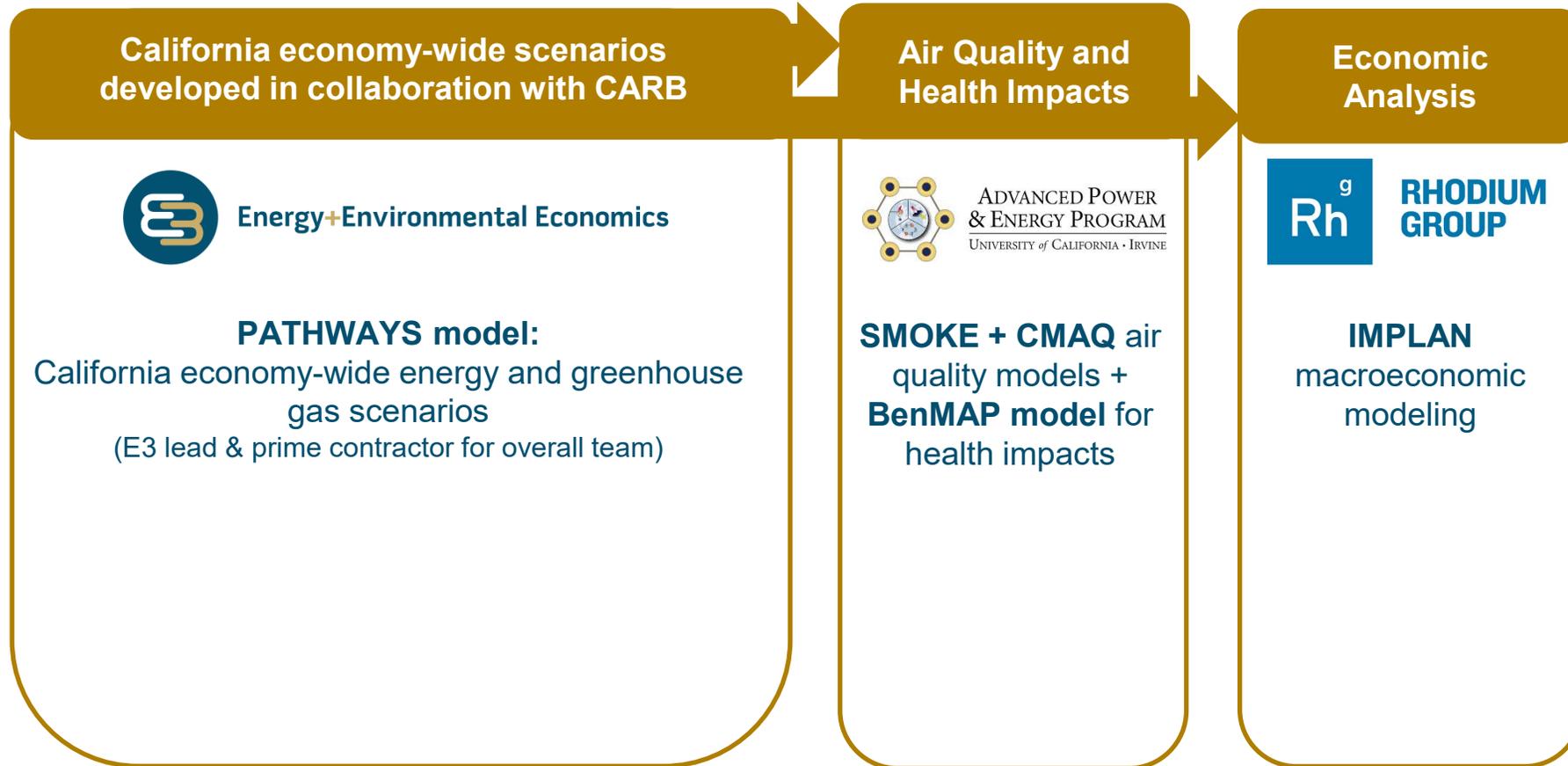
CARB Draft Scoping Plan: AB32 Source Emissions Initial Modeling Results

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



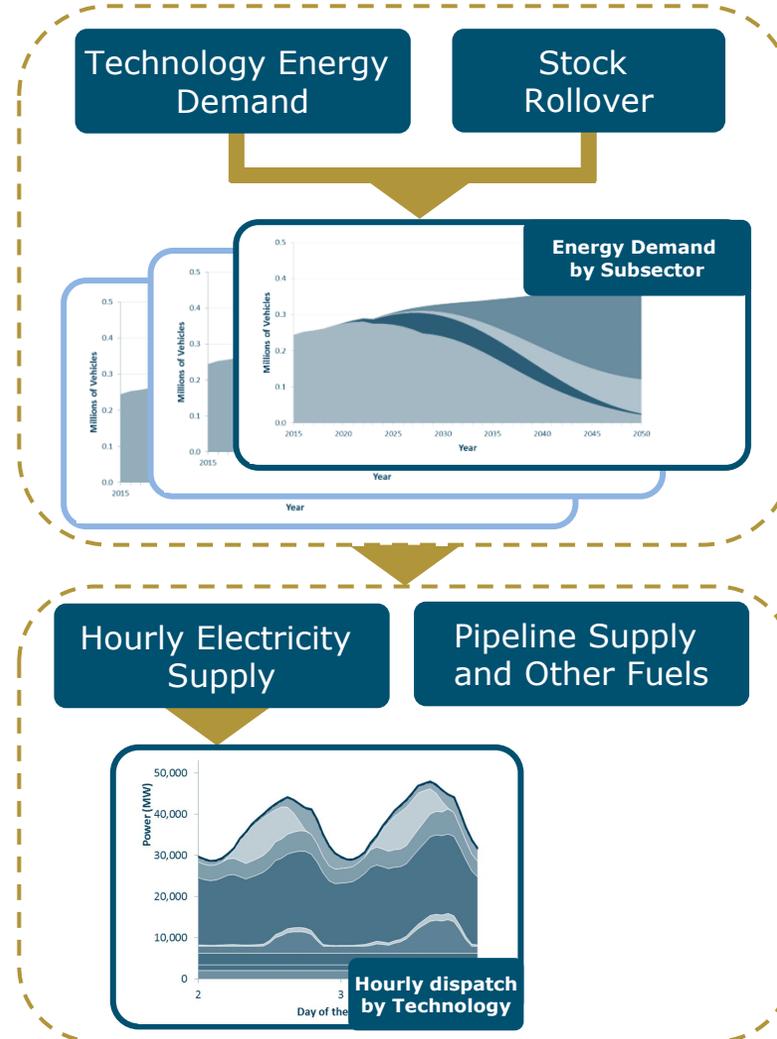
Scoping Plan 2022



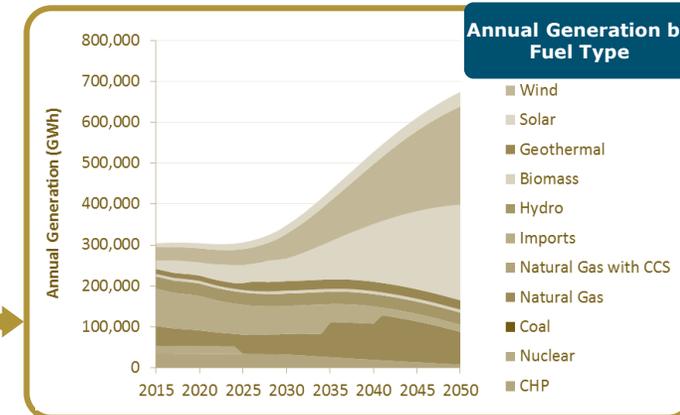
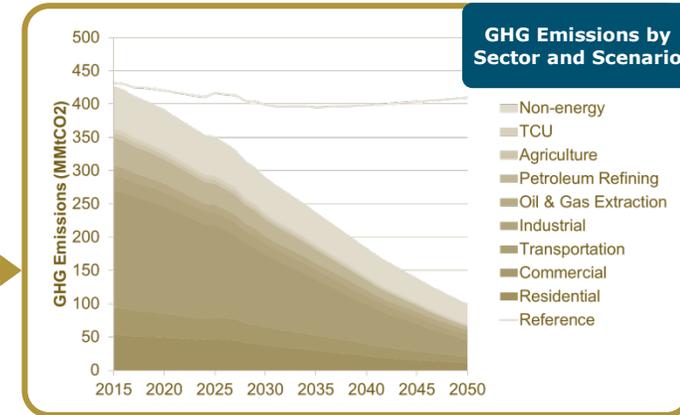


What is PATHWAYS?

