



ELECTRIC VS GASOLINE VEHICLES: COSTS, FUEL & ELECTRICITY PRICES, TAXES

Johannes Fuchsberger, Matěj Štěpánek

Co-operating Universities

UNIVERZITA J. E. PURKYNĚ V ÚSTÍ NAD LABEM



Financial support by



lebensministerium.at

Prague and Vienna, 2021

Content

1. Abstract	3
2. Comparison of electric vehicles and internal combustion engines	3
2.1. Comparison of the purchase costs	3
2.1.1. Purchase costs in Austria	3
2.1.2 Purchase costs in Czech Republic	4
2.1.3 Purchase subsidies	4
2.2 Fuel costs	6
2.2.1 Fuel costs in Austria	6
2.2.2 Fuel costs in Czech Republic	8
2.2.3 Fuel costs in Europe	8
2.2.3 Fuel costs comparison for Austria	9
2.2.5 Fuel costs comparison for Czech Republic	10
2.2.6 Fuel costs comparison for Europe	11
2.3 Taxes	11
2.3.1 Taxes in Austria	12
2.3.2 Taxes in Czech Republic	12
2.4 Maintenance	13
3. Economics calculations	14
4. Conclusion	15

1. ABSTRACT

In this work we analyze the difference between BEV&PHEV cars and cars with a combustion engine. We will consider the cost of a purchase and the running cost of a vehicle. Then we will calculate a NPV for both variations and discuss our results.

2. COMPARISON OF ELECTRIC VEHICLES AND INTERNAL COMBUSTION ENGINES

To start the comparison of the costs of different cars it is expedient to start at the beginning of an ownership. Therefore, the first thing to be talked about is the purchase costs of a conventional car and an electric car.

2.1. Comparison of the purchase costs

First, it is to be mentioned, that purchase costs of cars differ from country to country. This is because of different taxation and subsidies on the one hand but also different model features which also differs between nations. As it is hardly possible to compare all countries we will focus on Austria and Czech Republic. However, to give a good overview there will be a few selected examples.

2.1.1. Purchase costs in Austria

In the following the purchase price of two different types of cars will be compared. The electric car and the conventional car are selected from the same manufacturer and the same class.

The most sold internal combustion engine car in Austria is the VW Golf. Therefore, the first comparison will be between the Golf 8 and the VW ID.3 which was introduced by VW to offer an battery electric version of the Golf.

	ID.3	Golf Petrol	Golf Diesel	Golf PHEV
Lowest starting price	35.614,80 €	19.890,- €	24.890,- €	38.470,- €
Highest starting price	47.524,40 €	53.360,- €	39.040,- €	41.930,- €
Leasing [€/month]: Lowest starting price	243,89	118,-	151,-	240,-
Leasing [€/month]: Highest starting price	311,09	317,-	250,-	262,-

Tabell 1 Price comparison of Golf-sized cars (prizes correct at time of writing, prizes taken off the website of VW: <https://www.volkswagen.at/>)

Electric cars are more expensive at the purchase. The only petrol car which seems to be more expensive than the ID.3 is the Golf R which is a sports car and therefore more expensive.

An electric vehicle which is on the market for a long time now is the Renault Clio. It can be well compared to the Renault Megan as both vehicles are approximately the same size.

		Zoe	Clio Petrol	Clio Diesel	Clio Hybrid
Lowest starting price		30.890,- €	13.890,- €	-	21.840,- €
Highest starting price		38.690,- €	23.340,- €	-	27.990,- €

Tabell 2 Price comparison Renault Zoe/Clio (prizes correct at time of writing)

It is to be mentioned that Renault does not offer a diesel engine for their Clio as well as they do not have leasing offers. However, the same results as above. The electric vehicles are significantly more expensive than the petrol-powered cars.

2.1.2 Purchase costs in Czech Republic

For Czech Republic we decided to compareⁱ two versions (conventional and hybrid) of Škoda Octavia as it is the bestselling Škoda car. The purchase prices are **831 900 CZK for OCTAVIA iV** which is a PHEV and **493 900 CZK for OCTAVIA** which is a conventional combustion engine car.

2.1.3 Purchase subsidies

There are a variety reasons for the higher price for electric cars. The obvious reason is the enormous cost for the batteries. Moreover, a lot of money was spent developing those which also adds to the price. However, most of the time EVs have more special features included in their starting price. Therefore, a conventional car with the same specifications would be closer to the EV-price. But it is to be said, that this is only a relatively small part of the price. Another thing which lowers the price of EVs more significantly are subsidies. In many countries electric cars are getting subsidies so that they can compete to their internal combustion engine (ICE) cars. In Austria you get 5000€ for an electric car and 12.500€ for a transporter¹. In Czech Republic there are no subsidies for electric cars at this momentⁱⁱ. This raises the question if those control mechanisms of the market work. This can be easily answered by looking at car registrations in Norway.

