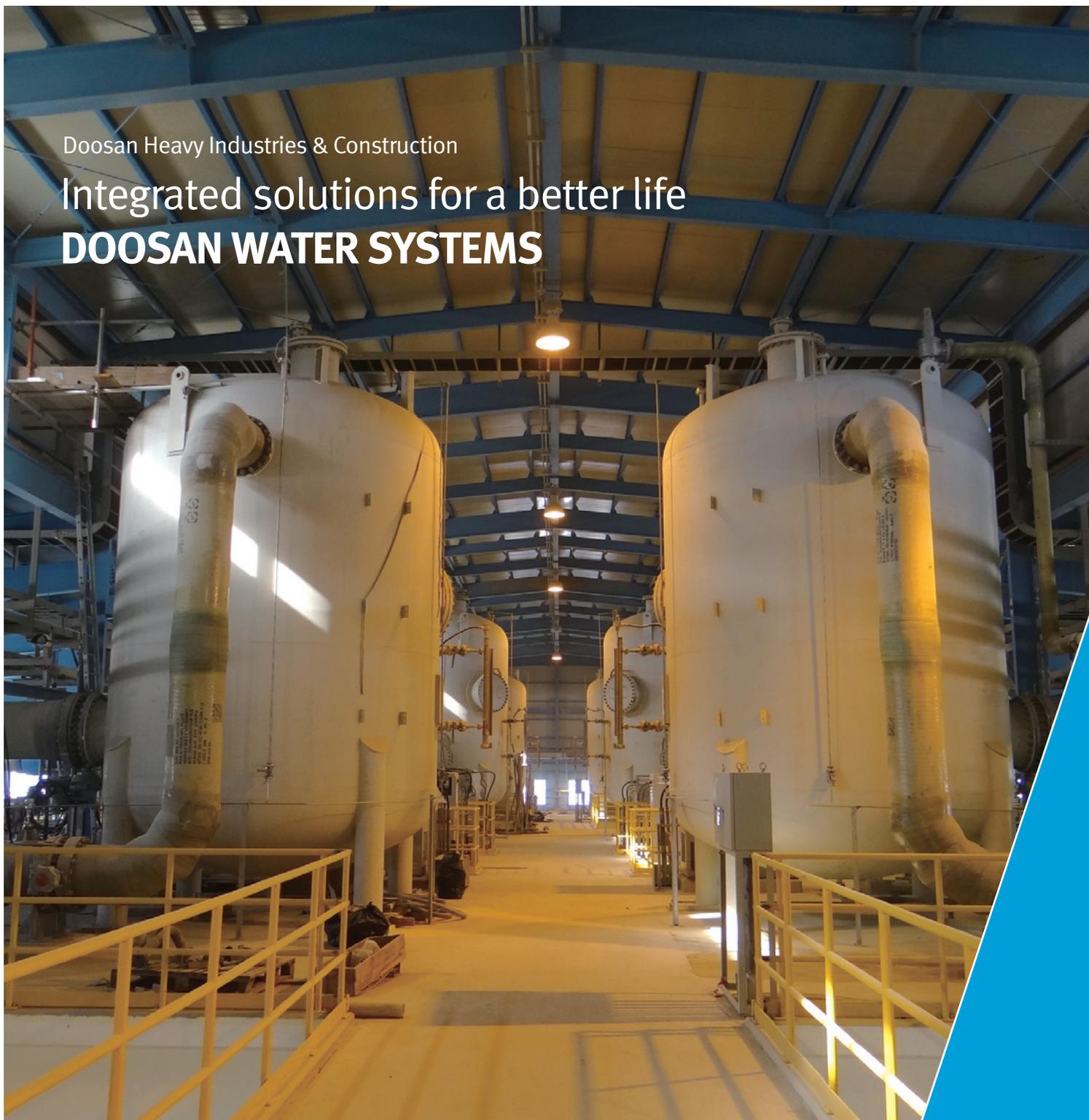


Doosan Heavy Industries & Construction

Integrated solutions for a better life

# DOOSAN WATER SYSTEMS



*Building your tomorrow today*

# LENA MBR

Low Energy No Aeration (LENA) Membrane Bioreactor (MBR) technology offers advances in energy efficiency and membrane performance utilizing inertia force on membrane fibers by reciprocating motion as a solution to energy-intensive air scouring in conventional MBR

