The University of Chicago

From Charger to Chassis – Tracing the Story of the Electric Tractor

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Submitted in partial fulfillment of the requirements for the degree of Bachelor of Arts in Environmental and Urban Studies at The University of Chicago

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Chicago IL
May 22, 2020

Table of Contents

ABSTRACT **3**

INTRODUCTION **4**

LITERATURE REVIEW – A FAMILIAR NARRATIVE, COMPLICATED **9**

Lines of Demarcation: The Urban versus The Rural 9
So, What is an Electric Vehicle? 12
Plug-In Electric Vehicles (PEVs) 14
The Electric Vehicle and Economy 16
Electric Vehicles as a Benefit to Agricultural Practices 19
Electric Vehicle Adoption in The 21st Century 23
Electric Vehicle Adoption Over Time 25
Fuel Types and Charging Stations 29
Mass Markets – Who Actually Purchases Plug-In Electric Vehicles? 31
Current Policy Related to the Electric Tractor 32
Current Suggested Electric Vehicle Policy Frameworks 34
Table 1 PEV Policy Considerations *35*
Why Illinois? 36

DATA AND METHODOLOGY **38**

Data in the Context of Imagery 38
Table 2 Categories for Assessing Image *38*
Table 3 Manufacturer Advertisement Specifications *39*
Data in a Technological Context 41
Table 4 Categories for Assessing Technology *41*
Table 5 Manufacturer Product Distributions - *42*
Data in a Policy Context 44
Table 6 Categories for Assessing Policy *44*

RESULTS – PURPOSE OF SECTION **45**

Results - Image as a Category of Analysis 46
The Search for the Electric Tractor *46*
Results - Technological Considerations 58
Product Offering and Vehicle Specifications *58*
Patents and the Future of the Industry *63*
Results - Policy Assessment 66
Unpacking Current Alternative Fuels Legislation *66*
Re-Defining Alternative Fuels Policy *73*

FURTHER DISCUSSION **78**

Figure 5 Current EV Policy Pathways 78

CONCLUSION **79**

Figure 6 Future Suggested EV Policy Pathways 80

APPENDIX **81**

Appendix 1 Gasoline Vehicle Parts 81
Appendix 2 Hydrogen Fuel Cell Electric Vehicle Parts 82
Appendix 3 Hybrid Electric Vehicle Parts 83
Appendix 4 Plug-in Hybrid Electric Vehicle Parts 84
Appendix 5 All-Electric Vehicle Parts 85

APPENDIX 6 DIESEL VEHICLE PARTS 86
APPENDIX 7 BIODIESEL VEHICLE PARTS 86
APPENDIX 8 SOLECTRAC WEBSITE ADVERTISEMENT 87
APPENDIX 9 FENDT NORTH AMERICA WEBSITE ADVERTISEMENT 1 87
APPENDIX 10 FENDT NORTH AMERICA WEBSITE ADVERTISEMENT 2 88
APPENDIX 11 FORD WEBSITE ADVERTISEMENT 88
APPENDIX 12 CHRYSLER WEBSITE ADVERTISEMENT 1 88
APPENDIX 13 CHRYSLER WEBSITE ADVERTISEMENT 2 89
APPENDIX 14 CHRYSLER WEBSITE ADVERTISEMENT 3 89
APPENDIX 15 TESLA WEBSITE ADVERTISEMENT 90
APPENDIX 16 CHEVROLET WEBSITE ADVERTISEMENT 1 90
APPENDIX 17 CHEVROLET WEBSITE ADVERTISEMENT 2 91
APPENDIX 18 CHEVROLET WEBSITE ADVERTISEMENT 3 91
APPENDIX 19 JOHN DEERE WEBSITE ADVERTISEMENT 91
APPENDIX 20 MASSEY FERGUSON WEBSITE ADVERTISEMENT 1 92
APPENDIX 21 MASSEY FERGUSON WEBSITE ADVERTISEMENT 2 92
APPENDIX 23 MASSEY FERGUSON WEBSITE ADVERTISEMENT 3 93
BIBLIOGRAPHY **94**

Abstract

Electric tractors (ETs) have the ability to become a major part of the American agricultural landscape in the near future. Currently available to consumers, ETs are beneficial in terms of environmental, personal, and public health. Despite this, policymakers have not yet paid attention to the benefits of ET production and adoption, failing to incorporate incentives for ET development in either U.S. or Illinois state energy and agricultural policy. Even in alternative fuels legislation, the category in which most electric vehicle policy is located, ETs are not yet acknowledged as an available or valuable alternative to traditional fuel vehicles. However, current alternative fuels policy frameworks act as a basis upon which changes to policymaking approaches can be made. This study explores cultural, technological and legislative barriers to ET production and adoption, highlighting the benefits of the technology as reasons for overcoming these barriers. A discursive and visual analysis focused on advertising, vehicular patents, manufacturer websites, and policy is employed in order to understand why ETs have not yet become a mainstay of rural life. The structure of this analysis provides the reader with an alternative way in which to discuss the electric vehicle, encouraging the development and adoption of these vehicular technologies as one way in which to acknowledge the full scope of electric possibilities in the vehicle industry. The result of this inquiry reveals a current, two-tiered framework in which electric vehicle policy is currently contained. Separating legislation into the categories of energy and agriculture, current methods of vehicular policy development are not conducive for the development of incentives for alternative fuel vehicles such as the ET. Because this framework is both continually creating and re-enforcing EV market conditions, a break from its structure is needed in order to facilitate rapid adoption of electric vehicles with a looming climate crisis in mind. This study makes some initial suggestions as to what a new framework might look like, focusing on alternative fuels policy as an area in which the electric tractor and other alternative fuels vehicles can be acknowledged alongside the electric car. However, in order for this framework to adapt over time, readers must continue to utilize the discursive framework provided here in order to encourage policy production, on a local scale, that best fits with the needs of the ET producer and consumer in each U.S. state.

Introduction

An understanding of the electric tractor begins with the capturing of memories associated with vehicle types used on an every-day basis.

Chris and Sophie, residents of Chicago's Bridgeport neighborhood, drive out of the city one morning at 8:00am. Switching between lanes of traffic rushing past each other on the Illinois I-55, they have little time to glance at the vehicles around them. Electric car owners for many years, their understanding of the experience of the electric vehicle is acute. As the car moves between stops and acceleration in the variable traffic, the quiet movements of the vehicle make the whirring of the gasoline and diesel engines speeding past them that much more unfamiliar. Chris and Sophie are likely aware of the central differences in structure, use, and experience between their own electric vehicle and more traditional models. However, other passengers may still struggle to identify differences between the vehicles passing by and their own. And, at the rate in which vehicles are passing by at rapid speeds, Chris and Sophie may still have difficulty examining how each of the vehicles surrounding them differs from their own. The taxonomy of each vehicle traversing in and out of the city is difficult to dissect. However, as rush hour hits and the movement of traffic around the two passengers slows, identifying the make and model of each car, imbued with information about the fuel type and vehicle structure, becomes a game in which to pass the time.

The experience of driving down the highway is a deeply personal one linked with the particular vehicles we drive. As traffic picks up and a new song comes on the radio, Sophie and Chris abandon their attempts at mentally deconstructing the vehicular ecosystem of the highway. In their brief moment of reflection on those vehicles contained on the road, neither succeeds in differentiating between vehicle types across a wide median. Eventually, both also lose interest in the changing landscape unfolding outside their window. In this moment, what they fail to notice is the nearby tractor, moving steadily through lines of crops along the edge of the highway. Separated by road and field, the electric car and the electric tractor seem to live in different vehicular ecosystems. Sophie and Chris drive rapidly past the tractor, oblivious to the fact that aspects of the tractor may be more similar to their own vehicle than those passing in the road's opposing lanes. Long past the moment where Sophie and Chris are no longer visible beyond the curve of the road, the electric tractor carries on with its purposeful work, turning back towards the farm only once it reaches the row of crops at the highway's edge.

What about the cars speeding past Chris and Sophie's window to the city on the lake? In one personal vehicle, the four-member Carter-White family heads into Chicago for the weekend. Unlike the vehicle that Sophie and Chris drive, the Carter-Whites' car whirrs with the familiar tone of the internal combustion engine. Like Sophie and Chris, the Carter-Whites fail to notice the agricultural vehicle churning steadily across the field ahead of them. The process of acknowledging the existence of the tractor is the same for both families, no matter what kind of car they drive. First, the passengers must acknowledge the existence of other vehicle types outside of the car's window. Then, previously acquired knowledge specific to vehicular forms and functions must be used to determine whether a vehicle might run on fossil fuels or electricity. In the case of the electric tractor, the first step in recognizing the vehicle's existence requires becoming aware of a vehicular ecosystem beyond the asphalt. Additionally, in determining fuel type and internal construction, previously acquired knowledge might be required to identify an electric vehicle from a distance. Identifying the fuel type of the tractor becomes even harder as the Carter-White's vehicle moves further from fields to factories and skyscrapers. In the metropolis, the likelihood of seeing a tractor of any make or model is low. So, some car owners continue onward, failing to realize the ways in which the electric tractor plays a larger role in vehicle markets as well as in American life.

The electric tractor, even if not a major player, is part of Chris, Sophie, and the Carter-Whites' narratives. However, these fictional tales about our chosen Chicago residents fall short in not challenging assumptions made about the use of the personal car and agricultural vehicle in two separate worlds. A second, fictional story could attempt to rectify this misstep with an opposing view. For a moment, look down to the laces of the work boots on your feet, ready to tackle the low-lying grassland in front of you, beyond which the Illinois I-55 lies. In this pastoral scene, visualize Chris and Sophie's electric car leaving the highway for the countryside, approaching by way of one-way lanes and dirt roads. Exiting the car, Sophie mounts the tractor as fully electric as the car parked nearby. In this moment, she seems to become the hero we've been looking for, one that rejects the urban-rural divide. However, her transition from road to field does not solve the problem of separation inherent in current legislation that controls the production and adoption of electric vehicles. This narrative also does not work enough to nuance societal assumptions and expectations associated with vehicle types from electric tractors to diesel cars. The tractor and car are so separated in our social and political idea of what it means to be not only an electric vehicle, but a vehicle in general. Because of this, farmers themselves might relegate the tractor and car into separate realms of use. This is only the more telling since farmers are uniquely suited to bridge the gap between urban and rural identities. As owners of

both cars and tractors, they are able to act as the protagonist in many tales of vehicle production and use told in the U.S. today. However, some of these tales twist the urban-rural divide to perpetrate cultural expectations that produce faulty policy frameworks and reject true technological considerations. So, it becomes our responsibility to determine which parts of this story only feel familiar and which are, in fact, accurate.

Even as readers critically assess where aspects of the urban-rural narrative can be countered and broken down into more subtly precise parts, narratives such as those presented above should not be relied upon to guide policy interventions and vehicle markets. These stories perpetrate romanticized pastoral myths. And, though they represent some popular depictions of vehicle industries, they are not enough to support robust future policy that urges positive growth in alternative vehicle production. Similar, incomplete narratives are produced in legislative boardrooms, industry meetings, and colloquial discussions between consumers. The idealized image of a universalized electric tractor capable of traversing spaces in which any vehicle can travel is indeed appealing. However, though pleasing because of the ease of adoption assumed in this tale, these anecdotes do not align with difficulties inherent in the range of electric vehicle offerings, especially on farmland. A more complete narrative requires questioning each existing assumption about the presence (and absence) of electric vehicle across a variety of landscapes, especially those in rural Illinois. If these alternate narratives are not encouraged, failure to acknowledge similarities between vehicle types while simultaneously burying differences will lead to the sidelining of the electric tractor in vehicle policy once again.

This study provides relevant information with which to better understand the place of electric tractors in U.S. and Illinois state life. The purpose of this effort is to provide tools for the development of policy frameworks supporting widespread adoption of alternative fuels vehicles, specifically the electric tractor. Despite concerns about the relevance of the tractor in the renewable energy sector, the larger story of the electric tractor emblemizes the transition to transportation systems reliant on electric vehicles for life, leisure, and work. This doesn't mean that the corner of the electric vehicle industry occupied by the electric tractor isn't important, however. In fact, the ability of the electric tractor to simultaneously support and transform the idea of what it means to be an "electric vehicle" cannot be dismissed. More informed policy produced with the value of this particular vehicle type in mind is not only possible, it is necessary. The electric tractor provides the opportunity to advance personal, public, and environmental health in regions of the United States that have increasingly been disconnected from both environmental problems and solutions such as the electric vehicle. Without a new approach, alternative fuels policy production, which already lags far behind the rate of electric

vehicle technological development, will continue to fail constituents that could benefit from easier access to renewable energies. Residents of both rural and metropolitan areas deserve intentional consideration placed on technological developments that can improve quality of life. Additionally, consumers and manufactures deserve purposeful action dedicated to the research and production of incentives, on a local scale, to encourage the adoption of technologies that can benefit Illinois state and U.S. residents.

A discursive and visual analysis focused on advertising, vehicular patents, manufacturer websites, and policy is employed in order to understand why ETs have not yet become a mainstay of rural life. The structure of this analysis provides the reader with an alternative way in which to discuss the electric vehicle, encouraging the development and adoption of these vehicular technologies as one way in which to acknowledge the full scope of electric possibilities in the vehicle industry. The result of this inquiry reveals a two-tiered framework in which electric vehicle policy is currently contained. Separating legislation into the categories of energy and agriculture, current methods of vehicular policy development are not conducive for the development of incentives for alternative fuel vehicles such as the ET. Because this framework is both continually creating and re-enforcing EV market conditions, a break from its structure is needed in order to facilitate rapid adoption of electric vehicles with a looming climate crisis in mind. This study makes some initial suggestions as to what a new framework might look like, focusing on alternative fuels policy as an area in which the electric tractor and other alternative fuels vehicles can be acknowledged alongside the electric car. However, in order for this framework to adapt over time, readers must continue to utilize the discursive framework provided here to encourage policy production, on a local scale, that best fits with the needs of the ET producer and consumer in each U.S. state.

The discursive framework mentioned above focuses on the three categories of *Image*, *Technology*, and *Policy* to discuss the electric tractor in the context of vehicles such as the diesel tractor, electric car, and gasoline-powered car. In the *Image* category, social and cultural perceptions are assessed in the context of vehicle manufacturer websites and vehicle advertisements, allowing for an exploration of the complex role of the electric tractor in American life. In the *Technology* category, information about product availability and vehicle specifications on the same manufacturer websites will be used to connect social and policy trends to physical aspects of the electric tractor. Patents will allude to possible future developments as well as to the range of electric tractor technologies produced over time. Finally, in the *Policy* category, breakdowns of current alternative fuels policies by way of original graphics and keyword analyses will speak to efforts that can be made in the legislative realm

to surpass social expectations in order to aid in the development of all corners of the electric vehicle industry. Ultimately, a focus on these three central categories as they relate to the perception, usage, and incentivization of the electric tractor, will lead to a policy framework suggestion meant to aid all those connected to the life-cycle of the vehicle in fulfilling emerging consumer and industry needs of the future.

Literature Review – A Familiar Narrative, Complicated

Lines of Demarcation: The Urban versus The Rural

Remember Chris and Sophie? They, unwittingly, were part of a narrative that took aspects of the urban and rural, transforming them to fit current social and political depictions of electric vehicles including the electric tractor. In order to nuance the world in which Chris and Sophie take their Saturday morning drive, new elements of the electric tractor's world located around the highway's bend, will be revealed.

This deconstruction could start, as most stories about the electric vehicle do, with detailed information about what makes the electric and diesel vehicle so different from one another. Though most U.S. residents would be able to recognize the term "electric vehicle," they may not have extensive knowledge of the vehicle's technological specifications, pricing, or success in various economic markets. It is also not unexpected that, in considering the electric vehicle, the typical assumption is that the electric vehicle is a car. Therefore, it's important to outline exactly what the electric vehicle is and why many argue for its efficiently, affordability, and function. However, current discussions about electric vehicles are limited by the fact that they don't recognize the wide range of electric vehicle offerings currently available.

This study, then, aims to give readers the tools to delve closely into the narrative surrounding the electric vehicle industry, a social and political story. This complex tale both contributes to the type of electric vehicle policy produced in the United States and is affected, in turn, by the outcomes of this legislation on vehicle users and American life. Consumers, policymakers, and industry executives make assumptions about the function and image of different vehicle types. A wide variety of frameworks are therefore informally produced, determining what it looks like to talk about the electric vehicle industry. As readers gain the skills to challenge narratives, they will make stronger assessments about how to perceive useful, alternative vehicles and their function. From there, more detailed policy supporting the production and adoption of these vehicles can be produced. An analysis of the contexts in which the electric tractor is currently represented, discussed below, contributes to this goal of challenging current assumptions and providing new frameworks for considering the electric tractor as an important, future part of the electric vehicle industry.

In many respects, rural and urban areas of the United States are thought to house different vehicles used by different types of people with different lifestyles and goals. In some ways, this makes sense. The farmer relies on agricultural vehicles like the tractor to complete work that is specific to the farm

and field. Yet, the urban dweller would not enter this sort of arrangement, using a vehicle to work the land. However, the basic technology used to build an electric vehicle does not discriminate between the tractor or the car. Though charging infrastructure for the rural use of electric cars may vary depending on place and may not always be as readily available in rural settings, electric cars can function just as well on urban and rural roads.[1] And although the typical depiction of the electric vehicle evokes images of sleek personal cars, a much wider range of vehicles with electric options are currently available; Heavy-duty trucks, school buses, and tractors are all examples of vehicles with electric options.[2,3] So, while a host of terms such as all-electric vehicles, plug-in hybrid electric vehicles, battery electric vehicles, and extended-range electric vehicles are typically used in reference to electric cars, these terms apply to the vehicle in the schoolyard, the weigh-station, or the animal pasture.[4] Unfortunately, the public imagination, memorialized in current policy, does not often consider agricultural vehicles as part of the category of electric vehicles as a whole. However, exploration of the separation between the urban and the rural aids in the process of deconstructing this narrative.

Part of the idea of the urban-rural divide stems from the low probability that tractors and cars will function in the same space at the same time. The tractor and the personal car were specifically made for different uses: one for the movement of people and one to facilitate in the production of goods. However, because these functions take place in different spaces, most notably the road versus the field, the car and tractor become separated in social commentary. The urban-rural divide is also applied to each vehicle's owner, their perceived image, and way of life. Think about what it might mean to be described as a rural farmer or a metropolitan Tesla owner. The distinctions that already exist between the tractor and the car, regardless of the vehicles' technological makeup, are already deeply ingrained in assumptions about urban and rural lifestyles associated with them.

Detailed studies have already been done on the ways in which cities and states are divided into different spheres of economic, political, and social possibility because of the way that cars are used differently in different spaces.[5] Further studies may be done looking at the outcomes of car use across

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[1] Lucas Nelson, "Paving the Way for Electric Vehicles in Rural America," Center for Rural Affairs online, 2019, https://www.cfra.org/news/190828/paving-way-electric-vehicles-rural-america

[2] Steve Hanley, "Heavy Duty Electric Trucks Aren't Coming, They're Already Here," Clean Technica, 2019, https://cleantechnica.com/2019/08/13/heavy-duty-electric-trucks-arent-coming-theyre-already-here/

[3] Ellen Rosen, "Making Yellow School Buses a Little More Green," The New York Times, 2020, https://www.nytimes.com/2020/01/22/business/energy-environment/electric-school-buses.html

[4] "Electric Vehicle Basics," Office of Energy Efficiency & Renewable Energy online, accessed October 2019, https://www.energy.gov/eere/electricvehicles/electric-vehicle-basics

[5] Richard Florida, "How Cars Divide America," The New York Times, 2018, https://www.citylab.com/transportation/2018/07/how-cars-divide-america/565148/

the urban-rural divide. However, socially produced conceptions of who uses both the car and tractor will be broken down by this study, challenging the idea of the urban and rural as separate areas of technological use and vehicle distribution. Not all urban residents are interested in using a tractor, but residents in both urban and rural areas need cars. With this in mind, barriers between consumers of different vehicle types may not be as concrete as they seem.

However, some elements of the urban-rural divide are hard to eliminate from the American psyche. As the car is unable to stray from the road onto the field, lines of demarcation between the urban and rural stay intact. Without a robust understanding of the traction afforded by the surface beyond the roadside, the individual in the car driver's seat may have little idea of how well the vehicle might hold up under surfaces requiring varying levels of grip and power.[6] In addition, the car owner must also consider whether or not their vehicle has been outfitted properly to function outside of its intended setting. For example, in even considering deviation from the highway surface, the driver must consider whether they have the right 4-wheel drive capabilities.[7] With knowledge of driving surface makeup as well as installed vehicle technology in hand, the driver then has to assess their comfort level in utilizing said technology effectively. At this point, any electric vehicle owner with little time on their hands would most likely have already returned to the roadway, realizing the sheer complication in moving through land of various compositions.

Difficulties, in turn, occur in efforts to have the tractor enter the world of the car. The driver of the tractor may be able to cross physical lines separating the highway and the field. But, even in this case, the presence of the tractor in car-centric spaces if often perceived as a nuisance. 10 years ago, the average speed of a tractor was 20mph.[8] Imagine being stuck behind a vehicle moving at 20mph on a 70mph roadway and you might also understand why a breach of the urban-rural divide might be considered a nuisance. Even if the tractor-driver chooses to spend brief moments on the road, their vehicle will always make its way back to the field in which it began. Meanwhile each car passing by will continue on their highway path. In a theoretical world, perhaps the one in which Chris and Sophie traverse geographic and social realms, some overlap can occur between areas in which the car and tractor are used. The tractor and car could potentially meet at the lines of demarcation between the

[6] Matt Scott, "What You Need to Know Before Driving Off-Road," Gizmodo, July 15, 2015, gizmodo.com/what-you-need-to-know-before-driving-off-road-1717626763
[7] Matt Scott, "What You Need to Know Before Driving Off-Road," Gizmodo, July 15, 2015, gizmodo.com/what-you-need-to-know-before-driving-off-road-1717626763
[8] "Agricultural Equipment on Public Roads," National Ag Safety Database online, 2009, nasdonline.org/2065/section4/d001906/agricultural-equipment-on-public-roads.html

road and the field. Outside of the fictional narrative produced here, the two vehicle owners most likely would only be part of such an interaction based on necessity and not because of the theoretical importance of this meeting's occurrence. However, this image of a physical barrier between the tractor/ field and the car/ road may help to visualize less tangible thought processes that divide vehicles into different spheres of work.

Even with all these factors in mind, the presence of tangible aspects of the urban-rural divide doesn't mean that synergy isn't possible between worlds separated by factors as simple as ground cover. This also doesn't mean that deconstructing the urban-rural divide means forcing urban and rural technology together into the same space. Instead, carefully considering whether tales told about vehicles are rooted in the vehicle's technological ability or just in what is thought about the lifestyle in which vehicles are used is productive in unpacking social and political assumptions holding back technology from being used to its full potential.

So, What is an Electric Vehicle?

Determining what the term "electric vehicle" describes is not easy. This is because not all electric vehicles are built or used in the same way. Terms used to describe the electric vehicle can range from simply the "electric vehicle" to definitions acknowledging specific capabilities under the sub-categories of hybrid, all-electric, and alternative fuel vehicles. A slew of acronyms and terms associated with the industry are listed below.[9] Not all are referenced in this study. However, the acronyms in bold will be used in further sections. Additionally, the existence of such a wide range of vocabulary, all which may be used in reference to the electric car as well as a few select vehicle types such as heavy-duty electric trucks or electric golf carts, speaks to the extent to which technological innovation has led to further specification of electric car types .[10]

EV – Electric Vehicle

BEV – Battery Electric Vehicle

PEV – Plug-in Electric Vehicle

PHEV – Plug-in Hybrid Electric Vehicle

HEV – Hybrid Electric Vehicle

[9] "Electric Vehicle Acronym Glossary," Electric Vehicle Institute, accessed March 2020, http://www.ev-institute.com/images/acronym_poster.pdf

[10] Justin Hughes, "Neighborhood Electric Vehicles: A Different Kind of Electric Car," 2018, The Drive Online, https://www.thedrive.com/tech/19658/neighborhood-electric-vehicles-a-different-kind-of-electric-car

HDEV – Hybrid Diesel Electric Vehicle

AFV – Alternative Fuel Vehicle

DFV – Dual-Fuel Vehicle

CEV – City Electric Vehicle

CFV – Clean Fuel Vehicle

EHDV – Electric Heavy Duty Vehicle

EREV – Extended Range Electric Vehicle

ILEV – Inherently Low Electric Vehicle

FCEV – Fuel Cell Electric Vehicle

FCHEV – Fuel Cell Hybrid Electric Vehicle

NEV – Neighborhood Electric Vehicle

SULEV – Super Ultra Low Electric Vehicle

ULEV - Ultra Low Electric Vehicle

ZEV – Zero Emission Vehicle

One term, however, does not yet exist in this dictionary of terms associated with the electric vehicle.

