
AEE INTEC
AEE - Institute for Sustainable Technologies

2017

AEE - Institute for Sustainable Technologies was founded in1988 as a non-university research institute. It is today one of the leading institutions in the field of renewable energy and resource efficiency.

1988

In the world of renewable energy and resource efficiency we transform ideas into reality through:

AEE INTEC

- Research
- Development
- Consulting
- Training

Our Employees

65

Staff Members

8-10

Masterstudents

3

PhD Students

AEE INTEC

Building and Retrofit

Thermal Energy Technologies and Hybrid Systems

AEE INTEC

Industrial Processes and Energy Systems

Monitoring and Lab

Christoph Brunner

Energy and Resource Efficiency for the Industry

Process Intensification
Membrane Distillation

Industry in Energy Systems

Solar Process Heat

Textile Industry-

ZLD and MD

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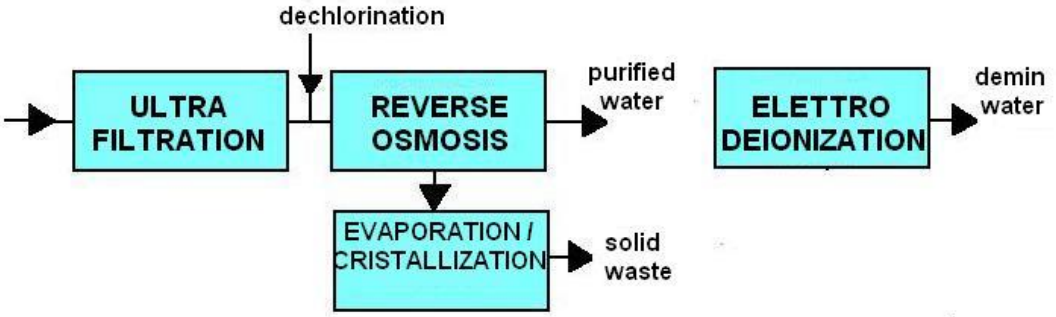
Zero Liquid Discharge

A **Zero liquid discharge facility** (ZLD), is an industrial plant without discharge of wastewaters.



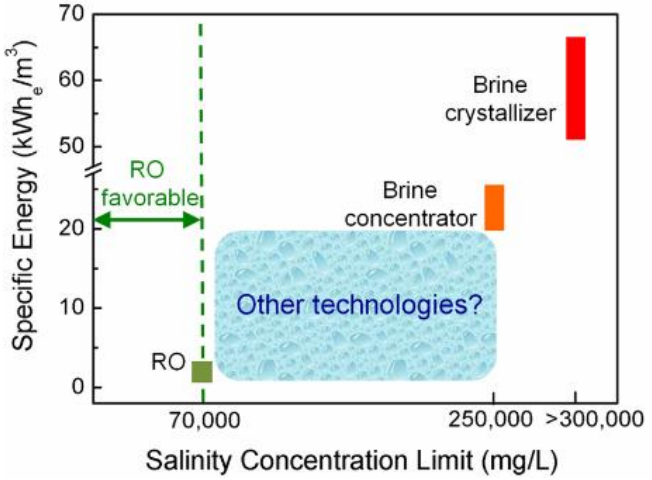
Source: Amolaterra - CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=26709164

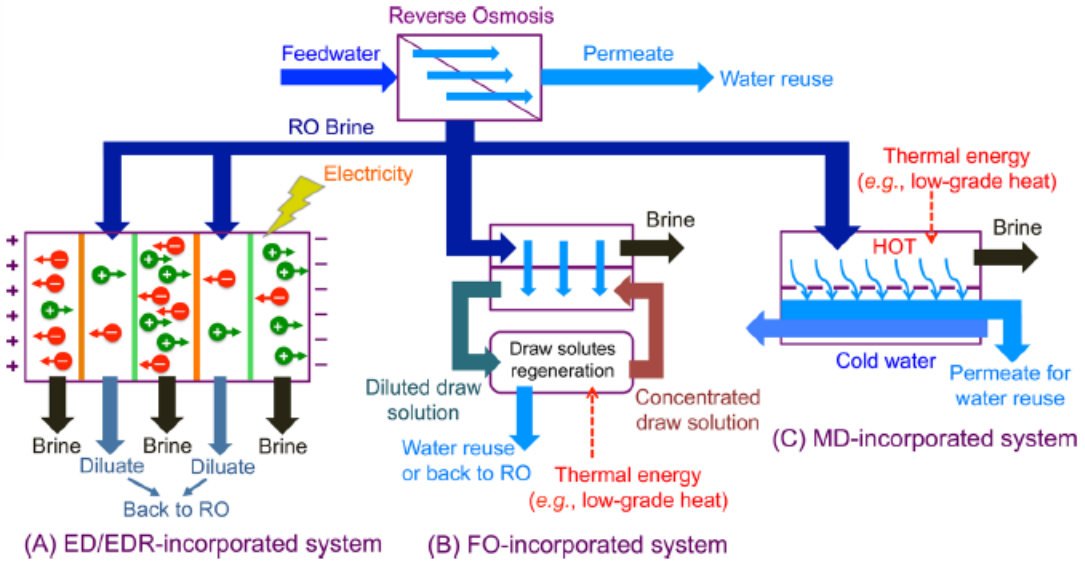
Challenges:

