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High Power Charging in Berlin

Sino-German Energy Transition Project

REINER LEMOINE INSTITUT

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Imprint

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1 Current Situation of high power charging in Germany

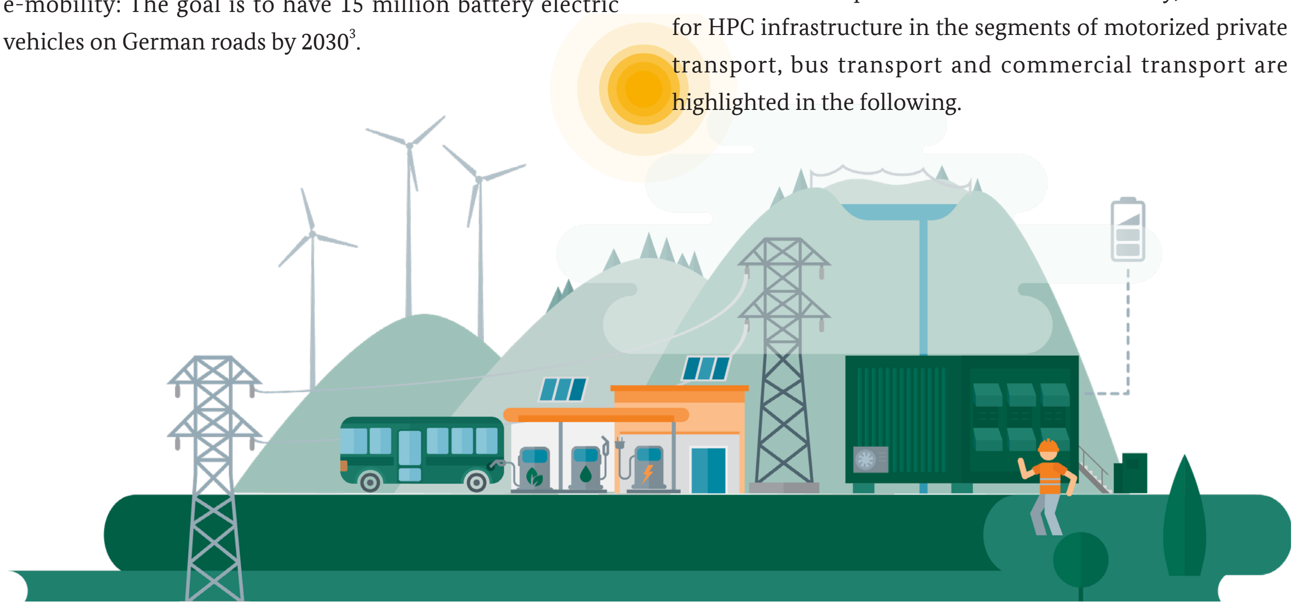
1.1 Introduction

High Power Charging (HPC) infrastructure with at least 150 kW charging capacity is crucial for the market ramp-up of e-mobility: it significantly shortens charging times. This allows integrating charging events for battery-electric vehicles into the daily routine of their users. In its coalition agreement, the new German government has set the goal of achieving a market ramp-up of at least 15 million battery electric vehicles (BEVs) by 2030. To achieve this, the HPC infrastructure must grow dynamically in line with rising demand.

For example, the government for several years has subsidized the purchase of battery electric vehicles (BEV) as well as plug-in hybrid vehicles (PHEV), launched various innovation programs and paid subsidies for private charging infrastructure[1]. In parallel, the federal and state governments have launched various programs to build publicly accessible charging infrastructure[2]. In addition, the new federal government will align the framework conditions and funding measures so that Germany is the lead market for e-mobility: The goal is to have 15 million battery electric vehicles on German roads by 2030[3].

This study focuses on the further expansion of the HPC infrastructure in Berlin. Various stakeholders are already electrifying their fleets. Private motorized transport is experiencing an ever-increasing degree of electrification. The public bus operator BVG aims to decarbonize its entire bus fleet by 2030. Numerous commercial fleet operators have been and are being encouraged to convert to electric propulsion through the WELMO funding program coordinated by the Senate. Suitable charging infrastructure must be created for these as well as other stakeholders, e.g., commuters, transit.

Previous studies on charging infrastructure expansion in the city have shown that the range of necessary charging infrastructure in the different areas in private, semi-public and public space is very large[4]. The required expansion path in the public space depends on the expansion activities in the private and semi-public space. The need for appropriate charging services depends, in particular in commercial traffic, on the charging strategies that continue to enable companies to provide their services reliably and economically. For this reason, in addition to the general infrastructure requirements for electromobility, the needs for HPC infrastructure in the segments of motorized private transport, bus transport and commercial transport are highlighted in the following.



1 https://www.bmu.de/themen/luft-laerm-verkehr/verkehr/elektromobilitaet/foerderung/

2 https://www.bmvi.de/DE/Themen/Mobilitaet/Elektromobilitaet/Ladeinfrastruktur/Ladeinfrastruktur.html

3 Bundesregierung Koalitionsvertrag - Mehr Fortschritt wagen, Berlin, 2021

4 https://www.berlin.de/sen/uvk/presse/pressemitteilungen/2021/pressemitteilung.1159454.php

1.2 Summary of stakeholder interviews

As part of the study, numerous experts from the electromobility scene were interviewed in order to discuss needs, challenges and implementation strategies and to assess their influence on the necessary further expansion of the charging infrastructure, especially in the area of HPC.

HPC is a solution for private motorized individual transport in the city, provided that people do not have their own parking spaces with charging infrastructure. In urban areas, the area is hotly contested, **HPC is an option due to the low space requirement. For this purpose, locations of conventional petrol stations are ideal**. On the one hand, these have the necessary medium-voltage connection and, on the other hand, they often already have a kiosk or toilet. This can increase the individual incentive to use these places. Due to the economic efficiency, the utilization of the charging points is to be maximized by the vehicles leaving the location immediately after completion of the charging process.

The public transport buses should be charged with HPC both in the depot and en route. **For bus companies the preferred charging strategy is depot charging**, with a charging power of 150 kW. In order to avoid an increase in the need for personnel, a charging point is ideally planned for each vehicle, as this means that vehicles do not need to be replaced while they are idle. **However, the depot charge will not be sufficient on all bus routes and will be supplemented by the charge en route**. Charging power of up to 450 kW at terminal stops are expected. If the personnel requirements in the depots can be reduced by locations in public space, this represents an economical alternative to only loading the depot.

The favoured charging strategy of commercial players is the depot charging, whereby the lowest possible charging capacity is sought. This is justified by the fact that the network connection costs and the power price are to be kept as low as possible by avoiding high load peaks. **The driving profiles show relatively long idle times outside of the tours, which is ideal for charging overnight. HPC is not intended or necessary in most cases.** The ratio between the number of vehicles and the available charging points is decisive for the need for HPC in depots. If this increases, for example if subcontractors are involved or a large part of the fleet is parked on public parking spaces without charging infrastructure, the required charging capacity increases. In this case, it is assumed that HPC will be used in the future. **Outside of depots, the need for HPC is increasingly seen for long-distance applications, which will, however, be located outside of urban areas.** It is important that there are separate parking spaces for commercial vehicles (possibly with the option of making a reservation), since the reliable availability of charging points is particularly important and these must not be blocked by private cars.

The high acquisition costs of electrically powered new vehicles and the lack of empirical values are currently seen as an obstacle or risk. Furthermore, it is important to provide separate parking spaces including charging infrastructure for (heavy) commercial vehicles in public spaces. **A dynamic reservation system including economic incentives such as flat rates is desirable for better planning**. For heavy commercial vehicles, it is not yet possible to foresee which drive technology will prevail. The selection of vehicles on the market is currently very limited. Furthermore, the question arises for many actors whether the current route plans and operational processes can be implemented with electric vehicles.

Basically, the **scarcity of space in the city poses a challenge when setting up charging infrastructure. Due to the lower overall space requirement, HPC is advantageous in this regard**. On the other hand, there are other challenges. The high charging capacities of HPC require cooling systems, which can be associated with noise pollution. Furthermore, fire protection, for example, cannot yet be planned in a standardized manner.

With regard to grid integration, the ramp-up of electromobility and the associated increase in the need for charging infrastructure are included in the grid operators' long-term planning. **HPC locations require a connection to the medium-voltage network. This can lead to relatively long planning processes**. The decisive factor here is the distance to the medium-voltage grid. A direct connection to the high-voltage grid is not necessary.

2 HPC demand and potential usage scenarios in Berlin

This study focusses on three different sectors of traffic in Berlin:

- Passenger cars
- Public transport busses
- Commercial vehicles

This study uses primarily public available data sources, which however vary strongly. Most detailed data are available for the bus sector, as these are exact timetable data from the Berlin public transport company BVG. The data are free of disturbance variables, as vehicles are only driving in Berlin and have fixed routes over a certain period. Database for scaling private transport and therefore HPC of passenger cars is the study "Mobility in Germany" (MiD)[5], which is the largest survey on everyday mobility in Germany. It asks around 150,000 households about daily trips, trip purposes, time and distance travelled as well as chosen transportation mode. In total the MiD recorded over 900,000 individual trips. Because of the differentiation of the study in rural and urban areas, a nationwide downscaling often is not necessary. In contrast to data of public transport buses and private transport with passenger cars, data of commercial vehicle traffic are less available. Because of many influencing parameters, the actual commercial traffic and therefore HPC demand is difficult to evaluate. To give a classification of HPC potential of commercial vehicles in Berlin, nationwide studies like KiD[6], studies and statistics focusing on Berlin like IWVK[7] or KBA[8] were combined.

5 Mobilität in Deutschland, BMVI, 2022, https://www.bmvi.de/SharedDocs/DE/Artikel/G/mobilitaet-in-deutschland.html

6 KiD 2010, WVI GmbH, 2012, accessed at https://www.bmvi.de/SharedDocs/DE/Anlage/G/kid-2010.pdf?__blob=publicationFile

7 Integriertes Verkehrswirtschaftskonzept, Senatsverwaltung für Umwelt, Mobilität, Verbraucher- und Klimaschutz, 2021, https://www.berlin.de/sen/uvk/verkehr/verkehrspolitik/integriertes-wirtschaftsverkehrskonzept-iwvk/

8 KBA, 2022, https://www.kba.de/DE/Statistik/Kraftverkehr/deutscherLastkraftfahrzeuge/verkehrdeutscher_node.html

2.1 Passenger cars

2.1.1 Scenarios: HPC under the influence of private charging infrastructure

The German Government differentiates between seven charging use cases for private passenger cars,, shown in Figure 1, three on private and four on publicly accessible space.[9] The charging use cases influence each other. Energy charged in one use case does not have to be loaded again in another. This study focuses on Use Case 4: High Power Charging stations in town.

The study considers four different HPCscenarios. Table 8 in the appendix summarizes the assumptions for the attractiveness of the use cases and the access to private charging infrastructure. The attractiveness of a use case can be raised for example by offering free charging, allowing for reservations or providing shopping options. The scenarios are described as follows:

- **HPC:** Reference scenario for HPC
- **HPC+:** Higher attractiveness of UC 4 & 5, lower attractiveness of UC 6
- **PrivateCharging:** High availability of private charging points, HPC less is relevant.
- **PrivateCharging+:** Low attractiveness of UC 4 & 5, high attractiveness of UC 6 & 7 for people without a private parking spot.

