# EVSE Impact on Facility Energy Use and Costs

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Need to understand EVSE charging based parameters that will impact cost

# Charging

- An EV can recharge at three power levels in increasing order:
- AC Level 1, AC Level 2, and DC fast charging. Level 1 chargers are typically located in homes and have power levels up to 1.4 kW.
- Level 2 charging have power levels up to 19.2 kW, but more typically offer charging at 3.3 kW or 6.6 kW. Level 2 stations are often located where drivers are expected to spend several hours, such as public parks and recreational areas,
- Recharging a typical EV can take 3.5 to 7 hours.

**Table 1: Charging Power Levels Based in Part on SAE Standard J1772[3]**

| Power Level Types | Charger Location | Typical Use | Energy Supply Interface | Expected Power Level | Charging Time | Vehicle Technology |
|---|---|---|---|---|---|---|
| Level 1 (Opportunity) 120 Vac (US) 230 Vac (EU) | On-board 1-phase | Charging at home or office | Convenience outlet (NEMA 5-15R/20R) | 1.4kW (12A) 1.9kW (20A) | 4-11 hours 11-36 hours | PHEVs (5-15kWh) EVs (16-50kWh) |
| Level 2 (Primary) 240 Vac (US) 400 Vac (EU) | On-board 1- or 3-phase | Charging at private or public outlets | Dedicated EVSE | 4kW (17A) 8kW (32A) 19.2 kW (80A) | 1-4 hours 2-6 hours 2-3 hours | PHEVs (5-15kWh) EVs (16-30kWh) EVs (3-50kWh) |
| Level 3 (Fast) (208-600 Vdc) | Off-Board 3-phase | Commercial, analogous to a filling station | Dedicated EVSE | 50kW 100kW | 0.4-1 hour 0.2-0.5 hour | EVs (20-50kWh) |

# Chargers

- All EVs can accept a Level 2 charge because they are currently equipped with a common connector, the Society of Automotive Engineers (SAE) J1772, which will fit a plug from a Level 2 charging station.
- However, DC fast chargers will not work with all EVs because of competing technology among equipment manufacturers.
- There are three different types of DC fast chargers, each with a unique plug designed for a different make of EV.
- CHAdeMO: developed by an association of Japanese companies and used by Nissan and Mitsubishi.
- SAE J1772 Combo: developed and adopted by the Society of Automotive Engineers in conjunction with the J1772 connector standard used for Level 2 charging and used by most American and European automakers.
- Tesla: a proprietary technology developed by Tesla Motors that is currently only compatible with Tesla vehicles.

# Charging

- An EV can be expected to travel 3.5 miles with each kilowatt-hour (kWh) of energy delivered to its batteries, equivalent to charging the vehicle at 1 kilowatt (kW) for an hour.
- Charging a vehicle at 30 kW for 30 minutes provides about 50 miles of range. Thus, the higher the power the charging station provides to the vehicle, the faster the vehicle's batteries can recharge.

# Charging

| Charging Level | Vehicle Range Added per Charging Time and Power | Supply Power |
|---|---|---|
| **AC Level 1** | 4 mi/hour @ 1.4kW<br>6 mi/hour @ 1.9kW | 120VAC/20A<br>*(12-16A continuous)* |
| **AC Level 2** | 10 mi/hour @ 3.4kW<br>20 mi/hour @ 6.6kW<br>60 mi/hour @ 19.2 kW | 208/240VAC/20-100A<br>*(16-80A continuous)* |
| **DC Fast Charging** | 24 mi/20minutes @24kW<br>50 mi/20minutes @50kW<br>90 mi/20minutes @90kW | 208/480VAC 3-phase<br>*(input current proportional to output power; ~20-400A AC)* |

# Revenue and Cost Aspects

- Charging station business models that rely solely on direct revenue from EV charging services currently are not financially feasible.
- Consider DC fast charging stations, capable of charging a Nissan LEAF to 80 percent in less than 30 minutes, and alternating current (AC) Level 2 charging stations, which can fully charge a Nissan LEAF in 3.5 to 7 hours.
- The analyses shows that investment in a single DC fast charging station results in a net loss of more than $44,000 for a private project developer (without public intervention) over a 10-year period.
- Similarly, investment in a charging site with five slower, lower powered, and lower cost alternating current (AC) Level 2 charging stations (without public intervention) results in a net loss of more than $26,000 for a private project developer over the same 10-year period.

