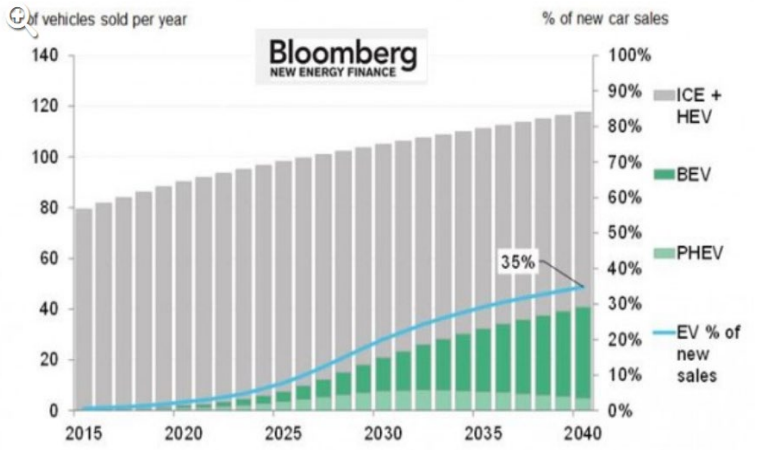
EV Charging Power Management System

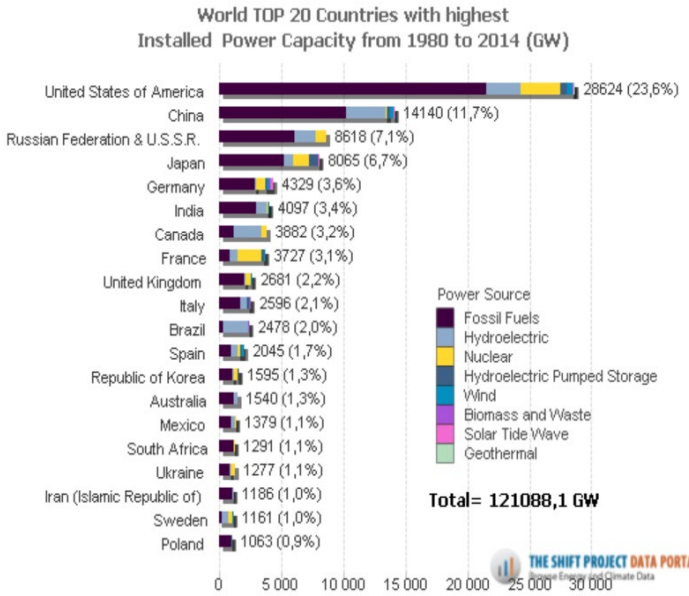
Introduction (Growth predictions of EV market)

Yes, this time Electric Vehicle (EV) arrived to stay. A total of 1,2 million EV's were worldwide manufactured in 2017. The total growth of new EV sales from 2016 was almost 60%. Expected growth for new EV's in 2018 is 48% worldwide. This level of growth is expected for many coming years. The total EV numbers will be 9-10 million units by 2020 (8,4% penetration) and will continue its growth so that they will be 35% of global sales by 2040. This fact will have big impact on the automotive industry, environment conditions and, specially, on the Electric Power sector: Generation, Transmission, Distribution and final use.



Regarding to the present Electric Power systems EV's are intruders, but also a great opportunity to improve its efficiency (energy storage, renewable energy use, flatten day power curve, …). But, is the Power system prepared to support the demand increase to fill the EV's batteries? What are the solutions to mitigate the predicable power shortage?