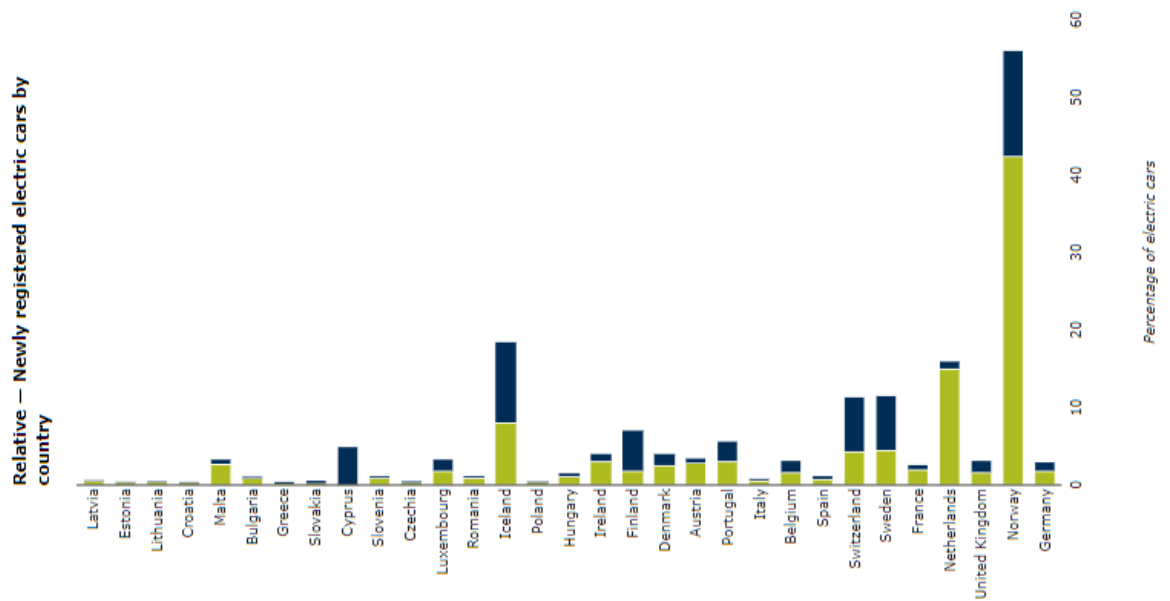


Figure 1 EV registration by country ²

This is a statistic from 2018 but Norway is still leader in EV-registration. It shows well that subsidies are a good approach to make people buy electric cars. It is to be said that Norway has a very high tax on imported cars. However, EVs are exempt from this taxation. This is a bit different approach but leads to the result that electric vehicles are not more expensive than an ICE-car. As a result, people purchase more EVs. Therefore, it can be assumed that when EVs cost about as much as conventional cars more people will decide to buy electric vehicles. This can also be seen in the statistic of registered cars in Austria.

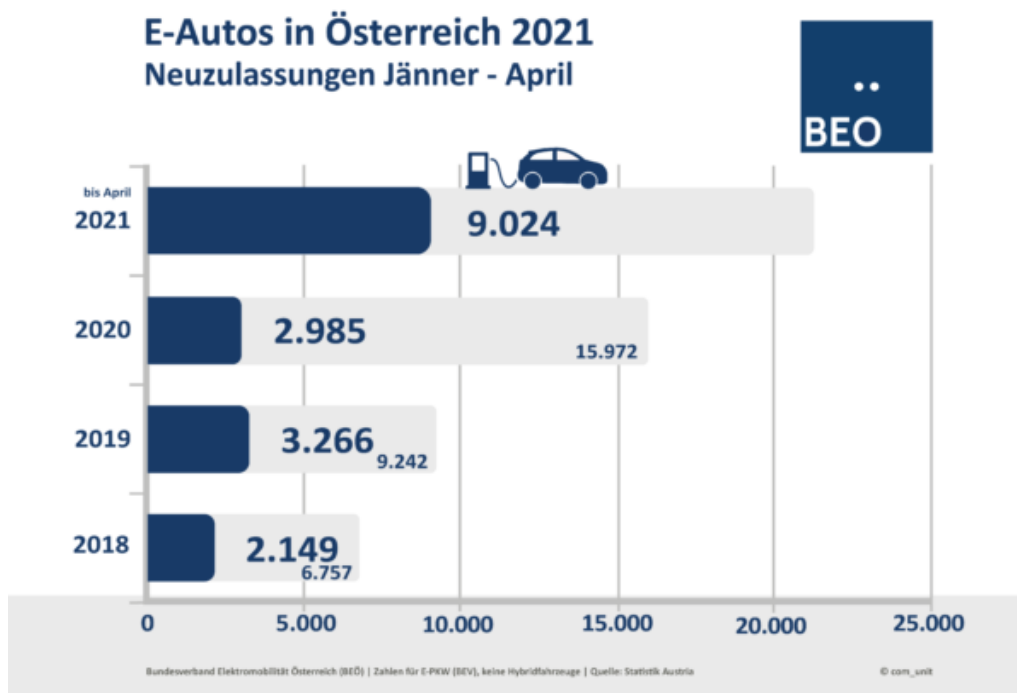


Figure 2 newly registered EVs in Austria³

Description: The headline reads “electric vehicles in Austria 2021 – new registrations January – April”. The plot shows the amount of EVs registered from January to April in different years.

