

# Organic Rankine Cycle Power Generation





**Large Engines**

**Organic Rankine Cycle**



## Power Systems

**EPC Service**



**After market**



**Mobile Power**



**Marine**



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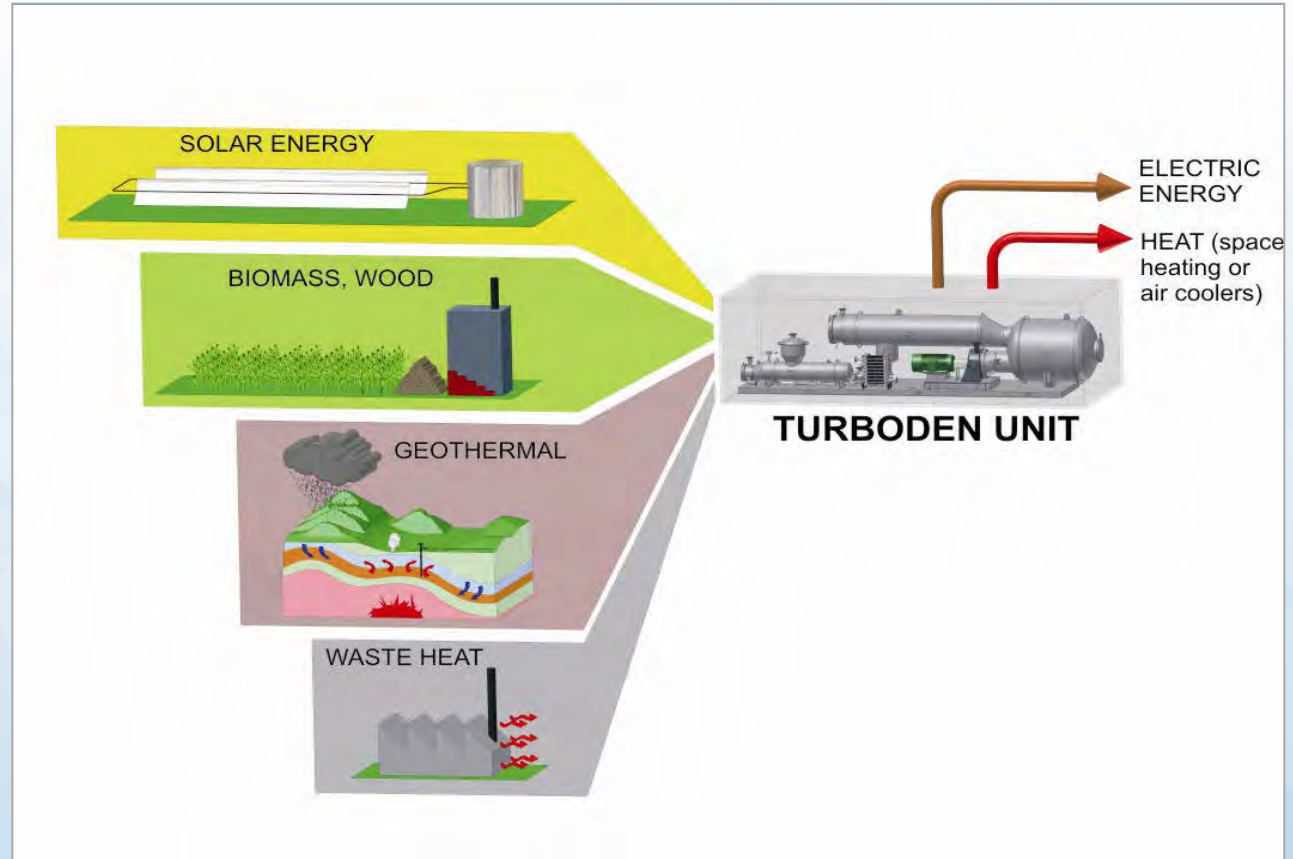


**Power Systems**

- Acquisition announced Dec. 2012
- Regulatory approvals underway
- Planned completion in 2Q13

