Smart charging

Smart charging is a series of intelligent functionalities to control the EV charging power in order to create a flexible, sustainable, low cost and efficient charging environment.

Benefits of smart charging:

- It can increase the flexibility of charging by controlling the charging power, charging time duration and charging power flow direction.
- With the high charging flexibility, the utilization rates of fixed assets like transformers and power lines can be higher, which also helps in reducing the cost of EV charging.
- Smart charging can increase the efficiency of power transfer and help reduce the peak demand on the distribution network.
- EVs can be made more sustainable by charging them based on solar and wind generation. Moreover, smart charging can provide new revenue streams to EV owners like providing frequency regulation and vehicle-to-grid services.

V2x

The battery power can flow from the vehicle to a home, to a building, to a load, etc. and it is called V2H, V2B, V2L, respectively. V2x is the generic term that is used to include all such applications.

Key benefits of V2x technology:

- It enables the storage of electricity in the car, especially from renewable sources which lead to emission reductions.
- By using the stored energy, the peak demand in the electrical grid can be reduced.
- Electric cars can now serve as an essential system component in an emergency power supply system.
- Ancillary services can be offered to the grid using an electric car with V2X configuration providing a revenue stream to the EV user.

Main challenges for V2x:

- V2x needs bidirectional chargers, which are bigger and more costly than unidirectional chargers.
- The lifetime of the battery inside the EV is partially reduced, since the bi-directional charging demands more charging cycles, causing additional degradation.
- Electric cars can now serve as an essential system component in an emergency power supply system.
- The ICT infrastructure, the required standardization and regulatory

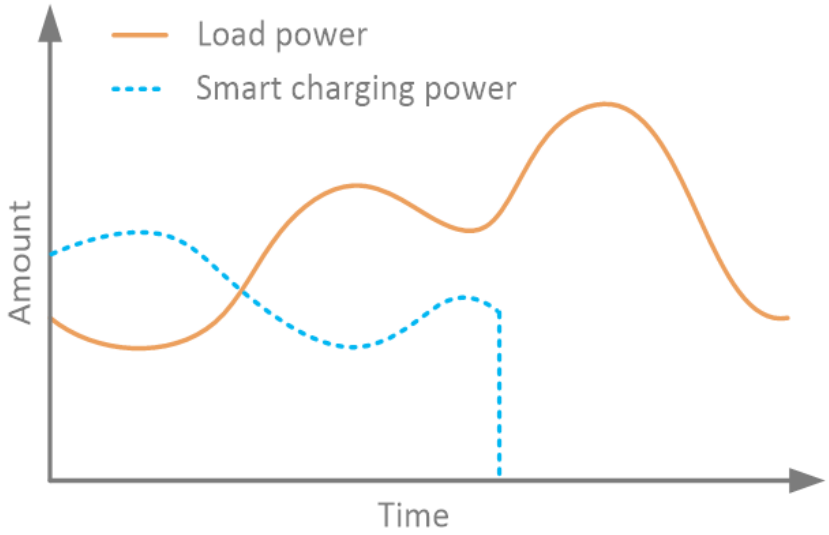
framework and financial incentives which are essential for the implementation of V2x are still under development.

Finally, it is important to note that vehicle-to-grid is currently not possible using AC chargers due to the technological limitations. This is because a bidirectional onboard charger is needed for vehicle-to-grid, but most current EVs only have a unidirectional charger. Further, V2x requires higher levels of communication between the EV and charger and this is not fulfilled by the simple PWM communication in Type 1 and Type 2 AC chargers. Hence, bidirectional off-board DC chargers are used for vehicle-to-grid applications using higher level of communication between the EV and charger using PLC, power line communication or CAN, control area network communication.

