Highway to electromobility
Are we ready for electric vehicles?
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Electromobility: an opportunity we need to use

In light of global transportation trends, we have been actively involved in the development of electromobility and the necessary infrastructure for it for the last several years. The innogy Group has its proprietary complex charging system for electric vehicles installed in nearly 6,000 points across Europe. The Group also cooperates with 150 municipal partners. Moreover, our new company in the US will soon offer these solutions in California and other states.

Meanwhile, innogy Polska is actively supporting the development of electromobility in Poland. For several years, we have been offering our customers electric car charging stations. Drivers have also used our network of 12 public charging stations located in different districts of Warsaw as well as near AGH University of Science and Technology in Cracow. Those in Cracow accompany the photovoltaic installation and energy storage system at the innogy AGH SolarLab, an educational and research project conducted in cooperation with the university. We are also working on other solutions to address the needs of this dynamically developing sector in Poland.

As an innovative energy company, it is our goal to take an active part in the transformation of the energy industry and co-create a new branch of the transportation sector based on electric vehicles, especially as Poland is one of the most important markets in Europe for innogy. In our reports and publications, we have pointed future solutions which may have a measurable impact on the energy industry. A few years ago, we identified electromobility as one of the solutions of the future. Today, electric cars are becoming a reality. That is why we have decided to analyse the prospects of electric transportation from the perspective of a regular user.

The car industry is currently facing challenges comparable to the launch of Ford T at the beginning of the 20th century. It is very likely that, in the next few years, hybrid and electric cars will become a viable alternative to combustion cars in terms of cost and quality.

Poland may be a beneficiary of these changes, among others due to the fact that contrary to traditional transport, it relies almost exclusively on national raw materials for energy production, including energy from renewable resources. As such, the development of electromobility may help the country become more energy independent.

A significant part of Poland’s electricity is produced from coal, which is also used indirectly to power electric cars. Although the base-load power plant system affects the level of CO₂ emissions, electricity produced this way has a smaller impact on the environment than low-emission sources from traditional combustion transportation. In this context, the development of electric transportation – by reducing particulate matter
innovation generates, I am convinced that our efforts will pay off.

As part of our report, we have decided to determine what Poles think about electric cars and how electromobility may affect their lives. We also want to communicate the main arguments for the development of the electric vehicle market and show that electric transportation is not limited to cars only.

I am pleased to present this report to you and hope you find it informative.

Filip Thon, Ph. D.

CEO, innogy Polska S.A.

Senior Vice President of the Retail Executive Committee at the innogy Group

„It is our goal to take an active part in the transformation of the energy industry and contribute to creation of a new branch”

and CO₂ emissions at the place of use – will contribute to improved air quality and quality of life for the residents of Poland, particularly in large metropolitan areas. This will improve people’s health and could result in reducing future healthcare costs. Moreover, the noise level will decrease and electric car-sharing will help reduce traffic in city centres. However, in the longer term, electromobility should be linked to decentralised renewable energy, photovoltaics in particular, which will ensure complete zero-emission transportation and increase the cost-effectiveness of such solutions.

The benefits of electromobility development are not confined to electric vehicle users, though. The widespread use of electric vehicles can positively affect the entire Polish economy. The first outcome would be a better use of the existing energy generation infrastructure. Introduction of electric vehicles on a large scale should increase demand for electricity, especially at night. The second opportunity rests in storing electricity in car batteries that can be used, for example, during periods of peak demand. The development of electromobility also provides a new opportunity for the wider use of decentralised renewable energy in a way that is neutral for the power grid and beneficial for Poland’s climate and its residents’ comfort. Two other areas also worth stressing are the chance to take advantage of the intellectual potential of Polish scientists and the development opportunities in the automotive sector.

This does not mean, however, that no challenge lies ahead for electromobility. Like any new technology, it raises concerns and questions because it interferes with existing and well-known business models. Regulations and solutions are needed that will support its present implementation and ensure its long-term development. We are currently at the stage of determining the rules for entities on this market. Thanks to cooperation of all parties involved, we can develop solutions that will ensure that the transformation of the transportation system, connected with the development of electromobility, will take place in a sustainable way. Having in mind the positive effects that every
Executive summary
Electromobility in numbers

over 155,000 electric vehicles and plug-in hybrid vehicles registered in 2016 in the European Union

over 1,000 electric buses planned for Poland by the year 2020

over 35,000 hybrid vehicles in Poland

over 112,000 publicly accessible electric vehicle charging points in Europe

almost 6,000 innogy electric vehicle charging points in Europe

over 1,600 electric vehicles and plug-in hybrid vehicles in Poland

around 330 publicly accessible electric vehicle charging points in Poland

400,000 km the distance covered by electric vehicles using energy from innogy Polska charging stations between 2012 and 2017

including 50,000 green km thanks to electric energy produced by the photovoltaic installation on the roof of innogy Polska headquarters in Warsaw since November 2015

4.3 TWh estimated electric energy demand for one million electric cars in Poland

14 publicly accessible innogy electric vehicle charging stations in Poland

2,000,000 electric vehicles and plug-in hybrid vehicles registered worldwide at the end of 2016
The report “Highway to electromobility: Are we ready for electric vehicles?” discusses the challenges and opportunities facing the development of electromobility in Poland. The electric revolution in the automotive industry has been analyzed from the perspective of the users of these vehicles. On the one hand, the analysis assesses whether drivers are ready for electric vehicles; on the other, it verifies the user-friendliness of the electromobility ecosystem, including the charging infrastructure. The most important conclusions produced during the work on this report are presented below.

Just a few years ago, electric vehicles were considered a technological novelty with little chance of becoming popular. However, thanks to technological progress, a greater range, shorter charging times and the reduced cost of electric vehicles, what we now have is a global electromobility revolution. There may be only 1,600 electric vehicles on Polish roads today, but the prospects for electric energy-based transport are promising. Not only are the government’s plans and activities oriented towards electromobility development but there is interest from the corporate side, especially power and automotive companies.

Potential users of electric vehicles point out that the main barriers to the development of electromobility include the lack of a publicly accessible charging network and home charging points. This problem can be solved by the government’s plan to develop a charging station network covering the entire country. However, it is important to provide appropriate prospects for the simultaneous development of the charging infrastructure and the number of electric vehicles. innogy Polska experience in Warsaw shows that the 12-station network, which is now several years old, is not yet used to its full capacity, which is why it is difficult to justify investing in its development at this time. The situation is similar throughout Poland, as there are only a few dozen stations currently under construction. However, this situation may change due to the new legal regulations and the potential for investment financing using public funds.

The next factor that is seen as an obstacle to the development of electromobility – which is not only limited to Poland – is the higher price of vehicles compared to those with gasoline-powered engines. However, analyses show that electric vehicles with high annual mileages may already be competitive when the total costs of operation are taken into account.

Furthermore, Poles are starting to pay more attention to aspects of the environment and the number of users prepared to pay more for environmentally friendly technologies is on the rise. We also assume that the combination of an electric vehicle and a home photovoltaic installation will gain popularity in Poland – when a car is powered by solar energy it turns into a zero-emission vehicle. Furthermore, the lower costs of electric energy fuel for electric cars speed up the return on investment in a photovoltaic installation.

The fact that the development of electromobility will have a positive effect on living conditions thanks to reduced air pollution and noise levels is also important to big city dwellers. It should also be noted that local governments have started a gradual replacement of city buses. Public transportation in large agglomerations is already based to a considerable extent on electric power (trams, city and local rail transportation, the Warsaw subway) and the replacement of diesel engines in buses with electric and gas motors will further reduce pollution. Furthermore, services like car sharing based on electric vehicles will reduce the inconveniences that may potentially be created by restrictions to gasoline-powered vehicle traffic in city centers.
In innogy Polska opinion, there is considerable potential in electromobility-based commercial services, with the biggest currently to be found in the business customers segment. As the market continues to grow under a sustainable and stable support model, electric vehicles will also continue to gain on popularity among individual consumers. The pace of development of the segment for publicly accessible stations will depend on the final form of the legal regulations that are currently being processed.

