Evolution of Electric Vehicles (EV) and Infrastructure Challenges

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Electric automobile, early 20's

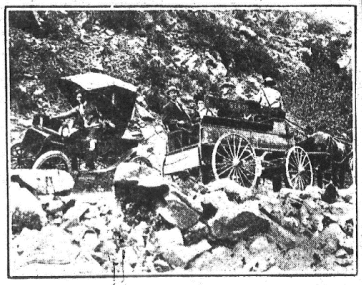
An Advertisement for the "One Hundred Mile Fritchle" (Denver Republican, December 11, 1910)

The 100-Mile Fritchle Electric Now Holds All Records for Hill Climbing, Mileage Per Charge,

Durability and Economy of Upkeep

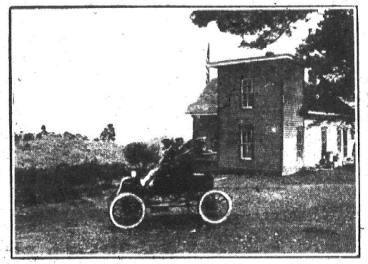
Four years ago we claimed that the 100-mile Fritchle Electric was years in advance of all competitors.

Four years ago a Fritchle Electric with a 16-cell, 600-pound Fritchle Battery made the first trip from Denver to Colorado Springs.



ELECTRIC AUTO RUN TO COLORADO SPRINGS

COLORADO SPRINGS, Colo., June 25th, 1907.—(Special.)—The first electric automobile driven from Denver to Colorado Springs, as far as known, was brought here tonight by Oliver P. Fritchle. The trip was made as the result of a wager with Denver motorists, who declared that Mr. Fritchle could not drive one of his cars to Palmer Lake on one charging of his battery. When he arrived here the odometer registered 73.5 miles. Mr. Fritchle was accompanied by a gas automobile which carried C. O. Springer, Charles Buckner, F. E. Frazier and Paul Waterman.



This feat at that time was a notable performance but the many superior feats that the later models of Fritchle Electrics have accomplished make this first one fade into insignificance.

Another stunt which was done with a regular stock car, Fritchle Electric worthy of mention at the present time was the climbing of Lookout mountain via Chimney Gulch.

LOOKOUT MOUNTAIN, JEFFERSON CO., COLO.

OLIVER P. FRITCHLE, Esq., Clarkson St., Denver, Colo.:

My Dear Sir—I wish to express my pleasurable surprise at your performance yesterday with your electric car. At first, when you passed my cottage here, I thought I must have been mistaken, and followed you to the Ranch House (the old Hurtzell place) to find out who it was that had come to the top of Lookout mountain, 7,600 feet above sea level and about one-half mile above Denver, with an electric car, and when I learned that you had actually come up Chimney gulch, the average grade for nearly four miles being 10 per cent, and in one place the grade being 27 per cent, I was more astonished than ever.

The more simple way to Lookout mountain and the one usually taken by automobilists is up Mt. Vernon canon; the grade there is easy and thousands come that way, but you are the very first who has ventured to come up with an electric car, and you chose the more difficult route. I consider your feat of yesterday marks another era in the progress of the electric motor for mountain travel. Your machine, the Fritchle 100-Mile Electric, is a very handsome one and does you great credit. Yours very truly,

(Signed) REES C. VIDLER.

Our Denver-to-Greeley-and-return run of 120 miles with a 1908 stock car has not been surpassed by the latest models of other makes.

We sincerely regret the failure of our competitor to approach our past performances, for the reason, had they surpassed us, we would have been inspired to greater effort, which would have been an aid to the advertisement of the Electric Automobile.

So confident are we of the superiority of the Fritchle-Electric that we again herewith publish our

"Standing Challenge

We, the Fritchle Automobile & Battery Company, challenge any manufacturer, agent or individual, to a 1,000-mile durability contest between a 1909 Fritchle Electric and any other manufacturer's 1910 stock car, equipped with Edison or any other make of battery."

The Fritchle Automobile and Battery Co.

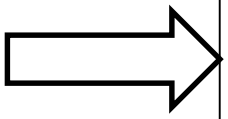
Denver Colo.

	Price of EV Vehicle in 1912	Price of EV Vehicle Equivalent in Today's Money
Henry Ford's Vehicles	$500	$14,000
Oliver Fritchle's Vehicles	$3,500	$105,000

LAST
GAS STATION

Which year over 60% of the vehicles maybe EV's?

Acceptance of electric cars was initially hampered by a lack of power infrastructure, but by 1912, many homes were wired for electricity, enabling a surge in the popularity of the cars. *In the United States by the turn of the century, 40 percent of automobiles were powered by steam, 38 percent by electricity, and 22 percent by gasoline. A total of 33,842 electric cars were registered in the United States*, and the U.S. Became the country where electric cars had gained the most acceptance. Most early electric vehicles were massive, ornate carriages designed for the upper-class customers that made them popular. They featured luxurious interiors and were replete with expensive materials. Sales of electric cars peaked in the early 1910s.



