The Power of Charging Stations: Smart Systems for the Future
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Charlotte Argue, Program Manager, Climate Change & Air Quality
cargue@fraserbasin.bc.ca
Today’s Speakers

• Jeff Turner, Engineer Electric Vehicles, PowerTech Labs
• Clay Howey, Research Head, Smart Micro-grid Applied Research Team, BC Institute of Technology
What is West Coast Electric Fleets?

Pacific Coast Action Plan on Climate and Energy

PREAMBLE

The Governments of California, British Columbia, Oregon and Washington,

Pursuant to the Memorandum to Establish the Pacific Coast Collaborative of June 2008, as provided for in Article 6;

Affirming our shared vision of Pacific North America as a model of innovation that sustains our communities and creates jobs and new economic opportunities for our combined population of 53 million;

Recognizing that the Pacific Coast is a region bound together by a common geography, shared infrastructure and a regional economy with a combined GDP of US $2.8 trillion, which makes it the world’s fifth largest;

existing carbon-pricing programs. Where possible, California, British Columbia, Oregon and Washington will link programs for consistency and predictability and to expand opportunities to grow the region's low-carbon economy.

2) Harmonize 2050 targets for greenhouse gas reductions and develop mid-term targets needed to support long-term reduction goals.

Climate scientists have identified the scale of greenhouse gas reductions that must be achieved globally to stabilize the climate. Where they have not already done so, California, British Columbia, Oregon and Washington will establish long-term reduction targets that reflect these scientific findings. To advance long-term reductions, Washington already has in place a mid-term 2035 target. California and Oregon will establish their own mid-term targets.
West Coast Electric Fleets implements the Zero Emission Vehicle (ZEV) commitment in the Pacific Coast Action Plan on Climate and Energy

2) Take actions to expand the use of zero-emission vehicles, aiming for 10 percent of new vehicle purchases in public and private fleets by 2016.

The Pacific Coast already has the highest penetration of electric cars in North America. The governments of California, British Columbia, Oregon and Washington will work together towards this ambitious new target by supporting public and private fleet managers to shift their procurement investments to catalyze toward electric car purchases and by continuing to invest in necessary infrastructure to enable low-carbon electric transportation.
30+ Partner Fleets!

Province of BC, BC
City of Vancouver, BC
District of Saanich, BC
BC Hydro, BC
City of Surrey, BC
Current Taxi, BC
Comox Valley Regional District, BC
Fraser Valley Regional District, BC
Gea Zone, BC
Onsite Equipment, BC
WA Dept Commerce
WA Dept Transportation
WA Dept Enterprise Svcs
City of Olympia, WA
City of Seattle, WA
Puget Sound Clean Air Agency, WA
King County, WA
State of OR Fleets
City of Portland, OR
Lane County, OR
City of Ashland, OR
Lane Regional Air Protection Agency, OR
CMTS LLC, OR
State of California Public Fleets, CA
City of Santa Ana, CA
LADWP, CA
City of San Diego, CA
City of San Francisco, CA
City of Los Angeles, CA
Oakland Public Works, CA
Pasadena Water and Power, CA
City of Sacramento, CA
Antelope Valley Trans, CA
Three-Tiered Commitment

- **On-Ramp**: Commit to evaluate ZEVs as part of every fleet purchase and revisit commitment annually.

- **Highway**: Commit to procuring at least 3% of ZEVs for all new fleet purchases by the end of 2016 and revisit the pledge annually.

- **Express Lane**: Commit to procuring at least 10% ZEVs for all new fleet vehicle purchases by the end of 2016.
The Toolkit

www.Westcoastelectricfleets.com

Target Audience
• Fleet managers, sustainability officers, etc.
• Private companies along with municipal and state governments

Site Needs
• Collect and organize information on ZEVs from across the internet
• Build a one-stop-shop for ZEVs targeted at public and private fleets
• Accommodate visitors having varied experience with ZEVs
• Enable visitors to find their information very quickly

West Coast Electric Fleets

Resource Library & Navigator

The Resource Library and Navigator help you find what you need quickly. Whether you’re looking for tools to analyze the cost of owning a ZEV or looking for the location of charging stations, it’s all in one place. If you’re new to ZEVs, use the Navigator to guide you to valuable information within a few clicks.

The Resource Library includes:
Antelope Valley Transit All-In on Electric Buses

The Antelope Valley Transit Authority was one of the first in the region to adopt electric buses. In 2018, the AVTA purchased 20 electric buses to replace its diesel fleet. This move was made to reduce emissions and improve air quality. The electric buses have made a significant impact on the community, offering a more sustainable transportation option.

