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# ROADMAP DRINKING WATER DISTRIBUTION: AN INVENTORY OF THE CHALLENGES OF THE DUTCH WATER COMPANIES AND RESEARCH NEEDS TOWARDS A FUTURE PROOF WATER SUPPLY

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## Abstract

New developments bring challenges for the water sector. While the world quickly changes, the distribution network is relatively inert and can only slowly change. The drinking water companies in the Netherlands perform a joined research program (BTO, BedrijfsTak Onderzoek) to the impact of rapid world changes to the drinking water supply and prepare measures to cope with this. In 2020 broad expert panels of all drinking water utilities participating in the BTO discussed their expected and desired future developments, ultimately leading to a new roadmap for distribution research for the period till 2050. This roadmap is the backbone for the new research period for the BTO and simultaneously serves as a reflection on the present research program. The most important societal challenges in which Dutch drinking water companies want to invest are found in in (a) cooperation in the underground, (b) customer satisfaction, (c) water quantity and quality and (d) future-proofing of the distribution network. For the research program this indicates that knowledge needs to be expanded in three directions: (1) water quality and temperature of the drinking water in the distribution network, (2) justified decisions on maintenance and replacements and (3) transition toward strategic network design.

**Keywords**
Water quality, asset management, research programming.

## 1 A STRUCTURAL APPROACH TO CHALLENGES FOR SAFE AND HEALTHY DRINKING WATER SUPPLY: THE BTO (*B*EDRIJFS*T*AK *O*NDERZOEK) RESEARCH PROGRAM

Social developments change the use of public space in short time and in new directions. Energy transition, artificial intelligence, urbanisation, climate change ICT- developments that generate massive amounts of data to mention a few of the drivers. The impact of these drivers on public drinking water supply will be substantial. There is a need to develop knowledge to analyse the possible impact and to develop a strategy to answer to these challenges and remain the high level of drinking water supply in the Netherlands.

The publicly owned Dutch drinking water companies jointly formulate six-year research plans to develop knowledge that is needed. KWR Water Research Institute facilitates the formulation of the research plans and is responsible for execution of these plans. Partly in own research and partly in close cooperation with scientific institutions as universities, laboratories, start-ups, private companies and international research institutes.

KWR is owned by the ten Dutch public water companies and as such is a not-for-profit, independent research institute serving to the best interest of the Dutch drinking water companies.

The funding for the BTO program is a solid base to develop universal knowledge that is tailored and implemented to the needs of individual companies/shareholders and further developed and challenged within an international arena of scientific and commercial stakeholders.

This structural approach to the challenges in the form of the joint research program BTO for basic knowledge in combination with the tailored company-wide implementation leads to a high performance public drinking water supply. The annually published statistics on the performance (the VEWIN factsheet) show the core figures: chlorine free drinking water supplied with non-revenue water of 3-5%, failure rate of 0.05 per km per year to an average tariff of €1.31/$m^3$ based on full cost recovery (figures 2020).

The BTO has six year cycle in which the headlines for research are established. On a yearly base the results of research are communicated and evaluated to and with the water companies. If needed topics are adjusted or changed gradually, keeping in mind the headlines.

In this paper the process and results of the preparation for the new cycle for the topic of distribution of chlorine free drinking water are described. The result is the Roadmap Distribution 2050.

## 2 THE PROCESS: WORKSHOPS WITH WATER COMPANIES

To develop the Roadmap 2050 while a pandemic is going on was a challenge in itself. As general set up we have chosen for a series of workshops with individual water companies in the period March-December 2020. The first workshop was on the 3rd of March and turned out to be the only 'old-fashioned' non-digital one and started from a common base. Each following workshop was updated with information of the previous one following a 'itterative concept'. Eventually, all retrieved visions and expectations on the development of the drinking water sector in the Netherlands were brought together in a final workshop on December 16, with all the pro's and con's of a massive digital workshop.

In 2008 the first roadmap for distribution research was set up, in which the planning period was 5 years (Vloerberg 2008). In 2017 the research plan for the guiding committee for the Distribution research was set up in close collaboration with a group of experts, the so-called Quartermasters. This plan looked 6 years ahead (Blokker, 2017). During the research periods in 2010/2011 various initiatives were undertaken to understand what is needed to get to the core of "operational excellence" and what research is needed to get there. Various policy relevant drivers were taken into account such as lowest (societal) costs, best performance, adaptivity, transparency towards end user, etc (see also Blokker et al. 2015).