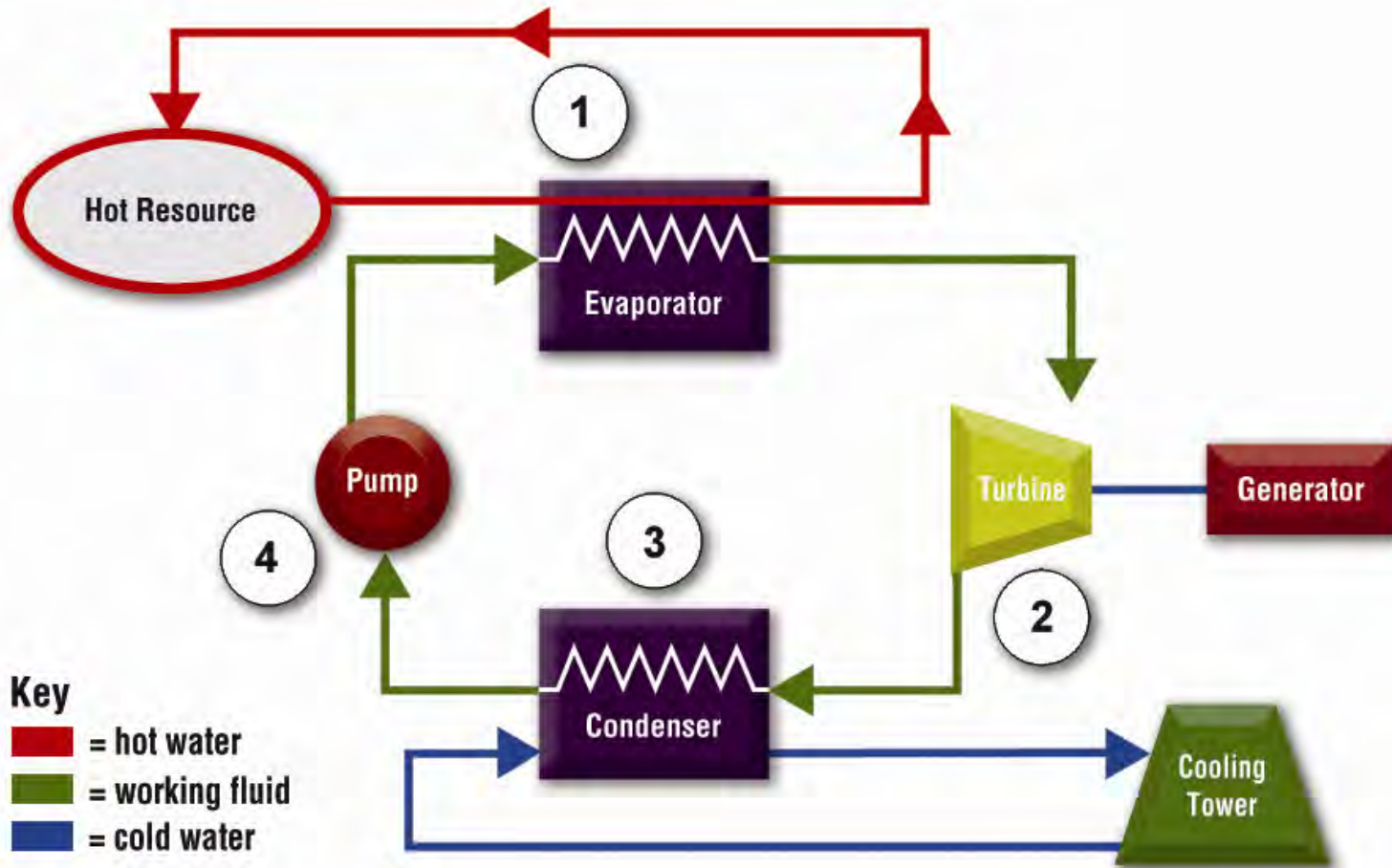
# ORC Applications

- **PWPS / Turboden designs & manufactures Organic Rankine Cycle (ORC) turbogenerators**
- **30 years of ORC experience**
- **Sizes from 1MW to 10 MW and up.**





