



Energy Program

WASHINGTON STATE UNIVERSITY

Our Mission

To advance environmental and economic well-being by providing unmatched energy services, products, education and information based on world-class research.

About Us

Our staff of energy engineers, energy specialists, technical experts and software developers work out of Olympia, Washington.

The WSU Energy Program is a self-supported department within the University.

Within WSU

We are part of the College of Agricultural, Human and Natural Resource Sciences.

Our Director, Todd Currier, reports to the Associate Dean of the College.

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An electric vehicle fleet charging station integrated with solar power generation.

Attention Resource Conservation Managers

Get Started on Transportation Electrification

An enormous and rapid shift is underway in the transportation sector to reduce CO₂ emissions from fossil fuels and move to low carbon sources. Washington State seeks to reduce all climate pollution 50% in the next nine years and have net-zero emissions by 2050. Transportation is the largest source of climate pollution and the focus of many efforts to meet these goals. Additionally, transportation electrification (TE) can deliver critical social benefits beyond emissions reductions and cost savings, such as community health and transportation equity. Much of the TE effort will target public transportation, but individuals as well as public vehicle fleets will see big changes. This document targets public organizations who are considering, or already planning to electrify their fleets. There are significant gains to be made by starting this process early, including cost savings, improved energy efficiency, a reduced carbon footprint and community leadership.

RCMs and TE

Transportation electrification can represent a change in many organizational processes – planning and cross-department coordination will be important. Resource Conservation Managers or Energy Managers may not have had a significant role in fleet management in the past, but as TE continues to expand, they could be an important asset to their organization's electrification efforts. As fleets electrify, the refueling cost

for vehicles will change the organization’s electrical load. RCMs can help in many ways, including optimizing the new fleet’s operations, bridging communications with the electricity provider and tracking and reporting the energy, cost, maintenance, and emissions savings over time.

EVs Total Cost of Ownership Dropping Fast

Many electric vehicles (EVs) have reached or have nearly reached cost parity with internal combustion engine (ICE) vehicles.¹ The purchase price, however, is just one of the costs of owning and operating a vehicle over its lifetime. The Total Cost of Ownership (TCO) is a better assessment of the long-term value of a vehicle purchase. Let’s take a closer look.

Maintenance Savings

EVs use simpler and more efficient drive systems, require no oil changes and have fewer moving parts than ICE, resulting in considerably lower maintenance costs. A 2020 analysis by Consumer Reports found that drivers of EVs are saving an average of 50% on maintenance and repair over the life of their vehicles (defined as 200,000 miles) as shown in Table 1.^{2,3}

Table 1
Repair and Maintenance Costs by Vehicle Type

Vehicle Type	Maintenance Cost per Mile	Lifetime Repair Cost	Lifetime Savings vs ICE
EV	\$.03	\$4,600	\$4,600
ICE	\$.06	\$9,200	

Fuel Savings

Fueling traditional ICE fleets can represent one third of the total cost of ownership over the life of the vehicle. Petroleum fuel prices fluctuate unpredictably. Electricity prices are relatively stable and can even be offset by integrating renewable energy sources. If your utility offers lower electricity rates for charging

during off-peak times, additional savings may be possible. Energy cost for EVs compared to ICEs is shown in Table 2.⁴

Table 2
Energy Cost Comparison by Vehicle Type

Vehicle Type	Energy Cost	Avg Vehicle Fuel Efficiency	Cost per Mile	Cost over 60k miles
EV	\$.10 per kWh	3.5 miles per kWh	\$.03 per mile	\$1,800
ICE	\$3.50 per gallon	27.5 miles per gallon	\$.14 per mile	\$8,400

Emissions Reductions

There are many costs currently born across society as climate change continues to impact our lives, and these societal costs will continue to increase. Washington State has passed many laws to incentivize and regulate the reduction of GHG emissions, including a cost on all GHG emissions that will take effect in 2023.⁵ TE presents an important opportunity for organizations to show community leadership while also reducing financial exposure to future emission price uncertainties.

