Chapter

# Smart Water—How to Master the Future Challenges of Water Management

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## Abstract

Innovative digital developments from industry like autonomous machine controls based on intelligent data acquisition, collection and evaluation, promises better adapting municipal infrastructure systems to changing conditions. When the technology initiative KOMMUNAL 4.0 was developed as an idea in 2015, digitalization was not a central topic in water management. As Industry 4.0 was present everywhere in the media, the idea of transferring suitable parts of the basic idea of Industry 4.0 to municipal water management was born. In particular, it was necessary to implement consistent IT and IoT communication at all levels of water management tasks. The aim was not only to create a uniform structure for networking a wide variety of applications, but also to round off KOMMUNAL 4.0's complete range of services with IoT for existing and newly developed products and solutions. Regardless of whether it concerns measurement and data technology applications, smart machines, SCADA or asset management systems, all application solutions contain a standardized network core that guarantees standard data communication and also complying with safety and cybersecurity requirements.


**Keywords:** digitization, smart water, municipal 4.0

## 1. Introduction

In Germany, approx. 6–7 billion EURO is invested every year in the renovation or new construction of buildings and plant technology in the municipal water and sanitation sector [1]. The German water and wastewater infrastructure has developed socially and spatially balanced in the past and has grown over many decades and guarantees today a comprehensive disposal with high drainage safety combined with an extremely long technical and economic service life. In opposite it results in a lack of operational flexibility for sewer network and sewage plant operators, e.g. in the event of extreme weather events as an effect of climate change, changed consumer behavior or the consequences of demographic change. Experts and decision-makers are therefore looking for ways to adapt the dimensioning and calculation of future investments more closely to real usage requirements and to dispense with previous inaccurate estimates. At the same time, the existing systems must be operated more flexibly and thus more efficiently, even under described changed conditions.

Innovative digital developments from industry like autonomous machine controls based on intelligent data acquisition, collection and evaluation, promises better adapting municipal infrastructure systems to changing conditions. When the technology initiative KOMMUNAL 4.0 was developed as an idea in 2015, digitalization was not a central topic in German water management. As Industry 4.0 was present everywhere at these time the idea of transferring suitable parts of the basic idea of Industry 4.0 to municipal water management was born. In particular, it was necessary to implement consistent IT and IoT communication at all levels of water management tasks (**Figure 1**). The aim was not only to create a uniform structure for networking a wide variety of applications, but also to round off KOMMUNAL 4.0's complete range of services with IoT for existing and newly developed products and solutions. Regardless of whether it concerns measurement and data technology applications, smart machines, SCADA or asset management systems, all application


**Figure 1.**
*Consistent IT and IoT communication of digital products and systems [2] (translation: IT-Sicherheit, Asset Management und Digitalisierung, Betriebsführung, Recht = IT security, asset management and digitization, operations management, law; Fernwirkung, Fernüberwachung = remote control, remote view; Automatisierung, software = automation, software; mess-und Datentechnik = measurement and data technology).*

solutions contain a standardized core that guarantees standard data communication and also complying with safety and cybersecurity requirements.

Another important requirement was (and is) that all applications work as individual and independent solution. This enables the user to go down the path to digitization in individual steps, which are, however, coordinated with each other right from the start. The purchase of a complete system at the beginning of a digital process is not absolutely necessary. The user can start where there is currently the most urgent need at daily work without losing the network compatibility of individual elements that have to be adding later. One of the most important tasks in municipal water management, for example, is an effective and efficient management of the entire infrastructure. Data plays an increasingly important role at this topic. Only where data from different sources can be usefully related to each other real added value can be created. Various IT systems such as GIS, process control (SCADA) or asset and maintenance management systems are used for this purpose in water management. Systems are desirable which, like MS Office, function in both ways as individual solutions and offer high benefits by networking with each other. And just as every printer today communicates perfectly with MS Office smart products, measurement and data technology applications as well as Smart Machines should be integrated in a plug & play manner. Some of the products and solutions belonging to KOMMUNAL 4.0 already offer these requirements already today.

## 2. Industry 4.0—a model for sustainable water management?

The digitization offensive of the industry, known since 2013 in Germany as Industry 4.0 and initiated by the Federal Government, is intended to turn simple machines using the Internet into so-called Smart Machines. These are self-regulating production units (they are also called CPS = Cyber-Physical Systems) which leads to significant cost savings. For example, they are fed with orders directly from commercial databases, receive their technical instructions directly from CAD/EPLAN tools of development engineers, order necessary materials independently from suppliers, coordinate their interdependencies and report the completion of the manufactured products to logistics for dispatch. The entire industrial value chain is recorded in data form, analyzed and controlled or optimized by automatic processes. Can this approach be transferred to the level of water infrastructures as a model?

