Water Reuse

National Water Co. , Riyadh , KINGDOM OF SAUDI ARABIA
16 October 2011

USED USEFUL | SAUDI ARABIA

Membrane Bioreactor Technology

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Presentation Outline

- Introduction to GE Water
- UF/MBR Technology
- Leap MBR
- UF/MBR Experience
- Why Water Reuse
- Servicing Our Customers

Why work with GE?

- General Electric Company … founded in 1892 and $150+ Billion in sales annually
- GE Water: 8000 employees around the world solving water problems
- $2+ Billion water business built upon experienced businesses that have been in the water space for 40-100 years
- Consistently one of the: Most Admired – *Fortune*, Most Respected – *FT companies*
- Recognized leader in Six Sigma and lean quality initiatives
- Only company listed in the Dow Jones Index today that was in the original list in 1896

1892

ecomagination℠

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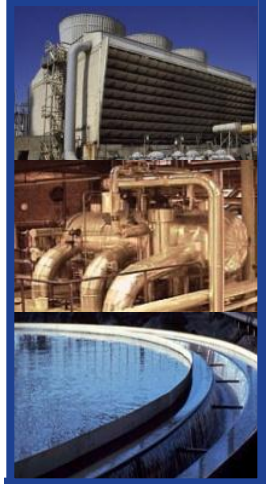
Broadest portfolio

Chemical & Monitoring Solutions

Water Services



Chemical Process

Industrial Process

Analytical and Monitoring Solutions

Engineered Systems

UF/MBR/ ABMet

RO/ED

Thermal/ZLD

Mobile/BOO

Filters & Membranes

Investment in the Middle East

Production, services, engineering, JVs, R&D facilities

- Water Center of Excellence Saudi Arabia
- Water center of Excellence in UAE
- Global Water Sustainability Center, Qatar

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Our commitment to the Kingdom

Growth

Innovative and localized solutions that allow GE to partner with customers in regional growth

Technology

Proven world class technology that provides diverse, efficient and reliable solutions whilst helping customers meet increased environmental challenges

Localization

Fulfillment and service capabilities that provide customer satisfaction

Investing together now for a better future

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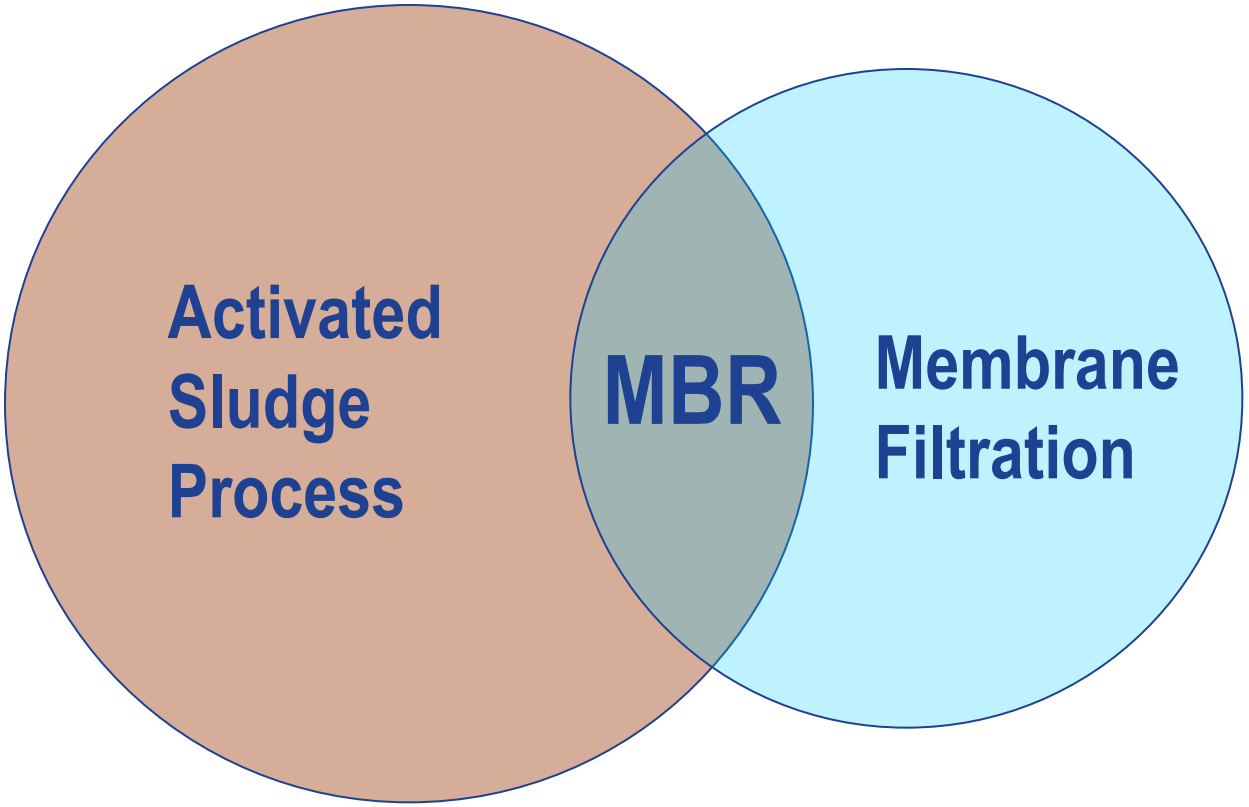
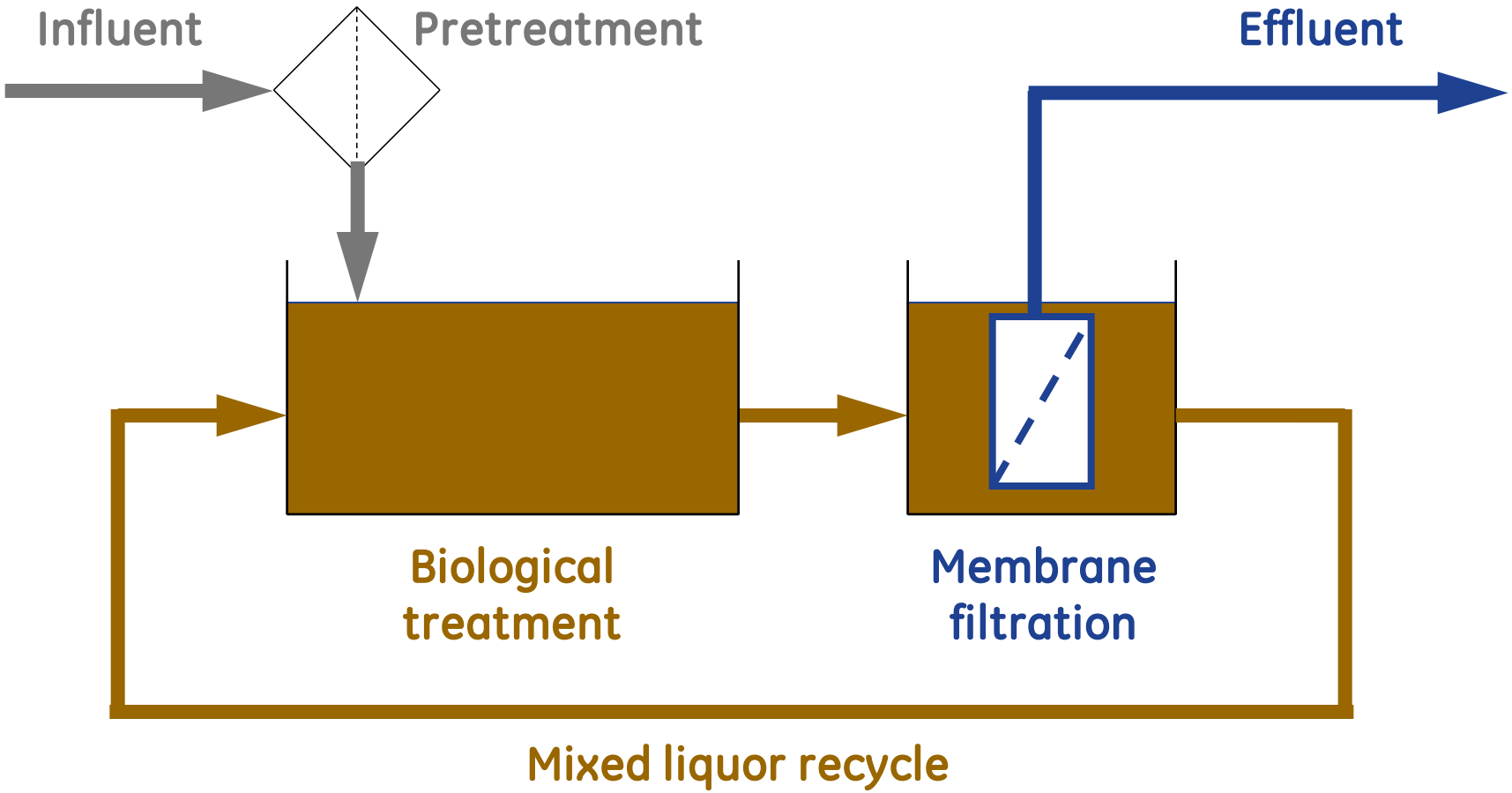
Membrane Bioreactor (MBR)



Stable Biological Treatment Process

Absolute Solids Separation

What is an MBR?



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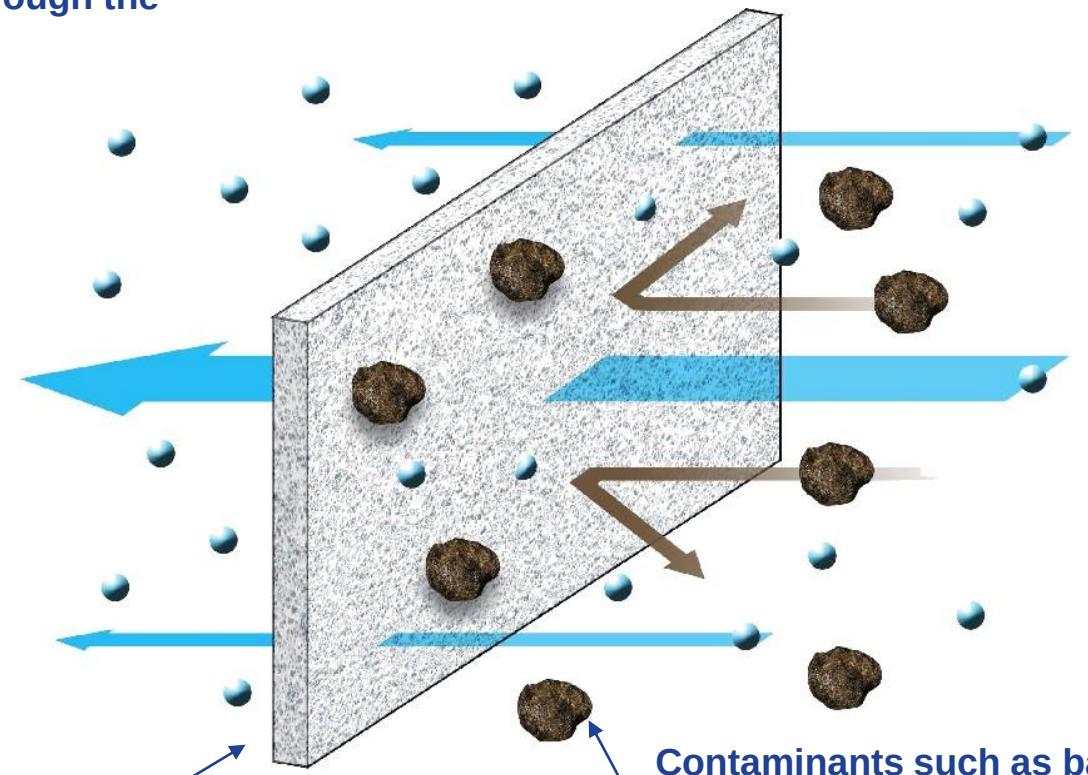
How do Membranes Work?

Water molecules and dissolved salts pass freely through the membrane pores



Semi permeable membrane wall with microscopic pores

Contaminants such as bacteria and viruses can not pass through the membrane's pores

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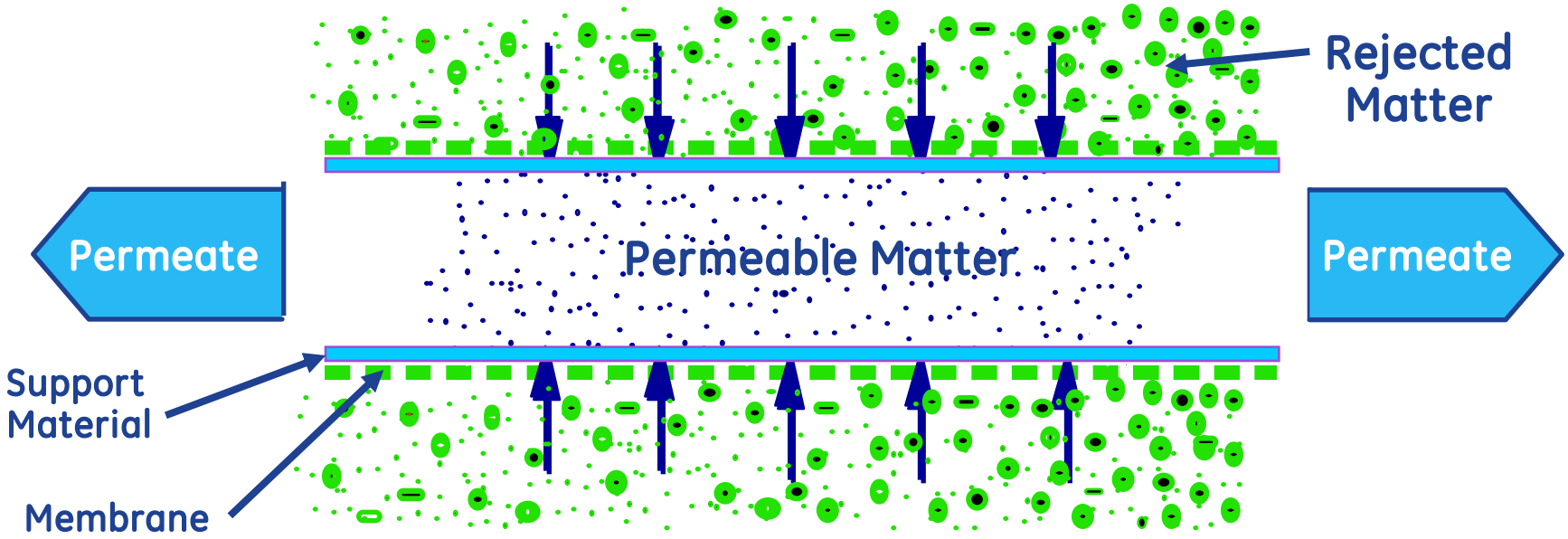
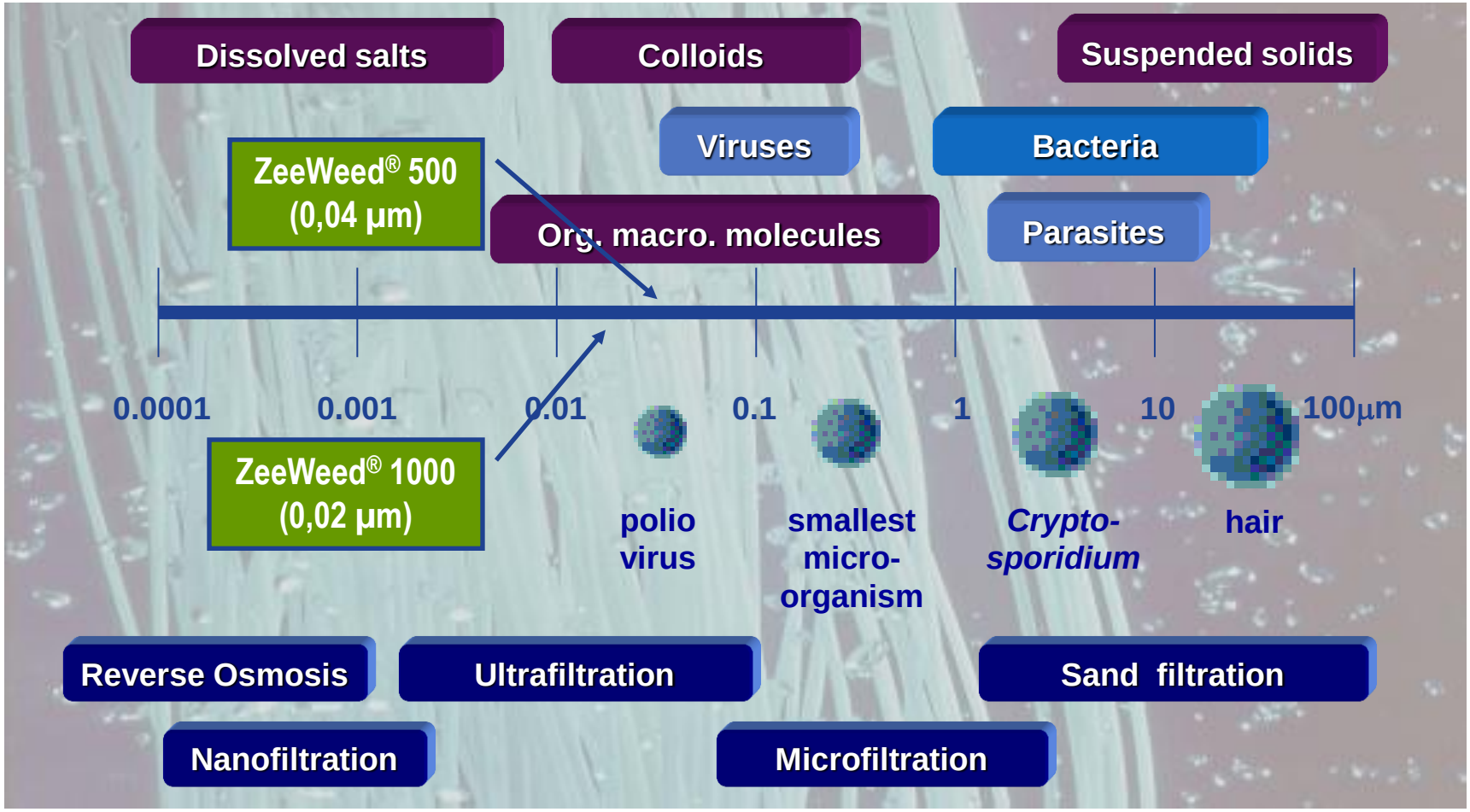
What is a membrane?