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Some Definitions

- EV : Electric Vehicles (Electric drive motors)
- HEV : Hybrid Electric Vehicles (Example – Prius; Gasoline engine with electric drive)
- PEV : Plug-in Electric Vehicles (Examples – PHEV and BEV)
- PHEV : Plug-in Hybrid Electric Vehicles (Example – Plug-in Prius; Some electric range then gasoline engine with electric drive)
- BEV : Battery Electric Vehicles (Example – Tesla; all electric, no gasoline engine)
- kW & kWh : Which one is comparable to a gallon of fuel? kWh

Annually Applied Technology Projections for Newly Deployed PEVs and Chargers

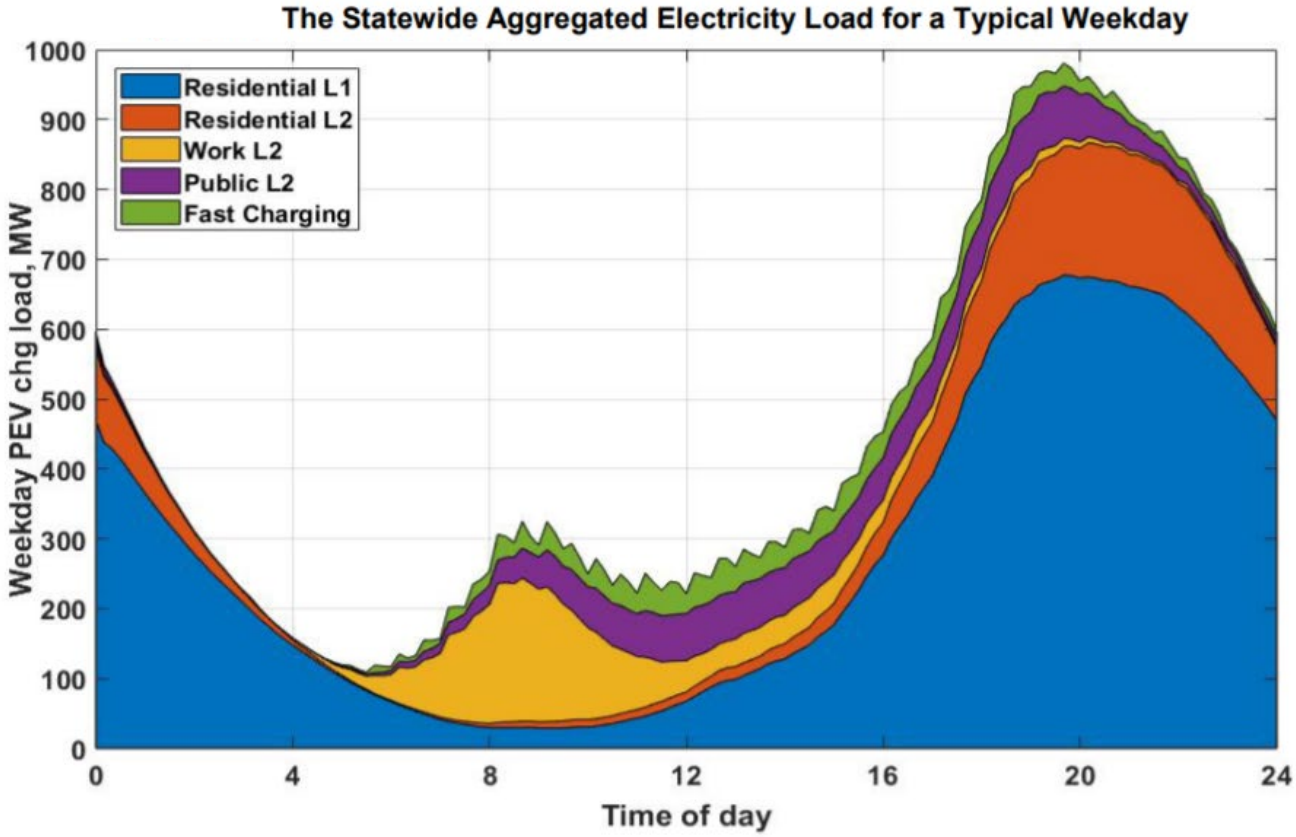
Electric Range and Charger Power Level Projections			
PHEVs	**(As-of-2017)**		**(By 2025)**
Electric Range (miles):	29.6	→	40.0
Residential L2 (kW):	3.6	→	4.9
Destination L2 (kW):	3.6	→	4.9
BEVs	**(As-of-2017)**		**(By 2025)**
Electric Range (miles)	121.8	→	210.0
Residential L2 (kW)	6.6	→	11.4
Destination L2 (kW)	6.6	→	6.6
Fast Charging (kW)	50.0	→	105.0

Source: California Energy Commission and NREL

Projections for Statewide PEV Charger Demand

Demand for L2 Destination (Workplace and Public) Chargers (The Default Scenario)			
	Total PEVs	**Lower Estimate (Chargers)**	**Higher Estimate (Chargers)**
As of 2017	239,328	21,502	28,701
By 2020	645,093	53,173	70,368
By 2025	1,321,371	99,333	133,270
Demand for DC Fast Chargers (The Default Scenario)			
	Total BEVs	**Lower Estimate (Chargers)**	**Higher Estimate (Chargers)**
As of 2017	133,386	2,005	5,877
By 2020	356,814	4,881	13,752
By 2025	729,094	9,061	24,967