- + 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
- + Hourly treatment of electric sector
- + Tracks capital investments and fuel costs over time



Sample Outputs:



Executive Summary



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Scenario Descriptions

+ Scoping Plan Scenarios:

- **Alternative 1 “Alt 1”**: Carbon neutral by 2035. Nearly complete phaseout of combustion, limited reliance on engineered carbon removal, restricted applications for biomass derived fuels, and ambitious innovation in technology and aggressive consumer adoption trends (e.g. electric aviation adoption and 100% electrification by 2035).
- **Alternative 2 “Alt 2”**: Carbon neutral by 2035. Use of full suite of technology options, including engineered carbon removal.
- **Alternative 3 “Alt 3”**: Carbon neutral by 2045. Use of broad portfolio of existing and emerging fossil fuel alternatives and alignment with statutes and Executive Orders
- **Alternative 4 “Alt 4”**: Carbon neutral by 2045. Use existing and emerging technologies, slower rate of clean technology and fuel deployment and consumer adoption. Reflects a higher reliance on engineered carbon removal.

- + **Reference Business-as-Usual (BAU) “BAU Reference”**: Aligns with current trends and includes the estimated impact of all current regulations. Reflects our best estimate of what will happen with no further policy intervention



Key Metrics

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Annual Build Rates Historic Max Builds: Solar: 2.7GW Battery: 0.3GW	Solar: 10GW Battery: 5GW	Solar: 5GW Battery: 3GW	Solar: 7GW Battery: 2GW	Solar: 6GW Battery: 2GW
Vehicle Early Retirements US-wide Cash for Clunkers \$3B and 690k vehicles	LDV: 16M 5-16 yr. old MHDV: 1.4M 5-16 yr. old	LDV: 0 MHDV: 0.6M 10-20 yr. old		
Residential Early Retirements	7M electric homes. Appliances 5-16 yr old			
Hydrogen Demand & Electrolysis Need Total CA Capacity: 83GW	Percent 2020 US: 19% Solar: 43GW	Percent 2020 US: 18% Solar: 39GW	Percent 2020 US: 17% Solar: 36GW	Percent 2020 US: 13% Solar: 27GW
Petroleum Refining Remaining	2035: 0% 2045: 0%	2035: 25% 2045: 8%	2035: 33% 2045: 13%	2035: 39% 2045: 18%
Total CCS Needs Industrial & Refining	2035: <1MMT 2045: <1MMT	2035: 7MMT 2045: 2MMT	2035: 10MMT 2045: 3MMT	2035: 11MMT 2045: 5MMT
Residual Emissions Current global DAC 0.01 MT/year	2035: 45MMT 2045: 37MMT	2035: 138MMT 2045: 75MMT	2035: 0MMT 2045: 95MMT	2035: 0MMT 2045: 114MMT