Membranes are engineered thin barriers or films of material that allow certain substances to pass by a size exclusion mechanism related to the size of the pores on the membrane surface



Filtration Spectrum



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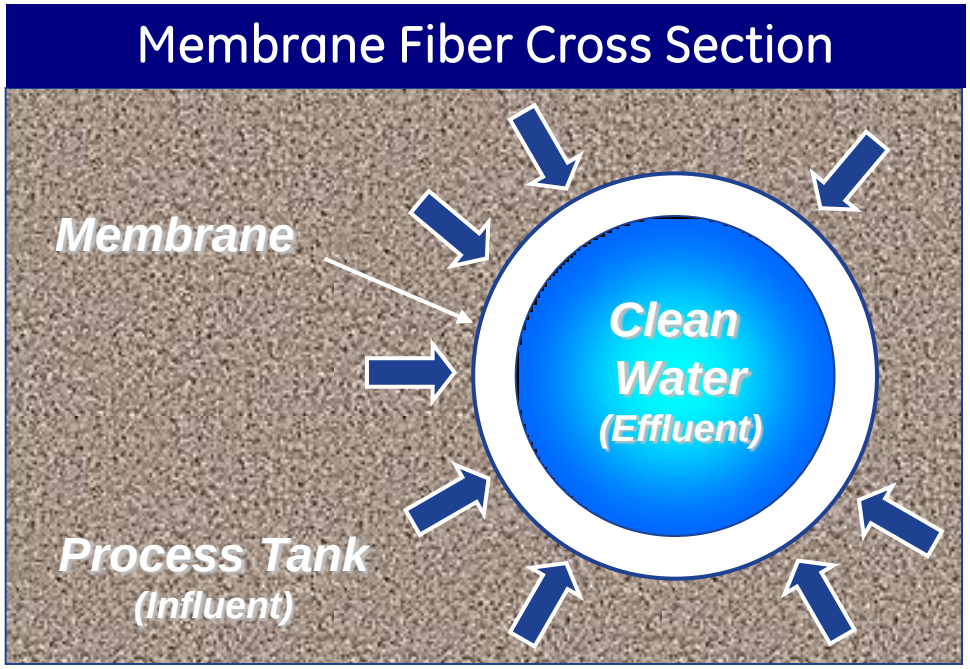
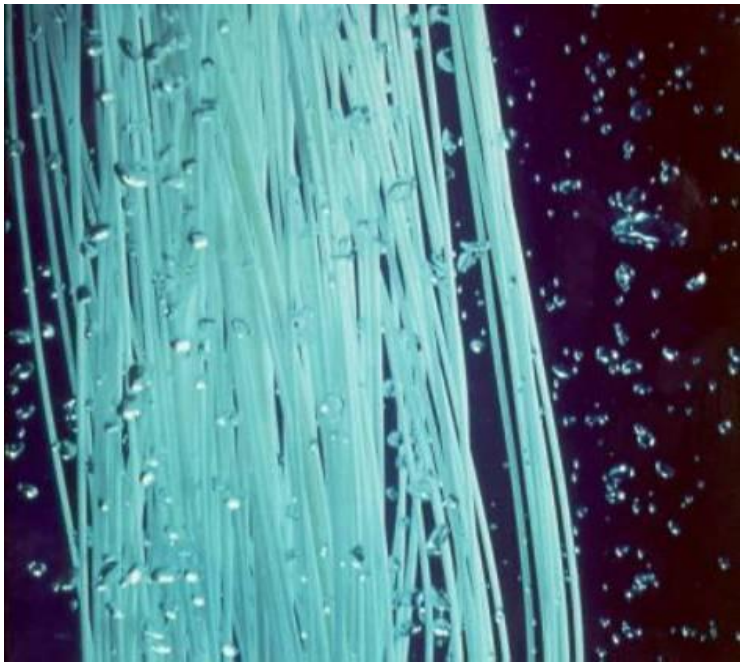
The ZeeWeed® Hollow Fiber – THE *Industrial-Strength* Solution

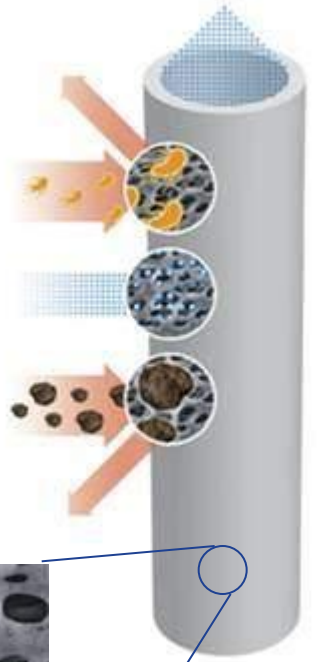




- **Immersed Hollow Fiber Ultrafiltration Membrane**
- **Outside-In Filtration Path**
- **PVDF chemistry (chlorine and oxidant-resistant)**

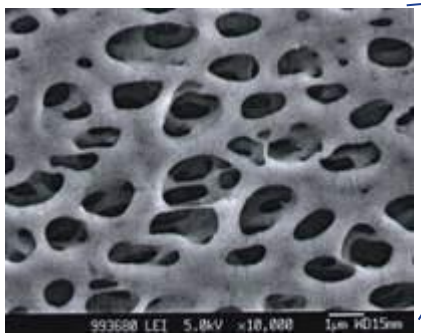
Membranes are The Key to Superior Effluent Quality

- Hollow strands of porous plastic fibers with billions of microscopic pores on the surface
- The pores are thousands of times smaller in diameter than a human hair
- Pores form a physical barrier to impurities but allow pure water molecules to pass
- Clean water is drawn to the inside of fiber by a gentle suction



Membrane Fiber

Membrane Module



Electron microscope view of membrane surface

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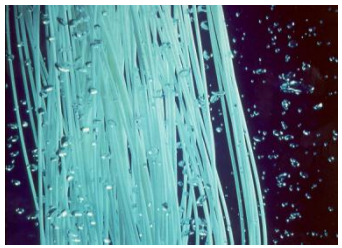
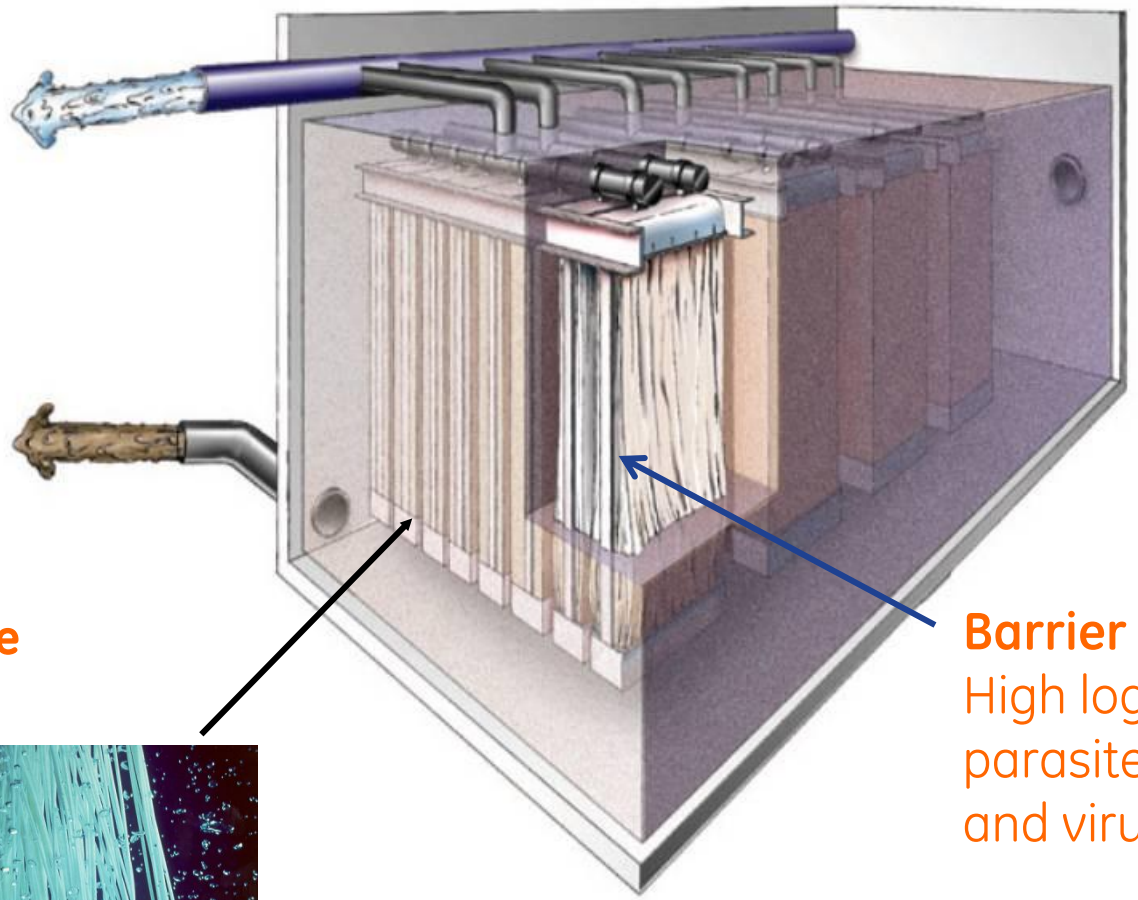
ZeeWeed® Water & Wastewater Treatment Processes

Particle-Free Treated Water

Water:
Concentrate
(5 - 8% vol.)

Wastewater:
Return Sludge/Concentrate
(3-5 x Feed Flow)





Barrier technology
High log removal for parasites, bacteria and viruses

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ZeeWeed® 500 for wastewater

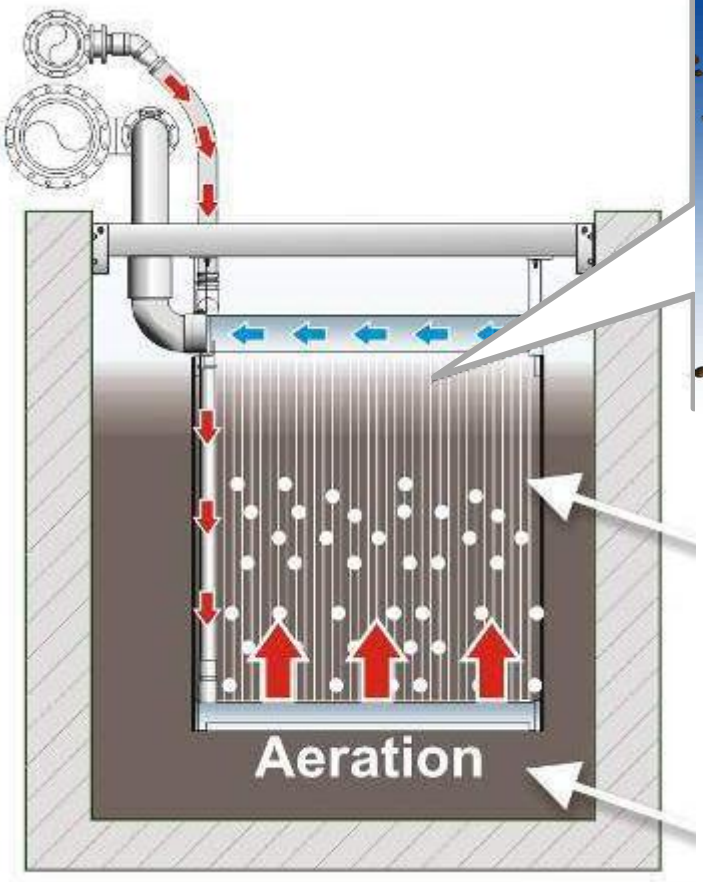
- ZeeWeed® 500 reinforced membrane system is used for majority of industrial wastewater applications:
  - ZeeWeed® membrane bioreactor
  - Low quality secondary effluent (tertiary treatment)

Principles of ZeeWeed® immersed membranes

Membrane Fiber

Air

Permeate



Membrane Cassette

Mixed Liquor

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ZeeWeed® 500 Animation Movie

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The ZeeWeed® 1000 Product

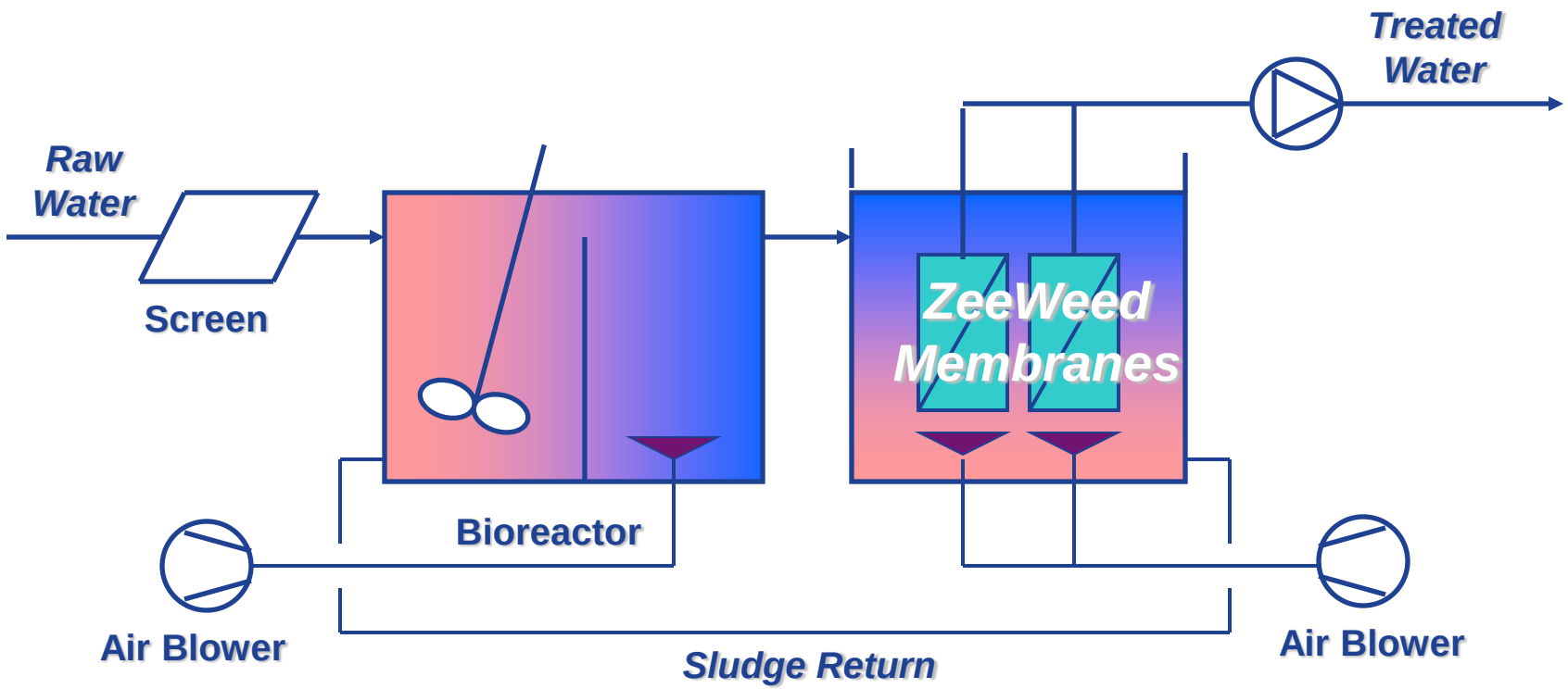
2004: ZeeWeed® 1000 V3

ZeeWeed® Applications

Typical ZeeWeed® Applications

- **Wastewater**
  - Membrane Bioreactor
  - Tertiary Filtration
- **Water**
  - Direct Water Filtration
  - Oxidation
  - Enhanced Coagulation

