Annual Technology Baseline (ATB): The 2024 Transportation Update

atb.nrel.gov/transportation/2024/index

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Acknowledgments

- **Biofuels:** Ling Tao, NREL
- **Biofuels and GREET* Analysis:** Uisung Lee, Argonne National Laboratory
- **Hydrogen and GREET* Analysis:** Clarence Ng, Argonne National Laboratory
- **Vehicles:** Halle Evans, Paige Jadun, Jiayun Sun, and Arthur Yip, NREL; Amgad Elgowainy, Ehsan Islam, Charbel Mansour, Paul Phillips, Aymeric Rousseau, and Ram Vijayagopal, Argonne National Laboratory
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* GREET = Greenhouse gases, Regulated Emissions, and Energy use in Transportation

Agenda

- Why the ATB?
- ATB Project Overview
- Website Demonstration
- Questions and Comments.

What Are the Content and Purpose of the ATB?

The ATB is a …

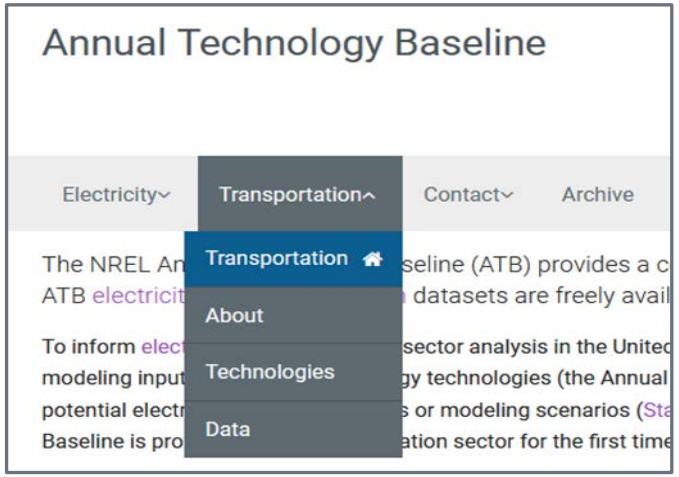
- Website and summary dataset of cost and performance estimates for selected vehicles and fuels
- Link to publicly available resources
- Set of scenarios that highlight potential technological improvements
- Platform for interactive exploration, selection, and download of specific data.

The ATB is *not* a …

- Primary analysis
- Model
- Set of all-encompassing future scenarios.

Why the ATB?

- The *rapid pace of technology development* results in reports of technology progress quickly becoming outdated, making it difficult for researchers to find *current, credible, and consistent* information in one place.
- By enabling *understanding of technology cost and performance across energy sectors,* the ATB informs transportation sector analysis nationwide.



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The ATB Targets Analytic Transparency and Consistency

Objective: Develop and publish energy technology cost and performance assumptions that are credible, comparable, transparent, and reflect current and potential future technology advancement.

EERE* Analysis Consistency

- Ensure consistent assumptions across technologies
- Provide comparability across EERE/national laboratory projects and publications.

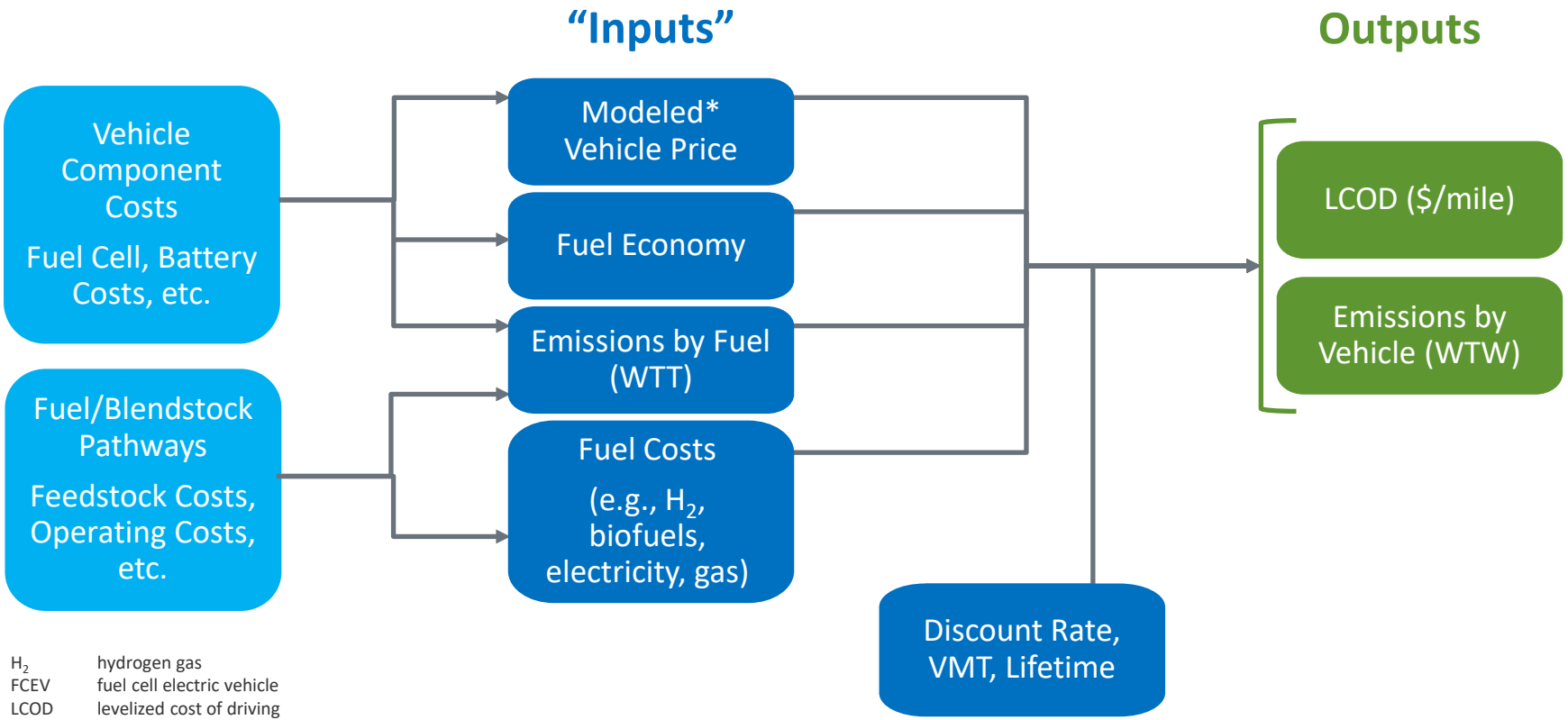
Third-Party Analysis

- Provide access to assumptions
- Leverage national laboratory expertise.

* EERE = U.S. Department of Energy Office of Energy Efficiency and Renewable Energy

ATB Project Overview

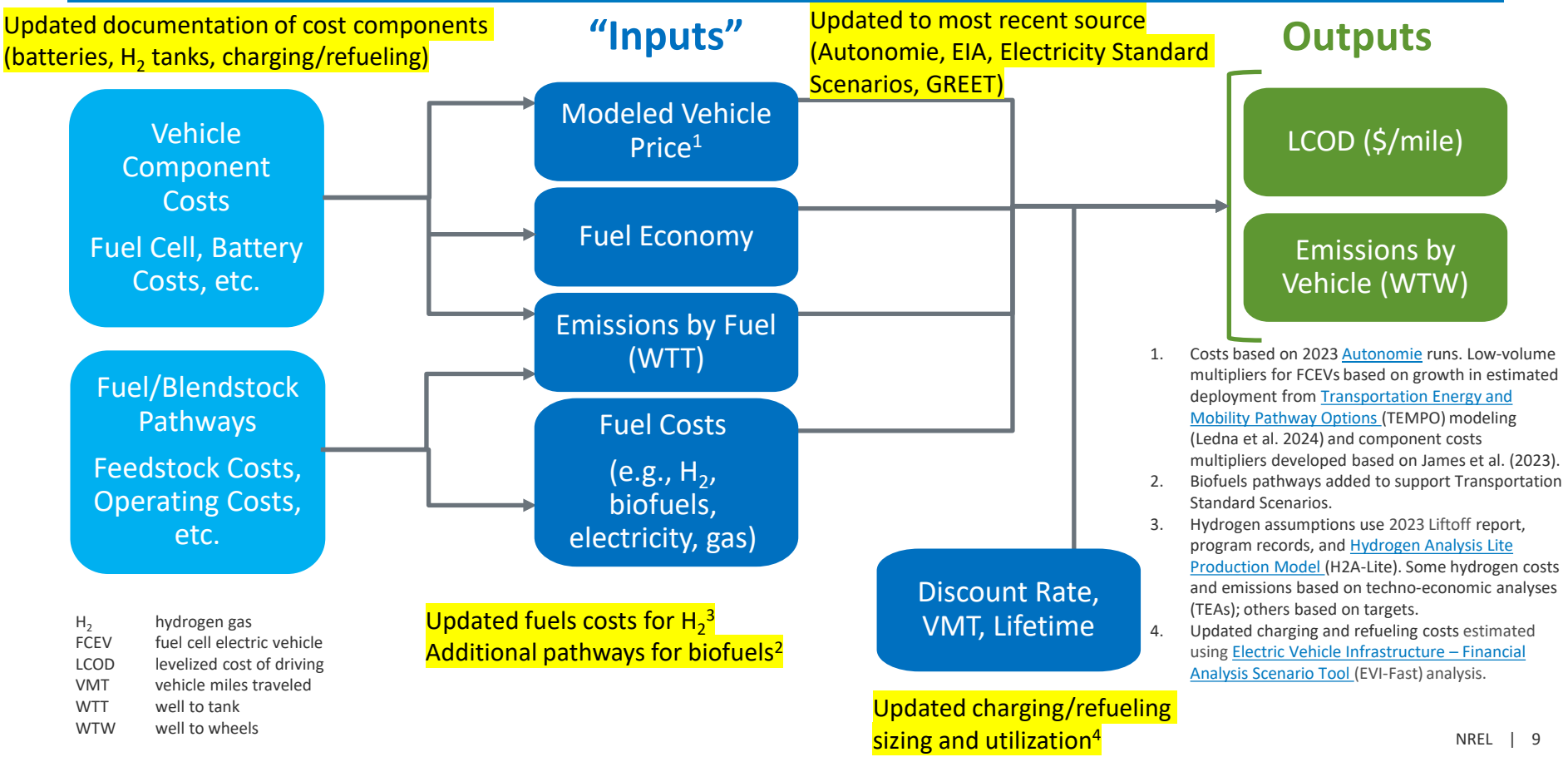
Transportation ATB Highlights Key Data



H_2	hydrogen gas
FCEV	fuel cell electric vehicle
LCOD	levelized cost of driving
VMT	vehicle miles traveled
WTT	well to tank
WTW	well to wheels

*See definition at atb.nrel.gov.