## Benefits

MBR is an advanced technology, which combines a biological wastewater treatment process with membrane filtration to provide a large treatment capacity and high effluent quality within a small footprint. The sludge production rate is also lower due to higher sludge retention time (SRT) compared to conventional activated sludge systems. Doosan's LENA MBR also has several additional benefits compared to conventional MBRs:

- Elimination Air scouring system: No air scouring blower or associated equipment and less internal recirculation for nutrient removal (OPEX/CAPEX savings)
- Membrane oscillation by reciprocation causes the fibers to move and creates inertia force on the fibers. This Provides more effective membrane fouling control compared to membrane air scouring
- Prevent sludge accumulation within fibers due to the combined effect of reciprocating velocity coupled with pulsating inertia force on fibers
- Also suitable for membrane filtration where it is necessary to maintain either anoxic or anaerobic conditions with less turbulence (e.g. anaerobic MBR for methane recovery, anoxic MBR for selenium, nitrate, sulfate removal in industrial wastewater)

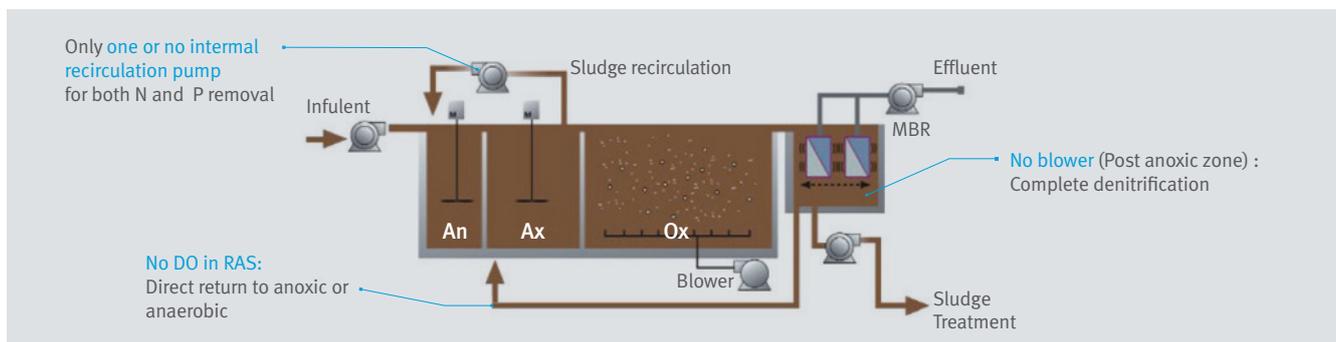
## How It Works

Unlike other MBR systems, the fouling control mechanism of LENA MBR is inertia force acting on fibers created by horizontal reciprocation of the membrane cassette, which shakes foulants from the membrane surface. LENA MBR employs a belt-driven reciprocating frame attached to the membrane cassette to provide horizontal reciprocation to the submerged hollow fiber membranes. This eliminates the need for the energy-intensive air scouring systems used in conventional MBRs.

Fluid and structural interaction (FSI) analysis is used to optimize the system design and enhance the system stability and performance. LENA MBR is a viable option for controlling membrane fouling effectively with lower energy consumption than energy intensive membrane air scouring.

## Applications

- Municipal / industrial wastewater treatment
- Anaerobic MBR (no biogas sparging)
- Anoxic MBR: Mining, FGD and industrial wastewater treatment MBR for selenium, sulfate, nitrate and metal removal



## LENA MBR Pilot

- Demonstrated significant energy savings (~75%) in membrane reciprocating system compared to membrane air scouring
- Higher operation flux (~40LMH) at 10,000 mg/L MLSS, which further reduces membrane costs
- More than 90% COD, TN and TP removal with less internal recirculation; average permeate TN level below 2 mg/L and TP below 0.3 mg/L.



# ZLD

The Zero Liquid Discharge (ZLD) process is the most advanced wastewater treatment technology available, achieving no or minimized effluent and highly purified water production.

