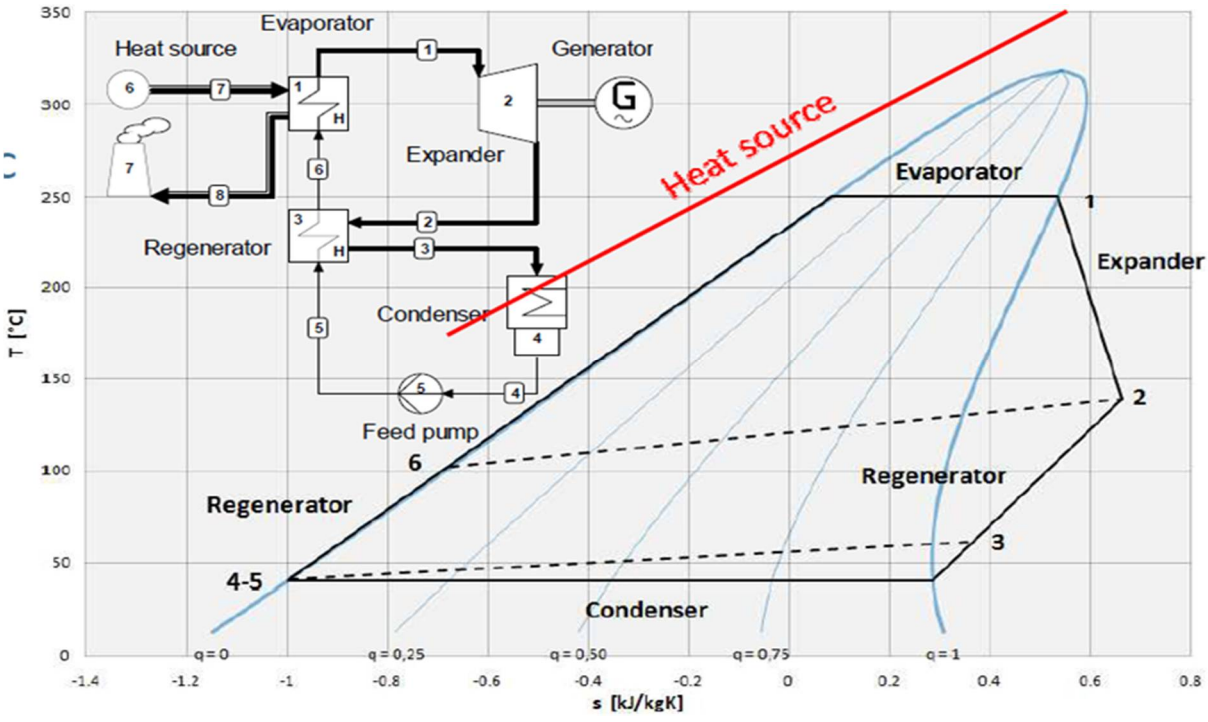
ELECTRICITY GENERATION FROM LOW-QUALITY WASTE HEAT BY ORC CYCLE

THE COMPARISON OF ORGANIC & CLASSICAL RANKIN CYCLES

In the classic Rankin Cycle, water vapor is produced at high pressure and temperature and directed to the steam turbine, generating mechanical energy and subsequent electrical energy. In the Rankin Cycle, steam is usually given to the turbine after it is super-heated because it comes out of the turbine wet, thereby reducing the degree of wetness and increasing system efficiency. (Superheating Requirement)

Although the principle is the same in the Organic Rankin Cycles (ORC) as in the classical Rankin cycles, there are differences in the fact that the fluid used is of organic origin. The common feature of these organic fluids is that their molecular masses are large and they can rise to high pressures at low temperatures. Because of this, they are more suitable for low-temperature waste heat recovery applications. In addition, organic fluids are heated at the outlet of the turbine (or expander), in contrast to water vapor. In this aspect, there is no requirement for a super-heater equipment to heat organic fluid in ORC systems.



ADVANTAGES OF ORC SYSTEMS

- ORC systems can operate up to 10% capacity without losing much efficiency.
- ORC fluid is still super-heated at turbine output, reducing erosion of the fins.
- For the same reason, there is no obligation to superheat the organic fluid before entering the turbine, superheating can be applied if desired to increase efficiency.
- ORC turbines run at lower speeds than steam turbines, providing low noise emissions.
- ORC systems generally do not require an intermediate gearbox, so transfer losses can be destroyed.
- ORC systems are less complex than steam systems and generally do not require operators.
- The system is completely closed circuit and there is no additional (make up) fluid or chemical loss except for the cooling tower.
- ORC systems can operate at lower temperatures and pressures
- Because the freezing points of ORC fluids are usually very low and the efficiency increases even more at low ambient temperatures, there is no need for freezing precautions.
- Due to the large molecular mass (density) of these fluids, the dimensions of installations and equipment are smaller.

DISADVANTAGES OF ORC SYSTEMS

- They do not provide as much efficiency as the classic Rankin cycle in high-temperature waste heat applications.
- Due to the high density of these fluids and the low enthalpy of evaporation, the energy internal consumption of the liquid phase circulation pump is higher.
- In general, ORC fluids are toxic and flammable, so they require more precise installation workmanship.

THE COMPARISON OF THE THERMOPHYSICAL PROPERTIES OF SOME ORC FLUIDS WITH WATER VAPOR

		T_{crit}	p_{crit}	Boiling Point	E_{evap} (1bar)
Fluid	**Formula / name**	**[°C]**	**[bar]**	**[°C]**	**[kJ/kg]**
Water	H20	373.9	220.6	100.0	2257.5
Toluene	C7H8	318.7	41.1	110.7	365.0
R245fa	C3H3F5	154.1	36.4	14.8	195.6
n-pentane	C5H12	196.6	33.7	36.2	361.8
cyclopentane	C5H10	238.6	45.1	49.4	391.7
Solkatherm	solkatherm	177.6	28.5	35.5	138.1
OMTS	MDM	291.0	14.2	152.7	153.0
HMDS	MM	245.5	19.5	100.4	195.8

SOME SECTORS WHERE ORC SYSTEMS CAN BE USED

- ❑ Waste heat recovery (Cement, glass, steel, industrial process, etc.)
- ❑ Concentrated solar power (CSP)
- ❑ Geothermal applications.
- ❑ Gas engines and gas turbines.
- ❑ Biogas and landfill gas plants.
- ❑ Biomass plants.