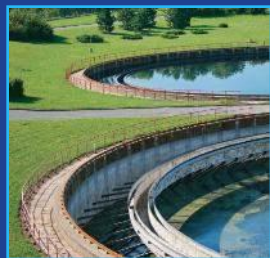


Business Overview

Ultra Pure Water

Arnaud Nauwelaerts

17 March 2014



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GE Overview

GE is a diversified infrastructure, finance and media company taking on the world's toughest challenges.

Quick Facts

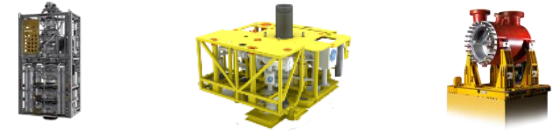
- Headquartered in Fairfield, CT, USA
- 300.000 employees globally
- Located in 160 countries
- \$142 billion in consolidated revenue*
- \$13 billion in earnings*

* Figures for 2011, GE excl. NBCU – Source: GE annual report 2011 (<http://www.ge.com/ar2011/index.html>)

GE Power & Water



GE Oil & Gas



GE Energy Management



GE Technology Infrastructure



GE Home & Business Sol.



GE Capital



Our Business: Water & Process Technologies

Water & Process Technologies

Aligning the best people with the most advanced technology, products and services to solve any water or process challenge our customers may have

Quick Facts

- Headquartered in Trevose, PA, USA
- 8,000 employees globally
- 50,000 customers in 130 countries
- 45 global manufacturing sites



Broad product and solutions portfolio

Chemical & Monitoring Solutions



- Cooling Chemistries
- Boiler Chemistries
- Wastewater Chemistries
- Fuel Oil Treatment
- Hydrocarbon Process Chemistries
- Industrial Process Chemistries
- Knowledge Management & Monitoring Solutions

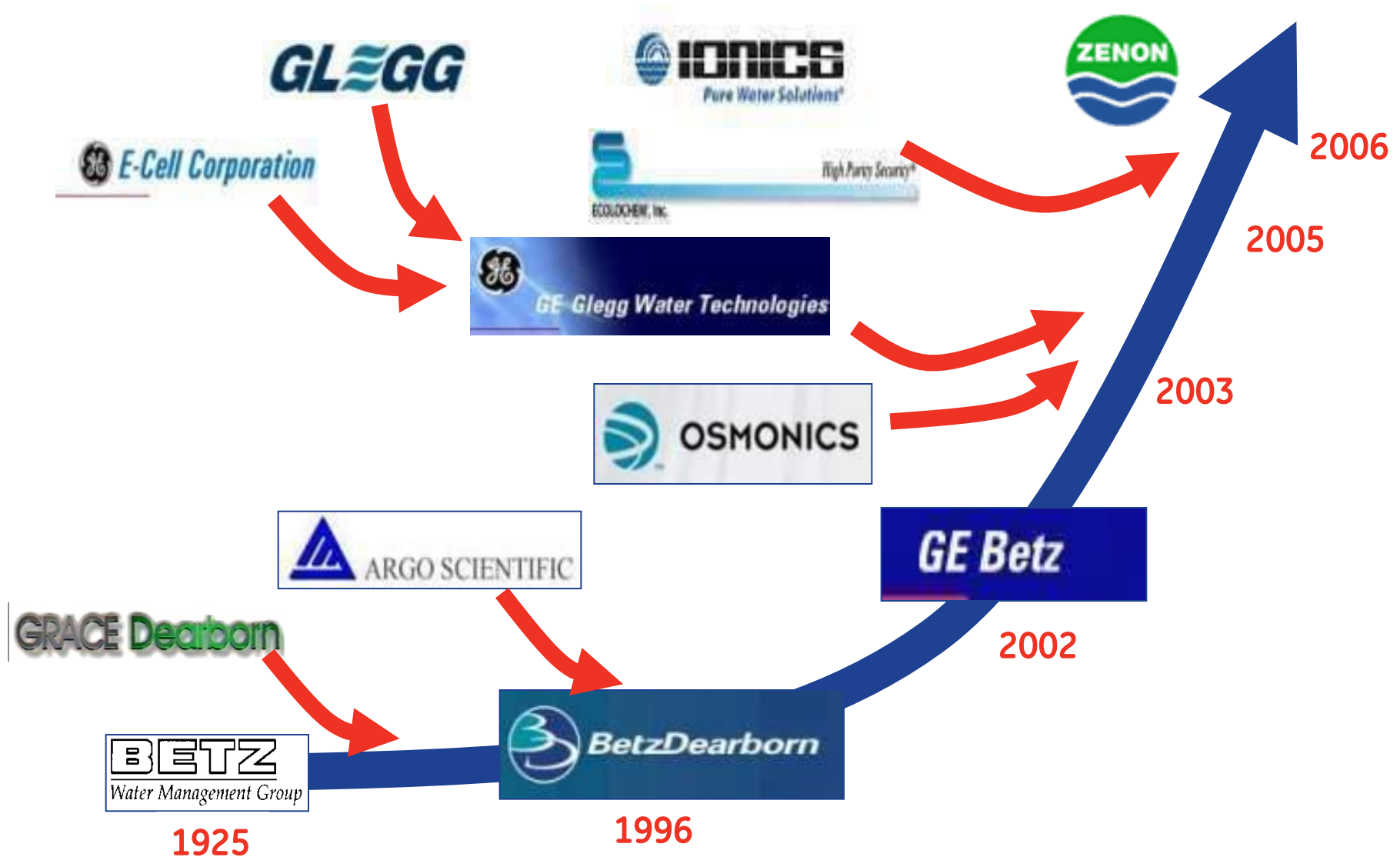
Engineered Systems



- Ultrafiltration/Membrane Bioreactor
- Mobile Water Solutions
- Water Outsourcing
- Thermal/Zero Liquid Discharge
- Reverse Osmosis/Electrolytic Systems
- Filters & Membranes
- Advanced Biological Metals Removal (ABMet)
- Analytical Instruments

