Contact:
Miranda Pieron
mpieron@uvw.nl

INTRODUCTION: DUTCH WATER AUTHORITIES

Corporate movie on YouTube: https://youtu.be/L0n4XdSod8g

WATER MANAGEMENT IN THE NETHERLANDS

More than 17 million people live in this country that lies within a delta of four major international catchment areas: The Meuse, The Ems, The Rhine and The Scheldt. Without proper water management 60% of the Netherlands will be flooded. Some areas of the Netherlands are 6 meters below sea level. No need saying that good water management is essential.

Disasters from the past

The flood disaster of 1 February 1953 (Watersnoodramp) was the latest disaster in the Netherlands in which people died and substantive material damage was done. The combination of high water on the North Sea and a severe North Western tempest worked out as a deathly cocktail. More than 3.000 houses were destroyed and 43.000 were seriously damaged. 72.000 people had to be evacuated. The total material damage was assessed at € 450 to € 650 million in the currency of that time. The repair costs were estimated at approximately € 450 million.

Struggles of the present

The United Nations reported that the Netherlands is potentially the most dangerous place in Europe to live. The country faced some serious floods in the past and it faces ongoing struggles. But through centuries of good water management, the Dutch actually live in the safest delta in the world. The OECD qualified Dutch water management as a 'global reference'.

But the work is never done and Dutch Water Authorities continues learning. With the recent challenges of climate change water management is more necessary than ever before and Dutch Water Authorities is seeking for creative solutions worldwide. In 2009 and 2013 our water systems could not process the enormous amounts of rain with flooding and damage as consequences. In a country with many big cities consisting of merely concrete and stone, greening of the cities is for example necessary to make our cities more climate resilient.

PLACE IN THE DEMOCRATIC STRUCTURE OF THE NETHERLANDS

The Dutch water authority model has its origins in the 13th century, meaning that regional water authorities have been in existence for about 800 years. This makes them the oldest form of democratic government in the Netherlands. Each regional water authority is run by a board that is elected by the inhabitants every 4 years.

Regional water authorities are legally embedded in the overall democratic structure of the Netherlands. They are therefore empowered to collect taxes, which totalled 2.7 billion euros in 2016. This equals 8% of the total tax burden in the Netherlands. An average Dutch family owning a house worth 200.000 euros pays an average of 315 euros per year for regional water management.

THE MAIN TASKS OF THE DUTCH WATER AUTHORITIES

The Dutch regional water authorities are responsible for flood protection, regional water management, water quantity management and treatment of urban wastewater. Water management therefore involves much more than building dykes and windmills.

In the Netherlands approximately 11.000 employees work 24/7 to keep the feet of the Dutch inhabitants dry and to make sure they are supplied with clean and safe water. For a small country we have an enormous amount of flood defences: a total length of 3.600 kilometres. 3.700 pumping stations make sure the water level stays adequate and 360 wastewater treatment plants purify almost 2 billion cubic meters on wastewater on a yearly basis.

Flood protection

The flood defences in the Netherlands are regularly tested and are always adapted to new standards. Our ministry of Infrastructure and Water makes sure there is always substantial budget for the reinforcement of our dikes and other flood defences. We work together with many governmental organisations and business partners to ensure our dikes are built to protect the inhabitants of the Netherlands from floods until 2050.

Water quantity management

Together with different stakeholders in an area we decide which water level is the most adequate. Which interests weigh the heaviest? Agricultural interests, touristic interests or environmental interests? In water level plans we make decisions for the long-term in which every stakeholder has its stay. With longer periods of drought and more heavy rainfalls water quantity management is more challenging than ever before. Through innovative solutions and an open attitude towards new ideas and technologies, we are equipping ourselves to face these challenges in order to make sure there is always enough water available.

Wastewater treatment and clean water

With 360 wastewater treatment plants we cover 99% of the sewage treatment in the Netherlands. 99,9% of the urban wastewater is purified through these treatment plants. In the Netherlands the municipalities are responsible for the sewerage. So we intensively work together to make sure the Dutch surface water is clean and healthy. We also stimulate the health of our water through environmental measurements. We increase the biodiversity in our weirs, canals and ditches. For example by making the migration routes of fish obstacle free.

Not a responsibility of the water authorities: drinking water supply and sewer system

Production of drinking water is not among the responsibilities of the Dutch water authorities. Drinking water is produced by ten drinking water companies. Their shareholders are municipal and provincial authorities in their supply area. Consumers pay for their drinking water per cubic metre. In the Netherlands we consume on average 119 litres of drinking water per person every day. We drink only about 1 litre of this, and use the rest to shower, wash or do the washing up. Drinking water is produced by extracting groundwater or surface water, purifying it and getting it to our tap via a water distribution network. (Source: http://www.vewin.nl/english/)

Used water disappears down the drain into the sewer system and must then be cleaned. Municipalities organise the collection and removal of our wastewater via the sewer system, after which the water authorities are responsible for wastewater treatment. Municipalities also play a pivotal role in urban water management. Water is playing an increasingly important role in the physical configuration of areas. Good coordination between water and spatial planning is essential to avoid water management problems such as groundwater levels that are either too high or too low.

DUTCH WATER AUTHORITIES: WHAT DO WE HAVE TO OFFER?

Dutch Water Authorities is an **expert on flood defence, water quantity and water quality**.

Abroad, Dutch Water Authorities usually builds a **partnership with organisations for regional water governance**. The aim is to be a sparring partner; reciprocity and respect for each other's context is key.

The exchange with the international partner organisation focusses on **elements of good water management**. Such as financing, technique & innovation, organisation strategy, long term maintenance, monitoring & evaluation, regulation & enforcement and planning.

Dutch Water Authorities offers a long tradition of regional water management. Characteristics are: the principle of interest- pay- say, good water governance, hands on mentality, institutional involvement, integrated approach and a long term perspective.

Dutch Water Authorities **shares knowledge, experiences and staff** offering **working methods** such as coaching, workshops, linking organisations, provide inspiration and learning by doing.

WASTEWATER TREATMENT CHALLENGES AND SOLUTIONS: A DUTCH PERSPECTIVE FROM HISTORY TO THE FUTURE

SITUATION BEFORE 1970

The water quality in the Netherlands in the '60s of the last century was very poor, due to increasing population, good quality supply of drinking water, construction of sewers for improving public health, and increasing untreated industrial discharges. The water smelled, the water was without any oxygen, the water foamed. Although measures had been taken to treat the produced wastewater, these facilities had insufficient capacity, removed insufficient contaminants, and were not properly managed and maintained.

Public health was again in danger. The quality of the living environment decreased as well. The story went that you would get poisoned in our surface waters, before reaching the point of drowning (even if you could not swim at all). The situation became so bad, that the situation was no longer accepted by politicians and management of the Dutch government. Something had to happen!

RESEARCHING CAUSES AND SOLUTIONS

According to good Dutch practice, causes of and solutions for water quality problems were researched. Obvious causes that emerged were:

- The discharges of wastewater were greater than the self-cleaning capacity of the water.
- The quality of the treatment plants; poor management and maintenance, too little treatment capacity and application of unsuitable technologies and methods.
- Industrial wastewater discharges; too many oxygen-binding and toxic substances.
- Not enough financial resources.

But research also provided insight into the less obvious, underlying causes of the problem:

- Not enough social awareness for the problems; the situation had slowly developed and worsened, so people got slowly used to it. 'If you bring the water slowly enough to boil, the frog does not jump out of the pan.'
- A lack of focus on solving the problems at the responsible stakeholders: the municipalities.
- Not enough interests/stakes/incentives to tackle the problem in general; a driving force for change lacked.
- Not enough knowledge about (and experience with) improving water quality and wastewater treatment.
- Too few staff members at treatment facilities, who were also insufficiently motivated and knowledgeable. Moreover, they were not socially appreciated; the village fool got to operate the treatment facility.
- A lack of long-term strategy and planning to address the problems.

STRATEGIES FOR IMPROVEMENT (1970)

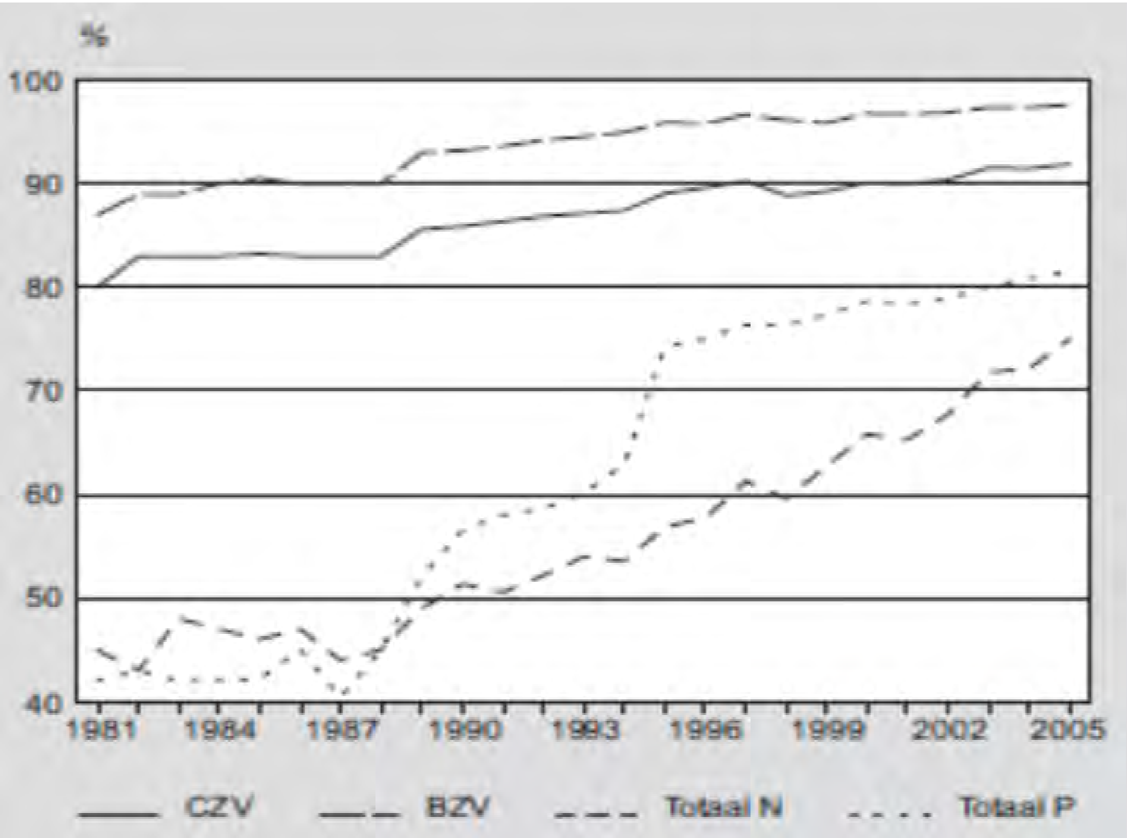
The research results formed the basis for an improvement strategy. This strategy included the following components:

- Increasing social awareness / incentives; drafting and adopting legislation for improving water quality.
- Increasing knowledge and skills; develop and provide structural training.
- Increase focus, by introducing organisations with only one single task: improving the water quality.
- More financial resources, by developing a separate tax system to finance improvements and management of utilities and (wastewater treatment) facilities. This was the start of the 'polluter-pays' principle.
- Patience and a step by step approach; Reaching the final goal takes decades!

