MILESTONE TWO REPORT

Executive Summary

The second milestone of the project is the completion of the preliminary engineering and the final preparation for the actual installation of a system. The centerpiece of the project is the gasification system; however, the key to economic feasibility at a small farm setting is the combination of several revenue streams and the ability to design a system to utilize the gasifier to optimize those opportunities. The final design and layout of the system includes the detailed fabrication drawings for the gasifier, the selection of the auxiliary equipment – feed system, fuel storage hopper, power conversion system from single phase to 3-phase power, ash handling system, heat exchanger, and air distribution system. The specification of the power generation equipment has been made.

The determination of the actual operating procedure and fuel supply has been completed. This is an extremely critical portion of the project. Since a significant portion of the revenue for the operation comes from areas outside of the actual energy usage, the fuel supply, blending, and quality is very important. The ability to utilize turkey litter as a fuel, and also have the ability to blend it with corn stover, wood byproducts, and/or
use each of those materials alone, gives the project additional economic potential. This will extend the number of operating hours beyond the volume of turkey litter available as fuel, and also opens up additional possibilities for ash products that may have enhanced values. As P & J Products produces corn and other crops on its land the ability to monitor and analyze the benefits of the ash is greatly increased.

**Technical Progress**

The project continues to remain ahead of schedule. Due to weather related issues the installation of the gasifier has been postponed to early March. Installation of the heat exchanger and the air distribution system will be later in the year based on the long lead time for delivery of the heat exchanger. There should be no concerns with completing their installation within the eleven months designated in the original Timeline.

The following technical components of the project were accomplished during this milestone:

**Fuel Supply Plan**

There will be a variety of fuels used in P & J Product's project. The key component will be turkey litter, with that from the finisher barns being used as the main fuel. There will be some litter eventually from the brooder barns and the associated cardboard partitions. The total volume of litter will be enough to operate the system for about four months per year. Additional operating days will be possible with the blending of corn stover and wood material. Both of these fuels have higher energy content than the litter (if reasonably dry, the material will contain 5,000 to 5,500 BTU/pound), so the performance of the gasifier will be improved.

An important result of the project will be to determine the most valuable benefits(s) of the project, whether they be heat/power or the value of the ash as a fertilizer or biochar product. If the findings prove that the value of the ash is the most beneficial the focus of the project will be to run more fuel through to produce the desired product. In addition to the ash product more heat will obviously be produced with more throughput.

Either way, the gasifier can supply enough heat to easily heat both of the adjacent starter barns. The unit will provide more heat than P & J will need for one barn, and at times more than will be required for one barn and the power generation. Utilizing a hot oil heat exchanger, the option of heating the second barn can be done with a small amount of piping, a heating coil and valves, and another air handler. Should P & J decide to use the heat for the second barn, the energy is available although doing it is not in the scope of this project. An important consideration will be the performance of the birds when the gasifier is used for the first barn. Obviously the economics will impact the decision - if the ash value is high, P & J may want to run the gasifier as close to capacity as possible. If this is the case there will likely be excess energy available.

The main consideration in the blending analysis will be the quality of the ash produced. The ash value may be the most important component of the economic analysis as the potential revenue for fertilizer amendment or replacement, or feed additive may exceed the value of the energy. The determination of this value will be a
major component of the work completed in Milestone 4, thus the actual optimum fuel blend is not known at this time. However, the combination of fuels will be available and blending and ash analysis will be one of the first priorities to determine the value. All of the fuels to be used (turkey litter, corn stover, and wood) have been analyzed and tested in the gasifier individually thus the work to obtain the initial background data for the fuel blending has been completed. The final operating plan will be determined after the above evaluations are complete. Additional litter is available from other locations which may be used if the economics are favorable.

Determining the value associated with each revenue stream is one of the key components to the final operating plan. The expected benefits include:

- Lower propane costs.
- Improved bird performance - due to lower relative humidity in the barns, which equates to lower ammonia generation.
- Mortality disposal.
- Potential lower labor cost associated with handling of turkeys when very small – heating the entire barn versus localized heating inside of the barn.
- Ash value – fertilizer supplement, fertilizer replacement, and/or feed supplement.
- Ash value as a biochar.

The system will consume approximately 1,000 pounds per hour of litter, and up to 1,200 pounds per hour as more corn stover and wood is added. The final output of the system will depend on the value provided by the system – the value of the energy (whether as heat and/or eventually as power), and the value of the ash, will determine how many hours the system is operated and at what level of throughput. The system can easily be operated at 25% capacity as long as the fuel quality is sufficient to sustain the reaction.

