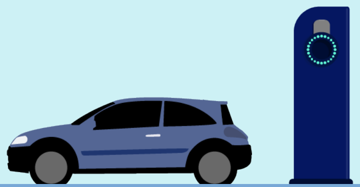
Flexpower

WHAT EV'S IN THE NETHERLANDS NEED

Flexpower

The electric car is becoming an increasingly important weapon in our fight against CO2 emissions. Not only will mobility become less dependent on increasingly scarce fossil fuels, the electric car can offer us a great deal more. Electric cars can be charged flexibly, storing energy in batteries when the supply of (sustainable) energy is at a maximum, thus helping us make optimal use of the electricity network. This requires flexibility: flexible EV drivers, flexible network operators, and flexible charging speeds. In Amsterdam, flexible charging is now undergoing tests in the Flexpower project. In this longread we discuss what this exciting innovation can bring to the future of mobility in the Netherlands.

Just like cars on the motorway and trains on the track, energy has its own rush hour on the network: a twice daily short peak in energy consumption. These take place roughly just before the morning and just after the evening rush hours. In the morning, we all turn on the lights, coffee machine, toaster, kettle and other appliances. And in the evening, once back at home, we turn the lights on, prepare dinner using an oven or microwave, watch television, and much more. Outside peak periods, there's much less grid demand.



FLEXIBLE CHARGING

In the near future, Amsterdam, together with Vattenfall, Amsterdam University of Applied Sciences (AUAS), Liander and ElaadNL, will prepare for the expected increase in electric cars and the use of more locally generated renewable energy. On 1 March 2017, Amsterdam initiated flexible electric car charging. This means that the charging points can now match electric car charging with the total demand and supply of energy. This trial also provides insights into the future in which sustainable electricity is used efficiently and stored in 'moving batteries', as part of our entire electricity grid.

The Flexpower Amsterdam project was initiated to investigate whether it is possible to adjust charging speeds to better match energy availability on the electricity grid. We set up a number of charging stations with special software with which the charging speeds could be varied at different periods throughout the day. The idea was to have faster charging outside the peaks in energy consumption, with slightly slower charging during the peaks. So far, we are pleased to announce that our initial findings are extremely positive.

FLEXIBLE CHARGING = QUICKER CHARGING

Amsterdam's residents participating in the Flexpower test greatly benefit from charging their cars outside peak hours. That's when there's more than sufficient grid power to charge their batteries faster than usual. Our research shows that 71% of fully electric cars* were actually charged with a higher payload. As a result, more batteries were fully charged, and in 70% of the cases in which the cars were not fully charged at departure, these cars charged more energy. Thanks to this higher payload, cars are back on the road more quickly, they may no longer need to stop at a quick-charging station en route, and less recharging is required when they reach their destination. All in all, higher payloads provide greater flexibility and more sustainable energy while charging when the sun shines.

In the worst-case scenario, when the grid itself is heavily used, only 4% of fully electric cars were charged with less energy.

The same test with hybrid cars showed that using Flexpower charging stations didn't alter the charging rate or the payload. 72% of hybrid cars were charged with the same level of power, and 95% charged the same energy as when using regular charging stations. Only 2% of the hybrid cars actually charged less energy.

**excluding 1x16A BEVs*

THE NEED FOR A FLEXIBLE NET

What the Flexpower project's results clearly show is that flexibility is the key to a more sustainable future. In order to achieve flexibility, the municipality of Amsterdam needed to overcome a number of obstacles. One of the most important of these was to ensure a reasonably priced connection, on the condition of a limited peak-load. In principle, grid operators are only permitted to install connections that are always capable of delivering energy at full power. Households never use this as the maximum capacity is never used; however, network operators are committed to do this. But, connecting increasingly large energy-users such as electric cars will have a major impact on the network, so greater flexibility will be necessary, especially at peak times. In the test, we used 'heavier' 3x35A connections; a normal home connection is 3x25A. This made it possible for us to vary the charging speed.