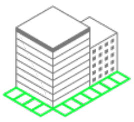
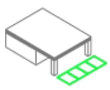
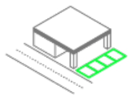
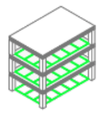
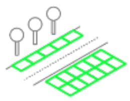
Installation location	Private space			Publicly accessible space			
	Charging use case 1	Charging use case 2	Charging use case 3	Charging use case 4	Charging use case 5	Charging use case 6	Charging use case 7
Typical locations for charging infrastructure	 Garage or private parking spaces at home	 Parking spaces (e.g. underground car parks in residential areas, multi-family houses, apartment blocks)	 Onsite company parking	 Charging station/ charging hub in town	 Charging station/ charging hub on road axes (e.g. trunk roads, highways, federal highways)	 Customer parking spaces or multi-storey car parks (e.g. shopping malls)	 Roadside, public parking spaces
Typical charging capacity (kW)	2.3 – 11 (AC)	2.3 – 11 (AC)	7.3 – 22 (AC)	Up to 150 (DC)	Up to 350 (DC)	7.3 – 22 (AC) Up to 50 (DC)	7.3 – 22 (AC)
Average standing time	Overnight	Overnight	7 h	10 – 20 minutes	15 – 30 minutes	30 – 90 minutes	< 15 minutes up to 14 h

Figure 1 Charging use cases for private passenger cars

9 Ladeinfrastruktur nach 2025/2030: Szenarien für den Markthochlauf, NOW GmbH, 2020, https://www.now-gmbh.de/wp-content/uploads/2020/11/Studie_Ladeinfrastruktur-nach-2025-2.pdf

2.1.2 Energy demand at HPC locations: Up to 25 GWh per month

The basis for the ramp-up of electromobility in Berlin is the German government's market ramp-up study. The study calculates 14.8 million electric vehicles (BEV + PHEV) registered on German roads in 2030.[10] This corresponds to just under 31 % of the total German vehicle stock of 48.8 million vehicles. This study transferred the German market rampup to Berlin, assuming a slightly stronger growth for Berlin, as from 20122021 the electric share was around 22 % above the German share of electric vehicles in the total vehicle stock.[11] **This results in a vehicle stock of 488,816 electric vehicles for Berlin in 2030, representing an electric share of 37.73 %.** Of those 488,816 electric vehicles 372,355 are private passenger cars and 116,461 are commercial passenger cars.

Figure 2 shows how the energy demand of the Berlin electric passenger car fleet is distributed to the charging use cases in the scenarios. In total, the assumed 2030 electric vehicle stock requires an energy demand of over 960 GWh/year, of which up to 300 GWh (Scenario HPC+) fall under HPC Use Case 4. The scenarios with a higher share of private charging infrastructure lower the demand at HPC locations in Berlin to around 15 GWh per month. In 2020, the total electricity demand in Berlin was about 12.3 TWh.[12] **The calculated electricity purchased at innercity HPC locations represents over 2.45% (275 GWh) of the overall 2020 Berlin demand in the scenarios with a focus on HPC, and up to 1.49% (183 GWh) in scenarios with a higher share of private charging infrastructure.**

Figure 2 shows that increased access to private charging infrastructure lowers the HPCdemand. In the PrivateCharging scenarios only up to 2,779 HPC points are needed, whereas in the HPC scenarios it is up to 4,309. Figure 2 also shows that the number of required HPC points (cross hatched) is lower than in the private Use Cases and that HPC points have a high utilitsation rate. For example, a rather low number of innercity HPC points leads to comparable energy consumption as at work (Use Case 3).

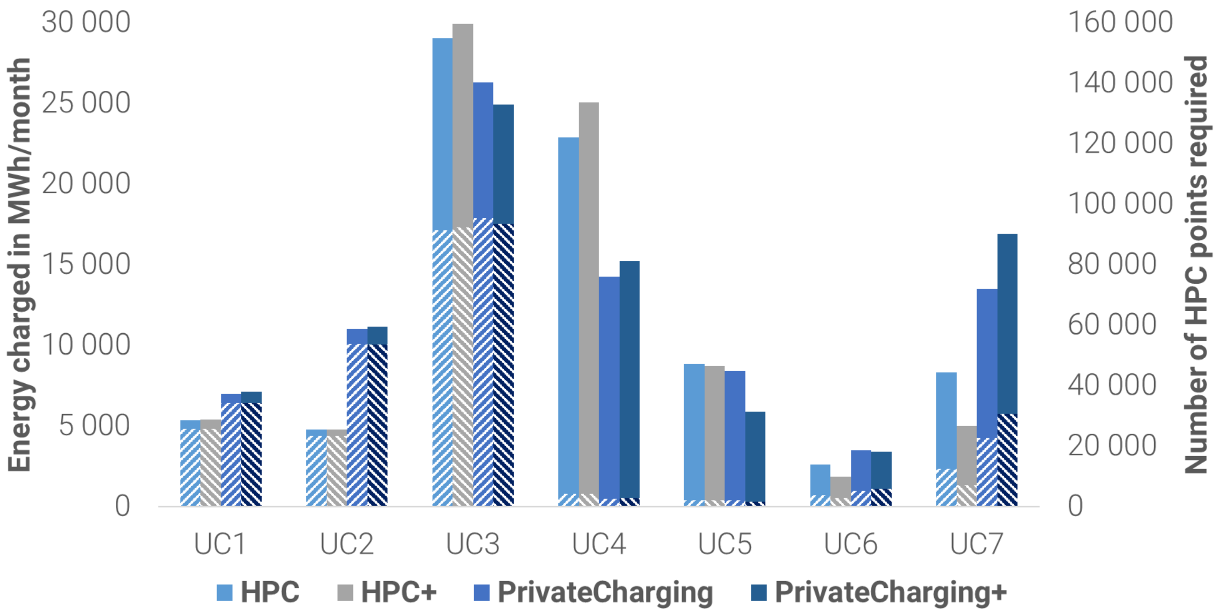


Figure 2 Monthly energy demand of the electric passenger cars and required charging points in Berlin

10 Ladeinfrastruktur nach 2025/2030: Szenarien für den Markthochlauf, NOW GmbH, 2020, https://www.now-gmbh.de/wp-content/uploads/2020/11/Studie_Ladeinfrastruktur-nach-2025-2.pdf

11 https://www.kba.de/DE/Statistik/Produktkatalog/produkte/Fahrzeuge/fz1_b_uebersicht.html

12 Stromnetz Berlin, 2021, https://www.stromnetz.berlin/uber-uns/veroffentlichungspflichten/energiewirtschaftsgesetz-enwg, accesed on 10.02.2022

2.1.3 Sensitivity analysis: Flexible charging behaviour can lower the number of charging points

This study uses a simulation, which creates charging points based on the mobility behaviour and therefore the charging needs of the population. Due to the limited number of households surveyed in the MiD and the simplified information on arrival times, the simulation may show highly condensed occurrences of charging processes. **Immediately fulfilling every triggered HPC event in Berlin would require 4,309 HPC points. However**, it can be assumed that the mobility behaviour would adapt to the infrastructure and that charging processes will be planned by users in the future before they start their journey or during their journey thanks to reservation and other intelligent usage functions, making it possible to avoid charging at peak times.

Figure 3 shows the load profile as a duration line of the total power per 15-minute time windows of a week. There are only few times in a week with a very high simultaneous charging demand. Charging points installed for that maximum demand would therefore stay unused most of the time. This study investigated the influence of timeflexibility in the HPC demand, allowing charging events to be shifted to other times with less simultaneous charging events.

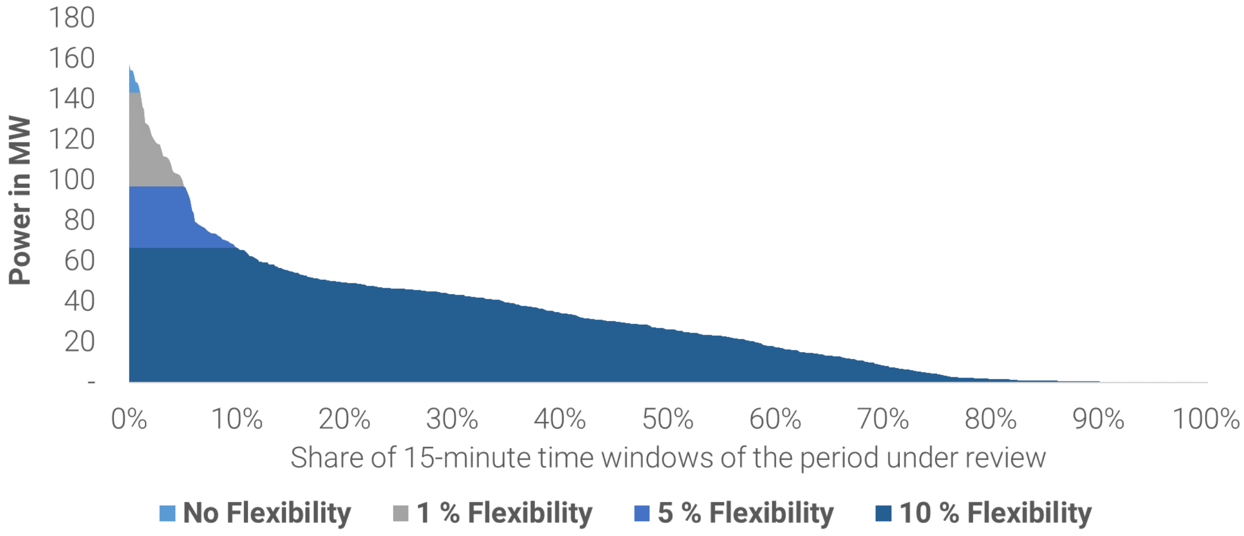


Figure 3 Distribution of the total charging power over the minutes of a week for scenario HPC

Table 1 shows the effect of the flexibility on peak power reduction in Berlin. 1 % flexibility lowers the peak power by up to 8.90 % for the scenarios with focus on HPC and 17.43% for the scenarios with focus on private charging infrastructure. **10 % timeflexibility can reduce the peak power by more than 50 %.**

Table 1 Effect of timeflexibility in charging events on total peak power at all HPC locations in Berlin

Power in MW				
	HPC	HPC+	PrivateCharging	PrivateCharging+
Peak power	157.24	154.09	92.87	103.40
1% Flexibility	143.25	143.66	86.77	85.37
5 % Flexibility	97.04	109.36	60.19	64.69
10 % Flexibility	66.54	75.72	43.25	44.99
Power peak lowered in %				
1% Flexibility	8.90 %	6.76 %	6.57 %	17.43 %
5 % Flexibility	38.29 %	29.02 %	35.18 %	37.43 %
10 % Flexibility	57.68 %	50.86 %	53.43 %	56.49 %

Temporal flexibility in charging behaviour can significantly reduce the number of HPC points required as Figure 4 shows, while also increasing the utilization of the publicly accessible charging infrastructure. 1 % timeflexibility in charging events decreases the demand for HPC points down to 72-82 %, depending on the scenario. A **10 % flexibility would even lower the demand for charging points to about 36 %**, as the example of the scenario HPC shows.

