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SGEM 3.3.6-3: Shopping centers and park-and-ride facilities in Vantaa region

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1 Introduction

Shopping centers and park-and-ride facilities are potential locations where an EV might be charged in the future. In this paper, such places and their capacities and utilization rates are mapped inside Vantaa region. Further, the aim is to estimate the demand of supply power and needed equipment and figure out the impacts on the distribution network. See Figure 1.1 for an overview of the Vantaa region.

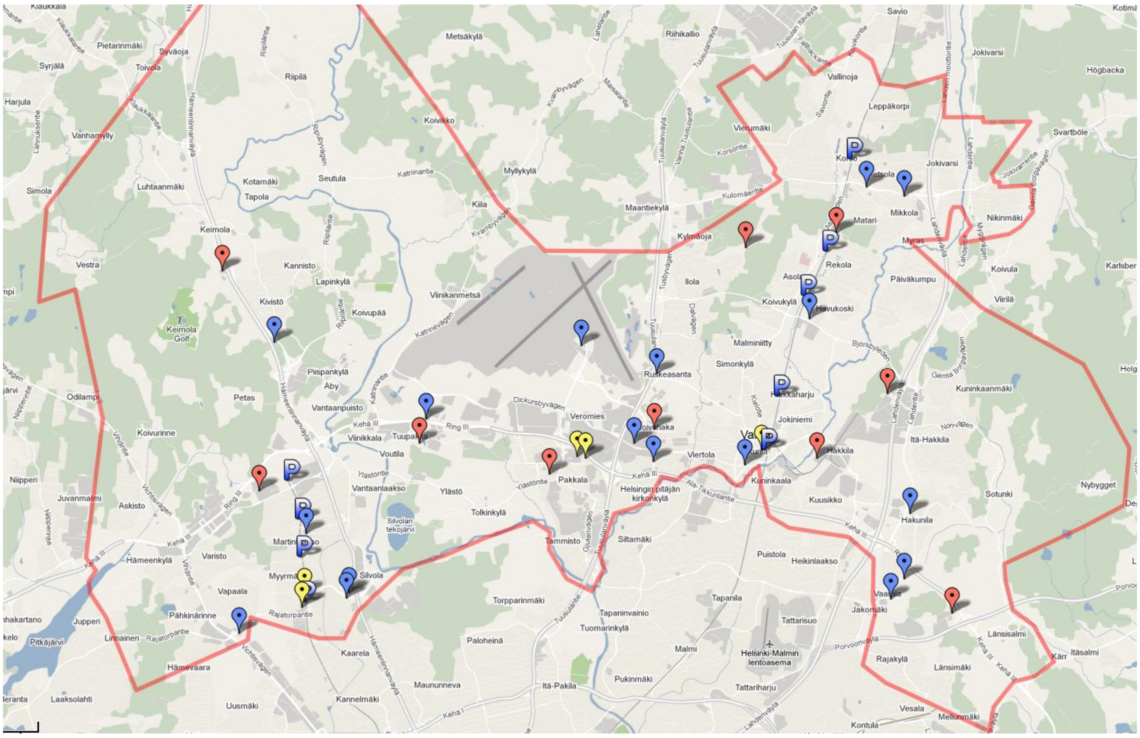

Figure 1.1. Gas stations (blue), primary substations (red), shopping centers (yellow) and park-and-ride facilities ("P") in Vantaa region

2 Applicable charging modes in shopping centers and park-and ride facilities

IEC 61851 includes technical specifications for an EV conductive charging system [1]. The standardization work is still going on. In the standard under preparation there are defined four modes for charging. These modes are shown in Table 2.1. Here the interesting issue is the power rating of each mode. Ultra-high and high modes that might be used in fast charging might be defining the requirements for the grid connection.

Table 2.1 Charging modes

Mode	Current rating max. [A]	Phases	AC or DC
1	16	1	AC
	16	3	AC
2	32	1	AC
	32	3	AC
3	32	1	AC
	70	1	AC
	32	3	AC
	63	3	AC
	250	1	AC
	250	3	AC
4	400	1	DC

Ultra-fast charging modes can provide a competitive alternative to present gasoline pumping in combustion engine vehicles.

3 Mileages

In Finland in 2009, the average total kilometers driven by a private car was 16500 km per car. Also other vehicle type annual average mileages can be seen in Table 3.1. [5]

Table 3.1 Mileages for different vehicle types

Vehicle type	Mileage [km/a]	Mileage per day [km/day]
private car	16500	45,2
truck	26600	72,9
van	11600	31,8
bus	44600	122,2

According to Henkilöliikennetutkimus 04-05 traffic survey [4] the average mileage in Finland per person as private car driver was 21,5 km/person/day and 10.5 km/person/day as a passenger. For Uusimaa region respectively 19,3 km/person/day and 9,9 km/person/day. [4]

In this case the first mileage, which was given per car and not per individual person, is more relevant.

