R&D Magazine

Vattenfall Research and Development Magazine • No 2, December 2009

THEME:
E-mobility

VATTENFALL

Welcome to the

R&D Magazine

The R&D Magazine is Vattenfall's magazine about research and development within the Group. We want to give a comprehensive view of what Vattenfall is doing within R&D and a deeper view on one theme, to keep the readers up to date on advances in research. The theme for this edition is E-mobility, which is a concept in which the transport sector is fuelled by electricity instead of regular oil-based fuels.

Today, car manufacturers are investing a great deal of money in the development of electric vehicles and a broad range of models and solutions will be on the market in the near future. The reason is that new and better battery technology has created entirely new conditions for the electrification of the transport sector. Concerns about global climate change and the security of the energy supply have also paved the way for a new wave of interest in electric vehicles.

The E-mobility programme at Vattenfall is working to speed up the development and the introduction of electric vehicles on the market. This magazine will give you an insight into the work Vattenfall is pursuing within the programme.

In this edition we have statements from Lars G Josefsson (Vice President and CEO Vattenfall Group) and from Lars Strömberg (Vice President Vattenfall Group R&D) telling us about the connection between R&D and Vattenfall's strategy "making electricity clean" and where we stand right now in our R&D work. We also write about our progress in the development of CCS and, as in the previous issue, we have a news briefing from the different research programmes within R&D.

We hope you will enjoy reading the magazine!

Staffan Görtz is legally responsible for the R&D Magazine.

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WHAT DOES VATTENFALL MEAN BY RESEARCH AND DEVELOPMENT AND WHY DO WE DO IT?

Vattenfall pursues research and development (R&D) as part of the business development of the Group. The aim is to meet the demands of customers, to reduce the environmental impact of our operations, to improve their efficiency and to contribute to our climate vision and "Making electricity clean".

Vattenfall as an energy company and a system builder and operator has little or no competence in the manufacturing or production of technical equipment; instead we define our needs to the manufacturing market. Consequently, we do not develop new hardware or software products. Our ambition is to be an excellent user of technology that is mainly developed by others, notably equipment manufacturers, to provide our customers with clean electricity. To achieve this, we often work together with different suppliers, large and small, from the laboratory stage or in demonstration or pilot projects. In these projects, we develop know-how and provide the operator's perspective on, for example, the usability and maintainability of new systems.

Vattenfall's Group R&D programmes are organized in different areas:

- **Renewables**
- **Operational efficiency**
- **Nuclear energy**
- **Energy efficiency**
- **Carbon capture and storage**
- **New technologies**

Read more about Vattenfall R&D at **www.vattenfall.com**

Crucial support for Vattenfall's strategy

Vattenfall Research & Development provides crucial support for our strategic direction Making electricity clean and should be clearly directed towards that aim. Making electricity clean means that our products shall be seen as something really positive – as ways to reach a better future. Reducing emissions in general is an obvious part, but a strong safety culture and advanced skills in interacting with society are also important.

We have stated that we are going to be climate neutral by 2050 at the latest. A centrepiece is how we handle greenhouse gases, first and foremost carbon dioxide, but we must also make a firm stand on the other greenhouse gases.

Making electricity clean first of all is a core part of our commercial agenda; it is not just an "add-on" contributing to the greening of our operations. Making electricity clean is our way of thinking regarding our use of resources and handling the consequences of what we do.

Making electricity clean means that we have to develop our knowledge and know-how. Research & Development is the first link in a longer chain building our future, providing tools for Business Development and full-scale commercialization. R&D activities in Vattenfall should be clearly focused on supporting our strategic direction with a passion to deliver.

Lars G Josefsson
President and CEO, Vattenfall.

How R&D supports "Making electricity clean"

As described above by Lars G. Josefsson, Vattenfall aims to be climate neutral by 2050. Research and Development (R&D) is an important support and tool in the effort to achieve this. Vattenfall's Head of Group R&D, Lars Strömberg, describes Vattenfall's research and development as follows:

"The strategic orientation "Making electricity clean" governs our activities. Developing a sustainable energy supply system is our highest priority in our R&D programs." he says.

There is already good technology available in the field of bioenergy. Our research focuses instead on how we can use the limited biomass resources in a better way and on how we can improve the availability and use of odd fuels. Our research in the field of wind power focuses on optimising and improving the wind power plants and analysing the problems that exist in order to become the best at owning, operating and maintaining large wind farms. Another renewable source of energy that we are working on is Ocean Energy. This has limited potential and is suitable in only a few places in Europe, but we must make the most of all the opportunities that exist.

Today, the energy supply system around the world is largely based on fossil fuels. Coal accounts for 60 per cent of electricity generation in Germany, 80 per cent in Poland, 40 per cent in the Netherlands, 40 per cent in England, and so on.

"On route to our objectives, that is climate neutrality and, ultimately, the sustainable energy system, we must also ensure in a responsible way that there is enough energy available, but with as little impact on the environment as possible," says Lars Strömberg. It is not realistic to expect that it will be possible to replace the fossil fuels with only renewables over a period of 30 years. This is why we have to work to reduce the carbon dioxide emissions from coal power. We have now come so far in our research that we know that the Carbon Capture and Storage (CCS) technology works well. Within a decade, we will be able to reduce emissions to the air from the coal-fired power stations to almost zero – and I mean all emissions," says Lars Strömberg.

Our way forward is to focus on low-emitting energy generation like CCS, nuclear power and renewable energy sources. We have chosen our route and are now moving forward, convinced that we will achieve our climate objectives and our other environmental objectives while still ensuring security of supply.

Lars Strömberg
Vice President, Vattenfall Group R&D

Vattenfall's engagement in CCS is moving forward

As a future user of the technology we are involved in driving the development of the technology forward and we are also in the lead when it comes to preparing to demonstrate the technology on a commercial scale. We are convinced that CCS will be commercially available by 2020 and have therefore also begun planning for an early commercial deployment. Planning and engineering in the energy sector entails investment cycles of at least 30 to 40 years, which makes this necessary already at this stage.

Since the official launch of the CCS pilot plant at Schwarze Pumpe in Germany on 9 September 2008, the oxyfuel process, one of three methods of carbon dioxide sequestration, has been operating successfully. From the very first day, the expectations of our engineers concerning the concentration of carbon dioxide in the power station boiler were significantly exceeded. Today, the pilot plant is already capable of achieving a capture rate of close to 90 per cent. Our goal is to further increase this rate during our trial period over the next five years. Regardless of the sequestration rate, after further cleaning the carbon dioxide reaches a technical grade degree of purity that is close to 99 per cent.