City of Vancouver: EV Fleet Manager

In 2009, the City of Vancouver was one of the first cities in BC to introduce an all-electric fleet. The city has since expanded its fleet to include a variety of electric vehicles, including buses and cars. The city’s fleet has played an important role in reducing greenhouse gas emissions and improving air quality.

Fraser Valley Regional Dist. Making the Case for EVs

In 2013, the Fraser Valley Regional District planned a deployment of electric vehicle charging stations. These stations were designed to support the growth of the region’s electric vehicle fleet. The stations have been well-received and have helped to increase the adoption of electric vehicles.

GEAZONE: All Electric Delivery

In 2012, GEAZONE launched its all-electric delivery fleet in Victoria, BC. The fleet consists of electric delivery vehicles and has been successful in reducing emissions and improving air quality.

City of Surrey: Leveraging Partners In EV Adoption

The City of Surrey is one of the leading cities in BC in terms of electric vehicle adoption. The city has partnered with several organizations to promote the use of electric vehicles and has seen a significant increase in electric vehicle sales.

Quick Facts

- Current fleet includes 5 Nissan Leaf electric vehicles.
- 40 kWh (79 kW) 3 Additional EVs to be purchased in 2021.
- Approximately 14,400 km (9,600 miles) driven.
- 1.7 tonne GHGs avoided.
- 3.12 kWh per km consumed.
- 5% growth in electric vehicle use.

Future plans include new partnerships and initiatives to further promote the use of electric vehicles.

For more information, visit www.westcoastelectricfleets.com.
West Coast Electric Fleets Peer Network and Webinar Series

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**Featured fleets in past webinars included** the City of Seattle; WSDOT; City of Surrey, BC; Foothill Transit; Antelope Valley Transit; California DGS; LADWP; and the Energy Secure Cities Coalition
Join Us!

Sign the Pledge!
Explore the Toolkit!

www.westcoastelectricfleets.com

Questions?
Contact Charlotte Argue cargue@fraserbasin.bc.ca
We offer a one-stop-shop approach for businesses that require technical engineering expertise, standards and code testing, as well as quality testing and failure analysis services.

Powertech is a subsidiary of BC Hydro. We provide specialized testing and investigation services to support BC Hydro's capital assets: generation, transmission and distribution.
Powertech combines an expert, responsive team of 120 engineers, scientists and technologists & 21 advanced labs
Smart Utility Technologies

Critical Infrastructure Comms

Connected Devices

Multi-service Mesh and FAN
We support the rapidly expanding EV market by providing engineering and consulting services to both local and global clientele. We are leading experts in all aspects of EV technologies, from infrastructure and smart grid integration, through to fleet deployments and component testing.
Powertech EV Services

- DCFC Critical Infrastructure
- Grid-Interoperability / Smart Grid
- Commercial/Retail EVSE Projects
- EV and Infrastructure Consulting
- Community/Municipality EVSE Projects
- EV Fleet Support
Types of vehicles

Graphic from Electric Power Research Institute: et.epri.com

1. Conventional Vehicle (CV)
2. Hybrid Electric Vehicle (HEV)
3. Plug-In Hybrid Electric Vehicle (PHEV)
4. Electric Vehicle (EV)

Sometimes called “Plug-in Electric Vehicles” (PEVs), or simply Electric Vehicles (EVs)

or “Pure Electric Vehicle”, or “Battery Electric Vehicle” (BEV)

Sometimes called “Electrified Vehicles”
Categorization of electrified vehicles; electric vehicles are highlighted in red.
**Examples of BEVs**

**Nissan LEAF - US$29,860**
- **Type:** BEV
- **Battery:** 24-30kWh
- **Electric Range:** 117km – 170km
- **Charging Power:** 6.6kW AC, 50kW DC
- **Charging Time:** 4h AC, 30min DC

- **Type:** BEV
- **Battery:** 70kWh or 90kWh
- **Electric Range:** 335km or 426km
- **Charging Power:** 10kW or 20kW AC, 120kW DC
- **Charging Time:** 4-8h AC, 1-2h DC

**Volkswagen e-Golf - US$29,815**
- **Type:** BEV
- **Battery:** 24.2kWh
- **Electric Range:** 134km
- **Charging Power:** 7.2kW, 50kW DC
- **Charging Time:** 4h, 30min DC
Examples of PHEVs