In water management, the possible applications of intelligent and smart solutions are being intensively discussed and are already being used (see e.g. at [3–6]). Modern automation technology for water management already has elements in its core that need not fear comparison with Industry 4.0 solutions. Real-time-based control or monitoring solutions are just as much in use as numerous intelligent sensor technologies. They form an important basic framework for future digital strategies. In order to obtain innovative and thus sustainable digitization solutions, such automation and IT systems must be extended by suitable analysis and evaluation tools (Big and Smart Data). Only this enables an intelligent networking of several objects with each other.

For the municipal user, the question now arises with whom he can start digitization. There are many specialist providers for individual application solutions, but how will be done a well integration into a future platform solution? Whoever is faced with the procurement of new IT systems, e.g. in the GIS/PLS-SCADA/ERP/BFS areas, that is not an easy task to master. If there is a high degree of network compatibility due to a close technological relationship between the individual solutions (see example MS Office), this facilitates the start incl. a step-by-step development of a complete digitization.

In the fields of municipal water management that are eligible for digitization, there are already a large number of established providers whose solutions in principle include these useful and expected functions. With regard to the basic functions, normal companies are moving forward in small steps. The differences in the functions can be recognized and evaluated more precisely after intensive use. If providers have several applications, there is concern on the user side not to obtain the supposedly best software for every task. If, however, a provider understands the current requirements of networking and has its own development of its product lines, this also has significant, clear advantages for the user compared to the sole availability of a special function. These range from interoperability up to the elimination of un-useful complex parameterizations. The importance of standardized user interfaces and dialogs, administration, data formats, menu navigation, etc., can be seen again when considering the development of the office world. For the KOMMUNAL 4.0 product lines, the overall system selection is based on the aspects of secure investment through technological sustainability as well as networking and usability. In this case, the technology is concerned with the methods, technologies and resources used in product development itself. They are essentially responsibilities for what is working today, in the future and what does not fit. At this point the user must inform himself accordingly early enough in order not to wait too long or also in vain for the necessary adaptations of his (special) provider in the future.

In particular, the currently pending change through digitalization is a good way to orient himself comprehensively and to make new decisions if necessary. If the user succeeds in procuring systems from one platform and possibly from one provider, the networkability and operability of the overall solution will be simplified. The solution should also offer the possibility to integrate already existing software applications. The conversion and renewal of software and its entire technological basis also requires a lot of orientation, strength, competence and investment at the providers side. A changeover from classic client-server software to web systems, for example, also requires new thinking in development. As a result of the high challenges, only small steps or adaptations of the outer shell are often successful but no innovative progress or better results have to be achieved. Fitting usability and an intuitive using of a software can only be determined after several days of practical work. On the other hand users expect more today. They want deep horizontal and vertical networking of the systems, e.g. with asset/maintenance and SCADA systems. This has taken on a new and higher significance and it is the most discussed topic of interfaces or integration capability or networkability of the systems. Synchronization functions, uniform grammar, file formats, reliability and warranty are more and more in focus. Regarding these requirements the KOMMUNAL 4.0 world is already one step ahead and offers compatible web systems for GIS/PLS-SCADA/ERP/BFS tasks as well as integrated measurement and data technology applications and smart machines. The company HST (consortium leader of KOMMUNAL 4.0) for example has converted all its systems to platforms and web technology in recent years and comprehensively networked its systems. The widely used asset/maintenance management system KANiO and the process control system SCADA.web are today highly communicative networkable solutions with open standard interfaces as well as integration and synchronization functions also for third-party systems. Reliability and optimal operability have priority.

An IT-supported ISMS (Information Security Management System) is already available (KANiO-ISMS) for secure compliance with the requirements of the IT German Security Act. It represents an important building block for the individual steps on the way to a legally compliant IT security structure and is available as a separate application and also as a component of the KANiO system. The use of the tool avoids uncoordinated individual measures that do not guarantee sufficiently secure IT operation. In addition, the tool ensures that the company's own efforts to ensure secure IT operation can be proven to customers or legislators. Earlier measures can thus also be better aligned with the current security standard. In addition, almost all process engineering machines of HST are gradually being equipped with sensors and actuators (so-called IntelliSystems) so that SCADA and asset/maintenance management system can be directly networked and collaborated. This means that there are already solutions for integrated IT and IoT communication across all application levels, as shown in **Figure 1**.

## 3. Why does digitization differ from earlier technology developments?

Classical engineering-based research does not fully reflect the comprehensive developments of digitization. With digitization, something very big has happening with increasing speed. It has now also reached the water industry. An analysis of publications, studies and research carried out in the context of KOMMUNAL 4.0 in the field of industry 4.0 has shown that, in addition to technology patterns, other subject areas are important which will also have a serious impact on the water management. This applies, for example, to data sovereignty, data law and public procurement law.