THE TRIAL SETUP

For the trial, we needed to adapt both the hardware and software of 52 charging stations in Amsterdam (each with two charging points). Most charging stations have a standard 3x25A connection to the electricity grid, however for the test a 3x35A connection was needed in order to charge at a higher power (24.2 kW), and therefore faster. The 104 test charge points were therefore able to charge up to 22 kW on both sockets (not simultaneously). These were the world's first charging stations equipped with an OCPP 1.6 protocol, making it possible to manage the charging transaction in a standard way according to a predetermined capacity profile. The profile stipulates that during peak hours, those times when demand for power on the grid is high – the batteries are charged more slowly, and faster outside these peak hours. The Dutch electricity grid is designed to withstand the highest forecast use in a year, however there are large local differences which have been taken into account when determining the peak times. The profile can thus be set up to respond to the expected local electricity consumption in a specific street. For example, there may be no lower capacity on specific weekends or on public holidays, when, generally, less grid pressure is expected.

WHO CAN CHARGE QUICKLY?

Charging stations are normally equipped with a fuse that limits the current to prevent overloading and/or short circuits. This fuse was temporarily removed from the Flexpower charging stations as the allocation and distribution of power is determined by software. The grid connections were increased from 3x25A to 3x35A which means twice as much power is available in practice outside peak times. Cars used in this study that can charge at higher power optimally benefit from this, and with a 3x35A connection, they can charge 110km per hour (=22kW). Should 2 cars be using the same charging station at the same time, they can both charge 55 km per hour (= 11kW). All electric cars (both fully electric and hybrid) can use these stations for charging their batteries. Currently, the standard output charge for older fully electric and most hybrid cars is only 3.7kW. Unfortunately, these cars cannot benefit from the higher charging speed. The focus of the Flexpower project was mainly on full electric cars which will determine the future road-identity; they have relatively large batteries and higher charging speed, for example the Tesla Model S / X / 3, the Hyundai Kona, KIA e-Niro, Nissan Leaf, and the Renault Zoë.

