Smart Charging – A Strategy for Charging EVs in Big Cities with Load Shifting and Control

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1. INTRODUCTION

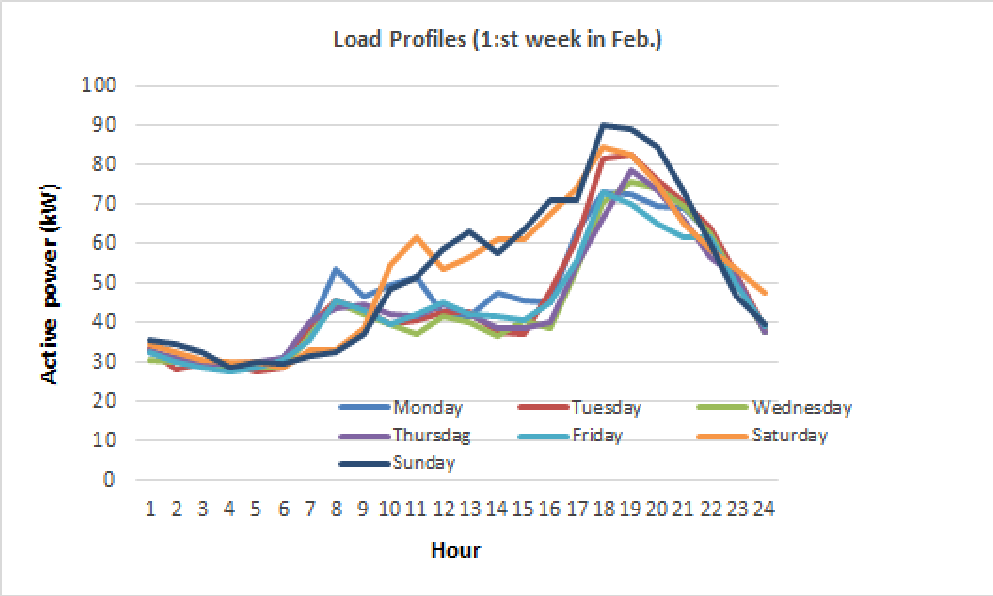
- By 2030 Swedish transport sector will reduce use of fossil fuels by 70% compared to 2010.
- A significant proportion of the vehicles in Swedish major cities will be electrified in the coming years.
- Electric vehicles will pose a number of challenges to the city's power supply system. Electricity supply of Swedish major cities is strained for a number of hours during a year. The network constraint can arise during high loads of about total 100 hours distributed during a year in Stockholm.

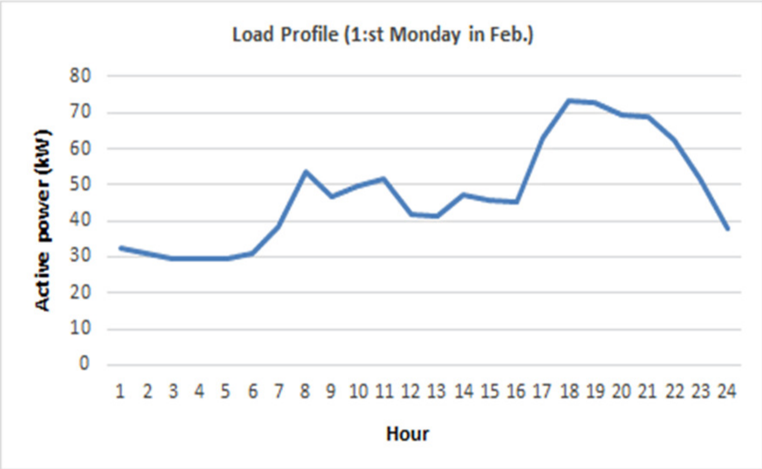
Objectives:

- Address strategies of how to deal with the challenges brought by increasing EVs.
- Present a study at Vattenfall R&D

2. TYPICAL LOAD PROFILES

- Load profiles of a typical Swedish residential apartment area.
- High power consumption occurred during winter season.
- Two peak loads, one in early morning 7:00-8:00 and one during evening at 18:00. Less power consumption during the day and night.