Thanks to the accompanying research of the federal technology program "Smart Service World", in which the KOMMUNAL 4.0 project is embedded, and the associated networking with other Industry 4.0 research networks such as the federal technology program "Smart Data", the project partners in KOMMUNAL 4.0 are able to access the current state of knowledge and expected developments not only at the field of IT security and legal issues. These coming topics, some of which have not even been discussed in the water industry until today, are already the subject of KOMMUNAL 4.0.

Previous technology flows primarily arose from development ideas that were examined in individual objects or tasks. An example of this is the extended elimination of nitrogen in sewage treatment plants. When this aspect was investigated and applied broadly after being anchored in legislation, the effects were limited to the respective sewage treatment plant or the responsible organization. The other departments of a municipality, city or association were not affected. The same can be noticed for example for the so called fourth sewage treatment stage. From this point of view, research institutes and plant operators were able to investigate into such issues independently to get an isolated developed solution. Consequences of a lack of communication between research institutes were not significant due to low need of interdisciplinary interfaces. Although the existing scientific-technical exchange among experts is maintained and also inspires research initiatives, a mutual agreement on the research and development contents was not absolutely necessary for the previous form of technology development.

In opposite to aforementioned situation the appearance of digitization must be judged differently. Since as a cross-sectional technology it has an almost unlimited influence on all technological and organizational environments. At the horizontal level individual objects such as rain basins, flood reservoirs, water treatment plants or sewage treatment plants have to be connected more and more with the entire infrastructure systems across city and municipal boundaries. At the organizational level (vertical level) different departments and organizations have to be linked to each other. In addition, regional and supra-regional administrative and authority units should also be integrated into these networking efforts.

"It also applies to water management that everything that can be digitized has to be digitized". This comment made by Martin Weyand, BDEW Managing Director Water/Wastewater [7] confirms the cognitions of KOMMUNAL 4.0. Previous technological developments in water management have had only a limited impact on organizations and working methods, but in contrast to this, digitalization is expected to bring about massive changes in the everyday working lives of individuals as it unfolds its full potential. Already from individual elements as part of growing complex systems more far-reaching effects are to be expected. This leads to the conclusion that an examination of new digital solutions must be more comprehensive and must go beyond the previous horizon of knowledge and understanding. This is where the holistic approach of KOMMUNAL 4.0 comes in, in which all relevant individual modules and their interaction with each other were taken into account from the very beginning. This approach allows a better assessment of how to deal with digitization, even if it increases the amount of work at the beginning. As a result, it is easier to assess the major consequences of individual solutions and thus enables the foresighted engineering of networked systems. Based on this, current and future products and solutions will be manufactured.

## 4. The KOMMUNAL 4.0 project—a German beacon of digitization

### 4.1 The funded project KOMMUNAL 4.0

The cooperation project KOMMUNAL 4.0, which is funded by the German Federal Ministry of Economic Affairs and Energy, will devote itself in a special way to the challenges described above. Current and expected future developments in the field of Industry 4.0 were examined for applicability in municipal water management. KOMMUNAL 4.0 was selected as one of the 16 winners in a pure industrial competition from 130 applicants [8]. The intended developments for digitization lead to higher efficiency, safety and control in the operation of water management plants and systems and can serve as a model for other infrastructure sectors. The current low adaptability of municipal infrastructures to changing conditions such as heavy rainfall or demographic change can be significantly increased with the help of the IT and organizational solutions from KOMMUNAL 4.0.

The project consortium (see www.kommunal4null.de) under the cooperation management of HST Systemtechnik GmbH & Co. KG strives for the following essential goals:

- Standardization of data acquisition and transmission from heterogeneous CPS (cyberphysical systems).

- Development of a web-based data platform for collection, structuring and conversion of different data/data formats.

- Development of flexible platform architecture for optional use as intranet or internet application.

- Development of application tools in the areas of design/engineering, benchmarking, object/network monitoring, data fusion, procurement, end-to-end process chain and operational optimization.

- Development of required IT security concepts.

- Development of digital business models such as machine sharing.
- Analysis of legal aspects of cloud computing.

The developments focus on modular and step-oriented solutions. It starts with individual intelligent aggregates, so-called smart machines, and lead to the linking of several objects with each other up to a completely networked infrastructure system. Essential objects of the project are so-called pilot projects. Here, the developed application tools were installed at selected municipalities or operators in a real infrastructure environment incl. comprehensively testing.

