Report Comparing Electric and Other Alternative Fuel Non-Tactical Vehicles with Internal Combustion Engine Vehicles

March 2023

Office of the Under Secretary of Defense for Acquisition and Sustainment

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Report to Congress

Comparing Electric and Other Alternative Fuel Non-Tactical Vehicles with Internal Combustion Engine Vehicles

The Department of Defense (DoD) provides this report to the Congress, in accordance with Section 328 of the James M. Inhofe National Defense Authorization Act for Fiscal Year (FY) 2023, Public Law 117-263. The global automobile market and associated supply chains are undergoing significant and rapid transformation. The assessments, estimates, and answers to questions below reflect the Department’s best effort to meet the elements of section 328. The answers below are based on currently available information and projections made on that information. Where the Department made or incorporated projections and assumptions—including on future energy prices and supply chain investment—it relied, to the greatest extent possible, on reliable sources and expertise. The report reaches the following broad conclusions:

- The DoD is a small fraction of America’s overall vehicle market, and future costs for alternative-fueled vehicles will be primarily determined by changes in the private sector.

- The Total Cost of Ownership for most light-duty Electric Vehicle (EV) models is lower than comparable Internal Combustion Engine (ICE) vehicles models today. The costs to procure EVs will likely decline over time, with smaller, light-duty vehicles reaching cost parity with ICE vehicles first, followed by medium- and heavy-duty vehicles.

- The automotive industry is globally integrated, and parts for many vehicles, whether EV or ICE, are sourced from China.

- China dominates the market of lithium-ion battery cell precursors (cathodes, anodes, electrolytes, and separators) and produces the majority of global lithium-ion battery cells and packs. The United States produces the majority of the cells and packs sold domestically, and relies on Japan, South Korea, Germany, Mexico, and Canada for most imported cells and packs.

- Most vehicle cybersecurity issues are not drivetrain specific but are related to driving automation and connectivity, both growing trends in the vehicle market. However, networked electric vehicle supply equipment (EVSE) represents a potential vulnerability if not properly addressed.

- The Department does not forecast constraints to ICE parts or services in the near term. As ICE market share decreases and supply chains evolve to respond to those demand shifts, access to ICE parts or services may become constrained.
- EVs are less likely to catch fire than ICE vehicles. However, different techniques are required to extinguish EV fires compared to ICE vehicles. Specialized training is available to prepare first responders to deal with these new fires safely.

- The deployment of EVs on military installations could also provide several benefits not fully captured in responses to questions posed by section 328. These include:

  - **Potential increases in installation resilience from additional electricity sources.** Bi-directional charging and the ability to connect to on-base micro grids could enable energy stored in vehicles to supply the installation power grid, enhancing resilience.

  - **Potential increases in capability for installation maintenance operations.** Vehicles with the ability to export on-board electrical power could reduce or eliminate the need for diesel, propane, or natural gas generators to make electricity at work sites, adding flexibility to base operations.

  - **Investment in domestic Li-ion battery industry to supply batteries for tactical systems.** Many of DoD’s tactical systems, e.g., hand-held radios, night vision systems, tactical vehicles rely on Li-ion batteries. Future capabilities like unmanned systems and directed energy weapons also depend on the technology. DoD is not a large enough customer to support a domestic supply chain. Domestic demand for EVs is expected to spur supply chain investment that could also benefit DoD weapon systems.

  - **Reductions in air pollution on military installations.** Zero emission vehicles reduce air pollution on installations, resulting in a healthier operating environment for service members, their families, and civilian staff.

**Cost Estimates for Vehicles and Infrastructure**

1. **A cost estimate for the procurement by the Secretary of Defense, or through contract mechanisms used by the Department (such as energy savings performance contracts), of electric non-tactical vehicles to replace the existing non-tactical vehicle fleet of the Department, which shall include:**

   A. An estimated cost per unit and number of units to be procured of each type of electric non-tactical vehicle (such as trucks, buses, and vans)

   B. The cost associated with building the required infrastructure to support electric non-tactical vehicles, including charging stations and electric grid requirements

   C. A lifecycle cost comparison between electric vehicles and combustion engine vehicles of each type (such as an electric truck versus a conventional truck)
D. Maintenance requirements of electric vehicles compared to combustion engine vehicles

E. For each military department, a cost comparison over periods of three, five, and 10 years of pursuing an electric non-tactical vehicle fleet versus continuing with combustion engine non-tactical vehicles

A. An estimated cost per unit and number of units to be procured of each type of electric non-tactical vehicle (such as trucks, buses, and vans)

Response:

The DoD plans to acquire between 4,000 and 9,000 EVs per year over the next 10 years. Planned EV acquisitions for FY 2023 are almost exclusively sedans.

GSA Fleet is the U.S. General Services Administration’s (GSA) program that provides vehicle purchasing, leasing and short-term rentals for federal agencies. GSA Fleet data was used to provide the basis for current vehicle costs because the DoD leases or purchases 99 percent of its non-tactical fleet from GSA.

