Waste Heat Recovery Systems

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Training on
Energy Efficiency and Conservation
conducted by
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Overview

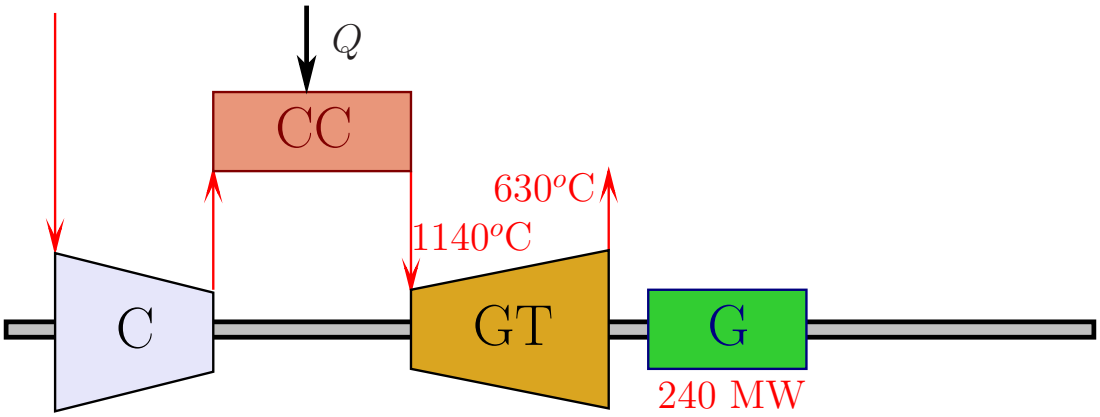
Factors Affecting Waste Heat Recovery

- Temperature of waste heat source
- Minimum temperature to which waste heat can be cooled
- Temperature to which the designed fluid is to be heated
- Flow rate of the fluid
- Chemical composition of waste fluid
- Properties of waste fluid (C_p, μ, ρ, k)
- Corrosive elements in the exhaust fluid

Classifications of WHR Equipment

- Gas-to-gas heat exchanger (Graphite heat exchangers, stack-type recuperators, direct contact recuperator, plate fin (ceramic and metal)heat exchangers and ceramic tubes)
- Gas-to-liquid heat exchanger (waste heat boilers, economizers and power generators)
- Liquid-to-liquid heat exchanger (shell-and-tube, spiral, coil, finned-tube, plate-and-frame (plate), and run-around heat exchangers)
- Other low-temperature WHR equipment (heat pumps, and heat pipes)

Gas Turbine Cycle



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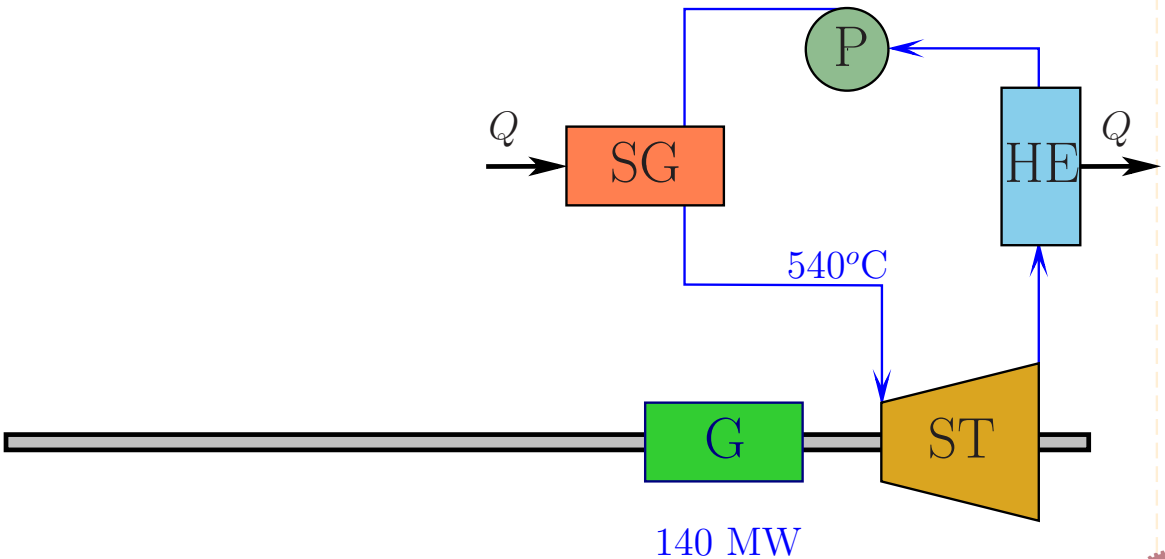
Rankine Cycle



