Preparing Rural America for the Electric Vehicle Revolution

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Executive Summary

The impacts of global warming are becoming increasingly common and threaten basic human needs. The emission of human-induced greenhouse gases into the atmosphere is resulting in extreme temperatures, severe flood and drought events, and sea level rise. These effects are displacing vulnerable communities and put future generations at risk.

The transportation sector is currently the leader of greenhouse gas emissions in the US. Vehicles for daily travel alone account for roughly one-fifth of *all* U.S. emissions. Emission reductions from the transportation sector will thus become increasing important to slow the impacts of greenhouse gases.

Electric vehicle technology and innovation offer the potential to significantly cutback emissions. But their ability to do so depend on proactive planning, policies, and incentives that drive investments in vehicle technology and charging infrastructure and promote adoption throughout the country.

This report builds on a previous paper from the Center for American Progress titled "Plug-in Electric Vehicle Policy" and analyzes three key challenges towards robust EV deployment and adoption across rural America. Policy recommendations are provided to address the following challenges:

1. **Vehicle cost, range, and design limitations.** Electric vehicles available today range between $9,000 to $13,000 above similar combustion-engine vehicles, depending on model type and battery range. These higher upfront purchasing costs may be prohibitive for the adoption of EVs. Limited electric range in spread out rural communities also create concerns of being unable to make it to a destination. Electric pickup trucks, which are highly desirable among rural Americans, are in the works but not currently available. Federal and state funding for research on stronger load carrying capacity batteries will support the development of electric pickup trucks and other vehicle models not currently available on the market.

2. **Electric vehicle market uncertainty.** The potential rollback of federal tax incentives for the purchase of new electric vehicles hinders vehicle investments and innovation. Market uncertainties disincentivize vehicle manufacturers to invest in high-capacity, long-range, and lightweight batteries for electric vehicles. These rollbacks will have a cascading effect on investments towards charging station infrastructure as well. Fewer vehicles manufactured and adopted will result in lower utilization of charging stations. Maintaining planned incentives and phase-out schedules will give manufacturers a clear sense of the market and drive investments towards what will likely be the future mode of transportation in America.

3. **High capital cost and remote areas for charging infrastructure.** Electric vehicle charging is expensive to install and maintain, which lower willingness to invest in infrastructure. Low population density, remoteness of certain rural areas, and charging time make it more difficult to find optimal areas for public charging infrastructure. Collaboration between local and regional transportation agencies will ensure a connected network with higher utilization.

Proactive planning between government, private, and cooperative stakeholders is necessary to facilitate robust deployment and adoption of electric vehicles across rural communities of America. Three policy principles will help guide stakeholders in preparing rural America for the onset and evolution of electric vehicles. These are:

1. **Market the benefits of nationwide electric vehicle adoption and ownership.** Electric vehicles offer environmental, public health, and long-term cost-saving benefits. Investing in education programs that highlight these benefits and purchase incentives will ease the transition from combustion engine vehicles to electric ones. Rural cooperatives can leverage their positioning to bridge electric vehicle knowledge gaps through the development of outreach programs that educate members about vehicle benefits.

2. **Collaborate early and often to implement and connect new and existing electric vehicle charging infrastructure.** State, regional, and local agencies will need to collaborate to ensure connectivity and long-range accessibility for electric vehicle travel. Coordinated planning, with federal government support and rural electric cooperative leadership, will drive smart EV infrastructure placement and increase utilization rates. The Regional Electric Vehicle West Memorandum of Understanding exemplifies a successful partnership between stakeholders to create an Intermountain West Electric Corridor.

3. **Invest in incentives and explore regulation for enhancing the production of electric vehicles and infrastructure across rural America.** Financial incentives at the point of purchase and non-monetary incentives, like carpool lane privileges, will encourage hesitant consumers to drive an EV. Regulations that require manufacturers to produce a certain number of electric vehicles (E.g. ZEV mandate) will drive the transition from combustion engine vehicles to electric. Providing federal and state rebates to private electric vehicle charging investors and rural cooperatives will help fund the charging infrastructure required to meet the needs of travelers in rural communities. Enabling rural electric cooperatives to establish flexible rate schedules to reduce charging costs to consumers will incentivize higher adoption. Both incentives and regulations are needed to push the switch to EVs.

I. Introduction

The transportation sector is currently the largest emitting sector of greenhouse gases (GHGs) in the US with roughly a third of total emissions (EPA, a). The buildup of GHG emissions is altering the earth's climate and impacting society. Populations around the world are experiencing record high temperatures, severe droughts, flooding events, and rising sea levels from a warming climate.

Vehicles account for more than 80% of GHGs within the US transportation sector (EPA, b). This includes light-[1], medium-[2], and heavy-duty[3] vehicles. Daily travel accounts for nearly a fifth of *all* GHG emissions from *all* sectors across the U.S. (Union of Concerned Scientists).

Total vehicle miles traveled (VMT) and per capita VMT in America is on the rise, as shown from Figure 1. This increasing trend in VMT suggests that transportation sector emissions will continue to rise unless there is a push for cleaner vehicle technology.

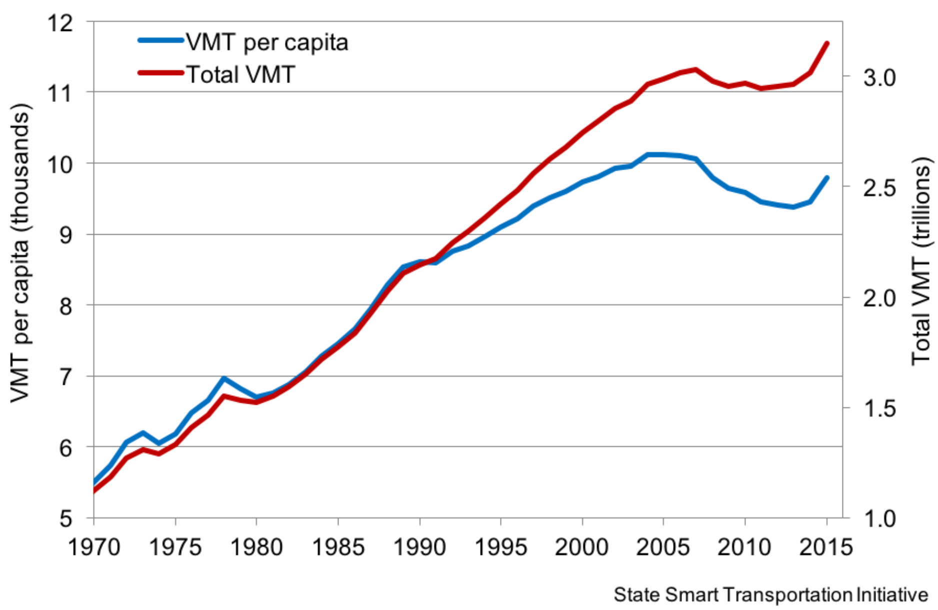

Figure 1. VMT per capita and Total VMT. Overall vehicle miles traveled in the US is on the rise. Source: State Smart Transportation Initiative.