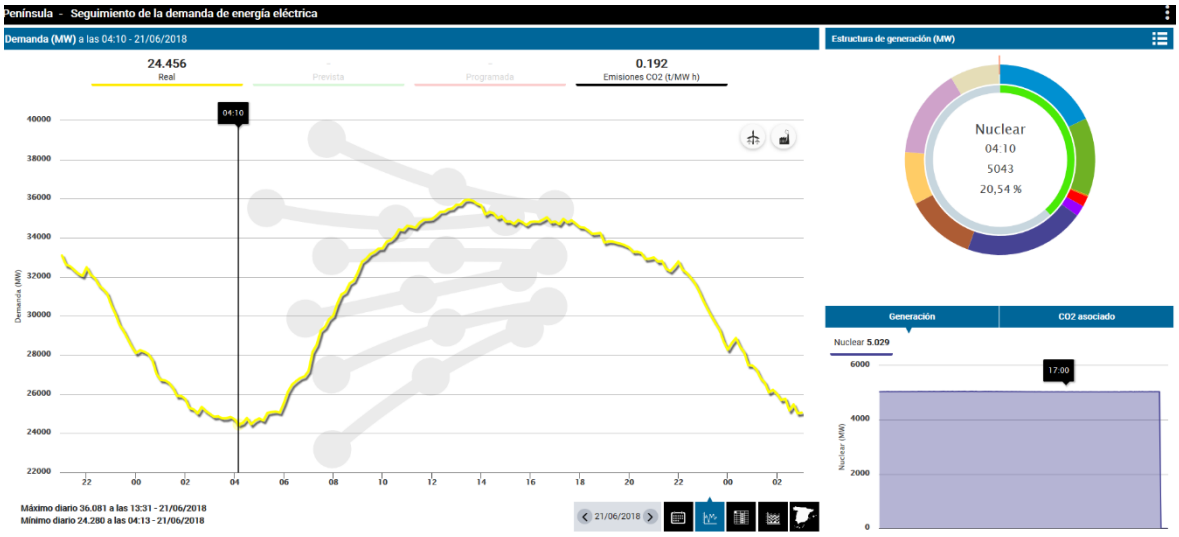
Available Power for EV Charge



Let's have a look to the top 20 countries with highest Electric Power Capacity. The approximate total Generation Capacity is 5800 GW. China to be 23%, USA 20%, EU27 16%. Assuming an average use of 60% of above figures, we have a potential non-used generation of 2320 GW which could be used to charge EV's.

Let's use as an example Spain. Installed Power is 100 GW. The sources are: 40% fossil fuels, 23% wind mills, 13% Hydroelectric, 7% Nuclear, 7% Solar, other 10%. The maximum requested instant peak power is 46 GW. We can observe that during valley

periods wind energy is minimized despite there is wind. So the power system from generation point could charge a lot of EV's.



The needed power to simultaneously charge 1Million car, at an average power of 10 kW, is 10 GW. Some will charge at home at 3,2-7,4 kW, some at work at 7,4-11 kW, some at public chargers at 22-50 kW, some at high speed chargers at 50-150 kW and more, …. Just for information the 1,000,000 EV's would get into its batteries around 20 GWh (considering an average charge of 20 kWh per session).
So, charging 1 million EV's simultaneously is only possible with appropriate country and local power management control (as the day power curve and the local power limitations on distribution are to be considered).

Methods to avoid overload and power system collapse

The generation and transmission grids could, in some countries, be prepared to take more energy to be used to charge EV's. Depending of the case, with an appropriate management they could even increase the use of renewable sources. This is the example of Germany, UK or Spain with considerable wind source generation that are disconnected during the valley demand hours despite there is wind.

The distribution grids have more difficulties to take more power. The grid was not designed to increase the extra requested power needed to charge EV's. Therefore, it will be necessary to invest in expanding the size of the grid and/or to reduce the demand grow impact.

There are some methods to avoid overload at distribution and local power lines:

- *Renewable energy local production*: Home or communities can produce their own energy (solar, wind) to charge EV's.
- *Energy Storage*: The Power can be stored when available to charge EV's during shortage time. The energy can be stored at homes, communities or massive hubs. Second life EV's batteries will pay an important role in the medium-term future. Even the EV can become a huge energy storage for the system. By this the power network goes to a new more complex system: the distributed generation (multiple small generation points instead some big ones).