Glossary and Acronyms

Electric Vehicle (EV) Types

- **EV or BEV:** Battery-powered, fully electric vehicle
- **PHEV:** Plug-in hybrid vehicle with L1 or L2 charging. Internal combustion engine (ICE) with an electric motor (typically with a smaller battery) and can charge or use gas.
- **ZEV:** Zero-emission vehicle
- **FCEV:** Fuel cell electric vehicle

Charging Equipment

- **EVSE:** EV supply or service equipment or charging stations
- **OBC:** On-board charger

¹ International Council on Clean Transportation: https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

² Consumer Reports: <https://www.consumerreports.org/car-repair-maintenance/pay-less-for-vehicle-maintenance-with-an-ev/>

³ Consumer Reports: https://advocacy.consumerreports.org/press_release/electric-vehicle-owners-spending-half-as-much-on-maintenance-compared-to-gas-powered-vehicle-owners-finds-new-cr-analysis/

⁴ U.S. Dept. of Energy, Plug-In Electric Vehicle Handbook for Fleet Managers https://afdc.energy.gov/files/pdfs/pev_handbook.pdf

⁵ WA GHG reduction policies: <https://ecology.wa.gov/Air-Climate/Climate-change/Greenhouse-gases/Reducing-greenhouse-gases>



EV charging stations. Photo courtesy of King County Metro.

EVs that run only on electricity have no tailpipe emissions, however emissions may be produced by the source of electricity used to charge the vehicle. Table 3 shows annual CO₂ emissions for vehicles charged by an average electric utility in Washington State and an average U.S. utility. EVs in regions of the U.S. that depend heavily on coal for electricity generation may not demonstrate a strong emissions benefit. By the end of 2021, Washington utility-level emissions data will be available for more granular emissions analysis.^{6,7} Also, on-site renewable generation can be integrated for additional savings and improve power reliability.

Table 3
Emissions Comparison of Gasoline-powered vehicles and EVs based on average utility emissions

Avg. Annual Emissions per Vehicle, lbs. of CO ₂ e		
	U.S.	Washington State
EV charged by electric utility	3,774	1,000
Gasoline	11,435	11,435

Sum Up the Savings

A TCO analysis includes maintenance, fuel, emissions and any other costs associated with operating a vehicle over its lifespan. Increasingly these analyses are showing a widening advantage of EVs over ICEs. The **Fleet Procurement Analysis Tool** provides the ability to compare options on the financial viability and environmental impact of light-, medium-, and

⁶ U.S. Dept. of Energy Alternative Fuels Data Center, State-level EV emissions https://afdc.energy.gov/vehicles/electric_emissions.html

⁷ WA Dept. of Commerce Fuel Mix Disclosure utility emissions reports, coming late 2021: <https://www.commerce.wa.gov/growing-the-economy/energy/fuel-mix-disclosure/>

heavy-duty vehicle fleet procurements: <https://atlaspolicy.com/rand/fleet-procurement-analysis-tool/>

Planning for and Implementing EV On-site Charging

Initial Planning

As you prepare to include EVs in your fleet, assess your organization's readiness to commit to an electrification strategy. The **Washington Green**



Transportation Program (GTP) is developing a resource for public fleets called **Fleet Electrification: Determining Infrastructure**

Needs for EV Charging which will be available at the GTP website in late 2021 (<http://www.energy.wsu.edu/GreenTransportationProgram.aspx>). Your organization will need to discuss, finalize and approve plans, up to the top-level decision makers. Planning for EVs may involve a variety of departments, leaders and managers within an organization that may not often be involved in fleet management or fueling decisions.

Ideally the team would include:

- Fleet owner or manager
- Facility owner
- RCM, energy or sustainability manager
- Site design planner
- Electrical contractor or on-site electrician
- Electric utility representative
- Vehicle procurement lead
- Parking enforcement lead
- Employee training or public outreach specialist

When the stakeholders have been identified, and goals, timelines and budgets established, the team would begin gathering data and developing a pre-site assessment by determining the following:

- What is the current vehicle maintenance and replacement process? What are current fuel and maintenance costs? How are vehicles currently refueling?
- Do garage or parking lot support personnel play a role in refueling or do the employees re-fuel 100% of the time? Will the public have access to vehicle charging equipment?

Charging Types ^{8,9}

Type	Voltage	Max Capacity (kW)	Avg Charging Rate	Avg Time to Recharge (depends on battery size)
Level 1 (L1)	120	1.2 kW of AC power, standard 30 A, 120 V outlet	2 to 5 miles per 1 hr of charging (depending on environmental conditions and % of battery charge)	Typically 8 hrs to replenish about 40 miles of driving range
Level 2 (L2)	240	Delivers up to 19.2 kW of AC power to a vehicle. Typically delivers about 7 kW from a 30 A, 240 V circuit	10 to 20 miles per 1 hr of charging (chargers wired to 50 A provide even faster charging)	Typically charges a vehicle in 4 to 6 hours
DC Fast Charger (DCFC)	240-550	Typically delivers 50 kW or more of DC power to a vehicle. Most DCFC deployed for public charging deliver up to 150 kW. High-powered DCFC used for fast-charging medium- and heavy-duty vehicles can deliver 350-500 kW.	At least 60 miles per 20 minutes of charging. Charging time may be shorter depending on station power.	Typically charges up to 80% in about 30 minutes

The pre-site assessment includes an initial TCO analysis to identify good EV candidates and help determine which vehicles to electrify first. The ***Fleet Procurement Analysis Tool*** (referenced above) will be helpful at this stage as well.

