Doosan Heavy Industries & Construction

Integrated solutions for a better life

DOOSAN SLUDGE MANAGEMENT
As an inevitable byproduct of municipal wastewater and many industrial processes, sludge treatment has traditionally focused on dewatering to minimize the mass of wet solids for disposal.

Increasingly, recent legislation now requires sludge to meet minimum standards for hygiene, toxicity and reuse. Additionally, the organic content of sludge is increasingly seen as a resource, either for mineral or metal reclamation or as a feedstock for anaerobic digestion, where it usually provides biogas for on-site combined heat and power generation to run the process.

The UK-based subsidiary of Doosan Heavy Industries & Construction, Doosan Enpure, provides a wide range of sludge treatment processes to meet all legislative requirements as well as maximising the amount of energy and other useful components of the sludge stream. These systems include thermal and ultrasonic pre-treatment, pasteurisation, thermophilic and mesophilic digestion, dewatering and drying.
Doosan Enpure provides total treatment solutions undertaking design, procurement, construction, commissioning and operations for a broad range of waste or blend of wastes. The diagram above summarizes the range of wastes that we provide treatment for and the typical treatment method utilized.
Our service areas include:

1) Process and M&E design
2) Procurement, Construction & Commissioning
3) Operation & Maintenance
4) Other: Feasibility Studies, Process Audits, Project Management, Technology Licensing, System Engineering

Destination of digestate dictates upstream processes

- FUEL: POWER STATION
- FUEL: CEMENT MANUFACTURE
- LAND RESTORATION
- AGRICULTURE
- HORTICULTURE
- LANDFILL COVER
- INCINERATION
- VITRIFICATION
- ENERGY OUT
- GAS TO GRID
Many wastewater streams, including municipal sewage, carry chemical energy in the form of suspended and dissolved organic materials. Traditional treatment processes use energy to aerate and oxidize these organic pollutants; the process is a net energy user. However, using careful design, it is possible to make the whole process energy-neutral by minimizing the energy input to the aeration stage, maximizing sludge production and generating the required energy for aeration from the sludge. The diagrams below show the energy fluxes for two different treatment processes: a traditional extended aeration plant combined with conventional anaerobic digestion and a plant using high-efficiency primary settlement combined with high-efficiency digestion incorporating ultrasonic cell lysis (sonix™). The following table shows biogas values produced by different sludge sources.

### Anaerobic Digestion of Sludge

<table>
<thead>
<tr>
<th>Sludge source</th>
<th>Generated by</th>
<th>Tonnes per year</th>
<th>Energy value of biogas, MW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wet mass</td>
<td>Dry mass</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal sewage sludge</td>
<td>1,000,000 people</td>
<td>490,000</td>
<td>29,500</td>
</tr>
<tr>
<td>Food waste (domestic, source segregated)</td>
<td>1,000,000 people</td>
<td>81,000</td>
<td>16,000</td>
</tr>
<tr>
<td>Farm waste (cattle slurry)</td>
<td>22,000 cows</td>
<td>361,000</td>
<td>36,000</td>
</tr>
<tr>
<td>Bio energy crops (grass silage)</td>
<td>250 hectares</td>
<td>10,000</td>
<td>2,500</td>
</tr>
</tbody>
</table>

[Typical figures based on UK]
Anaerobic digestion incorporates appropriate pre-treatment, digestion and gas-handling equipment to produce raw biogas as well as solid product (digestate), which meets the most stringent requirements for use as fertilizer, soil improver or fuel.

We have experience incorporating plants with the necessary equipment such that raw biogas may be burned in a power plant (CHP) generating electrical and heat energy for export or refined to produce bio-methane for export. (I think this sentence could perhaps be reworded)
ADVANCED PROCESS TECHNOLOGY
PASTEURISATION

Our system was developed specifically for sewage sludge and other biowastes undergoing anaerobic digestion. It operates with high thermal efficiency using low-grade waste energy taken typically from an associated CHP plant.

In this way, if an existing digestion plant is to be upgraded to meet the requirements of changing legislation, the pasteurisation stage can be installed without adversely affecting the existing energy balance. Alternatively, a bespoke system can be integrated into a greenfield site digestion facility to ensure that the highest overall energy recovery is obtained, maximizing revenues through the sale of energy and government green energy incentive schemes.
Most sludge treatment processes result in the production of a wastewater stream, which is high in ammonia and other pollutants. The most economic way of dealing with these liquors is to return them to the inlet of the wastewater treatment works, hence their usual name, return liquors.

