APPLICATION FORM **Fall 21 / Spring _____**

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Investigating the effects of eliminating gas burning cars in the United States

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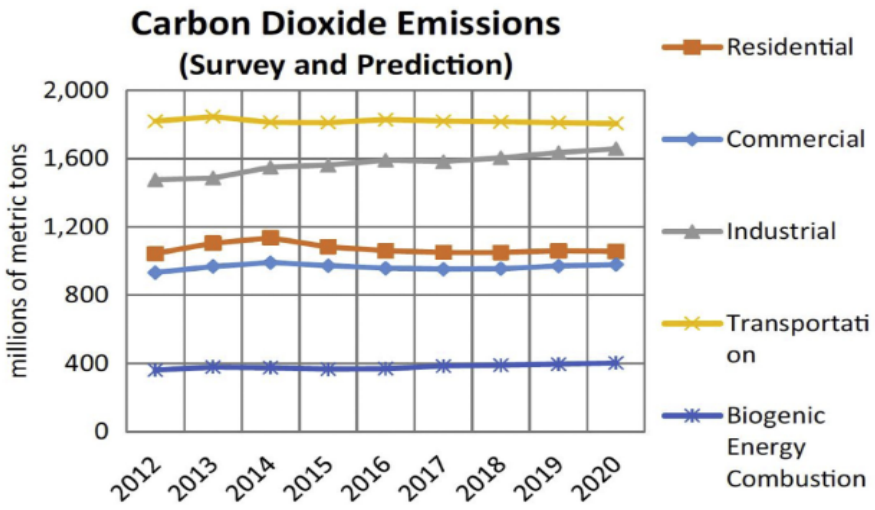
Investigating the effects of eliminating gas burning cars in the United States

In this research paper I will dive into the effects that would come if the United States were to switch solely to electric vehicles. In recent decades, it has been brought to the world's attention that climate change could cause havoc to humanity. This will happen in many ways, one of the most immediate worries being the heat waves and temperature changes. When the average temperature starts to rise, then there is a higher chance of heat related deaths. Most heat related deaths happen when there is a heat wave in an area that is not prepared for it. They aren't super common right now, but the data shows that as the average temperature rises, more of these extreme heat waves will start to happen more often. These heat waves will also have related consequences that aren't obvious to see. These include water temperatures rising, less agricultural production, drought, and rising sea levels. These are all reasons that scientists have been looking into what is causing climate change and ways to slow it down or even stop it. Scientists have discovered that carbon dioxide emissions are the leading factor of climate change. This led to studies on where all the carbon emissions are coming from.

One study conducted by the US Department of energy has shown that transportation makes up more carbon dioxide emissions than industrial, commercial, or residential sectors.

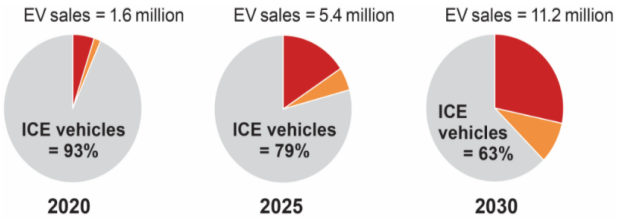


This raised the question from scientists of how they can reduce those carbon dioxide emissions. One obvious solution would be to stop traveling so much. In the modern world transportation is very important for every person. People are not going to just stop traveling, so there must be alternative ways of traveling that can cut the carbon emissions of the United States.

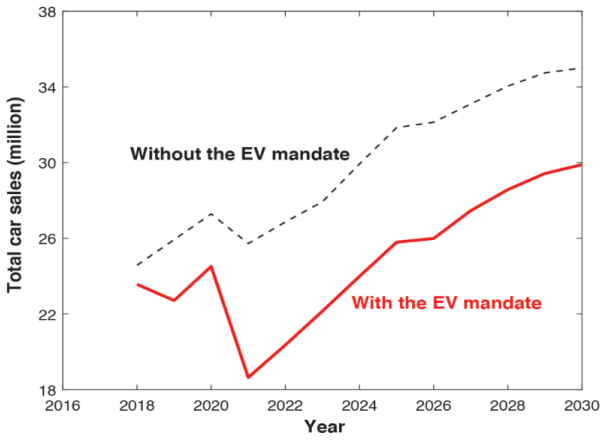
Electric cars have shown to be a key step in the journey to cutting carbon emissions. The US department of energy found that internal combustion cars, conventional gas burning cars, used on average 15% percent of the total fuel energy to run while electric cars used 75%. This is because in gas burning cars, the fuel is emitted as heat from the exhaust and there are friction losses. Electric cars also show to have an average maximum range of 350 miles, but due to extenuating factors such as temperature, the range would not be at maximum. An internal combustion engine car's maximum range averages about 375 miles before needing to refuel. According to the department of energy in the United States there are roughly 136,400 gas stations compared to 43,800 charging stations for electric cars in the United States. This is one set back that people see when deciding between an internal combustion car and an electric car. Also, if a driver is trying to drive an electric car in a snowstorm at about 5 miles per hour then the range is going to drop drastically to about 15 miles due to parasitic losses and reduced energy

