SMART WATER

Final Report, February 2019

Smart Water Digitalisation in the Water Sector

Supported by the Capital Region of Denmark

The Capital Region of Denmark

www.callcopenhagen.dk

Contents

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The project received funding from the Capital Region of Denmark

Executive summary

This is the final report covering the "Smart Water" project

Through interaction with more than 100 stakeholders in the Danish water sector this project has investigated the potential for optimisations in the water sector through the increased use of digital solutions.

The analysis was carried out in collaboration between CALL Copenhagen, CLEAN, City of Copenhagen and Frederiksberg Forsyning (the utility company of Frederiksberg). The project received funding from the Capital Region of Denmark.

Twenty-five city and utility representatives from the Capital Region of Denmark were interviewed during 2018 and the output was presented in December 2018 at the conference "Smart Water 2018". A further 100 stakeholders – also including consultants and suppliers – contributed to the discussion and prioritisation of the key challenges and potentials that are described in this report.

The background for the project includes international surveys which show that new, digital solutions may lead to significant optimisations of the operations of the water sector. Major value can be created through the development of digital solutions in the water sector – within drinking water, wastewater and drainage – if the right investments are made.

This knowledge is, of course, also reflected in Denmark, as can be seen in the whitepaper: "Vandvision 2025" ("Water Vision 2025") developed by The Ministry of Environment and Food, Confederation of Danish Industry, Danish Environmental Technology Association and DANVA.

Based on this foundation, the purpose of the project has been to analyse specific needs and opportunities related to digital solutions in a Danish context in order to move one step further in the identification of the most promising "Smart Water" investment areas for Danish communities and utilities.

Definition: "Digital solutions" are solutions including one or more of the following elements: Digital data collection, data transmission, data handling/analysis, presentation of data (raw or analysed). Solutions may include hardware (e.g. sensors) as well as software.

Main conclusions

Digital transformation requires investment before the benefits can be realised. We know from other industries that it typically takes an investment of just a few percent of the gross revenues per year over a number of years to complete a transformation, which, in return, is expected to reduce the long-term operating costs significantly.

The project participants specifically highlight two main areas where significant value could be created through the increased use of digital solutions:

1. The first area covers the planning, prioritisation and operation of climateadaptation solutions. Here they find clear opportunities for improvement – especially if it was possible to remove existing barriers of co operation across administrative units in order to allow for (or even require) prioritisation and operation of the urban drainage infrastructure based on the natural catchment area.

2. The second area covers maintenance of the water infrastructure. The responsibility for maintenance of the drainage infrastructure is divided between the municipalities and the utilities, but the actual planning and execution of maintenance are not coordinated to an extent that fully exploits the opportunities of optimising the lifespan of the infrastructure as well as ongoing maintenance activities.

Both areas require improved collection and easier access to monitoring of data. A strategic investment in the broader collection and sharing of data will form the basis for improved planning and more efficient operation of climate solutions – including active control of the water flow through the catchment area.

At the same time, this initiative will also enable analyses, which may lead to an extension of the lifespan of the infrastructure and to improved planning of maintenance activities. Finally, improved water quality data will enable a wider use of surface water solutions while avoiding associated health risks.

A critical element in an investment of this kind is gaining access to less expensive sensor systems – both in terms of purchase and operation. In this context, new digital business models may be relevant.

An interesting sub-conclusion is that there seems to be substantial differences in the perception of priorities between the users and their suppliers. According to the users, the suppliers need to develop new and more cost-effective products – or improve communication of the value of their existing products. According to the suppliers, the users could benefit from improving their competencies and hereby utilise their existing products more effectively.

Several project participants point out that the municipalities and utilities could benefit from working with digital business models as part of an increased awareness of the long-term potential of investing in digitalisation.

Recommendations

A strategic effort within "the intelligent catchment area" – a catchment area equipped with a large number of sensors and with the intelligent processing and sharing of data – could form a basis for an accelerated digitalisation of essential parts of the water sector. This would support the development of innovative solutions within both of the main areas mentioned in the main conclusions.

This type of strategic investment will also support both the financial efficiency of utilities and Danish energy policies as well as the international cooperation around the Paris Agreement – thereby contributing to promoting the global, green transition.

At the same time, strategic investment will foster growth in the development of new commercial products and services within an area of huge international potential and thereby establish a solid foundation for the export of Danish technology, consulting and capacity building.

Recommendation 1. Competency development

The project workshop as well as the market dialogue have indicated a need to strengthen the dialogue between suppliers and end-users of advanced solutions to accelerate and exploit the potential of the digital transformation. This kind of dialogue only develops once the end-users proactively demand innovative solutions while being more specific with respect to their requirements to the suppliers and their products. However, this requires that the end-users are appropriately prepared for a qualified dialogue with the suppliers. Therefore, it is recommended to implement a competency development programme for the utilities and municipalities.

Recommendation 2. The necessary framework

It is possible to initiate a positive transition towards the intelligent water catchment area if utilities and municipalities have sufficient motivation and incentive to develop strategies and action plans that include actual investments in the digitalisation of the utilities sector and the associated infrastructure. Therefore, it is recommended to establish – at a policy level – the necessary framework required for utilities and municipalities to plan and initiate long-term investments based on ambitious but realistic objectives supporting the long-term results.

Recommendation 3. Cooperation across administrative boundaries

The project's participants have clearly stated the need to create improved cooperation across administrative boundaries in connection with larger investments in infrastructure for climate adaptation. This cooperation is needed in order to achieve

a more holistic view of the prioritisation of the solutions. In particular, a broader view is required in relation to the sharing of costs and savings related to optimal drainage solutions for larger catchment areas that cut across administrative boundaries. It is recommended to improve the understanding of the benefits of catchment-area-based drainage infrastructure planning through one or more pilot projects with the participation of municipalities, utilities and regulators.

Recommendation 4. Development of inexpensive sensors

Additionally, it is recommended to start specific activities (proof-of-concept projects) regarding sensor development, where more cost-effective standard products are still missing. A need for innovation has been expressed within the measurement of water quality parameters in relation to the optimal control of drinking water as well as of surface runoff during cloud bursts.