Today, with the knowledge and solutions developed within the group and tested in numerous markets and by using our own experience, innogy Poland is able to prepare products and services that are adapted to the needs of all client groups. It also has the advantage of its potential to provide the whole value chain for electromobility-based solutions – from the sale of electric energy, including from renewable energy sources, through publicly accessible or private charging stations, to IT systems for managing the charging network and billing system. The electromobility revolution is well on its way and innogy Poland is ready.
Poles’ interest in electromobility
Results of the Kantar Public opinion survey

To learn more about the expectations of potential future users of electric vehicles, innogy Poland commissioned a survey on Poles’ interest in electromobility. The survey covered both private individuals and business representatives.

The answers may differ in details, but the survey proves that both groups see economic conditions as the most important factor when it comes to buying cars. In both groups, roughly half of the respondents who planned to buy a car within the next three years declared that they would consider an electric vehicle. Both groups also agree that the biggest barriers to the development of electromobility are the lack of a publicly accessible charging network and high vehicle prices. A detailed analysis of the survey is presented below.

**Purchase intentions**

The first question given to the respondents was whether they have plans to buy a car within the next three years. This question was aimed at identifying people who will actually be facing such a purchase decision.

One in five Poles (19%) plans to buy a car within the next three years. They include males (26%), people aged 18–24 (47%), and people with a monthly income exceeding PLN 3,000 (35%).

One in three companies (31%) plans to buy a car within the next three years. This includes 32% of micro companies, 23% of small companies and 37% of medium and big enterprises.

*Are you planning to buy a car within the next three years?*

- Yes; 19%
  - Private individuals
  - Yes; 31%
  - Entrepreneurs

- No; 81%
  - No; 69%
Selection criteria
What are the most important criteria when you are buying a car? (you can give more than one answer)

The respondents were asked about the most important criteria pursued when buying a car. Both groups listed price as the most important factor (55% of entrepreneurs and 35% of private individuals), followed by operating costs (54% and 34%) and fuel consumption (44% and 32%). Ecology came in fifth (24% and 13%). Factors such as safety, reliability, and travelling comfort were deemed less important. This shows that the criteria for private individuals and business representatives who are planning to buy cars are rather similar.
The respondents who were reluctant to buy an electric car because of the higher price were asked if they would reconsider their decision if the price was at a similar level.

One in three Poles (31%) would buy an electric car at the same price as that of a gasoline-powered car.

In total, 51% of Poles would be willing to buy an electric car and 35% would not (others have no opinion or are not planning to buy a car).

### Electric car purchase

**Would you buy an electric car knowing that it is going to be more expensive than a gasoline-powered car in the same class?**

**Private individuals**

- Yes; 32%
- No; 54%
- Not interested; 8%
- Hard to say; 6%

**Entrepreneurs**

- Yes; 26%
- No; 66%
- Not interested; 8%
- Hard to say; 8%

One in three Poles (32%) declared that he or she would buy an electric car even if its price was higher than that of a gasoline-powered car in the same class.

One in four business representatives (26%) declared that he or she would buy an electric car even if the operating costs were higher than those of a gasoline-powered car.

If the operating costs of electric vehicles were similar, 46% of those companies who would not buy one at higher costs, would change their minds.

In total, 60% of entrepreneurs would be willing to buy an electric car – 52% out of those planning to buy a car within the next three years. Simultaneously, 41% of respondents planning to buy a car would not choose an electric vehicle.
People who plan to buy a car within the next three years are even more determined in their opinions – 49% would buy an electric car and 47% would not.

The biggest interest in electric cars is among the residents of big cities with populations of 500,000 or more – 62% of them would buy an electric car.

According to Poles, electric cars are failing to gain popularity in Poland mainly because of the lack of a publicly accessible, fast charging station network (41%). Other major barriers include the high prices of the vehicles (35%) and the inability to charge such vehicles at home and/or the workplace (33%). Less frequently mentioned barriers included insufficient information about electric cars (21%) and their short range (20%). The lack of fiscal incentives and subsidy programs is seen as a barrier by 20% of Poles, while 7% note the fact that there are no additional privileges for the drivers. 15% of Poles have no opinion on the matter.

Entrepreneurs agree that the biggest barrier to the development of electric cars in Poland is the lack of a publicly accessible, fast charging station network (73%). Other problems include the short range of electric vehicles (46%) and their high price (44%). The inability to charge such vehicles at home and/or the workplace is not seen as equally important (35%). The lack of fiscal incentives and subsidy programs are seen as barriers by 11% of respondents, 14% in insufficient information about electric cars, and 9% in the fact that there are no additional privileges for the drivers. Both entrepreneurs and private individuals see similar barriers and are most concerned with the lack of a publicly accessible, fast charging station network. Entrepreneurs pay more attention to the short range of electric cars.

Kantar Public performed the survey under commission of innogy Poland on a representative sample of 700 residents of Poland, aged 18 and up, and 300 representatives of various businesses. The survey was performed on 21–23 June, 2017 through computer-assisted telephone interviewing (CAI).

### Barriers to electromobility development

In your opinion, what are the biggest barriers to electric vehicle development in Poland?

<table>
<thead>
<tr>
<th>Private individuals</th>
<th>Entrepreneurs</th>
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<tbody>
<tr>
<td>No publicly accessible, quick charging station network</td>
<td>41%</td>
</tr>
<tr>
<td>Short range</td>
<td>20%</td>
</tr>
<tr>
<td>High vehicle prices</td>
<td>35%</td>
</tr>
<tr>
<td>Lack of vehicle charging points at home/at work</td>
<td>33%</td>
</tr>
<tr>
<td>Insufficient information</td>
<td>21%</td>
</tr>
<tr>
<td>No tax incentives and subsidy programs</td>
<td>20%</td>
</tr>
</tbody>
</table>

60% of entrepreneurs and 52% of private individuals declared that they would buy an electric car if the price and operating costs were comparable with gasoline-powered vehicles.
The concept of electromobility development in Poland
The concept of electromobility development in Poland

3 objectives

1. Creation of conditions for the development of electromobility in Poland,
2. Development of the electric automotive industry,
3. Stabilization of the power grid.

3 documents

Package for the Benefit of Clean Transport, published by the Ministry of Energy

1. Electromobility development plan for Poland – a document presenting the areas and stages of electromobility development up to 2025, including proposed activities and instruments of support.
2. Domestic frameworks for the alternative fuels infrastructure development policy – a document containing an evaluation of the current status of alternative fuels infrastructure (including electric vehicle charging infrastructure) and defining the objectives and tools for its further development.
3. Act amendments to the Act on biocomponents and liquid biofuels - act is establishing the Low Emission Transport Fund, as a financial support instrument for the development of low-emission transport, including manufacturers and users of electric powered vehicles (Act under development).

3 stages

2. Stage II, 2019–2020: the development of a good social communication practices catalogue concerning electromobility, launch of production of limited electric vehicle series, development of infrastructure for electric and gas-powered vehicles.
3. Stage III, 2021–2025: increased electric vehicle popularity, completed charging infrastructure, production of electric vehicles in Poland.
The achievement of 3 strategic objectives

1. Million electric cars in Poland in 2025,
2. At least 30% of the added value associated with the production of electric vehicles registered in 2025 will be produced in Poland,
3. Smart charging station network meeting the requirements of the electric vehicle market.

During the creation of this document, the bill for the act on electromobility and alternative fuels passed the stage of public consultations. The report omits the content of the proposed records that were discussed due to the potential changes that may be made in future work on the bill.

