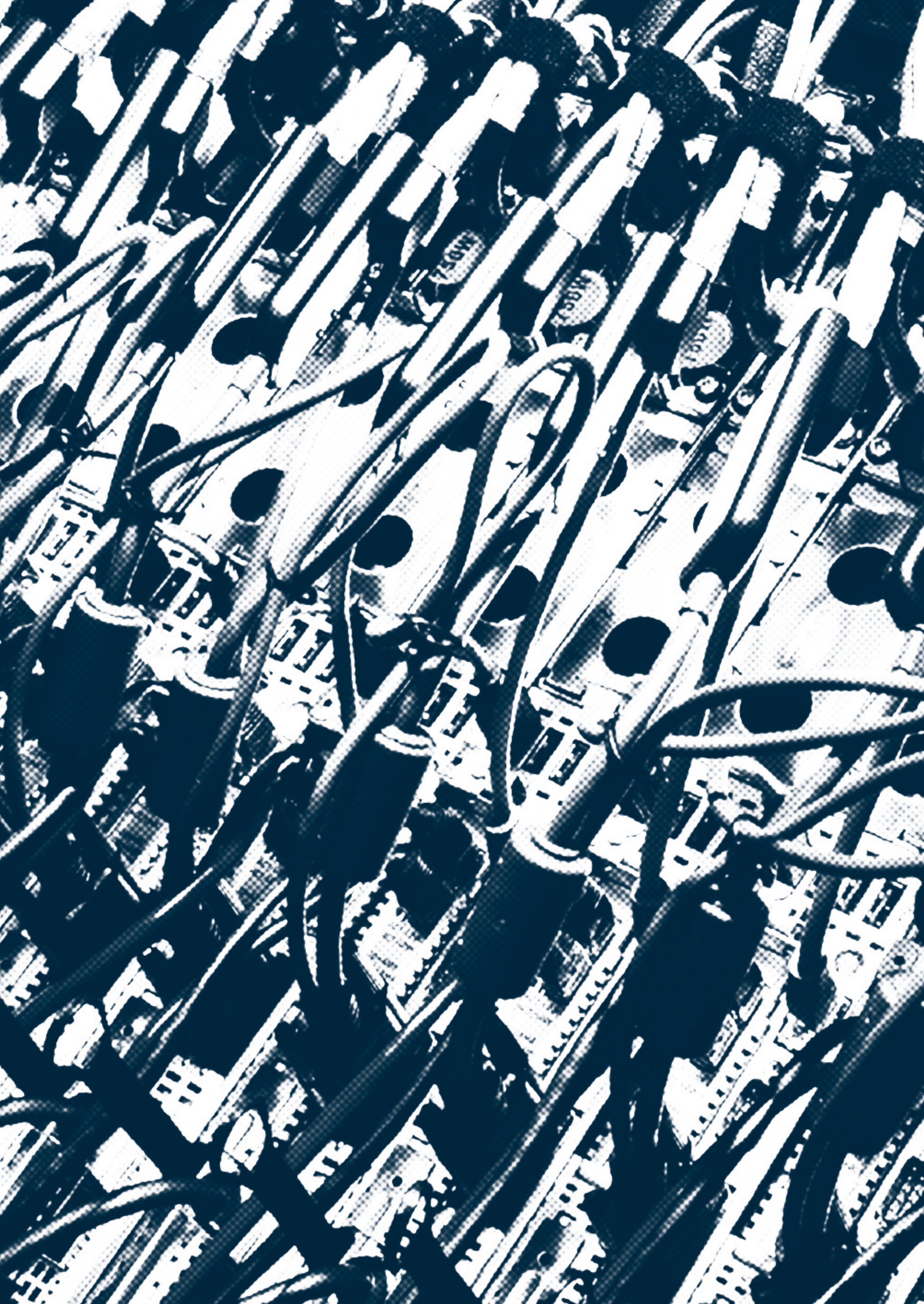
PBL Netherlands Environmental Assessment Agency

Mobility and electricity in the digital age

PUBLIC VALUES UNDER TENSION

TRENDS REPORT



MOBILITY AND ELECTRICITY IN THE DIGITAL AGE

Public values under tension

Trends Report

PBL
Netherlands Environmental Assessment Agency

Mobility and electricity in the digital age – Public values under tension

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Corresponding author
Guus.deHollander@pbl.nl

Authors
Guus de Hollander, Marijke Vonk, Daniëlle Snellen, Hiddo Huitzing

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Foreword

Sometimes, developments turn a society upside down. Daily routines change, deep-rooted certainties fade: 'all that is solid melts into air' (according to Marshall Berman). Along with the ongoing liberalisation of social relationships, the arrival of the steam engine, electricity, the automobile, the aeroplane, and in the past century of course, the computer, have represented a far-reaching change in many people's lives, including their day-to-day work and their residential environment. Those developments have brought us a great deal of comfort and welfare. But progress often also has a downside—simply consider environmental pollution.

In the 21st century, we are once again facing a major revolution. Digitisation and datafication are making an impact on our lives, at times almost inconspicuously, but always decisively. On the one hand, they open up unprecedented possibilities for action and control in all kinds of areas and at many scales: a tourist can go on holiday without a guidebook, because he can find hotels and maps on his smartphone; traffic controllers monitor the traffic flow on the motorway through sensors in the pavement; and a student attends lessons from her home via a live stream instead of going to the lecture hall. On the other hand, many public values are coming under pressure, including transparency and equal opportunities for all. Those who do not or cannot keep up with digital developments risk losing their connection with the rest of society.

Digitisation is all around us and in full swing: we are right in the middle of it. As a result, we lack a broad perspective. Unpredictability and uncertainty reign. But the outline of the untamed future is appearing: self-driving cars, energy-supplying greenhouses, interactive lighting, global platforms, neural networks, precision agriculture and smart meters.

And infrastructure. Another area where digitisation is undeniably making itself felt. Roads, railways and pipelines were once considered to be sturdy connections between A and B that furthered daily life and social life. Nowadays, digitisation means infrastructure is becoming interwoven, at an ever-faster rate, with everything that is present on and in those connections. Smart cars communicate with the road, the road communicates with traffic control, and traffic control uses variable message signs above the road to communicate with motorists. Physical and digital worlds are becoming intertwined in increasingly complex ways. Also, infrastructure is ageing faster, not so much because of ordinary wear and tear, but simply because it is no longer able to accommodate the latest digital developments.

In addition, through their control algorithms, digitisation and datafication lead to new systems that automatically generate decisions. But in actual fact, so far not enough thought has been given to the way the algorithms themselves are controlled, to the choices they make, or to how to those choices are checked. Finally, the greater intertwining of infrastructure and digitisation also means that different infrastructural worlds, such as mobility, energy and communication, start invading each other's domains more and more, with the accompanying confusion over applicable control systems, risks and responsibilities.

Here, a word of caution against overly rigid reactions would be appropriate. The uncertainty around the developments calls for responsive control and a capacity to learn. It is important to keep all options open, actively seek to experiment and allow space for imagination and public creativity. But in unpredictable times, exercising control requires, above all, awareness of what society's core values are and how they relate to each other. We need to think deeply about what we believe is genuinely important in the field of public values such as privacy, accessibility and legal certainty. How do we keep our finger on the pulse? How do we structure budgets, assessment frameworks and monitoring instruments so that they can evolve in accordance with changing insights and become truly useful to the task, beyond merely fulfilling requirements of accountability?

Public values are under pressure. If we passively consent to digitisation in the field of infrastructure, then values such as accessibility, transparency and security of supply will inevitably be compromised. Think, for example, of equal access to public transport or vital amenities such as electricity. As the infrastructure of infrastructures, digitisation increasingly determines how road, rail, electricity and water networks are used, and how the related services are provided. Many guidelines that have been established over time to safeguard public values are not entirely suitable for the digital age. As a result, for many digital developments there are no regulations and legislation in place yet, though they are necessary and increasingly urgent.

This essay presents seven perspectives that enable the government, politicians, social organisations and society to identify and address the most important issues and dilemmas, and take the first steps towards an exploration of new rules. The ultimate goal is to give room to innovative developments in a balanced way without compromising our widely shared public values.

Professor Hans Mommaas
Director-General

Digitisation of infrastructure: protect public values and ensure government control

The digitisation of infrastructure and the services related to it has great benefits for citizens, businesses and authorities. It makes our lives easier, increases our freedom of choice and makes our physical environment safer and more sustainable. Thanks to higher efficiency, we get more value for money, and sometimes we even get more value for less money; accessibility that is tailored to our wishes and customised service in the field of energy supply—including sustainable electricity.

At the same time, public values such as accessibility, security of supply, privacy protection and democratic management are coming under pressure. In this age of digitisation of infrastructure, protection of these public values calls for a government that focuses on the future, is aware of the dilemmas, starts a societal debate on the issue, establishes clear frameworks, defines goals and is not afraid to experiment with rules and supervision.

Many advantages, but also pressure on public values

Infrastructure is the vital, physical foundation of our society. The growing dynamics and complexity in digitising the services related to it, such as mobility and electricity supply, now require a reconsideration of public values. What are the values we want to protect in the Netherlands, in which areas are we willing to make room for new initiatives and how can we adapt our system of rules and supervision? This type of questions is becoming even more pertinent because digitisation does not work out equally well for everyone.

As a result of digitisation, Dutch infrastructure and the related services are rapidly becoming 'smarter'. The navigation systems in our cars help to sidestep traffic jams, our public transport app shows, in the wink of an eye, the fastest route from station A to event B at that particular moment, and digital monitoring systems help the traffic control centre to handle traffic with greater ease. In the long run, vehicles will communicate with each other and take over more and more of the tasks we carry out ourselves now, so that driving becomes safer, traffic flow is improved and our hands might even be freed up for other activities.

Similar advantages exist for energy infrastructure. The power grid, which is becoming more and more complex, can be kept at the right voltage more easily by adding 'smart' features to it. This is crucial for the energy transition, because it enables proper handling of the rapid increase in the number of local sources with highly weather-dependent and fluctuating performance. All these developments are the result of permanent connection to the Internet; our smartphones, laptops and tablets make it possible to exchange and process data continuously. Increasingly, this occurs without conscious action by the user, now that cars, household appliances, heating systems and portable medical devices are also being connected to and operated via the Internet.

This report shows that ICT innovations give a major boost to efficient and sustainable use of the infrastructure in the Netherlands, and to the expansion of the range of options for the consumer with many kinds of new services for personal convenience and with customised solutions. These innovations offer countless opportunities for creative entrepreneurship, such as the successful Internet platforms that have emerged in a short period of time, including those in the fields of mobility (Uber, SnappCar) and energy (Vandebron).

However, there is also a downside. Public values and established achievements, such as equal access to the public transport system and the high security of supply of vital energy facilities, are now in danger of running into problems. Digitisation may cause certain groups, such as people with low educational levels and the elderly, to be left out if they lack the necessary skills or capacity to make use of the new infrastructure services. There are also examples of automated systems excluding certain neighbourhoods from participation. There is a strong chance that digital innovations will strengthen the divide in society. Another risk of digitisation—applying particularly to the supply of electricity—is the increased vulnerability to power cuts and blackouts, especially if networks become more and more extensive and complex and operate in close interaction. In this regard, it is also necessary to take into account damage inflicted intentionally by means of hacking systems or data.

Other public values may also be at issue, such as security, the right to privacy and informational self-determination with regard to personal data that are often collected and shared without being noticed. Globally operating platforms can acquire an enormous concentration of market power in a short period of time, unhindered by national rules on privacy and fair competition. The 'Ubers' of this world can escape taxes and licensing obligations, while they do use local infrastructure and facilities. Over the course of many years, a system of formal regulations and informal rules has developed to enable the optimal functioning of infrastructures. This has brought about a balance between promoting a well-functioning market on the one hand, and safeguarding public values on the other. Due to digitisation, these rules are increasingly lagging behind the facts, which leads to new loopholes in regulations and supervision. Consider, for example, entrepreneurs who offer essential transport or energy services on digital platforms and, at the same time, have the possibility to market user data. This calls for extra concern for privacy issues and property rights around personal data. Self-driving cars also require different rules; they are set to radically change our understanding of traffic liability. After all, who is responsible in case of an accident?

Transparency is another value under pressure. The addition of digital 'smartness' to the infrastructure dedicated to citizen mobility or energy supply means that monitoring the way in which the system works is less straightforward for citizens, regulators and the public administration. It hampers regular, democratic management. The same applies even more strongly to self-learning systems. Over time, it becomes less and less clear which principles, procedures and rules form the basis for the functioning of smart environments.

Finally, digitisation reinforces the interlinking of areas of infrastructure that formerly were more independent. An example is the reflections on how the batteries of electric cars can play a role at the local level in optimising the electricity grid. They can be charged when electricity generation is high, and supply power to the grid when generation levels are low. Such interlinking of sectors further increases the complexity of the system and thereby also its vulnerability. If something goes wrong, the consequences are far-reaching and the system is difficult to repair. This puts pressure on public values such as security of supply and reliability of virtually indispensable facilities. The interlinking also couples policy areas that formerly were more or less separate, such as network management and privacy issues. Under current regulations, both policy areas guarantee public values such as accessibility, but each does so in its own way.

Altogether, this shows that without proactive intervention by the administration, there is a good chance that the ongoing rapid digitisation of infrastructure and related services will also have unwanted effects and consequently lead to substantial levels of social unease. For example, a further widening of the gap between citizens with high and low educational levels, social disruption deriving from poor manageability of vital energy facilities and the wearing away, slowly but steadily, of claims to privacy and self-determination. Moreover, this often involves technologies that can give online and offline entrepreneurs enormous power, while the disadvantages more often than not end up on the public sector's plate.

Seven perspectives for action to prevent digitisation from undermining protective public values

Digitisation of infrastructure and the related services does not only come with blessings, but also creates new dilemmas over public values. When dealing with recently created ICT applications, it is important to attain a new and healthy balance between, on the one hand, values enhancing innovation and welfare, such as efficiency, customisation and profitability, and on the other hand, protective values such as accessibility, safety, security of supply, privacy and accountability. What is urgently required is explicit government direction and forward-looking action. The role of the government is changing. In the past it was enough for public authorities to have an investment strategy for the most important infrastructures along with national rules on its use, while at present a regulatory strategy is of major importance. This strategy will also increasingly be set in an international context. This report provides seven perspectives for action to materialise this idea from this moment on.

1) Acknowledge that digitisation creates new dilemmas; organise and promote public debate on this issue

It is important to not passively accept that the mentioned ICT developments overtake society, and to proactively spur a public debate on fundamental questions such as what the basic level of access is that service providers must be required to ensure in a world increasingly marked by inequality. How to deal with the accumulation of power at large, elusive tech companies such as Google and Uber? To what degree is society prepared to modify the public space and even adapt spatial planning to the requirements imposed by self-driving vehicles or household energy generation? And to what extent can this occur at the expense of other users of roads or public spaces?

These social deliberations will benefit from joint recognition of the dilemmas; it is necessary to organise and facilitate the public debate on these questions and promote the presence of all normative perspectives and all relevant social groups. One way to do this is by commissioning visual and written explorations on a wide range of alternative futures of digitised infrastructure. Such explorations can be a useful resource in the search for strategic choices and policy considerations and for garnering the involvement of social groups. We should pursue the boundaries of the imaginable, precisely in those areas where varying traditional political convictions experience most friction. We need to explore the future not only by ‘counting’ but especially by ‘recounting’, so that we can make choices based on values, where necessary beyond vested interests.

2) Set clear frameworks and objectives…

The government should take a stand in this social debate. It is necessary to formulate recognisable, inspiring, mobilising and robust objectives with regard to the desired balance between the various public values, the reasonableness of the way benefits and burdens are distributed, and the level of vulnerability in vital services that we find acceptable. For example, digital customisation in passenger transport that focuses specifically on the inclusion of more vulnerable groups, such as the visually impaired and elderly people with disabilities; or the protection of privacy as a strict and normative criterion for designing digitisation projects for public transport or energy supply. Determine the core values upheld in the various domains; determine which of the current rules continue to serve properly in this light and which are in danger of falling short or are already failing. Finding public support in a pluriform society is the main issue: where possible, conflicting interests and beliefs must be reconciled; where necessary, clear choices must be made.

3) …and allow plenty of space for new ICT developments within these frameworks

The structural unpredictability of ICT developments does not sit well with plans for major changes using government prescribed instruments, but requires a process of small steps and continuous adjustments based on reflexive evaluation. The government cannot steer innovation, but it can offer ample space to an improvising, innovative and experimenting society. This can involve the elimination of regulatory barriers or government subsidies and investments to promote innovation, but it can also mean that new rules or agreements are made to avoid, insofar as possible, the ‘excesses’ that hamper the capability of society to improvise.

This form of regulation, characterised by setting frameworks rather than prescribing actions, assigns a more dominant role to supervisory bodies (e.g. the Netherlands Authority for Consumers and Markets). One of their tasks is to call parties to account for undesirable effects identified by the administration that are the result of, for example, monopolisation, improper competition stemming from the circumvention of local rules or discriminatory algorithms. An illustration of the latter is a platform for transport services that charges different rates for different types of neighbourhoods, based on the characteristics of the residents, or that does not even offer the service at all in certain neighbourhoods.

4) Think about new rules

The new challenges call for new rules. For instance, explore which issues can be properly regulated at the *local* or *national* level and which require *international* agreements, such as the circumvention of national rules or the development of technical standards. Learn which rules are *domain-specific*, such as those on safety of road infrastructure, and which apply *beyond domains*, such as those protecting privacy when infrastructure services become more and more interlinked. Draw inspiration from other policy areas on options to safeguard protective values. To give an example, accessibility is regulated more rigidly in the domain of electricity distribution, than in that of citizen mobility. We need to think about integrating the current sector-based regulations, as digitisation increasingly causes sectors to merge. Ensure rules and supervision are designed to be able to withstand the unpredictable developments we are facing. Investigate the possibilities offered under the new Environment and Planning Act and the National Integrated Environmental Policy Strategy to secure public values regarding infrastructure and the physical environment in consultation with citizens.

5) Especially in the case of smart city applications: ensure adequate supervision and democratic management

Find ways to always keep a finger on the pulse of ongoing digitisation, paying particular attention to values and normative principles that come veiled in technology. An important challenge is the operationalisation of the possibilities to give account (or demand account) when great deals of smart features have been added to the environment, such as cases where countless decisions are taken autonomously by self-learning algorithms. Are we able to understand the way our energy bills are composed, as the sum of dynamic electricity rates based on real-time supply and demand? If so, do we think they are fair? A similar story goes for dynamic road pricing, should this be introduced.

To ensure proper democratic management, the requirement for accountability for the quality of the service and the way public values are safeguarded must also apply to smart systems. This involves understanding how these systems make choices, how they deal with different and sometimes conflicting values, and how positive and negative consequences of digitisation can be made visible in a timely manner. In short, we will have to work on a tailor-made approach, in which the various parties can render account of the consequences of digitisation processes and the use of the data they collect.

6) Invest in digital expertise in the government

At times, innovative companies effortlessly bend digitised systems to their will, in part because of their lead in knowledge. If government authorities want to continue to live up to their steering role in the field of infrastructure and related services, they need to gain more insight into the nature of the new game, not to mention that of the new players, especially as the rules of the game and the playing field are becoming more and more international. At present, this expertise is lacking. Governments also need more technical knowledge of the new digitised systems, of what they can do and of what they can't do, and of their impact, which reaches down to the proverbial capillaries of society, including the government itself. We should think particularly about what this means for regulations here and now, and for those of tomorrow. It is equally important to have more knowledge of the ethical dilemmas posed by these developments. This is, of course, a task for universities and more policy-oriented knowledge institutes, but we could also consider engaging independent, highly experienced professionals who have a good understanding of the most technical ins and outs at the level of fine detail.

7) Accept the inescapable tension between 'heavy', fixed infrastructure and the rapidly moving virtual worlds and make robust choices

The points above deal mainly with efforts concerning regulation, but the more traditional challenges of long-term investment in infrastructure have also become considerably more complex. Digitisation increases the dynamics of the services on offer; the use of physical infrastructure becomes less predictable. At the same time, asphalt pavements, rail networks and electrical grids are intrinsically weighty and not readily adaptable. In the physical infrastructure 'big leaps' are inevitable because investment plans require time and the infrastructure will be in place for decades. Added to this, it is uncertain how accurately the current technological developments can serve as forecasts of what will be at issue in a decades' time or later, a concern that also applies to the behavioural patterns of users. Because of this, the coordination between the intrinsically sluggish fixed infrastructure and the limitless and timeless digital world is almost by definition suboptimal.

Therefore, it is necessary to concentrate on those choices for infrastructure investments that are relevant to a future that we as a society aspire to and also uphold the public values in various conceivable digital 'futures'. Give private players confidence about the chosen direction for the longer term. If the emphasis on mere economic efficiency or traffic efficiency in the present is too one-sided, this can increase the future vulnerability of infrastructure with regard to unexpected developments and form an obstacle for reaching other long-term goals. It is precisely the fixed infrastructure that offers possibilities to give 'nudges' in the desired direction, for example towards more sustainable or more inclusive options. This is our way to create a future-proof Netherlands with infrastructures that can properly handle a wide range of as yet unknown developments.

1 Digitisation of infrastructure and the public interest

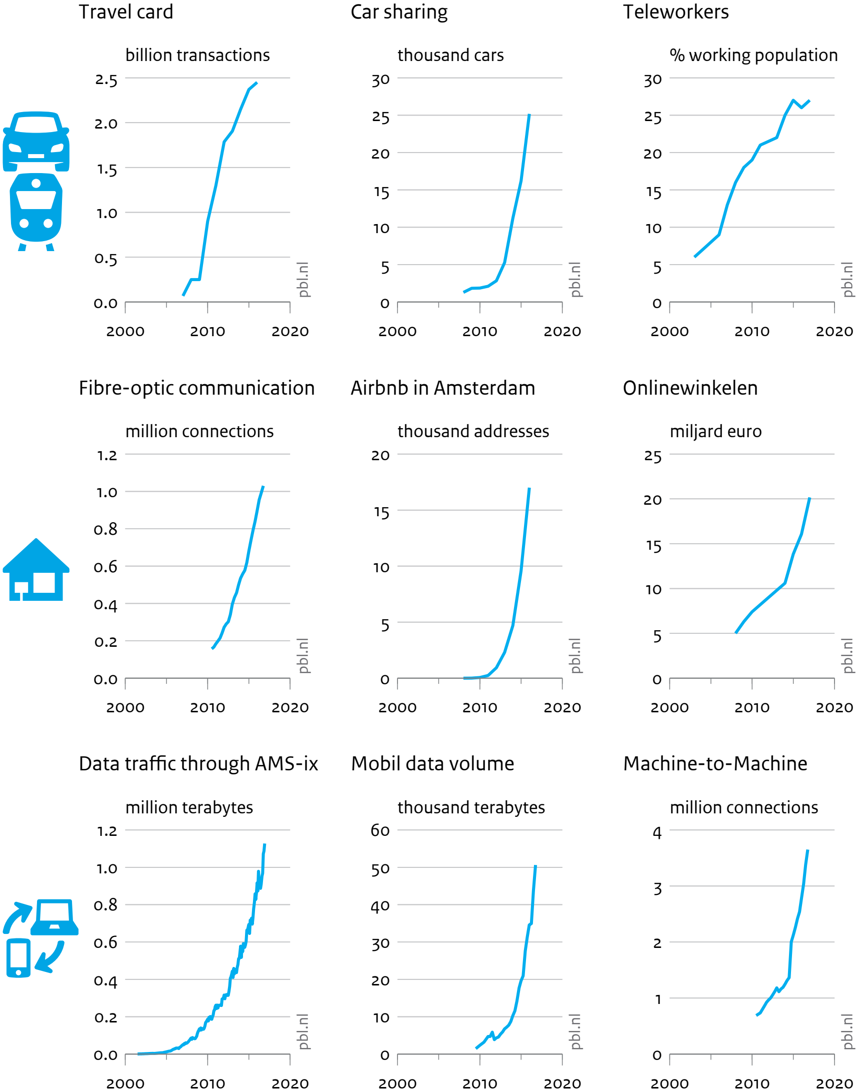
1.1 Digitisation spreads throughout infrastructures

Information and communication technology (ICT) is changing daily life at a breathtaking pace, yet relatively unnoticed. This is mainly the result of the increasingly intensive connectivity to the worldwide web. Thanks to ICT, we can undertake more and more activities whenever, wherever and with whomever we like, in ways that are more or less 'uncoupled' from time and place. Numerous Internet platforms offer fast and sophisticated solutions to questions or needs —Uber for a taxi ride or Vandebron.nl for green energy. Few economic sectors can avoid being gripped by the 'disrupting' platform fever that on several occasions has completely overturned the game of supply and demand, along with the palette of parties involved (Van Dijck et al., 2016; Frenken, 2016; Kreijveld, 2014). See Figure 1.1 for further details.