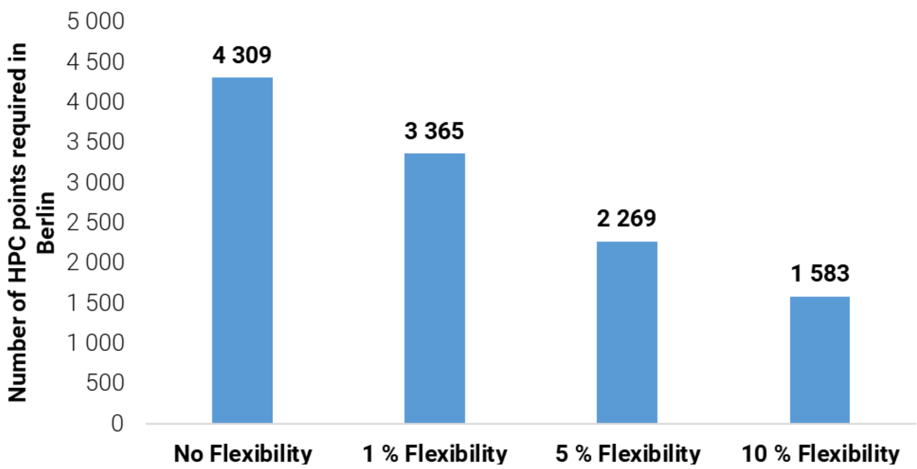


Figure 4 Influence of timeflexibility of charging events on the number of required HPC points for the scenario HPC

2.1.4. Weekly load profile: HPC demand especially on weekends

Charging demand on innercity HPC locations is higher on weekends than during the week, since people are not able to charge at work and more leisure trips occur. Especially on Sundays, the total charging power can accumulate to more than two times the highest power peak of weekdays, as Table 2 shows. **The highest demand takes place on Sunday late afternoon, representing up to 7.64 % of the total peak power in Berlin of 2,059 MW in 2020.**[13]

Table 2 Peak charging power of all high power charging points in Berlin

	Max. charging power in MW			
	HPC	HPC+	Privat-eCharging	Privat-eCharging+
Weekdays	63.50	69.92	40.13	41.22
Saturday	79.48	84.96	55.45	54.21
Sunday	157.24	154.09	92.87	103.40

Figure 5 shows the weekly load profile and the impact of the availability of private charging infrastructure and the attractiveness of the seven charging use cases. The availability of private charging infrastructure has a big impact on the cumulative power in Use Case 4 while the attractiveness only has little influence. The HPC scenarios result in 51 % 76 % more electricity demand at innercity HPC locations. The load profile also reveals that charging events happen primarily during the day with peaks at midday, whereas at night almost no charging takes place.

13 Stromnetz Berlin, 2021, https://www.stromnetz.berlin/uber-uns/veroffentlichungspflichten/energiewirtschaftsgesetz-enwg, accesed on 10.02.2022

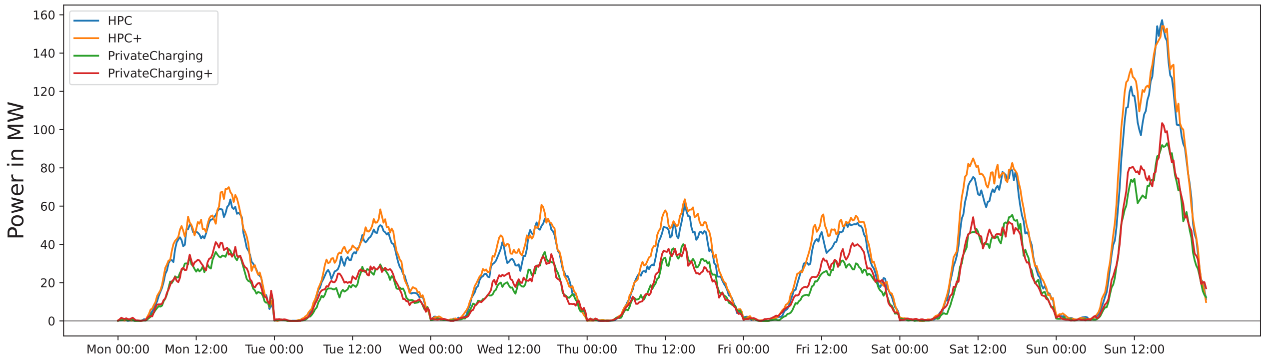


Figure 5 Impact of the availability of private charging infrastructure and the attractiveness of the charging use cases on the weekly HPC load profile of electric passenger cars in Berlin

In the passenger car sector a focus on HPC leads to a higher energy demand during midday, whereas increased access to private charging infrastructure allows shifting demand to nightimes as Figure 6 shows. In general the highest power occurs on Sundays with peaks of **247-255 MW in the HPC scenarios** and **212-217 MW in the private scenarios**.

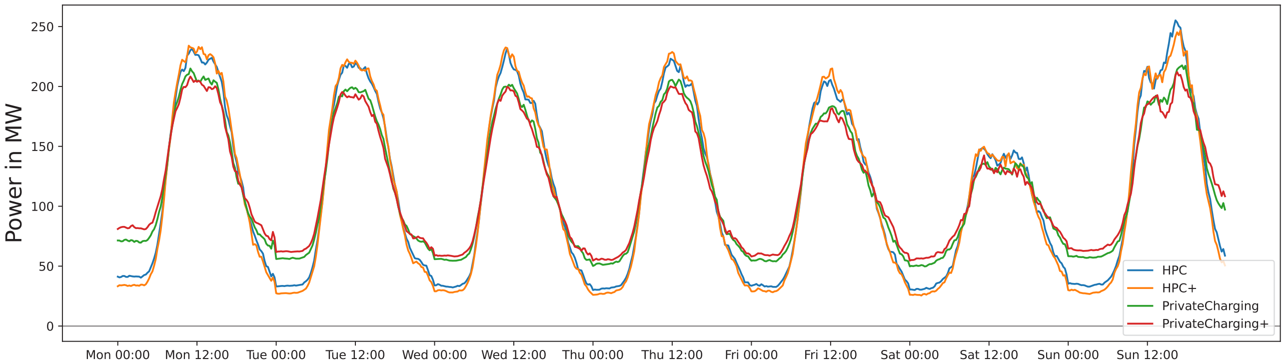


Figure 6 Total load profile of all charging use cases for passenger cars in Berlin

2.2 Public transport busses

The Berlin transport company BVG aims for an allelectric bus transport in 2030 with about 1,900 electric busses.[14] By the end of 2021, the BVG operated 137 electric busses in Berlin. An additional 90 electric busses will be delivered in 2022[15]. To analyse the demand for HPC in the public bus transport in Berlin this study used driving data of all bus lines for one week from the BVG. Specific trip lengths, the battery capacity and energy consumption are used to calculate the energy demand and required charging power for each bus. The analysis is based on the current bus schedule, including 1,450 busses.

The study investigated two scenarios:

Focus Depot Charging:

- Using depot chargers as preffered bus type
- 70 terminal stops electrified (most frequently used with long standing times)
- Higher battery capacity for depot chargers of up to 500 kWh

Focus Opportunity Charging:

- Using opportunity chargers as preffered bus type
- All terminal stops electrified
- Lower capacity for depot chargers of up to 310 kWh

In both scenarios the **energy consumption of the Berlin bus fleet cumulates to over 159 GWh/year** (3.05 GWh/week). The energy consumption is unaffected by the increasing number of busses, as the expansion of the fleet will ensure the current rotations.

2.2.1 What happens in the depots?

The study evaluated three different charging strategies at the bus depots of the BVG:

- **Uncontrolled:** charging with maximal power after plug-in (150kW)
- **Balanced:** charging with the minimal needed power over the whole idle time
- **Grid restricted:** balanced charging with a charging break between 6 - 8 pm

The charging strategy has a high impact on the load profile and the peak power at the depots, as Table 3 and Figure 7 show. Using uncontrolled charging leads to power peaks of more than 5 MW in most depots, whereas balanced charging can reduce the power peak by half. The energy demand however is unaffected by the charging strategy. In the scenario **focussing on depot charging results in a total of 57.69 GWh/year** with an average energy consumption per depot of around 158.04 MWh/week, whereas **focussing on opportunity charging results in a total of 15.02 GWh/year** (41.16 MWh/week per depot on average).

Table 3 Peak power and weekly energy demand of Berlin bus depots

	Britz	Cicerostraße	Indira-Gandhi-Straße	Lichtenberg	Müllerstraße	Spandau	Other
Focus Depot Charging							
Peak power in MW (uncontrolled)	4.65	7.04	5.96	3.52	5.40	5.55	5.27
Peak power in MW (balanced)	2.47	2.32	2.90	1.59	2.11	2.34	1.45
Peak power in MW (grid restricted)	2.62	2.42	3.04	1.67	2.21	2.48	1.56
Energy in MWh/week	167.89	195.32	196.11	102.78	168.04	143.96	132.18
Focus Opportunity Charging							
Peak power in MW (uncontrolled)	1.78	2.53	2.39	1.72	2.62	2.36	2.24
Peak power in MW (balanced)	0.57	0.61	0.65	0.48	0.65	0.47	0.39
Peak power in MW (grid restricted)	0.60	0.64	0.69	0.50	0.69	0.49	0.43
Energy in MWh/week	44.43	45.10	45.76	33.75	47.50	36.01	35.55

14 Torsten Mareck, BVG, VDVKonferenz 02.2020: Der Berliner Weg: Elektro und Trolley

15 https://www.tagesspiegel.de/berlin/65-millionen-euro-fuers-berliner-klima-bvg-kauft-90-weitere-e-busse-von-einem-neuen-hersteller/27879928.html

During the week, the buses operate more often than on weekends. Therefore, the energy demand is lowest in the nights from Sunday to Monday, as Figure 7 shows. Grid restricted charging only slightly increases the power peak compared to normal balanced charging, since the energy normally charged between 6-8 pm is charged later in the night. These effects are also shown in Table 4 for all depots combined.

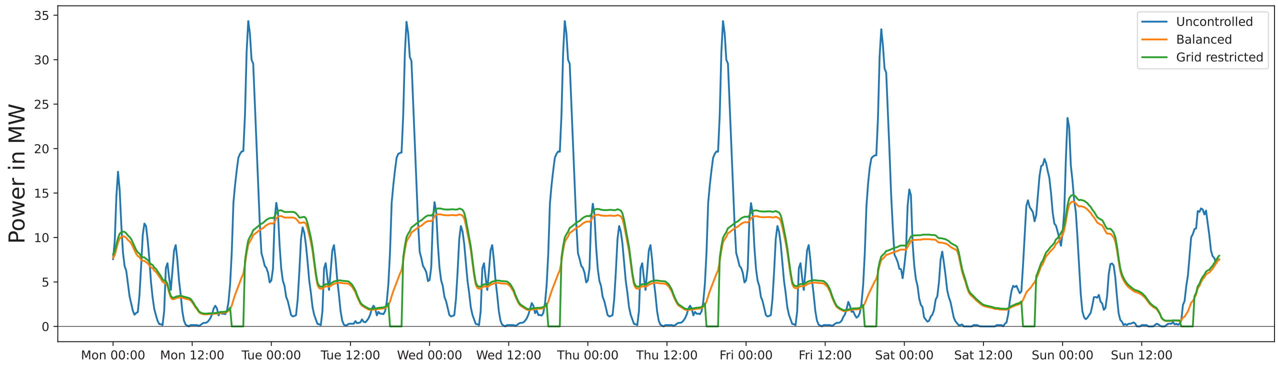


Figure 7 Load profile fo all Berlin bus depots depending on the charging strategy. Scenario "Focus Depot Charging"

The load profiles of the Berlin bus depots show that in contrast to the load profile of the passenger cars charging takes place mainly during the night. Only uncontrolled charging leads to high power peaks in the evening hours, when most of the busses return to the depot.

