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Scenario of public charging demand for power grid impact in 2030

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1 Introduction

This technical report summarizes the work to produce a charging scenario in Skåne for 2030, based on available prognoses and historical data. The end result is a distribution of newly installed charging stations in Skåne connected at different sub transmission grid transformer stations until 2030. The charging locations can be randomly allocated in a way to fulfill the distribution of charging stations in different transformer zones. Combined with the probabilistic charging profiles calculated for chargers of different power levels, a scenario is created which can be used to examine the grid impact of future EV charging.

2 Electric Cars Prognosis

The total number of passenger cars in Skåne today (January 2023) is just under 667 000 [7]. According to data from Powercircle [1], the historic trend showing the number of electric cars in Skåne in the years 2016-2022 are shown in figure 1. The average share of electric cars in Sweden located in Skåne is 12.9% during these years. This can be compared to the share of the entire Swedish car fleet which is 13.4% [7].

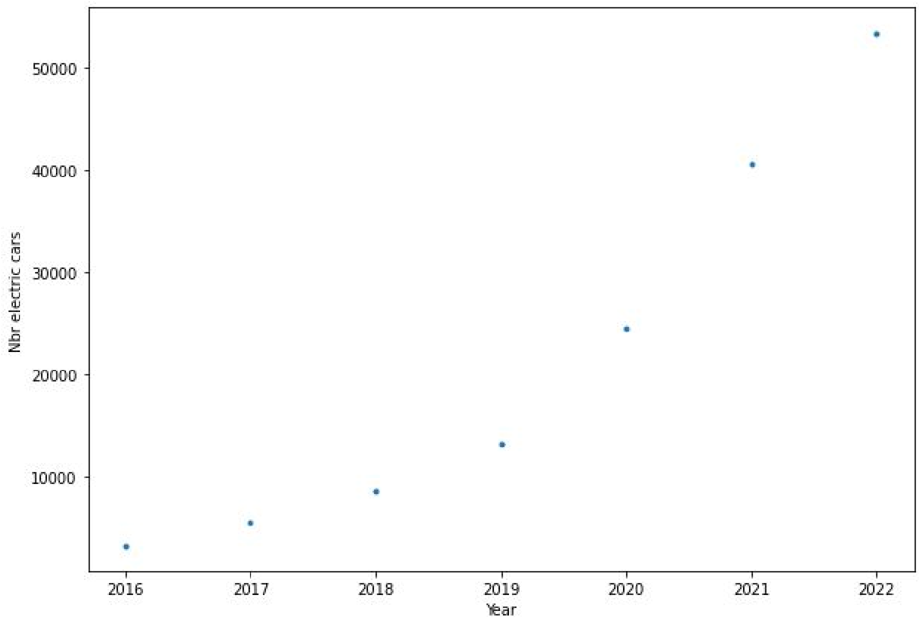


Figure 1: Historical trend of number of electric cars in Skåne.

A prognosis of the number of electric cars until 2030 in Sweden is available from Powercircle [1]. If the average share of the national electric car fleet registered in Skåne is expected to stay constant, the prognosis can be applied to Skåne specifically. This prognosis is shown in figure 2. The predicted number of electric cars in Skåne 2030 is just over 388 000.

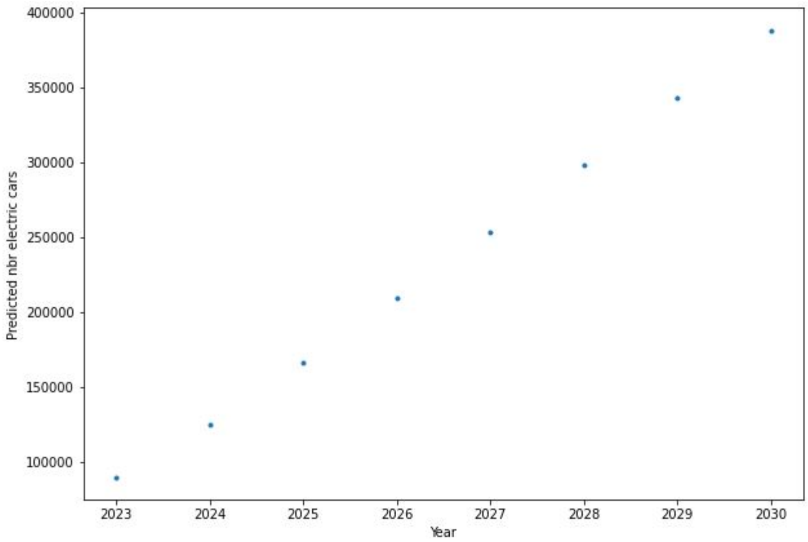


Figure 2: Prognosis of number of electric cars in Skåne.