Typical ZeeWeed Wastewater Applications ➲ **Membrane Bioreactor**



➲ Main Treatment Goal: **Compact Biological Treatment** of Municipal and Industrial Wastewaters

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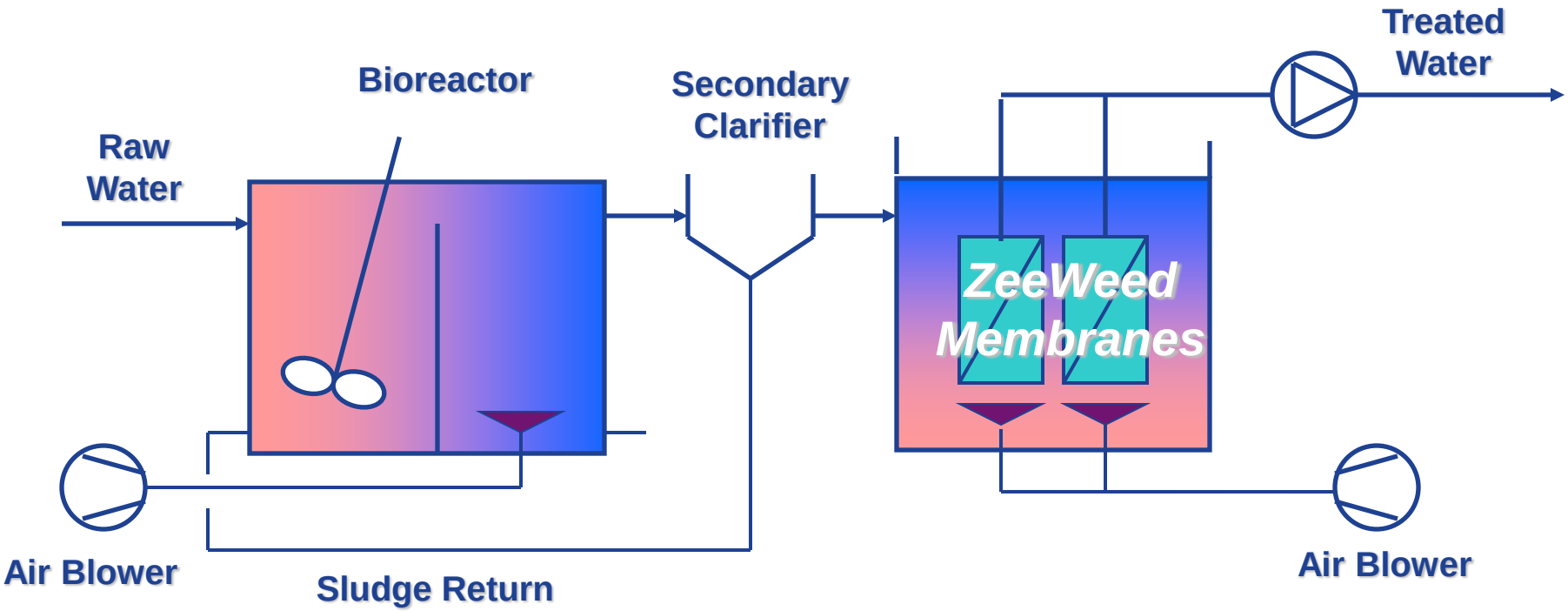
Typical ZeeWeed Wastewater Applications

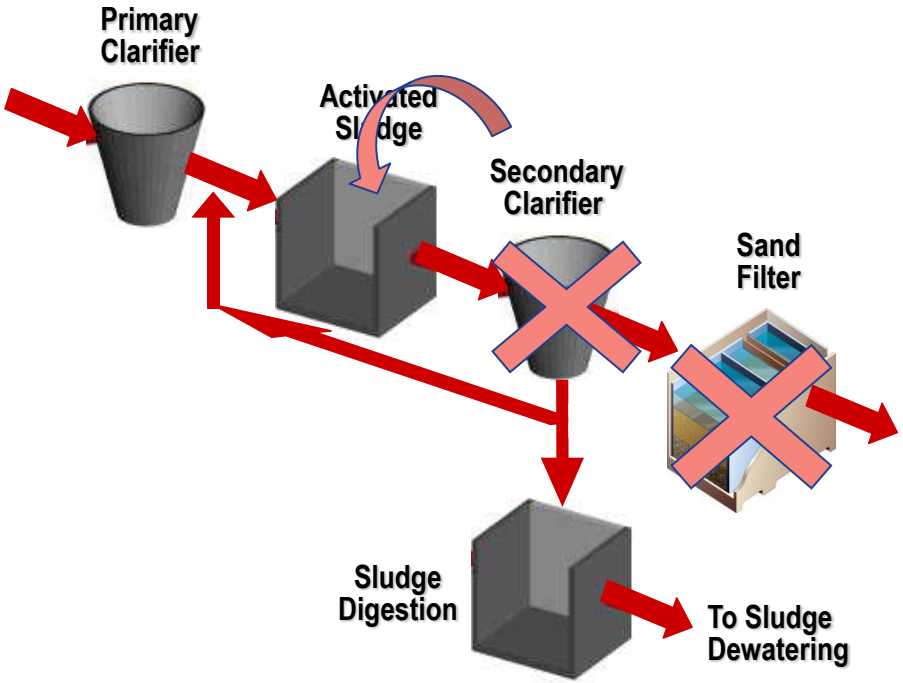
➲ Tertiary Filtration



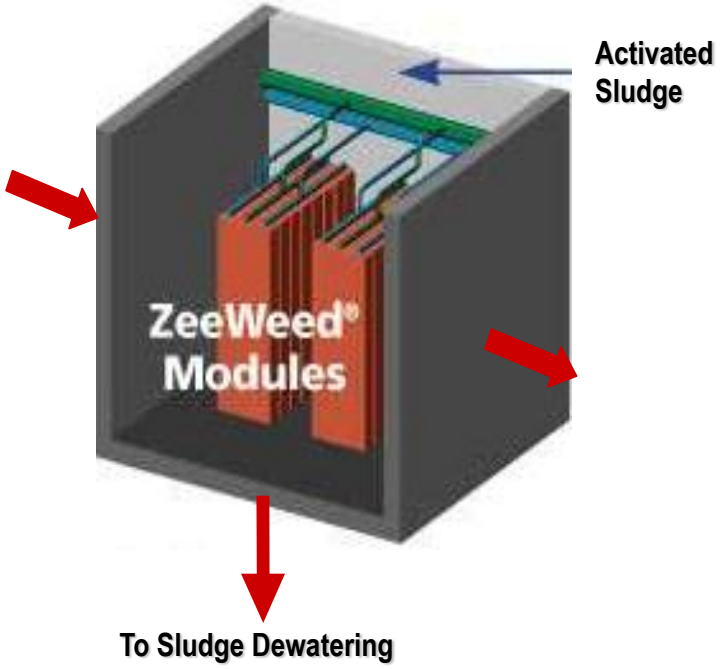
➲ Main Treatment Goal: **Suspended Solids** & **Turbidity, Phosphorus** Removal

Wastewater Treatment

Conventional WAS process



ZeeWeed® Bioreactor Process



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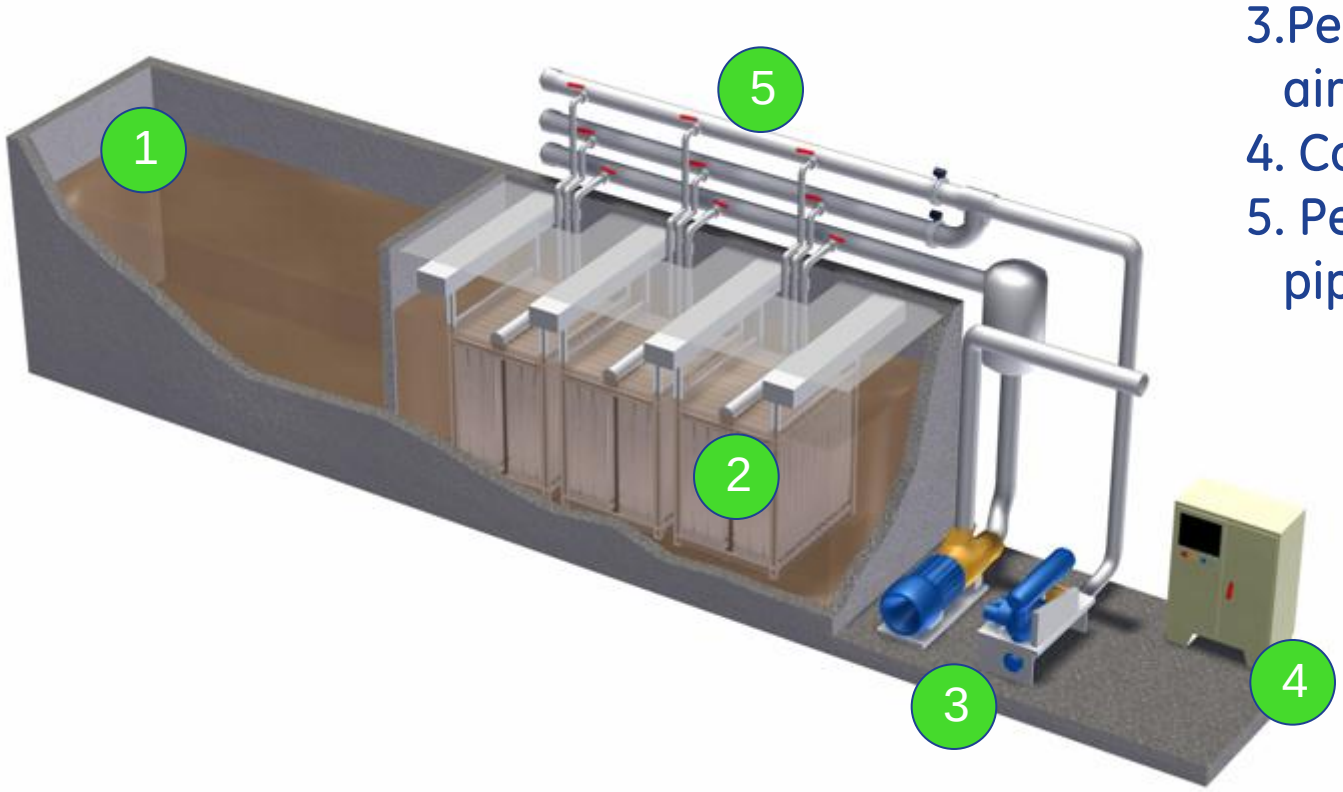
MBR means
Effective Separation between
Sludge and treated water

Higher biomass concentration

Less biological volume

Consistent effluent quality

A Basic MBR Production Train



1.Biological reactor
2.Membranes
3.Permeate pump & air blower
4. Control panel
5. Permeate & air piping

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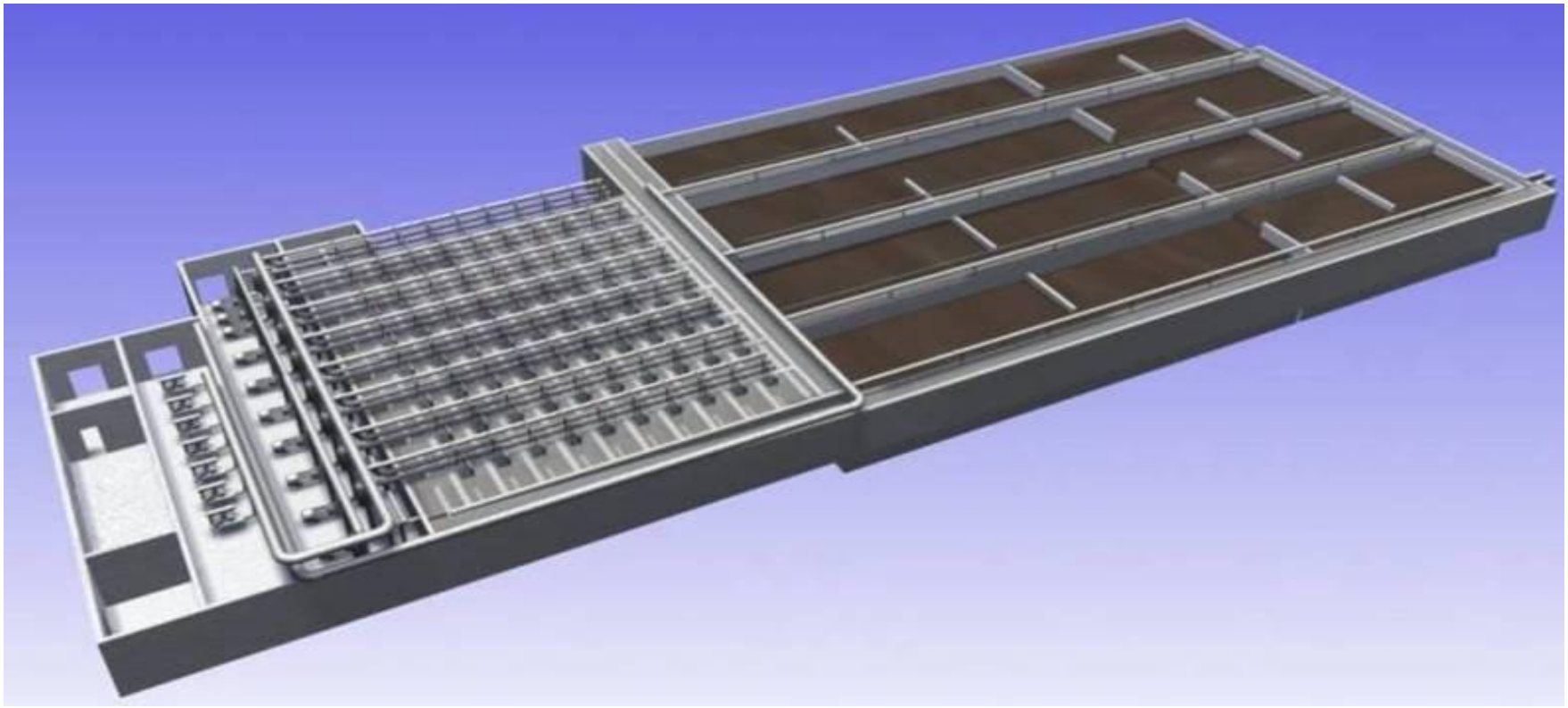
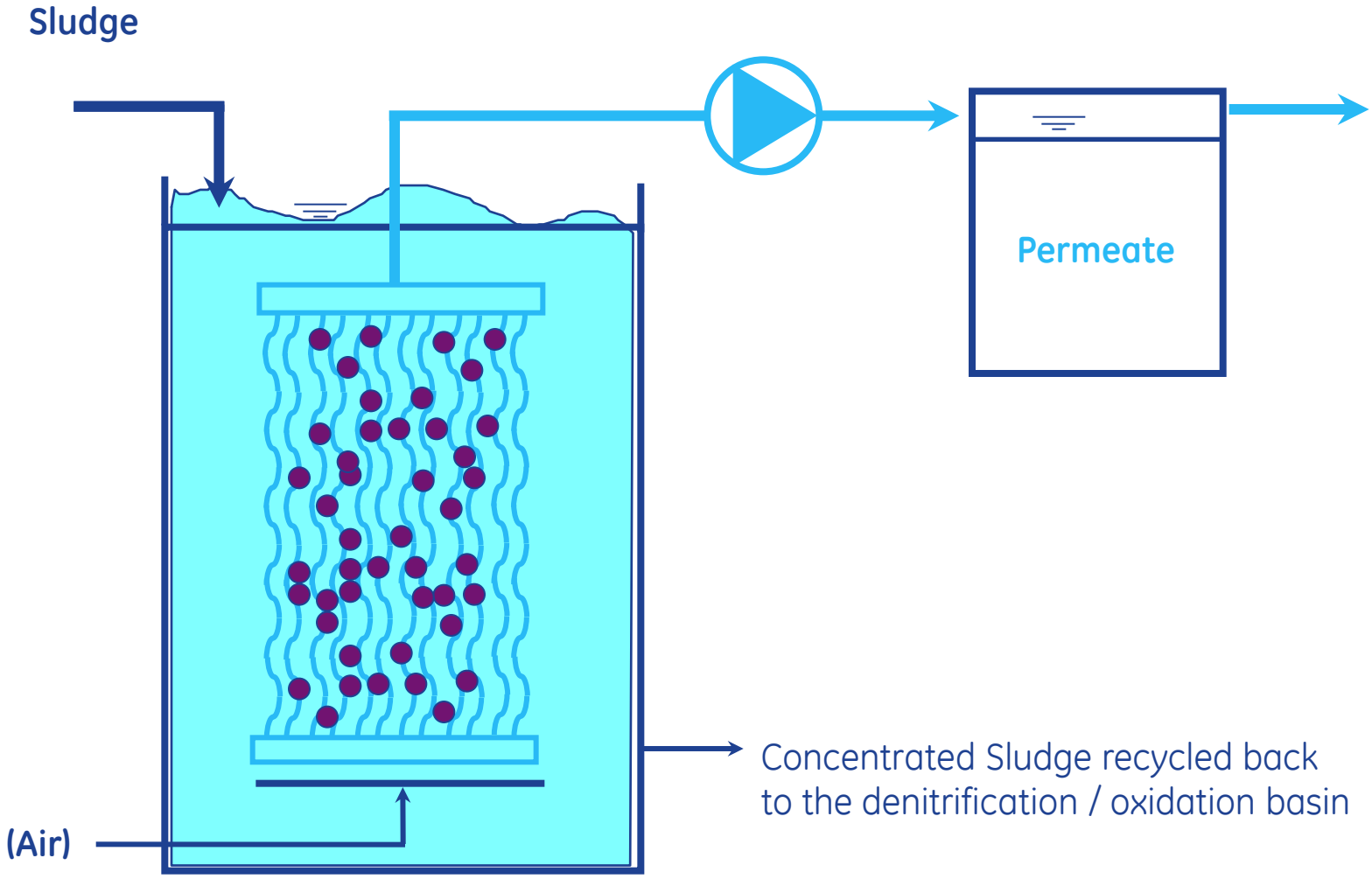
Trains are Simply Multiplied to Meet Capacity Requirements

