Wind Energy for Electric Vehicles

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MAE 579: Project

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Abstract

With the ever-growing need and demand for electric vehicles (EV) as an alternative to gasoline powered vehicles used today, it is important to have the electricity provided to these EVs be a clean resource.

The current system has most EVs use power that comes non-environmentally friendly sources.

Another issue with EVs is the range and difficulty recharging while on the move.

Wind energy has the potential to solve these issues, making EVs more attractive to consumers and leading to a greener future.

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Introduction

As of 2017, 272.48 million vehicles were registered here in the United States. The figures include passenger cars, motorcycles, trucks, buses, and other vehicles. The number of cars sold in the U.S. per year stood at 6.3 million in 2016.

According to the EPA, motor vehicles collectively cause 75 percent of carbon monoxide pollution in the U.S. The Environmental Defense Fund (EDF) estimates that on-road vehicles cause one-third of the air pollution that produces smog in the U.S., and transportation causes 27 percent of greenhouse gas emissions. The U.S. has 30 percent of the world's automobiles, yet it contributes about half of the world's emissions from cars.

This is not a sustainable situation with motor vehicles unless change towards cleaner/greener alternatives is made. One of the options is Electric vehicles or EVs.

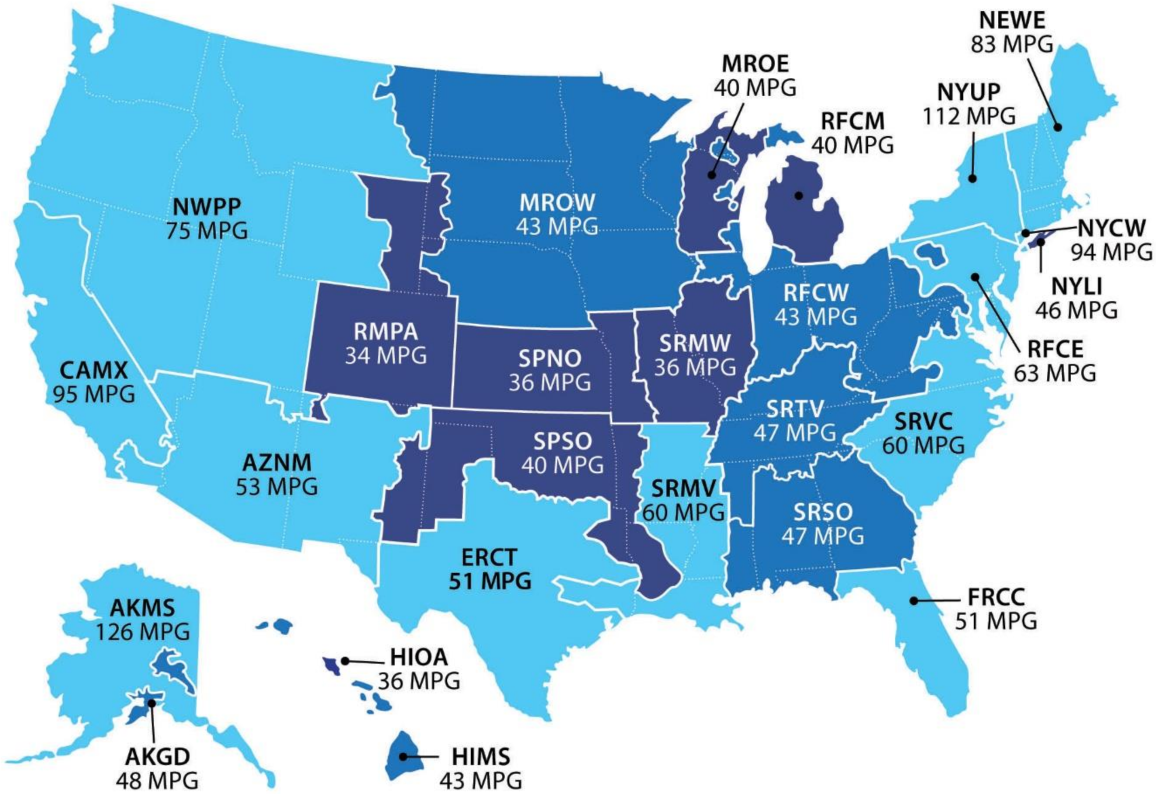
EVs are cleaner as they do not run on natural gas or fossil fuels, produce no emissions, produce very low noise and have very good torque and have instant power delivery.

