Penn Sustainability

Low-Emissions Vehicle Purchasing Guidance

Version 3 – Released March 2023

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OVERVIEW

How to Use this Guide:

This guide is intended to be a straightforward, easy-to-use document that provides purchasers considering electric vehicles with:

- A general understanding of the concepts and benefits of purchasing low- or zero- emission vehicles
- Resources for funding
- Recommended vehicle options (including alternatives for vehicle classes whose needs are not currently met by the available low- or zero-emissions vehicles available)
- An overview of the purchasing process at Penn
- Information on infrastructure and other support

Released in October 2019, the Penn's *Climate and Sustainability Action Plan (CSAP) 3.0* represents a vision for the University's sustainable future. In accordance with this vision and to reduce Penn's carbon and other emissions that impact human health, *CSAP 3.0* aims to encourage the purchase of low- or zero-emissions vehicles at Penn.

These vehicles are not only beneficial to the environment in reducing our carbon footprint; they also reduce the negative impact on human health, particularly in terms of air pollution, which leads to health conditions such as asthma and even lung cancer. The American Lung Association's 2022 State of the Air report placed Philadelphia as the 18th most air polluted city by year round particle pollution in the United States. Some of the main driving factors of Philadelphia's polluted air are local emissions, including those that come from Penn's vehicles. Philadelphia's individual State of the Air report card can be viewed for more details.

Recognition of the social and environmental impacts of University vehicles is particularly important given the environmental inequity that exists in the communities surrounding Penn's main campus, especially in those that are low-income. Contributions to Philadelphia's air quality also impact the University, both in maintenance costs and impacts to the health of faculty and staff. For Penn employees who live locally, vehicle emissions put themselves and their families at risk for the negative health impacts mentioned above.

The two main vehicle types that will be emphasized in this guide are battery electric vehicles (BEVs) and plugin hybrid electric vehicles (PHEV). When possible, preference should be given to electric vehicles (EVs) due to their greater ability to contribute to Penn's goal of carbon neutrality by 2042.

In the AASHE (Association of Advancement of Sustainability in Higher Education) 2021 Sustainable Campus Index, Penn ranked 7th as a top performer in transportation. In FY22, Penn Transportation purchased four Ford electric passenger vans for the first time. Each van will produce a minimum 13 MTCDE (metric tons of carbon dioxide equivalents) reduction per year, totaling to reductions of 53 MTCDE or more annually. These are great achievements in addressing the carbon footprint of our campus fleets, but Penn aims to push this even further with the aid of this guide.

For any questions about the information within this document, please contact the Penn Sustainability Office at sustainability@upenn.edu.

VEHICLE TYPES AND IMPACTS

Electric vehicles (EVs) generally fall under the following four categories:

- **Battery Electric Vehicles** (BEVs) – powered by electric motors and are offered in a wide range of vehicle types for both short- and long-distance travel
- **Low Speed Vehicles** (LSVs) – lightweight vehicles powered by an electric motor with a maximum speed of 25 mph
- **Plug-In Hybrid Vehicles** (PHEVs) – have both an electric motor and a gasoline motor to benefit from both fuel types; these are ideal when charging availability is limited or uncertain
- **Fuel Cell Electric Vehicle** (FCEV) – powered by hydrogen and emit only water vapor and warm air

Ford Focus, Battery Electric Model (BEV)

Columbia Electric Utilitruck (LSV)

Chrysler Pacifica, Plugin Hybrid Model (PHEV)

Hydrogen Powered Street Sweeper (FCEV)

Internal combustion engine vehicles (ICEVs) cover all vehicles that are powered by combustion, most commonly by burning gasoline or diesel. Alternative fuel vehicles (AFVs) are a subset of ICEVs that are powered by fuel sources such as compressed natural gas.

In some cases, the utility of a vehicle may not be able to be fulfilled by the current selection of EVs available; however, lower emissions options may be available and should be considered.

Achieving Penn's *CSAP* Goals

Penn's Climate and Sustainability Action Plan (CSAP) 3.0 expands upon the previous two iterations to address reducing Penn's emissions. The main goals regarding Penn's campus fleets are as follows:

- Achieve carbon neutrality by 2042
- Encourage purchasing of low- or zero- emissions vehicles
- Increasing the number of electric vehicle charging stations as demand requires

This guide aims to address these goals by providing a comprehensive set of resources and recommendations for purchasing and funding vehicles.

When possible, **preference should be given to battery electric vehicles** (BEVs) because of their greater ability to contribute to Penn's *CSAP 3.0* carbon neutrality goal. Research shows that the emissions associated with the lifecycle of BEVs are significantly less than their gas or diesel internal combustion engine vehicle (ICEV) counterparts, especially considering the energy makeup of Philadelphia's electrical grid combined with projected increases in renewable energy sources both for the electrical grid and through Penn's Power Purchase Agreement.

For more information on the global warming potential (GWP) of EVs see **Appendix I: Global Warming Potential (GWP) of EVs**.

Lifecycle Cost

In addition to reduced emissions, one of the major benefits of incorporating electric vehicles (EVs) into Penn's fleets is the **lowered cost of maintenance over time**. EVs cost less on average to keep running than internal combustion engine vehicles (ICEVs) since they don't need regular oil changes and have fewer moving parts that need to be maintained or replaced. According to a 2020 report conducted by Consumer Reports, the lifetime average maintenance cost per mile for EVs, both battery and hybrid, is half that of ICEVs. Battery electric vehicles and plugin hybrid electric vehicles have a lifetime (defined as 200,000 miles) average maintenance cost of about $0.03/mile, whereas ICEVs cost about $0.06/mile.

The cost to power EVs is also lower than it is for ICEVs. In Philadelphia, **it costs almost 4 times more to fuel a gasoline powered ICEV than an EV**. Based on the average price of commercial electricity for Philadelphia, a compact passenger EV costs about $5.97 to drive 250 miles. In comparison, based on average gasoline prices in Philadelphia, an equivalent gasoline powered ICEV costs about $22.34 for the same distance. For more information, see **Additional Resources: FAQ**.

There are also **federal tax credits worth up to $7,500** available to nonprofit educational institutions via the Commercial Clean Vehicle credit. This and additional rebates/incentives for fleet replacement and installing EV chargers can be found in the table under **Funding Resources**. Purchasing via the Climate Mayors EV Purchasing Collaborative provides further financial and infrastructure resources. For more information on the Collaborative, see the **Purchasing Process** section of this guide or view the Collaborative's webpage.

FUNDING RESOURCES

The following information provides various funding options for hybrid and electric vehicles and charging stations. For further assistance in searching for government rebates, grants, and other funding opportunities please contact the Sustainability Office at sustainability@upenn.edu.

Funding Quick Guide

The following table provides a quick overview of funding options available. See below or follow the link for each funding option for more details.