- High costs
- High energy demand
- ZLD ≠ 100 % reuse

→ Innovative Concepts

ZLD- other technologies?





Environ. Sci. Technol. 2016, 50,6846−6855;DOI:10.1021/acs.est.6b01000EnvironmentalScience and Technology·The Global Rise of Zero Liquid Discharge for Wastewater Management: Drivers,Technologies, and Future Directions

Technologies

Table 1. Advantages, Limitations, And Energy Consumption of Different Salt Concentrating Technologies used in ZLD Operations

technology	advantages	limitations	energy consumption
RO	energy efficient modular	limited salinity range (upper concentration ~75 000 mg/L)	seawater: 2−6 kWh_e/m^3 of product water;[8,16]
	technical maturity	high fouling propensity	brackish water: 1.5−2.5 kWh_e/m^3 of product water[16]
ED/EDR	high salinity limit (upper concentration >100 000 mg/L)	high energy consumption and cost when treating high salinity feedwater with high-quality water product	7−15 kWh_e/m^3 of feedwater (with feed salinity >15 000 mg/L)[52−55]
	low fouling propensity (especially for silica-enriched feedwater)	incapability of removing noncharged contaminants	
	modular	using only prime energy	
FO (with NH_3/CO_2 thermolytic draw solution)	high salinity limit (upper concentration >200 000 ppm)	low water flux at very high feed salinities	21 kWh_e/m^3 of feedwater (with feed salinity of 73 000 mg/L and recovery of 64% in average)[43]
	utilization of low-grade heat	reverse solute flux (NH_3 may contaminate product water)	
	low fouling propensity modular	emerging technology with limited field performance data	
MD	high salinity limit (upper concentration >200 000 ppm)	low water flux and water recovery	40−45 kWh_t/m^3 of product water[76]
	utilization of low-grade heat	potential of membrane wetting	22−67 kWh_t/m^3 of product water[72]
	low fouling propensity modular	post-treatment is needed if volatile pollutants are present	
		emerging technology with limited field performance data	
MVC brine concentrator	technical maturity	high energy consumption	20−25 kWh_e/m^3 of feedwater[11,22]
	high salinity limit (upper concentration >200 000 ppm)	high capital and O&M costs	28−39 kWh_e/m^3 of feedwater[43]
		operating at high temperature	
		using only prime energy	
		not modular	

