Sustainable, Clean Energy from Waste

Environmental, cost-effective solutions for generating power in a circular economy
The Babcock & Wilcox Company and its subsidiaries (B&W) have more than 150 years of experience in designing, supplying and servicing some of the world’s cleanest, most efficient energy and environmental systems. Our waste-to-energy (WtE) technology, developed and improved over the last 80 years, has been used in more than 500 applications – engineered, tested and proven to offer real and lasting benefits.

**Our WtE technology:**
- Avoids methane emissions from landfills
- Offsets greenhouse gas (GHG) emissions from fossil fuel electrical production
- Recovers/recycles valuable resources such as metals
- Produces clean, reliable base-loaded energy
- Requires less land per megawatt than most other renewable energy sources
- Uses a local and abundant renewable fuel source
- Results in very low emissions levels, typically well below permitted levels

Waste-to-energy (WtE) is a vital part of a strong and sustainable waste management chain. Fully complementary to recycling, it is an economically and ecologically sound way to provide a source for energy while diverting waste from landfills.

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### BENEFITS

#### ECONOMIC
- Reduces cost to landfill refuse
- Generates revenue from metals recovery
- Makes beneficial use of ash
- Contributes to electricity/steam and hot water sales
- Creates local job opportunities
- Helps to earn subsidies or avoid fines by meeting regulatory compliance targets

#### HEALTH / ENVIRONMENTAL
- Conserves natural resources otherwise used as fuel (i.e., oil, gas, coal)
- Creates a net negative GHG profile (methane, CO₂)
- Reduces the need for new landfill space and emissions (lead, mercury, dioxins/furans, sulfuric and hydrochloric acids, volatile organic compounds, sulfur dioxide, nitrogen oxides, carbon monoxide, particulates)
- Filters out drug residues, heat-resistant bacteria, harmful chemicals
- Eliminates landfill odor and thermally destroys contaminated waste

#### ENERGY
- Generates electricity and heat for use in local community
- Provides viable, effective alternative to fossil fuel
- Uses readily available fuel source
- Produces heat for district heating
- Supplies steam for process use
- Supplies steam to chillers for air conditioning
- Produces energy for desalination of seawater
- Reduces transportation energy by treating waste locally rather than shipping to distant landfills
Sustainable Waste Management

As urbanization and spending on consumables increases, more solid waste is generated. The amount of solid waste has grown over the last century to more than 3 million tons now generated per day globally, and the number is expected to double by 2025 (Organization for Economic Cooperation and Development).

Solid waste management is often one of the greatest costs to municipal budgets. Increasing the amount of municipal solid waste in landfills translates to increases in greenhouse gas (GHG) emissions, air and odor pollution, and soil and water contamination.

To reduce the size, cost and environmental impacts of landfills, many regions are shifting from a linear economy (make-use-dispose) to a more circular economy model, where materials are made, used and reused to their fullest extent. Complementary to recycling, WtE plants extend the useful life of the solid waste, converting it into electricity and/or heat for industrial processing and district heating systems, filtering out harmful substances and recovering metals and other material for reuse. WtE is one of the most robust and effective energy options to produce power while treating waste and reducing emissions as an alternative to fossil fuels.

The Clean Truth

For every ton of municipal solid waste processed at WtE facilities, GHG emissions are reduced by approximately one ton.

WtE plants provide a safe waste disposal option that complements (not replaces) recycling. Recycling rates have actually increased in municipalities that have WtE plants.

WtE technology supports business and industry ‘zero-waste-to-landfill’ initiatives.

The most recent WtE facility in the U.S., designed, supplied, operated and maintained by B&W, performs well below permitted emissions levels:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Air Permit Level</th>
<th>Test Results*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>50 ppm</td>
<td>30 – 31 ppm</td>
</tr>
<tr>
<td>SO2</td>
<td>24 ppm</td>
<td>11 – 21 ppm</td>
</tr>
<tr>
<td>CO</td>
<td>100 ppm</td>
<td>16 – 24 ppm</td>
</tr>
<tr>
<td>Opacity</td>
<td>10%</td>
<td>0.4 – 2.4%</td>
</tr>
<tr>
<td>VOCs</td>
<td>7 ppm</td>
<td>0.2 – 2.7 ppm</td>
</tr>
<tr>
<td>Particulate Matter (PM)</td>
<td>12 mg/dscm</td>
<td>0.6 – 2.5 mg/dscm</td>
</tr>
<tr>
<td>Pb</td>
<td>125 µg/dscm</td>
<td>0.5 – 8.1 µg/dscm</td>
</tr>
<tr>
<td>H2SO4</td>
<td>5 ppm</td>
<td>Non-detectable &lt; 0.01 ppm</td>
</tr>
<tr>
<td>HCl</td>
<td>20 ppm</td>
<td>1.5 – 2.1 ppm</td>
</tr>
<tr>
<td>HF</td>
<td>3.5 ppm</td>
<td>Non-detectable &lt; 0.1 ppm</td>
</tr>
<tr>
<td>Dioxins/Furans</td>
<td>10 ng/dscm</td>
<td>0.2 – 0.4 ng/dscm</td>
</tr>
<tr>
<td>Hg</td>
<td>25 µg/dscm</td>
<td>0.6 µg/dscm</td>
</tr>
<tr>
<td>Cd</td>
<td>10 µg/dscm</td>
<td>0.3 – 2.5 µg/dscm</td>
</tr>
<tr>
<td>NH3 slip</td>
<td>10 ppm</td>
<td>2.2 – 5.5 ppm</td>
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*Corrected to 7% O₂ dry basis
Environmental

