

# Wetsus 2020

combining scientific excellence with commercial relevance





## Wetsus, European Centre of Excellence for Sustainable Water Technology

Oostergoweg 9 (8911 MA)  
P.O. Box 1113  
8900 CC LEEUWARDEN  
The Netherlands

phone: +31 (0) 58 284 30 00  
e-mail: [info@wetsus.nl](mailto:info@wetsus.nl)  
web: [www.wetsus.eu](http://www.wetsus.eu)



### Wetsus is co-funded by

- the Dutch Ministry of Economic Affairs and Climate Policy (TKI-Topsector Water)
- the European Union (Horizon 2020, EIT and Interreg)
- Northern Netherlands Provinces (REP-SNN)
- the City of Leeuwarden, the Province of Fryslân
- The Netherlands Organisation for Scientific Research



Ministry of Economic Affairs and  
Climate Policy of the Netherlands



# Introduction

Wetsus, European centre of excellence for sustainable water technology, facilitates breakthrough innovations for water treatment technology.

Wetsus is a facilitating intermediary for trend-setting know-how development and uses a unique innovation model. Wetsus' main activity is the coordination of a world leading research program. The inspiring and multidisciplinary collaboration between companies and research institutes in Wetsus results in innovations that contribute significantly to the solution of the global water problems.

Wetsus is organized around its aim to stimulate collaboration between the various public and private organizations that together constitute the water sector: i.e. between public companies, private companies and universities; between scientific chairs; and between regional, national and European policy makers. The Wetsus Open Community Cooperation Model (see figure) creates the synergy and momentum required to achieve major objectives. As per January 1, 2020, 106 companies annually invest some € 3.4 million in the demand driven € 15.3 million/year research program, with a long term commitment. In the current Wetsus international know-how network, about 130 partners from all over the world, but with an emphasis on the EU, join forces in solving the global water problems.

Wetsus is a not-for-profit foundation located in Leeuwarden, the Netherlands. Wetsus combines a campus approach with an international know-how network strategy. At WaterCampus Leeuwarden, multidisciplinary know-how, education and talent are concentrated, valorization and commercialization are accelerated and facilities are shared.

## Combining scientific excellence with commercial relevance

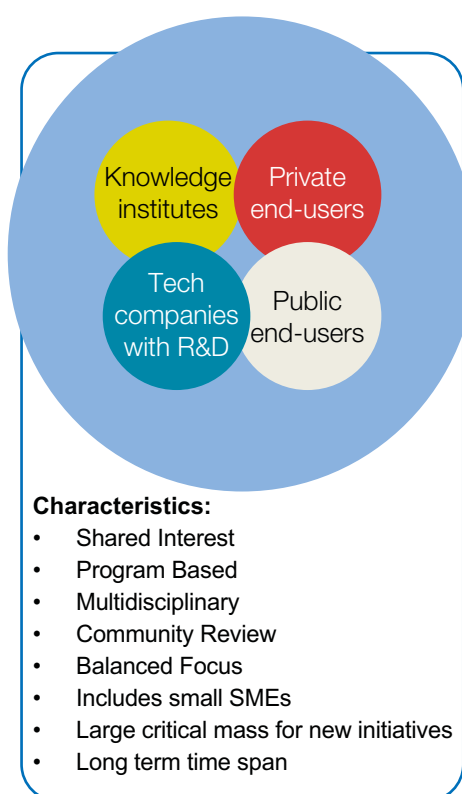
Companies, assembled in a Wetsus research theme, together determine the research program, which is executed in the Wetsus laboratory by the 22 involved research institutes. All research projects are performed under the responsibility of the participating universities. As per January 2020, 51 scientific chairs from all over Europe are involved.

Within several (inter)national scientific programs in Wetsus, research institutes and industry jointly implement market-driven, application-oriented, multidisciplinary, (pre)competitive scientific research in the field of sustainable water technology. This is typically done in four-year-long research projects carried out by PhD-students and their supervisors. The research goal of Wetsus is to develop innovative and sustainable water technologies. The scientific creativity required for that is to a large extent generated by the unique cooperation of 51 know-how disciplines in one physical laboratory.

A dedicated Intellectual Property Rights policy is in place, to enable optimal cooperation, innovation and the commercialization thereof. This way, Wetsus combines scientific excellence with commercial relevance, which ultimately results in successful innovations.

Innovation, partnership, reliability, joy and cooperation are the **values** around which all Wetsus' activities are performed.

## OPEN COMMUNITY



**Johannes Boonstra**  
**Prof.dr.ir. Cees J.N. Buisman**  
*Executive Board*

Wetsus' distinguishing **key success** factors are:

- High trust cooperation through relatively small research themes
- High commitment through long term cooperation contracts with companies and secondment agreements with universities
- Sharing of multidisciplinary knowledge from universities and companies in an idea driven program
- Strong involvement of SME's
- Independent meeting place for scientists from all over Europe
- Valorization and commercialization support from WaterCampus Leeuwarden

With regard to involvement in policy and programs for innovation, Wetsus is active on regional (smart regional specialization in the Northern Netherlands), national (direct involvement in national topsector Water & Maritime and TKI water technology) and European level (ERRIN Working Groups, Water Europe Working Group Resource Recovery, EIT Raw Materials, Water4All, Interreg, COSME, Horizon2020, LIFE, Erasmus+, etc).

In addition to Wetsus' research role, Wetsus also fulfills two other main functions. A talent and education program is operated, in order to develop the human capital required to fulfill the innovation ambitions of the international water sector. Besides, many activities in the field of stimulating spin-offs and entrepreneurship are performed to stimulate the translation of laboratory inventions into actual innovations applied in society.

Wetsus' activities are split up in 3 fields of attention, as summarized below and described in the following chapters.



## Societal water challenges and solutions

Breakthrough technological developments in the field of water treatment technology are required, not only to enable the export ambitions of the water sector, but also to help solve global societal threats and challenges. Challenges that are addressed are not just in the field of water quality and availability, but also in fields like sustainable energy, food security and circular economy. From Wetsus' perspective, global water problems and solutions have three aspects that need a combined approach:

- Societal needs: immense global water (and water related) problems and the social and health effects thereof, have a large impact on the everyday life of people:
  - Environmental and health issues
  - Water shortages; increasing due to pollution, population growth, wealth, climate change
  - Conventional water technologies are usually not circular; raw materials and energy are often wasted
  - Absence of safe drinking water, irrigation water and sanitation in the 2nd and 3rd world is causing immense stress (as described in the UN Millennium Development Goals)
- Business market combinations: water technology for public drinking water production and sewer water treatment is a very large market. Globally, the largest use of fresh water is for irrigation purposes. The industrial water supply and industrial waste water treatment also

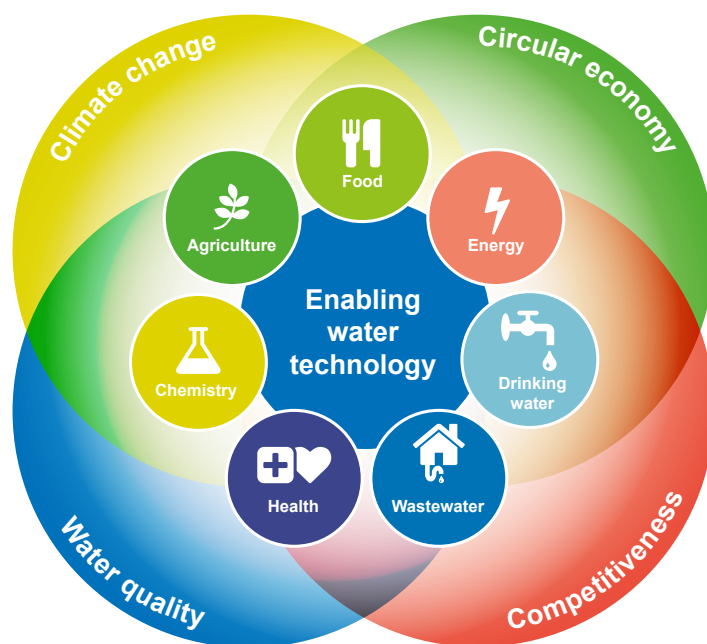


represent a significant market. In total the annual water treatment market exceeds € 700 billion per year with an annual growth of some 4 to 6%.

- State of the art science and process technology: multidisciplinary approaches from nano-technology, bio-sciences, separation technologies, physics and electro-chemistry are necessary to develop breakthrough solutions for the enormous water problems mankind faces.

## Enabling water technology for cross-overs

Many industries and public sectors depend on water technology. Cooperation between different sectors however often is difficult and not efficient. Wetsus is the natural place for these sectors to join forces in the field of water technology, Wetsus has labeled this as 'enabling water technology'.



## Demand driven cooperation model

The Wetsus research program is divided in themes, which essentially are Intellectual Property-clusters. Typically, per theme some 5 to 8 companies and 3 to 4 universities cooperate. The program is idea-based; the ideas are ranked by the involved company participants. These companies pay an annual participation fee which gives them the right to define the program (as a group with the other theme companies) and to exercise a shared right of first refusal on the results of the research. Excellent scientific chairs are invited to execute the research and to share their know-how with the other theme participants. Regular theme meetings ensure continuous involvement of all stakeholders.

## How can organizations join Wetsus?

In the Wetsus cooperation model, a distinction is made between company, platform and know-how institute participants, as described below. Specific IP rights for each participation form are part of the Wetsus IPR regulations. For the available participation forms, dedicated model agreements for cooperation in the Wetsus program are available (interested parties can contact Johannes Boonstra; johannes.boonstra@wetsus.nl).

All participants have free access to the following services offered by Wetsus:

- Early access to all Wetsus' scientific publications
- Membership of a growing exclusive water technology network containing specialists from about 130 partners
- Dedicated workshops
- Admission to internal (members only) conferences
- Free access to Wetsus' public congresses

Percentage of company participants that experience positive effects from Wetsus participation  
(Evaluation 2016)

|  | %  |
|--|----|
| Increased revenues                       | 23 |
| New products/technologies                | 35 |
| New products/technologies within 5 years | 96 |
| Improved products/technologies           | 50 |
| Expansion of own research                | 30 |



## Company participants

Companies participate in Wetsus per research theme. Knowledge, which results from pre-competitive research defined and funded by these participants, is commercially implemented by these companies and made accessible to third parties through patents and scientific publications. The participating commercial and research organizations are listed on the following pages. Wetsus' aim is to extend the number of company participants in order to further increase the commercial relevance and momentum of the scientific research. Wetsus has a collaboration policy that focuses on protecting the interests of the participants.

Cooperation in Wetsus is open to all companies. As per 2020, companies from Austria, Belgium, Canada, Denmark, Finland, Germany, India, Ireland, Israel, Japan, Monaco, Norway, Saudi Arabia, England, USA, Scotland, Spain, Switzerland, China and the Netherlands participate. Much attention will be given to further internationalization, particularly in Europe.