Cleaner vehicle technologies may come in several forms:

- Vehicles can be made more fuel-efficient, using less gas to travel over the same distances as less-efficient vehicles.

[1] Includes sedans, small SUVs, and small pickup trucks
[2] Includes larger pickup trucks and vans
[3] Includes schools buses and large freight trucks

- Fuels to power vehicles can be produced from alternative sources (e.g. fibrous parts of plant produce cellulosic biofuels) that emit fewer GHGs when burned.
- Vehicles can be made to run fully off of electricity that produces zero tailpipe emissions.

Regulations like the Corporate Average Fuel Economy Standards (CAFE) and Zero Emission Vehicle Mandate (ZEV), discussed in this report, are examples of how policies and incentives have been able to drive significant investments in less polluting vehicle technologies.

This report focuses on one such technology, electric vehicles (EVs). They not only have reduced emissions, but they also cost less to fuel and require less maintenance over the long-run. Current EV infrastructure and policies are focused on urban areas. For EVs to effectively reduce emissions for the entire transportation sector, adoption and deployment must be strong throughout the nation. Rural America represents a significant portion of the population. Their travel behavior, vehicle preferences, and accessibility to charging stations will play an important role for the future of EVs.

II. Electric Vehicle Background

There are three main types of EVs: Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Hybrid Electric Vehicles (HEVs). See table 1 for a breakdown of their engine components, battery ranges, and examples of model types available on the market.

Table 1. Types of Electric Vehicles

	Engine Components	**Battery Ranges**	**Examples**
Battery Electric Vehicles (BEVs)	Fully-electric: Rechargeable batteries No gasoline engine	Average 80 - 100 miles Up to 250 miles	Chevy Bolt Tesla Model S
Plug-in Hybrid Vehicles (PHEVs)	Partially-electric: Rechargeable batteries Regenerative braking* Gasoline engine	Average 10 - 40 miles	Toyota Prius Kia Optima
Hybrid Electric Vehicles (HEVs)	Regenerative braking Gasoline engine	---	Honda Civic Hybrid Toyota Camry Hybrid

*Regenerative braking takes the vehicle’s momentum and turns it into electricity to recharge the vehicle’s onboard battery as the vehicle slows to a stop.
Sources: Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy & EVgo

EVs offer numerous benefits. According to the U.S. Department of Energy, Alternative Fuels Data Center (d), on average, BEVs produce 4,352 pounds of CO_2 equivalent[4] over the course of a year. Traditional, combustion-engine vehicles on the other hand produce almost twice that amount (11,435 pounds of CO_2 equivalent per year). BEVs have the potential to cut emissions by more than half per user if they were to make the switch from a combustion-engine vehicle. Coupled with clean, renewable energy sources, BEVs allow for an even greater cut in emissions.

Lower fuel and maintenance costs balance out higher upfront purchasing costs and make EVs a long-term cost-efficient alternative to conventional combustion-engine vehicles. In the U.S., on average, a regular gallon of gasoline costs $2.84; an electric eGallon[5] costs roughly half that at $1.18 per eGallon (U.S. Department of Energy, g). EVs also require less maintenance since they have fewer moving parts and fluids to change. Their regenerative braking systems typically lasts longer than in combustion-engine vehicles (U.S. Department of Energy, b). Combined, these benefits make EVs a smart long-term investment for households.

Despite these wide-ranging benefits, key challenges remain in the way of EV market penetration. In 2017, EV sales represented only 1.15% of all vehicles purchased in the U.S. (Bellan). Slow adoption to new technologies is expected, especially for ones that require changes in travel behavior. That said, fewer public EV charging stations, EV model types, spread-out development, and regulatory uncertainty around EVs are slowing adoption.

Stronger EV deployment and adoption across rural America will becoming increasingly important for America to reach its national emission reduction goals and slow the rate of climate change. This report identifies and discusses three key challenges towards EV deployment and adoption across rural America and provides a set of policy recommendations and principles to help guide stakeholders in preparing rural America for the EV revolution.

III. Electric Vehicle Infrastructure

EV infrastructure must be dependable and robust to cater to a growing EV market. Public infrastructure must be readily accessible to meet driver needs. Charging infrastructure is generally installed by car makers, public entities, EV owners, commercial enterprises and employers. This section covers background information on the different types of charging levels, general cost of charging infrastructure, and charging accessibility.

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[4] CO_2 equivalent, as defined by the Organisation for Economic Cooperation and Development (OECD), is "a measure used to compare the emissions from various greenhouse gases based upon their global warming potential" (Organisation for Economic Cooperation and Development)
[5] An eGallon is the cost to fuel a vehicle with electricity compared to the cost to fuel a similar vehicle with gasoline. State by state residential electricity prices, reported by the Energy Information Administration, are used to calculate the U.S. average eGallon.

EV charging rates depend on the charging station and equipment on the vehicle. There are two types of chargers, Alternate Current (AC) chargers and Direct Current (DC) chargers with different voltages used for charging. DC fast chargers can typically charge an EV in less than 30 minutes. As seen in table below, DC chargers are more expensive to install and maintain than AC chargers.

Table 2. Charging Infrastructure - Types of Charging Levels

Type of Charging	Voltage(V)	Miles range per hour of charge (miles/hr)	Typical Locations	Types of Connectors	Installation cost/unit
Level 1	110-120	2-5	Home	J1772	$0-$3000
Level 2	208-240	10-20	Home, Workplace and Public	J1772	$600-$12,700
DC Fast	240-480	180-320	Public	CHAdeMO, CCS	$4,000-$51,000

(Source: Cattaneo)

IV. Rural America Landscape

US Rural Population

Nearly 60 million

25% of the the total population.

