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Introduction

The world now was not like this around 200 years back. Rhythm, routine, and patterns seemed far more aligned to the law of nature. The law of nature, in the philosophy of science, a stated regularity in the relations or order of phenomena in the world that holds, under a stipulated set of conditions, either universally or in a stated proportion of instances. (Law of nature | logic, 2019) Monsoon summer winter were in coordination with each other. And the cycle of weather was almost the same for millions of years. But what went wrong? In the 1800s, the industrial revolution took place. An expedient rise in factories, with an increase in production, demand, and innovation. Generating energy on such a big scale involved burning fuel and natural resources which resulted in CO₂ emissions. (Sources of Greenhouse Gas Emissions | US EPA, 2020) It has been said that industrial revolution is between 1780 to 1840, but current CO₂ emission proves it never stopped. (2041 Foundation, 2018) In just 200 years, many of the natural laws were malfunctioned. The system, which running fluently for millions of years got into trouble in just 200 years. Therefore, climate change act in 2008 included various sectors, to set goals to reduce the economy decarbonisation in the hope of making the world a cleaner place.

Since the act occurred:

- In England during 2008 renewable capacity stood at 2,618MW and grew to an outstanding 25,801MW during 2017.
- 33% of generated electricity by provided by coal in 2008 and is now 7% in 2017.
- Over the last ten years, the power industry has lowered its emissions by more than half, resulting in the power sector accounting for the majority of greenhouse gas emission reductions.
- Once the act became law low carbon sources used to be a poor 20% but now has increased to 51% (Dio, Energy UK, 2021)

There are two sorts of emissions that are produced by our automobiles.

The vehicle's exhaust pipe and this process all contribute to direct emissions. Smog-forming pollutants like nitrogen oxides, as well as other detrimental pollutants to human health and greenhouse gases like carbon monoxide, are all examples of direct emissions. All electric vehicles emit no direct emissions, which contributes to a cleaner environment. (Afdc.energy.gov. 2021.)

All emissions connected to fuel and vehicle manufacturing, processing, distribution, recycling, and disposal services were included in the life cycle emissions. When raw crude oil is collected from the ground, refined into gasoline, distributed to all station pumps, and finally burned in the combustion chamber, vehicle emissions are produced. (Afdc.energy.gov. 2021.) To help solve the harmful emissions crisis manufacturers have designed and produced cleaner application for the public.

Electric Vehicles

Media are promoting electric vehicles to the public across all platforms. Electric vehicles are an environmental boost which helps the government reach their targets due to automotive manufacturers allowing marketing budgets to introduce

The use of electric vehicles is constantly promoted and advertised to the public across all media platforms and sources. Manufacturers are devoting significant resources to research and development, production, and marketing to introduce electric drivetrains to new and existing platforms.

What is Vehicle to Grid?

Renewable energy like solar or wind is good for the planet, but the sun doesn't always shine, and the wind doesn't always blow. Therefore, people keep relying on fossil fuels. To solve for the irregular nature of renewable energy. The people need to store it so they can use it whenever they need. One solution comes from an unexpected source, electric vehicles. EV not only reduce harmful emissions but can also help stabilise the energy grid through proven reliable technology called vehicle to grid. This technology was first developed over 20 years ago and is being used all over the world. Instead of just pulling power from the grid, Vehicle to grid allows vehicles battery to store energy, including renewable and then safely discharge part of that energy back to the grid, when it is needed most. With Vehicle to grid, a fleet like electric buses could be charged overnight when energy demand is low, drive their regular schedule and then discharge energy back to the grid while parked. This technology also, allows batteries from multiple vehicles to be combined into a virtual power plant or VPP. This combined energy can then be sold on energy markets or used to provide what is known as grid services during peak times that help stabilize the grid and prevent blackouts. Vehicle to grid also saves fleet owners money for charging when electricity rates are low and even power buildings with low-cost energy stored in. EV batteries. All this is done while, prioritising battery health and ensuring that a vehicle has enough charge to perform its daily driving duties. Vehicle to grid generates revenue and reduces the overall cost of owning an electric vehicle by putting their batteries to use when parked and not being driven.

