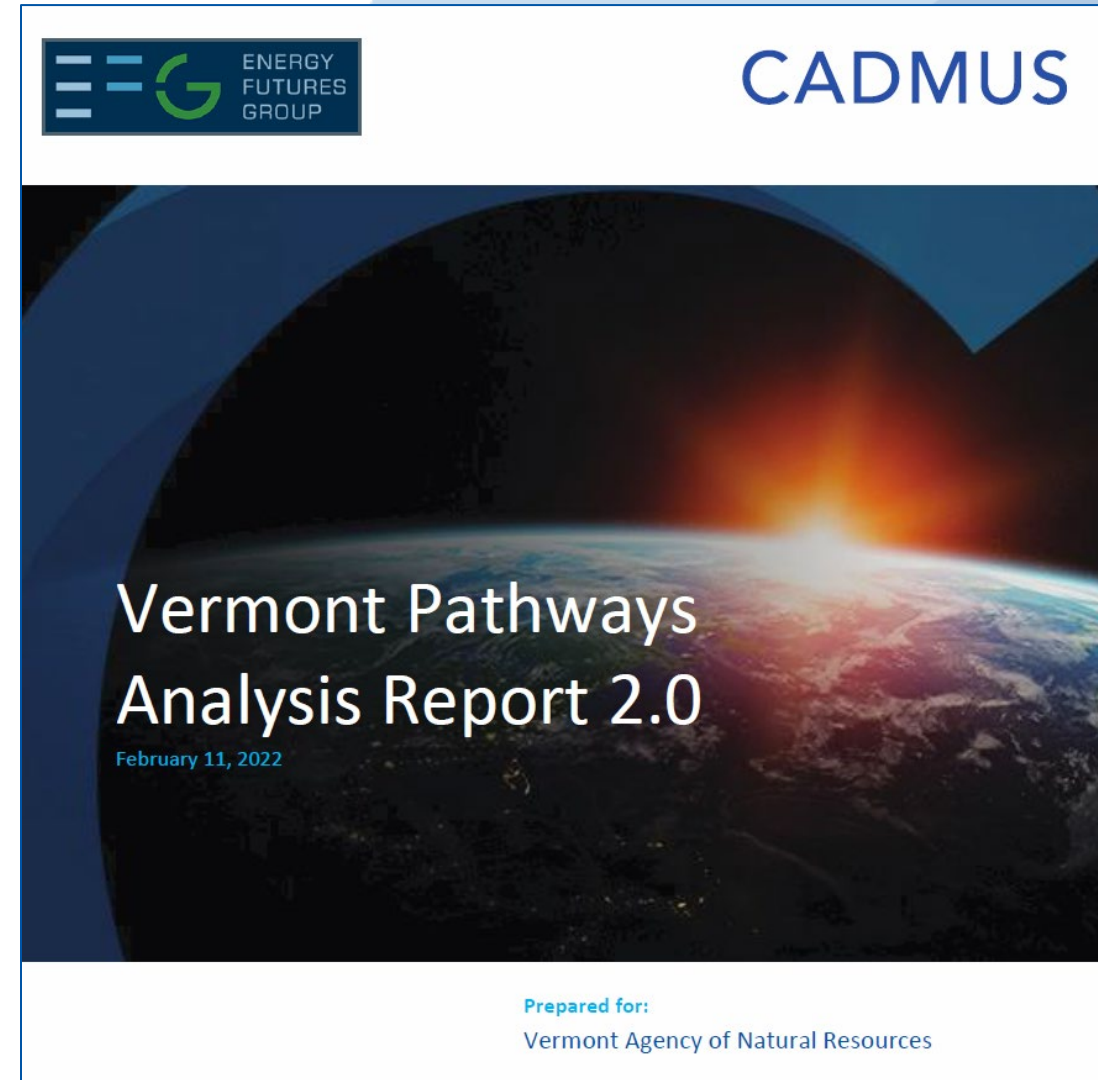# Vermont Pathways Analysis Report 2.0

February 17, 2022

Agenda

- Analysis Revisions in Version 2.0
- Overview of Results
  - Emissions and Key Indicators
  - IMPLAN Analysis
- Looking Forward
  - Sectoral Contributions
- Questions and Discussion
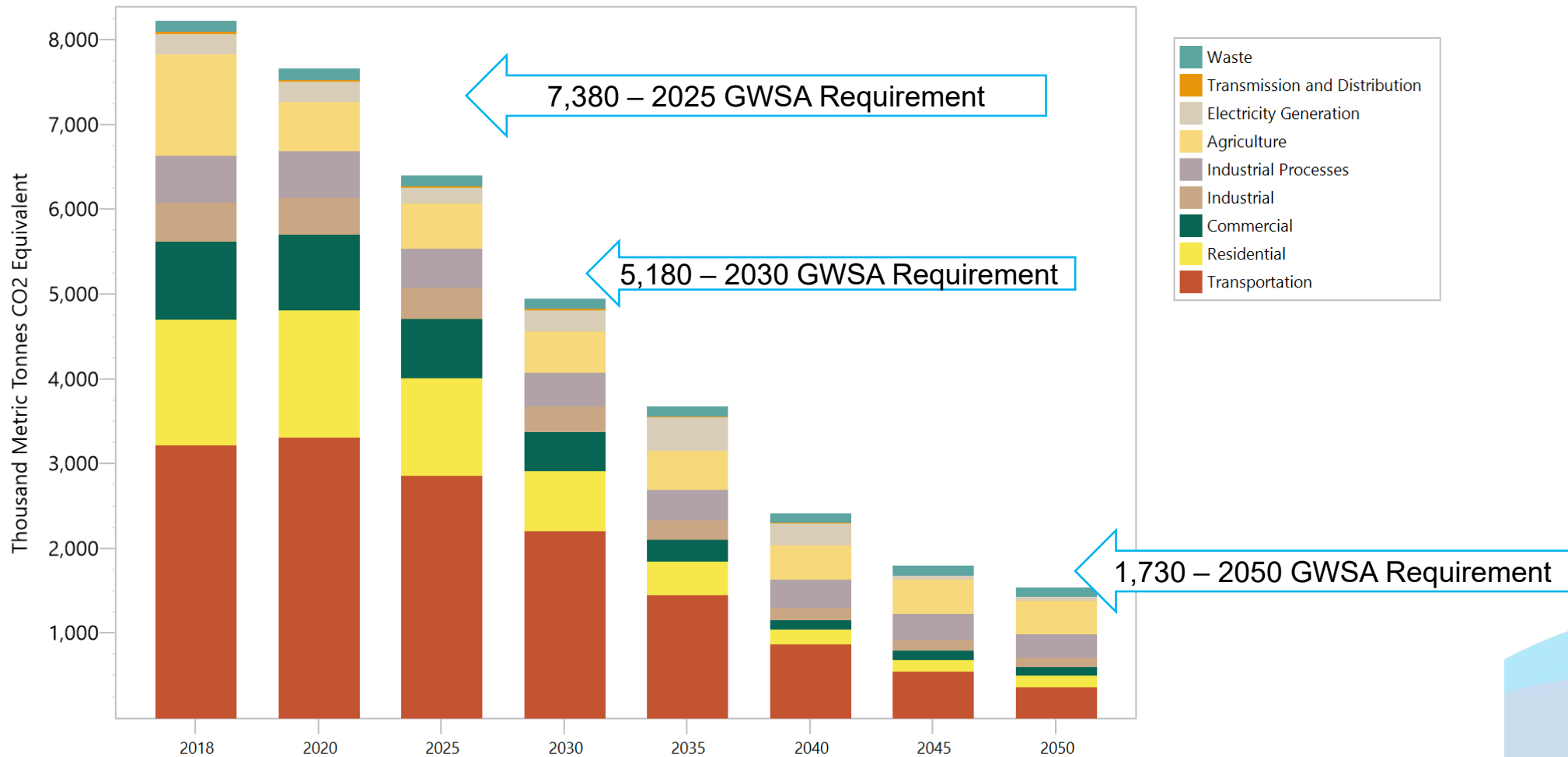
Analysis Revisions in Version 2.0

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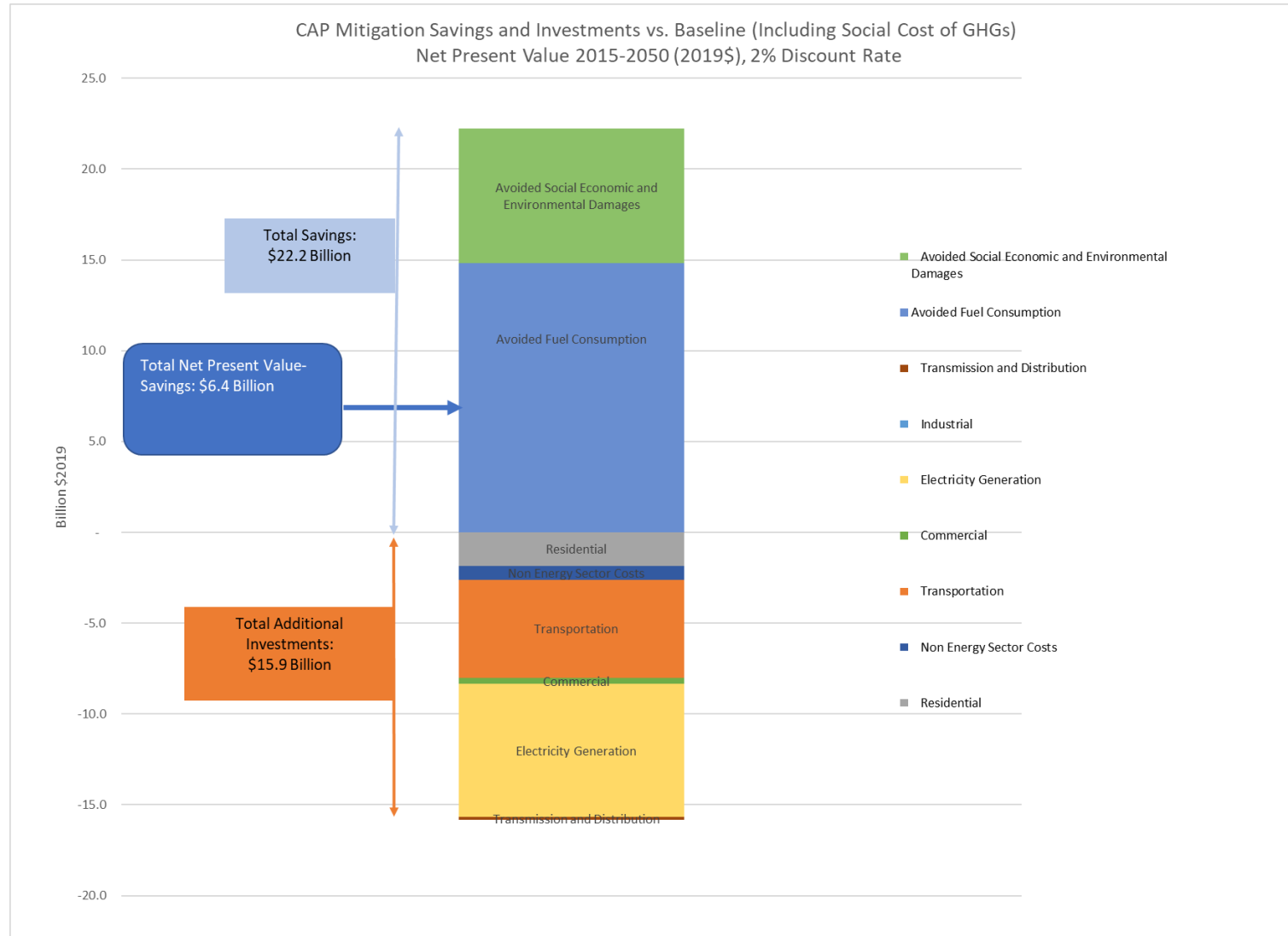| Item	Pathways Analysis November 2021	Pathways v 2.0 Analysis Update
Transportation	Linear adoption of EVs to ICE phase out in 2033	Reduced early adoption of EVs to reflect near term supply constraints and OEM announcements.
Advanced Wood Heat	Did not include high efficiency pellet and wood stoves. Share of heating declined to 8% by 2050	Incorporates high efficiency pellet and wood stoves. Wood provides 13% of heating by 2050.
Environmental Externality Values	Externality costs for road transport branches not calculated	LEAP update corrects calculation error – increases value of avoided emissions by $3.6 billion
IMPLAN – Inputs	Based on version 1.81 of LEAP model. Net investments ~$500 million	Adjusted based on version 2.04 of LEAP model. Net investments of $1.1 billion
IMPLAN – Opportunity Costs	Reduction of spending on non-CAP items not analyzed	Opportunity costs of net investment in CAP assessed