FUNDING QUICK GUIDE					
Name	**Source**	**Amount**	**Vehicle Type**	**Notes**	**Contact**
Commercial Clean Vehicle Credit	Federal	Up to $7,500 for vehicles with a gross weight under 14,000 lbs or $40,000 for all other vehicles	Plug-in EVs meeting specified battery capacities or fuel cell motor vehicles meeting specified requirements	For businesses and tax-exempt organizations	-
Grants for Buses and Bus Facilities Competitive Program	Federal	Up to 80% of project costs	Buses / Bus facilities	A competitive grant (check website for most recent information)	-
Clean Heavy-Duty Vehicle Program	Federal	Varies	Replace class 6 & 7 heavy-duty vehicles with zero-emissions alternatives	Funding available through 2031 in the form of grants and rebates; View website for latest information on how to claim this credit	-
Alternative Fuels Incentive Grant Program (AFIG)	State	Up to $100,000 per project	Covers projects that retrofit old vehicles, purchase new vehicles, purchase charging equipment, and conduct research	Organizations can get up to $600,000 per year for all projects; applications run annually (check website for current application period)	Josh Dziubek jdziubek@pa.gov

Driving PA Forward Truck & Bus Fleet Grant Program	State	Up to $1,500,000	Replacement of fleets of 6 or more class 4-8 diesel freight trucks or buses	Can cover multiple projects, operates as a reimbursement grant; accepts applications on a calendar year basis (check website for most recent information)	RA-EPVW MITIGATION @pa.gov
Driving PA Forward Level 2 EV Charging Rebate Program	State	$2,500-$4,000 per plug	Purchase & installation of Level 2 EV chargers	Requirements on restrictions of accessibility of the chargers; accepts applications for as long as funds remain (check website for most recent information)	RA-EPVW MITIGATION @pa.gov
PennDot NEVI Grants for Charging Infrastructure	State/ Federal	Up to 80% of project costs	EV charging infrastructure	Requires public access to charging stations; operates as a reimbursement grant; Applications due April 6, 2023 (check website for most recent information)	ra-pdevcorridors @pa.gov
PECO's Commercial Level 2 EV Charger Rebate	Private	$500 per charger, up to $1,500 total	Purchase & installation of Level 2 EV chargers	Provides rebate to commercial PECO customers; program is fully subscribed but accepting waitlist applications as of January 2023 (check website for most recent information)	-

Federal Funding

The federal government provides several sources of funding to support purchasing low-emission vehicles and charging infrastructure. **Federal tax credits worth up to $7,500** for vehicles under 14,000 lbs (and up to $40,000 for all other vehicles) are available to nonprofit educational institutions via the Commercial Clean Vehicle credit. Federal funding is also available through the Grants for Buses and Bus Facilities Competitive Program and the Clean Heavy-Duty Vehicle Program.

Pennsylvania Commonwealth Funding

The **Alternative Fuels Incentive Grant Program** (AFIG) is provided through the Pennsylvania Department of Environmental Protect. This competitive grant program provides up to $100,000 for each vehicle proposed for the project (depending on vehicle type) and caps at $300,000 per year for each organization. Grant application periods run each year, and more information can be found here.

Driving PA Forward is another state-funded opportunity that focuses on promoting better air quality. One rebate offered through this program is the Truck & Bus Fleet Grant Program, which provides up to $1,500,000 for the replacement of diesel buses and trucks from 2009 or older for fleets of 6 or more. The rebate for electric replacements is higher, however the replacement vehicle can be of any vehicle type.

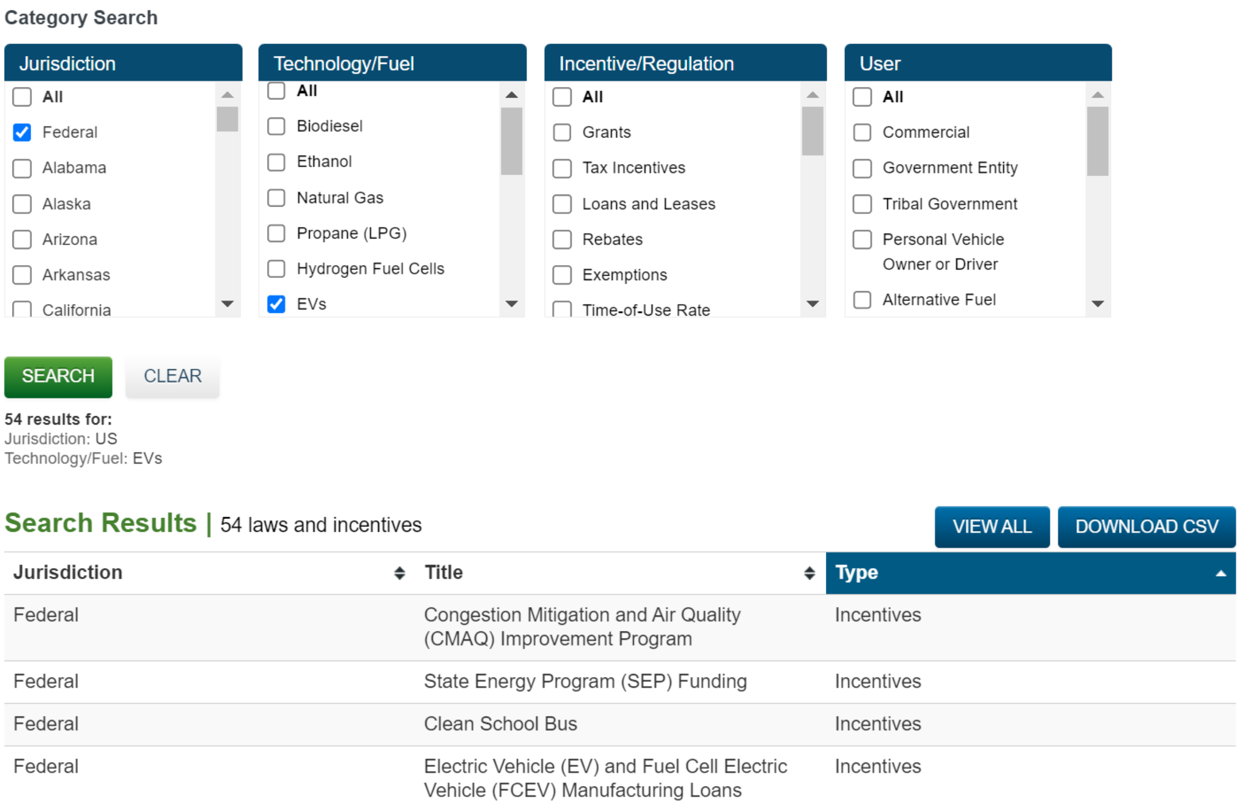
Driving PA Forward also offers funding for charging and fueling. The Level 2 EV Charging Rebate program provides $2,500 -$4,000 per plug depending on the location of the plugs.

Driving PA Forward also provides multiple other grant and rebate options that are focused on reducing emissions from diesel engines.

Additional Sources

Taking advantage of the **Climate Mayors Electric Vehicle Purchasing Collaborative's leasing options** allows savings to be passed along to your department. For more information regarding purchasing through the Climate Mayors EV Purchasing Collaborative, please refer to the **Purchasing Process** section of this guide. The Climate Mayors EV Purchasing Collaborative webpage detailing their leasing model can be viewed here.