Source: California Energy Commission and NREL



Source: California Energy Commission and NREL

Cost to Travel 100 miles

	Fuel Cost	MPG	Gal/100mi	Cost
Gasoline	$3.81	31	3.23	**$12.31**
Diesel	$4.11	40	2.50	**$10.28**
Biodiesel	$3.99	40	2.50	**$9.98**
E85	$3.72	26	3.85	**$14.31**
LPG/Propane	$2.35	29	3.45	**$8.10**
CNG	$1.75	29	3.45	**$6.03**
Electricity	$0.10kWh	3.5mi/kWh	28.6 kWh	**$2.86**

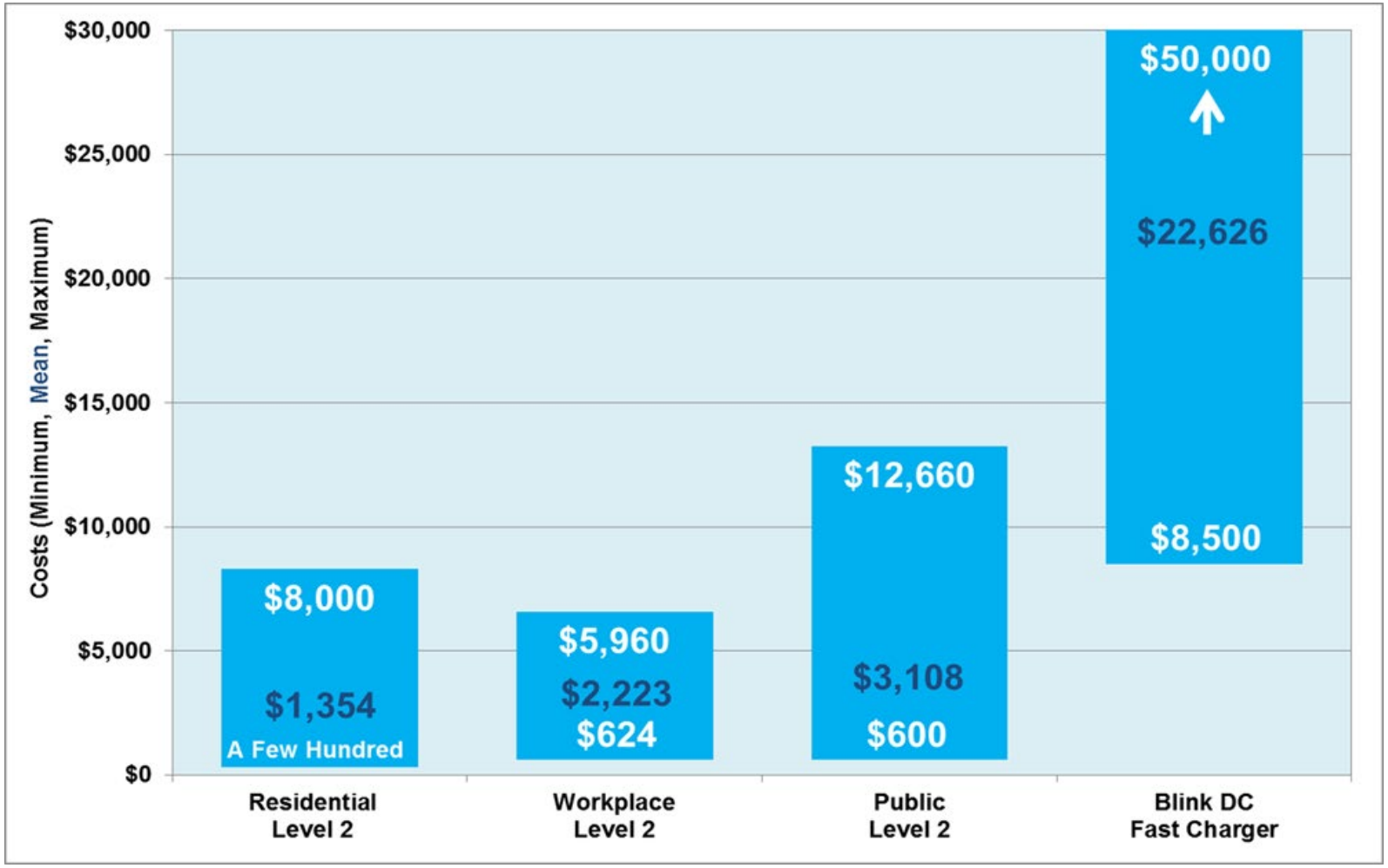
Source: Oregon DOT

opconnect
Electric Vehicle Charging System

Copyright © 2014 OpConnect, LLC
www.opconnect.com

EV Charger Installation Cost

