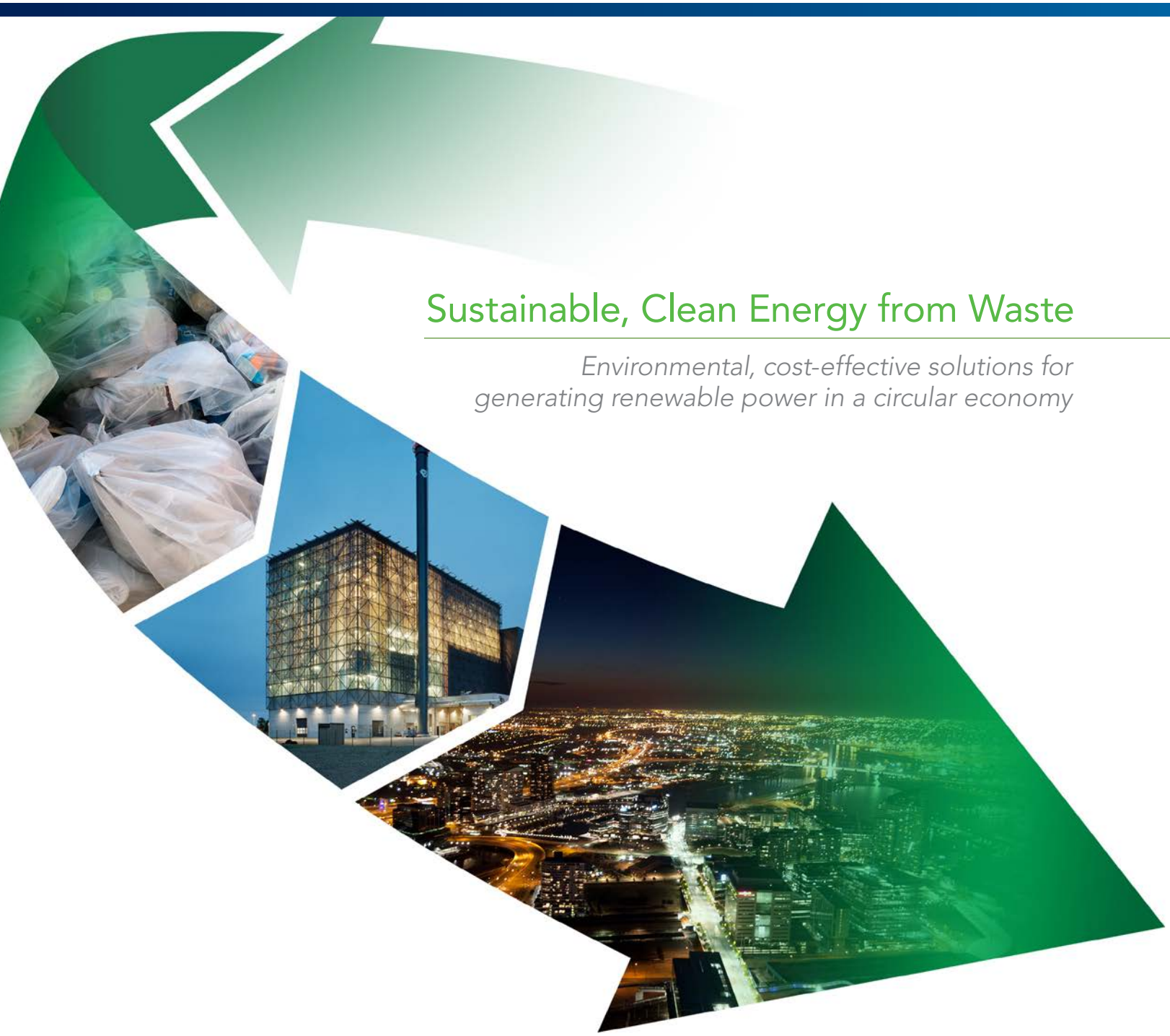


Sustainable, Clean Energy from Waste

Environmental, cost-effective solutions for generating renewable power in a circular economy

B&W BABCOCK & WILCOX RENEWABLE

RENEWABLE | ENVIRONMENTAL | THERMAL

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.