**Chevrolet Volt - US$33,995**
Type: PHEV or “EREV” – “Extended Range” EV  
Battery: 17kWh  
Electric Range: 80km  
Gas mode: 5.5L/100km, 610km total range  
Charging Power: 3.6kW  
Charging Time: 4h

**BMW i3 - US$43,395**
Type: BEV, “BEVx” with optional range extender  
Battery: 18.8kWh  
Electric Range: 130km  
Gas mode: 6L/100km, 240km total range  
Charging Power: 7.4kW, 50kW DC  
Charging Time: 3h, 30min DC

**Toyota Prius PHV - $35,700**  (updated Prius Prime coming soon...)
Type: PHEV  
Battery: 4.4kWh  
Electric Range: 18km (blended – burns some gas!)  
Gas mode: 4.7L/100km, 870km total range  
Charging Power: 3.3kW  
Charging Time: 1.5h
Upcoming trend: Affordable 200-mile range EVs

- Chevy Bolt (Pictured, late 2016): 200 miles, $37,500 US
- Tesla Model 3 (late 2017): 200 miles, $35,000 US
- 2nd Gen Nissan Leaf (late 2017): 150-200 miles, no pricing announced
Upcoming trend: Larger plug-in vehicles

- Mitsubishi Outlander PHEV
- Tesla Model X BEV
- Mercedes GLE PHEV
- Porsche Cayenne eHybrid PHEV
- Chrysler Pacifica PHEV
- Volvo XC90 T8 PHEV
Commercial EVs

- Smith Electric BEV Truck
- NOVAbus BEV Bus
- Proterra BEV Bus
- Nissan e-NV200 BEV Van
- VIA Motors VTRUX PHEVs
- Odyne PHEV Bucket Truck
- EVI BEV Step Van
- Smith Electric BEV Truck
- NOVAbus BEV Bus
- Proterra BEV Bus
- Nissan e-NV200 BEV Van
- VIA Motors VTRUX PHEVs
- Odyne PHEV Bucket Truck
- EVI BEV Step Van
AC Level 1 (120V):  
1-1.9kW  
~7.5km/hour  
12+ hours

AC Level 2 (240V):  
3.3kW to 20kW  
15 – 100km/hour  
~4-8 hours

DC Fast Charging  
25kW to 150kW  
125 – 500+ km/hour  
~20-45 minutes to 80%

Charging rates depend on the capabilities of both the charging station and the EV.
BC Electric Vehicle Smart Infrastructure Project

At-Home and On-the-Go

970 Level 2 EVSEs
- 240V, 3.3kW – 18kW
- 200 Single Family Dwellings
- 200 Multi Unit Buildings
- 570 Public Spaces
BC Electric Vehicle Smart Infrastructure Project

**At-Home and On-the-Go**

- **970 Level 2 EVSEs**
  - 240V, 3.3kW – 18kW
  - 200 Single Family Dwellings
  - 200 Multi Unit Buildings
  - 570 Public Spaces

**DC Fast Charge Critical Infrastructure**

- **30 DCFC Stations**
  - 50kW, 30 min charge
  - Pacific Coast Collaborative
  - Planning framework
  - Business models evaluation

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At-Home and On-the-Go

DC Fast Charge Critical Infrastructure

970 Level 2 EVSEs
- 240V, 3.3kW – 18kW
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30 DCFC Stations
- 50kW, 30 min charge
- Pacific Coast Collaborative
- Planning framework
- Business models evaluation
BC Public Charging Stations

www.chargehub.com
Example DCFC Station
Surrey Museum
BC DC Fast Charge Stations
BC Electric Vehicle Smart Infrastructure Project

At-Home and On-the-Go

- **970 Level 2 EVSEs**
  - 240V, 3.3kW – 18kW
  - 200 Single Family Dwellings
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DC Fast Charge Critical Infrastructure

- **30 DCFC Stations**
  - 25-50kW, 30 min charge
  - Pacific Coast Collaborative
  - Planning framework
  - Business models evaluation

Smart Grid

- **Initiatives**
  - evCloud
  - Grid-Aware
  - Smart-Charging
  - Demonstrations
  - Utility roadmaps

Utility Connectivity

- EV
- EVSE
- Internet
- Field Area Network
- Service Interface
- Utility
Impacts of EV charging on electrical infrastructure

**Residential charging**
- 6 kW charging increases residential peak by 155%
- High adoption areas will have 5% adoption in 2015, 50% in 2030

