

2017 Zero-Emission Battery Bus Showcase Wrap-Up



"I'm very excited about our opportunity, not just for our own fleet but also our opportunity to lead the country."

King County Executive Dow Constantine

"Leadership is not just the ability to purchase battery buses, but also to demonstrate a greater public good. We are uniquely situated to drive this forward...all of us in this room."

Metro General Manager Rob Gannon





King County Metro's 2017 Zero-emission Battery-Electric Bus Showcase brought together transit agency staff and stakeholders for a day of information sharing, problem solving, and discussion of the many issues and challenges involved in building a zero-emission fleet. Participants also heard about the promising experiences of agencies that have conducted trials and put battery buses into service.

By gathering together people from different places along the zero-emission journey continuum, the Showcase was a forum for people to learn from one another and begin the process of leveraging our national expertise to solve the complex problems we collectively face.

The following is a recap of what participants shared at the event.

Agenda

Zero-emission Battery Electric Bus Showcase, Sept. 27, 2017

Welcome

Harold S. Taniguchi, Director,
King County Dept. of Transportation
Dow Constantine, King County Executive

Presentations: The Zero-Emission Journey

Pete Melin, Director of Zero-emission Fleet,
King County Metro
David Cooper, Senior Planner, System Planning, TransLink,
British Columbia, Canada
Danny Ilioiu, R&D Director, New York City Metropolitan
Transportation Authority

Battery-electric Bus Ride

Expert Panel

Facilitator/Charging Infrastructure: Pete Melin,
King County Metro
Bus Base Planning and Retrofit: Lisa Shafer,
King County Metro
Bus Procurement: Leo Hrechanyk, King County Metro
Service Planning: Katie Chalmers, King County Metro
Technology: George Stites, King County Metro
Electric Power Utility Considerations: Andrew Lightfoot,
Puget Sound Energy

Looking Forward

Remarks by Rob Gannon, General Manager,
King County Metro

Facilitated discussion groups

Zero-emission opportunities, challenges, lessons learned

Next Steps, Summary, and Wrap-up

Summary

Transit agencies' zero-emission journey is complex and will require active, thoughtful planning and participation across sectors. The future requires a systemic reshaping of regional and national approaches to fuel and energy distribution and use, and will fundamentally alter how our transportation networks function.

The opportunities are vast and include positive environmental and human health benefits associated with zero-emission vehicles, greater integration of transit modes, and a new generation of clean, quiet and efficient public transportation. Transit agency speakers emphasized their commitment to realizing these benefits. For example, representatives of King County Metro Transit (Metro) described their agency's innovative approach to identifying communities that are vulnerable to impacts of air pollution and can benefit from early deployment of battery buses.

A number of speakers noted that battery bus technology is evolving quickly. The more we test battery electric buses and charging infrastructure, the more we learn and the better our questions become. How far can electric buses actually go? How long do they take to charge and what is the best approach for charging? How might the technology change in the future?

Showcase participants heard that answers to some of these questions are emerging from battery bus trials conducted by Metro, Translink (British Columbia), and the Metropolitan Transportation Authority (MTA – New York City). These trials



are demonstrating the capabilities of battery-bus technology to provide transit service today and revealing the needs of the future. These transit agencies also said they continue to press battery-bus manufacturers toward standardization that ensures interoperability of buses and charging technologies. Continued actions like these, across North America, will help advance the feasibility of zero-emission transit fleets.

Risk was a topic of discussion. In a rapidly evolving technology landscape, transit agencies are challenged to make the right investment, in the right technology, at the right time, while recognizing that they won't always get it 100 percent right. As Metro's Pete Melin said in his presentation, "We must learn about the technology, determine the impacts on our fleet and budget, and if it makes sense, take the leap. We're doing that at King County Metro, and even though we expect setbacks, we see those as opportunities to learn, and we accept that with eyes open."

Another subject was energy. A fully electric bus fleet requires significantly more power at bus depots and along routes, and a commitment to zero-emission transit fleets will reshape how energy is generated and distributed. That means a transition from fossil fuels to electricity will depend on close partnerships with electric utilities. Such partnerships are essential to ensure that rate structures encourage clean transportation; that transit agencies have access to clean, renewable sources of electricity; and that the electricity grids of the future are prepared for the impacts of climate change and emergencies. The partnership between Metro and Puget Sound Energy that was described in the Showcase is an encouraging example. PSE Account Executive Andrew Lightfoot said the utility is working to expand its renewables generation portfolio so it can provide the capacity that will be needed by a battery bus fleet.