Applications of smart charging

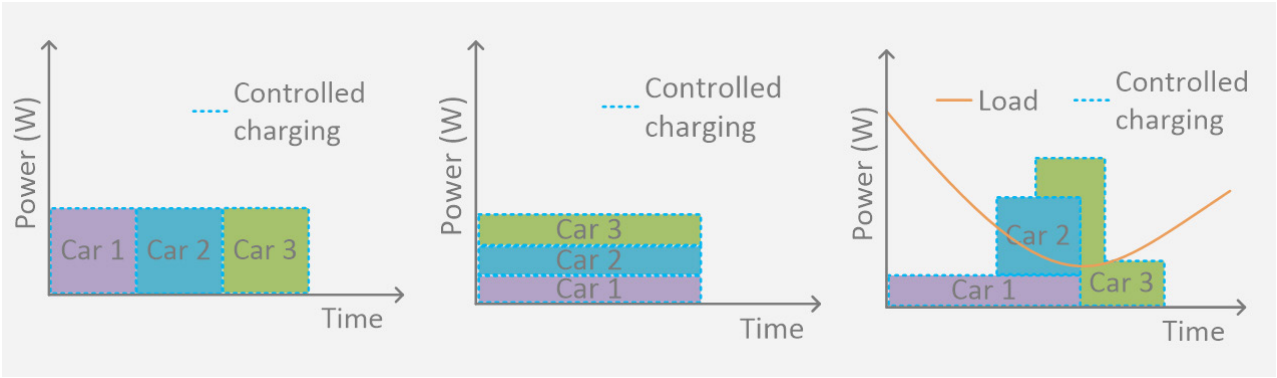
1. Local load balancing
    - Adjust charging time/power according to load
    - Balance multiple charge points with priority
2. Renewable energy utilization
3. Price based charging
4. Peak shaving
5. Grid back up

Local load balancing

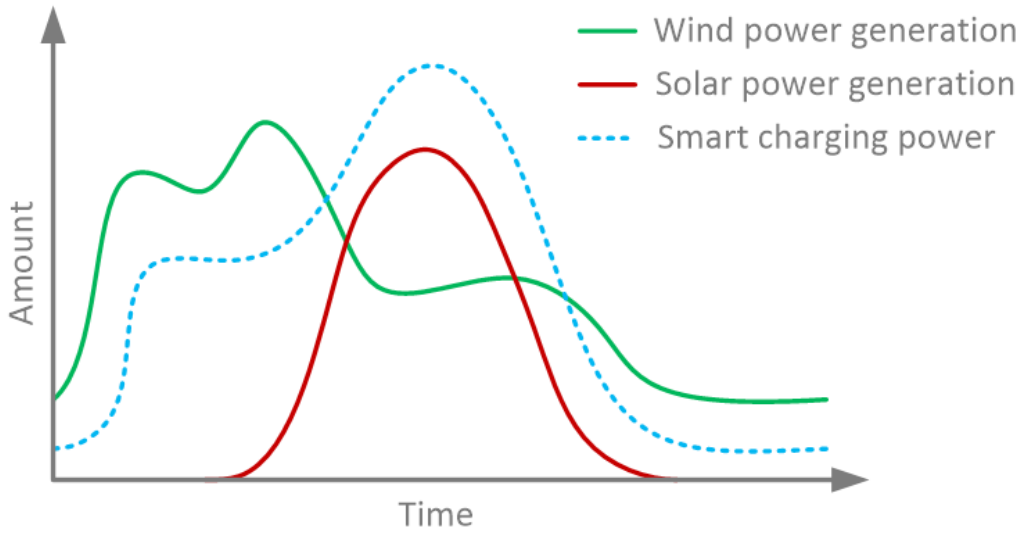


The first load balancing approach is to shift the charging time slot and to adjust the charging power based on the grid capacity and local loading condition.
For example, when the load on the grid is low, the EV charging power can be increased. Alternately, if the load power increases, then the EV charging power can be subsequently reduced. Finally, the EV charging can be stopped if the grid is overloaded and remain so until the load power is back to normal.

The second approach is to balance multiple charge points with priority. With a limited maximum power for charging the cars, smart charging can sequentially operate multiple charge points with priority, or adjust the power of each charging point so as to be within the maximum limit.