# The Organic Rankine Cycle (ORC)

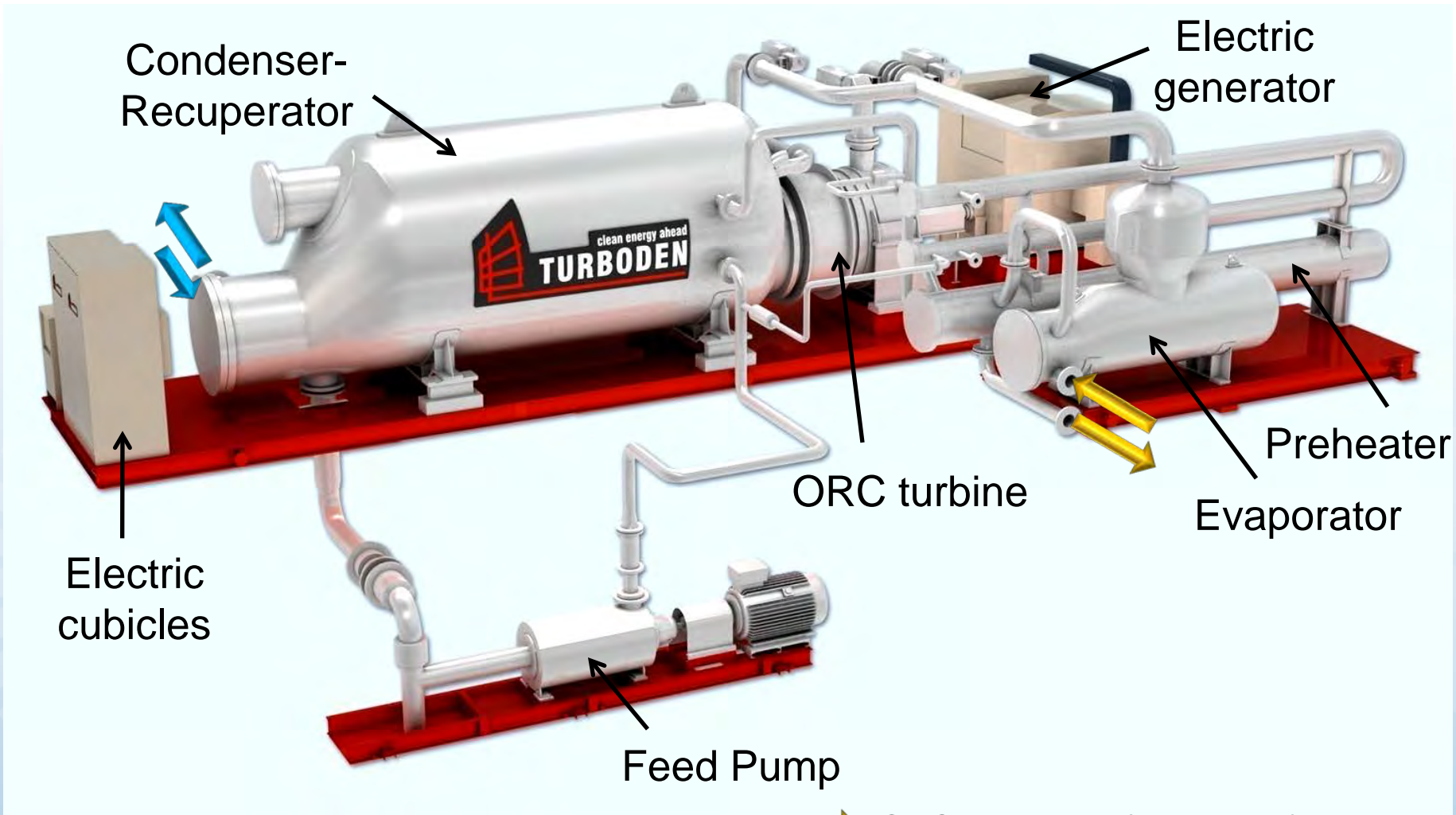


*Heat In – Power Out*

# Efficiency is a Function of Temperature

<b>EFFICIENCY</b>	<b>APPLICATION</b>	<b>HEAT CARRIER</b>	<b>HEAT RELEASE</b>
<b>25%</b>	Biomass / Heat Recovery / CSP	Thermal Oil 590° F	Water 80° F
<b>19%</b>	Biomass (CHP)	Thermal Oil 590° F	Water 170° F
<b>19%</b>	Heat Recovery	Thermal Oil 530° F	Water 80° F
<b>16%</b>	Geothermal / Heat Recovery	Water 355° F	Water 85° F
<b>10%</b>	Geothermal	Water 220° F	Water 50° F
<b>7.5%</b>	Geothermal / Heat Recovery	Water 195° F	Air 60° F