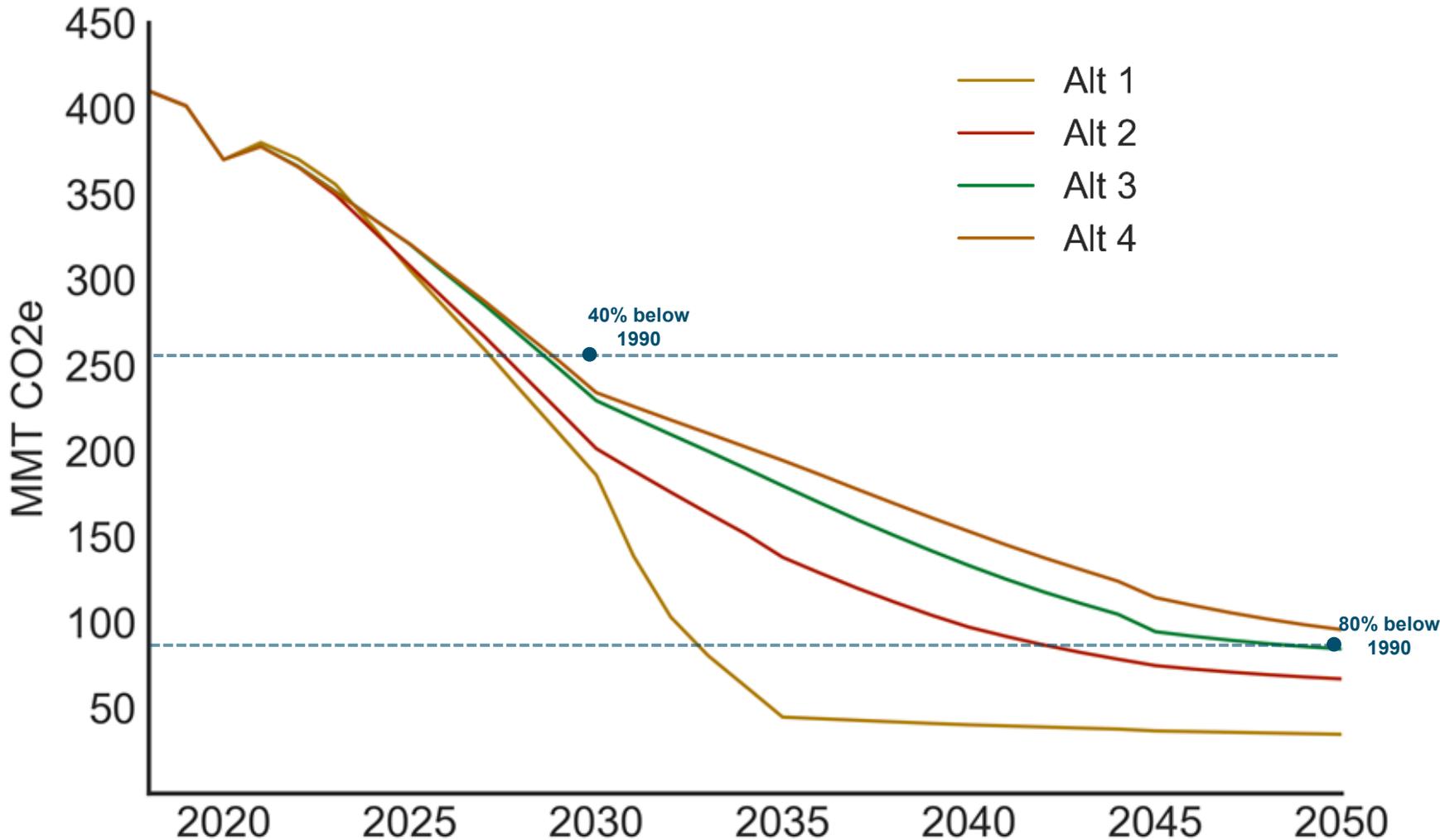
Emissions



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Direct Emissions



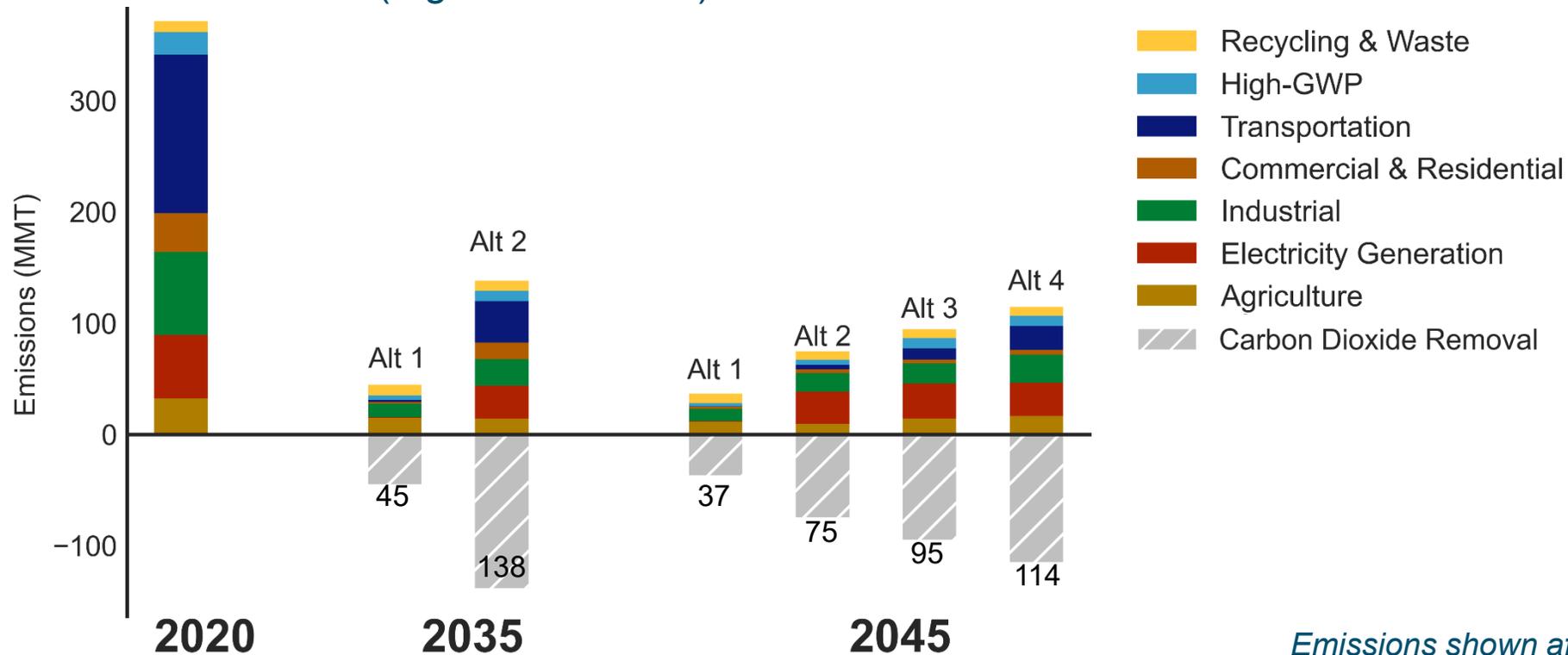
- + Each Alternative meets the 2030, 40% below 1990 target
- + All Scoping Plan Alternatives, except Alternative 4, meet the 2050 80% below 1990 target
- + All Alternatives will need to rely on carbon dioxide removal (CDR) to achieve carbon neutrality by 2035, for Alt 1 and 2, and 2045, for Alt 3 and 4

Emissions shown after CCS, before CDR



Total Emissions

- + **Agriculture and other** methane and fugitive emissions are a large source of remaining emissions in all alternatives explored
- + Persistent sources of emissions which remain in all alternatives include **industrial** emissions and **high global warming potential (GWP)** emissions
- + **Electricity generation** and **transportation** emissions remain in cases expect those with emphasis on non-combustion alternatives (e.g. Alternative 1)

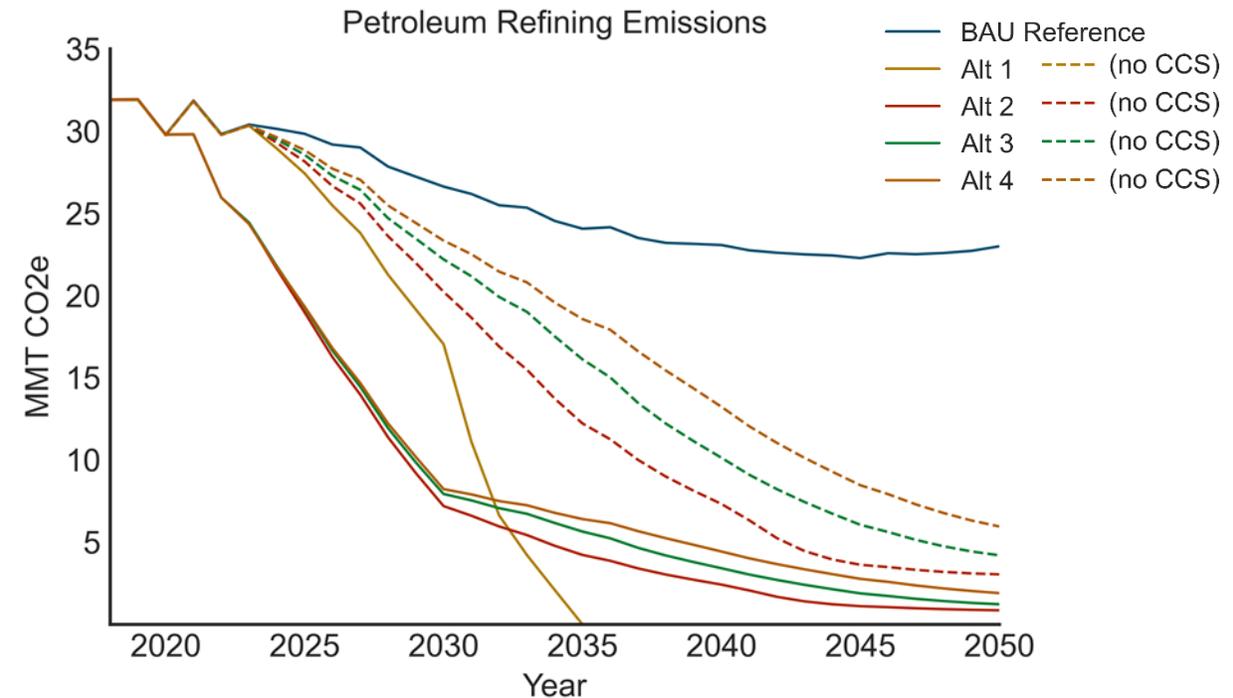
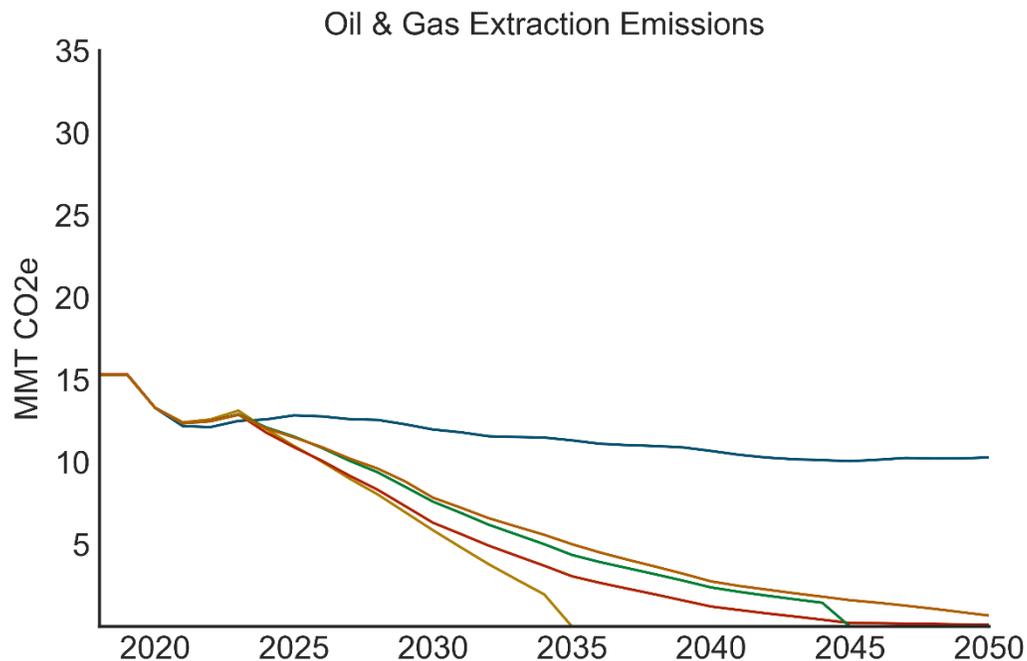