produced by the battery in the cold temperatures. When a car buyer compares electric cars performance, availability, and resources to gas powered cars, there are not many reasons to buy electric cars. So governments are now using their authority to help decrease carbon emissions.

One way that governments are trying to help reduce carbon emissions from gas burning cars is by imposing mandates. Specifically, China's government has made it mandatory for car manufacturers to make 40% of their sales in electric cars by 2030.

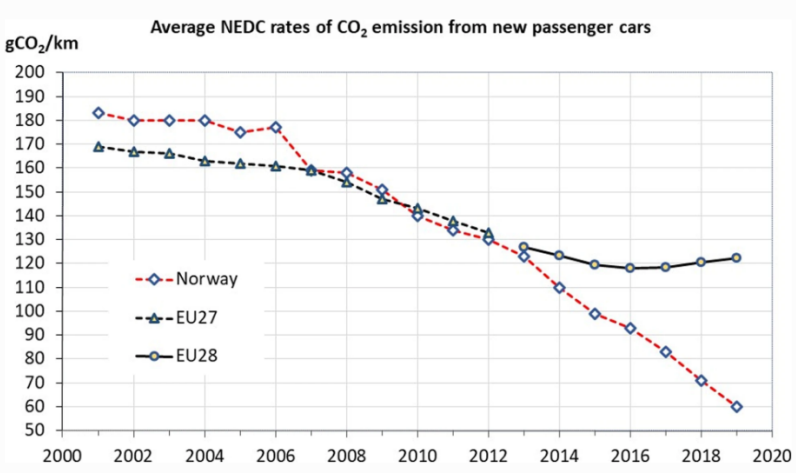


Makeup of projected vehicle sales at three points in time on the red curve above These pie charts show the split in projected sales among the three vehicle types: ICE vehicles (gray), hybrid EVs (orange), and pure battery EVs (red). The total number of number of EVs sold is indicated for each year.



This mandate is also predicted to drastically reduce the total numbers of cars sold as well. Less cars being sold and 40% of those sales being electric cars would ensure the lowering of carbon emissions in the transportation sector of china. Another government that has already started the switch to electric cars is Norway's. Norway has implemented incentives to electric car buyers and has seen a drastic increase in electric car sales. These incentives started in the late 90's and continue to grow today. These incentives include: Exemption from registration tax, free public parking, toll exemptions, value added tax exemption, bus lane access, reduced ferry rates, public charging stations, and more. Norway is currently leading the world with 75% of total cars being electric. They have already seen many improvements in the environment from this change. In 2019 Oslo, Norway reached the World Health Organization's target figure for clean air for ten

out of the twelve months of the year.



This data shows that even though electric cars don't trump internal combustion engine cars in many categories, it is possible to incentivise people to want electric cars. Norway is a small-scale example of the effects that come from limiting internal combustion engine cars and the data above shows some of those effects.

There was a case study conducted in Scotland that took into account the 5 most used electric cars and the 5 most used internal combustion cars and they compared many factors between the two.

