Electromobility – What does it mean for me?

The facts for today and tomorrow
Contents

THE CITY OF TODAY ...........................................................................................................................................................................4

INTRODUCTION
Why electromobility anyway? .................................................................................................................................................................6

1 THE CITY AS A PLACE TO LIVE
More electric vehicles – More quality of life? ................................................................................................................................................8

2 EFFICIENCY AND COSTS
Is it worthwhile running an electric vehicle? .............................................................................................................................................10

3 CLIMATE AND RENEWABLE ENERGIES
Is electromobility really climate-friendly? ..............................................................................................................................................12

4 RESOURCE BALANCE
What resources do electric vehicles require? ...........................................................................................................................................14

5 ELECTRICITY DEMAND AND GRIDS
Can the grid cope with electromobility? ..................................................................................................................................................16

6 NOT JUST CARS
Cars will be electric – Is that enough? ......................................................................................................................................................18

7 COMPETITIVE MARKET
What does electromobility mean for our economy? .....................................................................................................................................20

THE CITY OF TOMORROW ........................................................................................................................................................................22

FURTHER INFORMATION ON THE INTERNET ........................................................................................................................................24

LIST OF ABBREVIATIONS ...........................................................................................................................................................................25
The city of today

Traffic congestion, noise and bad air. Every day road traffic is reaching its limits. This is detrimental to the environment, health and quality of life. How can mobility change? And what role does electromobility have? We want to answer these questions according to seven core themes. We then show how the city of tomorrow might look, different to the current-day scenes depicted here.
ELECTROMOBILITY – WHAT DOES IT MEAN FOR ME?

1. Climate and renewable energies
2. Resource balance
3. Electricity demand and grids
4. Not just cars
5. Competitive market

The city of today
How will we get around in the future?

Attitudes towards cars are changing in urban communities. Some feel that their cars are becoming more of a burden. People want individual mobility but they want it to be flexible, efficient, accessible and with an awareness of the environment and the body. To give up car ownership does not mean being less mobile but rather being mobile in other ways. Flexible mobility requires a smooth functioning network of pedestrian and cycle ways, public transport systems and car and ridesharing services. This is best achieved by public and private providers working together, which they are already doing in Hamburg, Munich and Bremen. The campaign Zeit für #mobilwandel (time for a #mobility transformation) by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU), shows how environmentally friendly, healthier and less stressful mobility can look.

Cities are especially suited to combining different modes of transport according to need. Living on the outskirts of cities or in rural areas usually makes car ownership essential for commuting or shopping trips, for example. Rail and inland waterways are also limited in how far they can take up the growing volume of goods traffic. Getting goods from warehouse to recipient is normally only possible by motorised road vehicles. Care services, manual craft trades and cleaning services are also usually dependent on vehicles.

Effective climate and environmental protection targets can be achieved only when road traffic makes a major contribution (see Figure 1). Road traffic is where the majority of transport-related carbon dioxide (CO₂), air pollutants and noise emissions are generated. The growth in traffic therefore needs to be countered. But most people don’t want to be less mobile so relying solely on traffic avoidance, short distances and bicycles will not be enough. Road traffic therefore needs to become more environmentally friendly and have a reduced negative impact on climate and health: to achieve a better quality of life in the city of tomorrow. Vehicles will continue to be a necessity but they do not need to be powered by fossil fuels. Electric vehicles are emission-free and quieter than conventional vehicles, with an overall more friendly climate and environment balance. Based on today’s German electricity mix, electric cars already have a better climate balance than petrol and diesel vehicles. By using 100 percent...
renewable energy sources, almost climate-neutral operation is possible.

Are there alternatives to electric vehicles?
Yes, there are. Hydrogen and fuel cell vehicles, for example. And there are also synthetic fuels based on electricity from renewable energies (power-to-liquid/power-to-gas, PtL/PtG or e-fuels for short). These could even make petrol and diesel CO₂-neutral in the future.

To assess how much electric or the alternatives contribute to climate protection means comparing the energy required in each case. And electric vehicles do significantly better here. PtL and PtG as well as hydrogen require several conversion steps until electricity becomes liquid fuel or gas. This has an impact on costs and the number of facilities needed to generate electricity (for example, wind turbines). Electricity is directly used by electric vehicles. PtL and PtG are also more energy-intensive in operation because they still need combustion engines which are much less efficient than electric and also emit air pollutants.