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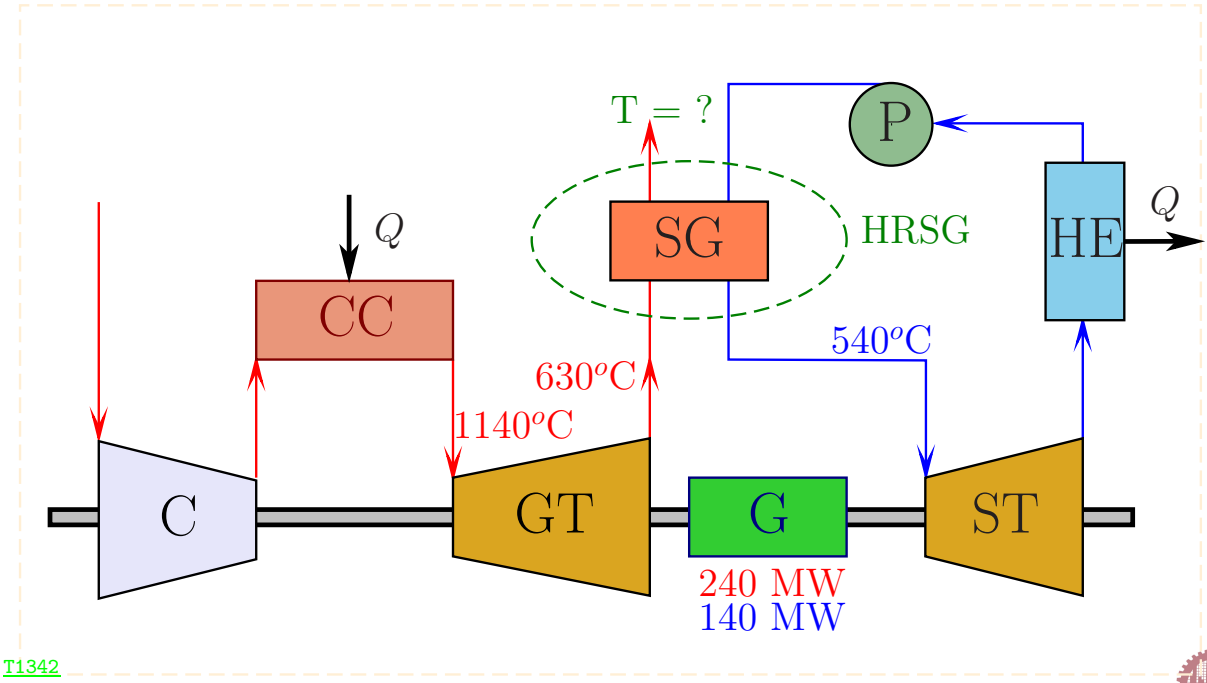
Combined Gas Turbine + Rankine Cycle



