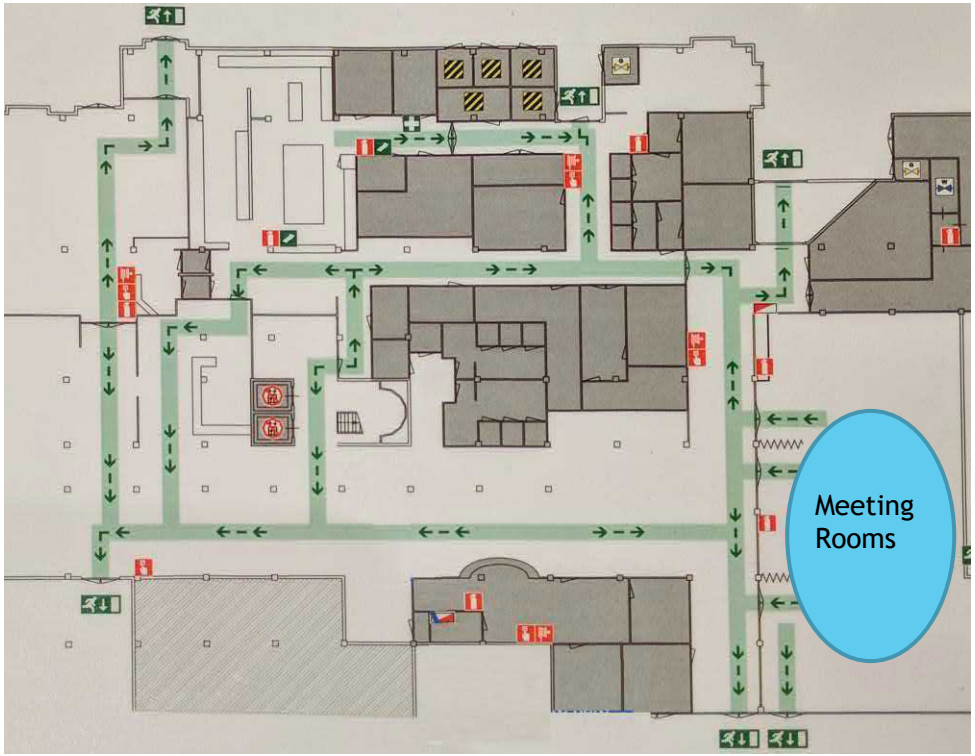

American Institute of Chemical Engineers
Netherlands | Belgium
AIChE
The Global Home of Chemical Engineers

Safety Moment



AIChE
The Global Home of Chemical Engineers

Sponsors

AIChE
The Global Home of Chemical Engineers

Contacts

Iek Risseeuw
Product Development Manager
Technip Energies
Iek.risseeuw@technipfmc.com

Matthias O. Bilawa
Senior Principal Process Engineer
McDermott
MBilawa@mcdermott.com

Burcu Ekmekci
Process Engineering Manager
Fluor
Burcu.Ekmekci@fluor.com

Geert Vercruysse
Site Coordination Director
BASF
Geert.vercruysse@basf.com

Reihaneh Feiz
Programme Delivery Manager
Shell Downstream Chemicals & Products
reihaneh.feiz@shell.com

AIChE
The Global Home of Chemical Engineers

Today's Topic

Veolia Solutions for Green Hydrogen Projects and Carbon Capture:

Water Treatment, Gas Conditioning and Conditioning Chemicals in the Periphery of Electrolyzers

by Egbert de Jong and Joël Van der Borght

VEOLIA Water Technologies & Solutions


American Institute of Chemical Engineers
Netherlands | Belgium
AIChE
The Global Home of Chemical Engineers

Green Hydrogen Services by Veolia presentation at AIChE meeting 14 December 2023 - Zoetermeer

AIChE
The Global Home of Chemical Engineers

https://activities.veolia.com/group/en/1

Egbert de Jong & Joël Van der Borght

Disclaimer & Acknowledgement

The enclosed materials are considered proprietary property of Veolia. No assignments either implied or expressed, of intellectual property rights, data, know how, trade secrets or licenses of use thereof are given. All information is provided exclusively for the purposes of evaluation and is not to be reproduced or divulged to other parties, nor used for manufacture or other means, without the express written consent of Veolia.

Press release 11 December 2023

Alarm!

At COP28, IEA emphasises urgent actions needed to keep 1.5 °C goal in reach

The **COP28 climate change conference** has brought together leaders from around the world in Dubai at a critical moment for the clean energy transition and international efforts to tackle climate change. While the rapid deployment of clean energy technologies in recent years has made a major difference to the climate outlook, the world is not on track to meet the Paris Agreement goal of keeping global warming well below 2 °C – let alone below the threshold of 1.5 °C that science has shown is crucial to avoid the worst effects of climate change.

What needs to be done by 2030 to shift the world onto a 1.5 °C pathway.

1. Triple global **renewable power** capacity
2. Double the rate of **energy efficiency** improvements
3. Commitments by the **fossil fuel industry**, and oil and gas companies in particular, to align activities with the Paris Agreement, starting by cutting **methane emissions** from operations by 75%
4. Establish **large-scale financing mechanisms** to triple clean energy investment in **emerging and developing economies**
5. Commit to measures that ensure an **orderly decline in the use of fossil fuels**, including an end to new approvals of unabated **coal-fired power plants**

At COP28, IEA emphasises urgent actions needed to keep 1.5 °C goal in reach

AGENDA

01 Veolia

02 Blue & Green Hydrogen Overview

03 UPW production

04 Zero Liquid Discharge

05 Hydrogen Purification & pre-Eng. Systems

06 Water conditioning chemicals

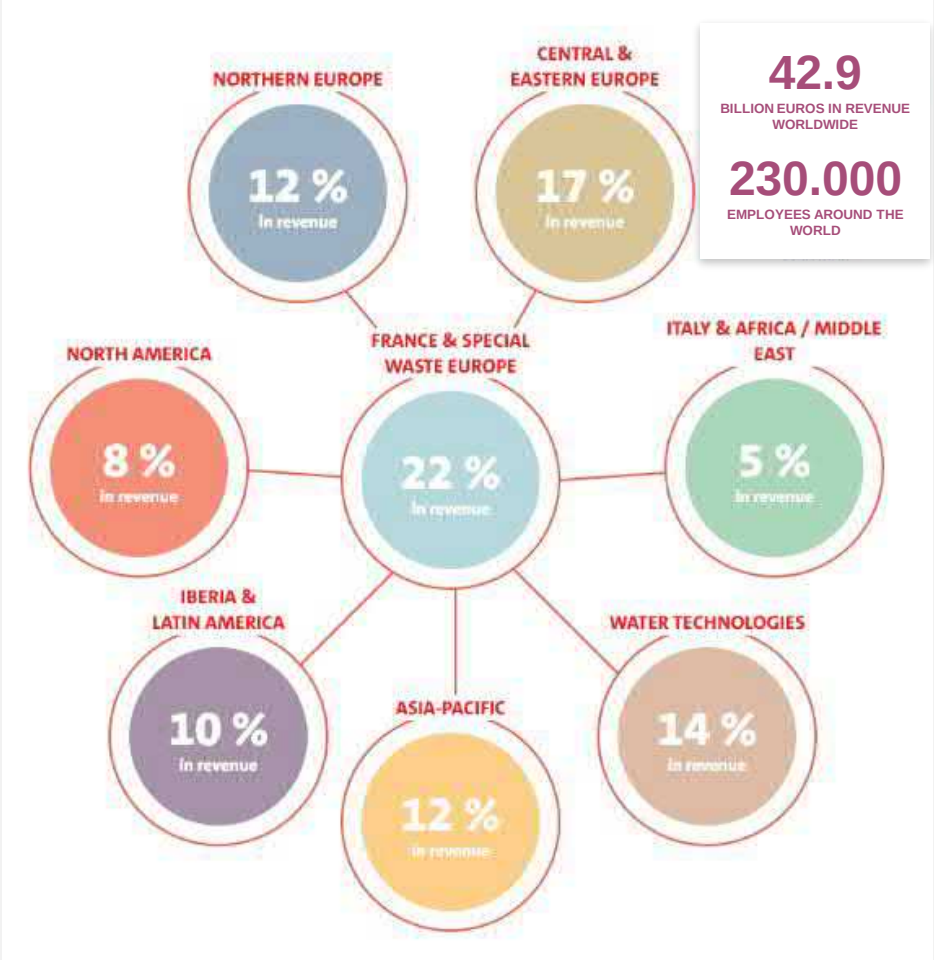
07 Carbon Capture and Total Amine Solutions

01 Veolia

Water Technologies & Water Technologies & Solutions Introduction

01 Veolia group overview

Historically French, naturally European and operationally international, Veolia can **support customers anywhere in the world**. In the forefront of ecological transformation, we are committed to the regions, where we contribute to their economic dynamism and attractiveness.



01 Veolia Water Tech group overview

~4.3
BILLION EUROS IN REVENUE WORLDWIDE FOR INDUSTRY

17.000
EMPLOYEES AROUND THE WORLD

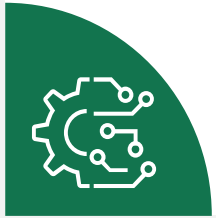
Equipment services

978 M€*
***63 % WTS** / 37 % VWT*

Temporary treatment
Asset care & Parts
Extended warrantees.

Products

749 M€*
***72 % WTS** / 28 % VWT*



Standard technologies
Replacement parts
.