This report uses the Census Bureau's definition of "rural" when discussing EV implementation: *"all population, housing, and territory not included within an urbanized area or urban cluster,"* (America Counts Staff). This equates to regions with less than 2,500 people, or less than 1,000 people/square mile. The rurality of an area has impacts on driver behavior and ultimately on EV adoption. This is evident in numerous areas and are explained under the following sections: Rural Driver Behavior and Rural Electric Cooperatives.

Rural Driver Behavior

On average, rural drivers are more likely to take longer trips than their urban counterparts. Figure 2 shows average trip length of both driver groups on a travel day[6], taken from the 2017

[6] A Travel Day is a 24-hour period starting from 4:00 a.m. to 3:59 a.m. the next day, in order to study trips and travel by members of a sampled household.

National Household Travel Survey (NHTS). These trip patterns are reflective of the vehicle fuels prefered by urban and rural drivers.

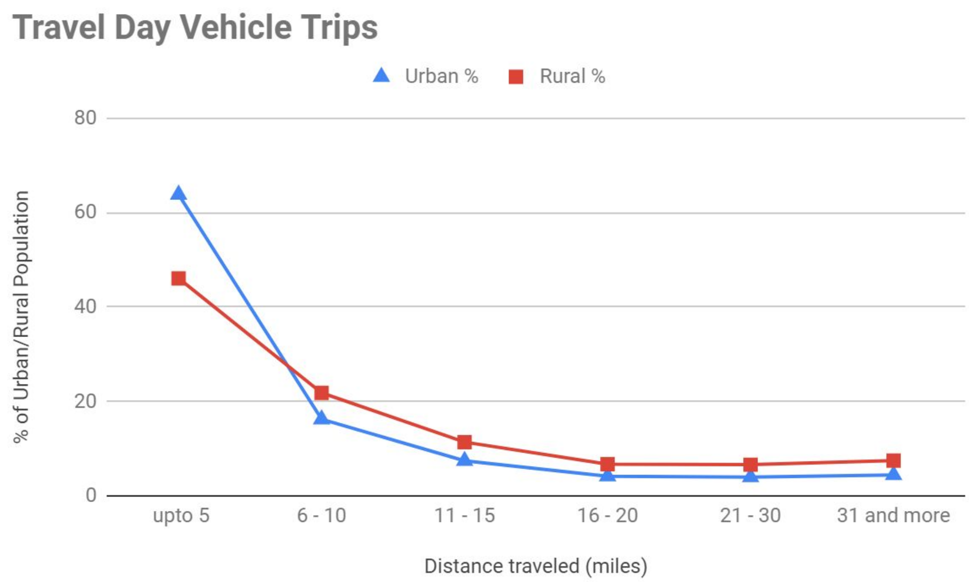

Figure 2. Urban and rural travel behavior. It can be seen that more rural drivers are driving more miles as compared to their urban counterparts (NHTS, 2017).

The majority of them own gasoline powered vehicles (93.7% and 95.8% respectively) (NHTS 2017). In rural communities, diesel fuel is the next dominant fuel source, with a 5% utilization rate versus a 1.7% utilization rate in urban communities (see figure 3). Electricity is the lowest ranking vehicle fuel source in both rural and urban communities with a 1.7% and 2.4% utilization rate respectively. These numbers show that there is a wide margin of opportunity for increasing EV usage throughout all parts of the country. With rural America consisting of 25% of the total US population, it is a significant portion of the US where EV efforts are less focused (America Counts Staff). The electric charging infrastructure reflects this in rural areas, where drivers may experience a level of “range anxiety”, the concern that vehicles will not be able to travel the distance needed, due to a lack of EV charging stations and choose options that are more readily serviced.

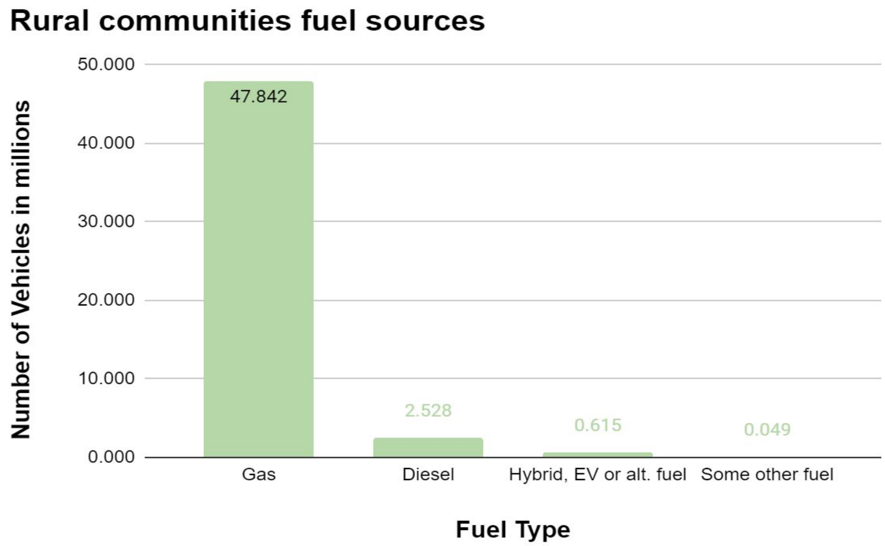

Figure 3. Rural communities fuel sources for privately owned vehicles**.** A significant amount of the population, almost 94%, owns gasoline-fueled ICE vehicles in Rural America (NHTS, 2017).

The lack diversity in EV model options impacts the appeal of ownership for rural Americans. Data shows that drivers in rural areas are more likely to own heavy- and medium-duty pickup trucks. Though automakers like Ford and Rivian, have announced interest in launching an all-electric truck, there are currently no electric pickups, 4-wheeler, or crossovers on the market (Stewart). Figure 4 displays this preference, where the top five vehicle models owned by rural households in 2017 are all pickup trucks (NHTS, 2017). It should be noted, that even if an EV pickup truck existed on the market, the high upfront cost of the EV may be especially prohibitive across rural America. In 2015, the median household income of rural American households was 4% lower than urban households, with about 13.3% of the population having incomes below poverty thresholds (Bishaw & Posey, 2016). EVs range from $9,000 to $13,000, depending on model type and electric range, above gasoline-powered vehicles. With higher costs it is more difficult to incentivize the consumers, who already prefer a certain vehicle design, to purchase EV’s.