- *Dynamic Power Management*: It is the most cost effective and easy to run system to avoid main breakers tripping and to perform the EV's charge at the fastest speed. By this method the EV's charge are adapted to the dynamic available power. There are templates and technology to implement the dynamic power management at homes, work, fleets, hospitality, public charging, …

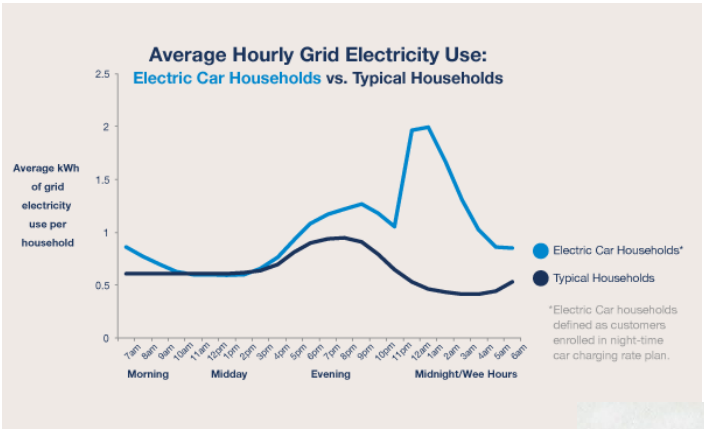
Dynamic Load Management scenarios

As said, the Dynamic Power Management is the most cost effective and efficient method to allow EV's charging, without overloading the available power and granting the fastest possible charge of the EV's, at the different scenarios. Let's see one by one.

Home:

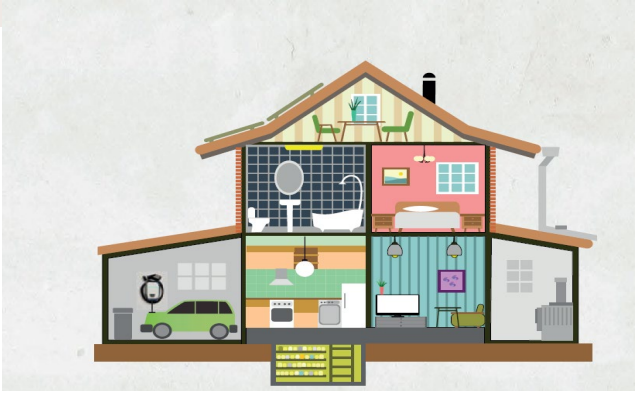
Home charging was already an issue earlier XX century with the first EV's.

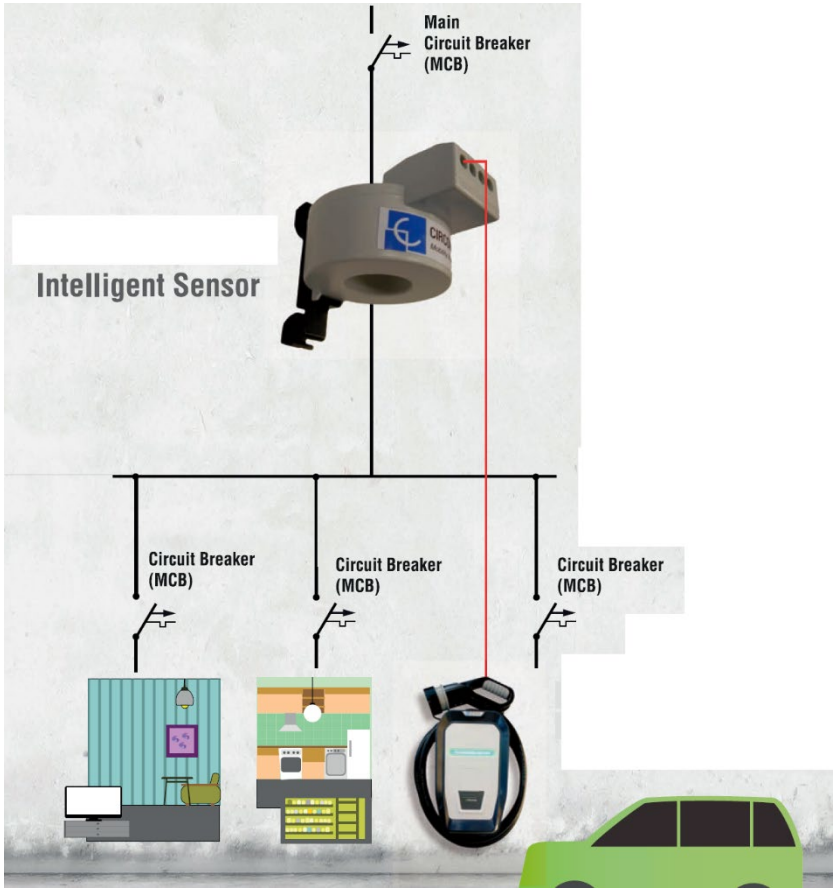
On most existing houses the electric system wasn't designing to charge EV's. Therefore, a power contact increase with the electricity provider is necessary, in some cases it is not possible (no more available power at the zone) or it is money costing. For new houses it is also highly recommended to install a dynamic power demand management system.