Figure 1: Greenhouse gas emissions since 1990: Emissions have risen only in the transport sector

<table>
<thead>
<tr>
<th>Year</th>
<th>Transport</th>
<th>Agriculture</th>
<th>Energy</th>
<th>Households</th>
<th>Industry</th>
<th>Trade, commerce, services</th>
<th>Waste, sewage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>-5 %</td>
<td>-20 %</td>
<td>-30 %</td>
<td>-31 %</td>
<td>-32 %</td>
<td>-50 %</td>
<td>-71 %</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Own portrayal based on data from the Federal Environment Agency 2018

Index: 1990 = 100
Air pollutants, especially nitrogen oxides, are a pressing problem associated with the growth in road traffic. The increasing methods of exhaust-gas aftertreatment are still not alleviating the problem. Traffic noise is also increasing even though modern combustion engines are quieter than 20 years ago. What type of vehicle is truly environmentally friendly? The ecobalance gives an answer. This takes into account not only local emissions but also a product’s entire life cycle. Another important aspect of the ecobalance is its use of realistic consumption data rather than the information and brochures from manufacturers.

What does the ecobalance indicate?

Let’s look first at the air pollutants particulate matter (PM) and nitrogen oxides ($\text{NO}_x$). There is no disputing that e-vehicles are better here, and even more so when compared with diesel rather than with petrol vehicles. But it is worthwhile taking a closer look at a vehicle’s manufacture and its fuel, for example electricity. Generating electricity for electric vehicles does not cause especially high particulate matter or nitrogen oxide emissions. This is so even when the electricity comes from fossil fuels because coal-fired
power plants use state-of-the-art exhaust gas purification technology. However, manufacturing cars – both electric and combustion-engine vehicles – contributes significantly to air pollution. Excessive fine dust is generated especially from steel production. Even though production is usually decentralised and not highly relevant to the health of the majority of the population, air pollutants can still harm the environment. Figure 2 shows a comparison of NO\textsubscript{X} emissions over the entire life cycle of a vehicle.

**Artificial sound (AVAS) for electric cars**

Electric cars are quiet and hard to notice. From 2019, an EU regulation therefore requires artificial noises (Acoustic Vehicle Alert Systems, AVAS) to warn pedestrians.

**Noise levels determined by speed**

The actual levels of noise reduction is also a much discussed aspect of electromobility. Electric motors are much quieter than combustion engines. However, it is not only the engine that we hear on roads but also the rolling of the tyres and, at high speeds, aerodynamic noise. Electric and combustion cars are on an equal level in these respects, but with a few differences: Car rolling noise only has an effect from about 25 kilometres per hour (km/h). When driving slowly or when pulling away, the main source of noise is the engine. Electric cars are therefore much quieter in low-speed areas (for example, residential areas) or when pulling away from junctions or traffic lights. Electric power offers major benefits to commercial vehicles such as buses, refuse collection vehicles and snowploughs. Across all urban-traffic speed ranges, electric vehicles are significantly quieter for such vehicles, as well as for mopeds and motorcycles.
Is it worthwhile running an electric vehicle?

Efficiency and costs

The current purchase price of vehicle powered only by electric is generally significantly more than its counterpart with a combustion engine. This is primarily due to battery costs. Is purchasing still worthwhile? The “inner values” of an electric car shine a light into the darkness.

Little energy for lots of kilometres

Engine efficiency is best compared using the energy conversion efficiency ratio. This shows how much of the energy supplied gets converted into vehicle motion. A petrol engine is only a good 20 percent efficient. More than three quarters of the energy within the fuel is therefore not used for motion. The energy is mainly lost as heat. If the energy loss in supplying the fuel, for example going from the borehole to the vehicle tank, is also taken into account, then less than one fifth of the energy is actually used.

Electric engines are different. They convert around 80 percent of the supplied energy into motion. Taking into account losses incurred in charging the battery and providing power, efficiency is still 64 percent. The electric car is thus around three times more efficient than a vehicle with a conventional combustion engine. And it wins also in direct comparisons with hydrogen-fuelled vehicles which convert the hydrogen into kinetic energy using a fuel cell. These vehicles achieve efficiency of around only 27 percent when taking into account the still relatively high cost of producing hydrogen. Figure 3 shows a comparison of the efficiencies.

