Vehicle purchase decision

Most financial incentive schemes for EVs, such as subsidies, involve some transfer of tax payers' money to a specific group of *early adopters*. Both for private users and firms the decision to be an early adopter is a combination of image or status and affordability. In practice, early private adopters are mostly found in the high-income and high-educated segment of the population. Depending on the duration and scale of income transfer to this privileged group, the majority of the population may feel left behind. If that happens, the government is at risk of eroding public support for the new technology.

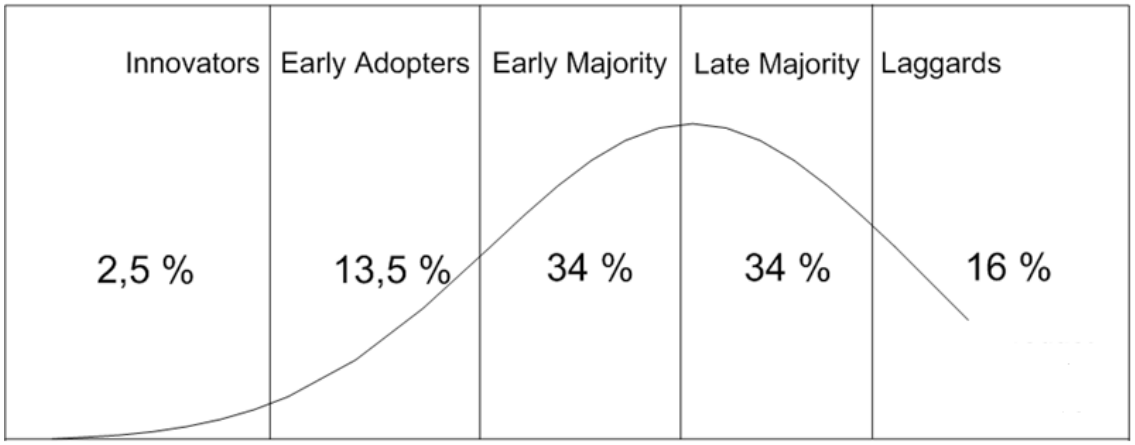

Figure: Adoption curve. Source: Door Vvdberg op de Nederlandstalige Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1942142

It is therefore crucial to *design* a financial incentive scheme in such a way, that it is clearly *limited in time* and in the *extent of income transfer*. Limited in time does not necessarily imply short duration, as innovative technologies that are in the interest of society as a whole may take many years to be embraced. The duration of the

financial incentive scheme should be aligned with the time needed to increase the efficiency of the new technology through *upscaling and incremental improvement*, and to reduce the costs to the extent that the new technology is made affordable for the population at large.

The relative additional benefit of offering financial incentives for high-end vehicles is limited. Policy makers may therefore consider capping financial benefits to lower price segments of the electric vehicle market. First, this would provide an incentive for automakers to invest into developing a wider variety of electric vehicles in these segments, as they become more affordable for many consumers. Second, this would result in a more even distributional effect of the incentive scheme in society. Policy makers may also think of *offering additional incentives* for second-hand electric vehicles, which could prevent export of used electric vehicles and associated leakage of subsidies to other countries.

Transaction costs

The deployment of EV batteries as flexibility providers for the power system entails a massive *increase* in transactions. Let us briefly dwell on the concept of transaction costs with an example. If you set out to buy a used car, you will investigate what cars are offered on the market, and you will need more detailed information to find out which cars match your requirements, in terms of model, color, price, mileage, condition, et cetera. Once you have selected the one you would like to buy, you need to negotiate a price with the seller, and you need to make sure that the car is delivered in the promised condition, and that the seller will remediate any defects that fall within the terms of the contract. Transaction costs are made up of *all these efforts*: search and information costs, bargaining costs, and measurement and enforcement costs.

Now take the electricity market before it was deregulated. Electricity was delivered to our homes by a regional monopolist, whether private or public, which also produced, transported and distributed the electricity. The transaction costs in this system were minimal, we had no bargaining power, and relied on governmental oversight to protect us from abuse of market power by the utility monopolist. Now electricity is produced in competition and the service is provided in competition, including the retail market in most countries. The transaction costs in this system are obviously higher than in the former monopoly, but that is not bad news, as competitive pressure and network regulation are curbing the overall costs of the power system to our benefit. Thanks to the rules for operation of the markets involved, and the regulatory institutions in place, transaction costs are kept as low as possible, so that the benefits of the liberalized electricity market outweigh the transaction costs. You could say that the liberalized power system has enabled a shift to a new welfare optimum, which benefits society as a whole.

Future mobility system

In the future system, electricity and mobility service provision are envisaged to be intricately linked. *New actors* are entering the stage, such as aggregators, charging point operators and e-mobility service providers, and with new actors come *new relationships*, with new exchanges of information, data, electricity and dollars, which are needed to make the system run, and which require new institutions to curb the new transaction costs. The overall increase in transaction costs must be weighed against the overall benefits, which largely hinges on the

value of the flexibility that the battery packs of electric cars can provide to the electricity system.