Emissions shown after CCS, before CDR



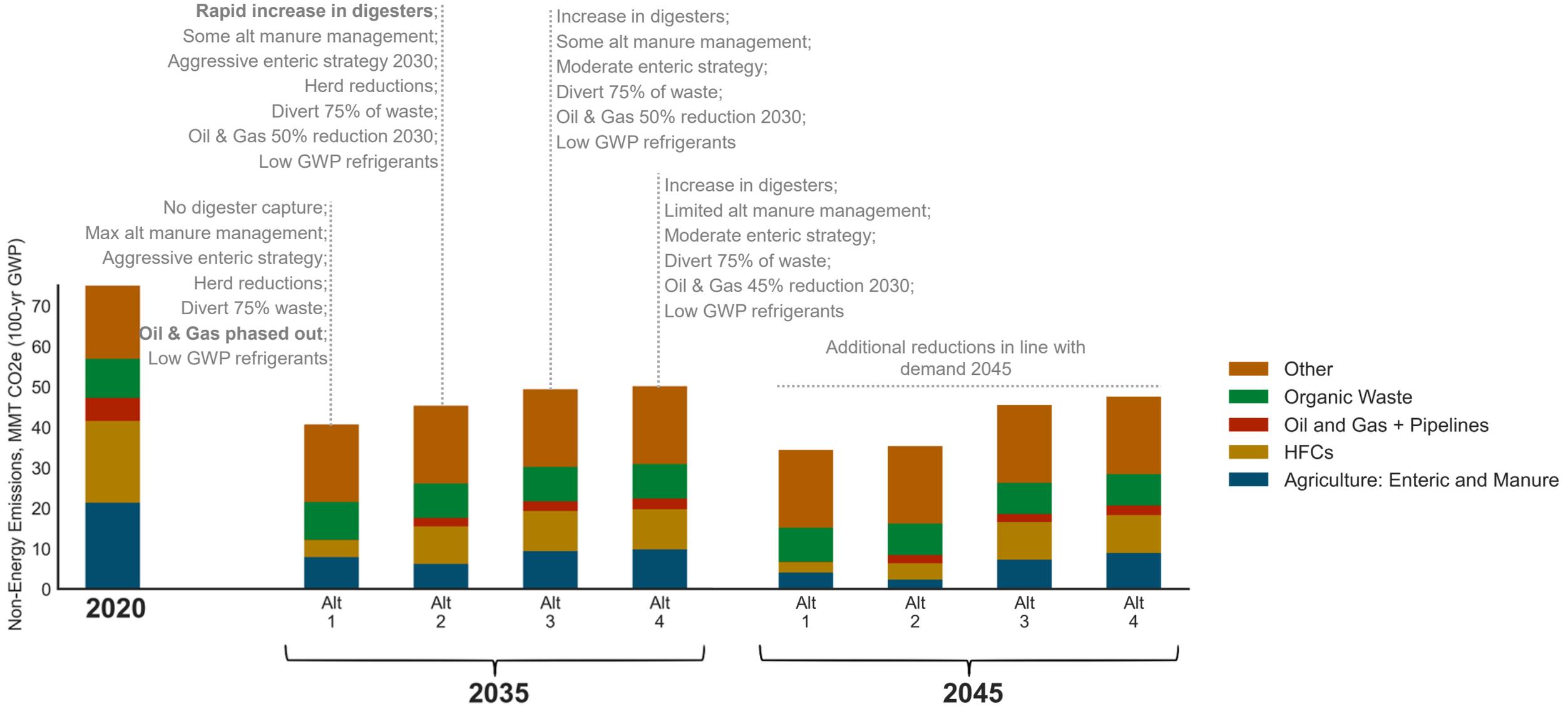
Oil & Gas Extraction and Petroleum Refining Emissions

- + Oil & Gas Extraction for **Alts 2, 3, & 4** tracks demand for petroleum while **Alt 1** was ramped down linearly. Full phase out of Oil & Gas Extraction in 2035 for **Alt 1** and 2045 for **Alt 3**.
- + Petroleum Refining Emissions is shown with and without application of carbon capture & sequestration (CCS) with a 90% capture rate. All Alternatives track petroleum demand and **Alts 2, 3, & 4** apply CCS on all major operations by 2030.





Non-Energy Emissions



Energy Demand

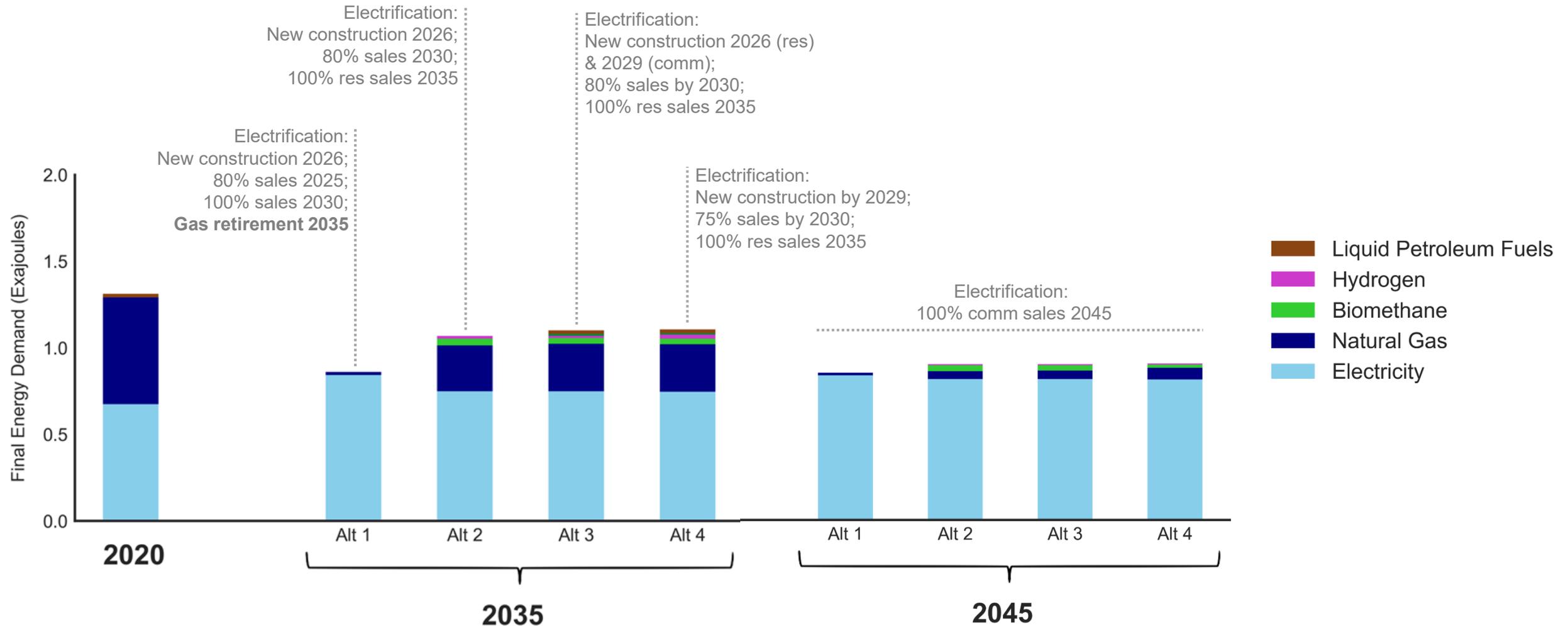


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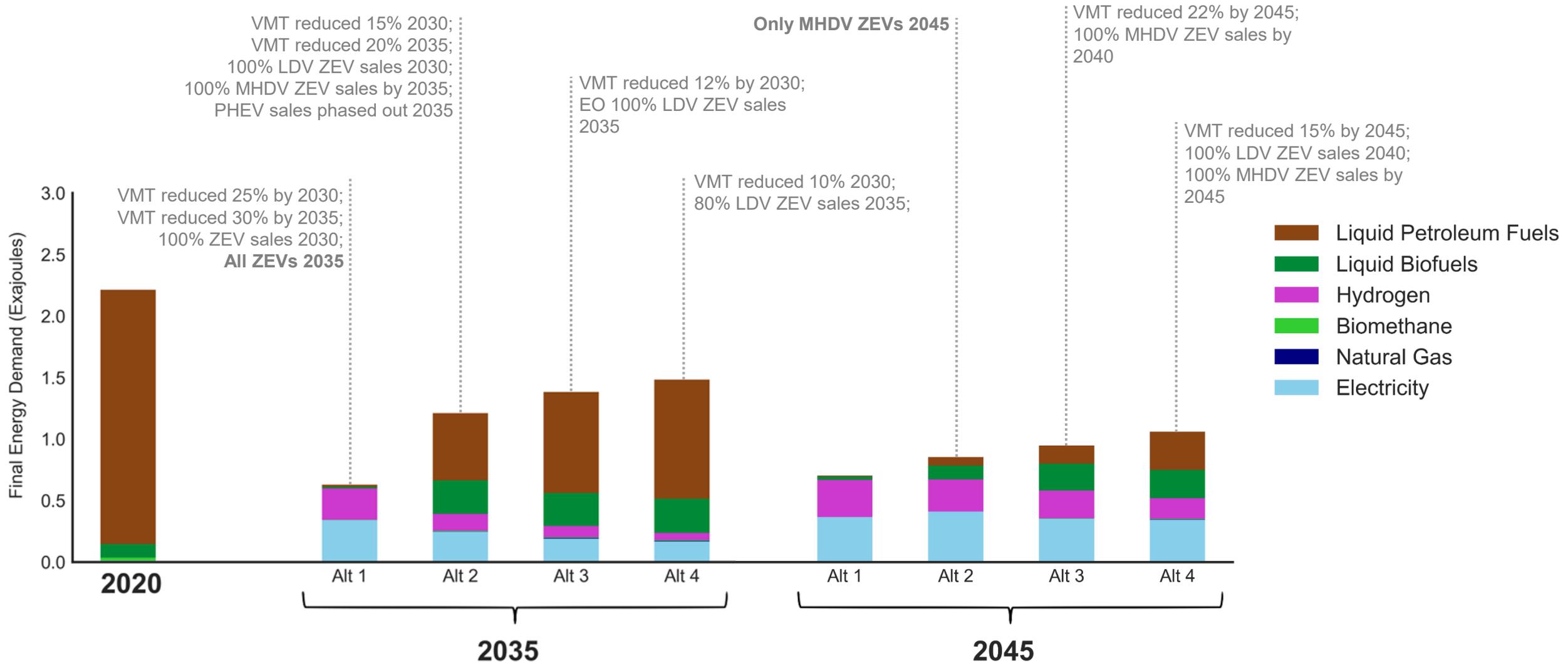
Building Energy Demand