The installation will be completed in Milestone Three; however, there will be about five months before the heat exchanger can be delivered. During this period, the gasifier will be used intermittently and the energy produced will be exhausted into the atmosphere and not utilized. However, during this period, the fuel blending and ash analysis will be done so that when the complete system is available, there will be a better understanding of the optimum blend.

One of the unique characteristics of this project is the use of zeolite as a feed additive. It has been used in both poultry and cattle applications in the past and has improved the performance of the animals. In this project the zeolite is being used to improve the health and growth rate of the birds and it is also anticipated to provide an improved litter for use in the gasifier. The zeolite will be used up to 2% in the feed being supplied to the birds in one of the finisher barns. This will begin by the time the next flock is moved into the barn in early to mid-March. This will provide a barn with a litter product that has zeolite, and will provide a good comparison to the other finisher barn which will have a litter without zeolite. Both the performance of the turkeys and the quality of the litter will be easily evaluated as there will be a base case in the other barn on site.
The zeolite being used will be supplied by St. Cloud Mining. Their product is a high quality zeolite with extremely high reactive capacity. This property aids in the digestive system of the birds to improve their health and energy conversion, thus increasing growth performance. It also provides manure that contains the zeolite, which continues to retain its ability to absorb and contain the ammonia produced in the manure. This feature will lower the ammonia emissions on the farm, and it is anticipated that the trapped ammonia will pass through the gasification process and continue to be retained in the ash. This experiment has not been done, but it is obvious that any delay in the release of the ammonia is valuable. If the zeolite can retain some of the nitrogen through until the ash is produced, it will deliver an ash product that not only is a pathogen-free, concentrated Phosphorus, Calcium, and Potassium rich material, but it will also contain elevated levels of nitrogen. This will make the ash product even more valuable.

Gasifier Design

The design of the gasifier did not change from Milestone 1. The design drawings and detailed fabrication drawings contain information that is confidential and are not included. Coaltec Energy represents the WESI gasification system produced by MaxWest Environmental Systems; therefore, the system itself will be supplied by MaxWest. However, there are auxiliary components of the system that are not supplied by MaxWest and were outsourced. The feed system will be purchased from typical manure storage hopper manufacturers and the belt feed conveyor will be purchased and then designed and modified to purpose by Coaltec. The ash removal system will be the same – the augers will be supplied by a local fabricator and Coaltec will provide the drive mechanism and design to match the needs. The design for both the ash and feed systems are identical to the systems currently being used on Coaltec projects with some field modifications to allow for site-based changes. The final component of the initial installation is the roto-phase system that converts the incoming single phase 110-volt power supply to 3-phase 230-volt power. The system contains several 3-phase motors and the typical poultry farm has only a single phase power supply. The cost associated with upgrading the power supply to 3-phase power is much too costly; it is simpler and more cost effective to install the roto-phase. This system is supplied by D & L Services and will be installed in the control building that contains the motor controls for the gasifier.

One of the variables in the project will be the quality of the ash produced. In the pursuit of another project, the gasification system, and its on-farm application, has been recognized as a good source for the production of biochar. This carbon char-enriched ash product has even more value than the nutrient value itself; as the carbon char enables the material to retain the nutrients for much longer periods of time, thus enriching the soil for years. This also makes the project carbon-negative, rather than carbon neutral, as it sequesters some of the carbon in the soil. Past performance has proven the ability to produce this biochar from the ash product from the gasifier. It is the quality of the char and the volume of carbon retained that is the question. There are variations of the actual process that can produce different results, as well as minor modifications to the design of the system. All of these will be explored during the operation of the system. As stated earlier, the key to small farm-based systems is the compound revenue streams that come from a variety of sources. Increasing the value of any of those streams has a huge impact on the economic viability. As with most operations, there are economies of scale with the gasifier; however, Coaltec believes
that designing large centrally located facilities is the wrong approach, and the solution is to identify the combination of benefits that make a small system viable. They will vary on a case-by-case basis, but having some consistent main revenue streams increases the transferability and the ease of developing multiple projects with similar characteristics.