2013 INL Study



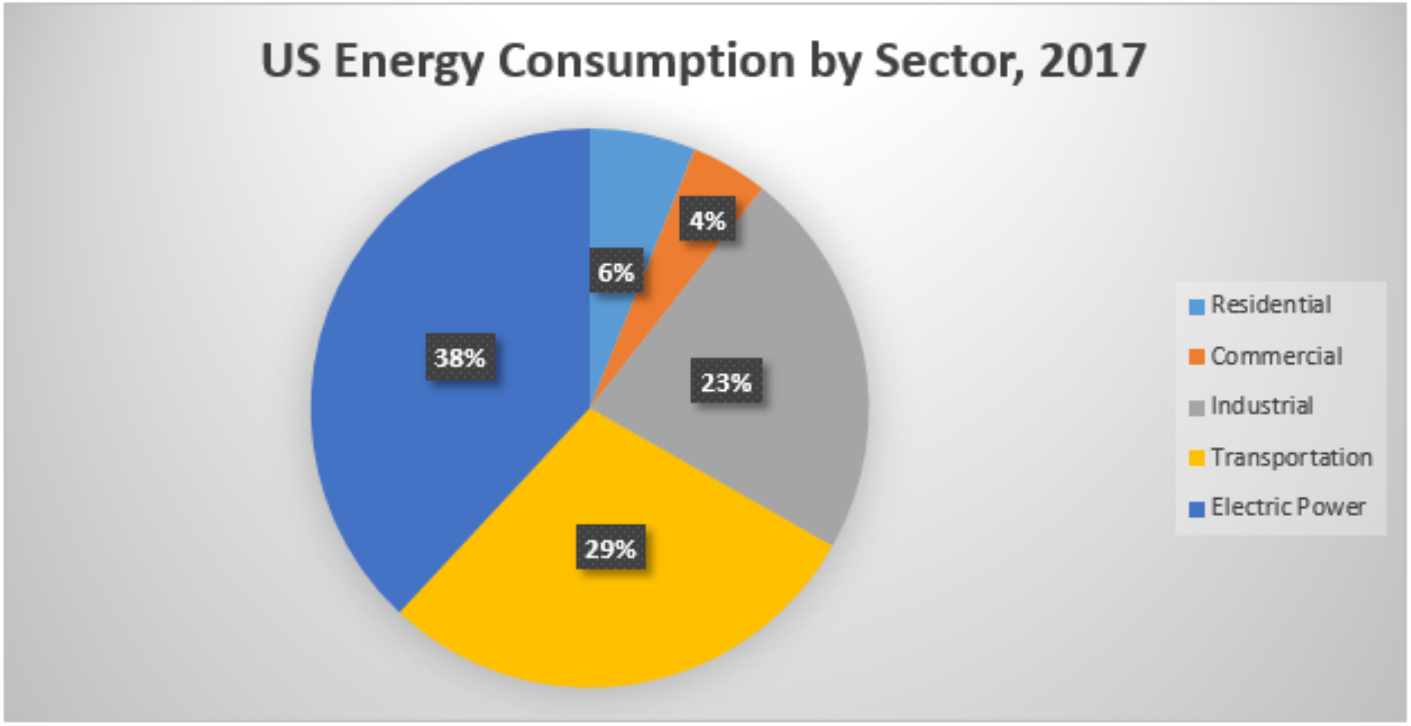


Figure: Energy Consumption by Sector

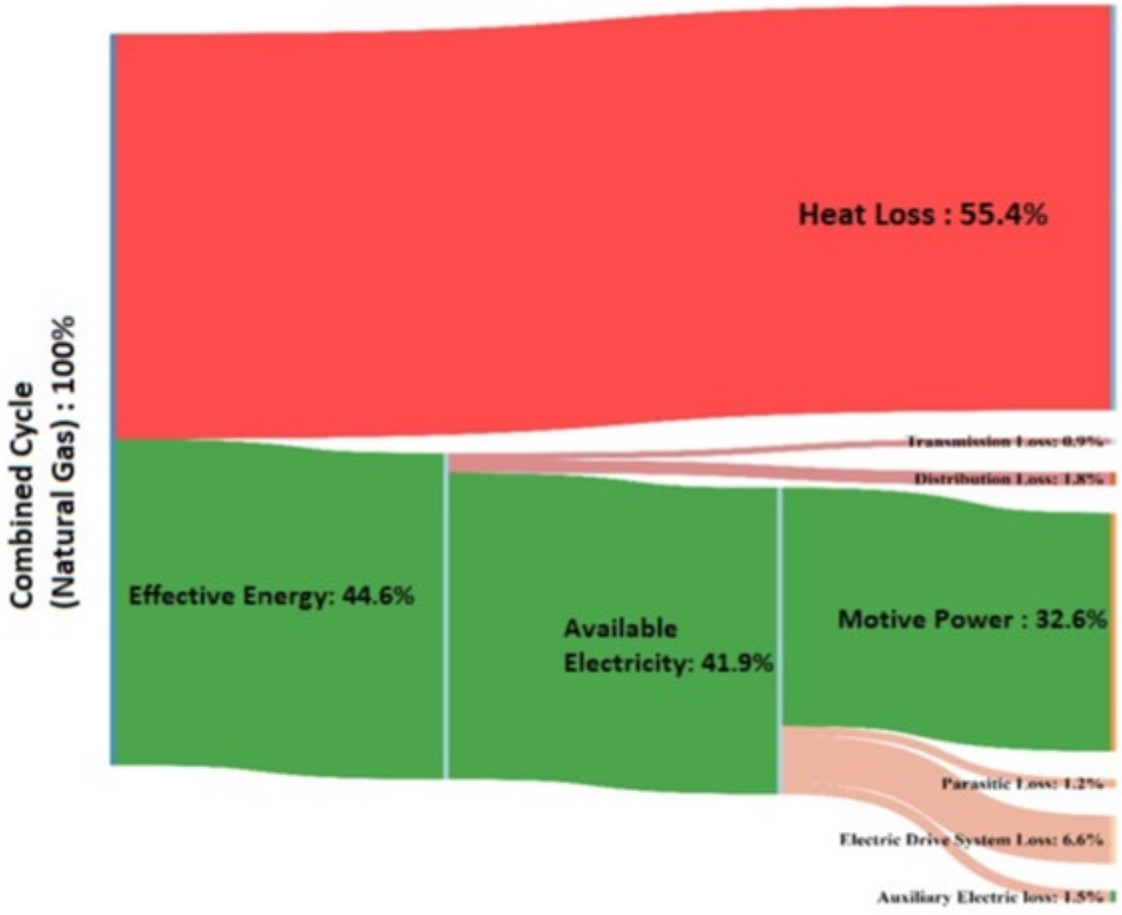


Figure: Energy Flow for Electric Vehicle.

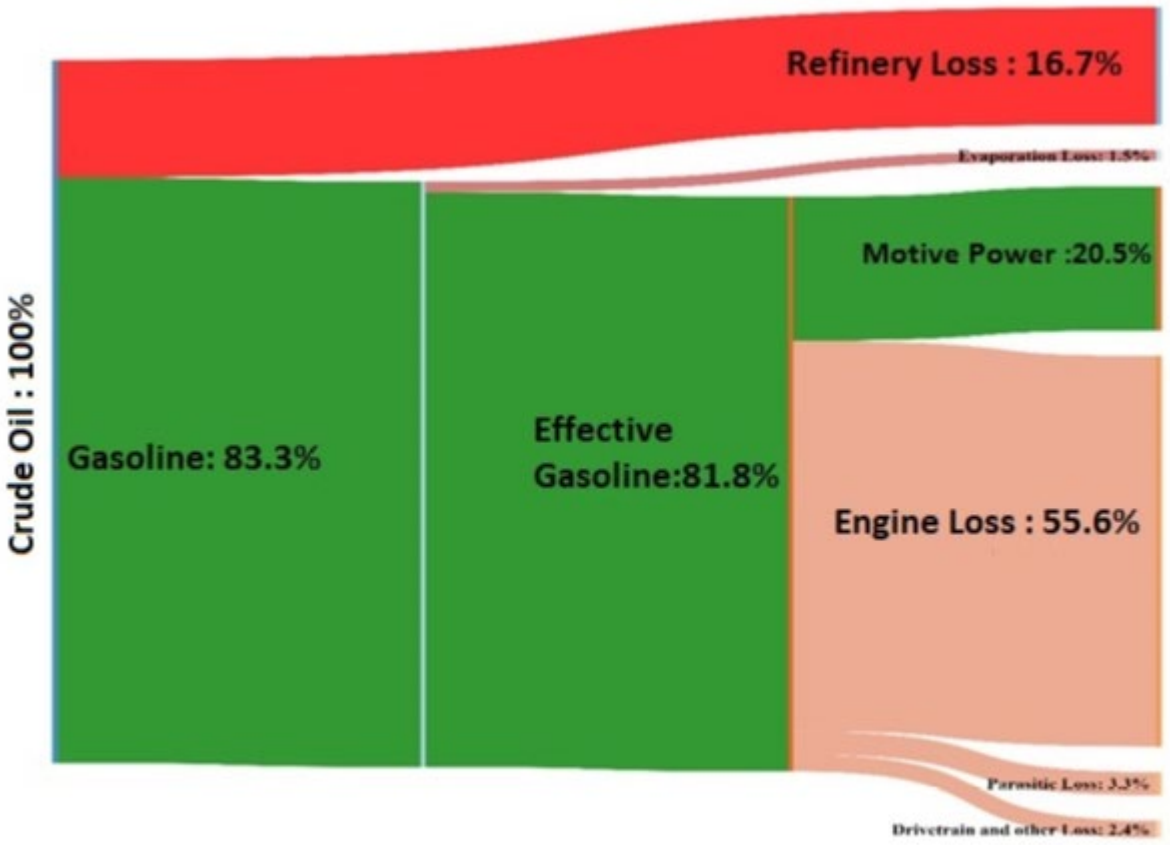


Figure: Energy Flow for Gasoline Vehicle.

