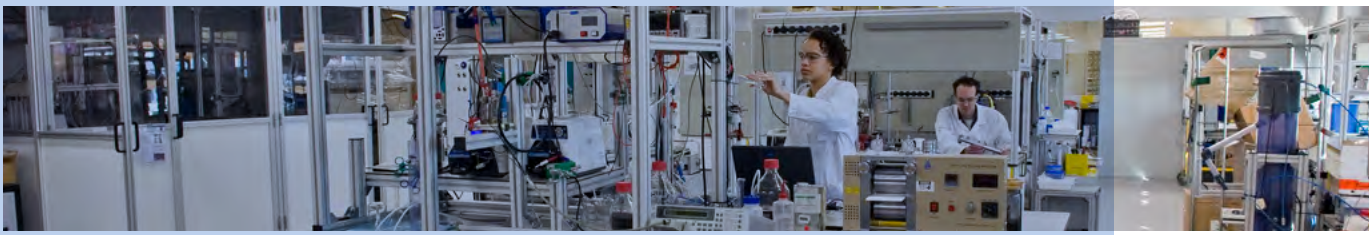
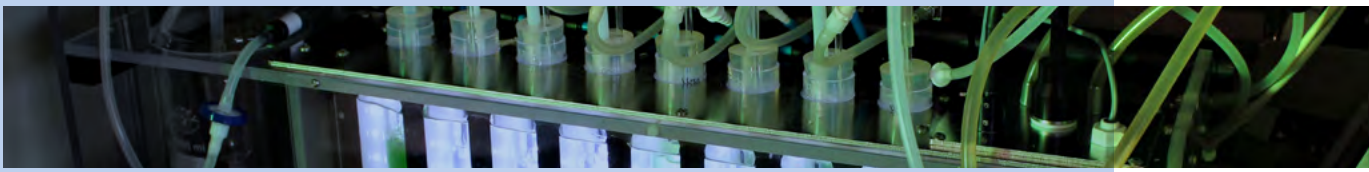
wetsus

european centre of **excellence**
for sustainable **water technology**





Wetsus 2024

combining scientific excellence with commercial relevance

SBO-instituut

Dutch Institute for Strategically Important Research

Wetsus, European Centre of Excellence for Sustainable Water Technology

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WATER CAMPUS Leeuwarden

Wetsus is cofunded by

- Dutch Ministry of Economic Affairs and Climate Policy
- Dutch Ministry of Education, Culture and Science
- Dutch Ministry of Infrastructure and Water Management
- TKI-Water Technology (Topsector Water & Maritime)
- European Union (Horizon Europe, Horizon 2020, EIT)
- Wageningen University, University of Groningen, University of Twente, NHL Stenden
- City of Leeuwarden, Province of Fryslân

Ministry of Education, Culture and Science
Ministry of Economic Affairs and Climate Policy
Ministry of Infrastructure and Water Management

WATER & MARITIME
RISING CHALLENGES, SMART SOLUTIONS

NWO

Introduction

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

Since the start in 2003, Wetsus has aimed at combining scientific excellence with commercial relevance. For this, it has developed a unique multidisciplinary open innovation model for water technology, bringing together companies and universities. Independent scientific and economical evaluations confirm the success and added value of the Wetsus model for science, innovation, economy, sustainability and society, illustrated by Wetsus' track record of high scientific quality and production, the large number of patents used in society and the extensive network of long-term connected partners. Innovations resulting from the Wetsus program contribute significantly to the solution of global water problems.

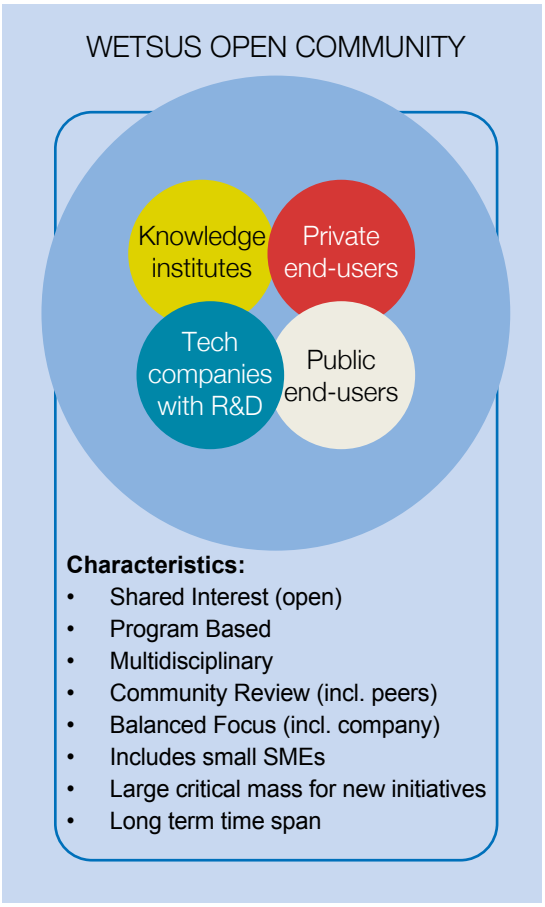
Wetsus is organized around its aim to stimulate collaboration between the various public and private organizations that together constitute the water sector: i.e. between public companies, private companies and universities; between scientific chairs; and between regional, national and European policy makers. The Wetsus Open Community Cooperation Model (see figure) creates the synergy and momentum required to achieve major objectives. As per January 1, 2024, 105 companies annually invest some € 3.4 million in the demand driven € 16 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. In 2022, the Dutch government has appointed Wetsus as national institute for strategically important research (Dutch: SBO-instituut). 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 26 involved research institutes. All research projects are performed under the scientific responsibility of the participating universities. As per January 2024, 48 scientific chairs from all over Europe are involved.

Within the (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



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

Wetsus Mission

Wetsus develops key enabling water technologies to foster a sustainable and fair society in a healthy and circular environment.
To achieve this, Wetsus creates an innovation community via trust-based networks of companies, universities and public bodies for generating, testing, and evolving innovative ideas and science based approaches within interdisciplinary PhD programs that shape innovations towards fruitful implementation, and where graduates become leaders in sustainable innovation.

technologies. The scientific creativity required for that is to a large extent generated by the unique cooperation of over 50 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 has proven to lead to successful innovations.

