

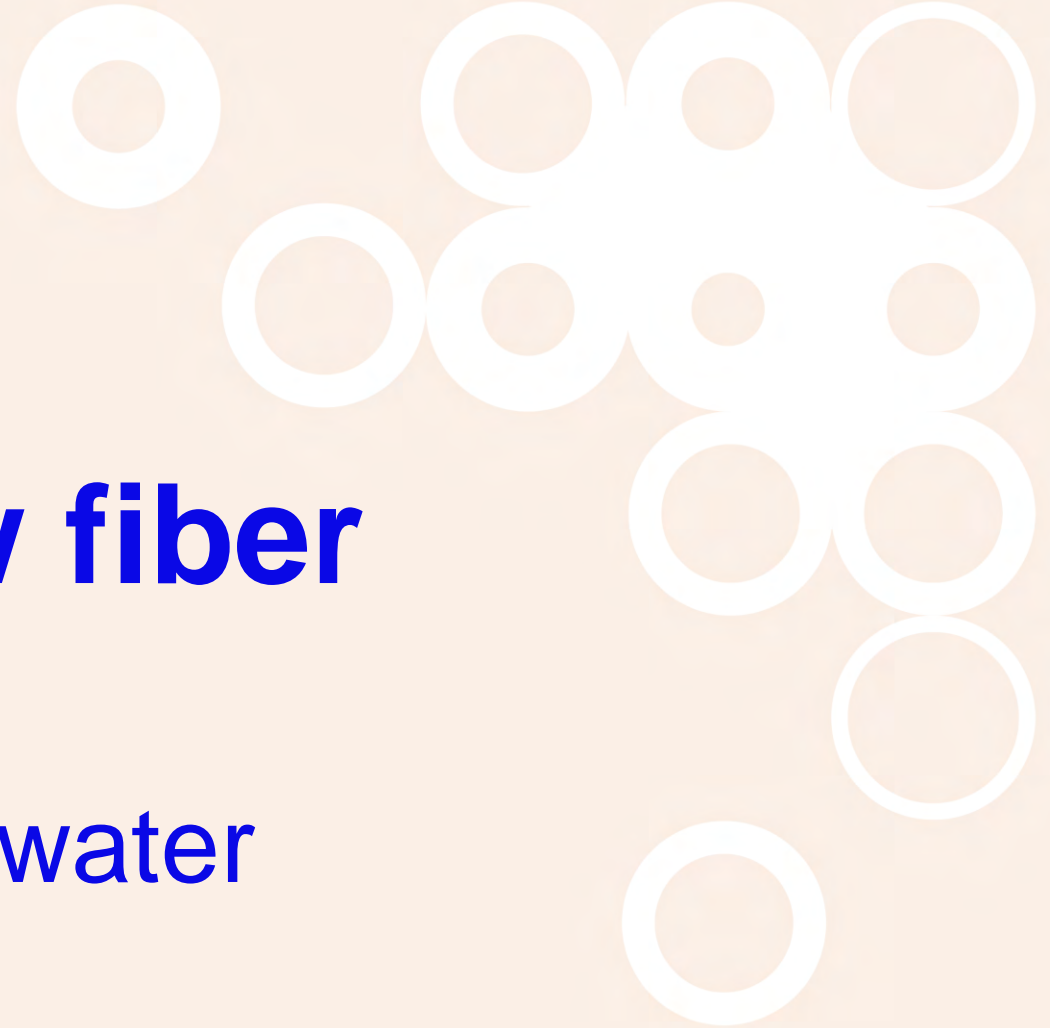
**nx**

**filtration**

# **Advanced hollow fiber membranes**

**for pure and affordable water**

**December, 2021**



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Direct nanofiltration

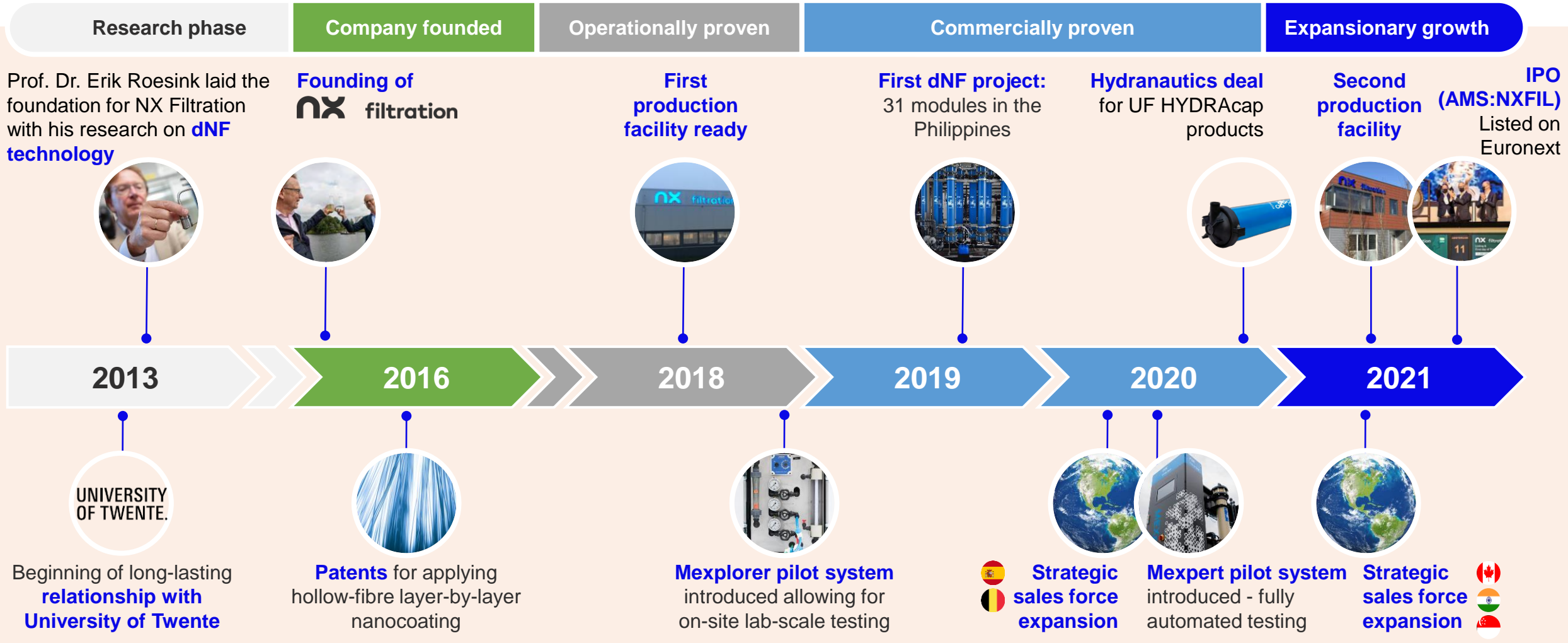
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# The NX Filtration journey started with technology developed at the University of Twente, growing to a worldwide business today



# NX Filtration recently expanded to a second production facility and has raised financing for a further ramp-up in capacity

## Current production facilities

Plant I: Institutenweg, Enschede, the Netherlands



- Original location since 2016
- Membrane production, innovation center and offices
- Ongoing expansion activities to increase production capacity approximately fourfold

Plant II: Josink Esweg, Enschede, the Netherlands



- Additional location since the end of 2020
- NX Filtration's HQ, module production and warehousing

