North Carolina PATHWAYS Study

Draft Results Presentation to the Clean Transportation Plan Workgroup Session

September 14th, 2022

Energy+Environmental Economics

Charles Li
Tory Clark
Rawley Loken

Agenda

- Background
- Scenario Design and Draft Results
- Technology Readiness & Risks
- Take-aways and Next Steps

Background

Energy+Environmental Economics

The PATHWAYS Study informs the potential role of transportation in achieving NC's near-term and long-term climate targets

+ Goals for the PATHWAYS Study

- Analyze various technologically feasible GHG emissions reduction pathways to achieve economy-wide 2025, 2030 and 2050 GHG targets.
- Identify high-level policy and planning takeaways that will inform near-term, mid-term and long-term decarbonization efforts.

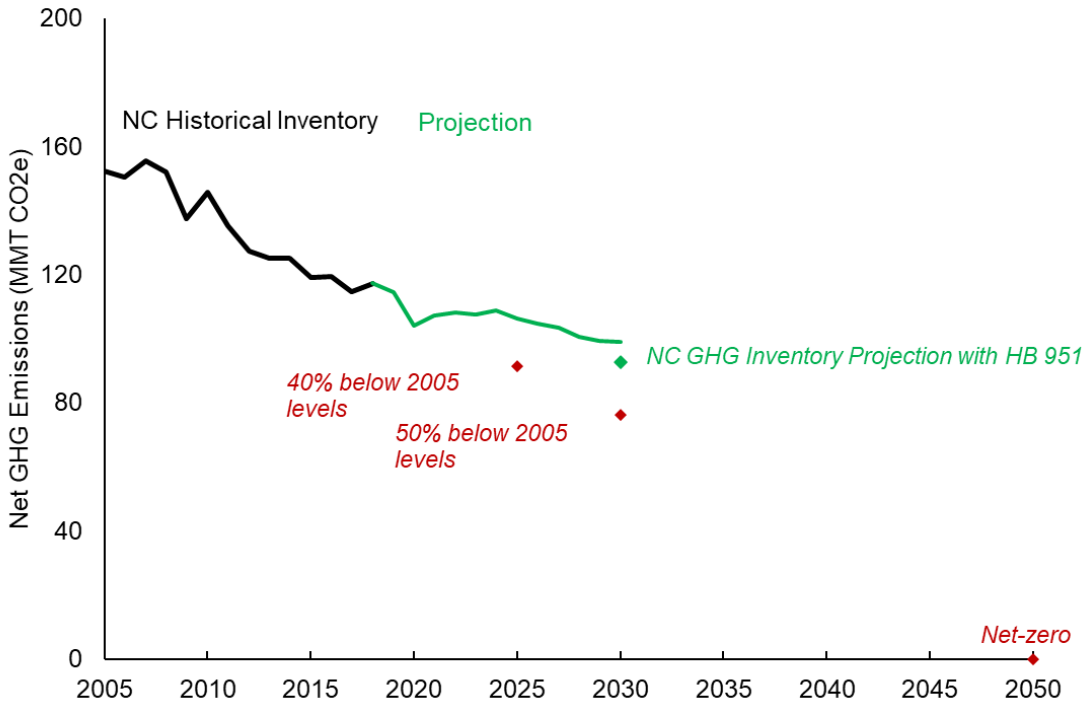
+ Synergies with the Clean Transportation Plan

- Facilitate a better understanding of potential pathways to effectively reduce emissions from the transportation sector, and its role in helping North Carolina achieve greenhouse gas reduction goals across the economy
- Explore opportunities and tradeoffs between different technology pathways in reducing GHG emissions

+ PATHWAYS study does NOT model some other important aspects considered in the CTP process

- For example, consumer and utility costs, health benefits, etc.

North Carolina Net Greenhouse Gas Emissions



Projection based on the 2022 NC GHG Inventory, developed using combination of EPA's Projections Tool module within State Inventory Tool and sector-specific data sources (e.g. MVOES for transportation, Duke forecasts) and incorporate the impact of HB 951

Summary of Key Findings from PATHWAYS Draft Results

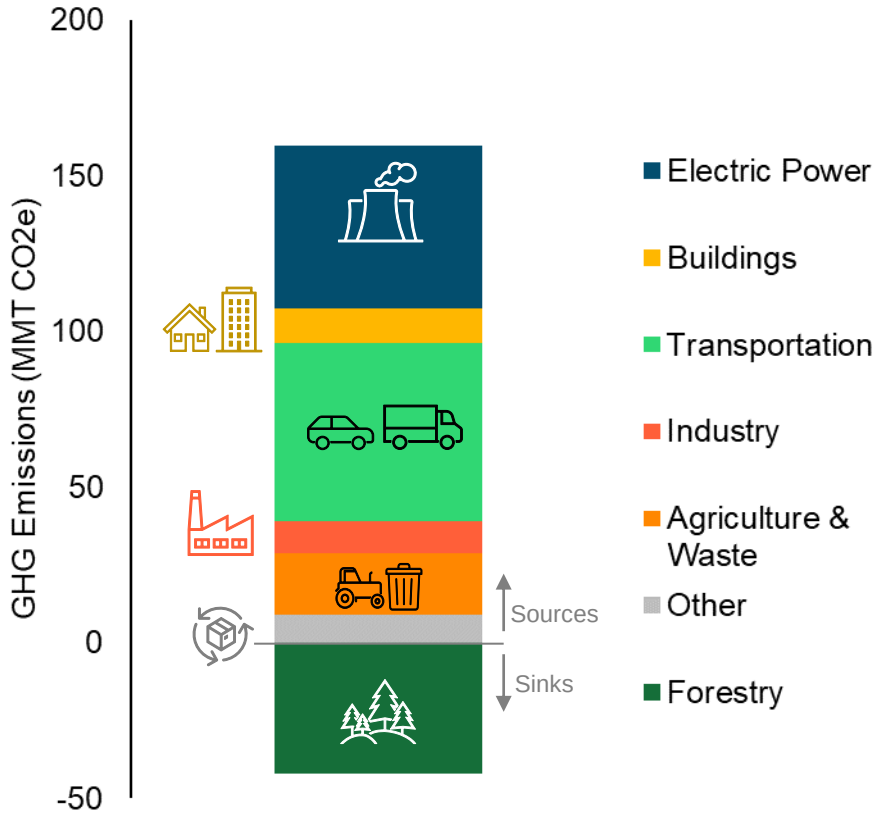
- **Transportation sector is the largest source of GHG emissions in North Carolina**
- **Initial modeling shows that transportation must hit 79-87% GHG emissions reductions by 2050 for the state to achieve net zero goal**
- **Key strategies to reduce GHGs include:**
  - Improved efficiency, transit, and smart growth
  - Adoption of zero-emission vehicles
  - Clean electricity
  - Low-carbon fuels
- **The PATHWAYS analysis is focused on GHG emissions, but other outcomes are critically important such as air quality, access to transportation solutions, smart urban design, walkable/bikeable cities, equity and affordability of solutions, etc.**

Scenario Design and Draft Results

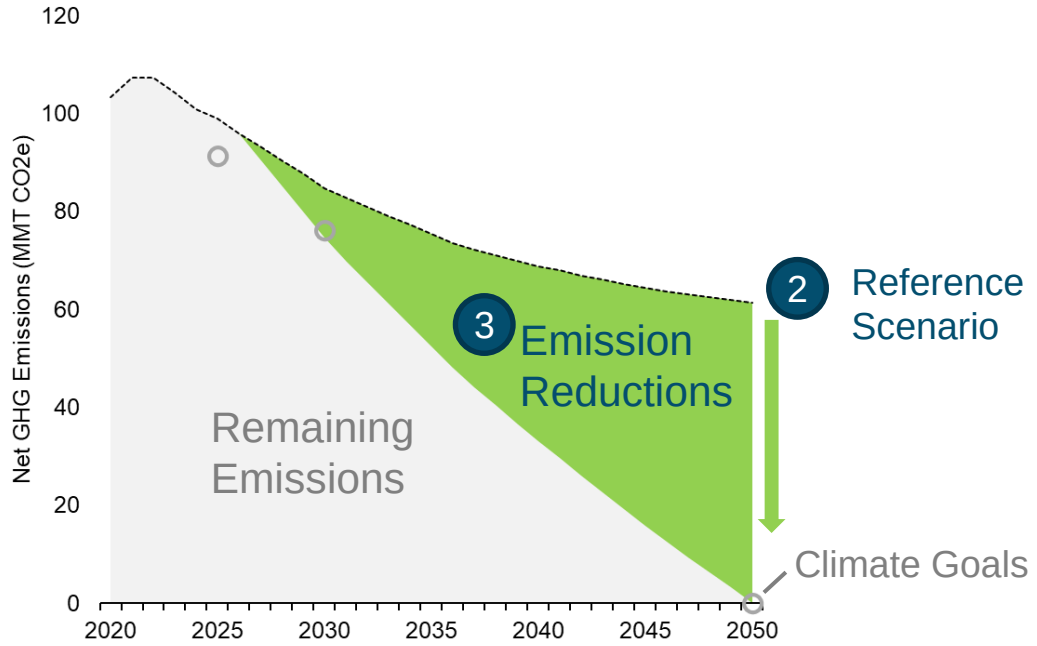
Energy+Environmental Economics

Steps of a PATHWAYS study

1 Measure current greenhouse gas emissions in North Carolina



2 Estimate future emissions based on current trends and existing policies



3 Evaluate impact of new potential measures and actions that would help the state meet climate goals

Current emissions profile based on the latest 2022 NC State Greenhouse Gas Inventory

Transportation is the largest source of GHG emissions among all sectors in North Carolina

+ **Passenger vehicles account for the majority of the GHG emissions within the transportation sector**
  - As a single source, passenger vehicles account for more than 25% of the total statewide GHG emissions

+ **Reducing GHG emissions from the transportation sector, the largest source of emissions, would be critical for NC to meet both near-term and long-term climate goals**

North Carolina Gross GHG Emissions Profile

Note: Emissions profile is based on the latest 2022 NC State GHG Inventory. All GHG emissions associated with consumption of electricity in buildings, industry, and transport are accounted for in the “Electricity Generation” category

Priority actions that impact emissions in transportation

Efficiency, Transit, Smart Growth

- Improved fuel economy for new vehicles sold
- Increased sales of hybrid gasoline or diesel vehicles
- Reductions in vehicle-miles traveled through transit and smart growth

