Case study: Nuna

Now that we've learned about the technical aspects of EV's, it seems obvious that the most straightforward way of powering a car is by using PV panels that direct power the electric motor. A prototype car with built-in solar panels has was first built in 1982 by Hans Tholstrup, who later conceived a race called the World Solar Challenge, which is a biennial race stretching 3000 km from North to South Australia.

The Nuon Solar Team of TU Delft have been starting this race since 2001 and they have a pretty impressive track record. This dream team have won seven times and have come in second the other two times they competed. So what does it take to build a solar car, and how is it different from a normal EV? How can you make it the best in the world?

Today we visit them and talk with Jelmer van der Hoeven, who is an electrical engineering student working on the car, called the Nuna 9S.

We build solar cars to race in solar races. We race in Australia where we do the world solar championship and in South Africa where we race in the Sasol Solar Challenge. And by doing this we hope to promote sustainable energy.

Well, Nuna, an electric vehicle, only uses the power from the power supplies from the power outlet and we use the power from the sun, which is the main difference. But, also how we use the output from the energy is also very different, because we want to maximise the power input from the sun and want to minimise the power that we choose to race. And, we minimise it by a couple of things. First, the drivetrain. A normal electric vehicle uses a shaft, which is powered by an electric motor and we use an in-wheel electric motor, which we only use one: the right rear wheel. And, by using only one motor we also save weight. And you don't have the losses from the shaft. This is on the drivetrain. We also have the air resistance and rolling resistance. The rolling resistance is minimized by choosing as light weight material as possible. Our own car is built from carbon fibres. Carbon fibres are very stiff and very strong. So, their weight to stiffness ratio is very high and that it is why it is a very good material for us to build our body. An electric vehicle is about 1500-2000 kg and our newest Nuna9S weighs only 140 kg, so that is very amazing that we can get such a low weight car.

And that really impacts the driving range I imagine?

Yes, our driving range without the solar panels is around 500 km and we have 5 kWh battery. And if you compare that to a Tesla which can also reach to about 500 km then the battery weighs around 500 kg and our battery weighs around 20 kg. So, that is a huge difference.

The first generation Nuna was a lot bigger. The solar panel was from the same kind of solar cells: Gallium Arsenide. But, they were recycled solar cells from a Hubble Telescope and they had around 8 m2 of solar cells and our newest, the Nuna9S, has around 2.6 m2 of solar cells.

And, also regulations have changed. The solar area was one of those regulations, but also the first Nuna was a three-wheeler and the regulations are now so that it has to be a four-wheeler. And, the challenge in that is that the three-wheeler had a good balance and with the driver now sitting at the right side of the car and not in the middle, the balance is a lot harder to improve.

That is still a little bit secret what we are working on right now. We have a new software engineer who is working on a new board computer, which will make it more intelligent, our vehicle.

Yes, we can separate it in like 3 parts. The income part, the storage part and the expense part. We start with the income part. We have a solar array, which generates electricity, and to make it sure that the solar cells are working at their optimum point, we have maximum power point trackers. And what these maximum power trackers do, is to make sure that the maximum energy is generated from our solar array. And, this is the I/V-curve of a solar cell and what the MPPTs do, is to make sure that the powermax is always reached. And, it does it by sweeping around the voltage line, where it checks at what point/at what voltage, is the most energy flowing out of the solar array. And, from the maximum power point tracker the energy is flown through the battery, where we store our energy. The battery, as I told, was 5 kWh. They are made of Lithium-ion cells and we make everything ourselves from the battery pack to make sure that the battery is monitored and keeping at the good temperature. We have a battery management system to protect our battery, so that we know at what voltages all the cells are and that we know if some errors appear that we can act on that. And, also inside the storage we have the high voltage that is coming out of the battery, but also lower voltage that is made through our DC-DC converter. From the high voltage, the motor controller and the motor. The motor controller makes sure that the right gas response is given to the motor. And, it does it through three phase connection to the motor and with the changing currency from the motor controller the motor creates an electric force, which drives our car. And from the low power side/from the lower voltage, is given to the board computer, which is the central communication hub in our car. And this, the steering wheel is connected to it. Everything is connected through the board computer, which collects all the data. Further, we have also lights, so that we can make sure that if we want to break, the rest of the vehicles at the road know what we are doing. And we have also communication, because we have also cars driving around us, so that we can communicate to. Our strategist, also in the car, which says at which optimum point, at which optimum speed, we need to drive.

And if we use this in a race in Australia, what would be a typical income from the solar array in terms of power?

That is around 1 kWh.

1 kWh. And the maximum power output of the motor?

The maximum out-power of the motor is 5 kWh, so if you need to accelerate then you also use the power from the battery.

And if it is stable going at maybe 90 km/h?

It depends a little bit on the weather conditions, because if we have side winds our car is so designed that it has a little bit like a sailing effect. So, that is drives the car. And, at 90 km/h it could be possible that we are energy neutral.

I think it will be more like a normal passenger car due to the regulations and also, because it is still a race car that will evolve over time. And, it will be more intelligent, so that it can do strategy: at what speed it the best should drive from the weather conditions. That can determine it itself, because now we have a special car driving behind Nuna, which calculates all weather predictions, all the calculations from what is the best speed to drive and other things that is calculated in a car behind Nuna. And, that will probably be done inside of Nuna.

I think people will eventually drive with solar cells on their roof. Eventually, it will mainly increase the range for now. But I think in highly solar adoration places, they have enough solar power to drive their daily uses.