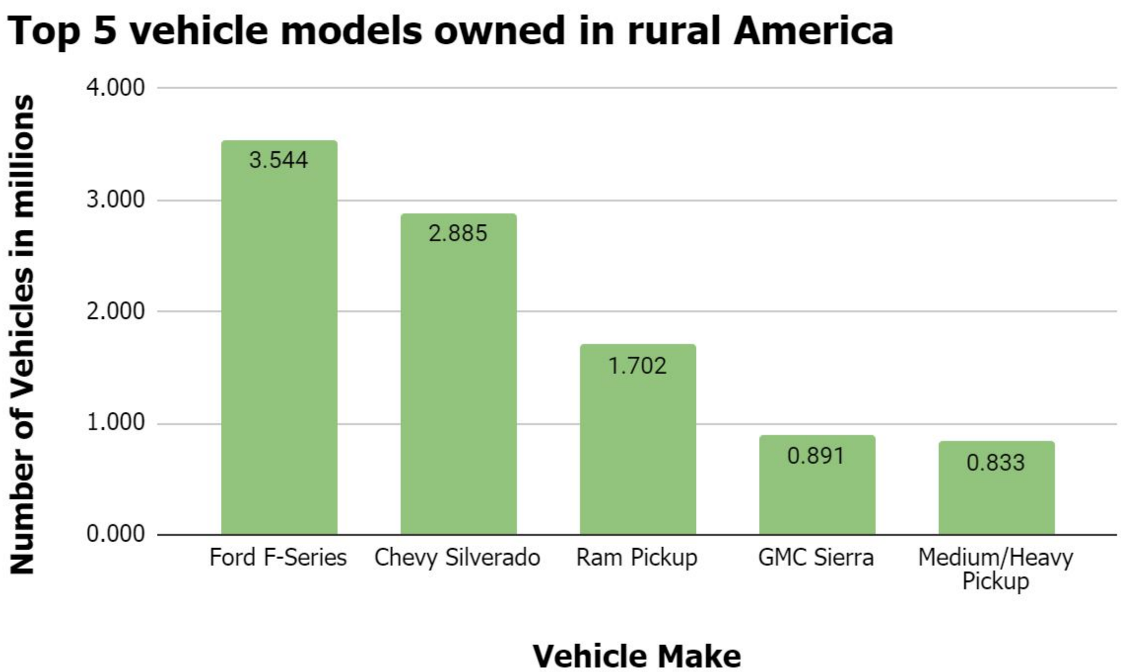

Figure 4. Top 5 vehicle models owned in rural America. It can be seen from the bar chart above that the preferred vehicles of choice consist of medium/ heavy duty pickup trucks. Source: NHTS, 2017

Public transit is generally a more affordable mode of travel than private vehicle ownership. Many cities are experimenting with electric buses and shuttles. However, this currently offers little benefit to rural areas of America where almost 40% of the population does not have access to transit service (Glotz-Richter & Koch, 2016; U.S. Department of Transportation, 2001). Studies have shown that in rural areas where transit service is available, trips are about 87% longer than in urban areas; this is more than twice as long as it would take to travel by personal vehicle in rural America (Pucher & Renne, 2005). Thus, longer trip lengths and already infrequent transit service limits the feasibility of robust electric transit adoption throughout rural America.

Rural Electric Cooperatives

The Rural Electrification Act of 1936 was adopted to bring electric lines to rural areas by enabling member-owned electric cooperatives (co-ops) to buy power at wholesale and supply to rural areas at a low interest rate. These co-ops differ from larger investor-owned utilities by sharing ownership among its customers, also known as members, rather than shareholders. One of the most unique unique aspects of co-ops is their ability to change rates without going through a regulatory hearing process. Only 14 of the 47 states with electric co-ops have mandated control over rate determination (National Rural Utilities Cooperative Finance Corporation, 2008). Co-ops in the other 33 unregulated states can too adopt rate structures that are supportive of EV charging. Not only do co-ops have greater flexibility in providing certain EV incentives, they are also critical for educating their members about the benefits of EVs.

The National Rural Electric Cooperative Association (NRECA) was established in the mid 1940's to unify and represent the 900+ electric co-ops in the nation. The NRECA receives federal grant funding administered by the Rural Utilities Commission for different cooperatives, and aids different co-ops in identifying and applying for private loans and grants which are needed to maintain and expand electricity distribution.

In addition to the national association, there are 38 states that have their own electric co-op statewide associations. These represent the interests of the co-ops by providing legislative assistance and feedback on policy-making, conducting community outreach and education, and fostering cooperation between individual co-ops. For example, the North Carolina Electric Cooperatives Association is working together with its member co-ops to strategize the set-up of a rural EV charging network across the state with plans to build about 100 stations by the end of 2019 (Kahn, 2018). The association is also assisting member co-ops in promoting EV adoption by offering educational programs and it is promoting the sharing of charging data between the co-ops to better understand infrastructure loads of EVs.

V. Electric Vehicle Policy Landscape

Government Regulations and Efforts

Since the introduction of the Clean Air Act in 1963, federal regulations and programs for the impact of transportation emissions on ambient air quality have significantly increased. The Corporate Average Fuel Economy (CAFE) Standards implemented in 1975, for example, require vehicles manufactured in the U.S. to increase in fuel efficiency over time, forcing an investment in cleaner-burning technology (Department of Transportation [DOT], 2018). More recently however, there have been federal efforts directed specifically toward promoting EV deployment as one way to address transportation emissions. With laws, incentives, and other EV-promoting programs, the federal government has a large influence on the EV market. For example, there are laws that require the U.S. Department of Transportation (DOT) to designate EV charging (and other alternative fuels) corridors, which should alleviate some of the range anxiety that deters EV adoption (Fixing America's Surface Transportation Act, 2015). There are also EV fleet requirements for government vehicles[7], as well as EV research and funding regulations that enhance EV deployment throughout the nation[8]

[7] The Energy Policy Act of 1992 requires 75% of new light-duty vehicles acquired for a federal fleet to be alternative fuel vehicles. Additionally, according to U.S. Code 2922g, the U.S. Department of Defense must exhibit preference for EVs and HEVs when procuring vehicles for its fleet.
[8] The Public Transportation Innovation Program (https://www.transit.dot.gov/funding/grants/public-transportation-innovation-5312) as well as the Low or

(https://afdc.energy.gov/fuels/laws/ELEC?state=US). In fact, one settlement requirement of the federal EPA case against Volkswagen[9] was that $2 billion of the $2.7 billion penalty to go toward the promotion and implementation of ZEV charging infrastructure.