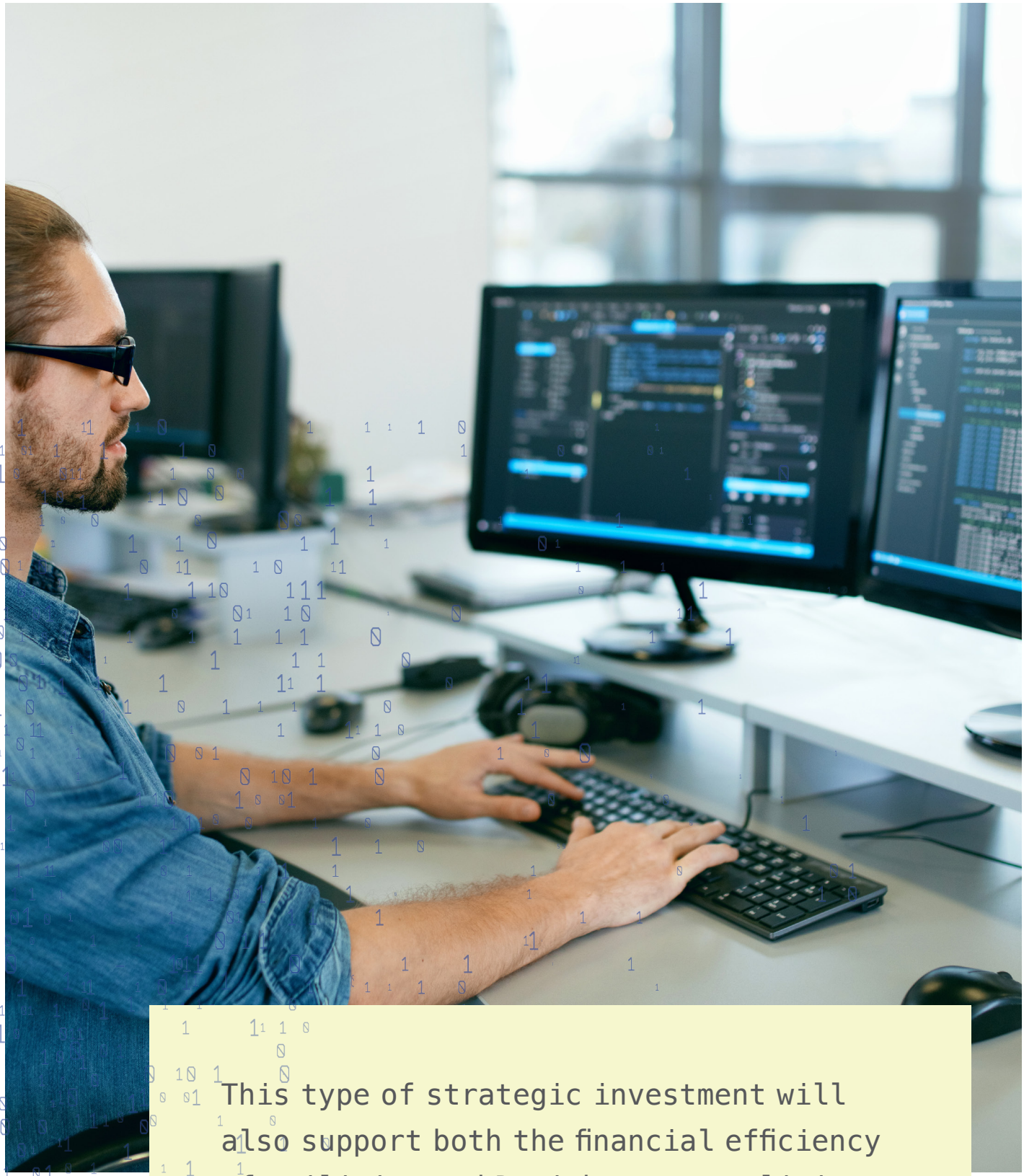
Recommendation 5. Common framework for data utilisation

The participants have expressed a desire for easier and smarter ways to access data outside of their own "fences". It is recommended to initiate a project that establishes a common framework for data utilisation. For instance, this could be expressed as a set of "dogma rules", that also address the requirements for the data communication protocols in sensors. A set of rules – developed with active participation from users – could also contribute towards creating a better common language concerning data as well as a more efficient use of data among all stakeholders.

Recommendation 6. Knowledge sharing

Knowledge sharing – including sharing across various types of organisations – is requested, and several of the project participants have expressed how an event such as the Smart Water 2018 conference has added value. It is recommended to make an effort to promote the use of already existing forums for knowledge sharing and possibly add more where needed.

Denmark is already in a good position internationally within the water industry and climate adaptation, and if the above recommendations are implemented Denmark's position could be maintained and further strengthened – benefitting Danish exports while at the same time supporting the UN Sustainable Development Goals and the Paris Agreement.



This type of strategic investment will also support both the financial efficiency of utilities and Danish energy policies as well as the international cooperation around the Paris Agreement – thereby contributing to promoting the global, green transition.

Introduction

This is the final report covering the "Smart Water" project carried out in a collaboration between CALL Copenhagen, CLEAN, the City of Copenhagen and the utility company Frederiksberg Forsyning.

The project has received funding from the Capital Region of Denmark.

Global Water Intelligence have published the report "Water's Digital Future", which summarises the potential for digitalisation in the water sector. The report concludes that the water sector can realise substantial operational benefits if the right investments are implemented.

The purpose of the Smart Water project has been to:

- Uncover the specific **challenges** in the water sector suitable for being solved using digital technology
- Describe the corresponding **needs** in terms of digital solutions
- Analyse and describe the **potentials** related to these solutions
- Uncover the possible **barriers** to the implementation of digital solutions

- and from there on identify the most attractive areas of investment.

This final report describes the methods used and the results of the project. The report is based on:

- Interviews with stakeholders in the water sector, primarily municipalities and utilities located within the Capital Region of Denmark
- Market dialogue with suppliers and potential suppliers of digital solutions to the water industry
- A conference workshop – with participants from the water industry, suppliers, regulators and other stakeholders – where the results from the interviews were discussed and further elaborated

Consequently, the conclusions and recommendations in this report have been reached through dialogues and discussions with more than 100 individuals representing a broad section of private and public industries, communities and authorities from the water sector.

Methodology

Interviewing stakeholders from cities and utilities

An initial mapping of challenges and needs in relation to increased digitalisation of the water sector was carried out through interviews with 25 stakeholders from cities and utilities in the Capital Region of Denmark. Phase one of the project included physical interviews with each of these stakeholders. The interviews were divided into three batches:

1. A pilot group (3)
2. The main group (20)
3. A feedback group (2)

All interviews were carried out as semi-structured interviews based on an interview guide. The three pilot-group interviews were used for quality checking of the methodology and the interview guide – followed by the interviews with the main group. All interviews involved two people from the project team. The interviews were recorded and the recordings were transcribed, used in the analysis phase and subsequently erased. After a preliminary analysis of the results from groups 1 and 2, this analysis was applied as part of the further two interviews (the feedback group). The purpose of this was to receive relevant feedback from technically competent people prior to publication and prior to using the results of the analysis as part of the stakeholder involvement at the Smart Water conference.