Electric vehicles save you money now

The initial investment in an electric vehicle is quite large. But you then save when driving because electricity is cheaper than fuel from petrol stations. Experience has also shown that replacing worn parts and servicing are also lower in electric vehicles. The bottom line is that electric cars are often worthwhile already today. And the benefits increase the more kilometres are driven. Why are the purchase costs for electric vehicles so high today compared to conventional vehicles? As with many new
CO$_2$-free delivery

Companies with larger vehicle fleets often find it easier than private individuals to convert a share of their vehicles to electric. This is making them pioneers of electromobility. In a CO$_2$-free delivery project sponsored by the BMU, Deutsche Post DHL is using 2,000 Streetscoters in a large-scale test fleet. These electric commercial vehicles have been developed according to the needs of the delivery company. The logistics group plans to replace its delivery fleet with electric vehicles over the medium term.

www.erneuerbar-mobil.de/projekte/co2-freie-zustellung (in German only)

But this is soon to change. In recent years, purchase costs have gone down significantly faster than expected – a trend that is to continue making the financial balance for buyers increasingly positive.

Energy conversion efficiency shows how much of the supplied energy gets converted into vehicle motion. Primary energy from renewable energies is assumed for electricity. On the right is the proportion of energy that is actually used for motion. On the left is the proportion of energy that is lost along the way from the energy source to the car (well-to-wheel).

Figures from Agora Verkehrswende and Öko-Institut, 2017
Electric driving is only as clean as the electricity it uses. Electric vehicles emit no carbon dioxide (CO\textsubscript{2}) on the road but their energy balance is only fully CO\textsubscript{2}-free when they run exclusively on electricity from renewable energy sources. Assessing the climate friendliness of electric vehicles therefore needs to include not only the actual driving but also the supply of electricity – that is the output from power stations – and the vehicle's manufacture. This of course applies also to combustion-engine vehicles with the supply of fuel being measured from the borehole to the filling station.

Figure 4 compares the impact on the climate of the different vehicle types based on the German electricity mix. The graph shows that an electric car purchased today performs better from a climate point of view than a combustion-engine vehicle. This applies at the current German electricity mix and when, as in this example, the comparison is made against very economical combustion engines.

What impact is Germany's “Energy Transition” having?

For petrol or diesel vehicles, the greenhouse gas emissions are largely known. For electric vehicles, developments in the electricity sector are having a major impact on such emissions. If the electricity mix becomes greener, electric cars become cleaner. An electric car purchased today, for example, will not use the 2019 electricity mix for its entire service life, but automatically

It is important to take an holistic approach to this question because for climate issues – unlike for air pollution – it is not important where the greenhouse gases originate but rather how large these emissions are overall. This section therefore focuses on the overall ecobalance, using as an example the complete course of energy from the power plant to the charging station.
“participates” in the development of electricity over the coming years. This is evident in the figure 4. A 2025 electric vehicle is further ahead despite the increasing efficiency of the combustion-engine vehicles. The fossil fuel ecobalance may also deteriorate in future, for example, from increased tar-sand mining and fracking.

Old engine, new fuel – An alternative?

Yes. Sustainable biofuels can be used. But land for the required production is limited. Fuels can also be produced synthetically from electricity. However, such power-to-liquids (PtL) or e-fuels require significantly more energy than directly using electricity for electric vehicles (see Section 1) because of the additional conversion steps involved in their production. Producing e-fuels using the German electricity mix means that emissions from coal and other power plants will be further increased. As a result, vehicles using such fuels would not only perform worse than electric cars in terms of climate protection, but would also be significantly more harmful than petrol and diesel. Only by using renewable energy sources would e-fuels be climate-friendly, although less efficient. Therefore, e-fuels make sense only when alternatives are not available, for example for air and sea transport. These sectors urgently require climate-neutral fuels whose development the Federal Government is therefore also supporting.

How climate-friendly are production methods?

For any electricity mix in Europe, an electric car bought today is more climate-friendly than a diesel. A detailed ecobalance of an electric car using electricity from the German electricity mix can be found on the BMU website:

www.bmu.de/en/topics/air-mobility-noise/mobility/general-information/

Figure 4: CO₂ emissions per vehicle-kilometre over the entire life cycle

- Production, maintenance, disposal
- Driving, energy supply

New vehicle 2017
Electric 27% lower emissions than petrol
Electric 16 % lower emissions than diesel

New vehicle 2025
Electric 40 % lower emissions than petrol
Electric 32 % lower emissions than diesel

Source: Own portrayal based on data from the Federal Environment Agency 2017
Electric vehicles require more and different types of raw materials

Two measures are usually used in assessing resource usage: cumulative energy usage; and the cumulative raw material usage. In terms of cumulative energy usage, electric vehicles perform better than combustion-engine vehicles mainly because they require much less energy due to their highly efficient electric engines (see also pages 10/11). According to Agora Verkehrswende, the use of electric vehicles up to 2050 will enable savings of over 1.5 billion tonnes (t) of crude oil. Producing electric vehicles requires more technology-metals than in conventional vehicles. Lithium and cobalt in particular are important raw materials for batteries. Electric motors contain magnets which usually require rare earth metals. Lightweight construction materials are also increasingly being used, such as aluminium and carbon-fibre reinforced plastics, the latter also being used in combustion-engine vehicles. Electric cars use heavier batteries so a lightweight body is particularly advantageous.

