# **Recommendation ${REC}: Install Heat Exchanger to Recover Heat from Exhaust Gas**

**Recommended Action**

Recover exhaust heat from the thermal oxidizer and use this recovered heat to preheat the air for the drying ovens by applying a heat exchanger.

**Summary of Estimated Savings and Implementation Costs**

|  |  |
| --- | --- |
| Annual Cost Savings | ${ACS} |
| Implementation Cost | ${MIC} |
| Payback Period | ${MPB} |
| Annual Natural Gas Savings | ${NGS} MMBtu |
| Annual Electricity Savings | ${ES} kWh |
| Annual Demand Savings | ${DS} kW |
| ARC Number | 2.2442.2 |

**Current Practice and Observations**

The furnace is exhausting heat to the atmosphere at about ${TI}oF with a volume of ${CFM} CFM. This exhaust heat can be recovered for use in the plant.

**Anticipated Savings**

The potential natural gas savings, NGS, can be estimated as follows:

NGS = CFM × ρ × C1 × CP × (TI - TO) × η × OH / C2

where,

CFM = Total exhaust flow rate of furnaces: ${CFM} ft3/min

ρ = Density of exhaust gas (at ${TI}oF): ${RHO} lb/ft3

C1 = Conversion constant: 60 min/h

CP = Specific heat of exhaust gas[[1]](#footnote-1) (at ${TI}oF): ${CP} Btu/lb⋅°F

TI = Temperature of exhaust air at the entry of heat exchanger: ${TI}°F

TO = Temperature of exhaust air at the exit of heat exchanger: ${TO}°F

η = Efficiency of air-air heat exchanger: conservatively ${ETA}% (depends on design)[[2]](#footnote-2)

OH = Oxidizer operating hours: ${OH} hrs/yr (${HR} hrs/day, ${DY} days/wk, ${WK} wks/yr)

C2 = Conversion constant: 1,000,000 Btu/MMBtu

Using the parameters discussed above, the natural gas savings, NGS, can be calculated as follows:

NGS = ${CFM} ft3/min × ${RHO} lb/ft3 × 60 min/h × ${CP} Btu/lb⋅°F × (${TI} °F - ${TO} °F) × ${ETA} × ${OH} hrs/yr / 1,000,000 Btu/MMBtu

= ${NGS} MMBtu/yr.

There will be an increase in electrical energy as a fan will be required to move the hot air through the heat exchanger and into the oven inlets. The associated cost is as follows:

HP = Fan horsepower: ${HP} HP

C3 = Conversion constant: 0.746 kW/HP

CF = Coincidence factor: ${CF}% per month

C4 = Conversion constant: 12 mos/yr

The potential fan electricity usage, EU, can be calculated as follows:

EU = HP × C3 × OH

= ${HP} HP × 0.746 kW/HP × ${OH} hrs/yr

= ${EU} kWh/yr

The potential fan demand usage, DU, can be calculated as follows:

DU = HP × C3 × CF × C4

= ${HP} HP × 0.746 kW/HP × 12 mos/yr × ${CF}%/mo

= ${DU} kW/yr

The total annual cost savings, ACS, is equal to:

ACS = NGS × Natural Gas Cost - EU × Electricity Cost - DU × Demand Cost

= ${NGS} MMBtu/yr × ${NGC}/MMBtu - ${EU} kWh/yr × ${EC}/kWh - ${DU} kW/yr × ${DC}/kW

= ${NGCS}/yr - ${EUC}/yr - ${DUC}/yr

= ${ACS}/yr

**Implementation Cost**

The implementation cost is associated with installing the heat exchanger, fan, and ducting to the existing oven inlets. This is estimated at ${IC}.<REBATE>

However, there could be energy efficiency rebates available through your utility company, which could potentially reduce the overall capital cost and thereby the payback period. The savings from the rebate is calculated below.

RB = ${NRR}⋅yr/kWh × NGS

= ${NRR}⋅yr/kWh × ${NGS} kWh/yr

= ${RB}

The incentives are capped at 50% of the project cost, which makes the modified rebate savings, MRB, equal to ${MRB}. Hence, the modified implementation cost, MIC, is estimated as follows:

MIC = IC - MRB

= ${IC} - ${MRB}

= ${MIC}

The modified implementation cost is ${MIC}.</REBATE>

**The annual natural gas savings for this recommendation will be ${NGS} MMBtu. The estimated annual cost savings is likely to be ${ACS} and, with ${MIC} in implementation costs, the payback period will be ${MPB}.**

**Implementation Cost References**

The below links are for implementation cost references. We do not endorse/recommend these brands or products. Furthermore, these products may or may not be suitable for the application. The client should contact a vendor(s) to conduct a detailed study of the process, in

order to determine the best product for the recommended application.[[3]](#endnote-1)[[4]](#endnote-2)[[5]](#endnote-3)

1. Density and specific heat of exhaust gas is approximated to the properties of air. [↑](#footnote-ref-1)
2. Sunden, B. "Heat exchangers and heat recovery processes in gas turbine systems." *Modern Gas Turbine Systems*. Woodhead Publishing, 2013. 229. Cited as 80-93% [↑](#footnote-ref-2)
3. A Guide to Heat Exchangers for Industrial Heat Recovery- New York State Energy Research and Development Authority cites the payback period for heat recovery - specifically, economizers and waste heat from boilers- between 2 and 3 years. [↑](#endnote-ref-1)
4. Boiler Economizer Systems - Presented by: Hayward Burton, H.V. Burton Co. cites the average payback period for economizers and other heat recovery as 3 years. [↑](#endnote-ref-2)
5. Willems, Daniel. “Advanced System Controls and Energy Savings for Industrial Boilers.” ASME 2006 Citrus Engineering Conference, 2006, <https://doi.org/10.1115/cec2006-5202>. Cites the payback period as 2 years for heat recovery projects. [↑](#endnote-ref-3)