It should be noted that in countries where the electric vehicle market developed quickly (Germany, Denmark, France), various forms of incentives and subsidies as well as indirect taxes have been introduced e.g. associated with emissions. Such actions seem justified in the early stages of implementation of new and particularly expensive technologies, but the market must return to the rules of competitiveness when it reaches a certain stage of maturity. Poland is facing the challenge of creating a system that supports the development of electromobility, but which will not be too expensive or threaten the whole industry when it expires.
Understanding electromobility
The electromobility ecosystem

The development of electromobility requires creation of an appropriate ecosystem, within which the following entities, institutions and organisations should cooperate:

1. Electric energy and fuel sellers
2. Distribution System Operators and the Transmission System Operator
3. Service providers (e.g. electric car charging, system operators)
4. Public administration
5. Scientific communities, clusters, and technology parks
6. The industrial sector (mainly automotive)
7. Business support organizations
8. Governmental institutions that support developmental projects (e.g. National Centre for Research and Development)
9. Financial institutions – banks and funds, including private equity funds

Only the combined action of all of the aforementioned entities will allow for the development of an environment that is friendly to electromobility could stimulate the popularization of electric transport in Poland.
Electromobility in the energy sector
1. **Conventional power plants** – installations producing electric energy from fossil fuels, mainly coal (hard or lignite) or gas.

2. **Renewable energy sources installations** – installations producing electricity from renewable sources, including water, sun, wind, geothermal springs, biogas, biomass, or sea tides.

3. **Power grid** – this network can be compared to a transit network delivering electricity from the generation unit to end user. It is composed of high, medium, and low voltage lines.

4. **Electric vehicle charging station network** – physical charging stations connected to the electric energy network, along with a required IT infrastructure, allowing users to charge their electric or plug-in hybrid vehicles.

5. **Electric cars and buses** – vehicles that have electric or plug-in hybrid engines with batteries that support charging from an external source. These may be used for various purposes depending on the needs of clients:
   - B2P (business to public) – electromobility will find a place in public transportation, for example, city buses, and vehicles for uniformed services and public administration officials,
   - B2B (business to business) – companies will take advantage of electromobility in their businesses. Examples include, taxi corporations, car fleet management companies, and enterprises investing in their own electric car fleets,
   - B2C (business to consumer) – private individuals will be able to have their own electric cars, but can also make use of innovative car-sharing and carpooling services.
Electromobility in the public transportation system
Public transportation

Since it emits no carbon dioxide or dust, and little noise, electromobility is the perfect solution for the transport of large numbers of people along fixed routes within urban agglomerations. Currently, a considerable segment of urban and suburban transportation means is based on electric energy.

Passengers divided by means of public transportation in Warsaw

Data presented above indicates that almost 47% of Warsaw’s current city transportation system is based on electric energy. The city is planning to continue the gradual modernization and replacement of gasoline-powered vehicles with electric vehicles, and to build a modern and environmentally sustainable infrastructure for the purposes of bus transit by the year 2020. However, Warsaw is only one example and a public transportation system could be composed of the following elements:

Subway (electric)
An aboveground and underground high-capacity rail system that transports a large number of passengers, most prominently between the center of a given metro area and suburbia. Subways offer many stops along the route and run at frequent intervals. They do not depend on urban road transit and can be connected to the rail infrastructure.

Tram (electric)
An urban transit vehicle powered by electric energy that runs on rail, usually along the roads of main communication arteries. Compared to individual transport, it provides smoother driving even in case of heavy traffic.

Urban and suburban rail (electric)
A vehicle using an electric rail traction system for everyday commuting, for example, to work in the city center by residents of suburban areas and satellite districts.

Buses (gasoline, hybrid, and electric)
Urban transit vehicles running on roads together with cars and trucks used for everyday commuting; for example, to work by the residents of urban agglomerations. Most buses run on gasoline.
There are also modern hybrid and electric versions of buses and interest in implementing electromobility in public transit is on the rise. Under the E-bus program, 45 Polish cities and local authorities, which have roughly 48% of the bus stock in Poland, declared the will to purchase over 800 electric buses by the year 2020; this would compose around 7% of the entire bus stock in Poland.

Due to the higher initial price and greater pricing range when compared to standard buses, the use of electric buses in public transportation requires the operators to take into consideration numerous factors and parameters in order to ensure the vehicle’s optimal adjustment to the needs of the given city or commune.

When selecting an electric bus, the most important thing is the way it will be used. The following factors are also of high importance:

- route length,
- time between runs,
- availability of charging infrastructure,
- passenger numbers.

These factors determine the bus’s size, capacity, battery type, and even the charging method. Appropriate parameters are important so that the higher costs of purchase can be brought down by the lower costs of operating during use.

Trolleybuses

These are wheeled electric vehicles that run on common roads but only when connected to the electric traction network with pantographs. Trolleybuses used to be common in big cities but now only appear in Gdynia, Lublin, and Tychy. Interestingly, thanks to batteries installed, modern trolleybuses can be disconnected from the traction system and continue to run for several kilometers, which raises their utility potential.

Urban (traditional and electric) bicycle system

Urban bicycle system provides bicycles for rental and return in many densely agglomerated regions. The system is connected to a mobile application allowing users to verify and manage their accounts. Warsaw has started testing electric bicycle rental, which will supplement the existing Veturilo infrastructure.

According to Miejskie Zakłady Autobusowe in Warsaw, an 18-metre electric bus (LTO 125 kWh battery) can be less expensive to run than a diesel bus when considering the total costs of the investment, fuel, and bus and infrastructure maintenance.

Urban car-sharing

Right now, most big cities in Poland are either considering or launching pilot city car rental programs. Some of the tenders organized by local governments are clearly oriented towards electrically powered vehicles. Paris with its Autolib electric vehicle system is an example of a city where public car sharing is very popular. In mid-2016, it had over 126 thousand registered users who had almost 4,000 electric cars at their disposal across almost 1,000 locations. It costs fourteen euros per hour to rent a car. It should be noted that the operator of the Paris system, Bolloré, has developed its own electric vehicle, the Bluecar, for the purposes of car-sharing.

Public electric vehicle charging station network

A network of publicly accessible free or paid electric car charging stations. The charging points can be established by local governments in cooperation with private partners, or by private entities alone. The sources of financing may differ also, ranging from public funds through European Union funds to private funds.
Electric buses on the Royal Route in Warsaw

Case study

The Miejskie Zakłady Autobusowe (MZA) city bus company in Warsaw is one of the largest transportation operators in Central and Eastern Europe and has over 1,300 buses that are used by 1.2 million passengers every day.

In June 2015, MZA introduced ten low-floor electric Solaris U12E maxi buses. Ten more buses are slated for delivery in the second half of 2017; furthermore, there is an open tender for another procurement of a similar size. But this is only the beginning of MZA’s plan, which encompasses the purchase of 120 electric buses within the next few years, and the replacement of their entire fleet with electric vehicles after the year 2030.

MZA also has an educational project for promoting its image, which is being conducted in cooperation with the Capital City of Warsaw and aims to replace all buses running along the Royal Route with electric vehicles.

Currently, all buses servicing route 222 are electric but the gasoline-based vehicles will continue to be retired as the new fleet is introduced on other routes.

According to this plan, there should be nineteen loops with pantographic charging points operating after the year 2020. MZA believes that the daily demand by all electric buses on these loops will exceed 48 MWh.15

MZA’s plans also include the development of a modern, two-floor, bus depot for roughly 300 buses, including 100 electric ones.

In accordance with the results of the tender organized by MZA, the electric energy for charging Warsaw’s electric buses during 2017–2018 will be provided by innogy Polska.
The plan to develop an electric car charging network in Warsaw was prepared together by the Capital City of Warsaw and Innogy Polska. The first station was opened in November 2009 in front of Innogy Polska’s headquarters at Wybrzeże Kościuszkowskie 41. The next eleven soon appeared in Warsaw both in prestigious locations and in places convenient for the city’s residents, including the front of the National Opera at Plac Teatralny.