Generator Specifications
The inclusion of the heat exchanger and power generation equipment is not a component of Milestone Two. However this is a key aspect and we have worked toward identifying it. The lead time for the heat exchanger is 22 weeks and the usage of the hot air distribution in the barns is dependent on the heat exchanger, so the specification, design, and ordering of the unit is in progress. The heat exchanger will be supplied by American Heating and will be a hot air to hot oil exchanger [brochure in Attachments]. The delivery of heat to the barns can be done through hot air, hot water, steam, or hot oil. However, hot oil has been selected as the medium the heat exchanger will use since the power generation equipment suppliers have stated that as preferential.

Infinity Turbines have been given the operating parameters and have designed the unit and supplied an initial quotation. They have tentatively been selected as the vendor. An Infinity brochure is included as an Attachment to this report (the design however is confidential information and is not included in this report). The specifications of the heat exchanger are to match the maximum output of the gasifier when using litter as the fuel (2.8 MMBTU/hr.) and will produce downstream hot oil to feed the power generation equipment and the air handler system. The power generation equipment will be supplied by Infinity Turbine. Since the generation equipment simply sees a flow of hot oil, the actual design of their equipment is standard – the system controls manage the flow and temperature of hot oil to provide the necessary energy to their equipment. The power system is not a highly efficient system, but is designed to use the excess energy and can be cost effective if the value of the power system is an auxiliary revenue stream rather than the main focus of the project. Either a 30 Kw or multiple 10 Kw units will be ordered to supply the power generation portion of the project. This will be completed for Milestone 4 after Milestone 3 is complete and the gasification system is running. Specifications of their equipment are also included in this report.

Additional Milestones:
The system fabrication is complete with small modifications being made before it is ready to ship. The transportation and installation crane services have been secured and the final installation and commissioning schedule have been tentatively completed – depending partially on the weather. At this point, the installation and commissioning is scheduled for early March 2009.

Project Status
The project is ahead of schedule and is within budget.

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WESI-36 GASIFIER ENERGY SYSTEM

Gasification is a staged oxidation process designed to provide optimal energy and environmental performance. The reactions take place in a refractory line Primary Gasification Chamber and an Oxidation/Temp Control Chamber. The WESI-36 is a two-stage gasification system consisting of:

1) one reaction bed area including one 200,000 BTU natural gas or propane start-up burner;
2) one ash removal section and standard removal conveyor;
3) one oxidizer/temp control section complete with a 2MMBTU natural gas or propane start-up burner.

The WESI-36 process consists of two steps in the process of delivering useable heat to the customer's applications:

Primary Gasification Chamber is where gasification of target fuel into producer gas takes place;
Oxidation / Temp Control Chamber is where high temp oxidation and combustion of the produced gases as well as air dilution to desired temperature takes place;

The Primary Gasification Chamber is an oxygen starved (fuel rich) chamber that promotes the production of CO, CH4, and H2 at a relatively low temperature. A small amount of CO2 is created in the chamber to provide the energy for the gasification process. As the amount of moisture increases in the fuel, additional CO2 has to be produced to maintain the target temperatures. This balance is accurately maintained by controlling the air/fuel ratio in the primary chamber and the resulting "producer gas" is ducted to the Oxidation Chamber. The Oxidation / Temperature Control Chamber is a cylinder with staged air added in a directional manner. This produces a spinning reaction area that promotes an even blending of the combustible producer gas, created in the Primary Chamber, with additional air. As the gas reacts it produces heat energy and additional air is added to keep the temperature within the target range. VFD Air fans and air valves are controlled by temperature and provide exactly enough air for complete Oxidation of the producer gas plus enough dilution air to maintain target temperatures.

The throughput of the unit and energy output is partially determined by the fuel utilized. The system will gasify a fuel with an energy content above 3,500 BTU/pound, and with a lower grade fuel, will produce about 3 MMBTU/hr. of energy. The throughput of this unit again is determined by fuel, but the fuel described will be consumed at a rate of up to 1000 pounds per hour. The rate can probably be turned down to 500 pounds per hour, but again this is determined by fuel quality. The system also has the capability of operating with the oxidizer propane burner providing intermittent energy to assist in consuming fuels that don't meet the required energy content. This is regulated by the automated control system.