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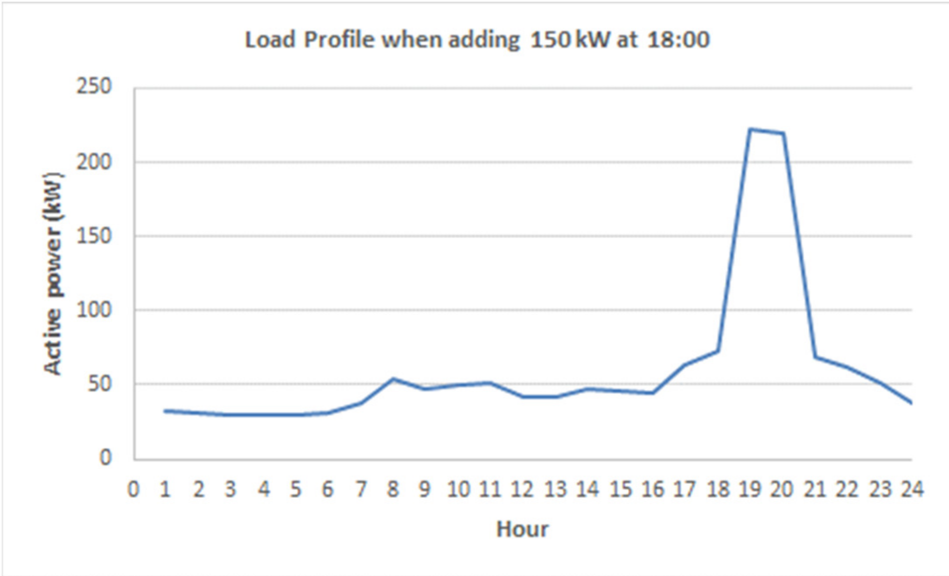
3. SENARIO WITHOUT CHARGING CONTROLL

- Most people in Stockholm return homes around 17:30-18:30 during weekdays.
- Scenario assumes:
  - Each household uses one electric vehicle, and 50-90 EVs could be charged simultaneously.
  - EV owners plug in EVs at 18:00 to obtain a fully charged battery for the next morning.
  - Charging rate is 3 kW.
- The uncontrolled charging can affect the existent load negatively with significant increase of peak load at 18:00-19:00. Without control the charging pattern would add 150-270 kW to the peak load at 18:00, an increase of the absorbed peak power by 147%.



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4. CONTROL STRATEGY AND ASSUMPTION

Principles of the control strategy:

- Manage EV charging power as an off-peak load and control the majority of charging to be moved to night hours during the off-peak period.
- Not increase the peak of non-EV base load, and retain the total power demand without exceeding the subscribed maximum power.
- EVs are charged on a daily basis at controlled rate between max. and min. charging power. The charging energy is controlled to a reasonable amount which meets the daily need.

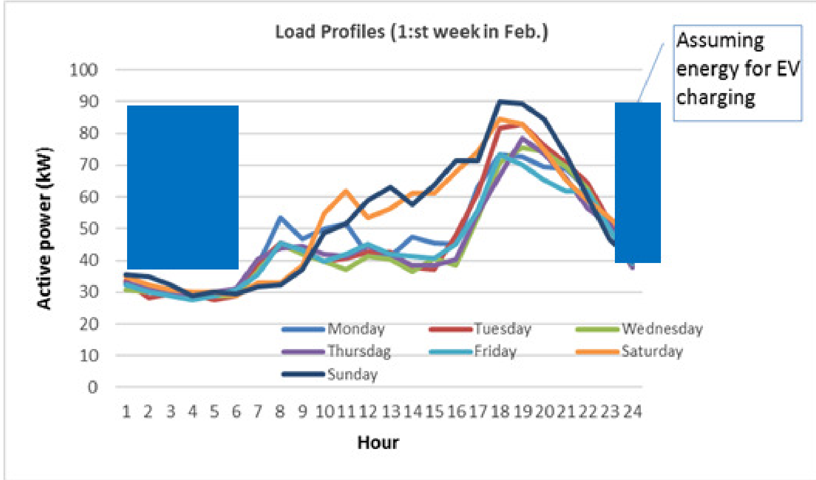
Assumptions:

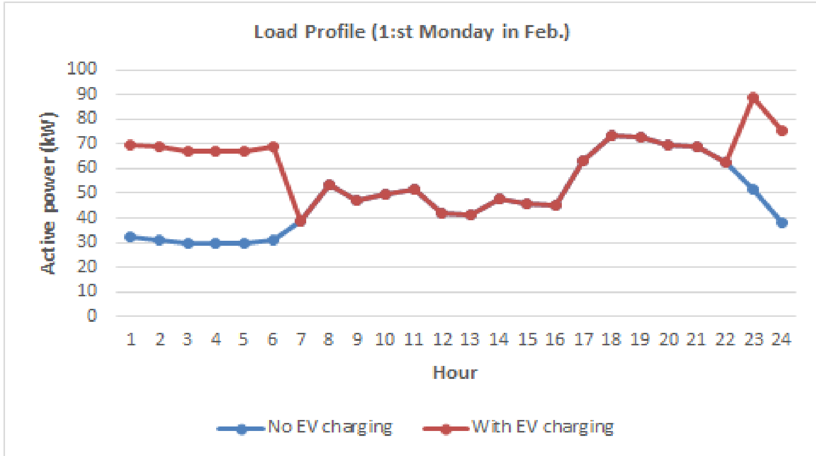
- An EV battery can be charged at a rate between its maximum and minimum charging rate.
- The EV charging points are situated at residential city area where the arrivals and departures of EVs are relatively stable.
- Plug-in electric vehicle charging from grid (G2V) is considered only.