The issues with EVs include the higher initial costs, the lower range combined with lower availability of charging stations and they are usually charged using electricity produced using Gas or Fossil fuels.

The following image shows that an EV can sometimes be worse than a gasoline vehicle depending on how clean the electricity grid is in the states. This means the issue needs to be tackled at the production level, not just the utilization level.

The ideal case would be to have clean energy production for the cars, meaning eliminating emissions and leading to a green fleet of cars. One way to achieve this is with the use of Wind Energy.

There are 2 ways of utilizing wind energy in cars, one is onboard to harness the wasted energy in breaking, and another is using wind farms to produce energy for green charging stations. These options are explored in this report.



How do the global warming emissions of electric vehicles compare with gasoline vehicles in your region?

GOOD	BETTER	BEST

Dirtiest electricity grid (High emissions) ⟵ ⟶ Cleanest electricity grid (Low emissions)

An EV charged in the given region produces emissions equivalent to a gasoline vehicle with a fuel economy rating of:

31-40 MPG	41-50 MPG	>50 MPG

The sources of electricity generation vary by region, meaning the global warming benefits of owning an electric vehicle depend on the electricity grid where it is charged.

On-board energy recovery system

The on-board recovery works on the same principle as a regular KERS system. The energy wasted while breaking can be recovered using a propeller-dynamo system that uses the head wind to generate electricity, providing more energy to the EVs batteries.

The proposed design is a system where a vent opens in the front of the car, which allows the oncoming air stream to turn a propeller.

The space concern is much lower in an EV than an IC engine vehicle, as the motors as well as the batteries are placed low down along the floor of the car, leaving empty room where traditional IC engines would be present.

The Average speed and stopping distance for cars in the United States is 70mph and 94m respectively. The time taken to stop is calculated to be roughly 6s. Newtons equations of motions are used.

$$v^2 = u^2 + 2as$$

$$v = u + at$$

Where: v is the final velocity, $v = 0ms^{-1}$ in this situation.
u is the initial velocity, and $u = 70mph = 31.3ms^{-1}$.
a is the acceleration, and is calculated to be $a = -5.211\ ms^{-2}$ (negative implying deceleration)
t is the time, and is found to be $t = 6s$

Using the above parameters, we can apply it to Betz law to find the approximate power output that we can expect.

Betz law: $P = \frac{1}{2}\rho u^3 A * Cp$

A is the area of the opening/propeller, which can be taken as 0.01m^2 for this case.
ρ is the density of air, which is 1.146 kg/m^3 at ambient conditions.
Cp is the coefficient of power, which by Betz law is limited to 59%, and 50% is a good estimate for real cases.
P is the power output.

With these criteria, the power output is found to be about 50kW, which is that of a lightbulb.

Increasing the area of the propeller further is not reasonable as the vehicle has limited space, and it adds weight.
The theoretical maximum output is also limited by Betz, to the 59% of input energy.

