MASTER THESIS

ELECTRICITY DEMAND OF PASSENGER CARS ON THE GRID IN THE NETHERLANDS IN CASE ALL VEHICLES ARE ELECTRIC

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ET – Civil Engineering

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Final version

25 August 2024

UNIVERSITY OF TWENTE.

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Institution

University of Twente
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Program

Civil Engineering and Management
Discipline: Traffic Engineering and Management

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Samenvatting

De belasting van het Nederlandse elektriciteitsnetwerk loopt al tegen zijn grenzen aan. In sommige regio's is de maximumcapaciteit al bereikt. Desondanks stimuleert de Nederlandse overheid het elektrisch rijden. Dit onderzoek is gericht op het berekenen van de vraag op het elektriciteitsnetwerk door elektrische voertuigen, veroorzaakt door de transitie naar volledig elektrisch rijden.

Hiervoor bekijkt deze studie de piekbelasting op het elektriciteitsnetwerk veroorzaakt door het laden van elektrische (personen)auto's. Een aantal aspecten worden bekeken, waaronder verschillen in verplaatsingsgedrag per PC2-gebied en de effecten van verschillende laadscenario's.

Wanneer Nederlanders hun huidige verplaatsingsgedrag behouden, en alle autoverplaatsingen met een elektrisch voertuig worden gemaakt wordt een totaal elektriciteitsverbruik van ruim 81 GWh per dag verwacht, veroorzaakt door elektrisch rijden over heel Nederland. Er zijn aanmerkelijke verschillen tussen PC2-gebieden, zowel in het totale verbruik per reguliere werkdag als het verloop van het verbruik over de reguliere werkdag.

Als auto's met een maximale laadsnelheid geladen worden, dan levert dat een duidelijk hogere piekbelasting op dan wanneer ze geladen worden met een minimale snelheid. De piekbelasting voor heel Nederland, wanneer er met maximale snelheid wordt geladen, is 7.288 MW en met minimale laadsnelheid is deze piekvraag 4.288 MW.

Gekeken naar de elektriciteitsvraag over Nederlands is er geconcludeerd dat deze sterk verschilt over Nederland. Zo is, wanneer er met maximale laadsnelheid wordt geladen, de hoogste elektrische piekvraag in Amersfoort (112 MW) en de laagste piekvraag in Bolsward (12 MW). Met minimale laadsnelheid is de hoogste piekvraag in Amsterdam (57 MW) en de laagste piekvraag in Zuidhorn (4 MW).

Summary

The demand on the electrical grid in the Netherlands is reaching its maximum capacity. At some locations, the maximum capacity has already been reached. Despite this, the Dutch government stimulates electric driving. This research aims at predicting the additional demand on the electricity grid, caused by a transition to electric passenger cars only.

To do this, this research examines the peak demand on the electrical grid caused by charging electric cars. Several aspects are considered, including differences in travel behavior between PC2 areas and the effects of different charging scenarios.

Assuming the Dutch maintain their current travel behavior, and all car trips are made with an electric vehicle, a total consumption of 81 GWh is expected, caused by electric driving throughout the Netherlands. There are differences between PC2 areas, both in the total consumption per regular working day and in the pattern of consumption over the day.

If electric cars are charged at maximum charging speed, this results in a significantly higher peak electricity demand on the electricity grid than when charging takes place at minimum charging speed. The peak demand for the Netherlands as a whole, when charging at maximum speed, is 7,288 MW and with minimum charging speed this peak demand is 4,288.

Looking at the electricity demand across the Netherlands, it was concluded that this varies greatly. For example, when charging at maximum charging speed, the highest peak demand is in Amersfoort (112 MW), and the lowest peak demand in Bolsward (12 MW). With minimum charging speed, the highest peak demand is in Amsterdam (57 MW) and the lowest peak demand is in Zuidhorn (4 MW).

Preface

Before you lies the master thesis '*The electricity demand on the electricity grid of the electric passenger cars in the Netherlands in the event that all cars in the Netherlands drive electric*'. This thesis is the conclusion of my Master's degree in Civil Engineering and Management at the University of Twente. The research was carried out at the University of Twente.

I would like to use this preface to thank my supervisors of the thesis. Eric van Berkum and Oskar Eikenbroek, thank you for the guidance and feedback. Thanks to you, I have learned a lot about conducting scientific research and writing a thesis. I would also like to thank my family and friends for their support during this research and my study as a whole.

I hope you will enjoy reading this report.

Eline Roosendaal
Enschede, June 2024

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Term	Description
Electricity grid	Electricity infrastructure in the Netherlands
(Electricity) consumption	Electricity used during operation of electrical cars (MWh)
(Electricity) demand	Electricity taken from the electricity grid during charging of electrical cars (in MW)
Peak demand	Maximum demand in a certain period (in MW)
Grid congestion	Situation where electricity demand is higher than the grid capacity
Car deficient household	Household where there are more driving license holders than cars
Possibility to charge	Period where cars can potentially be charged
Charging profile	Actual charging behavior

1. Introduction

The electricity grid in the Netherlands is overloaded in several places because the demand for electricity transmission from both contractor and customer exceeds the transmission capacity (the amount of electricity that can be transported through the grid) (Ministerie van Economische Zaken en Klimaat, 2022). This phenomenon is also known as grid congestion. The available capacity of the electricity grid in the Netherlands can be found in Figure 1. In this figure, available capacity means the transport capacity that can be used for new initiatives for generating of demanding electricity. Figure 1 only takes into account transport restrictions on the high-voltage grid of the national grid operator TenneT. The available capacity is given as the remaining power in MVA, which is equal to MW. It can be seen that the available capacity differs greatly across the Netherlands. The most residual capacity is available in the provinces of Groningen, Friesland, Zuid-Holland, and Zeeland. In the other provinces there is virtually (almost) no residual capacity left for new connections to the electricity grid or extensions of existing connections.

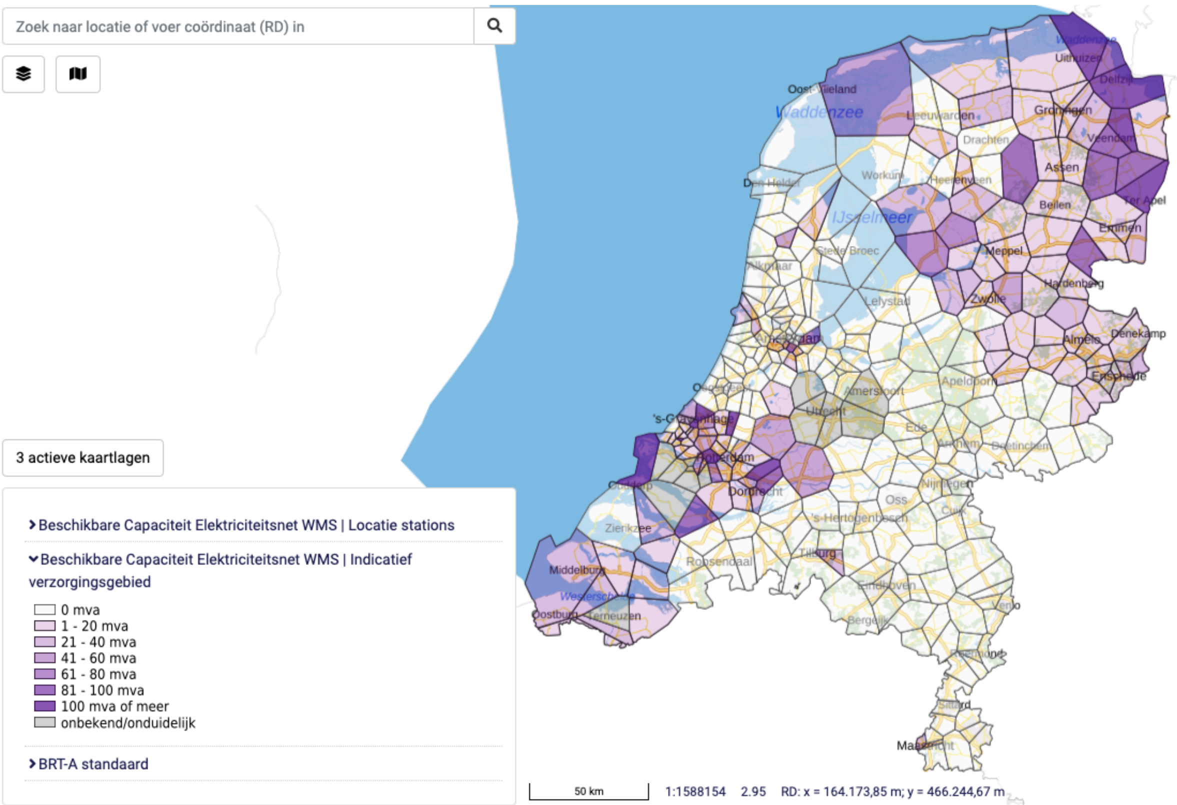

Figure 1: Available electricity grid capacity in the Netherlands (pdok, 2023)

Even though the electricity grid in the Netherlands is reaching its capacity, the government encourages electric driving as one of the measures to achieve the targets of the Climate Agreement. For example, the government requires all new passenger cars that enter market in 2030 to be fully electric, which means they run on electricity from a battery, hydrogen fuel cell or solar panels. In addition, electric driving is already being stimulated by providing benefits such as subsidies for fully electric cars, exemption from motor vehicle tax (road tax) and exemption from tax on passenger cars and motorcycles (purchase tax). Electric driving will also be stimulated in the future by providing more public charging stations. The Nationale Agenda Laadinfrastructuur (NAL) states the goal to have 1.7 million charging points in the Netherlands by 2030 (at the moment, there are more than 55,000 public charging stations).

It is estimated that 1.9 million electric passenger cars will be in use by 2030 (Rijksoverheid, 2023).

Because more electric passenger cars will be used in the future, charging these extra electric cars will put an additional load on the already heavily loaded electricity grid in the Netherlands. Looking at the forecasts, it can be concluded that the electricity grid will not be able to cope with the extra demand if no additional measures are taken (Eneco eMobility, 2024).

The aim of the study is to provide the electricity consumption of electric passenger cars and demand of electric passenger cars on the electricity grid throughout the Netherlands when all passenger cars in the Netherlands are electric. As shown in Figure 1, there are significant differences in the remaining capacity of the electricity grid across the Netherlands. It is therefore important to include the spatial aspect of consumption and demand in the research. In addition, the total demand on the grid depends on multiple users, such as households and companies that have an impact on the grid (Netbeheer Nederland, 2019). The temporal aspect is important because the impact on the network may be additionally amplified by coinciding user demands. For this reason, it was decided to include the electricity consumption of electric vehicles over the day in the study. Other users of the electricity grid are not considered in this research. The electricity demand of these users may also increase in the coming years, for example due to the usage of electric heat pumps (Netbeheer Nederland, 2019). This is outside the scope of this study; additional research is needed to include the impact of these users.

It is assumed that the situation will remain the same as the current situation. This is regarding the number of passenger cars and households, but also the travel behavior (including choice of mode and residential/work locations) of the individuals of a household. This assumption has been made, since electrical cars are a relatively new phenomenon. To date, there has not been any documented research into changes in travel behavior when people switch to driving electric cars. Some aspects of electric cars, such as a limited range, may result in behavioral changes. Also, changes in traffic and tax laws may impact car usage and travel behavior. Because of these unknowns, it was decided to use the current behavior as a basis.

2. Research context

2.1. Electricity grid in the Netherlands

It is important to understand how the electricity grid in the Netherlands is structured and where on the electricity grid problems may occur. The electricity grid in the Netherlands consists of the high-voltage grid, medium-voltage grids and low-voltage grids (Netbeheer Nederland, 2019). The high-voltage grid is used to transport large amounts of electricity from the energy producers to the distribution grids. The medium- and low-voltage grids are distribution grids which distribute the electricity to the electricity consumers, which includes households. The voltage is reduced at so-called electrical substations (Edelenbosch & AT5/NH Amsterdam, 2021).

2.1.1. General demand on the grid

An example of an average power demand profile (on a summer day) of a household, electric car and solar panels can be found in Figure 2. In addition, this figure shows the power demand profile in which the power demand profiles of the households, charging electric cars and solar panels are combined. These profiles are made based on a summer day, and these profiles can differ throughout the year (Netbeheer Nederland, 2019). The situation shown in Figure 2 is very specific (only applicable for a summer day) and does not include the exact value (kW) of the power demand, however it demonstrates the importance of the temporal aspect. It shows that the power demand of the household, electric cars and solar panels is not constant over time but shows several peak demands. It is therefore not accurate to assume that the electricity demand on the electricity grid will be evenly distributed over time. In addition, the peak demand of the household and electric car can reinforce each other.

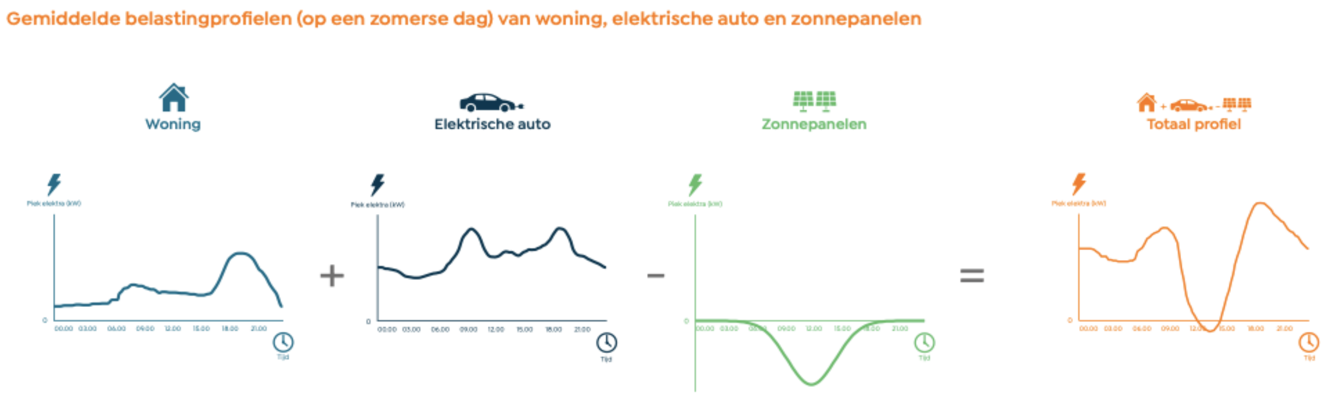

Figure 2: Average power profiles (on a summer day) of households, electric cars and solar panels (Netbeheer Nederland, 2019)

2.1.2. Demand on the grid due to charging electric cars

Charging electric cars has a major impact on the demand on the electricity grid. The power demand peaks of charging these electric cars are mainly in the morning and in the evening (Netbeheer Nederland, 2019). This matches the common behavior of people going to work in the morning and returning home in the evening, where charging takes place when they arrive at work and/or at home. Figure 2 shows that a peak demand can be expected in the morning and in the evening due to the charging of the electric cars. This can lead to high peak demand in electricity grid, which can lead to transformer overload, blown fuses and severe voltage drops (Hoogsteen, et al., 2015).

A simulation has shown that in the worst-case scenario the allowable technical limits of the voltages in the low voltage grid will be exceeded (Knezonić, et al., 2014). This is based on 43 households connected to a medium-voltage/low-voltage distribution transformer. In this scenario, 43 households (all with a full electric vehicle) start charging the electric vehicle at the same time. The charging pattern of the vehicles used in this paper is based on the Test-en-EV program, in which charging data from 184 electric vehicles (in 10 Danish cities) have been used (Andersen, 2013). In the Netherlands, a stress test was performed with 15 electric vehicles in one street (Hoogsteen, et al., 2015). The stress test resulted in a significant increase in peak consumption and significant voltage drops in the distribution grids. Even these limited studies show that the capacity limits for certain network assets can be exceeded, with the current allowed in the grid being the main limiting factor.

2.2. Electric passenger cars

This chapter discusses the technical aspects (electricity consumption and charging) of electric passenger cars. To determine the demand for charging electric cars on the grid, it is important to know more about the consumptions of electric cars and the technical aspects of charging a car.

2.2.1. Electricity consumption of electric passenger cars

The Electric Vehicle (EV) database (Elektrische Voertuigen Database, 2023) lists electric cars that are currently on the market or will be available soon. The website shows the average consumption per kilometer of the car per mode, these values are based on the consumption per kilometer when the car is tested against the NEDC-standards (in a laboratory in which driving conditions are simulated) (Elektrische Voertuigen Database, 2023). The average consumption and more statistics were calculated using the 270 fully electric car models that are on the list of current and upcoming electric cars (Elektrische Voertuigen Database, 2023). The average consumption and more statistics of the fully electric cars can be found in Table 1.

Average	198 Wh/km
Standard deviation	31 Wh/km
Mode	257 Wh/km
Median	192 Wh/km
Range	145 Wh/km
Maximum	295 Wh/km
Minimum	150 Wh/km

Table 1: Statistics based on the 270 fully electric cars shown in the EV-database (Elektrische Voertuigen Database, 2023)

Since the consumption of electric cars is expressed in Wh/km, the electricity consumption can be derived from the distance travelled (in km) in any given period.

The average consumption per kilometer of electric cars can vary greatly, for example a Hyundai IONIQ 6 (standard range 2WD) consumes on average 150 Wh/km and a Mercedes EQV 300 295 Wh/km (Elektrische Voertuigen Database, 2023). In this study it is not possible to account for the different models of electric cars, since the data used in the research does not provide any information about which type of cars would be used when driving full electric.

If the different models were to be included in the research, major assumptions would have to be made which does not lead to more reliable results. However, this does affect the average consumption per kilometer of the electric cars driven. For example, if on average more cars are used that drive more efficiently, the average consumption per kilometer will be lower. In addition, the consumption per kilometers also depends on vehicle dynamics, such as driving style and the speed driven. Therefore, a single value will be taken for the consumption of electric cars. This study uses the average value of 198 Wh/km for the consumption of electric cars. Note that there is a significant difference between the lowest consumption (150 Wh/km) and the highest consumption (295 Wh/km). Also note that there is no information available about the current and expected future composition of the total electric car fleet.

2.2.2. Technical aspects of charging electric passenger cars

To determine what the peak load on the electricity grid will be, it is important to know how long it takes to charge the electric car. This depends on several aspects: the power of the charging station, the on-board charger (which determines how much power your car can handle) and how empty the battery is. When there is a charging station at home, the power connection of the house is also important (Milieu Centraal, 2023).

The maximum charging capacity of a charging station (at home) depends on the household’s connection to the electricity grid. Relevant is the current (in amperes, A) and the number of phase wires (1-phase connection or 3-phase connection) of the connection. The voltage of the connection to the electricity grid is 230V. The maximum charging power can be calculated by multiplying the voltage by the current and the number of phases. The charging power must also take into account the maximum current of a single group and other electricity users within the connection. To prevent overload, a charging station with dynamic load balancing can be chosen, which the charging speed adapts to the actual power consumption the house (ANWB, 2023).

To get an idea of how fast an electric car charges at home, here are some practical figures. Newer houses usually have a 3-phase connection to the electricity grid, while older houses often have a 1-phase connection. With a 1-phase connection (with 25A) a charging station with an electrical power of 3.7 kW is commonly used. With a 3-phase connection, a charging station with a power between 7.4 kW and 11 kW is often chosen (Milieu Centraal, 2023). It is common for the charging station to have a lower power than the household’s connection to the electricity grid because other devices in the household also generate a demand on the same connection.

In the Nationaal Laadonderzoek (National Charging Survey) 67% of the respondents indicate that they have their own charging facility at home. In this study, a single value for the capacity of the charging stations is used. Considering the results of the Nationaal Laadonderzoek and the usual capacity for 1-phase and 3-phase chargers, a capacity of 7.8 kW is used in this study for the charging stations. This is a calculated average based on data from the Nationaal Laadonderzoek, which showed that 24% of the respondents have a charger with 3.7 kW, 73% have a charger with a power between 7.4 kW and 11 kW (average 9.2 kW is taken into account) and 3% of the respondents do not know which charger they have (6.5 kW is taken into account).

2.3. Charging behavior

In addition to the time it takes to charge the electric passenger car, the charging behavior of electric car users is important. The charging behavior of drivers of electric cars determines when electricity is demanded from the electricity grid. Suppose that all electric cars are charged evenly distributed over the day, the peak power demand will be different than when the majority of electric cars start charging at 6 p.m.

In the Netherlands, surveys are held annually among EV (electric vehicle) drivers for the Nationaal Laadonderzoek, looking at the experiences and opinions of EV drivers about charging electric vehicles in the Netherlands. The survey examines, among other things, where and when charging takes place, what the charging strategy (when to charge the electric car based on the battery percentage) is, the type of charging station at home and whether smart charging and fast charging (a public charging station with a charging speed of at least 50 kW (ANWB, 2024)) are used.

In short, 50% of the kilometers driven are charged at home, 21% of the kilometers are charged at a public charging station near the home. The remaining kilometers are charged at a public charging station elsewhere (7%), a socket elsewhere (1%), a charging station at work (13%) or a fast charger (8%). The survey also shows that 64% start charging at a preferred time (and 36% of the respondents claim to have no pattern). It is noticeable that the EV driver starts charging when he arrives at his workplace or when he/she comes home from work. The night rate of electricity also seems to be a reason for EV drivers to choose the charging times. When looking at the time the respondents stop charging, 62% indicate that they do this at fixed times, namely around 8:00 am and around 5:00 pm. 38% have no pattern for this. Looking at the charging strategy of the respondents, it can be concluded that 26% will charge when the battery is relatively empty (less than 15%), 43% ensure that it is recharged when possible, and 26% indicate that they use a different charging strategy.

Respondents with a private charging facility charge an average of 77% of their kilometers with this private charging station. 54% of private charging stations have a smart charging function, such as local load balancing. 54% of the respondents who have a charging station with a smart charging function indicate that they have charged smartly at least one time in the past six months.

When looking at fast charging, 5% of the respondents charge for less than 10 minutes on a fast charger. 28% of the EV drivers charge between 10 to 15 minutes. The majority (40%) charge between 15 to 20 minutes on a fast charger. The remaining 28% of the EV drivers indicate that they charge more than 20 minutes on a fast charger. In 88% of cases, the minimum number of kWh required is leading for the charging time.

This survey shows that the charging behavior of EV drivers can differ greatly. It is therefore important that the study takes the charging behavior of the various EV drivers into account, because the aspects mentioned above influence the (peak) power demand on the electricity grid.

While charging behavior is influenced by charging preferences (such as preferences for charging locations or times) mentioned above, charging behavior can also be influenced by the use of the car by multiple individuals. The electricity to be charged and the possibilities for charging the electric car are not only related to the travel behavior of an individual, but to the travel behavior of all car users. It is therefore important to have an idea of how many cases the car may be shared.

Looking at car ownership at the beginning of 2020, there were 8.7 million cars registered to private individuals and companies and 8 million households in the Netherlands (Zijlstra, Bakker, & Witte, 2022). This amounts to an average of 1.1 cars per household. However, in practice these cars are not equally distributed among households. At the beginning of 2020, 26% of households in the Netherlands do not own a car, 47% of households own 1 car, 21% of households own 2 cars and 6% of households own 3 or more cars (Zijlstra, Bakker, & Witte, 2022).

In addition to owning a car as a household, it is important to understand how a car is used and shared within the household. Where a car may be expected to be household property, a car is often seen as personal property (Claassen & Katteler, 1997) (Hoenjet, Jorritsma, & Van der Waard, 2018). Claassen and Katteler (1997) concluded that, if there are 2 cars in the household, in dual-income households the cars are generally linked to a main user. In addition, it appears that household members almost always choose their 'own' car to use, even when the other car is available. When household members mainly choose their own car, and the car is therefore not shared between household members, this means that charging behavior only depends on individual travel behavior and personal preferences. Hoenjet, Jorritsma and Van der Waard (2018) have also conducted research into the car use of households with more than 1 car (2, 3 and 4 or more cars per household). This research showed that a quarter of the cars are shared, almost two-thirds of the cars are only used personally and just over 10% of the cars are almost never used. Hoenjet et al. (2018) have drawn up 6 profiles to describe the car and its use, which are linked to characteristics of the car and car user(s). These profiles and characteristics can be found in Table 2.

It is important to remember that in Hoenjet's et al. research, if a car is shared, this does not necessarily mean that the car is used by multiple individuals on one day. Charging behavior is mostly affected if the car is used by multiple individuals on one day, as this strongly affects the available time for charging. However, charging behavior is also affected if, for example, the car is used the next day by another household member. Then the choice may have to be to charge the electric car, while this may not have been necessary for the individual's travel behavior (considering available battery capacity).

Description	Use	Personal/shared car
Solely for work (11.8%)	Solely for work	Personal car
Intensive use (19.1%)	Intensive use, mainly for work	Personal car
Shared (24.7%)	Various motives	Shared
Multifunctional (14.1%)	Various motives	Personal car
Not for work (24.8%)	Various non-work motives	Personal
Not used (11.8%)	Rarely used car	-

Table 2: Profiles for car use (Hoenjet, Jorritsma, & Van der Waard, 2018)

2.4. Knowledge gap

As can be read above, research has been done into the possibilities of overloading the electricity grid by charging electric cars and the charging behavior of the electric vehicle drivers in the Netherlands. The studies in the Netherlands on overloading of the electricity grid by charging electric cars mentioned are based on isolated stress tests, in which several electric cars are charged at the same time. This ignores the charging behavior and kilometers driven. To predict potential challenges to the electricity grid caused by an increased demand for charging electric cars, car ownership and car usage data must be included. In addition, the research on overloading of the electricity grid by charging electric cars in the Netherlands mainly examines whether the distribution grid becomes overloaded if several electric cars are charging at the same time. No research has been conducted in the Netherlands into the effect of charging electric cars on the electricity grid at a higher level, such as at a regional level. For the United States, a simulation has been used to determine what the additional peak load on the electricity grid in regions will be (Harris & Webber, 2014). However, research on the electricity demand on the electricity grid in the United States are not applicable in the Netherlands because of large differences in travel behavior and the data used is not available in the Netherlands.

In the existing literature, the connection between the travel behavior and the charging behavior is missing. For example, how much should the car be charged (based on the electricity consumed) and where and when will the charging take place (looking at the times the car is used and preferred travel behavior)? The studies in the Netherlands mentioned in the theoretical framework are based on isolated stress tests, in which several electric cars are charged at the same time. This ignores the charging behavior and kilometers driven. This research will focus on the combination of travel behavior and charging behavior to calculate the electricity demand of the electric cars on the electricity grid.

3. Research design

This chapter will discuss the research design of this study. First, the problem will be defined, after which the research objective will be determined. The research question and its sub-questions will also be presented. Finally, the scope of the study will be discussed.

3.1. Problem definition

The electricity grid in the Netherlands is reaching its maximum capacity in various places (Ministerie van Economische Zaken en Klimaat, 2022) (pdok, 2023). Despite this fact, the Dutch government encourages electric driving to achieve the targets of the Climate Agreement. In the future, charging electric passenger cars will put an additional load on the electricity grid, which may lead to grid congestion.

Previous studies have shown that the current distribution grid will not be able to cope with the increased electricity demand in the future. In the studies mentioned in the Research Context, it is usually assumed that several electric cars are charging at the same time. To determine whether the electricity grid will be able to cope with the expected demand of electric cars and (perhaps even more important) what the required capacity of the electricity grid is, it is important to know how much electricity the electric cars will consume. This will help to predict whether the capacity of the high-voltage grid will be exceeded in the future.

3.2. Research aim

The research aim of this thesis is to calculate the (peak) electricity demand of electric passenger cars on the electricity grid on a regular working day assuming unchanged travel behavior with the exception that all cars have become electric vehicles. The peak electricity demand will be calculated for PC2 areas (areas in the Netherlands based on the first 2 values of the postal code, shown in Figure 3. There is a correlation between PC2 areas and the distribution of the high-voltage stations (with a voltage of 110 kV or higher) so predictions per PC2 area can be extrapolated to the effects on these stations. These stations can be found in Figure 4.

Unfortunately, the research cannot calculate the total demand on the grid, because this requires knowing the demand of other users of the electricity grid. For example, little is known about a household's or business' consumption in exact values during the day.

Figure 3: PC2 areas in the Netherlands (Esri Nederland, 2024)

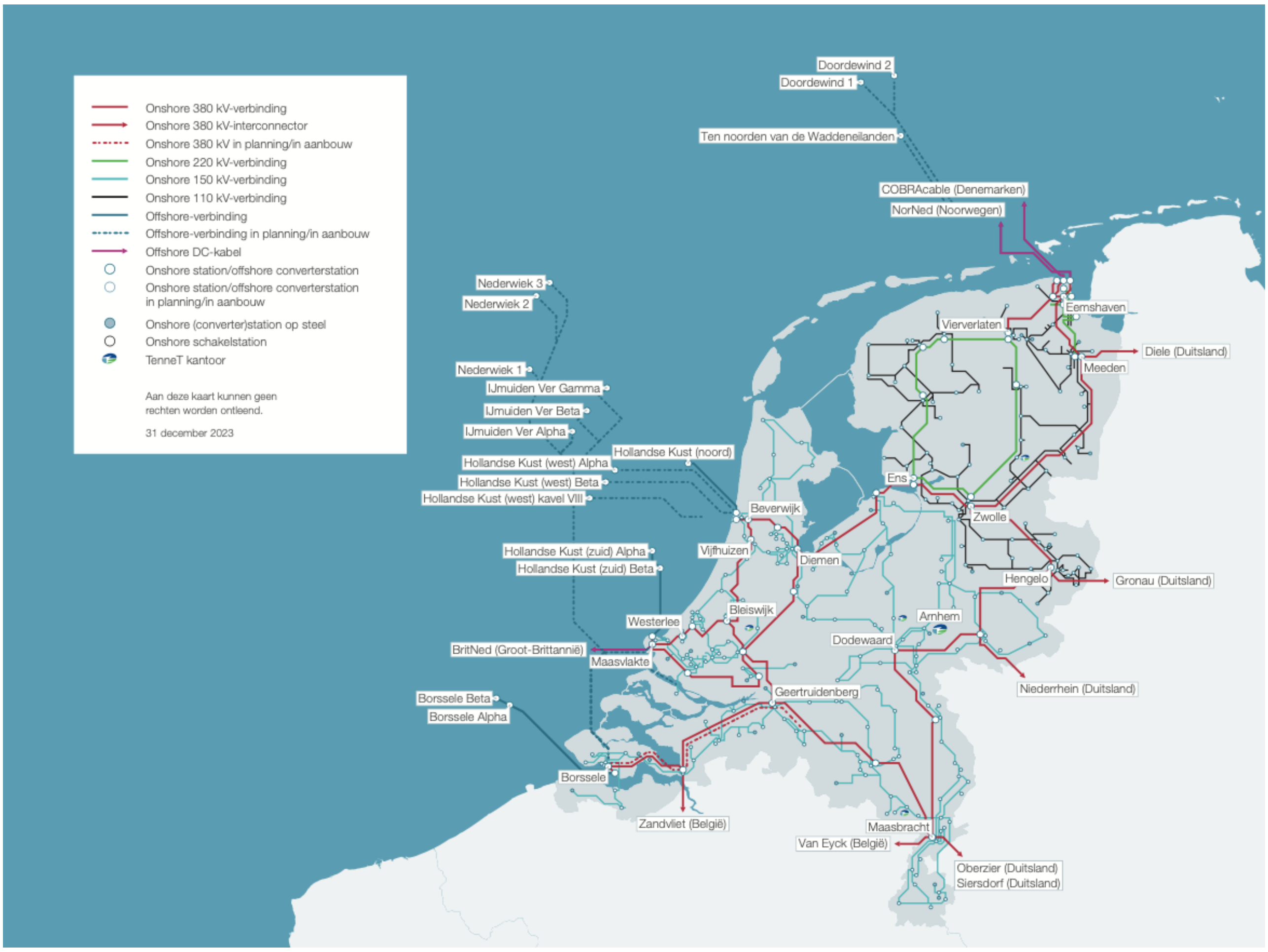

Figure 4: High voltage stations in the Netherlands (TenneT, 2024)

3.3. Research questions

The research aim of this thesis is to calculate the electricity demand of electric passenger cars on the electricity grid over time in a regular working week assuming all passenger cars are electric cars. This study will look at the consumption of electricity of the passenger cars based on the kilometers driven and when this electricity is required from the electricity grid because the electric car is charging. It will be assumed that the number of cars and the kilometers driven will remain the same as in the current situation. In the study, it is important to look at the demand for electricity across the Netherlands, since the available capacity of the electricity grid varies across the Netherlands. In addition, it is important to look at when (during which hours) the electricity is requested from the grid, since peak loads may result in overloading the electricity grid. The study also examines variations in electricity demand over the different working days and across seasons. The main question associated with the research aim can be found below.

Main question: What is the electricity (peak) demand of the (electric) passenger cars on the electricity grid during a workday across the Netherlands, assuming all passenger cars are electric passenger cars and the travel behavior and the number of passenger cars stays the same as in the current situation?

Before the main research question can be answered, it must be determined how much electricity must be charged. The electricity to be charged (the electricity consumed) is derived from the travel behavior of individuals. Based on the travel behavior, it can be determined how many kilometers the individuals travel by car. Based on the kilometers driven by car, the electricity consumption is calculated. This is done for an average working day for the Netherlands as a whole and for the PC2 areas, and for the different working days and seasons for the Netherlands as a whole. The associated research questions can be found below.

1. *What is the consumption of electricity of the (electric) passenger cars during a regular workday across the Netherlands assuming all kilometers are driven with electric cars?*
   - 1.1. *What is the electricity consumption of (electric) passenger cars during a regular workday in the Netherlands?*
   - 1.2. *What is the electricity consumption of (electric) passenger cars in the PC2 areas during a regular workday?*
   - 1.3. *Are there differences in electricity consumption of (electric) passenger cars between days in a regular workweek in the Netherlands?*
   - 1.4. *Are there seasonal differences in electricity consumption of (electric) passenger cars in the Netherlands?*

In order to calculate the electricity demand of the electric cars on the electricity grid, in addition to knowing the electricity to be charged, it is necessary to know when the cars can be charged. Research question 2 is related to the possible times when the cars can charge.

2. *When are the passenger cars at the household or at work for a longer period (long enough to charge the electric car), taking into account car sharing between household members?*

Based on the results of research question 1 and 2, the electricity demand on the electricity grid can be calculated. To answer the main question as completely as possible, this was done for multiple scenarios.

The demand on the grid was examined for the whole of the Netherlands on a regular working day. The demand on the grid per PC2 area for a regular working day was also examined. Additional, variations across days of the workweek and across seasons were examined. The demand on the grid is calculated for 2 charging strategies*. The associated questions can be found below.

3. *What is the (peak) electricity demand of the electric passenger cars on the electricity grid?*
   3.1. *What is the (peak) electricity demand of the electric passenger cars on the electricity grid on an average workday when the electric passenger cars are charged according to the charging strategies*?*
   3.2. *What is the (peak) electricity demand of the electric passenger cars on the electricity grid per PC2 area on an average workday when the electric passenger cars are charged according to the charging strategies*?*
   3.3. *What is the (peak) electricity demand of the electric passenger cars on the electricity grid on a regular workweek when the electric passenger cars are charged according to the charging strategies*?*
   3.4. *What is the (peak) electricity demand of the electric passenger cars on the electricity grid during the year when the electric passenger cars are charged according to the charging strategies*?*

* Charging strategies: in this research two charging strategies are used, namely: charging at maximum charging speed (7.8 kWh) and charging at minimum charging speed. The minimum charging speed refers to the lowest charging speed at which the car is fully charged in the available time for charging, which may vary per individual.

3.4. Scope

The study looked at electricity consumption and the consumption profiles of electric passenger cars on the electricity grid in residential areas. This means that freight traffic is not included in the study. In addition, the electricity consumption and the consumption profiles on the electricity grid are only drawn up for the days Monday to Friday. This assumes that it is an average working week, which can be expected to cover the vast majority of weeks in a year.

In addition, the electricity demand on the electricity grid in the residential areas by passenger vehicles was examined. The private charging stations and the public charging station in the vicinity of the households were included, assuming that these charging stations are connected to the same part of the electricity grid as the household to which the electric car belongs. The electricity demand on the electricity grid at work locations, fast chargers or other types of charging stations elsewhere is not part of the scope of this study. The electricity demand on the electricity grid due to other household activities (other than charging the electric passenger car) is also not in the scope.

One value was used for the consumption of the electric cars, since with the available data it is not possible to distinguish between different types of cars and other aspects that influence the electricity consumption of the passenger car, such as weather conditions and driving style. Also, one charging speed was chosen for all charging stations, because it is not clear which household has which type of charging station. Therefore, an average value will be used for the charging speed of the charging stations. The smart charging functions of the charging stations and demand side management will not be taken into account.

The study also assumes that the car ownership and car usage will remain the same as the current situation. The research will not take into account changes/trends in the number of passenger cars, households, driver's licenses, and inhabitants in the Netherlands.

Finally, the study assumes that the electric car is charged every day, for the kilometers driven that day. This does not correspond with reality, as in some cases users of electric cars may choose not the charge the car every day, but only when the battery is almost empty. There are many factors influencing whether a person charges the car every day or not, namely: the predictability of the journeys, the battery capacity, and behavior (some users of electric cars prefer to charge the electric car daily). Due to the complexity of those factors and the shortage of data, it is assumed that the car (if used) is charged daily and that the variations in charging behavior averages out (e.g. not all batteries are empty at the same time of the week).

4. Methodology

This research focuses on answering the main question, namely: '*What is the electricity (peak) demand of the (electric) passenger cars on the electricity grid during a workday across the Netherlands, assuming all passenger cars are electric passenger cars and the travel behavior and the number of passenger cars stays the same as in the current situation?*'. It was decided to divide the main question into several sub-questions. How these questions are answered will be discussed in this chapter. The research was divided into 3 parts. The first part focused on calculating the kilometers driven (read: electricity consumed) by the electric cars per time interval in a regular working week (in the PC2 areas). The second part focused on the scenarios for charging behavior and the opportunity for charging. In the third part, the demand of charging the electric cars on the electricity grid was calculated based on the electricity consumption (part 1) and the charging behavior/opportunities for charging (part 2).

It is important to remember that this study is not about the electricity consumption of one electric passenger car, but about the electricity consumption of groups of electric passenger cars. In addition, the study does not look at whether the electricity grid is overloaded by charging the electric cars, but only the additional demand on the grid of the electric cars will be calculated.

4.1. Available datasets

This chapter discusses the datasets used in this research, namely the ODiN, the MON and the CBS. The ODiN was used to determine the travel behavior, from which the electricity consumption was determined, and the times in which the car can be charged. The MON was used to investigate whether a passenger car is shared between household members on one day. The CBS was used to convert the travel behavior from the ODiN respondents to the entire population in the Netherlands.

4.1.1. ODiN – Onderzoek Onderweg in Nederland

The study attempted to gain insight into the electricity consumption of electric passenger cars (assuming that everyone drives electric) and the electricity demand of these passenger cars on the electricity grid. This is done by looking at the travel behavior of the residents of the Netherlands. By having insight into the travel behavior, it can be determined how many kilometers are driven with passenger cars and when these kilometers are driven. It can also be determined when the car is available for charging. The travel survey ODiN – Onderzoek Onderweg in Nederland (Research on the Road in the Netherlands) is used to record the travel behavior of the residents of the Netherlands.

The ODiN is a study in the travel behavior of the residents of the Netherlands, in which respondents record their travel behavior for 1 day of the year (Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS), 2018) (Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS), 2020). This includes information about where they are going, the means of transport, the travel time, the distance and the purpose of the trip. In addition, the ODiN provides information about personal and household characteristics, such as ownership of means of transport and highest level of education completed. The target population of ODiN is persons aged 6 years or older who are registered as residents in the Municipal

Personal Records Database (Basisregistratie Personen) excluding the institutional population (persons in establishments and institutions like nursing and care homes).

This research used the ODiN data from 2018 and 2019 (Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS), 2018) (Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS), 2020).. The decision was made not to include data from the years 2020, 2021 and 2022 as travel behavior was strongly influenced by the COVID-19 outbreak. The data from the years before 2018 was also not included in the study because the travel research in the years 2010 to 2017 was carried out by the OViN – Onderzoek Verplaatsingen in Nederland (Research on Travel in the Netherlands). The ODiN was carried out in a different way than the OViN, which resulted in a methodological discrepancy between OViN and ODiN (Centraal Bureau voor de Statistiek (CBS); Rijkswaterstaat (RWS), 2018). For example, the target population, the approach strategy and the questionnaire have changed. As a result, the data resulting from OViN and ODiN cannot be compared, and it was decided not to include data from OViN.

4.1.2. MON – Mobiliteitsonderzoek Nederland

To determine the possibility of charging electric cars, information is required about the travel behavior of the individual, but also about the sharing of the passenger car. The ODiN cannot be used to determine whether the passenger car is shared and which trips are made by a car, as it only concerns the travel behavior of an individual. That is why, in addition to the ODiN, the MON – Mobiliteitsonderzoek Nederland (Mobility Research Netherlands) is used. The MON is a study into travel behavior of household members. The MON is one of the predecessors of the ODiN and was carried out by Rijkswaterstaat in 2004 to 2009. It was decided to use the most recent database, namely the one from 2009 (Ministerie van Infrastructuur en Milieu; Rijkswaterstaat, 2009).

The MON consists of information about the household, the members of the household, the trips and sub-trips (which make up a trip). Holiday traffic and movements due to freight transport are not included in the MON. The Institutional population (persons in establishments and institutions like nursing and care homes) is also not included in the mobility research.

4.1.3. CBS – Centraal Bureau voor de Statistiek

In the research, predictions were made about the electricity consumption of the electric cars and the demand on the electricity grid in the Netherlands and per PC2 area. The ODiN was used to determine the electricity consumption of the electric cars and the demand on the electricity grid for an average person in the Netherlands as a whole and per PC2 area. The purpose of the research is to calculate the absolute consumption and demand, for which CBS data is used. CBS indicated how many inhabitants there are in the Netherlands and per PC4 area (which can be converted to inhabitants per PC2 areas). The absolute electricity consumption and demand on the electricity grid can be calculated using the number of inhabitants. The CBS sources used in this study can be found in Table 3.

Information	Year	Source
Number of inhabitants in the Netherlands	2023	(CBS, 2024)
Number of inhabitants per PC4 area	2022	(CBS, 2023)

Table 3: CSB sources used in this research

4.2. Data customisation

The data from ODiN, MON, and CBS have been customized to be used for this research. This chapter explains how the datasets have been customized.

4.2.1. ODiN – Onderzoek Onderweg in Nederland

The ODiN dataset contains information about the respondents and their trips. To make the ODiN datasets from 2018 and 2019 usable, these datasets were combined. Obviously incorrect data is removed from the dataset, such as data where the departure time is a non-existing value. The data from weekends (Saturday and Sunday) has been removed because the research concerns working days. Data from respondents under the age of 18 has also been removed, as this study focuses on car trips (where the respondent is the driver of a passenger car).

After this, it was checked how many respondents were in the combined dataset. It was also calculated how many respondents met certain characteristics. These characteristics are the working day the ODiN is filled in, the residential location (level: PC2), the household income, and the urbanization class of the residential address. These numbers were necessary to scale the dataset to the entire population. The number of respondents per characteristic can be found in Appendix B.

The ODiN does not only provide information about the trips with the respondent as the driver of a car, but about all trips made by the respondent. This concerns, for example, trips by bicycle, public transport or as a passenger in a car. The ODiN therefore provides more information than is necessary for this research.

To make the dataset usable for the research, all trips that were not taken by car (as the driver of this car) were removed from the dataset. In addition, identical trips that appear multiple times in the database were deleted, and the main trip is kept. Trips can appear multiple times in the data because a trip can consist of multiple sub-trips. ODiN is constructed in such a way that each line of the dataset consists of information about the respondent/household, information about the trip, and information about the sub-trips (when a trip consists of multiple sub-trips). For example, if a trip consists of 3 sub-trips, this trip will be displayed over 3 rows in the ODiN dataset. The information about the respondent/household and the trip is the same on these 3 rows, only the information about the sub-trips is different on these rows. Because this study only uses information about the respondent/household and the trip, it is sufficient to include only the first row of the trip.

Analysis of the ODiN dataset showed a 30-minute interval to be the optimum interval for this study. With shorter intervals, the variations in behavior of individual respondents would have a more prominent, undesired impact on the results.

4.2.2. MON – Mobiliteitsonderzoek Nederland

To prepare the MON data for this study, the households that were asked about travel behavior on weekend days (Saturday and Sunday) were removed. This was done because the research focuses on working days. After this, the number of households in the dataset was calculated.

Based on the MON, a dataset has been created with important information for car use within the household. This dataset shows the following information per household:

- Number of cars in the household
- Number of driving licenses in the household
- Number of household members who make at least 1 trip by car

4.2.3. CBS – Centraal Bureau voor de Statistiek

Data from CBS is used to make statements for the various groups in the Netherlands based on the results from the ODiN. Data from CBS was used for the following topics:

- Number of inhabitants in the Netherlands (18 years or older)
- Number of inhabitants per PC2 area (18 years or older)

The table with the data for the above topics can be found in Appendix A. The sources can be found in Table 3.

4.3. Electricity consumption of electric passenger cars

4.3.1. General approach

To answer each aspect of research question 1 the ODiN dataset was used to determine how many kilometers respondents traveled as the driver of a passenger car. This was done by calculating, per trip, how many kilometers the respondent traveled on average per minute. This was based on the travel time and the distance of the trip. Then, based on the start and end time of the trip, the kilometers covered are included in the corresponding 30-minute time intervals. By multiplying the kilometers traveled per 30-minutes time intervals by the consumption of the electric passenger cars which is 198 Wh/km (determined in Chapter 2.2) the electricity consumption of the ODiN respondents is determined.

In order to make statements about the electricity consumption of electric passenger cars for the whole population of the Netherlands (instead of the consumption of the ODiN respondents), the electricity consumption per time interval is divided by the number of respondents, which can be found in Appendix A. By multiplying the consumption of this average person by the number of inhabitants of the Netherlands (without the 0- to 18-year-olds), the total electricity consumption of electric passenger cars in the Netherlands has been calculated.

It was decided to use the number of inhabitants in the Netherlands without 0- to 18-year-olds, since this is the population group that is legally allowed to drive a car. The ODiN dataset is representative of the population, there is no need to correct for the population that does or does not have a driver's license. The population of the Netherlands (18 years or older) in 2023 is 14,498,000 inhabitants (CBS, 2024). Since the respondents in the ODiN are a representative representation of the Dutch population, it is not necessary to adjust the data from ODiN to the population compositions.

The above was performed for the various working days and seasons. This was done by only including trips on, for example, Wednesdays or by only including trips made in the summer. This is done to calculate the electricity consumption of the electric passenger cars for the different working days and for the different seasons. The meteorological definition of the seasons was used in the calculations.

4.3.2. Electricity consumption of electric passenger cars on a regular workday in the Netherlands as a whole

To answer research question 1.1 (*What is the electricity consumption of the (electric) passenger cars during a regular workday in the Netherlands?*) the ODiN dataset was used. The ODiN dataset was collected in 2018 and 2019. This is extrapolated to the population data in 2023.

In order to make statements about the electricity consumption of electric passenger cars for the whole population of the Netherlands (instead of the consumption of the ODiN respondents), the electricity consumption per time interval is divided by the number of respondents, which can be found in Appendix A. By multiplying the consumption of this average person by the number of inhabitants of the Netherlands (without the 0- to 18-year-olds), the total electricity consumption of electric passenger cars in the Netherlands has been calculated.

4.3.3. Electricity consumption of electric passenger cars on a regular workday in the PC2 areas in the Netherlands

The electricity consumption of the electric passenger cars per PC2 area was examined to answer question 1.2 (*What is the electricity consumption of (electric) passenger cars in the PC2 areas during a regular workday?*). This was done by grouping data per PC2 area. It was decided to only look at regular working days and not to distinguish between the working days as there is too little data available.

To calculate the electricity consumption of the residents of the PC2 areas, the ODiN dataset is divided into 90 groups with the associated respondents who lives in the PC2 area. This was done by only including trips when the respondent lives in the corresponding PC2 area, for example, PC25.

Next, it was determined how many kilometers are traveled per half hour as the driver of a passenger car per PC2 area. This was done by calculating, per trip, how many kilometers the respondent traveled on average per minute, based on the travel time and the distance of the trip. Then it is calculated how many kilometers were covered during the 30-minute time intervals per car per area. By correcting the kilometers traveled per 30-minute time intervals for the consumption of the electric passenger cars (198 Wh/km) the electricity consumption of the ODiN respondents per area is determined. In order to make statements about the electricity consumption of electric passenger cars per PC2 area, the electricity consumption per time interval is divided by the number of respondents, which can be found in Appendix A. By multiplying the consumption of this average person by the number of inhabitants of the PC2 areas (which can be found in Appendix A) the total electricity consumption of electric passenger cars per PC2 area has been calculated.

4.4. Possibility to charge the electric car

This chapter will discuss the methodology for determining the possibilities for electric cars to charge. First, the extent to which cars are shared within the household is determined. Then the charging behavior to be included in this research is determined. Finally, the number of cars that have the possibility to charge per 30-minute time intervals is determined.

4.4.1. Car use within the household

When looking at the demand on the electricity grid due to charging electric cars, it is important to look at the use of the cars and the possibility to charge the electric car (when the car is not used for a longer period). The use of a car depends on the number of users of that car and the travel behavior of these car users. The ODiN only provides information about the travel behavior of individuals, so it cannot be determined whether the cars are used by multiple people. That is why the MON was used to examine the use of the car within the household.

Based on the MON, a dataset has been created with important information for car use within the household. This table shows the following information per household:

- Number of cars in the household
- Number of driving licenses in the household (which determines the number of potential car users)
- Number of household members who make at least 1 trip by car

Based on the table with important information per household, the number of households per car deficient household groups is calculated. These groups are:

- 1 car and 2 or more driving licenses in the household
- 2 cars and 3 or more driving licenses in the household
- 3 or more cars and 4 or more driving licenses in the household

The number of households in which there are fewer cars than the number of household members who make at least 1 trip by car is then calculated per car deficient group. In those cases, a car is shared with multiple household members (assuming there is no car available from outside the household) to make all the trips. For each car deficient household group, the percentage of households in which a car is shared is calculated. In addition, the percentage of households in which a car is shared is calculated compared to all households in the MON.

In Appendix C the results of the above methodology can be found. These results show that, looking at the data from the MON, there are almost no cars shared within a household on a workday. Therefore, it was decided to no longer include car sharing in this research. It is assumed that every individual has their own car, which only he/she uses.

4.4.2. Charging profile

To make statements about the demand on the electricity grid due to charging electric cars, a charging profile was drawn up. This charging profile describes where, when and at what charging speed the electric cars are charged. When drawing up this profile, the Nationaal Laadonderzoek of the Netherlands was used, which is briefly explained in the Research Context (Chapter 2.3).

When looking at the charging locations in the Nationaal Laadonderzoek, the locations where most charging takes place are at the home and at work. 50% of the kilometers driven are charged at a private charging station at the house, 21% of the kilometers driven are charged at a public charging station near the house, and 13% of the kilometers driven are charged at work. The remaining 16% of the kilometers are charged at other locations, such as fast chargers. Since ODiN does not include information on charging locations, only charging at home and at work can be considered. The kilometers charged at other locations are divided equally between the 2 charging locations. This results in an assumed 79% of the kilometers charged at home (50 + 21 + ½ * 16) and 21% (13 + ½ * 16) of the kilometers charged at work. Note that this is a working assumption, because there is no data available to predict the actual charging behavior when all cars are electric.

Two different speeds are assumed for the charging speed, namely a maximum and minimum value. The maximum charging speed is 7.8 kW, which is based on the results of the Nationaal Laadonderzoek and the commonly used charging speeds of charging stations at home (Chapter 2.2). The minimum charging speed is the lowest charging speed at which the car is fully charged in the available time for charging, which may vary per individual.

In the charging profile it is assumed that the car is charged immediately when the car is parked at the charging location and is parked there for longer than 2 hours at the work location and longer Fhome. Other charging locations, such as supermarkets and parking garages, were not included in this study, as these locations are used for short-term charging, and the car cannot be fully charged. Fast chargers were also not included because the ODiN data cannot be used to determine where and when a fast charger is used, as they are located along the route and it is not known when a fast charger is used.

