

Revealing the Secrets – How to design a Heat Driven Refrigeration System

Disclaimer: So far every technology written about in these Tutorials have been applied and validated for energy use and savings at an actual facility. In this tutorial we are writing about a technology that has not been applied as shown. But, it will. I have been working on this design for more than 10 years, with electricity costs limiting its application. (it's was kind of my Ahab/Moby Dick Story) Just in the last few years the energy costs have risen to the point in which a technology like this is cost effective. We are currently evaluating our design and recommend others do the same. Yes, even writing this tutorial makes this technology public and not patentable in the US. We understand that and even applaud those that venture with us into this market.

To explain a heat recovery refrigeration system we must first understand where the heat comes from in this design. For the simplicity of this tutorial we are going to only describe two sources of waste heat, Micro Turbine waste heat and Boiler Stack waste heat , but Solar Thermal, Concentrated Solar, any Power Generation are other sources of waste heat that are available. Typical installation require a 24hrs a day process for cooling for cost effectiveness.

Micro Turbine Waste Heat

Everybody's seen and heard of absorption systems and understands the value of a properly applied heat recovery system. Capstone, Ingersoll Rand, and others make an electrical generator that provide grid level power that is synchronous (meaning it runs at the same time and cycle rate as the grid based power and matches the grid exactly) for reducing the energy used by a facility. (Back up generators used at data centers are not synchronous and cannot run useable power at the same time as the gird) Typically Micro Turbines have been applied where there is a need for electricity production and hot water / steam or a high temp cooling load. This technology would change the micro turbine industry for ever...



A typical Micro Turbine can produce 6,750 BTUH of 280°F Heat per kW of energy produced and come in sizes ranging from 65kW to 1000kW's

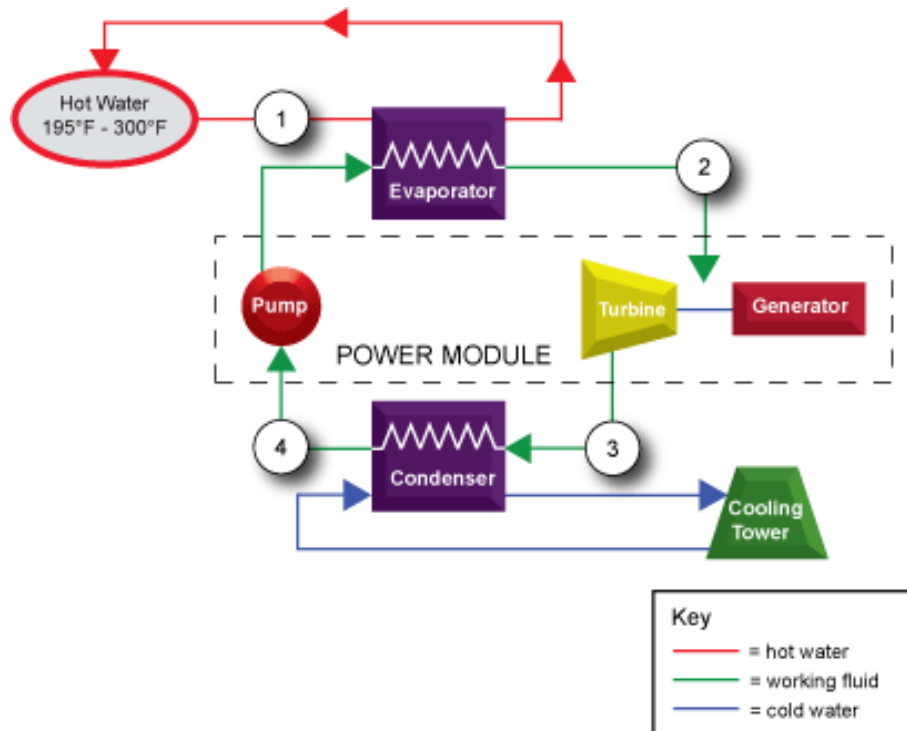
Boiler Stack Heat

Boilers for food production has been used for years and honest are very inefficient pieces of equipment but in general are very necessary for the end result, in general a product that is safe to eat. Boiler efficiencies can range any ware from 57-87%. Which means the remaining heat goes up

the stack and is exhausted as waste heat into the environment. We at some point were going to recover this waste heat to be applied to this system design.

enGEN System™ – The enGEN system our name for this ancillary (strap on) refrigeration product can be applied to any cooling system to reduced the overall load on the refrigeration system. The system is modeled after two proven distinct technologies combined to form a new technology, a heat driven Organic Rankin Cycle system and a Expander / Compressor vapor compression system.