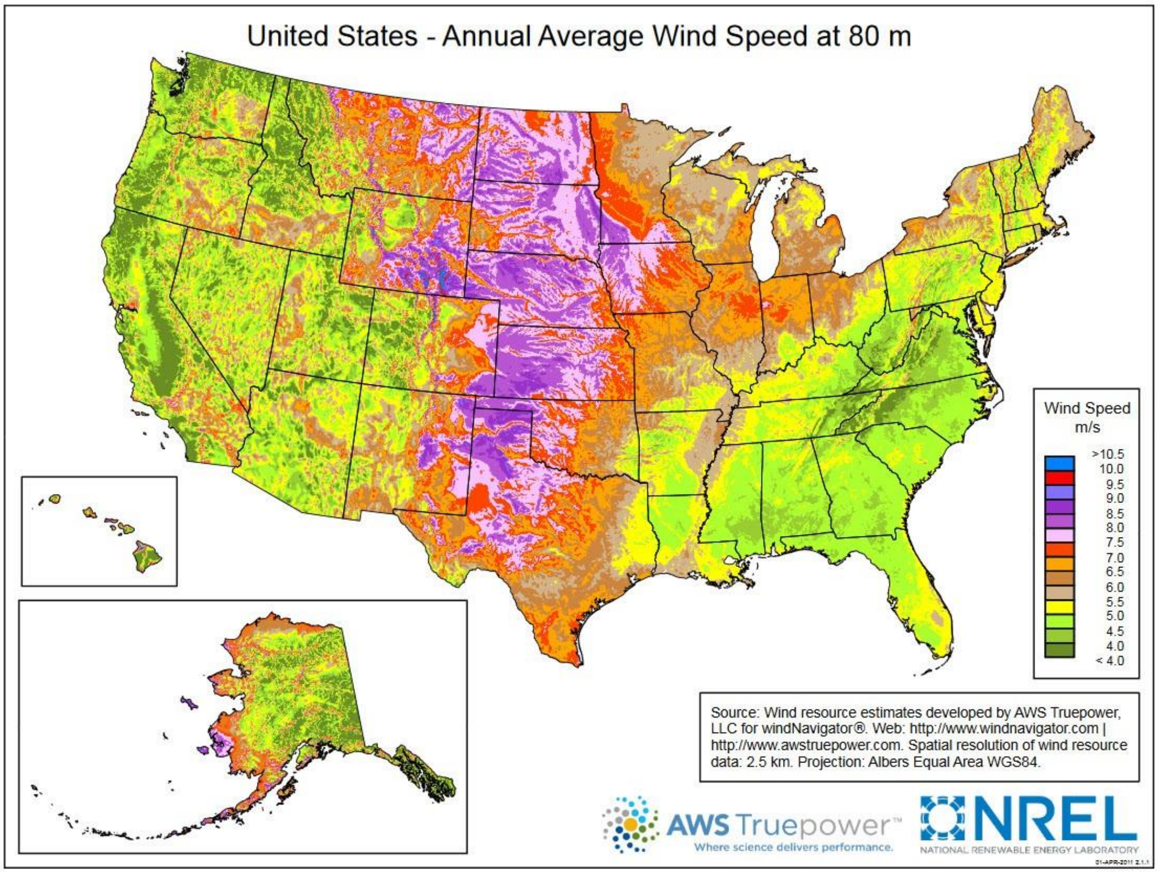
If we compare this to flywheel KERS system, that’s sometimes used in road vehicles today, we see that the KERS system has an efficiency of 45%, with new technologies pushing this higher.

So as a standalone system, the Wind Energy Recovery System will not be adequate or efficient enough, but it is possible for it to be used as an addendum to the existing KERS system to improve breaking performance and recover a bit more energy.

External wind energy production

The main idea is that using Wind energy to produce energy for EVs, essentially cutting down pollution and green house effects to zero.

From the map of grid emissions, its clear that the central area of the country, has the most need for greener energy. So we need to compare this to the wind potential in those areas.



We can see that the central area of the country has the highest average wind speeds at operating height of 80m, making it ideal for Wind farms.

The other areas can be used, but the energy output from each turbine will be lower.

The V90-2.0 MW™ IEC IIA/IEC S, at a hub height of 80m, is a good model to use in this situation.