4.4.3. Possibility to charge the electric car

To get a better picture of the times in which charging is possible, the number of cars that have the possibility to charge (at work or at home) was examined. This was done for a regular working day for the Netherlands as a whole. To be able to do this, the data obtained from the ODiN had to be adjusted, as there were inconsistencies in the data. This section discusses how the ODiN data was adjusted and which methodology was used to calculate how many cars have the possibility to charge per time interval.

Dataset check and correction

Analysis of the dataset showed that the data contained inconsistencies (mainly missing trips). For instance, respondents recording leaving home for work, but not recording returning home from work. Also, respondents indicate that they start their first car trip from “another” location and end their last trip at their home. It is unlikely that a large group will display this travel behavior, especially when it is assumed that the travel behavior of individuals is approximately the same on every working day. It has therefore been assumed that, when the other location is in the same PC4 area this is most likely the home location. This is the case in 18% of the total respondents. The details are outline in Appendix D.

Available time windows for charging

To determine the available time for charging the electric passenger cars, two charging locations have been considered:

1. At the work location
2. At the home location (either at the house or at a public charging location near the house)

For the work location, the available time window starts at the time the respondent arrives at work and ends when leaving work.

For the home location, there are two windows:

1. A respondent is at home for more than 6 hours during the day and the respondent is not at home in the evening. If the respondent is at home in the evening, it is assumed that he or she will fully charge the car in one go in the evening.
2. A respondent's last recorded trip ends at the home location and the first recorded trip starts at the home location. In that case the time window starts when the respondent arrives at the home location and is assumed to end on the following day at the same time the respondent recorded leaving from home. Since the dataset only contains data from a single day, a consistent travel pattern throughout the working week is assumed.

The actual charging location is unknown (not included in the ODiN data). Determining the charging location is derived from the distance travelled, using the work/home charging ratio explained above in *Charging profile.* It is assumed that a respondent charges at work, or at home, but not on both locations.

4.5. Power demand on the electricity grid in the Netherlands

In this section, the total demand on the electricity grid is calculated per 30-minute interval, considering 2 scenarios. This is done for an average working day. Also, variations between weekdays and between seasons are calculated for each scenario. The meteorological definition of the seasons was used in the calculations.

The demand is calculated by determining how much electricity is needed to cover the total consumption and the available time.

Demand on the electricity grid during full-window charging

For this scenario, the following steps have been taken per respondent:

1. Calculated the total available time available for charging
2. Calculated the total consumption in MWh, based on the total distance travelled by car.
3. Calculated the demand per 30-minute interval by dividing the total demand (assumed to be equal to the total consumption) over the available time.

This scenario has been applied to 2 situations:

1. Charging at the work location
2. Charging at the home location

Demand on the electricity grid during high-speed charging

For this scenario the following steps have been taken:

1. Calculated the total consumption in MWh, based on the total distance travelled by car.
2. Calculated the time needed to fully charge, using the 7.8 kW charging speed mentioned before.
3. Calculated the demand per 30-minute interval starting at the start of the window and ending when the car is fully charged.

This scenario has also been applied to 2 situations:

1. Charging at the work location
2. Charging at the home location

5. Results

5.1. Electricity consumption of electric passenger cars

This section will discuss the electricity consumption of electric passenger cars. The total electricity consumption and the consumption over the day for the Netherlands as a whole and for the PC2 areas will be presented. The differences between the electricity consumption (total and over the day) on the different working days and the different seasons will be discussed.

5.1.1. Electricity consumption of the electric passenger cars on a regular workday in the Netherlands as a whole

Figure 5 shows the electricity consumption of electric passenger cars on a regular working day in the Netherlands assuming all passenger cars are electric cars (the corresponding table can be found in Appendix E. The figure shows the consumption of the electric cars per 30-minute time intervals. The total consumption on a regular working day amounts to 80,618 MWh. Figure 5 shows 2 peaks in electricity consumption during the rush hours (morning and evening rush hour). In addition, a relatively large amount of electricity is consumed by electric cars between the peaks during rush hours. In the evening (after 7 p.m.) and in the morning (before 7 a.m.) little electricity is consumed by the passenger cars.

It can be concluded that the most electricity is consumed during rush hours (7 a.m. - 9 a.m. and 4 p.m. - 7 p.m.). However, a significant amount of electricity is also consumed during the day. Little electricity is consumed in the late evening and early morning.

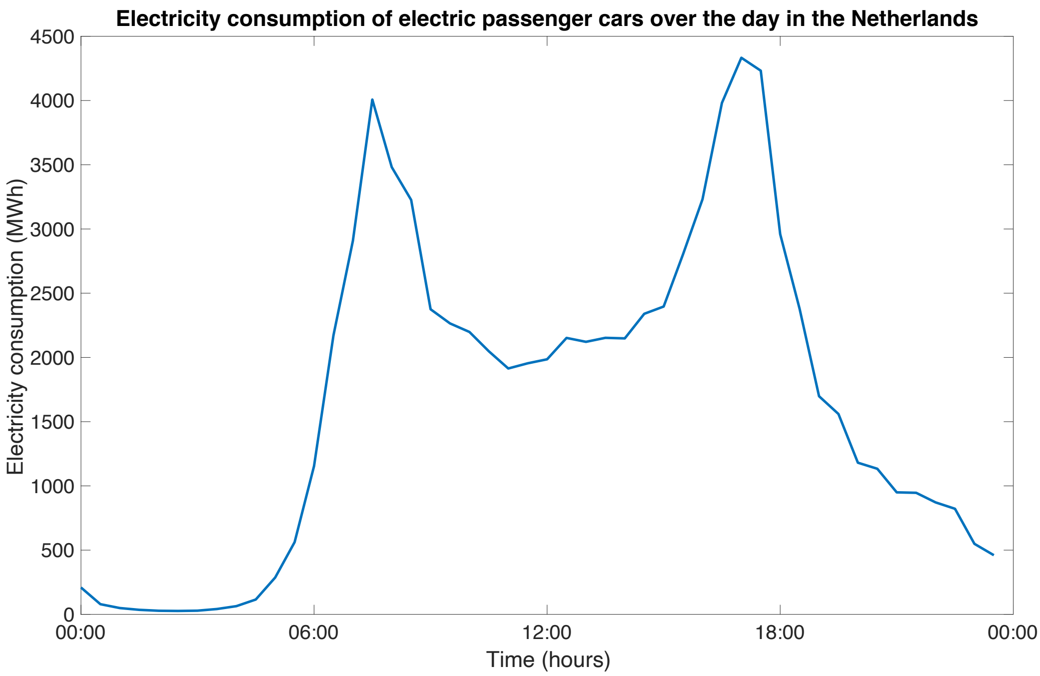

Figure 5: Pattern of electricity consumption of electric passenger cars over the day on a regular working day in the Netherlands

5.1.2. Electricity consumption of the electric passenger cars on a regular workday per PC2 area in the Netherlands

The study looked at the electricity consumption during the day and the total electricity consumption of electric cars per PC2 area. The total electricity consumption during a regular working day per PC2 area can be found in Figure 6 (the exact values can be found in Appendix E. Figure 7 shows the electricity consumption during a regular working day for PC10 to PC14, the figures of the other PC2 areas can be found in Appendix E.

What is obvious in Figure 6 is that the total consumption differs greatly between the PC2 areas. The differences are partly due to the number of inhabitants per area (which can be found in Appendix A). However, there are also differences in travel behavior between the areas. To determine whether the difference in total electricity consumption is mainly due to the number of inhabitants or to travel behavior, the electricity consumption per inhabitant was examined (which can be found in Appendix E). The higher the electricity consumption per inhabitant, the more kilometers the inhabitants have travelled on average per day. It is apparent that the consumption per inhabitant strongly differs between the PC2 areas. In the PC2 area near Enschede (PC75) and the PC2 area between Enschede and Apeldoorn (PC74), the consumption per inhabitant is the highest. This explains why the total electricity consumption in these areas is relatively high, even though there are relatively few inhabitants. The areas with the highest consumption are Amsterdam (PC10), Rotterdam (PC30) and the area around Amersfoort (PC38). It is noticeable that the consumption per inhabitant is low in Amsterdam and Rotterdam. However, the number of inhabitants in these areas is very high compared to the rest of the PC2 areas, which explains the high total consumption. For the PC38 area, the difference cannot be explained by a high number of inhabitants alone. In this area, the total electricity consumption is high, as the number of inhabitants and the consumption per inhabitants are above average. Due to the combination of the number of inhabitants and the consumption per inhabitant, the total consumption is the Amersfoort area is very high.

When looking at the development of electricity consumption over the day (Figure 7 and Appendix E), it is clear that in general the pattern of consumption corresponds to that throughout the Netherlands (Figure 5). From this it can be concluded that, in most cases, the trips made by car follow the same pattern over the 24 hours of the day in the different PC2 areas. However, it is noticeable that in a few PC2 areas the peak of the morning and/or evening rush hour falls slightly earlier or later. Also, the height of the graphs (the total consumption of electric cars) varies greatly per PC2 area.

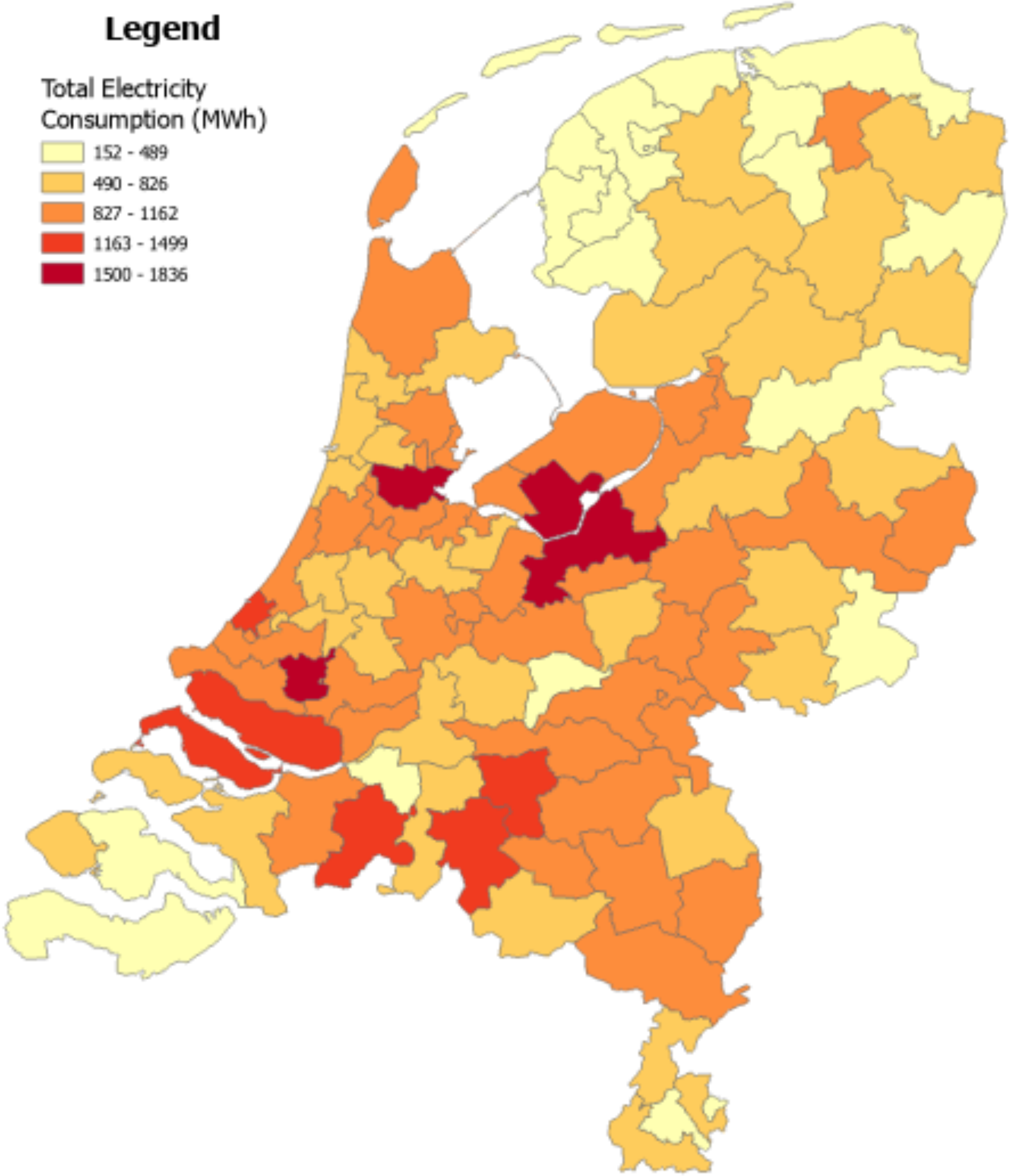

Figure 6: Total electricity consumption of electric passenger cars per day per PC2 area

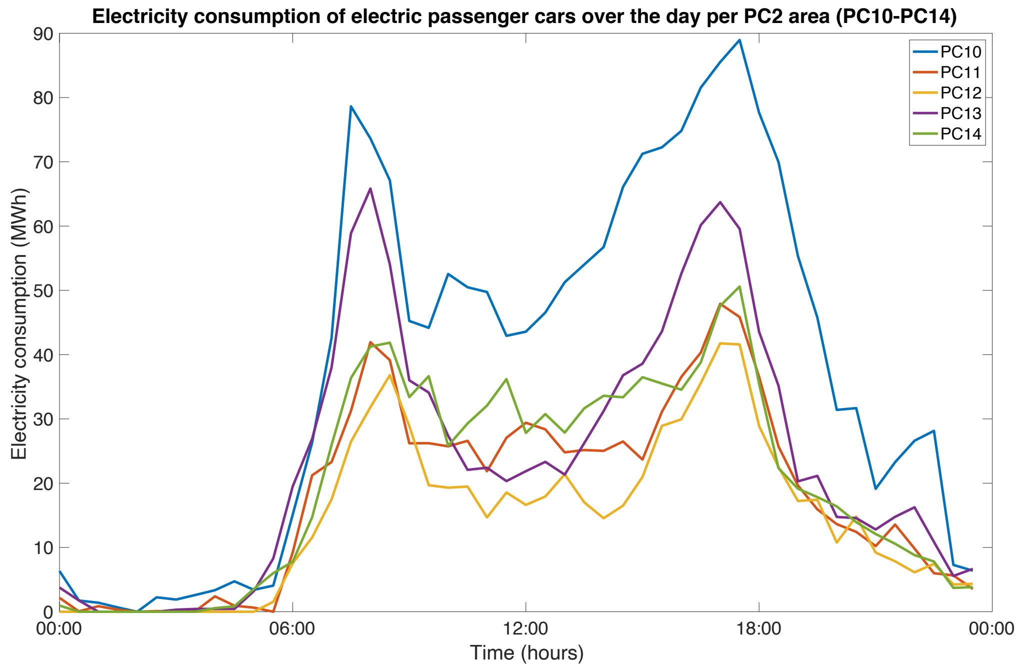

Figure 7: Electricity consumption of electric passenger cars over the day per PC2 area (PC10-PC14)

5.1.3. Electricity consumption per working day (Monday till Friday)

The correlation between the different working days (Monday till Friday) and the electricity consumption of electric passenger cars in the Netherlands can be found in Figure 8.This figure shows the pattern of the electricity consumption by electric cars for the Netherlands as a whole, with the different colors indicating the different working days. Which color belongs to which day is indicated in the legend in the figure. It can be seen in this figure that the electricity consumption on Tuesdays, Wednesdays and Thursdays corresponds well with the average consumption over all working days. What stands out is that the consumption on Mondays and Fridays deviates from the average over the working days. On Fridays it is noticeable that the consumption during the day (between rush hours) is much higher than the average workday and the consumption during morning rush hours is lower than the average workday. Electricity consumption on Mondays is lower than the average working day, both during the day (between rush hours) and during the evening rush hour.

When looking at the total electricity consumption of electric passenger cars over the various working days (which can be found in Table 4), it is obvious that the total consumption on Friday is higher than on the average working day (8% difference). On Mondays less electricity is consumed throughout the day, namely 8% less than on an average working day. The total electricity consumption on Tuesdays, Wednesdays and Thursdays most closely resembles the average consumption on a working day.

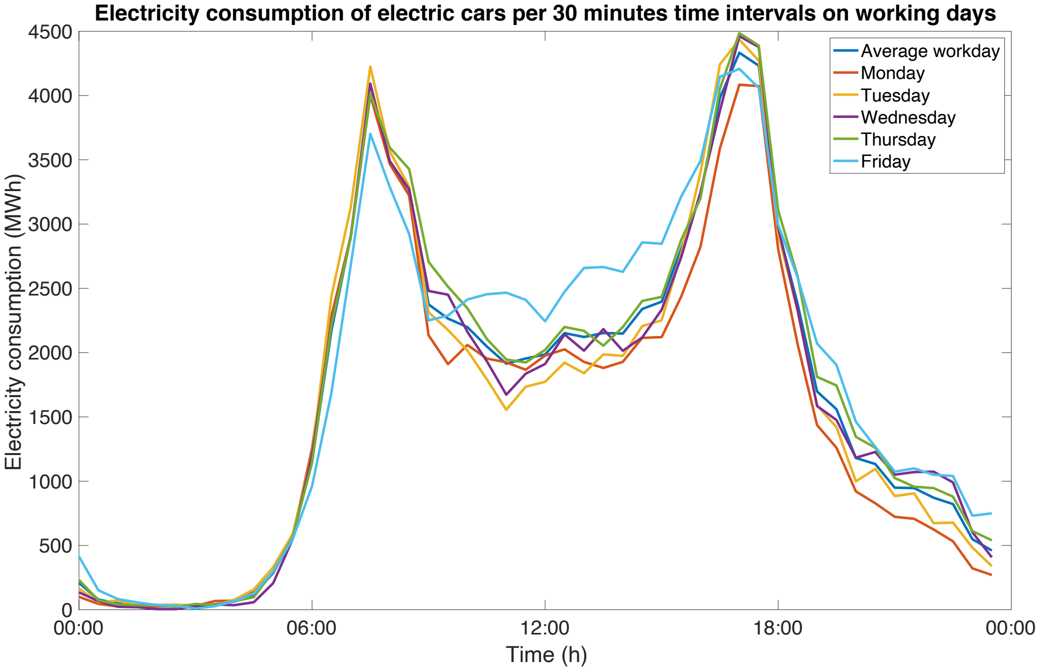

Figure 8: Electricity consumption of electric passenger cars over the day on working days in the Netherlands

Workday	Total electricity consumption (MWh)	Deviation from the average workday
Average (Monday till Friday)	80,618	-
Monday	73,894	-8.3
Tuesday	78,473	-2.7
Wednesday	80,297	-0.4
Thursday	83,690	3.8
Friday	86,910	7.8

Table 4: Total electricity consumption of electric passenger cars during working days in the Netherlands

The differences in electricity consumption between working days can be explained by examining the number of trips and the average distance travelled per trip for each working day (Table 5). Table 5 shows that the average distance driven per trip on Friday is lower than on the other days, but that the increased electricity consumption is mainly due to the number of trips, which are much higher on Friday. The electricity consumption on Monday is lower is mainly due to a lower number of trips, and also the average distance travelled is also lower than average.

Workday	Number of trips	Average distance per trip
Monday	19,531,598	19.23
Tuesday	20,230,046	20.04
Wednesday	20,933,240	19.96
Thursday	21,623,447	19.85
Friday	23,056,507	18.97

Table 5: Number of trips and the average distance per trip per working day

It can be concluded that there are differences in the total electricity consumption and the pattern of the consumption of electric cars on different working days. Mondays and Fridays deviate the most from the average working day. The report makes no further distinction between the different working days, but it is important to keep in mind that there are indeed differences in the electricity consumption of the passenger cars between the working days.

5.1.4. Electricity consumption per season

When considering the variation in electricity consumption per season, the total consumption (Table 6) and the consumption pattern during the day (Figure 9) are very similar. In summer, the electricity consumption is slightly higher. Also, in summer, the number of trips is lower, but the distance travelled per trip is higher (Table 7).

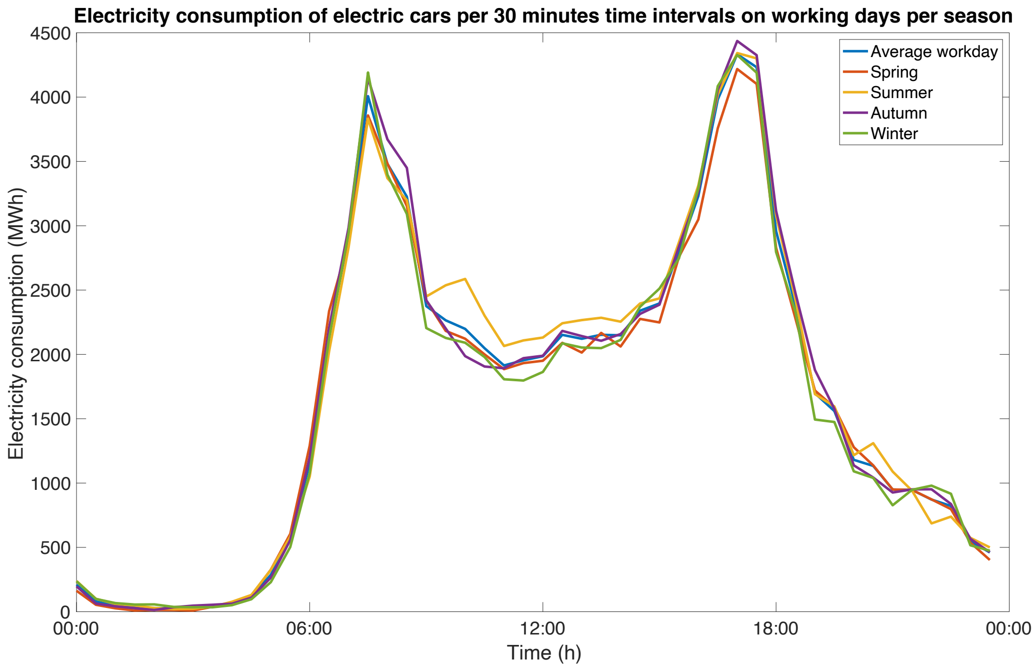

Figure 9: Electricity consumption of electric passenger cars over the day per season in the Netherlands

Season	Total electricity consumption (MWh)	Deviation from the average workday
Average	80,618	-
Spring	79,011	-2.0
Summer	82,737	2.6
Autumn	81,635	1.3
Winter	78,917	-2.1

Table 6: Total electricity consumption of electric passenger cars per season in the Netherlands

Season	Number of trips	Average distance per trip
Spring	21,008,705	19.37
Summer	19,652,560	20.95
Autumn	21,786,028	19.28
Winter	21,849,943	18.87

Table 7: Number of trips and the average distance per trip per season

5.2. Possibilities to charge the electric passenger car

The number of cars that have the possibility to charge the electric passenger cars at the household or at the work location in the Netherlands as a whole can be found in Figure 10.

When looking at the Netherlands as a whole, it can be seen that the most cars have the option to charge at home, but that a significant number of cars have the option to charge at work. The total number of cars that have the possibility to charge (the combination of the possibilities to charge at the household and work) in the morning and evening is mainly based on the cars parked at the household. In the afternoon, the cars parked at the work location have a significant influence on the total number of cars that have to opportunity to charge.

What is striking about Figure 10 is that in the morning hours, there seems to be no fluctuation in the number of cars with the possibility to charge. These fluctuations are expected, for example due to people coming home late or people going to work early in the morning. However, this is due to the scale of the figure; when looking at the exact values in Appendix F, it is noticeable that there are small fluctuations in the early morning.

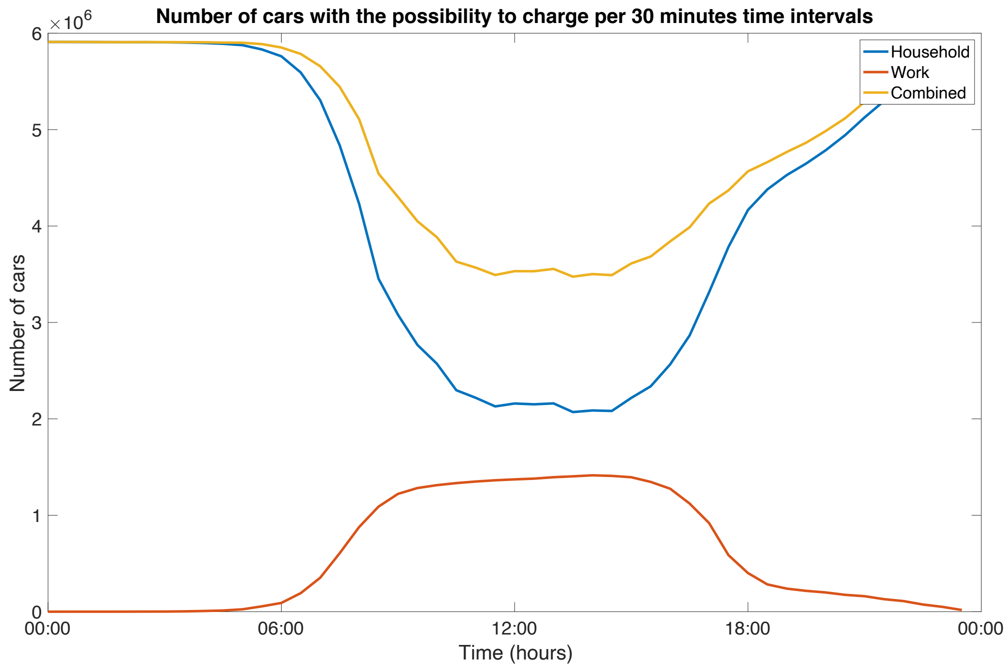

Figure 10: Number of cars per 30-minutes time intervals with the possibility to charge

5.3. Power demand on the electricity grid in the Netherlands

The demand on the electricity grid has been calculated using the data of active cars (cars that actually made a trip on a given day). Cars that have not made a trip do not contribute to the demand. Based on the ODiN data, 7.5 million passenger cars are used per regular working day.

5.3.1. Electricity demand on the electricity grid in the Netherlands as a whole

The demand on the electricity grid due to charging electric cars has been calculated. This involves calculation the demand for 2 charging profiles, namely charging with the maximum charging speed (7.8 kW) and charging with the minimum charging speed (the electricity to be charged is spread over the available time). In both profiles, 79% of the kilometers driven are charged at home and 21% of the kilometers driven are charged at work. Figure 11 shows the electricity demand on the electricity grid in the Netherlands as a whole when charging at the maximum charging speed. It is noticeable that the combined demand when charging with the maximum charging speed shows the same pattern as Figure 2, found in the research context. Clear peaks in the demand can be seen when the cars arrive at the work location or at the home location.

The electricity demand on the electricity grid in the Netherlands as a whole when charging at the minimum charging speed (Figure 12) shows a different pattern. The demand on the grid during the day does not show peaks in demand, and the demand is much lower.

When looking at Figure 11 and Figure 12, the area under the combined demand on the grid must be equal to the electricity consumption by the electric cars. The total electricity consumption in the charging at minimum speed strategy is 80 GWh, as calculated from the area under the graph (Figure 12). This is very similar to the electricity consumption as calculated in Chapter 5.1.1. (81 GWh). The value is slightly lower because individuals who do not have the possibility to charge at home or at work are not included. The total electricity consumption in the charging at maximum speed strategy is lower, namely 73 GWh (as calculated from the area under the graph (Figure 11)). This difference can be explained by the fact that the available charging time at work is too little in a number of cases, which leads to a required charging speed higher than 7.8 kW. If charging is done with the fixed (maximum) charging speed, less electricity than required for a full charge is charged in some cases, which leads to the area under the graph being too low.

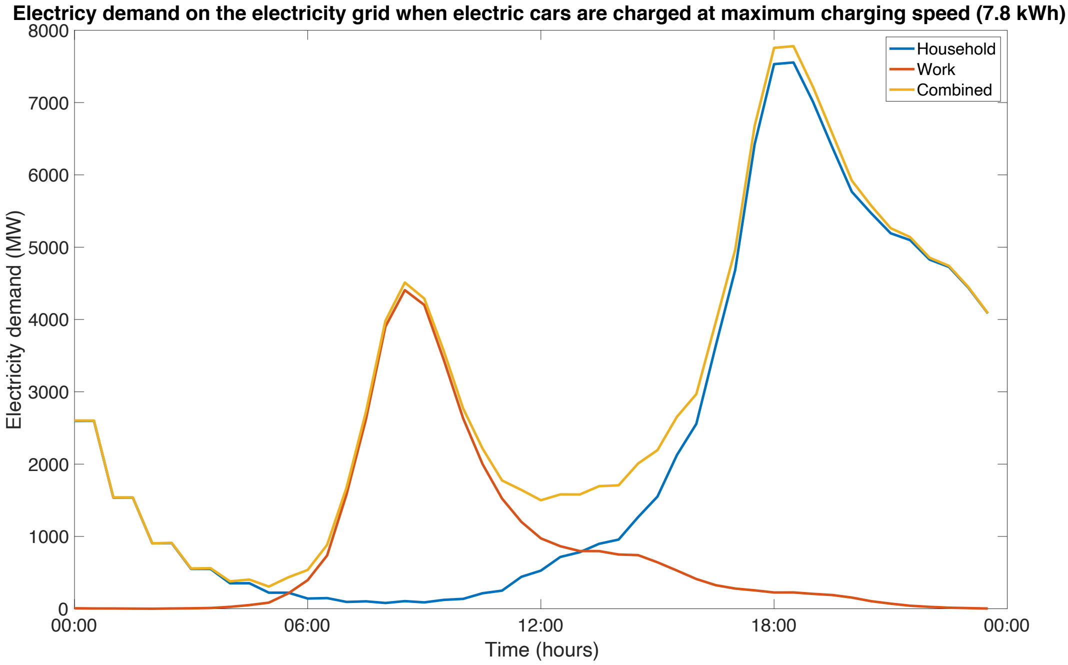

Figure 11: Electricity demand on the electricity grid when the electric cars are chards at maximum charging speed (7.8 kW)

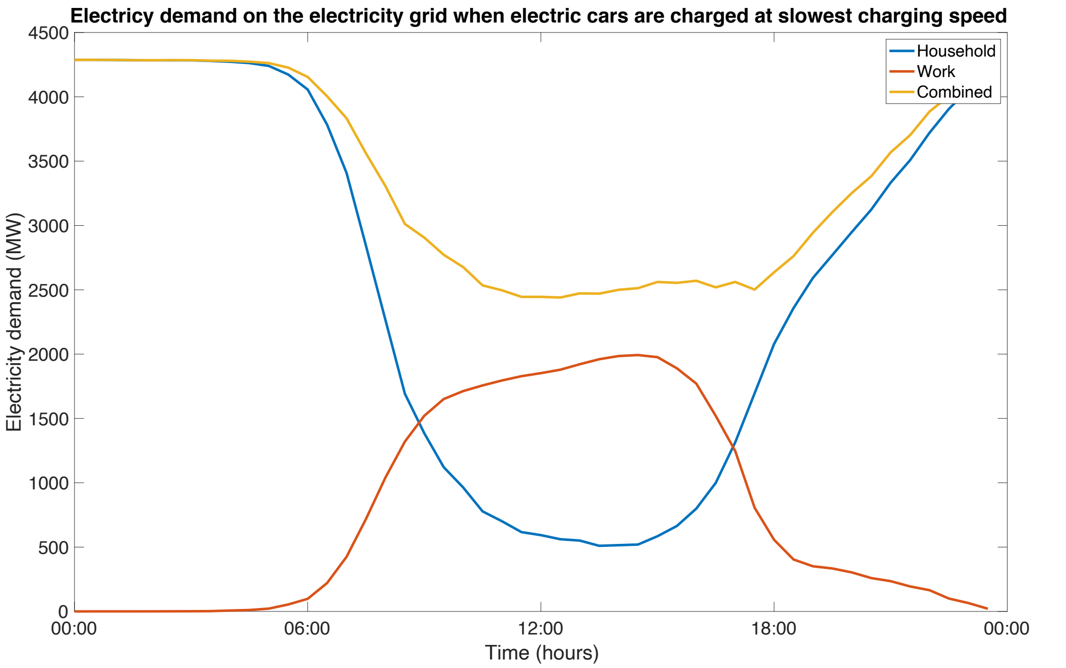

Figure 12: Electricity demand on the electricity grid when the electric cars are charges at the slowest charging speed

5.3.2. Power demand on the electricity grid in the Netherlands per PC2 area

Appendix G contains the figures for the electricity demand on the electricity grid due to charging the electric cars per PC2 area. The shapes of the demand on the grid per PC2 area are very similar to the demand for the Netherlands as a whole. It is noticeable that the electricity demand due to charging at work differs between the areas, as a result of which the combined demand also differs. The height of the graphs differs greatly between the PC2 areas. This is also noticeable when looking at the peak demand per PC2 area, which can be found in Figure 13 (the peak demand on the grid when charging at maximum charging speed) and Figure 14 (the peak demand on the grid when charging at the minimum charging speed). There are differences in the peak demand between the PC2 areas at both charging speeds and the peak demand varies greatly across the Netherlands. It is also noticeable that the peak demand is significantly reduces when charging at the slowest charging speed takes place compared to charging with maximum charging speed.

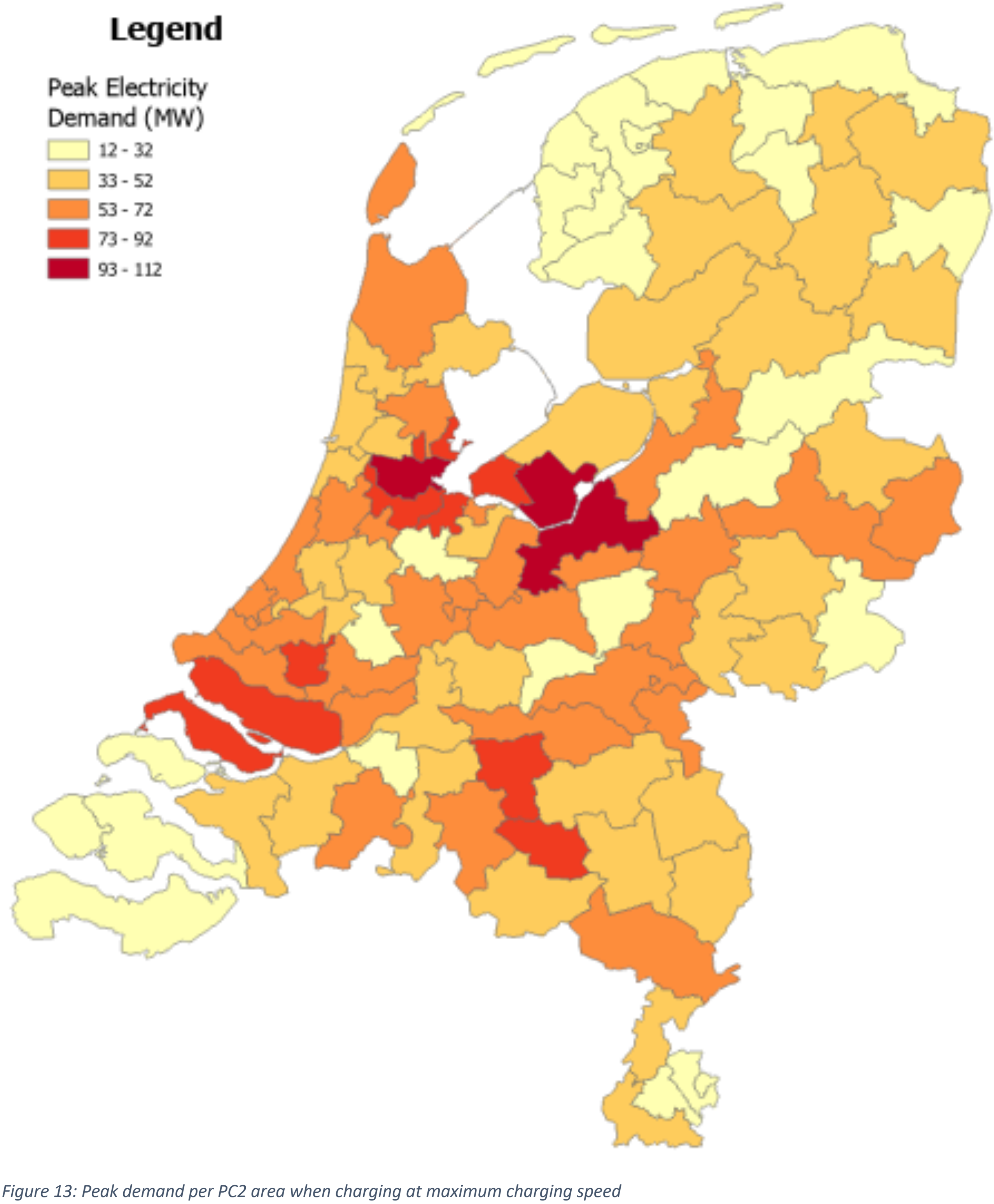

Figure 13: Peak demand per PC2 area when charging at maximum charging speed

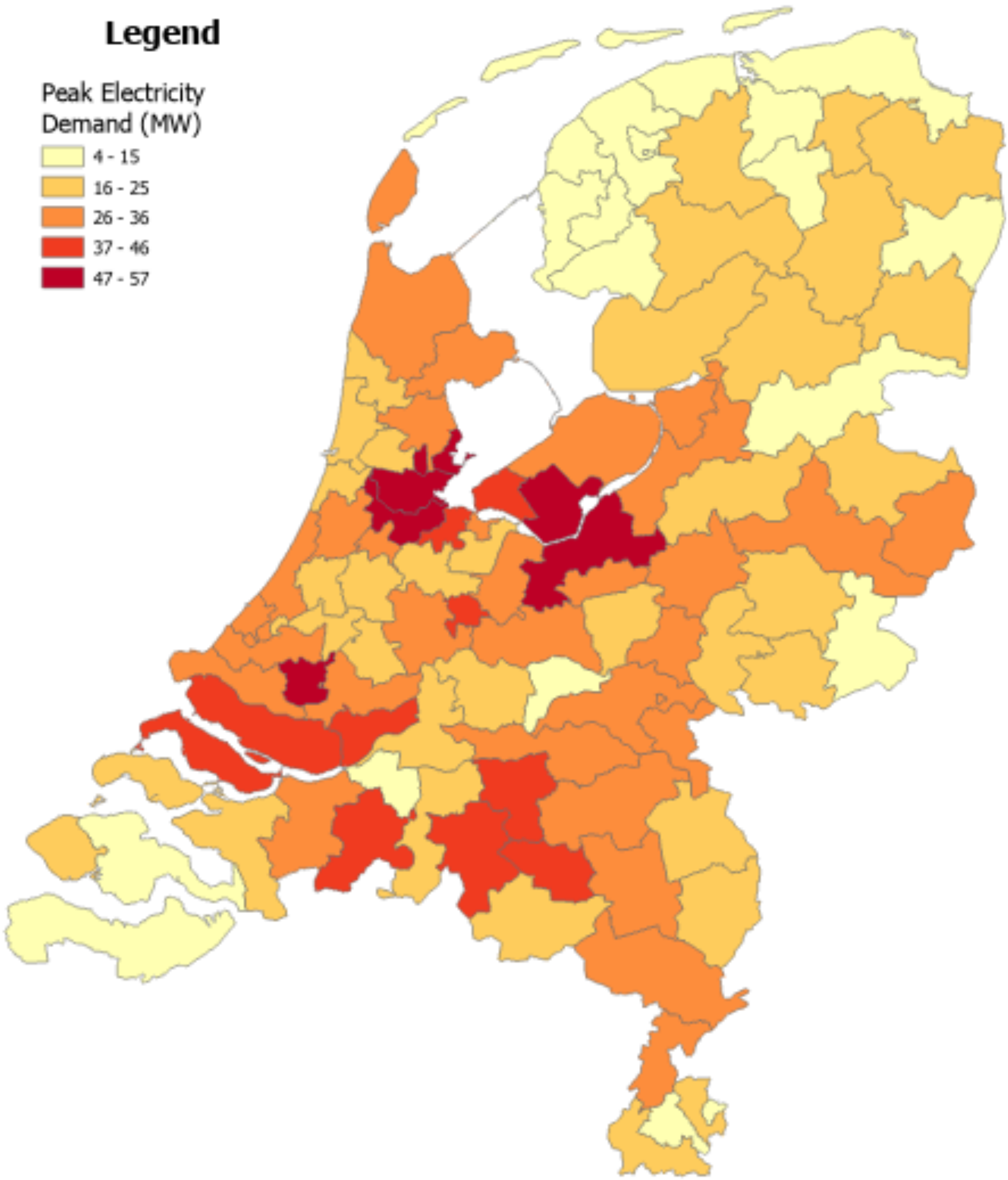

Figure 14: Peak demand per PC2 area when charging at minimum charging speed

5.3.3. Electricity demand on the electricity grid in the Netherlands as a whole per working day

When looking at the electricity demand on the electricity grid when charging, it is noticeable that the pattern over the day is very similar for each working day. This applies to both charging speeds: maximum charging speed (Figure 15) and minimum charging speed (Figure 16). However, there are differences between the height of the graphs, which can also be seen in the peak demand (Table 8). The exact values for the figures below can be found in Appendix G.

Workday	Peak demand (MW) when charging with maximum speed	Peak demand (MW) when charging with minimum speed
Monday	7,634	3,754
Tuesday	8,490	4,346
Wednesday	7,910	4,496
Thursday	7,890	4,600
Friday	7,140	4,262

Table 8: Peak demand on the grid for the working days

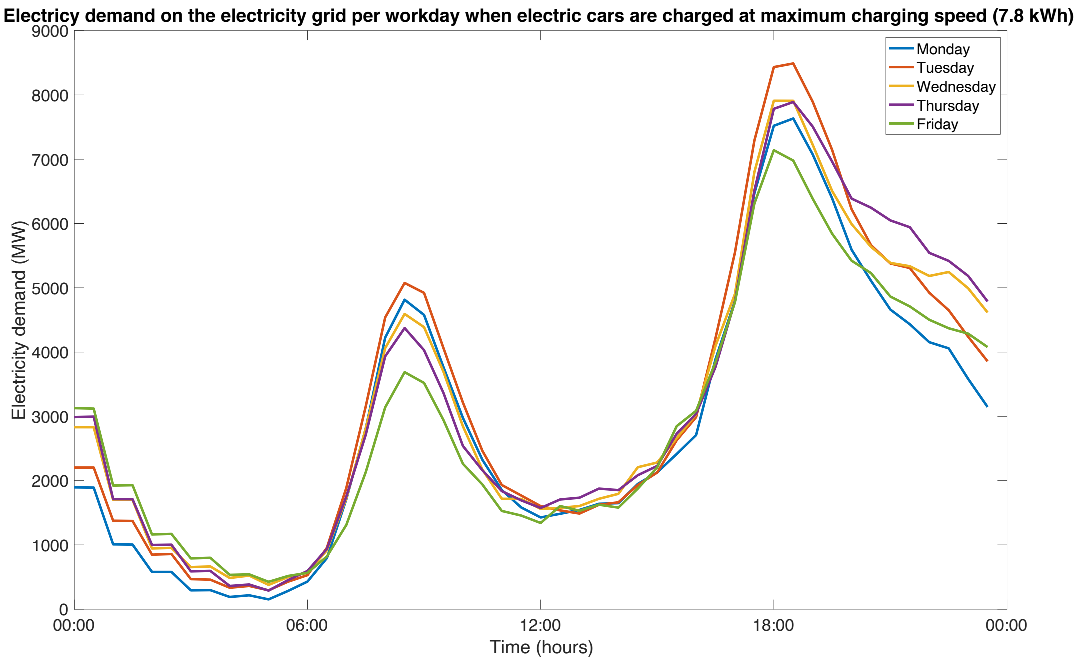

Figure 15: Electricity demand on the grid per workday when charging at maximum charging speed

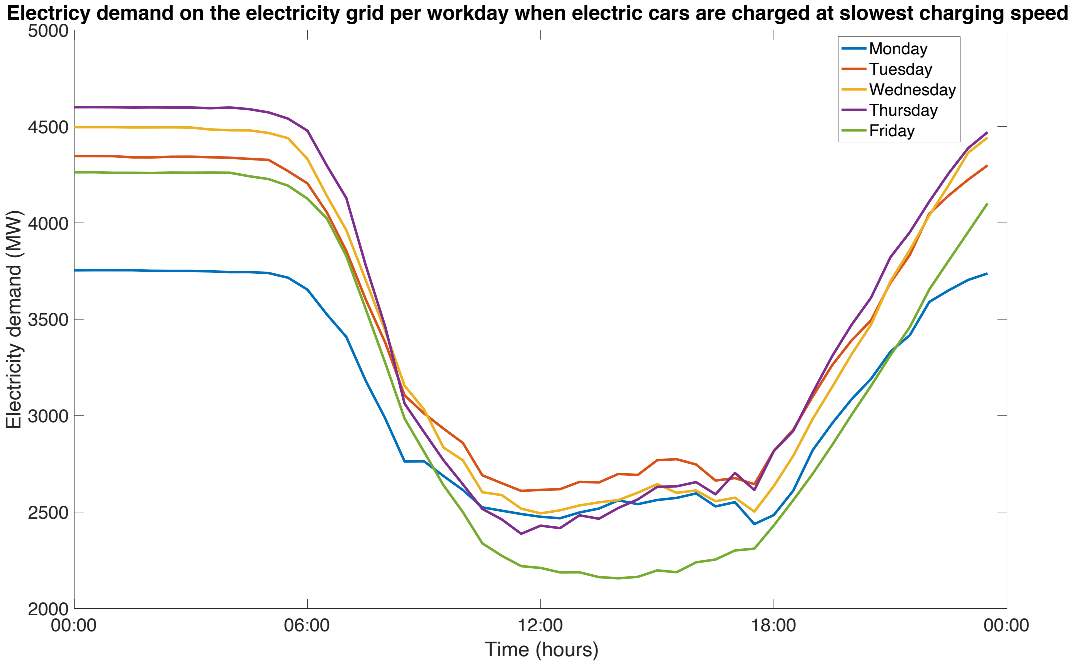

Figure 16: Electricity demand on the grid per workday when charging at minimum charging speed

5.3.4. Electricity demand on the electricity grid in the Netherlands as a whole per season

When considering the variation in demands per season, the peak demand (Table 9) and the demand pattern during the day (Figure 17) are very similar when charging at maximum charging speed. There is more variation between seasons when looking at peak demand (Table 9) and the demand pattern during the day (Figure 18) when charging at minimum charging speed. The exact values for the figures below can be found in Appendix G.

Season	Peak demand (MW) when charging with maximum speed	Peak demand (MW) when charging with minimum speed
Spring	7,753	4,215
Summer	7,679	4,198
Autumn	7,952	4,427
Winter	7,863	4,308

Table 9: Peak demand on the grid for the seasons

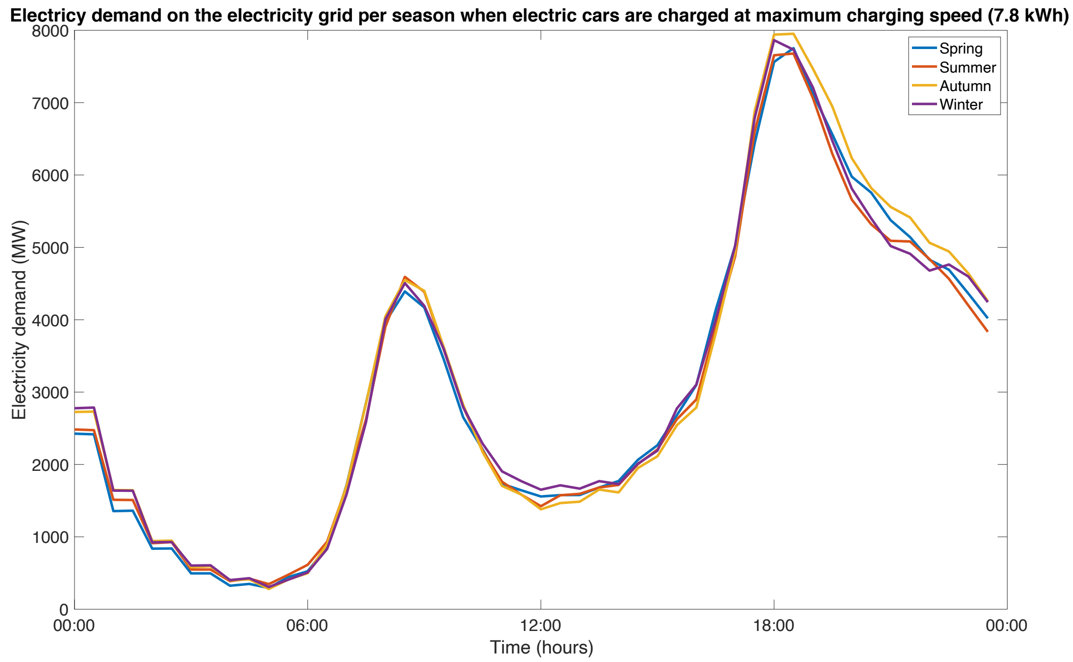

Figure 17: Electricity demand on the grid per season when charging at maximum charging speed

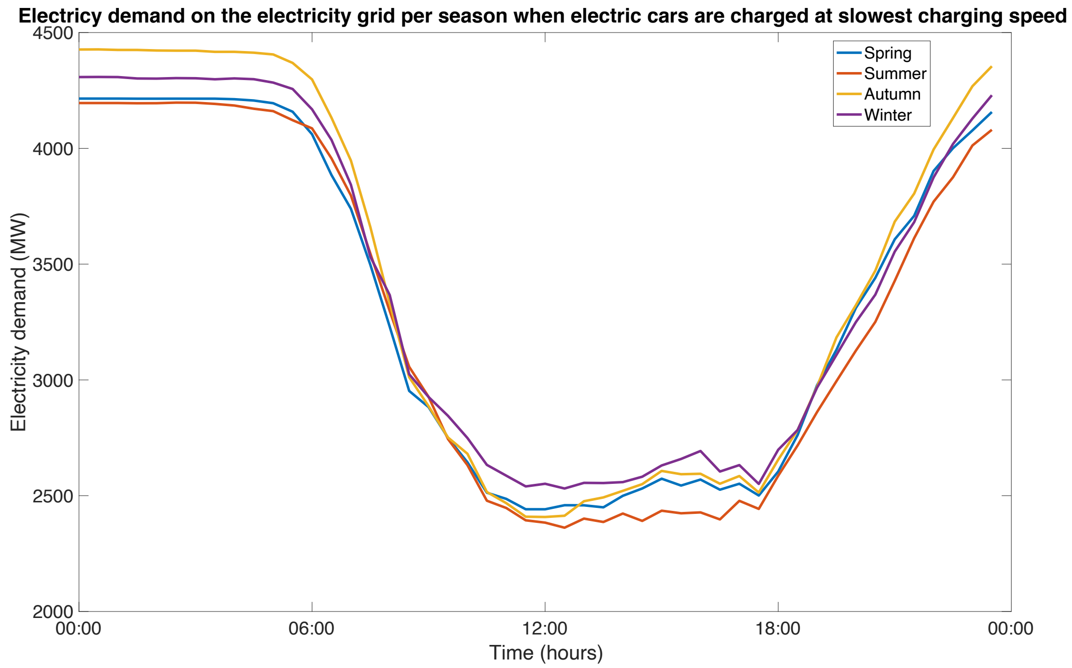

Figure 18: Electricity demand on the grid per season when charging at minimum charging speed

6. Discussion

The ODiN database has a number of limitations that need to be discussed.

Firstly, the ODiN database does not exactly provided the required information, namely when the car is used and how many kilometers are driven, because this requires the travel behavior of car users. The ODiN database provides the travel behavior of individuals, but not the travel behavior of the users of a car (which can be a combination of the travel behavior of the individuals). Assumptions had to be made about the use of the car. Based on the MON it is assumed that every individual has their own car, which is a simplification of the actual situation.

Secondly, the ODiN provides information about the travel behavior of the respondents on 1 day. The use of the car over multiple working days is not provided. As a result, the expected charging strategy over multiple working days cannot be determined. For example, if the respondent uses 20% of the battery of the car on Monday and 40% on Tuesday, the respondent may choose to charge the car only on Tuesday and not on Monday. However, the charging strategy depends also on personal preferences and the range of the car.