Table 4 Energy charged per year and peak power for all depots depending on the charging strategy and scenario

	uncontrolled	balanced	grid restricted
Energy charged in GWh/year			
Focus Depot Charging	57.69	57.63	57.63
Focus Opportunity Charging	15.02	15.02	15.02
Power peak in MW			
Focus Depot Charging	34.35	14.04	14.78
Focus Opportunity Charging	10.94	3.71	3.92

2.2.2 What happens on the road?

Berlin busses operate a total of 9,936 rotations peer week. The number of rotations fulfilled by charging en route highly depends on the number of terminal stops electrified. In the scenario "Depot Charging" the 70 terminal stops are selected by the waiting time of busses at a stop and the number of trips reaching that stop during a week.

Table 5 shows the number of rotations that can be fulfilled by only charging on the way. **Electrifying all terminal stops and only charging en route allows for an operation of 9,869 rotations. This represents 99.3 % of all rotations in a week**.

Table 5 Distribution of all rotations depending on the number of terminal stops electrified

	Focus Depot Charging	Focus Opportunity Charging
Rotations SoC drops below 0	40	52
Rotations with depot charging	4740	15
Rotations with opportunity charging	5156	9869

Since the buses are primarily in operation during the day, more opportunity charging takes place at this time as well. Figure 8 shows the load profile of all opportunity chargers in Berlin for the different scenarios. In the scenario with all terminal stops electrified, the load peaks add up to over 36 MW during the week. On weekends, when fewer buses are in operation, the load peak reduces to less than 26 MW. If the focus lies on depot charging and only 70 terminal stops are electrified, the total peak power during the week is about 28.5 MW.

In the scenario "Focus Opportunity Charging" the energy consumption at terminal stops accumulates to around 144 GWh/year, whereas in the scenario "Focus Depot Charging" it is only 101 GWh/year.

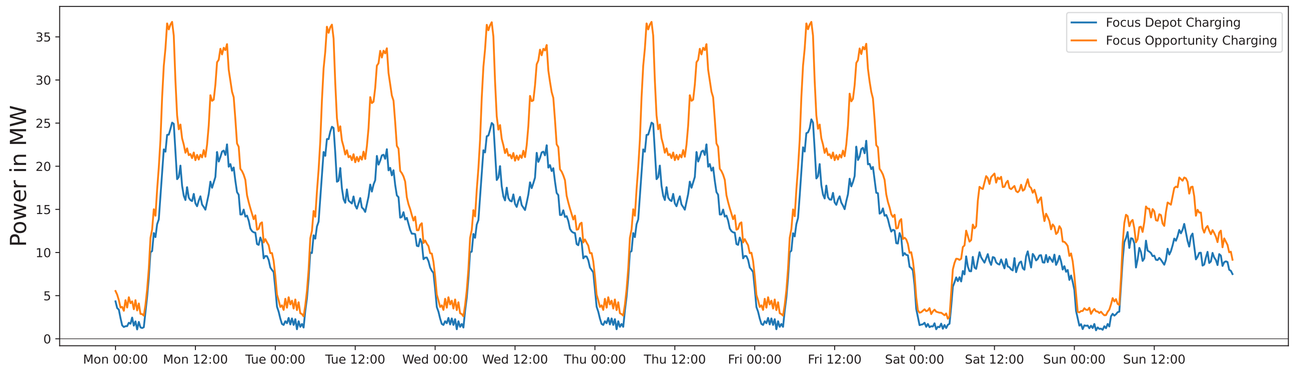
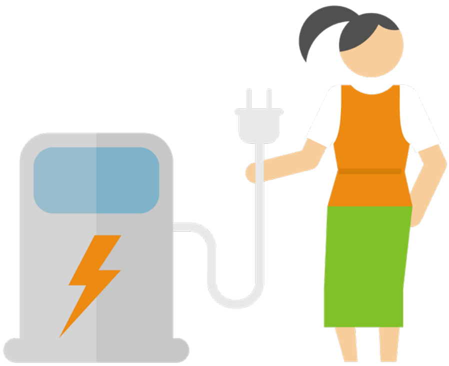


Figure 8 Load profile of all opportunity chargers in Berlin for both scenarios

2.2.3 Load profiles of all busses

The total load profile is dominated by charging during the day. However, Figure 9 shows that a **focus on depot charging and using a balanced charging strategy allows to fulfill more energy demand during nightimes, resulting in a more balanced load profile and lower power peaks**. In the scenario "Focus Depot Charging" the power amplitude is 21.14 MW, whereas for in the scenario "Focus Opportunity Charging" it is over 34.05 MW.



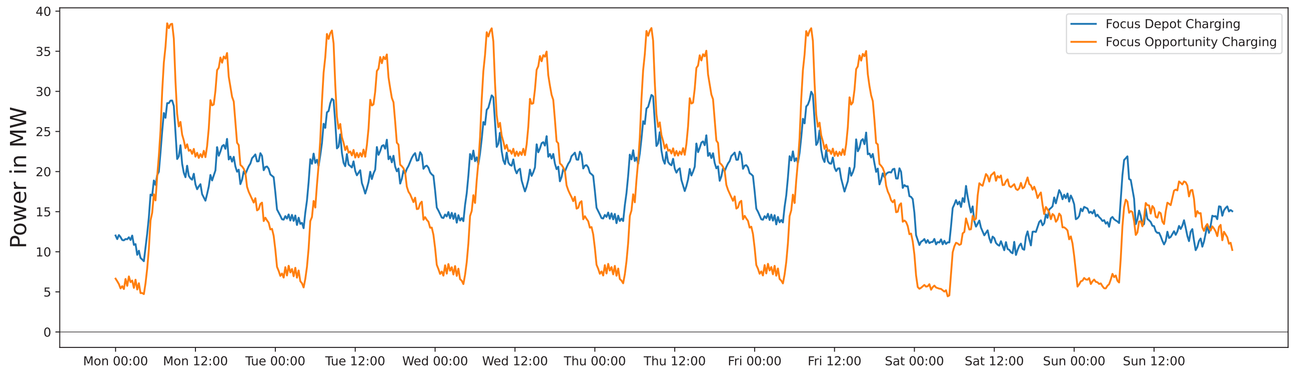


Figure 9 Weekly load profile for both scenarios. In depots balanced charging is applied.

2.3 Commercial vehicles

2.3.1 Scenarios

According to the German Government, charging for commercial vehicles can be classified in six use cases, which are shown in Figure 10[16]. On basis of conducted interviews, **the preference of most parties in commercial traffic is use case 1, which describes depot charging**. This use case includes charging in depot over night as well as charging in depot during daytimes.

Installation location	Private space		Public space			
	Charging use case 1	Charging use case 2	Charging use case 3	Charging use case 4	Charging use case 5	Charging use case 6
Typical locations for charging infrastructure	Charging at depot	Charging at transshipment points during un-/loading	Charging infront of transshipment points	Overnight charging during inactive times	Ad-hoc charging outside of breaks	Charging during stearing breaks
Typical charging capacity (kW)	100 – 150	350 – 500	150	100 – 150	750 – 1000	
Average standing time	Overnight or weekends	30 min – 2 h	0 min – 2 h	Overnight	45 min	individual

Figure 10 Charging Use cases for Commercial vehicles

Nevertheless, many commercial vehicles are highly dependent on public charging as they often do not have own depots. This applies in particular to smaller businesses and smaller vehicles fleets. Besides, many interview partner attribute use case 2 a great potential, especially with HPC. Use case 2 describes charging during un-/loading times of commercial vehicles, which may occur at own depots, logistical centres or at truck destination locations. However, barriers of use case 2 are due to varying costumers and therefore daily routes of logistical providers as well as space availability at specific locations. Therefore, use case 2 indicates a missing certainty of charging point availability. Interview partners did not explicitly mention other use cases mentioned described in Figure 10.

2.3.2 Energy demand

In general, the complexity to quantify the general charging demand and HPC demand by commercial vehicles in Berlin is due to various parameters and missing data very high. Table 6 shows parameters, which influence the commercial traffic in Berlin and therefore the charging demand. These arguments complicate statements according to total number of energy demand in Berlin, but also to the geographical allocation of charging stations.

16 Ladeinfrastruktur für batterieelektrische LKW, NPM, 2021, S.11, accessed at https://www.plattform-zukunft-mobilitaet.de/wp-content/uploads/2021/04/NPM_AG5_Ladeinfrastruktur_ELkw.pdf

Table 7 Parameters influencing commercial traffic

Parameters influencing commercial traffic
1. Heterogeneity of commercial businesses
2. Heterogeneity of commercial traffic
3. Total amount of incoming and outgoing commercial traffic
4. Heterogeneity of industrial parks
5. Fuel and energy price per use case
6. Exact allocation of industrial areas into districts
7. Heterogeneity of resting and breaking areas of various businesses
8. Exact number of van class vehicles contributing to commercial traffic
9. Share of HPC in charging infrastructure

First, commercial businesses in urban environments are very divers and have a high heterogeneity. Day-to-day businesses, vehicle fleets and operation times differ strongly between Craftsmen, Catering Services, Care Services or Courier and Express Services, just to mention a selection. Therefore, the commercial traffic is strongly heterogeneous, too. Actual driving distances, taken routes and used vehicle classes per company are difficult to identify. Other major issues to quantify commercial traffic are incoming and outgoing traffic flows. Even though registration numbers of various vehicle classes are available, those vehicles often have trips outside of Berlin. Moreover, many registered vehicles in Brandenburg conduct most of their trips in Berlin, but are not registered there. The same issue applies for incoming commercial vehicles from other countries, which are especially in the case of Berlin present due to Berlin's proximity to other countries. Furthermore, these vehicles are not included in statistics, which is why it is complicated to get a general overview about commercial traffic including all relevant vehicles. As well as businesses, industrial parks are heterogeneous, too. Especially industrial parks inside of cities evolved over decades with the cities. Therefore, the area of an industrial park frequently has various buildings with different space availabilities and business groups. Besides industrial parks, which evolved with Berlin, there are also areas, which have more space available, but are located outside of the city borders. However, even the allocation of charging processes to one of above mentioned use cases is uncertain due to future fuel prices and prospective energy prices per use case. Consumer's choices of use cases are strongly dependent on various energy prices per use case and therefore may change regularly during the development of HPC. Moreover, the exact location of these parks are often unclear as they reach over the borders of two or more districts. In chapter 2.3.3 a closer view on examples of industrial parks is given. As already mentioned, there are many different business—groups contributing to commercial traffic. Because of various businesses, also resting and breaking areas are divers. A long—haul truck as an example is more likely to rest at a highway station than a craftsman—van , which stays at his location of operation. Therefore, use 5 is very difficult to evaluate and next to a high unattractiveness. Furthermore, no data are given, explaining the distribution of private and commercial registered trucks under 3.5 tons. Eventually, most users of commercial vehicles in Berlin prefer low performance charging during nights in depots or at public spaces. Still, the calculation of the exact extent of HPC demand is hardly possible as every user makes an individual decision, which is also dependent on the current offer of charging infrastructure. These parameters impede the forecast of specific energy demand numbers for HPC induced by commercial vehicles. Therefore, a dynamic implementation of charging infrastructure for commercial vehicles is necessary and a permanent monitoring of the existing charging offer is recommended. Nevertheless, in 2.3.4 a calculation for all registered commercial vehicles in Berlin and their overall energy demand is demonstrated. As chapter 2.3.4 illustrates, commercial vehicles are not to be neglected when scaling charging demand of Berlin. Especially, to avoid those commercial vehicles block charging points, originally designed for private transport vehicles.