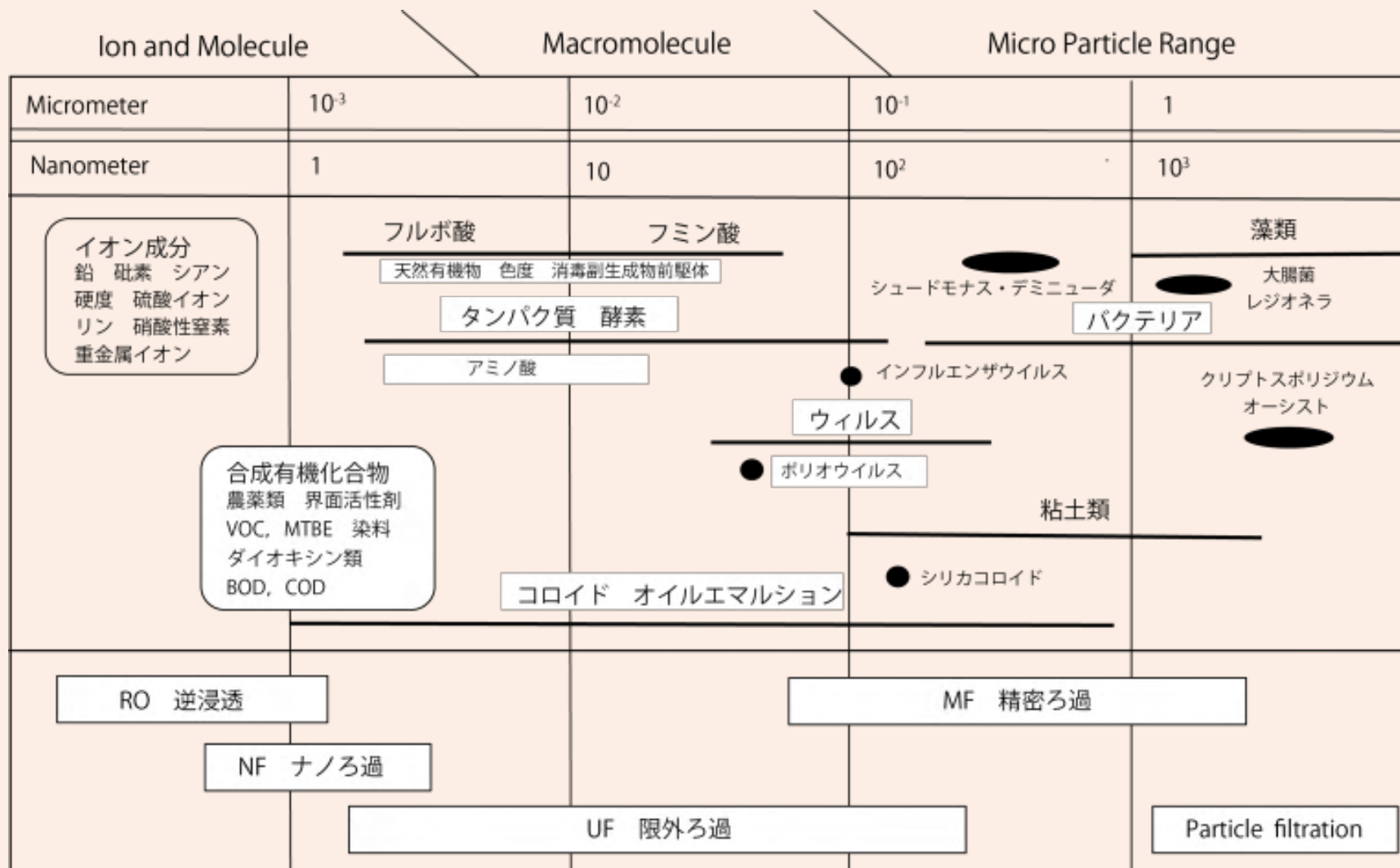
## Expansion

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



- June 2021, Green IPO raising approximately €165m, amongst others for further capacity expansion, commercial roll-out and fast-tracking innovation
- Aim to build and commission a new production facility by 2023 with a targeted total capacity of ~80,000 modules per year

# 膜分離の種類と分離対象物質





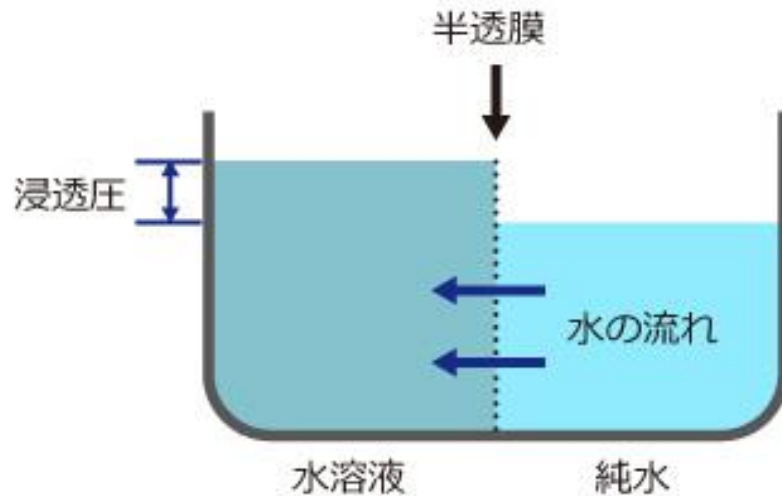
## ...with unique separation properties

Filtration objective	Nano		Ultra		Micro	
	dNF40	dNF80	UF010	UF150	MF100	MF500
Suspended solids and micro plastics	○	○	○	○	○	○
Bacteria	○	○	○	○	○	○
Viruses	○	○	○	○		
Protein and colloidal silica	○	○	○			
Micropollutants, color and nano plastics	○	○				
Selective salt, softening and pharmaceuticals	○					
Cut off	400Da	800Da	10kDa	150kDa	100nm	500nm
Typical flux (lmh)	20-40	20-50	50-100	60-150	25-100	25-100
MgSO <sub>4</sub> rejection <sup>1</sup>	90%	80%	n/a	n/a	n/a	n/a

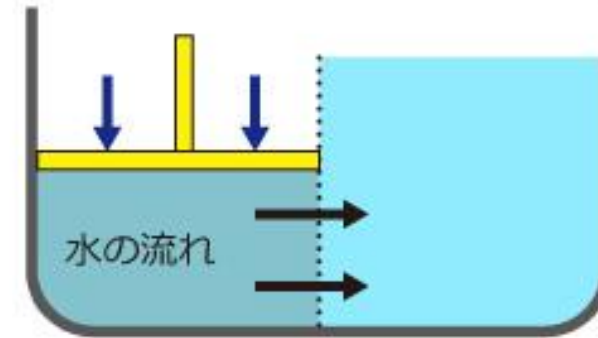
<sup>1</sup> Test conditions: 5.0 mMol/L MgSO<sub>4</sub>, 3.0 bar (43.5 psi), 25°C (77°F), v=0.5 m/s (1.6 ft/s)

# 逆浸透法(ナノ濾過法)の基本原理

## ■ 浸透現象

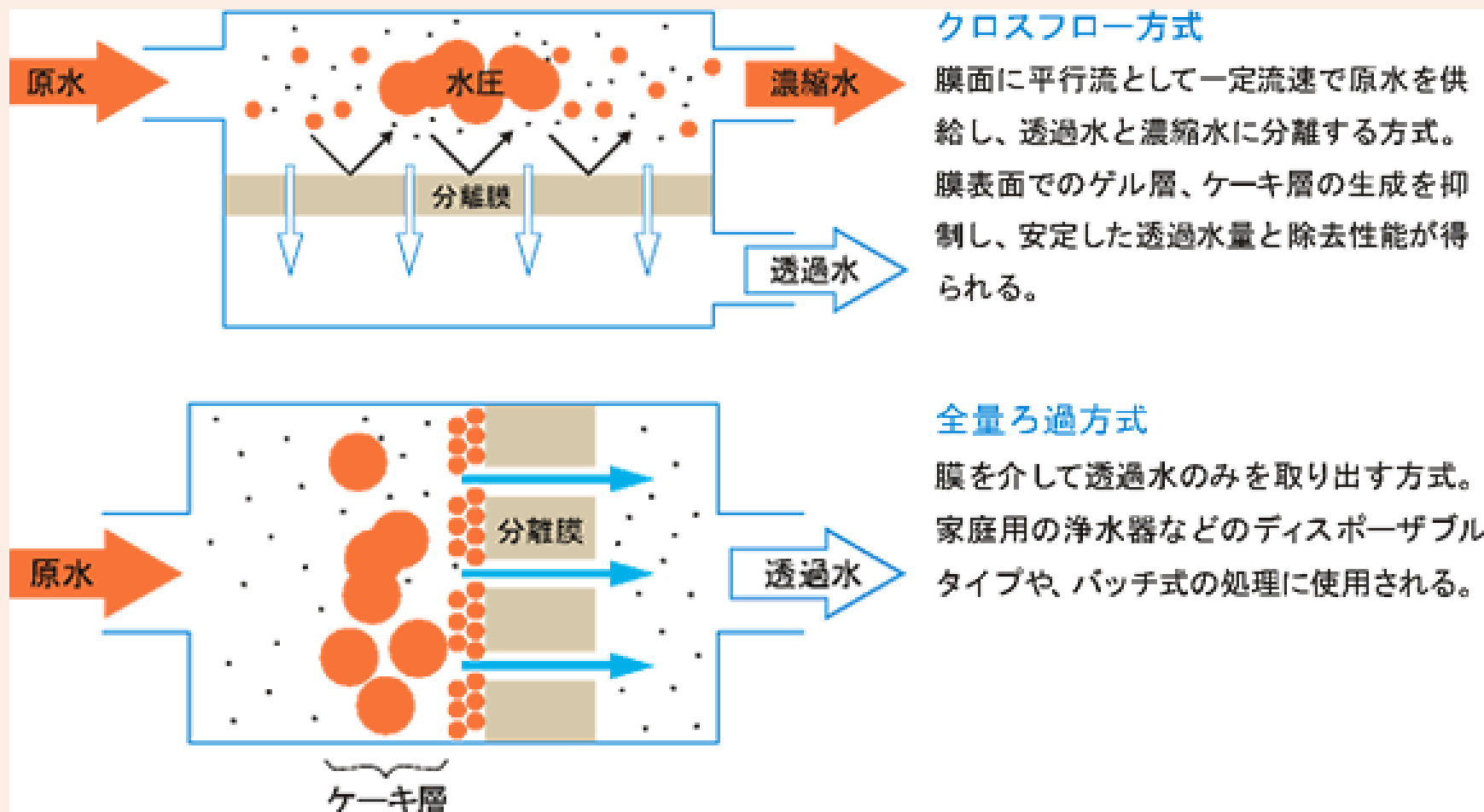


半透膜を挟んで水溶液と純水が接しているとき、水溶液の濃度を薄めようとして純水側から水が移動します。この時に発生する圧力が浸透圧です。



浸透圧以上の圧力を水溶液側にかけると、水溶液側から純水に水の移動が起こります。

# 全量ろ過方式とクロスフローろ過方式

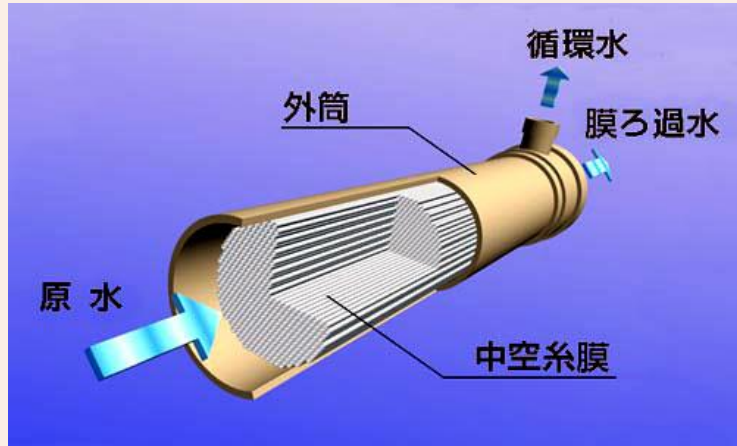


<sup>1</sup> Test conditions: 5.0 mMol/L MgSO<sub>4</sub>, 3.0 bar (43.5 psi), 25°C (77°F), v=0.5 m/s (1.6 ft/s)

