Governing the transition to e-mobility: *small steps towards a giant leap*

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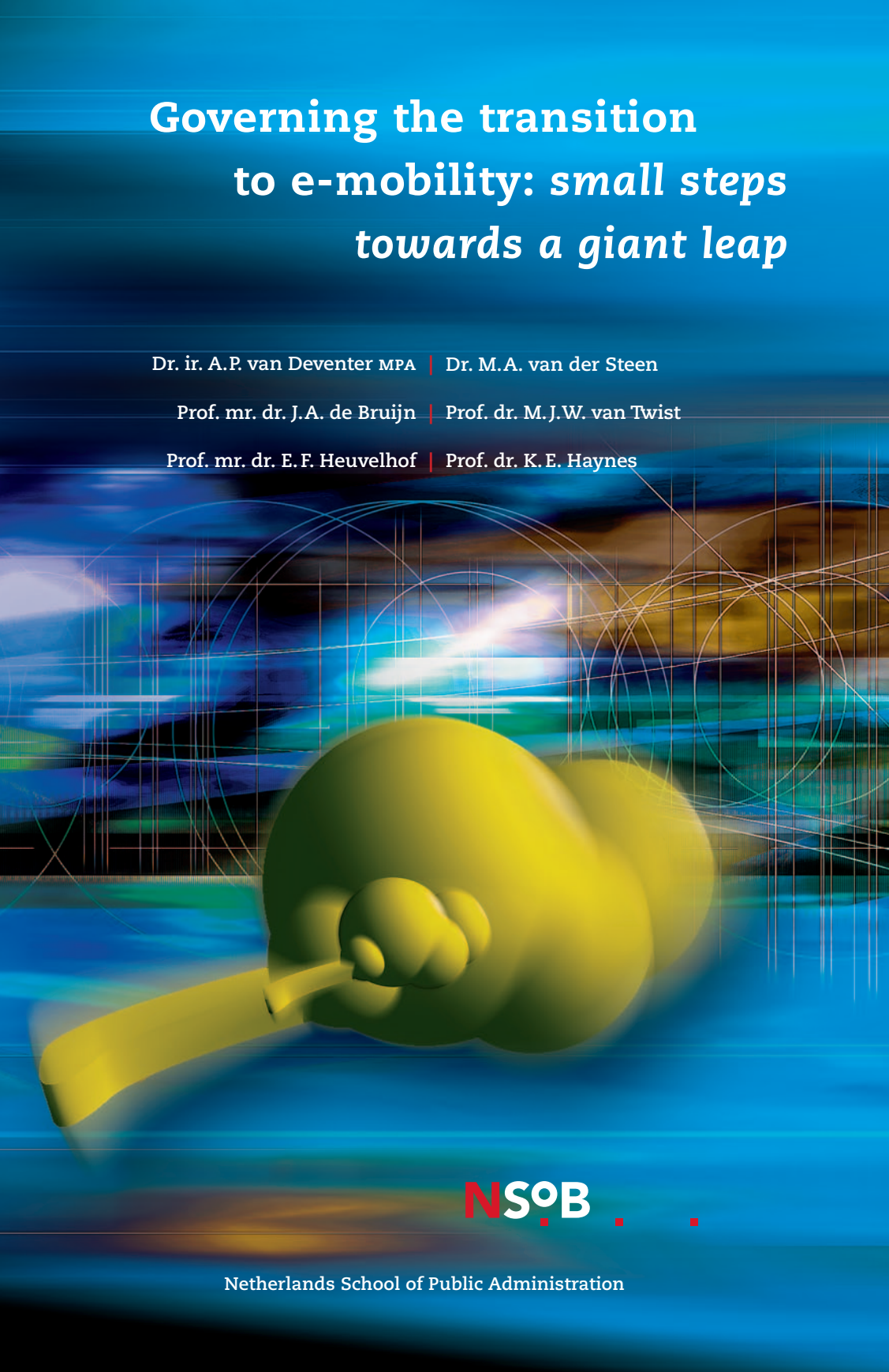

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Contents

1 **What is the problem?**
page 3

2 **Introducing the EV, clear and complex at the same time**
page 8

3 **Analysis of governance complexity**
page 20

4 **Small steps before the giant leap**
page 29

5 **Conclusion: smart strategies for governance dilemmas**
page 37

References
page 42

1 What is the problem?

It is 1996 and the first electric cars are starting to appear on Californian roads. The State of California is supporting the introduction with capital investment and political engagement and is rapidly developing the infrastructure in public places, commercial areas (e.g. the Vacaville shopping center) and in homes. In only a few years after the launch, the number of electric vehicles (EVs) reaches a peak of some 10,000.
Momentum builds and sales are booming. Then, suddenly, it all stops. Vested interests (oil companies) exert their influence and car companies like GM, Toyota, and Ford stop production, cancel lease programs, and start recalling their EVs. State governmental commitment starts fading and attempts to realize sustainable policy fail. Now it seems as if the economic promises of electric driving are no match to reality. And as rapidly as it arrived, the EV is killed, and vanishes without a trace.

If electric driving is the solution, what then is the problem? Is it the urge for clean mobility, the quest for alternative energy sources, public demand for oil independence, or is it all about a new economic perspective? And, if electric driving is the solution, then why is it just not happening, at least not by itself? Why did the introduction of electric cars in California fail in the late 1990s? And, crucial to the deliberation of governance options: what is the role of government? What can governments do to accelerate mass introduction, strengthen it, and make it sustainable?

Introduction

All over the world companies, universities, governments, and private individuals are working to introduce electric driving. All in their own ways are taking smaller or larger steps that one time or another will contribute to a relatively massive transition to electric driving. EVs are still a rare sight on the road but preparations are underway nearly everywhere. *Revenge of the electric car* (2011) is a new documentary on our near future and the possibilities we can expect at this point. It is the counterpart to *Who killed the electric car* (2006), a critical documentary on the failed launch of electric cars in California. It is a meaningful symbol of the turning of the tide for electric vehicles. It is happening, and fast. But is it fast enough? And is the growth steep enough to deliver the necessary volumes? And is the momentum sustainable?

Long preparation time is understandable. There is more involved to introducing electric driving than just launching a new type of car. The availability of technology and a handful of good-looking cars are not enough. Some EVs are on the market already, indeed some have been driving around for more than a decade. Yet these early EVs are not shaping our image of mobility. The question about electric driving is not just about doing it, about transporting ourselves from A to B. It entails a transition to new thinking about mobility.

Electric driving means a transition to a new *system,* with new applications, and even more so, it means radical change to the underlying infrastructure. New vehicles are one aspect; the introduction and integration of public charging stations is a second aspect. Electric driving will not cruise easily into the existing system of mobility but will crash into it with some violence, demanding various radical forms of substitution. A third aspect, further down the road but crucial to overall success, is the development of a smart grid; an electricity network that not only supplies energy to consumers but also allows consumers to give back to the grid. Customers will become 'prosumers', alternating between producers and consumers. To energy companies the opposite applies: they will no longer solely supply to clients but will have to start negotiating the supply with their clients.

All this means a fundamental change in the existing order and balance of authority in the system. Power companies will not only supply energy to customers, they will have to negotiate with customers on their energy resources. They will not only deliver energy they generate, but temporarily store and use the energy generated by what was previously known as customers and connections. The transition to a smart grid is comparable

to the transition to today's Internet. Twenty years ago, who could have imagined how the Internet of today would look like? In any case, it will involve a fundamental change in existing relationships, not only technologically but economically and socially as well.

The introduction of EVs is about a new technology, and about breaking through the existing balance of power and the emergence of a new balance. A change in mobility is not just random policy, but has everything to do with changing deeply rooted cultural patterns. For decades, car mobility has been ignoring economic and psychological principles; measures aimed at reducing car mobility have failed repeatedly in recent years. When oil prices peaked little change in behavior was noted among car drivers. Price inelasticity is huge, as vast as the public's silent tolerance for various forms of waiting. Millions of daily commuters are annoyed by never-ending traffic jams, but hardly any of them use this annoyance to changeover to alternative transport. Kept waiting, people either seek distraction or use the time productively: making (smart) phone calls, listening to audiobooks, language courses, podcasts, mp3s, radio, and the like.

There is a special relationship between consumers and their cars, not forgetting to mention the enormous economic value created by automobility. Any attempt to intervene in this special relationship at a level other than silent replacement of one system by the next will by definition be rough and tough to achieve. The car is not just an item, it is an icon.

The introduction is complicated enough, just looking at the elements involved: new technology, new infrastructure, and new behavior.

But it is more than just content complexity. Building acceptable, attractive cars is technologically complicated but to a degree, it can be done under competitive conditions. It is complicated, a degree of expertise is needed, but it is doable. The many prototypes and mass-produced models already available are proof that much of the technological hurdle has already been taken, or is well underway.

The real complexity stems from something else. To introduce electric driving on a large scale, different elements need to be in place in the system. Much needs to happen at different levels. The answers to what needs to happen and who will pay for it is unclear and highly debated. Charging stations will need to be installed, that is clear. But still unclear is which design technology is the best, which voltage is the most efficient and effective, and how and to who users will pay for using the charging stations. The technology is still developing and many options are still floating around. There are many known unknows.

