Low-Emissions Vehicle Purchasing Guidance
Version 1 - Released December 2021

Table of Contents:

Overview .................................................................................................................................... 2
Vehicle Types & Impacts .................................................................................................................. 3
Funding Resources .......................................................................................................................... 5
Recommended Vehicles ................................................................................................................... 8
Purchasing Process ........................................................................................................................ 12
Policies & Forms ............................................................................................................................ 14
Additional Resources .................................................................................................................... 15
Appendix I: Global Warming Potential (GWP) of EVs .................................................................. 19
Appendix II: EV Selection Quick Guide ......................................................................................... 24
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-emissions 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 and 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 2021 State of the Air report placed Philadelphia as the 17th most air polluted city 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.

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.

For any questions about the information within this document, please contact Natalie Walker in the Penn Sustainability Office at sustainability@upenn.edu.
VEHICLE TYPES AND IMPACTS

Electric vehicles (EVs) generally fall under the following three 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

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 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 $5.12 to drive 250 miles. In comparison, based on average gasoline prices in Philadelphia, an equivalent gasoline powered ICEV costs about $18.90 for the same distance.

There are also **federal tax credits worth up to $7,500** available for certain battery EV and hybrid EV models, as viewed here. Though the University cannot take advantages of these tax credits if purchasing directly, the tax credit can be claimed when purchasing via the Climate Mayors EV Purchasing Collaborative. For more information on the Collaborative, see the **Purchasing Process** section of this guide or view the Collaborative’s webpage. The commonwealth also provides rebates and other incentives for fleet replacement and installing EV chargers (see the table below for more information).
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.

<table>
<thead>
<tr>
<th>NAME</th>
<th>SOURCE</th>
<th>AMOUNT</th>
<th>VEHICLE TYPE</th>
<th>NOTES</th>
<th>CONTACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Tax Credit</td>
<td>Federal</td>
<td>Up to $7,500</td>
<td>For eligible EVs purchased new after 2010</td>
<td>Penn entities cannot take advantage of the tax credit unless purchasing through the Climate Mayors EV Purchasing Collaborative</td>
<td>-</td>
</tr>
<tr>
<td>Alternative Fuels Incentive Grant Program (AFIG)</td>
<td>State</td>
<td>Up to $100,000 per project</td>
<td>Covers projects that improve sustainability by retrofitting old vehicles, purchasing new vehicles, purchasing charging equipment, and conducting research</td>
<td>Organizations can get up to $600,000 per year for all projects</td>
<td>Colton Brown <a href="mailto:coltbrown@pa.gov">coltbrown@pa.gov</a></td>
</tr>
<tr>
<td>Driving PA Forward Truck &amp; Bus Fleet Grant Program</td>
<td>State</td>
<td>Up to $1,500,000</td>
<td>Replacement of fleets of 6 or more class 4-8 diesel freight trucks or buses</td>
<td>Can cover multiple projects, operates as a reimbursement grant</td>
<td>Colton Brown <a href="mailto:coltbrown@pa.gov">coltbrown@pa.gov</a></td>
</tr>
<tr>
<td>Driving PA Forward DC Fast Charging &amp;</td>
<td>State</td>
<td>Up to $250,000 for DC Fast</td>
<td>Installation of DC Fast chargers or</td>
<td>Plugs must be publicly accessible</td>
<td>Colton Brown <a href="mailto:coltbrown@pa.gov">coltbrown@pa.gov</a></td>
</tr>
</tbody>
</table>
Federal Funding

All-electric and plug-in hybrid vehicles purchased new after 2010 are eligible for up to $7,500 in federal income tax credits. A comprehensive list of which models are eligible and how much their associated tax credits are worth can be seen here.

Although tax exempt organizations are usually not able to qualify for this credit, by taking advantage of the Climate Mayors Electric Vehicle Purchasing Collaborative’s leasing options, these savings can still 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.

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 and caps at $600,000 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 DC Fast Charging & Hydrogen Fueling Grant Program provides up to $250,000 for DC fast chargers and up to $500,000 for hydrogen fueling. The Level 2 EV Charging Rebate program provides $3,000-$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.
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 will vary depending on the vehicle’s specifications. 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

<table>
<thead>
<tr>
<th>E-Assist Bicycles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VEHICLE</strong></td>
</tr>
<tr>
<td>RadWagon 4</td>
</tr>
<tr>
<td>Electric Cargo</td>
</tr>
<tr>
<td>Bike</td>
</tr>
<tr>
<td>Fuji E-Traversal</td>
</tr>
<tr>
<td>2.1 ST</td>
</tr>
<tr>
<td>Big Easy Longtail</td>
</tr>
<tr>
<td>Electric Cargo</td>
</tr>
<tr>
<td>Bike</td>
</tr>
</tbody>
</table>
### Low Speed Vehicles