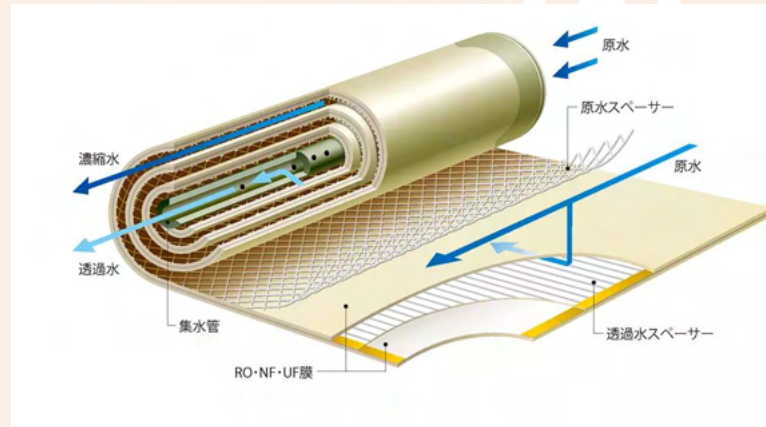


# 代表的なモジュール形状

## 中空系型



## スパイラル型



## 中空系吸引型(MBR)



## NF膜の主要用途

	無機物		有機物	
	Mg <sup>++</sup> /Ca <sup>++</sup>	SO <sub>4</sub> <sup>--</sup>	自然由来 (NOM*)	人工汚染物 (OMP**)
地下水フミン質硬度除去	○		○	
表層水フミン質、硬度、OMP除去	○		○	○
上水高度処理			(○)	○
石油二次回収		○		
食品（アミノ酸・ラクトース回収精製、色除去・低アルコールビール）			○	
ZLDでのCl/SO <sub>4</sub> 分離		○		
海水淡水化の高回収率運転・Mg回収	○			

\*NOM=Natural Organic Matter

\*\*OMP=Organic Micropollutants



# NX Filtration has developed unique direct nanofiltration (dNF) technology that lower carbon & chemical footprint

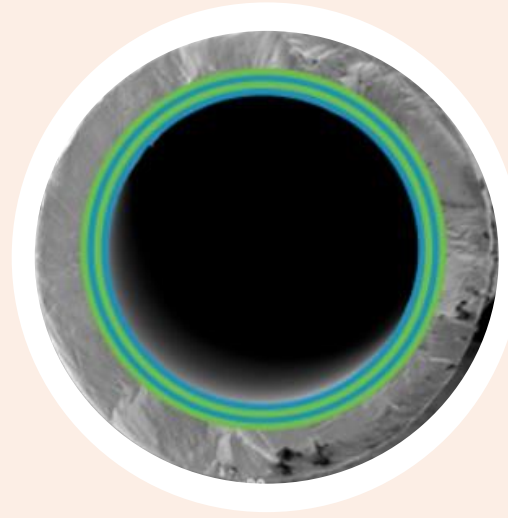
## dNF technology



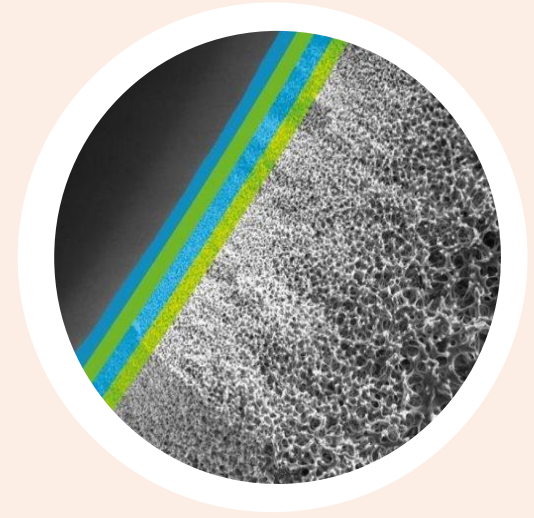
**NX Filtration's  
membrane modules in a  
client's system**



**Cross-section of a  
module containing  
thousands of  
membranes**



**Cross-section of  
one hollow-fiber  
membrane**



**Layer-by-layer  
nanocoating on the  
inner side of the  
membrane support**

## UN Sustainable Development Goals

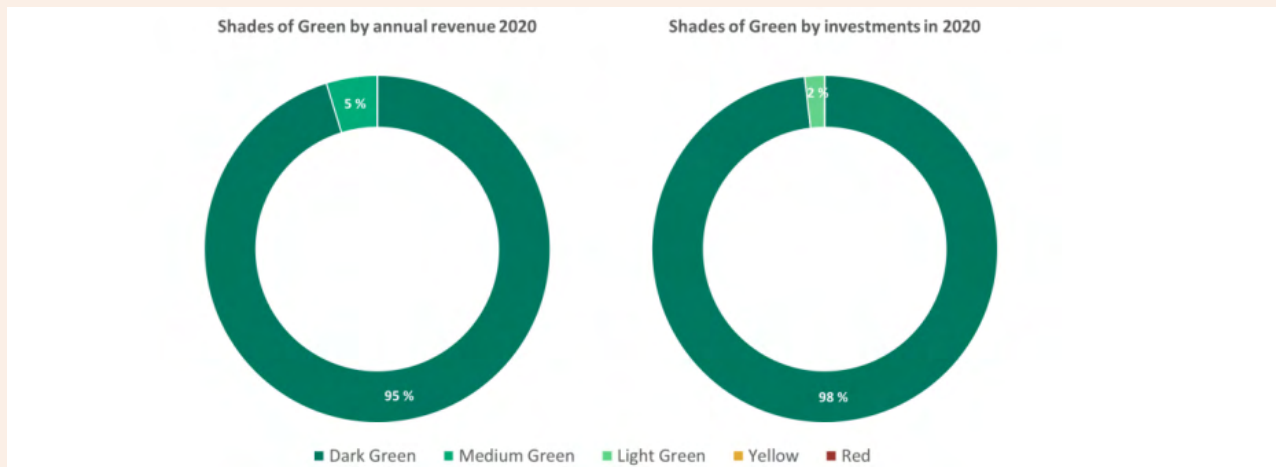
Building on our vision (to be a leading global provider of technology for producing pure and affordable water to improve our quality of life) and our mission (inspired by our team's passion for membranes, we develop and produce innovative products and solutions, enabling our partners to excel in membrane filtration applications), we have aligned our objectives to 5 UN Sustainable





# NX Filtration Shades of Green assessment

May 28, 2021













SHADES OF GREEN	EXAMPLES
 <b>Dark green</b> is allocated to projects and solutions that correspond to the long-term vision of a low carbon and climate resilient future.	 Solar energy projects
 <b>Medium green</b> is allocated to projects and solutions that represent steps towards the long-term vision but are not quite there yet.	 Green buildings with a high level of certification and energy efficiency
 <b>Light green</b> is allocated to transition activities. These projects and solutions could have lower emissions, but do not by themselves represent or contribute to the long-term vision.	 Substantially more efficient manufacturing of fossil fuel intensive materials
 <b>Yellow</b> is allocated to projects and activities that do not contribute to transition. These activities could have some emissions and be exposed to climate risks. This category also includes activities with too little information to assess.	 Efficiency in fossil fuel infrastructure
 <b>Red</b> is allocated to projects and activities that have no role to play in a low-carbon and climate resilient future. These are heaviest emitting assets, with the most potential for lock-in of investments and risk of stranded assets.	 New infrastructure for coal

Figure 1: NX Filtration 2020 revenue and investments by Shade of Green. The figures are aligned with NX Filtration’s financial reporting.