2.3.3 Case studies

Currently there are little specific cast studies about the use cases shown in 2.3.1. This is mostly because of reluctance reasons of various companies or logisticians. As every party participating to commercial traffic differs to each other, requirements also vary strongly. These various needs express in the composition of vehicle fleets, size of company, required space or day-to-day operations. As an example Figure 11 demonstrates five sections of industrial parks in or near Berlin and their differences.

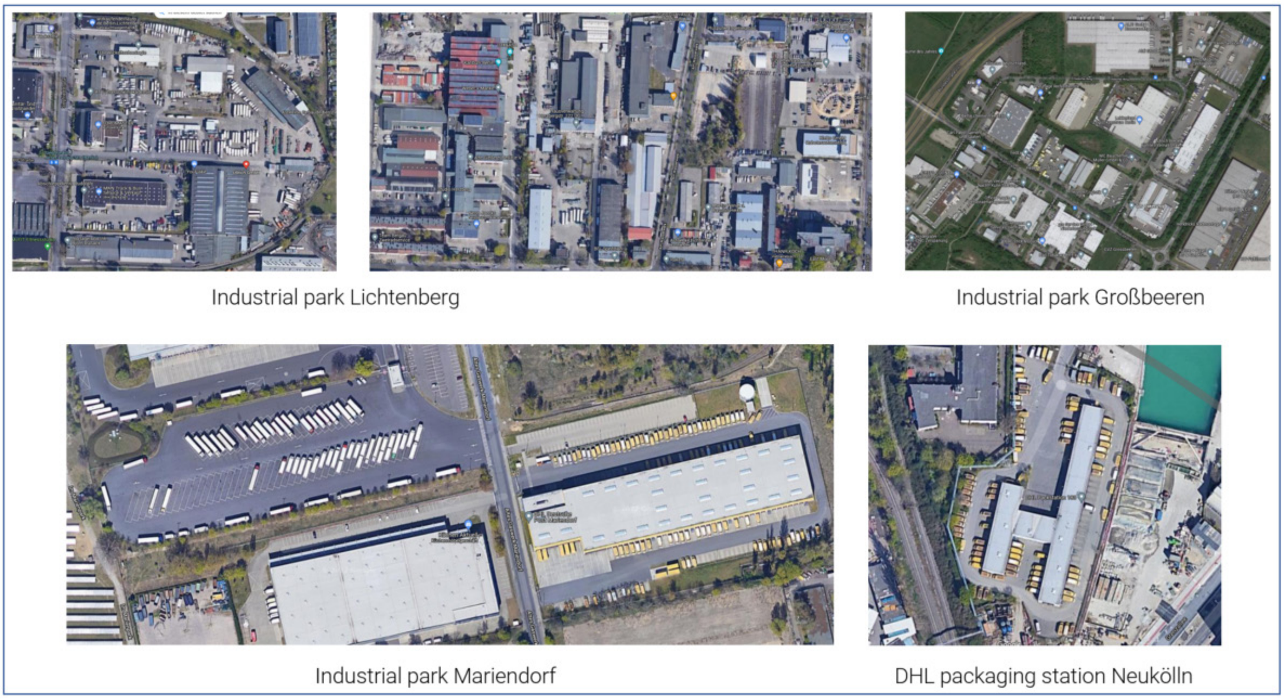


Figure 11 Diversity of Industrial Parks in Berlin

The industrial park in Lichtenberg illustrates the contrast of vehicles per square kilometer. Although both details of the industrial park are located next to each other, the density of trucks in the left picture is much higher. Moreover, it is an example of an industrial park with little space, surrounded by residential buildings and public facilities like a hospital. In comparison, the industrial park Großbeeren has much more space available for implementing new infrastructures. Großbeeren is actually outside of Berlin in Brandenburg, but serves as a logistical collecting center for Berlin. Therefore, the vehicles of this logistical site are official registered in Brandenburg, but doing their driving purpose mainly in Berlin. The industrial park of Großbeeren is one example of many logistical collecting centers around Berlin. In comparison, the industrial park of Mariendorf is allocated in the city of Berlin. In the selected picture, a supermarket distribution center on the left side as well as a DHL packaging center on the right side of the street is shown. Despite, both logistics centers are located in the same industrial park, requirements are very different. This can be seen in difference of used vehicles as well as in the difference of space demand per vehicle. The last example for diversity in logistical and industrial area sites in Berlin is the DHL packaging station in Neukölln. At this DHL packaging station, many, especially delivery vehicles are supplying a small logistical site with many private or infrastructural grounds surrounding. Therefore, it might be challenging to install the needed amount of charging stations for a 100 % electric fleet as well as to provide sufficient energy ports. Because of the great diversity of industrial areas in Berlin and the shift of logistical sites outside of the city, making a georeferenced forecast in terms of amount of charging stations is very difficult. Same issue applies for the georeferenced-required performance induced by HPC. Figure 12 shows the widely spread allocation of logistical sites in Berlin, which is a major challenge to quantify the charging demand for the future. Additionally, it must be noted that Figure 12 only shows all logistical clusters of Berlin, whether craftsmen businesses, company—fleets or taxi—services contribute to commercial traffic, too.

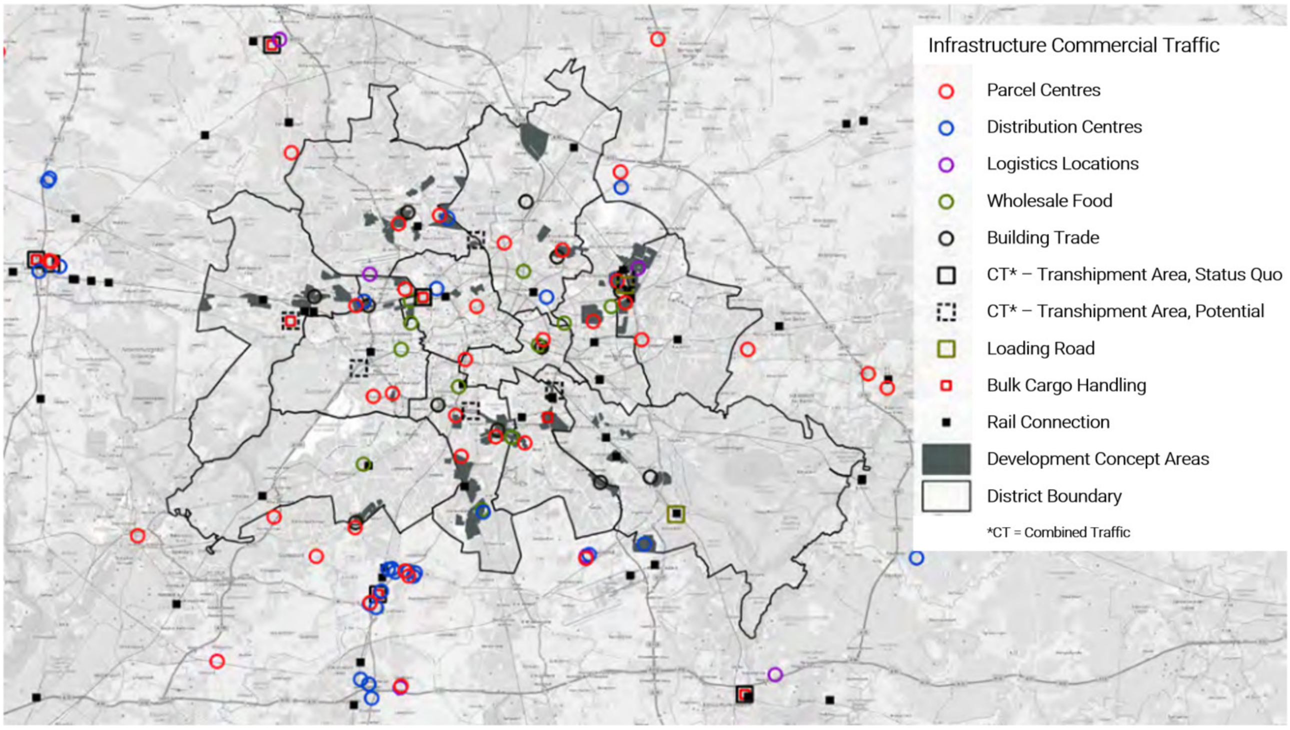


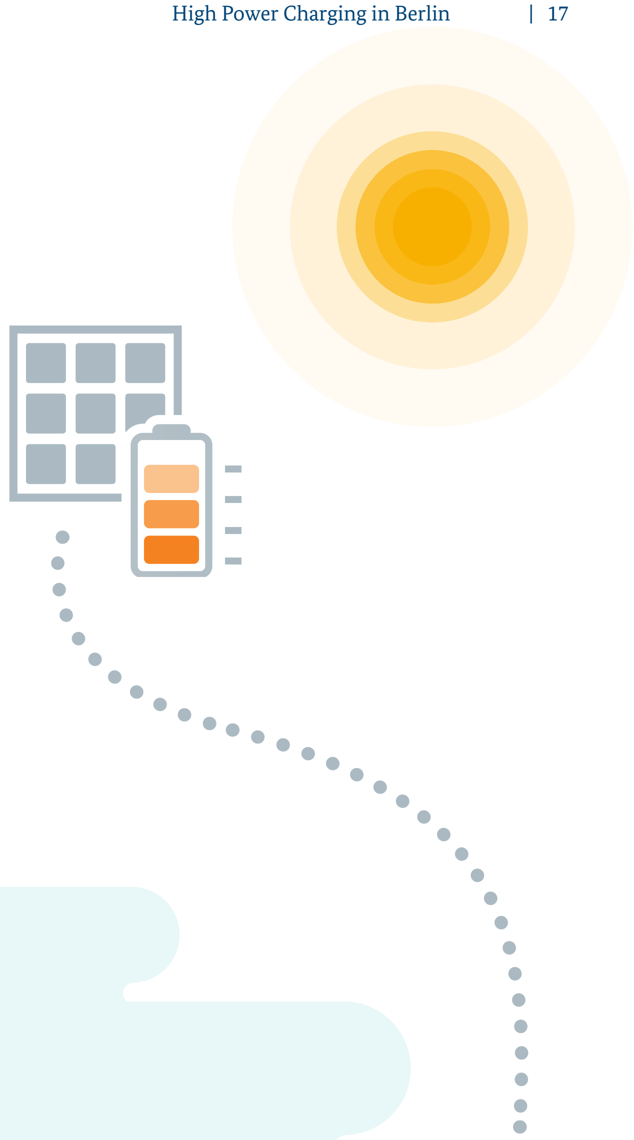
Figure 12 Logistics Sites in Berlin and Surrounding Area[17]

