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1 Introduction

Advancements in transportation technologies such as alternative fuels, connected and automated vehicles, and roadside infrastructure stand to change transportation networks worldwide. To best prepare for continued growth in the alternative fuel and advanced mobility sectors, the Regional Transportation Commission of Washoe County (RTC) endeavored to develop this *Electric Vehicle and Alternative Fuel Infrastructure and Advanced Mobility Plan*.

This plan investigates advanced mobility solutions that can be implemented in Washoe County to create a more convenient, connected, and environmentally friendly transportation network. After this introduction, it is divided into seven sections:

1. **Section 2** identifies the vision, mission, and goals of this plan.
2. **Section 3** describes the outreach activities carried out during the development of this plan, including meetings with Washoe County stakeholders and members of the public.
3. **Section 4** identifies existing policies and initiatives regarding advanced mobility and describes the current state of electric and alternative fuel vehicle infrastructure, connected vehicles, and mobility services across Washoe County.
4. **Section 5** evaluates the impacts of alternative fuel and advanced mobility technologies on safety, air quality, equity, and the commercial fleet industry.
5. **Section 6** discusses how to incorporate emerging technologies in travel demand modeling to inform transportation network planning.
6. **Section 7** identifies opportunities and recommendations that the RTC can implement as it works toward achieving its vision for the future of the County transportation network.
7. **Section 8** provides guidance for the RTC in implementing the recommendations identified in this plan.

This plan will guide the RTC to integrate emerging technologies and advanced mobility solutions into the Washoe County transportation framework. The recommendations identified in this plan were developed to be primarily under the control of and led by the RTC. However, support from Washoe County stakeholders and the public will be an essential component of the RTC's success. This plan should be used by the RTC to encourage those partner groups to participate in preparing Washoe County for the future of transportation in Nevada and across the United States.

2 Vision, Mission, and Goals

Developing a vision, mission, and goals for any project can be extremely useful in identifying the needs of an agency and opportunities to best address them. For this plan, these elements were developed with stakeholder input to ensure they reflected the needs of the larger community and not solely those of the RTC.

2.1 Vision

A vision describes the future state of the transportation network that the RTC hopes to achieve. It aims to answer the question, “How will Washoe County be better off because of our plans?” Incorporating stakeholder input, the vision of this plan is to:

“Enhance transportation safety, efficiency, sustainability, and equity in Washoe County through the effective application of emerging innovative mobility solutions.”

2.2 Mission

A mission describes the purpose of the project. It aims to answer, “What are we doing?” Based on coordination with the stakeholder working group, the mission of this plan is to:

“Outline the steps necessary to design and integrate emerging innovative mobility solutions in Washoe County within the planned and existing transportation network.”

2.3 Goals

Goals are broad, qualitative statements regarding what the RTC aims to achieve. The eventual strategies presented in this plan were developed to help the RTC reach its goals in support of its vision and mission. These goals were developed to reflect the desires of both the RTC and the stakeholder working group, which reflects the community at large.

1. Support electric and alternative fuel vehicle adoption by making charging and alternative fueling sites as accessible and convenient as gasoline fueling stations.
2. Promote advanced mobility solutions that benefit the broad range of Washoe County residents, visitors, and workers.
3. Prioritize equity when planning for the future of transportation in Washoe County.
4. Improve awareness of electric, alternative fuel, connected, and autonomous vehicles among individuals and businesses in Washoe County.
5. Remove financial and other barriers to adopting emerging technologies for residents, visitors, and workers in Washoe County.
6. Provide an industry-leading transportation network that integrates emerging technologies to promote safe and efficient travel in and across Washoe County.
7. Promote the success of regional freight corridors in and through Washoe County by supporting and incorporating emerging technologies in the trucking industry.
8. Identify the impacts of advanced mobility solutions on travel behavior and understand how to integrate them into the planning process.

3 Outreach Activities

Community involvement and support will be crucial to the RTC's success in preparing Washoe County for the future. To this end, a stakeholder working group was established to review progress and offer input into the opportunities and challenges associated with emerging technologies. The public was also offered the chance to review and comment on this plan during its development.

3.1 Stakeholder Working Group

The first stakeholder working group meeting was held on February 9, 2021. After receiving an overview of the project, attendees were asked to join "breakout" groups to discuss the biggest mobility challenges in Washoe County and the barriers to implementing solutions. The groups noted that communications infrastructure may form a barrier to connected technologies, and that a data management plan should be developed to determine how to route and process incoming data efficiently and effectively. The cost of this infrastructure and data management was identified as a barrier to implementation, particularly because infrastructure would need to cover the rural areas that form much of Washoe County. Due to this sprawling nature, micro-mobility would be a difficult solution to focus on and may not offer significant benefits beyond accommodating some first- and last-mile connections.

A second stakeholder working group meeting was held on Wednesday, May 5…

Stakeholder Roster of Participating Individuals/Agencies

Organization
Builders Association of Northern Nevada (BANN)
Carson City
City of Reno
City of Sparks
Governor's Office of Economic Development (GOED)
Governor's Office of Energy (GOE)
HDR Inc
High Sierra Industries Inc.
Human Services Network
Neighborhood Network of Northern Nevada
Nevada Center for Applied Research, UNR
Nevada Department of Transportation (NDOT)
Nevada Governor's Council on Developmental Disabilities
NV Energy
Reno and Sparks Chamber of Commerce
Reno-Sparks Indian Colony
Reno-Tahoe International Airport
RTC Washoe
Senior Coalition of Washoe County

Storey County
Tahoe Transportation District (TTD)
Truckee Meadows Regional Planning Agency (TMRPA)
University of Nevada, Reno (UNR)
Washoe Air Quality Management Division
Washoe County
Washoe County School District (WCSD)

3.2 Public Review

(…)

4 Existing Conditions

To develop recommendations for the RTC in promoting and utilizing emerging technologies, it is important to understand current policies and initiatives at the local, state, and federal levels. It is also important to know the current state of electric and alternative fuel vehicle (AFV) infrastructure, connected vehicles, and mobility services in Washoe County.

4.1 Policies and Initiatives

As new technologies emerge to solve today's transportation issues, governments and agencies must keep up by enacting legislation and initiatives to not only support but promote adoption. Policies and initiatives in place relevant to Washoe County include:

Nevada Clean Diesel Program[1]

In 2008, the Nevada Department of Environmental Protection (NDEP) launched the Clean Diesel Program to help reduce emissions from the State fleet of publicly and privately owned diesel-powered equipment. The Clean Diesel Program has three fundamental goals:

- Deliver significant reductions in diesel emissions in terms of tons of pollution produced and diesel emissions exposure from vehicles, engines, and equipment operating in areas designated as poor air quality areas.
- Reduce the exposure of sensitive populations to the harmful components of exhaust emissions from diesel-powered vehicles.
- Reduce diesel emissions to help improve and maintain air quality in communities across Nevada.

The NDEP recently partnered with the Clark County School District and the City of Reno to support the early retirement and replacement of 11 program-eligible diesel-powered school buses and five program-eligible diesel-powered municipal service vehicles.

Electric School Bus Incentives[2]

The Electric School Bus Incentives program was designed to assist school districts in the Nevada Energy (NVE) service area to replace diesel engine school buses for battery electric school buses and to install supporting charging infrastructure. Compared to diesel, electric school buses have lower maintenance costs and avoid an average of 54,000 pounds of CO_2 emissions per year. Inside air quality is also improved by a factor of six compared to diesel engine school buses. This program provides incentives that can cover up to 75 percent of the total cost to buy a new battery electric school bus and/or related charging infrastructure.

Since the start of 2020, NVE has also collaborated with the NDEP to inform school districts about funding available through the Nevada Clean Diesel Program and Volkswagen Clean

[1] Nevada Department of Environmental Protection, https://ndep.nv.gov/air/air-pollutants/clean-diesel-program
[2] Nevada Energy, https://www.nvenergy.com/publish/content/dam/nvenergy/brochures_arch/cleanenergy/electric-vehicles/Electric-School-Bus-EV-Incentives-Flyer.pdf

Air Act Civil Settlement fund. Washoe County School District (WCSD) is participating in the program to apply for funding of two electric school buses and two fast-charging stations.

Volkswagen Settlement Funding[3]

The State of Nevada is receiving $24.8 million through the 2017 Volkswagen Clean Air Act Civil Settlement to fund projects that will offset the excess pollution emitted by Volkswagen vehicles across the state. The NDEP has allocated the maximum amount allowed under the Volkswagen Environmental Mitigation settlement (15 percent of the funds) to electric vehicle supply equipment (EVSE). Other potential actions identified by the NDEP include:

- Facilitating transformative change by prioritizing EV and EVSE projects rather than diesel replacements.
- Prioritizing Phase 2 allocations to electric models.
- Maintaining the maximum investment of 15 percent in EVSE.
- Evaluating the Beneficiary Mitigation Plan (BMP) funding priorities annually to account for increased EV availability.