Other challenges transit agencies face involve the switch from conventional or diesel-hybrid engines to battery-powered motors. This will not happen overnight and will require a balance in operations, new capital investments, and changes in work flow. A zero-emission fleet transition will require new maintenance and repair equipment, technician training, and more space or different parking layouts to accommodate charging infrastructure. So, where do we put it all and how do we maintain efficient reliable operations in the face of change?



Several Showcase speakers commented on how they are addressing these challenges. Metro, for example, is starting to develop a new facilities master plan that will answer questions like what should a future base look like? How much room is needed for battery buses and charging infrastructure?

Bus operators must be comfortable with the new technology, and Metro's manager of bus procurement, Leo Hrechanyk, described a process that could be a model for other agencies. Using a bus mock-up, Metro and Proterra involved operators in designing features that would work well for them.

Costs must be considered as well. For public agencies, future zero-emission fleets must be comparable in price to the present day to allow for widespread transition. However, transit agencies must make investments in current technology to spur and inform the improvements needed in the future. Showcase presenters noted positive findings in this area. Metro's Pete Melin said his agency's analysis of their early tests found that battery-bus costs are competitive with diesel-hybrid buses; capital costs are a little higher initially, but operating costs are less. MTA's R&D Director Danny Ilioiu noted that the rapidly growing adoption of battery buses worldwide is lowering vehicle costs. David Cooper, Senior Planner at TransLink, described grant funding available in Canada.

Public transit agencies are at the forefront of a clean transportation revolution, and as we look to the future, we collectively expect battery-bus fleets to deliver sustainability benefits, improved customer experience, and lower operating costs. The onus is on transit agencies to develop and realize a vision for a cleaner, quieter future. The showcase made it clear that we have learned a lot so far and have a lot more to learn. Our zero-emission journey will continue to require critical questions, creative thinking, and a cohesive vision for how we'd like our transportation future to look.



Chat sessions

The Showcase included chat sessions—a series of small-group conversations among participants, each lasting 25 minutes. Table captains facilitated the discussions and took notes. The chats focused on the following topics: charging infrastructure and bus procurement; technology (battery, bus, chargers, telematics, etc.); electric power utility considerations; and base and service planning considerations.

Below is a list of the “Top 10 issues” we heard in the chat sessions (not in ranked order). Table captains’ notes are presented on pages 5 and 6.

Top 10 issues: Recurring themes and most-discussed topics

- 1 Costs**—What will it cost to procure buses, charging infrastructure, and other support needs?
- 2 Charging infrastructure**—What type is best? Will it be standardized and interoperable? How much time will it take to get permits and build chargers?
- 3 Base transition from diesel to battery**—How much space will be needed for charging? How will the time it takes to charge buses be managed?
- 4 Technology**—Many uncertainties and risks exist, including how to choose the right types of chargers and concerns about obsolescence.
- 5 Range anxiety**—Will the buses have the capability to travel long routes without risk of running out of energy?
- 6 Acceptance of change**—Will operators and mechanics readily adapt to this new technology?
- 7 Increased power requirements**—Costs, planning challenges, back-up power, support from utility companies, and potential demand charges are issues that need to be addressed early on.
- 8 Variables and unknowns**—Are there too many? Alternatively, are we too risk averse?
- 9 Route planning and scheduling challenges**—What affects might battery buses have on service quality, service reductions and route flexibility?
- 10 Batteries**—Are batteries safe, recyclable, and reliable, and can they be swapped quickly?



Specific issues, concerns, and challenges noted during the chat sessions

Charging

- ▶ Questions about charging infrastructure, power upgrade design and construction costs, and lifecycle costs. Capital and operating must pencil out.
- ▶ Comments and questions about charging infrastructure and plug type (fast, slow, inductive, etc.; flexibility in charging is desired), location, standardization, capacity, interoperability, lead time required to get it in place, and ratio of chargers to buses. Can plug adapters be helpful? Base flexibility: one can't easily move different types of buses to different areas of a base if you plan infrastructure in one area.
- ▶ Efficient charging. Timing of charging, plug-in protocol, and when to move the bus from its charger; ensure buses can get in and out on time and passengers can be on board when fast charging occurs.
- ▶ Managing charging infrastructure space requirements and the significant power requirements at bases or depots depends on so many variables. We don't have answers yet.