In recent years, Electric vehicles have managed to penetrate the vehicle industry. In 2019 over 20 new electric vehicles models were released and many manufacturers have pledged to have electric versions of all their vehicles available in coming years. With any industry that's growing this quickly, there come challenges for electric vehicles along with sourcing enough batteries to meet the demand of electric vehicles. One of the major challenges is ensuring that there is efficient electricity generation to meet the demand of charging electric vehicles. Now, if everybody charges their electric vehicles when they got home from work, this could lead to an increase of electricity demand with 50%. Therefore, for there to be enough power at any time the grid must be balanced. Generated needs to equal the power demanded. That's why they must make sure that the scales are always balanced. Thus, they've got two options. If they can increase the generation or decrease the demand at a given moment in time. (Eirgrid group electricity consumption, 2020)

For the first option, is most likely the generation would have to be provided by harmful gas turbines. That's because they have fast ramp rates, but because of this not only operate as few hours a day. They hold the key to electricity provision. As this is an inelastic demand that means that they can be expensive and charge a lot for every unit of energy they provide. The public's second option is to decrease the demand peak, smoothing the demand profile. This can be done by smart charging electric vehicles at times in demand is usually lower. However, this could result in no increase in the demand peak. Therefore, the question is, why would the public ever need to discharge your vehicle and use vehicle to grid?

People have been considering a traditional generation mix of nuclear and fossil fuels. But what happens when they move towards a more renewable based generation system? The value of their conscript becomes clear. With the 2050 net zero goal in the UK, (gov.uk,2021) installation of renewable generation is only going to increase. And this comes with its own challenges. Renewables transformed energy system, from one where power plant generation is modified to match our desire. Whereas in the future it's going to be that they need to make sure their demand matches the generation when they have it. One way around this is through energy storage. Every electric vehicle contains a battery and that will be considered a free storage asset. That can benefit at the moment is that cars are parked 95% the time during which they could be plugged in to an electricity socket. And used as an energy storage battery. Hence why vehicles are capable of energy storage. They need marketing to incentivise this practise. These markets will provide revenue streams for the electric vehicle's owner or operator. They could be behind the meter, reducing the cost of electricity imports. They could be providing ancillary services, for example, engaging in the frequency response market for distribution network operator interactions, to reduce congestion. (Science direct, 2018)

The main challenge using electric vehicles for vehicles grid is battery degradation and the cost associated with it. There are many factors which affect battery degradation. The age of the battery, the number of cycles that complete, whether the charging is done in a grazing fashion, just charging a little bit on each time, or whether the electric vehicle is feasting and charging back up to full each time. How full the battery kept and the temperature of the battery. This leads to a complex modelling system. Because of this, it's important to see the big picture and consider the amount of energy transferred. Some services require less energy to be transferred and therefore, could result in a lower cost of battery degradation. When anyone is thinking about which markets to interact with, optimization is to account for the cost of battery degradation when it's deciding what strategy to take. The end goal is to optimising profits over the lifetime of the vehicle.

Electricity demand

As seen in *figure 1* depict the electricity demand in England on a typical winter and summer day, as well as how people used it. The first line graph shows that electricity demand in England is substantially higher in the winter than it is in the summer. (Mentor, 2021)

In the winter, the electricity consumption is roughly 35000 units per day, (Mentor, 2021) whereas in the summer, it is around 18000 units per day. Again, the demand for power changes throughout the day, with demand between 6:00 and 9:00 a.m. being lower than demand at other times. During the winter, demand is highest between 21:00 and 23:00 hours, whereas during the summer, demand is highest between 13:00 and 14:00 hours. (Mentor, 2021)