These ICT developments are characterised by digitisation and datafication. More and more information is converted into ones and zeros, so that computers can process, edit and share it. Many aspects of daily life are stored, monitored, analysed, combined and optimised, and as a result they frequently are assigned a market value. More and more often, this all takes place instantly, in what is called *real time*. This is possible because almost everyone is constantly generating and sharing data on the web, through social media and search engines, through vehicle navigation systems, but also increasingly through electrical appliances that are becoming part of the Internet—*the Internet of Things*.

Figure 1.1

Dynamics of the digital age



Source: Amsterdam Internet Exchange (ams-ix.net); Netherlands Authority for Consumers and Markets 2012 – 2016; Insiteairbnb.com/tomslee.net; Thuiswinkel.org 2017; Translink; CROW.nl; CBS 2016

Digital infrastructure, digitally connected devices, and the provision and use of digital services are experiencing a rapid increase in the Netherlands.

This report examines how these digitisation processes affect the organisation and use of the Dutch infrastructure. A modern country cannot prosper without infrastructures such as waterways, railways and roads, and electricity, natural gas and communications networks. Infrastructure is often characterised as the 'physical, immovable foundation of the economy and of society' (WRR, 2008a). The Netherlands owes its strong economic position as a nation of trade, manufacturing and transport not only to its favourable geographic position, but also to its excellent infrastructure facilities (Weijnen et al., 2015; WRR, 2008b). A disruption in that network can have far-reaching consequences. If vital infrastructure is knocked out accidentally, deliberately or by the forces of nature, this can lead to social disorder (RIVM, 2016; PBL, 2014b)[1].

The focus is particularly on the impact of digitisation on the infrastructure for personal mobility and for the supply of electricity. Does it affect the achievements we almost take for granted when using infrastructure, such as equal access to the road network or the availability of mobility services? The reliability of the Dutch electricity grid is relatively high. Will this continue to hold true as it becomes increasingly dependent on ICT? What will happen to the distribution of the benefits and costs of physical infrastructure if the related services increasingly become integrated into the platform economy?

1.2 A matter for the government: public values

Historically, the national government has been intensively involved in infrastructure. There are a number of reasons for this. Firstly, since the 19th century, infrastructure has been built rapidly to promote the economic, socio-cultural and political development of the country. This includes transport (roads, waterways, railways), public health (drinking water and sanitation), energy (electricity, natural gas distribution in built-up areas) and finally, telecommunications (Van der Woud, 2006). Secondly, the construction of infrastructure is usually very expensive. In the past, the government was often the only party with access to capital to finance the heavy investments (Ménard, 2014).
A third reason for government to be involved in infrastructure is that it wants to ensure that infrastructure use is accessible to society at large, now and in the future. This accessibility can be endangered, if, for example, owners of infrastructure networks acquire such levels of market power that they are able to charge ever higher prices for their services (e.g. Joskow, 2007).

Accessibility is an example of what, here, is meant by *public values*. At issue are the fundamental principles behind public services that a society considers so important that they become the subject of government involvement. When dealing with public values in the context of infrastructure, references are often found to the four 'A's that appear in the Anglo-Saxon literature. *Accessibility* is the first and refers to the degree to which citizens and businesses are able to make use of the infrastructure and the services it provides. The other A's stand for *affordability, availability* and *social acceptability.* Affordability concerns the effective and efficient use of public funds, that is to say, affordability for society as a whole. Availability involves the proximity, reliability and safety of facilities. Meant especially in a technical sense, this is achieved through robustness or redundancy, in the present and in the long term. Finally, social acceptability refers to a broad category of issues, including fairness and solidarity, the impact on safety, health and other external effects[2], the functioning of the market (the level playing field) and respect for privacy and individual autonomy (Groenewegen and Correljé, 2009).

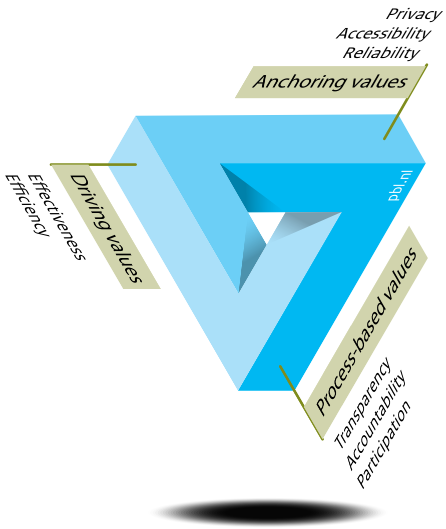
Since the end of the last century, government action has been characterised —also in the field of infrastructure management and use—by a strong emphasis on efficiency (rationalisation) and increased productivity, where possible to be achieved preferably through the market. It cannot be denied that the introduction of a market mechanism in infrastructure operation has increased public values in the Netherlands, such as affordability, efficiency and freedom of choice for consumers. A good example is the market for mobile phone services and the Internet. Governments want to prevent that the pursuit of efficiency, affordability or commercial interests occurs to the detriment of the promotion of public interests, and have often introduced strict regulations on infrastructure management and operation (Hensgens and Hafner, 2013). But, some doubt may still remain as to whether other public values, such as accessibility and the right to privacy will continue to be safeguarded in the long term, especially in view of the loss of the pertinent public authority that accompanies privatisation (e.g. Kuiper, 2014; WRR, 2011, 2012b).

Public values also play a major role in digitisation, largely overlapping with the four A's. After all, issues such as efficiency and accessibility also show up in digitisation efforts. Our analysis follows the example of The Netherlands Scientific Council for Government Policy (WRR, 2011) and make a three-way division: driving values, anchoring values and process-based or democratic values (see Figure 2.1).[3]

Increasing the efficiency of business management—something which, so to speak, you can never have enough of—and also increasing freedom of choice and possibilities for custom-made solutions are often strong drivers of the introduction of new ICTs. This can be seen in services provided through Internet platforms, which are often cheaper, faster and more suitably adapted to individual preferences than most traditional forms of service provision. Think of taxi rides with Uber, accommodation booked on Airbnb or bargains snapped up on the second-hand goods website Marktplaats.nl. These kinds of efficient, service-providing characteristics fall in the category of driving values.

Figure 1.2

Balancing public values



Source: PBL

But there are also public interests that do not necessarily or automatically benefit from additional implementation of ICTs. These include accessibility, reliability of the service and respect for privacy. Called *anchoring values*, they are based on moral principles that are broadly supported and usually laid down in the constitution.

The third group, the process-based values, determines whether driving and anchored values can be correctly assessed against each other. The choices that are made must be transparent. It must be possible to verify them and give account of them. Often, it is automation itself that makes processes less transparent. The opportunities for citizen involvement and participation and the open nature of decision-making are important aspects of such processes. This report focuses, among other things, on these three forms of public values and the tension between them.

1.3 Stable public values and institutions versus the dynamics of digitisation

Institutions play an important role in the balance between the public values and the influence digitisation has on them. This report views *institutions* in a wide sense as a highly varied range of written and unwritten rules for participation in organisations or societies. Violation of those rules leads to the application of written and unwritten sanctions[4] (Ostrom, 2005). In this regard, not conforming to social norms can lead to social exclusion. If, for example, owning a smartphone becomes the norm, people who do not have one become increasingly excluded from services provided over the Internet (Ostrom, 2005; Sing Grewal, 2008).

The institutions come in many shapes and sizes and can change under the influence of social and technological developments. To explain them, the *four-layer model* devised by Williamson (2000) is used. The first, deeply rooted in society, is an informal layer of culture, traditions, values, norms, and beliefs —sometimes religious—that are passed down through generations. These institutions only change very slowly and are related to the way people interact with each other, the distribution of welfare, the meaning of life, the family or the communities that people form[5].

Below this is a layer of formal arrangements based on the law and the constitution, which give legal status to the institutions of the next layer and other actors. They involve the basic rules, such as property law, market planning and various sector-specific systems of regulation. This layer remains fairly stable over tens of years.

Governance, the way the game is played by the participating parties, is the third layer. Here, institutions are embodied in arrangements, agreements, regulations, liabilities or guarantees that are often organisation-specific and determine how parties deal with each other.

The fourth layer has to do with the continuous interaction between individual actors who use transactions, cooperation or the allocation of people and resources to obtain results (Koppejan and Groenewegen, 2005; Kunneke et al., 2014).

These four layers shed light on the way rapid, dynamic digitisation affects institutions and ultimately also public values. Initially, digitisation primarily affects the bottom layer, but it can also disturb the balance in the layers above. For example, Internet platforms such as Uber, Airbnb and Amazon take advantage of the digital possibilities to make their transactions cheaper, faster and better tuned to consumer and service provider. This has enabled them to capture large parts of the taxi, hotel and retail sectors within a relatively short period of time. Consequently, many conventional arrangements lose their functionality—we only need to think of the taxi rank, the hotel chain or the High Street. This might mean that current rules based on outdated conditions are called into question and will eventually have to be adapted (see Chapter 2).

The digitisation of infrastructures can also exert such disruptive effects on the higher layers of existing institutions. This is because technologies such as smart meters or smart mobility systems can very accurately register, in terms of time and space, how an individual uses the infrastructure networks and the related services, while many institutions are still based on traditional, collectively funded usage.

In the somewhat longer term, cultural or traditional values may also be at stake. In this regard, many forecasters claim that, whether it concerns cars or real estate, digitisation will cause the emphasis to shift more and more from ownership to use (Kitchin, 2015; Mason, 2016; Rifkin, 2011).

1.4 Structure of the essay

This report explores possible, probable and already noticeable ICT developments in the infrastructure in the Netherlands, along with their potential effects on society, particularly with regard to public values. After providing a general interpretation of digitisation and datafication in Chapter 2, the examples of personal mobility and the electricity supply system are used in Chapters 3 and 4, to take a closer look at the effects that digitisation has on the use of infrastructure and service provision.

The infrastructure supporting mobility, such as roads, bridges, railways and stations, corresponds more or less to the archetypal image of infrastructure. In many regards, the energy infrastructure is equally essential—here, with a special focus on electricity—with its shorter history and distinct structure as to construction, management and ownership. The choices that are made for these networks also have consequences for the use and organisation of the physical environment and are expected to be profoundly shaped by digitisation (PBL, 2014c).

Efficiency is often the main consideration in further digitisation of the mobility and electricity infrastructure and the related services, but other driving values can also play a role, such as ensuring convenience of use for the individual, freedom of choice or sustainability. The digitisation of services can also occur at the expense of public, anchored values, such as accessibility, quality, safety or security of supply, as well as the right to privacy or self-determination. What consequences does digitisation have for process-based values, for the transparency of the system and for the possibilities for parties to give account? How much stronger or weaker are the possibilities becoming for citizen involvement, transparent decision-making and control?

Chapter 5 examines the main dilemmas identified in Chapters 3 and 4 with regard to several public values to see if they also apply in a more general context. The report also looks at existing institutions and to what extent they might be inadequate in the new, digitally supported ('enhanced') reality? The closing chapter explores a number of issues that the government should give careful thought to, given the inherently unpredictable dynamics of digitisation and social developments.

2 Turbulent ICT developments in an uncertain world

2.1 The Internet of Things: the process of connecting, digitising and converting into data

New information and communication technologies create great excitement
Anybody who occasionally checks the science or economics sections in the newspapers will have come across the story: an ICT revolution (or, yet another) is taking place that is changing many aspects of our lives. All things and all people are permanently connected to each other through the Internet; endless data exchange and processing, made possible by smartphones, laptops, tablets and a variety of gadgets. Moreover, the Internet is being expanded, so to speak, with extra senses and limbs (robots, home automation, 3D printing), and—not to forget—extra brainpower, thanks to many varieties of artificial intelligence (see also Figure 2.1). This hyperconnectivity leads to Cloud Computing, to the so-called *datafication* of many aspects of daily life (Kitchin, 2014; Mason, 2016).

Just like writing, printing, the steam engine or the transistor, the new ICT is presented as generally applicable technology which—by continuously generating new applications—could be standing at the beginning of a new, far-reaching and extensive transformation of production methods and ways of

Permanently connected to the Internet.

working, consuming and 'living the good life' (e.g. CPB, 2016; Mason, 2015; Pérez, 2013; Rifkin, 2011). The influence of digitisation does not, of course, exist in isolation. Technology changes along with societies, in connection with social, economic and political processes and geographic and demographic conditions (Finger et al., 2005; Hughes, 1987). Over the past decades, there has been a clear interaction between ICT development and liberalisation, privatisation and stimulation of market mechanisms in public services. It is precisely the ICT applications, along with trade liberalisation, that have made a significant contribution to the globalisation of economies (e.g. Baldwin, 2016).

Towards another economy?

A related development is the steady change in the economy, from a linear structure driven by assets (means of production) to a platform structure that is network-oriented and more information-driven (or data-driven)[1]. End products are made less and less in chains in a specific geographic location, but rather in a fragmented process in production and supply networks that often cross national borders, or even operate around the entire planet. Digitisation greatly reinforces this trend, because the necessary communication has become cheaper, faster and has immediate global reach[2] (Baldwin, 2016).

In this new economy the emphasis would not fall so much on supplying products made of raw materials, or offering services using resources and skills, but rather on providing access to products and services. While selling, say, a refrigerator, a hi-fi system or a car used to be a one-off operation, in the new understanding, the future buyer becomes part of a network that takes care of continuous use, management, maintenance, insurance and innovation of the product.

For example, consumers are already buying music on CD much less often, listening to it instead on streaming services such as Spotify. Pharmaceutical giant GlaxoSmithKline recently announced its intention to not only supply medicines for diseases, but to also make use of ICT for a gradual switch to health and disease management. This move can include lifestyle monitoring and advice, and the use of big data to gain more insight into the complex relationships between genes, lifestyle, medication and disease. Making diagnoses and treating diseases in the earliest stage possible is another option, also made possible thanks to an immense database of diagnoses, treatments and outcomes. Similar developments can be seen in agriculture (e.g. Monsanto and Bayer; seeds, pesticides, precision fertilisation) and in the automobile industry, where many manufacturers are now eyeing platforms such as Uber[3] and experimenting with self-driving cars (see Chapter 3).

Ongoing automation brings about new forms of economy of scale, in which the marginal costs are gradually approaching zero: many things are offered 'for free', are created in abundance or escape market forces, but whatever the case, they cause new revenue models to arise. The new models can include the sharing economy—think of how often people use their drilling machine, their electric saw or even their car—which could threaten the revenue model of the manufacturers of these products. Platforms such as Uber and Airbnb are already enabling households to operate as mini-entrepreneurs, using their time, car or home as a means to earn money.

In this choir of techno-optimists, dissonant notes can also be heard. The prominent US economist Robert Gordon, for example, has for a long time insisted that in spite of all the excitement about what ICT is to bring about, the promise is far from being fulfilled by the actual impact on society and the economy. This is especially true when seen against the great 'inventions' of the late 19th century, such as electricity, the telephone, the internal combustion engine and sanitation that, over the period from 1870 to 1970, brought unprecedented, and in his view probably one-off, social change and economic growth. Since the 1990s, a clear impact of ICT on economic indicators such as gross national product has not come into sight[4]. Gordon also maintains that ICT has not changed everyday life nearly as drastically as the changes at the beginning of the last century did, if only with regard to the enormous efforts and the amount of time that were required to cover the most basic necessities of life such as sanitation, food, drinking water and running the home. This is why he anticipates a stagnation of the American standard of living in the near future, a notion that is further supported by the headwinds of developments such as an ageing population, inequality, the diminishing added value of education, and climate change (Gordon, 2016; Krugman, 2016).

Another author points to new concentrations of market power, which enables a much cruder form of platform capitalism to make its appearance: 'What if this is

Contactless payment at a fast food vending machine.

not capitalism, but something worse?’ (McKenzie Wark, 2014). Think of the monopolies of high-tech companies and social media such as Google and Facebook. But also consider the increasingly elusive, globally operating financial-economic elite, which evades taxation and therefore benefits ‘free of cost’ from economic structures that enable it to accumulate wealth. It is becoming more and more evident that, as Castells predicted in the late 1990s, traditional institutions including the nation state, traditional companies and civil society, will see their influence and power vanish into the worldwide web, which is more mobile, more diffuse and less concrete (Castells, 2001).

2.2 Certain to affect infrastructure

The digitisation of society outlined here also increasingly affects infrastructure systems and their use; distances disappear, Internet platforms take over the service economy, and data flows blend with infrastructures.

The digital world is timeless and borderless

Due to digitisation, distances disappear; activities are no longer tied to a specific time or place. Many have the possibility to carry out their activities wherever, whenever and with whom they want; the whole world is within reach—this is how the classical barriers of time and space are broken down. A person continues to work for a few hours in the evening so that he has time to get to the schoolyard the following morning; he can multitask by sending emails during the commute or a meeting, and check his Facebook page while he is at work; a colleague sits at her kitchen table to attend a meeting in San Francisco. A large part of the population handles its social contacts as never before, whether worldwide over specialised Internet forums, or at a very local level in neighbourhood groups (e.g. Aguiléra et al., 2012; Hubers et al., 2008; Lyons, 2009).

Nevertheless, the prediction made by Cairncross at the end of the last century that all new possibilities for communication would lead to a 'death of distance', has proved to be incorrect (Cairncross, 1997). In spite of the ease with which everyone can manage social and professional contacts over great distances, for the moment the city continues to be the place where many people want to live, meet each other face to face and exchange ideas. In short, the place where they enjoy all kinds of benefits of agglomeration[5] (CPB and PBL, 2015; see also the analyses by Tordoir et al., 2015).

Time and space are also changing because mobile phones, global positioning systems and other gadgets continuously measure, gather and share data. This means that users are increasingly becoming a part of what is called *smart physical environments*, best compared to monitoring and control systems that combine the user-generated data in real time with those of others in the same environment, to make the activities of all as effective and efficient as possible (Kitchin, 2014). For example, people may receive travel advice based on a real-time analysis of GPS navigation data that enables them to bypass traffic jams (a form of smart mobility), or consumers may receive a balanced supply of electricity based on continuous measurements of consumption and production. In theory, this datafication of various aspects of infrastructure use leads to a definition of space that is somewhat malleable, since the fastest route from A to B changes every 15 minutes and the appeal of B as a place to go to changes every day or even faster. In short, we could say that a virtual, digital TomTom layer has been placed over (or through) the spatial structure and can change the function and use of the spatial structure from one moment to another (e.g. De Waal, 2015).

iPlatforms are taking over the world

A second, far-reaching development is the overwhelming success of the Internet platforms, mostly in the business world, though sometimes also resulting from private initiative (Van Dijck et al., 2016; Kreijveld, 2014; Parker et al., 2016). Uber, Airbnb, Facebook, Wikipedia and Amazon have rapidly gained a place in the traditional economy. Platforms provide a digital marketplace for customers and suppliers, which are quite often individual households. On this market, services are offered 'on demand', and information and goods are shared, often in the areas of accessibility, entertainment and personal services. Essential factors are the low transaction costs for all parties involved, not least the low start-up costs for entrepreneurs, especially in comparison with traditional businesses, the superior search and match facilities of the web, flexible pricing, highly simplified payment systems, and, last but not least, the so-called *reputation mechanisms* that deal with user and provider feedback. The large platforms in particular can also experiment more readily with their services and monitor in real time how people react to them[6], by tracking click, search and purchasing behaviour, and by linking information on individual users to the profiles available through big data.

Platforms might go on to play an interesting role in those areas that are not covered by ordinary public transport. In and between the big cities, public transport does not have to fear for its continuity, but it is quickly affected by cutbacks in more rural areas, such as the northernmost part of North Holland or the Achterhoek. More and more often it will be for-profit platforms and neighbourhood initiatives that organise accessibility in these areas (Vos, 2015)[7]. There are, in short, substantial gains to be made in the areas of customisation and efficiency. Chris Anderson calls this mechanism *the long tail* (2006); while traditional, physical trade focuses mainly on mainstream products to serve as many people as possible, Internet platforms direct themselves contrastingly toward the tail in the distribution of preferences. Numerous niches can be found in this area where supply and demand for very specific things can be brought together in a shift 'from mass markets to millions of niches'.

A striking feature of the platform world is that the 'survivors' quickly acquire great market power and market capitalisation—the winner takes all. This has to do with what is called *the network effect*; the user benefit of an Internet platform increases greatly with the number of participants. This means that, in this area too, a kind of natural monopoly arises (Werner, 2015). Another advantage, in terms of business competition, may be that service providers circumvent the legal requirements and regulations for conventional markets, including tax liability.

Merging' of infrastructures, sectors and data flows

ICT developments are leading to more intensive and more numerous cross-border connections between the various traditional forms of infrastructure. To quote Carl Bildt, chairman of the Global Commission on Internet Governance: 'The Internet has already become the most important infrastructure of

2.1. Digital disruption has been in place for a long time

The world's largest taxi company (the Uber transportation network company) does not own any taxis, the largest accommodation rental company (Airbnb) does not own any real estate, the largest communication companies (Skype, WeChat) do not own any telecom infrastructure, the world's largest retailer keeps nearly no stock (Amazon), the world's largest media company (Facebook) does not produce any content itself, the world's fastest growing bank (SocietyOne) has no gold ingots, the world's largest film company (Netflix) has no cinemas (though it does make television series and films), the world's largest hardware and software supplier (Apple) makes hardly any apps of its own (IBM, 2015).

the world. And that's just the beginning. Soon it will also be the infrastructure of all of our other infrastructures. To say that the governance issues are of importance is the understatement of the day'. Whether dealing with road traffic or rail traffic, shipping or aviation, energy supply or telecommunications, the functioning of traditional infrastructure is becoming more and more interlaced with the worldwide web and more and more dependent on it[8]. Consequently, global governance is becoming increasingly crucial and also more contested (e.g. Bildt, 2015).