Electric Vehicle Infrastructure Demonstration Program[4]

In 2019, Senate Bill 299 created the Electric Vehicle Infrastructure Demonstration program (EVID) in connection with which public utilities must submit an annual plan that identifies how they will carry out the program in their service area to the Public Utilities Commission of Nevada. The plan submitted by the utility is authorized to include measures that promote or incentivize the deployment of EV infrastructure, including, without limitation, the payment of an incentive to a customer of the utility that installs or provides the infrastructure.

The EVID program helps make residential EV charging more accessible, particularly for low-income residents and those living in apartments and condos due to new incentives offered by NVE. The developers of new low-income multi-family dwellings will receive the lesser of $10,000 per Level 2 charging port or 100 percent of the total project cost for two to four ports, with a maximum incentive per project of $40,000. The program was provided a total budget of $150,000 for 2020. In addition, the EVID program allocated funds for the Nevada Electric Highway program along US 95 between Las Vegas and Reno, with a maximum of $500,000 available per charging site.

Electrification Coalition Roadmap[5]

In 2020, the Electrification Coalition launched an initiative, the State EV Policy Accelerator, to engage five states (Michigan, Nevada, North Carolina, Pennsylvania, Virginia) to develop a replicable model advancing EV adoption through policy and fleet-scale development. The

[3] Nevada Department of Environmental Protection,, https://ndep.nv.gov/uploads/air-vwset-docs/NV_Volkswagen_Fund_FACT_SHEET.pdf
[4] Nevada State Senate, https://legiscan.com/NV/text/SB299/id/2019653
[5] Electrification Coalition, https://www.electrificationcoalition.org/programs/state-ev-accelerator/

effort would involve stakeholder convenings between state and local government officials with the intention of outlining a path forward to navigate roadblocks and address challenges. The Electrification Coalition conducted the Nevada EV Policy Bootcamp on December 9th, 2020, during which nearly 100 EV policymakers, industry experts, and advocates joined for a collaborative day-long session about how to accelerate adoption of EV in Nevada. The bootcamp focused on national and industry trends for EV as well as local opportunities, including national transportation electrification needs, the impacts of EV on air quality and public health, and equity concerns. The discussion of local opportunities included the vision for EV in Nevada, utilities involvement, and near-term policy actions. The final report should be complete this year (2021).

Executive Order 2019-22 – Advancing Nevada's Climate Goals[6]

On March 12, 2019, the State of Nevada joined the U.S. Climate Alliance and committed to supporting the United Nations' climate goals established at the 2015 Paris Climate Change Conference. Executive Order 2019-22 set a primary goal to reduce greenhouse gas (GHG) emissions to 28 percent below 2005 levels by 2025 and to 45 percent below 2005 levels by 2030. It also called for a statement of policy options needed to reach the emission reduction goals. As part of the U.S. Climate Alliance, Nevada would implement policies to reduce GHG emissions, track and report progress on its efforts to achieve GHG emission reduction goals, and accelerate policies to reduce carbon pollution and promote clean energy deployment.

Clean Cars Nevada[7]

In June 2020, the NDEP announced the start of a rulemaking process to evaluate adoption of low- and zero-emission light-duty vehicle (LDV) standards. Nevada adopted the California Code of Regulations which mandates that, beginning with the 2025 model year, all original equipment manufacturers (OEM) of passenger cars, LDV, and medium-duty vehicles (MDV) produced and delivered for sale in the State of Nevada shall not exceed the fleet average GHG emission standards set forth in the Code of Regulations.

As part of the Nevada Climate Initiative, the Clean Cars Nevada program will help advance the State's climate change and sustainability goals. Two new programs are being proposed: A Low-Emission Vehicle (LEV) program and a Zero-Emission Vehicle (ZEV) program. The LEV program would require new (as of model year 2025) passenger cars, light-duty trucks, and MDV sold in Nevada to meet certain emissions requirements that reduce emissions of GHG and criteria pollutants including carbon monoxide (CO), nitrogen oxide (NO_x), volatile organic compounds (VOC), and hazardous air pollutants (HAP). The ZEV program would include three major initiatives: A ZEV credit requirement based on average annual sales; generation of ZEV credits by OEM; and introduction of clean vehicle technologies such as battery electric, hydrogen fuel cell (HFC), and plug-in hybrid electric vehicles by OEM. The

[6] State of Nevada Executive Department, https://gov.nv.gov/News/Executive_Orders/2019/Executive_Order_2019-22_Directing_Executive_Branch_to_Advance_Nevada_s_Climate_Goals/

[7] Nevada Department of Environmental Protection, https://ndep.nv.gov/uploads/air-ccn-docs/Draft_Clean_Cars_Reg_Language.pdf

programs are currently going through a review of the draft regulation and the final formation of the legislative commission and filing is tentatively scheduled for December 2021.

Federal Tax Credit[8]

The Qualified Plug-In Electric-Drive Motor Vehicle tax credit is available in Nevada for plug-in hybrid electric vehicles (PHEV) and ZEV purchases until OEM meet a specified threshold of 200,000 vehicle sales per manufacturer). It provides a tax credit of $2,500 to $7,500 for new vehicle purchases, with the amount determined by vehicle size and battery capacity.

4.2 Charging Infrastructure

According to the U.S. Department of Energy (DOE) database, there are 404 public alternative fuel stations in the State of Nevada and 94 in Washoe County as of February 15, 2020[9]. A breakdown of these stations by type is provided in **Table X**, shown graphically in **Figure X**. A complete charging infrastructure inventory is provided in **Appendix X**.

Alternative Fuel Type	Number of Stations in Nevada	Number of Stations in Washoe County
Electric Vehicle Supply Equipment (EVSE)	380 (1,117 outlets)	90 (348 outlets)
Level 2	*316 (839 outlets)*	*82 (308 outlets)*
Direct Current Fast Charge (DCFC)	*72 (278 outlets)*	*8 (40 outlets)*
Hydrogen Fuel Cell (HFC)	0	0
Compressed Natural Gas (CNG)	3	1
Ethanol (E85)	10	0
Biodiesel (B20 and Above)	0	0
Liquefied Natural Gas (LNG)	0	0
Propane (LPG)	11	3

Nevada does not currently have hydrogen refueling stations. In contrast, the State of California has more than 40 retail liquid hydrogen stations as of 2019, and this number is expected to grow following the new 2035 zero-emission mandate. The ongoing development of a regional freight route on I-80 connecting California, Nevada, and Utah through the Reno/Sparks area, combined with an expected shift in the freight industry to HFC, indicates an opportunity for the RTC to promote hydrogen to avoid forming a gap in the planned network.

According to the Nevada Auto Outlook 2019, total light-duty vehicle sales in Nevada declined by 4.7 percent through 2019, consistent with national trends[10]. Light-duty truck sales continued to gain an increasing share of the market, growing from 43.2 percent in 2012 to 67.8 percent

[8] U.S. Internal Revenue Service, https://www.irs.gov/businesses/plug-in-electric-vehicle-credit-irc-30-and-irc-30d
[9] U.S. Department of Energy, https://afdc.energy.gov/stations/#/analyze?region=US-NV&country=US
[10] Nevada Auto Sales Outlook, https://climateaction.nv.gov/wp-content/uploads/2020/12/4Q-2019-Report.pdf

in 2019. Sales of new hybrid and electric vehicles (EV) represented 6.5 percent of the Nevada market share in 2019. Total sales were up 25 percent for low- and zero-emission vehicles through the beginning 2019 but dropped off rapidly later in the year. The onset of COVID-19 in early 2020 and the consequent economic slowdown drove new vehicle registrations in Nevada down by 12.7 percent from January to July compared to the same period in 2019. In the first half of 2020, the share of hybrids, battery electric vehicles (BEV), and PHEV declined slightly—by 0.5 percent or less—relative to the same time last year; however, sales are still growing. Based on the increasing sales of light-duty ZEV, there will be increasing demand for charging infrastructure. The RTC should work to accommodate future demand by planning for and siting new public charging stations across Washoe County.

Nevada plans to expand EV adoption across the state, not just in densely populated areas. The State and NV Energy have partnered to implement the Nevada Electric Highway (NEH) joint initiative to increase access to charging infrastructure between major urban centers[11]. The NEH represents the next phase in expanding charging infrastructure in Nevada to support EV owners. Once completed, the NEH will give BEV and PHEV drivers the freedom to travel the 450-mile route from Reno to Las Vegas, with charging stops along the US 95 corridor. As part of the NEH initiative, Nevada has also received acceptance from the U.S. Federal Highway Administration (FHWA) on designation of four strategic corridors as Alternative Fuel Corridors, including I-80, I-15, and US 50.

The NEH initiative was to be completed in 2020, but its status during the COVID-19 pandemic unknown. When it is done, the NEH will provide charging stations at the locations indicated in **Table X**. Completion of the NEH initiative is expected to help mitigate the range anxiety that EV owners often feel with battery ranges that typically fall below the fuel range of an internal combustion engine (ICE) vehicle.