Future vehicle costs are based on future cost scenarios developed by Argonne National Laboratory (ANL).1 For more than 20 years, ANL’s Vehicle and Mobility Systems Group (VMS) has maintained a state-of-the-art vehicle energy consumption, performance, and cost simulation tool. In November 2022, they leveraged that simulation tool to publish a report on future cost scenarios based on detailed analysis of vehicle component costs for both conventional ICE vehicles and EVs. In addition to the data from ANL, Bloomberg New Energy Finance predicts the cost to acquire EVs will decline as battery manufacturing costs decline with EV production volume increases.2

Estimated declining incremental costs (the difference in purchase price between EVs and ICE vehicles) are forecasted in the graphs below. Department EV acquisitions in FY 2023 are nearly 100 percent light-duty vehicles.

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Figure 1: Federal Light-Duty EV Incremental First Cost Forecast

Figure 2: Federal Medium-Duty EV Incremental First Cost Forecast

Data Sources: GSA and ANL; Graph: DoD
B. The cost associated with building the required infrastructure to support electric non-tactical vehicles, including charging stations and electric grid requirements

Response:

The cost of installing EV charging stations or EVSE varies depending on the mission use case, the type of charging station and the extent of construction required. Level 1 equipment provides charging through a standard residential AC outlet and is the slowest EV charging speed available. Level 2 chargers are common for residential and workplace applications, with 4-10 hours needed for charging. Their impact to the electric grid is analogous to that of a residential 220V clothes dryer. Level 3 Direct Current Fast Charging (DCFC) equipment enables rapid charging in one hour or less. DoD is exploring partnerships with electric utilities, local governments, and other entities to support financing and installation of EVSE.

Across all federal agencies from FY 2020-FY 2022, the average reported cost of Level 2 charging ports (most common at DoD sites) including their associated equipment and installation costs was $9,412 per charging port. This includes distribution system upgrades, which are typically limited to transformer replacements and service-side upgrades for Level 2 EVSE.

NREL estimated DCFC unit costs plus installation range from $40K for a 50kW charging port up to $224K for a 150kW port. Utility upgrade costs are paid for an entire site and depend on the number of ports being installed at the site.

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The Department’s EVSE plan focuses on installation of Level 2 chargers in the early years since charging will mainly be needed for light-duty vehicles that will charge overnight or during non-work hours. Some DCFCs may be needed later as medium- and heavy-duty vehicles and vehicles with more frequent charging requirements begin to enter the fleet.

C. A lifecycle cost comparison between electric vehicles and combustion engine vehicles of each type (such as an electric truck versus a conventional truck)

Response:

Due to fuel and maintenance savings, EV total cost of ownership (TCO) for most light-duty models on the market today is already lower than comparable ICE vehicles.\(^4\) In addition, the TCO for light-duty EVs is generally forecasted to drop in the coming years, so the Department’s lifecycle cost approach to procurement is projected to generate significant savings.\(^5\) The chart and graph below compare per mileage and TCO costs for light duty EVs and comparable ICE vehicles.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Example Vehicle</th>
<th>cost-per-natural-unit(^6)</th>
<th>$/gge(^7)</th>
<th>Fuel Economy (MPGe)(^8)</th>
<th>$/mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline (regular)</td>
<td>Hyundai Elantra</td>
<td>$3.79 / gallon</td>
<td>$3.79</td>
<td>37 MPG</td>
<td>$0.102</td>
</tr>
<tr>
<td>Electricity (LDV)</td>
<td>Chevy Bolt</td>
<td>$0.129 / kWh</td>
<td>$4.33</td>
<td>120 MPGe</td>
<td>$0.036</td>
</tr>
<tr>
<td>SUV (4x2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline (regular)</td>
<td>Ford Escape</td>
<td>$3.79 / gallon</td>
<td>$3.79</td>
<td>30 MPG</td>
<td>$0.126</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Hyundai Nexo</td>
<td>$9.41 / kg H2</td>
<td>$9.41</td>
<td>57 MPGe</td>
<td>$0.165</td>
</tr>
<tr>
<td>Electricity (LDV)</td>
<td>Ford Mach-E</td>
<td>$0.129 / kWh</td>
<td>$4.33</td>
<td>103 MPGe</td>
<td>$0.042</td>
</tr>
<tr>
<td>Pickup Truck (4x4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline (regular)</td>
<td>Ford F150</td>
<td>$3.79 / gallon</td>
<td>$3.79</td>
<td>20 MPG</td>
<td>$0.190</td>
</tr>
</tbody>
</table>


\(^5\) To understand lifecycle costs for vehicles currently available on the market, the Department reviewed ANL’s 2021 study Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains. In its work, ANL considered vehicle first cost and depreciation, financing, fuel costs, insurance costs, maintenance and repair costs, taxes and fees, and other operational costs to calculate TCO. However, for this report, TCO was calculated using only vehicle first costs, fuel costs, and maintenance/repair costs since federal agencies do not have costs associated with financing, insurance, and taxes.