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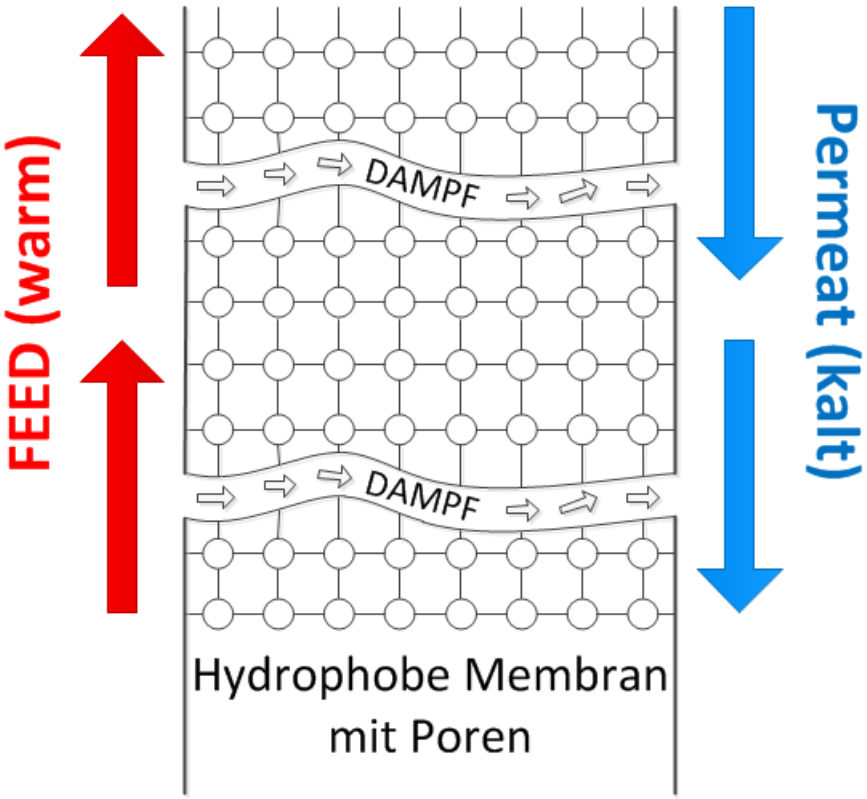
Membrane Distillation



- Driving Force: **Partialpressuredifference**

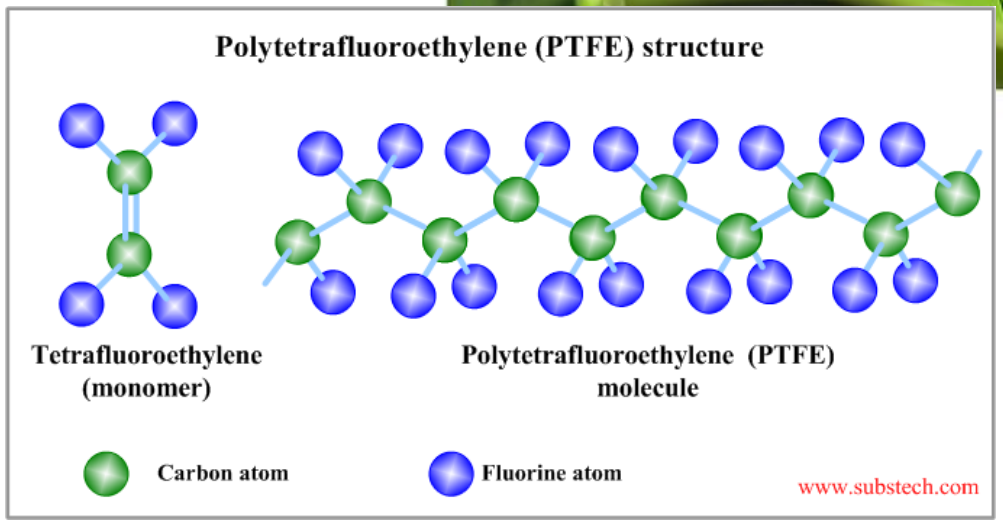
  Temperature difference between Feed and Permeate

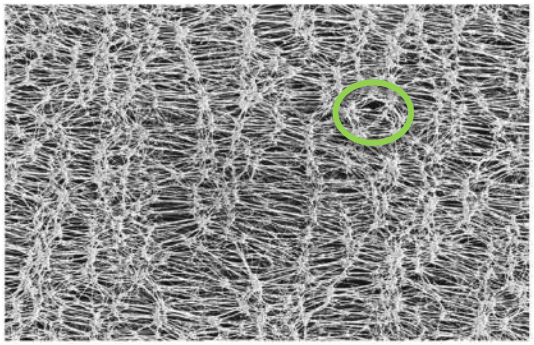
- Low operation temperatures (~ 80°C) – Usage of Waste heat (Industry) and Solar energy!
- Low fouling potential
- High product quality
- Operation at high feed concentration

Gore:
waterproof + breathable

Quelle: http://www.hotel-seelos.at/aktivitaten/winter/schifahren/; gore.com

Polytetrafluorethylen - PTFE





Source: gore.com, http://www.mpip-mainz.mpg.de/193539/research_report_67088532c=16785