Chemical services

Chemical formulations for industrial utilities: cooling , boiler, membrane, IWW
Chemical formulations for industrial processes: HPI, CPI, Ethanol , Upstream,

1 205 M€*
***89 % WTS** / 11 % VWT*

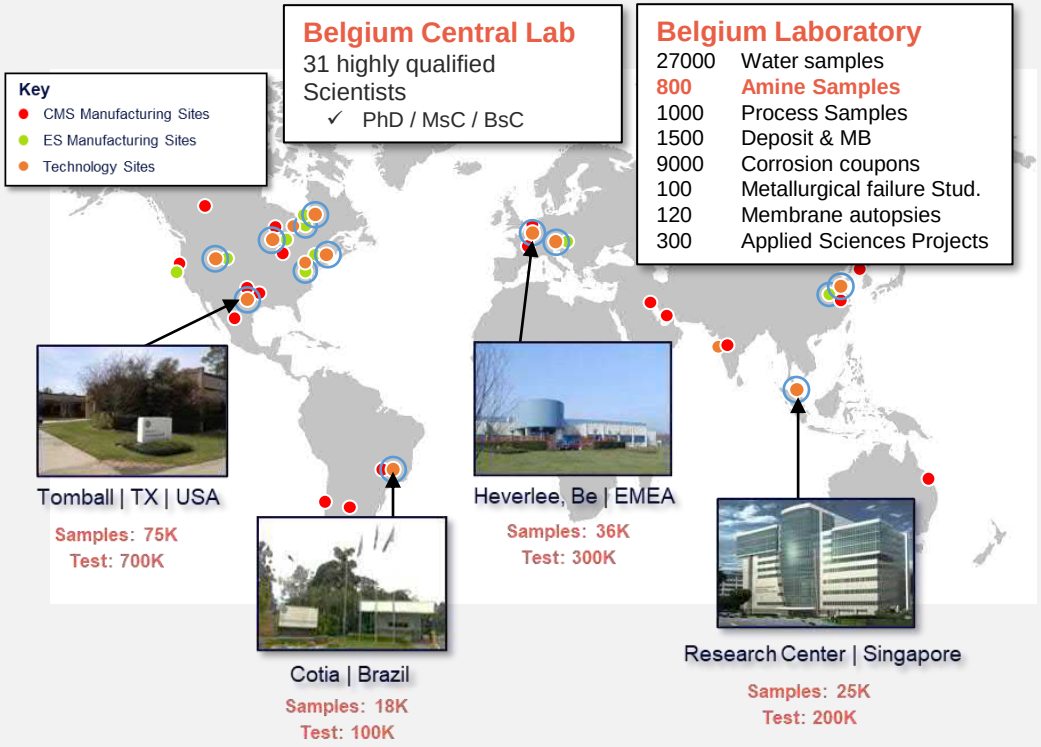
Projects

Highly engineered technologies
Complex flow sheets

1 349 M€*
*40 % WTS / **60 % VWT***

*Chiffre d'affaires 2022

01 Watertech Zone
Analytical Capabilities



Standard Amine Analysis (Grid 58)

Amine conc., H_2S Loading, Total Acid Gas, Heat Stable Amine Salts, Calcium, Magnesium, Iron, Copper, Chromium, Nickel, Manganese, Sodium, Potassium, Selenium, Silicon, Zinc, Phosphate, Sulphur, Chloride, Sulphate, Thiosulphate, Thiocyanate, Nitrate, Oxalate, Acetate, Formate, Butyrate, Propionate, Glycolate, Water content, Oil content, Foaming test, Particle size distribution, viscosity, Visual Inspection, pH, Conductivity, etc.

Amine Degradation Products:

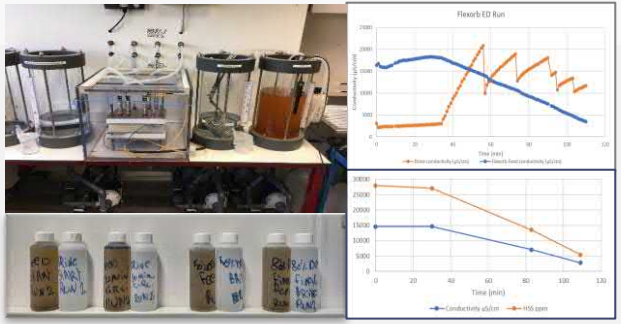
In-house Methods for degradation products in MEA, DEA, TEA, MDEA, DGA and Formulated solvents for Refineries, Chemical Industries and CO2 Capturing applications

Amine Speciation IC/MS:

More than 36 amines types (LOD = 0.1 ppm)

Pilot Tests:

ED pilot unit. Performance evaluation for new solvents.



01 Watertech Zone
Examples of Veolia WTS ES manufacturing sites

Oroszlány, Hungary

Technologies
- UF pressurized for Water & Reuse
- UF Membrane Bioreactor & Reuse
- Membrane aerated reator
- Bacteria selector

Plant
- 22,275 m^2
- 1000 HC
- Extension in progress
- Own WWTP
- NMP recovery in progress (N-Methyl-2-pyrrolidone)
- Flat sheet rolling

Volumes
- 100,000 modules per year

Minnetonka, USA

Technologies
- Nanofiltration for Process & water
- Reverse Osmosis for Process & Water
- Pleated & Depth filters
- Tonkaflo pumps

Plant
- 22,300 m^2
- 450 HC
- Extension in progress
- ED/EDR/BPED to come

Volumes
- 400,000 RO/NF modules per year

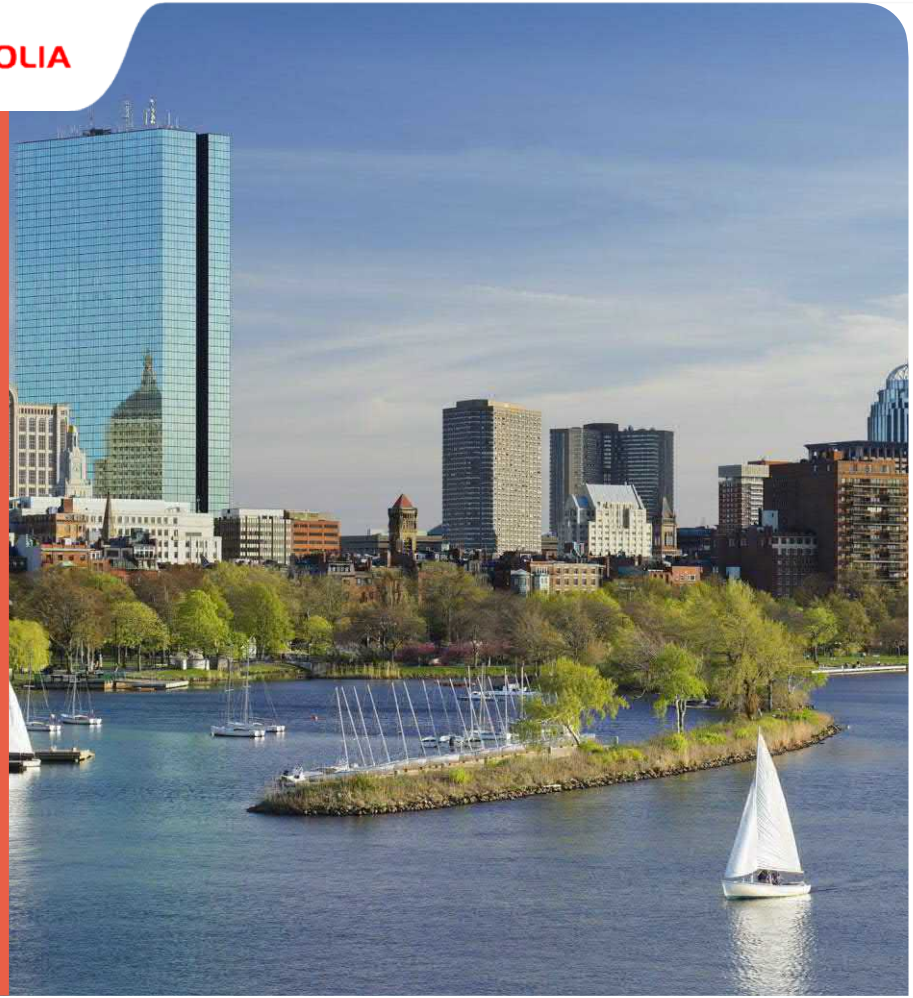
Wuxi, China

Technologies
- Nanofiltration rolling
- Reverse Osmosis rolling
- Chemicals formulation blending
- EDI

Plant
- 12,000 m^2
- 200 HC

02 Blue & Green Hydrogen Overview

Blue Hydrogen – refinery production employing a Steam Methane Reformer.
Green Hydrogen – produced using renewable energy and an Electrolyser.

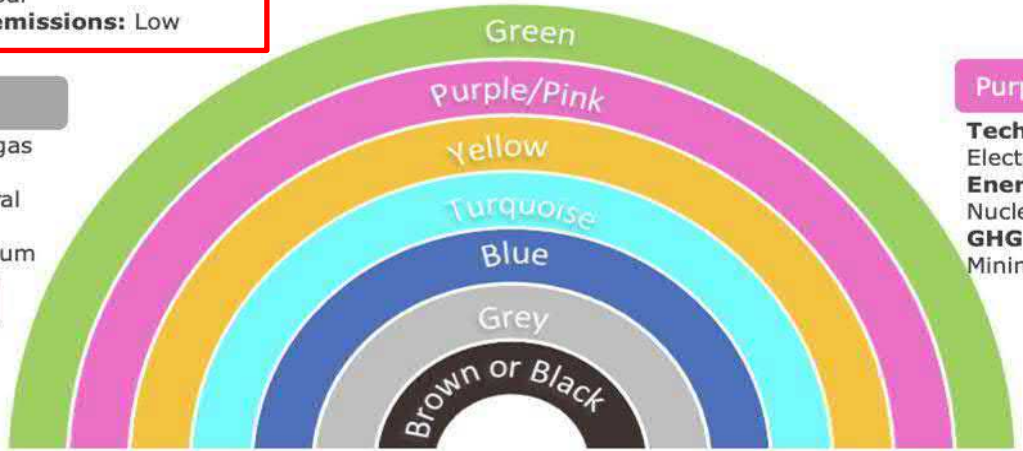


02 Types of Hydrogen in the Energy Transition

Blue hydrogen
Technology: Natural gas reforming + CCUS gasification +CCUS
Energy source: Natural gas, coal
GHG emissions: Low

Turquoise hydrogen
Technology: Pyrolysis
Energy source: Natural gas
GHG emissions: Solid carbon (by-product)

Yellow hydrogen
Technology: Electrolysis
Energy source: Mixed-origin grid energy
GHG emissions: Medium



Grey hydrogen
Technology: Natural gas reforming
Energy source: Natural gas
GHG emissions: Medium

Purple/Pink hydrogen
Technology: Electrolysis
Energy source: Nuclear
GHG emissions: Minimal

Brown/Black hydrogen
Technology: Gasification
Energy source: Black/ brown coal (lignite)
GHG emissions: High

Green hydrogen
Technology: Electrolysis
Energy source: Wind, Solar, Hydro, Geothermal
GHG emissions: Minimal