The U.S. Department of Energy provides a search tool that hosts a database of all Federal and State Laws and Incentives. This can be used to look for both federal and Pennsylvania specific incentives by fuel type. The example shown below shows federal incentives for EVs. This tool is useful to see the most up to date information for both funding and laws/regulations regarding alternative fuel vehicles.


Category Search

Jurisdiction	Technology/Fuel	Incentive/Regulation	User
All	All	All	All
Federal	Biodiesel	Grants	Commercial
Alabama	Ethanol	Tax Incentives	Government Entity
Alaska	Natural Gas	Loans and Leases	Tribal Government
Arizona	Propane (LPG)	Rebates	Personal Vehicle Owner or Driver
Arkansas	Hydrogen Fuel Cells	Exemptions	Alternative Fuel
California	EVs	Time-of-Use Rate	

SEARCH CLEAR

54 results for:
Jurisdiction: US
Technology/Fuel: EVs

Search Results | 54 laws and incentives

VIEW ALL DOWNLOAD CSV

Jurisdiction	Title	Type
Federal	Congestion Mitigation and Air Quality (CMAQ) Improvement Program	Incentives
Federal	State Energy Program (SEP) Funding	Incentives
Federal	Clean School Bus	Incentives
Federal	Electric Vehicle (EV) and Fuel Cell Electric Vehicle (FCEV) Manufacturing Loans	Incentives

RECOMMENDED VEHICLES

Below are recommendations for vehicles that are more sustainable alternatives by type/utility. Because this market is ever expanding, it is also recommended to refer to the U.S. Department of Energy's database of hybrids and federally recognized alternative fuel vehicles.

Please note that the **prices listed are estimates** – actual prices may vary depending on the vehicle's specifications/availability. Procurement Services at Penn recommends working directly with a dealership to obtain the best prices.

Sourcewell/the Climate Mayors EV Purchasing Collaborative updates its offerings frequently, so it is best to check the Offerings Page of their website for the most up to date information.

For tools to help you decide which vehicle is best for you, see Appendix I for a checklist of questions to consider and a framework for cost analysis between gas and electric powered vehicles.

Terminology:

- E-Assist Bike – Bicycles with built in electric motors
- BEV – Battery Electric Vehicle
- PHEV – Plugin Hybrid Electric Vehicle
- FCEV – Fuel Cell Electric Vehicle (hydrogen cell)
- ICEV – Internal Combustion Engine Vehicle

E-ASSIST BICYCLES/MOTORCYCLES				
Vehicle	**Image**	**Fuel Type**	**Est. Price**	**Notes**
RadWagon 4 Electric Cargo Bike		E-Assist Bike	$1,999	Product details; 350 lb weight limit
Fuji E-Traverse 2.1 ST		E-Assist Bike	$1,699	Product details; utilized by University of Florida's Police Department

Butchers & Bicycles MK1-E		E-Assist Trike	$7,250	Product details; utilized by Western Washington University for on-campus deliveries
Yuba Spicy Curry		E-Assist Bike	$5,199	Product details; 440 lb weight limit
LOW SPEED VEHICLES				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
Columbia Utilitruck		BEV	Contact vendor for pricing	Product details
Deere TE 4x2 Electric Gator		BEV	$14,649	Product details
GEM eL XD		BEV	$16,731	Product details
LIGHT-DUTY/PASSENGER VEHICLES				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
2023 Chevrolet Bolt EUV SUV		BEV	$28,795	Product details
2023 Chevrolet Bolt EV		BEV	$27,495	Product details
2023 Nissan Leaf		BEV	$28,040	Product details

2023 Hyundai Ioniq 5 SUV		BEV	$41,450	Product details
2023 Hyundai Kona Electric SUV		BEV	$33,550	Product details
2023 Kia Niro EV SUV		BEV	$39,550	Product details
2023 Ford Escape SUV		PHEV	$28,500	Product details
2022 Hyundai Tuscon SUV		PHEV	$35,400	Product details
2023 Kia Niro Plug-in Hybrid SUV		PHEV	$33,840	Product details
2023 Mitsubishi Outlander SUV		PHEV	$39,845	Product details
2022 Toyota Prius Prime		PHEV	$28,770	Product details
PASSENGER VANS				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
2022 Chrysler Pacifica Hybrid		PHEV	$49,995	Product details

2022 Ford Transit Connect Wagon		ICEV	$31,860	Product details
2022 Mercedes-Benz Metris Passenger Van		ICEV	$43,600	Product details
2022 Ford E-Transit Converted Passenger Van		BEV	$99,500	Available solely through Creative Bus Sales; Product details
2022 Ford E-Transit Converted Cargo Van		BEV	$73,000	Upfit with Service & Cargo upfits available solely through Creative Bus Sales; Product details
CARGO VANS				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
2023 Ford E-Transit		BEV	$49,575	Available through Sourcewell; Product details
2023 Dodge Ram ProMaster		ICEV	$40,635	Product details
2023 Ford Transit Connect Cargo Van		ICEV	$34,100	Product details

2023 Mercedes-Benz Metris Cargo Van		ICEV	$39,600	Product details
PICKUP TRUCKS				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
2023 Ford F-150 Lightning		BEV	$55,947	Product details
2023 Rivian R1T		BEV	$74,800	Battery range of 260-400 miles; all-wheel drive & 3ft wading depth; Product details
2023 Ford Maverick		HEV	$22,195	This model has experienced high demand, contact local dealer for more information; Product details
BUSES				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
BYD Electric Transit Bus		BEV	Contact BYD for pricing	Product details
Gillig Zero Emissions Electric Bus		BEV	Contact sales@gillig.com for pricing	Product details
GreenPower EV Bus		BEV	Contact GreenPower for pricing	Product details
New Flyer Xcelsior CHARGE NG		BEV	Contact the local rep for pricing	Product details

Proterra ZX5 Electric Transit Bus		BEV	Contact Proterra for pricing	Product details
MEDIUM- AND HEAVY-DUTY CHASSIS & EQUIPMENT				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
Kenworth K270E/K370E		BEV	Contact brett.duarte @paccar.com for pricing	Available through Sourcewell; Product details; medium-duty vehicles
Kenworth T680E		BEV	Contact brett.duarte @paccar.com for pricing	Available through Sourcewell; Product details; for regional haul and drayage
Lion Electric Lion8 – Tandem		BEV	Contact Lion Electric for pricing	Available through Sourcewell; a class 8 truck that can be customized based on use
Peterbilt 220EV		BEV	Contact Peterbilt.Info @paccar.com for pricing	Available through Sourcewell; for pickup & delivery; see their operating costs calculator to compare power consumption & fuel costs
Peterbilt 579EV		BEV	Contact Peterbilt.Info @paccar.com for pricing	Available through Sourcewell; for regional haul & drayage; see their operating costs calculator to compare power consumption & fuel costs
Global Environmental Sweepers M4 Electric Sweeper		BEV OR FCEV	Contact cbormann@ globalsweeper.com for pricing	Available through Sourcewell; 11 hours of operational time

