

nx

filtration

Technology for water re-use:

Advanced hollow fiber nanofiltration membranes

August 29th, 2023

nx filtration



1 Clean and affordable water for all

2 Hollow fiber nanofiltration (dNF)

3 Applications



Water scarcity and water quality are major global and structural issues

Water transition



2 in 7 people globally do not have daily access to clean, drinkable water



2/3 of the world's population will live in water stressed areas by 2025



95% of medicine waste reaches nature through sewerage systems



Only 2% of treated wastewater in the EU is reused



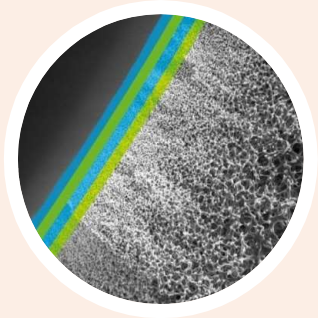
Energy-water nexus

More and more water is needed to enable the energy transition, whilst existing treatment technologies are very energy and chemical intensive



NX Filtration's direct nanofiltration (dNF) membrane technology effectively removes micropollutants with 70% energy and >90% chemicals savings

NX Filtration's sustainable hollow fiber nanofiltration membranes address global major water issues through two business lines



- Breakthrough **direct nanofiltration (dNF) technology**, designed to remove bacteria, viruses, micropollutants (including pharmaceuticals, medicines, PFAS and insecticide), colour, nano plastics and selective salts from water in one single step
- **Innovative and patented** products and production methods developed over the past decade and brought to industrial scale production at NX Filtration since 2016
- Key USPs include sustainability, **low energy use, no use of chemicals**, low OPEX and small physical footprint



Clean Municipal Water

- **Producing drinking water** from surface or well water by removing micropollutants, nano plastics and medicine residues in one single step
- **Treating wastewater** streams to enable reuse and prevent discharge of polluting substances in the environment

Sustainable Industrial Water

- **Treating well water and surface water** to optimise quality and characteristics for process water
- **Enabling reuse of wastewater** for industrial processes; preventing discharge of polluting wastewater
- **Recovery and recycling of valuable raw materials** from wastewater streams, such as indigo in the textile industry or cleaning chemicals in beer breweries

The NX Filtration journey started with membrane technology developed at the University of Twente, which is being applied globally today

Research phase

Company founded

Operationally proven

Commercially proven

Expansionary growth

Prof. Dr. Erik Roesink laid foundation NX Filtration with dNF technology research.

Founding of
nx filtration

First production facility ready

First dNF full scale industrial project

Second production facility

Strategic sales force expansion

High PFAS retention according to KWR

Dumai Project municipal drinking water



2013

2016

2018

2019

2020

2021

2022

2023

UNIVERSITY OF TWENTE.



Beginning of long-lasting relationship with University of Twente

Patents for applying hollow-fibre layer-by-layer nanocoating

Mexplorer pilot system introduced allowing for on-site lab-scale testing

Mexpert full scale demo system fully automated testing

Acquired HYDRA cap UF products from Hydranautics

IPO (AMS:NXFIL) Listed on Euronext

Recolab Project municipal wastewater reuse

Construction new production facility

Strong focus on sustainability in production processes and during operation of membranes

Green chemistry

Our coating process for dNF membranes applies water-based chemistry, in contrast to conventional solvent-based coating processes. Our membrane spinning process is highly energy efficient thanks to our unique in-line polymer mixing concept

Energy efficient

Our membranes require less energy and therefore realise significant CO₂ footprint reduction during operations compared to conventional technologies

Avoidance of chemicals

Our solution avoids the use of flocculants and coagulants in pre-treatment (which are required for traditional filtration processes) and requires a low cleaning frequency



Fast track implementation with an advanced Projection Tool, Application Engineering Support, and over 160 Pilot- and Full-scale Demo Systems

Mexplorer



Lab-scale dNF module

The Mexplorer test unit enables quick filtration tests with MP pilot modules, providing retention and flux data within an hour using hollow fiber membranes. It can be transported easily and is available for rent or purchase for conducting personalized tests.

