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how-to-get-started-waste-heat-to-power-by-infinity-turbine

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How to Get Started with Harvesting Waste Heat Using Organic Rankine Cycle (ORC) or Supercritical CO2 Expander



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Learn how to harness waste heat effectively using Organic Rankine Cycle (ORC) or supercritical CO2 expanders. This guide covers key steps, benefits, and technologies for converting waste heat into valuable energy, ideal for industrial and data center applications.

PDF Version of the webpage (first pages)

<https://infinityturbine.com/how-to-get-started-waste-heat-to-power-by-infinity-turbine.html>

How to Get Started with Harvesting Waste Heat Using Organic Rankine Cycle (ORC) or Supercritical CO2 Expander

Waste heat is an often overlooked resource that can provide a valuable source of energy for both industrial and commercial applications. By harvesting this waste heat, you can improve overall energy efficiency, reduce operational costs, and contribute to sustainability efforts. In this guide, we will discuss how to get started with waste heat harvesting using technologies like the Organic Rankine Cycle (ORC) and supercritical CO2 (sCO2) expanders that can power a generator.

Step 1: Assess the Waste Heat Resource

The first step in harvesting waste heat is to determine whether you have a sufficient and viable source of waste heat. Consider the following:

- **Temperature Range:** Determine the temperature range of your waste heat. The ORC is ideal for low- to medium-grade waste heat (typically 70°C to 300°C), whereas supercritical CO2 systems start at 31°C and are more efficient at higher temperatures (100°C and above).
- **Heat Source Location:** Identify where the waste heat is generated. Common sources include exhaust gases from industrial processes, cooling systems from data centers, and waste steam from power plants.
- **Availability:** Evaluate how consistently the waste heat is available (e.g., continuous, intermittent). A consistent source is preferred for optimal power generation.

Step 2: Choose the Right Technology

- **Organic Rankine Cycle (ORC):** ORC systems operate similarly to steam Rankine cycles but use an organic working fluid with a lower boiling point than water, making them suitable for low-grade waste heat. The heat is transferred to the organic fluid, causing it to vaporize and drive a turbine connected to a generator.
- **Supercritical CO2 (sCO2) Expander:** sCO2 operates above the critical point of CO2 (31°C), combining properties of both liquids and gases. This enables high efficiency for waste heat conversion into electricity, especially for higher temperatures (above 100°C). The sCO2 expands through a turbine to generate electricity with minimal energy loss. CO2 is 10-100 more dense than steam, at varying temperatures.

Step 3: Size the System

Sizing the waste heat recovery system is critical to maximize efficiency and return on investment (ROI). Key factors include:

- **Heat Availability:** Calculate the total thermal energy available per hour (e.g., in BTU/hr or kWh).
- **Power Output Requirements:** Determine the power output you want to achieve and size the turbine, generator, and heat exchanger accordingly.
- **Heat Exchanger:** Choose an appropriately sized heat exchanger to transfer heat efficiently from the waste heat source to the working fluid. For low-grade heat, larger heat exchangers may be required.

Step 4: Install and Integrate Components

Once the system is sized, install the necessary components:

- **Heat Exchanger:** Capture heat from the source and transfer it to the working fluid.
- **Turbine or Expander:** Use an ORC turbine or an sCO2 expander to convert the heat into mechanical energy.
- **Generator:** Connect the turbine to an electrical generator to produce electricity.
- **Control System:** Implement a control system to monitor fluid temperatures, pressures, and flow rates, ensuring efficient and safe operation.

Step 5: Monitor and Optimize

- **Data Collection:** Continuously collect data on the temperature, pressure, and power output of the system.
- **Performance Optimization:** Use the data to optimize performance, adjusting turbine speed or heat exchanger flow rates for maximum efficiency.

Comparison: Low-Grade Waste Heat vs. Solar Photovoltaic Panels

When deciding between using low-grade waste heat and solar photovoltaic (PV) panels for electricity generation, it is important to consider the costs, efficiency, and practical implications of each option.

1. Cost Considerations

- **Low-Grade Waste Heat Recovery:**
 - The initial capital cost for ORC or sCO2 systems can be relatively high due to the requirement for specialized components (turbine, heat exchanger, control systems).
 - If you already have a source of waste heat, utilizing it represents an opportunity to make use of an existing resource, which can improve the ROI over time.
 - Maintenance costs can also be higher compared to PV panels, as moving parts such as turbines require periodic servicing.
- **Solar Photovoltaic Panels:**
 - Solar PV panels have become extremely inexpensive due to advancements in manufacturing and economies of scale.
 - The capital cost is lower compared to a complete waste heat recovery system, especially for smaller installations. Solar panels have no moving parts, resulting in minimal maintenance costs.
 - However, solar PV panels require a large surface area for installation, which can be a limiting factor for some sites.

2. Efficiency and Output

- **Low-Grade Waste Heat Recovery:**
 - The efficiency of ORC systems for low-grade waste heat is relatively low, typically ranging between 4-10%, due to the low temperature of the heat source.
 - Supercritical CO2 systems can achieve higher efficiencies but are better suited for higher temperature sources. They are generally more efficient at converting heat to power than ORC systems when the temperature exceeds 100°C, but can be useful at 31°C where liquid CO2 goes supercritical, and can be used to make power.
- **Solar Photovoltaic Panels:**
 - Solar PV panels have an efficiency of around 15-22%, depending on the type of panel (e.g., monocrystalline, polycrystalline).
 - The power output of solar panels is directly dependent on sunlight availability, making them less consistent compared to waste heat, which may be available continuously in an industrial process.

3. Practical Considerations

- **Low-Grade Waste Heat Recovery:**
 - Best suited for industries or facilities that have continuous waste heat generation, such as manufacturing plants, refineries, or data centers. It requires a waste heat source with a stable temperature.
 - Installing a waste heat recovery system may be more complex due to the need for integration with existing processes, heat exchangers, and space requirements for the turbine and generator.