Waste-to-Energy

A proven technology with measurable results

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) capabilities, including the state-of-the-art Vølund™ technology, developed and improved over the last 80 years, has been used in more than 650 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

BENEFITS

ECONOMIC

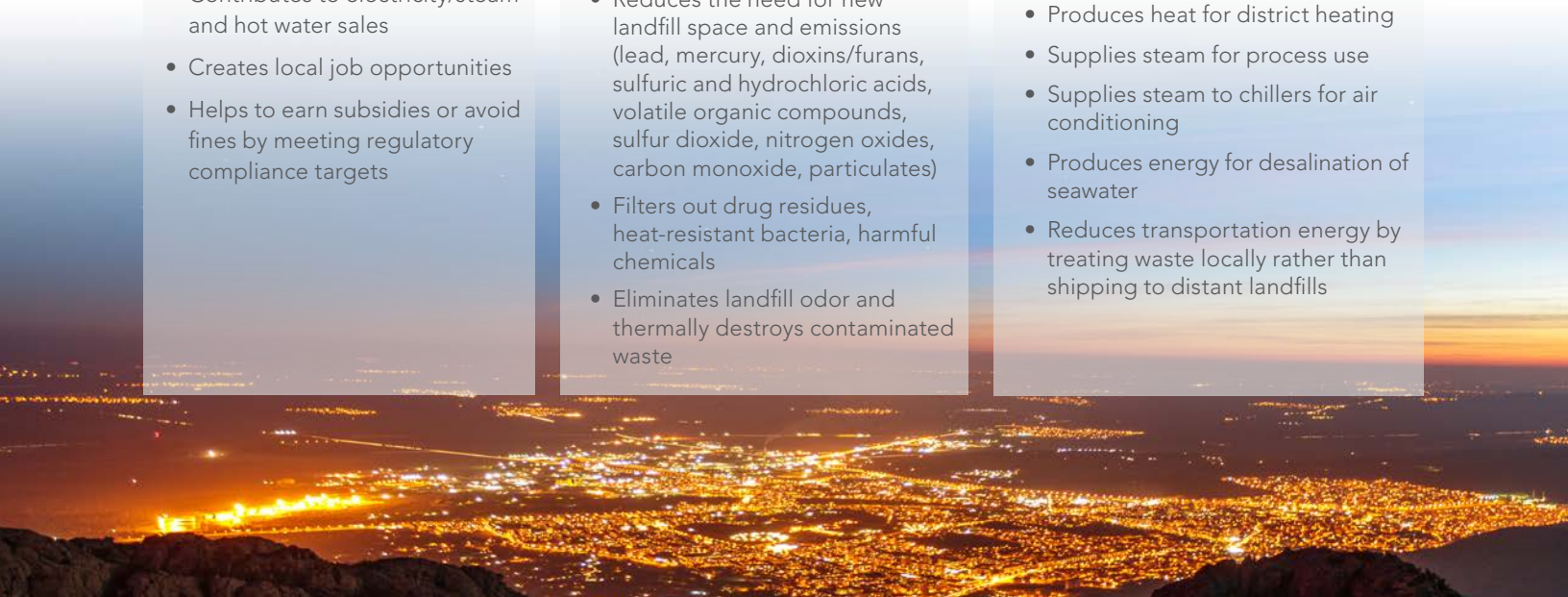
- Reduces cost to landfill refuse
- Generates revenue from metals recovery
- Makes beneficial use of ash
- Contributes to electricity/steam and hot water sales
- Creates local job opportunities
- Helps to earn subsidies or avoid fines by meeting regulatory compliance targets

HEALTH / ENVIRONMENTAL

- Conserves natural resources otherwise used as fuel (i.e., oil, gas, coal)
- Creates a net negative GHG profile (methane, CO_2)
- 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.