Transportation ATB Highlights Key Data: Changes in 2024



H_2	hydrogen gas
FCEV	fuel cell electric vehicle
LCOD	levelized cost of driving
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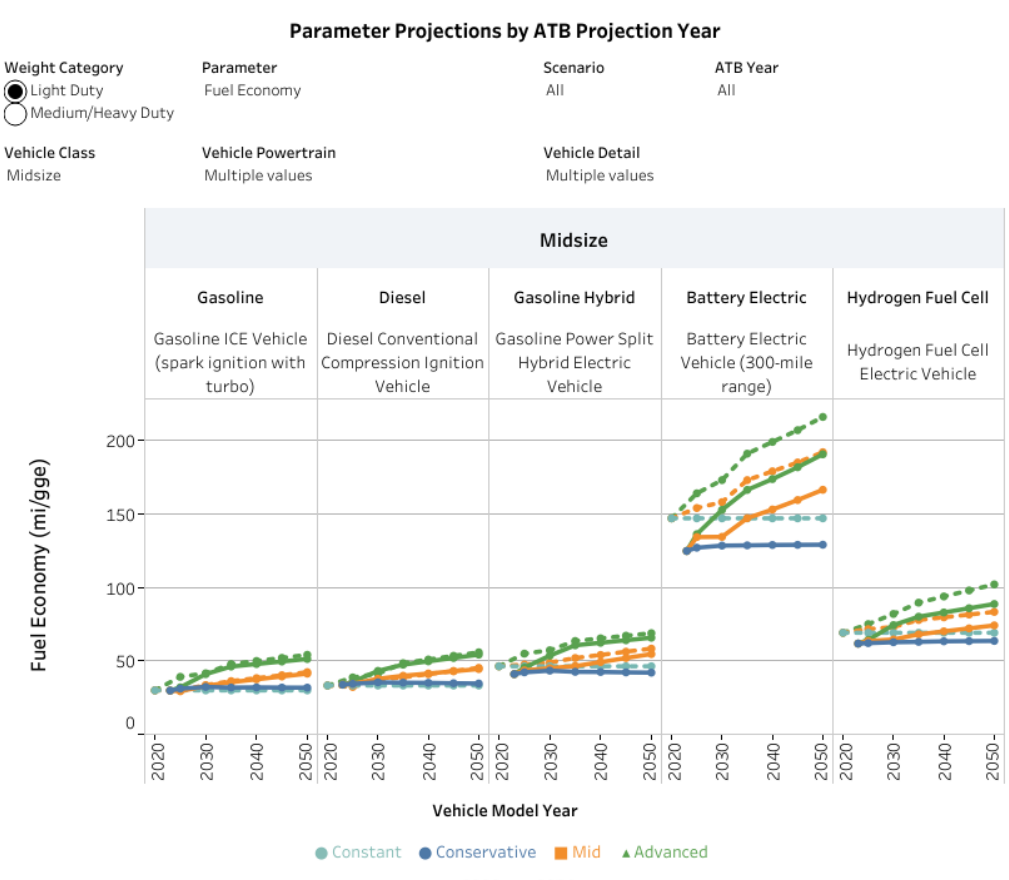
WTT	well to tank
WTW	well to wheels

1. Costs based on 2023 Autonomie runs. Low-volume multipliers for FCEVs based on growth in estimated deployment from Transportation Energy and Mobility Pathway Options (TEMPO) modeling (Ledna et al. 2024) and component costs multipliers developed based on James et al. (2023).
2. Biofuels pathways added to support Transportation Standard Scenarios.
3. Hydrogen assumptions use 2023 Liftoff report, program records, and Hydrogen Analysis Lite Production Model (H2A-Lite). Some hydrogen costs and emissions based on techno-economic analyses (TEAs); others based on targets.
4. Updated charging and refueling costs estimated using Electric Vehicle Infrastructure – Financial Analysis Scenario Tool (EVI-Fast) analysis.

New Feature: Comparison to Previous Update



Summary of Transportation ATB 2024 Data Sources

Key Inputs	Primary Sources
Vehicle Costs and Fuel Economy	ANL's modeling from Autonomie (Islam et al. 2023) and TechScape (ANL 2024). Low-volume multipliers used for FCEVs based on Hydrogen Program Record (James et al. 2023) and in alignment with TEMPO-based market penetrations (Ledna et al. 2024). EIA (2023) Annual Energy Outlook (AEO) used for rates of improvement in Conservative case.
Fuel Costs	Biofuels: Published EERE TEA reports. Hydrogen: 2023 Liftoff report (DOE 2023), H2A-Lite (NREL 2024), Hydrogen Program Record (Hubert et al. 2024), and Bracci et al. 2024. Gasoline, diesel, and ethanol: EIA and EIA AEO (various updated years, not 2023). Electricity: EIA, AEO, and NREL 2023 Standard Scenarios (Gagnon et al. 2024). Recharging: Assumptions based on Borlaug et al. (2020 and 2022), Bennett et al. (2022), and Wood et al. (2023).
Fuel Emissions (WTT)	ANL's GREET model (Wang et al. 2023).
Other LCOD Calculation Assumptions (Discount Rate, VMT, Lifetime, Maintenance, Utility Factor)	LDV: Elgowainy et al. (2016), Burnham et al. (2021), Greene and Leard (2024), and SAE J2841. MHDV: TechScape (ANL 2024); Hunter et al. (2021).

Note: The full list of references can be found here: https://atb.nrel.gov/transportation/2024/references.

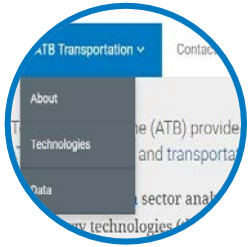
The ATB: Assumptions for Energy Systems Analysis

Core Transportation ATB Assumptions

Base Year and Projected Data for…

- Component costs
- Vehicle price
- Fuel economy
- Fuel costs
- Financing assumptions
- Levelized cost of driving
- Emissions.

ATB Product Suite



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- User guidance
- Additional analyses
- Methodologies
- Comparison to other projections (e.g., U.S. Energy Information Administration [EIA]).

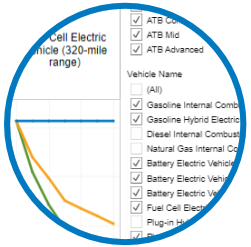
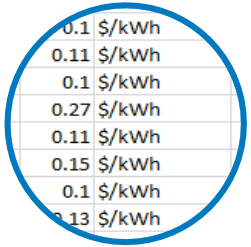


Tableau Workbook

- Summary of selected assumptions (no calculations)
- Cost and performance projections, 2022–2050
- Interactive charts
- Visual exploration.



Formatted Data

- Database-friendly summaries
- Cost and performance projections, 2022–2050
- Structured format.

Presentation Slides

- Webinar presentation
- Summary presentation.

What Is the Value of the ATB?

Transparency, Consistency, Credibility, and Accessibility

- **Consolidates** assumptions from—and for use within—the U.S. Department of Energy's (DOE's) Sustainable Transportation analysis
- **Summarizes** assumptions to the high level needed for systemwide analysis
- **Organizes** data in highly structured format, enabling:
  - Display of data in interactive charts
  - Exploration, selection, and download of specific data.

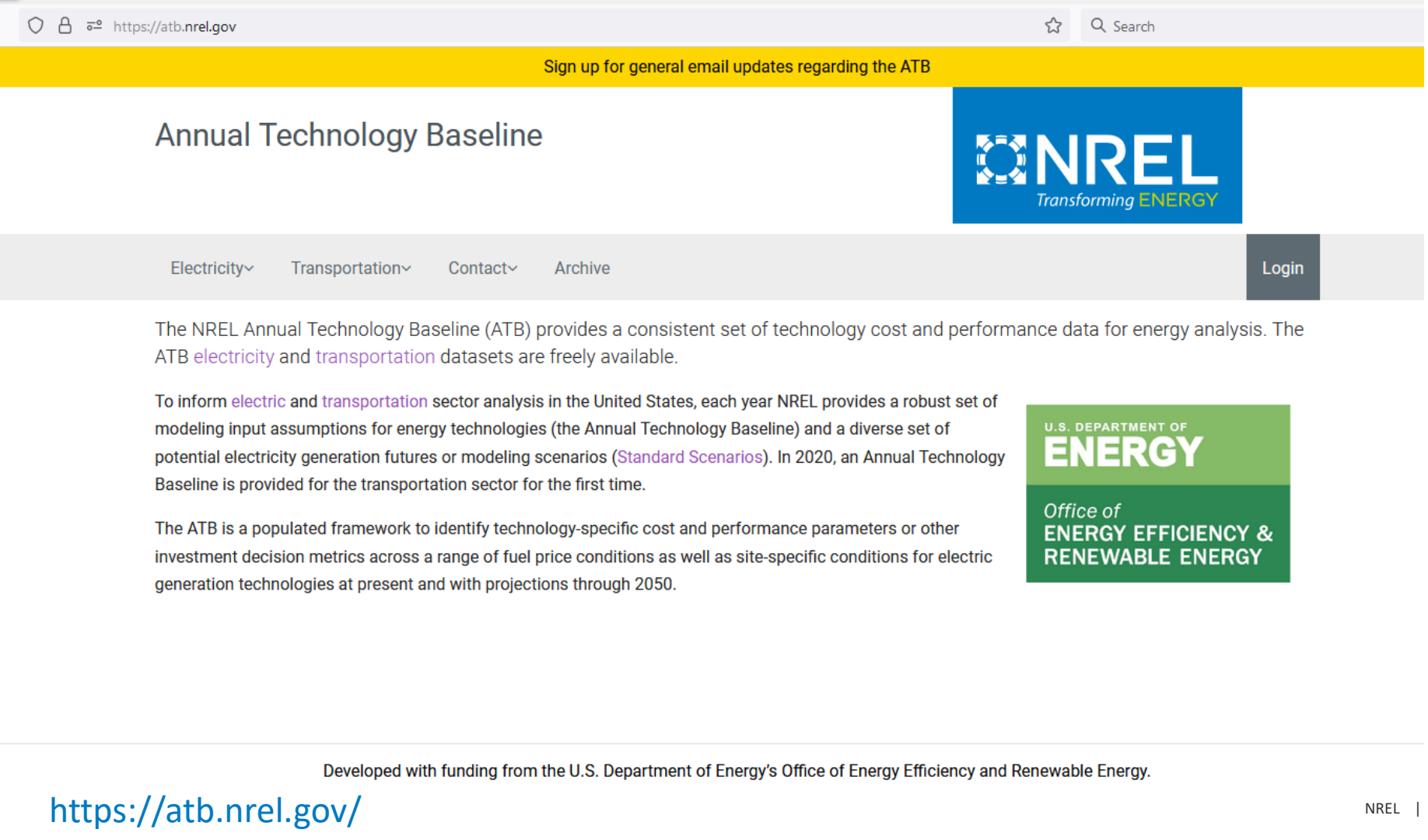
Data are free, publicly available, and easily accessible.

The Transportation ATB Aims for Various Applications

- Sector-specific modeling and analysis
  - TEMPO model
  - Bioenergy Scenario Model (BSM)
  - EPA transportation models
  - Transportation Standard Scenarios analysis
- Integrated, economy-wide modeling and analysis
  - Global Change Analysis Model (GCAM)
  - Decarbonizing Energy through Collaborative Analysis of Routes and Benefits (DECARB) analysis

Technology Specifics:
Web Demo

- Fuels
- Vehicles



https://atb.nrel.gov/

Annual Technology Baseline

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Technologies

The 2024 Transportation Annual Technology Baseline (ATB) provides detailed cost and performance data, cost estimates, and assumptions for vehicle and fuel technologies in the United States.