Thirdly, the ODiN database is not completely reliable, as is it based on information provided by respondents of a survey. It is likely that not every respondent has completed this information accurately. The distance traveled can be estimated wrong, the departure/arrival times may be rounded and trips may be forgotten. It is noteworthy that in the ODiN a large proportion (12%) of the respondents who leave the household by car do not return to the household by car or vice versa. This is likely to be incorrect, and upon checking the database it seems that respondents either forgot to fill in a trip or entered it incorrectly.

To calculate the demand on the electricity grid, it was decided to correct the database where possible so that the results are close to reality. This is done when the first trip made by car is not from the home address, but from an “other” address, and the respondents ends the last trip made by car at home. In these cases, it was checked whether the departure location (at PC4 level) of the first trip is the same as the location of the household. If this is the case, the departure location is changed from ‘other’ to ‘home address’. In the study, the decision was made not to add trips, even when it is obvious that a trip is missing. For example, the respondent makes a trip to work with the car, but there is no successive trip leaving the workplace (with the car). No trips are added as it would then be necessary to estimate the distance and departure/arrival time of this trip. Since the distance and arrival/departure time are important for the results, and it cannot be derived from the data, it is unwise to estimate those values because it can influence the final results.

Lastly, when looking at the different groups in ODiN, it is noticeable that certain groups are under/overrepresented in the database (Appendix A and Appendix B). For example, in the ODiN database there are relatively few respondents from the non-urban class and relatively many respondents from the strongly urban class. In the results of the underrepresented groups, the behavior of single individuals may have a larger impact on the results of the group. This is not desirable because this study examines the behavior of large groups and not individuals. However, when looking at the results, the underrepresented groups do not appear to show signs of individual behavior.

There are several limitations in the charging profile included in this research. Firstly, there are limitations concerning the starting time of the charging. The study assumes that, when the car is parked for a longer period, charging begins at the time the car is parked. The charging profile does not account for other external factors that influence the starting time for charging. For example, the availability of solar panels, the evening electricity rate, consumption within the household, the availability of charging stations or personal preferences.

Secondly, the charging profile assumes charging at home and at work. The charging profile does not take into account charging at fast chargers, public charging stations (excluding the stations near the household) or other charging options. This is a simplification, but the ODiN database does not include the necessary data.

The final shortcoming of the charging profile is that in some cases the available charging time at work is too short to fully charge the car with a fixed maximum charging speed (7.8 kW). As a result, based on this charging profile, these cars are not fully charged. This problem does not occur when charging with minimum charging speed strategy, since the charging speed is then based on the available time, which means that in some cases the charging speed would be higher than 7.8 kW.

6.1. Assumptions

To conduct the research, it was necessary to make several assumptions. These assumptions will be discussed in this sub-chapter.

Firstly, an assumption has been made about the consumption per kilometer of (future) electric cars. When looking at the different car models, the consumption per kilometer can differ greatly. It was decided to use the average consumption per kilometer of the electric car models that were listed in the EV database at that time (Elektrische Voertuigen Database, 2023). However, there is a significant difference between the lowest consumption per kilometer (150 Wh/km) and the highest consumption per kilometer (295 Wh/km). The assumed value may (in the future) not correspond to the average consumption per kilometer, because this is related to the models driven. It may be that on average more cars are used with a lower or higher consumption per kilometer. In addition, the car's consumption per kilometer also depends on weather conditions, driving style and the type of kilometers (driving on the highway or through urban areas).

Secondly, the maximum charging speed of the charging stations has been assumed. This is based on the household's connection to the electricity grid and the common charging speed of the charging stations at the associated connections. However, the charging speed of the charging station may be lower due to consumption within the household.

Thirdly, when calculating the electricity consumption and the demand on the electricity grid of electric cars, it was assumed that there is a 'regular' working day, and that travel behavior on all working days looks like this 'regular' working day. However, when the electricity consumption for the different working days was calculated, it turned out that there were indeed differences in consumption and therefore travel behavior. Because there was too little data available, it was not possible to further include the different working days in the research.

Finally, it is assumed that every individual has their own car. The MON has shown that in few cases a car within the household is used by several people. Since no further information was provided about car sharing in the ODiN and the car is only shared in a few households, it was decided not to include car sharing between household members in this research. However, it may be that car sharing between household members will happen more often in the future.

7. Conclusion

7.1. Answering the research questions

7.1.1. The consumption of electricity of (electric) passenger cars

Research question 1 and its sub questions address the electricity consumption of electric passenger cars in the Netherlands, assuming that all passenger cars are electric vehicles. To determine the electricity consumption several aspects have been examined. Survey data on travel behavior has been used as input to establish patterns. This survey data has been collected for all types of vehicles and makes no distinction between electric and fossil fuel cars. This data has then been used to extrapolate travel behavior when all passenger cars are assumed to be electric.

Additionally, predicted electricity consumption has been examined at a PC2 area level to determine if there are regional differences. This research showed that the overall pattern of electricity consumption is comparable between PC2 areas. However, there are marked differences in the total electricity consumption per PC2 area. Based on this research a total electricity consumption of 80,618 MWh per working day is predicted for the whole of the Netherlands. The consumption per PC2 area can be found in Figure 6.

7.1.2. Electricity demand on the electricity grid by electric cars

Research question 2 and its sub questions address the demand on the electricity grid resulting from charging electric cars.

This research considers 2 possible charging locations (home and work) and 2 different charging scenarios (minimal and maximal charging speeds).

In the minimal charging speed scenario, it is assumed that the total demand of a car is spread out over the total available time window in which charging is possible. In the maximal charging speed scenario, a car is charged at the maximum speed supported by the charging station. For this maximum speed the average value of 7.8 kWh has been used.

This research shows that in the maximum speed scenario, the peak demand on the electricity grid is significantly higher. The peak demands for both scenarios can be found in Figure 13 (maximum charging speed) and Figure 14 (minimum charging speed). These scenarios show the 2 extremes. In reality, the maximum demand will be somewhere in between these scenarios.

7.1.3. Total demand

The main research question was: *What is the electricity demand of the (electric) passenger cars on the electricity grid during a regular workday across the Netherlands, assuming all passenger cars are electric passenger cars and the travel behavior and the number of passenger cars stays the same as in the current situation?*

As can be seen above, there are several factors influencing the demand on the electricity grid. Looking at the electricity demand across the Netherlands, it was concluded that this varies greatly. For example, when charging at maximum charging speed, the highest peak demand is in Amersfoort (112 MW), and the lowest peak demand in Bolsward (12 MW). With minimum charging speed, the highest peak demand is in Amsterdam (57 MW) and the lowest peak demand is in Zuidhorn (4 MW).

When looking at the available capacity (Figure 1), in the areas where there is excess capacity on the electricity grid, there is relatively low demand on the grid. Zuid-Holland is an exception to this, with a high demand on the grid and relatively much capacity. In the provinces of Utrecht and Noord-Holland, there is relatively high demand, but there is virtually no available capacity.

7.2. Recommendations for future research

Based on the conclusions and the methodology of this research, several recommendations are made for future research. These recommendations are discussed in this sub-chapter.

Firstly, in this research it is assumed that if everyone drives electric, the situation will remain the same as the current situation, looking at the number of households/inhabitants, the number of cars, travel behavior (including the alternative modes of transportation), the locations of the house and work and the (average) consumption per kilometer of electric cars. It is likely that the future situation will not be the same as the current situation, but it is unclear how the situation will change in the future. Additional research into the future situation would be a good addition to this research, in order to predict electricity consumption and electricity demand on the electricity grid more accurately.

Secondly, two charging profiles were included in this study, which attempts to capture (future) charging behavior. However, in the Nationaal Laadonderzoek it can be seen that charging behavior is more varied than what was assumed in the research. Unfortunately, the data used in this study does not make it possible to include charging behavior as described in the Nationaal Laadonderzoek. An important limitation in this study is the inability determine the charging strategy, such as when electric car users charge their car based on the battery percentage. The travel behavior and the predictability of this travel behavior of individuals over the week needs to be known to determine when electric car users need to charge the car. Of course, this also depends on personal preferences.

Lastly, by conducting additional research into the electricity demand on the electricity grid from other users of the electricity grid, the total electricity demand can be calculated. By doing this, it can be determined whether the electricity grid has sufficient capacity to meet this total demand and, perhaps even more important, what the capacity of the grid needs to be to meet the demand. This research should also take into account the increasing or decreasing demand of users in the future (for example due to the extra use of heat pumps or the storage of solar energy in the household), which makes the estimates for the future more accurate.

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Appendix A – CBS data

PC2 area	Inhabitants	PC2 area	Inhabitants	PC2 area	Inhabitants
10	674435	**40**	68790	**70**	68790
11	254374	**41**	105557	**71**	105557
12	142482	**42**	96141	**72**	96141
13	210524	**43**	124519	**73**	124519
14	189927	**44**	85629	**74**	85629
15	148421	**45**	88818	**75**	88818
16	162214	**46**	114356	**76**	114356
17	218930	**47**	142329	**77**	142329
18	126017	**48**	221276	**78**	221276
19	164214	**49**	78626	**79**	78626
20	166971	**50**	253440	**80**	253440
21	185952	**51**	135198	**81**	135198
22	268118	**52**	219803	**82**	219803
23	189758	**53**	160858	**83**	160858
24	147353	**54**	182738	**84**	182738
25	416340	**55**	147328	**85**	147328
26	268487	**56**	295998	**86**	295998
27	153787	**57**	175738	**87**	175738
28	106388	**58**	81678	**88**	81678
29	230891	**59**	159577	**89**	159577
30	488628	**60**	192259	**90**	192259
31	232041	**61**	144366	**91**	144366
32	245364	**62**	161004	**92**	161004
33	221866	**63**	82144	**93**	82144
34	193283	**64**	148396	**94**	148396
35	259148	**65**	206453	**95**	206453
36	80873	**66**	164348	**96**	164348
37	216460	**67**	130308	**97**	130308
38	289126	**68**	194093	**98**	194093
39	204920	**69**	135669	**99**	135669

Table 10: Inhabitants per PC2 area (CBS, 2023)

Appendix B – Number of respondents per characteristics

Total database: 66,337

Workdays	Number of Respondents
Monday	13,589
Tuesday	13,299
Wednesday	12,979
Thursday	13,201
Friday	13,269

Table 11: Respondents per working day (ODiN)

Season	Number of respondents
Spring	16,073
Summer	16,980
Autumn	17,088
Winter	16,196

Table 12: Respondents per season (ODiN)

PC2 area	Number of Respondents	PC2 area	Number of Respondents	PC2 area	Number of Respondents
10	2,823	**40**	316	**70**	580
11	1,960	**41**	517	**71**	453
12	713	**42**	448	**72**	620
13	1,047	**43**	641	**73**	798
14	1,295	**44**	476	**74**	1,036
15	1,044	**45**	412	**75**	1,299
16	815	**46**	529	**76**	763
17	1,109	**47**	701	**77**	1,109
18	648	**48**	1,115	**78**	438
19	1,162	**49**	368	**79**	612
20	957	**50**	1,195	**80**	1,037
21	1,132	**51**	684	**81**	488
22	1,847	**52**	1,115	**82**	1,435
23	1,032	**53**	813	**83**	456
24	1,251	**54**	930	**84**	529
25	2,525	**55**	812	**85**	226
26	1,982	**56**	1,564	**86**	191
27	901	**57**	910	**87**	144
28	554	**58**	460	**88**	164
29	1,403	**59**	827	**89**	383
30	3,019	**60**	995	**90**	279
31	1,309	**61**	743	**91**	147
32	1,313	**62**	759	**92**	561
33	1,043	**63**	444	**93**	277
34	940	**64**	673	**94**	643
35	1,387	**65**	1,143	**95**	267
36	377	**66**	864	**96**	589
37	1,106	**67**	687	**97**	1,160
38	1,537	**68**	1,034	**98**	174
39	1,172	**69**	638	**99**	348

Table 13: Respondents per PC2 area (ODiN)

Appendix C – MON

Number of households in the dataset: 14,434
Number of persons in the dataset: 32,393

Number of cars owned by the household	Number of drivers licenses within the household	Percentage of the households in de dataset (MON)
0	0	12.3874
0	1 or more	4.5171
1	0	0.1732
1	1	28.7723
1	2 or more	26.9225
2	0	0.0485
2	1	0.9561
2	2	20.4656
2	3 or more	2.8059
3 or more	0	0
3 or more	1	0.1247
3 or more	2	0.9907
3 or more	3	1.0392
3 or more	4 or more	0.7967

Table 14: Car ownership and driving license holders per household

Car use in the household

The percentage of households in which the passenger cars was used by multiple household members on the same day, for the car deficient households, can be found in Table 15. For households consisting of 1 car and 2 or more driving licenses, it is noted that in 3.7% of households the car was used by multiple household members. Looking at the group of households with 2 cars and 3 or more driving licenses, in 5.9% of the households the cars were used by multiple household members.

In 1.2% of the households in the MON database of 2009 is a car shared between multiple members of the household. Since the percentage of households where the cars are shared is considerably small, it was decided not to include car sharing any further in this study. From now on, it is assumed that each individual has an own car, which is only used by that individual only.

Number of cars owned by the household	Number of drivers licenses within the household	Percentage more car users than cars compared to the car deficient household groups	Percentage more car users than cars compared to all the households
1	2 or more	3.7	1.0
2	3 or more	5.9	0.2
3 or more	4 or more	4.3	0.0

Table 15: percentage of car sharing within the households in car deficient households, based on the MON database (2009)

Appendix D – Data structure ODiN

	Percentage respondents	Percentage distance travelled compared to total distance travelled
Starts at home address and end at home address	82.0457 %	82.7978 %
More than 6 hours at home in between trips (if day does not start and end at home address)	0.4754 %	0.5235 %
Starts at home address and ends at "other" address	5.6029 %	6.0716 %
Starts at "other" address and ends at home address	9.7289 %	8.7329 %
Starts at "other" address and ends at "other" address	2.1471 %	1.8743 %

Table 16: Information about the (incorrect) data in the ODiN

Appendix E – Results electricity consumption

Electricity consumption for a regular working day for the Netherlands as a whole

30-minutes time intervals	Electricity consumption (MWh)	30-minutes time intervals	Electricity consumption (MWh)
00:00 – 00:30	209	**12:00 – 12:30**	1986
00:30 – 01:00	79	**12:30 – 13:00**	2152
01:00 – 01:30	49	**13:00 – 13:30**	2122
01:30 – 02:00	35	**13:30 – 14:00**	2153
02:00 – 02:30	28	**14:00 – 14:30**	2148
02:30 – 03:00	27	**14:30 – 15:00**	2340
03:00 – 03:30	29	**15:00 – 15:30**	2396
03:30 – 04:00	42	**15:30 – 16:00**	2804
04:00 – 04:30	64	**16:00 – 16:30**	3231
04:30 – 05:00	116	**16:30 – 17:00**	3981
05:00 – 05:30	287	**17:00 – 17:30**	4333
05:30 – 06:00	562	**17:30 – 18:00**	4232
06:00 – 06:30	1155	**18:00 – 18:30**	2960
06:30 – 07:00	2172	**18:30 – 19:00**	2378
07:00 – 07:30	2908	**19:00 – 19:30**	1698
07:30 – 08:00	4007	**19:30 – 20:00**	1560
08:00 – 08:30	3482	**20:00 – 20:30**	1181
08:30 – 09:00	3226	**20:30 – 21:00**	1133
09:00 – 09:30	2375	**21:00 – 21:30**	950
09:30 – 10:00	2265	**21:30 – 22:00**	946
10:00 – 10:30	2198	**22:00 – 22:30**	872
10:30 – 11:00	2048	**22:30 – 23:00**	822
11:00 – 11:30	1914	**23:00 – 23:30**	549
11:30 – 12:00	1954	**23:30 – 24:00**	461

Table 17: Electricity consumption for a regular working day for the Netherlands as a whole

Electricity consumption for a regular working week for the Netherlands as a whole

30-minutes time intervals	Average electricity consumption (MWh)	Monday electricity consumption (MWh)	Tuesday electricity consumption (MWh)	Wednesday electricity consumption (MWh)	Thursday electricity consumption (MWh)	Friday electricity consumption (MWh)
00:00 – 00:30	209	100	165	135	233	414
00:30 – 01:00	79	46	59	67	73	152
01:00 – 01:30	49	26	71	23	42	83
01:30 – 02:00	35	30	32	20	36	58
02:00 – 02:30	28	25	37	5	37	36
02:30 – 03:00	27	36	40	5	21	31
03:00 – 03:30	29	30	32	28	45	9
03:30 – 04:00	42	68	34	41	37	28
04:00 – 04:30	64	71	78	36	68	67
04:30 – 05:00	116	137	157	58	97	126
05:00 – 05:30	287	295	332	207	299	300
05:30 – 06:00	562	563	589	548	564	548
06:00 – 06:30	1155	1257	1210	1201	1142	961
06:30 – 07:00	2172	2286	2441	2228	2216	1689
07:00 – 07:30	2908	2908	3136	2907	2901	2688
07:30 – 08:00	4007	4004	4225	4092	4015	3702
08:00 – 08:30	3482	3468	3565	3491	3596	3289
08:30 – 09:00	3226	3222	3291	3270	3427	2923
09:00 – 09:30	2375	2135	2314	2480	2706	2251
09:30 – 10:00	2265	1911	2176	2451	2513	2288
10:00 – 10:30	2198	2060	2016	2161	2345	2413
10:30 – 11:00	2048	1954	1792	1933	2106	2454
11:00 – 11:30	1914	1925	1555	1673	1947	2466
11:30 – 12:00	1954	1867	1735	1836	1923	2411
12:00 – 12:30	1986	1977	1773	1912	2022	2243
12:30 – 13:00	2152	2026	1922	2142	2200	2474
13:00 – 13:30	2122	1928	1840	2015	2170	2658
13:30 – 14:00	2153	1881	1986	2183	2054	2666
14:00 – 14:30	2148	1928	1975	2014	2199	2628
14:30 – 15:00	2340	2115	2207	2119	2402	2858
15:00 – 15:30	2396	2121	2252	2334	2434	2847
15:30 – 16:00	2804	2434	2767	2740	2876	3212
16:00 – 16:30	3231	2824	3401	3248	3201	3493
16:30 – 17:00	3981	3590	4243	3882	4055	4145
17:00 – 17:30	4333	4084	4435	4462	4486	4208
17:30 – 18:00	4232	4073	4271	4377	4389	4059
18:00 – 18:30	2960	2804	2925	2973	3107	2995
18:30 – 19:00	2378	2066	2323	2332	2593	2586
19:00 – 19:30	1698	1437	1591	1585	1812	2071
19:30 – 20:00	1560	1260	1420	1476	1745	1905

20:00 – 20:30	1181	921	999	1183	1345	1463
20:30 – 21:00	1133	828	1095	1227	1260	1267
21:00 – 21:30	950	722	884	1051	1025	1074
21:30 – 22:00	946	707	906	1071	957	1099
22:00 – 22:30	872	625	674	1074	946	1050
22:30 – 23:00	822	532	678	990	880	1040
23:00 – 23:30	549	322	484	603	612	732
23:30 – 24:00	461	270	339	408	539	750

Table 18: Electricity consumption for a regular working week for the Netherlands as a whole

Electricity consumption for the seasons for the Netherlands as a whole

30-minutes time intervals	Average electricity consumption (MWh)	Spring electricity consumption (MWh)	Summer electricity consumption (MWh)	Autumn electricity consumption (MWh)	Winter electricity consumption (MWh)
00:00 – 00:30	209	163	239	197	236
00:30 – 01:00	79	54	100	63	99
01:00 – 01:30	49	27	61	42	67
01:30 – 02:00	35	9	49	27	56
02:00 – 02:30	28	14	29	13	57
02:30 – 03:00	27	13	21	35	37
03:00 – 03:30	29	9	23	47	35
03:30 – 04:00	42	39	39	54	35
04:00 – 04:30	64	64	77	63	51
04:30 – 05:00	116	125	130	109	97
05:00 – 05:30	287	326	326	265	230
05:30 – 06:00	562	605	583	557	503
06:00 – 06:30	1155	1291	1050	1201	1079
06:30 – 07:00	2172	2337	2026	2206	2128
07:00 – 07:30	2908	2870	2832	2985	2945
07:30 – 08:00	4007	3858	3833	4148	4191
08:00 – 08:30	3482	3483	3369	3672	3397
08:30 – 09:00	3226	3153	3199	3450	3091
09:00 – 09:30	2375	2419	2450	2421	2205
09:30 – 10:00	2265	2183	2537	2201	2128
10:00 – 10:30	2198	2122	2587	1986	2091
10:30 – 11:00	2048	2000	2301	1906	1980
11:00 – 11:30	1914	1885	2065	1893	1807
11:30 – 12:00	1954	1932	2109	1971	1797
12:00 – 12:30	1986	1951	2131	1990	1864
12:30 – 13:00	2152	2090	2242	2183	2087
13:00 – 13:30	2122	2014	2267	2143	2053
13:30 – 14:00	2153	2167	2285	2106	2049
14:00 – 14:30	2148	2062	2255	2158	2113
14:30 – 15:00	2340	2276	2396	2315	2370
15:00 – 15:30	2396	2249	2435	2387	2512
15:30 – 16:00	2804	2757	2871	2837	2746
16:00 – 16:30	3231	3049	3313	3264	3291
16:30 – 17:00	3981	3757	4020	4056	4085
17:00 – 17:30	4333	4218	4342	4436	4328
17:30 – 18:00	4232	4103	4301	4326	4190
18:00 – 18:30	2960	2830	3081	3116	2796
18:30 – 19:00	2378	2278	2422	2474	2330
19:00 – 19:30	1698	1719	1691	1879	1494
19:30 – 20:00	1560	1589	1596	1578	1475

20:00 – 20:30	1181	1279	1216	1138	1091
20:30 – 21:00	1133	1137	1310	1043	1040
21:00 – 21:30	950	950	1089	927	827
21:30 – 22:00	946	947	940	951	948
22:00 – 22:30	872	873	686	952	980
22:30 – 23:00	822	797	739	837	917
23:00 – 23:30	549	537	574	566	516
23:30 – 24:00	461	402	500	463	474

Table 19: Electricity consumption for the seasons for the Netherlands as a whole

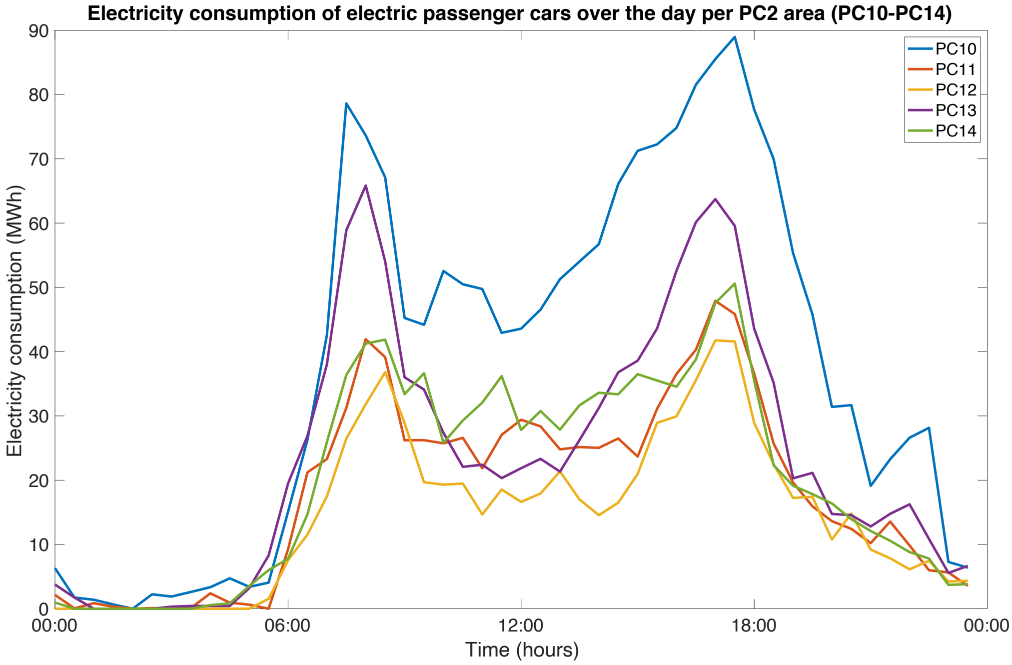
Electricity consumption per PC2 area

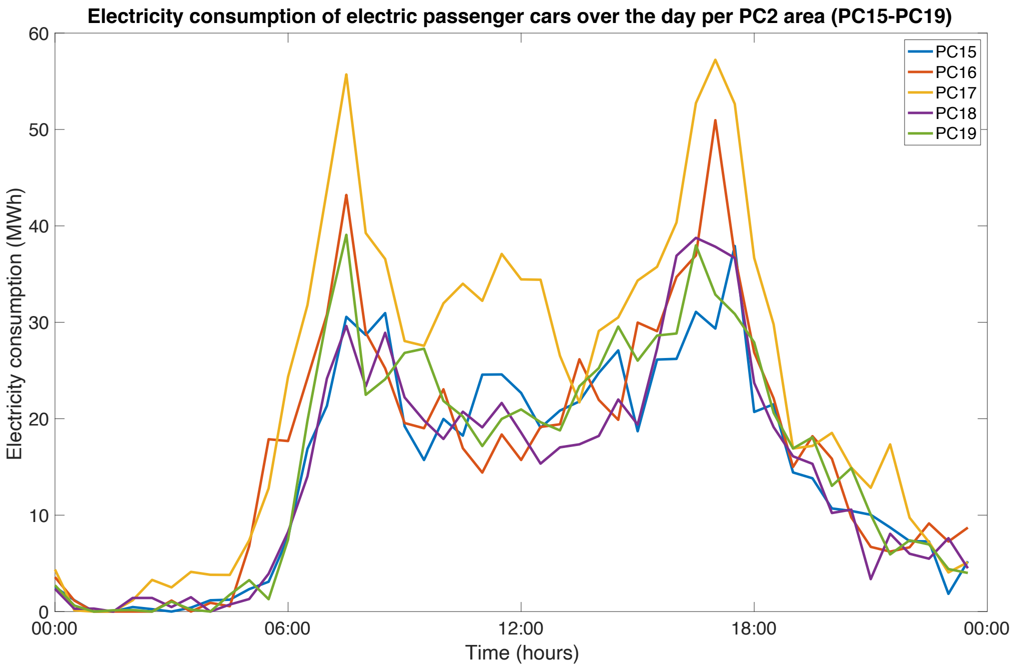
PC2 area	Total consumption (MWh)	PC2 area	Total consumption (MWh)	PC2 area	Total consumption (MWh)
10	1836	**40**	389	**70**	716
11	885	**41**	631	**71**	379
12	707	**42**	566	**72**	589
13	1140	**43**	691	**73**	919
14	974	**44**	389	**74**	1034
15	709	**45**	453	**75**	1122
16	807	**46**	647	**76**	775
17	1106	**47**	876	**77**	286
18	699	**48**	1205	**78**	604
19	761	**49**	401	**79**	757
20	684	**50**	1203	**80**	1091
21	883	**51**	773	**81**	502
22	1162	**52**	1222	**82**	985
23	616	**53**	867	**83**	679
24	690	**54**	1000	**84**	646
25	1236	**55**	719	**85**	332
26	1036	**56**	1150	**86**	205
27	795	**57**	826	**87**	249
28	519	**58**	545	**88**	264
29	1126	**59**	862	**89**	329
30	1629	**60**	1152	**90**	306
31	1111	**61**	776	**91**	153
32	1443	**62**	744	**92**	806
33	1162	**63**	371	**93**	223
34	1061	**64**	663	**94**	695
35	1013	**65**	1036	**95**	333
36	549	**66**	1034	**96**	667
37	1141	**67**	640	**97**	861
38	1691	**68**	1150	**98**	152
39	1062	**69**	847	**99**	337

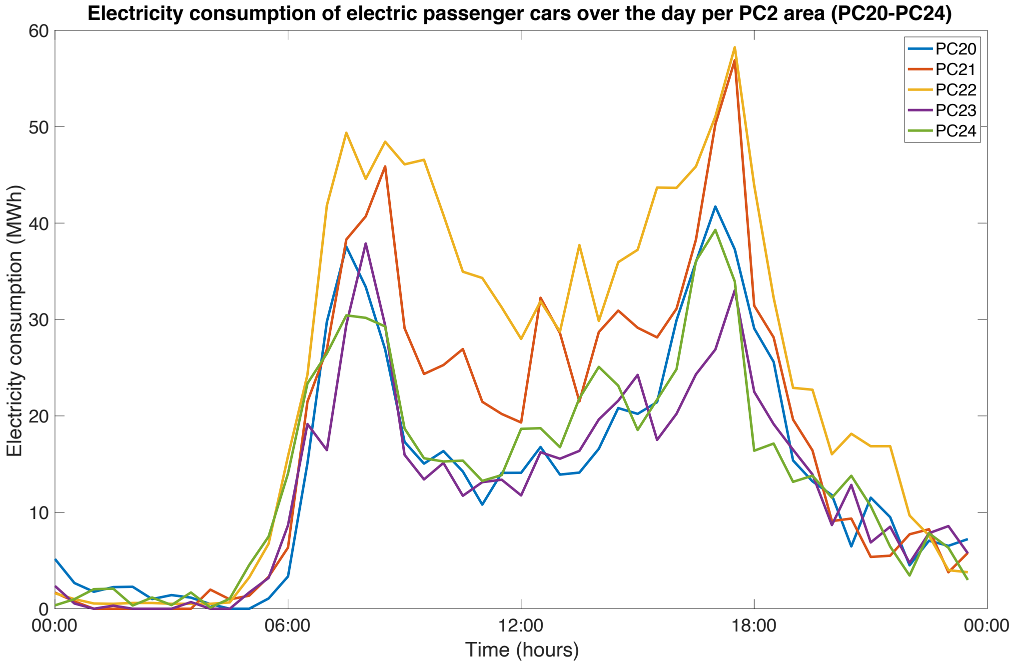
Table 20: Total electricity consumption per PC2 area

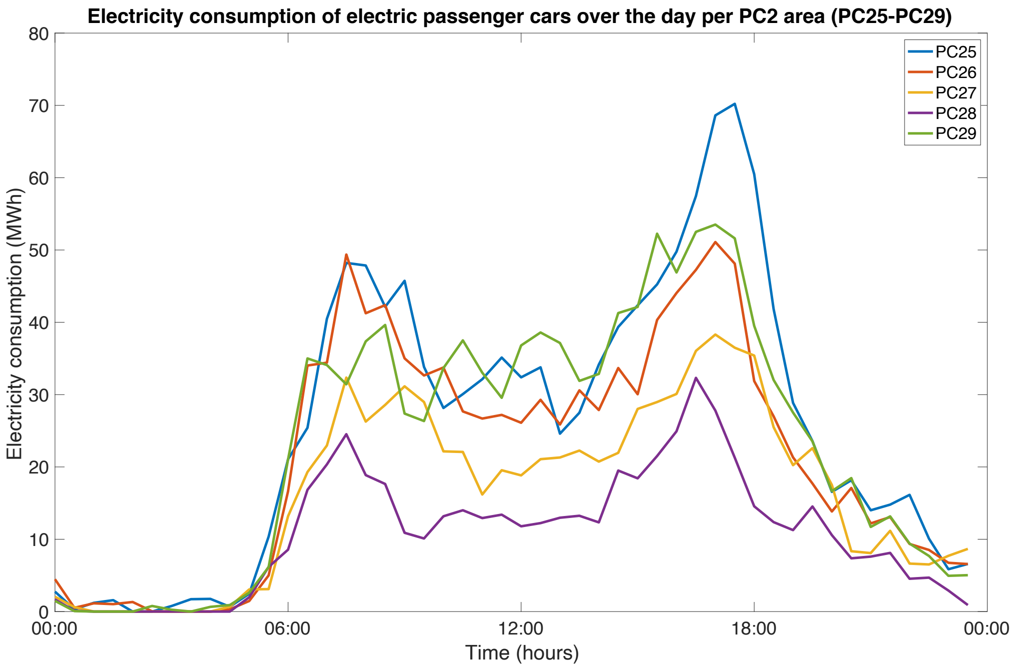
PC2 area	kW/inhabitant	PC2 area	kW/Inhabitants	PC2 area	kW/Inhabitants
10	2,7	**40**	5,7	**70**	10,4
11	3,5	**41**	6,0	**71**	3,6
12	5,0	**42**	5,9	**72**	6,1
13	5,4	**43**	5,5	**73**	7,4
14	5,1	**44**	4,5	**74**	12,1
15	4,8	**45**	5,1	**75**	12,6
16	5,0	**46**	5,7	**76**	6,8
17	5,1	**47**	6,2	**77**	2,0
18	5,5	**48**	5,4	**78**	2,7
19	4,6	**49**	5,1	**79**	9,6
20	4,1	**50**	4,7	**80**	4,3
21	4,7	**51**	5,7	**81**	3,7
22	4,3	**52**	5,6	**82**	4,5
23	3,2	**53**	5,4	**83**	4,2
24	4,7	**54**	5,5	**84**	3,5
25	3,0	**55**	4,9	**85**	2,3
26	3,9	**56**	3,9	**86**	0,7
27	5,2	**57**	4,7	**87**	1,4
28	4,9	**58**	6,7	**88**	3,2
29	4,9	**59**	5,4	**89**	2,1
30	3,3	**60**	6,0	**90**	1,6
31	4,8	**61**	5,4	**91**	1,1
32	5,9	**62**	4,6	**92**	5,0
33	5,2	**63**	4,5	**93**	2,7
34	5,5	**64**	4,5	**94**	4,7
35	3,9	**65**	5,0	**95**	1,6
36	6,8	**66**	6,3	**96**	4,1
37	5,3	**67**	4,9	**97**	6,6
38	5,8	**68**	5,9	**98**	0,8
39	5,2	**69**	6,2	**99**	2,5

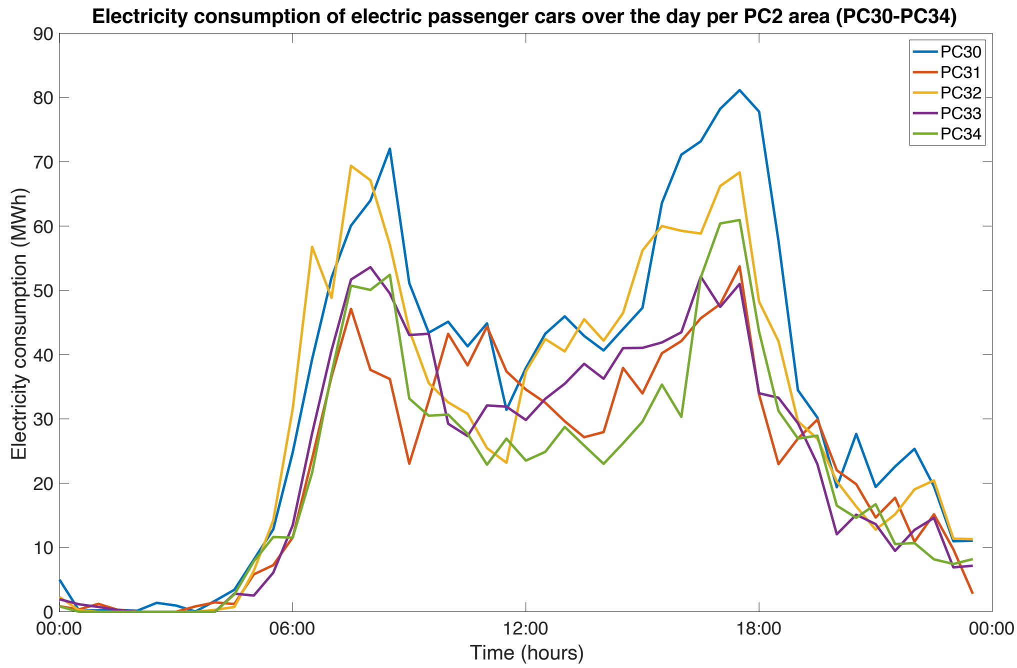
Table 21: Electricity consumption per regular workday per inhabitant per PC2 area

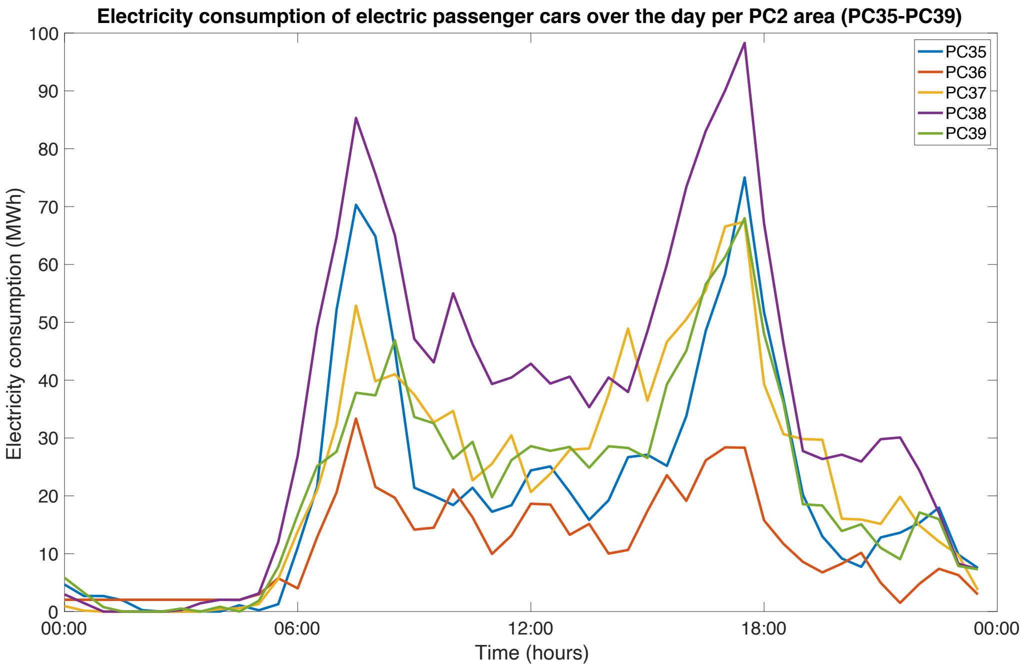

Electricity consumption of electric passenger cars over the day per PC2 area (PC10-PC14)
PC10
PC11
PC12
PC13
PC14
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70
80
90

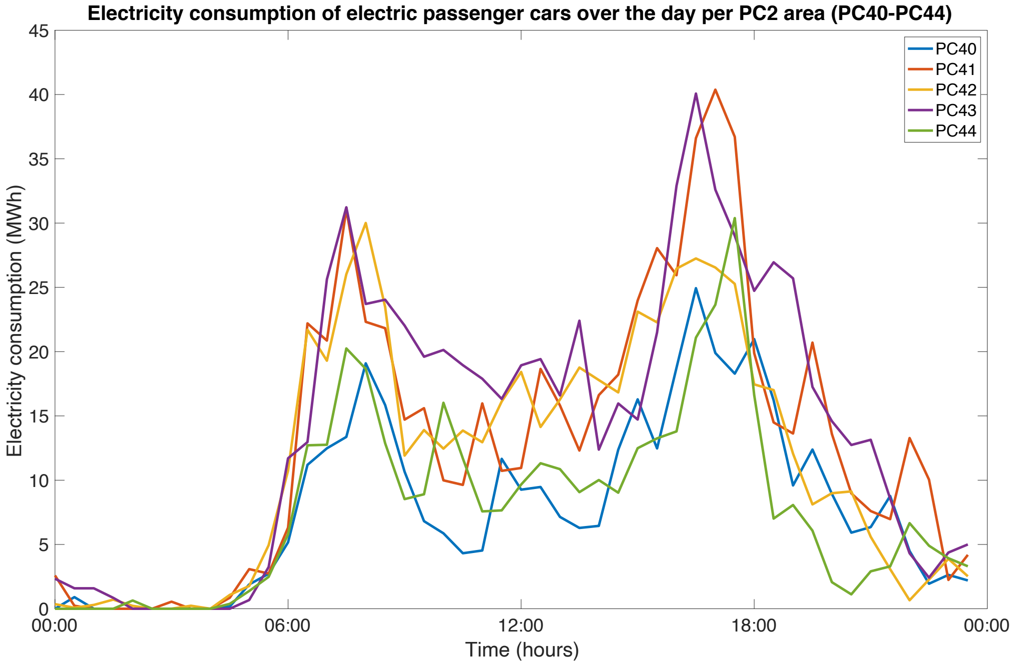

Electricity consumption of electric passenger cars over the day per PC2 area (PC15-PC19)
PC15
PC16
PC17
PC18
PC19
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60

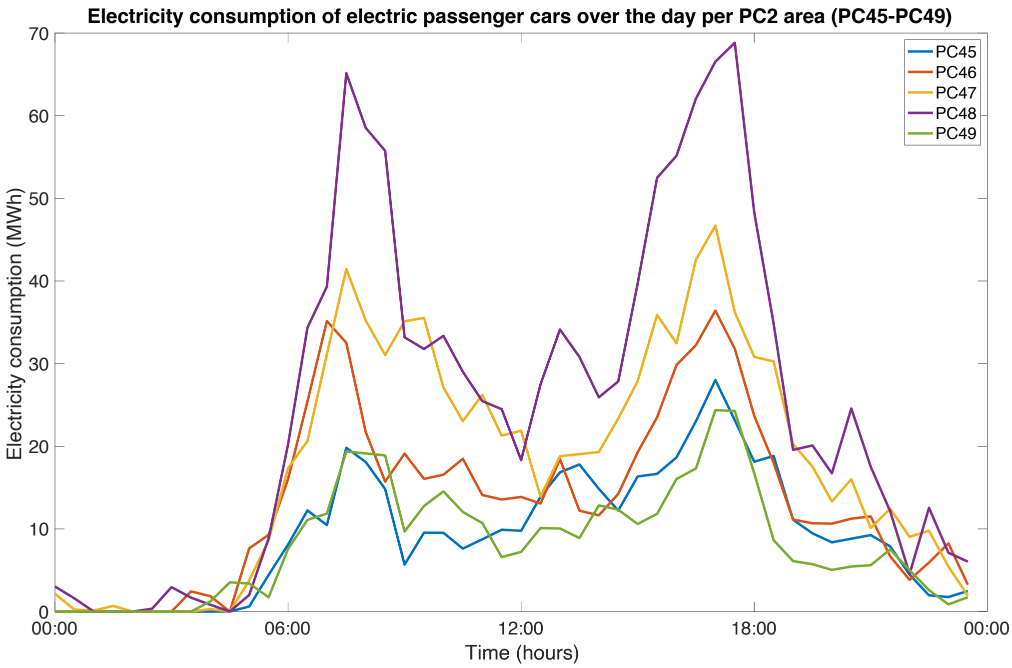

Electricity consumption of electric passenger cars over the day per PC2 area (PC20-PC24)
PC20
PC21
PC22
PC23
PC24
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60

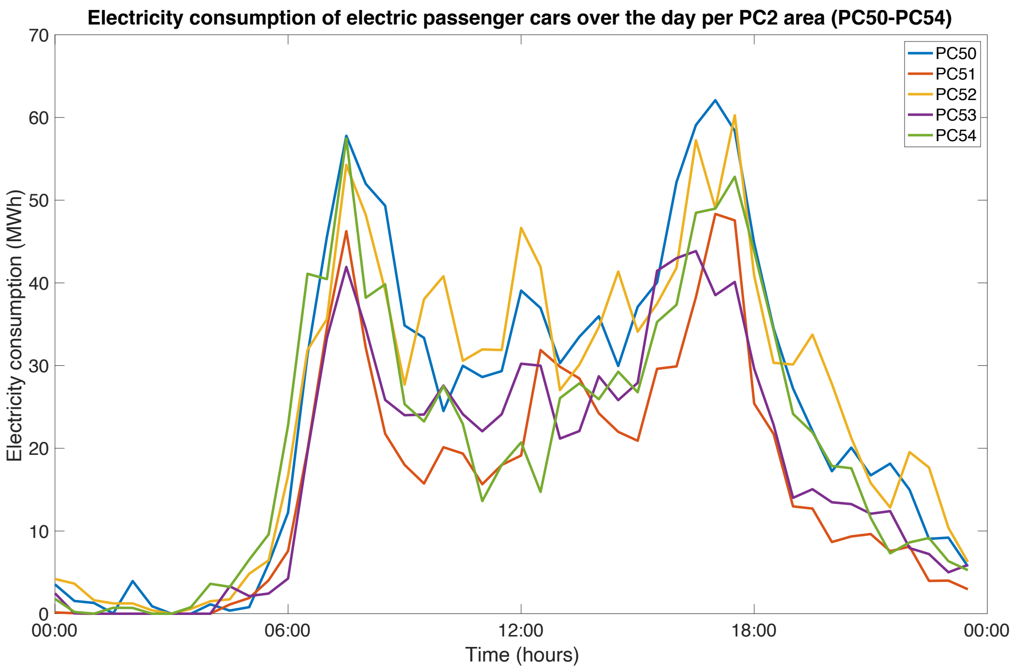

Electricity consumption of electric passenger cars over the day per PC2 area (PC25-PC29)
PC25
PC26
PC27
PC28
PC29
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70
80

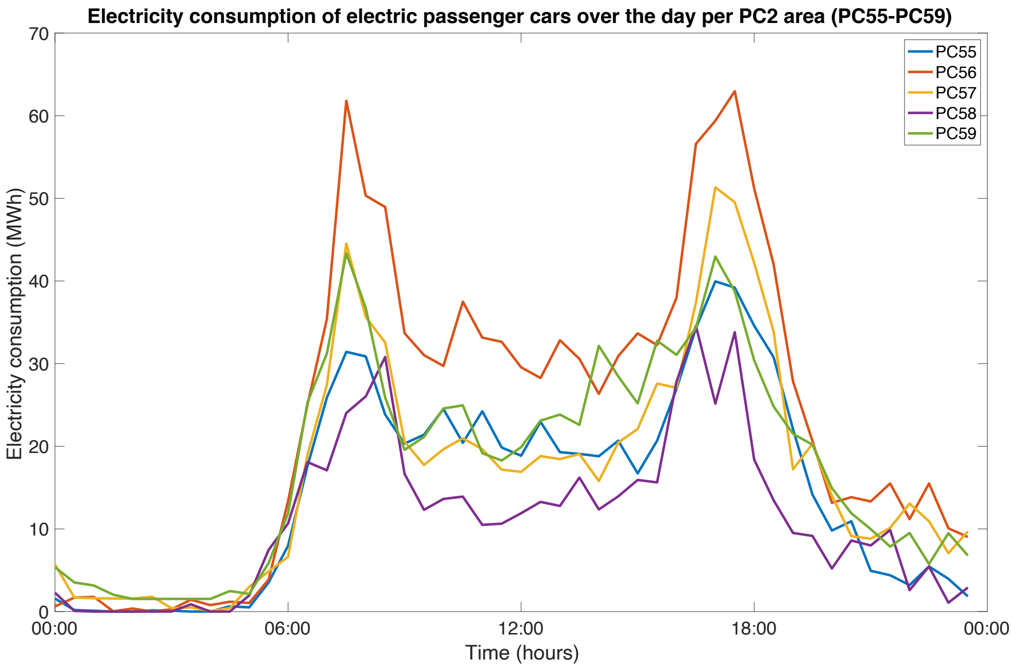

Electricity consumption of electric passenger cars over the day per PC2 area (PC30-PC34)
PC30
PC31
PC32
PC33
PC34
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70
80
90

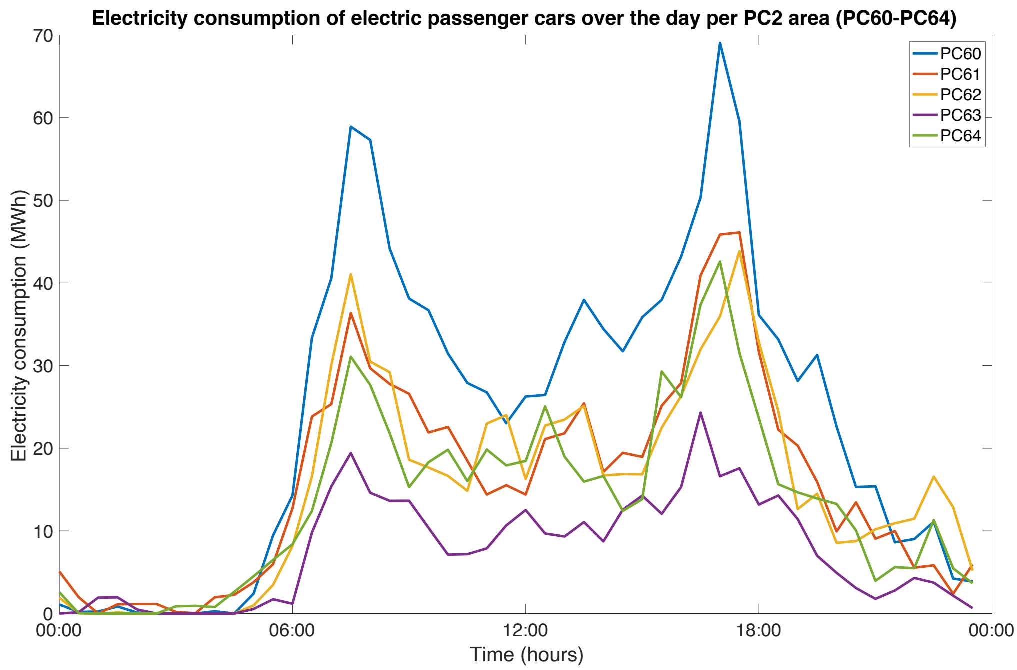

Electricity consumption of electric passenger cars over the day per PC2 area (PC35-PC39)
PC35
PC36
PC37
PC38
PC39
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70
80
90
100

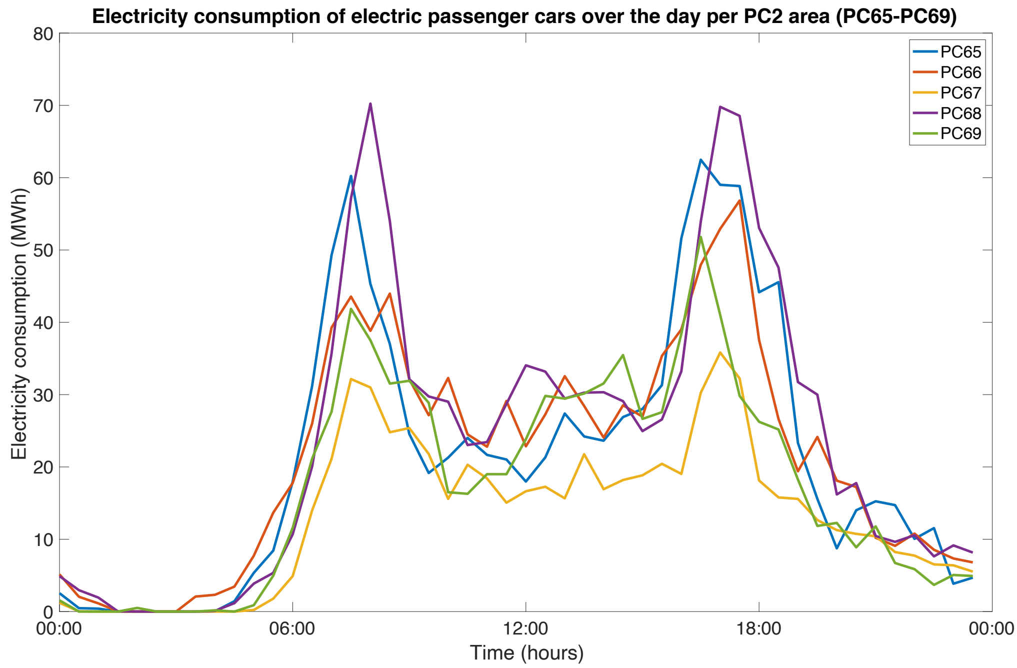

Electricity consumption of electric passenger cars over the day per PC2 area (PC40-PC44)
PC40
PC41
PC42
PC43
PC44
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
5
10
15
20
25
30
35
40
45