Are there enough raw materials?

Recent studies show that even with a rapid worldwide growth in electric vehicles and other electric appliances, the global reserves of raw materials important for electromobility, such as lithium, cobalt and gallium, clearly exceed forecast demand. In the short term,
Research project in battery recycling

In the “Lithorec II” lighthouse project, a consortium of eight well-known companies and two renowned universities have shown how the recycling of lithium-ion batteries can be efficient and economical. At the end of 2015, a full recycling chain was set up on as a pilot. Since 2017, the results of the research project have been implemented by Duesenfeld GmbH in an environmentally friendly recycling process for electric-vehicle batteries.

www.lithorec2.de/index.php/en

However, shortages or price increases may occur, especially for lithium and cobalt (see Figure 5).

The extraction of raw materials is often associated with negative ecological and social impacts. It is therefore important to reduce raw material demand through advances in production, material efficiency and recycling. This trend is already evident in batteries. The German Federal Government is supporting research into the economical utilisation and recovery of raw materials and battery re-use (second life). Batteries are also now available that require much less cobalt. Industry is also becoming increasingly involved in initiatives for the sustainable supply of raw material (responsible mining).

Figure 5: Lithium and cobalt – The basis for many future technologies

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global cobalt reserves*</td>
<td>7 million t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global cobalt resources**</td>
<td>120 million t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of secondary material from recycling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt requirement Li-ion batteries (in t)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global lithium reserves*</td>
<td>14 million t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global lithium resources**</td>
<td>50 million t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of secondary material from recycling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt requirement Li-ion batteries (in t)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Reserves: recorded and technically recoverable
** Resources: known but not yet fully recoverable

Source: Own portrayal based on data from the Initiative Agora Verkehrswende
The spread of electric vehicles will increase demand for electricity in the transport sector. Is there enough electricity from renewable sources for climate-friendly operation? Is the grid able to cope with a large number of electric cars?

First the good news. Even though electromobility is gaining ground faster than planned, there are enough renewable energies available to power the vehicles. If all 45 million passenger cars currently on German roads were to be mainly electric powered, around 100 terawatt hours (TWh) per year would be required. This corresponds to just one sixth of the overall electricity consumed by Germany each year. In 2017, 218 TWh of electricity was generated from renewables, more than twice as much as the demand of a complete electrified vehicle fleet. The expansion of renewable energies is also progressing fast (see Figure 6).

From the grid to the smart grid

However, the future grid needs to be adapted to permit a multitude of electric vehicles to be charged simultaneously. This applies especially to local distribution grids. First and foremost, the grids need to get “smart”. This means that intelligent grid management and storage technologies are used to balance local and temporary grid loads. Only then can the grid be expanded. Development of the electricity grid into a smart grid is already in full swing. Germany’s “Energy Transition” means that electricity supply is becoming more dependent on sun.
and wind and increasingly decentralised, for example as roof-top solar systems. Intelligent network technologies are therefore already indispensable. Electric vehicles that can charge as “flexible electric consumers” can become a stabilizing part of the smart grid in the long term.

Can electromobility cope with the grid?

Controlled charging of electric vehicles works. Demonstrations and field trials have already shown this. This can also help to relieve the grid. In the future, we will just need to instruct our mobile phones to “fully charge the battery at 7 am”. Software will do the rest according to actual electricity supplies and prices.

Electromobility as part of a transformation in transport thus means a stronger link between the electricity and transport sectors. It is the most energy-efficient way of progressing Germany’s “Energy Transition” in transport and thus the way towards climate-friendly and sustainable mobility.

**3E apartment building research project**

In the three-year project, an innovative system consisting of on-site energy generation and electromobility was tested for the first time in an apartment building. At its core was the interlinking of micro combined heat and power units, solar systems, electric vehicles and stationary storage. These was also a link to energy trading markets via an IT platform. Also part of the study was the need to charge vehicle batteries as part of neighbourhood car sharing.