Despite few studies regarding the electrification of commercial vehicles in Berlin are published, yet, many logistical companies, supermarket chains or industrial companies are now focusing on the electrification of their fleet. In November 2021 Fraunhofer ISI published a study regarding the electrification potential of a distribution center fleet of a supermarket chain in Berlin. In the study, the focus was clearly set on depot charging during the night and no other option was mentioned. This proves explicitly that the preference of commercial parties in cities is overnight charging in depots. Another aspect included the actual daily mileage of vehicles driving in Berlin, whereby only vehicles over 12 tons have been considered. Nevertheless, 96 % of daily driving distances could be classified under 200 km, whereas the maximum daily mileage was 320 km. Corresponding to the offered vehicle battery capacities of 250 kWh to 550 kWh and average energy consumptions of 1.1 kWh/km, **Fraunhofer gauges that 100 % of trucks doing inner-city routes are electrifiable and only 4 of 62 vehicles might need a charge between their daily routes**. As a result, the Use Case of in—between charging, ensures little daily trips, but has in general a low importance. Besides the depot in Berlin, the case study considers a depot outside of the city in Brandenburg. In comparison, daily driving distances at this depot have a greater variety and are between distances of under 200 km and over 1,000 km. Only 45 % of all daily routes are under 200 km. This punctuates the statement that daily driving distances for commercial vehicles are much lower in cities than in other regions[18].

17 INTEGRIERTES WIRTSCHAFTSVERKEHRSKONZEPT BERLIN 2021, Senatsverwaltung für Umwelt, Verkehr und Klimaschutz, 2021, S.77, accessed at https://www.berlin.de/sen/uvk/verkehr/verkehrspolitik/integriertes-wirtschaftsverkehrskonzept-iwvk/

18 Lieferverkehr mit Batterie-Lkw: Machbarkeit 2021, Fraunhofer ISI, 2021, accessed at https://www.transportenvironment.org/wp-content/uploads/2021/11/Rewe_Machbarkeit_E-Lkw2021.pdf

2.3.4 Upscaling commercial vehicle energy demand



With a higher total amount of registered commercial vehicles classified to passenger cars[19], also the total mileages per year of these vehicles are higher in comparison to vehicles related to trucks[20]. For the calculation of the total mileages of various commercial vehicle types in Berlin, the average daily mileage of each vehicle type[21] as well as the utilization rates regarding days during the week and days on weekends[22], are taken into account. Moreover, the goal of electrifying one third of the total annual mileage until 2030 was considered[23]. This factor however should be even higher in Berlin, as disproportionate vehicles under 7.5 tons are registered. Eventually, the total energy demanded by commercial vehicles in Berlin is calculated by the total mileages per year of passenger and truck related vehicles with according average energy consumptions respectively[24 25].

19 Fahrzeugzulassungen Bestand an Kraftfahrzeugen und Kraftfahrzeuganhängern nach Haltern, Wirtschaftsgruppen, KBA, 2021, S.14, accessed at https://www.kba.de/SharedDocs/Downloads/DE/Statistik/Fahrzeuge/FZ23/fz23_2021_pdf.pdf?__blob=publicationFile&v=5

20 Bestand nach Fahrzeugklassen und Aufbauarten, KBA, 2021 accessed at https://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Fahrzeugklassen Aufbauarten/2021/2021_b_fzkl_tabellen.html?nn=3524712&fromStatistic=3524712&yearFilter=2021&fromStatistic=3524712&yearFilter=2021

21 KiD 2010, WVI GmbH, 2021, S.16f., accessed at https://www.bmvi.de/SharedDocs/DE/Anlage/G/kid-2010.pdf?__blob=publicationFile

22 KiD 2010, WVI GmbH, 2021, S.13f., accessed at https://www.bmvi.de/SharedDocs/DE/Anlage/G/kid-2010.pdf?__blob=publicationFile

23 Klimaziele im Verkehr erreichen: Wege zur Elektrifizierung schwerer Nutzfahrzeuge und zum Einsatz alternativer Kraftstoffe, NPM, 2020, accessed at https://www.plattform-zukunft-mobilitaet.de/news/klimaziele-im-verkehr-erreichen-wege-zur-elektrifizierung-schwerer-nutzfahrzeuge-und-zum-einsatz-alternativer-kraftstoffe

24 Business Insider, 2019, accessed at https://www.businessinsider.de/tech/experten-halten-elektro-trucks-wie-den-tesla-semi-fuer-volkswirtschaftlich-und-oekologisch-unsinnig-2019-2/

25 Logistra, accessed at https://logistra.de/news/nfz-fuhrpark-lagerlogistik-intralogistik-vergleichstest-leichte-strom-vans-schwer-im-kommen-73081.html

	Commercial vehicles in Berlin				
	Passenger car related		Truck related		
Vehicle types	**Cars**	**Delivery vehicles**	**Trucks**	**Trucks w. trailer**	**Semitrailer trucks**
Vehicle registrations	165,250	96,016	15,477	6,442	
Total mileage per year	1,004 Mio. km	511 Mio. km	540 Mio. km		
Electrifing total truck mileage by 33% until 2030		170 Mio. km	180 Mio. km		
Total energy demand per year		**300 GWh**			

Figure 13 Summary of Commercial Vehicles in Berlin and energy demand

This results in an energy demand of currently registered commercial vehicles in Berlin of 300 GWh/year, about double the demand of busses (159 GWh/year) and a third of passenger cars (960 GWh/year). Passenger cars contributing to commercial traffic are excluded in this projection, as they are already included in chapter 2.1. It is to mention that this calculation only refers to all registered vehicles in Berlin and incoming as well as outgoing traffic flows are not considered. However, this energy demand does not consider specific charging performance. Especially, as industry and logistics parties prefer low charging performances over night at depot locations, the energy demand for HPC will be much smaller. Currently a more specific georeferenced statement in relation to HPC is due to in 2.3.2 mentioned unknown parameters not possible. To quantify the HPC phases of commercial vehicles in Berlin, an improved data situation is necessary. Still, a great demand of charging station for commercial vehicles in Berlin is to be expected. Therefore, increased research is needed in this segment.

3 Sector coupling

The ramp-up of electromobility represents a new load in the electricity system that must be covered by renewable electricity in the future. As a city-state, this poses challenges for Berlin because of the potential for renewable energies. The transmission grid connects Berlin to surrounding grid areas. Thus, not only the innercity photovoltaic potential, but also energy generation outside the city can fulfil the future HPCdemand. This study uses electricity generation and demand data for the year 2035 from the project eGon[26] for both Berlin and Brandenburg.

3.1 Power generation in Berlin

The major driver for HPC demand in Berlin are passenger cars. Therefore, charging events occur mostly during the day with peaks around midday. During the night, the demand from passenger cars is very low and mainly depot charging for busses and commercial vehicles takes place. The demand for high power charging during the day therefore fits the generation of photovoltaic systems, which also peaks at midday. Figure 14 shows the weekly PV generation in summer for the status quo and the PV potential.

As of 2021 there are 8,672 photovoltaic systems with a capacity of 128.276 MWp installed in Berlin, mainly in the Eastern part the German capital.[27] With its “Masterplan Solarcity” Berlin pursues the goal of a total installed PV power of 4,440 MWp, which represents about half of the maximum solar potential for Berlin of 8,981 MWp. To achieve this, Berlin only has to cover 2.2 percent of its total area with photovoltaic modules.[28] Figure 14 shows the PV generation in Berlin in 2021 and 2035.

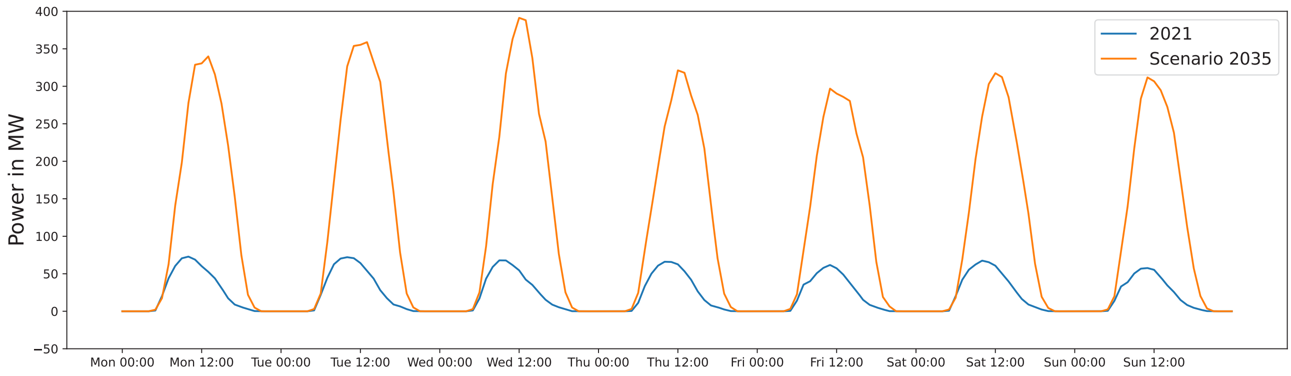


Figure 14 Average weekly PV generation in summer in 2021 and 2035 in Berlin

26 https://ego-n.org/

27 https://www.berlin.de/sen/energie/energie/erneuerbare-energien/masterplan-solarcity/masterplan_solarcity_monitoringbericht-2021.pdf

28 https://www.berlin.de/sen/energie/energie/energiepolitik/masterplan-solarcity/expertenempfehlung_masterplan_solarcity_berlin.pdf

With 391.27 MW, the peak generation in 2035 lies above the peak demand of all passenger cars by a factor of around 1.4 to 1.7. However, this electricity is not exclusively available for HPC. Figure 15 shows the excess energy when substracting other loads. The average load from other sectors like industry or heat in 2035 is 1,624 MW. Figure 15 shows that **in both summer and winter there is the need for electricity throughout the day to meet the future demand of electric vehicles**. This need is higher during daytime then at night. This makes it necessary to obtain electricity from surrounding grid areas.