## Benefits

The ZLD process complies with all regulatory requirements for effluent disposal. Also, ZLD provides a technically feasible option for dramatically reducing the salt of the effluent stream providing opportunities for treated water reuse. In summary, the main benefits of the ZLD process are:

- No discharge of wastewater
- Highly purified distillate water production
- High water recovery with a small footprint
- Recovery of commercial grade salts
- Accelerated payback of CAPEX/OPEX through water reuse

## Applications

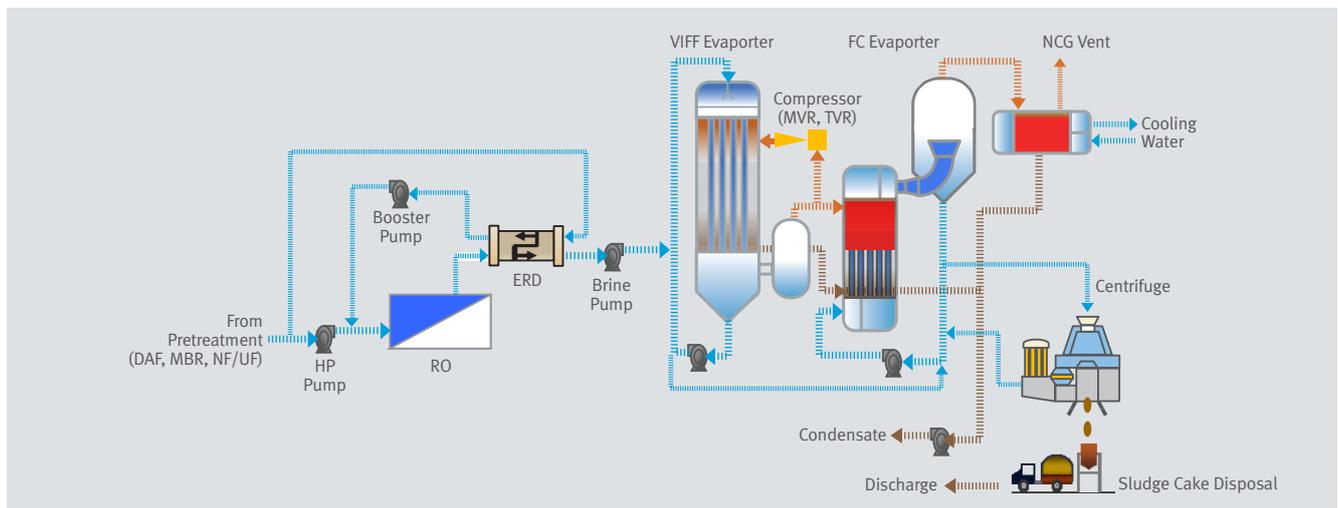
- Power plant wastewater treatment (FGD)
- Oil & gas field wastewater treatment (SAGD, CSG)
- Refinery wastewater treatment
- Textile, dyeing, chemical wastewater treatment
- Other industrial wastewater sectors

## How It Works

Doosan designed a ZLD process based on High Pressure Reverse Osmosis (HPRO) and thermal evaporation technology.

HPRO technology pushes water through an RO membrane at higher than normal pressure. This removes most of the salts producing a concentrated effluent which is then crystallized.

Thermal evaporation technology then separates and concentrates the solids, ions and other polluted substances from the feed waste water using high temperature/pressure vapor. The evaporator is composed of a vertical tube falling film (VTFF) evaporator, a forced circulation (FC) evaporator, and a dryer/centrifuge. Depending on the water quality and treatment level requirements steam compression (MVR, TVR) can be combined with a variety of treatment processes to achieve the desired effluent quality.



## ZLD Pilot

- VTFF Evaporator-type Brine Concentrator 2 Effects + FC Evaporator Crystallizer 1 Effect
- Tube Length : 50.8 x 6 m (titanium)
- 1<sup>st</sup> Effect : MVR / 2<sup>nd</sup> Effect : TVR
- Feed: 120 ton/d (32,000 ppm TDS)
- Recovery : 95%



# Enflo-DAF™

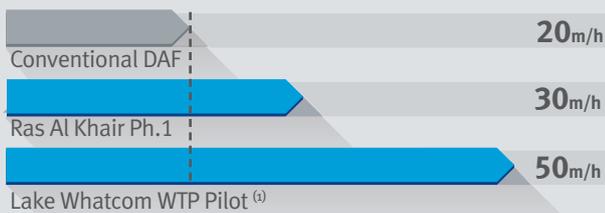
Enflo-DAF™ is Doosan Enpure's patented Dissolved Air Flotation technology developed for potable, industrial and desalination pretreatment applications. The technology continues to be developed and presently offers reduced flocculation times, typically 5~10 mins, and enhanced treatment rates of up to 50 m/h to produce a high quality clarified water product.