5. CONTROLL SENARIO 1

- Shifting EV charging load away from the evening load peak around 18:00 into low load hours 22:00 - 06:00.
- Scenario assumes:
  - EVs have a daily driving distance 40 km
  - An energy consumption of 0.15 kWh/km
  - Charging rate is controlled at 0.75 kW
- While charging is performed during night valley hours, the total energy delivered to 50 vehicles for daily driving results in no increase of the maximum subscribed power.

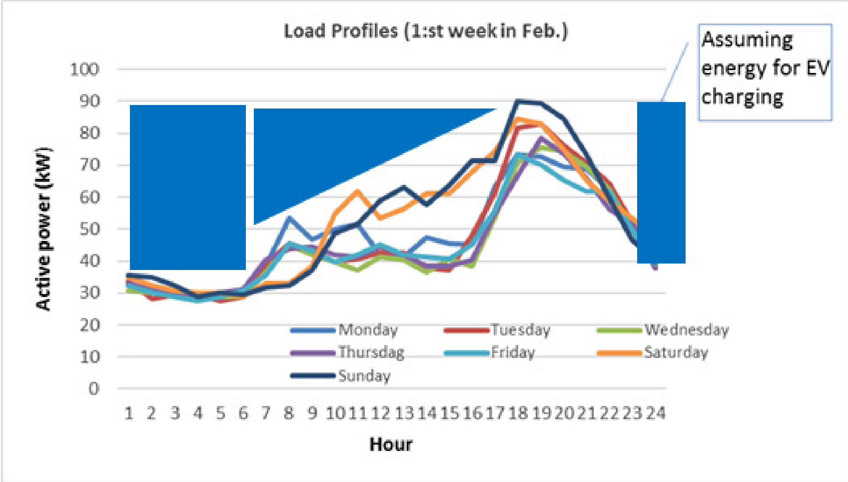
  The additional charging demand is not coincidental with the evening base peak load around 18:00.

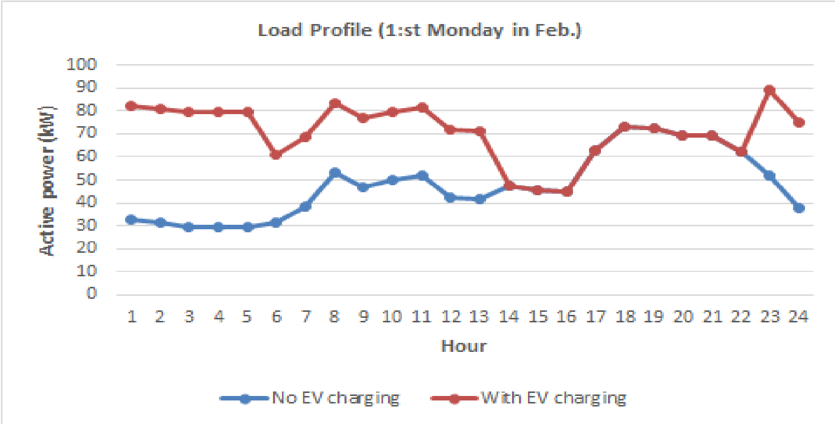




6. CONTROLL SENARIO 2

- A coordinated charging situation considering higher charging demand, variable charging rate and different EV parking times.
- Scenario assumes:
  - ➢ charging demand increases to 540 kWh in order to fully charge 90 vehicles for daily energy usage.
  - ➢ the vehicles are divided into two groups, one group for night charging and the other for daytime charging. 40 vehicles park over a day and are charged during daytimes.
  - ➢ The charging power is controlled to higher rate during night and lower after 05:00 during daytime.
- The results indicates that it is possible to deliver more energy to EV charging without increase in the facility electricity subscription.





6. CONCLUSIONS

- Smart charging control is a key aspect in the strategy for EV charging in big cities and is a solution to the challenges brought by increasing numbers of electric vehicles. If no charging control, it is very likely to cause system overloads and have a negative impact on the electric networks.
- Moving EV charging load to low load hours, typically night valley hours, is a simple and feasible approach.
- Residential load profile has fundamental importance for the analysis of the control strategy. A schedule-controlling EV charging should be based on real-time load profiles and residential practical load variations.

Thank you for your attention

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