Clean Electricity

- Scale up of renewable electricity sources (wind and solar)
- Scale up of battery storage
- Targeted role for zero-carbon firm generation

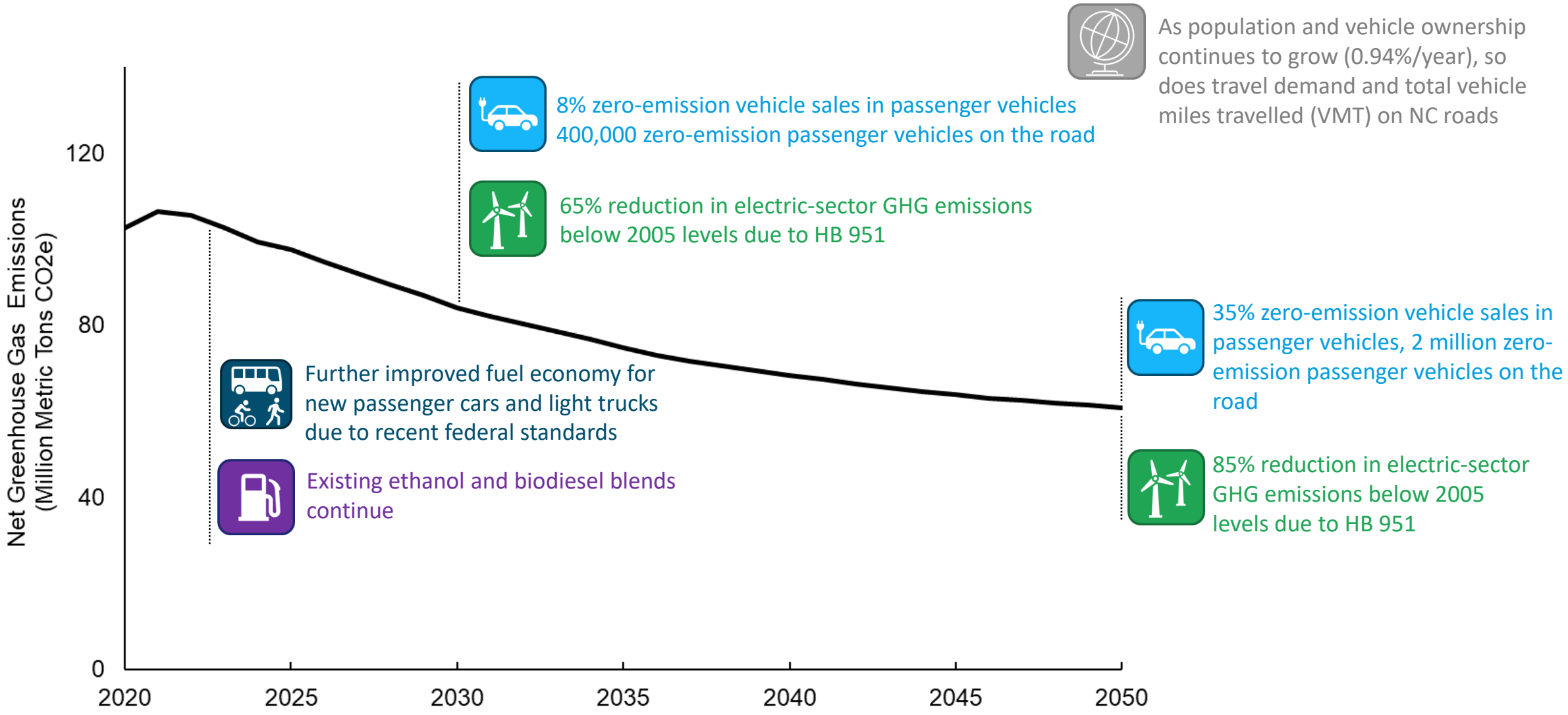
Electrification

- Increased sales of zero-emission vehicles, including
  - Plug-in hybrids
  - Electric vehicles
  - Hydrogen fuel cell vehicles
- Electrification of off-road transportation such as boats and locomotives

Low-carbon fuels

- Production of advanced biofuels
  - Produced with sustainable biomass feedstocks
- Production of green hydrogen
  - “Green” hydrogen is created by splitting water through renewable electricity

North Carolina Greenhouse Gas Emissions Reduction Measures in Transportation, Reference Scenario

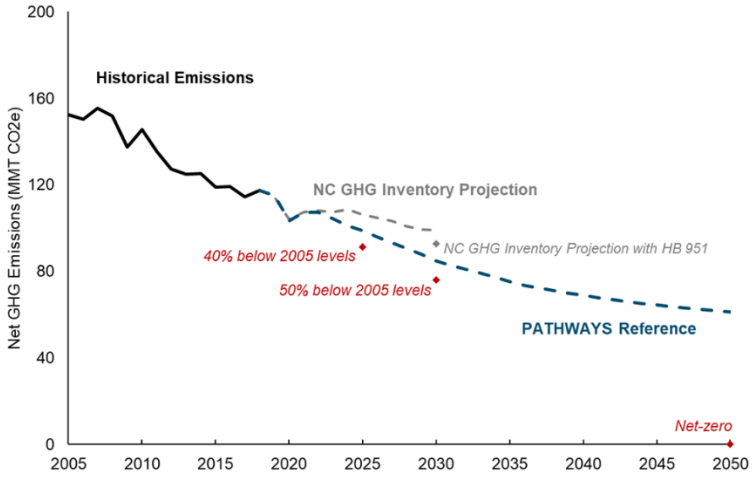


Note: Impacts of the Inflation Reduction Act are still being represented

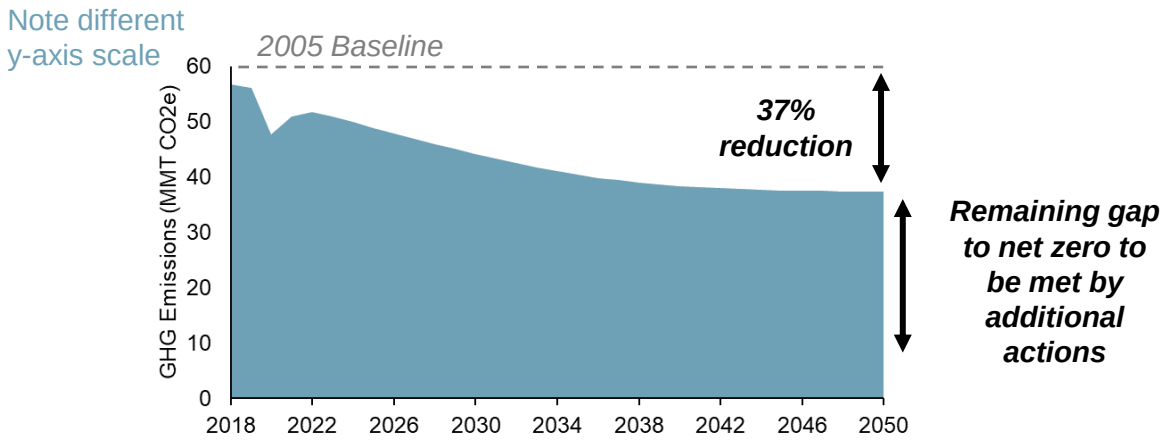
With current policies, transportation emissions are projected to decline, but NC is still short of achieving E.O. 246 GHG goals

- **Both transportation and total net GHG Emissions in PATHWAYS Reference Scenario decline through mid-century**
  - The decline in transportation emissions are driven by (1) improved vehicle fuel efficiency due to federal CAFE standards and (2) some adoption of electric cars leveraging a cleaner mix of electricity thanks to HB 951
- **However, the PATHWAYS Reference is still short of meeting the near-term GHG targets, and has a big gap to achieving net zero by 2050**