The Transportation ATB provides current and projected estimates including time-series through 2050 for light-, medium-, and heavy-duty on-road vehicle technologies as well as scenarios for conventional and alternative fuels. It details the assumptions used to calculate those costs, such as natural gas and electricity prices, discount rates, and vehicle miles traveled. At this time, the ATB does not include other vehicles such as two- and three-wheeled motorized vehicles, or nonroad vehicles such as aircraft, vessels, locomotives, and those for industry and agriculture.

https://atb.nrel.gov/transportation/2024/technologies

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Fuels

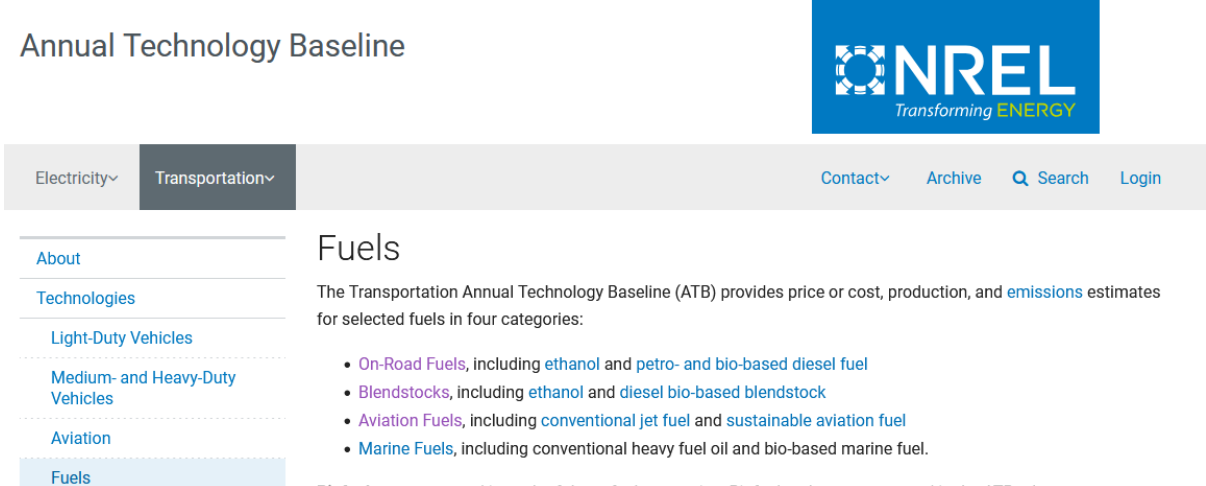
The Transportation Annual Technology Baseline (ATB) provides price or cost, production, and emissions estimates for selected fuels in four categories:

- On-Road Fuels, including ethanol and petro- and bio-based diesel fuel
- Blendstocks, including ethanol and diesel bio-based blendstock
- Aviation Fuels, including conventional jet fuel and sustainable aviation fuel
- Marine Fuels, including conventional heavy fuel oil and bio-based marine fuel.

Biofuels are presented in each of these fuel categories. Biofuel pathways presented in the ATB rely on various biomass resources that include agricultural residues such as corn stover; forest residues; sludges; fats, oils, and greases; and corn. Changes in the market for biomass feedstocks can cause market prices at any given time to differ from the biofuels market prices noted in the ATB. The supply curve costs and quantities of these resources are not presented in the ATB; users of the ATB are encouraged to refer to other literature for this information, such as (U.S. Department of Energy, 2023). These results do not include effects of credits such as those from the Inflation Reduction Act, Renewable Identification Numbers (RIN) credits from the Renewable Fuel Standard, or credits from the California Low Carbon Fuel Standards (LCFS).

https://atb.nrel.gov/transportation/2024/fuels

Update includes additional biofuels pathways to support Transportation Standard Scenarios



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Petro- and Bio-Based Diesel Fuel
Natural Gas Fuel
Electricity
Hydrogen
Blendstocks
Aviation Fuels
Marine Fuels

On-Road Fuels

The Transportation Annual Technology Baseline (ATB) provides fuel price or cost and emissions for select on-road vehicle fuels, including gasoline and ethanol, diesel fuel, natural gas, electricity, and hydrogen.

Finished fuel prices are meant to represent retail prices, and they include estimated taxes (for fuels that are currently taxed) and distribution costs. Blendstock data do not include taxes or distribution costs.

We use the U.S. Energy Information Administration Annual Energy Outlook 2023 for current and projected petroleum fuel prices. Projected fuel prices are associated with particular years; however, because the ATB does not provide a time-series trajectory, we present fuel price at a frozen level for all years, offering different scenarios for a range of fuel price values.

Fuel Scenarios

For nonpetroleum fuels, the Transportation ATB presents five fuel scenarios, which include current market, current modeled, or future modeled conditions at low or high production volume scales, based on techno-economic modeling of potential technology advancement:

- The Current Market scenario represents fuel price and emissions data for fuels that are commercially available, with the exact source, timing, averaging, and other details described in the references. Current Market fuel prices are primarily based on the data from the U.S. Energy Information Administration. Fuel price may differ from retail prices because of market volatility and local market conditions. Fuel emissions data are primarily from the Research & Development Greenhouse gases, Regulated Emissions, and Energy use in Technologies (R&D GREET) model. See specific notes on each fuel page and references for specific dates and averaging methods.

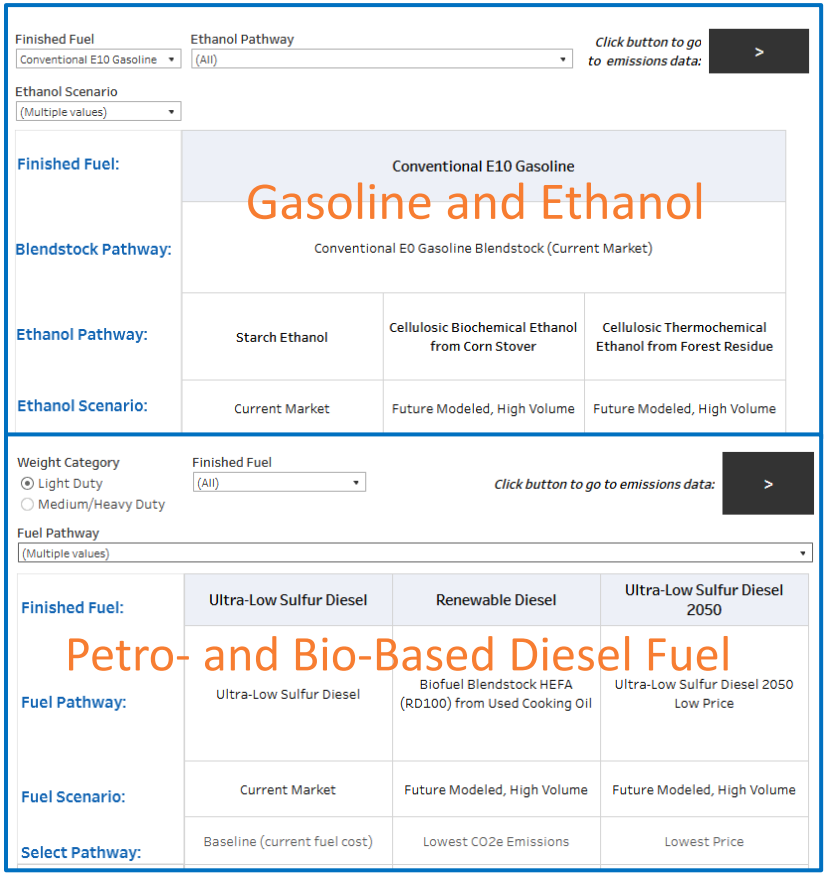
https://atb.nrel.gov/transportation/2024/on-road_fuels

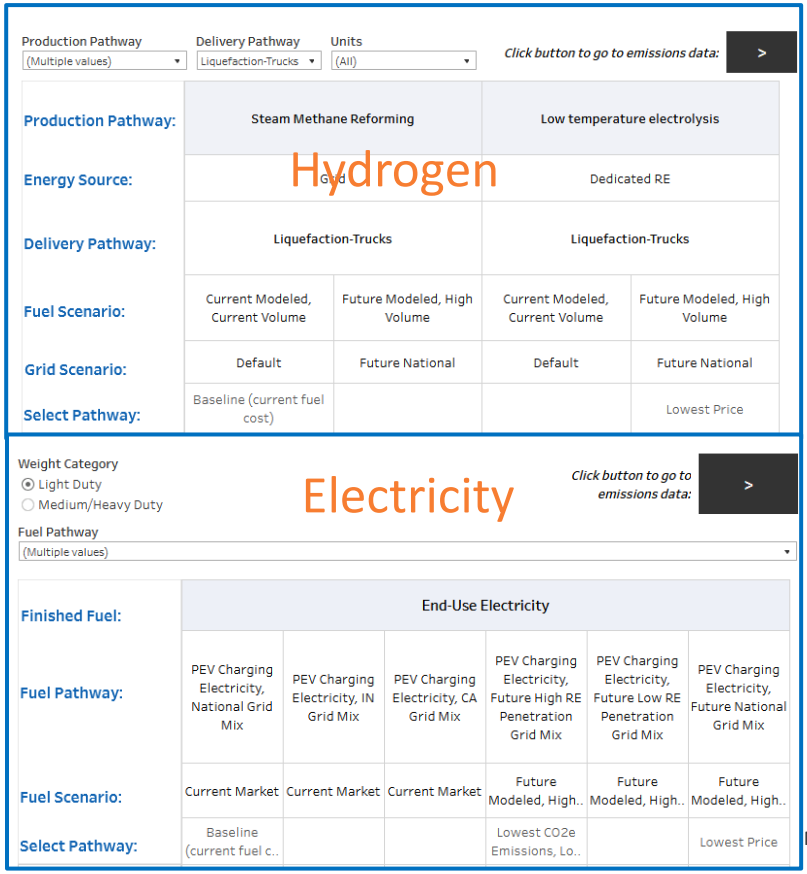
Fuels Scenarios

- **Current Market:** In the Current Market scenario, fuel price and emissions data are shown for fuels that are commercially available; the exact source, timing, averaging, and other details are described in the references. Fuel metrics are primarily based on data from EIA. Fuel price may differ from retail prices because of market volatility and local market conditions. See notes and references on the fuels pages for specific dates and averaging methods.
- **Current Modeled, Current Volume:** In this scenario, fuel metrics are based on techno-economic modeling of the current technology at current market production volume as specified in the notes and references on the fuels pages.
- **Current Modeled, High Volume:** In this scenario, fuel metrics are based on techno-economic modeling of the current technology at high market production volume. Timing of this scenario depends on when high production volume is achieved.
- **Future Modeled, Low Volume:** In this scenario, fuel metrics are based on a future technological state modeled at low market production volume, as might be the case for a pioneer plant.
- **Future Modeled, High Volume:** In this scenario, fuel metrics are based on a future technological state, based on engineering-economic modeling at high market production volume, often called "n^{th} plant." Timing of this scenario depends on when high production volume is achieved.

https://atb.nrel.gov/transportation/2024/definitions

Explore Fuels Data via Interactive Tables





Electricity Example

Metric Type: (•) Emissions ( ) Price
Weight Category: (•) Light Duty ( ) Medium/Heavy Duty
Class: All Classes
Grid Mix: (Multiple values)

Grid Mix:	PEV Charging Electricity, National Grid Mix	PEV Charging Electricity, IN Grid Mix	PEV Charging Electricity, CA Grid Mix	PEV Charging Electricity High Cost, National Grid Mix
Class:	*All Classes*	*All Classes*	*All Classes*	*All Classes*
CO_2e WTT (g/mmBtu)	129000	235000	79500	129000
CO_2e WTW (g/mmBtu)	129000	235000	79500	129000
NO_x WTT (g/mmBtu)	96.1	167	57.4	96.1
NO_x WTW (g/mmBtu)	96.1	167	57.4	96.1
PM_{10} WTT (g/mmBtu)	13.2	29.4	4.35	13.2
PM_{10} WTW (g/mmBtu)	37.2	53.4	28.3	37.2
SO_x WTT (g/mmBtu)	76.9	178	19.5	76.9
SO_x WTW (g/mmBtu)	76.9	178	19.5	76.9

In this table, you can explore the fuel prices and emissions data for all of the electricity fuel pathways in the ATB. Use the filters on the top to choose a metric type and to drill down to specific pathways and scenarios. *WTT="Well to Tank", WTW="Well to Wheels"*

For documentation, see website https://atb.nrel.gov

+ableau

Metric Type: (•) Price ( ) Emissions
Weight Category: (•) Light Duty ( ) Medium/Heavy Duty
Class: All Classes
Grid Mix: (Multiple values)

Grid Mix:	PEV Charging Electricity, National Grid Mix	PEV Charging Electricity, IN Grid Mix	PEV Charging Electricity, CA Grid Mix	PEV Charging Electricity High Cost, National Grid Mix
Fuel Scenario:	Current Market	Current Market	Current Market	Current Market
Class:	*All Classes*	*All Classes*	*All Classes*	*All Classes*
Fuel Price ($/gge)	3.49	3.44	4.05	4.80

https://atb.nrel.gov/transportation/2024/electricity

Annual Technology Baseline

Electricity | Transportation | Carbon Dioxide Removal | Contact | Archive | Editing | Admin | Laura Vimmerstedt

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Technologies

The 2024 Transportation Annual Technology Baseline (ATB) provides detailed cost and performance data, cost estimates, and assumptions for vehicle and fuel technologies in the United States.