As per January 2020, the following rates apply for participation (these rates are subject to inflation correction):

Company Participants: € 29,000/theme/year

Company Participants, turnover of less than € 3 million/year: € 17,500/theme/year

## Platform participants

Further, a platform membership with network function is a participation form companies can choose for. The platform participants have no voting rights on the research program and indirect access to the intellectual property of Wetsus (to patents that are not transferred to relevant theme participants). They have a privileged position with respect to information. Each 'regular' company participant automatically is a platform participant. The 2020 annual rate for platform participation ranges from € 3,500 (company turnover < € 1.5 million/year) to € 8,200 (turnover < € 3 million/year) to € 11,700 (turnover > € 3 million/year).

## Know-how institute participants

The actual research in Wetsus is performed by the know-how institute participants. Leading university research chairs from all over Europe are invited for this purpose. This results in a multidisciplinary and excellent scientific workforce with a clear focus. The research is mainly performed by PhD-students, who are recruited from all over Europe and the rest of the world. Access to research facilities of 22 research institutes and a very large scientific network are important added advantages of this approach.

As per 2020, 51 scientific chairs from 22 know-how institutes from 10 countries participate. The strategy is to maintain this network of EU chairs and to further increase its relevance and impact.

## Communication

Wetsus communicates with participants and the outside world in several ways.

On [www.wetsus.eu](http://www.wetsus.eu) all up-to-date information about the organization, events and program can be found. Dedicated information for participating companies and universities is published in a closed section on the website, with exclusive access for participants. For (future) PhD's we offer [www.phdpositionswetsus.eu](http://www.phdpositionswetsus.eu) and for the master track [www.wetsusacademy.nl](http://www.wetsusacademy.nl).

A monthly email newsletter is made available for the entire Wetsus network, and is sent to some 5.000 interested individuals. A science & technology newsletter with updates on the research developments in the Wetsus program is issued regularly. Further, from time to time Members Only email newsletters are sent to inform the participants about meetings and developments in the program and organization. Social media (Twitter, Facebook, LinkedIn, Instagram) are used for quick news updates. Relevant movies about Wetsus can be found on YouTube.

Meetings and congresses, both Members Only and public, are used for the exchange of knowledge and to strengthen the know-how network. Annual highlight is the Wetsus Congress, with a broad variety of topics and international renowned speakers. Biannually (in even years), the Wetsus Congress is part of the European Water Technology Week (also see page 11).



# Participants (January, 2020)



[www.aaenmaas.nl](http://www.aaenmaas.nl)



[www.brabantsedelta.nl](http://www.brabantsedelta.nl)



[www.acquaint.eu](http://www.acquaint.eu)



[www.brightspark.nl](http://www.brightspark.nl)



[www.agriton.nl](http://www.agriton.nl)



[www.brownandcaldwell.com](http://www.brownandcaldwell.com)



[www.alliander.com](http://www.alliander.com)



[www.kwrwater.nl](http://www.kwrwater.nl)



[www.aquanirvanafoundation.com](http://www.aquanirvanafoundation.com)



[www.coherentwatersystems.co.uk](http://www.coherentwatersystems.co.uk)



[www.aquabattery.nl](http://www.aquabattery.nl)



[www.coolseparations.nl](http://www.coolseparations.nl)



[www.aquacare.nl](http://www.aquacare.nl)



[www.dewater.com](http://www.dewater.com)



[www.aramcooverseas.com](http://www.aramcooverseas.com)



[www.dommel.nl](http://www.dommel.nl)



[www.avebe.nl](http://www.avebe.nl)



[www.desah.nl](http://www.desah.nl)



[www.avecom.be](http://www.avecom.be)



[www.dirkse-milieutechniek.com](http://www.dirkse-milieutechniek.com)



[www.biosoil.com](http://www.biosoil.com)



[www.dow.com](http://www.dow.com)



[www.biotrack.nl](http://www.biotrack.nl)



[www.deme-group.com](http://www.deme-group.com)



[www.brabantwater.nl](http://www.brabantwater.nl)



[www.dunea.nl](http://www.dunea.nl)





[www.easymeasure.nl](http://www.easymeasure.nl)



[www.izore.nl](http://www.izore.nl)



[www.evides.nl](http://www.evides.nl)

**Kemira**

[www.kemira.com](http://www.kemira.com)



[www.evoqua.com](http://www.evoqua.com)



[www.vanderknaap.eu](http://www.vanderknaap.eu)



[www.feyecon.com](http://www.feyecon.com)



[www.laborelec.be](http://www.laborelec.be)



[www.frieslandcampina.com](http://www.frieslandcampina.com)



[www.lascon.nl](http://www.lascon.nl)



[www.esco-salt.com](http://www.esco-salt.com)



[www.landustrie.nl](http://www.landustrie.nl)



[www.georgfischer.com](http://www.georgfischer.com)



[www.metalmembranes.com](http://www.metalmembranes.com)



[www.fujifilm.nl](http://www.fujifilm.nl)



[www.mulderagro.nl](http://www.mulderagro.nl)



[www.grundfos.com](http://www.grundfos.com)



[www.nwtr.nl](http://www.nwtr.nl)



[www.h2motion.nl](http://www.h2motion.nl)



[www.nxfiltration.com](http://www.nxfiltration.com)



[www.hubert.nl](http://www.hubert.nl)



[www.oasen.nl](http://www.oasen.nl)



[www.icl-group.com](http://www.icl-group.com)



[www.oosterhof-holman.nl](http://www.oosterhof-holman.nl)



[www.integro.nl](http://www.integro.nl)



[www.paqell.com](http://www.paqell.com)



[www.grander.at](http://www.grander.at)



[www.paques.nl](http://www.paques.nl)





[www.x-flow.com](http://www.x-flow.com)



[www.waterbedrijfgroningen.nl](http://www.waterbedrijfgroningen.nl)



[www.pwn.nl](http://www.pwn.nl)



[www.waterfuture.nl](http://www.waterfuture.nl)



[www.redstack.nl](http://www.redstack.nl)



[www.wbl.nl](http://www.wbl.nl)

Schauburger  
Natur Technik

[www.schauburger-natur-technik.at](http://www.schauburger-natur-technik.at)



[www.wavin.com](http://www.wavin.com)



[www.shellglobalsolutions.nl](http://www.shellglobalsolutions.nl)



[www.theweathermakers.nl](http://www.theweathermakers.nl)



[www.snb.nl](http://www.snb.nl)



[www.wf-technologies.odoo.com](http://www.wf-technologies.odoo.com)



[www.stowa.nl](http://www.stowa.nl)



[www.wmd.nl](http://www.wmd.nl)



[www.trojanuv.com](http://www.trojanuv.com)



[www.hunzeenaas.nl](http://www.hunzeenaas.nl)



[www.unilever.nl](http://www.unilever.nl)



[www.noorderzijlvest.nl](http://www.noorderzijlvest.nl)



[www.vandcenter.dk](http://www.vandcenter.dk)



[www.wetterskipfryslan.nl](http://www.wetterskipfryslan.nl)



[www.vecoprecision.com](http://www.vecoprecision.com)



[www.wln.nl](http://www.wln.nl)



[www.verenigingafvalbedrijven.nl](http://www.verenigingafvalbedrijven.nl)



[www.yara.com](http://www.yara.com)



[www.vitens.nl](http://www.vitens.nl)



[www.zuiderzeeland.nl](http://www.zuiderzeeland.nl)



[www.voltea.com](http://www.voltea.com)



# Platform Participants (January, 2020)

|   |  |   |  |
|---|--|---|--|
|    | <a href="http://www.am-team.com">www.am-team.com</a>                   |    | <a href="http://www.O2env.com">www.O2env.com</a>                     |
|    | <a href="http://www.aquatechtrade.com">www.aquatechtrade.com</a>       |    | <a href="http://www.royalhaskoning.com">www.royalhaskoning.com</a>   |
|    | <a href="http://www.avans.nl">www.avans.nl</a>                         |    | <a href="http://www.rabobank.nl">www.rabobank.nl</a>                 |
|    | <a href="http://www.bioclear.nl">www.bioclear.nl</a>                   |    | <a href="http://www.scottishwater.co.uk">www.scottishwater.co.uk</a> |
|    | <a href="http://www.biocompact.nl">www.biocompact.nl</a>               |    | <a href="http://www.sensor-factory.com">www.sensor-factory.com</a>   |
|   | <a href="http://www.cew-leeuwarden.nl">www.cew-leeuwarden.nl</a>       |    | <a href="http://www.skion.de">www.skion.de</a>                       |
|  | <a href="http://www.civwater.nl">www.civwater.nl</a>                   |  | <a href="http://www.tatasteel.nl">www.tatasteel.nl</a>               |
|  | <a href="http://www.empower-people.nl">www.empower-people.nl</a>       |  | <a href="http://www.tauw.nl">www.tauw.nl</a>                         |
|  | <a href="http://www.energyvalley.nl">www.energyvalley.nl</a>           |  | <a href="http://www.tcnn.nl">www.tcnn.nl</a>                         |
|  | <a href="http://www.estrelladelevante.es">www.estrelladelevante.es</a> |  | <a href="http://www.vhl.com">www.vhl.com</a>                         |
|  | <a href="http://www.ews.eu">www.ews.eu</a>                             |  | <a href="http://www.wafilin.nl">www.wafilin.nl</a>                   |
|  | <a href="http://www.hhnk.nl">www.hhnk.nl</a>                           |  | <a href="http://www.wateralliance.nl">www.wateralliance.nl</a>       |
|  | <a href="http://www.en.jitri.org">www.en.jitri.org</a>                 |  | <a href="http://www.waternet.nl">www.waternet.nl</a>                 |
|  | <a href="http://www.nalco.com">www.nalco.com</a>                       |  | <a href="http://www.wrij.nl">www.wrij.nl</a>                         |
|   |  |  | <a href="http://www.wml.nl">www.wml.nl</a>                           |

# Know-how Institute Participants (January, 2020)



[www.boku.ac.at](http://www.boku.ac.at)



[www.tugraz.at](http://www.tugraz.at)



[www.deltares.nl](http://www.deltares.nl)



[www.unesco-ihe.org](http://www.unesco-ihe.org)



[en.ktu.lt](http://en.ktu.lt)



[www.uva.nl](http://www.uva.nl)



[www.icra-edu.org](http://www.icra-edu.org)



[www.umcg.nl](http://www.umcg.nl)



[www3.imperial.ac.uk](http://www3.imperial.ac.uk)

UNIVERSITY OF TWENTE.

[www.universiteittwente.nl](http://www.universiteittwente.nl)



[www.kwrwater.nl](http://www.kwrwater.nl)



[www.muni.cz](http://www.muni.cz)



[www.uni-duisburg-essen.de](http://www.uni-duisburg-essen.de)



[nioo.knaw.nl](http://nioo.knaw.nl)



[www.uminho.pt](http://www.uminho.pt)



[www.rivm.nl](http://www.rivm.nl)



[www.ugent.be](http://www.ugent.be)



[www.rug.nl](http://www.rug.nl)



[www.uu.nl](http://www.uu.nl)



[www.tudelft.nl](http://www.tudelft.nl)



[www.wur.nl](http://www.wur.nl)



[www.tue.nl](http://www.tue.nl)



[www.pwr.wroc.pl](http://www.pwr.wroc.pl)

## International Know-How Network

Wetsus' objective to create an innovative network in the water technology sector is fulfilled through the Wetsus platform. In this platform, all activities and services for the participating companies and institutes (company participants, platform participants and know-how institute participants) are organized. In Wetsus technology providers, public water boards, drinking water companies, end users, consulting engineers, high-tech companies, financial institutes and of course the universities, know-how institutes and young talents together constitute the assembly of all relevant players in the water treatment field. Platform activities stimulate cooperation and business development around technological innovation.

