ALASKA ELECTRIC VEHICLE WORKSHOP

Report of the ACEP-USARC Virtual Workshop Held June 16–17, 2020

UAF UNIVERSITY OF ALASKA FAIRBANKS

ACEP Alaska Center for Energy and Power

UNITED STATES ARCTIC RESEARCH COMMISSION

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CONTENTS

PREFERRED CITATION

Haupert, C., Leach, T., Rosa, C., Whitney, E., Wilber, M. and Byrd, A., eds. 2021. *Alaska Electric Vehicle Workshop: Report of the ACEP-USARC Virtual Workshop Held June 16–17, 2020*. US Arctic Research Commission, 20 pp.

Credit: ZEF Energy

EXECUTIVE SUMMARY

Electric vehicles (EVs) are becoming increasingly popular in the United States (U.S.) in response to improving technology, lower costs, increasing EV infrastructure, and policy incentives. In Alaska, EV ownership doubled, from 2018 to 2020, to nearly 1,600 registered vehicles. EVs have a strong foothold in Southeast Alaska, especially in Juneau, where there is relatively inexpensive electricity produced by hydropower. The EV market is now expanding into Southcentral and Interior Alaska. However, gaps remain in our understanding of how to further encourage the transition in vehicles, from traditional combustion engines, to EVs, throughout Alaska.

To address the challenges and opportunities of EVs in Alaska, the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks (UAF) and the U.S. Arctic Research Commission (USARC) hosted a two-day virtual workshop in June 2020, involving technical, academic, and policy experts who shared information, research findings, emerging research questions, and best practices relevant to EVs in Alaska and the Arctic.

The workshop was divided into four sessions: **Policy Environment**, **Charging Behavior**, **Operations and Performance**, and **Grid Impacts**. Opportunities for research, technology deployments, product innovations, and policy were identified and discussed. This report synthesizes their presentations, panel discussions, and question-and-answer sessions.

With Alaska in its infancy as an EV market, EV policies can help drive EV adoption, and in turn, support a grid that is more sustainable and is based on local fuel sources. Jurisdictions with climate goals can use EV adoption as a significant tool in reducing emissions. To ensure maximum public benefit, the EV strategy needs to be aligned with infrastructure plans for home, work, and public electrical charging and to include fast-charging networks. If the long-term cost to own and operate an EV is clear and attainable, then drivers are more likely to purchase one.

EVs are a flexible electrical load that can help utilities reverse the trend of declining sales. As communities transition to electrified transportation, electric utilities can benefit by increasing grid efficiency, thereby reducing rates for all customers and enabling better use of grid renewables. While EVs are operating in extreme cold climates, more research into cold climate consumer charging behavior is needed, as is additional knowledge on real world performance of EVs and chargers at temperatures below –20°C/–4°F.

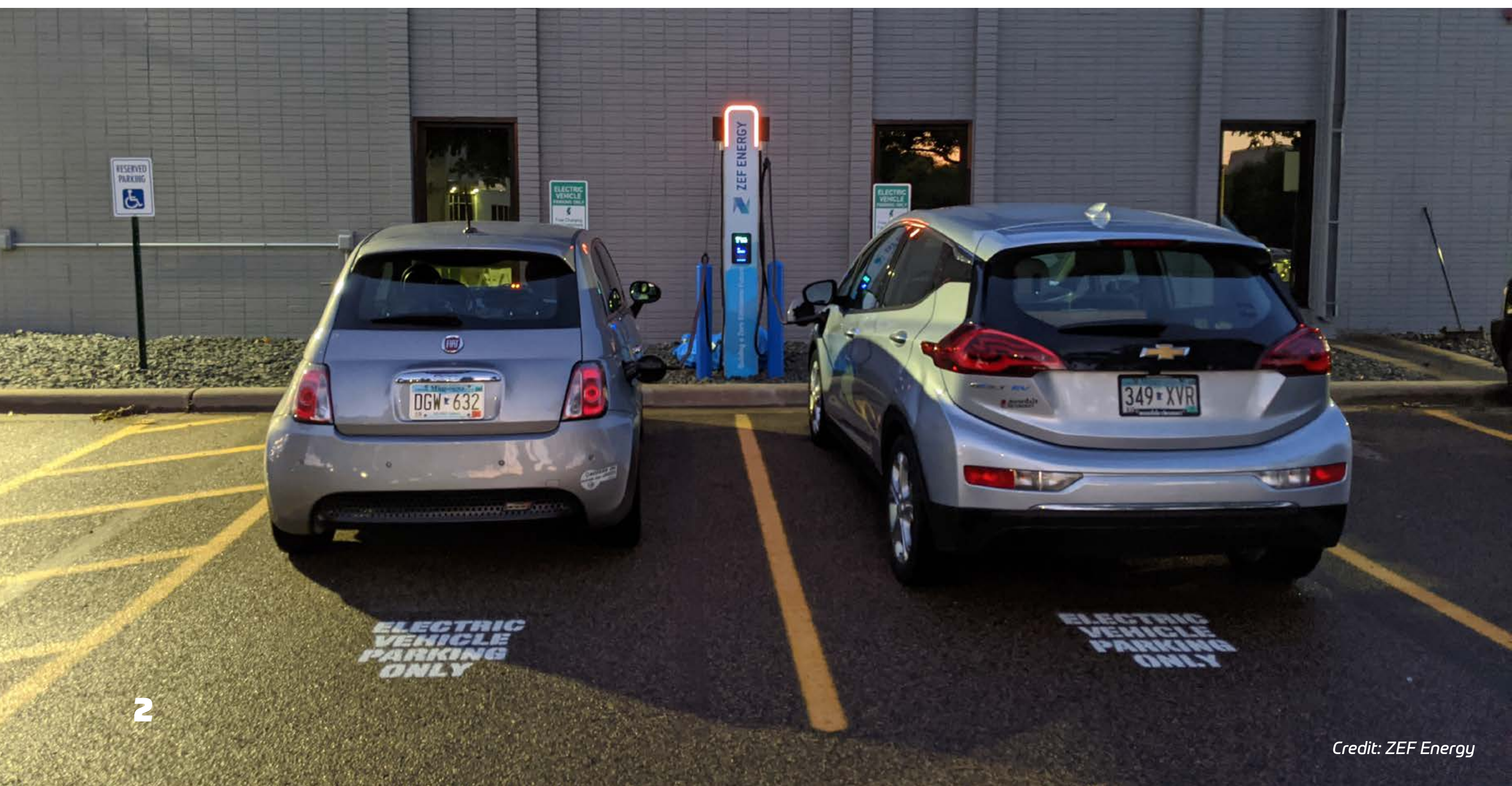
Using managed EV charging programs, utilities can meet increasing energy demands from EVs in the near term. Metering data is critical in managing energy demands and can be done through networked EVSEs. EV management programs can be used to align EV charging with periods of high intermittent generation, and thus temper load reduction caused by an increased use of renewable energy. Utilities across Alaska can plan for the future now.