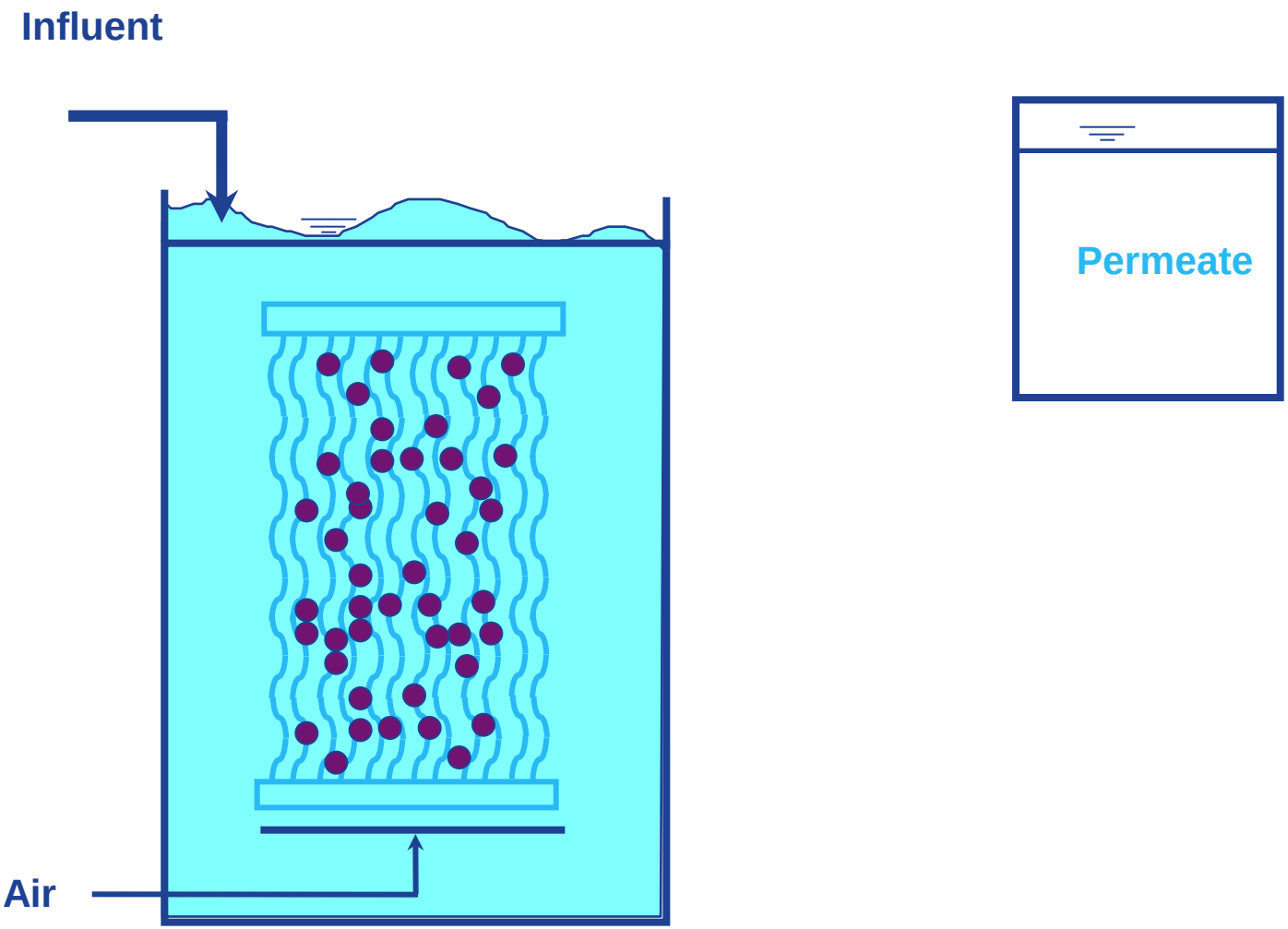


Above example: 60,000 M3/Day average daily flow MBR plant design with an approximate footprint of 100 m long x 50 m wide.

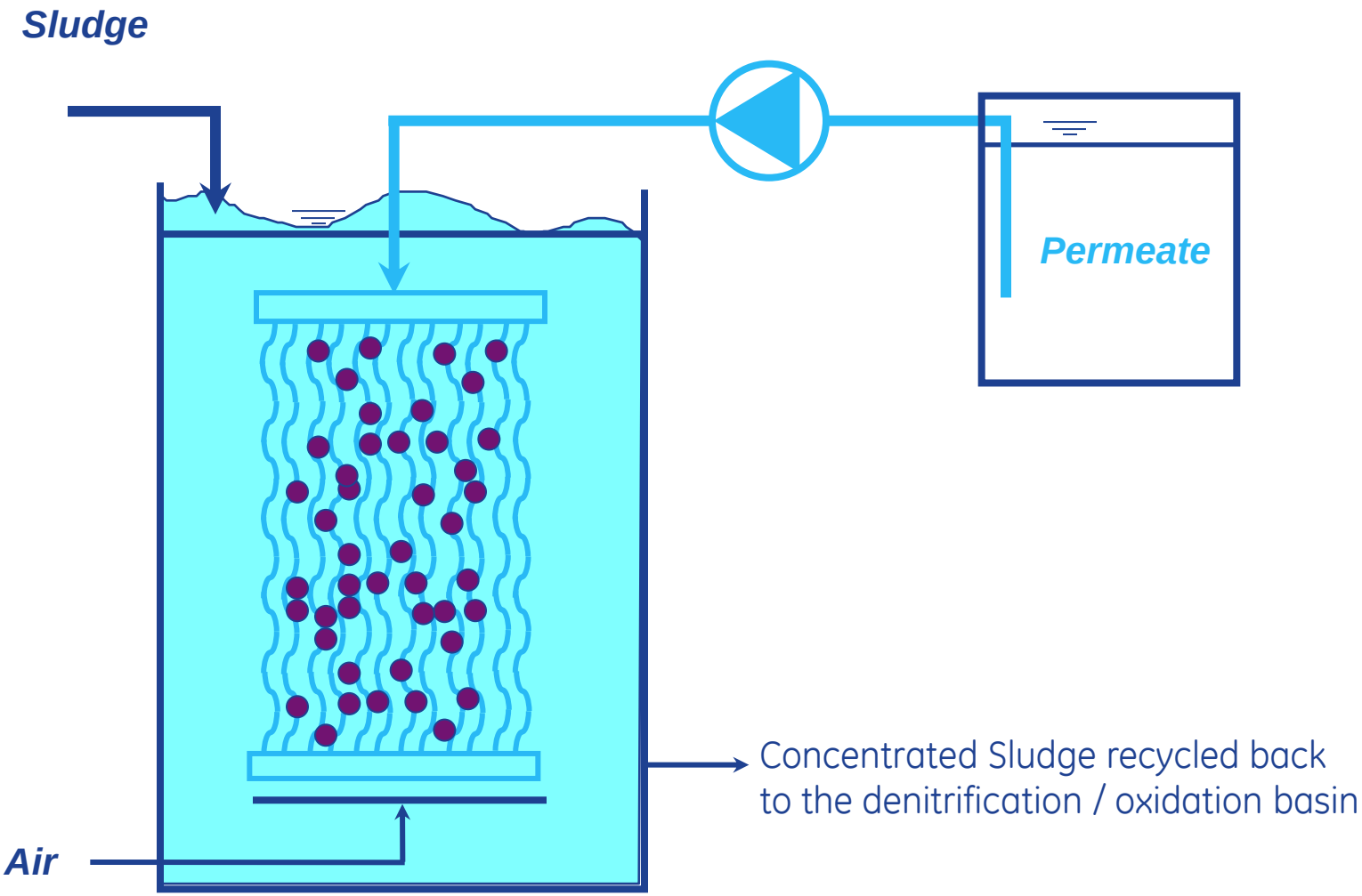
Permeation Schematic



Relaxation Schematic



Backwash Schematic



Why a Membrane Bioreactor

1 Effluent High Water Quality

Meet irrigation reuse standard quality

Source of cheap drinking water quality if combined with RO (concrete production, district cooling, aquifer recharge)

2 Footprint

Combination biological system and physical barrier

Greenfiel or upgrade treatment capacity (staged expansions)

3 Global Experience

Consolidated design for municipal WW (pretreatment, O&M procedures)

Effluent Quality

Membrane Pore Size

Average Pore Size

0.04 μm

Maximum Pore Size

0.1 μm

ZENON

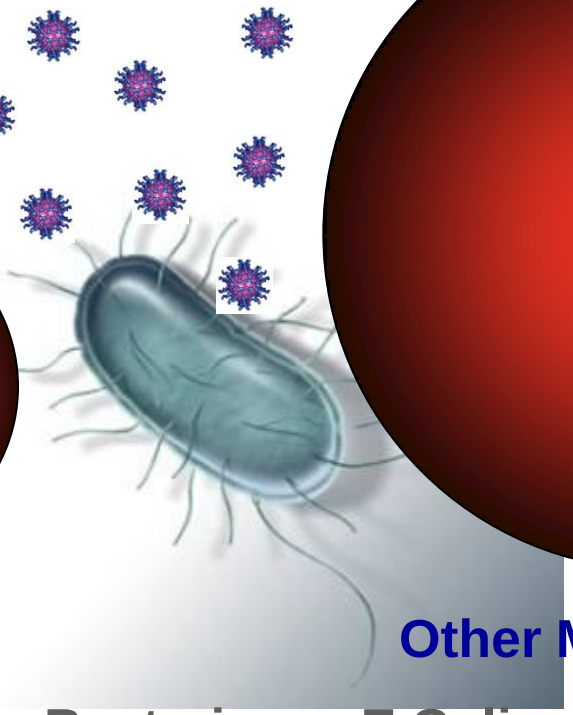
Viruses eg. polio
0.02 μm – 0.085 μm

0.1 μm

0.2 μm

0.4 μm

Other MF membranes



Bacteria eg. E.Coli
0.2 μm - 10 μm

ZeeWeed has the smallest pores of all major MBR membranes = lower solids fouling, easier cleaning

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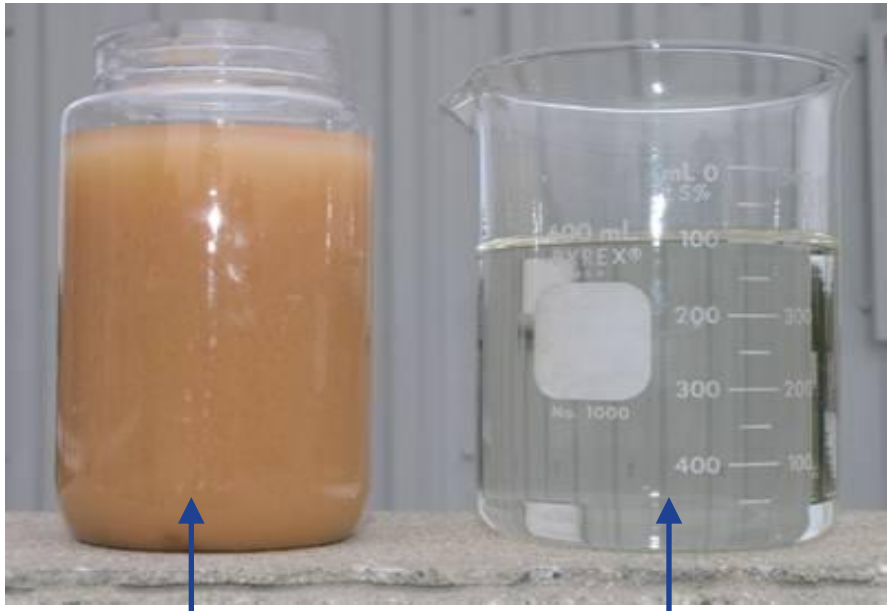
Treated Water Quality Exceeds the World's Toughest Standards – Current *and* Future



Raw Sewage

Treated Water

- World Health Organization's Standards for Unlimited Irrigation
- European Union's Bathing Water Directive
- California's Title 22 Code of Regulations

US EPA turbidity limit for drinking water is 0.3 NTU

Treated wastewater from a ZeeWeed®-MBR system is typically <0.2 NTU

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Wastewater Treatment with a ZeeWeed® MBR - **Effluent Quality***

- Suspended Solids < 3 mg/L
- BOD_5 < 5 mg/L
- NH4-Nitrogen < 1 mg/L
- Total Nitrogen < 5 mg/L
- Total Phosphorus < 0.1-0.2 mg/L
- Fecal Coliform < 2.2 CFU/100 mL
- Turbidity < 0.5 NTU
- Silt Density Index < 2-3

* for treatment of municipal sewage

Footprint

ZeeWeed® MBR Footprint

- MBR can operate at much higher MLSS values (2-3 x higher than conventional)
- *The biological compartment is smaller*

The MBR replaces the secondary clarifier and the sand filtration

The overall footprint is reduced

Advantages of footprint savings

- **Lower land costs** – for developers or for clients with limited space (ie, expansions)
- **Upgrades** - ½x footprint at same flow or 2x flow at same footprint
- **Architecture** – blending into surroundings is more affordable
- **Quick Construction & Semi Mobile** – Package MBRs

Significantly Reduced Footprint

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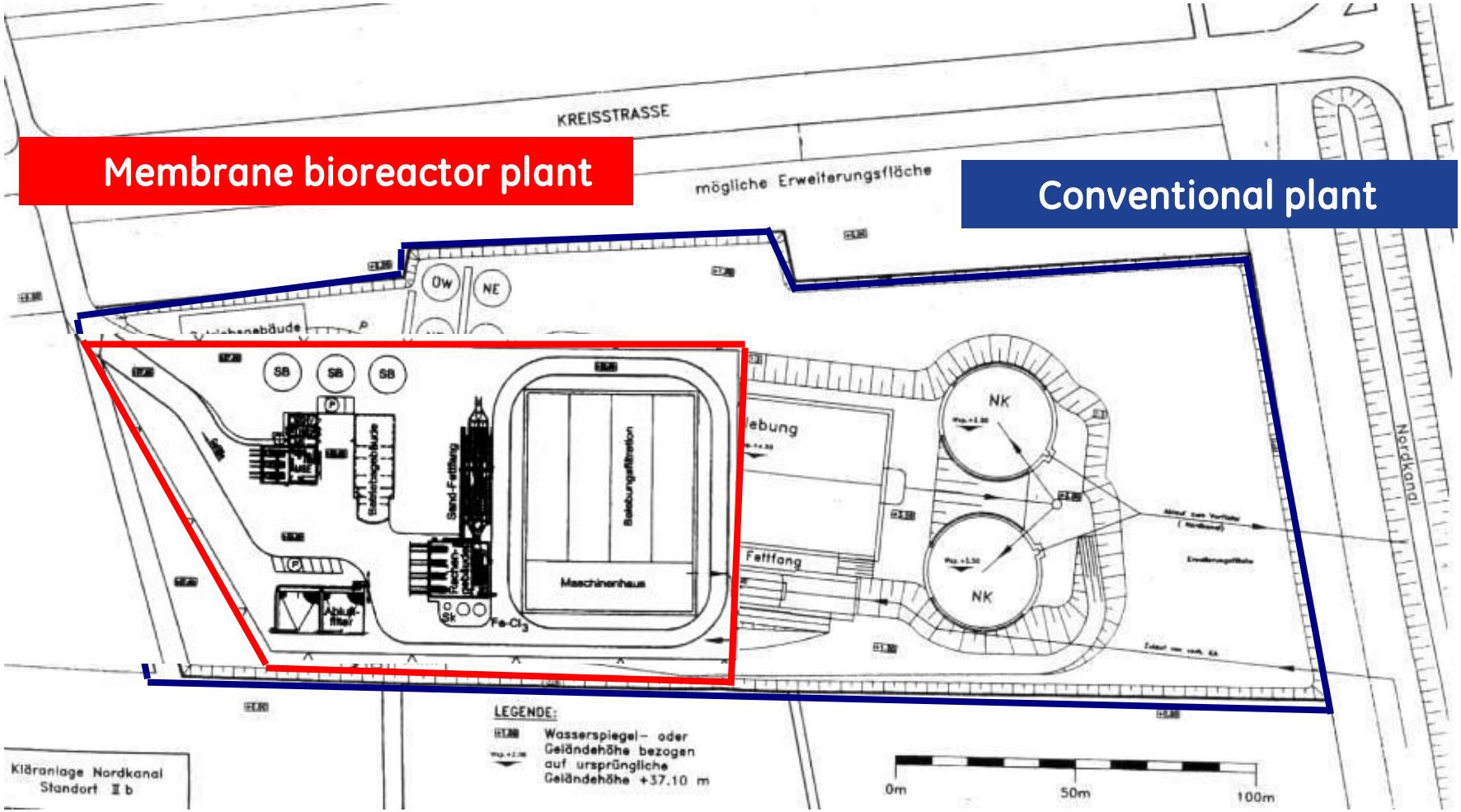
Land Savings - Nordkanal