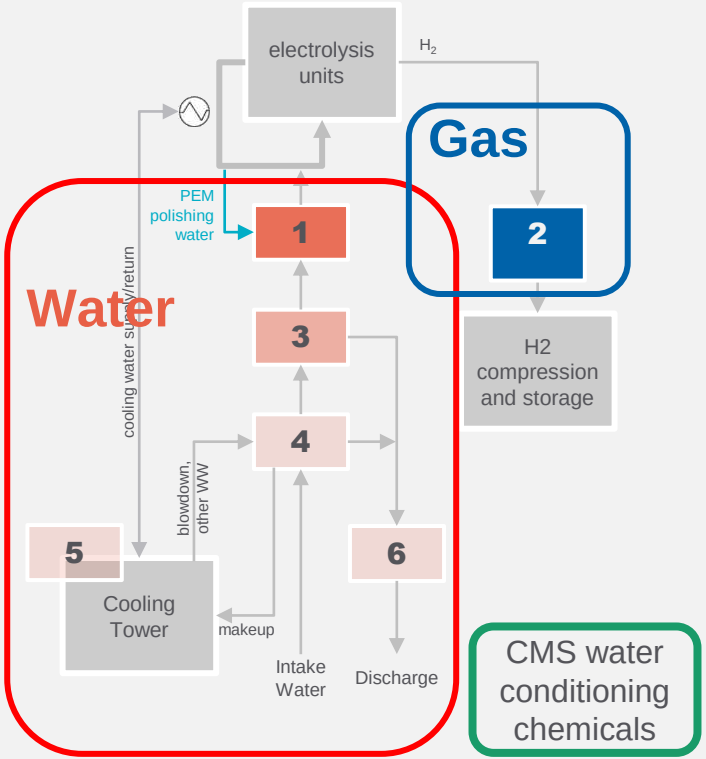
02 Electrolysis technologies available

02 Electrolysers
Alkaline (AEL) & Proton Exchange Membrane (PEM)

- AEL works with a liquid electrolyte in the form of potassium hydroxide. The electrodes are made of metal. Between the two electrodes is a diaphragm that is non-permeable to hydrogen and oxygen. AEL have been deployed on a large scale since 1927.
- AEL achieves efficiencies of about 70% and about 80% on a long-term average basis. AEL currently achieves the highest nominal outputs (>100MW) while not needing critical raw materials.
- AELs are not as robust as PEM electrolysers. They are more sensitive to impurities in the product gas as the gases dissolved in the electrolyte remain in the cycle. In addition, the AEL has a long cold start time of 50 minutes.

- PEM electrolysis began in the 1960s, which makes it a rather new technology compared to AEL. However, it is also already available on an industrial scale and nominal outputs of over 10MW can be achieved with efficiencies between 80 – 85%.
- PEM electrolysis works in an acidic environment. Precious metals such as iridium or platinum must therefore be used to protect the electrodes from corrosion. Furthermore, a gas-proof, proton-conducting plastic membrane is used, enabling a higher purity to be achieved than with the other technologies.
- Due to its good dynamic properties, the PEM electrolysis is best suited for operation with fluctuating electricity from renewable sources. An important factor is the load gradient, which means the property of increasing or decreasing load absorption. This is highest with PEM electrolysers. In addition, the cold start time is only about 15 minutes.

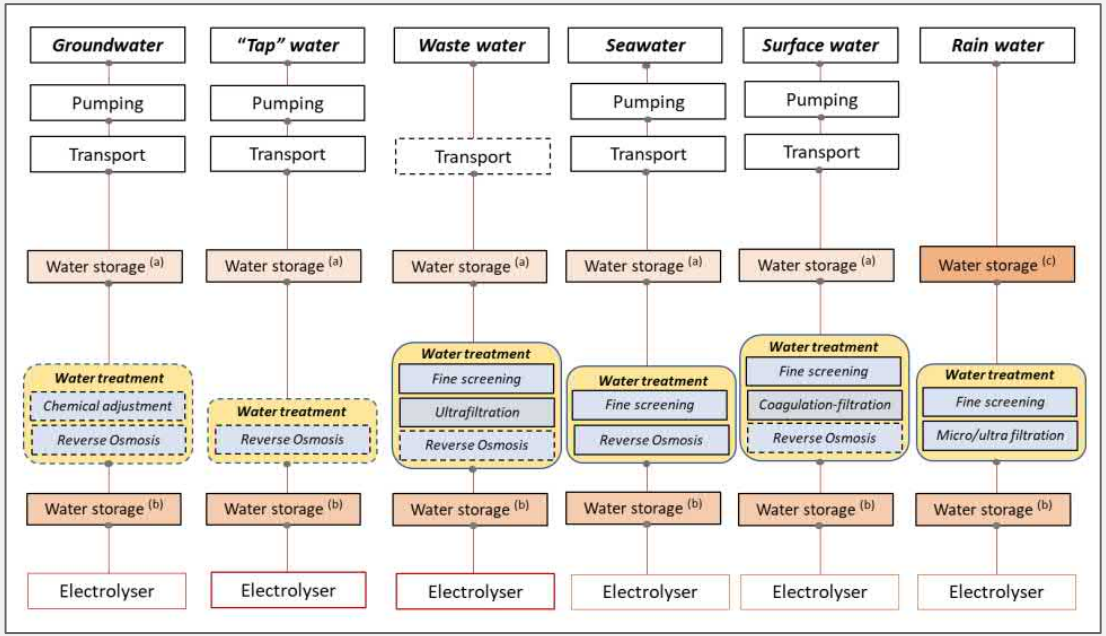
02 Application and Technologies
Green Hydrogen



	Application	Technology
1	PEM Water Polishing	•EDI •Mixed Bed
2	H2 Gas Purification	•De Oxygenation •H2 Dehydration
3	Makeup Water Deionization	•RO Membranes •Thermal Desalination
4	Intake Water Treatment	•Membrane Filtration •Clarification •Biological treatment •Disinfection
5	Cooling Tower	• Chemicals: antiscalant,antifoulants •Filtration •BD reuse
6	Wastewater System	•RO for high salinity •thermal ZLD

02 Water in the Electrolysis Process

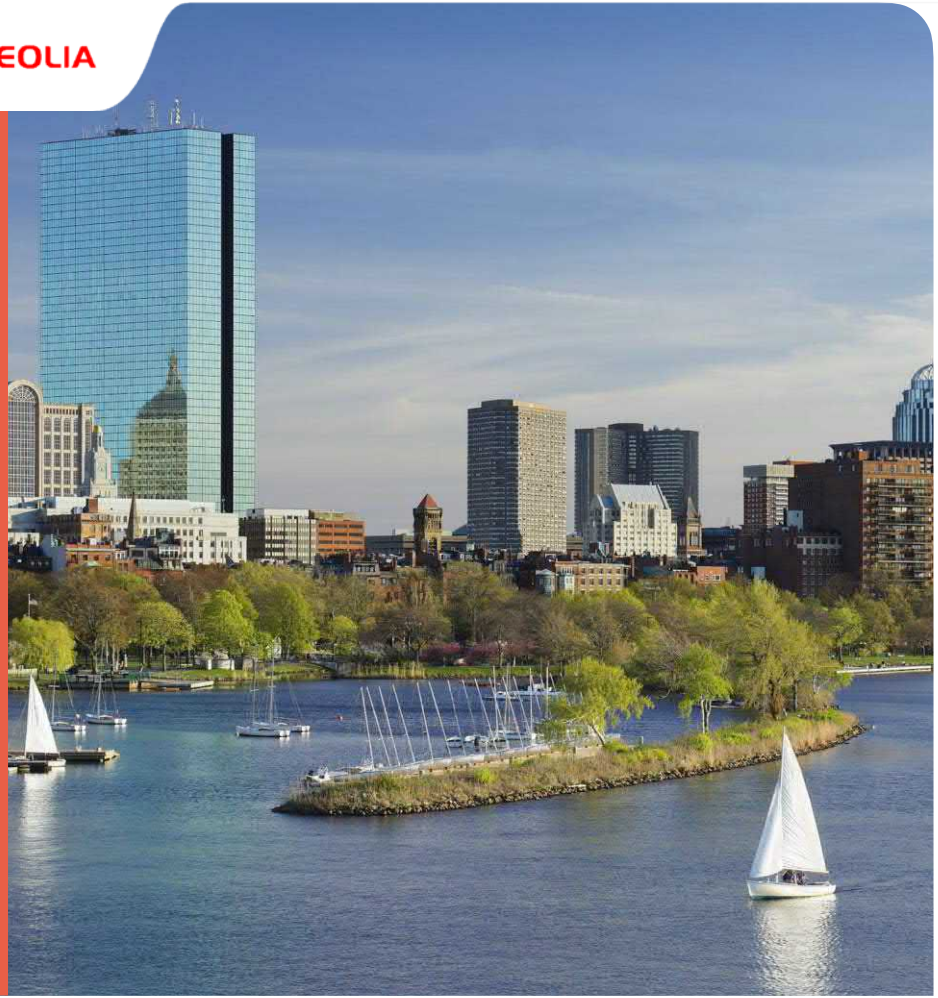
Water collection supply steps per potential source



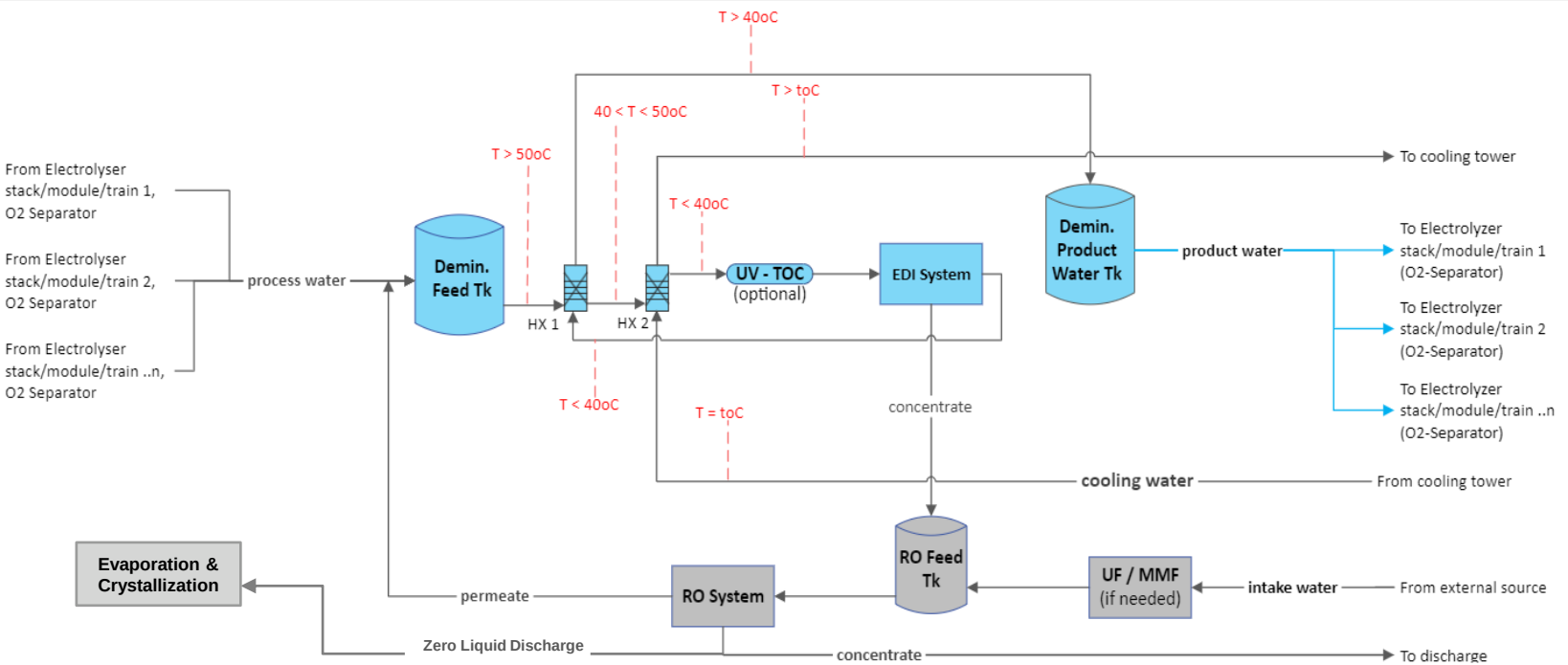
General demand for modularisation / packaged system

