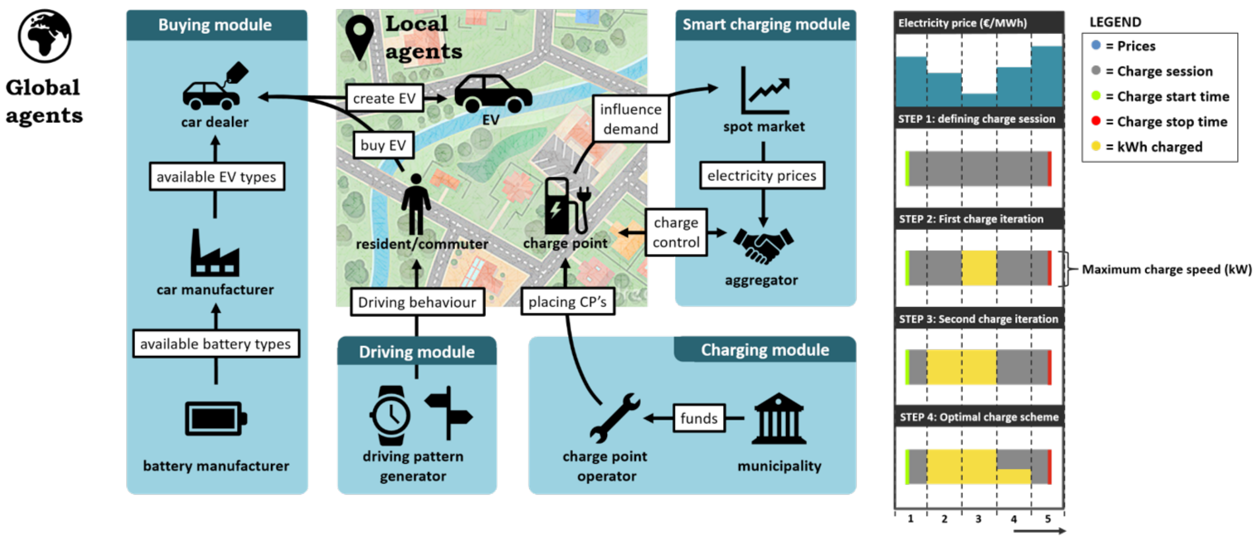
TU Delft dutch-incert

Sparkcity outline

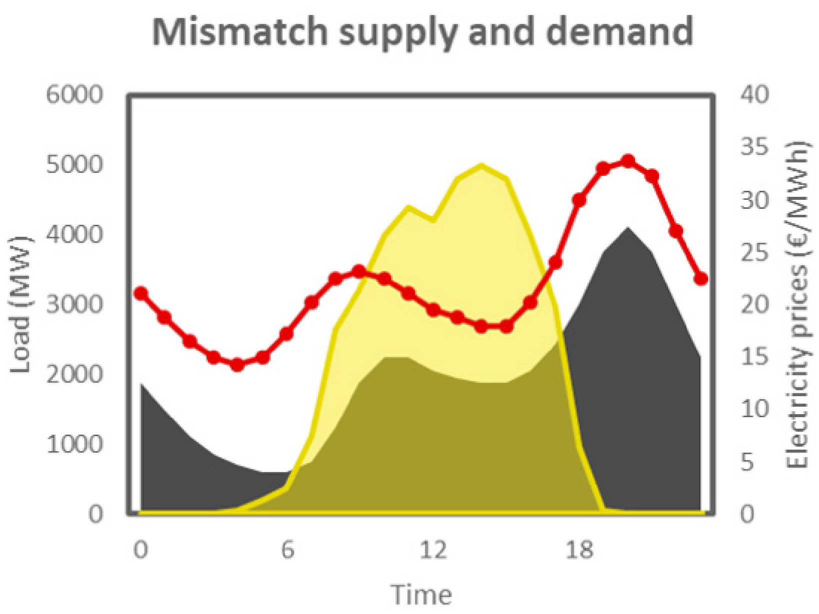


In SparkCity, virtual neighbourhoods were created based on GIS data of real neighbourhoods. In and around these neighbourhoods live a number of agents that are visualized. So, we have people that live in houses, and they use energy and they move around. We also have car manufacturers and dealers that can sell them electric vehicles. Charge point operators and municipalities can initiate charge points at home, work or in the streets. And when the electric cars use the charge points, they are connected to a realistic electricity grid. This grid has - among other things - solar, wind, and a spot market. When cars charge, they can optimize the moment of charging using a simple linear algorithm that looks for the lowest price.