Madvac LR50e Compact Sweeper		BEV	Contact gbally@exprolink.com for pricing	Available through Sourcewell
PUBLIC SAFETY VEHICLES				
Vehicle	**Image**	**Fuel type**	**Est. Price**	**Notes**
Chevy Bolt Patrol Vehicle EV/SUV		BEV	$31,000/$33,000	Product details; Max range of 259 miles per charge
Ford Police Interceptor Utility		HEV	Contact your local rep for pricing	Product details

For additional options, see the following resources:

- Sourcewell's complete list of light-duty vehicles
- Sourcewell's list of medium and heavy-duty vehicles
- Creative Bus Sales' Ford Transit Passenger Van information
- U.S. Department of Energy's Alternative Fuel and Advanced Vehicles search
- Contact your preferred local dealer for options for electric or alternative fuel vehicles with competitive quotes
- Popular brands for electric mowers, leaf-blowers, and other equipment: EGO, Greenworks, and Ryobi

To get connected with municipalities that purchase EV and hybrid police vehicles, please contact Sean Greene at sgreene@dvrpc.org or Liz Compitello at ecompitello@dvrpc.org.

For further assistance finding more environmentally friendly vehicle options or with any questions about the information within this document, please contact the Sustainability Office at sustainability@upenn.edu.

PURCHASING PROCESS

When purchasing a university vehicle, make sure to complete the following steps as per Procurement Services' guidelines:

- Obtain at least 3 bids* (online quotes are discouraged as better prices can be obtained by contacting dealers directly)
- Have the paperwork signed by Procurement Services
- Register the vehicle with Risk Management

* When purchasing through Holman, at least 3 bids are still required. When purchasing via Sourcewell, multiple bids are encouraged to secure the best price but are not required. Regardless of the vehicle's source, if your department would like to choose a higher bid, a justification should be provided.

When purchasing a vehicle, we recommend buyers **utilize the information and resources provided in this guide** to obtain the best vehicle options to help Penn reach zero emissions. Questions regarding the content of this guide can be directed to the Penn Sustainability Office at sustainability@upenn.edu.

For questions about the purchasing process, please contact Procurement Services at sourcing@upenn.edu.

Sourcing Options

When **purchasing from a dealership**, mention that your department is associated with the University of Pennsylvania and is **eligible for COSTARS** pricing. COSTARS is the Commonwealth of Pennsylvania's Cooperative Purchasing Program and offers deeper discounts on items purchased through the cooperative.

If your department does not want to purchase directly through a vehicle dealership, **Holman** may be helpful. Holman is a fleet management service that handles leasing and purchasing.

For electric vehicles (EVs), the **Climate Mayors Electric Vehicle Purchasing Collaborative** is the best option. The Collaborative provides a more affordable, streamlined way to purchase EVs. It is a partnership between Second Nature, Climate Mayors, and Sourcewell and has recently opened memberships to universities. The Collaborative's main objective is to decrease the upfront costs for EV procurement.

They also give members access to:

- Leasing options
- Competitively solicited EVs
- Charging infrastructure
- Technical analysis support
- Information for best practices with EV fleets

Vehicles that are currently available through the Collaborative can be found on their website. Sourcewell also provides access to numerous other products.

Penn's point of contact at Sourcewell is Abby Meinke and can be reached via email at abby.meinke@sourcewell-mn.gov. You can also reach out to the general email at service@sourcewell-mn.gov. Please contact Penn Procurement for Penn's member number.

Vehicle Registration

When your department purchases a new vehicle, it is critical to **notify Risk Management** so that they can properly insure the vehicle.

When purchasing and registering a new vehicle, the following name and address should be used on all vehicle documents:

> The Trustees of the University of Pennsylvania
> 2929 Walnut Street
> Suite 460
> Philadelphia, PA 19104-5099

The following information should be emailed to the Office of Risk Management and Insurance at dofriskmgmt@pobox.upenn.edu:

- Bill of Sale
- MV-1
- Registration (temporary or permanent if initial registration service provided by vendor)
- Name, mailing address, email, and phone number of the person who will be managing and/or responsible for the vehicle
- 26 digit account code for allocation of annual registration expenses

Risk Management can be reached at dofriskmgmt@pobox.upenn.edu, and additional questions can be emailed to Dana D'Amore at ddamore@upenn.edu. Further information can be found at Risk Management's website.

POLICIES & FORMS

Risk Management's website summarizes existing vehicle registration, disposition, and driver's safety information.

ADDITIONAL RESOURCES

Charging Stations & Resources

ChargeHub provides information on the types and number of EV charging stations in Philadelphia. They also provide a map of charging locations, including ones on Penn's campus, which can be viewed here (type Philadelphia, PA into the "Search for a location" bar).

PennDOT similarly provides a map of charging stations; this map is particularly useful for planning longer trips in Pennsylvania, as it shows designated Alternative Fuel Corridors (AFCs). AFCs are populated with EV charging stations to provide accessible roadways for traveling in an EV.

Currently, all installed EV charging stations on campus are provided by Blink Charging Co. Campus charging locations are as follows:

- 34th & Chestnut – x4 Level 2 Plugs
- 38th & Walnut – x4 Level 2 Plugs
- Penn Museum – x4 Level 2 Plugs

An additional four charging stations are being planned for purchase and installation in FY23.

If your department would like to purchase and install its own charging stations (Level 1 or Level 2), please reach out to Penn Transportation and Parking. The cost of the project will vary, but funding assistance may be available through the state of Pennsylvania and through PECO. Please refer to the Funding Quick Guide under **Funding Resources** for more information.

Fleet Certification

CALSTART Sustainable Fleet Accreditation recognizes sustainable fleets by setting objective, meaningful standards and guidelines. This accreditation stems from a partnership between CALSTART and NAFA and performs a rigorous assessment of your fleet's sustainable vehicle inventory and sustainable practices. There is a focus on collection and organization of data, so documentation is important for fleets interested in this accreditation.

FAQ

Are electric vehicles able to travel as long as or as far as we need it to before running out of battery?

> Though the range varies with each vehicle make and model, the average electric vehicle (EV) has a range of around 250 miles. Select parking lots at Penn host Level 2 electric chargers that reach full charge in 4-6 hours. Fast Chargers (Level 3 chargers) reach full charge in around an hour. There are 22 Fast Chargers in Philadelphia, and a map of their locations can be viewed on ChargeHub. In the rare case that a Penn vehicle needs to travel long distances, PennDOT provides a map of charging stations along designated Alternative Fuel Corridors (AFCs). This allows for easier travel planning along EV accessible roadways.
>
> It should be noted that overusing Fast Chargers may reduce the lifespan of the vehicle's battery.

Are electric vehicle alternatives as powerful as gasoline or diesel-powered models?