However, if the works is already fully loaded or is a centralized treatment facility with no associated wastewater treatment equipment, this is not an option. It is then necessary to either upgrade the wastewater treatment process or provide a stand-alone liquor treatment facility. As part of our Sludge Treatment “Start to Finish” capability, Doosan Enpure offers a variety of treatment processes tailored to fit into the available space and, if appropriate, make use of existing assets. This could range from the construction of a simple stand-alone SBR to the addition of MBBR capacity to an existing activated sludge plant or provision of side-stream phosphorus recovery.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Country</th>
<th>Sludge Process</th>
<th>Completion Year</th>
<th>Capacity (tDS/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliance Street Plant</td>
<td>UK</td>
<td>AD, MBR</td>
<td>2012</td>
<td>44.7</td>
</tr>
<tr>
<td>Derwenthaugh Eco Park</td>
<td>UK</td>
<td>MBBR, MSW</td>
<td>2012</td>
<td>100,000</td>
</tr>
<tr>
<td>Poole STW</td>
<td>UK</td>
<td>SLT, MBR</td>
<td>2008</td>
<td>11.2</td>
</tr>
<tr>
<td>Cumnock STC</td>
<td>UK</td>
<td>AD, SLT, MBR</td>
<td>1998</td>
<td>4.675</td>
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<tr>
<td>Millbrook STC</td>
<td>UK</td>
<td>AD, SD, SLT, MBR</td>
<td>1998</td>
<td>40</td>
</tr>
</tbody>
</table>
sonix™ is a patented technology that uses ultrasound frequencies at 20KHz to enhance energy and product recovery from organic sludge, raw material, or other solids. It maximizes gas production while minimizing sludge volume in the digestion processes, making the sonix™ technology fit well in a world where sustainability is the focus and biosolids are viewed as a valuable resource.

**Performance Data:**
- Volatile solids destruction up to 75%
- Gas production increased by up to 75%
- Sludge dewaterability increased by up to 15%
- Increased digester stability
- Overall solids destruction up to an additional 50%

**Commercial Benefits:**
- Approximately £1 per person capital
- 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

**sonix™ uses high temperatures and pressure to:**
- Rupture cellular material
- Solubilise organics
- Improve availability of micronutrients
- Reduce particle sizes
- Breakdown refractory organics
- Enhance interaction between immiscible liquids
- Accelerate rates of chemical reaction

**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
- Cell lysis of TWAS* using sonix™
  * TWAS: Thickened Waste Activated Sludge

<table>
<thead>
<tr>
<th>Plant</th>
<th>Country</th>
<th>Year</th>
<th>Capacity (tDS/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minworth WwTW</td>
<td>UK</td>
<td>2007</td>
<td>68</td>
</tr>
<tr>
<td>Molina WwTW</td>
<td>Spain</td>
<td>2006</td>
<td>3~4</td>
</tr>
<tr>
<td>Sagunto WwTW</td>
<td>Spain</td>
<td>2006</td>
<td>3~4</td>
</tr>
<tr>
<td>Villanova WwTW</td>
<td>Spain</td>
<td>2006</td>
<td>2.5~3</td>
</tr>
<tr>
<td>Alzira WwTW</td>
<td>Spain</td>
<td>2005</td>
<td>4.5~5.5</td>
</tr>
<tr>
<td>Kavlinge WwTW</td>
<td>Sweden</td>
<td>2002</td>
<td>4</td>
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</table>

**Major References**
SLUDGE PROJECT EXPERIENCE

Our experience extends to more than 50 sludge management projects with various sludge processes.