4 Shopping centers

4.1 Provided charging modes

It shall be assumed that in a shopping center the provided charging power would be 1- or 3-phase and maximum of 32 A of current. This would provide a maximum charging power of 22 kW. If a customer spends for example one hour in a shopping centre, this would enable charged energy (80 % total efficiency) of

$$E = 0.80 \cdot 22.17 kW \cdot 1h = 17.74 kWh \tag{1}$$

.

If an average consumption of an EV is estimated to be around 0.20 kWh/km [2], this would equal to

$$range = \frac{0.80 \cdot 22.17 kWh}{0,20 \frac{kWh}{km}} = 88 km \tag{2}$$

.

No higher charging power can be seen necessary in this particular case.

4.2 Vantaa region shopping centers

4.2.1 General

The biggest shopping centers in Vantaa region are

- Jumbo
- Myyrmanni
- Kauppakeskus Tikkuri
- Kauppakeskus Flamingo
- Kauppakeskus Isomyyri
- Marja-Vantaa (planning).

Table 4.1 Shopping centers and their car parking capacities

Jumbo	4500	[Jukka Parkatti]
Myyrmanni	1100	[http://www.myyrmanni.fi/]
Tikkuri	300	[www.tikkuri.fi/]
Flamingo	-	
Isomyyri	-	

The utilization rate of the car park capacity varies a lot over time. The peak hours occur most likely at evening after work and on weekends. According to manager from Jumbo (Jukka Parkatti, in charge of the estates of Jumbo), the utilization rates are roughly 20 percent during working hours on working days and roughly 60 percent in the evening rush hours and on Saturdays [email conversation with Jukka Parkatti].

4.2.2 Charging load

It shall be assumed that the amount of EV:s follows the pattern shown in Figure 4.1. up-left corner. Now the number of arriving EV:s (up-right corner) can be calculated recursively from this information. Further the charging load (below-right corner) can be calculated as the number of arriving EV:s for each minute is known. Here the duration of the visit for each EV was defined randomly between a maximum visit time of 100 minutes and minimum of 41 minutes (chg time). This means an average visit duration of 70.5 minutes.

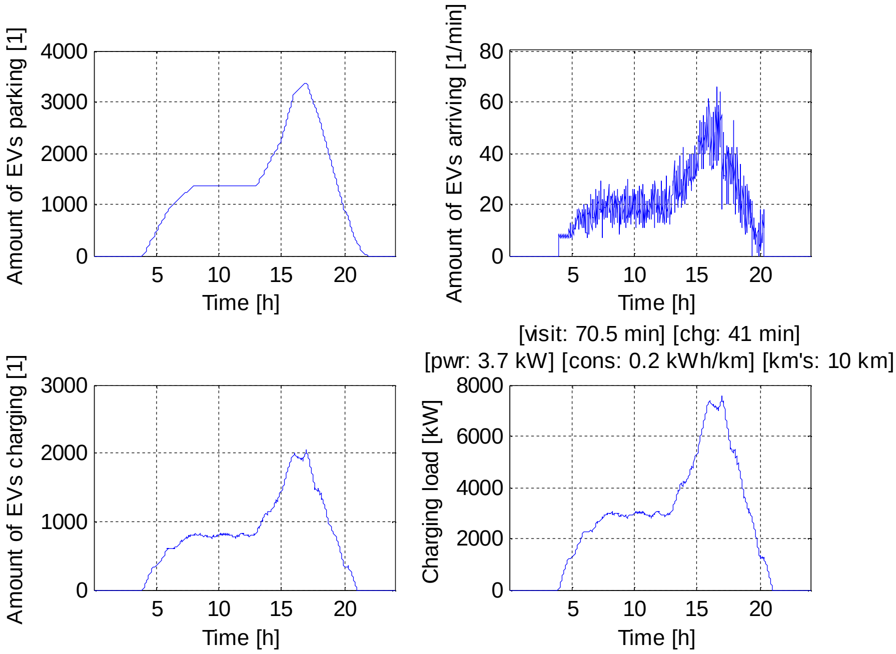

Figure 4.1. Jumbo case

4.2.3 Results

The parameters used in the calculations are shown in Table 4.2

Table 4.2 Parameters

Parameter	**Value**	**Unit**
Maximum visit time	100	[min]
Available chg power	3.7	[kW]
Consumption of EV:s	0.20	[kW/km]
Charged km:s per EV (fixed)	10	[km]

