



Aquaporin

US Water & Wastewater Technology



1. **Company**

2. Technology

3. Production

4. Applications

5. Markets

Aquaporin Mission and vision



- Our **mission** is to develop and produce biomimetic membranes with disruptive market potential in water treatment using cutting-edge R&D, and market them through Strategic Commercial Partners, who develop the market, build the necessary systems and sell to end users
- Our **vision** is to become the leading company in membranes for water treatment



Agenda



1. Company

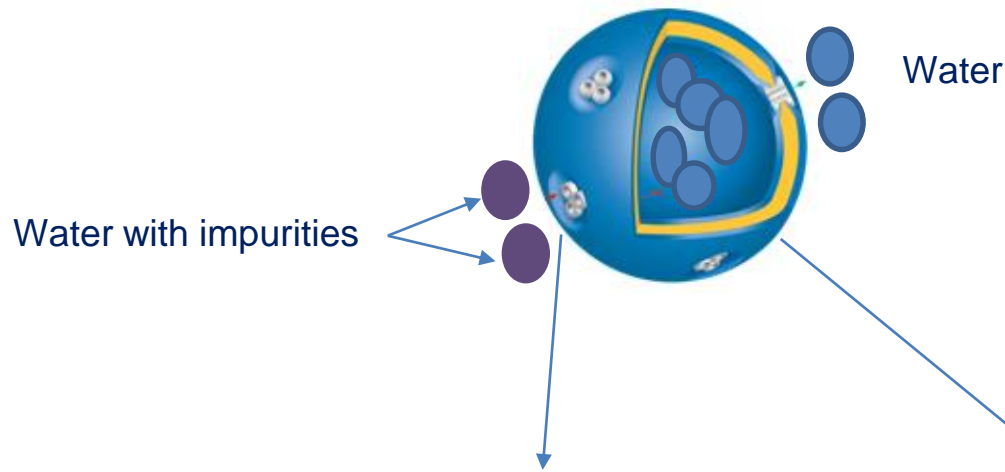
2. Technology

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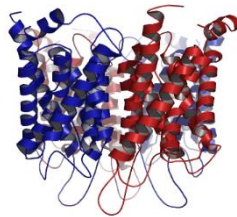
5. Markets

The Aquaporin Inside™ technology – High rejection rates



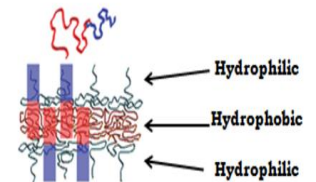
Aquaporin water channels

- Selectivity for water molecules
- Blocking all other present impurities, regardless of molecular weight

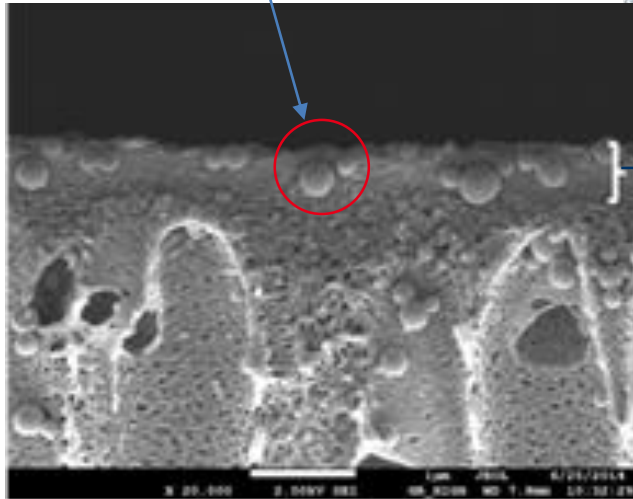
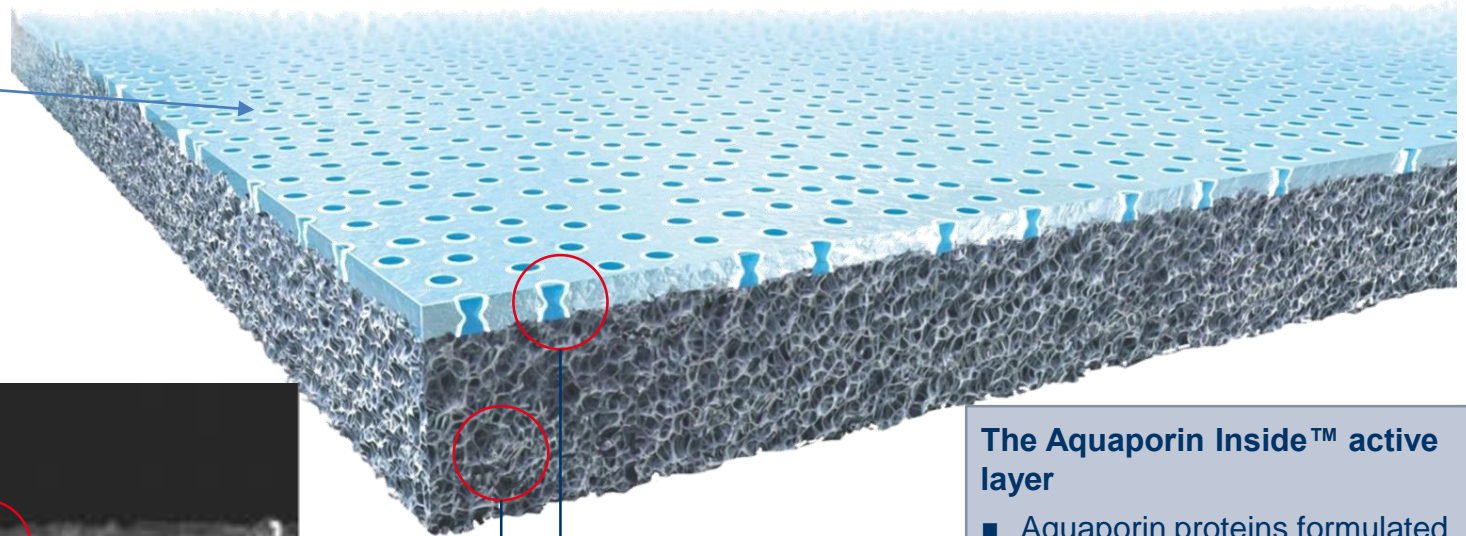