For the present series of workshops we used several theories to develop future visions, some brought in by the water company, some developed by KWR, resulting in the universal core set up for the workshops. With each specific water company the approach was tailored to the developments within the company towards strategic approach of future scenario's. With one company the workshop was based on their own vision towards 2040, another workshop concentrated on four future scenario's based on urban/societal development. In several workshops we worked with thematic scenario's (drought, foreseeable future, pandemic, energy transition, etc). Each new workshop was adapted to the results of the previous one, resulting in the snowball effect and a maturing insight.

The horizon for the roadmap was set at 2050 as a suitable date. In that year society plans to be 'climate adaptive', 'energy neutral' and natural gas as energy source is banned and replaced with solar and wind energy. Basic question is "How can we see to it that in 2050 the drinking water network is equipped for task in line with contemporary societal expectations?"

## 3 THE RESULTS OF THE WORKSHOPS

Most of the participants in the workshops had a technical background in the distribution of drinking water. In total over 80 people participated in 10 workshops, including the Belgian Watergroep as 'foreign' participant in the BTO (one of workshops was a combination of two companies; one of the benefits of digital working) in which a good mix could be found of researchers and scientists as well as practical operators. All being well familiar with distribution issues, sometimes discussions went very in depth on technical impact and consequences of various developments. But thanks to the broad set up, also the societal and other aspects were contemplated.

The closing workshop in December 2020 was visited by 59 participants. The results of the company workshops and the earlier roadmaps were consolidated into a number of statements that could be confirmed or denied, followed by lively discussion. This technique enforces clear statements on how to formulate the outcome of the very elaborate discussions. It also channels the conclusions into clear and comprehensive outcomes.

The first set of outcomes make clear in what topics water companies are prepared to invest:

a) cooperation in the underground or urban subsurface space;

b) customer satisfaction;

c) water quantity and quality;

d) future-proofing of the distribution network;

This results into research need in three directions:

- water quality and temperature of the drinking water in the distribution network;
- justified decisions on maintenance and replacements;
- transition toward strategic network design.

Not surprisingly this highly coincides with the outcomes of the earlier outcomes for the period 2018-2023 that resulted in three research directions: Decision making on maintenance and replacements networks; Design of futureproof networks and Ensuring good water quality in the network.

This shows the complexity of the topics mentioned and the validity of the results already obtained in the various research projects conducted in the period 2018-2023.

The Roadmap Distribution 2050 is schematically draw in Figure 1

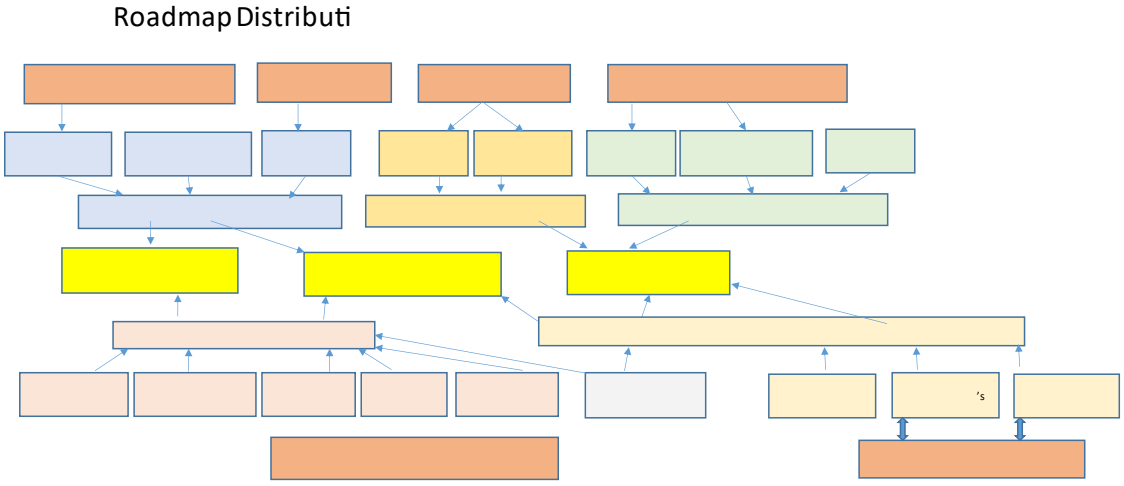


*Figure 1 Distribution Roadmap 2050*

The yellow boxes in the centre form the projected outcome: knowledge to be used for achieving the main goals. The brown boxes at the top and bottom of the roadmap give the models that were developed within earlier research programs. Compared to the earlier roadmap these modes are not new, but are entering in a new phase. All the other boxes give the developments that need to be clarified and quantified and can be translated into research projects.