### 4.2 Association KOMMUNAL 4.0 e.V

In order to maintain the previous ideas and the already established network of experts in the KOMMUNAL 4.0 funding project after the end of the project (31.12.2019), the Federal Association KOMMUNAL 4.0 (www.kommunal4null-ev.de) was founded in 2017. It supports the previous basic and competence transfer of the funding project and will work as a hub for the digitization of municipal infrastructures. It also takes care of central tasks such as public relations for digitization, training and further education, standardization and networking. The association sees itself as a central point of contact for planning and implementing the first steps toward the digitization of municipal infrastructures or for carrying out advanced technological expansions. Even though the current focus is on the municipal water sector due to the proximity to the funding project, all other relevant sectors of municipal infrastructure are to be added in the future.

A central importance for the water sector is the establishment of a KOMMUNAL 4.0 academy. So far, the sector is not be able to offer any application-related further training courses. The Federal Association KOMMUNAL 4.0 will offer a corresponding service which covers the topics IT security, IT systems, operational management, process control engineering as well as measurement and automation engineering. But there will also be application-related offerings, e.g. how digitization can look specifically in water supply or wastewater disposal or in special structures such as pumps, rainwater basins, sewage treatment plants, etc. In addition, there will be special seminars for mayors, heads of offices and planners so that these industry participants can set their very special requirements in relation to the challenges of digitization.

### 4.3 From smart machines to smart infrastructures

Embedded systems have been around for a long time at the water management. The state of the art is that mechanical aggregates are connected to automation technology, which takes over monitoring, control and regulation functions based on various information (mostly from measurement sensors). Automation technology is also used for data acquisition and transmission to higher-level units such as SCADA systems. They form an important part of a complete networking solution (see **Figure 1**).

The stored specifications of a smart machine follow clear assignments and rules, especially for control. Changes to the specifications are made by the operator via set points or directly at the PLC level by a programmer. Data is linked locally by cable. And how do smart machines emerge from this? Thanks to the availability of rapidly increasing web-based application options, the monitoring, control and regulation of actuators no longer needs to be carried out in isolation with locally recorded data and locally used automation technology. For example, additional information such as current precipitation data or status information from a piping system can be transferred from a central database to the local controller via a wireless Internet connection or data line. Based on corresponding algorithms, the controller permanently analyzes the functional environment (in real time) and independently adapts the control specifications (set points) to changing environmental conditions. This is illustrated by the example of a pumping station.

Pumps are designed for an optimal but static operating point based at only one expected operating situation. However, fluctuating water volumes and losses due to unfavorable piping or other operating conditions cause pumps to run outside their selected characteristic curve. This is also due to the fact that, unaware of the actual delivery peaks, corresponding safety surcharges/reserves are provided while dimensioning the pumps. This results in higher energy consumption and less efficiency of the overall system and thus also reduces the service life of the units. Innovative pump controllers (software solutions such as so-called IntelliPump system) permanently evaluate the entire operating situation and, by using frequency control, enable operating sequences that permit several optimum operating points depending on the requirements. This permanently guarantees the intended pumping safety and thus reduces wear and energy consumption of the pump. Another advantage is the continuous monitoring of system operation. This enables faults to be detected more quickly and a better condition assessment of the machine, thus increasing overall operational safety. The formerly simple pump becomes a smart pump system.

In the near future, smart machines will become standard equipment in water management, also as a result of the KOMMUNAL 4.0 project. The connection to web-based data portals, such as the precipitation portal NiRA.web, increases the adaptability and efficiency of individual machines and the system in complete. The virtual connection of the machines with the Internet allows access to all operating data from a central location. Selected operation-relevant data supports local machine control, link systems/objects with each other and ensure efficient operation throughout the entire infrastructure system. An example of this is a sewer network with various rainwater basins, pumping stations and a central connected sewage treatment plant.

The interconnection of the objects, as shown in **Figure 1**, permits an optimal congestion, flushing and operating regime of the entire infrastructure network. A central data evaluation of all structures decides about the right time to empty storm water tank, e.g. to keep sufficient storage capacities free for a next heavy rainfall or flood event, or to make optimum use of capacities or to control the relief events from storm water tanks in the sense of optimum water protection. The more quantitative and qualitative data are available for each structure/object, the better and more efficiently each individual machine, each object and also the entire infrastructure system can be operated. Similar applications, e.g. the intelligent basin cleaning system IntelliGrid, the self-regulating occupancy control system IntelliScreen for increasing the material retention in horizontal bar screens or the EMA flow rate recording system at rainwater overflows, are increasingly being used in water management. In the course of the KOMMUNAL 4.0 project, the prerequisites are now being created for networking individual applications across buildings in order to create a genuine, smart infrastructure.