<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Example Vehicle</th>
<th>cost-per-natural-unit$^{6}$</th>
<th>$/gge$</th>
<th>Fuel Economy (MPGe)$^{8}$</th>
<th>$/mile$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity (LDV)</td>
<td><em>Ford F150 Lightning</em></td>
<td>$0.129 / kWh</td>
<td>$4.33</td>
<td>68 MPGe</td>
<td>$0.064</td>
</tr>
<tr>
<td>MD Truck</td>
<td><em>Freightliner M2 106 Plus</em></td>
<td>$3.79 / gallon</td>
<td>$3.79</td>
<td>10 MPGe*</td>
<td>$0.379</td>
</tr>
<tr>
<td>Electricity (LDV)</td>
<td><em>Freightliner eM2</em></td>
<td>$0.123 / kWh</td>
<td>$4.16</td>
<td>45 MPGe*</td>
<td>$0.093</td>
</tr>
<tr>
<td>Bus</td>
<td><em>New Flyer</em></td>
<td>$3.79 / gallon</td>
<td>$3.79</td>
<td>6 MPGe*</td>
<td>$0.632</td>
</tr>
<tr>
<td>Electricity (LDV)</td>
<td><em>New Flyer</em></td>
<td>$0.123 / kWh</td>
<td>$4.16</td>
<td>18 MPGe*</td>
<td>$0.231</td>
</tr>
</tbody>
</table>

*MPGe estimated

Figure 4: EV Total Cost of Ownership Over 8 Years Compared to ICE Vehicles

Data source: ANL; Graph: DoD
D. Maintenance requirements of electric vehicles compared to combustion engine vehicles

Response:

EVs generally cost less for maintenance and have fewer maintenance requirements, when compared to ICE vehicles according to Consumer Reports⁹ and ANL.¹⁰ For example, all combustion engine vehicles must regularly change oil and engine filters, due to the need for air intake and the resulting contamination of dirt and pollutants. Electric vehicle motors do not require an air intake or exhaust and thus do not have frequent oil change requirements. Electric vehicles also leverage regenerative braking to recapture energy for the traction battery when braking. This regenerative braking reduces the need for friction brakes and results in a reduced need to replace brake pads and brake rotors and drums. Battery electric vehicles (BEV) do not have spark plugs or timing belts or emissions control systems or complex transmissions that wear and need to be replaced or repaired. Hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) contain both ICE vehicle components and EV components, and thus have more maintenance requirements and costs than BEVs.

ANL estimates average light-duty BEV maintenance costs are 40 percent less than ICE vehicles, with $0.061/mile for BEVs compared to $0.101/mile for ICE vehicles. ANL also estimates maintenance costs for electric transit buses and medium-duty/heavy-duty trucks to average 40 percent less than ICE counterparts.

Figure 5: Comparison of Maintenance Cost for Various Vehicle Drivetrains

Data source: ANL; Graph: ANL

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E. For each military department, a cost comparison over periods of three, five, and 10 years of pursuing an electric non-tactical vehicle fleet versus continuing with combustion engine non-tactical vehicles

Response:

The charts below show cumulative EV plan costs, including incremental first cost of vehicles, EV charging infrastructure, fuel, and maintenance costs, compared to the cumulative costs the Department would incur if it continued acquiring and operating ICE vehicles rather than EVs in those years. They do not reflect the Department’s overall fleet budget.

NREL combined counts of planned DoD EV acquisitions and associated EVSE with the projected declining EV incremental costs, average EVSE cost estimates, fuel savings, and maintenance savings to create three-, five-, and 10-year cost estimates for each DoD branch. These cost estimates are compared to a primarily ICE-focused strategy. NREL held EVSE unit/installation cost estimates constant and assumed DoD continues to replace vehicles every 8 years. ICE vehicle costs do not include the cost to capitalize, operate, and maintain hydrocarbon fueling infrastructure.

In the early years of the transition to EVs, the Department expects to spend more on EV incremental costs and EVSE than they would in the ICE context. However, by 2030 the fuel and maintenance savings from EVs are projected to result in lower total costs than continuing to acquire ICE vehicles.

Data Source: GSA, ANL, DoD Reporting; Graph: DoD
Figure 7: Comparison of DoD 3, 5, and 10-yr EV Costs vs ICE Costs

Figure 8: Comparison of Army Cumulative Costs to Acquire and Operate EVs vs ICE Vehicles

ICE costs do not include costs to capitalize, operate, and maintain hydrocarbon fueling infrastructure.
Figure 11: Navy Comparison of 3, 5, and 10-yr EV Costs vs ICE Costs

Figure 12: Comparison of USMC Cumulative Costs to Acquire and Operate EVs vs ICE Vehicles

ICE costs do not include costs to capitalize, operate, and maintain hydrocarbon fueling infrastructure.
Figure 13: USMC Comparison of 3, 5, and 10-yr EV Costs vs ICE Costs

Data Source: GSA, ANL, DoD Reporting; Graph: DoD

Figure 14: Comparison of Air Force Cumulative Costs to Acquire and Operate EVs vs ICE Vehicles

ICE costs do not include costs to capitalize, operate, and maintain hydrocarbon fueling infrastructure

Data Source: GSA, ANL, DoD Reporting; Graph: DoD
Figure 15: Air Force Comparison of 3, 5, and 10-yr EV Costs vs ICE Costs

Figure 16: Comparison of Defense Agencies Cumulative Costs to Acquire and Operate EVs vs ICE Vehicles

Data Source: GSA, ANL, DoD Reporting; Graph: DoD

ICE costs do not include costs to capitalize, operate, and maintain hydrocarbon fueling infrastructure
Figure 17: Defense Agencies Comparison of 3, 5, and 10-yr EV Costs vs ICE Costs