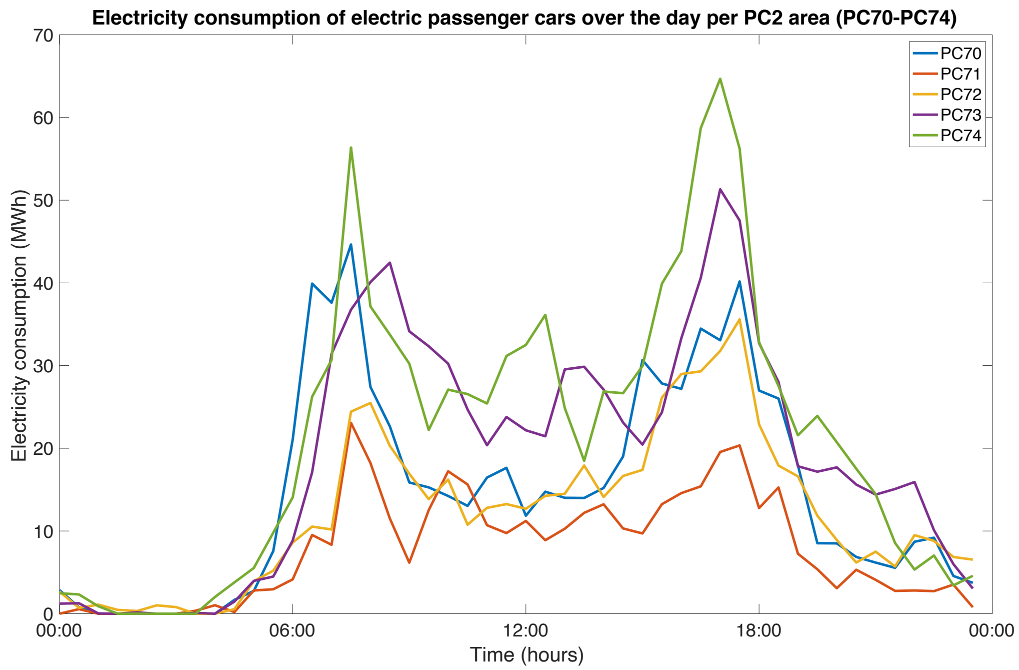

Electricity consumption of electric passenger cars over the day per PC2 area (PC45-PC49)
PC45
PC46
PC47
PC48
PC49
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70

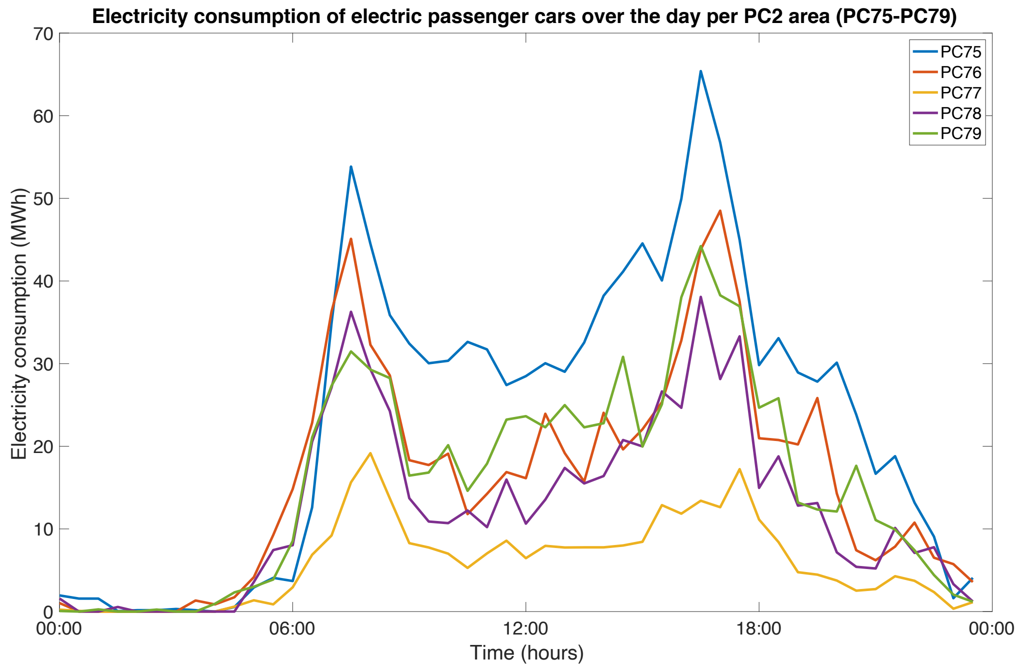

Electricity consumption of electric passenger cars over the day per PC2 area (PC50-PC54)
Electricity consumption (MWh)
Time (hours)
PC50
PC51
PC52
PC53
PC54
0
10
20
30
40
50
60
70
00:00
06:00
12:00
18:00
00:00

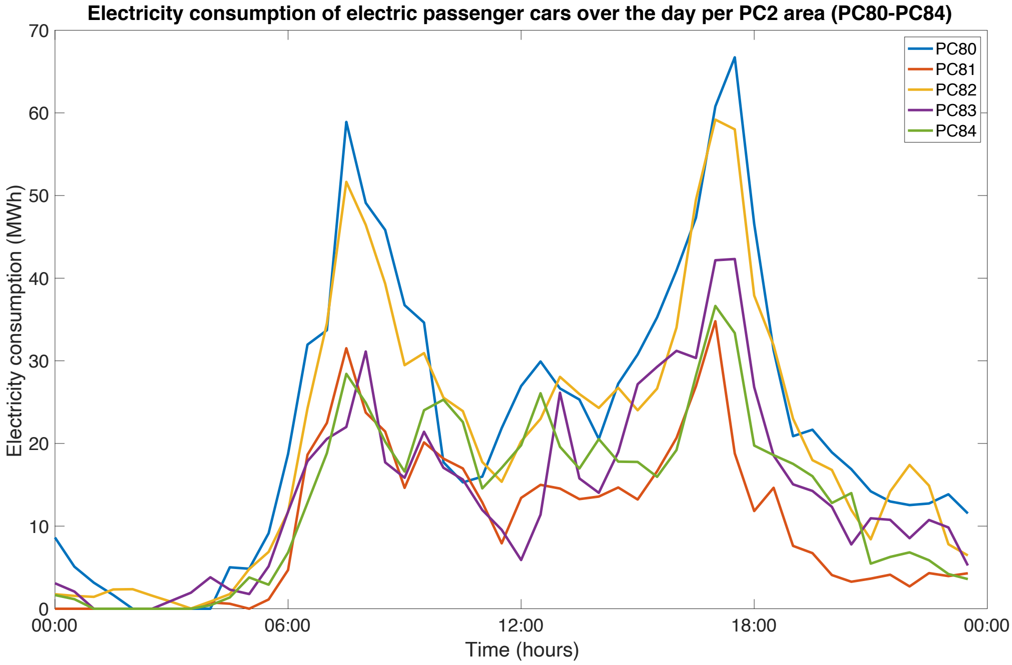

Electricity consumption of electric passenger cars over the day per PC2 area (PC55-PC59)
Electricity consumption (MWh)
Time (hours)
PC55
PC56
PC57
PC58
PC59
0
10
20
30
40
50
60
70
00:00
06:00
12:00
18:00
00:00

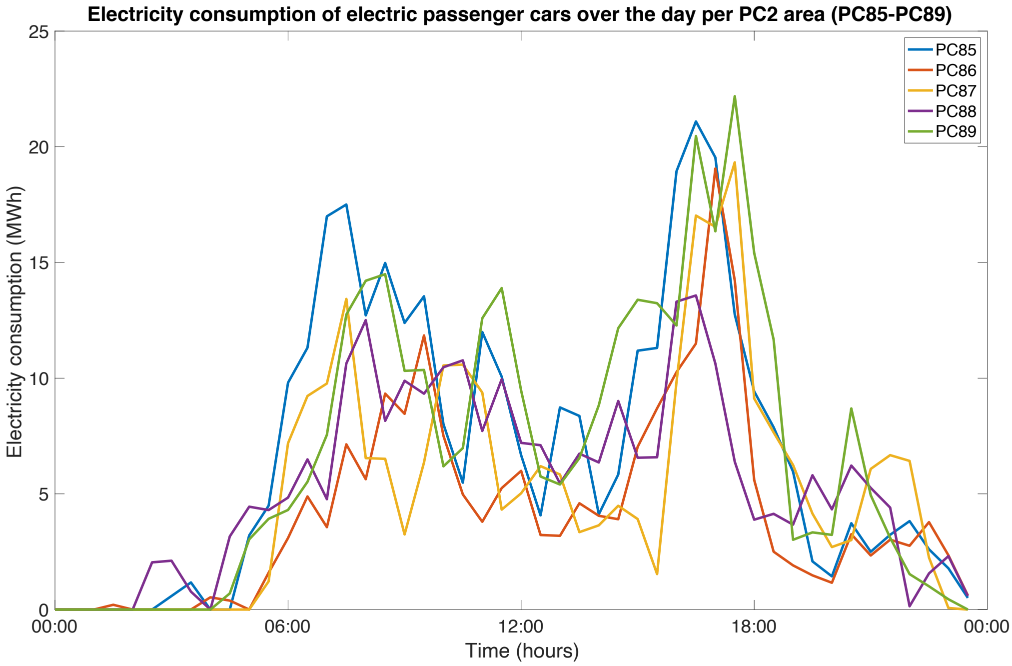

Electricity consumption of electric passenger cars over the day per PC2 area (PC60-PC64)
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70
PC60
PC61
PC62
PC63
PC64

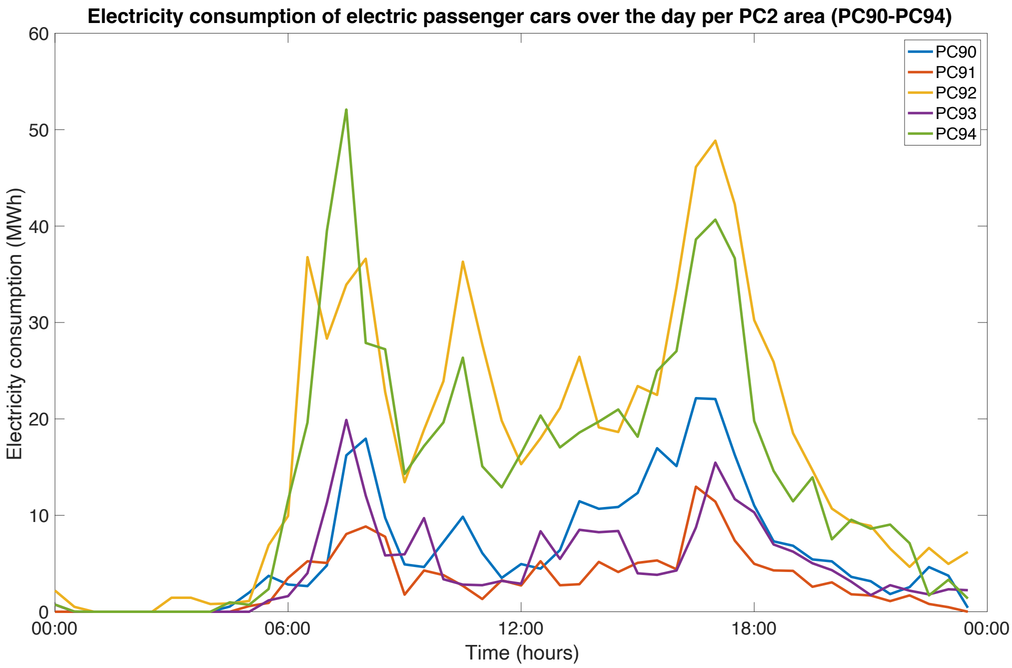

Electricity consumption of electric passenger cars over the day per PC2 area (PC65-PC69)
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70
80
PC65
PC66
PC67
PC68
PC69

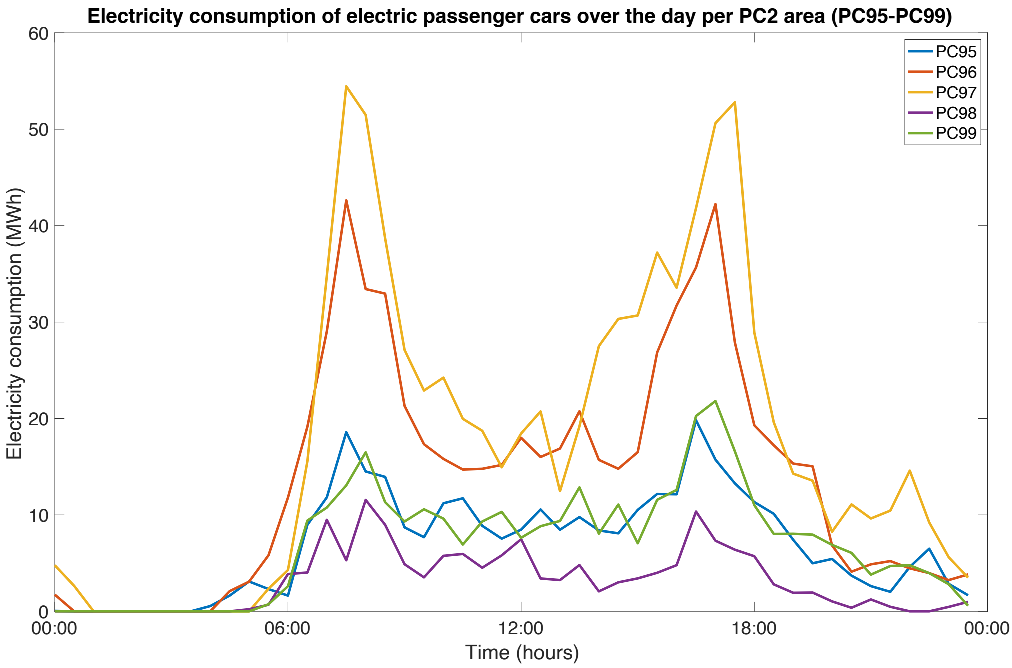

Electricity consumption of electric passenger cars over the day per PC2 area (PC70-PC74)
Electricity consumption (MWh)
Time (hours)
PC70
PC71
PC72
PC73
PC74
0
10
20
30
40
50
60
70
00:00
06:00
12:00
18:00
00:00


Electricity consumption of electric passenger cars over the day per PC2 area (PC75-PC79)
Electricity consumption (MWh)
Time (hours)
PC75
PC76
PC77
PC78
PC79
0
10
20
30
40
50
60
70
00:00
06:00
12:00
18:00
00:00


Electricity consumption of electric passenger cars over the day per PC2 area (PC80-PC84)
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
10
20
30
40
50
60
70
PC80
PC81
PC82
PC83
PC84


Electricity consumption of electric passenger cars over the day per PC2 area (PC85-PC89)
Electricity consumption (MWh)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
5
10
15
20
25
PC85
PC86
PC87
PC88
PC89


Electricity consumption of electric passenger cars over the day per PC2 area (PC90-PC94)
Electricity consumption (MWh)
Time (hours)
PC90
PC91
PC92
PC93
PC94
0
10
20
30
40
50
60
00:00
06:00
12:00
18:00
00:00


Electricity consumption of electric passenger cars over the day per PC2 area (PC95-PC99)
Electricity consumption (MWh)
Time (hours)
PC95
PC96
PC97
PC98
PC99
0
10
20
30
40
50
60
00:00
06:00
12:00
18:00
00:00

Appendix F – Number of cars with the possibility to charge the electric car

Time intervals	Average workday (MW)	Time intervals	Average workday (MW)
00:00 – 00:30	4287	12:00 – 12:30	2445
00:30 – 01:00	4288	12:30 – 13:00	2440
01:00 – 01:30	4287	13:00 – 13:30	2472
01:30 – 02:00	4285	13:30 – 14:00	2470
02:00 – 02:30	4284	14:00 – 14:30	2500
02:30 – 03:00	4285	14:30 – 15:00	2513
03:00 – 03:30	4285	15:00 – 15:30	2561
03:30 – 04:00	4281	15:30 – 16:00	2554
04:00 – 04:30	4280	16:00 – 16:30	2570
04:30 – 05:00	4273	16:30 – 17:00	2519
05:00 – 05:30	4262	17:00 – 17:30	2561
05:30 – 06:00	4227	17:30 – 18:00	2502
06:00 – 06:30	4155	18:00 – 18:30	2636
06:30 – 07:00	4004	18:30 – 19:00	2762
07:00 – 07:30	3833	19:00 – 19:30	2943
07:30 – 08:00	3560	19:30 – 20:00	3104
08:00 – 08:30	3306	20:00 – 20:30	3252
08:30 – 09:00	3012	20:30 – 21:00	3383
09:00 – 09:30	2906	21:00 – 21:30	3568
09:30 – 10:00	2772	21:30 – 22:00	3702
10:00 – 10:30	2676	22:00 – 22:30	3886
10:30 – 11:00	2534	22:30 – 23:00	4007
11:00 – 11:30	2496	23:00 – 23:30	4123
11:30 – 12:00	2445	23:30 – 24:00	4206

Table 22: Number of cars with the possibility to charge the electric car

Appendix G – Results electricity demand on the electricity grid

Electricity demand on the grid for the Netherlands as a whole

Time intervals	Electricity demand maximum charging speed (MW)	Electricity demand minimum charging speed (MW)
00:00 – 00:30	2,604	4,287
00:30 – 01:00	2,602	4,288
01:00 – 01:30	1,540	4,287
01:30 – 02:00	1,539	4,285
02:00 – 02:30	905	4,284
02:30 – 03:00	911	4,285
03:00 – 03:30	557	4,285
03:30 – 04:00	561	4,281
04:00 – 04:30	379	4,280
04:30 – 05:00	404	4,273
05:00 – 05:30	307	4,262
05:30 – 06:00	435	4,227
06:00 – 06:30	537	4,155
06:30 – 07:00	884	4,004
07:00 – 07:30	1,677	3,833
07:30 – 08:00	2,726	3,560
08:00 – 08:30	3,982	3,306
08:30 – 09:00	4,511	3,012
09:00 – 09:30	4,290	2,906
09:30 – 10:00	3,567	2,772
10:00 – 10:30	2,769	2,676
10:30 – 11:00	2,214	2,534
11:00 – 11:30	1,775	2,496
11:30 – 12:00	1,643	2,445
12:00 – 12:30	1,501	2,445
12:30 – 13:00	1,581	2,440
13:00 – 13:30	1,580	2,472
13:30 – 14:00	1,696	2,470
14:00 – 14:30	1,707	2,500
14:30 – 15:00	2,008	2,513
15:00 – 15:30	2,194	2,561
15:30 – 16:00	2,654	2,554
16:00 – 16:30	2,968	2,570
16:30 – 17:00	3,964	2,519
17:00 – 17:30	4,964	2,561
17:30 – 18:00	6,677	2,502
18:00 – 18:30	7,757	2,636
18:30 – 19:00	7,780	2,762

19:00 – 19:30	7,218	2,943
19:30 – 20:00	6,569	3,104
20:00 – 20:30	5,922	3,252
20:30 – 21:00	5,574	3,383
21:00 – 21:30	5,263	3,568
21:30 – 22:00	5,140	3,702
22:00 – 22:30	4,855	3,886
22:30 – 23:00	4,742	4,007
23:00 – 23:30	4,449	4,123
23:30 – 24:00	4,088	4,206

Table 23: Electricity demand on the grid for the Netherlands as a whole

Electricity demand on the grid on the workdays for the Netherlands as a whole

Time intervals	Average workday (MW)	Monday (MW)	Tuesday (MW)	Wednesday (MW)	Thursday (MW)	Friday (MW)
00:00 – 00:30	2,604	1,896	2,203	2,832	2,989	3,128
00:30 – 01:00	2,602	1,892	2,203	2,831	2,996	3,121
01:00 – 01:30	1,540	1,009	1,376	1,699	1,712	1,923
01:30 – 02:00	1,539	1,005	1,372	1,699	1,711	1,929
02:00 – 02:30	905	579	849	945	999	1,163
02:30 – 03:00	911	579	859	954	1,004	1,172
03:00 – 03:30	557	293	468	654	588	790
03:30 – 04:00	561	296	459	665	596	800
04:00 – 04:30	379	190	333	486	361	534
04:30 – 05:00	404	216	362	523	384	542
05:00 – 05:30	307	152	294	378	289	425
05:30 – 06:00	435	284	428	499	452	516
06:00 – 06:30	537	429	530	568	594	566
06:30 – 07:00	884	795	955	916	938	819
07:00 – 07:30	1,677	1,711	1,887	1,724	1,753	1,311
07:30 – 08:00	2,726	2,811	3,156	2,813	2,714	2,132
08:00 – 08:30	3,982	4,225	4,539	4,062	3,933	3,140
08:30 – 09:00	4,511	4,815	5,076	4,593	4,374	3,688
09:00 – 09:30	4,290	4,578	4,921	4,388	4,029	3,520
09:30 – 10:00	3,567	3,765	4,062	3,693	3,364	2,942
10:00 – 10:30	2,769	2,976	3,215	2,846	2,539	2,262
10:30 – 11:00	2,214	2,325	2,465	2,173	2,162	1,941
11:00 – 11:30	1,775	1,854	1,932	1,717	1,837	1,528
11:30 – 12:00	1,643	1,583	1,768	1,716	1,693	1,457
12:00 – 12:30	1,501	1,427	1,603	1,561	1,574	1,341
12:30 – 13:00	1,581	1,484	1,537	1,576	1,707	1,605
13:00 – 13:30	1,580	1,544	1,488	1,605	1,734	1,531
13:30 – 14:00	1,696	1,640	1,624	1,717	1,876	1,626
14:00 – 14:30	1,707	1,650	1,663	1,794	1,852	1,580

14:30 – 15:00	2,008	1,948	1,931	2,208	2,084	1,876
15:00 – 15:30	2,194	2,129	2,127	2,282	2,229	2,207
15:30 – 16:00	2,654	2,414	2,628	2,660	2,729	2,847
16:00 – 16:30	2,968	2,708	2,988	3,031	3,039	3,086
16:30 – 17:00	3,964	3,891	4,220	4,098	3,770	3,843
17:00 – 17:30	4,964	4,795	5,551	4,905	4,791	4,777
17:30 – 18:00	6,677	6,472	7,292	6,801	6,514	6,310
18:00 – 18:30	7,757	7,521	8,434	7,910	7,784	7,140
18:30 – 19:00	7,780	7,634	8,490	7,909	7,890	6,979
19:00 – 19:30	7,218	7,075	7,895	7,226	7,508	6,386
19:30 – 20:00	6,569	6,393	7,145	6,506	6,963	5,841
20:00 – 20:30	5,922	5,593	6,224	5,992	6,388	5,422
20:30 – 21:00	5,574	5,109	5,664	5,637	6,246	5,229
21:00 – 21:30	5,263	4,661	5,378	5,387	6,048	4,864
21:30 – 22:00	5,140	4,432	5,308	5,336	5,942	4,710
22:00 – 22:30	4,855	4,153	4,923	5,184	5,544	4,503
22:30 – 23:00	4,742	4,058	4,651	5,246	5,419	4,370
23:00 – 23:30	4,449	3,583	4,239	4,992	5,185	4,287
23:30 – 24:00	4,088	3,146	3,856	4,616	4,788	4,078

Table 24: Electricity demand on the grid per workday when charging at maximum charging speed

Time intervals	**Average workday (MW)**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
00:00 – 00:30	4,287	3,754	4,346	4,496	4,600	4,262
00:30 – 01:00	4,288	3,754	4,346	4,496	4,600	4,262
01:00 – 01:30	4,287	3,754	4,346	4,496	4,599	4,260
01:30 – 02:00	4,285	3,754	4,339	4,495	4,598	4,260
02:00 – 02:30	4,284	3,751	4,339	4,495	4,599	4,258
02:30 – 03:00	4,285	3,751	4,343	4,495	4,598	4,261
03:00 – 03:30	4,285	3,751	4,343	4,494	4,598	4,260
03:30 – 04:00	4,281	3,749	4,340	4,484	4,594	4,261
04:00 – 04:30	4,280	3,744	4,338	4,480	4,598	4,260
04:30 – 05:00	4,273	3,744	4,332	4,480	4,590	4,242
05:00 – 05:30	4,262	3,740	4,327	4,466	4,573	4,227
05:30 – 06:00	4,227	3,716	4,268	4,439	4,540	4,193
06:00 – 06:30	4,155	3,654	4,205	4,331	4,478	4,125
06:30 – 07:00	4,004	3,525	4,054	4,140	4,297	4,023
07:00 – 07:30	3,833	3,409	3,854	3,962	4,129	3,827
07:30 – 08:00	3,560	3,181	3,603	3,702	3,780	3,553
08:00 – 08:30	3,306	2,986	3,380	3,441	3,463	3,275
08:30 – 09:00	3,012	2,763	3,105	3,155	3,063	2,985
09:00 – 09:30	2,906	2,763	3,012	3,033	2,915	2,813
09:30 – 10:00	2,772	2,687	2,933	2,835	2,769	2,639
10:00 – 10:30	2,676	2,614	2,859	2,768	2,644	2,499

10:30 – 11:00	2,534	2,525	2,691	2,603	2,516	2,338
11:00 – 11:30	2,496	2,507	2,650	2,588	2,462	2,273
11:30 – 12:00	2,445	2,490	2,610	2,518	2,387	2,220
12:00 – 12:30	2,445	2,476	2,615	2,494	2,430	2,210
12:30 – 13:00	2,440	2,468	2,619	2,509	2,417	2,187
13:00 – 13:30	2,472	2,498	2,657	2,535	2,483	2,188
13:30 – 14:00	2,470	2,518	2,654	2,551	2,465	2,163
14:00 – 14:30	2,500	2,561	2,698	2,562	2,521	2,157
14:30 – 15:00	2,513	2,541	2,693	2,601	2,566	2,164
15:00 – 15:30	2,561	2,563	2,769	2,645	2,631	2,198
15:30 – 16:00	2,554	2,574	2,774	2,600	2,634	2,188
16:00 – 16:30	2,570	2,597	2,747	2,612	2,655	2,239
16:30 – 17:00	2,519	2,529	2,664	2,556	2,592	2,254
17:00 – 17:30	2,561	2,551	2,676	2,575	2,703	2,301
17:30 – 18:00	2,502	2,438	2,645	2,502	2,615	2,310
18:00 – 18:30	2,636	2,485	2,817	2,635	2,816	2,431
18:30 – 19:00	2,762	2,611	2,927	2,792	2,921	2,562
19:00 – 19:30	2,943	2,821	3,099	2,983	3,120	2,699
19:30 – 20:00	3,104	2,960	3,261	3,148	3,308	2,847
20:00 – 20:30	3,252	3,085	3,390	3,318	3,471	3,004
20:30 – 21:00	3,383	3,191	3,494	3,471	3,611	3,154
21:00 – 21:30	3,568	3,332	3,689	3,697	3,821	3,313
21:30 – 22:00	3,702	3,417	3,834	3,860	3,952	3,460
22:00 – 22:30	3,886	3,590	4,048	4,038	4,110	3,654
22:30 – 23:00	4,007	3,650	4,142	4,196	4,257	3,804
23:00 – 23:30	4,123	3,704	4,224	4,364	4,387	3,953
23:30 – 24:00	4,206	3,738	4,298	4,442	4,470	4,101

Table 25: Electricity demand on the grid per workday when charging at minimum charging speed

Electricity demand on the grid per season for the Netherlands as a whole

Time intervals	**Average workday (MW)**	**Spring (MW)**	**Summer (MW)**	**Autumn (MW)**	**Winter (MW)**
00:00 – 00:30	2,604	2,426	2,484	2,726	2,777
00:30 – 01:00	2,602	2,417	2,474	2,731	2,786
01:00 – 01:30	1,540	1,356	1,512	1,647	1,639
01:30 – 02:00	1,539	1,361	1,509	1,644	1,637
02:00 – 02:30	905	837	912	942	925
02:30 – 03:00	911	839	927	947	928
03:00 – 03:30	557	495	548	580	603
03:30 – 04:00	561	495	548	593	607
04:00 – 04:30	379	325	388	399	403
04:30 – 05:00	404	349	423	412	428
05:00 – 05:30	307	293	347	280	307

05:30 – 06:00	435	443	476	410	408
06:00 – 06:30	537	525	614	498	509
06:30 – 07:00	884	866	932	902	833
07:00 – 07:30	1,677	1,716	1,698	1,706	1,587
07:30 – 08:00	2,726	2,849	2,623	2,845	2,585
08:00 – 08:30	3,982	3,971	3,905	4,047	4,005
08:30 – 09:00	4,511	4,391	4,593	4,549	4,506
09:00 – 09:30	4,290	4,170	4,386	4,400	4,192
09:30 – 10:00	3,567	3,453	3,589	3,622	3,597
10:00 – 10:30	2,769	2,653	2,800	2,826	2,793
10:30 – 11:00	2,214	2,207	2,193	2,172	2,288
11:00 – 11:30	1,775	1,732	1,761	1,704	1,905
11:30 – 12:00	1,643	1,643	1,582	1,583	1,769
12:00 – 12:30	1,501	1,558	1,423	1,381	1,652
12:30 – 13:00	1,581	1,577	1,574	1,467	1,712
13:00 – 13:30	1,580	1,578	1,594	1,486	1,666
13:30 – 14:00	1,696	1,682	1,682	1,653	1,770
14:00 – 14:30	1,707	1,771	1,718	1,614	1,729
14:30 – 15:00	2,008	2,066	2,006	1,952	2,012
15:00 – 15:30	2,194	2,266	2,207	2,113	2,191
15:30 – 16:00	2,654	2,682	2,625	2,543	2,774
16:00 – 16:30	2,968	3,099	2,898	2,787	3,103
16:30 – 17:00	3,964	4,137	3,912	3,814	4,003
17:00 – 17:30	4,964	5,024	4,880	4,934	5,025
17:30 – 18:00	6,677	6,438	6,598	6,879	6,785
18:00 – 18:30	7,757	7,563	7,655	7,940	7,863
18:30 – 19:00	7,780	7,753	7,679	7,952	7,732
19:00 – 19:30	7,218	7,123	7,063	7,469	7,210
19:30 – 20:00	6,569	6,561	6,291	6,946	6,471
20:00 – 20:30	5,922	5,977	5,660	6,232	5,812
20:30 – 21:00	5,574	5,756	5,318	5,820	5,399
21:00 – 21:30	5,263	5,375	5,091	5,559	5,018
21:30 – 22:00	5,140	5,141	5,081	5,413	4,912
22:00 – 22:30	4,855	4,829	4,838	5,068	4,679
22:30 – 23:00	4,742	4,691	4,566	4,943	4,763
23:00 – 23:30	4,449	4,361	4,197	4,639	4,597
23:30 – 24:00	4,088	4,020	3,833	4,257	4,243

Table 26: Electricity demand on the grid per season when charging at maximum charging speed

Time intervals	Average workday (MW)	Spring (MW)	Summer (MW)	Autumn (MW)	Winter (MW)
00:00 – 00:30	4,287	4,215	4,196	4,427	4,308
00:30 – 01:00	4,288	4,215	4,196	4,427	4,308
01:00 – 01:30	4,287	4,215	4,196	4,425	4,308
01:30 – 02:00	4,285	4,215	4,195	4,425	4,302
02:00 – 02:30	4,284	4,215	4,195	4,423	4,301
02:30 – 03:00	4,285	4,215	4,198	4,422	4,303
03:00 – 03:30	4,285	4,215	4,197	4,422	4,303
03:30 – 04:00	4,281	4,215	4,192	4,417	4,298
04:00 – 04:30	4,280	4,212	4,185	4,417	4,302
04:30 – 05:00	4,273	4,207	4,171	4,413	4,299
05:00 – 05:30	4,262	4,195	4,161	4,406	4,284
05:30 – 06:00	4,227	4,158	4,122	4,369	4,256
06:00 – 06:30	4,155	4,061	4,086	4,298	4,169
06:30 – 07:00	4,004	3,885	3,957	4,132	4,037
07:00 – 07:30	3,833	3,739	3,797	3,948	3,843
07:30 – 08:00	3,560	3,498	3,546	3,661	3,532
08:00 – 08:30	3,306	3,230	3,297	3,331	3,367
08:30 – 09:00	3,012	2,953	3,057	3,012	3,024
09:00 – 09:30	2,906	2,883	2,927	2,887	2,926
09:30 – 10:00	2,772	2,750	2,745	2,751	2,845
10:00 – 10:30	2,676	2,644	2,632	2,681	2,749
10:30 – 11:00	2,534	2,513	2,478	2,516	2,633
11:00 – 11:30	2,496	2,486	2,447	2,468	2,587
11:30 – 12:00	2,445	2,442	2,394	2,409	2,540
12:00 – 12:30	2,445	2,441	2,384	2,408	2,552
12:30 – 13:00	2,440	2,459	2,362	2,414	2,531
13:00 – 13:30	2,472	2,459	2,401	2,476	2,556
13:30 – 14:00	2,470	2,450	2,387	2,493	2,555
14:00 – 14:30	2,500	2,500	2,423	2,521	2,559
14:30 – 15:00	2,513	2,531	2,391	2,550	2,582
15:00 – 15:30	2,561	2,573	2,435	2,607	2,631
15:30 – 16:00	2,554	2,544	2,424	2,593	2,659
16:00 – 16:30	2,570	2,570	2,428	2,595	2,693
16:30 – 17:00	2,519	2,526	2,398	2,552	2,604
17:00 – 17:30	2,561	2,552	2,478	2,585	2,632
17:30 – 18:00	2,502	2,501	2,443	2,514	2,551
18:00 – 18:30	2,636	2,604	2,586	2,656	2,698
18:30 – 19:00	2,762	2,762	2,717	2,784	2,784
19:00 – 19:30	2,943	2,977	2,861	2,971	2,967
19:30 – 20:00	3,104	3,130	2,995	3,184	3,108
20:00 – 20:30	3,252	3,311	3,127	3,323	3,250
20:30 – 21:00	3,383	3,441	3,251	3,472	3,368
21:00 – 21:30	3,568	3,607	3,428	3,684	3,554

21:30 – 22:00	3,702	3,709	3,612	3,805	3,681
22:00 – 22:30	3,886	3,902	3,770	3,995	3,875
22:30 – 23:00	4,007	4,001	3,875	4,131	4,019
23:00 – 23:30	4,123	4,078	4,013	4,268	4,129
23:30 – 24:00	4,206	4,157	4,080	4,355	4,229

Table 27: Electricity demand on the grid per season when charging at minimum charging speed

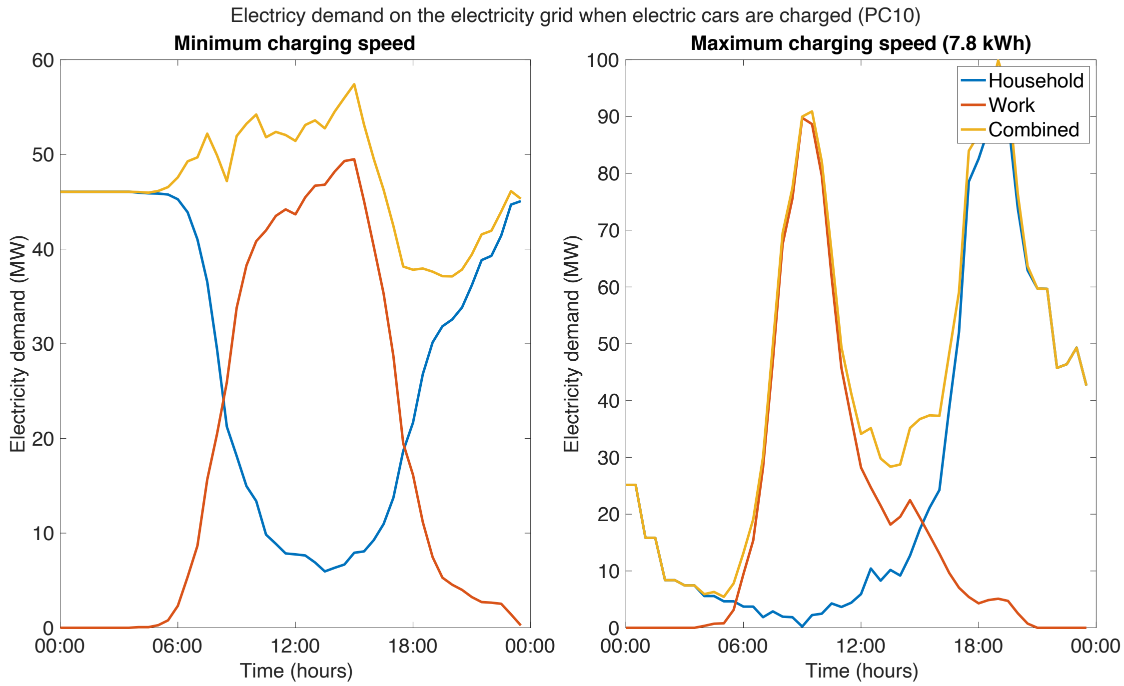
Electricity demand on the grid for a regular workday per PC2 area

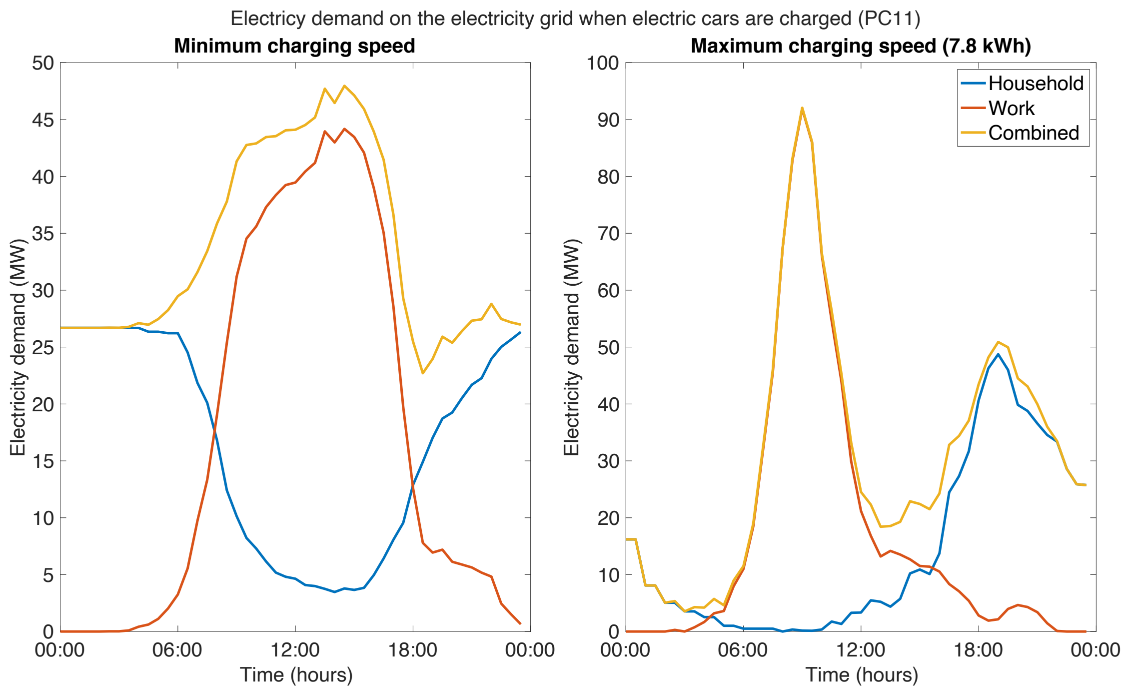
PC2 area	Peak electricity demand (MW)	PC2 area	Peak electricity demand (MW)	PC2 area	Peak electricity demand (MW)
10	100	**40**	22	**70**	38
11	92	**41**	34	**71**	17
12	43	**42**	41	**72**	33
13	73	**43**	32	**73**	53
14	60	**44**	20	**74**	56
15	41	**45**	19	**75**	54
16	42	**46**	43	**76**	49
17	60	**47**	38	**77**	17
18	39	**48**	66	**78**	34
19	46	**49**	29	**79**	44
20	43	**50**	66	**80**	57
21	59	**51**	49	**81**	30
22	63	**52**	77	**82**	50
23	36	**53**	58	**83**	33
24	46	**54**	49	**84**	36
25	67	**55**	39	**85**	20
26	58	**56**	81	**86**	14
27	39	**57**	44	**87**	12
28	28	**58**	37	**88**	15
29	57	**59**	42	**89**	24
30	90	**60**	70	**90**	22
31	53	**61**	38	**91**	13
32	78	**62**	42	**92**	45
33	67	**63**	19	**93**	13
34	65	**64**	27	**94**	52
35	67	**65**	61	**95**	22
36	27	**66**	66	**96**	38
37	67	**67**	32	**97**	49
38	112	**68**	61	**98**	14
39	67	**69**	41	**99**	24

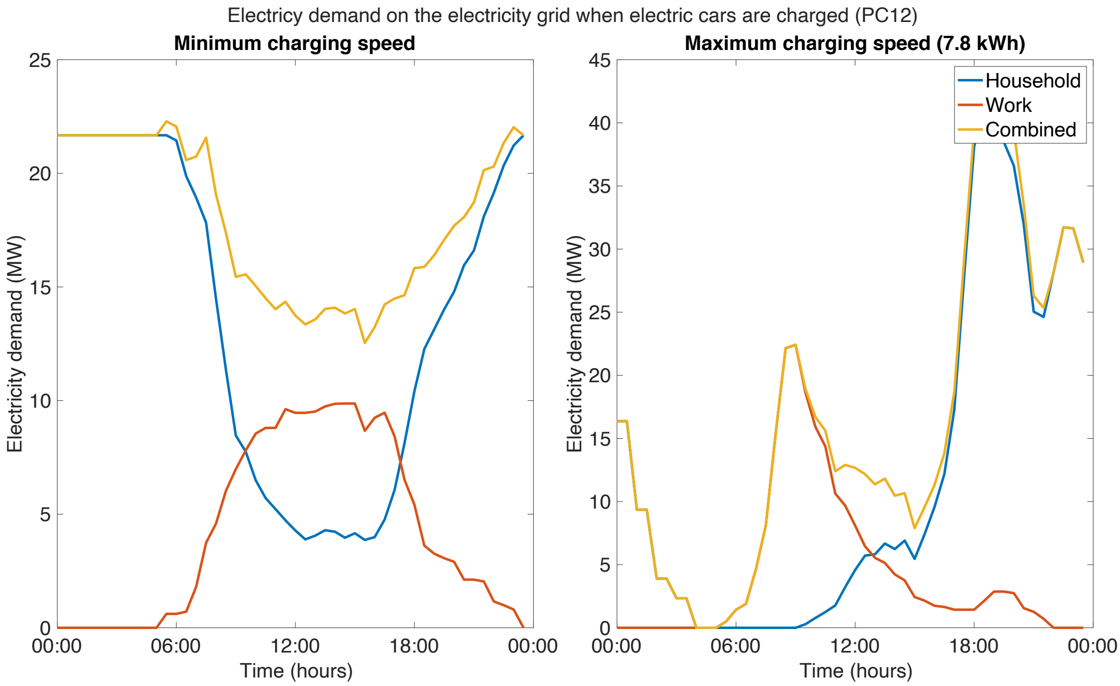
Table 28: Peak demand per PC2 area when charging with maximum charging speed

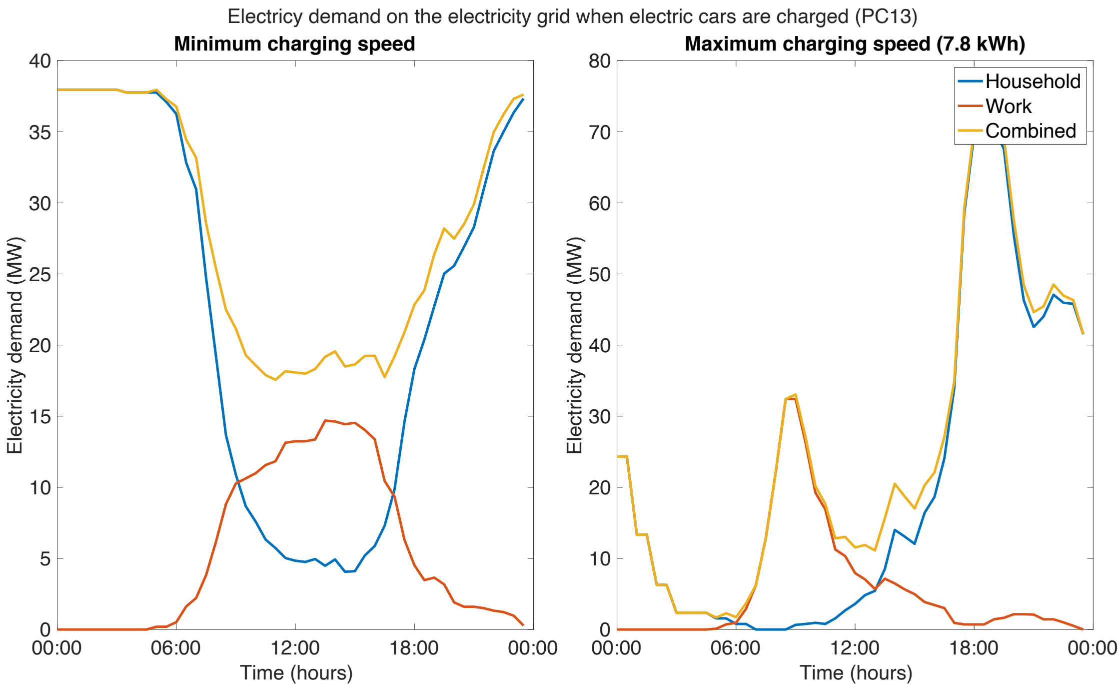
PC2 area	**Peak electricity demand (MW)**	**PC2 area**	**Peak electricity demand (MW)**	**PC2 area**	**Peak electricity demand (MW)**
10	57	**40**	13	**70**	23
11	48	**41**	20	**71**	11
12	22	**42**	18	**72**	18
13	38	**43**	22	**73**	26
14	29	**44**	13	**74**	32
15	18	**45**	12	**75**	30
16	26	**46**	21	**76**	24
17	35	**47**	27	**77**	10
18	20	**48**	37	**78**	19
19	24	**49**	13	**79**	22
20	21	**50**	36	**80**	33
21	27	**51**	25	**81**	16
22	34	**52**	39	**82**	31
23	18	**53**	27	**83**	20
24	22	**54**	32	**84**	20
25	33	**55**	23	**85**	9
26	32	**56**	39	**86**	7
27	23	**57**	26	**87**	9
28	15	**58**	16	**88**	8
29	32	**59**	23	**89**	13
30	49	**60**	35	**90**	10
31	30	**61**	26	**91**	5
32	46	**62**	20	**92**	23
33	38	**63**	11	**93**	7
34	34	**64**	18	**94**	23
35	41	**65**	33	**95**	13
36	17	**66**	34	**96**	18
37	35	**67**	16	**97**	25
38	53	**68**	35	**98**	4
39	33	**69**	24	**99**	10

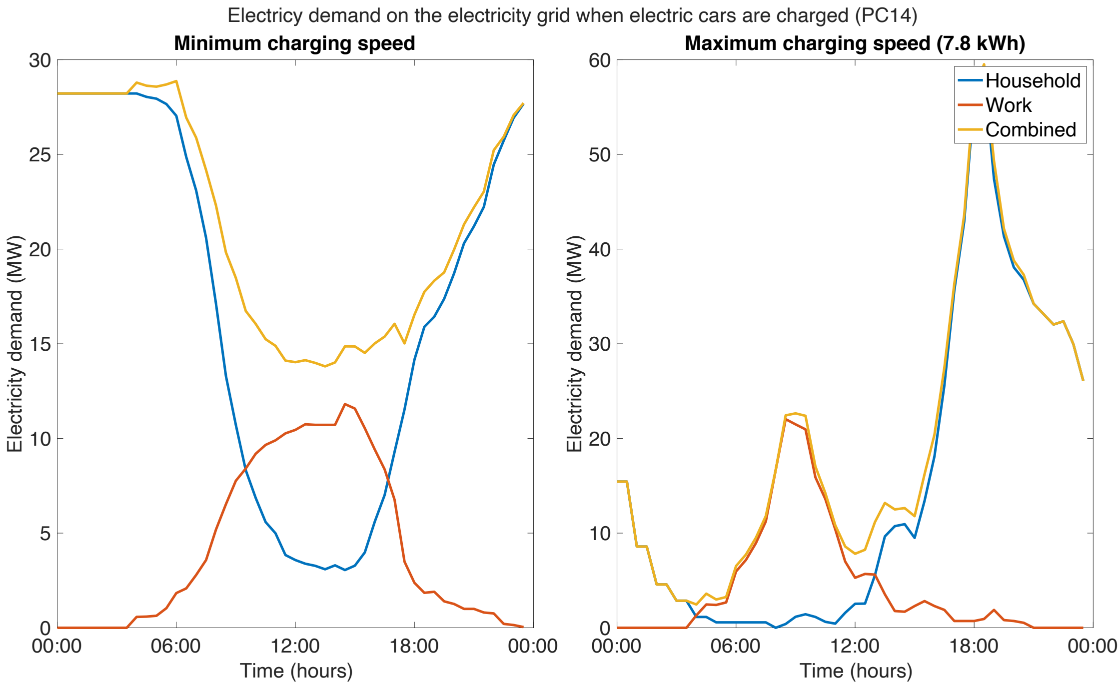
Table 29: Peak demand per PC2 area when charging with minimum charging speed

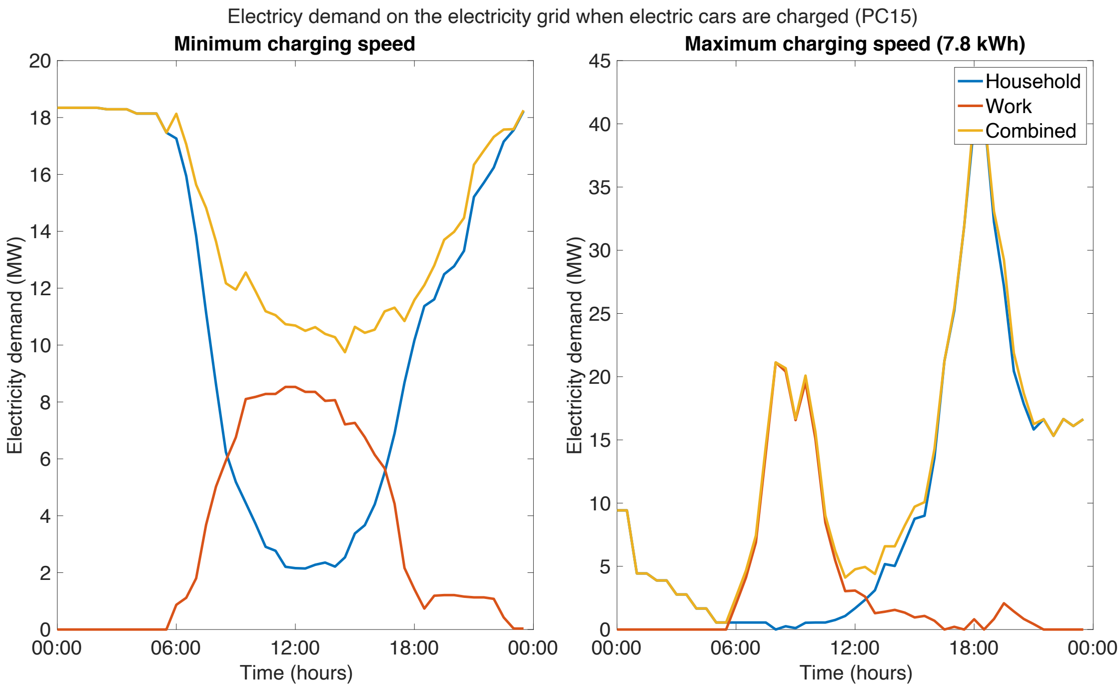

Electricy demand on the electricity grid when electric cars are charged (PC10)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

