REFUELING ››› DOI 10.1051/epn:2008005

L.J.F. (Jo) Hermans,
Leiden University • The Netherlands • **Email:** Hermans@Physics.LEidenUniv.nl

We don't usually think about it when driving down the highway, but what will traffic look like after the fossil-fuel age? How will our grand-grand-children move 'in the fast lane'? No longer in a gasoline-powered car, probably. An all-electric car perhaps? Or a hydrogen car powered by fuel cells? Or will they use some synthetic liquid fuel to power their engine? Things don't seem very clear yet.

Let us assume for a moment that it will be an all-electric car. Sure, there is a problem with the weight of the batteries: Even with the best battery type now available, the weight of our car would roughly double if we want to carry batteries with the equivalent of 50 or so litres of gasoline. But let us be optimistic: let us assume that we are able to improve the energy density of batteries by another order of magnitude. That would make the extra weight quite acceptable. Problem solved, one would think. But now another interesting aspect comes up. How about refueling? When driving long stretches on vacation in our present cars, refueling is a piece of cake. We can do it during the coffee break, for example. Now let us consider the electric car. Suppose our batteries are running low, and it is late afternoon. Fortunately, our hotel is near. No need for a gasoline station: there are power outlets in the hotel, and we will nicely reimburse the hotel owner. But how long will the charging procedure last, if we want to drive another 700 km the next day?

Let us do a back-of-an-envelope calculation. A standard power outlet can draw 16 A at most if we don't want to blow the fuse. At 220/230 V this yields a power of, say, 3,5 kW.

Compare this with the average car driving on the highway: it uses about 15 kW, which is higher by a factor of 4.

The conclusion is that we need to charge the batteries for roughly 4 hours for every hour of driving. Since we want to drive for about 7 hours the next day, we need to charge for about 28 hours.

So if our grand-grand-child will be driving an electric car, he had better pick a hotel that is especially equipped for fast overnight charging. And become very good friends with the hotel owner. Otherwise: forget about an early start the next morning.

Given the above result, it is interesting to calculate the energy flow into our present car when we fill our tank with gasoline. It turns out that we pump about 0,6 litres of gasoline each second. With the heat of combustion being about 35 MJ per litre, this translates into 21 MJ/s = 21 MW (!). In terms of electric power, given a conversion efficiency of ⅓, this is some 7 MW. That is 2000 times as fast as charging batteries from a standard electric outlet, see above.

Should our grand-grand-children muse about such numbers when driving down the highway, chances are that they'll look back at us and our petroleum age, and think: gee, weren't *those* guys lucky… ■