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SIGI – Sustainable Integrated Grid Initiative

About

SIGI was established as part of the WCGEC, is located at BCOE's Center for Environmental Research and Technology (CE-CERT) and is one of the largest integrated renewable energy projects of its kind in the state. A key component of the project is to demonstrate that electric vehicles can be seamlessly introduced into the existing grid system through "smart integration" of renewable energy, storage and advanced dispatch controls.

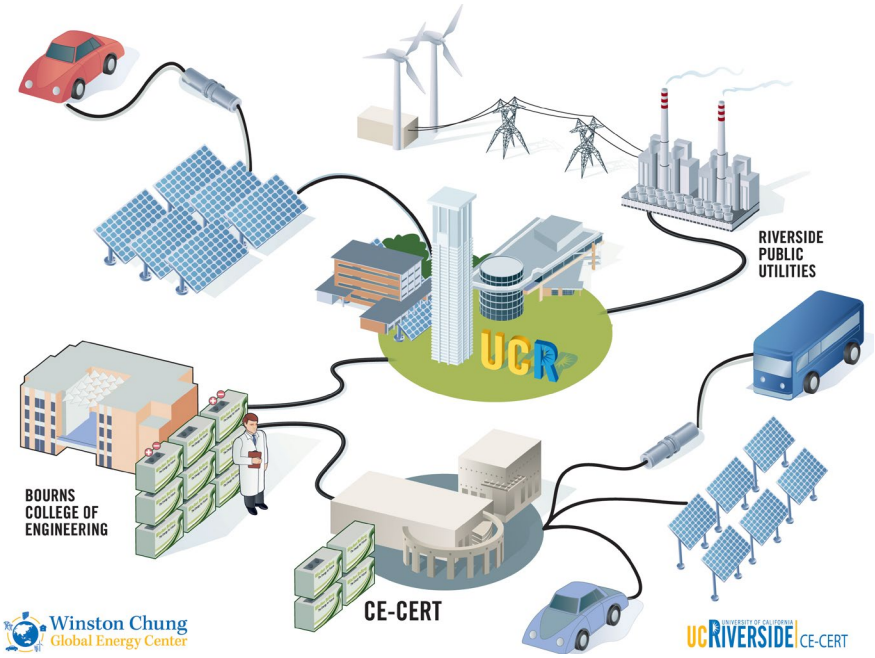
Key Project Features

Load Management
- Reduces risk of grid failure/blackout (due to decreased peaks)
- Increased predictability of demand (flattens peak demand)

Outage Prevention
- Relieves stress on grid

Outage Support
- Battery dedicated to critical loads

Distributed Energy Resource Support
- Microgrids support distributed solar systems



Project Partners

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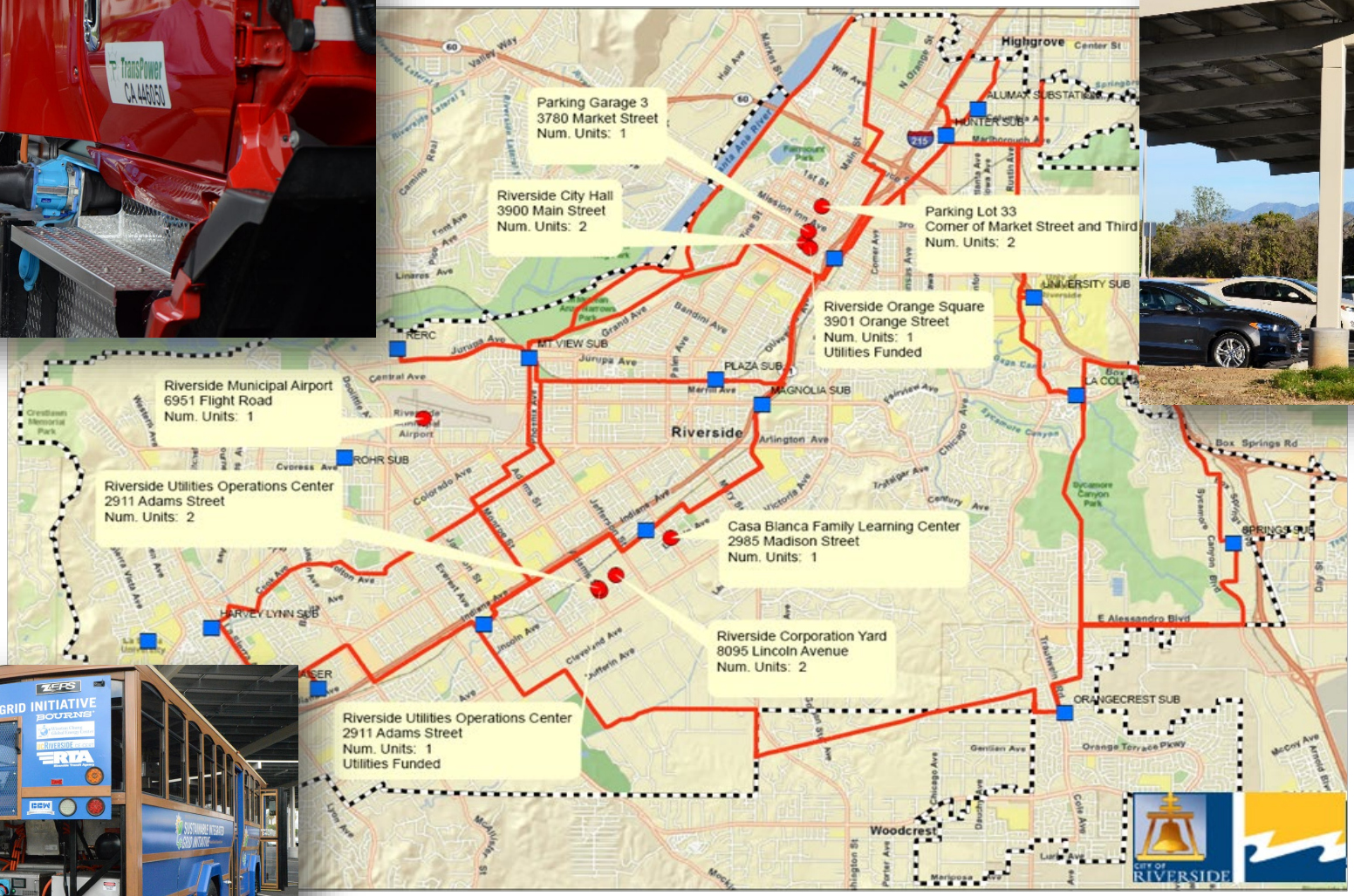
SIGI: Citywide EV Chargers