4.2.3.1 Jumbo

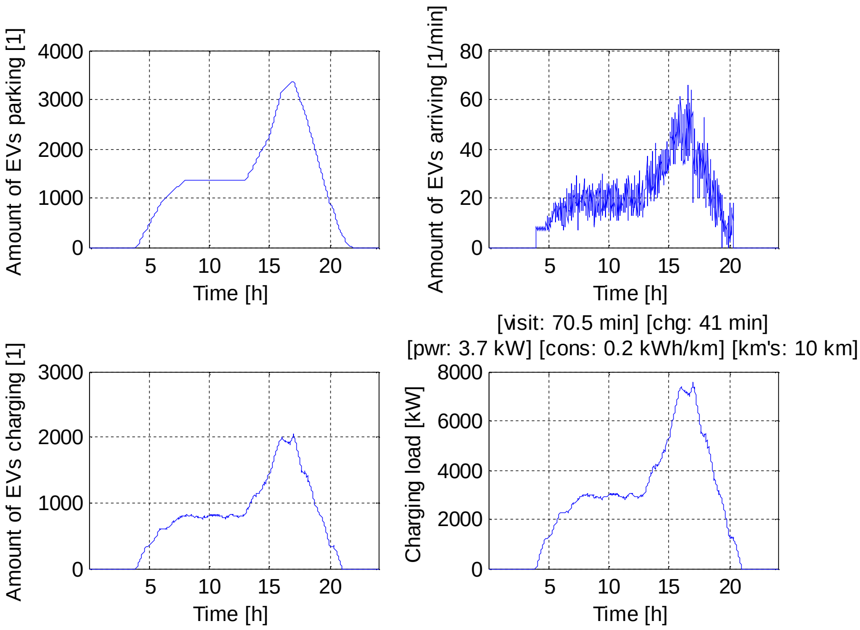

Figure 4.2. Jumbo case, 100 % EV penetration

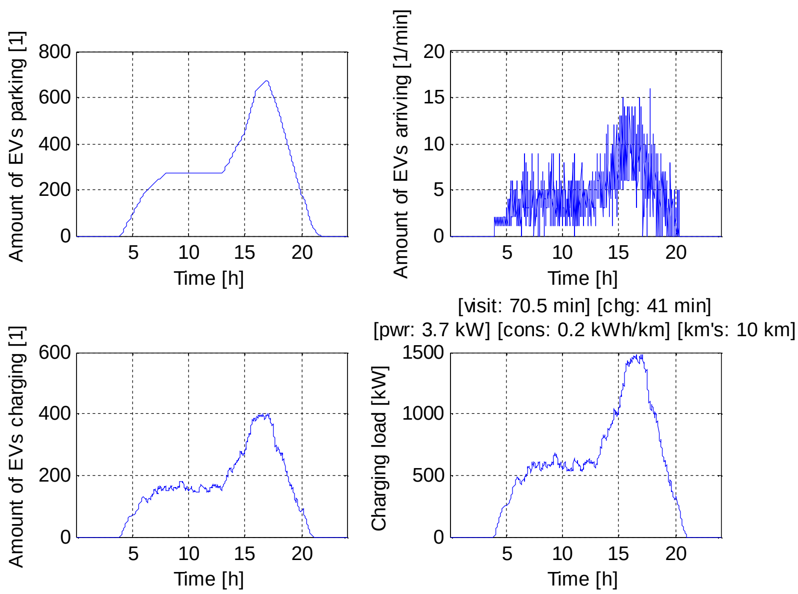

Figure 4.3. Jumbo case, 20 % EV penetration

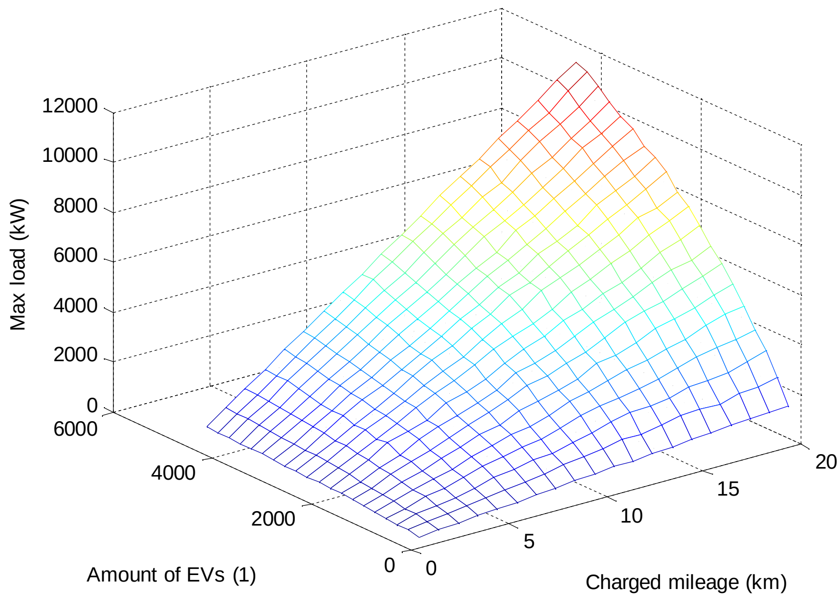

Figure 4.4. Jumbo case peak load, 0 - 100 % EV penetration, 0 – 20 km charged km:s

Figure 4.5 shows the peak load for the Jumbo case as a function of amount of EV's (0 – 100 % penetration) and charged mileage per car (0 - 20 km). Figure 4.6 shows the average load for the same case.