Electric driving is an emerging domain: new opportunities are hovering

on the horizon, but what they actually are and what they exactly make possible is still unclear. On top of that, we have cars that run, prototypes and techniques in development, and a sizeable population of users but it is still unclear how useful all this will be in the future. This makes it hard for all concerned to forge a clear and focused course of action. Everybody is trying to act strategically, but the best direction of that strategy is unclear, as unclear as the context in which it will have to develop.
Those involved realize that they can influence the future, but they can also see that the future is not something that they can determine alone.
Also interesting is the connection between the parts and the whole.
The whole of electric mobility sounds simple: a car that runs on electricity. But before that whole car can drive, and do so competitively, it needs many systemic parts. It is unclear if each part will ever become a reality and, to an extent, if it will even be realistic. These parts are crucial for the whole to be successful, for the introduction of electric vehicles needs collective action in the system. Many processes and sub-processes that have little direct overlap will have to be tied together, more or less. They range from car development and support networks for charging stations, through marketing a range of services, through certification and licensing by the government and, by most estimates, up to an upgrading of the national power grid. And all this must be done by a host of parties under conditions that make collective action highly unlikely. Indeed, very many parties are involved, but there is little interaction between them.
Beyond the obvious interest all the parties share in having mass e-mobility sometime in the future, right now, at the start of the process, these parties often have competing or conflicting interests. For stakeholders, it may be very appealing in the future, but converting to action today, investing in persistent efforts now, is still unattractive. Therefore, the introduction of electric cars is a complex and widespread issue that crosses boundaries of both time and domains. And time again the complexity comes back to the question: what can we do to sustain progress in the long term? This essay tries to answer that question.

Research approach and guideline

This essay adresses the various circumstances and system properties that constitute the dilemmas surrounding the introduction of e-vehicles.
First, we describe the dilemmas and then elaborate on possible strategies for dealing with them, not only for governments but also other organizations, depending on the specific dilemma and field of tension.
This essay is based on research, including a study of relevant literature

and data collected at conferences and meetings in the Netherlands and the US. We have spoken with a large number of parties and stakeholders active in this field. We went on three study tours to the US to collect information on the introduction of EVs in the US. While traveling we shared knowledge with many contacts and stakeholders engaged in the process. We not only studied the field, in a sense, we have now become a part of it.

It is important to note here that our findings have been reviewed by US and Dutch experts and stakeholders from both policy groups and civil society. We want to express our special gratitude to the Netherlands Embassy in Washington DC for presenting us with the opportunity to hold a Policy Forum to review our findings with US stakeholders and experts. Finally, we are grateful for the extensive support that we gained from the Dutch Consulate General in San Francisco, CA.

2 Introducing the EV, clear and complex at the same time

So, what is the actual problem? There is widespread public support for sustainable production and consumption. Various actors benefit from electric driving and unlike their predecessors, they have deep pockets. There is a powerful business case in favor of the economics of electric driving. If volumes grow large enough, many will undoubtedly profit and from this viewpoint alone, this essay should be redundant.
It should be easy to organize electric driving but it is not. Why not? Why do governments find it so hard to take decisive action in this domain, when they easily seem to do so in many other domains? And why are companies and consumers not making their move? In conclusion, what's wrong with the apparently streamlined model of electric driving? Where's the 'Catch 22'? How complex is it all, really?

Powerful arguments

Let us begin by defining the most frequently heard arguments in favor of electric mobility. All these arguments usually appear whenever electric mobility is considered, although never all at once, which makes sense given their very different nature. These arguments make the case for a rapid transition to EV's. Why should governments strive to replace the classic internal combustion engine with electric driving? Motives differ, depending on the specific application of electric driving and the local context, as the following arguments demonstrate.

Sustainable, clean mobility

A primary, often used argument is the clean and sustainable character of electric driving. This argument has two levels. First, e-vehicle CO^2 emission is close to zero. Put simply, there is no dirty smoke from an electric exhaust. The e-car does not pollute the air. In highly urban areas, EVs would have a great impact on ***local air quality***. In big Dutch cities, such as Amsterdam and Rotterdam, reducing air pollution is an absolute

necessity. If local air quality does not improve, further development will be prohibited: EU legislation will block projects and polluting vehicles will be kept outside the inner city. With clean vehicles, the city will not need to be made car-free. It's not just about keeping the inner city environment clean, but also about the suburbs. Keeping polluting cars outside the city will lead to additional congestion on the surrounding road infrastructure.
Besides this first benefit, local air quality improvement, the second benefit involves improvement on the system level. Electric mobility creates a drastic reduction in pollution, but only under certain circumstances.
If energy for the electric vehicle is produced more cleanly than it is produced for the classic oil-fueled combustion engine, everyone and the environment will profit. If power is generated in 'dirty' coal plants, then the gain on the whole – regardless of the tangible benefits for local air quality – would be limited, even if emissions are cut down to less than half of those made by an efficient combustion engine. If energy comes from nuclear power plants, there would be no emissions, but we would get a serious waste problem instead. With nuclear energy, air pollution caused by transportation would be practically non-existent in densely populated areas. But nuclear power plants may cause even greater environmental hazards.
The solution may be to generate power from solar, wind or water resources. Natural resources make it possible to drive fully sustainably and virtually free of pollution and emissions. Potentially it means that governments can stride forward in achieving public goals for sustainability and pollution. The same goes for car batteries; if they can be recycled, it will increase the sustainability of clean electric vehicles overall.
Car mobility is not the only cause of air pollution, but it is an important, steadily growing cause. If expectations for global prosperity growth and car use are correct, another billion cars will be on the road in the next decade or so. With a sustainable solution for this part of the global problem, the world can make a giant leap forward to a cleaner future.

Reduction of oil dependence

The second argument in favor of electric vehicles for Western countries, including the Netherlands, is that they would be a major step towards reducing dependence on foreign oil. Current dependence on foreign oil means large capital investments in countries and regimes with which Western economies may find themselves at odds. It creates dependency in the sense of political vulnerability to oil pricing and boycotts. The ***capital flows*** from the West to the oil-producing countries and flows back to

the West as investments in companies and property. Zakaria speaks of 'reverse colonization' that creates dependence in both the relationship and property. With oil dollars to invest in the West, oil states can take all kinds of strategic positions in areas where industry and key raw materials are produced. This is how capital – driven largely by oil dependence – is slowly creating a shift in the structural balance in global relations. Thus, the West depends not only on foreign oil; it is dependent in a much broader and deeper sense.

Of course, energy is not only produced from oil, there are alternatives, but automobility is entirely dependent on oil because of engine technology. Cars require refined oil. Therefore they are inherently connected to the places where oil is extracted. Combustion engines are, by definition, ***riveted to oil*** and thus to oil-producing countries and their regimes. Western economies and countries can only break free their oil dependence when their engines are replaced with new technology. The electric car is one of the most practical options available to achieve independence.

International competitiveness

A third argument for electric vehicles is found in the economic advantages that national economies could achieve. The idea is that in the long run, internal combustion technology will disappear. Eventually, oil will run out. Internal combustion is a relatively old technique in which, apart from optimization in the combustion process (more kilometers per liter), little innovation has occurred. In essence, ever since its introduction at the turn of the 20th century the car has not changed. It is an industrial technology, refined in its appearance and production processes. The expectation is that one day this technique will be replaced by something else, out of several possible alternatives. Electric driving is one option, with hydrogen-fueled driving the main competitor. If this is the long term trend, it would be economically rewarding for national economies to hold ***advanced positions*** in the EV field. This substantial field includes: the development industry that focuses on production of cars, batteries or components; innovation industry that focuses on improving the processes associated construction; service industry that provides many new opportunities around the new technology; and finally, ICT industry that sees new opportunities for Applets, smart grid technology, nanotechnology, and semiconductor technology.

From the assumption or belief that new technology is indeed coming, there are all sorts of arguments for governments to be actively involved at an early stage, to get started now on the introduction of electric vehicles.

For countries with a relatively small automotive industry, it is all about exploring new opportunities. For countries with a big established car industry, it is also about replacing existing jobs and businesses. If electric vehicles are on the way, then the US auto industry, for example, and the large communities connected to the industry both economically and culturally, will face major consequences. For Americans, the first issue related to the successful introduction of electric vehicles is how to deal with commensurate economic loss in the classic car industry.

Public pressure and reference drift

A fourth argument is that the public, or certain parts of it, simply wants electric driving. There is great public pressure on governments to get busy. Parts of the public are demanding that the government step forward to respond to developments, because they believe it is important. They can see what other countries are doing, and compare their efforts with their own government's. The idea is that the government must take relatively big strides on sustainability to stay in step with other parts of the world. For example, the large amount of public funding Germany has invested in solar energy puts pressure on the Dutch government. 'Why can the neighbors do it and not us?' Dutch citizens are asking aloud. 'What are we missing out on?' And, 'We should be up there, with the leaders.' It is political fact: a group in society is exerting significant pressure on the Dutch government to do something about electric cars. It is not only an economic rationality, but a broad sense of public ***urgency*** that steps can and should be made to attain sustainable mobility. This urgency translates into political pressure for governments to act.