As electric vehicles are getting cheaper and better in terms of range, there are more registrations. In this plot the period under review is not the whole year but January to April of each listed year. This allows to give numbers of 2021 as well.

However, you do not just purchase a car you also have to pay taxes, insurance, maintenance, and fuel costs. These costs will be discussed in the following starting with the fuel costs

2.2 Fuel costs

Fuel costs are very different across the world. The costs are highly dependable from subsidies and production costs. Especially fossil fuels are subject to price fluctuations. As electric energy can be produced more predictable, and the price is rather stable. There are more types of fuels than electricity, petrol, or diesel. To mention all of them with their price would go beyond the scope of this paper. Therefore, the focus will be placed on petrol, diesel, and electricity.

2.2.1 Fuel costs in Austria

Austria is famous for their low prices on fossil fuels especially diesel. The reason is that diesel still gets high subsidies in Austria beside the environmental pollution. The average pricing after taxes in the year 2020 for petrol, diesel and electric energy is listed in the following table.

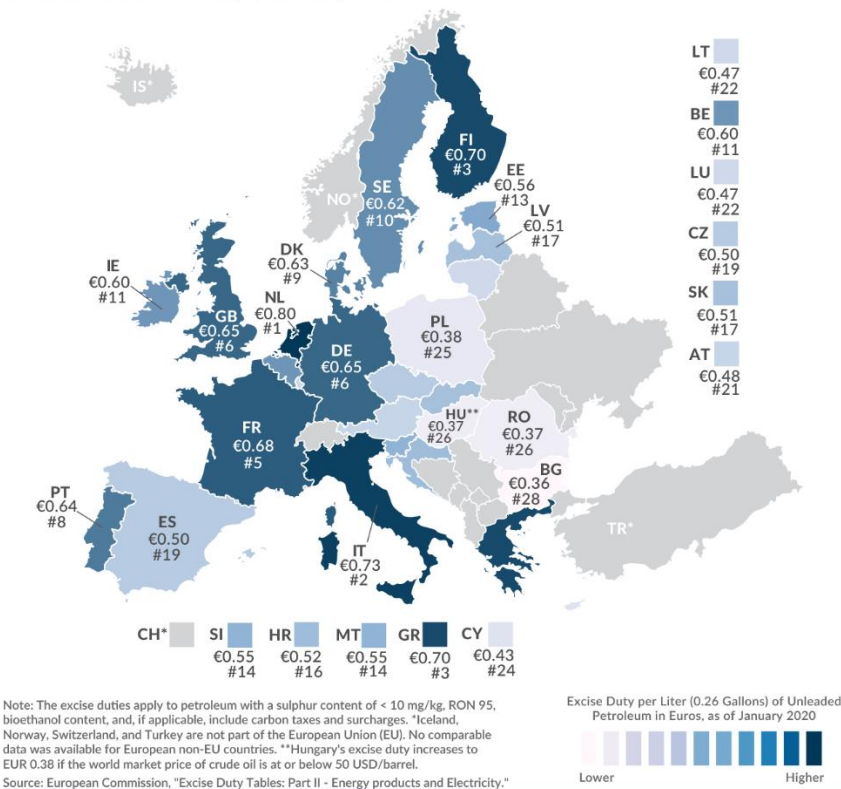
Fuel type	Taxes	Price after taxation
Diesel (commercial)	0,41€/l	0,88€/l
Diesel (private)	0,58€/l	1,05€/l
Petrol (commercial) (95 Oct)	0,49€/l	0,9€/l
Petrol (private) (95 Oct)	0,67€/l	1,08€/l
Electric Energy (industry)	0,027€/kWh	0,104€/kWh
Electric Energy (private)	0,073€/kWh	0,204€/kWh

Tabell 3 fuel costs 2020 by type⁴

To point out how cheap this is it will be compared to the prices for fossil fuels in other countries.

Gas Taxes in Europe

Excise Duty per Liter (0.26 Gallons) of Unleaded Petroleum in Euros, as of January 2020



TAX FOUNDATION

@TaxFoundation

Figure 3 Petrol taxes across Europe⁶

The map shows the different taxation on petrol across Europe. It shows that Austria has one of the lowest taxes on gasoline. Furthermore, the taxes in Austria and Czech Republic are about equal. The tax is sufficient to give an overview over the fuel prices as the cost per litre comes from the producer and therefore are similar. That means that the price difference is mainly determined by the taxes.