Steps to Electrification

The Washington GTP Fleet Electrification guide lays out several steps involved in the TE Master Plan. This document summarizes the full report.

Estimate New EV Demand

The fleet load profile determines the charging infrastructure required to meet driving needs.

- Determine the duty cycle and drive cycle for the vehicles planned for replacement.
- Compare and select EVs to replace current vehicles by make, model, and battery size.
- Estimate the electrical capacity needed to charge the new EVs (the new fleet “load profile”).
 - Estimate the EVs’ energy needed per charge per vehicle.
 - Determine the duty cycle of each EV (likely based on the duty cycle of the vehicle it is replacing).
 - Determine the EV’s charging window.
 - Sum the energy needs of each EV based on its charging window. This will provide the total fleet charging energy requirement, or the fleet load profile. The **fleet load profile** will be dynamic but will give a better understanding of the electrical needs for charging the new vehicles.

All commercially available plug-in electric vehicles have the ability to charge using L1 and L2 charging equipment.

Preliminary Layout and Timeline

Create a draft layout and map the initial parking and EV charging stations.

- Determine which electrical panel(s) will be used.
- Determine the proximity of the charging stations to the electrical power service. Placing the charging equipment near an existing power supply will reduce cost and time for installation. The electric utility may have valuable advice on laying out charging stations.
- Based on the layout, draft a parking plan for the EVs deployed.
- Identify operating issues, costs, or fees that may play a role in charging location. Consider a shared revenue model with workplace and public charging.
- If networked charging is planned, ensure the location has adequate cell connection.

⁸ U.S. EPA: <https://www.epa.gov/greenvehicles/plug-electric-vehicle-charging>

⁹ U.S. Dept of Energy: https://afdc.energy.gov/fuels/electricity_infrastructure.html



The City of Olympia charging stations serve city fleet vehicles and the public.

EV Fleet Operations Concepts

The **fleet (or vehicle) duty-cycle** is the time of day the fleet (or vehicle) may be in use. Additional duty-cycle information could include the hours or shifts per day, days per week, total miles per cycle and average or peak load profiles.

The **fleet (or vehicle) drive-cycle** is different – this includes the maximum and average speeds, number of stops, idle time, etc.

The **charging window** is the period of time in the fleet's duty cycle when vehicles can charge.

Estimate Electrical Load

Once an initial charging station layout has been drafted, determine the electrical charging capacity of the specific site or location. An electrician will complete a load calculation for each electric panel or service in proximity to planned charging stations.

Engage the Electric Utility

Connect with the electric utility to gain an understanding of tools and data that they can offer to support the charging infrastructure installation. Determine specifics related to the facility or site that requires panel, transformer, electric distribution line, or substation level upgrades leading to significant cost or timeline implications. Inquire if they offer charging station support, incentives toward capital investments, or operational support. Do they provide, own, or manage the hardware for charging? Utilities play an important role and can be an ally with early project development and may incentivize fleet electrification.

Engage an Electrical Contractor

Confirm the site layout plan. This will create an electrical upgrade estimate and validates sufficient information is gathered to ensure the most cost-effective hardware installation for the site.

Schematics and Budget

Finalize the design for vehicle parking and charging; use this to determine associated site installation costs, and the final timeline. Map the parking layout and add the fleet schematic electrical load profile analysis. Illustrate the final design to create a final fleet schematic. Combine the preliminary layout, hardware specifications, and electrical specifications to prepare the budget and timeline, and create construction plans. Ensure you meet all applicable EV readiness codes or ordinances.

Plan Purchases

The material gathered when creating the schematics and budget enables the procurement team to initiate the purchase order (PO) or Request for Proposal. Include vendor contact, quantity, and specific L2 or DCFC hardware warranty and network requirements (see *Charging Type* sidebar). Ensure the manufacturer warranties, technical support, and training services provided are robust and will meet your organization's needs.

- ⇒ Remember that greater efficiency equals greater savings! Check out the U.S. Department of Energy, Energy Star® website for guidance on charger selection: https://www.energystar.gov/products/other/ev_chargers
- ⇒ Washington State Department of Enterprise Services Electric Vehicle Supply Equipment Procurement Contract Information: <https://apps.des.wa.gov/DESContracts/Home/ContractSummary/04016>

- ⇒ BE CAUTIOUS of proprietary charging and equipment that may not match the rest of your equipment. Also beware of warranties that restrict in-house maintenance. Pay close attention to maintenance service agreements, technical support, access to diagnostic tools and equipment training provided by manufacturers or dealers.