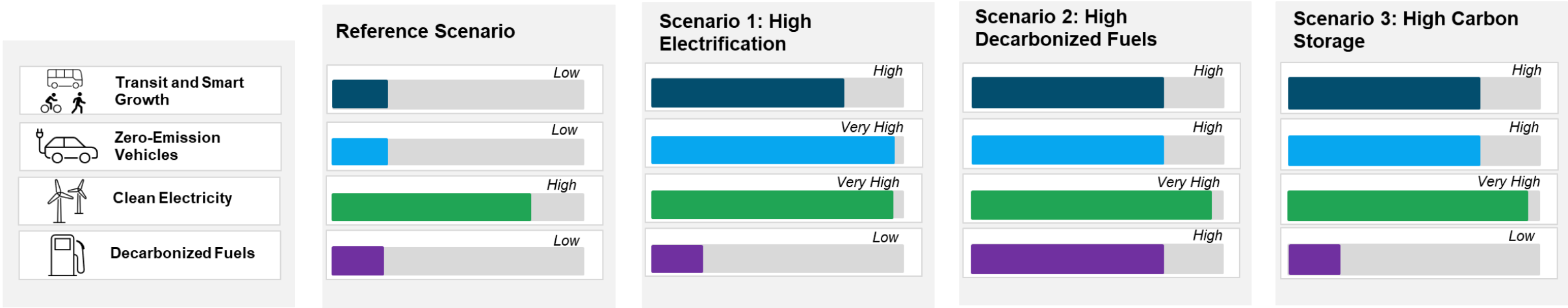
Total Net GHG Emissions



Transportation Direct GHG Emissions
PATHWAYS Reference Scenario

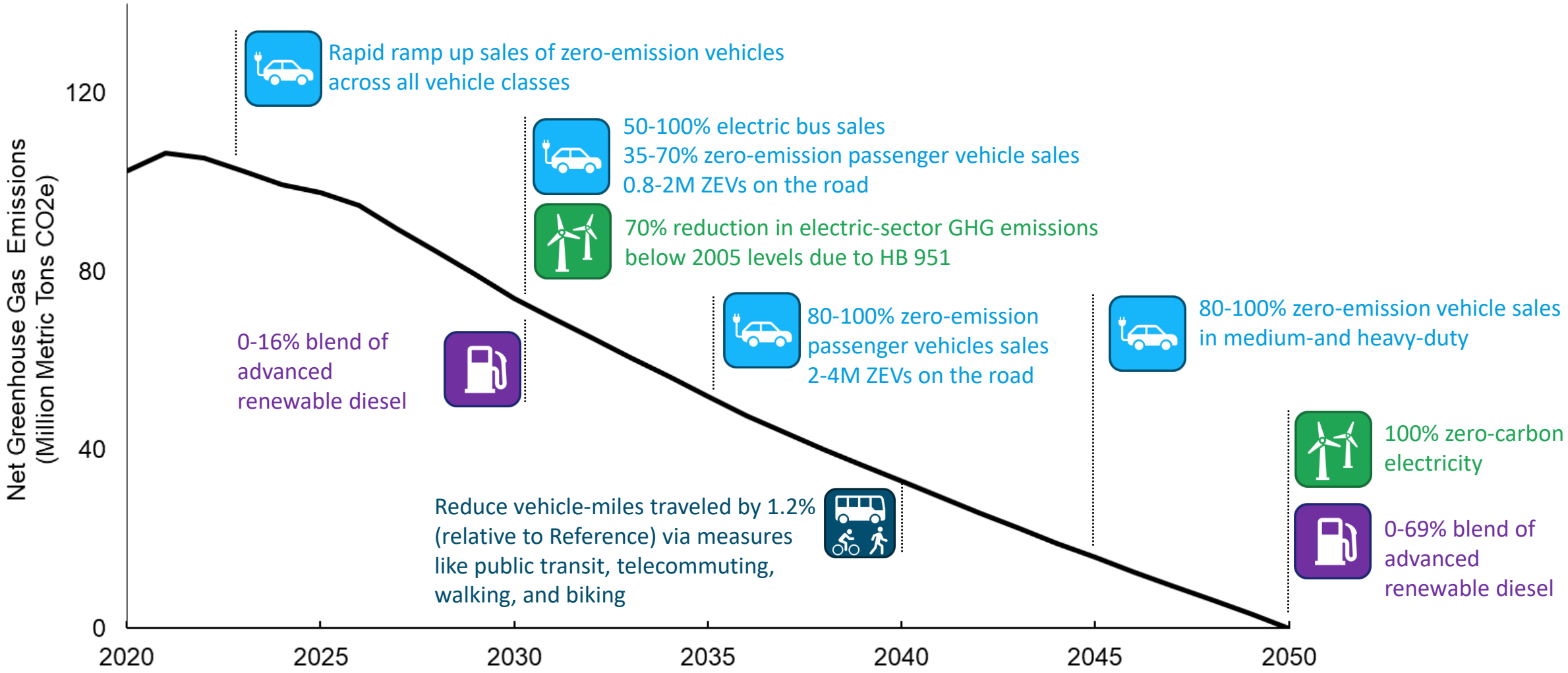


Net Zero Scenarios and Key Transportation Measures

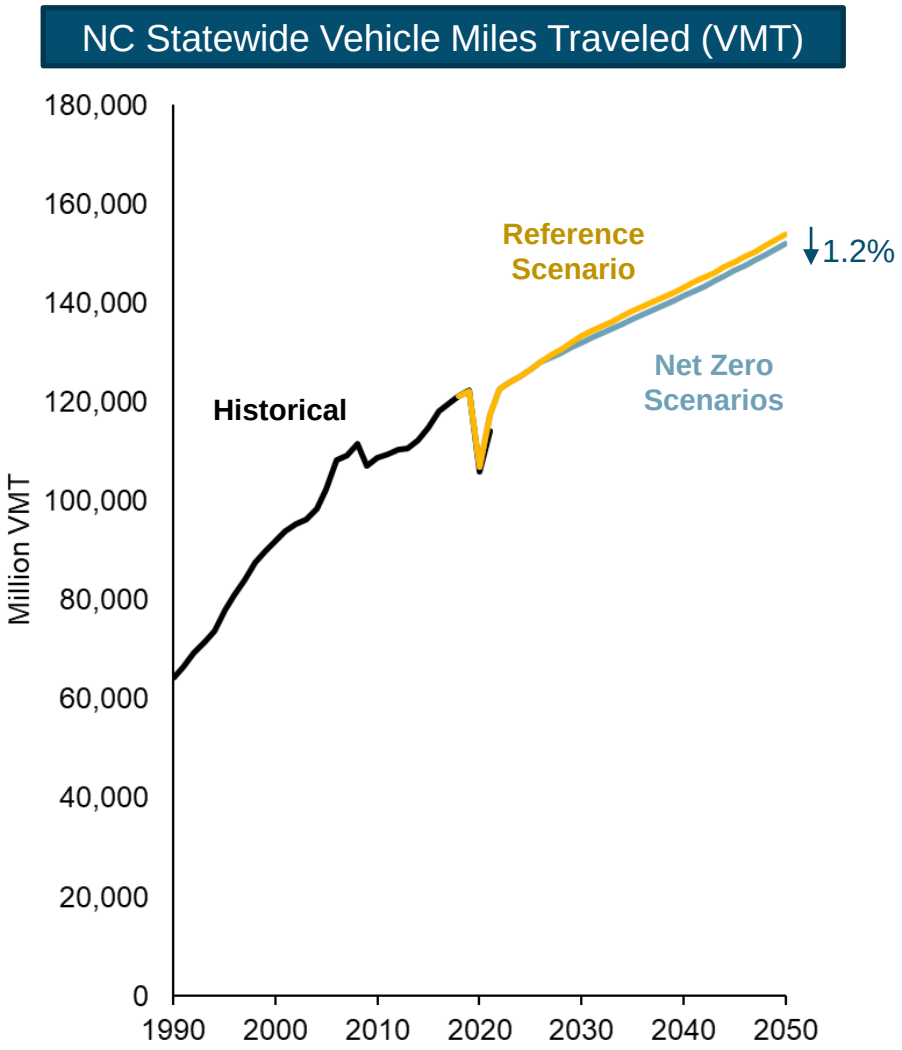


- **All Net Zero Scenarios** will achieve high levels of vehicle miles traveled (VMT) reduction from **transit and smart growth** based on the 2021 North Carolina VMT Reduction Study
- **The High Electrification Scenario** features **an accelerated transition to zero-emission vehicles (ZEVs)** that leverages a cleaner electric grid
- **The High Decarbonized Fuels Scenario** will leverage **additional advanced biofuels** using sustainable wastes and residue feedstocks within the region
- **The High Carbon Storage Scenario** will rely on **carbon sequestration through natural and working land** and **negative emissions technologies** if needed, to offset remaining emissions

North Carolina Greenhouse Gas Emissions Reduction Measures in Transportation, Net Zero Scenario Ranges



Transit and Smart Growth



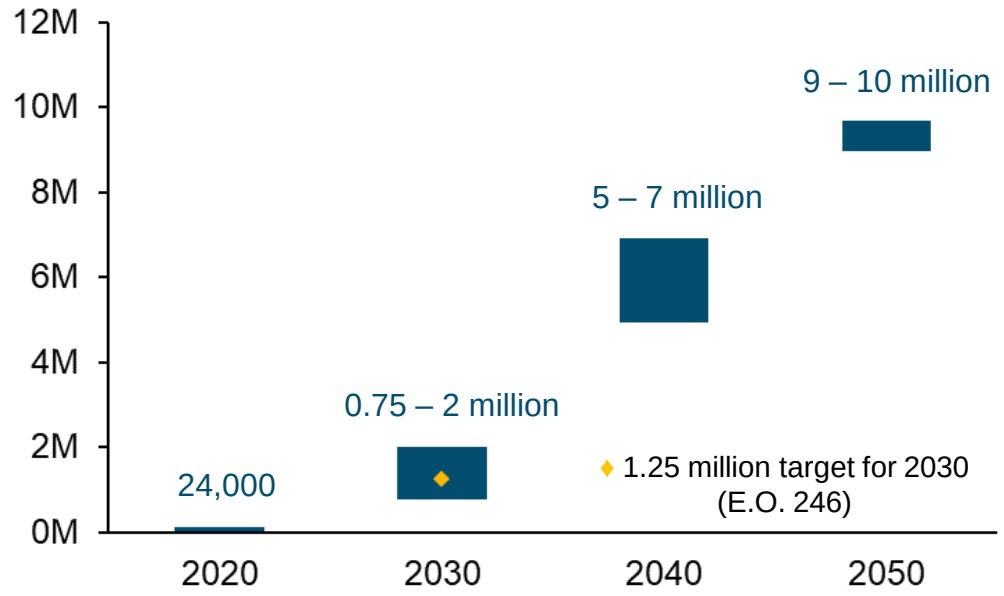
+ **The Transit and Smart Growth measure in the Net Zero Scenarios reduces statewide Vehicle Miles Traveled (VMTs) by 1.2% compared to the Reference Scenario**

+ **The measure reflects the average impact of a broad range of potential actions modeled in the *2021 NCDOT VMT Reduction Study*, including:**
  - Increased public transit and transit-oriented development
  - Increased telecommuting
  - Support for non-motorized transportation modes like biking and walking

+ **The GHG impact of the Transit and Smart Growth measure is relatively small compared to the overall projected increase in VMTs**
  - These strategies provide a number of important co-benefits that are not thoroughly evaluated as part of this analysis.

Zero-emission Vehicles – Passenger Vehicles

Range of Zero-emission Passenger Vehicles Across Net Zero Scenarios (million vehicles)



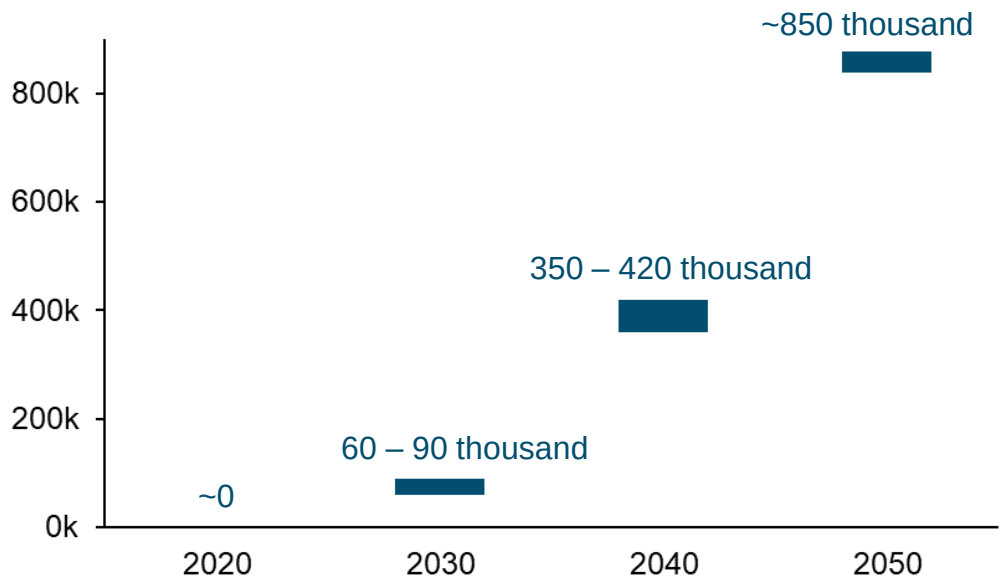
ZEV Sales	2%	35-70%	95-100%	100%
E.O. 246 Target		50%		