# TD UNITS – MAIN COMPONENTS

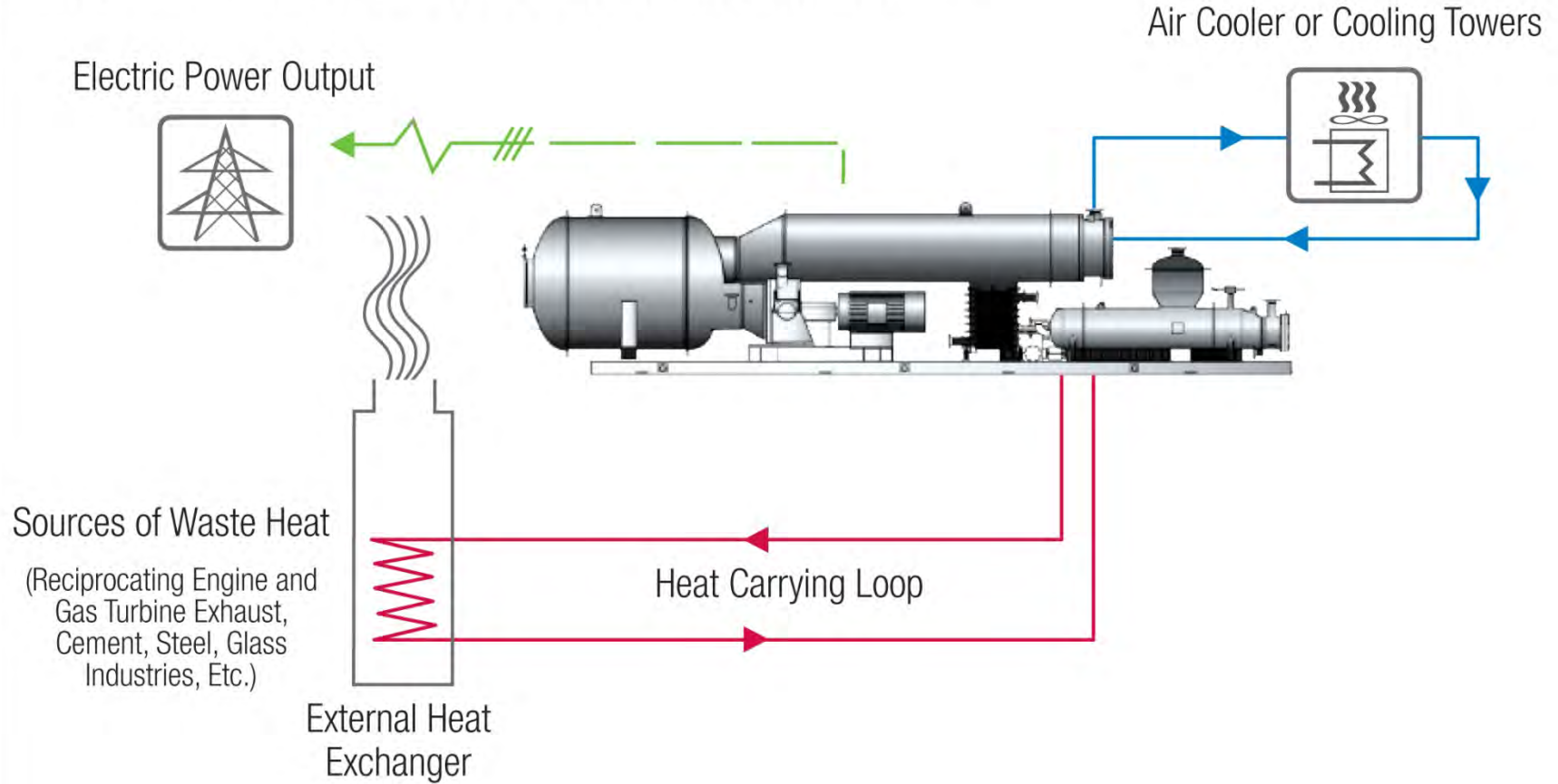


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# Heat Recovery Applications (HR & HRS)