Using this model 3 case studies were simulated to see how electric vehicles can help to optimally make use of the renewable energy.

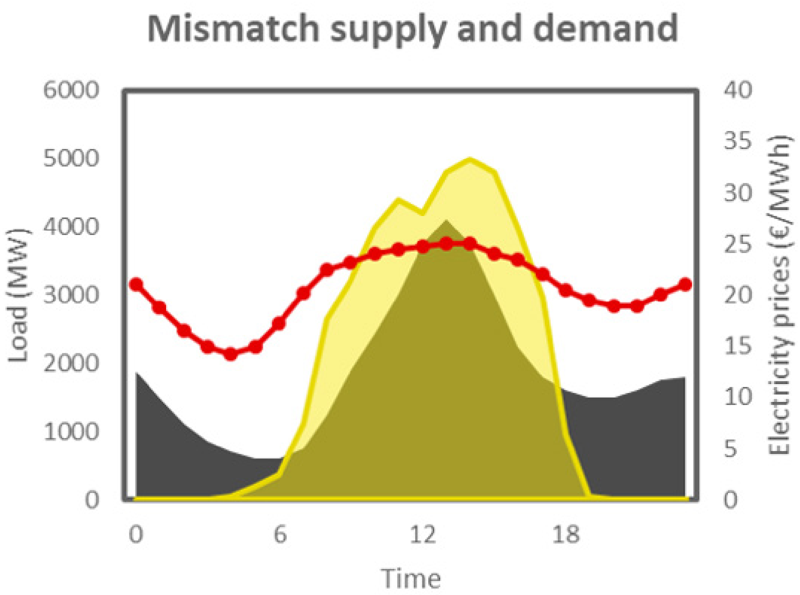
Case 1

A sample of 200 households in a neighbourhood was taken and their energy use was monitored. That is the dark mountain landscape that forms the base of the graph seen below. In this case we assume that these neighbourhoods are running almost entirely on solar energy. That would generate a big peak in electricity generation around noon, which you see as the yellow bump in the picture below. Let's further concentrate on the charging of electric vehicles. If we do nothing, their electricity use would peak around 7 in the evening.



This is not only a mismatch with solar energy but it is also expensive, because prices are highest during peaks in demand (as is shown by the dotted line.

So, we start smart charging the electric cars. We assume they must always be fully charged when the user takes the electric car for a ride. But that still gives us plenty of flexibility. It's relatively easy to shift the charging towards the middle of the day without inconveniencing the user. Now the price is much less volatile. This was a simplistic illustrative example, but this is also what we found in realistic situations.`