**“NX Filtration is a Dutch company that produces water filtration membranes. They announce their initial public offering (IPO) with an independent climate risk assessment from CICERO Green. Our assessment confirmed 100% of NX Filtration’s revenues and investments are green”**

# Sustainability has been a strong focus from the outset, both in our production processes as well as during operation of our 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 CO<sub>2</sub> 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





# NX Filtration has drinking water approvals from Kiwa, KTW and NSF

## Product certificate: Membrane filtration elements



## Test certificate: Environment Agency approval



## Product certificate: Drinking water system components



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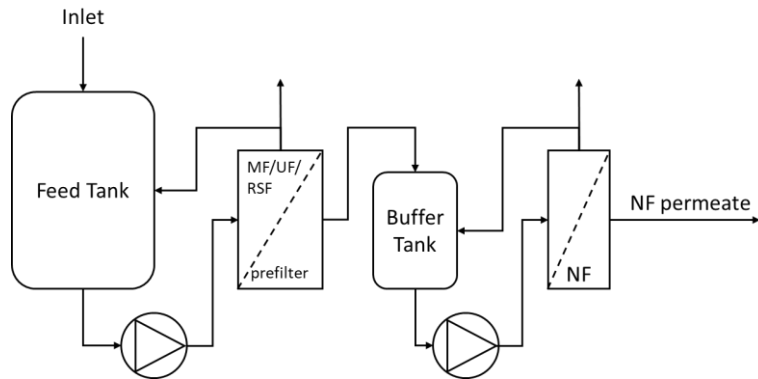
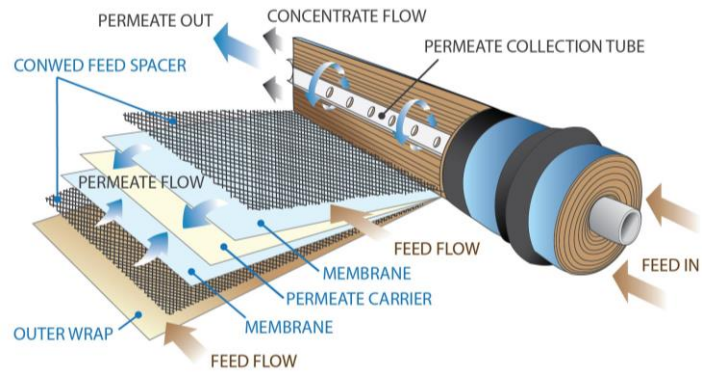
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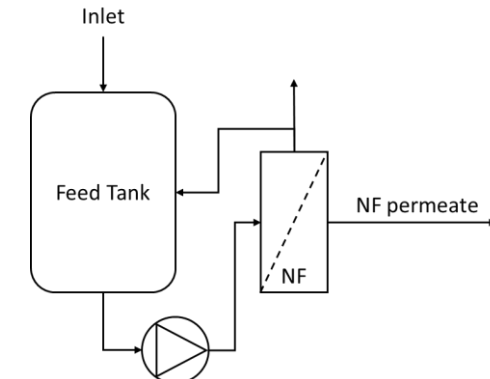
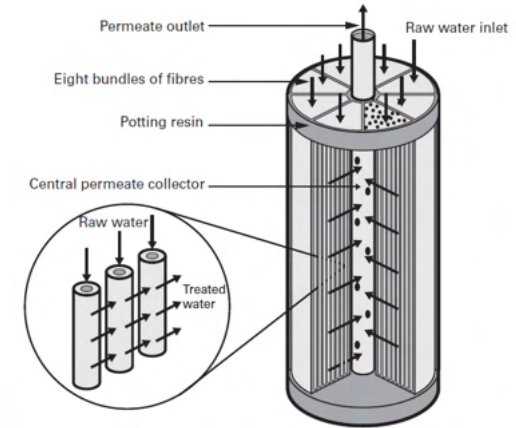


# Value Proposition : One-step process

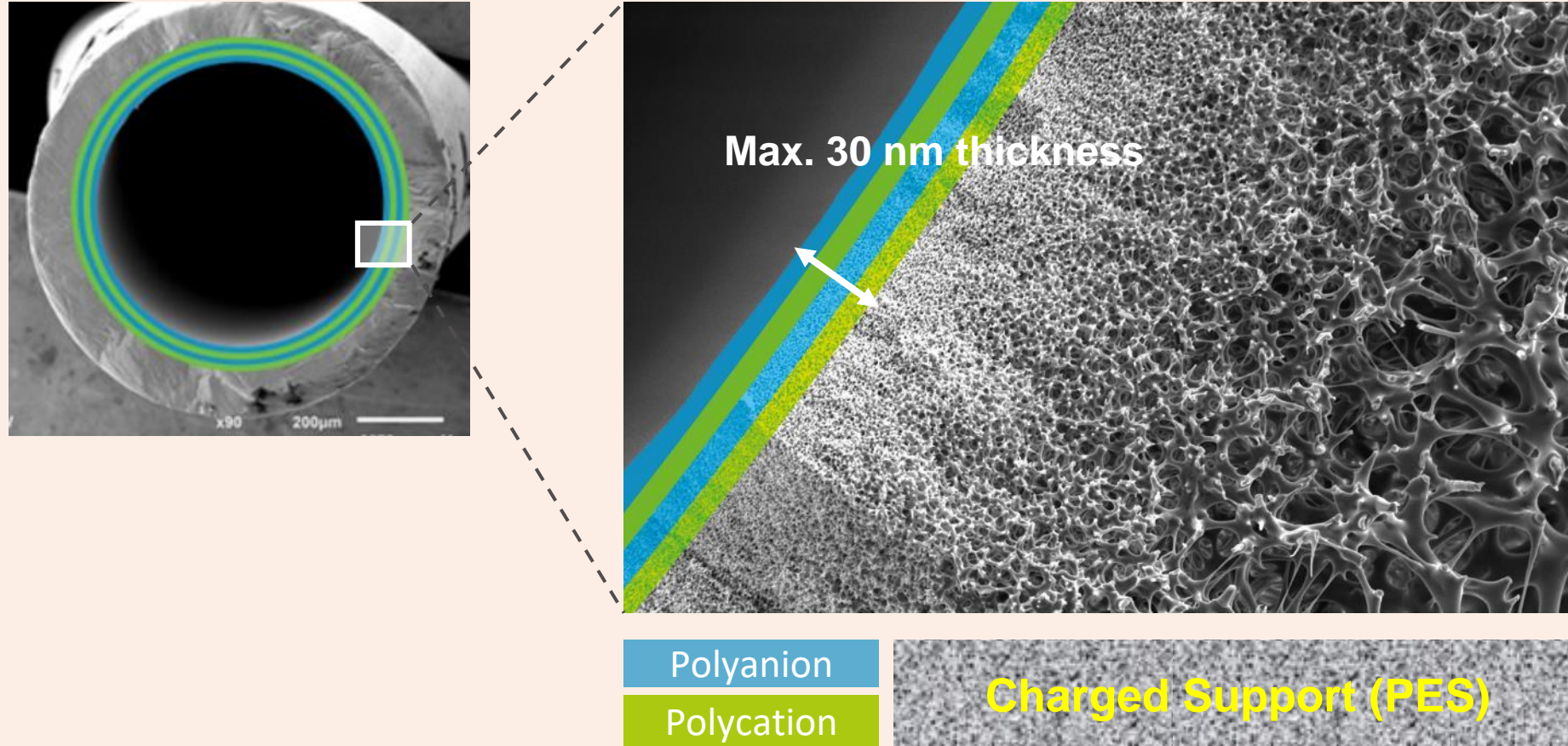
## Traditional NF scheme



## Hollow fiber dNF scheme



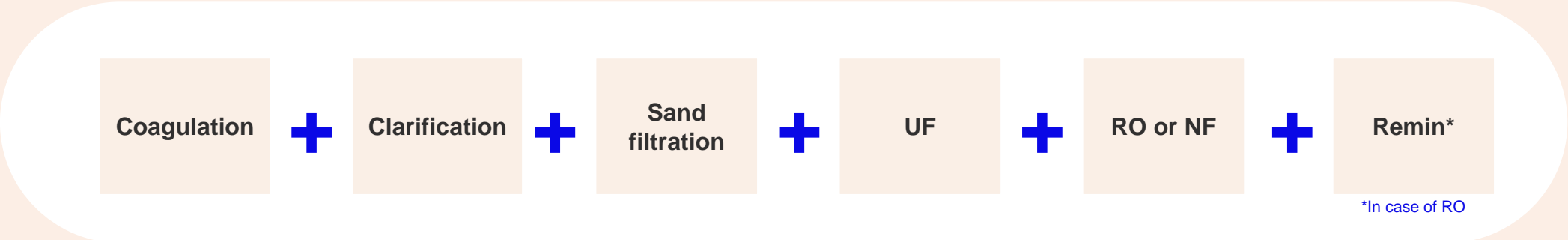
# Unique Layer-by-Layer Coating





# Value Proposition : One-step process Surface Water Treatment

Traditional processes



NX Filtration



# Three key markets for our nanofiltration membranes

## Drinking water from surface water



## Reuse of industrial wastewater



## Reuse of municipal wastewater



### Key use

- One-step solution for drinking water from surface water: decolorization, removal of TOCs and hardness (partial)

- Water intensive industries, such as Chemical, Pharma, Textile, Beer & Beverage, Food industry

- Prevent discharge of micro-pollutants in the environment
- Enable reuse of wastewater
- Enables recovery of e.g. nutrients and chemicals (circular economy)

### Key drivers

- Reliance on surface water for drinking water

- Water scarcity
- Discharge surcharges
- Corporate Social Responsibility goals

- Water scarcity
- Legislation
- Public awareness on environmental and health risks