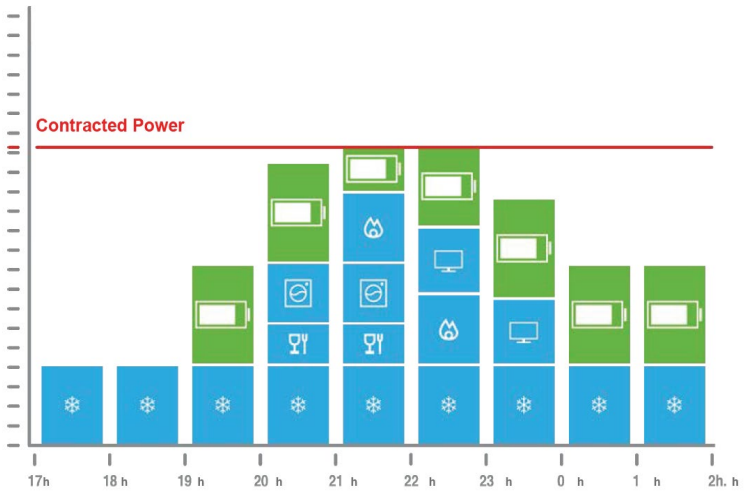
The installation of a home dynamic power management system will allow to charge the EV faster without the need of a costly installation upgrade, avoiding any risk of blackout when using the appliances and charging the EV at the same time.

Home with a garage where EV will be charged.





A sensor is to be installed at the main breaker home cabinet to get the real time house power. This sensor will send the signal to the EV charger and it will decide to let the EV get tits full requested charge power or to reduce it until necessary. This is possible only with EV charger type 1 or 2 but not with the existing home garage plug.



Garage curve example where intelligent system reduces the EV charge to avoid main breaker trip.

The home runs without problems. All domestic appliances are doing its job. The EV charges at available maximum power and never will cause main breaker tripping.

Condominium, Work, Fleet, Public Parking

When we have multiple EV's that can be charged at the same time, at the same place we have an additional issue. Not only we have to charge all cars at maximum possible speed, but we also have to protect the main breaker to trip.

Obviously, the investments on increasing the power could be done but most times this is not possible either because the power increase is not available at this zone or because the owner of the building does not like to spend more money.

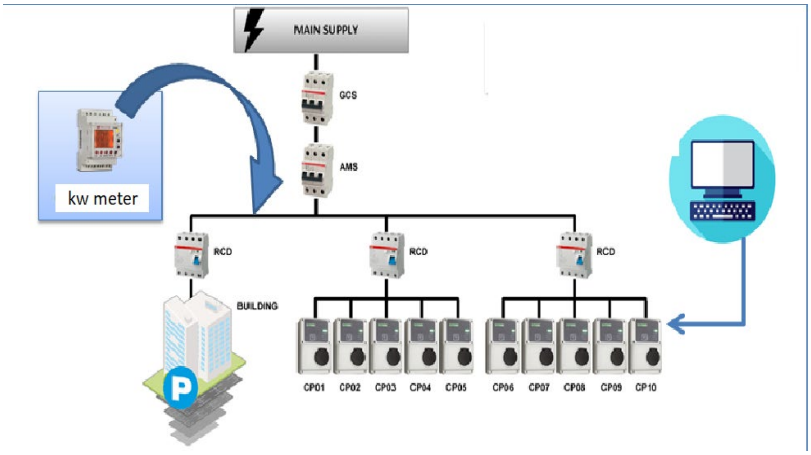
In 1917 charging multiple EV's at the same place was possible but controlling the power.