The Transportation ATB provides current and projected estimates including time-series through 2050 for light-, medium-, and heavy-duty on-road vehicle technologies as well as scenarios for conventional and alternative fuels. It details the assumptions used to calculate those costs, such as natural gas and electricity prices, discount rates, and vehicle miles traveled. At this time, the ATB does not include other vehicles such as two- and three-wheeled motorized vehicles, or nonroad vehicles such as aircraft, vessels, locomotives, and those for industry and agriculture.

https://atb.nrel.gov/transportation/2024/technologies

New Feature

Comparison with previous update

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Gasoline Hybrid
Plug-In Hybrid
Battery Electric
Fuel Cell
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Aviation

Light-Duty Vehicles

The 2024 Transportation Annual Technology Baseline (ATB) provides current and future projections of cost and performance for select light-duty vehicles and fuels (and for select Medium- and Heavy-Duty Vehicles).

The Transportation ATB provides data in a series of interactive charts for either a single year or a trajectory out to 2050 showing the following:

- Fuel economy, which is reported in miles per gallon gasoline equivalent and represents how efficiently a vehicle converts fuel during operation
- Modeled Vehicle Price, which represents an estimated cost, including manufacturing costs and profit, to the consumer purchasing a new vehicle
- Levelized cost of driving, which is an indicator of the cost of operation over the vehicle lifetime on a per-mile basis
- Emissions, which represent the well-to-wheels emissions (including emissions from fuel production to vehicle operation).

The Transportation ATB presents these metrics for individual powertrains and in comparison with other powertrains.

Vehicles Scenarios

Advanced Trajectory

In the ATB Advanced trajectory, technology advances occur with breakthroughs, increased public and private research and development (R&D) investment, and other market conditions that lead to significantly improved cost and performance levels, but technologies do not necessarily reach their full technical potential. Vehicle technologies advance substantially and achieve high performance, low cost, or both. Attaining this level of cost improvement is assumed to be very uncertain.

Mid Trajectory

In the ATB Mid trajectory, technology cost and performance improve at moderate levels with continued industry growth and R&D investment (both public and private). Vehicles include moderate technology advancements (in between the currently manufactured technology and the Advanced trajectory) to achieve higher performance, lower costs, or both. Attaining this level of cost improvement is assumed to be moderately uncertain.

Conservative Trajectory

In the ATB Conservative trajectory, technology cost and performance improve from Base Year levels at rates based on the Annual Energy Outlook (EIA, 2023).

Constant Trajectory (used only for vocational and refuse vehicles)

In the ATB Constant trajectory, technology cost and performance from the Base Year are shown through 2050, without further advancement in R&D or markets. This cost level is extended through 2050 for reference only; it does not imply that frozen costs and performance are anticipated and should not be confused with a business-as-usual or baseline scenario.

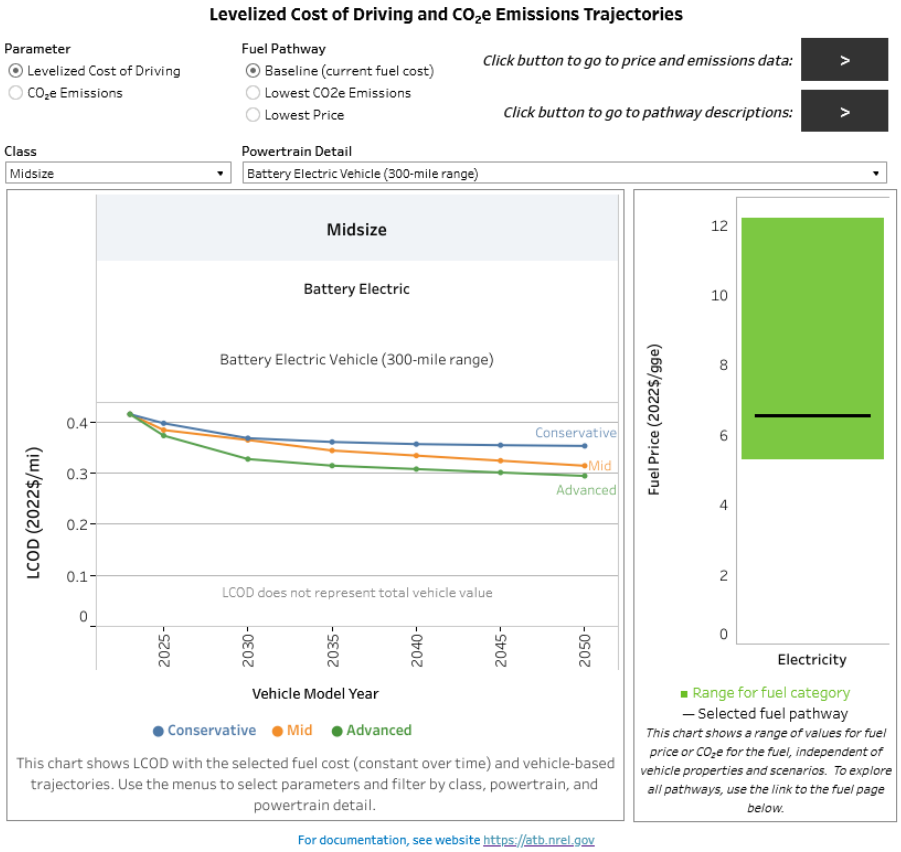
Technology advances include changes that may reduce costs or may increase costs while improving performance, which implies costs do not always decline between less-advanced and more-advanced scenarios. However, although technology advancements that improve performance may increase vehicle cost, they might also result in a lower LCOD because of potential fuel savings.

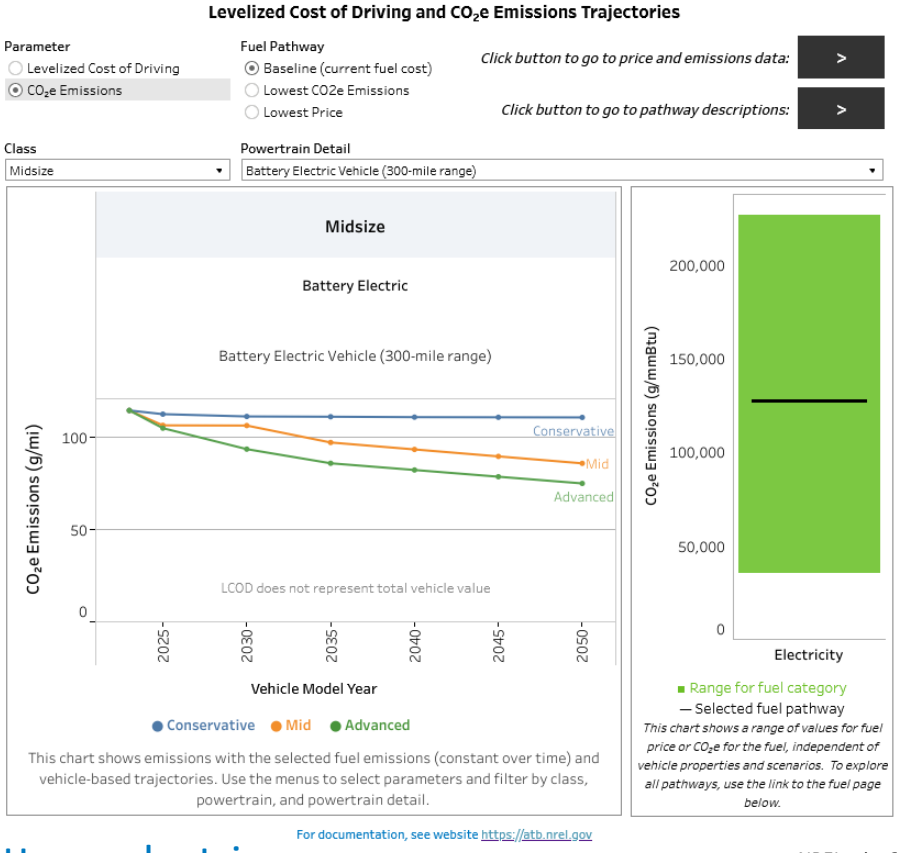
https://atb.nrel.gov/transportation/2024/definitions