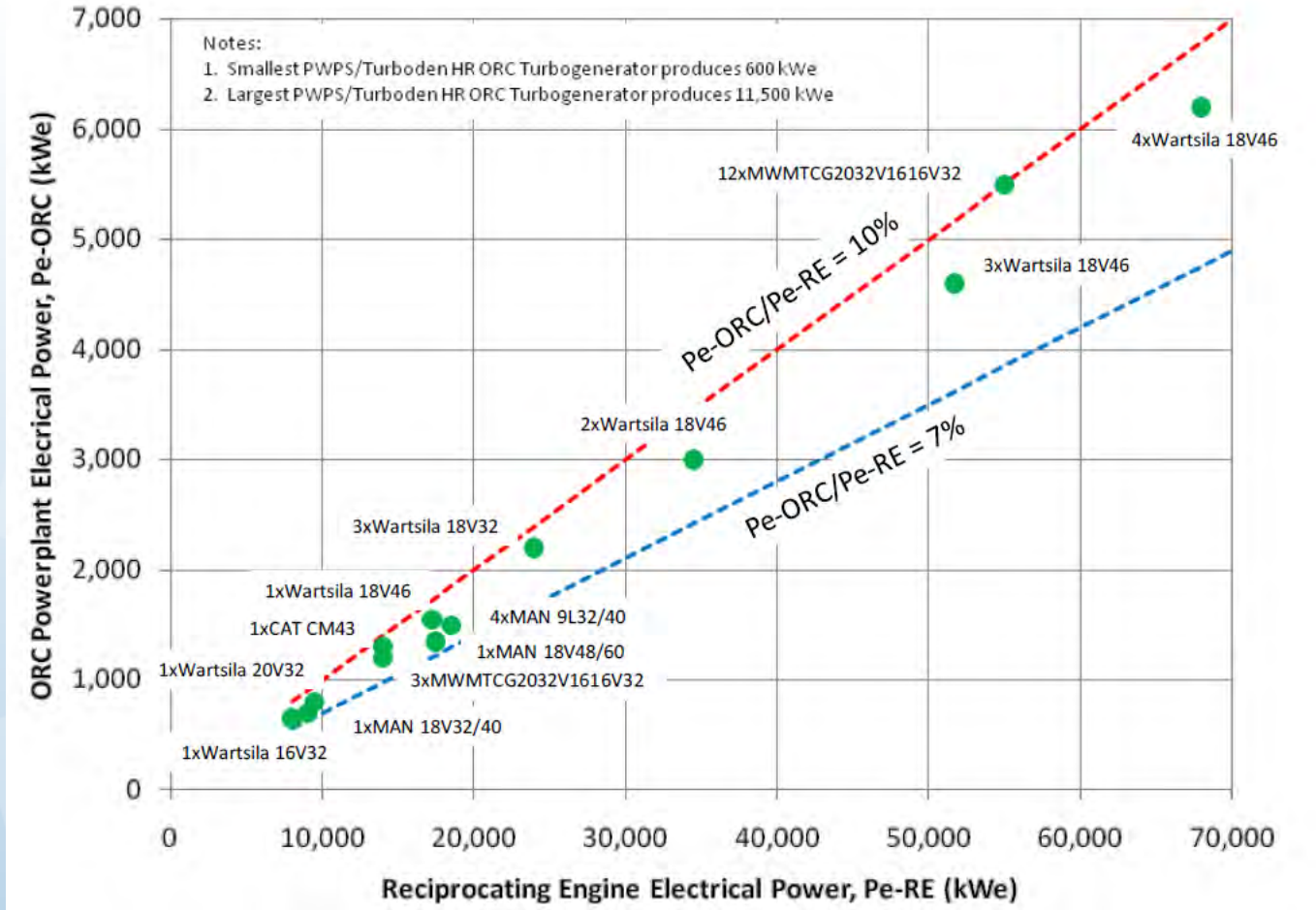


## Example of ORC Waste Heat to Power Applications



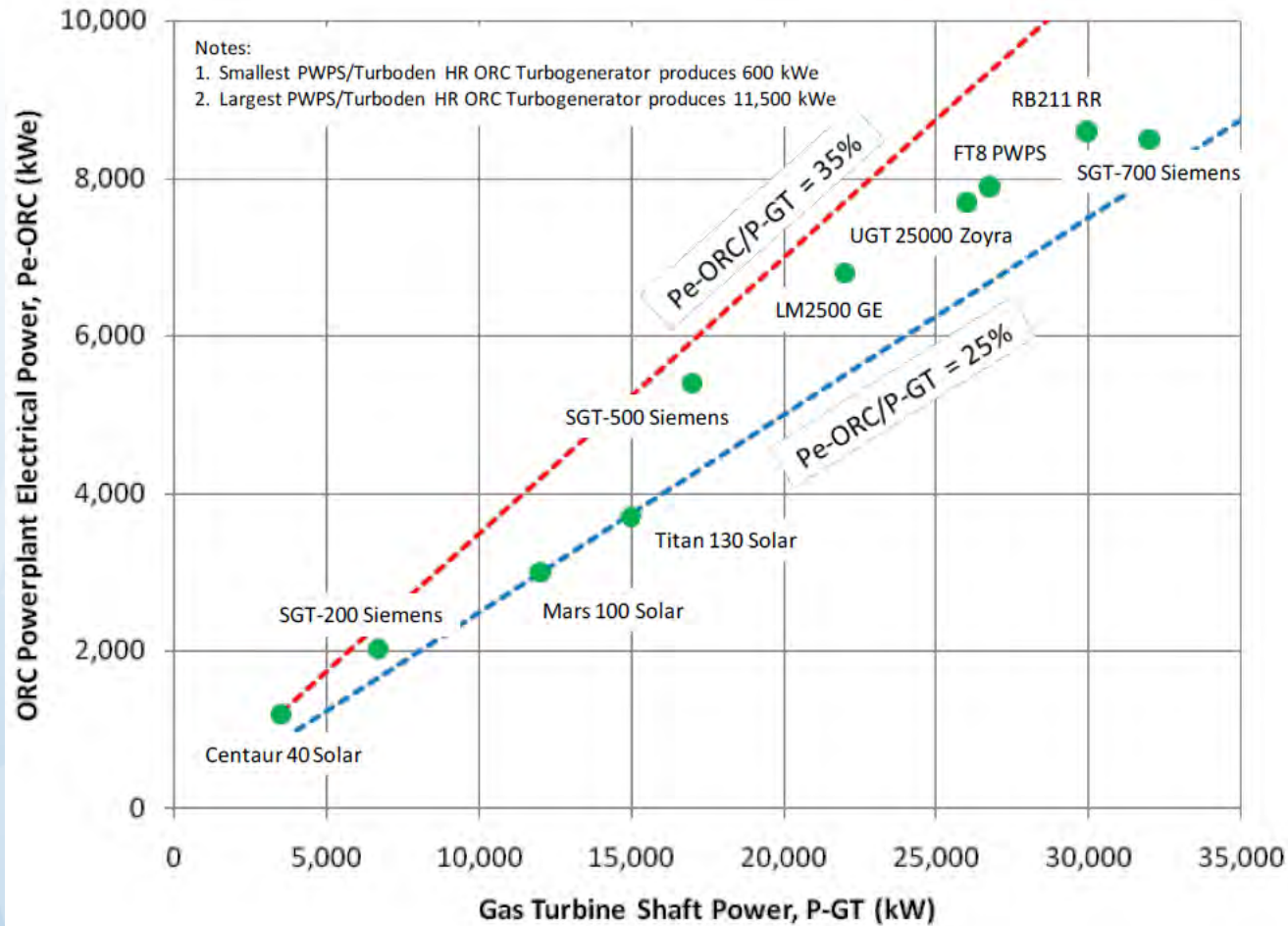