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

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 acceleration by WaterCampus Leeuwarden

Regarding involvement in policy and programs for innovation, Wetsus is active on regional level (smart regional specialization in the Northern Netherlands), national level (direct involvement in national topsector Water & Maritime and TKI water technology) and European level (as member of Water Europe, ERRIN and the Water4All partnership, and as coordinator or partner in Horizon Europe, Interreg and LIFE projects).

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. Further, 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.

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, agriculture, health, 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 due to poor water quality and insufficient availability
  - Pollution, population growth, wealth and climate change lead to decreasing availability of safe, freshwater
  - Economic instability and food insecurity due to decreasing water availability for agriculture and industry
  - Conventional water technologies are usually not circular; raw materials, water and energy are often wasted
  - Absence of safe drinking water, irrigation water and sanitation in large parts of the world is causing immense stress and tension (as described in the UN Millennium Development Goals)
- Business-market combinations: innovative companies providing sustainable enabling water technology will be leading in the highly competitive 150 billion dollar world market of water technology.
- State-of-the-art science and process technology: multidisciplinary approaches from, e.g., nano-technology, bio-sciences, separation technologies, artificial intelligence, 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

Enabling water technology enables industries to keep on producing (economic value) without depleting water resources, while regenerating the environment. The development of such technology gives the water tech industry involved a competitive edge. Wetsus focuses on four impact areas where novel technology is expected to generate the biggest benefits: sustainable water, healthy environment, recovered resources and drought resilience.

sectors however, often is difficult and inefficient. 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'. Above this is graphically illustrated.

Demand driven cooperation model

The Wetsus research program is divided in themes, which essentially are Intellectual Property clusters. Typically, per theme some 4 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, Wetsus Executive Board; johannes.boonstra@wetsus.nl).

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

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

Company participants

Companies participate in Wetsus per research theme. Knowledge resulting from pre-competitive research defined and co-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 2024, companies from, Australia,

Austria, Belgium, Canada, Denmark, Finland, France, Germany, India, Ireland, Monaco, USA, Sweden, Switzerland, China and the Netherlands participate. Much attention will be given to further internationalization, particularly in Europe.

As per January 2024, the following rates apply for theme participation (these rates are subject to inflation correction):
Company Participants: € 32,900/theme/year
Company Participants, turnover of less than € 3 million/year: € 19,800/theme/year

For state-owned companies based outside the European Union different rates apply.

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.
Platform participation is often used as a first step into Wetsus for companies who are not yet sure in which Wetsus research theme(s) they want to participate. As Platform participant companies get acquainted with Wetsus and the research program, and from that basis they can make a motivated choice to 'upgrade' to theme participant.
The 2024 annual rate for platform participation ranges from € 3.950 (company turnover < € 1.5 million/year) to € 9,250 (turnover < € 3 million/year) to € 13,200 (turnover > € 3 million/year).

Know-how institute participants

The 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 Europe and the rest of the world. Access to research facilities of 26 research institutes and a very large scientific network are important added advantages of this approach. As per 2024, 48 principle investigators and professors from 26 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 all up-to-date information about the organization, events and the research program can be found. Dedicated information for participating companies and universities is published on a closed section of the website, with exclusive access for participants. For (future) PhD's we offer www.phdpositionswetsus.eu and for the master track www.masterwatertechnology.nl.

Percentage of company participants that experience positive effects from Wetsus participation (Evaluation 2022)

	%
Increased turnover	33
New products/technologies	40
New products/technologies within 5 years	93
Improved products/technologies	47
Expansion of own research	47

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 the Wetsus YouTube channel.

Meetings, congresses and webinars, 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), Wetsus co-organizes the European Water Technology Week, in which the Wetsus Congress is integrated.

Hester Henstra
Manager communication and PR
hester.henstra@wetsus.nl

Participants (January 2024)

wetsus

Platform participants (January 2024)

Know-how Institute Participants (January 2024)

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 cooperation 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 representatives 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. Biannualy, 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 2024 (more information: 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 ten members. Four members are appointed by company participants, four members are appointed by knowledge institutes and the supervisory board is completed by 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 € 16 million per year is available.

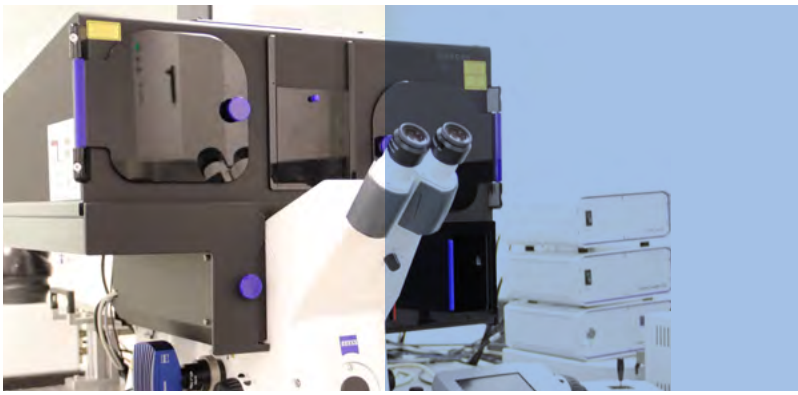
Ed Nijpels
Chair supervisory board

Albert Bosma
Controller
albert.bosma@wetsus.nl

Facilities

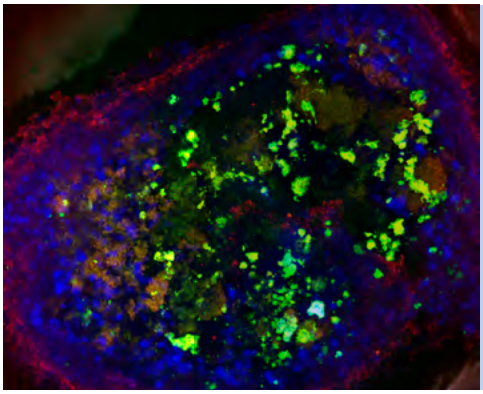
Wetsus has moved into its landmark building early 2015. In this inspiring building, situated on WaterCampus Leeuwarden, all Wetsus activities are concentrated. The highest standards in water and energy sustainability have been applied, leading to a BREAAM Excellent classification of the Wetsus building.