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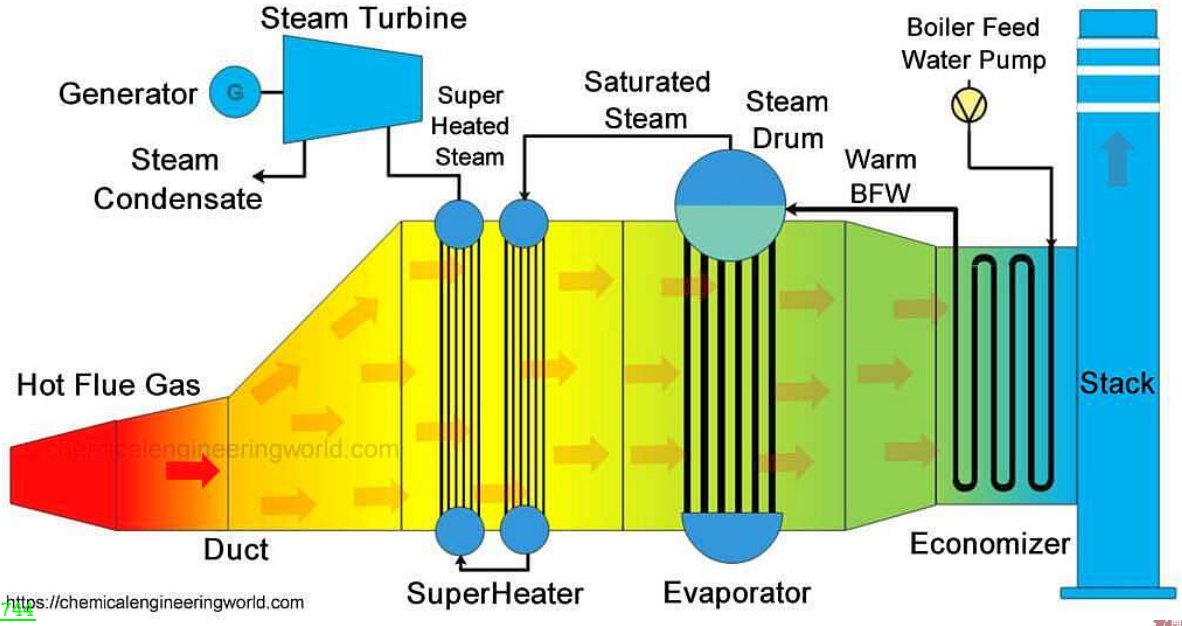
Waste Heat Recovery Boiler



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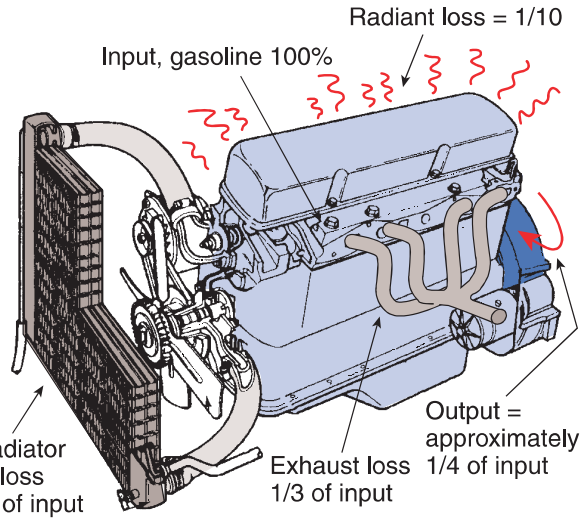
Engine Energy Balance



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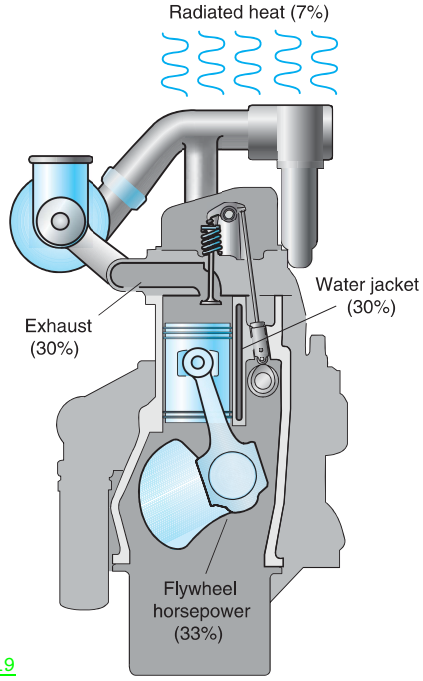