Vehicle Metrics: Battery Electric Vehicle (BEV) Example

https://atb.nrel.gov/transportation/2024/battery_electric

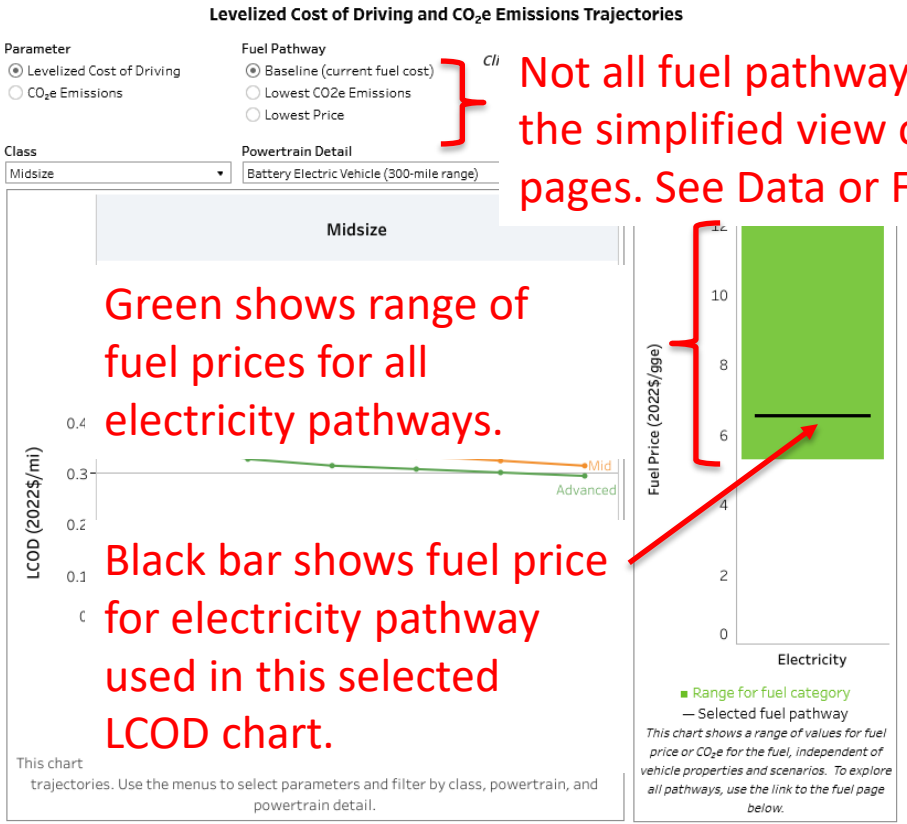
Vehicle and Fuel Metrics: BEV Example





https://atb.nrel.gov/transportation/2024/battery_electric

Vehicle and Fuel Metrics: BEV Example

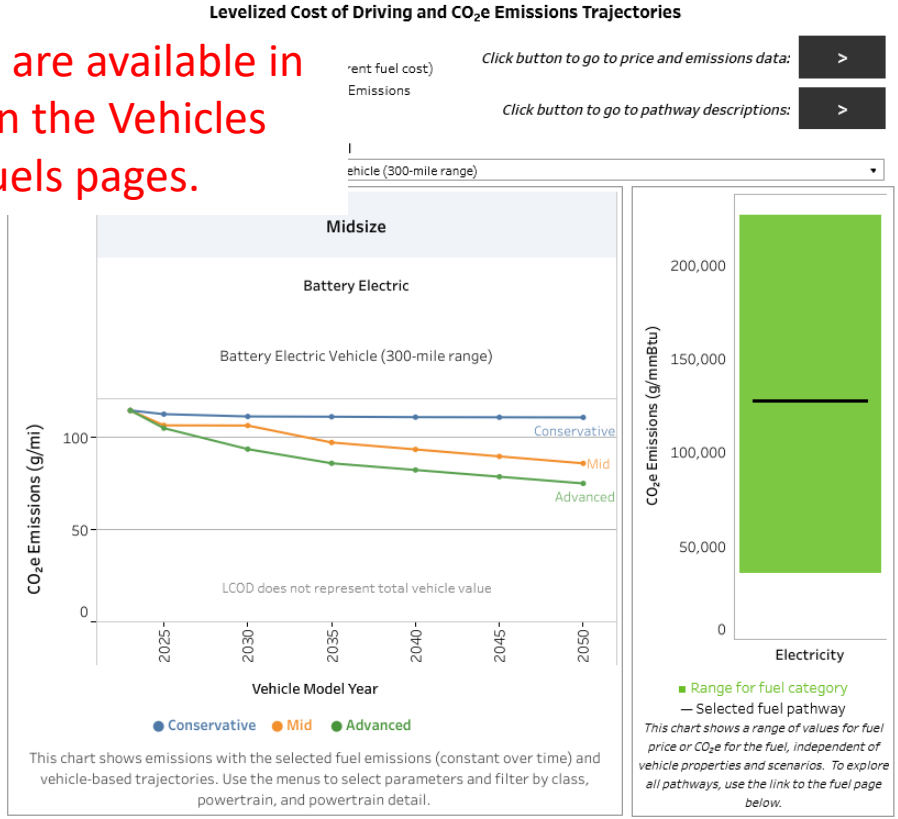


Not all fuel pathways are available in the simplified view on the Vehicles pages. See Data or Fuels pages.

Green shows range of fuel prices for all electricity pathways.

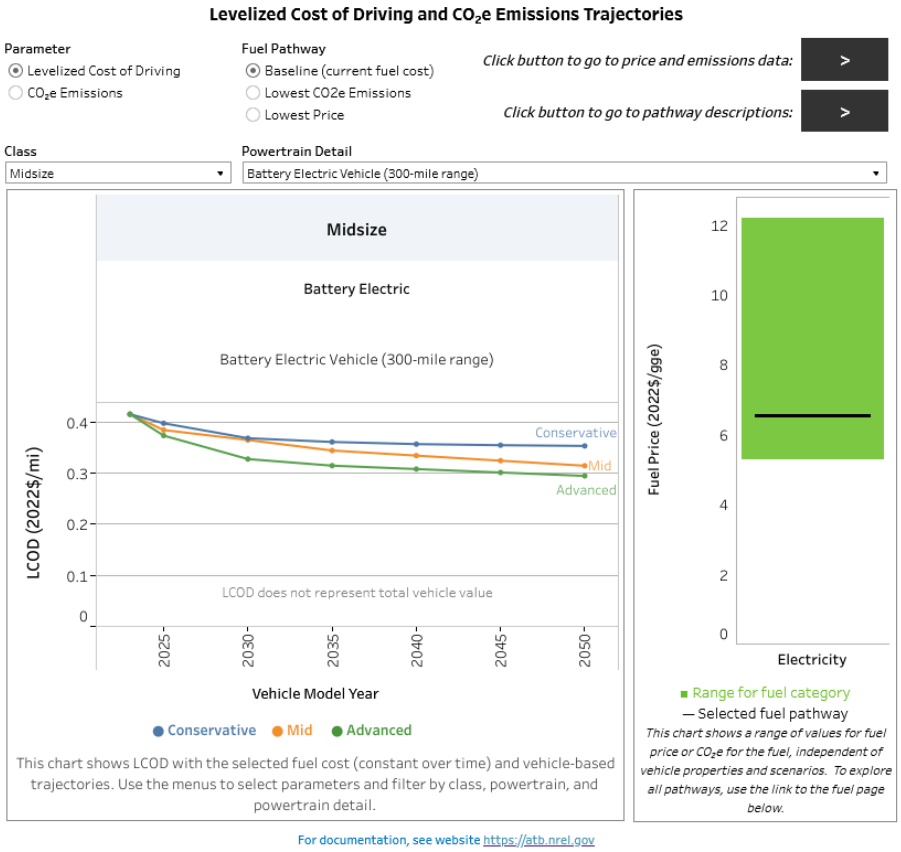
Black bar shows fuel price for electricity pathway used in this selected LCOD chart.

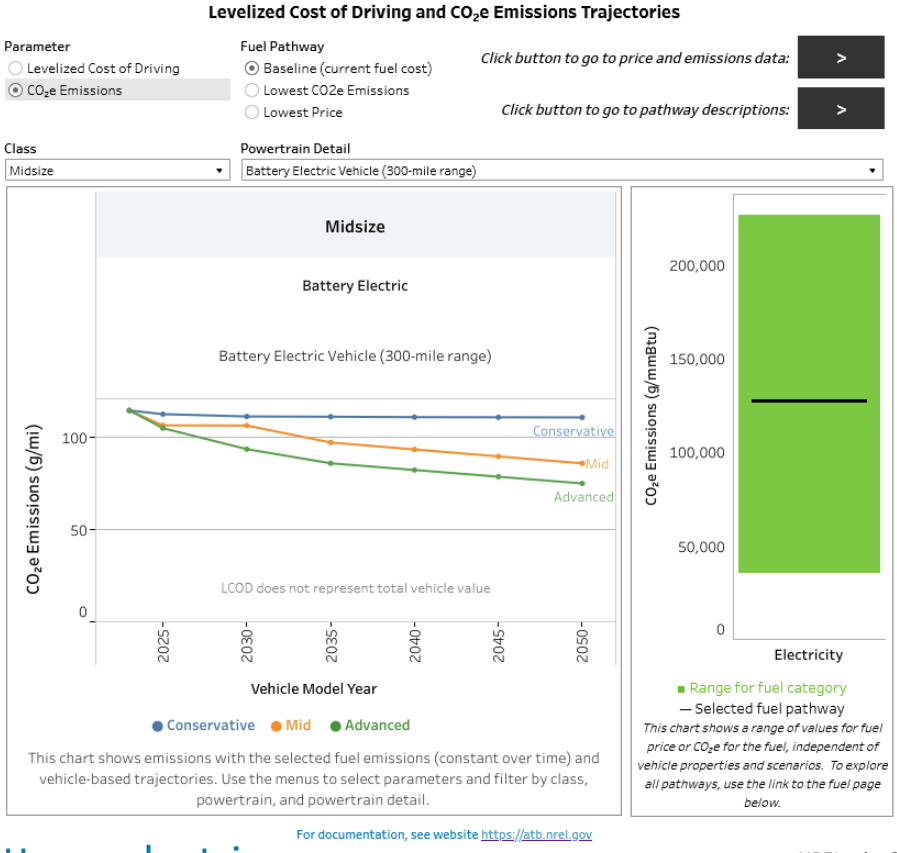
For documentation, see website https://atb.nrel.gov



For documentation, see website https://atb.nrel.gov

Vehicle and Fuel Metrics: BEV Example

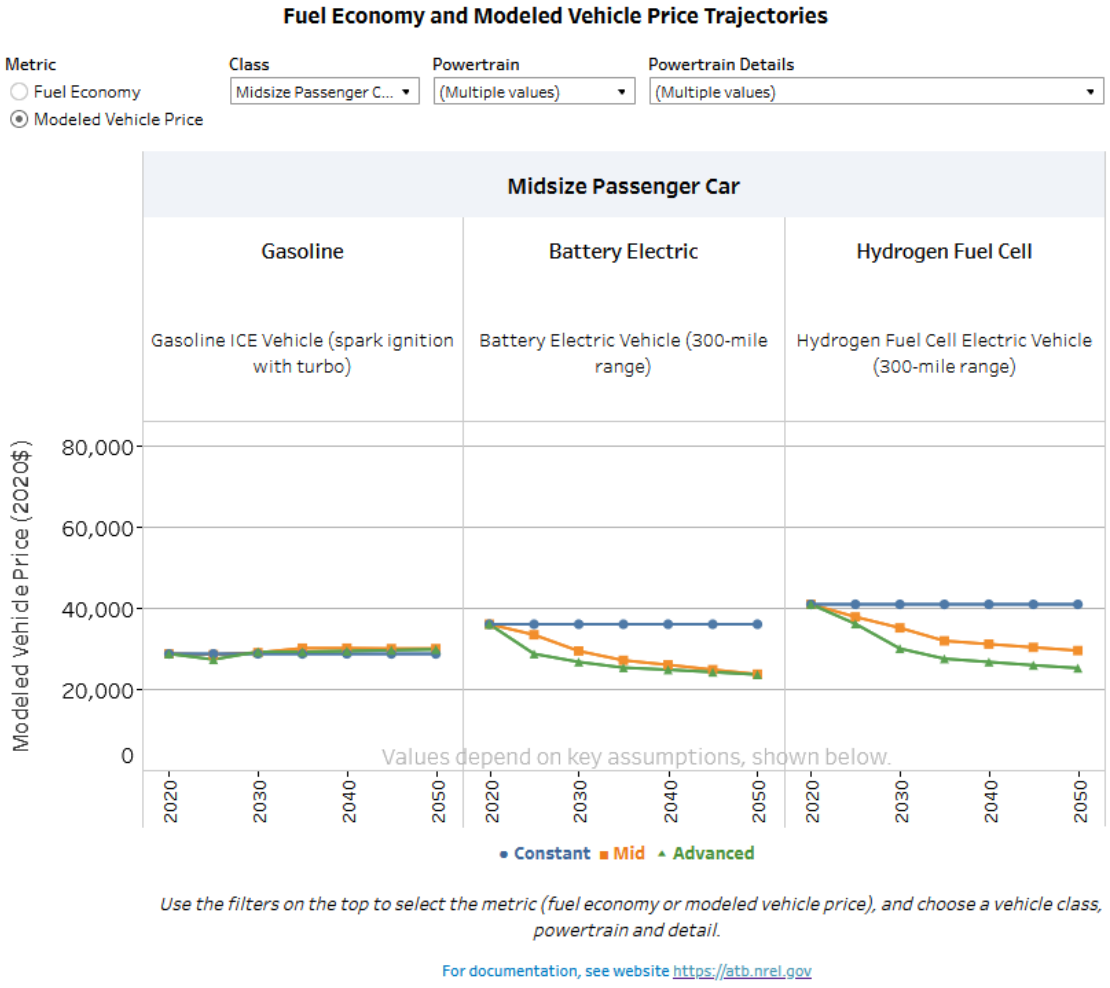




https://atb.nrel.gov/transportation/2024/battery_electric

Light-Duty Vehicle Comparison Example

Modeled Vehicle Price



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Plug-In Hybrid MDHD
Battery Electric MDHD
Fuel Cell MDHD
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Literature Context for MDHD Vehicles
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Medium- and Heavy-Duty Vehicles

The 2024 Transportation Annual Technology Baseline (ATB) provides current and future projections of cost and performance for select medium- and heavy-duty vehicles and fuels (and for select Light-Duty Vehicles).