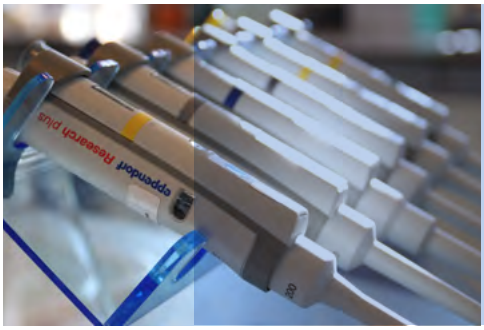
Wetsus has its own state-of-the-art research infrastructure and dedicated staff to operate these facilities. Almost the entire research program is carried out in the laboratories of Wetsus. The researchers can also use research infrastructure of the Wetsus participants. To maintain and expand the Wetsus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

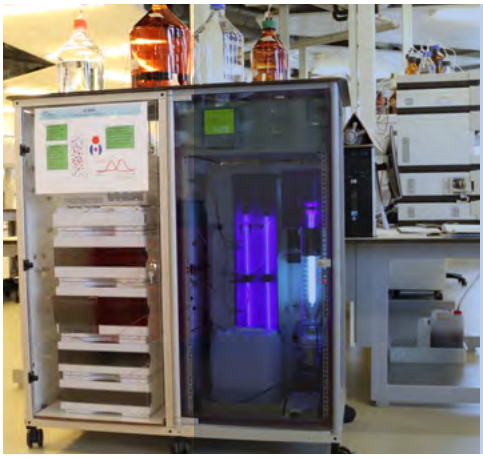


Analytical equipment

- µ-GC (biogases)
- Absorbance/fluorescence/ luminescence plate reader
- AFM (atomic force microscopy)
- CO2 precision analyzers
- CLSM (confocal laser scanning microscopy)
- CPD (critical point dryer for SEM)
- Critical point dryer
- DSC (differential scanning calorimetry)
- Dynamic and monotonic titration systems
- EA (elemental analyzer)
- Flowcytometer (total and targeted cell enumeration)
- FT-IR (composition of solids, liquids)
- GC-FID
- GC-FPD
- GC-MS/MS (with pyrolysis & autosampler station)
- Gel electrophoresis (DGGE, DNA, protein)
- Gel imaging system
- High-speed camera and image acquisition
- IC (ion chromatography of anions, cations & fatty acids)
- ICP-OES (elemental analysis, microwave digestion)
- ICP-MS (trace level elemental analysis)
- LC-MS/MS
- LC-OCD (organic carbon detection)
- Microscopy: Brightfield, DIC, fluorescence (inverse and upright), phase contrast
- Minlon (mobile long-read sequencing)
- Nanodrop spectrophotometry (nucleic acid quality assessment)
- OCT (optical coherence tomography)
- Particle sizing 1-1000 nm AF4-MALS hyphenated to ICP-MS
- Particle sizing (50-1500 nm, including zeta potential)
- qPCR (quantitative real-time polymerase chain reaction)
- Quantus (fluorometer for nucleic acids and proteins quantification)
- Raman spectrometry
- Rheometer
- SEM-EDS (scanning electron microscopy combined with elemental analysis)
- Surface area and porosity analyzer
- TGA (thermogravimetric analysis)
- Thermocycler for PCR (polymerase chain reaction)
- TOC (total organic carbon analyzer)
- UHPLC UV/VIS
- Vacuum filtration systems
- Viscosity meter







Research facilities

- -80 °C freezer
- Amplicon sequencing
- Anaerobic glove box
- Automated research fume hoods with PLC and SCADA
- Automatic film applicator
- Ball mill
- Bead beater with cryolys cooling system (mechanical cell disruption)
- Biobench algae flatpanel reactor systems
- Biofouling monitors with and without water production
- Biological safety cabinets (HEPA filtered)
- Black water, urine and water storage tanks
- Climate unit/Indoor Plant Growth Room
- CNC mill
- Continuous and batch reactors
- Cooling and heating compartments
- Cutting plotter
- Soldering station
- Doppler echo imaging system
- Extruder for bioplastics
- Fermentation equipment
- Filament and resin 3D printers
- Flat sheet membrane production
- Freeze dryer
- Fully equipped electrotechnical station
- Fully equipped optical lab facility
- GAP fume cabinets
- Gas and sewage water distribution network
- High voltage lab
- High-speed cooled centrifuge
- Hot rolling press/calendering machine
- Knife mill
- Labopress (molding and pressing)
- Laboratory eStretching machine / membrane spinning device
- Laboratory information management system (LIMS)
- Laser cutter
- Metagenomics
- ML-II level advanced microscopy lab
- ML-II level microbiology lab
- Multi-channel potentiostats
- Nanofiltration system (pilot scale)
- Online process control
- Respirometer
- Safety precaution measurements and systems
- Safety vacuum drying oven
- Shaking incubators (hot, cold, light)
- Sonication equipment
- Temperature monitoring system (sample quality control)
- Transcriptomics (RNA sequencing)
- Tube furnace
- Ultra Turrax homogenizer
- Ultrasonic underwater inspection system
- Walk-in fume cupboards
- Welding equipment for foils and exotic metals
- Whole-genome sequencing
- Moisture analyzer

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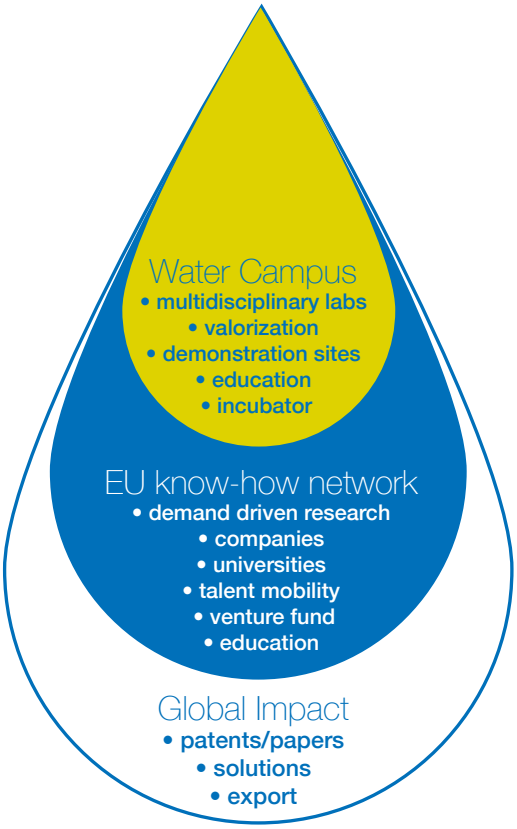
International cooperation

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 to us and our partners. Wetsus' international activities are placed in a regional, national, European and 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 300 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 as a science and innovation institute in a region without a university. Wetsus has transformed from a national science institute into Europe's main spark plug for water technology innovation. The combination of a long-term focus, the concentration of the multidisciplinary core activities in a physical place and the committed connection of an international professional network, has been essential to realize this.