The prognosis made by Powercircle was based on an assumption that Sweden would have a ban on diesel and petrol cars by 2030. As an alternative scenario, the ban would begin by 2035, along with EU regulations. This scenario gives a lower prognosis of electric cars in Sweden and Skåne until 2030. [5] The analysis in this report is based on the first scenario, with 100% market share of electric cars by 2030.

AFIR Proposal

The European Commission issued a proposal for a regulation on the deployment of alternative fuels infrastructure (AFIR) in 2021 [3]. The proposal states that in member countries, for each battery electric light-duty vehicle, 1kW of public charging must be installed. Additionally, for each plug-in hubrid electric light-duty vehicle, 0.66 kW public charging must be installed. The electric cars in Skåne prognosis of 388 000 electric vehicles by 2030 gives a minimal installed capacity of 256 MW - 388 MW of public charging in Skåne, depending on the share of plug-in hybrid vehicles. If the share of Sweden's public charging spots within Skåne equals that of the share of EV's in Skåne, the installed public charging capacity today is around 57 MW [1]. This indicates a need of an additional charging capacity of 200 - 330 MW until 2030. As a comparison, the average consumption in Skåne in 2021 was around 1,4 GW [8].

3 Probabilistic Charging Profiles

Electric vehicles have been part of the vehicle fleet for enough years to have produced a significant amount of charging data. A study by Hecht [2] compiles charging data from over 22 000 German public charging spots. The data is made available in the form of power deciles aggregated based on power level and on daily basis. The power level spans are below 4 kW, 4-12 kW, 12-25 kW, 25-100 kW, 100-200 kW and 200+ kW. An example of what the data looks like is shown in figure 3.

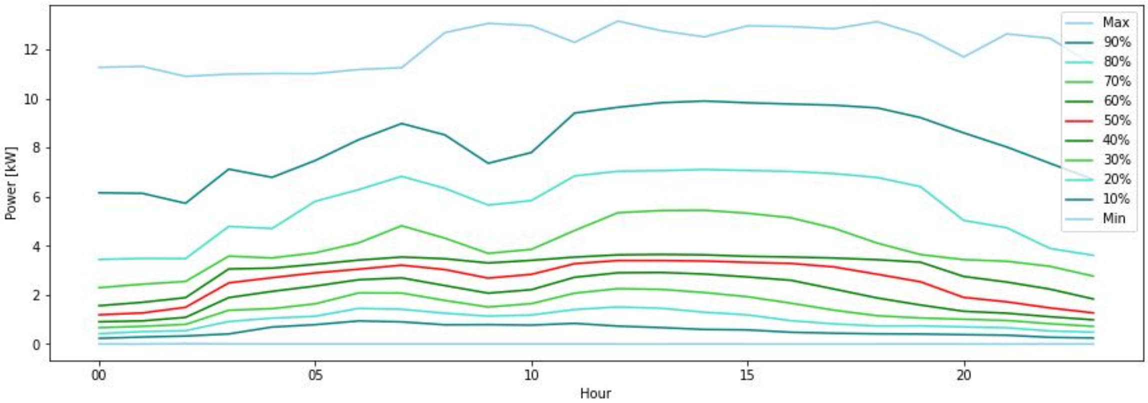
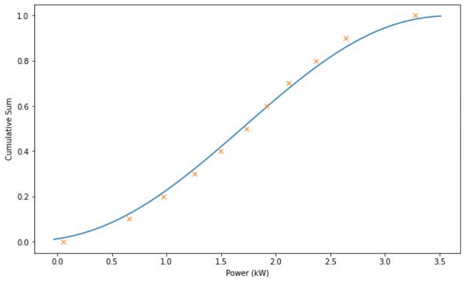
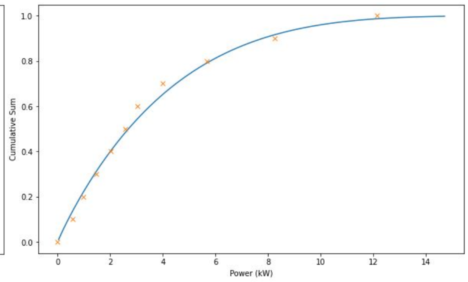


Figure 3: Example plot of German public charging data, for chargers of 4-12 kW installed power.