Mexperience



1 full-scale dNF module

The semi-automatic Mexperience pilot installation is designed for extended testing with full-size WMC110 dNF40 or 80 modules, providing in-depth insights into the behaviour of dNF membranes over time. It offers datalogging for detailed analysis.

Mexpert



1 or 2 full-scale dNF modules

The fully automated Mexpert pilot installations offer maximum flexibility for piloting with WMC200 dNF modules, providing realistic full-scale testing results. Digital control and monitoring allow for adaptable running conditions and module cleaning, while datalogging enables detailed analysis.

Mexpert XL



10 full-scale dNF modules

The fully automated pilot installations, housed in a 40-foot container, offer maximum flexibility for piloting with WMC200 dNF modules, providing realistic full-scale testing results. Digital control and monitoring allow for adaptable running conditions and module cleaning, while datalogging enables detailed analysis.

NX Filtration recently expanded to a second production facility and will further expand in 2024

Current production facilities (~10,000 modules)

Plant I: Kennispark, Enschede, the Netherlands



Original location since **2016**
Membrane production, innovation centre and offices

Plant II: Josink Esweg, Enschede, the Netherlands



Additional location since November **2020**
NX Filtration's HQ, module production and warehousing

Expansion (>120,000)

Plant III: High Tech Systems Park, Hengelo, the Netherlands



2024: Commission a new production facility with a targeted total capacity of >120,000 modules per year

Continued recognition by the industry



2021 - Breakthrough Technology Company of the Year (Distinction)

2022 - Waste Water Project Of The Year

2023 - Water project Of The Year (Distinction)

2023 - Water Technology Company Of The Year (Distinction)



Total BlueTruffle score: 5 out of 5

Large addressable market 1 out of 1

Strong management team 1 out of 1

Strong IP position 1 out of 1

Innovative technology 1 out of 1

BlueTech opinion 1 out of 1

Disrupt-o-Meter Breakdown



Inclusion in the new **Euronext Tech Leaders initiative NX Filtration:** Sole water tech company among 100+ in Euronext Tech Leaders



NX Filtration honoured with **Product Star Award by the Desalination Branch of China Water Enterprises Confederation**



Customer Value Award Recognizing NX Filtration's exceptional performance in the **global water treatment market.**

Increasing traction with global blue-chip customer base



Continuation and expansion of pilot program with Veolia, jointly working towards an increasing number of concrete project opportunities



Delivered ultrafiltration replacement modules to Evoqua for various water treatment plants around the world



Supplied our Mexpert pilot system for the European innovation project LIFE PRISTINE, an Acciona-led initiative to eliminate emerging pollutants from water sources



Repeat order from Ekopak to supply dNF membranes for the extension of a water treatment project in Belgium



Repeat project with Aquarius H2O Dynamics for textile industry wastewater treatment in India



Strong entry with our microfiltration membranes into Carlsberg's Fredericia brewery in Denmark that has the aim to have zero water waste by 2030



Repeat projects for Ecoazur for municipal drinking and wastewater treatment projects in Mexico



Pilot project with Suez in France on micropollutants removal with dNF technology



Replacement order for Hidrofilt, replacing dNF modules for industrial wastewater treatment at the site of an aerospace multinational in Hungary