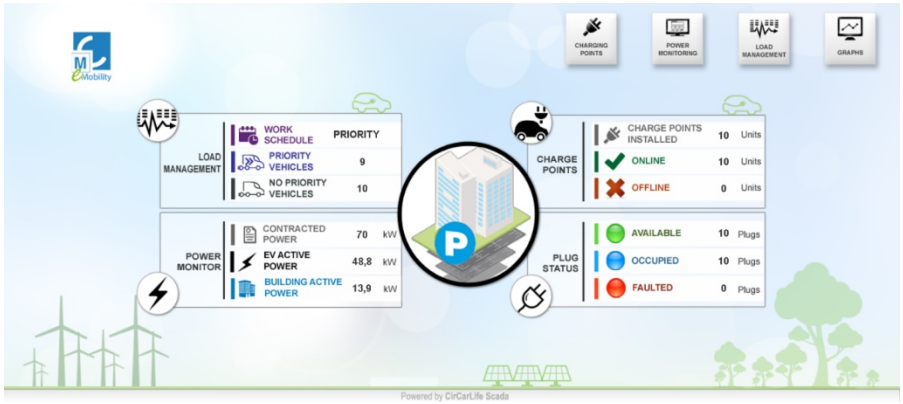
A good solution to manage the power available in a set of Charging Points should have the following features:

- Avoiding the high cost of upgrading the grid
- Optimize the power supplied by the Charging Points
- Reduce the time it takes to fully charge a fleet
- Supervise and Control in real time the status of each Plug and the current consumption in detail
- Adaptable installation to possible future changes

The system is designed to balance the supply of electricity given to the Electric Vehicles depending on the building demand.

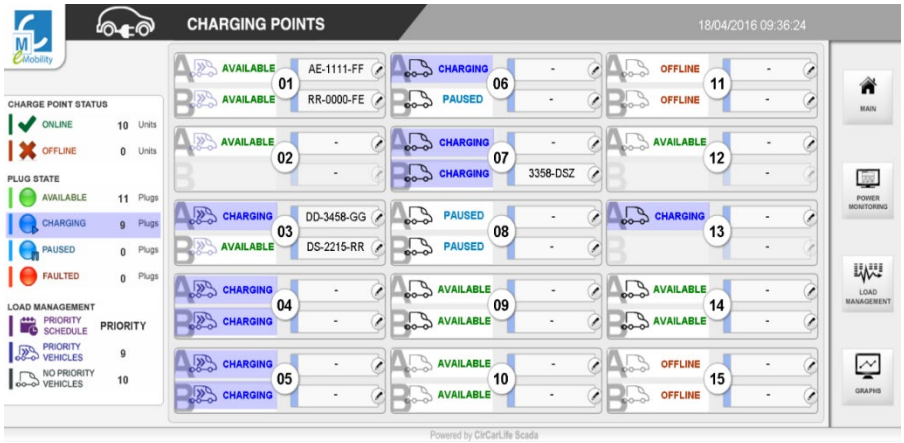
A power meter shall be installed to read the total building consumption. The differential of kW is allowed to the EV charging purpose. When the maximum allowed power is reached the intelligent control must reduce the charge of the EV's by using the derating option on EV charger mode 3.

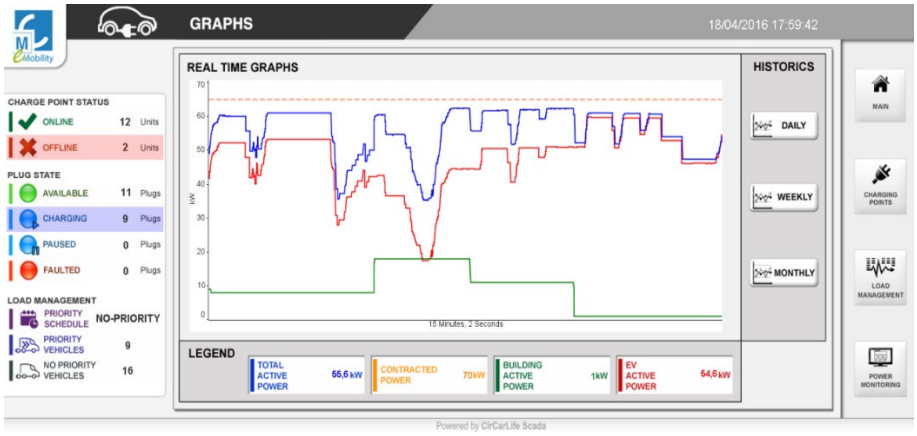




It is highly recommended that a screen displays information about the Power Consumption and the status of the Charging Points to the parking owner (the operator).