Engage Contractor

Compile construction specifics for facility or parking. Identify site work to be completed for charging infrastructure installation not included in the earlier electrical design and planning, such as earthmoving, concrete, paving, and landscape work. Create a list of non-electrical permits, inspection timelines and fees. Develop contracts.

Plan for Implementation, Driver Engagement & Operations

As with any new technology, the new fleet is an organizational change. Prepare employees and management for vehicle adoption, study fleet process changes due to the addition of the electric cars in the

fleet, and employ any new checkout or changes due to charging in parking areas.

- Track efficiency savings for all fleet improvements, analyze the TCO. Create a report and illustration of the data collected – fuel, maintenance, cost, and emission results.
- Networked EVSE can capture clean fuels and Clean Fuels/Low Carbon Fuel Standards savings and GHG tracking.
- Identify vehicle and charging station maintenance workers' training requirements. This is a new and rapidly-evolving field. Some fleet managers report finding inadequate support from equipment dealers and manufacturers. Some warranties prevent equipment purchasers from servicing their equipment in-house. Ensure any equipment purchases have clearly defined warranties and provide adequate support as your organization adapts to new technology. Some automotive or electrical programs in community and technical colleges are beginning to provide training, as are some electrical unions.



Washington

Green Transportation Program

Moving forward with Washington's public fleets

Resources from the Washington Green Transportation Program

<http://www.energy.wsu.edu/GreenTransportationProgram.aspx>

The Washington Green Transportation Program (GTP) provides technical assistance and education to public agencies, including local governments on the use of alternative fuels and vehicles. The program provides:

- Support for the adoption of passenger electric vehicles (EVs) and installation of more EV infrastructure by cities, towns, and public agencies.
- Support for the adoption of electrification of public medium- and heavy-duty vehicles in public fleets.
- Promotes innovations in green transportation that are relevant to Washington communities.

Resources available at the GTP website include:

Educational opportunities, funding opportunities, news about technology advances, access to the Alt-Fuels-Vehicles Technical Assistance Group (AFV-TAG), highlights of successful public fleet projects, and policy and research updates.

Subscribe to the GTP communications list to stay up to date.

- Provide training and education about best practices for EV drivers and charging station users.
 - Clean Cities Coalition has developed a Workplace Charging Employer Workshop Toolkit: <https://cleancities.energy.gov/technical-assistance/workplace-charging/>
 - U.S. EPA posted a Webinar on state and local government experiences with workplace EV charging: <https://www.epa.gov/statelocalenergy/webinar-state-and-local-government-experience-workplace-ev-charging>

The Future is Now

Change is coming fast to transportation electrification. Meeting Washington State's goal to reduce all climate pollution 50% in the next nine years calls for all-hands-on-deck action. Early deployment of EVs results in energy, cost, emissions and maintenance savings, while demonstrating community leadership. RCMs and Energy Managers are well positioned to help propel their agency's transportation electrification forward.

Many resources are available to support this effort, including resources listed at the Washington Green Transportation Program website. Sign up for the GTP newsletter for updates on this rapidly changing movement.

Additional Resources

- Western Washington Clean Cities Coalition Network: <https://www.wccleancities.org/>
- U.S. Dept of Energy EERE Plug-in Electric Vehicle Handbook for Fleet Managers: https://afdc.energy.gov/files/pdfs/pev_handbook.pdf
- Southern California Edison Take Charge: A Guidebook to Fleet Electrification and Infrastructure https://www.sce.com/sites/default/files/2020-07/Electrification%20%26%20Infrastructure%20Guidebook-Final_06.29.20.pdf
- Resource for estimating various EV recharging times: <https://clippercreek.com/charging-times-chart/>
- Zero-Emission bus and truck market in the U.S. and Canada: A 2020 Update Fact Sheet: <https://theicct.org/sites/default/files/publications/canada-race-to-zero-FS-may2021.pdf>

The WSU Energy Program RCM Program supports the creation and successful implementation of RCM programs in the public sector by providing program and technical support. Public sector RCMs and energy managers in the State of Washington may join the RCM listserv to receive informative monthly RCM Newsletters.

Contact **Karen Janowitz** at janowitzk@energy.wsu.edu or visit <http://www.energy.wsu.edu/PublicFacilitiesSupport/ResourceConservation.aspx>

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