Organic Rankin Cycle (ORC) The Organic Rankin Cycle has been around for years and many companies are making major strides in this arena of heat recovery to power. Companies like Ormat, Infinity, and others occupy this market. The **Organic Rankin cycle (ORC)** is named for its use of an organic, high molecular mass fluid with a liquid-vapor phase change, or boiling point, occurring at a lower temperature than the water-steam phase change. (Refrigerants) The fluid allows Rankin cycle heat recovery from lower temperature sources such as industrial waste heat, geothermal heat, solar ponds etc. The low-temperature heat is converted into useful work, which can itself be converted into electricity. The working principle of the organic Rankin cycle is the same as that of the Rankin cycle: the working fluid is pumped to a boiler where it is evaporated, passes through a turbine and is finally re-condensed. If this sounds familiar, it's the exact same process as refrigeration but in reverse...



The enGEN System is packaged much like all our current lines. This is what we envision it looking like, we see packages for supermarkets going from 50-250 tons and our chilled water lines going from 50 – 500 tons.



As we stated in the beginning of the tutorial this units is designed to be an ancillary (strap on) product to a primary refrigeration system and should not affect the refrigeration system other than to reduce the mass flow rate of the primary refrigeration system. The original design was to be applied with Micro Turbines to an existing rack based market refrigeration racks or refrigeration cold storage plants. These are some other applications for the package if done properly.

Thermo Siphon Package for Ammonia Plants – In this case applying the system as a separate secondary refrigeration unit designed to condenser gas from the medium or high temp pumping accumulator would reduce the compressor loads from the main plant. The heat source would be boiler stack waste heat which would be recovered with a Fuller Rotary Booster Compressor to soak out as much energy out of the flue gas as possible. If we operate with boiler Waste Heat recovery the enGEN should be able to produce 1-3 tons of “compressor free” cooling for 18,000 BTUH with 160°F waste heat and even less waste heat at higher heat qualities.

Turbine Inlet Air Cooling – Applying systems like this to turbine inlet air cooling at power plants would increase the efficiency of the power plant by about a 27% increase in efficiency. With no additional power needed to drive the typical chillers. The heat source would be turbine exhaust stack waste heat which would be recovered with a Fuller Rotary Booster Compressor to soak out as much energy out of the flue gas as possible or a bottom cycle off the Rankin Cycle. If we operate with exhaust Waste Heat recovery the enGEN should be able to produce 2-5 tons of “compressor free” cooling for 18,000 BTUH with 160°F waste heat and even less waste heat at higher heat qualities.

Server Cooling – My eventual goal is to work with modular data center manufacture to package a unit like this to recover the low quality heat from the servers to provide the cooling. We calculate that we will be able to capture 43% of the server heat from a hot isle containment type system design 100F to 80F within our main air stream heat recover coil. The air side heat exchanger will provide a fluid temp rise of 75F-95F. If the facility load is 1800 kW the system should be able to absorb 2.6 M BTUH, more heat than needed to operate the enGEN to drive the expander compressor system, due to our *Reduced Compression* design, we will be able to operate the enGEN compression system at the rate of 26,000 BTUH for 2-5 tons of cooling at 100F.

Chiller Unit - Applying systems like this to as a primary chilled water system is also possible. The heat source would be a Micro Turbine exhaust stack waste heat which would be recovered with a Fuller Rotary Booster Compressor to soak out as much energy out of the flue gas as possible. If we operate with exhaust Waste Heat recovery the enGEN should be able to produce 6-8 tons of reduced compression cooling for 18,000 BTUH with 212°F waste heat.

Conclusion – One thing I am absolutely certain of is that there will be a solution made out in the real world at some point and every supermarket in America will have a unit like this. I just hope I see it in my life time.