Policy making takes off

The arguments for taking giant leaps onwards to electric cars are powerful. Unsurprisingly, many countries have already undertaken important policy steps. At various levels in several countries much is being done to introduce electric vehicles. In the Netherlands, for instance, there is a Task Force, headed by His Royal Highness Prince Maurits with support from the Ministries of Economic Affairs and Transportation. What the Task Force does may seem a lightweight coordinating effort, but in the Dutch context, it is a strong and effective means of intervention that can quickly create pressure, focus attention, and direct progress on a given subject. The Task Force does not determine policy itself, but it coordinates the many already existing policies. Its purpose is to bring together in

a coherent strategy the various initiatives within the public services, institutions, and enterprises. The Task Force has 60 million euros at its disposal for the period 2010–2011.

The Dutch government provides support for electric vehicles through ***tax credits***. Provincial governments are also trying to become launching customers by purchasing vehicles on a limited scale and by building infrastructure to support their own use. Initial infrastructure is being built in the cities of Amsterdam and Rotterdam and the provinces of Noord-Brabant and Noord-Holland are holding exploratory talks about regional cooperation with municipalities and transport authorities. The policy theory is that developments should be market-led with (local) government stimulus. The goal is to have one million electric vehicles driving on Dutch roads in 2025. Furthermore, the joint network operators have established, *Stichting* E-*Laad*, (E-Load Foundation) with the aim of ensuring a reliable electricity network for the transition to electric cars on a large scale.

The E-Laad goal is to have 10,000 EV chargers in place by 2012, available to users for an all-in tariff of 100 euros a year, including electricity generated from sustainable sources.

The EU recently formulated a strategy for electric vehicles, setting aside an innovation budget of some 5 billion euros. The 'Green Cars Initiative' aims to support the automotive industry during economic downturns and make the transition to new forms of sustainable mobility. Besides this European-level initiative, EU member states are planning individual initiatives, with the Netherlands, Denmark, Ireland, and Portugal leading the way.

In the US, the federal government has made large sums available through a ***stimulus package*** to support EV innovation and research, including research into battery and charging technologies. Market participants are supported to develop, manufacture, and sell electric cars (fully electric and plug-in hybrids). As in the Netherlands, the US government is supporting the introduction of electric vehicles on the market through massive tax breaks. The US policy has an obviously huge impact; all sorts of regional incentives are blowing fresh air through the system; US money not only goes to a particular industry or type of innovation, it is highly targeted at regions or even specific municipalities.

It is important to note that most US policymaking is not federal, but done at the local state level. As in the Netherlands, US cities run their own agenda to establish governmental fleets of electric cars or charging stations. States like California have led the way over the past four decades with ground-breaking policies on air quality, incentives, programs, and infrastructure. California expects to have two million EVs by 2020.

It supports the landmark change law, Assembly Bill 32 (AB32) with some 100 million dollars annually through the California Energy Commission (CEC). However, as the Californian strategy is not to pick winners or losers these funds are allocated to various technologies (electric, LNG, biofuel, hydrogen, etc.). The CEC regularly organizes workshops, meetings, and hearings to support the Californian goal of a 30% reduction in CO^2 emissions by 2020.

A strong base of cooperation between committees, NGOs, companies, utilities, and universities makes the California approach very interesting. Various initiatives between these organizations have resulted in the development of so-called ***EV corridors***. Other interesting US initiatives can be found in states like Oregon, Washington, and Maryland (Baltimore EV Initiative). States like Ohio and Tennessee are investing in electric driving components as industrial reform is needed due to high unemployment rates (>10%). The state of Tennessee, in contrast, has made large subsidies available for the Nissan Leaf production site. In California the Nummi plant at Fremont with a potential production of 600,000 cars per year did not close when GM and Toyota moved away but stayed open for the production of the Tesla Model S, starting with about 20,000 cars a year.

And yet: uncertainty, fear and lack of clarity

If the promise of electric vehicles is that great, and if policy-wise so much is going on, why is it not happening – at least not yet and not automatically? Put differently, if we have four economically and politically sound arguments for doing something, and if ambitions and policy have been translated into many concrete goals and programs with associated budgets, then why is it not all systems go? The answer is of the same order as argumentation in favor: several ***powerful uncertainties*** hinder the large scale introduction of electric vehicles.

Technical uncertainty and perceived discomfort

The first cluster of concerns focuses on technology. What is the battery quality like? How far can I drive on a full battery? How secure is the technology? How long does recharging take? Technical limitations are still unclear to the public and because ultimately these limitations are crucial to the use of the technology, they are crucial to its release. This is not purely about technology as such, but more about the perception of its potentials and limitations. ***Range anxiety*** (how far can I drive?) may deter many potential users and suppliers. The car runs on batteries which

after a certain distance require recharging. The vast majority of trips people take every year are well within the range of some 200 kilometers. Yet many people are afraid of the technology because each year they might want to take a few trips beyond that range. People wonder, can I use the e-car on vacation or not? Thus an objective, technical limitation gains subjective meaning, which in this case is somewhat blown out of proportion so that lots of attention gets drawn onto the limitations of the battery technology. With this anxiety in mind, an electric car would seem to be inferior in comparison with the conventional fuel engine. The electric car will go only 'so far' whereas range is not an issue for regular car users. The technical uncertainty cluster is partly truly technical – what exactly is (im)possible, at what cost and what risk? – and partly symbolic.

Creative destruction and social discomfort

A second discussion focuses on the social impact of electric vehicles. This is mainly about suspicions of creative destruction. Electric driving makes something new possible, but at the expense of something existing. For example, in areas where there is great dependency on traditional automotive industry, introducing electric vehicles may create unemployment. While some people perceive economic impact as an opportunity, others fear the opposite. As with any innovation, it is uncertain how and where the revenues and costs of the alternative will appear. This causes people to worry. In addition, there are doubts about the ***accessibility*** of electric vehicles for ordinary consumers; is it not just a toy for the rich? Available cars are relatively expensive; will the introduction of EVs cause new social distinctions between the haves and have-nots? And is it fair that those who already get big tax breaks and other incentives from tax revenue would be getting extra support?

Dependence on the supporting system

A large area of misgiving about electric cars surrounds the entire infrastructure of the electric car. It covers many aspects, such as the network of charging stations that must be built, the power needed for the electricity supply, the required capacity to handle varying peaks and the charging speed. Again, not all of these details can be dealt with at the time of the introduction, but they are crucial processes. For day-to-day use, the charging time of a battery is important: one, three, or twelve hours? Similarly, what is the necessary density of charging points. And how to build charging points in homes? Electricity is a key element in our homes. Electric chargers are different from what usually happens in and around

a house. Installation will require renovation and rerouting of cables and pipelines, and brings along questions about ***safety***. Add to this the uncertainties about the support system, a general uneasiness about the use of electric vehicles, and the public may get the idea that the system can only be credible and economically viable when all conditions are met.

Truly renewable energy

As for the impact on the environment, electricity needs to be generated in high volume: how and where will that happen? How clean will the produced energy be? Is it truly sustainable? Can we find a solution for the problem of proper distribution of electricity through the grid? As we explained above, a massive shift to clean energy could mean that electric driving would cause virtually no emissions, but if energy is generated in ***coal plants***, there would be a less positive effect. There are also questions related to battery lifespan and the possibility of using EV batteries as storage capacity with vehicle-to-grid technology currently under investigation by Ohio State University and University of Delaware. Can we develop markets for used batteries or will batteries have to disappear in the waste cycle? Recycling could be a solution, but will this really get off the ground? Once electric cars are actually used on a large scale, significant volumes of used batteries will soon start entering the system. If we are unable to resolve the issue of battery recycling then the environmental problem merely shifts, from emission to storage. Even if energy is'clean', old batteries may cause new and massive environmental problems.

Economic conditions

Price is another uncertainty about electric cars. Can electric cars become competitive with existing methods of mobility without an extra tax on gasoline or through other taxes? The cost of the vehicles is still uncertain. Fully electric cars are on the market, but they are still relatively expensive, especially due to the ***costs of batteries***. Tax incentives and subsidies can compensate, but the question is how long such arrangements can last. The government's purse is rather depleted now, forcing many possible worthy subjects to compete for scarce subsidies.

The price of the infrastructure is unclear and literally unpredictable. It is difficult to anticipate how prices will develop, because this is heavily dependent on production volume and that still needs to be established. Technology has yet to crystallize, and as many different systems are in use, it is unclear how the price will develop in the next few years.

Uncertain markets and firmly established parties

The market is another big uncertainty. The established automotive industry is clearly in motion and several brands are entering the market, including Japanese, European, and US manufacturers such as GM, Renault, BMW, VW, and Peugeot. New players are producing cars, or specialize in vital components such as batteries and charging stations. The market is moving, big players and a host of smaller players are making an entrance, some with very deep pockets. How will the market develop? Traditional players are still making margins on conventional cars. Some of these players appear to be entering the EV market reluctantly; it seems as if they are joining in to not miss out. It is unclear how firm commitments are and what the top priorities are when financial resources become scarce.
What happens when government incentives fail or decrease? Players are still waiting to hear the real ***preferences of consumers***. It is unclear if consumers are ready for EVs. In today's car industry, how will companies market electric driving to interest consumers? Again, range anxiety is important, and seems to be one of the main consumer concerns. As long as such barriers are perceived by consumers, mass introduction may seem like a mass illusion. Who is willing to cover the cost of negative perceptions, which, if they could only be turned around, could benefit all the actors? Who is willing to bear the risks?