[www.erneuerbar-mobil.de/projekte/3e-mfh](http://www.erneuerbar-mobil.de/projekte/3e-mfh) (in German only)
Electric power is not just an alternative for personal modes of transport. Increasingly more vehicles in the commercial and public transport sectors are being electrically powered. Electric power is also opening up new possibilities for bicycles.

**Clean commercial transport**

Observe the traffic on any busy road and you will notice the high proportion of commercial vehicles. And motorised service providers are growing (see Figure 7). For a variety of reasons, vehicles are essential for nursing services, parcel and food deliveries and city cleaning. If they all drove electrically, enormous gains in quality of life would be achieved. The air would be cleaner, the city quieter and the climate less polluted. The electric motor also makes it worthwhile for some companies to switch to two-wheelers. For example, supported by the BMU, growing numbers of electric cargo bicycles are being used. Even scooters are increasingly being driven electrically. Commercial-transport needs vary depending on the sector. For example, manual craft workers need e-transporters with a specific minimum range for their daily trips, while removal companies require specific loading capacities. Businesses therefore know exactly what is required of their vehicles and can accurately estimate their daily driving distances. This means that electric commercial vehicles can be designed to match needs. The Deutsche Post Streetscooter, for example, shows how this works (see also page 11).

**Heavy goods can also be transported electrically**

The larger and heavier a vehicle, the more difficult it becomes to electrify it. This is because more mass requires more power which then requires larger batteries. Battery technology is constantly evolving and ranges are increasing. Electric commercial vehicles that are heavier and larger than passenger cars can also contribute to environmental and climate protection. Even heavy articulated trucks could be electrically...
Hamburg electric bus demonstration

In 2016 and 2017, the public transport operator Hamburger Hochbahn commissioned three plug-in hybrid buses and three electric buses on its “Innovation Line 109”. The BMU-funded project has delivered important findings into vehicle and charging technology and economic efficiency. Hamburg is also one of the cities that aspires to multi-modal mobility by linking public transport and various sharing services via its “switchh” platform.

www.erneuerbar-mobil.de/projekte/held
(in German only)

powered in the near future. This is important because rail alone cannot cope with the growing volumes of freight transport. The types of goods and time schedules have also changed. Can long-distance heavy goods vehicles take a major leap forward for the environment and climate? At the least they would require batteries and overhead lines on motorways for fast recharging along their routes. This is now being tested in Germany. Three routes in Hesse, Schleswig-Holstein and Baden-Württemberg are currently being equipped with overhead lines. From 2020, the first overhead-line trucks will be used there for routine haulage operations. The overhead line is required only on short sections and functions as a kind of quick charging station without the vehicles having to stop.

Cities converting their bus fleets

In many cities, such as Cologne, Berlin and Hamburg, electric buses are already part of regular services. Their power needs are met by high-speed, occasional charging at bus stops, and by overnight charging in depots. Many German cities want to operate electric-only buses in the near future.

Figure 7: Freight transport performance in million tonne-kilometres (tkm)

- 2010 - 2016 - 2030

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2016</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>154,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>116,164</td>
<td>107,317</td>
<td></td>
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<tr>
<td>2030</td>
<td>607,000</td>
<td>440,600</td>
<td>464,000</td>
</tr>
</tbody>
</table>

Growth up to 2030

43 %

Source: 2010–2016: German Federal Statistical Office
2030: Traffic forecast of the Federal Ministry of Transport and Digital Infrastructure (BMVI), 2014

Not just cars ➤ ELECTROMOBILITY – WHAT DOES IT MEAN FOR ME?
The German automotive and supplier industry currently employs more than 800,000 people. Will these jobs be lost if the share of electric cars increases? Looking into the future shows that for German business, electromobility offers both challenges and opportunities.

**Figure 8: Worldwide new registrations of electric vehicles by manufacturer in 2016**

Source: Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg and Manager Magazin 2016
We often hear that giving up the combustion engine will endanger many jobs. Why? Because electric vehicles have much fewer individual parts? Because they require less maintenance and servicing? But electric vehicles also have chassis, tyres, brakes, doors, electronics, interior fittings and so on.

According to a study conducted by the Fraunhofer Institute for Industrial Engineering IAO on behalf of the IG Metall trade union, some 210,000 of the 840,000 employees in the German automotive industry work on producing powertrains (such as engines, transmissions, fuel tanks, exhausts, etcetera). Of these 210,000, around 75,000 jobs would be lost by 2030 in a probable scenario of the study. However, the loss of around only 20,000 jobs would actually be attributable to electromobility. The others would be due to productivity gains.