**Distribution transformers**
- Aging assets – ~70% over 20 years old
- 22% already experience peak loads over rated capacity
- Will have 5-10 kW sustained additional load in 2015 (1-2 EVs), 40 kW in 2030 (6-8 EVs) per transformer
- Substantial risk of increased failures
- Larger equipment sizing required

**Generation and transmission**
- Additional 60 MW peak load by 2015, 890 MW by 2030
- 4,000 GWh of additional energy load by 2030
- Peak mitigation planning required
- Longer term need for additional peak and energy capacity or DSM

**Substations**
- 26% of substations currently experience peak loads over 90% of firm capacity, including many in high adoption areas
- Sustained peak EV charging load per substation of 2-10 MW by 2015, 20+ MW by 2030
- Accelerates requirement for load transfers and capacity expansions

SOURCE: BC Hydro Distribution Planning; Energy Planning; EPRI; team analysis
Smart Charging Communications Options

Utility Back-Office
- OpenADR
- Energy Services Provider interface (ESP)

Utility Interface
- B2B
- Direct
- SCADA
- Utility IP Web Server
- SMI Web Server
- Meter Head End Collector
- Utility SCADA Front End

Transport
- Internet
- Smart Meter Infrastructure
- SCADA telecom or WAN

Network
- ESGOs and Aggregators
- Direct Internet
- Smart Meter Network
- SCADA network

Device Comms
- From Vehicle Over IP
- From EVSE Over IP
- From EVSE Over SMI
- From EVSE Over H/LAN
- From EVSE Over SCADA

Powertech
The Power of Trust. The Future of Energy
The Powertech EV Tech Park provides an environment for testing new EV charging technologies, supporting communications through both internet-based pathways as well as direct pathways through utility-owned Smart Metering Infrastructure.
Smart Charging – Minimizing Grid Impacts

Nissan Leaf - Overnight Charge with multiple DLC events

- **Start of charge**
- **Unrestricted**
- **Unrestricted**

**Charging Power (kW)**

- **Load control:** 0kW
- **Load control:** 1.5kW
- **Load control:** 0kW

Full charge
Impacts of EV charging on electrical infrastructure

Customer-side electrical constraints: Not all smart charging use cases require bi-directional utility communications.

- Maximize use of available electrical capacity
- Minimize utility demand charges based on peak demand

SOURCE: BC Hydro Distribution Planning; Energy Planning; EPRI; team analysis
Smart Charging Communications Options

Multiple Communications Pathways

B2B

Back-Office Applications

Utility Enterprise Service Bus (ESB)

Utility Web Server

SMI Head-End Collection Engine

Internet

SMI

Direct

Telematics

EVSP

HAN

EV Cloud (data portal)

EV Cloud Web Portal

Transport

Utility Back-Office

Utility Interface

Network Device

Power tech

The Power of Trust. The Future of Energy
BC EVSI

Smart Grid Initiatives
BC EVSI
Smart Grid Initiatives

[Diagram showing EVSE Aggregator connected to AddEnergie, with optional connections to Facility Energy Manager and Building Automation System, and Charge Station Group.]
EVSI Demo Site:  
BC Hydro’s Edmonds Complex
EVS Demo Site: BC Hydro’s Edmonds Complex
EVSI Demo Site:
BC Hydro’s Edmonds Facility

Power Sharing
• Shares limited electrical capacity across a greater number of charging stations

Power Limiting
• Limits charging power according to time of day or in real time based on available capacity
• Minimizes demand charges
EVSI Demo Site:
University of British Columbia
FleetCarma Smart Charging Platform
- Incorporates vehicle-side data to optimize smart charging decisions according to vehicle and driver needs
- Compatible with AddEnergie and ChargePoint stations
- OpenADR interface for bi-directional utility communications
The Powertech EV Tech Park provides an environment for testing new EV charging technologies, supporting communications through both internet-based pathways as well as direct pathways through utility-owned Smart Metering Infrastructure.
Thank You!

Jeff Turner, Electric Vehicles and Energy Systems
jeff.turner@powertechlabs.com
APPLIED RESEARCH
SMART MICROGRID APPLIED RESEARCH TEAM (SMART)

CLAY HOWEY
What we do.