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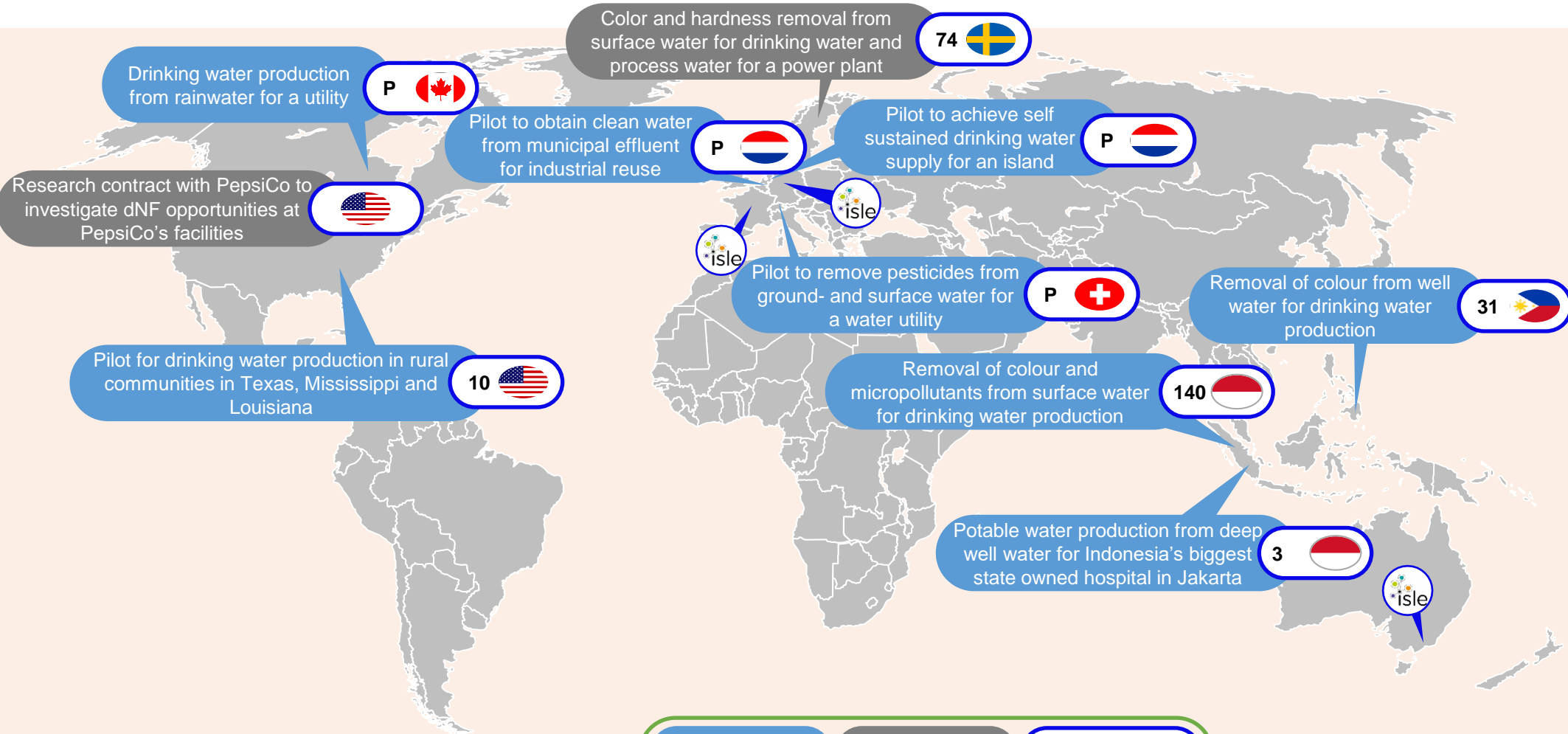
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# This technology has already proven successful across applications around the world – *selected examples and clients*



Clean Municipal Water
Sustainable Industrial Water
# of modules<sup>(1)</sup>

# Direct surface water treatment to produce potable water in Enschede, The Netherlands

## Climate change

Climate change causing severe droughts, also here in The Netherlands. We need to make a switch from using ground water to surface water, and are in need for more sophisticated treatment processes

## Our approach

We apply our dNF40 nanofiltration membranes, providing a unique one-step solution for direct surface water treatment

## Results

Our dNF40 membranes are operated without pre-treatment and very low frequency of chemical cleaning. Permeate water produced of higher quality than local drinking water



**1**

step solution, no pre-treatment required

**100%**

Drinking water quality

**>80%**

recovery

**0%**

Chemical dosing during filtration

# Direct surface water treatment to produce potable water in Dumai

## 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 3,000 m<sup>3</sup>/d (0.8 MGD) from the Masjid river.

## Results

Our dNF80 modules are operated in a Once-through arrangement to achieve maximum recovery.



**1** step solution, no pre-treatment required

**>95%** Color Removal

**80%** Recovery

**0%** Anti-scalant injection

# Removal of micropollutants from municipal wastewater in Netherlands

## The customer's query

The customer, a wastewater treatment plant in the Netherlands, was looking for a solution to remove micropollutants from the wastewater effluent prior to discharge into an environmentally sensitive local water stream.

## Our approach

We applied our dNF40 nanofiltration membranes directly on the wastewater after biological treatment and settling tanks. Contrary to conventional membrane processes, our process only required a strainer as pre-treatment

## Results

Our dNF modules are operated in a Once-through arrangement to achieve maximum recovery with stable operation since 2019  
CEF every two weeks with 250 ppm NaOCl @ pH>10



20

LMH flux

>97%

Rejection of  
TOC

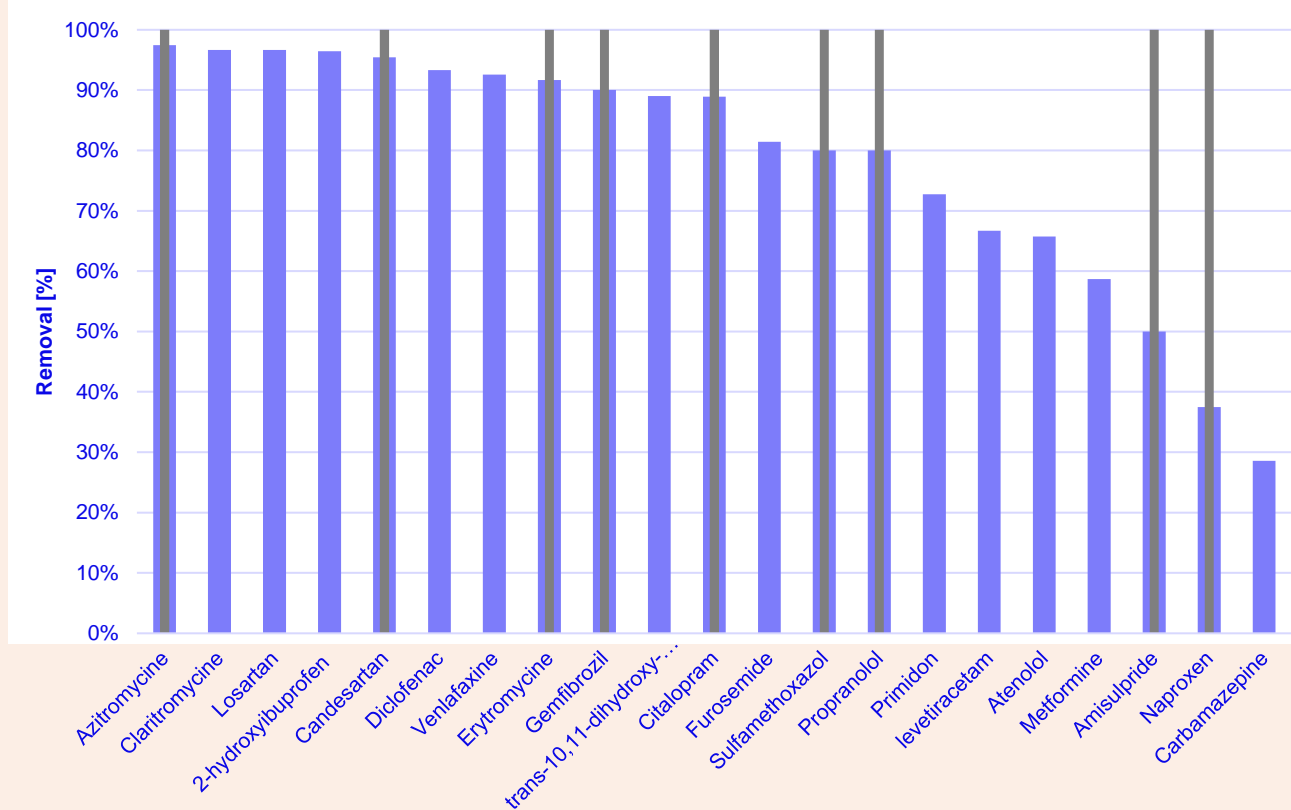
>80%

Rejection for a cocktail of  
micropollutants



# Removal of micropollutants from municipal wastewater after biological treatment

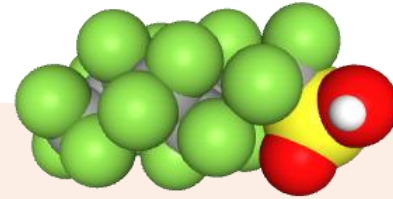
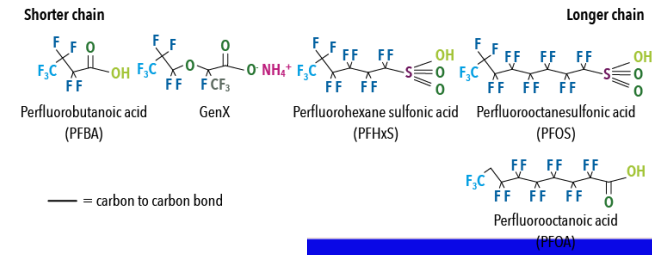
## Removal of micropollutants