To increase further strengthening of the network, Wetsus stimulates the interaction between the participants as much as possible. Wetsus offers several network events in which science meets business and talent. Several groups are targeted in dedicated events, like theme meetings, a Members Only congress and a workshop session.

Wetsus, in cooperation with its scientific partners, hosts and organizes international scientific conferences, focusing on the new field of water process technology innovations, to strengthen the EU image on science and technology in water. Besides, Wetsus organizes its own annual congress. This is a well-attended networking event where science, government and business people meet. Companies present their progress and new products, governments share their needs and policy development. Strong scientific presentations aiming at breakthrough solutions inspire the international business and scientific community. A high number of SME's as well as multinational companies are represented.

Biannually, the annual Wetsus Congress is part of the European Water Technology Week (EWTW), which is organized in close cooperation with the WaterCampus Leeuwarden partners. The following edition of the EWTW will be in 2020 (more information: [www.watercampus.nl](http://www.watercampus.nl)).

## Legal form and Management

Wetsus is a not-for-profit foundation. Wetsus is managed by its executive board. This Board is formed by a two-person executive, prof.dr.ir. Cees Buisman and Johannes Boonstra.

The participating organizations are represented in the Wetsus supervisory board. This board consists of four members appointed by company participants, four members appointed by knowledge institutes and two independent members, the chair and vice-chair.

## Funding

Wetsus derives its funding from multiple sources. Regional, national and European government funds are combined with contributions from participating companies and universities. This way, a total budget of around € 15 million per year is available until 2023. The Wetsus funding model also promises to be robust for the further future.

## Facilities

Wetsus has moved into its landmark building early 2015. In this inspiring building, situated on WaterCampus Leeuwarden, all Wetsus activities are concentrated. The highest standards in water and energy sustainability have been applied, leading to a BREAAAM Excellent classification of the Wetsus building.

In the new building, Wetsus has its own state of art research infrastructure and dedicated staff to operate these facilities. Almost the entire research program is carried out in the laboratories of Wetsus. The researchers can also use the research infrastructure of the Wetsus participants. To maintain and expand the Wetsus research facilities, funding (from regional authorities) is available to continuously upgrade the equipment.



**Ed Nijpels**  
*Chair supervisory board*



**Albert Bosma**  
*Controller*  
[albert.bosma@wetsus.nl](mailto:albert.bosma@wetsus.nl)



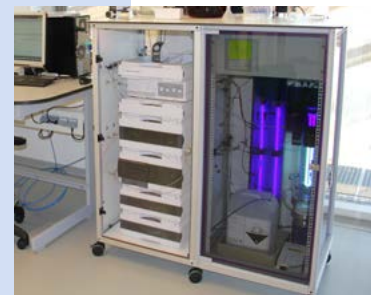


### Analytical equipment

- CLSM (confocal laser scanning microscopy)
- SEM (scanning electron microscopy), EDS (elemental analysis)
- AFM (atomic force microscopy)
- OCT (optical coherence tomography)
- Raman spectrometry
- ICP-OES (elemental analysis), microwave digestion
- IC (ion chromatography)
- LC-MS/MS
- LC-OCD (organic carbon detection)
- UHPLC
- $\mu$ -GC (biogases)
- GC-FID
- GC-FPD
- GC-MS/MS
- TOC (carbon analysis)
- UV-VIS spectroscopy
- Particle size analysis, zeta potential
- Surface area and porosity analyzer
- Absorbance/fluorescence/luminescence plate reader
- Gel electrophoresis (DGGE, DNA, protein)
- Microscopy: Brightfield, DIC, fluorescence, phase contrast
- qPCR
- Quantus (fluorometer for nucleic acids and proteins quantification)
- High-speed camera and image acquisition
- Flowcytometer
- Rheometer
- TGA (Thermal Gravimetric Analysis)
- DSC (Differential Scanning Calorimetry)
- EA (Elemental Analyzer)
- Minlon (sequencer)

### Research facilities

- Continuous and batch reactors
- Gas and sewage water distribution network
- Black water, urine and water storage tanks
- Safety precaution measurements and systems
- Walk-in fume cupboards
- Flat sheet membrane production
- Biofouling monitors with and without water production
- Multi-channel potentiostats
- Shaking incubators (CO<sub>2</sub>/light)
- High-speed cooled centrifuge
- Labopress (molding and pressing)
- Fermentation equipment
- Sonication equipment
- Anaerobic glove box
- Cooling and heating compartments
- Freeze dryer
- Hot rolling press/calendering machine
- GAP fume cabinets
- Automatic film applicator
- Online process control
- Safety vacuum drying oven
- Tube furnace
- -80 °C freezer
- Bal mill
- Respirometer
- Automated research fume hoods with PLC and SCADA
- 3D printer
- Cutting plotter
- Biobench algae flatpanel reactor systems
- Laser cutter
- laboratory eStrechting machine / membrane spinning device
- Nano-imprinter-coating device
- Climate unit/Indoor Plant Growth Room
- High voltage lab
- Laser lab
- ML-II level microbiology lab



**Janneke Tempel**  
Manager laboratory  
janneke.tempel@wetsus.nl



**Wim Borgonje**  
Manager facilities  
wim.borgonje@wetsus.nl

## International cooperation

Wetsus' internationalization vision is summarized in the scheme on the right.

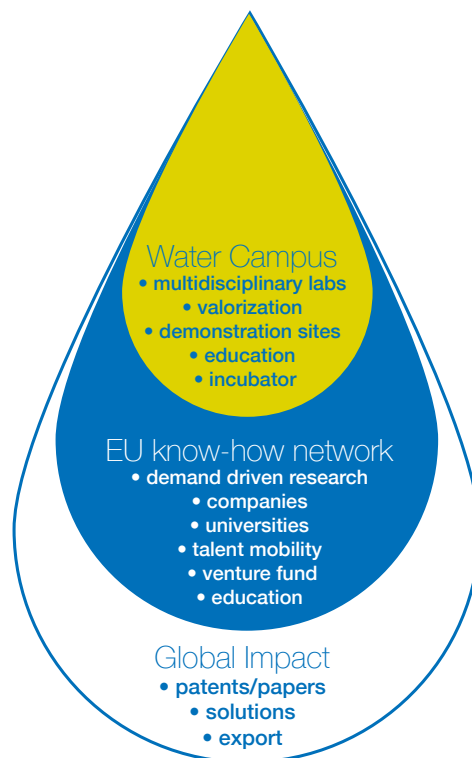
Water innovations can be applied all over the world. International cooperation is therefore essential for our partners. Wetsus' international activities are placed in a regional, a national, a European and a global dimension. The physical core is formed by WaterCampus Leeuwarden, which offers facilities like a multidisciplinary laboratory, demonstration sites and an incubator. WaterCampus collaborates with a network of over 250 national and international organizations. These cooperate in the fields of research, know-how, entrepreneurship, venture capital, talent and education. With this integrated network, WaterCampus can operate effectively on European and global level. WaterCampus has become a magnet for the world's top talent. The beating heart of WaterCampus is formed by Wetsus. Today in the Wetsus laboratory, about 150 international professionals work on water technology research and innovation, connecting a global science network.

## European Innovation Academy

Wetsus is the result of a very successful Research and Innovation Strategy for Smart Specialization (RIS3). It has managed to develop in a region without a university. Within a decade it transformed from a national science institute into Europe's main spark plug for water technology innovation. A long-term focus on a specific theme, with the multidisciplinary core activities concentrated in a physical place, connecting an international professional network, have been key ingredients to realize this.

The amount of international companies and institutes in Wetsus is increasing, currently over 25% of the partners is non-Dutch. Further Europeanisation is enhanced by participation in European research and innovation projects, such as Horizon2020, EIT Raw Materials, COSME, Interreg, LIFE, ERDF and Erasmus+. Wetsus and WaterCampus also actively cooperate within the European Innovation Partnership on Water (EIP Water), ERRIN and Water Europe. All of these projects and activities further enhance the critical mass and reputation of WaterCampus Leeuwarden. Wetsus fulfils the role of European Centre of Excellence with a proven capacity to generate world class knowledge, high value patents and competitive spin-offs. In this way Wetsus' research program supports the development of growth and jobs across the EU.

The European water sector, often characterized as fragmented, has found a focal point in Wetsus: time to market has been reduced, investments in start-ups have increased, industry is long-term committed and world class research is achieved. Wetsus strives to be the most integrated program for this emerging industry in the world. The impact of Wetsus is multiplied by funding synergies between regional, national and EU programs.



**Pieter de Jong**  
*Liaison Officer (Brussels)*  
pieter.dejong@wetsus.eu



**Jantienne van der Meij-Kranendonk**  
*Liaison Officer (The Hague)*  
j.vandermeij@watercampus.nl



## Cooperation with European regions

To further increase collaboration within Europe, Wetsus and WaterCampus Leeuwarden are expanding cooperation with EU regions. The Interreg Europe project iWATERMAP forms the core of this strategy, which aims to cooperate in the fields of education, research and innovation.

Through active cooperation and coordination within the thematic platform Water Smart Territories, Wetsus contributes to the European strategy for industrial modernization and promotes further interregional collaboration.

## Global connections

The global water technology sector is increasingly organized in hubs. WaterCampus Leeuwarden connects these hubs and strives to create synergy between them. Biannually, during the European Water Tech Week, the global hubs are assembled in Leeuwarden. The 2018 edition attracted some 1000 participants from 40 countries. Even more are expected at the EWTW2020, taking place from September 21-24, during which the water tech sector meets and inspires each other in the innovative climate of WaterCampus Leeuwarden.

## Meeting of international minds

Wetsus is a place where water technology minds meet and inspire each other. Currently, over 55% of the scientific staff, researchers and students are from outside the Netherlands (from 30 different countries). In addition, on a regular basis the connected professors and the R&D managers of company members convene at Wetsus to discuss research outcomes and define future projects.

The multidisciplinary research needed to develop breakthrough water technologies depends on PhD-students of various disciplines to work side-by-side on one physical location. Only by continued exposure to each other can knowledge from one discipline be applied in another. The H2020 Marie Skłodowska-Curie Co-Fund project WaterSEED further enhances the attractiveness of Wetsus for international talent. From time to time calls with vacancies are published on [www.phdpositionswetsus.eu](http://www.phdpositionswetsus.eu).