2.2.2 Fuel costs in Czech Republic

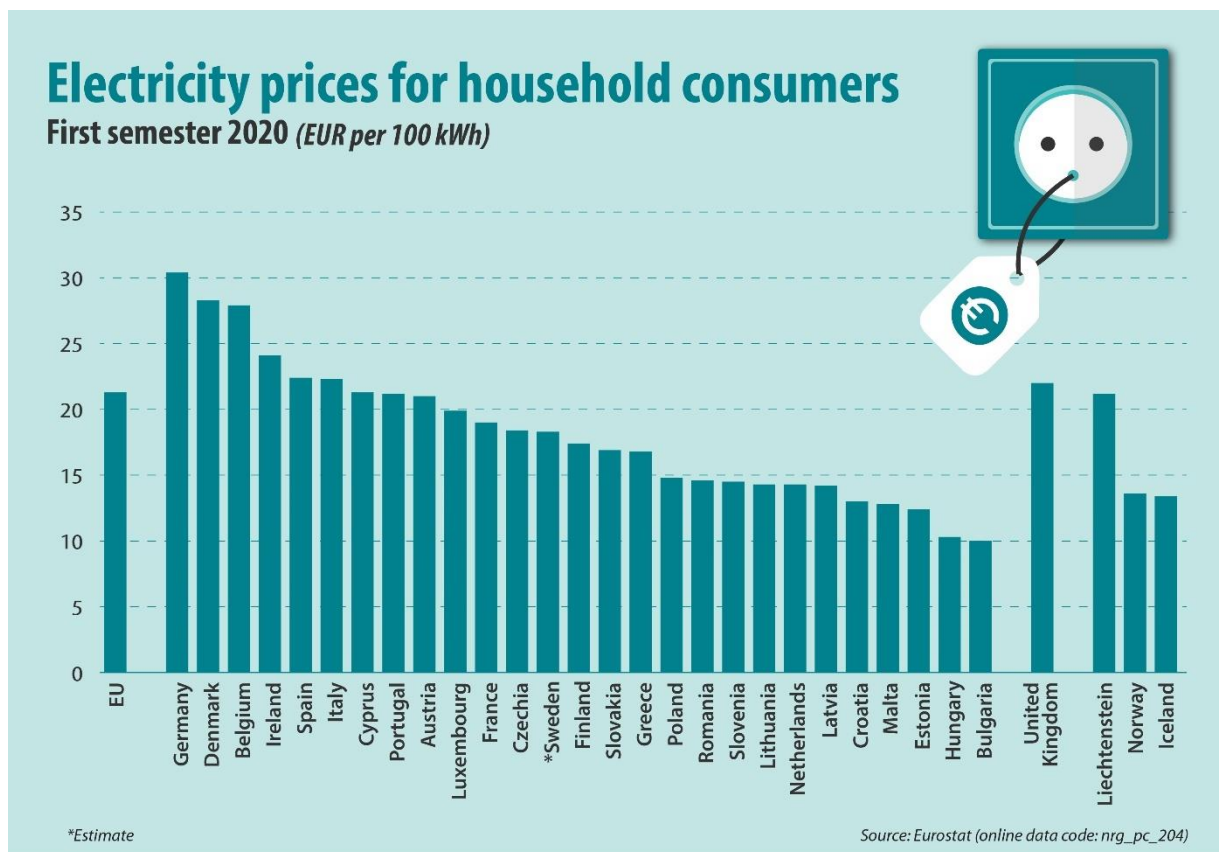
In the following table we can see the average prices of different fuels in Czech Republic in the year 2020.ⁱⁱⁱ

Fuel type	Price CZK/l(kWh)	Price EUR/l(kWh)
Diesel	31.70	1.25
Petrol (95 Oct)	31.93	1.26
Electricity	4.88	0.19

As can be seen, the prices for diesel and petrol are significantly higher in Czech Republic than in Austria, but the prices for electricity are about the same.

2.2.3 Fuel costs in Europe

For the sake of completeness, electricity prizes will be compared across Europe. There are a few differences between the costs of each country. However, the differences are much smaller compared to the fossil fuels. The prizes in the following visualisation is for household consumers in the first Semester of 2020.