- **Passenger vehicles include light duty cars and trucks, such as sedan, SUVs, small pick-up trucks**
- **Zero-emission passenger vehicles modeled are battery-electric vehicles (BEVs) and plug-in-hybrid vehicles (PHEVs)**
- **By 2030, to meet the E.O. 246 target, ZEVs need to reach at least 50% of new vehicle sales and 1.25 million in total stock**
  - This is within the range of the achieved sales and stock across the Net Zero Scenarios, with the High Electrification Scenario over-achieving the E.O. target
- **By 2050, zero-emission vehicles (ZEVs) are projected to reach 9+ million in total stock, accounting for 90%+ of all passenger vehicles statewide**

Draft and Preliminary

Zero-emission Vehicles – Medium-and-Heavy-Duty Vehicles

Range of Zero-emission MHDVs Across Net Zero Scenarios (million vehicles)

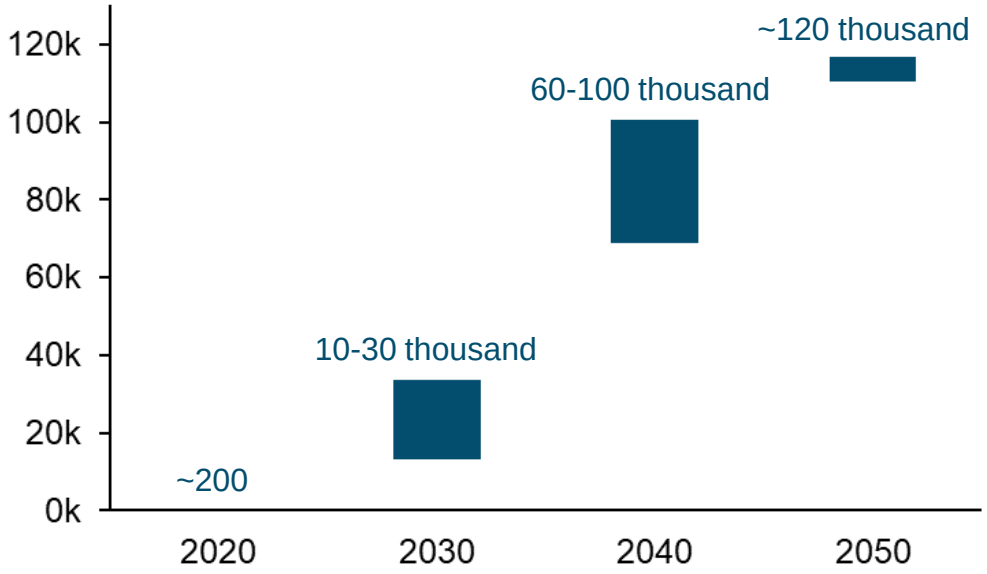


ZEV Sales	~0%	29-39%	77-80%	100%
MHD ZEV Action Plan Targets		30%		100%

- **Examples of MHDVs include large pick-up trucks, freight trucks, dump trucks, tractor-trailers, buses (more details on buses on the next slide), etc.**
- **Zero-emission MHDVs modeled are battery-electric trucks and hydrogen fuel-cell trucks**
- **The Net Zero scenarios almost all achieve the targets recently released in the *Multi-State Medium- and Heavy-Duty Zero-Emission Vehicle Action Plan***
  - The Multi-state Action Plan pledges to achieve 30% sales of new ZEV MHDV by 2030 and 100% by 2050
- **By 2050, zero-emission vehicles (ZEVs) will reach ~850,000+ in total stock, accounting for 70%+ of all MHDVs statewide**

Zero-emission Vehicles – Bus Fleets

Range of Zero-emission Buses Across Net Zero Scenarios (million vehicles)



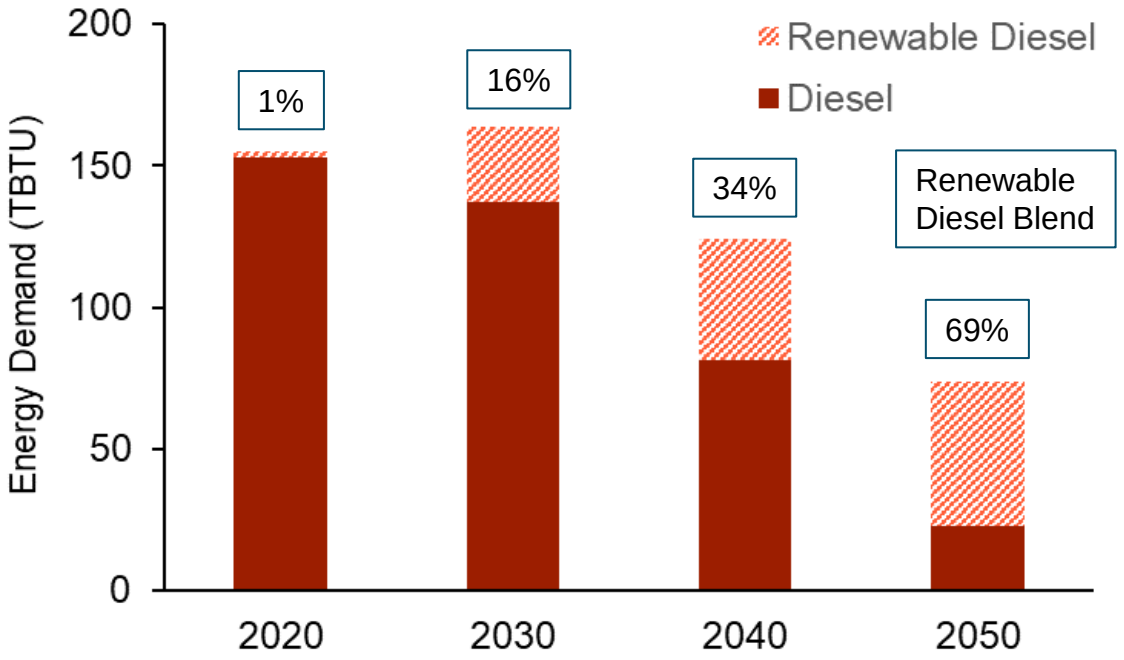
	2020	2030	2040	2050
ZEV Sales	1%	50-100%	100%	100%

- **Buses are part of the MHDVs but are modeled with different assumptions**
- **Specifically, zero-emission buses modeled are battery-electric, and the PATHWAYS High Electrification Scenario achieves 100% sales of new ZEV buses by 2030**
- **Electrification of bus fleets are assumed to be faster than other MHDVs**
  - Recent studies have shown that battery-electric buses are already cost-competitive for certain applications and are projected to be well below the total operating cost of diesel buses by the early 2030s
- **By 2050, all buses will become battery-electric across the Net Zero Scenarios**

Advanced Biofuels

Diesel and Renewable Diesel Demand in the PATHWAYS High Decarbonized Fuels Scenario

(Trillion BTU)



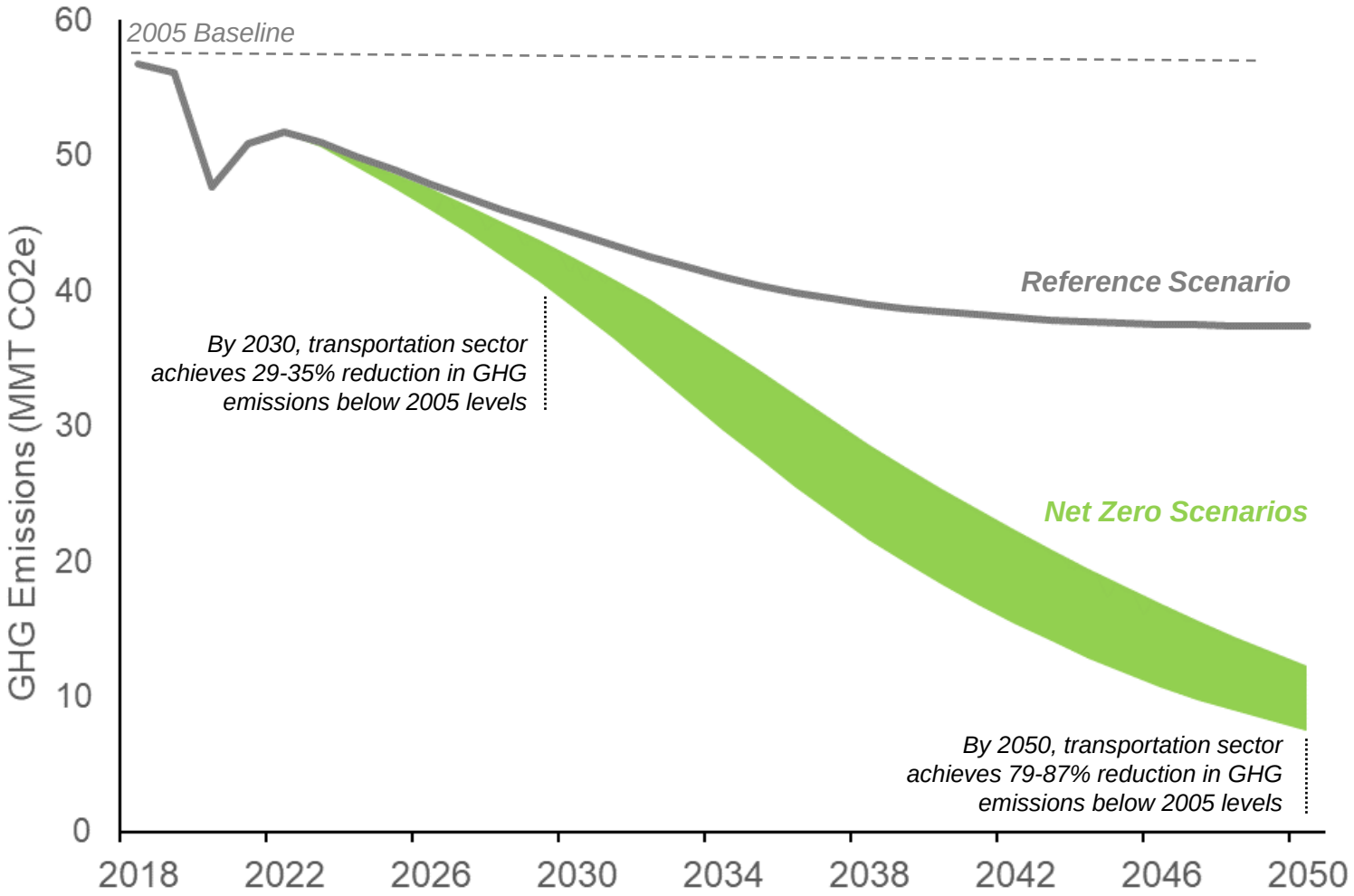
+ **Diesel demand declines as on-road fleet transitions to zero-emission vehicles powered by electricity or hydrogen fuel cells**