Some of these federal regulations also include incentive programs for EVs. One such program is the Qualified Plug-in Vehicle Tax Credit in which a tax credit up to $7,500 is provided to those who purchase a new EV. In this program, each EV manufacturer has a limit on the number of these credits given out, so the amount of credit received by consumers phases out over time with each manufacturer[10]. The federal DOT also recognizes High-occupancy Vehicle (HOV) lane exemptions for EVs, to provide further incentive for driving a clean-energy vehicle.

State governments are also pushing for EV implementation by utilizing California's low emission vehicle standards. Section 177 of the Clean Air Act allows only the state of California to set their own standards as long as they are more stringent than federal ones in regulating greenhouse gas emissions and air pollutants for passenger vehicles. This section also allows for other states to adopt California's unique standards in lieu of following federal requirements. Thus far, thirteen other states have opted into California's low emission standards. This is a critical policy foundation that provides a starting point for other states to push for further EV adoption despite a shifting federal policy landscape.

Section 177 States (As of May 10, 2019)

Zero Emission Vehicles Program

- Connecticut
- Colorado
- Maine
- Maryland
- Massachusetts
- New Jersey
- New York
- Oregon
- Rhode Island
- Vermont

Low-emission Vehicles Program

- Delaware
- Pennsylvania
- Washington

Figure 5. Section 177 States

No Emission Vehicle Program (https://www.transit.dot.gov/funding/grants/lowno) are examples of programs in which the federal DOT provides funding for EVs used for public transportation.

[9] In 2016 the Volkswagen company was sued by the EPA for falsification of their tailpipe emissions data. The settlement amount was $2.7 billion, with $2 billion going to the promotion and implementation of ZEV charging infrastructure. $800 million goes to California ZEV efforts and $1.2 billion to other states.

[10] The Qualified Plug-in Vehicle Tax Credit phases out for a manufacturer's vehicles once 200,000 qualifying vehicles are sold. Approximately 6 months after reaching the 200,000 mark, the tax credit for that specific manufacturer's vehicles reduces to $3,750, then $1,875 for 6 months after that, until no tax credits are offered for that manufacturer. Tesla, for example, reached this 200,000 vehicle mark in late 2018, so from January 1st, 2019 through June 30th, 2019, Tesla can only offer up to a $3,750 tax credit. After June 30th, 2019, the credit will reduce to $1,875 for 6 months and finally beginning January 1st, 2020, Tesla will not be able to offer any tax credits (https://www.fueleconomy.gov/feg/taxevb.shtml).

The Zero Emission Vehicle Program is a California state regulation requiring major auto-manufacturers to sell a minimum number of electric vehicles proportional to their total vehicle sales in the state. In 2018, this percentage was 2.5% and in 2025 it is projected to be approximately 8.0%. Under the same exception offered by Section 177 of the Clean Air Act, nine other states have adopted both the ZEV and Low-Emissions Vehicles (LEV) programs of California. The ZEV program is one of few existing policies that directly requires a set number for EV deployment.

VI. Current EV Initiatives

With this understanding of the EV industry roadmap, we now discuss some of the existing investments, programs, and incentives that promote the supply and demand of electric vehicles. Through researching the different EV initiatives and their relative efficacies, we hope to identify how these programs are suited for rural America and potentially address these issues in our policy recommendations.

Utility Investments

Duke Energy's North Carolina Electric Transportation Pilot | Investment: $76 million
In North Carolina, Duke Energy is proposing a $76 million project focused on investigating EV charging behavior, building out public charging infrastructure, offering customers EV incentives, and electrifying school and transit bus fleets. The public charging commitment will provide up to 100 additional Level 2 charging stations throughout the utility's service territory and fast charging stations along interstate corridors. Duke Energy seeks to utilize some funding from North Carolina's share of the Volkswagen Settlement to provide cost sharing on school and transit bus electrification. The remaining costs will be recovered through rate fees generated by implementation (charging station users, increased at-home charging, etc).

While the Pilot does not specify a focus on either urban or rural, the service territory covers a majority of North Carolina. Given the state's rurality, rural communities are poised to benefit from this program.

Implementation Programs

Provided below are several examples of how rural electric co-ops and statewide organizations are implementing programs to increase adoption of EVs.

Fresno County-wide Solar Powered EV Charging Program | Total Cost: $800,000
In 2017, CALSTART, a non-profit focused on reducing transportation emissions, partnered with Fresno County Rural Transit Agency to install thirteen charging stations in rural incorporated cities of the county. This is one of the first efforts in California to implement electric vehicle infrastructure specifically meant to serve rural communities. The project had a total cost of

$800,000 where $78,000 was provided by the San Joaquin Valley Air Pollution Control District through local DMV fees, and the remaining $722,000 was funded through a Caltrans grant.

Gunnison County Electric Association Electric Vehicle Program

Education Component - This Colorado based electric cooperative offers two electric vehicles open for week long loans to its members free of charge (Gunnison County Electric Association, NO DATE). The loaner program offers co-op members to experience driving an electric vehicle for their day to day tasks through an extended period of time. The one week time-frame is important to allowing users to decide whether electric vehicles are a good fit as a daily driver.

Utility Rate Component - A reduced cost Time-of-Use rate is offered to members that charge their vehicles overnight when local energy demand is lower. Not only does this save the members money, but it also reduces the load on the cooperative during peak energy demand. To further incentivize members, up to $500 in rebate is offered toward home chargers when they sign up for the Time-of-Use rate structure.

Great River Energy Revolt Program

Great River Energy is a generation and transmission electric coop whose energy is distributed throughout Minnesota by 28 other coops and services nearly 1.7 million members.The coop's internal research had shown that a primary reason for EV adoption among their members is the environmental benefits (Great River Energy, 2017). Their Revolt program, which ran from 2015 to 2018, aimed to promote EV adoption by offering charging options that were entirely sourced from renewable wind power at no additional cost for the lifetime of the EV.