Thanks in part to ICT, new players are also taking advantage of current infrastructure; established providers and new providers are penetrating existing sectors, such as mobility, culture, local community healthcare or manufacturing. Eventually, the car will not simply be a means of transport, but also a device for smart energy storage, a moving sensor, and a source of personal data. For some time now, Internet giant Google has been dedicating attention to self-driving cars to promote mobility, apps for social cohesion at the neighbourhood level, and health care. Electricity producers such as RWE and Eneco are focusing on residential climate control. Philips and Vodafone are entering into a partnership for smart street lighting—lamp posts are set to become the 'iPhones of the street'[9]. The Internet and electricity meet in street lights. Public funds are used to integrate sensors, cameras, charging stations for electric vehicles and outdoor advertising displays. Other giants such as KPN, Cisco, IBM, Siemens and ABB have similar plans for smart cities and smart grids.

Among companies, an important motive for capturing new markets is the big data they are then able to collect. The new revenue model consists of making money out of acquiring, combining, analysing and then exploiting the broadest possible spectrum of data about users, including their daily activities, consumption and interests, their income and expenses, purchases and sales, their health and social environment. Or, as Neelie Kroes once said: 'While oil used to be the black gold, data are the new gold of the digital age' (2012). It has already been predicted that the vehicle of the future will be a free search engine; Google pays for the energy and availability of the vehicle in exchange for data obtained from the users (e.g. Vos, 2015).

The related data flows also merge to some degree. For example, Rijkswaterstaat (a division of the Dutch Ministry of Infrastructure and Water Management) needs larger and larger amounts of big data and more data scientists to carry out its tasks. The same goes for the bodies managing electricity grids, and all kinds of cyber security agencies and ethical watchdogs. Technically, Rijkswaterstaat can send information on road users to the tax authorities or the police at the push of a button, as it were. However, for now the law prevents this from happening[10]. TransLinkSystems, the company behind tools such as the Dutch public transport travel card, manages the big data collected by the public transport companies, which includes the data on all travellers. A gold mine for marketing companies or—to give but a suggestion—election campaign strategists.

In Eindhoven, the Living Lab Project analyses and guides the activity of people on a night out with cameras and sensors.

Information flows are knowingly and unknowingly shared and combed through, and it is easier than ever before to use them, rightly or with more questionable motives. The flows also move about more and more between public authorities, companies and intermediate bodies, which together enrich the data and reuse them. This often takes place, by the way, without explicitly defining the responsibilities with regard to privacy, quality or other values (WRR, 2011). In short, existing institutions that previously safeguarded matters related to ownership, use and access, may fall short here.

2.3 Between uncertainty and ignorance

There is little doubt that dramatic changes are taking place. The forecasters may say what they want, but the speed of technological developments and the direction they are taking are still highly uncertain, if not simply unknowable. These are developments that since Donald Rumsfeld's 2002 speech have become known as 'the unknown unknowns'.

Over the decades, the practice of exploring the future has shown that the present reality and the line of developments that has led to it often produce future predictions that range from poor to flawed, especially when dealing with a somewhat more distant future[11]. In addition, it seems that the quirkiness and the consequent unpredictability of today's world only continue to increase under the influence of factors such as globalisation, economic and political instability, refugee issues, climate change and technological innovation (Lyons and Davidson, 2016; Van der Steen, 2016).

What it comes down to is that systems are often complex or even chaotic. It is not possible to derive the unknown future from the past using causal, stable, linear and sequential relationships. As Van der Steen remarked fittingly: 'Platforms are not the 2.0 shop, but represent a completely different way of thinking about transactions between manufacturers, service providers and consumers' (Van der Steen, 2016). In the same line of reasoning, Airbnb and Uber are not merely new ways of managing hotel groups and taxi companies. All of this also means that collecting more data or making models even more complex and accurate does not contribute much to improving forecasts or resolving uncertainty, if at all. Uncertainty also exists about how a pluriform society feels about and responds to change; uncertainty exists about how values, beliefs, wishes and interests are going to evolve (WRR, 2010).

This picture should not inhibit researchers from exploring the future, if only because politicians and policymakers often need to make choices at this very moment on the basis of that information. The challenge for researchers, on the one hand, is to quantitatively predict that which is possible to know, such as the relatively stable demographic developments and some economic developments, and on the other hand, to provide accompanying, more narrative visions—from several perspectives—of what might happen, what would be plausible, convincing or likely, and even what would be desirable. This is necessary, if only in order to have the possibility to classify important dilemmas that arise when the balance between conflicting public values is disturbed, that is to say, when broad strata of society no longer accept the chosen balance of values.

A good example of this kind of approach is the Re-programming Mobility study, carried out in the United States by Townsend and his team (2014). Working under roughly the same assumptions for the development of ICT applications for mobility, they describe both a future variant with a very high level of urban sprawl and private ownership of electric vehicles, and a very compact future variant that almost exclusively features public transport and, of course, large numbers of journeys made by bicycles and on foot (see Chapter 3, Text box 3.1)[12]. Multiple future perspectives are also possible for electricity supply systems (e.g. Enexis, 2016). For example, the required flexibility of demand and supply can be controlled locally by smart micro grids; the big tech companies coordinate the electricity management for smart households or mobility. But in another future vision, the emphasis is on relying on efforts to reinforce national and international grids (see Chapter 4, Text box 4.1). The chapters on personal mobility and electricity supply systems reflect on these future explorations in more detail, to obtain a sharper focus on the dilemmas about conflicting public values.

2.4 Can the institutions cope?

The digitisation and the social developments described here pose the danger of creating so-called *institutional gaps* (e.g. Hajer, 2003). The existing legislation and regulations are becoming increasingly unsuitable for the new reality, because, to give an example, datafied and interlinked activities already transcend the traditional, sector-based policy columns, and their dynamics are more intense than the pace of the existing, familiar policies. It may also be the case that there is no generally accepted definition of the problem, or no system of standards, values and rules that tie interested parties to a result. The interlinking of ICT and existing infrastructure systems, such as mobility, energy and communication, is precisely what makes it possible to break through traditional, sector-specific institutional spaces or for actors to circumvent existing institutional frameworks.

Globally operating companies, such as Airbnb or Uber, are often cited as simple and telling examples of platforms that can easily evade all types of local institutions, such as licence requirements, tax obligations, labour laws and a wide range of regulations on quality of life and safety (Frenken, 2015). This means new realities are created outside the existing institutions, possibly beyond the reach of democratic and constitutional management. To quote the 19th-century politician Thorbecke, 'the public interest is in danger of disappearing from the public eye'. As the outcome of these processes may conflict with public values, once again a need arises for a recalibration of institutional frameworks (Hajer, 2009).

An integrated perspective is required in reflections on new institutional frameworks and arrangements. The institutions need to serve as an umbrella for many developments, such as digitisation, the shift to a platform-based economy and the various infrastructure systems. But they must also serve, for example, the quality of the physical environment and the energy transition needed to achieve the required CO_2 reduction. According to the Netherlands Scientific Council for Government Policy, the country can only aspire to meet that emission target if the effort is supported by the fixed infrastructure; infrastructure determines, to a very high degree, the routines of individuals, companies and society as a whole (Faber et al., 2016; Weijnen et al., 2016). In this regard, starting in 2019, the new Environment and Planning Act will form a new institutional framework, grouping laws and regulations in the fields of space, infrastructure, housing and the physical environment (IenM, 2016; SCP, 2016). This may also bring opportunities to close institutional gaps related to digitisation by means of policy measures for the use of space.

3 Smart mobility

3.1 Mobility policies continue to face enormous challenges

Thanks to a steadily growing population and rising prosperity, the need for mobility will increase even further in the oncoming decades (CPB and PBL, 2015). As a result, the infrastructure and mobility system will face major social challenges. For example, it has to connect larger numbers of people with their destinations and continue to facilitate goods transport for the benefit of a well-functioning society, and the national and international economy. At the same time, efforts need to be made to curb congestion on the network as much as possible.

And if the Netherlands is to comply with international climate agreements, means of transport can and must be made considerably cleaner, quieter and more economical. According to the Dutch National Energy Agreement, the traffic and transport sector needs to make a 60% reduction in CO_2 emissions by 2050 compared to 1990 levels. Since, at the technical level, passenger mobility offers more options for reducing emissions than goods transport and aviation, this sector must achieve an emissions reduction of 80 to 90% (PBL, 2009). For this issue, the short-term targets for 2020 seem to be within reach, but the long-term targets do not (PBL, 2016a).

Safety is and will continue to be another important issue. Though the annual number of traffic fatalities did fall over many years, recently there has been mention of an increase (SWOV, 2016). The number of seriously injured road casualties also continues to rise. While the tasks outlined here are huge, the budgets available for infrastructure and mobility policies are becoming smaller rather than bigger. This is reflected, among other things, in a government policy shift from, mainly, construction and investment to initial efforts geared towards more optimal use of existing infrastructure (IenM, 2011; CPB and PBL, 2016a).

The effect of digitisation on mobility and public values

The digitisation of mobility is taking place against the backdrop of the challenges described above. Digital technology will dramatically change the infrastructure, mobility and transport services. This chapter gives a rough outline of the present state of those developments and of what they may be like in the future (for a more detailed discussion, see Snellen and De Hollander, 2016). Think, for example, of the fact that people no longer need to commute to the office every day because they can work, in part, from their homes thanks to ICT. Or that more and more products can be purchased from the living room sofa using the Internet. New services such as Uber have made their entrance and eventually there may be a self-driving car. When that becomes a reality, everyone will be able to drive to a destination on their own, including children, the elderly and the visually impaired. For the descriptions of the possible changes, the study drew a lot of inspiration from the widely diverse scenarios that Townsend et al. created with regard to the development of mobility in cities in the United States, especially in light of the arrival of self-driving means of transport (see Text box 3.1).

Following the description of these developments, the report looks at what they mean for various public values. What is the impact of digitisation on the effectiveness and efficiency of traffic, on accessibility, reliability and the transparency and accountability of transport systems? The report also examines areas where the relevant, formal institutions may fall short, now and in the future, as a result of the influence of the developments outlined above. This includes issues such as the aptness of rather slow planning processes for the unpredictable digital reality and the adequacy of regulation when robot cars or new platform-based transport services arrive. This chapter is limited mainly to issues relating to personal mobility, with occasional side steps to goods transport.

3.1 Re-programming mobility

Given all the developments in digitisation, a wide variety of future views is imaginable, depending on the specific way technological developments take place and how the government, society and the market react. Under the title *Re-programming Mobility*, Townsend (2014) conducted a study into four alternative futures for the United States, whose common denominator is the role of self-driving vehicles. The study describes four markedly different mobility systems and patterns of urban development along with interpretations of public values and the consequences for them.

In the scenario for *Atlanta*, there are special roads and lanes to be used exclusively by electric self-driving cars. With some sections even privately developed and managed, the road system exists in combination with built-up areas of spacious residential districts while a major role is assigned to sustainable energy supply. Due to standardisation, there is little congestion in this world and energy is virtually free of cost. But public planners lose out here; it is hard to guarantee equal access, partly because access to data is complicated and algorithms are not very transparent and can be exclusive.

In another future, projected on *Los Angeles*, there is no standardisation in the area of self-driving cars. Driving around here (or rather, continuously pulling up and slowing down) is a fleet of self-driving and conventional vehicles that is very diverse and mostly inexpensively produced in China. This gives a great deal of freedom of choice, but it also leads to much, or rather, continuous congestion. This scenario also sees the emergence of a completely new and diverse market of do-it-yourself public transport, with an urban environment offering little space to slow-moving traffic (pedestrians and cyclists).

Public planners are set to face lots of work in future scenarios that focus heavily on collective, innovative solutions such as smart traffic management based on algorithms and public transport services. In the case of *Boston*, the city dwellers' daily routine involves walking and cycling in a very compact city made up of mostly small, one-person apartments that are fitted with many digital devices and other gadgets and form comfortably liveable 'cocoons'. An ingenious parcel delivery system using autonomous drones operates at night.

New Jersey had to confront the extremes of climate (heavy weather, flooding) and the limited amount of space and supplies and has rigorously adapted its mobility system. The traditional centres of growth are mainly linked by automated public transport, regulated through a dynamic, electronic pricing system (road pricing). The drawback is that it is a paternalistic, technocratic operating system—the smart city from a command-centre perspective.

Developed for urban surroundings in the United States, these scenarios obviously contain some elements that are hardly applicable to the Netherlands, if at all. But they also outline dilemmas and challenges that certainly are relevant, such as the issues concerning standardisation, public space, accessibility, manageability, the role the government chooses to play, its reasons for doing so, and the possible consequences for the relationships between different modes of transport.

3.2 The impact of ICT on mobility

Changes in time and space
Developments in both mobility and ICT seem to have brought about a disconnect with regard to time and space. Activities are less and less tied to a certain place and time. Everyone can do things wherever and whenever they want, with whomever they want and in whatever way they want. This leads to changes in travel needs; people do not necessarily travel less, but make journeys from and to other places, maybe also at different times, and using other forms of mobility. They may choose to buy new clothes, shoes or household appliances over the Internet instead of on the nearest city's High Street, as they used to. They may work from home for one or even more days per week—depending on the kind of job, of course—and more and more people are even working as freelancers full-time from their homes. Large numbers of people take long flights more and more often to ever more distant destinations (the global village), or accept jobs further away from home because they do not have to commute every day or because they can dedicate part of the travel time to work. In hotspots—the rapidly growing, internationally oriented cities such as Amsterdam—these developments are of course very different from those in cities that are shrinking or have come to a standstill, such as Assen and Venlo (Rabobank, 2016). Still, changes are taking place everywhere.

In theory, these developments in mobility and ICT could lead to new forms of urban expansion that entail the spreading out of cities over wide areas. Since there is no need, or at least much less need, for proximity and physical accessibility, businesses, customers and employees do not have to be located near each other (De Waal, 2015). However, similar expectations have been expressed in the past as well, for example at the end of the 19th century when the telephone was introduced (Mokhtarian, 2009) or at the beginning of the current ICT revolution. In 1997, Cairncross wrote about 'the death of distance'. There is, however, still no empirical evidence that distance is actually becoming irrelevant and that a decrease in physical movement is really taking place.

Deliberations on the so-called *agglomeration effect* show that proximity offers all kinds of advantages that ICT does not necessarily make up for (Ponds and Raspe, 2015). This is why it is difficult to predict whether increasingly advanced technologies will lead to fundamental changes in urban development patterns (higher density or increased sprawl). In addition, while ICT makes it possible to stay in touch, in straightforward ways, with people who live far away, eventually these virtually managed connections will often lead to actual encounters and therefore, to additional mobility.

Whatever the case, it is clear that ICT is going to change the geography of destinations[1] (De Waal, 2015). E-commerce is playing an important role in the changes in the physical retail landscape (e.g. Ouwehand and Haringsma, 2016; CBS, 2017), and leading to a reduction in the physical presence of shopping facilities. A logical consequence is that, on average, people have to travel longer distances to get to a physical shop, though they do have more opportunities to do so thanks to the extended opening hours.

In addition, traditional location features have become less relevant. For example, visibility of the premises (being in a high-profile location) is less important for a specialist retailer, because the shop is also easily found on the Internet and customers will visit it anyway, regardless of its location. The same goes for other types of businesses and locations, such as trendy clubs, restaurants, and meeting places for certain target groups. People choose places that suit them using the restaurant booking app *iens* or *TripAdvisor*, and *Google Maps* will show them the location.

Smart environments and the self-driving car

Thanks to smart applications in vehicles, every road user can become part of a larger measuring and monitoring system, known as a *smart environment*. For example, a car measures and registers routes, speed and braking distance. Present-day navigation systems already alert drivers of traffic jams and other hold-ups and offers them suggestions to bypass the congestion. The interlinking of vehicles and ICT makes it possible that the car, at any given moment, is not only a means of transport, but also a data collection device. After all, those data on driving style, location and surroundings are valuable. And in the long run, the data may even be more valuable than revenue from car sales or transport services (e.g. see http://money.cnn.com/2017/02/07/technology/car-data-value/).

In the future, the smart environment will make it possible to tune the driving styles of motorists to each other at a collective level. If, for example, the vehicles of road users communicate with each other, they can group themselves into *platoons*, moving like trains do. This is a way to make the work of lorry drivers more efficient; when platooning, only the driver of the front vehicle is at work while the others can rest during the journey. This means more rides can be made.

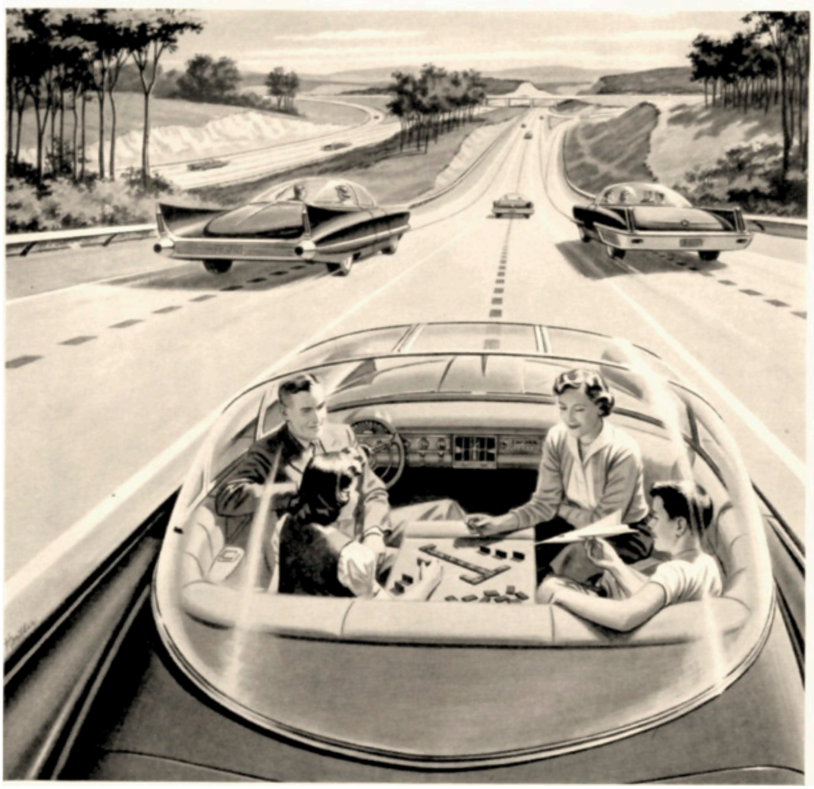
However, these systems can also lead to undesirable and uncontrolled shifts of traffic onto roads and streets in quiet neighbourhoods. The preferred route is no longer determined by the signs of the National Road Signage Service, but rather by an app with customised settings.

On the Amsterdamsestraatweg in Utrecht, the Flo system advises a cyclist to adjust his speed so that he can benefit from a 'green wave'.

Passengers on public transport also use this type of technology. The optimal journey can be planned and adapted on the go on the apps and websites of NS (Dutch Railway Company) and OV9292 (travel information body, run by Dutch public transport providers). In the future, these systems will be able to gather, process and make available increasing amounts of real-time information on trains, trams, buses, shared-use bicycles (including electric models) and possibly also shared taxis. As a result, at any time and from any place, it will be possible to find the fastest and lowest-priced public transport from A to B. While existing chains are being optimised through improved information provision, this field also sees new forms of service emerging in which passengers share useful multimodal routes with each other, using apps such as *Waze*.

In the current debate on smart mobility, self-driving vehicles are undoubtedly the most frequently discussed technical innovation (e.g. Burns, 2013; KiM, 2015; Milakis et al., 2015; Smetsers, 2016; Townsend, 2014; Townsend, 2013; statements by the Minister of Infrastructure and the Environment, and a torrent of articles in newspapers and trade journals). Self-driving cars use sensors to explore their surroundings in great detail, and communicate with the road, other cars and, when necessary, with the driver-cum-passenger. The EU Member States have agreed to support the development of self-driving technology in the Declaration of Amsterdam (EU, 2016). The step may be motivated by the desire to stimulate innovation from an economic point of view, but obviously also by the objectives for traffic flow, ease of travel and safety (see also EZ, 2017).

Self-driving cars can make a profound impact on mobility and traffic, whether they provide a high level of support for the task of driving, or they are fully autonomous and enable the 'driver' to spend travel time differently. If these developments continue, they may give rise to a situation in which travel time is considered less of a burden or a cost because it is possible to spend part of the travel time on other, day-to-day activities (Van de Weijer, 2015; Disrupting Mobility Conference MIT, 2015[2]). A fully self-driving car can take anyone, regardless of age or disability, to the desired destination in a safe manner. This enhances the independent mobility of groups such as young people, the elderly and those who at present are unable to drive a car for one reason or another. Most probably, this will result in increased automobility (ITF, 2015), because of, among other things, cars driving around without passengers on the way to a distant parking space or to a new passenger. Road safety may increase enormously, perhaps speed limits can go up, and self-driving vehicles are said to take up less space on the road. Other effects are also possible, such as on health or on issues of a social nature; for example, when automobility becomes more readily available, it may be at the expense of physically active forms of mobility such as walking and cycling, or it may lead to increased alcohol consumption because still having to drive is no longer a restraint on drinking.



Back in 1957, people also imagined electric, self-driving cars.

All in all, it is still highly uncertain what impact self-driving cars will have on mobility and infrastructure, and when the effects will become apparent. It does seem reasonable to affirm, judging by the available knowledge, that more and more supporting functions will be assigned to cars in the coming years, and that autonomous rides on motorways and main roads should be possible in the near future. However, fully automated driving in all kinds of settings, including complex urban environments, is not going to make an appearance for quite some time (CPB and PBL, 2016b; Milakis et al., 2015).

The platform economy

Internet platforms open up the possibility for people to offer, share and sell products and services. A platform for transport makes it possible to offer and find the most convenient and cheapest form of personalised transport service at any time of the day, to any destination. New services such as car sharing, bicycle sharing and taxi services are made possible or much easier. Car sharing has become far more convenient due to the growing number of people listing their cars for rent (e.g. on *MyWheels* and *SnappCar*), but also because booking and use have become easier with mobile apps. For example, the traditional car key has already been replaced by digital access systems for which you need a smart card or a mobile phone. And an Uber car will pull up in front of your house after just a few clicks or swipes.

As a result, digital platforms and the services they run are enabling a shift from owning to using, a development that has raised great expectations in the domain of mobility (e.g. KiM, 2015; Disrupting Mobility Conference MIT, 2015). After all, if a customised transport solution is readily available at all times, why should you bother owning a vehicle, with all the hassle that it involves, such as maintenance and parking?

In time, these developments may contribute to a process in which the traditional distinction between public and private transport becomes obsolete and the services that are now offered under the banner of public transport are replaced or lose their position to competing private initiatives—something that is also known as *creative disruption of the sector* (e.g. Van Dijck et al., 2016). The measure of this change will also depend on the quality that the transport services deliver. The emergence of self-driving vehicles may stimulate the process, because it can eliminate several current inconveniences in sub-systems, such as the need to pick up a car at a certain, fixed location.