The composition of stakeholders was as follows:
Seventeen representatives from different municipalities in the Capital Region of Denmark, including seven from HOFOR municipalities, four from Novafos municipalities and ten from BIOFOS municipalities (HOFOR and BIOFOS municipalites overlap), five representatives of other water utilities in the Capital Region of Denmark (in addition to HOFOR and Novafos).

Market analysis – Interviews with consultants and suppliers

The methodology as well as results from the market analysis are provided in the section Market Dialogue.

Analysis – Part 1

The results from the stakeholder interviews have been analysed in order to extract the most important challenges and needs related to the digitalisation of the water sector. Seven challenges with a total of 14 sub-challenges were identified based on the interviews. The analysis and the results are described in the section Analysis of Challenges and Needs.

Smart Water 2018 conference and workshop

The results from the analysis of challenges and needs were presented at a conference in December 2018 with more than 100 stakeholders from the water sector registered. The market analysis including interviews with consultants and suppliers was also presented at the conference (www.callcopenhagen.dk/smartwater).

During the conference the participants were asked to give their own priority choices among the 14 challenges. Each participant was given four votes for distribution among the 14 challenges.

Based on this ballot the five top priority challenges were found and thus became the topics of the afternoon workshop. Nine groups of participants were asked to describe the most important barriers related to each challenge and to provide suggestions for useful next steps towards solutions to these challenges.

Analysis – Part 2

The priorities assigned by the conference participants are described in the section Prioritisation of Challenges.

The workshop results in terms of barriers and subsequent steps as suggested by the nine workshop groups have subsequently gone through a further analysis. The results are summarised in the section Barriers and Recommendations.

Analysis of challenges and needs

The 25 interviews conducted with stakeholders from municipalities and utilities have been analysed in order to identify the key statements related to challenges and the associated needs. The key statements have been summarised in a table where challenges and needs attached to each key challenge were listed and coded.

Based on this, seven key challenges were identified as important because:

- Each challenge has been expressed by several stakeholders
- Each challenge can be associated with specific needs in terms of new or improved digital solutions

In other words: these are seven challenges with a broad appeal and the potential of being solved through investing in – and possibly developing – digital solutions.

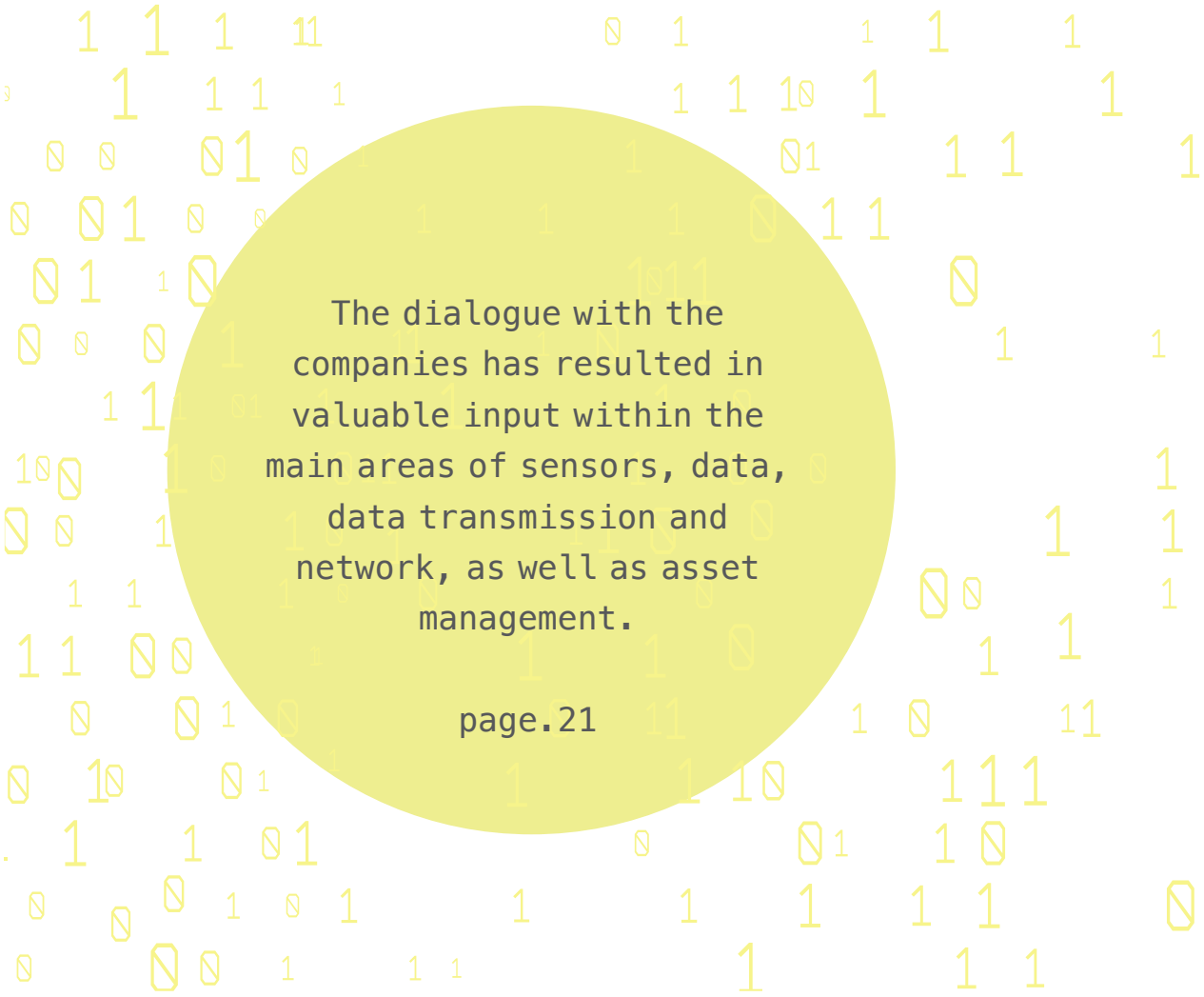
The seven challenges involve different degrees of complexity. Some are relatively constrained and well defined, while others are very comprehensive; each with several sub-challenges. The seven main challenges and their sub-challenges are provided in the following section. The table below provides an overview.