## 5. Where to start? Start digitizing correctly!

If, for example, current new installations of technical equipment are due, this can be the ideal start of digitization on the basis of individual measures. At this stage, it should be examined whether it makes sense to design the new technical equipment as a so-called smart machine or as a smart system. If digitization is started with a smart local solution, it must be ensured that this solution is also future-compatible with larger networking solutions, such as the KOMMUNAL 4.0 platform. A municipality benefits from this kind of digitization very early, for example by installing a smart machine. This is a comparatively simple way of approaching the complexity of digitization.

Smart machines and solutions based on the Intelli principle work autonomously with the full advantages of digitization and can therefore be easily integrated into a higher-level networking system at a later point in time, even if an overall digital strategy for the municipality has not yet been defined. **Figure 1** shows the systematics of networked products that are already prepared for a platform connection and cover almost the entire range of applications on a horizontal and vertical level. The same applies to upcoming new acquisitions of software solutions in the areas of asset/maintenance management systems and SCADA. The compatibility to the (smart) machine world has to be checked. The necessary knowledge can be acquired by the KOMMUNAL 4.0 experts.

The example of the selection of a computer system on a relief threshold of a sewer system will illustrate how smart systems as described can be applied. Increasingly, screening systems are being used on discharge thresholds to reduce the amount of dirt discharged into water bodies during discharge events. Conventional systems automatically clean the screen bars at fixed intervals. The focus here is on ensuring the hydraulic capacity, regardless of whether the current operating condition requires this or not. Smart rakes equipped, for example, with the IntelliScreen system (see Smart Machines IoT level in **Figure 1**) use networked information from local machine, operating data, webcam data and precipitation data from data portals (see Measurement and Data Technology level in **Figure 1**) to achieve greater operational safety and water protection.

While overflow screens have been cleaned by continuous comb and/or clearing devices up to now, screens equipped with Intelli systems have the advantage of recognizing their current and prognostic screenings. In addition, speed-controlled drives enable variable combing and clearing speeds and extended power reserves. Networking and the inclusion of precipitation data enables an even more accurate prognosis of the operating process and the combing and clearing requirements. On the basis of this expanded and improved information situation, the filter effect of the screenings is now used more intensively and for longer in terms of water protection on the one hand. On the other hand, in the case of heavy rainfall and overflow requirements, the spatial performance and thus the relief safety is increased. The machine works locally by integrating digital precipitation data from a web portal. In further steps, the machines are connected to a process control system (see level Telecontrol or remote monitoring technology in **Figure 1**) or integrated into an asset/maintenance management system for the organization of the necessary maintenance and repair work, in which the documentation requirements of the IT Security Act are also fulfilled by using an ISMS system (see IT Security, Asset Management and Digitization, Operations Management, Law in **Figure 1**).

The integration of the various system modules as shown in **Figure 2** into a data and service platform (e.g. KOMMUNAL 4.0) optimize the technical side of digitization. All data streams flow together at this platform and can be processed for further analyses and purposes such as Big and Smart Data or for operational support with a user-specified dashboard (see **Figure 3**). The system in **Figure 1** can also be used in the form of a process template to derive the necessary organizational measures from the technical elements.

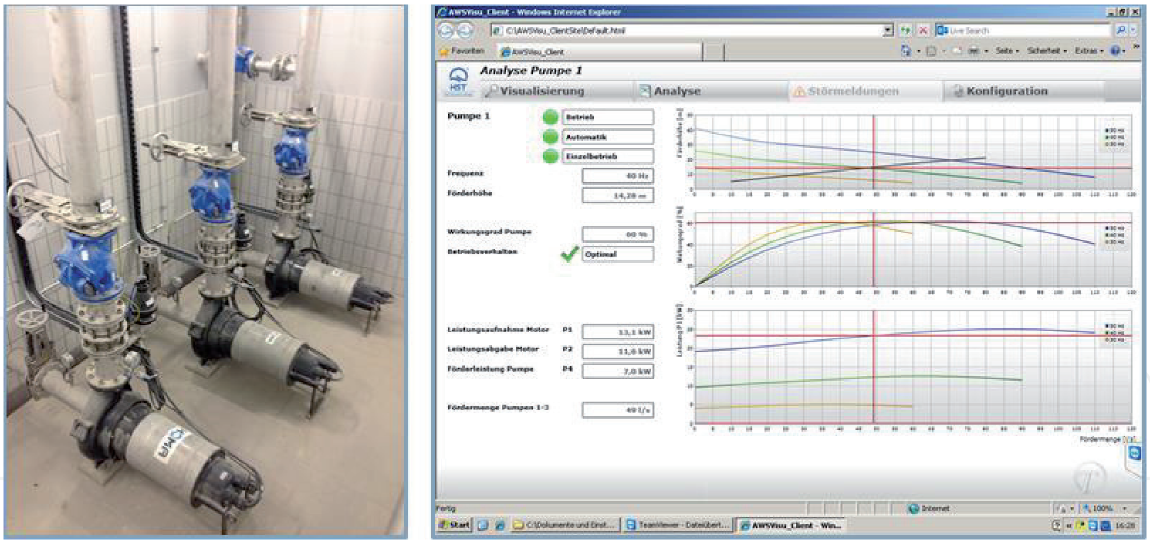


**Figure 2.**
*Increase pump efficiency with IntellPump software [4] (screenshot shows real pump characteristic curve and its adaptation by software to ideal curve).*