The amount of international companies and institutes in Wetsus is increasing, currently about 25% of the partners is non-Dutch. Further Europeanisation is enhanced by participation in European research and innovation projects, under programs such as Horizon Europe, EIT, Interreg and LIFE. Wetsus and WaterCampus also actively participate in Water Europe, ERRIN and the European Partnership Water4All. All 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

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start-ups have increased, industry is long-term committed and world class research is achieved. Wetsus strives to be the most integrated innovation program for this emerging industry in the world. The impact of Wetsus is multiplied by funding synergies between local, regional, national and EU programs.

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 EWTW2022 three-day program was very well received by the 500 attendees per day. Overall, some 700 individual participants from 31 countries were present. During EWTW2024, September 23 - 26, the water tech sector will meet and inspire each other again 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, 61% of the scientific staff, researchers and students are from outside the Netherlands (from 34 different countries). In addition, on a regular basis the connected professors and the R&D managers of company members meet 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 Sklodowska-Curie projects EMPOWER and RecaP further enhance the attractiveness of Wetsus for international talent. Calls with vacancies are published on www.phdpositionswetsus.eu.

Wetsus Values

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

Performance Indicators Wetsus

	cumulative until 2020*	2020 realized	2021 realized	2022 realized	2023 realized	2024**	2027
Finance and commitment							
Program Budget (mln €)		14,3	14,8	14,9	**16,2**	14,8	15,3
Company Contribution (mln €)		3,4	3,4	3,4	**3,4**	3,5	3,6
Science Progress							
Science projects started (PhD/postdoc) (cumulative)	247	6	21	51	**67**	58	97
Papers total (cumulative)	703	66	137	197	**255**	248	404
Citation Impact (-1y)		2,6	1,8	3,0	**2,7**	>1,5	>1,5
Competitiveness							
Number of spin-off companies (cumulative)	36	2	4	8	**10**	8	13
Number of patents generated (cumulative)	88	2	5	8	**13**	14	23
Number of patents transferred (cumulative)	37	3	3	6	**6**	12	18
Number of SME companies in program (turnover < 100 mln €)		51	57	57	**55**	55	56
Novel/Patented Technologies from idea to pilot (cumulative)	24	3	5	7	**9**	10	14
Participants using Wetsus know-how in existing products (%)		46			**47**		
Innovation Community							
Number of participating companies (active)		105	113	109	**104**	109	112
Number of principle investigators and professors (cumulative)	101	53	56	63	**74**	70	83
Trust & Cooperation valued by partners (grading scale 1-10)		8			**8,6**		
Future Innovation Leaders							
Ph.D. Graduates (cumulative)	108	12	23	33	**46**	61	97
Joint Degree Msc graduates (cumulative)	123	15	25	35	**45**	97	157
Research Students (non-PhD) (cumulative)	803	60	114	167	**231**	425	725

* The cumulative values until 2020 have been realized in the 2004-2019 Wetsus program
** Values as of 2024 are targets from businessplan 2021-2023

Innovation Ecosystem

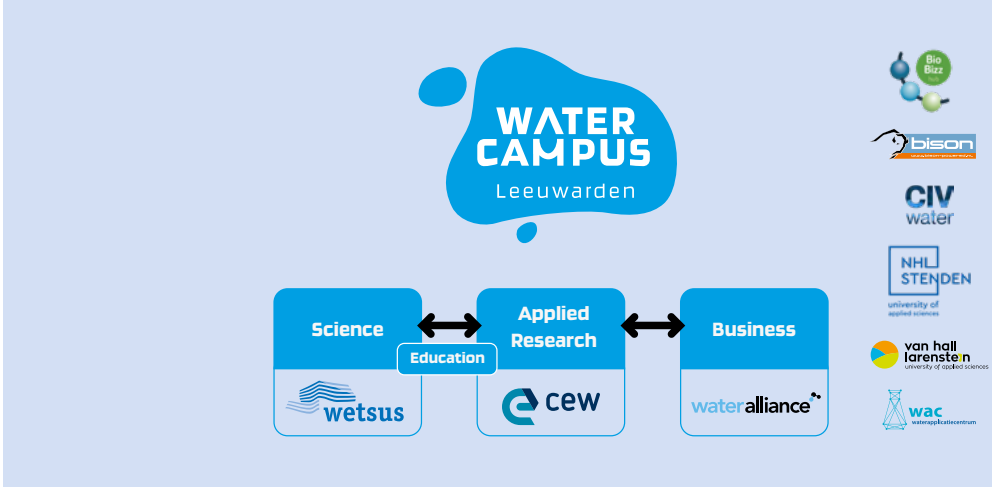
Wetsus' main objective is to develop (pre) competitive know-how with respect to water treatment technology, by bringing scientists and entrepreneurs together.

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) and the Centre of Expertise Water technology (CEW; www.cew.nl), Wetsus is one of the main pillars of WaterCampus Leeuwarden (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. It 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 centre is water technology research on higher technology readiness level (TRL 4-8). By performing applied research projects in the laboratory, at demo sites or at the location of end users, CEW supports innovation. 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 or contact Länk Vaessen; 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 or contact Pieter Hoekstra: p.hoekstra@civwater.nl).

cew centre of expertise water technology

CIV water

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, 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.
- SenTec demosite for drinking and surface water quality sensoring in Glimmen. Contact: h.prummel@wln.nl.
- Demosite for sewage water treatment in Leeuwarden. Contact: sgerbens@wetterskipfryslan.nl or j.moreno@cew.nl.
- Test facility for hospital waste water treatment in Sneek. Contact: j.moreno@cew.nl




With these sites, companies can accelerate the introduction of new technologies considerably. 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, companies can test their new innovations on bench scale at the Water Application Centre.