History

GE Infrastructure
Water & Process Technologies



EMEA Technology Center Heverlee

Analytical Services



- 30 highly qualified & skilled scientists
- PhD, Masters, Lab technicians
- Annual Sample Load:

Applied Sciences



- 27.000 water samples
- 6.000 deposit samples (solids)
- 9.000 corrosion coupons
- 300 metallurgical failure studies
- 150 Reverse Osmosis autopsies
- 500 Applied Sciences projects

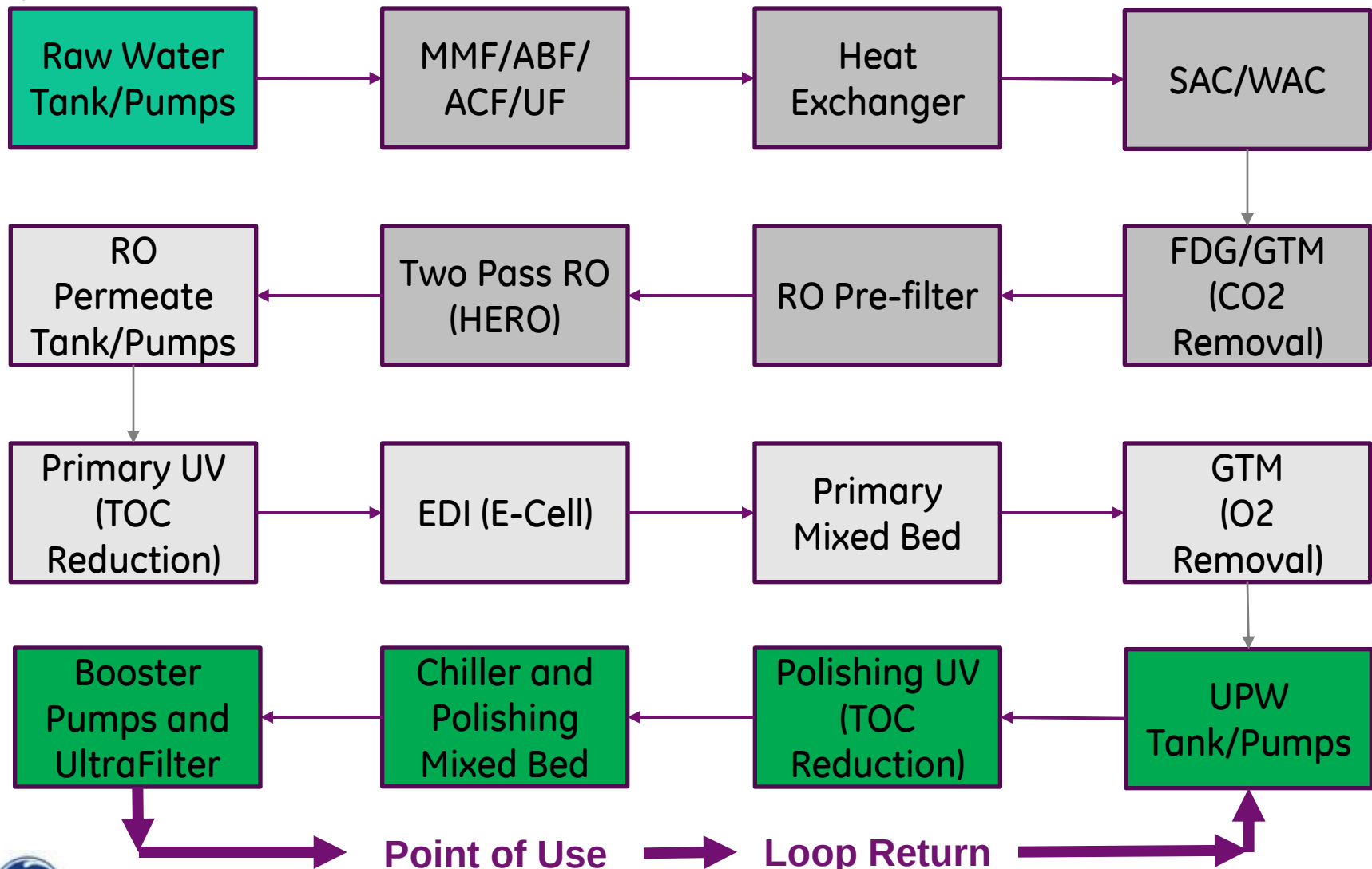
Field Analytical Support



UPW SYSTEMS AND TECHNOLOGIES



System Overview – Typical Ambient UPW System



HERO™

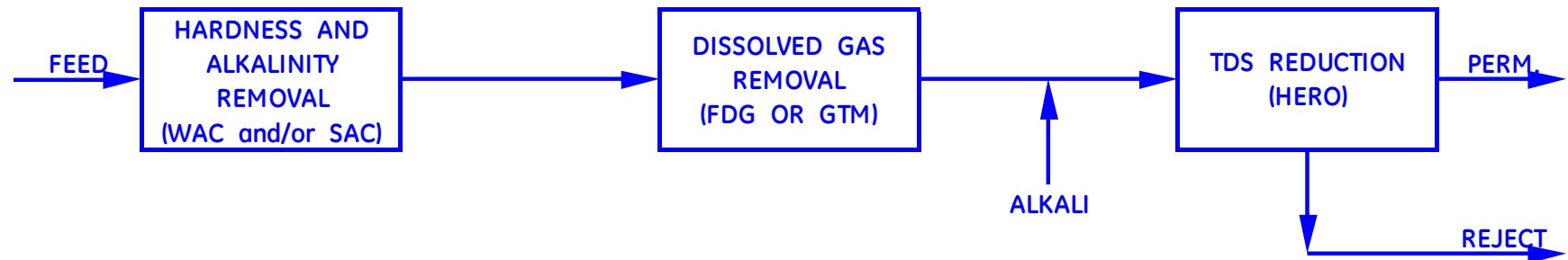
What is the HERO Process?