> Electric motors generate 100% of their available torque instantly, enabling them to accelerate even faster than gasoline-powered vehicles. Although most electric vehicles (EVs) are able to deliver equivalent power, they do typically have added weight from their fuel cells, which can cut into their total hauling capacity. For some models such as the Rivian R1T, this issue has been overcome; it has a hauling capacity of up to 11,000 lbs. For comparison, the diesel-fueled 2021 Ford F-150 can haul 5,000-11,300 lbs. Therefore, care should be taken in selecting which EV model to consider when purchasing specialized utility vehicles to ensure the vehicle will be able to meet the desired use.
>
> Though EVs aren't currently able to cover every corner of the market, the number and variety of EVs has been expanding and equivalent electric options are expected to emerge steadily.

What if electric models are prohibitively expensive?

> The cost of most electric vehicles (EVs) is higher than internal combustion vehicles because of the cost to manufacture their batteries. Market trends show that battery prices are decreasing, indicating a lowering cost of EVs as well. Given the Federal government's goal to achieve a 50-52% reduction in emissions by 2030, the market also expects to see further incentives to reduce the cost of

EVs. There are also multiple opportunities for grants, rebates, and tax credits associated with purchasing electric or hybrid vehicles, as shown in the **Funding Resources** section of this guide.

Do electric vehicle batteries present a safety risk?

A 2017 report by NHTSA on the safety of lithium-ion batteries, which power battery electric vehicles, states that fires and explosions from lithium-ion batteries are estimated to be comparable or less than those for gasoline or diesel vehicles.

Are electric vehicles more costly to maintain and repair than vehicles with internal combustion engines?

While electric vehicles (EVs) can have a higher upfront cost for each maintenance event, EVs cost less on average to keep running than internal combustion engine vehicles (ICEVs) since they don't need regular oil changes. Additionally, EVs don't have parts such as spark plugs, valves, and catalytic converters that tend to fail and need replacement.

The cost to fuel EVs is also lower than it is for ICEVs. In Philadelphia, the average commercial electricity rate is $0.09557/kWh (from PECO). The average battery electric sedan reaches a full charge of 60kWh and is able to run for about 250 miles per charge – each full charge costs about $5.97. In comparison, the average internal combustion light duty passenger vehicle has a fuel economy of 39.4 mpg (based on 2017 data from the Federal Bureau of Transportation). Philadelphia's gas is $3.52/gallon on average, so it costs $22.34 to travel 250 miles (from AAA, as of February 2023). That means it costs almost 4 times more to fuel an ICEV than an EV in our region.

Are the emissions from charging an electric vehicle as bad as internal combustion engine vehicle emissions?

No, the overall carbon footprint for electric vehicles has been shown to be lower than that of internal combustion engines.

Philadelphia's electric grid draws its power from four main categories: nuclear power, coal, and natural gas, and "other" sources. Our region's energy sources have been trending towards an increase in renewable energy sources, especially in wind and solar. This has resulted in an overall decrease in emissions associated with electricity production in Pennsylvania.

In 2020, Penn signed a Power Purchase Agreement that involves the construction of two solar energy facilities in central Pennsylvania. Penn will purchase all energy produced, which is estimated to amount to 75% of the campus's demand.

Additionally, Penn's emissions have been decreasing due in large part to shifts towards renewable energy grid sources. Penn's recent Power Purchase Agreement combined with our region's general trends towards more sustainable energy sources will result in Penn's energy being sourced from predominantly renewable sources, decreasing the carbon footprint of campus operations including vehicle charging.

More information can be found in the Achieving Penn's *CSAP 3.0* Goals under the **Vehicle Types & Impacts** section.

Can we support the infrastructure needed to use electric vehicles?

While Penn has 12 charging stations across campus, the capacity is currently larger than the demand. Additionally, as batteries become cheaper and more electric vehicles (EVs) populate the roads, the cost of charging stations is estimated to go down. There are also multiple grant and rebate programs for funding EV charging stations, such as the Driving PA Forward's Level 2 EV Charging Station Rebate Program and PennDot NEVI Grants for Charging Infrastructure. Due to these factors and rising demand, an increase in charging stations is predicted to be seen not just at Penn but across the region, expanding the number of stations available in general.

How does the manufacturing process for EV batteries impact their overall carbon emissions?

The manufacturing of EVs is more energy intensive and produces more emissions than manufacturing a conventional car because of the electric vehicles' complex batteries. Lithium-ion battery production requires extracting and refining rare earth metals and is energy intensive because of the high heat and sterile conditions needed. However, increasing the percentage of renewable energy used in plants that produce EV batteries would significantly reduce these emissions. Increased demand for EVs has led to the development of larger, more efficient factories that produce a lower carbon footprint per battery. Even without these improvements in manufacturing, EVs still have a lower lifetime carbon footprint than ICVs. Based on recent European studies of life-cycle emissions of EVs, an average EV produces 50% less life-cycle greenhouse gases over the first 150,000 kilometers (about 93,200 miles) of driving than an internal combustion engine vehicle.

What happens to the batteries of EVs at the end of their useful life?

Currently, it is difficult to recycle most EV batteries. There is no standardized design for EV batteries, and most are not designed with recycling in mind. Some governments are beginning to promote the recycling of EV batteries. China imposed new laws in 2018 that made EV manufacturers responsible for ensuring batteries are recycled, and as a result recycles more lithium-ion batteries then the rest of the world combined. In the US, the federal government has yet to tackle EV battery recycling laws, but several states, including California—the nation's largest car market—are exploring setting their own rules. Pennsylvania currently does not have state battery regulations in place. In the US, most EV manufactures can recycle parts of used batteries, but what cannot be recycled goes into the landfill. Tesla reportedly recycles 60 percent of the components from its lithium-ion batteries once they've reached end of life.

References

- Information on the Health Effects of Ozone Pollution by the EPA
- Calculator from the Union of Concerned Scientists showing comparisons of emissions from EVs versus internal combustion engines
- EV Battery Degradation Comparison Tool by Geotab
- Case Studies on Fleet Electrification by the Climate Mayors Electrification Coalition
- Electrifying Transportation in Municipalities guide by the Electrification Coalition
- Plug-In Hybrid & Electric Vehicle Research Center at UC Davis
- Electric Vehicle Resource Kit provided by the Delaware Valley Regional Planning Commission
- Resources for Plugin Electric Vehicles and Charging Equipment provided by the Delaware Valley Regional Planning Commission

APPENDIX I

Global Warming Potential (GWP) of EVs

In a report by the European Commission published in 2020, a comprehensive look into the overall environmental impact using life cycle assessment (LCA) was conducted. This study covers fuel and electricity production, vehicle production, use and operation, and end-of-life.

The results of this study are measured by global warming impact (GWP) based on emissions. Lower medium vehicles, shown in Figure 1, include the following passenger vehicles: class C vehicles (e.g. Ford Taurus) and medium SUVs (e.g. Ford Escape). Urban buses, shown in Figure 2, include models that have a single deck and are 12 meters long.

