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Strategic planning of drinking water infrastructure: a conceptual framework and building blocks for drinking water companies

KWR Watercycle Research Institute

BTO

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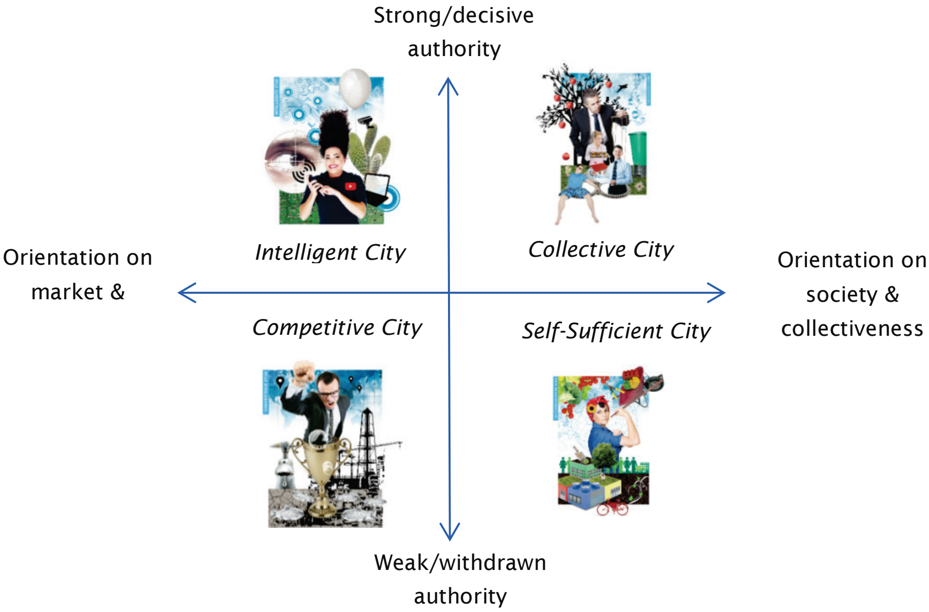
BTO *Executive summary*

Developing a strategy on drinking water infrastructure in an uncertain future

Author(s) Mirjam Blokker, Chris Büscher, Luc Palmen, Claudia Agudelo-Vera

Since investments in drinking water infrastructure are usually for the long term, it is important to consider the future in which the infrastructure has to operate. The future is not entirely open because of past and present drivers, conditions and physical state, plus the future in itself is uncertain. This report provides an approach and building blocks and inspiration for strategic planning of drinking water infrastructure by looking at past and present, defining alternatives for investments and testing robust options in various possible futures. Drivers for investment are shown to be largely determined by the societal context, and currently cost, sustainability and customer satisfaction compete. Potential transitions in the infrastructural chain from source to tap typically take 20 to 30 years. Even if changes take a long time, the infrastructure is both robust and flexible and changes can be made. We advise the water companies to monitor key uncertainties, or even to try to influence them with suitable partners. The four context scenarios of cities that were developed are useful in discussions with various stakeholders in thinking about long term investments.



Four future scenarios of the city

Importance: consider uncertain future in long term investments in drinking water infrastructure

Because investments in drinking water infrastructure are usually for the long term it is important to consider the future in which the infrastructure has to operate. The future is in itself uncertain. The source water quality can change, legislation is not fixed (e.g. tax on ground water extraction), stakeholders' expectations may change (e.g. as other stakeholders appear, or their role changes), the infrastructures' condition and function may change. Next to that social, economic, and technical trends may impact the (future) infrastructure.

Approach: considering past, present and possible futures.
We treat the drinking water infrastructure (extraction, treatment and distribution) as a socio-technical system, where the technical aspects and the social context in which the infrastructure functions are considered. We have described the historic development in the Netherlands and in more detail into water companies investments in infrastructures. Also, we looked at transitions in the choice of source water, treatment schemes, networks design and drinking water demand.
We developed context scenarios for future cities along the axes of A) the size and strength of local authorities and B) the prevailing societal structure that orients and steers actors. The scenarios were described, enriched and an illustration was developed to get a quick feel for what the scenarios entailed.

Results: transitions take 20 to 30 years and may be influenced; context scenarios available
The report provides insight into drivers for investments over the past 100 to 150 years. Early choices for water sources and locations of treatment works have a decisive influence on all future planning, we found evolution rather than revolution in infrastructures. Drivers for investment were shown to be largely determined by the societal context: in the past water quantity (supplying all) and then water quality were main drivers; currently cost, sustainability and customer satisfaction compete. We showed that transitions in the choice of source water, treatment schemes, networks design and drinking water demand typically take 20 to 30 years and may either lead to full transitions, limited transitions or back lashes. There is flexibility in infrastructure, but changes take a long time. We advise the water companies to monitor key uncertainties, or even to try to influence them with the suitable partners.

We have included some examples on investment dilemmas: 1) to continue with centralized treatment facilities or move towards more decentralized facilities, 2) to prevent any possible inconvenience or manage customers' expectations, 3) Dunea's process towards a new five-year strategic plan .
We developed context scenarios with illustrations for the collective city, the self-sufficient city, the competitive city and the intelligent (or smart) city. These proved valuable in determining the robustness of investment options.

Implementation: foundation and inspiration for approach of future drinking water infrastructure
This report can be used by the water companies in different ways to construct their own strategic planning process on their drinking water infrastructure. The sections can be used as a foundation (use as is), as a starting point (i.e. expand on this with extra studies along the lines described here, or made more specific for own use), or as an inspiration (and own studies will be used instead). We do not offer building blocks in every step, as some of the steps are very company specific; we do offer inspiration as we have held workshops with a delegation of the Dutch water companies and a specific implementation of Dunea. The descriptions and illustrations of the four cities, can be used in discussing the investment consequences in the various possible futures with a multi-disciplinary team of people. These scenarios can easily be enriched, made more specific for a region or be used for discussion with not just water company decision makers but also with other stakeholders. We advise water companies to apply the method to current investment dilemma's.

Report
This research is described in the report *Strategic planning of drinking water infrastructure: a conceptual framework and building blocks for drinking water companies* (BTO 2015.048).

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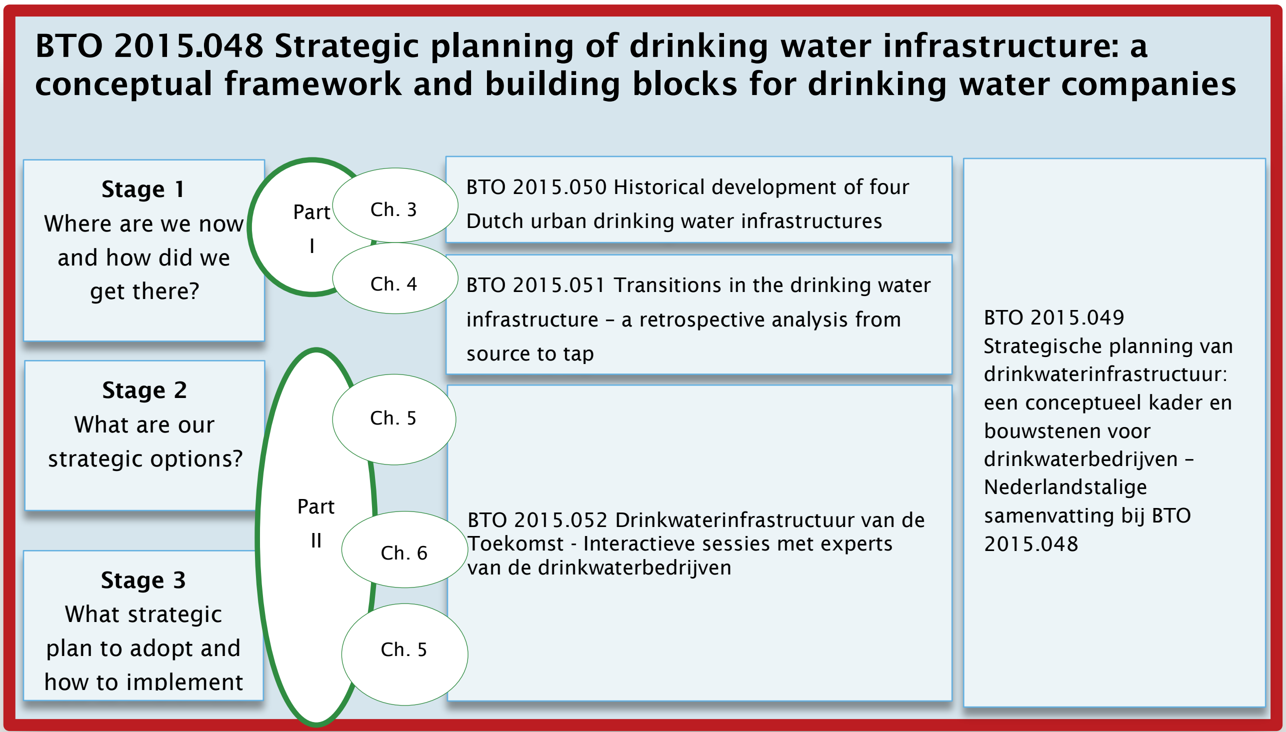
Foreword

Within the Joint Research Programme of the Dutch drinking water companies (BTO) explorative research was conducted on how to best take possible futures into account when making strategic plans on drinking water infrastructure. Several reports were produced: the overall report, a Dutch extended summary, and in depth background info on chapters 3, 4 and 5 of the report (see schema below). This report is the main report, which provides a conceptual framework and building blocks for drinking water companies to use when making strategic long term plans for their drinking water infrastructure (extraction, treatment, transport and distribution).



Contents

1 Past, present & futures of drinking water infrastructure: towards a guiding framework

Drinking water is and will remain a topic of high priority on the international and national political agendas. A critical element of this agenda comprises the infrastructure required to extract, produce and distribute water. This study deals with drinking water infrastructure in the Netherlands that although highly advanced, faces some major challenges. Major parts of the infrastructure are in need of maintenance, replacement, expansion and/or adaptation to changes and such works are likely to take place in the (near) future. Surely, these do not take place all at the same time, at the same place. But it will require huge amounts of resources, financial or otherwise and, moreover, typically involves investments for the (very) long term. Those responsible for these investments will want to know how best to plan for and carry out such works. The aim of this report is to support in this task, by providing a framework that will help practitioners in their strategic planning of drinking water infrastructure investments. This introductory chapter provides the foci and main assumptions underpinning the chapters and findings in this report, and introduces the overarching framework, its elements and what the reader can expect in this report.

1.1 Focus, main assumptions, outputs & outcomes

Firstly, the focus in this framework is on planning for and adapting to socio-technical change of drinking water infrastructure. This assumes that any strategic planning of drinking water infrastructure needs to consider both the social and technical aspects in relation to each other, not in isolation. Drinking water infrastructure comprises physical elements like pipes and pumps, but they are designed, implemented and operated by people (often through IT systems as intermediaries). Furthermore, all this occurs in a broader (urban) environment that influences (facilitates and hampers) the design, implementation and use of drinking water infrastructure. While the engineer might look for technologically optimal ‘solutions’, but often loses sight of who is to operate this technology or trends in behavior, the strategist might come up with the brightest ideas and concepts without taking into account the technical limitations. This report thus proposes that from the start of a strategic process, the two (and other professions) work closely together. This might seem like an open door. The research project where this report is based upon, however, has shown it is not; technical and social/ strategic departments and professionals still work very much in isolation.

Secondly, strategic planning of drinking water infrastructure requires investigating as well as combining socio-technical insights of the past and present with visions of the future. Physical drinking water infrastructure typically has a long-term lifespan; many of its parts in the Netherlands have been designed and implemented long ago, in a society with different values than those of today, with less urbanized landscapes, with less advanced (technological) knowledge and so forth. Hence, knowing how particular drinking water infrastructure systems have developed over time and how they have shaped its present state, is imperative for transitions to desired future states of such systems. This does not mean that alternative infrastructure systems cannot be visualized or planned for; on the contrary, this report argues that strategic planners do well to contemplate alternative futures and how their desired water infrastructure systems hold under such futures. Best, however, is to do this knowing how infrastructures have historically been shaped. The framework presented in this report provides examples of and building blocks for how to integrate socio-technical elements of past, present and (possible) futures.

Following from this, thirdly, the fact that strategic planning processes necessarily deal with the future, requires some comments on what 'the future' is and how it can be explored. In brief, when this report speaks of the future*s*, it actually means future*s*. The future, after all, is essentially unknown, but we can forecast and imagine short- and longer term futures and anticipate such futures by defining visions and actions to realize those visions (Segrave, 2014). The future is, moreover, both 'open' and 'closed'; past structures and agencies have created conditions that partly shape present and future ones, but there is also space to 'innovate' and do things differently, in the sense of reassembling existing things and processes in ways that are considered 'new'. And, as our actions today have implications for people, nature, etc. in the future, it is the task of strategic planners to assess what might be potential future consequences of the actions we intend to take now and take responsibility for those. For instance, certain strategic actions may be deemed unethical by strategic planners, or from the perspective of stakeholders such as citizens, in that they are likely to do harm to people/nature in the future, and hence, not be taken up in an organization's strategy. This is all the more important for drinking water infrastructure, given its (average) long-term lifespan[1].

What can the reader expect to find and what are limitations of the findings in this report? Here, it is useful to distinguish between *outputs* and *outcomes*. The report essentially provides strategic planners in the Dutch drinking water sector with three types of *output*. One is a framework providing guiding principles for the strategic planning of drinking water infrastructure. Readers can use this framework as starting point for *designing* the strategic planning process for water infrastructure. A second output comprises more concrete 'building blocks', 'tools' and specific insights strategic planners can use *during* this process, including methodologies, external future scenarios and drivers that characterize certain transitions in Dutch water infrastructure. A third output are research questions that emerged during the project underpinning this report, which provide fruitful directions for research agendas on drinking water infrastructure. Outputs differ from outcomes in terms of the 'value-added'; the outputs in this report are generic and must in strategic processes be adapted and made specific for companies' unique contexts and needs. Therein, too, lies its main limitation: those readers expecting to find what the future holds in store for them, for instance in terms of the most innovative, new drinking water technologies or ready-made chunks to be immediately applied, will not be served by this report. Rather, it offers a way of seeing and an approach for tackling present and future strategic challenges of drinking water infrastructure.

1.2 The framework and its elements

The strategic planning framework for drinking water infrastructure and its elements are visualized in Figure 1-1, which also indicates which chapter describes which stage of the framework. There are four main stages.

The first deals with the present state of the water infrastructure, how it has historically developed and the main drivers and patterns behind this development. Insight in these (historical) drivers and patterns enable strategic planners to better estimate, and thereby

[1] These assumptions on how to perceive of and study futures are elaborated upon in chapter five.

enhance their steering possibilities towards the desired future state of the water infrastructure system.

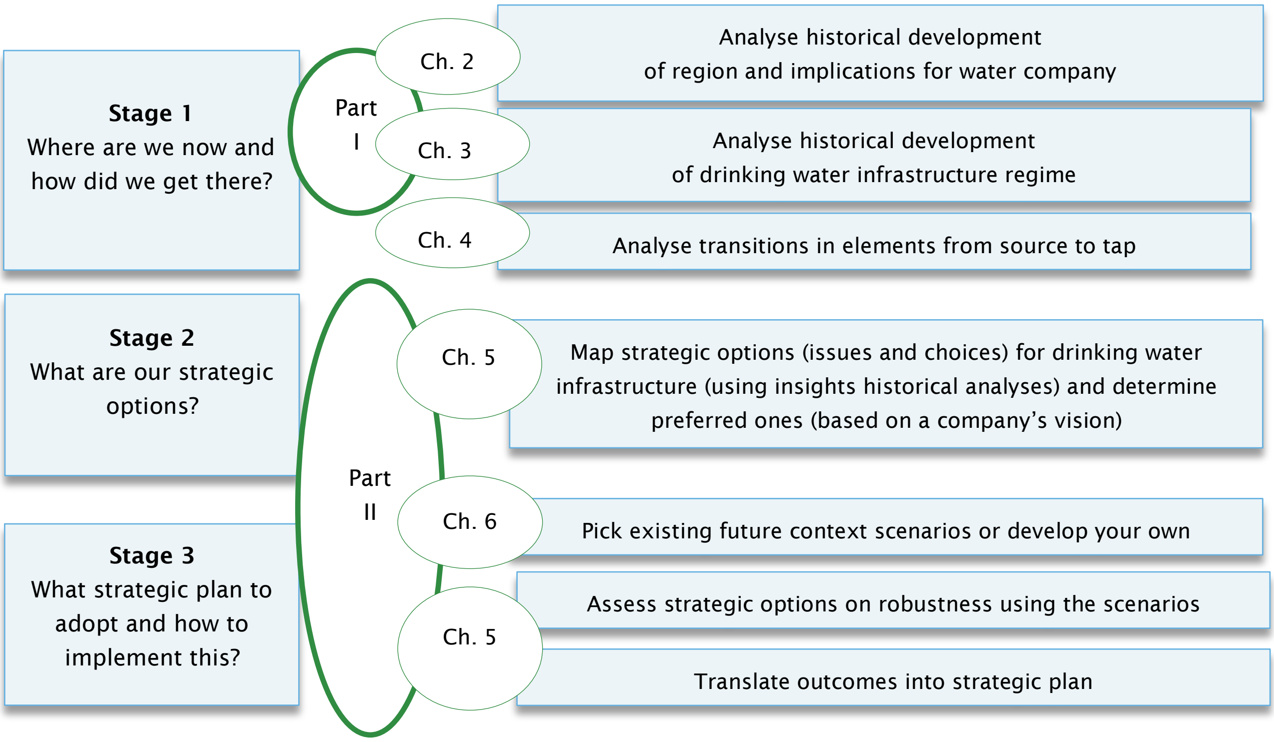


FIGURE 1-1 THE STRATEGIC PLANNING FRAMEWORK FOR DRINKING WATER INFRASTRUCTURE AND ITS ELEMENTS

The second stage is concerned with mapping the range of strategic issues regarding drinking water infrastructure. In line with the overall vision of the water company, and based on the insights gained in the first stage, a multidisciplinary team determines what are important strategic issues and choices for the entire drinking water infrastructure system. Then they prioritize strategic options in terms of preference, i.e. the options that best match the overall vision of the company.

In the third stage, strategic planners assess the robustness of all strategic issues and choices and decide what strategic pathway to follow. Assessing robustness is done by the use of external (context) scenarios, based on which strategic planners analyze and weigh the outcomes, resulting in favored strategic pathways. If a preferred strategic option proves not to be robust, and in order to avoid opportunistic behaviour, it is recommended to stick with the preferred choice and draw up a plan how to deal with the perceived conditions and factors negatively affecting the strategic option. Afterwards the question of how to implement and monitor the strategic pathway defined is tackled, including whom to collaborate with is addressed, as well as actions how to deal with emerging uncertainties and trends.

Before going into more detail how the report is structured and what the different parts and chapters entail, the next section briefly discusses some of the main theoretical starting points of the material presented in this report.

1.3 Theoretical starting points

Some of the key- assumptions and foci of this report have been described above, but the parts and chapters in this report draw on some (additional) theories and conceptual points of view that are briefly pointed out here. Theoretical and conceptual ideas and models that have been used for one or only a few of the studies will be explained in the respective chapters.

1.3.1 Socio-technical transitions

Generally, the report is concerned with *socio-technical transitions* –large and small– in drinking water infrastructure and how these can be studied, visualized and steered in strategic planning processes. In the chapters, we mainly draw on the multi-level perspective (MLP) to analyse socio-technical transitions (Geels, 2002). The MLP distinguishes three levels: niche-innovations, sociotechnical regimes and sociotechnical landscape (see Table 1-1). A sociotechnical system can be thought of as a set of heterogeneous interlinked elements that fulfil a societal need through technology. In the MLP, a system transition to a new regime is the result of interactions between the three levels. The landscape at the macro level provides long term gradients for the established sociotechnical regime where technologies develop incrementally, and for the niche(s) where radical innovations incubate and proliferate. The dynamic stability of the regime can be perturbed by innovations that develop in niches, pressures from the landscape that act on the regime, or from the build-up of internal regime tensions. Social groups within the regime can mount an endogenous response to absorb the pressures and/or niche innovations. In some cases however, this response to persistent problems/pressures, is not sufficient and a system transition to a completely new regime takes place. In a transition, the prevailing attitudes, practices of technology production, and its use in the system are gradually substituted by new ones that originate in niches – novel small-scale sociotechnical systems (Schot and Geels 2007; see Figure 1-2).

TABLE 1-1 DESCRIPTION OF THE THREE LEVELS OF THE MLP (GEELS, 2002)

Level	Speed of change	Characteristics
Macro level (landscape)	generally slow (decades and generations)	Incorporates dominant cultures and worldviews, as well as the natural environment and large material systems such as cities. Change is generally slow and often beyond the direct influence of individual actors or organisations, and might include changes in population dynamics, political models, macroeconomics or environmental conditions.
Meso level (regime)	Change is thought to move in decades.	Regimes are broad communities of social groups with aligned activities who operate according to formal and informal rules and norms, which are maintained to deliver economic and social outcomes.
Micro level (niche)	Generally rapid, can occur in months, years.	Niches provide a protective space for radical products, processes, and technologies to emerge substantially different from status quo. Innovations are fostered and protected from the dominant regime by a small network of dedicated actors, sometimes operating outside of the dominant regime.

As shown in Figure 1-2, urban transitions are the result of mutual interactions between the three levels and within regimes. In an urban area several transitions occur simultaneously and each transition can be characterised according to the initial status of the regime, landscape and niches, driving forces, and stakeholders involved. It is important to keep in mind that at the same time that transitions occur in the “socio-technical regime”, the landscape changes and new niches are being formed. Transitions are not stand alone events but they can reinforce or disrupt other parallel transitions. Moreover, the starting of a transition can be a technological development (niche), changes in society (regime) or form of landscape (new environmental policies, economic crisis, etc.). Influential actors, resources, processes and events, can reside in niches(s) and regime(s) or even outside the system, in the landscape.

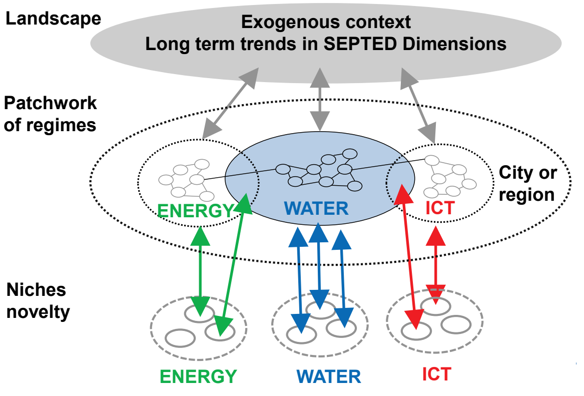


FIGURE 1-2 SCHEMATIC REPRESENTATION OF THE MULTI-LEVEL PERSPECTIVE (MLP) FOR THIS STUDY, INTERACTIONS BETWEEN THE INFRASTRUCTURE REGIMES IN THE CITY AND THE NICHES AND LANDSCAPE.