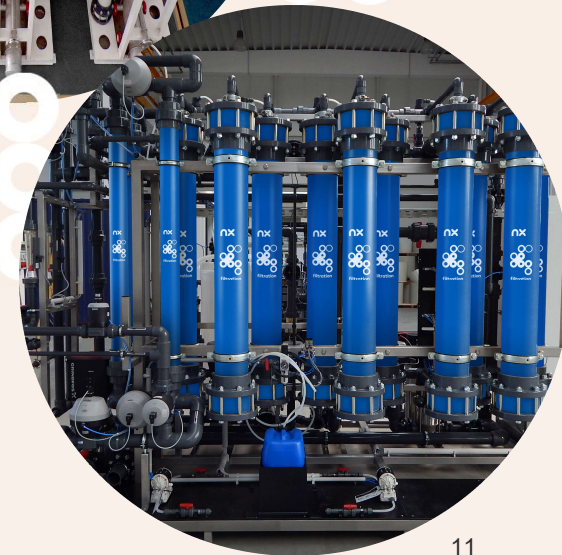
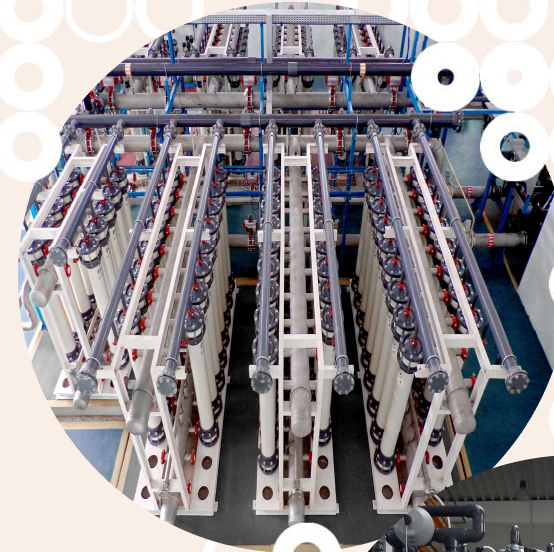


Pilot project with Vitens, the largest drinking water utility in the Netherlands, to test IJssel river water as potential source for drinking water

1 Clean and affordable water for all

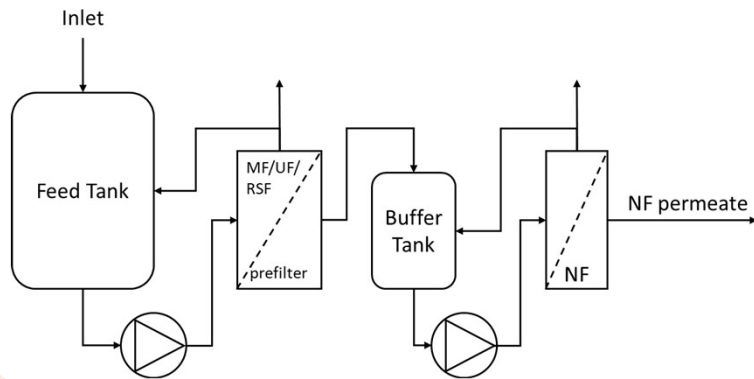
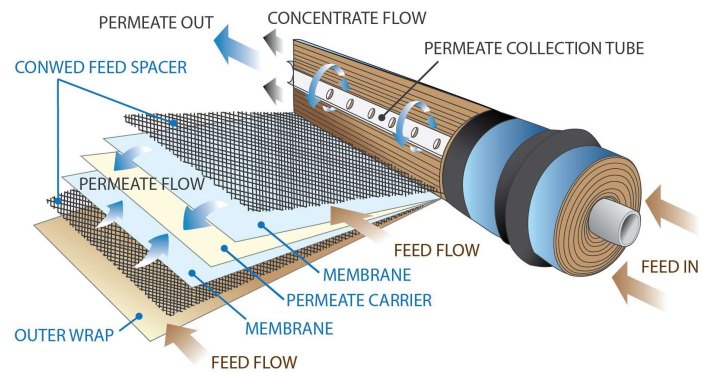
2 Hollow fiber nanofiltration (dNF)