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Ideal for expansion or retrofit of existing plants

- Modular design allows for easy expansion
- Retrofit existing sand filters or clarifiers
  - Convert existing treatment plant to a high-efficiency membrane process
  - Reduced capital costs through use of existing infrastructure
  - Increase capacity by 3-5 times within existing footprint
  - Upgrade effluent to reuse quality

Brescia, Italy: Membranes retrofit into existing activated sludge treatment lines

City of Duvall, WA: MBR replaced and expanded existing conventional system, using existing tanks for part of the biological process

Simple, clean, easy access

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Membranes vs. conventional technology

Membrane treatment

Conventional treatment

Modern and continuously improving	**Technology**	Developed in the 1800's
Extremely compact	**Footprint**	Large land requirement
Physical barrier = reliable filtration	**Separation Process**	Gravity driven with coarse filtration
Fully automated with minimal chemical use	**Operation**	Labor and chemical intensive

The next generation of ZeeWeed MBR technology

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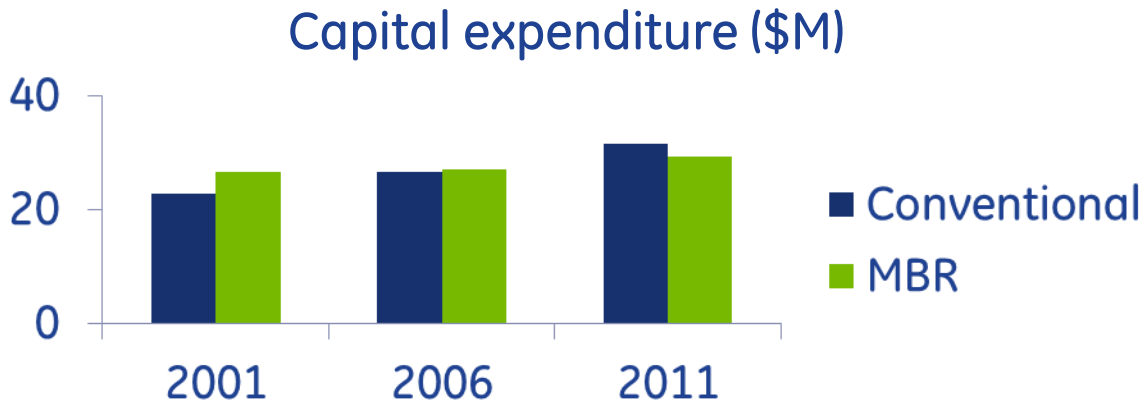
Program Introduction

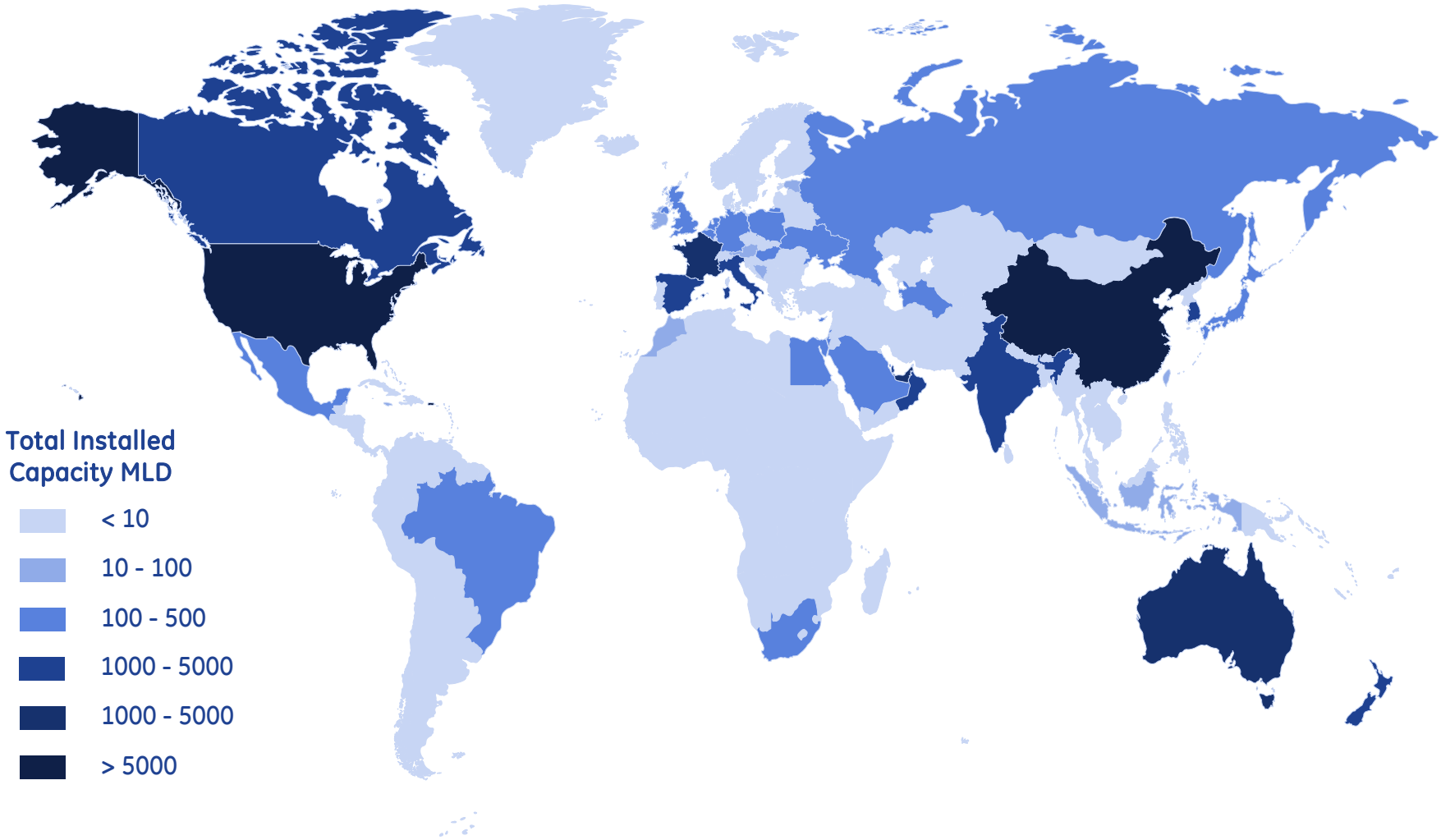
Cost of MBR vs. conventional



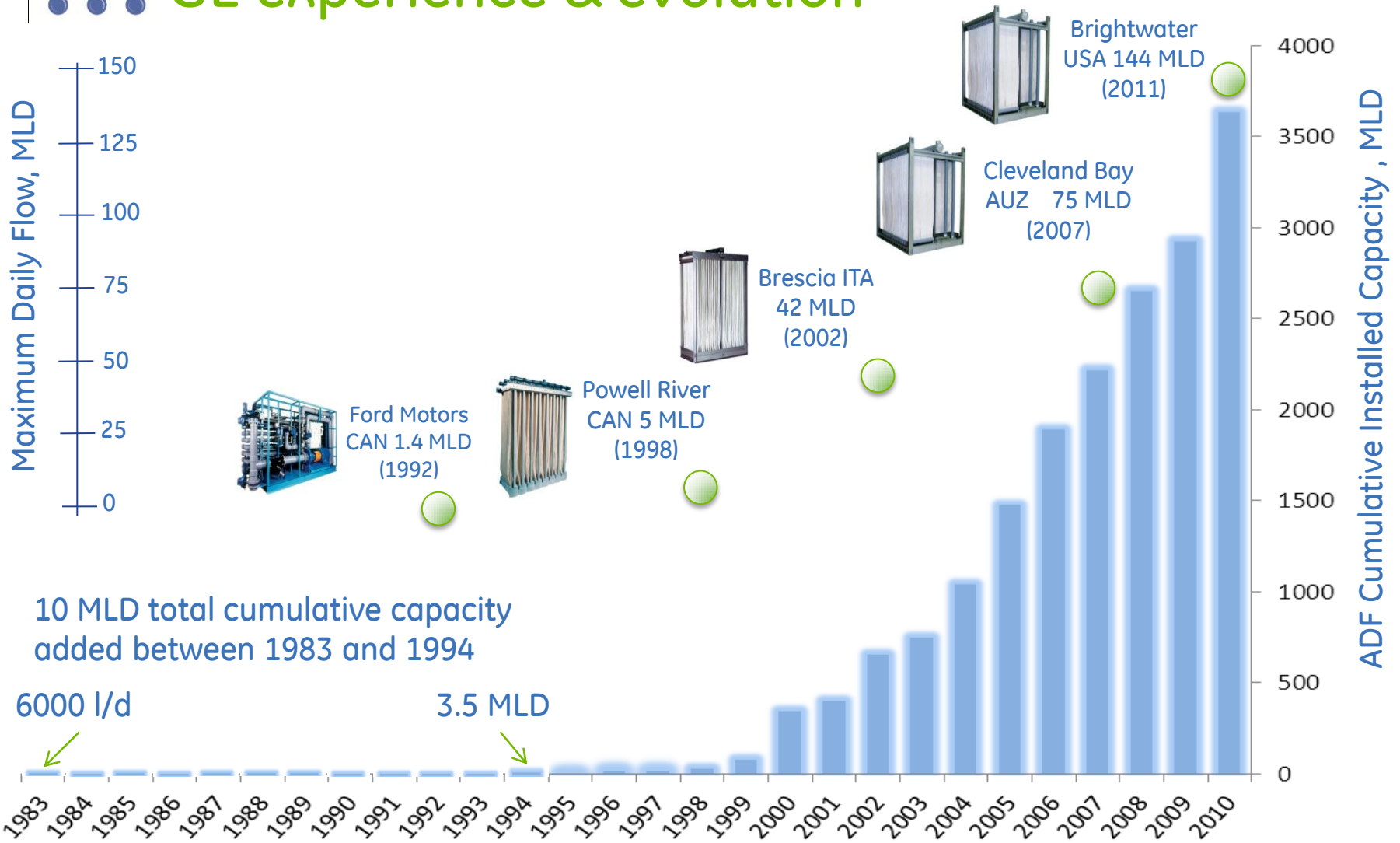
* Based on 20 MLD treatment capacity

Lifecycle cost of LEAPmbr is equivalent to conventional treatment

Global adoption of MBR technology



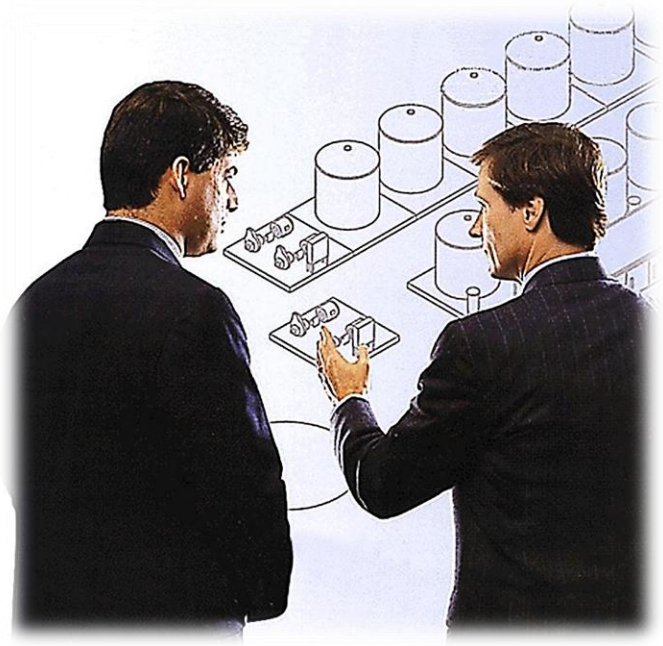
GE experience & evolution



So what are our customer's challenges?

"I understand the benefits of MBR, but the cost per gallon needs to be closer to conventional treatment."
Consulting Engineer

Productivity



So what are our customer's challenges?

Footprint

"MBR's smaller footprint is a huge advantage versus conventional; this is very important as my city grows and we need to expand our capacity." City Planner

So what are our customer's challenges?

"My old plant was a lagoon system and now I'm running an MBR; it's like going from a horse & buggy to a car. It would be nice if the car could drive itself like the horse" Operator

Simplicity

So what are our customer's challenges?

Energy

"Every year my operating budget gets cut and energy costs go up; I have no money to maintain my plant" Utilities Manager

So what are our customer's challenges?

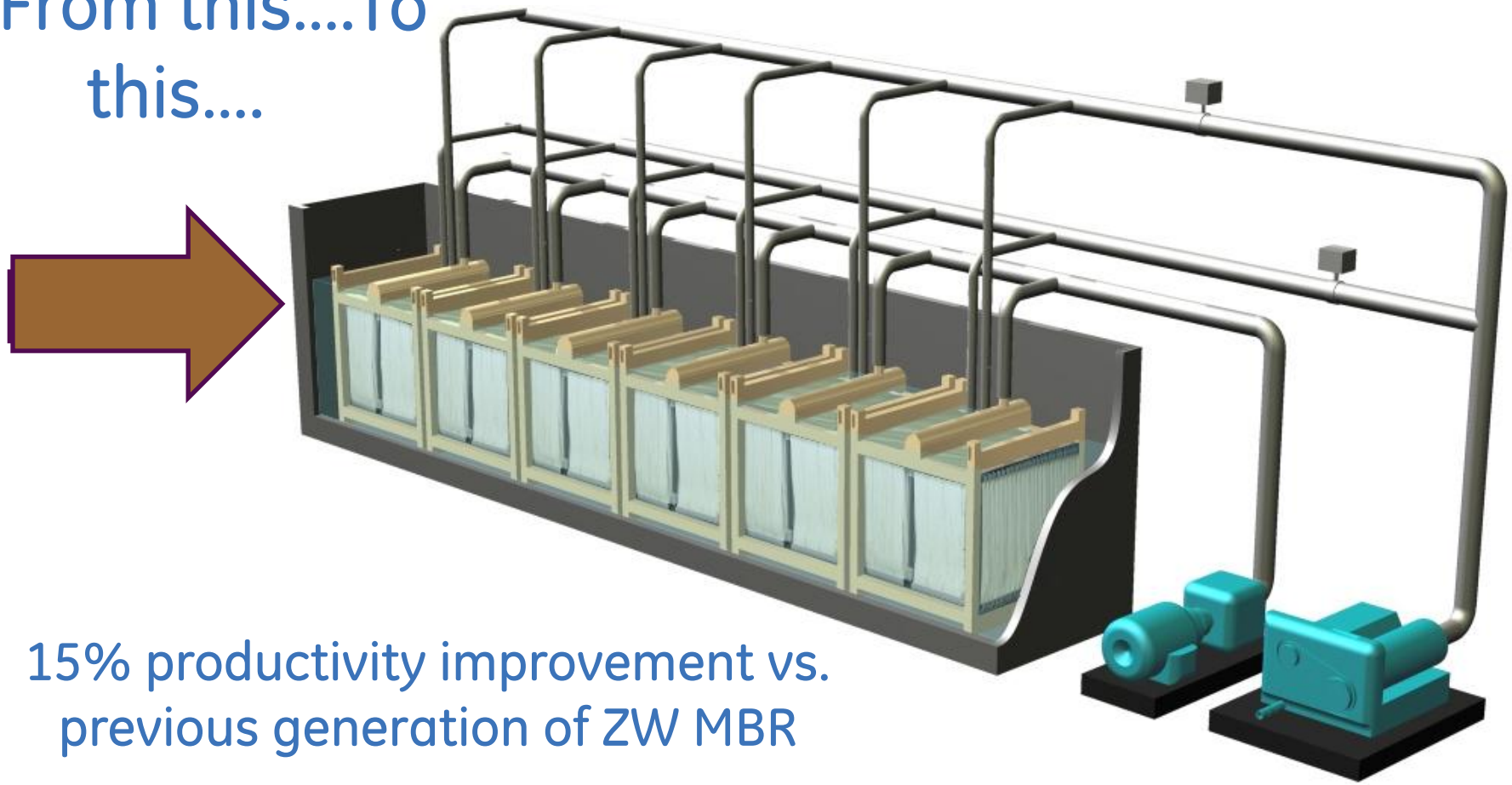
Reliability

"I need to trust that the local watershed is protected and our drinking water sources aren't being polluted"
Mayor

LEAPmbr
simple • reliable • efficient

answer to Productivity

From this….To this….

