Baseload Renewable Energy using Diesel Engines

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Continuous duty gensets provide base load power generation in diverse applications around the globe. In the past, there were no proven commercial products for converting engine heat to power so operators had little choice but to accept the heat loss to the atmosphere. Today ElectraTherm has deployed more than 50 units worldwide with over 70 years of cumulative fleet experience with excellent availability. ElectraTherm is the leader in small-scale, distributed power generation from waste heat utilizing Organic Rankine Cycle (ORC) and proprietary technologies to generate power from low temperature heat ranging from 77-122°C.

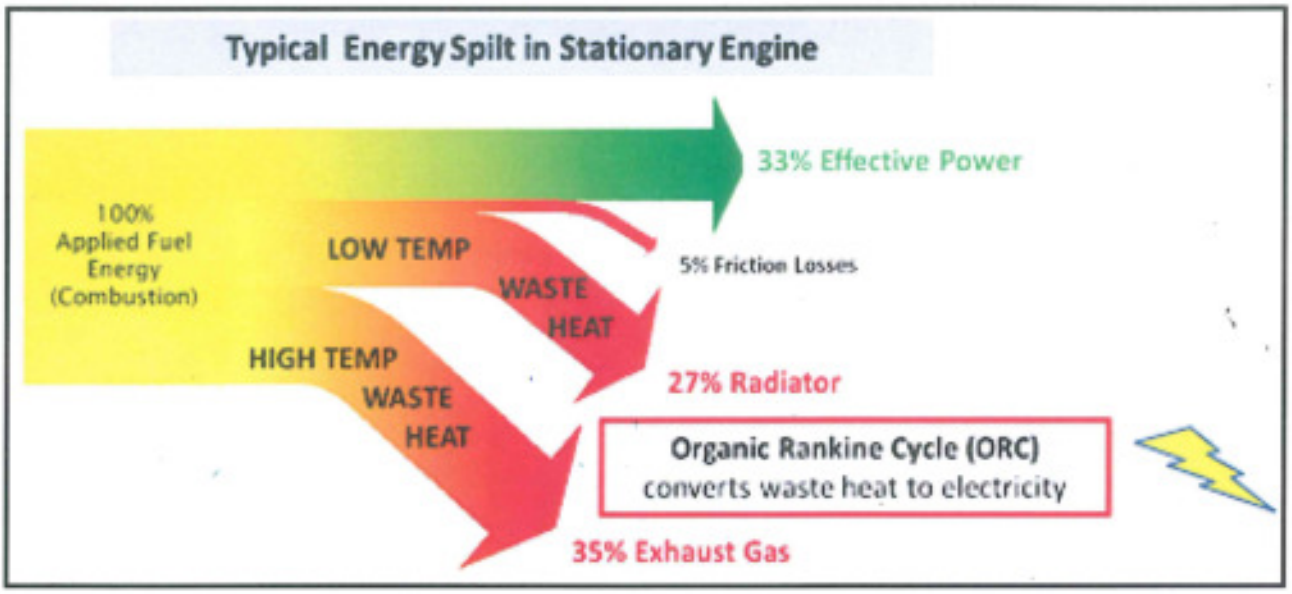
ElectraTherm's Waste Heat to Power (WHP) technology converts various sources of heat into power, including internal combustion engines, small scale geothermal, biomass, flare gas, and process heat. ElectraTherm's primary market is waste heat from stationary internal combustion engines. With the typical engine running at about 33% efficiency, there is considerable waste heat between the jacket water and the exhaust. Typical engine sites include: prime power production in remote areas, island and developing nations, biogas gensets including landfill and wastewater treatment plants, natural gas compression stations and renewable biofuels.

ElectraTherm has demonstrated over a 10% increase in fuel efficiency along with simple installation, mobility and low maintenance. The Power+ can replace the engine's radiator entirely and deliver a payback of three years or less for diesel or heavy fuel oil-fired gensets such as those deployed all across Asia Pacific. In effect, the engine's waste heat becomes a source of cost savings by displacing the radiator's capital cost and parasitic load, i.e. more power with no incremental fuel costs and no added emissions.

How it Works

ElectraTherm's Power+ Generator operates using a closed loop ORC, where hot water is the fuel. Hot water from the engine enters a heat exchanger to pressurize the non-flammable, non-toxic working fluid, driving the twin-screw expander and generator to create electricity. ElectraTherm's patented twin-screw expander is unique in its configuration, lubrication and specifications, but the core technology is based on reliable, proven compressor technology that has been around for more than 20 years.