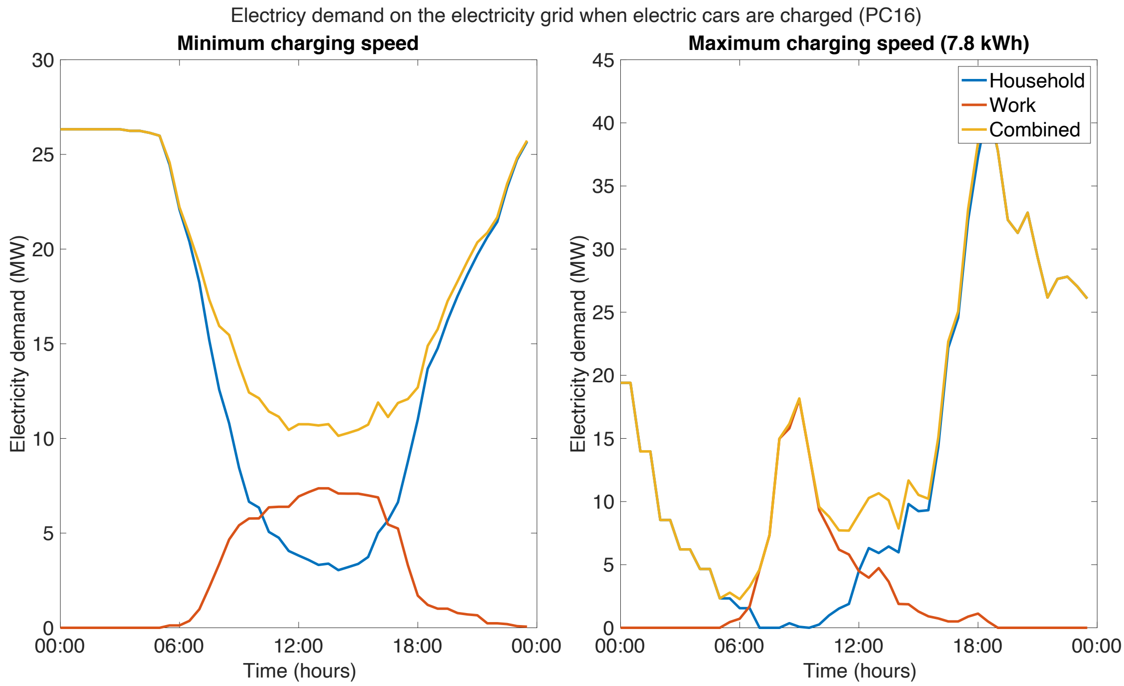

Electricy demand on the electricity grid when electric cars are charged (PC11)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC12)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

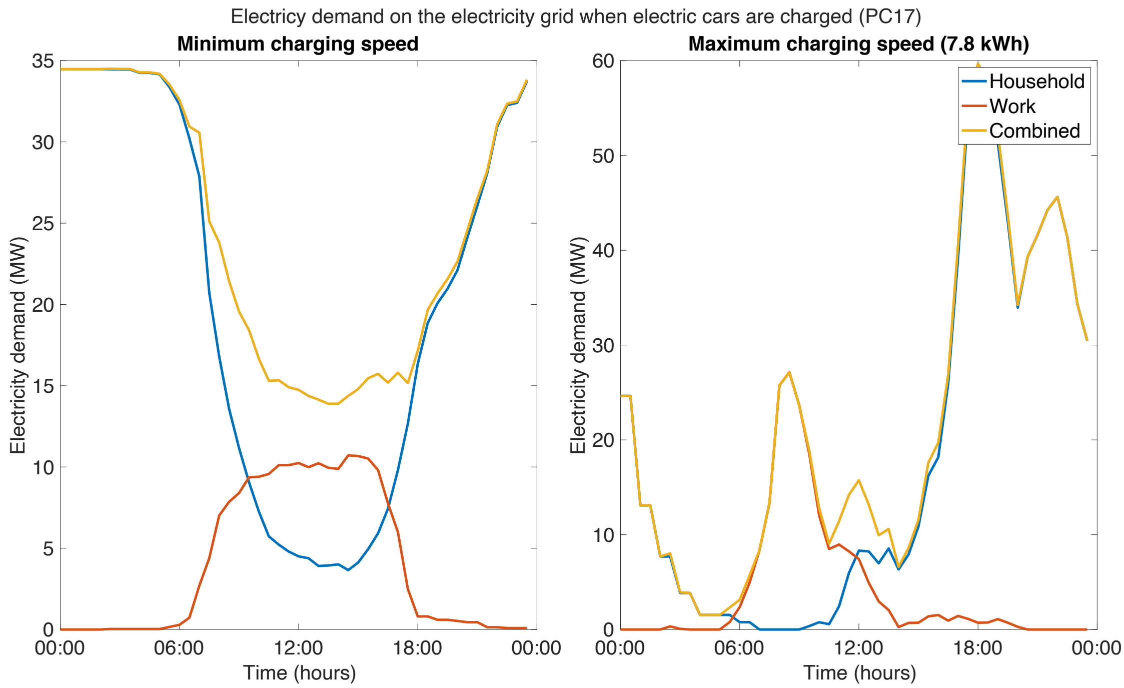

Electricy demand on the electricity grid when electric cars are charged (PC13)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00


Electricy demand on the electricity grid when electric cars are charged (PC14)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
5
10
15
20
25
30
0
10
20
30
40
50
60
Household
Work
Combined

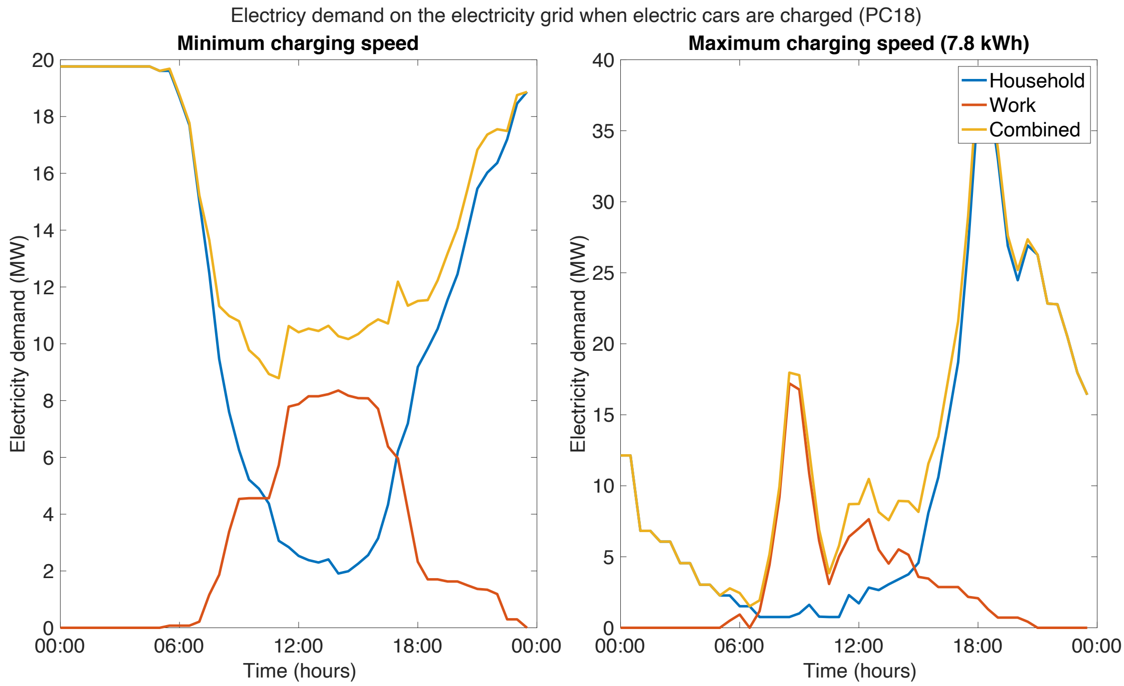

Electricy demand on the electricity grid when electric cars are charged (PC15)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
35
40
45
Household
Work
Combined

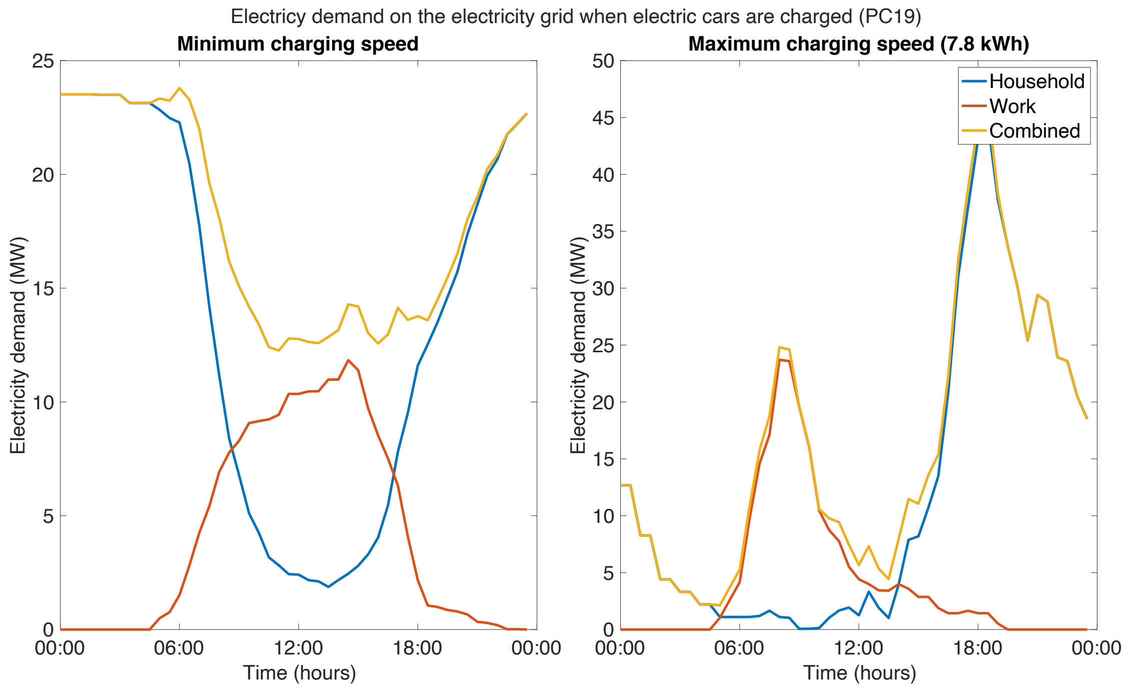


Electricy demand on the electricity grid when electric cars are charged (PC16)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

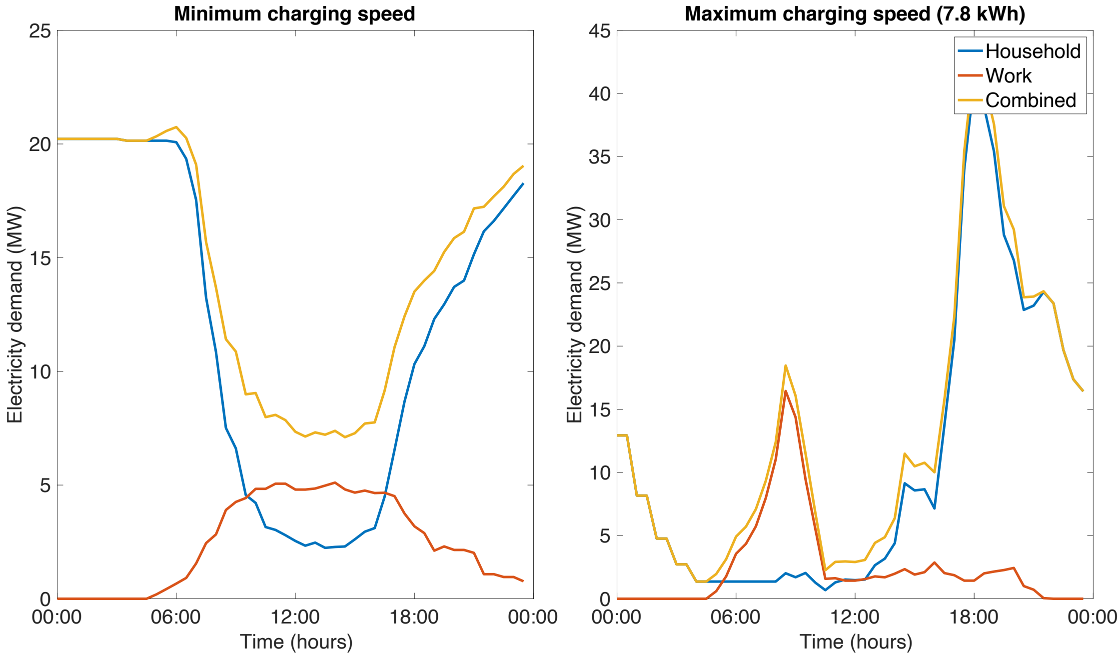


Electricy demand on the electricity grid when electric cars are charged (PC17)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

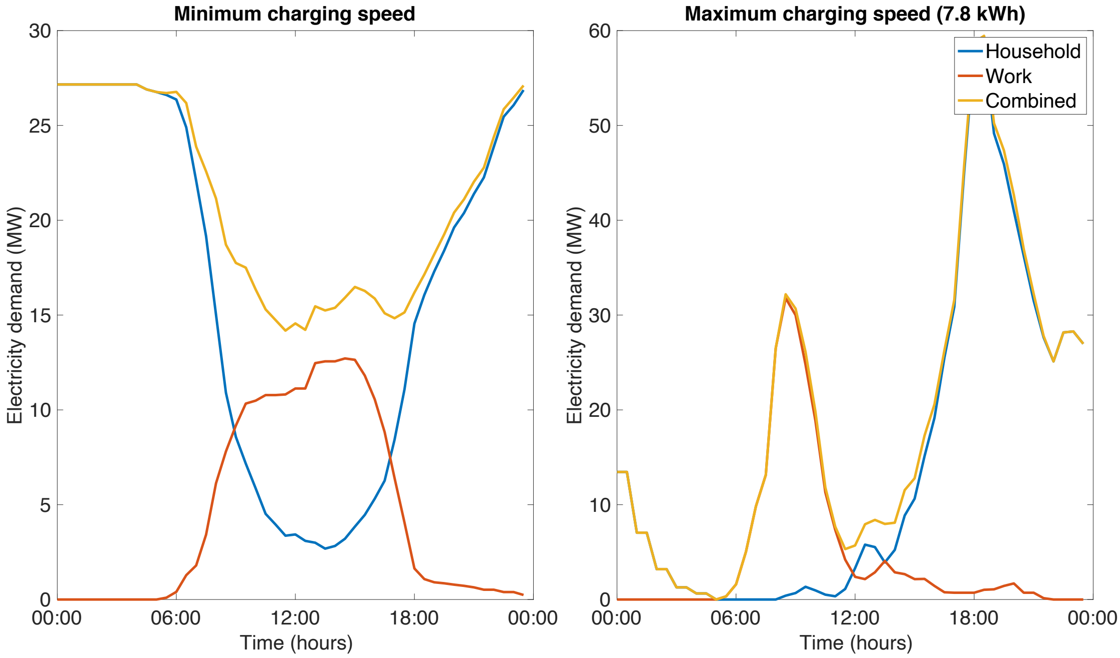

Electricy demand on the electricity grid when electric cars are charged (PC18)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC19)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

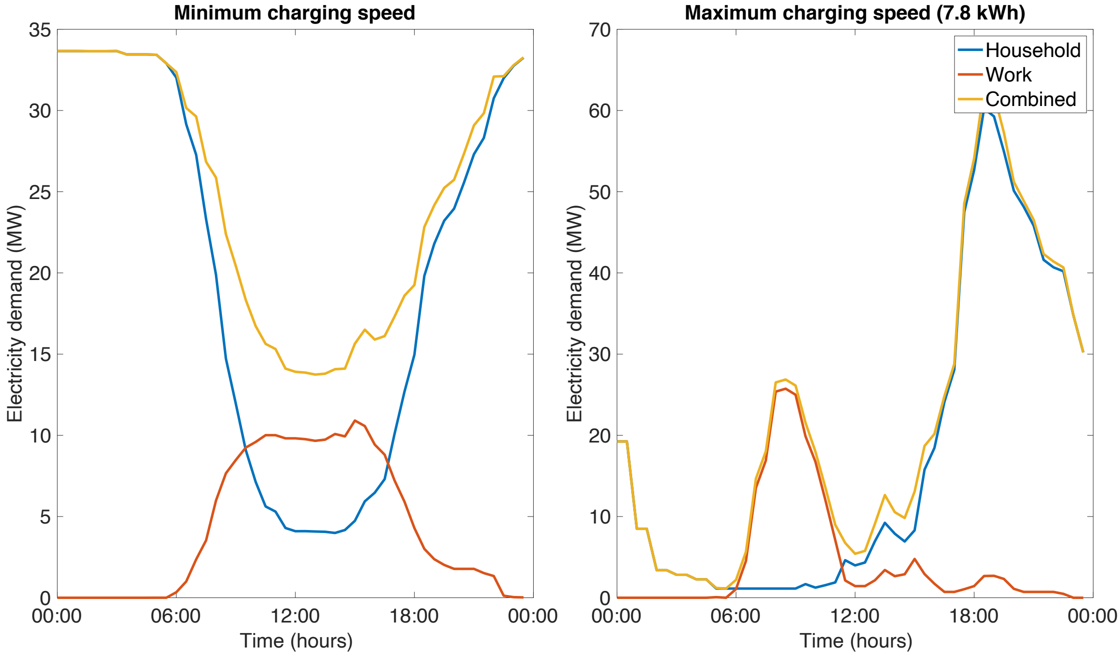
Electricy demand on the electricity grid when electric cars are charged (PC20)



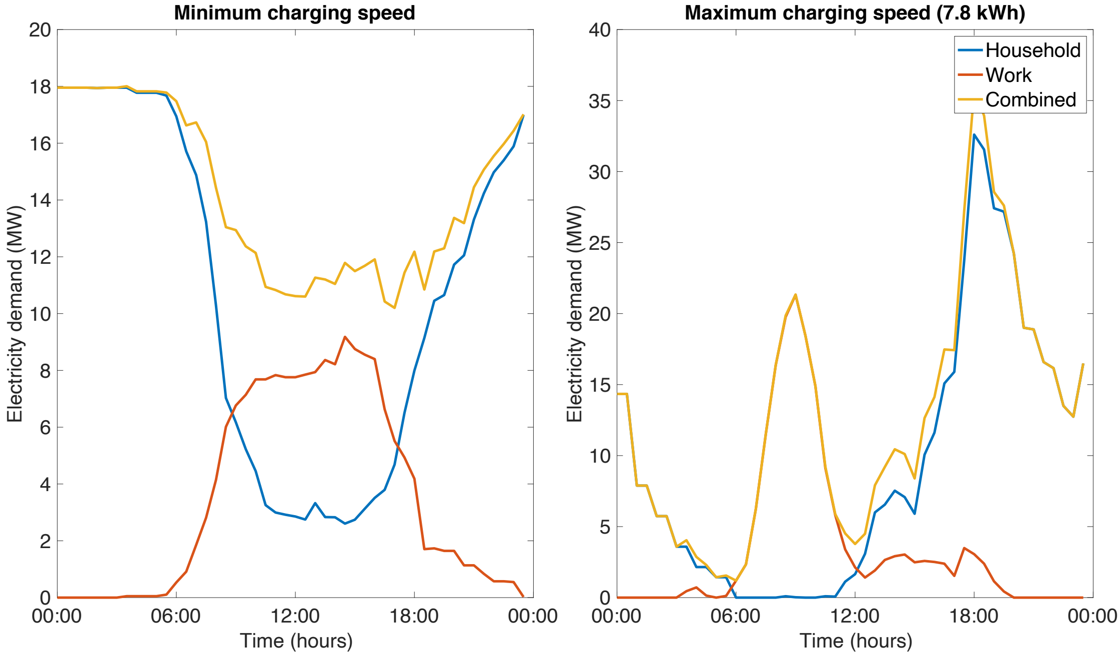
Electricy demand on the electricity grid when electric cars are charged (PC21)

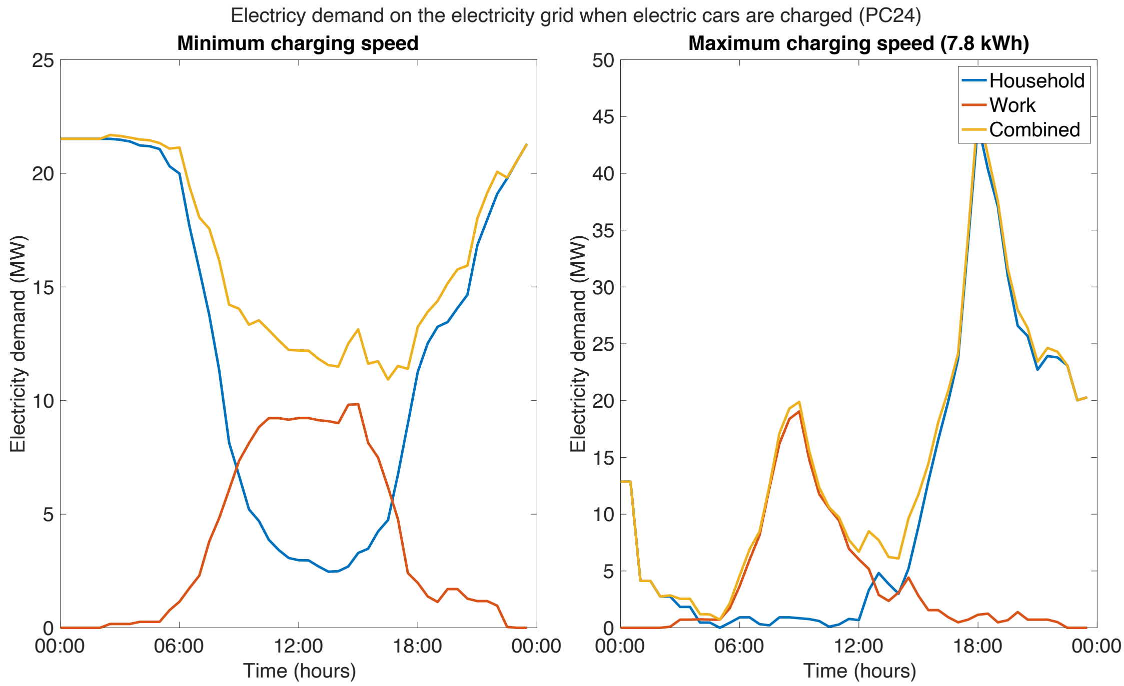


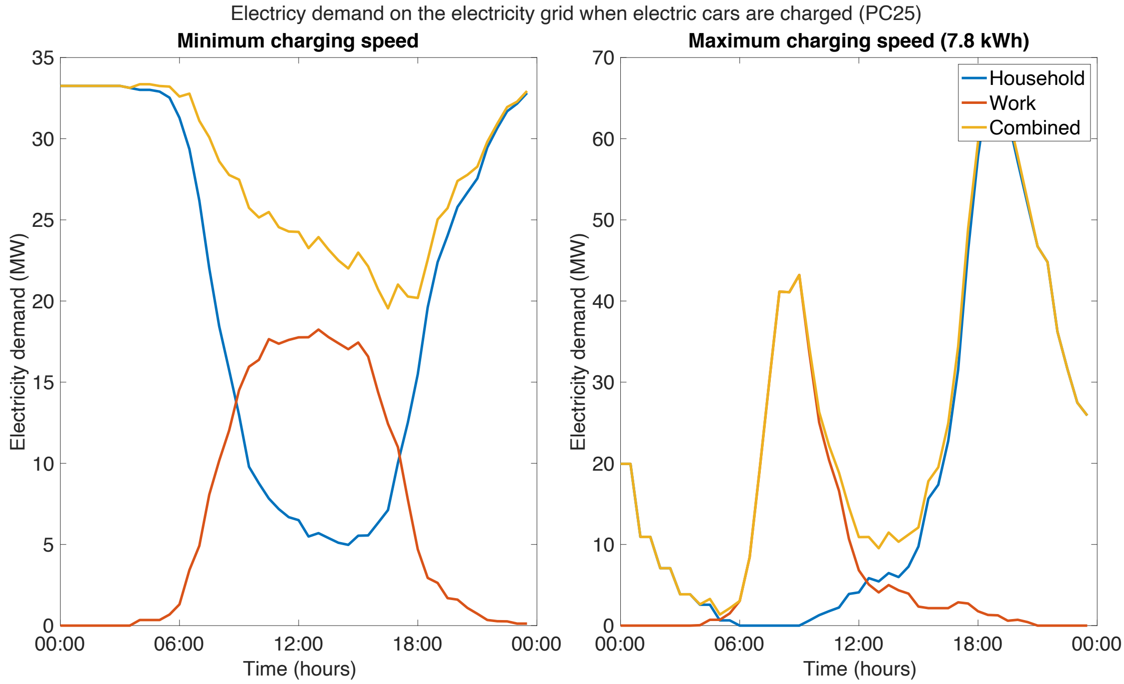
Electricy demand on the electricity grid when electric cars are charged (PC22)



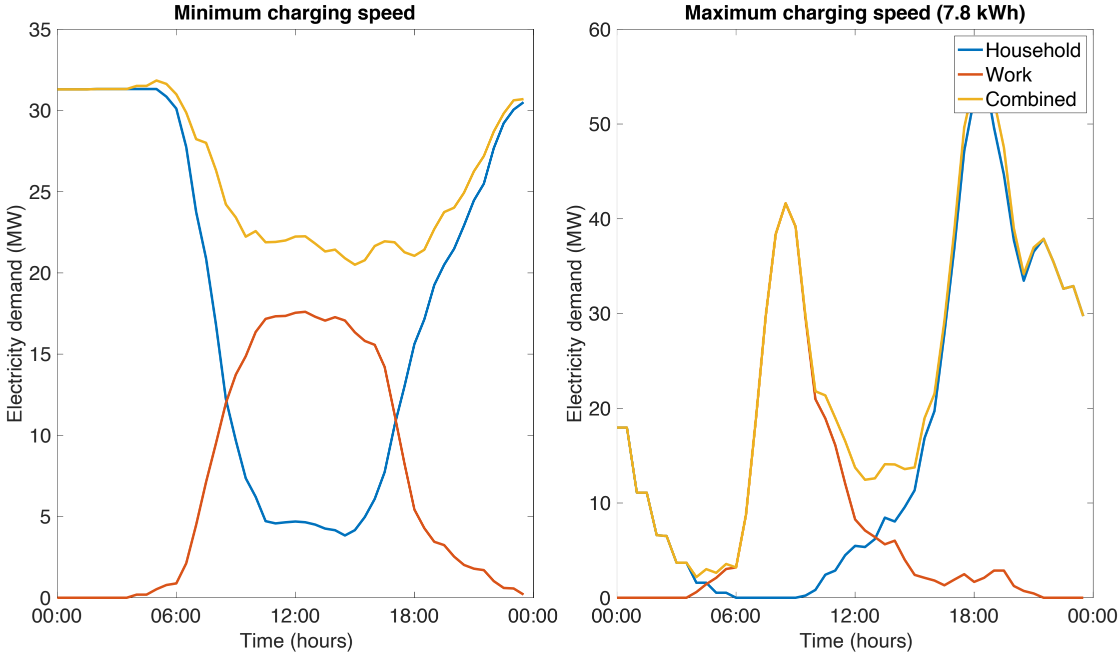
Electricy demand on the electricity grid when electric cars are charged (PC23)



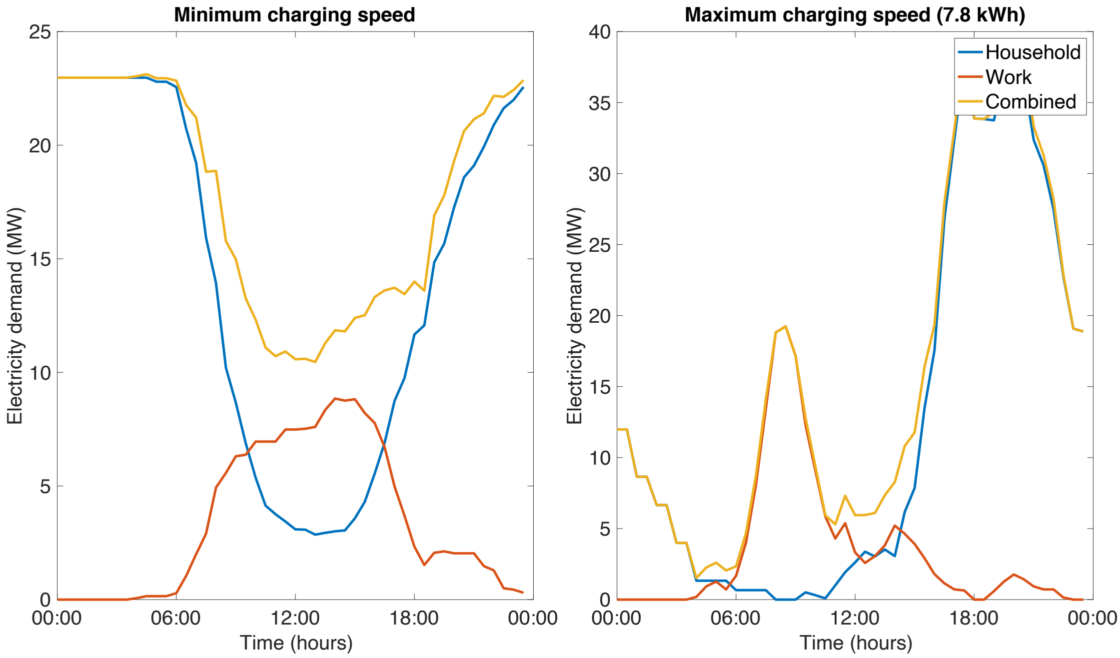

Electricy demand on the electricity grid when electric cars are charged (PC24)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

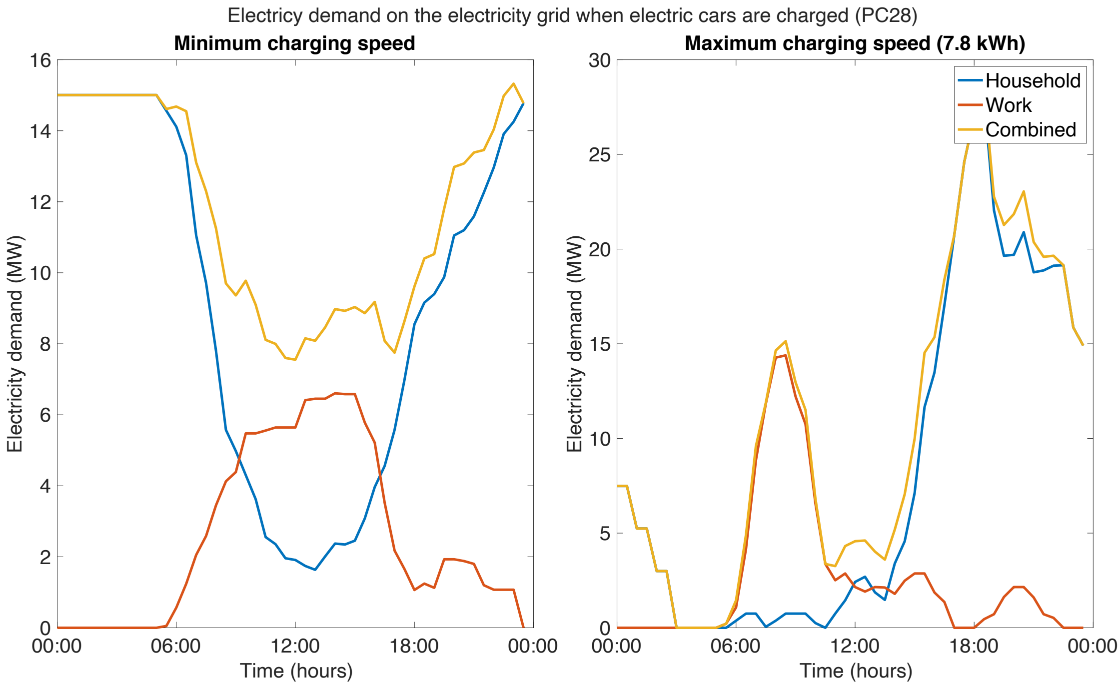

Electricy demand on the electricity grid when electric cars are charged (PC25)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

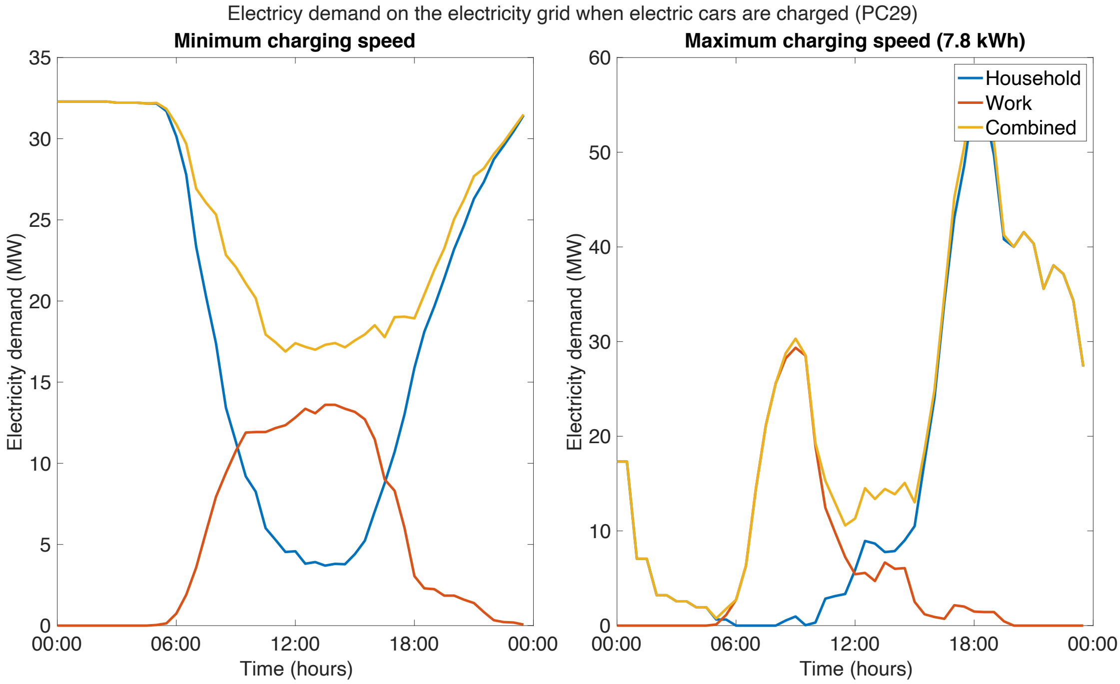
Electricy demand on the electricity grid when electric cars are charged (PC26)

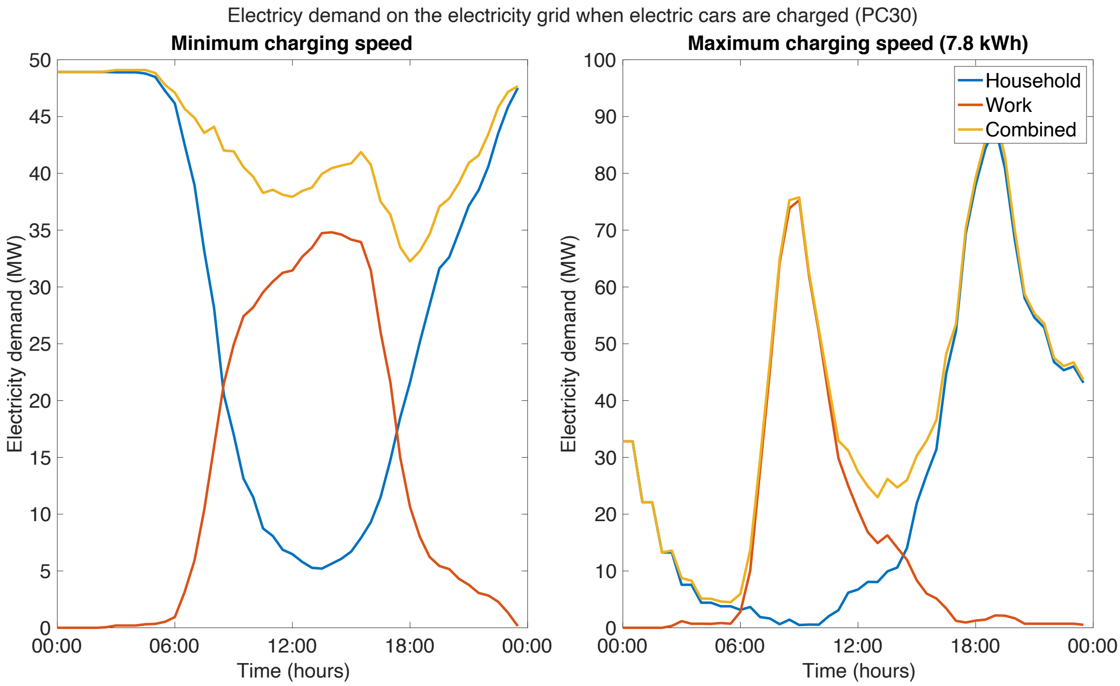


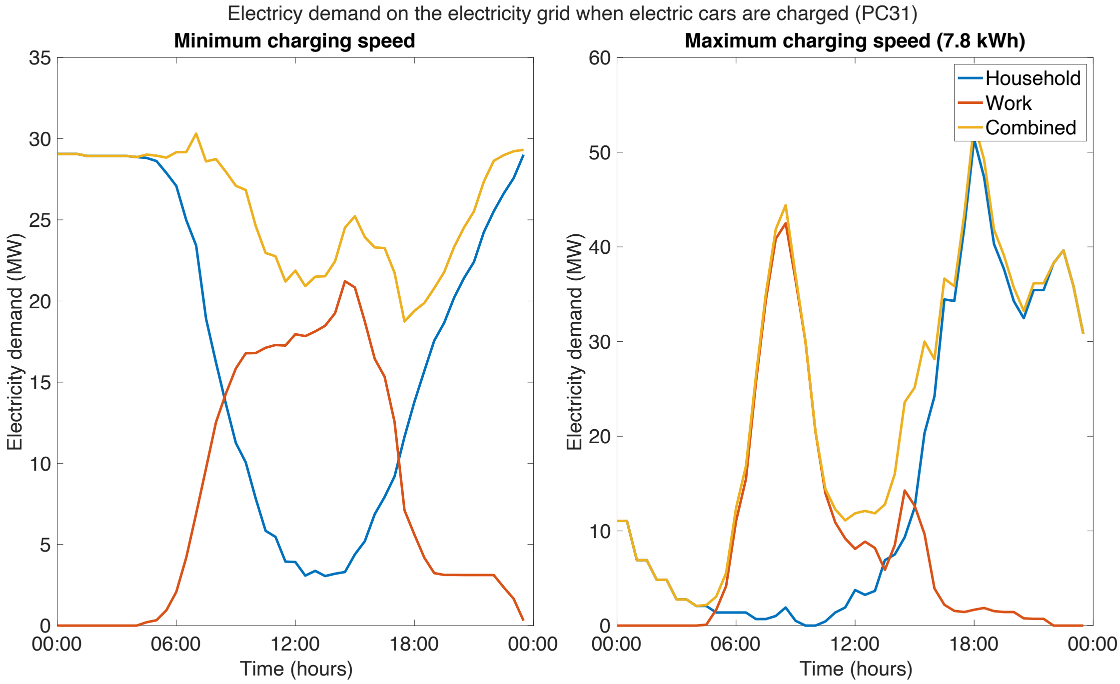
Electricy demand on the electricity grid when electric cars are charged (PC27)

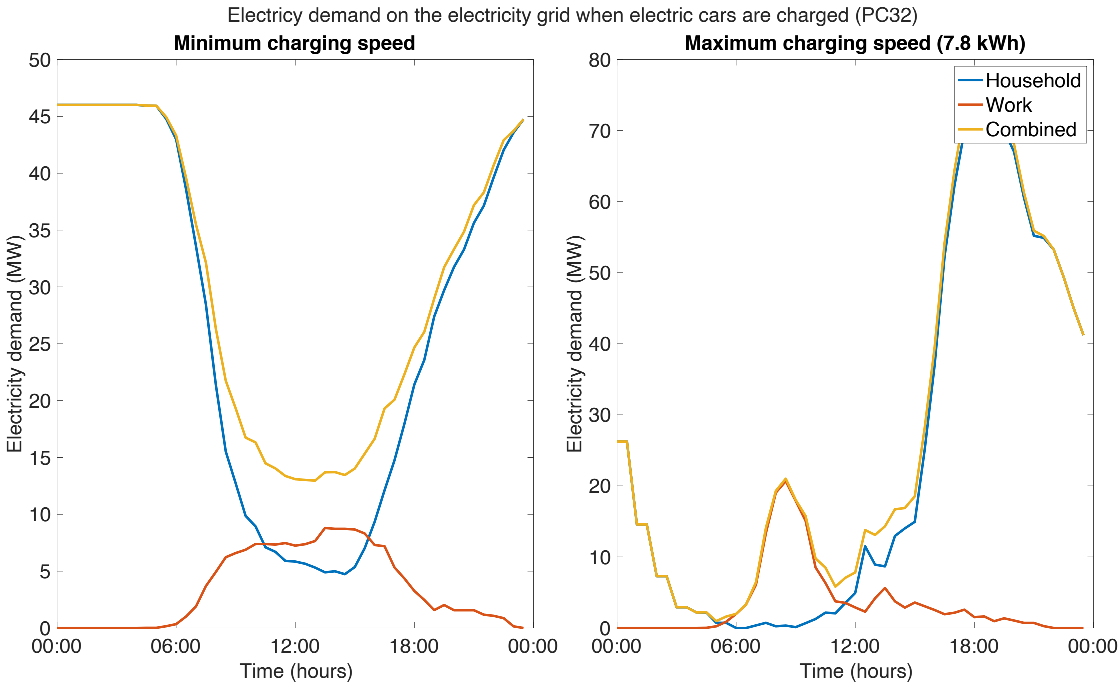


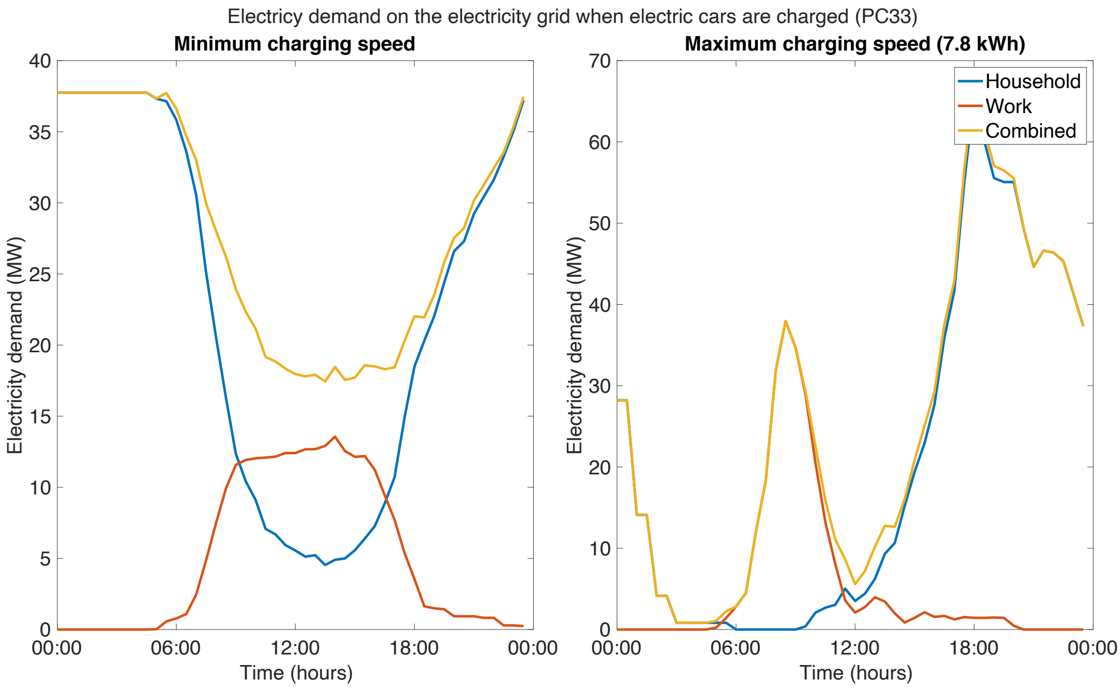

Electricy demand on the electricity grid when electric cars are charged (PC28)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

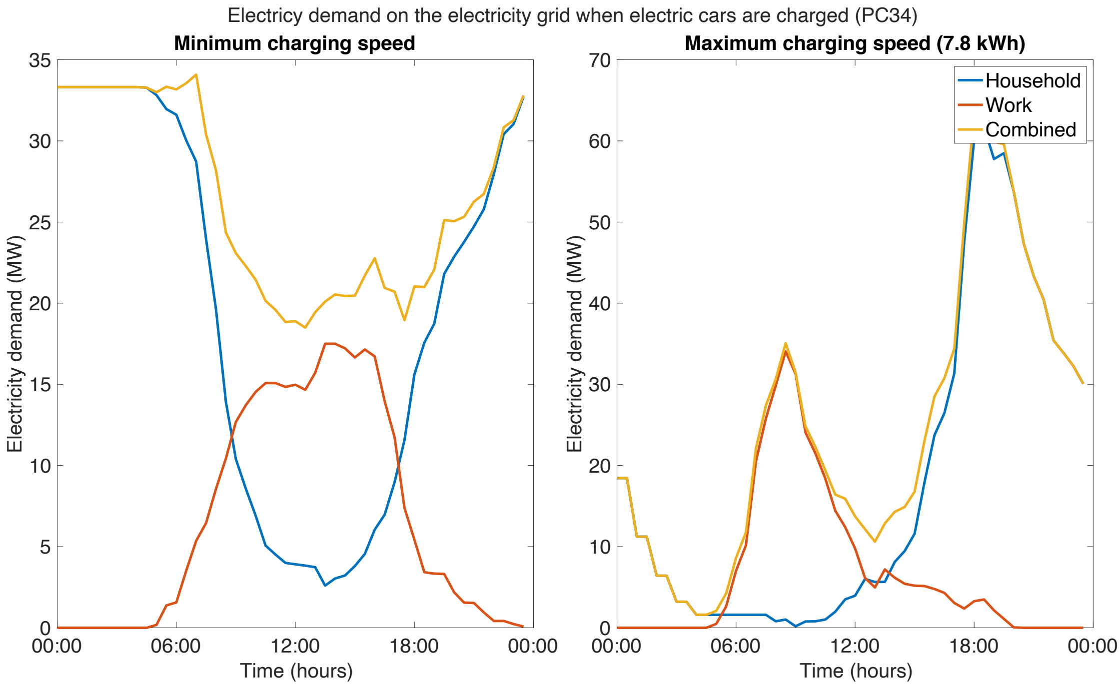

Electricy demand on the electricity grid when electric cars are charged (PC29)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

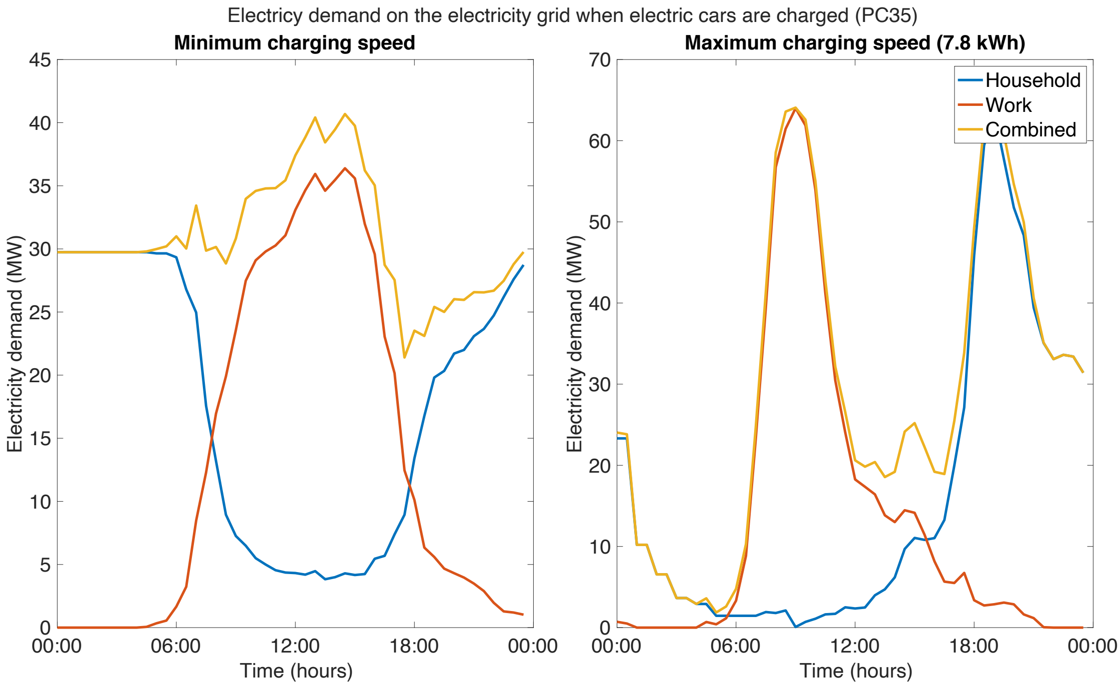

Electricy demand on the electricity grid when electric cars are charged (PC30)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

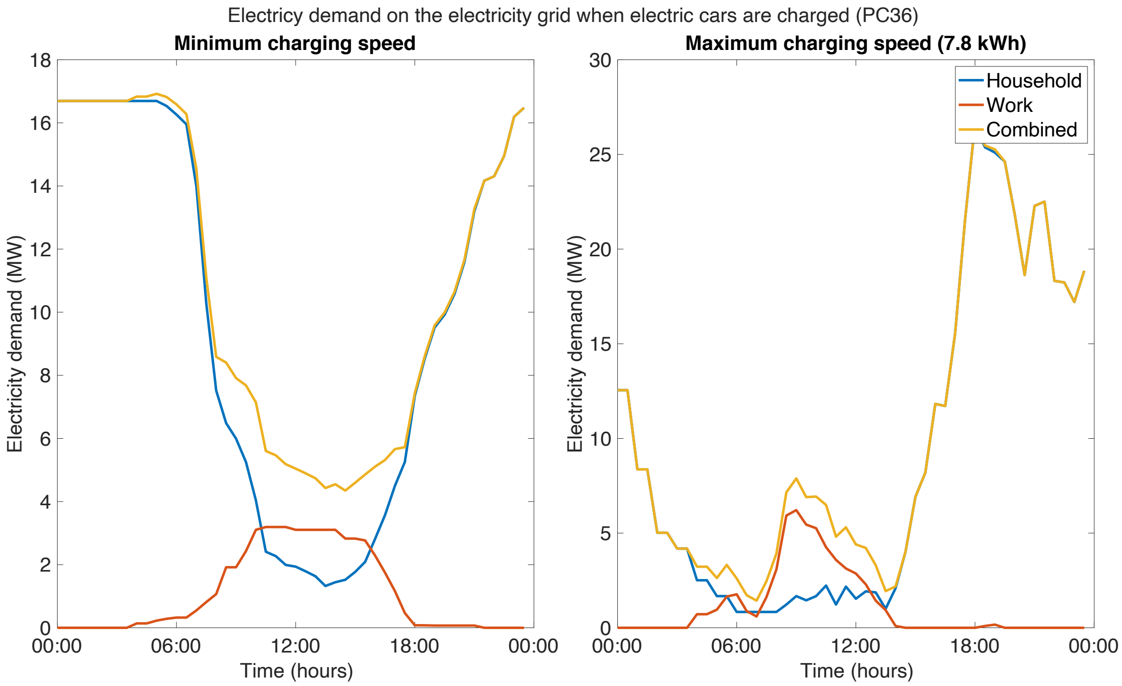

Electricy demand on the electricity grid when electric cars are charged (PC31)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