Amphiphilic polymer membrane

- Impermeable for water + small molecular weight molecules
- Tunable properties, high mechanic strength, flexibility
- Long shelf life time



The Aquaporin Inside™ technology



The Aquaporin Inside™ active layer

- Aquaporin proteins formulated into a biomimetic matrix
- Embedded on the surface by an immobilization matrix

- Customized support substrate (both flat sheet and hollow fiber geometries can be used)

- SEM picture showing aquaporin loaded vesicles in the active layer

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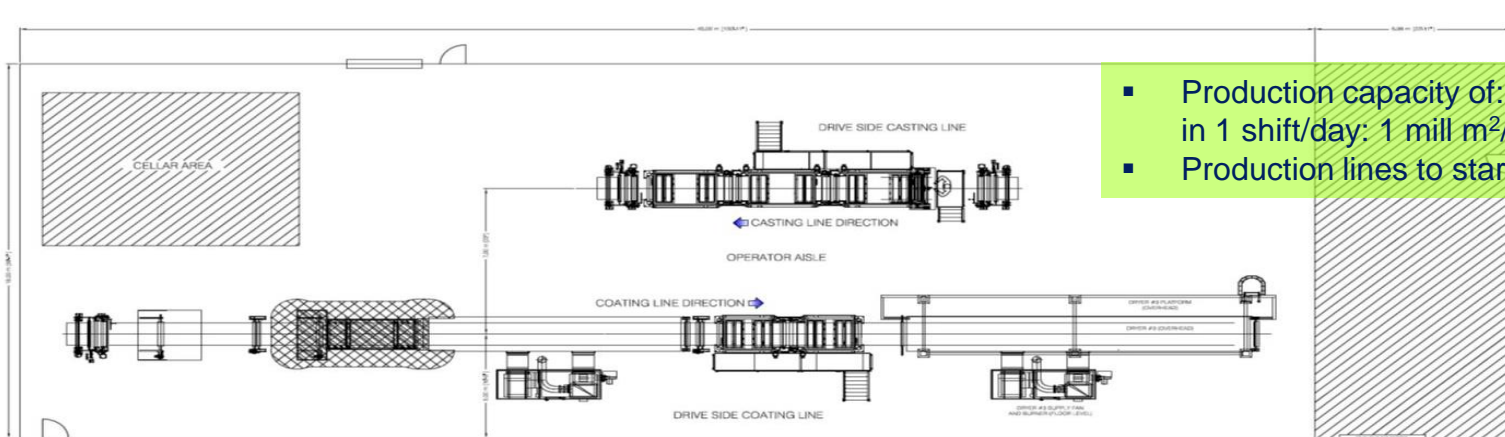
Upscaling of membrane production is ongoing



Thin active layer with a low consumption of aquaporin coating allows **cost-effective production** at scale