3 Applications

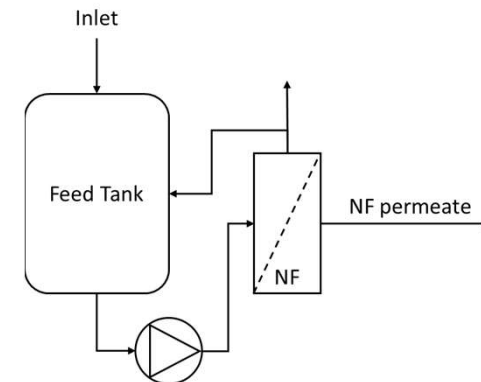
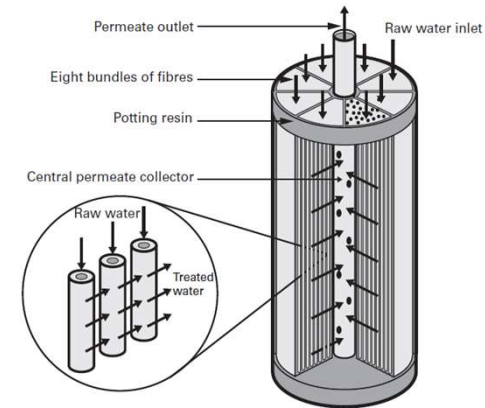


direct Nanofiltration – Innovative coating creates robust materials and enables simple process