Although the Revolt program only lasted three years, it offered members an attractive reason to purchase an EV during that time period. Cooperatives can utilize similar programs to influence early adoption in their service areas.

Nevada Electric Highway

The project started in 2016 as a partnership between the Nevada Governor's Office of Energy, NV Energy (investor-owned utility), and Valley Electric Association (electric co-op) to build out publically available EV charging infrastructure along the state's major corridors. The target completion date of this project is currently set for the end of 2020.

Phase 1 - Three new charging stations completed and two more underway along U.S. 95. The station located near Fallon is on tribal land that is part of NV Energy's service area. Installing this charging station was made possible through a partnership between the Governor's Office of Energy and the Paiute-Shoshone Tribe. This example brings to attention the importance of considering tribal partnerships for supplying EV infrastructure throughout rural parts of the country.

Phase 2 - Currently underway, with thirty nine additional charging stations to be completed along I-15, I-80, U.S. 93, and U.S. 50.

REV West MOU

The Regional Electric Vehicle West Program is a multi-state initiative to increase the number of charging stations by over 5,000 along interstate routes to alleviate range anxiety. This is implemented through a Memorandum of Understanding (MOU) between eight western states (Utah, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Wyoming). The signatories of the MOU are also promising to promote EV adoption by creating minimum standards for charging stations, incorporating EV infrastructure in planning and development processes, and identifying funding for the support of this plan. The REV West MOU is an exemplary example of the collaborative effort that multiple state entities will need to pursue for building out the EV charging network across the entire country.

Incentives

This section aims to summarize the incentives offered for electric vehicles and their usage. These can be broadly organized into the following categories: incentives for vehicle purchase, EVSE, and user experience. Table 3 below showcases the specific incentives under their broader categories, their associated value, timing of the benefits, and examples of implementing entities.

Table 3: Common incentives found throughout the US for EV purchase and ownership.

Category	Subcategory	Value	Timing	Examples (not exhaustive)
Vehicle	Income tax credit	$2,500 - $7,500	End of tax year	Federal Government
Vehicle	Purchase rebate	$500 - $2,500	At purchase to 3 months	CA, OR, CT
Vehicle	Sales tax exemption	Up to $525	At purchase	NJ
Public Charging Station	Purchase/Installation Rebate	$250 to $5,000	Several months	CA, DE, FL, PA
Home Charging Equipment	Purchase/Installation Rebate	$250 to $650	At purchase to several months	CA, CO, WA, ID, OR
User Experience	Off-peak rate structure	Reduced electric bills	Monthly bill cycle	CO, MN
User Experience	HOV lane access	Expedited travel	At time of use	CA

User Experience	Free metered parking	Ease of parking	At time of use	CA

VII. Challenges & Policy Recommendations

While the aforementioned efforts act as guidelines for success, they are not specifically addressing EV deployment in rural areas. This section identifies challenges and provides a set of principles to guide policy options for achieving successful EV deployment across rural America.

Challenge 1. Vehicle cost, range & design limitations

Issue 1: Pickup trucks are the most commonly owned vehicle make in rural America, but they are currently not available in the EV market. Even if they do become available in the future, the newer technology necessary to make EV pickup trucks possible will be costly.

> **Recommendation 1:** Support the development of EV pickup trucks by funding research for batteries with stronger load carrying capacity.
>
> This recommendation falls in line with the overall goals of the EV Everywhere Grand Challenge by the U.S. Department of Energy's Vehicle Technology Office. This initiative directs the department to assist in the reduction of battery costs, increasing EV range through lighter vehicle weight, and reducing costs for electric drive systems to make EVs comparable to conventional vehicles for consumers (U.S. Department of Energy, 2013). Although there are current research efforts supporting EVs in general, there is a lack of focus on research supporting specific model types. Greater load carrying capacity for batteries is directly supportive of the purpose of pickup trucks and could potentially attract manufacturers to develop EV models. Even if major manufacturers, like Ford, are already making large investments toward the development of EV pickup trucks (Warren, 2019), ongoing support for this type of research is still necessary to continually push for cost reductions and improved performance. The goal of this recommendation is to enhance consumer preference of EV pickup truck models over conventional ones once they eventually enter the market.

Issue 2: EVs have high up-front purchasing cost, compared to combustion-engine vehicles. A standard tesla model S, a BEV, for example, costs $75,000 before rebates (Tesla). The average price of a combustion-engine sedan, on the other hand, costs around $35,000 (Turrentine, Hardman, & Garas, 2018). This is about a $40,000 difference, not accounting for rebates and tax incentives. Consumers will be less willing to make the switch to an EV if the benefits do not outweigh those of combustion-engine vehicles, both in the short-term and over the long-term.

Recommendation 2: Offering point-of sale financial incentives rather than offering rebates after purchase or tax credits will encourage hesitant consumers to make the purchase.

These point-of-sale incentives would reduce the purchase price of an EV when a consumer decides to buy a vehicle. Reductions can come as government purchase discounts or grants. The United Kingdom, for example, takes about $5,800 USD off of the purchase price of any BEV, and about $3,000 USD off of the purchase price of a PHEV (Hardman, Chandan, Tal, & Turrentine, 2017). Canada, China, France, Germany, and Japan have also offered various point-of-sale incentives to make EV adoption more attractive to the average consumer.

Challenge 2. EV market uncertainty disincentivizes EV production

Issue 1: Market uncertainty comes from the instability of EV market incentives. As administrations change, there are considerations of repealing some of the previously implemented incentive programs. The current federal administration, for example, has proposed to eliminate the aforementioned Qualified Plug-in Vehicle Tax Credit in the upcoming (2020) budget. Uncertainty in the incentives that promote EV adoption presents a serious problem for market supply and demand. For example, auto manufacturers must be able to predict the state of the auto market several years out in order to meet the demand of specific vehicle types. Thus, having a consumer incentive schedule aids manufacturers in the prediction of this market, however, any disruption in these incentives could have serious implications to this market balance. Additionally, rural consumers, which tend to be later adopters of EVs, are also at a disadvantage if incentives are repealed earlier than intended.

Recommendation 1: Rather than repealing incentives for the promotion of EVs, incentive schedules should be maintained, or at least, should maintain their phase-out schedules.