We will go deeper into this during our presentation.

RESULTS

Wastewater treatment in the Netherlands has improved enormously in the past decades. Almost all wastewater is treated before it is discharged into the surface water. The discharges of industrial wastewater are greatly reduced as well. Management of our surface water quality and wastewater treatment is done by thousands of well-qualified people in professional organizations: the Dutch water authorities. There is enough financing a professional approach of constructing, managing and maintaining the treatment installations. The performance of the treatment facilities has improved considerably.



BZV = ***BOD****; CZV=* ***COD****; Totaal P =* ***Total phosphorous****; Totaal N =* ***Total nitrogen***

Treatment facilities in the Netherlands

ARE WE DONE?

There have been impressive improvements over the decades in the water quality and in the treatment of wastewater. But challenges remain, such as the extra removal of medicine residues and other so-called emerging substances from wastewater. We also realise that wastewater has value: we can recover substances, with which we can contribute to the transition towards a sustainable circular economy. Our current facilities for the collection and treatment of wastewater, in which a lot of money was invested, hamper this transition.

Are we done in the Netherlands with learning and improving? The answer to that question is clearly 'no'! We still have a great deal of work in the coming decades. Let us hope that we have learned from our past lessons.

BENCHMARKING: KNOW, LEARN AND IMPROVE

BENCHMARKING FOR TRANSPARENCY AND LEARNING

The Dutch Water Authorities use benchmarks as a tool for transparency and learning from each other. The objective is to compare the water authorities' performance and costs. Because by analysing the differences, opportunities for improvement (towards better quality or lower costs) can be identified across the whole sector. **Our wastewater benchmark exists for more than 20 years now, and will be conducted for the seventh time in 2019.**

Benchmarks support **transparency and accountability** of water authorities as public organisations. They show how taxes are spent, monitor how we work towards agreements and keep to (inter)national laws and guidelines. Society wants to see to which degree the Dutch water authorities do what they promise, and which costs are involved. Especially because the water authorities are public organisations, that do not account for their actions towards shareholders for example. Also, more than a few organisations are interested because of professional objectives. The results are therefore publicly available as open data.

Even more important, the benchmarking process and results are at the basis and core of **learning** among water authorities. Throughout the benchmarking process, specialists from all 21 authorities are involved in the design of shared indicators and interpretation of the results. Lots of knowledge and experiences are shared, and many insights are developed throughout this process. The benchmarks are a starting point for **improving** the sectors' performance, and lead often to new cooperative initiatives and communities of practice. We never 'rank' or 'judge' each other, but use the results to start asking questions.

The Dutch water authorities take part in various benchmarks with different topics and frequencies, depending on the needs and wishes of the sector. The topics are depicted in the figure on the next page.

STAKEHOLDERS INVOLVED

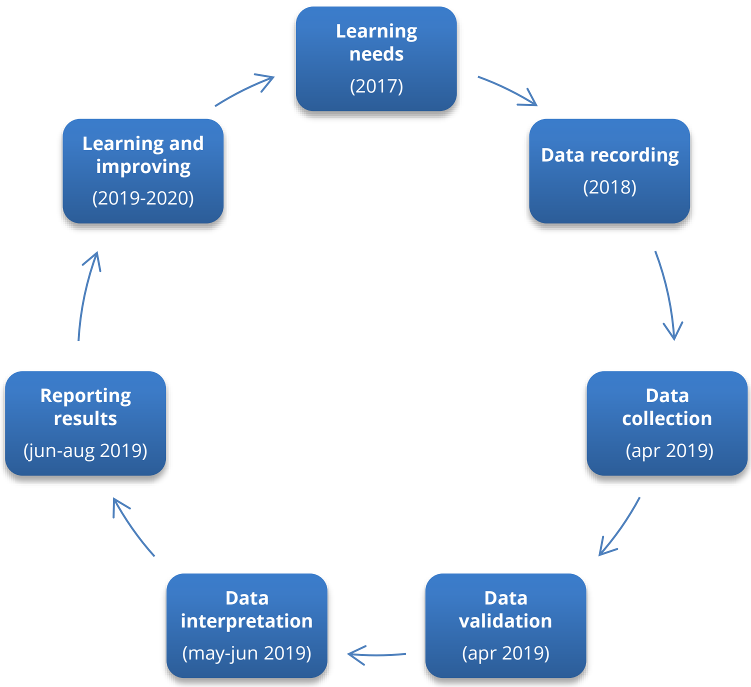
In a successful benchmarking activity, many stakeholders are involved on many different organisational levels. Generally we distinguish three groups: democratically elected board members, managers, and specialists. Each group of stakeholders is motivated to cooperate in the benchmark for their own reasons:

- **Board members (representatives of society)** use the benchmark results to see how performance of their organisation develops over the years, and to learn which aspects influence this. They see how their organisations differs from other organisations, and stimulate performance improvement based on good practices from others.
- **Directors** and **managers** use the results to manage their organisation and improve their plan-do-check-act cycle. They identify performance gaps and learning opportunities. To them, the benchmark is a starting point for improving their operations and policy guidelines.
- **Specialists** are involved with the content of the benchmark. They design the indicators, based on what they want to learn from each other, and share insights and experiences during the interpretation of the results. Their main motivation is to improve their own technical processes.

The organisation of each benchmark is structured along these lines. In the example of the benchmark on wastewater treatment management, the national directors' association on wastewater treatment management is 'product owner'. There is a steering group of selected board members and directors for major decisions with regard to the development of the benchmark, a project group of directors and managers that coordinates the benchmarking process, and working groups of specialists that develop the list of indicators and take the lead in the interpretation of the results. Furthermore, interpretation meetings are facilitated for experts from all 21 water authorities, to improve the quality of the results, and to stimulate learning. A fulltime project coordinator (employed by the association of Dutch water authorities) facilitates the benchmark process.

BENCHMARKING CYCLE

The process of benchmarking by the Dutch water authorities consists of multiple steps. These steps involve not only data collection and reporting, but – at least as important – also activities that build support in the sector and stimulate learning among organisations and improving performances. The six steps of the current wastewater benchmark are shown and described below.



Step	Process description	Involved stakeholders
1	**Determining the need for insight and learning** • What does society (or politics) want to know from the water authorities? (transparency) • What do water authorities want to know/learn from each other? (learning and improving)	• The project group, a delegation of the national directors' association on wastewater treatment management, is responsible for including current challenges and trends. • The working groups develop the benchmark's indicators (taking care of historical trends, and including new developments). This is facilitated by an external consultant with expertise on wastewater treatment.
2	**Recording data** • Sharing benchmark indicators before the start of the year over which data will be collected (for authorities to know which data to record). • Making sure that authorities make use of the same measurement and data recording methods; standardized as much as possible (for good data quality).	• The project coordinator organises an interactive session for experts from all authorities, to build support for the benchmark. • Working group members organise specific sessions for experts when new measurement or recording methods have (or are advised) to be used.
3	**Collecting data** • Sending out digital data collection surveys to all water authorities.	• A database consultant develops the new data survey to be used for data collection. • Water authorities get a couple of weeks to complete the survey.
4	**Validating data** • Checking to which degree surveys are completed. • Checking the data quality. • Adjusting data, based on validation results.	• Database consultant provides a full overview of all recorded data. • Members of working groups validate the data (quantity and quality), together with an external consultant. • Project coordinator returns the validation results to the contact persons at the water authorities, requesting them to complete or recalculate certain data entries.
5	**Interpreting data** • Analysing the collected data: historical trends and important (surprising) insights. • Organising the Day of the Data, to share and validate the interpretation of the data with the experts at the water authorities. • Broad discussion on noted differences between performance of water authorities, possible causes of these differences, resulting conclusions, main lessons and learning opportunities.	• Members of the working groups analyse the data, together with an external consultant. • Project coordinator organises the Day of the Data, where working group members present historical trends and major insights to the water authorities. The main goal is to discuss the analysis and interpretation of the data (does everyone understand the meaning of the data in the same way?) with the data suppliers, and to define learning opportunities among water authorities.

6	**Reporting insights** • Reporting insights and learning opportunities (printed reports, website). • Updating WAVES database and dashboard/application, to make collected data accessible for everyone.	• Members of the working groups report the insights and resulting learning opportunities, together with external consultant. • Data consultant manages data in central database and application.
7	**Learning and improving** • Working out defined learning opportunities, within and between water authorities and utilities. • Defining collective (learning) goals for the next years. • Sharing knowledge, expertise and experiences, one to one or in communities of practice.	• The project group, a delegation of the national directors' association on wastewater treatment management, defines collective (learning goals). • Project coordinator starts communities of practice, when/if requested by water authorities.