1.3.2 Systems thinking and spheres of influence

The framework presented in this report aims at providing strategic planners in water companies with guidelines, example studies and building blocks. In doing so, it is imperative to distinguish between different spheres or domains of influence from the perspective of water companies, and how they relate to one another. Systems thinking was used to define these spheres of influence. This means that a distinction is made and boundaries are drawn between an internal and external system, and a so called ‘transactional’ environment (Figure 1-3).

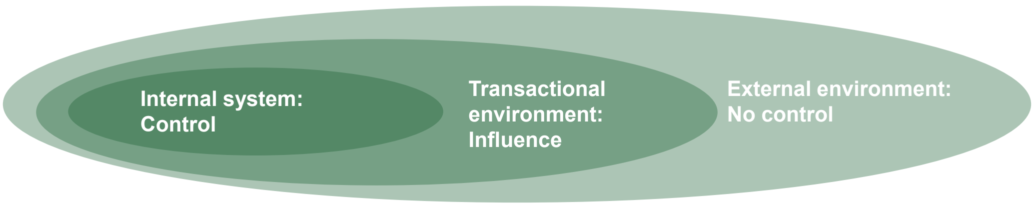


FIGURE 1-3 SPHERES OF INFLUENCE: INTERNAL, TRANSACTIONAL AND EXTERNAL ENVIRONMENTS (GHARAJEDAGHI, 1999)

The internal system encompasses the space and attributes that we assume drinking water companies have full or significant control over. Strategic decisions can generally be made and implemented without having to argue with third parties. The external system is determined by the interplay of different types of developments and trends (such as in the social, economic, political, technological, ecological and demographic domains, abbreviated SEPTED). It is assumed drinking water companies have no control over the external system.

Whereas drinking water companies cannot influence those, or so we presume, they do impact on *their* operations, to varying degrees. In between the internal and external systems is a space we label "transactional". It is in this 'grey' area that water companies have no full control over their decisions and actions, as they depend on third actors to realize their will. They may decide to act in this space one way or another, and they often do so in a more implicit or explicit way, but they always do this in mutual interdependence.

1.4 Contents and structure of the report

Having outlined the central features of the framework and some of the main theoretical and conceptual starting points, this last section will describe in more detail what readers can expect to find and read in the report. The framework introduced above is composed of and provides different elements such as guiding principles, example studies and building blocks for strategic planning processes regarding drinking water infrastructure. These adhere to one part that deals with 'the past', another one that deals with 'futures' of drinking water infrastructures and a last one that combines all this in steps and recommendations that can be followed up in concrete strategic planning processes.

As some themes may be of more interest than others to readers, below one can find a special 'reader's guide' to the report (Table 1-2). It indicates relevant questions for strategic planners, associated themes discussed in the report and what one can expect to find or learn in a specific chapter. The chapters are briefly introduced after Table 1-2.

TABLE 1-2 A READER'S GUIDE TO THE REPORT

Are you interested in the question/domain of…		**Read chapter**	**What to expect/ learn in these chapters?**
…how (aspects of) drinking water infrastructure have developed historically?	At the landscape level/ context water companies operate(d) in	2	Understanding (trends in) drivers for change
	At the level of water company's service area	3	Specific drivers behind investments in water infrastructure
	Regarding infrastructure from source to tap	4	Examples of different types of transitions and their speed of change
…how to influence transitions?	At the level of water company's service area	3, 4	The actors in the different spheres of influence (see Figure 1-3)
	Regarding infrastructure from source to tap	4	That there is time and space to steer or adjust transitions
…how to deal with the future in strategic planning of drinking water infrastructure?	In the strategic planning process	5	How to design a strategic planning process
	In the realisation of strategic plans	4, 5	How to cope with (key) uncertainties and how to monitor these
	In a specific case study of a Dutch water company	5	Inspiring / telling example
…what future scenarios are, how they can be used in strategic planning processes and generic, ready-made scenarios	Building your own future scenarios	5	Process of and tools for building scenarios
	Enriching the generic, ready-made scenarios	6.2	How to make the generic, ready-made scenarios specific for one's own operating context
	Applying the generic, ready-made future scenarios	6.1	How to use the generic, ready-made future in one's own strategic process
…. where to find additional/ background information?		Attachment I	Additional and more extensive descriptions

The report consists of three parts, in line with the framework. The first is concerned with the present state and the historical development of drinking water infrastructure, the second with the strategic options/ dilemma's and how to assess those on robustness with the use of future scenarios and the third addresses the conclusions and recommendations.

1.4.1 Part I: historically informed strategic processes

This part contains three chapters. Chapter two is concerned with so-called 'landscape' changes (see Table 1-1) and the broad historical developments and trends in the SEPTED dimensions at the local, national and global levels. Major changes in one or more of these dimensions have had considerable impact on how water companies view the(ir) world and therefore, how they made decisions on water infrastructure. Chapter two describes some of these major changes and the impact on water companies and water management in the Netherlands. It provides an understanding in some of the fundamental drivers for change.

The focus of chapter three is on so-called 'regime' changes. The concept of 'regimes' in this report refers to a particular drinking water infrastructure system, which runs (or not) on the interplay of a myriad of socio-technical elements including pipes, pumps, operators and organizations (see also Table 1-1). Over time, such overarching regimes change, based on and driven by driving forces in both the landscape and the smaller elements of which it is composed. In chapter three a study example of this approach is given, highlighting how drinking water infrastructure regimes have changed in four Dutch urban areas, namely Groningen, Amsterdam, Arnhem/Nijmegen and Maastricht. It thereby indicates the drivers behind these changes, and how influencing such transitions took (and can take) place.

In contrast, chapter four takes as the starting point of analysis changes in one or more of the socio-technical components that together make a drinking water infrastructure regime run. It gives a compiled version of a study of changes in specific parts of the infrastructure, namely in the field of extraction, treatment, distribution and consumption of water in the Netherlands. The value of this chapter for the overarching framework is not only the historical sketch and insights, but also, like chapter three, how such (mini) transitions have been and can be steered.

1.4.2 Part II: Visualizing and planning for futures of drinking water infrastructures

This part is meant to give readers inspiration and tools for approaching futures of drinking water infrastructure in planning processes.

The first chapter of this part, chapter five, provides guiding principles with which strategic planning for the future of water company's infrastructure can be carried out and the results of their application in some case studies. It describes and discusses assumptions for how to deal with the future in strategic planning processes and it provides a selection of methodologies and planning techniques, such as for the building of future scenarios. In the research project underpinning this report, these tools have been applied with the ten Dutch drinking water companies together, as well as with one water company in particular. The results that these processes generated are also discussed in this chapter.

Chapter six proceeds by providing water companies and strategic planners a concrete building block in the strategic planning process, namely four future context scenarios for cities and urban regions. Drawing on ongoing horizon scanning activities in the BTO and in participation with a transdisciplinary team of water researchers and practitioners, these scenarios present four plausible and internally consistent storylines of how future urban societies may look like. These can be used by water companies for testing the robustness of strategic choices. The scenarios are ready to be used by water companies as they are, but can even be of more use when they are enriched by trends and developments specific for the region of a particular drinking water company.

1.4.3 Part III: Conclusions and recommendations

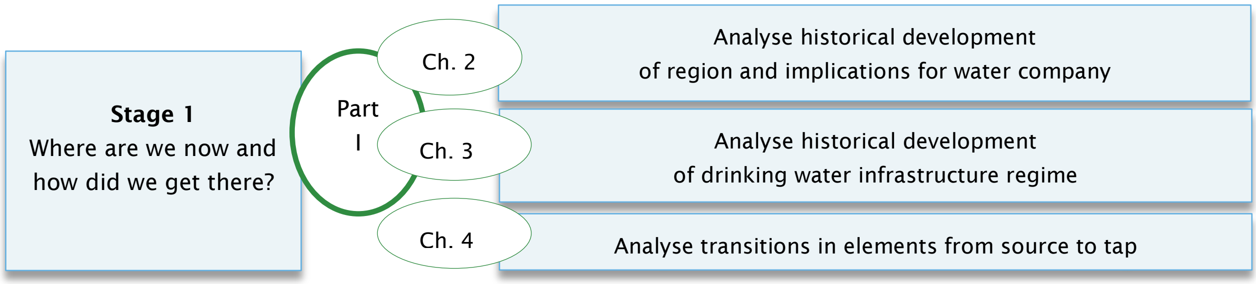
The last part of the report brings insights from the previous chapters together in conclusions and recommendations. It provides strategic planners with ‘stepping stones’ for setting up and implementing a strategic planning process for drinking water infrastructure. It provides learned lessons gained during the research project, as well as concrete recommendations on for instance team composition and the use of techniques. Lastly, some knowledge gaps and promising research questions are given that can be tackled in future research endeavors.

Finally, although this report is the main and final output deriving from a research project carried out in 2013-2014, there are several other (types of) outputs that one may consult, such as articles, presentations and (background) reports. Attachment I provides an overview of these outputs.

Part I

Historically informed strategic planning processes

The following part of the framework, and the accompanying chapters, will be described in Part I:



And the following questions addressed:

Are you interested in the question/domain of…		Read chapter	What to expect/ learn in these chapters?
…how (aspects of) drinking water infrastructure have developed historically?	At the landscape level/ context water companies operate(d) in	2	Understanding (trends in) drivers for change
	At the level of water company's service area	3	Specific drivers behind investments in water infrastructure
	Regarding infrastructure from source to tap	4	Examples of different types of transitions and their speed of change
…how to influence transitions?	At the level of water company's service area	3, 4	The actors in the different spheres of influence (see Figure 1-3)
	Regarding infrastructure from source to tap	4	That there is time and space to steer or adjust transitions

2 Landscape developments and their impact on transitions in water management, 1880 – 2015

This chapter is concerned with sketching changes on the level of the 'landscape', that is, the broader trends and developments that take place in a society and which influences the way water is and ought to be managed. Studying and making sense of such bigger external changes, and how they relate to one's 'internal' system (see Figure 1-3), is an important part in the broader strategic planning framework presented in the previous chapter. As the project on which this report is based was concerned with the Dutch drinking water sector as a whole, this chapter accordingly provides an analysis of landscape changes in the Netherlands (and 'the West' more generally) and how these have influenced (drinking) water management in the Netherlands over the past one and a half century.

The analysis in this chapter draws on Allan (2003), who distinguishes the following five phases or major paradigm changes on the landscape level:

- A 'premodern' phase (until approximately 1880)
- From industrial to reflexive modernity (1880 – 1970)
- The rise of environmental consciousness and the green movement (1970s onwards)
- The rise of free-market thinking (1980s onwards)
- Focus on institutions, governance and management (2000s onwards)

Allan (2003) describes how during these phases societies and its major actors have looked at and treated nature and specifically, water[2]. Each of these landscape phases and associated 'water management paradigms' know their own dynamics, (dominant) world views and conditions that for a great part determined what type of ideas and policies were or were not deemed relevant, legitimate and/or innovative. The core ideas of these five phases/paradigms are explained below and taken as basis for the description of (specific) influential landscape trends and developments that have been (and some still are) of importance to the Dutch context. These will then be related to changes in the way water and nature more generally has come to be seen and approached, and specifically to major (past) changes of and in the Dutch (drinking) water sector.

2.1 Premodern phase (until approx. 1880)

The premodern phase, that lasted until far in the nineteenth century, is characterized by a limited technological and organizational capacity. Securing essential goods for existence, on a local and regional scale, occupied a large share of the day for most people. Although history has seen sophisticated drinking water systems, such as those of Romans, many people depended long after these times on local and regional sources for their drinking

[2] These landscape phases derive from so called 'modernity theory', an influential branch of sociological theory used to explain modernization processes in societies, and the stages they go through when advancing from 'pre-modern', 'traditional' societies to the highly developed and to some, 'civilized' nations of today – at least in the Western world where this study focuses on. Although the framework of Allan (2003) takes the professional field of irrigation and only part of the Western European geography as starting points, it is also a useful heuristic for interpreting how (aspects of) the Dutch drinking water sector developed and unfolded over the last one and a half a century, as we will see in this and the subsequent chapters.

water, notably rain-, ground- and/or surface water. Technical and hydrological knowledge only began to progress later in the Middle Ages and the development of advanced drinking water systems really kicked off after the start of the industrialization, first elsewhere in Western Europe and later in the 19th century also in The Netherlands (De Moel et al., 2006).

2.2 From industrial to reflexive modernity (approx. 1880 – 1970)

The industrial revolution and the idea of modernization that came up in the second half of the 19th century quite radically changed the fabric of Western societies. Central in this phase was the notion of progress, building on the ideals of Enlightenment such as reason, ratio and science. This phase saw the emergence and fast growth of modern banking, different types of industries and public entities, as well as major breakthroughs in science and technology, which greatly spurred the modernization of society and the growth of the economy. This made for instance interventions in nature possible on an unprecedented scale, driven by normative views to control the hitherto 'unpredictable' nature and to adjust nature to the needs of modern man. Major (state) investments in large infrastructural works in various domains such as water and energy followed and these also had clear economic purposes, like in the straightening of rivers. But these were also opportunities to apply the newest technological and hydraulic features, which often became an end in itself, hence, the term 'hydraulic mission'. This view on nature and subsequent interventions is embodied especially well in water (flood) management during this time period. (Allan, 2003; Disco, 2002; Molle, et al. 2009, Mollinga, 2008; Koot, 2005).

Modernity also implied a move away from dirty and decease prone cities towards higher levels of cleanliness and hygiene for first the elite and later the mass of people. This is where drinking water comes in (along with other essentialities like sanitary services); advanced and integrated processes of extraction, treatment and distribution enabled an efficient and secure provision of large quantities of high quality water and would take away a major cause of (the spread of) infectious deceases like cholera. Such systems were first initiated by private funders and operators in cities and, following a strong perception that water (like other resources) should be available for the public at large, local and regional governments took over this function (Brown et al. 2009). The first drinking water system of The Netherlands emerged in Amsterdam in 1853, by 1900 some 60 water companies provided water to hundred cities and municipalities, but it was only until the late 1960s that almost every Dutch household was connected to a centralized drinking water system (De Moel et al., 2006).

Overall, this phase of industrial modernity contributed greatly to social welfare of people, particularly in the interwar period and after World War II. It created conditions for structural growth in population and life expectancy in The Netherlands. New economic sectors stimulated employment, especially in and around cities that during the early industrialization rejuvenated, expanded or came into being. New sectors brought new types of labour (e.g. administrators) and social classes (e.g. growth of middle classes). Based on class, religion and/or political views, people began to organize themselves in so called societal pillars, all having their own social institutions, from schools to newspapers (Manning & Bank, 2005). After World War II, a grand reconstruction program soon brought industrial production back to pre-War levels. This, in combination with other important milestones like the discovery of the large natural gas field in Slochteren at the end of the 1950s, heralded a period of rapid and renewed economic growth and prosperity and laid the foundation for the modern consumer society, in which citizens' increasing spending capacity and spare time enabled them to consume and recreate more and more intensely (Kromhout, 2007).

Industrial modernization came with a price however. A relentless pursue of ‘progress’, ever higher levels of economic growth and prosperity went hand in hand with severe and tangible environmental degradation and erosion of representative democracy more generally. Growing discontent eventually incited a new phase commonly referred to as “reflexive modernization” (Beck, 1992). Under this phase, the assumptions and ideals of industrial modernization were critically assessed or even rejected, most prominently from three dimensions, namely from an environmental, free market economic and institutional/ governance perspective. The impact of these three movements on a landscape level and specifically for the Dutch (drinking) water sector will now be explored.

2.3 Dimension I: environmental consciousness and the green movement (approx. 1970/1980 onwards)

The end of the 1960s and beginning of the 1970s saw a growing environmental awareness in society, as well as more democratization and citizen involvement in political and policy decision making. The social and green movements took advantage of this momentum and pointed out the negative consequences of a century of industrial modernization on the environment and, more generally, on the social fabric of society. Such concerns and sentiments of initially minor movements were widely shared in society and the government too felt it could no longer move on like they commonly did. They decided on (more) regulation on industry and other sectors, for instance aimed at the reduction of harmful emissions.

Normative views on nature changed due to these developments, which had repercussions for the water sector at large. The belief that nature could and should be controlled, made way for a more nuanced vision, one that stressed nature’s fragility and uncontrollability and that (effects of) interventions in nature are highly uncertain. The founding of the Club of Rome and its well-known report *Limits to Growth* published in 1972, followed a decade and a half by the Brundtland Report, effectively raised environmental concerns up to the highest political stages and formed the starting point for mainstreaming the discourse of sustainable development. On a national level and specific to water, the introduction of the Law on Water Surface Pollution, with water quality as main concern, nicely reflects an environmental issue that formerly received little political attention and which now had become a prime concern (Disco, 2002). Environmental laws and guidelines like the polluter pays principle were introduced and industry was compelled to obtain licenses for wastewater discharge. The building of modern wastewater treatment plants also took off and these measures combined proved highly effective in improving (surface) water quality, which also benefited drinking water companies in producing drinking water. The grand water (flood) management projects that were commonly proposed and executed without any meaningful alterations, increasingly received (critical) attention from citizens and special interest groups alike, demanding their voices to be heard and projects to be altered or abolished altogether (Simissen, 2009).

Although environmental consciousness is a very noticeable development during these decennia, with particular effects on how nature and water is perceived and managed, the 1970s and 1980s of course knew many more major landscape trends and developments. The Cold War, in its peak those days, entailed not only a conquest for global hegemonic power, but also an ideological struggle for supremacy of either the capitalist or communist (economic, cultural) system – although neither system was homogenous and both knew many variants. Economies had also become increasingly interconnected and oil-dependent. Two oil crises in the 1970s, in combination with other factors, therefore led in the early 1980s to the deepest recession since the one in the 1930s, with huge implications for national economies and the daily lives of many in Western Europe and the Netherlands

(Bhageloe-Datadin, 2012). It is from here on that, next to the environment, another dimension rose to prominence: the free market economy and free market thinking.

2.4 Dimension II: free market thinking (approx. 1980s/1990s onwards)

During the phase of industrial modernity, the State played a major role in stimulating and steering the market economy. This came under attack by neoclassical economists at the end of the 1970s and beginning of the 1980s, who revived the idea of the free market economy in the West[3]. In their vision, the State should play only a minimum role in steering the economy and instead leave that to the 'invisible hand' of the market (see Smith, 2010 [1790]) and its assumed self-regulating capacities. These economists claim this to be the best way to create welfare and distribute income and wealth. This variant on liberal thought, often referred to as *neo*liberalism, reigned especially during the 1990s, after the fall of the Berlin Wall in 1989. Well-known manifestations of this dimension were acts of privatization and deregulation, most prominently in the financial sector that grew exponentially from then on. Capital that became available as a consequence, gave an enormous boost to technological and other innovations, especially in the then upcoming and fast growing ICT sector. All this led to high rates of economic growth in the second half of the 1990s.

On the longer term, the influence of this dimension on society and specifically nature and water, comprises the less tangible (free) market based thinking and a growing predominance of financial-economic reasoning within not only private, but also public organizations (Veenswijk, 2005; Harvey; 2005). From this point of view, nature is not only seen as having an intrinsic value on which humankind depend, but also, or even more, an economic good or commodity. In line with these thoughts, water became formally recognized as an economic good in the Dublin Principles defined in 1992 (ICWE, 1992). Examples of market based approaches applied to nature/ water are most prominently the cap and trade system to reduce carbon dioxide emissions, but also include the more recent attempts of attaching a price to natural resources (monetarization) or applying economic principles to (reducing) water use.

The Dutch drinking water sector adopted similar market based- and private sector principles in their implementation of the so called New Public Management (NPM) concept. In short, NPM entails the trend of (semi)public organizations becoming increasingly molded after private organizations, assuming the latter to be superior in terms of efficiency and ways of working (Hernes, 2005). As such, water sector organizations were not privatized, like those in the telecom and other public sectors, although fierce political debates at the end of the 1990s between those in favour of and others opposing water privatization in The Netherlands did take place. Instead, liberalization and deregulation of drinking water companies took place, with NPM as a leading vision. Government-led provision of water for the sake of universal coverage were gradually replaced by autonomous, semi-public utilities whose drivers to operate changed, for instance towards more efficient and market like service delivery and securing or improving their "market position". These drivers underpin

[3] Economic policy under industrial modernity in the West was strongly influenced by the renowned economist John Maynard Keynes, especially during and after the great recession in the 1930s. Milton Friedman and others at the Chicago School of Economics were amongst the main economists designing the doctrine of (neoliberal) free market economy, of course building on the principles of neoclassical economy as established by Adam Smith and others. Their ideas were first adopted and implemented on a larger scale in Chili under the Pinochet regime, but really gained momentum after President Ronald Reagan of the United States of America and Prime Minister Margaret Thatcher of the United Kingdom implemented the neoliberal political agenda from the early 1980s onwards. In The Netherlands, the then Prime Minister Lubbers adopted similar principles for his cabinet's (economic) policies. During the second course of the 1990s, the two administrations of Prime Minister Wim Kok tried to reconcile neoliberal free market principles with those of the social democratic movement in the so called "Third Way" (see Giddens, 1998).

also many of the mergers in the drinking water sector roughly after the 1980s, whilst before that, mergers of municipal water utilities into provincial ones were commonly instigated by the government (Schwartz, 2011).

NPM influenced not only drinking water companies, but water management more generally. Rijkswaterstaat, for instance, underwent multiple major reorganizations, with great reductions in labour and budgets, legitimized on the promise of becoming more efficient and service-oriented whilst claiming the private sector could better do the job than the organization itself. Hence, outsourcing and competitive tendering became the norm at Rijkswaterstaat (Metze, 2010; Van den Brink, 2009).

This dimension, amongst other factors, also pushed forward the much debated shift from "government to governance". This basically implies a shift in power from the State [government] as central actor in making and implementing (water) policies, common during the industrial modernity phase, towards a much more fragmented dispersion of power over a diversity of actors on different levels, from the national to local, supranational and global levels [governance] (Swyngedouw, 2006: 58). Thus, (yet) another dimension emerged at the end of the 1990s, the institutional/governance/management paradigm (Allan, 2003).