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Summary Results

CAP Mitigation Pathway and GWSA Requirements

100-Year GWP: Direct (At Point of Emissions)

Scenario: CAP With Social Cost of GHGs, All Fuels, All GHGs

7,380 – 2025 GWSA Requirement

5,180 – 2030 GWSA Requirement

1,730 – 2050 GWSA Requirement

Legend:
- Waste
- Transmission and Distribution
- Electricity Generation
- Agriculture
- Industrial Processes
- Industrial
- Commercial
- Residential
- Transportation

Y-axis: Thousand Metric Tonnes CO2 Equivalent

X-axis: 2018, 2020, 2025, 2030, 2035, 2040, 2045, 2050

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Summary Economic Results

CAP Mitigation Savings and Investments vs. Baseline (Including Social Cost of GHGs)
Net Present Value 2015-2050 (2019$), 2% Discount Rate

Total Savings: $22.2 Billion

Total Net Present Value- Savings: $6.4 Billion

Total Additional Investments: $15.9 Billion

Avoided Social Economic and Environmental Damages

Avoided Fuel Consumption

Residential

Non Energy Sector Costs

Transportation

Commercial

Electricity Generation

Transmission and Distribution

Legend:
- Avoided Social Economic and Environmental Damages
- Avoided Fuel Consumption
- Transmission and Distribution
- Industrial
- Electricity Generation
- Commercial
- Transportation
- Non Energy Sector Costs
- Residential
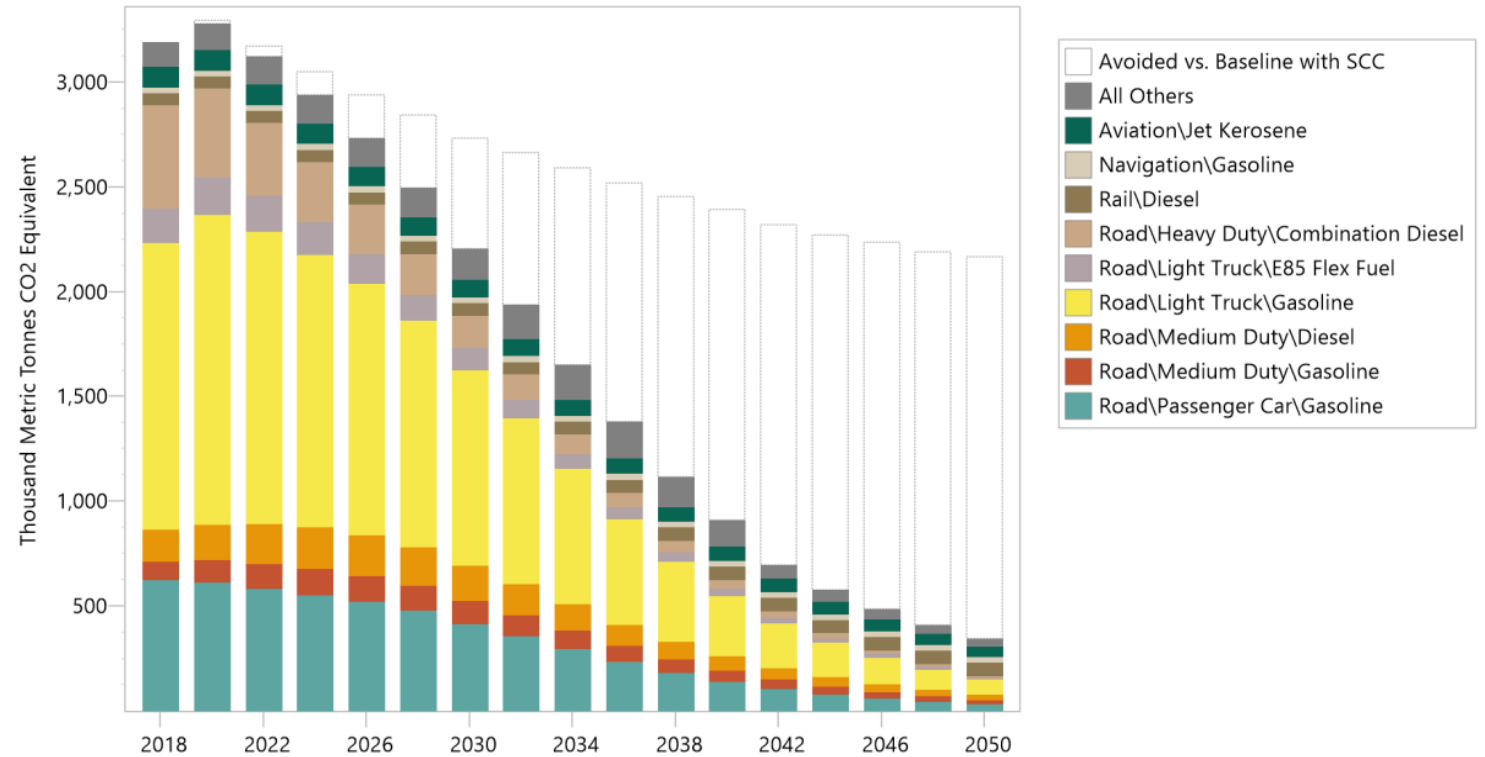
Billion $2019

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Sector Pathways

Transportation Key Indicators and Emission Reductions

Table 2. Transportation Key Indicators for 2025 and 2030

Transportation	2025	2030
Number of EVs	27,000	126,000
EV Share of Sales	17%	68%
VMT Reduction from Baseline	1.9%	3.5%
EV share of VMTs	5%	23%
EV Managed Charging	27%	50%

Transporation Emissions Mitigation Scenario Avoided vs. Baseline
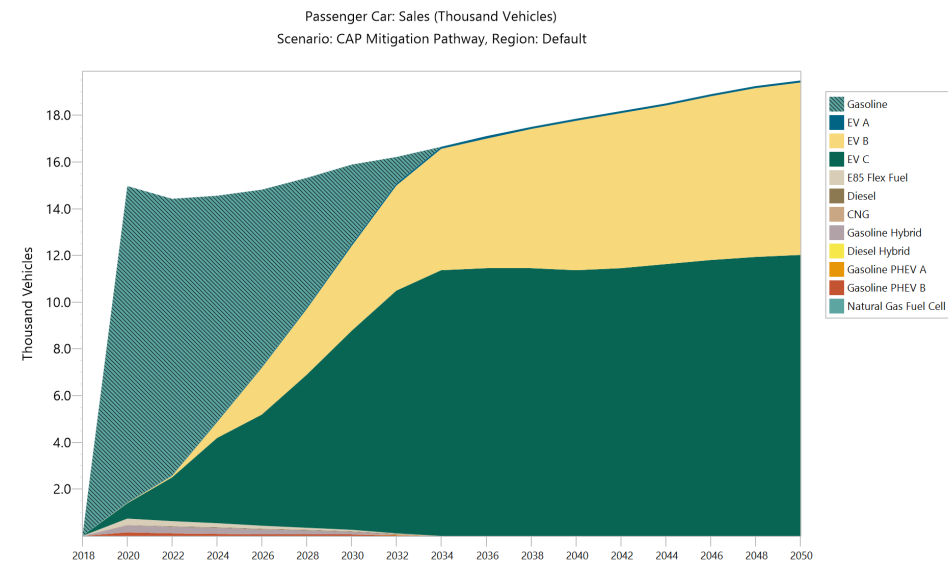100 Yr GPW, Point of Emissions and Indirect Allocated to Demand