From the planned launch of the regular research operation in mid-November until the beginning of transport to the Altmark in April, Vattenfall has different options for using the captured CO_2. Various companies in the chemical and food industries have expressed interest. Additionally, Vattenfall is in talks with the Research Centre for Geosciences in Potsdam about the possibility of using some of the CO_2 from the pilot plant in the international CO_2SINK research project in Ketzin.

Carbon dioxid storage tanks at Schwarze Pumpe.

In Jänschwalde, not far from Schwarze Pumpe, the pre-engineering work on converting an existing power plant block into a CCS demonstration plant is ongoing. Transport options are being investigated to three different storage sites. Initial geological investigations have started at the possible storage sites. Similar activities are also ongoing in Denmark and in the Netherlands.

Vattenfall began conducting research and development on carbon dioxide capture and storage from coal-fired power plants already in 2001. From the beginning, the objective has been to secure a competitive future supply of electricity and heat, and also to reduce today's greenhouse gas emission levels. The target has always been to achieve secure and feasible technologies for the almost complete elimination of carbon dioxide emissions at commercial, cost-effective levels.

The idea is to capture carbon dioxide from a coal-fired power plant, transform it into a liquid and store it deep underground. The depositories are of the same kind as where oil and gas are extracted – an area of porous rock with a sealing cap on top. The ability to store carbon dioxide in Europe seems to exceed the needs based on the available amounts of fossil fuels.

According to the original plans, the development phase will end with the construction and testing of a large-scale demonstration plant. The aim is to develop a commercial concept(s) by 2020.

The commercial base is set by the EU's emission trading system (ETS). Vattenfall's target is to develop a concept at a total cost that could match a stable price for emission rights with a large trading volume of captured and stored carbon dioxide. Carbon dioxide capture and storage is attracting huge international interest. Extensive R&D efforts are underway. Vattenfall has a central position in many of these initiatives. ■

Two new programme managers within R&D

Thomas Munch-Laursen
Thomas Munch-Laursen is the new programme manager for Sustainable Cities. Thomas' professional experience is based on a combination of technology development "from early idea to product realization" and business and strategy development. He holds a Master of Science degree in building construction and a Master of Business Administration degree. His passion lies within technology development and the processes surrounding it; Thomas is therefore looking forward to meeting new colleagues and partners and to hearing about their projects and challenges.

The Sustainable Cities programme focuses on the use of energy, the efficiencies in these processes and the role of electricity in end-user systems. Distributed generation and distributed heat and cooling are also part of the programme. The technical base in this programme constitutes the new technologies and new systems activities on the end-user side of energy systems.

Jürgen Jacoby
Jürgen Jacoby is the new programme manager for Biomass and New Technologies. Jürgen comes originally from Germany, but has lived in Stockholm for almost 12 years. He has studied aeronautical engineering at the Technical University in Stuttgart, Germany, and holds a Ph.D. from the Royal Institute of Technology in the field of catalytic combustion for gas turbine applications. Jürgen started working at Vattenfall in the spring of 2006 and over the last few years he has worked with the oxyfuel CCS pilot plant project in Schwarze Pumpe in Germany. Within the project, he has had overall responsibility for the planning and performance of the measurement activities. Jürgen is looking forward to the new challenges as the new programme manager at Vattenfall R&D.

The Biomass Programme focuses on increasing the yield from biomass in new technologies in order to better utilize the limited resources and on creating new sources of biomass. New technologies is the programme where we compile, analyze and evaluate all the new technologies that appear. This is also where we follow emerging technologies and eventually engage in new development.

R&D Briefing

A news briefing from Vattenfall Research and Development

R&D seminar in Amsterdam

On 29–30 September, about 100 colleagues from all the Vattenfall Countries attended the second annual Group R&D seminar in Amsterdam and Buggenum. This year it was hosted by our new colleagues from NuOn – the newly-formed Business Group Benelux.

The first day of the seminar was spent in Amsterdam and focused on presentations and discussions about Vattenfall's and NuOn's R&D and its connections to Business Development. Day 2 offered the opportunity to visit the Willem-Alexander Power Station at Buggenum where a pilot plant to test pre-combustion CO_2 capture is currently in the construction phase. On the first day, participants were able to listen to interesting presentations from Helmar Rendez (Head of Group Functions), Lars Strömberg (Vice President, Vattenfall Group R&D), Robert de Kler (Head of Engineering Services at NuOn), Arnoud Kamerbeek (Vice President Business Development at NuOn), Göran Lundgren (Head of Business Development Pan Europe) and from the R&D Programme Managers.

"We are convinced that all the participants had a wonderful time in Amsterdam as NuOn had arranged a great meeting and made us all feel welcome in the Netherlands. It was a good opportunity to meet old and new colleagues for two intensive days of discussion, debates, fun and conversations and to exchange ideas regarding the R&D performed at Vattenfall. Warm thanks to the organizing committee at NuOn who made this seminar worth remembering," says Mr. Lars Strömberg, Head of Group R&D.

Workshop on gearbox failure

Vattenfall R&D hosted a two-day workshop where 26 experts from Vattenfall and other companies and organizations (Romax, NREL, SKF, Aalborg University, DMT, Risø, Moventas, Engineering College of Aarhus, Garrad Hassan, Vestas and VTT) met to discuss the results of an intensive wind-turbine gearbox measurement campaign, which Vattenfall R&D conducted over the last year. The measurement points are numerous and with high resolution, and provide a good picture of the operational conditions for the gearbox components. The aim of the measurement campaign was to investigate possible reasons for the well-known high number of wind turbine gearbox failures. Many interesting discussions followed and the participants indicated that they want to collaborate closely with Vattenfall in the continuation of the work on investigating the gearbox failures.

Improved methods for characterizing biomass

Vattenfall is already a large user of biomass fuels for electricity generation and heat production but our aim is to substantially increase this use even further. This includes biomass-dedicated boilers and co-combustion with coal in coal-fired plants. Improved methods for characterizing fuels are being developed that will secure efficient operation also with unproven and less common fuels. Two novel instruments have been put into operation in 2009 and another two are planned for 2010.