2.5 Dimension III: focus on institutions, governance and management (approx. 2000 >)

From roughly the start of the 21st century, increasing attention went to institutional factors and aspects of governance and management. Politics and policies of the 1980s and 1990s, combined with the rise and growth of ICT technologies such as the PC, mobile phones and the Internet, spurred the already ongoing process of globalization. Economically, this meant that national economies and financial sectors became even more entwined than they already were, further stimulating international trade and growth. Politically and policy wise, levels and actors other than the nation state grew in importance. That is, on the one hand, institutions on a 'higher' (e.g. supranational) or 'lower' (e.g. city scale) level are often attributed increasing decision-making powers (Ray, 2007; Walters, 2001). On the other, the political and policy landscape had become increasingly fragmented, with non-profit and private actors increasingly filling up the vacuum left by the State in the 1980s and 1990s. The effects of neoliberal (economic) policies also became much more clear and visible. Firstly, while it created immensurable wealth, its distribution turned out to be highly uneven in social and geographical terms. Secondly, it led to growing pressure on the environment and (the use of) fossil fuels, as well as accelerated climate change. Lastly, it soon turned out that the high rates of growth were mainly based on speculation, which has been a major cause of the "dot-com bubble" in 2002 and, after a short economic recovery, of the credit- and debt crises in 2007 and 2009 (Harvey, 2005; Piketty, 2014; Castree, 2011).

All these landscape developments made society and the problems and issues it faces appear increasingly complex. Understanding grew that the drivers and causes of these problems were multiple, highly interconnected and multidimensional. This in particular spurred a depart from technocratic views, common during earlier phases, to a growing appreciation of the deep social, institutional and political roots of these problems. On the assumption that the nature of these problems is multidimensional, solutions should also be of an interdisciplinary kind. Therefore, actors have become increasingly concerned with seeking approaches and solutions in the institutional and 'social' sphere, next to those technological or economic. Because society had also become more fragmented and 'networked', such institutional, and especially management, approaches came to be addressed more often in so called governance processes or arrangements. This is reflected in now prevalent ideals underpinning many of these governance arrangements, which are often 'photo negatives' of the problems we face nowadays. Thus not *fragmented*, but *integrated*. Not *apart*, but *participatory* and, lastly, not to the benefit of the minority, but *inclusive* of everyone (Molle, 2008; Allan, 2003). This dimension blends in with the other two in the popular credo of People, Planet, Profit, which is used by many organizations in their (rhetorical) quest for win-win(-win) solutions.

In the (globalized) world of drinking water the institutional dimension can be traced, often again in relation to the environmental and economic dimensions. A typical example is the often cited quote of the World Water Council on a so called global water crisis, which they say is "…not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people –and the environment– suffer badly" (Cosgrove and Rijsberman, 2000: xix). It is indicative of how many other water actors currently perceive of the water problem, i.e. that it not so much a supposed lack of adequate technologies or expert knowledge, as it is a question of how to best manage our water resources and drinking water services. That this latter question is an inherently political and ideological one, and thus deserves (political) debate, is still little acknowledged (Swyngedouw, 2011; 2013). Rather, normative views on how best to manage water are presented as 'best practice' or as uncontested statements assuming consensus. This is where the economic dimension comes in once again, since one of the most powerful such statements is that water should be everybody's *business* – gently stressing water as an economic resource.

Today the three dimensions or paradigms are still very influential. From rather small, alternative groups in the periphery who claimed to be defending the environment, being 'green' has now almost become a prerequisite if one wants to be taken seriously. Economic and market based approaches for various types of issues, be they environmental or related to water or health, remain popular in governance and policy circles. A good example hereof, in the drinking water sector and elsewhere, is the emphasis on not only developing and implementing (public) goods for the sake of its *use-value* to the public, but also on its *exchange-value,* i.e. bringing these to the market (*vermarkten)* for reasons of accumulation of surplus-value and additional income, often in public-private constructions. And questions of governance and institutions are gaining ever more attention, up to the point of becoming all-encompassing terms that risk losing analytical and explanatory value. Nevertheless, major and often cited landscape trends such as urbanization, climate change or the (fragmented) network society presents us with many institutional challenges, from questions related to policy scales and bottom-up initiatives, to new and innovative management approaches.

2.6 Conclusions

This chapter provided an overview of major paradigm changes in the Netherlands (and Western Europe more generally) and how those have influenced perceptions on nature and the management of (drinking) water. Central during processes of industrialization and so-called modernization in the early and mid-19th century, was the 'controlling' of nature and water through engineering, in support of economic well-being. This came to be challenged with the rise of environmental movements in the 1970s, who pointed out the detrimental socio-ecological effects of industrialization. "Thinking and doing green" has only become more influential, a trend that can be witnessed in the water sector. This has come to be accompanied by two other major paradigms: those associated with the (free) market and with institutions. The former points at the rising power of market and financialized thinking and –mechanisms, the latter with a broader embracement of the view that institutions matter in the management of natural resources, next to the hitherto predominant focus on technology.

Albeit brief and inevitably incomplete, this overview indicates that sociotechnical transitions in the water sector and hence, in water infrastructure, do not 'just' occur, but are intimately related to and influenced by broader societal structures[4]. In this case, the Netherlands as a whole was taken as study object. Those intending to study (the impact of) broader landscape changes as part of their planning process may do the same for and thus limit the analysis to the region or city of their concern.

[4] Following from what in social theory has a well-established position: debates on "structure-agency".

3 Urban infrastructure ‘regime’ transitions

The focus in this chapter is on transitions in drinking water infrastructure on the “regime” level, that is, on the level of the city or the urban region. This perspective is useful for gaining insight in how integrated drinking water infrastructure as a ‘system’ developed in a particular city or urban region over time and the drivers behind such change. Based on that, planning for maintenance works or other types of interventions in the city can be significantly enhanced. In the research project, four cities in different parts of the Netherlands have been examined from this perspective, namely Groningen, Amsterdam, Nijmegen/Arnhem and Maastricht. These case studies have been described in detail in a separate report: “BTO 2015.050 Historical development of four Dutch urban drinking water infrastructures” and will only be briefly recalled here, followed by an analysis of the (pattern in) drivers behind these changes.

3.1 Introduction and short theory recap

Drinking water infrastructure systems comprise various subsystems from source to tap, i.e. water extraction, treatment, and distribution systems, and can be considered in an integrated and holistic way. The drinking water infrastructure should be considered a socio-technical system, whereby its physical components are inextricably linked to social and organisational processes, such as its design and management. As explained in chapter 1, a transition can be defined as a change from one socio-technical configuration to another, involving substitution of technology as well as changes in other elements, such as practices, regulation and symbolic meaning (Geels, 2002). The Multi-Level Perspective (Geels, 2002) distinguishes between niche-innovations, the sociotechnical regime and sociotechnical landscape. Using these three levels, the different factors and actors that influence a transition can be traced and described, as well as their interrelations. Transitions can be related to the changes of an integral drinking water infrastructural system (breadth-oriented analysis, this chapter), or they can be related to one specific socio-technical aspect of an entire drinking water system (in-depth analysis, chapter 4). Transitions are characterized by the extend of an adoption, the rate of change, the drivers for change and the spheres of influence. The spheres of influence distinguish between an internal and external environment and a transactional space. The internal system comprises of all those infrastructural aspects water companies have full control over, whereas the external system include trends and developments water companies have no control over, but which do influence the drinking water system. The transactional space is the grey area between the in- and external environments: water companies have no full control over developments in this space, but can exert influence, for instance by drawing up strategic agendas with important third parties.

3.2 Historical development of four Dutch cities and the drivers behind change

In order to find the major drivers for transitions in drinking water systems, we studied historical infrastructural development of four different Dutch cities and we identified the drivers behind these changes. We studied the major investments in the primary drinking water infrastructures, that is abstraction, treatment, storage and distribution, of the urban areas of Amsterdam, Groningen, Arnhem-Nijmegen and Maastricht in the past one and a halve century. Also, we determined whether the investments were driven by internal, transactional or external (f)actors. All incentives for 225 identified investments were classified into a limited number of 23 drivers. The occurrence of the drivers was analysed for each city and for three time periods in order to search for patterns or trends in the driver occurrence. Next, a summary of the main characteristics and developments of the drinking water infrastructure of the four Dutch cities is provided.

3.2.1 Infrastructural development Groningen

The first surface water facility of Groningen was built in 1880 and is still in use. This facility has been adapted several times between 1880 and 2012. The source changed from surface water only, to mixed treatment of surface- and groundwater, to groundwater only, and since the early 1970s both surface water and groundwater are used and treated in a separate configuration. The treatment of the surface water was gradually expanded, in order to adapt to variations of the source water quality and meet more stringent water quality standards, because of technological development and in order to meet the growing water demand. In the beginning of the 20th century, the city had two water companies (a private enterprise and the municipality); some districts had two distribution networks. At the end of the 20th century the city of Groningen had grown, but the water production of the municipality stagnated because the municipality got 'isolated' by the provincial water company for which the municipality could not grow further, and the water consumption in the city had stagnated. Shortly after, the municipality and the provincial water company merged (in 1998) The transport capacity of the source water and the drinking water was expanded a couple of times due to the increasing drinking water demand and requirements on security of supply.

3.2.2 Infrastructural development Arnhem-Nijmegen

Both the cities of Arnhem and Nijmegen were served by a municipality for a long time. Groundwater is abundant is this region and both cities had one or two treatment facilities for most of the time. Due to the geological situation, both cities have storage reservoirs in the higher parts of the city. The drinking water treatment was relatively uncomplicated, comprising aeration, filtration and conditioning, except for the facility in the city center of Nijmegen which was facing groundwater pollution at the end of the 20th century. The municipal water companies were acquired by a private enterprise at the end of the 20th century. The municipalities got 'isolated' by the provincial water company. After the merger of the city water companies and the provincial water company, the water supply plans were considered in an integral way on a larger scale. The increase of the scale of production, the desired reduction of groundwater extraction in natural reserves and the hardness of the water of facilities led to the shutting down of certain smaller scale facilities, clustering towards larger scale facilities and larger scale transport of drinking water towards the city and from the city towards rural areas.

3.2.3 Infrastructural development Maastricht

The basic set-up of the drinking water infrastructure in Maastricht was rather constant during the entire period. Groundwater has always been used as drinking water source. The required treatment of the groundwater has always been limited, although disinfection was required in some cases and the treatment is expanded with softening. The building of a nitrate removal plant could be prevented by cooperating with farmers, as well as mixing with water with low nitrate levels. The city got served by two or three groundwater facilities until the 21st century. Some facilities were closed, because of water quality or capacity problems, only after they could be replaced by new facilities. In the beginning of the 21st century, the switch from separate drinking water production facilities to centralized softening was realized. This project, together with the acquisition of the municipality of Maastricht by the provincial water company WML (around 2000), had great impact on the main distribution infrastructure since water supply plans were considered in an integral way on a larger scale.

The availability of groundwater has always been scarce on the west side of the river, and groundwater was abundant east of the city. Many efforts were done to find adequate groundwater sources on the west side of the river, which was hardly successful because of water capacity and quality problems. This also explains the existence of several transport pipeline connections crossing the river, and the presence of high storage reservoirs at the west side of the city.

3.2.4 Infrastructural development Amsterdam

The city of Amsterdam is supplied with drinking water which is produced at two different sites, namely Leiduin and Weesperkarspel. Both surface water facilities were built in the nineteenth century. The Leiduin site was built in 1853 and was initially operated by a private enterprise, the Dune Water Company. In 1896, the concession of the Dune Water Company was sold to the municipality of Amsterdam. For about a century, the Leiduin facility extracted water from the dunes when it was shown that the dunes got depleted and upcoming of brackish water occurred. In order to replenish the dunes with freshwater, a large scale pretreatment of river water and extended distance transport works were realized mid-20th century. The Weesperkarspel site was built in 1888, but for many decades the water was not suitable for drinking purposes, because of the poor quality of the source. After several source switches, the river water source was replaced by lake water in the 1930s. Its water quality improved significantly, and therefore the double distribution network, which had separated the potable water of Leiduin and the non-potable water of Weesperkarspel for many decades, could be eliminated. In the past decades, both the treatment of Leiduin and Weesperkarspel have had many capacity expansions and process adaptations, in order to meet growing water demands and anticipate on changes of the source water quality and meeting more stringent quality demands. Also the transport pipeline infrastructure, both of source water and drinking water, and the storage capacity works were expanded many times to meet growing water demands and to increase security of supply. Since 2006, the municipal water company of Amsterdam is named Waternet, and is the first and today only water cycle company of the Netherlands.

3.3 Drivers of change and change in drivers

The incentives for the 225 identified investments were clustered into and classified by 23 different drivers. The Table 3-1 presents the drivers that were found. The driver codes are used in Figure 3-1 and Figure 3-2.

The drivers ‘water quality’ and ‘water demand’ are the most frequent occurring drivers. Investments because of third parties, geographical factors, costs, and policy are of secondary interest. Some drivers, such as ‘image’ and ‘sustainability’, were only identified one or two times. Most of the drivers found are recurring throughout the entire period, although some trends were found in the occurrence of drivers.

Important trends are the search for suitable drinking water sources and the increasing customer connectivity and water demand in the early decades. The water demand is found to be an important driver, but its relative occurrence decreases over time. This observation is in accordance with the landscape analysis provided in chapter 2, in which the modernization of society and the ‘hydraulic mission’ were amongst the key driving forces until the seventies, and related to this, an aimed for and accomplished connectivity rate of almost 100% in the late 1960s. Investments induced by the merger of municipalities and larger scale companies, and the importance of environmental impact and costs occurred in the following later decades. This observation, too, is in accordance with the landscape analysis of chapter 2 which shows an increased environmental consciousness from the 1970s and a growing (perceived) need for cost efficiency, from the 1980s onwards. Despite the fact the considered cities are embedded in the same landscape and common generic drivers are found for these cities, its effects on the development of the infrastructure of the cities are also significantly influenced by local factors.

TABLE 3-1 DRIVER CLASSIFICATION AND DRIVER CODE

Driver description	Driver code
Water quality (raw water or drinking water quality)	WQ
Availability of source water (related to capacity or quality)	AVB
Water demand or production / distribution capacity	WD
Security of supply (related to water demand)[5]	SEC
Water pressure in the distribution net	P
Water supply plan	SUP
Geographical or climate related factors	GEO
Governmental or provincial policies, laws, or Water Decree	POL
Influenced / imitated by third parties	3rd
Customer related	CUST
Scarcity of materials	SCAR
(In)dependency of other parties	DEP
Technological development, the availability of new technology	TECH
Renovation (because of age, or rate of failure)	RNV
Costs	€
Investment- and project planning / timing	PLAN
Dependency of historical infrastructure (continuation of existing	HIST
Contracts with clients or other parties	CONTR
Operational reasons	OP
Organizational (mostly related to merger and acquisition)	ORG
Image (or customer confidence)	IMG
Energy (cost related)	E
Environment, sustainability	ENV

The relative driver occurrence for the period of one and a half century is presented for the four cities in the spider plots below. The identified absolute number of drivers for the investments in this period was 117 for Amsterdam, 70 for Groningen, 90 for Maastricht and 88 for Nijmegen-Arnhem.

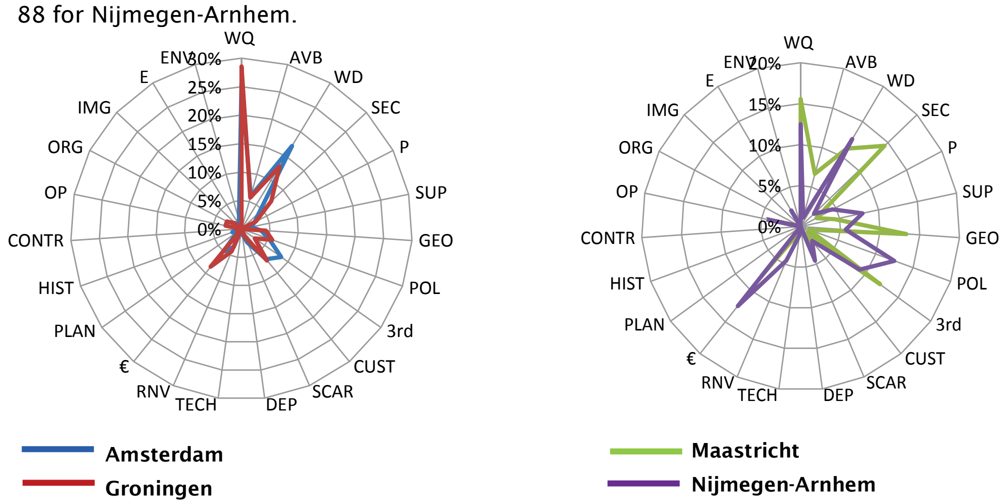


FIGURE 3-1 RELATIVE DRIVER OCCURRENCE FOR FOUR DUTCH CITIES. CODES REFER TO TABLE 3-1

[5] Security of supply concerns the number of customers that is shut down from the centralized water supply for a certain amount of time after an interruption of water production or water supply. In the Netherlands, this parameter has been of great importance since many decades, and demands regarding the minimum level of security of supply is integrated in the Dutch Drinking Water Decree around 2000. It was not possible to always clearly distinguish between the drivers ‘water demand’ and ‘security of supply’ while assessing the information obtained from literature and interviews.

The driver occurrence pattern of the two surface water treatment systems show differences, and the pattern of the two groundwater treatment systems show differences as well. Despite these differences, the following pie charts combine the driver occurrence patterns for Amsterdam and Groningen on the one hand, and Maastricht and Nijmegen-Arnhem on the other hand in order to visualize the change in driver occurrence patterns over time.

Period **Surface water (Amsterdam and Groningen)** **Groundwater (Maastricht and Nijmegen-Arnhem)**

< 1960

1960 - 1985

1985 - 2014

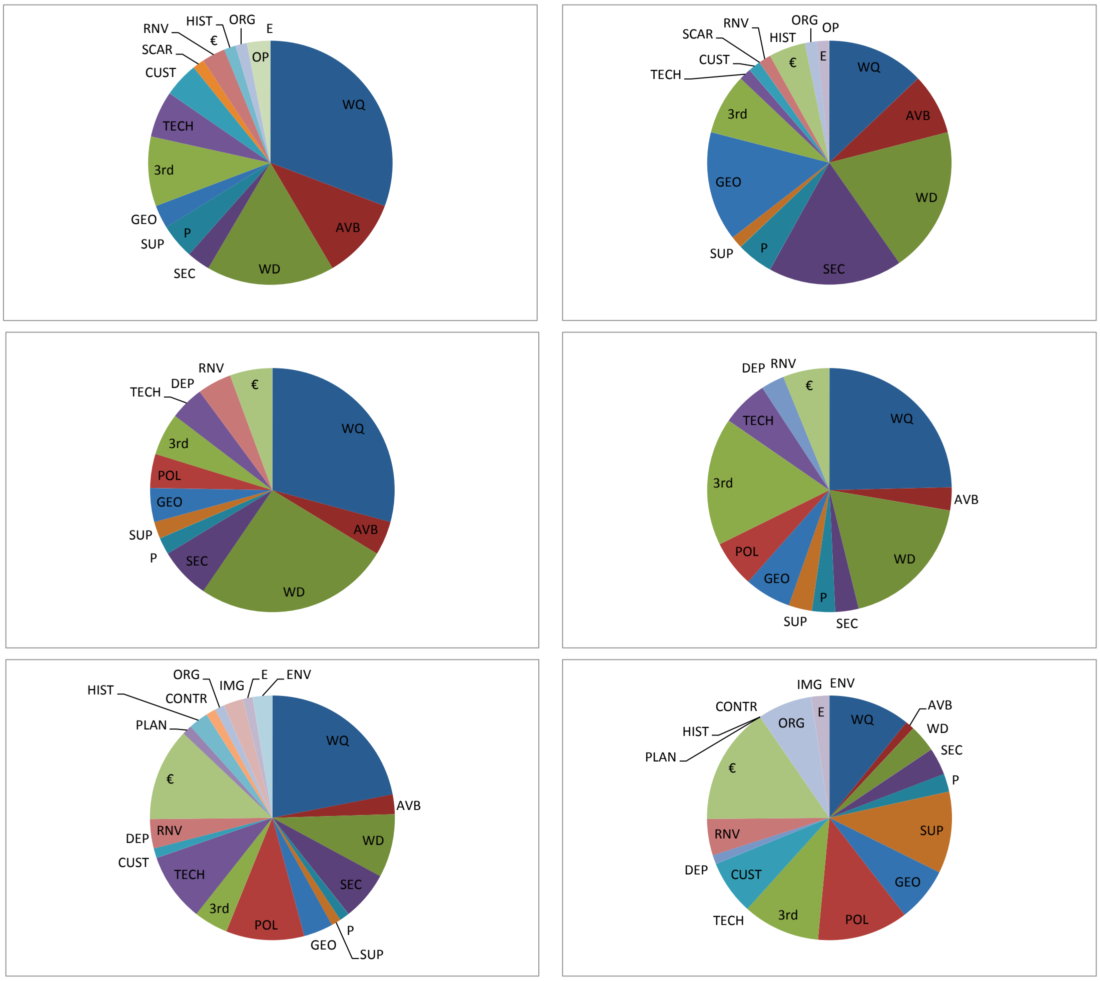


FIGURE 3-2 TRENDS IN DRIVER OCCURRENCE RATES OVER TIME, ADDED UP FOR SURFACE WATER SYSTEMS AMSTERDAM AND GRONINGEN AND GROUNDWATER SYSTEMS MAASTRICHT AND NIJMEGEN-ARNHEM. DRIVER CODES REFER TO TABLE 3-1.

The large inertia of drinking water systems – or path dependency – is confirmed, caused by large investments and long life times. However, it is also shown that the system is flexible, meaning that the system can be adapted to cope with changing conditions over the decades. During the time span of a century, several important changes are observed, such as managerial issues regarding company ownership and mergers, continuous capacity expanding to meet the growing water demand, and frequent adjusting of source and treatment to changing water quality demands. Larger scale infrastructural sites (with sunk costs) are likely to stimulate continuous development (expanding, modification and renovation) rather than developing new sites. Trends were based on the data of three periods of at least 25 years, and for similar studies, it is recommended to analyse at least a period of half a century to identify trends or differences in the occurrence of drivers as well as to identify transitions in integral infrastructural drinking water systems. This, in contrast to the transition of one specific sub-system or one asset-type, which typically takes two or three decades, as will be shown in chapter 4 (also see Report BTO 2015.051 Transitions in the drinking water infrastructure – a retrospective analysis from source to tap in Further reading).

Rate of system change: inertia and flexibility

The sites of the surface water treatment plants of Amsterdam and Groningen have been at the same location ever since the first establishment. However, the drinking water treatment infrastructure is flexible in many aspects, for instance, to cope with changes in the source of the water. Also the transport pipeline system connecting the treatment plant to the cities was gradually expanded to meet the growing water demand and guarantee a secure water supply, but the basic outline of the transport pipeline system was rather constant due to the steady situation regarding the location of the treatment plants and the cities.

Many of the groundwater production facilities of the cities of Arnhem, Nijmegen an Maastricht have always existed since the establishment. As opposed to the location of the surface water treatment plants of Amsterdam and Groningen, some groundwater extraction sites near Maastricht, Arnhem and Nijmegen were abandoned because of the search for alternative groundwater sources or because the original extraction was located in the city center.