**Figure 3.**
*Dashboard KOMMUNAL 4.0 [9] (screenshot shows example for a KOMMUNAL 4.0—cockpit = cockpit of a smart city. It shows different data monitoring systems of water facilities that includes energy consumptions, water level, traffic, dust, alarm events incl. local weather data).*

## 5.1 Start with "anyway" projects

Even it is often propagated that the development of a comprehensive digital strategy is needed to start digitization, it is often better to start digitalization at a concrete and manageable practical case. Also at the beginning of KOMMUNAL 4.0, the planned application ideas were very strongly described from the perspective of an abstract digitization vision. Addressed municipal users (rightly) hardly understood these ideas and could not transfer them to their own application needs. More and more the communication of the project goals and the first results were changed to take the needs of the municipalities in clear focus. With this strategy suitable digitalization ideas could be discussed and subsequently projected. The most important result to achieve an ideal start was using a current and manageable investment project as an introduction to digitalization [10]. For this purpose, the project partners carried out an analysis of a possible "Anyway" project (investment project, which has already been determined for implementation) and examined how a KOMMUNAL 4.0 solution would serve the respective project objective. In many cases, individual measures have to be filtered out from these "Anyway" projects, in which digitization could be tested to a manageable extent. If the use of the selected digitization measures were reached, the ideas were transferred to the further measures of the "Anyway" projects or would be taken into account in future projects. One example is the above-mentioned development of standardized switchgear for digitized physical precipitation recording. In this pilot project a KOMMUNAL 4.0 idea was tested at 10 physical precipitation measuring stations. If the test run would be successful, the digitization technology of KOMMUNAL 4.0 will also be used in more than 200 measuring stations. The feasibility of more than 40 application development was checked at the project KOMMUNAL 4.0. Also corresponding application concepts and business model possibilities were examined. 20 ideas could be developed up to implementation maturity, half of which were put into practice and tested. The other half of ideas will be implemented outside of the KOMMUNAL 4.0 project starting in 2020 with the exception of four cases. This corresponds to an implementation rate of 80%. This high rate was only possible because almost all pilot projects were based on "Anyway" projects of the communal partners. Three exemplary applications are presented below.

### 5.2 Predicting the flooding of gullies

An exemplary example of a KOMMUNAL 4.0 pilot project is the so called "sinkbox management". It was developed and tested as one of the first ideas in close coordination with the municipal partner. All sinkbox data were already stored in the HST asset/maintenance system KANiO before the project starts. However, at the beginning it was not possible on the basis of the existing data to estimate which sink boxes were under the risk of flooding during a rainfall event, so an effective preventive maintenance with regard to future heavy rainfall event was not possible. This had to be changed by the joint project.

On the basis of 10 assessment criteria developed in cooperation with the operating people (**Figure 4**), a hazard matrix was developed that could be individually created for each sink box. The matrix was integrated into the KANiO software by connecting KOMMUNAL 4.0 platform elements. By linking the KANiO software to KOMMUNAL 4.0 platform and precipitation portal NiRA.web, an automatic data comparison of precipitation forecasts for selected urban areas with the data of the hazard matrix is now carried out. If, for example, a defined rainfall event is forecast for the selected period (e.g. >15 $l/mm^2$ in the next 24 hours), the data of the hazard matrix is compared with the precipitation forecast of NiRA.web and those sink boxes are identified which are most at risk. The system automatically generates a work order for the endangered sink boxes so that the affected sink boxes can be emptied and cleaned as a precaution.