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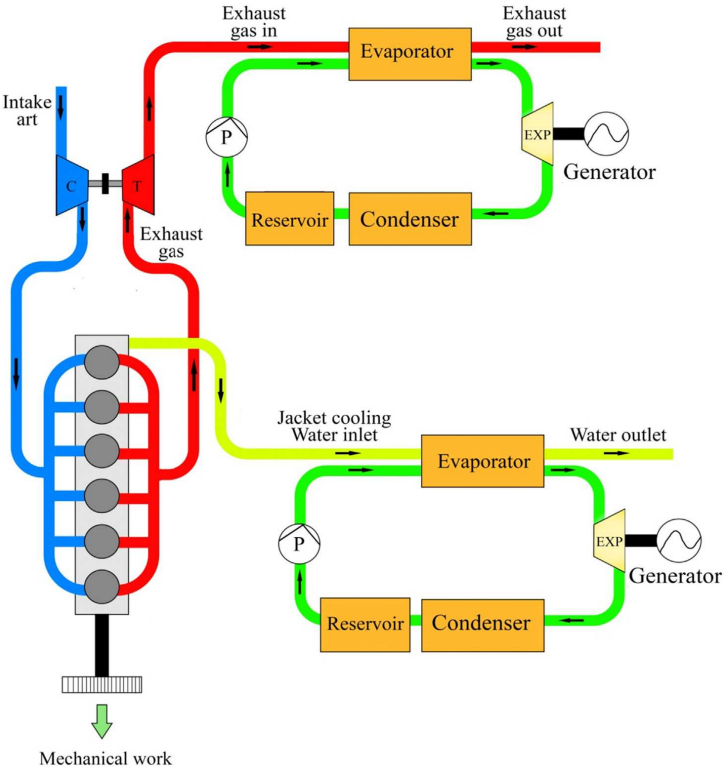
SI Engine *CI Engine*

Engine Waste Heat Recovery using ORC



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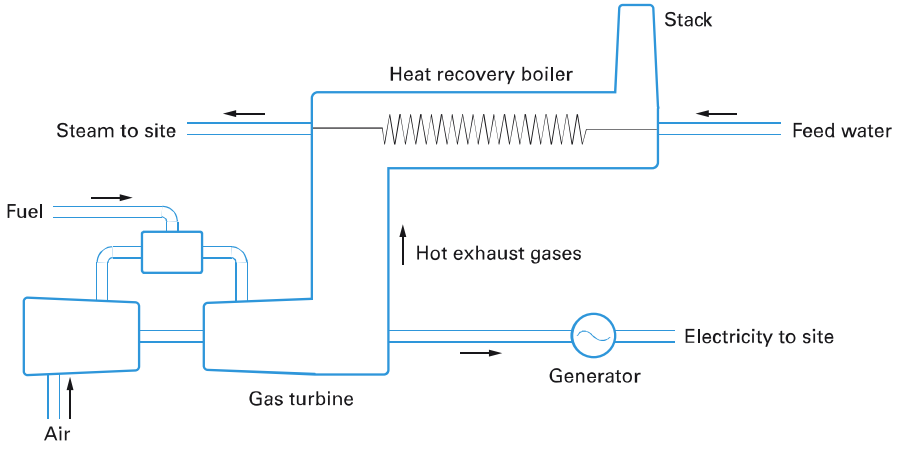
Typical WHR



Example sizes for custom-built CHP units

	Gas-turbine CHP				CCGT CHP		
Electricity output (MW)	1.1	4.9	9.7	31.0	53.0	99.8	316.0
Heat output (MW)	1.8	7.2	14.5	36.5	40.5	99.3	205.3
Fuel input (MW)	4.3	16.3	34.0	96.1	134.3	271.6	686.4