Generic landscape and drivers but local implications

The surface water treatment facilities of Amsterdam and Groningen have shown a continuous adaptation and improvement since their establishment, anticipating on changing source water conditions and striving for improvement of drinking water quality, whereas the groundwater production facilities of Arnhem, Nijmegen and Maastricht supplied its water without or with very limited treatment until the 1980s.

Hence, the drinking water infrastructure is strongly linked to the water source. Amsterdam, Groningen and Maastricht have put many efforts in the search for new, supplementing or more suitable water sources. The water extraction system and the surface water treatment plants of Amsterdam and Groningen were adapted to the changing raw water quality. Several groundwater facilities of Maastricht were shut down, but only after new groundwater extraction sites were found.

The analysis of the sphere of influence of drinking water companies shows that the majority of the investments is driven by factors perceived as external in the early decades, mostly because the growing water demand drove the increase of the connectivity and the capacity expanding. In the later decades, many of the investments are internally driven, mainly because water companies can decide whether or not facilities need renovation or further improvement. The relative occurrence of transactional drivers is smaller than the occurrence of external and internal drivers, although the occurrence of transactional processes seem to increase over time. It is important for water companies to identify and explore their transactional sphere of influence, since it contains possibilities to influence or steer transitions.

3.4 Historical drivers versus future uncertainty factors

Examining the historical development of four Dutch drinking water systems revealed 23 drivers for change. Some of the drivers were identified as relevant throughout the existence of centralized drinking water supply systems, such as water quality and water demand. Some drivers only occurred a few times. Also, we found some trends in the occurrence rate of drivers over time. But how do these 'historical' drivers relate to drivers that are perceived to be influential on drinking water infrastructure in the long-term future?

Together with a group of Dutch water professionals and researchers, ten uncertainty factors have been identified that they think will likely have significant impact on a water company's operation, and the way they invest in or operate drinking water infrastructure. Identifying these uncertainty factors was part of a process of scenario planning, the outcomes of which are fully described in chapter 5. However, it is interesting to know the importance of those uncertainty factors when seen from a historical perspective, i.e. how they relate to the outcomes of and the drivers identified in the historical study of this chapter. Therefore, in Table 3-2, the ten key uncertainty factors are given in the first column, and how these relate to the historical study in the second column.

Like the studies in this chapter indicated, drivers for investment in drinking water infrastructure have changed over a longer period of time, influenced by developments at the 'landscape level' (chapter 2). The Table 3-2 shows that in the future, compared to developments in the past, three groups of drivers may drive investments in drinking water infrastructure:

1. Drivers that have always been influential, and will likely remain so in the future, such as the ownership and organisation of the water company;
2. Drivers that have gradually become more influential, but that will likely become only more important, such as importance attributed to sustainability, the availability of resources and climate change;
3. Drivers that have played no or a very minor role in the past, but will likely become increasingly significant for water infrastructure decision-making, such as trust in water company, the regulatory framework and political stability.

Surely, the list and the drivers are not exhaustive; these drivers that have been identified as important in a particular project, in the context of the Netherlands and for Dutch drinking water companies. But they do point out the usefulness of not only studying past drivers, but also potential future uncertainty factors that may affect (investment in) water infrastructure and how the two relate. As opposed to established and well-known drivers, emerging and new ones (driver group 2 and 3) require strategic planners to consider how they might impact on their operations and investment decisions and draw action plans on how to achieve a certain vision or mitigate certain undesired or potentially harmful developments.

In doing so, the question is whether a particular driver is completely out of control to the water company or that it might somehow be influenced for instance by working together with third parties or influencing the public perception. A factor such as political stability may well impact on a water company's operation, but cannot be influenced, whereas trust is something that can to some extend be influenced. Chapter 5 will provide in more detail how water companies can identify such factors and how they can strategically plan in the context of an uncertain future.

TABLE 3-2 UNCERTAINTY FACTORS IN A HISTORICAL PERSPECTIVE

Key external uncertainty factor identified as having major impact on drinking water companies in the (long-term) future	**Uncertainty factor in historical perspective (vis-à-vis the outcomes of the historical analyses)**
Trust in drinking water company	Trust in drinking water companies was not found to be a driver for investments.
Importance attributed to sustainability	Sustainability ('ENV') was found to be a driver for investments in a few occasions in the last decades. The decision to invest driven by environmental concerns was assessed to be an internal choice. In the future, society is likely to expect drinking water companies to increasingly operate in a more sustainable way. Therefore, the sphere of influence is shifting from internal to transactional.
Water demand	Water demand was found to be a very important driver. In the first period of study – until after mid-20th century, water demand was one of the most frequent found drivers for investment, and was met by an increase in connectivity. The driver was assessed to be an external factor in the historical study. However, drinking water companies could influence the water demand to some extend (which would rather make it a 'transactional' driver) by discouraging water usage by means of campaigning or tariff structure manipulation, or stimulating water usage in industry or large-scale consumers by means of account managing and campaigning or tariff structure manipulation.
Regulatory framework	Regulation was not found to be a driver for investments.
Ownership and organizational structure of water entity	The merger between municipalities, private enterprises and provincial water companies was found to be an important driver for investing in and changing the water system. The decisions to invest because of organizational changes or to changes in the organizational structure (through merger, acquisition) was assessed to be an internal choice or a transactional choice respectively. Important to know for drinking water companies: Decision to merge is mostly transactional, although EU/governmental laws can initiate, stimulate or accelerate this process. Decision to change the water system (by investing) after the merger is often an internal choice.
Political stability	Political stability in drinking water companies was not found to be a driver for investments.
Availability water and other resources	Availability is characterised by quantitative and qualitative availability and has been a driver in the past. The availability of both surface- and groundwater is greatly affecting the water system infrastructure.
Pressure on/ use of the underground	Use of underground was not found to be a driver for investments, although '3rd parties' was found to be a driver for investment. And in previous times there were less people and hence, less infrastructure, but nowadays, space is running out.
Climate change	No driver that was perceived influential (far) in the past. Indirect through resource availability and geographical factors (river, hill, availability of groundwater and its quality, availability of surface water and its quality)

4 Transitions in water infrastructures from source to tap

The previous chapter looked at how drinking water infrastructure historically developed in a city as a whole, taking all types of drinking water infrastructures and their integration into consideration. This chapter, in contrast, takes a rather 'disintegrated' but in-depth view on particular selected parts of the total infrastructure and how transitions in these occur. This can in itself be valuable for strategic processes that focus solely on one or some parts of the larger infrastructure system, but it can also be fruitfully combined with the other approaches in the previous chapters in studying the occurrence of transitions. In the research project this report draws on, one socio-technical transition was studied in each of the different parts of drinking water infrastructure, from source to tap.

The transition regarding the drinking water source was about changing from a 100% groundwater extraction to a mix of ground and surface water extraction. The transition in the treatment was the change towards a chlorine free drinking water production and distribution in the whole of the Netherlands. A third transition was the change in practices and guidelines for the design of drinking water and hot water installations. The last transition that we considered was at the tap: the change in domestic drinking water demand.

This chapter briefly sums up what these different studies entailed and what they combined produced in terms of results and insights.

4.1 Models to analyse and steer micro-transitions

Socio-technical transitions in this chapter have much in common with the so-called "niche-innovations" in the multi-level framework of Geels (2002). Transitions on this 'micro-level' can be explained by the S-curve model that outlines the diffusion of innovation (see Figure 4-1)

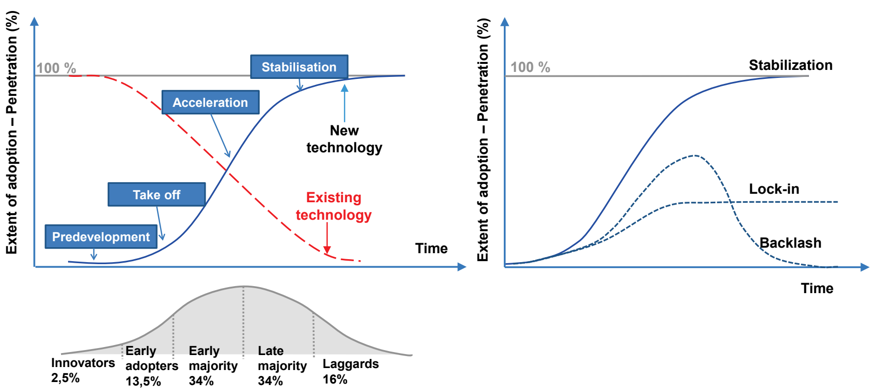


FIGURE 4-1 SCHEMATIC DESCRIPTION OF TRANSITION TRAJECTORIES A) SUCCESSFUL TRANSITION, B) RESTRICTED OR FAILED TRANSITION TRAJECTORIES (AFTER ROTMANS ET AL., 2001)

In this model, four stages can be identified: i) a “predevelopment” phase of equilibrium in which innovators play a major role; ii) A “take off” phase in which early adopters start a process of change in the system; iii) An “acceleration” phase where visible structural changes take place in the system. In this phase collective learning processes, diffusion and embedding processes occur when the majority has adopted the innovation; and iv) A “stabilization” phase is achieved, when the speed of social change decreases and a new dynamic equilibrium is reached. However, not all transitions lead to a full adoption; different trends and factors interact and innovation can “lock-in” or “backlash”, (Figure 4-1b). Therefore, a transition can be characterized by the extend of adoption of the innovation, the rate of change of each phase, and the total time period of change.

To what extent can transitions on the ‘micro-level’ be managed or steered? Seeing transitions as evolutionary processes that mark possible development pathways, the direction and pace could be influenced by slowing down or accelerating phases, as indicated in Figure 4-2. But to slow down or accelerate phases, it is important to understand what (technical, economical, etc.) factors drive the transitions and whether these factors are or are not within full control by the water company (internal or external system, Figure 1-3) or that they lie within the ‘transactional’ environment, whereby water companies do not have direct control over factors but may, for example through collaboration or lobbying, influence other organisations or individuals to change circumstances in a certain (for them beneficial) way.

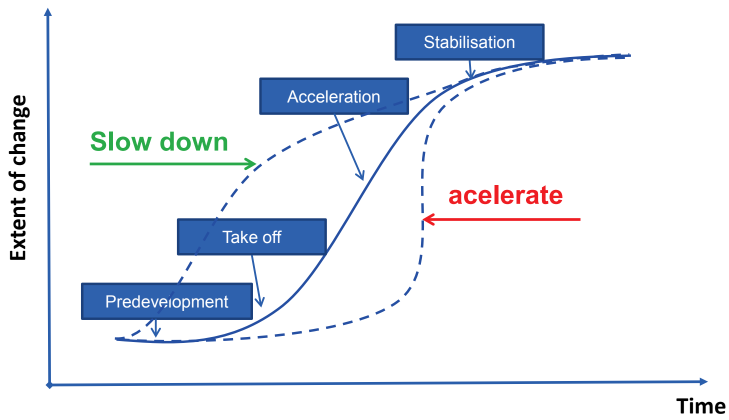


FIGURE 4-2 POSSIBLE DEVELOPMENT PATHWAYS IN A TRANSITION PROCESS

4.2 Socio-technical transitions in particular drinking water infrastructures

4.2.1 Introduction

An in-depth analysis was done on four relevant transitions in the Dutch drinking water infrastructure, covering the route from source to tap. The transition regarding the drinking water source was about changing from a 100% groundwater extraction to a mix of ground and surface water extraction. The transition in the treatment was the change towards a chlorine free drinking water production and distribution in the whole of the Netherlands. A third transition was the change in practices and guidelines for the design of drinking water and hot water installations. The last transition that we considered was at the tap: the change in domestic drinking water demand. What follows is a brief background on these studies, after which they will be analysed in terms of extent of adoption, rate of change and drivers for change and how these were steered.

4.2.2 Source: from groundwater only to groundwater and surface water

Predevelopment

In the Netherlands approximately two thirds of the drinking water is produced from groundwater and one third from surface water. Traditionally, there has been a division between pure groundwater water companies, which only use groundwater to produce their drinking water, and drinking water companies that (also) use surface water sources. Both Brabant Water (then WOB) and WML, prior to the transition period, used exclusively groundwater for the production of drinking water.

There were a number of macro-level triggers that got the transition underway (see also Chapter 2):

1. Expected increase in demand: starting in the 1970s, a strong increase in water demand was expected. This was driven by population growth and economic growth leading to an increased per capita demand.
2. Decrease in demand: In 1970, the Pollution of Surface Waters Act came into effect. This meant an incentive for the industry to produce less waste water, and this led to using less drinking water. The 1970s oil crisis meant an incentive to save energy, and using less hot water was one of the ways to reach this goal (see also § 4.2.5).
3. Decrease in groundwater availability: With the increasing concern for nature and the environment (the Nature Conservation Act of 1967; *Limits to Growth* in 1972), the consequences of groundwater abstraction were more apparent. There would be less groundwater available for agricultural crops, and semi-natural and natural vegetation, leading to harvest losses and changes, or the impoverishment of species composition in semi-natural and natural vegetation. In the Second National Drinking and Industry Water Structure Plan of 1985 (enforced by EU legislation), the alternative water supply options Heel-Panheel (WML) and the Maaskant infiltration (Brabant Water) were specifically referred to by name. The planning actions showed a need here to research alternatives to groundwater abstraction.
4. Abstraction from several small, shallow abstraction sites that were difficult to protect and where water quality issues (Nickel, Nitrate) would be too costly to solve, lead to a reconsideration of the source water. This applied only to WML.

Take off

The combination of growing demand and diminishing possibilities of expanding groundwater abstraction forced the provinces of North-Brabant and Limburg, and Brabant Water and WML water supply companies, to look for alternatives.

Around 1989 Brabant Water found that it needed an extra of 10 million m^3/year above the groundwater abstraction license. The Maaskant Filtration Project (PIM) was then considered the best alternative. It came the closest to groundwater, because it involved soil passage. PIM was planned for the banks of the river Meuse, but the Waal River also flowed close by at the location which provided a surface water backup.

Around the early 1990s, WML, under pressure from the province, decided to start preliminary work on surface water abstraction in Central-Limburg. Even though it became clear in the mid 1990s that water consumption would increase less than originally forecasted, WML decided to go ahead with surface water abstraction. Internal drivers, such as scale benefits – and thus cost-efficiency – flexibility and a quest for innovation, led WML to adapt and implement surface water abstraction.

Acceleration

Brabant Water: In the first half of the 1990s, an Environmental Impact Assessment (EIA) was carried out for the PIM project. The PIM plan would consist of: an intake basin, pre-treatment, an infiltration system, soil passage, with recovery via enclosed abstraction techniques (drains/wells), and post-treatment. Several key actions and licences were required for the realisation of PIM. They started in 1990 and the total process took approximately a decade. Major preparatory actions (EIA Report, Communication with the community, purchase of land, two infiltration tests, several licenses for building treatment and pipe systems) were completed and even the definitive designs and specifications were made, but the project was never realized. The River Act licence for raising embankment was granted but later, in the second half of the 1990s, it was revoked.

WML: the preparatory work for the realisation of the surface water abstraction at Heel began in the first half of the 1990s. Approximately six years were assigned to the preparations, which included, for example, selecting a system, organising an EIA and applying for the licences. Research was conducted into the removal of microbes in the case of relatively short travel times during soil passage. The results showed that, for the conditions in Heel, 30 days was sufficient to meet the Drinking Water Act’s requirements. The Heel project involved about 175 different licences, (e.g. production, abstraction, discharge and environmental licences). In the process of arranging and applying for licences, great attention was paid to collaborating with the licensing authorities. For instance, in organising the zone in an open manner, the abstraction activities could be combined with recreational ones. Thanks to good preparation and the involvement of the authorities, not a single licensing procedure underwent any delay. In 1998, the construction of the treatment system and the installation of the wells got under way; it was completed in 2001-2002.

Stabilisation

At this point the two projects of Brabant Water and WML diverge. At WML the entire transition has been gone through, and a new stable situation has been created, in which the company is using both groundwater and surface water as its sources. Brabant Water, in turn, is experiencing a so-called backlash: the transition has not been pushed through and the company still uses only groundwater as its drinking water source.

Brabant Water: the River Act licence was revoked. This meant that an intake basin, which was an inextricable part of the plan, could not be used. Without the intake basin, the plan had to be re-examined, particularly the pre-treatment. The decision as to whether or not to proceed with PIM was postponed. In the meantime, it became clear that drinking water consumption was stabilising and even declining. Since it became clear that there was enough room within the existing groundwater abstraction licences, Brabant Water began by designing a modular PIM and, at a later stage, effectively stopped the project. Following 2001, a number of abstraction reallocations were carried out with a view to further optimising water supply. These reallocations concerned the quality, costs and sustainability adaptations of the abstraction points.

WML: WML knows that it needs surface water because there is not enough deep groundwater (the preferred raw water) available. Because of economic reasons, there is a preference for groundwater. Also, Heel appears to be more costly because both the number of surface water intake stoppages (because of water quality reasons) as well as their maximum duration have been much larger than anticipated. With respect to the environment, it is not clear whether the closure of specific groundwater abstraction points has contributed much to nature conservation.

Summary

The transition from ground water only to both ground and surface water took approximately 20 years, Figure 4-3. Looking at the system as a socio-technic system, in this transitions different management decisions can be compared. We see that for one of the companies the transition was completely achieved while for the other it ended in a backlash. The dynamics of the drivers can also be clearly identified. In the 1990s the expected increasing water demand played an important role in the decision making. Note that by the time that the transition in source water was achieved the expected demand increase was much smaller.

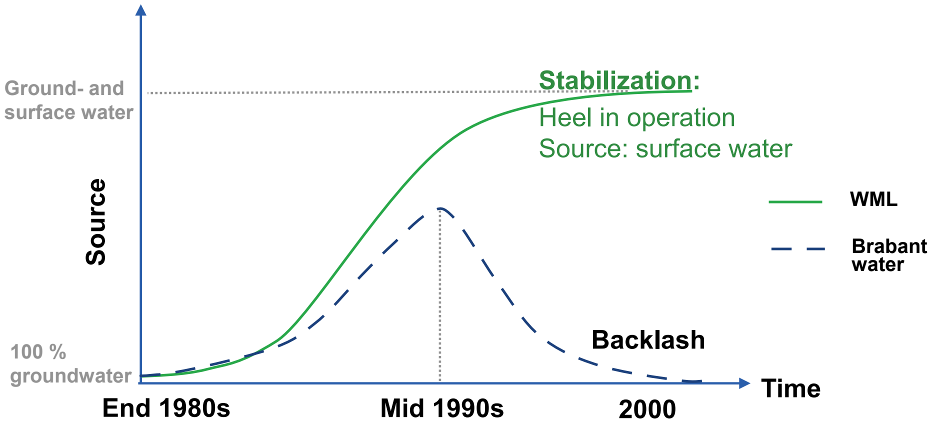


FIGURE 4-3 SCHEMATIC TRANSITION FOR THE TWO WATER COMPANIES.

4.2.3 Treatment: towards a chlorine free production and distribution

Predevelopment

Around 1910, direct surface water treatment commonly comprised of sedimentation and slow sand filtration. In order to meet the growing water demand, rapid sand filtration was introduced prior to slow sand filtration and later, coagulation and flocculation were applied to reduce the load of the rapid sand filtration. The continuous increase of the water demand limited the application of slow sand filtration and it was more and more replaced by chemical disinfection (breakpoint chlorination). In many places in the world, chlorine is used in drinking water treatment and distribution systems. An advantage is that it is a low cost disinfectant and it is easy to control. Chlorine can be applied for several purposes, such as transport or breakpoint chlorination, iron oxidation or post-chlorination.

The first known application of chlorine in drinking water treatment is in Belgium in 1902, breakpoint chlorination was introduced in drinking water treatment in 1939 for ammonia removal purposes. The estimated annual chlorine usage in the Netherlands increases between 1950 – 1970 because of the increased use of surface water for drinking water production. By the 1970s chlorine use was common in the Netherlands for surface water treatment (about one third of the total water production).

In 1974, it was discovered that disinfection byproducts such as trihalomethanes (THM) are formed during chlorination. Some of these byproducts cause toxicological and mutagenic effects. In the Netherlands, discovery of THM led to a strong joint effort of the drinking water companies and KIWA (now KWR) to investigate the possibilities to reduce the formation of these harmful byproducts.

Take off

Important arguments for the use of a disinfectant residual are that the presence of a residual reduces the risk of microbial contamination, and the presence of a residual inhibits the growth of micro-organisms in the network. Some of the important drawbacks of chlorine usage are the formation of harmful disinfection byproducts, taste and odor complaints. Also, chlorine is less effective as a disinfectant against some relevant microorganisms such as parasitic protozoa.

In the Netherlands, the discovery of THM led to a strong joint effort of the drinking water companies and Kiwa (nowadays called KWR) to investigate the possibilities to reduce the formation of these harmful byproducts. That research comprised of investigating the use of minimal chlorine dosing, health effects of THM, the THM formation processes and control measures, alternative technologies for chlorine addition.

Some of the recommendations based on this research were implemented quickly and successfully. This led to a decrease of the chlorine usage of 40% within three years. The number of chlorine applications was not yet reduced. This initial improvement was realized due to the adaptation of the chlorine dosing conditions in transport chlorination (chlorination was limited to the summer period, with a reduced dosage), limiting breakpoint chlorine usage by closely monitoring the actual breakpoint curve and the reduction of iron oxidizing chlorine usage. The sharp decrease of the chlorine usage between 1971 – 1974 (Figure 4-4), is ascribed to the changes occurring at one specific facility. During these years, this facility changed both its surface water source as well as the technology for iron oxidation.

Acceleration

The research efforts regarding chlorine usage continued in the beginning of the 1980s, and lead to a further reduction of chlorination usage. Facility investments and optimizations have contributed to the overall chlorine reduction through further reduction of process chlorination and iron oxidation, the introduction of biologically active filtration and biological ammonia removal (replacement of chlorination with sand filtration) and the replacement of chlorination with micro-sieve filtration or activated carbon filtration. For the final two facilities that did not meet the sum of THM criterion, the breakpoint chlorination was replaced with advanced oxidation and UV disinfection processes in 2004 en 2005. The chlorine usage shows an increase in the 1980s due the start-up of a newly built pretreatment facility, this facility also causes the peak shown in 1990.

The post-chlorination was practically left unaffected in the initial effort in the 1970s for chlorine reduction. The efforts of the chlorine reduction in the water treatment led to lower concentrations of disinfection byproducts, but it was discovered that this positive effect was partly erased due to the strong amount of disinfection byproduct formation during distribution. Therefore, the research continued focusing on post-chlorination. In 1983, the water company of Amsterdam stopped its post chlorination and some others followed.

Currently, a few facilities still use a small dose of chlorinedioxide as polishing step in treatment.

Stabilisation

Nowadays the application of chlorine in the Netherlands is limited to a minimum amount (as chlorinedioxide). The important conditions for distributing drinking water without disinfectant residual are met: usage of the best available source, a multi-barrier treatment, production of biological stable water, good engineering practices to prevent water ingress, and strict procedures for hygiene during mains construction and repair.