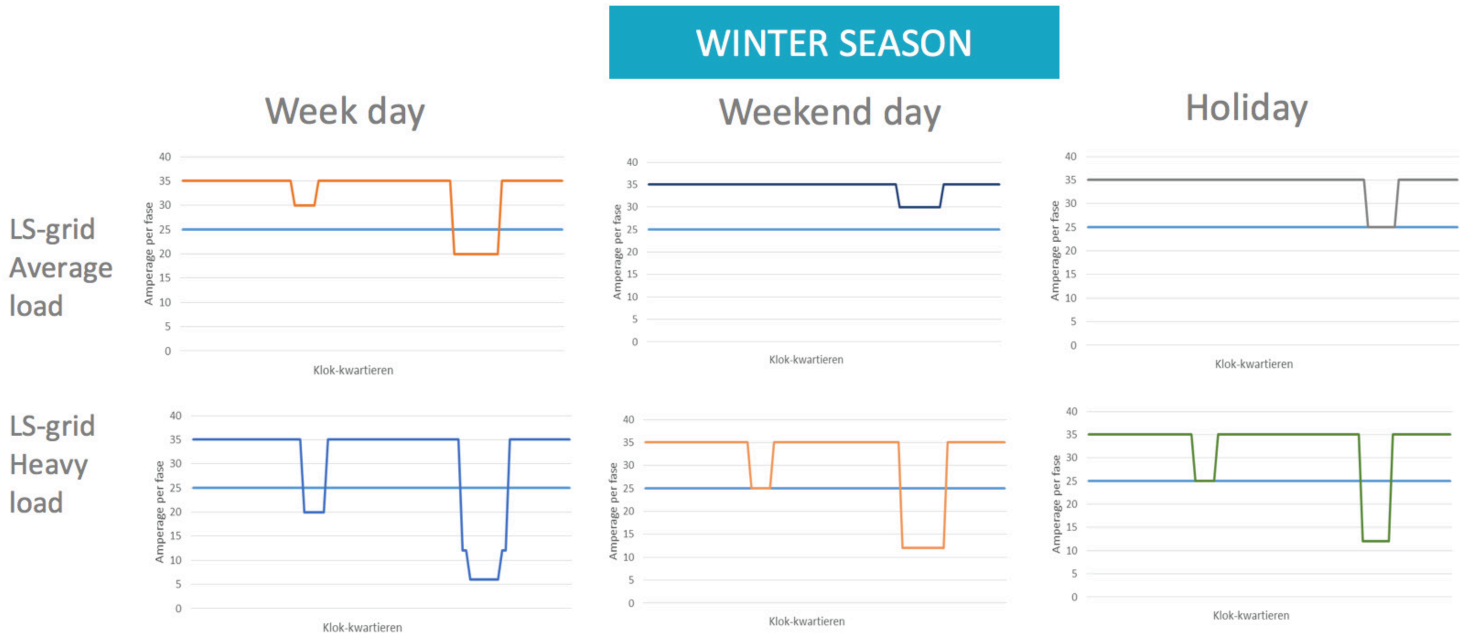


FIGURE : FLEXPOWER PROFILES AS APPLIED IN FLEXPOWER AMSTERDAM

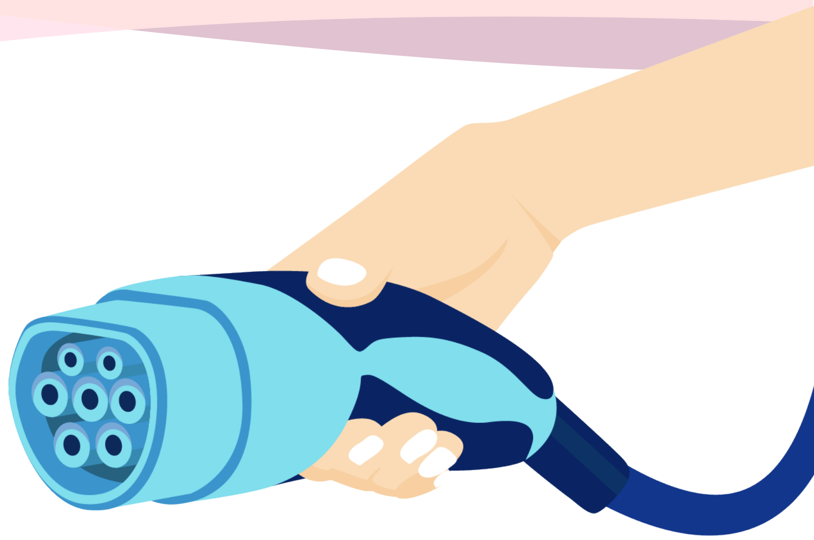
Seasonality can also be taken into account; in the summer there is less energy demand than in the winter.
On weekdays, a restriction in capacity is normal, but we were able to set up the exact time depending partly on the expected peak load in a street. For example in this test, we set the peak times to between 7:00 - 9:00, and between 17:00 - 20:00. During these peak times, we reduced charging station capacity to 4.1kW (3x6A).

The charging stations are the first to use a trial version of software selectivity, a technical adjustment to the security system with the aim of making a larger part of the connection power available to the car to be charged per charging point. The current security system makes charging visible in the meter cupboard. Should a specific group be overloaded, there is an automatic break on that group only. In the tested charging stations, we removed the 16A group fuses; an overload is prevented by special software.

Finally, all charging stations in the trial were equipped with a smart meter that collects data every 15 minutes by means of a network of open protocols for communication between grid operator, charging station operator, e-driver, and the charging station. In this way, we were able to analyse all the resulting data.

