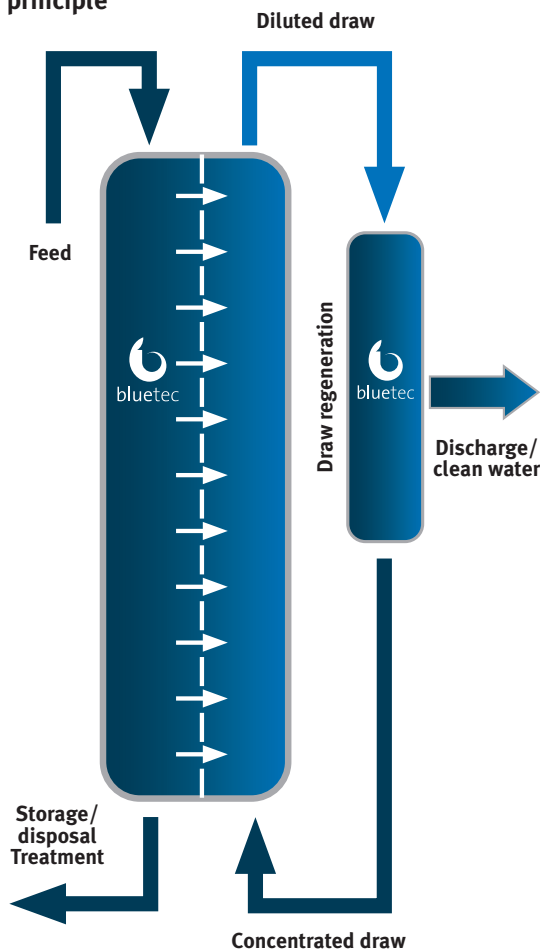


# Technical Factsheet: Forward Osmosis

Forward osmosis (FO) is a promising technology to treat feed streams with a high fouling tendency. The core element is a semi-permeable membrane, over which a highly saline solution (draw solution, DS) draws water from the feed. Since no mechanical pressure is used in this step, FO shows a low tendency for irreversible fouling. FO produces a concentrate and a diluted DS with diminishing fouling risk. Coupled with a subsequent treatment to re-concentrate the DS, e.g. reverse osmosis or membrane distillation, FO facilitates efficient membrane treatment for feed streams with high fouling risks.

## Working principle



## Advantages

- ▶ Facilitating use of membranes for feeds with a high fouling risk
- ▶ Reduction of energy consumption in comparison to thermal treatment
- ▶ Very high up-concentration close to Zero Liquid Discharge can be possible
- ▶ No use of mechanical pressure in the FO unit
- ▶ Low irreversible fouling
- ▶ No high temperatures required
- ▶ Excellent permeate quality

## General data

Typical applications	Highly fouling waste waters Product concentrate Bio-processes Zero liquid discharge
Average energy consumption	10 – 15 kWh/m <sup>2</sup> with energy recovery system
Average chemical consumption	DS salts: depending on selected salt and feed composition, typically: <ul style="list-style-type: none"> <li>• NaCl: 15 g h<sup>-1</sup> m<sup>2</sup></li> <li>• MgCl<sub>2</sub>: 3 g h<sup>-1</sup> m<sup>2</sup></li> </ul>

## Remarks

- ▶ At high concentration factors, some concentrates can be further treated by anaerobic digestion
- ▶ For high osmotic pressures, DS recovery can be done using a multi-step high brine RO treatment (HBRO™)

## Key Performance Indicators (KPIs)

KPI description	Unit	KPI
FO flux	L/m <sup>2</sup> /h	5 - 7
Volumetric concentration factor	-	2 - 3/9**
Permeate quality	g <sub>NaCl</sub> /L	0.1 - 2.7*
NaCl consumption	kg <sub>NaCl</sub> /h	1 - 2.7*
Energy demand	kWh/m <sup>3</sup> <sub>permeate</sub>	20***
Cleaning detergent acid	L/m <sup>3</sup> <sub>permeate</sub>	1.5
Cleaning detergent base	L/m <sup>3</sup> <sub>permeate</sub>	1.2
Cleaning detergent HCl	L/m <sup>3</sup> <sub>permeate</sub>	0.02

\* The higher value was obtained towards the end of the testing period, due to membrane wear

\*\* Volumetric concentration of 9 was reached in a batch test

\*\*\* In the pilot an energy consumption of 36 kWh/m<sup>3</sup> was found, with the use of pressure recovery systems an energy use of 20 kWh/m<sup>3</sup> is expected.