In the case of the tax credits, for example, it is recommended that rather than repealing all credits, manufacturers that have not begun the phase-out portion of this incentive program should be allowed to offer the reduced credits for the allotted phase-out time. By prohibiting the immediate elimination of these incentives, both EV manufacturers and consumers can better prepare for the EV revolution.

Issue 2: Rural consumers currently do not have easy access to information regarding the benefits and incentives of EVs, and often have not had the opportunity to even test-drive one. The act of purchasing a car is a significant financial commitment and provokes a great amount of thought from the buyer. Dealerships are a critical point of contact for buyers, because they provide the opportunity for buyers to physically interact with these vehicles. The servicing of vehicles is a major source of revenue for dealerships (Forbes). One of the benefits of EVs is a lower need for servicing since there are less moving parts. This means that for the dealerships there exists a monetary disincentive to their sale. Based on discussions with NRECA representatives, there are dealerships that are lacking the knowledge about the benefits of EVs, their available incentives, or other technical information buyers may want to know. This knowledge gap may be attributed to the fact that dealerships would lose out on servicing revenue as EV sales rise.

Recommendation 2: Rural cooperatives should bridge the EV knowledge gap by developing outreach programs and/or materials to educate members about the benefits of EVs and offer test-drives.

Rural electric co-ops have an important role in being able to communicate directly with their members. Gunnison County Electric Association provides a model of how co-op's can set-up their educational programs, where there is a focus on allowing members to test-drive EVs for extended loan periods. Since co-op members consist largely of local residents, there is also an opportunity for community-driven outreach. For example, co-ops can facilitate discussions about the benefits of EVs and potential incentives during local community gatherings and events.

Challenge 3. Charging infrastructure is expensive to install. Utilization rates are low in remote areas.

Issue 1: As seen in figures 6-8, there is a lack of charging infrastructure in rural landscape. A dependable and robust EV infrastructure is needed to cater to a growing EV market in rural areas. A robust electric grid is a must for a charging station. Rural areas tend to have less robust electrical infrastructure. This affects the number of EVs that can be charged by a single charging station and smart charging systems are required (Hardman, S et al.). Smart charging systems are based on real-time electricity supply and demand. Ideally, a charging stations should have high utilization rate to maximize its benefits. The income of the electric infrastructure mainly depends on the usage & number of infrastructure units installed. Rural charging stations may have a low utilization rate and high capital costs associated with the installation; therefore, it is more difficult to attract outside investment.

Recommendation 1: Encourage investments in charging infrastructure by providing vouchers/grants to help fund planning and installation of public charging infrastructure that specifically meet the needs of rural communities.

Installing charging stations in strategic locations to obtain high utilization rate is importance. Hence, it is recommended to install charging infrastructure in public places like hospitals, schools, theatres, community centers, etc. Since most charging occurs at home and overnight, there is an opportunity to reduce charging costs by providing flexible utility rates by utility companies. As energy demand is much lower at night, utilities have the opportunity to reduce charging costs at this time, while still returning a profit. Local government agencies should work with regional transportation agencies to create a map of areas that will accommodate EV charging. Potential EV charging locations should be located at centralized community locations. Utilization rates are likely to increase if there is a systematic planning approach that will provide incentives for infrastructure installation.

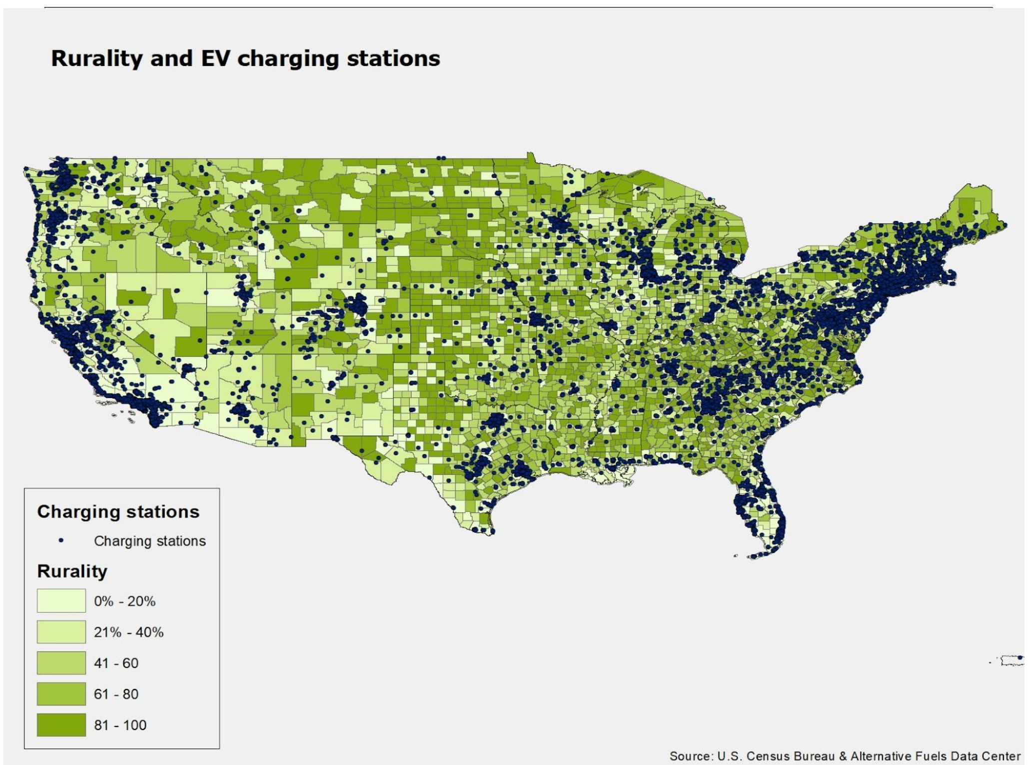

Figure 6. Rurality across the U.S. and public EV charging stations. More public charging stations are available in more urban areas.