Summary

Several drivers can be identified for the transition. Complaints about taste and odor due to the application of chlorine have been recurrent over time. Between 1940 – 1960 this subject attracted much attention resulting in research and the application of different types of chlorine containing disinfectants. However, after the discovery of THM we find that human health is the main driver behind the described transition. Within the period of concern, the Drinking Water Decree was revised twice. Legal standards and guideline values on byproducts were formulated, and contributed as a driver for further reduction of the chlorine consumption. Safety issues of chlorine production and handling as well as the pollution occurring in the production process of chlorine can be considered to be (small) drivers. Due to the introduction of additional technologies, the multi barrier concept steadily grew. So, another driver is the improvement, availability and feasibility of alternative technologies. Of course, the discovery of the disinfection byproducts boosted the search of such alternative technologies. Figure 4-4 shows the development of the annual usage of chlorine products (left axis) and the development of the number of chlorine dosing applications (on the right axis).

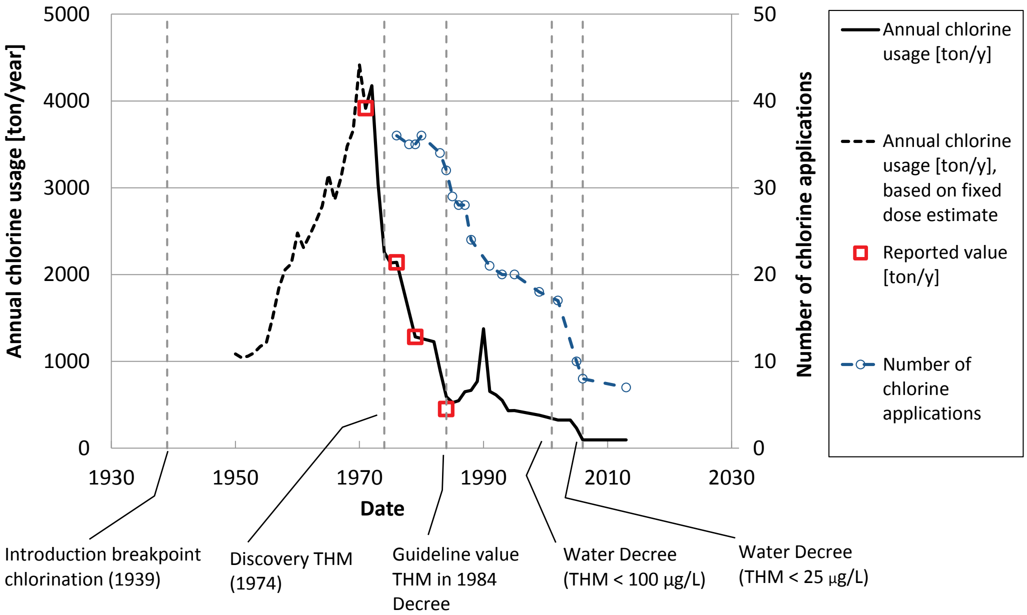


Figure 4-4 Indication of the historical chlorine usage in Dutch drinking water production for the period between 1950 and present. 'Reported values' (marked □) are based on data available from literature. 'Annual chlorine usage' (solid line) is a composed estimation based on different sources. 'Annual chlorine usage, based on fixed dose estimate' (dotted line) is an estimation based on the annual usage of surface water for drinking water production and a chlorine dosage of 13 mg/L for all surface water treated. 'Number of chlorine applications' (dotted line with o-markers) is on the right axes.

4.2.4 Drinking water installation: guidelines for the design of drinking water and hot water installations

Predevelopment

Despite all the changes in appliances and increasing hot water use, described in § 4.2.5, Dutch guidelines on the design of drinking water installations for non-residential buildings were, until recently, based on measurements carried out between 1976 and 1980 and there were no guidelines for predicting hot water use. As a result, suppliers of heating systems use company specific guidelines. In 2002, the old approach was no longer deemed suitable for the current situation due to the increasing range of available appliances in the market and to the changes in people's behaviour. In general, old guidelines overestimated the peak demand values. These peak values are crucial for the optimal design of the water system. Old designed systems are not only less efficient and therefore more expensive, but can also cause stagnant water, possibly leading to increasing health risks.

In the late 1970s, it was found that the "new" dangerous Legionella bacteria could grow in warm water. It was only after 1999, after a catastrophic outbreak, that strict regulations for Legionella prevention in drinking water were introduced in the Netherlands. Audits by water companies made clear that a lot of drinking water installations were not safe enough. The need for safe and reliable (hot) water systems was recognized, giving a boost to the development of new insights into the design and implementation of hot water installations. In 2001, guidelines for drinking water installation for buildings ISSO-55 were published, in which (hot) water use was still based on old measurements and calculation methods.

Take off

Understanding hot water demand is essential to select the correct type of water heater as well as the design capacity of the hot water device. For a proper design of (hot) water systems, the instantaneous peak flow and the hot water use in several time steps need to be determined. A reliable estimation of these values for an arbitrary building (type and size) by on-site measuring would require an intensive and expensive measuring campaign and would consume a lot of time. Therefore, in 2003, the water companies and the installation sector (TVVL / Uneto - VNI) commissioned KWR Watercylce Research Institute to investigate the possibilities of modelling (hot) water demand patterns

In the late 2000s, KWR developed a software tool to simulate cold and hot water use patterns called SIMDEUM. It is a stochastic model based on statistical information of water appliances and users. SIMDEUM models water use based on people's behaviour, taking into account the differences in installation and water-using appliances. This means that in each building, whether it is residential or non-residential, the characteristics of the present water-using appliances and taps (i.e. flow rate, duration of use, frequency of use and the desired temperature) are considered as well as the water-using behaviour of the users who are present (i.e. presence, time of use, frequency of use). With this tool, customize calculation of the peaks required for an optimal design of water installations was possible.

Acceleration

In 2010, the installation sector asked KWR to derive "design-demand equations" for the peak demand values of both cold and hot water for various types of non-residential buildings (office, hotel, nursing homes), using SIMDEUM. Then the new design rules were validated, in a two-step approach. The first step focused on validating the assumptions of how to standardize the buildings (the appliances and users). This was done with measurements and surveys. Cold and hot water diurnal demand patterns were measured (per second) for three categories of small-scale non-residential buildings. The surveys gave information on the number and characteristics of users and appliances, and on the behaviour of the users, like the frequency of toilet use, or the use of the coffee machine. Comparison of the simulated water demand patterns with the measured patterns showed a good correlation. The results showed that the basis of the design-demand equations, the standardised buildings in SIMDEUM, is solid. The second step focused on validating the design-demand equations by comparing the simulated and measured peak flows. The results were very good. Also, the studies showed that the old guidelines overestimated the maximum instantaneous peak flow for both cold (e.g. 70%-170% for hotels) and hot water.

Next, the consequences for design of the drinking water installation and heating system were assessed. The new equations lead to a better estimation of the maximum instantaneous peak flow than the old guidelines. The new equations reduce the design of heater capacity with a factor 2 to 4 compared to suppliers proposals, while still meeting the desired need and comfort. Thus, the improved insight of the new design-demand equations will lead to an energy efficient choice of the hot water systems, and thus save energy. Also, the smaller design of the heating system reduces the stagnancy of water, which may lead to less hygienic problems.

Stabilisation

With a 10 year study, more insight into the actual (hot) water consumption was gained. Simulating the water demand patterns with SIMDEUM showed to be a reliable method to predict water peaks and daily water patterns, leading to an update in the guidelines for the design of drinking water installations and hot water systems in non-residential and multi-residential buildings (ISSO-55. 2013). The guidelines for the design of drinking water distribution systems also refers to these guidelines. The revision of the guidelines will lead to smaller systems than the ones used in practice and the ones predicted by the old guidelines.

Summary

Guidelines are enforced when there is a need for them. Guidelines are based on state-of-the-art knowledge. For instance, hot water guidelines were needed due to 1) increase gas use and fast adoption of showers, 2) new buildings and new water connections, 3) laws and regulations regarding safety. Due to the changes in the (hot)water use and routines, these guidelines became obsolete. Guidelines are adapted when 1) calamities happen (e.g. legionella outbreak), 2) new requirements have to be met (sustainability/energy efficiency) and 3) new knowledge is developed, for instance measurements showing that the old guidelines are overestimating demands or the development of SIMDEUM. Nowadays new knowledge is based on research, possibly as a result of calamities or new requirements.

Figure 4-5 shows an overview of the use of guidelines for the design of water systems in the Netherlands for residential and non-residential buildings.

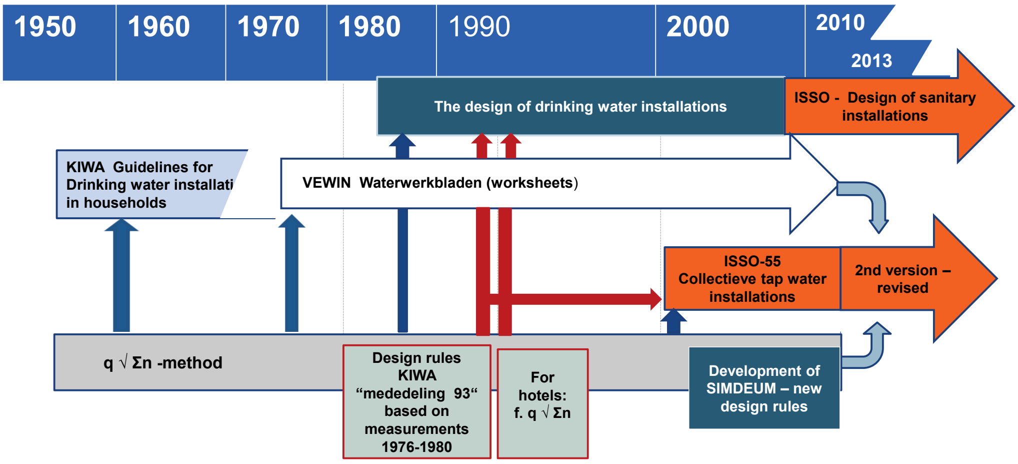


Figure 4-5 Overview of available methods and guidelines in the Netherlands.

4.2.5 Customer’s tap: change in drinking water demand

Predevelopment

In 1901, with the Dutch Housing Act, installation of a toilet in each household became compulsory. Showers started to be installed in the 1930s. However, introduction of showers was limited due to lack of hot water supply. In 1933, a compulsory installation of warm water would be unaffordable for most. The shower was first mentioned in a national guideline in 1940, where it was stated that bathing was a necessary provision in the home and a bathroom should have at least 1.5 m² with a shower or bath and a sink. Hot water was needed to encourage the residents to bathe but high prices were still a barrier. The majority of households did not feel the urgency to adapt to the new technology and kept using cold water only. The Housing Census of 1956 reported that nearly 30% of the households - 750,000 - had a separate bath or shower. However, the majority of the population took a shower or a bath in public baths.

Take off

By 1951, 82.4% of the population was connected to piped water, mainly in urbanised areas. In some cities, housing corporations and energy companies took action to accelerate the market penetration of gas appliances. For instance, in Maastricht, the municipal gas company came in the 1950s with a new, attractive hire and purchase (lease) scheme for geysers. The gas company could purchase and finance the installation of a geyser, including faucets and showerheads, and the tenant would pay back the costs in sixty monthly instalments to the gas company. In the 1950’s, some intermediary organizations were founded to assist consumers: The Dutch household council and the Consumer association. These organizations provided independent and objective advice and information to the people, playing an important role in the transition towards modern households. In 1954, a cost comparison (instigated by the Dutch association of housewives) showed that washing clothes at home was comparable to the costs in a central laundry facility, thus giving a boost to washing machines in the homes.

In 1957 the Drinking Water Law was enacted by the Dutch government. This was the beginning of the involvement of the Dutch government and the EU in laws and regulation concerning the drinking water supply.

Acceleration

In the 1960s, a period characterized by rapid growth, prosperity and social changes began, driven by the discovery of large quantities of natural gas in Groningen. The decision to use gas for heating of buildings brought the desired comfort. Almost all Dutch households started to use natural gas within a few years. In 1968, 78% of homes had a gas connection. The natural gas coverage rose rapidly to 89% in 1975 and further to 97% in 1980. Not only the number of connections, but also the average annual use per home rose largely. The main reasons for this was the increasing use of gas for stoves and central heating and the increasing use of warm water for shower and bath.

Consumers' need for comfort and luxury also grew. Low gas prices enabled the acceleration on the adoption of domestic water heaters. This led to an important change: in the mid-1960s, warm water was no longer seen as luxurious. And by 1970, adoption of showers reached 75% and 97% of the new houses had warm water and a shower or a bath. Adoption of showers implied changes in routines, this is seen by the "lock-in" of the adoption of bathtubs. The 1970's and 1980's witness an accelerated diffusion of use of water consuming appliances. Daily water consumption per person grew from 80 litre per capita per day in 1960 to 108 in 1980, a 35% increment in two decades.

The price of natural gas price for households rose sharply between the early 1970s and 1985 – the first energy crisis. During this period the real price increased (taking inflation into account) with 135%. The average household gas consumption for heating decreased significantly in 1990 due to better insulated buildings and more efficient heating systems. However, energy consumption for hot water supply did not decline since the energy crisis of 1973. On the one hand, the bathing frequency increase slowed down in the 1970s and many households installed a water-saving shower head. On the other hand, people nowadays take a shower or bath more often than in the 1970s as a result of increased standards of personal hygiene.

Stabilisation

The residential water consumption had a peak in 1995, and since then a slow downward trend in per capita household water consumption took place. In 1991 the third 10 year plan of the government was established which led to increased household water costs. To slow down the increasing water use, Vewin started the campaign "Be wise with water" and to slow down the increasing hot water use, the *National Consultation Platform for Hot Water* was formed. In 1995 the government, water companies, energy companies and other relevant market parties signed a cooperation declaration *Approach for Hot Water Conservation*. In 1997 European legislation made energy labelling mandatory for washing machines, and for dish washers in 1999, which specifies the energy and water consumption of an appliance and grades overall energy performance. As a consequence, the average consumption per washing load of washing machines is almost halved starting from 100 litres in 1992 to 50 litres in 2010. Furthermore, new European norms of sanitary fixtures were developed that take specific water consumption into account, e.g. NEN-EN 1112 of 1997.

Summary

In the Netherlands, the availability of energy (gas) was a main driver behind the increase of the per capita water demand. Gas availability influenced changes in the regime at first by increasing standards of comfort and in the long run by influencing building codes. Energy efficiency has been a constant driver in the last two decades, as shown in the transition towards more energy-efficient systems to heat water, also for heating tap water. This transition has been supported by technological developments while comfort and user behaviour were not affected. Figure 4-6 shows the residential water consumption per capita since 1960.

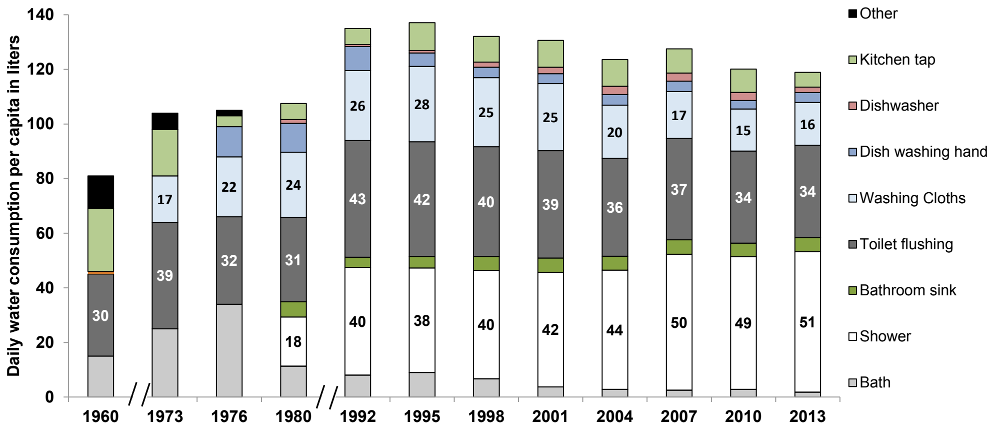


Figure 4-6 Residential water consumption per capita since 1960

4.3 Conclusions & steering possibilities

4.3.1 Extent of adoption

The examples of transitions that we studied showed a wide variety of end results. Full penetration, lock in and stabilization (see Figure 4-1 and Figure 4-2) were all found.

The transition to chlorine free drinking water production and distribution was developed to almost 100 % penetration; the transition in water demands showed for households a 100 % penetration for a shower and a "lock-in" of a 50% penetration of a water saving shower head; the transition towards an alternative raw water source stabilized for WML (using both the existing ground water sources and the newly developed extraction of surface water) and a back lash for Brabant Water (where surface water was in the end not adopted for drinking water production). The transition in guidelines in household appliance installation practices in still ongoing. A change is noticeable in the design of the installation from the craft of the plumber towards a model and water quality based design. The guidelines have been adopted, but not all consultants have implemented the new approach yet.

4.3.2 Rate of change

The examples of transitions that we studied all showed more or less the same rate of change; the transitions all typically took 20 to 30 years.

The full adoption of the new water source of WML took 20 years, the study and then backlash for Brabant Water also took ca. 20 years. Although the last 20 years the per capita water use has hardly changed, there has been a change within the residential water demand. There was a change in penetration rate of more water using appliances, then a change in the more water efficient versions of these and a more efficient behaviour (less bathing, more showering). Typically these changes took about 20 years to reach the stabilization phase, the acceleration phase takes about 10 years. The chlorine reduction was first established by reduction in (optimisation of) existing treatment plants; after that by introducing new treatment technologies. The total transition took ca. 30 years.

4.3.3 Drivers of change and steering possibilities

The cases showed that it is important to understand the components in the transition in order to understand the extend of the adoption and the rate of change. Also, this gives some insight into the sphere of influence and especially into the transactional zone.

The transition towards a chlorine free distribution was fully driven by the internal system, i.e. the Dutch drinking water sector. The health problem caused by disinfection by-products was first raised by an employee of a drinking water company, then the problem was further studied and a technological solution was investigated, paid for by the Dutch drinking water sector. The change of legislation was strongly influenced by the drinking water companies.

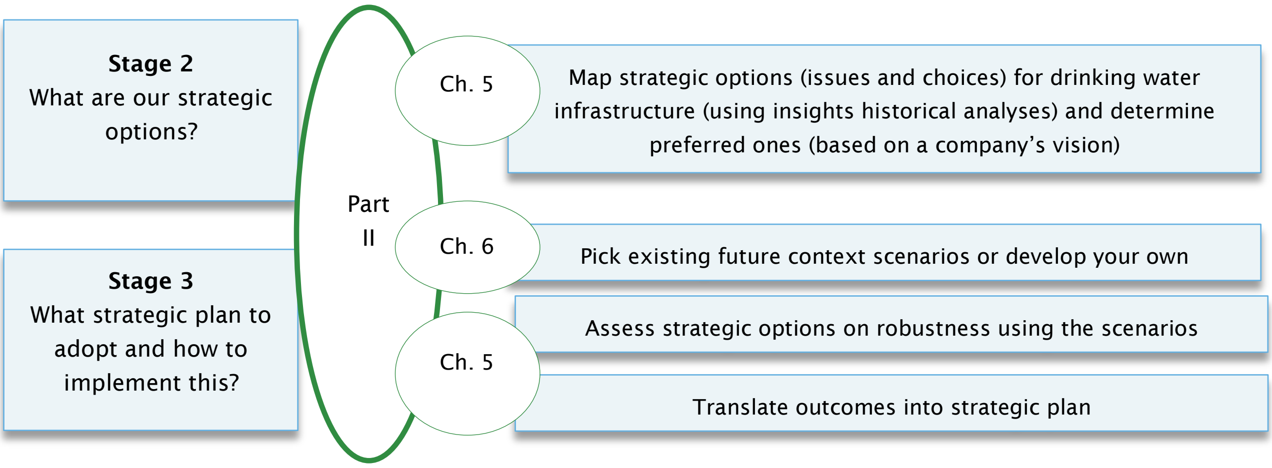
The transition (or not) towards a second source for drinking water was driven by the external system (expected increase of drinking water demand, expected environmental legalisation influencing water quality) and with respect to the rate of change by the internal system (the two drinking water companies determined how fast studies were done and when permits were requested). Also, there was a great need for the transactional zone with respect to accelerating the transition (cooperation for spatial planning, and extraction permits) or changing the transition towards a backlash (not pursuing legal requirements).

The changes in per capita water demand were driven mainly by the external system; the drinking water companies hardly tried to influence this. The energy availability had the largest influence on per capita demand; first the access to gas in every house led to the increase in showers, then the gas price and environmentally driven desire to save energy led to more efficient hot water appliances such as showers, washing machines and dish washers. EU regulation had an influence on water efficient toilets as well. With the changes in water demand and the increasing of cost of measuring the transitions, a need for a more model based approach of understanding water demand came up. As we see that after the pure need for water availability, there is a change in drivers for water demand in both quantity and quality aspects (e.g. individual demands for comfort as people are used to unlimited availability led to more luxury showers that are being installed; awareness of limited resources drives people to save energy and water; economic incentives may affect water use; health awareness causes more focus on water quality), there is a need for more justification of the design of the drinking water installation and distribution network. Here, the internal system is more than just the drinking water companies; it also entails the installation sector.

Part II

Visualizing and planning for futures of drinking water infrastructures

Part II looks at stages 2 and 3 of the framework, which will be described in chapters 5 and 6:



The following questions are addressed:

…how to deal with the future in strategic planning of drinking water infrastructure?	**In the strategic planning process**	**Read chapter**	**How to design a strategic planning process**
	In the realisation of strategic plans	4, 5	How to cope with (key) uncertainties and how to monitor these
	In a specific case study of a Dutch water company	5	Inspiring / telling example
…what future scenarios are, how they can be used in strategic planning processes and generic, ready-made scenarios	Building your own future scenarios	5	Process of and tools for building scenarios
	Enriching the generic, ready-made scenarios	6.2	How to make the generic, ready-made scenarios specific for one's own operating context
	Applying the generic, ready-made future scenarios	6.1	How to use the generic, ready-made future in one's own strategic process

5 Strategic planning of drinking water infrastructure: assumptions, techniques and outcomes

This chapter describes the process and potential outcomes of strategic planning processes for drinking water infrastructure. As strategic planning is inherently bound up with the future, assumptions on how to perceive of, and how to deal with, the future are essential. The first section of this chapter makes those assumptions explicit. Strategic planning is furthermore carried out using certain techniques, some of which are provided in this chapter in subsequent sections. In particular, the chapter outlines how strategic questions and options may be identified, how future scenarios may be developed and how those options can be assessed on robustness using such future scenarios. Outputs that are generated by this process for water companies in the Netherlands are discussed in the last section.