# So what is needed to be done to make it financially viable?

- To build a business case that will attract capital and convince the private sector to invest in EV charging, total revenues must be greater than the project's total cost, and an acceptable level of profit is necessary.
- There are four general ways to improve the financial performance of charging station projects: increase revenues, decrease capital costs, decrease operating costs, and/or decrease the cost of funds for the project.
- Public intervention will help

# Approaches that may help

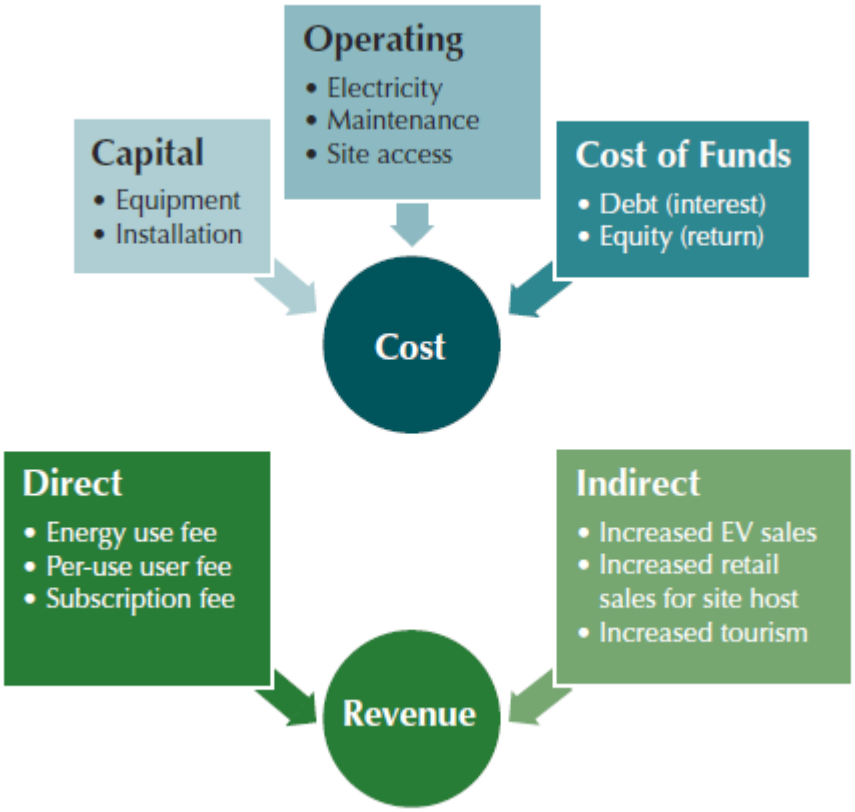
- One promising opportunity to improve the financial performance of charging station investments is to develop business models that, through private partnerships and joint investment strategies, capture other types of business value in addition to selling electricity.
- This might include tourist revenue for retailers and tourism businesses that get more sales from EV drivers when located near EV charging stations; automakers selling more EVs; and “clean energy” marketing and brand-strengthening opportunities for businesses visibly involved in EV charging deployment projects.

# An important finding

- Use of subsidies and interventions for five years can help the EV market to develop to the point where, after five years, no further public sector intervention will likely be needed to make EV charging business models profitable and sustainable.
- This key finding assumes significant growth in the number of EVs on the road (and therefore increased charging station utilization), and a decreased cost of DC fast charging station equipment.