A study of aging behaviour at Ringhals

At Ringhals, a project regarding the aging behaviour of the reactor pressure vessels has been initiated. The most significant parameter when it comes to agiwng is the effect of neutron irradiation. The objective of the project is to validate the long-term safety of the pressure vessels, as well as to build up a knowledge data base on aging mechanisms and behaviour in materials and structures typical of the Swedish nuclear power plants as a fleet. There are currently no limitations regarding mechanical behaviour from a plant-operating perspective, but it is important to have a broad understanding of the long-term behaviour in order to assess the future generation capacity correctly.

New research will provide more electricity from hydro power

New research at Luleå Technical University will increase the amount of electricity generated in the hydro power plants. Urban Andersson, who works at Vattenfall Research and Development, has recently finalized his doctoral thesis at Luleå Technical University. He has established an experimental data base that allows tests and the development of efficient data calculations. These data calculations can be used instead of expensive experiments regarding the adjustment of new equipment in hydro power plants and this will be profitable for both the environment and the economy.

New challenges for Ocean Energy

The Ocean Energy programme is facing new challenges. We need to acquire ocean sites where conditions are especially favourable and where we can try out various techniques from different companies. We have therefore established the company Tonn in co-operation with Wavebob, an Irish wave farm development firm. We have also established another company in Scotland where we will test the Pelamis equipment. Together with Wavebob we are also engaged in an EU project.

The electric vehicle in your everyday life – a vision

The introduction of electric vehicles will affect peoples' lives in so many ways. In the future, when buses and cars are powered by electricity, local air quality will be dramatically improved and climate change can be combated without drawbacks in welfare or the quality of life. Moreover, the electrification of the car will open doors to a whole range of additional services making everyday life a little easier for you and me.

Imagine the urban life of the future where you wake up to the sound of birdsong rather than of a roaring bus pulling away from a stop in a cloud of diesel fumes. As you wander out onto the balcony and take a deep breath of crisp morning air, your senses are filled with the scent of freshly-brewed coffee rather than that thick, greyish haze that used to envelop the city in earlier days.

When you are ready to go to work, so is your electric car. As always, the battery of your car has been successfully recharged while you were asleep. You simply unplug and drive off – it is so much easier than before when you actually had to drive to a filling station as soon as you ran out of gas.

Morning traffic is a breeze now that the city has imposed clean city zones accessible only to zero-emission vehicles such as your own. Higher road tolls for CO_2-emitting cars also keep traffic flowing, which clearly minimizes frustration. It seems like upset drivers leaning on their horns are a mere memory now, you might speculate, as you drive along to the silent whispering from the electric engine.

When early morning slowly turns into day, you pull up the car at your workplace parking lot. Maybe the wind catches your hair as you connect your car to the charging socket. Since you signed up for wind power when buying the car, you can be quite sure the battery will be charged with pure, renewable electricity today. It is amazing how simple it is to care for the environment, you might reflect, as you press your pin code to confirm that the cost for charging can be added to your credit card. And not to forget, it is all at a very reasonable price. In fact, you have noticed that your fuel expenses have fallen dramatically since you switched from petrol to the electric drive.

On your way back to the parking lot, after a satisfying working day, your mobile phone rings. Maybe it is your friend inviting you to a spontaneous dinner get-together at her holiday cottage. What a perfect start to the weekend, you might reply, as you unplug the car ready to go there straight away.

As you open the car door and jump in, you are welcomed by comforting warmth from the interior heater and the car seat warmer. One of the many

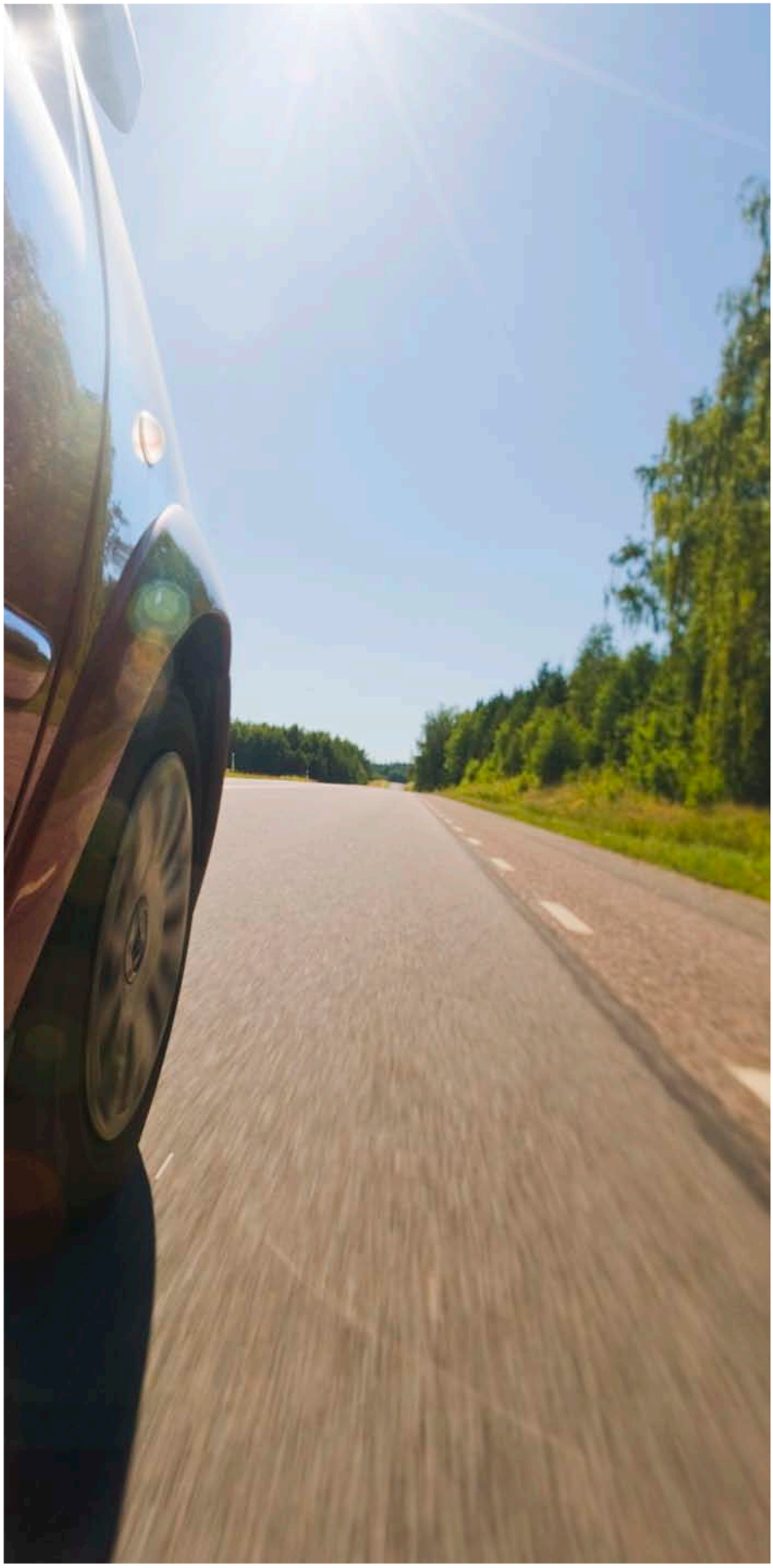


Photo: Björn Ohlin/Folio.

blessings of your electric car is that you can actually tell the car to start the heating system or AC a few minutes before you want to go. Perhaps you do not know exactly how it works – you simply send an SMS or e-mail and the car takes care of the rest.