INITIAL RESULTS

NFrom the results of our research into the effects of flexible charging for grid operators and EV drivers, the following six conclusions were drawn:



1. On average, cars charge more quickly at a flexible charging station;
2. Flexible charging has no negative effects for users in general, even for those with hybrid cars. Drivers of fully electric cars experience a higher average charging speed and benefit from either a shorter charging time or a higher payload in the same time;
3. Flexible charging may result in a lower cost when using a charging station: the cost of use can be divided over a larger amount of energy, which may reduce the costs per kWh;
4. Flexible charging uses the electricity grid more efficiently thereby reducing the need to extend its capacity;
5. Because charging is quicker and more effective during the day, more solar-generated energy is used;
6. Software selectivity ensures that when only one of the two charge points is used, the charging process is significantly faster.

PRACTICAL IMPLICATIONS

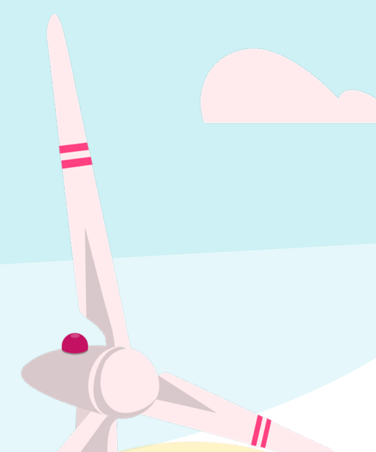
These conclusions give us a good impression of the advantages of flexible charging and charging behaviour in practice. For example, we found that most electric cars are already being charged outside peak demand hours, which in turn means that these cars are charged faster, for cars that are technically able to benefit from this

This has other positive effects: it minimizes people's frustrations regarding charging. Only 15% of the users with a fully electric car had to deal with slower charging at peak demand. This was also true for 28% of the plug-in hybrids, but these always take longer to charge, so this remained unnoticed by the user. This is noteworthy because the charging speed at peak demand times is significantly lower (sometimes up to 81%). For many charging stations in the city-centre, that certainly did have an effect, however the overall average charging speed was higher.

In conclusion: faster charging results in charging the same amount of energy in a shorter time (or more energy in the same amount of time). An additional effect of our findings may be that EV drivers will disconnect their fully charged car sooner and drive on. Further research will give us greater insights into these effects.

Our conclusions and the fact that flexible charging may improve the use of the electricity grid without having to extend capacity provide an extremely positive outlook for the future. Instead of expensive investments in expanding the number of cables and the rest of the electricity network, the balance between supply in both.

Altogether, these findings demonstrate the underlying sustainability of the Flexpower solution: charging is faster with a higher payload and cars charging when the sun shines make better use of solar-generated electricity. In order to further test our conclusions in practice, it is essential that municipalities and network operators make joint agreements about electricity connections that will guarantee this flexibility in the future.



KEY FIGURES

Flexpower Pilot

Outcomes are very promising!

Our electricity grid

Evening peak

The evening peak demand hasn't increased any further, however, the length of the peak did increase. Immediately after 20:00, we see a slight increase in demand, as EVs are starting to charge faster again. We therefore learned that we had to increase supply just after the evening peak.

duration **19 MONTHS**

First implementation of OCPP1.6 worldwide — 1ST

The Pilot ran on **104** charging points, divided over 52 chargers in **Amsterdam** City Center, West, New-West and South