Traditional NF scheme

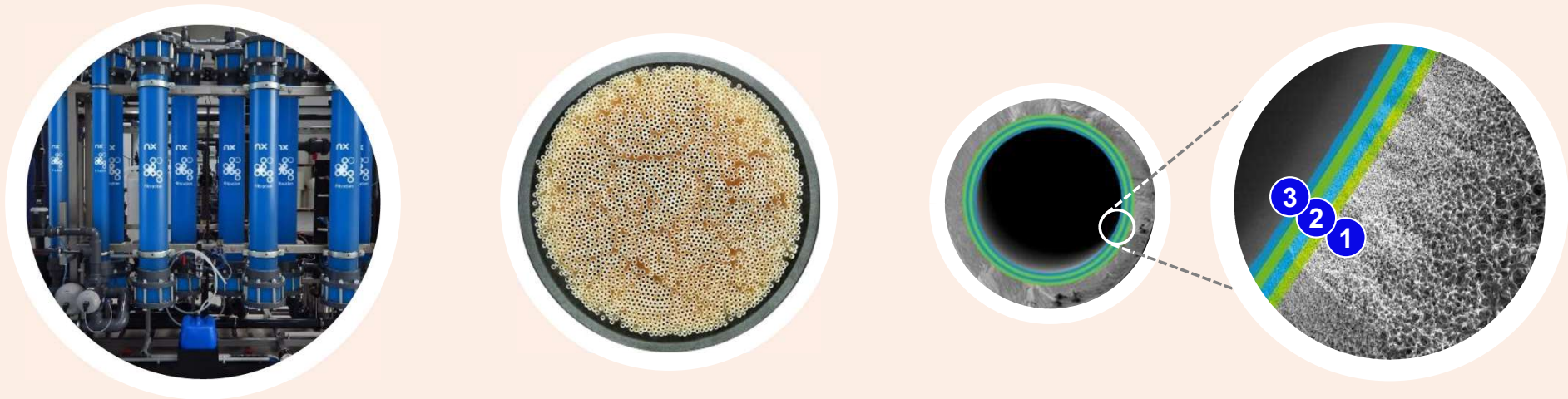


Hollow fiber dNF scheme



Breakthrough hollow fiber nanofiltration (dNF) membrane technology

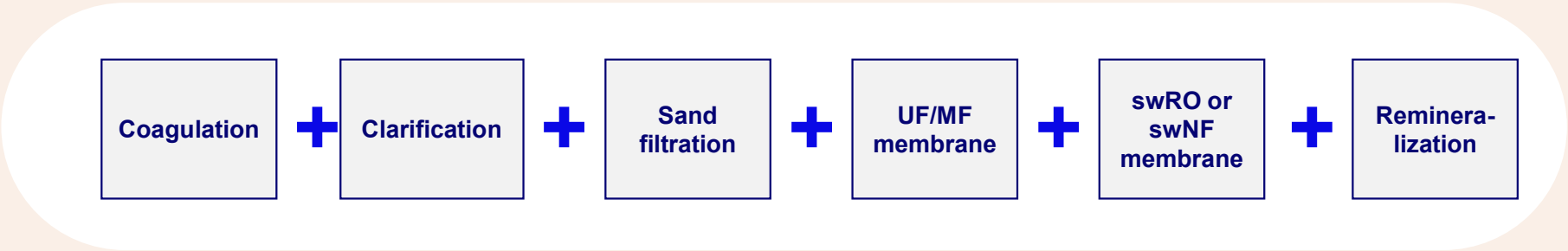
Direct nanofiltration (dNF) patent protected technology



- 1 Family of patents around **dense membrane support structure** to ensure optimal selective layer adhesion
- 2 Family of patents around the in-line application of a **first selective charged layer**
- 3 Family of patents around the **layer-by-layer** application of positively and negatively charged nanolayers, offering precise control of the membrane selectivity properties. *Ongoing nanolayer innovations aim to enable new applications, such as further penetrating RO markets*