+ **In the High Decarbonized Fuels Scenario, blend of renewable diesel produced from biomass feedstock reaches ~70% by 2050**
  - ~25 TBTU of "drop-in" ready biodiesel is used mainly for MHDVs by 2030, and 50 TBTU by 2050

+ **E3's analysis only considers eligible biofuel feedstocks screened by**
  - Locations within and near North Carolina assuming a regional market of biomass feedstock
  - Land use and sustainability concerns using only agricultural residues, forest thinnings and food waste
  - Quantity and location of the feedstock is based on the *DOE Billion Ton Report* and *NREL Biogas Potential in the United States Study*

All Net Zero Scenarios Achieve Deep GHG Reductions

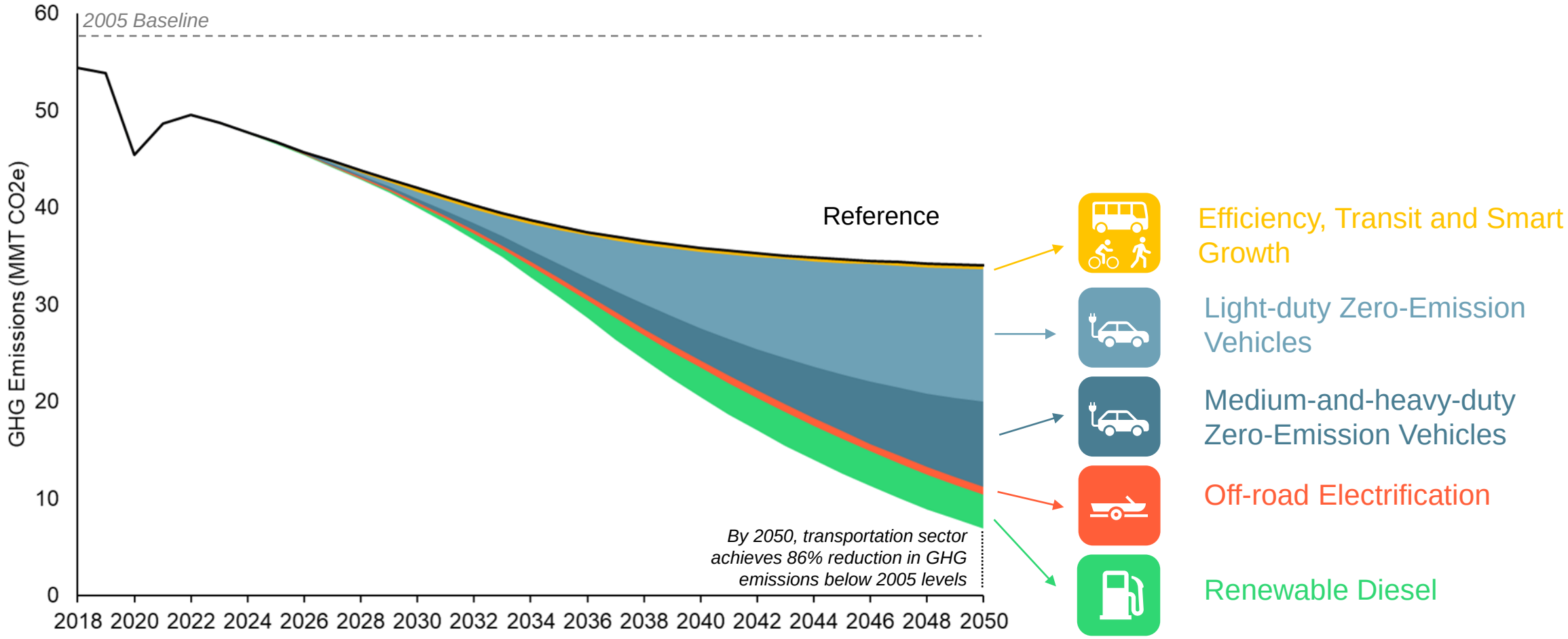
Transportation Sector Direct GHG Emissions (MMT CO2e)



- **Wide adoption of zero-emission vehicles is the main driver for all Net Zero Scenarios to achieve 79-87% reductions in transportation emissions below 2005 levels by 2050**
- **The High Decarbonized Fuels scenario has lower level of electrification compared to the High Electrification scenario, but due to the use of biodiesel it almost achieves the same level of emissions reductions**
- **High Carbon Storage scenario is on the lower end of the range for direct emissions reductions since it relies more on negative emissions from natural and working lands and direct air capture of CO2**

Wide Adoption of Zero-emission Vehicles is the Main Driver to Achieve Deep Decarbonization of Transportation Across All Net Zero Scenarios

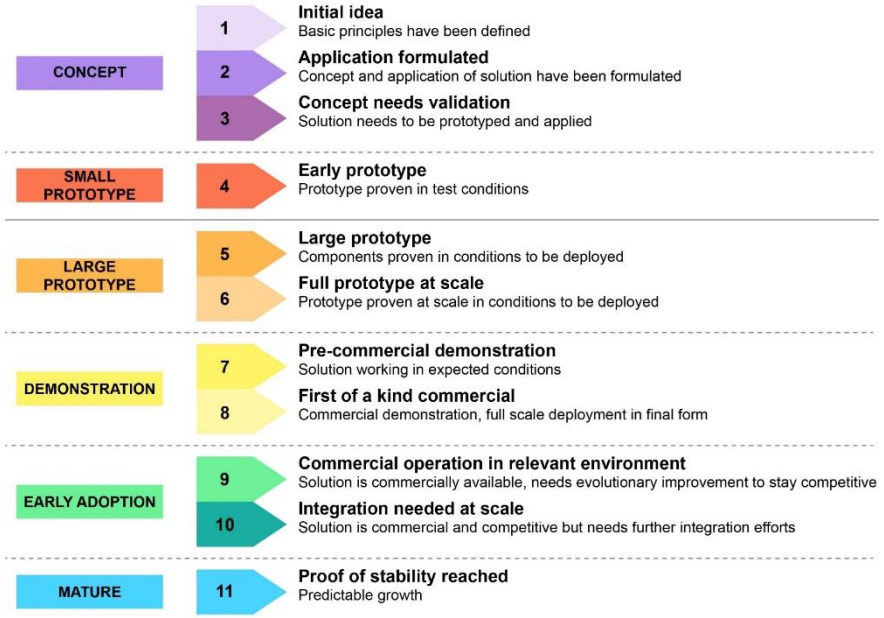
Transportation Sector Direct GHG Emissions in the PATHWAYS High Decarbonized Fuels Scenario (MMT CO2e)



Identifying Risks in an Uncertain Future

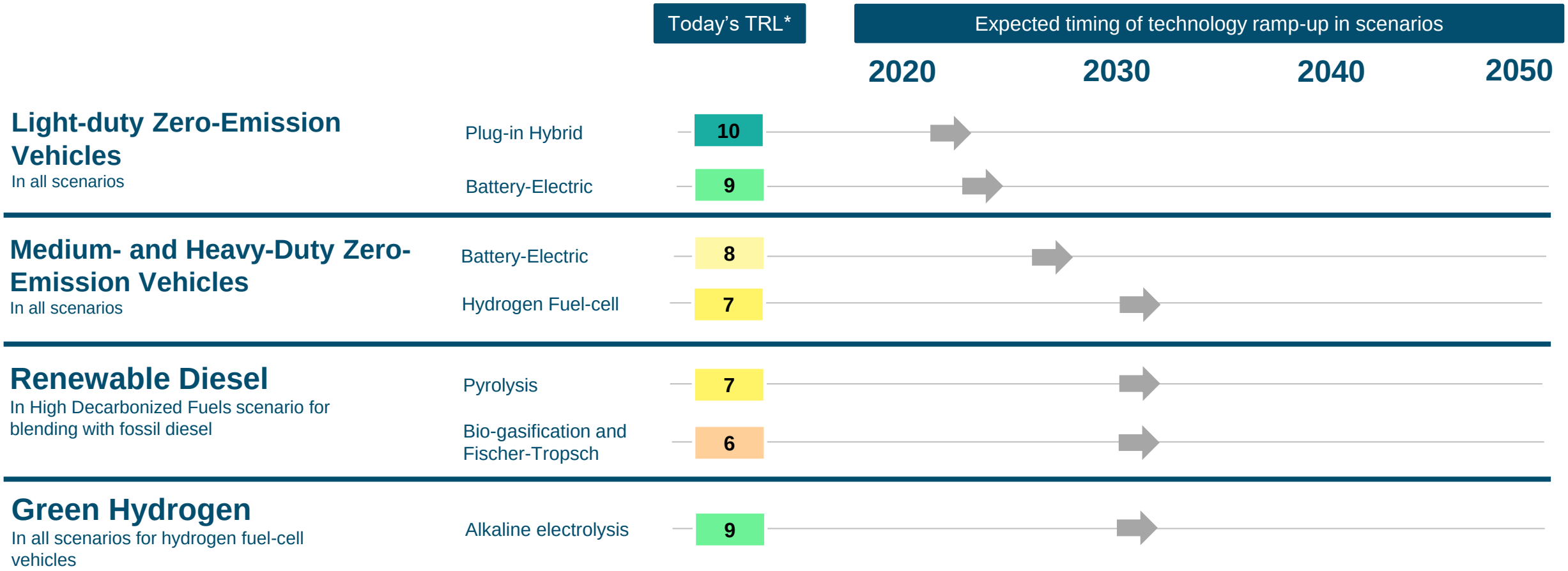
+ **Developing scenarios across a 30-year time horizon includes many uncertainties and risks, including:**
  - Customer adoption risk
    - Widespread adoption of zero-emission vehicles will require affordable model options, accessible charging infrastructure, and large-scale technology acceptance
  - Commercialization risk
    - Decarbonization scenarios rely on technologies with varying levels of commercialization, or readiness.
    - IEA has established a Technology Readiness Level (TRL) scale for decarbonization measures.
    - A technology with a TRL of 11 is ready to scale, options lower than that need R&D and/or commercialization support.
    - Portfolios of decarbonization options that rely on lower TRL measures carry additional risk.
    - E3 and other deep decarbonization researchers generally screen out technologies that are low (<5) on the TRL scale because of their speculative nature and the short time horizon of mid-century climate goals.