Nevada Electric Highway Charging Station Locations			
I-15 Primm	I-80 Battle Mountain	US 95 Goldfield	US 50 NDOT ROW
I-15 I-15 / US 93	I-80 Carlin	US 95 US 95 / SR 267 Jct.	US 50 Ely
I-15 Moapa	I-80 Elko	US 95 Amargosa Valley	US 50 / US 93 Jct.
I-15 Mesquite	I-80 Wells	US 95 Indian Springs	US 50 Baker
I-80 Fernley	I-80 Oasis	US 50 Silver Springs	US 93 Coyote Springs
I-80 / US 95 Jct	I-80 West Wendover	US 50 Middlegate	US 93 Alamo
I-80 Lovelock	US 95 Shurz	US 50 Cold Springs	US 93 Sunnyside
I-80 Mill City / Imlay	US 95 Luning	US 50 Austin	US 93 / US 93A Jct.
I-80 Winnemucca	US 95 Mina	US 50 Rest Area	US 93 Jackpot
I-80 Valmy	US 95 Coaldale	US 50 Eureka	US 50 NDOT ROW

[11] Nevada Electric Highway, https://nevadaelectrichighway.com/

In 2020, Air Liquide outlined its $200M investment to build a new renewable liquid hydrogen plant and related logistics infrastructure in North Las Vegas[12]. With a capacity of nearly 30 tons of liquid hydrogen per day—an amount that can fuel 42,000 hydrogen fuel cell electric vehicles (HFCEV)—Air Liquide's hydrogen plant is expected to provide a reliable solution to the large-scale deployment of hydrogen mobility on the west coast. The plant will serve the complete range of ZEV, from cars and buses to forklifts and heavy-duty freight trucks. When complete, the plan stands to offer significant support to the RTC in promoting hydrogen as an alternative fuel source in Washoe County.

Nevada has the largest lithium prospects in the U.S. and the only active lithium mine in North America, at Silver Peak[13]. Increasing global demand for battery production has prompted the mining industry to pursue an extraction enterprise at Thacker Pass, the largest known lithium resource in the country. Several entities are considering investments or have already secured rights to a lithium claim in Nevada. According to the Lithium Americas 2018 annual report, Phase 1 of the Thacker Pass project projects an annual production capacity of 30,000 metric tons lithium carbonate equivalent (LCE) by 2022. Phase 2 (2026) projects a production capacity of 60,000 metric tons LCE per year.

4.3 Connected Vehicles

Advancements in connected vehicle (CV) technology have allowed vehicles to communicate with each other (vehicle-to-vehicle, V2V) and roadside infrastructure (vehicle-to-infrastructure, V2I) to improve operations and user safety by preventing dangerous situations. Automated vehicles (AV) can use internal sensors to gather information about the vehicle's surroundings and operate in isolation. Connected automated vehicles (CAV) can use a combination of on-board sensors and vehicle connectivity[14].

V2V technology allows vehicles to transfer data within an ad-hoc "mesh network," or a network where a vehicle can "hop" between other vehicles to obtain data farther ahead than the range would typically allow[15]. V2V is expected to be more effective than today's systems, which rely on the functionality of on-board hardware. V2I enables communications between vehicles and roadside infrastructure, including RFID readers, traffic lights, cameras, lane markers, lighting, signage, and parking meters. V2I is a wireless, two-way system that transfers information via Dedicated Short-Range Communication (DSRC) units. Using V2I technology, vehicles receive information on aspects such as road conditions, crashes, construction zones, congestion, and parking spaces. Traffic management systems can use data coming from the vehicles to set variable speed limits and adjust signal phasing and timings to facilitate traffic flow.

V2V safety applications and the crash type they can address include[16]:

[12] S&P Global, https://www.spglobal.com/marketintelligence/en/news-insights/trending/jD82l4lVcUvZP96jDOOTMQ2
[13] Sierra Nevada Ally, https://sierranevadaally.org/2019/10/22/lithium-nevada-is-on-schedule-to-begin-thacker-pass-construction-in-2021-a-carbon-neutral-mine/
[14] https://www.nevadadot.com/mobility/avcv
[15] Arena & Pau, Kore University of Enna, https://www.mdpi.com/1999-5903/11/2/27
[16] National Highway Traffic Safety Administration, https://rosap.ntl.bts.gov/view/dot/27999/dot_27999_DS1.pdf

- Forward Collision Warning and Electronic Emergency Brake Light, for rear-end crashes
- Do Not Pass Warning and Left Turn Assist, for opposite direction crashes
- Intersection Movement Assist, for intersection crashes
- Blind Spot Warning/Lane Change Warning, for lane change crashes

Table X shows additional applications of connected vehicles that can improve operations and safety[17].

V2V Safety	Agency Data/Environment	Smart Roadside/Mobility
Emergency Electronic Brake Lights (EEBL)	Probe-based Pavement Maintenance	Wireless Inspection
Forward Collision Warning (FCW)	Probe-enabled Traffic Monitoring	Smart Truck Parking
Intersection Movement Assist (IMA)	Vehicle Classification-based Traffic Studies	Intelligent Traffic Signal System (I-SIG)
Left Turn Assist (LTA)	CV-enabled Turning Movement & Intersection Analysis	Signal Priority (transit, freight)
Blind Spot/Lane Change Warning	CV-enabled Origin-Destination Studies	Cooperative Adaptive Cruise Control (CACC)
Curve Speed Warning	Work Zone Traveler Information	Guidance for Emergency
Do Not Pass Warning (DNPW)	Dynamic Eco-Routing (light, vehicle, transit, freight)	Emergency Communications and Evacuation (EVAC)
Vehicle Turning Right in Front of	Low Emissions Zone Management	Connection Protection (T-CONNECT)
Bus Warning (transit)	Eco-ICM Decision Support System	Freight-Specific Dynamic Travel
Queue Warning (Q-WARN)	Eco-Smart Parking	Emergency Vehicle Preemption (PREEMPT)

Source: Kore University, 2019

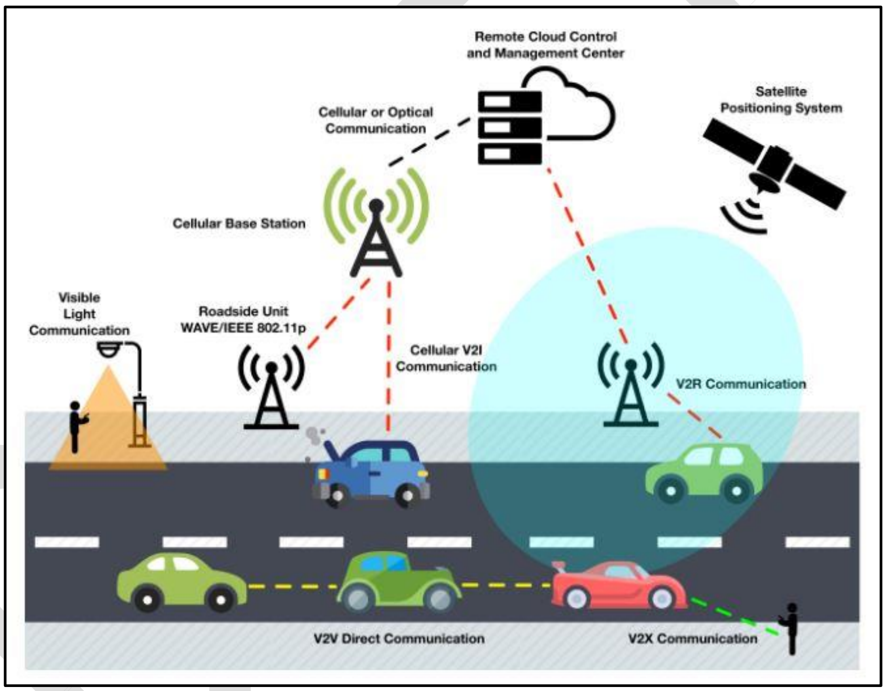
The National Highway Traffic Safety Administration (NHTSA) evaluated a scenario where 100 percent of vehicles were equipped with Left Turn Assist and Intersection Movement Assist and found that at full adoption the two technologies combined could prevent nearly 600,000 crashes and save over 1,000 lives per year[18]. Intersection Movement Assist specifically accounts for about 90 percent of these reductions. NHTSA estimates that the total cost passed on to each consumer for V2V-enabled vehicles would be around $350 (2014), decreasing over time to around $220 by 2058.

The IEEE 802.11p standard was explicitly introduced to support Wireless Access in Vehicular Environments (WAVE) and is intended to facilitate V2V/V2I communications19. Data rates can range from six to 27 Mbps with a short transmission range of approximately 1,000 feet. Cellular technologies have also been evaluated, specifically Long-Term Evolution (LTE) which offers

[17] Arena & Pau, Kore University of Enna, https://www.mdpi.com/1999-5903/11/2/27
[18] National Highway Traffic Safety Administration, https://rosap.ntl.bts.gov/view/dot/27999/dot_27999_DS1.pdf
[19] Arena & Pau, Kore University of Enna, https://www.mdpi.com/1999-5903/11/2/27

download rates of 300 Mbps, upload rates of 75 Mbps, and a transmission range of around 60 miles. Other current protocols include Bluetooth and IEEE 802.15.4/ZigBee.