Another cost factor to be taken into account is the one of *curbing cybersecurity* risks in the future integrated electricity and e-mobility system. Given the many uncertainties about the new costs and vulnerabilities of this new system, we should perhaps more systematically weigh the costs and benefits of the new system against the alternative: expanding the capacity of the electricity infrastructure and building alternative energy storage units. Basically, this is a choice between a smart, highly complex, integrated power and e-mobility system versus a robust power system which remains decoupled from the mobility system.

For consumers, most of this complexity is handled behind the scene. What matters

Charging costs

to the electric vehicle owner, besides the purchase costs, is the ease and cost of battery charging. Charging costs do not only depend on the way the electric vehicle battery provides flexibility to the power system. In practice, many other factors play a role in determining the final cost incurred to the consumer, especially in using the public charging infrastructure. We will briefly examine to what extent differences in charging costs can be justified on the basis of differences in local context and service levels provided. In the public electric vehicle charging chain several actors contribute to the *price of charging*. These include the grid operators, the utility, the charging point operator and the e-service providers. The grid operator and utility *bill* the charging point operator for the grid connection and the energy delivered. The charging point operator *forwards these costs* and a potential additional flexibility revenue to the consumer. The consumer uses the charging card

he is provided with by the e-service provider, to operate the charging station and, depending on the contract, he *pays* the service provider for the amount charged or the time connected to the charging station.

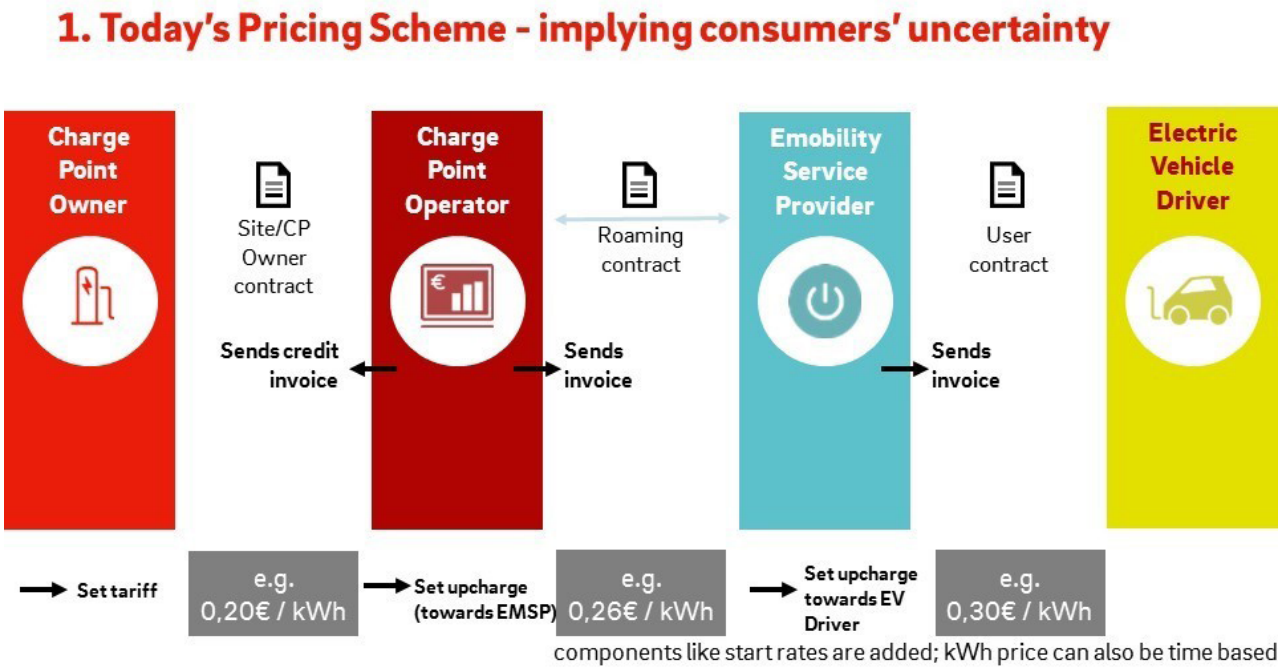

Figure: Costs of charging

In practice, *two factors* are dominant in determining the costs of charging. The first one is *where you are charging*: at a private or a public charging station. At home the hardware investment costs have been made by the consumer himself, so only the electricity costs are left to be paid. If a public charging station is used, the charging point operator has to recoup the investment by charging a premium on top of the electricity costs, and in addition, the consumer has to pay for access to the public charging station through the e-service provider. Such additional cost can of

course be justified by the additional investment made. From a policy perspective, however, it is important to understand that those relying on-street parking and thus public charging cannot avoid this premium. In the long run, this could result in distributional effects as the richer segment of the population can mostly afford private parking and thus charge at home.

A second important factor that determines the price of charging, is the *speed of charging*. High speed chargers often ask a higher premium for charging as this type of equipment and grid connection requires substantially higher investment cost than slow chargers. Prices at fast charging stations can be up to 5 times as high compared to slow charging at home or at the workplace. Given the fact that many fast charging stations today still *do not make a profit*, these high charges seem justified. Government could enable fast charging station operators to generate *additional revenue streams*, for example, by allowing them to offer additional sales such as food and beverages, or allowing them to build next to shopping malls to attract more customers. It is evident that such permits clash with the permits and vested interests of established refueling stations.