Research questions and opportunities addressed during the workshop were also compiled and are summarized here.

- In the **Policy Environment** session, research questions were identified with regard to infrastructure, rate structures, price points, and personal incentives that will best suit EVs in both urban and rural Alaska, as well as the role that EVs could play in Alaska military installations. Opportunities were identified in the areas of battery cost improvements, charging infrastructure planning, and data collection and analysis from EV chargers, vehicles, and drivers.
- In the **Charging Behavior** session, questions about charging station options and the impact of demand charges arose, and opportunities were identified to better characterize EV vehicle counts and distributions across the state, along with charging behavior, alternatives to demand charges, models for ownership of fast chargers, and charger and metering technology development.

- In the **Operations and Performance** session, research questions were identified with regard to performance and degradation of batteries at very cold temperatures. Opportunities hinged on the identification of data gaps on real world performance of EVs below −20°C/−4°F and EVSEs at temperatures below −40°C/−40°F for Level 2 and −35°C/−31°F for Level 3. Other opportunities included the need to understand and mitigate cold-weather impacts on batteries as well as all-terrain vehicle (ATV) and e-snowmachine applications.
- In the **Grid Impacts** session, research themes were distinguished around the interaction between EV penetration and subsequent grid demand and upgrades, as well as the pairing of renewable energy generation and availability with EV charging demand. Opportunities were highlighted in the areas of data collection systems for tracking charger use and vehicle-to-grid technology.

The themes addressed during the two-day virtual workshop represented a subset of electric vehicle industry and policy topics. The content was not intended to be an exhaustive overview but rather a forum to broaden awareness of emerging research questions and opportunities. The authors of this report recognize the information provided herein is a summary of only the topics discussed during the workshop and does not attend to all of the issues facing the incorporation of electric vehicles in Alaska.



Credit: ZEF Energy

INTRODUCTION

Electric vehicles (EVs) have grown increasingly popular in the United States (U.S.). In Alaska, ownership of EVs has doubled in the past two years, with EV registrations increasing from just over 600 to nearly 1,200 between 2018 and 2020 (Chugach Electric). EVs have a strong foothold in Southeast Alaska, especially in Juneau, where inexpensive electricity, produced by hydropower, has reduced operational costs to roughly half that of traditional internal combustion engines (Alaska Business). Because Juneau has a truncated road system (190 miles of city and state-maintained roads), early adopters were not limited by the short ranges offered by the early model EVs. Juneau's milder climate also allows for optimal battery performance. The EV market is now expanding beyond Southeast Alaska, and other hydroelectricity-powered communities (like Cordova), into Southcentral and Interior Alaska. However, gaps remain in our understanding of how EVs may best fit into the transportation framework for the benefit of Alaskan communities.

To address the challenges and opportunities of the emerging EV sector in Alaska, the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks (UAF) and the U.S. Arctic Research Commission (USARC) hosted a two-day virtual workshop in June, 2020, with technical, academic, and policy experts who shared information, research findings, emerging research questions, and best practices relevant to EVs in Alaska and the Arctic. The workshop was divided into four sessions:

- Policy Environment
- Charging Behavior
- Operations and Performance
- Grid Impacts

Workshop presenters and participants are listed at the end of this report and included a broad range of EV professionals with expertise on policy, innovation, technical leadership, and energy services. They identified and highlighted opportunities for research, technology deployments, product innovations, and policy. This report synthesizes their presentations, panel discussions, and several question-and-answer sessions.

The consensus that emerged from the workshop was that EVs can benefit not only EV drivers, but also electric utility ratepayers, power generators, charging providers, the State of Alaska and the nation. Additional benefits include safer and convenient fueling, a smoother and quieter driving experience, cleaner air, reduced carbon dioxide (CO_2) emissions, and price stability. Challenges admittedly exist related to upfront initial investment, availability of charging infrastructure, potential grid impacts under high and clustered adoption scenarios, and cold-weather impacts, especially in Alaska. However, in the long term, **electrifying transportation can lead to job creation, increased U.S. competitiveness in the renewable energy sector, economic growth in the State of Alaska, grid efficiency, increased use of grid renewables, and energy self-sufficiency.**

Energy experts identify EVs as a form of "beneficial electrification" which is the replacement of direct fossil fuel use (e.g., propane, heating oil, gasoline) with electricity in a way that reduces overall emissions and energy costs (Farnsworth). In the case of EVs, beneficial electrification is described as adding EVs to the grid to leverage existing energy generation resources and installing the right equipment—controls and software—to help these resources work at their optimal potential for electric utility customers and ratepayers. Through these means, beneficial electrification can be in the public interest. In general, it can save money over the long term, reduce environmental impacts, support local economies, and enable better grid management. The impacts on and in remote Alaska communities are still to be seen and warrant additional discussion and consideration.

To achieve 'beneficial electrification' for transportation, decision makers need to balance EV market adoption with utility rate design considerations including costs, resources, and customer fairness and social acceptability.

The workshop emphasized that utilities and policymakers seeking to promote beneficial electrification should establish goal-specific policies guided by robust data analysis and refined by expert and public review.

REPORT STRUCTURE

The report is broken into four sections, each representing one session of the workshop. The first part of each section is a summary of material provided by the invited speakers and details shared during the panel discussion. The second part is a list of research questions and opportunities that emerged from the presentations and discussions.

Credit: Duluth Transit Authority

POLICY ENVIRONMENT

Summary of Presentation Material and Discussions

Public policies established by legislative and administrative bodies play a crucial role in determining the rate of EV adoption in local and regional markets (Gross). EV policies are bolstered by the judicially mandated investment from the Volkswagen (VW) diesel emissions settlement (U.S. District Court). This settlement requires that VW spend $2 billion on a National Zero Emission Vehicle (ZEV) Investment Plan to create infrastructure, programs, and brand-neutral media activities aimed at increasing public awareness of and access to ZEVs. The settlement also requires compensatory payments from VW, including $8 million for the State of Alaska. To unlock the full potential of this private investment, policymakers should consider addressing existing barriers to EV adoption and develop key EV-enabling policies that acknowledge the full value of transportation electrification, such as benefits to ratepayers, energy security, a cleaner and more resilient grid, and societal goals. Many jurisdictions with EV policies seek to accelerate EV adoption to reduce emissions and achieve air quality and climate goals. To date, Alaska has one EV-enabling policy, the EV-specific rate established for Juneau electric customers, compared to states like Washington with 13 policies, Texas with 10, and California with 53 (Gross).

Norwegian EV Incentives – Clara Good

Norway has mandated that all new cars sold by 2025 will be zero-emission (electric or hydrogen). The mandate required incentives, listed below, that promote ZEVs into the market and investments in a charging network. As EV ownership increases, the incentive packages have changed. In 2017, the Norwegian Government launched a program to finance at least two multi-standard fast charging stations every 50 km on all main roads. With the exceptions of Finnmark and Lofoten, fast charging stations have been successfully established on all main roads in Norway.

