THERMOMECHANICAL TREATMENT FACILITY Emissions

Like all combustion processes (e.g., cars, trucks, fossil-fuel power plants, landfill gas to energy, campfires) and nearly all waste management processes (e.g., landfilling, composting, anaerobic digestion, recycling), thermomechanical treatment facilities (TTF, globally known as waste-to-energy (WTE)) have air emissions. To minimize these, TTFs employ a carefully controlled combustion process with temperatures exceeding 2,000 °F and sophisticated air pollution control equipment. Emissions are monitored both continuously and with periodic testing. 99.9% of what exits the stack are normal components of air, including water vapor, nitrogen, oxygen, and carbon dioxide (CO_2).

The installation of air pollution control equipment was primarily driven by the Clean Air Act Amendments of 1990 and the included Maximum Available Control Technology (MACT) requirement. Following implementation of these requirements, emissions from the industry dropped dramatically, both as a result of the closure of outdated facilities and the installation of updated air pollution control equipment for those remaining in operation. In reviewing the data, the U.S. EPA noted that "**[t]he performance of the MACT retrofits has been outstanding**".[1] Since then, emissions have continued to drop, with average 2020 concentrations 43-99.9% lower compared to 1990 levels, even as the industry processes more waste than ever before (Table 1). Since our first sustainability program in 2007, emissions from Reworld's TTFs have decreased by up to 74% (Figure 1). As a result, our TTFs operate well below federal standards (Figure 2).

Table 1. *Change in U.S. TTF Emissions, 1990-2020*[1-3]

Dioxins & Furans	▼99.9%
Mercury (Hg)	▼99.5%
Lead (Pb)	▼99%
Cadmium (Cd)	▼98%
Hydrochloric acid (HCl)	▼97%
Particulate Matter (PM)	▼96%
Sulfur Dioxide (SO_2)	▼89%
Nitrogen Oxides (NO_x)	▼43%

How are emissions measured and monitored?

Air emissions from thermomechanical treatment are heavily regulated by both the U.S. EPA and state environmental agencies. Emissions from TTFs are determined through routine stack tests (performed at least once a year) and through continuous emissions monitoring systems (CEMS). CEMS monitor flue gases for carbon monoxide (CO), nitrogen oxide (NO_x), sulfur dioxide (SO_2), opacity (surrogate for monitoring particulate matter), and CO_2 and/or oxygen. Facility operators monitor these parameters and adjust as needed to ensure proper operation and compliance. For example, monitoring CO levels continuously allows operators to respond to changes in the waste (e.g. wetter than normal waste that may have been collected during a rainstorm) to ensure complete and efficient combustion.

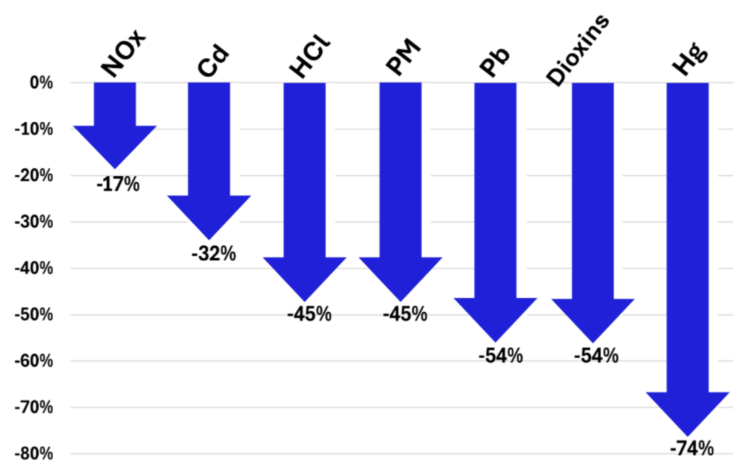

Figure 1. *Reworld TTF 2021-2023 emissions compared to 2007*

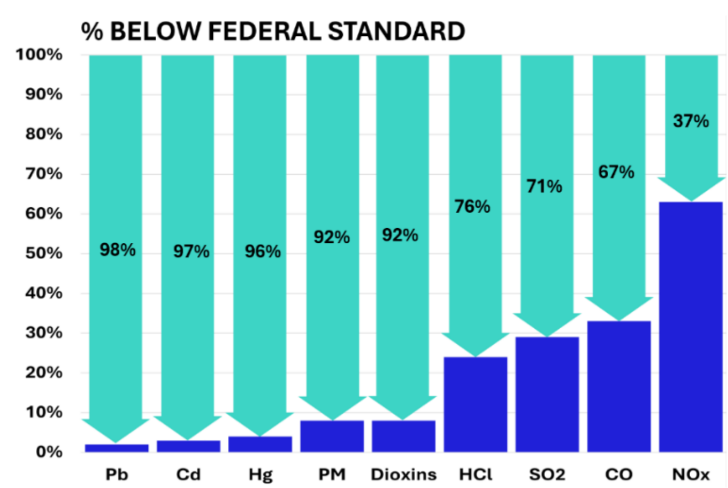

Figure 2. *Reworld TTF 2020-2023 emission performance vs. federal air emission standards*

Other regulated pollutants are checked through a rigorous stack testing program performed by a regulator-approved third-party and signed off by independent test engineers. Testing is completed under normal operating conditions; operations are not altered in any way to improve emissions performance. For example, the waste stream is **not** managed (such as by removing plastics) to influence results.