# IC Engine – TYPICAL OUTPUTS



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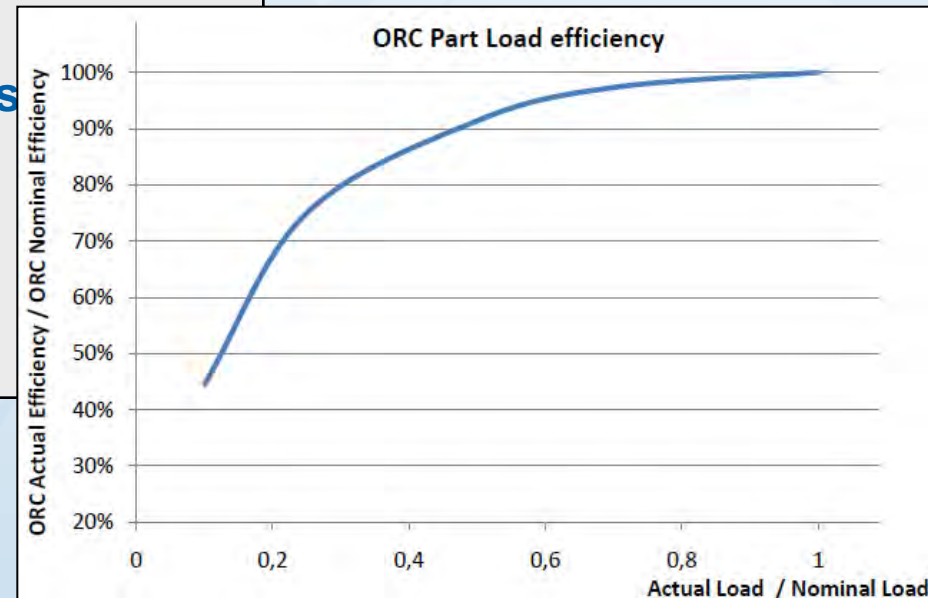
# GAS TURBINES – TYPICAL OUTPUTS