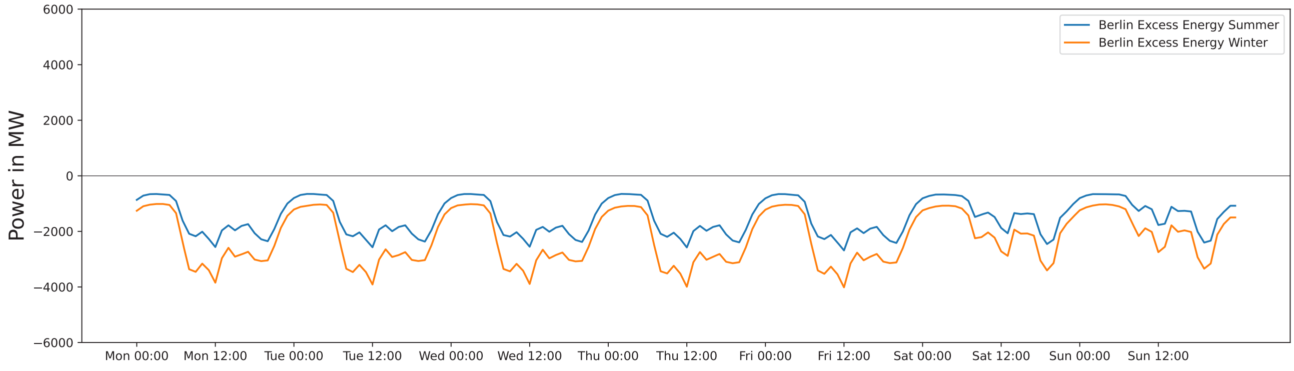


Figure 15 Excess energy in summer and winter in Berlin in 2035

3.2 Power generation outside of Berlin

Another possible scenario is to use renewable power generation outside of Berlin to meet the future HPCdemand in town. To analyse this, the study examined the area of Brandenburg, which fully surrounds Berlin. Figure 16 shows the available excess energy for both an average summer and winter week. Throughout the year there is excess energy. This energy could be used to fulfil the HPCdemand in Berlin. In summer, excess energy peaks during midday, whereas in winter the generation is generally higher and more levelled over the day. This shows, that there is a p**otential to use power generation outside of Berlin to meet the HPCdemand**.

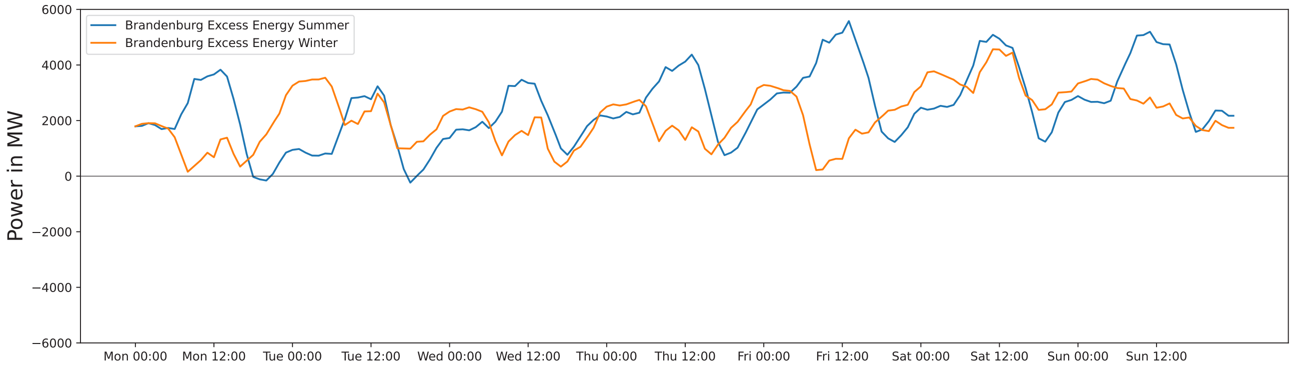


Figure 16 Excess energy in summer and winter in Brandenburg in 2035

3.3 Sector coupling potential

To analyse how the current renewable excess energy in Berlin and Brandenburg fit the demand of electric vehicles, different scenarios were combined for the demand from electric vehicles:

- **Depot**: PrivateCharging+ for cars and Focus Depot Charging for busses
- **HPC:** HPC+ for cars and Focus Opportunity Charging for busses

Figure 17 shows the excess energy for four times throughout the day. In Berlin the needed energy from out of town is highest during midday and in the evening and lowest at night. As also shown in Figure 18 especially in the evening the energy demand of Berlin exceeds the possible energy surplus in Brandenburg, underlining the need for additional energy from other areas and for storages. In winter this applies to all times of day except at night, where the energy demand in general is rather low.

The winddominated grid areas in the north of Germany offer a high potential throughout the day. However, this electricity has to be transported through the transmission grid, which therefore needs to be adequately expanded.

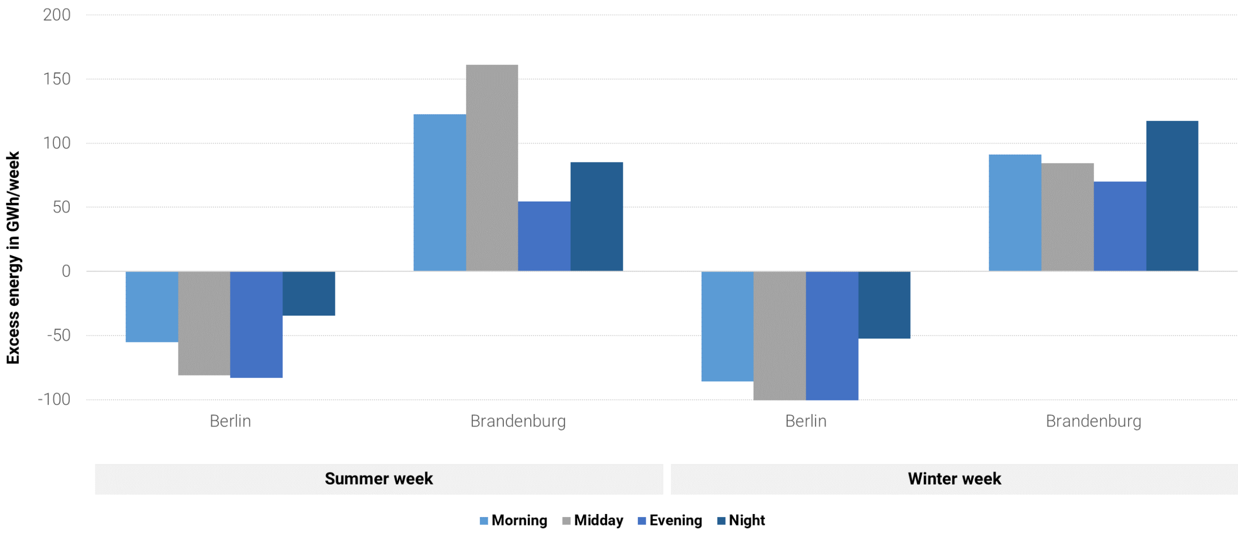


Figure 17 Distribution of excess energy from inside and outside Berlin over the day

Combining the potential useable energy from inside and outside Berlin results in positive excess energy in night and morning hours. During midday Figure 18 shows a huge difference between summer and winter, since solar generation is lower and energy demand is higher in winter than in summer. **In evening hours the demand often exceeds the generation with only minor differences between private charging and HPC**, as Figure 6 shows, making storages necessary.

Private charging could be benefitial in general, since it shifts electricity demand to night times. Incentivising HPC would increase the energy demand during midday. Where as **HPC would be counterproductive in winter, in summer it could decrease the need for storages since the area outside of Berlin offers a huge potential for PV generation**.

The combined excess energy reveals midday power peaks of 3,992 MW in summer 2,668 MW in winter. These power peaks are 10 to 15 times higher than the demand peaks in the HPCscenario or 12 to 17 times higher than in the depotscenario.

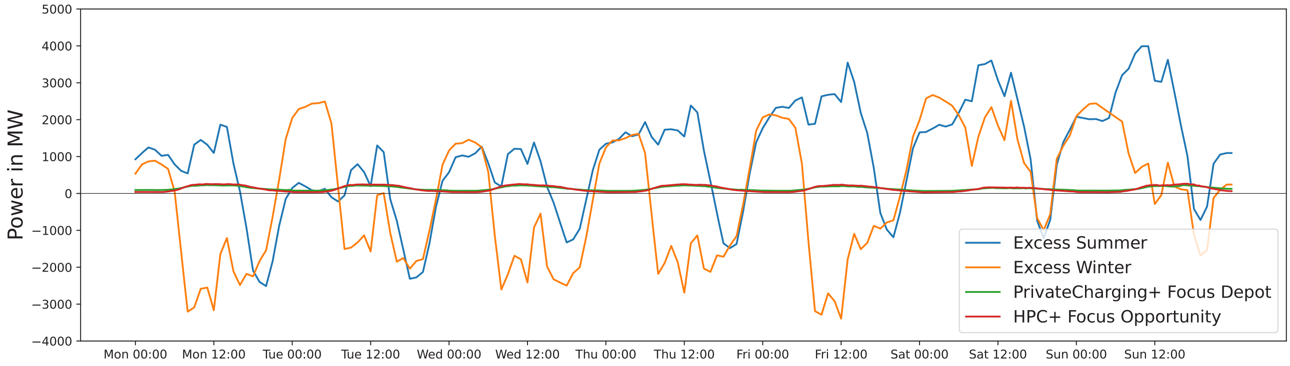


Figure 18 Comparison between excess energy in Berlin and Brandenburg and the demand from passenger cars and busses

The analysis shows that a strategy focussing on HPC during the day shows similar behaviour as the load profile of excess energy with peaks during midday. Additionally, the peak power of potential useable energy far exceeds the peak power of electric vehicle demand.

4 Technical and regulatory challenges

The development of charging infrastructure in cities is a process that brings together various stakeholders with different interests. Public transport is electrifying its bus fleet and needs high-performance charging infrastructure at the depot and on the route. Private motorized transport (MIV) is becoming increasingly electric and needs to be served by normal and fast charging infrastructure at the roadside, at POIs such as supermarkets, at gas stations, in front of homes, and at many other locations. Commercial transport is contributing to the decarbonisation of transport through the electrification of its plannable fleets. Opposed to this are:

- The grid operator, who must integrate the charging infrastructure into the power grid; and
- The city, which must moderate competition for space in public areas.

The challenges of building HPC in the city are detailed below.

4.1 Space requirements

Public space in the city is limited and highly contested. As in many other cities, public space in Berlin should become more bicycle and pedestrian friendly. On the one hand, the development of charging infrastructure is imperative, but it also manifests the importance of the car in the urban cityscape. However, due to the lower overall space requirements compared to normal charging infrastructure, HPC infrastructure can play an important role here. In addition, restrictions such as the distance to trees, street signs, etc. often reduce the available space for charging infrastructure. Necessary arrangements with relevant authorities can greatly delay the siting of charging infrastructure and installation.

4.2 Business model

So far, the operation of HPC infrastructure is not yet a viable business model; this is not expected to happen for at least two years. Reasons for this are:

- A low utilization rate: So far, hardly any vehicles are available that can use charging capacities of 150 kW and more. At present, the development of HPC would thus only target a small privileged group, as electric vehicles are not expected to be HPC-capable en masse for another 5 years or so.
- Poor planning ability: On the one hand, it is still unclear which path will be taken in urban development and what significance the car will have in urban areas in the future. On the other hand, in some areas (especially trucks) there is still uncertainty about which technology (battery charging, battery exchange systems, hydrogen) will prevail.