Current or previously applied Norwegian EV incentives (duration of time that incentive was offered) (Norsk elbilforening):

- No purchase/import taxes (1990–current).
- Exemption from 25% Value Added Tax (VAT) on purchase (2001–current). This is the most important incentive. The VAT exemption for zero-emission vehicles in Norway has been approved until the end of 2020. After 2021 the incentives will be revised and adjusted in conjunction with market development.
- No annual road tax (1996–current).
- No charges on toll roads or ferries (phased out in 2017).
- Maximum charge of 50% of the total amount of ferry fares for electric vehicles (2018–current).
- Maximum charge of 50% of the total toll amount on toll roads (2019).
- Free municipal parking (1999–2017).
- Local parking fee for EVs with an upper limit of 50% of the full price (2018–current).
- Access to bus lanes (2005–current).
- New rules allowing local authorities to limit the access to only include EVs that carry one or more passengers (2016).
- 50% reduced company car tax (2000–2018).
- Company car tax reduction reduced to 40% (2018–current).
- Exemption from 25% VAT on leasing (2015).
- Fiscal compensation for the scrapping of fossil fuel-powered vans when converting to a zero-emission van (2018).
- Allowing holders of a class B driver's license (equivalent to the class D non-commercial license in the U.S.) to drive electric vans class C1 (light trucks) up to 4250 kg (2019).

States in the U.S. that have been most successful in adopting EVs are those with state-constituted task forces. Britta Gross, of the Rocky Mountain Institute, noted that 13 U.S. states have adopted ZEV mandates. The mandates are technology-forcing policies that increase consumer choice and accelerate the number of EVs (Clean Energy Transition Institute).

In Alaska, the Alaska Energy Authority has recently convened an EV Working Group comprising EV stakeholders (government agencies, utilities, nonprofit organizations, businesses, and interested individuals, etc.). Through strong local and regional partnerships, the EV Working Group strives to minimize barriers to adoption of electrified transportation and to create an enduring ecosystem for electrified modes of transport.

EV policies can drive demand, EV awareness, and encourage utility investment and engagement. Successful policies promote consumer education, EV affordability and access, and EV charging affordability and access (smart rate design, i.e. aligning the choices consumers make with the choices that work best to minimize overall costs).

Consumer education is fundamental to EV adoption. Electric utility companies have a unique opportunity to play a critical role in education, awareness, and outreach as they have access to a large customer base..

The cost-benefit consideration, according to Britta Gross at the Rocky Mountain Institute, is such that if the cost to own and operate an EV is clear and favorable among other factors, a driver is more likely to purchase one. While the total cost of ownership of an EV is typically lower than a comparable conventional vehicle, the purchase price, or first cost, is still a barrier to adoption. Financial and non-financial incentives can be applied to remove this barrier. EVs are expected to reach price parity with conventional vehicles in the near- to medium-term as battery costs continue their steep decline and the market scales (Gross). The EV market is rapidly extending into government, corporate, and commercial fleets. In addition, with only 20% of vehicle purchases being new, plans for a used EV market should be considered.

Mark LaBel of the Regulatory Assistance Project asserted that developing a utility rate design structure that works for the unique characteristics of Alaska can result in revenue that stays in the state. If electrification is identified as being in the public interest, rates that benefit all can result (LaBel). Smart rates have proven successful. Unlike gasoline vehicles and stations, a smart EV load—with home and workplace charging—provides compelling new opportunities to build a greener, more flexible grid. Demand charges—fees based on a customer's peak use during a billing cycle—or alternatives need to be developed specific to the unique EV needs of the region, so they are not a barrier to EV adoption.

To ensure maximum public benefit, the Regulatory Assistance Project recommends the EV strategy be aligned with infrastructure plans for home, work, and public charging, and to include fast-charging networks (LaBel). Range anxiety is a common barrier for many when purchasing an EV and Alaska has unique challenges because of the long distances between population centers. Currently, public charging stations in Alaska are centered in more urban areas and not along travel corridors. **Policy can shape how EVs integrate with electric utility regulations and transportation funding and can be developed to maximize public benefits.** EV policies should also consider the opportunity to harness private sector investment in public charging stations and consider the removal of regulatory barriers where they exist. Tesla, a leader in the EV industry, is interested in bringing charging stations to Alaska. The question for them is how much to bring and what it will cost (Wahl).

Research Questions and Opportunities

RESEARCH QUESTIONS

- Further research is needed into the best Alaska site hosts, partners, and co-location with other EV owners (e.g. fleet operators, businesses). What routes would they connect first, considering 100 miles between stations? What are electricity costs? A robust plan should include proposed sites that consider limitations in existing transmission and distribution infrastructure.
- How much EV infrastructure does the public need before widely adopting EVs? How does EV infrastructure interplay with other factors to encourage EV adoption?
- What utility rate structure is best suited for Alaska and its distinct regions?
- At what price point will Alaskans buy EVs?
- Personal incentives may make a big difference. What is the right incentive package to encourage EV adoption in Alaska?
- Is there an EV market for the military, and what impacts would this have on Alaska?
- Beyond the connected Alaska communities on the Railbelt, how can EVs and EV infrastructure best support remote isolated grids in Alaska?
- Are the behaviors and driving and charging patterns of EV consumers in other regions consistent with those of consumers in Alaska?

OPPORTUNITIES

- Despite significant (85%) battery price reductions since 2010, additional cost improvements are needed to achieve parity with conventional vehicles (Gross). Research and development need to improve before this happens.

Educational Opportunities – Nancy Brown

Nancy Brown, from the Duluth Transit Authority, recommended developing educational opportunities for EVs—including EV scholarships and EV-specific courses. At the University of Alaska Anchorage, the Automotive Technology Program now offers EV and manufacturer-specific curricula. Scholarship opportunities to train technicians in EV technology and incentive programs to encourage local dealerships to train technicians to repair EVs can be expanded. In much of Alaska (except for Juneau) non-Tesla EVs cannot be repaired at local dealerships. This is likely a significant barrier to EV adoption in more remote and rural areas.

CHARGING BEHAVIOR

Summary of Presentation Material and Discussions

Based on the workshop outcomes, understanding the driving and charging behaviors of each community is key to developing a vibrant EV ecosystem. As EV use matures, early adopter charging behavior may not be the same as the behaviors of those who enter the EV market after it has been fully established (Lepold). As such, consumers want an EV charging system that is flexible and able to change as behaviors change. Each state and community will have a unique charging profile and incentive programs that will influence EV use and charging behavior. In Alaska the average driving distance to work and recreation is approximately five miles, but population centers are hundreds of miles apart (Dunckley).