WHY IT WORKS: SUCCESS FACTORS OF THE DUTCH WASTEWATER BENCHMARK

- **Shared ownership**
  On all levels people are motivated to contribute to and cooperate in the benchmark. Participants are not forced to participate, but 'seduced' to share their data and knowledge. By involving the stakeholders on the various organisational levels, the benchmark gains a lot of support. They feel a certain degree of co-ownership of the benchmark, and want to contribute to its success.
- **Trust within and among organisations**
  True and sincere learning can take place when people trust each other enough to show their vulnerability and their weak spots, when they are willing to listen to each other, take each other's advice, and share their knowledge. We experience that this is the case between management and operators within the Dutch water authorities, and also between organisations.
- **Close (tight) network**
  On each level (directors, managers, experts, operators), people from different water authorities meet regularly. Due to the existence of many joint network events, learning groups, communities of practice, conferences, etc. colleagues from different water authorities know how and where to approach each other with questions, tips and tricks.
- **Relevant content**
  The benchmark results contain relevant content for several stakeholder groups. Board members use the benchmark to gain insight in the performance of their organisation in relation to other organisations, directors and managers want to learn from other organisations, technological experts want to know which buttons to push to improve the performance of their utilities.
- **Reliability of data**
  Thanks to collective agreements (on management level) about how to measure, record and collect which data. The benchmark has been done for more than 20 years, resulting in strong, clear and unambiguous indicators. The measurement methods for the most basic indicators are prescribed by law. Moreover, most utilities use the same software to record their data, which is automatically uploaded to the benchmark data survey. The data survey software shows the data from last benchmark cycle, and conducts some basic calculations to check responses. Validation of the data is done internally (by experts from water authorities) as well as by an independent external consultant. Based on the initial benchmark results all water authorities receive an exception report, showing which data seem to break a historical trend. This is an extra validation step. Interpretation of the data is a collective activity as well. All involved stakeholders are well aware of the benchmark cycle, and very much willing to contribute as high quality data as possible.

- **Accessibility of data**
  A home page (http://www.waterschapsspiegel.nl) and database have been developed for the benchmark results: WAVES (http://waves.databank.nl). In 2013, the water authorities decided that the benchmark data should be publicly accessible, unless it is recorded for the first time, part of an experiment, not (yet) validated, or contains confidential information. Even then, the data is always accessible for all water authorities (password protected).
- **Sharing the story behind the data: learning instead of ranking**
  The numbers do not tell the full story. Water authorities make different policy decisions, depending on the characteristics of their area and the preferences and views of the democratically elected board members. It is tempting for board members to use benchmark results to rank their organisations and to make them accountable for their actions. However, experience has shown that these motivations to not stimulate managers, experts and operators to be open about the results and ask the right learning questions. The benchmark publications stimulate water authorities therefore as much as possible to look for differences, and get in touch with each other to explore the stories behind them. The focus is on learning, not on ranking.

INDICATORS OF THE WASTEWATER BENCHMARK

The contents of the Dutch wastewater benchmark are structured in a 'tree' of main learning goals, sub learning goals, success factors, and indicators. It includes the following learning themes:

- **Functioning of the WWTP facilities**: Technical indicators on transport and treatment of wastewater and sludge processing, and maintenance of facilities.
- **Environmental responsibility**: Consumption and production of renewable energy, recovery of resources from wastewater.
- **Costs**: Total and separated costs for the complete wastewater management process.
- **Reliability and availability of the treatment facilities**: disruptions of the process (transport, treatment, sludge processing), and efficiency and effectivity of solving them
- **Innovation**: Innovative initiatives that water authorities apply to improve and become resilient with regard to future developments.

The case studies in the next chapter show and explain our most important indicators (in relation to our goals of transparency, accountability, learning and improving).

CASE STUDIES: HOW WE LEARN FROM OUR BENCHMARK

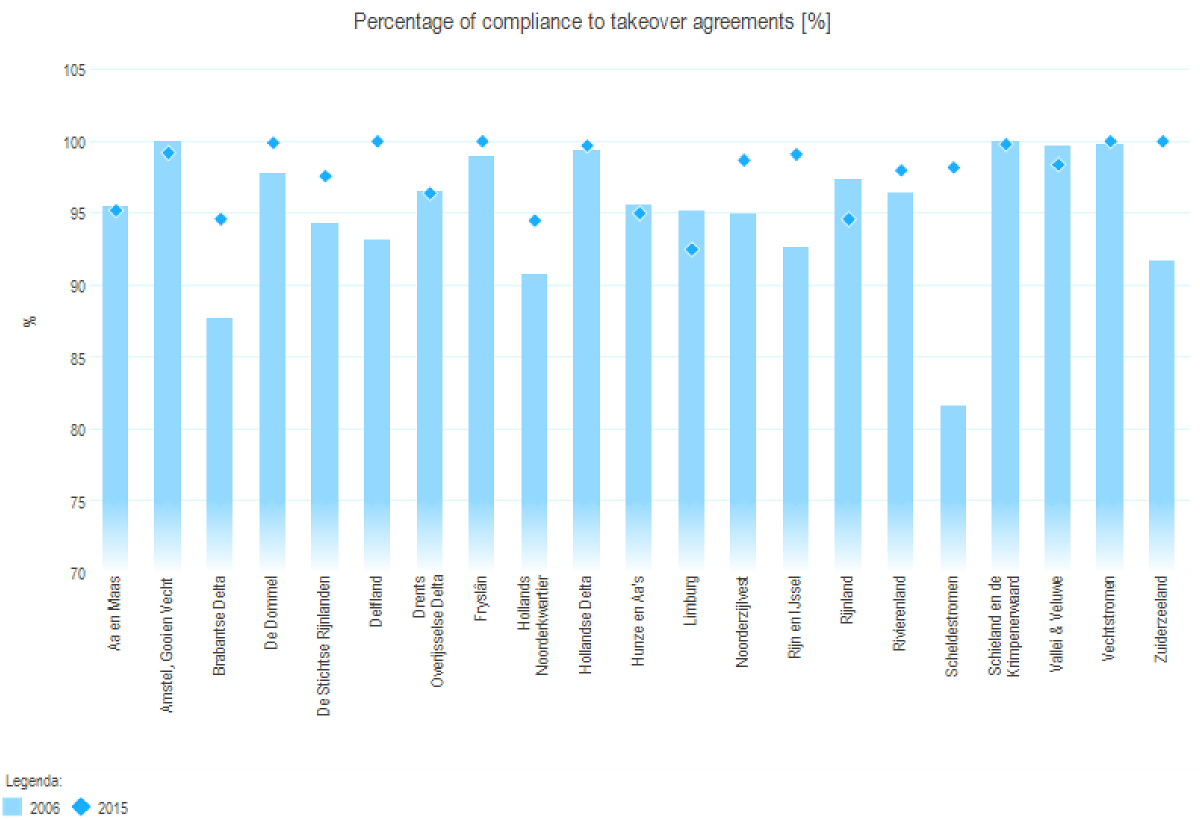
In this part, we illustrate how we learn (or have learned) from our wastewater benchmark. Eight examples show how the data (and the stories behind the data) help to learn and improve within and between water authorities. The examples cover the most important indicators of the wastewater benchmark.

Each example describes:

- the importance of the indicator (mostly showing to which degree water authorities keep to laws or agreements),
- the results from the benchmark (exported from our database),
- the insights we gain from them, and the emerging learning opportunities.

1. Taking over wastewater from municipalities [% compliance]

Municipalities organise the collection and removal of our wastewater and part of the rainwater via the sewer system, after which the water authorities are responsible for wastewater treatment. The point where the responsibility shifts from municipality to water authority is called the 'takeover point'. The water authorities set up agreements with the municipalities in their area about the maximum flow of wastewater to be taken over. An important indicator in the benchmark is the percentage of compliance, in which this takeover agreement has been met by the water authority (between January 1st and December 31st of the benchmark year).

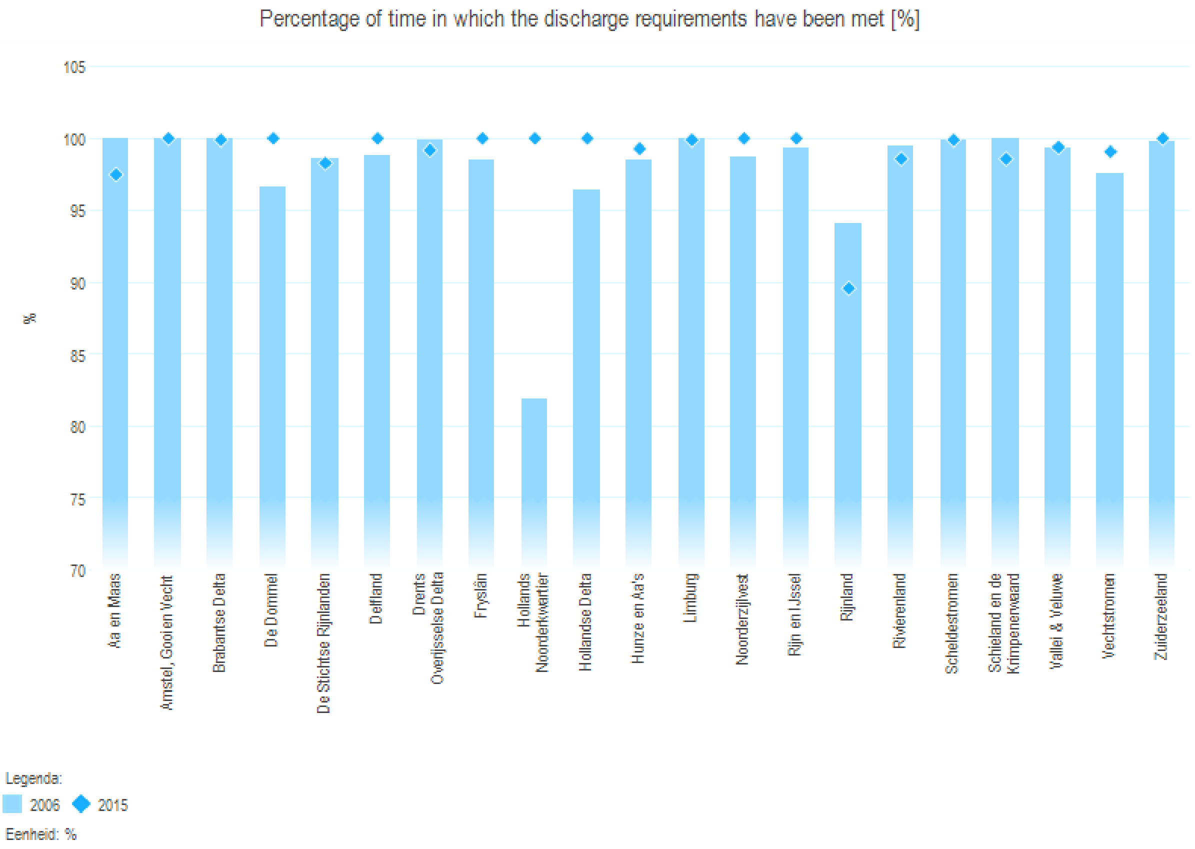


Horizontal axis: 21 water authorities
Vertical axis: Percentage of compliance to takeover agreements

In 2006 (bar graph) water authorities succeeded in taking over the agreed flow of wastewater between 82% and 100%. . As can be seen, the situation has improved a lot for most water authorities; in 2015 (dot graph) the agreements were met between 93% and 100% of the time. Situations in which the agreements are not met the hydraulic capacity of the transport system or the wastewater treatment plant is not sufficient. More sewer overflow to the surface water is then the result. The municipality and water board together discuss how to solve the shortage of capacity. For example: disconnecting paved surface from the sewer system, adding more buffer capacity in the sewer system, or increasing the hydraulic capacity of the transport system or the treatment plant.