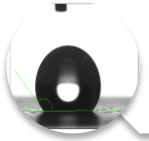
MD @ AEE INTEC

- **MD for Nutrient Recovery in Waste Water Treatment Plants**
- **Recovery of Ammonia from liquid biogas sludge via MD**
- **Concentration of Gold and Palladium Bath in Electroplating Industry**
- **Recovery for Recycling of galvanic bath**

Experimental

Exposure of membrane in media

Liquid Entry Pressure Tests (LEP)



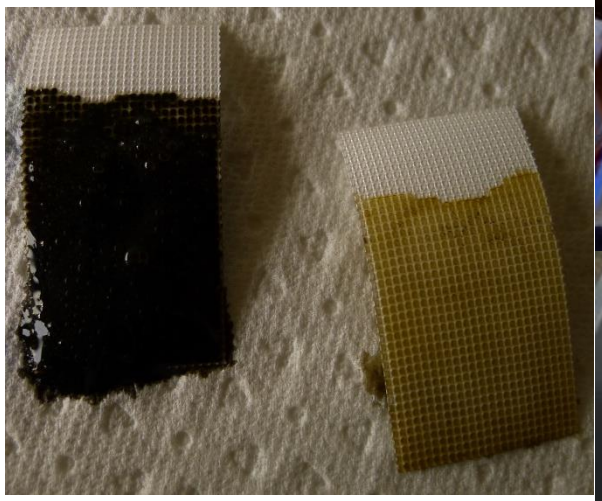
Contact angle measurements

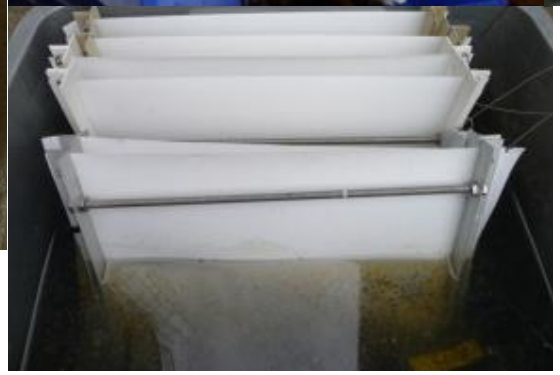