Simple incorporation into industrial standard form factors, such as hollow fiber modules and spiral wound modules

Unique membrane **technology platform** and know-how can be tailored for any industrial applications



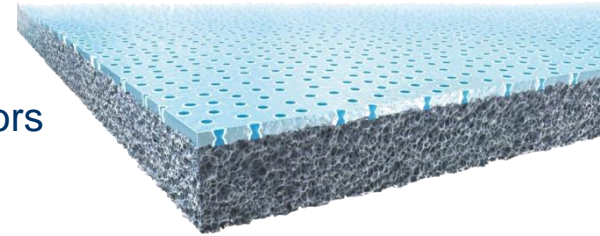
- Production capacity of: 500.000 m²/year in 1 shift/day; 1 mill m²/year in 2 shift/day.
- Production lines to start September 2016

Agenda



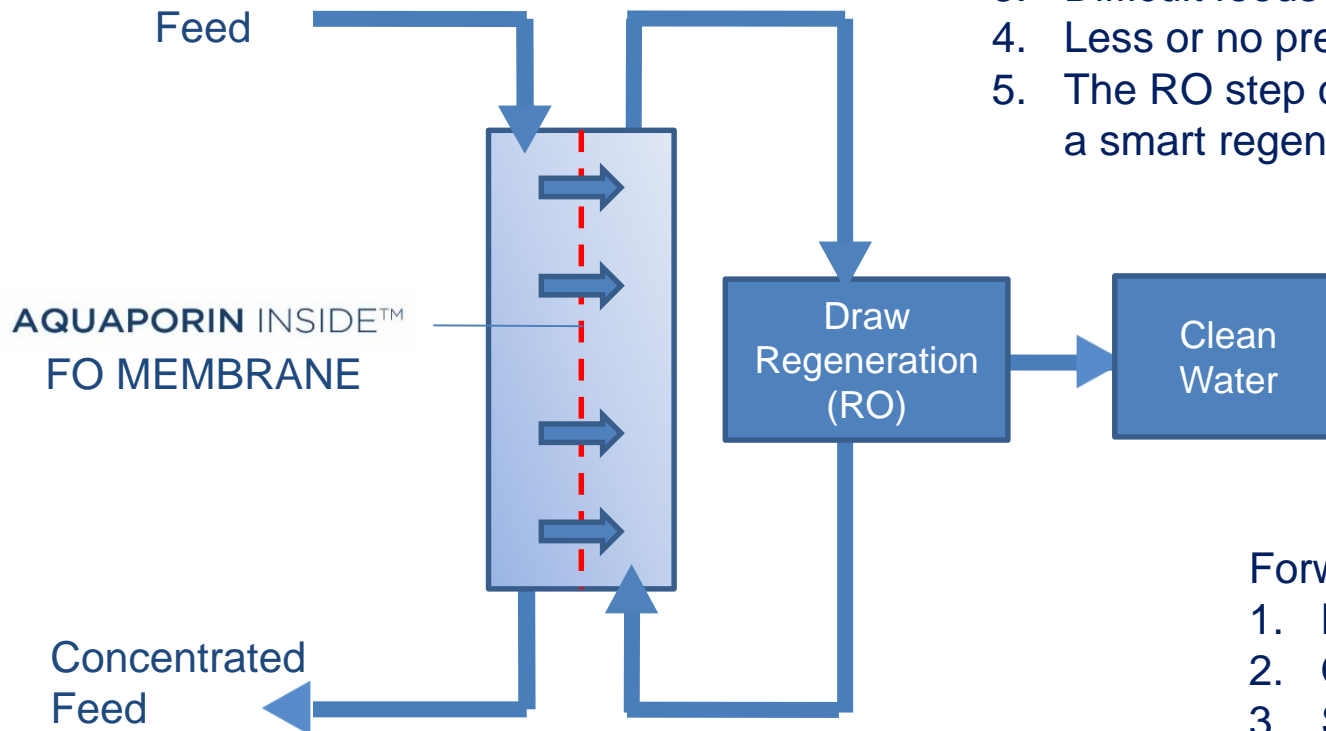
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Aquaporin Inside™ RO Applications



- The Aquaporin Inside™ RO membranes have the same form factors as conventional RO membranes (Plug-And-Play)
- Cleaning of Aquaporin Inside™ RO membranes equal to conventional RO membranes (CIP cleaning at pH 1-11 and elevated temperature)
- pH tolerances during operation of the Aquaporin Inside™ RO membranes equal to conventional RO membranes (pH 2-10)
- Temperature tolerances during operation equal to conventional RO membranes (up to 50°C)
- Lifetime expectancy equal to conventional RO membranes
- The only difference between Aquaporin Inside™ RO and conventional RO is the **20-30% higher flux or lower energy consumption**