Bases or depots

- ▶ Base expansion, base parking, yard redesign, real estate acquisition, and transition of bases to electric fuel. Retrofitting bases is harder than adding new ones.

Technology

- ▶ Technology uncertainties, risk, and fear of obsolescence. Acknowledge the risk and take it; expect to learn from setbacks.
- ▶ Range and reliability anxiety and range limitations. Range equivalent to current diesel or diesel-hybrid is needed.
- ▶ Questions about staying power of bus and charging infrastructure manufacturers and ability to meet future orders.
- ▶ Are people jumping the gun before the technology is fully baked, or should agencies simply plan for long-term fleet transformation, assuming ongoing improvements in batteries, ranges, and reliability? Could hydrogen fuel cell buses supplement battery-electric buses? Infrastructure and real estate required is different and the CNG fueling footprint is generally similar to diesel or CNG.

Costs

- ▶ Costs associated with transition (buses, infrastructure, training etc.). Are battery-electric buses the most cost-efficient zero-emission choice?

Training

- ▶ Operators and mechanics: Acceptance of new technology and training for mechanics and operators may be a challenge. Consider driver and maintenance staff health from driving and maintaining electric vs. diesel buses. Operator training on bike and pedestrian safety, regenerative braking.

Maintenance

- ▶ Expect less maintenance with so many fewer parts.

Utilities and power

- ▶ Questions about power costs, especially peak demand charges and peak demand analysis and how demand matches up with supply. What are realistic power requirement assumptions? We need to understand power capacity and get help from our utility on understanding how to minimize costs. Negotiate rates in advance.

Regulations

- ▶ Federal Transit Authority regulations.

Procurement

- ▶ Procurement document preparation unknowns.
- ▶ Uncertainty about availability of articulated buses and concerns about bus quality.
- ▶ Testing a few buses is way simpler than scaling to large electric fleets. Start small, learn, and then take a bigger bite.



Decision-making

- ▶ Challenge with identifying all the requirements and variables.
- ▶ Analysis paralysis.
- ▶ Bigger agencies get more priority.
- ▶ Limited data out there to compare battery bus options.
- ▶ Concerns and questions about battery failure, reuse/recycling options, and environmental concerns.
- ▶ Inconsistent battery charge time and “real” available range.
- ▶ Battery purchase or lease? Which makes the most sense?

Safety

- ▶ Battery safety (especially during wash cycle), and retaining water-tight integrity. Disable bus while charging so it can’t drive off.
- ▶ Safety of batteries and bus materials, warranties, and ongoing maintenance and support. What about fire liability and passenger safety, ground faults? Also ensure charging cord doesn’t become active until connected to bus, to satisfy safety concerns.
- ▶ Buses are quiet. Educate people that they may not hear one coming.
- ▶ Electrical safety is now even more important.

Data and data security

- ▶ Need to capture bus and charger performance data (battery life, kWh/mile, charge-time duration, state of charge, remaining range, accessory load demand, historical performance, voltage, actual energy consumption and how energy is used) while ensuring network security.
- ▶ Cyber security needed for electric charging because it is all networked. Vulnerability to hacking.

Emergency preparedness

- ▶ Power source back-up and/or redundancy.

Planning

- ▶ Route planning/scheduling challenges in light of differing range and fueling specifications. Traffic challenges will have a negative effect on getting buses back to a charging station on time before they die. Traffic is a significant service reliability issue.
- ▶ Concerns with general disruption, time differential required for charging versus diesel fueling, and change to existing work routines. Also job losses/migration, worker retraining and union concerns.

Equity and social justice

- ▶ Equity and social justice considerations and public health data should be used to determine where to deploy zero-emission buses. This is an opportunity to prioritize service to neighborhoods more vulnerable to air pollution. Nevertheless, it’s important to recognize that the bus fleet is only one of many choices (e.g. service levels) that a transit agency makes concerning equity and social justice.

Public perception

- ▶ Public perception is also important. Have education/info campaigns on zero-emission buses so that stakeholders and public don’t start or spread negative rumors on the changes. Stakeholder concerns about aesthetics, residential load (will it affect home energy loads?).