03 Ultrapure Water Production

UF / RO / EDI



Centralized demineralization to optimize larger electrolysis facilities



- **common make-up water and process water polishing**
- **minimize waste with a single, efficient, simple to operate and maintain system**

Key Veolia water technologies

ZEEWEED MEMBRANE UF

- Intake water treatment, demineralization pre-treatment
- 500D (hollow-fiber, outside-in, submersed) 1500 (hollow-fiber, outside-in, pressurized) 700b (hollow-fiber, inside-out, pressurized)

PROFLEX RO

- Intake water demineralization
- Seawater membranes
- Pre-engineered skids or customized skids
- From 11 – 114 m3/h permeate capacities and larger

PRO E-CELL RO/EDI

- Intake water demineralization
- Integrated RO and EDI pre-engineered skids
- 10 – 23 m3/h capacity for standard skid range

E-CELL EDI

- Make-up water demineralization and electrolyzer process water polishing
- E-Cell electrodionization membranes
- Up to 75 m3/h skids available pre-engineered – larger skids can be developed

Key Veolia water technologies for smaller projects

TERION™ S MKII — TECHNICAL PERFORMANCES

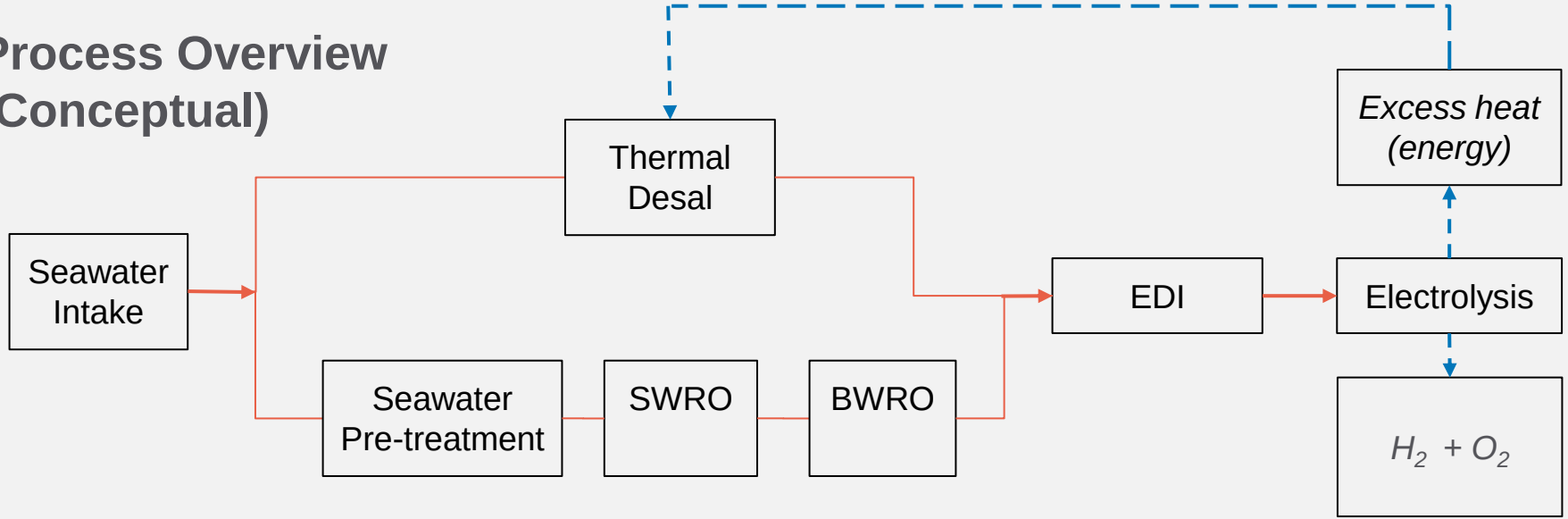
System Operating Parameters

Model	Unit	110	250	500	1000	2000	3000	4000
Permeate Nominal Flowrate	m^3/h	0.11	0.25	0.5	1.00	2.00	3.00	4.00
Nominal Feed Flowrate	m^3/h	0.15	0.35	0.70	1.40	2.81	4.21	5.61
Typical Design Flux	$l/h/m^2$	28						
Recovery	%	RO 75% - CEDI 95%						
Installed Power(1)	kW	1.75	2.50	3.10	3.30	5.20	7.70	9.80

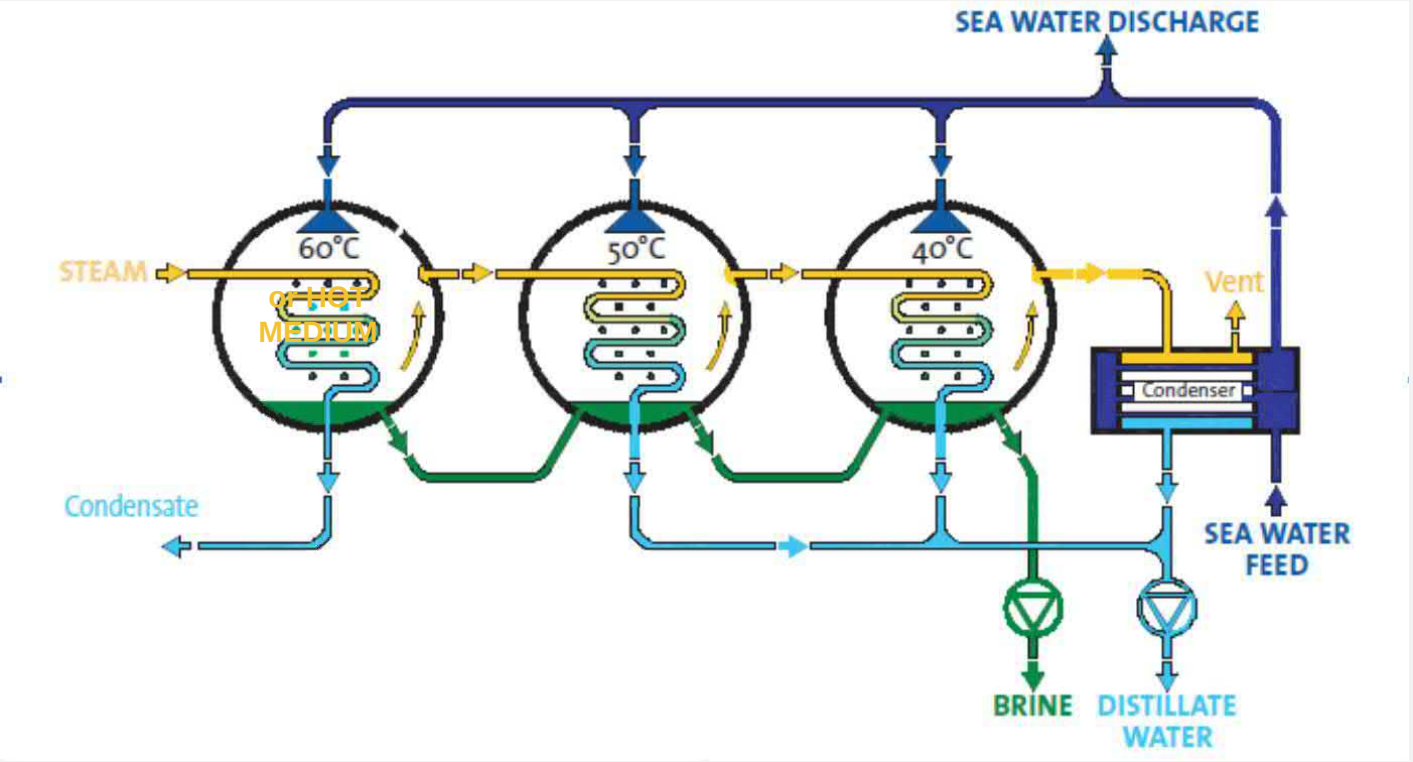
(1) Installed power without optionals. For total power including options, review schedules or contact SOLYS.