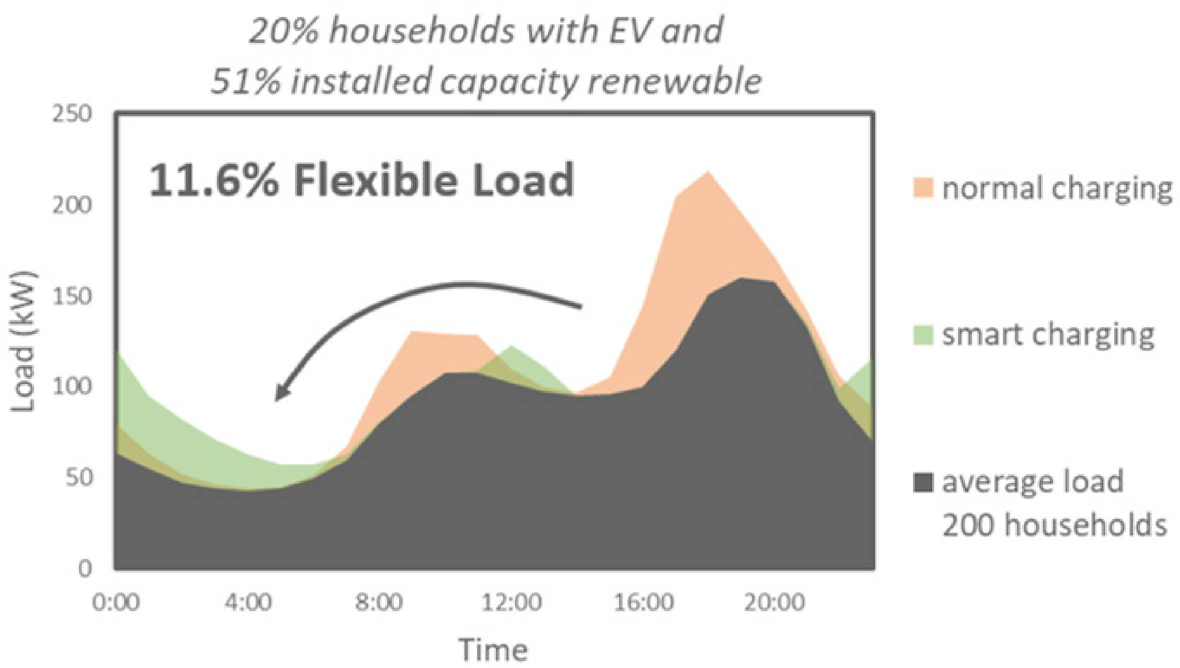


Case 2

A sample of 200 households in a neighbourhood was taken and their energy use was monitored. That is the dark mountain landscape that forms the base of the graph. As you see, there is a little peak in the morning around 10 o clock and a larger peak in the evening around 7 PM. The highest peak is around 160 kilowatts of power. So that is what the local transformer in the electricity grid would see

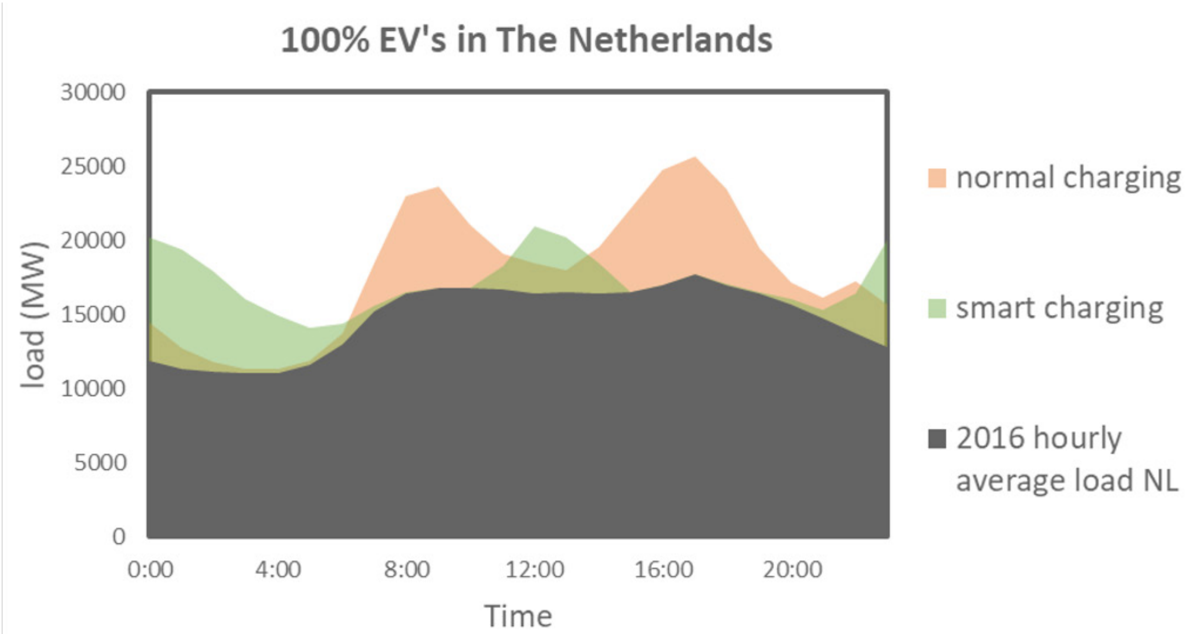
from these 200 households. Now, we give 20% of households an electric vehicle, so 50 electric vehicles. In that case we would see a sharp increase in the afternoon peak. You see that it rises to about 220 kilowatts.

This could mean that the transformer must be upgraded or that extra wiring must be implemented. Both are costly investments. It could also mean that in some households the voltage during peak times is now so low that it could damage their equipment. But with smart charging we can completely avoid the higher peak and shift demand to the middle of the day and – mostly – the middle of the night. This is better for the electricity grid and hence can lead to a lower grid connection bill for the customer.