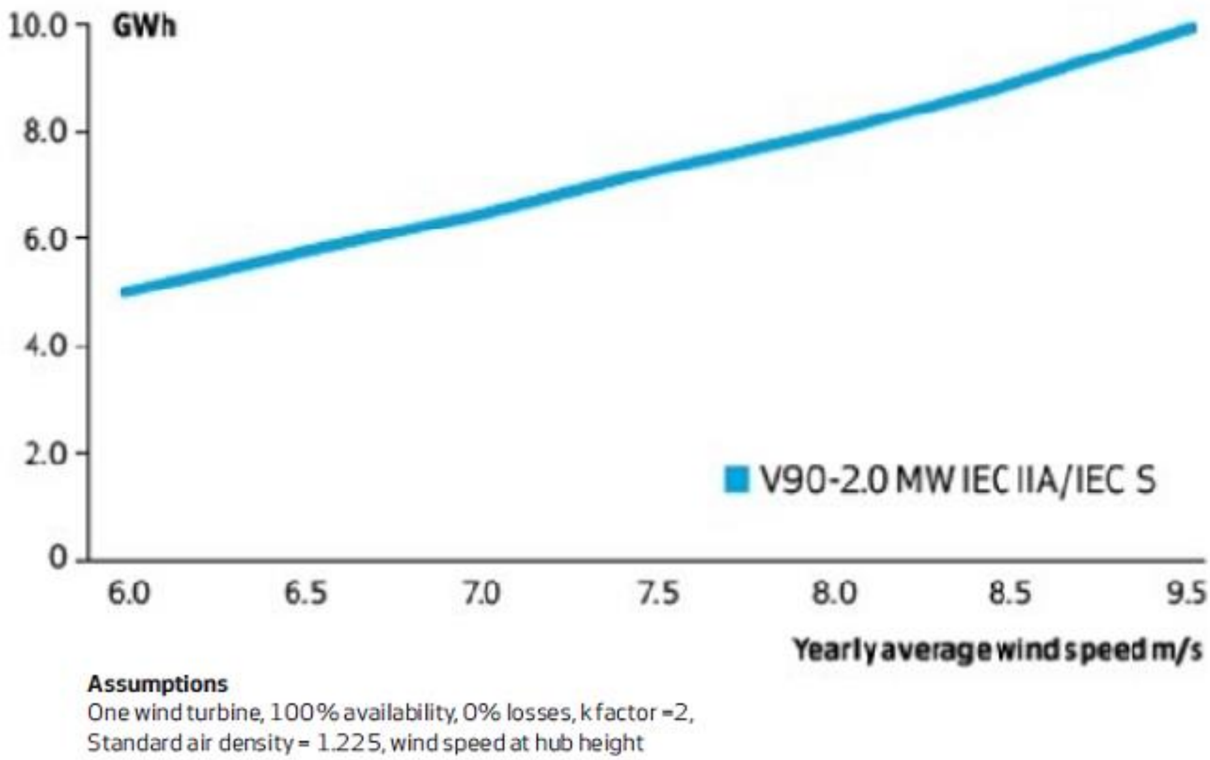
PERATIONAL DATA

Rated power	2,000 kW/2,200 kW
Cut-in wind speed	4 m/s
Cut-out wind speed	25 m/s
Re cut-in wind speed	23 m/s
Wind class	IEC IIA; IEC S
Operating temperature range standard turbine	-20˚C to 40˚C
Operating temperature range low temperature turbine	-30˚C to 40˚C

TOWER

Type	tubular steel tower
Hub heights	80 m (IEC IIA), 95 m (IEC IIA) and 105 m (IEC IIA)

Power Curve:



The turbine cost roughly $3 million fully installed.