ec.europa.eu/eurostat

Figure 4 Electricity prices for household consumers ⁷

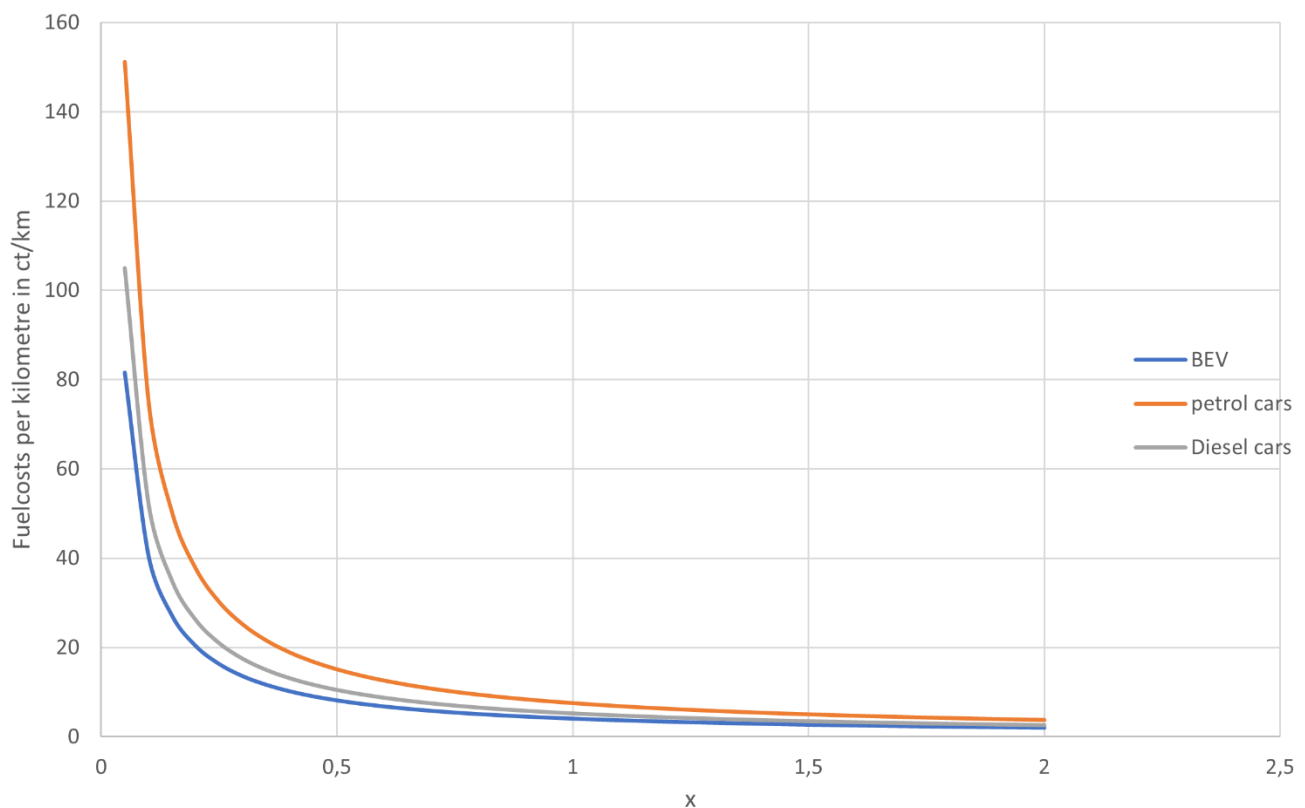
The price for electricity is the highest in Germany with approximately 30ct/kWh. Austria meets the average of the EU at circa 22ct/kWh. As mentioned before the variation of the

price is much smaller compared to fossil fuels. The difference between the highest and the lowest electricity costs is about 20ct/kWh whereas the difference between the highest and the lowest gasoline tax is about 44ct/l.

It seems that electricity is much cheaper than fossil fuels. However, the comparison is not quite easy as the types of fuels have different units. To compare them you could either calculate the amount of energy contained in one litre of fossil fuel and compare the price directly. The disadvantage of this method is, that an electric car has a much higher efficiency compared to ICE cars. So, to compare the fuel costs of conventional cars and EVs it is useful to look at the average power consumption of each car per kilometre and divide it by the fuel cost. Then you can compare the fuel costs per kilometre which allows a precise statement about the fuel costs of the cars. To make that another figure is needed. The average consumption of a car.

2.2.3 Fuel costs comparison for Austria

Cost per kilometre by fuel type



In this plot the fuel costs per kilometre are plotted. For the calculation an average consumption per 100 km was assumed and is divided by the x axis. That means that the average consumption at the point 0.5 is doubled.

$$\text{Fuelcosts per km} = \frac{\text{avarage consumption per 100km}}{100 x} \cdot \text{avarage costs per unit of fuel}$$

x ... Value of the x – Axis unit 1

avarage costs per unit of fuel ... costs of 1 Litre gasoline or 1kWh electricity

The choice of the average consumption is not too crucial because the values are spread by the division over the x-value. Following values were assumed for the average consumption:

Fuel type	Assumed average consumption
Electricity	20kWh/100km
Petrol	7l/100km
Diesel	5l/100km

As mentioned, the exact figure is not very important. However, the figures should be representative values of each fuel type and they must be comparable. That means, it has no point to compare the costs of a petrol car that has an average consumption of 20l/100km to a diesel car that needs 4l/100km. These values were approximated and should be a real-world fuel consumption representative for each type.

With this method different fuel types can be compared. It is obvious that the electric car has the lowest fuel costs per kilometre. The difference is smaller as the consumption lowers. Especially the diesel curve comes close to the EV curve. Nevertheless, even with the cheap diesel and the rather expensive electricity in Austria the fuel costs of electric vehicles are lower. This can be further enhanced by charging with own power, for example by household photovoltaic power plants.

2.2.5 Fuel costs comparison for Czech Republic

Fuel consumptions for different types of engines in Škoda can be seen in the table^{iv}:

Engine type	Fuel consumption l/100km	Fuel consumption kWh/100km
Diesel	4.1	0
Petrol	5.1	0
PHEV	1*	13.8

Source: OCTAVIA and OCTAVIA iV on the website of Škoda: <https://www.skoda-auto.cz/modely/octavia/octavia> and <https://www.skoda-auto.cz/modely/octavia/octavia-iv>