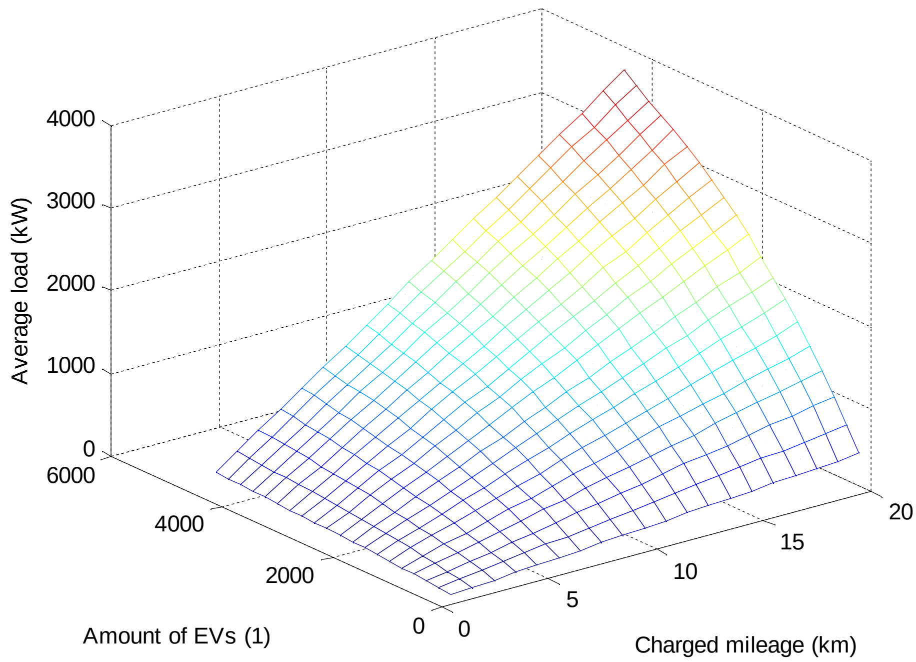

Figure 4.5. Jumbo case average load, 0 - 100 % EV penetration, 0 – 20 km charged km:s

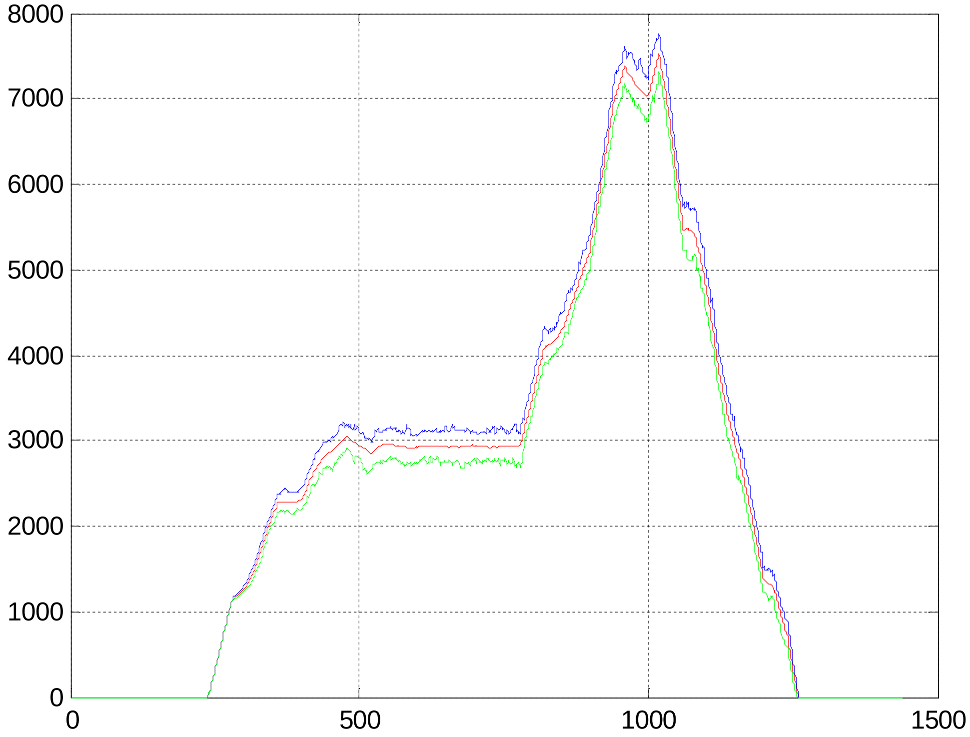

Figure 4.6. Jumbo case average load, 100 % EV penetration, 100 runs of the simulation, min (green), max (blue) and average (red) curves

Figure 4.6 shows the difference of the maximum, minimum and average for 100 runs of the simulation.