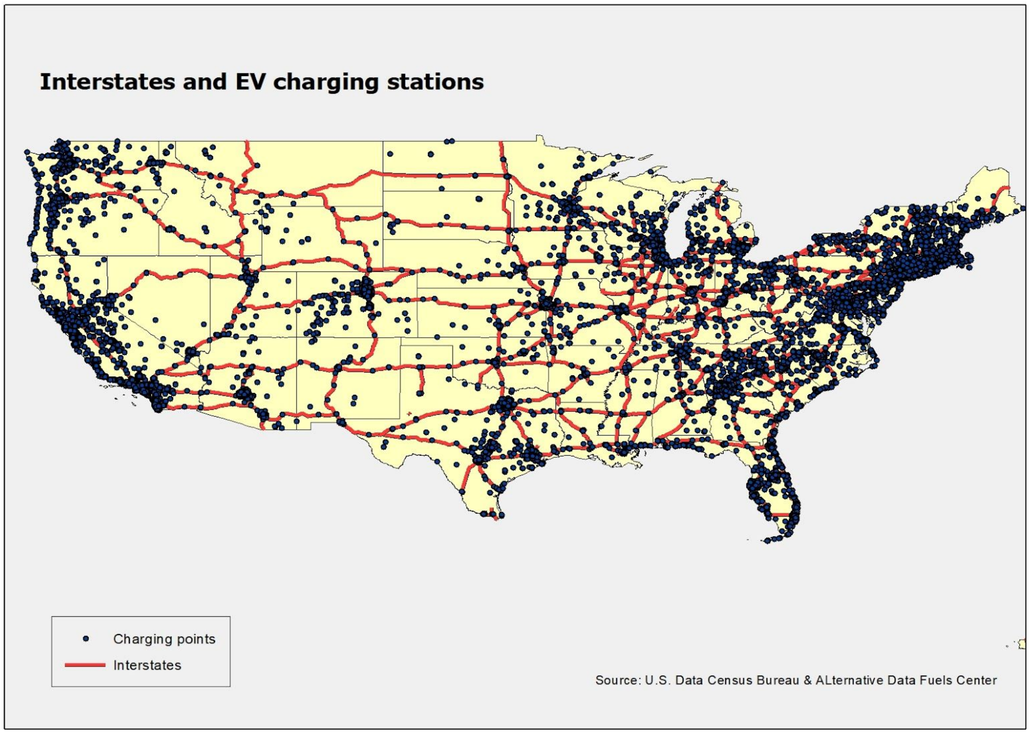

Figure 7. Interstates and EV charging stations. Mostly, charging stations can be seen installed along the interstates. But not many charging stations can be seen installed in midwestern states like Montana, South Dakota and North Dakota.

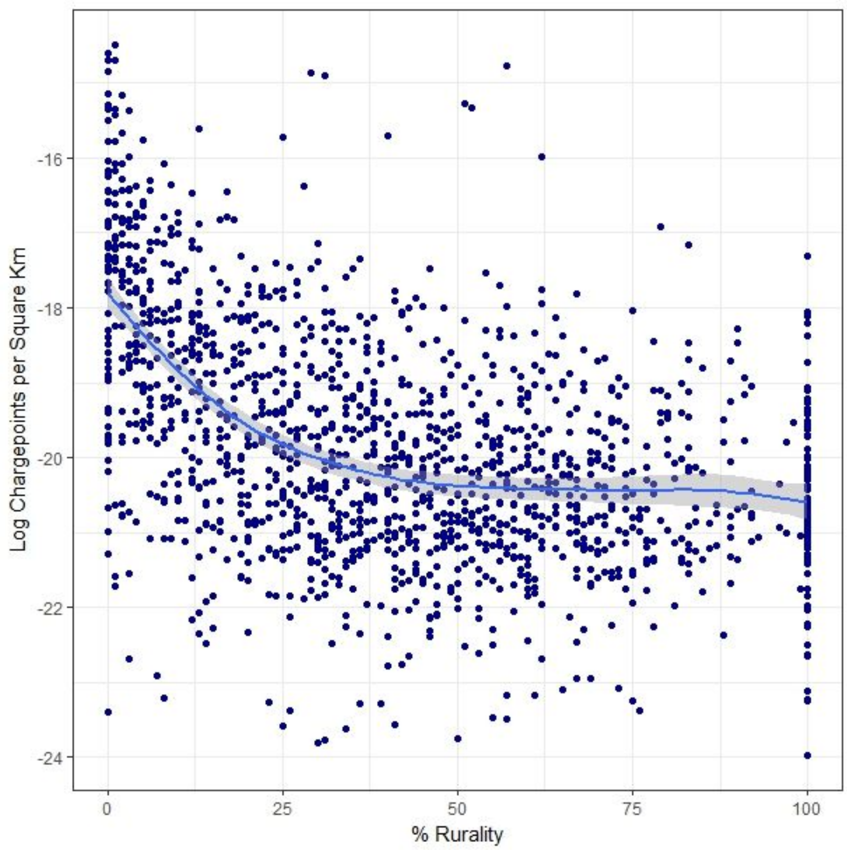

Figure 8. Correlation between rural areas in America and public charging stations available. As the percent rurality increases, the fewer charging stations there are[11]. Source: U.S. Census Bureau and Alternative Fuels Data Center

While determining policy recommendations to address each of the main challenges to EV adoption in rural America, broad direction was driven by three core policy principles. First, it is essential to market the benefits of nationwide EV adoption and ownership. Second, stakeholders must collaborate early and often to implement and connect new and existing EV charging infrastructure. Finally, it is critical to continue investing in incentives and exploring regulation for enhancing the production of EVs and infrastructure across rural America. As stakeholders decide to move forward with or without this report's policy recommendations, the above principles should guide their vision moving forward in the EV movement.

[11] The values on Y-axis shows that the values of charge points per sq. km. are between 0 and 1. Log form of the density was calculated as not all the counties in US had a charging station(as seen in the Fig. 5 below) and this would drop the overall density and skew the results. This graph was developed by Prof. Frances Moore using R.

VIII. Conclusion

Currently, the overall EV market shares a very small portion of the total vehicles on the road. Policies can help address issues pertaining to the deployment of EVs in Rural America, such as vehicle cost, range and design, market uncertainty and high costs associated with charging infrastructure.

Policies at the state and federal level like tax credits, purchase rebate, HOV lane access and more have established the foundation. But it will take plenty amount of time to reap the benefits from these policies for reducing greenhouse gas emissions. Bridging the education gap and creating awareness around EV benefits amongst the rural population plays an important role to influence EV production and deployment in rural landscape. In order to prepare rural America for the EV revolution, policies that aim to educate the rural population around EV benefits encourage EV adoption. Now is the right time to take action to enhance the deployment of EVs in Rural America to meet nationwide greenhouse gas reduction goals.

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