日本では、滋賀県大津市にある京都大学の「流域圏総合環境質研究センター」がOMPに関して高い分析能力を保有。



# direct Nanofiltration for PFAS removal

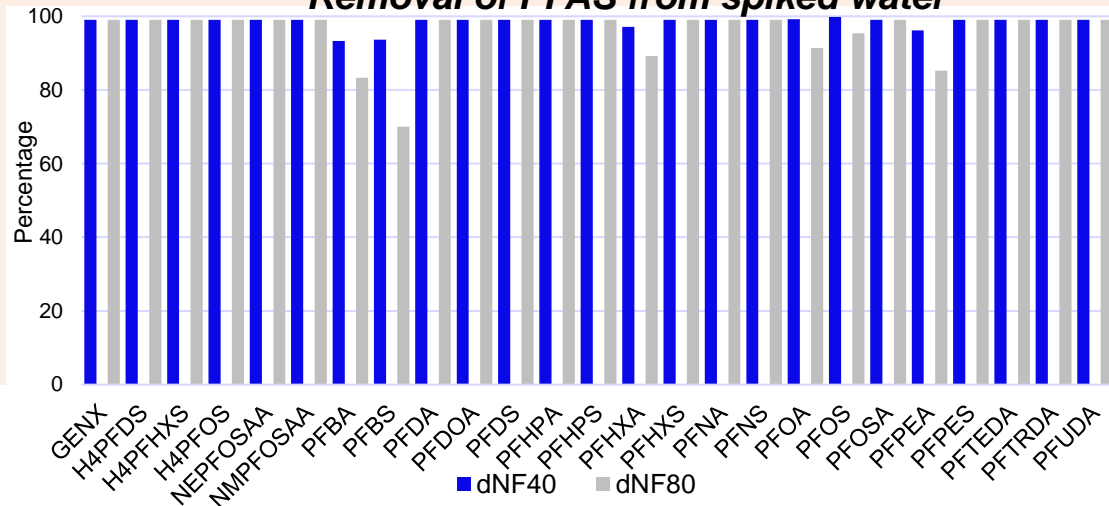


Per- and polyfluoroalkyl substances (PFAS) are manmade substances used in many industries and products that often end up in the environment. PFAS are not biodegradable and have a negative effect on the environment and health. Because of this, PFAS have been identified as substances of high concern.

## Our Solution

Our dNF membranes offer an unprecedented effective and efficient barrier for many of the different PFAS molecules and can be integrated into processes to produce safe and PFAS free drinking water or remediation of contaminated water sources.

Removal of PFAS from spiked water



## Project details



Pressure  
4 bar

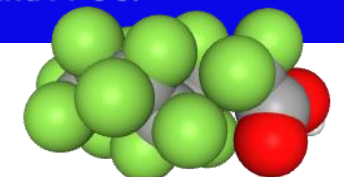


Recovery  
80%



Feed  
(Spiked) Riverbank  
filtrate

Together with a Dutch drinking water company, both the dNF40 and the dNF80 membranes were tested on bank filtration water. Analysis showed that all PFAS levels in the permeate were below the detection limit of the analysis (<1-5 ng/L). Additional tests performed with water spiked with high levels of PFAS showed excellent retention on most of the PFAS molecules in the assay, including PFOA and PFOS.



# PFAS問題を知るために

- West Virginia州のDupont工場の廃棄物処理場からの漏洩水汚染に端を発した訴訟で、2018年にDupontが和解金US\$650Mを支払うまでの経緯を実話に基づいて描いた映画。
- 3Mもミネソタ州と同年US\$720Mで和解。
- 昨年末から、長期に同様の理由で3M ベルギー工場が稼働停止。
- 日本でも、沖縄本島北部で、日本の水道水暫定基準値の100倍以上の濃度で検出。原因は米軍基地内での軍用消火器使用によるものと推定されている。
- 韓国では、大邱付近で2018年に漏洩事故あり、洛東江流域の大邱、釜山での水道水中のPFAS濃度が高いことが報告されている。
- 中国の諸大学からも本物質による水質汚染に関する文献は多数発表されている。



# Pre-treatment for RO process at an aerospace multinational in Hungary

## The customer's query

The customer, an American aerospace multinational located in Hungary, was looking for a pre-treatment solution for its reverse osmosis (RO) process of wastewater streams from the cleaning of airplane engine parts.

## Our approach

We applied our dNF40 nanofiltration membranes after a complex wastewater treatment process to decrease the cleaning frequency of the RO system and increase the lifetime of the reverse osmosis elements.

## Results

The dNF unit combines 200mm and 110mm dNF40 modules in a Christmas tree arrangement with partial recirculation to increase the overall recovery. We realized a reduction of the RO cleaning frequency as well as a prolonged lifetime of the RO elements.



**>90%** recovery

**2x** doubling of the RO flux

**80-90%** COD removal



# Wastewater reuse project for multinational soft drinks producer in Canada

## The customer's query

As part of its sustainability goals, a soft drinks plant in Canada was looking for a solution to reduce Biological Oxygen Demand in a sugary wastewater to cut wastewater discharge costs and enable use of the sugary concentrate in feedstock.

## Our approach

- We applied our dNF40 nanofiltration membranes after a self-cleaning strainer directly on the wastewater discharge without the use of any coagulation chemicals.

## Results

The dNF40 unit has a single pass Christmas tree arrangement. The unit is operating at a recovery of more than 75%. Producing a concentrate stream containing 10,000 ppm BOD and a product water with 600 ppm BOD from a 2700 ppm BOD feed water at a flow of 90 gpm (20 m<sup>3</sup>/h).



**1** Single pass process for minimum energy usage

**>75%** recovery

**>75%** BOD rejection

# One-step surface water treatment for drinking/process water production

## Why dNF?

Removal of color, organics, bacteria and viruses.  
Pretreatment consists of a rotating drum strainer with no additional chemical injection

## Project details

<b>Location</b>	<b>Forsmark, Sweden</b>
Application	Surface water treatment
Objective	Color removal
Membrane	dNF40
Flux	12 LMH
Recovery	75%
Capacity	36 m <sup>3</sup> /h permeate
Installed membrane area	3182 m <sup>2</sup>
Operational since	December 2020



**VATTENFALL** 

# Micropollutant removal and potable reuse of municipal secondary effluent in Northern Europe

## The customer's query

A municipal wastewater treatment plant in Northern Europe required an effluent polishing solution that reduces micropollutants and produces potable water.

## Our approach

We applied dNF80 nanofiltration membranes in a fully automated, containerized pilot unit. The membranes are hydraulically flushed and backwashed once per hour, with a 30-minute chemical flush daily (250 ppm NaOCl), and provide a stable, high quality permeate to the downstream UV peroxide unit.

## Results

Our dNF80 modules reject micropollutants at levels well above that of standard advanced oxidation or activated carbon.





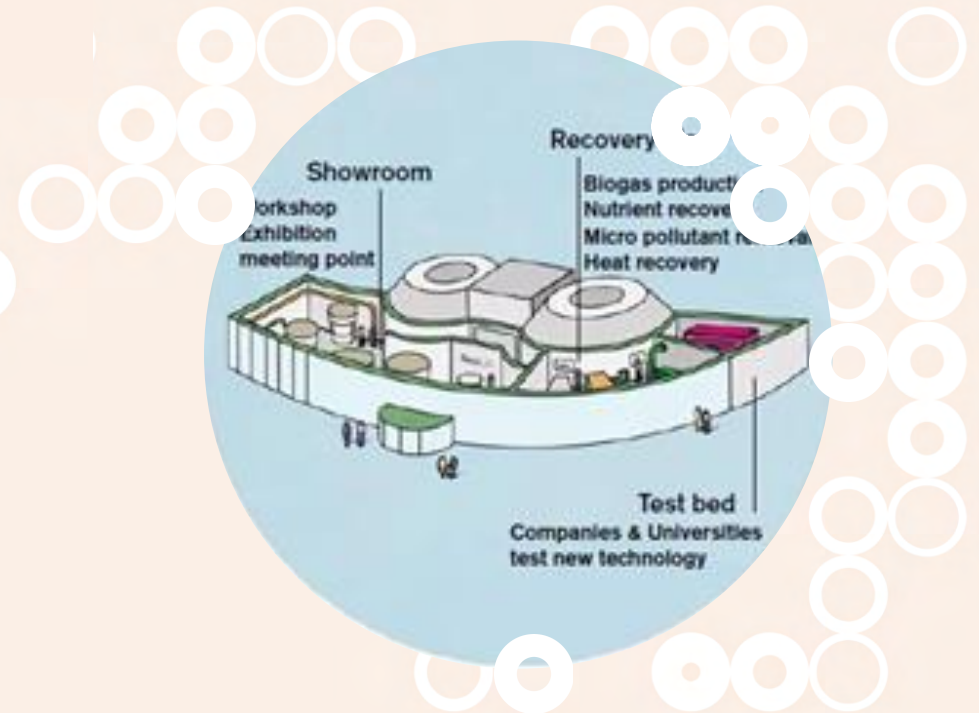
# Reco Lab: recovering nutrients from an urban waste stream in Sweden

## 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

# Direct surface water treatment to produce potable water in Vietnam

## The customer's query

The customer was looking for a simple and robust solution to remove color ("humic acids") and micropollutants that accumulate in the Mekong River. This water source can be used to produce drinking water.