ET – Electric Tractor

So, why, as typified in the introductory narrative to this study, does the electric tractor (ET) seem excluded from the story of the electric vehicle? The complex and contradictory factors leading to the separation of the ET from the electric personal car emerges from the historical development of different vehicle types over time as well as images, technologies, and policies associated with each type. With contextual information from advertisements, governmental educational initiatives, vehicle manuals, and technological journals, readers will be better prepared to use nuanced frameworks in order to consider the use and importance of electric agricultural vehicles. From here, invested individuals ranging from corporate vehicle industry leaders to farmers working directly in the field may continue to re-assess these frameworks as more information on the ET comes to light. These efforts foreshadow the development of codified policy related to the electric tractor, an effort further discussed later in this study.

Because of the disparities in attention paid to electric vehicles in urban settings versus those in agriculture, it may seem ironic that the focus of much of the dialogue surrounding the electric

tractor, in this study, focuses on the car as a point of cross-comparison. However, both electric and diesel cars provide contexts with which to look at the existence, function, and importance of the electric tractor. When talking about the electric tractor, it is important to recognize that other types of agricultural vehicles have paved the way for its existence. But, it's also important to acknowledge that new technologies continue to develop over time, even when older vehicle types still serve useful functions. By recognizing unique technologies such as the ET, industry actors can prepare to mobilize renewable energy technologies for a changing future. Assessments made about the present and future electric vehicle industry in the categories of economic viability, technological availability, social relevance, and legislative importance will not be accurate without knowledge of the industry's full extent and capabilities. This very point of contention reveals the importance of this study as providing nuance to already existing examinations of the electric car. With only a focus on the electric car, important information about other areas of electric vehicle development is lost. Therefore, the challenge in discussing the electric tractor, not only in this study but in further efforts to talk about the industry, is to do so keeping in mind the range of vehicles available across the perceived urban-rural divide.

Plug-In Electric Vehicles (PEVs)

The terminology associated with the electric vehicle emerges from this almost singular focus on the electric car. However, a few particular types of electric cars stand out as the core of current alternative fuels policy as well as broader discussions about electric vehicles as a whole, especially the Plug-In Electric Vehicle. Understanding how the plug-in electric vehicle has been perceived, produced, and included in policy over time will better inform industry actors as to what a similar dedication in focus to the electric tractor, in Illinois as well as the United States as a whole, might look like.

The plug-in electric vehicle is important to recognize, in the field of electric vehicles as a whole, as indicative of what most consumers tend to think of as an electric vehicle. Even if the individuals familiar enough with the electric tractor to conceptualize its form in comparison to other vehicle types comes across the term "electric vehicle," the image of a car with space for an electric charging cable will likely be the first to come to mind. Gasoline and Diesel vehicle owners will undoubtedly recognize the feeling of the repeated motion of refueling. It then makes sense that the image of the electric vehicle with a place to physically plug into a power source for energy renewal sounds familiar even as the experience is labelled as different.

Differing from a traditional gasoline vehicle which houses a fuel tank for its driving fossil fuel source, the main differentiating component of a plug-in electric vehicle seems to be, at first sight, the charge port conducive to electricity usage.[11] However, what it means to be a "plug-in electric vehicle" is more complicated than the difference between the fuel tank and the charging port alone. For example, certain hybrid electric vehicles may also be referred to as plug-in electric vehicles.[12] These vehicles may have alternate means of charging other than through a connecting charger and charging port.[13] To further complicate this issue, some electric vehicles with charging ports are not referred to under the label of plug-in electric vehicles.[14] One realization stemming from this complication is that terminology used to describe electric vehicles is not always clear cut; It is difficult to define what a PEV is supposed to do and look like. With this in mind, visual representations of different vehicle types have been provided for cross-comparison in Appendices 1 through 7 at the end of this study. However, such complexities extend outside of the range of a few figures meant to further explain the issue. These complications point to a lack of focus spent on clearly defining the range and products in the electric vehicle industry. Without particular attention paid to vehicle types central to EV industry considerations, other alternative vehicles such as the electric tractor are effectively ignored completely.

Ironically, studies that have aimed to better understand the electric vehicle industry have often fallen into this trap, ignoring this lack of widespread definition. Studies that focus on only one vehicle type in the electric vehicle market are not inherently problematic. This range of focus makes sense as knowledgeable individuals want to provide information about a particular aspect of the electric vehicle industry. Audiences also might respond more readily to clear-cut information about one vehicle type in which studies, advertisements, or policies advocate for their use. However, promoting discussion of one vehicle type without acknowledging others gives readers the false sense that electric vehicles of only one kind and purpose exist. Vehicle adoption is not completely understood until barriers inherent in the larger categories of perception, use, and production are deciphered further. In an industry focused on one particular vehicle type, the PEV, the rise of another vehicle essential to the growth of the industry has been stunted. This vehicle is the electric tractor.

[11] Appendices 1, 4, and 5
[12] Appendix 4
[13] Appendix 4
[14] Appendix 5

The Electric Vehicle and Economy

If ETs were as successful as PEVs in current vehicle markets, the number of times that the terms PEV and ET might be used in academic studies, codified policies, and everyday conversations might be completely different. Electric cars continue to become more economical as the costs of batteries lowers in addition to the total up-front costs of the vehicles as a whole.[15] Currently, both long-term prices for hybrid and plug-in electric vehicles are lower than that of their gasoline counterparts.[16] Projections from 2017 predict a point during 2026 in which the price of the electric car will be more affordable than its gasoline counterpart.[17] Projections from only a year later, in 2018, predict that this crossover point will occur in 2018.[18] With these and continuing predictions in mind, current downward trends in electric vehicle pricing seem likely to continue soon, and quickly.[19]

However, this increasing ease in consumer adoption, specific to vehicle costs, is not always perceived in the same way by manufacturers assessing the costs and benefits of entering into the electric vehicle industry. Often, manufacturers have relied on the support of tax breaks and rebates in order to sustain sales. [20] An apparent lack in state incentives for electric tractor will be focused on later in the study. However, it is important to acknowledge now this apparent lack of incentives appears in the realm of electric cars also. Manufacturers of the electric car have struggled with the demands of electric vehicle production as well as the production price now and in the past. For example, the narrative of Tesla's rise to power includes many instances of near failure in the "valley of death," coined to describe the electric vehicle industry.[21] Described as a "miserable market failure," electric cars have never quite been able to breach the 1% mark of global vehicle sales. [22] With economic

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[15] Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost," Bloomberg online, 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost
[16] "Electric Vehicle Benefits and Considerations," Alternative Fuels Data Center online, accessed October 2019, https://afdc.energy.gov/fuels/electricity_benefits.html

[17] Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost," Bloomberg online, 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost
[18] Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost," Bloomberg online, 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost
[19] Nathaniel Bullard, "Electric Car Price Tag Shrinks Along With Battery Cost," Bloomberg online, 2019, https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost
[20] Matthew DeBord, "California wants to deal with the 'valley of death' for electric cars," Business Insider, 2017, https://www.businessinsider.com/california-valley-of-death-for-electric-cars-2017-6
[21] Katie Fehrenbacher, "Yep, It's Still Incredibly Hard to Build an Electric Car Startup," Green Tech Media, 2017, https://www.greentechmedia.com/articles/read/yep-its-still-incredibly-hard-to-build-an-electric-car-startup
[22] Matthew DeBord, "California wants to deal with the 'valley of death' for electric cars," Business Insider, 2017, https://www.businessinsider.com/california-valley-of-death-for-electric-cars-2017-6

challenges already determining the rate of production in electric car markets, it has become clear how difficult it might be to argue for the current adoption of the electric tractor on a widespread scale. However, this doesn't mean that purposeful effort made to provide the necessary incentives, to both manufacturers and consumers, for purchase and adoption of the electric tractor will not lead to comprehensive adoption in the future.

This history of troubled yet improving electric car sales and pricing suggests that robust support is needed in order to bolster growth and development of the electric vehicle industry as a whole, with consideration for both the electric car and the electric tractor. So why add complication in considering vehicles such as the electric tractor before fueling more efforts to drive cost-effective production of electric cars alone? There are considerable benefits in investing in the future of a range of electric vehicles rather than one or two. The process of acknowledging vehicle types not usually considered under the umbrella of electric vehicles spurs the development of technologies that can be used in a range of applications even associated with the traditional electric car. Trends in costs or lack of social, economic, or political support for ETs, for example, might also nuance current trends related to the category of electric vehicles as a whole. With this in mind, acknowledgment of the electric tractor becomes extremely important no matter its current value in world markets or Illinois state life.

The monetary cost of the electric tractor plays a central role in the feasibility of its adoption on both a state and national scale. Comparing trends in economic value between the electric tractor and the electric car reveals some similarities in the affordability of each vehicle. Companies such as Solectrac, discussed later on, cite charging costs for ETs as between 12.5-50% what it would cost to fuel a tractor with a diesel engine. [23] Additionally, while diesel motors have hundreds of moving parts requiring frequent maintenance, the one-part electric motor may have a longer working life.[24] Similar to the electric car, the savings in costs for ETs seem to be considerable over time. However, limitations in cost-effectiveness specific to ETs persist. An electric tractor owner can expect to save in the categories of upkeep and refueling.[25] However, at the same time that it's difficult to predict what might happen in the lifetime of a vehicle, causing it to need repairs, there is no concrete way of assessing

[23] Jake Richardson, "Electric Tractors Have Advantages Over Diesels," Clean Technica online, 2018, https://cleantechnica.com/2018/09/20/electric-tractors-have-advantages-over-diesels/
[24] Jake Richardson, "Electric Tractors Have Advantages Over Diesels," Clean Technica online, 2018, https://cleantechnica.com/2018/09/20/electric-tractors-have-advantages-over-diesels/
[25] Matt McIntosh, "Changing how you view electric tractors," Future Farming online, 2019, https://www.futurefarming.com/Machinery/Articles/2019/10/Changing-how-you-view-electric-tractors-482010E/

what the exact balance of high up-front price with low additional costs will be over time.[26] What becomes a central area of concern, for purchasers of electric agricultural vehicles, is a balance between cost-effectiveness and the strength of the vehicle's power systems.[27] If the vehicle can hold up to the needs of the work required on agricultural fields, and if it can do so without massive costs surpassing that of its diesel alternative, then ETs will be a fiercely competitive choice. However, information on the cost-effectiveness of electric tractors is not widely available in the current moment. Additionally, the electric tractor is not widely discussed in general. Because of these factors, the burden becomes increasingly placed on the consumer to do the heavy-hitting research on feasibility of adoption.

This burden on the consumer to be constantly up to date on relevant economic information in the electric vehicle industry places manufacturers in a space of power within which to argue for the feasibility and affordability of their individual products in the long term. Although this will be discussed in more detail with manufacturer advertisement analyses in the following sections, this topic is worth mentioning now in order to contextualize the realm in which consumers must search for important vehicle information. It makes sense that interested consumers will find sources that are catered to a particular kind of individual. For example, agricultural vehicle manufacturers can assume that a visitor to their on-site locations or their online pages will have some knowledge of and interest in agricultural vehicles. Manufactures will therefore assume that their advertisements and information will be accessed by those willing to look further into what each company has to offer. Media or news outlets containing information about recent developments on ETs specifically are most likely not producing articles without thinking about the interested manufacturers and consumers who are willing to actively absorb their product information in the first place. While federal and state agencies currently contain little to no data on ET technologies or sales, small-scale platforms such as energy and agriculture media sources and manufacturer webpages become the primary paces in which this kind of information can be found. It seems likely then, that legislators who may benefit from knowledge on the true expanse of the current electric vehicle industry would miss out on important information if they were not already part of the group of consumers actively interested in ET purchasing.

Given the difficulties that ETs face in both production and consumption, multiple arguments emerge for the development of robust electric vehicle policy to support a part of the electric vehicle

[26] Matt McIntosh, "Changing how you view electric tractors," Future Farming online, 2019, https://www.futurefarming.com/Machinery/Articles/2019/10/Changing-how-you-view-electric-tractors-482010E/
[27] Matt, McIntosh, "Changing how you view electric tractors," Future Farming online, 2019, https://www.futurefarming.com/Machinery/Articles/2019/10/Changing-how-you-view-electric-tractors-482010E/

industry that is not yet powerful enough to sustain widespread success on its own. First, the cost effectiveness of both electric car and ET usage has been proven achievable under the right conditions. However, barriers preventing the achievement of laudable rates of production that may drive down vehicle manufacturing and purchasing costs include limited access to vehicle products as well as a lack of incentives for vehicle production. Forward-thinking policy, its effectiveness bolstered by nuanced research and discussion, might contribute to a new cycle of knowledge dissemination benefitting consumers and manufacturers.

Electric Vehicles as a Benefit to Agricultural Practices

It is important to assess the value of the electric tractor in economic terms, as outline above. However, ET or even EV technology as a whole would not have been developed without additional benefits driving its development and production. ET manufacturers claim that cost is not the only reason that consumers want the availability of electric agricultural vehicles to increase. Investment in personal and public health on individual farms as well as in larger communities drives farmers to continue to purchase electric agricultural goods.[28]

One of the benefits associated with electric tractor use over its diesel counterpart comes in the form of personal experience with the vehicle. It's important to recognize the particular experience of farmers who will have access to ETs because of the intrinsic connection between vehicles and their users. The effects of vehicle usage and adoption are experienced far past the date of purchase, and this is partly due to the long-term connection between the farmer and the tractor that works the field. Noise and emissions, in particular, are essential points of sensory experience associated with tractor usage.[29] Described as "brutal," the emissions produced from diesel tractors make periods of 6 hours or more where the driver is in direct contact with the vehicle exceedingly uncomfortable.[30] ET users experience less noise than those driving diesel vehicles and also experience little to no fumes, resulting in a drastic increase in comfort associated with the job.[31] Not to be taken lightly, these benefits are worthy of consideration when producing legislation related to

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[28] Jake Richardson,"Electric Tractors Have Advantages Over Diesels," Clean Technica, 2018, https://cleantechnica.com/2018/09/20/electric-tractors-have-advantages-over-diesels/
[29] Urban Farmer Curtis Stone, *Farming with an Electric Tractor,* Wheelbarrow farm, From the Field, 2019, Youtube Video, 10:52, https://www.youtube.com/watch?v=NM9GMVz9-sI
[30] Urban Farmer Curtis Stone, *Farming with an Electric Tractor* Wheelbarrow farm, From the Field, 2019, Youtube Video, 10:52, https://www.youtube.com/watch?v=NM9GMVz9-sI
[31] Jake Richardson, "Electric Tractors Have Advantages Over Diesels," Clean Technica online, 2018, https://cleantechnica.com/2018/09/20/electric-tractors-have-advantages-over-diesels/

the users of vehicles who may be making difficult decisions about personal health, cost-effectiveness, or usability when purchasing a vehicle in the future.[32]

The combined interaction of the vehicle user and the electric tractor is also interrelated with environmental and health factors. A 2019 study from Northwestern University links the use of electric vehicles to a decrease in air pollution, improving air quality.[33] Some of the specific outcomes of electric vehicle cited in this study include a decrease in summer ozone levels and a decrease in particulate matter or "haze" in the winter.[34] The Respiratory Health Association helps to explain what continued levels of poor air quality could do to individual and public health. The combined effects of fine particulate matter, as well as ozone containing multiple kinds of exhaust at the ground level, can irritate airways with coughing spells and asthmatic symptoms.[35] Air pollution can also increase risk for lung cancer, heart attacks, and strokes. [36] Unfortunately, the risk for any of these negative health effects becomes more likely for a few different categories of individuals.[37] Individuals who spend time outdoors are more at-risk that those who do not.[38] This risk only increases with age or pre-existing conditions including heart or lung disease.[39] Increased use of electric vehicles of all types decreases exposure to poor air quality and harmful particles.

The use of electric vehicles including the electric tractor is important to the health of U.S. populations and the environment surrounding them. However, residents of the city center are not the only individuals who come into contact with large amounts of air pollution and could benefit from renewable energies that decrease the release of harmful chemicals and substances into ambient air. There is a fundamental misunderstanding in the assumption that air quality is only dangerous in the city center. It's true that urban populations, especially those that are at-risk and low-income, are

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[32] Urban Farmer Curtis Stone, *Farming with an Electric Tractor* Wheelbarrow farm, From the Field, 2019, Youtube Video, 10:52, https://www.youtube.com/watch?v=NM9GMVz9-sI

[33] Northwestern University, "Electric vehicle adoption improves air quality and climate outlook: Ozone pollution reduced even when electricity is produced by combustion sources," ScienceDaily, accessed April 24, 2020, www.sciencedaily.com/releases/2019/04/190412122912.htm

[34] Northwestern University, "Electric vehicle adoption improves air quality and climate outlook: Ozone pollution reduced even when electricity is produced by combustion sources," ScienceDaily, accessed April 24, 2020, www.sciencedaily.com/releases/2019/04/190412122912.htm

[35] "Understanding Air Pollution," Respiratory Health Association, accessed April 25, 2020, https://resphealth.org/clean-air/understanding-air-pollution/

[36] "Understanding Air Pollution," Respiratory Health Association, accessed April 25, 2020, https://resphealth.org/clean-air/understanding-air-pollution/

[37] "Understanding Air Pollution," Respiratory Health Association, accessed April 25, 2020, https://resphealth.org/clean-air/understanding-air-pollution/

[38] "Understanding Air Pollution," Respiratory Health Association, accessed April 25, 2020, https://resphealth.org/clean-air/understanding-air-pollution/

[39] "Understanding Air Pollution," Respiratory Health Association, accessed April 25, 2020, https://resphealth.org/clean-air/understanding-air-pollution/

extremely likely to live in conditions of poor air quality that don't comply with air quality recommendations for health and safety.[40] However, peri-urban areas, where crops are produced, as well as rural areas, are not immune from the spread of ground-level ozone pollutants and also can be severely impacted by atmospheric interaction with these particles and chemicals.[41] There needs to be a fundamental shift from the concept of the agrarian ideal that assumes a life in the country as utopian in terms of connection to nature and access to clean air and water. As mentioned earlier, farmers spend a lot of time in direct contact with machinery, such as tractors, that use fossil fuels, produce exhaust and noise, and affect the health of the farmer through both the act of sitting on the machine for hours a day as well as coming in contact with the fumes that the vehicle produces. Electric tractors can't act as a cure-all to air quality and public health issues in both rural and urban areas. But a technology doesn't have to be applicable in all contexts to be able to improve the quality of environment and life for many individuals on a smaller scale. The availability of ET technology in the first place, as a way for the quality of environmental and human health for many residents in rural areas to increase, merits effort put into further discussion and incentivization of electric tractor adoption in the near future.

The possibility of future innovation makes the hope of an imminent increase in vehicle adoption opportunities possible. Even if electric tractors are not the main focus of vehicle industries at the moment, technological innovations are still being suggested for the electric tractor. More precise vehicle control is one area in which these developments are occurring.[42] Additionally, speed variability, specifically, has become one creative solution beneficial to the user and specifically associated with ETs.[43] Functionality during overburdened load capacity is also an area of development that farmers can benefit from and that could be combined effectively with technologies associated specifically with the electric version of the tractor.[44] ET manufacturers also acknowledge that other renewables such as solar power could be combined with their vehicle

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[40] Christopher Black, "Air Pollution," World Health Organization, accessed April 26, 2020, https://www.who.int/sustainable-development/cities/health-risks/air-pollution/en/

[41] Christopher Black, "Air Pollution," World Health Organization, accessed April 26, 2020, https://www.who.int/sustainable-development/cities/health-risks/air-pollution/en/

[42] Amin Ghobadpour et al., "State of the art autonomous agricultural off-road vehicles driven by renewable energy systems," Energy Procedia, Vol. 162, 4-13, 2019, https://www.sciencedirect.com/science/article/pii/S187661021931361X

[43] Amin Ghobadpour et al., "State of the art autonomous agricultural off-road vehicles driven by renewable energy systems," Energy Procedia, Vol. 162, 4-13, 2019, https://www.sciencedirect.com/science/article/pii/S187661021931361X

[44] Amin Ghobadpour et al., "State of the art autonomous agricultural off-road vehicles driven by renewable energy systems," Energy Procedia, Vol. 162, 4-13, 2019, https://www.sciencedirect.com/science/article/pii/S187661021931361X

technology to charge existing batteries.[45] Many types of renewable, on-site production sources, if installed on farms to act in combination with electric vehicle technology, could increase the quality of life and agency over energy use for farmers.[46] A part of this future innovation involves breaking from dependency on fossil fuels.[47] Should policymakers work to further acknowledge the viability of ETs in the global market, mobilizing legislation to aid in this process would fit with current goals in global energy legislation.[48] All these advancements will provide benefits to the user that enhance the experience and viability of electric tractor usage in the long term.

Similarities exist between the electric car and electric tractor industry in terms of benefits produced through the development and use of both vehicle types. For example, both electric tractors and electric cars curtail the production of emissions and have lower fuel costs than traditional vehicles.[49] However, the electric car and the electric tractor are not the same. The distinct population that electric tractors serve could benefit from increased availability of a vehicle type in a workplace in which the vehicle and its associated benefits and drawbacks become a large part of the workday. Though relatively dormant in the electric side of the alternative fuels industry for a considerable period of time, electric agricultural vehicles have begun inching closer to the forefront of the industry.[50] With the number of vehicles in use still low, however, methods of bolstering this side of the electric vehicle industry are necessary in order to best mobilize further production in the future.[51]

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[45] Jake Richardson, "Electric Tractors Have Advantages Over Diesels," Clean Technica online, 2018, https://cleantechnica.com/2018/09/20/electric-tractors-have-advantages-over-diesels/

[46] Amin Ghobadpour et al., "State of the art autonomous agricultural off-road vehicles driven by renewable energy systems," Energy Procedia, Vol. 162, 4-13, 2019, https://www.sciencedirect.com/science/article/pii/S187661021931361X

[47] Amin Ghobadpour et al., "State of the art autonomous agricultural off-road vehicles driven by renewable energy systems," Energy Procedia, Vol. 162, 4-13, 2019, https://www.sciencedirect.com/science/article/pii/S187661021931361X

[48] Amin Ghobadpour et al., "State of the art autonomous agricultural off-road vehicles driven by renewable energy systems," Energy Procedia, Vol. 162, 4-13, 2019, https://www.sciencedirect.com/science/article/pii/S187661021931361X

[49] "Electric Vehicle Benefits and Considerations," Alternative Fuels Data Center online, accessed October 2019, https://afdc.energy.gov/fuels/electricity_benefits.html

[50] Amin Ghobadpour et al., "State of the art autonomous agricultural off-road vehicles driven by renewable energy systems," Energy Procedia, Vol. 162, 4-13, 2019, https://www.sciencedirect.com/science/article/pii/S187661021931361X

[51] Lukas Riedner et al., "E-mobility in agriculture: differences in perception between experienced and non-experienced electric vehicle users," Clean Technologies and Environmental Policy, 2018, https://link.springer.com/article/10.1007/s10098-018-1615-2

Electric Vehicle Adoption in The 21st Century

So, keeping in mind the particular benefits and drawbacks associated with both electric tractors and electric cars, what does the electric vehicle industry look like today? A slowing electric vehicle market in 2019 indicates some difficulties associated with EV markets in the current day.[52] A 9% decline in plug-in electric vehicle sales, for example, hints at a lack of commitment on both the part of manufacturers and consumers to commit to the efforts needed to produce growth in the industry.[53] Some of the reasons cited for this development are low gasoline or diesel prices in a given year, federal EV tax credits that have not been renewed, difficulties in costs as discussed earlier, or simply lack of product availability.[54] These hurdles do not lead to the conclusion, however, that the EV industry needs to focus on traditional electric car development instead of spending time on alternative electric vehicle options such as the electric tractor. Instead, now is a pivotal time to come up with new ways to look at the industry in order to revive it.

Adoption of electric vehicles is not equal across the whole of the United States. This makes it more difficult to make a blanket statement about the buying experience for the electric vehicle consumer. However, it is possible to generally map what differences in consumption and production might be associated with the electric tractor and electric car, across the nation, today. Electric cars are adopted in greater numbers in states with zero-emission vehicle standards. These include California, Massachusetts, New York, Oregon, and a few other politically "blue" states.[55] Unfortunately, data is not yet available on the distribution of ET sales across the U.S. So, it is not feasible to determine what additional factors specific to agricultural vehicle production might determine where ETs are more easily purchased and sold. Information on the number of ETs sold in rural areas with different types of agricultural goods would help hint at what kind of farms (small or large), commodity types (animal or produce), and other factors might be linked with interest in ET adoption. Further studies may be able to incorporate this data into determinations about the EV industry, inclusive of the ET, in the future. However, until then, trends in electric car production, as a counterpart to electric tractor production plans, still contextualize the surrounding industry in

[52] Gerdes, Justin, "Why Is It So Hard to Buy and Electric Car in Many Parts of America?" Green Tech Media, 2020, https://www.greentechmedia.com/articles/read/why-is-it-so-hard-to-buy-an-electric-car
[53] Gerdes, Justin, "Why Is It So Hard to Buy and Electric Car in Many Parts of America?" Green Tech Media, 2020, https://www.greentechmedia.com/articles/read/why-is-it-so-hard-to-buy-an-electric-car
[54] Gerdes, Justin, "Why Is It So Hard to Buy and Electric Car in Many Parts of America?" Green Tech Media, 2020, https://www.greentechmedia.com/articles/read/why-is-it-so-hard-to-buy-an-electric-car
[55] Gerdes, Justin, "Why Is It So Hard to Buy and Electric Car in Many Parts of America?" Green Tech Media, 2020, https://www.greentechmedia.com/articles/read/why-is-it-so-hard-to-buy-an-electric-car

which the ET will be sold. Unfortunately, studies have cited difficulties in getting both consumer and manufacturers to commit to non-traditional vehicles, a trend coinciding with a lack of incentives in the same areas.[56] Ultimately, both consumers and manufacturers could benefit from more robust outside support given to research, incentivization, and discussion of the extent of the electric vehicle industry including electric tractors.