Legend:
- Avoided vs. Baseline with SCC
- All Others
- Aviation\Jet Kerosene
- Navigation\Gasoline
- Rail\Diesel
- Road\Heavy Duty\Combination Diesel
- Road\Light Truck\E85 Flex Fuel
- Road\Light Truck\Gasoline
- Road\Medium Duty\Diesel
- Road\Medium Duty\Gasoline
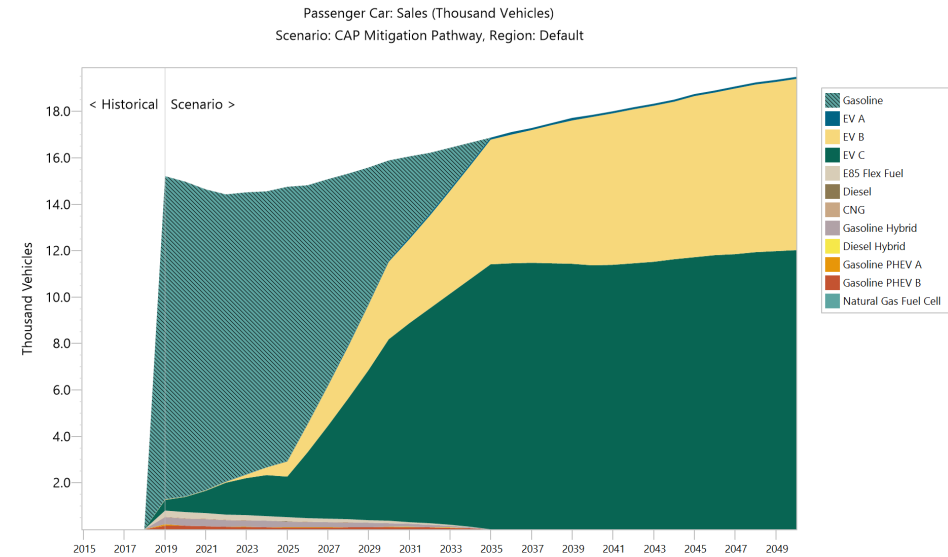- Road\Passenger Car\Gasoline

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Transportation: Modifications for Version 2.0 Update

- November Pathways Analysis (bottom graph) linear adoption of EVs
- Revised to reflect availability based on near term supply constraints and OEM announcements.
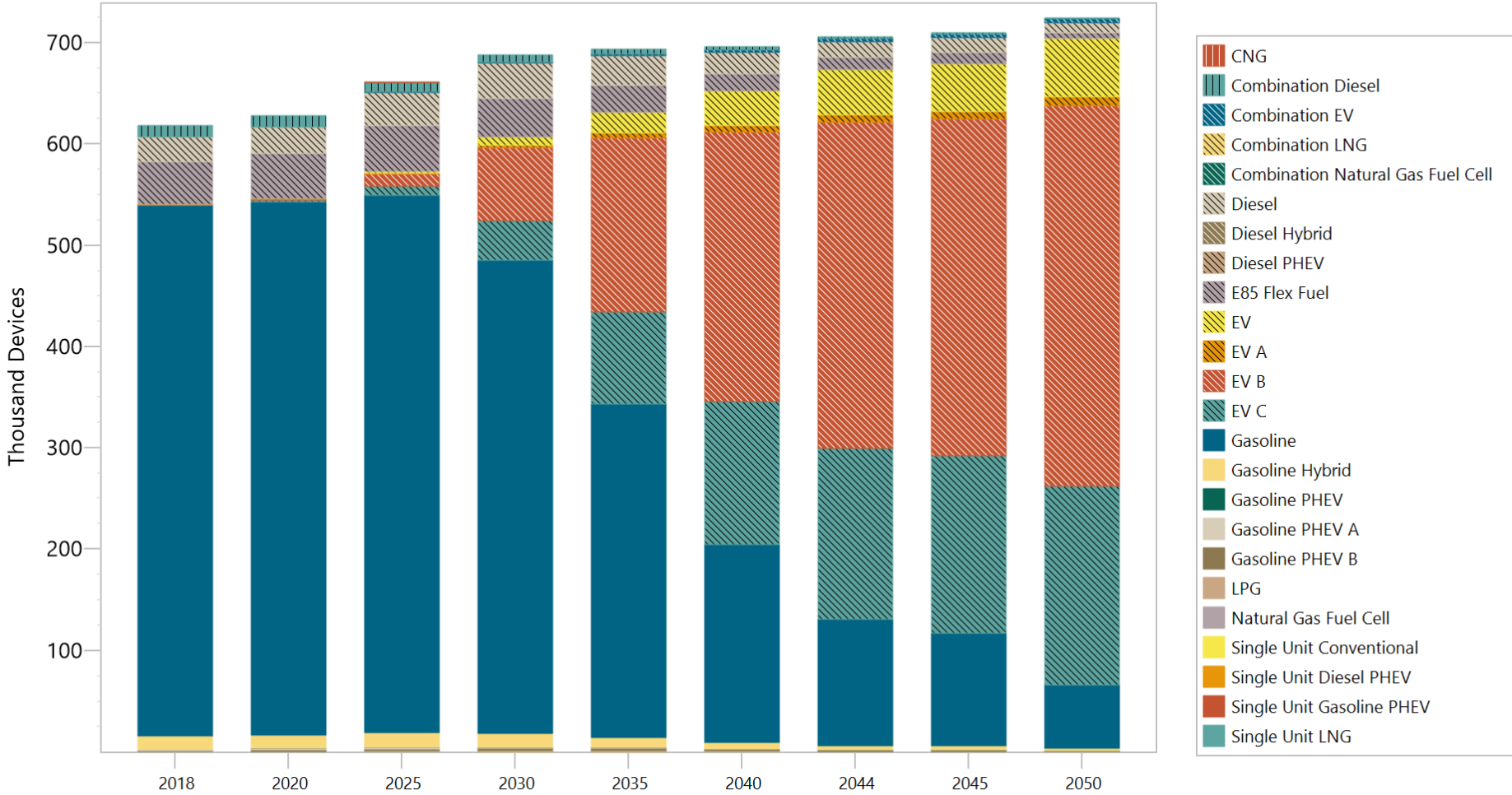- Resulting Total EV stock: 27,000 by 2025, down from 43,000.

Impacts:
-    Reduced EV costs and mitigation through 2035

Passenger Car: Sales (Thousand Vehicles)
Scenario: CAP Mitigation Pathway, Region: Default

Passenger Car: Sales (Thousand Vehicles)
Scenario: CAP Mitigation Pathway, Region: Default

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Mitigation Scenario Vehicle Stocks

Buildings Key Indicators and Emission Reductions

Table 3. Residential Buildings Key Indicators for 2025 and 2030[10]

Residential	2025	2030
Homes Weatherized	69,000	120,000
Heat Pumps Installed	96,224	177,107
Heat Pump Water Heaters Installed	63,247	136,558
Homes with Advanced Wood Heat	12,898	14,992
Homes with Biofuels	12,112	21,086

Building Sector Emissions and Avoided vs. Baseline
100 Yr GWP, Direct plus Indirect Allocated to Demand

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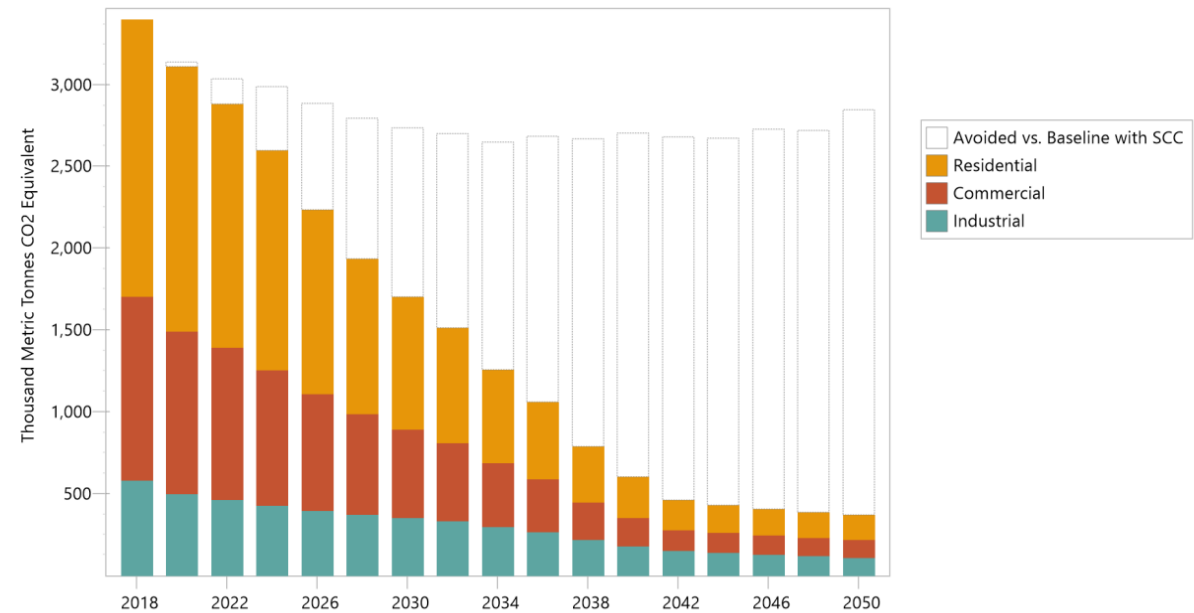
Buildings Sector – Modifications for Pathways Update

- Advanced wood heating maintains 13%+ share of heating by 2050 – compared to 8% from initial Pathways Analysis
- Include high efficiency wood and pellet stoves so that 50% of all wood units are HE by 2030.
- Increase B100 heating oil uptake so by 2040 all remaining heating oil is B100.
- Increase renewable distributed gas, by 2050 80% of remaining distributed gas is renewable

Impacts:
- Small reduction in electric demands
- Reduced decline in wood fuel demand
- Greater diversification of mitigation in building sector