This centre, abbreviated as WAC, has been developed in cooperation with Van Hall Larenstein (university of applied sciences) and local water companies. (www.waterapplicatiecentrum.nl; koos.oosterhaven@hvhl.nl or l.vaessen@cew.nl).

wac
waterapplicatiecentrum

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 valorize new know-how into business has resulted in a large number of demonstration projects of new technological concepts. Further, 99 water technology companies have started their business in and around WaterCampus Leeuwarden since 2003. Of these 99 companies, 46 are spin-off companies from Wetsus. Below an overview of these spin-offs is provided.

Wetsus and the other partners in WaterCampus Leeuwarden created the right conditions and instruments to allow companies to emerge from the ecosystem (start-ups) and to grow (start-ups and SMEs). WaterCampus helps companies to bring an invention to an innovation and successful business. The structure of this support is set-up along 5 pillars:

- Access to talent: WaterCampus offers education programs in science and entrepreneurship to increase the availability of skilled talent (new employees) on all educational levels and to train the entrepreneurs of the future;
- Access to market: the WaterCampus ecosystem gives startups and innovative companies access to the most connected water technology network in the world and, via this network and facilitation programs, to the international market for water technology;
- Access to capital: at WaterCampus startups

and innovative companies have access to a variety of investors and funds to help them to bring their technology to the market and scale up (inter)nationally;
- Access to knowledge: WaterCampus is the gateway to all knowledge, networks and cooperation programs that are necessary for turning an innovative idea into a successful breakthrough innovation;
- Access to facilities: WaterCampus offers access to unique physical facilities (eg laboratories, demosites, incubator, etc.) that are necessary for optimally developing, scaling up and market-launching new technologies, products and services.

Wetsus spin-off companies		
REDstack	Automatic Electric Europe Special Products (ended)	DeSaH
HydrOwashr	Westt	Salttech
Aqua Explorer	Biotrack	Dutch Rainmaker
TailTec (ended)	EasyMeasure	Ynovio BV
Water ProMaSys (ended)	Aiforo	Capilix (now: Metrohm)
Duplaco	Pure Green	Somut (ended)
Smart Frequencies	Wisect	Water Waves
Djipper	Metal Membranes (ended)	High Voltage Water (ended)
AquaBattery	NewAna	Izer
Lamp-ion	NX-Filtration	Aquacolor Sensors
AppSen	Evacon	Dutch Blackworms (ended)
Sensor Factory	W&F Technologies	Water Future
Protodromics	Hytoxgen (ended)	Galama Sustainable Solutions
Hulo	Aquature	Nautic Waterloo
SeaO2	Aqa.earth	VerSi Watertech
DualSoil		

More information about the WaterCampus entrepreneurship program and business support opportunities can be obtained at www.watercampus.nl/entrepreneurship-portal, or by contacting Ronald Wielinga (r.wielinga@watercampus.nl).

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 funders and technology suppliers, which has subsequently resulted in several finance successes.

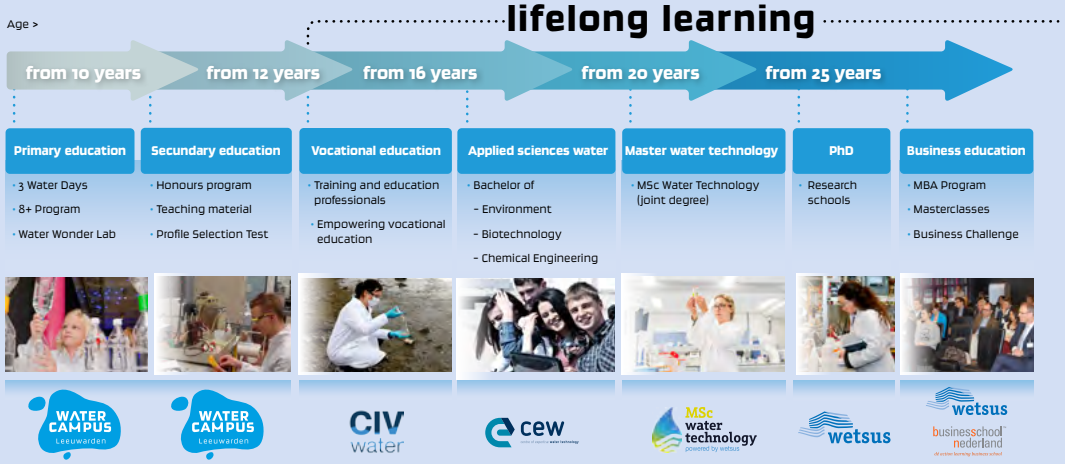
So, Wetsus and WaterCampus Leeuwarden have the ideal position to, in a neutral way, create a platform for water technology companies to showcase and demonstrate their innovation propositions to investors. This is structured in, among others, 'Financieringstafel Friesland'. Further, in 2021 we started the NEW-project together with partners Deltares, University of Groningen and the NOM. The NEW-plan offers support for early stage startups. For example with the NEW-fund that invests around 6 million euros in promising early stage startups the coming years. In addition, 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 (or contact albert.bosma@wetsus.nl).

NEW ttt Netherlands Enabling Watertechnology

bison www.bison-powered.nl

Human Capital and Education

In the education and talent fields, Wetsus closely cooperates with the other actors in WaterCampus Leeuwarden and with several other national organizations. The activities in this regard are summarized in the below scheme. All programs are characterized by an integrated science, technology, engineering, and mathematics – STEM – approach.



WaterCampus Talent Program

Together with the partners at WaterCampus Leeuwarden, Wetsus plays 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**; Scientific research shows 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 behavior, Wetsus sends 'Water Professors' to primary schools for a three-day inspiration program. One of these days the students visit a water tech site to experience real-life examples of what it looks like to solve world water problems. In the past years, more than 850 Water Professor visits have been made to primary schools.
- **Excellence program**; a unique course that offers four lessons which are adapted to the level of highly gifted students. The kids are challenged to solve world water problems, using technology. In one of these lessons, experiments are performed in the Wetsus lab.

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:

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- **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 researchers. After one year of research the young researchers qualify for participation in an international Science Fair. And if qualified, they can spend two more years on their project – teaching younger students the ins and outs of doing research.
- **Lab Experience day**; twice per month a practical course 'water technology' is organized for 2nd grade high school students, aged fourteen to fifteen. The one-day course, held at Wetsus, encourages research skills, cooperation, accuracy, out-of-the-box thinking and taking initiative.