Influencing charging behavior starts with an EV charging strategy for the region. The EV strategy should include a robust system for metering electricity use, adequate access to charging stations, a community appropriate electric rate structure, incentives for electric vehicles and charging equipment, and investments in education and outreach to build consumer awareness. According to the Electric Power Research Institute (EPRI), across the U.S. approximately 80% of EV charging takes place at home, 15% at the workplace, and 5% at public charging locations (Dunckley). Utility rate structure matters, and the right rewards program, incentive package, or pricing plan sways charging behavior. Studies conducted by EPRI have found redundancy and availability of plugs at each station are important to the consumer, as

Credit: Cordova Electric Cooperative

Minnesota Power Electric Vehicle Strategy – Yusef Orest

In 2007 the State of Minnesota passed the Next Generation Energy Act which requires the state to have 25% of its energy generation from renewable energy by 2025 and has the goal of reducing emissions by 80% between 2005 and 2050. To meet these goals, the Minnesota Public Utilities Commission adopted a Transportation Electrification Plan (TEP) effective Feb. 1, 2019. The TEP stated the importance of EV grid integration as critical for the public interest (a higher grid utilization would lead to a rate benefit for all), an emphasis on rate design pairing with low demand times and high renewable generation times, and the need to have distributed energy resource management system capability; EV owners should benefit through low EV fuel costs. The role of the electric utilities is 1) facilitating electrification of the transportation sector through policies and investments that educate customers on the benefits of EVs and infrastructure, and 2) optimizing the cost-effective integration of EVs through appropriate rate designs, policies, and investments that improve system utilization/efficiency and benefit utility ratepayers, including non-EV owners.

Minnesota Power, the electric utility servicing most of northeast Minnesota, developed a set of guiding principles for transportation electrification. The principles identified include forming dedicated cross-functional teams and hiring dedicated staff to help foster growth of EV use. The utility will work to expand their internal and external fleet (which currently totals four EVs). Rates are to be established for both residential and commercial use that offer off-peak incentives. Customer education and outreach events will be emphasized. Minnesota Power plans to support the electric bus pilot and the state's plan to use VW settlement funds to reduce emissions. Finally, a pilot program supporting Level 2 chargers is underway with future expansion desired.

is knowing there is another charging station nearby (within 40 miles) (Dunckley). Educational opportunities and programs also play important roles in influencing EV adoption and charging behavior.

For large market electric utilities, charging EVs often results in flexible loads on the grid, which can allow the utilities to harness and shape the demand curve for optimal use of grid assets. **As communities transition to electric transportation, the increased efficiency and sale of energy can translate to lower rates for all customers.** Increased EV penetration can also enable better use of variable renewable energy resources within larger markets. However, utilities need strategies for how to handle growing demands on the grid and smaller markets need to better understand if EVs can provide similar benefits.

Alaska Electric Light and Power Co (AEL&P) in Juneau currently powers its service region with 90% hydroelectricity and is working towards moving away from fossil fuels (Mesdag). With the highest EV use in Alaska, AEL&P has worked out a utility rate design based on a Time of Use (TOU) rate structure for EV users that encourages charging during off-peak energy demand periods, usually overnight. The TOU rate schedule offers two different levels: one in which residential and small commercial EV owners can reduce costs of operating their EVs by charging vehicles when loads on the electric grid are low, and a second option allows customers to participate in the off-peak charging rate and avoid the upfront cost of purchasing a Level 2 charging station by renting one from AEL&P (Mesdag). With TOU rate schedules, AEL&P sees 70% of charging during off-peak times.

Minnesota Power, servicing most of northeastern Minnesota, had developed a set of guiding principles used by the utility to inform the development of transportation electrification programs (Orest). Residential and commercial rates were developed with off-peak TOU schedules. Residential rates are offered at a significant reduction in the cost of energy if used during off-peak periods (off-peak rates are 82% lower than peak rates). Charging during off-peak periods can lead to substantial consumer savings. To incentivize commercial customers, rates are offered as on-, off-, and super-off-peak periods and include a 30% cap on demand charges. With these rate structures, Minnesota Power EV owners are using the off-peak periods for 85% of their charging. As interest in EV use has grown, a customer survey has found that charging behavior could also be influenced by rewards programs, vehicle and charger rebates, and more education including topics that address range anxiety and cold weather performance.

ZEF Energy believes smart chargers can benefit utilities (Hoye). Smart chargers are capable of capturing charging data, limiting the power draw at a single charge or at the group level, balancing feeder level loads, syncing with renewables power options, leveraging TOU rate schedules, enabling installation of useful functions in the vehicle to allow drivers to make better use of chargers, and serving multiple use cases in parallel. To balance their grid impacts and keep down costs, smart chargers are designed to control the speed of charge locally and can reduce charging costs and maximize up-time, which can be vital for mission-critical fleets, and provide broader operational efficiency. Managed charging in most utility circumstances makes economic sense from day one, but it is important for a utility to get hands-on experience to understand its value and incorporate smart charging at the inception of their EV strategies, since infrastructure upgrades can be extensive. While smart charging can harness the benefits of EVs, a traditional rate structure, specifically a high demand charge, can be a barrier to transit and corridor fast charging. High demand charges may make fast charging stations cost-prohibitive for site hosts and EV drivers and limit private investment in charging infrastructure and utilization of those that are built. In the end, there are multiple ownership models for publicly-available charging stations, including fast-chargers, without a single best fit for all jurisdictions.

Research Questions and Opportunities

RESEARCH QUESTIONS

- What are the charging station options in Alaska? How many long trips are people taking, and might there be alternative modes of transportation for those trips?
- What rate structures, incentives, and rewards programs would work best for Alaska? How will demand charges impact charging behavior?

OPPORTUNITIES

- Collaboration with the Alaska Department of Motor Vehicles is necessary to determine consistent and accurate EV vehicle counts and distribution across Alaska.
- To better understand charging behavior and plan for EV expansion, examination of current driving behavior in Alaska and how EV owners are using their vehicles is needed.
- Technology development opportunities exist in portable chargers, effective metering, and apps for sharing data/information with consumers.
- Examination of alternatives to demand charges is needed. High demand charges are a barrier to transit and corridor fast charging. These inelastic charges deter use of charging stations by EV drivers and investment in new charging stations.
- Investigation into models for ownership of public and fast-chargers is needed, including opportunities for cities, large institutions, and convenience retailers.