# 4 RESEARCH PROGRAM AND COLLABORATION WITH STAKEHOLDERS; OBSERVATIONS AND RECCOMANDATIONS

Relevant research in drinking water networks can only be done in very close cooperation with water companies. Modelling has proven to be a very strong method to do research in a network and calculate effects of many scenario's. Useful data needed as input for the models for verification and validation can be obtained when researchers and technicians of the water companies work closely together . Only than reliable simulations can be made and scenario's calculated or optimisations performed.

In the intensive series of workshops several effects are reached. During the presentations it became clear that even despite the numerous meetings and dissemination activities in the past it takes more time to adapt to new knowledge on a broad level in companies. A lot of the research questions and topics raised in the workshops were already dealt with in theoretical studies and reported on. This brings to mind the statement "the power of education is repetition" but also that there is still a gap to be bridged to bring the theory to the day to day practice. This implies an obligation of both the water company as the researchers.

Data on all aspects of the drinking water distribution are needed for the research. Though much is expected from sensors and sensor networks, most relevant data must be generated 'in the field'. This identifies the need for a culture change at water companies. The culture of water companies is to measure performance in quantities: km pipe constructed, cubic metres water produced, continuity of supply, etc. In such a culture a failure is almost an insult that needs to be corrected as soon as possible, also encouraged by performance indicators on continuity of supply. However, a lot of information can be gathered by carefully observing the failure in it's circumstances, salvage of the material and thorough analysis of that. This demands for a culture in which the analysis of events and safeguarding data is at least equally important as rapid repair and re-instalment of the supply service.

Together with this culture change on the relevance of careful data capturing in conventional operation (next to the promising sensor data on water quality) pilots and demonstrators should be part of the research process. In a 'true pilot', technology or concepts proved in laboratories, bench scale testing or modelling are applied in practice to see if they are scalable and still effective. Only in a 'demonstrator' the scalable technology is tested for factors that are essential for a commercial application. In the BTO- research 'true pilots' are often confused with demonstrators and it is highly recommended to align the goals and expectations before starting a pilot or demonstrators and communicate consequently with respect to these goals and expectations.

With increasing possibilities of modelling and optimisation in combination with a rapid growing knowledge base and data availability, the fundamentals of drinking water distribution came up as a topic in the workshops: What is resilience, robustness, continuity, capacity, accessibility, maintainability, sensor usage, interaction with environment, societal costs, stewardship, etc. These discussion require a broad interaction with all (technical) aspects of drinking water supply system with the societal wishes and demands. Especially this is interesting and involves a lot of new skills and knowledge.

## 5 REFLECTION

Direct, non intended, result of this series of workshops is a broadening of the knowledge of the results of previous research within all the drinking water companies. Also the realisation that implementation needs constant attention and care. Very helpful in this has been the overview of 20 years of research on distribution, and the robust approach on main lines. All the research fitted within the three main topics both identified in this roadmap as in the previous research roadmaps and plans. The development is consistent and logical and gives confidence that this are the most important topics.

The clusters of knowledge needs and questions are sharpened from a practical perspective. It gives a better insight in the coherence with external factors and stakeholders and results in more explicit wording of the various approaches and steps that are needed. Effectively, the overarching questions on which the new research program will focus are:

- On the field of temperature and residence time: what is the microbiological risk of high temperature in the network, given the existing (spread in) residence times; how can these risks be contained; what role is played by the house installation.
- On the field of collaboration in the underground (with other 'inhabitants'): How can partners in the underground align their replacement or construction plans to optimise the societal benefit; how do we get specific knowledge on our networks enabling us to make well contemplated decisions on maintenance and replacement.
- On the field of design of networks for the future: which goals do we formulate for the future networks and what are the drivers for networks design for the next 100 years? Which network structures will help us realise these goals? Which measuring technologies and which models need to become 'parts of the network' to help realising these goals.

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