Robustness of governmental intentions

It is also unclear how robust the commitment of governments is.
Various countries are showing political support for many innovations and experiments, but how long will this continue? Political tides change. In the US it is almost inconceivable that a Republican president would continue current Democratic policy. Simply because Obama turned electric driving into big issue, a Republican successor is likely to downplay it. For instance, the State of California witnessed a political battle in November 2010: Proposal 23, supported by two Texan oil companies, aimed to suspend AB32 (see above), until unemployment had dropped below 5.5 percent for a full year. Although Proposal 23 was rejected by Californian voters, it demonstrated the 'anti movement', which can become an important factor to consider. The same applies to other countries.
If sustainability has lower priority, the anticipated millions of euros to promote electric cars may become an illusion. Under current economic circumstances, it is difficult for governments to maintain prolonged profound commitments. In addition, it is unclear how much ***political capital*** governments are willing to spend on keeping this issue on the agenda, let alone intensifying attention for it.

Uncertainty as strength

Many of the uncertainties described here may have an unintended negative connotation and be regarded as threats to the introduction of electric cars. But uncertainty can also be seen as a positive strength. Things we do not know about electric cars now could turn out to be decisive in future. The inventors of the first smart phones had no idea of the Android phones and iPhones of the future, and all the other smart phones to follow. Important here is that the introduction of the electric car is an innovation that brings two systems together: electricity and transport. The innovation logic straddles the borders of both systems so there is lots of potential for innovation; this usually leads to ***unforeseen creativity*** and invention. So, the potential is great, but so is the uncertainty. We can say little about it now – it's uncertain – but we do know that serendipity can be a significant aspect of innovations and usually occurs. And often just these unforeseen innovations turn out to be the most crucial.

Here are two examples, although giving them slightly undermines the fundamental element of uncertainty. Renault is launching the Twizy e-car at the end of 2011. The Twizy is 2.30 meters long, has two seats, and is priced closer to a three-wheel scooter than a car. This is what's happening: with the rise of new technology, we are abandoning the concept of the existing car, or redefining it at least. A new concept brings new opportunities. We haven't interpreted all the possibilities yet, but clearly something fundamental is going to change, with space left space for positive value creation. Perhaps the electric car is not just another engine, perhaps it will be a truly different car, or new hybrid, a cross between a scooter and a car? Conceivably, large cities will only allow these types of vehicle into their centers. Is this the prelude to a totally new kind of car, unlike the Twizy, but also unlike the cars of today? Is the Twizy the iPhone, or rather, the 'dumb' version of the smart phone that back in the 2000s slowly began conquering the telecom market? We do not know.

And that is exactly the point.

The impact of the Twizy may be small but it could far bigger and more different than we think. The real promise of the innovation may be beyond our current imagination. What we do not know as yet, may be the 'killer app' of the EV in the future.

This also applies to the second example. Clearly, we need EV charging systems. We have lots of experience with charging, from wall sockets or through the electrical variant of fuel stops. But we expect this to be merely the start of developments, not the end. We expect tremendous developments around the charging of electric cars. What the charging

system will look like, nobody knows, not now. Will it be a stand-alone energy system, or will it link to other systems, such as street lighting, parking and wireless phones? We do not know: we only know that links are probable. Then again, we do not know what the killer link will be, the breakthrough that, like the smart phone, will prove to be the one big innovation. Charging may just be bigger, better and faster: but it may also be radically different and systemic in the sense that it will allow for a range of new possibilities and applications to develop.
So many uncertainties, but one certainty: one innovation ignites other innovations and all these innovations will explode in a lot of ***critical mass***, even if we do not know which direction they will all take. Innovation is based on the interaction between interface and usage, between electricity and the car. Just as with the iPhone and mobile Internet, the two chase each other round the development loop: faster Internet allowed hardware and software producers to develop faster smart phones with steadily increasing functionality that combines various technologies (GPS positioning, Internet, and social media), altogether and this has led to unprecedented, fast innovation. The advent of smart phones saw providers fighting to accelerate and broaden their telephone networks. And that, in turn, caused Apple and Google to enter the market, which pushed providers to increase bandwidth; radical innovations support the new capabilities of the iPhone, the Android, the Blackberry, Nokia, Samsung and all the other smart phones in the slipstream of this market. Innovation does not happen in a single stroke: it is interactive.

In conclusion

There is a strong call for rapid and massive deployment of electric vehicles. In many aspects it is a cleaner, cheaper, smarter and advanced solution for mobility. This is important for many reasons: a better environment, less oil dependency, reduced emissions of CO^2 and new economic opportunities. But it is also a ***controversial technology.*** The benefits are unclear, as are the possibilities of competing technology to further improve and respond to current concerns. Gasoline engines could definitely be made cleaner. The limited consumption cost of an electric car is presently not offset by the higher purchase cost. In that respect, driving on electricity is not cheap, at least not on the day of purchase.
There is still so much to do before electric mobility can take place on a sufficiently large scale. Big investments in the power grid must take place, but which ones exactly? The answer is anything but obvious. There is a

correlation between electric vehicles and a smart grid. The electric car can be the killer app for the introduction of a smart electricity grid, but that in itself would not necessarily mean anything to the pace of introduction of electric cars. But without a ***smart grid***, the electric car is not as attractive as it could be. The prospect that one sweet day there will be a smart grid, and electric cars will gain more than usual benefit from it is no argument for consumers to purchase an e-vehicle today. Two processes that can reinforce each other – the smart grid and electric cars – seem to have little impact on each other. There is much confusion surrounding the electric car system. There seem to be plenty of long term opportunities for all kinds of wonderful connections and improvements, yet time and again the arguments against complexity and uncertainty raise their ugly heads, all signs that momentum is slowing down.

This chapter has been about the opportunities and the uncertainties of electric cars. The next chapter will explain some dynamic interactions that will give us a clearer idea of what governments could and perhaps should do for the introduction of electric mobility.

3 Analysis of governance complexity

There are many signs that a mass introduction of electric driving will benefit society, but at the same time there are forces and conditions that make it just as unlikely. Overall, circumstances are balanced in the sense that there is no overriding pressure on electric vehicles. This is not because factors make electric driving impossible, but because the interplay of factors is probably making it more attractive to wait and see where it is going. We are not saying that no investment is taking place, but we are saying that only some of all the actors that could be embarking on investment have done so to date. Some actors are going for it, yet many others are offering only half-hearted gestures, or less. This is the current state of play in a number of dynamics surrounding electric vehicles.

Our analysis of current conditions can form an effective basis for new movement in the EV arena. Armed with this analysis, government can intervene to organize and (in part) steer the action, propelling the start of electric driving without having to take over the introduction from those actors who should be managing it. Government can offer electric mobility the impetus to run out of the starting blocks, where it now rests, waiting for the starter's signal. The question now is how to bring the process of mass introduction beyond this first step, to make it more substantial and to initiate a possible giant leap.

Searching for dynamics and game play patterns

Doubts and uncertainties, and their distribution across the different actors in the electric driving arena have led to complexities that we will catch and describe in ***game plays***. In each play, the game construction is the same: actors face both advantages and disadvantages but, in the current situation, the disadvantages always come in first. They appear

earlier than the advantages and are more compelling, at least on the short term. We demonstrate the dynamics of the various games and present possible solutions that may reverse the favour for waiting into a bonus on early moving and action. In the next chapter, we will translate those more abstract plays into smart strategies for meaningful action.
Taking the first step is crucial. Our analysis shows that fundamental interventions could indeed be made to resolve current tensions. The problem is that the dynamics are such that taking that first tentative step might not lead to any of these major interventions being made. This is only likely to happen if a number of significant actions are put first. The analysis in this section is aimed at identifying the most appropriate initial action.

A 'wicked policy' problem

The introduction of electric cars is a classic example of what is usually referred to as a 'wicked policy' problem. And not one, but several. First there is the combination of uncertain, controversial knowledge and values. Regarding technical knowledge, there is no clear answer to the questions of what exactly is going on and what is needed. What is the problem? Is it climate change, oil dependency, range anxiety, or nothing more (or less) than inaccurate perception and flawed public opinion? Is the battery strong and stable enough? Are charging stations safe? And what are the reasons for these problems?
There are various theories about the usefulness of electric driving, including best solutions and alternate options. There are as compelling theories that argue that electric vehicles are not a realistic or cost-effective option. Although this analysis deals with both supporting and opposing theories, it is also deals with the different camps of supporters and opponents and their arguments. At the level of knowledge, it is not easy to find stability, to get simple solutions to simple problems; it is not possible to hire the ultimate expert who can and will provide the solution based solely on knowledge.
For wicked policy problems, there is no agreement at the level of underlying values. Not only is it unclear what a problem's characteristics are, there is also uncertainty about its desirability. It is complicated in that proponents of electric cars often fall back on conflicting values. Geopolitical considerations about oil dependency and sustainability do not need to clash head on, but often these good 'eggs' are not even 'in one basket' among politicians. The usefulness and necessity of electric cars is not unequivocal for everyone; the value of sustainability is not shared by all, especially when placed head-to-head against other values. Because it concerns the

deployment of scarce resources, such as tax revenue, this dilemma is always lurking just around the corner.