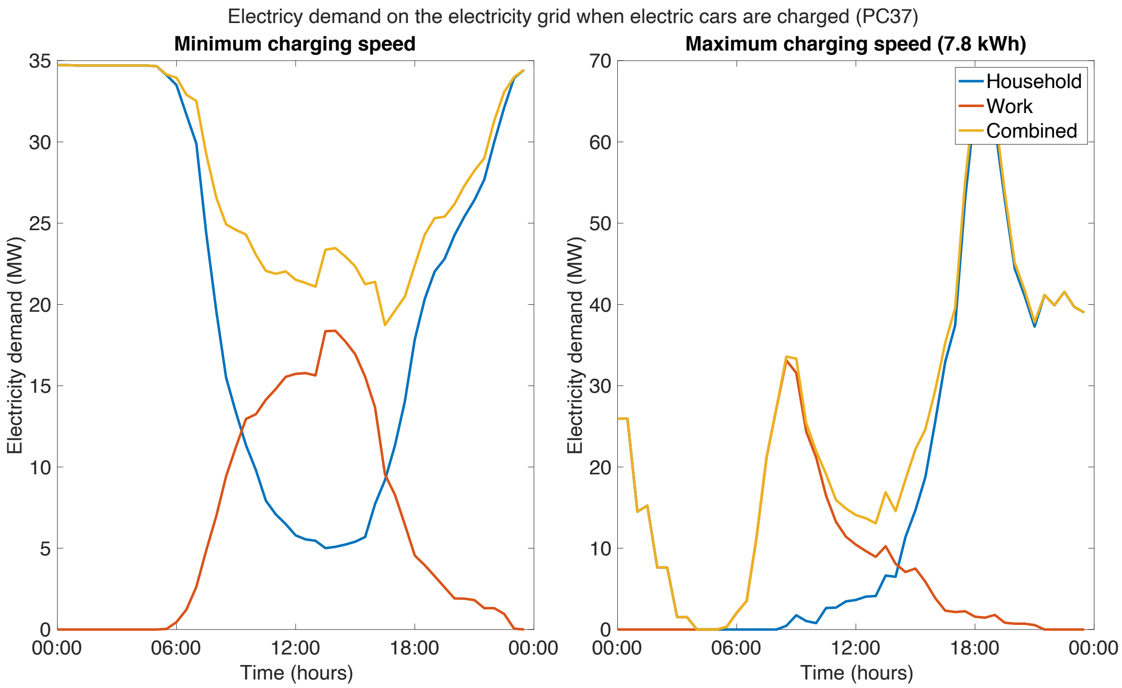

Electricy demand on the electricity grid when electric cars are charged (PC32)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

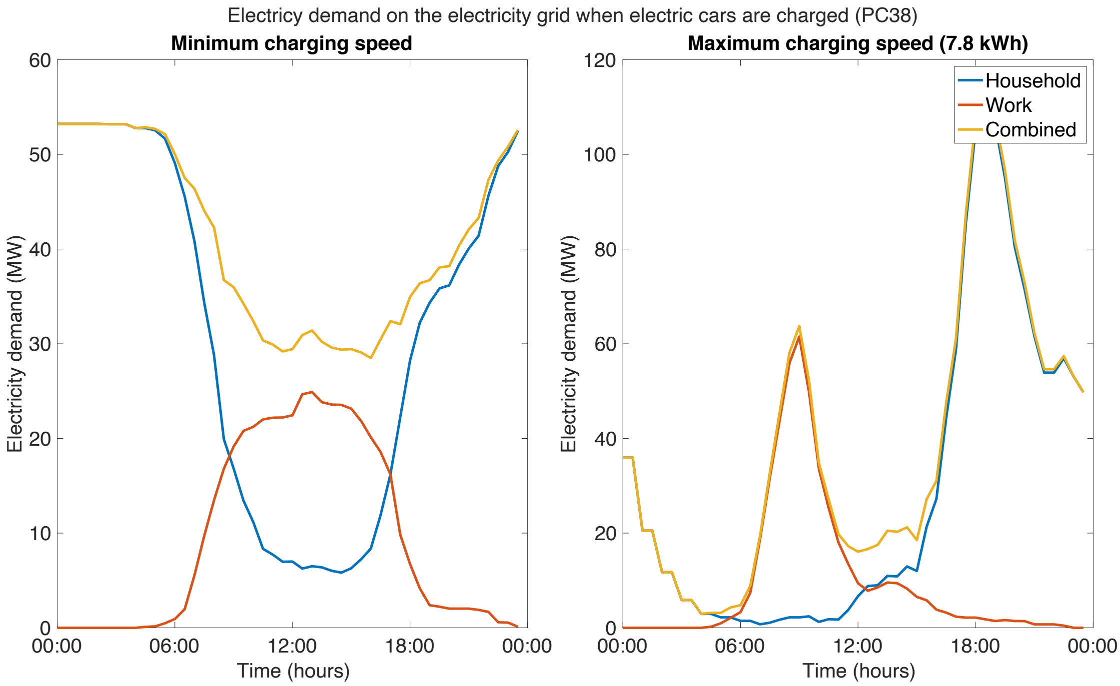

Electricy demand on the electricity grid when electric cars are charged (PC33)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00


Electricy demand on the electricity grid when electric cars are charged (PC34)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
Household
Work
Combined

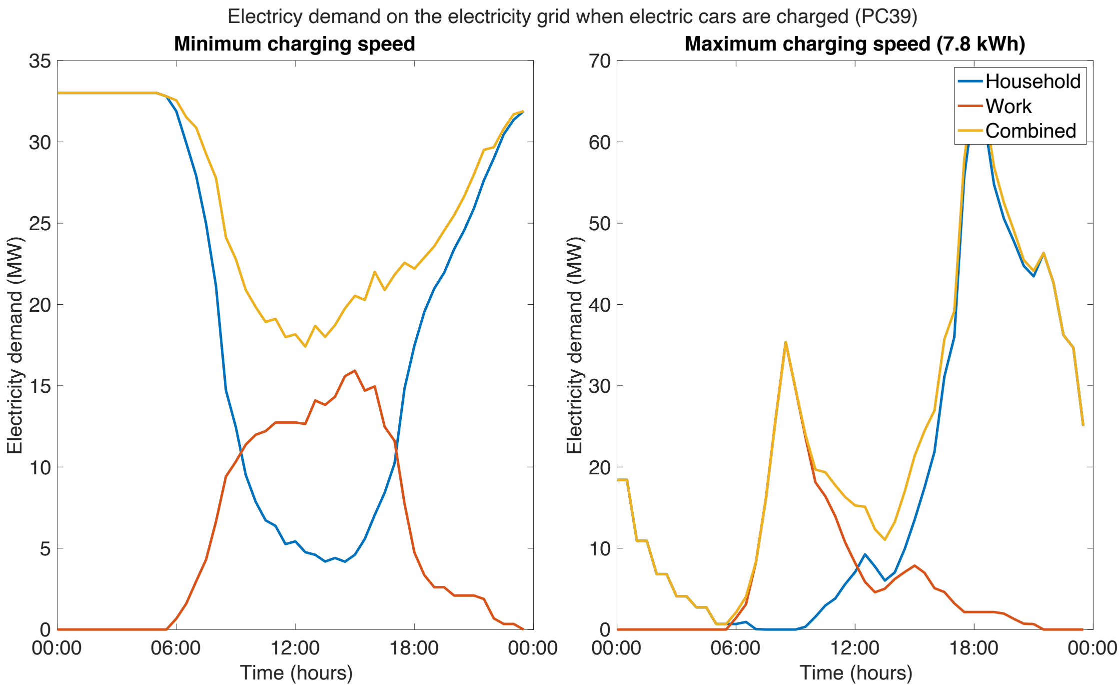

Electricy demand on the electricity grid when electric cars are charged (PC35)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC36)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00


Electricy demand on the electricity grid when electric cars are charged (PC37)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

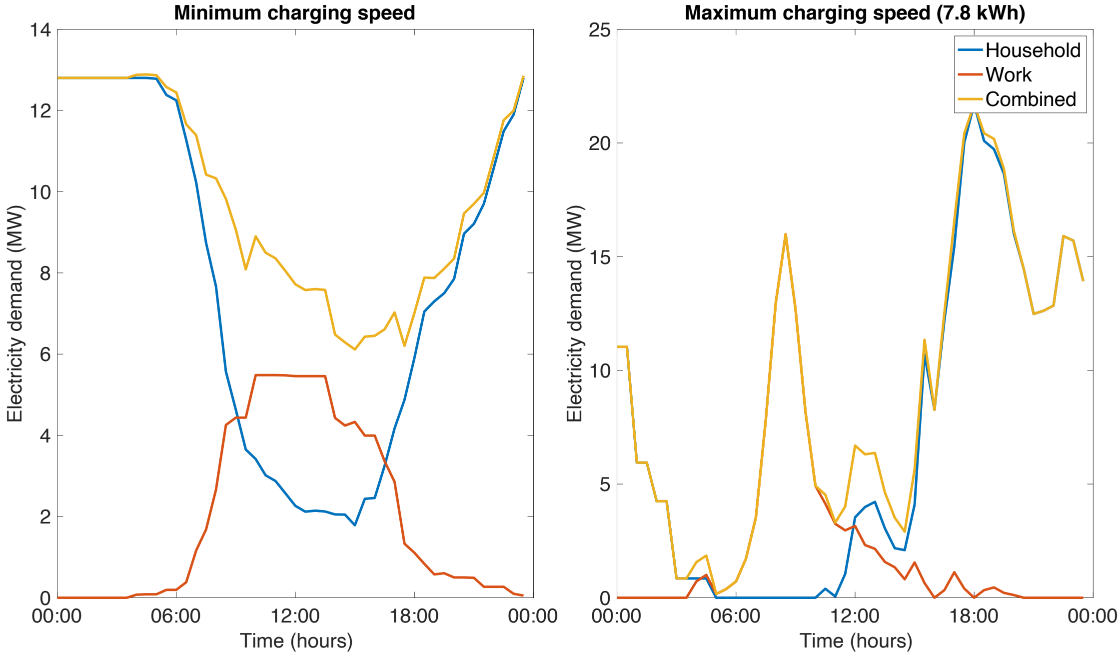


Electricy demand on the electricity grid when electric cars are charged (PC38)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

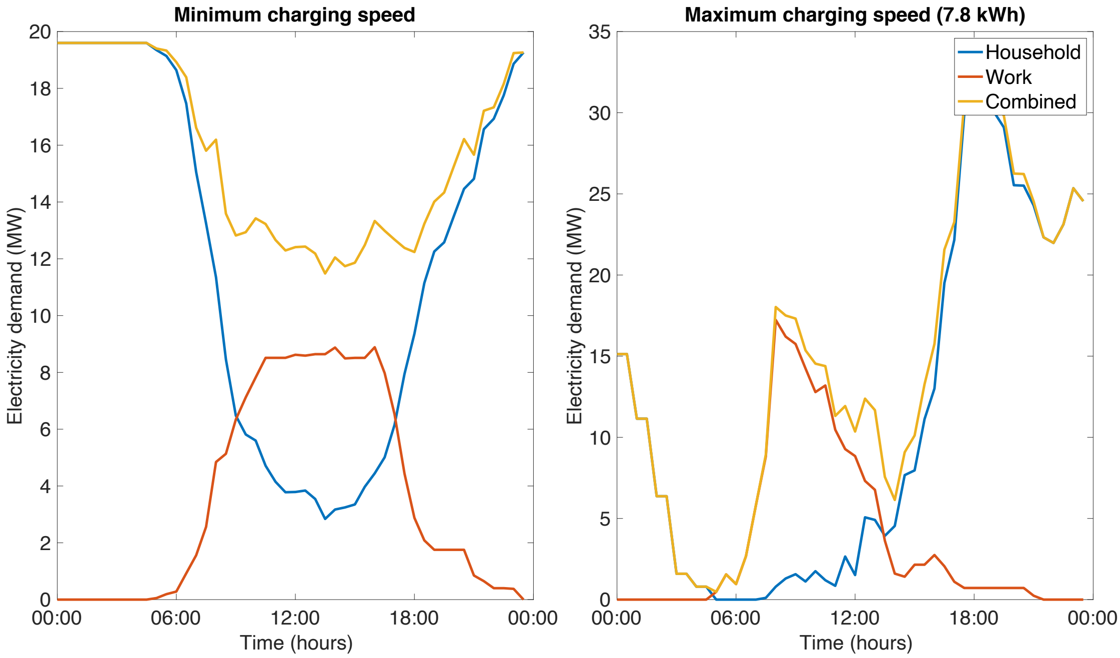


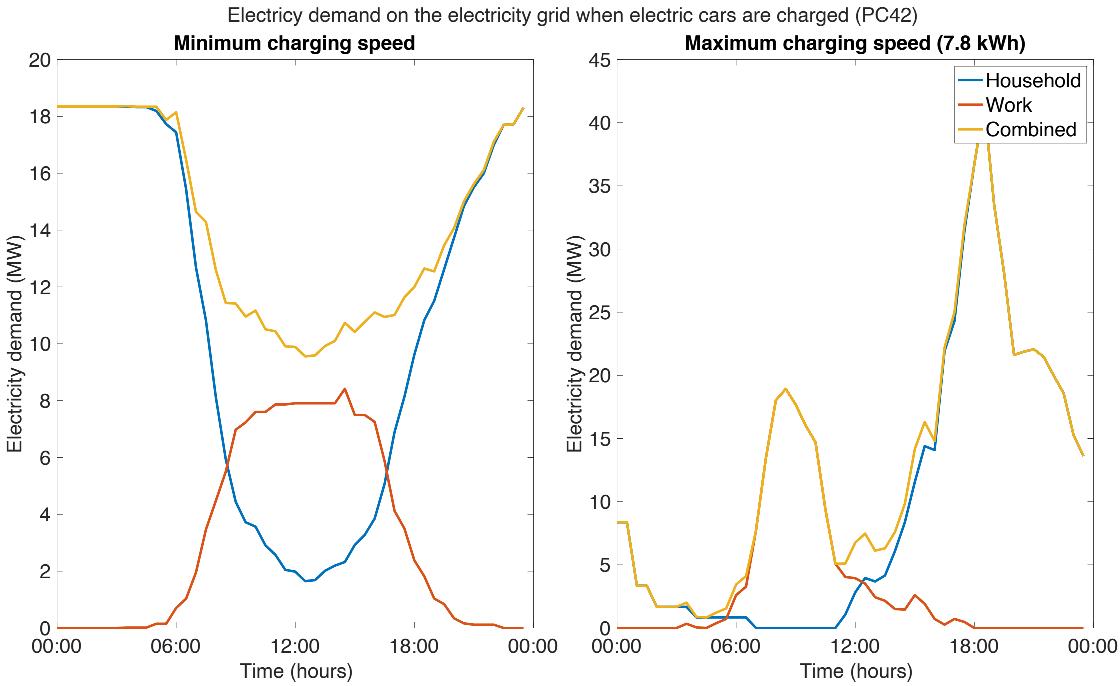
Electricy demand on the electricity grid when electric cars are charged (PC39)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

Electricy demand on the electricity grid when electric cars are charged (PC40)

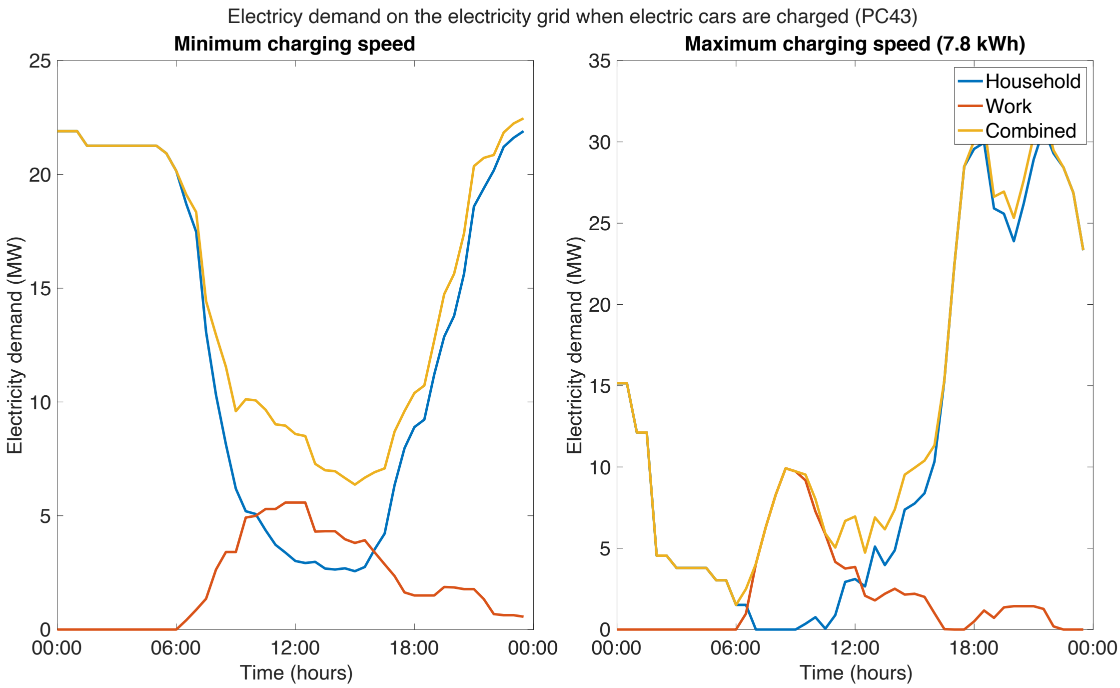


Electricy demand on the electricity grid when electric cars are charged (PC41)

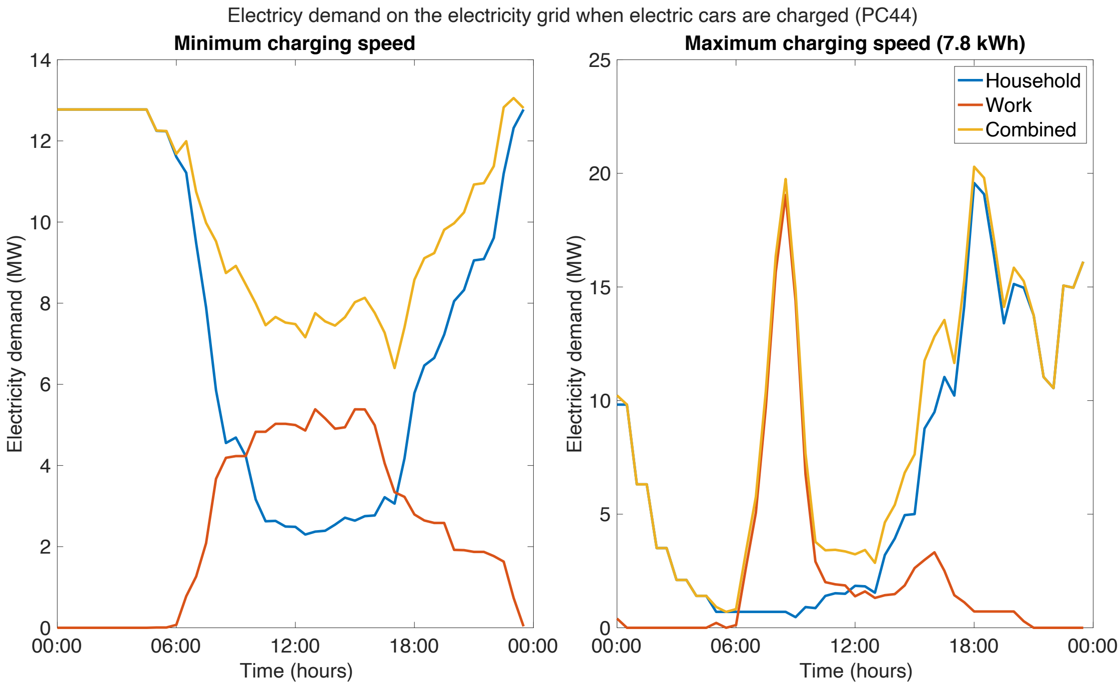


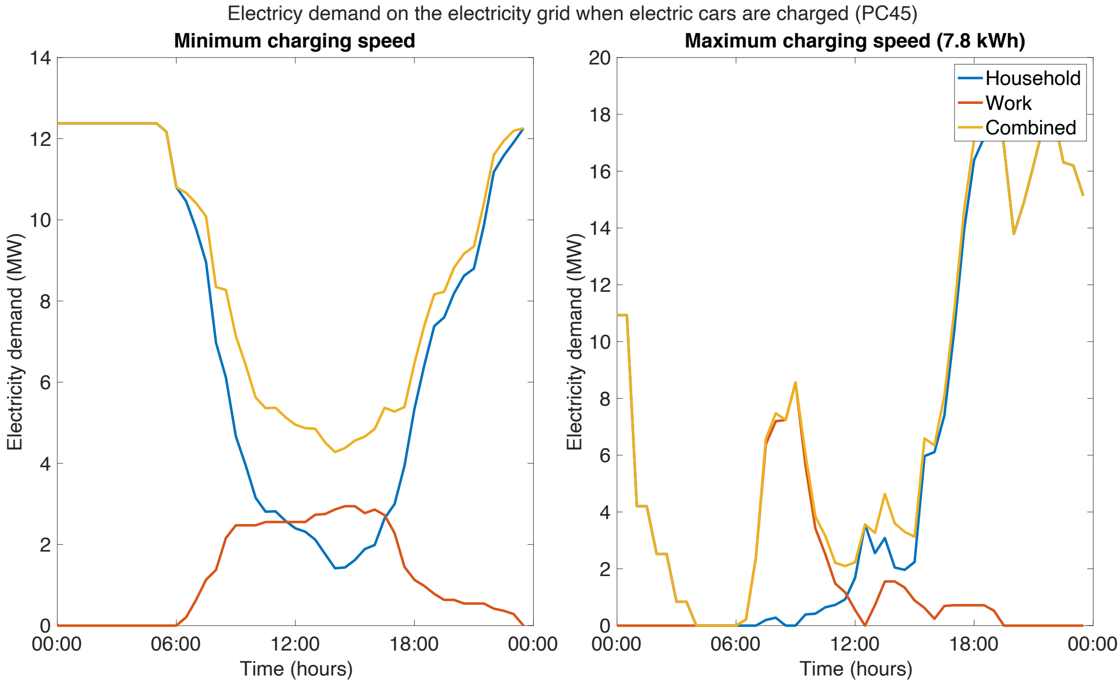


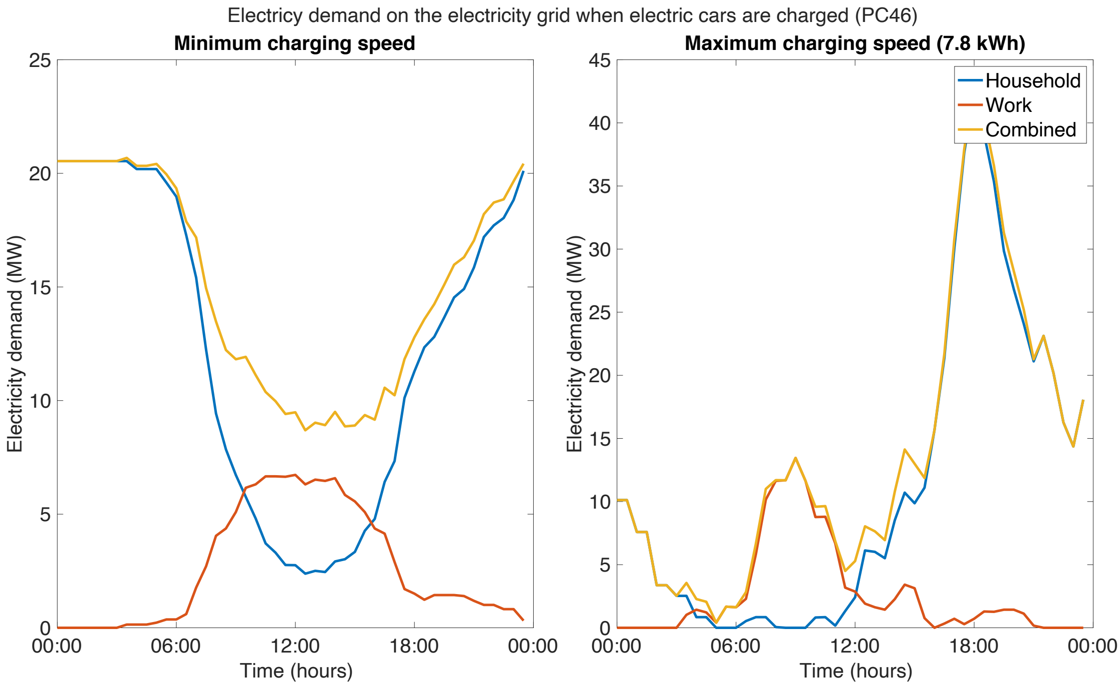
Electricy demand on the electricity grid when electric cars are charged (PC42)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined



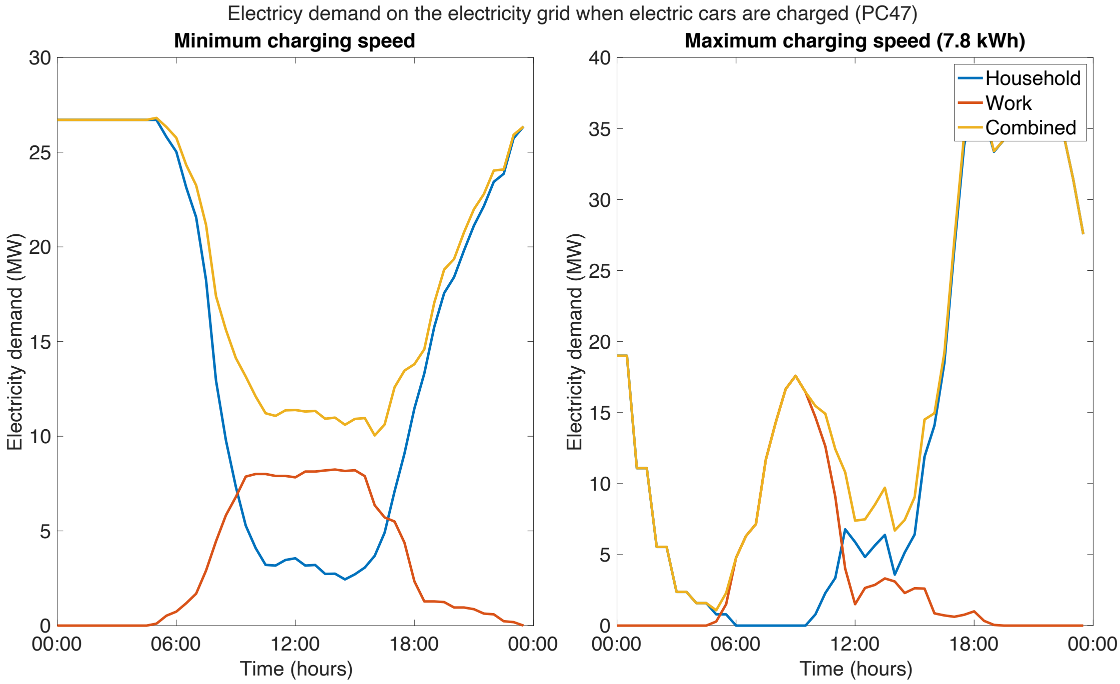
Electricy demand on the electricity grid when electric cars are charged (PC43)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC44)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

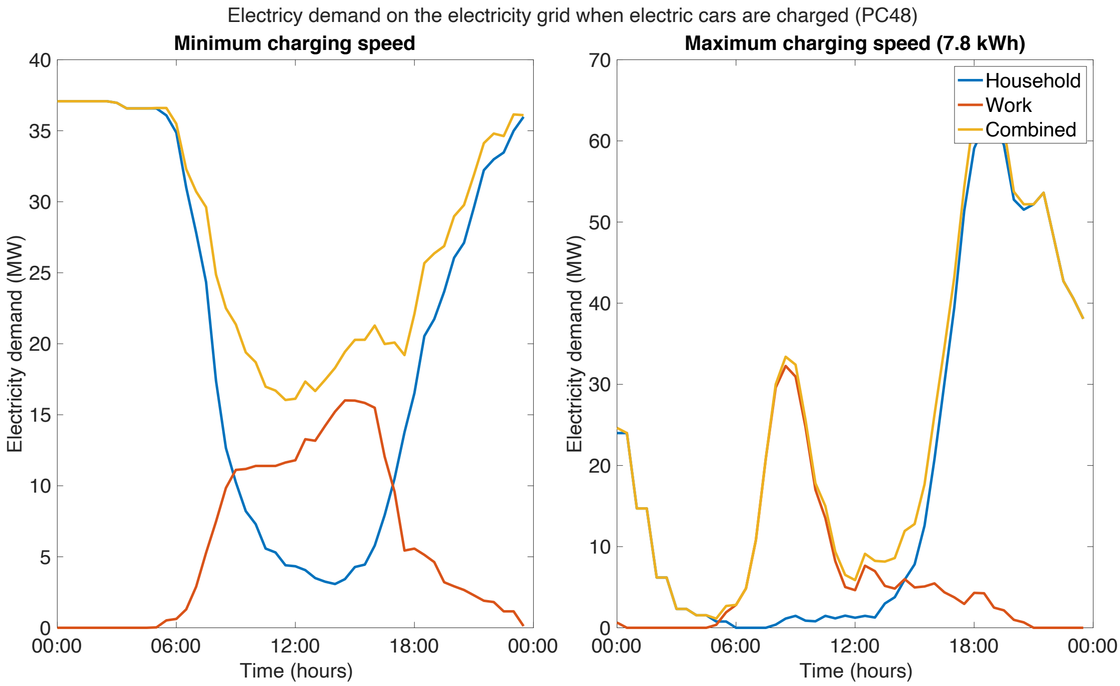

Electricy demand on the electricity grid when electric cars are charged (PC45)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

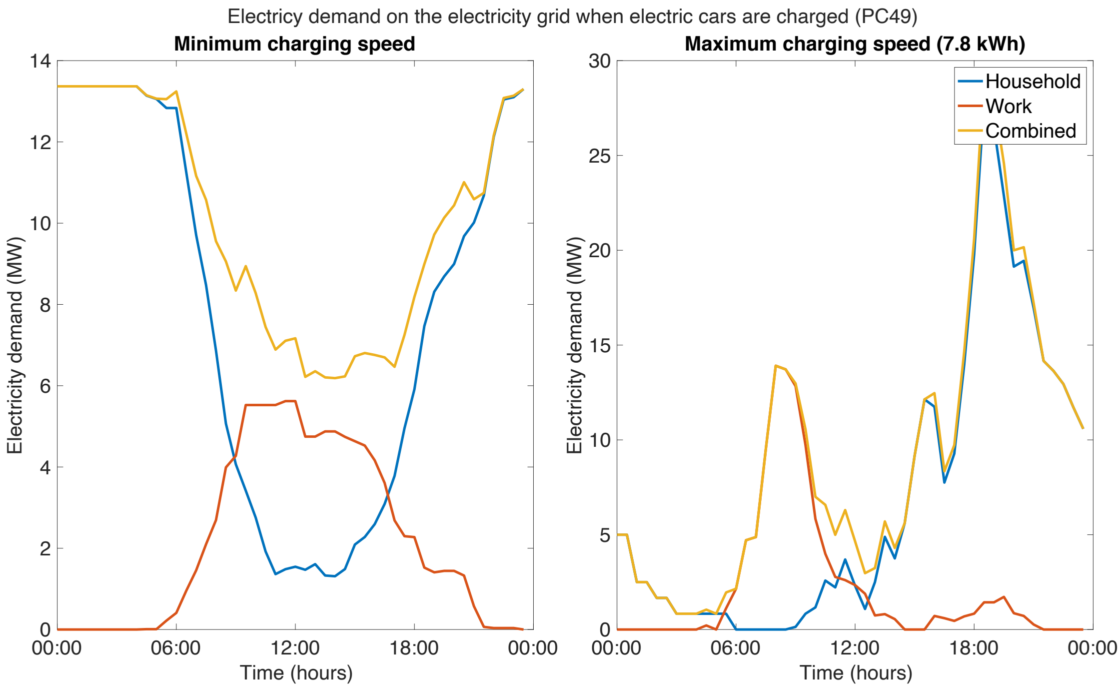


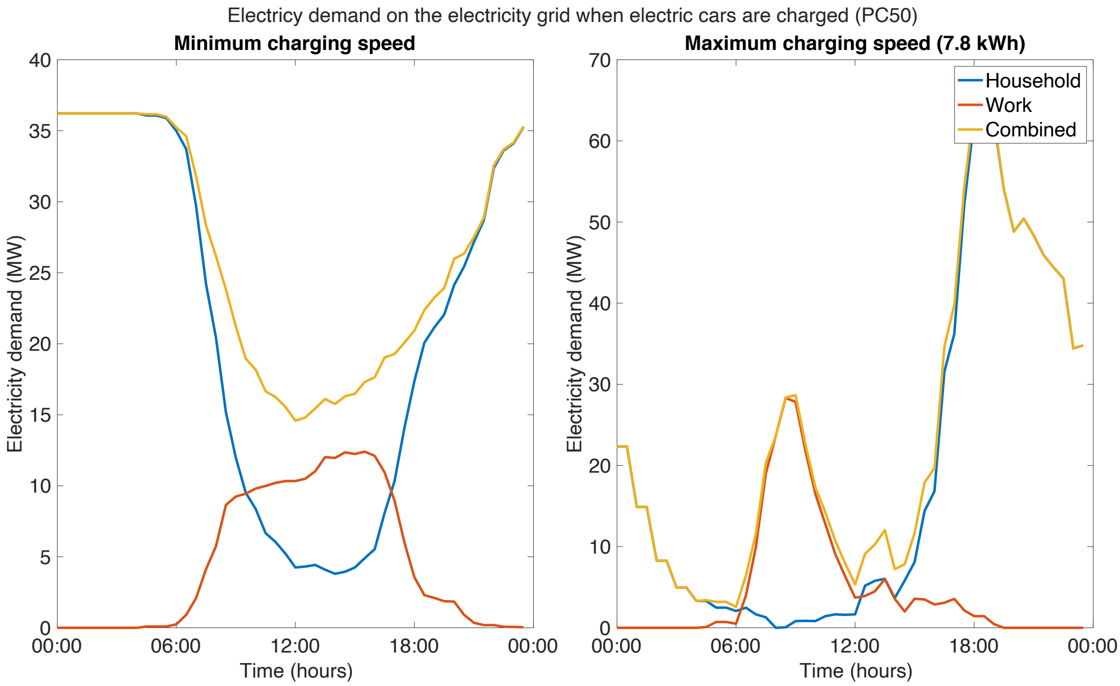
Electricy demand on the electricity grid when electric cars are charged (PC46)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

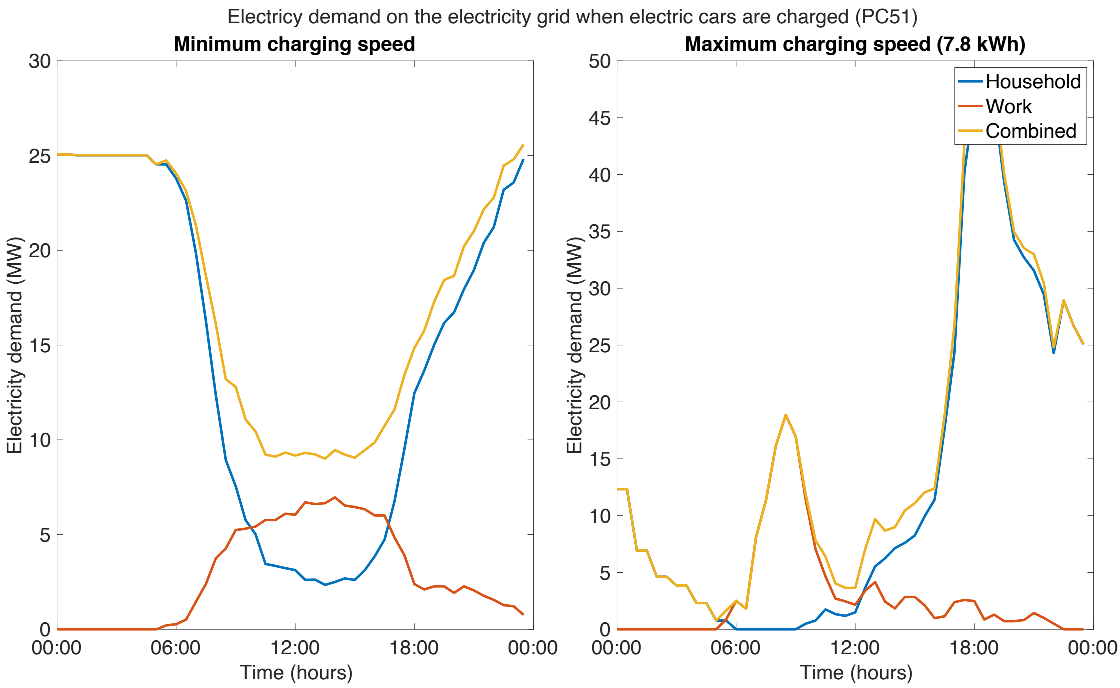


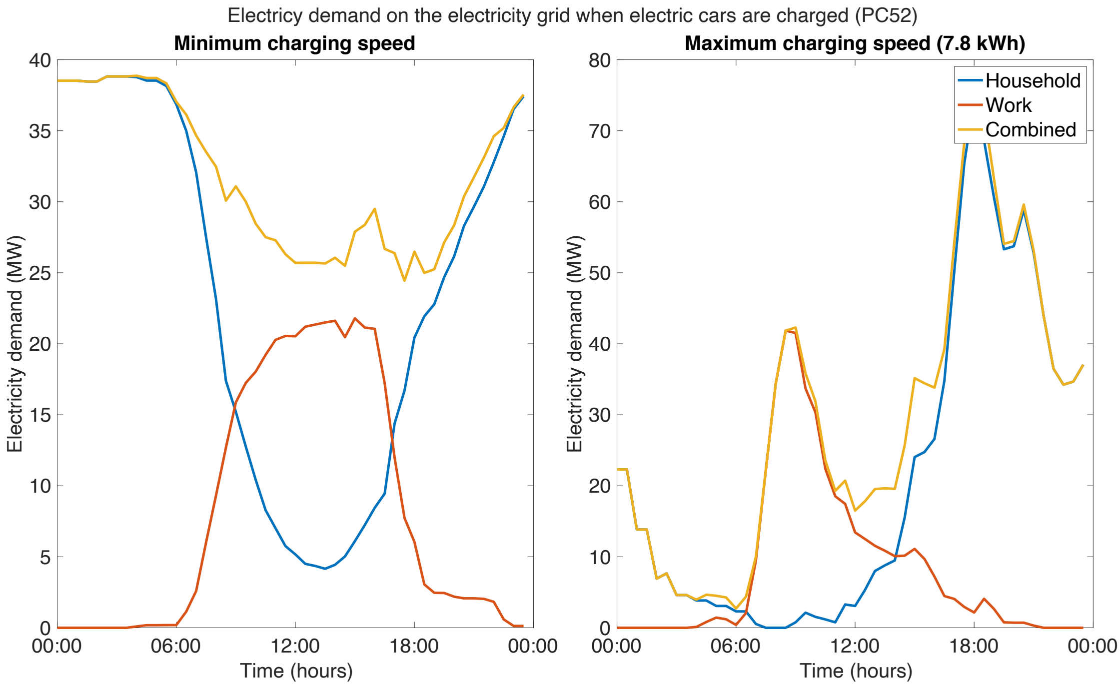
Electricy demand on the electricity grid when electric cars are charged (PC47)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

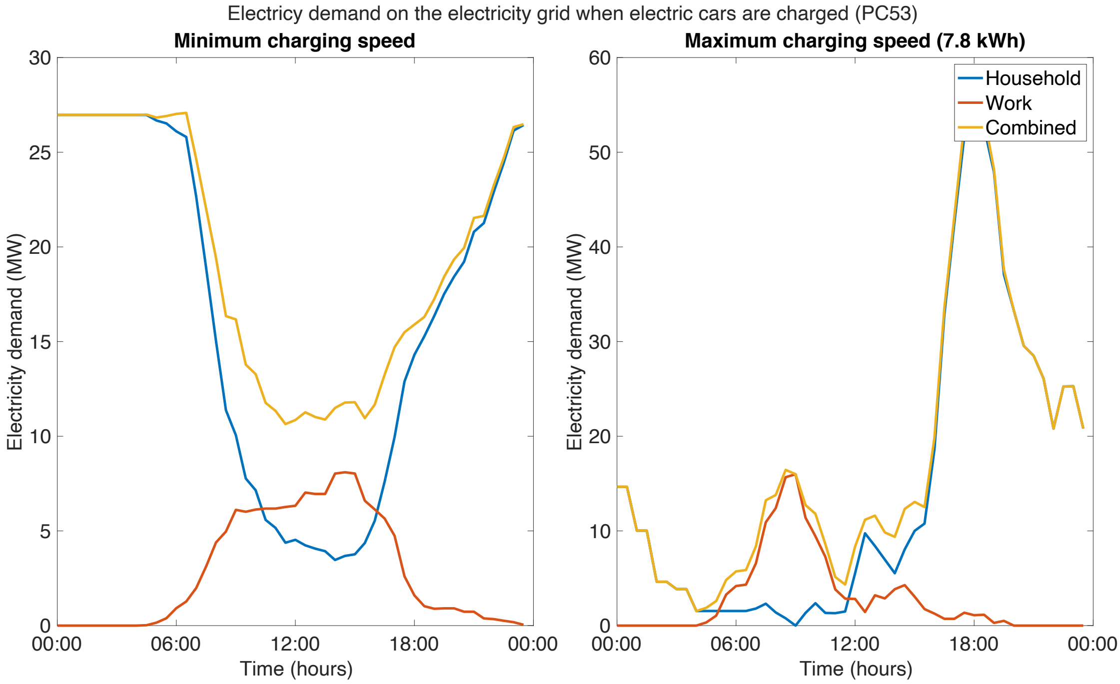

Electricy demand on the electricity grid when electric cars are charged (PC48)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

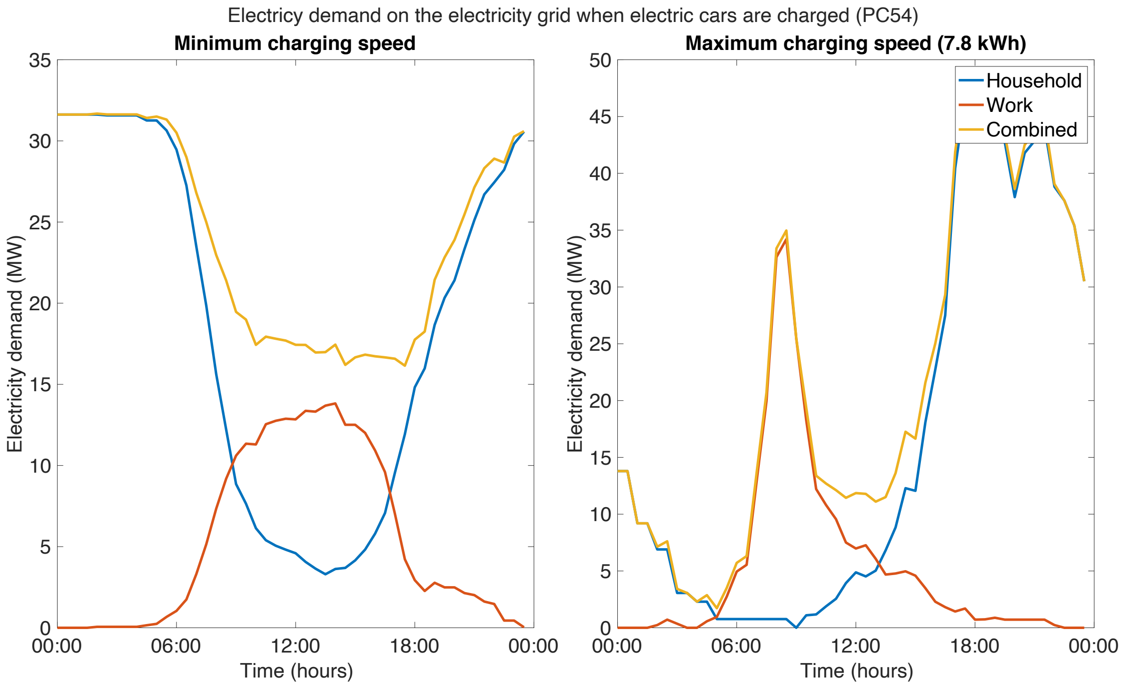

Electricy demand on the electricity grid when electric cars are charged (PC49)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

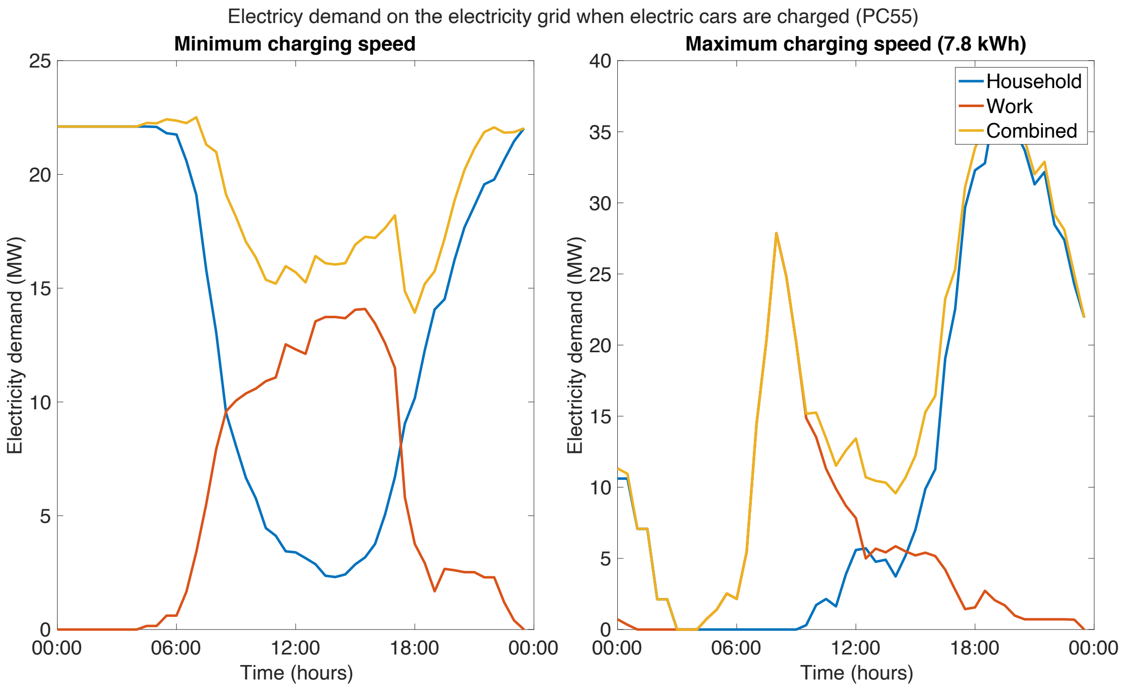

Electricy demand on the electricity grid when electric cars are charged (PC50)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

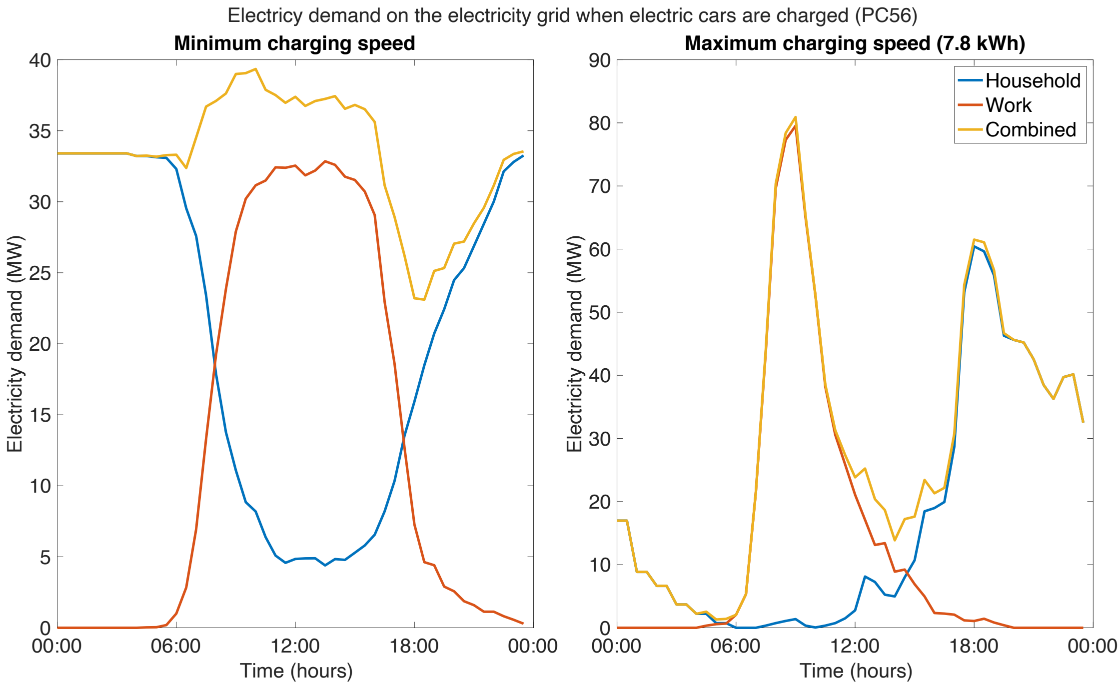

Electricy demand on the electricity grid when electric cars are charged (PC51)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

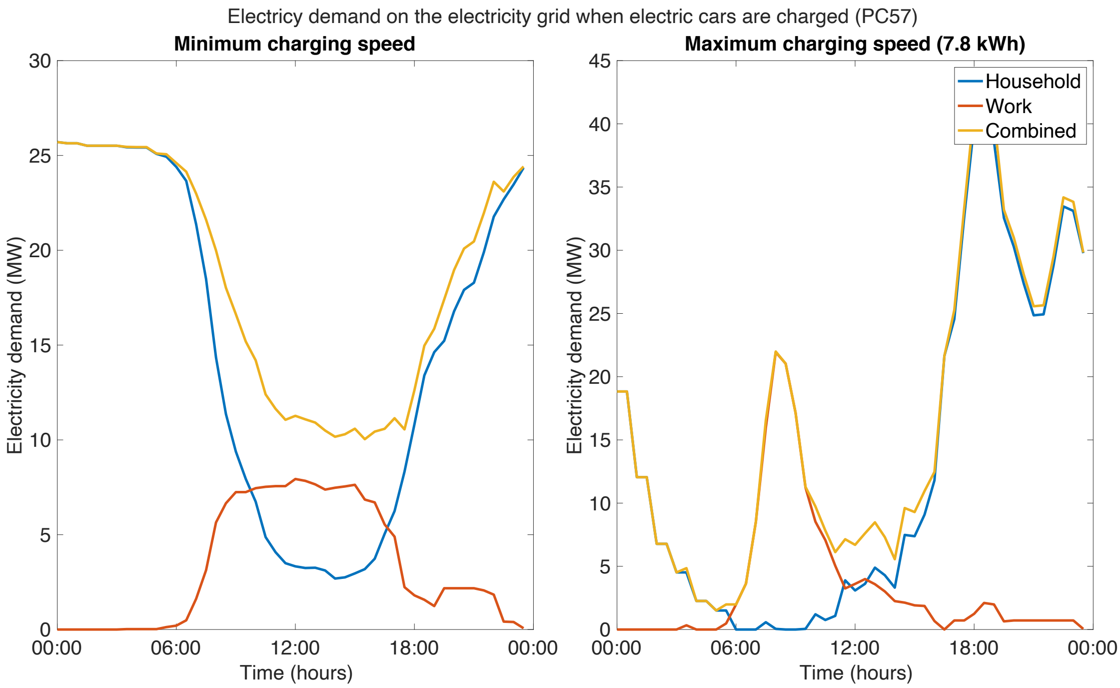

Electricy demand on the electricity grid when electric cars are charged (PC52)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00