Are stack tests representative of year-round performance?

Yes. The operating parameters under which the stack test is conducted (e.g., activated carbon addition rate, steam flow rate) set the standard for the facility's operation until the next stack test is completed. Operating the combustion process and air pollution control equipment in accordance with these standards ensures compliance. By maintaining these operating conditions and monitoring CEMS data, facilities can ensure that combustion emissions are consistent and predictable throughout the year.

Are TTFs major sources of mercury & dioxins in the U.S.?

No. According to peer-reviewed research by Columbia University scientists, the total dioxin emissions of all U.S. TTF plants in 2012 represented less than one-tenth of one percent of the pollutant's total sources.[3] Similarly, TTFs are a minor source of mercury in the U.S., representing just 0.8% of man-made sources in 2014, roughly half that emitted from landfills (Figure 3). Scrap metal processing and recycling emits 7 times as much mercury as U.S. TTFs.[5]

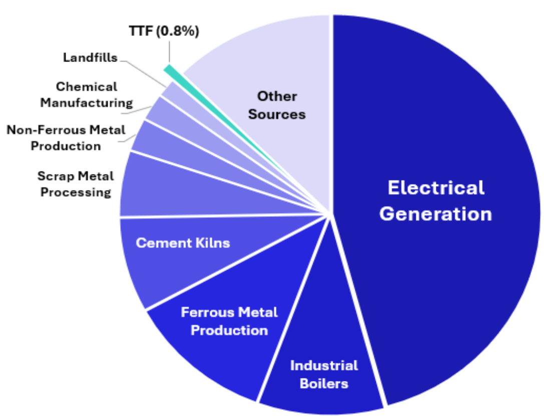

Figure 3. *Share of U.S. mercury emissions by sector*

What about particulate matter?

Particulate matter, including fine particulate matter smaller than 2.5 microns (PM2.5) and nanoparticles (smaller than 0.1 micron) is filtered via air pollution control equipment installed at TTFs. Other local sources of fine particulates, such as dust, fuel combustion, and mobile sources (cars, trucks, and other mobile sources) are significantly greater and are emitted at ground level much closer to us than TTF stacks. According to the 2020 National Emissions Inventory, Reworld TTFs make up less than 1% of local PM2.5 emissions, with the aforementioned sources making up nearly a third of PM2.5 emissions in the same airsheds.[4] Additionally, recently published studies have concluded that TTF emissions were negligible relative to typical exposures in urban environments and highways.[6] One study concluded that emissions of ultrafine particles (sometimes called nanoparticles) from TTF stacks are lower than one single heavy-duty vehicle.[7]

> ***"The [nanoparticle concentrations] produced by MSW incineration plants are generally reported similar to rural background."***[4]
> *Atmospheric Environmental Journal*, 2013

What about NOx?

Nitrogen Oxides, or "NOx", are gases formed during combustion that can contribute to ground-level ozone or smog. TTF facilities must meet stringent permit limits on NOx emissions. Reworld's proprietary Low NOx (LN™) technology is in use at numerous facilities to minimize NOx formation. TTFs are also typically equipped with selective non-catalytic reduction (SNCR) systems to reduce NOx emissions.

According to the 2020 National Emissions Inventory, TTFs account for 3% of NOx emissions, on average, in the counties in which they operate. Mobile vehicles, including cars and trucks are the largest source, contributing 60% of local NOx emissions.[3]

For more information, please e-mail us: sustainability@reworldwaste.com

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References

[1] U.S. EPA. (2007). Letter from Walt Stevenson, OAQPS/SPPD/ESG (D243-01) to Large MWC Docket, (EPA-HQ-OAR-2005-0117), https://downloads.regulations.gov/EPA-HQ-OAR-2005-0117-0164/content.pdf.

[2] Dwyer, H. and Themelis, N.J. (2015). Inventory of U.S. 2012 dioxin emissions to atmosphere. *Waste Management*, **46**, 242-246. http://dx.doi.org/10.1016/j.wasman.2015.08.009.

[3] U.S. EPA. 2020 National Emissions Inventory (NEI) Data. https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-data.

[4] Kumar, P., L. Pirjola, M. Ketzel, and R.M. Harrison. (2013). Nanoparticle emissions from 11 non-vehicle exhaust sources – a review. *Atmospheric Environment*, **67**, 252-277.

[5] Themelis, N.J., and Bourtsalas, A.C. (2019). Major sources of mercury emissions to the atmosphere: The U.S. case. *Waste Management*, **85**, 90-94. https://doi.org/10.1016/j.wasman.2018.12.008

[6] Buonanno, G. and L. Morawska. (2015). Ultrafine particle emission of waste incinerators and comparison to the exposure of urban citizens. *Waste Management*, **37**, 75-81. http://dx.doi.org/10.1016/j.wasman.2014.03.008.

[7] HDR Engineering, Inc. (2017). Metro Health impact Assessment Evaluation of Landfill and Waste To Energy Options for Managing Municipal Solid Waste. https://www.oregonmetro.gov/sites/default/files/2017/07/06/Metro_WTE_Landfill_HIA_Final_with_appendices_20170706.pdf