Waste Heat Recovery Power Generator

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Introduction – Why recover waste heat?

**Current Situation**

- Increasing energy prices and CO₂ emission controls
- 20-50% of industrial energy consumption released as waste heat
- Proven technology

**Industry changes**

- Mandate for “Green facility & footprint”
- Convert waste heat into monetary value in the form of electricity
- Can be applied to several industrial applications

Huge potential in waste heat recovery although not known
As other alternative energy types like solar, wind, biomass
Waste heat sources in an Oil & Gas complex

**DIESEL ENGINES:**

- Typical Diesel Engine Shaft Power Efficiency: ~ 40-45%
- Exhaust Temperature: 850 – 950 °F
- Exhaust Gas Thermal Loss: ~ 30-35%
- Jacket Cooling Thermal Loss: ~ 15-20%

**GAS TURBINES:**

- Typical Gas Turbine Shaft Power Efficiency: ~ 40-45%
- Exhaust Temperature: 800 - 900 °F
- Exhaust Gas Thermal Loss: ~ 50-55%
Organic Rankine Cycle (ORC) Generator

BASIC COMPONENTS OF ORC UNIT

High Pressure Organic Working Fluid Vapor

Heat Source
Thermal oil or high pressure hot water

Heat exchanger/evaporator

Turbine

Power generator

Condenser

Cooling water

Low-pressure steam piping

High-pressure piping

Low-pressure piping

Pump
ORC Power Generator Unit

Units are available from 250 kW up to 10 MW
ORC System Properties

• Working fluid R245fa or Silicon based depending on the resource temperature

• Heat source: Hot water or Thermal Oil 195–580F (91° - 305° C)

• Cooling requirement: Water 39F–109F (4° - 43° C)

• Controls: PLC with Remote monitoring Web-based gateway Operation

• Designed for unattended operation

• Enclosure Not required
Waste heat recovery diagram for Gas turbines & Diesel Engines
Sample data for Gas Turbines

• Turbine Shaft Power: 10,000 HP (7457 kW)
• Exhaust Waste Heat Recovery: 9,750 kW
• Net ORC power: ~ 2243 kW (at 23% efficiency)
• Thermal Oil: ORC inlet 570°F / ORC outlet 410°F (300°C / 210°C)
• Thermal Oil Flow: ~ 102 lbs/sec (46 kg/sec)
• Cooling Water: inlet 81°F / Outlet 108°F or (27°C / 42°C)
• Cooling Water Flow: ~ 1900 GPM (430 m3/h)
• Heat Exchanger Size: 33.2 MMBTU

~30% of Turbine Shaft Power
ORC Payback calculations

Return On Investment (without incentives and not considering future escalation of electricity prices)

Price of Electricity ($/kW)

Pay off Years

- $2000/kW
- $2500/kW
- $3000/kW
- $3500/kW
ORC Advantages

- Auto Start/Stop
- Ability to work with low temperature heat source
- Partial load capability down to 10% power with high efficiency
- Low maintenance, no operator required for operation
- Design life ~ 20 years
- Quiet Operation
- High availability > 98%
Application Examples
Other ORC applications

Steel Mills

Patent Pending
Configuration
ORC generator slab furnace evaporative cooling application
Recent Heat Recovery Project in Turkey

Recovery from slab furnace evaporative cooling system:

- Installed power capacity 1 MW
- Resource Temperature : 140C
- In operation since September 2011
- Typical waste steam was about 16 tons/hour
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Recent Heat Recovery Project in Turkey

BEFORE

AFTER

NO MORE WASTE OF STEAM
Recent Heat Recovery Project Pictures
Recent Heat Recovery Project Pictures
Recent Heat Recovery Project Pictures