Updated Mitigation Scenario
Advanced Wood Heating Systems by Type

Legend: ■ High Efficiency Pellet Stoves ■ High Efficiency Wood Stoves

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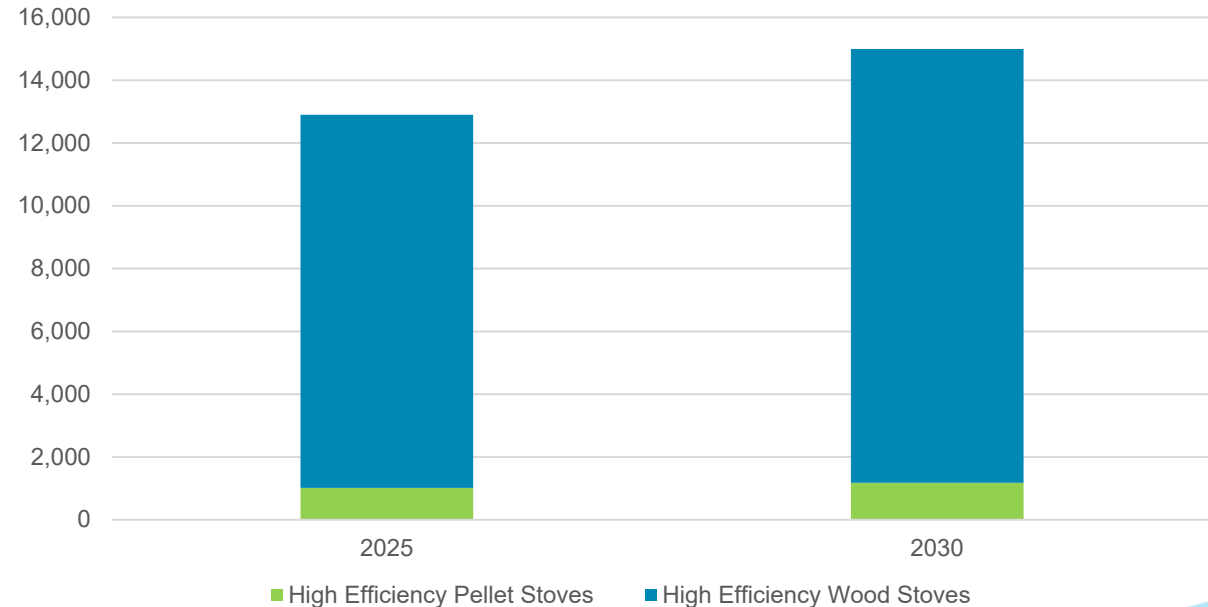
Non-Energy Key Indicators and Emission Reductions

Table 4. Non-Energy Key Indicators for 2025 and 2030 - Percent Emissions Reductions from 2020

Non-Energy	2025	2030
Enteric Fermentation	20%	39%
Manure Management	29%	57%
Agricultural Soils	9%	19%
ODS Substitutes	25%	41%
Semiconductor Manufacturing	4%	8%

Non Energy Emissions Mitigation Scenario and Avoided vs. Baseline
100 Yr GWP Point of Emissions

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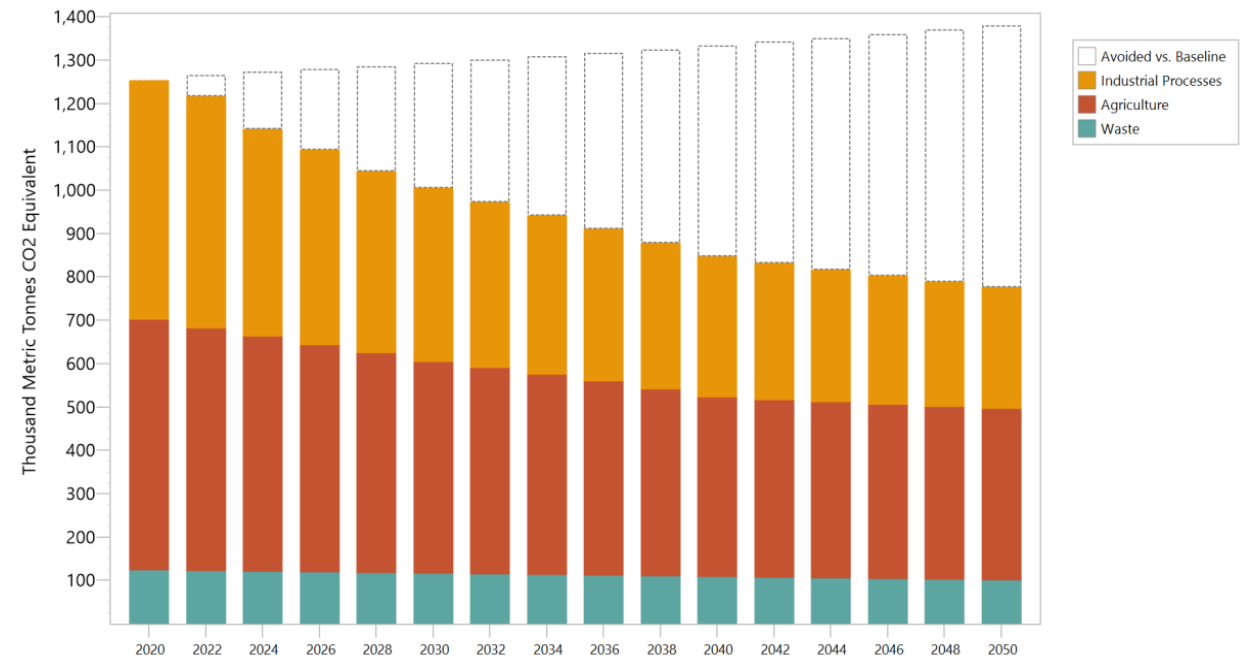
Electricity Key Indicators and Emission Reductions

Table 5. Electric Sector Key Indicators for 2025 and 2030

Electric Sector	2025	2030
Electricity as Share of Energy	20%	30%
Total Demand (GWh)	6,182	7,436
Peak Demand (MW)	1,374	1,652
Share of EV Managed Charging	27.3%	50%

Energy Demand Final Units

Scenario: With Social Cost of GHGs, Fuel: Electricity, All Urban Rurals, All Housing Structures

Legend:
- Transportation
- Residential
- Commercial
- Industrial

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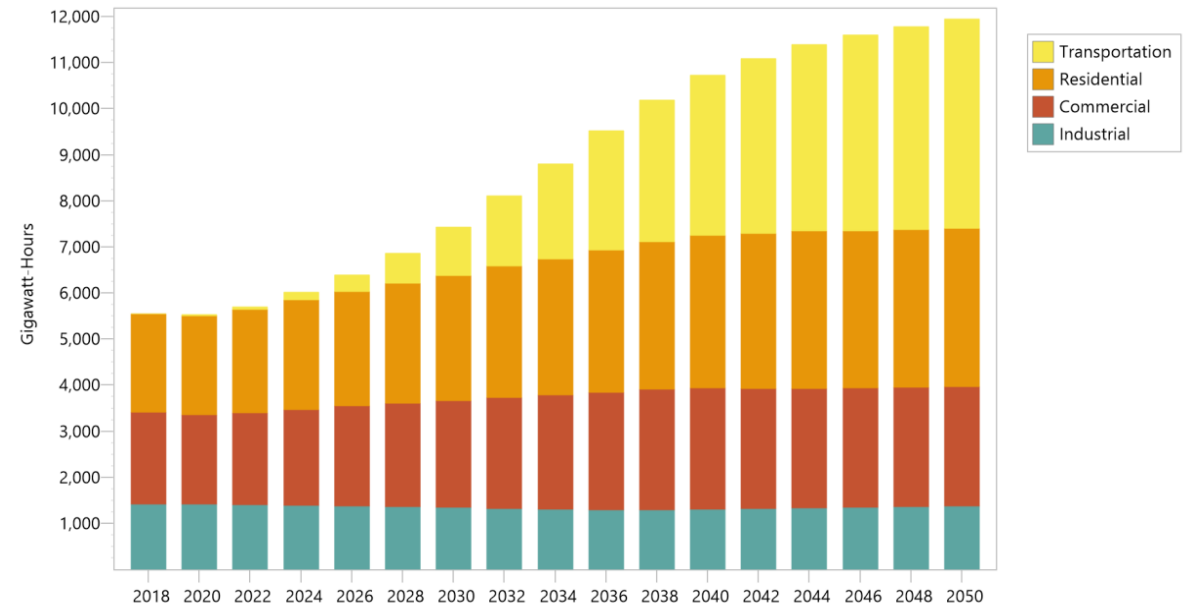
Avoided Social, Economic and Environmental Damages

Avoided Damages

Externality costs were not being calculated for road transport branches in the version of LEAP used for initial Pathways Report.

LEAP 2020 1.54 update corrected calculation.

Present value of avoided externalities increased $3.6 Billion - from $3.8 to $7.4 Billion ($2019)

Reflected in LEAP summary Economic Results but not in the IMPLAN analysis as they are global damage-based estimates for externalities and not easily allocated and attributable for IMPLAN.
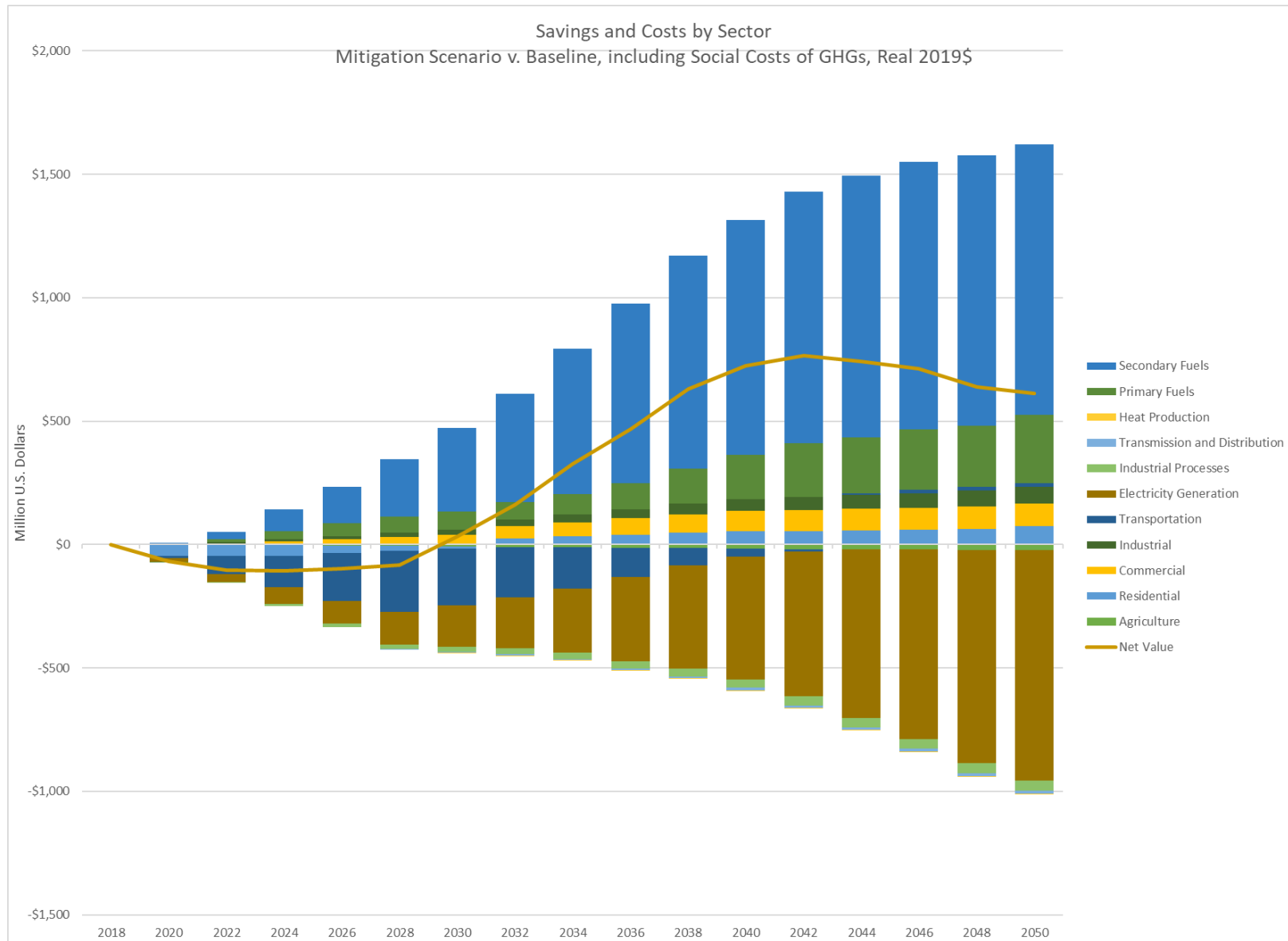
Cumulative Costs & Benefits: 2015-2050. Relative to Scenario: Baseline with SCC. Discounted at 2.0% to year 2019. Units: Billion 2019 2019 USD