There are a few manufacturers currently producing electric tractors in the United States. Fendt, an agricultural vehicle company, currently has a battery-powered compact tractor in production.[57] Solectrac, a manufacturer focusing solely on ETs, has three different models available.[58] John Deere has also spoken for multiple years about its efforts in experimenting with electric vehicle prototypes.[59] However, from the limited information available either through the John Deere website or through other publications, it seems as if the vehicle has not yet been made available to a general consumer base.[60] A small number of international ET manufacturers also exist. A Swiss company called Rigitrac produces an electric tractor called the SKE 50, although the extent to which ordering and shipment of the product for use in the United States is possible is unclear. Additionally, as of 2017, India has released its first electric tractor, the Farmtrac 26E through a manufacturer called Escorts Group.[61]

As stark as these offerings may seem, these numbers actually show resiliency of the electric tractor in a niche corner of the electric vehicle industry which receives much less economic, social, and legislative support than is currently given to electric cars. For example, the electric vehicle industry also seems stark as it only currently has 17 EPA-approved electric cars for sale in the U.S., with 12 companies in charge of their respective production.[62] However, this bulk of the industry is aided by many years of support and success in consumer markets. These factors indicate potential

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[56] Gerdes, Justin, "Why Is It So Hard to Buy and Electric Car in Many Parts of America?" Green Tech Media, 2020, https://www.greentechmedia.com/articles/read/why-is-it-so-hard-to-buy-an-electric-car

[57] "Fendt e100 Vario: The battery-powered compact tractor," Fendt online, 2017, https://www.fendt.com/int/fendt-e100-vario

[58] "Solectrac – Climate-Smart Electric Tractors: Home Page," Solectrac, accessed January 2020, https://www.solectrac.com/

[59] Fred Lambert, "John Deere unveils latest all-electric tractor prototype for zero-emissions agriculture," Electrek, 2016, https://electrek.co/2016/12/05/john-deere-electric-tractor-prototype/

[60] Rene Koerhuis, "John Deere: 'We believe in electric tractors. 100%," Future Farming, 2020, https://www.futurefarming.com/Machinery/Articles/2020/3/John-Deere-We-believe-in-electric-tractors-100-552869E/

[61] Peter Hill, "Tractor maker launches Indias first electric-power tractor," Future Farming, 2017, https://www.futurefarming.com/Machinery/Articles/2017/11/Tractor-maker-launches-Indias-first-electric-power-tractor-4115WP/

[62] Kyle Hyatt, Steven Ewing, "Here's every electric vehicle on sale in the US for 2020 and its range," Road Show by CNET online, 2020, https://www.cnet.com/roadshow/news/every-electric-car-ev-range-audi-chevy-tesla/

for a future increase in market viability for a vehicle type (the electric tractor) that has not yet been tested at its highest capacity in the industry.[63]

Electric Vehicle Adoption Over Time

In the stories of Sophie, Chris, and the Carter-Whites, historical narratives embedded in cultural narratives determine how each passenger or driver relates to the technological objects around them. In order to understand why the terminology currently used to discuss the electric vehicle obscures particular aspects of the industry, a partial deconstruction of the historical narrative of the electric vehicle in United States history is essential. Stories told about EV development do not need to be limited to the urban sphere alone. Looking at vehicle development as a whole, in the agricultural sector of the United States, points to important aspects of the relationship between technological advancement, agricultural production, and the farmers responsible for this rural work. Additionally, a more robust focus on rural technological histories works partially to combat urban-centric discussions of the electric vehicle. This is because aspects of agricultural development are recognized, in tandem with urban developments and trends, as influential to worldwide vehicle markets, technological development, cultural practices, and the research and development of more robust policy. Comparing such narratives with representations of vehicle development in metropolitan areas, leads to an understanding of differences in urban and rural electric vehicle conception, development and usage today.

Chris and Sophie, in their travels outside of the city center, never acknowledged the presence of the electric tractor, let alone comparisons that might be made between the agricultural vehicle and the car. However, the game they played in identifying other car makes and models is indicative of the way that vehicle owners compare vehicle types in both Illinois and the United States as a whole. Tied up in the names and numbers labelling car products are social considerations gained from cultural narratives about vehicle types as well as policies talking about particular vehicles in different ways. But, off the road, concerns related to agricultural practices as well as the people working on the land reveal the importance of environmentally sustainable vehicle development. A different vantage point emerges, one that relies on the perspective of the agricultural worker. Consider this inverted narrative: 50 miles out from the city center, the quiet rustling of a corn field in Yorkville, IL is eclipsed by a different collection of sensory experiences, ones associated with the whir of an off-road vehicle type:

[63] TractorLab, *New Rigitrac SKE 50 Electric Tractor | TractorLab,* Youtube Video, 1:49, 2019, https://www.youtube.com/watch?v=z8-yn0yiLr8

the tractor. This new narrative places the farmer at the forefront of the determinations and conceptions made about the vehicles at hand. Here the farmer wakes up, not at 8:00am on a Saturday but at 6:45 to solve a technical issue with the diesel tractor upon which he has relied for this growing season. This farmer has not yet adopted an electric counterpart to the diesel vehicle that has proved reliable on his land for a considerable length of time. This decision, complicated by the farmer's idea of what the electric vehicle is all about as well as the availability of legal incentives and technological considerations, has not been made lightly.

The history of production associated with the electric tractor may help to build a stronger understanding of why choice of vehicle type in agricultural processes is complicated. Looking at the timeline on which agricultural electric vehicle technologies were developed, it doesn't seem as if a lack of technological innovation on electric agricultural vehicles has been the primary limiting factor to ET adoption. Although there is a relative lack of electric agricultural vehicles in current markets, as compared to electric cars, the timeline on which electric farming vehicles have been developed is not much different than that on which the development of electric cars has taken place. For example, while the first self-propelled electric plow was created in 1894, the first crude electric vehicle was developed in 1832.[64,65] This timeline is complicated by the fact that the first electric vehicle didn't arrive in the U.S. until a few years before the electric plow was developed. More like an electric wagon, the first U.S. electric vehicle was created between 1889 and 1891.[66] Put directly, the technology required for the development of electric vehicles in the agricultural sector has been available since close to the time that electric cars have been produced in the nation. What, then, explains the near lack of ET adoption leading up to the modern day? Other factors must have held back the development and dispersion of the electric tractor across the United States before the 20th and 21st centuries.

A wide range of historical factors beyond technological development did and still do contribute to the narrative of ET adoption that we see today. As much as it would be helpful to use the inverted narrative of the farmer's early morning run-in with technical issues on his tractor in order to explain difficulties in ET adoption, this may not be indicative of the typical farming experience in the state of Illinois. The idea of the small farmer as a beacon of the American dream and the hopeful

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[64] Michael Williams, "Machinery Milestones: Electric Tractor Power," *Farmers Weekly, 2019,* www.fwi.co.uk/machinery/technology/machinery-milestones-electric-tractor-power

[65] U.S. Department of Energy, "Timeline: History of the Electric Car." *Energy.gov*, accessed February 7, 2020, www.energy.gov/timeline/timeline-history-electric-car

[66] U.S. Department of Energy, "Timeline: History of the Electric Car." *Energy.gov*, accessed February 7, 2020, www.energy.gov/timeline/timeline-history-electric-car

beneficiary of policy changes pervades the current national, cultural imaginary. But do small farmers really make up most of the agricultural landscape of the state? And then, are small farmers or, instead, larger ones, more willing to adopt EVs under current legislative constraints? The Illinois Department of Agriculture acknowledges the difficulty in describing the typical Illinois farm.[67] Part of this difficulty stems from the shifting image of agriculture in the state over time. Between 2007 and 2012, the number of farms in the state of Illinois dropped from 76,860 to 75,087.[68] Between 2012 and 2017, this number fell to 72,651.[69] Though the total number of farms has decreased in the state over the past two decades, an increase in the approximate total land acreage of farmland has occurred.[70] For example, in 2007, while the number of farms was the largest, the approximate total land acreage of farmland in the state was 35,529,619 acres.[71] In 2012, while the number of farms dropped, the approximate total land acreage rose to 35,532,405 acres and even in 2017, when the total acreage of farmland had fallen back to 35,529,830, this acreage was still higher than that seen in 2007 when the number of farms was 4,209 units greater.[72]

In 2007, the average size of an Illinois farm was 348 acres.[73] In 2012, this number rose to 359 while in 2017, the number rose to 372.[74] The Illinois Department of Agriculture describes the average acreage of Illinois farms, three years later in 2020, as extending across 375 acres.[75] Even across a brief 10-year period, a trend appears showing the increase in average size of farm across the state. While current data is not available on the distribution of electric vehicles across farms of certain sizes or product types, data such as that explored above can give us an image of what the average Illinois farm might look like. With this information in hand, the feasibility of using the electric tractor on most of the state's farms is assessable throughout the rest of the work. Benefits

[67] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx
[68] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[69] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[70] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[71] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[72] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[73] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[74] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[75] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx

particular to farms that are more likely to adopt ETs as well as those that are not are tied to needs for the incentivization of ET adoption that exist across a range of situations and landscapes. Without an understanding of the economic needs of small and large farmers in the modern day, policy suggestions nuanced around various rural farming practices in Illinois will not be as helpful to the recipients of this policy: the users of the electric tractor.

Although each of these trends is supported by 21st century data, this does not mean that mechanization and industrialization are new in the American agricultural experience. Since the American Dream first manifested itself in the "expansionary energy" used to conquer the "volatile, marginal land" of the American West, a tendency towards increasing growth as well as a rift between rural and urban life has been central to life in the agricultural landscape.[76] However, memories of the outcomes of such expansionary actions, rooted in the experience of the Dust Bowl, bring to light questions about capitalist responsibility and the treatment of the environment.[77] Is it the responsibility of society as a whole or primarily agricultural communities to invest their time and efforts into healthy relationships with the land and with the vehicles on which they work? The answer is probably both. Resource hunger, eagerness to take risks, and diminished capacity for restraint are all tendencies that have been associated with the use of U.S. land for commodity production for a long time.[78] However, these same tendencies can also be tracked across the history of development of the EV. Capitalism has always been part of automobile production, beginning with the vehicle empire of Henry Ford.[79] Today, farming communities continue to evolve towards Henry Ford's use of machinery with technological infrastructure that keeps becoming more streamlined to fit a wide array of agricultural uses.[80] However, a pull between mechanization and sustainability has always existed across the rural landscape.[81] So how does ET adoption bring forward historical trends deeply tied with agricultural land and development? The same push and pull of urban and rural considerations in ET development is present even in the social and policy-oriented imagery associated with the electric vehicle. A second push and pull of sustainability goals and benefits associated with mass-market production becomes central to ET development as proponents of the technology want more commodities produced from machines that work on the

[76] Donald Worster, Dust Bowl: the Southern Plains in the 1930s, New York: Oxford University Press, 1979, 3-18

[77] Donald Worster, Dust Bowl: the Southern Plains in the 1930s, New York: Oxford University Press, 1979, 5-25
[78] Donald Worster, Dust Bowl: the Southern Plains in the 1930s, New York: Oxford University Press, 1979, 6
[79] Donald Worster, Dust Bowl: the Southern Plains in the 1930s, New York: Oxford University Press, 1979, 5
[80] Donald Worster, Dust Bowl: the Southern Plains in the 1930s, New York: Oxford University Press, 1979, 8
[81] Donald Worster, Dust Bowl: the Southern Plains in the 1930s, New York: Oxford University Press, 1979, 8-28

land in more sustainable ways than their diesel counterparts. Finally, the third push and pull between responsibility on behalf of farmers who adopt sustainable infrastructure and legislators who write the policy governing the ease of adoption of the ET drives industry actors to place blame on one another for not doing their part to support industry growth and development. There are no clear sides on which these contradictions should land. However, they are rooted in age-old aspects of the American experience that will continue long past this study is published.

Fuel Types and Charging Stations

Mechanization and industrialization have not only taken over the rural landscape. They dominate the lives of all consumers who purchase vehicles made over the mass market. The specific smell of gasoline is central to the life of an American car owner and this effect on the senses appears no-where, in consumer life, quite as powerfully as at the gas station. The heat emanating from the vehicle in colder months or climates is experienced hand-in-hand with the living movement of the vehicle as its systems "come to life." The slight blurring of air around the exhaust pipe creates a mirage of gasses, particles, water, and soot reminding the vehicle user briefly of the vehicle's eventual output.[82] This follows soon after the familiar moment of locking the fuel filler in the gap leading to the vehicle's tank. In all these experiences, the personal gasoline-powered car is familiar to most consumers. Memories specific to the gas station are also associated with repeated experiences with the vehicle in use. If the car's passenger were to walk, for a moment, away from the car to stand on the side of a Chicago metropolitan highway, the familiar noise of the diesel vehicle's internal combustion engine would be amplified in volume by the sheer number of vehicles passing by. The familiar pitch of the engine's whir, differing by vehicle type, combined with the low and, infrequently screeching, noise of rubber pressing against the road at 70 miles per hour changes with the familiar distortion that the Doppler Effect makes on the vehicle's produced tone.

A comparison of the experience of finding a gasoline station to that of searching out an electric charger helps readers to begin exploring intricacies inherent in the separation between the gasoline and electric car. With this understanding in hand, readers can later go on to compare experiences, specific to the car, with the process of re-fueling the electric tractor. The process, for example of locating and building strong sensory memories associated with the electric vehicle charging station diverges from the typified experiences with the gasoline vehicle. In theory, it's difficult to assess the

[82] "Car choice impacts your green score and your cash," Automobile Association Developments Ltd. online, January 11, 2017, www.theaa.com/driving-advice/fuels-environment/emissions.

actual availability of electric charging stations in Illinois. This predicament is based on a few factors. First, locating charging stations is difficult on online platforms. A few sources such as PlugShare, Open Charge Map, and the Alternative Fuels Data Center host maps on their websites that show electric vehicle charging stations across the U.S. However, the types of data visualizations created on each of these platforms seem more conducive for the researcher than the passenger with an immediate need for the information at hand. Data from each source is hard to read and even the sources that do make an effort to make information available to the public may not be completely accurate. For example, Google maps locates electric charging stations for the consumer. However, the source content for these stations is difficult to find and the accuracy of this data is difficult to pinpoint. Ultimately, the complicated experience of locating a charging station divulges a sense of division between the EV user and the electrical grid on which they depend to help run their vehicle.

It seems reasonable to assume that if charging infrastructure is difficult to find for the electric car, it will be even harder to find for the electric tractor. But, charging needs and structures for the ET and the electric car are not the same. A tractor both cannot and does not need to travel far distances in order for its function to be fulfilled. Because of this, the ET driver does not need to look out for charging stations along the road. Personal charging stations are needed on the farm that the tractor is put to work. However, this infrastructure is not inexpensive. An electric car charging station costs around $437 - $986.[83] Although this number does is not specific to ET charging stations the technology needed for an electric car charging station and an electric tractor charging station is relatively similar, excluding specific changes made to elements such as the charging ports and amount of space for maneuvering the tractor up to the unit. This information does not point to the infeasibility of ET adoption. Instead, this is only further evidence that incentives will be needed to make the adoption of the vehicle more affordable. These incentives may have to be produced from a perspective different from ones that currently consider the vehicle to be a separate purchase from the fuel with which it must be driven. With the ET being so closely linked to the grid on which the ET charging station is located, new methods of supporting affordable price points could include the ET and its charger in the same conversations about incentivization with economic feasibility in mind. Additionally, research and development efforts could help drive prices down per unit over time. In either case, price often lowers as more of a particular product is available in consumer markets. With efforts made to codify incentives and research efforts for the ET and its associated charging

[83] "How Much Does an Electric Car Charing Station Installation Cost?" HomeAdvisor, accessed April 20, https://www.homeadvisor.com/cost/garages/install-an-electric-vehicle-charging-station/

infrastructure, on a local scale, future electric vehicle policy could greatly aid in the expansion of the electric vehicle industry to agriculture.

Mass Markets – Who Actually Purchases Plug-In Electric Vehicles?

Chris and Sophie seemed comfortable in their role as electric vehicle owners and passengers. However, are they representative of the mass market of consumers targeted by plug-in electric vehicle manufacturers and the electric vehicle industry? The overall focus of EV policy before the early 2010s was intended to respond to consumption on the part of mainstream consumers.[84] The term "mainstream consumer," however, isn't really clear in defining the setting in which the consumer is being considered. The lack of specificity in describing who might make up the majority of the mainstream market reveals either that this fact is unknown or that the electric vehicle industry is assumed to be streamlined enough that the common consumer could understand their place in the industry narrative based on their adoption, or lack thereof, of the electric car.

Earlier studies outline this perceived simplicity. In one study from 2013, electric cars are equated with electric vehicles as a whole.[85] In this study, researchers determined that the electric vehicle industry was comprised of "oblivion lying in one direction, and the mass market in the other," a characterization of the failed electric vehicle boom in the last decade.[86] Contrasting studies acknowledge the importance of this assessment as showing a need to focus more clearly on market and technological considerations that were ignored earlier in the decade.[87] However, these studies also hold firm to the idea that the expansion of the perceived audience is needed to widen the scope of the electric vehicle industry if growth in the industry is to continue properly.

In suggesting ways that this this expansion may occur, early adopters are identified as a possible, preferred market for PEVs. Early adopters can be defined as "consumers who care about the environment and are willing to accept tradeoffs in features and price in order to achieve the energy and environmental benefits of driving a PEV".[88] The typical early adopter is one of the first users of

[84] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, 562, https://doi.org/10.1016/j.enpol.2013.10.024
[85] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, 562, https://doi.org/10.1016/j.enpol.2013.10.024
[86] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, 562, https://doi.org/10.1016/j.enpol.2013.10.024
[87] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, 562, https://doi.org/10.1016/j.enpol.2013.10.024
[88] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, 563-564, https://doi.org/10.1016/j.enpol.2013.10.024

a product or technology. However, even this revised and expanded conception of the electric vehicle consumer to include groups of individuals such as early adopters does not reach far enough to incorporate groups of potential consumers that live outside of metropolitan areas. Though early adopters are relegated to the sphere of the urban, the idea that certain consumers in the rural sphere could be interested in trade-offs to experience certain kinds of benefits should not be excluded from such a discussion. Although the pursuit of an understanding of the mindset behind early adoption versus general consumption will not be the focus of this paper, a sense of how the language used to refer to electric vehicle technology as a whole borrows from car-centric assumptions about an urban sphere separated from a rural one is, nevertheless useful to better understand the context in which the ET is situated.

Current Policy Related to the Electric Tractor

When conducting a basic online search for electric tractor legislation, the first results lead to articles talking about John Deere tractor concepts, legislation tractors for electric vehicles as a whole, personal statements related to the experience of the electric tractor, and a Pennsylvania bill to increase electric truck weight. No codified list of legislation specific to the electric tractor or any other electric vehicle used in the agricultural sphere appears. It makes sense that legislation might not yet be produced, on an extensive scale, for an aspect of the EV market that has not yet reached noticeable status in mass, commercial markets. However, legislation does exist relating to the electric vehicle (but more generally, in the terms of alternative fuels). Additionally, legislation exists separately governing agriculture. So, it becomes important to examine both the contents of alternative fuels and agricultural policy in order see in which legislative spaces future ET policy might best fit.

The United States Department of Agriculture (USDA) lists farm policy under the more extensive label of "Farm & Commodity Policy".[89] In this way, both the commodity produced by agricultural workers as well as the land on which the agricultural work is done seem to be considered in tandem. However, does this particular category leave room for the vehicle that connects the farmer and the land? Acknowledging farm policy as the well-used moniker referring to all U.S. agricultural policy, the USDA describes a 5-year cycle of defining this type of legislation in the

[89] "Farm & Commodity Policy – Overview," United States Department of Agriculture - Economic Research Service online, August 20, 2019, www.ers.usda.gov/topics/farm-economy/farm-commodity-policy/

United States.[90] Every five years, a Farm Bill is introduced that defines policies on farming and the function of rural communities.[91] The specific interests of this legislation are listed as animal products, crops, farm economy, food & nutrition assistance, food choices & health, food markets & prices, food safety, and rural economy & population. Considering these classifications alone makes it difficult to assess where the electric tractor may be contained in current agricultural policy, if at all.

The United States Environmental Protection Agency (EPA) also outlines laws and regulations specific to agricultural operations. These specific categories differ from the ones outlined by the USDA as they at least allude to the surface-level inclusion of vehicles, in general, in agricultural considerations. This reference to the inclusion of vehicles in agricultural policy comes from the category of farm activity listed by the EPA as "Farm Facilities, Fuel and Equipment".[92] The sub-topics of legislation discussed in this area relate to reciprocating internal combustion engines, on and off-road equipment, oil storage, underground storage tanks, used oil, oil spills, and air emissions.[93] Although each of these categories relates certainly to the tractor, the frequent references to oil and combustion engines, yet not to electricity and built-in batteries, only further shows that the ET may not be yet considered in the realm of agricultural policy. Even policy related to air emissions in this category is related more closely to the regulation of traditional engines, showing a current focus on the diesel vehicle over the electric.[94]

If the electric tractor is not included directly in current vehicular-inclusive agricultural policy, is there further opportunity for the electric tractor to be included in energy policy, particularly that specifically related to alternative fuels?

Federal agencies such as the Alternative Fuels Data Center outline electricity laws as an area in which electric tractor policy might be listed on both a federal and state level.[95] However, electricity

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[90] "Farm & Commodity Policy – Overview," United States Department of Agriculture - Economic Research Service online, August 20, 2019, www.ers.usda.gov/topics/farm-economy/farm-commodity-policy/
[91] "Farm & Commodity Policy – Overview," United States Department of Agriculture - Economic Research Service online, August 20, 2019, www.ers.usda.gov/topics/farm-economy/farm-commodity-policy/
[92] "Laws and Regulations That Apply to Your Agricultural Operation by Farm Activity," United States Environmental Protection Agency online, October 30, 2019, www.epa.gov/agriculture/laws-and-regulations-apply-your-agricultural-operation-farm-activity
[93] "Laws and Regulations That Apply to Your Agricultural Operation by Farm Activity," United States Environmental Protection Agency online, October 30, 2019, www.epa.gov/agriculture/laws-and-regulations-apply-your-agricultural-operation-farm-activity
[94] "Laws and Regulations That Apply to Your Agricultural Operation by Farm Activity," United States Environmental Protection Agency online, October 30, 2019, www.epa.gov/agriculture/laws-and-regulations-apply-your-agricultural-operation-farm-activity
[95] "Electricity Laws and Incentives in Federal," Alternative Fuels Data Center, accessed February 22, 2020, https://afdc.energy.gov/fuels/laws/ELEC?state=US

laws, like the agricultural policies listed above, are not best fit to contain all relevant information on the ET. For example, all federal electricity laws that reference the electric vehicle are also contained under the list of federal alternative fuels legislation.[96] While electricity laws cover topics outside of the categories of vehicles, alternative fuels policies reference other types of alternative fuels and hybrid vehicle technologies.[97] The inclusion of ET considerations in alternative fuels policy is essential, therefore, as a part of the larger category of nuanced, alternative vehicle development essential to future efforts to combat both climate change and challenges inherent in community and public health.

Current Suggested Electric Vehicle Policy Frameworks

Having identified legislative areas where future policy related to ETs might be contained, this study must now identify what kind of framework may form the basis for a policy suggestion located at the end of this analysis. Labels attached to particular categories of policy are important. They orient policymakers as well as those reading the policies in the goals of industries and economic markets as a whole. However, specific policy frameworks built for only one subject such as the electric vehicle are the closest form of template available for future policy developed to fit the needs of the ET. It becomes useful, then, to see what types of policy frameworks have been produced to support EV infrastructure in the modern day. One set of electric vehicle policy frameworks currently seen in U.S. federal legislation focuses on PEVs as the central core of electric vehicle development and incentivization. Originally, such frameworks seem helpful as templates for the development of legislation specific to agricultural electric vehicles. However, two complications appear in this category of policy specific to this vehicle type. First, current PEV policies are "inefficient and costly."[98] Second, PEV policies lack effectiveness in their focus on the wrong target markets.[99] Further logistical aspects and drawbacks found in the three categories of research and development, investment, and tax credits or rebates can be viewed in the table below.