## Major References

<table>
<thead>
<tr>
<th>Plant</th>
<th>Country</th>
<th>Sludge Process</th>
<th>Completion Year</th>
<th>Capacity (tDS/day)</th>
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</thead>
<tbody>
<tr>
<td>Bellozanne STW</td>
<td>States of Jersey</td>
<td>AD, Past</td>
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<td>10.6</td>
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<tr>
<td>Reliance Street Plant</td>
<td>UK</td>
<td>AD, MBR</td>
<td>2012</td>
<td>44.7</td>
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<tr>
<td>Brighton &amp; Hove WwTW</td>
<td>UK</td>
<td>AD</td>
<td>2012</td>
<td>47</td>
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<tr>
<td>Esholt WwTW Digestion Plant</td>
<td>UK</td>
<td>AD</td>
<td>2009</td>
<td>34.1</td>
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<tr>
<td>Jebel Ali Thermal Sludge Dryer</td>
<td>UAE</td>
<td>SD</td>
<td>2009</td>
<td>70.8</td>
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<tr>
<td>Ringsend WwTW</td>
<td>Republic of Ireland</td>
<td>THP, AD</td>
<td>2009</td>
<td>56(extension), 120(total)</td>
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<tr>
<td>Waterford WwTW</td>
<td>Republic of Ireland</td>
<td>Past, AD</td>
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<tr>
<td>Sligo WwTW</td>
<td>Republic of Ireland</td>
<td>Past, AD</td>
<td>2008</td>
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<tr>
<td>Colchester Thermal Sludge Dryer</td>
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<td>SD</td>
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<tr>
<td>Lowestoft WwTW</td>
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<tr>
<td>Bromborough WwTW</td>
<td>UK</td>
<td>BAFF, AD</td>
<td>2000</td>
<td>37.4</td>
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<td>Pyewipe STC</td>
<td>UK</td>
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<td>1999</td>
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<td>Truro Newham Sludge Stage 2</td>
<td>UK</td>
<td>DH</td>
<td>1998</td>
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<td>Cliff Quay STW (Ipswich)</td>
<td>UK</td>
<td>AD, Past</td>
<td>1997</td>
<td>19.5</td>
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<tr>
<td>Harwich &amp; Dovercourt STW</td>
<td>UK</td>
<td>ASP, Past, AD</td>
<td>1997</td>
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</tbody>
</table>

## Major Processes

### Abbreviations
- AD: Anaerobic Digestion
- ASP: Activated Sludge Process
- BAFF: Biological Aerated Flooded Filter
- CHP: Combined Heat & Power
- DH: Dehydrate
- THP: Thermal Hydrolysis Process
- Past: Sludge Pasteurisation
- SD: Sludge Drying
- SLT: Sludge Liquor Treatment

<table>
<thead>
<tr>
<th>Process</th>
<th>Number of Projects</th>
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<tr>
<td>Thickening</td>
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<td>Dewater</td>
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<td>Drying</td>
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<td>Pasteurisation</td>
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<tr>
<td>AD</td>
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<tr>
<td>sonix™</td>
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<tr>
<td>Thermal</td>
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<tr>
<td>CHP</td>
<td>8</td>
</tr>
<tr>
<td>Odour</td>
<td>25</td>
</tr>
</tbody>
</table>

### Number of Major Sludge Projects by Category
WATER NETWORK

CORPORATE NETWORK

Overseas Subsidiaries

DOOSAN ENPURE
Birmingham, UK

DOOSAN HYDRO TECHNOLOGY
Tampa, USA

DOOSAN POWER SYSTEMS
Crawley, UK

DOOSAN POWER SYSTEMS INDIA
Haryana, India

DOOSAN POWER SYSTEMS (EUROPE)
Ratingen, Germany

DOOSAN POWER SYSTEMS (NORTH AMERICA)
Atlanta, USA

DOOSAN POWER SYSTEMS (LATIN AMERICA)
Sao Paulo, Brazil

DOOSAN BOBCOCK
Kentville, UK

SKODA POWER
Pilsen, Czech

DOOSAN CHENNAI WORKS
Chennai, India

DOOSAN HF CONTROLS
Carrolton, USA

DOOSAN IMBG
Bucharest, Romania

DOOSAN ENGINEERING & SERVICES
Montvale, USA

DOOSAN VINA
Dung Quat, Vietnam

DOOSAN VINA HAIPHONG
Haiphong, Vietnam

HANJUNG POWER
NCD, Papua New Guinea

DOOSAN LENTJIES
Ratingen, Germany

Overseas Branches

ASIA

BEIJING OFFICE
Beijing, China

NEW DELHI OFFICE
New Delhi, India

DOOSAN HEAVY INDUSTRIES JAPAN
Tokyo, Japan

BANGKOK OFFICE
Bangkok, Thailand

HANOI OFFICE
Hanoi, Vietnam

JAKARTA OFFICE
Jakarta, Indonesia

MUMBAI OFFICE
Mumbai, India

SHANGHAI OFFICE
Shanghai, China

TAIPEI OFFICE
Taipei, Taiwan, R.O.C.

EUROPE

FRANKFURT OFFICE
Frankfurt, Germany

BIRMINGHAM R&D CENTER
Birmingham, UK

MIDDLE EAST & AFRICA

RIYADH OFFICE
Riyadh, Saudi Arabia

KUWAIT OFFICE
Salmiya, Kuwait

DUBAI OFFICE
Dubai, UAE

ABU DHABI OFFICE
Abu Dhabi, UAE

MIDDLE EAST OPERATIONS CENTER
Dubai, UAE

NORTH AFRICA OFFICE
New Cairo, Egypt

DAMMAM R&D CENTER
Al Khobar, KSA

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