OPERATIONS AND PERFORMANCE

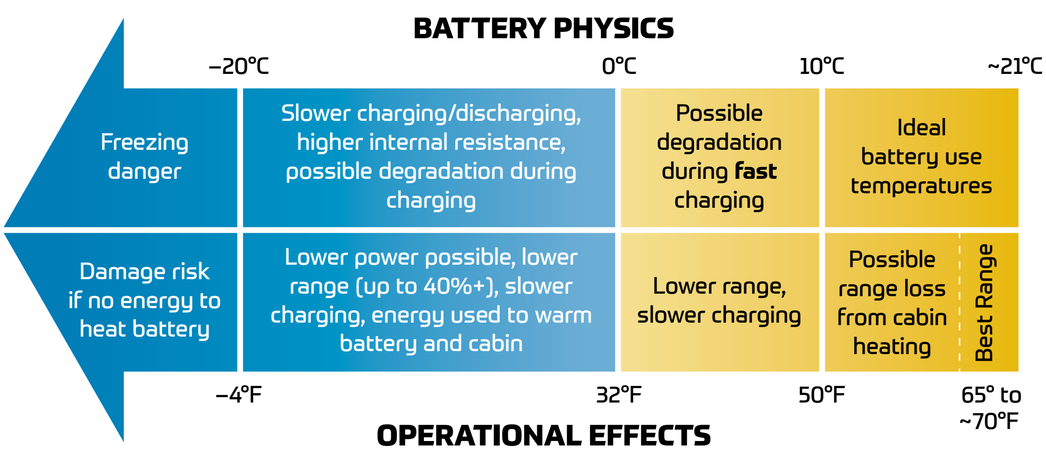
Summary of Presentation Material and Discussions

Ambient air temperature can have a large impact on the operation and performance of electrified transportation and chargers.

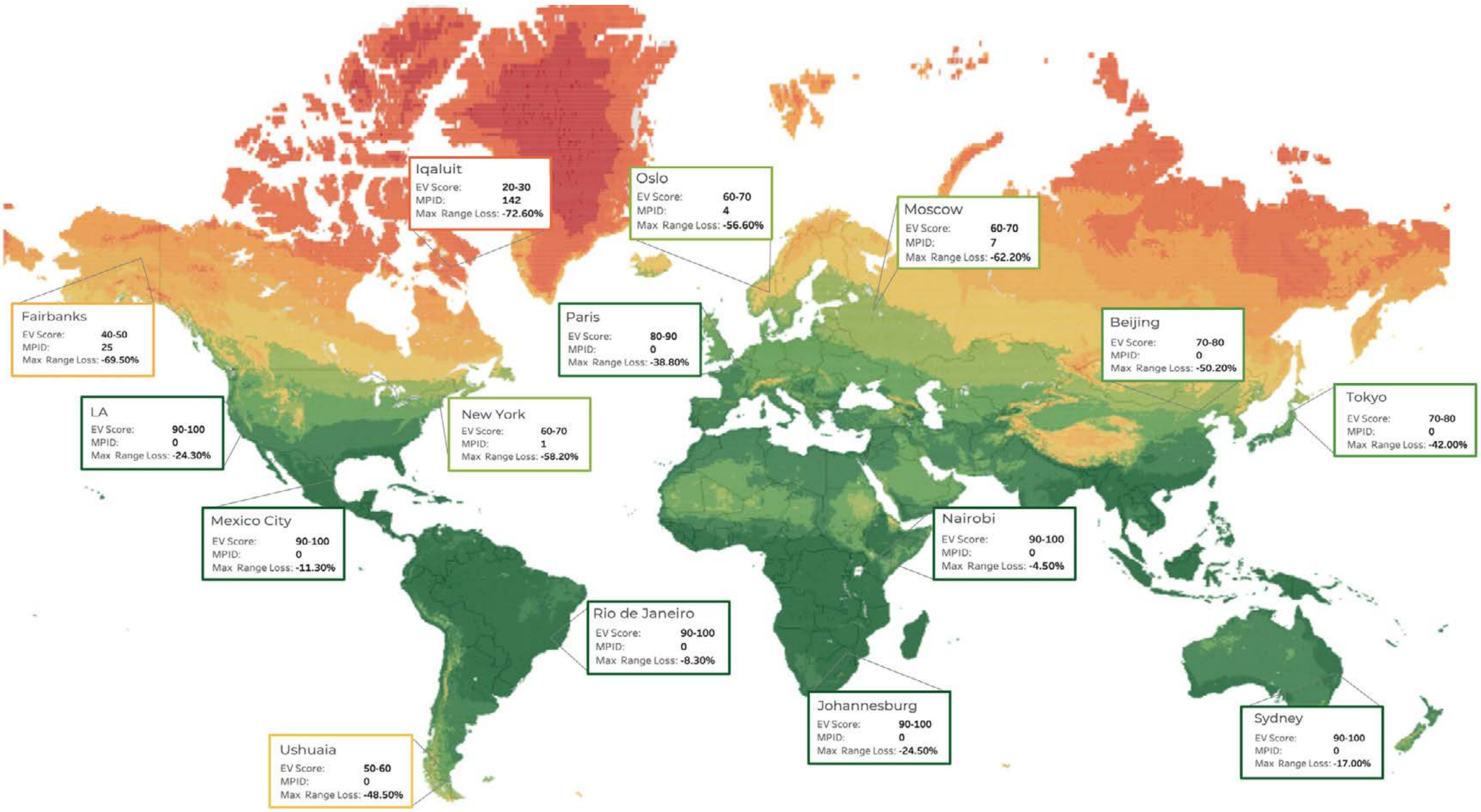
Electric Vehicle Batteries & Operations: Michelle Wilber described the effects of cold temperatures on battery and EV operation. These effects are shown in Figure 1, which was included in her presentation. Lithium-ion batteries are sluggish in very cold temperatures because they lose the ability to store and release energy. Crystal growth can damage batteries charged below recommended temperatures, and at extremely low temperatures, batteries can even be damaged in storage. To avoid these impacts, EVs have been designed with battery thermal management systems that keep batteries within an optimal temperature range. This minimizes loss in battery performance and battery damage but is an auxiliary load. **The main cold weather issues impacting EVs are large range decreases, slower charging speed, lower power in extreme cold, and the need to keep a vehicle plugged in or housed in a heated space, especially during extended periods below about −4°F to prevent battery freezing and damage.**

Operational effects on EV performance at temperatures below freezing increase as the temperature decreases with the additional possibility of battery damage if stored for extended periods at temperatures below −20°C/−4°F, which is possible if the EV is not able to get enough power from a charger or its own battery to run the battery heater (Wilber).

Temperature studies have been conducted down to −20°C/−4°F. However, much of Alaska's population lives in areas that experience temperatures below −4°F, with significantly colder temperatures in the Interior and the Arctic, sometimes for extended periods. Although EVs are operating in extreme cold climates, more research into the charging patterns and long- term maintenance is needed to accommodate regular use in colder climates. Further studies can fill in data gaps with real world performance of EVs and chargers at temperatures below −20°C.



Effects of cold temperatures on batteries and EVs. The top half shows temperature effects on batteries based on physics. The bottom half of the figure shows the operational effects on EV performance. *Source: Cold Weather Impacts on EVs, Michelle Wilber, Alaska Center for Energy and Power*



This screenshot from an online interactive EV Map produced by ACEP and University of Washington researchers shows colored zones of an 'EV score' metric based on yearly average range loss due to temperature, selected locations also call out 'Must Plug In Days' (MPID) for maximum number of consecutive days below -20C, and an estimate of the maximum range loss which would be expected for today's battery electric vehicles on the coldest day of the year. Go to https://public.tableau.com/profile/michelle1506#!/vizhome/ACEPEVMAP_16061795177860/Home?publish=yes to see the interactive map.