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SIGI: Battery Energy Storage System (BESS)

Winston Chung Hall

One megawatt-hour of battery energy storage was installed at UC Riverside's Winston Chung Hall. The system is physically comprised of two 500 kilowatt-hour systems; each with its own inverter, battery management system (BMS), and control hardware. The Princeton Power Systems bi-directional inverters are capable of charging the batteries at a rate of up to 95kW, and discharging at up to 100kW. The Battery Energy Systems BMS provides real-time data of the system, including pack state-of-charge, pack voltage, and pack current. The control hardware provides a gateway to inverter control, inverter data, and BMS data, and allows implementation of different control algorithms such as peak-shaving, and demand-response.

Winston Chung Hall: 1 MWh Lithium Iron Phosphate Battery at BCOE

CE-CERT's 500 kWh Stationary Battery System

CE-CERT Building 1200

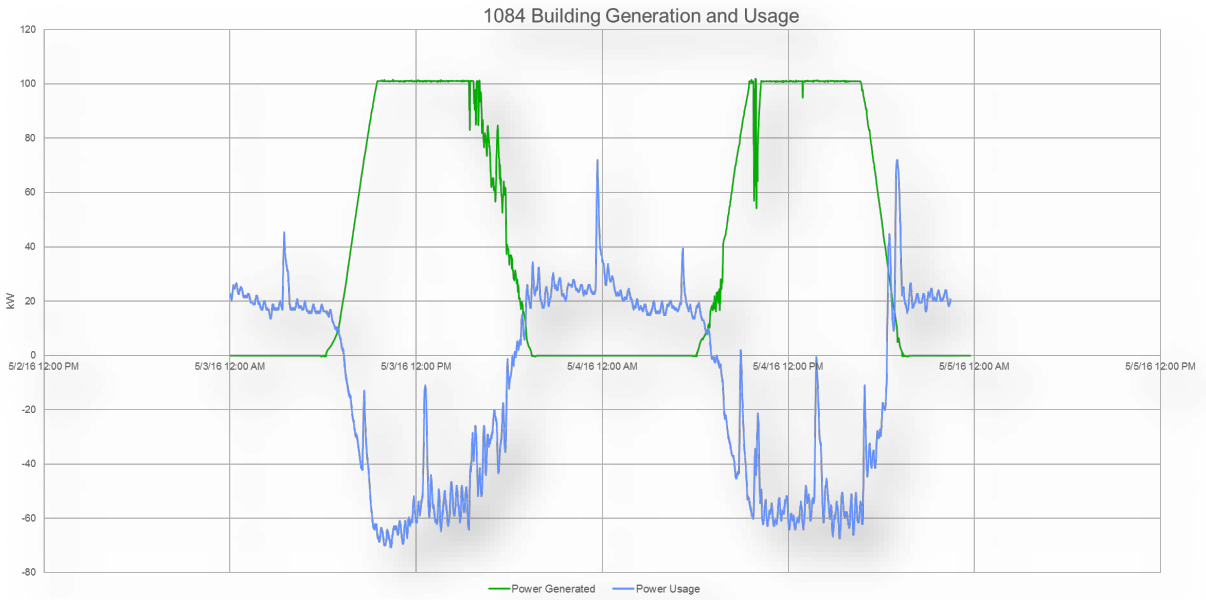
500 kilowatt-hours of battery energy storage were installed in CE-CERT's 1200 building. This system has a similar design to the systems in Winston Chung Hall and uses the same components as well.