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HERO Process (Key Components)

- Weak/Strong acid cation (WAC/SAC) for hardness and alkalinity removal.
- Degasification step for CO₂ and TOC/THM removal.
- Alkali addition to increase RO feed pH



MAXIMUM Reject pH is 11 for Membrane Warranty

Effects of High pH:

The negatively charged membrane has a higher charge density at high pH (meaning it is more negatively charged), so:

- Negatively charged ions are more highly rejected. For instance, for TOC, boron, silica, and all anions, rejections are much higher at high pH.
- Particulates, typically with negative charge, are repelled strongly.
- Bacteria cannot grow or reproduce at high pH.
- Solubility of silica is increased at high pH.

Strengths of HERO Mode Operation

<u>Parameter</u>	<u>Conventional 2 Pass RO</u>	<u>Typical 2 Pass HERO™</u>
Quality of Product	B: > 2 ppb SiO ₂ : < 20 ppb TOC: 10 to 20 ppb	B: < 100 ppt SiO ₂ : < 1 ppb TOC: < 5 ppb
Basis: Feed boron 12 ppb, Feed SiO ₂ 10 ppm & Feed TOC 2 ppm		
Recovery (Overall)	70 to 75%	90 to 98%
Bio-Fouling	Potential Problem	No Bio-Fouling, <u>NONE!</u>
Particulate Fouling	Problem, SDI < 5 needed	Typically not a problem
Cleaning Frequency	3 to 4 Times / year	Typical is once per year or less
Quantity RO Elements	X Units	X / 2
Cleaning	Off-Line	On-Line

HERO – Process Steps

Hardness Removal Step

- Accomplished with a weak/strong acid cation resin, regenerated with HCl or H_2SO_4
- Average hardness leakage must be in the “ppb range”.

Degasification Step

- Use forced draft degasifier (lowest cost) or GTM (gas transfer membrane).
- Reduce carbon dioxide in cation effluent to low ppm levels.

pH Adjustment Step

- Inject alkali in RO feed to raise pH in the RO reject to 11.0 max.
- Feed pH will be in the 10.0 to 10.5 range depending on RO recovery.
- Permeate pH will be in the 9.5 to 10.0 range.

RO Step

- RO designed for very high flux.
- Recovery 90 to 99%, depending on feed water chemistry.
Typical target is 95 to 98%.
- Membrane Type:
 - Low pressure high rejection
 - Standard brackish type
 - Seawater (typically used for recycle/reclaim applications). Limit flux to 20 GFD with this membrane