Charging Equipment. Megan Hoye of ZEF Energy explained that electric vehicle supply equipment (EVSE), known commonly as charging stations, is also impacted by cold temperatures. Unlike batteries, the transfer of charge in EVSE does not slow with decreasing temperature. Instead, the transfer of power is binary—working or not working—and will remain constant until a sufficiently cold temperature stops operation of the charger (Hoye). Industry standards have rated Level 2 charger operation as optimal between –20°C/–4°F to 50°C/122°F and fast-charger ratings as optimal between –35°C/–31°F and 50°C/122°F. The speed of charging, whether for Level 2 chargers or fast chargers, can be degraded in cold temperatures because, as discussed above, the properties of the battery's ability to absorb power is affected below –20°C/–4°F.

In northern Minnesota, commercial uses of electric transportation are emerging with electric buses (e-buses). The Duluth Transit Association (DTA) launched a fleet of fast-charge e-buses in 2018 (Brown). Over the course of the year, the temperature in Duluth typically varies from 7°F to 78°F and is rarely below –15°F or above 88°F. In a study of the effects of ambient temperature on fuel economy and vehicle range, the DTA e-buses lost approximately 30% efficiency when temperatures dropped to –6°C/20°F and continued to decrease at colder temperatures (Henning et al.). DTA manages the e-bus fleet in winter by using it on shorter routes. Additionally, diesel fired auxiliary heaters have been installed as primary heaters. This conserves battery power and helps to keep the passengers and driver warm. The electric heater is used only as supplemental heat is required.

Research Questions and Opportunities

RESEARCH QUESTIONS

- Real world EVs use battery heating systems: Are the current battery heating system(s) the best solution(s) for cold climates? How do these battery-heating systems perform at very cold temperatures?
- What impact do very cold temperatures have on battery degradation? A current published tool for general battery degradation is available (Geotab). However, it does not extend to cold temperatures normally seen in Interior Alaska and the Arctic.

OPPORTUNITIES

- There are data gaps on real world performance of EVs below −20°C/−4°F and EVSE at temperatures below −40°C/−40°F for Level 2 and −35°C/−31°F for Level 3.
- There is a need to investigate technologies that ameliorate cold-weather impacts, like alternative battery chemistries, novel battery-warming systems, alternative heating for cabins and batteries.
- More or improved data is needed on how much power is used in battery conditioning at very cold temperatures. Block heaters are commonly used in conventional vehicles during the winter. Does an EV battery conditioning system use more power than a block heater?
- All-electric all-terrain vehicles (ATVs) and e-snowmachine applications need to be further developed, including verification of operations and performance claims of existing commercially available options.

Duluth Transit Authority Electric Bus Program – Nancy Brown

Spurred by the Minnesota Pollution Control Agency's Emissions Reduction plan, the Duluth Transit Authority put a fleet of six Proterra 40-foot fast-charge battery e-buses into operation in 2018. The DTA has one fast-charging location with eight indoor plug-ins at their main facility. A second charging location was intended but was not allowable under zoning restrictions. The chargers are connected to a secondary power supply in case the main power is lost. The electric heaters on the e-buses could not keep the cabin warm enough, so diesel-fired auxiliary heaters were installed. This had the added benefit of conserving battery power and minimizing the loss of range of the e-bus due to cold weather.

Additional recommendations for commercial e-transportation were to:

- Have an infrastructure plan that can quickly adapt to rapidly changing e-transportation technology;
- Distribute the risk of power outages with redundant chargers, spare vehicles, emergency generator capacity, and off-site charging on a separate grid;
- Establish new procedures specific to e-bus operations;
- Consider fogging effects, venting, heating, performance on winter roads, and reduced range for cold weather operations.

GRID IMPACTS

Summary of Presentation Material and Discussions

EVs present a unique opportunity as well as a challenge for electric utilities. During the workshop four utilities shared insights on how each is managing its growing EV market: Alaska Electric Light and Power in Juneau, Alaska; Cordova Electric Cooperative in Cordova, Alaska; Minnesota Power in Duluth, Minnesota; and Green Mountain Power in Vermont. As Green Mountain Power developed its EV program, it found if proper infrastructure is available (e.g. managed or smart charging equipment and software) and utility rate structures are enacted, EV charging has the potential to be a large, flexible load that can be turned off during times of peak demand and turned on when inexpensive excess renewable generated energy is available (Turk). Electric utilities can plan for the impact EVs will have on the grid by understanding the load and enacting programs to manage EV charging.

Studies conducted by FleetCarma show trends in the EV market rapidly shifting to longer range EVs (Lepold). These vehicles can travel farther per charge and are driven more, often resulting in greater charging demands and less predictable charging patterns. They have larger battery capacities and consume more energy per charging session. The increased battery capacity drives the demand for higher power home charging infrastructure. It should be noted, however, that studies by Green Mountain Power in Vermont observed that the average connected load per EV is much lower than the charger nameplate capacity (Turk). These results indicated that charging was varied across time.

Sam Dennis of Renewable IPP and Graham Turk of Green Mountain Power agreed that electric utilities will need to plan for this increased and variable load. EV management

Credit: Matanuska Electric Association

In 2017 the Vermont Public Utility Commission implemented the TIER III – Renewable Energy Standard program which requires Vermont electric distribution utilities to acquire specified amounts of renewable energy, in the form of renewable attributes or renewable energy credits, and to achieve fossil fuel savings from energy transformation projects.

Green Mountain Power (GMP) services around 265,000 customers across most of southern and central Vermont. To support a growing EV market and meet TIER III goals, GMP established a pilot EV charger program that was paired with a managed EV program. Consumers were offered special rates for energy use, and using the load management system, GMP was able to manage the load to the grid which reduced peak-related costs and benefited all customers. As part of the program, smart Level 2 chargers were offered to all customers, free with the purchase of a new EV. The chargers, paid for by the TIER III project, were programmable and supplied metered energy use directly to the EV management platform.

By using an EV management platform, GMP was able to forecast peak demand periods and manage them by shifting loads. GMP would notify customers 8–24 hours in advance of a planned energy management event and allow the customer to opt out. A low opt-out rate demonstrated that customers accepted active management and load shifting if they got a full charge by morning. The pilot program demonstrated that a small amount of interruptions targeted at system peaks is an effective management strategy. Data from the pilot directly informed tariff design.

Providing a free Level 2 charger was critical for pilot rate adoption and allowed customers to realize savings quickly. The grid value of managed charging was about $120 per year, which was the cost of avoiding charging during peak time periods, so even outside of TIER III, the chargers would pay for themselves in about five years. Installing a smart charger early allowed for consistent and meaningful data collection.

programs and customer-controlled charging incentives provide scalability and growth potential for utilities. The near term, while EV deployment is still relatively small, is the ideal time for utilities to try different pilot programs to see what works and what doesn't. Examples can include installing smart charging infrastructure and testing time of use rates and other pricing signals.