Data Source: GSA, ANL, DoD Reporting; Graph: DoD
Supply Chain Shortfall Assessment and Chinese Component Sourcing

2. An assessment of the current and projected supply chain shortfalls, including critical minerals, for electric vehicles and combustion engine vehicles

5. An identification of components for electric non-tactical vehicles, advanced-biofuel-powered vehicles, hydrogen-powered vehicles, and combustion engine vehicles that are currently being sourced from the People’s Republic of China

Response:

These two questions are addressed in a single response because there are several overlapping areas of interest between the supply chains for EVs and ICE vehicles and vehicle components currently sourced from the People’s Republic of China. This response focuses first on EVs and then on advanced-biofuel-powered vehicles, hydrogen FCEVs, and ICE vehicles, considering in both cases current and projected reliance on the People’s Republic of China.

Electric Vehicle Supply Chain and Chinese Component Sourcing:

Dependence on foreign sources of minerals and on foreign production of lithium-ion battery components creates vulnerabilities for the DoD and the U.S. EV market. A group of Federal agencies led by the U.S. Department of Energy (DOE) has partnered through the Federal Consortium for Advanced Batteries to address these vulnerabilities through a combination of scientific exploration and manufacturing development.11 U.S. dependence on foreign materials is particularly relevant for the mining of graphite and cobalt, two key minerals required in the production of lithium-ion batteries. For these minerals, China extracts a majority of the world’s graphite, and the Democratic Republic of Congo mines a majority of the world’s cobalt, with each country supporting 59 percent and 70 percent of the world’s supply for these resources, respectively, as seen in the graphic below.12

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Figure 18: Global Mining Production for Lithium-ion Battery Minerals by Country of Origin
Data: USGS; Map/Graph: NREL

While China plays a dominant role in the supply chain in the mining and refinement of key lithium-ion battery minerals, they are also a major consumer due to their growing EV demand. According to data from the International Trade Centre, the U.S. supply chain for these minerals is more diversified.\textsuperscript{13} For raw and refined mineral imports directly to the U.S., Chile and Argentina are the primary sources of lithium, Canada is the primary source of nickel, Norway is the primary source of cobalt, Mexico and China are the primary sources of graphite, and Gabon is the primary source of manganese.

China also plays a major role in the production of lithium-ion battery subcomponents, including cathodes, anodes, separators, and electrolytes. According to DOE and the International Energy Agency (IEA), China produces over 60 percent of global lithium ion battery subcomponents, while U.S. production of these battery precursors is quite limited, as illustrated in the table below.\textsuperscript{14 15} This means that raw or refined minerals are sent to China, developed into battery cell

\textsuperscript{13} International Trade Centre (organization with joint mandate under the World Trade Organization and the United Nations)
https://intracen.org/resources/data-and-analysis/trade-statistics
\textsuperscript{15} IEA, “Global Supply Chains of EV Batteries.” https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf
precursors, and then shipped to the U.S. and other countries to be manufactured as cells that are ultimately inserted in EVs sold in the United States.

<table>
<thead>
<tr>
<th>2021 Global Production Share Lithium-Ion Battery Subcomponents</th>
<th>Country</th>
<th>United States</th>
<th>China</th>
<th>Rest of World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathode</td>
<td>&lt;1%</td>
<td>63%</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>Anode</td>
<td>&lt;1%</td>
<td>84%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Separator</td>
<td>3%</td>
<td>66%</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>Electrolyte</td>
<td>7%</td>
<td>69%</td>
<td>24%</td>
<td></td>
</tr>
</tbody>
</table>

China produces 80 percent of the world’s lithium-ion battery cells as well, with the U.S. producing only 13 percent of global capacity.\(^\text{17}\) However, for EVs sold domestically, the U.S. produces 57 percent of the battery cells and 73 percent of the battery packs, according to ANL research.\(^\text{18}\) These cells contain precursors, including cathodes, anodes, separators, and electrolytes, which are primarily manufactured in China.

The current state of the lithium-ion battery supply will not be able to support the rapid growth in demand for electric vehicles. Therefore, the U.S. is investing heavily in battery cell and pack manufacturing, spurred by domestic policies such as the incentives in the Inflation Reduction Act. The map below illustrates the size of lithium-ion battery production worldwide and highlights in red China’s very large share of the market as of 2021. The map also shows U.S. present and future capacity; the darker blue shade represents U.S. capacity in 2021 and the lighter blue shade represents projected U.S. capacity in 2025. Much of this projected growth is attributed to the expected expansion of annual battery manufacturing capacity in the U.S., from 59 GWh at the end of 2020 to 656 GWh by 2025.\(^\text{19}\) U.S. battery manufacturing capacity in 2025 should therefore support approximately 6.9 million EVs in annual production (significantly exceeding the capacity required for the most aggressive domestic EV demand projections made by the International Energy Agency\(^\text{20}\)). Nevertheless, the U.S. is projected to continue relying on other countries, including China for raw and refined minerals and battery cell precursors.