A well-running platform economy could bring about a much more efficient use of cars; at present, cars are parked for more than 90% of the time. Even at the busiest time of day, there are at most 2.8 million cars on the road, while the vehicle fleet currently consists of more than 8 million cars (CBS, 2017). By achieving a shift, if only partial, from ownership to use, the Netherlands would be able to manage with a much smaller fleet of vehicles. Even so, the question remains whether this development would also serve other objectives that concern sustainability, quality of life and congestion reduction. In this regard, a rather optimistic study into the impact of a fully shared self-driving vehicle system concludes that such schemes also lead to a substantial increase in kilometres travelled (ITF, 2015). Cities in particular experience important external effects; the existing urban structure is often not well-suited to handle more car journeys, not to mention the related additional emissions and the visual impact on the cityscape.

3.3 Public values: opportunities and challenges

As outlined in the previous section, digitisation can affect mobility in several ways. Some influences are already a daily reality, others are still rapidly developing. Below, the consequences that digitisation of mobility may have for public values are explored (Sections 3.3.1 to 3.3.4). Are journeys going to be more efficient and cheaper? Is everybody going to be able to keep on making use of the transport options? What are the implications for the environment? If digitisation and data become dominant features, who is going to be accountable?

3.3.1 Impact on efficiency, effectiveness and freedom of choice

For many, waste of time and money is a thorn in the eye. Therefore, efficiency and effectiveness in traffic are regarded as important public values. Digitisation can contribute by ensuring better use of the available road capacity, high levels of safety and faster journeys, and by reducing congestion and unnecessary detours. In the world of public transport too, digitisation enhances the effectiveness and efficiency of the travel system, because digital tools enable better management and monitoring. At the same time, however, a more detailed profile of passenger behaviour can be built up, generating a novel, perhaps even intimidating form of information asymmetry.

Within the system of mobility services tied to infrastructure, an aspect that is also feeling the pressure of digitisation is accessibility. A very wide gap in digital skills already exists between groups with higher and lower levels of education, and between the elderly and younger people. In different population groups and at different locations, equal access to mobility can be affected by poor ICT skills, any socio-psychological barriers that may exist, financial barriers to installing expensive hardware at homes or in vehicles, and black spots on the 3G/4G coverage map. Having more information and more options does not necessarily mean that people can actually make use of them. A discussion of this issue is found in *Weten is nog geen doen* (Knowing does not imply doing), a recently published report by the Netherlands Scientific Council for Government Policy (WRR, 2017).

On the other hand, digitisation also offers the possibility of designing applications that really are socially *inclusive*. In the United Kingdom, for example, experiments have been conducted to make cities more easily accessible for blind and partially sighted people. Using interactive headphones, they received real-time information in 3D sound about their surroundings, including footpaths, pedestrian crossings, the availability of public transport and the shops and facilities in the immediate vicinity. Digitisation offers opportunities to create more inclusive applications, but whether they achieve that target groups actually use them depends partly on the perspective and the values of the developer, and on the requirements that the market or the government set for products or services. When accessibility and user convenience are the main focus of the system's design, the result will be different from that of alternatives that prioritise monitoring, efficiency and profitability for the service provider. A target group that is too small will not be of interest to the market.

Advances in technological developments can cause inequality to increase even further, if there are no contrary forces. If road information is increasingly shared and processed over in-car systems (rather than being made available along the road[3]), this will be at the expense of those road users who still have to manage without these options. While GPS devices with dynamic traffic information may now be a standard feature of premium models of new cars, a large part of the fleet consists of more basic or older vehicles.

Pilot project of a self-driving minibus in Appelscha; the bus is driving on the bicycle lane and creates confusion among the cyclists.

If technology becomes the foremost consideration, then this could lead to a situation in which, for example, manufacturers, transport companies and motorists all demand that for safety reasons part of the road be reserved exclusively for self-driving cars[4], or even that human drivers be banned there[5]. This may seem far-fetched, but a report on the significance of self-driving cars dedicates a great deal of attention to the adjustments that need be made to the infrastructure in order to prepare the city for the self-driving car (BCG, 2016). They include separate lanes for self-driving cars, more traffic lights to improve traffic management and reducing the number of possible crossing points for pedestrians. The report labels the consequences for other road users as 'a slight disadvantage for pedestrians and cyclists'.
The use of 'handy' digital tools can also lead to imbalances in public services. To give an example, Boston has a *pothole app* that allows residents to report damage to the road surface to the local authorities. In more affluent neighbourhoods, damage is reported more frequently because more people own a smartphone, and as a result the roads there are more properly maintained.

The new digital possibilities may also have consequences for the accessibility of public transport. When new transport services become hugely successful, maintaining public transport is no longer feasible. This does not necessarily have to be a problem, because the new transport services may even be an improvement. But whether that really is the case depends on the degree to which they are physically and financially accessible, and psychologically acceptable to every citizen.

A relatively new form of inaccessibility can emerge if transport service providers start avoiding certain population groups or neighbourhoods. Considerations of efficiency may lead to such behaviour, and it is already happening in rural areas, as reducing the offer of public transport results in proportionately large cost savings. But avoiding certain groups or neighbourhoods can also be the unconscious result of choices in the algorithm on which the service is based[6]. This is because certain values are already built into programming code (Code is Law) and they can reinforce themselves when the algorithm continues to evolve independently (in what is called *a self-learning system*) on the basis of use by a selective part of the population[7]. After all, 'if you are not in the data, you don't count'. Reduced accessibility will mainly affect low-income groups, but can also discriminate on the basis of other characteristics. Mobility systems can, of course, be set up according to criteria of inclusion, but this often goes together with higher costs.

3.3.2 Availability and security of supply

Closely related to accessibility is the concept of availability of transport services. Digitisation can cause the range of services to widen when new players enter the market. However, this also entails risks. The services being provided today may disappear tomorrow, because the platforms do not own any infrastructure or even any vehicles (e.g. Uber, BlaBlaCar). In areas with many different providers, this does not pose much of a problem. But regions with a relatively limited offer may face serious consequences because successful introduction of new transport services can lead to the disappearance of the traditional options, even in the short term. If subsequently the new service disappears, the impact is profound.

Another risk of digitisation is that digital systems are, almost by definition, sensitive to disruption, outages and unauthorised use occurring in places deep down in complex networks (Perrow, 1984). Townsend (2013) calls this 'buggy, brittle and bugged'. Bugs in software are often inevitable and typically manifest themselves in exceptional, dangerous situations. Systems are increasingly being stacked and 'closely' interconnected, making them highly dependent on each other. Many smart applications, for example, depend entirely on the proper functioning of the mobile phone network, a system that is far less robust than the Internet. In addition, many services are also based on satellite positioning systems being readily available, but only a limited number of these systems exist[8]. Then there is also the risk of viruses and hacking. Finally, as systems become more all-encompassing and self-learning, the question arises as to whether they will still be manageable and keep from turning against people. It is worth noting that these reflections do not imply that systems *without* ICT are free of risk of disruption, outages and unauthorised use, but the situation is rather different.

3.3.3 Impact on liveability, spatial quality, safety and privacy

The digitisation of mobility does not only affect its accessibility and availability, but also other public values that are deeply rooted in society, such as liveability, safety and the right to privacy. For example, ICT applications make it possible to have advanced forms of traffic management that are able to ensure, among other things, that those areas in the city with poor air quality are given relief by permanently or temporarily banning vehicles with relatively high emissions.

When new transport services and self-driving vehicles enter the market and use infrastructure, a need may arise for redesign of the infrastructure itself, cities and villages, or for a certain form of management based on spatial planning. Who or what should be allowed to have access to the infrastructure? What kinds of infrastructure may they access? And when? What are the admitted modes of transport? How much space is assigned to each of them? How are liabilities distributed? Time will tell whether self-driving vehicles are able to share the road with other users (such as pedestrians, cyclists and conventional cars) without compromising safety, traffic flow and use of the public space. This can pose unusual challenges, especially in the transition phase to a fleet of fully self-driving vehicles.

Perhaps self-driving vehicles require 'robot-proof' infrastructure and therefore space on the road that is exclusively designated for them. This may not only have an impact on accessibility, as outlined above, but can also make a fundamental difference in the physical appearance of cities. After all, the arrangement of stretches of road may change, and the amount of public space available for other activities may decrease. But there will also be other changes, such as the high likelihood of less parking space being needed in cities (since self-driving cars can also park elsewhere), and a demand for places to safely get in and out of cars.

Digitisation also makes it possible to imagine ways to make traffic safer. Real-time data can keep congestion from occurring by continuously redistributing traffic. In-car driving support systems can also effectively increase safety. Therefore, images of a future world with self-driving vehicles almost always go hand in hand with appealing accounts of how much safer these smart systems are—safer than with human-driven vehicles.

However, the safety issue is not as simple as it seems, and comes with moral and legal dilemmas. For example, who is to be held responsible when a self-driving car is involved in an accident, the passenger or the software developer? Fields of tension may arise between liability, safety and moral choices. A recent study reveals a that a classic social dilemma exists (Bonnefon et al., 2016). Respondents to this research believe that self-driving vehicles should make ethical choices that are aimed at minimising the number of victims in emergency situations. However, they also affirm that if they were to buy this kind of vehicle, they would choose one that is programmed to protect its own occupants as much as possible. The development of public opinion with regard to safety and self-driving cars is another source of tension. For example, is the bar going to be set higher for robot cars than for human drivers, or should it be accepted that these vehicles too can cause accidents? The introduction of self-driving cars therefore calls for a moral discussion about which public values should predominate, which moral perspectives may or may not be worked into the operating systems and how to oversee developments in cases involving machine learning (see also Section 3.3.4 on transparency).

Another issue that repeatedly crops up is privacy. The widespread availability of data and the enormous capacity to process them offer many advantages, but the practical and theoretical possibilities to attain increasingly high levels of monitoring and information do, of course, not mean that the data are always used in a proper way. For example, both car manufacturers and transport service providers collect all kinds of personal details of their customers. They can combine them, analyse and sell them, even for uses that go far beyond the scope of improving their own work in the field of mobility. Whether society wants to allow this to happen seems to be an eminently public and political issue.

3.3.4 Impact on the adequacy of the existing rules

As mentioned in Chapter 2, this section also examines whether so-called *process-related values* are affected. Can all aspects be accounted for? The quality, accessibility and reliability of the service? The fitness of new investments in infrastructure with regard to the future? Can the parties involved assume their responsibilities? The choices that are made on infrastructure and transport services must be verifiable and transparent. The parties involved must be able to account for their actions and provide insight into their working methods. Ongoing digitisation and datafication have brought changes to the substance of the obligation to give account, the process itself and the availability of the required data. New questions also arise about where government responsibility ends and where that of the market or the citizen begins.

Who owns the data?

Generally, mobility infrastructure is publicly managed and also publicly funded. In decision-making processes dealing with new investments for infrastructure, cost-benefit analyses play an important role in justifying the required funding. Reliable estimates are needed on qualitative, quantitative and geographical trends in the demand for, and provision of transport.

Thanks to digitisation, more and more detailed data are becoming available, but traffic model designers and cost-benefit analysts do not necessarily always have access to them. Sometimes the owners of the data are willing to sell, but often they also benefit precisely from *not* sharing the data with others. This can be a matter of principle or a strategic move. In the United States, for example, Uber shares its data with the city of Boston, but not with New York. Boston—or rather Massachusetts—legally recognises Uber as a transport provider, while New York does not (Morozov, 2014; Ballon, 2016).

Another interesting example is the Dutch travel card (*ov-chipkaart*, a multi-modal public transport smartcard valid throughout the country). Both the operation of public transport services and the management of the *ov-chipkaart* system have been privatised. Initially, the government did not have access to the public transport usage data because it had failed to make sufficiently clear agreements with these transport services, even though these are owned or heavily subsidised by that very same government. Since then, the availability of these data has improved considerably (IenM, 2016). These examples show that the way data are handled is an important focal point when drawing up new regulations, issuing concessions or granting licences.

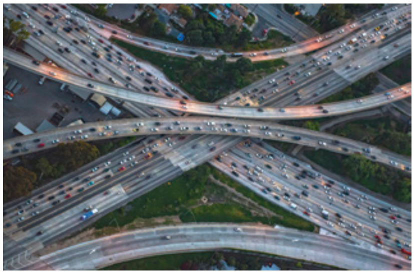
Other rules?
The arrival of new players in the transport market, such as Uber, also calls for a reflection on—and probably a revision of—regulations and policy. Digitisation has changed the world of traffic and transport and made it increasingly difficult to define the transport sector. The new players may be relatively elusive, as existing laws and regulations were not created for digital services such as Internet platforms. As a result, the new players can often quite easily steer clear of all kinds of collective regulations with regard to issues such as tax liability, labour law, sustainability and competition. Uber, for example, has always profiled itself as an *intermediation service* rather than a taxi company, partly in order to avoid having to comply with all kinds of regulations concerning matters such as requirements for drivers, vehicles and employment contracts. In May 2017, however, the European Court of Justice ruled that Uber is a transport company and therefore needs to comply with the rules that are applicable to that sector.

This all means that it is difficult for governments to keep a clear perspective of these new markets and regulate them. All around the world, they are struggling to set and enforce limits, and they are using case law to define new limits case by case. In addition to taxation and business economic matters, this also involves court actions on privacy or nuisance issues. Consider, for example, the inconvenience that many cities endure because of Airbnb—dwellings are withdrawn from the housing market while there are large numbers of house seekers; regular residents experience trouble from—sometimes partying—tourists in their apartment block; and hotels are faced with unfair competition because Airbnb hosts do not have to comply with all kinds of fire and safety regulations. When dealing with new services that are organised very differently than before, for example through Internet platforms, determining how a government can impose requirements on the activity is something of a quest. Sometimes governments even choose to offer services themselves or argue in favour of such steps, because monitoring and regulating seem too difficult. In South Korea, for example, a competitor for Uber has been set up with the support of the government and the taxi industry[9], and in Amsterdam an appeal was made to then Mayor Van der Laan to have the municipality establish a local platform for renting accommodation[10].

Normative matters buried in software?
In fact, there is the more generic question of how we can safeguard public interests in a digital age marked by smart vehicles and Internet platforms that can collect and disseminate all kinds of data. Moreover, these systems operate more and more independently on the basis of programmed rules and self-learning mechanisms, which are even more difficult to follow. Especially with regard to self-learning systems, the primary concern is no longer setting requirements for what may be included in the code, but setting requirements for the subsequent machine learning processes. This involves, for example, the question of which data form the basis for a learning process and whether it is desirable or necessary to make data sharing compulsory, so that the process does not draw exclusively on its own circle of customers. Another major new challenge is the monitoring of adherence to the rules and to the requirements set out in the rules.

In any case, it is no longer just individual citizens, organisations, conventional vehicles and the corresponding infrastructure that are the object of policies and regulations, but also robots and algorithms. The increased diversity of entities for which rules or policies are to be developed also means that the focus should shift from formulating specific technical requirements and specifications to formulating the public values and goals that are to be safeguarded.

Investing in uncertainty
The increasingly important role of the digital world means it is becoming more difficult to determine whether the right public investments are being made. It is becoming more and more difficult to make well-founded estimates of future mobility, and therefore to determine which long-term investments in, for example, road infrastructure or public transport are wise and which are not. Partly due to digitisation, the variety of journey patterns keeps on growing, while the patterns themselves change more and more rapidly. The service providers in the mobility system, and the roles they play, are also changing. New questions focus on the type of services that the infrastructure should include, and on the responsibilities of the various players in the chain. For example, about the basic offer that market players may expect: can manufacturers of self-driving cars assume that all traffic lights are capable of communicating with vehicles, or that all parking spaces are fitted with a sensor that communicates their availability to the world? This information is relevant for the large-scale implementation of certain services, such as parking assist apps, or driving support functions in a car. It involves making choices. Does the government itself want to be the party that sets the framework or even offers the services, or will it leave things—regulated or otherwise—to the market?



Various futures for automobility.

It is clear that digitisation creates greater uncertainty about the future demand for infrastructure. But even in a society that has gone highly digital, there is still a need for physical infrastructure to move people and goods. This infrastructure requires great investments with long depreciation periods. Given that it makes no sense to build a single kilometre of motorway and then see if more is needed, infrastructure is almost by definition large scale. Worked out on the drawing board, it is the result of a long and careful planning process and based on offering functionality in a one-size-fits-all approach. Moreover, the long service life of infrastructure leads to high levels of path dependency: roads and railway lines determine the options for transport for extended periods of time and are one of the factors affecting spatial developments that may take place.

4 Smart electricity supply

4.1 The electricity system on the move: energy transition and digitisation

Over a period of a hundred years, the basic infrastructure for electricity supply has hardly changed in the Netherlands (Weijnen et al., 2015)[1]. However, in the past few decades, the organisation of the service has changed considerably. Since 1998, the market has been liberalised and internationalised, and a round of privatisation has taken place, causing a shift towards commercial suppliers and producers. This means that electricity production has been uncoupled from the grid infrastructure. The electrical grids in north-western Europe have become more interconnected, a European electricity market has opened up, and grid managers and electricity producers now operate across borders.

In addition to internationalisation, privatisation and liberalisation, two other developments play an important role in the electricity system: the transition to renewable energy and digitisation. A basic aspect of the transition is that electricity is set to play a much greater role as an energy carrier, which of course has major consequences for the design of the infrastructure. As mentioned in previous chapters, digitisation probably plays a decisive role in making the transition in the electricity system possible.

This chapter first examines the transition and the digitisation of the electricity system. After that, it discusses their effects on the public values that are relevant to energy supply services. For example, what does digitisation mean for every citizen's access to affordable electricity, and what are the consequences of digitisation for the reliability of the energy supply?

4.2 Pressure on the electricity system: the energy transition

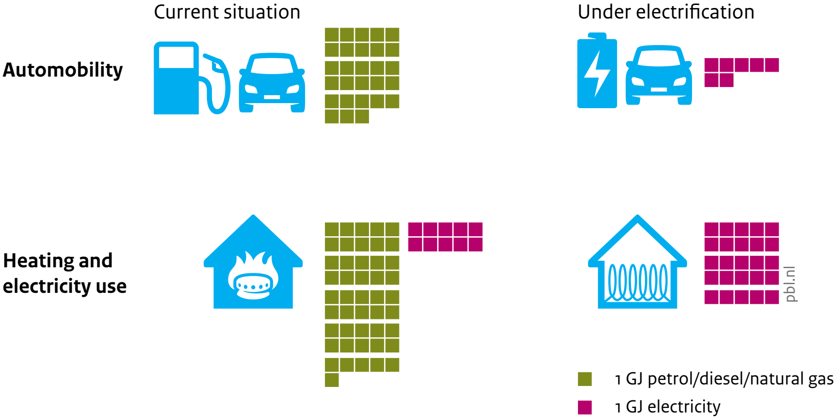
The transition to sustainable energy, which is now slowly getting under way, has major consequences for the Dutch electricity system. Production must not only be made more sustainable, but also drastically increased. To comply with the pacts made in the 2013 Energy Agreement, around 40% of electricity has to be generated using renewable sources by 2023. For comparison, in 2016, the figure was just over 12%[2]. According to the 2016 National Energy Survey, about half of the electricity production could originate from solar and wind energy by 2030 (ECN/PBL/CBS/RvON, 2016).
The increasing number of sustainable production sources calls for a more flexible electricity system. This is because clean energy sources, such as sun and wind, are not able to supply a steady amount of electricity without interruption. They depend highly on local weather conditions and their production is subject to large seasonal fluctuations. The current system has big problems with responding flexibly to the varying supply of electricity. Electrical grids are sensitive to overload and disturbed balance between generation and consumption. The physical characteristics of the network call for a proper balance.

Disruptions can occur in the network if the amount of electricity exceeds the maximum capacity of the network or if consumption and generation are not balanced. For example, it has already emerged that solar panels in Groningen cannot at all times supply electricity at their full capacity, because the low-voltage grid in the area cannot handle such amounts[3]. There have also already been reports of overloads in neighbourhood networks due to the concurrent charging of several electric cars. For now, these are local occurrences, but they may well be the harbingers of more extensive incidents that need to be prevented.

These problems exist at different levels, ranging from local to international. It is possible to achieve a more flexible load on the grid by creating a stronger, cross-border network and enhancing flexibility in generation and consumption. Short peaks and drops, lasting hours or days, in the supply of electricity could be offset by storing energy, both locally—such as in batteries—and remotely, for example, by pumping water up to elevated water reservoirs, as is done in Scandinavian countries and the Alps. The size of the grid also counts: the larger it is, the better the local variations in the supply of solar and wind energy can be cancelled out.

Figure 4.1

Effect of electrification on household electricity use, 2015



Source: PBL

Electrification leads to heavier loads on the power grid

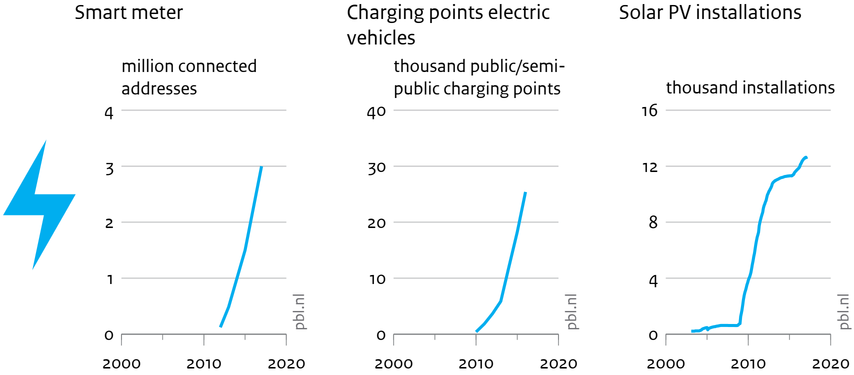
Explorations of ways to make electricity consumption more flexible aim to make it adjust better to a more erratic pattern of supply. For example, the power consumption of refrigerators and washing machines could be tuned more finely to the fluctuating generation by solar panels. According to many, digitisation plays a crucial role in this field.

At the same time, the production of electricity has to increase due to electrification, the process of replacing fossil energy sources such as natural gas, diesel and petrol. This leads to more pressure on the network. For example, the forthcoming revision of the natural gas supply system means homes will have to be heated in a different way, by switching to electric heating or using heat networks and heat pumps (EZ, 2016c). Also adding to the demand for electricity is the growing number of electric cars, a development related to the ambitions of car manufacturers and the Dutch Government. One of the aims of the Energy Agenda is that 100% of the cars sold in 2035 be sustainable, that is, powered by electricity or hydrogen (EZ, 2016c). When a household chooses to have electric heating and an electric car, their electricity consumption triples (see Figure 4.1). If these are introduced at a large scale, the load on the low and medium-voltage distribution network is sure to increase proportionately, and probably more so at peak times.

There are also other ways in which the transition to renewable energy causes a great deal of dynamism in the physical electricity infrastructure. In recent years, the number of installations connected to the network has been growing dramatically, including charging stations for cars and solar panel systems (see Figure 4.2). And many homes have already been connected to the grid via a smart meter.

Figure 4.2

Dynamics of electricity infrastructure



Source: ACM; CROW; CertiQ

The number of smart meters, charging points and photovoltaic installations has been growing quickly in the last few years.