**Dr. ir. Martijn Bijmans**  
*Manager Europe*  
[martijn.bijmans@wetsus.eu](mailto:martijn.bijmans@wetsus.eu)

### Innovation

searching actively for and the development of trendsetting technological innovations which are applicable to society

### Partnership

focusing on inspiring relationships with our partners in order to create an effective network

### Joy

creating a pleasant working atmosphere in which colleagues can grow professionally and personally

### Cooperation

supporting and respecting each other in an open and safe environment

### Reliability

our ability to keep promises and providing declared standards

## Wetsus values

# Performance indicators

| Performance indicators Wetsus                                      |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|  | 2007 realized | 2008 realized | 2009 realized | 2010 realized | 2011 realized | 2012 realized | 2013 realized | 2014 realized | 2015 realized | 2016 realized | 2017 realized | 2018 realized | 2019 realized | 2020 realized |
| Input  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Program budget (mln €)   | 7.0           | 9.2           | 11.7          | 13.2          | 13.8          | 15.7          | 16            | 16            | 14.9          | 14.1          | 14.5          | 14.9          | 15.3          | 15.4          |
| Contribution of companies to research programme (mln €)            | 2.3           | 2.8           | 3.0           | 3.4           | 3.6           | 3.8           | 3.6           | 3.3           | 3.3           | 3.3           | 3.3           | 3.4           | 3.4           | 3.5           |
| Overhead (%)   | 11            | 10            | 10            | 10            | 10            | 10            | 10            | 10            | 10            | 10            | 10            | 10            | 10            | 10            |
| Network  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Number of participating companies                                  | 53            | 66            | 78            | 86            | 92            | 95            | 93            | 95            | 105           | 104           | 105           | 109           | 109           | 115           |
| Percentage of SME companies (turnover < € 100 mln/y)               | 34            | 51            | 54            | 56            | 55            | 54            | 54            | 56            | 57            | 57            | 56            | 57            | 57            | 50            |
| Percentage of foreign companies                                    |               |               | 17            | 17            | 20            | 20            | 23            | 25            | 24            | 24            | 25            | 24            | 27            | 30            |
| Number of participating research chairs                            | 17            | 25            | 33            | 38            | 45            | 46            | 48            | 52            | 54            | 50            | 50            | 49            | 51            | 50            |
| Number of public knowledge institutes (participants)               | 6             | 8             | 14            | 16            | 16            | 18            | 19            | 19            | 21            | 22            | 22            | 22            | 22            | 21            |
| Impact, Output and Outcome   |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Education  |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Number of PhD-students and postdocs (cumulative)                   | 44            | 60            | 90            | 102           | 117           | 131           | 148           | 163           | 179           | 197           | 214           | 231           | 247           | 250           |
| Number of joint degree students                                    |               | 10            | 8             | 15            | 11            | 21            | 23            | 30            | 36            | 40            | 35            | 35            | 31            | 50            |
| Number of MSc thesis students / year                               | 21            | 46            | 37            | 71            | 61            | 80            | 76            | 72            | 79            | 83            | 97            | 103           | 139           | 80            |
| Number of talent events  |               |               | 10            | 20            | 19            | 19            | 16            | 20            | 25            | 29            | 31            | 31            | 22            | 25            |
| Scientific   |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Number of scientific papers in international journals (cumulative) | 19            | 39            | 66            | 121           | 176           | 234           | 294           | 376           | 425           | 505           | 569           | 634           | 703           | 700           |
| Numbers of papers in top 10% citations (cumulative - 1y)           |               |               |               |               |               | 45            | 67            | 80            | 107           | 120           | 146           | 164           | 186           | 140           |
| Citation impact (overall)  |               |               | 2.5           | 1.9           | 1.8           | 2.4           | 2.8           | 2.4           | 1.8           | 2.1           | 2.4           | 2.7           | very high     | very high     |
| Valorization/entrepreneurship                                      |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| Number of spin-off companies (cumulative)                          | 3             | 3             | 9             | 15            | 17            | 20            | 24            | 26            | 27            | 30            | 33            | 34            | 36            | 35            |
| Number of patents (submitted, filed and granted) (cumulative)      | 13            | 22            | 32            | 39            | 53            | 61            | 64            | 67            | 76            | 79            | 83            | 86            | 88            | 90            |
| Number of transferred patents (cumulative)                         | 3             | 4             | 7             | 14            | 14            | 22            | 22            | 26            | 27            | 28            | 33            | 35            | 37            | 45            |
| New technologies (cumulative)                                      |               |               |               |               |               |               |               |               |               |               |               |               |               | 25            |
| Optimization existing technologies (cumulative)                    |               |               |               |               |               |               |               |               |               |               |               |               |               | 20            |

# Innovation Ecosystem

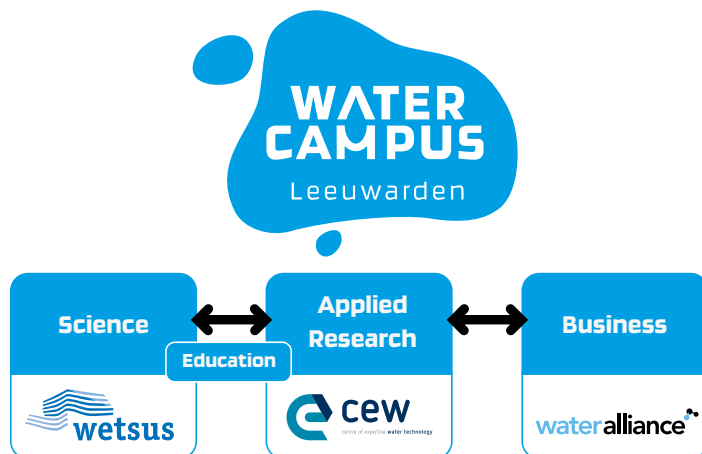
Wetsus' main objective is to develop (pre)competitive know-how with respect to water treatment technology, by bringing scientists and entrepreneurs together. It is crucial that this know-how is converted into successful, profitable innovations, not only to create business, but also to help solve the global water crisis. In this respect, the facilitation of start-ups and a stimulating climate and infrastructure for collaboration in the water sector are of great importance. This support is available for the entire water sector, so not just for Wetsus participants. The activities in this respect are described in this chapter.

## WaterCampus Leeuwarden

In order to stimulate know-how clustering and valorization, it is important that the critical mass of the international research program of Wetsus is embedded in a dedicated innovation ecosystem. Wetsus is located in Leeuwarden, the United Nations Innovating City for water technology and capital of the Dutch province of Fryslân. This province is characterized by a relatively high density of independently owned and globally exporting water companies. Together with Water Alliance ([www.wateralliance.nl](http://www.wateralliance.nl)) and the Centre of Expertise Water technology (CEW; [www.cew.nl](http://www.cew.nl)), Wetsus drives the development of WaterCampus Leeuwarden ([www.watercampus.nl](http://www.watercampus.nl)).



WaterCampus Leeuwarden is the physical core of the Dutch water technology sector and has the ambition to play a sector uniting role for the rest of Europe as well. WaterCampus stimulates cooperation between (inter)national businesses, knowledge institutes and governments within the water technology sector, in order to create synergy for world class innovation, education and entrepreneurship. This strengthens the global position of the European water technology sector. Additionally, WaterCampus offers a unique research infrastructure, and is a meeting point for scientists and companies from all over Europe and beyond.



## Education and applied research

The Centre of Expertise Water Technology (CEW) has started in 2011 on WaterCampus Leeuwarden as a centre for knowledge and innovation in water technology. CEW is a unique collaboration between universities of applied science, SME's, large technology providers, end users and local and national governments. The focus of the CEW is water technology research on higher technology readiness level (TRL 4-8). The CEW supports innovation by performing applied research projects in the laboratory, at demo sites or at the location of end users. The research is performed by students, teachers and experts, depending on the request of the customer. The CEW forms in that sense a valuable contribution in the knowledge chain from inventions to innovations. ([www.cew.nl](http://www.cew.nl); or contact Länk Vaessen; [l.vaessen@cew.nl](mailto:l.vaessen@cew.nl)).



In addition, the 'Centrum voor Innovatief Vakmanschap Water' (CIV Water) enhances and supports vocational education and training for water-related professions. In day school, but also in part-time education and tailor-made programs, the CIV collaborates in partnership with several companies in the water sector, the manufacturing industry, service, maintenance, etc. ([www.civwater.nl](http://www.civwater.nl) or contact Pieter Hoekstra: [p.hoekstra@civwater.nl](mailto:p.hoekstra@civwater.nl)).



## Shared Demonstration Sites and Facilities

For larger scale research and demonstration activities, it is not economically feasible to transport large quantities of specific water to a laboratory. Arranging "on site" testing however, is often time- and money consuming (piping, utilities, permits, etc. need to be arranged), if at all possible. To overcome this bottleneck and enhance the innovation chain, Wetsus, together with its WaterCampus Partners and other stakeholders, have realized several demonstration sites within a radius of 50 km around WaterCampus Leeuwarden. At these demosites, new concepts and technologies can be scaled up, tested, validated and demonstrated. The sites can be used according to the plug and play principle. The following sites are available:

- Wetsalt, demosite for sea water desalination technologies and Blue Energy at Frisia Zout, Harlingen. Contact: [j.moreno@cew.nl](mailto:j.moreno@cew.nl).
- SenTec demosite for drinking and surface water quality sensing in Glimmen. Contact: [h.prummel@wln.nl](mailto:h.prummel@wln.nl).
- Demosite for sewage water treatment in Leeuwarden. Contact: [yvanderkooij@weterskipfryslan.nl](mailto:yvanderkooij@weterskipfryslan.nl) or [j.moreno@cew.nl](mailto:j.moreno@cew.nl).
- Demosite for hospital waste water treatment in Sneek. Contact: [j.moreno@cew.nl](mailto:j.moreno@cew.nl) or [a.vanschellinga@gemeenteswf.nl](mailto:a.vanschellinga@gemeenteswf.nl).







With these sites, companies can accelerate the introduction of new technologies considerable. A good example is the DyVaR technology of the Salttech company. First “proof of concept” prototypes were demonstrated and validated at the Wetsalt demosite. The DyVaR technology is now sold worldwide and is winner of several innovation awards.

Further, the Water Application Centre for bench scale testing, available for commercial companies, has been developed in cooperation with Van Hall Larenstein (university of applied sciences) and local water companies. This centre, WAC, has opened its doors in 2013. ([www.waterapplicatiecentrum.nl](http://www.waterapplicatiecentrum.nl); [koos.oosterhaven@hvhl.nl](mailto:koos.oosterhaven@hvhl.nl) or [l.vaessen@cew.nl](mailto:l.vaessen@cew.nl))



## From inventions to innovations to business

Start-up companies and SME's are a crucial vehicle for the introduction of ground-breaking innovations into the market place. The continuous strive of Wetsus and WaterCampus Leeuwarden to stimulate the translation of know-how into business has resulted in several demonstration projects of new technological concepts and in the fact that 72 companies have started their business in and around WaterCampus Leeuwarden since 2003. Of these 72 companies, 36 are spin-off companies. Below an overview of these spin-offs is provided.