## Benefits

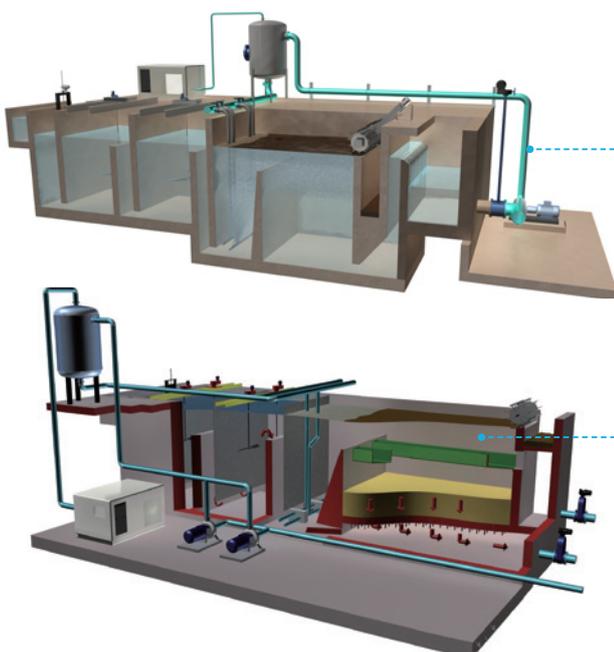
A novel high-loading rate DAF with patented design to allow for high loading rate operation without increasing the depth of the DAF tank.

- High loading rates in large-scale water & desalination plants directly result in CAPEX savings
- Most effective solution for algae rich water treatment
- Systems offered include proprietary patented designs operating at high net loading rates of up to 50m<sup>3</sup>/day

### Classification by Loading Rate



<sup>(1)</sup> Report AWWA-WQTC 2012 Proceedings Whatcom Falls WTP trials in city of Bellingham, WA, USA



## How It Works

Dissolved Air Flotation (DAF) works by using air to remove suspended solids and oils from water. First, air is dissolved into the water at high pressure. The pressure is then lowered causing the air to form small bubbles and rise to the surface. When this occurs, the air bubbles carry solids and oils with them forming froth at the surface of the water.

A skimmer is then used to remove the froth, and the clear effluent flows out of the tank. Doosan's Enflo-DAF™ systems incorporate patented technologies to improve the efficiency of DAF systems and provide highly purified water for a range of applications.

## Enflo-DAF™ Technology Family

### Enflo-Vite™

Parameter	Max To Date
Loading Rate (Net)	50 m/h
Turbidity	~500 NTU
Recycle	6~20%
Nozzle Type	Needle Valves or Nozzles <sup>(2)</sup>

### Enflo-Filt™

Parameter	Max To Date
Loading Rate (Net)	15 m/h
Turbidity	~3.5 kg/m <sup>2</sup> /m depth
Recycle	6~20%
Nozzle Type	Needle Valves or Nozzles <sup>(2)</sup>

### Enflo-Sep™

Parameter	Max To Date
Loading Rate (Net)	~10 m/h
Recycle	10~150%
Nozzle Type	Needle Valves

### Enflo-PI™

Parameter	Max To Date
Material	Stainless steel/ Plastic
Number of Headers	1~3
Nozzle Type	Nozzles <sup>(2)</sup>

<sup>(2)</sup> TAD-W or TAD-S-proprietary in-house designs

## Applications

Available for a wide range of applications, including potable, wastewater, industrial and SWRO pretreatment. The potable systems applicable to seawater applications have demonstrated the capacity to treat high algae laden water, ensuring downstream filtering systems are not compromised. Enflo-DAF™ is a modular system that can be configured to address plant throughputs up to 1,010,000 m<sup>3</sup>/day. For flows up to 100,000m<sup>3</sup>/day, flocculation and flotation tanks can be constructed in concrete or supplied as a set of steel tanks.

## References

Enflo-DAF™ has been installed in more than 250 locations worldwide including Australia, Belgium, Brazil, Canada, Chile, China, Finland, Malaysia, Romania, Russia, South Africa, United Arab Emirates, United Kingdom and the USA.