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96 "Electricity Laws and Incentives in Federal," Alternative Fuels Data Center, accessed February 22, 2020, https://afdc.energy.gov/fuels/laws/ELEC?state=US

97 "Electricity Laws and Incentives in Federal," Alternative Fuels Data Center, accessed February 22, 2020, https://afdc.energy.gov/fuels/laws/ELEC?state=US

98 Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, https://doi.org/10.1016/j.enpol.2013.10.024

99 Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, https://doi.org/10.1016/j.enpol.2013.10.024

Research and Development (R&D)	**Investment in Charging Infrastructure and Electric Vehicle Service Equipment**	**Vehicle Tax Credits and Rebates**
• Assumes that PEVs must compete with conventional vehicles • Fails to reduce, may increase vehicle costs in the short term by alienating consumers • Takes up valuable space that could be filled by investment in more basic EV design, a desirable factor appealing to early adopters	• Focuses on charging stations for mainstream markets • Builds on consumer "range anxiety" over perceived lack of infrastructure • Mobilizes millions to be spent on public electric vehicle service equipment (EVSE) while little increases PEV adoption in a sustainable way	• Recognizes the Plug-In Electric Vehicle Tax Credit as a central policy in this category • Subsidizes purchases that would have been made regardless of the credit • Produces the outcome of minimal effect on lessening reliance on petroleum or reducing emissions

Table 1 PEV Policy Considerations - The information above is derived from the Green et. al study cited in this section.[100]

Electric vehicle studies have suggested more appropriate frameworks that those listed above. For example, PEV policy could be more effective if focused on niche markets, specifically postal and carsharing services.[101] Legislator can focus on re-orienting current PEV policy in order to produce two outcomes: "increase PEV market penetration and realization of intended societal benefits."[102] As viable as these proposed solutions may be to metropolitan areas, they may not be as applicable to agricultural communities. These solutions alone will not be able to facilitate the transition to a deeper focus on the development of electric tractors.

Ultimately, in assessing this particular framework for electric vehicle policy organization, it becomes clear that existing policies may not be sufficient for electric vehicles that are already well

[100] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, https://doi.org/10.1016/j.enpol.2013.10.024
[101] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, https://doi.org/10.1016/j.enpol.2013.10.024
[102] Erin H. Green et al. "Increasing Electric Vehicle Policy Efficiency and Effectiveness by Reducing Mainstream Market Bias," *Energy Policy*, 2014, https://doi.org/10.1016/j.enpol.2013.10.024

known in the market. Legislation that is inefficient for EVs will only further exacerbate mistreatment of ETs in the context of social and political discourse. With this in mind, new frameworks that work off of previous suggestions for electric vehicle policy, but that take into account new routes for the inclusion of alternative fuels vehicles, are needed for the categorization and further production of more robust alternative fuels policy inclusive of the electric tractor.

Why Illinois?

It is important to discuss the development of electric tractors, in the context of the electric vehicle, across the United States as a whole. However, the importance of state policy in determining the future of the electric vehicle industry, inclusive of the electric tractor, relies on close, state-specific studies to provide necessary information about the needs of a particular geographic area. In this study, Illinois works well as a region with many elements of cross-comparison described throughout the literature review.

With 75% of the state's land area covered by farmland, Illinois has a strong connection to agriculture.[103] 27 million acres covered by land with crops ranging from soybeans, corn, wheat, and hay to sorghum, fruits and vegetables as well as livestock from swine, cattle, and poultry to ostriches and fish. [104] Illinois farmland produces a wide range of products. However, the main components of the state's agricultural output are grain, corn, and soybeans.[105] Cattle dominates the bulk of livestock in the state, residing on 22% of Illinois farms.[106]

Illinois benefits greatly from an efficient use of farmland in the state. With agricultural commodities contributing $19 billion to the national economy annually, the state has seen robust success in its farming practices.[107] An additional $8.2 billion worth of goods are shipped internationally annually, placing Illinois as the third largest ranking state in the U.S. for global agricultural exports.[108] At the same time, the city of Chicago dominates a small area but roughly 1/6th

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[103] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx
[104] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx
[105] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx
[106] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx
[107] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx
[108] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx

of the population of the entire state.[109] In this sense, Illinois acts as an ideal case study in which the rural-urban divide is visualizable. This comparison allows for a discussion of differences in perception between the tractor and car.

It is also essential to consider the actual individuals who are not only part of the system of agriculture in the state, but part of the category of consumers who might have interest in the development of the electric tractor. Making up 11% of the total population, rural state Illinois farmers represent a way of life indicative of a significant portion of the state.[110] Yet not all members of this population are the same. While farming families are still in place in much of Illinois, some have been incorporated, and 49% of farmers consider farming to only be their second form of employment.[111] With all this in mind, a critical look at the many facets of the electric vehicle industry, inclusive of the electric tractor, is owed to the residents of the state who range from metropolitan dwellers to full-time farmers and part-time agricultural workers.

[109] "QuickFacts – Illinois," United States Census Bureau online, 2019, https://www.census.gov/quickfacts/IL
[110] "State Fact Sheets: Illinois," United States Department of Agriculture Economic Research Service online, November 27, 2019, https://data.ers.usda.gov/reports.aspx?StateFIPS=17&StateName=Illinois&ID=17854
[111] "Facts About Illinois Agriculture," Illinois Department of Agriculture online, accessed January 5, 2020, https://www2.illinois.gov/sites/agr/About/Pages/Facts-About-Illinois-Agriculture.aspx

Data and Methodology

When considering the role of the electric tractor in the state of Illinois as well as in the United States as a whole, there are three contexts in which the vehicle must be discussed. The first area, *Image*, considers how the electric tractor is perceived. The second, *Technology*, looks at the form of the electric tractor and how this relates to function. Because form and function is intimately tied with the way that the electric tractor is perceived, readers will see that these categories are best discussed in tandem. Finally, in the view of a third lens, *Policy*, legislation becomes a category in which work done in the contexts of *Image* and *Technology* to nuance discussions of the electric tractor can be put into practice.

The *Image* section compares advertisements from the front pages of U.S. vehicle manufacturer websites. The *Technology* section discusses data on product distribution and vehicle specifications alongside patents from the same manufacturers. Finally, the *Policy* section produces an assessment of Illinois state alternative fuels legislation. Although U.S. federal alternative fuels legislation is referenced for context, the focus of policy assessment in this study remains on Illinois state. An in-depth analysis of national EV policies would benefit from additional research, though the results of this manuscript are not limited by a lack of focus on federal policy here. In each of these three categories, the electric tractor is discussed in comparison to the diesel tractor, electric car, and gasoline car. The cross-comparisons that take place due to these pairings are meant to stimulate discussions of nuance currently missing in policy related to the electric vehicle. All these factors allow for a more robust understanding of why electric tractors are produced, how accessible the technologies and their associated benefits are to consumers, and why current alternative fuels policy fails to incorporate the ET into modern depictions of the electric vehicle.

Data in the Context of Imagery

	Setting	Depiction of Strength	Accessibility
Image			
	Background Visuals	Extent of Production	Consumer Accessibility
	Man-Made Structures	Vehicle Technology	Purchasing Information
	Drivability of Surfaces	Vehicular Function	Ease of Vehicle Use

Table 2 Categories for Assessing Image -The figure above outlines areas of focus in discussing data, related to the electric tractor, in the context of imagery. Readers can use the general categories outlined above to organize their own discussions on topics related to the electric tractor. They may also apply these instructive categories to further discussions of other vehicle types, especially those considered to be electric vehicles.

This study compares eight vehicle manufacturers. Two manufacturers each were chosen to represent one of four vehicle types. Solectrec and Fendt North America are discussed in the category of the electric tractor. John Deere and Massey Ferguson represent diesel tractor manufacturers. Tesla and Chevrolet are compared in the category of electric vehicle, specifically electric car, manufacturers. Finally, Ford and Chrysler are chosen for discussion in the category of the gasoline car. Each manufacturer was allowed to have multiple kinds of products (i.e. electric cars and diesel cars) even if they were chosen to represent one particular category. However, each was required to offer, in 2020, at least one vehicle of the type assigned to the manufacture. The companies were chosen based on name-recognition qualities, if possible, where a reader with relative general knowledge on vehicle manufacturers and types could recognize the company being discussed. They also were checked for the presence of a headquarters in the U.S. These choices are not meant to be comprehensive, but representative of the vehicle industries in which they are produced. Each chosen company curates their image differently based on the public, online websites they maintain. Interested parties such as policymakers, manufacturers, researchers, and investor can use this information to better understand the unfulfilled needs and goals of consumers and stakeholders. Consumers can better understand what is currently made available by manufacturers. Finally, policymakers can use the contexts in which ETs are produced to better inform the development of legislation centered in the framework suggested at the end of this study.

Manufacturer	Media Type	Number of Advertisements	Number of Vehicles Represented	Number of Vehicle Models Represented
Solectrac	Image	1	3	3
Fendt	Video, Image	2	2	1
Ford	Image	1	1	1
Chrysler	Video	3	4	3
Tesla	Image	1	3	1
Chevrolet	Image	3	6	4
John Deere	Image	1	1	1
Massey Ferguson	Image	3	2	1

Table 3 Manufacturer Advertisement Specifications - The data above comes from the individual home website page of each manufacturer listed. "Number of Vehicles Represented" refers to the total number of vehicles seen across all advertisements, whether or not each image or video depicts the same type or model. "Number of Vehicle Models Represented" refers to the number of different vehicle models represented across all advertisements immediately visible on each website home page. In cases where the make and model of a vehicle was difficult to distinguish, especially in the case of uncertainty as to whether the same vehicle was portrayed in multiple pieces of media, the number of vehicle models represents the larger possible number assuming that two indistinguishable vehicles were not the same.

Front-page advertisements on each manufacturer's website were selected, because of their visibility, as one method of cross-analysis between each company listed above. With wide reach and easy accessibility, any individual with internet access and an interest in clicking on the company's webpage link would be able to view this media. Though the scrollable length of each company's webpage includes many pieces of media such as images, video, and interactive text, the landing page of the site was chosen as the point of comparison. When accessing each website for information on the company and its products, viewers see these images and/ or videos first before all other information on the site. It is important to note that consistency in type of media (image or video) and number (one or multiple rotating pieces of media) was not exact across each manufacturer website. However, this does not hinder a general discussion of trends discovered here because the function of the media is partially to use different techniques and elements to produce different reactions among viewers. It is also important to acknowledge that the specific images or videos used by each manufacturer changed, over time, throughout the study. Vehicle manufacturer website advertisements are rarely stagnant. As changes in company offers, goals or products come about, the media chosen to represent these changes shifts. However, this does not limit the effectiveness of cross-comparison of media across the same time period. The tendency to change, described here, only further points to the relevance of advertisements to the conversation of vehicle adoption, production, and purchase. With the use of such up-to-date representations of current vehicle industry, conversations will occur that nuance the understanding of the place of the electric tractor in the electric vehicle industry.

Data in a Technological Context

	Setting	Depiction of Strength	Accessibility
Technology	Presence of Visuals	Volume of Content	Readability of Manual
	Location of Manuals	Powertrain Specifics	Extent of Application
	Area of Application	Energy Usage	Gaps in Content

Table 4 Categories for Assessing Technology - The above figure provides central points around with the discussion of data in a technological context is oriented. As with the first chart of this type introduced in the section on data in the context of imagery, readers can use these categories to orient their discussions on electric tractors and other vehicle types in a way similar to the exploration of the topics produced in this study.

This section assesses two types of data. First, information about the distribution of products for each manufacturer is presented in combination with vehicle specifications located on manufacturer websites. This data was collected by visiting the webpages for each the same eight manufacturers compared in the *Image* section. The number of products for each manufacturer was determined by visiting each area of the website to count the number of vehicles available for sale. Terminology used to describe vehicular form and function for each manufacturer differed slightly. So, in order to make cross-comparison easier, products were organized by this study into 5 categories: electric tractors, diesel tractors, electric cars, gasoline cars, and "other." More specific indicators of what products are located in each category are discussed in the analysis. Finally, a list of the models for which specifications are compared is shown in Figure 5. Though a full analysis of each vehicle model is beyond the scope of this study, the chosen products do represent the full range of vehicle offerings for each manufacturer.

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Solectrac	eUtility	X				
Solectrac	Compact Electric Tractor	X				
Solectrac	eFarmer	X				
Fendt	Fendt e100 Vario	X				
Fendt	Fendt 1000 Vario		X			
Ford	F-650 FSD Diesel Tractor		X			
Ford	2021 Mach-E			X		
Ford	2020 Explorer				X	
Ford	2020 Explorer Limited Hybrid					X
Ford	2020 Fusion Plug-In Hybrid					X
Ford	2020 Escape Sport Hybrid					X
Ford	2020 Fusion Hybrid					X
Chrysler	2020 Chrysler Pacifica				X	X
Chrysler	2020 Chrysler Pacifica Hybrid					
Tesla	Model S			X		
Tesla	Model 3			X		
Tesla	Model X			X		
Tesla	Model Y			X		
Chevrolet	2020 Equinox				X	
Chevrolet	2020 Bolt EV			X		
John Deere	4WD/ Trac Tractors		X			
John Deere	Compact Tractors		X			
John Deere	Row Crop Tractors		X			
John Deere	Specialty Tractors		X			
John Deere	Utility Tractors		X			
Massey Ferguson	MF 12V Electric Tractor		X			
Massey Ferguson	Sub-compact Tractors		X			
Massey Ferguson	Compact Tractors		X			
Massey Ferguson	Utility Tractors		X			
Massey Ferguson	Mid-range Tractors		X			
Massey Ferguson	High-Horsepower Row Crop Tractors		X			

Table 5 Manufacturer Product Distributions - The information above comes from research done into the online webpages of eight manufacturers, referenced and cited in the following section of the study. This depiction is not meant to quantify the exact distribution of vehicles produced in the United States as of 2020. Instead, these different categories of uses and applications enable readers to understand the different variations complicating the discussion of vehicle use and production across the diesel and electric vehicle industries.

The second type of data discussed in this section are U.S. patents specific to the electric tractor. Similar to manuals, patents use visual cues as well as written information to accompany technical descriptions of vehicle parts and function. They are also accessible in the public sphere through simple web searches of official patent databases like the United States Patent and Trademark Office. The use of a second type of data in this section adds to comparisons made across manufacturers and vehicle types discussed earlier, showing potential future development trends across the categories of setting, depiction of strength/ force, and accessibility. Up to date numbers on product availability refer to the present use of a particular vehicle model or type. Patents, however, indicate past, present, and future promise for the electric vehicle. This promise is particularly important in relation to the electric tractor, a vehicle not as widely available for purchase as the other vehicle types discussed here. In a discussion starting with vehicle depiction, moving through technological development as seen in product availability, and ending in legislative language associated with the EV, patents bridge the information gap between manufacturer websites and policy.

Data in a Policy Context

	Setting	Depiction of Strength	Accessibility
Policy			
	Range of Applications	Policy Type	Length of Policy
	Publication Information	Amount of Legislation	Relation to Consumer
	Locational Terminology	Power of Word Choice	Clarity of Word Choice

Table 6 Categories for Assessing Policy - The above figure provides central points around with the discussion of data in a technological context is oriented. As with the first chart of this type introduced in the section on data in the context of imagery, readers can use these categories to orient their discussions on electric tractors and other vehicle types in a way similar to the exploration of the topics produced in this study.

Two types of data and analyses are presented in this section. First, data from the Alternative Fuels Data center is compiled so as to show the current foci of both Illinois State and United States Alternative Fuels policy. Second, this section contains a comprehensive spreadsheet with information on the extent and content of current Illinois State alternative fuels legislation. One of the main components of the data located here is a series of word choice analyses done on each piece of legislation. The number of times that particular words occur in each piece of policy is mapped. Information on policy length, location in larger series of policies, and relevance to particular vehicle types are also mapped for viewers to view.

Results – Purpose of Section

Understanding perceptions related to conception, usage, and politicization of electric tractors, as compared to other vehicle types, leads to more nuanced and robust conversations about the role of ETs in Illinois state and U.S. everyday life. Those interested in the formulation, production, and usage of energy legislation have likely already been exposed to some range of both qualitative and quantitative information about the electric car. Whether or not this case is the same for the ET, the relative ambiguity of information available on ETs in comparison to other, more common vehicle types necessitates some guidance on how to discuss its place in policy as well as in local communities. Though the following sections move forward primarily in order of focus on *Image*, *Technology*, and *Policy*-related considerations, both qualitative and quantitative assessments shared across all three categories frequently intersect. This shows the importance of looking at aspects of historical and societal depictions of the ET as well as technological contexts for its production, even with the production of alternative policy frameworks in mind. In considering all three areas of analysis, policy can be developed in which the language used to affect vehicle use and outcomes is carefully constructed with a nuanced understanding of the vehicle and industry in mind.

Results - Image as a Category of Analysis

The Search for the Electric Tractor

Reasoning for the use of advertisements located on manufacturer websites was already outlined in the previous *Data and Methodology* section. However, additional factors play into the importance of this data set in connecting the experience of manufacturers and consumers to the work done by politicians to produce legislation that affects all interested parties. In order to find the advertisements assessed below in the first place, the viewer must access the manufacturer websites housing this information. These webpages themselves are extremely important to consider as rich data sources. Because of their public accessibility, they function as virtual spaces in which individuals can search to find information for their own personal use and employ their own judgement to decipher what available products might be best for their particular needs. Additionally, these websites house information that can be used for cross-comparison with other company webpages. In this way, they are utilizable for professional services such as acquiring information about another industry or company. Ultimately, these resources provide a window into the thought-process of company representatives who try and portray their products as filling the perceived needs of certain circles of American society. The experience of perusing a company website for product information, therefore, is one that is important to be analyzed as both a physical and mental experience intimately tied with the individuals' connected to vehicle industries. It bears keeping in mind, however, that the experience of looking through a website will be different depending on the individual going about this task. For example, nationwide studies of the electric vehicle have named certain companies such as Tesla as highest in consumer shopping experience with Chrysler falling towards the bottom of the list.[112] Some viewers may agree with these rankings while many others may not. Company websites, goals, products, and initiatives may also shift at the same time that societal perceptions attached to corporations or electric vehicles in general might change. In all of these cases, still, documenting the feasibility (or lack thereof) of finding information on vehicle manufacturer websites is part of a process of knowledge acquisition that any consumer or interested party can become a part of.

In the following short narratives, analyses based on a close look at depictions of strength, accessibility, and settings in which vehicles are shown are produced based on manufacturer website

[112] Hieu Le, Andrew Linhardt, "Rev Up Electric Vehicles – A Nationwide Study of the Electric Vehicle Shopping Experience," Sierra Club, 2019,https://www.sierraclub.org/sites/www.sierraclub.org/files/press-room/2153%20Rev%20Up%20Report%202019_3_web.pdf

information. These takeaways provide legislators with contexts in which they may confidently assess how to best identify, support, and produce legislation for different electric vehicle types with a robust understanding of the societal factors involved in assumptions made about vehicle types and their viability. Each narrative below demonstrates how such conversations between individuals, ones who carefully consider the depiction of vehicle types including the ET, might occur. With the focus on the electric tractor as the main point of focus and analysis, each additional narrative only provides further context for conversations in which the electric tractor remains central.

Solectrac - "Simple, Clean, Quiet Power"[113]

Solectrac, a vehicle manufacturer that only produces electric tractors, is clear about the scope of its product selection on the opening page of the website. A banner reading "Climate-Smart Electric Tractor" can be viewed directly underneath pictures of the vehicles being described. At the top of the webpage, three links titled "eUtility," "CET," and "eFarmer" refer to the only three electric vehicle models produced by the company. The three linked categories that follow, reading "Join Us," "Order Now," and "Events," allude to both the ease in accessing company product as well as the community-centric aspects of the company. Unlike some of the larger manufacturers being explored here, a deeper search through the company website is not needed to sift through different product categories. For Solectrac, the focus on the electric tractor, as a reliable vehicle contributing positive elements to a process of work, is clearly shown to the website viewer. For an electric-vehicle specific producer, little focus is needed on the urban consumer who has no need for technology specific to areas of agricultural land not seen in metropolitan centers. This limitation is not experienced equally by the car company that could market its vehicle both to rural and metropolitan residents depending on the company goal and campaign focus.

Advertising central to Solectrac's website presents the electric tractor in a way that complicates assumptions about who the consumer of the electric tractor might currently be. The first image that shows up when entering the company website places the electric tractor in an idyllic scene of rolling green hills broken up by a forest glen behind which a farmhouse emerges. The tractor itself is bare bones in its construction. Each aspect of the vehicle from the wheels to the driver's seat and functional battery is uncovered. The surrounding field, filled with a grassy, low-lying crop, is unladed with difficulties that might prevent the smaller tractor from moving easily

[113] Solectrac Website Home Page, accessed August 1, 2019, https://www.solectrac.com/

across the terrain. The field that is shown in the picture does not look like the field that every farmer has in their own backyard. However, this does not mean that certain consumers are excluded from the opportunity to purchase the vehicle. The company may just currently believe that they are better off marketing their product to agricultural farms that rely less on heavy vehicles or mass production and more on niche product development specific to small-scale farms. Everything about the electric tractor, in this image, seems easy. And, the vision of a life with the electric tractor as the means of completing a day's work seems almost utopian. No allusion to the struggles inherent in the adoption of ETs is present in this image. This makes sense as manufacturers don't want to deter viewers with too much information about uncertainties inherent in the process of ET adoption. However, this and similar images may plant hope in the farmer perusing the website based on their interest in electric tractor adoption, even if the farmer knows that the process of adoption is not yet as easy as shown in idyllic ones such as these.

Fendt North America - "I Have a Clear Vision"[114]

In the search to understand the range of vehicle types produced by Fendt North America, a few moments in the process of navigating the company website stand out as complicating the story of the electric tractor in the scheme of agricultural machinery as a whole. First of all, the "Products" section of the site offers three different channels for exploration. The first category is "Tractors". The second: "Combines". A third category reads as "Planters." This three-way separation widens the conception of the agricultural vehicle as greater in scope than the tractor alone. This nuanced clarification in deconstructing the range of agricultural vehicle types makes sense for a company such as Fendt with a legacy of providing farmers with in-depth knowledge of the industry. Slogans given to each category of products on the website bolster this image of the company's strength in knowledge about agricultural vehicles and work. In the second section, the only vehicle listed is the Fendt IDEAL, personified under the slogan "I FEAR NO FIELD. I AM A CUT ABOVE." The Fendt Momentum, a vehicle model located under the "Planters" category, is associated with the phrase "Achieve with Momentum". Such slogans, eliciting strong emotive responses to the products across the company website, show a clear vision exhibited by the company in relation to their product aesthetic, function, and goals. However, the same attention or acknowledgment of assuredness does not seem to be paid to the ET also produced by the company.

[114] Fendt North America Website Home Page, accessed August 22, 2019, https://www.fendt.com/us/index

The moving images at the top of the Fendt webpage are produced in order to give an aesthetic to the company, but this aesthetic is very different from that highlighted in Solectrac's images. First of all, none of the visuals shown in this area of the website include ETs. Unlike the open-frame vehicles shown in Solectrac's visuals, the Fendt tractor parts are contained within bulky, solid constructions. Multiple sets of wheels flank driver's cabins outfitted with floodlights and clearly visible exhaust pipes. The farmer is shown at work inside the vehicle and although the grassy expanse shown here is not so different from that displayed on the Solectrac website, the domination of the diesel tractor over the field is clearer. The cultural narrative of the powerful tractor working the land by way of the farmer who controls it is reminiscent of the conquering of nature and the American "West" centuries earlier on the American landscape. Assumptions about the type of person that would choose a diesel tractor over an electric one partially contributes to the level of interest agricultural workers have in the adoption of an ET. Masculine qualities associated with the diesel vehicle and feminine qualities associated with alternative vehicles that don't run on fossil fuels are still imbued in the images used to represent these products on different manufacturer websites. Although theses narratives are difficult to unpack in one study, they speak to the work yet to be done in order to decipher what it means to be an ET owner in a largely agricultural state like Illinois as well as the U.S. as a whole. It is not only the work of researchers to demystify the image of the electric tractor. As the ET becomes more prevalent in the EV industry, there is room for farmers, companies, advertisers, and distributors to produce new images about what it means to be an ET owner or producer. Additionally, not all efforts needed to break down these assumptions may need to take place directly. If increased research, development, and incentives are encouraged for electric tractors specifically, more vigorous assessments of the drawbacks and benefits of the ET will be publicly available. Through this, adoption will be easier and assumptions about the ET and its owner will undoubtedly change over time. These outcomes alone will drive consumers, manufacturers, industry executives, and policymakers to have conversations that incorporate nuanced understandings of rural life with an ET on site.

Ford - "Welcome to the Showroom"[115]

Upon entering the Ford website home page, a series of small images, each specific to a different available vehicle type, are listed in quick succession. Here, Ford lists clear categories

[115] Ford Website Home Page, accessed October 15, 2019, https://www.ford.com/

subsumed under the general idea of the gasoline-powered car. SUVs & Crossovers, Trucks & Vans, Cars, Electrics, Commercial Vehicles, Performance Vehicles, and Future Vehicles are all groups of products meant to show the breadth of the company offerings and also aide in the ease of search for vehicle types across the website. Under each category, the small-scale images referenced above show individual vehicles accompanied by helpful information on base pricing. This effort provides a sense of uniformity to the cross-comparison of vehicle offerings. However, no indication of the fuel type specific to each vehicle is immediately available without delving further into a comparison of specific models. Not dissimilar to the experience of entering a physical vehicle showroom, the virtual showroom experience created by Ford attempts to convey to the reader that there is "something for everyone" on the site. But, does this "something" include products meant for the electric vehicle consumer? And is the rural agricultural worker included in this category of "everyone"?