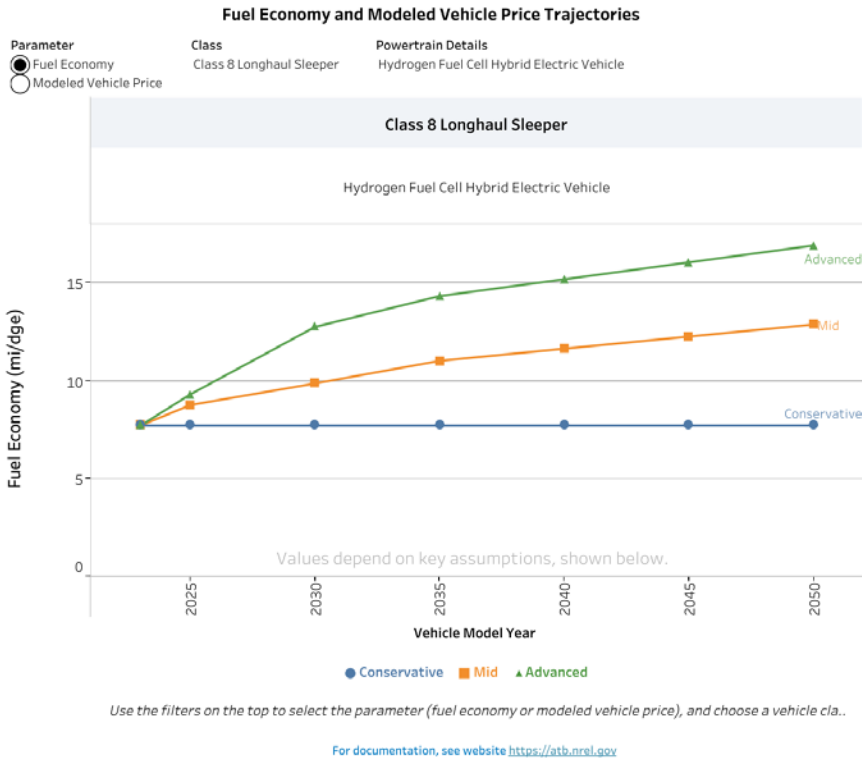
The Transportation ATB provides data in a series of interactive charts for either a single year or a trajectory out to 2050 showing the following:

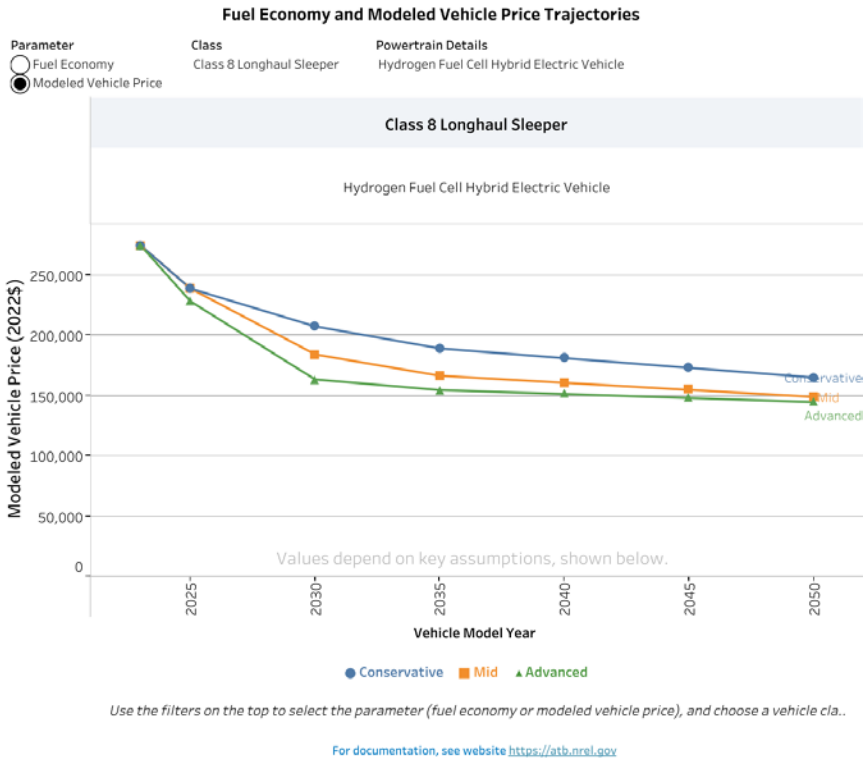
- Fuel Economy, which is reported in miles per diesel gallon equivalent and represents how efficiently a vehicle converts fuel during operation
- Modeled Vehicle Price, which represents an estimated cost, including manufacturing costs and profit, to the consumer purchasing a new vehicle
- Levelized Cost of Driving, which is an indicator of the cost of operation over the vehicle lifetime on a per-mile basis
- Emissions, which represents the well-to-wheels emissions (including emissions from fuel production to vehicle operation).

The Transportation ATB presents these metrics for individual powertrains and in comparison with other powertrains.

https://atb.nrel.gov/transportation/2024/medium-_and_heavy-duty_vehicles

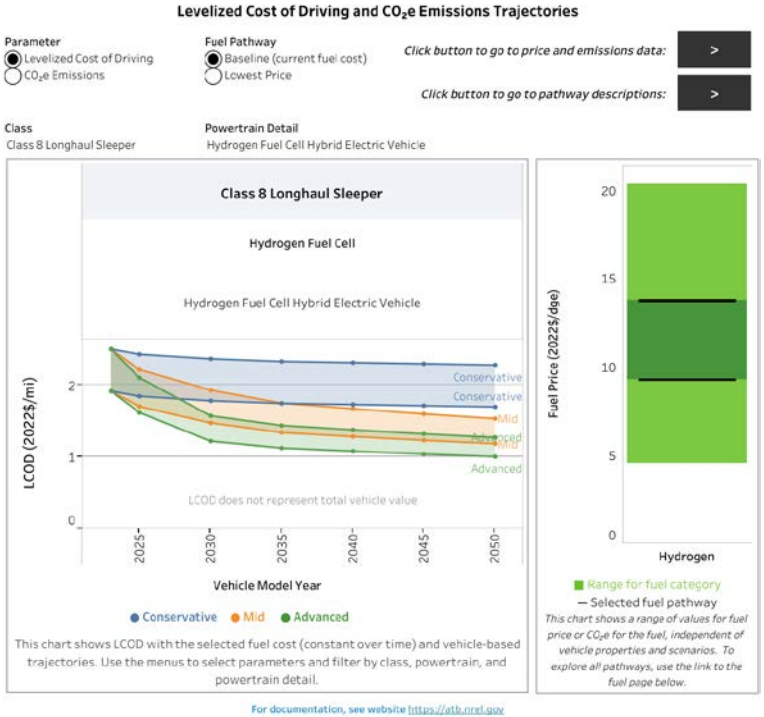
Fuel Economy, Modeled Vehicle Price: FCEV Example

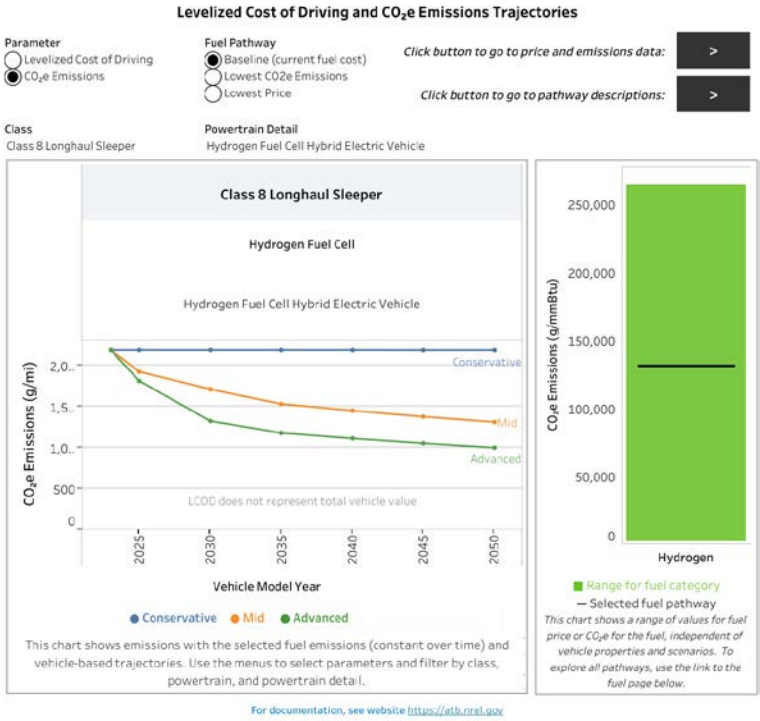




https://atb.nrel.gov/transportation/2024/comparison_of_mdhd_vehicles

LCOD and CO_2e: FCEV Example





https://atb.nrel.gov/transportation/2024/comparison_of_mdhd_vehicles

Simplified Fuel Pathway Options (on Vehicles pages)

ATB Select Pathways

		Baseline (current fuel cost)	Lowest CO_2e Emissions	Lowest Price
Light Duty	Diesel	Ultra-Low Sulfur Diesel	Biofuel Blendstock HEFA (RD100) from Used Cooking Oil	Ultra-Low Sulfur Diesel 2050 Low Price
	Electricity	PEV Charging Electricity, National Grid Mix	PEV Charging Electricity, Future High RE Penetration Grid Mix PEV Charging Electricity, Future High RE Penetration Grid Mix, Future Charging	PEV Charging Electricity, Future High RE Penetration Grid Mix
	Gasoline	Conventional E0 Gasoline Blendstock and Starch Ethanol	Biofuel Blendstock FP from Forest Residue	Conventional E0 Gasoline Blendstock 2050 and Starch Ethanol 2050
	Hydrogen	Steam Methane Reforming and Liquefaction-Trucks	High temperature electrolysis and Liquefaction-Trucks	Low temperature electrolysis and Liquefaction-Trucks
	Natural Gas	Natural Gas	Natural Gas	Natural Gas
	Diesel	Ultra-Low Sulfur Diesel	Biofuel Blendstock HEFA (RD100) from Used Cooking Oil	Ultra-Low Sulfur Diesel 2050 Low Price

For documentation, see website https://atb.nrel.gov

See Fuels pages or Data page (Tableau workbook) for all fuel options.