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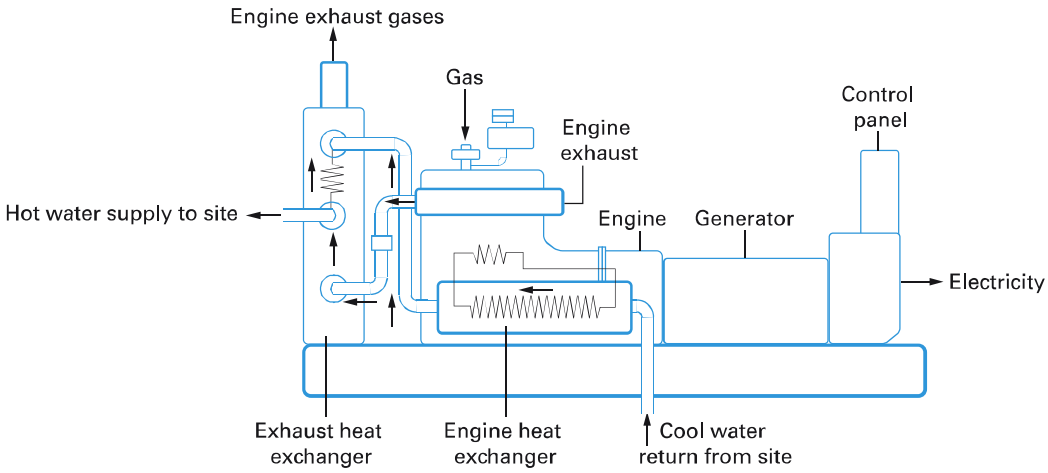

Typical sizes for packaged CHP units

	Gas-engine CHP					Small-scale gas turbine CHP	
Electricity output	60kW	100kW	300kW	600kW	1,000kW	60kW	100kW
Heat output	115kW	130kW	430kW	880kW	1,300kW	100kW	150kW
Fuel input	215kW	310kW	990kW	1,950kW	3,000kW	280kW	350kW

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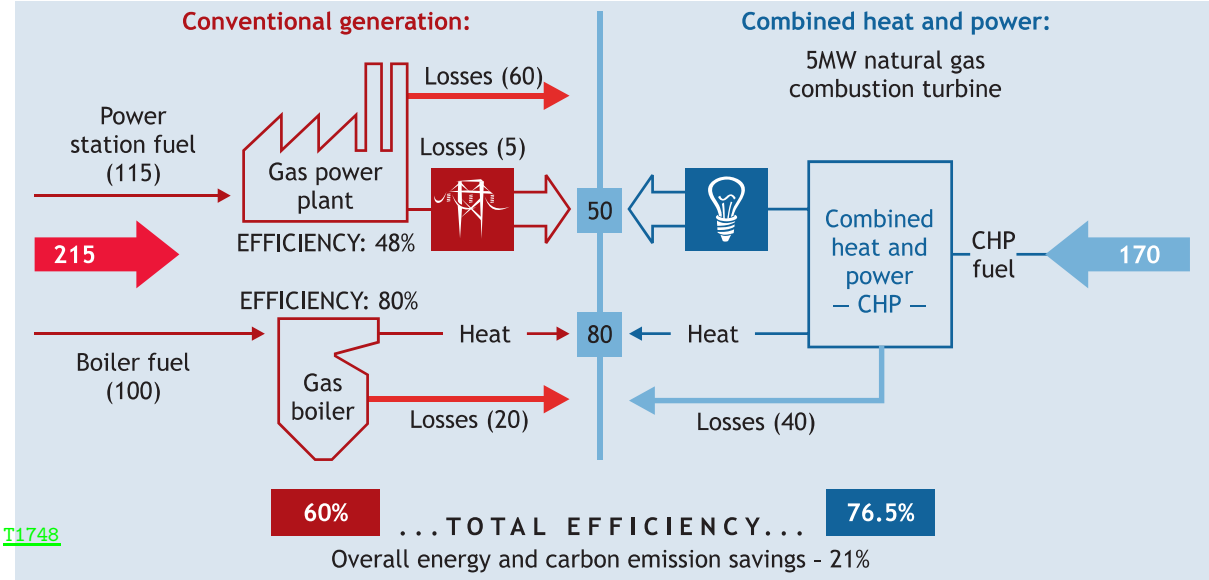
Combined Heating and Power