4.2.3.2 Myyrmanni

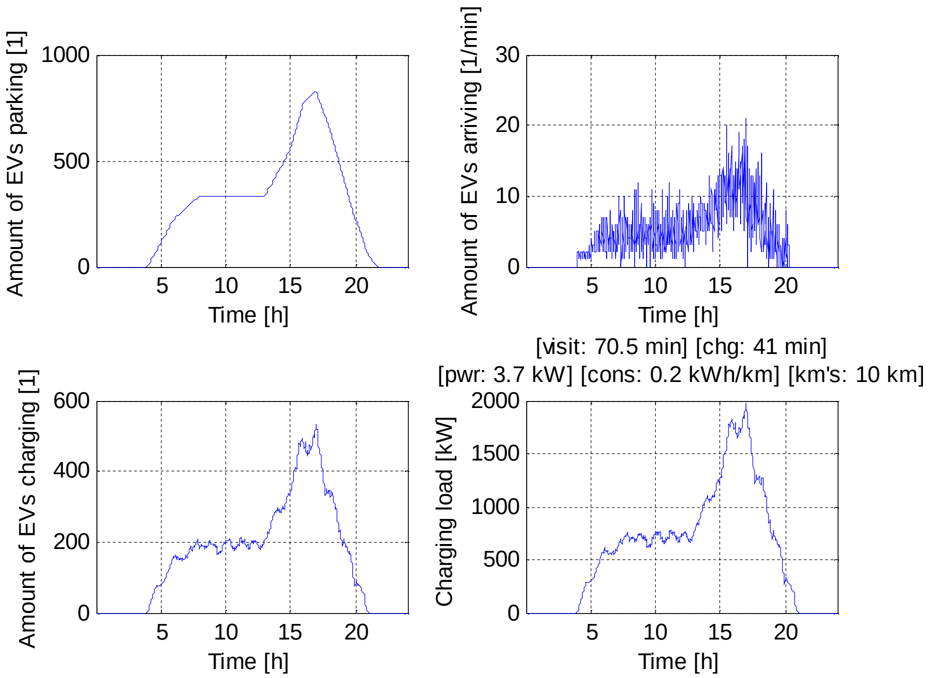

Figure 4.7. Myyrmanni case, 100 % EV penetration

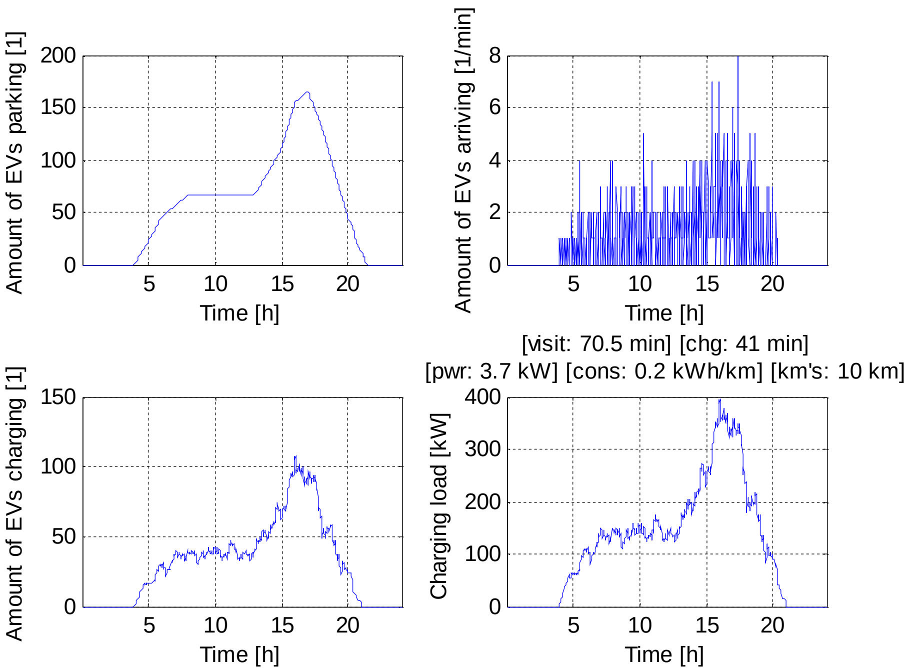

Figure 4.8. Myyrmanni case, 20 % EV penetration

4.2.3.3 Tikkuri

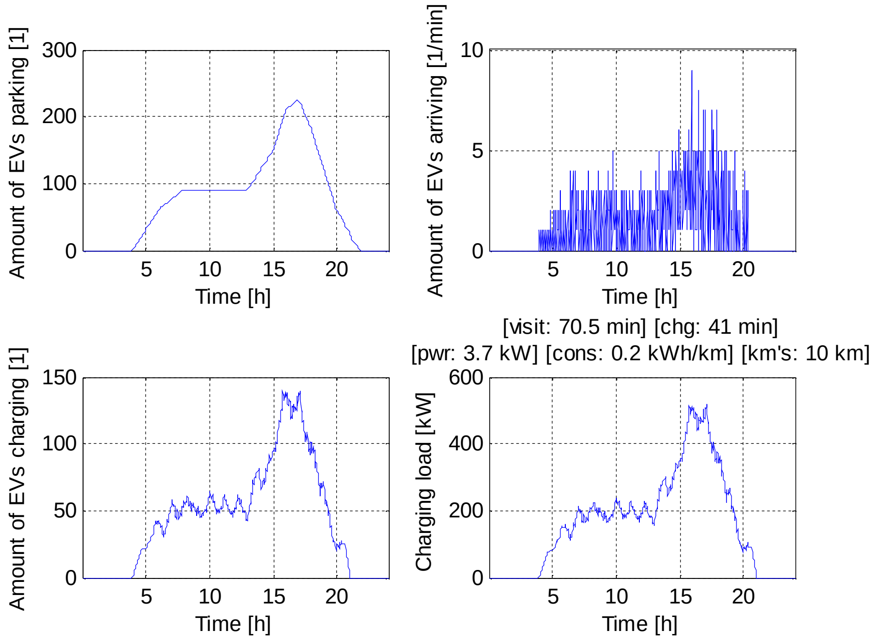

Figure 4.9. Tikkuri case, 100 % EV penetration

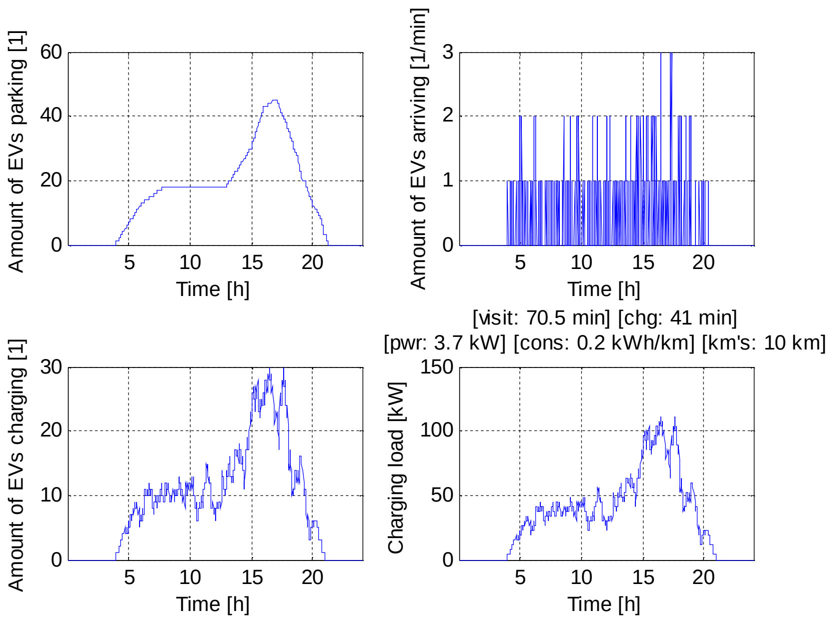

Figure 4.10. Tikkuri case, 20 % EV penetration

4.2.3.4 General comments on the results

The estimated peak load of shopping center of a scale of Jumbo would be high for a distribution network. This would mean rather high expenses for the connection to the grid.

All the calculations presented here are based on very rough and not precise numbers that are based on the present situation. However, if large parking halls are in the future equipped with extensive charging infrastructure, the usage of these places most likely will not follow the pattern of present day. Night time charging would be very attractive alternative for many reasons. For this reason very detailed considerations can be seen unnecessary.

5 Park-and-ride facilities

Park-and-ride facilities are basically car parks that are meant for private car users wishing to transfer to public transport (usually train or bus) and to continue their commute or other purpose trip by the means of public transport. Park-and-ride facilities are often located outside the city center and have good connections to city downtown.[1]