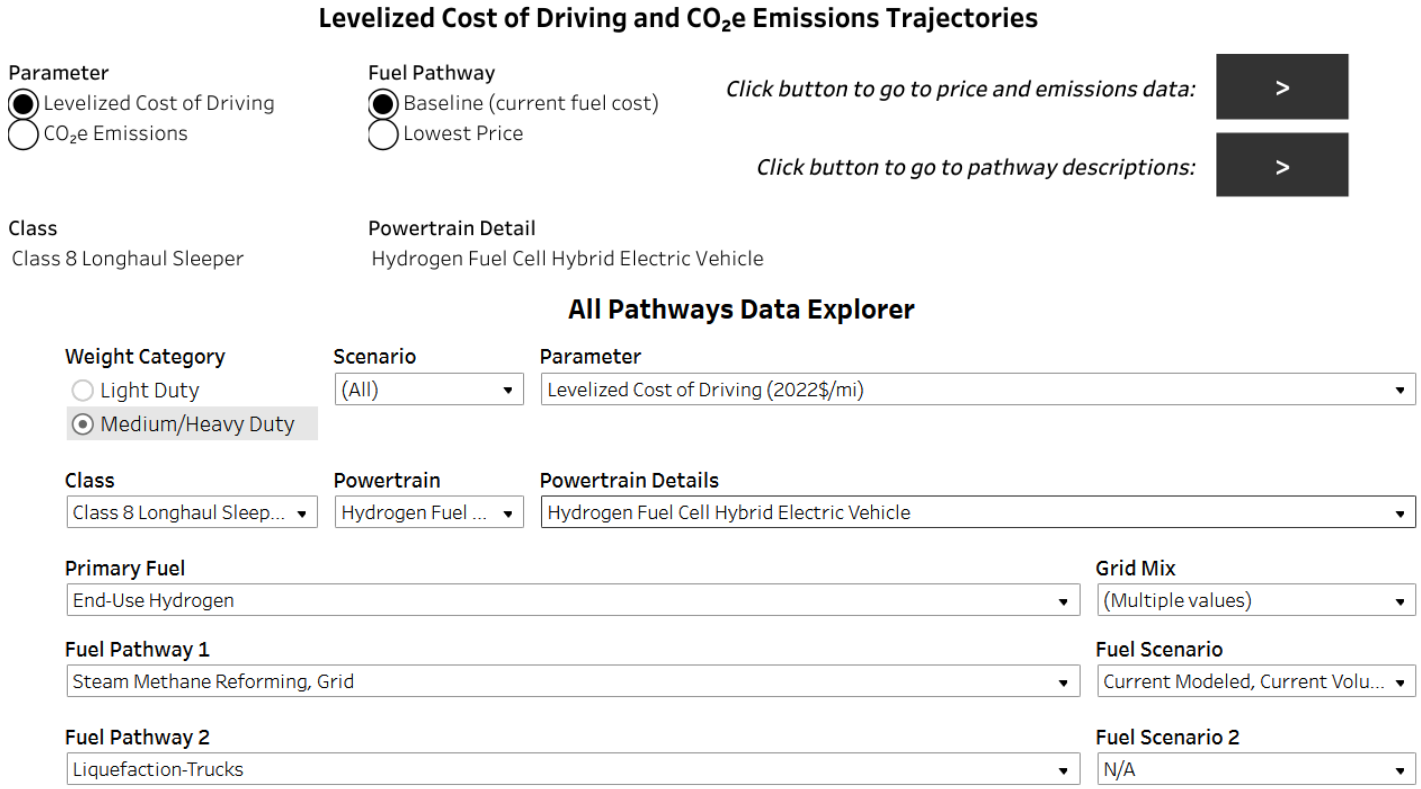
https://atb.nrel.gov/transportation/2024/definitions

Full Set of Fuel Pathway Options

(available on Data page or via download)

Vehicles pages

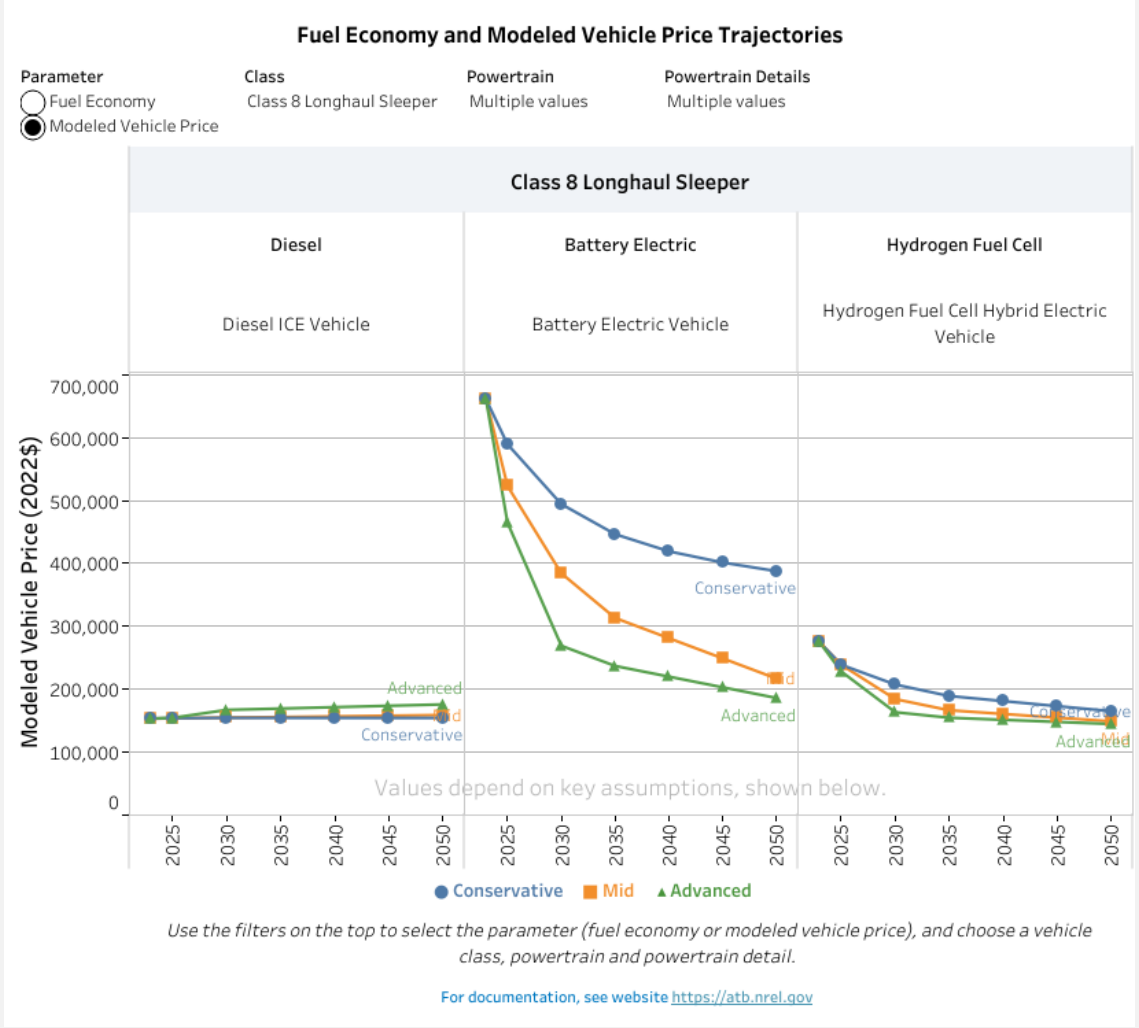
Tableau workbook on Data page

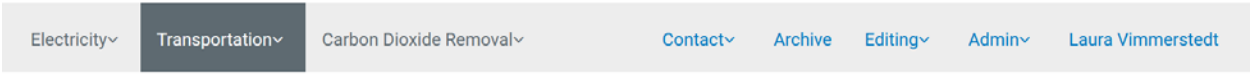


Multi-powertrain view available on “Comparison” vehicles pages or on “Data” page in embedded Tableau workbook.

Example shows comparison of Modeled Vehicle Price on “Comparison of MDHD Vehicles” page.

MDHD = medium- and heavy-duty vehicles





About
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Definitions

Definitions of common terms in the 2024 Transportation Annual Technology Baseline (ATB) are presented below.

Vehicles

Battery Electric Vehicles

Battery electric vehicles (BEVs) use a battery pack to store the electrical energy that powers the motor. The batteries are charged by plugging the vehicle into an electric power source (DOE, 2024). For additional background, see the

Fuels

Biodiesel

Biodiesel is a renewable and biodegradable fuel that consists of fatty acid methyl esters and is manufactured from vegetable oils, animal fats, or used cooking oil (recycled restaurant grease) to specifications listed in ASTM D6751 (DOE, 2019). For additional background, see the Alternative Fuels Data Center's Biodiesel Fuel Basics webpage.

Scenarios

Vehicle Scenarios

Vehicle scenarios in the Transportation ATB incorporate assumptions on both the level of technology advancement achieved in each powertrain (e.g., lightweighting and engine efficiency) and the projected costs for the assumed

Metrics

Base Year

This version of Transportation ATB generally adopts 2022 as the Base Year, which is the Base Year for our major data sources, such as the U.S. Energy Information Administration's 2023 Annual Energy Outlook (EIA, 2023), (Islam et al., 2023), and NREL Standard Scenarios.

Definitions cover vehicles, fuels, scenarios, and metrics.

Key assumptions and references detailed at the bottom of each fuel or vehicle webpage.

Example of Web Page Sections

Definitions

For detailed definitions, see:

Key Assumptions

The data and estimates presented here are based on the following key assumptions:

References

The following references are specific to this page; for all references in this ATB, see References.

https://atb.nrel.gov/transportation/2024/definitions

Data Downloads Include Data, Tableau, and Slides

2024 Transportation ATB Data

Download the 2024 Transportation ATB Data

For convenience, the transportation data used on this website are provided in the following zip archive which is organized into "input" and "output" folders.

2024_atb_transportation_data_v0.2.zip

We also provide Tableau workbooks that are used for all the visualizations on the site:

2024_atb_transportation_tableau_v0.2.zip

A major source of the 2024 Transportation ATB vehicles and emissions data is Argonne National Laboratory (ANL), which develops and applies the Autonomie simulation tool and Research & Development Greenhouse gases, Regulated Emissions, and Energy use in Technologies (R&D GREET) model (Wang et al., 2023). Links to data from the ANL report (Islam et al., 2023) on modeled vehicle price and fuel economy are available here.

2024 Transportation ATB Webinar

The 2024 Transportation Annual Technology Baseline Update Webinar was held on . During the webinar, the ATB team reviewed the 2024 updates and answered questions from attendees. To learn more, view the webinar recording and presentation slides.