7.738 unique users participated in the pilot

226.386 kWh was charged by FlexPower chargers

41.605 transactions

20.642 BEV

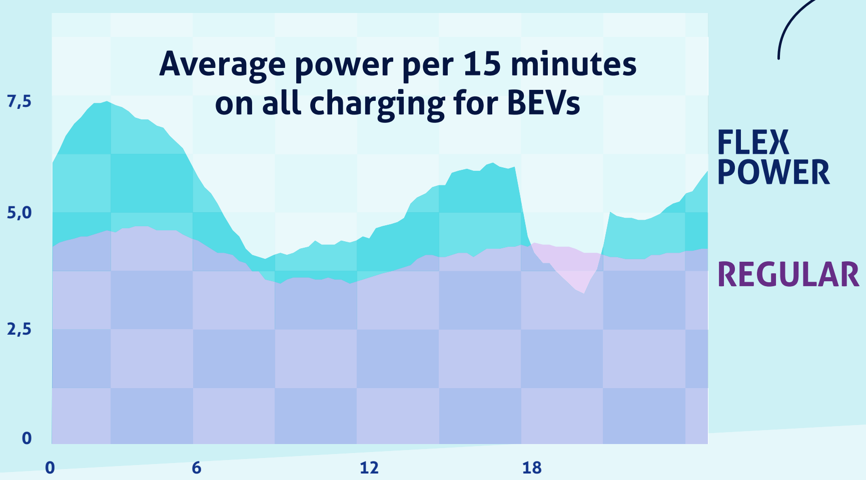
20.625 PHEV

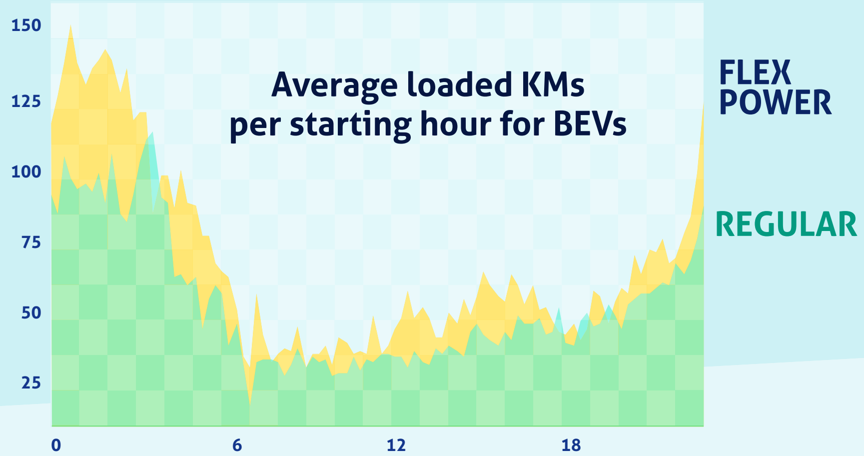
On average, BEV charging speeds increased by **30%**

71 % — 71% of ***fully electric cars**** charged with a higher payload. In 70% of the cases of cars that were not fully charged on departure, these cars had more energy.

72 % — 72% of ***plugin hybrid EVs*** (PHEV) were charged with the same level of power. 95% of PHEVs charged the same energy as when using standard charging stations. Only 2% charged less energy.

*excluding 1x16A BEVs





Due to a higher charging speed during the day, **more power from solar panels is used.**

A FUTURE BASED ON SUN AND WIND

Flexpower's stakeholders have been working for years preparing the Dutch charging infrastructure for the electric car's inevitable arrival. In recent years, the added-value of flexible charging has become a dominant factor in this quest. Flexpower Amsterdam is the result of this quest, but it is only a beginning: the success of our trial will pave the way to a more optimal use of sustainable energy.

In the near future, the ideas underlying capacity profiles will make it possible to actively focus on wind and solar energy. During daytime, when the windmills are running and the sun is shining, charging profiles can be adjusted so that this energy ends up directly in car batteries. Charging energy when it is readily available and the electricity demand is low is the most efficient way to use sustainable energy: cars of the future will be driving on power from the wind and the sun!

However, this is only a first step. In the future, we expect the so-called 'vehicle-to-grid' technique to make inroads in energy supply systems. Imagine; during the day, your car is charged with energy from a nearby solar field outside peak hours. You drive back home in the evening and connect your car to your own home network where you light and heat your home with your car-battery's renewable energy. Your car will retain sufficient power for the next morning, and when arriving at work, you recharge your battery.

This future is less distant than we may think: the batteries in today's electric cars are larger and more powerful, and this will only increase in coming years. This will not only extend the driving range but will enable storage of surplus energy. The Flexpower test shows that the current network is more than adequate to facilitate smart charging of larger batteries at off-peak times.