At present, Innogy Polska has a network of twelve publicly accessible charging stations in Warsaw, which are spread out across the whole city. Each post has two sockets, which means that there are a total of twenty four charging points for cars. Each station offers 22 kW per point. The power available for the connections is not sufficient at all locations and some locations have a lower actual charging power.

The charging network management system allows the use of individual points and the amount of distributed electricity to be monitored. Data collected from the end of 2012 onwards shows the evolution of the electric car market in Warsaw.
Before 2015, few electric cars visited the stations. The electric Fiat 500 used by innogy Polska was responsible for a certain number of charges at the station in front of the company’s headquarters. This means that other users did not use the station much. However, it should be noted that there were just over 500 electric and plug-in hybrid vehicles registered in Poland before the year 2015. There was a clear spike in the number of charges in the year 2016 when there were just few electric and plug-in hybrid vehicles registered in the country (only about 550 new registrations) but the one responsible for most of the charges was a taxi corporation that was established in early 2016 and uses exclusively electric cars, with some of its drivers taking advantage of the innogy Polska’s publicly accessible charging network.

Between October 2012 and the end of June 2017, the charging station in front of innogy Polska’s office distributed a total of 52 MWh of electric energy, most of which was distributed in 2016. On average, less than 10 kWh of energy was collected per charge and the charging time was between 40 minutes and 3 hours.

**Electric vehicles were able to cover 50,000 green km since November 2015 thanks to the energy produced by the photovoltaic installation on the roof of innogy Polska headquarters in Warsaw**

<table>
<thead>
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<th>Year</th>
<th>Charges</th>
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<tr>
<td>Q4 2012</td>
<td>15</td>
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<tr>
<td>Q1 2013</td>
<td>137</td>
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<tr>
<td>Q2 2014</td>
<td>440</td>
</tr>
<tr>
<td>Q3 2015</td>
<td>621</td>
</tr>
<tr>
<td>2016</td>
<td>2,013</td>
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<tr>
<td>H1 2017</td>
<td>2,000</td>
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Assuming that an electric car’s energy consumption per 100 km is 13 kWh\textsuperscript{17}, we can calculate that the electric energy used at the innogy Polska’s station was used to cover over 400,000 km. There was an additional benefit for the residents of Warsaw: these charges prevented the emission of over 54 tons of CO\textsubscript{2}\textsuperscript{18} and a considerable amount of harmful dust in the city.

Between July 2016 and the end of June 2017, the station at Plac Defilad was used over 1,540 times. The total charging time exceeded 5,180 hours, 2,590 hours per socket. This means that point utilization reached almost 30% of the available time (8,760 hours/year). There is no information on the length of time the cars spent in the parking spot after the charging process was over. However, daily observations of the station at Wybrzeże Kościuszkowskie 41 (over 3,700 charging hours between 01.07.2016 and 30.06.2017) show that it is used regularly during the day and charges at least one car at a time.

The information presented above leads to the conclusion that the existing network of twelve charging stations is currently sufficient to handle the number of electric cars in Warsaw because the points are under-utilized even by half of their capacity. However, the most popular stations may be difficult to access, especially during the daytime. The development of Warsaw’s public network should be based on an analysis of the needs and habits of electric vehicle users. Other than the city center, the natural locations for charging stations would seem to be shopping centers, bus and train stations, transfer locations (Park&Ride parking lots), and transport junctions.

Currently, innogy Polska is developing various business models based on charging services and is preparing their commercialization.

The following stations were used most frequently:

1. Plac Defilad at Emilii Plater St.,
2. Arena Ursynów (Pileckiego St. 122),
3. Wybrzeże Kościuszkowskie 41 (innogy Polska headquarters).
Operation and use of electric cars
Electric cars

There are over 27 million motorized vehicles in Poland, including over 20 million cars\(^\text{19}\). This means that when electric vehicles surpass 1 million in number, they will compose only about 5% of the country’s cars. In comparison, there were almost 3 million cars with LPG systems installed in 2016\(^\text{20}\), which accounted for roughly 15% of all cars and were responsible for a similar percentage in demand for transport fuels\(^\text{21}\).

First-time registrations of new electric cars and hybrids in Poland

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>I-VI 2017</th>
<th>VI 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrids</td>
<td>3,900</td>
<td>5,583</td>
<td>9,849</td>
<td>8,252</td>
<td>~35,000</td>
</tr>
<tr>
<td>Electric cars and plug-in hybrids</td>
<td>100</td>
<td>337</td>
<td>556</td>
<td>361</td>
<td>~1,600</td>
</tr>
</tbody>
</table>

Source: Own estimations based on information from the Polish Automotive Industry Association

Currently, there are approximately 1,600 electric cars and plug-in hybrids on Polish roads. Traditional hybrids are more popular as there are over 35 thousand of these in Poland. The most popular electrically powered vehicles (including plug-in hybrids) are the BMW i3, Nissan Leaf, and Tesla.
Most popular electric cars in Poland in the first half of 2017 (according to number of registrations):

- BMW i3
- Nissan Leaf
- Tesla Model S
- Tesla Model X
- Renault ZOE

62 49 16 14 7

Source: Central Registry of Vehicles and Drivers

Today, Polish drivers can choose from several models in the electric, city cars’ segment. BMW i3, Hyundai Ioniq, Nissan Leaf, Renault ZOE, and Volkswagen eGolf are all priced under PLN 165 thousand\(^2\). One manufacturer offers a version without a battery for PLN 89.9 thousand, but this requires a leased battery at an additional monthly fee that depends on the mileage and capacity. This is in response to users’ concerns about battery life, because the risk is transferred to the vehicle manufacturers. According to their declarations, the total range of these models falls between 160 and 400 km, but it is determined mainly by battery capacity, which can be between less than 19 kWh and up to almost 41 kWh. These parameters are more than enough for cars used mainly in the city.

Currently, most car manufacturers are working on an electric vehicle or on a whole line. Within a few years, every segment except gasoline engines will be offering hybrid and electric motors. This means that everyone will be able to find something to suit their needs.

Currently, there are approximately 1,600 electric cars and plug-in hybrids on Polish roads.
Operating costs

Information on the use of innogy Polska’s vehicle fleet was analyzed to determine the TCO (total cost of ownership) of electric vehicles in comparison to gasoline-powered vehicles used for similar purposes. The calculation assumes a monthly mileage of 2,000 km, a leased vehicle with 60 financing months, a PLN 0 first payment, insured, and with mechanical and tire servicing.

<table>
<thead>
<tr>
<th>Segment C, diesel engine</th>
<th>Segment B, electric engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage/month</td>
<td>2,000 km</td>
</tr>
<tr>
<td>Fuel and energy consumption /100 km</td>
<td>5.86 l**</td>
</tr>
<tr>
<td>Fuel or energy price*</td>
<td>3.62 PLN**</td>
</tr>
<tr>
<td>Fuel or energy cost*</td>
<td>424 PLN</td>
</tr>
<tr>
<td>Monthly financing cost*</td>
<td>1,500 PLN***</td>
</tr>
<tr>
<td>Monthly cost*</td>
<td>1,924 PLN</td>
</tr>
<tr>
<td>TCO (60 months)</td>
<td>115,500 PLN</td>
</tr>
</tbody>
</table>

Source: Own study; * net value; ** 2016 information for innogy Poland’s fleet; *** Own calculation based on available information.

For a monthly driving distance of 2,000 km, the total ownership cost (TCO) of an electric vehicle is about 16.5% higher than that of a diesel-powered vehicle. However, the TCO starts to even out at a monthly mileage of over 4,000 km. This means that the costs of a leased electric car may already be comparable to those of a gasoline-powered vehicle despite the fact that the catalogue price of the former is higher by around 60%.