HERO Plant layout

Module 1 Pretreatment

Module 2 HERO

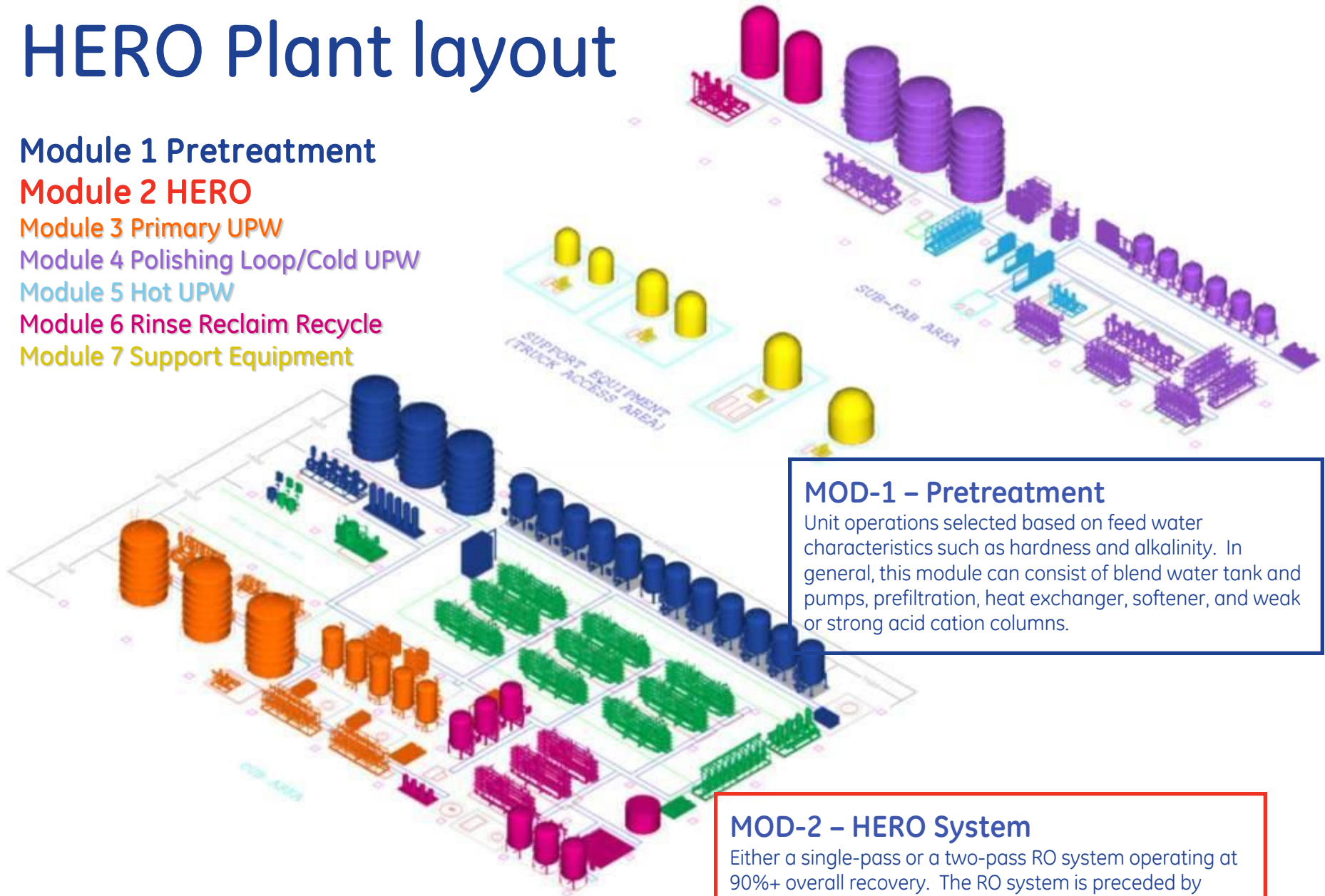
Module 3 Primary UPW

Module 4 Polishing Loop/Cold UPW

Module 5 Hot UPW

Module 6 Rinse Reclaim Recycle

Module 7 Support Equipment



MOD-1 – Pretreatment

Unit operations selected based on feed water characteristics such as hardness and alkalinity. In general, this module can consist of blend water tank and pumps, prefiltration, heat exchanger, softener, and weak or strong acid cation columns.

MOD-2 – HERO System

Either a single-pass or a two-pass RO system operating at 90%+ overall recovery. The RO system is preceded by cartridge filtration and a degasification step. Optional CIP System for RO cleaning.

Taiwan HERO Train (45 m³/h)



Singapore Two Pass HERO Train (90 m³/h)



France Gas Transfer Membrane System



Malaysia

Forced Draft Degasifier Towers



Singapore Polishing Mixed Beds



EDI

Process Principles- EDI Process

Cathode(-)

Process Principles- EDI Process

Anode (+)

Cathode(-)

Process Principles- EDI Process

Anode (+)

Cation Membrane

Cation Membrane

Cathode(-)

Process Principles- EDI Process

Anode (+)