Research and develop solutions to problems in:

- Smart Microgrids
- Critical Infrastructure Security
- Information Technology
How we interact with industry:

- BC Hydro is a strategic partner in our Smart Microgrid research
- OASIS project involves partnerships with Siemens, Panasonic, Schneider Electric, enCompass, PowerTech Labs
- NSMG-Net involves BC Hydro, Hydro One, Hydro Quebec, EION Wireless, Schneider Electric
- Provide a vendor-agnostic test bed for smart grid technologies
- IT firms directly contract R&D services to create solutions that yield competitive advantages
- 10 research staff dedicated full time to R&D projects
How we interact with students:

- Currently have 2 McGill PhD Candidates (Elec Eng), 1 UofA Masters student (Elec Eng)
- In recent past had 1 BCIT B. Eng (Elec Eng), 1 SFU PhD Candidate, 1 UBC PhD & 1 SFU Masters Candidates
- Have had numerous BCIT Diploma, B. Tech, and B. Eng students on variety of projects
- Via our NSERC Smart Microgrid Network (NSMG-Net), we involve students from McGill, U of Toronto, UBC, U of Manitoba, U of Waterloo, U of New Brunswick, U of Alberta, U of Western Ontario
Featured Project - OASIS

- Project to build a 250 kW solar canopy over a parking lot
- 40’ container houses 500 kWh Li-Ion Battery Energy Storage System (BESS)
- Powers two DC Fast Charge, six Level 2, and two Level 1 Electric Vehicle Charging Stations, LED parking lot lighting
OASIS Project continued…

- System is “islandable”, meaning it can disconnect, and reconnect to the grid
- System can backfeed surplus energy to the grid
- Project demonstrates state of the art solar technology coupled with energy storage, and the direct displacement of CO2 emissions related to transportation
OASIS Project continued...

- EV drivers can make reservations
- System can deliver power based on availability of solar energy, and destination of EV driver
- Advanced generation and load forecasting system from Siemens
- Mitigation of EV charging on grid load
What is the Problem?

- We have adequate generation and transmission capacity in BC to electrify fleet
- Distribution, however, is another story
- If many EVs plug in simultaneously, distribution transformers and feeders may become overloaded
- “Demand Response” solutions need to be researched, tested and verified
Demand Response

- OASIS can do Demand Response to shave demand peaks, and fill in valleys
- Reduces demand charges, reduces peak load on distribution feeders
OASIS Project: Demand-Response Control, PV, and Energy Storage Mitigate EV Charging

Weather forecast (3 days)

EV Charging Usage forecast

Power Grid Power Demand forecast

OASIS power

DEMS

Decentralized Energy Management System

WHEN?

From Grid To Grid
How many cars can OASIS charge in a day from Solar?

- Vancouver averages 3 sun hours per day, which equates to $3\text{hours} \times 250\text{kW} = 750\text{kWh}$ per day (average) over a year.
- Average Nissan LEAF charging session is 10kWh
- Average Session time is 30 minutes
- We could support 75 LEAFs charging every day
- After factoring in house loads that number drops to about 50
- But it would still be hard to get that many cars through the chargers without having big lineups.
OASIS Project continued…

Typical Power Curve (Summer)
Unforeseen Challenges

- Location Selection
  - lots of campus roof space but little of it able to support load

- Battery Module Layout
  - Re-orientation of modules required
  - Resulted in innovative rack re-design

- PCS and Noise By-law
  - Requires noise abatement enclosure
  - Resulting in solutions with technology transfer potential

- EV Charger Power Loss
  - Power Quality to Fast Charger must be high, UPS required
OASIS Generation Data

Monthly PV Solar Generation
System Commissioning in Progress

Total Measured PV Generation: 58,782.98 kWh
If Fully Operational: 156,647.09 kWh
OASIS Project continued...

Major Project Components

- Panasonic – PV modules (solar panels) and four quadrant inverter
- Siemens – Substation Automation gear, Distribution Energy Management System
- Schneider Electric – DC Fast Charge EV Chargers, Smart Meters
Other BCIT EV Chargers

- Downtown campus – two Level 2 chargers
- Centre for Applied Research & Innovation (CARI) – one Level 2 charger
- Gateway Building, main Burnaby campus – two Level 2, four Level 1 chargers
- AFRESH Home, main Burnaby campus – one Level 2, one Level 1 charger
Consumer Behaviour Research

- Research Project with UBC, UVic, and SFU
- Uses the six Level 2 EV chargers at OASIS
- Researching EV driver appetite for aligning charging with availability of renewables
- Level 2 chargers can be “throttled” between 0, 1, and 7 kW.
- EVs will be charged when drivers need them, but time may be delayed to availability of renewables
Future Applied Research Projects

Future Projects
- Improvements to forecasting system
- Pilot project with Powertech Labs on Utility Controlled Charging at BCIT’s AFRESH home
- More collaboration with UBC, SFU, UVic on behaviour change research
BC Leading Canada in EV Chargers