2. Meeting discharge requirements [% of time]

Regional, national or international law prescribe what requirements the discharged treated wastewater must meet. This concerns the quantities of COD (chemical oxygen demand), BOD (biochemical oxygen demand), suspended solids, phosphorus and nitrogen in the discharged water. The requirements are different for various types of surface water. In most cases the water authority is responsible both for treating wastewater and for maintaining the water quality; it has a dual role. This is why it often cooperates with another (neighbouring) water authority, as an independent regulator. An important indicator in the benchmark is the percentage of time that the discharge requirements are with by the water authorities.



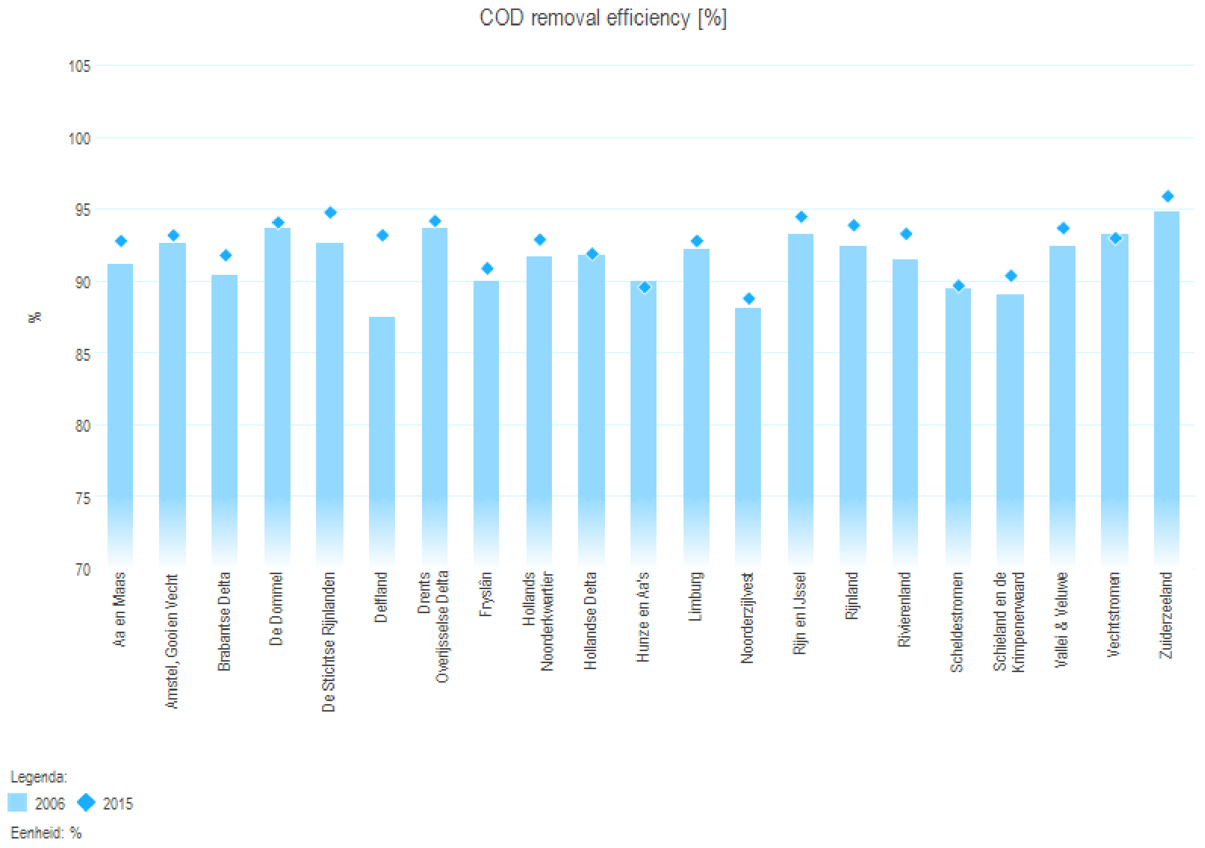
Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

Horizontal axis: 21 water authorities
Vertical axis: Percentage of time in which the discharge requirements have been met

In 2006 (bar graph) water authorities met the discharge requirements between 82% and 100% of the time. As can be seen, the situation has improved a lot for most water authorities; in 2015 (dot graph) the requirements were met between 90% and 100% of the time. Situations in which the agreements are not met are for example: loss of suspended solids due to poor settling properties of the activated sludge, technical disruption of the process, or insufficient of capacity. Through process improvements, additional training of employees, improvement of maintenance and capacity expansion, the problems can be solved.

3. COD, phosphate and nitrate load in effluent

The European water framework directive aims for chemically clean and ecologically sound water. The nutrients nitrogen and phosphorus are important parameters for the prevention of unbridled algae growth in surface water. For this reason, requirements apply to the quantities of nitrogen and phosphate that the WWTP may discharge. Also, the COD removal efficiency is an important process parameter. Too high COD discharges cause oxygen shortages in the surface water. This can lead to fish mortality.

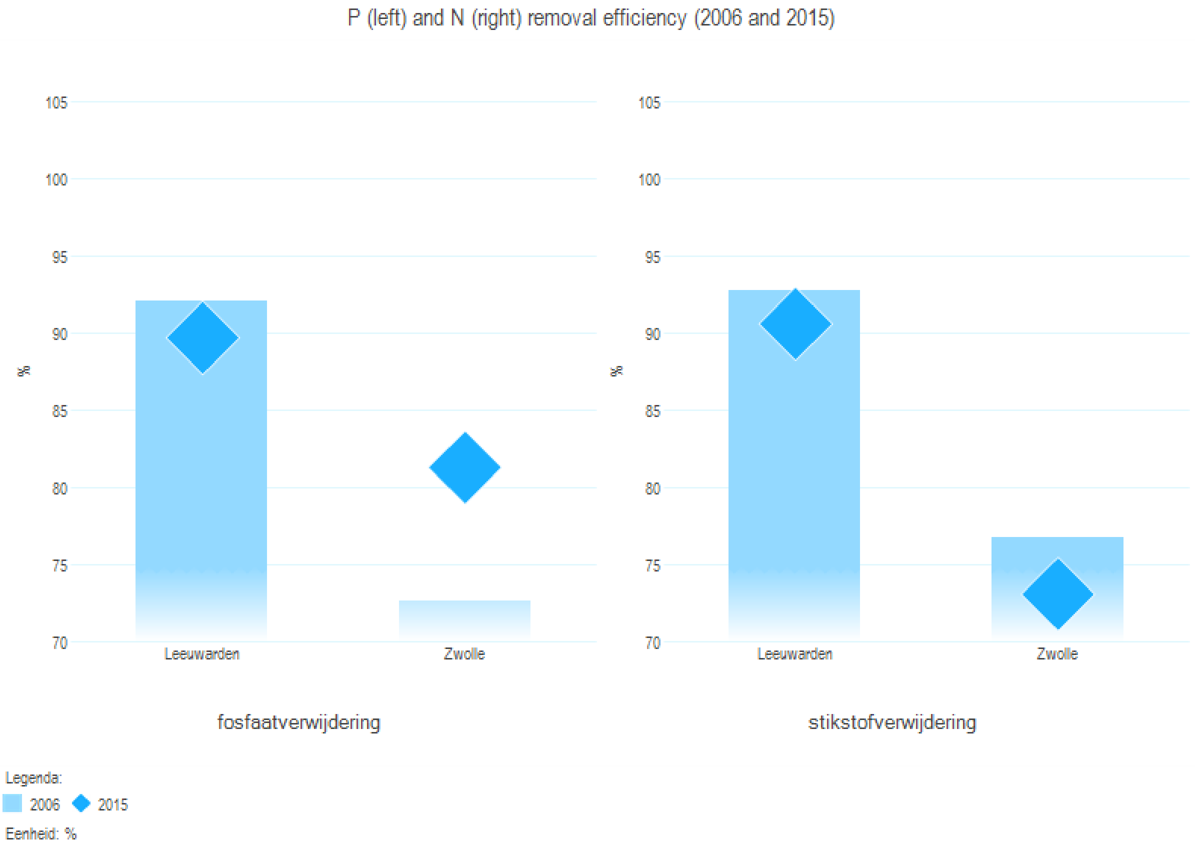


Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

Horizontal axis: 21 water authorities
Vertical axis: COD removal efficiency (%)

In 2006 the removal efficiency amounted to 87 - 95% (bar graph). In 2015 this percentage was between 88 - 96% (dot graph) . Almost every water board shows an improvement from 2006 to 2015. The improvements for some water authorities are rather big.

Every WWTP in the Netherlands has discharge requirements that suit the surface water where it is discharged. In the benchmark, it is (for all indicators) possible as well to zoom in on individual WWTPs. In the example below, the phosphorus and nitrogen removal efficiency of the Leeuwarden WWTP (Mr Jongejans) are compared with those of Zwolle (Mr Schepman).



Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

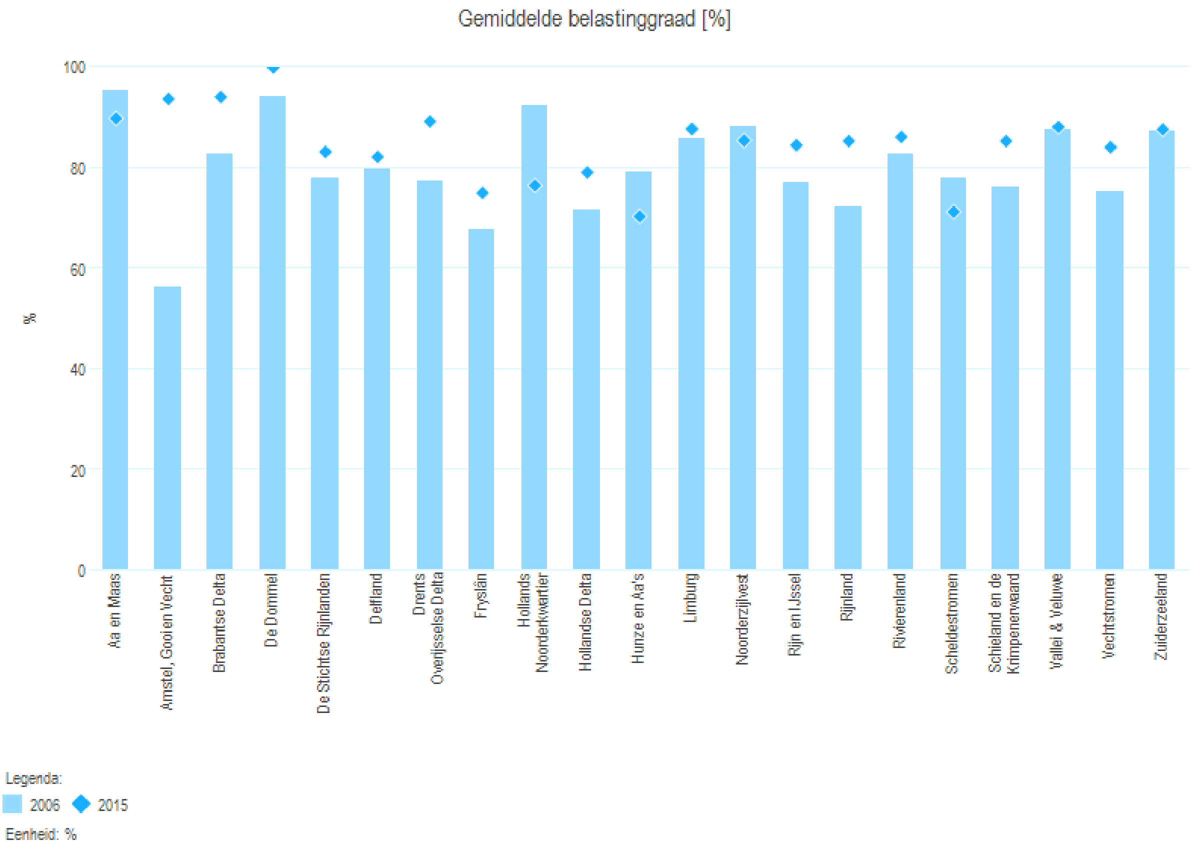
Horizontal axis: Two examples of wastewater treatment plants – Leeuwarden and Zwolle
Vertical axis: Phosphorous (left graph) and Nitrogen (right graph) removal efficiency

The graph clearly shows that the removal efficiency of the WWTP Leeuwarden is higher than that of the WWTP Zwolle. This has to be seen within the context that the WWTP Leeuwarden discharges its effluent into a canal with little flow of water (and has therefore more stringent requirements that are more difficult to meet). The WWTP Zwolle discharges on a large river with a lot of water flow. Because this water is much less vulnerable, the discharge requirements for Zwolle are much less stringent than those for Leeuwarden. The graph also shows that phosphorous removal at Zwolle WWTP improved from 2006 to 2015.

This example shows that it is very important to look further than just the numbers. The numbers never tell the full story. A higher removal efficiency in this case does not necessarily mean that the requirements (laws or guidelines) are better met. The numbers serve a bigger goal; they form the basis to start a discussion about each others' context, challenges, policy measures, and results. Only when these 'background' stories are shared, learning opportunities emerge.

4. Average load factor of the WWTP

The WWTPs are designed to remove a certain amount of pollutant from the wastewater. The average load factor of the WWTP's is shown in the graph below. 100% average load factor means that the WWTP is fully loaded up to its design capacity. A fully loaded WWTP is more vulnerable to disruptions and requires extra attention in operational management and maintenance.



Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

Horizontal axis: 21 water boards
Vertical axis: Average load factor for WWTPs [%]

In 2006 (bar graph), the average load factor varies between 58 and 95 %. In 2015 (dot graph), the average load factor had increased to 76 – 100 %. The average load factor increased for almost all water authorities. The reason why is that – in order to save money – the WWTPs are increasingly being operated to the cutting edge, for example by using more automatic process control. This results in a more efficient process.

The graph also shows that the average load factor for some water authorities has decreased (Aa en Maas, Hunze en Aa's, Scheldestromen). A reason for this is the population decrease; people leave these rural areas and move to urban areas.

This insight shows that the operation of wastewater treatment plants in most parts of the country is getting more vulnerable. How to other water authorities handle this? Are we working in the right direction? Should we make different strategic choices? These are questions that emerge from benchmark results like this.

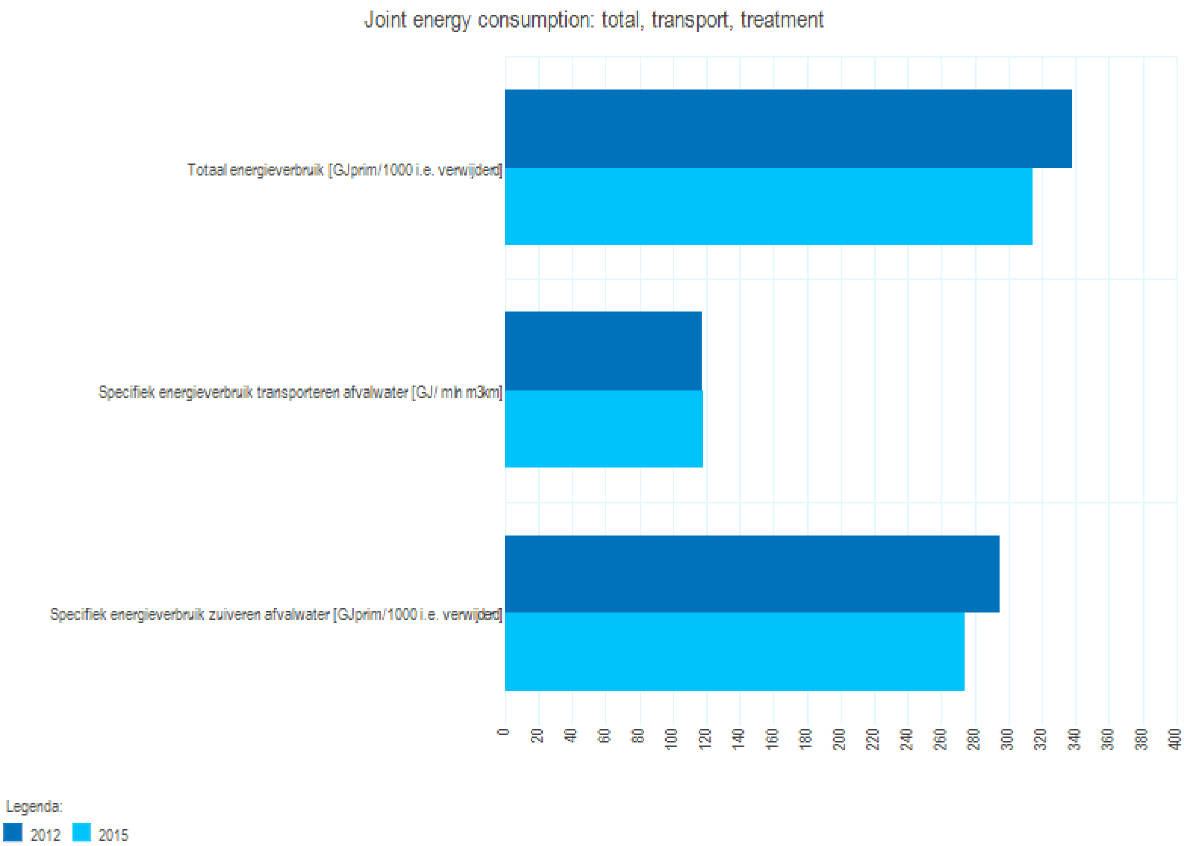
5. Energy consumption and (sustainable) production

Along the same lines as the worldwide Paris Climate Agreement, the Dutch water authorities have set the ambition to reduce their energy consumption and CO2 emission. In 2020, 40% of the consumed energy should be produced (in a sustainable way) on the water authority's own premises and/or within the authority's own processes. In 2025 the goal is to produce all (100%, sustainable) consumed energy. Within these ambitions, water authorities want to reduce their energy consumption, produce more energy, and buy as much as possible green/renewable energy until they are self-sufficient.