Anion Membrane

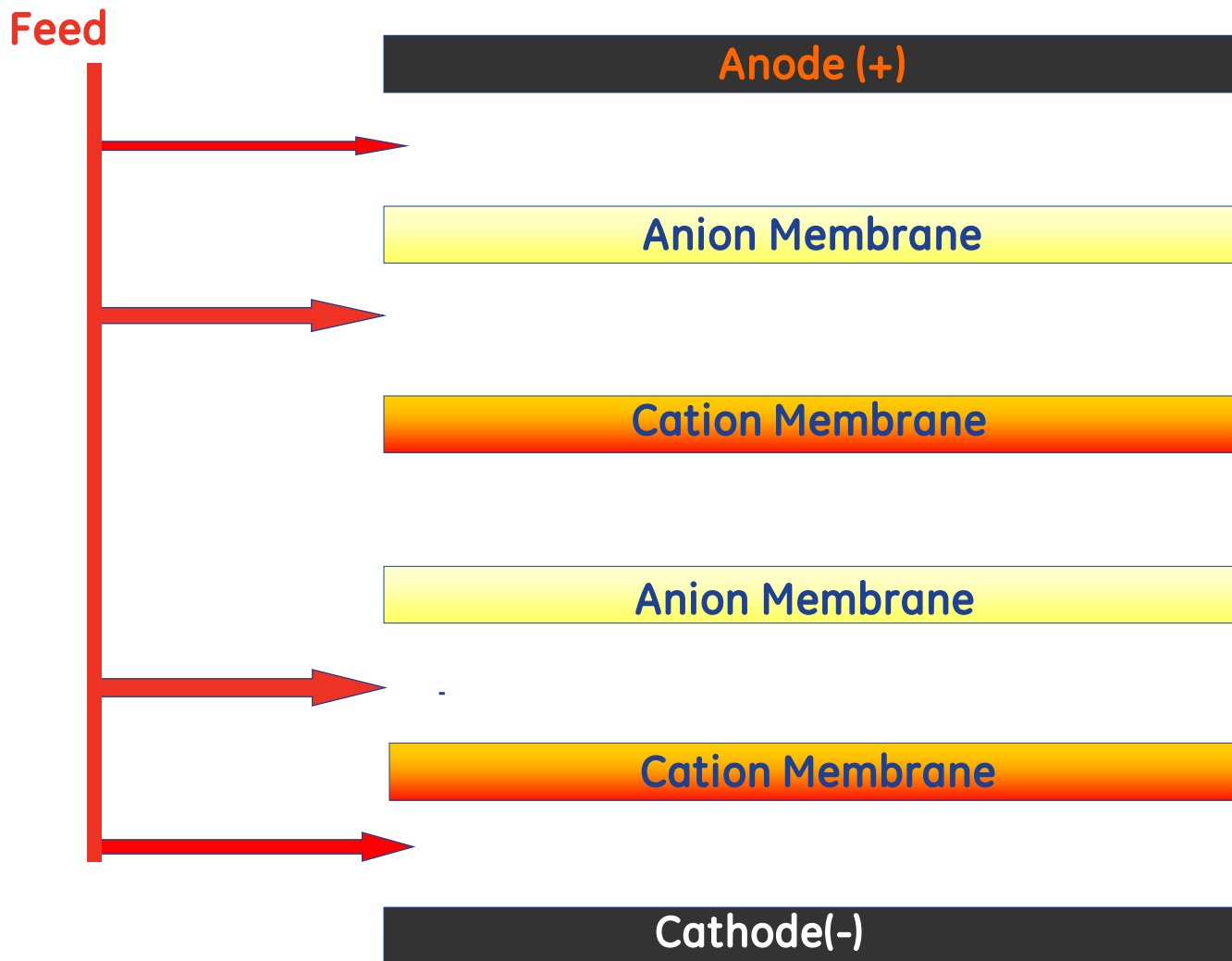
Cation Membrane

Anion Membrane

Cation Membrane

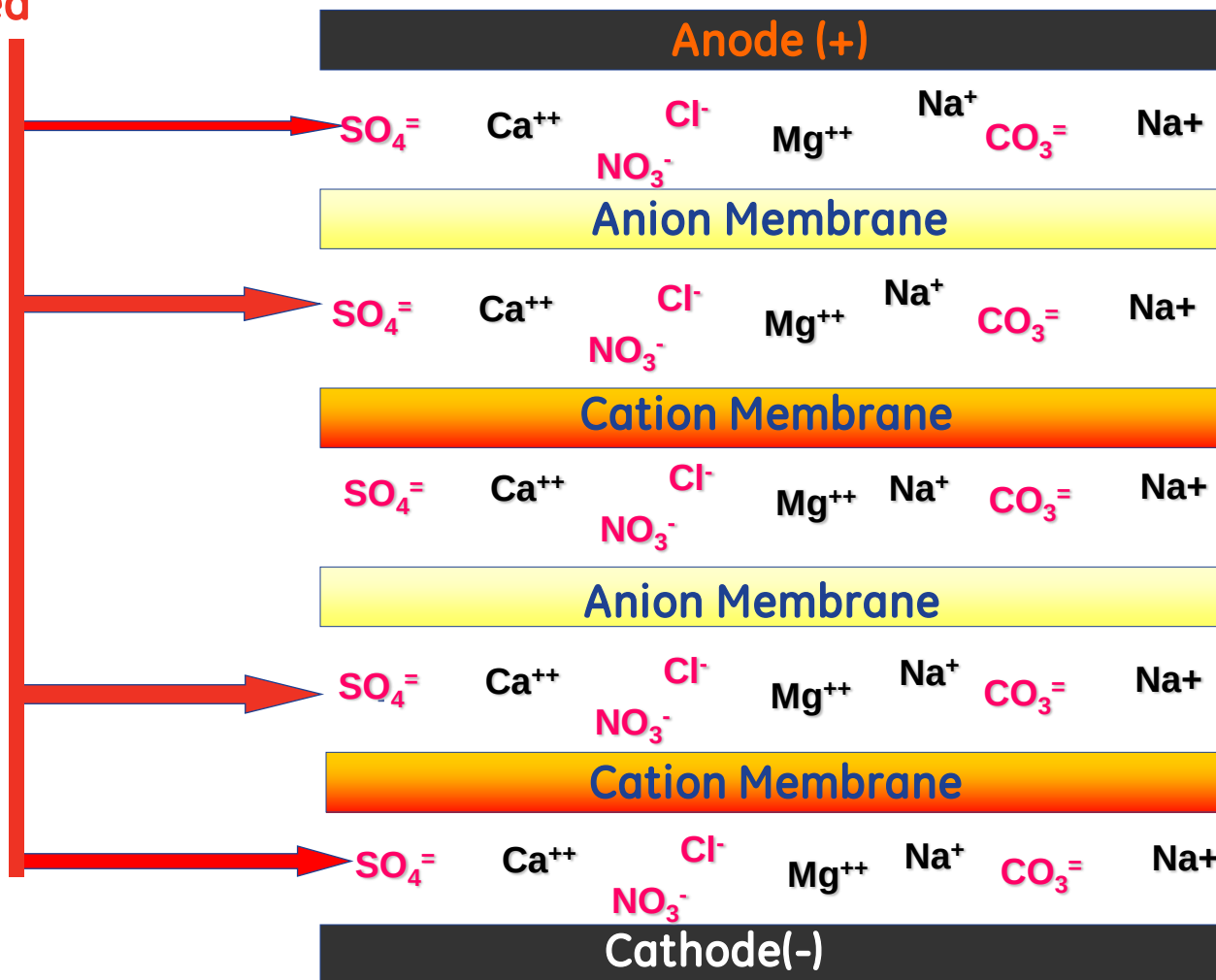
Cathode(-)