5.1 Assumptions: Exploring future presents in strategic planning processes

Chapter 1 briefly outlined some key assumptions underpinning the study of futures. This section will elaborate on these, given their important implications for both the process and results of strategic planning. The previous part of the report showed that past and present (social and technological) developments create conditions that partly shape future ones. This is obvious in the case of physical drinking water infrastructure. For instance, the building of an urban water supply network over time enables *and* constraints subsequent developments in cities; it allows for the city to flourish and expand, but it also provides limitations, say for entirely different water supply systems that require another logic and very different (politico-juridical) rules of the game in order to function well. It indicates that the future is not entirely ‘open’, that new beginnings are an illusion and that (implicitly) taking on an a-historical view can have serious future implications when it comes to investing in drinking water infrastructure.

But equally problematic to disregarding historical analyses is discounting or ‘commodifying’ the future: seeing the future as an empty ‘hole’ that is ours to fill, driven (solely) by *present* interests. Still, this is how the future has come to be increasingly seen in contemporary industrialized countries (Adam and Groves, 2007). This perspective of the future has serious time-space implications. It pretends the future itself is devoid of context and people, and assumes the future can be calculated, predicted and ‘traded’. Our actions in the present are primarily driven by short term gains, many of which lay a claim on the (long-term) future, without explicitly considering and hence, taking responsibility for, the implications on the socio-material dimensions of that future. Practices, instruments and products in the financial sector comprise a prime and very explicit example hereof. Many of these are driven by *immediate* or *short-term* gains and based on some *assumed* future state, like in the case of subprime mortgage markets and derivatives. But the financial sector by no means stand alone in this and short term, self-interest has become a notable driver for many an actor’s actions in the present. Approaches whereby the future is predicted, transformed and controlled for the benefit of today is what Adam and Groves (2007) call the “present future”.

In contrast, what needs to be explored in strategic planning processes are so-called ‘future presents’ and ‘futures in the making’. The ‘future present’ stands for a position that allows us to account for historically shaped conditions and processes, upon which to build further, whilst explicitly acknowledging the possible effects of these and our present actions on the future and future social and environmental well-being. 'Futures in the making' point at actions already set in motion, without having transferred into tangible outcomes yet. Crucial in these concepts is taking responsibility for potential effects of our present actions on places and generations in the future. This can only be done by contemplating the future vis-à-vis our present will, and by taking seriously historical processes. The starting points deriving from these assumptions are to explore:

- not one, but various possible futures
- how present desires regarding drinking water infrastructure fit in these futures
- In relation to historical drivers and patterns studied earlier, robust alternatives to present strategies of creating and using drinking water infrastructure.

Making all this clear and explicit helps actors "taking responsibility for the time-space distantiated effects of their (in)actions" (Adam and Groves, 2007).

5.2 Scenario planning for developing strategic plans

Building on the abovementioned assumptions, a suitable method with which to develop strategic plans for drinking water infrastructure is called scenario planning (Nekkers, 2006). Given that the long-term future is characterized by high levels of uncertainty and low levels of determinacy (see Figure 5-1), exploring how preferred strategic options may hold in the future is done by the use of future scenarios rather than by predicting the future or forecasting the most plausible one.

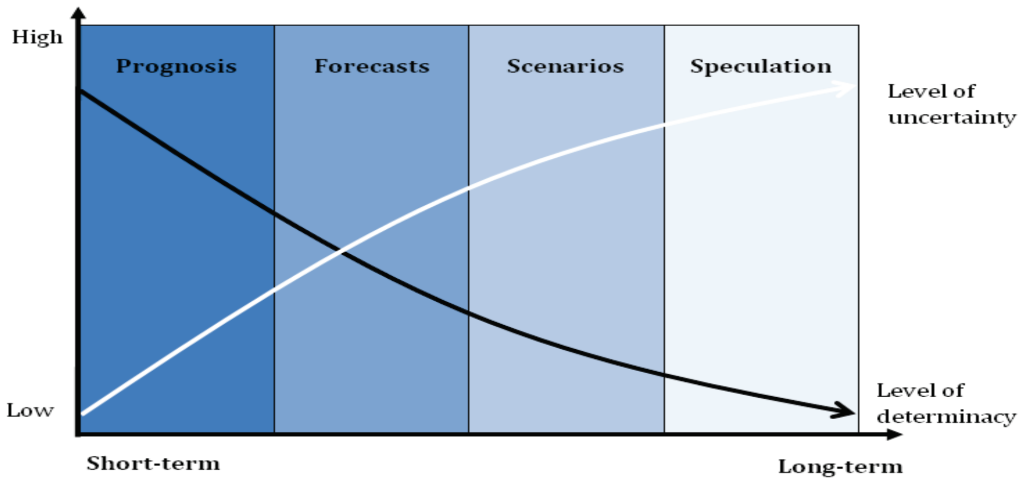


FIGURE 5-1 TIME, UNCERTAINTY AND WAYS OF STUDYING THE FUTURE (NEKKERS, 2006: 66)

Scenario planning steps are those that are listed under stages 2 and 3 in the approach adopted in this report. There are three steps:

1. Mapping strategic questions and options for drinking water infrastructure (using insights from the historical analyses) and determine preferred ones (based on a company's vision)
2. Pick existing future context scenarios or develop your own
3. Assess strategic options on robustness using the scenarios

These steps adhere to different spheres of influence (see Figure 1-3). In the first step, those options are mapped where water companies have full or partial control over, thus related to their internal and transactional systems. The second step on future scenarios deals entirely with the external environment; plausible external trends and conditions are integrated in (usually four) future scenarios. In the third step the previous two steps and spheres of influence are linked, i.e. this involves the assessment of 'controlled' options in possible environments one has no control over. This is visualized in figure 5.2.

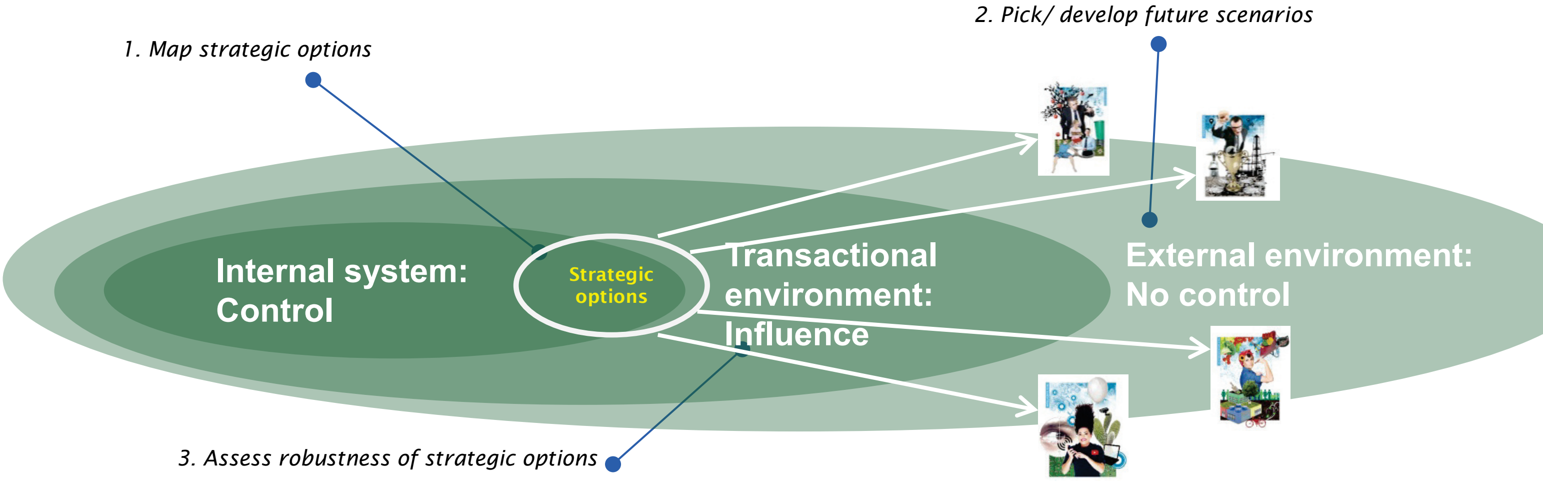


FIGURE 5-2 SCENARIO PLANNING STEPS IN THE DIFFERENT SPHERES OF INFLUENCE

These steps will be further explained below, illustrated by experience and outcomes from the implementation of these steps in the project that led to this report and in the water company Dunea.

5.3 Mapping strategic options

An important step in the strategic planning process is identifying and determining the most relevant strategic questions and options regarding water infrastructure. Important in this step is to focus on those strategic fields you (think you) have full control over (internal system) or those which can reasonably be influenced (transactional environment), for instance by working together with stakeholders or by lobbying. Also relevant when doing this for water infrastructure is to recall that there are both social and technological aspects related to the strategic questions and options. This step is greatly facilitated with insights gained from historical studies into (parts of) the water infrastructure system, for instance when it comes to influential drivers behind the development of (parts of) the water infrastructure, the extent to which infrastructure is 'path-dependent' or the ways in which decision-making on water infrastructure takes place.

This step has been carried out in a workshop with asset managers and water infrastructure specialists from all Dutch drinking water companies. Their task was to tackle the following:

> *What are the most relevant strategic questions regarding drinking water infrastructure for the coming five years, with potentially far-reaching effects on the long-term (i.e. time horizon of 2050)?*

They were asked to write down all strategic questions that came up in a brainstorm, related to all parts of drinking water infrastructure, such as sources, treatment, distribution as well as the customer. Each strategic question was then specified by identifying different strategic options. In the workshop, two (and in one case, three) options were identified for each strategic question, but this need not necessarily be confined to two options only; there are more alternatives to think of, and all alternatives could be assessed in the third step of the strategic planning process. These combinations of strategic questions and options were then prioritized in terms of their uncertainty, impact and urgency. Out of this emerged eight strategic questions and options deemed the most relevant ones by the group of asset managers. These questions and options are listed in Table 5-1.

TABLE 5-1 TOP EIGHT RANKING OF STRATEGIC QUESTIONS AND OPTIONS REGARDING DUTCH DRINKING WATER INFRASTRUCTURE

Strategic questions/ dilemma's regarding drinking water infrastructure	**Strategic options***
What treatment units will we build the coming five years?	**A:** Modular, flexible, decentralized **B:** Full-scale, fixed, centralized
How will we operate in the underground the coming five years?	**A:** Alone, driven by own vision and perspective **B:** With other asset owners, driven by a collective vision
How will we identify and assess asset risks the coming five years?	**A:** Proactive (identifying risks and assess whether these can be mitigated or tackled with available means (time, budget, personnel)) **B:** Reactive (intervene after clear risks occur)
What is the margin on top of the predicted capacity, based on which we design and utilize assets the coming five years?	**A:** As usual (5% marge) **B:** Different (3% or less)
How will we organize the supply of water without surprises for customers the coming five years?	**A:** Emphasis on the reduction of time that customers are without water by investing in physical assets **B:** Emphasis on prevention of or adaptation to potential surprises by (communicative) interaction with customers
How will we achieve the greatest degree of comfort for customers (e.g. related to water hardness) the coming five years?	A: By focusing on costs B: By focusing on water quality C: By focusing on costumer services
How will we cope with the result of potential reduced demand of drinking water the coming five years?	A: Shedding sources B: Reduce pipe diameter (to prevent long residence time)
Will we remain focused on drinking water only or will we extent our focus the coming five years?	A: Focus limited to drinking water B: Extended focus towards water cycle (or even multi-utility) company

A final important part of this step involves determining for each strategic question which of the strategic options are most worth pursuing. This is a question of will, i.e. what is deemed most desirable by the actor undergoing the strategic process, rather than what the actor think he *must* or *can* do. This is done by taking a company's identity and vision as starting points, asking which of the options identified are most in line with who you are and what you want to accomplish as an organization. Furthermore, in line with exploring 'future presents' (see paragraph 5.1), this is done by examining the potential ethical, social, environmental and other types of consequences of pursuing a strategic option.

5.4 Future scenarios: building your own or using existing ones

5.4.1 Process and techniques

There are different types of scenarios one can use, depending on one's goal. Börjeson *et al.* (2006) distinguish between three main categories of scenario planning: predictive, explorative and normative scenarios. Predictive scenarios are constructed in answer to the question what *will* happen, assuming the future can be known. Explorative scenarios tackle the question of what *can* happen, on the basis of a highly uncertain future that can be explored, but not known. Lastly, normative scenarios respond to the question of how an explicit normative target in the future can be reached, which require changes in prevailing systems/structures. Each of these categories are further subdivided into specific scenario types (see the typology depicted in Figure 5-3).

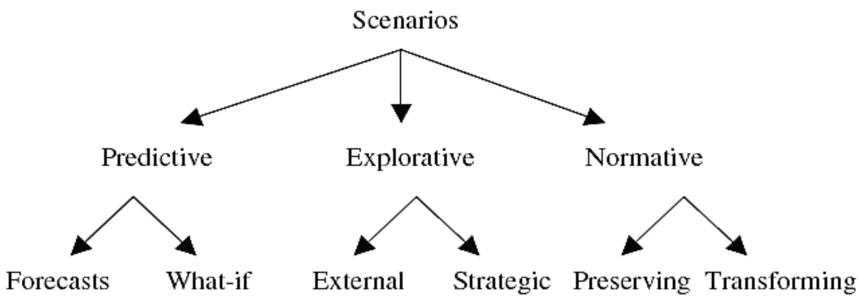


FIGURE 5-3 TYPOLOGY OF SCENARIO TYPES (BÖRJESON ET AL., 2005: 14)

The approach of this report uses explorative, external scenarios. External scenarios describe how external developments or 'the context', where one has no control over, develop over the long term. Building external scenarios typically involves a process of horizon scanning and identifying two key external developments that score high both on 'uncertainty' and 'impact' and of which scenario developers and users agree that these trends will remain highly influential for the decades to come. These two key uncertainties are then plotted on two axes yielding four distinct, but equally plausible future scenarios (Van 't Klooster & Van Asselt, 2006; see Figure 5-4).

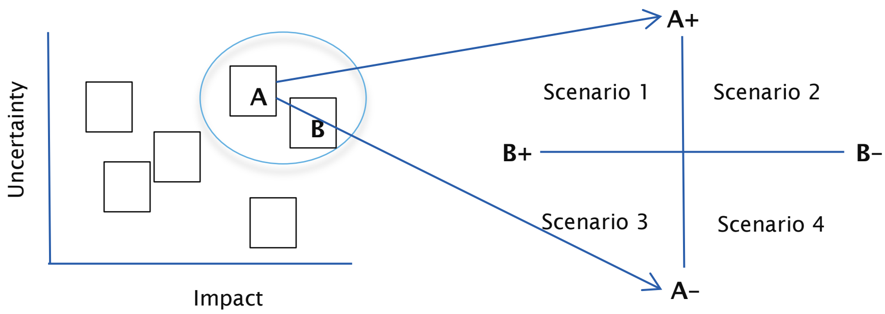


FIGURE 5-4 SCENARIO BUILDING PROCESS ALONG TWO AXES REPRESENTING KEY UNCERTAINTIES

Strategic planners have a choice to develop their own scenarios using such techniques. But this is a process that requires considerable resources (time, budget) that not every organisation has available or would like to spend. In that case, there are alternative options. Strategic planners could also pick and use existing scenarios and use those without any alteration, or they could pick existing ones and make those applicable to their own context before using them. There are national and international institutes producing external future scenarios, such as the Welfare, Prosperity and Quality of the Living Environment scenarios developed by the Netherlands Bureau for Economic Policy Analysis (CPB) and the Netherlands Environmental Assessment Agency (PBL) on the Dutch national level, or the related GEO5 scenarios made by the UNEP Global Environmental Outlook on a global scale. In the project that led to this report, four future scenarios have been developed specifically for water companies. These scenarios are ready-made and can directly be used in strategic planning processes, but they could also be made more specific for a water company's service area. These options and the scenarios are described below.

5.4.2 Four future scenarios

Four generic scenarios have been developed and used in a project for all ten drinking water companies in the Netherlands. Two highly uncertain driving forces with a large impact on drinking water companies and their infrastructure were chosen as the two axes in this project. These are:

A. The size and strength of local authorities
B. The prevailing societal structure that orients and steers actors.

Regarding axis 'A', it is assumed that in thirty years from now there will still be a public steering body that governs the city, which (re)produces and/or transforms structural conditions in that city. The extent to which these conditions shape socio-material developments and actors in the city varies however, depending on size and strength of this governing body. The axis thus becomes a strong/ decisive local government on the one end of the continuum versus a weak/ withdrawn government on the other.

Axis 'B' denotes a simplified dichotomy of the market and individual as the one major structure and orientation in the city vis-à-vis a dominant orientation on society and collectivism. The two axes together yield four future scenarios of the city, briefly titled the Collective City, the Self-sufficient City, the Competitive City and the Smart City. Each city has been characterized and described using 'uncertainty factors' such as dominant thinking, type of economy, ways of living, science and technology systems, etc. The two axes and the four scenarios are illustrated in Figure 5-5. The storylines of each scenario are described in detail in chapter 6.

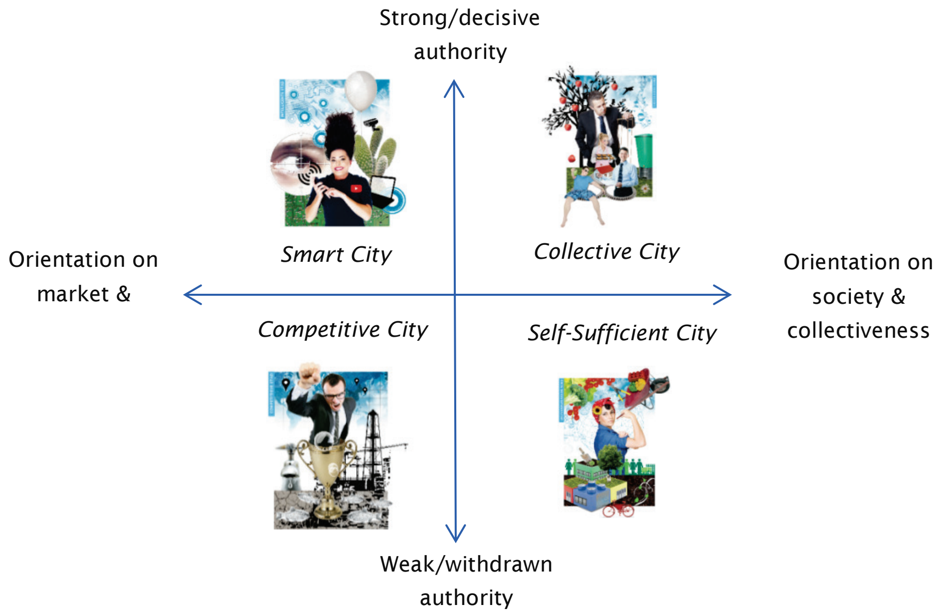


FIGURE 5-5 FOUR FUTURE SCENARIOS OF THE CITY

5.4.3 Enriching scenarios for the water sector

These generic scenarios were "enriched", i.e. made more connected to the water sector. That is, additional uncertainties in the external environment were identified and included in the above scenarios that may have significant consequences for future operations of water companies. The outcome are 'enriched scenarios' that describe in more detail the uncertainties for water companies. The use of such scenarios for the testing of strategic options enhances the reliability of the strategic planning process.

Enriching existing scenarios and make them more applicable to a specific context can be done in a workshop with an interdisciplinary group of participants. A variety in backgrounds and roles of participants is important, in order to identify important uncertainty factors over a range of social and technical dimensions. In our example project, the abovementioned scenarios were enriched for the water sector and therefore, a workshop was organized in which researchers from a water research institute and professionals from water companies participated. There were specialists in natural sciences including water technology and microbiology, as well as strategists and social scientists.

Five steps were followed to come up with the enriching uncertainty factors:

1. Identifying external trends and developments that would specifically impact on a water company's operation
2. Prioritizing the key uncertainty factors from all identified factors in step 1
3. Determining the scale or 'bandwidth' of each key uncertainty factor (see Figure 5-6 for the example of water quality; this can be ranged from 'high' to 'low' quality)
4. Embedding the key uncertainty factors in all four scenarios
5. Making scenarios internally consistent. This check is necessary for constructing a diverse set of scenarios with each having its own, distinctive path, whilst remaining plausible stories of how futures may look like.

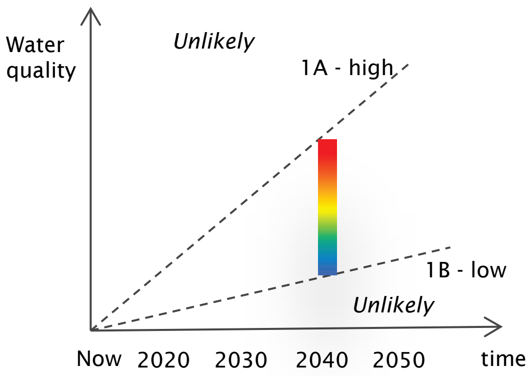


FIGURE 5-6 EXAMPLE OF UNCERTAINTY FACTORS IN THE EXTERNAL ENVIRONMENT: WATER QUALITY

The output of this workshop were the ten key uncertainty factors in the external environment and how they are embedded in the future scenarios, see table 5.2. It is assumed these factors will have considerable impact on the water sector's operation, but are out of the water company's sphere of influence; they cannot (or only to a limited extend) be controlled.

Water companies can go further still and enrich the future scenarios for the external environment of their specific service area. Dunea, a water company with its service area in the Randstad in the western part of the Netherlands, has done just that. In a strategic planning process for their organization, they have used the generic scenarios outlined above and made those specific for the Randstad. The next section will describe what it contributed to their process.

TABLE 5-2 KEY EXTERNAL UNCERTAINTY FACTORS INFLUENCING WATER SECTOR OPERATIONS AND THEIR MEANING IN THE SCENARIOS

Key external uncertainty factors	Scenario: Collective City	Scenario: Self-Sufficient City	Scenario: Competitive City	Scenario: Intelligent City
Trust in drinking water company	High (1)	Fairly high (2)	Low (4)	Fairly low (3)
Importance attributed to sustainability	Fairly high (2) –	High (1)	Low (4)	Fairly low (3)
Water demand	Low (4)	Fairly low (3)	Fairly high (2)	High (1)
Regulatory framework	Fairly stringent (2)	Fairly loose (3)	Loose (4)	Stringent (1)
Ownership water entity	Public	Public	Private	Private
Political stability	Stable (1)	Fairly weak (2)	weak (4)	Fairly stable (3)
Availability water	Abundance (1) –	Reasonable (2)	Scarcity (4)	Critical (3)
Availability resources other than water	Abundance (1) –	Reasonable (2)	Scarcity (4)	Critical (3)
Pressure on subsoil	Low (4)	Fairly high (2)	High (1)	Fairly low (3)
Climate change	KNMI/Gh (3)[6] –	KNMI/Gl (4)	KNMI/Wh (1)	KNMI/Wl (2)

5.4.4 Making scenarios applicable to individual water companies: the case of Dunea

The strategy of the water company Dunea is revised every five years. In their latest revision and strategic planning process, Dunea used the four future scenarios, but decided to adapt those to their specific external environment, the Randstad. They thus adopted the axes of the existing scenario framework and their main features, but enriched the scenarios with self-identified uncertainty factors relevant to the Randstad, in each of the PESTLE dimensions (Political, Economic, Social and demographic, Technological, Legislative, Ecological). Examples of trends identified in these dimensions include new models for financing public services, experiencing nature and combining nature reserves with a specific function, such as water extraction, the participation society and bottom-up initiatives and 'circular' and 'share' economies. The integration of these trends in the generic scenarios generated the Dunea-specific future scenarios, namely the Smart Randstad, the Collective Randstad, the Self-sufficient Randstad and the Competitive Randstad. The adapted illustrations of these scenarios are depicted in Figure 5-7.