In the benchmark, we thus monitor:

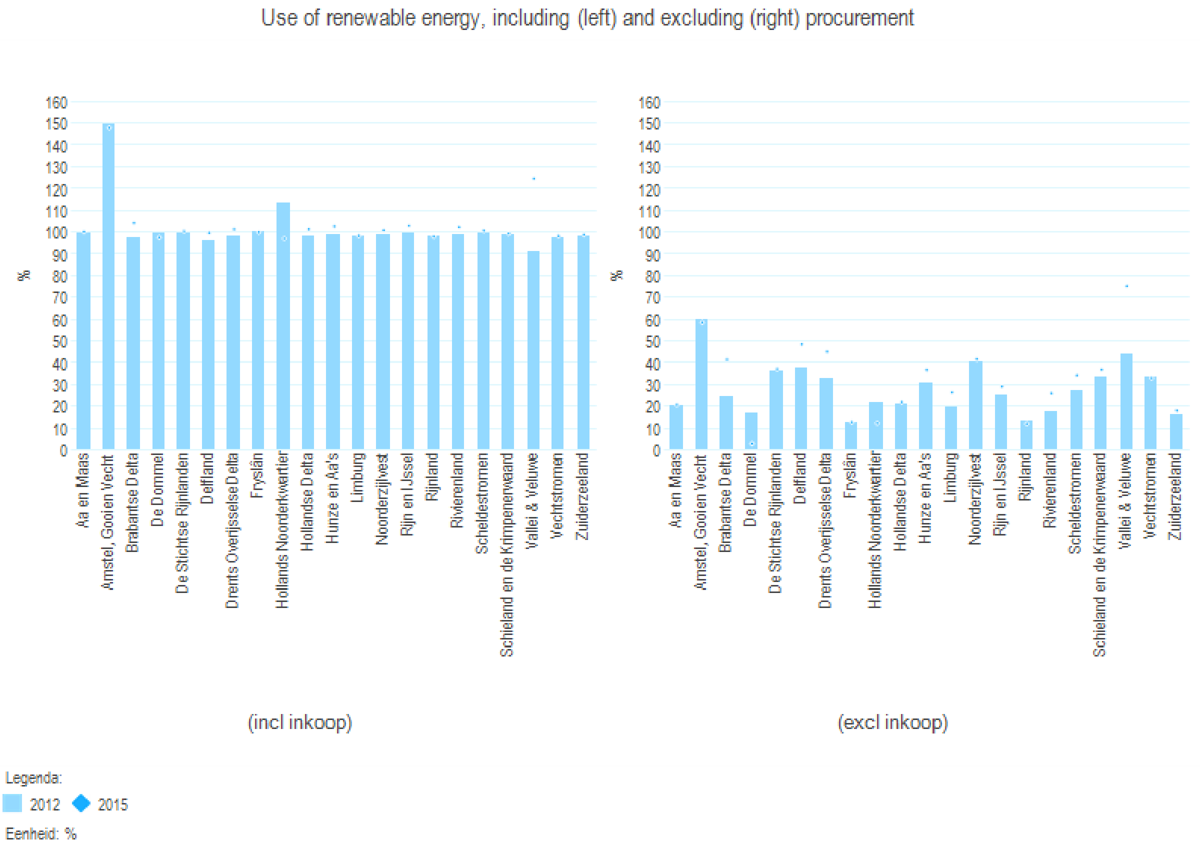
- Energy consumption (in total and per water authority);
- Percentage of energy from renewable sources (contracted or own production);
- Sustainable energy production.

In order to decrease our 'footprint', one of the aims is to use less energy overall. The graph below (upper bars) shows the decrease in total energy consumption for all water authorities together. This indicator was measured for the first time in 2012. In the middle part of the graph we see that wastewater transportation costs approximately as much energy in 2015 as in 2012. The savings are clearly caused by a more energy-efficient treatment process (lower part).



Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

*Horizontal axis: Gigajoules of energy consumed (per 1000 treated units, or per million m3*km)*
Vertical axis, from top to bottom: Joint total energy consumption, Joint energy consumption for wastewater transportation, Joint energy consumption for wastewater treatment.



Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

Horizontal axis: 21 water authorities
Vertical axis: Percentage use of renewable energy by water authorities (left – including contracted energy, and right – excluding contracted energy)

The second measure towards sustainable wastewater treatment is to increase the percentage of consumed energy from renewable sources: energy from biogas, windmills, solar cells, etc. instead of energy from coals. The graph above shows this percentage, including contracted energy (left) and excluding contracted energy (right – only renewable energy produced by the water authority itself). This clearly shows that the total percentage of renewable energy stays stable around 100% between 2012 and 2015 (to the left). However, many water authorities increasingly become energy producers (to the right). Water authorities – in 2015 – produced up to 75% of their own energy consumption, mainly through recovered biogas.

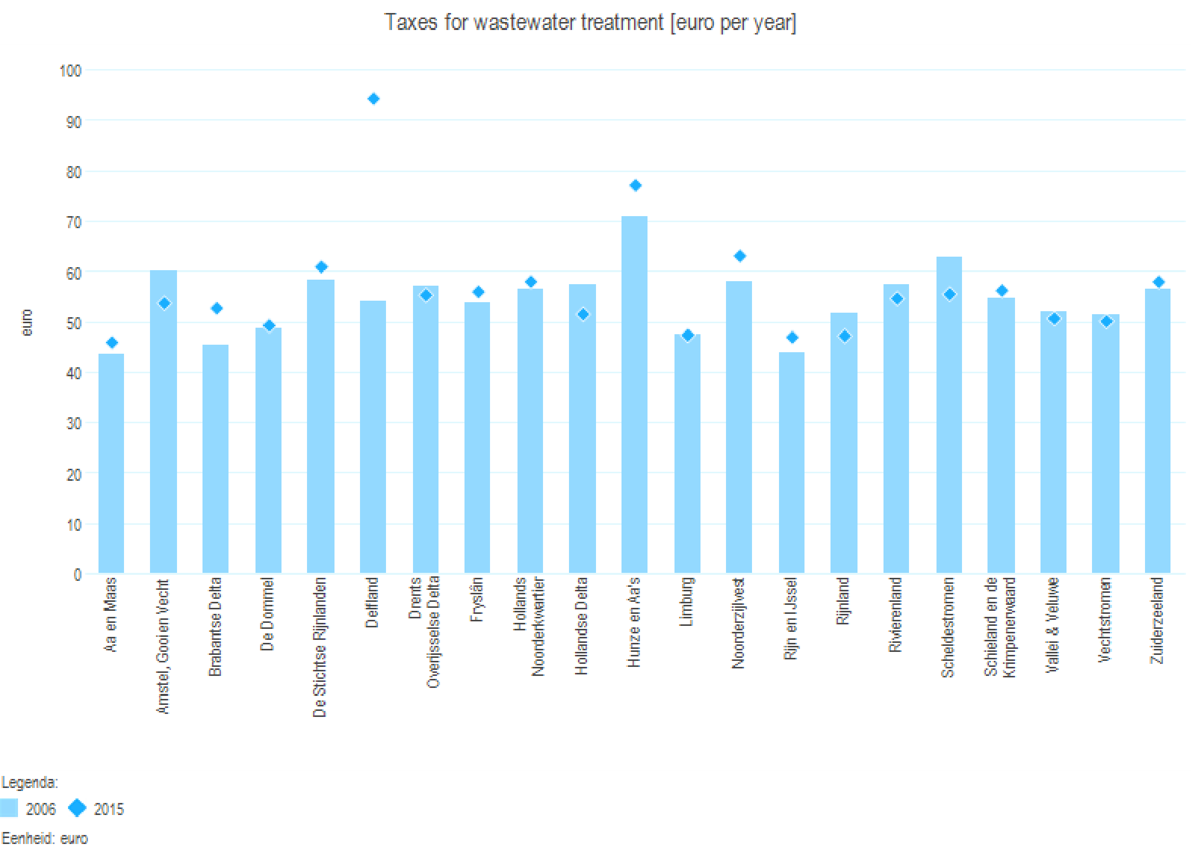
This role - being (renewable) energy producer – is a very 'new' practice. These benchmark results show which water authorities are innovators in this field. What causes their great progress? Is this because of different technologies? Because of different policy decisions? Because of higher investments? Wat authorities use these insights to share practices with each other, learn and improve towards more sustainable processes.

These results are not only used to learn from each other, but also to show that we – as Dutch water authorities – make progress towards the energy related goals and agreements.

6. Wastewater treatment costs

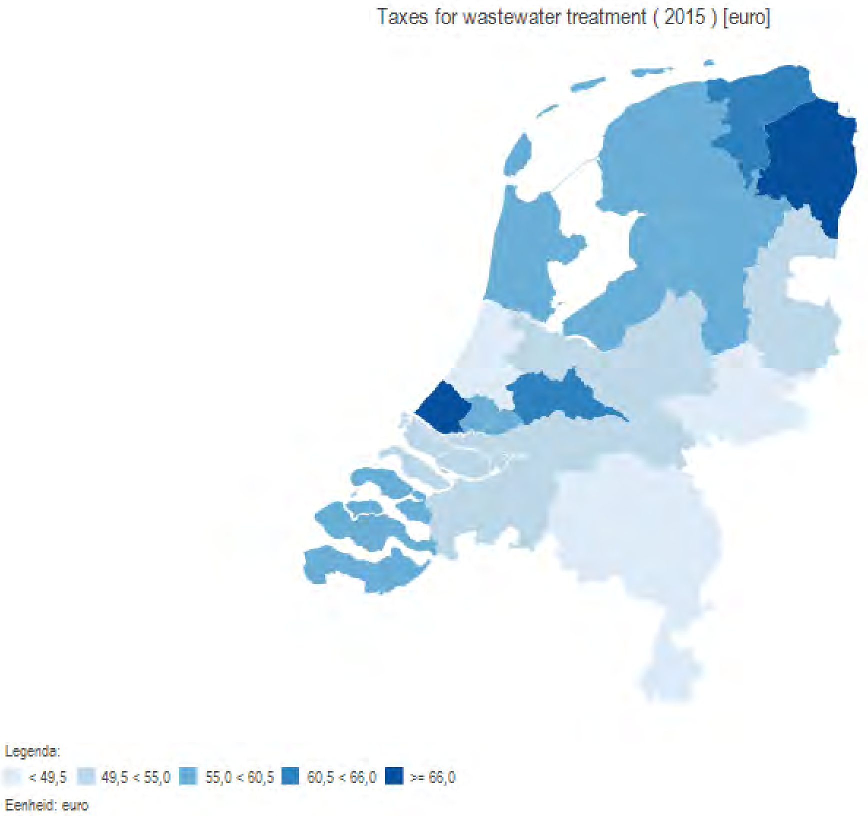
The work of the Dutch water authorities is mainly financed by public taxes. Each household pays – depending on the amount of people in the household – a certain amount of taxes to the authority that manages the water system and wastewater treatment in their area. Wastewater treatment taxes are paid per ‘unit of pollution’, a standard for the amount of wastewater produced by one person. The ambition is to keep these taxes (public costs) as low as possible. This means that water authorities generally aim to keep tax increases within 2,5% (excluding basic inflation).