Finally, the pressure on the capacity of the electricity grid is also increasing due to the growing number of decentralised producers of renewable energy. The energy transition is occurring together with a shift from power supply by a few large generation plants within a hierarchical, mostly centralised system, to supply of electricity that is generated more and more at the local level. Increasing numbers of local parties, both individual and collective, are producing sustainable electricity with solar panels and wind turbines. Thanks to tax incentives and the falling prices of solar panels and batteries, more and more opportunities are opening up for consumers to produce electricity themselves, join a collective or sign up with a supplier of their choice. This results in two-way traffic on the power grid: it is no longer just about power supply from the grid to the user, but also from the user back into the grid. The predictability of the network load is also decreasing. Together, these two factors make it more complicated to balance the electricity grid.

4.3 Digitisation is closely linked to the energy transition

Digitisation is penetrating the world of electricity more and more. Ever-growing numbers of producers and devices are continuously connected to the Internet through sensor technology and consumers can check their electricity consumption at any time on in-home displays. As discussed above, digitisation is also seen as a possible solution for the issue of flexibility in the electricity system.

4.1 Smart meters offer opportunities and meet resistance

With the introduction of the smart meter, the Dutch Government wants to serve the public interest: the most important aims are to reduce greenhouse gas emissions, keep the energy supply affordable and ensure the reliability of the energy supply. In 2015, the grid managers started offering smart meters to households and small businesses on a large scale. Up to 2015, there were 1.9 million connection points; by 2020, smart meters will have been offered for approximately 8.5 million connections points (EZ, 2016ab). Some of the potential users of these meters are putting up resistance because of possible violations of privacy. Further introduction has therefore been postponed and after a debate in the Dutch Upper House, consumers have been granted the right to refuse a smart meter or the sending of data. It should be noted that only about 3% of the potential users refuse having their consumption data sent to the electricity supplier[4,5].

The smart meter therefore serves various purposes[6]. The expectation was that smart metering would play an important role in energy saving in built-up areas and that households would start using less energy as they became more aware of their consumption, and especially, of the related costs. A smart meter would provide more insight and thereby contribute to goals of sustainability. However, now that over 20% of the smart meters have been installed, it appears that actual energy savings are falling short of the expectations (Vringer and Dassen, 2016). It might be possible to more fully exploit the potential of smart metering by adjusting the lines of the current policy. A promising option is to start up an experimental programme that combines the installation of smart meters with the use of energy consumption managers such as in-home displays.

Digitisation in the world of electricity: smart meters and smart grids

As more and more electricity producers and consumers and electric appliances are being connected to the Internet, they become part of a 'smart' environment. Many homes, for example, are already equipped with a smart meter that automatically sends the electricity readings to the energy supplier (see Text box 4.1). These meters also generate a treasure trove of personal data, which suppliers, consumers, service providers, infrastructure planners and the like can have at their disposal, provided all involved want and allow them to. At a larger scale, the grid managers can carry out their capacity management by using vast amounts of these data along with the algorithms derived from them: building on the real-time data, they are able to face the challenge that lies in variations in consumption and production and keep the electricity grid stable and optimise its operation. Smart meters can also optimise household electricity consumption by adjusting the functioning of refrigerators, freezers, washing machines, dryers, heating systems and other appliances to the fluctuating electricity production by installations such as solar panels and local storage. Or, of course, by adjusting to fluctuating prices.

The smart grid is part of the solution to the flexibility issue

Aside from the smart meter, in the future smart grids will also be able to absorb the spikes and dips in electricity production and consumption. This involves connecting devices to each other over the Internet. Spikes can be avoided by temporarily storing production from solar panels in batteries or by temporarily shutting down consumption. An often-used example of levelling out local spikes is smart combi-fridges that, in a certain area, all switch their cooling motors off (or on) at the same time, thereby lowering local electricity consumption. Refrigerators and freezers do need to stay within a certain temperature range, but as long as that is the case, it does not matter much when the cooling system is switched on.

When many different devices are interconnected via the Internet, they form a whole with a huge consumption potential and can function as a system to maintain the power grid load balance in a certain region (e.g. Elzenga, Montfoort and Ros, 2006; PBL, 2009b). The development of smart grids is already well underway (IEA, 2014,2016; ECN, 2016; Naber, 2016). This mainly concerns distribution networks, the regional medium-voltage and local low-voltage networks where two-way traffic is becoming more common due to the growing number of individual citizens who generate solar energy (Figure 4.3). This means that the electricity supply must not only be tuned to local consumption, but also to local production. This can be done at the neighbourhood level or that of a single building[7]. Consider the possibility of using the batteries of electric cars as temporary storage (optionally with blockchain technology[8,9,10]) or using geothermal energy or waste heat from industries. But there are also options at the country level: cross-border electricity exchange can be carried out when a country's national production is very low while consumption is high, and vice versa.

Internet platforms also operate in the energy world: globally and locally

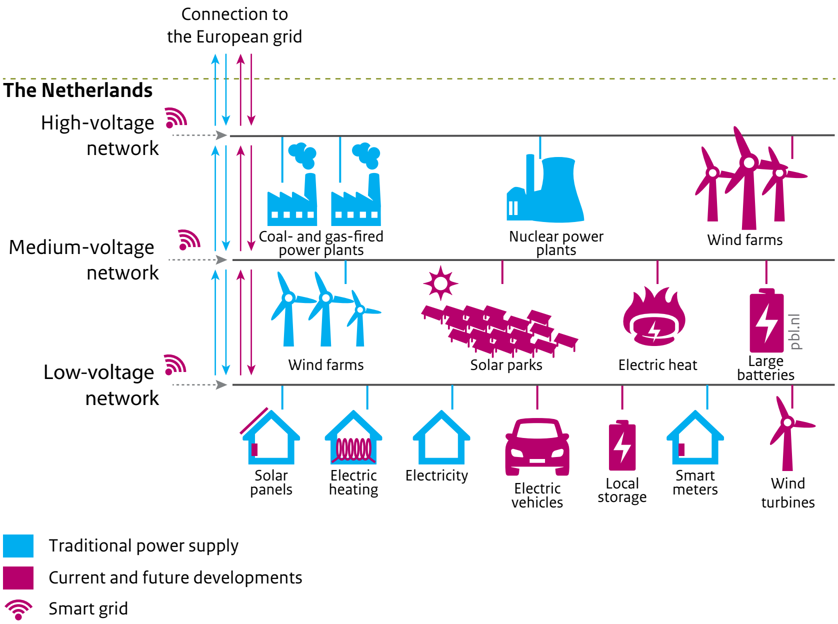
Thanks to digitisation, more possibilities exist to provide and use electricity services. A wide range of electricity-related services is in development, including those offered via Internet platforms.

As described in Chapter 2, digital platforms can be interesting for both consumers and providers. For example, through platforms individual consumers create market power, which they can use to negotiate a lower price or increased sustainability. It is a way for consumers to further the market mechanism that was being sought in the early 21st century by liberalising the electricity market. The number of people switching to another energy supplier has been growing in the last few years.

And, although they still only represent a small share of the total supply, both private individuals and electricity companies are launching numerous local cooperative initiatives. Grid manager Enexis, for example, has set up *Buurkracht* (neighbour power), a digital platform where local residents can register to be part of a joint, neighbourhood-level effort to save and generate energy. There are also

Figure 4.3

The Dutch electricity infrastructure



Source: Tennet; adaptation by PBL

The existing electricity grid has undergone many changes in recent years and will continue to change significantly in the coming decades. Enormous amounts of decentralised generation capacity will be connected to the network, including solar panels, storage equipment and appliances such as charging poles. Digitisation will also increase, partly due to the connection of smart meters and growing numbers of smart devices.

platforms for individual citizens and companies that generate their own energy with, for example, solar panels or biomass generators. On these platforms, they offer their excess production directly to consumers. Notable nationally operating platforms in the Netherlands are Powerpeers and Vandebron, which has already become known as the *Airbnb of green electricity*[11].

At the local level, a lot of experiments are being done on the possibilities of smart grids. Along with the local authorities, businesses and citizens are taking part in trials, such as the 12 testing grounds for smart grids that started in 2012 (EZ/RVO, 2016; Naber, 2016). Tests on smart grids are also taking place on a larger scale, for instance in Rotterdam. In the Merwe-Vierhavens district, grid manager Stedin is working with the municipality and business partners to roll out a smart grid on a much larger scale than usual, with more than 20,000 connection points.[12]

In all sustainable energy initiatives and platforms, the challenge remains of really involving citizens. Leaving aside the so-called *early adopters*, it is difficult to get citizens involved in smart energy (Dignum et al., 2017; Vringer and Dassen 2016).

A requirement for the introduction of smart grids is that larger groups of people join in. Depending on the made assumptions, between 4 and 20% of households need to adopt flexible patterns of electricity consumption to ensure the introduction of smart grids in the Netherlands is cost-effective (CE Delft and KEMA, 2012).

In addition to bodies working on local, small-scale initiatives and grid managers, the traditional and large energy suppliers, such as RWE in Germany, are also making grateful use of the opportunities offered by digitisation. They are trying to restyle themselves as electricity managers or traders in smart leisure time services and smart lifestyle[13]. Besides providing the physical product, electricity, they are developing more and more digital services in areas such as climate control, culture and entertainment, and provision of information.

There are also new players entering the world of electricity supply, ranging from large tech giants to local collectives, who sometimes operate in collaboration with municipalities. For example, the major Internet companies such as Google (Alphabet), Apple, Facebook and Amazon are getting more and more involved in bundled services (smart living package) in the areas of lifestyle, health and care activities, energy, mobility, music, entertainment, social contacts, goods delivery and news. This includes the corresponding hardware, such as data centres and solar parks (Google Energy[14]), cable systems (Google Fiber) and gadgets such as glasses, watches, home energy displays (Google Nest, Apple HomeKit), and (self-driving) cars (Apple cars and the Google Cars spinoff Waymo).

This wide variety of services is delivered through an equally broad range of revenue models, some of which are motivated by idealistic notions, but often related to electricity supply. The individual real-time data on energy consumption and production, and their combination with all kinds of related issues such as consumption and cultural preferences are matters that undoubtedly represent a high potential monetary value in the new digital age. This kind of business model is no longer only concerned with extracting and exploiting natural sources of energy, or providing services that are more and less related to that, but also about collecting and using data (big data) that are monetised in another way. As Marc Hijink put it in the newspaper NRC: 'It is the curse of the Internet era. Objects with a plug become objects that leave a trace of data [...]. All of a sudden you go from being the owner of a product to being a part of the product.'[15]
Traditional players are also trying to get a foothold in sectors they previously had never explored. TenneT is trying to attract customers to cover the excess capacity of their fibre optic cables[16]. Therefore, in 2003, TenneT and ProRail set up the joint venture Relined to lease the unused glass fibre capacity[17], also known as *dark fibre*. Similar initiatives have been launched in Iceland and Switzerland. A state-owned electricity company in Italy is making plans to build a high-speed fibre optic network in order to further increase gains from the smart grid, in terms of both money and data.

4.4 Uncertainty lies ahead: three outlines of the future of electricity supply

Here, three possible futures are described to show how the electricity system might evolve and what the consequences could be for public values. The descriptions are loosely based on the future scenarios created by the Dutch grid manager Enexis (Enexis, 2016): *Silicon Valley City*, *Swarm City* and *Cockpit City*. They differ in the extent to which market parties drive change and governments exert control. The scenarios are used only to compare three general possibilities and reflect on their consequences. Dilemmas and challenges emerge from these future visions with regard to matters such as security of supply and efficiency, the role assumed by the government and questions about accessibility and manageability. The study has also drawn inspiration from various other sources, such as the *Horizon Scan for Welfare and the Physical Environment* (PBL/CPB, 2013), *Re-programming Mobility* (Townsend, 2014), *Governing the data polis* (Meijer, 2015) and an interview with Pallas Agterberg of grid company Alliander on the future of the energy supply (Vrij Nederland, 2016).

4.2 Three outlines of the future of electricity supply

Silicon Valley City: a market with small players and big players

In Silicon Valley City, households occupy a smart home full of controllable devices, electric bicycles and cars, home batteries, solar panels and the like. For their energy production and consumption, they use management services offered by globally operating platforms. Many households are *prosumers*: they form small private 'power plants' that feed electricity into the capillaries of the low and medium-voltage grid. Regionally operating private service providers will increasingly be assisted or taken over by large global Internet platforms with an extensive network and broad knowledge of customers, such as the large tech companies. Specialising in big data and algorithms, they are able to combine their services and data with other services such as mobility and care. For these companies, data are hard cash and not merely an item on the expense account. New players will start to operate. Google, for example, whether or not in collaboration with the traditional electricity companies and other new players, such as Siemens, ABB, Shell and Tesla. Car manufacturers operating worldwide will take care of the home charging piles and high-speed charging stations for electric means of transport, possibly in combination with the provision of international goods transport with their own self-driving lorries.

To make the most of their energy management, households need space for solar panels, charging piles and energy storage. In Silicon Valley City, physical space is therefore a prerequisite for private electricity production and storage. As a result, the dense city centre is left behind in favour of spacious suburbs or even countryside developments with new dwellings built in a traditional farmhouse style. This alternative, therefore, foresees fragmented urban development within vast, spacious, green cities. Self-produced energy means that driving all those extra kilometres can be done almost free of charge in an electric car, at least by those who can afford one. The electric car can also be used to further expand the storage capacity.

While consumers and suppliers can all freely feed energy into the grid without playing an active role in network management, the grid will need to be reinforced considerably to deal with all the peaks and troughs. So much more is needed that grid managers are constantly digging trenches for cables. If no grid reinforcement is undertaken, even the slightest issue can lead to power cuts in local networks.

Digitisation and a smart grid can provide a solution for the balancing of supply and demand and level out peaks. However, the associated data and algorithms for real-time consumption and real-time use are mostly in the hands of private service providers. If the regional and even national and international grid managers and governments do not have the data, it is more difficult for them to plan network and production capacity for the short and long term. The grid managers may then try to work out the network load by charging those service providers—and therefore the households—not only on the basis of variable kilowatt-hour rates, but also through variable transmission tariffs. Due to the high cost of transmission during peaks, it may become profitable for those service providers to produce additional electricity locally or store it, to ensure they will only need to transmit as little electricity as possible over the public grid. This can also result in service providers deciding to build their own local networks to have control over transmission and distribution costs; for example, in more affluent neighbourhoods where service provision is most cost-effective and data are the most valuable. These consumers then become the so-called *deserters* of the collective network. The downside of this development is that the cost of the collective network has to be shared between fewer and fewer consumers, which frequently include the most vulnerable groups.

Silicon Valley City innovates intensively and can contribute to a sustainable system of energy supply. Equal access to services can be compromised. Not nearly everybody will have the resources and possibilities to benefit fully from the services. Silicon Valley City is also vulnerable to concentration of power, safety issues and security of supply. Network balancing and, therefore, security of supply is largely in the hands of market players with their self-learning algorithms. If there is only one, or just a few suppliers, there is a risk of high costs and limited freedom of choice. The heavy concentration of power among international technology giants means the possibility of government control is also limited. Such control is best exerted at the level of the EU (competition). Efficiency is enhanced if grid managers also have access to the data on production and consumption.

Swarm City: citizens and market parties come together in a smart grid

In Swarm City, citizens themselves take care of electricity management together with local market players. The number of decentralised initiatives for sustainable energy provision grows dramatically. Citizens make optimal use of their freedom of choice offered by the market for digital electricity services. Affordability, sustainability and self-sufficiency are important motives. Local communities aim to collectively satisfy their own energy needs as much as possible. The local authorities adhere to their vision of the 'energy-neutral region of Swarm City' and subsidise all kinds of initiatives for individual generation and energy saving. Many so-called *prosumers* produce electricity—usually collectively—in shared solar parks outside the city. This generated and stored energy is traded through a variety of digital service providers who operate on online platforms employing super algorithms to make optimal use of place-based and time-based dynamic prices. Self-driving cars from outside the city are also powered with collectively produced electricity. The sharing economy of electricity and mobility services in the city is thriving on digital platforms.

To apply the Swarm City model on a large scale, there has to be a smart grid serving as the pivot of energy demand and supply. The regional grid manager is first of all responsible for system balance on the network at the regional level. This requires an amendment to the Electricity Act of 1998. The managing body takes maximum advantage of the opportunities of digitisation and platform structures (see Chapter 2). Swarm City will use as little electricity as possible from the collective grid. A less appealing aspect of this future is that residents who do not wish to be part of a neighbourhood collective are more or less expected to move.

A variant of Swarm City could be a district or village where energy saving and sustainability are key to the main motive of being locally self-sufficient. Residents want to become deserters of the collective network as soon as possible, out of mistrust towards governments and large companies, and in order to protect their privacy. If, consequently, the collective electricity infrastructure is only used in emergency situations, the financing of the infrastructure will come under pressure. Moreover, those costs will mainly be borne by those who do not join the deserters because they lack, for example, ideological fervour, money, organisational capacity, knowledge or the necessary space.

Cockpit City: the government as the protagonist in a smart supergrid

Cockpit City aims to have mandatorily collective, large-scale, standardised solutions to which everyone has access. The government is without question the administrator of the electricity system. There is a single central control room for overseeing energy management. The grid manager deals with the stability and optimal use of the network. To this end, a comprehensive measurement and control system has been created to remotely collect, combine and analyse individual data on consumption and production. Whenever possible the data are used for real-time optimisation of the system. A possible measure is remotely switching on and off power-intensive appliances, such as the combi-fridges mentioned in Section 4.3. The user has few options and little to gain with individual initiatives, and the number of local service providers on digital platforms remains limited. Electricity is mainly drawn from large-scale solar farms and wind farms within the country, abroad and at sea. Grid managers exploit their own smart grids. The government also owns the data needed for long-term planning for infrastructure and grid reinforcement. Strict legislation and tax measures are in place to ensure solutions are achieved. The grid manager is also responsible for the implementation of charging equipment. There is a strong focus on grid reinforcement at the local level, which means public works are carried out regularly. The European supergrid connects countries and regions and is also intelligent: a smart supergrid.

Cockpit City is vulnerable to power outages or shortfalls in production throughout north-western Europe. Due to the complexity of the network, centrally controlled from the cockpit, the risk of a large-scale outage is small, but the consequences are far-reaching, because a malfunction or a power cut can disrupt the entire society. These problems can also be caused deliberately, given the many interactions with the Internet. Balancing supply and demand is expensive due to the huge tasks related to grid reinforcement and buffer capacity. Network balancing offers few opportunities for the market and consumers. However, the costs are covered by Cockpit City as a whole, which means that for the individual household the price tag will be reasonable. Security of supply, solidarity (collective payment, partly in proportion to income) and equal access are properly safeguarded. This vision leaves a lot of space for government control, but at the same time there is little room for alternative opinions on sustainable and fair energy supply systems, privacy aspects with regard to use and ownership of data, and possibilities for self-determination beyond collective solutions. The guiding principles are the cockpit and the values and norms that are hidden in technology, software and algorithms.

4.5 Public values: opportunities and challenges

Because of developments such as the energy transition and digitisation discussed in Sections 4.2 and 4.3 above, the electricity grid is undergoing rapid changes. The future electricity system can develop in various directions (see Text box 4.2). Wherever that is depends on choices, ambitions, the scope for regulation and options for financing among players such as grid managers, energy producers, service providers, investors and consumers. But the room that the Dutch Government leaves for the interpretation of digitisation and the energy transition can also have a major influence.

Developments in energy transition and digitisation are posing dilemmas and challenges around public values. The digitisation of the electricity infrastructure and the associated provision of services bring great benefits to citizens, businesses and public authorities. It ensures more optimal use of the network, increases our freedom of choice and helps make our energy supply sustainable. But what is the outcome with regard to accessibility and affordability of facilities for all citizens, or with regard to security of supply?

4.5.1 The impact on efficiency and freedom of choice

Digitisation contributes to efficient use of the electricity infrastructure; a smart network can make optimal use of the capacity of the infrastructure[18]. Smart flexibility options make it possible to improve the matching of supply and demand. In other words, a smart grid promotes efficient and balanced energy management which avoids overburdening or underutilising the network.

Such improved use of infrastructure reduces the need for costly expansion of infrastructure facilities. Smart flexibility options can be an alternative to grid reinforcement with additional cables, since they can limit the extent of the necessary upgrade or defer it. For example, digitisation enhances affordability for users who have to contribute to the cost of cabling work through fixed charges and taxes. Cost savings are biggest in the scenario that projects a drastic increase in electric transport, that is, the vision requiring the highest level of flexibility (Ecofys, 2016). Although the cost savings are substantial, the costs of setting up smart grids are not insignificant either (CE Delft and KEMA, 2012). These costs are passed on to the grid managers and energy suppliers, and therefore ultimately end up affecting energy users: consumers and businesses.

Efficient, balanced energy management brings down the costs of transition to a cleaner power supply service. Consequently, the Dutch Government, the EU and the grid managers welcome digitisation. This is, by the way, not only for reasons of efficiency and cost: the government also sees a market for Dutch companies to sell the technology they develop for infrastructure digitisation. In short, from the point of view of efficiency and the transition to sustainable energy supply, the application of digital technology is an obvious part of the solution. Still, not everyone is fully convinced that this is so: 'Electrocrats have been plugging the 'smart grid' for years. Now others have joined them' (The Economist, 2009).

However, digitisation and smart grids alone are not enough to ensure load balancing on the grid. Dynamic rates can also serve as an incentive to reduce peaks in grid use and contribute to efficient energy supply. If electricity becomes more expensive during certain time slots, this may have consequences for public values such as accessibility and privacy, and possibly also for acceptance (see also Text box 4.1).

There is no doubt that ICT can enhance freedom of choice because it means more options become available in the energy services. Consumers have more opportunities to organise their own tailor-made solutions (see Swarm City in Text box 4.2). Digitisation simplifies tasks such as setting up co-operative energy producers, choosing energy suppliers, and calculating the balance of individually

Grid managers maintain the load balance on the network.

consumed and produced electricity. In addition, it enables a more optimal use of the fixed networks. And since more parties can share a single network, the efficiency of that part of the infrastructure also increases.

A point open to discussion is what digitisation means for the knowledge position of supervisory bodies, grid managers and governments. Digitisation is creating ever-growing amounts of increasingly detailed data, in various systems and at various parties. Information flows are being optimised according to the data collectors' needs, such as avoiding congestion on the grid and efficient energy use. But are these data always accessible or suitable for long-term planners, designers of cost-benefit analyses and supervisory bodies? It may well be that these parties find the data unhelpful or that they have no access to them due to legal, administrative or technical obstacles. This could make the issue of giving account more complicated. In addition, it may become more difficult for supervisory bodies, grid managers and governments to render account for the effectiveness of long-term investments in infrastructure services and networks.

4.5.2 The impact on security of supply, accessibility and sustainability

Every household in the Netherlands must have the possibility to use electricity. To safeguard this, the power grids remained in public hands during the liberalisation process—the national government, the provinces and city councils. Public network companies are responsible for issues such as grid stability and security of supply. Besides their regulated management tasks, they also carry out commercial activities. One of the supervisory bodies, the Netherlands Authority for Consumers and Markets (ACM), is responsible for overseeing the functioning of the electricity market. The question is what the influence is of the digitisation of the electricity domain on public values such as security of supply, accessibility and privacy.