These scenarios played a key role in Dunea's strategic planning process, which eventually resulted in a new five-year strategic plan for the period 2015 – 2020. The scenarios were primarily used for assessing the robustness of strategic goals Dunea professionals had identified earlier. The value of the scenarios as a tool in the strategic planning process is that it provided a very structured and original way to discussing amongst colleagues what influential trends and developments are in the (future) environment Dunea operates in, and how to make sense of these. It helped Dunea deciding which trends and developments are and which are not relevant for their future operations. It is the integration of various types of trends and developments in four different, but all plausible future scenarios that makes it particularly valuable; it makes that one does not attribute one scenario (or trend) a greater likelihood than others, a tendency often present in the analysis of trends and developments.

[6] KNMI is the Royal Netherlands Meteorological Institute and translates research results from the IPCC into climate scenarios for the Netherlands. The latest scenarios, developed in 2014, differ in the extent to which the global temperature increases ('moderate' and 'warm') and the possible change of the air circulation pattern ('low value' and 'high value') (KNMI, 2014, see http://www.climatescenarios.nl/scenarios_summary/index.html). The four scenarios are Gh (moderate global temperature rise and high value change in air circulation pattern), Gl (moderate; low value), Wh (warm, high value) and Wl (warm, low value).

FIGURE 5-7 ENRICHING GENERIC TO CONTEXT-SPECIFIC FUTURE SCENARIOS FOR DUNEA

The scenarios were also used by Dunea for decision-making in a policy issue regarding fire hydrants in their service area. Professionals imagined what potential consequences for Dunea would be if the scenarios would come true. Here too, the scenarios helped professionals arriving at a shared view on how to position Dunea in this policy field. Thus, the scenarios are useful not only for strategic processes, but can help in decision-making in specific policy issues as well.

5.5 Assessing robustness of strategic options and translating into a strategic plan

In the third step in the strategic process, the outputs of the previous ones are confronted and how the identified strategic options hold under the four future scenarios is assessed. This too is a participatory activity and the outcome is an extensive weighing of options, giving direction to and building blocks for the ultimate strategic plan.

In the project, this third step was carried out in a workshop with strategists from nearly all Dutch water companies. This was the target group deemed most suitable for the workshop, as the exercise gains from familiarity and experience with both strategic planning methodologies and decision-making practices in the context of the Dutch water sector. The assessment of whether or not a strategic option is considered ‘robust’ followed from discussion and debate amongst these strategists. If one faces, for instance, the strategic question whether to choose between surface water and groundwater as (main) source for the production of drinking water, this strategic planning technique generates an outcome like that pictured in Table 5-3.

TABLE 5-3 FICTITIOUS EXAMPLE: TESTING ROBUSTNESS OF STRATEGIC OPTIONS OF USING GROUND- OR SURFACE WATER AS (MAIN) SOURCE IN EACH OF THE FUTURE SCENARIOS

Strategic Question	Strategic Option					Conclusion
Preferred source for producing drinking water	Groundwater	V Argument x	V	V	V	Robust, because …
	Surface water	V	X	X	V	Not robust, because …

With all strategic options assessed, what rests is the analysis and translation into concrete strategic steps and all steps together should form a coherent strategic plan. The translation from strategic building blocks into a strategic plan basically involves two types of actions:

1. If the preferred strategic option is considered robust in all future scenarios, it can be formally adopted as part of the overall strategic plan. Possibly specify the option for the foreseeable future, for instance in terms of what is to be accomplished, why (rationale), how and when, who is responsible and where it should take place.

2. If the preferred strategic option is *not* considered robust in one or more of the future scenarios, there are two possible routes: [1] you make a so-called contingency plan. In this case, you still adopt and follow the preferred strategic options, even though it is not considered robust. In the plan you specify how to cope with and monitor the factors that were deemed threats, thereby preparing for and mitigating outcomes that may occur and could have major consequences for the company's operations; [2] you reject the initially preferred option and choose to adopt another option that is deemed robust and still in line with the overall vision of the organisation.

Assessing robustness was done for the eight strategic questions and options listed in Table 5-1. The results of this workshop for drinking water infrastructure in the Netherlands can be read in another report, namely "BTO 2015.052 Drinkwaterinfrastructuur van de Toekomst - Interactieve sessies met experts van de drinkwaterbedrijven", and are not given here. The following and last sections highlight some major insights and outcomes for Dutch drinking water companies.

5.6 Linking past, present & future: strategic issues for drinking water infrastructure in the Netherlands

Now that we have come full circle, from studying historical events, to exploring the far future and 'back' to actions in the present and foreseeable future, what has the approach contributed in terms of outcomes and insights regarding drinking water infrastructure in the Netherlands? Attachment I provides an overview of the various contributions in which outcomes have been reported, but this last section of the chapter provides what the approach generated regarding two water infrastructure themes, namely water treatment of the future and water customer service of the future. Each will be discussed below.

5.6.1 Water treatment of the future: full-scale and fixed or modular and flexible?

One of the strategic questions considered most important by asset managers in Dutch drinking water companies relates to the future treatment of water; will this be done by the use of full-scale, fixed and central treatment systems, by modular, flexible and decentralized units or hybrid systems?

The *historical* analyses showed that full-scale, fixed and central treatment systems have for very long been the standard option, although some space for flexibility or adaptability in options was maintained. Overall though, these systems are characterized by considerable inertia and high levels of path dependency. This means that especially in technological sense, systems require high investments for the long term, and its basic *modus operandi* remains largely the same. Such major systems were initially built following the logic of development and growth in cities or regions: an expanding population and industry, higher levels of welfare and a 'modern' society, which require robust systems capable of treating both increasing quantities and potentially decreasing quality of raw water. This of course also has repercussions for other stages in the water production and distribution process. Preferences of and/or changes in treatment are also very much a matter of what is deemed suitable in a specific context or by management.

Assessing the *future* robustness of the two treatment options (full-scale or flexible) by strategists of the Dutch water companies, indicated that the flexible option is more robust and provides more opportunities under the four future scenarios than the full-scale one, although the latter is still considered a good option. The decentralized option is considered more robust under assumed circumstances of:

- Changing spatial-temporal patterns in water consumption
- Changing demand in types of water services
- Suitability to a self-sufficient lifestyle and society

A transition towards flexible treatment options raises numerous (research) questions, as became evident in a workshop with managers of water companies. Such questions relate to:

- Financial resources: decentralized treatment options require significant financial investments (not only for purchase, but also for operation, for instance regarding energy consumption) and such costs must be legitimized
- Sustainability: what are the environmental impacts of small-scale, flexible treatment units?
- Connectivity with distribution: how to connect smaller units to the distribution network and what are the consequences?
- Protection: how to secure and protect multiple units spread out over the service area?

For these and other issues, a transition to flexible, decentralized treatment units -if desired and in line with one's vision- will likely occur in a stepwise manner, when replacement of an existing system or the building of new systems are due.

5.6.2 Customers satisfaction: water quality, costs or service as main factor?

A second important strategic issue identified for (change in) water infrastructure relate to citizens' or costumers' needs: how will water companies achieve the greatest degree of comfort and the best services for citizens/customers the coming five years?

From a historical point of view, water quality was perceived to be the main driver for attaining customer satisfaction. Later, in the second half of the 20th century, costs became an important driver. Thinking in terms of 'water services' to 'customers' is a relatively recent phenomenon, and is more than the former two a strategic issue that straddles the boundaries between water companies and their customers/citizens. In other words, where water quality and costs are factors that can to a large degree be controlled (internal system), customer services require water companies to think about strategic interaction in the so-called transactional system (see Figure 5-8).

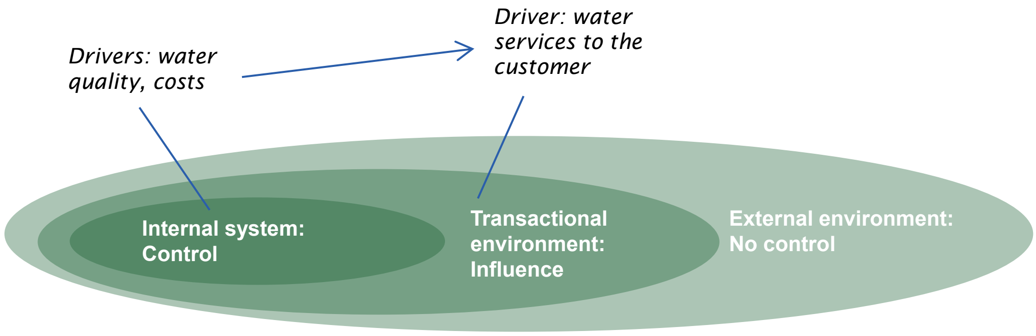


FIGURE 5-8 WATER QUALITY AND COSTS AS MAIN DRIVERS FOR SATISFYING CUSTOMERS IS COMPLEMENTED WITH ANOTHER DRIVER: THE FOCUS ON CUSTOMER SERVICES

These three factors, water quality, costs and customer service, were also the ones tested on robustness by strategists. Assuming the scenarios of the four cities would indeed unfold in the far future, the most robust strategic option is focusing on the development of water/ customer services. In all scenarios, the importance of customer services is expected to grow only stronger, because of an increased importance attributed to comfort and individuality in most scenarios, but also the tendency to become increasingly self-sufficient requires more attention paid to (tailor-made) services.

Water quality, moreover, will likely remain an important factor irrespective of the type of scenario. Perhaps most striking is the factor of costs; except for in the competitive city, it will lose significance as driver for customer satisfaction. This is rather different from the situation now, whereby costs are one of the main drivers behind the operational strategies of water companies (driven in part also by their shareholders: provinces and/or municipalities). If indeed costs would be attributed less significance and factors such as the quality and type of service more, than this could have major implications for the type of water infrastructure used or the spatial dimensions of water infrastructure (e.g. decentralized units spread out over an area).

If water/ customer services are indeed amongst the main strategic foci of water companies, then there is still the major question how exactly this should take shape. It requires reflection on the type of relation a water company will want to develop with the citizens/customers they serve and their role in the broader environment in which they operate. Is this for instance one of a producer – customer relationship, whereby the water company divides their customer base into segments and develop different types of products for different types of customers? Do citizens perhaps ask for water services to be organized and offered in a 'co-productive' manner, close to one's house and if so, what does this mean for centrally organized water companies and water infrastructure? In any case, multiple issues need to be addressed in this transition, amongst which:

- Demographic/socio-cultural/economic traits of citizen/customer base: What typifies citizens/ the customer base whom are served by water companies?
- Customer/ citizen participation: to what extent, and in what type of (policy/strategy) fields will costumers be asked/ allowed to participate, e.g. in crowdsourcing activities?
- Juridical: how are boundaries shifting in terms of responsibility and accountability?

6 Four future scenarios of the city

The previous chapter already lifted a tip of the veil of the future scenarios created in the project; this chapter will describe the scenarios in full and provides the accompanying illustrations made by a professional artist, Figure 6-1. The scenarios can be considered concrete “building blocks” or “tools” that strategic planners in water companies can use in their strategic planning processes. The scenarios being ‘ready-made’ is also why a separate chapter is dedicated to them; the strategic planner who intends to use scenario planning, but does not want to build scenarios all from scratch, can readily use the ones here presented. If one is interested in how they came into being and how they can be used in a strategic planning process, then reading the previous chapter is recommended.

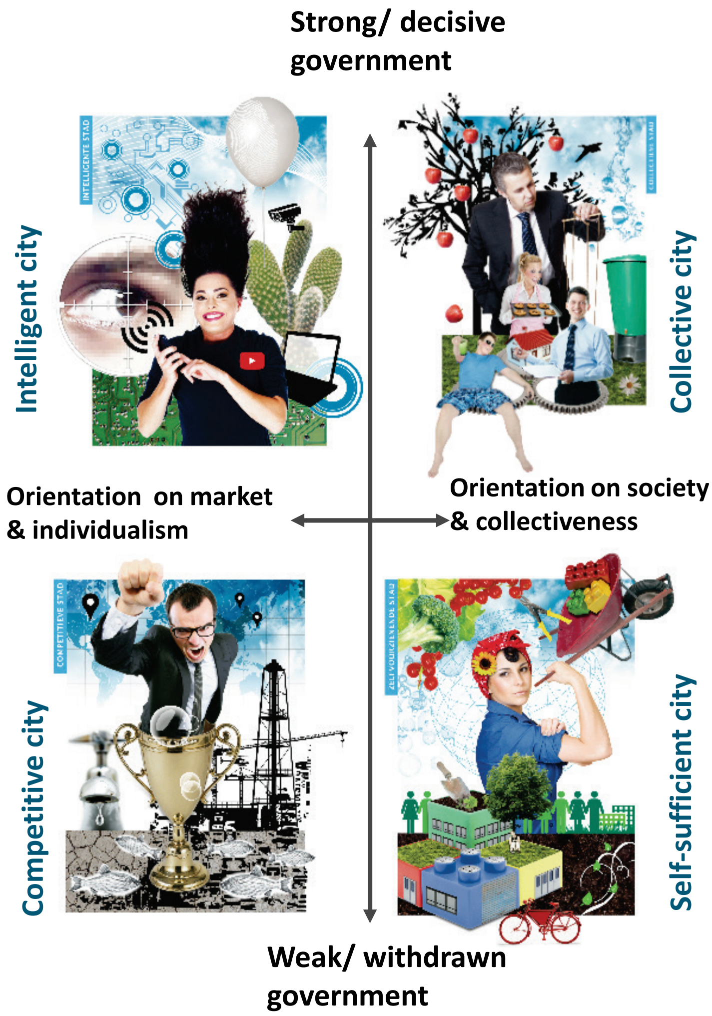


FIGURE 6-1 THE FOUR CITY SCENARIOS ILLUSTRATED

As the previous chapter showed for the water company Dunea, the scenarios can also be enriched by incorporating specific trends and developments for the city or urban region a planning process is focusing on, thus adapting them to specific contexts.

6.1 The four future, context scenarios of the city

The reader is reminded that the scenarios here presented are all external, context scenarios, as explained in the previous chapter. Each of them provides a unique description and plausible story of how a city might be like in about thirty years from now. The term 'external' or 'context' is used to denote scenario narratives of the intertwined political, economic, social, technological, demographic, juridical and ecological environment in which water companies could be operating in due time. The environments in each scenario know specific enabling and impeding conditions that influence the water sector's operations, whereas vice versa, it is assumed water companies cannot influence such external trends (see paragraph 1.3.2 and Figure 1-3 for the concept of different spheres of influence). The scenarios thus provide an overview of different urban environments of the future, against which water companies can systematically assess how their strategic intentions and needs work out.

Chapter 5 also already explained in detail how these scenarios originated. To briefly recall; through systematic horizon scanning two key external, uncertain developments were selected which were plotted on two axes, yielding four scenarios. The key uncertain developments that make up these scenarios relate to [A] the size and strength of local authorities and [B] the prevailing societal structure that orients and steers actors and each can be attributed two opposing directions, namely whether [A1] a strong/ decisive local government or [A2] a weak/ withdrawn government is in place and whether [B1] the market and individual serve as the one major structure and orientation in the city vis-à-vis [B2] a dominant orientation on society and collectivism. Together, these axes constitute the fundamentals for the following four future, urban scenarios: the Collective City, the Self-Sufficient City, the Competitive City and the Intelligent City. Figure 6-1 highlights the illustrations of the four scenarios, whereas Figure 6-2 emphasizes the axes.

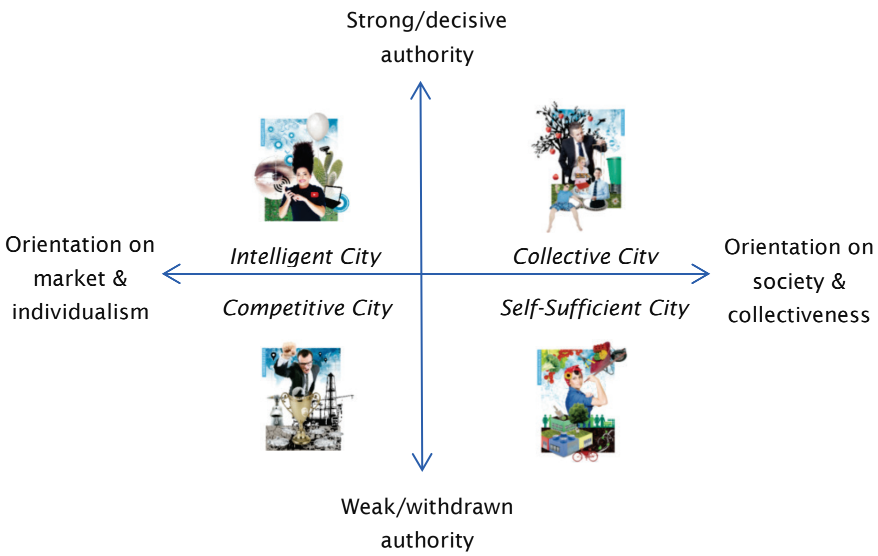


FIGURE 6-2 TWO AXES, FOUR FUTURE SCENARIOS OF THE CITY

Using scenario's for strategic planning purposes involves a creative process in which participants should be (en)able(d) to rather easily imagine and conceive of the very fabric of a city scenario. The following sections aim to support this by providing the context 'stories' of each city, first in narrative and visual form, followed by the external trends that have been identified as particularly influential on the water sector's operations. These key external trends are, once again, the Table 6-1:

TABLE 6-1 KEY EXTERNAL TRENDS INFLUENCING WATER SECTOR OPERATIONS

Key external trends	Scale
Trust in drinking water company	High (1) – Low (4)
Importance attributed to sustainability	High (1) – Low (4)
Water demand	High (1) – Low (4)
Regulatory framework	Stringent (1) – Loose (4)
Ownership water entity	Public or private
Political stability	Stable (1) – weak (4)
Availability water	Abundance (1) – Scarcity (4)
Availability resources other than water	Abundance (1) – Scarcity (4)
Pressure on subsoil	High (1) – Low (4)
Climate change	KNMI/WH (1) – KNMI/GH (4)

6.2 The Collective City

FIGURE 6-3 ILLUSTRATION OF THE COLLECTIVE CITY

The crux of this city is in the name; there is a strong collective sense, which is particularly well reflected in the high levels of trust that citizens place in the local authorities and the city council. The latter is of significant influence when it comes to the number and size of institutions it governs, in terms of legislative powers it can exert and the influence it has on shaping the city in socio-material sense. The city council is highly ambitious. It has a strong normative preference for equality and sustainability in society and it seeks to develop the city and its surroundings such that it can derive essentials like water, energy and food from or in the vicinity of the city as much as possible. The city is relatively wealthy, which, together with its formative powers, enables it to start up and carry out large-scale projects in line with the aforementioned ambitions.

The city council also assigned specific areas within or just outside the city for functions related to water, food and energy. Large strokes of land, pieces of which were bought one by one by the city in the last decades from private land owners, are for instance. used to growing food. A ditto amount of land is used for generating solar and wind energy. These and other primary services are managed by one centralized utility company. This utility company provides citizens with many of their basic needs. It adopts integrative options in support of sustainable ways of operating and an efficient use and reuse of basic services, thereby limiting the city's dependency on others (e.g. regarding energy or food imports). The central parts of the city are reserved mainly for purposes of living, recreation and professional activities.

Mainly top-down, integrative urban planning means that people are fairly limited in their actions; certain types of recreation, architecture or employment are simply preferred over others and the city actively steers and regulates developments. City entities also try to shape and influence citizen's behaviour and this too sorts effect. People are stimulated to adopt (more) sustainable lifestyles when it comes to for instance (re)use and disposal of food, water, energy and waste, but also as to how communities interact with one another, thereby trying to maintain or enhance social cohesion in the city. Science and technology are considered important in the development of the city and are (therefore) being subsidized. Especially so-called "low risk/ high gain" scientific work is stimulated and subsidized, i.e. tools, methodologies and technologies that are perceived 'robust' and having high potential benefits. An important criterion for subsidy is that scientific outcomes and inventions help develop the city in line with the aforementioned ambitions.

The fairly big, decisive and largely autonomous local government of the Collective City has major steering capabilities, enabling interventions to be effective and objectives to be realized. However, this government can also be characterized as being slightly anonymous, indifferent, authoritarian and 'autistic'; Kafkaesque practices are not unheard of. Sharp criticism from the public on such practices provides for some countervailing power. Ultimately though, as long as a certain level of quality of life is warranted, people take such excesses largely for granted, see Figure 6-3 and Table 6-2.

TABLE 6-2 THE COLLECTIVE CITY IN TERMS OF KEY EXTERNAL TRENDS INFLUENCING WATER SECTOR'S OPERATIONS

Key external trends	**Scale**	**Score Collective City**
Trust in drinking water company	High (1) – Low (4)	High (1)
Importance attributed to sustainability	High (1) – Low (4)	Substantial (2)
Water demand	High (1) – Low (4)	Low (4)
Regulatory framework	Stringent (1) – Loose (4)	Extensive (2)
Ownership water entity	Public or private	Public
Political stability	Stable (1) – weak (4)	Stable (1)
Availability water	Abundance (1) – Scarcity (4)	Abundance (1)
Availability resources other than water	Abundance (1) – Scarcity (4)	Abundance (1)
Pressure on subsoil	High (1) – Low (4)	Low (4)
Climate change	KNMI/WH (1) – KNMI/GH (4)	KNMI/G (3)

6.3 The Self-sufficient City

Policies implemented in 2014, aimed at increasing self-reliance and sustainability, have certainly paid off in the decades after. Agenda setters then foresaw –correctly in hindsight– that citizens would increasingly take initiative and responsibility for local, sustainable developments. Such behavior was further stimulated by local politicians promoting the credo of “Big Society”. That this occurred against the (political) background of a shrinking and retreating government supposedly committed to doing “more, with less”, is often left unmentioned, see Figure 6-4 and Table 6-3.