Initial utility experience suggests that with managed EV charging programs utilities can meet increasing energy demands from EVs in the near term without adding more generation resources (Dennis). As EV growth continues, smart chargers can be a non-wire alternative that can help avoid expensive traditional grid upgrades. Smart chargers also are one way to acquire the charging data that is critical to managing energy demands. EV management programs can be used to align EV charging (and other flexible loads) with periods of low demand or high intermittent generation, and thus temper load reduction caused by an increased use of renewable energy and energy efficiency. Initial data suggests that electric vehicle charging is much more elastic to price signals than other home energy loads. Scott Leopold of FleetCarma explained that because of the highly elastic nature of electric vehicle charging, indications are that price signals do not have to be very big to encourage people to shift their charging behavior, and in some cases, people are willing to shift their charging without a change in price. This trend presents a unique opportunity for real time price signals to align EV charging with energy generated from renewable energy and other sources with low marginal costs (Good). A study in Norway shows that pairing solar generation with workplace charging times can meet charging demands, even in northern regions (Good et al.). Controlling the charging voltage based on solar energy availability may allow for charging at higher power during sunny hours and lower the charging voltage during non-sunny hours.

Clay Koplin reported that Cordova Electric Cooperative (CEC) is powered primarily by hydroelectricity in the summer and diesel in winter. During the summer months the utility has excess hydroelectric power that it is unable to utilize. Currently the utility is moving forward with storage solutions that will allow it to maximize their use of hydroelectricity and minimize the electrical generation from diesel. In addition to centralized battery energy storage systems, CEC is interested in using vehicle to grid technology as a Distributed Energy Resource (DER) (Koplin). In this scenario, DER systems are small-scale storage technologies used to provide an alternative to or an enhancement of the traditional electric power system. CEC has installed free EV charging stations that outnumber the EV demand and is working to automate the delivery of excess hydroelectricity to the charging stations when it is available—for a fraction of the cost of gasoline. As vehicle-to-grid (V2G) technology develops, CEC is also looking to have a true managed V2G system which would make it a prime candidate to be an early adopter or to be the site of a pilot project in this technology. CEC does acknowledge, however, that improvements in communications, controls, and interconnectivity will be necessary before this is possible. In addition, advances are needed with vehicle warranties for V2G use. CEC believes that with the proper planning and technology advancements, EV's can be a foundational element of future efficient grid architectures that will continue to become more interactive.

According to Sam Dennis, Renewable IPP, there is a misconception that utilities would need to implement substantial upgrades to handle increasing demand from EVs. While utilities should prepare for future upgrades, utility experience and modeling show these are not usually needed in the near-term (Dennis). Due to the variety of distribution infrastructure across utility territories, modeling the specific grid topology and EV uptake is prudent, especially as the number of long-range EVs increases. Utilities can consider rates and programs to incentivize off-peak charging to minimize negative grid impacts where they do exist and to shift demand to times of low cost, increasing the margin on the energy sold. **By using an array of existing tools such as smart-charging technology, managed EV charging programs, and TOU rate schedules, the electric utility can shift EV demand to off-peak periods, meaning grids can handle short-term forecasted EV increases.**

Research Questions and Opportunities

RESEARCH QUESTIONS

- What level of price signaling is required to incentivize customers to alter their charging behavior?
- At what level of EV penetration do grid upgrades become necessary? Can these upgrades be avoided through smart charging and other non-wire alternatives?
- What are the relationships between projected EV use in Alaska and grid demand. How will Alaskan utilities need to adapt?
- How can renewable energy generation and availability be paired with EV charging?

OPPORTUNITIES

- Data collection systems for tracking charger use need to be developed. Charging behavior is less predictable as batteries go long distances and are not charged every day. Being able to track use of a vehicle helps to predict what is expected. In addition, as long-range batteries are used more, greater charging needs will be required.
- V2G technology needs to evolve along several paths—communications, controls, interconnectivity, and commercial.

CONCLUSIONS

Many opportunities exist to advance research, technology, and policy relevant to EVs in Alaska and the Arctic. With Alaska in its infancy as an EV market, EV policies and incentives can help drive EV adoption and support a grid that is more sustainable and uses local fuel sources. Jurisdictions with climate goals can use EV adoption as a significant tool in reducing emissions. To ensure maximum public benefit, the EV strategy needs to be aligned with infrastructure plans for home, work, and public charging and to include fast-charging networks. If the long-term cost to own and operate an EV is clear and attainable, then drivers are more likely to purchase one.

EVs are a flexible electrical load that can help utilities reverse the trend of declining sales. As communities transition to electrified transportation, electric utilities can benefit by increasing grid efficiency, thereby reducing rates for all customers and enabling better use of grid renewables.

While EVs are operating in extreme cold climates, more research into cold climate consumer charging behavior is needed, as are further studies to address real world performance of EVs and chargers at temperatures below –20°C/–4°F.

Using managed EV charging programs, utilities can meet increasing energy demands from EVs in the near term. Metering data is critical in managing energy demands and can be done through networked EVSEs. EV management programs can be used to align EV charging with periods of high intermittent generation, and thus temper load reduction caused by an increased use of renewable energy. Utilities across Alaska can plan now.

Credit: iStock.com/John Pennell

APPENDIX 1. WORKSHOP PRESENTATIONS

The workshop was recorded and can be viewed in its entirety. Please visit http://acep.uaf.edu/ev-workshop.

PRESENTATIONS

Farnsworth, David. *Beneficial Electrification and EVs*. Regulatory Assistance Project. 2020.

Policy Environment

Gross, Britta. *How do we get more EVs on the Road?* Rocky Mountain Institute. 2020.
LaBel, Mark. *Electric Vehicles and Rate Design*. Regulatory Assistance Project. 2020.
Wahl, Francesca. *Tesla*. Tesla. 2020.

Charging Behavior

Mesdag, Alec. *Electric Vehicles in Juneau*. Alaska Electric Light and Power. 2020.
Orest, Yusef. *Minnesota Power's Electric Vehicle Strategy*. Minnesota Power. 2020.
Dunckley, Jamie. *Charging Behavior: What have we learned so far?* Electric Power Research Institute. 2020.

Operations and Performance

Wilber, Michelle. *Cold Weather Impacts on EVs*. Alaska Center for Energy and Power. 2020.
Brown, Nancy. *Duluth Transit Authority Electric Bus Program*. Duluth Transit Authority. 2020.
Hoye, Megan. *EV Smart Charging Performance & Operations*. ZEF Energy. 2020.