Wetsus and WaterCampus Leeuwarden enable start-ups and SME's in several ways:

- Matchmaking and access to the Wetsus and WaterCampus network (with partners, end users and universities)

- Creating an innovative and entrepreneurial environment
- Facilitating the access to seed and venture capital in a dedicated way for the water sector
- Working closely with organizations like Bison, EIP-Raw Materials, BeStart, NWP and Water Alliance. Entrepreneurs or inventors with early business ideas can be supported by these organizations. Bison supplies coaching and pre-seed capital
- Organizing business education (see next chapter) and co-offering the BeStart business accelerator program ([www.bestart.nl](http://www.bestart.nl); or contact Ronald Wielinga: [ronald@bestart.nl](mailto:ronald@bestart.nl))
- Supporting an incubator for spin-off's from Wetsus and universities and for other small water technology companies
- Facilitating the availability of research infrastructure; access to demo sites
- Stimulating the creation of joint-ventures for the further development, scale-up and commercial implementation of new technology

| Wetsus spin-off companies |  |
|---------------------------|--|
| • REDstack                | • Automatic Electric Europe Special Products |
| • DeSaH                   | • HydrOwashr                                 |
| • Westt                   | • Saltech                                    |
| • Aqua Explorer           | • Biotrack                                   |
| • Dutch Rainmaker         | • TailTec                                    |
| • EasyMeasure             | • ExtIns Technologies                        |
| • Water ProMaSys          | • Aiforo                                     |
| • Capilix (now: Metrohm)  | • Duplaco                                    |
| • Pure Green              | • Somut                                      |
| • Smart Frequencies       | • Wisect                                     |
| • Water Waves             | • Djipper                                    |
| • Metal Membranes         | • High Voltage Water (ended)                 |
| • AquaBattery             | • NewAna                                     |
| • Izer                    | • Lamp-ion                                   |
| • NX-Filtration           | • Aquacolor Sensors                          |
| • AppSen                  | • Evacon                                     |
| • Dutch Blackworms        | • Sensor Factory                             |
| • W&F Technologies        | • Water Future                               |



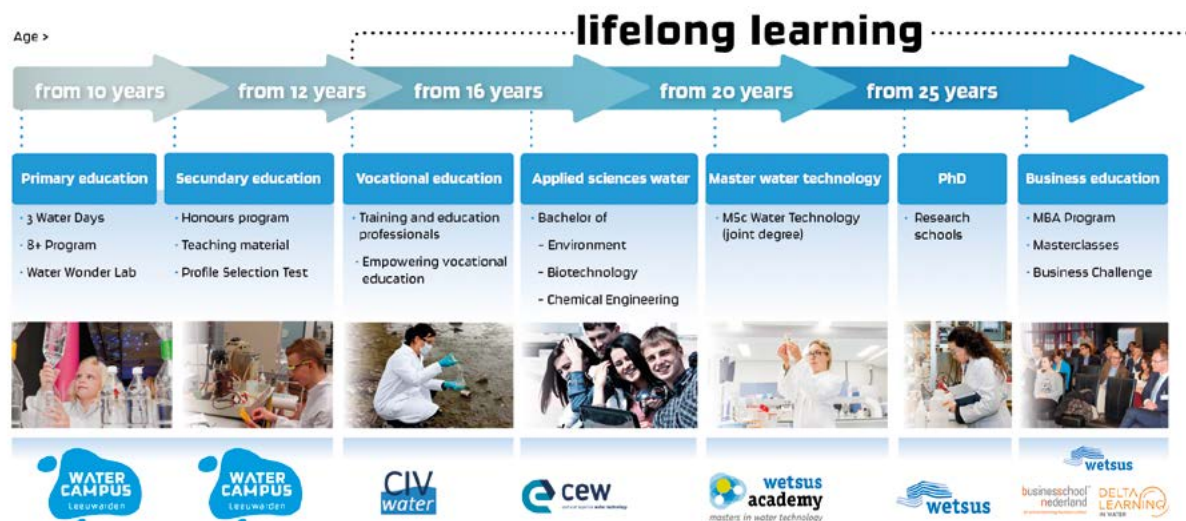
## Financial Facilitation

Venture Capital, Private Equity and other financiers can stimulate entrepreneurship around water technology significantly. Many funds, water companies and other investors are actively looking to add water technology propositions to their portfolio. Wetsus plays a role as matchmaker between financiers and water technology companies in need for capital. Frequently Wetsus and other WaterCampus partners welcome visitors from all over the world with a water technology investment interest. This has led to an interesting network of financiers and technology suppliers, which subsequently resulted in several real finance successes.

So, Wetsus and WaterCampus Leeuwarden have the ideal position to, in a neutral way, create a platform for water technology companies to showcase and demonstrate their innovation propositions to investors. This is structured in, among others, 'Financieringstafel Friesland'. Further, through Bison WaterCampus can financially support companies in the pre-seed phase. More information about financial facilitation can be found on [www.bison-powered.nl](http://www.bison-powered.nl) (or contact [albert.bosma@wetsus.nl](mailto:albert.bosma@wetsus.nl)).

# Human Capital and Education

In the education and talent fields, Wetsus closely cooperates with the other actors in WaterCampus Leeuwarden and with national organizations. The activities in this regard are summarized in the below scheme. Many of these programs are characterized by a STEM approach. STEM is based on the idea of educating students in four specific disciplines — Science, Technology, Engineering and Mathematics. Rather than teach the four disciplines as separate and discrete subjects, they are as much as possible integrated into cohesive learning models based on real-world applications.



## WaterCampus Talent Program

Together with the partners at WaterCampus Leeuwarden, Wetsus is dedicated to play an important role in the inspiration of young people to choose for a scientific or entrepreneurial career in which they can help solve the global water problems.

### Primary education

- **Water professor**; new theoretical ideas and empirical research show that very young children's learning and thinking are strikingly similar to much learning and thinking in science. Preschoolers test hypotheses against data and make causal inferences; they learn from statistics and informal experimentation, and from watching and listening to others. To stimulate this behaviour, Wetsus sends Water professors to primary schools. More than 750 schools have already been visited by the 'Water professor'.
- **Excellence program**; a unique course that offers 4 lessons which are adapted to the level of highly gifted students. The kids are challenged to solve world water problems, using technology..

### Secondary education

Together with teachers, researchers and companies, the Talent Program translates water technology to a level that allows youngsters to discover its impact and how it is applied in the sector. The results of this cooperation have led to the development of events, competitions, teaching material and a variety of programs, such as:

- **Honors Program**; a selected group of students is invited to work on their own research project at Wetsus, supported by a team of Wetsus PhD's. After one year of research the young researchers qualify for participation in an international Science Fair.
- **Lab Experience day**; twice per month a practical course 'water technology' is organized for 2nd grade students at Wetsus. The one-day course encourages research skills, cooperation, accuracy, 'out of the box thinking' and taking initiative.





- **Masterclasses;** students can receive support from PhD's or experts during their thesis or science projects. Masterclasses are offered to share the latest developments in science and water with the students enabling them to elevate the level of their projects.

## BSc Water Technology

Wetsus cooperates with 4 universities of applied sciences (Dutch HBO) in the Netherlands that have a minor in water treatment: Van Hall Larenstein, NHL Stenden Hogeschool, Hogeschool Zeeland and Saxion Hogeschool. Wetsus supports these institutes and their applied research water technology professors in several ways, in order to help them to continuously improve the curriculum, to connect them with the sector and to enable them to attract more and better students.



## European MSc Water Technology: Wetsus Academy

Wetsus offers an internationally unique master program in water process technology. Wageningen University, University of Twente and the University of Groningen started in 2008, in co-operation with Wetsus, a new master track Water Technology in order to combine research and education. In 2013 the involved universities and Wetsus have formally changed the mastertrack into a master program Water Technology with a joint degree. This way, Wetsus' research program is used simultaneously to educate new talents in the field of water technology. The quality of the Master was externally evaluated in 2018, resulting in the qualification 'good'.

Typically, the attended bachelor programs of the participating students are based on one discipline. The master program is based on multiple disciplines and thus requires a high level of (new) interdisciplinary knowledge assimilation and inquisitiveness from the student. Therefore, student recruitment emphasizes on quality (talent) more than quantity (number). Students register at Wageningen University, and will hence automatically be registered at the two other universities. After successful completion of the master program, students receive a joint MSc degree from the three universities.

## Business Education

Together with Delta Learning in Water and business school Netherlands (BSN), Wetsus launched an **Executive Water MBA** program that combines management issues with important water themes. The international water sector is facing several technical and societal challenges, such as climate change, water scarcity, environmental pollution, aging population, aging infrastructure and urbanization / mega cities. These challenges require multidisciplinary solutions. The future water managers therefore require more than just technical skills. The eMBA program addresses those needs and is tailored to the water technology sector.



**Ir. Nelleke van Doremalen**  
Program Director Wetsus Academy  
nelleke.vandoremalen@wetsus.nl



**Ronald Wielinga**  
Business Education  
ronald.wielinga@wetsus.nl  
tel. +31 6 121 38 876

Another initiative in the business education field is the **PhD Entrepreneur-program**. In this 3 day training program PhD-students take the first steps in transforming their innovative research ideas into a viable business plan and learn how to pitch this before an expert jury. The next step for the PhD students can be to join the European WaterCampus Business Challenge.

The **European WaterCampus Business Challenge** is a one week training program on water entrepreneurship, intended for students, startups and experienced professionals from all over Europe and beyond. This challenge is organized annually in close cooperation with entrepreneurs and specialists from the international water sector. During the program, participants work on their potential commercial business case that is ready for launching a (new) water product or service on (new) markets. The business challenge gives the participants an opportunity to interact with successful innovative technology providers, professional financiers and CEO's of all stakeholders in the water sector, who share their experiences with them.

In the **Resourcing Water program**, European startups with innovative ideas and concepts related to raw materials and water can get support in accelerating time to market of their innovative business cases. This startup program is a cooperation between EIT RawMaterials and Wetsus (WaterCampus) and may comprise of business education, accelerating programs, research facilities, network events and coaching.

Since 2016 Wetsus (WaterCampus) is supporting the **BeStart business accelerator program** ([www.bestart.nl](http://www.bestart.nl)). This program was launched in close cooperation with Omrin, Ecomunitypark and Paques and focusses on the clean tech sector. Annually 10 - 12 entrepreneurs are intensively coached and trained to make sure that the full potential of a startup company is utilized. Several spin-off companies of Wetsus already participate in this accelerator program.