The near future may see the introduction of new regulations that turn electric vehicles into a realistic alternative to traditional ones. There are various options – from the introduction of additional charges for diesel-powered vehicle users (e.g. environmental fees associated with combustion emissions) to subsidies for electric car purchases and/or support in the form of tax benefits for electric car users.

The calculation of the electric vehicle’s operating costs could also include the option of it being charged from solar power generated by home photovoltaic panels.
Photovoltaic installations and electric cars

In Poland, a 3.2 kW model photovoltaic installation on the roof of a single-family home will generate over 3.1 MWh of electric energy annually. If all of this energy is used to charge electric vehicles, it would be enough for roughly 24,000 km per year, or 2,000 km per month. This means that the annual fuel saving compared to a gasoline-powered car will exceed PLN 6,000 or PLN 2,000 when buying electric energy from the network. The purchase cost of such installations, comes to around PLN 18,000, which means that a return on investment can be expected within 3 years, and beyond this, charging our cars will be more or less free. If an electric car costs over PLN 120,000, the value of the photovoltaic installation will not exceed 15% of the vehicle’s price.

The innogy fleet is being replaced

In March 2017, innogy SE decided to replace its company car fleet in Germany, which includes over 1,000 vehicles, with electric and hybrid cars within the next four years. innogy SE employees who order an electric company car will receive charging infrastructure from innogy, including a home charging station. innogy will also cover the costs of the electric energy associated with charging the car at home.

We are fully aware that electromobility is the future of the automotive industry and innogy is already one of the leading providers of infrastructure for charging electric vehicles. We have over 5,800 charging points throughout Europe. Our group is now entering a new era of electromobility, says innogy SE’s CEO Peter Terium.
Currently, depending on the production year, an average-class fully charged electric car can cover a distance of 100–200 km. At a daily mileage of around 25 km\(^2\), a fully charged car will need to be recharged every two to three days even when the air conditioning or heating is off. If the car is used to get to and from work and go shopping, the charging points at home or the workplace will be enough; but there is a challenge when it comes to a trip out of town or to another distant city.

Examples of routes in km that are drivable in an electric vehicle (with an assumed range of 160 km)\(^2\):  

Examples of routes in km that will be drivable in an electric vehicle (with an assumed range of roughly 350 km) in the near future\(^2\):  

This range will continue to grow in the near future due to technological developments and bigger batteries. However, before this happens, the charging infrastructure must grow.

According to projections by the Ministry of Energy, 32 selected agglomerations will have over 400 publicly accessible fast charging points and 6,500 regular charging points available for around 50,000 electric vehicles by the year 2020\(^2\). Private companies are also growing the charging network. innogy Polska has installed over 70 charging stations in Poland, fourteen of which it owns. These fourteen stations are open to the public (a 12-station network in Warsaw and 2 stations at the AGH University of Science and Technology in Cracow).

This collective central and local activity combined with private business initiatives should eliminate, within a few years, the barrier to the development of electromobility in Poland presented by an insufficient charging infrastructure.
In 2016, innogy released a mobile application for Android and iOS dedicated to electromobility that makes it easier to plan travel with an electric car. It supports route setting, finding charging stations along the way, and making potential payments. It also supports the monitoring of the car’s energy consumption, range, and incurred costs. Today, the map covers most of Europe (including Polish innogy stations) and new functions are still being added.
Charging
Development of the electric car charging infrastructure

For markets in the early stages of development, adjusting the pace of infrastructural expansion to the number of users is very important. An excessive number of vehicles with an insufficient number of charging stations may discourage future users. On the other hand, the construction of numerous stations when there is little demand for charging will cause initial investment losses. According to the Ministry of Energy’s plans, the main priority will be to expand the infrastructure in the big agglomerations and along the trans-European transport corridors running through Poland.

Europe currently has over 112,000 publicly accessible fast and standard electric vehicle charging points, led by the Netherlands (29,473), Germany (20,295), and France (16,129). According to statistics of the European Alternative Fuels Observatory, there are around 330 points in Poland. The country with the most electric and plug-in hybrid vehicles per point is Norway with around fifteen. The Netherlands, Germany, and France have around four, five, and six vehicles per point respectively. Norway is the undisputed leader in Europe and its sales of electric and plug-in hybrid vehicles composed roughly 30% of the local market as from the beginning of 2016. However, such dynamic development was possible only because of an incentives system; this has taken various forms since 1990 in its support for the development of zero-emission transport – tax benefits, road or parking fee exemptions, infrastructural subsidies.

In accordance with Directive 2014/94/EU of the European Parliament and of the Council, member states should have one publicly available charging point for every ten vehicles by the end of 2020. This means that in Poland, one million electric cars should have access to approximately 50,000 public charging stations (1 station = 2 points).

Furthermore, in accordance with art. 4 section 9 of the Directive, a publicly available charging point is one that allows electric vehicle users to charge as needed, with no requirement to enter into agreements with the electric energy provider or operator. This regulation, therefore, should help create a common payment system for charging services (there is more information concerning payment models later in the report).
Electric car charging stations

Power

Power rating of electric vehicle charging points:
• low voltage (mainly for private purposes) – up to 3.7 kW, alternating current,
• standard voltage – between 3.7 kW and 22 kW, alternating current,
• high voltage – over 22 kW, alternating and direct current.

Connectors

Currently, there are several connector standards on the market for electric vehicle charging points. The standard IEC 62196-2 (2014)34 developed by the International Electrotechnical Commission introduced the standard for alternating current (AC), while car manufacturers usually install two types of connectors: type 1 for single-phase power and type 2 for 3-phase power. Direct current (DC) is subject to three standards: CCS, CHAdeMO and a third one adapted by Tesla, similar to the type 2 connector35. There is no common standard in the industry and it seems that only European Union regulations can help in selecting a uniform solution. It should also be noted that this does not pose a problem for the development of electromobility.

Electric buses are subject to the so-called Combo 2 connector standard (European Union Directive 2014/94/EU). A standard for pantographic charging (an automatic connector between the bus and the station located on the vehicle’s roof) is currently in development.

The name CHAdeMO is allegedly drawn from the Japanese “O cha demo ikaga desuka”, which means “Let’s have a tea” and refers to the charging speed.
Client group segmentation

1. Private charging stations (B2C)

In most cases, these will be single-phase or 3-phase charging stations in garages, on home driveways or in underground garage complexes. In free-standing buildings, the charging stations will not need a separate meter because it will be connected to the existing home installation. The stations in underground garages will have to be equipped with a separate meter and the energy used will have to be billed. However, if the charging infrastructure is designed at the construction stage, it will be possible to install comprehensive systems connected to all points. In such cases, billing systems could be based on actual consumption or a monthly charge included in the rent.

2. Charging stations for business clients (B2B)

Compared to gasoline-powered vehicles, operating an electric car can already be less expensive, but this is conditional on the monthly mileage. Because of this, companies will be more willing to introduce electric vehicles if it can be economically justified. The dedicated charging stations that meet specific user’s needs will respond to these enterprises’ needs. Access to charging infrastructure is very important for enterprises operating businesses based on continuous vehicle use. This will lead to the development of fast charging stations accessible only to one enterprise, for example, a courier service. Real estate administrators will also develop charging networks to meet the expectations of their tenants. Today, decisions on parking spaces for electric vehicle charging are often dictated by the desire to obtain an environmental certificate for the building, but tenants will begin demanding bigger infrastructure as the number of cars rise. The business sector may help increase the number of charging stations, but most of these stations will not be available to the public.

3. Public charging stations (B2P)

Today, there are around 330 publicly accessible charging points in Poland (one station can have multiple distributors). Warsaw alone has over a dozen, including the network that has been in development by innogy Polska in the capital city since 2009. Most public charging points are free and available to everyone, but there are locations where access to charging requires registration, which means that you cannot charge your car without prior planning and fulfilling certain formalities. The publicly accessible network should continue to grow. It will be developed by private companies, local governments, and with public and European funds. At the present time, when there are still only a few electric cars, the development of the infrastructure should be supported by a system of appropriate incentives that eliminate the barriers to electric vehicle promotion. Furthermore, electric car users should expect the introduction of a fee for vehicle charging. The harmonization of billing system models would help them avoid potential problems. The role of the state seems to be important, especially in the early stages of work on the terms and conditions of operating in this new market.
Solutions prepared by innogy Polska

innogy Polska offers several charging station models in Poland for various client groups. The series of three main stations are presented below.