Security of supply is at issue
Digitisation improves the balancing, management and maintenance of the power grid. ICT lessens the chances of network failure. But bringing intelligence into the network also has its drawbacks: security of supply can be compromised in several new ways.

Society is highly dependent on the Internet, digital facilities and electricity. The consequences of a failure or a hack can be important and chaotic and degenerate into social disruption. The increasing complexity of ICT applications, however, means they are actually very sensitive to disruptions and power cuts anywhere along the supply chain. And since the system is connected to the Internet —through smart meters, for example—it is also sensitive to influences originating at great distance. It means the system can be disrupted intentionally by hacking attacks on algorithms, systems and data. At the end of 2015, for example, a power plant in Ukraine was hacked and 700,000 households had to do without electricity for several hours. Other power plants were also hit. Further attacks have occurred in the United Kingdom, and recently also in Ireland energy companies have been the target of hackers.[19] Cars that are becoming increasingly intelligent, refrigerators and homes can more and more be looked upon as supercomputers, a part of a computing grid that can also be used for unlawful purposes.

Thanks to digitisation, larger and larger amounts of increasingly detailed data are available. However, at the same time, systems are becoming more and more complex and inaccessible, self-learning algorithms are becoming less transparent (doubts as to whether the appropriate data are being used), less traceable, and more difficult to test prior to implementation. The coming and going of platforms leads to networks that are potentially very dynamic and increasingly complex, and to fragmented chains of service provision. This causes things to get less manageable, since it is not possible to identify a central body that is in charge. All parties are necessary to ensure the software and associated data flows function properly. It is necessary to determine the understanding of all players' roles with regard to responsibilities and issues such as rules for data exchange. If this is not done, or done too late, the security of supply for individual customers may be endangered.

Accessibility is compromised
Equal accessibility too can be compromised, if more use is made of the possibilities to supply electricity under more customised arrangements and self-sufficiency schemes. One of the ways this is done is by joining collectives that use digital solutions to help their members optimise electricity consumption, self-generation and storage. The threat to equal accessibility can have financial

causes—when an individual lacks the resources to buy or repeatedly upgrade the necessary devices; social causes—when an individual has no social contact with rapidly innovating groups or is under-represented in the big data that drive change; and psychological causes—when an individual is no longer willing or able to keep up with yet another new development. Just as in the case of mobility and, for example, care services, accessibility is partly determined by the extent to which people have the skills and psychological flexibility to assimilate all the changes in the new, digital, hyper-connected world (see also WRR, 2017: *Weten is nog geen doen*). Decentralised, private arrangements also require that users and participants have a certain capacity for self-organisation. For example, not everyone can take advantage of the new possibilities of personalised energy management in equal measure.

Social fairness can become an important issue when infrastructure systems increasingly rely on private platforms and providers whose services run on unidentified supporting algorithms. While this can offer many advantages, in some cases customisation and commercial profiling may lead to the exclusion —consciously or unconsciously—of users from services[20]. Supervisory bodies provide protection against this, but the question is whether they have sufficient means to identify new cases of abuse and take remedial action in good time. The minimum services will remain accessible, but will the less affluent also be able to share in the benefits offered by digitisation? Or is it the case that people who are able to handle digitisation benefit in such ways that the divide between '*cans*' and '*cannots*'[21] actually gets bigger (see Putters, 2017)?

Incentives in the form of dynamic pricing may promote efficient use of the network, but they can also increase inequality between people. Digitisation and datafication of electricity supply make it possible to monitor, in great detail, who uses what and when. In other words, to know who is demanding network capacity at any given moment. Electricity transmission rates can then be adjusted for peak hours. In California, this has already translated into reduced electricity consumption during peak hours by people with low-cost energy contracts: they switch off the air conditioning during that time frame, and get a lower energy bill in exchange[22]. The Dutch Ministry of Economic Affairs has also proposed complementing the current system with a dynamic pricing scheme (EZ, 2016b). Peak rates, the higher rates that apply during spells of intensive consumption, promote efficient use, but may exclude lower-income groups from consumption at peak times. With the datafication of the electricity supply, the question also arises whether consumers restrained by a lack of financial resources are urged to waive some of their privacy rights: obtaining a discount if their personal data are made available to the service provider.

Inequality can also arise because price-conscious consumers start investing in their own energy management and storage systems and therefore become less dependent on the collective electricity grid. People may also be inclined to make less use of public services for idealistic reasons, and aspire to generate and store their own energy, such as electricity from solar panels. Along with other groups, they can choose to become what are called *network deserters*: they disconnect, literally or functionally, from the collective network because of the costs, or for reasons of self-sufficiency, a move that is comparable to the ambitions of Texel Energie and Lochem Energie[23]. This means that part of the basis of collective financing disappears and that low-income groups may find collective power supply services becoming less accessible in financial terms. In extreme circumstances, and only if legal changes are introduced first, can this lead to a situation in which remote areas receive less maintenance, or households have to pay more for their connection point if they live further away from built-up areas (see also Text box 4.2).

Sustainability
Digitisation can contribute to the feasibility and affordability of the transition to sustainable electricity supply. Users can save energy once they have detailed insight into their consumption data, for example through the smart meter (see Text box 4.1). All kinds of new products and services can be linked to the smart meter to ensure that households manage energy as consciously and sparingly as possible. However, it appears that so far, smart metering has not been living up to energy saving expectations (Vringer and Dassen, 2016), probably because not enough attention has been directed to involving citizens in the process of introducing smart features into electricity services (Hoenkamp et al., 2011).

A new dimension for privacy
Digitisation of electricity supply services leads to a certain level of democratisation. Freedom of choice is greater and more parties can benefit from it, including consumers. However, it also contributes to businesses and governments getting to know a great deal more about consumers and citizens. Datafication and merging sectors can bring about the emergence of big data monopolies in both large platforms and governments and thereby concentrations of knowledge and power. This brings up questions about the legitimacy and supervision of data usage (see also Section 4.3.4).

4.5.3 Impact on transparency and accountability

Transparency on the use of data and algorithms is needed
As mentioned earlier, thanks to digitisation, ever-growing amounts of increasingly detailed data are becoming available. It is hard to ascertain what kinds of data are collected. It is hard to ascertain who collects those data and why, and how they are used. In other words, the types of data and the methods of collection and use are often not transparent for citizens, businesses and governments.

For example, it is hardly ever clear for citizens what exactly they are giving permission for, when an energy supplier requests authorisation to use data for service improvement. In addition, consumers do not know how properly those data are secured and find it difficult to gain a clear view of the consequences of giving consent. In 2015, the collection of smart meter data was temporarily suspended because third parties had been able to gain unauthorised access[24]. Today, questions remain as to whether users can assess data permission issues and whether security is properly organised.

Transparency is not only an issue for citizens, but also for governments and grid managers. Transparency about how data have been collected and processed is highly important to be able to provide insight and support in decision-making processes for investments in infrastructure.
While at present, data and data collection are often not transparent, the systems (smart grids) are only becoming more complex and inaccessible, and it is less and less clear to what degree the functioning of self-learning algorithms is still in line with the criteria that were initially programmed into them. Important questions are which data and decision-making principles formed the basis for this learning process and whether it is possible to verify if the values and norms that are factored into the algorithms, implicitly or otherwise, still apply. Another question is to what extent it is possible to ensure that smart grids, smart meters and Internet platforms comply with legislation and regulations.

Keeping a finger on the pulse of accountability
Accountability is all about assuming responsibility for the functioning of the service, which includes providing clear proof that the pertinent public values are protected. As result of digitisation, among other things, this seems to be getting more and more complicated for the infrastructure-based services for electricity. Supply of electricity has evolved into a highly dynamic and increasingly complex chain of services involving numerous players, and in which all kinds of information flows have become interlinked, and are being collected and analysed in real time. In such a system, it is difficult to gain a clear understanding of who is legally liable if things go wrong, how the responsibilities and rules for data exchange between players are organised, and how accountability is ensured.

The interlinking of information flows and actors is an issue in, for example, smart metering. Although the meter is installed in somebody's home or company, it remains the property of the grid manager. The data belong to the users, but they pass through many hands: the grid manager, the central data-controlling body of the network operators, the energy supplier (who needs to itemise consumption) and the users themselves (e.g. on in-home displays or via independent providers of energy management services). In this entangled web of involvement and implication, it is less and less clear who is responsible for what—take, for example, security of data (data leaks, identity fraud): a journalist was able to gain access to other people's smart meter data by providing some of their—easily available—personal data (NRC, 2015). Who is responsible? And what for exactly? And if the responsible party is identified, what consequences will that have for them and for the origin of the problem?

5 Public values are shifting and rules are lagging behind

The previous chapters have brought up the idea that digitisation of infrastructure and the associated provision of services brings great benefits to citizens, businesses and public authorities. Digitisation makes life easier, increases freedom of choice and makes the physical environment safer and more sustainable. Thanks to higher efficiency, consumers get more value for money, such as mobility solutions that are tailored to their wishes and customised service in the field of energy supply, sustainable electricity in particular. At the same time, however, pressure is mounting on familiar achievements such as accessibility, security of supply, privacy protection and democratic management. This chapter deals with the developments that threaten these protective public values.

5.1 More efficient and more sustainable, but at the expense of public values such as accessibility and security of supply

The chapters on mobility and electricity supply show that digitisation is mainly employed to make infrastructure and related services more efficient. For example, a wealth of new opportunities is being opened up to improve the use of fixed road infrastructure (Chapter 3)[1]. In the area of electricity supply, when more and more renewable electricity is generated at small-scale, local sources and fed into the grid, digitisation can help to work out and maintain the right balance in the network (Chapter 4). In digitisation projects, the general rule applies that efficiency is by definition 'good' (you can never have too much of it); the concept is often embraced as a 'natural and unmovable feature' of any ICT initiative (WRR, 2011). This is closely in line with the relatively dominant discourse of the last few decades, which considers efficiency to be the highest attainable goal in a context of a free market process (e.g. WRR, 2012b; Morozov, 2014). The new ICT-related opportunities also bring about technological and social innovations that greatly enhance freedom of choice in services that used to be in the public domain, such as accessibility and energy. Many new players are taking advantage of the situation. There are of course start-ups and the larger tech companies, but individual citizens and households can also gain more control, for example by generating their own energy, offering customised services individually or through small collectives, or selling their data.

However, something else is sneaking in along with this (unbridled) digitisation: the risks posed to protective, anchoring values. Accessibility and security of supply in particular are enduring pressure. Moreover, ongoing datafication and shifts to platform-based services can lead to social discontent, for example when globally operating platform monopolies systematically evade national rules, licences and tax obligations, while not hesitating to use the existing fixed infrastructure that has been collectively funded. The use of big data may also compromise privacy, self-determination and aspects of liveability and safety.

Accessibility: growing divides between social groups

Access to infrastructure and infrastructure-related services is generally regarded as a basic general right. Roads, public transport, electricity and natural gas are, roughly, equally accessible to every citizen. That is why planning, construction, maintenance and management of necessary infrastructure facilities are jointly financed through taxation or other collective schemes (see Chapter 1). The political consensus is that access to infrastructure should not be a problem for anyone. Consider in this regard the political sensitivity to road pricing.

ICT is exactly what makes it possible to survey the individual use of infrastructure facilities in better and more reliable ways. This information serves as a basis for price adjustments and makes it possible to deliver customised solutions: fares for passenger mobility during rush hour and rates for electricity consumption during peaks in demand. However, there is a downside to this: a loss of financial accessibility. Services can simply become too expensive for certain people in certain places at certain times, and then the threat of exclusion looms. Also, considerable numbers of applications using smart environments require relatively advanced hardware or gadgets. Just think of a smart refrigerator that only switches itself on during low-rate periods or an electric car that a household can also use to store its self-generated energy. Not everyone can afford to buy these digital devices and not everyone is equally able when it comes to using them. In addition, current technological developments can rapidly become outmoded—some smart meters already are. In short, if potential savings depend mainly on the level of sophistication of an individual household's equipment, it may well be that the expensive time slots and locations are precisely those that less well-off citizens are unable to avoid.

An extreme example of exclusion is described in one of Townsend's future scenarios for the United States: specific roads that can only be accessed by a certain type of self-driving vehicle (see Chapter 3). It seems unlikely that this will occur in the Netherlands, but it is conceivable that here too the use of ICT facilities for navigation or optimising traffic flow will be limited to relatively advanced vehicles.

Another effect of digitisation might be that the organisation of public services shifts more and more to the local level, where collectives or market players armed with ICT take a bottom-up approach. In extreme cases, neighbourhoods or regions would be able to largely or even completely disconnect from the national electricity grid, a move that is referred to as *grid desertion*. While in most cases full disconnection will not be feasible in the Netherlands, given the long periods of insufficient wind or sunshine, the support base for public funding of the collective national network can still be seriously eroded. A similar line of reasoning may apply to passenger transport, which is increasingly being organised via platforms, particularly in more rural areas. These might be about to take the place of more traditionally organised public transport systems (usually based on long-term concessions). They offer more customisation and more choice, but also make affordability and security of supply more vulnerable (Chapter 3).

Another factor determining accessibility is the level of necessary skills and psychological resilience that citizens need to possess to enable them to get on with all the changes and cope with the choice stress of the new digital, hyperconnected world. Of course, digitisation has the potential to greatly simplify access and use, but user-friendliness is not always a priority in the final result. It has become apparent that not everyone is taking part now, not by a long shot. Nor will everybody be able to take part in the future.

Although almost all citizens in the Netherlands are now connected to the Internet, in the digital world too, the social and cultural divide seems to be widening rather than narrowing (Van Deursen et al., 2014; CBS, 2015; SCP, 2009, 2016; WRR, 2017). Groups with higher levels of education do not only have more Internet skills, but they also use those skills much more often to advance their position in society, for example by taking online training courses, participating in knowledge networks and consuming great deals of news. People with lower levels of education tend to use the Internet more often for entertainment, to chat, play games, check their Facebook page, or exchange or buy goods. They are also more likely to pull out if they have to carry out administrative procedures over the Internet (Van Deursen et al., 2015).

Physical travel information panels remain useful for many people.

It is not in any way a matter of course that the dichotomy will become less pronounced over time, even when familiarity with ICT increases in all layers of the population (digital natives, SCP, 2016). Even with the current level of education offering in the Netherlands, there are still 2.5 million citizens aged over 16 who have low literacy (language skills below the standard for mid-level vocational education). Almost three-quarters of this group are under 65 years old (Van Deursen and Van Dijk, 2015). It is of course sometimes possible to make practical arrangements for citizens who are less digitally literate and help them to keep up—for example, by keeping physical front offices in place—but this is by no means always a solution. In certain cases, making improvements to the user interface can be of help. For example, software and hardware can be made more ‘people-friendly’ and less complex. Think of the special phones for the elderly with fewer and larger keys, and fewer, clearer functions. The process of population ageing, which is slowly but steadily unfolding, has led to the emergence of a growth market for specific ‘tech for the elderly’. In this group, inequality with regard to financial resources crops up once again. Not every elderly person has the money to buy these special devices (e.g. ING, 2016).

Finally, inequality in access to infrastructure services may increase as a result of calculated choices made by companies providing ICT services. Optimisation algorithms can readily exclude certain population groups or neighbourhoods, for example by combining data on social status, public security and similar concepts (Frenken, 2016; Townsend, 2014). This form of exclusion may arise unconsciously or unintentionally, if the service provision is tuned to a demand that is identified through the analysis of big data. If a population group is insufficiently represented in those data, or not all, then the corresponding demand is not identified. And especially in the first stages, self-learning algorithms will mainly learn from data on early adopters, who usually do not accurately represent the population as a whole (O'Neil, 2016).

Reliability: greater risks due to greater complexity and interdependence
With smart grids and smart mobility, infrastructures can be used in better ways and more flexibly. Use also becomes safer and can be matched to demand more effectively. A 'sightless' electrical grid gains the power of vision thanks to omnipresent sensors in homes and devices. From the control centre, the motorway manager can see traffic jams forming and take action, using variable message signs to lower the speed limit or divert traffic.

However, digitisation has also caused infrastructure to become more sensitive to malfunctions and failures, anywhere in a network that is as extensive as it is complex ('buggy, brittle and hackable', Kitchin, 2014). Failure can also be intentional, caused by hacking attacks on systems or data[2]. Smart cars, smart refrigerators and home automation systems can increasingly be regarded as supercomputers that are part of an all-encompassing computing grid that can also be used for malicious purposes. While it is true that failure in vital infrastructure can be tackled reasonably well, the consequences of a disruption are greater because the systems are more complex, more interconnected and, above all, more difficult to repair. A newspaper report on a power outage in Amsterdam in early 2017 illustrates this problem (NRC, 2017). In his well-known research into failing nuclear power plants, Perrow coined the term *normal accidents*: fateful events that have become practically unavoidable due to the ever-increasing complexity, interlinking and interdependence of systems and subsystems, almost regardless of the design effort that has been put into them (1999).

Even without the difficulties posed by hackers or other problems, manageability is becoming more and more complicated in day-to-day operation. The linking of data flows and software applications means that more players—both public and private—are involved in management (WRR, 2011). As a result, it is becoming increasingly difficult to identify a central body that is in charge. All players are needed to ensure the software and related data flows work properly. As long as everything goes as planned, this is all right. But if a public authority wants to make a change to the software supporting the infrastructure services, it may turn out that steps must be taken outside their own organisation, by another public body or maybe even by a private player. Conversely, the disappearance of a player can also have consequences far into the chain. For example, if an agency stops a data collection process, this can affect the functioning of municipal or commercial services.

The increasingly complex ICT applications, including those beyond the realm of infrastructure, demand a very high level of competence from managers, supervisors, policy makers and politicians. However, as yet knowledge about data and algorithms seems to be limited among public players, most certainly in the top tiers (Rob, 2016; Dutch House of Representatives, 2015; WRR, 2011). This can lead to situations in which no decisions are taken at all on important issues such as reliability, privacy, accountability along the chain, or other ethical dilemmas. In that case, what continues to prevail is the explicit or implicit choice towards effectiveness and efficiency[3]. This can be seen in the supervision efforts by ACM (the Netherlands Authority for Consumers & Markets), which are focused on efficiency and avoiding market failure. The authority does not necessarily have sufficient means or a mandate to assess data exchange, data security and algorithm control. This is already felt when trying to oversee purchasing mechanisms and the related responsibilities. Many Internet companies are taking over markets from traditional companies precisely because in technical, organisational and institutional terms, they have better command over software and aspects concerning data. An interesting development in this context is the growth market that the four largest accounting firms are observing in the field of big data control[4]. The question is whether the managing bodies of energy grids and road infrastructure are soon going to have the resources, employees and mandate to handle the new challenges equally effectively, and whether the accounting firms will also be able to recognise those aspects of software that have a normative drive.

Other public values are also at issue

The use of Internet platforms and big data means that other public values are also at issue. The platform economy operates in a grey area, and is not curbed by national regulations. Developments often take place too quickly for politics and the administration to monitor them (Frenken 2016; Van Dijck, Roell and De Waal. 2016). Global platforms, such as the Big Five—Alphabet, Apple, Microsoft, Facebook and Amazon—can therefore largely evade local agreements, and laws and regulations in areas such as safety, competition, environmental nuisance and accessibility. There have been, for example, regular reports of drivers working via platforms who refuse to serve disabled people or religious minorities (see Hall and Krueger, 2015). Platform structures often also sidestep all kinds of labour law requirements when it comes to unfitness for work, guaranteed minimum income, sick leave and pension accrual. It is no surprise that Uber prefers to be regarded as a digital service provider by the EU and not as a transport company[5], a sector that involves many more responsibilities and obligations towards drivers.

The platforms are getting bigger and bigger, they have large networks, access to vast amounts of data and often operate on a global scale, all of which means there is a risk of them becoming very powerful. They affect behaviour, they direct socio-economic processes, and, ultimately, they drive society—in visible and invisible ways. There has been mention of 'governance by platform' and even 'government by platform' (O' Neil, 2016; Morozov, 2014). But other large companies too can become so powerful that they can evade democratic decision-making. If major multinational companies dominate the large-scale hardware for energy supply, such as wind farms, huge buffer power plants and all things related, they will also determine standards and ultimately the pricing system (see Chapter 4). The automobile industry is very powerful too and may have a decisive influence on the organisation of the infrastructure of charging piles for electric cars. For these reasons, Hoenkamp et al. highlight the importance of proper procedures and solid criteria for setting smart grid standards in Europe with an eye on safeguarding a wide range of public interests, including security of supply and climate and energy policies (2013).

The data drifting around on platforms pose another risk to public values. Businesses have many ways to make money from the data that people provide when using platforms, including methods that compromise fundamental values such as the right to privacy or self-determination. User data are at present the very basis of the most important revenue models in industries dominated by ICT.

But the issue does not only concern the business world. Public authorities that engage in large-scale data collection may also be about to overstep certain limits of acceptability. By providing their data, citizens unconsciously hand over a great deal of power to governments and large technology companies (Morozov, 2014; Van Dijck et al., 2016; O' Neil, 2016). Technology companies are strongly encouraging local authorities to satisfy their hunger for data. TomTom and Google sell anonymised data about urban traffic flows to the municipality of Amsterdam. The social network LinkedIn provides Amsterdam with anonymised data on job changes and members' skills so that the municipality can carry out a more targeted policy for its labour market[6]. IBM, Oracle, Siemens, Palantir, Cisco, Microsoft and Philips are leading the rapidly growing list of companies that sell smart-city services to local authorities (Helbing, 2015).

5.2 Norms and values lie hidden behind digital systems; are democratic values at stake?

To ensure proper democratic management, smart systems must also be subject to the requirement for accountability for the quality of services and the way public values are safeguarded. Making infrastructure systems smart (sensor systems, Internet of Things) requires increasingly complex digitisation. The systems can become so complex that they are almost inaccessible, unclear and incomprehensible to citizens. Algorithms are becoming less and less transparent, harder to understand, and difficult, or even impossible, to test beforehand[7]. This applies even more to self-learning systems. As times passes, it becomes less and less clear what the principles, processes and rules are that form the basis for the functioning of smart environments.

Police control room during the International Four Day Marches Nijmegen.

Behind smart environments there often lurks a technological world view, which assumes that complex social systems can ultimately be understood as rational, technical systems. As long as enough data, models and algorithms are at hand, everything can be managed from a kind of cockpit or control room (Kitchin, 2014; Meijer, 2015), including the mobility and electricity infrastructures. Public authorities (and their modellers) also tend to see inherently chaotic, unpredictable and complex systems as nothing but arrangements that are complicated but can ultimately be captured in a model (Van der Steen, 2016).

There are several fundamental objections against this strictly technical outlook. First of all, it is not possible to know the complex world. Individuals construct their own reality on the basis of information, ideas, concepts, techniques and technologies, experience, contexts and world views. This means that there is never a single solution; there are many solutions depending on the uncertainty about how the system or sub-system will respond to interventions, and on the variety of views that may exist on interventions and outcomes in terms of their desirability, or their ethical or political load. In short, it is not just a matter of deep-lying uncertainty, but also of uncertainty about values (often referred to as ambiguity, for example in Hisschemöller and Hoppe, 1995). When applying a purely technical world view, public authorities tend to sweep such differences of principle under the carpet, since the choices have already been built in into technology. This can, of course, handicap democratic decision-making in a pluriform society.