Seawater Desalination - Veolia Process Conceptual Overview

Process Overview (Conceptual)



Seawater - Illustration of MED Process



Seawater - Main characteristics of MED for Green H2

Heat recovery

High quality distillate < 1µS/cm

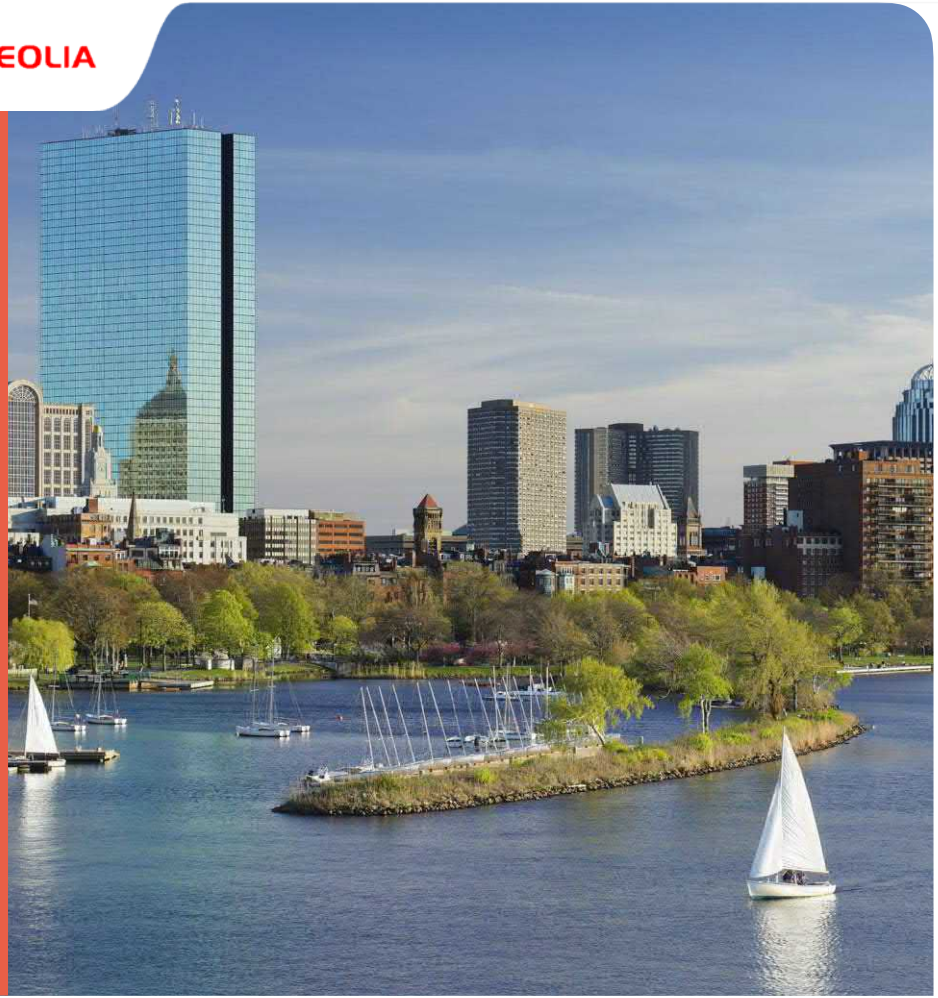
Robust and renowned for their reliability

No pretreatment requirement

Low OPEX (electrical, chemical, maintenance)

04 Zero Liquid Discharge (ZLD)

Eliminate liquid discharge, recover valuable process water

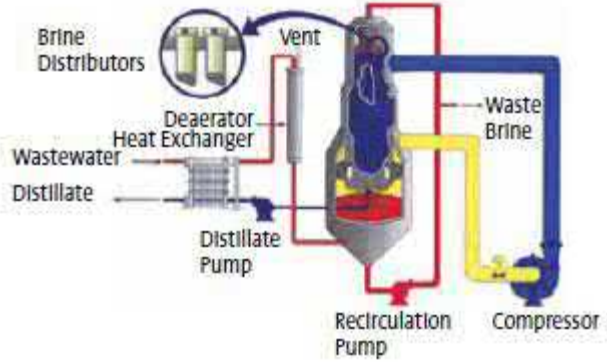


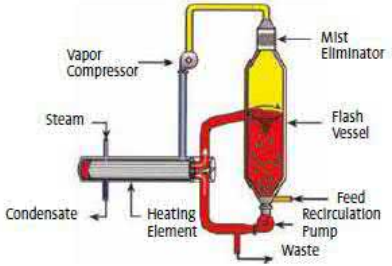
Achieving ZLD: Equipment Overview. Customized Large Scale

HPD® Evaporation and Crystallization

Brine Concentrator

Veolia brine concentrators recover up to 95% of industrial wastewater as high purity distillate. This can be used for boiler makeup, NOx control, cooling tower makeup and process use. The remaining five percent is a slurry concentrate that may be sent to a small solar pond, reduced to dry solids in a crystallizer or spray dryer, or used for ash wetting.





Crystallizer:

Meeting stringent zero-liquid-discharge requirements also requires a crystallizer, to reduce brine concentrate to a dry solid. Recovered water can be recycled back to plant processes, while an easy-to-handle dry solid can be safely disposed of in an approved landfill.

- **Ease of use**—With simple color graphic controls and an automatic wash system, Veolia's crystallizers are easy to operate.
- **Ease of installation**—Skid-mounted, fully packaged systems with all auxiliary equipment and controls.
- **Valuable product recovery**—Systems can be designed to recover specific salts from a waste stream.
- **Expertise in zero liquid discharge**—Veolia has more than 35 years of experience developing and implementing thermal technologies to solve zero liquid discharge challenges for customers worldwide.

Brine Concentrators Can Recycle:

- Cooling tower blowdown
- Oil and gas field produced water
- Demineralizer waste
- Reverse osmosis reject
- Electrodialysis reject
- FGD wastewaters
- Boiler blowdown
- Softener waste
- Plant drains
- Salty effluents
- Mine drainage
- Landfill leachate

PEMEX Cadereyta Refinery, Monterrey, Mexico, 116 gpm, 1998

Huntington Power Station, Huntington, UT, 200 gpm, 1974

Indiantown Generating Plant, Indiantown, FL, 580 gpm, 1995

Gila River Power Station, Gila Bend, AZ, 2,400 gpm, 2003

Achieving ZLD: Equipment Overview. Modular Units Small Scale

EVALED® Evaporation Leadership since 1978

An effective ready-to-market solution for concentrating and removing salts, heavy metals and a variety of hazardous components.

Technology

Evaled vacuum evaporators are an effective fluid waste management solution for concentrating wastewater volumes, removing pollutant substances and producing high quality, reusable distillate (ZLD).

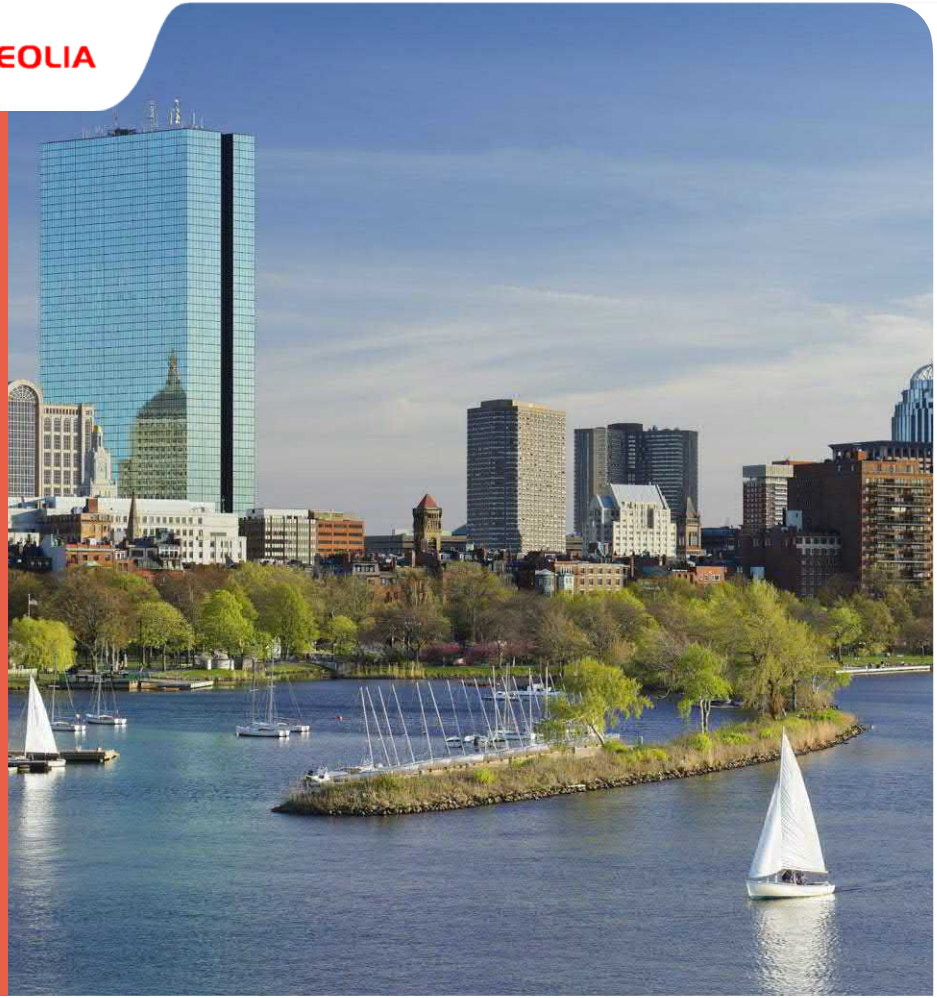
Three different evaporation technologies operating in under vacuum close loop systems to meet your water treatment needs.

Wastewater treatment units with distillate production capacities from 0.1 to 200 m3/day (0.02 - 37 gpm).

SERIES		specifications	MODELS	m3/day								
PC Heat pump		Designed to offer flexibility and superior reliability - low boiling temperature - recovery of heat- sensitive products - good distillate quality - low fouling and scaling	F	0.7	1.4	2.4	4	6	8	12	24
			R	0.1	0.5	1	2				
AC Hot/cold water		Ideal when waste thermal energy and cold water are available on site (cogeneration) - high concentration levels - available in single and multiple effect - engineered to work in either continuous or batch mode	F	20	40	60					
			R	3	6	12					
RV Mechanical vapour recompression		Engineered for the treatment of large wastewater flowrates - very low energy consumption - high efficiency	F	10	15	25	40	60	120		
			N	3	6						

05 Hydrogen Purification

DeOxygenation Reactor – conversion of O_2 to H_2O
Molecular Sieve Dryers – Water removal