### Highlighted Project : Ras Al Khair Ph.1, KSA

- Largest seawater pretreatment DAF plant in the world
- Client: SWCC
- Capacity: 1,010,472m<sup>3</sup>/d
- Scope: DAF/DMF

Plant	Country	Year	Capacity (m <sup>3</sup> /d)	Max Net Loading Rate (m/h)
Ras Al Khair Ph.1	KSA	2013	1,010,472	30
Lake Whatcom WTP (pilot)	USA	2011	438	50
Marchbank WTW – DAF	UK	2009	62,000	10
Maundown WTW	UK	2005	82,400	10
Barrow WTW	UK	2004	120,000	20
Mount Grand WTW	New Zealand	2000	44,000	10
Ipoh WTW	Malaysia	1999	275,000	13



# sonix™

The sonix™ radial horn technology produces intense, concentrated ultrasound waves within the reactor, increasing and accelerating the break-up of cells and particulates. When applied to wastewater sludge, this activity results in more effective downstream processing in terms of sludge reduction post digestion, conditioning and biogas generation. In a world where sustainability is the focus and biosolids are seen as a resource, sonix™ technology is a valuable proposition.

## Benefits

The main feature of the sonix™ technology is the novel design of the ultrasonics horn, the tool that actually disperses the sound energy into the liquid. Shaped like a torus or a ring doughnut, this radial horn sits horizontally or vertically in the sludge pipeline, with the fluid flowing through and around it. In summary, the main benefits of sonix™ are:

### Better Performance

- Volatile solids destruction up to 75%
- Accessible substrate increased
- Gas production increased by up to 75%
- Sludge dewaterability increased by up to 15%
- Digester stability increased
- Overall solids destruction increased by up to 50%

### Lower Cost

- Power OPEX costs are approximately 20 times less than the power produced from the biogas released
- Savings from:
  - ✓ Lower disposal costs
  - ✓ Lower power costs
  - ✓ Lower chemical costs

## How It Works

Ultrasound is the term given to sound energies of frequencies in excess of 20KHz but below 10Mhz, outside the audible range (16Hz to 16KHz). The origin of the power of ultrasound in a liquid is primarily cavitation. At sufficiently high power densities, bubbles will form and grow in size until, at the high pressure part of the cycle, the bubble reaches its critical size and explodes exerting violent forces sufficient to provide cleaning/rupturing action. Additionally extremely high temperatures at the foci are believed to aid in the action. The sonix™ configuration/geometry enables the cavitation energy to be focused by the horn face, thereby increasing the cavitation intensity and ultimately reducing the required exposure times.

## Components

### TRANSDUCER

Also referred to as the converter, the transducer converts electrical signals to mechanical energy. It comprises a series of piezo-electric crystals sandwiched together. The transducer is also encased in a protective cowling.

### EXTENDER/BOOSTER

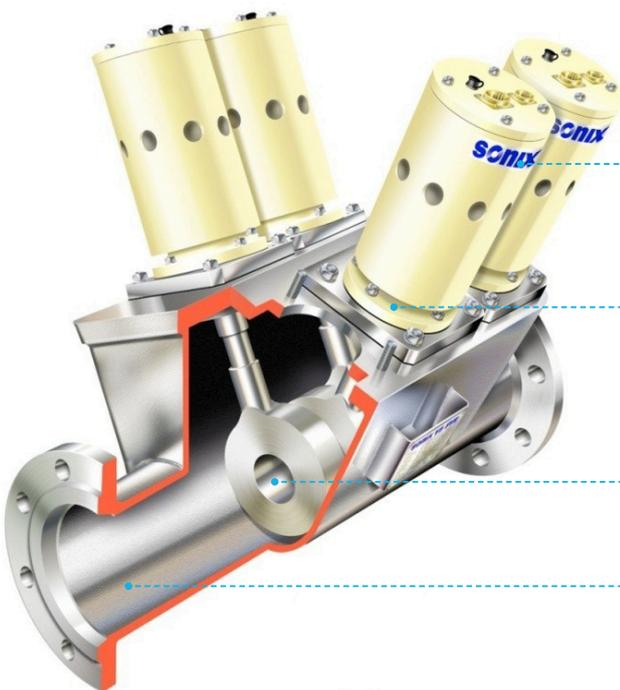
The extender/booster connects the radial horn to the transducer through the flange booster. While the horn operates in radial mode shrinking and expanding thousands of times a second, the extender/booster operates in the axial (up and down) mode. It is both an amplification and transmission device.

### RADIAL HORN (TOOL)

Normally made of titanium, the radial horn or sonotrode vibrates at 20KHz. Sludge passes through the inner zone and around the edges of the radial horn with its curved surfaces focusing the cavitation. The process is most intense within the inner core.