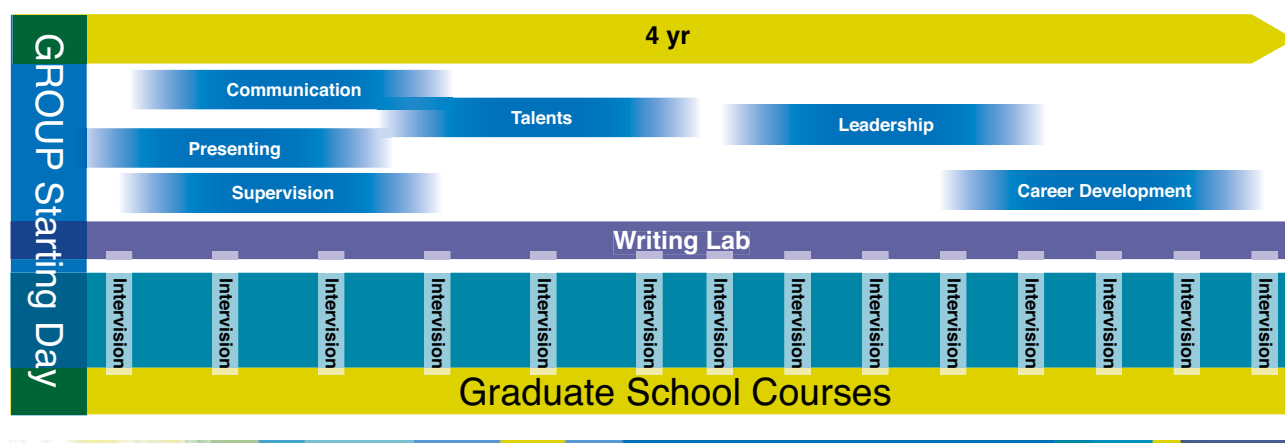
## PhD student recruitment

Since 2015 Wetsus recruits new PhD-students via a call system and a dedicated website [www.phdpositionswetsus.eu](http://www.phdpositionswetsus.eu). Twice a year, in March and September, a call with available PhD student positions is launched. The selection and recruitment of the candidates is via a 3 step selection process. The first selection is based on the required application documents. After selection, the remaining candidates are interviewed by means of a video call. The final selection is during a recruitment challenge held at Wetsus. On average, 50 applications are received per PhD position. This recruitment approach is integrated in the WaterSEED project, coordinated by Wetsus, which received funding from the European Union's Horizon 2020 research and innovation program (Marie Skłodowska-Curie Co-funding of regional, national and international programs).



## Doctorate Program for PhD-students

In addition to their university's graduate school courses, the Wetsus PhD-students follow the doctorate program of Wetsus. In this program, they not only learn how to work as excellent independent researchers, but also how to have impact on science and society. Personal development is a major part of this doctorate program. This is crucial as Wetsus has a challenging goal that requires not only high scientific standards, but also a high personal involvement. To work meaningful, commitment, spirit and free thinking are needed while curiosity, openness and astonishment are needed for groundbreaking accomplishments. Through our company partners a unique insight in innovation is experienced. Wetsus offers a specific training program which supports and nourishes the personal development of the PhD-students. During the 4 year doctoral program the PhD-students will follow the courses presented in the figure below.



# Wetsus Research

The world requires solutions to growing existing and new problems in the availability and quality of water for personal, agricultural, industrial use and nature. At the same time, the focus must be on sustainable solutions for these problems, requiring less energy, reusing valuable minerals and metals and low or no production of greenhouse gasses. Thereby, enabling higher water availability with a lower environmental footprint.

Traditional engineering solutions will not be able to provide solutions for these challenges that our society faces now and in the future. New water process technology will be necessary to develop new concepts to treat waste water and to produce clean water from alternative sources like salt (sea) water, waste water or humid air to minimize the use of precious groundwater.

The research objective of Wetsus is to develop innovative and sustainable water technology. In our vision, this technology must be:

- based on process technology
- a potential breakthrough solution
- emission free
- part of an endless cycle (cradle to cradle)
- introduced into society by entrepreneurs

As part of the Dutch Topsector Water approach within Wetsus research institutes and industry jointly implement market-driven, application-oriented, multidisciplinary, (pre)competitive scientific research in the field of sustainable water technology.

Wetsus focuses on research and development of entirely new concepts and on breakthrough improvements of existing technology. In both cases, an entirely new approach has been chosen whereby the basic principle is always the integration of various knowledge disciplines. In addition to collaboration between industry and universities, there is also unique scientific collaboration within Wetsus. Many scientific chairs from multiple scientific disciplines cooperate in the program. Leading researchers from various universities and other research institutes can physically work side-by-side in the Wetsus laboratory. This unique collaboration brings synergy and new creativity to the search for new sustainable water treatment technology.

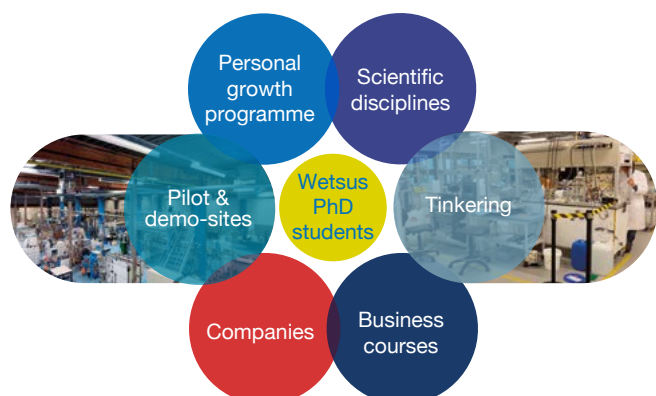
Not only new solutions are needed but also new minds that can develop and bring further breakthrough concepts. These future leaders of the sustainable water technology sector should have, next to high scientific standards, a high societal awareness. The interdisciplinary scientific nature of the Wetsus research and the intensive collaboration between companies and research institutes create a unique multi-faceted learning environment for this as shown on the right. A dedicated personal development program has been developed (on top of that of research school) to enable the PhD-student to develop personal skills required to make a meaningful contribution.



**Dr. ir. Bert Hamelers**  
Program director  
bert.hamelers@wetsus.nl

## Peer review scientific evaluation results 2017

|                  |  | score    |
|------------------|--|----------|
| <b>Quality</b>   | most influential and effective group in the world in its field | <b>1</b> |
| <b>Relevance</b> | outstanding contribution to society                            | <b>1</b> |
| <b>Viability</b> | excellently equipped for the future                            | <b>1</b> |



Research projects are defined within a research theme during an idea driven iterative process between the participating commercial parties and invited academic researchers. This leads to a clear business orientation combined with excellent academic quality of the research activities. The final project proposal is evaluated by the management board and by an independent program council. The program council, consisting of independent experts from the field, advises the management board on the project proposal based upon three pre-defined criteria. Based upon this advice, the management board decides on acceptance of the proposal after positive evaluation of its strategic fit in the program and its financial feasibility.

## Research proposal evaluation

After pre-selection by the relevant company participants, research proposals are evaluated on the following criteria:

- Scientific quality
- Innovation potential
- Composition of research team

## Research areas and scientific focus

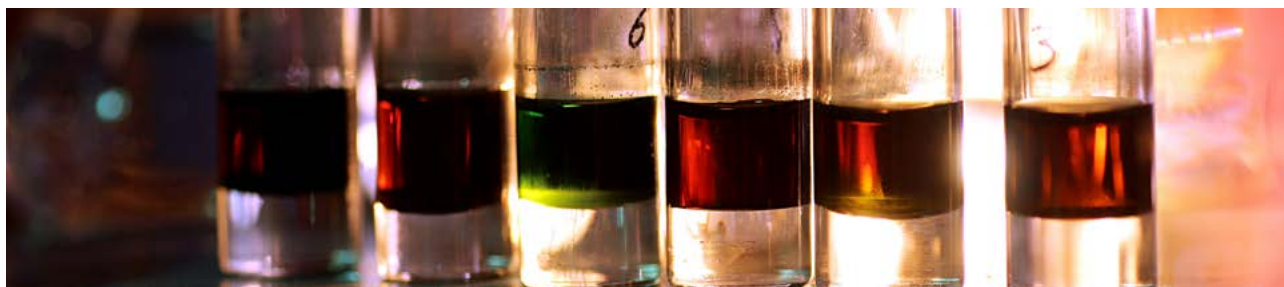
The research goal of Wetsus is to develop innovative and sustainable water technologies. Combining biological and chemical conversion technology with separation technology and new materials has high potential to develop important innovations in water technology especially if researchers work in close collaboration in one laboratory.

Despite the enormous importance of water technology for society it is not a focal point of most academic research groups. The expertise in various research groups is usually used for other processes and only later adapted for water treatment in spin-off projects. Within Wetsus the scientific expertise of different European knowledge institutes is pooled, leading to a bundling of monodisciplinary science and resulting in a world leading multidisciplinary research program on water technology.

In the program, in which 51 professors are connected, the focus is on the following five main research areas in clean water production and waste water treatment:

1. Sustainable water supply
2. Waste water treatment and reuse
3. New water sources
4. Reuse of components and production of energy
5. Detection of pathogens and micro/nano pollutants

The **Research Management Team** coordinates the research program. This MT has six members: Cees Buisman (chair), Bert Hamelers, Elmar Fuchs, Inez Dinkla, Jan Post and Roel Meulepas.



## Research program

The research program for 2016 – 2020 is defined in 23 research themes.

### Sustainable water supply

#### 1 | Applied water physics

The emphasis in this theme is on the physical interaction of water with external signals. For instance, application of a high electrical potential difference between two closely located glass beakers filled with de-ionized water leads to the formation of a so-called “floating waterbridge”. The physical principles that can describe this phenomenon are studied using advanced measurements (ultrafast fluorescence spectroscopy, neutron scattering, high-speed video imaging and analysis). The effect of other water treatment concepts that are based on physical interaction technology are further investigated in physical, chemical and biological model systems that have practical relevance. Any proven effect of the new water treatment concepts on the behavior of the model systems may result in new insights and (new) breakthrough technologies. Theme started: 2007.



## 2 | Biofilms

Biofilms consist of cells embedded in a polymeric extracellular matrix, mostly produced by the organisms themselves, which form the scaffold for a three-dimensional architecture that protects the microbial community from environmental and shear stresses. Biofilms are found in several environments, and play both beneficial and detrimental roles depending on whether their formation is controlled, or it occurs naturally.

Biofilm formation is a multi-stage process resulting from the balance of several physical, chemical and biological factors. At Wetsus, the Biofilms Theme focuses on a multi-level research approach to examine all these factors, as well as the various technologies to characterize, monitor, and control the biofilms growth. In this way, we aim to find practical solutions for industries, and a better understanding of both beneficial and detrimental forms of biofilms. In particular, elucidation of biofilm structure is a prerequisite to understand and to model the mass transfer and growth of cells within the sheltering extracellular matrix. Theme started: 2004.

## 3 | Groundwater technology

Our drinking water springs from the natural system of ground and surface water and extracting water from usable underground freshwater supplies is very important. Innovative research is needed to improve current operations but also gives bidding opportunities for the international market. An important reason to develop smart concepts for the development of the underground is the increasing pressure on available space. Theme started: 2008.

## 4 | Priority compounds & Virus control

Chemical-free and non-specific degradation and inactivation of human-originated trace contaminants into harmless products is the main focus of this theme. Two lines of research are pursued. Firstly, to develop effective and efficient chemical-free UV-based advanced oxidation technologies to produce safe drinking water from impaired water sources. Secondly, the goal is to develop instruments and methods for fast and simple process validation on log removal and log inactivation values. Lack of sensitivity of operational monitoring may otherwise reduce the log credits that can be claimed. Theme started: 2009.

## 5 | Smart water grids

The network of drinking-water pipelines in the Western world is very extensive. However, it varies in age and many different materials and laying methods have been used. Generally the condition of the network is hard to gauge because it is underground. New technologies are vital to allow inspection of the condition of pipelines and appendages at low cost. Developments such as (ultrasonic) sound, magnetic wave and radar technologies are very relevant. The ambition for this theme is to develop methods for the in-line and on-line inspection of pipelines, to make well-founded decisions about the possible replacement of pipelines. Theme started: 2009.