In Figure 1 and Figure 2, the following fuel types are represented:

- ICEV-G – gasoline fueled internal combustion engine
- ICEV-D – diesel fueled internal combustion engine
- ICEV-CNG – compressed natural gas fueled internal combustion engine
- HEV-G – gasoline and battery hybrid electric vehicle
- HEV-D – diesel and battery hybrid electric vehicle
- PHEV-G – gasoline and battery plug-in hybrid electric vehicle
- PHEV-D – diesel and battery plug-in hybrid electric vehicle
- FCEV – hydrogen fuel cell electric vehicle
- BEV – battery electric vehicle

The calculated GWP for 2020, 2030, and 2050 for each fuel type is shown for Figures 1 and 2. For 2050, the “TECH1.5” scenario reflects projected adjustments in infrastructure, policy, etc. to align with the Paris Agreement and keep global temperature increase to a 1.5°C maximum. The GWP for 2020 and 2030 are based on baseline conditions in 2020.

The results of this study indicate that for both classes of vehicles, **battery electric vehicles (BEVs) have the lowest overall global warming potential** projected over the next several decades.

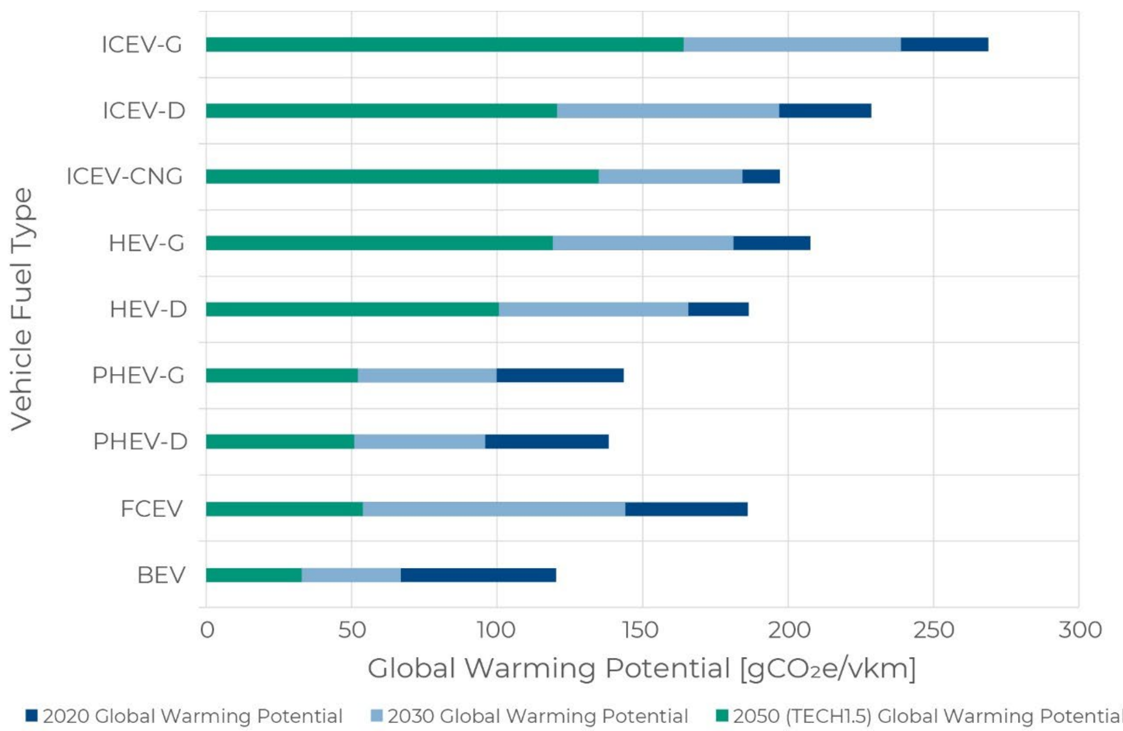


Figure 1. Summary of overall lifecycle GWP impacts for Lower Medium Cars by fuel type (*Determining the environmental impacts of conventional and alternatively fueled vehicles through LCA*, Figure 5.58).

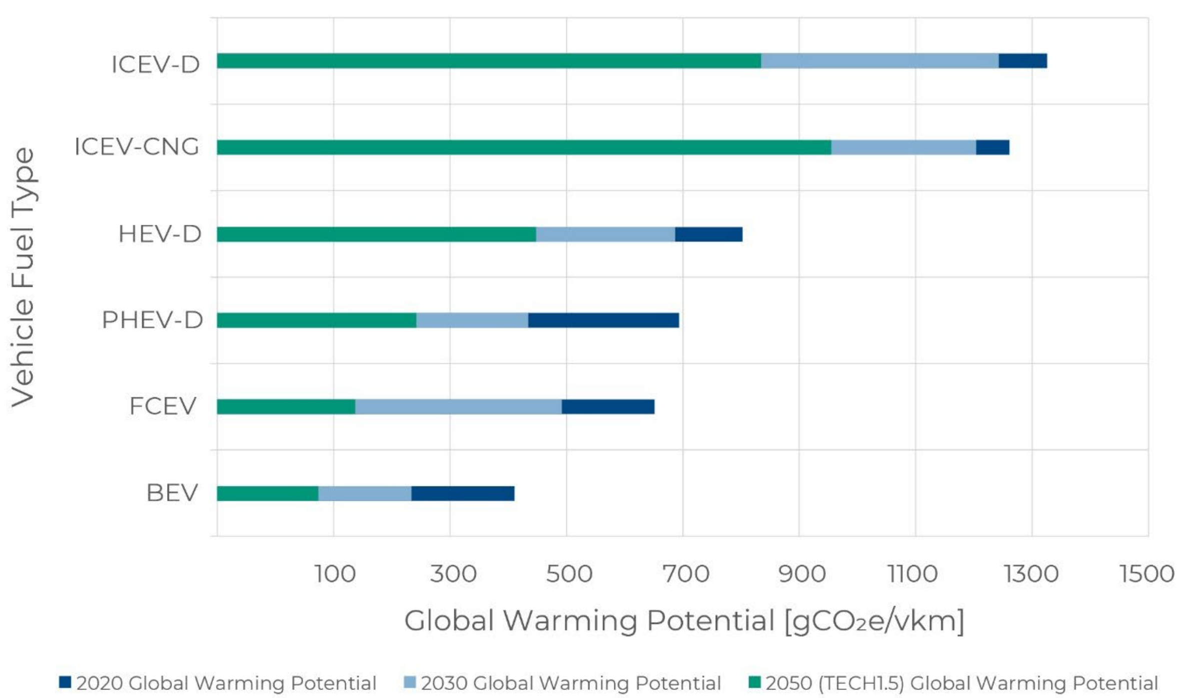


Figure 2. Summary of overall lifecycle GWP impacts for Urban Buses by fuel type (*Determining the environmental impacts of conventional and alternatively fueled vehicles through LCA*, Figure 5.72).

As shown in Figures 1 and 2, adjustments in infrastructure and sources of energy over time will result in a significant decrease in the lifecycle emissions of battery electric vehicles and plug-in hybrid electric vehicles compared to internal combustion engine vehicles.

The primary energy sources for electricity in the State of Pennsylvania are coal, gas, and nuclear power. Shown in Figure 3.1, the percentage of coal sourced electricity has decreased while gas sourced electricity has increased between 2004 and 2019. Figure 3.2 shows a decrease in oil sourced electricity and an increase in renewable power sources (water (hydro), biomass, and wind) between 2004 and 2019.