Data, models, indicators and related actions are not dissociated from values; tucked away in the most basic indicator there is usually a world of values and norms, which are subject to differences of opinion (Morozov, 2014; Van Twist et al. ,2017). New technologies are often introduced as objective, down to earth, pragmatic and—above all—benign. However, they can be political to the core, permeated with the beliefs and values of their designers and other interested parties (Kitchin et al., 2015, 2016). What are the moral principles that a self-driving car adheres to when it is facing the risk of an accident? Who is at fault or liable when things go wrong? Can a self-driving vehicle be a legal person?

Finally, the values that are at stake are mostly those linked to transparency (understanding), open decision-making and accountability. They are also decisive for the learning capacity of those structures known as *complex systems* (Van Twist et al., 2017). Transparency is, certainly in the digital age, a concept that goes far beyond mere access to every piece of data. While in the past transparency involved boxes and boxes of documents and files, now it can mean dealing with countless terabytes of meaningless data. It is therefore necessary to have, at the very least, the corresponding algorithms or alternative forms of data processing to reveal the true nature of the data usage. How is an electricity bill drawn up to represent the sum of dynamic electricity rates based on real-time supply and demand? Is the reckoning easy to understand for consumers? Can they assess the bill? If so, do they think it is fair (Neuteleers and Mulder, 2017)? How are these questions going to be answered with regard to dynamic road pricing, should the latest possibilities of ICT make its introduction possible? This requires skills, and sometimes expensive software and computing power. And added to all of this, being able to render account is not the same as achieving transparency. It requires insight into the system, into critical dependencies and outcomes, and of course, ways to measure and test democratic, albeit sometimes conflicting, core values. Annany and Crawford have presented an elegant analysis of the limitations of the ideal of transparency in today's digital age in the publication *Seeing without Knowing* (2016). In short, the pressing issue today is active public access, rather than simply making data available.

5.3 The digital world versus the physical world

Rules lagging behind

The digital world is dynamic and developing rapidly. New infrastructural players are popping up like mushrooms, offering new services, attracting customers and processing transactions on platforms. The 'physical' world, with laws and regulations that evolved slowly in the past, can hardly keep pace. With a somewhat schematic approach to Williamson's four-layer model (Chapter 1), it could be said that in the bottom layer the variation and dynamics of the interactions and transactions between players are steadily increasing, while in the layers above the 'solidified' institutional arrangements are hardly capable of making sufficient corresponding moves. Or, as a policy maker expressed with a sigh during an interview, 'How do we connect the 19th-century physical infrastructure, which is regulated by 20th-century governance systems, to the 21st-century dynamics of the network society?'

Another telling example is the revision of the basic principles of regulation, which is likely to be necessary if vehicles or residential care facilities (home automation applications) really become more or less autonomous. Robots and self-learning digital control systems increasingly operate as independent actors in the infrastructure systems. Liability is of course is an important aspect here, since these actors will almost inevitably find themselves in situations where they will need to take moral decisions (Chapter 3).

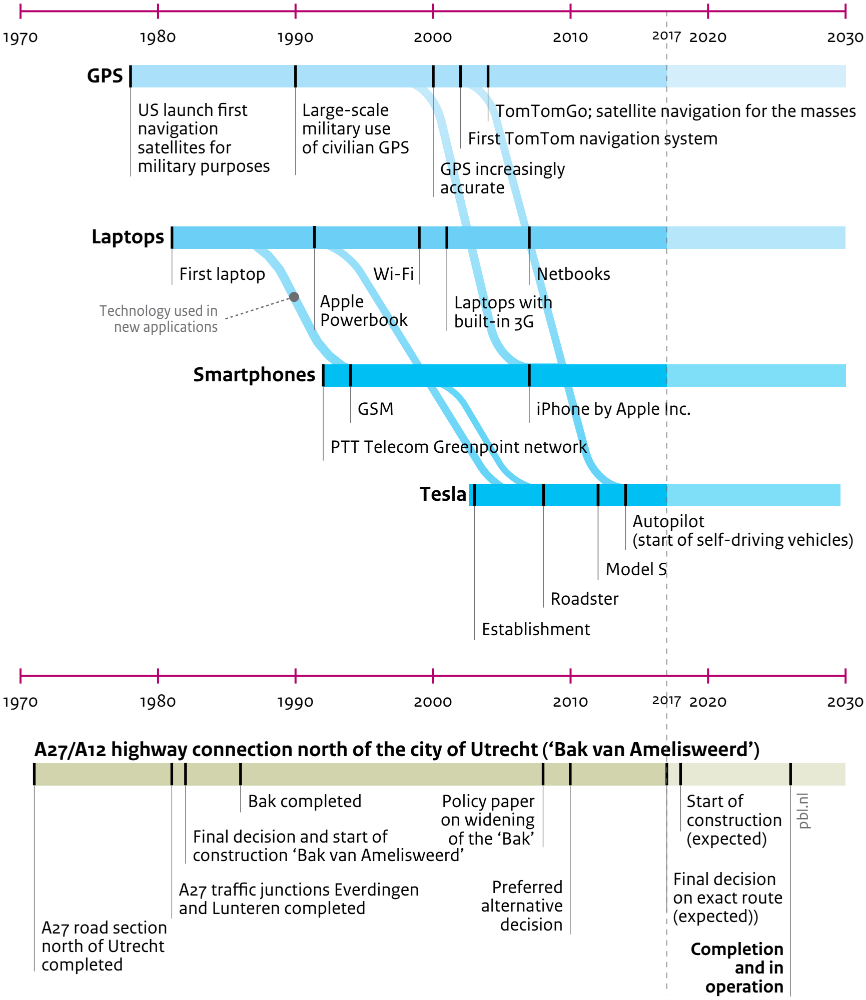
As a result, the rapid and comprehensive digitisation of service provision is putting pressure on the appropriateness of rules and institutions that have been built up over time. But the fact that the institutions no longer satisfactorily meet the applicable requirements does, of course, not mean that the underlying values and objectives are not relevant any more. Uber may not be covered by the Dutch Taxi Law, but that does not mean that the fundamental reasons that once served to adopt the law are not applicable now. In the digital age, it will be will increasingly necessary to take specific situation-based considerations into account.

Existing regulations are also under pressure from globalisation and 'localisation'. On the one hand there are the globally operating, relatively elusive platform giants, which challenge the nation state; markets have been *globalised*, while regulation, licensing and tax liability have often remained in the *national* or even the *local* realm. On the other hand, it is precisely the local platform initiatives that threaten supra-local interests. At the local level a great deal of experimentation is going on with smart mobility and smart grids. Think of a future with local electricity grids that are more or less autonomous. That will both complicate national network balancing and possibly reduce the affordability of an accessible national network[8]. Dilemmas around onshore wind farms are another example of supra-local sustainability interests conflicting with local interests. Everyone is in favour of sustainable energy, but not necessarily in their own backyards. Also, the question crops up whether dilemmas have a more local or a more regional character, and therefore require specific solutions or rather, a generic national approach. Airbnb, for example, provokes great social discontent, primarily in Amsterdam, but not in the rural regions of Zeeuws-Vlaanderen.

Major difference between the rates of change in the digital and the physical world
The dynamics and speed of the virtual, digital world contrast greatly with the pace of development of infrastructures. Whether dealing with mobility networks or electrical grids, at least a decade is needed for planning, design and execution. For the Ministry of Infrastructure, a 10-year period represents a very fast project course, but 10 years ago, tablets or smartphones did not exist yet and Google and Amazon were still busy establishing their global monopolies (Figure 5.1).

Figure 5.1

Differences in development rate between the digital world and infrastructural projects



In the time it takes to build and widen a motorway, the digital world has evolved from GPS to the self-driving car.

The economic lifespan of investments in roads, railways and energy networks also covers lengthy periods of time, easily lasting for 30 or 40 years, which is an eternity for digital platforms and ICT development.

The long development time of infrastructure means that choices made today are only materialised in the long term. They have a long-lasting impact and determine the better part of the future possibilities for adaptation. Since it is not possible to predict technological and social developments, there are considerable uncertainties about the future influence of ICT on infrastructural facilities. At the same time, the reliability and consistency of expectations about future developments are critical for short-term plans (Van der Steen, 2017; Van Twist et al., 2017).

When it comes to investments in hardware, it is easy to back the wrong technological horse. Imagine having a network of charging piles and charging stations for electric cars, and then hydrogen becoming the energy carrier of the future, or a somewhat different technical standard being chosen. To what extent should roads now be fitted with devices that enable communication with the partially or completely self-driving cars of the future? The implementation of smart technology is costly and time-consuming, and involves more than just motorways and the electrical grid. Seven million households are receiving a smart meter, which can no longer reasonably be called smart, given the current state of the technology and the pervasive use of smartphones, even without additional apps (Vringer and Dassen, 2016).

In a few words, due to the intrinsic slow pace of the physical infrastructure, choices will always turn out to be sub-optimal and have long lasting and far-reaching effects—even if in the decision-making stage they are well-conceived and made with an eye on the long term (PBL, 2015). The great task lying before us is designing and developing roads and power grids in such a way that they can gradually integrate with the evolution of the Internet of Things, reaping as much benefit as possible from it. This task is to be taken on by designers and developers, but also by public authorities, members of parliament and ultimately perhaps even citizens. In the current situation no institutional tools are available. This contrasts with the past, where just a limited number of actors —who often knew each other inside out—used to link insights and knowledge to policy.

6 Government control is needed to achieve a new, healthy balance between public values

6.1 Digitisation has its blessings, but it also puts pressure on public values

The previous chapter has shown that digitisation of infrastructure services does not only have its blessings, but also poses new dilemmas around public values. Moreover, due to digitisation, the trusted informal and formal rules (institutions) to safeguard these public values are increasingly failing to stay on top of things.

Detailed analyses for mobility and electricity supply show that widespread digitisation is not a distant future vision, but something that has already largely come into being. Smart, more or less self-driving cars are already on the streets and many new applications are just around the corner. The platform economy is spreading rapidly. Local sources for energy generation are already being added to the electrical grid. The functional connection between the grid and the batteries of self-driving cars is now being established. And with that also a link between two policy areas that until now were independent.

Without government intervention, the rapidly progressing digitisation of infrastructure and related services will also start having undesirable results and consequently lead to social disquiet. Think of a further widening of the divide between citizens with high and low levels of education, social disruption stemming from poor manageability of vital energy facilities, or the slow but steady wearing away of claims to privacy and self-determination. Moreover, these issues often concern technologies that can give online and offline entrepreneurs enormous power, while the disadvantages more often than not end up on the public sector's plate. (Morozov, 2014; Jasanoff, 2016). As recently noted by the Rathenau Institute, the far-reaching digitisation of society means that fundamental democratic and ethical values are at stake (Kool et al., 2017).

The government approach is still mainly reactive, trailing technological developments. When dealing with recently created ICT applications for infrastructures, the administration can seize more initiative in order to attain a new and healthy balance between, on the one hand, 'driving' values that enhance innovation and welfare, such as efficiency, customisation and profitability, and on the other hand, protective, anchoring values, such as accessibility, safety, security of supply, privacy and accountability. This also requires explicit government control and forward-looking action.

The controlling role of government is also subject to change, precisely because of digitisation. While in the past it was usually enough for public authorities to have an investment strategy for the most important infrastructures along with national rules on its use (e.g. discussed in PBL's Dutch report *Kiezen en delen*, 2014c (about strategies for better coordination between urbanisation and infrastructure), at present a regulatory strategy is of major importance. Partly because of the boundless, often global reach of the Internet platforms, such a strategy will also increasingly have to take the international context into account. Regulatory strategies should (mainly) focus on ensuring there is a balance between driving values and anchored values.

The developments pointed out here and the questions they raise with regard to government action do not only apply to the national level, but also affect regional and local governments. The perspectives for action, as described out below, may also be helpful for these authorities.

6.2 Organise and facilitate the public debate on the new dilemmas raised by digitisation

Research on previous innovation processes shows that unbridled technological developments can lead to outcomes that are far from optimal or even socially undesirable (e.g. Mazzucato, 2015; Jasanoff, 2016). The ongoing erosion of the notion of truth on the Internet (bubbles and alternative facts) is a present-day, and worrying illustration of how possible uses of technology can lead to social disorder or breakdown.

The government has to ensure that society is not overrun by the ICT developments in infrastructure examined in the previous chapters. Instead, it needs to adopt a forward-looking attitude and start up a public debate on fundamental questions such as: What is the minimum, basic level of access that service providers have to ensure in an increasingly unequal world? How to deal with the accumulation of power, identified above, at large, elusive tech companies such as Google and Uber? To what degree is society prepared to modify the public space and even adapt spatial planning to the requirements imposed by self-driving vehicles or household energy generation? And to what extent can this occur at the expense of other users of roads or public spaces?

Adding smart features to infrastructure increases efficiency of use and is potentially more sustainable. However, complexity can also be the cause of failures. What are acceptable levels of increase in the probability and the extent of social disruption if power cuts or traffic jams become more frequent and more prolonged? Key infrastructure facilities are usually reinforced with redundancy measures, so that interruption of use is not necessary in the event of a malfunction. While nobody doubts the usefulness of this, it is generally also expensive. To what degree does smart technology render redundancy unnecessary? This is also a clash of values: in a narrow definition of efficiency, redundancy measures usually score poorly, because they are expensive. But if resilience or regional autonomy is made the point of focus in infrastructure systems, the balance may shift the other way.

The government should endeavour to organise the public debate on these questions and push for the representation of all points of view and all relevant social groups. To achieve a result with lasting legitimacy and wide support, such a process must at all times be open to new information, new insights and opinions, changing considerations and new actors whose input may generate differing points of view and choices (Pesch, 2014; Dignum et al., 2015).

The government can facilitate the search for strategic choices and policy considerations by exploring a wide range of alternative futures that capture the outlook for infrastructure in words and images. This necessarily involves looking for the boundaries of the imaginable, beyond the normative patterns of values and political convictions that dominate the present-day public debate on technology (e.g. Lanier, 2014). The imagination needed for this does most certainly not only have to come from science, but can also come from art or other creative fields. Think of the enormous influence that science fiction books or films have on deliberations about the social aspects of technology, from classic novels such as *Brave New World* and *1984* to feature films such as *The Matrix* and *Minority Report*. Also consider the concept of the *socio-technological imaginaries* framed by Jasanoff and Kim (2015): social groups that share visions of technological progress and the related implicit ideas about useful public functions. Or think of innovative and provocative applications of design research that manage to get parties around the table to work together on a creative search for feasible and sustainable solutions for issues such as the energy transition (Hajer, 2017). The main point is to develop a common language, with or without imagery, to make it possible to have a meaningful discussion about the implications of technological futures with all parties in society, draw inspiration and, eventually, weigh up the situation in a democratic way. It will be possible to make strategic choices based on different value systems if future scenarios are devised from several normative points of view, and then interpreted and discussed with all parties involved. This exercise can include considerations that go beyond vested interests.

As stated in Chapter 2, there is an ever-growing and fundamental uncertainty —even ignorance—about what the future will look like. Explorations based on projecting past and present trends into the future only have rather limited utility. Other forms of exploration are therefore also needed. Or, as Professor Van der Steen put it in his acceptance speech, we should explore the future not only by 'counting', as in the more classic scenario studies by CPB and PBL, but also by 'recounting' (Van der Steen, 2016). The mobility scenarios for the United States, devised in *Reprogramming mobility* (Townsend, 2014) and described here in Chapter 3, are a very fitting example, showing how several normative reference points lead to widely differing future perspectives, each with its particular major social dilemmas. In the Netherlands there have been interesting initiatives for normative explorations that make a wide range of dilemmas visible and discussable. They include the *Public Health Future Scenarios* by the National Institute for Public Health and the Environment (RIVM, 2014), the recent exploration *Data is power* carried out by the Netherlands Study Centre for Technology Trends (STT, 2017) and the *Nature Outlook* studies published by PBL Netherlands Environmental Assessment Agency (PBL, 2012; Van Zeijts, 2017). The forthcoming *Spatial Planning Outlook* by PBL, to be published in 2018, also aims to contribute to the debate with convincing visions for the future of urban development and infrastructure.

6.3 The digitisation of infrastructure requires clear and robust frameworks and goals

As a participant in the public debate, the government will have to take a stance. Not a dogmatic position, but rather an open attitude towards the other parties and a willingness to consider different propositions if the outcome of the debate calls for it. In line with this, the government will also have to formulate recognisable, inspiring, mobilising and robust goals that relate to the desired balance between the various public values, the fairness of the distribution of benefits and burdens and the level of vulnerability that society finds acceptable in vital services. Consider, for instance, digital customisation in passenger transport that is geared towards the inclusion of weaker groups, such as the visually impaired and elderly people with disabilities, or the concept of *privacy by design* that takes privacy protection as the main, normative design criterion for the digitisation of public transport or energy supply. A good illustration of the importance of these considerations is the Dutch public transport smartcard. While it perfectly serves the various transport providers in terms of cost-effectiveness and opportunities for competition, it also causes inconveniences to travellers, such as uncertainty about the different check-in posts on platforms, hefty fines after accidentally checking in or out in the wrong way and confusion about different types of travel cards and season tickets. All of this means that the system creates a barrier to participation in precisely that component of the infrastructure that should be accessible to everyone (Veeneman et al., 2011; Boonla, 2011).

The government should determine what the core values are within the various domains. Which of the current rules still function correctly in that light, and which are falling short or will soon do so? It is a search process that not only needs to steer, but also motivate and mobilise. Wherever possible, conflicting interests and beliefs should be bridged; where necessary, clear choices must be made.

6.4 Make way for ICT developments and the improvising, innovative and experimenting society

The increased complexity and structural unpredictability of the (digital) developments do not tolerate major government-imposed plans for change with prescribed instruments. It is becoming more and more difficult to capture issues in sound descriptions of a system and its related set of policy measures, the conventional 'field model' (Van Twist et al., 2017). More importantly, lurking under the surface is the tragic paradox of the likelihood of today's solutions turning out to be the lock-ins of tomorrow (e.g. Koopman, 2015; Faber and Idenburg, 2017).

If it is not possible to fully understand social issues, and if no interventions are ready that can be identified, planned and calculated beforehand, then the most obvious moves are experiments, try-outs and learning; a process that involves small steps and continuous adjustments based on reflexive evaluation, and takes into account the uncertainties and the kaleidoscope of views in society on collective values related to infrastructural services. In recent publications, this has been referred to as radical or strategic 'incrementalism' (NSOB and PBL, 2014; Hajer, 2011; Raven, 2016; Faber and Idenburg, 2017; Van Twist et al., 2017). It is not just room for experimentation that deserves intensive attention from the Dutch Government, but especially reflective evaluation and finely tuned adjustments—which can be reversed if necessary.

The government cannot and should not steer innovation, but what it can do is make room for the improvising, innovative and experimenting society. Outlined above are clear and robust frameworks with regard to the public values that are to be safeguarded. If the government sets these frameworks, then relevant social parties can decide for themselves how they give substance to them. They are granted the freedom to discover alternatives that lead to the same results, or even better results (see also Camps, 2016 and 2017). This can mean removing regulatory barriers, or government promotion of innovation through subsidies or investments, but it can also imply making new rules or agreements to prevent, insofar as possible, 'excesses' or perverse stimuli that block society's ability to improvise. This form of regulation, characterised by setting frameworks rather prescribing actions, assigns a more dominant role to supervisory bodies. Their task is, among other things, to call parties such as tech companies to account for undesirable effects, specifically those that are produced by monopolisation, improper competition stemming from the circumvention of local rules or discriminatory algorithms. An illustration of this is a platform for transport services that charges different rates for each neighbourhood based on the characteristics of the residents, or that does not even offer the service at all in certain neighbourhoods.

6.5 Looking for new, appropriate rules

The new tasks also require new rules. Which things can be regulated properly at the local or national level and which call for international agreements? Consider, for example, circumvention of national rules or the development of technical standards. Understand which rules are domain-specific, such as those on safety of road infrastructure, and which apply beyond domains, such as those protecting privacy in cases where infrastructure services become more and more interlinked. Draw inspiration from other policy areas on options to safeguard protective values. To give an example, in the domain of electricity distribution, accessibility is regulated more tightly than in citizen mobility. When dealing with social disruption resulting from system failures, it may be possible to learn lessons from flood risk policies. Establish a basic safety level for every Dutch citizen and additional safety standards for areas with high population density or intense economic activity (PBL ,2014b).

Digitisation—especially when coupled with the use of the Internet as the infrastructure of infrastructures—creates the need for policies that transcend domain boundaries in a broader sense. Fulfilling this need calls for an approach that is truly integrated: parliamentary committees that effectively and coherently approach sectors that are becoming more and more digitally decompartmentalised; executive programme boards that tackle new challenges across departments and sectors; and, above all, supervisory bodies that not only monitor the proper functioning of the market, but also oversee the situation of anchoring values such as accessibility and the right to privacy. In short, think about how the integration of sectoral regulation and supervision can be achieved, so that they, along with the practical details, are able to withstand the unpredictable developments that are heading towards society. Study the possibilities offered by the Environment and Planning Act and the Environmental Vision to secure, in consultation with citizens, certain public values regarding infrastructure and the physical environment.

6.6 Democratic management needs to be dealt with precisely in the area of smart infrastructure

In this rapidly changing world, it is of essential interest for government and society to keep moving with the flow and constantly keep a finger on the pulse of ongoing digitisation. Particularly important here are the values and normative principles that are hidden in technology (see also the *Black Box Society* by Pasquale (2015) or the critical comments on the smart city by Meijer (2015)). The government may decide to take charge of organising the process of continuous evaluation and feedback. However, it is precisely in this area —evaluating experiments and learning from them—that the government has sometimes fallen short in the past.[1]

Full transparency does not automatically imply account can be rendered for the functioning of the system. An important challenge is the operationalisation of the possibilities to give account (or demand account) when many smart features have been added to the environment, such as cases where countless decisions are taken autonomously by self-learning algorithms. Do citizens still see their energy bills as the sum of dynamic electricity rates based on real-time supply and demand? If so, do they think the bills are fair? A similar story goes for dynamic road pricing, should this be introduced thanks to the latest ICT developments. It is by no means certain that citizens are able to sufficiently understand an advanced road-pricing system (smart mobility) that is optimised in terms of time and distance. And even if they are able to, can they also agree with the preprogrammed moral principles related to justice, efficiency, allocation of costs, fulfilment of basic needs and the fight against income inequality?

To ensure proper democratic management, smart systems must also be subject to the requirement for accountability for the quality of the service and the way public values are safeguarded. This involves gaining an understanding of how artificial intelligence systems make choices, how they deal with different and sometimes conflicting values, and how positive and negative consequences of digitisation can be made visible in a timely manner. In short, work needs to be done on a tailor-made management system, in which the various parties can demonstrate their commitment, provide input and render account for the consequences of digitisation processes and for the use of the data they collect. (Annany and Crawford, 2016). A detail that is in no way negligible is the fact that the processes subject to accountability procedures often transcend the level of a single domain. Those processes do not limit themselves to the domains of energy or mobility, but combine them with other domains. The institutional regime that gives shape to these democratic values needs to be custom-built, apply beyond the level of the domain and able to adapt to rapidly occurring new developments. This type of customisation should then enable a proper balance between the driving values and the protective, anchored values. The task of devising the necessary policy instruments will therefore be a great puzzle.