Unlike the images presented on the two previous tractor manufacturer websites, one image central to the Ford website transports viewers away from the field and to the asphalt road. An electric car is not featured on this central image. However, electric counterparts are technically available for use in settings in which Ford shows its gasoline vehicles. Ford does play with the use of language in naming one of their vehicle models the "Explorer." Ford places the car, in the front-page advertisement, on a dangerously icy road surrounded by a snowy forest. Although there is no reference to agricultural land in this image, this is also no explicit reference to the city either. Images such as these are a reminder that the car is not exclusively an "urban" or a "rural" vehicle. It can be used in any landscape in which a road is present. Yet, electric tractors produced by other automotive suppliers, though extremely important in its own space, is unable to market itself along these same lines of applicability.

Chrysler - "It Does More So Your Family Can Too"[116]

Looking for the core product technologies on Chrysler's website begins with "Vehicles," "Shopping Tools" and a section with newsworthy partnerships and initiatives called "This is Chrysler." A cursory look at the manufacturer's vehicle offerings reveals four current vehicles, with one listed as a hybrid, and section dedicated to future vehicles expected in 2021. Without a further in-depth search into the technology surrounding the 2020 Chrysler Pacifica Hybrid (which actually is only linked to the page on the 2020 Pacifica, lacking a webpage of its own), it remains unclear what

[116] Chrysler Website Home Page, accessed October 15, 2019, https://www.chrysler.com/

it means for a Chrysler vehicle to be a hybrid. If Chrysler has the technology to produce electric counterparts for its traditional vehicles, why is only one of the manufacturer's models currently altered to run on renewables? The company website does show some dedicated interest in electric vehicle development. An interested individual returning to the original homepage can find linked sections on hybrid vehicle incentives and offers, information on accessing charging stations, frequently asked questions, rideshare service partnerships, drivability for disabled consumers, and options for vehicle trade-ins that take into account concerns the consumer might have about community and family life. A section titled "Get Hooked Up" specifically describe a charging station installation partnership with Amazon, placing electric vehicle concerns at the same level of gasoline-powered diesel interests.

It makes sense that a personal car company does not provide information on electric vehicles outside of the realm of the personal car. Images on the Chrysler website show a car that favors the commuter instead of the all-terrain explorer alluded to in Ford's media advertisements. Not all diesel car manufacturers are going to depict their products in the same way. They work to best reach a market of consumers that might be inherently interested in the products made available by the manufacturer. In this case, Chrysler imagines mass market consumers as residents of the city center willing to drive their purchased vehicles on well-paved roads. Chrysler does not indicate that it produces an electric (hybrid) alternative in these advertisements. However, viewers will most likely assume that any electric car offerings made available by the company will align with the functionality of the gasoline or diesel Chrysler vehicle. So far it seems as if car manufactures (such as Ford, Chevrolet, and Chrysler) that focus on products of one primary fuel type, with some additional electric options, take advantage of their ability to market vehicles to a variety of individuals interested in different lifestyles, as long as these lifestyles include transportation by way of a personal vehicle. ET manufacturers, however, are not afforded this same range of options for advertising their image. Consumers interested in adopting ETs will be looking at available options with functionality associated with work on the agricultural field in mind. This limitation makes the economic success of this currently designated niche aspect of the electric vehicle industry seem difficult to achieve. However, it also only further points to the importance of clear marketing and product availability so that the existing ET consumer base, most likely farmers, will be able to easily access and become interested in ET adoption at any time.

Tesla - "Power Everything"[117]

There is little question that Tesla is, for many, a household name for electric vehicles. With only four vehicles featured directly at the top of the Tesla website, the minimalist focus of the company is clear. However, an additional product line complicates the Tesla image as an electric car manufacturer. This expansion of the Tesla product line into solar roofs and panels reveals a willingness to delve into product development beyond the category of the vehicles per se. This reveals some kind of hesitation, for companies knowledgeable of the car, to expand to other vehicle types compatible with electric retrofitting or production. This begs the following question: what is preventing Tesla or any other electric car company from producing an electric tractor? Those with access to public company websites and advertisements are inadvertently asked to come to terms with what it means for a car company to decide to support the production of sustainable infrastructure in many respects, but not, evidently, working agricultural vehicles.

But does this seeming rejection of vehicle development in spheres of work outside of the city center confirm a lack of interest in focusing on alternative vehicles such as the electric tractor? The answer is likely no. Solar innovations have already been proven successful in the mass market as both efficient and affordable renewable energy technologies.[118] However, trusting in the marketability in the electric tractor is, at this time, not easy as companies must often decide to be one of the first to recognize ET technologies. Companies such as Tesla also have to think about the range in which each technology is perceived as usable. Those familiar with solar and electric car industries may feel similar confidence in the reliability and function of both technologies. But, the same individuals seem hesitant to acknowledge the same qualities in the electric tractor.

As mentioned earlier in the work, a distinct line of demarcation is often drawn between vehicle used across perceived rural and urban space, leading to misunderstandings about the use and viability of certain vehicle types. Many traditional fuel vehicle industry executives may inadvertently alienate the electric car in the same way that some electric car industry members may struggle with equal acceptance of the ET. True, some electric cars may function less well on rural roads, but this complication also holds true for many gasoline-driven cars. Technically, the electric car can be sold and used in any area of the U.S. regardless of whether the person in the driver's seat is a rural farmer or a metropolitan city dweller. However, agricultural equipment is seen as contained to a specific

[117] Tesla Website Home Page, accessed August 22, 2019, https://www.tesla.com/
[118] "Solar Success Stories," U.S. Department of Energy Office of Energy Efficiency & Renewable Energy online, accessed January, 27, 2020, www.energy.gov/eere/success-stories/listings/solar-success-stories

market with only agricultural use in mind. There is nothing wrong with this determination. In fact, the social power of ET technology lies in the fact that the use of the ET is for a specific, essential purpose. However, for many, this restriction may limit the extent to which profit is possible. Though no clear answers to these hesitations may be available yet, the conversations presented here aim to provide readers with a clearer orientation with which to approach these tough subjects on technologies often left to the side in conversations on sustainable energy, fuel, and particularly vehicle development.

The main advertisement on the front page of Tesla's webpage adds to this discussion of contrasting decisions made by the company. In this opening image, three Tesla vehicles are spaced apart on a stretch of well-paved asphalt. However, behind the three vehicles lies a mountain range dramatically cloaked in fog. Although natural imagery in this depiction is clear, so is the separation between each vehicle and the organic scene behind them. These types of advertisements attempt to bring urban life and natural imagery, representing the importance of environmental goals, into the same picture. Yet, the same message could be achieved by placing an ET product in a rural field. Electric tractor technology is not less impactful than electric car technology. Both produce environmental, social, and personal health benefits even if one does so in rural contexts and one does so in urban contexts. However, some cultural assumptions about electric tractors, their drivers, and the communities in which these technologies are used fuel (for some) the idea that sustainability efforts are not as important in rural regions as in urban areas. Unfortunately, conversations about the EV industry have not yet developed enough for companies to consider the electric tractor as a positive image to place on company websites. If conversations about the EV industry change, producers will have to re-think their image, deciding whether or not to incorporate the ET not only into their product line but into their online media presence. Acceptance of the electric tractor, once it occurs on a larger scale, will only contribute to the expansion of its production, bringing renewable energies to niche sectors of markets not yet acknowledged fully.

Chevrolet - "448 Owners Spoke. J.D. Power Listened"[119]

In the same way that manufacturers such as Ford subdivide their online vehicle information into categories representing different uses and types, Chevrolet provides seven different categories in which website viewers can search for desired products. Consumers most likely will not have too

[119] Chevrolet Website Home Page, accessed October 15, 2019, https://www.chevrolet.com/

much difficulty distinguishing between personal cars and commercial ones. Many current consumers may have grown up with both types of vehicles in use, to some extent, around them and have no difficulty determining what function different car types have in the world around them. This contrasts a lack of knowledge, for some consumers, on how to identify the purpose and function of various agricultural vehicles. Chevrolet recognizes the types of consumers that may be interested in their product, however, and make it easy for website viewers to access product information specific to their needs. Like Ford, Chevy lists a category on their website titled "Electric" and makes this category easily accessible to the viewer. This category is also located in an area of the website where it is almost guaranteed to be noticed and explored by the consumer. However, the presentation of the vehicle offering in this category makes EV technology not seem as desirable as it actually is. As the only information located under pictures of both traditional and alternative fuel models is the base price, a lack of context is given to the expense of the EV. Vehicular base price indicators can be particularly problematic as EVs cost more up front but achieve considerably higher savings over time. With these factors in mind, it becomes clear that even vehicle manufacturers producing electric cars (in addition to traditional cars) can do their own products a disservice in terms of how or if they advertise the beneficial aspects of the technology.

The three primary images on the Chevy home page are perhaps the most widely varied of the automobile manufacturers listed here. The first image is unusual in terms of its close similarity to media produced by agricultural companies instead of car companies. In this image, a broad Chevy Silverado truck sits in the middle of a field of grass, a forest and mountain range behind it. Although the land does not seem to be cropland, a fence far beyond the car hints at the use of the field for livestock. Chevy clearly wants viewers to connect their vehicles to powerful natural imagery, contrasting the choice to feature a diesel truck instead of an electric car. The second image, however, completely rejects the imagery presented in the first advertisement. Instead of a rugged, pastoral scene, viewers see a simple white box reminiscent of a modern art gallery. A singular 2020 Equinox sits in the middle of the image almost as if its waiting for the viewer to pluck it straight from the production floor. No longer playing to the adventurous nature of consumers looking for the rugged, off-road experience, this advertisement calls to the consumer who wants a clean-cut vehicle they can trust, with no strings attached. Finally, the last image again upends previous marketing tactics in order to show a range of vehicles directly outside of the vehicle part factory, with the skyline of a city behind. A series of achievements awarded to the company are photoshopped in front of the vehicles, adding to a sense of power exuding from the chosen products. Combined with previous

imagery depicting a domination of the natural world, this presentation of urban control by way of gasoline vehicle usage encourages the Chevy vehicle consumer that they can rule over all aspects of the urban-rural sphere. You could own this city too, if only you drive a Chevy car. Clearly, the strategies used to sell vehicles on this platform hint at the fact that the company's product offerings are fit to serve a range of consumers looking for different experiences from their chosen car.

However, Chevy seems to make no assessments about who might be interested in the electric vehicle, particularly the electric car. Previous analyses have hinted at the possibility that the range of consumers interested in ET adoption may not be as wide as those interested in EV adoption. This may still be relatively true based on the pure number of individuals who have use for the car versus the number that might use a tractor on a regular basis. However, this blanket statement does not adequately acknowledge the unique variety of agricultural consumers in the United States. Representing small farms, large farms, and corporate institutions, farmers have differing levels of agency in choosing what type of tractor to purchase and use. Selling niche products, certain crops, or livestock, farmers have different technological needs when it comes to the every-day tasks of a successful season. Heading an agricultural corporation, splitting margins with family members, or working seasonally as a migrant laborer, "farmers" have different capabilities in making short and long-term decisions about the spaces in which they work. This only further speaks to the level of nuance needed in current EV policy in order to provide appropriate incentives for consumers with different needs.

John Deere US - "Just Add Grit"[120]

The experience of clicking through the John Deere website is one in which a viewer with little knowledge of agricultural vehicle terms and specifications could spend hours uncovering what they might actually be looking for in terms of products. Though the website contains clear and catchy slogans that grab the viewer's attention, it becomes clear that, to navigate the website, you either have to know what you're looking for in terms of an agricultural vehicle or be very familiar with the agricultural industry as a whole. This experience differs from that of perusing all previous car manufacturer websites assessed here. In each instance of contact with the car manufacturer, the language used to describe vehicles seemed universal - both urban and rural residents are equally familiar with the car. However, the John Deer experience also differs from the experience of

[120] John Deere US Website Home Page, accessed August 22, 2019, https://www.deere.com/en/

locating information on electric tractor manufacturer webpages. This alludes to efforts made by ET manufacturers to be more inclusive of not only ET-specific customers, but also interested parties looking to know more about what the vehicle is all about. Tractor manufacturers, however, especially those such as John Deere with great renown in the industry, don't need to use this kind of universal language. While advertising does curate the narrative told about automotive companies, some companies already have such strong narratives about their consumer base, product usage, and company goals that advertisement can be used to only strengthen this message of accountability. John Deere executives, as well as any individuals who recognizes the name of the company, know who their consumers are and what they, in turn, know about John Deere Products. And since this approach to knowledge dissemination and advertisement has worked for the company for many years, why change now?

One central image is located at the top of the John Deere website. Like Fendt America, a bulky vehicle front with headlights on tackles the space ahead. No driver can be seen in the vehicle. A trend has started to appear, among diesel tractor manufacturers, where the advertised vehicle is depicted with power in mind. Though "power" here refers to strength in the ability of the vehicle to conquer any challenges that lie ahead, this representation is not exactly separate from imagery used to represent fossil fuels used to push the vehicle forward. While few images exist depicting the ET in action, ET manufacturers in the future will have to decide whether or not they decide to reproduce current imagery depicting the tractor in an aggressive fashion or if they decide to toy with new types of media representation. However, the future development of higher numbers of ET manufacturers still depends on the production of policy incentivizing the adoption of vehicles in this category.

Massey Ferguson - "AGCO – Your Agriculture Company"[121]

The experience of visiting the Massey Ferguson site is similar to that of visiting the John Deer online platform in terms of what kinds of specialized terminology is used to reach specific consumers. However, Massey Ferguson does incorporate elements into its media platform that highlight approachability. This is particularly visible in the three images used to introduce Massey Ferguson products to website visitors on the manufacturer's online home page. The first image in the three-image cycle depicts a tractor exiting a stable, driven by the farmer as he looks towards his horses in the adjacent corral. Unlike Fendt and John Deer, Massy Ferguson decides to show a

[121] Massey Ferguson Website Home Page, accessed August 22, 2019, https://www.masseyferguson.us/

smaller tractor more similar to Solectrac offerings than to the behemoths dominating the view of other diesel tractor manufacturer front pages. In the second image, a tractor isn't shown at all. Instead, a helpful tool specific to choosing the right vehicle for you is provided so that viewers don't have to traverse the site alone. However, Massey Ferguson does still make it clear that this tool is specific to farmers who know information about their operation. Finally, the third image shows a tractor, again with a passenger located inside, actively at work lifting bales of hay. An additional helpful tool is provided in this image as well, connecting viewers to experts in the industry in order to determine if you're using the right hay for your agricultural practice. It's interesting that this manufacturer, one that only focuses on diesel tractors, is able to produce imagery reminiscent of that used to advertise the ET. Because of this, hope for the divide between consumers committed to either vehicle type remains in place.

Results - Technological Considerations

There is no question that the technology is theoretically available for large-scale rollouts of functioning electric tractors. However, in order for this expansion to occur, social, technological, and political preconditions must be fulfilled. In this way, technology acts as the bridge between socially constructed image and policy. Both evolve along with the vehicle technology in question. "Technology" can include information on vehicle parts, manufacturer capabilities, documents detailing technological considerations, and other additional factors not listed here. With this in mind, technological elements specific to each particular vehicle type are important to study as they are the basis for differences that manufacturers and consumers perceive, produce, and deem important. In the same way that the actual form of the vehicle binds together formulation of image and policy, the development of further technology is, in turn, influenced by the combined power of both. An understanding of both the state of development and availability of information on different vehicle types, assessed through the specifications available on each manufacturer website and outlined below, will enhance the understanding of images evaluated in the previous section as well as prepare interested individuals for a more robust discursive analysis of current EV policy.

Product Offering and Vehicle Specifications

At first, the theoretical discussion of technological manufacturer capabilities in this study, beginning with a detailed analysis of vehicle offerings by manufacturer, seems to direct readers to the idea that product availability across automotive companies is relatively clear cut. Decisions made by each manufacturer to develop (or to not develop) ETs hint at the goals and capabilities of the company. Similarly, the decision made to manufacturer other vehicles in addition to or as a substitute to ETs speaks to company characteristics that can be connected to each manufacturer's perceived social connections and technological capabilities. Manufacturers are defined by the vehicles (or other commodities) that they produce. The experience of the consumer, also, is dependent on how these products are represented on each advertisement or web page. However, the path towards understanding exactly what specific models and products are available on each manufacturer website does not always lead to expected conclusions. At first, it seems reasonable to divide vehicle manufacturers into the following clear-cut categories: the electric tractor, diesel tractor, electric car, and diesel car. However, as numerical depictions of the scope of product offerings located below show, not all manufacturers focus on one vehicle type over others. A few, such as Solectrac, however, do remain consistent with one product choice.

Solectrac Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Solectrac	eUtility	X				
Solectrac	Compact Electric Tractor	X				
Solectrac	eFarmer	X				

Table 7 Solectac Products for Comparison- *The above table is an original graphic produced for this study by aid of product information from Solectrac's online web page.*

Solectrac is purely an ET company. The manufacturer offers a total of three electric tractors and these are the only products available for sale. Solectrac also assumes that the viewer knows what kind of products are sold by their company. They don't explicitly state what variation of electric vehicle each of the company's three models are. Instead, they refer to Solectrac Electric Tractors as "the clean, quiet, zero-emission alternative to diesel tractors".[122] However, in this search for products, it quickly became clear that Solectrac is an unusual case.

Fendt North America Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Fendt North America	Fendt e100 Vario	X				
Fendt North America	Fendt 1000 Vario		X			

Table 8 Fendt North America Products for Comparison - The above table is an original graphic produced for this study by aid of product information from Fendt North America's online web page.

Another vehicle manufacturer that lists ETs as a product for sale is Fendt. The company produces one electric vehicle.[123] However, its main products come in the form of 13 diesel tractors and 23 other diesel agricultural options.[124] The ET does play a role in the representation of company goals. However, this role is a small one. Even though Fendt might sell an electric tractor, it does not label itself as an electric tractor company. Even in the small list of manufacturers associated with the

[122] Solectrac Home Page, accessed August 21, 2019, https://www.solectrac.com/
[123] Fendt North America Website Home Page, accessed August 22, 2019, https://www.fendt.com/us/index
[124] Fendt North America Website Home Page, accessed August 22, 2019, https://www.fendt.com/us/index

ET, not all of the companies have the same goals in mind. This makes it difficult to come up with one set of attributes and goals for corporations selling ET products and reveals that the ET industry may be able to rely on a wider range of narratives and incentives to make the adoption of the ET technologies look favorable to different interested parties.

Ford Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Ford	F-650 FSD Diesel Tractor		X			
Ford	2021 Mach-E			X		
Ford	2020 Explorer				X	
Ford	2020 Explorer Limited Hybrid					X
Ford	2020 Fusion Plug-In Hybrid					X
Ford	2020 Escape Sport Hybrid					X
Ford	2020 Fusion Hybrid					X

Table 9 Ford Products for Comparison - The above table is an original graphic produced for this study by aid of product information from Ford's online web page.

Chrysler Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Chrysler	2020 Chrysler Pacifica				X	
Chrysler	2020 Chrysler Pacifica Hybrid					X

Table 10 Chrysler Products for Comparison - The above table is an original graphic produced for this study by aid of product information from Chrysler's online web page.

Both Ford and Chrysler were originally chosen to represent manufacturers in the category of gasoline-powered vehicles. However, as the search for the electric vehicle in both agricultural and metropolitan sectors continued, it became clear that these two selected manufactures were not interested in limiting their product selection to the diesel car. While Ford does make 5 electric cars, it also currently has 21 gasoline cars in production.[125] SUVs, crossovers, trucks, vans, vehicles listed specifically under the label "Cars," and performance vehicles are included in this number.[126]

[125] Ford Website Home Page, accessed October 15, 2019, https://www.ford.com/
[126] Chrysler Website Home Page, accessed October 15, 2019, https://www.chrysler.com/

However, there are 8 other products currently listed as "Commercial Vehicles." [127] To clarify, commercial vehicles often include larger trucks requiring different (or larger) technologies to support the powering of vehicles with greater weight and size. With this in mind, the technologies used for commercial vehicles and personal cars may differ, yet sometimes smaller commercial vehicles look very similar at a glance to larger commercial cars. This reveals that the categorization of vehicles by technological specification is mostly subjective, except in terms of decisions made about vehicular groupings based on function. When separating the ET from personal cars by reason of technological differences, legislators must consider if they are doing so based on true functional differences or perceived differences in aesthetic makeup.

Tesla Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Tesla	Model S			X		
Tesla	Model 3			X		
Tesla	Model X			X		
Tesla	Model Y			X		

Table 11 Tesla Products for Comparison - The above table is an original graphic produced for this study by aid of product information from Tesla's online web page.

Chevrolet Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Chevrolet	2020 Equinox				X	
Chevrolet	2020 Bolt EV			X		

Table 12 Chevrolet Products for Comparison - The above table is an original graphic produced for this study by aid of product information from Chevrolet's online web page.

Tesla and Chevrolet were chosen, by this study, as electric vehicle manufacturers. There is no doubt that Tesla belongs in this category with a product line completely committed to electric vehicles, at least in terms of vehicle products. As described earlier, Tesla has chosen to dabble in renewable energy products outside of the vehicle industry but has yet to acknowledge the electric tractor as another possible product for production in the future. Chevrolet, instead, focuses on

[127] Chrysler Website Home Page, accessed October 15, 2019, https://www.chrysler.com/

traditional car technologies with few renewable alternatives. The company produces 24 gasoline personal cars, options for 7 different gasoline commercial cars, and only 1 available option for electric car purchase.[128] Again, the industry spotlight on technologies rooted in commercial functions show a preference for the functionality of the niche gasoline car over the niche electric tractor. However, as technological development continues to become more nuanced, with ETs being made not only in all-electric form but with other alternative fuels capabilities, the consideration of urban and rural commercial vehicles as equally important may begin to occur.

John Deere Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
John Deere	4WD/ Trac Tractors		X			
John Deere	Compact Tractors		X			
John Deere	Row Crop Tractors		X			
John Deere	Specialty Tractors		X			
John Deere	Utility Tractors		X			

Table 13 John Deere Products for Comparison - The above table is an original graphic produced for this study by aid of product information from John Deere's online web page.

Massey Ferguson Product Offerings

Manufacturer	Example Model	Electric Tractor	Diesel Tractor	Electric Car	Diesel Car	Other Vehicle Type
Massey Ferguson	MF 12V Electric Tractor		X			
Massey Ferguson	Sub-compact Tractors		X			
Massey Ferguson	Compact Tractors		X			
Massey Ferguson	Utility Tractors		X			
Massey Ferguson	Mid-range Tractors		X			
Massey Ferguson	High-Horsepower Row Crop Tractors		X			

Table 14 Massey Ferguson Products for Comparison - The above table is an original graphic produced for this study by aid of product information from Massey Ferguson's online web page.

[128] Chevrolet Website Home Page, accessed October 15, 2019, https://www.chevrolet.com/

As described in the *Search for the Electric Tractor,* it is difficult to determine how many products are available on diesel tractor manufacturer websites such as John Deere and Massey Ferguson. Originally, it seems as if there are a certain number of products in each of the categories of agricultural vehicle located on the site. However, many versions of the vehicle's powertrain technology are available depending on what type of agricultural site you are purchasing the vehicle for. Additionally, the pure range of agricultural vehicles needed for different functions limits observers from quickly assessing how many options are out there. Instead, it makes sense to access product information on diesel agricultural vehicles with not even specific product, but specific technological needs in mind.

The complications inherent in each category of vehicle produced by automotive and agricultural manufacturers are not always perceived at first glance. With companies that have a strong product base, such as John Deere or Massey Ferguson with tractors, Tesla with electric cars, Ford and Chrysler with traditional fuel vehicles, and Solectrac with electric tractors, relatively knowledgeable individuals may be pleasantly surprised by additional components of each company's product line. However, when the tables are turned and companies like Chevrolet and Fendt North America are depicted as electric car companies and electric tractor companies respectively, efforts to accept that a company can and should be defined by its renewable energy technologies are harder to see to fruition. Practical and holistic approaches to sustainability across automotive supply chains would benefit from a limitation on doubt cast towards companies that choose to branch out of their traditional product lines to become part of renewable energy industries. Should the incentives for electric tractors become high enough that more companies would begin to adopt this vehicle type, the same argument would hold true for the acceptance of manufacturers that define themselves as electric tractor producers, even with traditional vehicles still within their capabilities.

Patents and the Future of the Industry

Patents inherently embody both present and future considerations related to a particular technology and its usage. This is because, while these documents illustrate technologies that have already been conceived of in the present, they also hint at future products that may enter the market in a few years. The United States Patent and Trademark Office describes the process of patent approval as occurring across a timeline with an average traditional total pendency of 23.5 months.[129]

[129] "March 2020 Patents Data, at a Glance," United States Patent and Trademark Office, 2020, https://www.uspto.gov/dashboards/patents/main.dashxml

With this in mind, patents provide a latency period in which to look at the future state of the electric tractor industry for insight into how policy might be best oriented to include this vehicle type in the future.