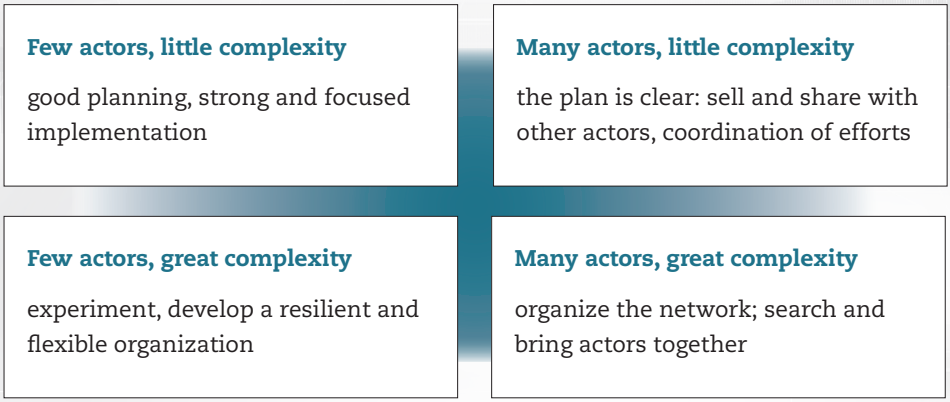

Figure 1. The arena of e-mobility

The arena of e-mobility: many stakeholders, many interests

Electric driving is not only a wicked policy problem, it must also be developed in an arena that requires many actors and actions in order to make progress. The wickedness is played out by many actors. It causes all kinds of ***collective action*** problems. If Amsterdam promotes electric vehicles with infrastructure, grants and licenses, but forgets to make arrangements with the region, its citizens might be able to drive on the beltway, but they will never get into Utrecht, Alkmaar, or Almere. For a useful introduction, Amsterdam has limited capability, overall success lies in the hands of others. This is a recurring principle for the introduction of electric vehicles.

If substantive complexity is limited and there are only a few players, implementation is relatively simple. If there are few players, but there is more substantive complexity, a longer and better thinking process could provide the ultimate solution and strategy. Then simple implementation could still follow, at least through a manageable number of actors. However, when the arena has many different actors, each with different levels of commitment and involvement, and often with the ability to control and add on to the process, possible strategies will change. Control is focused more on moving and bringing together the interests of the various actors than on formulating what is needed and rolling out the plans.

However, the complexity and multiplicity of actors is not necessarily restricted to the commercial players in the market. It is also includes governmental authorities. For example, many Dutch provinces have invested for years in a natural gas network. They are stuck in this earlier strategy. How to straighten this out through governance?
In situations with many different actors and issues of limited complexity, it is all about intelligent network management through the execution of prearranged plans, in other words, proper project management. When complexity is substantive, and the policy arena is cluttered by many and diverse players, it is not possible to work out preemptive solutions. It requires strategic game play by various actors to combine their knowledge and cooperatively create viable and sustainable solutions. These actors must also be committed to continuing the process of implementation later on. Instead of project management, this is good ***process management***.
Serial brainstorming and implementation run more or less in parallel and at same time, involve many actors at all stages of the process.
The provincial government of Noord-Holland is currently discussing the first steps in creating a 'circle corridor' with strategically located fast-charging stations. The construction of the stations is not the most complex of tasks, but connecting the charging stations to many other features, such as rail, park-and-ride bus services, and other public services is complex. The combination of features increases the value and potential of the charging stations, but it also increases complexity. It is not difficult to roll out such networks independently of other networks and infrastructures, but in relative isolation, their value is limited. The combination of many different functions and networks is what makes it hard: but it is also what makes it most worthwhile.

Commercial actors: wait, move, invest, or copy?

All actors who have to come up with the goods somehow keep each other hostage in a game ruled by the timing of their efforts. This is particularly true for commercial actors. Electric driving involves initial large investments, while many benefits can only be reaped later on and will often profit actors who contributed little initially. As we showed earlier, actors may be uncertain about the best technology to invest in. Although the path has not crystallized yet, all parties must make binding decisions at the start of the process.
This is the dilemma: all potential solutions have advantages and disadvantages. Waiting and early movement are both promising strategies, but they also harbor risks. Whoever starts quickly could gain first mover

advantage and shape market standards. Remember TomTom? First on the market in the EU/Netherlands at least, it has become almost the killer brand for mobile navigation. First movers can often count on extra government subsidies, which are larger in the earlier stages than later on in the process. On the down side the early mover may get ***trapped*** in his tracks. By investing heavily when the product was still under development, early actors may lose the ability to respond to what the market really wants. They based their move on a possible projection of what the product or market turned out to be. It may be very hard to alter investments to meet more realistic developments and so they become stuck in the path they forged as an early mover.

The opposite of moving early is to wait and see. The actors thus involved are in the waiting game or playing 'chicken': who dares wait the longest before making investments? Who moves first? Who sets this crucial game in motion? Given the circumstances, this is a very understandable strategy. Who dares wait long enough can ignore the traps of early leadership and simply copy successful product strategies at no developmental cost or risk. Yet the risk of such strategy is obvious: wait too long and you run into the costs of catching up. Particularly when the early mover is successful, more cautious parties will incur market recovery costs. Sometimes they will not be able to catch the leaders and that will considerably limit their strategic options. The leaders may have put out patents, divided the market between them, and snapped up the best talent in the business. Consumers may have developed certain images of the market. TomTom literally created its own market and has made it very hard for other parties to enter successfully. Those who wait may be too late and miss out on significant benefits. The ***risk of waiting*** is missing the right boarding moment. At this very moment, all players in the electric driving market are facing the same dilemma. Should they wait or get in early? Who dares move first? Who dares wait the longest? Who is chicken? And at what price? In practice the distinction is obviously not so binary. Many parties seek to cope with both sides of the dilemma, even if the cost of this dual strategy is high. They invest, but not at any price. They participate, but not all out. They bet, but take hardly any risk. They bring new models onto the market, but prefer to supplement the existing market rather than start a transition. Government intervention could contribute by bending the curve of this process. They could do this for a number of actors, shaping the curve in such a direction that the actors step in quickly and overcome the associated risks. The paradox of this game is that the motion of the

early starters automatically activates the waiting actors. Once the process swings into motion, the others follow the leaders. Yet arena dynamics suggest that starting up this process does need some help.

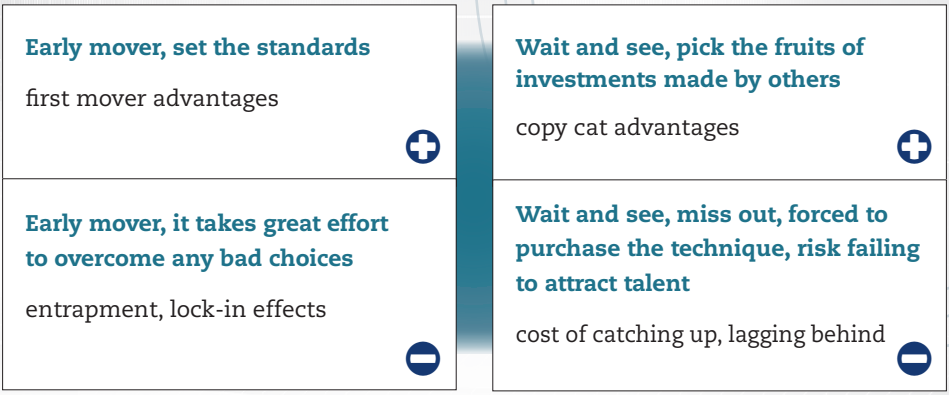

Figure 2. Who makes the market?

Supporting innovations: policy, planning, regulation, or just letting go?

Policymakers face a similar dilemma in the game that shapes their strategic actions. They too must consider a number of actors and the processes in which they invest. They want to give supportive nudges but they are not clear on whom they should choose to nudge or by how much. The choice requires knowledge of who is or will become the best player on the market, but favoring some ahead of the rest may reduce the stimulus of entrepreneurship. Such support will not push the market constructively, it will only result in processes aimed at tapping subsidies. Remember the debate on sustainable energy? Do windmills turn because of the wind or do they blow subsidies? Do solar panels generate energy or do they burn subsidies? Every choice that governments make means they lose part of their freedom to act. Support, especially in the current era, is a zero sum game. Funding for one initiative comes inevitably at the expense of resources for other initiatives. Financial space is limited, so the use of scarce resources and political capital is by definition risky.

Electric driving is a scarcely emergent issue and therefore, by definition, unclear. The broad contours may be well known, but the exact interpretation of the fine lines will only become clear gradually, over time. Now there is a multitude of possibilities, some familiar, in a known

direction or established trend, others partly unknown, emerging, or marginal. This is forcing governments to rethink the idea of selection and choose policy for maintaining a variety or guarding against prematurely applying focus ('prematurely' because the focus itself has not yet emerged from the process). Should governments pick winners in advance? The actors that now look the most promising may not turn out to be so promising in future. Or should government stick to policies that support variety thereby allowing the process to be the winner. Both options have advantages and disadvantages. An early prioritization has benefits in that it allows government to apply resources with focus and commitment. The government goes for it and guides both development and implementation, resulting in close, profound ties with the chosen winners. Focusing on a winning technique means that support can be selective. It may be efficient, but only if the technique is good. And in an emergent field that is never clear.