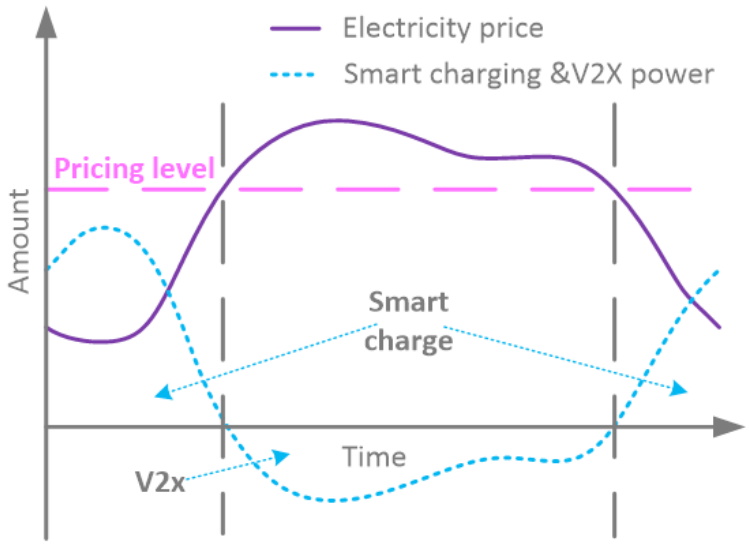


Renewable energy utilization



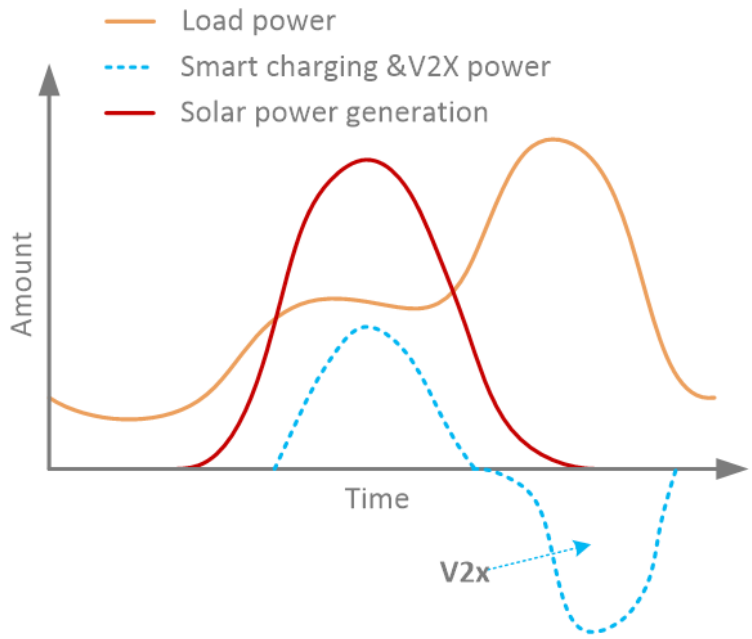
Smart charging can help in controlling the charging power of the car based on the renewable energy production, say from solar and wind generators. Further, with V2G, the electric cars can be used as massive energy storage to balance the variable generation from renewable energy sources.

Price based charging



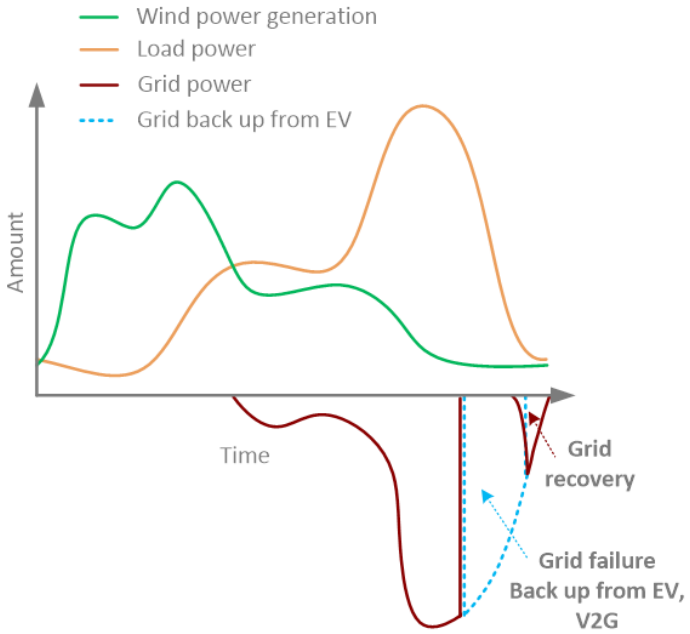
The charging power is increased when the electricity price is low, and the charging power is decreased or even stopped when the electricity price is high. Further, customers can get more profit when the V2x is applied. For example, we can charge the cars when the electricity is cheap and discharge the car via V2x when electricity is expensive and above a certain pricing level. In this case, the “x” of the “V2x” can be home, building or the grid.

Peak shaving



Here, the aggregated EVs can work as mass storage in the grid. With controlled charging, the EVs can be charged when there is extra renewable energy generation, and they can discharge via V2G to feed the grid when is a peak load in the evening. By doing so, the peak of both generation and consumption can be shifted, and the electric power demand-supply gap can be perfectly matched.

Grid backup



In the future, electric vehicles can even operate as a backup for the grid on a relatively large scale. In case of a short duration failure, EVs can be connected to the grid, to our homes or to loads and can be controlled to provide emergency power via V2G.