Vehicle-to-everything (V2X) encompasses V2I and V2V as well as other communications such as vehicle-to-pedestrian and vehicle-to-grid (**Figure X**). Many technologies exist, but each has its limitations. Some concepts to overcome current limitations include a Bluetooth Low Energy (BLE)-based approach and utilizing the emerging U.S. 5G network. Implementation of V2X will require partnerships between vehicle manufacturers and local/state transportation agencies to fund initiatives and infrastructure, and joint innovation and cross-industry collaboration will be important. New ITS technologies will need to be integrated effectively with mobile networks and will need to be applied on less frequented roads, like those in rural areas, to cover entire states. This will be important in Nevada, which, outside of its urban areas, is largely rural and not densely populated.



Source: Kore University, 2019

Green Light Optimized Speed Advisory (GLOSA) systems use timely information about traffic signal timings and locations to provide advice to drivers that can enable them to stop less often at traffic signals by adjusting their speed accordingly. The goal is to provide more uniform travel by optimizing and smoothing traffic flows on arterial streets, improving travel time consistency and reducing vehicle emissions. If signal timings are fixed and known, a reduction in stopped delay of more than 50 percent could be achieved[20]. With fixed timings, a GLOSA system could offer a 27 percent reduction in overall delay and a 46 percent reduction in the number of stops. However, implementing GLOSA along an actuated-coordinated signal system could result in

[20] Stevanovic, Stevanovic and Kergaye, Transportation Research Board, https://journals.sagepub.com/doi/10.3141/2390-06

anywhere from just a three percent reduction to a 13 percent increase in stopped delay. Fuel consumption savings begin to increase at approximately 30 percent adoption and when speed advisory data is transmitted at least every five seconds.

The benefits of GLOSA systems are primarily seen at low traffic densities, where fuel savings and emissions reductions are estimated at up to 12 percent, waiting times at 17 percent, and stops at six percent[21]. The benefits increase linearly with the number of equipped signals and/or vehicles but decrease at higher densities as more unequipped drivers are present and blocking signals, in turn forcing equipped vehicles to stop.

4.4 Mobility Services

The RTC currently offers eight transportation programs to promote mobility for Washoe County residents, visitors, and workers. The RTC RIDE service, consisting of 24 fixed bus routes, acts as the public transit system of the greater Reno/Sparks area. The remaining seven programs aim to supplement this service in areas where it is not immediately available. They are:

- **RTC ACCESS:** The paratransit service providing prescheduled, door-to-door transportation for people meeting the ADA eligibility criteria. Service is provided so long as the trip origin and destination are within 3/4-mile of a “regular” fixed-route RTC RIDE service. Access does not operate where/when RTC RIDE does not/is not currently operating.

- **RTC FlexRIDE:** A curbside-to-curbside public transit service for some areas outside the RTC RIDE coverage area. As of October 2020, service is available in parts of the North Valleys, the Sparks/Spanish Springs area, and Somersett/Verdi.

- **RTC Smart Trips:** A free service to assist local businesses in encouraging employees to use alternative modes of transportation like public transit, bicycling, walking, car and vanpooling, and telecommuting. Businesses may be eligible for federal tax deductions and employees get a tax-free benefit. The Bus Pass Subsidy Program matches an employer’s contribution toward monthly bus passes up to 20 percent.

- **RTC Trip Match:** A free, web-based trip matching program for the Truckee Meadows area. Users can enter travel preferences and receive help with carpools, biking, walking, and finding “bus buddies.” The program is run under RTC Smart Trips in partnership with Greenride.

- **RTC VANPOOL:** A commuter van is driven by one member of a group, who picks up and drops off passengers at agreed upon locations and times. Riders share expenses and up to $3.60 per person per day is subsidized by RTC. The program is run under RTC Smart Trips and is available in the Truckee Meadows area.

[21] David Eckhoff, https://www.david-eckhoff.net/pdf/eckhoff2013potentials.pdf

- **Washoe Senior Ride:** A subsidized taxi program, funded by 1/4-percent of the County sales tax allocated for public transportation. Service is available for residents over 60 years old, any RTC ACCESS client, and veterans. Each month, up to $60 in fares can be bought for $15.

- **Uber Rides Pilot Program:** In August 2020, RTC Washoe entered into an agreement with Uber for a one-year pilot program modeled after the Washoe Senior Ride program. RTC will subsidize 75 percent of fares up to $9 for Uber trips starting and ending in the Reno/Sparks area, up to 5 trips per month. For the pilot, service is available for residents over 60 years old, RTC ACCESS clients, and veterans. Service is available 24/7/365.

4.5 Pilot Programs and Studies

The Nevada Department of Transportation (NDOT) and the RTC have worked with numerous partner groups to initiate pilot programs and studies for the future of transportation in Washoe County. These include electric buses and autonomous buses, communications-equipped fleet vehicles, and roadway and roadside connected infrastructure.

NDOT launched a pilot program, Integrating Mobile Observations (IMO), in 2011 that aimed to improve road safety, reliability, and mobility during winter weather events. Phase I utilized an Enhanced Digital Access Communication System (EDACS) radio system for communications. Phase II added cellular capabilities which often replaced EDACS. In Phase III, NDOT added Dedicated Short-Range Communications (DSRC) devices to vehicles. Each vehicle equipped with multiple technologies can switch to the most effective one based on location. Challenges identified in the case study include:

- **Customization:** Custom software/hardware are difficult to develop, test, and maintain.
- **Infrastructure:** Component configuration, addressing, and firewalls during initial setup.
- **Security:** Vehicle network protection requires firewall, encryption, etc.
- **Protocol:** Newer IPv6 protocol is needed for DSRC but not all components support.
- **Costs and Coverage:** Cellular data plan costs and coverage, especially in rural areas.
- **Costs of Wear and Tear:** Uses like snowplows are demanding on equipment.
- **Rural Coverage:** Range of each DSRC leads to delays when transmitting long distances.

Per the study, suggested solutions to the above challenges include:

- **Customization:** Use well-tested, commercially available software/hardware.
- **Infrastructure:** Involve IT personnel with networking expertise, especially in initial setup.
- **Security:** Back-end firewall, two-factor authentication, and encrypted communication.
- **Protocol:** Possible to circumvent using WAVE short message protocol or current IPv4.
- **Costs and Coverage:** Choose plans that share data usage across many devices.
- **Costs of Wear and Tear:** Use rugged, not consumer-grade, components when needed.

- **Rural Coverage:** Evaluate cellular providers/plans with coverage in rural areas.

The study concludes hybrid communications can reduce cost, leverage existing connections, and improve data access for Road Operations Centers (ROC). DSRC can be used as a cost-effective solution that augments existing communications.

NDOT is coordinating with the Northern Nevada Intelligent Mobility Living Lab to learn how to use big data in new technologies, and the University of Nevada Reno (UNR) has worked with RTC to use state-of-the-art electric buses that are instrumented with several systems to gather and integrate roadway data[22]. The US Department of Transportation (USDOT), NDOT, UNR, and the National Center for Atmospheric Research (NCAR) tested a variety of communications methods between snowplows in the Tahoe/Reno/Carson City area. A Hybrid Communications Platform allowed vehicles to communicate with each other and roadside DSRC units. The plows collected information from Road Weather Information System (RWIS) field units and shared this information with motorists through Dynamic Message Signs (DMS), traffic-focused mobile applications, and vehicle displays.

The Nevada Intelligent Mobility Project has used Virginia Street in Downtown Reno as a living lab to test vehicle communications using the RTC's electric buses from Proterra[23]. The project aims to determine what sensors and communication tools are needed to enable full automation in cities. The buses have been outfitted with sensors and cameras, and streetlights have been equipped with radios monitoring conditions at intersections ahead. The data will be used to develop perception algorithms that paint a picture of the travel environment around a vehicle.

The RTC has also coordinated with UNR to install 360-degree light detection and ranging (LiDAR) equipment along Virginia Street in Downtown Reno[24]. While conventional systems like loop and video detectors and Bluetooth sensors provide macro traffic data but do not measure vehicle trajectory and can only provide averaged data, LiDAR) sensors are attractive because they detect objects with high accuracy and frequency in a range of lighting conditions. This project used Velodyne's 360-degree "Ultra Puck" LiDAR sensors, which are cost-efficient and commercially available on the market. One or two sensors were installed on the existing traffic signal poles at eight intersections on Virginia Street and at one along McCarran Boulevard. Data collection will begin this year (2021).