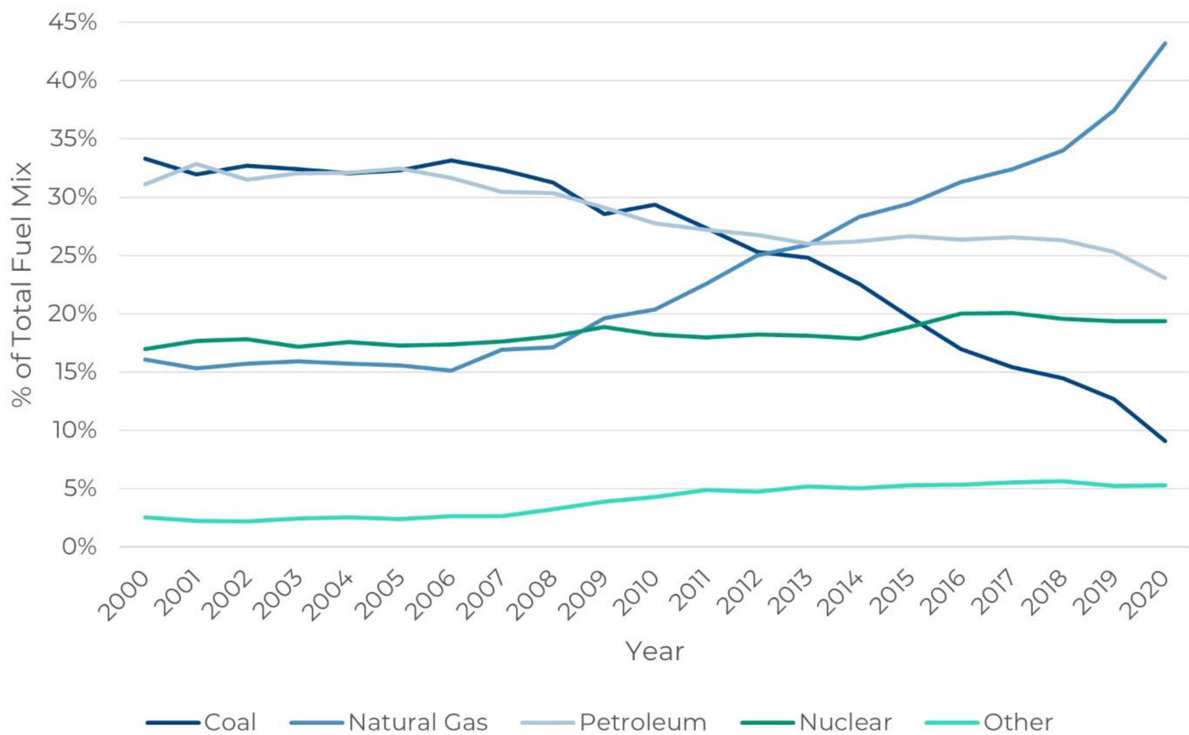


Figure 3.1. Pennsylvania electric grid source trends from 2004-2019 (U.S. Energy Information Administration State Energy Data System).

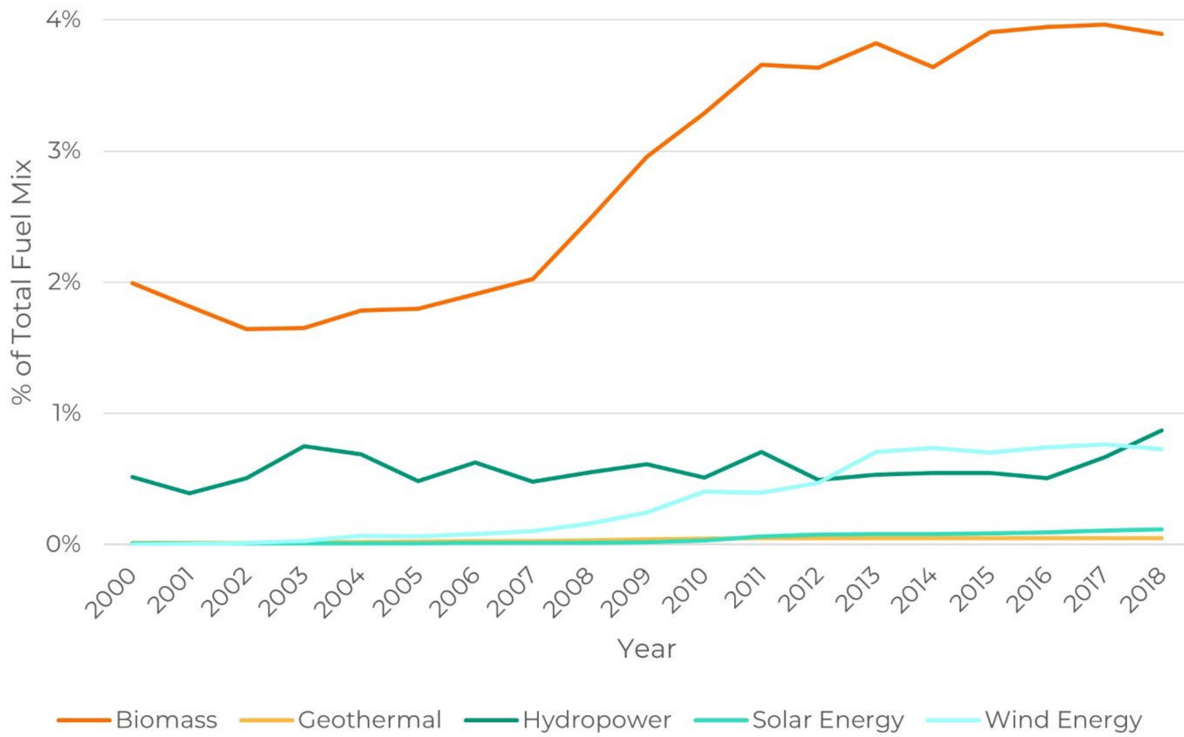


Figure 3.2. Pennsylvania electric grid source trends from 2004-2019, breakdown of “other” sources shown in Figure 3.1 (U.S. Energy Information Administration State Energy Data System).

According to data from the EPA, Pennsylvania’s carbon dioxide equivalent emissions (CO_2e) have also decreased between 2004 and 2019 and are projected to continue to drop due to the increase in lower emission electricity sources as shown in Figures 3.1 and 3.2.

Figure 4 indicates West Philadelphia’s three main electricity sources: nuclear power, coal, and natural gas. These sources have been trending towards an increase in renewable sources, predominantly in wind and solar.