Grid Impacts

Lepold, Scott. *Grid Impacts: Findings from the EV Growing Pains Study*. FleetCarma. 2020.
Koplin, Clay. *Electric Vehicles (EVs) as Distributed Energy Resources (DERs)—Grid Impacts*. Cordova Electric Cooperative. 2020.
Turk, Graham. *Cutting Costs & Strengthening Customer Engagement with Managed EV Charging*. Green Mountain Power. 2020.
Dennis, Sam. *EV Benefit to Utility Rates*. Renewable IPP. 2020.
Good, Clara. *Electric vehicles and solar energy in Tromsø*. University of Tromsø. 2020.

ADDITIONAL REFERENCES

Argue, C. (2020, July 7). What can 6,000 vehicles tell us about EV battery health? *Geotab*. https://www.geotab.com/blog/ev-battery-health

Chugach Electric Association (2020). *Electric Vehicles.* Chugach Electric Association. https://www.chugachelectric.com/energy-solutions/electric-vehicles

Clean Energy Transition Institute (2019, September 3). Zero-Emission Vehicle Mandates Accelerate EVs. *Seven-Part Series on Electric Vehicles.* https://www.cleanenergytransition.org/post/zero-emission-vehicle-mandates-accelerate-evs

Good, C., Shepero, M., Munkhammar, J., Boström, T. (2019). Scenario-based modelling of the potential for solar energy charging of electric vehicles in two Scandinavian cities. *Energy 2019, 168, 111-125.*

Henning, M., Thomas, A., Smyth, A. (2019). An Analysis of the Association between Changes in Ambient Temperature, Fuel Economy, and Vehicle Range for Battery Electric and Fuel Cell Electric Buses. *Urban Publications, 0 1 2 3 1630.* https://engagedscholarship.csuohio.edu/urban_facpub/1630/

Orr, V. (2018, June). Alaska Embraces Electric Vehicles. *Alaska Business, 34(5).* https://www.akbizmag.com/industry/transportation/alaska-embraces-electric-vehicles

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United States District Court, Northern District Court of California (2017). *Attachment A: Environmental Mitigation Trust Agreement for State Beneficiaries. Case 3:16-cv-00295-CRB, Document 51-1.* https://www.epa.gov/sites/production/files/2017-10/documents/state-beneficiaries.pdf

APPENDIX 2. WORKSHOP AGENDA

Alaska Electric Vehicle Workshop

A VIRTUAL WORKSHOP HOSTED BY ALASKA CENTER FOR ENERGY AND POWER AND UNITED STATES ARCTIC RESEARCH COMMISSION

June 16–17, 2020

June 16 (All times are Alaska time)

9 am **WELCOME**
Gwen Holdmann, Alaska Center for Energy and Power
Cheryl Rosa, U.S. Arctic Research Commission

9:15 am **INTRODUCTION – BENEFICIAL ELECTRIFICATION AND EVS**
David Farnsworth, Regulatory Assistance Project – Beneficial Electrification and EVs

9:35 am **SESSION 1 – POLICY ENVIRONMENT**
Moderator: Chris Rose, Renewable Energy Alaska Project

> Britta Gross, Rocky Mountain Institute – How Do We Get More EVs on the Road?
> Francesca Wahl, Tesla
> Mark LeBel, Regulatory Assistance Project – Electric Vehicles and Rate Design

Topics for Discussion: What policy instruments and incentives are used in other locations and how are they working? What policies can increase the social, economic and environmental net benefits from EV adoption in Alaska? What policies could help reduce the risk of increased costs to utilities and their ratepayers in Alaska? What EV policy challenges exist in Alaska?

11:05 am **BREAK**

11:20 am **SESSION 2 – CHARGING BEHAVIOR**
Moderator: Sean Skaling, Chugach Electric Association

> Alec Mesdag, Alaska Electric Light and Power – Electric Vehicles in Juneau
> Yusef Orest, Minnesota Power – Minnesota Power's Electric Vehicle Strategy
> Jamie Dunckley, Electric Power Research Institute – Charging Behavior: What Have We Learned so Far?

Topics for Discussion: What are typical EV charging behaviors for other geographical areas that have been studied with respect to charging levels and energy usage, charging times and frequencies, costs, and accompanying amenities? Will EV drivers in Alaska demonstrate charging behavior similar to trends seen in other locations?

12:50 pm **CLOSING COMMENTS**

12:55 pm **END DAY 1**

Continued on next page…

June 17

9 am **SESSION 3 – OPERATIONS AND PERFORMANCE, EVS AND EVSE**

Moderator: Dave Messier, Tanana Chiefs Conference

> Michelle Wilber, Alaska Center for Energy and Power – Cold Weather Impacts on EVs
> Nancy Brown, Duluth Transit Authority – Duluth Transit Authority Electric Bus Program
> Megan Hoye, ZEF Energy – EV Smart Charging Performance & Operations

Topics for Discussion. What effect does cold weather have on EV and EV Charging equipment performance? What opportunities exist for electrification of fleet equipment in Alaska and other regions? What are the installation and operating costs of Level 3 charging equipment?

10:30 am **BREAK**

10:45 am **SESSION 4 – GRID IMPACTS**

Moderator: Julie Estey, Matanuska Electric Association

> Scott Lepold, Geotab – Grid Impacts: Findings from the EV Growing Pains Study
> Clay Koplin, Cordova Electric Cooperative – Electric Vehicles (EVs) as Distributed Energy Resources (DERs)—Grid Impacts
> Graham Turk, Green Mountain Power – Cutting Costs & Strengthening Customer Engagement with Managed EV Charging
> Sam Dennis, Renewable IPP – EV Benefit to Utility Rates
> Clara Good, University of Tromsø – Electric Vehicles and Solar Energy in Tromsø

Topics for Discussion. What are the grid impacts, at transformer and regional levels, of increased use of EVs and EV supply equipment? What are the technological capabilities and barriers related to Vehicle-to-Grid (V2G) and Vehicle-to-Household (V2H) technologies and systems? How could EVs be used for peak shaving? How could EVs support variable energy resources at residential and grid scales? How can EVs enhance renewable energy penetration in isolated Alaska microgrids?

12:25 pm **CLOSING COMMENTS**

12:30 pm **END DAY 2**

ACRONYMS

AEL&P	Alaska Electric Light and Power
°C	Degree Celsius
CEC	Cordova Electric Company
CO_2	Carbon dioxide
DER	Distributed Energy Resource
DTA	Duluth Transit Authority
e-bus	Electric bus
EV	Electric Vehicle
EVSE	Electric vehicle supply equipment
°F	Degree Fahrenheit
GMP	Green Mountain Power
kWh	Kilowatt hour
TEP	Transportation Electrification Plan
TOU	Time of use
U.S.	United States
V2G	Vehicle-to-grid
VAT	Value added tax
VW	Volkswagen
ZEV	Zero Emission Vehicle

Credit: ZEF Energy

Alaska Electric Vehicle Workshop

http://acep.uaf.edu/ev-workshop

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