**Electromobility also creates new jobs**

Vehicles of the future will increasingly resemble computers on wheels. This offers new opportunities, for example for specialist electronics and IT personnel. Many expect that the future will have many plug-in hybrid vehicles with both internal combustion engines and electric motors. German car manufacturers are among the strongest suppliers of this technology. But according to the Fraunhofer study, this could even be a plus. How many jobs there will be in the automotive industry in Germany in the future is therefore difficult to estimate today. A look at the world market helps here.

**German manufacturers positioning themselves**

More than three quarters of cars produced in Germany go abroad so many jobs depend on foreign trade. Will the market share for German manufacturers decline when the combustion engine disappears? Not necessarily. Germany is already well positioned for the electrically powered future (see Figure 8).

**Quick changeover improves opportunities**

If Germany’s good competitiveness is assured via the future technologies on which global markets rely, then electromobility could, on balance, create even more jobs. IG Metall therefore also sees no reason for concern. “It is a major challenge, but it can be overcome if the right basic conditions are created now”, said IG Metall head Hofmann, commenting on the results of the Fraunhofer study. And a look at the world market shows that if the global trend towards electromobility continues, domestic jobs will be safeguarded not by a defensive approach but by actively being a part of the development.
The city of tomorrow

More cooperation between modes of transport – Lower emissions – Higher quality of life
The city of tomorrow

ELECTROMOBILITY – WHAT DOES IT MEAN FOR ME?
The following links have further information on sustainable mobility, electromobility and support of electromobility by the BMU:

Transport as a topic at the BMU
www.bmu.de/en/topics/air-mobility-noise/mobility/general-information

The “Zeit für #mobilwandel” campaign by the BMU
www.bmu.de/mobilwandel (in German only)

Promoting electromobility by the BMU
www.erneuerbar-mobil.de/en

Transport as a topic at the Federal Environment Agency
www.umweltbundesamt.de/en/topics/transport-noise

The Agora Initiative on a transformation in transport
www.agora-verkehrswende.de/en
### List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACEA</td>
<td>European Automobile Manufacturers Association</td>
</tr>
<tr>
<td>AG</td>
<td>Aktiengesellschaft (public limited company)</td>
</tr>
<tr>
<td>AVAS</td>
<td>Acoustic Vehicle Alerting Systems</td>
</tr>
<tr>
<td>BAIC</td>
<td>Beijing Automotive Industry Holding Company Limited</td>
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<tr>
<td>BMU</td>
<td>Federal Ministry for Environment, Nature Conservation and Nuclear Safety</td>
</tr>
<tr>
<td>BMVI</td>
<td>Federal Ministry of Transport and Digital Infrastructure</td>
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<tr>
<td>BMW</td>
<td>Bayerische Motoren Werke</td>
</tr>
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<td>BMWi</td>
<td>Federal Ministry for Economic Affairs and Energy</td>
</tr>
<tr>
<td>BYD</td>
<td>Build your dreams Company Limited</td>
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<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
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<tr>
<td>RE</td>
<td>Renewable energies</td>
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<tr>
<td>E-</td>
<td>Electro-</td>
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<tr>
<td>E-fuels</td>
<td>Electric fuels</td>
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<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>GmbH</td>
<td>Private limited company</td>
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<tr>
<td>GmbH &amp; Co. KG</td>
<td>Limited partnership with a limited liability company as general partner</td>
</tr>
<tr>
<td>IG Metall</td>
<td>German Metalworkers’ Union</td>
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<tr>
<td>IT</td>
<td>Information technology</td>
</tr>
<tr>
<td>km/h</td>
<td>Kilometres per hour</td>
</tr>
<tr>
<td>m</td>
<td>Million</td>
</tr>
<tr>
<td>mm</td>
<td>Millimetre</td>
</tr>
<tr>
<td>NOₓ</td>
<td>Nitric oxide</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate matter</td>
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<tr>
<td>PtG</td>
<td>Power to Gas</td>
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<tr>
<td>PtL</td>
<td>Power to Liquid</td>
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<tr>
<td>t</td>
<td>Tonne</td>
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<tr>
<td>tkm</td>
<td>Tonne-kilometre</td>
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<tr>
<td>TWh</td>
<td>Terawatt hours</td>
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