Here the ultimate question is whether policymakers can indeed ***predict*** the winners of a battle over a largely uncertain, still developing issues. By definition this is difficult, if not impossible. The stakes are high. If the policymaker chooses the wrong winner and bets on an inferior system, he will get trapped by his commitment. The government gets locked in by previous choices and market players may strategically play on this. They may ask for additional resources to strengthen an inevitably dwindling position. The government understands that complying with the request will distort the market, but it has to accept that this is the only way to maintain the value of the initial investment. The history of state support is crowded with sad examples.

In a sense, this view also applies to the current carbon industry furor. The carbon industry has deep ties with government. In the US it funds political campaigns, it is deeply rooted in local economies, and it uses those links in its call for protection. If the government wanted to cut free from the carbon industry, it would mean breaking the intertwined worlds of organized businesses and government.

However, if the government wanted to leave enough room for variety and selection, and ignored choosing the ultimate winner as a starting point, this would postpone the final choice as long as possible. Then the choice of winner is not made by an external party (i.e. government), but arises in the market. ***The market selects***, some actors and their techniques will grow stronger while others will disappear or marginalize. If the government maximized opportunities broadly and provided more or less equal support, the best alternative will float to the top of the market. That is, if the market is truly open and honest.

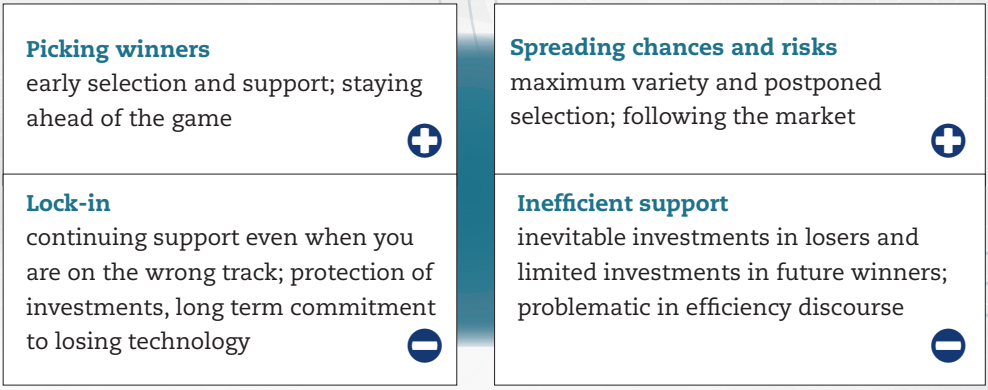

Figure 3. ***Supporting innovation***

Therefore, government strategy should be to ensure ***diversified funding***, and couple that ideally with interventions that ensure the market stays as fair as possible, with a level playing field for all actors. Providing a maximum set of equal opportunities for a variety of options will bring out the best. But it also means investing possibly large amounts in inferior solutions, which ultimately will never be successful. Many of these investments should be amortized as sunk costs and the government should be prepared in advance for companies to perish if they do not appear to be a winner. This is a high price, both economically and politically. Redundant use of government resources is hard to sell in times of shortages, even if it the investment will show a return in the long run. 'Targeted efforts' sounds better, even if actual costs are eventually not much lower than those incurred by redundant use.

Dealing with costs: distribute, allocate, divide

Because the transition to electric driving is so radical, a crucial feature of the problem is the long time lag between the moment of investment and the generation of income. Investment in research and development and in new infrastructures must be done in the short term, but it will only get paid back in the long run. The costs and benefits are often also divided among several actors.

Sometimes distribution is relatively simple. The actor that invests is the one to get the first, most tangible benefits. Then the choice of whether to invest can be made through a simple business case. But more often investments and return on investments are further apart or scattered among various actors. An early investment may create immediate benefits to all actors (including those who wait), or it will create benefits only over

a very long period, possibly after a few generations. That does not mean it's still a problem, but it can make assessment harder. If it is harder for actors to protect investments, uncertainty increases. And there is always a risk that other actors will run away with the benefits. Whoever invests first is sometimes forced to see other actors who have waited enjoying the benefits. That implies that waiting may be a productive strategy; don't be the first to build the infrastructure, but wait until it's there and then use it. Time and again, it seems simpler when costs and benefits are close together and end up in the hands of the actual investors. This may be because the costs and benefits source to and from one actor, but it is also possible that actors forge alliances, so they can divide the costs and benefits among themselves.
Actors who invest wish to protect their investments. They do this partly by investing early in the process and thus creating ***path dependency***. But that is still a risky strategy, especially if the investments are as major as in the case of electric vehicles. Another option for protecting investment on such things as infrastructure is to keep your investment closed off to others, or make it accessible at great cost. Telecom providers earn loads of money on 'roaming' whereby they require others to pay for using their network. Closing systems off or charging for access to protect investments can persuade actors to invest early, which may be good for the process, but it can also lead to the innovation process closing down. ***Open systems*** and standards are more innovative, but from the standpoint of investment protection it may be more profitable to keep the system as closed as possible.

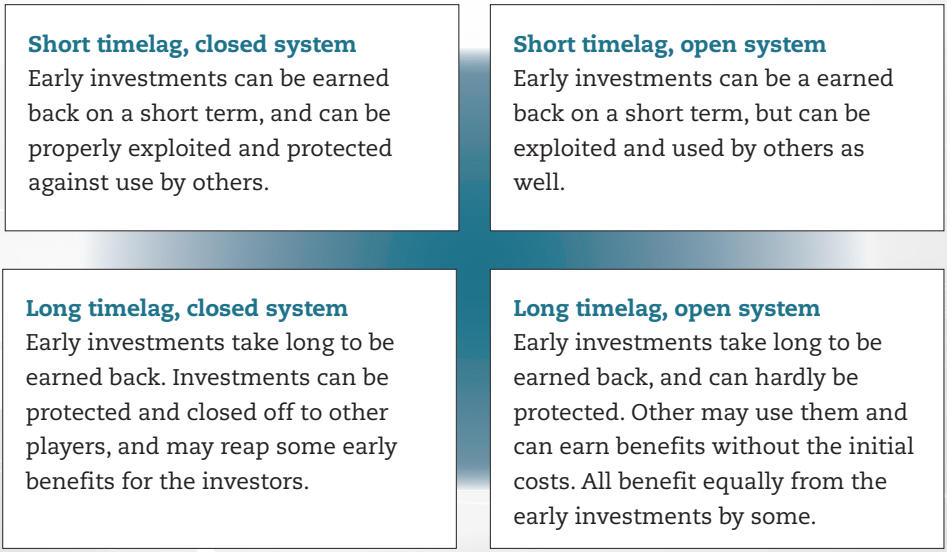

*Figure 4. **The costs of investment and the spread of benefits***

4 Small steps before the giant leap

Achieving the large scale introduction of electric vehicles is a significant issue of inherent complexity. Electric cars are already on the road and in the near future there will only be more. Yet the rate and scale of increase is insufficient to achieve the necessary volumes and scale. There is a good chance that the process will dissipate in a half-hearted state that truly satisfies no one. There is commitment from NGOs, companies and governments, but even put together, that is ultimately not enough to break the deadlock of the waiting game and enable us to take that one giant leap forward. And that leap is essential because, while we are stuck in the middle we lack the power to make e-mobility profitable. In fact, this is the loser's scenario for electric mobility. It is the existential dilemma surrounding electric cars. Investments are needed right now, but deeply ingrained institutional rationality designates waiting as the most promising, productive strategy.

Meaningful steps forward

The introduction of e-mobility is an issue connected to a high degree of lock-in and effects related to the burden of the past. Choices early in the process, for example, regarding the leading infrastructure and technical standards, can end up in long term commitment to – on hindsight – inferior techniques. Increasingly this involves processes that touch established commercial and political interests, which in turn touch the lives of citizens in action and can generate much media attention. Technology choices are never objective considerations, but are put under pressure by political and strategic considerations. Another feature mentioned earlier is that visible costs always come before expected benefits, and investments are made without guarantees, knowing that benefits can only be distributed after the elaboration of endgame details, which cannot possibly be known at the begin of the game. Uncertainty surrounds investment; up until the last moment it can all go wrong; stakes are huge in this at times fragile game. Without intervention

chances are limited for the mass introduction of electric cars. The first few thousand cars will roll out of the factories without problems, thanks to government support. What really matters are the steps that take us beyond those first few thousand, or tens of thousands of cars, onwards and upwards to mass production and deployment, and the ultimate normality of the electric car.