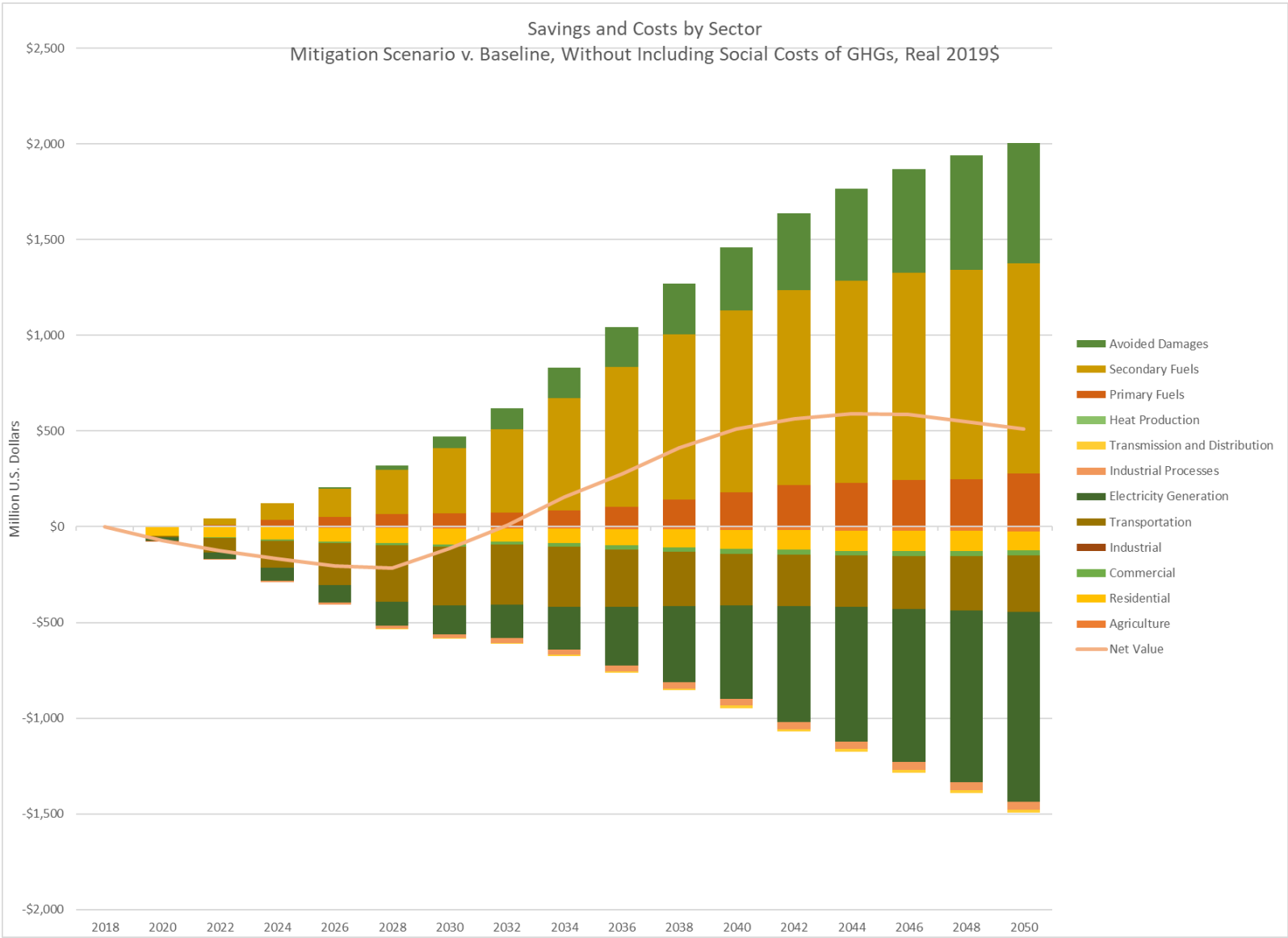| Sector	Updated Pathways CAP	November Pathways CAP
Demand	7.6	8.3
Transportation	5.4	5.9
Residential	1.8	2.0
Commercial	0.3	0.3
Industrial	-	-
Transformation	7.5	7.8
Distributed Gas Blending	-	-
Transmission and Distribution	0.2	0.2
Electricity Generation	7.3	7.6
Heating Oil Blending	-	-
Heat Production	-	-
Resources	-	-
Avoided Fossil Fuel Imports	-14.8	-16.2
Imports	-	-
Exports	-	-
Other Costs		
Unmet Requirements	-	-
Avoided Environmental Damages	-7.4	-3.8
Non Energy Sector Costs	0.8	0.8
Total Net Present Value	-6.4	-3.2
GHG Savings (Mill Tonnes CO2e)	85.1	81.0
Cost of Avoided GHGs (2019 USD/Tonne CO2e)	-75.2	-38.9

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Updated Economic and IMPLAN Analysis & Results

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Early Investments, Net Positive Values after 2030

Savings and Costs by Sector
Mitigation Scenario v. Baseline, including Social Costs of GHGs, Real 2019$

Legend:
- Secondary Fuels
- Primary Fuels
- Heat Production
- Transmission and Distribution
- Industrial Processes
- Electricity Generation
- Transportation
- Industrial
- Commercial
- Residential
- Agriculture
- Net Value

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Savings and Costs: Separating Avoided Damages

Savings and Costs by Sector
Mitigation Scenario v. Baseline, Without Including Social Costs of GHGs, Real 2019$

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Savings & Costs Excluding Social Cost of GHGs

Savings and Costs by Sector
Mitigation Scenario v. Baseline, Without Including Social Costs of GHGs, Real 2019$

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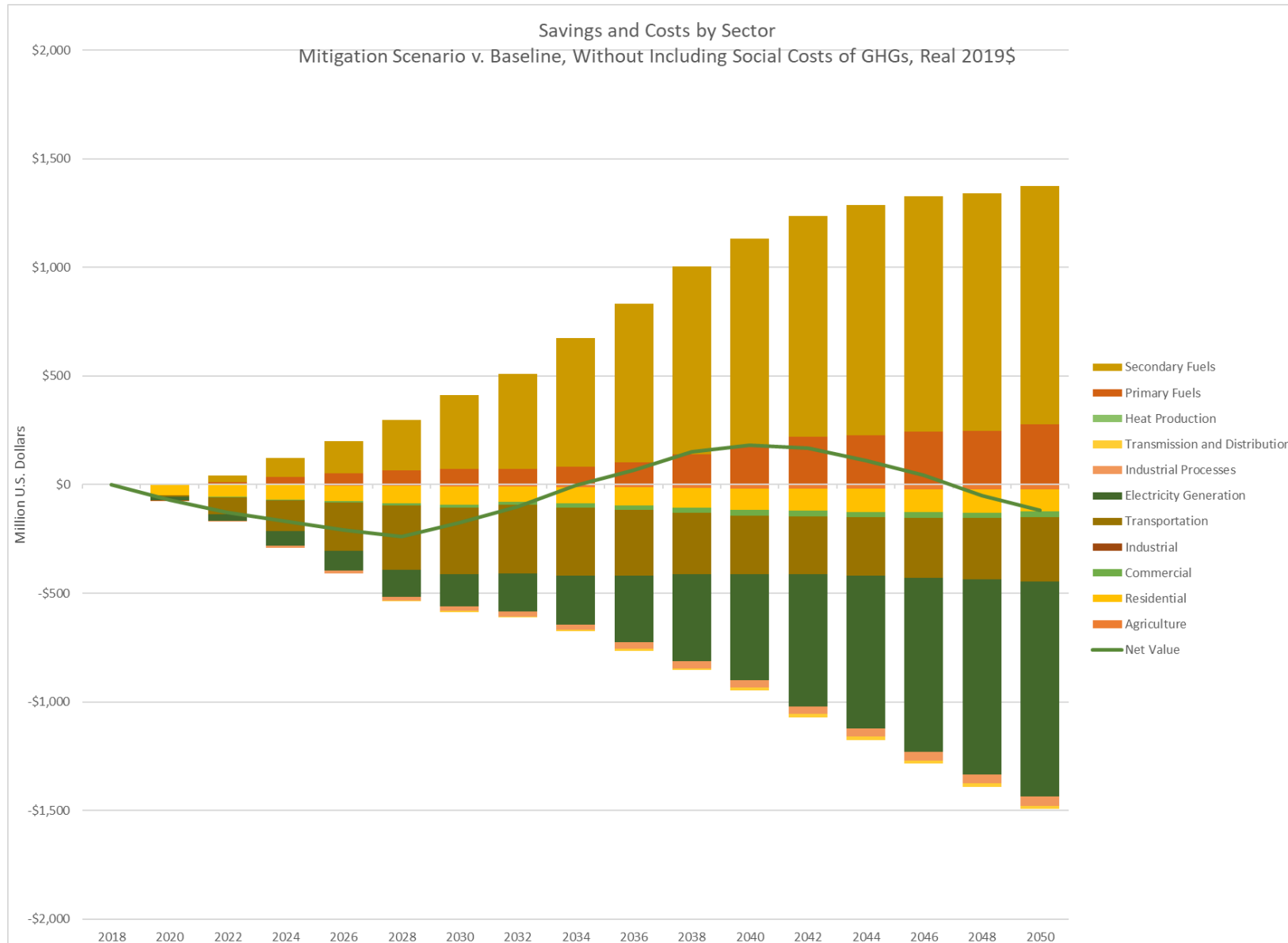
Mitigation Scenario IMPLAN Inputs