Nr.	Challenge / sub-challenge
1.	Planning and management of pipe network maintenance
2.	Climate adaptation A. Controlling the runoff through the catchment area B. Catchment area based prioritisation of solutions C. Control and maintenance of LID/SUD solutions D. Insufficient data E. Catchment area models for planning of control systems F. Control system technology
3.	Forecasting
4.	Water quality A. Polluting substances in road water B. Health and safety in relation to surface runoff C. Real-time monitoring of sewer overflows
5.	Citizen contacts
6.	Knowledge regarding existing data
7.	Data for optimising daily operations

The seven challenges correspond to needs for investment in digital technology within four main areas:

1. **Sensors and data**
   Monitoring equipment and software for data management
2. **Analytical Tools**
   Software for the analysis of measurements and other data
3. **Asset Management**
   Software for the planning and management of infrastructure maintenance
4. **Automation and control**
   Hardware and software for controlling the flows of water through a catchment area

These main areas were the basis for the market dialogue with consultants and equipment suppliers, as described in the corresponding chapter.



The dialogue with the companies has resulted in valuable input within the main areas of sensors, data, data transmission and network, as well as asset management.

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Challenge 1.

Planning and management of pipe network maintenance

The lifespan of the pipe network is one of the most important factors in relation to the total annual costs of the pipe network. If the service time can be extended, then this will imply large savings for utilities and communities. Savings can also be achieved through improved coordination of the maintenance activities for roads and house connections (in Denmark this is the responsibility of municipalities) with maintenance of the collectors (responsibility of the utilities).

Needs:
Improved IT systems (e.g. asset management systems) could lead to improved planning and management of maintenance.

Long term, the improved data collection could enable more detailed analyses of the remaining service life of the pipes – e.g. through combining asset management data with data on traffic and on winter activities for roads.

The municipalities of Herlev and Frederikssund, Novafos and Glostrup Utility are among the stakeholders who have mentioned this challenge.

"If you have replaced a house connection, backfilled and compressed in accordance with all the manuals, then you will still see subsidence after a year. This means that if we replace a pipe and renew the road surface, then we have to make repairs one year later. We see an obvious potential for asset management systems which can establish an overview of when and where to make replacements and repairs in an optimal way."
The Municipality of Herlev

Challenge 2.

Climate Adaptation

Billions of euros are being invested in the climate adaptation of our cities – and the protection of our infrastructure against the effects of cloud bursts. The overall challenge consists of ensuring the best possible value from the money invested. This challenge is sufficiently complex to merit its division it into several sub-challenges.

Controlling the runoff of water through the catchment area

The runoff of water through the catchment area (e.g. during cloud bursts) should be controlled on a catchment-area basis – rather than for separate administrative

units. The challenge is, among other things, that investments and the associated economic benefits (e.g. reduced flooding) do not necessarily follow administrative boundaries.

Needs:
Political decisions stating that control must be catchment-area-based and models for the sharing of costs and benefits. Tools to support equitable solutions.

Greater Copenhagen Wastewater (BIOFOS), The municipalities of Egedal and Hvidovre, Ishøj Utility and Glostrup Utility are among the stakeholders who have mentioned this challenge.

"We have to invest billions in constructing sufficient capacity for runoff from the total catchment area if we are to stay within our effluence permits and construct all the extra capacity at the downstream end of the catchment area. We could optimise the use of the entire system if we could implement advanced control of the flow from the catchment area to the treatment plant – and hence minimise our effluents to the environment. Advanced control could also significantly reduce the required capital investments in basin capacity. It would, however, require some smaller investments in sensors, regulators and software."
BIOFOS

Catchment-area-based prioritisation of solutions

Insufficient knowledge and technology exist for the prioritisation of climate adaptation solutions. This includes methods and tools for catchment-area-based optimisation as well as knowledge regarding the growing range of solution types (e.g. comparing the cost-efficiency of local versus centralised options).

Needs:
Planning tools which can simulate the economic consequences of multiple climate adaptation options and help the planners prioritise between the available options. The City of Copenhagen and Novafos are among the stakeholders who have mentioned this challenge.

"We have plenty of models from consultants telling us about the dissipation of pollution. What we are lacking are models that can show us the total consequences of effluents to the harbour for different cloud burst solution scenarios. How are the spills to the harbour affecting us and what are the long-term effects for the water quality?"
The City of Copenhagen

Control and maintenance of LID/SUD solutions

Knowledge concerning decentralised climate solutions (LID/SUD solutions) and systems for maintenance of such solutions are lacking.

This area requires coordination. There are multiple owners of LID/SUD structures (including private property owners). No standard is available for the registration of the structures and responsibility for the maintenance of some structures is not clearly established. Should we register data concerning LID/SUD structures in

existing building registration systems or should we establish new systems? Or perhaps some of the systems should simply be permitted to live (and die) without further administration?

Novafos and Frederiksberg Utility are among the stakeholders who have mentioned this challenge.

"Twenty years from now, Frederiksberg Utility Company will have implemented hundreds of solutions which must be functional in case of a cloud burst, but are inactive on a daily basis. It is a challenge to ensure that the systems are ready when needed."
Frederiksberg Utility

Insufficient data

We do not have adequate data for supporting simulations of optimal investments in climate adaptation. In particular, we are missing spatially distributed rainfall data in high resolution – as well as the methods needed to make use of such data.

The lack of data and knowledge regarding the runoff – the path of water through the urban catchment area during cloud bursts – leads to conservative (expensive) solutions because the guidelines have to take the lack of information into account.

The price of this is less than optimal value for our investments. A change of culture is needed starting with a shift towards the considerably more detailed monitoring of precipitation. Cloud bursts are very local phenomena and currently we do not collect the data which we need in order to manage cloud bursts more effectively in the future. The need for new, smart and inexpensive sensor systems goes far beyond just precipitation data. Therefore, the potential for innovation is huge in this area.

The Municipality of Allerød, Frederiksberg Utility, BIOFOS and Hillerød Utility are among the stakeholders who have mentioned this challenge.

"There is a clear potential in establishing a better basis in terms of data when creating synergetic projects. As an example, improved flow data can validate the optimal location of new retention storage."
The Municipality of Allerød

Catchment area models for the planning of control systems

We are designing our city with precipitation runoff on the surface – partly because we need this in order to be able to cope with the amounts of water during cloud bursts and partly because we can use the water for improving the urban habitats. However, we do not have sufficient knowledge regarding the quality of the surface water that we bring close to people – and that limits our options for designing smart surface water solutions.