Process Principles- EDI Process

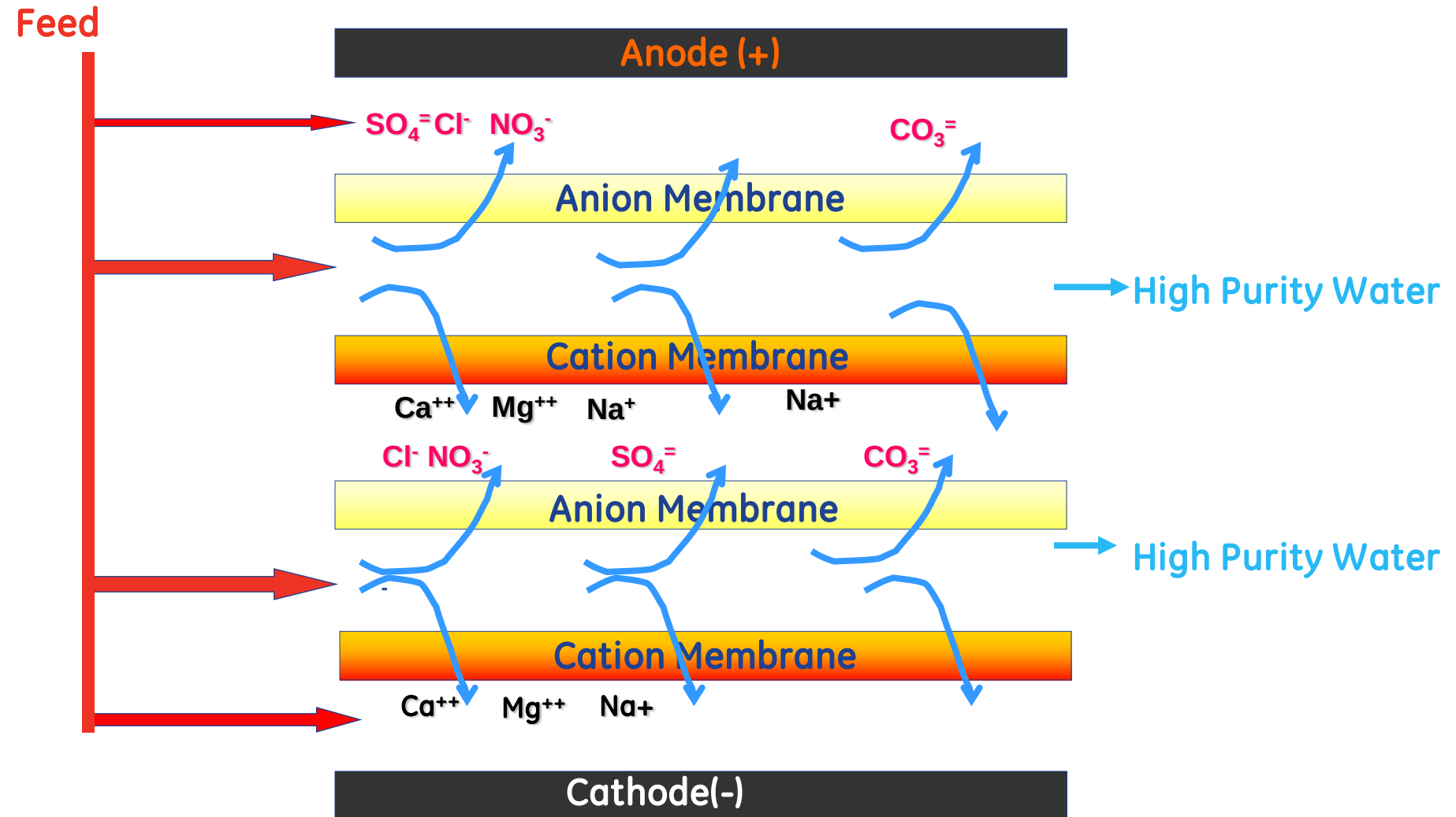


Process Principles- EDI Process

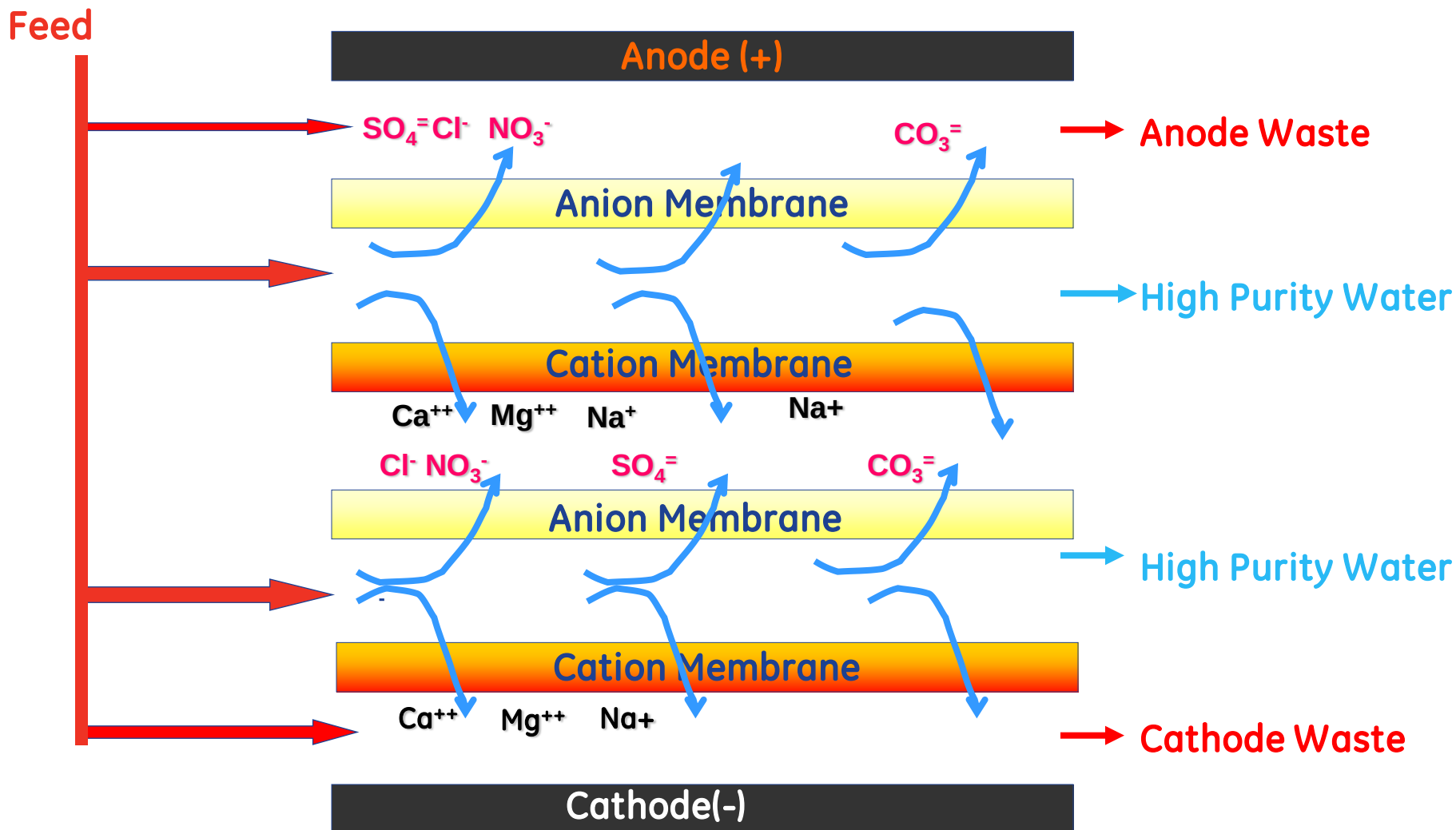
Feed



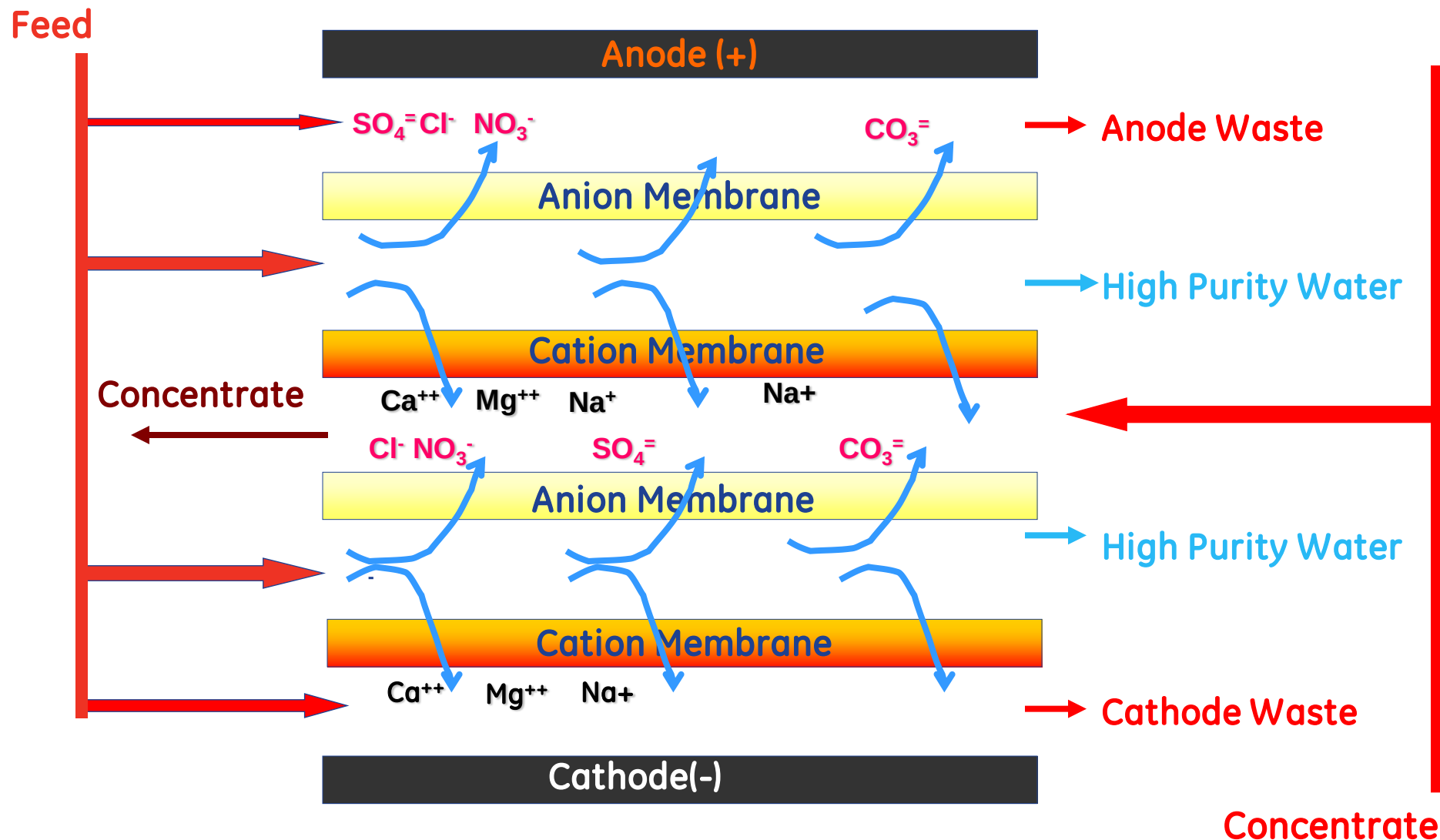
Process Principles- EDI Process



Process Principles- EDI Process

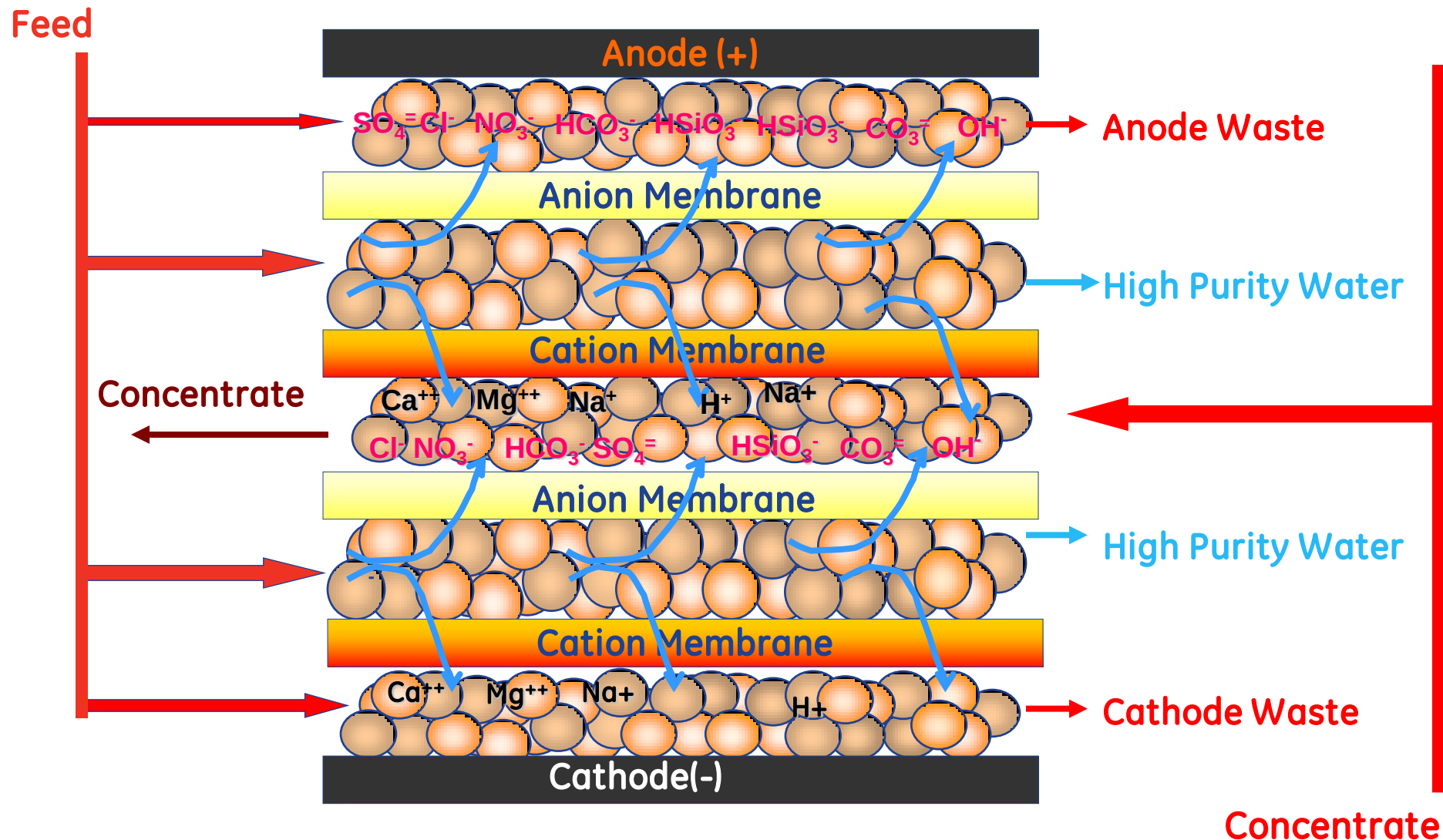


Process Principles- EDI Process



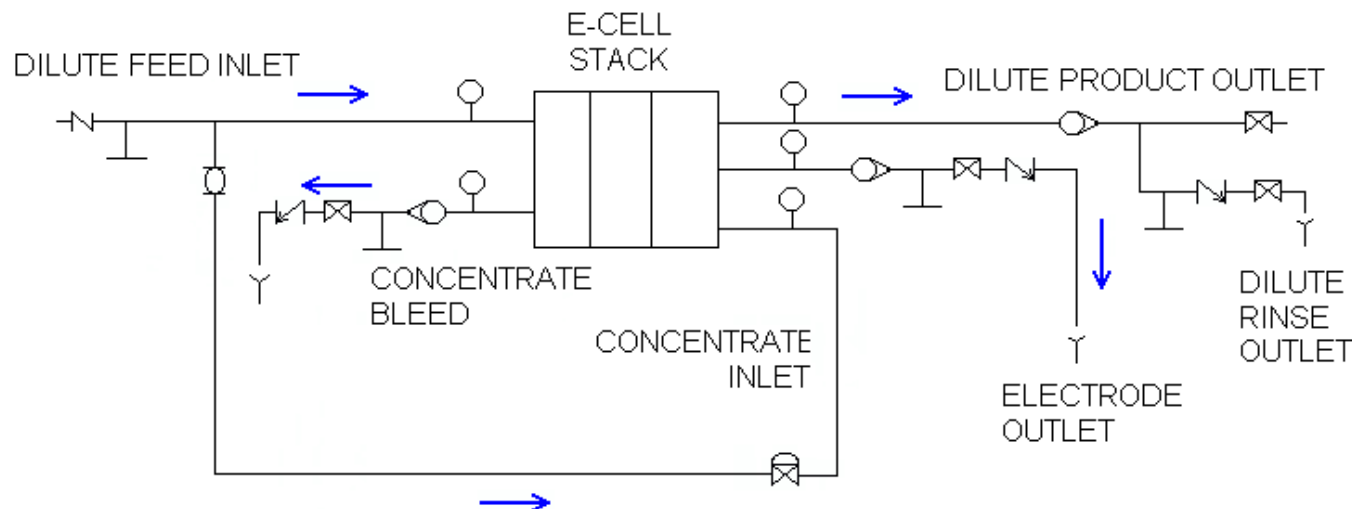
Concentrate typically flows Counter current to Dilute and Electrode

Process Principles- EDI Process