UNR reported the most significant achievement of the project was implementation of LiDAR-based automated Rectangular Rapid Flashing Beacons (RRFB). A benefit of using LiDAR for these is the collection of 24/7 traffic trajectory data in addition to controlling the RRFB flashing. The sensors can perform traffic data collection, assist in adaptive network control, detect and record jaywalking events, and broadcast information and safety messages to CAV. UNR found that vehicle accuracy was over 95 percent and pedestrian accuracy was 99.5 percent. UNR is

[22] Nevada Department of Transportation, https://www.nevadadot.com/mobility/avcv
[23] RTC of Washoe County, https://www.rtcwashoe.com/engineering-project/lidar-living-lab-implementation/
[24] Velodyne Lidar, https://velodynelidar.com/blog/roadside-lidar-is-key-to-building-smart-safe-transportation-infrastructure/

looking to provide data services to agencies, including 24/7 volume classifications, vehicle speeds, and time-space diagrams for signal efficiency improvements. This offers opportunities for the RTC to collaborate further with UNR and improve operations and safety along Washoe County roadways.

Nevada is the first statewide launch of Nexar's V2V system through its mobile application[25]. The system provides real-time alerts to prevent crashes by recording video outside a vehicle and measuring vehicle dynamics. Warnings from adjacent vehicles can be communicated to other drivers through the mobile application. The RTC may consider investigating this system for use in its transit and fleet vehicles.

4.6 Case Study – Foothill Transit Battery Electric Bus Demonstration

In March 2014, Foothill Transit (operating services northeast of Los Angeles, California in the San Gabriel and Pomona Valleys) began operating 12 next-generation battery electric buses (BEB) from Proterra to evaluate the technology compared to CNG buses of the same model year. During the test period, both types showed 93-94 percent availability. The BEB, however, showed an average efficiency of 2.15 kWh per mile (17.5 miles per diesel gallon equivalent, or DGE) while the CNG buses showed 4.5 miles per DGE—four times less than that of the BEB.

Monthly BEB energy efficiency was found to fluctuate with outside temperature, dropping when it was high and air conditioning was used and rising when it was mild (11°C-25°C). Fifty percent of the buses' time was spent stopped, when the main energy demand comes from the HVAC system. It was also found that road grade has a significant impact on BEB efficiency, with faster discharge rates when traveling uphill. As such, grade is important in determining BEB energy storage requirements and charging station locations.

Buses were charged when docked at two fast-charging stations along the route, for about five minutes at a time. Transit agencies such as the RTC will need to consider charging time when scheduling BEB routes, something that is not needed for CNG or gasoline buses. The BEB were found to have significant excess battery storage, as only a small charge was received at each charger. Transit agencies could consider charging buses less frequently or reduce energy storage requirements when procuring a vehicle, which could reduce vehicle weight and cost.

Noted challenges during the test period were electricity costs/demand charges, driver training, and parts availability. For electricity costs, Foothill Transit partnered with the utility provider on an agreement to set a reasonable charge rate considering the increased electricity demand of the BEB. These agreements will be needed for agencies electrifying their fleet, especially when buses are expected to charge during peak demand times.

4.7 Case Study – Zero Emission Bay Area Fuel Cell Bus Demonstration

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[25] Nevada Department of Transportation, https://www.nevadadot.com/mobility/avcv

5 Impacts of Advanced Mobility

Technological advancements such as alternative fuels and CAV stand to dramatically change the transportation framework in Washoe County, in Nevada, and across the United States. Impacts to aspects such as safety, air quality, and equity must be considered as the RTC prepares for the future. With important regional freight corridors passing through Nevada, such as I-80 through the Reno/Sparks metropolitan area, it is also important to consider the impacts that changing vehicle technologies will have to the freight industry. Finally, as the primary operator of transit

5.1 Safety

According to the U.S. DOT, connected vehicles will change the way Americans travel "through the creation of a safe, interoperable wireless communications network—a system that includes cars, buses, trucks, trains, traffic signals, smartphones, and other devices."[26] They estimate that Red Light Violation Warning and Pedestrian in Signalized Crosswalk Warning connected vehicle features could address more than 250,000 crashes and 2,000 fatalities per year, and that the Curve Speed Warning feature could address more than 169,000 crashes and 5,000 fatalities per year.

Each V2V/V2I safety application can be tied to specific crash type(s) they address[27]. Forward Collision Warning could reduce the frequency of rear-end crashes, and when combined with Automatic Emergency Braking (AV) the injury severity of rear-end crashes that still occur can be further mitigated. Cooperative Intersection Collision Avoidance Systems, which serve as a combination of Intersection Movement Assist, Red Light Violation Warning, and Stop Sign Violation Warning, address crashes related to non-compliance and crossing traffic at signals and stop signs. Blind Spot/Lane Changing Warning can address same-direction crashes. Do Not Pass Warning can address opposite-direction crashes. Road Departure Crash Warning, which combines Lateral Drift Warning and Curve Speed Warning features, can reduce road departures. "V2Pedestrian" and "V2Pedalcyclist" can allow transmissions between phones and DSRC devices in vehicles to alert drivers, pedestrians and/or cyclists of impending conflicts, preventing many high-severity crashes.

AV technologies are also gaining prevalence, including Cooperative Adaptive Cruise Control, which extends Adaptive Cruise Control by incorporating radar/LiDAR measurements. Lane Keeping Assist can be combined with Road Departure Crash Warning to reduce departures. Automatic Emergency Braking and Electronic Stability Control, which maintains the stability of a vehicle during critical maneuvering and loss-of-control incidents, can be combined to reduce crashes involving vehicles making evasive maneuvers around roadway obstructions. Finally, Backup Collision Intervention can brake upon recognizing a hazard when reversing, reducing related crashes.

A study from the University of Texas at Austin found that 90 percent deployment of the full suite of AV measures may reduce crash costs in the US by $126 billion per year and save nearly 2

[26] U.S. Department of Transportation, https://www.its.dot.gov/factsheets/connected_vehicle_benefits.htm
[27] Li and Kockelman, University of Texas at Austin, https://www.caee.utexas.edu/prof/kockelman/public_html/trb16cavsafety.pdf

million functional life-years[28]. The greatest potential was found in the combination of Forward Collision Warning and Cooperative Adaptive Cruise Control, which together could result in an annual economic savings of over $53 billion and almost 500,000 life-years saved per year. This suggests that the two technologies may merit priority deployment; agencies should work with manufacturers and develop incentives and policies to promote adoption of these features. Cooperative Intersection Collision Avoidance Systems were also found to have significant benefits, with the potential to offer an annual economic savings of over $22 billion and nearly 1.24 million life-years saved per year.

Finally, the increasing prevalence of micro-mobility in urban areas must be accommodated to provide safe travel for all users. Per the International Transport Forum (ITF), micro-mobility is defined as "personal transportation using devices and vehicles weighing up to 350kg [770lb] and whose power supply, if any, is gradually reduced and cut off at a given speed limit which is no higher than 45 km/h [28mph]"[29]. Type A devices have a maximum mass of 35kg (77lb) and speed not exceeding 25km/h (15.5mph). Type B has a higher mass, Type C has a higher speed, and Type D has both a higher mass and higher speed. Type A micromobility in particular stands to improve traffic safety by reducing car and motorcycle trips in cities. It can also increase demand for a safe network of cycle paths and other multimodal infrastructure, in turn spurring those projects. Though E-scooter safety has been noted as a growing concern, it is likely to improve as both users and vehicle drivers become accustomed to micro-mobility's presence and more safe, supportive infrastructure is installed.

The ITF offers recommendations to improve the safety of micro-mobility in cities:

- Allocate protected space for micromobility and keep pedestrians safe
- Focus on motor vehicles to increase safety for micromobility users
- Regulate low-speed micro-vehicles as bicycles and higher-speed ones as mopeds
- Collect data on micro-vehicle trips and crashes to fill current gaps in knowledge
- Proactively manage safety performance by prioritizing proactive crash prevention.
- Include micromobility in training for car, bus, and truck drivers.
- Tackle drunk driving and speeding for all vehicles by defining and enforcing limits.
- Eliminate incentives for micromobility users to speed by reviewing pricing mechanisms.
- Improve micro-vehicle design to enhance stability and road grip.
- Reduce wider risks associated with micromobility by minimizing van use for rebalancing, using higher-capacity batteries and plug-in docks, and allocating on-street "parking."