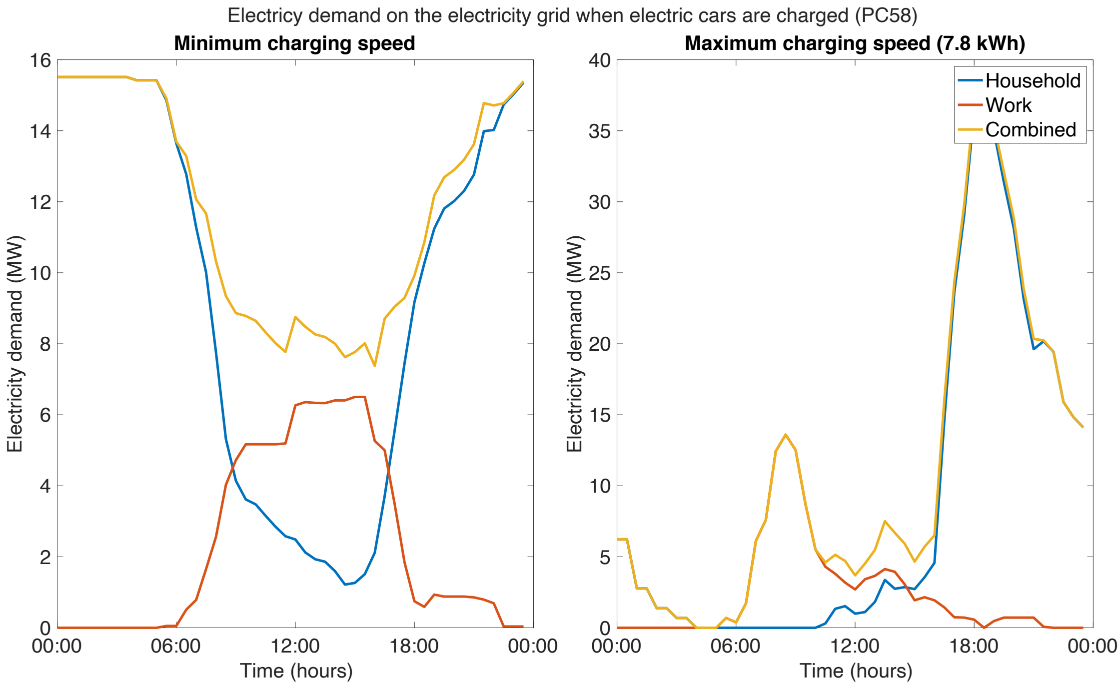

Electricy demand on the electricity grid when electric cars are charged (PC53)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00

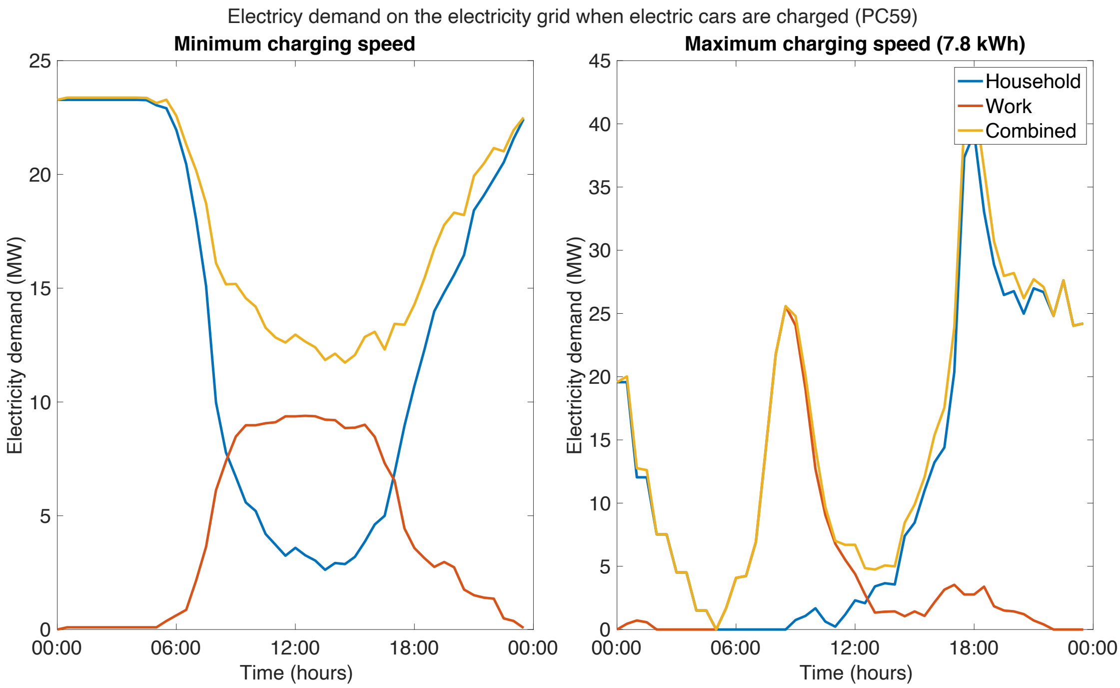

Electricy demand on the electricity grid when electric cars are charged (PC54)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
5
10
15
20
25
30
35
40
45
50
Household
Work
Combined

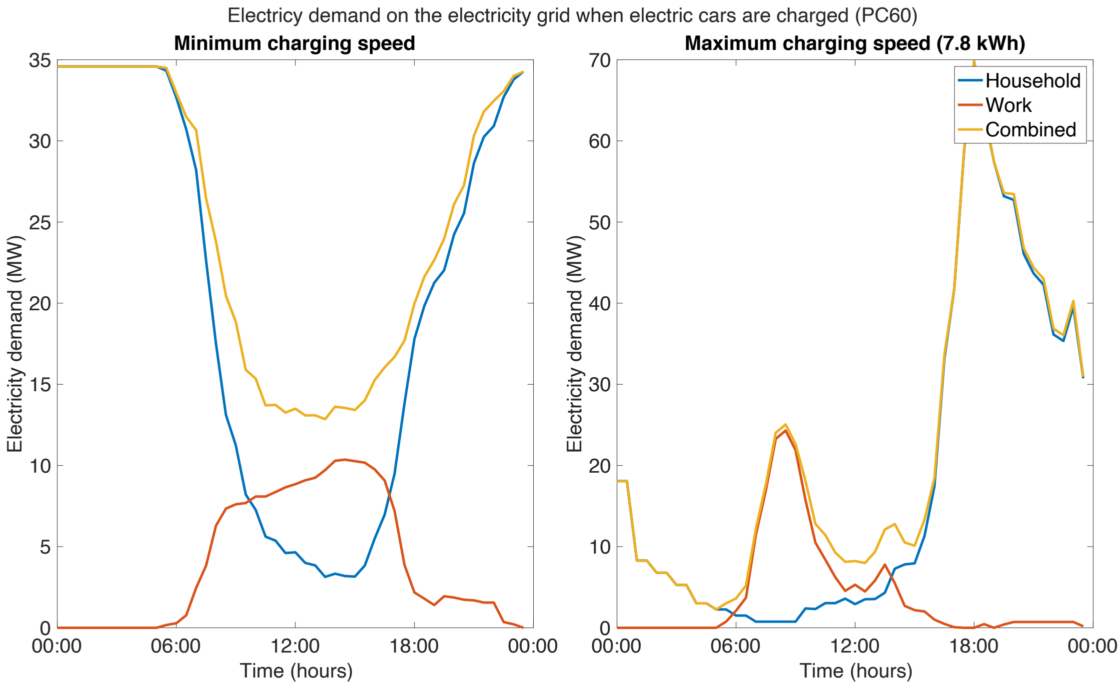

Electricy demand on the electricity grid when electric cars are charged (PC55)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
5
10
15
20
25
30
35
40
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC56)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

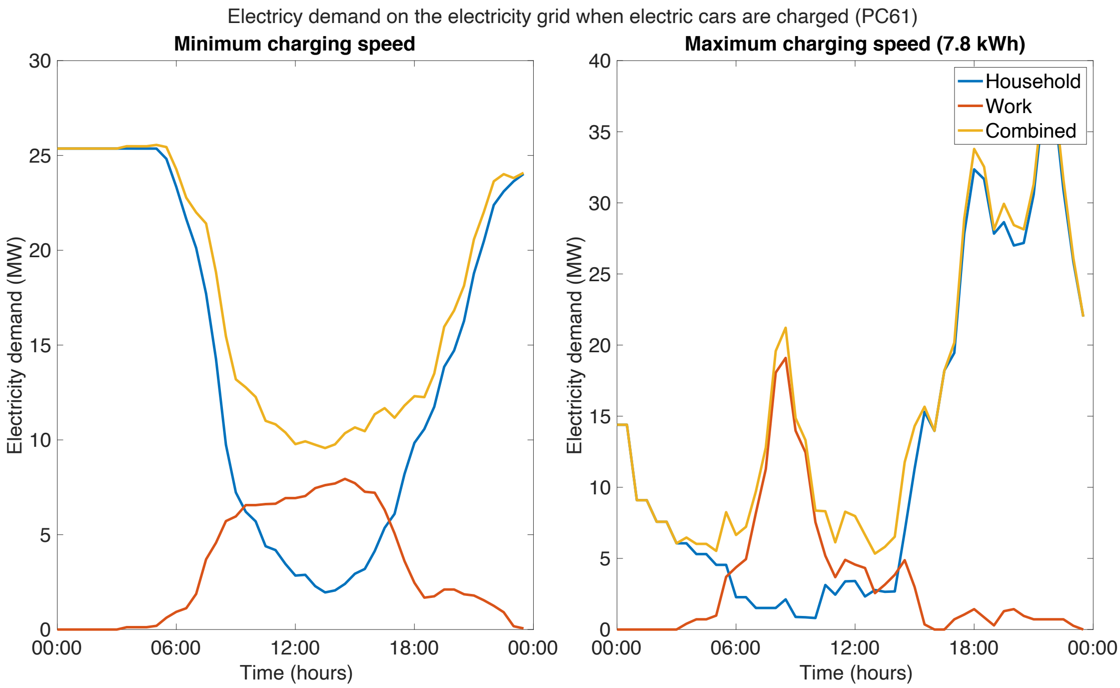

Electricy demand on the electricity grid when electric cars are charged (PC57)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC58)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

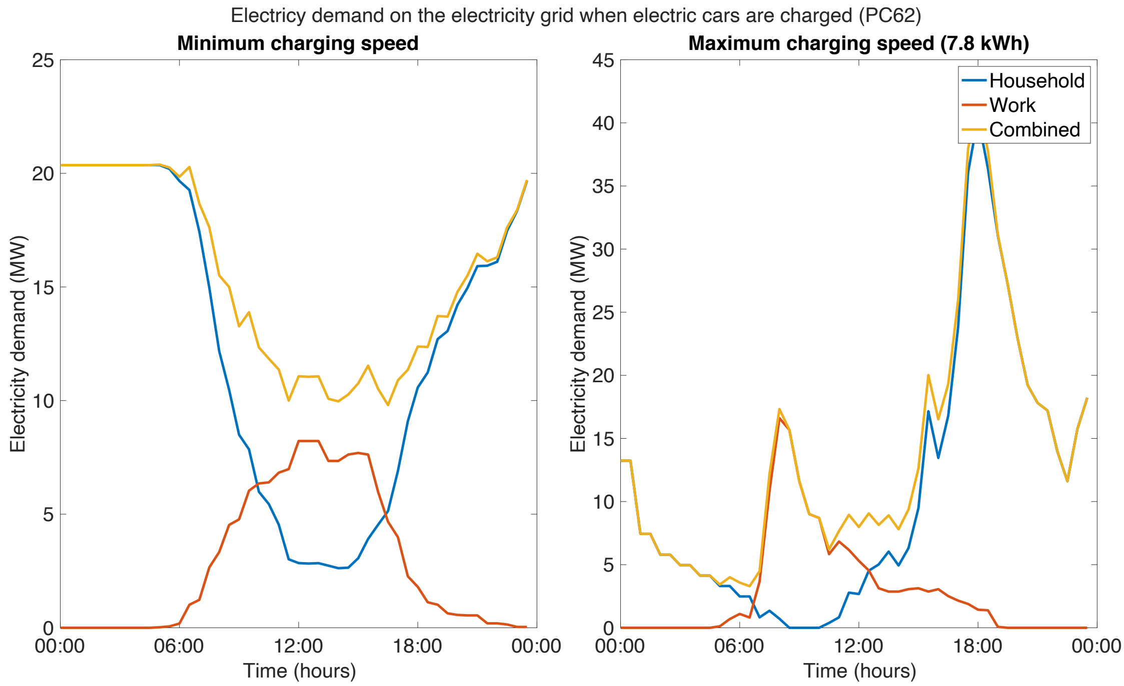

Electricy demand on the electricity grid when electric cars are charged (PC59)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

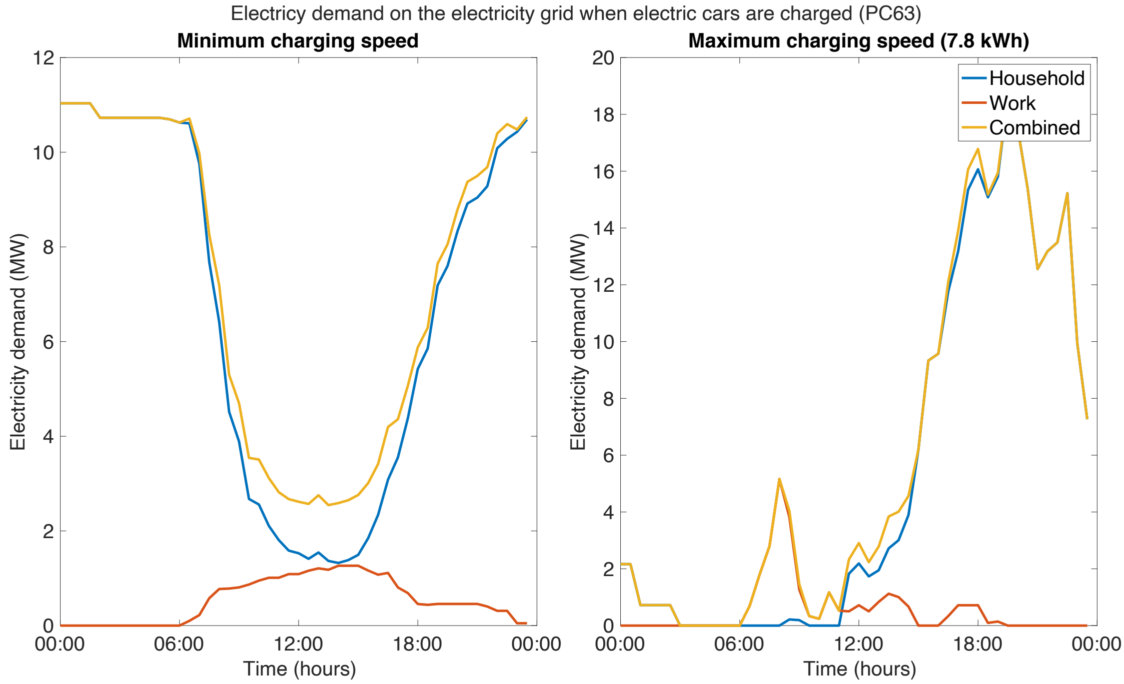


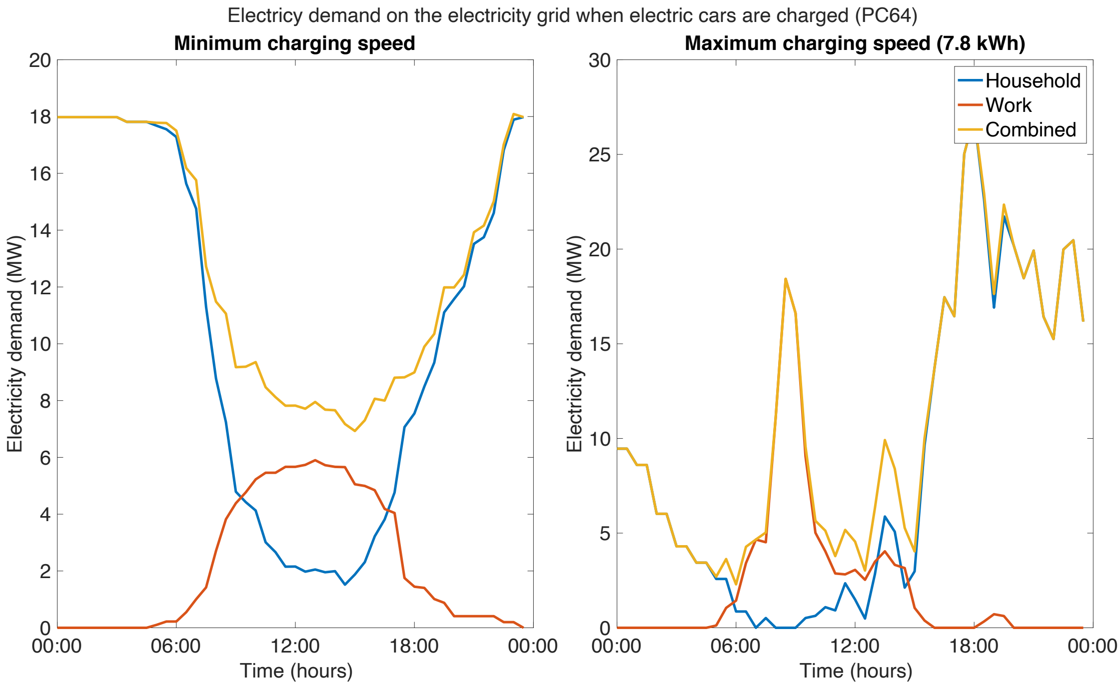
Electricy demand on the electricity grid when electric cars are charged (PC60)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

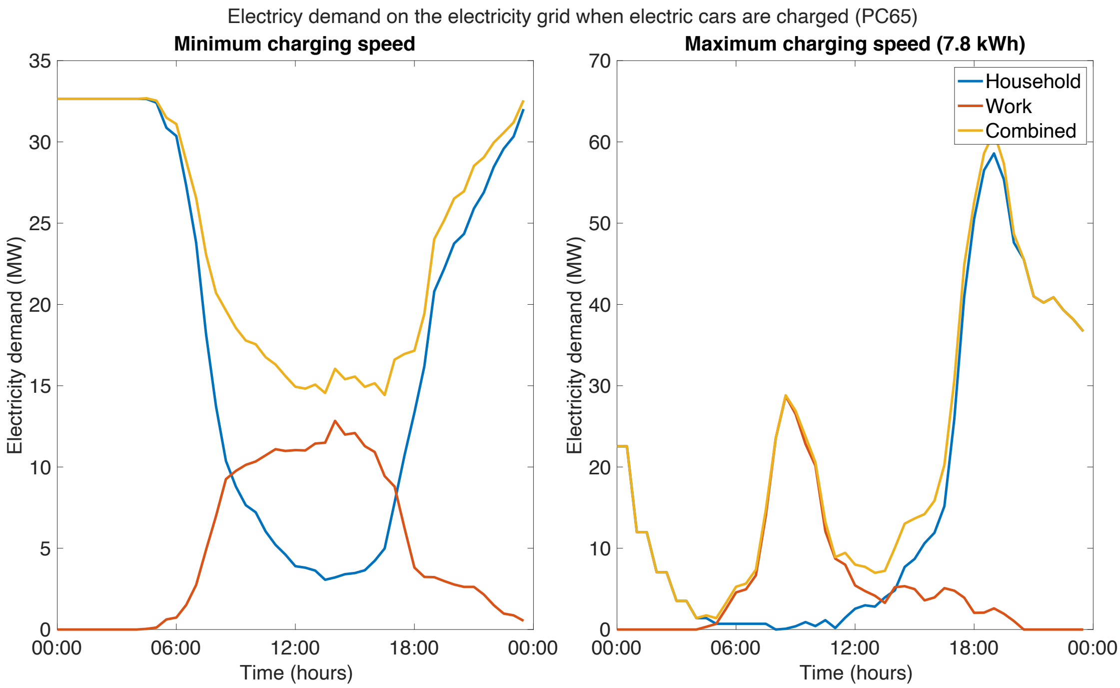


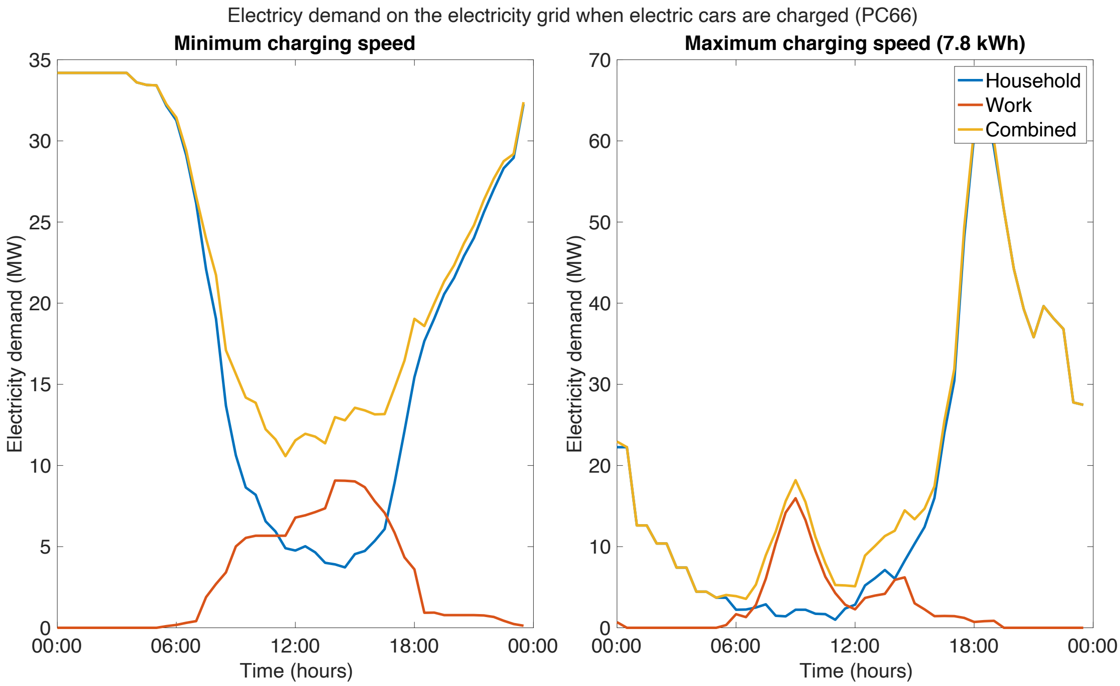
Electricy demand on the electricity grid when electric cars are charged (PC61)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

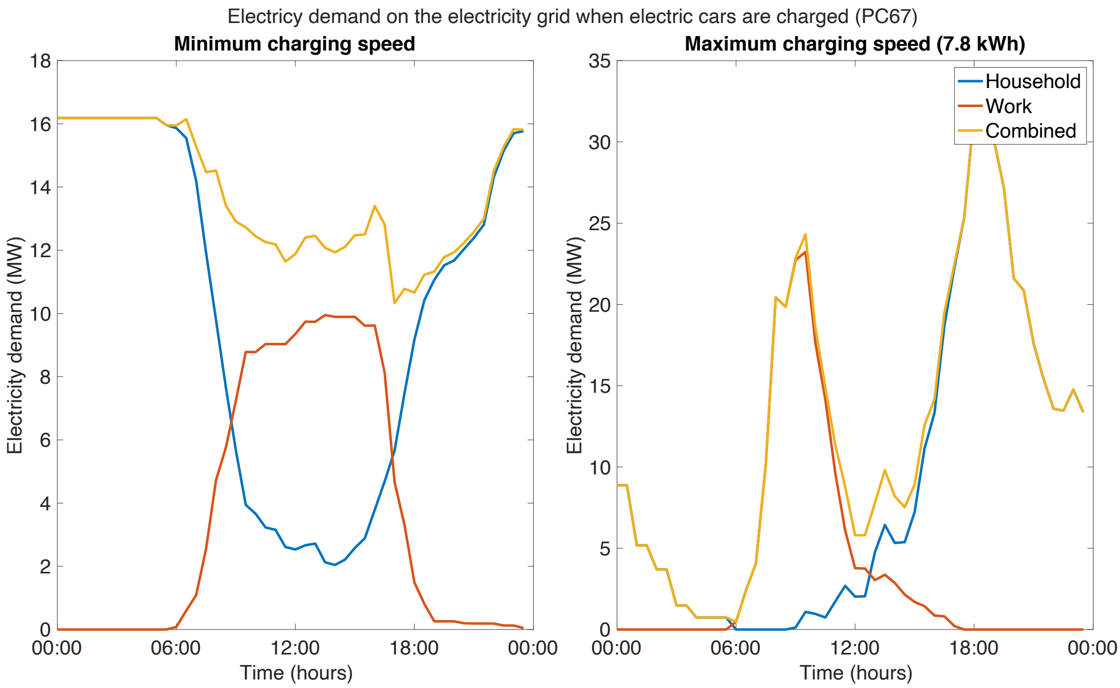

Electricy demand on the electricity grid when electric cars are charged (PC62)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

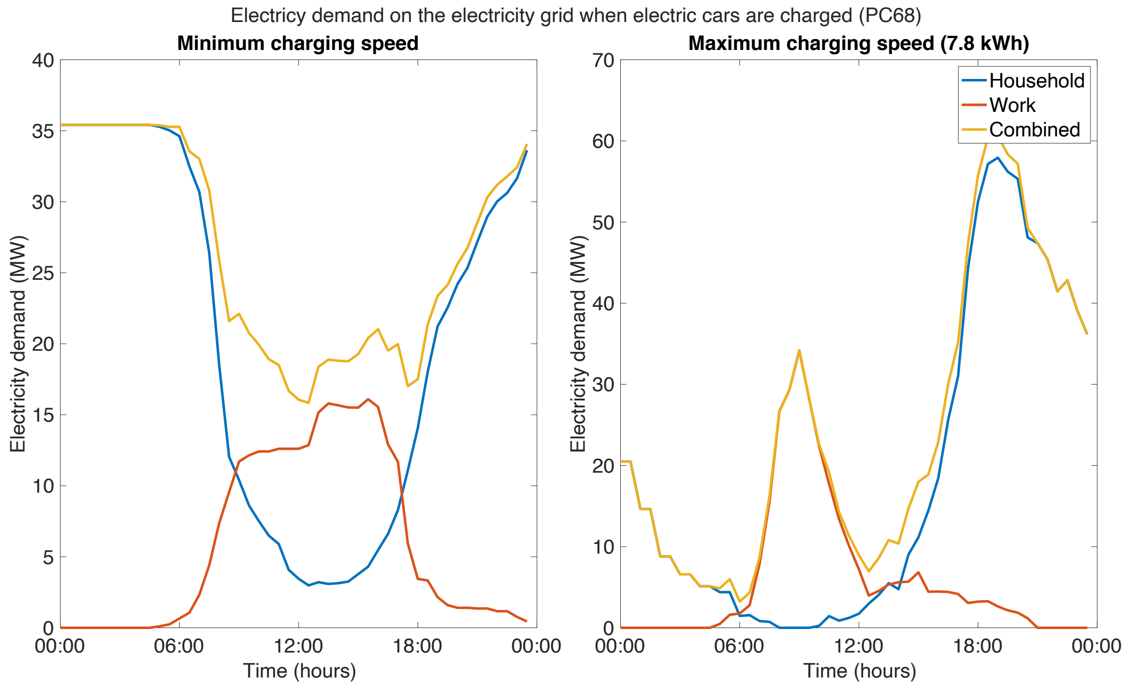

Electricy demand on the electricity grid when electric cars are charged (PC63)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

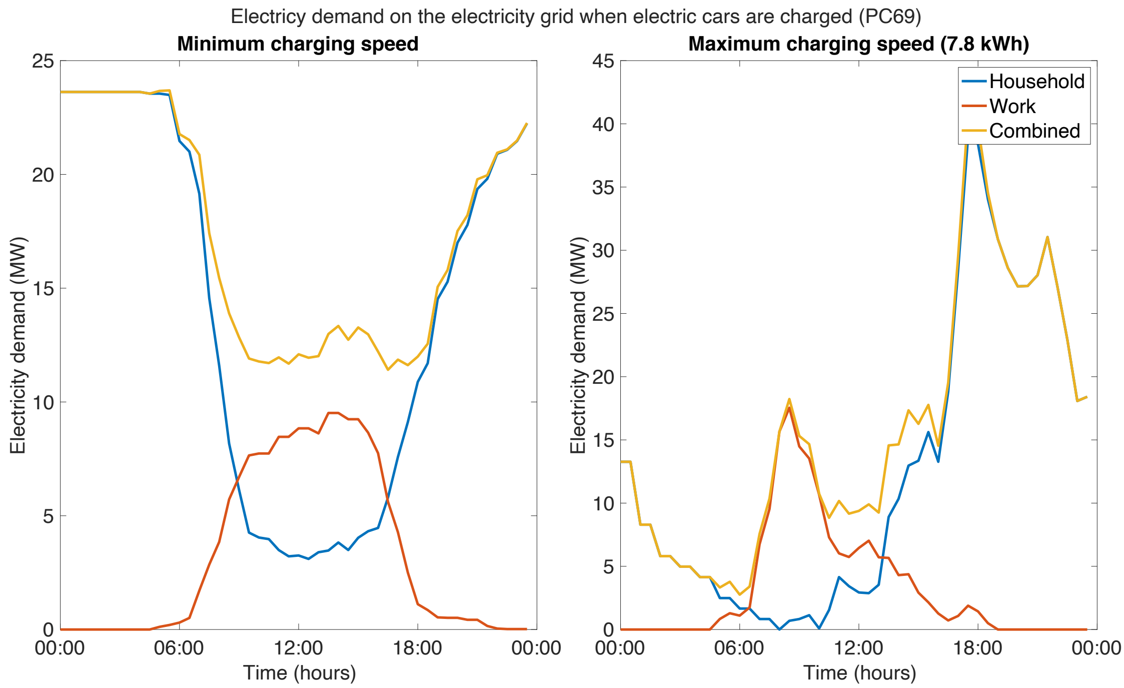

Electricy demand on the electricity grid when electric cars are charged (PC64)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
Household
Work
Combined
00:00
06:00
12:00
18:00
00:00

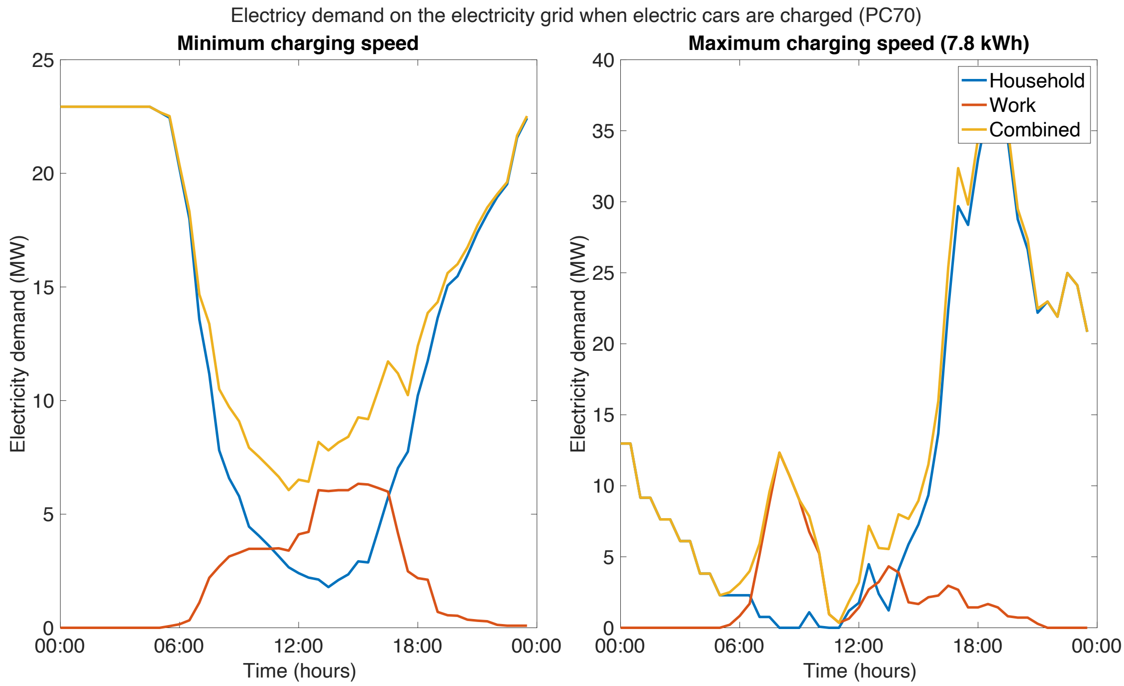

Electricy demand on the electricity grid when electric cars are charged (PC65)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
Household
Work
Combined
00:00
06:00
12:00
18:00
00:00

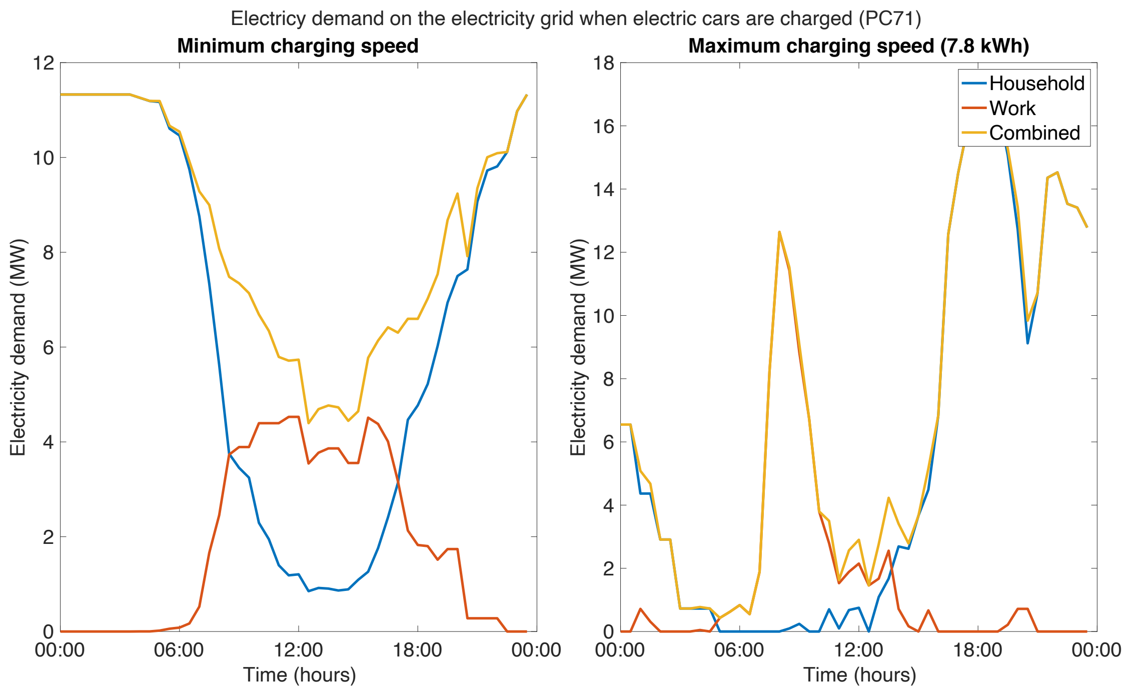

Electricy demand on the electricity grid when electric cars are charged (PC66)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
5
10
15
20
25
30
35
40
50
60
70

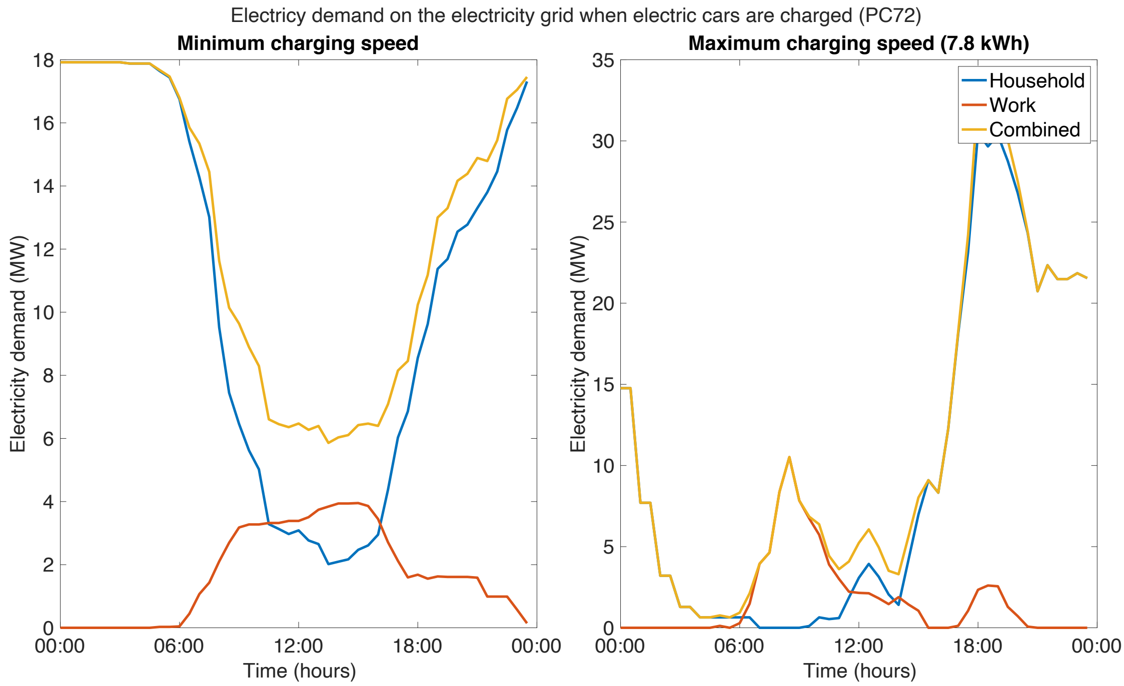

Electricy demand on the electricity grid when electric cars are charged (PC67)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
2
4
6
8
10
12
14
16
18
5
15
20
25
30
35

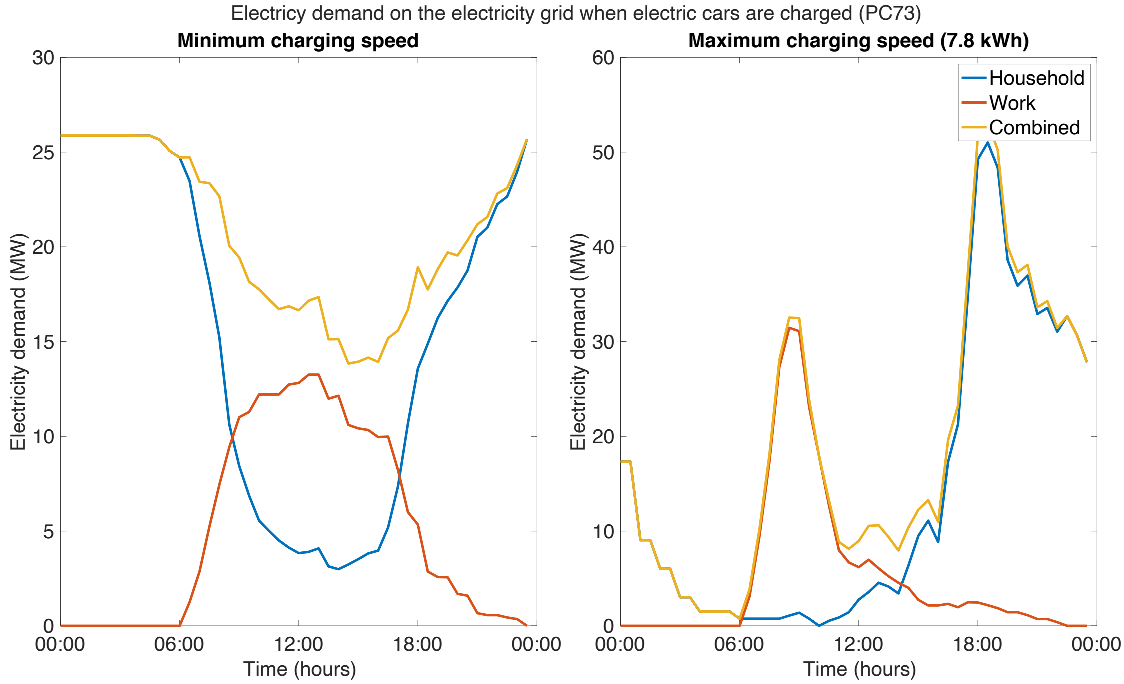

Electricy demand on the electricity grid when electric cars are charged (PC68)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
Household
Work
Combined

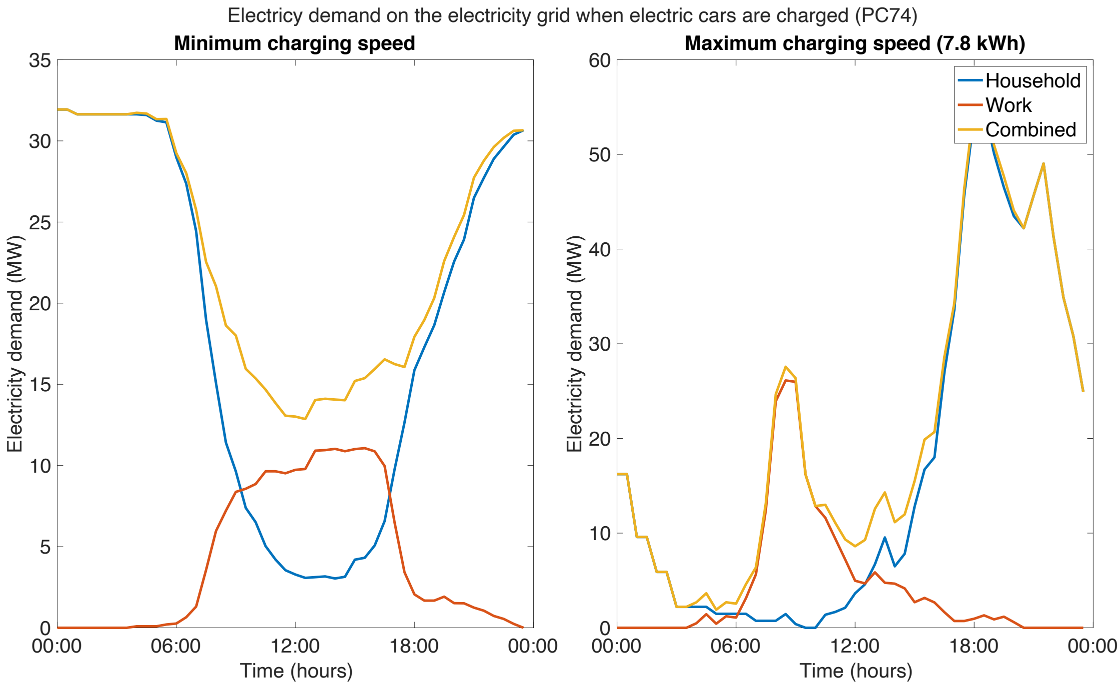

Electricy demand on the electricity grid when electric cars are charged (PC69)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
Household
Work
Combined

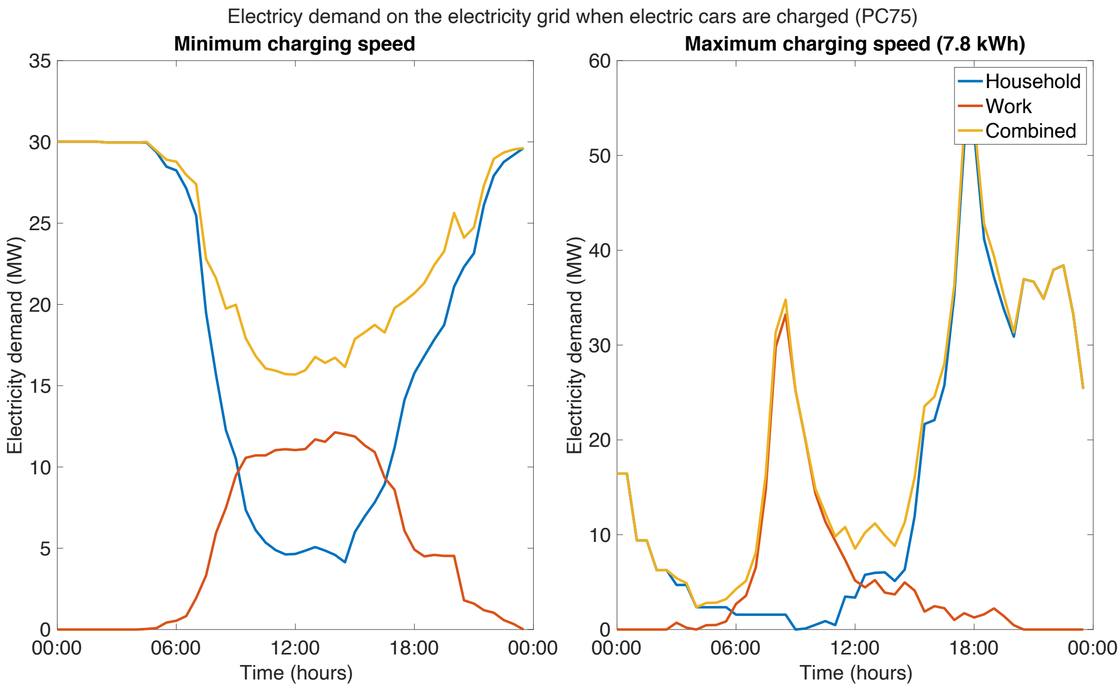

Electricy demand on the electricity grid when electric cars are charged (PC70)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00


Electricy demand on the electricity grid when electric cars are charged (PC71)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

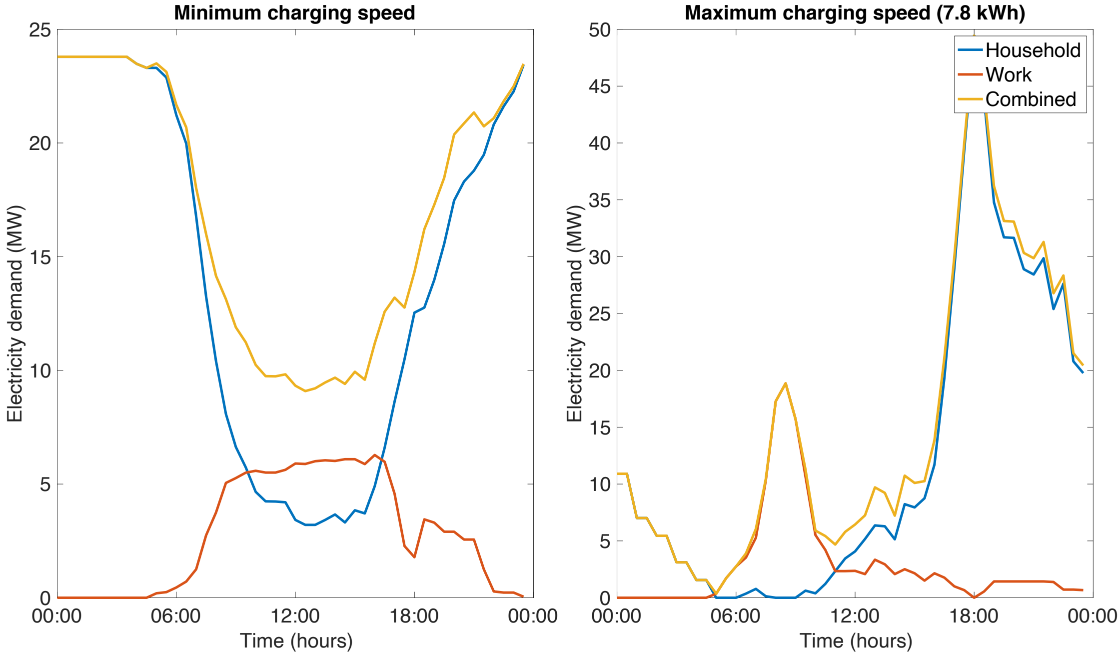

Electricy demand on the electricity grid when electric cars are charged (PC72)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
2
4
6
8
10
12
14
16
18
5
15
20
25
30
35
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC73)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
5
10
15
20
25
30
40
50
60
Household
Work
Combined

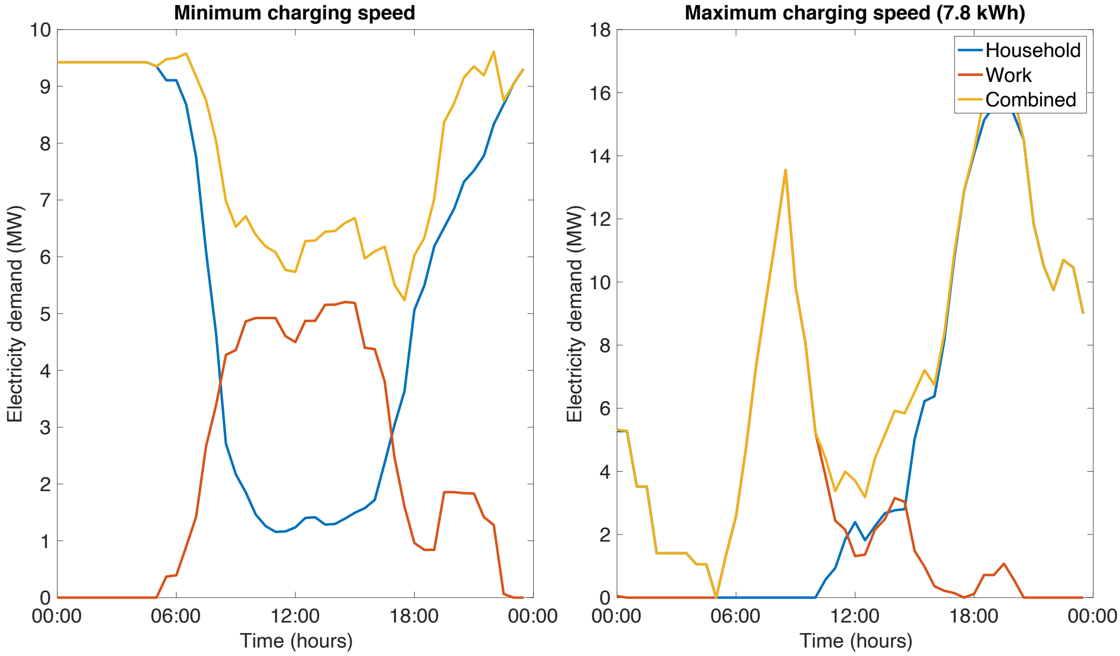

Electricy demand on the electricity grid when electric cars are charged (PC74)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

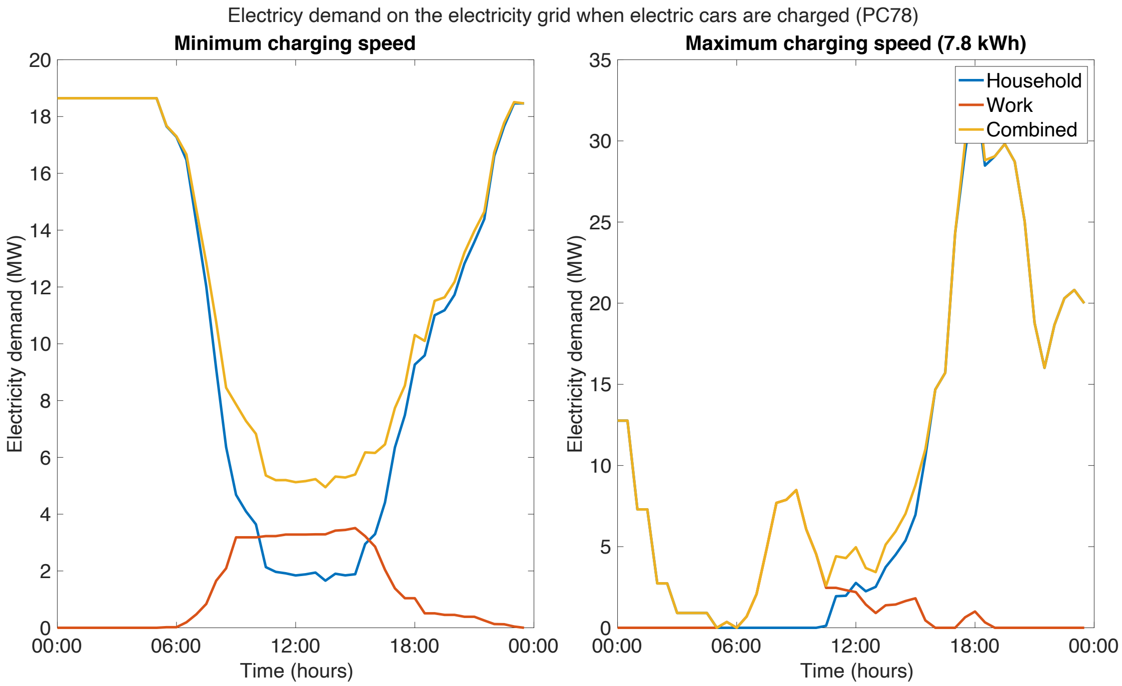

Electricy demand on the electricity grid when electric cars are charged (PC75)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