Hollow fiber nanofiltration enables a simple and robust water treatment process

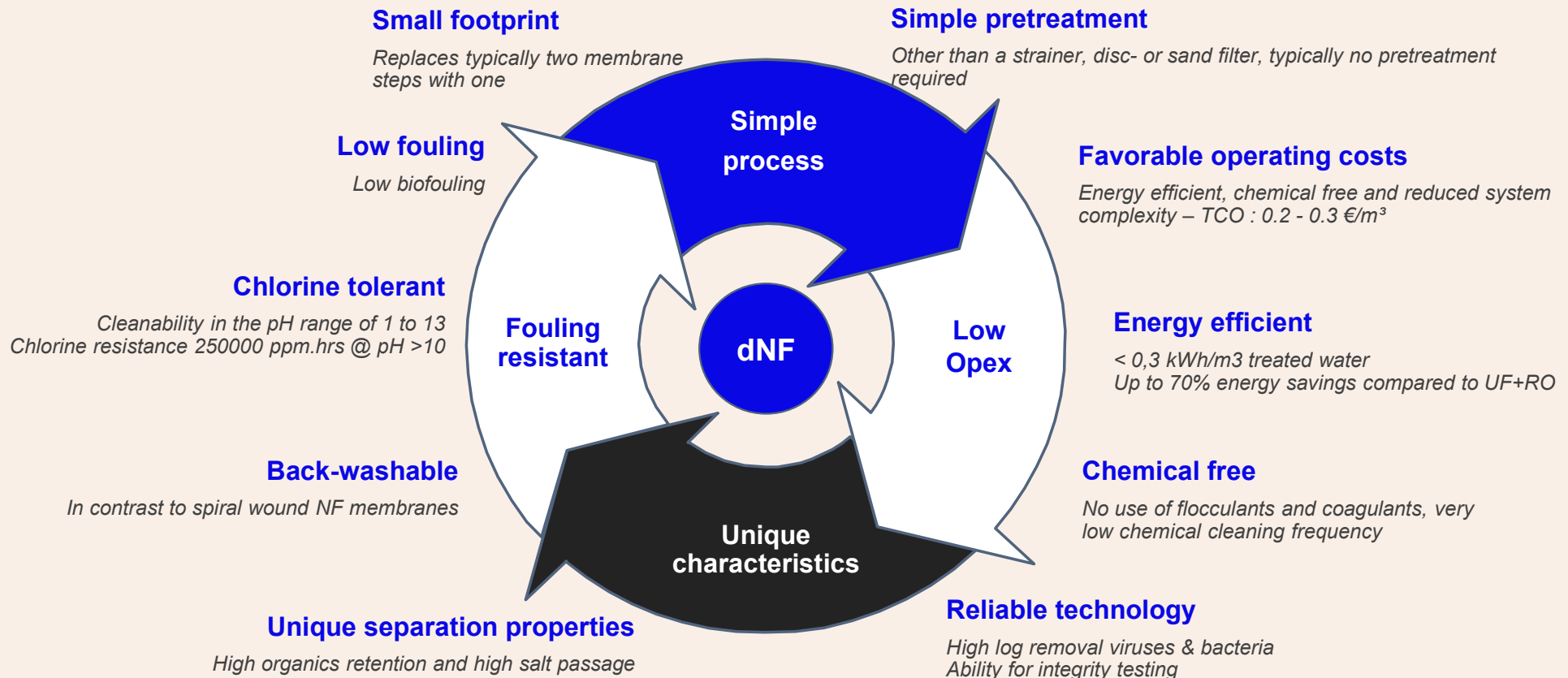
Traditional processes



NX Filtration

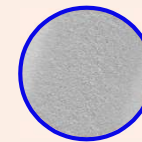


Unique features of our dNF technology



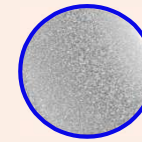
Our membrane portfolio also comprises of PES based hollow fiber Ultrafiltration and Microfiltration membranes

Filtration objective	Nano dNF		Ultra UF		Micro MF	
	dNF40	dNF80	UF010	UF150	MF100	MF500
Suspended solids and micro plastics	○	○	○	○	○	○
Bacteria	○	○	○	○	○	○
Viruses	○	○	○	○		
Protein and colloidal silica	○	○	○			
Micropollutants, color and nano plastics	○	○				
Selective salts, softening and pharmaceuticals	○					
Cut off	400Da	800Da	10kDa	150kDa	100nm	500nm
Typical Flux (l/m ² h)	20-40	20-50	50-100	50-100	25-100	25-100
MgSO ₄ rejection (%)	90	80	n/a	n/a	n/a	n/a



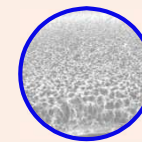
Nanofiltration

Worldwide unique nanofiltration concept, designed to remove organics from water in one single step: without pre-treatment and without the use of chemicals



Ultrafiltration

The best choice for the removal of small particles, bacteria beverages, such as wine and beer, as well as for dairy and pharmaceutical applications



Microfiltration

Ideally suited for high quality – low energy clarification of and viruses from water. Used for RO pre-treatment, potable water and wastewater treatment

Innovation is at the core of our business...

High pressure header concept

Low footprint
Standard connections

Patented module design

Optimal flow conditions
High packing densities

Patented high-end potting

High temp. & press. resistant
FDA and drinking water approvals



Unique patented support formulation

High pressure rating
Optimal selective layer adhesion

Patented first layer technology

In-line applied first selective
Proprietary process

Precise selectivity

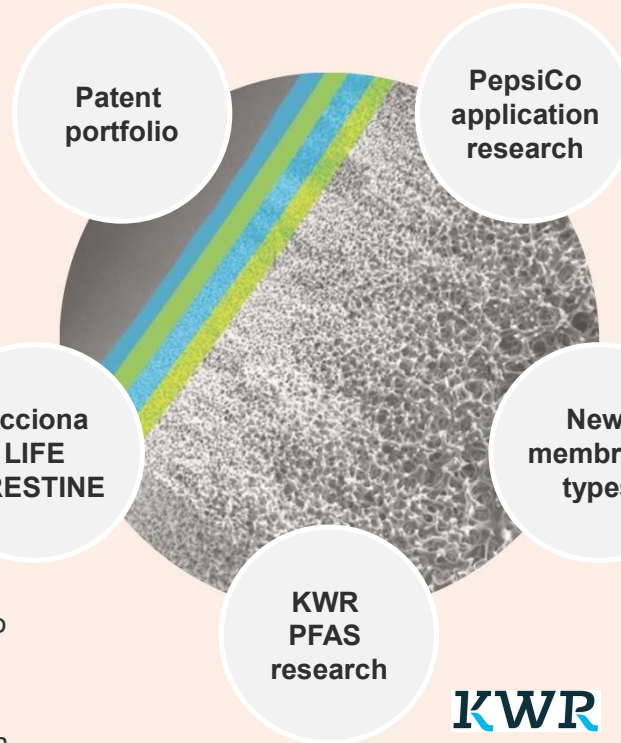
Patented Layer-by-layer process
Precise control of the membrane properties