5.2 Air Quality

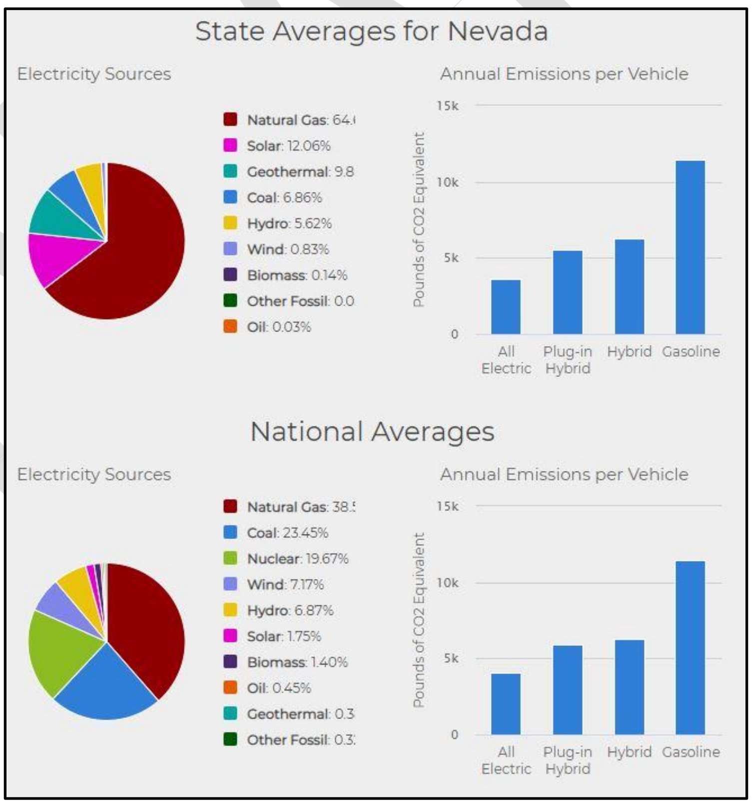
Today's transportation sector accounts for 23 percent of worldwide GHG emissions and 28.5 percent of U.S. GHG emissions[30]. In 2016, transportation-related CO_2 emissions surpassed

[28] Li and Kockelman, University of Texas at Austin, https://www.caee.utexas.edu/prof/kockelman/public_html/trb16cavsafety.pdf
[29] International Transport Forum, https://www.itf-oecd.org/safe-micromobility
[30] Taiebat, Brown, Safford, Qu and Xu, University of Michigan, http://css.umich.edu/publication/review-energy-environmental-and-sustainability-implications-connected-and-automated

those from the electricity production sector for the first time, a trend which will continue as use of renewable energy sources is expanded. This rapidly increasing trend is the fastest of any GHG-emitting sector; annual transportation-sector emissions are projected to double by 2050.

Emerging technologies such as electric, alternative fuel, and connected vehicles are expected to reduce fuel consumption, in turn reducing harmful vehicle emissions. Vehicle emissions can be air pollutants, which contribute to smog, haze, and health problems, and GHG. Traditional vehicles produce emissions directly from the tailpipe and through evaporation from the fuel system and during fueling. EV on the other hand produce zero direct emissions. PHEV produce no direct emissions when in all-electric mode, but still produce evaporative emissions.

According to the U.S. DOE, using compressed natural gas (CNG) to power vehicles can reduce lifecycle GHG emissions by 15 percent, or up to 84 percent if renewable natural gas (RNG) is used[31]. EV and hydrogen fuel cell electric vehicle (HFCEV) lifecycle GHG emissions are mostly derived from the energy production process; depending on the energy source used lifecycle emissions they can be anywhere from significantly lower than to nearly the same as gasoline-powered vehicles. Hydrogen production, for example, can reduce GHG emissions to zero or it can increase them by 20-60 percent relative to ICE vehicles if typical U.S. energy production mixes are used.

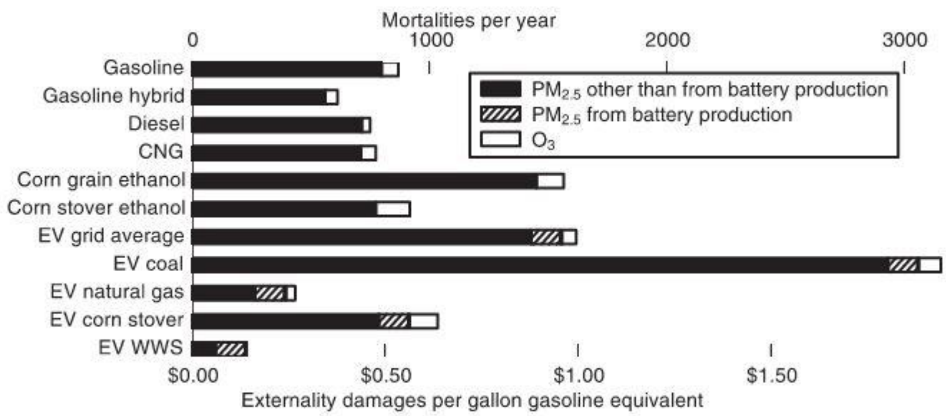


Source: U.S. Department of Energy, 2021

[31] U.S. Department of Energy, https://afdc.energy.gov/

The U.S. DOE website provides a calculator showing the annual emissions by vehicle type per state versus the national average (**Figure X**). Nevada is generally in line with the average, but EV and PHEV vehicle well-to-wheel emissions are lower than the average by up to 400 pounds of CO_2 equivalent. This is due to its minimal reliance on coal, favoring natural gas instead) and high use of solar and geothermal energies.

A 2014 study from the University of Minnesota Twin Cities estimated the impacts on air quality if 10 percent of vehicle miles were driven in various types of vehicles including gasoline-powered, gasoline hybrid, diesel-powered, CNG, ethanol, and electric[32]. Air quality impacts were measured in well-to-wheel emissions of fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3). The estimated emissions include tailpipe exhaust, electricity production, natural gas compression, and battery production. EV emissions were measured for multiple scenarios using different energy sources, including the projected 2020 U.S. average generation mix, coal, CNG, corn, and wind/water/solar. The study estimated the increase or decrease in mortalities expected for each scenario compared to a baseline of gasoline-powered vehicles.



Source: University of Minnesota Twin Cities, 2014

As shown in **Figure X**, the gasoline-powered baseline scenario results in 870 deaths per year. Estimates for the EV scenarios ranged from 230 deaths per year using wind/water/solar to 3,200 per year using coal. The gasoline hybrid, natural gas EV, and wind/water/solar EV scenarios showed decreases in air quality-related health impacts of 30, 50, and 70 percent, respectively. In contrast, the ethanol, U.S. grid average EV, and coal EV scenarios showed increases of 80, 200, and 350 percent, respectively.

A 2018 study from the University of Michigan summarized the key environmental impacts of CAV at various levels of transportation[33]. At the vehicle level, lower-level automation can result in 20 percent fuel savings and reduced emissions through increased efficiency. Full automation can increase this by an additional five to seven percent, or up to 17 percent for fleet vehicles.

[32] Tessum, University of Minnesota Twin Cities, https://conservancy.umn.edu/handle/11299/185125
[33] Taiebat, Brown, Safford, Qu and Xu, University of Michigan, http://css.umich.edu/publication/review-energy-environmental-and-sustainability-implications-connected-and-automated

Increased CAV penetration will lead to increased fuel savings, lower travel times, and reduced emissions. One study found that even a single CAV on the road can dampen stop-and-go traffic patterns and provide up to a 40 percent reduction in total traffic fuel consumption. Connected heavy-duty trucks, which can platoon at decreased headways, could result in drag reductions of up to 15 percent and consequent fuel and emissions savings. The RTC should continue its evaluation of autonomous buses and their benefits to fuel consumption and vehicle emissions.

At the transportation system level, CAV could increase roadway capacity by 80 percent and reduce fine particulate matter emissions in urban areas by up to 15 percent. Studies show that using shared autonomous vehicles (SAV) could allow for reductions in fleet sizes due to the efficiencies associated with them. This could result in reduced congestion, increased highway capacity, and lower emissions. Reduced congestion can generally be linked to a reduction in crashes, particularly those associated with stop-and-go traffic such as rear-ends. Finally, at the urban system level, CAV could allow for up to a 30 percent reduction in road lighting. In tandem with widespread deployment of CAV, this could yield a savings of $1.65 billion per year. CAV can also reduce needed parking space by an average of 67 percent, providing environmental benefits associated with less pavement and fewer spaces influencing mode choice. The RTC may consider planning for less parking in the future to take advantage of CAV technology and help influence travel decisions.

5.3 Equity Issues

According to the University of Michigan study, at the society level CAV will expand mobility for people with unmet travel needs, such as the disability community and senior groups, offering significant equity benefits[34]. It is estimated that this unmet demand is equal to about 14 percent of the current U.S. vehicle miles traveled (VMT), equating to about 295 billion additional miles of vehicle travel. Agencies and governments should work together to develop pilot programs for CAV that focus on fostering independence and improving mobility for these groups.

According to the Bureau of Transportation Statistics, 40 percent of disabled persons report difficulty accessing needed transportation. The Ruderman Family Foundation estimates that about 11 million medical appointments are missed every year by people with disabilities due to inadequate transportation[35]. Expanding accessible transportation for this community could enable proactive care, reducing health care expenditures by an estimated $19 billion annually. It would also enable new employment opportunities for two million individuals with disabilities.

The U.S. Department of Commerce estimates that 15.5 million workers work in fields that could be affected negatively by increasing adoption of CAV. Unemployment has economic and social consequences; one mitigation measure is to help workers transition to sectors that will expand with CAV penetration. Job displacement due to the ongoing growth of alternative fuels can be partially mitigated in a similar fashion.