Sector	Net Demand (MM)	Description
Road Transport	$ 2,744	Vehicles and charging
Transportation VMT	$ 2,642	Road improvements and public transit
Non-Energy	$ 779	Agriculture support services, refrigeration
Delivered Heat	$ 154	Construction and power boiler
Electricity (in and out of state)	$ 7,523	Construction of power structures, generation, natural gas, batteries and solar
Fuels	$ (14,887)	Refined fossil fuels, direct selling (firewood)
Residential	$ 1,840	Maintenance and equipment
Commercial	$ 348	Maintenance and equipment
Total	**$ 1,142**	

- 2020-2050 discounted costs and savings
- $1.1B in net costs
- Opportunity costs for Vermont residents and businesses

All values in $2019

Aggregate Impacts by Component (2020-2050)

Mitigation Scenario	Employment	Labor Income	Value-Added	Output	Value-Added % of state GDP
Direct	78,000	$ 3,073	$ 2,741	$ 7,002	8%
Indirect	15,000	$ 856	$ 1,518	$ 3,001	4%
Induced	22,000	$ 1,001	$ 1,779	$ 3,098	5%
Totals	**115,000**	**$ 4,930**	**$ 6,039**	**$ 13,101**	**18%**

Residential Opportunity Cost	Employment	Labor Income	Value-Added	Output	Value-Added % of state GDP
Direct	0	$ 0	$ 0	$ 0	0%
Indirect	0	$ 0	$ 0	$ 0	0%
Induced	(5,000)	$ (248)	$ (443)	$ (771)	1%
Totals	**(5,000)**	**$ (248)**	**$ (443)**	**$ (771)**	**1%**

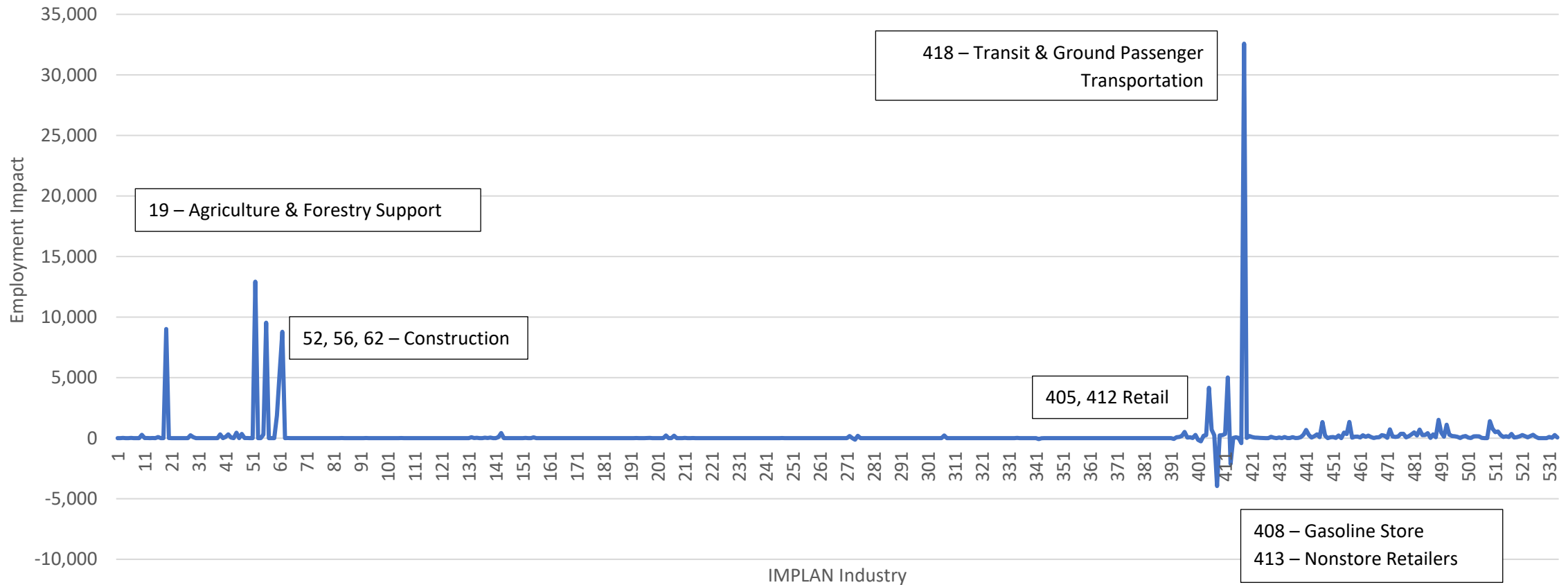| Aggregate	Employment	Labor Income	Value-Added	Output	Value-Added % of state GDP
Direct	78,000	$ 3,073	$ 2,741	$ 7,002	8%
Indirect	15,000	$ 856	$ 1,518	$ 3,001	4%
Induced	17,000	$ 753	$ 1,336	$ 2,327	4%
Totals	**110,000**	**$ 4,682**	**$ 5,595**	**$ 12,330**	**16%**

All values in $2019MM

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IMPLAN Results net of Opportunity Costs

Investment Time Period	Employment	Labor Income (billions)	Value Added (billions)	Output (billions)
2020-2030 (11 years)	18,500	$0.8	$0.9	$2.2
2031-2050 (20 years)	91,400	$3.9	$4.7	$10.1
2020-2050 (31 years)	**110,000**	**$4.7**	**$5.6**	**$12.3**
VT Economy 2019	440,000	$34	$34	$67

- Two components: Mitigation Scenario Spending and Savings & Residential Opportunity Costs
- Overall impacts are positive along all indicators but under 1%/year due to spreading over decades

All values in $2019

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Mitigation Scenario Employment By Industry

- Most industries are not affected directly
- Spikes are from mitigation scenario related industries
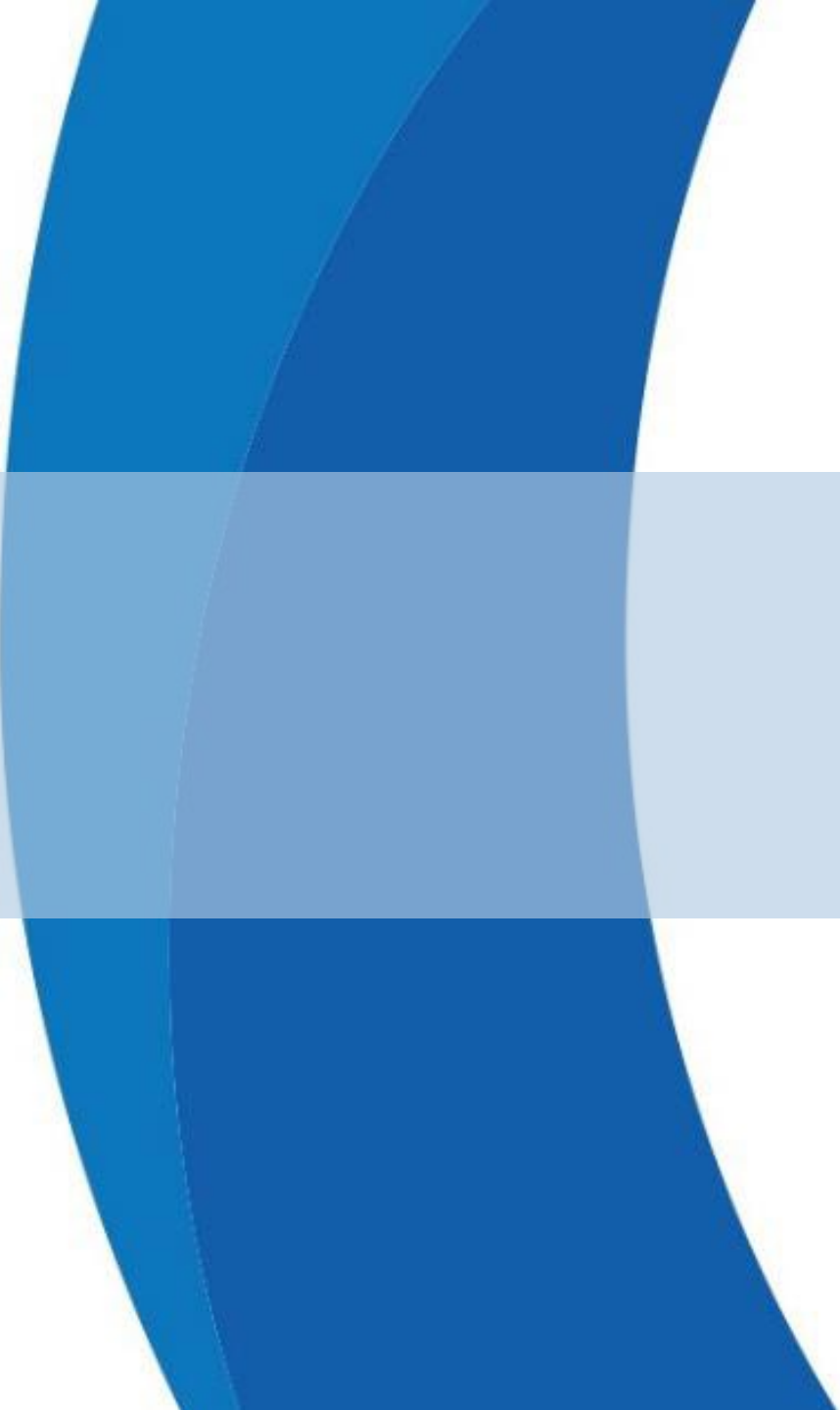- Positives greatly outweigh negatives

Mitigation Scenario: Top Impacted Industries

| Industry	Employment	Labor Income	Value-Added	Output
Positive Impacts				
418 - Transit and ground passenger transportation	32,000	$701	$996	$1,331
56 - Construction of other new nonresidential structures	10,000	$265	$278	$1,264
62 - Maintenance and repair construction of highways, streets, bridges, and tunnels	9,000	$291	$464	$1,321
Negative Impacts				
413 - Retail - Nonstore retailers	-3,000	($55)	($177)	($350)
408 – Retail – Gasoline stores	-4,000	($109)	($214)	($406)