3 Series Schematic

E-CELL SYSTEM SCHEMATIC E-Cell 3 Series



LEGEND

	VALVE		PRESSURE INDICATOR		DRAIN
	CLEANING CONNECTION		CHECK VALVE		FLOW DIRECTION
	FLOW INDICATOR		PRV		

GE E-Cell 3 Series Stacks

Stack	Nominal Flow (m ³ /h, gpm)	Flow Range (m ³ /h, gpm)
E-Cell-3X E-Cell-3X-HH	5.0 m ³ /h 22 gpm	2.3 - 6.4 m ³ /h 10 -28 gpm
MK-3	3.4 m ³ /h 15 gpm	1.7 - 4.5m ³ /h 7.5 - 20 gpm
MK-3Pharm MK-3PharmHT*	3.4 m ³ /h 15 gpm	1.7 - 4.5m ³ /h 7.5 - 20 gpm
MK-3Mini MK-3MiniHT*	1.1 m ³ /h 5 gpm	0.6 - 1.5m ³ /h 2.5 - 6.5 gpm



* Hot water sanitizable to 80°C – 180°F, Same performance as non-HT

- Applications: Power, Industrial, Microelectronics, Pharmaceutical
- HH: <2.5 ppm hardness as CaCO₃ 80-97% recovery
- Other: <1ppm hardness as CaCO₃ 87-97% recovery
- 16 MOhm-cm - microelectronics, industrial
- 10 MOhm-cm - power, industrial, pharmaceutical
- 20, 10, 5 ppb Silica guarantees



The End



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