This system comes with the following features:

-Heavy duty mechanical design for harsh environments;
-Highly automated, simple and effective design providing reliable, consistent and high quality operations;
Great accessibility and visibility into the machine;
Allen Bradley control system (PLC) installed in a NEMA 12 cabinet with user-friendly interface;
Standard safety features such as: No Burn Back System, High temp shutdowns, alarms, high fuel bed controls/shutdown, downstream equipment failure shutdown, fuel piles monitor and control critical temperatures;
Standard and high quality components used throughout;
TEFC electrical motors;
Compact ‘footprint’ allowing easy integration into many site layouts;

**STARTUP BURNERS**
System will be delivered complete with 2MMBTU per hour natural gas burner integral to the oxidizer/temperature control section as well as a 200,000 BTU natural gas burner integral to the primary section of the WESI-36 Gasifier System. Burner controls are integrated with the PLC. These burners are available for start-up as well as smokeless shutdown of the system.

**WEB BASED REMOTE MONITORING AND OPERATING SYSTEM**
The WESI-36 System comes with an internet-based SCADA monitoring and data collection application. The industry proven CitectSCADA automation platform provides remote access to current gasifier operational data, full equipment control, alarming logging, trending and report generation. Reporting features include total energy produced, total up time, total fuel consumed, total natural gas consumed as well as additional customer project specific information. Access to the system comes via a computer with internet connection running the CitectSCADA client application. Built-in software features, internet firewall equipment and strict login information provides a high level of plant access security.

**AUTO ASH REMOVAL**
An automatic ash removal system is supplied with the unit. It will remove a measured amount of ash by means of a live floor system that covers the base of the fuel bed. As the reacted material moves down through the gasifier primary chamber it drops below the air injection system and starts to cool. The cooler material is then removed by a timed activation of the floor and dropped into a conveyor.

**STANDARD FUEL INFEED SYSTEM**
Infeed System: This unit will come with an infeed system consisting of a loader feed hopper / side-metering system capable of storing 2-4 tons of fuel and will supply a measured amount of fuel to the feed ram as required. System will handle a product size less than 6 inches. System also includes an inclined conveyor to feed unit, plus an 8-ton storage hopper. Feed system controls are automated to feed unit as needed – will provide 16-hour operating storage capacity.

**AUTOMATED CONTROLS**
Full feature Allen Bradley PLC control system. Local Magelis Human-Machine Interface (HMI) provides complete control of all plant operations.
This system is set to a specific energy and temperature target, which is controlled by the amount of the air injected into the primary reaction chamber. To further protect the operation of the gasifier, a secondary mechanical method of stopping the fuel feed was added to the gasifier design. A high temperature arm extends a short distance in the
primary chamber and rests on the top of the fuel bed. A proximity sensor on the control end of the arm prevents the overfilling of the gasifier chamber with fuel. As the bed reacts and reduces the size of the fuel bed the arms will drop and allow the introduction of more fuel.

Fuel feed automation includes sequential, interlocked operation of the feed system plungers and various chopper/metering systems which in turn will call for fuel from the customers fuel handling system. The feed system is interlocked with the gasifier fuel high signals to prevent overfilling the gasification chamber.

Ash system automation includes sequential, interlocked operation of the ash floor and ash removal conveyor as well as the customer's ancillary ash removal equipment.

Gasifier automation includes: static and modulating air fan controls, remote actuated valves, ACFM flow meters, all working together to maintain adequate fuel reaction rates and acceptable reaction temperatures.

Oxidizer automation includes: modulating air fan controls, remote activated valves, ACFM flow meters, all working together to promote complete oxidization of the producer gases as well as maintain acceptable delivery temperatures to the customer's applications.

Boiler or kiln inlet temperature control comes via automated modulation of the customers 'pull through' ID fans as well as modulation and blending of fresh or re-circulated air from an outside louvered inlet or from pulling down the by-pass stack. This operation provides the proper mixture of air with the hot oxidizer air to maintain required boiler or kiln inlet temperatures.

High alarm limits as well as integrated tripping signals with end-user equipment provide safe, automatic bypass-to-stack or system shutdown controls for the gasifier if downstream equipment is not operating.

**ENGINEERING, CONTROL INTEGRATION AND SOFTWARE**

Engineering drawings will be created in AutoCAD format. All drawings submitted to the client will be in Adobe Portable Document format (pdf).

**Deliverable documents are:**

- Electrical Single line Diagrams
- Electrical Three line Diagrams
- General Arrangement Diagrams of PLC and MCC control cabinets
- Electrical Control Wiring Diagrams for Gasifier cabinet and field wiring
- Wiring Cable Schedule
- Three (3) paper copies of all relevant equipment manuals
- Three (3) electronic copies of all relevant equipment manuals
- Plant Control Narrative close to project commencement
- System Operations Manual close to project completion

PLC programming software used for the project is Allen Bradley Compact Logix with PLC firmware version RS Logix 5000.