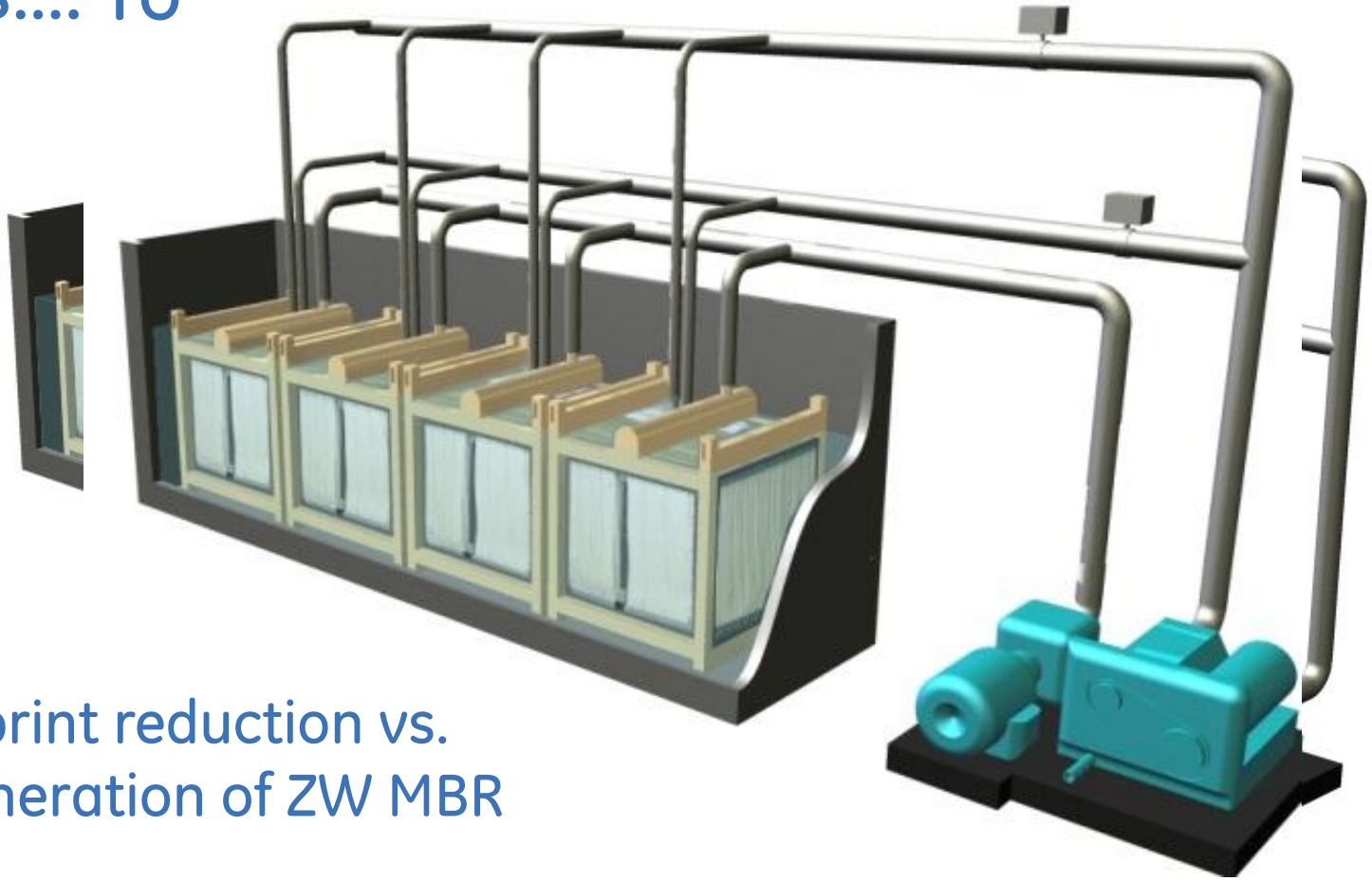


15% productivity improvement vs. previous generation of ZW MBR

LEAPmbr
simple • reliable • efficient

answer to Footprint

From this…. To this….

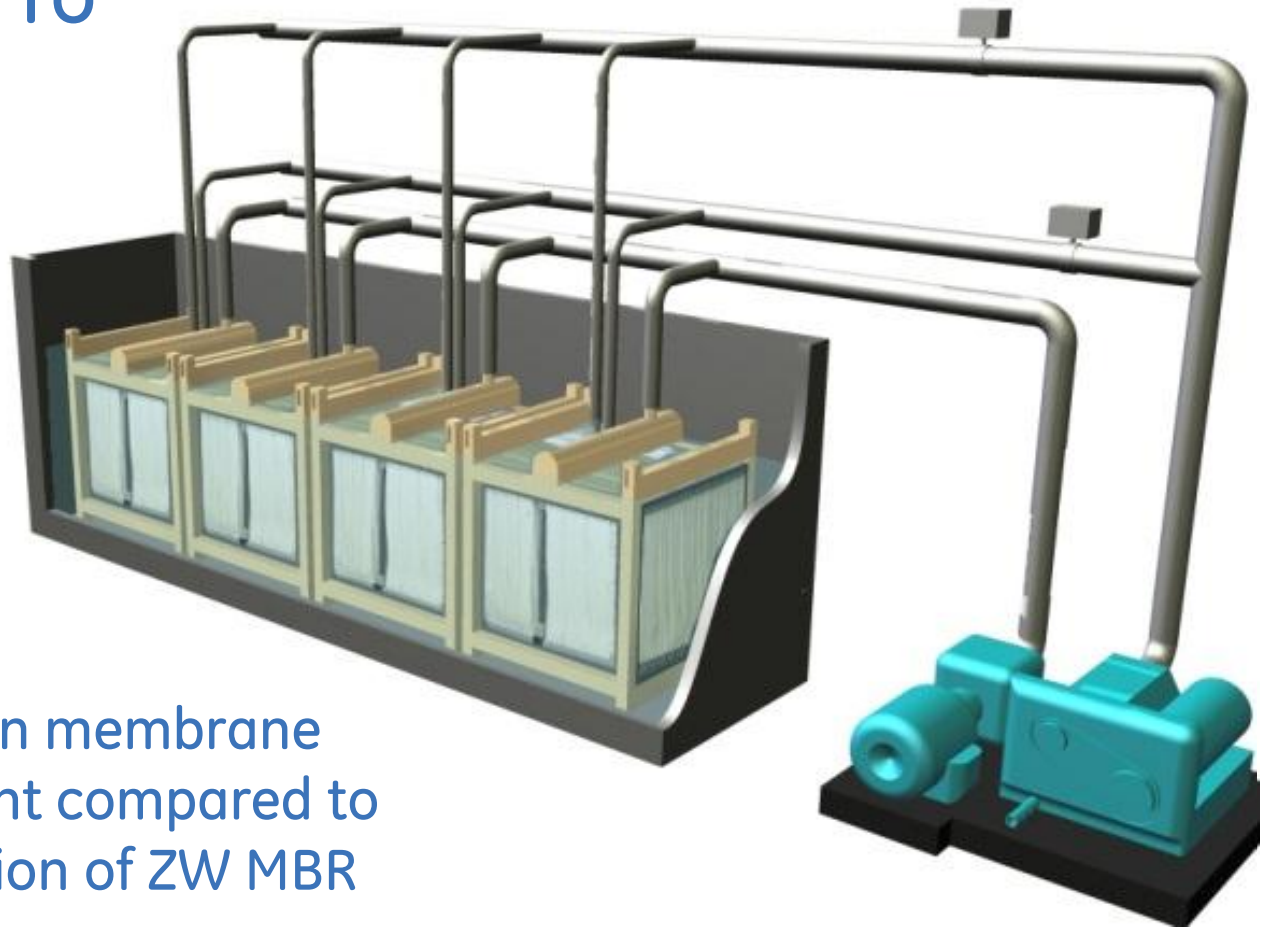


20% footprint reduction vs. previous generation of ZW MBR

LEAPmbr
simple • reliable • efficient

answer to Simplicity

From this…. To this….



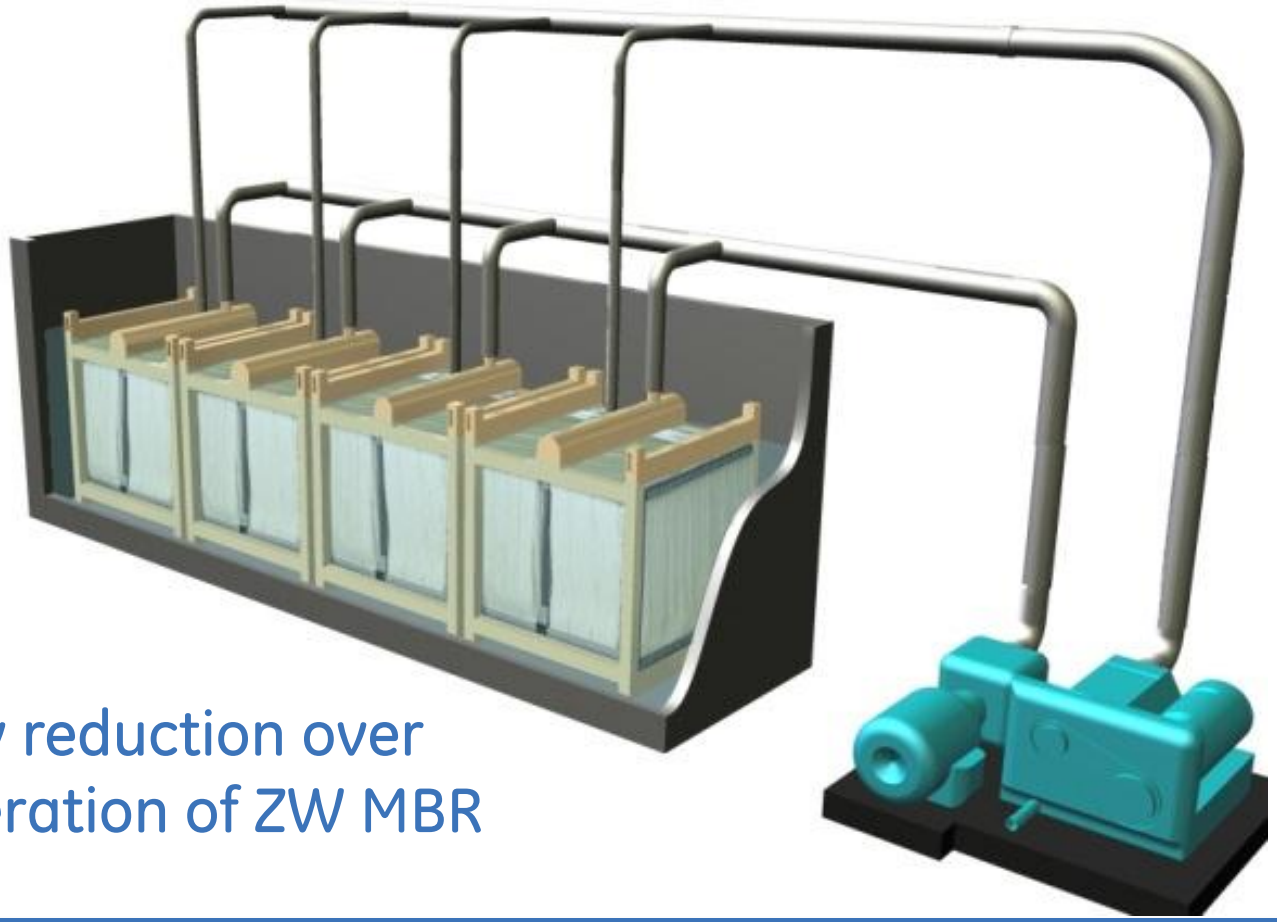
50% reduction in membrane aeration equipment compared to previous generation of ZW MBR

LEAPmbr
simple • reliable • efficient

answer to Energy

From this....

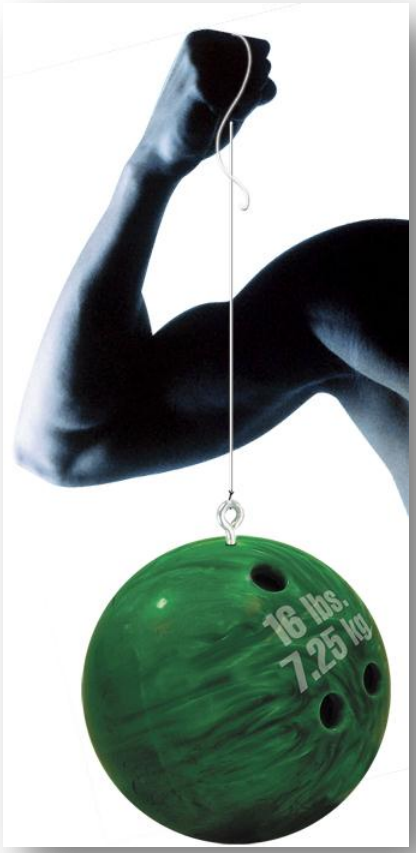
To this....



30% energy reduction over previous generation of ZW MBR

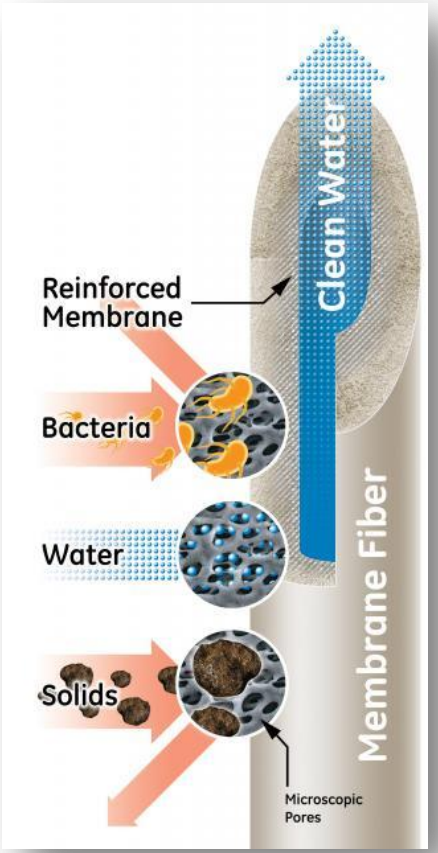
LEAPmbr answer to Reliability

simple • reliable • efficient

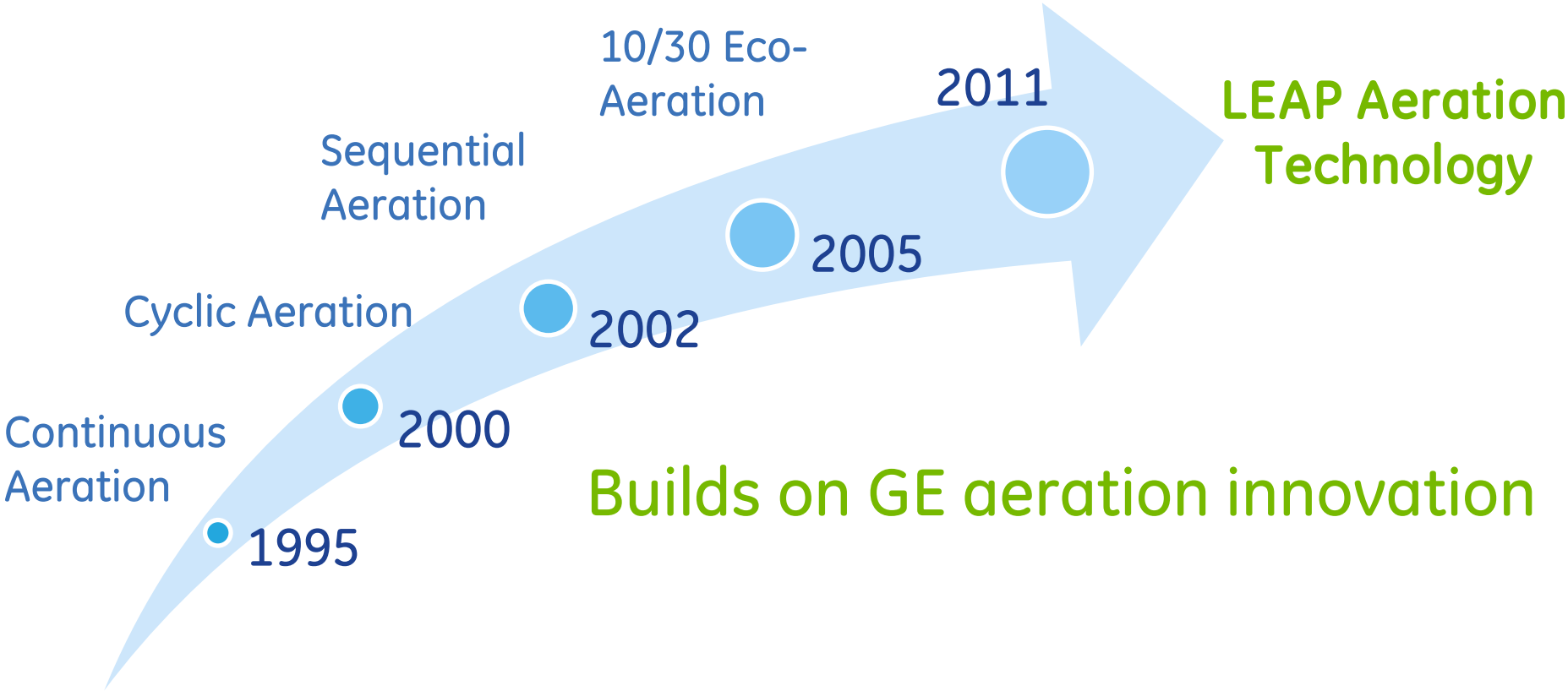


ZeeWeed Reliability at the Core

- Strong, reinforced UF hollow fiber membrane
- Two decades of ZeeWeed MBR experience
- Meets or exceeds toughest regulatory standards in the world