Searching for smart strategies

Turning the process into a success means bringing technical and social assessment together. As we have shown, choices tend to make themselves in this field; critical decision-making needs help. And, merely announcing intentions or even releasing funds does not mean that the process is well organized. Others have to get moving as well. The introduction of electric cars requires commitment from the three pillars of government, industry and society. It is far from clear that all the actors involved will find each other easily and simply follow suit. There is no shortage of strategy, in fact there has been a surplus of strategies with individual actors navigating their own courses, all well motivated, all with good intentions. It is a task to bring all of these courses together. And we still have the group of critics, the critical consumers and followers on the lookout for failures. We still have the complex vested interests that will benefit from the failure of the transition to electric vehicles. It is in the opponents' interests to nip the EV transition process in the bud, as quickly and soon as possible; to this end they can exploit all sorts of resources, lobbying politicians, playing the media game and competing for economic opportunities. They can dramatically cut the prices of their carbon-based products, they can produce better, more fuel-efficient cars and improve driving performance. Settled actors in the automotive industry or the oil industry are not taking direct part in the transition, but they can certainly exert great influence on the process.

Translating smart strategies into meaningful first steps

How can we bring together the various stakeholders more effectively to achieve large scale introduction of e-mobility? Discovering the answer to this question is the *raison d'être* of this essay. Until now, we have discussed many complicating factors, with the aim of distinguishing the best options for success. The question for this section of the essay is how to translate knowledge from various layers of complexity into smart strategy, breaking this down into ***meaningful steps*** for the final run up towards the introduction of the electric car.

The run up to the giant leap

The proposals suggested here, which we will research further and make more concrete, derive from combinations of the dimensions that cause complexity. It is necessary to undertake early action that will have long term effects, either because the action concerned will be significant in the long run, or because it will enable the system to develop significantly. In principle, this would be one government action – or done with a limited number of partners – that mobilizes many other parties into action. The government-initiated action should be small, relatively quick and easy to connect. It should have ***symbolic value***, but at the same time much more than that. It must deliver a powerful image, but behind the spin must be real content. It should give more than the suggestion of great progress, it should be doing something that really matters.

When applying smart strategy it is important to access local knowledge, and engage lay skills and talents ('amateurism'). While the mainstream game should focus on getting the major actors moving, it should also tap into the passion, commitment and impressively serious knowledge available in various garages, workshops and home attics. Electric driving is literally a pioneer movement; because of the structure of the playing field and the type of technology involved it is ideally suited to grass roots development. The open innovation character should be preserved and enhanced, not allowed to deteriorate into a fad or a hobby project. Meanwhile, engaging the major actors should not compromise the opportunities to mobilize skilled amateurs, potential creators of the most critical solutions and applications.

Challenging the challengers: mobilize unexpected third parties

First, it is necessary to get the challengers involved in the process. One of the powerful features of the transition is that it is not primarily embedded in the established actors, but that new and surprising connections can be made. Employing smart strategy does not imply that government singlehandedly identifies various ***new actors*** and brings them together, but it does suggest that government should create the conditions that makes it increasingly likely that these actors will find each other.

The government could encourage banks, supermarkets and department stores to present EV charging facilities to customers parked on their grounds and offer services around the EV chargers. They could create favorable conditions for leasing companies so that their electric fleets can provide the business market with electric vehicles. Think also of the

potential value of highly visible electric vehicles to small businesses, so that the public at large can quickly see the benefits. In Washington DC an EV-based pizza delivery service is clearly demonstrating that electric driving is efficient, reliable and cost-effective. The pizza is cheaper if is it delivered by EV, which experiences has shown gets delivered as fast and reliably on time as consumers want, and using clean energy too. The same goes for the electric taxi project in California; from 2011 three locations in San Francisco's Bay Area will be served by 70 e-taxis with a battery swap station at each location. In the Amsterdam region discussions are in progress on a similar taxi project as well as a logistics project that will use electric vans to supply the city.

Being a ***launching customer*** can help during the introduction: the Californian cities of Santa Monica and Vacaville have made dozens of electric cars visible to the public. Also, parking lots or garages, equipped with solar panels, can be attractive to potential e-car users. A good example is the Sonic Burger parking lot in Vacaville, which includes fast-charging facilities fed by a solar rooftop. For EV drivers, dining and charging go hand-in-hand, and they can see the electricity is generated from sustainable resources. This is how consumers get familiar with the phenomenon of electric driving, without having to delve deeply in the subject. Time and again, the challenge for governments is to allow easy entrance for these types of unexpected actors. This means keeping standards open, awarding innovation grants, or reducing regulatory barriers for a broad spectrum of actors. The dialogue should open to include not only the auto manufacturers, energy companies and research institutes, but also national business chains (Albert Heijn, Rabobank, New York Pizza), government departments (Veteran Affairs, Labor) and, of course, the car leasing industry.

Create symbolic links: fast 'circle corridoring'

The idea behind taking a series of small steps before the giant leap is to break the circle of sit-down passivity caused by the enormity of the problem. The game is now so large and uncertain that many actors are tending to sit and wait for someone else to do the demolition work. The government is incapable of breaking this impasse by themselves, which for various reasons we do not recommend anyway, but they can force small cracks in the glaze of the closed circle. It would be smart to make these cracks meaningful through powerful symbolism and good selection. From this perspective we think that the idea of circle corridors is interesting. The corridor principle is applied in many US regions, including

Baltimore, San Diego and the Bay Area. A series of charging points is constructed, each at a prescribed distance from the next, enabling drivers to recharge EVs along this corridor and travel a decent distance. Stringing charging stations between Haarlem and Amsterdam (about 20 km), around the Amsterdam Ring or between Amsterdam and Utrecht (about 40 km) will create popular pathways. Although the distance traveled on the national road network is relatively limited, in symbolic terms it would count for a lot; for those who have to be in and around Amsterdam the use of EVs is easily justified.

In Japan they have demonstrated that installing rapid charging stations leads to more kilometers driven electrically, not so much because people use these stations to recharge their batteries, but because the stations dramatically reduce the users' range anxiety. People evidently do not use the stations – for the majority of trips there is no actual need – but the fact that the charging stations are there makes the users feel safe enough to drive an EV. The security symbolized by the corridor's chargers allows people to dismiss their fear of electric driving and then, in practice, discover that the predictions are right: they do not actually need fast chargers. Symbolism leads to strong results on the ground. Powerful symbols materialize in desirable behavior. Such insights means that small acts of intervention can result in significant changes in very large systems. Eight fast-charging stations mean that an entire region is now accessible, a fact that can be strongly emphasized and supported by map images. The corridor thus created is directly in line with other corridors under construction around the world. Symbolically Amsterdam opens up not only to its own EV commuters, but it connects with EV commuters in Tokyo, the Bay Area and the other innovative parts of the world with which the Dutch regions usually like to associate themselves.

A corridor is not just a network that enables mobility, it is also a marketing network that supports and strengthens city or ***regional branding***.

It is an open category: new, small corridors can be constructed, time and again, with five to eight charging points connected to other corridors. This creates a branch network that needs no master plan or coordinated roll out across the Netherlands or European regions but spreads like a virus across the globe with no universal strategy other than governmental stimulus and support of the construction of small networks. Early adopters may play the hub role; a hub is where different networks and corridors meet and where additional services can be provided. Thus, a small step of a placing few charging poles can connect symbolically to far more than that. We call this process 'circle corridoring'.

Policymaking and iconoclasm: connecting interests through powerful images

A major problem with the notion of electric cars is that it is usually expressed as a battle between two vehicles. The EV must beat the car which, unfortunately, happens to be one of the most popular consumer products. A powerful industry that uses great marketing and advertising may force a win in this battle of images. Therefore *iconoclasm* and ***framing*** are key elements of any smart government strategy. How to get electric driving to move away from its bold alternative image and become the inevitable, superior solution of the future?

We know from the Apple example that David can beat Goliath: despite holding marginal market share, Apple manages to successfully out run its competitor Microsoft in select domains. Apple not only trumps Microsoft, it has also gained a significant share in the telecom market, between strong players like Nokia and Blackberry. And, up till now Apple has been able to keep Google's Android in check. We can see similar competition between Facebook and Google. A few years ago Google seemed to have won a monopoly on Internet traffic, but Facebook is maneuvering itself as a new giant on the playing field, with powerful technology, but also through selective and above all, smart marketing.

In the case of electric vehicles it could be important to expand the product to other actors than car manufacturers and energy companies. It is still very much about creating new opportunities, but part of the importance of framing also stems from the need to block risks. One thing is certain: the more electric driving becomes a serious alternative, the more the traditional industry will increase resistance. How can electric driving defend itself? How to deal with the first major accident or traffic jam involving an electric car? How to deal with research into the danger of charging stations? How to act if a leaky battery creates victims? How should elected officials address the media if/when a funded initiative goes bankrupt? We urge governments not to start marketing campaigns in favor of electric cars, but to get actively involved in the game of brand imaging electric vehicles in order to tap into new opportunities and access actors who did not know they were connected. It is important to be resilient to inevitable risks. In that sense it is not up to government to start the imaging game; rather, it should enter an existing game and take up its own smart position.

Investing in roads that pay for themselves: looking for vital coalitions

According MIT Professor John Heywood, old cars should be phased out by systematic subsidies in ten years time. This will serve both the environment and the economy. The banning of leaded gasoline and the imposition of catalytic converters in the 1980s were handled well by the entire automotive industry and consumers. Governments have an explicit role to play here. They can intervene through legislation as well, although we do not necessarily advocate using this tool. Another role for government is that of infrastructure and asset manager, ensuring that EV (road) infrastructure is built, maintained and used. Recently the TNO Institute and the Province of North-Holland in coalition with several companies launched the 'Solaroad'. With this innovation, they want to contribute to sustainable energy-producing infrastructure and perhaps eventually climate-neutral mobility. Solaroad combines the functionality of solar cells with transport infrastructure. If all of the 137,000 km of roads in the Netherlands followed the Solaroad principle, more than enough electricity could be generated for all vehicles to drive on solar energy. It would generate energy, environmental and health benefits and indeed, the road network would pay for itself.