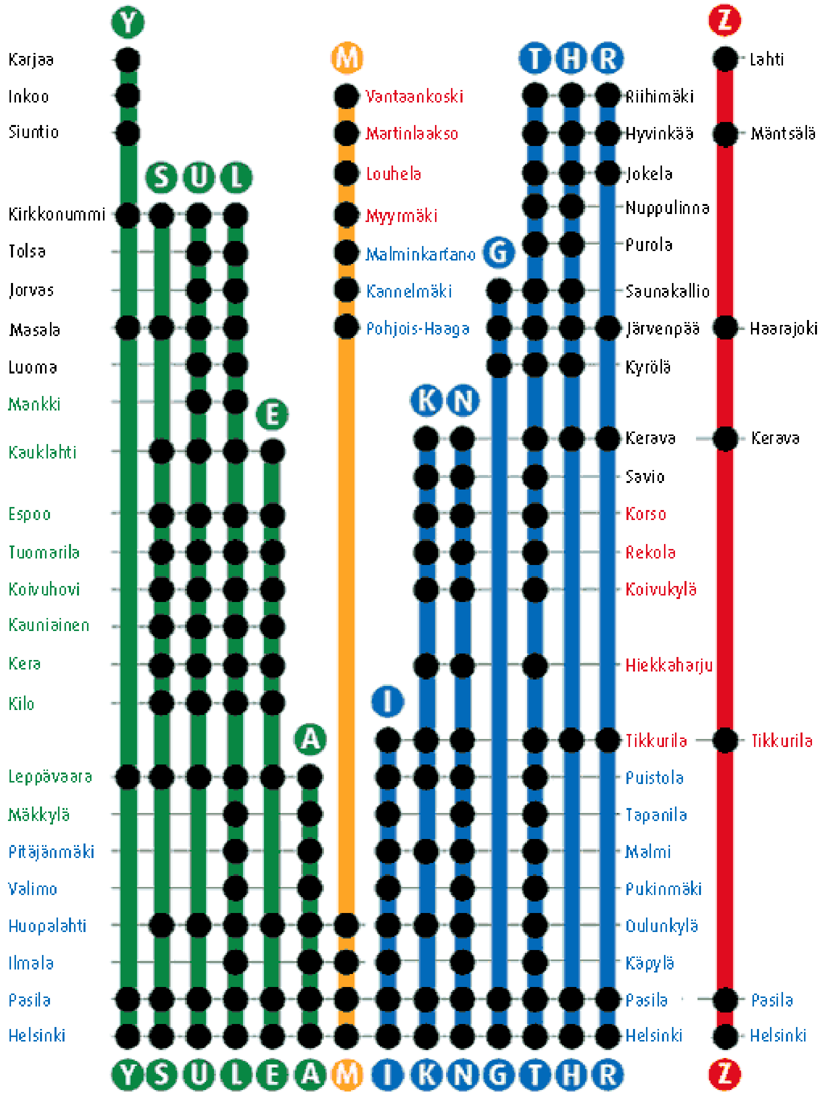

Figure 5.1. Commuter train stations in Helsinki metropolitan region, stations in Vantaa marked by red text[2]

[1] [http://en.wikipedia.org/wiki/Park_and_ride]

[2] [http://www.vr.fi/fin/aikataulut/reittikartat/lahiliikenne.shtml]

In Vantaa region, the most important park-and-ride facilities are located mainly at the train stations. The train stations (and their car park capacities) in Vantaa region are (Figure 5.1)

- Tikkurila (397)
- Hiekkaharju (84)
- Rekola (42)
- Korso (390)
- Myyrmäki (83)
- Louhela (14)
- Martinlaakso (120)
- Vantaankoski (67)

Tikkurila train station is the main station in Vantaa region and also the biggest park-and-ride place in Vantaa. According to HSL[1] the car parking capacities of these stations vary from only 14 to approximately 400 car parks.

According to HSL the parking time in the previous facilities is often limited to 12 hours. It might be reasoned to assume that a car parker might park one's car rather long time, one to 10 hours or so, in a park-and-ride facility, as the idea is to use it to continue to city downtown to work. If it is assumed that for example a 1-phase 16 A connection is provided, the average upper limit for the charged energy would be

$$E = 0.80 \cdot 3.7kW \cdot 5h = 14.8kWh\,. \tag{3}$$

This means

$$range = \frac{14.8kWh}{0{,}20\dfrac{kWh}{km}} = 74km\,. \tag{4}$$

Typically the charged kilometers would most likely be much less than 74 km. A significant proportion would be charged at home. If, however, the charging is arranged without any intelligence and staggering in the system and a great proportion of the car park is filled approximately the same time in the morning, the maximum peak load in those hours might rise rather high. Here shall be calculated an average load with average charged kilometers of 50 percent of the daily total average kilometers. It is assumed that the main usage of the park-and-ride facility is the workers who arrive to the facility between 6 and 9 am. It is assumed that in the beginning the car park is empty and in the

[1] [http://www.hsl.fi/FI/matkustajanopas/liityntapysakointi/Sivut/pysakointialueet.aspx]

end of the ramp the car park is 100 percent full, see Figure 5.2. Maximum visit time used here is 300 minutes.