Hybrid FO/RO process



FO/RO advantages:

1. High rejection of small molecules
2. Draw can be chosen freely
3. Difficult feeds can be handled
4. Less or no pre-treatment
5. The RO step could be exchanged with a smart regeneration of draw

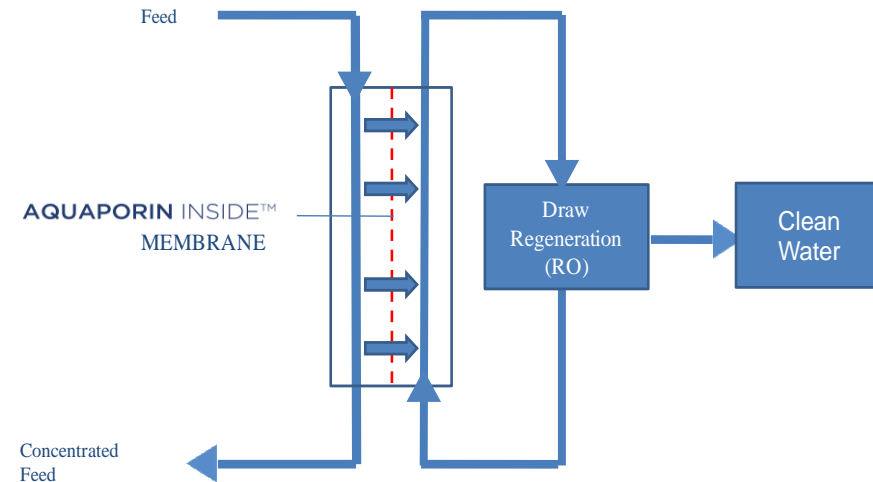
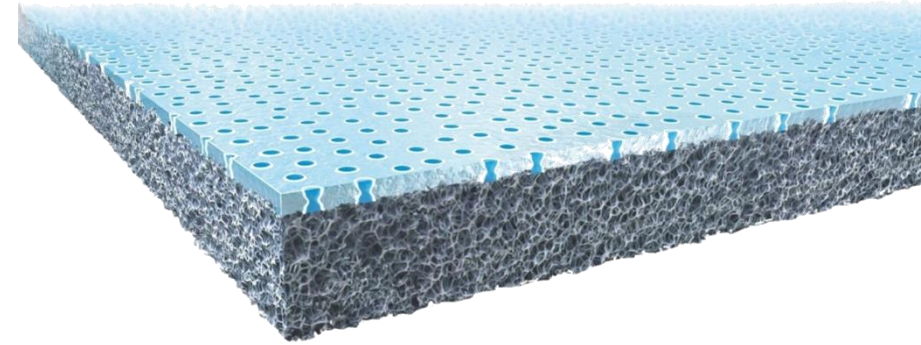
Forward Osmosis (FO):

1. No hydraulic pressure
2. Osmotic pressure driven
3. Superior rejection
4. Low fouling
5. Low energy consumption

Aquaporin Inside™ FO Applications



- **Hollow fiber FO modules and spiral wound FO modules will be available in late 2016**
- Up-concentration of valuable products (foods, proteins, peptides, pharmaceuticals, small organics etc.)
- Up-concentration of waste water streams (produced water, dairy waste water, textile waste water, scrubber water, ZLD etc.)
- Pre-treatment step to RO when handling difficult feeds (desalination, waste water treatment, high fouling feeds etc.)
- Pre-treatment step to RO when extra high rejections are necessary (desalination, re-use of water etc.)
- Special Applications (fertilizer, industry streams, fermentation, PRO etc.)



Aquaporin in space



- The European Space Agency has chosen Aquaporin in its program for reusing waste water on space missions.
- Samples for analysis will return in April 2016

Danish astronaut Andreas Mogensen testing Aquaporin Inside™ membranes aboard the International Space Station, September 2015

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The Forward Osmosis market

- Blue ocean industry
 - Opportunity for innovators.
 - Challenge to work in conservative market.
- Current estimate of market size equals USD 10 million but expected growth to USD 100 million in 3-5 years



The Reverse Osmosis market

- Red ocean industry
 - Known technology & demand from customers
 - Competitive advantages of aquaporins
- Current estimate of market size equals USD 6.8 billion



Join the water revolution !

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