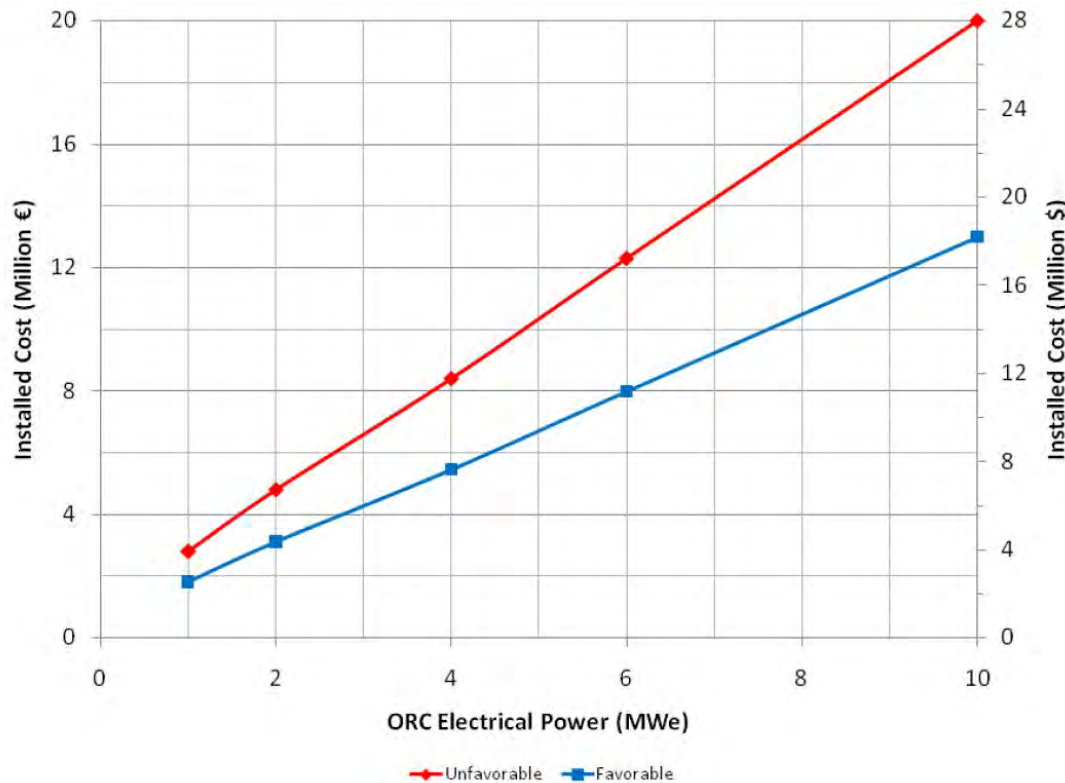


**NOTE:** Indicative values assuming ambient air temperature of 15°C, Gas Turbines operating at nominal load; calculations based on Gas Turbine exhaust gas properties as reported in specific suppliers web sites.

# SYSTEM ADVANTAGES

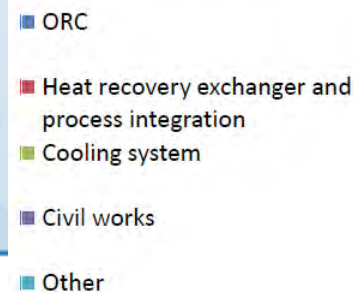
- Completely automated – no operator in most case
- Do not consume water
- Remotely monitored and controlled
- Very low O&M Costs
- No effect on main power plant operation
- Maintains good efficiency at partial load
- Turn-down to 10% of nominal power
- Low turbine RPM, low mechanical stress
- Simple Start/Stop procedures
- Can reach efficiencies up to 25%
- Quiet Operation