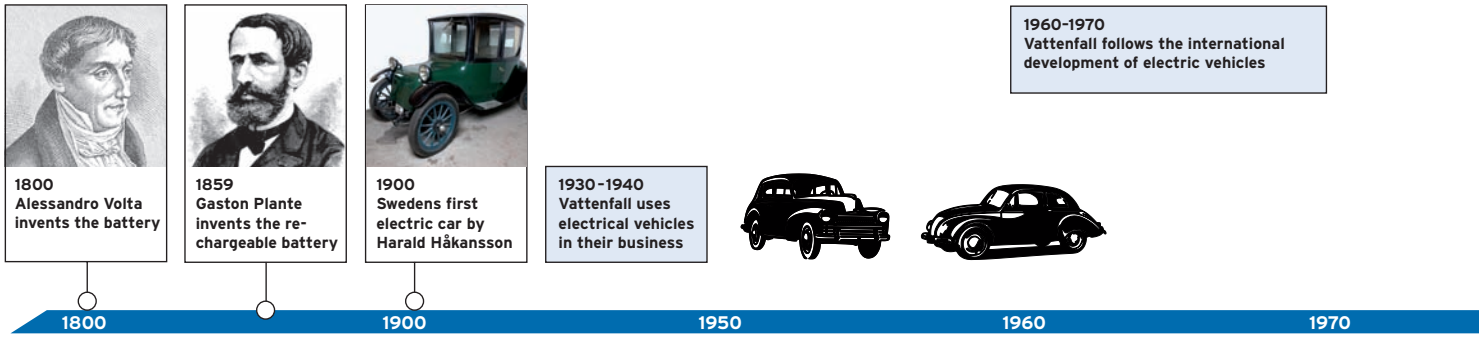
Halfway to your friend's cottage, the battery status indicator indicates low battery power. That does not happen often, only on longer-distance trips like this one. It does not bother you much, though, since your car is equipped with an eco-fuel combustion engine that automatically kicks in when battery power is insufficient. However, the car computer system tells you there is a fast-charging station only a few kilometres further down the road. Maybe you decide to stop there for a few minutes to charge the battery and get your friend a big bouquet of fresh flowers.

Once at the cottage, your taste buds are tempted by a delicious dinner in front of the sparkling fireplace. As you enjoy your dinner, maybe a newspaper lying on the table catches your eye. On the front page, there is a headline saying in big letters that the EU's climate goals for 2020 have been reached, partly because of the plug-in vehicle trend. Your friend, who has already read the article thoroughly, explains how the introduction of electric vehicles has drastically lowered emissions of carbon dioxide from road-bound transport. At the same time, eco-fuels will now last longer because of the broad electrification of the transport sector. The EU's concern about the security of energy supply therefore seems to be manageable in the future.

Perhaps you feel a little extra satisfaction that night in front of the fireplace, knowing that your decision to get an electric car has not only made your everyday life easier – it has contributed to making life on earth easier for many generations to come! You glance out of the window and notice your electric car parked in front of the cottage. It is a good car, you might reflect. And a true eye-catcher too. Maybe the most beautiful car ever? ■

Why engage in E-mobility and why do it now?

Today, private transport is highly dependent on oil and vehicles emit both local and global emissions. Electricity offers new possibilities for long-term efficient and sustainable private vehicle transport. Electric cars are not a new invention, in fact they existed already a century ago, however earlier attempts to introduce them widely have failed. But today, the situation is different and a large-scale transformation of the transport sector may be imminent.



The first electric car was built already in the 1830s. However, a more widespread development of electric cars was not seen until the late 1800s, starting in France and Great Britain before reaching America.

By the turn of the century, when most journeys were local commuting and good roads were only to be found in urban areas, electric cars actually outsold steam or gasoline cars in the U.S. However, in the 1920s the electric vehicle had to give in to the gasoline car. Improved road systems brought about a need for longer-range vehicles, oil prices fell, and the invention of the electric starter finally eliminated the need for the difficult and dangerous crank to start the gasoline engine.

In the 1960s and 1970s, there was a renewed interest in electric vehicles prompted by international oil crises and concerns about air pollution. Again, in the 1990s attempts were made in California and other cities worldwide to promote zero-emission vehicles. However, heavy batteries with insufficient capacity and limited production volumes caused high costs for relatively small environmental gain.

Today, concerns about global climate change and security of energy supply have paved the way for a new wave of interest in electric vehicles. Society is now generally aware of the climate issue and this motivates political decisions as well as individual behaviour.

New and better battery technology (lithium ion batteries) has created entirely new conditions for electrification in the transport sector. Substantial cost reductions and higher oil prices are good reasons for expecting greater success this time.

Electricity has become generally accepted as an excellent carrier of energy and hybrid car development has whetted the appetite for electric driving. Car manufacturers are investing a great deal of money in the development of electric vehicles and a broad range of models and technical solutions will be on the market in the near future. This time, plug-in hybrid vehicles will clearly have a role in combining the best of the electric drive and the combustion engine.

Today, nearly all transports are based on oil products, such as diesel and gasoline. Vattenfall envisions that electric private vehicles could make up a 10–15% market share in 2020 and 25% in 2030. This requires that the industry, governments and the public embrace and support an introduction of the new technology.