We need better and far more data about the quality of the surface water and we need procedures that can protect us from unwanted health and safety risks in rela-

tion to surface runoff of precipitation.The City of Copenhagen and the municipalities of Allerød and Hvidovre are among the stakeholders who have mentioned this challenge.

"We do have in-house knowledge and capabilities for building and maintaining models. But this is not the case for all utilities and municipalities – and it is expensive to sustain this capability. Collaboration regarding how to achieve uniform quality of models and regarding streamlined procedures for modelling would be very useful."
Frederiksberg Utility

Control system technology

The technology for controlling the flow of water through the city during cloud bursts (model-based control) is not mature.

This technology is under development and a new generation of technology is about to be implemented, e.g. in the City of Aarhus. However, validation of the technology is required prior to implementing it in larger cities, such as Copenhagen.

BIOFOS and the City of Copenhagen are among the stakeholders who have mentioned this challenge.

Challenge 3.
Forecasting

The forecast systems for cloud bursts which are currently available are of limited value. The forecasts are not precise enough and warnings are too frequent to be of practical use. On the other hand, more accurate and detailed forecasts would be useful for traffic management and other emergency management purposes.

Improved forecast services are needed; services which can track cloud bursts and issue forecasts with a resolution down to street level. These forecasts would obviously only cover minutes rather than hours, but even that would be useful if it could be linked to traffic control systems. High-resolution forecasts – even of short duration – would also improve the capabilities of the emergency services and potentially limit damages.

The City of Copenhagen, Tårnby and Frederiksberg Utililties, the municipalities of Herlev, Frederikssund, Dragør and Novafos are among the stakeholders who have mentioned this challenge.

We need improved warning systems for our citizens. At present, warnings are issued based on data from DMI and they are not of sufficiently high resolution. We need a warning system for our citizens, but it requires better data."
The City of Copenhagen

Challenge 4.
Water Quality

Challenges related to water quality are triggered by new knowledge regarding polluting substances – in combination with the emergence of new techniques for transport and removal of cloud burst precipitation on the surface and in combination with increased focus on recreational use of rivers, lakes and harbour basins. Water quality is a complex topic. At least three sub-challenges are highlighted:

Polluting substances in road water

We would like to infiltrate precipitation locally, for instance through road rain gardens, soak-aways, etc. Do these solutions pose a new risk to our groundwater?

Measurements and analyses of the types and levels of pollutants in road water, roof water, etc. are needed.

The City of Copenhagen, the Municipality of Herlev, Ishøj and Frederiksberg Utilities are among the stakeholders who have mentioned this challenge.

"The community as well as the utility have outlets for receiving waters of road water. We all realise that water is being released and that particles and heavy metals end up somewhere out there. But how we can intercept the pollutants or just measure the amounts, that we do not yet understand."
Ishøj Utility

Health and safety in relation to surface runoff

We are designing our city with precipitation runoff on the surface – partly because we need this in order to be able to cope with the amounts of water during cloud bursts and partly because we can use the water for improving the urban habitats. However, we do not have sufficient knowledge regarding the quality of the surface water that we bring close to people – and that limits our options for designing smart surface water solutions.

We need better and far more data about the quality of the surface water and we need procedures that can protect us from unwanted health and safety risks in relation to surface runoff of precipitation.

The City of Copenhagen and the municipalities of Allerød and Hvidovre are among the stakeholders who have mentioned this challenge.

"We are lacking documentation of the quality of the water when we decouple, e.g. a roof from the collectors… In the community we use a safety-first approach with respect to water quality. If we don't have information about the quality of the water then we cannot allow the water to be released to lakes and rivers. This leads to significantly higher costs for our projects."
The City of Copenhagen

Real-time monitoring of sewer overflows

We are constructing harbour bathing facilities, bathing facilities in rivers, etc., but we have insufficient monitoring data to enable us to assess the quality of the bathing water, e.g. in connection with heavy precipitation.

We need real-time measurements of sewer overflows (quantity and quality) for improved forecasting and for improving our knowledge of the importance of first flush. Are we capable of decreasing/avoiding pollution of sensitive waters through controlling first flush?

The City of Copenhagen and the Municipality of Hvidovre are among the stakeholders who have mentioned this challenge.

"We are lacking measurements of overflows – both quantity and quality – in order to improve our forecasts for the users of the harbour bathing facilities."
The City of Copenhagen

Challenge 5.
Citizen contact

Contact from citizens in relation to water issues is not systematically recorded and, accordingly, is not available for daily operations or for analysis with a view to identifying hotspots. For example, after every rain shower, the sewer inlet at X-road clogs just outside the local supermarket.

The stakeholders indicate a need for an app which citizens could use when reporting a water-related issue. Data from the app should be available real-time to service personnel as well as to citizens and statistics should be available for planning purposes.

The municipalities of Brøndby, Allerød, Glostrup and Tårnby Utility are among the stakeholders who have mentioned this challenge.

"We don't always know where damages occur in connection with cloud bursts or storm surges because we are not generally notified. We see a potential in improving the data collection regarding damages after cloud bursts so that we know where we have had problems with flooded basements or water on the roads. It would be smart if the citizens were able to report problems themselves through an app; and this information could be shared between community, utility and insurance companies."
The Municipality of Brøndby

Challenge 6.

Knowledge regarding existing data

Lack of knowledge means that the value of already available data is underutilised.

The level of knowledge in the cities regarding the available data needs improvement. This applies both to knowledge regarding the actual availability of data as well as knowledge on how these data can be shared between administrative units and used across city departments.

The municipalities of Egedal, Dragør and Hillerød are among the stakeholders who have mentioned this challenge.

"My job is in the Center for Technical and Environmental Administration. Another department is responsible for our IT strategy and GIS data is in a third department. This creates natural barriers when data is located within the different centers."
The Municipality of Egedal

Challenge 7.