- 1 Clean and affordable water for all
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- 3 Applications – Selected examples



NX Filtration's technology position is not only build around membrane technology, but also on application know-how

- Patent grant for our 'Positively charged membranes' patent family in India
- New patent family addition around innovative application of nanolayers on membranes



- Research with PepsiCo around additional opportunities for dNF membranes within PepsiCo's facilities



- Participation in the European innovation project LIFE PRISTINE, led by Acciona, to eliminate emerging pollutants (e.g. PFAS) from water sources
- Sustainable alternative for the elimination of emerging pollutants in the water cycle



- Tests by independent Dutch water research institute KWR to demonstrate NX Filtration's membranes' high retention of PFAS

- Continued progress on more open dNF membrane in addition to mainstream dNF40 and dNF80 products
- Longer-term research program on tighter dNF membranes, to further penetrate applications concerning brackish waters

Case study Dumai: direct surface water treatment to produce potable water

The customer's query

The customer, a municipal drinking water company, was looking for a simple and robust solution to **remove color (humic acids)** and micropollutants which are accumulated in the Masjid river during its flow through the rainforest. This water source can be used to produce drinking water to the city of Dumai.

Our approach

We applied our dNF80 nanofiltration membranes, providing a unique one-step solution resulting in a product water flow of up to 4,000 m³/d (0.8 MGD) from the Masjid river.

Results

Our dNF80 modules are operated in a Once-through arrangement to achieve maximum recovery. In operation since May 2020.

1 step solution, no pre-treatment required

>95% Color Removal

80% Recovery

0% Anti-scalant injection



QWi
GLOBAL WATER INTELLIGENCE

Distinction Water
Project of the Year
2023

Case study Reco Lab: recovering nutrients from an urban waste stream in Sweden

The customer's query

The City of Helsingborg together with NSVA (Northwest Skåne Water and Wastewater) and NSR (Nordvästra Skånes Renhållnings) were seeking to recover nutrients from separated urban waste streams (grey and black water) from the new residential area Oceanhamnen (the Ocean Harbour) in Helsingborg.

Our approach

We applied our dNF40 nanofiltration membranes for the removal of micropollutants (amongst other pharmaceuticals, estrogens, micro plastics, antibiotics, and personal care products) from greywater and recovery of nutrients, producing water for reuse. For this project, NX Filtration partnered with DeSaH (process design) and Jotem (membrane skid).

>80% Micropollutant removal

>80% recovery



Independent Dutch water research institute KWR demonstrates NX Filtration's membranes retention of PFAS

Full scale demonstration on Municipal Wastewater and Surface Water

A long-term full-scale demonstration has been conducted by Dutch independent research institute KWR to investigate the actual retention of PFAS with NX Filtration's dNF membranes under real live circumstances. The tests were not only performed on surface water from the Lekkanaal in The Netherlands, but also on biologically treated effluent from a municipal wastewater treatment plant.

KWR tested on a realistic and representative subset of main PFAS

The aim of the research was to determine the retention of various PFAS with dNF membranes by dosing PFAS into real surface water and municipal effluent streams.

The test has been performed with a containerized full scale Mexpert pilot unit of NX Filtration located at the premises of KWR.