Due to different situations throughout the country, and due to different wastewater treatment strategies and investments, taxes differ as well. How much taxes water authorities raise per unit of pollution is another important indicator in the benchmark. The results for 2006 and 2015 are shown in the following graph. It becomes also visible that not all water authorities manage to keep to the upper boundary of a yearly 2,5% raise. The good news is that 9 of 21 water authorities charged less in 2015 than in 2006.



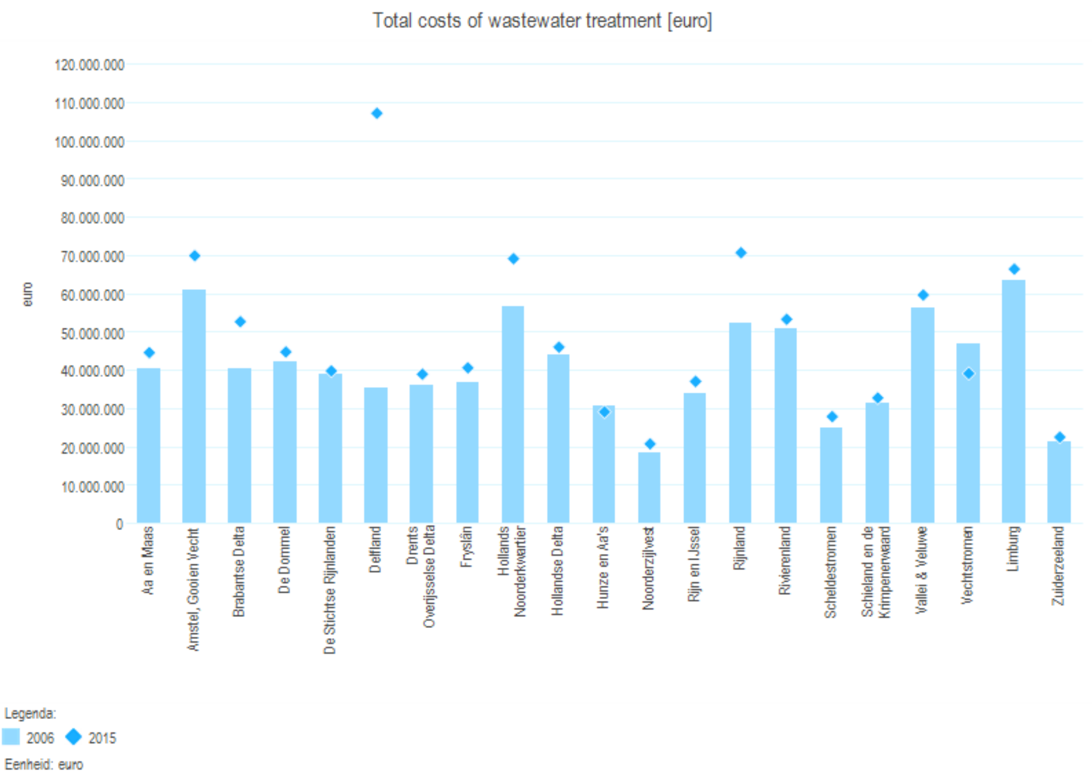
Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

Horizontal axis: 21 water authorities
Vertical axis: Tax rates per person per year [euros]

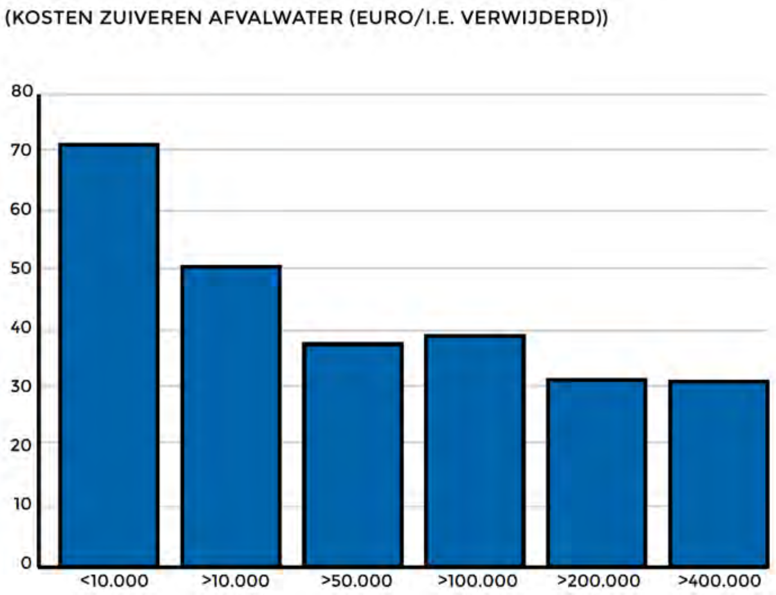


This figure shows in a different way (exported from our benchmark database) how the tax rates vary across the country.

How are these taxes spent? Also an important part of our benchmark. From the data we learn that the costs for management and exploitation of the treatment plants amounted in total (for all authorities together) to more than 1000 million euro's in 2015. This is an increase compared to 2006 (see graph for results per authority), but an average decrease of 3% compared to 2012 (without inflation correction). Most of the costs (68%) are for treating wastewater, 9% goes to transportation, and 23% to sludge processing.



To conclude this example about the financial insights that result from the benchmark, the graph below shows the relation we find between WWTP capacity and treatment costs. It can be seen that treatment at smaller WWTPs is more expensive than at larger WWTPs.



Horizontal axis: Capacity of treatment plant
Vertical axis: Average standardized costs of wastewater treatment (excluding transport and sludge processing)

These results ‘call’ for centralisation of wastewater treatment, However, then we need to take into account as well that transport costs increase for bigger centralised treatment facilities. We must also take into account – while interpreting the above graph - that there is a large variation in the data (+/- 30 euros per removed unit of pollution). We should thus ask ourselves as well under which circumstances these ‘quick and dirty’ conclusions hold.

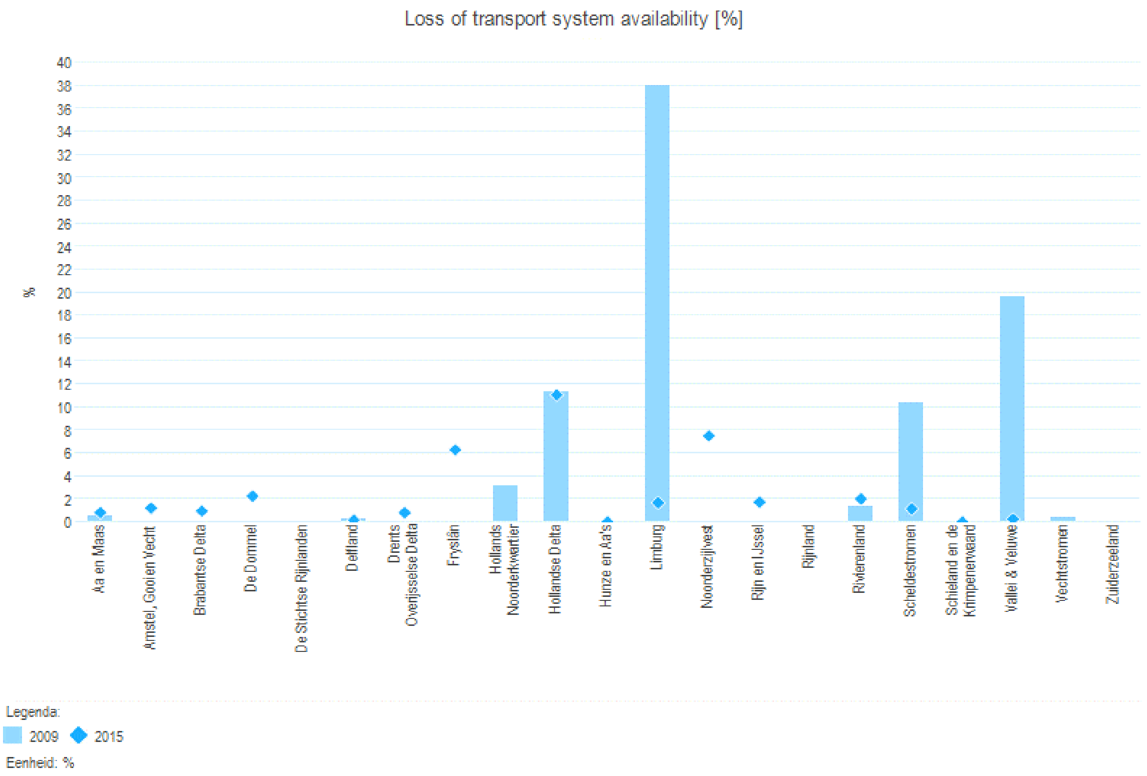
7. Maintenance of wastewater treatment plants

The above examples show how we use basic indicators in the benchmark to be transparent, account for our practices, gain insights, and learn from each other. However, there are also themes for which we first need to work on the quality of our data to be able to draw conclusions and use the data as a basis for sharing practices. One of those examples is the maintenance of wastewater treatment plants.

One of the important indicators in the benchmark is the percentage of time in which the wastewater transport system (from municipal sewers to treatment plants) is not available. For example due to (technical) disruptions or malfunctioning. In order to calculate this percentage, we need information about the amount of times that the transport system was disrupted, the amount of time these disruptions lasted. However, it turns out that different water authorities define ‘disruption’ of the system in various ways. Is this about any technical failure in the system? Or only the ones causing the system to shut down completely? Or something in between?

Such ambiguities result in unreliable data. We do have data for our indicator, but we know that different interpretations of the indicator lie at the basis of our data. Thus, the results are worthless. If we communicate these results, for example to board members governing the water authorities, discussion might start that are based on misinformation. This is a great risk for the reputation of the benchmark. The analysis of and communication about the results must therefore be very nuanced and considerate.

Indicators on the maintenance of wastewater transport systems and treatment facilities are thus still in development currently. The association of wastewater managers turned this into a focus point for improvement towards the next benchmark cycle in 2019. Together with colleagues from all 21 water authorities we’re currently working towards clear and unambiguous indicators.