# Cost Information

# Cost aspects



# Cost aspects

- The costs associated with owning and operating EVSE include:

- EVSE unit hardware cost, which may include:
- -- EVSE unit
- -- optional EVSE equipment (e.g., RFID card reader);
- Installation cost, which may include:
- -- contractor labor and materials for
- * connecting EVSE to the electrical service (e.g., panel work, trenching/boring, and repaving parking)
- * new electrical service or upgrades (e.g., transformers)
- * meeting Americans with Disabilities Act (ADA) requirements
- * traffic protection
- * signage

# Cost aspects

- Lighting
- -- permitting and inspection
- -- engineering review and drawings;
- Additional capital cost, which may include:
- -- hardware extended warranty
- -- repair labor warranty
- -- land/parking space purchase or lease;
- Incentive credits (to reduce equipment or installation costs), which may include:
- -- rebates
- -- tax credits/exemptions
- -- grants
- -- loans

# Cost aspects

- Operation and maintenance cost
- -- electricity consumption and demand charges
- -- EVSE network subscription to enable additional features
- -- management time
- -- billing transaction costs
- -- preventative and corrective maintenance on EVSE unit
- -- repairs (scheduled and unscheduled).

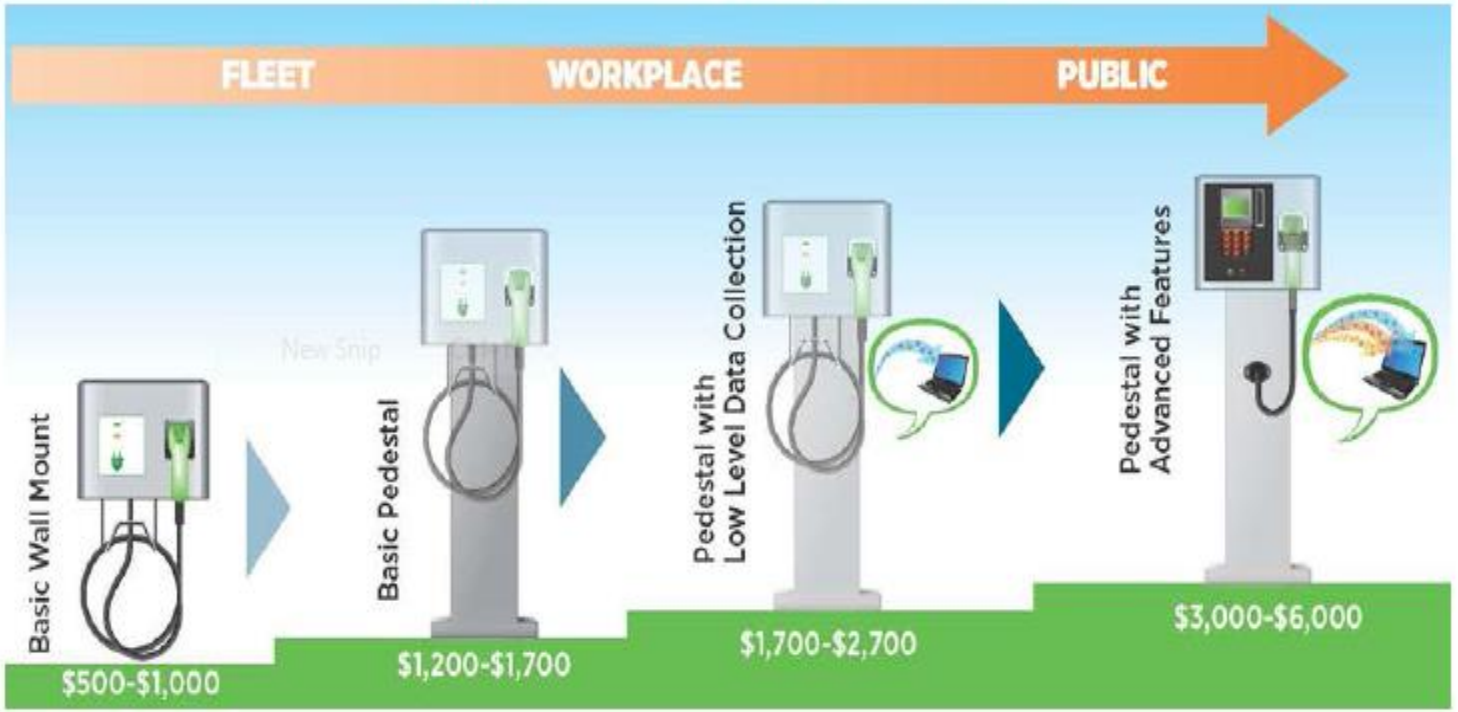
# Cost information

| COMPONENT | COST (2012) | COST (STUDY) |
|---|---|---|
| DC Fast Charging Equipment | $58,000 per unit | $35,000 per unit |
| Level 2 Charging Station Co-Located with DC Fast Charging Station | $2,500 per unit | $2,500 per unit |
| Equipment Installation (Labor and Electric-Panel Upgrade) | $26,000 per location | $26,000 per location |
| Host-Site Identification, Analysis, and Screening | $5,000 per location | $5,000 per location |
| Negotiation, Legal Review, and Execution of Lease | $6,000 per location | $6,000 per location |
| Utility Interconnection | $12,500 to $25,000 per location | $20,000 per location |
| Total | $109,500 to $122,000 | $94,500 |

# EVSE Unit Costs

| EVSE Type (single port) | EVSE Unit Cost Range |
|---|---|
| Level 1 | $300-$1,500 |