### Typical V5 five-stack sonix™ Unit

A sonix™ unit measures a mere 700mm from entry flange to exit flange. Operating with a retention time of between 1.5 and 2.0 seconds, a unit size is capable of processing 200m<sup>3</sup>/day of sludge.



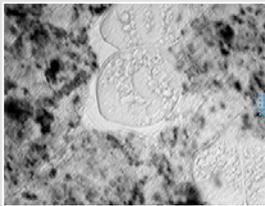
## Applications

- Sludge treatment : Contributes to enhanced anaerobic digestion, reduced sludge volume and increased biogas production
- Wastewater treatment : Reduces filamentous bulking phenomenon and foaming rise while enhancing biological nutrient removal

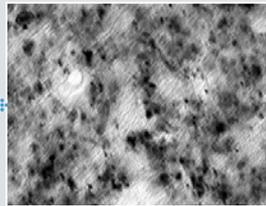
## References

### Highlighted Case Study : Orange County Sanitation District, USA

- Solids destruction: 50% increase
- Dewatering: 10~12% increase
- Gas production: ~50% increase (compared to control digester)
- Payback: ~2 years
- Test digester stable at 65% of Thickened Waste Activated Sludge (TWAS) feed when sonicated

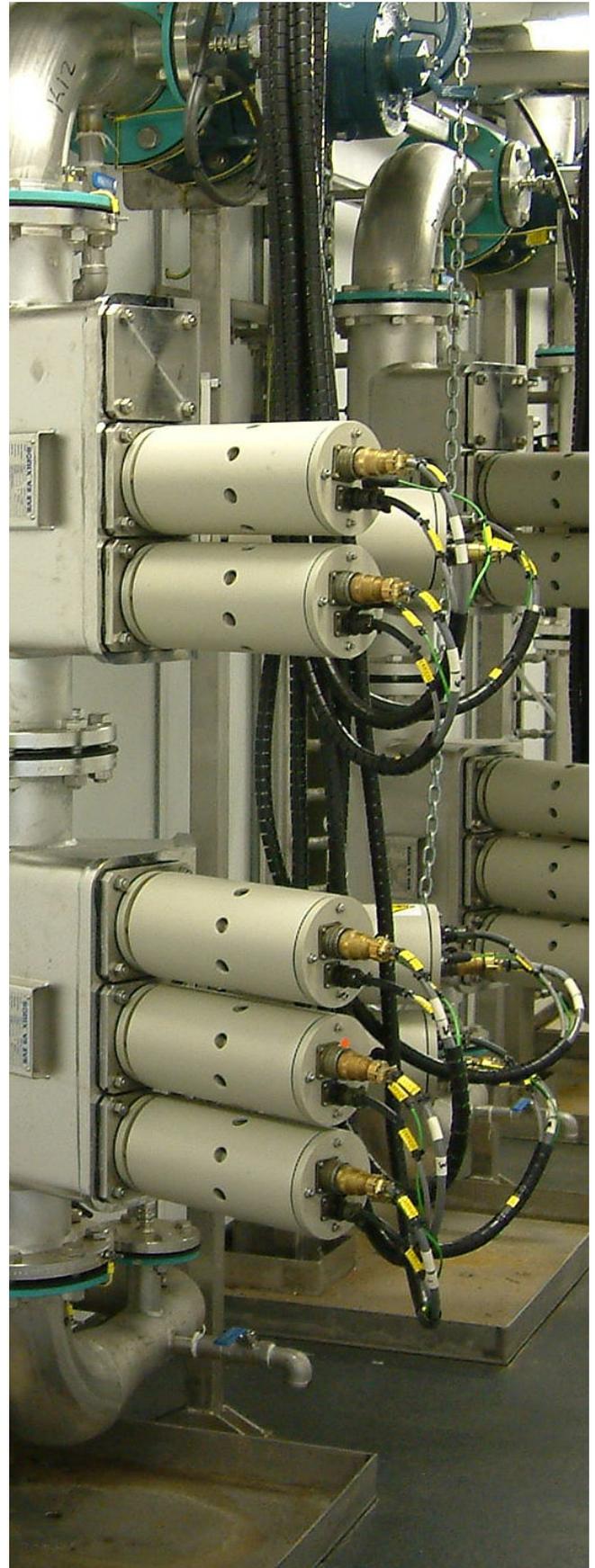


Before sonix™

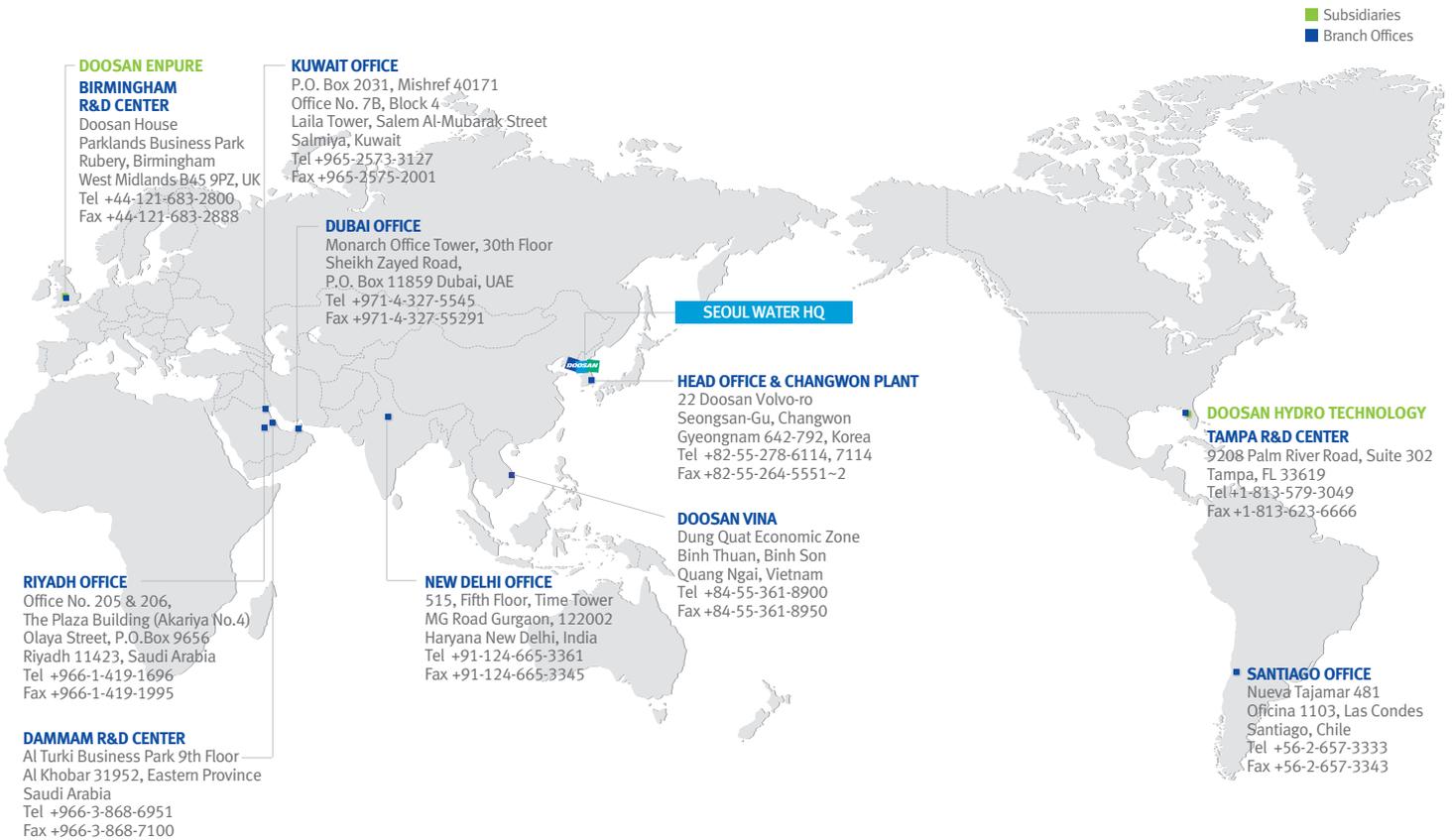


After sonix™

Plant	Country	Year	Size (kW)
Ulu Pandan plant	Singapore	2011	30
Minworth WwTW	UK	2007	192
Molina WwTW	Spain	2006	18
Sagunto WwTW	Spain	2006	18
Villanova WwTW	Spain	2006	18
Alzira WwTW	Spain	2005	18
Mangere plant	NewZealand	2005	432
Beenyup WwTW	Australia	2004	42
Los Angeles plant	USA	2004	30
Tamano WwTW	Japan	2004	30
Kavlinge WwTW	Sweden	2002	12



# WATER NETWORK



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