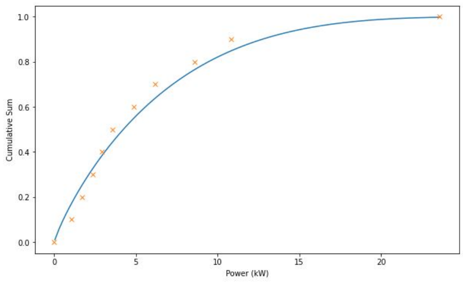
From the decile data of charging power, probabilistic load profiles can be created. Deciles are per definition the values in a data set which divides the data points into 10 equal parts. This means that 10% of the data points are within the span of two neighbor deciles. Recreating a dataset based on the deciles can be performed by drawing a set number of random values uniformly in each 10% span. In this report 1 000 values have been uniformly drawn in each span, creating a total data set of 10 000 values. To verify that the generated data sets match the deciles, the cumulative sum of the data sets have been plotted together with the deciles in figure 4.



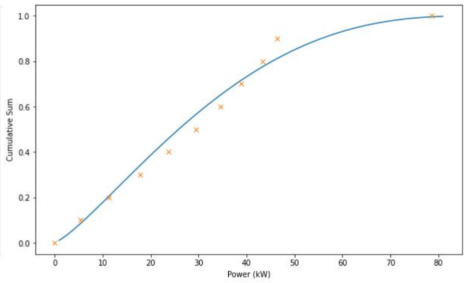
(a) 4 kW and below



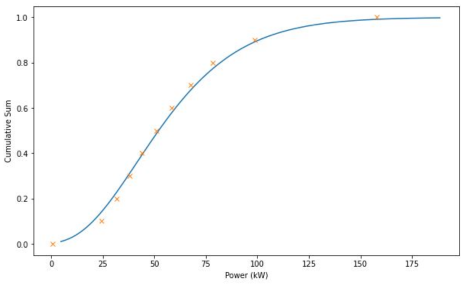
(b) 4-12 kW



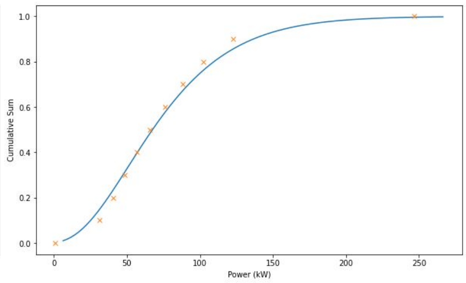
(c) 12-25 kW



(d) 25-100 kW



(e) 100-200 kW



(f) 200 kW and above

Figure 4: Cumulative sum (blue) and deciles (orange) for the power level spans

The fitted beta parameters to the load profiles for different power spans are presented in table 1. For all power spans, the distributions are left-skewed, as seen from the fact that the b-parameter is larger than the a-parameter. The location and scale parameter reflects on which span the distribution will stretch. The two largest power level distributions have very large b- and scale-parameters. However, the cumulative sum and decile comparison in figures 4e and 4f suggest that the distribution well matches the input data.

Table 1: Beta distribution parameters of load profiles

Size	a	b	loc	scale
0-4	1.848	2.156	-0.062	3.743
4-12	0.942	4.22	0.0001	19.1564
12-25	0.854	3.602	0.0006	29.271
25-100	1.281	2.644	-0.1	88.085
100-200	4.357	$2.3 \cdot 10^6$	-10.491	$3.6 \cdot 10^7$
200+	3.436	$1.3 \cdot 10^{12}$	-8.472	$3.2 \cdot 10^{13}$

4 Number of Charging Stations and Power Levels

Historical data of the number of charging points and stations installed in Sweden is available from Powercircle [1]. The number of charging locations in Skåne in January 2023 are 2 464. The data has been filtered to evaluate the number of charging points in Skåne in the years 2012-2030. A linear trend was fitted to the historical data and extended to create a prognosis until 2030, as seen in figure5. With the linear trend assumption, the number of charging stations in Skåne in 2030 are 4 122. This corresponds to 1 658 new charging locations.