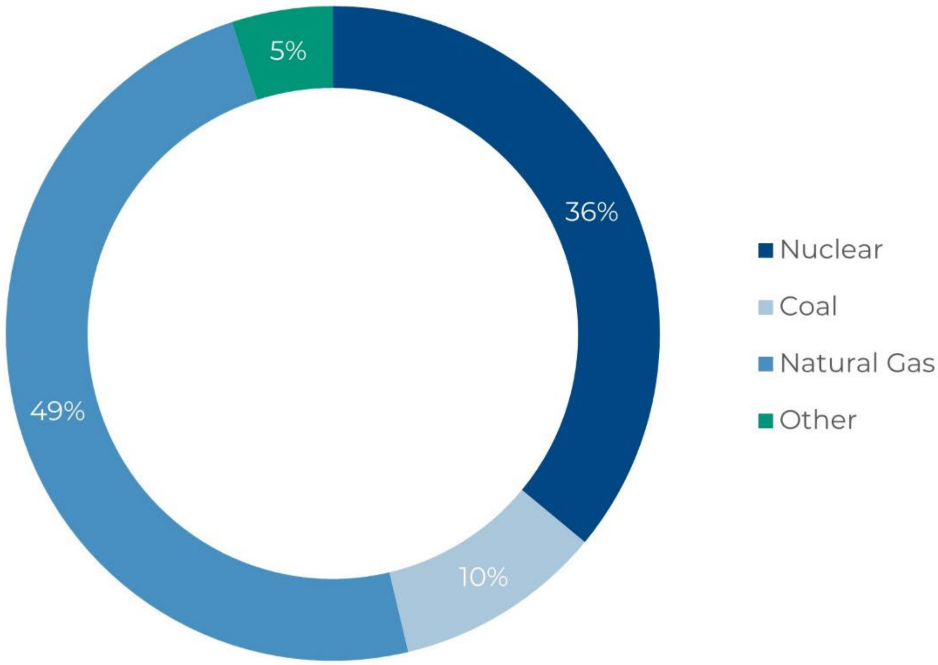


Figure 4. Fuel mix used to generate electricity in the RFCE region (includes Pennsylvania, New Jersey, Delaware, and Maryland) as of 2021 (EPA's Power Profiler, Fuel Mix for RFCE Region).

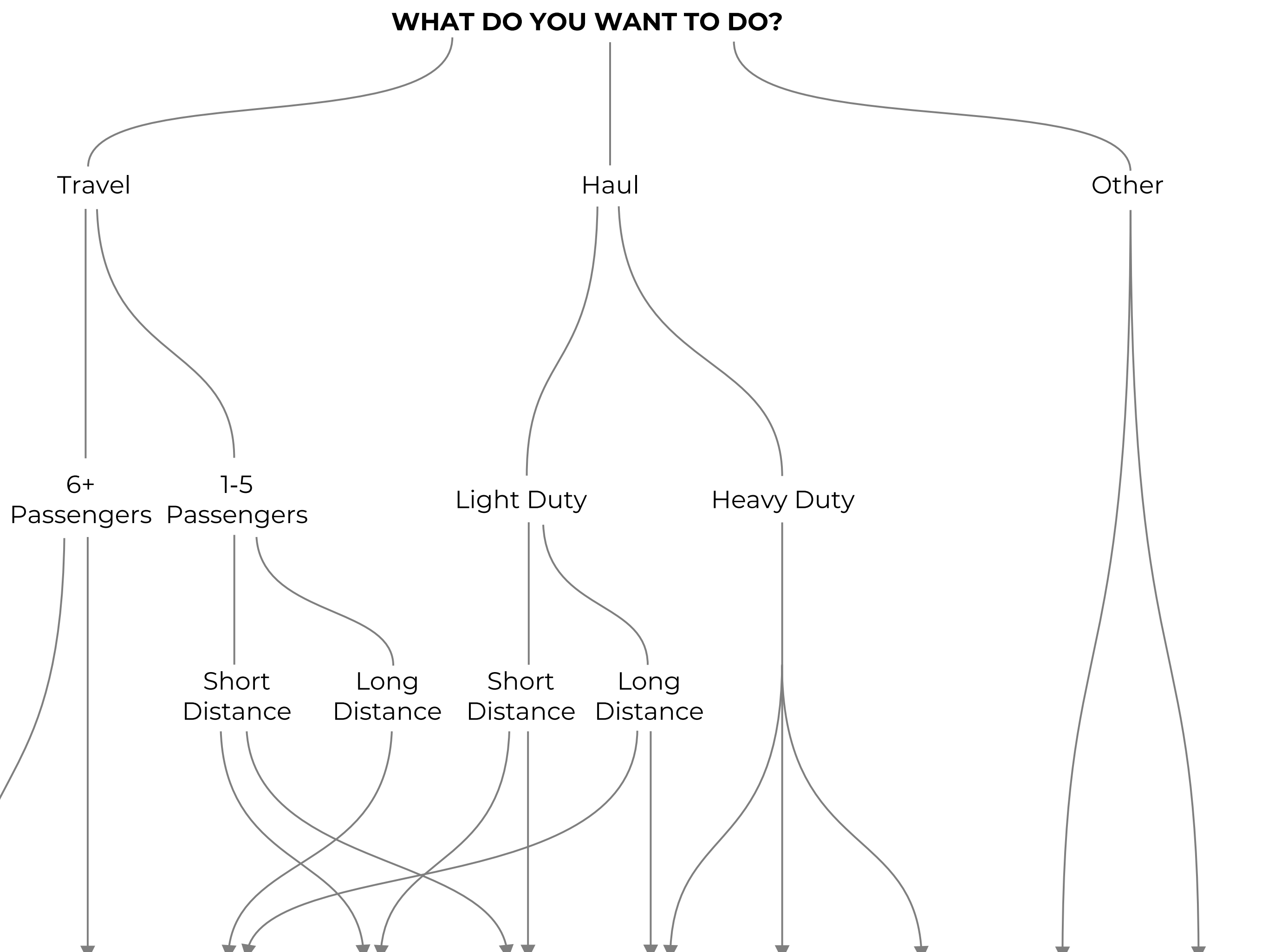
In 2020, Penn also signed a Power Purchase Agreement (PPA) that involves the construction of two solar energy facilities in central Pennsylvania. Penn will purchase all electricity produced. An estimated **75% of the campus's electricity demand will be met with solar power** once this is implemented. This PPA will also shift Penn's electricity to be predominantly sourced from renewable sources. Additionally, as the United States moves towards carbon neutrality, it is expected that clean electricity sources will become more accessible, thus further lowering the emissions associated with the electricity used to power EVs (as demonstrated in Figures 1 and 2's 2050 TECH 1.5 scenarios).

Overall, the current and projected electricity sources for our area and their associated emissions make EVs highly beneficial for reducing Penn's fleet emissions.

APPENDIX II

EV Selection Quick Guide

For more information, click on the name of each vehicle category. This guide is provided to assist purchasers in vehicle selection.



Bus	Passenger Van	Light-Duty /Passenger Vehicle	E-Assist Bike	Low Speed Vehicle	Cargo Van	Pickup Truck	Chassis	Public Safety Vehicle	Equipment
									
Consult Vendor for Price Range	Est. Price Range: $31,860 and up	Est. Price Range: $28,040 and up	Est. Price Range: $1,999 and up	Consult Vendor for Price Range	Est. Price Range: $34,100 and up	Est. Price Range: $22,195 and up	Consult Vendor for Price Range	Consult Vendor for Price Range	Consult Vendor for Price Range