Table 3: Top 5 electric vehicles in the UK in 2015 and their specifications [11]

Brand	Battery capacity (kWh)	Consumption (kWh/100km)	Registered cars in 2015	Price (£)	Distribution (%)
Nissan Leaf	24	14	11,000	29,000	49
BMW i3	22	13	3,574	38,000	16
Renault Zoe	22	11	3,327	21,000	15
Volkswagen e-UP	18.7	14	2,500	19,000	11
Tesla Model S	85	16.9	2000	75,000	9

Table 4: Top 5 conventional cars sold in the UK for 2015, their CO_2 factor, price, Distribution and average fuel consumption [13]

Vehicle model	CO_2 (g/km)	Price (£)	Distribution (%)	Registered car	Consumption (L/100 km)
Ford Fiesta	147	15,400	30	133,434	4
Vauxhall Corsa	129	10,800	21	92,077	4.7
Ford Focus	159	18,000	19	83,816	3.7
Volkswagen Golf	112	20,600	16	73,409	3.9
Nissan Qashqai	162	19,800	14	60,814	4

There is no column for CO2 emissions for the electric cars because they would all be 0, but we can compare some of the other columns. The first one that a consumer would be the most worried about is the price. The average price of the conventional cars is roughly 17,000 euro while the average of the electric cars is 36,000 euro. This makes the electric cars on average more than twice as expensive as internal combustion cars. When a consumer looks to buy a car one of the most important things to them is going to be the price. How does a consumer decide to spend twice as much money on a car that is going to do the same thing as the cheaper one except it is not going to emit carbon into the environment. This is where the government incentives come into play. Many governments are paying electric car drivers subsidies when they purchase their car. In this case, the government paid subsidies averaging 3,500 euros. That still doesn't quite make up the difference between the two though. The next thing the case took into account was the price spent on fuel. Annually the electric car drivers spent on average only 218 euros to power their car, while the internal combustion engine drivers spent on average 602 euros. This means that electric car owners also saved about 400 euros a year on fueling their car. Prices of electricity to power the electric cars is expected to rise as the demand for electric rises, but it would still be well below the 602 euros a year that internal combustion engine drivers are paying. Each government also has their own individual incentives to help consumers choose electric cars. As mentioned in the previous paragraph, Norway gives electric car drivers free

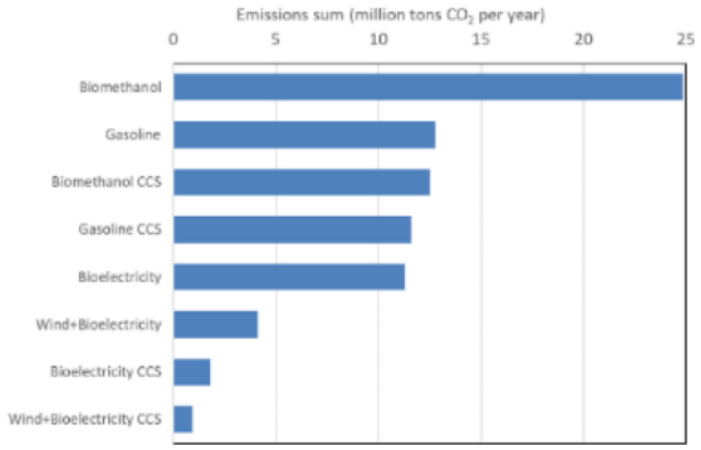
public driving and they are exempt from certain taxes. In the end, the price difference between the two types of cars is not that drastic and would be less of a problem for a consumer.

The transportation sector is not just made up of personal vehicles though, it also includes public transportation and tractor trailers that transport cargo. Buses and tractor trailers are shown to have much more carbon emissions than personal vehicles. So scientists have started looking into electric alternatives as well. The electric buses are starting to be distributed throughout the world but China has a large head start with 99% of the world's electric buses deployed there. As of 2019 China had over 421,000 electric buses deployed on the road. China has shown that using electric buses on a large scale is possible and it is predicted that many other countries will follow in their footsteps. China also produces all of the electric bus models, which gives them a little bit of help in being ahead of all other countries in electric bus numbers.

One huge factor that dissuades buyers from buying electric cars is the battery. While the price difference between internal combustion engine cars and electric cars are not too different when incentives and subsidies are taken into account, an electric car battery does not have a super long battery life. An electric car battery life is estimated to be between 8 and 10 years. This can range to be higher or lower depending on driving conditions. A driver who lives in a cold climate and enjoys accelerating fast will have a battery life of less than 8 years while someone who lives in a normal climate and doesn't drive too often will get much more time out of their battery. Getting your battery changed wouldn't be much more than getting the oil changed in an internal combustion engine car, which wouldn't be a problem in an electric car, except the price is much higher. The average battery replacement cost around $6,000 which is not something that the driver of an internal combustion car has to worry about. On average an

engine in an internal combustion car has to be changed after about 10 years, again this ranges a bit on how the driver treats the engine.