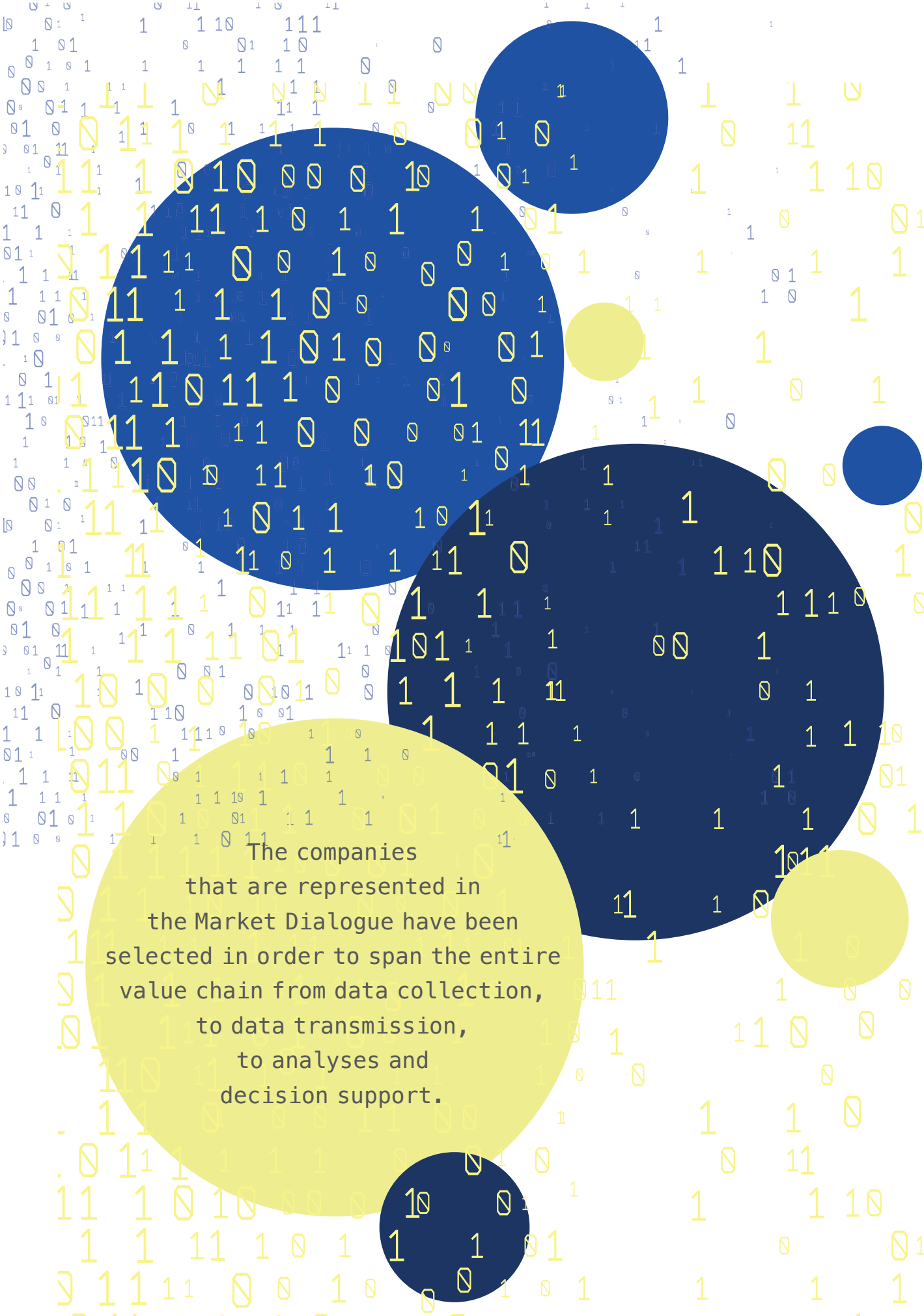
Data for optimising daily operations

Lack of monitoring of water levels in manholes, clogging of gutters, and overloading of sediment traps leads to higher costs of operational procedures and maintenance processes and/or less efficient operations.

More sensors for the monitoring of water levels in manholes and house connections, monitoring of water on the road, and filling of sand traps, etc. are required. In general, many inexpensive, less accurate sensors could provide better value than few expensive more accurate sensors.

The municipalities of Egedal and Herlev, Hillerød Utility, Tårnby Utility and the City of Copenhagen are among the stakeholders who have mentioned this challenge.

"We could definitely use 100 manhole covers equipped with on/off sensors which indicate how often water reaches the service level. It would be a useful supplement to our models and a good way of showing the citizens how often we experience flooding."
Hillerød Utility


The companies
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selected in order to span the entire
value chain from data collection,
to data transmission,
to analyses and
decision support.

Market dialogue

One of the project's primary target groups is companies engaged in the digitalisation of the water sector. Therefore, a market dialogue has been conducted with a representative group of companies to assess the extent to which the private sector is able to meet the challenges of municipalities and utilities.

The market dialogue has been carried out as a series of interviews with companies that have an interest in and the capacity to deliver products and services in the field of digitalisation and information technology.

Based on the interviews with municipalities and utilities, the project team has prepared a long list of companies that actively work with the potential of digitalisation and information technology. There has been a special focus on the involvement of small- and medium-sized enterprises, which are often known to experience difficulties in accessing public partners. A total of 22 companies have been approached, all of which are servicing utilities and municipalities within the water sector.

A few companies declined to participate for various reasons, while others required full anonymity for their participation. The project team has listened to the companies' requests, which is why the results of the market dialogue interviews are fully anonymous.

The companies have been selected in such a way that they cover a representative section within the following sectors:

- Sensors and data collection
- Network, data transmission and data storage
- Business intelligence and professional experts

The companies have been selected in order to span the entire value chain from data collection, to data transmission, to analyses and decision support.

Based on the identified challenges of municipalities and utilities, in the market dialogue with the companies the project team has focused on:

- strategy and ambition level within digital solutions
- Products and services that address one or more of the main challenges of the municipalities and utilities
- Activities and initiatives focus one or more of the main areas in relation to the challenges of the utilities and municipalities
- The need for collaboration partners – now and in the future
- Assessment of the technological matureness in relation to the business model
- Challenges and barriers in relation to the challenges of the municipalities and utilities with regards to:
  - data and data quality
  - choice of technology
  - business model

The dialogue with the companies has resulted in valuable input within the main areas of sensors, data, data transmission and network, as well as asset management.

Sensors

In relation to water supply, the interviews have revealed a need for the development of new technology that can replace traditional sampling methods that are unsuitable in an operational context.

With regards to flow and pressure measurements, much of the technology is already digital, and there is no similarly urgent need for major investments in this area.

Nowadays, in the field of wastewater treatment, the use of intelligent and advanced control of the treatment processes (including biological and chemical processes) is already widespread. Likewise, in the field of sewers, drainage and climate adaptation there is a clear tendency for more extensive use of digital online sensors and observations.