In some cases, patents are able to provide information on technological developments created long ago. Some of these past innovations may complicate the definition of what it means to be an ET. For example, one patent filed in 1923 and granted in the same year shows the blueprints for a toy electric tractor.[130] Some of the first ideas surrounding the production of the electric tractor existed on a smaller scale and were oriented around the experience of enjoyment instead of utility. However, ideas such as these that would lead to further, large-scale ET developments later on show how long ago the conception of the technology began.

Some patents hint at what technologies may have been set aside in the search for electric vehicle technologies outside of the agricultural sector. For example one patent filed in 1977 and granted in 1978 describes an all-electric tractor specifically driven by a certain kind of power system called an A.C. induction motor.[131] Another electric tractor application filed in 1984 and granted in the same year describes a two-motor vehicle with unique hydraulic articular apparatus parts to enhance the pivot of the vehicle.[132] These kinds of technologies represent developments that could be revived for the benefit of consumers in the modern day.

In other cases, patents show relatively recent developments that hint at the continued innovation of technologies related to the ET, even if industry actors have not yet mobilized resources to make such technologies are effective in the mass market. A patent filed in 2008 by Stephen Heckeroth depicts an electric tractor with interchangeable options of reconfiguration for different purposes.[133] Granted in 2018, the application is available until adjusted expiration or renewal occurs in 2028.[134] The wording of this patent allows for the reader to consider the possibilities of multiple electric motors, drive wheels, or battery packs to be utilized along two simplified, stream-lined rail parts. The simplicity of the design strongly alludes to the ease in which

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[130] Arthur A Heaton Jr., Toy electric tractor, U.S. Patent 1518324A, filed for March 1923, application granted in December 1923, expired in April 2020, https://patents.google.com/patent/US1518324

[131] James H. Downing Jr., All-electric a.c. tractor, U.S. Patent 4113045A, filed for February, 1977, application granted in September, 1978, expired in April, 2020, https://patents.google.com/patent/US4347907

[132] Leslie Christianson et al, Electric Tractor, U.S. Patent 4662472A, filed for September 1984, application granted in May 1984, expired in April 2020, https://patents.google.com/patent/US4662472A/en

[133] Stephen Heckeroth, Electric Tractor. U.S. Patent 7828099B2, filed for February 2008, application granted in November 2010, adjusted expiration granted for August 2028, https://patents.google.com/patent/US7828099B2/en

[134] Stephen Heckeroth, Electric Tractor. U.S. Patent 7828099B2, filed for February 2008, application granted in November 2010, adjusted expiration granted for August 2028, https://patents.google.com/patent/US7828099B2/en

electric tractor technology can be implemented in functional vehicles in the future. However, the possibility for personalization and optimization shows growth in the technological development of the electric agricultural vehicle to fit multiple needs and purposes.

Patents developed outside the U.S. give indication as to the global relevance and usage of electric tractors as well as international potential that has not yet been activated. One patent developed in Europe and filed in September 2005 depicts a multifunction electric tractor.[135] Published in 2006 and comprised of images showing the complex inter-relationship between the different elements of the vehicle, this patent reveals a similar thought process across global communities to search for iterations of the ET that may be boost the range of practical uses for this particular vehicle type.

[135] Brian Wilfred Edmond, Multifunction electric tractor, European Patent 1645456A2, filed for September 2005, published in April 2006, withdrawn in April 2020, https://patents.google.com/patent/EP1645456A2/zh

Results - Policy Assessment

Unpacking Current Alternative Fuels Legislation

Data provided by the Alternative Fuels Data Center shows the distribution of programs, laws/ regulations, and various incentives across EV type as well as by state and federal alternative fuel vehicle policy. An analysis of this information reveals trends in current EV policy development that policymakers themselves may not be aware of. Additionally, decisions made by trusted agencies on how to present current legislation reveals what kind of information is currently labeled, by federal and state governments, as important for manufacturers and consumers.

Language used in policy conveys particular meaning. Scholars on language theory may reject the idea that language directly produces thought.[136] However, they do acknowledge that access to certain vocabulary can influence the amount in which a concept is discussed and considered to be universally true.[137] With this in mind, the language used to discuss electric vehicles is extremely important. When certain terms are chosen, by trusted institutions, to represent the field of electric vehicles as a whole, important information about the industry including the relevance of the ET is ignored. It is essential, then, to understand alternative fuel policy as an effective category in which legislation related to the electric vehicle can be compared.

There are a few caveats to the use of legislation in this category, however. It's difficult to determine what exactly is meant by alternative fuels policy. There is not one, codified acknowledgment of what counts as an "alternative fuel." With variation in the terms used to acknowledge alternative fuel vehicles such as the electric tractor, it becomes even more difficult to determine what policy may be contained in this category. With this in mind, finding a specific listing of policies specifically related to the electric tractor is virtually impossible. This problem is not specific to alternative fuels policy. The comprehensive inclusion of EVs in this category surpasses those mentioned in energy or agricultural policy. This makes the chosen category of cross-comparison best fit for this study. However, if in-depth discussions on alternative electric vehicles are not readily available, circulating on social media, extending into regular conversations between consumers, or existing between policymakers who may not be looking for information about each specific vehicle, the level of work done to make this information accessible will most likely not be

[136] Catherine L. Caldwell-Harris, "Our Language Affects What We See," Scientific American online, 2019, https://www.scientificamerican.com/article/our-language-affects-what-we-see/

[137] Catherine L. Caldwell-Harris, "Our Language Affects What We See," Scientific American online, 2019, https://www.scientificamerican.com/article/our-language-affects-what-we-see/

completed. At the same time that a cycle occurs where areas of knowledge scarcity are the very same where further discussion is needed, the eventual placement of knowledge into categories inappropriate for their effective usage also takes place, unnoticed by policymakers.

With the importance of legislative language in mind, the graphs below contain verbiage made available by the Alternative Fuels Data Center in relation to specific vehicles associated with U.S. alternative fuels policy. The graphs below contain terminology first appearing in the beginning of this study, when highlighted in bold in the Literature Review's list of EV terms. For reference, "EVs" refers to electric vehicles, "HEVs" refers to the hybrid electric vehicles, "PHEV" refers to Plug-In Hybrid Electric Vehicles, and "NEVs" refers to Neighborhood Electric vehicles.[138] It bears noting that out of the list of 19 EV terms first provided early on (subject to grow as a greater variety of EV technologies are produced in the future) only 4 are acknowledged by the major federal agency responsible for codifying this information as having data robust enough to include on the agency website. On one hand, this shows the importance of these 4 electric vehicle types, essential for representing the EV industry in the context of both federal and state legislation. On the other hand, it becomes clear that not all EV types, even those that are cars, are accompanied by accessible policy data. The work of this study will, in the following section, be to distinguish between a lack of policy specific to certain EV types and the lack of public accessibility of the actual contents of this legislation. However, for now, it is important to recognize what this lack of perceived recognition of the range of EVs current for sale means for the future of the electric tractor. The electric vehicle industry is still prevalent in American society even without the support of up-to-date information on many of the electric cars still in production. Although this may limit the success of the industry, it shows that a current lack of data on electric tractors should not limit adoption of the technology.

[138] "Alternative Fuels and Advanced Vehicles," Alternative Fuels Data Center, accessed October, 2020, https://afdc.energy.gov/fuels/

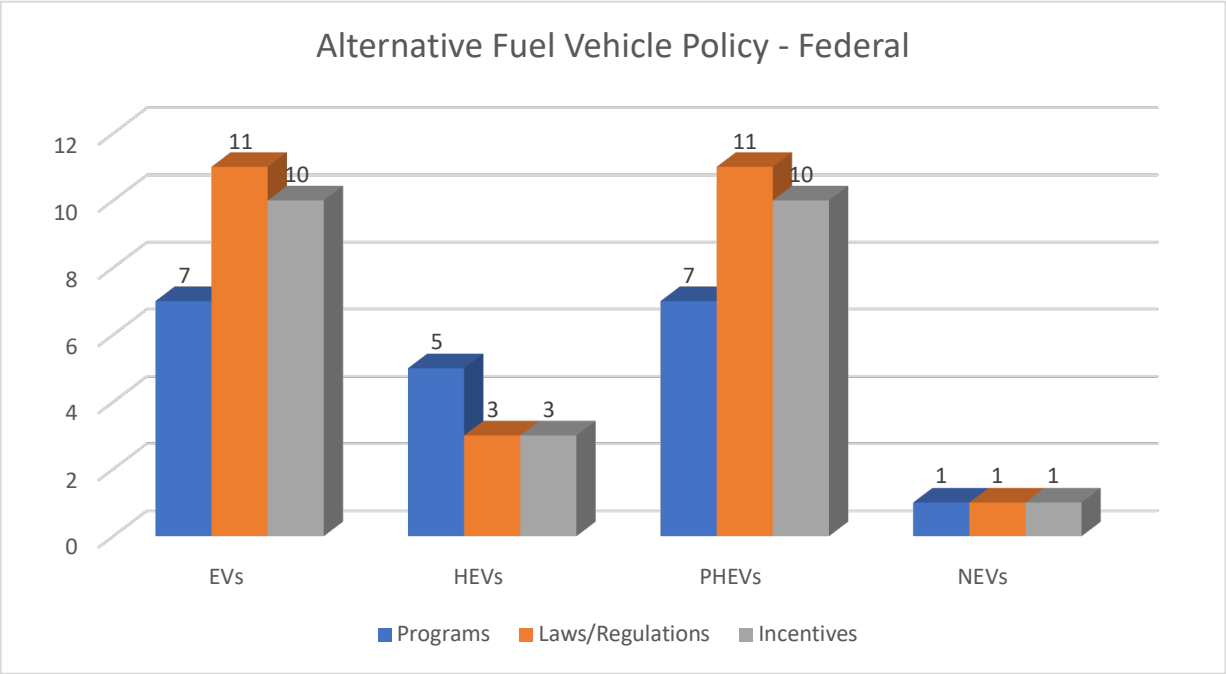


Figure 1 Current Federal Alternative Fuel Vehicle Legislation by Vehicle Type – *The data included in the graph above is from Alternative Fuels Data Center, a part of the U.S. Department of Energy focusing on Energy Efficiency & Renewable Energy.*[139] *The data for EVs, HEVs, PHEVs, and NEVs comes from the search tool located on the Alternative Fuels Data Center website. The jurisdiction was selected as "Federal" while the technology/ fuel type was selected separately for each of the four electric vehicle types listed above.*

When looking at Figure 5 it becomes clear that PHEVs dominate the EV industry, at least with regards to federal policy. This only further affirms work done earlier in the study to outline PHEV policy as a robust point of comparison for any ET policy that might be in place. This determination was made because of the fact that the PHEV column contains the same amount of policy as the EV policy furthest to the left. The presence of policy in the categories of HEVs and NEVs, in this case, is possible because of the overlap in policy shown on the Alternative Fuels Data Center website. This overlap is helpful because it allows the full number of policies to be shown in each of the categories of EVs, HEVs, PHEVs, and NEVs. This information is important in depicting how alternative fuels policy is currently categorized, in terms of vehicle type, by the prominent U.S. federal agency focused on alternative fuels specifically.

Additional takeaways from this graph relate to the perceived importance of HEVs and NEVs in federal alternative fuels policy. Legislative documents inclusive of NEVs are represented least while those inclusive of HEVs follow PHEVs in number. A commentary on hybrids and why

[139] "Search Federal and State Laws and Incentives," Alternative Fuels Data Center online, accessed October 2020, https://afdc.energy.gov/laws/search

the number of policies governing them seems to be so low exceeds the scope of this study. Instead, it is important to acknowledge the low number of policies currently related to NEVs. NEVs are not the same as ETs. The first category, respectively, contains electric cars used in the setting of a neighborhood for community purposes. The latter category, encompassing a range of electric tractors, includes vehicles that are used in the setting of an agricultural field for the production of agricultural goods. However, both NEVs and ETs are part of niche sectors of the electric vehicle industry. A distinct lack of legislative focus on NEVs speaks to current disinterest (on whose part is unclear) to produce EV legislation outside of the category of the electric car. With this in mind, a lack of legislative focus on the electric tractor does not necessarily indicate that ET will not be a successful part of the EV industry in the future.

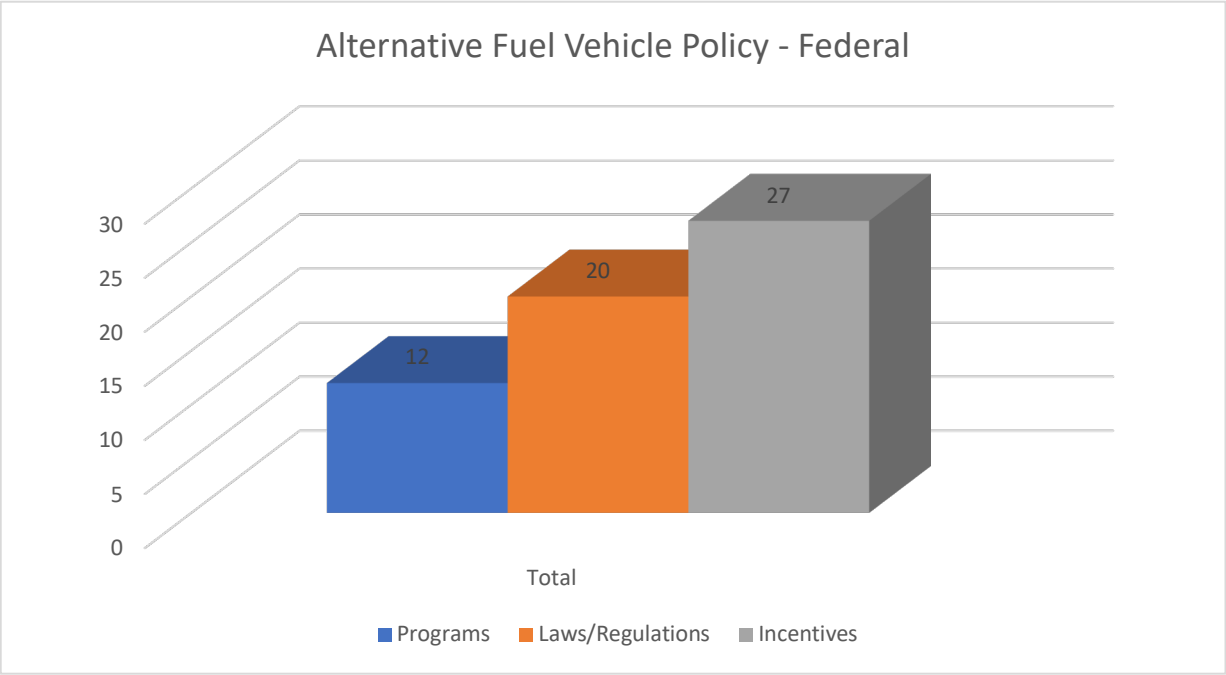


Figure 2 Current Federal Alternative Fuel Vehicle Legislation by Policy Type - *The data included in the graph above is from the Alternative Fuels Data Center.*[140] *"Total" refers to the total number of laws, regulations, and incentives listed by the Alternative Fuels Data Center under alternative fuels, advanced vehicles, and air quality in the United States. This data from this final column was last updated after the passing of each piece of federal legislation.*

Current federal policy places a higher importance on incentives than research and development programs or laws and regulations. As will be discussed shortly, this distribution varies greatly from the focus of Illinois state alternative fuels policy which contains robust laws and

[140] "Search Federal and State Laws and Incentives," Alternative Fuels Data Center online, accessed October 2020, https://afdc.energy.gov/laws/search

regulations yet little support in the categories of research and development or incentives. It makes sense that research and development programs are available on a federal level, as these are most often awarded to larger corporations with the ability to support larger-scale studies on a wider range of issues. The presence of laws and regulations is also not surprising. These exist in high numbers on both a federal and state level and indicate a focus, in American legislative production, on the punishment of harmful actions instead of the re-enforcement of ones meant to inspire positive changes in environmental and human health. Finally, the large number of incentives at the federal level does seem surprising given that incentives seem better fit for production on a local scale in order to better take into account the needs of particular communities looking to EV use and adoption for tangible community solutions. Incentives are not unimportant at the federal level. When implemented as a supplement those introduced at a local level, federal incentives may only aid in advocating for the adoption of renewable vehicle technologies on a nation-wide scale. With this in mind, were the number of programs in federal alternative fuels policy higher, the graph of federal legislation above would be an idealistic representation of hopeful next steps for policy distribution on a state level. While this study continues to advocate for the development of further programs and incentives on a national scale, it focuses the particular importance of their municipal counterparts, discussed more fully below.

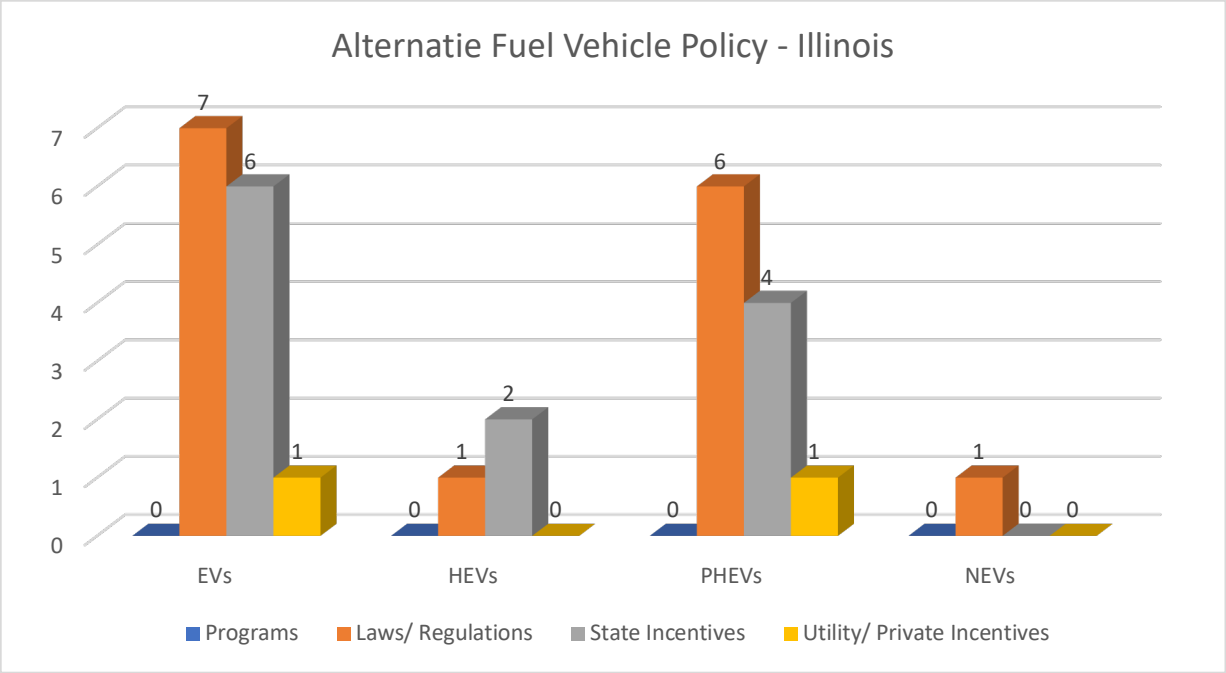


Figure 3 Current Illinois State Alternative Fuel Vehicle Legislation by Vehicle Type – *The data included in the graph above is from Alternative Fuels Data Center, a part of the U.S. Department of Energy branch specific to Energy Efficiency & Renewable Energy.*[141] *The data for EVs, HEVs, PHEVs, and NEVs comes from the search tool located on the Alternative Fuels Data Center website. The jurisdiction was selected as "Illinois" while the technology/ fuel type was selected separately for each of the four electric vehicle types listed above.*

When looking at Figure 8 it becomes clear that PHEVs dominate the EV industry on the state level. HEVs again follow PHEVs in the number of Illinois alternative fuels policies in which they are referenced. However, this number dropped dramatically from the number of policies inclusive of HEVs on a federal level. The number of alternative fuels policies related to NEVs also dropped from 3 at a federal level to 1 at the state level. This only further indicates a lack of interest, at least in the legislative arena, in acknowledging alternative fuel vehicles on a smaller scale. This contrasts the sphere of use in which alternative fuel vehicles such as the electric tractor are currently utilized. Vehicles specific to niche markets in the EV industry may not be equally desirable across all regions of the U.S. However, they are important for residents of local municipalities who rely on certain vehicles for specific kinds of work. With this in mind, it becomes even more important to urge the adoption of policies for electric vehicles other than PHEVs (without lessening the number of policies related to this vehicle type) on a local level.

[141]"Search Federal and State Laws and Incentives," Alternative Fuels Data Center online, accessed October 2020, https://afdc.energy.gov/laws/search

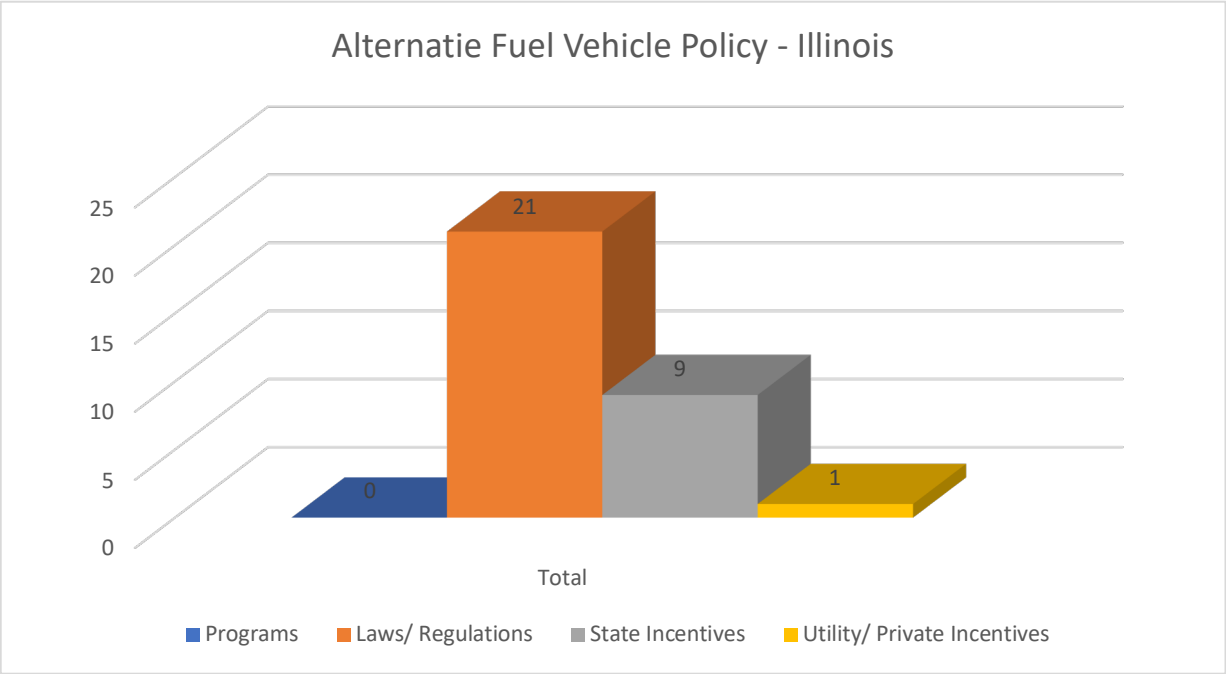


Figure 4 Current Illinois State Alternative Fuel Vehicle Legislation by Policy Type - *The data in the graph above is from the Alternative Fuels Data Center.*[142] *"Total" refers to the total number of laws, regulations, and incentives listed by the Alternative Fuels Data Center under alternative fuels and advanced vehicles in Illinois. The data from this column was last updated in November 2019 after the end of Illinois' annual legislative session.*

On the state level, specifically in Illinois, it become clear that laws and regulations are the focus of state policy related to alternative fuel vehicles, especially the electric vehicle. At the same time, the number of codified programs drops to none when looking at Illinois state. It makes sense that certain programs, especially those focused on research and development might stem from federal policy as larger agencies and companies are given the task of acquiring knowledge about a vast and complex industry. However, robust research and development is also needed specific to rural farms and carbon markets, as related to electric vehicles.[143] If specific attention isn't given to rural commodities, producers or markets, important technology such as the electric tractor is left out of consideration. When the development of this technology is prevented, lasting benefits in the realms of public and environmental health aren't realized. Additionally, if this attention isn't given on a local or regional basis, differences in geography, commodities produced, and methods of agricultural work and consumption are not taken into account. Therefore, the development of

[142] "Search Federal and State Laws and Incentives," Alternative Fuels Data Center online, accessed October 2020, https://afdc.energy.gov/laws/search
[143] Giana Amador, "Where is the 'electric car' for the agriculture industry?" Green Biz online, 2015, https://www.greenbiz.com/article/where-electric-car-agriculture-industry

programs for research, development, and implementation might benefit from also being oriented in state policy with focus on the needs of each particular area.