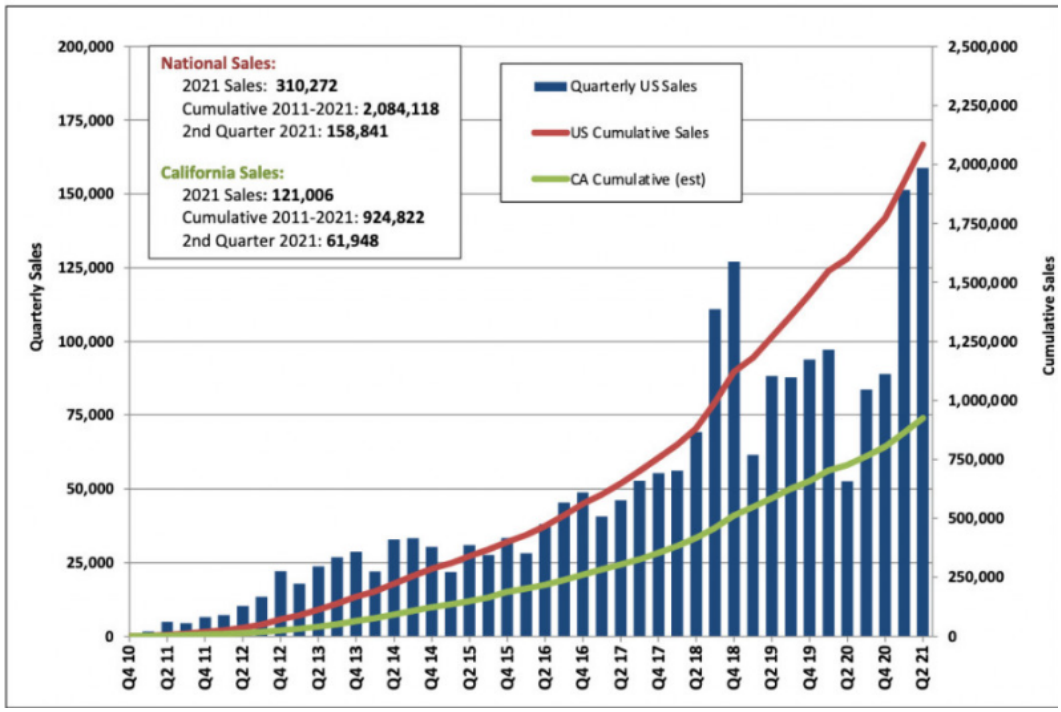
The big question when using electric cars is where does the energy come from to power the electric cars and does it produce more carbon than the internal combustion cars. The answer is not so simple. There are many places that the power will come from, but it will technically all come from the grid. The power for the grid will come from hydroelectric, solar, wind, biothermal and nuclear.



Looking at the graph above the only form of energy that gives off more carbon emissions is biothermal energy. This is because biothermal energy is made by the composting of organic materials. Every living thing is made up of carbon and releases it when composting. There is no way to stop these carbon emissions but we can use them to help power the grid instead of just wasting it. As the grid has to expand it will be necessary to increase some of the energy making techniques at the bottom of the graph since they don't give off as much carbon emissions. Once electric cars are fully implemented the gasoline emissions will be almost nonexistent and the bioelectricity ccs and wind bioelectricity ccs will go up slightly.

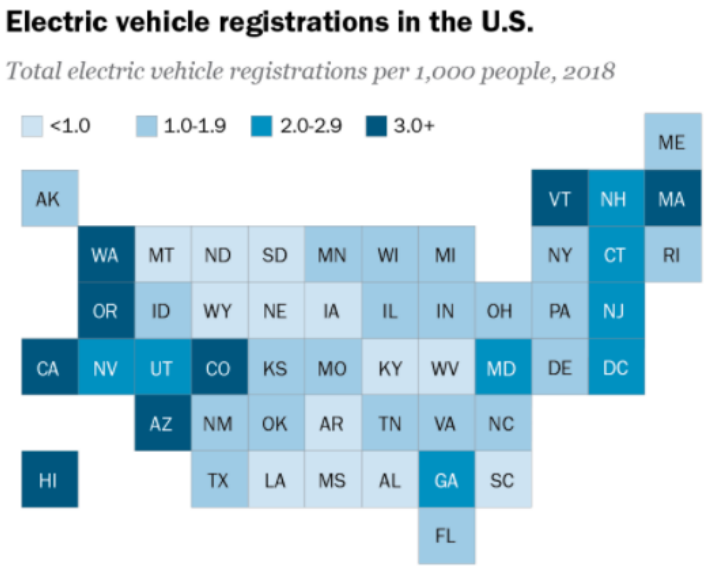
Using the data above, we can predict that if the United States was able to incentivise it's citizens to switch to electric vehicles, both personal and public, that it would help the