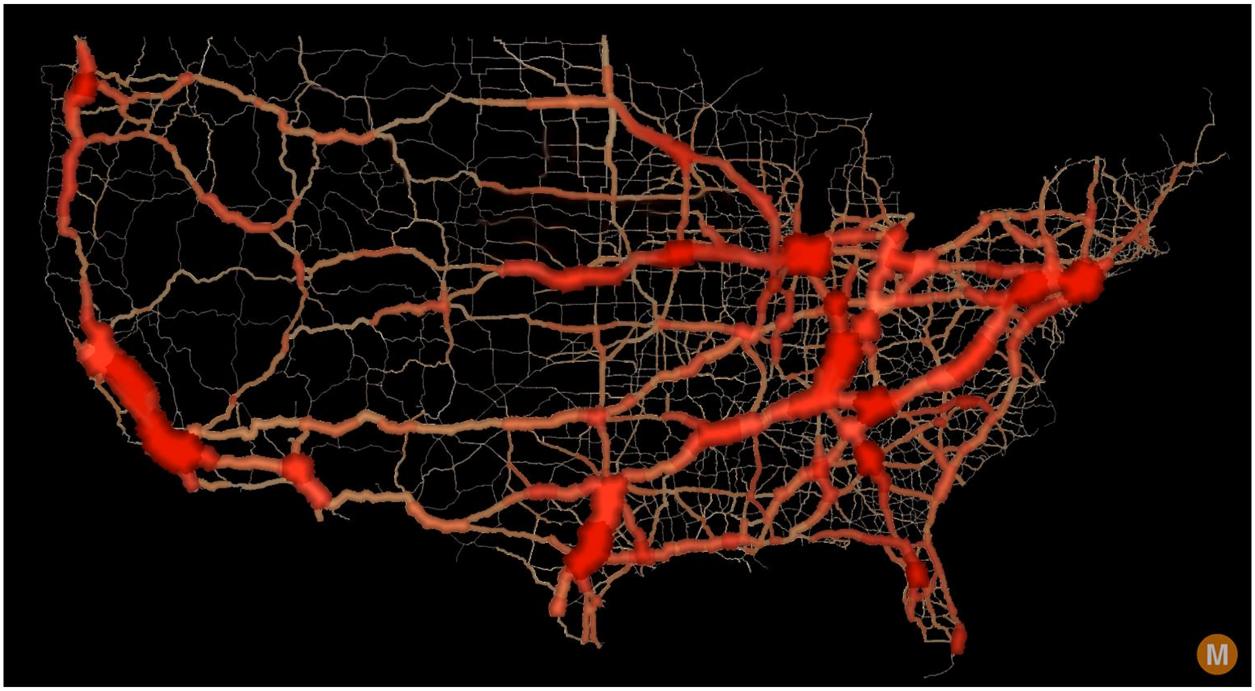
The average power is 7GWh for the wind speed in the considered zone. This amounts to 19.17 MWh per day per turbine.

7GWh translates to around $1M worth of electricity. In terms of just energy savings, the turbine will pay back the installed cost in 3 years if customers are charged the same amount.
The Nissan Leaf is the most popular EV currently. It has a range of around 150 miles on its 40kWh battery on the base model. It has a Battery charge time of 35h at 110V, 8 to 11h at 220V, 0.75h at 440V.

This means that one turbine can produce enough electricity to power about 480 full charges of the Nissan Leaf battery per day. That's 72,000 miles worth of electricity.

The average passenger vehicle emits about 404 grams of CO_2 per mile. So you essentially eliminate 32 tons of CO_2 per day per turbine!

The following image shows the traffic density on the road in the USA.



We can see there is a lot of potential for Electric vehicles along the points of interest.

Some other areas have slightly lower wind speeds, but with the cut in wind speed being 4m/s, it is possible in select areas.

Wind recharge stations

About 40% of all car owners avoid EV cars dude to their low range and fear of not having recharge stations on highways. 65% of EV owners said they had range anxiety when they purchased their cars.
The issue with EV cars on long drives is compounded by the fact that there are very few electric charge stations out on the highways.

As the number of EV cars increased, the need for these stations increases as well. A wind powered recharge station has some of the best advantages in this situation.

- Remote, so wind turbines can easily be put up.
- Self-sufficient, it does not rely on the energy grid as a normal station would.
- Can be backed up by hybrid electricity production, either by the grid or through solar, etc.
- Green, no emissions, no pollution.

A wind recharge station with about 5 turbines can provide about 500 miles worth of electricity per day for the Nissan Leaf, which is one of the most basic EVs. Other vehicles such as the Tesla, Volvo etc. can benefit much more.

The wind farm can either be set up by the government or be privatized, incentivizing building by providing rebates, tax returns, etc.

If the extra charging stations can convince half of the 40% of car owners to go electric, that translates to about 3million fewer IC engine cars per year.