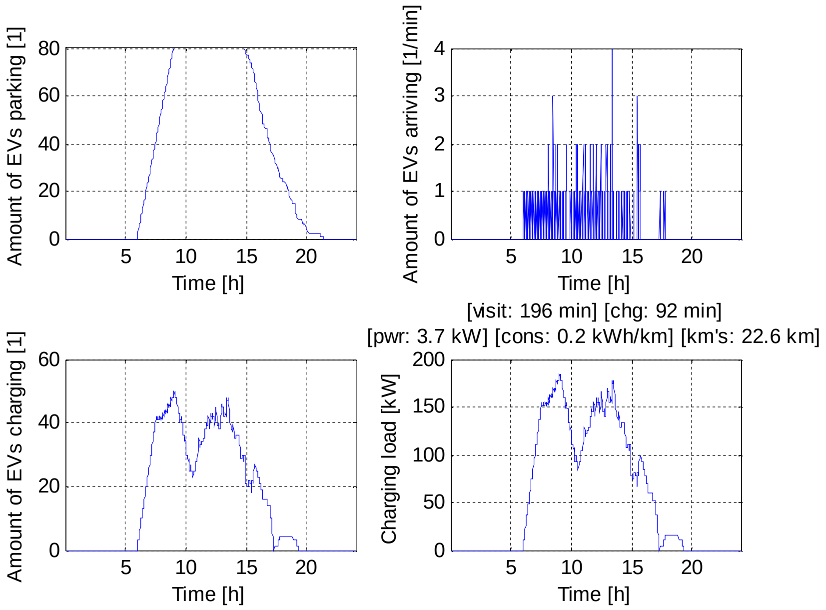

Figure 5.2. Tikkurila train station case, 20 % EV penetration

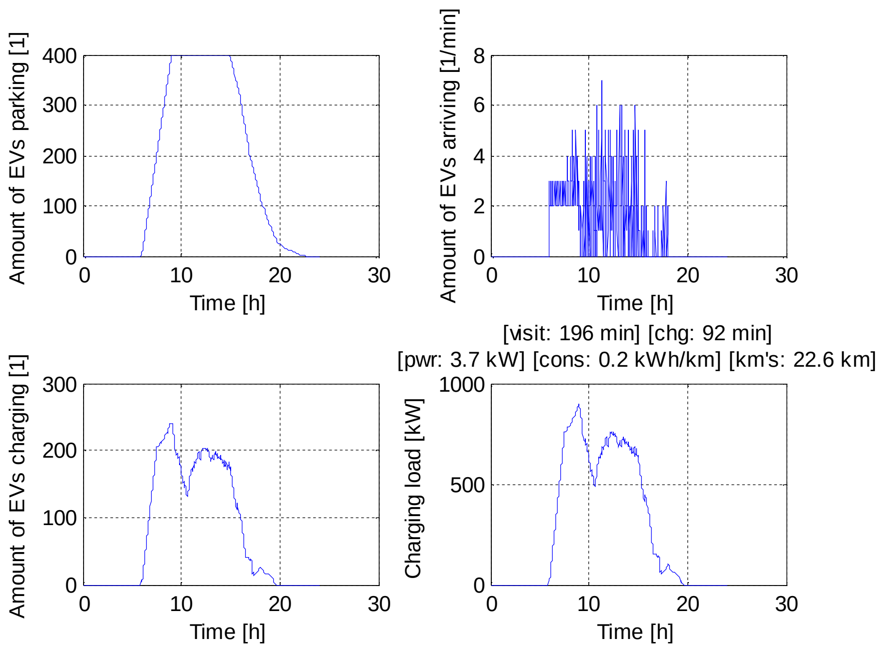

Figure 5.3. Tikkurila train station case, 100 % EV penetration

Table 5.1 Approximated power needed, 20 and 100 percent penetration of EV:s

Railway, Station	Car parking capacity	Average load, 20 % [kW]	Peak load, 20 % [kW]	Average load, 100 % [kW]	Peak load, 100 % [kW]
Martinlaakso railway					
Vantaankoski	67	10	44	48	167
Martinlaakso	120	18	70	85	266
Louhela	14	2	11	10	37
Myyrmäki	83	12	52	57	192
Main railway					
Korso	390	56	170	276	918
Rekola	42	7	33	29	96
Koivukylä	148	22	74	105	318
Hiekkaharju	84	14	59	62	207
Tikkurila	397	57	170	282	918

Note that the values shown above are based on one run of the simulation and for that reason the random nature of the values may have rather high influence.

6 Helsinki Airport

Helsinki Airport (also known as Helsinki-Vantaa airport) has a very large car parking capacity of 12400 car parks in total. There are several different areas and car parks for both short term and long term car parking (Pikaparkki, Lomaparkki, Bisnesparkki, Kaukoparkki). [3]

In an airport the car parking times vary a lot. There is a proportion with typically longer staying times than in the previous park-and-ride and shopping center cases. Also there are a lot of cars coming to drop a passenger. This might lead to favoring a concept where both fast charging and very low power charging are provided. The fast charging could be handled with a fast charging station comparable to a present gas station.

7 Discussion

The shopping centers have very high car parking capacities. If, in the future, even a certain proportion of this capacity is equipped with an EV-charging possibility, it would result in high or extremely high load for the distribution network. Present LV-installations would not most likely be sufficient and strengthening of the cabling and equipment would be needed.

The car parking capacity in the park-and-ride facilities is much lower than that of shopping centers. These loads might in many cases be able to be handled without significant changes to MV-network.

References

[1] IEC 61851

[2] Wikipedia, Sähköauto
http://fi.wikipedia.org/wiki/S%C3%A4hk%C3%B6auto

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