As a single-source supplier, we can develop an integrated multi-pollutant strategy to meet your long-term requirements. Our technologies include:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Control Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>• Selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) systems</td>
</tr>
<tr>
<td>Acid Gas (including SO$_2$, HCl and H$_2$SO$_4$)</td>
<td>• Spray dryer absorber (SDA) with fabric filter</td>
</tr>
<tr>
<td>Particulate – PM, PM$<em>{10}$, PM$</em>{2.5}$ and Municipal Waste Combustion (MWC) Metals</td>
<td>• Wet flue gas desulfurization systems</td>
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<tr>
<td></td>
<td>• Circulating dry scrubbers</td>
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<tr>
<td></td>
<td>• Dry sorbent injection systems</td>
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<tr>
<td>Lead</td>
<td>• Pulse jet fabric filters (baghouses)</td>
</tr>
<tr>
<td>CO</td>
<td>• Wet and dry electrostatic precipitators (ESP)</td>
</tr>
<tr>
<td>VOCs</td>
<td>• Wet particulate scrubbers</td>
</tr>
<tr>
<td>MWC Organics (as Dioxins/Furans)</td>
<td>• Multiclone® dust collectors</td>
</tr>
<tr>
<td>Mercury Dioxins/Furans</td>
<td>• Design with good combustion practices</td>
</tr>
<tr>
<td></td>
<td>• Regenerative thermal oxidizers</td>
</tr>
<tr>
<td></td>
<td>• SCRs</td>
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<tr>
<td></td>
<td>• Activated carbon injection with fabric filter</td>
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<tr>
<td></td>
<td>• ADIOX™ scrubbers and absorbers</td>
</tr>
<tr>
<td></td>
<td>• MERCOX™ flue gas cleaning technology</td>
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Combustion

B&W provides two boiler options when using waste as a combustion fuel:

1. Mass-burn: uses the municipal solid waste in its as-received, unprepared state.
2. RDF: uses prepared refuse, or refuse-derived fuel (RDF), where the as-received refuse is first separated, classified and reclaimed in various ways to yield salable or otherwise recyclable products. The remaining material is prepared for thermal processing in the boiler.

Ferrous and non-ferrous metal recovered from the ash is often recycled while the ash itself can be reused in road construction or other applications in circular economies.

B&W’s advanced design DynaGrate® reciprocating combustion grate, Vølund combustion grate and advanced overfire air systems provide environmental benefits during combustion:

- Destroy dioxins and furans
- Minimize formation of NOx and CO
- Minimize unburned carbon

We also offer:

- Adsorption systems for solvent recovery, distillation and purification
- Biological abatement systems
- Blower/vent silencers for noise reduction
- Air-cooled condensers
- Filtration systems
- Emissions management and monitoring systems
- Ash and material handling
- Absorption heat pumps and chillers
Proven Experience

Palm Beach County
Renewable Energy Facility, No. 2
West Palm Beach, Florida, USA

- B&W designed, supplied and serves as O&M service provider
- Ranks as cleanest, most efficient plant of its kind in the world
- First WtE plant built in U.S. in 20 years (2015)
- More than 25,000 tons of metal recovered annually
- Reduces volume sent to landfill by 90%
- Better than zero discharge on water
- Generates electricity for more than 40,000 homes
- Added more than 1,000 design, manufacturing and construction jobs to local community

Likeng II
Guangzhou, China

- Located in China’s third largest city with a population of 12.8 million and situated along the Pearl River, 75 miles from Hong Kong
- One of the largest WtE plants in China, specifically designed for Chinese waste with high moisture and low calorific value
- Features 3 lines, each with the capacity for more than 825 tons of waste per day
- B&W Velund supplied basic design of boiler as well as the air-cooled Velund grate, waste charging system with feeding damper, feeding chute and feeding pusher, slag pusher, and construction and commissioning advisory support

“This is the second renewable energy project for which we have selected B&W. In both cases, B&W was selected as the result of a vigorous and competitive public bidding process. During this process they demonstrated superior, cutting-edge technology leadership providing the overall best economic value and a proven track record of performance driven by experienced, professional personnel from start to finish.”

Raymond H. Schauer
Director, Engineering & Public Works
Solid Waste Authority of Palm Beach County
Indaver
County Meath, Ireland

- Ireland’s first WtE plant
- Delivers electricity to 20,000 households through the city’s grid
- Features B&W boiler, proprietary combustion DynaGrate® technology, and selective non-catalytic reduction (SNCR) system for NOx reduction
- Completed on schedule and with multiple safety awards
- Capacity to process approximately 200,000 tons of waste per year

Amager Bakke
Copenhagen, Denmark

- Integrates innovative WtE technology and architecture to form practical, aesthetic solution to meet clean energy demand
- Equipped with 2 furnace lines and a joint turbine and generator system, capable of burning 2 x 35 tons of waste per hour
- Designed to treat around 400,000 tons of waste annually produced by approximately 700,000 people and 46,000 businesses, and supply a minimum of 50,000 households with electricity and 120,000 households with district heating
- Features a roof-wide artificial ski slope open to the public
- Includes B&W-supplied combustion system from crane through feeding, DynaGrate combustion grate, boiler, ash handling, as well as a particulate and NOx reduction system
Established in 1867, Babcock & Wilcox is a global leader in advanced energy and environmental technologies and services for the power, industrial and renewable markets, with operations, subsidiaries and joint ventures worldwide. For more information or to contact us, visit our website at www.babcock.com.

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