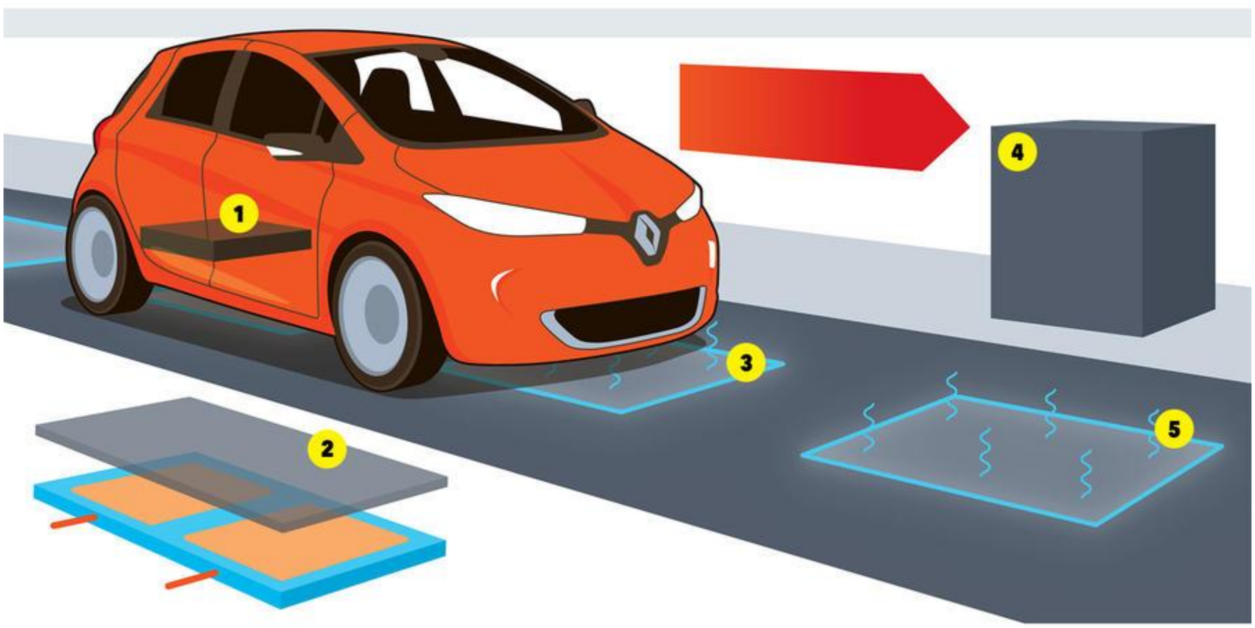
A typical passenger vehicle emits about 4.6 metric tons of carbon dioxide per year.

So that means 12 million metric tons of CO_2 reduced per year!

Recharge Lanes

One major flaw of EVs is the long recharge times that's usually present. But recharging/refueling can be turned into a strength rather than a weakness.

Through inductive charging, a moving magnetic field in the road, can charge a moving EV above it.



For example, about 2km (1.2 miles) of electric rail has been embedded in a public road near Stockholm.

The electrified road is divided into 50m sections, with an individual section powered only when a vehicle is above it.

When a vehicle stops, the current is disconnected. The system can calculate the vehicle's energy consumption, which enables electricity costs to be debited per vehicle and user.

€1m per kilometer or $1.6m per mile, and for comparison the cost of electrification is said to be 50 times lower than that required to construct an urban tram line.

This added cost will mean it takes more customers to recover the cost, but the convenience will mean more people are likely to use such lanes.

The lanes can be toll roads, so customers can be charged, and regular vehicles can be kept off the charging lanes.

Qualcomm's Halo system is pushing the boundaries of how effective these roads can be. Qualcomm also says its Halo system transfers electricity from the pad to the car with 90% efficiency, while conventional charging is 95% efficient.
With the chargers buried beneath a regular road surface, the system is not affected by bad weather and is claimed to work equally well when the road is covered in water.
Qualcomm has already proved that charging while driving is possible, even while the vehicle is traveling at up to 70mph. The technology is called Dynamic Electric Vehicle Charging (DEVC).

Most wireless charging equipment is Level 2, meaning it operates on 220–240 volts. Whether a Level 2 charging station is wireless or wired has no bearing on the speed of the charging process.

For example, if a vehicle is moving along the 1-mile recharge lane in 1 min, at 60mph, it can, with todays technology, can yield it 45 miles of range.

Once this technology hits the level 3 or 440V capacity, one can expect extremely fast recharge while on these lanes.

These lanes will provide a fast, hassle free recharge experience to EV owners. Couple this with the Wind powered stations, you have energy that is green and zero emission as well.

These avenues make the future of green energy in the automobile world very exciting.

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