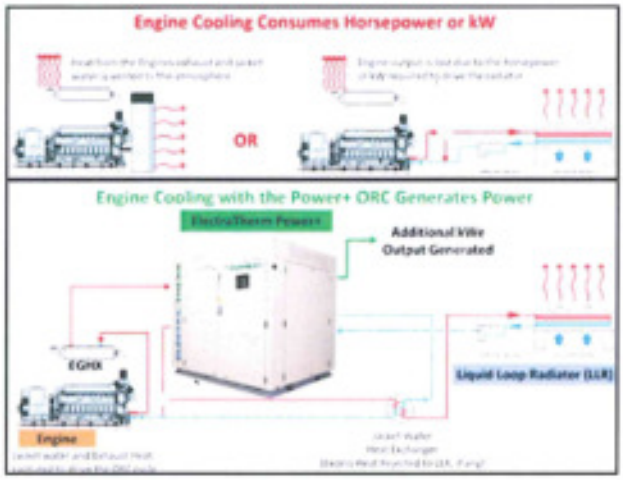
The twin screw expander has a rotational speed of 1800 - 4900 RPM, considerably less than turbo expanders. Unlike high speed turbo expanders, screw expanders are robust units that tolerate "wet" dual phase flow. This allows the Power+ Generator to utilize more cost effective and compact heat exchangers that tolerate perturbations in both temperature and flow with turn down ratios of 6:1 available on demand. This is particularly advantageous in low temperature waste heat streams such as engine jacket water. Through a patented lubrication scheme, the Power+ Generator design is simplified and eliminates lubrication reservoirs, oil coolers, pumps and land filters, creating a simple, robust, and efficient system with fewer parasitic loads and maintenance requirements. Engine gensets are a great match for ElectraTherm since a significant portion of the waste heat is at low temperatures and engine throttle positions can vary widely depending on the electrical load demand.



Because there are multiple waste heat streams from an engine there are correspondingly multiple ways to apply ORC technology to an engine.

1) JW only – single heat stream to ORC
2) JW boosted by exhaust – single heat stream to ORC
3) JW and exhaust utilized separately – dual heat streams to ORC
4) Exhaust only – single heat stream to ORC

Maximum electrical output is achieved when both JW and exhaust waste heat streams are utilized. Maximum parasitic load offset from engine cooling is achieved when all the JW energy can be consumed by sizing the ORC appropriately. The combined benefit by offsetting the cooling loads AND producing power can have a 10%+ effect on engine fuel consumption. With a new site, the engine radiator can be replaced (never purchased) by the Power+ Generator and its condenser, a liquid loop radiator. A secondary loop is configured between the engine and the condenser for the ORC, and this loop controls the return temperature of the jacket water to the engine. The ORC condenser is sized for 100% heat rejection for the engine, so the ORC and the engine cooling operate seamlessly whether the ORC is on or off.



Many Benefits of Heat-to-Power for Stationary Engines

There are multiple benefits to integrating an ORC heat to power generator with an engine genset. The first benefit is clear: the additional electrical output from the conversion of the waste heat to electricity with no additional fuel consumption or emissions. Second and less obvious is the reduction or elimination of the parasitic load from the engine cooling fans. The Power+ Generator acts as the radiator and, therefore, the engine-driven radiator fans can actually be disconnected, allowing more work to be performed by the engine to generate additional electricity. A third benefit can be achieved in hot climates or seasonally high ambient conditions, since the ORC's cooling requirements are much greater than the engine's

cooling requirements – additional cooling capacity at high ambients may improve engine performance. The Power+ Generator electricity output combined with reduced parasitics account for more than 10% fuel efficiency gain depending on engine size and configuration. The additional benefit from decreasing the engine's de-rate period or the amount of de-rate will, of course, vary with ambient conditions.

ElectraTherm currently manufactures a 35 kW unit that fits well with ~500 kW gensets (4200 model), a 65 kW unit which fits well with ~800 kW engines (4400 model), and a 110 kW unit (6500 model), well suited for 1-2 MW engines.

ElectraTherm's experience to date with genset integration has been very successful. Applications include single engines and multiple engines utilizing jacket water heat alone as well as jacket water combined with exhaust heat. Engine models that have been integrated with the Power+ Generator include Jenbacher, Deutz and MWM engines in Europe as well as CAT and Waukashau engines in North America.

Collaboration with Chuuck Public Utility Corporation

ElectraTherm collaborated with the Chuuck Public Utility Corporation on a Power Station waste heat recovery feasibility study. The utility was seeking a waste heat recovery solution to their newly built power station. With the station already built and in operation, it was critical to find a solution that fit perfectly with their specific needs and could be seamlessly integrated with little to no downtime.

The study determined that ElectraTherm's Power+ 6500 was the optimal fit for a 900kW engine and a flue gas heat exchanger. The project was estimated between 3-5 years for return on investment based on all costs and labor. The study was favorable to the ORC integration, based on economics and the robust, proven technology of ElectraTherm and its international fleet.

Conclusion

Distributed WHP systems for stationary engines are not yet well known or mainstream in Asia Pacific, but the technology is field proven, and the economics are attractive. ElectraTherm's various packaged solutions are making it easier to economically capture waste heat and make emission-free and fuel-free power from sources that already exist.