<table>
<thead>
<tr>
<th>Station name</th>
<th>innogy eBox</th>
<th>innogy eStation</th>
<th>innogy eStation Smart Multi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>5–8 kg</td>
<td>50 kg with installation frame; 150 kg with concrete foundation</td>
<td>700–1,200 kg</td>
</tr>
<tr>
<td>Installation type</td>
<td>Installed on a wall</td>
<td>Installation on a foundation, installation on a special frame fixed to the ground</td>
<td>Installation on a foundation or specially prepared ground</td>
</tr>
<tr>
<td>Connector</td>
<td>IEC type 1 or type 2</td>
<td>IEC type 2, CCS, or CHAdeMO</td>
<td>IEC type 2, CCS, or CHAdeMO</td>
</tr>
<tr>
<td>Number of charging points</td>
<td>1</td>
<td>1–2</td>
<td>up to 3</td>
</tr>
<tr>
<td>Power</td>
<td>230 V AC single-phase 16 A (3.6 kW); 400 V AC 3-phase 16 A (11 kW) and 32 A (22 kW)</td>
<td>400 V AC 3-phase 32 A (22 kW) and 63 A (44 kW)</td>
<td>400 V AC 3-phase, 3 x 32 A, 22 kW or 73 A, 50 kW</td>
</tr>
<tr>
<td>Charging start</td>
<td>Key lock, Plug&amp;charge, RFID or remote (smart home/network)</td>
<td>Key lock, Plug&amp;charge, payment system (optional)</td>
<td>innogy eCharge application, RFID, Plug&amp;charge, payment system (optional)</td>
</tr>
<tr>
<td>Additional features</td>
<td>Optional connection to home installation; operation with a separate meter; remote consumption measurement, support for up to 99 devices</td>
<td>Optional display, remote energy consumption reading</td>
<td>Color display</td>
</tr>
</tbody>
</table>

Source: Own materials
An investigation of the solutions available on the market leads to the conclusion that there are several ways to charge electric vehicles:

- **cable charging** – requires manual connection of the vehicle to a power source with a cable. This solution dominates when it comes to cars,
- **pantograph charging** – encountered mainly on buses and performed using an automatic connection in the form of a retractable pantograph between the installation on the vehicle’s roof and the charging station,
- **changing the whole battery set** – requires mechanically changing the vehicle’s batteries; this solution is slowly becoming obsolete,
- **wireless charging** – at present time induction charging is in the testing stage, but there are many companies working on the development of this technology. This solution will not replace traditional charging, but may extend a vehicle’s range by, for example, allowing buses to recharge at bus stops,
- **solar charging** – through photovoltaic panels installed on the vehicle’s roof. Toyota has implemented such a solution, but a one-day’s charge provides only enough energy for up to 5 km.

Charging speed is determined by several factors:

- the power rating of the charging station or network socket,
- the power available at the connection from the power network; this may be lower than the power of the station and may cause the power available to be distributed unevenly when charging on multiple sockets,
- the power of the vehicle’s converter – a car with standard options is often equipped with chargers that have limited parameters (e.g. 3.6 kW), while a superior version (e.g. 6.6 kW) costs more. When buying a car, consumers are often not aware that the charging process will be slower when they choose the standard version,
- the vehicle’s operating software and its communication with the charging station,
- the charging cable and its parameters.

For the first three factors, the charging pace will be determined by the lowest power of any one of these and it might not be possible to charge the car at all if there are problems with its communication with the charging station or if the cable is damaged.

The charging time is also determined by the type of current. Most chargers support alternating current (AC) – these form the common charging stations and the sockets at home, which are usually slower. The so-called fast chargers support direct current (DC), which allows for the efficient charging of a battery in less than an hour.

<table>
<thead>
<tr>
<th>Battery capacity</th>
<th>Charging point parameters</th>
<th>Charging time</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 kWh</td>
<td>2.2 kW</td>
<td>14–16 hours</td>
</tr>
<tr>
<td>100 kWh</td>
<td>2.2kW</td>
<td>45–50 hours</td>
</tr>
<tr>
<td>30 kWh</td>
<td>3.3 kW</td>
<td>9–10 hours</td>
</tr>
<tr>
<td>30 kWh</td>
<td>6.6 kW</td>
<td>4.5–5 hours</td>
</tr>
<tr>
<td>30 kWh</td>
<td>62.5 kW</td>
<td>30 minutes</td>
</tr>
<tr>
<td>100 kWh</td>
<td>120 kW</td>
<td>50–60 minutes</td>
</tr>
</tbody>
</table>

Source: Own calculation
Note that the calculations presented above do not include losses. The energy lost in filling gasoline-powered vehicles is relatively low (a few drops spilled), but for electric cars, it should be taken into account that there are additional energy losses produced in the charging process – these can reach 5–10%. They mainly concern losses by the onboard (or external) charger, which should have an efficiency within range of 90–95%. Lithium-ion batteries also have a small share in the losses, usually in the range of 1–2%, with the precise value determined by the type.

The following formula can be used to calculate the time required to charge a vehicle:

\[
\text{charging time in h (hours)} = \frac{\text{battery capacity to full charge in kWh}}{\text{available power in kW}} \times 0.9 \text{ - efficiency}
\]

Example: for a 30 kWh battery and 3.3 kW of charging power:

\[
\text{approx. 10 hours} = \frac{30 \text{ kWh}}{3.3 \text{ kW}} \times 0.9
\]
Transmission and distribution infrastructure

A considerable part of responsibility for ensuring a public infrastructure for a transportation system based on electromobility will fall to the Distribution System Operators (DSO), who will be operating in accordance with three acts: the act on electromobility and alternative fuels (under development), the Energy Law (dated 10 April 1997), and the Building Law.

In accordance with the act on electromobility and alternative fuels of June 2017, DSOs will be responsible for a program covering the development of publicly accessible charging points, and the projects required for connecting these points to the network. This task will include the modernization, expansion, and construction of the electric energy network in order to develop the electric vehicle charging infrastructure in selected local authorities.

In accordance with the bill, the DSOs’ plan for local authorities should specify the following:

• the number of planned publicly accessible charging points,
• the technical parameters and the proposed locations of the points connected to the electric power grid,
• the available connection capacity,
• the projected demand for electric energy by road transport,
• the number and technical parameters of the publicly accessible charging points.

The DSOs will have to develop a five-year plan, which will be subject to approval by local authorities (city president, mayor, or commune head). This should lead to a plan for the locations of publicly accessible charging points and include the expected deadlines for their installation.

From the perspective of the consumer, the important factors are the time of release and the parameters of the publicly accessible charging points. Considering the fact that the act for electromobility will likely take effect in 2018, the plans for the communes may be delayed by budgets and, therefore, not start until the year 2019. Taking into consideration the construction time and the scale of the venture, it may be expected that a considerable number of the stations will not be operational until 2020–2021. Until that time, electric vehicle users will have to manage with the points that exist already and stations developed by private entities.

As for the station’s specific technical parameters it must fulfil the minimum power of 3,7 kW.

Publicly accessible points cannot be located just anywhere. When deciding upon the locations for charging points, a DSO will have to consider the capacity of the distribution network, the ownership rights of the land at the charging point, the construction work required, the changes required to the existing infrastructure, and the accessibility of the parking space at the charging point.