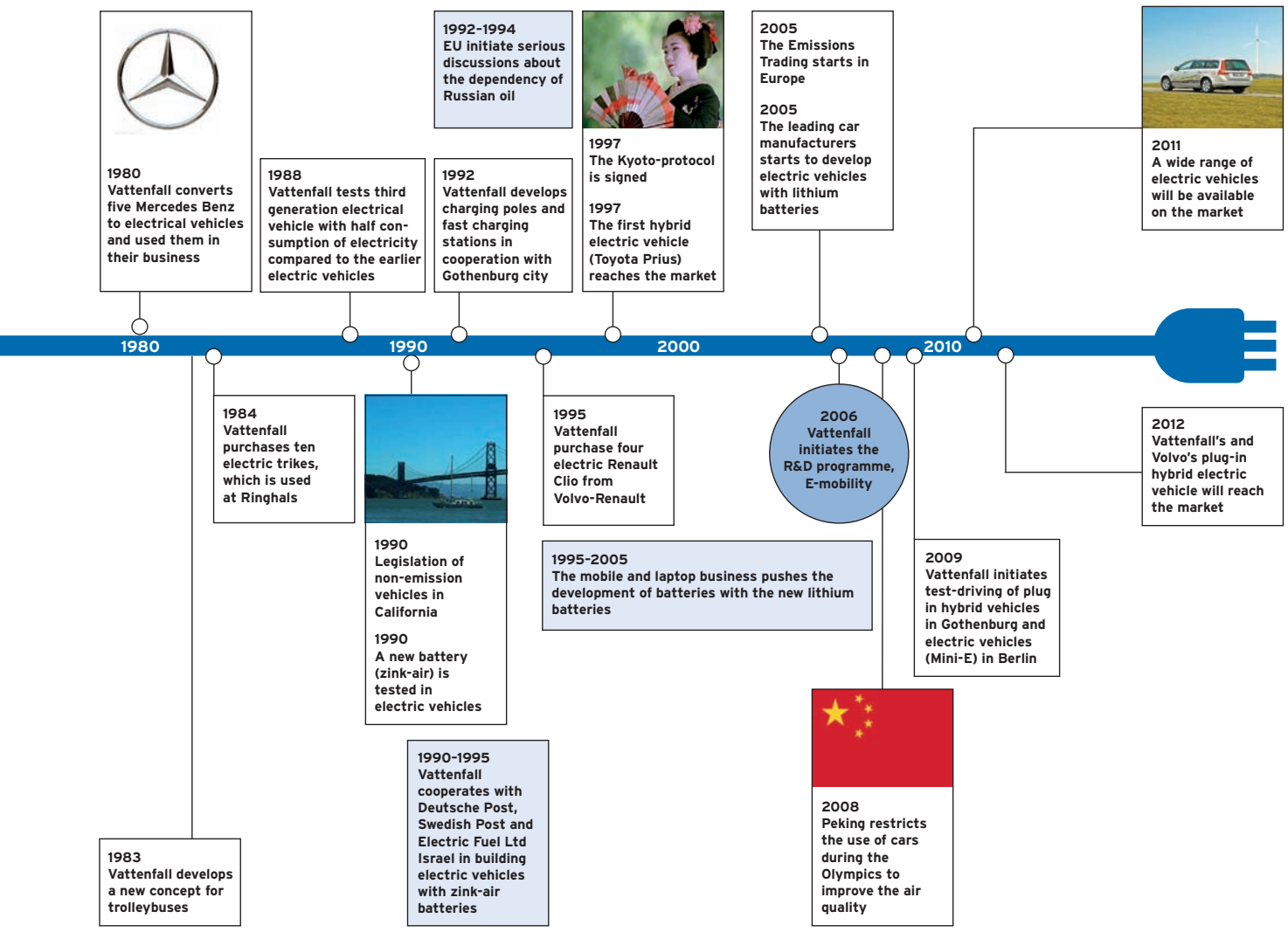
Using more electricity to fuel vehicles entails many advantages. Since electric motors require only some 25% input of energy as compared to conventional combustion engines, replacing oil-based fuels with electricity reduces the amount of energy needed for transport. It also expands the diversity of energy sources, making it possible to use a range of low-emitting and domestic energy sources.

The impact on the climate as well as local emissions will be significantly reduced. When driving on an average EU electricity mix, well-to-wheel greenhouse gas emissions will be cut by 60% compared to modern, fuel-efficient petrol driven cars. Using the Nordic electricity mix will cut emissions by as much as 90%. The vehicles emit no local exhausts, and they run silently.

The electrification of the transport sector implies that emissions of greenhouse gases will move from the unregulated transport sector to the energy sector, which is regulated by the European Emission Trading System, ETS. ETS limits the total emissions of greenhouse gases in the energy sector by stating an annual maximum. Thus, if the transport sector is electrified, the emissions in the transport sector will be significantly lowered while the energy sector will have to produce more electricity without increasing its emissions of greenhouse gases.

Insufficient infrastructure and capacity may be barriers to other alternative fuels, but the electricity system has developed constantly over the last century, so now only charging access points remain to be built. The number of charging access points needed will depend on technological development and customer preferences. Vattenfall is actively investigating the need for charging access points and working to develop and demonstrate solutions. To simplify the use of electric vehicles and maintain transparency on the market, standards must be developed and cooperation within and across industrial sectors promoted.

There are a number of challenges, including public acceptance, infrastructure for battery charging and price levels, still to be overcome before electric vehicles are ready for the market. Vattenfall is working with all of these issues. Vattenfall and the City of Stockholm have e.g initiated cooperation to gather companies and municipalities together for the joint procurement of electric vehicles. Standardization is important to the development of the market. Vattenfall is therefore cooperating with the energy and automotive industries to make charging transparent regardless of country or vehicle type.



Building public acceptance through demonstration projects

Closely cooperating with the auto industry, Vattenfall is participating in test and demonstration projects in which individuals will run demo vehicles on an everyday basis. This will increase the understanding of how customers experience the electric drive as well as charging and payment. The projects will enhance know-how on preparations for market introduction.

Vattenfall is participating in two demonstration projects, one with Volvo in Gothenburg and the other with BMW in Berlin. The overall aim of the demonstration projects is to speed up the development of electric vehicles and the transition to an electrified transport sector.

In the cooperation with Volvo, plug-in hybrid vehicles is tested. This is one of the first real-life tests of plug-in hybrid vehicles, cars that combine an electric engine and a fuel-efficient diesel engine which is put into use when driving distances over 50 kilometres. In the project, overnight charging is expected to be sufficient to cover daily average driving distances. In case of longer journeys when the battery runs empty the combustion engine kicks in.