- Public transportation will have the largest industry output at $1.3 billion along with the largest employment gains at 32,000
- Decreased demand for gasoline/petroleum at the retail level yields the largest losses across all four result categories
- Decreased demand for non-store retail (direct to consumer firewood) is caused by lowered demand for cord wood as a fuel source
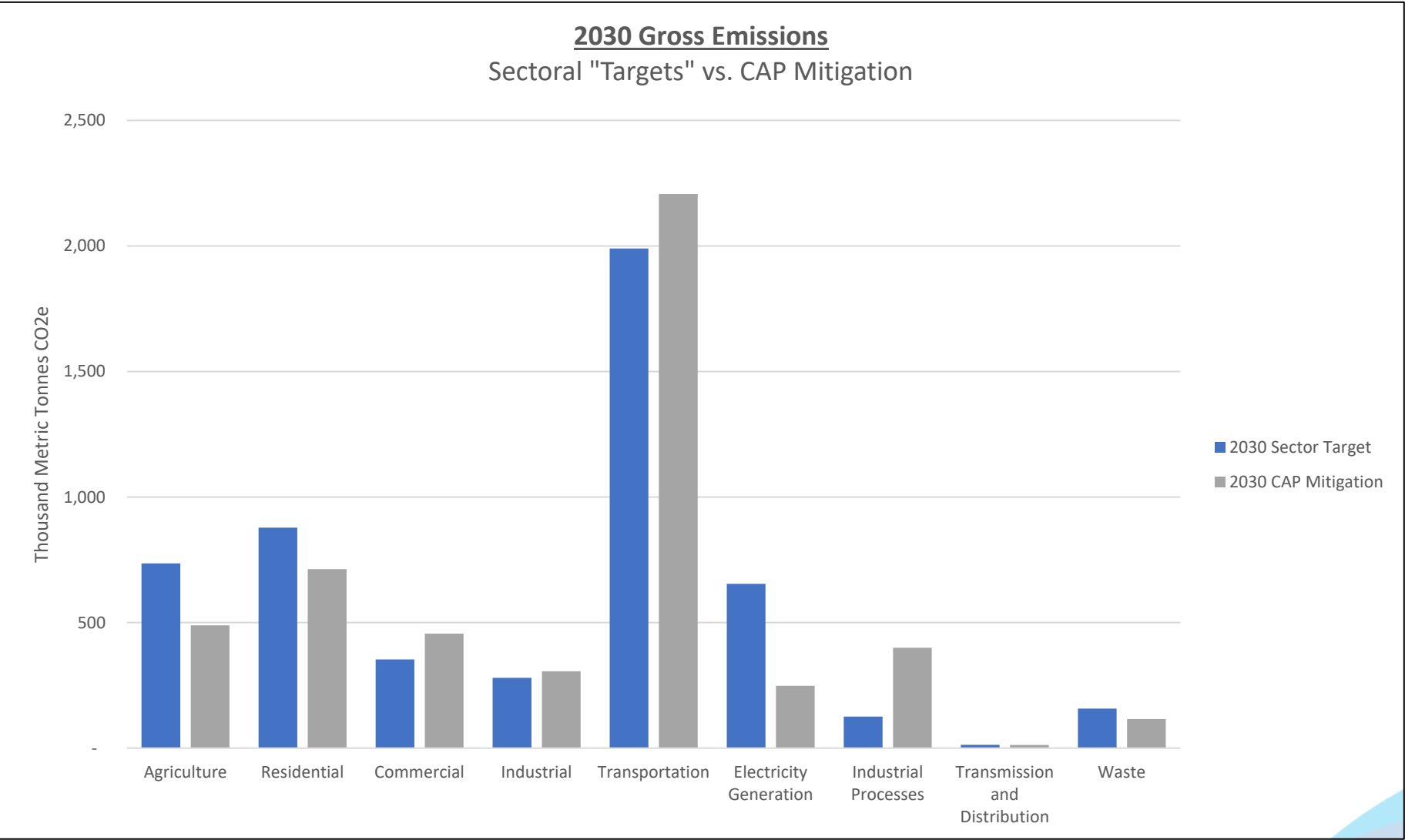
All non-employment values in $2019MM
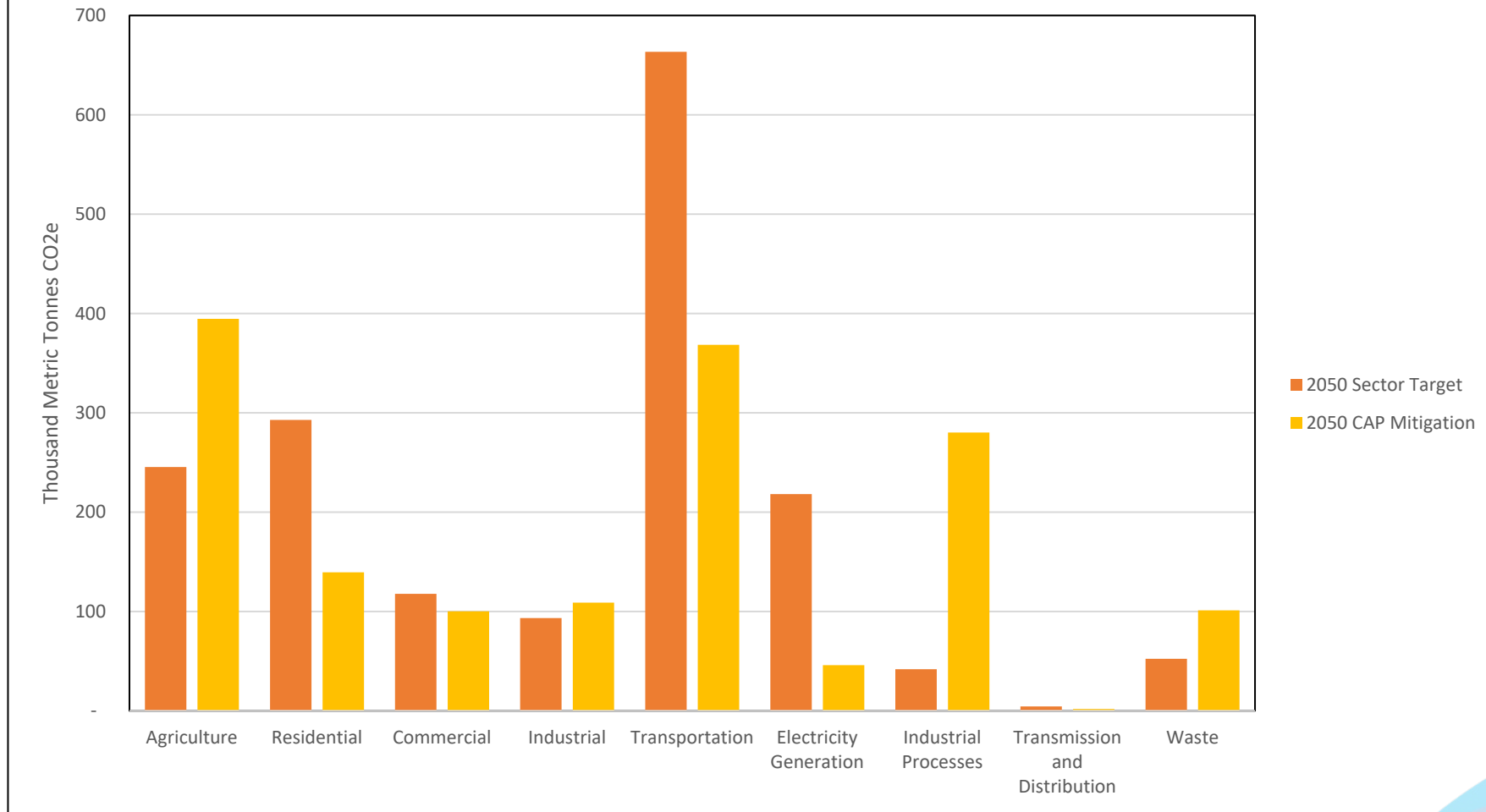
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Reductions by Sector and GWSA Period

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2025 Gross Emissions
Sectoral "Targets" vs. CAP Mitigation

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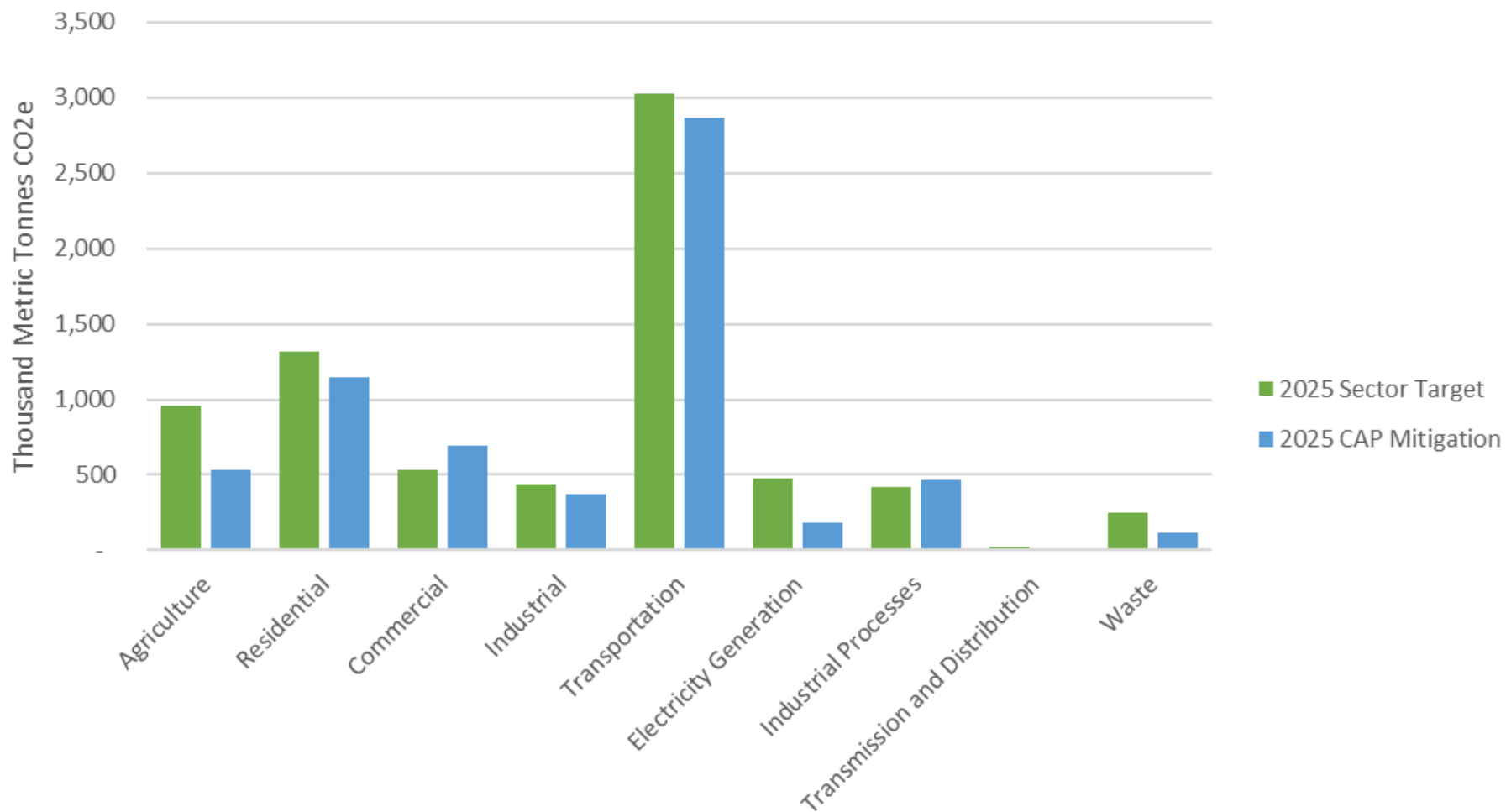
2030 Gross Emissions
Sectoral "Targets" vs. CAP Mitigation