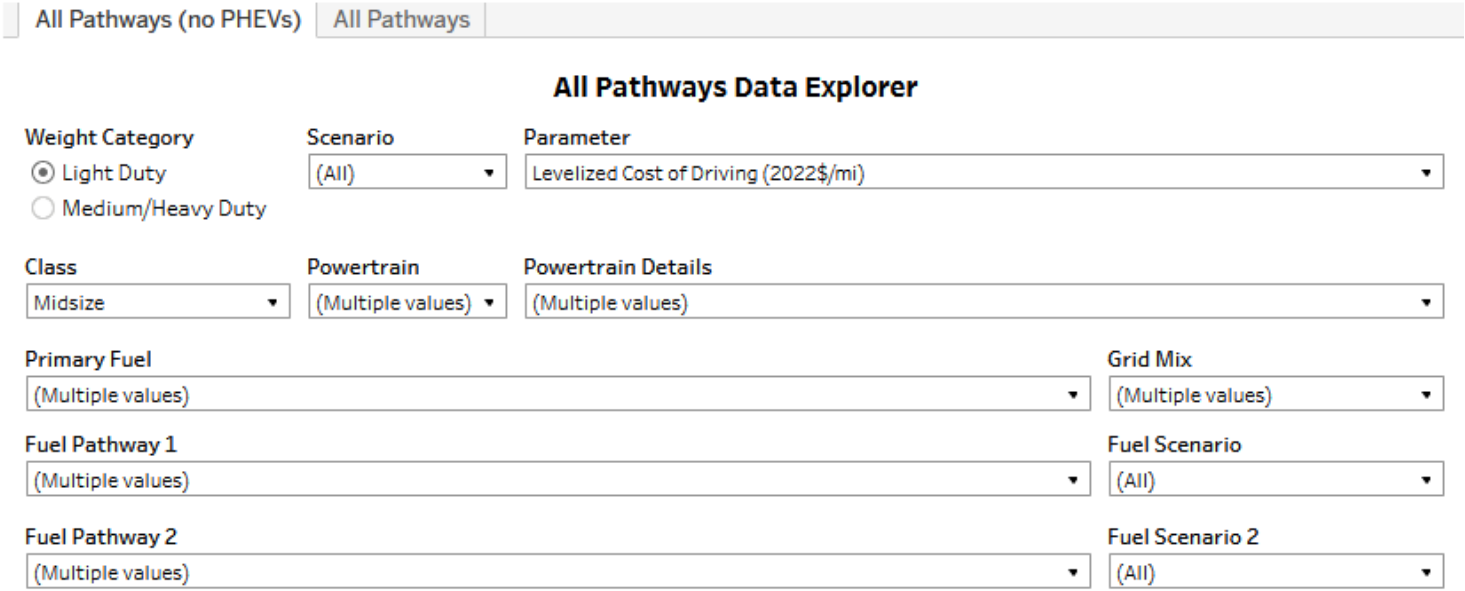
Coming Soon

https://atb.nrel.gov/transportation/2024/data

Explore All Data via Interactive Tables or Downloadable Workbook

Tableau Workbook

View a Tableau workbook to further explore the data, including LCOD and emissions estimates with additional fuel pathways.



https://atb.nrel.gov/transportation/2024/data

Conclusion

The ATB Vision

The Vision

The ATB—a flagship analytic product—facilitates access to credible, consistent, transparent, timely, relevant, and public data about current and future energy technologies and systems from a laboratory/DOE perspective for a large and diverse audience.

Please let us know your comments (at https://atb.nrel.gov/contact) on what additional datasets or data metrics would be useful.

Sign up for updates!

To receive email announcements about changes and updates to the Annual Technology Baseline, sign up at atb.nrel.gov/contact/register.

Acknowledgments

This work was funded by the U.S. Department of Energy's Strategic Analysis Team, Hydrogen and Fuel Cell Technologies Office, Vehicle Technologies Office, and Bioenergy Technologies Office, all within the Office of Energy Efficiency and Renewable Energy.

Thank You!

Questions? Please let us know at https://atb.nrel.gov/contact/.

www.nrel.gov

NREL/PR-6A20-91635

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References

ANL (Argonne National Laboratory) 2024. TechScape. https://vms.taps.anl.gov/tools/techscape/.

Bennett, Jesse, Partha Mishra, Eric Miller, Brennan Borlaug, Andrew Meintz, and Alicia Birky. 2022. *Estimating the Breakeven Cost of Delivered Electricity to Charge Class 8 Electric Tractors*. Golden, CO: National Renewable Energy Laboratory. October 19, 2022. https://doi.org/10.2172/1894645.

Borlaug, Brennan, Shawn Salisbury, Mindy Gerdes, and Matteo Muratori. 2020. "Levelized Cost of Charging Electric Vehicles in the United States." *Joule* 4, no. 7 (July 15, 2020): 1470–85. https://doi.org/10.1016/j.joule.2020.05.013.

Borlaug, Brennan, Fan Yang, Ewan Pritchard, Eric Wood, and Jeff Gonder. "Public Electric Vehicle Charging Station Utilization in the United States." Transportation Research. Part D, Transport and Environment 114 (December 12, 2022). https://doi.org/10.1016/j.trd.2022.103564.

Bracci, Justin, Mariya Koleva, and Mark Chung. 2024. *Levelized Cost of Dispensed Hydrogen for Heavy-Duty Vehicles*. Golden, CO: National Renewable Energy Laboratory. March 5, 2024. https://doi.org/10.2172/2322556.

Burnham, Andrew, David Gohlke, Luke Rush, Thomas Stephens, Yan Zhou, Mark A. Delucchi, and Alicia Birky et al. 2021. *Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains*. Argonne, IL: Argonne National Laboratory. April 1, 2021. https://doi.org/10.2172/1780970.

DOE. 2023. Pathways to Commercial Liftoff: Clean Hydrogen. March 2023. https://liftoff.energy.gov/wp-content/uploads/2023/05/20230523-Pathways-to-Commercial-Liftoff-Clean-Hydrogen.pdf.

Elgowainy, Amgad, Jeongwoo Han, Jacob Ward, Fred Joseck, David Gohlke, Alicia Lindauer, and Todd Ramsden et al. 2016. *Cradle-to-Grave Lifecycle Analysis of U.S. Light-Duty Vehicle-Fuel Pathways: A Greenhouse Gas Emissions and Economic Assessment of Current (2015) and Future (2025–2030) Technologies*. Argonne, IL: Argonne National Laboratory. ANL/ESD-16/7. Rev. 1. https://doi.org/10.2172/1324467.

EIA. 2023. Annual Energy Outlook 2023. Washington D.C.: U.S. Energy Information Administration, March 16, 2023. https://www.eia.gov/outlooks/aeo/.

Gagnon, Pieter, An Pham, Wesley Cole, Sarah Awara, Anne Barlas, Maxwell Brown, and Patrick Brown et al. 2024. *2023 Standard Scenarios Report: A U.S. Electricity Sector Outlook*. Golden, CO: National Renewable Energy Laboratory. January 1, 2024. https://doi.org/10.2172/2274777.

Greene, David L., and Benjamin Leard. "Trends in Scrappage and Survival of U.S. Light-Duty Vehicles." *Transportation Research Part A: Policy and Practice* 180 (2024): 103982. https://doi.org/10.1016/j.tra.2024.103982.

Hubert, McKenzie, David Peterson, Eric Miller, James Vickers, Rachel Mow, and Campbell Hoew. "Clean Hydrogen Production Cost Scenarios with PEM Electrolyzer Technology." DOE Hydrogen Program Record. DOE Hydrogen and Fuel Cells Technology Office, May 20, 2024. https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/24005-clean-hydrogen-production-cost-pem-electrolyzer.pdf?sfvrsn=8cb10889_1.

Hunter, Chad, Michael Penev, Evan Reznicek, Jason Lustbader, Alicia Birky, and Chen Zhang. 2021. *Spatial and Temporal Analysis of the Total Cost of Ownership for Class 8 Tractors and Class 4 Parcel Delivery Trucks*. Golden, CO: National Renewable Energy Laboratory. September 16, 2021. https://doi.org/10.2172/1821615.

Islam, Ehsan Sabri, Daniela Nieto Prada, Ram Vijayagopal, Charbel Mansour, Paul Phillips, Namdoo Kim, Michel Alhajjar, and Aymeric Rousseau. 2023. Detailed Simulation Study to Evaluate Future Transportation Decarbonization Potential. Report to the U.S. Department of Energy. Argonne National Laboratory, October 2023. https://vms.taps.anl.gov/research-highlights/u-s-doe-vto-hfto-r-d-benefits/.

James, Brian, Jennie M Huya-Kouadio, Cassidy Houchins, Rajesh Ahluwalia, Xiaohua Wang, Michael Ulsh, Gary Robb, David Masten, Christian Appel, and Vivek Murthi. 2023. "Heavy-Duty Fuel Cell System Cost – 2022." DOE Hydrogen Program Record. DOE Hydrogen and Fuel Cells Technology Office, May 30, 2023. https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/23002-hd-fuel-cell-system-cost-2022.pdf?Status=Master.

Ledna, Catherine, Matteo Muratori, Arthur Yip, Paige Jadun, Christopher Hoehne, and Kara Podkaminer. 2024. "Assessing Total Cost of Driving Competitiveness of Zero-Emission Trucks." *IScience* 27, no. 4 (March 2, 2024). https://doi.org/10.1016/j.isci.2024.109385.

NREL. 2023. *EVI-FAST: Electric Vehicle Infrastructure – Financial Analysis Scenario Tool,"* 2023. https://www.nrel.gov/transportation/evi-fast.html.

NREL. 2024. *H2A-Lite: Hydrogen Analysis Lite Production Model*, 2024. https://www.nrel.gov/hydrogen/h2a-lite.html.

SAE J2841. 2010. Utility Factor Definitions for Plug-In Hybrid Electric Vehicles Using Travel Survey Data. SAE International, 2010. https://doi.org/10.4271/J2841_201009.

Wang, Michael, Amgad Elgowainy, Uisung Lee, Kwang Hoon Baek, Sweta Balchandani, Pahola Thathiana Benavides, and Andrew Burnham et al. 2023. Summary of Expansions and Updates in R&D GREET® 2023. Argonne, IL: Argonne National Laboratory December 1, 2023. https://doi.org/10.2172/2278803.

Wood, Eric, Brennan Borlaug, Matt Moniot, Dong-Yeon (D-Y) Lee, Yanbo Ge, Fan Yang, and Zhaocai Liu. "The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure." National Renewable Energy Laboratory (NREL), Golden, CO (United States), June 26, 2023. https://doi.org/10.2172/1988020.

These key references are noted in this presentation. The full reference list for the Transportation ATB is located here: https://atb.nrel.gov/transportation/2024/references

Acronyms and Abbreviations

AEO	Annual Energy Outlook
ATB	Annual Technology Baseline
ANL	Argonne National Laboratory
BEV	battery electric vehicle
BSM	Biomass Scenario Model
DECARB	Decarbonizing Energy through Collaborative Analysis of Routes and Benefits
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EIA	U.S. Energy Information Administration
EVI-FAST	Electric Vehicle Infrastructure – Financial Analysis Scenario Tool
FCEV	fuel cell electric vehicle
GCAM	Global Change Analysis Model
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation
H_2	hydrogen gas
H2A-Lite	Hydrogen Analysis Lite Production Model
LCOD	levelized cost of driving
MDHD	medium- and heavy-duty vehicles
NREL	National Renewable Energy Laboratory
R&D	research and development
TEA	techno-economic analysis
TEMPO	Transportation Energy and Mobility Pathway Options Model
VMT	vehicle miles traveled
WTT	well to tank
WTW	well to wheels