The Department anticipates the competition for EV production components to be an ongoing issue for supply chain security. The Department has developed an internal “Lithium Battery Strategy 2023-2030” that details the concerns and approaches to this supply chain in more detail.\textsuperscript{22} As noted in the report, “The Communist Party of China (CPC) specifically proclaimed the strategic goal of dominating the global battery supply chain in its Made in China 2025 strategy and Belt and Road Initiative (BRI), with the intention of challenging industry in the U.S. and its allies, including the U.S. automotive sector. The U.S. and its allies are presently working to correct this imbalance but are far behind, despite the efforts of many U.S. Government agencies.\textsuperscript{23}”

**ICE, Biofuel, and HFCV Supply Chain and Chinese Component Sourcing:**

The overall vehicle market is part of a complex global supply chain, and certain vehicle parts, critically semiconductors and instrument control panels, are produced heavily in China. However, the U.S. imports semiconductors most heavily from Malaysia.\textsuperscript{24} All motor vehicles,


\textsuperscript{23} Simon Moores, Managing Director of Benchmark Mineral Intelligence, written testimony to U.S. Senate Committee on Energy and Natural Resources, June 24, 2020.

\textsuperscript{24} International Trade Centre (organization with joint mandate under the World Trade Organization and the United Nations) \textit{https://intracen.org/resources/data-and-analysis/trade-statistics}
regardless of fuel type, rely heavily on semiconductors to power electronic control modules (ECMs or small computers that control nearly every aspect of modern vehicle functionality). These components incur similar costs and present similar risks as they are consistent across vehicle fuel types.

**Figure 20: Semiconductor Imports to United States in 2021**
*Data source: International Trade Centre (under WTO); Graph: DoD*

Gasoline, diesel, electric, biofuel, and hydrogen vehicles differ primarily in their drivetrains, energy consumed for propulsion, and energy storage systems. The following figures from the U.S. DOE illustrate the primary differences between vehicles of different fuel types.
Advanced-biofuel-powered vehicles are either flexible fuel vehicles that combust ethanol, or diesel vehicles that combust biodiesel or renewable diesel. In either case, the vehicles themselves differ minimally from other gasoline or diesel ICE vehicles. For example, vehicles designed for high mixtures of ethanol or biodiesel (e.g., E85 or B99) typically incorporate components into their fueling systems like hardened valves and valve seats that better resist corrosion. EVs and HFCVs vary more significantly. The differences are summarized below.

<table>
<thead>
<tr>
<th>Function</th>
<th>Petroleum Vehicles</th>
<th>Biofuel Vehicles</th>
<th>EVs</th>
<th>HFCVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fueling system</td>
<td>Petroleum fuel filler</td>
<td>Biofuel filler</td>
<td>Electric charger</td>
<td>Hydrogen fuel filler</td>
</tr>
<tr>
<td>Fuel storage</td>
<td>Petroleum fuel tank</td>
<td>Flexible fuel tank</td>
<td>Traction battery pack</td>
<td>Hydrogen fuel tank</td>
</tr>
<tr>
<td>Fuel conversion</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Fuel cell stack</td>
</tr>
<tr>
<td>Propulsion</td>
<td>Internal combustion engine</td>
<td>Internal combustion engine</td>
<td>Electric motor</td>
<td>Electric motor</td>
</tr>
<tr>
<td>Transmission</td>
<td>5-10 speed transmission typical</td>
<td>5-10 speed transmission typical</td>
<td>1-2 speed transmission typical</td>
<td>1-2 speed transmission typical</td>
</tr>
<tr>
<td>Local pollution control</td>
<td>Emission control systems</td>
<td>Emission control systems</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Engines, motors, and transmissions are commonly developed and produced by the vehicle manufacturer (e.g., General Motors, Ford, and Chrysler). Like the vehicle assembly, much of this production occurs within the North American Free Trade Agreement region, but not all. Cars.com publishes an American Made Index, based on NHTSA (National Highway Traffic...
Safety Administration) American Automobile Labeling Act Reports, that ranks which cars are most American, accounting for location(s) of final assembly, percentage of U.S. and Canadian parts, countries of origin for all available engines, countries of origin for all available transmissions, and U.S. manufacturing workforce. The Tesla battery electric models Y and 3 ranked first and second in 2022,25 and the list below ranks manufacturers according to the same criteria.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Vehicle Make(s)</th>
<th>% American Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tesla Inc.</td>
<td>Tesla</td>
<td>100.0%</td>
</tr>
<tr>
<td>2</td>
<td>Stellantis N.V.</td>
<td>Alfa Romeo, Chrysler, Dodge, Fiat, Jeep, Maserati, Ram</td>
<td>72.3%</td>
</tr>
<tr>
<td>3</td>
<td>Ford Motor Co.</td>
<td>Ford, Lincoln</td>
<td>70.8%</td>
</tr>
<tr>
<td>4</td>
<td>Honda Motor Co. Ltd.</td>
<td>Acura, Honda</td>
<td>69.4%</td>
</tr>
<tr>
<td>5</td>
<td>Renault-Nissan-Mitsubishi Alliance</td>
<td>Infiniti, Mitsubishi, Nissan</td>
<td>56.0%</td>
</tr>
<tr>
<td>6</td>
<td>General Motors Co.</td>
<td>Buick, Cadillac, Chevrolet, GMC</td>
<td>55.8%</td>
</tr>
<tr>
<td>7</td>
<td>Subaru Corp.</td>
<td>Subaru</td>
<td>54.7%</td>
</tr>
<tr>
<td>8</td>
<td>BMW AG</td>
<td>BMW, Mini, Rolls-Royce</td>
<td>52.8%</td>
</tr>
<tr>
<td>9</td>
<td>Toyota Motor Corp.</td>
<td>Lexus, Toyota</td>
<td>47.5%</td>
</tr>
<tr>
<td>10</td>
<td>Mercedes-Benz AG</td>
<td>Mercedes-Benz</td>
<td>41.0%</td>
</tr>
<tr>
<td>11</td>
<td>Hyundai Motor Co. Ltd.</td>
<td>Genesis, Hyundai, Kia</td>
<td>40.1%</td>
</tr>
<tr>
<td>12</td>
<td>Volkswagen AG</td>
<td>Audi, Bentley, Bugatti, Lamborghini, Porsche, Volkswagen</td>
<td>18.7%</td>
</tr>
<tr>
<td>13</td>
<td>Zhejiang Geely Holding Group Co. Ltd.</td>
<td>Lotus, Polestar, Volvo</td>
<td>5.7%</td>
</tr>
<tr>
<td>14</td>
<td>Ferrari N.V.</td>
<td>Ferrari</td>
<td>0.0%</td>
</tr>
<tr>
<td>15</td>
<td>Mazda Motor Corp.</td>
<td>Mazda</td>
<td>0.0%</td>
</tr>
<tr>
<td>16</td>
<td>McLaren Group Ltd.</td>
<td>McLaren</td>
<td>0.0%</td>
</tr>
<tr>
<td>17</td>
<td>Tata Motors Ltd.</td>
<td>Jaguar, Land Rover</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