According to the model proposed in the bill and the projections presented in the “Domestic Frameworks for the Alternative Fuels Infrastructure Development”, the base infrastructure for electric vehicles will proceed under a system of tenders in 32 agglomerations (municipalities with a population exceeding 100,000 with at least 60,000 registered cars and at least 400 cars per 1,000 people). The plans are to equip such areas with 6,000 regular power charging points and over 400 fast charging points.
The sustainable development of the electric vehicle charging network is the best solution

The creation and connection of an infrastructure for charging one million electric vehicles presents a considerable challenge for the domestic electric energy network. Since this market is in its early stages of development, it is possible to gradually prepare the network for the development of electromobility. However, this process requires the cooperation of the Transmission System Operator, Distribution System Operators (DSO), energy companies, representatives of Polish central and local authorities, and companies dealing in electromobility.

It should be noted that the demand for charging stations will not be limited to electric cars. It will also rise with the increasing numbers of zero-emission city buses – we have already installed 220 kW charging stations for buses in Warsaw. Because of this, one of the current priorities is to determine the power supply demand for fast charging stations for electric cars and buses. From the perspective of the DSOs, there are two major challenges associated with the rising demand for fast electric vehicle charging stations:

- Charging distribution by location and time – the most economical solution is balanced charging proportionate to network capacity. If there are too many stations in a small area, those stations used simultaneously may not be able to charge at full power. There will also be places where the existing load or lack of appropriate infrastructure could prevent the installation of any charging point. Analyses of big city infrastructures that aim to determine connection potentials are already in progress. The question is: who is more important in big city centers, public transportation such as buses, or urban car sharing? The answer could determine the distribution of the electric vehicle charging infrastructure and the power demand structure.

- Distribution of costs associated with network development – fast charging stations require a high power connection, but their actual energy use will be disproportionally low. According to simple calculations, the maximum connection power could almost double for one million electric vehicles, but the consumption of electric energy on a nationwide scale will rise annually by only about 1.5–3%. This
means that the fee for electric vehicle users should not only include the price of the electric energy per 1 kWh and its distribution, but also the costs of the connection’s development and charging station construction – this will often reach into the high thousands of PLN.

Personally, I am in favor of the electromobility market model discussed in the European Commission documents, where the Distribution System Operators do not invest in charging posts as part of their regulated activity. Under this model, the DSOs establish agreements with electromobility operators, i.e. the companies funding the posts and providing access to them at various locations for various fees dictated by the standards of the free market. Anything else will restrict the market’s innovation and competition development at the very start.

The slow home charging points, which will be used mainly at night, will both help and hinder the network. First of all, they require smaller power of grid connection. A common 230 V home socket will charge an electric car, but it will take several hours. Second, this will generate more demand for electric energy at night when other consumer demand drops. This will reduce the so-called “night valley” and improve the network’s safety. Third, slow charging is beneficial to battery life.

The developing electromobility will be accompanied by more and more slow charging points appearing in, for example, underground garages as most drivers will not need fast charging stations. Currently, an average electric car can surpass 100 km on a single charge, even with the air conditioning or heating on, which means that if it is used as a city car, it will rarely need to be recharged at a fast charging station during the day.

Considering the advantages of slow charging points, users should be encouraged to charge their cars at home. Potential incentives include tariff plans that offer electric energy at lower prices outside of the peak periods.

The development of an electric vehicle charging infrastructure presents a major challenge for the Distribution System Operators, but, if spread over time, it can be prepared properly and carried out in a sustainable manner, including in the context of preserving safety and at reasonable costs for the entire electric power grid.

Robert Stelmaszczyk
CEO, innogy Stoener Operator Sp. z o.o.
Charging payment models

Charging point business models are not yet fully mature because of the need to combine the high initial investment costs with a relatively low margin. Furthermore, they must be adapted to the particular country’s market and regulatory conditions. An analysis of various solutions distinguishes the following models:

- **Free charging** – a solution usually aimed at supporting technological development. On a global scale, Tesla was offering free lifelong charging at its stations with cars purchased before 15 January 2017, but the models sold after this time no longer include this solution. The free model is sustainable when it is based on, for example, a subsidy system, which is usually in effect for a certain period of time to promote a particular technology, or is offered together with other services (e.g. charging services included in the electric vehicle purchase price),
- **Charging for a fee** – a fee is established for the amount of kWh used,
- **Fee for charging time** – this solution favors drivers with more powerful converters and new generation electric vehicles that charge at a higher energy for a given time than standard chargers,
- **Fee per charge** – the advantage of this solution is its simplicity. The driver pays for a recharge regardless of its time or the energy used,
- **Subscription fee** – a fixed fee irrespective of the charging volume, time, or power; usually limited to one station,
- **Services package** – standard charging combined with additional services, for example, parking spot rental.

It should be expected that some form of fee structure for electric vehicle charging will appear in Poland. The development and popularization of the technology will entail a growth in charging point maintenance costs and the amount of power collected from these points, and station owners will attempt to cover their rising costs and ensure that the venture produces a positive business result.

Business operators are not the only ones to introduce fees for electric vehicle charging. A range of countries that previously offered it for free, are doing the same. For example, the government of Portugal has decided to introduce charging fees to fund further development of the station network.
Besides the charging costs, which fall to the user, the fees can also help control daily power demand. This process requires stimulating a price reaction in consumers, which can be done by diversifying energy prices depending on market demand, for example, by introducing controlled rates or temporary price signals for consumers (e.g. dynamic rates)\textsuperscript{41}. It is hard to imagine that anyone would give up charging when their car battery is empty, but, with time, the introduction of such price stimuli may affect the behavior of electric car users, who will move vehicle charging to a time when the prices are lower, i.e. when the energy demand in the system is lower.

Furthermore, in the future users could receive a monetary reward or free energy for connecting their electric cars at specific hours. In this way, the car battery could be used as an “energy bank”, charged when there is a lot of energy in the network and consumed when network demand is high. Right now, vehicle manufacturers do not offer such options because of an insufficient smart network infrastructure, high battery prices, and limited battery lifespan. However, thanks to the continuing development of technology, we can assume that battery prices will drop. The International Energy Agency concludes that the price for 1 kWh could drop from $200 to $125 within the next five years (by 2022)\textsuperscript{42}. 


innogy global electromobility development
Innogy Worldwide

With over 5,800 charging points installed, the Innogy group is one of the largest players in the electromobility market in Europe. In Germany alone, its network is composed of almost 3,000 points developed in cooperation with 150 partners from urban and municipal companies. Furthermore, Innogy has been working with the University of California San Diego since 2015 and its stations were certified for the American market in 2017, which now opens the way for development of charging stations in the United States.

Electric car users usually associate electromobility with charging stations. Because of this, Innogy focuses on solutions that ensure that every-day charging is easy and convenient for its users. However, the whole electric vehicle ecosystem is more comprehensive and is composed of numerous elements. Its foundation is a smart infrastructure, i.e. charging stations connected to electric power grid, supporting a dedicated IT solution. The charging process is not possible without appropriate software and billing system. Therefore, Innogy offers comprehensive solutions and adapts them to the needs of the various client groups:

- **Public charging points** – generally accessible and paid charging points commissioned by external entities and installed in cooperation with partners or using Innogy’s own funds,
- **Office parking points for private cars** – installed in cooperation with the office space operators or companies that want to provide their employees with the ability to charge their electric cars at work,
- **Dedicated points for electric vehicle fleets** – offered to business clients using electric vehicles for business purposes and requiring regular and exclusive access to charging points,
- **Points at stores and shopping centres** – paid or free charging points in parking lots and commercial spaces aimed at encouraging electric car drivers to, for example, shop at a given location,
- **Comprehensive offer for hotel businesses** – parking spaces and charging points for hotel guests and electric car rental from the hotel for the duration of a visit in a given town,
- **Private charging points** – solutions offered to individual consumers who want to have their own charging points with specific parameters at home.

