The e-charging infrastructure requires specific *technological and institutional means*. From a technological perspective, certain charging technologies are necessary, for instance with respect to home charging or DC fast charging. From an institutional perspective for example the charging connectors: there might be specific standards that can be used with different providers of e-charging facilities, and payment settlement agreements are very important in this respect. For example: are you always able to pay for the electricity you charge for your car for different providers?

So, these institutions and technologies are very *interrelated*. The technological and institutional coordination needs to be coherent to meet societal expectations. So, if you drive with your car to a shopping mall and you are not able to pay for the electricity because there are no agreements between the different providers of payments, this will be a situation which is not attractive for the users of electric cars.

Like in any other infrastructural systems also with respect to e-charging facilities, we identified *four critical functions* that are essential for providing e-charging services, and these four functions are called:

1. Interoperability
2. Interconnection
3. Capacity management
4. System management

Interoperability is about the use of these facilities and the usability of these facilities between different service providers. *Interconnection* is related to the distribution of e-charging stations in space, for instance throughout Europe, not only throughout a certain part of the country or the country, but perhaps even internationally. *Capacity management* is about the availability of e-charging capacity in time, so if you drive by car to a shopping mall, you want to use this charging pole directly, and not waiting for an hour and then charging your car for another hour, that would take too much time. So, you would be willing to have this facility available if you need it, and that's the critical function of capacity management. *System management* is related to the availability of the as expected e-charging services. So, if you drive to an e-charging pole which provides fast charging facilities, you want to be sure that these facilities are provided as you want.

Coherence is related to the comparability of the technical and institutional means for safeguarding the above critical functions, and now will elaborate this based on two examples given in the lecture. And as already mentioned, this notion of coherence is important to meet societal expectations. So, let's elaborate these ideas a little bit more in detail, based on two examples with respect to e-charging facilities.

Example 1

Let's first elaborate the example of interoperability. A very exciting idea with respect to interoperability of e-charging facilities is the so-called e-roaming. Car owners can charge at any station with a single ID, so there is no difference which provider you choose, you can always use your ID, your payment facilities, your plug,

to use these facilities wherever you want with each possible provider.

The case of the Netherlands is very interesting in this respect. The Netherlands applied some regulations in which all public charging points are required to use a single ID, so this regulatory requirement of the Netherlands really influences the technological choices these operators of these charging poles make, and in that respect, there is an established coherence between these institutions to enable e-roaming and the technology that is required to do it. So, in this case of the Netherlands, we can expect superior societal and economic performance of the e-charging infrastructures, compared to a situation in which these charging operators rely on different fragmented proprietary payment technologies.

Example 2

The second example in this respect is capacity management, and capacity management now in a little bit broader context. Technically many e-charging stations are operated without taking public grid effects into consideration and this might at future be a problem, especially with respect to fast DC charging. These fast DC charging stations really take a lot of power from these public grids and there might be a problem, because at peak hours the public network might not be equipped to technically meet demand, especially with respect to fast charging facilities, so there is a problem.

This might also result in possible outages, so if more power is demanded then would be available through the public grid this charging pole would not work or even worse, the public network would have a blackout. So, this would be a case of

incoherence, because there would be a lack of institutional arrangements for data exchange between the public network provider and the e-charging operator. So, to have a coherent situation, we would need some institutional arrangements to exchange the relevant data of the use of the e-charging facility and the status of the public network between the network operator and the e-charging operator.

Coherence between institutions and technology

So if there is coherence between the technical coordination and the institutional coordination we would expect superior infrastructure performance with respect to economic social or even technical system integrity. In the case of incoherence we would expect problems in that respect.