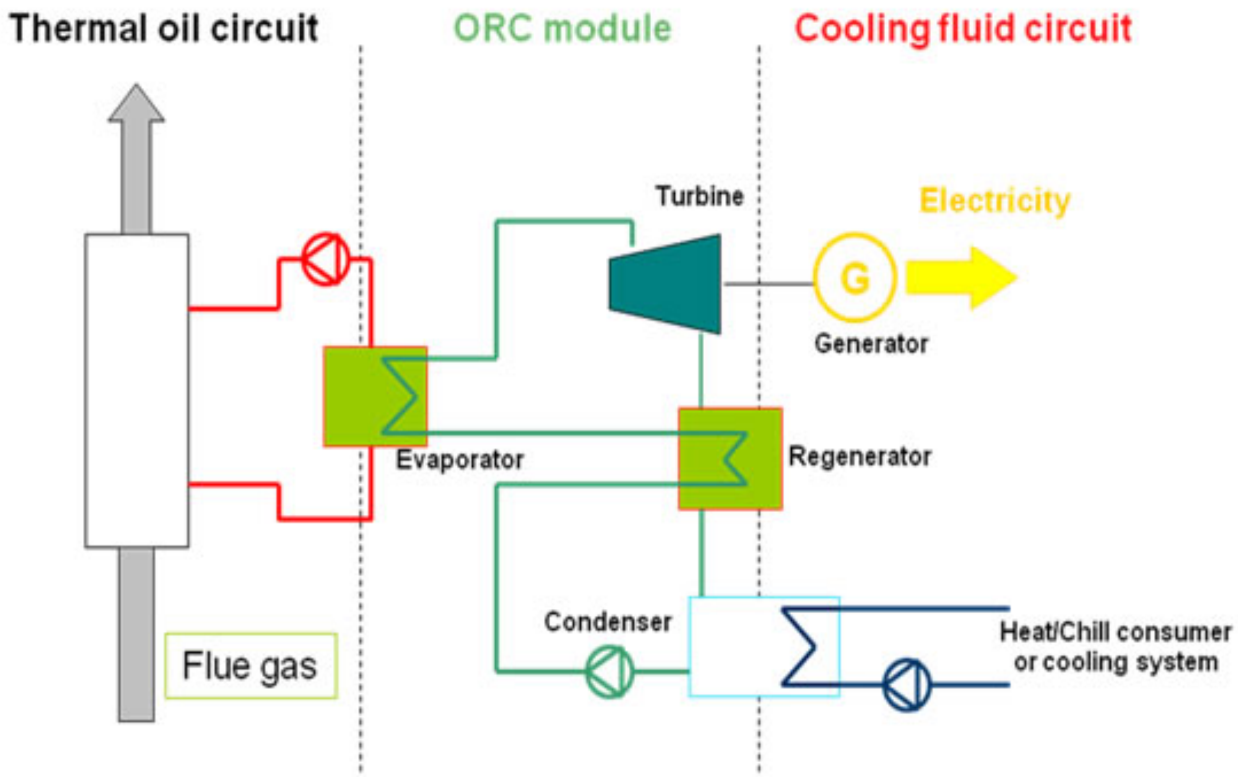
The Organic Rankine Cycle (ORC) Power Generation System

For the metallurgical and chemical industries Vuselela developed Thermal Harvesting™ technology to collect the waste energies from various sources on site.

The hot thermal medium is then processed in an Organic Rankine Cycle plant where the thermal energy is converted to electrical power.

A typical schematic of the ORC process is shown below.



The Organic Rankine Cycle (ORC)

The ORC is a pre-engineered, pre-packaged power unit specifically designed for low to medium temperature heat sources. It consists mainly of a vaporizer, preheater, turbine-generator set, air cooled condenser and feed pump.

The envisaged ORC power generation system used produce electrical energy is designed for outdoor installation (no buildings required) and remote control unattended operation.

The ORC technology is a field proven, mature commercial product operating worldwide with an accumulated experience of millions of operating hours.

The ORC Thermodynamic Cycle

The driving mechanism of an ORC plant is based on the principle of a typical thermodynamic cycle. Hot thermal fluid provides the heat to the power cycle. The organic cycle motive fluid is a hydrocarbon selected for optimal utilization of the available heat source.

Organic fluid is pumped into a pre-heater from where it flows to the vaporizer. The organic vapor is pre-heated and evaporated and then expands in the organic turbine producing turbine shaft power. After expansion to a low pressure, the vapor is condensed in an air cooled condenser. The condensate is then collected and returned to the cycle pump to complete the cycle.

Mechanical Subsystem

The mechanical subsystem consists of the thermal-mechanical energy transfer equipment and includes a vaporizer, pre-heater, recuperator, condenser, turbine, oil system and feed pump as well as motive fluid piping, automatic control and safety relief valves, level, pressure and temperature controls and pneumatic piping.

Electrical Subsystem

The electrical subsystem consists of the mechanical-electrical energy transfer equipment and includes a generator, power and control boards.

The ORC generators are supplied complete with synchronization and control equipment for HT connection. Based on the assumption that the power will be used on-site at 11kV or 6.6kV site voltage, no step-up transformers are envisaged.

Control Subsystem

The control subsystem is based on a programmable logic controller (PLC) which can accept all discrete and analog signals coming from the system components, process them according to a dedicated program, and send back logic or analog output signals.

The unit includes a personal computer with dedicated application used by the operator to operate the ORC and monitor its functions locally and remotely.

ORC Features and Advantages

Condensing near atmospheric pressure

The thermodynamic properties of an organic motive fluid provide much higher condensing pressures than comparable steam systems. By operating at condensing pressures near atmospheric, the turbine requires shorter blades and the ingress of air into the system is significantly minimized. The latter feature mitigates the need for vacuum maintenance.

High turbine efficiency at low output

Due to the motive fluid's low sonic velocity (compared to steam), favorable aerodynamic matching is achieved at low blade speed. This yields high turbine efficiency at 1500 rpm without a gearbox, and plant output increases while cost is reduced.

Moisture-free turbine expansion

Unlike its steam turbine counterpart, the ORC turbine remains dry under all expected working conditions (a thermodynamic consequence of the hydrocarbons' 'drying fluid' saturation curve). This eliminates the possibility of erosion damage to the turbine's buckets and nozzles. Thus, the ORC can accommodate part load operation and large transients more effectively than steam systems.

Remote, unattended operation

ORC-type power systems have compiled an exemplary reliability record wherever they have been installed. Also, these systems do not require 24/7 manning by a licensed steam plant operator. These two features result in the ability to operate ORC plants in a remote, unattended mode.

Water-free cooling

Air cooled ORCs operate on a closed loop, do not consume any water and are therefore free of the environmental consequences that accompany water based systems. Chemical additives are not required for the cooling tower operation and therefore there is no waste disposal.

The plant has a much lower profile than a conventional condensing steam turbine with water cooled condenser and wet cooling towers, and has the advantage of never producing a visible plume resulting in a low visual profile that blends into the surroundings with minimal impact to the landscape.

Low maintenance

ORCs are proven to require minimal maintenance resulting in high availability, low maintenance and low operational costs.