- **Masterclasses**; Masterclasses are offered where students can receive support from PhD researchers or experts during their thesis or science projects. Furthermore, students and teachers are encouraged to do their own research with the help of various toolkits, that allow for independent and curriculum-extending STEM programs..

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.

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European MSc Water Technology:

Wetsus hosts an internationally unique master program in water process technology. The curriculum was conceived with the idea of creating a multidisciplinary MSc program with a clear scientific and technological approach, embedded in the top-class research environment of Wetsus.

Today the MSc water technology program aims at the education of new talents capable to face the increasing challenges in this field. The program is based on several scientific disciplines which are involved in the Wetsus research program. The students are trained to acquire a high level of (new) interdisciplinary knowledge and inquisitiveness. The quality of the Master was externally evaluated in 2018, resulting in the qualification 'good'.

The MSc Water Technology is a joint degree provided by Wageningen University, University of Twente and the University of Groningen. Students of this program are required to register at Wageningen University and will then be automatically registered at University of Twente and the University of Groningen. After successful completion of the master program, the students receive a joint MSc degree from all three universities.

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PhD student recruitment

Wetsus recruits new PhD students via a call system and a dedicated website **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 proceeds via a 3-step selection process. The first selection is based on the application documents. The remaining candidates are interviewed by means of a video call. The final selection takes place during a recruitment challenge held at Wetsus. On average, 65 applications are received per PhD position. This recruitment approach was

developed as part of two Marie Sklodowska-Curie projects coordinated by Wetsus, WaterSEED and EMPOWER, which received funding from the European Union's Horizon 2020 research and innovation program.

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. In addition, a unique insight in innovation is experienced by the PhD students through their intensive cooperation with our company participants.

Business Education

In order for startups to emerge and develop into healthy companies, WaterCampus offers several programs to stimulate and enhance entrepreneurship.

As part of the Wetsus PhD Development Program, PhD's are offered the possibility to join the **Business Development Course**. In this 4-day training program PhD researchers 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. For this program Wetsus has a close collaboration with the Sustainable Entrepreneurship program of the University of Groningen. The next step for PhD researchers with the ambition to develop a sustainable business, 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, PhD researchers, 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.

Together with the University of Groningen and Deltares, Wetsus launched the **Netherlands Enabling Water technology (NEW) program**. The aim of this initiative is valorization of scientific research in concrete solutions to tackle international water challenges and to create impact. NEW offers, among other things, a cohesive one-year business development program for knowledge starters called VentureLab, which is the perfect link between the European WaterCampus Business Challenge and the BeStart Accelerator.

BeStart
BOOSTING CLEANTECH

Wetsus (WaterCampus) is co-founder of the **BeStart business accelerator program** (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 have already successfully participated in this accelerator program.

Together with Business School Netherlands (BSN), Wetsus launched an **Executive Water MBA** program that combines business and management issues with important water themes. The graduated MBA-candidates are especially interesting for growing companies that need more management experience. The eMBA program addresses those needs and is tailored to the water technology sector. The PhD students recruited at Wetsus under the EMPOWER project will combine their PhD research project with the eMBA training; they will graduate with the broad skillset needed to bring about innovation in the water sector. The eMBA program is open for everybody interested.

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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 gases. Wetsus wants to create enabling water technologies that allow for societal value creation while supporting and regenerating a sustainable world.

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 integrated concepts to treat wastewater and to produce clean water from alternative sources like salt (sea) water, wastewater, 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 the Wetsus Research Program research institutes and industry jointly implement market-driven, application-oriented, multidisciplinary, (pre)competitive scientific research in enabling water technology.

Wetsus focuses on research and development of entirely new concepts and on breakthrough technology improvements. 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 experts from other research institutes and participating companies 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

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Peer review scientific evaluation 2023	
Scientific quality	‘Excellent’
Societal relevance	‘Most effective academic-industry collaboration’ ‘Significant economic and societal impact’
Viability	‘The future of Wetsus is sound and very promising’

of the sustainable water technology sector should have a high societal awareness next to high scientific standards. 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 implemented to enable the PhD student to develop personal skills required to make a meaningful contribution.

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 and 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, advices the management board on the project proposal based on three criteria. The management board then decides on acceptance of the proposal after a positive evaluation of its strategic fit in the program and its financial feasibility.

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 a high potential to develop important innovations in water technology, especially if researchers collaborate closely in one laboratory. Furthermore, environmental science, assisted with artificial intelligence and sensors, is required to validate the potential and inspire applications of enabling water technology for regenerating ecosystem functioning.

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 the research team

Despite the enormous importance of enabling 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 applications 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 diverse excellent science disciplines with key technologies and resulting in a world-leading multidisciplinary water technology research program.

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

In the research program, in which over 60 professors are connected, the focus is on the following four main research lines for enabling water technology contributing to:

Sustainable Water: Sufficient and safe water supply by developing chemical-free and natural treatment, drastically reducing the use of chemicals and energy.
Healthy Environment: Protecting our health and our environment by developing advanced (bio) sensors (incl. networks), integrated via Artificial Intelligence, enabling advanced monitoring, control, and management of assets and open water systems
Recovered Resources: Enabling the recovery of, among other things, polymers, macro- and micronutrients, energy, and metals from diluted water and waste flows.

Drought resilience: Developing technological concepts for restoring water cycles and degraded lands to re-establish the balance in the water cycle.

In order to enhance the impact and efficacy of innovation, the Wetsus Research Program incorporates **Social Sciences** as part of its initiatives since 2023.

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 is currently defined in 22 research themes.

Sustainable water

1 | Advanced water treatment

This theme emphasizes 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 selectivity in membrane transport for organic micropollutants and salt ions to treat various water, driven by electricity or pressure, and molecular degradation in biologically activated porous media. Technologies presently studied are reverse osmosis, nanofiltration, multilayer membranes, and biologically activated carbon-based filtration and conversion.
The theme started in 2007.