The objective of the project is to study social issues such as customer experience of the electric drive as well as of charging. The test-drives started at the end of 2009. Employees at Vattenfall and Volvo have the cars totally for private use. The cars is operated under real-life conditions and charged either through ordinary wall sockets or at a small number of charging poles with test-payment systems that have been erected for general service and demonstration. The project focuses on the home-charging system and the interplay between the car and the house. One hypothesis is that only a very limited number of public charging points, if any at all, are needed since most charging will take place either at work or at home.

In Berlin, Vattenfall and BMW are jointly running a project called Mini E, which uses fifty electric BMW Mini Coopers, hence the name of the project. The project is divided into two six-month periods, allowing a total of 100 people to lease and drive an electric vehicle for half a year. Charging points have been installed in each test driver's home or workplace, and 50 charging poles have been erected in public places around the city.

The purposes are, beyond increasing public acceptance for electric vehicles, to study easy-to-use communication between the customer, the vehicle and the charging pole, the specifications of the charging systems and the influence on the electricity distribution grid. The idea is to demonstrate that wind energy can be utilised to charge the cars. Vattenfall has designed a system that registers when there is a surplus of wind energy in the electricity system and steers the charging sockets. The project also develops and test a pricing model with an ecological incentive effect, a suitable billing procedure and a grid management system. The driver's own electricity supply contract is charged, so the system is non-discriminatory with respect to supplier in order to promote open, deregulated competition on the market. ■

Electric BMW Mini Cooper from the project "Mini E" in Berlin.

Other activities within the E-mobility programme

Electric vehicle alliance pilot in Amsterdam
Vattenfall will provide companies with a car fleet (lease) and/or a car pool system with a turnkey solution; car, charge infrastructure and preferably mobility solutions for ease and registration.

Charge point Amsterdam
In Amsterdam, 35 charge stations have been installed with the purpose of learning more about charging behaviour and the use of electric vehicles and to explore future business models when it comes to infrastructure and payment. The project is managed in cooperation with the Grid Company, Alliander.

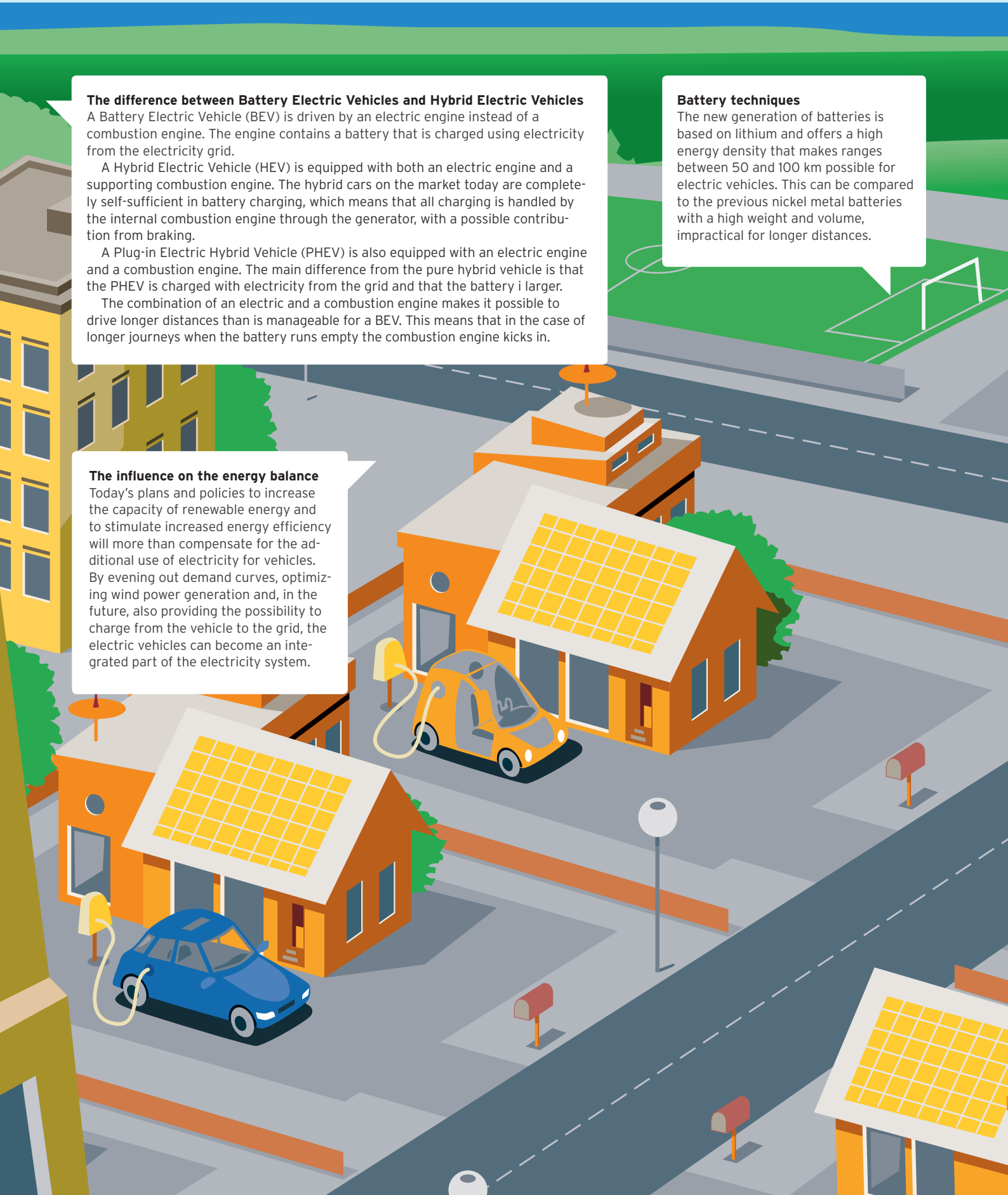
Model regions Berlin and Hamburg
In Germany, Vattenfall is working to integrate electric vehicles in fleet applications and public transport. This is in cooperation with public transport companies, authorities and other companies.

Fast charging
Vattenfall is cooperating with technology developers to gain more knowledge and expertise regarding technical solutions for the fast charging of electric vehicles. The output for fast charging is from 50 kW and more compared to a regular wall socket with an output of 2.3–3.7 kW.

Developing technology standards
The lack of standards for the interface and the communication between vehicle and charging points is a barrier to market progress. Vattenfall is working together with both the energy industry and the automotive industry to develop standards for the physical connector to the vehicle, communication between vehicles and charging stations and physical protection

Home charging optimization
Vattenfall is running a project in order to investigate and evaluate various solutions to improve the possibility to charge at home.