Re-Defining Alternative Fuels Policy

Part of the discussion above focuses on the importance of meaning associated with terms made part of the vocabulary related to the electric vehicle. On one hand, policy is not created without the influence of social, political, and economic factors determining what kind of legislation is important to produce at any given time. On the other hand, the language used in policy can also influence how certain products such as the electric vehicle are treated in practice, in consumer markets. With this in mind, focusing on detailed aspects of legislative language reveals hidden trends and nuanced assumptions that become overlooked in the legislative process. Policymakers can use this information to inform future policy on alternative vehicles, specifically the category of electric vehicles inclusive of iterations such as the electric tractor. However, consumers, manufacturers, industry executives, or simply those interested in the subject can also use this information to become more aware of the policy contexts in which the vehicles that they use are supported or limited. In order to learn more about the detailed use of language in current alternative fuels policy, use the link provided here to follow along with the discussion below:

shorturl.at/cioK7

Keyword analyses described here further confirm considerations that have already been brought forward, for the reader's review, throughout all previous sections of this study. The data below focuses specifically on alternative fuels policy in Illinois. However, future studies may compare these results to federal policy or other municipal sets of legislation related to the electric vehicle. By understanding that legislative language perpetrates societal assumptions about the ET and that legislation up to this date has failed to consider the technical, associated benefits of the product, readers and legislators can make active efforts to support a shift in alternative fuels policy that relies on remodeled language. The ET first needs to be acknowledged in policy that is supposed to cover the full expanse of issues related to electric vehicles as a whole. Additionally, needs specific to the ET should be codified separately in alternative fuels legislation so that growth in this section of the industry occurs rapidly and sustainably. The following data gives clear evidence as to the lack of nuanced discussion currently present in today's EV legislation. However, frameworks for more

nuanced consideration of the expanse of the electric vehicle industry as well as specific efforts needed to bolster EV adoption and production, can be used to change the number of instances in which important terminology, outlined below, is produced.

16 policies are listed in the category of alternative fuels policy, in the state of Illinois, by the Alternative Fuels Data Center. However, the true number of Illinois State alternative fuels policies is more complex. There are actually 20 distinct pieces of legislation related to alternative fuels. These policies, combined, overlap to form the 16 policies listed by the Alternative Fuels Data Center. All these pieces of legislation are actually only contained under 8 larger pieces of policy. These include the Toll Highway Act, Illinois Highway Code, Electric Vehicle Act, Public Utilities Act, School Code, Illinois Vehicle Code, Illinois Procurement Code, and Alternate Fuels Act. The range of acts listed here span many different areas of social life. However, only 2 directly reference electric vehicles or alternative fuels in the title. There are positive takeaways stemming from the fact that Illinois state considers aspects of EV development in many areas of resident life. However, whether or not these efforts come to fruition in accurately aiding the EV industry in further development depends on what specific language is used in each of the policies listed here.

All about the Law(s)

The policies acknowledged by the Alternative Fuels Data Center are made up of language adding up to over 80,000 words. The 8 larger pieces of policy referenced above added together come out to a grand total of 1,660,206 words. However, each piece of legislation varies in size. The smallest section, outlining user fees in the Alternative Fuels Act, is only 220 words long while the entire Illinois Vehicle Code has a total of 564,184 for legislators and interested parties to sift through in order to access information about vehicle regulations, incentives, and R&D programs. Variation in policy length and substance makes it difficult for information located in these policies to be easily accessible. However, shorter pieces of policy might not contain enough information required for up-to-date changes in consumer preferences, industry goals, and economic markets. It makes sense that, regardless of length, many policies will be written in general language so as to keep each piece of legislation relevant for as long as possible. However, on a local level, more detail can be put into policies specific to a region without placing undue responsibility on the state legislators active in the production of this policy. Moving forward, it is important to acknowledge the length of policy when analyzing key-word based outcomes showing where the focus of each particular policy lies.

However, readers will realize that for some terms, the length of the policy in which they are contained doesn't really matter. Some subjects are not yet considered important in the Illinois state alternative fuels policies of the 21st century.

Vehicular Terminology

The plug-in electric vehicle, although identified as a current definitive product of the EV industry, is mentioned a total of four times across all policies used here. Plug-in hybrids are actually acknowledged in one additional policy, mentioned a total of five times across all Illinois state legislation. Hybrid vehicles are mentioned most frequently, however, but this is not the case for the term "hybrid electric vehicle". Readers may learn two things from these outcomes. First, the particular terms used to describe electric vehicles of similar types are vary across pieces of legislation. We can infer that there is, therefore, little acknowledgment across regional or industry boundaries that certain terms universally align with particular images of vehicles with the same internal structure. This is problematic as it shows that legislators may be making decisions about electric vehicles with limited knowledge of the small but important differences between electric vehicle types in mind. Readers can also learn that even though electric vehicle policies, contained under the umbrella of alternative fuel legislation, seem to govern electric vehicles specifically, a higher emphasis is placed on vehicles with stronger ties to traditional fuel types. There is a hesitancy in acknowledging the EV at all, let alone the ET, that can be rectified by use of more inclusive language for a wide range of industry products.

Additionally, although the terms used to describe electric vehicles may be problematic in their lack of consistency, in no case are abbreviations (e.g. "PEV") for EV terms present in Illinois state alternative fuels policy even if the terms on which the abbreviations are based (i.e. "plug-in electric vehicle") are used. On one hand, this could be an equalizing factor preventing the need for abbreviations such as "ET" suggested in this study. However, readers must not forget that abbreviations are commonly used on almost every platform that discusses electric vehicles outside of a legislative context. It is ok that policies don't use abbreviations, if this best serves the function of the legislation. However, it does point to an unfamiliarity, on the part of legislators, with the EV industry and its terminology. Manufacturers and consumers may at least benefit from definitions, written out in legislation, standardizing the use of these terms by agencies, industry actors, and consumers, outside of policy. Though it would make more sense for this initiative to begin at a

federal level, this would not exclude state policymakers from taking part in the process of definition or including these definitions in state policy for future reference and revision.

The four vehicles (the electric tractor, diesel tractor, electric car, and diesel car) referenced throughout this study as technologies best suited for cross-comparison are also each mentioned a total of zero times across all policies related to both electric and traditional vehicles. This outcome is surprising, considering that the use of these terms in a colloquial sense was effective for the narration and conversation produced here. However, this points less to the viability of the methods of this study than it does to a lack of commonplace terminology used in state policy to depict vehicle types.

Certain niche terminology related to the internal structure of the diesel car plays an essential role in alternative fuels policies. The term "motor vehicle" comes up more times that the word "car" in policies such as the Illinois Vehicle Code and School Code. The number of times that this term appears is also impressive. In the Illinois Vehicle Code, the term "motor vehicle" appears 2,078 times while references to the car only appear in 87 cases. Unfortunately, few of these references are made in relation to the electric vehicle. Out of these 2,563 references to the term "motor" in general, only three allude to the electric motor. Though policies associated with EV development do contain information about incentives and programs specific to the electric vehicle, this information is scarce compared to the bulk of policy focused on the regulation of traditional fuel vehicles in urban contexts.

Information on charging infrastructure as an essential part of the success of both ETs and EVs as they function in the every-day life of Illinois residents, is also scarce in policy meant to support EV production and adoption. While references to charging stations outweigh those made to gas stations, the use of charging station terminology is limited to a few policies such as the Illinois Vehicle Code and the Public Utilities Act. Without robust incentives and research programs made available with charging infrastructure in mind, it is unlikely that the electric tractor industry will take off quickly enough to become successful in economic markets without the help of supporting legislation.

Although alternative fuels policy is more inclusive of electric vehicle legislation than both agricultural policy and energy policy focused on electricity, efforts must be made by legislators to produce future amendments or new pieces of legislation that are more inclusive of the electric tractor. For this to take place, greater clarity in the language used to describe the electric vehicle industry as a whole may be needed. These efforts will not only pave the way for the ET to enter into

consumer markets at a sustainable pace. Efforts to better acknowledge the extent of the EV industry as a whole benefit all vehicle types to which more attention, through careful and consistent word choice, is made.

Agriculture: The Missing Link

The tractor is not absent from vehicular considerations in the realm of alternative fuels policy. The term is mentioned 98 times in the Illinois Vehicle Code. Yet, the only other instance in which it appears is once in the Illinois Highway Code. Terms ranging from "rural" to "agriculture" and "farm" to "farmer" also appear from time to time in policy theoretically meant to support the development of a range of EVs and alternative fuel vehicles wherever they occur. The term "rural" comes up 9 times in the Illinois Vehicle Code, 13 times in the School Code, and 5 times in the Public Utilities Act. The words "farm," "farmer," and "agriculture" also appear in these same three policies. These are the same pieces of legislation that contain the most references to electric vehicle motors, and electric vehicles. So, depictions of rural life can co-exist side-by-side with information about vehicle types not often considered in rural contexts. However, many of these references to rural life are separate from discussions about the electric vehicles contained in different regions of the text. Legislators must work to include terms, sentences, and paragraphs in state policy that talk about alternative fuels vehicles and agricultural work in tandem.

It is clear, when looking at keyword analyses across Illinois state alternative fuels legislation, that verbal acknowledgement of both the electric vehicle and the electric tractor, as well as their benefits, are scarce. Unfortunately, this lack of intentional focus on renewable energy technologies in agricultural and automotive industries only means that the constituents of state legislators are not best served in ways that could increase their quality of life as well as the health of the environment around them. To rectify this problem, legislators can reconsider the types of language that they use in alternative fuels policy. Additionally, manufacturers and consumers can utilize methods of discursive analysis, suggested throughout this study, to change cultural perceptions of the electric tractor in order to spur on support of adoption.

Further Discussion

Based on analyses done in the categories of Image, Technology, and Policy as well as in the background information located earlier in the study, the diagram below shows the complex ways in which current EV policy seems to be categorized.

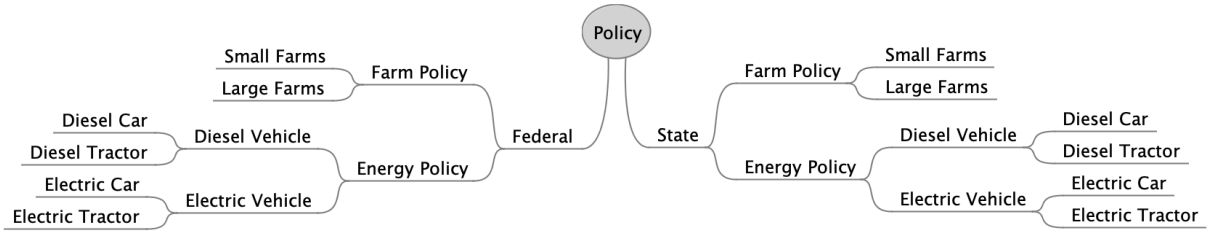


Figure 5 Current EV Policy Pathways – The image above is an original graphic created with the FreeMind mind-map software in February of 2020.

As shown above, federal and state policy are separated by jurisdiction. However, what remains at both the national and state level is a division between energy and farm policy. In this case, energy policy encompasses alternative fuels policy as well as associated policy categories such as advanced vehicle legislation described earlier in the study. There are elements shared between farm and energy policy such as a focus on the regulation of traditional vehicle or fossil fuel usage. However, where these two branches concretely differ is in the intentional inclusion of electric vehicles, particularly the electric tractor. There are frameworks already in place supporting the categorization of electric vehicle policy under energy policy. However, the crowded presence of electric vehicle policy in the context of other topics labelled under energy policy is not enough to support the production and utilization of robust electric tractor legislation. Such frameworks for use in supporting ET development are also not present in farm policy, where the focus remains on aspects of agricultural life outside of the renewable fuel sector. Taking all that is learned from the visual above, readers must separate the four types of vehicles (the diesel car, diesel tractor, electric car, and electric tractor) from the branches on which they are currently expected to lie. Instead, readers must think about where policies related to the electric vehicle and electric tractor specifically might be newly placed, in the context of the rest of the study, in order to be part of a more robust library of codified legislation inclusive of the electric tractor.

Conclusion

A journey is now complete beginning with the narrative of Chris, Sophie, and the Carter-Whites and ending with the search for the electric tractor in social, technological, and political aspects of American life. This study has helped uncover two-fold agricultural and renewable technological prowess, hidden for years under the guise of infeasibility, latent in the form of the electric tractor and waiting to strike in vehicle markets when the time is right. However, credit cannot be given to this study alone. The possibility of the electric tractor has existed since the technology was first developed, in the 19th century, near to the time that the electric car was first being produced in the United States. As the technology has evolved through the end of the 20th century to the modern day, a slew of benefits for farmers, their surrounding communities, and the environment in which agricultural work takes place have continued to develop and grow. Unfortunately, there are still concrete ways in which the electric tractor is excluded from the dominant expectations that farmers, the vehicle industry, consumer groups and policy makers have of American life.

Ultimately, this study produces methods with which to both urge and sustain the development of ETs, within current EV and vehicular industry infrastructure, with the support of robust EV policy. A framework for policy production related to the electric vehicle industry and inclusive of the electric tractor is strengthened by a method of thinking suggested in this study. This three-category suggestion for considering the electric tractor as a central part of Illinois state agriculture has been structured according to the results of this study's analysis of EV *Image*, *Technology*, and *Policy*. By looking at the way in which this method is actively used throughout the study, readers can learn how to access and utilize knowledge of the ET in a way that recognizes nuance in the electric vehicle industry and explores the electric tractor as part of American society. You, as the reader, are now able to use the knowledge gained here to include ETs in everyday conversations about vehicle use, fuel price, energy options, and environmental as well as public health. Legislators now armed with this knowledge can take these efforts a step further by making intentional resolutions to include language supporting the development of ET infrastructure in all future alternative fuels policy. An original framework, shown in Figure 12, has been developed in order to aid in the production of local policy rooted in research and development programs and, more directly, municipal and state incentives.

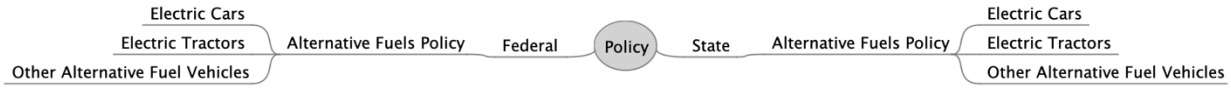
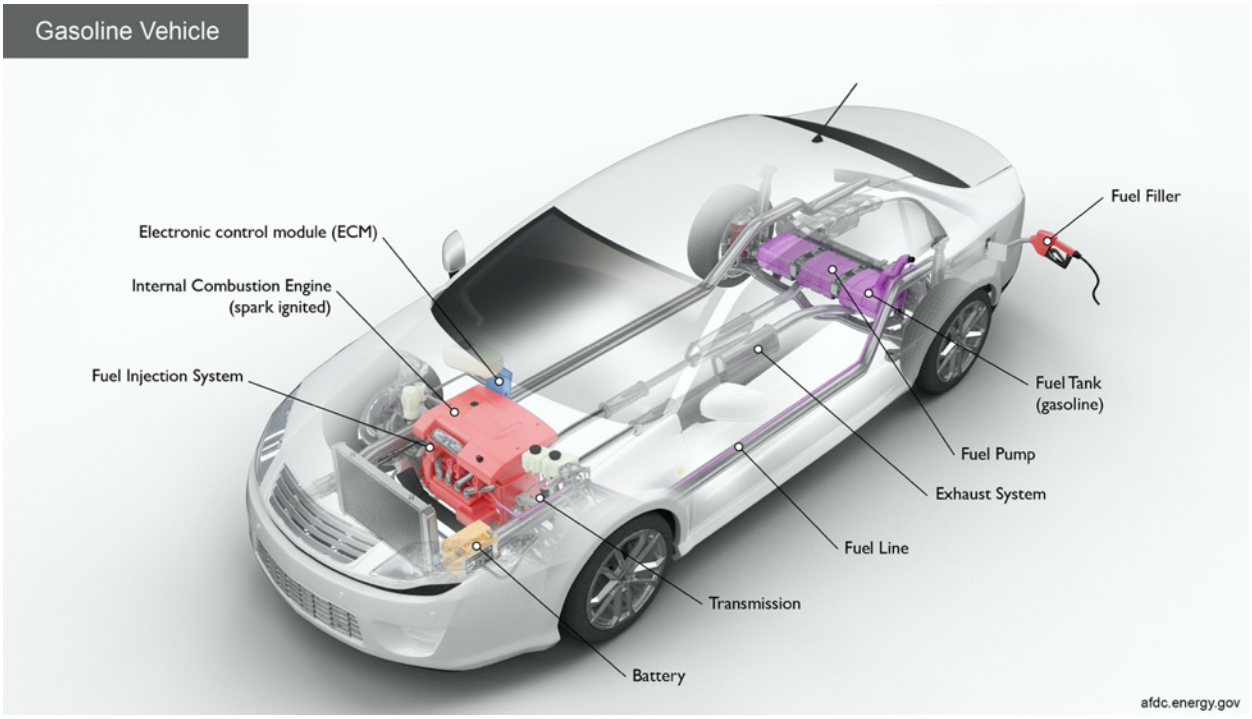


Figure 6 Future Suggested EV Policy Pathways - The image above is an original graphic created with the FreeMind mind-map software in April of 2020.

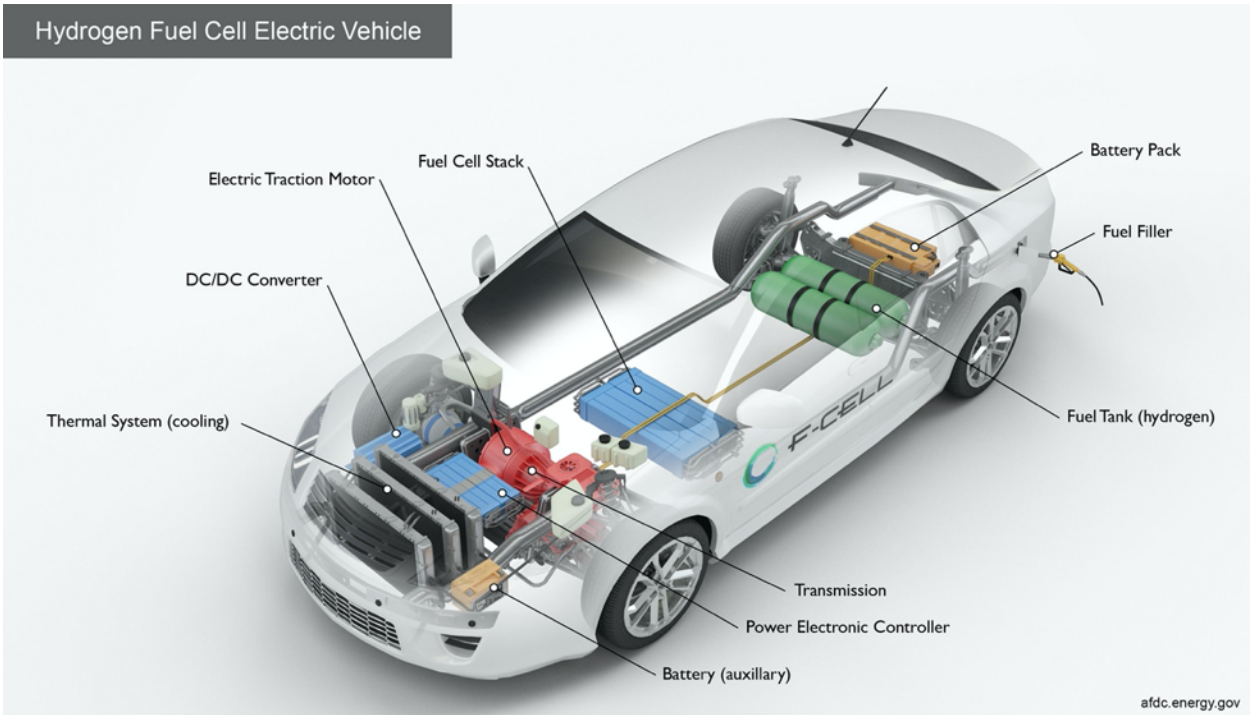
The framework, above, suggests using the already existing category of alternative fuels as a space in which to combine ET and EV considerations inherent in both energy and farm policy. However, such outlines are ineffective if they don't acknowledge change as part of the necessary, future state of vehicular industries. Other alternative fuel vehicles will be developed over time. And, when this occurs, the framework above will be in place to support the development of these technologies, no matter where they take place along the urban-rural divide. Until then, the electric tractor dominates a special place in the electric vehicle industry as a technology primed for use in the rolling fields and resilient communities that are ready for it.

Appendix



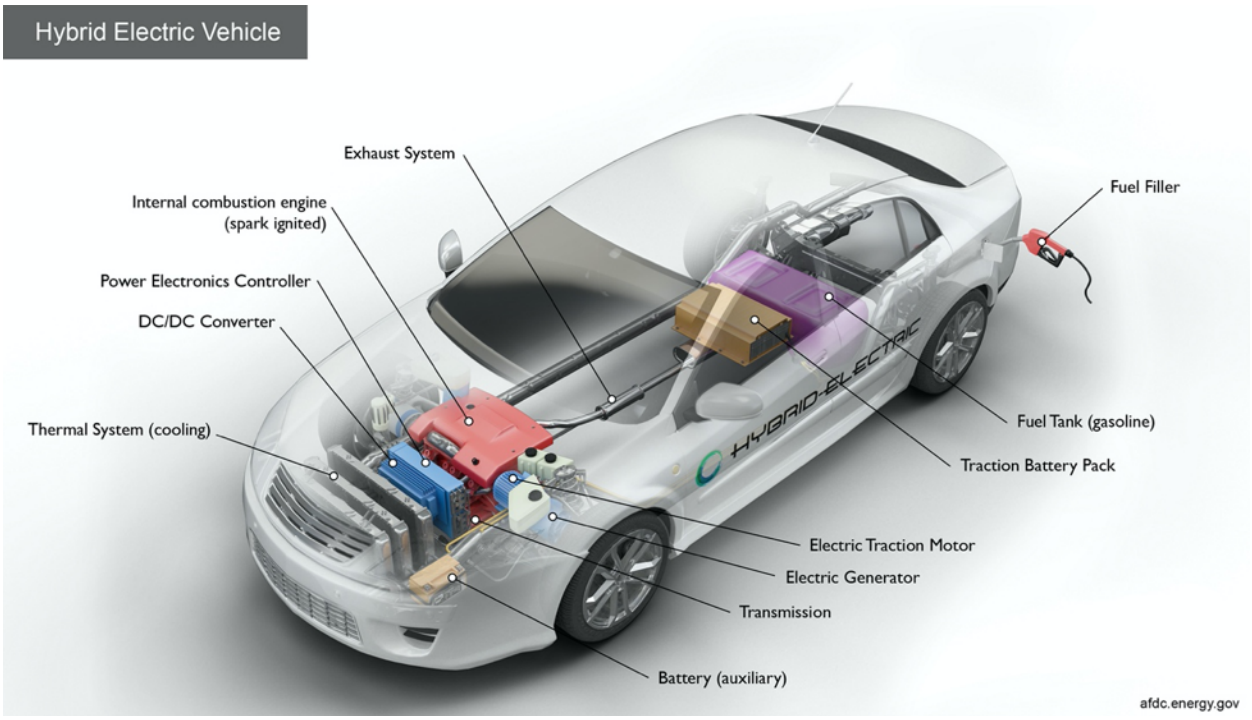
Appendix 1 Gasoline Vehicle Parts[144]

[144] "How Do Gasoline Cars Work?" Alternative Fuels Data Center online, accessed January, 2020, https://afdc.energy.gov/vehicles/how-do-gasoline-cars-work