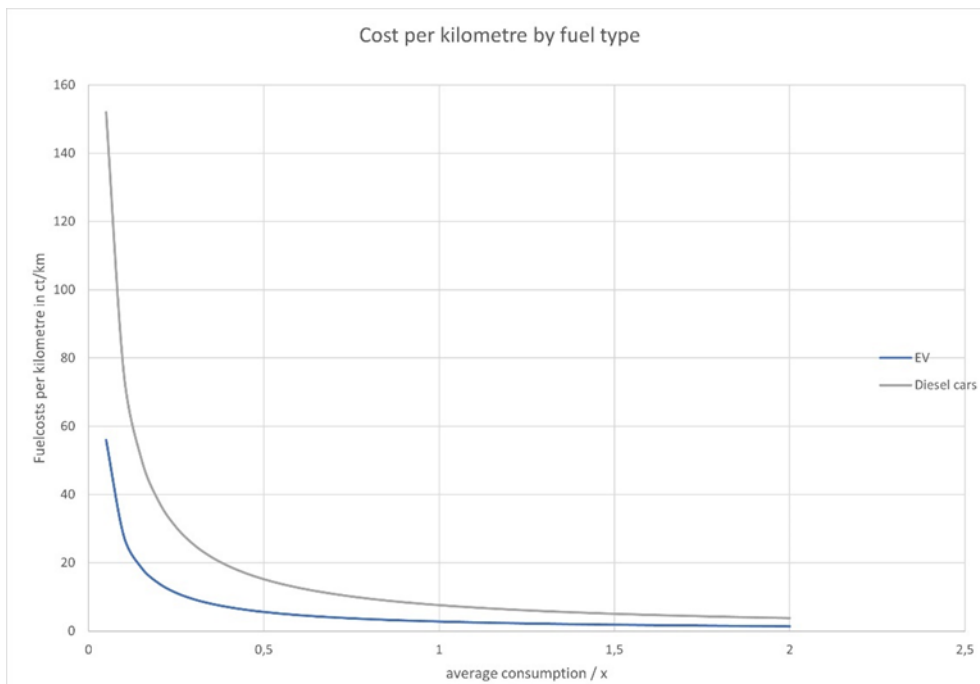
*PHEV consumes about a litre of Petrol for 100km

From this table and the one of prices of fuels in Czech Republic we can get the average price of fuel for 100 km in different cars in Czech Republic.

Engine type	Price of fuel in CZK/100km	Price of fuel in EUR/100km
Diesel	129.98	5.13
Petrol	162.84	6.42
PHEV	99.27	3.91

2.2.6 Fuel costs comparison for Europe

In most countries the costs for diesel are higher than Austria. For example, Norway. There one litre of diesel costs 1,52€⁸ while the electricity costs about approximately 14ct/kWh.



This plot shows the fuel costs per kilometre for electric vehicles and diesel cars in Norway. The parameters of the calculation are the same as above except the fuel costs. It is obvious that the EV is significantly cheaper in terms of fuel costs than the diesel car. This may be another reason why EVs are so much more popular in Norway than elsewhere in Europe. But as mentioned above, the main reason why Norwegians is the fact that electric vehicles are not more expensive than ICE cars. This is achieved by exempting EVs from taxation. This leads to another important point.

2.3 Taxes

Taxes differ heavily within Europe and are an important factor when buying a car. Taxes have a great share on vehicle costs. Not only running costs but also add to the purchase costs. There is a variety of different taxes which can be applied on vehicles. For example, import taxes, environmental taxes, value add tax (VAT) etc. In the following the taxes that add the most to the costs of vehicles in Austria and Czech Republic are discussed.

2.3.1 Taxes in Austria

The first tax in Austria you must pay for a car is the so-called NoVA (Normverbrauchs Abgabe -> Standard consumption tax). This tax is applied when buying or importing a car. It adds a certain amount of the purchase price to the full price depending on CO2 emission as claimed by the manufacturer. The maximum tax rate is 50%. This means that the purchase price is increased by the factor 1.5. Excluded from this tax are, among others, electric vehicles. This tax can be very high, but this is mostly for small transporter. For most cars, the NoVA is under 25%, however rates around 25% are already for sports cars like the BMW M4 which has claimed CO2 emissions of 241-235g/km which is still very high. Another problem about this tax is, that diesel cars have lower CO2 emissions than petrol cars. Nevertheless, they produce more greenhouse gases, just other greenhouse gases. So for example the NoVA rate for an Audi S7 with a 6 cylinder diesel engine and 344hp would only be 15%. For a normal sized diesel car like a Seat Leon with a 2-litre diesel engine the NoVA actually drops completely.⁹

After a car is bought the so called KFZ (motor vehicle) tax. The tax is to be paid regularly and is contained in the insurance. Other than the NoVA the amount of the tax can be easily calculated by a simple formula:

$$M = (P - 64) \times 0,72 + (E - 112) \times 0,72$$

P ... Power of the car in Kilowatts

E ... CO2 emissions of the car as claimed by the manufacturer

M ... monthly amount in Euro

There is a tax-free amount of power and CO2 emissions for a car. This formula was introduced in January 2021 and should charge those more who produce more CO2 emissions. Before that the KFZ tax was only based on the power of the car. Again, electric vehicles are exempted from that tax. Furthermore, diesel cars are also taxed lower due to their lower CO2 emission.¹⁰

Concluding it is obvious that electric cars are cheaper in taxation just like in Norway. This raises the question why there are not as much EVs in other countries. The example in Austria shows, that while EVs are tax free, the taxation on diesel cars is not high mainly due to their lower CO2 emissions.