Test cell experiments

Experiments with synthetic WW

Experiments with real WW

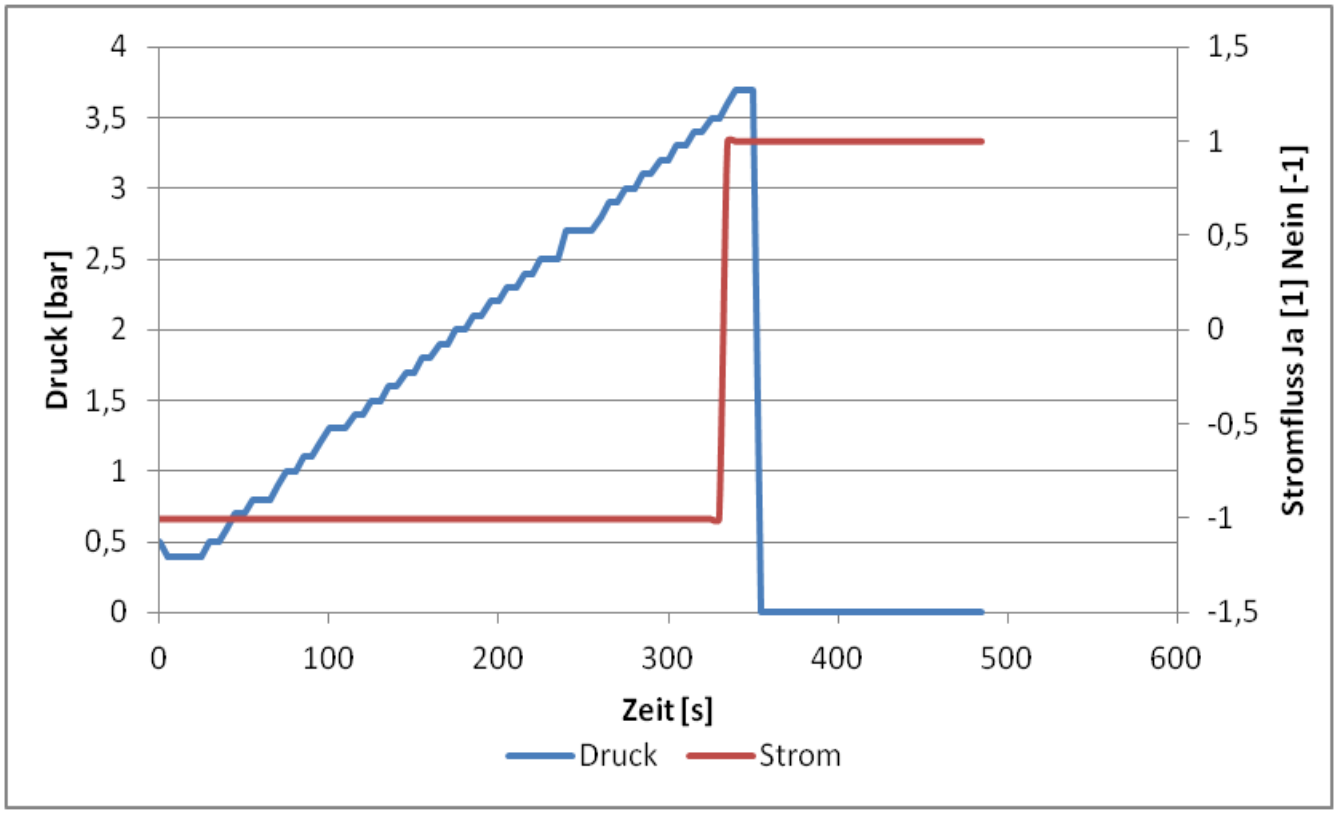
Exposure and Stability of membranes





Quelle: http://uk.hach.com/ammonium-cuvette-test-2-0-47-0-mg-l-nh-sub-4-sub-n/product?id=26370269011

Liquid Entry Pressure Tests (LEP)



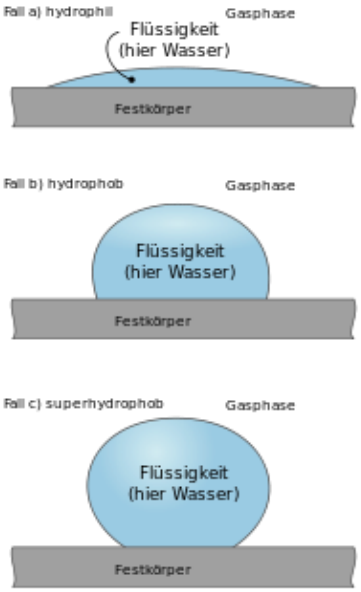
Max. pressure on new membrane: 3,5 bar
Min. pressure for MD: 1,5 bar

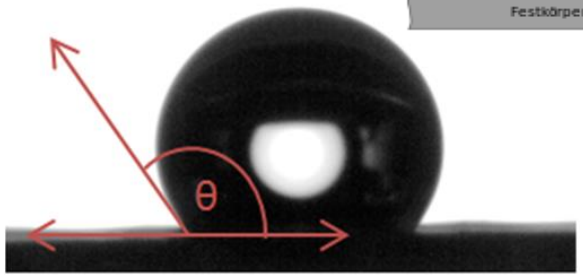
Quelle: Fraunhofer ISE; Solar Spring GmbH