| Level 2 | $400-$6,500 |
| DCFC | $10,000-$40,000 |

## Ballpark Cost Ranges for Level 2 EVSE




Ballpark cost ranges for different tiers of Level 2 EVSE units. *Image from Kristina Rivenbark, New West Technologies.*

# Cost

- For Level 2 commercial EVSE, the installation cost break down is approximately:
- Labor: 55 - 60%
- Materials: 30 - 35%
- Permits: 5%
- Tax: 5%.

# Installation cost

**Installation Cost Drivers**

- A simple installation will be at the lower end of the cost range while a more complex installation will move toward the middle or higher end. An installation becomes more complex when it requires one or more of the following:
- Trenching or boring a long distance to lay electrical supply conduit from the transformer to the electrical panel or from the electrical panel to the charging location
- Modifying or upgrading the electrical panel to create dedicated circuits for each EVSE unit if none are already available
- Upgrading the electrical service to provide sufficient electrical capacity for the site
- Locating EVSE on parking levels above or below the level with electrical service; and/or
- Meeting ADA accessibility requirements such as ensuring the parking spaces are level.

# Wiring

- The EVSE unit is connected to the electrical service by wiring enclosed in an electrical conduit. A surface-mounted conduit can be placed along a wall or ceiling.
- If the conduit needs to run underground, such as in a parking lot, contractors will trench or bore a path for the conduit.

# Costs

- Level 2 commercial sites that required special work such as trenching or boring were about 25% more costly than those that did not need special work (EPRI 2013).
- Assuming $100 per foot to trench through concrete, lay the conduit, and refill, it would cost:
- $5,000 to trench 50 feet
- $10,000 to trench 100 feet

# Electrical needs

Three Fundamental EVSE Electrical Needs

1. A dedicated circuit for each EVSE unit on the electrical panel (in most cases).
2. Sufficient electrical capacity from the utility connection to the electrical panel.
3. Sufficient electrical capacity at the panel.