2.3.2 Taxes in Czech Republic

In Czech Republic you must pay taxes for cars with conventional combustion engine but not for electric cars. The amount you must pay is given by this table:

Volume of the engine in cm ³	Yearly tax in CZK	Yearly tax in EUR
< 800	1200	47.32
801 - 1250	1800	70.98
1251 - 1500	2400	94.64

1501 - 2000	3000	118.30
2001 - 3000	3600	141.96
> 3000	4200	165.62

Source: <https://money.cz/novinky-a-tipy/dane/silnicni-dan-kdy-ji-musite-platit-a-jak-se-pocita/>

You also get a discount for the tax for first 9 years after the registration of the car. The discount is 48 % for first 3 years, 40 % for the next 3 years and 25 % for the last 3 years.

Škoda OCTAVIA has a engine volume of 2 000 cm³ so you must pay 3 000 CZK minus the discount each year.

Another topic to be discussed is the maintenance of different cars.

2.4 Maintenance

Maintenance costs are hard to compare. They do not only differ between the countries, but also between manufacturer, service provider and region. Therefore, it makes no sense to compare the price. However, the maintenance costs can have a big share of the vehicle costs.

The amount of maintenance needed is dependent on different things like how many parts, especially moving parts, a vehicle has, wear of certain parts like breaks or the consumption of oil or other fluids. So, a car that has less parts, less fluids and less wear the maintenance costs will decrease.

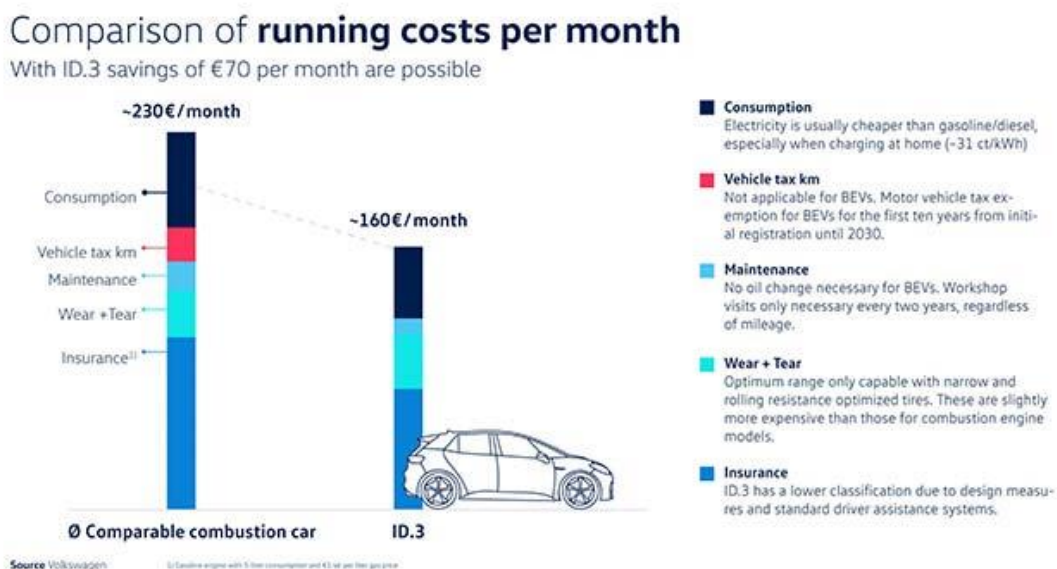


Figure 5 comparison of running costs per month in Germany¹¹

The figure shows the approximated monthly costs of a conventional car and an electric vehicle in Germany, but the general need of maintenance is independent from taxes or subsidies. It shows that the maintenance cost, beside others, are significantly lower by an electric car. This is because EVs have a lot fewer moving part. Moreover, they do not need oil for their engines or gearboxes. While their tires normally use off quicker due to their

heavier weight, the breaks last much longer. This is because EVs mostly use their eddy current break. As this break uses the principle of electro-magnetic induction, it has no mechanical contact. Furthermore, you can recharge your battery while decelerating. The mechanical break is mostly used in emergency situations therefore they are not used often. Concluding it can be said, that EV are cheaper to maintain. Conventional cars need oil changes and have more movable parts and filters. Electric vehicles have a lot less to take care off and therefore are cheaper to maintain.

Estimation for the yearly maintenance cost are 3000 CZK for third party insurance and about 10 000 CZK for service of which about 1500 CZK are the cost of the change of oil. That gives us an estimation of 13 000 CZK (about 500 EUR) yearly for a combustion car and 11 500 CZK (450 EUR) yearly for an electric car.