## Our approach

We applied our dNF80 nanofiltration membranes, providing a unique one-step solution resulting in a product water flow of up to 2,400 m<sup>3</sup>/d from the Mekong river.

## Results

Our dNF80 modules are operated in a Once-through arrangement to achieve maximum recovery.



**1** step solution, no pre-treatment required

**>95%** Color Removal

**70%** Recovery

**0%** Anti-scalant injection

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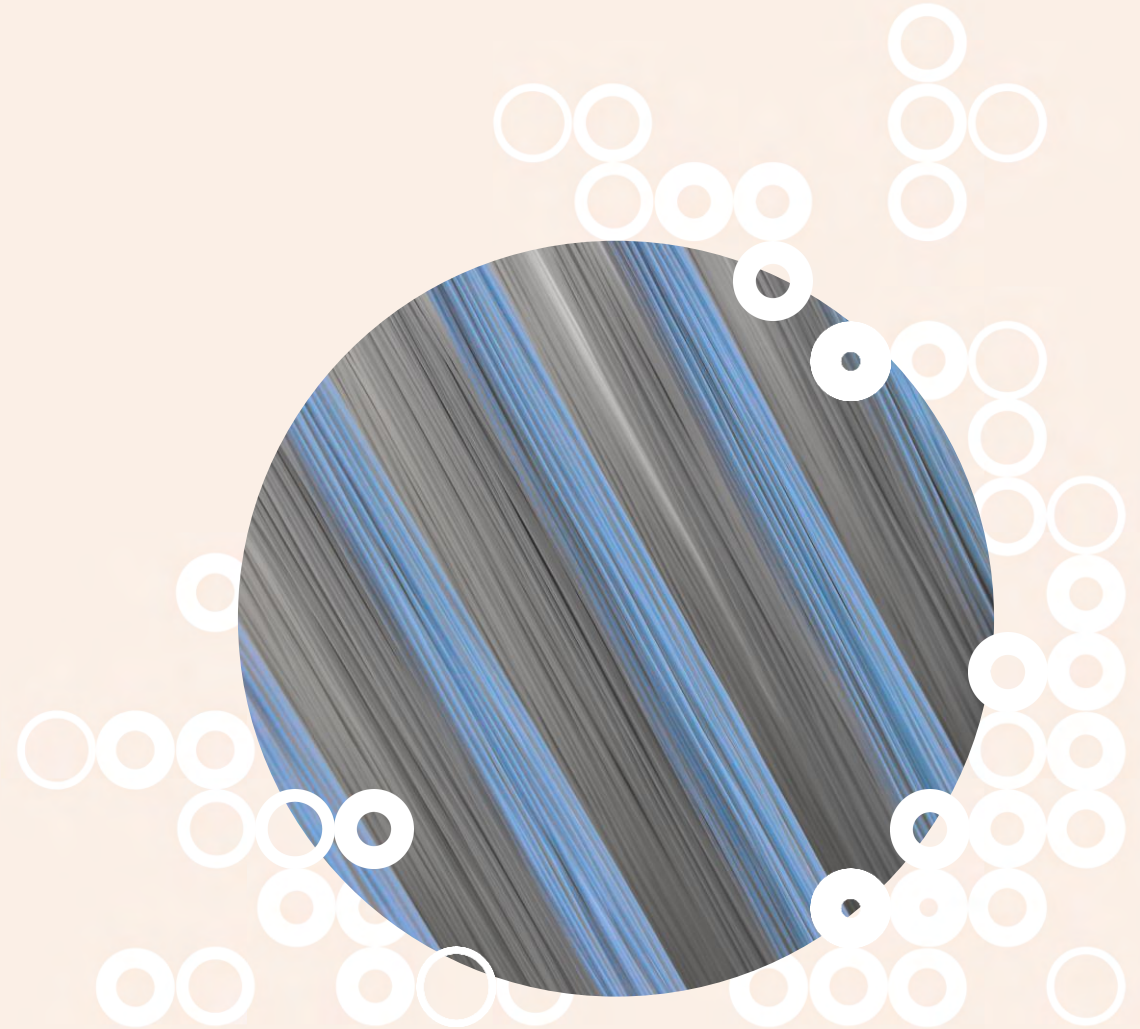
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# Mexplorer™ Pilot Unit



- Lab-scale / table-top
- Proof of concept
- Permeate flow: Up to 2 l/hr (3.7 gal/hr)
- 1 x MP025 module



# Mexperience™ Pilot Unit



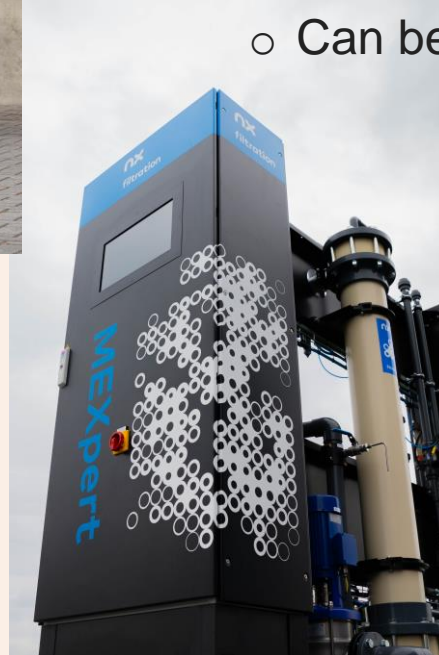
- Commercial-scale pilot unit
- Continuous, semi-automatic operation
- Remote monitoring
- Permeate flow: 200-400 l/h (1.1 – 2.6 gpm)
- 1 x WMC110 module



# Mexpert Pilot Unit



- Full-scale pilot unit
- Continuous, fully-automatic operation
- Remote monitoring and control
- Permeate flow: 600-2400 l/h (3.5 - 13.2 gpm)
- 1 or 2 x WMC200 module(s)
- Can be containerized