KPI description	Unit	KPI
FO flux	L/m <sup>2</sup> /h	4 - 6
Volumetric concentration factor	-	3 - 4.5
Distillate quality	g <sub>NaCl</sub> /L	0.08 - 0.1
Energy demand	kWh/m <sup>3</sup> <sub>distillate</sub>	300*

\* In the test set up, an energy consumption of 430 kWh/m<sup>3</sup> was measured. It is expected, that by optimizing process conditions an energy consumption of 250 – 300 kWh/m<sup>3</sup> could be achieved

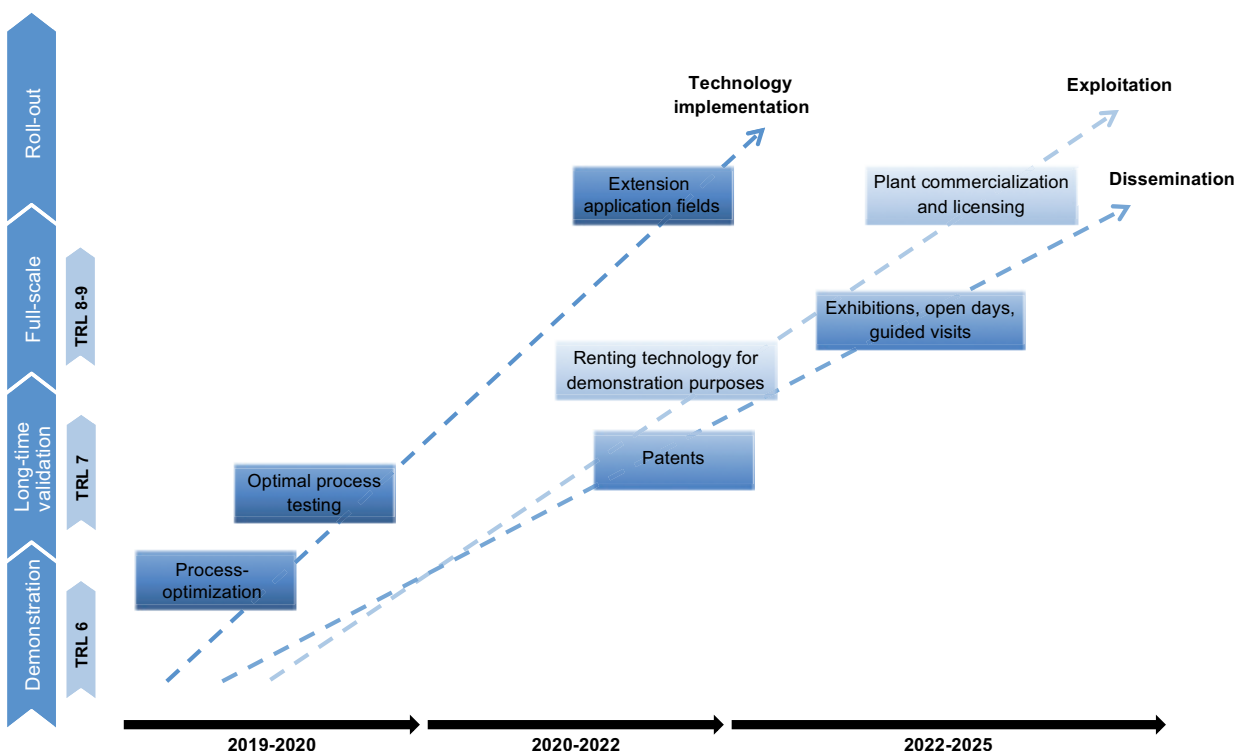
### SWOT analysis

<b>INTERNAL</b>	<ul style="list-style-type: none"> <li>• Ambient temperature and pressure required for wastewater concentration</li> <li>• No phase transition required for wastewater concentration</li> <li>• Low energy consumption of the HBRO™ compared to evaporators</li> <li>• Low quality heat can be used in the MD</li> </ul>	<ul style="list-style-type: none"> <li>• Frequent membrane cleaning may be necessary , definition of adequate cleaning procedures required</li> <li>• FO are still under development</li> <li>• High reverse salt flux, subject of advanced membrane research</li> <li>• High pressure is required in the draw solution recovery section</li> <li>• Insufficient FO membrane selectivity considering exchange of components in feed and draw solution</li> <li>• New MD technology is still improvable, but high potential available</li> </ul>
	<b>EXTERNAL</b>	<ul style="list-style-type: none"> <li>• Huge market potential in industry for concentration of different type of streams not just wastewater but also product streams with high added value</li> </ul>

### References, patents and licenses

References	Pilots of 12 m <sup>3</sup> /day and 0.5 – 5 m <sup>3</sup> /day.
Patents	Under application.
Licenses	–

### Overview Roadmap



### Contact

BLUE-tec BV: Lex van Dijk

lexvandijk@blue-tec.nl

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