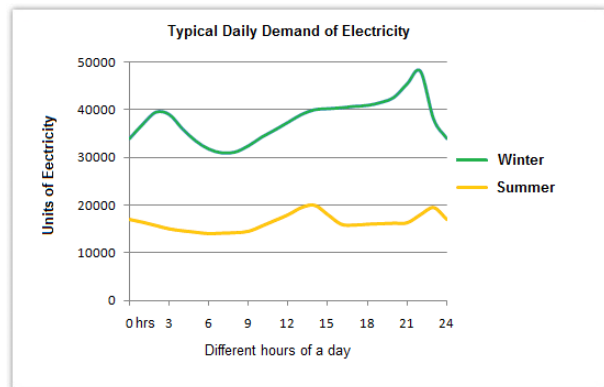


Figure 1: Graph showing typical daily demand of electricity of summer and winter

Based on the pie chart, we can deduce that room heating, and water heating are the most common reasons for people in England to use electricity. The demand for washing machines, kettles, and ovens accounts for roughly 18% of overall power use, while two other groups each account for 15%. Light, TV, Radio, vacuum cleaner, food mixer, and other electric tools and equipment are among the other two groups that require 30% of total electricity.

According to Statista the annual demand for electricity in the United Kingdom (UK) from 2000 to 2020 is decreasing. The demand for electricity in the United Kingdom has been declining since 2005, and by 2020, it had dropped to a low of 331,448 gigawatt-hours. This is even though the UK's population grew by about five million people over this time. Energy efficiency standards, energy-efficient lighting, and changing consumer behaviours are all contributing to this drop. (Total electricity demand UK 2020 | Statista, 2021)

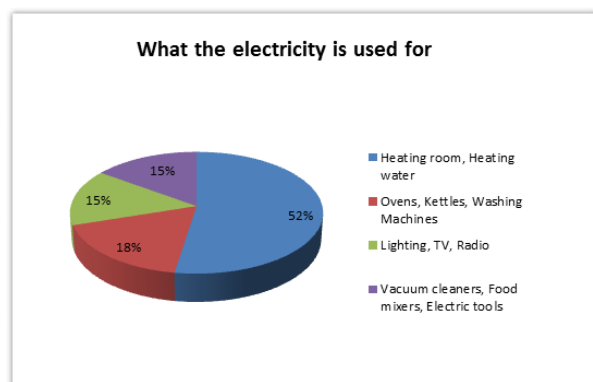


Figure 2: Pie Chart showing what electricity is used for in household items

Electricity consumption in the home

The average residential electricity consumption per family in 2019 varied significantly by area. The East of England had the greatest average use of 4,125 kilowatt hours, while the Northeast had the lowest. (Total electricity demand UK 2020 | Statista, 2021)

The production of electricity is decreasing

Electricity generation has been declining in tandem with electricity consumption. The amount of power generated in the UK decreased to its lowest level since 1994 in 2018. Even though power generation has decreased, renewable energy generation has surged dramatically. Renewable energy sources are expected to account for 70% of global electricity output by 2035, according to projections. The use of coal is expected to be phased out by 2023. (Total electricity demand UK 2020 | Statista, 2021)

Practicalities of using such technologies for my chosen application

I believe that car to grid technology will be underutilised because upgrading the national grid to allow two-way power flow will be prohibitively expensive, not just in terms of infrastructure but also in terms of environmental impact. However, there are other ways due to a worldwide pandemic. In 2018, the United States had roughly 273.6 million registered automobiles. According to KPMG, this equates to an average of 1.97 cars per home, which it predicts will fall to 1.87 if its projections are true. As a result of individuals driving less, the equivalent of 14 million fewer automobiles will be required. People are turning to new greener applications such as electric bikes. E-bikes are predicted to grow from 3.7 million bikes sold in 2019 to 17 million in 2030. The e-bike market in 2020 is already up by 23% year on year, and on the current trajectory, there will be 10 million e-bikes sold per year as early as 2024. (Reid, 2020)



Figure 3: Electric Bike

First, it lowers the barrier to biking. Therefore, if it is for someone who is older or they're stressed out about the strains of biking, it really lowers the barrier and easier to justify getting on a bike and just ride. Electric bikes are more sustainable than electric cars they're going to make cities more liveable, and they're going to help clear up traffic congestion. (FuroSystems, 2019) Since cities are becoming more congested. Some companies are turning contrast towards electric bikes to make their deliveries. Domino's Pizza recently announced they're going to be using Rad power bikes to make pizza deliveries in some cities. (Electrek 2019) UPS using electric cargo bikes, German delivery company DPD is going to be using these mini trucks that are electric bikes in disguise as seen in *figure 4*. Electric bikes are changing the way that businesses, are doing business.