The primary minerals present in ICE vehicles, biofuel vehicles, and hydrogen FCEVs that are not common in EVs are platinum, palladium, and rhodium, categorized under a joint code by the World Bank that also includes iridium, osmium, and ruthenium. These minerals are used in emission control systems and hydrogen fuel stacks. The primary exporters of these minerals to the U.S. are smaller countries in Asia as well as South Africa, Russia, and several European countries.26


Cybersecurity Risks

3. An assessment of the security risks associated with data collection conducted with respect to electric vehicles, combustion engine vehicles, and the related computer systems for each.

Response:

Modern vehicle cybersecurity risks are relatively similar across all drivetrain types, with most of the potential risks resulting from communications and automation, as opposed to the vehicle drivetrain, as outlined in the figure below.

Cybersecurity risks associated with EVSE are exclusive to network connected EVSE (typically a cellular connection) and non-networked EVSE pose little to no cybersecurity risks. If network connected EVSE are required for managed charging or transaction processing to support workplace charging of personally owned vehicles, solutions like encrypted communications and the avoidance of physical access ports on the EVSE can mitigate these risks. Additionally, all of
the cloud connected EVSE options on the GSA blanket purchase agreement are currently undergoing the process for FedRamp approval, which would further mitigate these risks.

**Current Range Requirements**

4. **An assessment of the current range requirements for electric vehicles compared to combustion engine vehicles and the average life of vehicles of the Department necessary to maintain current readiness requirements of the Department.**

Response:

Current EV ranges are sufficient to support most DoD missions. Most DoD vehicles operate on base and travel less than 50 miles per day. The current average range for EV’s is 250 miles per charge. The range of current light-duty BEVs, PHEVs and ICE vehicles on the FY 2023 GSA schedule are listed below for comparison purposes.

- BEVs average 262 miles of driving range, with some as high as 400 miles. These range averages are expected to increase based on industry trends of older low-range EVs being phased out and replaced by longer range EVs.

- PHEVs have an average all-electric range of more than 25 miles with a total range of 370-640 miles.

- ICE vehicles have an average total range of more than 400 miles on a full tank of gas.

DoD will not assign an EV to a mission that it cannot perform.

**Costs and Benefits to Falling Behind Industry Trends**

6. **An assessment of the mid- and long-term costs and benefits to the Department of falling behind industry trends related to the adoption of alternative fuel vehicles including electric vehicles, hydrogen-powered vehicles, and advanced-biofuel-powered vehicles**

Response:

In the long term, the Department sees financial advantages, as well as resilience and operational benefits, from adoption of alternative fuel vehicles, and EVs in particular. Many electric vehicle models are already cheaper to own and operate than ICE counterparts, and their batteries could feed power back to microgrids when not needed for missions. Falling behind industry trends

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27 General Services Administration. EVSE Blanket Purchase Agreements. [https://www.gsa.gov/cdnstatic/EVSE%20BPA%20Fact%20Sheet_FY22_June%202022%200.pdf](https://www.gsa.gov/cdnstatic/EVSE%20BPA%20Fact%20Sheet_FY22_June%202022%200.pdf)

related to the adoption of alternative fuel vehicles could result in higher total cost of ownership for the Department fleet due to fuel and maintenance costs as detailed in Section 1.