Charging points are only a part of the solutions for the future; only recently a theoretical concept they are now being offered by Innogy to individual consumers in a range countries. The whole process starts with an energy audit at the consumer’s home and an extensive analysis of the consumer’s needs and electric energy consumption. The results are used to design a comprehensive system composed of a photovoltaic installation on the building’s roof, an energy bank, an electric vehicle charging station, and a smart home system to take advantage of things such as energy-efficient LED lighting. This solution allows the management of electric energy and heat demand to be monitored. If these solutions are balanced appropriately, often in combination with a system that supports pro-environmental investments in a given market, they lead to lower power bills and more independence during power failures as well as raising the standard and value of the property – all the while reducing CO₂ emission to the environment.
The search for innovation

The term “innogy” is derived from the words innovation and energy because the group’s direction of development is strongly associated with innovative technological solutions. In individual countries, the group’s companies are very independent when it comes to seeking out appropriate solutions and partners, including start-ups, to support the development of their business concepts. Additionally, there is a separate entity, the innogy Innovation Hub, at our headquarters, which handles innovation in the following five fields:

- Machine economy and blockchain
- Smart cities
- Internet of things
- Disruptive digital
- Big data

Share&Charge

One of the companies growing with the support of the innogy Innovation Hub is Share&Charge. This start-up is developing a charging network by affiliating private owners who are willing to provide access to their points for a fee.

The founders of Share&Charge realized that one of the biggest barriers facing the development of electromobility is the insufficient vehicle charging infrastructure. Due to the high costs and the special connection required, the expansion of public station networks often cannot keep up with the demand presented by electric vehicle users. The start-up’s founders recognized a potential in home stations, which are used for only a few hours a day, mainly in the evening. Taking advantage of the new trend based on people willing to share their resources (so-called “sharing economy”), with innogy’s support, they decided to develop a system that affiliated owners of home charging stations that were willing to open them to other users.

The station owner collects an access fee, can set the rate per kWh, and even create special plans for friends and acquaintances. Charging points connected to photovoltaic installations are also gaining prominence. They allow cars to be charged with renewable energy and the potential surplus they produce can be transferred into the network for an additional fee.

The users can use their Android and iOS mobile applications to access a map of charging points. Currently, the network includes almost 1,200 different charging stations in Germany and plans for the near future forecast its expansion all over Europe as well as the further development of the application.

The billing system involves blockchain technology, which does not require a central computer because it is dispersed and decentralized. During the charging process, the revenue from energy sales for the station owner and the costs of its purchase for the electric vehicle user are calculated in real time. The virtual wallet can be recharged by credit card, PayPal, or bank transfer and it can also be used to withdraw money. An invoice is issued after every transaction and this is also saved in the system. The user can access, send, or print the invoice at any time.
innogy drives electromobility in Poland

Taking advantage of the group’s knowledge, the solutions it has developed and its own experience in, for example, the Warsaw market, innogy Polska has been operating in the field of electromobility for almost eight years, which makes it well-prepared to meet the dynamic development of the electric vehicle market in Poland. By observing the industry, and analyzing it, as well as the experience discussed in this report the opportunities for making innogy Polska’s offer more attractive for business solutions, home charging points, and public stations have been identified.

At the present stage of development in the electric vehicle market, there is considerable potential in the business client segment and there is growing interest in home charging points among individual consumers. innogy has already prepared an appropriate offer and there is ongoing work on the solutions dedicated to various client groups and recognizing their specific needs. Based on the main client groups, the major directions of innogy Polska’s electromobility development are outlined below:

Business clients (B2B)

As previously noted, high mileage and the way the electric car is used can even out the purchase cost, which is higher than that of a gasoline-powered vehicle. Because of this, electromobility is gaining more and more supporters in the enterprise segment. However, needs may differ from company to company. The key factor for transportation companies will be charging time. Office operators and developers will be more interested in a high number of points with less power. As a result, innogy’s experts analyze the needs of the client and the way in which the electric car will be used at a very early stage and use the results to prepare a dedicated solution. An increasing number of companies who represent different industries come to innogy with questions not just about the charging stations but also about the potential of additional services like parking spaces, dedicated payment models, and consumption monitoring systems.
An example of a solution dedicated to business clients is our pilot program that provides access to charging stations as a service. The client is a certain Warsaw-based company with its own electric vehicle fleet. We analyzed their daily mileage, the working hours of the drivers, and the technical parameters of the cars and used the results to develop an optimal model for charging station use. Within the scope of our cooperation, we offered a dedicated fast, electric vehicle charging station including parking space. This station will be exclusive to this company’s electric vehicles. Under our agreement, the client will pay a monthly fee (subscription), which will not depend on the charging time or the amount of energy used. The point’s location was chosen to complement the company’s existing charging point system. The solution’s innovative approach is based on the fact that we offer the client a simple billing system (subscription), a comprehensive service including parking space and guaranteed station access, which will become more restricted in big cities.

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Individual consumers (B2C)

Fast charging points are most needed on the road or by drivers covering long distances each day, but the regular electric car user wants to have a charging point at home – the lack of potential to recharge a car at home is currently the biggest barrier facing electromobility development in the of individual consumers’ segment. innogy has been offering equipment to individual consumers for years. The demand for charging stations was initially limited, mostly by the narrow offer of electric vehicles on the Polish market, but innogy has recorded considerable growth in consumer interest since 2016. The costs for purchase and installation of such points are relatively low when compared to the costs of the vehicle itself or an underground parking spot. Individual charging points are starting to appear in the garages of newly built, high-standard, multifamily homes as well as in single family homes, where it is possible to connect a charging station to the existing electric installation. According to innogy, the number of new points will initially rise in proportion to the number of newly registered electric vehicles.

Public partners (B2P)

In the German electromobility market, innogy is cooperating with approximately 150 partners who represent urban and municipal companies, which means that it has experience in the development of comprehensive solutions across a range of publicly accessible electric vehicle charging stations. Poland is currently preparing an act on electromobility and alternative fuels, the objectives of which include the regulation of construction, operation, and accessibility of public electric vehicle charging points. When the aforementioned regulations take effect, innogy Polska will be able to take advantage of its knowledge in order to develop the charging infrastructure in Poland and prepare dedicated solutions. The potential for participation in future tenders for the commercial development of electric car charging stations will be analyzed on a case by case basis taking into account the resources held by innogy Polska.
Sources

1. ACEA European Automobile Manufacturers Association
3. Own calculations based on information from the Polish Automotive Industry Association as of 30.06.2017
5. Electromobility Development Plan for Poland, Ministry of Energy, p. 5
6. Own calculations based on information from the Polish Automotive Industry Association as of 30.06.2017
9. Document approved by the Council of Ministers on 29 March 2017
10. Sustainable Public Transport Development Plan for the Capital City of Warsaw, March 2015, p. 43, information for 2013
15. Electric Bus Operating Costs” presentation, Miejskie Zakłady Autobusowe (city bus company) in Warsaw, Jan Kuźmiński, 30 March 2017, E-bus Conference, Ministry of Development
16. Data Polish Automotive Industry Association
17. BMW claims that their i3 model consumes 12.9 kWh/100 km
18. Assuming an emission of 135 g/1 km for gasoline engines
22. Information based on manufacturer’s catalogues
24. Own calculations
26. Based on www.odleglosci.pl, accessed on 24.06.2017
27. Based on www.odleglosci.pl, accessed on 24.06.2017
30. European Alternative Fuels Observatory, statistics “Countries”, http://www.eafo.eu, 13.07.2017 (the statistics for Europe include the information for EU-28 and EFTA states and Turkey)
35. A Quiet Revolution in the Power Industry, Polityka Insight, p. 18
39. Draft bill on electromobility and alternative fuels, act 3
40. Domestic Frames for the Alternative Fuels Infrastructure Development Policy, Ministry of Energy, date: 29.03.2017
42. Electromobility Development Plan for Poland, Ministry of Energy, September 2016, p. 9-10
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