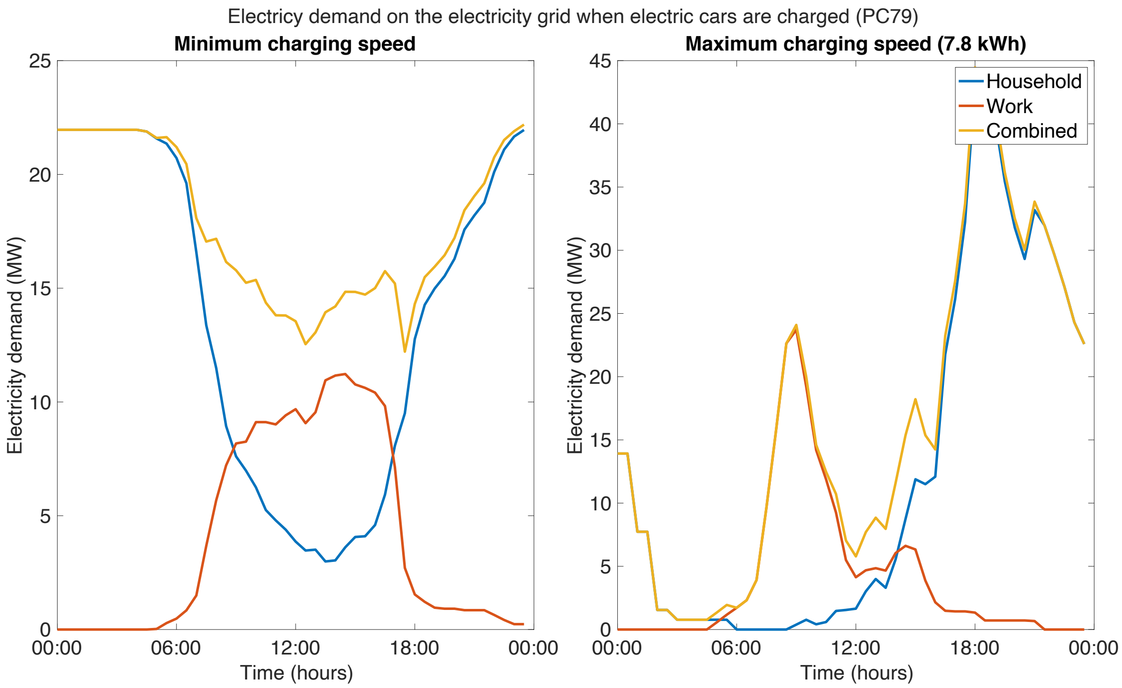
Electricy demand on the electricity grid when electric cars are charged (PC76)

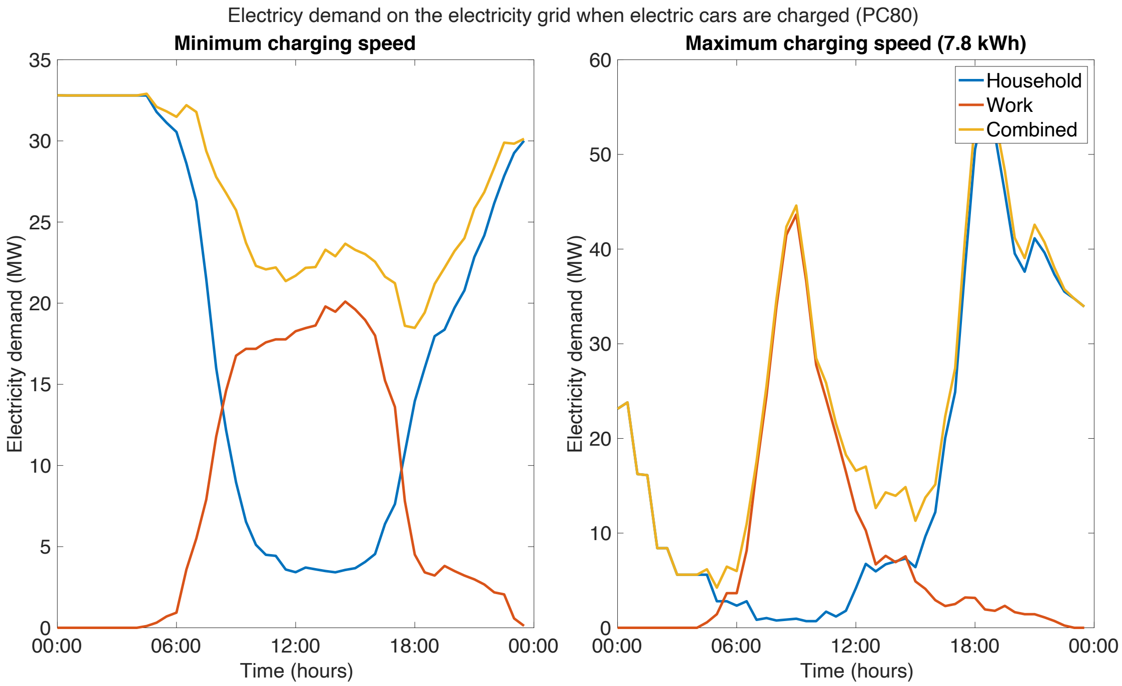


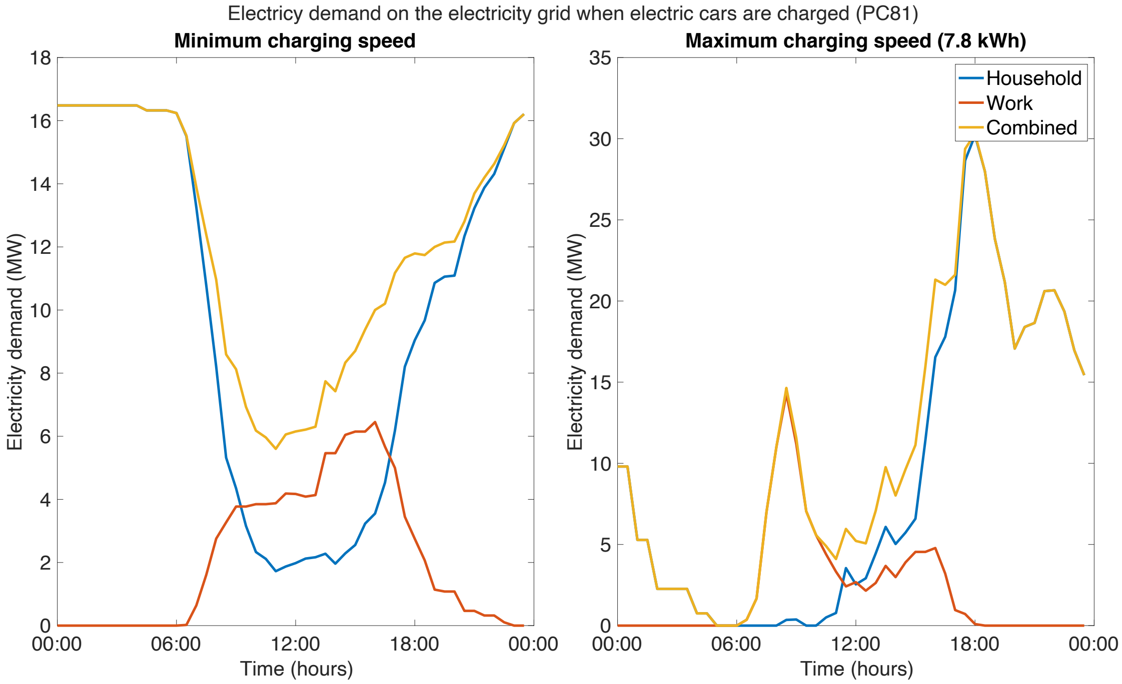
Electricy demand on the electricity grid when electric cars are charged (PC77)

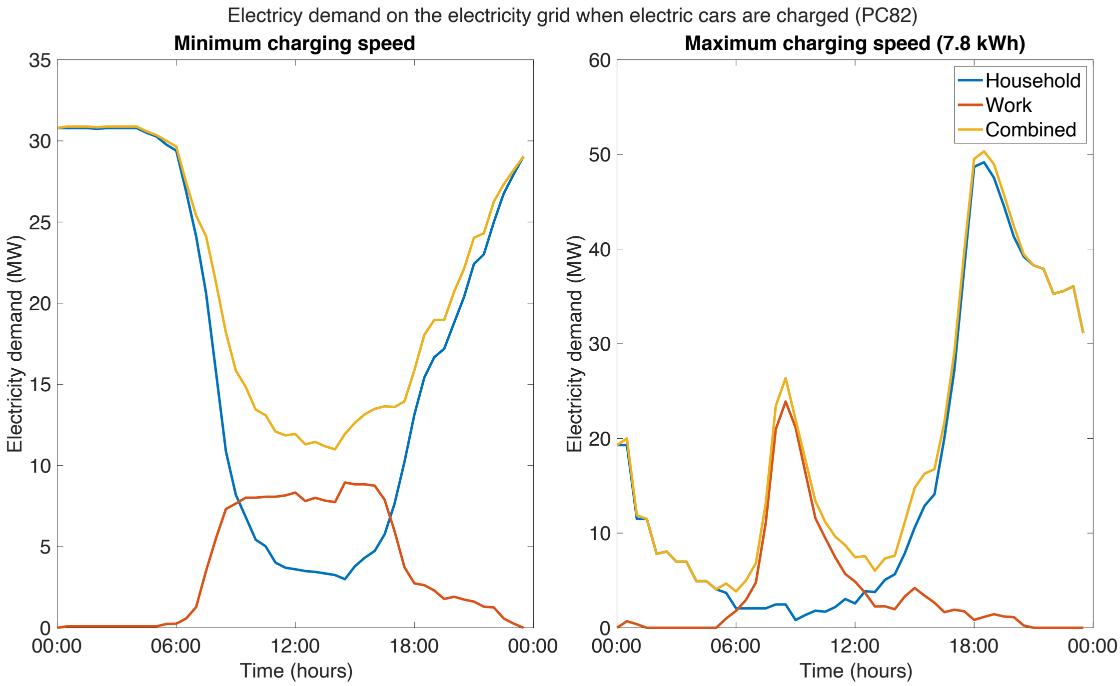


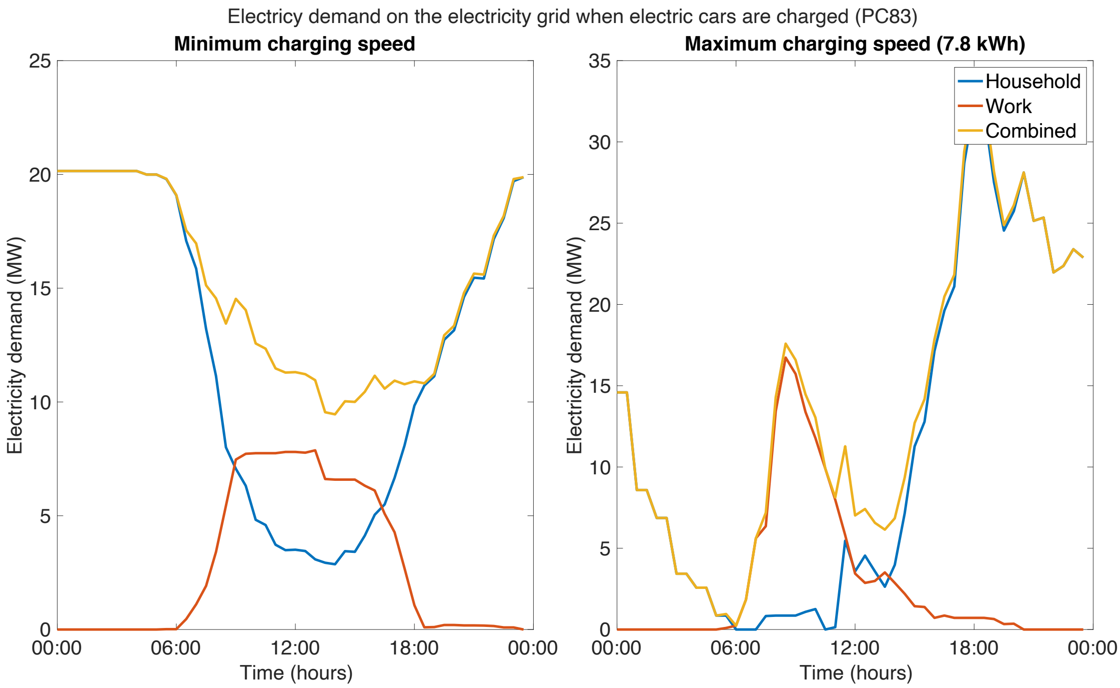

Electricy demand on the electricity grid when electric cars are charged (PC78)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

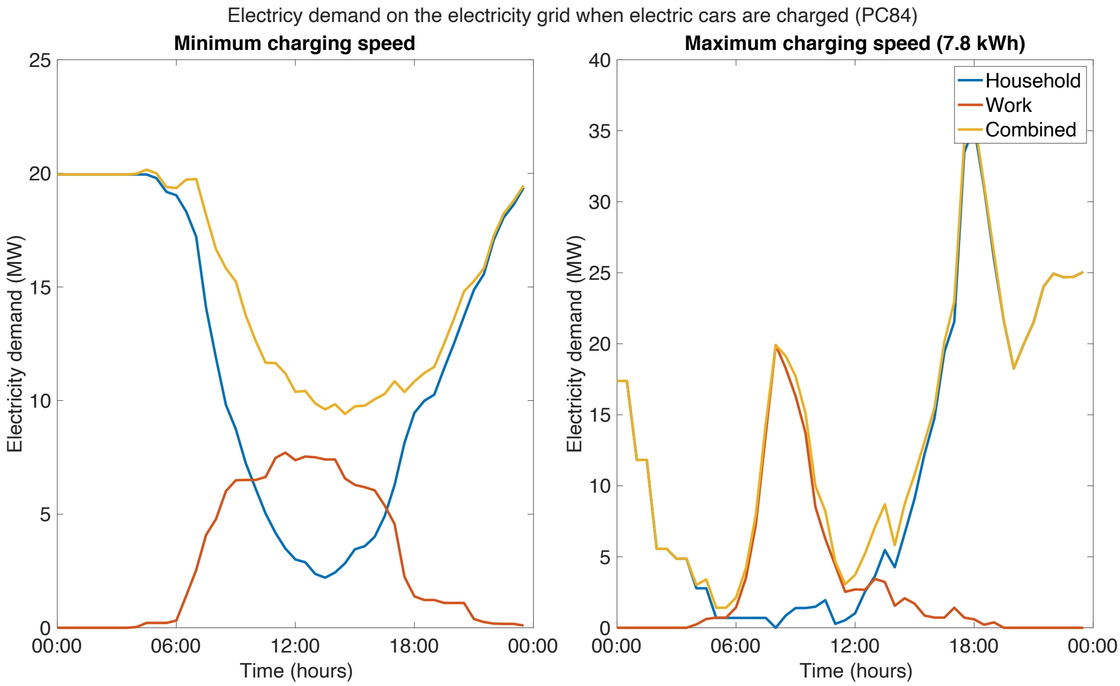

Electricy demand on the electricity grid when electric cars are charged (PC79)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

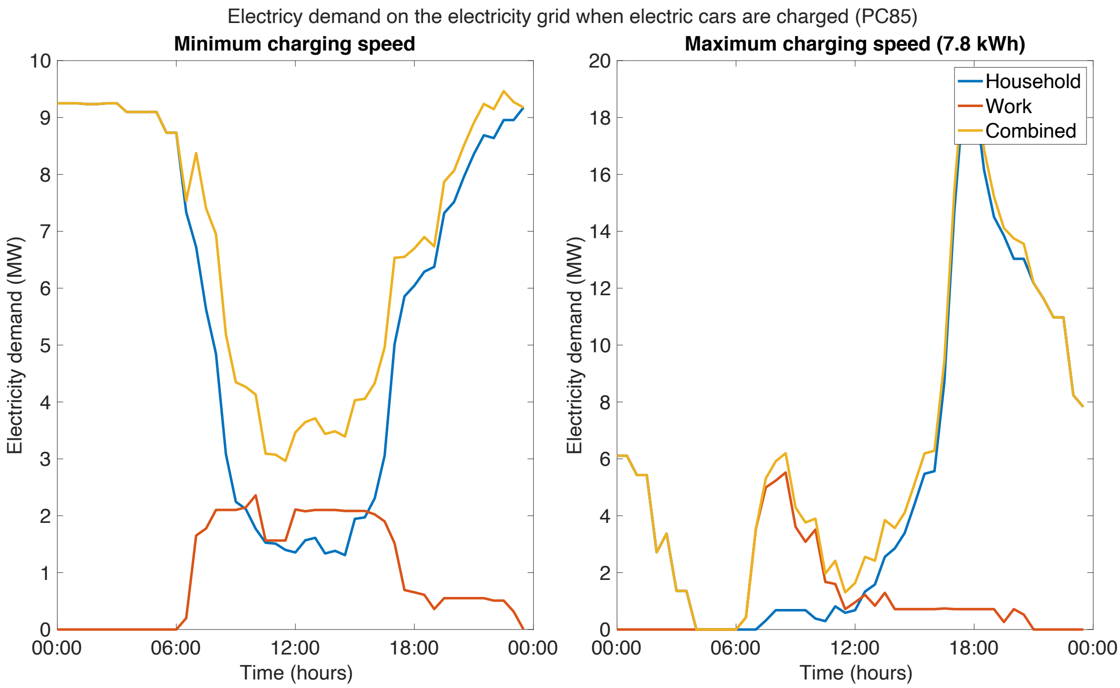

Electricy demand on the electricity grid when electric cars are charged (PC80)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

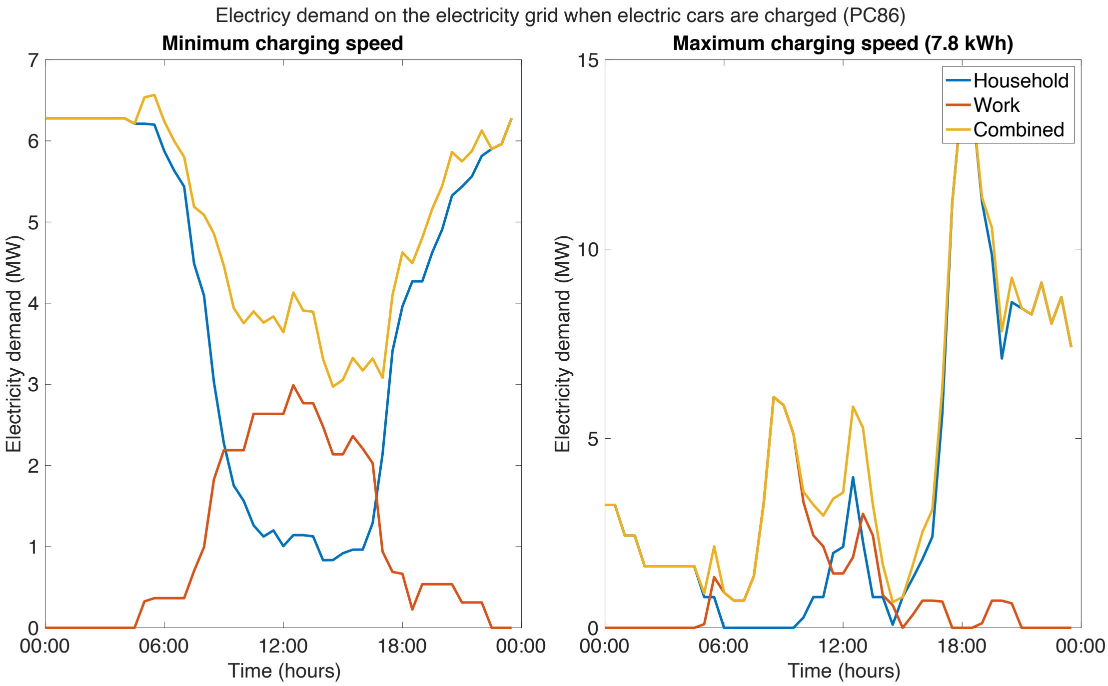

Electricy demand on the electricity grid when electric cars are charged (PC81)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

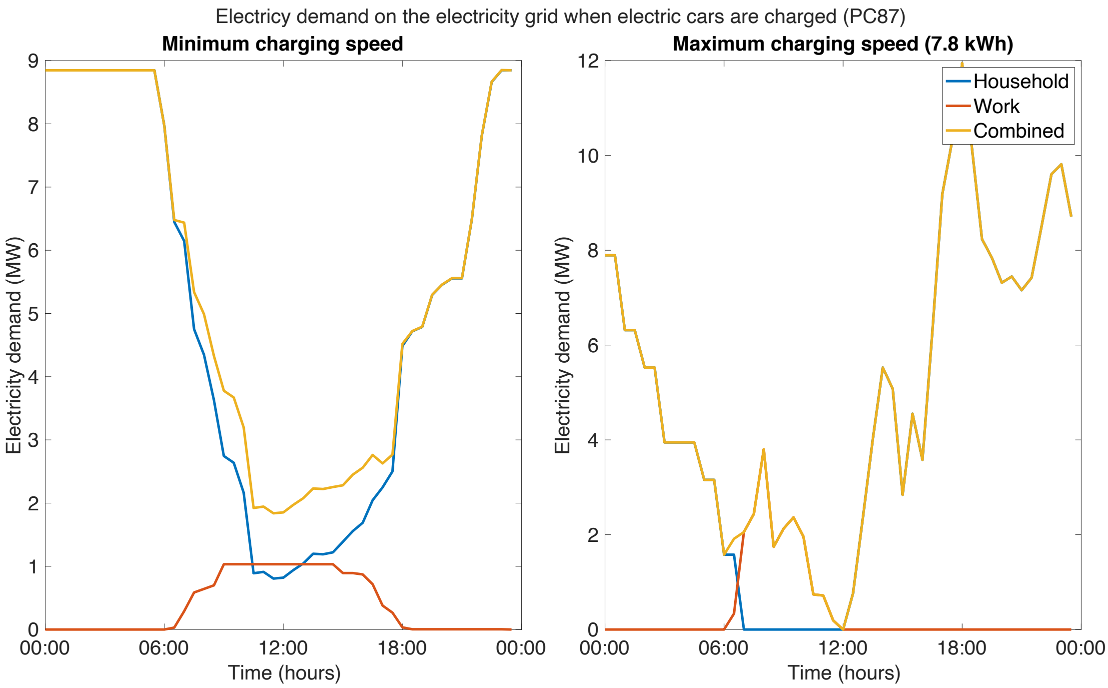

Electricy demand on the electricity grid when electric cars are charged (PC82)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

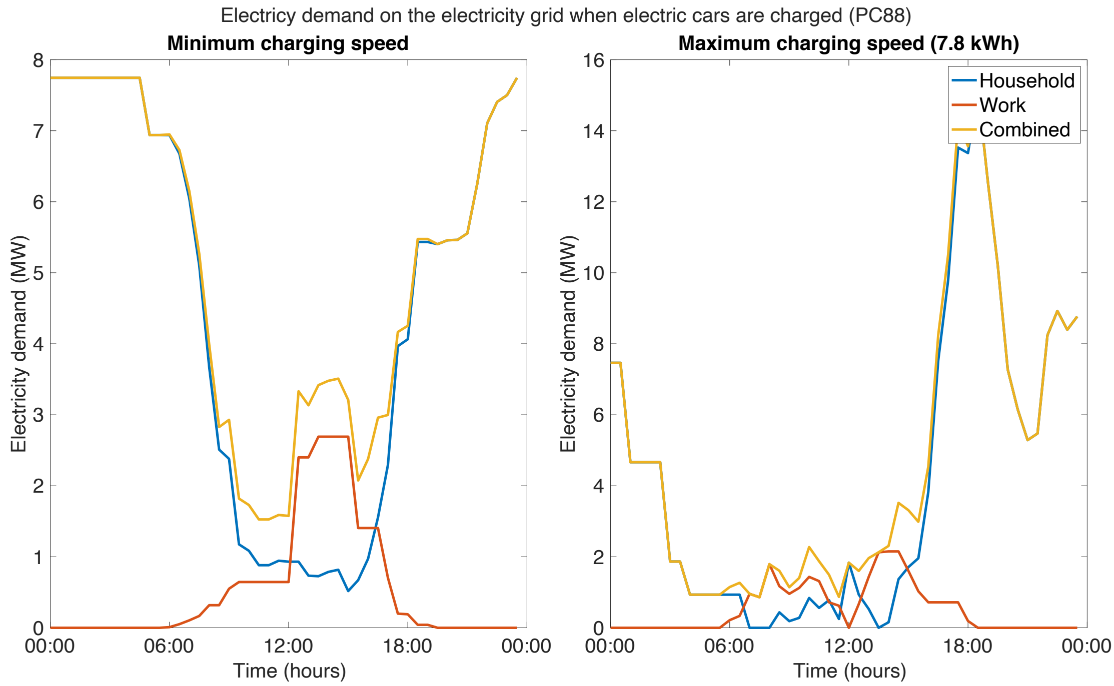

Electricy demand on the electricity grid when electric cars are charged (PC83)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

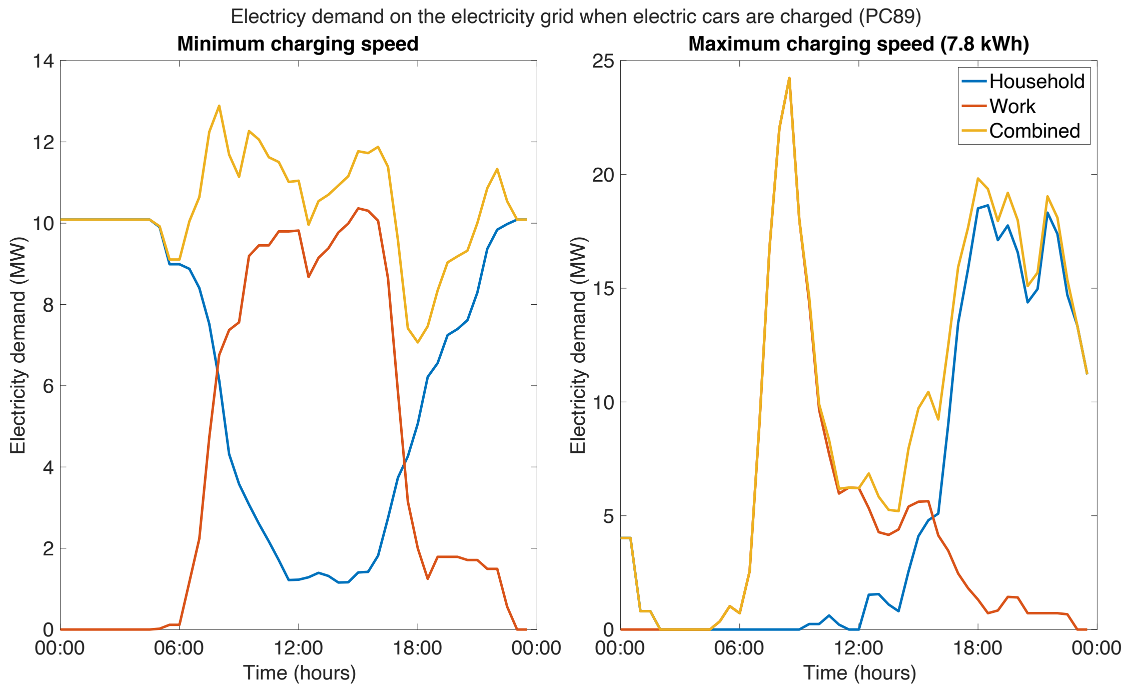

Electricy demand on the electricity grid when electric cars are charged (PC84)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

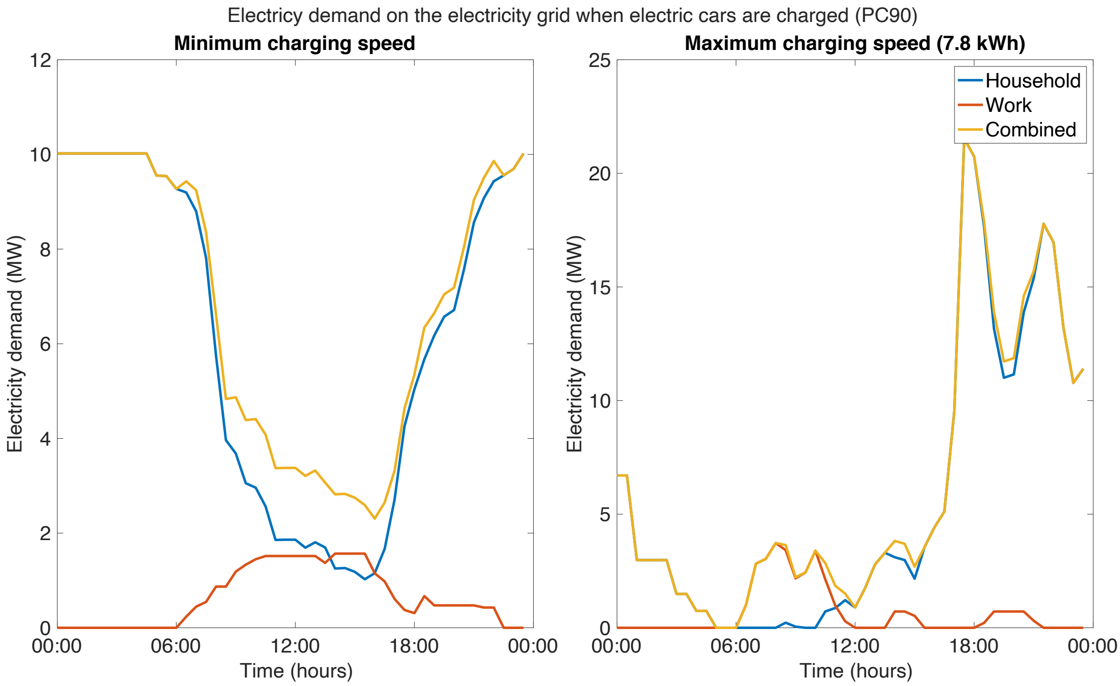

Electricy demand on the electricity grid when electric cars are charged (PC85)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00

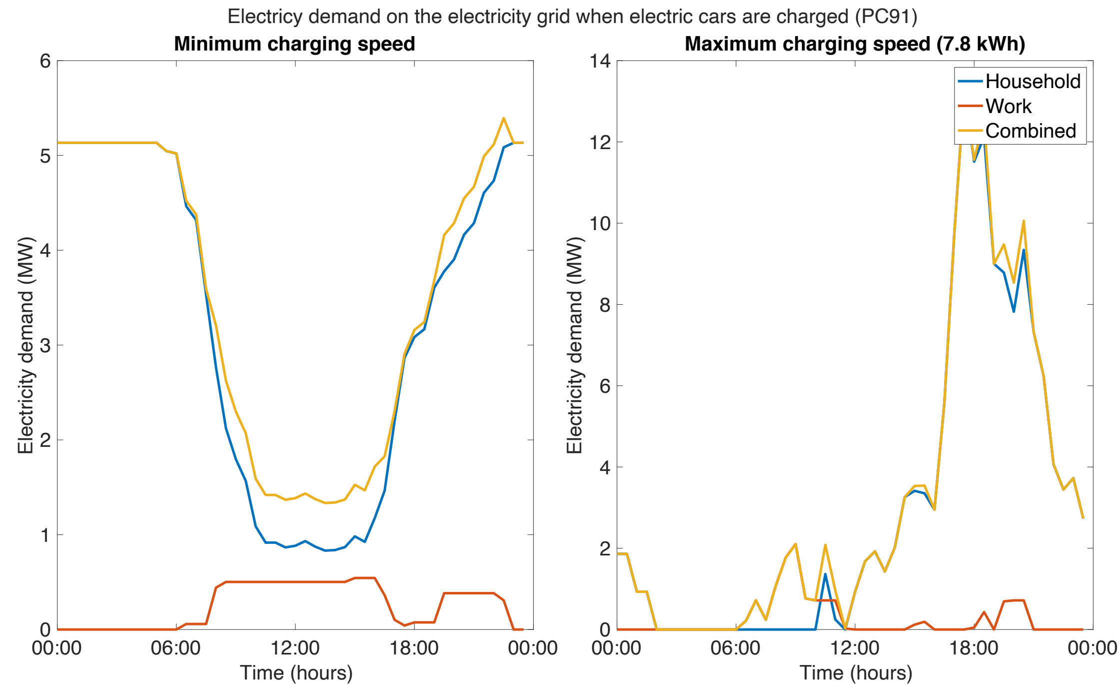

Electricy demand on the electricity grid when electric cars are charged (PC86)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
1
2
3
4
5
6
7
5
10
15

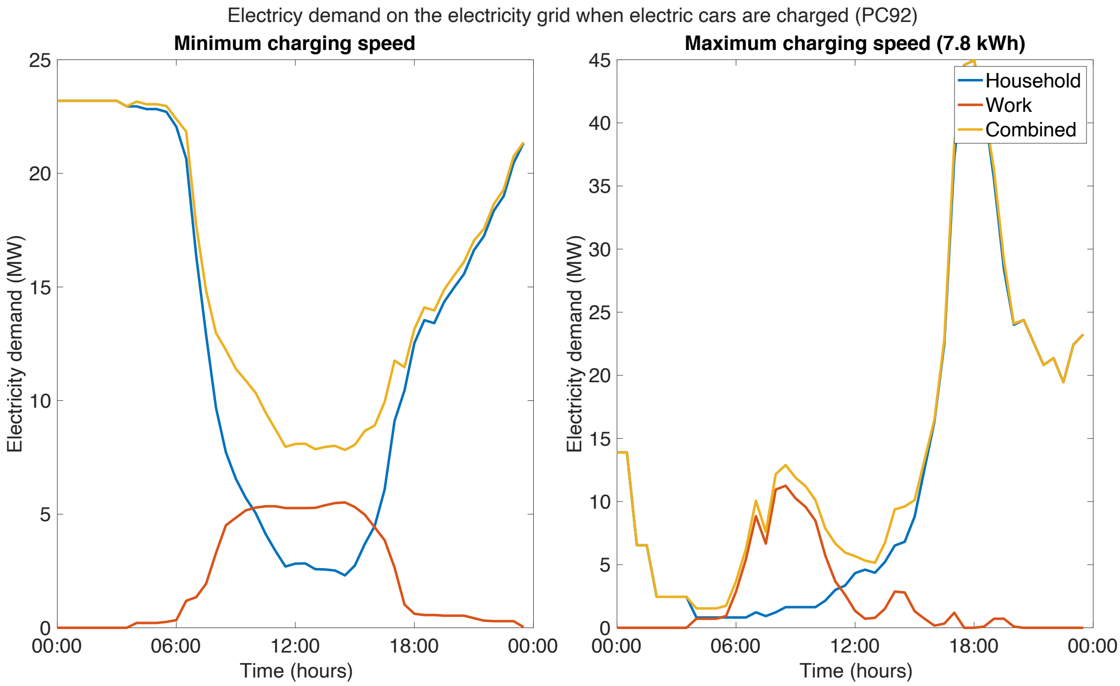

Electricy demand on the electricity grid when electric cars are charged (PC87)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Household
Work
Combined
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
0
1
2
3
4
5
6
7
8
9
2
4
6
8
10
12

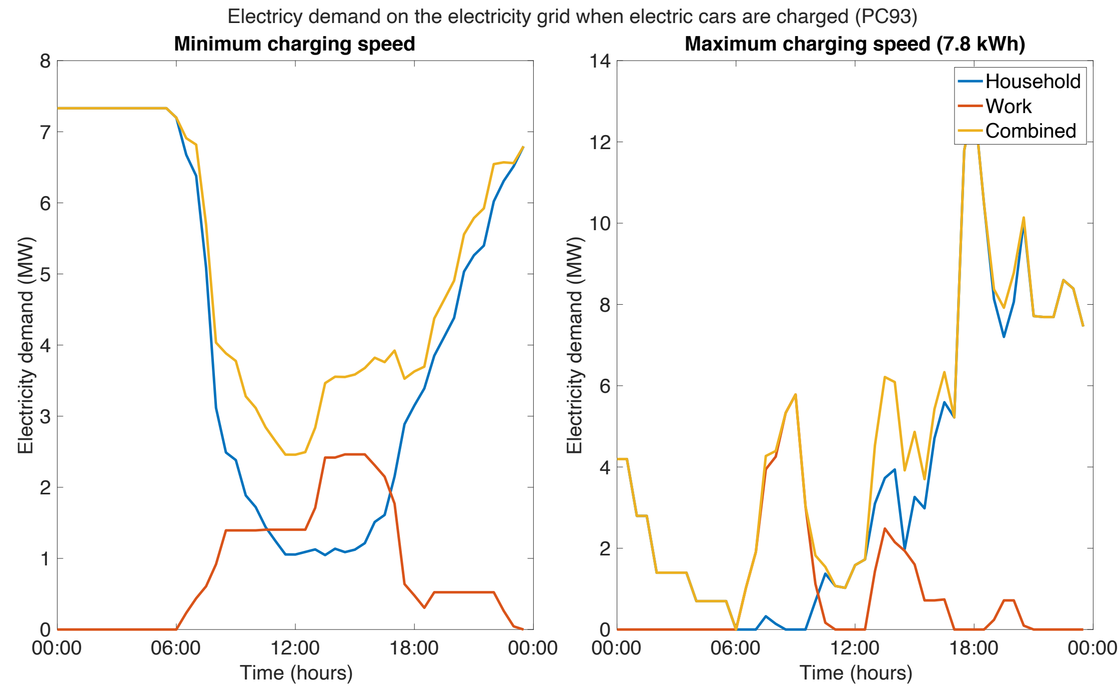

Electricy demand on the electricity grid when electric cars are charged (PC88)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC89)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined

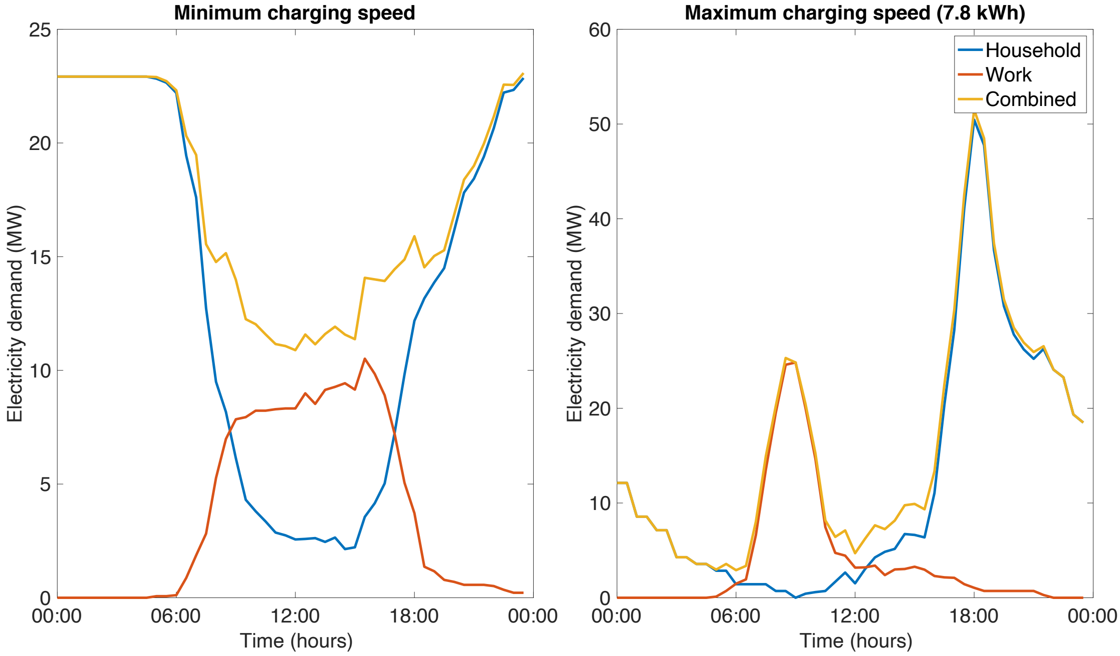

Electricy demand on the electricity grid when electric cars are charged (PC90)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC91)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

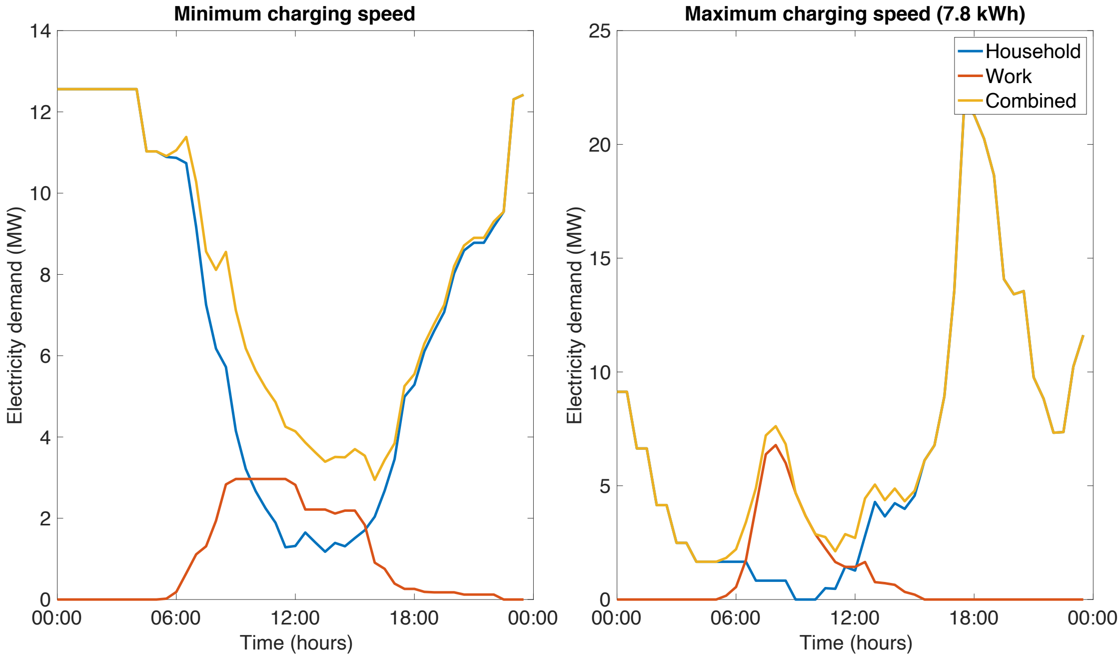

Electricy demand on the electricity grid when electric cars are charged (PC92)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

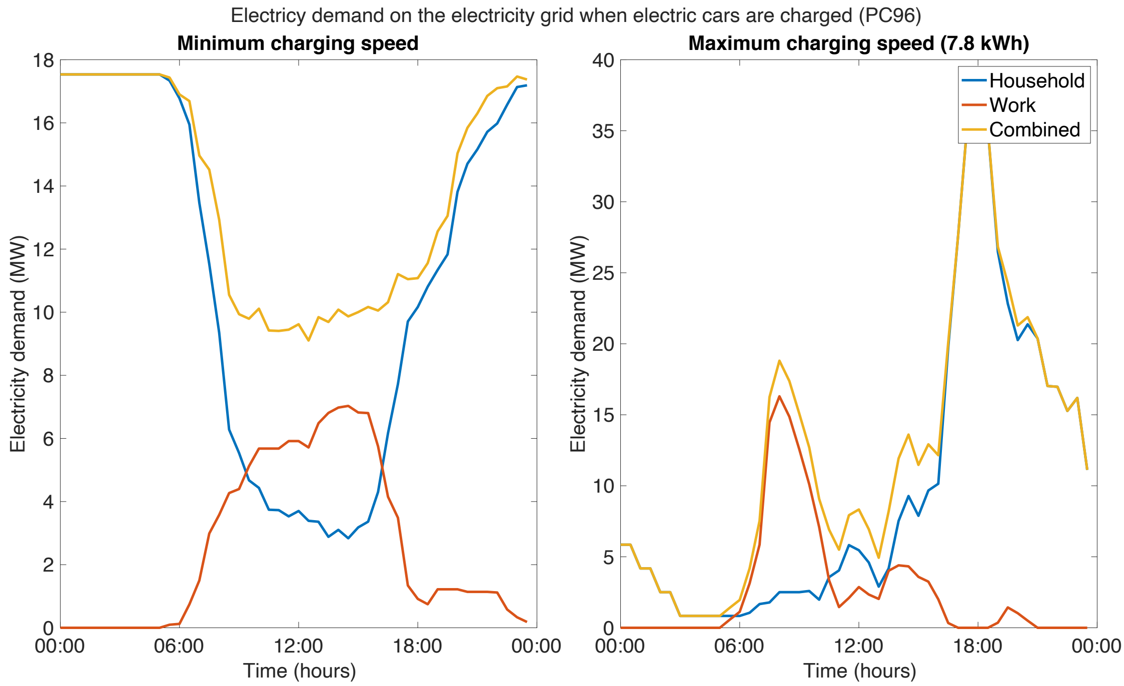

Electricy demand on the electricity grid when electric cars are charged (PC93)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined

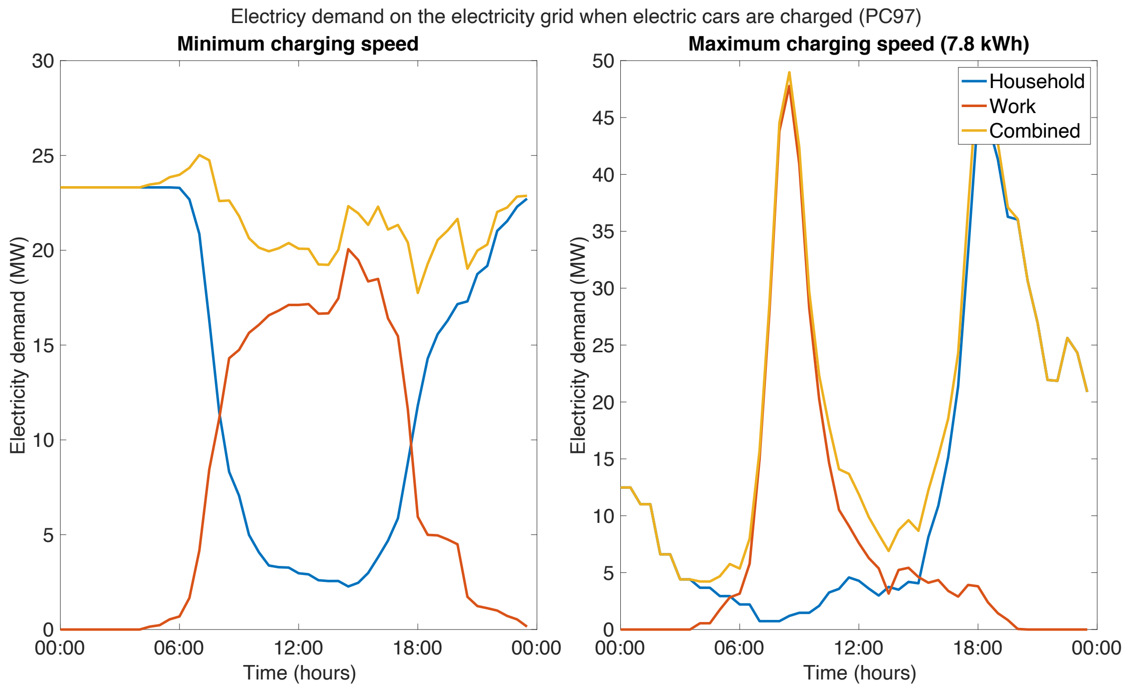
Electricy demand on the electricity grid when electric cars are charged (PC94)

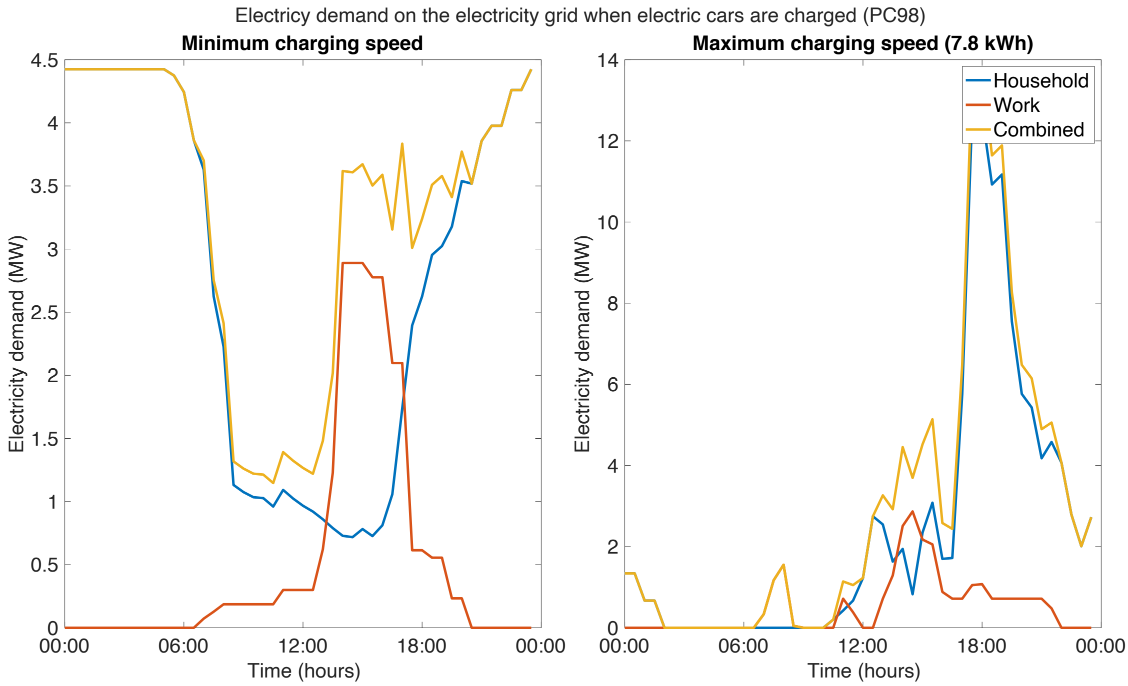


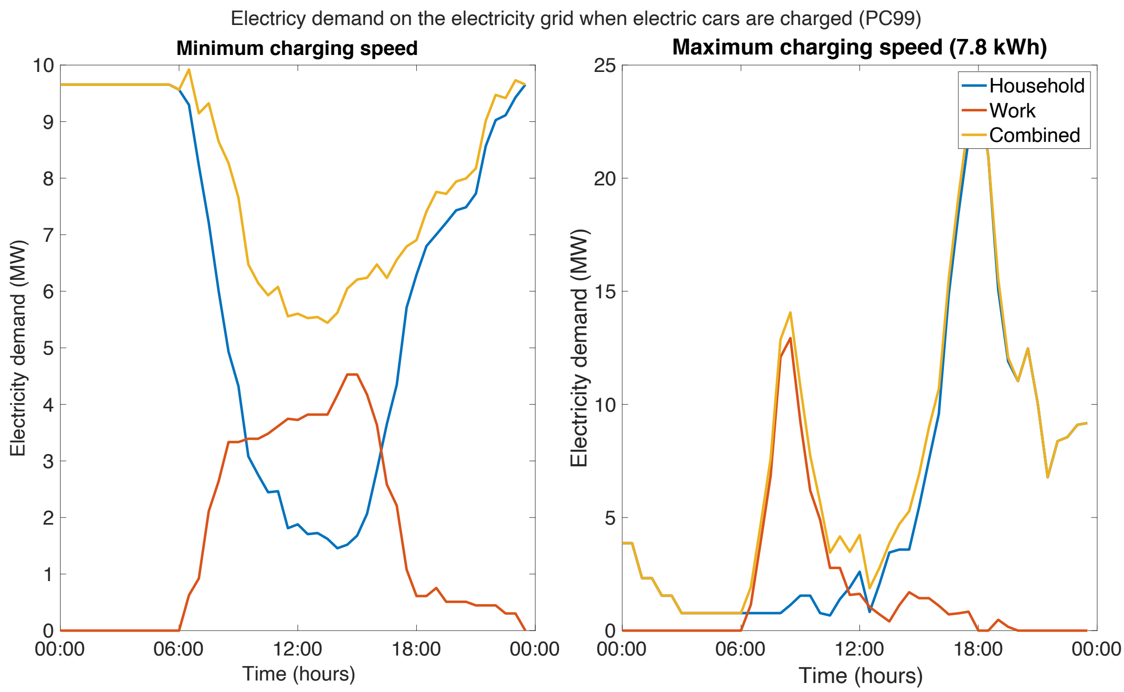
Electricy demand on the electricity grid when electric cars are charged (PC95)




Electricy demand on the electricity grid when electric cars are charged (PC96)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC97)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC98)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined


Electricy demand on the electricity grid when electric cars are charged (PC99)
Minimum charging speed
Maximum charging speed (7.8 kWh)
Electricity demand (MW)
Time (hours)
00:00
06:00
12:00
18:00
00:00
Household
Work
Combined