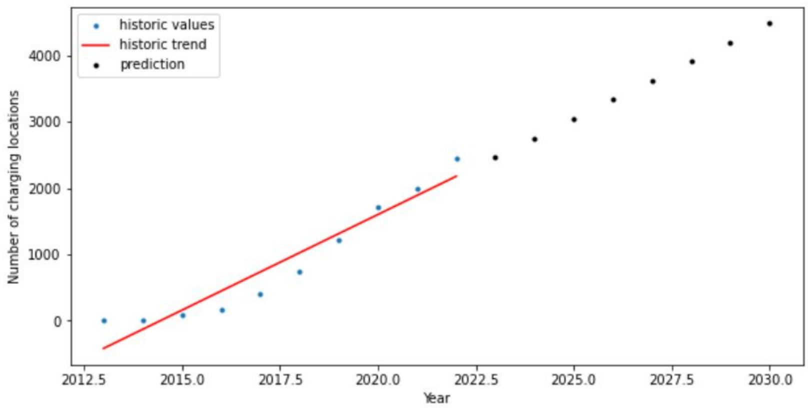


Figure 5: Linear trend fitted to historical charging station installations

As the trend 2016-2022 does not seem linear to the eye, a polynomial trend has been fitted to the data, as shown in figure 6. This trend has been extended to 2030, resulting in an expected number of charging locations of 9 069. This corresponds to 6 605 new charging locations installed until 2030. Based on the visual better fit of the polynomial trend on the historic data as well as the expected rapid increase of electric vehicles and charging points, the polynomial trend prognosis has been the focus in this report.

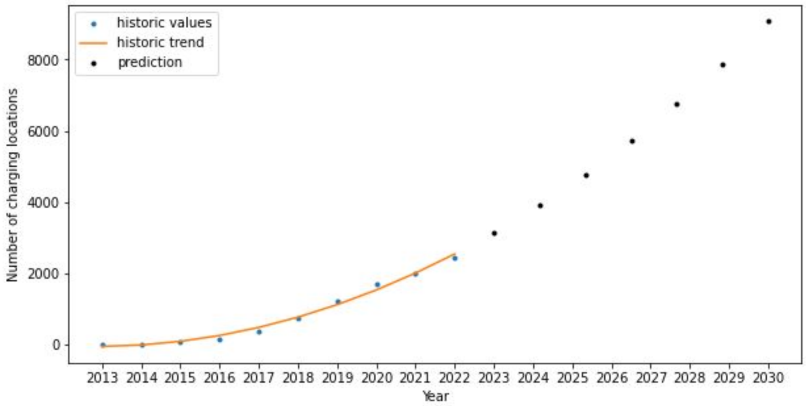


Figure 6: Polynomial trend fitted to historical charging station installations

The historic charging point data can be divided into power levels. The number of newly installed charging points can be calculated as the change in the number of charging points per year. The share of newly installed charging points for each power level in the years 2016-2022 are shown in figure 7.

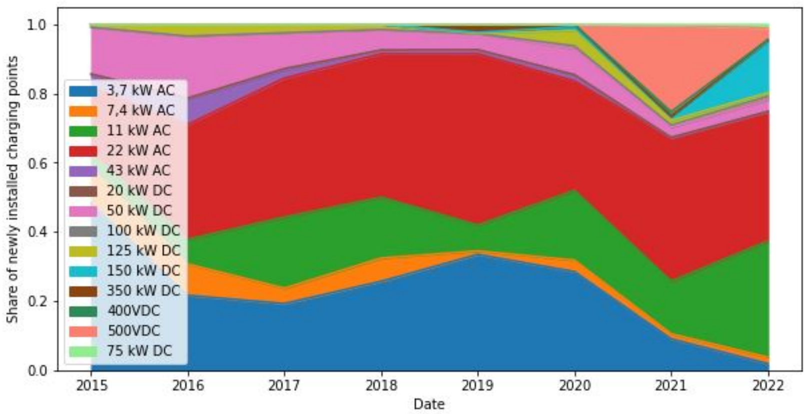


Figure 7: Share of newly installed charging points per power level 2016-2022

Looking at the trends in the last years, the following assumptions have been made:

- DC chargers will be of at least 150 kW
- There will be an increase in the share of 11 and 22 kW AC chargers
- There will be no more installations of 3,7 kW AC chargers, as the power levels of new chargers will be larger than this
- There will be no more installations of 43 kW AC chargers, as fast chargers will be of DC type
- The share of power levels in new installations will otherwise follow that in 2022

With these assumptions, the expected number of new chargers of each power level by 2030 are calculated and presented in table 2. The installed capacity of the chargers per power level are also calculated. The total installed power sums up to 301.3 MW. This is in the span of the required installed power in public charging stations by 2030 as discussed in section 2.1.