LEAP Aeration Technology

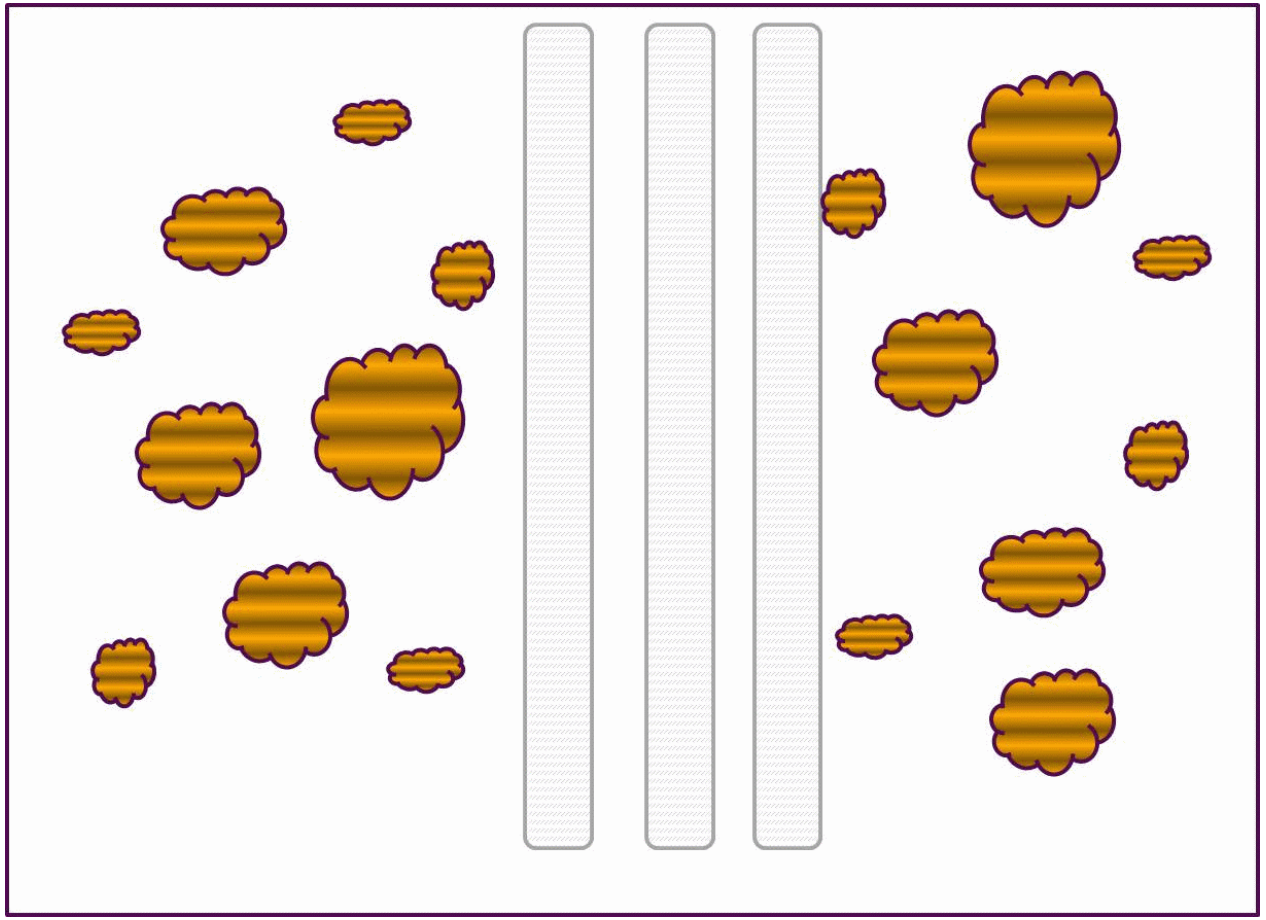


Builds on GE aeration innovation

Why Bigger Bubbles are Better

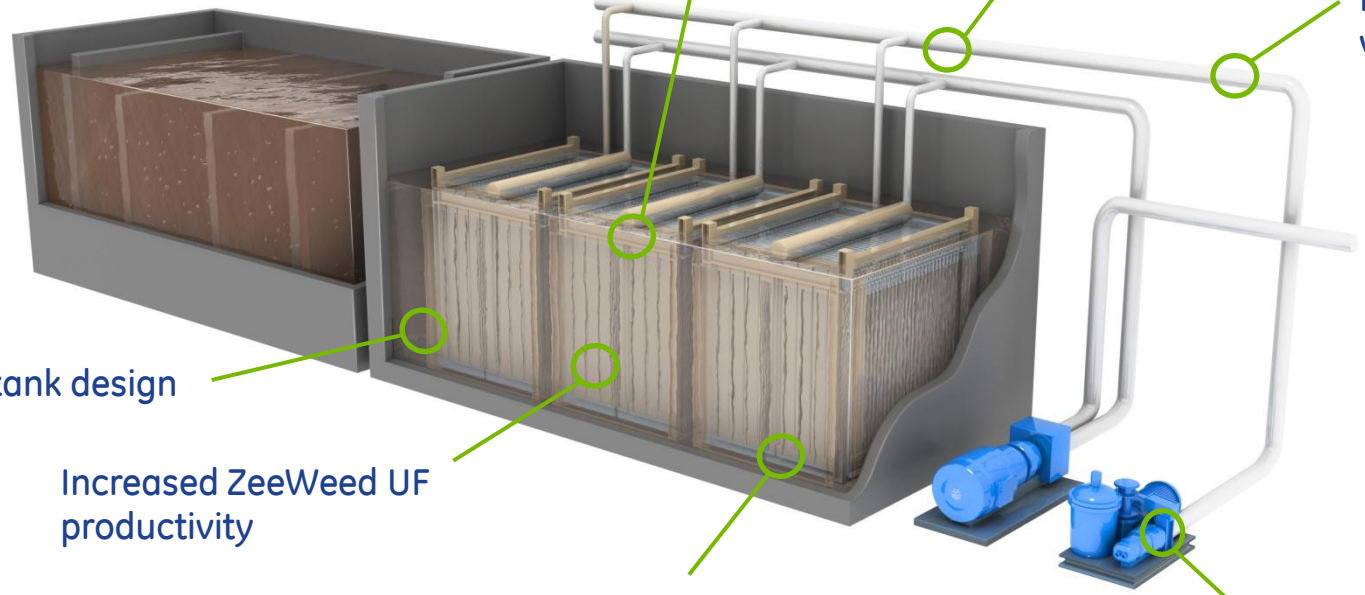
Larger bubbles delivered at shorter intervals create more shear and reduce fouling.

The effectiveness of the large bubbles results in less total air volume being required.



LEAPmbr
simple • reliable • efficient

Significant reduction in lifecycle cost of the MBR system



LEAPmbr lifecycle cost advantage

Operational savings	
Membrane aeration energy	↓ 45%
Cleaning chemical consumption	↓ 25%
Equipment savings	
Membrane cassettes	↓ 25%
Membrane aeration blower size	↓ 45%
Aeration headers and valves	↓ 50%
Air compressor size	↓ 70%
Construction savings	
Membrane tank size	↓ 30%
Mechanical installation	↓ 15%
Electrical installation	↓ 10%
Connected horsepower	↓ 25%

LEAPmbr offers the lowest cost of ownership in the industry

* Based on a 20 MLD LEAPmbr versus previous generation ZeeWeed MBR

13 of 20 largest MBRs awarded* use ZeeWeed®

Project	Technology	Date	ADF/MDF (mgd)
Brightwater, WA	GE/ZENON	2011	31/45
Qinghe, China	MRC/BOW		39.6
Jumeirah Golf Estates, UAE	GE/ZENON	2010	29.9/35.7
North Las Vegas, NV	GE/ZENON	2012	25/35
Frederick County, MD	GE/ZENON	2011	15 /34.8
Cox Creek, MD	GE/ZENON	2013	15/30
Yellow River, GA	GE/ZENON	2011	18.3/29.3
Shiyan Shengdinghe, China	BOW		29.1
Cannes (Aquaviva), France	GE/ZENON	2013	15.6/27.9
Busan City, Korea	GE/ZENON	2010	26.4/26.4
Guangzhou, China	Memstar/NOVO	2010	26.4
Wenyuhe Phase II, China	MRC/BOW		26.4
Wenyuhe, China	Asahi/BOW	2007	26.4
Johns Creek, GA	GE/ZENON	2009	10.9/24.7
Turkmenistan - Polimeks	GE/ZENON	2010	18.5/23.1
Jordan Basin WRF, UT	GE/ZENON	2010	13.9/20.9
Beixiaohe, China	Siemens	2008	15.8/20.6
Al Ansab, Muscat, Oman	Kubota	2009	14.0/20.6
La Moree, France	GE/ZENON	2012	15.7/20.2
Cleveland Bay, Australia	GE/ZENON	2007	7.7/19.8

Brightwater, WA

Lusail, Qatar

Cannes (Aquaviva), France

*As of August 2010, in order of Maximum Daily Flow (MDF)

10 of 20 largest operating MBRs use ZeeWeed®

Project	Technology	Date	ADF/MDF (mgd)
Wenyuhe, China	Asahi/BOW	2007	26.4
Guangzhou, China	Memstar/NOVO	2010	26.4
Johns Creek, GA	GE/ZENON	2009	10.9/24.7
Beixiaohe, China	Siemens	2008	15.8/20.6
Al Ansab, Muscat, Oman	Kubota	2009	14.0/20.6
Cleveland Bay, Australia	GE/ZENON	2007	7.7/19.8
Broad Run WRF, VA	GE/ZENON	2008	10/18.8
Cairns North, Australia	GE/ZENON	2009	5.1/15.4
Cairns South, Australia	GE/ZENON	2009	5.1/15.4
Peoria, AZ	GE/ZENON	2008	10.0/15.0
Yas Island, UAE	Metito/Toray	2009	10.0/15.0
Sabadell, Spain	Kubota	2009	9.25/14.2
Mianyiang, Sichuan, China	Asahi	2008	13.2
Wuxi Chengbei, China	MRC/BOW	2010	13.2
Jeddah, Saudi Arabia	Suido/Toray	2009	10.6/13.2
Syndial, Italy	GE/ZENON	2005	10.1/12.6
San Pedro Del Pinatar, Spain	GE/ZENON	2009	5.2/12.6
Beijing Miyun, China	MRC/BOW	2006	7.9/11.9
NordKanal, Germany	GE/ZENON	2004	4.4/11.9
Tempe Kyrene, AZ	GE/ZENON	2006	9/11.7

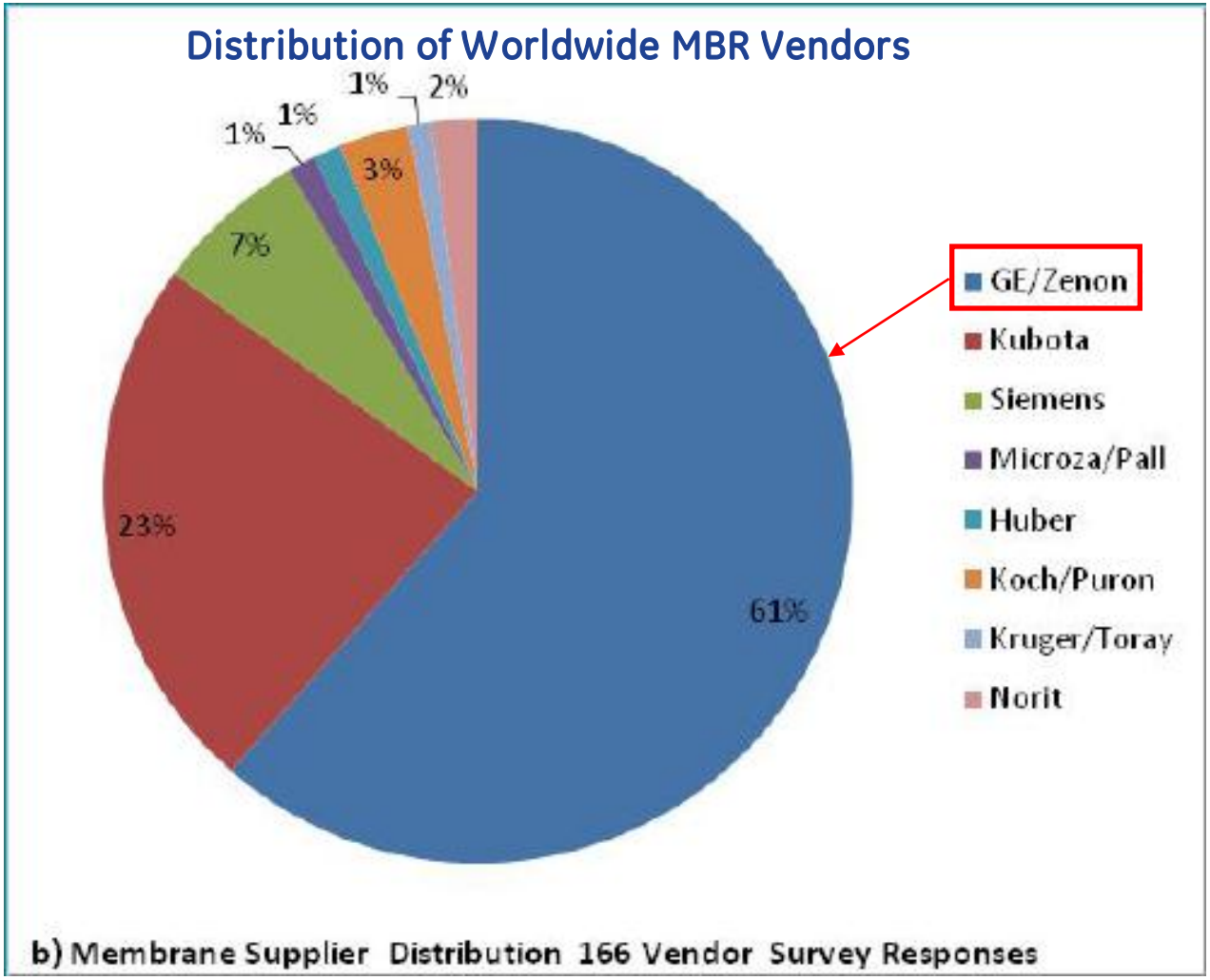
Johns Creek, GA, USA

Peoria, AZ, USA

Cleveland Bay , Australia

*As of August 2010, in order of Maximum Daily Flow (MDF)

Global Ranking by Third Party



Source: "Investigation of MBR Effluent Water Quality and Technology – A Worldwide Survey (WRF-06-007)" by James F. DeCarolis, Joan Oppenheimer, Zakir Hirani (MWH) Bruce Rittmann, PhD (Arizona State University); dated September 14, 2009