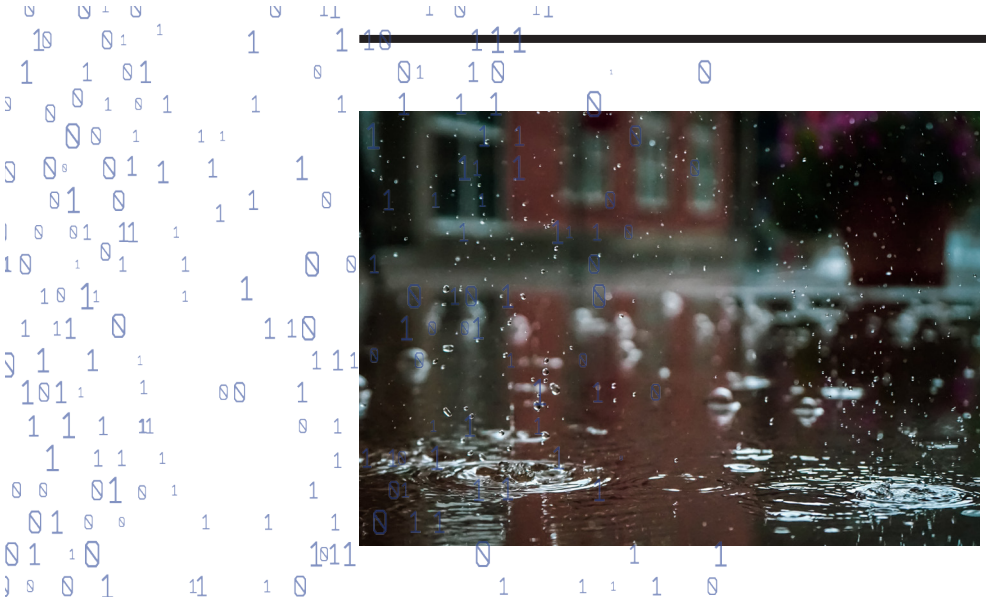
In the sensor technology area, there is an ongoing and continuous development and although there is need for improvements and further developments, the technology is not considered a showstopper for accelerating the digitalisation.

Today, waste water treatment plants are generally well equipped and covered with regards to physical as well as bio- and geochemical parameters, while there is a stronger need for new technology and innovation within measurements of bio-/geochemical parameters in relation to the water supply, drainage and climate adaptation

Table 1

Assessment of the sensor technology area

+	−
Clear trend towards online, digital data collection and transmission The technology is not a showstopper for the use of digital solutions in terms of physical parameters	Need for new technology/innovation in relation to bio-geo-chemical parameters



Data

On the data collection side, the market dialogue indicates a number of areas where there is scope for improvement. These are briefly considered in the overview below.

In particular, smaller companies express a request for broader cooperation and openness in relation to data. There is virtually no exchange of data across utility sectors, which is attributed to the fact that there are still numerous low-hanging fruit to pick within each utility sector, so that the need to exploit data more broadly is not yet high on the agenda.

Many companies also experience some concerns and uncertainties within utilities in relation to storing data outside their own "IT fences".

Table 2

Assessment of the data collection area

+	-
A great deal of data is being collected	Organisations do not always get the optimal benefit out of the data Organisations do not always collect sufficient data (especially spatial coverage) Need for data ecosystem • greater openness and sharing of data • clarification of ownership of data

"There is a great deal of concern with the utilities when it comes to hosting data outside their fences"

Consultant

Data transmission and network

Today, there are already nationwide networks that are successfully used in the water sector for data transmission. Currently, there are limitations on the bandwidth of the data transmission, but these are primarily of a regulatory nature and thus not a technology bottleneck.

At the same time, there is rapid development within 5G network technology, which means that within a few years we will have significantly greater bandwidth for data transmission and communication. This is expected to put an end to today's limitations in data transmission and communication regarding online data collection, which currently restricts online management and control.

However, there may still be regulatory challenges (e.g. GDPR) that limit the use of data for online management and monitoring.

Some companies have expressed a need for an embracing and coherent digitalisation strategy, which ensures a "red thread" in the initiatives undertaken by municipalities and utilities. The overall assessment of the technology in data transmission and networking is presented in Table 3 below.

Table 3

Assessment of the data transmission and network area

+	-
The technology is in place Trend towards online data collection and transmission	Practical challenges in relation to online data collection

"No overall strategy, which means initiatives become sporadic and incoherent"

Network operator

Asset Management

The general conclusion from the market dialogue is that there are already many options available for adopting digital technology and addressing most of the challenges faced by municipalities and utilities.

The question, therefore, is why has the use of digital technology in the water sector not progressed further? The answer to this must – according to the interviewed

companies – be found in a lack of an embracing strategy amongst municipalities and utilities, which means that initiatives often become incoherent and sporadic and not sufficiently anchored in the organisations.

The latter is probably due to insufficient competencies and internal expert knowledge of smaller utilities, in particular. Thus, there are several companies that point toward a need for management assistance and consultancy within the utilities, so that the digitisation strategy is properly anchored in the organisations and turned into roadmaps, which again are to be converted into specific plans and implementation in practice.

Competence-building programmes are considered to be central, because these will not only give the utilities a better professional IT insight but also provide the utilities a sound basis for embracing and implementing digitisation. Thereby, the organisations can more easily maximise their benefits of adopting digital technology, reduce investments and avoid reinvestments while leveraging the digital opportunities. Today, the water market is characterised by a diverse range of players, which in turn means many different technology choices. There may therefore be a need for a dialogue between municipalities and utilities about their needs in relation to common tools, technology, etc.

The market dialogue points to business models as another factor impacting the utilisation of the digital opportunities. Municipalities and utilities often rely on classic and supply-oriented business models, but there is a growing need for new digital business models that take greater account of the cross-cutting benefits of the digitisation.

This also applies to private companies that typically rely on the sale of hours and/or equipment (including hardware/software). In almost all interviewed companies' digital business models are only at a consideration stage.

Table 4

Assessment of the asset management area

+	−
Many excellent tools and technologies which, from an overall perspective, address most of the challenges within municipalities and utilities	The large range of players implies many different solutions in relation to technologies and platforms which can ultimately lead to limitations and less optimal utilisation of the digital potential Need for competence development and professional IT insight with the utilities Need for a dialogue on an overall digitalisation strategy and business models with the utilities

"Many utilities are not dressed internally to think about digitalisation"

Supplier

Summary

The market dialogue with relevant companies has pointed to several areas where improvements are needed if the water sector is to gain the full benefit of digitisation. Specifically, this relates to the need for:

- new technology/innovation within the bio-/geochemical parameters;
- consensus on an IT ecosystem;
- common data policy;
- common technology and interface policies;
- digitalisation strategy that supports the business – from vision to practical implementation;
- competency building in the organisations and introduction of digital business models.