# Waste water treatment and reuse

## 6 | Advanced water treatment

The emphasis in this theme is on new sustainable water purification technologies to remove salt, priority compounds, biological material and other contaminants, as stated in the Water Framework Directive. New water treatment technologies are investigated based on physical, electrical and electrochemical principles. These principles can include molecular transport in electrical fields, magnetic, photonic and acoustic driving forces, or driven by pressure. Technologies presently studied are UV-LED reactors, in-situ formed membranes, and reverse osmosis. Theme started: 2007.

## 7 | Concentrates

Membrane filtration and ion exchange chromatography are both proven technologies in the food & beverage and process water industry. They have major advantages over traditional methods: excellent product quality, limited use of chemicals and the simultaneous removal of a variety of contaminants. The disadvantage, however, is the production of a concentrated salt liquid waste product.

Current practice is to discharge the concentrate stream into the sewer system or directly to surface water. This can lead to exceeding the (local) emission standards. Increasingly strict emission standards (including the European Framework

Directive on Water) means that more sustainable recycling techniques must be found. Also in the oil and gas industries, concentrated salt streams are found. They are produced during the exploration of oil and gas and their salinity exceeds that of sea water. The theme is focused on finding solutions for membrane concentrates, ion exchange reclaim and concentrated salt industrial effluents. The research is aimed primarily at: technologies to remove (and preferably reuse) specific components such as salts and anti-scalants, concepts for the reuse of concentrates in agriculture and industry, and technologies to reduce the volume of the concentrates. Theme started: 2007.



## 8 | Natural flocculants

In this theme the focus is on the development of natural alternatives for synthetic organic polymeric flocculants for treatment of surface waters or wastewaters. These alternative flocculants should overcome the disadvantages of synthetic polymers: produced from scarce fossil sources, non-specific, non-biodegradable and produce large amounts of (toxic) waste that cannot be reused in e.g. agriculture. Mixed extracellular polymers produced by microorganisms during biological wastewater treatment not only are more sustainable than synthetic polymers, indications are that they also can give a better flocculation performance. Moreover, possibly in combination with physical separation technology such as membrane treatment, natural flocculants have a potential application to remove particles in drinking water, to produce industrial process water from fresh or saline surface and waste waters, to treat oil-containing wastewaters, to separate algae from their medium in algae cultivation systems, to assist in the retention of valuable biomass in biological wastewater treatment processes, etc. Theme started: 2004.

## 9 | Source separated sanitation

Source separation sanitation (SSS) is a concept in which waste streams with specific characteristics (e.g. urine, faeces, greywater, hospital waste streams) are collected, transported and treated separately at the source. Hospital wastewater, for instance, contains about 10 fold the concentrations of pharmaceuticals in municipal wastewater and is considered an important source of antibiotic resistant bacteria. By treating (hospital) wastewater at the source the risks associated to wastewater can be addressed more specifically and effectively, thereby preventing the spread of antibiotic resistant bacteria and other pathogens in the population and discharge of toxic components into the environment. Furthermore, sustainability objectives such as water reuse, recovery of resources and energy savings can also be more effectively reached within SSS. The main advantage is that source separation prevents dilution of wastewater streams. New technology must be developed to treat these concentrated waste water streams. For the treatment of hospital wastewater it is important to remove antibiotics and to develop a disinfection technology in which bacteria are not only killed but their DNA is destroyed. Theme started: 2004.

## 10 | Sulfur

This theme focuses on integrated processes for removal and conversion of volatile sulfur compounds from aqueous solutions. These aqueous are used to scrub volatile sulfur compounds from oil and gas and have a high pH and salt concentration. The process scheme consists of scrubbers and bioreactors and aims at removal of all volatile sulfur compounds like sulfide and thiols (e.g. methanethiol). The water consumption of this process can become zero by treating the bleed stream enabling recycling of all water. The scientific disciplines needed for development of such an integrated process are chemistry, microbiology, biotechnology and modeling. Theme started: 2011.

# New water sources

## 11 | Capacitive deionization

Capacitive electrosorption with activated carbon electrodes is a new and promising technique that has important advantages when compared to existing techniques for removing salts from water. Capacitive deionization combines a high salt removal efficiency with low use of energy, virtually no chemical requirement and simple and robust operation. In this theme this technology is further developed. Theme started: 2004.

## 12 | Dehydration

This theme focuses on enhancing the efficiency of dehydration processes. A key element for enhancing this efficiency is selective water vapor removal. This enables small scale water production systems that can produce water directly from air at the location where it is needed. The approach is to use water vapor selective membranes to separate water directly from air before cooling it. In this way only the water vapor is condensed without producing cold air. By this means up to 60% of energy could be saved reducing the price of water significantly. The quality of water is improved drastically as no pollutants can permeate the membrane.

Super critical CO<sub>2</sub> is applied in food drying technology as alternative to hot air drying, vacuum drying or freeze drying. However, continuous operation of such process requires efficient dehydration of the pressurized CO<sub>2</sub> stream. Water vapor selective membranes are used to efficiently separate water from a CO<sub>2</sub> stream. Membrane development is needed to produce membranes which are resistant against CO<sub>2</sub>. Theme started: 2009.

## 13 | Desalination

To face the current and future demands for fresh water and water reuse, sustainable desalination of seawater and treatment of groundwater and wastewater is required. New technology is needed, with the capacity to remove the salts and to recover them in a reusable form. Low energy use and prevention of harmful chemical discharge are further demands for sustainable desalination. In this theme, the focus is on the development of desalination technologies for sea water, brackish water and waste water. In this theme, several desalination technologies are applied and combined together, such as electrochemistry, supercritical water, crystallization, membrane separation, and adsorption in for instance ionic liquids. Theme started: 2004.

## 14 | Natural water production

The theme natural water production aims at enhancing precipitation and in this way making more fresh water available. The key to enhancing precipitation is to increase evaporation and increase the water recycling in a watershed. To make this vision a reality, a strong interdisciplinary program is under construction, including disciplines like meteorology, hydrology, forestry and water technology. Theme started: 2019.

## Reuse of components and production of energy

### 15 | Biopolymers from water

Wastewater treatment most often involves the use of biological processes to reach effluent water quality objectives. The by-product of biological treatment is a surplus biomass that is rich in microbial activity. Research has shown that it is possible to engineer biological treatment processes for both municipal and industrial wastewater to be naturally enriched with bacteria that can store an excess of biopolymers. The biopolymers are from the family of polyhydroxyalkanoates (PHAs). PHAs are biodegradable thermoplastic materials that are attractive ingredients for bioplastics. The status of current know-how provides for an interesting opportunity of synergy to combine water quality management services with resource recovery and the realization of new biopolymer value chains in regional circular economies. Research in this theme is to build on and bridge fundamental bioprocess engineering and materials science with downstream commercial opportunities for platform chemicals and bioplastics. The theme is an incubator to reach optimal insights and strategies to produce value added biopolymers for industry in combination with the ongoing demands for increasingly more effective wastewater treatment methods. Theme started: 2017.

### 16 | Blue energy

Sustainable energy production is a huge challenge in our world. Obtaining energy from environmental resources will play an important role in future energy supply. For example, electricity can be produced from advanced mixing of salt and fresh water in a process called reverse electro dialysis, or blue energy. In this visionary theme ionic current technologies are developed in which electrochemistry, membrane technology, and process technology are combined in the research program. Theme started: 2004.

### 17 | Phosphate recovery

Phosphate is an important fertilizer needed for food production. The sources are finite and mining and processing of the ore is an energy intensive and polluting process. An appreciable part of the phosphate in food ends up in the wastewater and manure. Currently chemicals and energy are used to remove the phosphate from the wastewater as emissions from phosphate to the surface water is unwanted. This theme focuses on technologies to remove phosphate from wastewater in such manner that the phosphate becomes available as fertilizer and the water will be clean. The theme will focus on expanding and improving current technology so that more phosphate can be at lower costs, while producing high value products. Theme started: 2013.

### 18 | Protein from water

The theme Protein from Water aims to develop technologies to upgrade nitrogen and other nutrients from wastewater and manure into valuable microbial proteins. The theme focuses on technological breakthroughs needed to create sustainable and economically production of single cell proteins and to ensure product safety. High-quality microbial proteins will be produced efficiently at high rate and can be applied as a substitute for proteins in the feed and food chain originating from soy and fish. This concept has the potential to revolutionize the water-energy-food nexus. Compared to current food production, less land and less water is needed while off-peak electricity can be used. Theme started: 2015.

### 19 | Resource recovery

In this theme new technology related to the harvesting of energy and valuable compounds from waste water is developed. Ionic current technologies will be combined with physical and chemical technology to specifically recover compounds and produce energy. With technologies involving microbial fuel cell and biocatalyzed electrolysis, electricity or hydrogen is produced from waste water. Hydrogen production from biocatalyzed electrolysis makes a much wider variety of waste waters suitable for energy harvesting. This is a revolutionary breakthrough technology in the field of biological hydrogen production from waste water. Ionic current technologies have the possibility to combine energy generation with separation. For instance ammonia can be separated from urine and used as a fertilizer or as a fuel for additional electricity generation. Biological conversion of soluble sulfur compounds can be combined with metal recovery in a single process. Co-precipitation with in situ generated precipitants like iron oxides makes it possible to adsorb or include compounds like selenate. Selective recovery of components via specifically designed adsorbents are necessary to recover only the compounds of interest. The adsorption/desorption cycles need to be reversible and independent of other chemicals. Preferably light or electricity driven regeneration of the adsorption material is used to enable chemical-free regeneration of adsorbents. Development of technology to develop these advanced materials is necessary to specifically recover compounds from waste water in an economical and sustainable way. Theme started: 2004.



## 20 | Soil

Soil fertility is a central parameter in the global ecosystem, linking water, food and nutrient flows. Soil erosion and declining soil fertility present a significant threat not only to food production, but also to fresh water availability and carbon storage. Soil organic matter plays an important role in the buildup of healthy soil in terms of soil structure and biological activity. To strengthen circular economy approach, organic streams such as sewage sludge, animal manures and agricultural plant residues can be used to recycle organic matter and nutrients back to soil. Treatment of organic matter is required to reach appropriate biochemical conditions for soil application. The scope of this theme is to define the most suitable form of organic matter addition, required treatment concept and the interactions between the organic matter and soil components with respect to micro-organisms, organic carbon and nutrients/minerals. Theme started: 2016.

## 21 | Sustainable carbon cycle

Interest in Carbon Capture and Utilization (CCU) has been growing recently, i.e. the development of technologies to remove CO<sub>2</sub> from flue gas and from the atmosphere, and use the captured CO<sub>2</sub> as a working fluid, or as a source of carbon.

At Wetsus, the Sustainable carbon cycle theme aims to develop energy-efficient technologies to capture CO<sub>2</sub> from the atmosphere and from renewable sources, and convert the captured CO<sub>2</sub> into valuable chemicals. Our research focuses on electrochemical methods based on new electrode materials, ion exchange membranes, and new reactor design. The SCC theme builds on the long research experience at Wetsus in the field of applied electrochemistry for salinity gradients, capacitive deionization (CDI), and energy recovery from flue gas (CO<sub>2</sub> energy). Theme started: 2015.