# Electrical needs

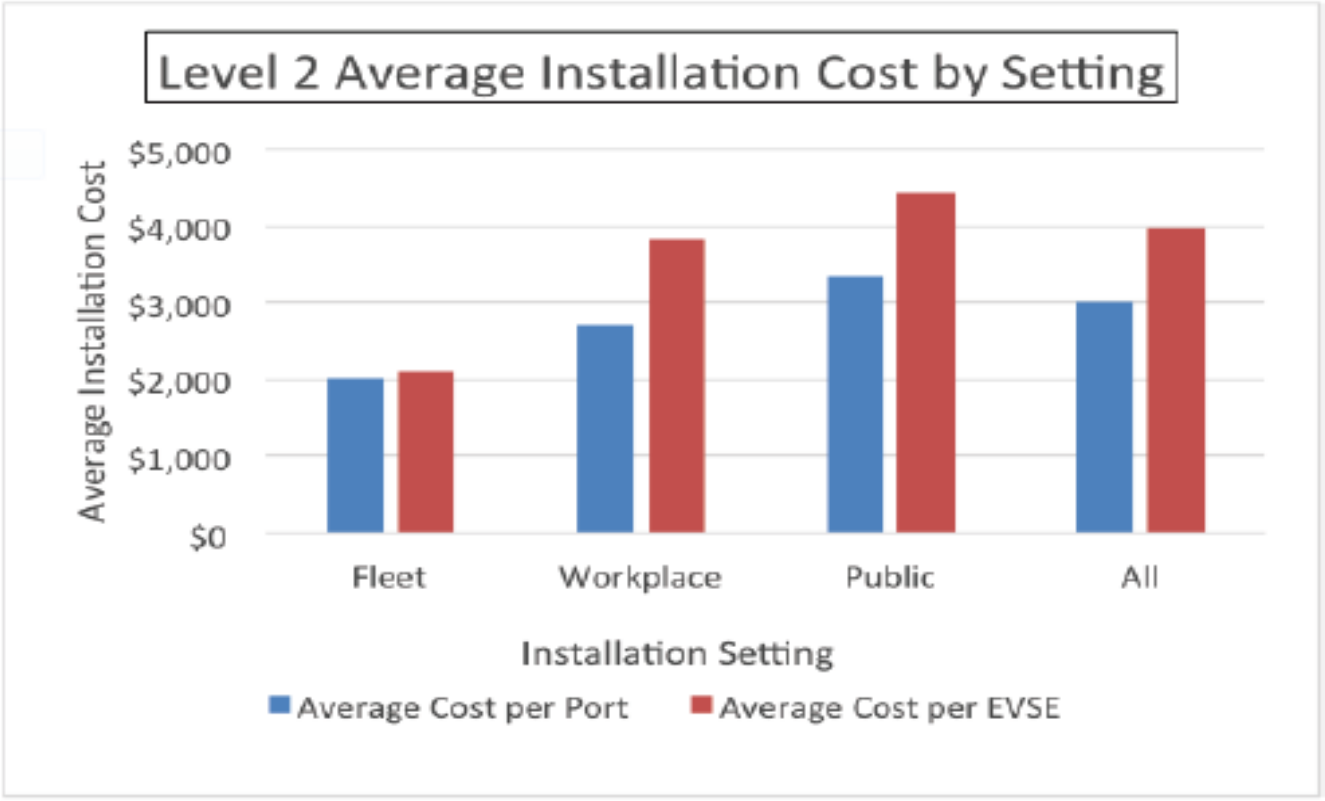
- Upgrading the electrical service for future EVSE loads and installing conduit to future EVSE locations during the initial EVSE installation can result in significant future cost savings.