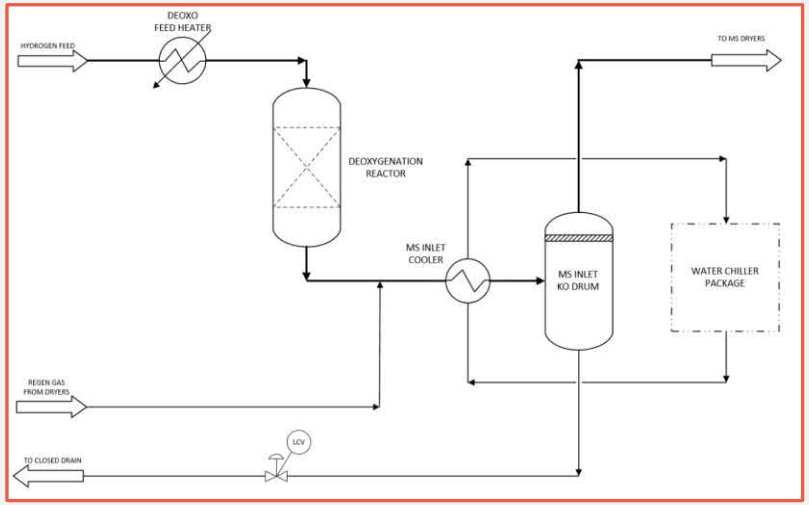


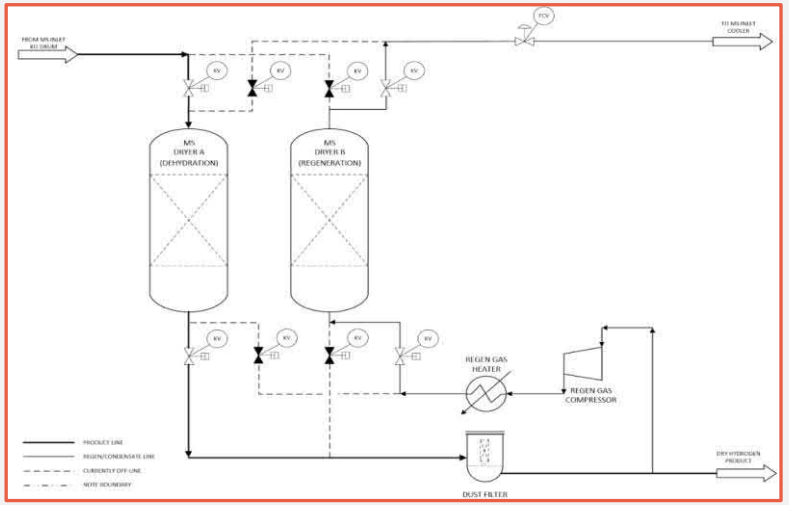
Hydrogen Purification
pre-Engineered Systems

Hydrogen Purification Design Basis	Feed	Product
H_2 Concentration	> 99.8 mol%	> 99.999 mol%
O_2 Concentration	< 100 - 2000 ppmv	< 1 - 5 ppmv
H_2O Concentration	saturated	< 1 ppmv
H_2 Discharge / Venting	Zero H_2 Discharge[1] - TSA System with recycle gas compressor installed	
Turndown	10% of the Feed rate	
Standby	System can be isolated for the Electrolyser - H2 recycled in a closed loop	

Note 1 - unlike Pressure Swing Absorption (PSA) which can release between 10 - 20% of the H2 Product when regenerating the Molecular Sieve beds, the Veolia EPS unit using Temperature Swing Absorption which uses ~15% of the H2 Product in a closed loop to regenerate the Molecular Sieve beds.

Hydrogen Purification
pre-Engineered Systems





- O_2 removed via catalytic (noble metal based) reaction, O_2 + H_2 converted to H_2O.
- Heat tracing, Dehydration Regen. recycle enables maximised turndown and accelerated startup.
- H_2O is removed via molecular (mol) sieve Temperature Swing Adsorption (TSA).
- Regen. Gas, recycle Compressor means Zero Hydrogen discharge.

Hydrogen Purification
pre-Engineered Systems

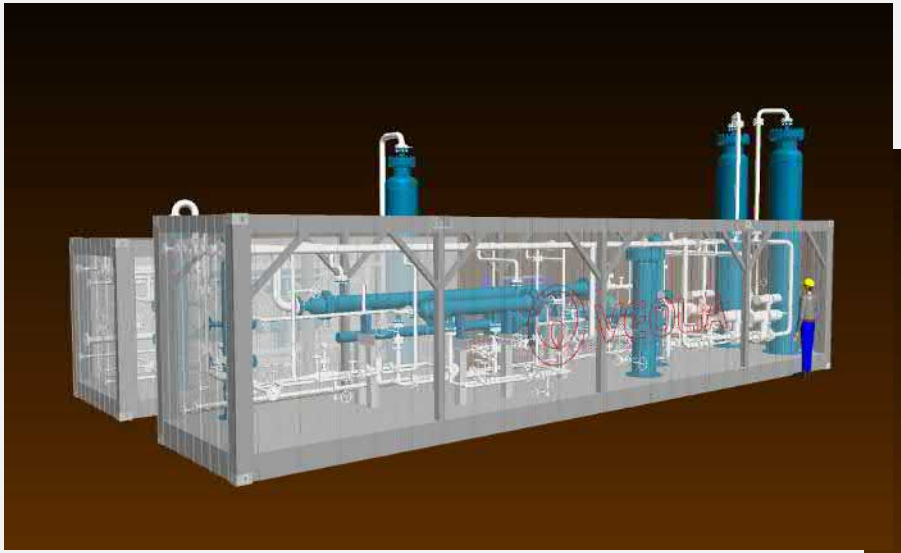
- Veolia offers three (3) pre-Engineered Hydrogen Purification Systems catering for Hydrogen produced by both Alkaline and PEM Electrolyser. The system designation pE-050 for example, pre-Engineered 50 MW Electrolyser H_2 purification unit.

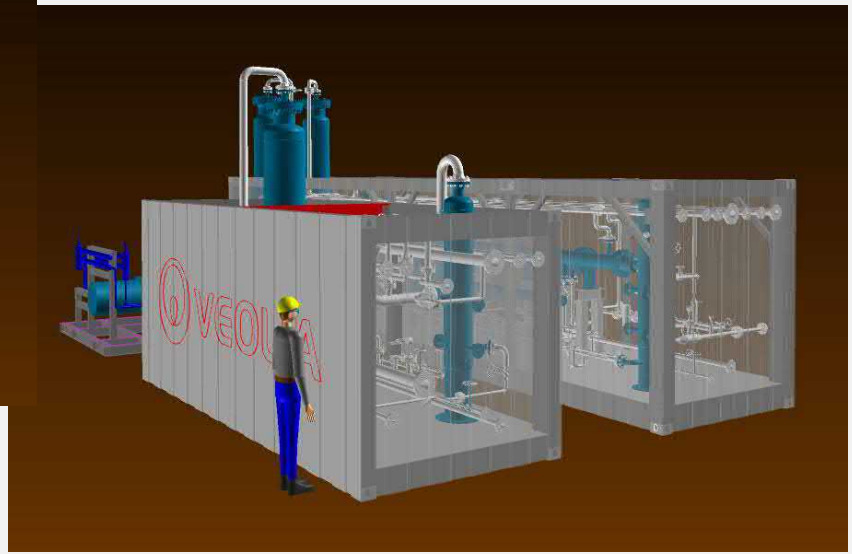
pE Hydrogen System	Capacity (kg H_2/hr)	Capacity [1&2] (Nm^3 H_2/hr)	Pressure Class (ANSI)	Materials [3]	H_2 Product Purity (mol%)	dP (bar)	Footprint [4] (m^2)
pE-050	±1000	11,000	300 & 600	Carbon Steel	99.999	1.5 – 2	50
pE-100	±2000	22,000	300 & 600	Carbon Steel	99.999	1.5 – 2	70
pE-250	±5000	55,000	300 & 600	Carbon Steel	99.999	1.5 - 2	100

- Regeneration Gas Compressor is provided on a standalone skid base, it can be excluded from the scope of supply.

1. *Capacity is based on a feed pressure 30 - 40 bar inlet (post Electrolyser), the system can also accommodate a continuous recycle from the Molecular Sieve dryers .*
2. *Gas cooling to < 20 deg C at the inlet to the Molecular Sieve dryers.*
3. *Majority of components Carbon Steel, PWHT applied and where conditions or client specifications dictate Stainless Steel is employed.*
4. *Footprint excludes the BoP equipment which is located in the non-Hazardous area ie. Electric Heater Thyristor and Chilled Water System (if included in our scope).*

Hydrogen Purification
pre-Engineered Systems





06 Chemical Storage, Monitoring and Dosing Systems for Cooling Systems & Membranes

CMS process chemicals and CHEMFEED equipment

Baseline

Specification Cooling Towers

System parameters:

Total volume:	3050 m^3
Recirculation rate:	15250 m^3/h
Cooling tower:	x cells
Evaporation rate:	220,4 m^3/hr
Materials:	carbon steel, stainless steel (type = Duplex)
Water source:	clarified river water

Specifications cooling water / blowdown:

Limitation on chlorides 1000 ppm
TOC < 33
COD < 100
TP < 3
AOX <1

Average make-up water quality:

pH:	8,0
Conductivity:	880 µS/cm
Total hardness:	198 ppm CaCO3
Calcium hardness:	145 ppm CaCO3
M-alkalinity:	90 ppm CaCO3
Sulphates:	50 mg/l
Chlorides:	215 mg/l
Nitrates:	20 mg/l
Iron and Manganese:	0,5+0,2 mg/l
Total suspended solids:	6,4 ppm
COD:	18
TOC:	6,6
Tot N:	6
Manganese:	0,02 ppm Mn
oPO4:	0,06 ppm PO4
SiO2:	12 ppm
Free chlorine:	1 ppm Cl2

Typical Cooling Tower Suppliers:

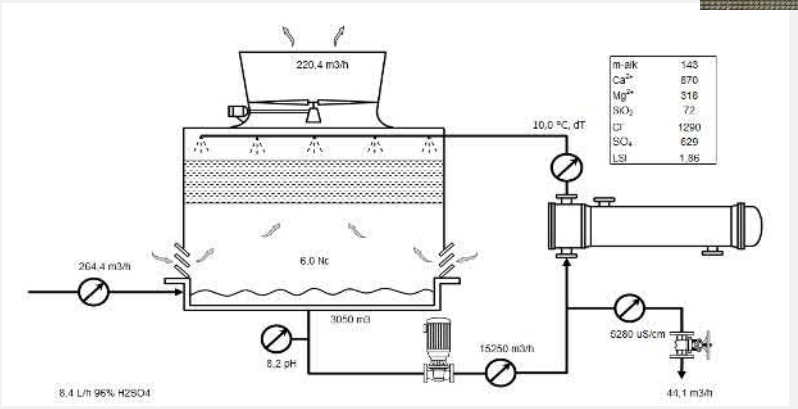
- GEW (Polacel)
- Evapco
- SPX
- Kelvion
- Almeco

Cooling tower
Cycle Up

VEOLIA

Company:
System:
Comment:

Date:	26-May-23		
Volume, (m3)	3050	Target pH	8,2
Recirculation, (m3/h)	15250	Acid used	H2SO4
Temperature drop, (°C)	10,00	Acid strength, (%)	96
Hot skin temperature, (°C)	60	Acid density, (kg/L)	1,8
m-alkalinity factor	0,90	Target alkalinity	143
Ev. factor, (% per 10 °C)	1,445		
Drift, (% RR)	0,050		
Target Cycle	6,00		
Target Increment	1,00		
pH correction	Yes		
Working days	365		