# Sensing of micro/nano pollutants

## 22 | Genomic based water quality monitoring

The application of direct cell counts (microscopic and flow cytometry) has shown that the culturable microorganisms in water are only presenting a fraction of the total microbial population (<1%) and that most of the cells seem to be active. Drinking water sources, treatment and distribution have an enormous impact on the (micro) biological composition/quality of the drinking water produced and distributed. The main question is whether it is possible to predict and control the changes in biological quality and stability of drinking water caused by changes in drinking water processes. Within this theme the focus will be on generating fingerprints (sometimes called barcoding or barcodes) of the complete microbial population present in (drinking) water based on Next Generation Sequencing (NGS). With this the effect of disturbances on the fingerprint can be examined and indicator organisms/markers can be characterized. The final aim is to develop applications for a precise (online) monitoring/control of water quality and water treatment processes. Theme started: 2013.

## 23 | Sensing

The Sensing theme of Wetsus focuses on the development of devices for monitoring the quality (composition) of water, whether that is, surface water, drinking water or industrial waste water. The motivation to develop reliable water quality sensors is twofold. First, from the point of view of public health, safe drinking water is of utmost importance. Secondly, the quality of discharged industrial waste water is more and more dictated by governmental regulation, implying the need to strictly control its quality. The technology applied within this research theme ranges from microfluidics combined with Raman spectroscopy to (waveguide) laser optics and acoustics. Whatever the technique and whatever it is a sensor to detect pathogens or chemical toxins, the challenge always is to develop a system that operates on-line and continuously, sensitive, fast and cheap. The currently used method of culturing and plating out in order to test for the presence of pathogens may serve as an example. This analysis is laborious and takes a couple of days, requires skilled personnel and therefore is rather expensive. The alternative we work on is based on an on-line recording able not only to test for the presence of just a single bacteria cell in 10 ml of water but, in addition, also identifies the particular bacteria species we are dealing with. Theme started: 2006.

# Research staff of Wetsus

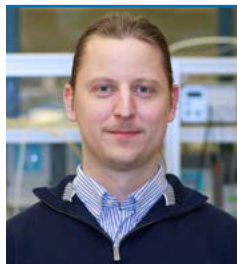
## Research Management team



**Prof. dr. ir. Cees J.N. Buisman**  
Member executive board  
cees.buisman@wetsus.nl



**Dr. ir. Bert Hamelers**  
Program director  
bert.hamelers@wetsus.nl



**Dipl.-Ing. Dr. Elmar C. Fuchs**  
Program manager, theme coordinator  
Applied water physics  
Specialization: physical and theoretical chemistry, experimental physics  
elmar.fuchs@wetsus.nl



**Dr. ir. Jan W. Post**  
Program manager, theme coordinator  
Desalination, Priority compounds & Virus control  
Specialization: drinking water technology  
jan.post@wetsus.nl



**Dr. Inez Dinkla**  
Program manager, theme coordinator  
Genomic based water quality monitoring, manager microbiology laboratory  
Specialization: environmental microbiology and molecular biology  
inez.dinkla@wetsus.nl



**Dr. ir. Roel Meulepas**  
Program officer, theme coordinator  
Groundwater technology, patent coordinator  
Specialization: Industrial waste water treatment, metal recovery  
roel.meulepas@wetsus.eu

## Theme coordinators



**Dr. Michel Saakes**  
Resource recovery, Blue energy  
Specialization: electrochemistry, bio-electrochemistry, fuel cells, batteries  
michel.saakes@wetsus.nl



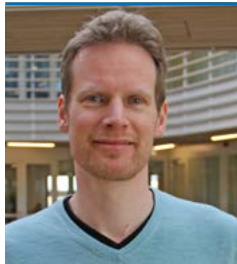
**Dr. Henk Miedema**  
Dehydration  
Specialization: (biological) membrane transport  
henk.miedema@wetsus.nl



**Dr. ir. Hardy Temmink**  
Natural flocculants  
Specialization: waste water technology  
hardy.temmink@wetsus.nl



**Dr. ir. Maarten Biesheuvel**  
Capacitive deionization, Concentrates, Advanced water treatment  
Specialization: electrochemical process modeling, physical chemistry of soft matter, fuel cells, ion-exchange membranes  
maarten.biesheuvel@wetsus.nl




**Dr. ir. Doekle Yntema**  
Smart water grids  
Specialization: physics, specialization on electronics, micromechanics and acoustics  
doekle.yntema@wetsus.nl



**Dr. Lucia Hernandez**  
Source separated sanitation  
Specialization: environmental engineering, decentral sanitation  
lucia.hernandez@wetsus.nl



**Ir. Leon Korving**  
*Phosphate recovery*  
 Specialization: phosphate recovery and reuse, sludge dewatering, sludge treatment, environmental engineering, thermal waste treatment, gas cleaning  
[leon.korving@wetsus.nl](mailto:leon.korving@wetsus.nl)



**Dr.ir. Tom Sleutels**  
*Protein from water*  
 Specialization: bioprocess technology, (bio-)electrochemistry  
[tom.sleutels@wetsus.nl](mailto:tom.sleutels@wetsus.nl)



**Dr.ir. Martijn Wagterveld**  
*Sensing*  
 Specialization: crystallization, microfluidics, electronics, acoustics  
[martijn.wagterveld@wetsus.nl](mailto:martijn.wagterveld@wetsus.nl)




**Dr.ir. Jan Klok**  
*Sulfur*  
 Specialization: bioprocess technology, gas desulphurization  
[jan.klok@wetsus.nl](mailto:jan.klok@wetsus.nl)




**Dr. Cristina Gagliano**  
*Biofilms*  
 Specialization: environmental anaerobic microbiology, fluorescence microscopy, extracellular polymeric substance  
[cristina.gagliano@wetsus.nl](mailto:cristina.gagliano@wetsus.nl)



**Dr.ir. Valentina Sechi**  
*Soil*  
 Specialization: soil ecology, trophic interactions and functional traits  
[valentina.sechi@wetsus.nl](mailto:valentina.sechi@wetsus.nl)




**Dr. Alan Werker**  
*Biopolymers from water*  
 Specialization: bioprocess and environmental engineering, water quality, mixed microbial cultures, polyhydroxyalkanoates, materials science  
[alan.werker@wetsus.nl](mailto:alan.werker@wetsus.nl)



**Dr. Michele Tedesco**  
*Sustainable carbon cycle*  
 Specialization: electrochemical process modelling, ion exchange membranes, (reverse) electrodialysis  
[michele.tedesco@wetsus.nl](mailto:michele.tedesco@wetsus.nl)


## Senior advisors




**Dr. Renata D. van der Weijden**  
 Specialization: biogeochemistry and mineral recovery  
[renata.vanderweijden@wetsus.nl](mailto:renata.vanderweijden@wetsus.nl)



**Dr.ir. Antoine Kemperman**  
 Specialization: membrane fouling, membrane water treatment, membrane bioreactors  
[antoine.kemperman@wetsus.nl](mailto:antoine.kemperman@wetsus.nl)

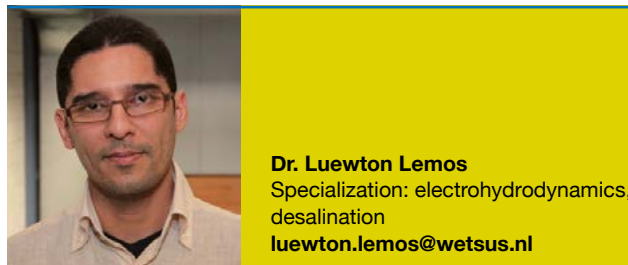
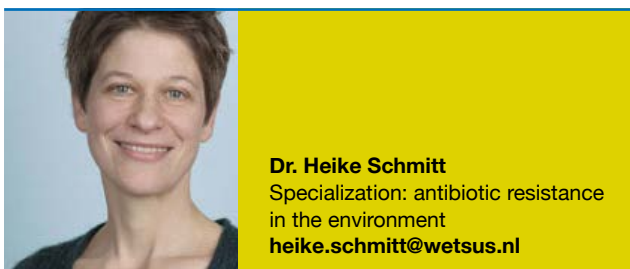


**Dr. Caroline Plugge**  
 Specialization: general and applied microbiology of aquatic ecosystems  
[caroline.plugge@wetsus.nl](mailto:caroline.plugge@wetsus.nl)

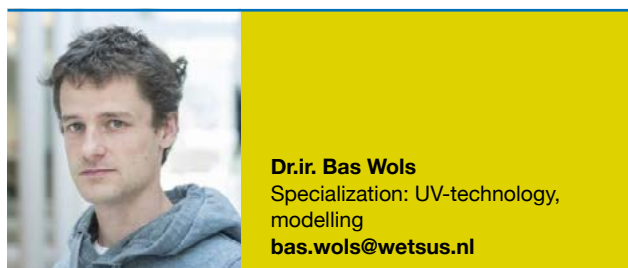
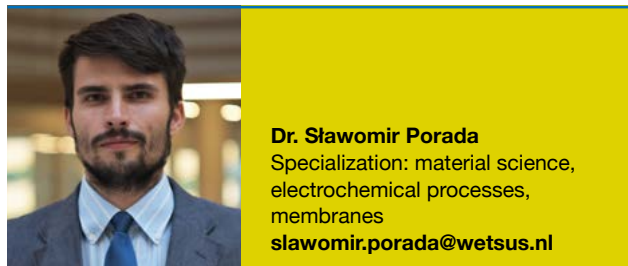


**Prof.dr.ir. Karel Keesman**  
 Specialization: system identification, modelling, control, water treatment  
[karel.keesman@wetsus.nl](mailto:karel.keesman@wetsus.nl)

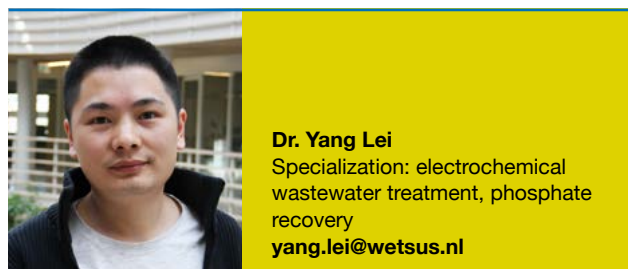




## Scientific project managers



## Postdoctoral researchers



## Researchers



**Ir. Wokke Wijdeveld**  
Specialization: mineral processing  
and urban mining  
[wokke.wijdeveld@wetsus.nl](mailto:wokke.wijdeveld@wetsus.nl)



**Erik de Vries MSc, MBA**  
Specialization: biotechnological  
processes and bioplastics  
[erik.devries@wetsus.nl](mailto:erik.devries@wetsus.nl)



**Ragne Pärnamäe MSc**  
Specialization: electrochemical  
impedance spectroscopy and bipolar  
membranes  
[ragne.parnamae@wetsus.nl](mailto:ragne.parnamae@wetsus.nl)





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