Accordingly, HPC parks are seen as a long-term infrastructure investment. It must be kept in mind that the locations must be attractive so that people want to stay for 10 minutes or longer.

4.3 Grid connection

Grid operators in Germany are well prepared for the ramp-up of electromobility; many are involved in projects for grid integration of electromobility and already include electromobility in long-term planning. Congestion situations in the power grids currently arise primarily due to the integration of renewable energy systems (RE systems). The main challenge in connecting HPC infrastructure or charging hubs is that they usually have to be connected to the medium-voltage grid. The coordination between the operator/installer of the charging infrastructure and the distribution grid operator (DSO) is often difficult. If no medium-voltage connection is available at the selected location, the implementation process can often take several months or even more than a year. One of the reasons for this is that the medium-voltage grid is less closely meshed than the low-voltage grid. In cities, the distance is usually not as great as in rural areas because the network is more tightly meshed. However, the distance to the medium-voltage grid basically makes planning more difficult and also has an impact on costs. In Germany, there are almost 900 VNBs, some of which have different technical connection conditions. For example, a special transformer may be required. This has an additional impact on investment costs.

4.4 Regulations

Due to the discrepancy between the different definitions of the end consumer in the Energy Industry Act (EnWG) and the Renewable Energies Act (EEG), there is also no incentive to use locally generated renewable electricity (e.g., from photovoltaics) to supply the charging infrastructure. As a result, renewable electricity is fed into the public grid with EEG compensation and then drawn from the grid again to charge the electric vehicles.

In addition to energy-related regulations, operational safety issues such as fire protection pose a hurdle.

4.5 Target groups

Currently, publicly accessible HPC sites are mostly built exclusively for passenger cars. While these can also be used by smaller vans, they cannot be used by larger vehicles due to space limitations. Crucial to this is that stakeholders do not anticipate large electric commercial vehicles in the foreseeable future. In addition, the inclusion of trucks greatly increases the amount of space required, as charging locations must be passable so that trucks do not have to maneuver. For this reason, most charging infrastructure operators are currently focusing on passenger cars.

In addition, the focus for the current HPC expansion is on long-distance traffic and thus primarily on traffic axes such as highways.

4.6 Demand per use category

Individual transport

The need for HPC infrastructure for motorized private transport in Berlin results from the fact that only 37 % of vehicle users have their own parking space and that even at the workplace there is not always the possibility of using the longer standing time for charging, mainly by normal chargers. Thus, only a part of the required energy can be charged in the private area For the remaining charging demand, fast or high-performance charging points are required, at which the users can recharge in usually short stopping times at POIs or on the way.

Public transport

Due to the high energy consumption of buses, BVG in Berlin is currently planning charging capacities of 150 kW for its depots and 450 kW at occasional charging points at terminal stops/turning loops.

Commercial vehicles

For logistics companies, there is a need for HPC infrastructure at the depot if not all vehicles can be parked directly at the site, for example because there are not enough parking spaces available. Here, vehicle recharging can be implemented during loading and unloading operations, for example, although it is important that there is no disruption to operational processes. HPC outside the depots is currently not of much interest. There are two main reasons for this. First, employees* are busy during downtime. Adding non-automated loading would increase work hours and decrease profitability. Furthermore, the locations where stand times take place are often variable and cannot be planned.

The need for HPC in the commercial vehicle sector is largely dependent on the size of the vehicles as well as the range requirements. In domestic logistics, the length of the daily distances covered is less than 350 km in 69% of cases. In long-distance traffic, this corresponds roughly to the distance that a driver can cover within the legally prescribed driving times. The prescribed break times after 4.5 hours of driving are therefore suitable for charging via HPC. However, it can be assumed that locations outside the Berlin city area will be used for this purpose. These can be located, for example, at existing service stations or car depots on the federal highways. For long-distance freight and transit traffic, the need for HPC infrastructure will increase as fleets are electrified.

Basically, the focus in the commercial vehicle sector is currently on electrifying fleets, although especially for SNZs (>12 t), the supply of vehicles is not yet satisfactory for the players. HPC will play a minor role in the inner-city sector for commercial vehicles,

- as the electrification of fleets will be solved via smaller vehicles,
- daily mileage will be within the range of announced vehicle models,
- fleet operators push for operation without intermediate charging to avoid adjustments in the operational process

and thus depot charging without HPC is sufficient or favored. This may change if the trend in the future is toward 24-hour vehicle operation or economic benefits are realized if vehicles with low battery capacity are intermediately charged and schedules can be adjusted to accommodate these charging strategies.

5 Conclusion and further recommendations for action

The study shows that focussing on HPC has both advantages and disadvantages in a city like Berlin. Since most of the inhabitants do not have a private parking spot and the area is limited, HPC offers a good solution. With assumptions made for temporal flexibility in charging behaviour, the study shows that the number of HPC points can be significantly reduced, while on the same time increasing the utilization rate. Only 10 % time flexibility reduces the demand for HPC points by 2/3. Whereas for both private vehicles and public transport HPC will play a big role, in the logistic sector private charging is considered to be more attractive for charging commercial vehicles over night.

The study shows, that Berlin will have to rely on electricity from outside of town to meet the future energy demand. The area of Brandenburg offers a high potential for excess energy, especially at night and during midday. In evening hours, however, the demand in Berlin often exceeds the generation with only minor differences between private charging and HPC. This makes storages and load shifting necessary. Whereas private charging could be benefitial in general, by shifting electricity demand to night times, incentivising HPC would increase the energy demand during midday. This would be counterproductive in winter but could decrease the need for storages in summer since the area outside of Berlin offers a huge potential for PV generation.

The following are recommendations for action to expand HPC.

5.1 Using existing areas

Using existing areas avoids having to create additional areas for the construction of HPC infrastructure. Gas stations are particularly suitable for this purpose. In Berlin there are around 250 gas stations, that could be used:

- Gas stations often already have a medium-voltage connection, and a structural extension or a new contract is usually easier to implement than a new connection.
- Locations of gas stations are usually already well distributed in the urban area and could thus ensure a high level of coverage.
- A build-out of charging infrastructure at gas stations also allows vehicle users to maintain current habit patterns.

In addition, parking spaces at points of interests (POI) such as supermarkets can also be used for cars and small commercial vehicles. During the day, fast charging points are ideal due to the short standing times, e.g. when shopping, and at night the parking areas can be used for slow recharging via normal charging infrastructure. There are already initial collaborations in this area, such as that of the Schwarz Group with Volkswagen's car-sharing provider WeShare. Another option is to use so-called park-and-ride lots on the outskirts of the city, but these are more suitable for normal charging infrastructure.

5.2 Making HPC stations attractive

Even with charging capacities of 150 kW, recharging takes longer than a conventional refuelling process with an internal combustion vehicle. For this reason, planning HPC locations usually considers the aspect of attractiveness. For example, there is often a store at the sites on traffic axes, and individual players cooperate here with supermarket chains, for example. In addition, other entertainment options (e.g. snack bar, parcel stations, etc.) are conceivable.

Parking spaces for charging vehicles should also be covered. In some cases, this is already done with photovoltaic roofs.

5.3 Sharing charging infrastructure

A major challenge is that building and operating HPC infrastructure has not been a business case to date. Sharing charging infrastructure can increase utilization. Bilateral contracts can also create better predictability. Some of the players from the retail and public transport sectors are already in talks on this.

HPC infrastructure would need reservation functions so that players can rely on this shared infrastructure and integrate it into their route planning, for example. A best-practice example for normal charging infrastructure is the cooperation between the Schwarz Group and WeShare, in which carsharing vehicles can use the parking spaces at the Lidl and Kaufland supermarket chains to charge the outside of opening hours.

5.4 Demands and wishes of the stakeholders

The majority welcomes the use of HPC infrastructure in publicly available space by different actors. One possibility to implement this is the realization of a platform for fast charging. Such a platform should guarantee the following aspects:

- Presentation of the availability of charging points
- Reservation functions for players
- Transparent display of charging tariffs

In the future, vehicles of the logistics sector could use rest periods for recharging. However, this requires legal certainty; for example, it must be clarified how the process of starting and ending the charging process is formally handled.

Another requirement is that the coordination process with distribution network operators be simplified and accelerated, as this often takes a long time, especially in the HPC area, and can delay the planning and construction of charging points. This aspect is highly relevant, especially due to the strong market ramp-up.

In the area of site selection, municipal stakeholders would also like to see greater consideration given to urban areas in the federal fast-charging law. So far, this has been aimed primarily at traffic arteries such as highways. LIS operators are also critical of the requirement discussed in political circles that charging points be installed at every service station. More decision-making authority is called for here, as the LIS operators themselves carry out analyses to identify ideal locations, especially in the ramp-up phase of electromobility.

6 Appendix

6.1 Passenger cars

Table 8 Attractiveness of the UC in percent and access to private charging infrastructure for all scenarios

		HPC	HPC+	PrivateCharging	PrivateCharging+
Private charging infra. in %	Single Family House	60		80	
	Living Quarter	30		70	
	Workplace	85		90	
Attractiveness in % With private parking spot	UC1	100	100	100	100
	UC2	100	100	100	100
	UC3	45	45	50	50
	UC4	45	70	25	15
	UC5	70	80	65	50
	UC6	20	15	30	30
	UC7	5	5	5	5
Attractiveness in % Without private parking spot	UC1	0	0	0	0
	UC2	0	0	0	0
	UC3	100	100	100	100
	UC4	85	100	55	30
	UC5	55	70	55	30
	UC6	25	15	60	75
	UC7	10	5	25	40

6.2 Busses

The study made various assumptions for the bus operation:

- Charging power of 300 kW at the terminal stops.
- In each pause, 2 minutes are subtracted due to docking and driving to the pantograph.
- Heating/cooling is assumed to be turned off after 2 minutes when the bus stands idle.

6.3 Commercial vehicles

Determination Commercial Vehicle Energy Demand					
	Passenger cars	Delivery vehicles	Trucks	Truck with trailer	Semitrailer trucks
Registered commercial vehicles	165,250	96.016	15.477	6.442	
Average daily mileage weekdays	(72.2 km + 33.1 km)/2	(61.1 km + 45.7 km)/2	152 km	360 km	
Average daily mileage weekends	(24.3 km + 25.3 km)/2	(8.2 km + 12.4 km)/2	53.9 km	20.9 km	
Utilization rate weekdays	(0.672 + 0.666)/2	(0.653 + 0.6)/2	67.6 %	81.1 %	
Utilization rate weekends	(0.278 + 0,474)/2	(0.101 + 0.205)/2	9.2 %	13.6 %	
Total mileages per year	1.004 Mio. km	511 Mio. km (Reduction of 40%)	910 Mio. km >~40%> 540 Mio. km[29]		
Goal of electrifying one third of total annual commercial mileage	-	170 Mio. km	180 Mio. km		
Average energy consumption		0,24 kW/h 18	1.44 kW/h		

29 Verkehrsaufkommen deutsche Lastkraftwagen 2020 3a, KBA, accessed at https://www.kba.de/DE/Statistik/Kraftverkehr/deutscherLastkraftfahrzeuge/vd_Verkehrsaufkommen/vd_verkehrsaufkommen_node.html

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