"TIMING IS EVERYTHING"

says Frank Geerts, *aProgramme director Flexible Charging at ElaadNL, participant in the Flexpower project*

"HIt turns out that it is possible to adjust the loading speed to the availability of energy on the grid, with no consequences for the user. This not only avoids overloading on the grid, it also opens the door to more optimal uses for renewable energy: solar and wind energy can be directly funnelled into car batteries when they are fully available!"

FLEXIBLE CHARGING ON A FLEXIBLE NETWORK

When it comes to network reliability and stability, the only alternative to Flexible charging is grid reinforcement. The network operators would have to invest heavily in expanding the capacity of the existing network. This is extremely costly, and not of much added-value if this is solely driven by the need for extra power at peak periods. The current grid can also handle the future power demand of electric cars as long as it is smart enough to coordinate both demand and supply.

The Flexpower Amsterdam project has demonstrated the potential of flexible charging: it works technically, the results are promising, and further application is necessary. More municipalities should join in this test, but there are a number of important obstacles that still have to be overcome.

The most important of these are legal issues. The Electricity Act includes requirements that makes it difficult for grid operators to offer flexible

WHY AMSTERDAM?

Amsterdam has a unique and extensive public network of approximately 3,000 charging stations. This network offers the perfect environment for large-scale implementation of innovations such as these.

- This study's focus is on the next generation of fully electric cars. These cars have a larger battery (> 40kWh) with a higher charging speed (> 1x32A). Amsterdam has large numbers of these types of cars, for example the Schiphol Airport Tesla taxis.
- In Amsterdam, only a few homes have their own parking facilities. In order to charge their electric car, owners are mainly dependent on public charging points.
- Data on charging has been collected for the past five years, so the city understands how the charging points are used; so-called charge and location profiles.

These data facilitated the selection of charging points where many next generation, fully electric cars are charged. The pilot started in Amsterdam's City Centre, West, New West and South.

solutions. For example, they are obliged to ensure that the maximum capacity is always available throughout the grid; this means they must always ensure sufficient spare capacity for transporting electricity. Thus, the desired flexibility to deliver less energy via public charging stations at peak hours is currently not possible. In Amsterdam, we found a temporary solution for Flexpower: the municipality of Amsterdam and Vattenfall voluntarily installed the Flexpower profile, thereby settling for less peak power, but this came at the cost of having a heavier and more expensive connection.

Should we, in the long term, want to make optimal use of flexible charging, these restrictions will have to be changed, making it possible to provide a more flexible power supply.

BETWEEN NOW AND THE FUTURE

Amsterdam is a dynamic city full of creative and enterprising residents who make the city both forward-thinking and unpredictable. Electric driving matches the city's character, however it needs to become more predictable. Car manufacturers, network operators, companies, municipalities, and other governmental departments have all taken a look at the future and have taken some first steps. Between now and 2025, almost all major car brands will be producing new electric models with larger batteries and range. Brands like Toyota, Mercedes and Lexus have stated that will supply electric versions of all their models from that year onwards. Some brands like Volvo and Mazda predict that they will only produce electric cars in the next decade. In addition, the current government has stated the ambition that all newly sold cars in the Netherlands must be emission-free from 2030 onwards. This means that in 2030, three million electric cars will be driving around in the Netherlands. Until then, municipalities will be focusing on making inner cities fossil-fuel driven car free.

If we look more closely at the steps to be taken and our ambitions regarding sustainable energy, we can see that a number of objectives have been set, with concrete expectations. Europe is investing in 32% renewable energy by 2030. Urgenda would even like to achieve 100% sustainable energy for the Netherlands. Whatever the scenario, substantial investments will be made in wind and solar parks in coming years.

Thus, it seems that we are looking forward to a bright future, however perhaps we are overlooking an important factor: how do we efficiently transfer energy from sustainable sources to the places where it is most needed? In the next decade, Flexible charging can answer this question. If we are able to store renewable energy in the larger batteries of electric cars, we can build a stable and boundless electricity grid that grows naturally with our energy demands.

PARTNERS VAN FLEXPOWER AMSTERDAM

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