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[34] Taiebat, Brown, Safford, Qu and Xu, University of Michigan, http://css.umich.edu/publication/review-energy-environmental-and-sustainability-implications-connected-and-automated

[35] Ruderman Foundation, https://rudermanfoundation.org/white_papers/self-driving-cars-the-impact-on-people-with-disabilities/

A significant cost barrier exists for consumers, fleet owners, and agencies looking to enter the EV, AFV, and CAV markets. Financial incentives are key to overcome the affordability barrier for ZEV and to expand the early market. Equity approaches include increased rebates for low- and moderate-income households, incentives for vehicle replacement, and rebates for used ZEV[36]. To improve access for low-income households, financial incentives can be provided at the point of sale. Funding should also be dedicated to community-led outreach to build trust between governments and communities like low-income families and non-English speakers. It will be critical to assess how mobility is approached by different populations rather than simply assuming private ZEV ownership for all. Agencies may choose to focus on lower-cost options such as E-bikes, E-scooters, buses, and carshares.

Charging infrastructure can often be viewed by some groups as a symbol of displacement and gentrification, and acceptance is closely linked with equitable vehicle access. Agencies must consult with communities about barriers and mobility needs, then work backwards. Targeted investment in high-pollution areas can demonstrate benefits and increase community support. EV readiness (i.e. pre-wiring for future private charger installations) is critical to reduce costs and EV-ready building codes are essential to support equitable investment.

Inclusive ZEV access will maximize the economic benefits of electrification for all. In Portland, Oregon, the local utility (Portland General Electric, PGE) has partnered with Forth Mobility to help low-income ride-hail drivers secure fair financing for ZEV[37]. Combined with standard state and federal rebates and PGE's free public charging program, ride-hail drivers can see large savings when choosing a ZEV over a traditional ICE vehicle. The re-entry community, or those coming out of the criminal justice system, and other marginalized groups offer opportunities to meet market and economic growth goals. Workforce development should be prioritized; an example is Portland's Clean Energy Fund, which focuses on low-income communities and communities of color and offers job training in growing markets. Education and outreach will be crucial in promoting ZEV adoption in Nevada's rural areas.

As shared mobility and CAV reshape the nation's transportation framework, they offer agencies a chance to address the inequities of America's long-standing approach to transportation. A 2017 brief from the University of California Davis prioritized four equity concerns related to EV, CAV, and shared mobility: cost, access, public health, and employment[38]. The brief identifies strategies governments and agencies may consider in addressing these four priority issues, specifically those that stand to benefit low-income, mobility-challenged, and other historically disadvantaged communities (e.g., people of color, immigrant communities, rural communities). **Table X** summarizes the recommended strategies in relation to the issue they aim to address.

[36] ZEV Alliance, http://www.zevalliance.org/expanding-zev-access/
[37] Forth Mobility, https://forthmobility.org/events/electrify-your-ride
[38] Cohen, TransForm and Shirazi, University of California Davis, https://www.transformca.org/transform-report/can-we-advance-social-equity-shared-autonomous-and-electric-vehicles

Issue	Strategy
Disadvantaged communities are not strongly engaged in issues of shared mobility and have difficulty affording or accessing infrastructure related to EV.	-Engage disadvantaged communities in transportation planning. -Evaluate equity goals and policy impacts using the priority issues above. -Support demonstration projects and spread information. -Create support networks assisting in overcoming shared mobility barriers.
Disadvantaged communities face financial, technological, language and cultural barriers to shared mobility.	-Support demonstration projects, such as automated or electric bus pilots. -Develop accessible platforms for households without bank accounts, credit cards, or online payment systems, such as a membership card or mobile application.
Shared mobility is not always the priority in planning.	-Enforce and/or expand High Occupancy Vehicle (HOV) laws to reduce congestion in shared mobility lanes. -Convert mixed-flow lanes on highways and in urban areas to shared mobility lanes. -Analyze how shared mobility and CAV can more efficiently use road and parking space and how some can be reallocated to multimodal transportation.
Shared mobility may replace transit in some places without accounting for the resulting barriers to disadvantaged communities.	-Reexamine transit routes and subsidies for low-income riders to serve populations more efficiently.

Source: North American Council for Freight Efficiency, 2020

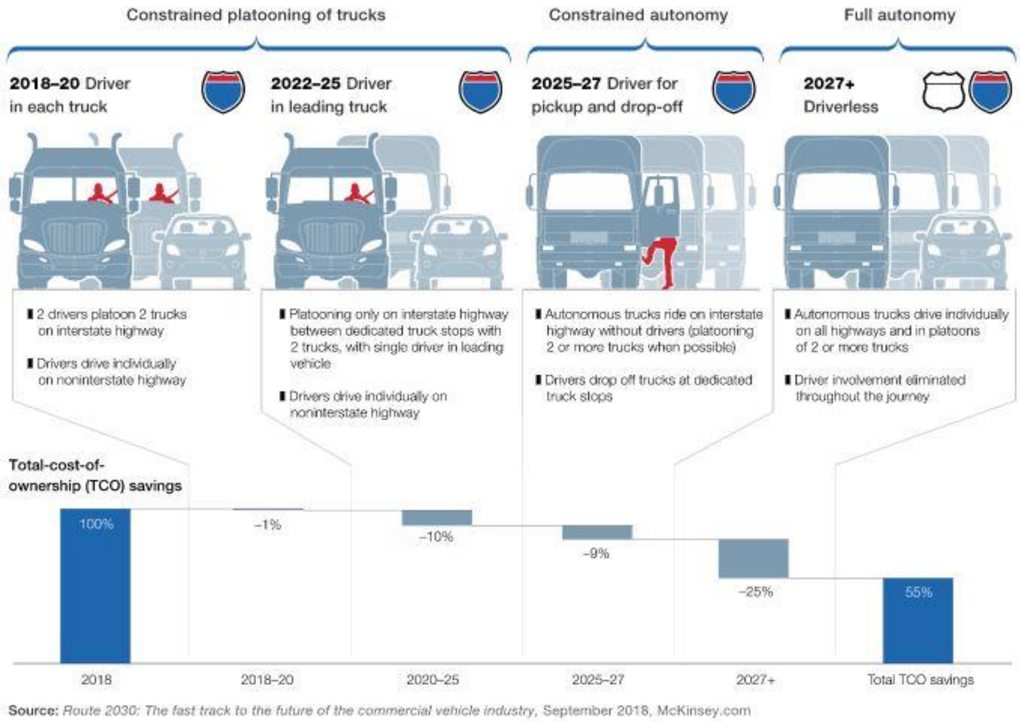
5.4 Freight and Commercial Fleets

Today, 65 percent of America's consumable goods are trucked to market. With full deployment of autonomous trucks (AT), operating costs would decline by about 45 percent, resulting in a savings for the trucking industry of between $85 billion and $125 billion[39]. AT could also spur consolidation of the national trucking fleet, alleviate the existing capacity crunch, and create opportunities for truck OEM to enter new markets.

The first two waves of AT deployment (2018-2025) will introduce "platooning," which allows a convoy of trucks to connect to a lead truck with a driver (**Figure X**). In the first wave, there will be a driver in each truck; in the second wave, following vehicles would be driverless. Once the vehicles leave the highway, drivers would take control of each truck. Total operating costs per vehicle will drop by about 10 percent due to fuel and labor cost reductions. In the third wave, "constrained autonomy" will be introduced, where ATs are deployed within "geofenced" areas

[39] Chottani, Hastings, Murnane and Neuhaus, McKinsey & Company, https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/distraction-or-disruption-autonomous-trucks-gain-ground-in-us-logistics

without platooning. Drivers will take control of the trucks at interstate exits, saving an additional 10 percent of operating costs. In the fourth wave, fully autonomous operations from loading to delivery will begin, resulting in a 45 percent cost reduction.



Source: McKinsey & Company, 2018

In July 2020, 15 states and Washington, D.C. signed a Memorandum of Understanding (MOU) targeting 30 percent of new medium- and heavy-duty truck sales to be ZEV by 2030 and 100 percent of new sales to be ZEV by 2050[40]. The State of California has implemented regulations requiring ZEV trucks to account for five percent of the trucking market in 2024 and 40 percent in 2032, and an executive order states a goal of all medium- and heavy-duty trucks to be ZEV by 2045. OEM have accelerated development of medium- and heavy-duty ZEV, and many will have market-ready vehicles by 2023.

Production costs will need to reduce significantly to make hydrogen economically competitive. However, heavy-duty trucks alone cannot create enough demand to justify scaling up hydrogen (thereby reducing costs). Industrial use of hydrogen must also increase to help create demand before hydrogen fuel prices will decrease—even 30 percent adoption of these technologies in the trucking industry by 2030 would be just 100,000 vehicles per year, compared to 1.8 million freight trailers on U.S. roads today. Current commercial trucks can have lifespans of up to 20 years, so it will likely take decades to see a meaningful switch to alternative fuels in the industry.