Commercialization Risk through TRLs



Credit: International Energy Agency

Technology Readiness & Risks



Footnote: Technology Readiness Levels (TRLs) are based on values from an IEA database, modified in some cases by E3 based on our professional judgement

Take-aways and Next Steps

- **The draft PATHWAYS transportation results identifies several near-term opportunities for "no-regret" actions:**
  - Incentivize the adoption of and a fast transition to zero-emission vehicles in the next decade across all vehicle classes, especially battery-electric passenger vehicles
  - Encourage transit and smart growth to reduce driving and vehicle miles traveled
  - Pilot bio-based renewable diesel production using sustainable biomass feedstock, replacing fossil-based diesel for medium-and-heavy-duty vehicles
  - Support commercialization of hydrogen fuel-cell trucks and hydrogen production, as clean alternatives to diesel-powered medium-and-heavy-duty vehicles
- **Next Steps:**
  - Feedback for the draft results is welcome by September 23rd submitted to contactgov@nc.gov
  - E3 will take feedback from this group, as well as other stakeholders under the PATHWAYS process, and provide updated results in November-December

How you can stay engaged with the PATHWAYS process

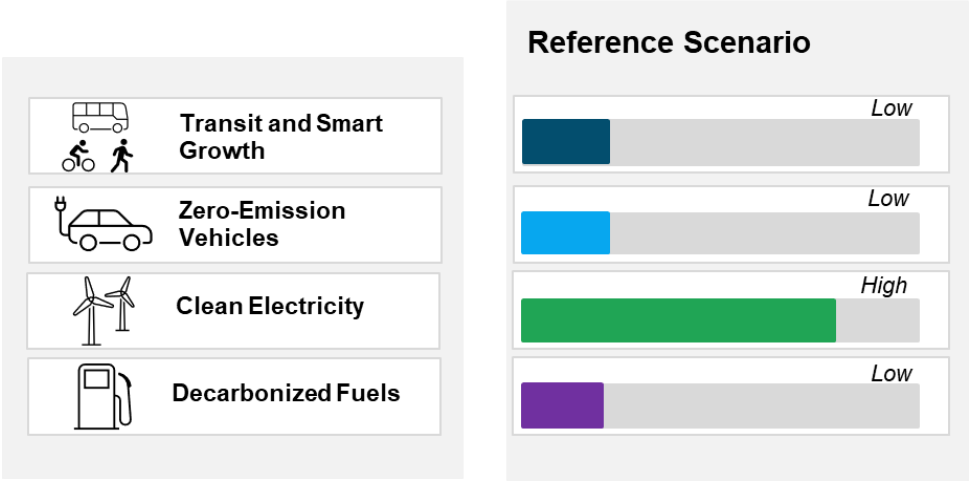
	Aug	Sep	Oct	Nov	Dec	Jan
Planned Public Engagement Sessions						

- **Public Engagement Session #1 (August 11th):** Introducing the pathways analysis scope, process and scenario design and soliciting public feedback
- **Public Engagement Session #2 (TBD in Oct):** Presenting draft scenario results and soliciting public feedback
- **Public Engagement Session #3 (TBD in Dec):** Presenting updated final scenario results and soliciting public feedback
- ***Website to stay up to speed on the Pathways and learn more:*** ***https://governor.nc.gov/issues/environment***

Supplemental Results

Energy+Environmental Economics

“Business-as-usual” Scenario and Transportation Assumptions



Transit and Smart Growth	Total number of vehicles increase with population and existing driving patterns continue.
Zero-Emission Vehicles	Moderate increases in electric vehicles, but no new policies or incentives
Clean Electricity	New renewables and storage are built to meet new electric sector goals (HB 951)
Decarbonized Fuels	Existing biofuel blends continue (e.g. ethanol blended into motor gasoline)

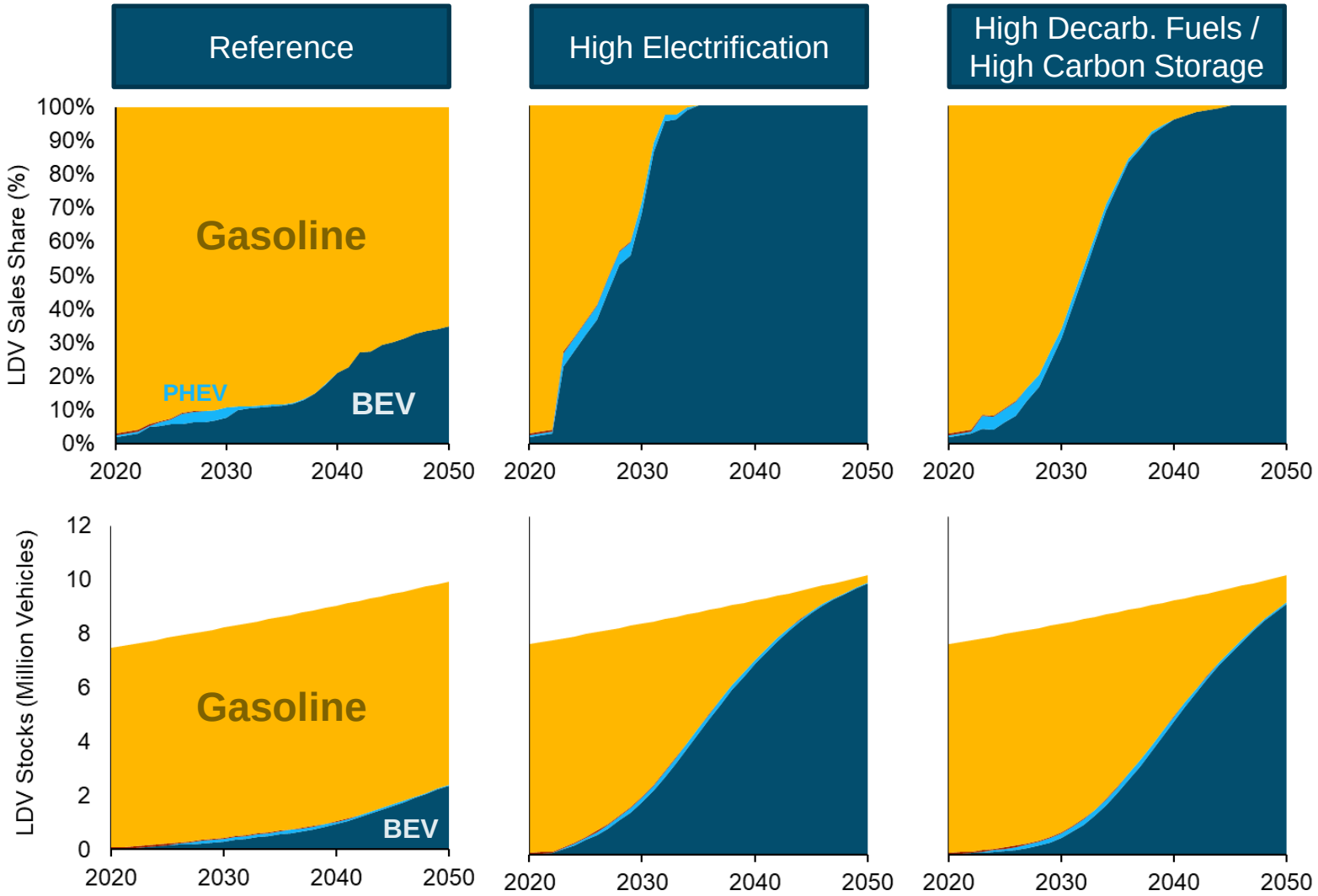
+ **Reference scenario is designed to represent a “business-as-usual” view of the future that incorporates existing state and federal policies and current technology trends**
+ **Major policies relevant for the transportation sector included:**
  - **Federal Corporate Average Fuel Economy (CAFE) standards**
    - Recently announced fuel economy standards for passenger cars and light trucks in model years 2024-2026
  - **House Bill (HB) 951**
    - 70% reduction in electricity generation carbon dioxide emissions from in-state generation by large utilities by 2030, net zero emissions by 2050

Transportation Sector Measures by Scenario

Measure	Reference	High Electrification	High Decarbonized Fuels	High Carbon Storage
LDV ZEVs	8% ZEV sales by 2030, 35% ZEV sales by 2050 (based on latest NHTSA forecast)	100% ZEV sales by **2035**	100% ZEV sales by **2045**	100% ZEV sales by **2045**
MHDV ZEVs	~10% ZEV sales by 2050 (based on the Congressional Budget Office forecast of incentive spending for the Inflation Reduction Act)	100% ZEV sales by **2045** (**90/10** split for BEV/HFCV)	100% ZEV sales by **2050** (**75/25** split for BEV/HFCV)	100% ZEV sales by **2050** (**75/25** split for BEV/HFCV)
VMT Reductions	No reductions below BAU forecast	**1.2%** reduction in total VMT below BAU forecast by **2040**	**1.2%** reduction in total VMT below BAU forecast by **2040**	**1.2%** reduction in total VMT below BAU forecast by **2040**
Biofuels	Existing blends of ethanol and biodiesel held constant	Existing blends of ethanol and biodiesel held constant	**~70%** blend of renewable diesel by **2050**	Existing blends of ethanol and biodiesel held constant