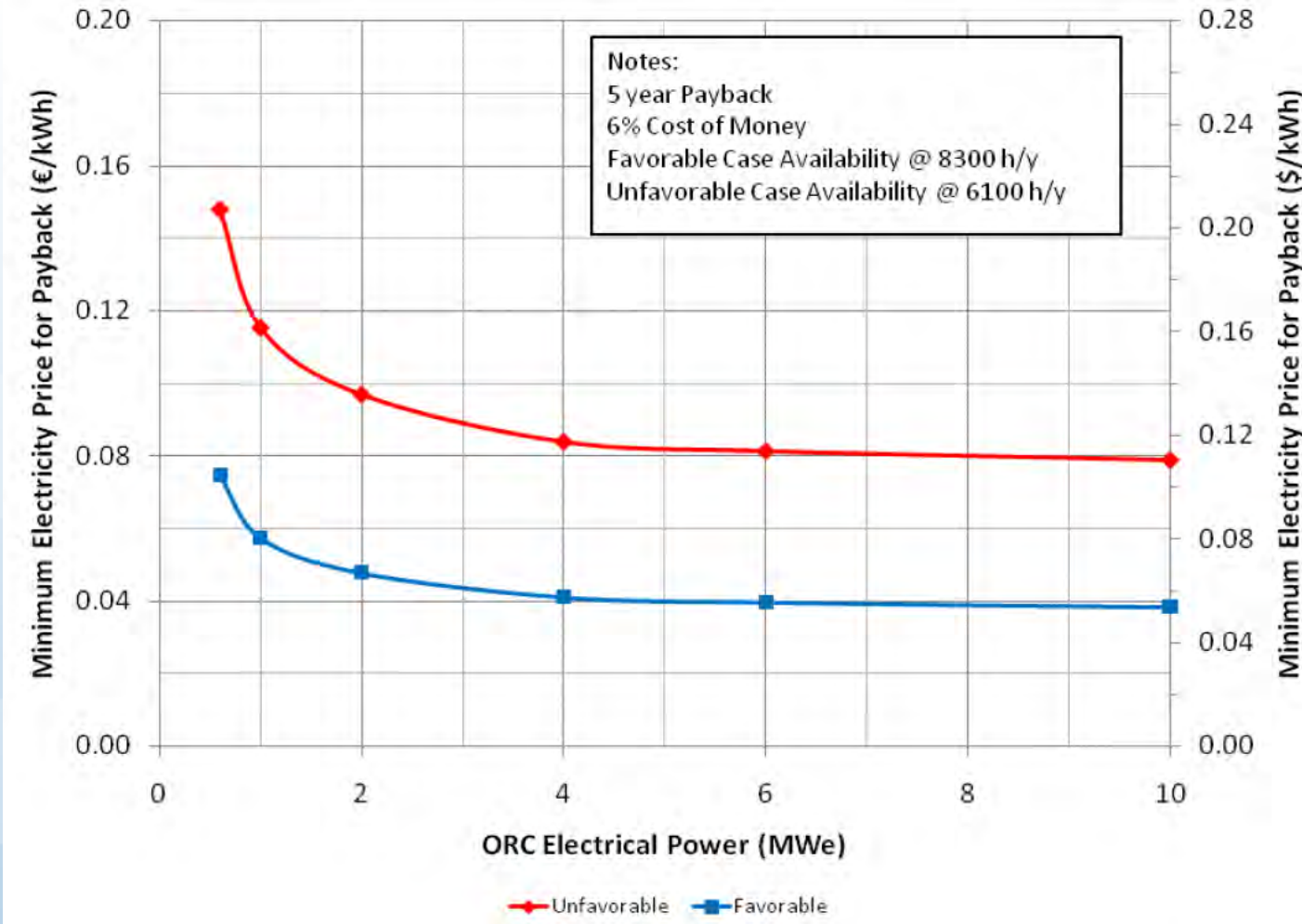
- Installed cost varies widely
- ~\$1800 – \$3000/kW
- Depends on:
  - Heat quality and Accessibility
  - Cooling: air/temp, water/humidity
  - Electrical interconnect
  - Project location
  - Labor rates

Heat Recovery System: Major Items Relative Costs





# Electricity Price for 5yr Payback



# THANK YOU !



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