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>IMAGE</th>
<th>FUEL TYPE</th>
<th>EST. PRICE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbia Utilitruck</td>
<td><img src="image1.png" alt="Image" /></td>
<td>BEV</td>
<td>$20,000</td>
<td>Product details</td>
</tr>
<tr>
<td>2021 Deere TE 4x2 Electric Gator</td>
<td><img src="image2.png" alt="Image" /></td>
<td>BEV</td>
<td>$13,000</td>
<td>Product details</td>
</tr>
</tbody>
</table>

### Light-Duty/Passenger Vehicles

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>IMAGE</th>
<th>FUEL TYPE</th>
<th>EST. PRICE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022 Chevy Bolt</td>
<td><img src="image3.png" alt="Image" /></td>
<td>BEV</td>
<td>$31,835</td>
<td>Product details; available through Sourcewell</td>
</tr>
<tr>
<td>2022 Nissan LEAF/LEAF PLUS</td>
<td><img src="image4.png" alt="Image" /></td>
<td>BEV</td>
<td>$23,759-$28,583</td>
<td>Product details</td>
</tr>
<tr>
<td>2021 Toyota Prius Prime Plus</td>
<td><img src="image5.png" alt="Image" /></td>
<td>PHEV</td>
<td>$27,258</td>
<td>Product details</td>
</tr>
<tr>
<td>2021 Chrysler Pacifica Hybrid</td>
<td><img src="image6.png" alt="Image" /></td>
<td>PHEV</td>
<td>$40,751</td>
<td>Product details; available through Sourcewell</td>
</tr>
<tr>
<td>2020 Ford Fusion Energi</td>
<td><img src="image7.png" alt="Image" /></td>
<td>PHEV</td>
<td>$31,630</td>
<td>Product details; eligible for federal refund of $4,609</td>
</tr>
</tbody>
</table>

### Passenger Vans

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>IMAGE</th>
<th>FUEL TYPE</th>
<th>EST. PRICE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021 Ford Transit Connect Wagon</td>
<td><img src="image8.png" alt="Image" /></td>
<td>ICEV</td>
<td>$29,515</td>
<td>Product details; ranked as the most fuel efficient passenger van by GreenerCars.org</td>
</tr>
<tr>
<td>VEHICLE</td>
<td>IMAGE</td>
<td>FUEL TYPE</td>
<td>EST. PRICE</td>
<td>NOTES</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-----------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>2021 Ford Transit Connect Van</td>
<td></td>
<td>ICEV</td>
<td>$24,655</td>
<td><a href="#">Product details</a>; ranked as the most fuel efficient cargo van by <a href="#">GreenerCars.org</a></td>
</tr>
<tr>
<td>2021 Nissan NV200</td>
<td></td>
<td>ICEV</td>
<td>$23,630</td>
<td><a href="#">Product details</a>; ranked highly for fuel efficiency among cargo vans by <a href="#">GreenerCars.org</a></td>
</tr>
<tr>
<td>2022 Ford E-Transit</td>
<td></td>
<td>BEV</td>
<td>$45,000</td>
<td><a href="#">Product details</a></td>
</tr>
</tbody>
</table>

### Pickup Trucks

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>IMAGE</th>
<th>FUEL TYPE</th>
<th>EST. PRICE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivian R1T</td>
<td></td>
<td>BEV</td>
<td>$67,500</td>
<td><a href="#">Product details</a>; Fully electric pickup truck with a range of 300+ miles;</td>
</tr>
<tr>
<td>2021 Chevrolet Silverado 2WD</td>
<td></td>
<td>ICEV (diesel)</td>
<td>$29,300</td>
<td><a href="#">Product details</a>; ranked as the most fuel efficient pickup truck by <a href="#">GreenerCars.org</a></td>
</tr>
<tr>
<td>COMING SOON Ford F-150 Electric Pickup Truck</td>
<td></td>
<td>BEV</td>
<td>-</td>
<td>Scheduled to start production mid-2022</td>
</tr>
</tbody>
</table>

### Buses

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>IMAGE</th>
<th>FUEL TYPE</th>
<th>EST. PRICE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proterra ZX5 Electric Bus</td>
<td></td>
<td>BEV</td>
<td>-</td>
<td><a href="#">Product details</a></td>
</tr>
</tbody>
</table>
## Medium- and Heavy-Duty Chassis & Equipment