Draft and Preliminary

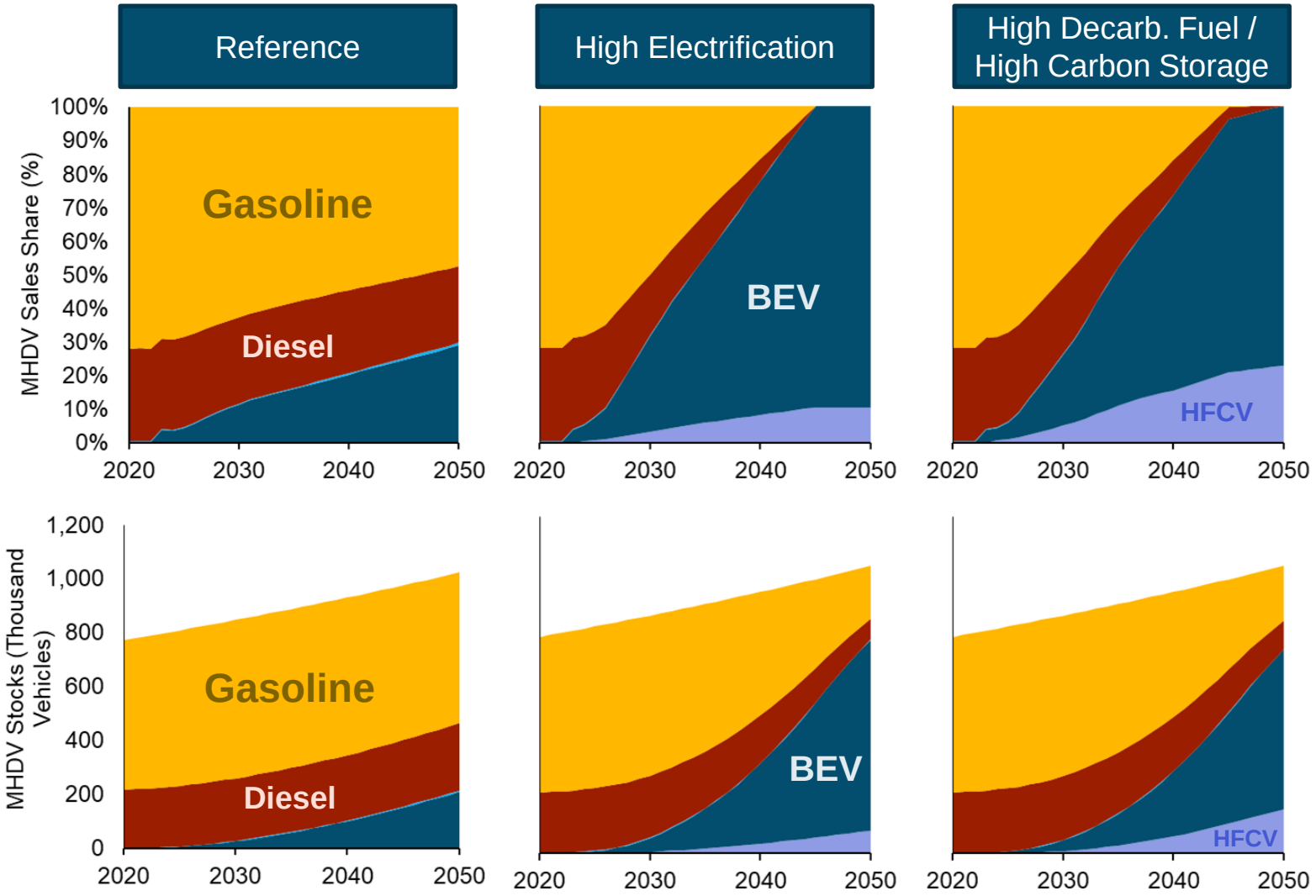
Transportation Sector Results: Light-Duty Vehicles Sales & Stocks



- Reference scenario LDV EV adoption is based on NHTSA CAFE Compliance and Effects Modeling System analysis used for the latest federal fuel economy standards for MY2024-2026
- In High Electrification, EV sales reach 100% by 2035 based on annual sales requirements from CARB Advanced Clean Cars II
- The High Decarbonized Fuels and High Carbon Storage scenarios both have a slower ramp up to 100% EV sales by 2045
- ZEV Stock

	Reference	High Electrification	HDF and HCS
Stock	410K by 2030, 2M by 2050	2M by 2030, 10M by 2050	770K by 2030, 9M by 2050

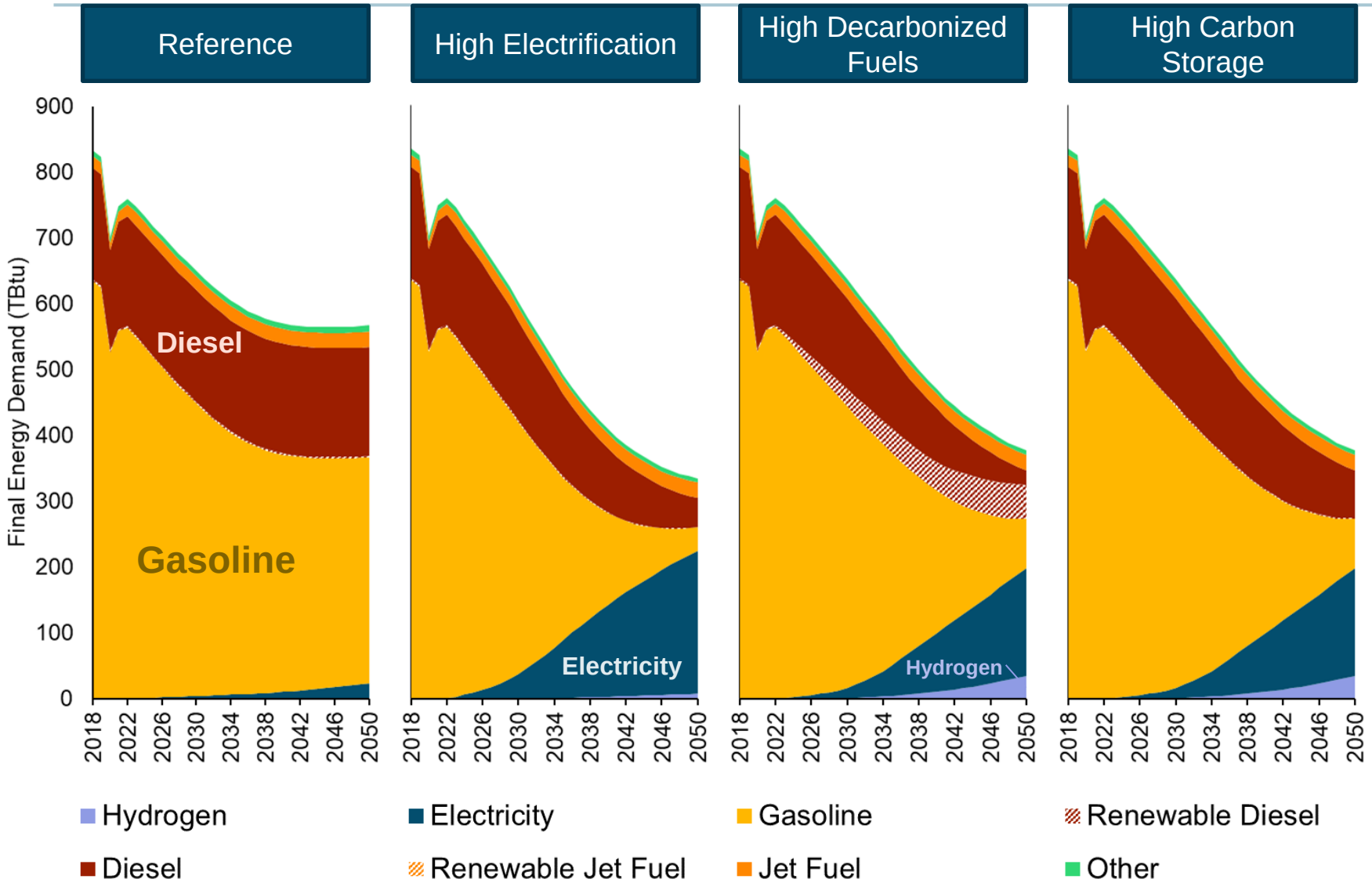
Transportation Sector Results: Medium & Heavy-Duty Vehicles Sales & Stocks



- **Reference scenario MHDV ZEV adoption is based on EIA Annual Energy Outlook 2021, with increased EV sales based on CBO forecast of commercial EV incentives**
- **In High Electrification, ZEV sales reach 100% by 2045**
  - Balance between battery electric and H2 fuel cell vehicles based on "Conservative H2" case from 2022 NREL MHDV ZEV Cost Analysis
- **The High Decarbonized Fuels and High Carbon Storage scenarios both have a slower ramp up to 100% ZEV sales by 2050**
  - Higher sales of H2 fuel cell vehicles based on the "Central" case from same NREL report
- **ZEV Stock**

Reference	High Electrification	HDF & HCS
25K by 2030, 200K by 2050	60K by 2030, 760K by 2050	50K by 2030, 730K by 2050