The initial years of fleet electrification will require additional expenditures related to the installation of Electric Vehicle Charging Infrastructure, expenditures that would not be required were the Department to retain only ICE vehicles. The costs associated with infrastructure upgrades should be viewed as an investment to prepare for a future where EV’s predominate the market.

Industry forecasts indicate that EV sales will grow from 7 percent of total new passenger vehicle sales in the U.S. will accelerate between the present and 2030, growing to between 15 percent and 50 percent by 2030 to over 60 percent by 2035. Bloomberg New Energy Finance projects that hydrogen vehicles and advanced biofuel powered vehicles will play a smaller role in the alternative fuel vehicle space in the next 5-10 years.

If the Department falls behind industry trends, then it would fail to realize financial advantages, enhanced resilience, and operational benefits from the adoption of alternative fuel vehicles, and EVs in particular. Hydrogen fuel cells hold promise for medium and heavy-duty vehicles as well as off-grid operations, silent running, and power off-take.

Long Term Availability for ICE Engines/Spare Parts

7. An assessment of the long-term availability to the Department of internal combustion engines and spare parts for such engines, including whether or not such engines and spare parts will be manufactured in the U.S. or repairable with parts made in the U.S. and labor in the U.S.

Response:

The Department anticipates that in the mid to long term, access to internal combustion engines, vehicles and spares will decline, based on industry projections.

Automotive manufacturers have announced significant plans to electrify their vehicle fleets sold in the U.S., and several states have established timelines for phasing out the sale of ICE

32 General Motors. “Our Path to an All-Electric Future.” https://www.gm.com/electric-vehicles
vehicles.\textsuperscript{34, 35} However, Bloomberg New Energy Finance projects that over 20 percent of new passenger vehicle sales in the U.S. will still be ICE vehicles in 2040.\textsuperscript{36}

The overall parts market is expected to continue supplying ICE engines and parts as long as ICE vehicles are sold in the U.S., but prices for those parts could increase as the production of ICE vehicles decreases.

**Risks of Storing Vehicles Inside Parking Structures**

8. An assessment of the relative risks associated with parking and storing electric vehicles, hydrogen-powered vehicles, advanced-biofuel-powered vehicles, and combustion engine vehicles inside parking structures, including fire risk and water damage

Response:

The Department assesses that there is no additional fire risk to storing EVs or Hydrogen powered vehicles as compared with ICE vehicles. EVs have been documented to have a significantly lower rate of fire compared to other types of vehicles.

Analysis completed in 2022 by an insurance company\textsuperscript{37} calculated the rate of fires by fuel type from data compiled by the National Transportation Safety Board (NTSB) and vehicle sale information provided by the Bureau of Transportation Statistics (BTS). As shown in the table below, hybrid vehicles were found to have the highest rate of fires, gas powered vehicles were second, and BEVs were third with only 25 fires per 100,000 sales reported.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Fires per 100k Sales</th>
<th>Total Fires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid</td>
<td>3,274.5</td>
<td>16,051</td>
</tr>
<tr>
<td>Gas</td>
<td>1,529.9</td>
<td>199,533</td>
</tr>
<tr>
<td>Electric</td>
<td>25.1</td>
<td>52</td>
</tr>
</tbody>
</table>

In July 2020, the Fire Protection Research Foundation (an affiliate of the National Fire Protection Association [NFPA]) completed a comprehensive study titled *Modern Vehicle Hazards in Parking Structures and Vehicle Carriers*. The study found that modern vehicles (regardless of drivetrain) are designed with more plastics and other combustible materials that leads to faster flame spread within the vehicle, easier ignition and more rapid fire spread to neighboring vehicles. The study also noted that BEVs have not been shown in testing to yield

\textsuperscript{34} California Air Resources Board. “California moves to accelerate to 100% new zero-emission vehicle sales by 2035.” \url{https://ww2.arb.ca.gov/news/california-moves-accelerate-100-new-zero-emission-vehicle-sales-2035}


\textsuperscript{36} Bloomberg NEF. “Electric Vehicle Outlook.” \url{https://about.bnef.com/electric-vehicle-outlook/}

larger fires than ICE vehicles of similar size and design. However, lithium-ion battery fires have
different burn characteristics and present different challenges for firefighters as large amounts of
water are required to cool the battery unit for an extended time to prevent reignition.38

The DOE publishes information about EV water and fire safety and related issues on the
Alternative Fuel Data Center:

EVs and HEVs have high-voltage electrical systems that typically range from 100 to 600
volts. Their battery packs are encased in sealed shells and meet testing standards that
subject batteries to conditions such as overcharge, vibration, extreme temperatures, short
circuit, humidity, fire, collision, and water immersion. Manufacturers design these
vehicles with insulated high-voltage lines and safety features that deactivate the electrical
system when they detect a collision or short circuit.39

Although battery packs are sealed, there have been instances of the batteries becoming flooded.40
The flooding can short-circuit lithium-ion batteries, cause thermal runaway, and generate a fire.
DoD Directive-type Memorandum (DTM) 22-003, “Flood Hazard Area Management for DoD
Installations,” attempts to eliminate vehicle parking and other operations in flood zones to the
maximum extent possible.41