# Mexpert Pilot Unit - Layout





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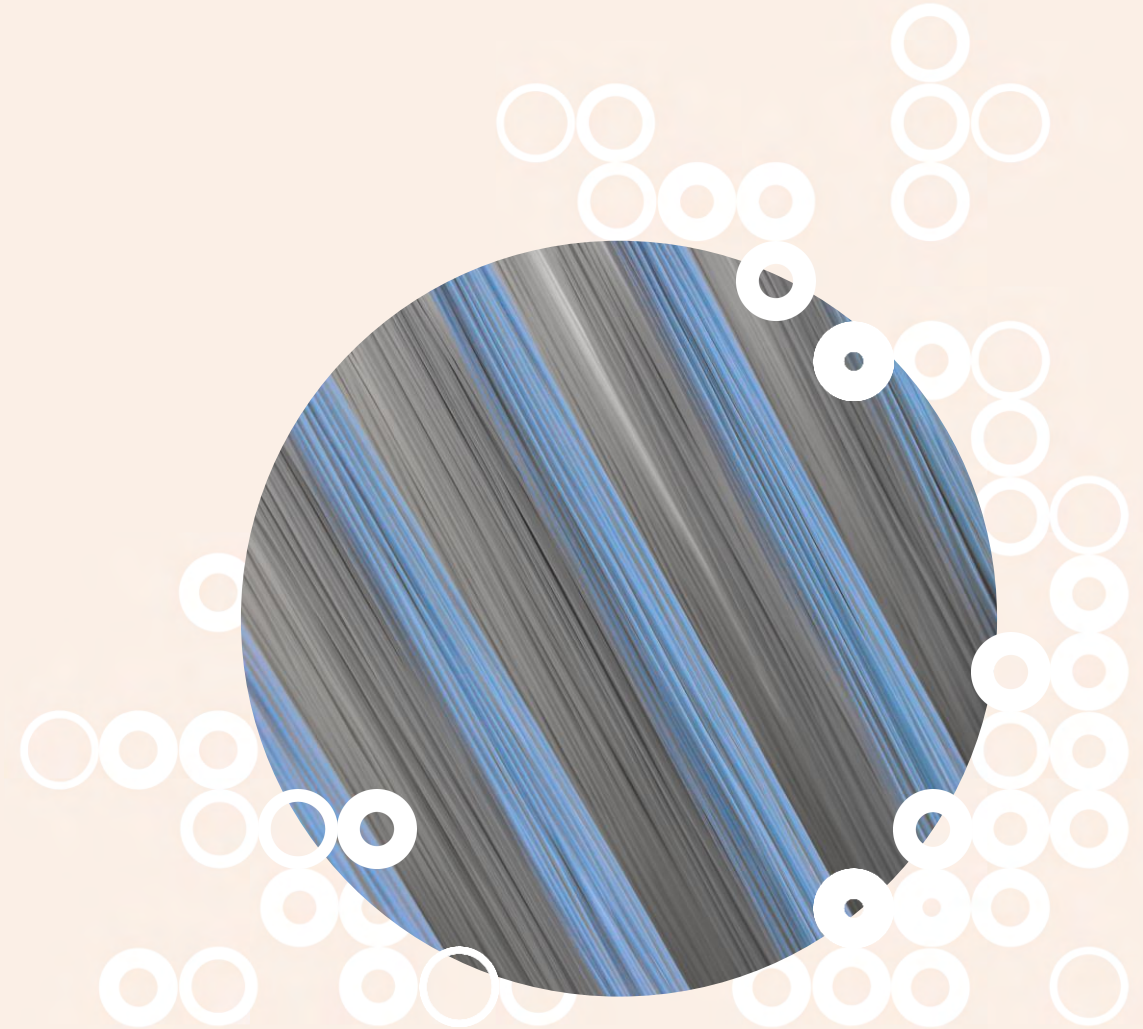
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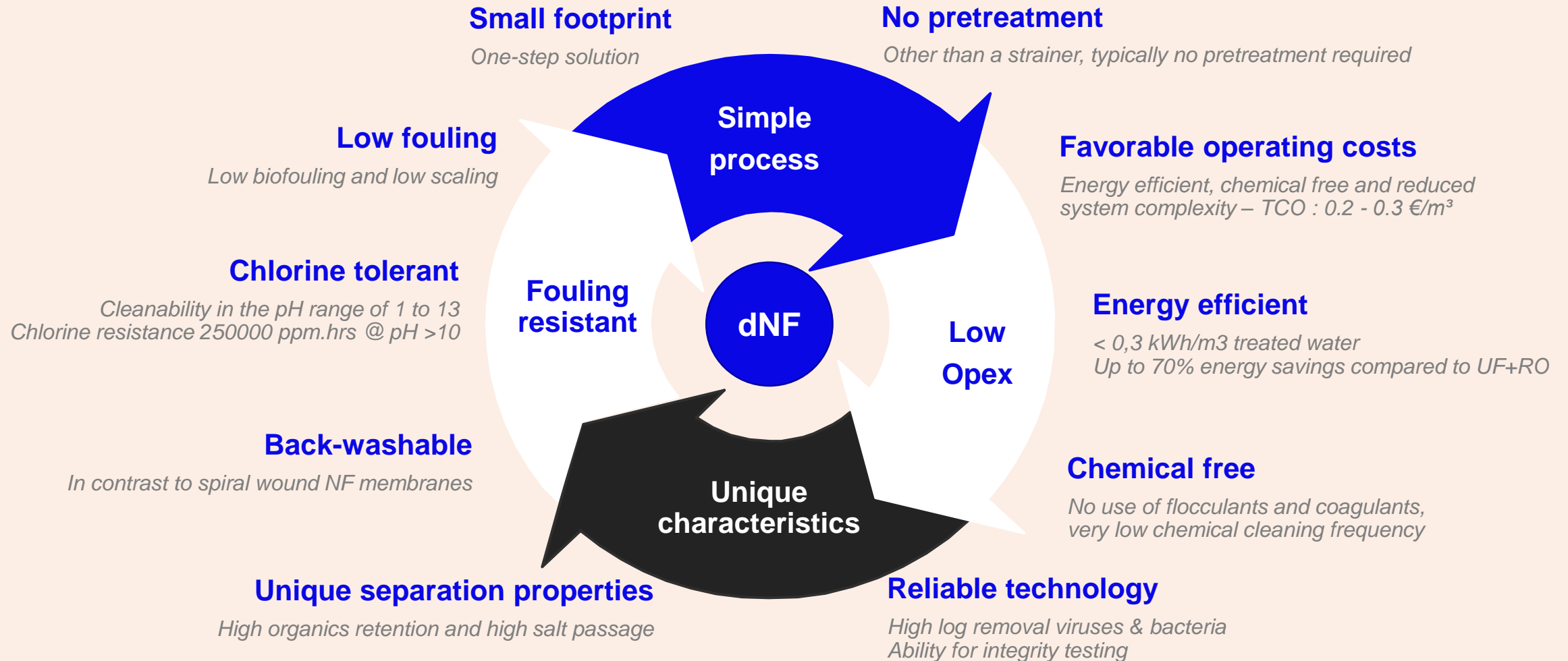
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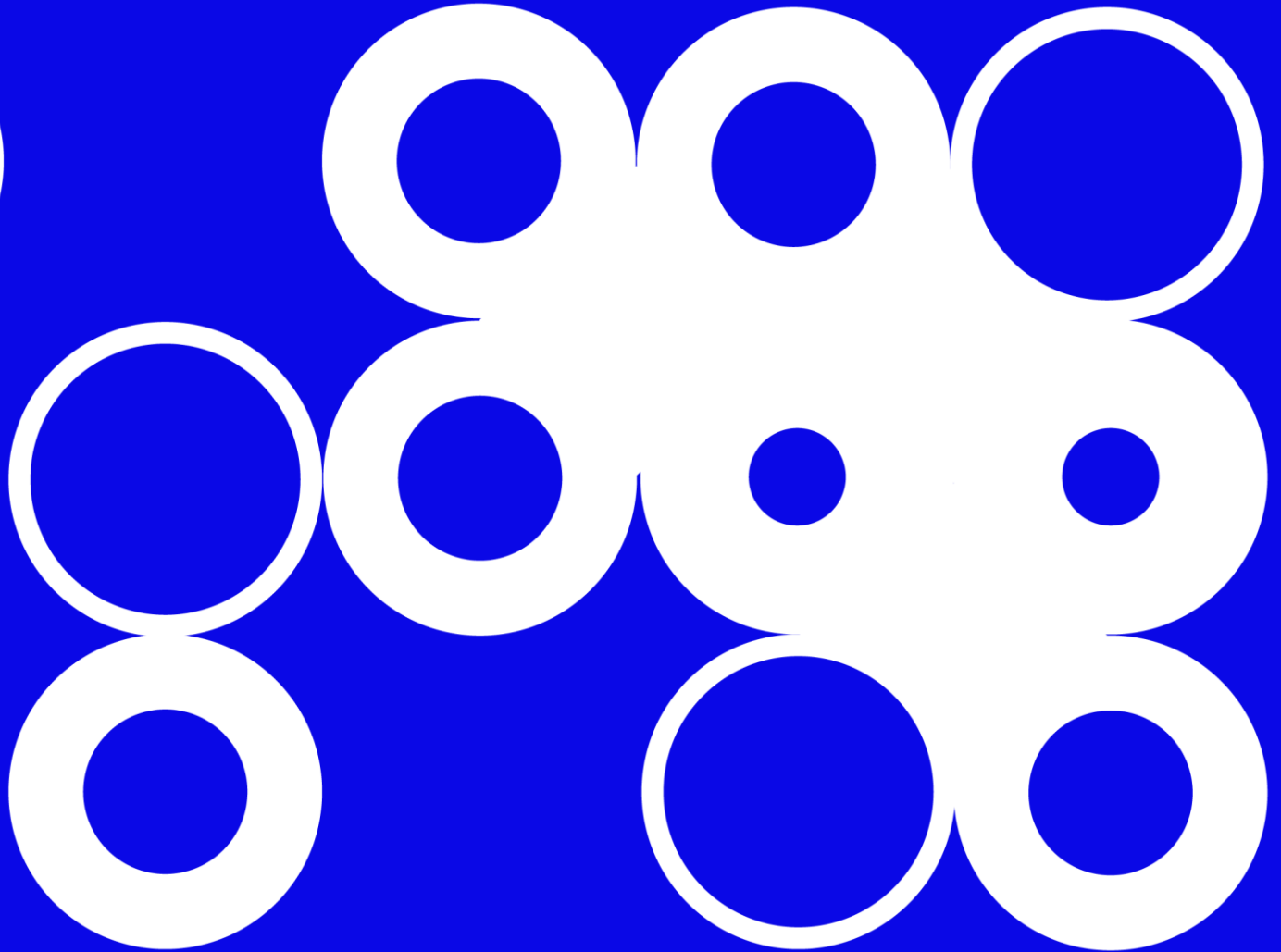
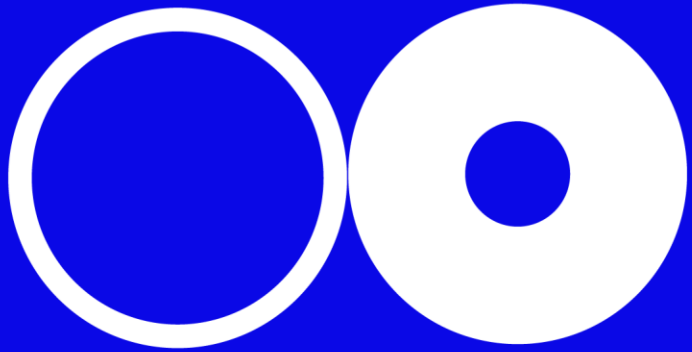
Pilot Fleet

**Conclusion**



# Unique features of our dNF nanofiltration membrane





Thank you

**nx**  
**filtration**