A relatively new development is the use of robots and self-learning digital control systems that are increasingly operating as independent actors in the infrastructure systems. As a result, liability becomes an important issue. This is because robots or other automated control systems will inevitably find themselves in situations where they have to make moral decisions. Who is responsible for those choices and, if things go wrong, who can be held liable? It is not easy to answer these questions. Research must be carried out into the kinds of rules and frameworks that are needed to establish liability.

6.7 Invest in learning capacity of the government

Systematic monitoring and evaluation of developments around the digitisation of infrastructure can also provide the government and other involved parties with insight into better ways to lend substance to the realisation of strategic goals, and into possible ways to respond to changing circumstances. This can explicitly concern the effectiveness of the various types of rules on different playing fields. For all the parties involved, it is a learning process and the government could or should facilitate and organise it. The Dutch newspapers Volkskrant and NRC Handelsblad recently published an appeal made by a large number of (behavioural) economists for the systematic testing, monitoring and evaluation of policy changes on a smaller scale before implementing them on a large scale (Van den Broek et al., 2017). At the same time, it is necessary to look for common denominators, to identify, assess and share 'well-functioning real-life examples' of digital applications, and to find ways to scale up. To achieve this, it is hugely important that the government itself seeks renewal too, that it changes its organisational structure and methods of operation while it is learning: 'learn and renew' (Van Twist et al., 2017).

The points of concern highlighted above illustrate the great importance of knowledge for all parties involved and, most particularly, for governments. As for innovative companies, their lead in knowledge is one of the reasons they effortlessly bend digitised systems to their will. If governments want to continue to live up to their role as controllers in the field of infrastructure and related services, they need to gain more insight into the nature of the new game, not to mention that of the established players and new players, especially there where the rules of the game and the playing field are becoming more and more international. This expertise is currently lacking. Governments also need more technical knowledge of the new digitised systems, of what they can do and what they cannot do and of their impact, which reaches down to the proverbial capillaries of society, including the government itself. What is equally important is to have more knowledge of the ethical dilemmas posed by these developments.

This is, of course, a task for universities and more policy-oriented knowledge institutes, but we could also consider engaging independent, highly experienced professionals who have a good understanding of the most technical ins and outs at the level of fine detail. Following the UK example of the Government Digital Service, several countries, including the United States, Australia and Singapore, have now set up similar services. They employ professionals who are granted great independence to move across hierarchical divisions and departmental boundaries to get involved in the government's digital innovation projects[2]. In these initiatives, the emphasis lies more on user-friendliness and the interests of the citizen who has to use the systems, and less on organisational effectiveness and efficiency. Similar calls have appeared recently in a report by the Study Group on the Information Society and Government (2017) and in the evaluation memo of the National Commissioner for Digital Government (2017).

What is needed, therefore, is more knowledge among the public authorities, politicians and policy makers about the opportunities of ICT and the consequences of choices that are made. In the field of ICT, business management is still referred to too often. It is true that the number of Chief Information Officers is growing, but decisions are often taken by people who are rather unacquainted with the matter. For example, in 2013 the Council for Public Administration observed that the Dutch House of Representatives hardly ever discussed ICT issues in strategic terms, but almost exclusively in instrumental terms. There has been no noticeable change in the years since 2013. The Council for Public Administration and recently also the Rathenau Institute have come to the conclusion that government, supervisory bodies, the business world and society are not yet equipped to handle questions about the new ICT (ROB, 2013; Kool et al., 2017). For these reasons, a governance strategy for ICT calls for a method for dealing with the combination of ICT knowledge, ICT education and the role of policy makers. The aim here is to be able to optimally use the potential of ICT in infrastructures, also in times of great uncertainty about the direction and the rate of technological development and about the related norms and values.

6.8 Accept the inescapable tension between 'heavy', fixed infrastructure and the rapidly moving virtual worlds and make robust choices

The points discussed above deal mainly with efforts concerning regulation, but the more traditional tasks in the area of investment have also become considerably more complex. Digitisation is increasing the dynamics of the services being offered, and the use of physical infrastructure (and therefore also the applicable requirements) are becoming less predictable. At the same time, an intrinsic property of asphalt pavements, rail networks and electrical grids is that they are not readily adaptable. Big leaps are an inevitable feature of the physical infrastructure because investment plans require a great deal of time, and once built, the infrastructure stays in place for decades. Added to this, it is extremely uncertain how accurately the current technological developments can serve as forecasts of what will be at issue several decades from now, a concern that also applies to the behavioural patterns of users. Ten years is a normal time frame for the development of road infrastructure, but an eternity in the world of digitisation (see Figure 5.1). Because of this, the coordination between the intrinsically sluggish fixed infrastructure and the limitless and timeless digital world is almost by definition suboptimal.

This is precisely why it is important to develop fixed infrastructure in ways that make it able to effectively confront several 'futures'. The wide disparity between the pace of development of the physical world and that of the virtual world is yet another reason to do so. Future-proof, multi-functional infrastructure works are of course often expensive, and therefore, if planning tools and decision-making tools, such as cost-benefit analyses, are not found to produce future-proof outcomes, they will need to be adapted. Lyons and Davidson argue for the use of an instrument from the financial world: the real options analysis framework. It considers the additional costs of building in flexibility during the design phase even though the need for flexibility is still uncertain. These additional costs are then balanced against the costs that would ultimately need to be incurred in a later stage, if it turned out that a less flexible design was mistakenly chosen (Lyons and Davidson 2016). The potential benefits of flexibility are another factor that should be taken into account in social analyses of costs and benefits (see also UK Treasury, 2009).

Future developments can hardly be predicted, if at all, but it is already clear that they will be 'disruptive'. Fitting strategies may therefore be based less on historical patterns and more and more they will need to presume that there are discontinuities (Van Twist et al., 2017; Van der Steen, 2016). This also means that choices for infrastructure investments have to be in line with the future that society aspires to. They need to serve public values as much as possible in various conceivable digital 'futures'.

If it is no longer feasible to make predictions and take measures, then it is important to come to decisions and adapt services accordingly. In the words of Lyons and Davidson, this means making a move from 'predict and provide' to 'decide and provide' (2016).

In this process, private parties need certainty about the chosen direction for the longer term. It is precisely the fixed infrastructure that offers opportunities to push developments in the desired direction, for example towards more sustainable or more inclusive choices (e.g. Faber and Van Weijnen, 2016). Sometimes it will prove necessary to provide strong stimulation to break out of an inflexible lock-in. This can be achieved with national regulations, but also with substantial investments, aimed at, for example, opening up opportunities for large-scale electrification or power-to-gas projects, or making numerous small contributions at the local level. Or, freely quoting Mazzucato, the government could also occasionally cause the playing field to tilt in the socially desirable direction (2015).

Once the fixed infrastructure has been built, it often casts its shadow over the future for decades. In these times of predictable abundance of unexpected developments ('predictably uncertain times'), there is therefore every reason to think long and hard about incorporating flexibility, and about operating with greater tolerance and bandwidth with regard to the possible future dividend of flexibility. It is not just about adaptive planning, but also about planned adaptivity. In mobility policies, for example, accessibility is still very often equated with smooth traffic flow, and therefore the aim is large-scale widening of roads or installing ICT solutions for traffic control. But proper accessibility is more than just that: the point is whether people can actually get to where they need to be or want to be. And this depends on how far they need to go and how conveniently they can do it (PBL, 2014c). What are we to do if congestion, rather than between cities, occurs more and more in the urban environment itself, where the solution does not lie in massive projects, but in making many small adjustments, devised on the basis of a different conception of accessibility?

A strong emphasis on efficiency in strictly economic or traffic-management terms does not only have significant benefits but also comes with costs: the tightly interconnected system becomes vulnerable or uncontrollable when unexpected developments form an obstacle to reaching other long-term objectives, or cause it to operate beyond the bandwidths it is prepared for. A robust approach sees to it that not all eggs are placed in one basket and also takes into account the possibility of serious disruption occurring. With such an approach, we can create a future-proof Netherlands with infrastructures that can successfully withstand a wide range of as yet unknown developments.

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Notes

1 Digitisation of infrastucture and the public interest

1 For example, in January 2017 a power cut did not only disrupt half of the city of Amsterdam, but also affected the operating schedule of the Dutch railway company NS, during most of the day.
2 The negative or positive side-effects ('welfare effects') of production or consumption which are felt by people other than those who bring them about, and which are not worked into the price of the goods or services.
3 This three-way division is a deliberate simplification. There may also be tension between values within these categories, for example between safety and effectiveness. Also, sometimes a value may be considered to fall in one category, and sometimes in another. This can be the case with freedom of choice, which is labelled either as a driving value or as an anchoring value.
4 In a recent publication, the Council for the Environment and Infrastructurestructuur refers to *regulating mechanisms* (Rli 2017).
5 Expressions of this are the Judeo-Christian tradition that politicians sometimes refer to (which includes a certain distance from 'unfamiliar' values) and the social democracy with its (government) concern for the weaker members of society.

2 Turbulent ICT developments in an uncertain world

1 An often-used term is *commodification*, the online transformation of actions and ideas into goods or products that can be traded — in literal terms: to convert into an economic good. Facebook even turns 'schoolyard conversations' into a commodity.

2 The iPhone, for example, is in fact essentially a Chinese export product, though the added value is mainly enjoyed by Apple in the United States (http://www.economist.com/node/2154317). Global networks are also able to conveniently take advantage of time zones between continents. While the United States is asleep, Asia can process orders and deliver them to the US the next morning.

3 For example http://money.cnn.com/2016/08/18/technology/uber-volvo-self-driving-cars/?iid=EL

4 Several reservations can be expressed here. For example, there are doubts as to how much stays under the radar of traditional indicators such as GNP (see for example Brynjolfsson & McAfee 2014).

5 Incidentally, there are signs of a so-called *cottage model*; more and more 'breeding grounds' or startups are located in the 'countryside', also because of the high costs in the city (Strijker & Markantoni 2011).

6 The experiments are done on a massive scale, sometimes involving hundreds of thousands of users per day.

7 Ultimately, the choice to make commercially less attractive areas accessible is a political one which comes with a price tag. In Switzerland, even the most remote mountain villages are readily accessible.

8 This dependence actually works both ways: without electricity there is no Internet, without roads and streets there is no delivery of goods ordered online.

9 These developments also imply that levels of 'public surveillance' are increasing without the explicit consent of the citizen and involving a whole range of dilemmas (see also the 2015 documentary by Sara Blom and Dorien Zandbergen, *Smart City. In search of the Smart Citizen*).

10 https://www.nrc.nl/nieuws/2017/02/24/fiscus-mag-geen-kentekens-verzamelen-6971403-a1547618

11 WRR 2010: 'time is space to move' or 'the future is open but not empty'.

12 PBL is currently working on a more or less similar study for the Netherlands in the context of its *Spatial Planning Exploration 2018*.

3 Smart mobility

1 There are, of course, many other driving forces which explain changes in the physical landscape of destinations, including demographic trends (e.g. the ageing population), economic developments (e.g. the crisis) or changes in preferences.

2 http://www.disrupting-mobility.org/

3 https://www.verkeersnet.nl/9642/minder-drips-en-minder-verlichting-op-de-snelwegen/

4 https://www.theguardian.com/science/political-science/2017/apr/07/autonomous-vehicles-will-only-work-when-they-stop-pretending-to-be-autonomous
5 https://www.theguardian.com/technology/2015/mar/18/elon-musk-self-driving-cars-ban-human-drivers
6 https://www.washingtonpost.com/news/wonk/wp/2016/03/10/uber-seems-to-offer-better-service-in-areas-with-more-white-people-that-raises-some-tough-questions/?utm_term=.ca6c1a8de0ce
7 Lawrence Lessig has observed that programme code always contains values — those of the developers and those of their clients. 'Code is never found; it is only ever made, and only ever made by us' (http://codev2.cc/download+remix/Lessig-Codev2.pdf). The same applies to self-learning systems, which also contain values. If their learning input comes mainly from a privileged group they can become 'racist' (see for example http://www.theverge.com/2016/3/24/11297050/tay-microsoft-chatbot-racist).
8 Worldwide, there are four systems in operation which are all entirely publicly owned. The most well-known and most intensively used is the GPS system of the United States. The others are GALILEO (EU and ESA), BeiDou (China) and GLONASS (Russia).
9 See https://techcrunch.com/2015/03/30/kakaotaxi-launch; https://www.bloomberg.com/news/articles/2015-06-08/korean-hailing-app-looks-to-new-york-after-beating-uber-in-seoul; Note that Uber has resumed operations in South Korea, following negotiations with the authorities.
10 For example http://s.parool.nl/s-a4404603/

4 Smart electricity supply

1 This infrastructure consists of a high-voltage grid for transmission from power stations to the distribution-level grid, intermediate voltage networks for regional distribution, and then on to low-voltage networks which has transformers to step the power down to the service voltage for households and other consumers (see Figure 4.3).
2 Renewable electricity CBS statline 30 June 2017 http://statline.cbs.nl/statweb/publication/?dm=slnl&pa=82610ned
3 http://energeia.nl/nieuws/777631-1708/nieuw-trafostation-enexis-biedt-oplossing-voor-veel-decentrale-opwek
4 Between Januari 2012 and December 2013, the network managers installed smart meters in almost 600,000 dwellings. In that period, 1.7% of the smart meters were refused and 0.6% of the installed meters were switched off by administrative order — there is no remote data collection and the device works as a conventional meter (Letter to Parliament Min EZ DGETM-EM / 14041239).
5 http://energeia.nl/nieuws/855403-1506/eerste-stap-gezet-in-uitrol-slimme-meter-3-weigert
6 http://energeia.nl/nieuws/997900-1701/kamp-energiebesparing-met-slimme-meters-geen-doel-op-zich
7 https://www.nytimes.com/2017/01/30/business/energy-environment/battery-storage-tesla-california.html?_r=0

8 http://energeia.nl/nieuws/688070-1705/tennet-zet-voor-het-eerst-blockchain-in-voor-balanshandhaving
9 https://www.nrc.nl/nieuws/2017/05/02/geld-verdienen-met-je-autobatterij-8494369-a1556756
10 http://energeia.nl/nieuws/688070-1705/tennet-zet-voor-het-eerst-blockchain-in-voor-balanshandhaving
11 http://www.nrc.nl/handelsblad/2014/04/11/airbnb-voor-groene-stroom-1365020
12 http://energeia.nl/nieuws/167132-1704/smart-grid-rotterdam-ontstijgt-met-20.000-aansluitingen-pilot-schaal
13 https://fd.nl/frontpage/ondernemen/900392/energiereus-rwe-gaat-strijd-aan-met-apple-en-google, FD, 29 October 2014
14 Google makes new moves on the energy market and is going to sell its surplus power.
15 See the Marc Hijink column in NRC, 1 May 2017, https://www.nrc.nl/nieuws/2017/05/01/je-koptelefoon-luistert-mee-8507957-a1556757
16 http://energeia.nl/nieuws/137718-1609/tennet-zoekt-markt-voor-datacapaciteit-bij-cobra
17 https://relined.nl/over-ons/
18 https://www.rijksoverheid.nl/documenten/rapporten/2012/03/30/maatschappelijke-kosten-en-baten-van-intelligente-netten
19 http://energeia.nl/nieuws/869931-1707/hackers-dringen-brits-energienetwerk-binnen
20 NRC 12-11-2016, Do not rely blindly on algorithms.
21 *Can's* and *Cannot's* taken from the Machiavelli lecture by Kim Putters (2017).
22 Time Of Use rates for homes: https://www.sce.com/wps/portal/home/residential/rates/Time-Of-Use-Residential-Rate-Plans. Time Of Use rates for businesses: https://www.pge.com/en_US/business/rate-plans/rate-plans/time-of-use/time-of-use.page
23 TexelEnergie also supports the objective of the Municipality of Texel to be electrically self-sufficient in 2020: http://www.texelenergie.nl/onze-doelen/10/. LochemEnergie is an initiative started up by citizens who want their energy to be produced by residents and businesses in their own communities by 2030: https://www.lochemenergie.net/lochemenergie/wat-wil-lochemenergie-0
24 https://tweakers.net/nieuws/101095/netbeheerders-staan-tijdelijk-geen-opvragingen-van-data-slimme-meters-toe.html and http://www.netbeheernederland.nl/nieuws/nieuwsbericht/?newsitemid=921010176

5 Public values are shifting and rules are lagging behind

1 In the United States, smart mobility is often also promoted under the flag of safety.
2 In late 2015, a power plant in Ukraine was hacked and 700.000 households had to do without power for several hours. Other power plants were also hit.
3 Bachrach and Baratz refer to *nondecisions* (1962), a notion which, with regard to mobility, has been further elaborated in Hajer et al. 2012.
4 See https://fd.nl/economie-politiek/1193904/big-four-duiken-in-big-datacontrole?utm_source=nieuwsbrief&utm_campaign=fd-ochtendnieuwsbrief&utm_medium=email&utm_content=20170330&s_cid=671

5 See http://www.theverge.com/2017/4/6/15204098/deliveroo-gig-economy-language-dos-donts-workers
6 See also initiatives by Eindhoven and Amsterdam: https://fd.nl/economie-politiek/1196413/amsterdam-en-eindhoven-willen-greep-op-de-digitale-stad?utm_source=nieuwsbrief&utm_campaign=fd-ochtendnieuwsbrief&utm_medium=email&utm_content=20170410&s_cid=671
7 https://www.linkedin.com/pulse/you-ready-deliver-grid-future-jacob-fonteijne
8 The so-called *network deserters* are less likely to appear in the densely populated, close-knit and well regulated Netherlands than in, for example, the United States (except for strictly ideological reasons, but that would probably only occur to a limited extent).

6 Government control is needed to achieve a new, healthy balance between public values

1 See the interview given by Kees Vendrik when he left the The Netherlands Court of Audit: http://www.volkskrant.nl/economie/vier-dringende-lessen-van-kees-vendrik-scheidend-lid-van-de-rekenkamer~a4481561/?utm_source=twitter&utm_medium=social&utm_campaign=shared%20content&utm_content=paid&hash=36f0b76034b6fbfc14cf27c6632c938a4b280115
2 'People with a good understanding of technology can generate policy ideas that may not have been otherwise apparent'. *Digital Government Report* 2016

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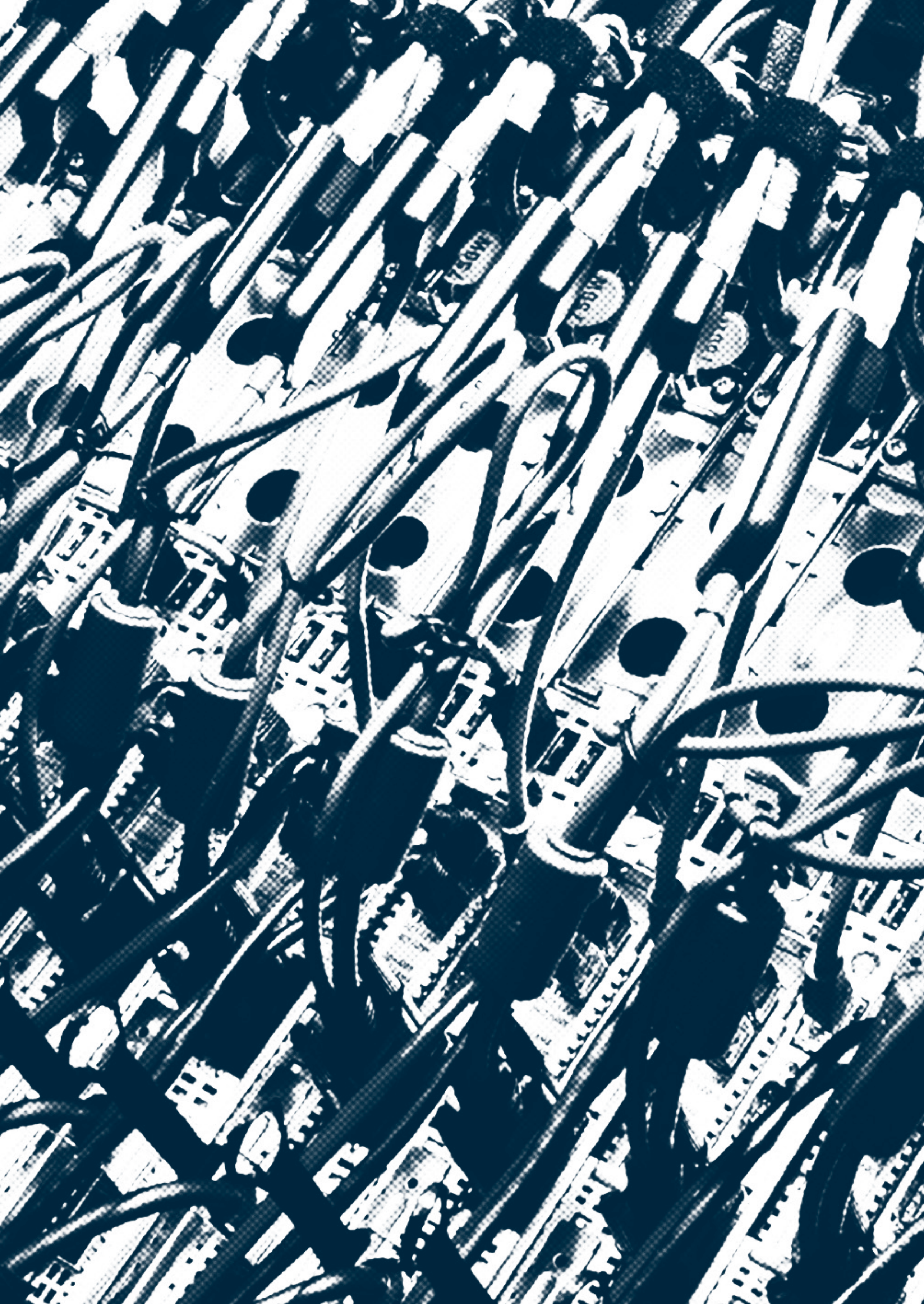

Digitisation is all around us and affects countless aspects of our everyday lives. For example, Internet platforms offer consumers fast solutions for practically everything—from a taxi ride with Uber to green electricity provided by Vandebron. Digitisation increasingly determines how roads, railways and power grids are exploited and how related services are provided. For some, digital developments are a blessing, while others are struggling to keep up.

What are the consequences? Will everyone still have access to the road network? How reliable will the Dutch electricity supply be when it becomes increasingly dependent on ICT? In this age of digitisation of infrastructure, the protection of public values such as privacy and transparency calls for a government that looks ahead, a government that is aware of the dilemmas and engages in public debate, a government that sets clear frameworks and objectives, and dares to experiment with rules and forms of supervision.

PBL

Postal address
PO Box 30314
2500 GH The Hague

Visiting address
Bezuidenhoutseweg 30
2594 AV The Hague
T +31 (0)70 3288700

www.pbl.nl/en