Coordination opportunities

- ▶ Can battery buses be integrated into the existing trolley network?
- ▶ Base siting to consider power availability, technology and deadheading.
- ▶ Align routes and technologies rather than assuming one drives the other.



**Katie Chalmers, Supervisor, Service Planning,
King County Metro Transit, Seattle**

Katie's group has responsibilities for route and service design and fleet planning. The group helps ensure that Metro's future zero-emission fleet can meet the needs of riders and service characteristics. They will continue to develop plans for deploying buses based on technical features and policy considerations such as geographic distribution and equity and social justice. The group is also responsible for helping to identify any added service costs that this fleet may bring.

**Leo Hrechanyk, Vehicle Procurement Administrator,
King County Metro Transit, Seattle**

Leo managed the first battery-bus procurements at Metro, and along with the Bus Procurement Team, has been working on battery-electric vehicle and infrastructure development since 2012. Metro has operated three 40-foot fast-charge buses since early 2016 using the fast charger installed in 2015. Metro expects eight more fast-charge buses in fall 2017, and up to 10 extended-range buses in the first half of 2018 to test.

**Andrew Lightfoot, Major-Account Executive,
[Puget Sound Energy](#), Bellevue, WA**

For the majority of his nine years at PSE, Andrew was a Transmission & Distribution Engineer. He now manages some of the largest commercial and industrial customers in PSE's service territory, including King County. He is working closely with the King County team to support the installation of electric chargers at Metro transit centers.

**Lisa Shafer, Senior Transportation Planner,
King County Metro Transit, Seattle**

Lisa has been with King County for more than 20 years, with the past 12 years in transit and transportation planning. Her current projects include the development of a long-range Metro Facility Master Plan for bus bases and other operating facilities. She is also working on base capacity modeling, and on planning and implementation of Metro's long-range plan, METRO CONNECTS.

**George Stites, Superintendent, Fleet Engineering,
King County Metro Transit, Seattle**

George started his career in maintenance more than 40 years ago and has worked for King County for more than 30 years. He is responsible for testing new technologies. The introduction of hybrids was the first major technology change he led. Converting to a battery-only fleet is his next challenge.

Presenters and Panelists

**David Cooper, Senior Transportation Planner, [TransLink](#),
Vancouver, B.C.**

David has expertise in rapid transit development, service planning, strategic policy and public consultation. He has worked on key transit projects across Canada, most notably in Toronto, Calgary, and Vancouver. David leads the development of Translink's battery-electric bus program.

**Danny Ilioiu, Research & Development Director, [Metro Transit Authority](#),
Regional Bus Operations, New York**
Danny is the Electric Bus Program Lead. Over the past 16 years at MTA, Danny led the introduction and scaling-up of a fleet of 1,700 diesel-electric hybrid buses, the testing of all-electric buses, renewable diesel, regenerative active suspension, fuel-cell technologies, and collision avoidance systems.

**Pete Melin, P.E., Director, Zero-Emission Fleet Technologies,
[King County Metro Transit](#), Seattle**

Pete manages the evaluation of required operating and maintenance infrastructure for uniquely new fleet types (buses and smaller vehicles), particularly electric charging infrastructure. He is the coordinator for infrastructure, planning, bus testing, and procurement as Metro moves toward a zero-emission future.



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Resources

[All-Electric Bus Program](#), presentation by Danny Ilioiu, Research & Development Director, Metro Transit Authority, Regional Bus Operations, New York

[Transitioning to a Zero-Emission Fleet](#), presentation by Pete Melin, Director Zero-Emission Fleet Technologies, King County Metro Transit, Seattle

[Feasibility of Achieving a Carbon-Neutral or Zero-emission Fleet](#), report prepared by King County Metro Transit, March 2017.

Metro's Zero-emission Fleet website: <http://kingcounty.gov/depts/transportation/metro/about/innovation-in-motion/zero-emission-fleet.aspx>

King County's Strategic Climate Action Plan:

www.kingcounty.gov/climate

What's next?

Thank you to all Showcase participants for your engagement—you inspired us with progress made to date and identified important issues to be considered going forward.

King County Metro is planning a second Showcase to be held in spring 2018 in Seattle. Watch for an invitation!

For more information

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