### 5.3 Wastewater flexibility "Diemelsee 4.0"

The municipality of Diemelsee in the district of Waldeck-Frankenberg/Germany is currently constructing a new biological wastewater treatment plant by using the SBR process in the holiday resort of Heringhausen. With its 400 inhabitants, the

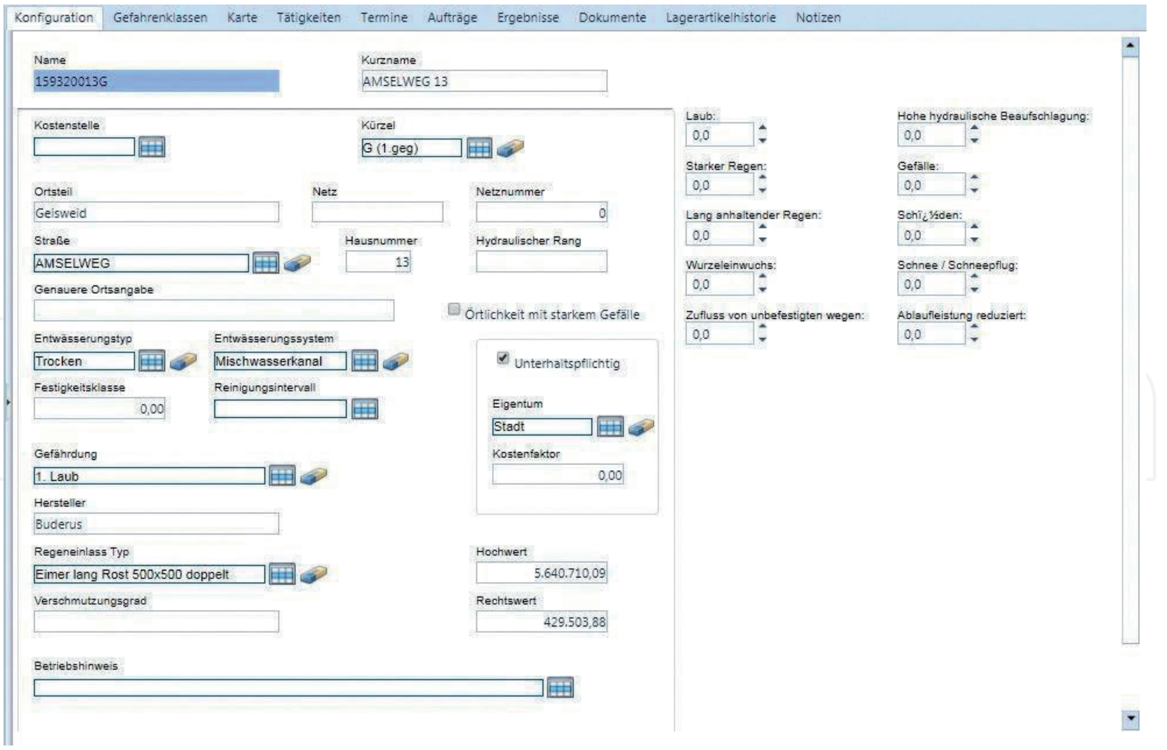


**Figure 4.**
*Input screen sink box management (screenshot shows the input screen for one sink box with different influencing criteria like e.g. heavy rain, leaves, high hydraulic flow, street gradient, root ingrowth snow, flow from dirt roads, drainage capacity; also geodetic and type date).*

town has an estimated 4000 overnight guests and 1000 day visitors in the summer months. The large number of guests leads to an extremely fluctuating amount of wastewater monthly and daily. With the help of KOMMUNAL 4.0, the idea was developed to equip the infrastructure with digital control technology to increase the flexibility and efficiency of the sewage treatment plant and the sewer network. The idea was modeled on the pilot project "Digital Sewage Plant Söllingen", which has already been reported on in detail elsewhere [11]. The wastewater treatment plant and the associated sewer network will be equipped with KOMMUNAL 4.0 control technology elements and networked with precipitation forecasts and tourism data. An additional innovative data analysis for the optimal coupling of the wastewater treatment plant with pressure pipes, pump stations, rainwater retention basins (which are connected upstream of the wastewater treatment plant), for the absorption of hydraulic peak loads and inlet fluctuations into the new SBR plant to be built and the associated sewer network are part of the project. A core element of the project is the Case-Based Reasoning (CBR) approach, which is a kind of artificial intelligence that learns from experience from previous events and derives improvements from it.