HMI programming software is Magelis XBT-L1000 V4.20 light for any alphanumeric screen included in the project. Touch panel programming software is GE Cimplicity Machine Edition Version 5.50 HMI programming suite.

Web-based remote SCADA access will be implemented using the CitectSCADA V6.0 automation platform. The data server will be running CitectSCADA Internet Display Server while the clients will use CitectSCADA Internet Display Clients.
Below are photos of a similar system operating on a poultry operation

Gasifier, Feed Hopper, Ash Removal

Ducting Running Into One of Three Poultry Houses

Frye Poultry Farm - Wardensville, WV
Infinity Turbine Systems
Specifications – Price Quotation

General specifications - Infinity Turbine systems.

Heat Rate: The ORC systems can use heat in the range of 70-120 C input heat. If it is lower than 100 deg C, then efficiency of 42,000 BTU / kWe. The heat rate is better as temperature goes up.

The standard system is the R 245fa (using Genetron) system which operates between 80-120 C. This represents 8-11 percent efficiency.

Input Fluid: Using water, glycol or thermal oil (for higher temps), expect a flow rate of 2-3 gpm (11.4 liters/min) per rated kW. So a 30 kW rated system needs around 90 gpm (1,026 liters/min). Temperature drop of 15-20C between the input and exit of the preheater/evaporator.

Condenser: The standard systems use a water cooled condenser. Expect a temperature increase of 10C from the input and exit water flow.

STANDARD SYSTEMS:

Standard System:

Infinity Turbine 30 Series Platform: 30 kw.

The 30 Series Platform dimensions:

Width - Base Overall: 7 ft. 4.5 inches (2247 mm)

Length - Base Overall: 8 ft. 3 3/8 inches (2523 mm)

Height: 6 ft. 7 1/4 inches (2013 mm)

Approximate Weight: 2,500 lbs.

Refrigerant: R245fa

SMALL SYSTEMS – EXPERIMENTAL

IT10 (5-12 kWe ORC) Experimental System: For smaller applications, including solar, diesel generator, engine coolant, small biomass boilers and waterstoves, microturbine exhaust, taking diesel exhaust heat to power to supply electricity to refrigeration vans, there is an experimental kit.

IT10 General Specifications:
- 5 to 12 kWe
- 150,000 to 450,000 Btu/hr heat load (liquid, > 80 C)
- 130,000 to 400,000 Btu/hr cooling requirement (liquid or air, < 30 C)
- R134a, R245fa, R22, R6xx, R7xx (seals and lubricants are application specific)
- Brushless, Rectified AC Alternator (high ripple, DC Output)
- Output Options:
  - Raw or Conditioned DC Output
- AC Inverter (grid connect options available)
- Compact: ~ 300 mm wide by 800 mm long by 500 mm high
- Modular: Units can be stacked, side by side and vertically; interfaced through standardized hot, cold and electrical connections. Units can be hot-swapped
- No claims to efficiency since this is an experimental system

GENERAL ORC INFORMATION

The Organic Rankine Cycle (ORC) Infinity Turbines can use any thermal fluid to power the system evaporator (which in turn evaporates the high molecular mass fluid - an environmentally friendly refrigerant). It is recommended the system runs through a heat exchanger that has thermal oil as the fluid, which is then run through the system.

How it works: The organic Rankine cycle has three steps -

(a) The heat source in the form of a liquid then goes through the preheater and evaporator heat exchanger. This is where the working fluid for the ORC turbine gets vaporized and pressurized. The heat source should be at least 80 deg C. Once it passes through the evaporator, it comes out at about 10-20 deg C cooler. This can then be used for additional process heat (CHP hot water or chiller).

(b) The working fluid for the ORC closed system is pressurized by the evaporator, then is expanded by the turbogenerator. This produces the shaft horsepower to turn the generator and produce electricity. The turbine can power a generator, pump, or whatever is required.

(c) The expanded working fluid then goes through a condenser to return the vapor to a liquid state. The condenser requires some method of cooling fluid, typically water which is provided from a cooling tower, or ground based geothermal (the ground has a constant temperature of 15 deg C or less temperature). The liquid is then pumped back into the evaporator unit to complete the cycle. Only environmentally friendly working fluid is used in the system.