2 | Source separated sanitation

Source separation sanitation (SSS) is a concept in which waste streams with specific characteristics (e.g., urine, feces, greywater, hospital waste streams) are collected, transported, and treated separately at the source. Hospital wastewater, for instance, contains about tenfold the concentrations of pharmaceuticals in municipal wastewater and is considered an essential source of antibiotic-resistant bacteria. Treating (hospital) wastewater at the source can address the risks associated with wastewater more specifically and effectively, thereby preventing the spread of antibiotic-resistant bacteria and other pathogens in the population and the 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 the dilution of wastewater streams. New technology must be developed to treat these concentrated waste water streams. To treat hospital wastewater effectively, the aim is to remove antibiotics and develop a disinfection technology in which bacteria are inactivated, and their DNA is destroyed. The theme started in 2004.

3 | 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. The theme started in 2009.

4 | Desalination & Concentrates

Sustainable desalination of seawater, groundwater and wastewater is required to face the current and future demands for freshwater and water reuse. Wetsus focuses on research and development of innovative, sustainable, and cost-effective desalination technologies that are complementary or substitutionary to state-of-the-art thermal or membrane desalination techniques.

These new technologies can be incorporated into closed-loop water treatment schemes, or mineral extraction schemes. Key aspects the PhD projects contribute to are (i) low-impact desalination (energy and chemical use), (ii) specific removal of ions that limit downstream processing or water reuse, (iii) recovery of water and/or valuable organics and inorganics from (saline) wastewater, and (iv) brine treatment towards zero liquid discharge. Wetsus is studying several new approaches based on various know-how disciplines. Technologies include capacitive deionization, electrodialysis, nanofiltration, extraction, and crystallization. Fields like electrochemistry, crystallization, membrane separation, extraction, and adsorption are combined in the research projects. The theme started In 2004.

5 | Dehydration

The 'Nutrition Targets' set by the World Health Organization and the 'Sustainable Development Goals' defined by the United Nations emphasize the urgency to remedy the malnutrition of still too many people. Sustainable ways to do so include the transition from animal to plant-based proteins, e.g., those that can be sourced from beans, peas, and lentils, all known for their richness in proteins. In addition, proteins or other valuable substances can be recovered from streams previously considered as waste, e.g., the wash water produced during the processing of potatoes and sugar beets. The added benefit is a much more sustainable practice that also adds to the manufacturer's product portfolio. Different separation technologies will be explored to address these questions. The two (low-temperature) dehydration technologies already represented in the Dehydration theme, Eutectic Freeze Crystallisation and Super Critical CO2, are well suited, especially for food products containing heat-sensitive proteins. The theme started in 2009.

6 | Applied water physics

The emphasis of the Applied Water Physics Theme lies in the exploration of these basic properties of water, especially its interactions with electric, magnetic and electromagnetic fields, vortical flow fields, and the effect of such interactions on living organisms like bacteria. Based upon deeper insights into the fundamentals of water, the Theme furthermore focuses on screening commercially available water treatment concepts based upon such interaction. Thereby breakthrough discoveries through fundamental research and pioneering screening experiments with physical, chemical and biological model systems are combined to pave the way for the development of seminal, epoch making water treatment technologies. The theme started in 2007.

7 | Natural flocculants

In this theme, the focus is on developing natural alternatives for synthetic organic polymeric flocculants for the treatment of surface water or wastewater. 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 micro-organisms during biological wastewater treatment are more sustainable than synthetic polymers, and indications are that they can also 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. The theme started in 2004.

8 | Biofilms

Biofilms consist of cells embedded in a polymeric extracellular matrix, produced mainly by the organisms, forming 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

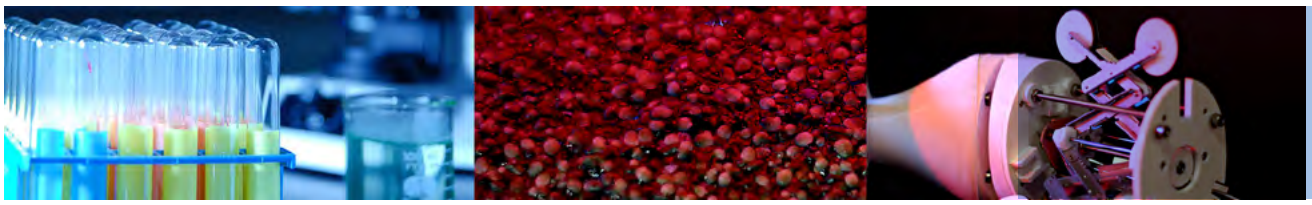
detrimental roles depending on whether their formation is controlled or occurs naturally.
Biofilm formation is a multi-stage process resulting from the balance of several physical, chemical, and biological factors. At Wetsus, the Biofilms Theme focuses on a multi-level research approach to examine all these factors and the various technologies to characterize, monitor, and control 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 understanding and modeling cell mass transfer and growth within the sheltering extracellular matrix. The theme started in 2004.

9 | Advanced coagulation for nanoparticles

Conventional water treatment processes are very well suited to remove particles. However, the smaller particles get (micro- and nanometre-sized), the harder they are to remove. Still, a significant part ends up in effluent and eventually in the environment. The chemical composition (e.g. plastic particles) and size cause these particles to be unwanted in the environment. Their small size allows uptake and accumulation in aquatic life, eventually posing a risk to human health. New technologies are urgently required to address the problem of nanoparticles and to remove them from water effectively. This theme focuses on a more sustainable approach in conventional water treatment techniques, such as coagulation/flocculation, to remove nanoparticles. We will develop enhanced coagulation approaches to aggregate, especially the fraction of the smallest nanoparticles, allowing their effective removal through standard flocculation and floatation approaches. The theme started in 2022.

10 | Integrated PFAS treatment

Elevated concentrations of Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are increasingly detected in waste streams, raising concerns regarding their potential adverse impacts on human health and the environment. These compounds exhibit remarkable stability and resistance to biodegradation, rendering their removal and degradation particularly challenging in water treatment processes. The combination of these properties makes that these compounds are of concern in water treatment, as removal (for example by adsorption) and degradation are both challenging. We will develop a scheme with novel adsorbent materials implemented in high-throughput filters, including regeneration of the filter before breakthrough, and a thermal reductive step to mineralize the PFAS-concentrated regenerate solution. The theme started in 2024.



Healthy environment

11 | Groundwater technology

Our drinking water springs from the natural system of ground and surface water and extracting water from usable underground freshwater supplies is essential. 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 underground is the increasing pressure on available space. The theme started in 2008.

12 | 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 a 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. The theme started in 2009.