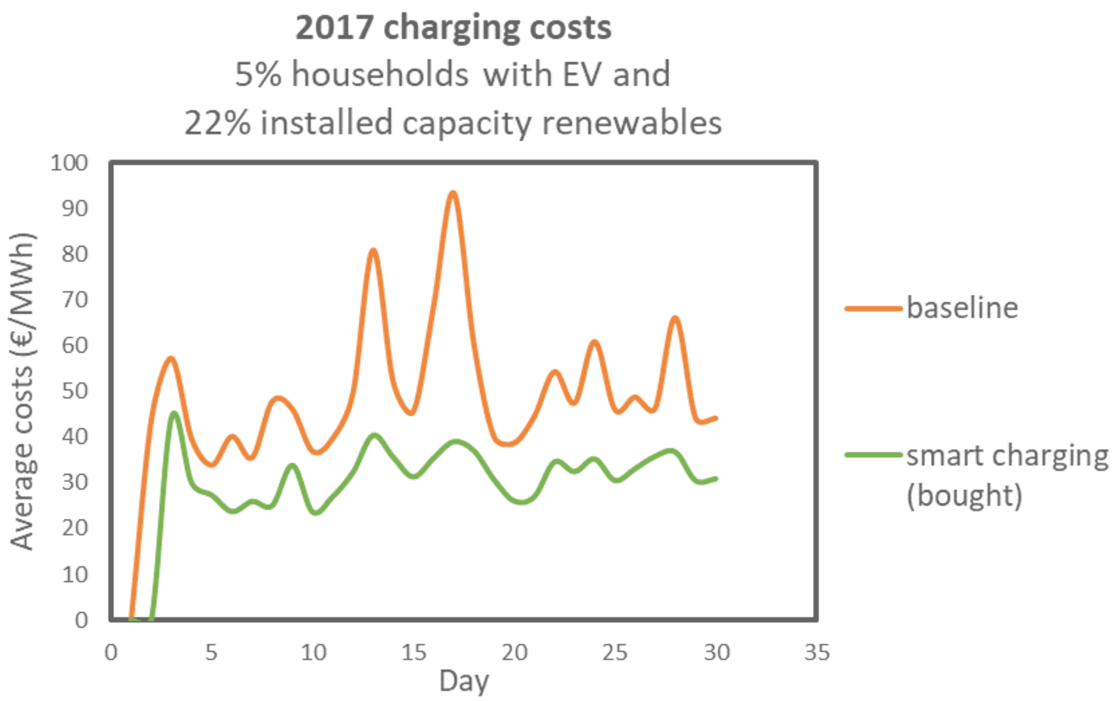


Case 3

This exercise was again carried out but now for the entire electricity market in the Netherlands. So not only residential use but also all commercial and industrial electricity use. Here, all cars were replaced by electric vehicles. You see that the afternoon peak on the grid rises from around 17 thousand megawatts to around 25 thousand megawatts. Now if we introduce smart charging and we charge on the cheapest possible moment, the peaks shift to the middle of the day and middle of the night. This is with 50% of installed capacity from solar and wind. We see new peaks of around 20 thousand megawatts appearing in the middle of the night and middle of the day. Smart charging works too well from the standpoint of the grid operator here. We could tweak the smart charging algorithm to make the daily profile straight as a ruler.



In the above situation (calculating the prices without taxes and without grid costs) the user would pay around 38% less for the electricity. This would save him around 7 euros (that's around 10 dollars) a month. You also see that the price becomes less volatile.