3. ECONOMICS CALCULATIONS

Here is the Net Present Value (NPV) calculated from our data for Czech Republic. We considered the cars to drive 13 000 km each year. We calculated with the value of our rate of interest as 4 % and estimated that we will use these cars for 15 years.

$$NPV = \sum_{k=0}^n \frac{CF_k}{(1+i)^k}$$

CF_k ... Cash flow in the k^{th} year

i ... rate of interest

Car type	Diesel	Electric	Diesel	Electric
Purchasing cost	493 900 Kč	831 900 Kč	19 476 €	32 804 €
Fuel cost [CZK/yr.]	16 898 Kč	12 905 Kč	666 €	509 €
Maintance cost	13 000 Kč	11 500 Kč	513 €	453 €
Tax*	3 000 Kč	- Kč	118 €	- €
Years of usege	15	15	15	15
NPV	- 865 353 Kč	- 1 114 103 Kč	- 34 123 €	- 43 932 €

* The tax is lowered in the first 9 years.

We can see that the car which uses diesel as its fuel is economically wiser and the difference in the first 15 years is almost 10 thousand Euros. On the other hand the electric car produces less CO₂.

4. CONCLUSION

Looking at the NPV, a EV is not able to compete against conventional cars. The technology is just too expensive right now. The main problem is the purchase price mainly because of the expansive batteries. Not only are they expensive but they also cause pollution and are often mined in poor countries under poor conditions. However, the battery technology is progressing and there are different approaches that do not need rare earths like lithium. Furthermore, these technologies promise higher range at higher charging powers. Therefore, it can be expected, that EVs will get better, cheaper, and even more environmentally friendly.

On the other side, in Austria, there are high subsidies for diesel fuel and taxation on diesel cars are low. It seems ridiculous considering that Germany bans diesel cars from their cities because of their high pollution but Austria still makes people buy diesel cars. It is not sufficient to exempt electric vehicles from taxes while the taxes on diesels are low. These subsidies cost the state a lot of money while impeding investments in new technology and therefore proceeding in a better future.

Looking at Norway, it is obvious what a country can do to raise the amount of EVs. It must make the purchase price for internal combustion engines and electric vehicles about equal. Then many people will choose the EV over the conventional cars. This can either be made by raising the taxes on non-electric vehicles or by subsidizing electric vehicles. When subsidizing it is important that it really closes the gap between conventional cars and electric vehicles.

Electric vehicles have a lot of advantages over ICE cars and therefore they will prevail as soon as the technology is advanced enough that the purchase price is marketable. Till this point is reached the state must get involved to make them a real alternative for ICE cars.

REFERENCES

- ¹ "Bundesverband Elektromobilität Österreich" <https://www.beoe.at/aktionspaket-e-mobilitaet/>
- ² European Environment Agency
<https://www.eea.europa.eu/data-and-maps/indicators/proportion-of-vehicle-fleet-meeting-5/assessment>
- ³ „Bundesverband Elektromobilität Österreich“ „E-cars new registration in Austria January to April”
<https://www.beoe.at/statistik/>
- ⁴ Data from „Statistik Austria“
http://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/energie_und_umwelt/energie/preise_steuern/125551.html
- ⁵ "Statista" "Comparison of consumer prices for diesel fuel in EU member states with and without taxes in May 2021"
<https://de.statista.com/statistik/daten/studie/239043/umfrage/verbraucherpreise-fuer-dieselmotorkraftstoff-in-ausgewaehlten-laendern-der-eu/>
- ⁶ "Taxfoundation" July 9, 2020
<https://taxfoundation.org/gas-taxes-in-europe-2020/>
- ⁷ "Eurostat" 24/11/2020
<https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20201124-1>
- ⁸ Source: <https://www.adac.de/reise-freizeit/reiseplanung/reiseziele/norwegen/uebersicht/kraftstoffpreise/>
- ⁹ Nova general: ÖAMTC (Austrian automobility club)
<https://www.oeamtc.at/thema/steuern-abgaben/nova-normverbrauchsabgabe-18177294>
Car prizes and specific NoVA rates: Manufacturer sites
- ¹⁰ KFZ tax general: <https://www.finanz.at/steuern/kfz-steuer/#:~:text=Die%20KFZ%2DSteuer%20oder%20motorbezogene,Euro%20je%20Fahrzeug%20nicht%20%C3%BCberschreiten.>
- ¹¹ <https://electriccarsreport.com/2020/03/the-big-cost-comparison-electric-car-vs-ice/>

ⁱ Source: OCTAVIA and OCTAVIA iV on the website of Škoda: <https://www.skoda-auto.cz/modely/octavia/octavia> and <https://www.skoda-auto.cz/modely/octavia/octavia-iv>

ⁱⁱ Source: <https://elektrickevozy.cz/clanky/dotace-na-elektromobily-v-roce-2021-v-cr-pravdepodobne-nebudou>

ⁱⁱⁱ Source: Czech administration of statistics Tab. 8 Průměrné ceny pohonných hmot za jednotlivé měsíce roku 2019 a 2020
<https://www.czso.cz/documents/10180/123242678/012018200208.pdf/b1d9779f-c4d4-4793-82d2-bf28c7047b72?version=1.0>

^{iv} Source: OCTAVIA and OCTAVIA iV on the website of Škoda: <https://www.skoda-auto.cz/modely/octavia/octavia> and <https://www.skoda-auto.cz/modely/octavia/octavia-iv>