Figure 4: DPD's
Electric mini truck

Ethical issues that might occur

A downside of using electric bikes are the batteries due to them containing cobalt. Before Cobalt was discovered as a metal. Miners found ores that lacked appreciable amounts of the metal they desired. Additionally, these ores were dangerous that gave up arsenic, they named these ores Cobalt. Eventually, in 1735, these ores were able to be reduced to a new metal cobalt. Fast forwarding today cobalt is used in manufacturing of lithium-ion batteries, jet or rocket engines and medical applications. And with 50% of total cobalt mined being used for lithium-ion batteries, which looked to grow exponentially, the hunger for cobalt is high. Cobalt and eight properties of thermal stability in high energy density, making a good choice for lithium-ion battery cathodes, or which it often composes anywhere from 10 to 30% of the cathode.

Cobalt is a by-product of copper and nickel mining. The Central African Copperbelt is a major source of cobalt, representing over 50% of the global supply. (Science direct 2020) More specifically, the Democratic Republic of the Congo (DRC). However, mining operations in the DRC are plagued with issues, namely human rights violations, environmental damages, child labour, government corruption. Big changes to the coal mining industry are long overdue.

Luckily large companies like Tesla requiring a large supply of cobalt, reducing their dependence on DRC, cobalt is a high priority, since cobalt is the most expensive material in the battery, it could save them a little money too. Another way to reduce cobalt pendants is reducing the amount of cobalt used in batteries in the first place and replacing it with other metals like nickel. For example, from a 'Verge' interview 2018, Tesla and Panasonic had reduced the amount of cobalt by that 60% and have likely driven down even further since then. (Elon Musk, 2021) Introducing the cobalt content of battery cells, a few challenges and problems exist. Since Cobalt provides thermal stability to the battery, reducing the amount of cobalt can lead to higher cell temperatures and reduced cell life cycles if not managed properly. In the future, Cobalt could be drastically reduced or even eliminated from lithium-ion batteries. Elon Musk said that their next Gen batteries used in their Tesla vehicles will use no cobalt (Tesla to make EV battery cathodes without cobalt, 2020).



Figure 5: Cobalt Mine

While the previously mentioned companies are opening mining operations on land, a company called Deep Green Metals is looking to Harvest Rocks that are almost entirely made from cobalt off the ocean floor. They are currently developing their technology and assessing the environmental impact to the ocean floor ecosystem. However, they can reduce the number of ore necessary to produce 1 kilogramme of cobalt by up to 10 times.

Ultimately, the future of Cobalt looks likely to change. Some companies like Tesla will reduce their dependence on it. Other companies will want to ethically in North America and yet other companies made pulled up from the sea floor. Additionally, companies and research teams are racing to produce cobalt free battery chemistries. But until they create an equivalent or superior battery chemistry, perhaps different types of batteries will be used for short- and long-range models of the Electric vehicle.

Conclusion

To conclude, due to a lack of infrastructure, using vehicle-to-grid technology with electric vehicles as a substitute for fossil fuels is not possible. However, it can be a dampener to the world's emissions crisis if cobalt can be mined cleanly. Hydrogen and other blended fuels are alternatives to be considered and could be the answer to the emissions crisis, due to them not being electric and not demanding massive amounts of electricity which the national grid cannot handle at peak times. For the grid to be able to power electric vehicles at peak times a costly infrastructure will be needed. Nonetheless electric bikes could be the solution to most people current situation. Especially in urban cites avoid traffic and reducing emissions in polluted cities. Vehicle to grid will not work in urban cites due to majority of people living in cites live in big block building with minimal parking. Therefore electric bikes could be the a alternative solution to insure to help the planet

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