13 | Sensoring

The Sensoring theme of Wetsus focuses on developing devices for monitoring water quality (composition). The envisioned sensor devices and sensor networks should measure online and continuous, be sensitive, reliable, fast, and low-cost. Applications can be found in drinking water, industrial (waste)water, and surface water. The technologies and methods applied to this research theme are very diverse and interdisciplinary. Measurements can be specific, e.g., micropollutants (pesticides/herbicides /

pharmaceuticals), ions, bacteria, or other toxins, or measurements can be focused on obtaining a fingerprint of the water quality. Sensors are more than the measurement principle only. It also involves signal conditioning, the interface, and how to interpret data (converting data to information). Networks of sensors make it possible to combine data to increase accuracy, sensitivity, or the number of parameters measured (sensor fusion and soft-sensing), but can provide additional challenges such as the need for self-powering, self-calibrating, and self-cleaning sensors. All of this is tackled in the Sensoring theme to improve water quality.
The theme started in 2006.

14 | Genomic based water quality monitoring

The application of direct cell counts (microscopic and flow cytometry) has shown that the culturable micro-organisms 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 greatly impact 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 whole 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 precise (online) monitoring/control of water quality and treatment processes.
The theme started in 2013.

Recovered Resources

15 | Sulfur

This theme focuses on integrated processes for removing and converting 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 to remove 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 the recycling of all water. The scientific disciplines needed to develop such an integrated process are chemistry, microbiology, biotechnology, and modeling. The theme started in 2011.

16 | Phosphate recovery

Phosphate is an important fertilizer needed for food production. The sources are finite, and mining and processing the ore is energy intensive and polluting. An appreciable part of the phosphate in food ends up in 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 a manner that the phosphate becomes available as fertilizer and the water will be clean. The theme will focus on expanding and improving current technology to produce more phosphate at lower costs while producing high-value products. The theme started in 2013.

17 | Resource recovery

In the Resource Recovery theme, new electrochemical technologles are developed to harvest resources from water. An example ls the recovery of nitrogen from waste streams like urine and industrial wastewater in the form of ammonia converted to, e.g., ammonium sulphate. Another focus is the electrochemically harvesting of phosphate from waste streams from the dairy industry, in the form of hydroxyapatite. As a continuation of studies on microbial fuel cells and microbial electrolysis cells, the bio-anode is studied in case of intermittent control to improve store of energy in the biofilm. Bio-anodes can also be used for a biological cell for harvesting of ammonia.
The theme started in 2004.

18 | Biopolymers from water

Wastewater treatment most often involves using biological processes to reach effluent water quality objectives. The by-product of biological treatment is surplus biomass rich in microbial activity. Research has shown that it is possible to engineer biological treatment processes for municipal and industrial wastewater to be naturally enriched with bacteria that can store

excess 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 an interesting opportunity for 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 the industry in combination with the ongoing demands for increasingly more effective wastewater treatment methods. The theme started in 2017.

19 | Sustainable carbon cycle

Interest in Carbon Capture and Utilization (CCU) has been growing recently, i.e. the development of technologies to remove CO2 from flue gas and the atmosphere, and use the captured CO2 as a working fluid or source of carbon. At Wetsus, the Sustainable carbon cycle theme aims to develop energy-efficient technologies to capture CO2 from the atmosphere and from renewable sources, and convert the captured CO2 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 (CO2 energy). The theme started in 2015.

Drought Resilience

20 | Soil

Soil fertility is a central parameter in the global ecosystem, linking water, food, and nutrient flows. Soil erosion and declining soil fertility pose a significant threat to food production, freshwater availability, and carbon storage. Soil organic matter plays a vital role in the buildup of healthy soil in terms of soil structure and biological activity. To strengthen the circular economy approach, organic streams such as sewage sludge, animal manures and agricultural plant residues can recycle organic matter and nutrients back to the soil. Organic matter treatment 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, the treatment necessary and the interactions between the organic matter and soil components concerning micro-organisms, organic carbon, and nutrients/minerals. The theme started in 2016.

21 | Natural water production

The theme natural water production aims to enhance precipitation and make more freshwater available. The key to enhancing precipitation is to increase evaporation and water recycling in a watershed. To make this vision a reality, a strong interdisciplinary approach Is taken, including disciplines like meteorology, hydrology, forestry, and water technology. The theme started in 2019.

Social Sciences

22 | Sustainability in the making

Wetsus aims for responsible water technology innovations that strengthen a fair, sustainable, productive society. To get ahead, it is necessary to have both an excellent technological innovation base and a clear insight into the road towards these responsible innovations. This theme focuses on studying such responsible innovation roads using state-of-the-art social sciences theories, concepts and models. Projects will focus on specific Wetsus innovations and will be tightly embedded within the Wetsus network. In this way, social sciences and public companies, end users, technology companies, and technological sciences will cooperate in providing a framework for analyzing and strengthening the responsible innovation process of Wetsus and its partners. The theme started in 2022.

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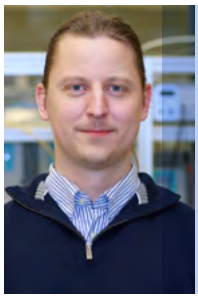

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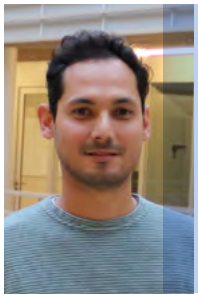

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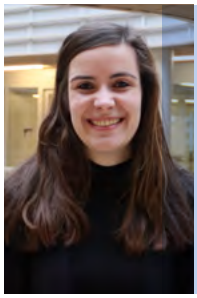

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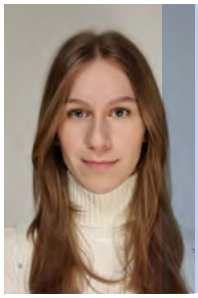

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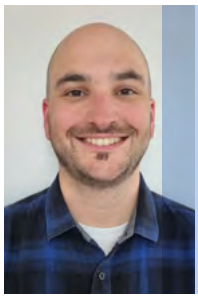

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wetsus

Wetsus, European centre of excellence for sustainable water technology is a facilitating intermediary for trend-setting know-how development. Wetsus creates a unique environment and strategic cooperation for development of profitable and sustainable state of the art water treatment technology. 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.

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