PFAS20 – A subset of substances on the EU monitor to be regulated.

Average dNF40 process retention for these molecules is **94.7%**

PFAS4 – A subset of substances that e.g. Sweden will be using in their

legislation. Average dNF40 process retention for these molecules is **94.6%**



KWR



Netherlands: Re-use of papermill effluent for process water applications after conventional treatment

The Customer's query

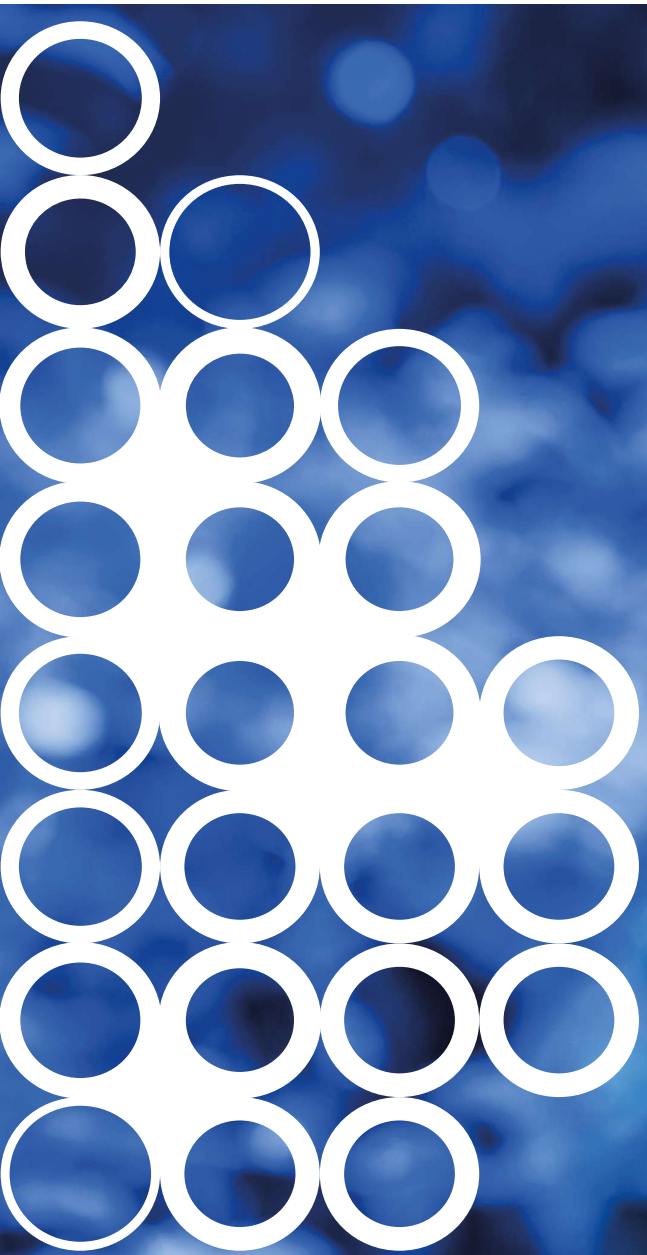
Our customer was aiming to minimize the impact on the intake of water from natural resources in its region by recycling their conventionally treated wastewater. Recognizing the potential of NX Filtration's hollow fiber nanofiltration membranes for such purposes, a pilot study has been carried out to generate relevant technical data for the design and implementation of a pioneer full-scale system that will deliver good quality water for reuse by the paper mills.

Our approach

- **Pilot testing** in 2021 demonstrating how the dNF system could effectively remove various pollutants to enable for reuse as process water
- **Demo plant** of 10 m³/h to start up in summer '23 to demonstrate system integration in operational process
- **Full-scale project** will have a capacity of 550 m³/h consisting of **368 NX Filtration dNF80** membrane modules



System Design	
System	dNF80 F&B
No Modules	8
Application	Industrial WW → Re-use
Start-up	June 2023



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