E-mobility – in brief



The difference between Battery Electric Vehicles and Hybrid Electric Vehicles
A Battery Electric Vehicle (BEV) is driven by an electric engine instead of a combustion engine. The engine contains a battery that is charged using electricity from the electricity grid.

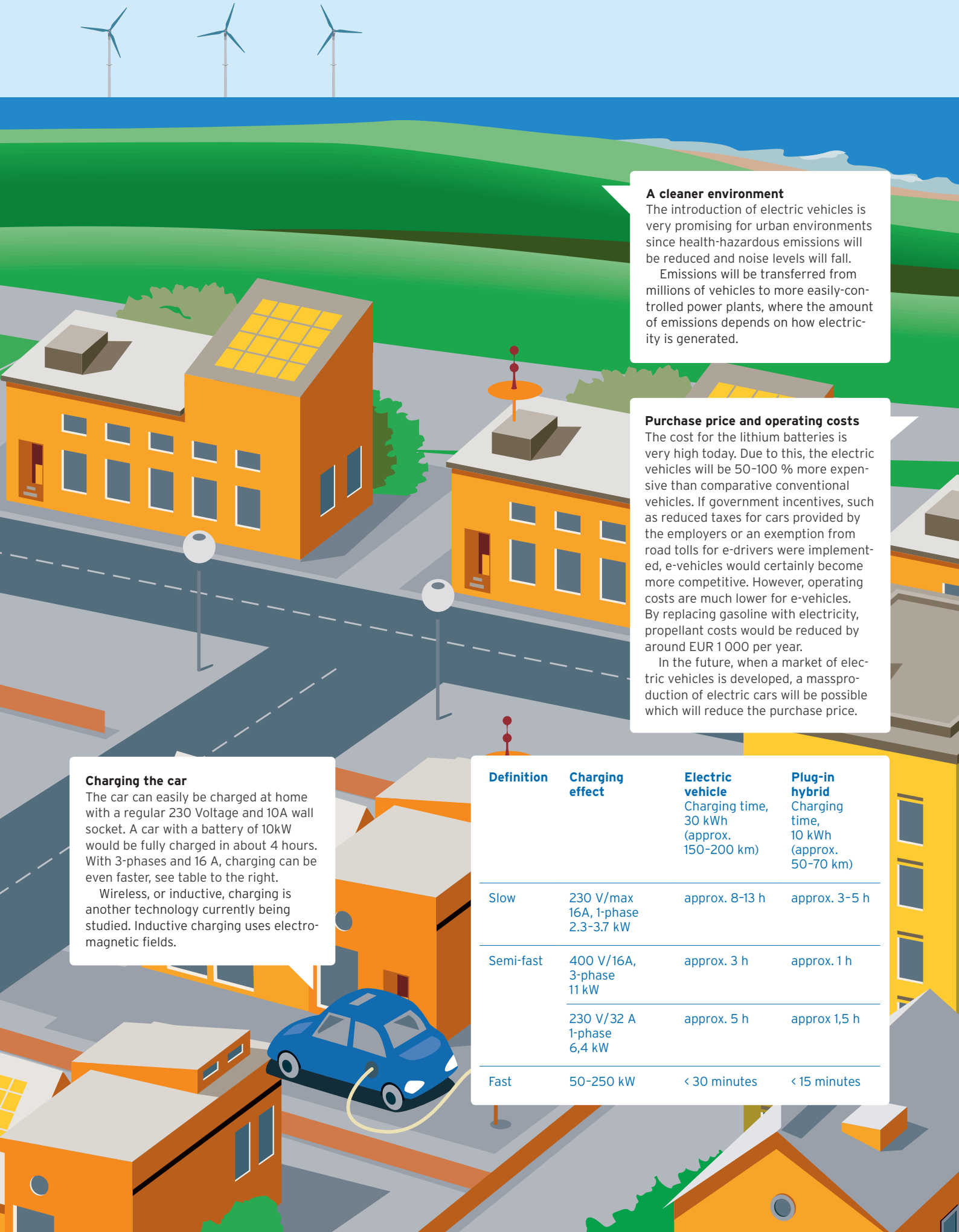
A Hybrid Electric Vehicle (HEV) is equipped with both an electric engine and a supporting combustion engine. The hybrid cars on the market today are completely self-sufficient in battery charging, which means that all charging is handled by the internal combustion engine through the generator, with a possible contribution from braking.

A Plug-in Electric Hybrid Vehicle (PHEV) is also equipped with an electric engine and a combustion engine. The main difference from the pure hybrid vehicle is that the PHEV is charged with electricity from the grid and that the battery i larger.

The combination of an electric and a combustion engine makes it possible to drive longer distances than is manageable for a BEV. This means that in the case of longer journeys when the battery runs empty the combustion engine kicks in.

Battery techniques
The new generation of batteries is based on lithium and offers a high energy density that makes ranges between 50 and 100 km possible for electric vehicles. This can be compared to the previous nickel metal batteries with a high weight and volume, impractical for longer distances.

The influence on the energy balance
Today's plans and policies to increase the capacity of renewable energy and to stimulate increased energy efficiency will more than compensate for the additional use of electricity for vehicles. By evening out demand curves, optimizing wind power generation and, in the future, also providing the possibility to charge from the vehicle to the grid, the electric vehicles can become an integrated part of the electricity system.



A cleaner environment
The introduction of electric vehicles is very promising for urban environments since health-hazardous emissions will be reduced and noise levels will fall.

Emissions will be transferred from millions of vehicles to more easily-controlled power plants, where the amount of emissions depends on how electricity is generated.

Purchase price and operating costs
The cost for the lithium batteries is very high today. Due to this, the electric vehicles will be 50–100 % more expensive than comparative conventional vehicles. If government incentives, such as reduced taxes for cars provided by the employers or an exemption from road tolls for e-drivers were implemented, e-vehicles would certainly become more competitive. However, operating costs are much lower for e-vehicles. By replacing gasoline with electricity, propellant costs would be reduced by around EUR 1 000 per year.

In the future, when a market of electric vehicles is developed, a massproduction of electric cars will be possible which will reduce the purchase price.

Charging the car
The car can easily be charged at home with a regular 230 Voltage and 10A wall socket. A car with a battery of 10kW would be fully charged in about 4 hours. With 3-phases and 16 A, charging can be even faster, see table to the right.

Wireless, or inductive, charging is another technology currently being studied. Inductive charging uses electromagnetic fields.