FIGURE 6-4 ILLUSTRATION OF THE SELF-SUFFICIENT CITY

However this trend may be explained, truth is, the society and citizen of 2040 are markedly different from those in 2014. Citizens are much more critical of the local government than they were then. The ‘certainties’ that governments held out for citizens weren’t nearly as certain as they said they were. Promises of continuous energy supply, climate neutral water management or food security have often not been met the last three decades. But just as critical are citizens of big multinationals, who claimed to be ‘green’ and sustainable, but were often making vast profits at the expense of people and the environment, here and elsewhere. The consequent void left by the state and the market, has thus largely been filled by citizens themselves. Some have become more conscious about their lifestyle and behaviour and its effects on society and nature. Others simply saw their quality of life slowly but surely deteriorating.

Driven by a vision of society or self-interest; citizens increasingly took matters into their own hands, and public and private organizations followed suit. Their actions are guided by themes such as sustainability, self-sufficiency, locality, craftmanship and simplicity. Imported food from the other side of the world has, where possible, been substituted by food from the private or shared garden. Reusing materials and old stuff for construction, renovation or decoration of houses is now common practice. New homes or neighbourhoods are designed and built in connected ways, commonly equipped with flat, green roofs or even roofs on which park-like environments have been created. So called “low-technologies” that can easily be assembled, maintained and operated by people have taken off and, with the support of high-technologies where needed, serve many puposes, such as refreshing air, treating wastewater or generating electricity. While many of these efforts are aimed at increasing independence from third parties, city entities still play an important, but subordinate role, for example in organizing the circulation of (used) materials. Those small to medium sized companies florish that offer people professional support, materials or courses in such topics as horticulture or the processing of materials.

All this has led to a way of living in the city that has changed quite dramatically over the last decades. The typical hurried, individualistic and materialistic consumer has given way to a large group of socially conscious citizens. Comfort for this group of people is not so much found in materialistic consumer goods. They are more appreciative of and find status in the mastering of (local) knowledge and crafts, although this does not necessarily mean that modern technologies are done away with – items such as 3D-printers can be of great use in their quests for increased self-sufficiency. People work fewer hours per day and fewer days a week than before and spend more time on activities in and around the (largely self-supporting) house. Public spaces (parks, squares, gardens) have increased in number and size and are being used to expose the latest socio-technical features in support of a self-sufficient lifestyle. The city deals with problems relating to climate change by creating or stimulating more green spaces (public and private gardens, roof gardens, etc.) and cars run on hydrogen, which is extracted from water using clean energy sources. Social principles aimed at having a good (but not necessarily perfect) quality of life with relatively few means are embraced by many, while neoclassical economic principles, emphasizing the 'competitiveness' or 'modernity' of the city, have slowly lost appeal. 'Less is more' is the credo of this city.

Although this city and its citizens embrace harmony in society, this is quite often challenged in practice. A sustainable, self-conscious and less individualistic city and the accompanying social initiatives by citizens or city entities, clash regularly with people's desire for privacy. And while citizen's dependence on state or market has decreased, they have become more dependent on one another. The functioning of decentralized systems that enable a block of houses to be (partly) self-supporting depends on the joint effort of residents. It makes clear that without a strong social commitment and organization, tensions (a)rise between people, which potentially undermine the foundations on which this society is based.

TABLE 6-3 THE SELF-SUFFICIENT CITY IN TERMS OF KEY EXTERNAL TRENDS INFLUENCING WATER SECTOR'S OPERATIONS

Key external trends	**Scale**	**Score Self-sufficient City**
Trust in drinking water company	High (1) – Low (4)	Modest (3)
Importance attributed to sustainability	High (1) – Low (4)	High (1)
Water demand	High (1) – Low (4)	Modest (3)
Regulatory framework	Stringent (1) – Loose (4)	Mild (3)
Ownership water entity	Public or private	Public
Political stability	Stable (1) – weak (4)	Moderate (3)
Availability water	Abundance (1) – Scarcity (4)	Moderate (3)
Availability resources other than water	Abundance (1) – Scarcity (4)	Moderate (3)
Pressure on subsoil	High (1) – Low (4)	Fairly high (2)
Climate change	KNMI/WH (1) – KNMI/GH (4)	KNMI/GH (3)

6.4 The Competitive City

FIGURE 6-5 ILLUSTRATION OF THE COMPETITIVE CITY

Remember Detroit; a thriving industrial city in the 1960s with a growing number of inhabitants, of which was little left in 2014. With a flourishing (car) industry, Detroit developed into an economic centre in America and beyond and hosted one of the largest and most profitable companies in the world, General Motors (GM). When GM's focus shifted towards financial services and 'innovation', it began producing financial bubbles rather than cars, which eventually burst in 2005. That had major consequences and these even exacerbated when the mortgage crisis broke out in 2007. GM imploded and massive job cuts were announced and implemented. Many people were forced to leave their homes up to the point that entire districts turned into ghost neighbourhoods. Streets were abandoned and boarded up houses and infrastructure in decay determined its sight. The city even went bankrupt. Crime and poverty peaked. Yet Detroit was able to gradually get back on its feet, flourished once again, but only until the next depression...

Although a one on one comparison is flawed, there are interesting parallels to be drawn between the Competitive City in 2040 and Detroit (and its broader cultural, economic, political context during the first decade of the 2000s). Take for instance the popular credo of the American Dream. The idea behind this –you can achieve whatever you want, as long as you work hard; if you are not successful, blame yourself- is also commonly accepted amongst people in the Competitive City. This idea has a great appeal that provides the majority of people (whether rich, poor, healthy, weak, young or old) with hope and perspective on success. However, from this highly individualistic and ‘everyone for himself’ mentality gains only a small group, while the majority have a hard time making ends meet. Falling back on public support is hardly possible for the latter group; the local government has been greatly reduced in size and possesses very weak powers. Subsequent welfare state retrenchment have basically eliminated social provisions and these are only discussed during history courses. Goods and resources are (re)distributed mainly through market and money means, two elements that are illustrative for this city. The government’s role in this is small and limited to regulatory duties.

In the broader global and regional context economic growth is hard to realize and development and wealth creation is still fundamentally based on the use of fossil fuels. Cities and countries compete for scarce resources like water, space and energy. There is little investment in new technologies, although particular lucrative business opportunities may quite suddenly attract huge investment. This may bring some development and prosperity on the short run, but just as soon as it appears, it disappears. Financial and industry bodies have a great influence on infrastructure development in the city and the country at large. Essential services are hardly cost-effective, unless privatized. All this can be seen as a variant of Schumpeter’s concept of “creative destruction” on a city scale. Any concept or development that flourishes is quickly considered a “vivid example” and hence, followed or copied by others. Likewise, what fails is apparently considered unfit by the market and has no further right to exist, or so one believes. People are used to these types of reasoning and act indifferent; there is little you can change by yourself. While for many this is a very stressful existence, there is always that perspective of hope: “tomorrow it could all be different”.

Urbanization and concentrated ways of living is positive for most people as that keeps (a minimal amount of) essential services like education and health still accessible. Almost no one owns a car, public transport is expensive and only available on for provider’s profitable lines. Hence, people are mostly condemned to easy and cheap ways of moving around, that is, walking or cycling. The city council saves money on public lightning and security, and keeps maintenance of public spaces and services to a minimum. Citizens accept that things break down and remain temporarily or at all unrepaired. They also accept a lower quality of basic goods such as food and drinking water, see Figure 6-5 and Table 6-4.

TABLE 6-4 THE COMPETITIVE CITY IN TERMS OF KEY EXTERNAL TRENDS INFLUENCING WATER SECTOR’S OPERATIONS

Key external trends	**Scale**	**Score Competitive City**
Trust in drinking water company	High (1) – Low (4)	Low (4)
Importance attributed to sustainability	High (1) – Low (4)	Low (4)
Water demand	High (1) – Low (4)	Substantial (2)
Regulatory framework	Stringent (1) – Loose (4)	Mild (4)
Ownership water entity	Public or private	Private
Political stability	Stable (1) – capricious (4)	Weak (4)
Availability water	Abundance (1) – Scarcity (4)	Scarcity (4)
Availability resources other than water	Abundance (1) – Scarcity (4)	Scarcity (4)
Pressure on subsoil	High (1) – Low (4)	High (1)
Climate change	KNMI/WH (1) – KNMI/GH (4)	KNMI/WH (3)

6.5 The Intelligent City

FIGURE 6-6 ILLUSTRATION OF THE INTELLIGENT CITY

In the intelligent city the ideal is (continuous) progress in the modernist sense; all effort is directed towards building a 'modern' city, fully equipped with the newest facilities and latest features. Although the primacy for development lies with the market, it is strongly steered and (re)directed by local authorities. The latter successfully stimulate and subsidize innovation and technology, which enable large, but also small and medium, companies to introduce one after the other (technological) breakthrough. Those are exported to other regions and countries, but are also being used by and implemented in the city itself. That has indeed led to a high-modern city, which –it seems– stands and falls with technology. You can be online anytime of the day, anywhere; public space is full of 'smart' devices designed to make life supposedly more comfortable. Attributes such as telephones and "personality chips" are non-stop connected, so that a range of activities, from shopping to park visits, are continuously being adapted to the (perceived) needs and preferences of the individual. The physical environment and people themselves have become inherently intertwined with the virtual world and only few who can still make a distinction between the two.

This city offers a high degree of comfort and convenience, but it is also the city of great contrasts. A city like this offers citizens many possibilities to participate in a variety of issues, from politics to culture. But a city so dependent on technology also makes for a very fragile society. Technology (e.g. ICT infrastructure) normally runs well, but also fails sometimes, and with the most essential services like water depending on such technical infrastructures, there is more than predicted a break down. And since people's self-reliance has diminished dramatically, such breakdowns often have large effects. All this ironically undermines the concept of 'trust'. One can do without the help of technology no more, but they are also deeply distrustful of it. The increased application of technology and the available data and information may have made the city more 'intelligent', but citizen's dependency on and the automatic processing of information leads to a state of lethargy. One can ask whether this has indeed made citizens wiser.

The intelligent city will be most useful to those who fully expose themselves and their characteristics, experiences and preferences. Availability of data and information, and increased transparency better enables various actors (citizens, companies, authorities) to inform themselves, but this has come with reduced privacy. This may lead to information being used for other than intended purposes. Whether or not this is indeed the case; the fear for the latter is constantly present. That fear penetrates deeply and divides citizens, and their relation with official authorities. Finally, psychosocial symptoms are widespread. This however, is not necessarily seen as a social problem, as it perceived as a new 'market' that can be 'conquered' with the newest innovations, see Figure 6-6 and Table 6-5.

TABLE 6-5 THE INTELLIGENT CITY IN TERMS OF KEY EXTERNAL TRENDS INFLUENCING WATER SECTOR'S OPERATIONS

Key external trends	**Scale**	**Score** **Competitive City**
Trust in drinking water company	High (1) – Low (4)	Substantial (2)
Importance attributed to sustainability	High (1) – Low (4)	Modest (3)
Water demand	High (1) – Low (4)	High (1)
Regulatory framework	Stringent (1) – Loose (4)	Stringent (1)
Ownership water entity	Public or private	Private
Political stability	Stable (1) – weak (4)	Substantial (2)
Availability water	Abundance (1) – Scarcity (4)	Critical (3)
Availability resources other than water	Abundance (1) – Scarcity (4)	Critical (3)
Pressure on subsoil	High (1) – Low (4)	Modest (3)
Climate change	KNMI/WH (1) – KNMI/GH (4)	KNMI/W (2)

7 Conclusions & recommendations

In this report we describe how water companies can take an uncertain future into account in strategic planning for their drinking water infrastructure. Because investments in drinking water infrastructure are usually for the long term it is important to consider the future context in which the infrastructure has to operate. The future is in itself uncertain; various important factors may change, such as the source water quality (nitrate, emerging substances, etc.), legislation (e.g. tax on ground water extraction), stakeholders' expectations (e.g. as other stakeholders appear, or their role changes) and the infrastructures' condition and function. Furthermore, social, economic, technical en societal trends may impact the (future) infrastructure. This research treats drinking water infrastructure (extraction, treatment and distribution) as a socio-technical system, meaning that not only the technical aspects are considered but also the social context in which the infrastructure functions.

We have noted that for many decisions on infrastructure investments the future is only considered in a limited way. For instance, operational investments only consider a limited time horizon when a specific pipe is replaced with the same pipe diameter, or strategic investments only consider one (most likely) future when a replacement transport network is designed with smaller diameters to cater for expected decrease in demand. Often a safety margin is added for potential growth. In the past, the drinking water companies took an expected increase in demand into account; the large demand predictions of the 1970s, however, were not fulfilled. Strategic decisions often are the result of a one-sided approach towards the future, when only current criteria for investments are considered, a mono-disciplinary attitude is taken, or only one future scenario is studied. It is assumed that one future is usually most likely or an anticipated worst case scenario, where in reality the future in itself is uncertain. In this study a scenario planning approach using explorative external scenarios is adopted to overcome this issue.

We distinguish three stages in deciding on long term investments for drinking water infrastructure (Figure 7-1):

1. Determining the starting point and preconditions by looking at past and present.
2. Determining the investment options following from the water companies long term vision; alternative options are widely considered.
3. Deciding on the investment and plan for the implementation. All options are tested on their robustness in several distinct future scenarios where important trends that need to be monitored and which partners are required to reach the goals with are reflected on.

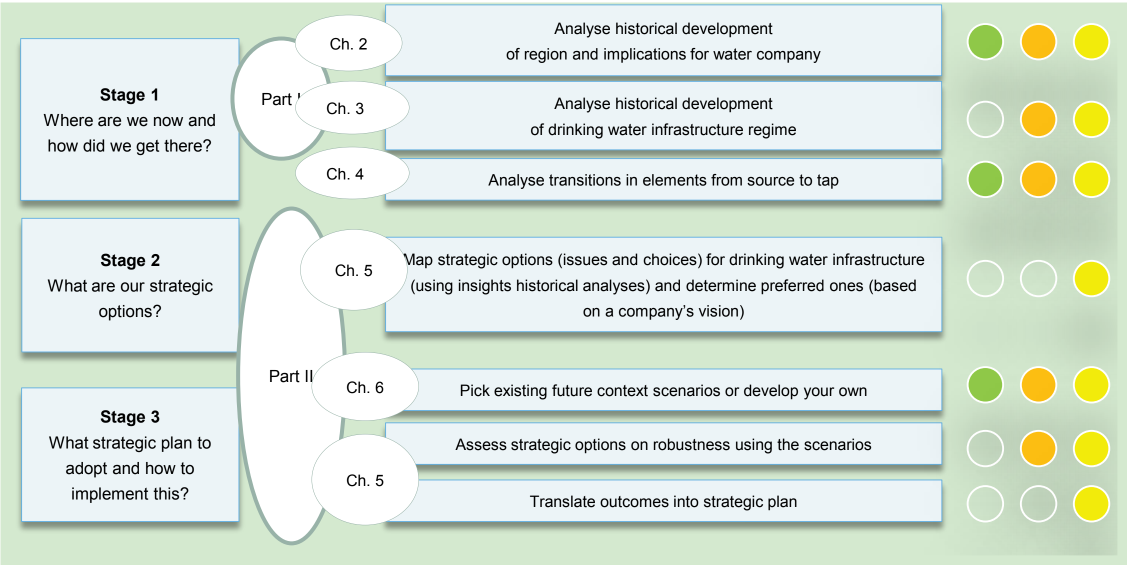


FIGURE 7-1. STAGES TOWARDS A STRATEGY ON DRINKING WATER INFRASTRUCTURE, WHILE TAKING INTO ACCOUNT AN UNCERTAIN FUTURE. THIS REPORT IS A GUIDANCE FOR WATER COMPANIES TO CONSTRUCT THEIR VISION AND SECTIONS CAN BE USED AS EITHER A FOUNDATION (GREEN DOTS), AS A STARTING POINT (ORANGE DOTS), OR AS AN INSPIRATION (YELLOW DOTS).

This report provides a guide and building blocks and inspirations on each of the three stages that can be used by water companies to construct and implement their own strategic planning process regarding their future drinking water infrastructure. They can be used as a foundation (use as is), as a starting point (i.e. expand on this with extra studies along the lines described here, or made more specific for own use), or as an inspiration (but own studies will be used instead). We do not offer foundations in every step, as some of the steps are very company specific or specific for the Dutch situation, but we do offer inspiration, drawing on workshops held with a delegation of the ten Dutch water companies and a specific implementation of drinking water company Dunea.

For stage 1 we have described the historic development in the Netherlands (in some respects exemplary for Western Europe more generally) and the impact on infrastructure on the scale of a country or water company. This provides insight into drivers for investments over the past 100 to 150 years. We also looked in more detail into water companies' investments in infrastructure since their establishment. This showed how early choices for water sources and locations of treatment works have significant influence on future planning; we found evolution rather than revolution in infrastructures. Drivers for investment are largely determined by the societal context: in the past water quantity (supplying all) and then water quality were main drivers; currently cost, sustainability and customer satisfaction compete alongside water quality. There is flexibility in infrastructure, but changes take a long time. A water company may review past decisions on infrastructure and see if they still hold, or that a transition to a better solution may be beneficial. We looked at transitions in the choice of source water, treatment schemes, networks design and drinking water demand and found that these typically take 20 to 30 years and may either lead to full transitions, limited transitions or back lashes. We advise the water companies to monitor key uncertainties, but also to try to influence them with suitable partners.

Stage 2 is very company specific, but we have included some examples on investment dilemmas: 1) to continue with centralized treatment facilities (with the economy of scale) or move towards more decentralized facilities or centralized with a more modular approach, 2) to prevent any possible inconvenience for customers or to manage customers' expectations with respect to an aging infrastructure and the cost to maintain it, 3) Dunea's process towards a new five-year strategic plan for the period 2015 – 2020.

For stage 3 we have developed context scenarios for future cities along the axes of A) the size and strength of local authorities and B) the prevailing societal structure that orients and steers actors. This culminated into four views for the extremes of the axes that are called 1) the collective city, 2) the self-sufficient city, 3) the competitive city and 4) the intelligent (or smart) city. The descriptions of these cities and the accompanying illustrations support in contemplating and discussing the investment consequences in the various possible futures. The options defined in stage 2 were discussed for the four context scenarios in a workshop with the ten Dutch water companies and also specifically within water company Dunea. The outcome of the discussions could be an input for an investment plan that is considered robust under all possible futures. The future scenarios can easily be enriched, made more specific for a region or be used for discussions with not just water company decision makers but also with other stakeholders. We advise water companies to apply the method to current investment dilemma's.

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Attachment I Further reading

This report: "**BTO 2015.048 Strategic planning of drinking water infrastructure: a conceptual framework and building blocks for drinking water companies**" has an extended Dutch summary: "**BTO 2015.049 Strategische planning van drinkwaterinfrastructuur: een conceptueel kader en bouwstenen voor drinkwaterbedrijven – Nederlandstalige samenvatting bij BTO 2015.048".** This report is based on a series of three reports were different aspects of the (future) drinking water infrastructure were analysed.

Report I: BTO 2015.050 Historical development of four Dutch urban drinking water infrastructures

L. Palmen; C.M. Agudelo-Vera

This report describes the results of a study of the infrastructural developments of four different Dutch urban drinking water systems and the identification of the drivers behind these changes. The major investments in the drinking water infrastructure of the four Dutch urban areas of Amsterdam, Groningen, Arnhem-Nijmegen and Maastricht were identified as well as the drivers behind the investments. The incentives for the 225 identified investments could be classified into 23 different drivers. The drivers 'water quality' and 'water demand' are the most frequent occurring drivers. Investments because of third parties, geographical factors, costs, and policy are of secondary interest. Most of the drivers found are recurring throughout the entire period, although some trends were found in the occurrence of drivers. Important trends are the search for proper drinking water sources and the increasing customer connectivity and water demand in the early decades. Despite the presence of common generic drivers for all four cities, its effects on the development of the infrastructure of these cities are influenced by local factors. This report is the basis for the chapter 3 in this report: Urban infrastructure 'regime' transitions.

Report II: BTO 2015.051 Transitions in the drinking water infrastructure – a retrospective analysis from source to tap

C.M. Agudelo-Vera, C. Büscher, L. Palmen, I. Leunk and E.J.M. Blokker

This report describes the results of a study into past transitions in drinking water infrastructure. Four case studies have been carried out, each describing a transition relating to a specific part of drinking water infrastructure and the role of drinking water companies in these transitions. The four case studies included transitions in the residential water consumption in the Netherlands, transitions in the design of (hot) drinking water installations, transition to minimum chlorine usage in drinking water production in The Netherlands and a transition from groundwater to surface water in one water production facility. The analysis of the transitions showed that the drinking water infrastructure systems is in a continuous change due to transitions in the subsystems and in the external environment. Changes in the subsystems occur at different speed and driven by different factors. Transitions in the drinking water system are relatively slow. The changes found in these analysis showed that we can describe transition in the drinking water infrastructure in decades. This report is the basis for the chapter 4 in this report: Transitions in water infrastructures from source to tap.

Report III: BTO 2015.052 Drinkwaterinfrastructuur van de Toekomst - Interactieve sessies met experts van de drinkwaterbedrijven

C.M. Agudelo-Vera, E.J.M. Blokker, C. Büscher and L. Palmen

This report describe the outline and outputs of a number of workshops held within the project "Drinking water infrastructure of the future". These sessions formed a series of four steps in the so-called scenario planning. The development of four context scenarios for future cities was the first step (2013). These generic scenarios were "enriched", i.e. made more connected to the water sector in a session on March 2014 with the participation of an interdisciplinary team of researchers and professionals of drinking water companies. Ten key uncertainty factors in the external environment and how they are embedded in the future scenarios were defined. After that a session was organized to identify current strategic choices, issues, dilemmas and tradeoffs of professionals from water companies who take care of drinking water infrastructure and assets (April 2014). Finally, the robustness of their strategic considerations and dilemmas were tested (October 2014). In this step in the strategic process, the outputs of the previous sessions are confronted and how the identified strategic options hold under the four future scenarios is assessed. This is also a participatory activity and the outcome is an extensive weighing of options, giving direction to and building blocks for the ultimate strategic plan. This report is the basis for the chapters 5 and 6 in this report: "Strategic planning of drinking water infrastructure: assumptions, techniques and outcomes" and "Four future scenarios of the city".

Articles

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Interactive sessions with experts from de drinking water companies:

Workshop 20 November 2013 - Future-proof drinking water infrastructure. Defining the scenarios.

Session 3 February 2014 - Inventory of implications of the scenarios for the drinking water infrastructure. Dissemination of the first description of the scenarios and interdisciplinary discussion.

Workshop 19 March 2014 - Enrichment of future scenarios : Enrichment of context scenarios of four cities of the future by a multidisciplinary group of KWR researchers and representatives of the drinking water companies.

Workshop 7 April 2014 – Determining dilemmas: Charting strategic options regarding water infrastructure (extraction, treatment, distribution, including assets in and around the home). Theme Group Asset Management

Workshop 2 October 2014 – Testing de Robustness: Testing the robustness of the strategic choices. Theme Group Trends.

Mini-symposium CO 24 November 2014 - Verify and refine outcomes: Current and ' future ' CO – members.