***Methane** has roughly **84 times** the Global Warming Potential (**GWP**) of carbon dioxide on a 20-year basis.**

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 and supplied by B&W, performs well below permitted emissions levels:

PROVEN RESULTS

Pollutant	Air Permit Level	Test Results *(Corrected to 7% O_2 dry basis)*
NO_x	50 ppm	30 – 31 ppm
SO_2	24 ppm	11 – 21 ppm
CO	100 ppm	16 – 24 ppm
Opacity	10%	0.4 – 2.4%
VOCs	7 ppm	0.2 – 2.7 ppm
Particulate Matter (PM)	12 mg/dscm	0.6 – 2.5 mg/dscm
Pb	125 µg/dscm	0.5 – 8.1 µg/dscm
H_2SO_4	5 ppm	Non-detectable < 0.01 ppm
HCl	20 ppm	1.5 – 2.1 ppm
HF	3.5 ppm	Non-detectable < 0.1 ppm
Dioxins/Furans	10 ng/dscm	0.2 – 0.4 ng/dscm
Hg	25 µg/dscm	0.6 µg/dscm
Cd	10 µg/dscm	0.3 – 2.5 µg/dscm
NH_3 slip	10 ppm	2.2 – 5.5 ppm

Produce Heat/ Cooling/Power

Recover Metals

Reduce Emissions

Destroy Toxins

Divert Waste

* Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: *The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Babcock & Wilcox Technology Solutions

- More than 650 installations utilizing B&W technology in more than 30 countries
- Flexible designs to accommodate various capacities, fuel compositions and steam requirements
- Experience as both a supplier to and operator of WtE facilities
- Environmental equipment solutions for a wide range of emissions

Environmental

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

Pollutant	Control Technology
NO_x	• Selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) systems
Acid Gas (including SO_2, HCl and H_2SO_4)	• Spray dryer absorber (SDA) with fabric filter • Wet flue gas desulfurization systems • Circulating dry scrubbers • Dry sorbent injection systems
Particulate – PM, PM_{10}, $PM_{2.5}$ and Municipal Waste Combustion (MWC) Metals	• Pulse jet fabric filters (baghouses) • Wet and dry electrostatic precipitators (ESP) • Wet particulate scrubbers • Multiclone® dust collectors
Lead	
CO	• Design with good combustion practices • SCRs
VOCs	
MWC Organics (as Dioxins/Furans)	
Mercury	• Activated carbon injection with fabric filter
Carbon Dioxide	• OxyBright™ oxygen combustion • SolveBright™ post-combustion carbon capture




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 NO_x and CO
- Minimize unburned carbon

We also offer:

- Ash and material handling systems
- Boiler cleaning equipment and systems
- System upgrades and replacement parts
- Field engineering services
- Construction

Proven Experience

Palm Beach County Renewable Energy Facility, No. 2

West Palm Beach, Florida, USA

- Designed and supplied three mass burn boilers, combustion grate system, ash systems, metals recovery systems, emissions control equipment, automated refuse crane, and other components
- 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

Dunbar

East Lothian, Scotland, UK

- Commissioned in 2019, the plant is integral to the Scottish government's ambitions of generating renewable energy, phasing out landfills and developing a viable circular economy.
- Features two lines, each with the capacity for 19.2 tons of waste per hour, or more than 300,000 tons of waste annually
- Powers 70,000 homes with 258 GWh of baseload green electricity
- Supplied all equipment from crane to stack, including boiler and DynaGrate combustion grate.
- Includes long-term service contract for grate inspection and maintenance

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

XPERIENCE

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 NO_x 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 two 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, hiking trail and climbing wall, all 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 NO_x reduction system

B&W designed and delivered state-of-the-art Vølund™ technology for the world's largest waste-to-energy plant, located in Shenzhen, China.

B&W waste-to-energy technology is installed in more than 650 applications in more than 30 countries

Waste-to-energy technology has seen dramatic improvements in efficiencies and effectiveness over recent years. With B&W's researched, developed and successfully applied WtE technology, almost 100% of the energy contained in waste is recovered in combined heat and power applications. Modern plants can provide a significant reduction in greenhouse gases by avoiding landfilling and by replacing fossil fuel. For its economic, environmental and energy recovery benefits, WtE is a responsible, clean, sustainable option for generating power and protecting the planet.

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B&W BABCOCK & WILCOX RENEWABLE

RENEWABLE | ENVIRONMENTAL | THERMAL

Established in 1867, Babcock & Wilcox is a global leader in renewable, environmental and thermal technologies and services for power and industrial applications.

For more information or to contact us, visit our website at www.babcock.com.

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