SIGI: Operational Results

New Configuration Results

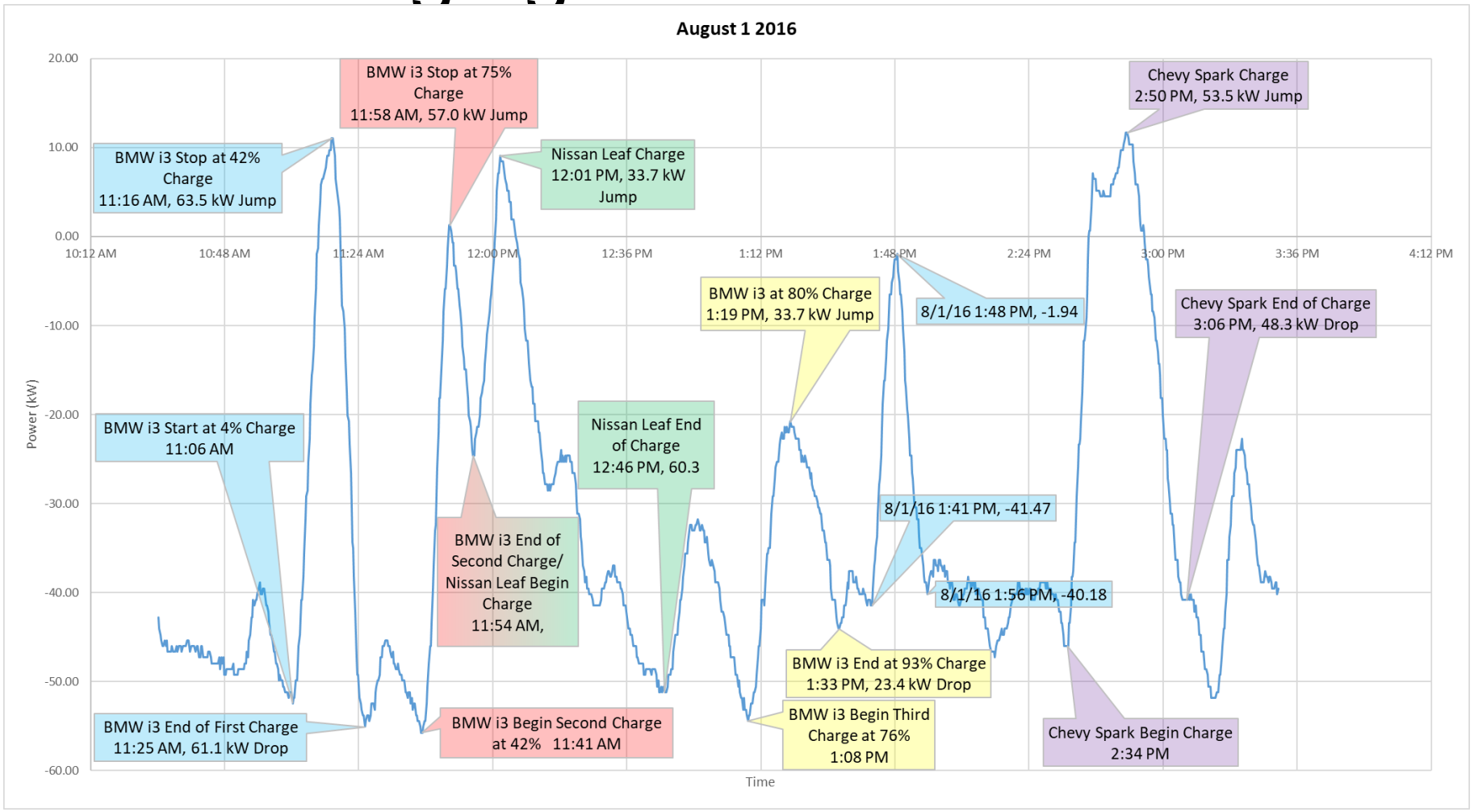
Results of the Administration Building's new configuration with PV production, shown in green with 100 kW inverter limiting solar production during mid-day hours. The figure shows actual data for May 3rd and May 4th 2016. The net electricity usage of the building, as seen by the power company meter, is shown in blue.

The blue values above horizontal zero axis are energy being imported from the grid at night while, the blue values under zero axis are energy being exported to the grid during the day due to surplus solar production. This building is net zero because the exported energy is larger than the imported energy usage.



1084's Building Generation and Usage

Operational Results: Level 3 EV Charging Characteristics



SIGI
Trolley V2G Bi-Directional DC Port

Benefits

- Bypasses on-board AC charger
- Data line integration
- CAN Bus Monitoring
- DC connection
- Contactors for safety
- 100 kW micro-grid integration

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SIGI
Light Duty V2G Micro-grid Integration

Goals

- Integration on .5 MW mobile battery trailer platform
- Capable of 30kW DC bi-directional operation
- Evaluate operation in micro-grid setting
- Integrate with DR operations
- Respond to vehicle state, driver behavior, building needs and solar generation variability

Questions