We anticipate that the successful introduction of electric vehicles will need more combinations of instruments like the Solaroad initiative. Government should be encouraging actors, through laws, subsidies, standards and other regulatory interventions, but above all, it should look for promising links and allow new technology to enter government-managed systems. It should always be on the lookout for interventions that provide ***new platforms*** for electric vehicle innovations. The government cannot singlehandedly cause the introduction of e-mobility, but it can create platforms and pathways along which stakeholders can move easily and faster to bring the electric car closer to the market.

Organize coincidence and volatility: innovative, open path deployment

So far, the unpredictable nature of the issue of transition seems imbued with a certain note of negativity. 'It is unpredictable, unfortunately, and that's just the way is' might seem to be the tenor of the message. In fact, we see the unpredictability and volatility of the issue as a positive strength. The unintended emergent elements should not be organized out of existence but rather encouraged, strengthened and protected.

Openness should continue: the unexpected should be at the core of what we can expect.

What does this mean for government? First, this design element should have a place in development strategies: proposals should be assessed on their impact on the openness of the process. Do unpredictable actors win or lose their ability to enter the arena? Will the risk of surprise increase or decrease? Will an outcome be easier or harder to predict? It means that government are taking steps onto an open path – towards developing electric cars – and at the same time keeping the path open, preventing overly hasty closure of standards and ensuring low thresholds for new entrants. It means spreading innovation budgets around and opening experimental areas, for example, by local and temporary deregulation if projects request this. It also means not relinquishing accountability for initiatives but ensuring tolerance for the necessarily open and unpredictable nature of project outcomes.

5 Conclusion: Smart strategies for governance dilemmas

The transition to electric driving is already underway. The considerations for doing so are strong and the establishing the necessary policy is gaining momentum. So, the first important steps have been made. There is a good business case for electric cars and insight into the benefits is spreading rapidly. Car makers can see the value, power utilities and grid operators are preparing themselves, motor car enthusiasts, even the 'petrol heads' are keen on the prospects offered by the electric car. Movement is in the air. So what do we do now?

At first glance it seems as if there is no longer a problem. Electric mobility is moving in the right direction. First sales of electric cars and the many new models being launched by virtually every car maker give the impression that everything will be all right with the electric car. But, on closer examination there are big problems. The introduction phase is progressing well, yet all kinds of collective action problems are emerging: stakeholders have to invest substantially in an area where investments will only render a return in the long run. This means investments will be difficult to protect and even if successful, may benefit other stakeholders who have chosen to wait. For government, the choice of winning technology is difficult: the risk of lock-in is too big for drastic or impulsive decisions. For consumers, there is still far too much uncertainty. The true believers are already convinced, thanks to the initial subsidies; but in fact they were already convinced. The effect is therefore only marginal.
The crux lies with the more cautious cohorts that follow the leaders: they represent the real volume, the critical mass. And, as we have shown, ***critical mass volume*** is far harder to achieve. If we don't reach critical mass, then there is no self-reinforcing dynamic and the introduction will risk getting stuck somewhere along the road to success. Even if this worst case scenario happens, the electric car would not go away; the prospects

for this new car are too firm for that, but then it will not breakthrough any time soon.

The tipping point for the introduction has been breached (we already have electric cars) but the tipping point for a social transformation is still beyond reach. Pilot projects abound, as do experiments and well-intended subsidies. But is this enough? Will current government action be enough to nudge the movement towards success? Is the movement irreversible or could it digress off into something entirely different? It demands guidance and attention from governments to arrive at the next level with sufficient volumes to ensure critical mass. How can car manufacturers and suppliers, the operators and developers of the supporting infrastructure and the developers of as yet unknown services and applications all get on the move? How can governments mobilize the movement?

Our analysis is intended to clarify why the introduction is at this stage and why, despite early success, it can still get stranded. We have shown that this is not an anomaly, but given the system characteristics, actually a normal development. We have outlined the game play patterns that have created this situation and that might in future still be typical.

If governments do not develop enough clever (smart) strategies, then the currently dominant strategies will linger on: the waiting game, wait and see, free-riding, and half-heartedness will stay on the winning side.

The question is whether existing policies apply sufficient, smart enough strategies. Perhaps the early, quick wins have made them subject to a disadvantage: they obscure the view of the potentially far less prosperous sequel to the now promising-looking first action. Policy is beset with highly ambiguous options. The initial impression we have of the government's own perception is one that smacks of complacency: 'Government should sit back, stop intervening and go with the flow. It's up to the market, to society, to make it happen so let them get on with it.'

Then there is the broad attention given to electric driving, to pilot projects and the first electric cars ordered by individuals. Yes, it is a beginning, and it is going well. That in itself is true, but all this is still no guarantee for success in the long term.

This leads us to the second impression we observe in existing government policy: 'Things must improve, it can all go faster, the scale must be bigger, it must be a mass introduction.' Here policy still faces major obstacles and there is much apprehension about the future. The risk of getting stuck halfway with too much invested to crawl back from and not enough critical mass to persevere becomes even more realistic. In this light, it is

important to consider scaling up strategy, from possibility to reality, from experiment to actual practice, from pilot projects to daily routines. Here, especially, governance will be crucial.

The strategic options that we have proposed are focused on governance and indicate the direction in which scaling up should be contemplated. Though well-considered, our proposals are still rudimentary and will be further supplemented and strengthened, for this essay is certainly not the end of our study. On the contrary, we are now preparing the next steps. The direction we have chosen is both conceptual and practical development of understanding governance capacity. That is: we are looking at the small steps in the final run up to the 'giant leap'. We are looking for small acts that could have giant repercussions, at government action that creates platforms for others to enter and grow on.

A suitable implementation strategy in this respect implies acceptance of the notion of 'patchwork' combinations on all levels: for instance, an automobile could be an electric car with a range extender, and in two-car households, families could take an electric car as their second car. Increasingly, the strength lies in combinations, through stakeholder connections and through the development of new propositions and products.

Some early adopters of EV technology are disappointed by the range extenders of current e-cars because they are not fully electric. That is, the range extender consists of a gasoline engine, which recharges the battery. We believe, however, that these are the right interventions: the innovation is radical in the sense that everything under the hood has been developed according to the new electric drive train. The current generation of hybrid vehicles, such as the Prius, is based on the smart innovative range extender. It is smart since it eliminates the consumers' main concern (range anxiety) with the confidence-inspiring need to fill a petrol tank, yet it satisfies the consumers' concern about carbon emissions by not using combustion to drive the engine.

We think such clever hybrids that innovate radically, yet show understanding of traditional user concerns are highly important to the scaling up process. We will be searching the markets and networks for models with equally clever methods. In terms of market models, we are considering the practice of leasing batteries, which stands at the basis of EV construction, in much the same way that energy companies lease high-efficiency boilers, a consumer service that builds on a contract for a certain period of time. With lease batteries, the consumer would not pay for ownership – besides range anxiety, initial cost is problematic for consumers – but

for using the car. Then, as they become familiar with the reliability of the electric car, consumers will discover the financial benefits. This is a good direction for utilities to step into. It will have important benefits for them to deliver electricity as well as to obtain extra capacity on the grid. Good financially related options include initiating a special refund ('freebates') for EV purchasers, to help set off the distinction between buying a clean or a dirty car, or substitution subsidies for new cars. Another option is to set up a system of 'trial subscriptions' where you let people test drive an electric car for a few months: range anxiety and other objections fade with experience within a few weeks. Such a radically new system could help to nudge the status quo and get people out of comfort zone of using a petrol-driven car. Each of these solutions is an important step off the beaten track. And we believe these relatively small interventions will inevitably result in large volume. The process will not be 'phased', it will be viral.
Despite our occasional – necessarily – somber message, we are optimistic about the chances of electric driving, and certainly not pessimistic about the potential of government control. Precisely here lies a great opportunity for a breakthrough. There is plenty of good potential for governments to obtain large societal benefits. Finally, we will devote a few words on the interpretation of uncertainty and innovation.
Uncertainty and confusion as to where the e-car is going is often – even in this essay – regarded as a nuisance. How much easier it would be if the path of e-mobility was clear. This is true, but it would not do justice to the entire process. Indeed, here the very unknown belongs to the promise of electric mobility. What we do not know will surprise us the most and in the most positive manner. We still do not know what electric vehicles may achieve. System innovations often create new innovations. These are partly unforeseen, and will have the character of a small catch, but even something small can be of great importance. We do not know what these small things will be, only that we almost certainly will catch them. Policies should therefore be primarily geared to keeping the road to innovation open. Uncertainty should not be limited but actually maximized. Moving forward to the mass introduction of electric mobility means accepting that we do not know where the first small step will take us. In that sense it is, perhaps, a leap of faith. Through deepening our on-going study we will further explore the parameters so that the giant leap becomes easier to take.

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