GE – UF/MBR Plants in Region

- UAE: 16 plants (12 Running, 4 To Be Commissioned)
- Saudi Arabia: 8 plants (7 Running, 1 To Be Commissioned)
- Qatar: 3 plants (1 Running, 2 To Be Commissioned)
- Oman: 4 plants running
- Bahrain: 3 plants (2 Running, 1 To Be Commissioned)
- Lebanon: 2 plants running
- Egypt: 2 plants running
- Iran: 1 plant running
- Kuwait: 1 plant running

TOTAL.....40 plants (32 Running, 8 To Be Commissioned)

Tempe Kyrene, AZ
Municipal MBR reuse for Power Industry

- ZeeWeed Membrane Bioreactor (MBR) system to treat municipal sewage
- MBR permeate is sent to the Salt River Power Plant, where it is treated with an RO/demin system for cooling tower makeup and boiler feedwater
- Additional flow is sent to a local golf course irrigation or discharged to the storm water drain
- Retrofit of existing conventional plant with membrane technology
- Flow: 34,000 m3/d ADF / 44,300 m3/d MDF

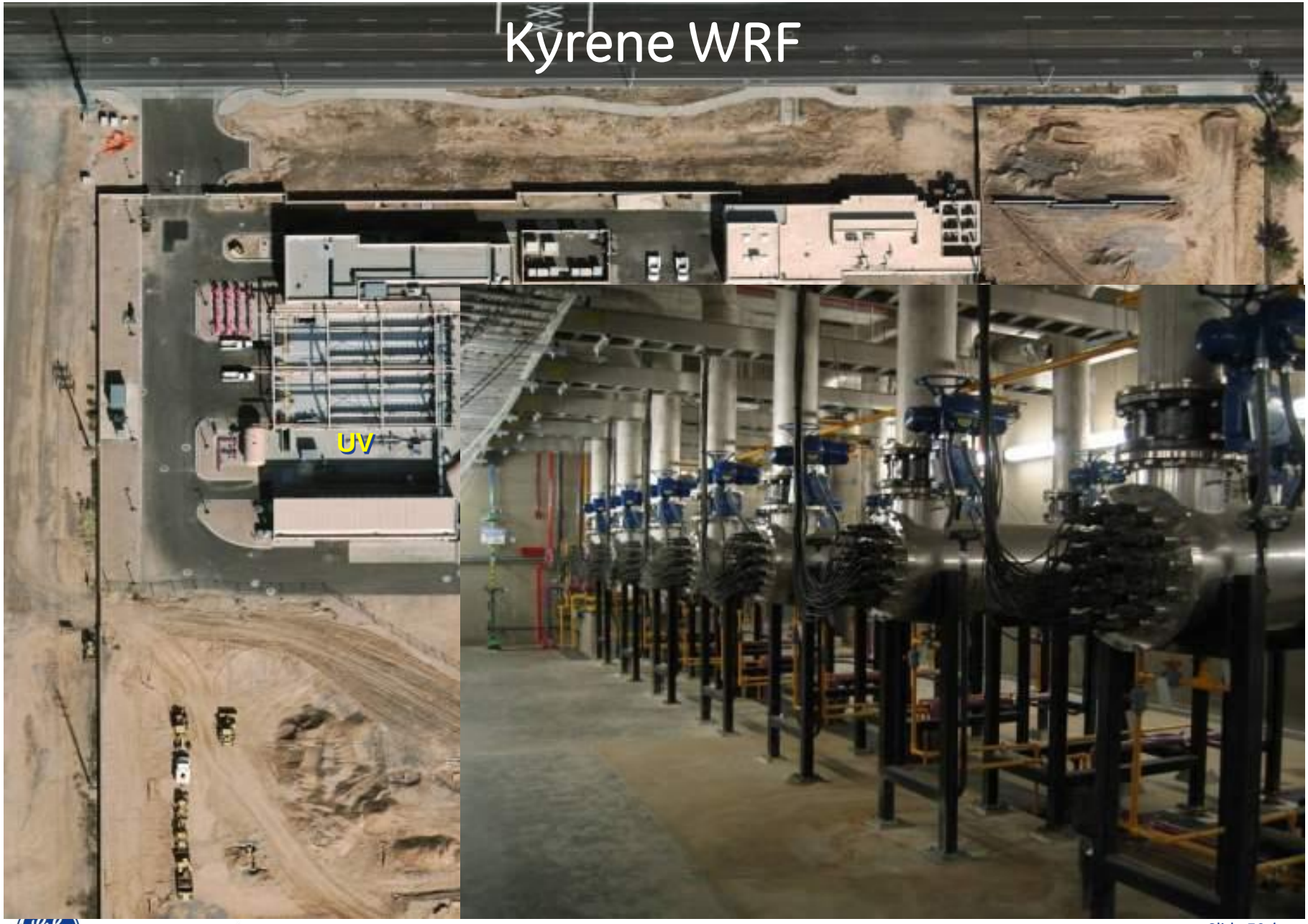
Kyrene WRF


RW
Membrane Units
UV
Bioreactor
EQ
Screens
10000. square meter

Kyrene WRF

Kyrene WRF

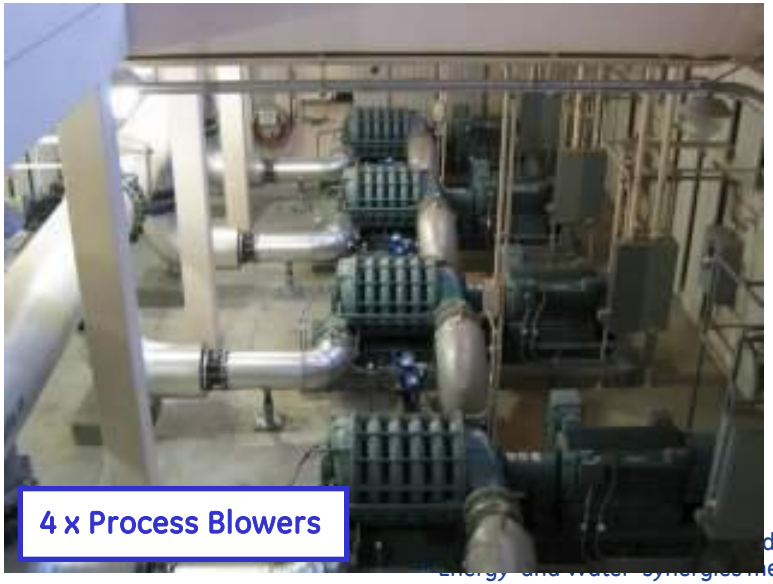
Kyrene WRF



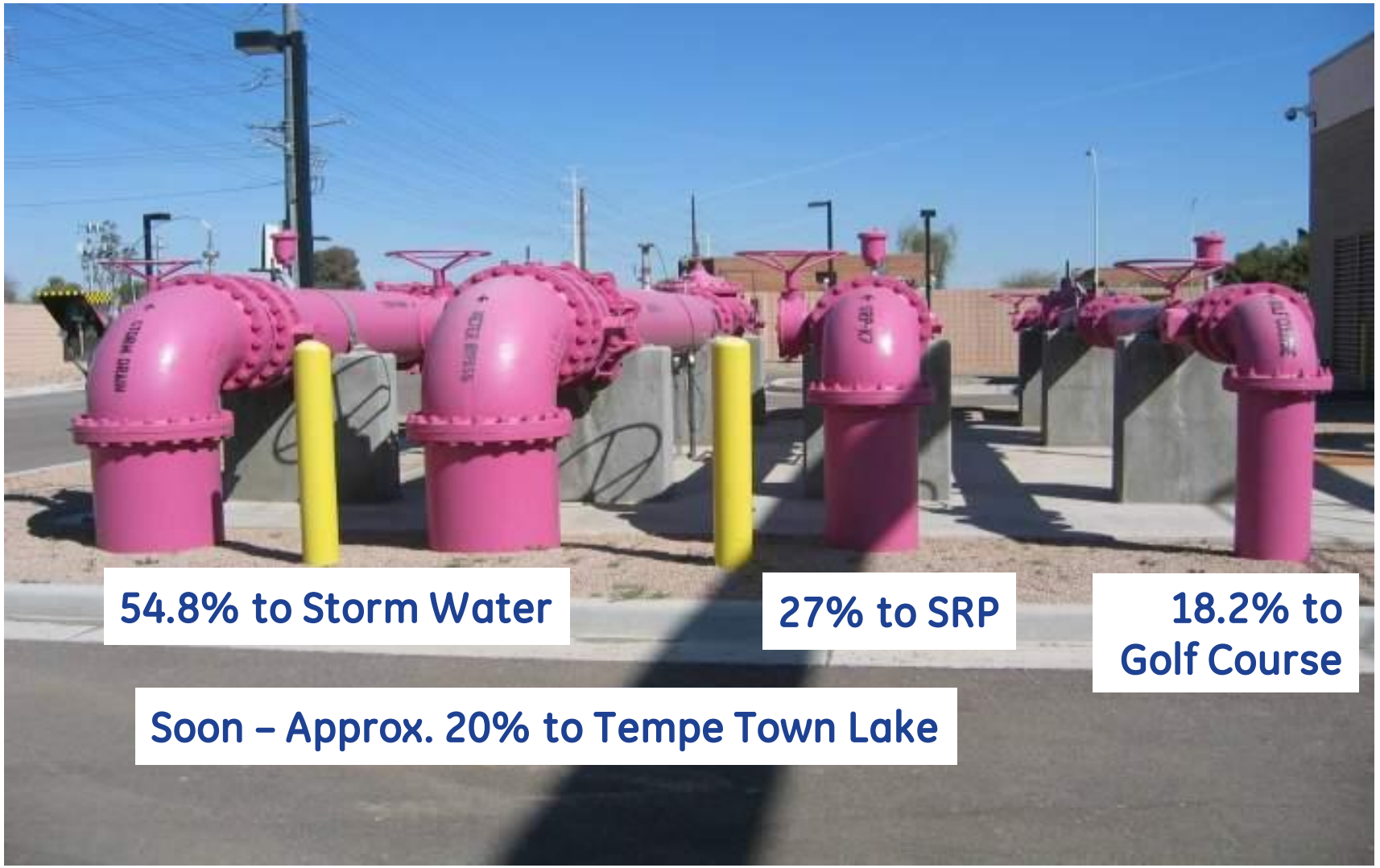
Kyrene WRF

Scrubbers

Major Operating Components



Reclaimed Water Discharge



Creating new water sources

Challenge: Insufficient quality water for irrigation and human consumption
Solution: Purify wastewater for irrigation, use fresh water for drinking

Sulaibiya plant in Kuwait City

Water produced for irrigation

Frees up fresh water for human consumption

375,000 cubic meters/day (100 MM gal/day)

World's largest membrane based wastewater filtration project

Dubai Sports City STP

Effluent used as TSE for irrigation

ADF: 25,000 m^3/d

Commission Date: April 2009

- Partnership with local contractor (Eagle Electromechanical)
- MDF is 30,000 m^3/d
- Low foot print : 80 x 40 m2
- Completely in-house (closed)
- Producing drinking water quality

THE ENGINEERING STRUCTURE OF THE WWTP IS COMPLETELY ENCLOSED WITHIN A BUILDING, ENSURING THAT IT ARCHITECTURALLY BLENDS IN WITH THE SURROUNDINGS WHILE PREVENTING ODOUR EMISSIONS

Shadi Al Qurum & Madina Al Qaboos

ADF: **7,500 m³/d & 2,500 m³/d**

Commission Date: **Nov 2008+**

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Package MBRs (TECOM & MASDAR)

ADF: **packages of 500 m³/d**

Why MBR for reuse

- Consistent effluent quality for direct reuse
- Simple operation
- Small footprint, easy expansion
- No TSS in effluent, stable option
- Generally accepted as best available technology for reuse globally

Why GE MBR for reuse

- Reinforced fiber
- Best track record, membranes that last
- Lowest total cost of ownership based on lifecycle costs
- GE experience

GE Power & Water

Water & Process Technologies

ES Services – Middle East & Africa

Servicing our Customers

Safety

Operational Excellence

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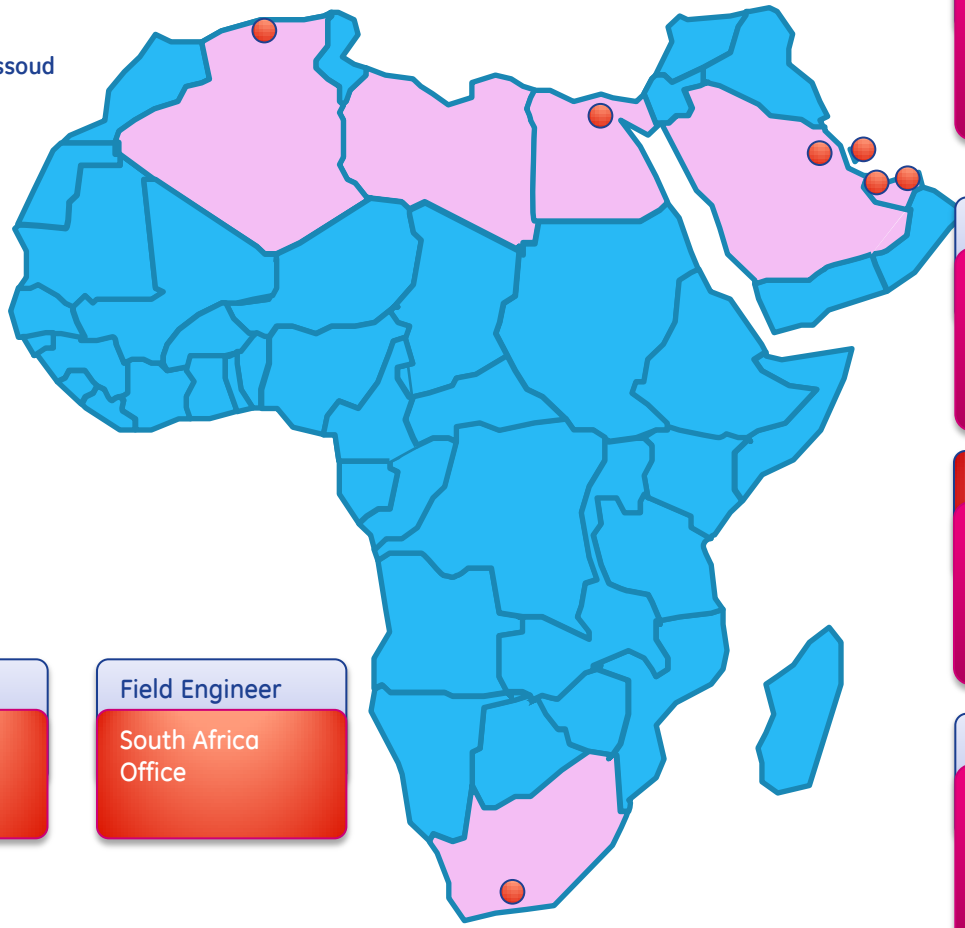
Field Service Organization Chart
Middle East & Africa Q1 - 2011

- **(2) Egypt, Cairo**, Lebanon Street Mohandessin
- **(1) Saudi Arabia, Dammam** , First Industrial City
- **(4) UAE, Dubai**, Jebel Ali Free Zone South
- **(2) UAE, Abu Dhabi**, West-Towers at the Trade Centre
- **(1) Bahrain, Al Manamah**,
- **(1) South Africa, Midrand**
- **(1) Algeria, Algiers, Hessi Massoud**



Service Manager
Zaid Al-Ansari
Dubai Office
Chemical Engineer

Field Engineer
Algeria Office

After Market Mgr.
Dubai Office
Chemical Engineer

Field Engineers
Dammam Office
RO/ED & UF/MBR

Sr. Field Engineer
Cairo Office
RO/ED Specialists

RO/ED Field
Dubai Office
RO/ED Specialists

UF/MBR Field
Dubai Office
UF/MBR Specialists

Field Engineer
Cairo Office
RO/ED Specialists

OTR Field Eng.
Bahrain
RO/ED UF/MBR Specialists

OTR Field Eng.
Dubai Office
UF/MBR Specialists

PLC Field Eng.
Dubai Office

Field Engineer
South Africa Office

Field Engineers
Abu Dhabi Office
RO/EDR Specialists

Field Engineers
Abu Dhabi Office
RO/ED Technician

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Introducing ZenoTrac….

- **Remote monitoring system that:**
- measures critical process variables
- helps detect & troubleshoot problems
- helps prevent serious failure
- helps with long term optimization

- **Stores all process data in a central database and**
- makes historical data accessible to authorized
- users through a secure web site

imagination at work

Zenotrac Service Levels

	Assigned Process Analyst	Access to ZenoTrac Graphs	AIDER Alerts	Contact Frequency	Report Frequency
Monitor Level	Y	Y	Y	Daily-Weekly	Biweekly
Lite Level	Y	Y	Y	Weekly-Monthly	Monthly
Warranty Service	Y	Y	Y	Monthly-Quarterly	N/A

شكرا

Thank You