Contact angle measurements

Hydrophobicity of a liquid on a surface
Water troplet: θ> 90°

Standard membrane: **MD: θ= 146°**



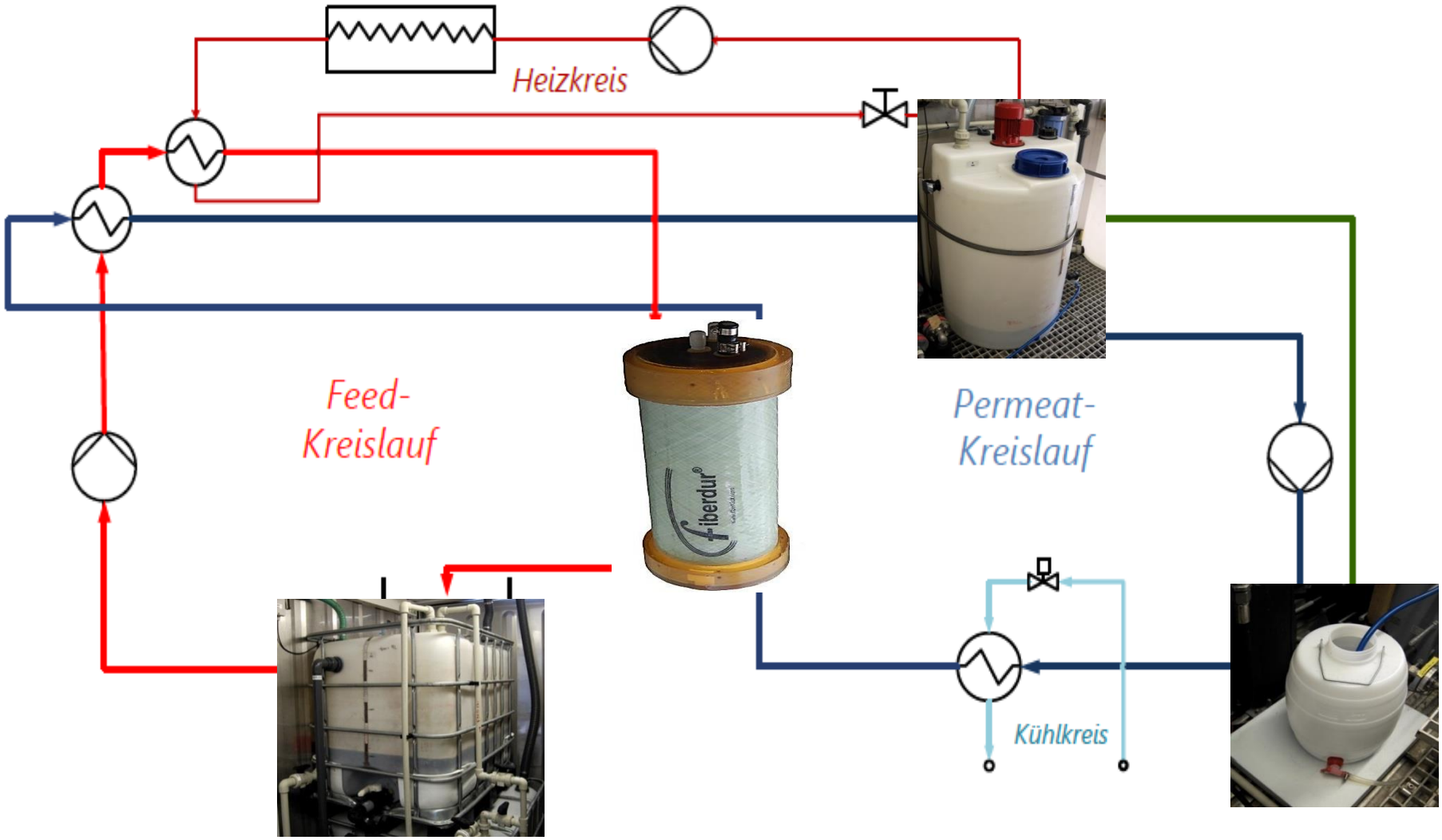


Quelle: Wikipedia, 05.12.2014

Quelle: Staffan Enbom, Wikipedia, 10.11.2015

Test Series with synthetic and real WW/biogas sludge in Pilot Plant

Pilot Plant


Heizkreis
Feed-
Kreislauf
Permeat-
Kreislauf
Kühlkreis
fiberdur

Summary

- 2,8 m^3/day biogas sludge at Maria Lankowitz´s plant
- Ammonia separation rate in average 18,4 %
- Maximal flux of 0,042 kg/m^2.h
- 95 % at 10 Modules in series – scale up concept
- 10,4 kg/d or 3628,2 kg/year ammonium sulfate
- Q_{MD}= 29,1 kWh/d, waste heat 360 kWh/d
- Savings disposal fees up to 25 €/t at liquid manure market (24 500€ /year)

Thanks to Research Promotion and Consortium

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ROTREAT

ABWASSERREINIGUNG GMBH

ZERTIFIZIERT NACH ISO 9001 OFFICIAL CERTIFIED

SFG

Im Auftrag des Wirtschaftslandesrates

Future for ZLD System?

- Optimization – more effective technologies/ energy efficiency
- Integration of emerging technologies
- Smart combinations of technologies
- Resource Recovery (valuable substances, additional revenue)

AEE INTEC

IDEA TO ACTION

Thanks for your attention