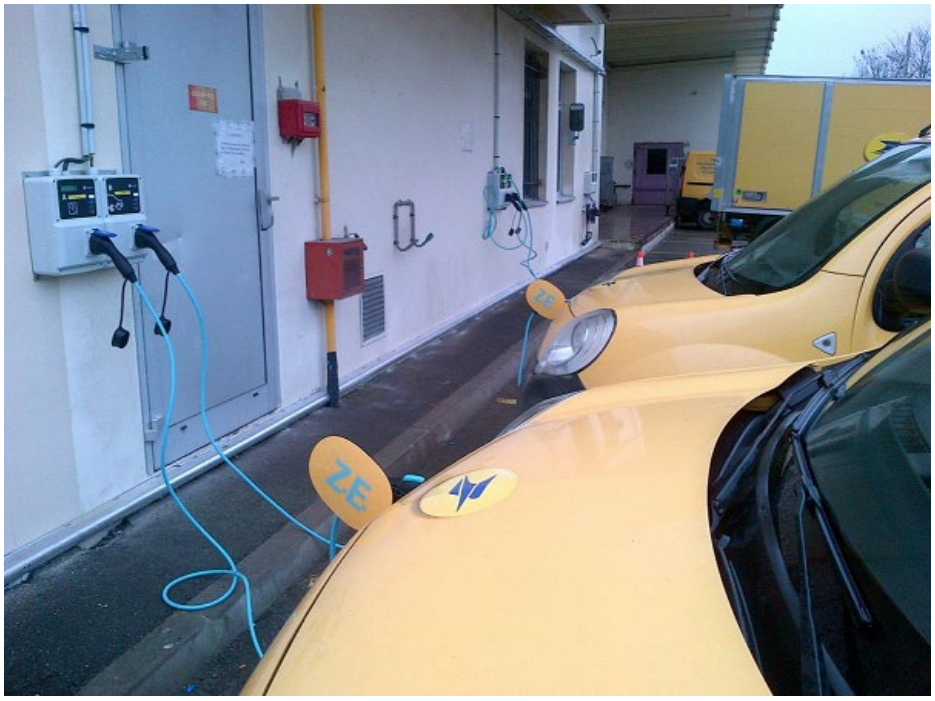
A charging points screen should display information about each Plug. Such as the status, the priority, if the car is connected or not, and the license plate. A power monitoring screen should display information about each plug, the current consumption per phase and a distribution panel of power.





A graph screen should display a graph in real time of the consumption of the building, the EV and the sum of both, compared to the contracted power, giving access to historical graphs.

Example of Dynamic Power Management in public car parks. Tele2 Arena, in, Stockholm, Sweden. 160 loading points in its public parking lot. These loading points are managed by a Dynamic Load Management system.
The public parking is operated by the company Stockholm Parkering.



Example of Dynamic Power Management in Fleets. La Post France. Charging delivery EV's with the existing building power by intelligent and dynamic management system (in most cases no more power is available). This is implemented in multiple places, always the same solution.

Conclusions

- The EV's arrived to stay.
- Each 1 million EV's need a 10GW power grid to be charged by 20GWh.
- In general, the generation and transmission grid is prepared to charge millions of EV's but the distribution and local networks have more difficulties to adopt EV's since they were not sized for this extra power.
- There are few methods to assist the grid to charge EV's: Renewable energy local production, Energy Storage and Dynamic Power Management.
- The Dynamic Power Management is the most cost effective and efficient method to allow EV's charging, without overloading the available power and granting the fastest possible charge of the EV's, at the different scenarios: home, work, fleets, public car parks, hospitality, …

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