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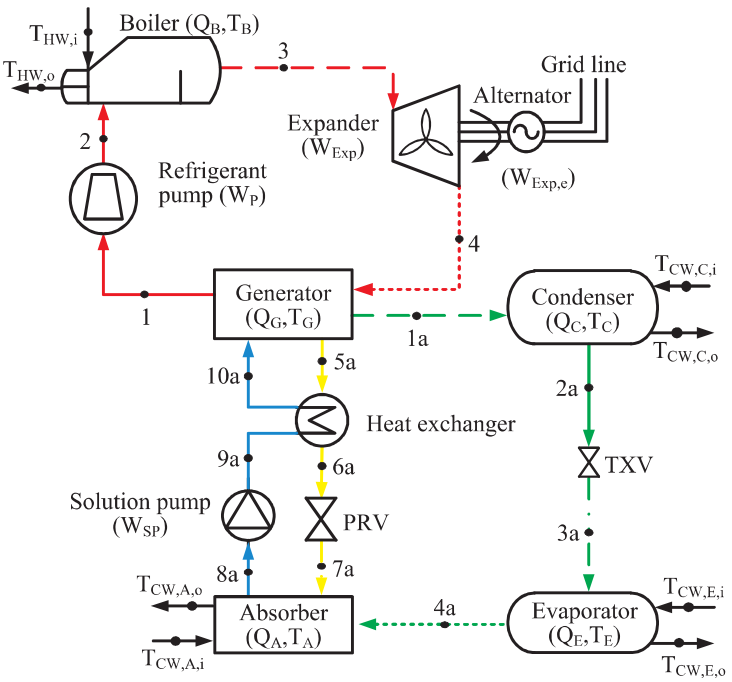
ORC + Absorption Refrigeration System



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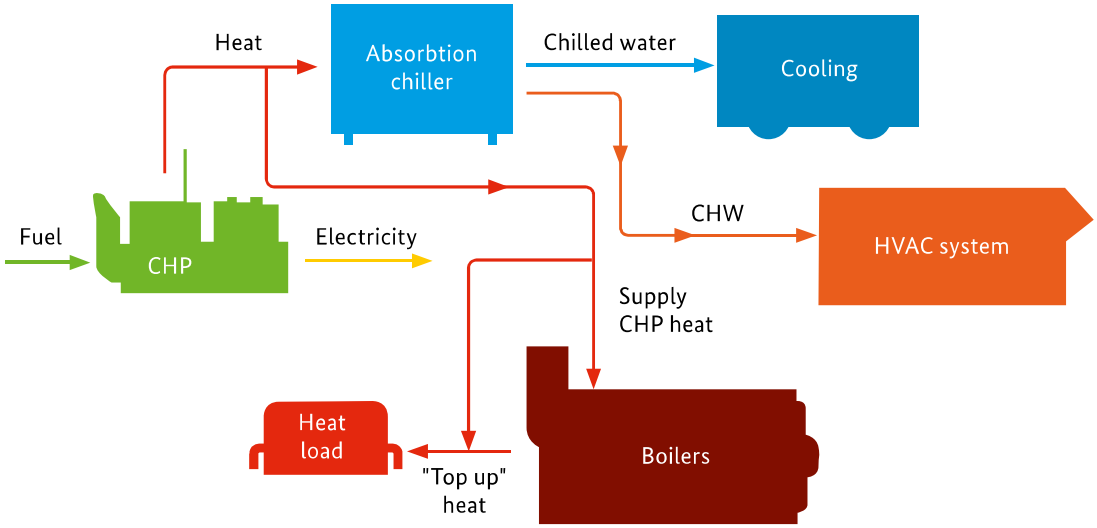
Combined Heating, Cooling and Power

- Overall efficiency is further improved by tri-generation - using additional absorption chillers to convert waste heat into cooling.



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Thanks a Lot