# Costs

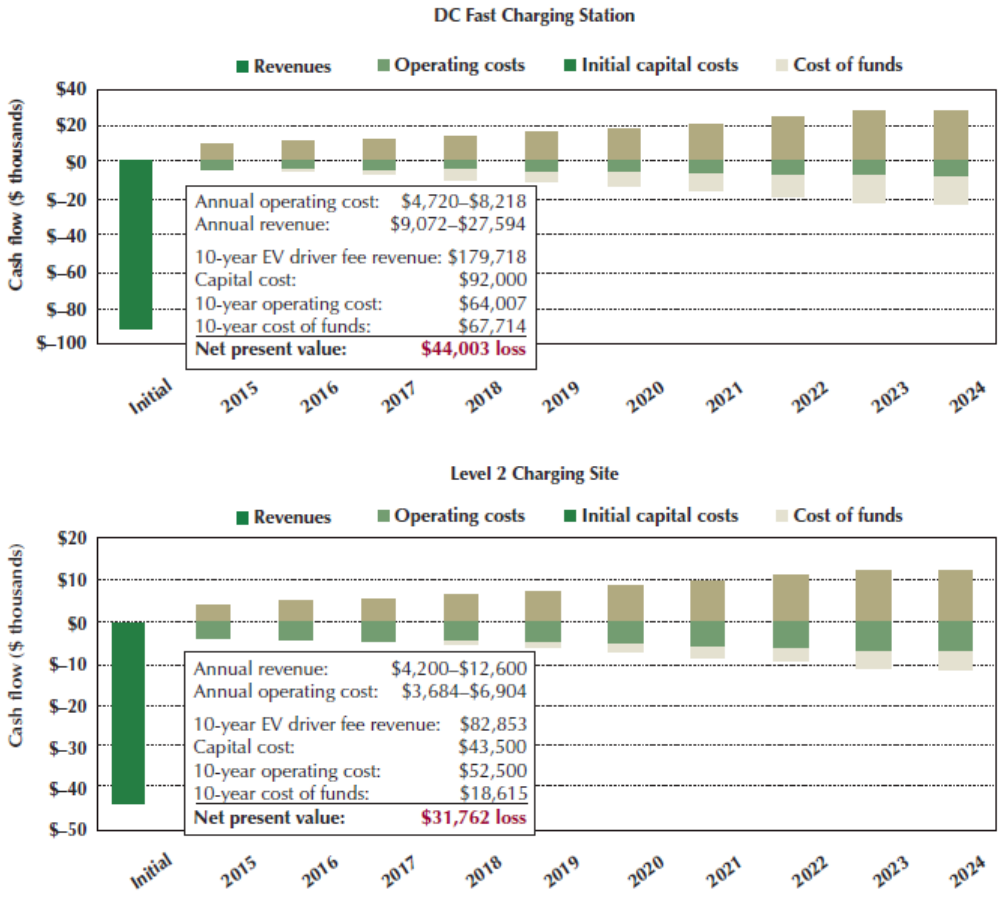
## Ballpark EVSE Installation Costs

| EVSE Type | Average Installation Cost (per unit) | Installation Cost Range (per unit) |
|---|---|---|
| **Level 1** | not available | $0-$3,000*<br>*Source: Industry Interviews* |
| **Level 2** | ~$3,000<br>*EV Project (INL 2015b)* | $600-$12,700<br>*EV Project (INL 2015b)* |
| **DCFC** | ~$21,000<br>*EV Project (INL 2015d)* | $4,000-$51,000<br>*EV Project (INL 2015d) and (OUC 2014)* |

# Costs


Level 2 Average Installation Cost by Setting
Average Installation Cost
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Fleet
Workplace
Public
All
Installation Setting
Average Cost per Port
Average Cost per EVSE

Revenues and cost - User fees were assumed to be $0.25 per kilowatt-hour for Level 2 (three times the cost of retail electricity) and $0.50 per kilowatt hour for DC fast charging (equivalent to $3.50 per gallon of gasoline).



# Stakeholder Opportunities

| | PUBLIC/GOVERNMENT | PUBLIC UTILITY DISTRICTS AND MUNICIPALLY-OWNED UTILITIES | INVESTOR-OWNED ELECTRIC UTILITIES | MERCHANT ELECTRICITY GENERATORS | DEDICATED CHARGING SERVICE PROVIDERS | CHARGING EQUIPMENT MANUFACTURERS | AUTOMAKERS | CHARGING SITE PROPERTY OWNER |
|---|---|---|---|---|---|---|---|---|
| *Vehicle Fuel Cost Savings* | x | | | | | | | |
| *Reduced Environmental and Public Health Costs* | x | x | | | | | | |
| *Economic Development from EV and Charging Station Use* | x | x | | | | | | x |
| *Increased Electricity Use* | | x | x | x | | | | |
| *More Efficient Use of off-Peak Generation Capacity* | x | x | x | x | | | | |
| *Long-Term Prospect of Vehicle-To-Building and Vehicle-To-Grid Benefits* | x | x | x | x | x | x | x | x |
| *Greater EV Sales* | | | | | | | x | |
| *Sales of EV Charging Equipment* | | | | | | x | | |
| *Increased Retail Sales from Offering Charging On-Site* | | | | | | | | x |
| *Sales of Charging Network Support Services* | | x | x | | x | | | x |