Transportation Sector Results: Final Energy Demand by Fuel

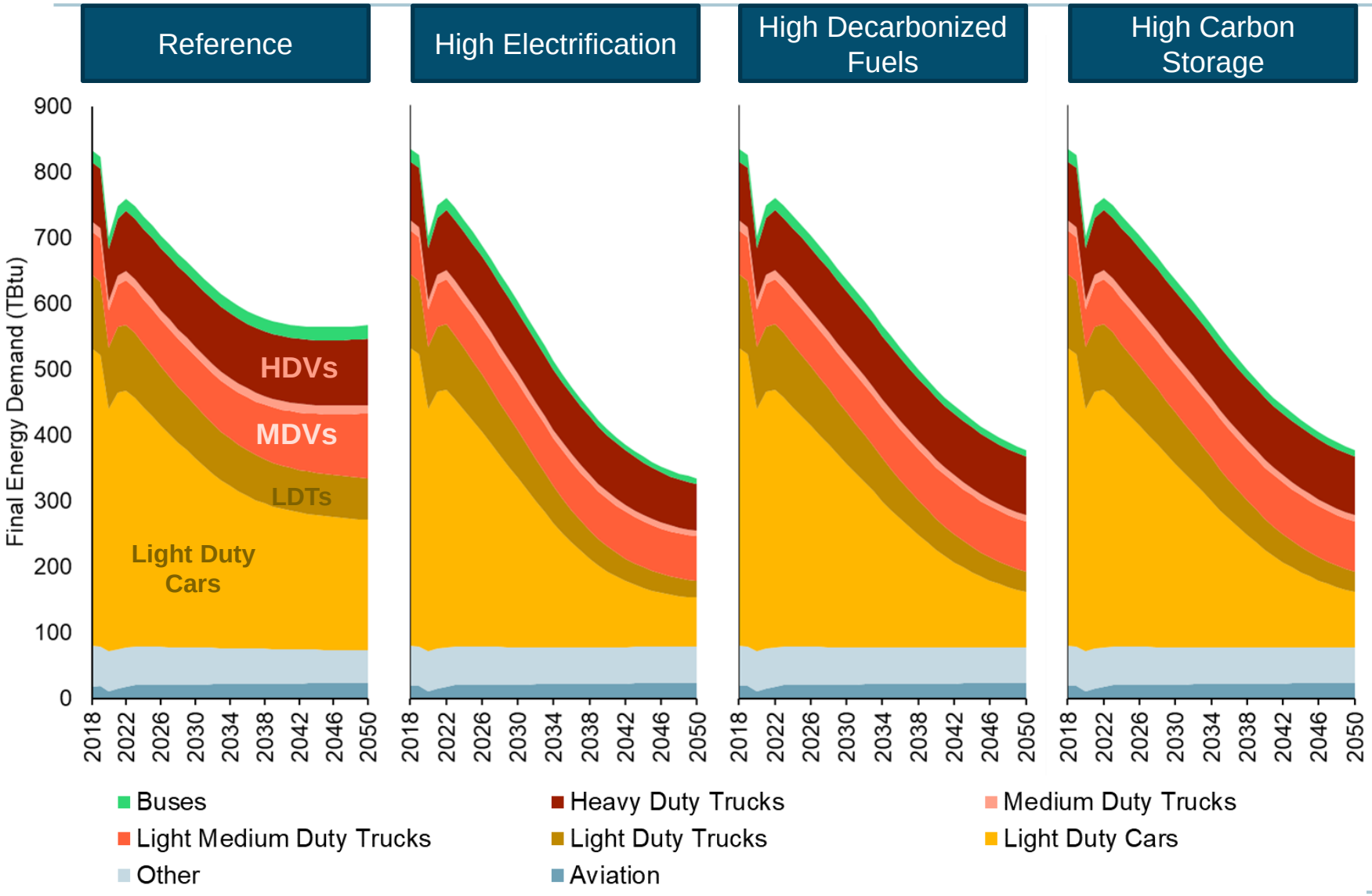


+ **Largest reductions in energy demand by fuel are for gasoline and diesel as on-road fleet transitions to battery electric and H2 fuel cell vehicles**
  - Jet fuel demand remains relatively constant through 2050

+ **Renewable diesel blend reaches ~70% by 2050 in the High Decarbonized Fuels scenario**
  - Not enough supply to meet 100% of remaining liquid fuels demand with renewable fuels under current scenario constraints (population weighted share of national wastes & residues feedstocks)

Draft and Preliminary

Transportation Sector Results: Final Energy Demand by Subsector

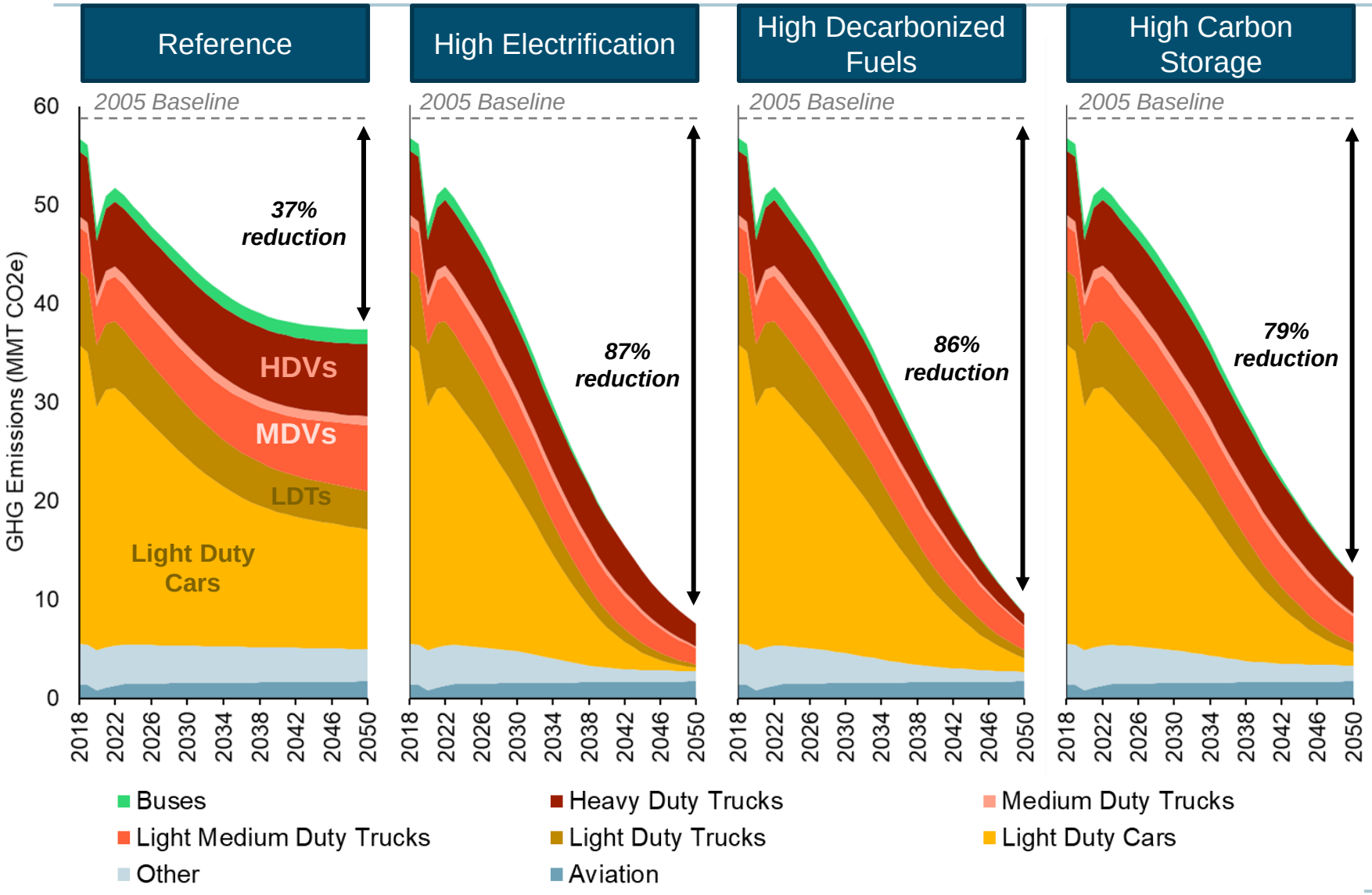


+ **Despite increasing travel demand, final energy needs for transportation decline in all scenarios**
  - This reduction is driven by the increased efficiency of electric drivetrains vs. conventional internal combustion engine vehicles

+ **In the mitigation scenarios, the transportation sector consumes less than half of current energy demands by 2050**

Draft and Preliminary

Transportation Sector Results: GHG Emissions by Subsector



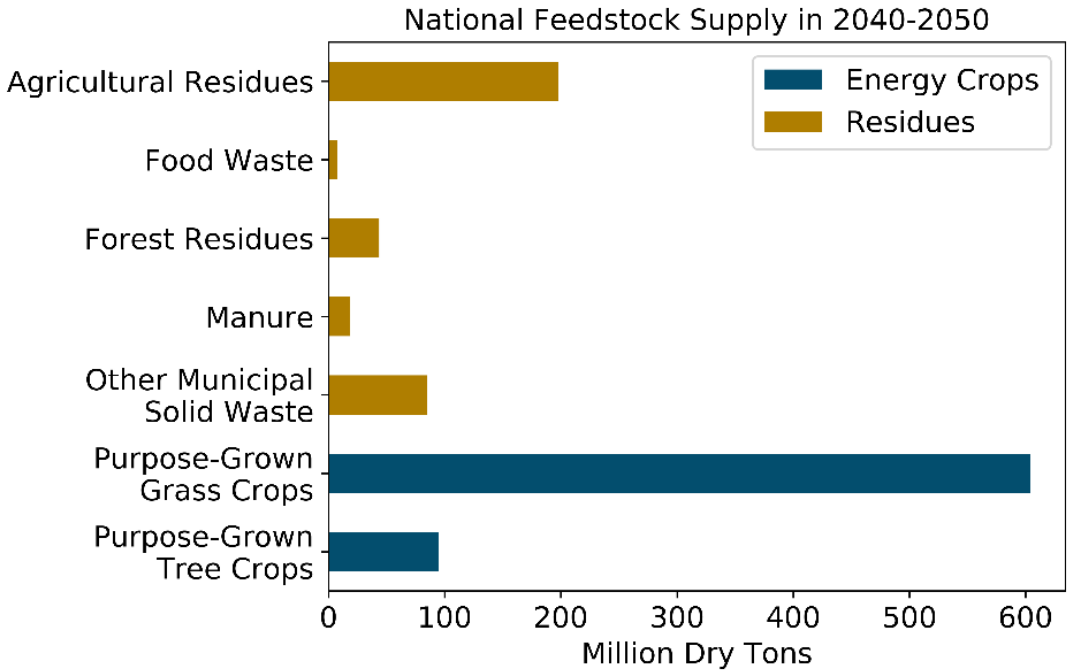
+ **Reference scenario sees reductions in GHG emissions from LDVs due to fuel economy improvements and increased EV adoption**
  - Little to no reductions in non-LDV subsectors

+ **All mitigation scenarios have deep reductions below 2005 levels**
  - High Decarbonized Fuels almost reaches the same level of reductions as High Electrification despite slower ZEV adoption due to blending of renewable fuels
  - High Carbon Storage also has slower ZEV adoption but no increased renewable fuels use

Draft and Preliminary

Screening of Biomass Feedstock Potential

- **E3 relies mostly on the DOE Billion Ton Report and NREL Biogas Potential in the United States Study to estimate the quantity and location of eligible biofuel feedstocks, including two major categories of feedstock:**
  - **"Residues"** include feedstocks such as agricultural residues, forest thinnings, and food waste
  - **"Energy Crops"** include dedicated land to grow high-energy crops or new forests for conversion to biofuels
- ***For this analysis*, E3 plans to screen the availability of feedstock for biofuel production based on two main criteria:**
  - **Geographic locations,** e.g. assuming access to only in-state biomass feedstock, or NC's population-weighted share of national feedstock
  - **Land use and sustainability concerns,** e.g. excluding dedicated energy crops from the feedstock supply curve. Only feedstocks from wastes and residues will be considered



Source: DOE, 2016. Billion Ton Update

Draft and Preliminary