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>IMAGE</th>
<th>FUEL TYPE</th>
<th>EST. PRICE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lion Electric Lion8 – Tandem</td>
<td><img src="image" alt="Lion Electric Lion8" /></td>
<td>BEV</td>
<td>-</td>
<td>Available through <a href="#">Sourcewell</a>; a class 8 truck that can be customized based on use</td>
</tr>
<tr>
<td>Peterbilt 220EV</td>
<td><img src="image" alt="Peterbilt 220EV" /></td>
<td>BEV</td>
<td>$344,178</td>
<td>Available through <a href="#">Sourcewell</a>; for pickup &amp; delivery; see their <a href="#">operating costs calculator</a> to compare power consumption &amp; fuel costs</td>
</tr>
<tr>
<td>Peterbilt 579EV</td>
<td><img src="image" alt="Peterbilt 579EV" /></td>
<td>BEV</td>
<td>$334,167</td>
<td>Available through <a href="#">Sourcewell</a>; for regional haul &amp; drayage; see their <a href="#">operating costs calculator</a> to compare power consumption &amp; fuel costs</td>
</tr>
<tr>
<td>Global Environmental Sweepers M4 Electric Sweeper</td>
<td><img src="image" alt="Global Environmental Sweepers M4 Electric Sweeper" /></td>
<td>BEV OR FCEV</td>
<td>$545,832</td>
<td>Available through <a href="#">Sourcewell</a>; 11 hours of operational time</td>
</tr>
</tbody>
</table>

## Public Safety Vehicles

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>IMAGE</th>
<th>FUEL TYPE</th>
<th>EST. PRICE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chevy Bolt Patrol Vehicle</td>
<td><img src="image" alt="Chevy Bolt Patrol Vehicle" /></td>
<td>BEV</td>
<td>-</td>
<td>Range of 238 miles per charge, utilized by Columbia University’s public safety fleet</td>
</tr>
</tbody>
</table>

For additional options, see the following resources:

- [Sourcewell’s complete list of light-duty vehicles](#)
- [Sourcewell’s list of medium and heavy-duty vehicles](#)
- [GreenerCars’ sustainability ratings](#)
- [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

To get connected with municipalities that purchase EV and hybrid police vehicles, please contact Rob Graff at [rgraff@dvrpc.org](mailto:rgraff@dvrpc.org).
For further assistance finding more environmentally friendly vehicle options, please contact the Sustainability Office at sustainability@upenn.edu.

For any questions about the information within this document, please contact Natalie Walker in the Penn 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 ARI, at least 3 bids are still required. When purchasing via Sourcewell, multiple bids are encouraged in order 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, justification should be provided.

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

For questions about the purchasing process, please contact Procurement Services at procure@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, ARI may be helpful. ARI 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. In addition to giving Penn access to the federal EV tax credit, the Collaborative also 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:

- Federal tax credits
- 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 Katie Alba and can be reached via email at katie.alba@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 Kevin Tracy at Kevin.Tracy@upenn.edu or Josh Tabler at jtabler@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).

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

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. In the rare case that a Penn vehicle needs to travel long distances, 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.

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 upcoming Ford electric F-150, this issue has been overcome; it is projected to be the most powerful F-150 to date. For comparison, the diesel-fueled 2021 F-150 is able to haul 5,000-11,300 lbs, meaning the upcoming electric model will have an even higher hauling capability. 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 steadily 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.

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 have a tendency 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 $0.0854/kWh. 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 $5.12. In comparison, the average internal combustion sedan has a fuel economy of 39.4 mpg (based on data from the Federal Bureau of Transportation). Philadelphia’s gas is $2.98/gallon on average, so it costs $18.90 to travel 250 miles. 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 March of 2021, Pennsylvania governor Tom Wolf announced a major clean energy initiative that will implement 191-megawatts of new solar energy arrays across the state and will contribute significantly to the energy grid. Also 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 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 DC Fast Charging Grant and Level 2 EV Charging Station Rebate Program. 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 have 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 ICV.

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 than 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.
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

Figure 2. Summary of overall lifecycle GWP impacts for Urban Buses by fuel type (source).
sourced electricity and an increase in renewable power sources (water (hydro), biomass, and wind) between 2004 and 2019.

Figure 3.2. Pennsylvania electric grid source trends from 2004-2019, breakdown of “other” sources shown in Figure 3.1 (source).

According to data from the EPA, Pennsylvania’s carbon dioxide equivalent emissions (CO₂e) 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.
In March of 2021, Pennsylvania governor Tom Wolf announced a major clean energy initiative that will implement 191-megawatts of new solar energy arrays across the state by 2023. This will increase the percentage of solar powered electricity in Pennsylvania to nearly 50% of the state’s total electricity and further decrease the CO₂e emissions associated with electricity production.

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. West Philadelphia electricity sources (source).](image)

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.

What do you want to do?

<table>
<thead>
<tr>
<th>Bus</th>
<th>Passenger Van</th>
<th>Light-Duty/Passenger Vehicle</th>
<th>E-Assist Bike</th>
<th>Low Speed Vehicle</th>
<th>Cargo Van</th>
<th>Pickup Truck</th>
<th>Chassis</th>
<th>Public Safety Vehicle</th>
<th>Equipment</th>
</tr>
</thead>
</table>