

Systems & Equipment Opportunities



In

Waste Heat Recovery for Improved Process Efficiency

Research conducted for Babcock & Wilcox

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Background

- US industry consumes approx. 32 quadrillion btu of energy per year
- Between 20% and 50% of that energy is rejected to the environment
 - Hot exhaust gas and liquid discharges
 - Heat convection, conduction, radiation
- Captured and reused waste heat can provide an emissions-free substitute for purchased fuel or electricity
- Drivers for waste-heat recovery include **increased process efficiency, lower operating costs, and protection of the environment**
- **Despite well-known and widely used heat recovery equipment, it is estimated that between 5 to 13 quadrillion btu of waste heat remains unrecovered from US industrial processes**
- **Economic value of unrecovered industrial waste heat is between \$25-B and \$65-B per year, just in the United States, at a natural gas cost of \$5/MMBtu**



Waste Heat Opportunities

- Waste-heat opportunities require the following:
 - Source of waste heat
 - **Recovery technology**
 - End use for recovered energy
- Waste heat sources are **“traditional”** or **“non traditional”**
 - Traditional Sources include:
 - Hot exhaust gases, i.e., stack gases, from power plants, gas turbines, cement kilns, refineries, petrochemical plants, coking units, FCC units, thermal oxidizer gases, incinerators, other industrial sources
 - Non-Traditional Sources include:
 - Radiative side-wall losses on furnaces, reactors, piping, etc
 - Heat-loss from manufactured goods including hot-poured or rolled ingot and sheet steel or aluminum, hot glass, waste slag, other
 - Process off-gases
 - Condenser and equipment cooling air or cooling water



Traditional Heat Sources

- Experience has shown that waste heat is most often re-captured from “traditional” sources providing high quality waste heat that is generally relatively **clean** and at a **high-temperature** (a thousand degrees Fahrenheit, or more), and used to generate steam. Such sources include:
 - Coal-fired power plant stack gas
 - Simple cycle and combined cycle gas turbine stack gas
 - Other industrial heat sources including cement plants, refineries, petrochemical plants, metal smelting, others
 - **Traditional waste heat sources are already a significantly developed resource serviced by HRSGs, regenerators, recuperators, and other heat-exchanger equipment**



Non-Traditional Heat Sources

- Non-traditional waste heat is often at a relatively **low temperature** (several hundred degrees Fahrenheit) and less easily recovered in terms of equipment design and availability
- Non-traditional waste heat often requires a **new set of end-use applications**, separate and distinct from the steam-generation, combustion air preheating and boiler feedwater pre-heating for traditional applications.
- Low-quality waste heat represents a currently under-utilized resource



Summary of Waste Heat Sources and End Use Applications

Waste Heat Sources and Uses

Waste Heat Sources	Uses for Waste Heat
<ul style="list-style-type: none"> • Combustion Exhausts: <ul style="list-style-type: none"> Glass melting furnace Cement kiln Fume incinerator Aluminum reverberatory furnace Boiler • Process off-gases: <ul style="list-style-type: none"> Steel electric arc furnace Aluminum reverberatory furnace • Cooling water from: <ul style="list-style-type: none"> Furnaces Air compressors Internal combustion engines • Conductive, convective, and radiative losses from equipment: <ul style="list-style-type: none"> Hall-Hérout cells ^a • Conductive, convective, and radiative losses from heated products: <ul style="list-style-type: none"> Hot cokes Blast furnace slags ^a 	<ul style="list-style-type: none"> • Combustion air preheating • Boiler feedwater preheating • Load preheating • Power generation • Steam generation for use in: <ul style="list-style-type: none"> power generation mechanical power process steam • Space heating • Water preheating • Transfer to liquid or gaseous process streams

a. Not currently recoverable with existing technology



Opportunities in Non-Traditional Low Quality Waste Heat



Sources for Low Quality Waste Heat

- Low quality waste heat may be characterized by a relatively low temperature in the range of 100F to 400F
- Possible sources include:
 - Cooling water
 - Many sources including: power plant condenser cooling, general industrial machinery cooling, compressor cooling, etc.
 - Cooling air
 - Many sources including: power plant “dry cooling”, general industrial machinery cooling, compressor cooling, etc
 - Sub-cooling of flue gas below condensation dew point temperature using deep economizers



End Uses for Low Quality Waste Heat

- Possible applications for low-quality waste heat include:
 - Domestic hot water for the industrial plant
 - Space heating for the industrial plant
 - Low temperature process heating (food & beverage processing, etc)
 - Low temperature power generation
 - Non-traditional power cycles including Organic Rankine Cycles using special organic liquids like alcohol or other organic liquid with a lower boiling point than water
 - Direct heat-to-electricity conversion with thermoelectric generators
 - Other power generating techniques including piezoelectric



Equipment Needs in Low Quality Waste Heat

- Higher efficiency, smaller size low-temperature heat exchangers
- Corrosion resistant heat exchangers, particularly for flue gas vapor condensing applications



Low Quality Waste Heat Equipment Suppliers

- TBD