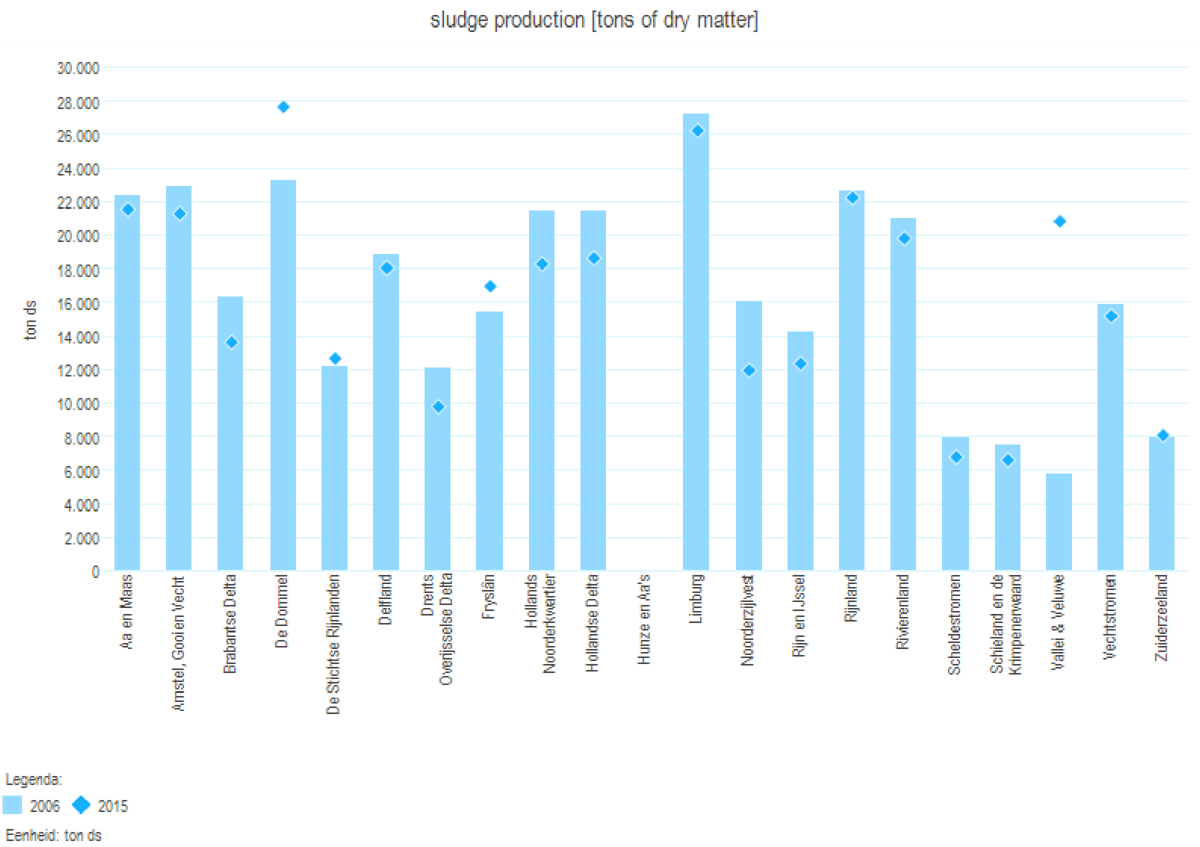


Horizontal axis: 21 water authorities
Vertical axis: Percentage of time that transport systems was not available [%] → ‘worthless’ data due to ambiguity

8. Sludge production and processing

The benchmark results also show us the downsides of our wastewater management system. This is illustrated by the following example, regarding sludge production and processing.

Because of increasingly stringent quality requirements, it was no longer allowed to apply sewage sludge in agriculture from the 1980s. In the nineties of the last century, it was also no longer allowed to dispose dewatered sewage sludge to a landfill. All this has led to the establishment of large-scale sewage sludge processing, for example by drying and burning the dewatered sludge. The costs for sludge processing have therefore increased considerably. To save costs, the water boards are committed to reducing sludge production. How are we doing with regard to this aim, according to the benchmark data?



Bron: ABF Research, WAVES - Bedrijfsvergelijking Zuiveringsbeheer

Horizontal axis: 21 water authorities
Vertical axis: Sludge production [tons of dry matter]

The graph shows that some water boards have indeed managed to reduce sludge production in 2015 (dot graph) compared to production in 2006 (bar graph). For example by realizing extra sludge digestion or reducing the use of chemicals for phosphorus removal. But this did not work for all water boards. Apparently we are not yet 100% in control at this point.

9. Towards the future: Innovations in wastewater treatment

Using renewable energy, reducing our CO2 emissions, removing drugs residuals from wastewater, recovering resources from the wastewater… These are all relatively 'new' themes for water authorities. Although the benchmark has existed for more than 20 years, these themes are just recently added to it. The first step towards including such new themes in a benchmark is to exchange knowledge and experiences. When certain innovations become established practices, the possibility emerges to quantify them and start measurement of quantitative trends (performance and costs).

Part of our benchmark consists therefore of qualitative questions, resulting in a qualitative report. These results inspire the water authorities: which resource recovery practices do others apply? Which top 3 innovations will be implemented over the next three years? Which sludge processing methods do others apply? Experiences with pilot practices can be shared, based on overviews such as the one below. As long as these innovations are in pilot phase it is interesting to gain insight in for example the costs involved with innovation; some water authorities are more innovative and take more risks than others. However, quantification of performance of such new technologies only becomes possible when they turn into established practices, with standard measurement methods, and clear and unambiguous defined indicators.

It generally takes two benchmark rounds (6 years) before new themes are implemented well into our benchmark.

INNOVATIES IN HET ZUIVERINGSBEHEER — UNIE VAN WATERSCHAPPEN

Waterschap	Grondstoffen	Innovaties	Slibeindverwerking
Aa en Maas	Aa en Maas produceert in eigen beheer struviet. Struviet wordt afgezet via Waterstromen B.V. Vanaf medio 2016 wordt cellulose in eigen beheer geproduceerd, eindverwerking door externe partij. Vanaf 2018 productie van CNG aan afvalstoffendienst en afzet van Biogas aan bierbrouwerij.	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Superkritisch vergassen 2. Big Brown Data (benutting data uit rioolwater voor verbetering gezondheid van de stad/omgeving) 3. Verwaarding grondstoffen - Produceren en verwaarden van cellulose, Slib inzetten als grondverbeteraar, terugwinnen fosfaat uit afvalwater en slib, van biogas in WKK's naar CNG in vrachtauto's. Aa en Maas koppelt dit ook aan de biomassa's uit het watersysteem: zoals productie van bio composiet of eiwitten uit maaisel	SNB (monoverbranding)
Amstel, Gooi en Vecht	Amstel, Gooi en Vecht produceert in eigen beheer struviet en zet dit af via ICL. Geproduceerd cellulose gaat nu naar AEB	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Optimalisatie slib-en biogasverwerking 2. Wind- en zonne-energie 3. Nieuwe sanitatie	AEB (slib- en afvalverbranding)
Brabantse Delta	Op dit moment produceert Brabantse Delta nog geen grondstoffen uit full-scale installatie. Vanaf 2018 wordt fosfaat uit as verbrand slib teruggewonnen. Wel loopt er kleine proef met productie van bioplastic uit slib	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Bioplastic (PHA) uit slib 2. Thermofiele gisting/stikstofterugwinning/struviet 3. Koude anammox, doorontwikkeling Demon, EssDe en UNAS technologie	SNB (monoverbranding)
Delfland	Er worden door Delfland op dit moment geen grondstoffen teruggewonnen	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Zoetwaterfabriek 2. Continu aeroobkorrel slibsysteem 3. Optimalisatie slib- en biogasverwerking	HVC (monoverbranding)
De Dommel	Vanaf 2016 produceert de Dommel in eigen beheer struviet, afzet valt onder verantwoording aannemer	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Implementatie Kallisto 2. Verwaarden afvalwater 3. Nieuwe stoffen	SNB (monoverbranding)
Wetterskip Fryslân	Er worden door Wetterskip Fryslân op dit moment geen grondstoffen teruggewonnen	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Bioplastic uit slib 2. Schroefpers 3. Fosfaat en stikstofterugwinning	Extern gedroogd en granulaat ingezet als granulaat
Groot Salland			GMB (composteren)
Hollands Noorderkwartier	Het winnen van cellulose uit afvalwater door het inzetten van fijnzeven op de RWZI Beemster	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Onderzoek naar nuttige toepassing van CO2 uit biogas 2. Proef met winnen van struviet op RWZI Den Helder 3. Biogas omzetten naar aardgaskwaliteit op RWZI Beverwijk en gebruiken als brandstof voor transport	Gedroogd in eigen installatie. Granulaat naar bio-energiecentrale HVC
Hollandse Delta	Hollandse Delta levert effluent aan de industrie en produceert zand, roostergoed en slib	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Koude anammox 2. Verlagen energieverbruik / verhogen energieproductie 3. Sluiten van kringlopen	HVC (verbranding)
Hunze en Aa's	Bij Hunze en Aa's wordt biogas opgewerkt tot aardgas.	De beoogde top 2 van innovaties voor de komende 5 jaar zijn: 1. Slibdroging met lage temperatuur droging 2. Gruisdosering bij ontwatering	Thermisch gedroogd (SwissCombi), granulaat naar ENCI
Noorderzijlvest	Er worden door Noorderzijlvest op dit moment geen grondstoffen teruggewonnen		Thermisch gedroogd (SwissCombi), granulaat naar ENCI
Reest en Wieden			GMB (composteren)
Rijn en IJssel	Rijn en IJssel levert centraat aan Waterstromen B.V dat hieruit struviet terugwint en afzet	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. Alginaat uit industrieel afvalwater 2. Ephyra/Themista 3. Slibdroging met restwarmte	GMB (composteren)
Rijnland	Rijnland levert zoet water ter bestrijding van verziltingsproblematiek in watersysteem	De beoogde top 3 van innovaties voor de komende 5 jaar zijn: 1. EssDe proces 2. Slibontwatering zonder chemicaliën 3. Achiever actief slib (AAS)	HVC (monoverbranding)

Published overview of innovations at water authorities