Energy Efficiency: Aligned with Integrated Energy Policy Report (IEPR) Mid-High (electric) and Mid-Mid (gas)





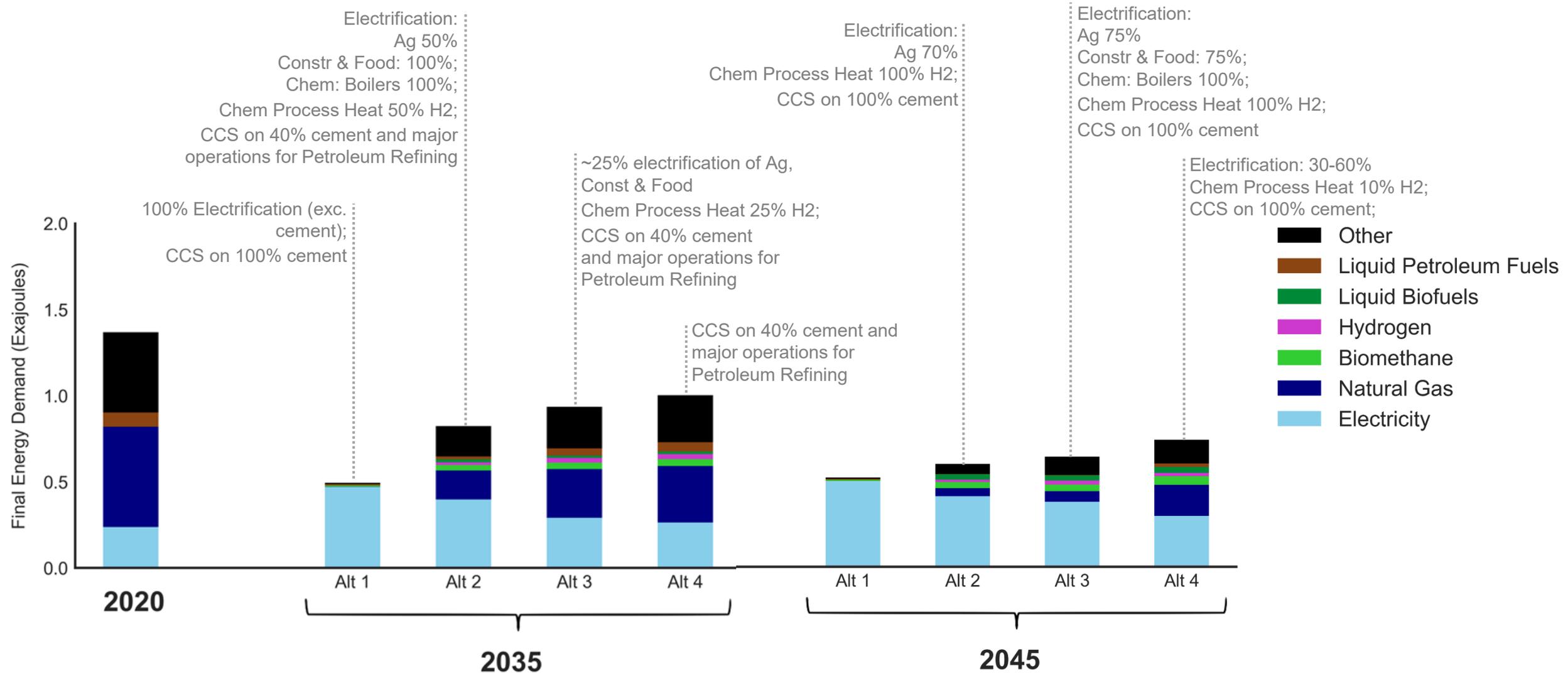
Transportation Energy Demand





Industry and Agriculture Energy Demand

Energy Efficiency: Aligned with 2017 Scoping Plan with a 6% energy demand reduction for industry and agriculture



Fuel and Stock Transitions

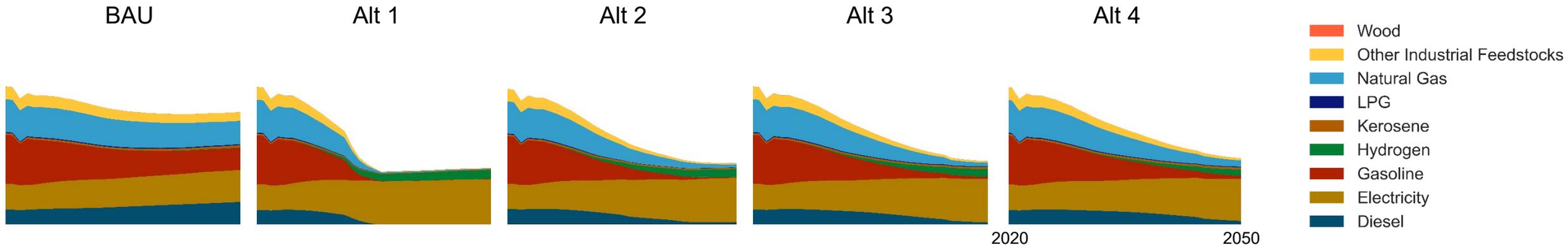


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Energy Demand by Fuel

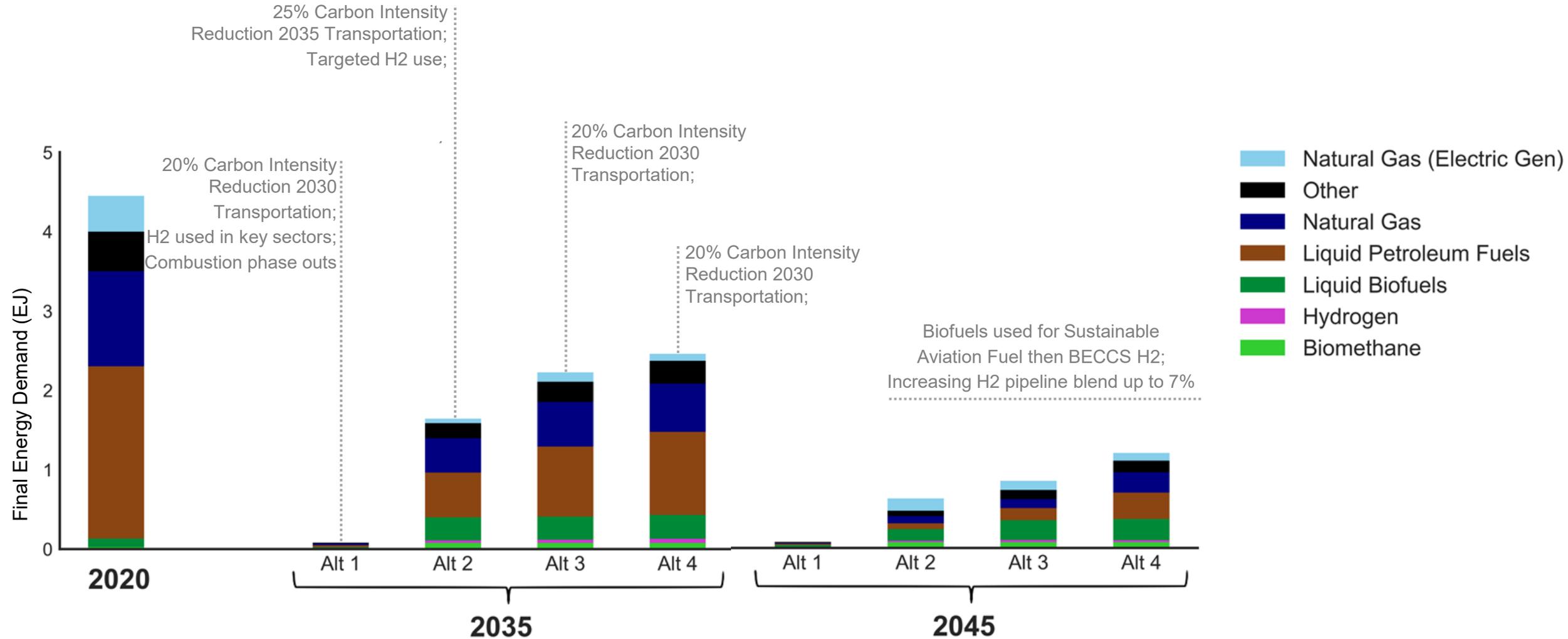
- + **Natural gas** phases down as electrification measures ramp up
- + **Hydrogen** is assumed to be biomass gasification with carbon capture and sequestration (CCS) and electrolysis and is heavily utilized in multiple sectors
 - Alt 1: 25% aviation 2035; 10% OGVs 2035; HFCV trucks 2030; line haul/passenger rail 2030
 - Alt 2: 7% pipeline blend 2040; 10% OGVs 2035; HFCV trucks 2035; line haul/passenger rail 2030
 - Alt 3: 7% pipeline blend 2040; 25% OGVs 2045; HFCV trucks 2040; line haul/passenger rail 2035
 - Alt 4: 7% pipeline blend 2040; HFCV trucks 2045; line haul/passenger rail 2045
- + **Gasoline** ramps down in line with ZEV targets
- + **Electricity** ramps up in line with building and transportation electrification targets
- + **Diesel** ramps down in line with MHDV targets and industrial electrification