Definition	Charging effect	Electric vehicle Charging time, 30 kWh (approx. 150–200 km)	Plug-in hybrid Charging time, 10 kWh (approx. 50–70 km)
Slow	230 V/max 16A, 1-phase 2.3–3.7 kW	approx. 8–13 h	approx. 3–5 h
Semi-fast	400 V/16A, 3-phase 11 kW	approx. 3 h	approx. 1 h
	230 V/32 A 1-phase 6,4 kW	approx. 5 h	approx 1,5 h
Fast	50–250 kW	< 30 minutes	< 15 minutes

A unique joint venture cooperation between Vattenfall and Volvo

On 1 June 2009, Volvo and Vattenfall started a unique cooperation with the goal of having a plug-in hybrid vehicle on the market by 2012. Vattenfall is contributing its experience of the electricity system and Volvo its knowledge of manufacturing cars. Both parties see electric vehicles as an opportunity to reduce CO_2 emissions and thus contribute to curbing climate change.

Cooperation between Vattenfall and Volvo to develop plug-in hybrid cars started already in 2007, with a test and development project that involved charging and payment infrastructure as well as vehicles. The Swedish Energy Agency was also a party to the cooperation, supporting the project financially. On 1 June 2009, Volvo and Vattenfall decided to take their successful cooperation to a higher level and joined forces with the goal of introducing a plug-in hybrid car on the market by the end of 2012. The development of the car will be carried out and financed by both companies.

In the joint venture, Vattenfall will contribute its knowledge of electricity and also supply the electricity, while Volvo will contribute its ability to build and sell cars. By joining forces with Volvo, Vattenfall will speed up the introduction of plug-in hybrid cars on the market.

The 2012 plug-in hybrid car will contain a lithium-ion battery that takes about five hours to charge from a standard wall socket. The car will be able to drive 50 kilometres on electricity before recharging, but since the car is a hybrid it will cover a longer distance because it also contains a fuel-efficient diesel engine. When the distance exceeds 50 kilometres the diesel engine takes over.

Most journeys by car consist of short daily trips to get to and from work. The electric part of the vehicle will cover these daily trips, while a diesel engine will give the car the capacity for longer distances as well.

Vattenfall and Volvo see the plug-in hybrid car as an opportunity to reduce CO_2 emissions and as a means of controlling these emissions. To emphasise this, Vattenfall will offer hybrid car customers the opportunity to choose the energy source by signing an agreement for a renewable source of energy such as wind power or hydro power instead of the regular mixture of energy sources. ■

"Plug-in-hybrid vehicles can easily be charge at home. The car will contain a lithium-ion battery that will take about five hours to charge from a standard wall socket."

Visitors at Stockholm climate week interested in the new electric Volvo, manufactured together with Vattenfall.

ANOTHER PERSPECTIVE:

Being an enthusiast of electric vehicles

We found him under one of the cars in a huge garage; there were tools all over the place. At first we could not see him, we only heard him yelling: "Can someone please hand me a spanner?" Suddenly we saw a pair of oil-stained shoes sticking out under the car...

No, not really. Our enthusiast does not match the traditional picture of a car-mechanic very well. Tommy Engkvist says that he is more of an energy-buff than a car-lover, however he cannot deny that he finds a combination of both quite appealing.

It all started in the late 80s when Tommy was watching an American television show about electric vehicles and thought that it could not be too hard to turn out one of those on his own. He ordered the parts he needed and transformed his old VW Golf into an electric plug-in car with solar panels on the bonnet. He used a lead battery that enabled him to drive as fast as 140 km/hour and a maximum distance of 50–60 kilometres before recharging.

Tommy says that he had no problems at all recharging the car, it only took two hours with his three-phase charger. "There are three-phase sockets at every gas station and in the backyard of every supermarket". However, he also says that "the employees at the supermarket or gas station are often quite surprised and do not know how much they should charge for the electricity".

He drove his home-made electric vehicle for twelve years before he sold it and bought a new one. The new one had slightly more modern nickel-cadmium batteries, which are easier to handle since they only require limited maintenance and they contain enough energy to drive almost twice the distance compared to the old lead battery in his VW Golf. If he bought a new electric vehicle today it would most certainly use modern lithium-ion batteries with a much better performance.

There was a great deal of interest in electric vehicles in the early 90's compared to the last ten to fifteen years, but today the spark has returned. Tommy tells us that the attitude to electric vehicles has changed dramatically over the years; back in the 90's the common reaction was "that's cool" or "how funny", today people ask a lot of questions and wonder whether they can get one as well. People in general are most worried about the charging time and the limited distance. He usually tells them that it is much easier than they think to use an electric vehicle; it is very rare that people drive more than the maximum range of a modern electric vehicle, at least in everyday life, and it only takes a few hours to recharge.

> "There are three-phase sockets at every gas station and in the backyard of every supermarket"

Once every year, Tommy takes off for a road trip with his electric vehicle and his friends from Elbil Sverige, an organization for electric vehicle enthusiasts that he is a member of. These road trips can be thousands of kilometres long, but according to Tommy there are no big problems; they recharge while having lunch or dinner.

He admits that even if people's worries are exaggerated it takes a different mindset to have an electric plug-in vehicle; for example you have to drive carefully in order to make use of all the available energy in the battery. Therefore he welcomes the plug-in hybrids that will reach the market just a few years from now: "With these people will be able to utilize the benefits of the electric drive without worrying about limited distances."

Tommy believes that the responsibility for a transition to a transport sector driven by electricity lies with the consumers. If we all say loud and clear that we want high-performance electric vehicles and are ready to buy them, the car manufacturers will make it happen: "We live in a functional market economy after all". However, to make the electric vehicles cheap enough for the consumers large-scale production is needed, which in turn requires government incentive programmes in the initial phase.

Tommy and his organization, Elbil Sverige, have presented a complete menu of incentives to the Swedish government where they, for example, suggest abolishing the tax imposed on fringe benefits for electric vehicles, free parking with the possibility to charge for electric vehicles and non-emission traffic zones in city centres.

They point to Norway as a leading country in this field; there the electric vehicles are zero rated for VAT, they are allowed to drive in lanes for public transport and they do not have to pay tolls and parking fees. This has resulted in an immense demand for electric vehicles. According to Tommy, people even queue to buy them since the manufacturers are not able to keep pace in their production. He believes that electric vehicles are here to stay, they are the future, but it will take a very long time before the transition is complete. ■