Table 2

Power level	**Share of new installations**	**#Stations**	**Total capacity**
7,4 kW	0.05	330	2 442 kW
11 kW	0.35	2 316	25 476 kW
22 kW	0.4	2 647	58 234 kW
150 kW	0.15	993	148 950 kW
200 kW	0.05	331	66 200 kW
Total	**1.0**	**6 617**	**301 302 kW**

5 Location of Charging Stations

There are scenarios of the number of electric vehicles as well as public charging stations, but no prognosis of where these will be located. When examining the public charging infrastructure listed by Chargefinder [9], it is evident that the majority of chargers of every power level are placed in the larger cities. Fast charging stations are also to a large extent located along the highways with high traffic flows. Open source data on the yearly average day traffic flow in Sweden in available from the Swedish Transport Administration [10]. The average daily traffic flows in Skåne are plotted in figure 8.

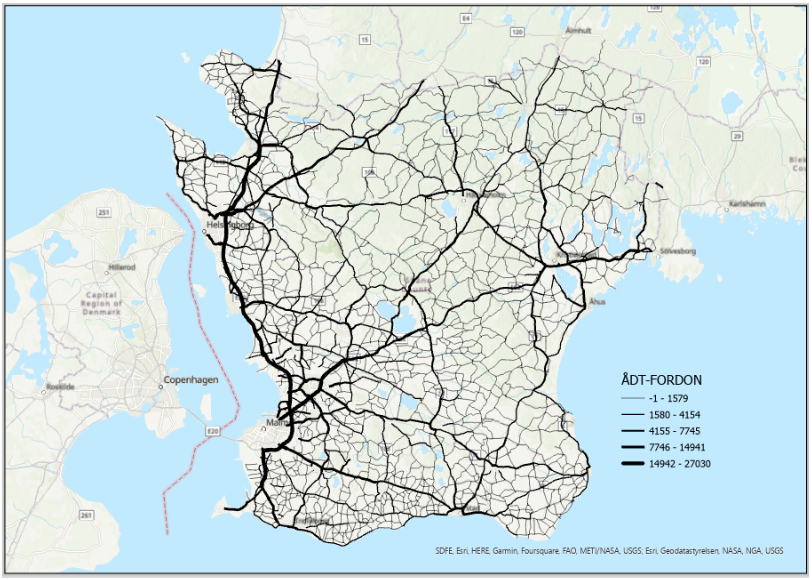


Figure 8: ÅDT cars

The locations of the transformer stations of the sub-transmission network are known in the study.

All geographical points in Skåne have been allocated to a transformer station based on the nearest distance. Based on the known distribution of chargers and traffic flows in Skåne, four zone categories have been defined for the created transformer zones. The categories are defined as:

- 1. Zone contains one of the major cities (Malmö, Helsingborg or Lund)
- 2. Zone contains major transport route
- 3. Zone contains other city with at least 10 000 inhabitants
- 4. Zone contains none of the above

Table 3 presents the assumed share of charging locations in each zone type for the different power levels. Different charging location scenarios can be generated by randomly deciding in which zone the individual chargers are placed in, as long as the overall distribution follows that defined in table 3.

Table 3

Power	**#Stations**	**Share in 1**	**Share in 2**	**Share in 3**	**Share in 4**
7.4 kW	265	0.40	0.15	0.30	0.15
11 kW	2 316	0.40	0.20	0.30	0.10
22 kW	2 647	0.40	0.20	0.30	0.10
150 kW	993	0.35	0.40	0.20	0.05
200+ kW	331	0.35	0.40	0.20	0.05

6 Conclusion

This report has provided a summary of the methodology and data sources behind the created 2030-scenario for public charging of electric cars in Skåne. The scenario can be implemented in a power grid simulating tool, such as DIgSilent's PowerFactory, to analyse the grid impact from the installed charging. To include the total demand from electromobility in road traffic, the scenario needs to be combined with other scenarios of the power demand from non-public charging of private cars as well as charging of heavy transport.

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