Biofuels categorized in natural gas, kerosene, and diesel

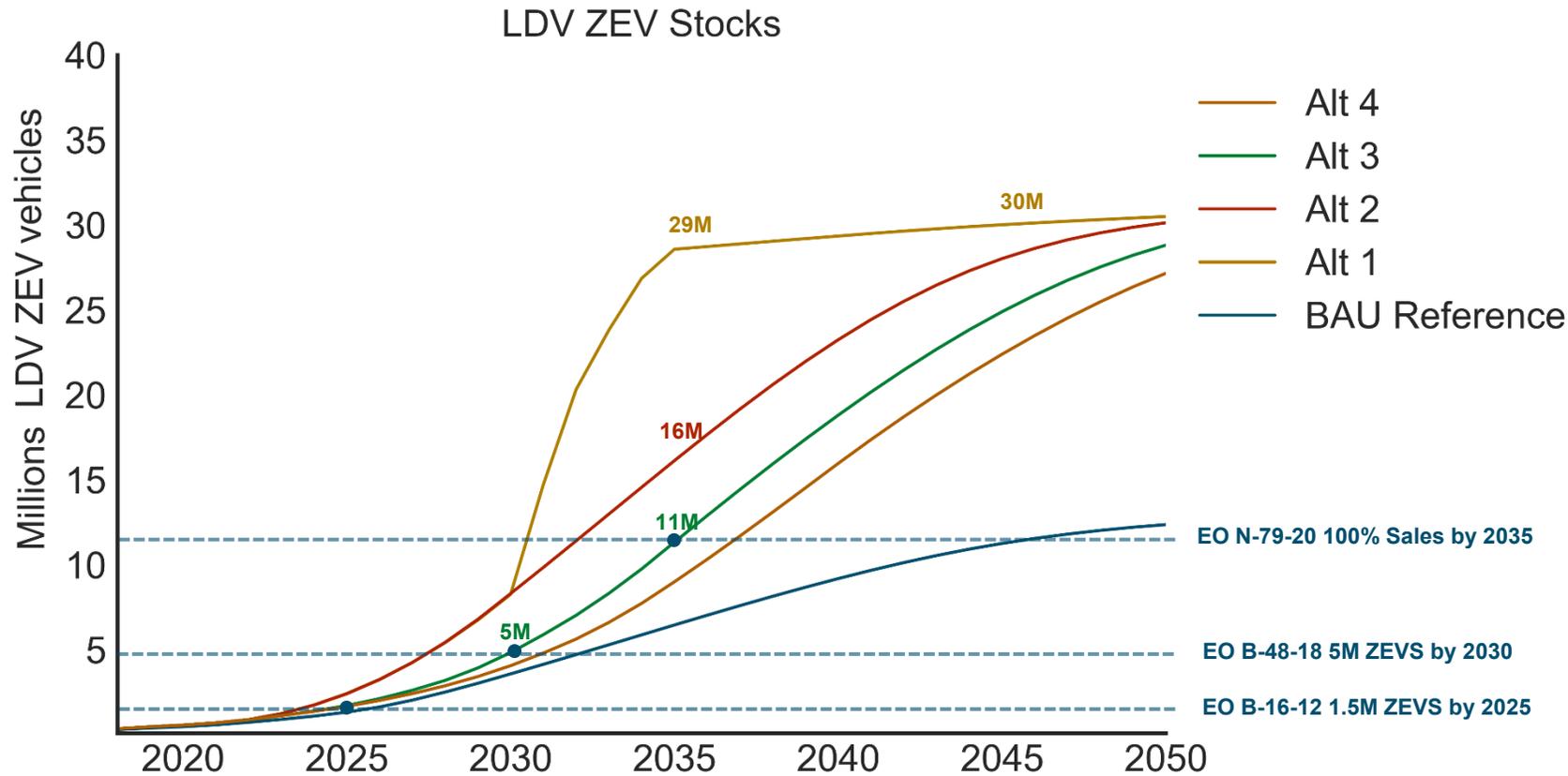


Combustion Fuels Transition





Light Duty Vehicle Stocks

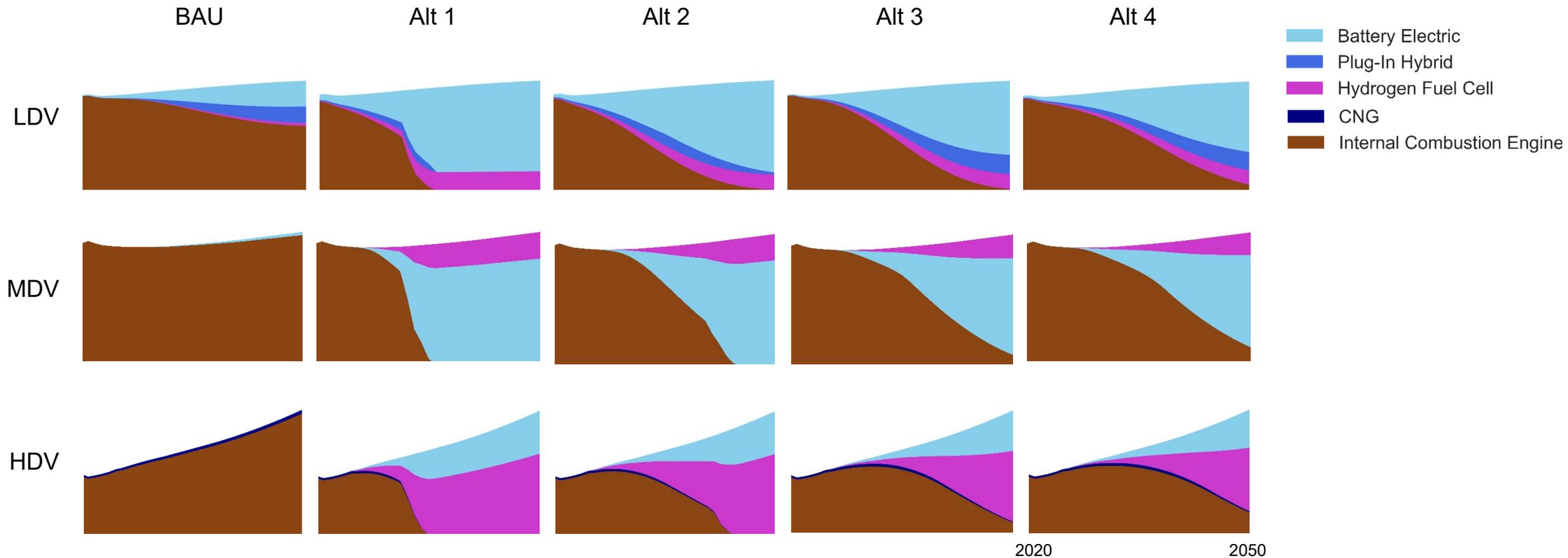


- + Alternatives 1, 2, and 3 meet each of the Executive Orders
- + Alt 1 has ~19M ICE vehicles remaining in 2030 and 0 by 2035
- + Alt 2 has ~2M ICE vehicles remaining in 2045
- + Alt 3 has ~5M ICE vehicles remaining in 2045
- + Alt 4 has ~8M ICE vehicles remaining in 2045