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/media/Files/News-and-Research/Fire-statistics-and-reports/Building-and-life-safety/RFModernVehicleHazards-in-
ParkingGarages.pdf
40 USA Today. “Something surprising can cause electric vehicles to catch on fire. Here's what experts want you to know.”
https://www.usatoday.com/story/money/cars/2022/10/26/electric-vehicle-fires-florida-flooding-what-happened/10553207002/
Management for DoD Installations”.” https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dtm/DTM-22-
003.PDF?ver=AJgBy7aXkhVQL9Ludt5N-g%3D%3D
Appendix I – Report Language from the Law

This appendix includes the relevant language excerpted from the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (Public Law 117-263), Section 328:

SEC. 328. LIMITATION ON REPLACEMENT OF NON-TACTICAL VEHICLE FLEET OF DEPARTMENT OF DEFENSE WITH ELECTRIC VEHICLES, ADVANCED-BIOFUEL-POWERED VEHICLES, OR HYDROGEN-POWERED VEHICLES.

(a) In General.—Until the date on which the Secretary of Defense submits to the Committees on Armed Services of the House of Representatives and the Senate the report described in subsection (b), the Secretary may not enter into an indefinite delivery-indefinite quantity delivery order contract to procure and replace the existing non-tactical vehicle fleet of the Department of Defense with electric vehicles, advanced-biofuel-powered vehicles, or hydrogen-powered vehicles.

(b) Elements.—The report described in this subsection shall include the following:

1. A cost estimate for the procurement by the Secretary of Defense, or through contract mechanisms used by the Department (such as energy savings performance contracts), of electric non-tactical vehicles to replace the existing non-tactical vehicle fleet of the Department, which shall include—
   A) an estimated cost per unit and number of units to be procured of each type of electric non-tactical vehicle (such as trucks, buses, and vans);
   B) the cost associated with building the required infrastructure to support electric non-tactical vehicles, including charging stations and electric grid requirements;
   C) a lifecycle cost comparison between electric vehicles and combustion engine vehicles of each type (such as an electric truck versus a conventional truck);
   D) maintenance requirements of electric vehicles compared to combustion engine vehicles; and
   E) for each military department, a cost comparison over periods of three, five, and 10 years of pursuing an electric non-tactical vehicle fleet versus continuing with combustion engine non-tactical vehicles.

2. An assessment of the current and projected supply chain shortfalls, including critical minerals, for electric vehicles and combustion engine vehicles.

3. An assessment of the security risks associated with data collection conducted with respect to electric vehicles, combustion engine vehicles, and the related computer systems for each.

4. An assessment of the current range requirements for electric vehicles compared to combustion engine vehicles and the average life of vehicles of the Department necessary to maintain current readiness requirements of the Department.

5. An identification of components for electric non-tactical vehicles, advanced-biofuel-powered vehicles, hydrogen-powered vehicles, and combustion engine vehicles that are currently being sourced from the People’s Republic of China.

6. An assessment of the mid- and long-term costs and benefits to the Department of falling behind industry trends related to the adoption of alternative fuel vehicles including electric vehicles, hydrogen-powered vehicles, and advanced-biofuel-powered vehicles.
(7) An assessment of the long-term availability to the Department of internal combustion engines and spare parts for such engines, including whether or not such engines and spare parts will be manufactured in the United States or repairable with parts made in the United States and labor in the United States.

(8) An assessment of the relative risks associated with parking and storing electric vehicles, hydrogen-powered vehicles, advanced-biofuel-powered vehicles, and combustion engine vehicles inside parking structures, including fire risk and water damage.

(c) ADDITIONAL PROHIBITION.—None of the funds authorized to be appropriated by this Act or otherwise made available for the Department of Defense may be obligated or expended to procure non-tactical vehicles that are electric vehicles, advanced-biofuel-powered vehicles, or hydrogen-powered vehicles, or any components or spare parts associated with such vehicles, that are not in compliance with subpart 22.15 of the Federal Acquisition Regulation (or any successor regulations).

(d) DEFINITIONS.—In this section:

(1) The term “advanced-biofuel-powered vehicle” includes a vehicle that uses a fuel described in section 9001(3)(A) of the Farm Security and Rural Investment Act of 2002 (7 U.S.C. 8101(3)(A)).

(2) The term “charging station” means a parking space with electric vehicle supply equipment that supplies electric energy for the recharging of electric vehicles with at least a level two charger.

(3) The term “electric grid requirements” means the power grid and infrastructure requirements needed to support plug-in electric vehicles and vehicle-to-grid requirements.

(4) The term “electric non-tactical vehicle” means a non-tactical vehicle that is an electric vehicle.

(5) The term “electric vehicle” includes—

(A) a plug-in hybrid electric vehicle that uses a combination of electric and gas powered engine that can use either gasoline or electricity as a fuel source; and

(B) a plug-in electric vehicle that runs solely on electricity and does not contain an internal combustion engine or gas tank.

(6) The term “hydrogen-powered vehicle” means a vehicle that uses hydrogen as the main source of motive power, either through a fuel cell or internal combustion.

(7) The term “non-tactical vehicle” means a vehicle other than a tactical vehicle.

(8) The term “tactical vehicle” means a motor vehicle designed to military specification, or a commercial design motor vehicle modified to military specification, to provide direct transportation support of combat or tactical operations, or for the training of personnel for such operations.