For the companies themselves, there is a real danger of digital disruption in the water sector, because consultants and suppliers who know how to put digital solutions into play in the right manner are expected to outperform or swallow up the others.

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Prioritisation of challenges

More than 100 stakeholders, representing communities, utility companies, public authorities, private consultants and suppliers of equipment for the water industry took part in the concluding conference of the Smart Water project.

The programme included presentations of the interviews with municipalities and utilities as well as a presentation of the market dialogue part of the project further to a number of presentations of specific challenges and solutions within the scope of digitalisation of the water sector.

The conference participants were given a presentation of the 14 challenges identified based on the stakeholder interviews. They were then asked to vote for those challenges that they considered to be the most important. Each participant had four votes which they were allowed to use on 1 to 4 challenges.

The results, in the order from number 1 to number 5 ranked challenges, were as follows:

Challenge 7:	Data for optimising daily operations
Challenge 2b:	Climate adaptation: Catchment area-based prioritisation of solutions
Challenge 6:	Knowledge regarding existing data
Challenge 2a:	Climate adaptation – Controlling the runoff through the catchment area
Challenge 1:	Planning and management of pipe network maintenance

The exercise in general showed good agreement between the priorities of the end-users (communities and utilities) and their suppliers (consultants and equipment suppliers). However, the end-users did rank two areas significantly higher than the suppliers. The two areas did not make the top five in total, but they might nevertheless merit a closer look on a different occasion. These two areas are:

Challenge 4:	Polluting substances in road water
Challenge 2c:	Control and maintenance of LID/SUD solutions

The next section summarises the most important findings from the workshops in terms of barriers identified and recommendations for next steps for the top five challenges.

Barriers and recommended next steps

The afternoon workshop of the Smart Water 2018 conference consisted of nine groups, all discussing barriers and the recommended next steps for the top five ranked challenges.

Each group was assigned a secretary from the Smart Water project team responsible for summarising and verifying the feedback from the group.

The feedback from the nine groups has been collected into one form per challenge. The predominant ideas and comments have been identified and are reported below.

Challenge 7. Data for optimising daily operations

Lack of monitoring of water levels in manholes, clogging of gutters, and overloading of sediment traps leads to higher costs of operational procedures and maintenance processes and/or less efficient operations.

Needs:
More sensors for the monitoring of water levels in manholes and house connections, monitoring of water on the road, and filling of sand traps. In general, numerous inexpensive, less accurate sensors could provide better value than a few expensive, more accurate sensors.

Barriers:
- Are enough sensors available?
- Documentation of the effects is currently lacking
- Conservatism (do we dare invest in something new?)
- Lack of clear responsibilities for innovation. Who will initiate the process?

Next steps:
- Knowledge sharing, forum for experience exchange
- Proof of concept pilot project
- Data must be open – as a starting point for value creation. Digital business models
- We need to analyse one step further in order to identify the data requirements for active control of flows
- We need a "Dogma Manifesto" for data collection and sharing

Challenge 2b: Climate adaptation – Catchment area–based prioritisation of solutions

Insufficient knowledge and technology for the prioritisation of climate-adaptation solutions. This includes methods and tools for catchment-area-based optimisation as well as knowledge regarding the growing range of solution types (e.g. comparing the cost-efficiency of local versus centralised options).

Needs:
Planning tools which can simulate the economic consequences of multiple climate-adaptation options and help the planners prioritise between the available options.

Barriers:
- Methods and tools that would enable cities and utilities to optimise solutions based on evidence are lacking
- Missing knowledge regarding solutions that work – including lack of operational experience for local drainage solutions
- Administrative boundaries create barriers for catchment-area-based planning

Next steps:
- Create specifications for a tool for prioritisation of climate solutions – also including "soft benefits"
- Establish shared hydraulic simulation models for transboundary catchment areas
- Establish an open catalogue of climate-adaptation solutions that solve specific problems
- Create mandatory collaboration agreements on a catchment area level

Challenge 6. Knowledge regarding existing data

Lack of knowledge means that the value of already available data is under-acknowledged.

Needs:
The level of knowledge in the cities regarding the data that is available needs improvement. This applies to both knowledge regarding the actual availability of data as well as knowledge on how this data can be shared between administrative units and used across city departments.

Barriers:
- The organisations do not currently support knowledge and data sharing
- Nobody is responsible for looking at the business opportunities related to the available data. Digital business models are lacking
- Staff collaboration across professional backgrounds is insufficient

Next steps:
- Knowledge sharing: Benchmarking – best practice
- Treat data like valuable assets
- Pilot project on digital business models for cities and utilities

Challenge 2a. Climate adaptation – Controlling the runoff of water through the catchment area

The runoff of water through the catchment area (e.g. during cloud bursts) should be controlled on a catchment area level rather than for separate administrative units. The challenge is, among other things, that investments and the associated economic benefits (e.g. reduced flooding) do not necessarily follow administrative boundaries.

Needs:
Political decisions stating that control must be catchment-area-based and models for sharing of costs and benefits. Tools to support equitable solutions.

Barriers:
- Legal constraints, permissions to look at the big picture
- Administrative structures hinder the necessary decisions on a catchment area level.
- Financial models for shared solutions are lacking
- Management focus on the potential benefits of collaboration is lacking both in communities and utilities

Next steps:
- Initiate a discussion (e.g. managed by the Environment Agency) with a view to creating incentives for collaborative solutions
- Support political initiatives in the direction of creating "Water Boards". In the meantime, establish mandatory collaboration agreements across the existing units
- Shared operation of data and IT tools
- Open data, allowing all to use the data in control systems

Challenge 1. Planning and management of pipe network maintenance

The lifespan of the pipe network is one of the most important factors in relation to the total annual costs of the pipe network. If the service time can be extended, then this will imply large savings for utilities and communities. Savings can also be achieved through improved coordination of the maintenance activities for roads and house connections (in Denmark this is the responsibility of communities) with maintenance of the collectors (the responsibility of the utilities).

Needs:
Improved IT systems (e.g. asset management systems) could lead to improved planning and management of maintenance.

In the long term, the improved data collection could enable more detailed analyses of the remaining service life of pipes – e.g. through combining asset management data with data on traffic and on winter activities for roads.

Barriers:
- Lack of data
- Lack of incentives
- Lack of systems and sensors
- Lack of responsibilities of data owners
- Insufficient management

Next steps:
- Utilities should establish strategies based on a most-value-for-money principle
- Make use of experience from other industries, e.g. railways
- Legislation requiring better documentation of systems and capacities should be promoted
- Proactive management should be tested in a pilot project – needs-driven main tenance

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