[40] North American Council for Freight Efficiency, https://nacfe.org/emerging-technology/electric-trucks-2/making-sense-of-heavy-duty-hydrogen-fuel-cell-tractors/

The North American Council for Freight Efficiency (NAFCE) notes that hydrogen fuel cell trucks should be considered for duty cycles in cases where[41]:

- Zero emissions at the tailpipe is important.
- Tractor tare weight is critical to maximizing payload.
- Long distance routes over 500 miles are common.
- Winter conditions are significant to operations.
- Green or blue hydrogen is readily available.
- Regions have incentivized hydrogen use.
- Travel is completed in less mountainous regions.

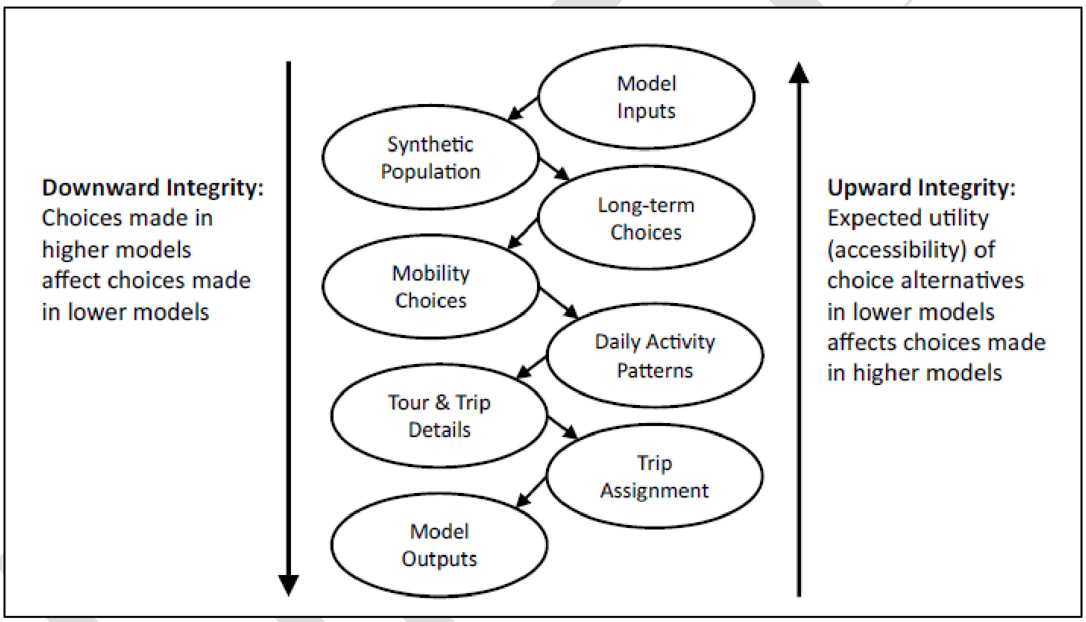
Many of these considerations are applicable to Washoe County, including the presence of long-distance routes (e.g., the I-80 freight corridor) and winter conditions. To support the industry's shift to hydrogen, the RTC should develop partnerships with the County and partner agencies that work to promote the installation of HFC infrastructure.

[41] North American Council for Freight Efficiency, https://nacfe.org/emerging-technology/electric-trucks-2/making-sense-of-heavy-duty-hydrogen-fuel-cell-tractors/

6 Advanced Mobility in Travel Demand Modeling

While the term "advanced mobility" covers a broad spectrum of travel modes, this section primarily focuses on incorporating CAV in travel demand modeling, as other advanced mobility options are not expected to have the same impact on travel behavior. For example, micromobility (e.g. E-scooters and E-bikes) or rideshare options provided by transportation network companies (TNC) are most appropriately addressed in mode choice as another option available to consumers.

The RTC completed the development of an "activity-based" (AB) travel demand model in 2020. Compared with "trip-based" models, AB models have much more detailed input data and generate more detailed output information. AB models are developed as a "disaggregate" as they simulate the travel of each individual person in a household. **Figure X** shows the main steps and data flow of an AB model system.



Source: SHRP 2, *Activity Based Travel Demand Models - A Primer*

The main components of AB models include synthetic population, where detailed characteristics of every person in a household are created based on observed data from the U.S. Census (e.g. Public Use Microdata Sample files), and long-term choices and daily activity patterns where the models predict activity purposes, locations, timing, and mode. In the RTC's AB model, long-term choice is referred to as "mandatory location choice." This step determines, for example, where a person works or goes to school.

Modeling CAV explicitly in an AB models will require modifications to the RTC's existing AB model structure. Since there is no observed data for model calibration, changes would be made to the model framework based on current research on which models would be affected by widespread AV/CV adoption and the extent of those effects. Once observed data are available, they could be used to calibrate the model parameters that have been incorporated to account for CAV. Potential changes to the AB model system to incorporate CAV are illustrated in **Table X**.

Model Component	Disaggregate AB Model Improvements
Sociodemographic	
Population Synthesizer	➢ Control for age and income ➢ Add smartphone ownership and income level
Built Environment	
Urban Form	➢ Set place type by area type and development type
Mobility	
Vehicle Ownership	➢ Add CAV as an option for households to own ➢ Add purchase cost, incentive policies, parking cost, or accessibility variables to distinguish vehicle type
Mobility as a Service	➢ Add carsharing, ride-hailing, bike sharing memberships
Activity Generation and Scheduling	
Activity Generation	➢ Lift age restriction for CAV, add constraint for person with disabilities and seniors using conventional vehicles ➢ Adjust value of time (VOT) and review induced demand ➢ Add representation of empty car trips
Destination/Location Choice	
Work/School Locations	➢ Integrate with land use model to provide sensitivity
Mode Choice	
Mode Choice	➢ Add new modes (CAV, TNC, shared modes, micro-transit) ➢ Adjust VOT for CAV ➢ Add dynamic pricing for new modes, adjust parking cost for CAV ➢ Adjust age and disability requirements for CAV
Access/Egress	➢ Add access/egress modes (TNC, shared modes, micro-transit)
Parking Choice	➢ Add parking choice model to include off-site parking
Pricing	
Cost Model	➢ Determine cost per mode for each new mode by time period
Parking Costs	➢ Adjust parking cost as demand shifts away from high-cost areas

Source: NCRHP, *Report 896, Guidance 2018*

Making structural changes to the AB models to account for automated and connected vehicles is not a trivial task. While some of the above changes could be accomplished by staff with extensive experience in AB model development, most Metropolitan Planning Organizations (MPO) will require the assistance of consultants to make them. However, until some of the structural changes can be made to the models, there are other approaches to using AB models to account for the impacts of CAV on travel behavior. These can be characterized primarily as adjustments to model parameters to approximate expected impacts of advanced mobility on the transportation system. For example, two MPO with AB models conducted scenario planning to evaluate potential impacts of automated vehicles on travel behavior.

Childress et al. (2015) tested four adoption scenarios involving partial or full automation[42]:

- In the first scenario, they considered expected improvements in traffic operations resulting from automation. They tested a capacity increase of 30 percent on all freeways and major arterials in the travel demand model.

- In Scenario 2, they cite existing research that indicates higher income households are generally the early adopters of technology due to high initial costs. In the travel demand models, they reduced the weighting of auto travel time to 0.65 for high "value of time" (VOT) trips. In traffic assignment, trip-based VOT was reduced by 65 percent for the highest income households (from $24.00 to $15.60 per hour).

- In Scenario 3, they include the above changes but halve parking costs to reflect widespread adoption and full automation. Reduced parking costs reflect the assumption that AV specifically would self-park in cheaper locations or better utilize existing spaces. It should be noted that this approach would not capture the additional VMT associated with vehicles searching for cheaper parking locations.

- The final scenario serves as a counterpoint and assumes that AV are commonplace and shared AV systems so effective that vehicle ownership is not necessary. Thus, mobility is treated like a public utility and all trips are provided by a taxi-like system at a set rate. Vehicle and road prices are determined by the industry and government to cover operation and maintenance costs. Modeled auto operating costs were increased to $1.65 per mile.

Kim et al. (2015) also evaluated potential impacts of AV using the Atlanta Regional Council's AB model[43]. Their methodology involved adjustments to some of the same model parameters as done by the Puget Sound Regional Council (PSRC), which serves the Seattle, Washington metropolitan area. They reduced the in-vehicle time coefficient for automobiles by 50 percent, increased fuel efficiency in operating costs (a 71 percent reduction in vehicle operating costs), set parking costs at primary destinations to zero, changed generalized costs in highway assignment, and increased roadway capacity by 50 percent.

[42] Childress et. al., Transportation Research Board, https://journals.sagepub.com/doi/10.3141/2493-11
[43] Kim et. al., Transportation Research Board, https://cdn.atlantaregional.org/wp-content/uploads/tp-mug-travelimpactofautonomousvehiclesinmetroatlantathroughabm--052915-1.pdf

7 Opportunities and Recommendations

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7.1 ITS Requirements

(…)

7.2 Traffic Analysis

(…)

8 Action Plan

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