B&W Company Profile

Global leader in energy and environmental technologies and services for the power and industrial markets

Installed electricity generation capacity of more than 300,000 MW in more than 90 countries

More than 500 WTE/biomass units installed worldwide

Pioneered environmental equipment in the 1970s with most comprehensive suite of products available

Employees in 25 countries

Headquarters: Charlotte, NC

Founded: 1867

Employees: Approximately 6,000 employees, in addition to 2,500 joint venture employees worldwide

Web: www.babcock.com
What is Waste-to-Energy?

• **Part of an environmentally sound refuse disposal program**, WTE is the combustion of refuse to generate steam for heat, process or power generation applications.

• **“Energy from what’s left.”** After recyclables have been collected, B&W’s WTE technologies produce energy from the remaining waste. Post-combustion metals collection further benefits recycling efforts.

• **B&W plants use two primary technologies.**
  - **Refuse-Derived Fuel (RDF)** - Refuse is first separated, classified and reclaimed in various ways to yield salable or otherwise recyclable products. The remaining material is prepared for firing in the boiler.
  - **Mass Burn** - Refuse is combusted in its as-received, unprepared state. Recyclable metals are removed after combustion.
Benefits of Waste-to-Energy

- **Revenues**
  - Metals recovery/recycling
  - Tipping fees
  - Steam/hot water
  - Electricity
  - Beneficial use of ash

- **Environmental**
  - Low emissions
  - Lower CO$_2$ emissions than coal, oil, natural gas
  - Elimination of landfill methane
  - Overall net-negative GHG
  - Lower air and water emissions and runoff from landfills

- **Other**
  - Resilience/disaster recovery (i.e. waste from hurricane/storm damage)
Palm Beach Renewable Energy Facility #2

Photo - Solid Waste Authority of Palm Beach County
Achievements - Palm Beach County Renewable Energy Facility

- First WTE plant built in U.S. in 20 years
- Most-advanced WTE plant in North America
- 33,000 tons of metal recovered annually
- Reduced volume sent to landfill by 90%
- Better than zero discharge on water
- Key part of county’s overall recycling, composting and clean energy program
- On-site electric vehicle charging
- LEED certified visitors center for community education
- Asset to the community
  - Generates electricity for 40,000+ homes
  - Generated over 1,000 design, manufacturing and construction jobs
  - Operated by more than 70 full-time, highly skilled workers
Achievements - Palm Beach County Renewable Energy Facility

- Ultra-low emissions well-below permitted levels
  - Lead, mercury, dioxin/furans, hydrochloric acid, VOCs
  - Sulfur dioxide, nitrogen oxides, carbon monoxide, particulate, sulfuric acid
  - Landfill methane eliminated
  - Lower net CO$_2$ emissions than coal, oil or natural gas
  - Net negative GHG profile (CO$_2$, methane)
  - Lowest emissions of any WTE plant in the world
- Environmental controls
  - SCR (NO$_x$, dioxin/furan destruction)
  - Dry scrubber w/ fabric filter (SO$_2$, HCL – acid gasses)
  - Fabric filter (particulate matter, heavy metals)
  - Advanced plant design and combustion system (carbon monoxide, VOCs, dioxins and furans, sulfuric acid)
  - Activated carbon injection with fabric filter (mercury)
  - Advanced continuous emissions monitoring
Economics of WTE

• Waste reduction results in reduced cost to landfill trash
• Landfill elimination or life extension
• Elimination of expensive landfill permitting process
• Metals recovery – revenue on recycled metals
• Resilience and disaster remediation
• Recovering energy from waste
  • Electricity sales – revenue on energy recovery
  • Steam sales – revenue on energy recovery
  • Localize energy production
Waste-to-Energy for Greenhouse Gas Avoidance

- According to the U.S. EPA, WTE emits less net CO$_2$ than fossil fuels, including natural gas
- Renewable biomass is a significant component of MSW fuel
- “Although MSW power plants do emit carbon dioxide, the primary greenhouse gas, the biomass-derived portion is considered to be part of the Earth's natural carbon cycle.” - U.S. EPA web site, 2015
- “In contrast, when fossil fuels (or products derived from them such as plastics) are burned, they release carbon dioxide that has not been part of the Earth's atmosphere for a very long time.” - U.S. EPA web site, 2015
Waste-to-Energy For Greenhouse Gas Avoidance

• “If the goal is greenhouse gas reduction, then WTE [waste-to-energy] should be considered as an option under U.S. renewable energy policies.”
  –U.S. EPA, University of North Carolina study, 2009

• “Solid waste management practices can reduce greenhouse gas emissions from the waste sector, as well as reduce upstream and downstream emissions.”
  –U.S. EPA Fact Sheet, 2002

• By landfilling only ash, WTE prevents the potent greenhouse gas methane from forming and being emitted

• Methane is 25 to 85 times more potent GHG than carbon dioxide

• Landfills are the third largest source of human-caused methane emissions in the U.S., after natural gas and oil production (#1) and agriculture (#2)

Waste-to-Energy For Greenhouse Gas Avoidance

Source: Lifecycle Assessment of WTE GHG Reductions (2014), Energy Recovery Council
## Waste Fuel v. Natural Gas Emissions

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Natural Gas Turbine Exhaust</th>
<th>WPB Emissions Permit</th>
<th>WPB Actual Emissions Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitric Oxide</td>
<td>20 - 220 PPM</td>
<td>&lt;50 PPM</td>
<td>30.5 PPM</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>2 - 20 PPM</td>
<td>Included above</td>
<td>Included above</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>5 - 330 PPM</td>
<td>&lt;100 PPM</td>
<td>5 - 24 PPM</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>Trace – 100 PPM</td>
<td>&lt;24 PPM</td>
<td>10 - 21 PPM</td>
</tr>
<tr>
<td>Sulfur Trioxide</td>
<td>Trace – 4 PPM</td>
<td>Not required</td>
<td>Not Detectable/Trace</td>
</tr>
<tr>
<td>Unburned Hydrocarbons</td>
<td>5 - 300</td>
<td>&lt;7 PPM</td>
<td>0.2 – 2.7 PPM</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>Trace – 25 PPM</td>
<td>12 MG/DSCM</td>
<td>0.6 – 2.5 MG/DSCM</td>
</tr>
</tbody>
</table>

* All Data Shown For Typical Concentration (Parts Per Million Volume) Except Where Noted
* Natural Gas Data Source: *Gas Turbine Emissions and Control, GE Power Systems White Paper*
* West Palm Beach REF #2 Data Source: Babcock & Wilcox
* Actual emission test conducted during compliance test three 4 hr. test per unit – 9 total test with range showing high and low measurement under stable full load testing
Recycling Rates For WTE Communities and States

EU Waste-to-Energy Policy
A Model For Responsible Waste Management

- More than 450 WTE plants in Europe vs. 87 in U.S.
- Stated EU Objectives
  - Reduce amount of waste generated
  - Maximize recycling
  - Limit incineration to non-recyclables
  - Limit landfilling to non-recyclables
  - Ensure full implementation of waste policy targets in all Member States
- Top 8 Euro Countries
  - 2% Landfill
  - 52% Recycling
  - 46% Energy Recovery

Amager Bakke Waste-to-Energy Plant near Copenhagen, Denmark currently under construction. Features B&W Vølund boilers and environmental equipment, low emissions, cutting-edge architecture and artificial ski slope.
Questions?