### 5.4 Practice-integrated learning ensures effective knowledge transfer

To ensure that even small measures from the "Anyway" projects are suitable as a start into digitization, a high level of learning and transmission success should be ensured. For this reason, KOMMUNAL 4.0 tested two further developments in practice in addition to the technical pilot projects. On the one hand it is about securing the knowledge of older employees and on the other hand it is about the question how planning, variant consideration, implementation and learning can be integrative and agilely interlinked in a common project execution. In view of the increase in municipal tasks and the simultaneous shortage of personnel and skilled workers, there is a lack of human resources to try out new developments as complementary projects. In the course of KOMMUNAL 4.0, the new methodology HELIP (Highly Efficient Learning in Projects/Processes) was developed in order to meet this challenge effectively. On the basis of current research results on learning and transfer research as well as from project management, measures such as the pilot projects presented are suitable for starting practical digitization at an early stage, even if many digitization topics still need to be learned [12]. The HELIP concept is based on a 360° reflection of the tasks and necessary learning content at the beginning of the planning phase. It assigns the necessary knowledge transfer of new contents to individual organizational contexts and the task of the respective municipality/department/division and integrates them into selected "Anything" projects. The appropriate practice-related task packages are also adapted to the further decisions and planning steps of the overall process. This ensures that the learning outcomes of smaller "Anyway" projects are optimally transferable to larger digitization projects. Learning takes place in everyday working life and is not separated from practice in remote seminars or training courses. The separation of planning/implementation and further training, which has been customary up to now, is thus abolished. In addition, HELIP supports the effective implementation of the Sustainable Development Goals No. 4, 6, 8, 11 and 13 of the United Nations and can be further developed as a basic principle for management and education in projects to achieve the goals No. 7, 9, 12, 14 and 15.

## 6. KOMMUNAL 4.0 ensures that infrastructures retain their value in the future

Many small and medium-sized communities are faced with the challenge of reliably planning for the future in terms of maintaining and expanding their infrastructure in view of the consequences of demographic change. It is not unusual for the largest infrastructure assets to be hidden underground. Up to 70% of this can be accounted for by the sewer system with its special structures and sewage treatment plants [13]. Sufficient and reliable data is required to achieve optimum investment planning. Decisions, based on inaccurate assumptions and estimates, must be reduced to a minimum in the future. A major role is playing a value-preserving operation of existing plants and objects, e.g. through efficient control solutions or cost-saving condition monitoring.

The basis for intelligent data management and the control and operation management is meaningful data acquisition and evaluation. This requires modern IT structures that can be used both locally and as web-based solutions. KOMMUNAL 4.0 pursues this premise and takes care of a fully comprehensive data and IT structure. This starts locally at the machines (CPS), networks the objects with each other and aims at a networked analysis and management of entire infrastructures via the web-based data and service platform. This will create a basic structure that is not limited to applications in water management alone, but will also be suitable for use in other infrastructure sectors. The start into digitization can be made from an overall strategic perspective by setting up a central data and service platform, but also on the basis of software-related or machine-related individual solutions. It must be ensured that all required individual components (see **Figure 1**) can be networked and thus integrated into the intended overall system.

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## References

[1] UBA. Wasserwirtschaft in Deutschland, Wasserversorgung und Abwasserbeseitigung, Stand April 2014, Zahlen für. 2010

[2] Bildquelle. Bundesverband KOMMUNAL 4.0 e.V.

[3] Uwe Frigger, Günter Müller-Czygan, Tobias Wiese. Sichere Vor-Ort-Anlagenbedienung mit mobilen Geräten, Automation Blue 2. 2017

[4] Günter Fehr, Günter Müller-Czygan, Die Digitale Kläranlage Söllingen—Pilotprojekt in KOMMUNAL 4.0, Automation Blue 4. 2017

[5] Günter Müller-Czygan, Andreas Stolz, Digitalisierung von Entlastungsschwellen, Automation Blue 1. 2018

[6] Christopher Becker, Günter Müller-Czygan, Mit smarten Maschinen in die digitale Wasserwirtschaft starten, Wasser und Abfall 9/2016

[7] EUWIDD-Interview mit Martin Weyand (BDEW) in: EUWID Wasser und Abwasser 3. 2018

[8] Available from: http://www.bmwi.de/DE/Presse/pressemitteilungen,did=720380.html

[9] Bildquelle: HST Systemtechnik GmbH & Co. KG

[10] Becker C, Müller-Czygan G. Mit smarten Maschinen in die digitale Wasserwirtschaft starten. In: Springer Vieweg, Wasser und Abfall, 9/2016. 2016

[11] Fehr G, Müller-Czygan G. Die "Digitale Kläranlage Söllingen" – Pilotprojekt in KOMMUNAL 4.0. In: Vulkan-Verlag GmbH, Automation Blue, 4-2017. 2017

[12] Müller-Czygan G.. "Empirische Untersuchung zur Bedeutung von Lerntransfer-und Umsetzungsfaktoren im Digitalisierungsvorhaben "KOMMUNAL 4.0" unter besonderer Beachtung der Wechselwirkungen von Technik und Veränderungsmanagement" (Master Thesis business psychology at FOM Hochschule für Oekonomie & Management Münster). 2018

[13] Stefan Hattenbach. Markus Vogel "Das verborgene Vermögen der Kommunen: Entwicklung einer Strategie zum Werterhalt in einer Dorfgemeinde", Tagungsband DWA Landesverbandstagung. 2015