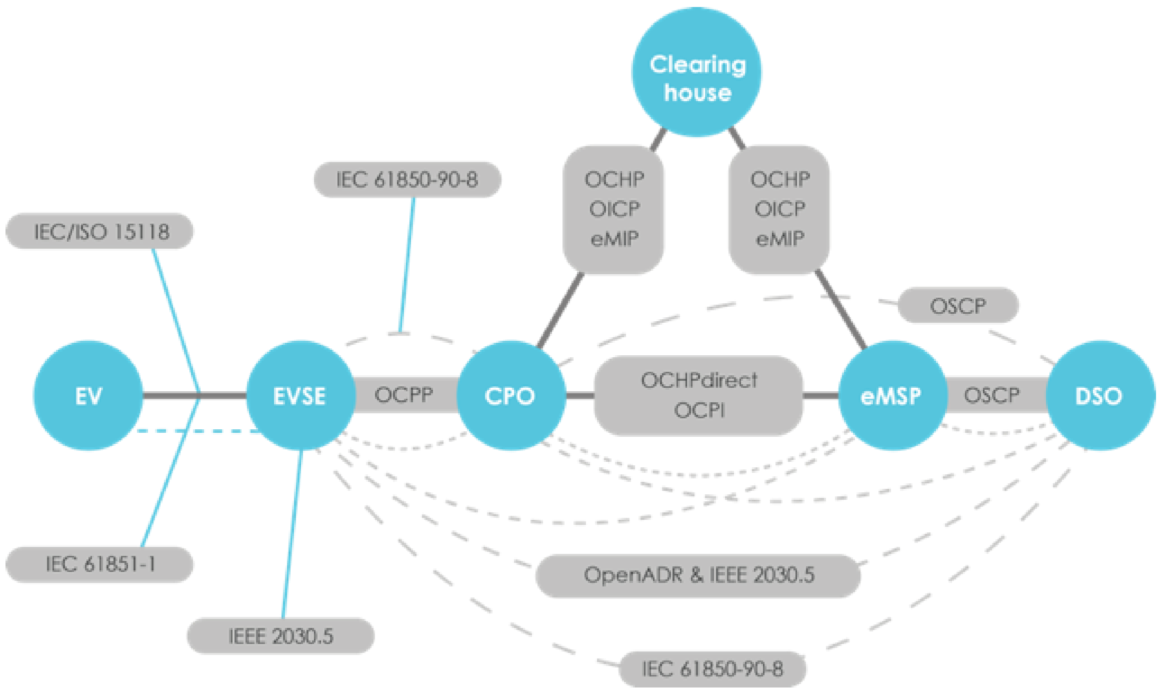


Smart grids

In order for the smart charging grid (and the smart grid in general) to work, we need to harness the power of the Internet. Electricity grids have changed very little in over a century and when they were built, computers were not around, let alone Internet. Now in order to use those computers we should use what we have

learned from the Internet and apply it. And probably the most important lesson from the Internet is that open standards work:

Firstly, they stimulate innovation because nobody owns them, so anybody who has a good idea can jump in and use them. The goal should be to have no red tape if you want to download the standard and no license fees.
Secondly, they avoid lock in, because they make equipment like charge points interchangeable. Market leaders usually hate this: they have everything to gain by creating lock-in. But for customers and society as a whole it's important to see through their game and stick to the open standard. In the end this leads to better competition and lower cost. Governments have an important role here. Not because they should write the standard, but because they should steer the process towards open standards. The simplest way to do this is to require open standards.



The picture on the previous page shows a whole range of relevant open standards. Specifically, for charge points two are more important than others: OCPP (which stands for open charge point protocol and has nothing to do with the firm of the same name) standardizes how everything, but the car interaction with the charge point. If your charge point is OCPP compliant you can always switch it for another charge point by another manufacturer without breaking the system. OCPI (open charge point interface) connects users to the back office managing the charge point. In practice this ensures that wherever you go, you can pay for your charging transaction.

Smart grids

An especially interesting and hip new development is the use of distributed ledger technology. You may know it as Bitcoin or Blockchain. A distributed ledger is basically a list of verified transactions that can be shared by anyone. It's peer to peer so you don't need a central party, like a bank, that calls the shots. Instead it's like a booklet that you can pass around and that everybody can use to write down or look up transactions.

Imagine that somebody requests – using an automatic message of course - that you postpone charging your electric vehicle, because they want to avoid a peak on the electricity grid or want to offer you cheap renewable energy in the middle of the night. Your charge point or car could ask that person: how much is it worth to you? After you agree on a price, you document the agreement in the ledger. You say:

my car will stop charging now and start charging again at midnight. And somebody says: I will then provide you with 10 kWh of electricity for e.g. €0,50. Now the contract is clear for everyone to see. It's definitive. If you start charging earlier, somebody can point to the ledger and say that you should be held to account. If somebody doesn't pay you it's equally clear.

Now the only problem is that the energy use of Blockchain is growing off-the-charts. It's already using more than a small country and if you would scale it up to the level of Mastercard of PayPal you would simply run out of energy. Fortunately, there are energy sipping alternatives that scale very well. One of them is IOTA. And just to prove that this can work, ElaadNL recently made a charge point running IOTA. If you want to find out more, have a look at this video.

Why is smart charging and smart grid more important now than ever?

We are moving towards a future in which solar, wind and electric vehicles are not only cleaner alternatives, but also cheaper alternatives. That means that electricity flows through the network are now bidirectional. Furthermore, the new technologies are much more decentralized. Where there used to be dozens of power plants, you can now have thousands of wind turbines and millions of solar installations and electric vehicles. And not only do we have millions of unique machines, we have millions of unique owners and users too.

In order to use our new physical energy system efficiently, we need to harness the power of the Internet. So next to the physical layer, we need to think of the information technology layer. And in order to make this more advanced marketplace work we also need to rethink the contractual layer. A more in-depth description of how this could work is available in the lecture on smart charging in the technical track. But this is not only a technical matter. It’s also a redistribution of money and power. The incumbents such as the grid operator and energy supplier probably won’t like it, because it takes away their dominant roles.