Transportation Adoption Transitions

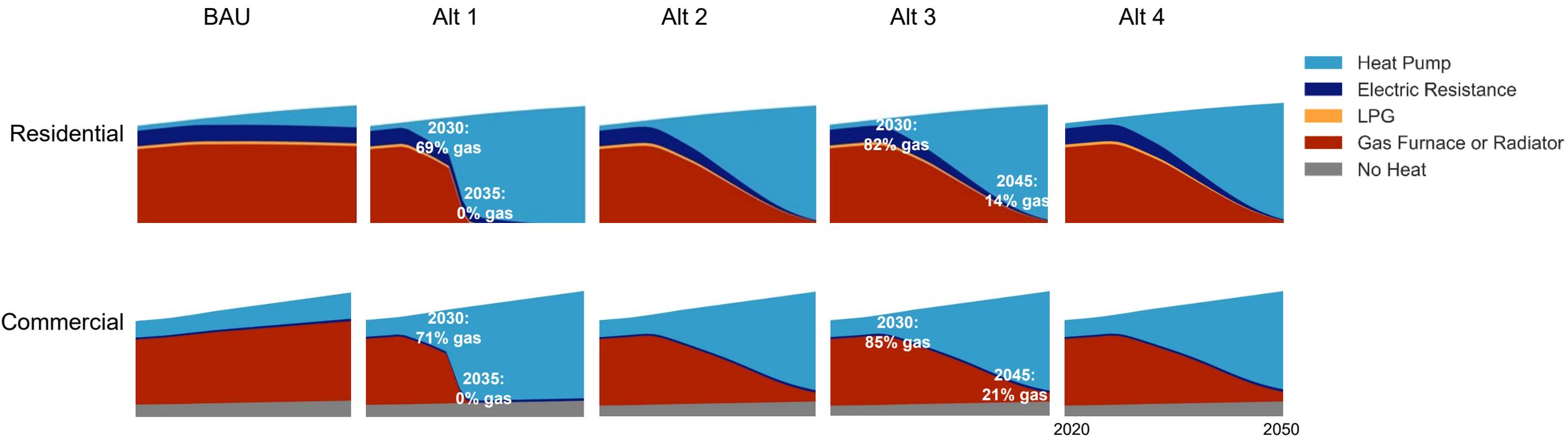
- + Alt 1 requires large scale early retirement of internal combustion vehicles to achieve only ZEVS by 2035
- + Alt 2 requires some early retirement to achieve only ZEV MDV and HDV by 2045
- + Alt 3 and Alt 4 have a slower transition that requires no early retirement





Building Sector Adoption Transitions

- + Alt 1 requires large scale early retirement of gas end-use appliances to achieve gas retirement by 2035
- + Alt 2, Alt 3, and Alt 4 have a slower transition that requires no early retirement



Electric Sector

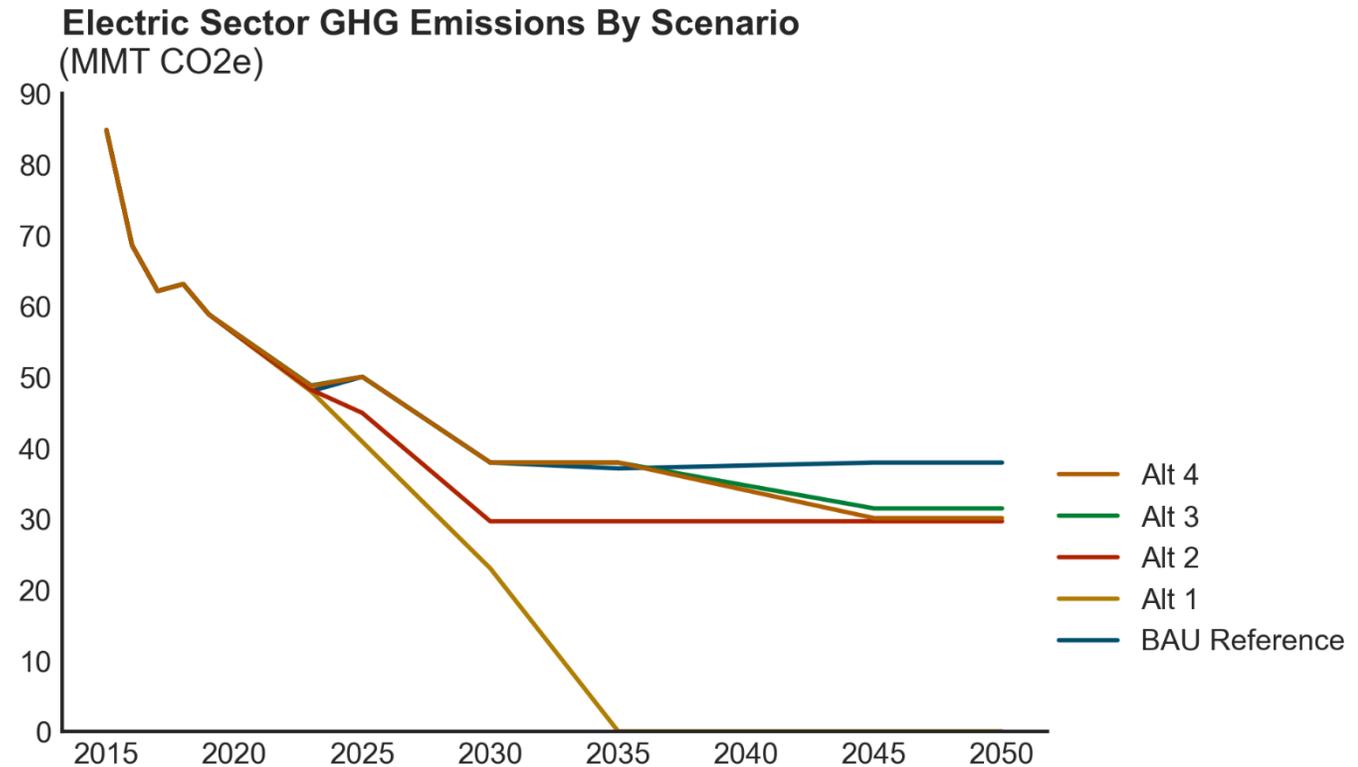


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Summary

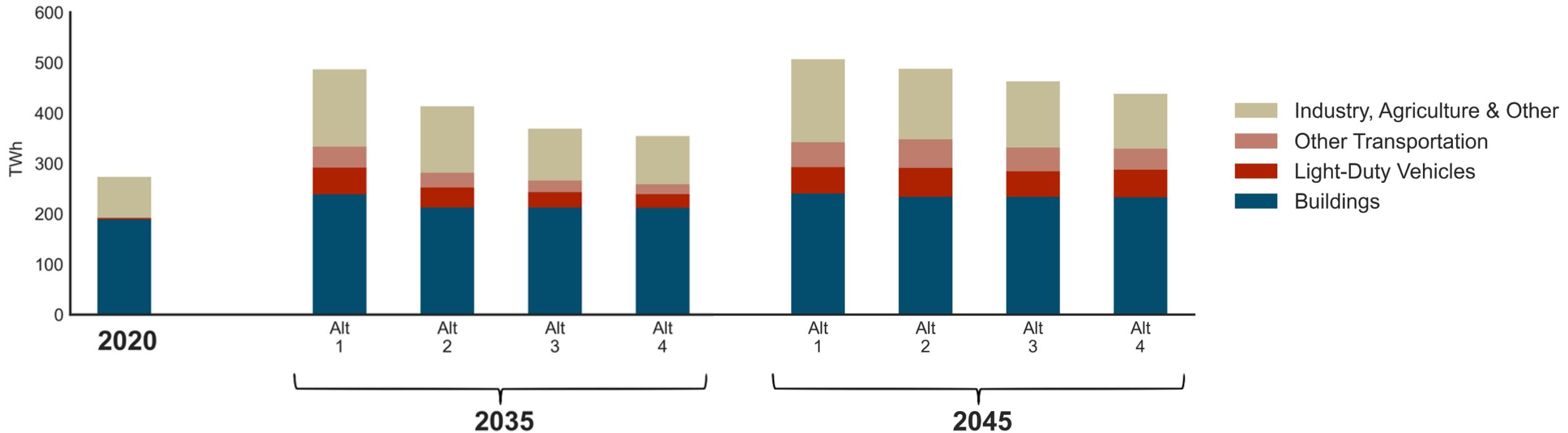
- + Reference case stays constant at currently-mandated 38 MMT target
- + Alt 1 has a 0 MMT by 2035 target with no combustion
- + Alts 2, 3 and 4 all feature an SB100 100% of retail sales clean energy target by 2045. All scenarios remain at around 30 MMT through 2050