*Source: C2ES*

# Stakeholder Challenges

| | PUBLIC/ GOVERNMENT | PUBLIC UTILITY DISTRICTS AND MUNICIPALLY-OWNED UTILITIES | INVESTOR-OWNED ELECTRIC UTILITIES | MERCHANT ELECTRICITY GENERATORS | DEDICATED CHARGING SERVICE PROVIDERS | CHARGING EQUIPMENT MANUFACTURERS | AUTOMAKERS | CHARGING SITE PROPERTY OWNER |
|---|---|---|---|---|---|---|---|---|
| *Cost to Public of Charging Investment and Subsidies/ Equity Concerns* | x | x | x | | | | | |
| *High-Power Charging Impacts on Grid Reliability/Need for Distribution Upgrades* | x | x | x | | | | | |
| *Vehicle-to-Building Technology Could Reduce Demand for Grid Electricity* | | x | x | x | | | | |
| *Financial Sustainability of Charging Station Investment* | x | x | x | x | x | | | x |
| *Rate of Return of Charging Station Investment* | | | | x | x | | | |
| *Uncertain Impacts of Charging Station Deployment on EV Adoption* | x | | | | | | x | |
| *Lack of Interest in Owning and Operating Charging Infrastructure* | x | x | x | | | | x | |

*Source: C2ES*

# Energy Assessment Findings

# State Parks and Public Facility Energy assessment – Energy Costs

| Resource | Units | Rate |
|---|---|---|
| **Natural Gas** | $/Mcf | 8.44 |
| **Electricity** | $/kWh | 0.0526 |
| | $/kW | 11.508 |

| Resource | Units | Rate |
|---|---|---|
| **Natural Gas** | $/Mcf | 9.411 |
| **Electricity** | $/kWh | 0.06905 |
| | $/kW | 7.608 |

| Resource | Units | Rate |
|---|---|---|
| **Natural Gas** | $/Mcf | 8.506 |
| **Electricity** | $/kWh | 0.03927 |
| | $/kW | 16.495 |

# Findings

- Energy assessment reports for 2 of the 3 facilities has been completed
- Facility 1 can reduce baseline energy use by 18%
- Facility 2 can reduce baseline energy use by 23%
- Facility 3 report is not ready yet; estimate of savings is 15 to 20%
- Reducing baseline energy use is important to increase the economic feasibility of the project

# Findings

- Assumption
- On an average 5 vehicles with Level 2 charging per day (6.6 kW for 5 hours per day per car) and 2 vehicles with DC fast charging (50 kW for 30 minutes per day per car) per day, 350 days a year

# Findings on Cost

Annual energy cost

| Facility | Energy Cost | Demand Cost | Total Cost |
|---|---|---|---|
| 1 | $3,958 | $18,354 | $22,312 |
| 2 | $5,196 | $12,142 | $17,338 |
| 3 | $2,955 | $26,326 | $29,281 |

Other annual costs will be incurred for maintenance as per list shown earlier

# Findings

- Detailed cost based sensitivity analysis will be done for the 3 facilities based on computer simulation of car arrival patterns and other pertinent factors
- A decision support system will be developed to enable facilities to analyze cost implications of installing and operating EVSE

# References


- Business Models for Financially Sustainable EV Charging Networks, Report Authors Nick Nigro, Matt Frades, *Center for Climate and Energy Solutions, Washington State Legislature,* March 2015
- ENERGY STAR Market and Industry Scoping Report, Electric Vehicle Supply Equipment (EVSE), September 2013
- Costs Associated With Non-Residential Electric Vehicle Supply Equipment Factors to consider in the implementation of electric vehicle charging stations November 2015, Prepared by New West Technologies, LLC for the U.S. Department of Energy Vehicle, Technologies Office

Questions?