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2050 Gross Emissions
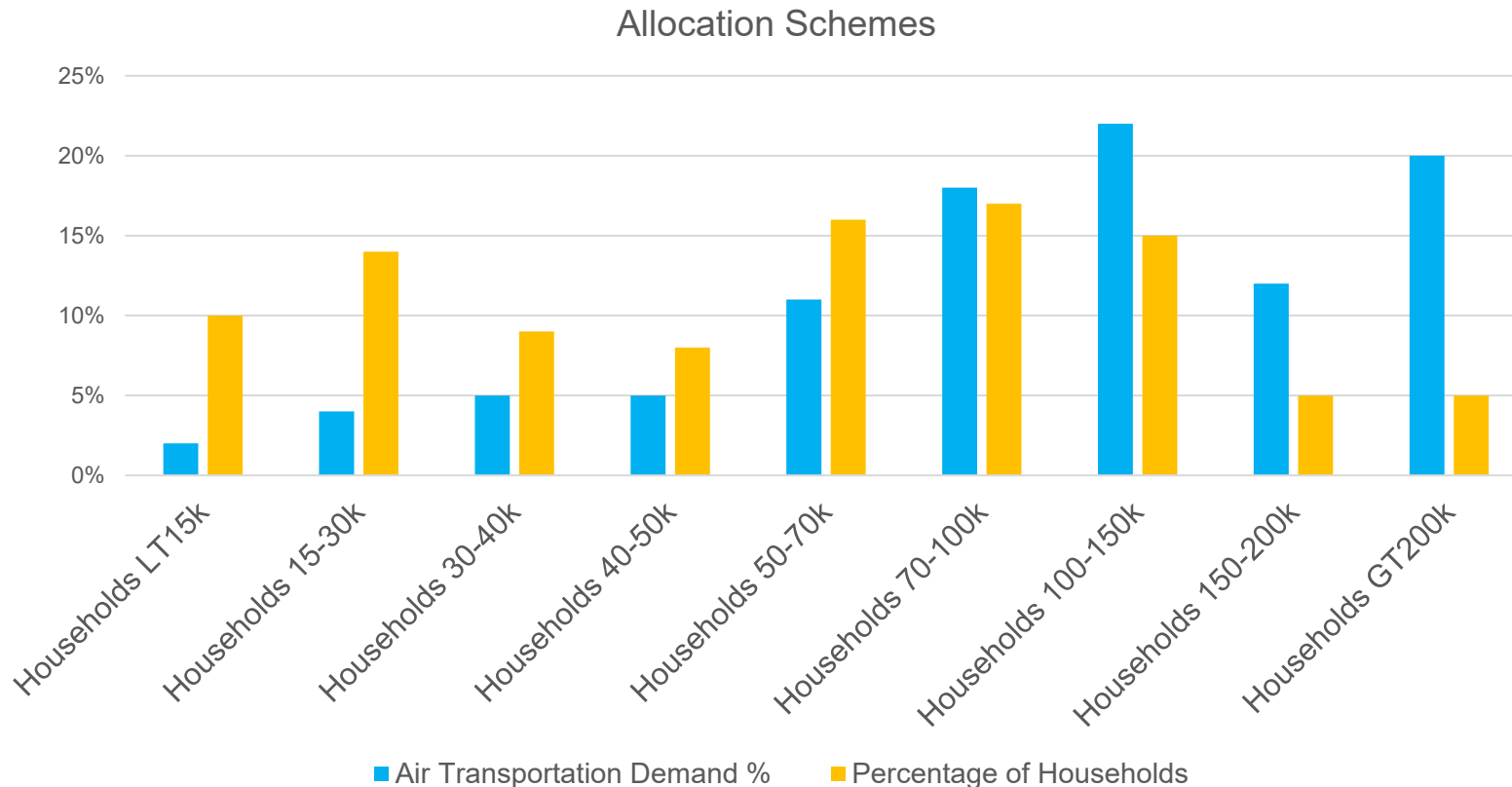Sectoral "Targets" vs. CAP Mitigation

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Questions and Discussion

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Thank You!

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Summary of Opportunity Cost Inputs

Time Period	Total Mitigation Scenario Demand
2020-2030	$ 1,593
2031-2050	$ (450)
Total	**$ 1,142**

- Opportunity costs are greatest in near term (2020-2030)
- $1.1 billion in net costs over mitigation scenario time period

- Assumption: 70% of costs & savings accrue to households
- Cannot model changes to cost of production for business savings
- IMPLAN can only model changes to household income and requires allocating to 9 income ranges
- To inform policy development, allocated along two schemes

Allocation Schemes

Legend: ■ Air Transportation Demand % ■ Percentage of Households

Categories: Households LT15k, Households 15-30k, Households 30-40k, Households 40-50k, Households 50-70k, Households 70-100k, Households 100-150k, Households 150-200k, Households GT200k

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Impact of Residential Opportunity Costs
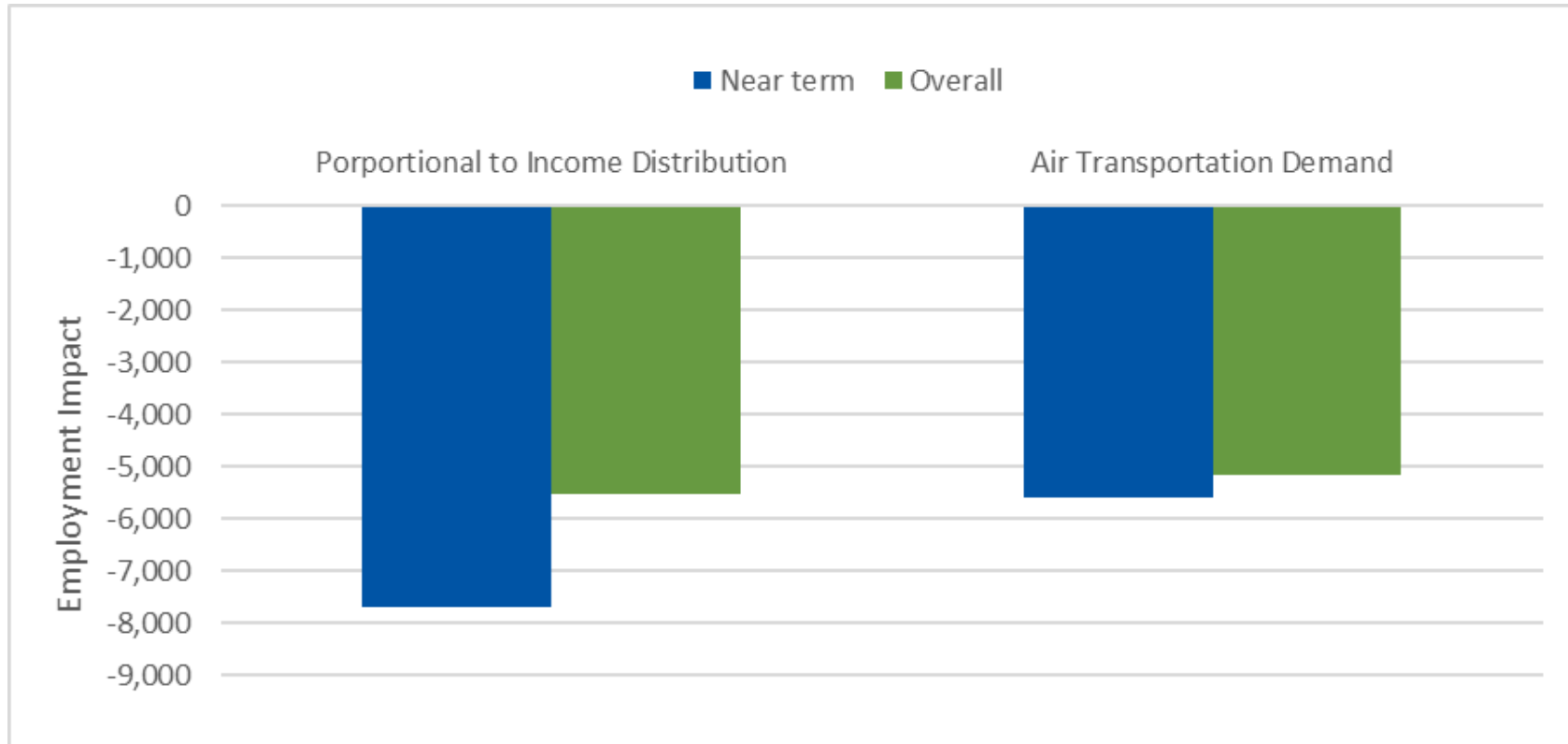
- Near term (2020-2030) opportunity costs are greater and impacts differ more between schemes
- Little difference at end of mitigation timeline
- Opportunity costs are small compared to mitigation scenario spending and savings