Loads by Scenario

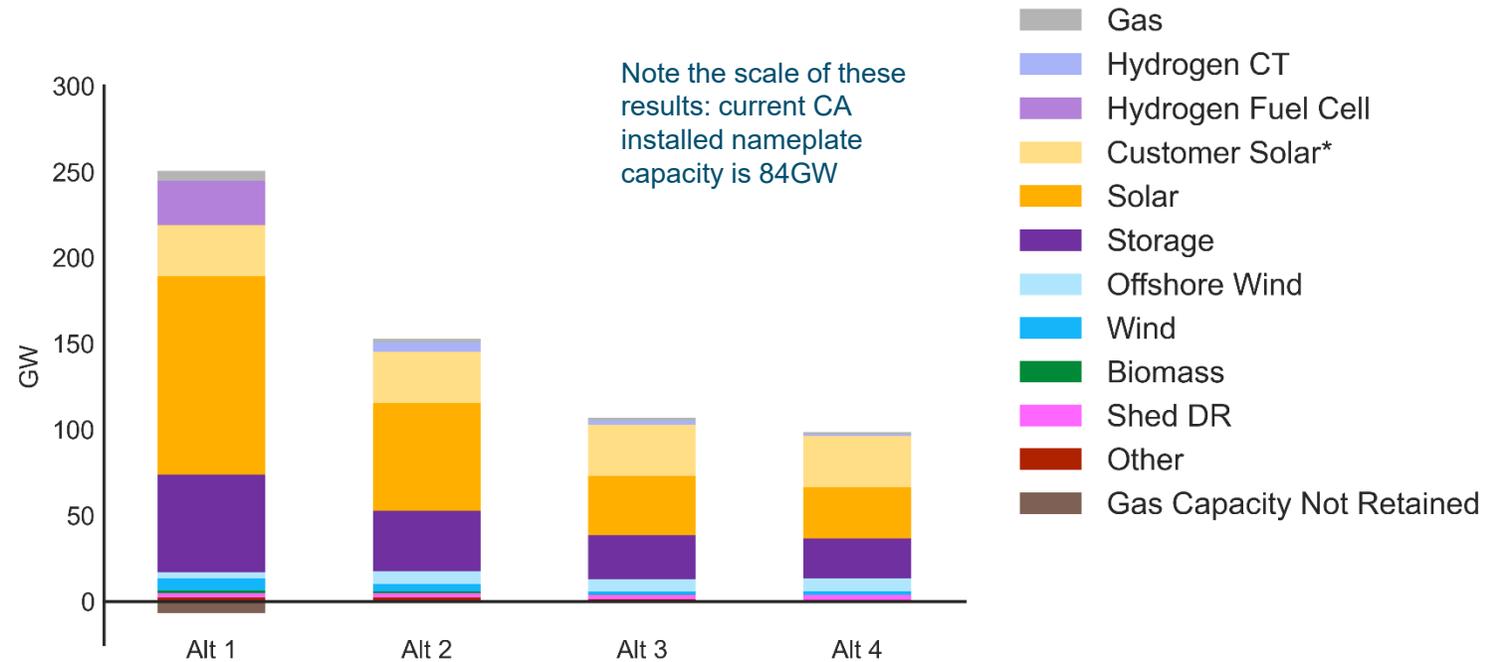
- + Electric loads increase by 30-80% relative to today by 2035 and 60-90% by 2045
- + Loads for direct air capture and hydrogen production are assumed to be provided by off-grid renewables, and are not included in this graphic
- + **Other transportation** includes all non-LDVs and reflects electrification of things like passenger and freight rail, aviation, and ocean-going vessels (OGVs)





Cumulative New Resource Capacity Build in 2035

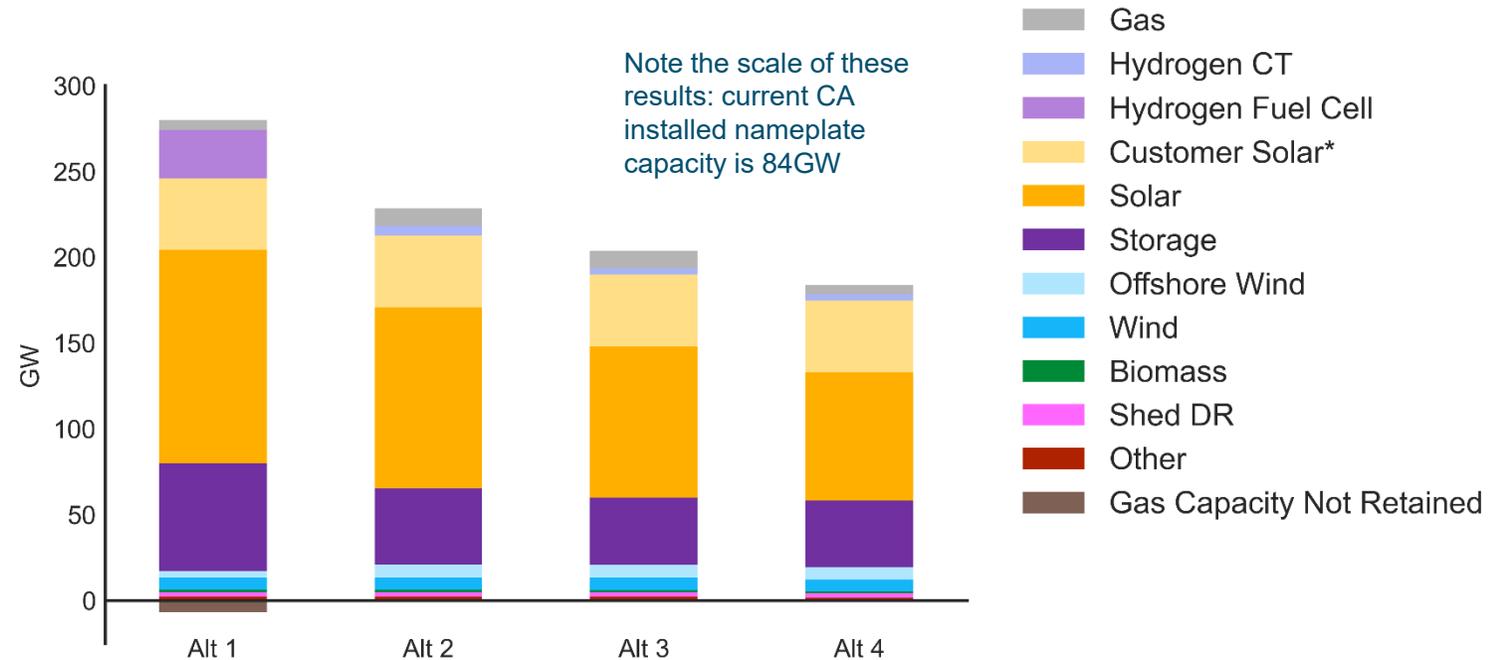
- + Alt 1 features a 100% no combustion target by 2035 and significantly higher electrification loads, causing resource builds to be much higher than the other scenarios
- + This Alt 1 constraint leads to ~7GW of gas retirements in 2035 and ~6GW of new gas build for capacity (CF: 0%)
- + Alt 1 builds ~56GW of battery storage and ~26GW of hydrogen fuel cells as firm clean capacity
- + Alt 2 also features a notably higher build in 2035 due to the higher loads





Cumulative New Resource Capacity Build in 2045

- + In Alt 1, builds ~62 GW of battery storage and ~30 GW of hydrogen fuel cells as clean firm capacity
- + Alt 1 builds ~124 GW of solar, compared to ~26 GW in the BAU
- + Alts 2 through 4 are similar in 2045 due to SB100 goal, while in Alt 1 the model builds significantly more clean energy resources to meet the 0 MMT, no combustion target
- + In Alt 3 scenario, model builds ~90 GW of solar and ~40 GW of batteries to meet SB100 retail sales target. All gas remains online and ~10 GW of new gas is built



Thank You

Jessie.Knapstein@ethree.com



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