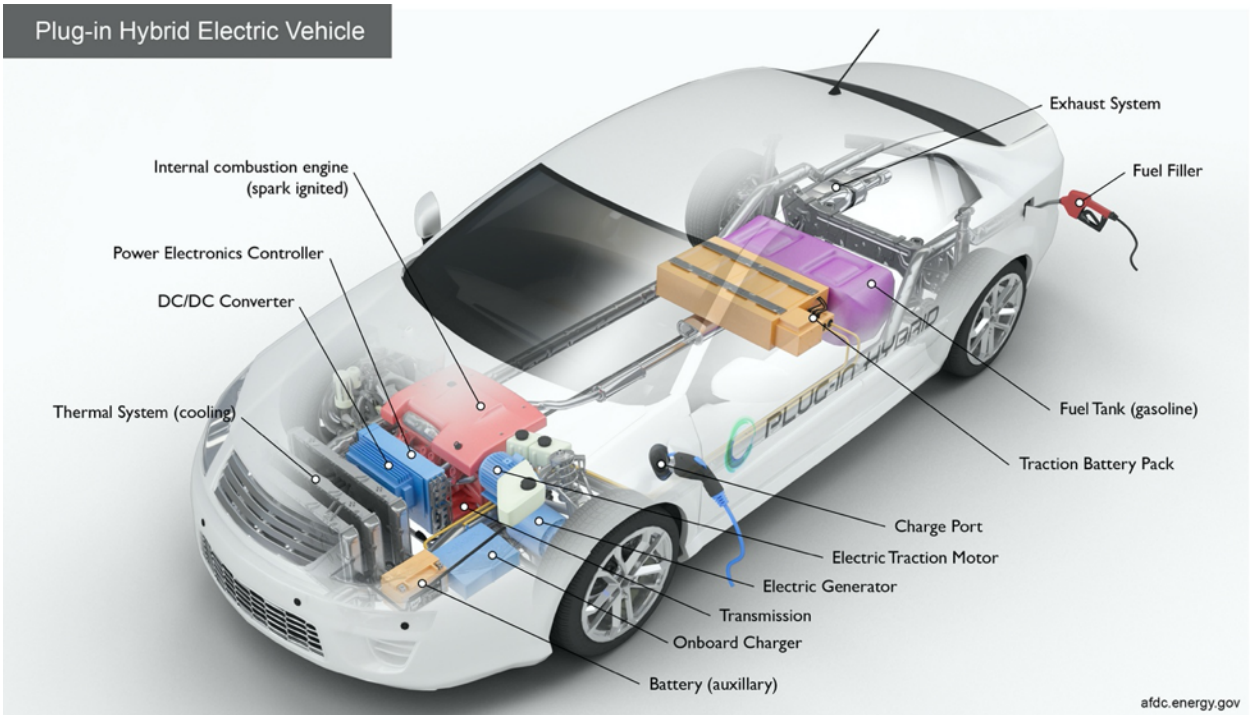
Appendix 2 Hydrogen Fuel Cell Electric Vehicle Parts [145]

[145] "How Do Fuel Cell Electric Vehicles Work Using Hydrogen?" Alternative Fuels Data Center online, accessed January, 2020, https://afdc.energy.gov/vehicles/how-do-fuel-cell-electric-cars-work



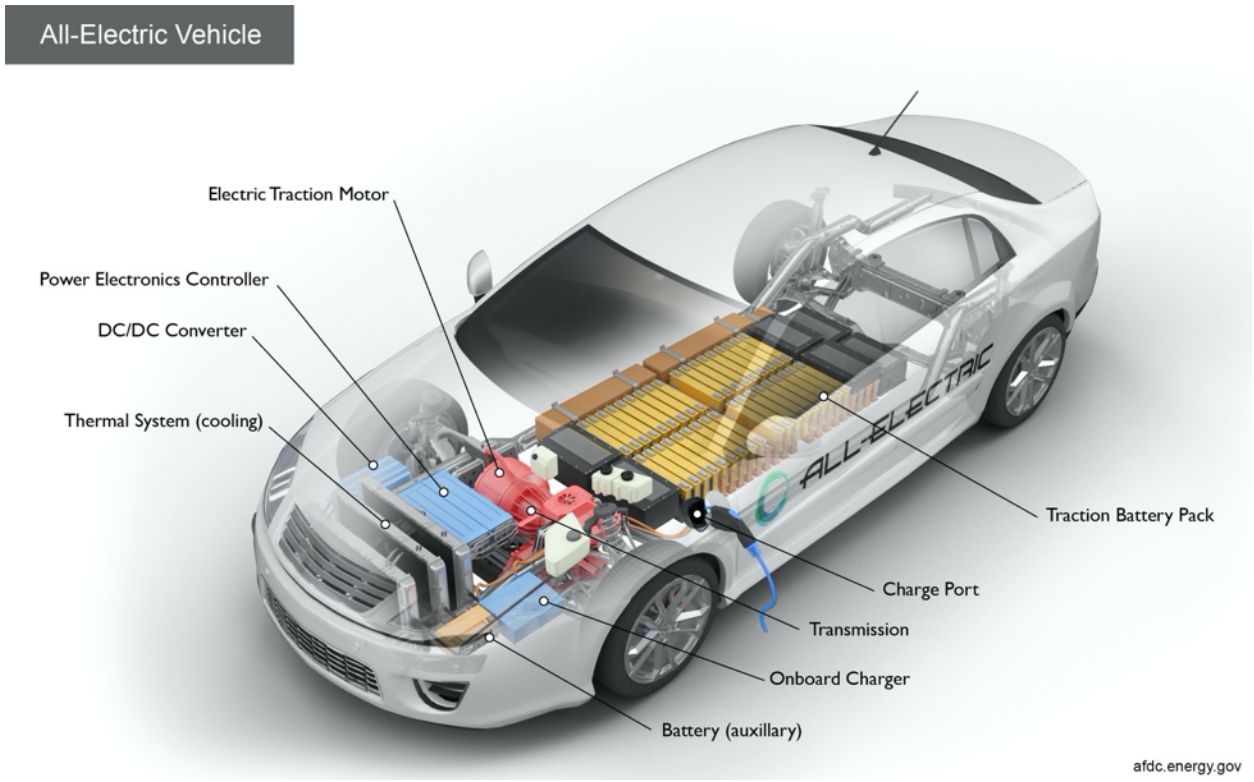
Appendix 3 Hybrid Electric Vehicle Parts[146]

[146] "How Do Hybrid Electric Cars Work?" Alternative Fuels Data Center online, accessed January, 2020, https://afdc.energy.gov/vehicles/how-do-hybrid-electric-cars-work



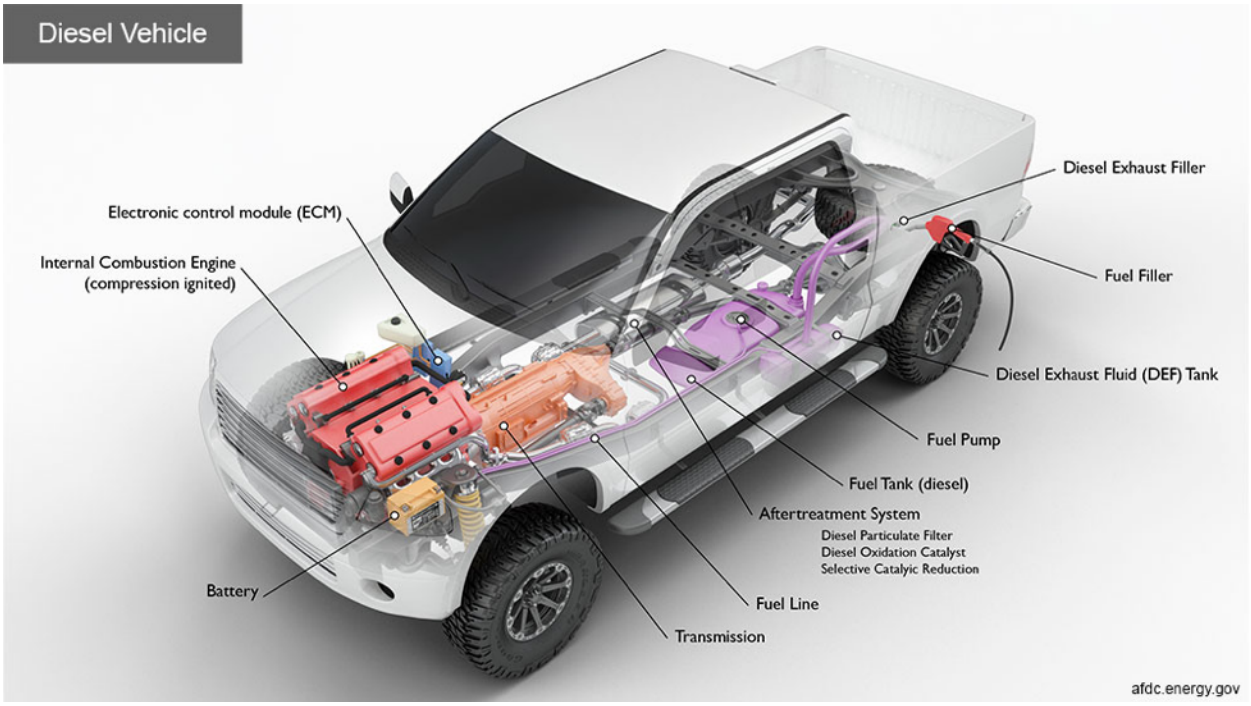
Appendix 4 Plug-in Hybrid Electric Vehicle Parts[147]

[147] "How Do Plug-In Hybrid Electric Cars Work?" Alternative Fuels Data Center online, accessed January, 2020, https://afdc.energy.gov/vehicles/how-do-plug-in-hybrid-electric-cars-work

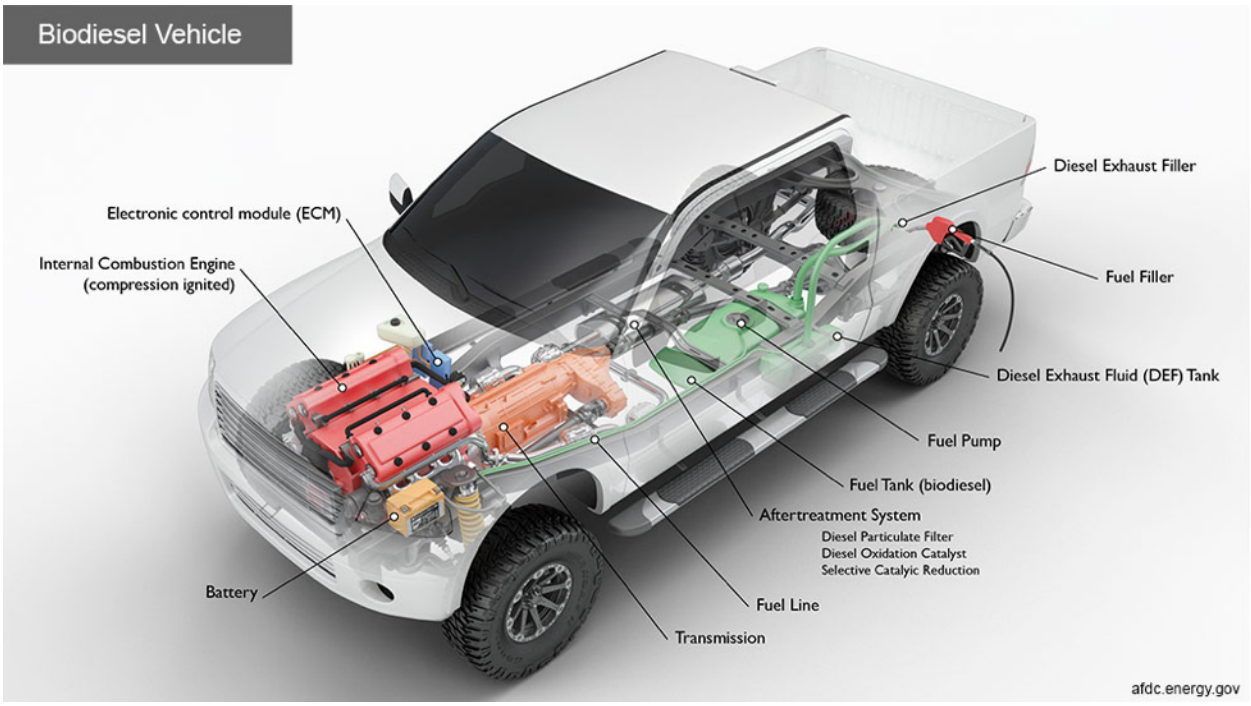


Appendix 5 All-Electric Vehicle Parts[148]

[148] "How Do All-Electric Cars Work?" Alternative Fuels Data Center online, accessed January, 2020, https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work



Appendix 6 Diesel Vehicle Parts[149]

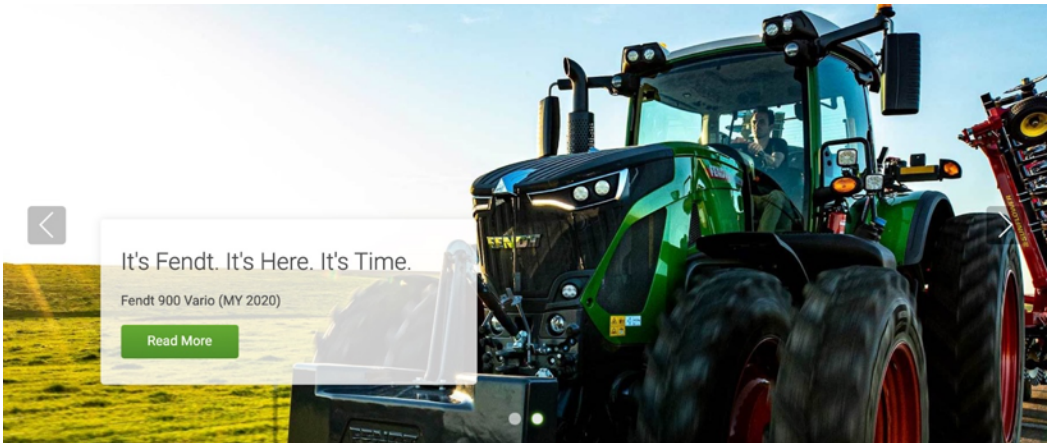


Appendix 7 Biodiesel Vehicle Parts[150]

[149] "How Do Diesel Vehicles Work Using Biodiesel?" Alternative Fuels Data Center online, accessed January, 2020, https://afdc.energy.gov/vehicles/how-do-biodiesel-cars-work

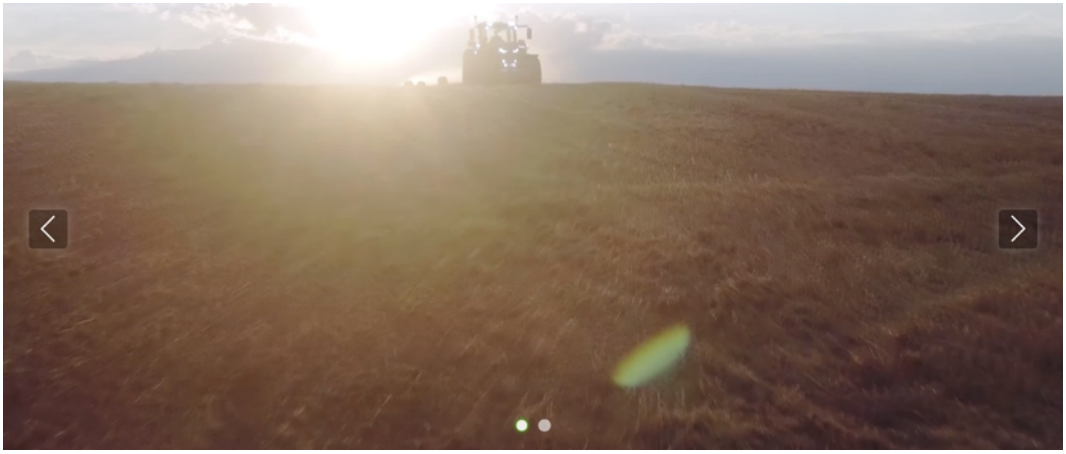
[150] "How Do Diesel Vehicle Work?" Alternative Fuels Data Center online, accessed January, 2020, https://afdc.energy.gov/vehicles/how-do-diesel-cars-work

Appendix 8 Solectrac Website Advertisement[151]



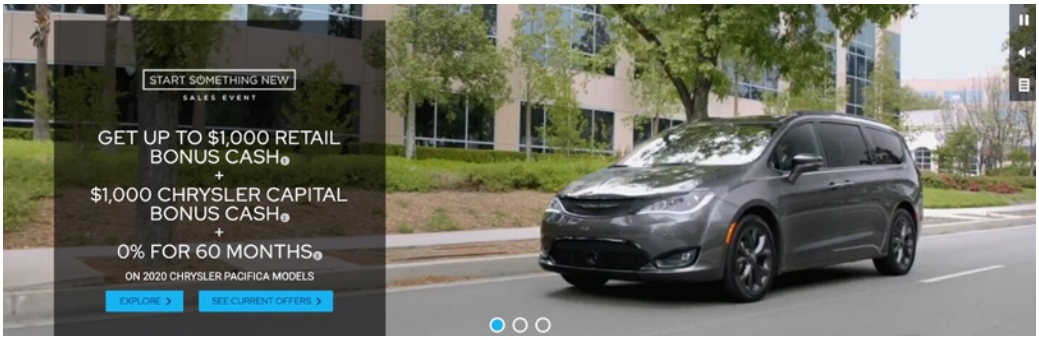
Appendix 9 Fendt North America Website Advertisement 1[152]

[151] Solectrac Website Home Page, accessed August 1, 2019, https://www.solectrac.com/
[152] Fendt North America Website Home Page, accessed August 22, 2019, https://www.fendt.com/us/index



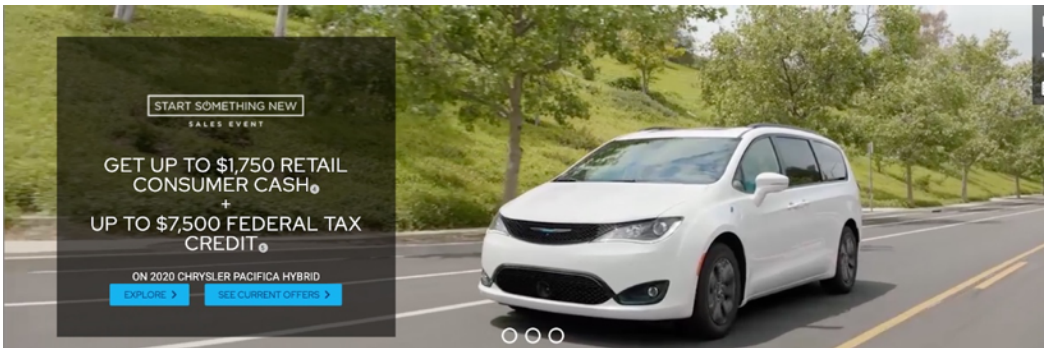
Appendix 10 Fendt North America Website Advertisement 2[153]

Appendix 11 Ford Website Advertisement[154]

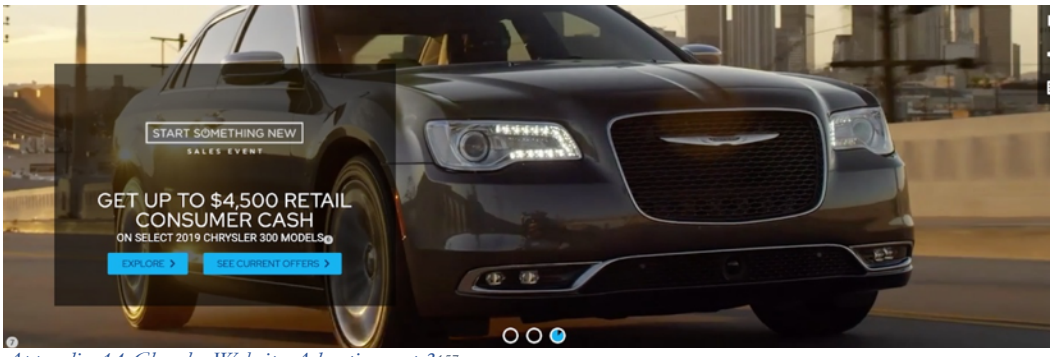


Appendix 12 Chrysler Website Advertisement 1[155]

[153] Fendt North America Website Home Page, accessed August 22, 2019, https://www.fendt.com/us/index
[154] Ford Website Home Page, accessed October 15, 2019, https://www.ford.com/
[155] Chrysler Website Home Page, accessed October 15, 2019, https://www.chrysler.com/

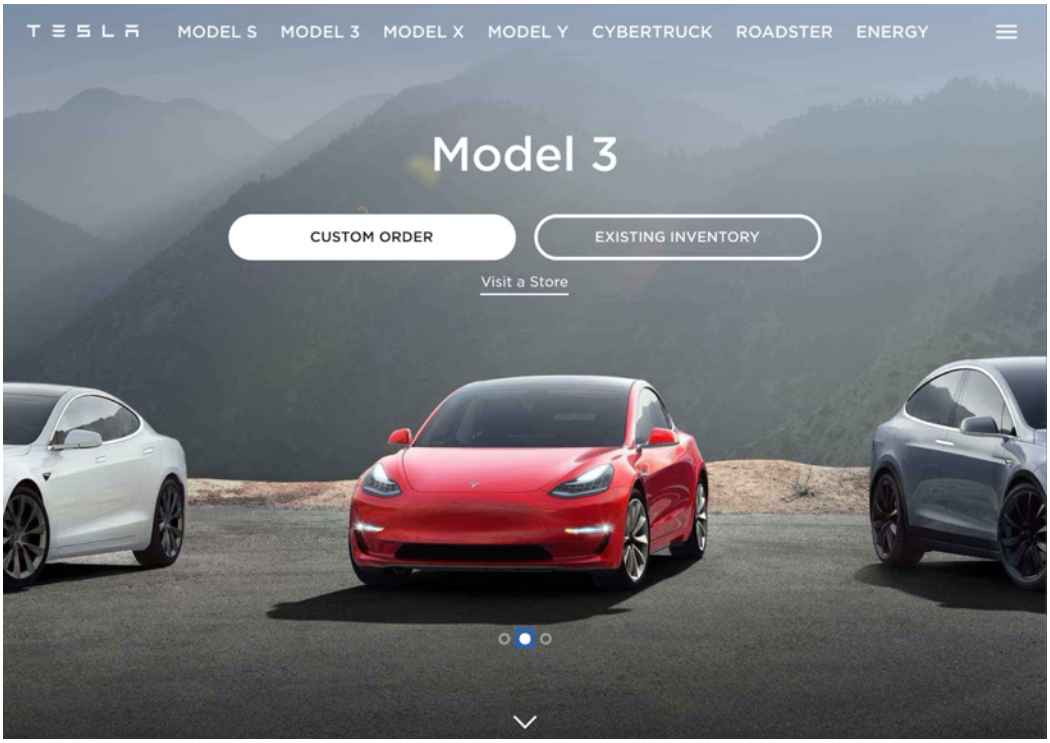


Appendix 13 Chrysler Website Advertisement 2[156]



Appendix 14 Chrysler Website Advertisement 3[157]

[156] Chrysler Website Home Page, accessed October 15, 2019, https://www.chrysler.com/
[157] Chrysler Website Home Page, accessed October 15, 2019, https://www.chrysler.com/



Appendix 15 Tesla Website Advertisement[158]

Appendix 16 Chevrolet Website Advertisement 1[159]

[158] Tesla Website Home Page, accessed August 22, 2019, https://www.tesla.com/
[159] Chevrolet Website Home Page, accessed October 15, 2019, https://www.chevrolet.com/

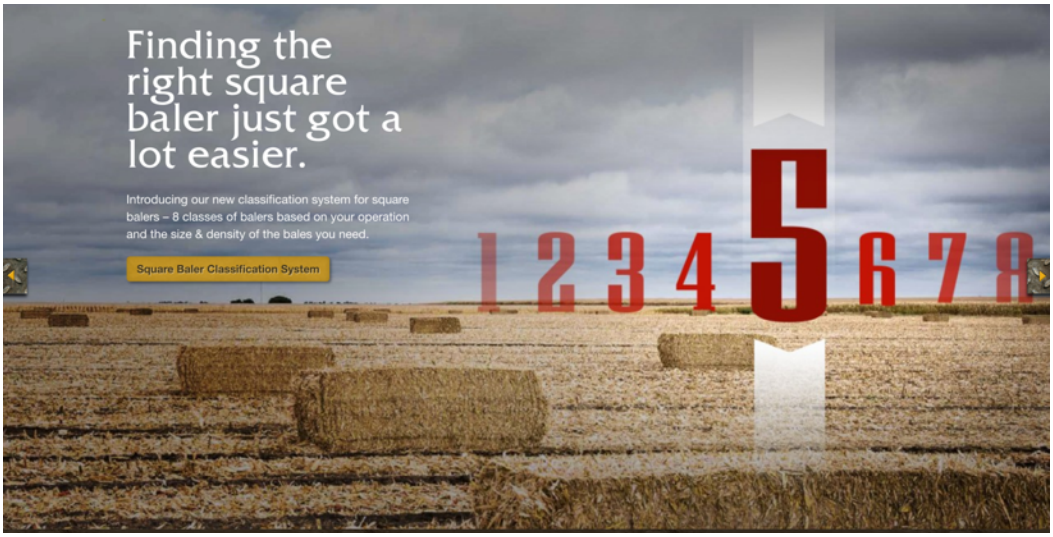
Appendix 17 Chevrolet Website Advertisement 2[160]

Appendix 18 Chevrolet Website Advertisement 3[161]

Appendix 19 John Deere Website Advertisement[162]

[160] Chevrolet Website Home Page, accessed October 15, 2019, https://www.chevrolet.com/
[161] Chevrolet Website Home Page, accessed October 15, 2019, https://www.chevrolet.com/
[162] John Deere US Website Home Page, accessed August 22, 2019, https://www.deere.com/en/

Appendix 20 Massey Ferguson Website Advertisement 1[163]



Appendix 21 Massey Ferguson Website Advertisement 2[164]

[163] Massey Ferguson Website Home Page, accessed August 22, 2019, https://www.masseyferguson.us/
[164] Massey Ferguson Website Home Page, accessed August 22, 2019, https://www.masseyferguson.us/

Appendix 22 Massey Ferguson Website Advertisement 3[165]

[165] Massey Ferguson Website Home Page, accessed August 22, 2019, https://www.masseyferguson.us/

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