environment and air quality. Given that electric vehicles emit no carbon dioxide, then the only carbon dioxide emissions would be from making the energy to power the cars, which would be much less than all the carbon emissions from gas powered vehicles. The United States has already seen sales increase drastically since 2010 and it is only estimated to increase from here. With the United States having a major electric car manufacturer based in it, it will be cheaper and easier to get electric cars if there was not one. California is one of the first states to really start to incentivise buying electric cars and it has shown to be a great success with almost half of the United States electric car sales being made there.



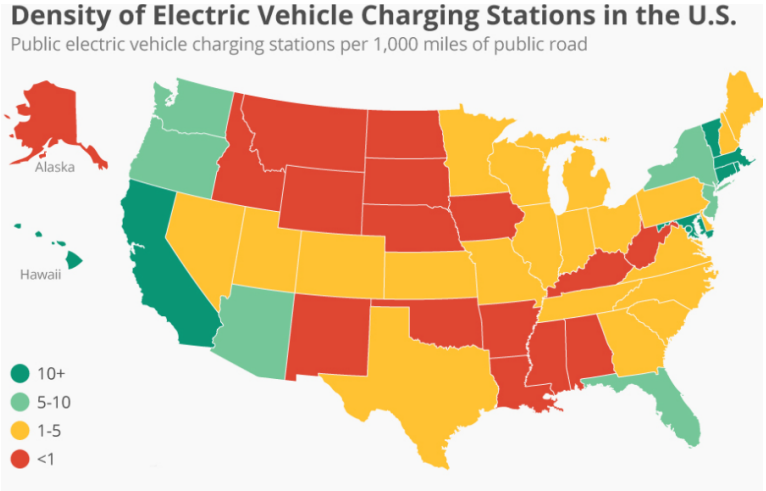
California has successfully adopted some of the same incentives used in Norway, such as a subsidy for electric car owners. The California Air Resources Board offers up to $7000 in Compared to China, the United States is still way behind in electric vehicle sales, but as the market continues to grow the United states' sales are expected to grow with it. The graph below

shows how many car owners per 1000 people have an electric car in the United States by state.



If all the lighter blue states were able to turn into dark blue, there would be an almost immediate improvement in air quality and the environment would start to improve as well. An effect of climate change that some of the coastal states have seen, specifically Florida, is the coral reefs dying. This is because as the average air temperature increases, so does the average water temperature. Last summer parts of Florida had to shut down their beaches because when the coral reefs die so do all the animals that live among it. Climate change isn't just hurting humanity but it is hurting everything that lives on Earth, but humans produce 100 percent of the carbon emissions. The United States currently has less than half the number of electric car charging stations as gas stations, so for the United States to be serious about increasing the

number of electric cars, they will have to increase the number of charging stations.



Comparing this map to the previous map, there is a direct correlation between the states with the most electric cars and the states with the most electric charging stations. For there to be a realistic possibility of the United States running solely on electric vehicles then every state on this map must be at least light green, meaning each state needs 5 or more electric charging stations per 1,000 miles of public road. The number of charging stations is increasing every year, this same map 10 years ago is completely red, so it is realistic that in another 10 years the United States could have the ideal number of electric stations.

In conclusion, the data shows that over the next 20 years the United States could become almost completely electric. Over the last 10 years the United States' eclectic car ownership has grown almost exponentially and increased drastically. Once the United States is able to get close to being completely electric, there will be an improvement in air quality, weather patterns, and environment. Norway has been able to lead the world in the electric car movement, but as they grow the data shows many other countries growing with them. The only difference is Norway is much smaller than Countries such as the United States and China and Norway also had about a 10 year head start. The data shows that if carbon emissions don't decrease it will cause havoc on

the world with heat waves, droughts, warmer ocean temperatures, bad air quality, and death to many living things on the planet. It appears to be in humanities best interest to find a way to lower carbon emissions, and the data shows that driving electric cars could be the first step in this process.

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