	Canal	0	Make Up	3,00	4,00	5,00	↓ **6,00**	7,00	8,00	9,00	10,00
Evaporation, (m3/h)				220,4	220,4	220,4	**220,4**	220,4	220,4	220,4	220,4
Blow-down, (m3/h)				110,2	73,5	55,1	**44,1**	36,7	31,5	27,5	24,5
Make-up, (m3/h)				330,5	293,8	275,5	**264,4**	257,1	251,8	247,9	244,8
% Make Up	100,0%	0,0%	100,0%								
pH	8,0		7,9	8,2	8,2	8,2	**8,2**	8,2	8,2	8,2	8,2
m-alk, (mg/L $CaCO_3$)	90		90	143	143	143	**143**	143	143	143	143
Ca, (mg/L $CaCO_3$)	145		145	435	580	725	**870**	1015	1160	1305	1450
Mg, (mg/L $CaCO_3$)	53		53	159	212	265	**318**	371	424	477	530
Conductivity, (uS/cm)	880		880	2640	3520	4400	**5280**	6160	7040	7920	8800
SiO_2, (mg/L)	12		12	36	48	60	**72**	84	96	108	120
Cl^-, (mg/L	215		215	645	860	1075	**1290**	1505	1720	1935	2150
SO_4, (mg/L)	50		50	246	374	501	**629**	757	884	1012	1140
oPO_4, (mg/L)	0,1		0,1	0,2	0,2	0,3	**0,4**	0,4	0,5	0,5	0,6
Suspended solids, (mg/L)	6,4		6	19	26	32	**38**	45	51	58	64
$Fe^{+2} + Al^{+3}$, (mg/L)	0,7		0,7	2,1	2,8	3,5	**4,2**	4,9	5,6	6,3	7,0
LSI @ 60°C	0,76		0,63	1,59	1,70	1,79	**1,86**	1,92	1,97	2,02	2,06
MgSi	OK		OK	OK	OK	OK	**OK**	OK	OK	OK	High
CaMgSi	OK		OK	OK	OK	OK	**OK**	OK	OK	OK	OK
$CaSO_4$	OK		OK	OK	OK	OK	**OK**	OK	OK	OK	OK
Half-life, (days)				0,8	1,2	1,6	**2,0**	2,4	2,8	3,2	3,6
Larson-Skold Index	3,9		3,9	8,1	11,2	14,2	**17,3**	20,3	23,4	26,4	29,5
Sulfuric acid, (mg/L)				102,0	184,7	267,3	**350,0**	432,7	515,4	598,1	680,8
Sulfuric acid, (kg/day)				269,6	325,5	353,5	**370,2**	381,4	389,4	395,4	400,0
Sulfuric acid, (L/h)				6,1	7,4	8,0	**8,4**	8,7	8,8	9,0	9,1

Cooling tower

Cycle Up CoC = 6

Acid dosage is needed to minimize deposition and control LSI.

pH setpoint best at 8,1-8,3 with high Calcium hardness. Because of **positive LSI** still some **dispersant** is needed.

As **carbon steel** is present we need some **corrosion inhibitor**; a small amount of ortho phosphate will be used.

GenGard GN8070 @ 35 ppm in cooling water
GenGard GN8300 @ 5,5 ppm in cooling water

Based on an average blow down of 44,1 m^3/h and 365 days of production:

	Dose rate in CW	kg/h	kg/y (approx.)
GenGard GN8070	35	1,54	13.500
GenGard GN8300	5,5	0,24	2.100

Cooling tower
Cycle Up CoC = 6

For **biological control** we propose **NaOCl** in the cooling water.
To minimize use of bleach and to avoid free chlorine in blowdown we propose daily shots of NaOCl. When shot dosing starts and as long as free chlorine is >0,2 ppm Cl_2, blowdown remains closed.

The consumption of NaOCl is difficult to predict and cannot be calculated theoretically because it depends on the temperature, the environment,....

Best estimate is a yearly consumption of around 40 tons.

	dose rate in CW	kg/y
NaOCl	ca 110 kg per shot	ca 40.000

H_2SO_4 (96% is used to control pH at 8,2.
Average consumption of 96% H_2SO_4 will be 370 kg/d; or 8,4 l/h.

This results in a yearly consumption of 135 ton or ca 74.000 liters per year.

Cooling tower

Comparison CoC 6 with acid dosing vs CoC 4 with and without acid dosing to control pH

Evap = 220,4 m^3/h		CoC 6 with pH @ 8,2	CoC 4 with pH @ 8,4	CoC 4 @ free pH
MU	m^3/h	264,4	293,8	293,8
BD	m^3/h	44,1	73,5	73,5
GenGard GN8070	kg/h	1,54	2,57	3,31
	kg/year (approx.)	13 500	22 500	29 000
GenGard GN8300	kg/h	0,24	0,40	0,22
	kg/year (approx.)	2 100	3 500	2 000
H_2SO_4 (96%)	kg/h	15,43	10,15	0
	kg/year (approx.)	135 000	89 000	0
NaOCl (12%)	kg/shot	110	110	110
(1 shot/day)	kg/year (approx.)	40 000	40 000	40 000

Chemfeed Solutions

Chemicals storage, monitoring & dosing

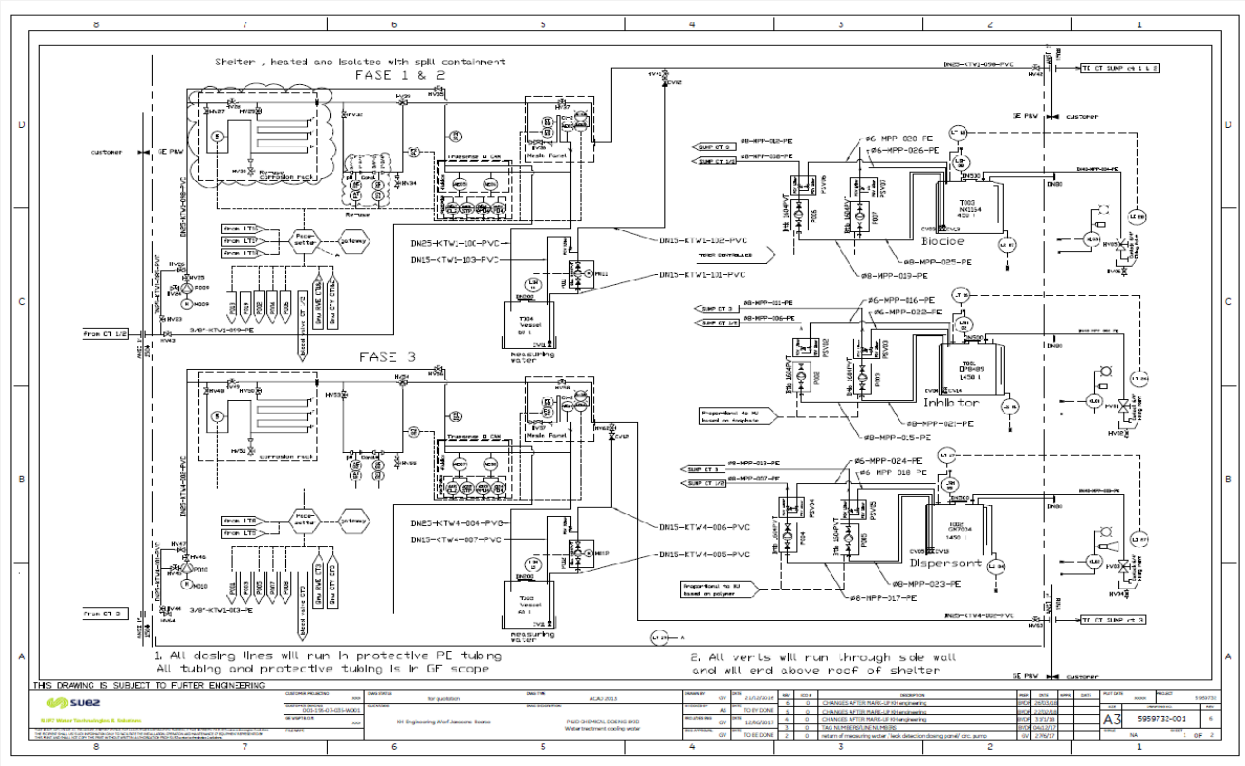
System Integration based on:

- customer needs,
- customized standard design & engineering,
- standard equipment:
  - analysers, controllers and dosing pumps,
- standard customized equipment:
  - storage vessels in line with local legislation.

Chemfeed Solutions

Chemicals storage, monitoring & dosing

EXAMPLE P&ID:

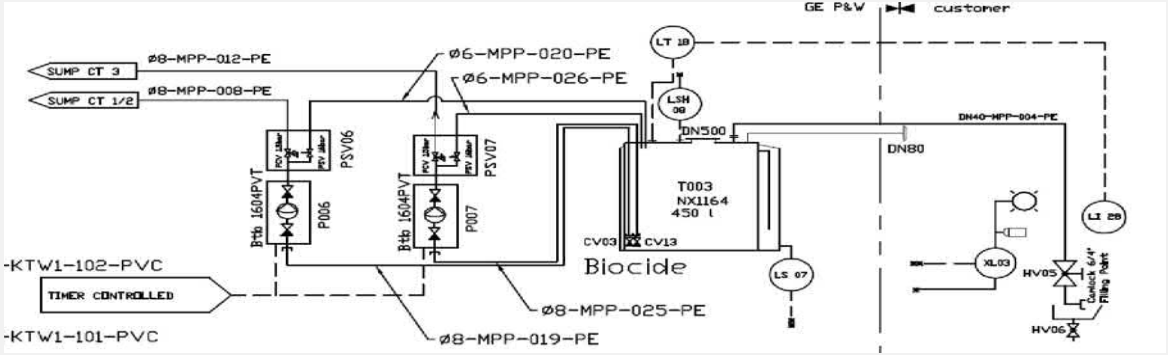


Chemfeed Solutions

Chemicals container

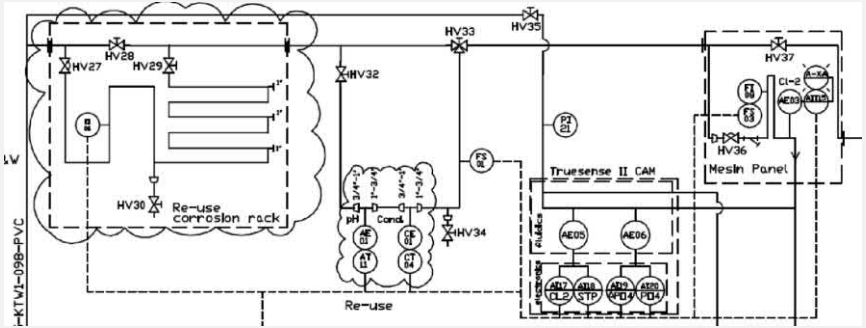
Chemfeed Solutions

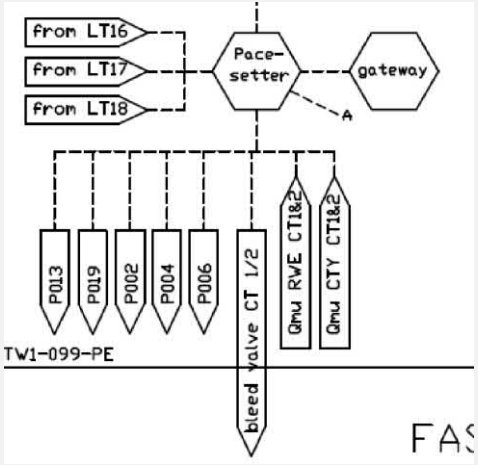
Biocide dosing



Chemfeed Solutions

Cooling towers conditioning chemicals





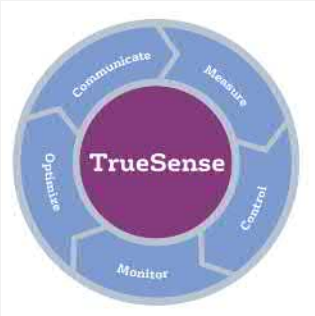
Monitoring
Cooling towers

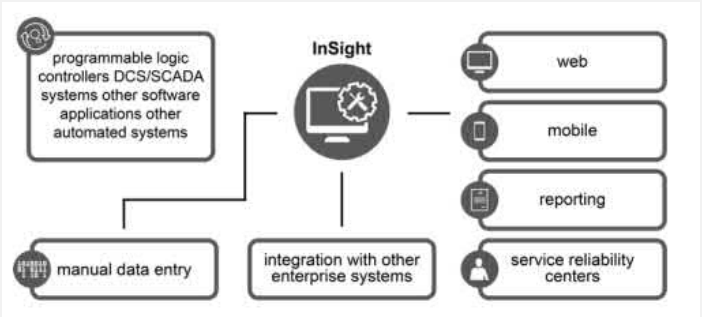
Key performance benefits of InSight

- Get crucial information to the right people with secure remote monitoring
- Be informed of emerging problems with real time alarm notifications
- Receive weekly or daily plant performance reports

What InSight means to our customers

- Make better business decisions with live data
- Reduce unplanned downtime
- Lower operating costs





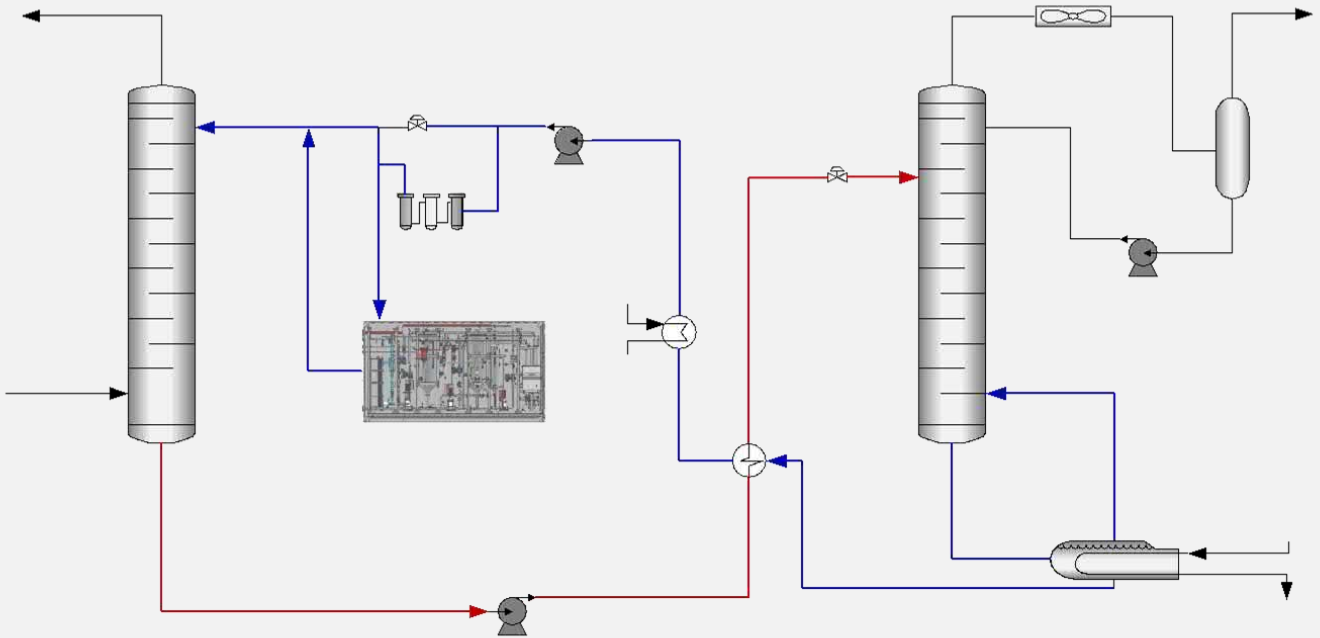
07 Carbon Capture and Total Amine Solutions

Amine Recovery in support to EPC technology providers

Total Amine Solution Portfolio
VWTS Differentiation

MINIMIZING
- Corrosion
- Fouling
- Foaming
- Solvent losses / consumption
- Solvent degradation / contamination
- Capacity losses
- Energy consumption

Amine Unit – CO2 Capture



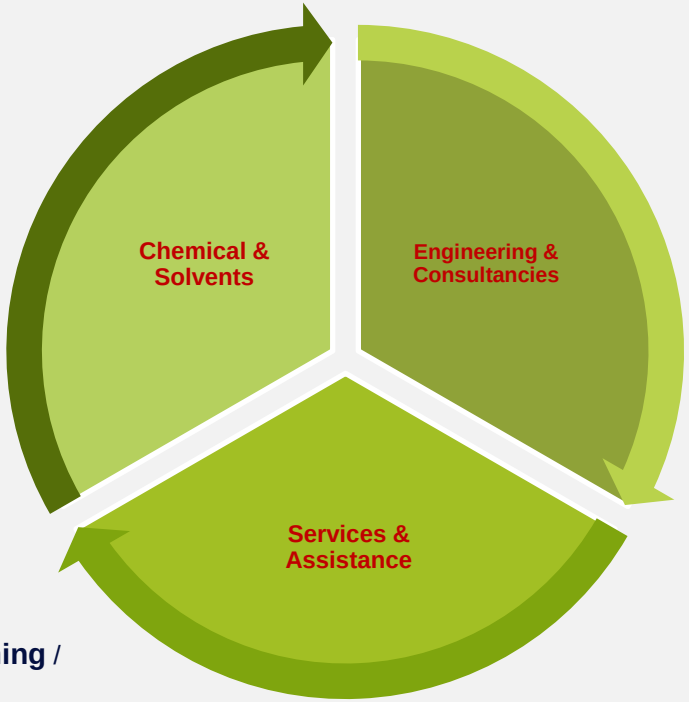
Total Amine Solution Portfolio
VWTS Differentiation

Chemical Supply

- Corrosion inhibitors
- Antifoams and emulsion breakers
- Neutralizers and Cleaning aids
- Amine Consumption Reducers
- Commodity Solvents
- Customized/Formulated Solvents

Service & Assistance

- Local Analytical Support
- Operational Support
- Central Lab Support
- Special Services (**Amine Reclaiming** / Filtration)
- Online measurement amine loading/strength *(under development)*



Consultancy and Engineering

- Field simulation
  - Energy saving calculation
  - Amine flow rate and Steam consumption evaluation
  - Calculation of theoretical and real amine losses
- Process Simulations
  - Rigorous simulation of complete amine units
  - Sensitivity analysis
- Engineering consultancies
  - Main equipment evaluations
  - Capacity Improvement
  - Solvent Swaps (online/offline)
  - Test run development
  - Feasibility studies
  - Conceptual Engineering
  - Training Courses for Engineers and Operators.

TAS Portfolio
Reclaiming Service

Heat Stable Salts & Degradation Products cause

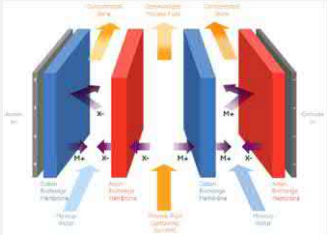
- Corrosion
- Fouling
- Energy and solvent loses

Current Solution

- Solvent Bleed and Feed
- Thermal Reclaiming
  - High energy consumption
  - High Amine loses / difficult waste management
- Resin Technology
  - High quantity effluent production
  - High operational cost
- **ED Technology (Veolia WTS)**
  - Competitive technology (proven in refineries)

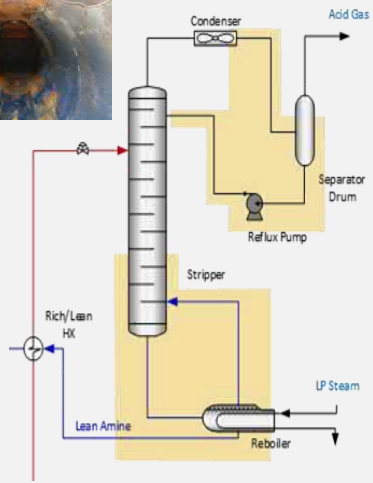
Veolia WTS Reclaiming Units

- **2 Mobile Units available in Europe**
- **1 Dedicated Unit operating in a refinery**
- Useful for common amine solvents
- Environmentally compliant
- Continuous/batch process
- Do not need chemicals for regeneration



Common Name	pKa
Hydrogen Chloride	-6.10
Sulphate	-3.00
Thiocyanide	-1.85
Thiosulfate	0.60
Oxalic Acid	1.27
Sulphur Dioxide	1.89
Phosphate	2.15
Formic Acid	3.75
Glycolic Acid	3.83
Acetic Acid	4.76
Butyric Acid	4.82
Propionic Acid	4.87

Corrosion Zones



Dedicated Reclaiming Unit

Mobile Unit

Thank You

egbert.de-jong@veolia.com
joel.van-der-borght@veolia.com