The basic system has a evaporator, turbogenerator unit and condenser. The temperature difference between the evaporator and condenser must be at least 125 deg F, or about 65 deg C. The heat rate is about 42,000 BTU / kilowatt electricity which is about 8-11 percent efficient.

INFINITY TURBINE LLC ORC SYSTEMS

The standard is the following (note that the minimum input temperature is 70 deg. C and max on the standard system is 115 C - higher temps are available for custom systems). Pricing is based on lower temperature systems with an induction generator and 60 hz.

(1) IT10  5-12 kw Infinity Turbine: Small experimental unit. Includes disc turbine with PM generator, evaporator, water cooled condenser, feedwater pump and basic controls. This unit does not come with warranty or any performance guarantees. It is designed for solar, engine waste heat, etc.

(2) 30 kw Infinity Turbine: Standard unit is skid mounted.

Note: These are the power skid units, and include a heat exchanger evaporator, turbine, induction generator, condenser heat exchanger, recirculation pump and basic grid connect switchgear. Available in 50 hz or 60 hz. All skid mounted or as an option into a shipping container.

Order Terms: 40 percent down, 40 percent at 6 weeks, balance at time before shipment to customer.
Order Time: From time of deposit on equipment the mfg. time is around 11-16 weeks depending on orders in process.

To run this unit, you will need to provide hot fluid (water, oil, etc.) to run through the evaporator heat exchanger. You will also need condenser cold fluid, which may be provided by an air cooling tower, ground source geothermal, or cold water from another source.

A. 5-12 kw ORC System - Experimental Kit: Turbine, generator, evaporator, condenser, feed pump. Hybrid disc turbine design. Variable flow is optional and extra. R134a will actually perform slightly better but R245fa can run a slightly higher temperature.
Gasifier Schematic

- Air
- Conv. Hopper
- Feed Hopper
- Gasifier (1000 lbs litter/hr)
- Stack
- Heat Exchanger
- Induced Draft Fan
- Hot Air
- Air Distribution
- Grid
- Power Interconnect
- Turbine
- Coil
- Fan
- Storage Hopper

BARN

Coaltec Energy
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10-30% Tax Credit

If you order and install in the USA a solar or geothermal system, you may be entitled up to a 30 percent Federal Tax Credit.

For equipment installed through 2016, the credit is set at 30% for solar technologies, microturbines 10% credit. The geothermal credit remains unchanged at 10%.

Solar energy property includes equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat.

Geothermal energy property includes equipment used to produce, distribute, or use energy derived from a geothermal deposit.

Infinity Turbine

Our Organic Rankine Cycle (ORC) Infinity Turbine can use any thermal fluid to generate power. Since our output is 1,800 RPM you can generate electricity, run a pump, compressor, or most shaft horsepower equipment.

To run this unit, you will need to provide hot fluid (water, oil, etc.) to run through the evaporator heat exchanger. You will also need condenser (fluid), which may be provided by an air cooling tower, ground source geothermal, or cold water from another source.

INFINITY TURBINE APPLICATIONS AND COMBINED HEAT AND POWER (CHP)

The Infinity turbine is a modular, skid mounted waste heat power generation system that not only allows you to produce electricity, but has generous amounts of exiting thermal fluid heat which can be used for hot water, process heat, or even to run through ancillary application modules like desalination units. The exiting fluid heat can also be used to run a chiller, that can provide you with air conditioning, or refrigeration/chiller process. This cogeneration allows you to use your waste heat source multiple times from one platform. We can even mount the unit in standard ocean shipping containers.
This unique system allows you to use your biomass, flare gas, waste heat, waste hot water, geothermal, geo-pressurized, hydrothermal, enhanced geothermal, turbine exhaust, or re-injected waste water to power a organic Rankine cycle (ORC) turbine generator. The technology developed using a ORC can operate off any heat source, with a minimum of 125 deg F temperature differential between the heat source and sink. Geothermal energy is only one potential application. Similar systems are already in operation off heat generated from landfill flares and gas turbine exhaust. Other applications may include using biomass as a fuel.

The oil and gas also provides another possible application for the ORC power plant. Because most oil and gas wells are quite deep, they are warmed by the natural thermal gradient of the earth. In 2004 the U.S. produced over 2 billion bbl of “waste” water along with the oil and gas production, primarily from the Gulf States with temperatures high enough to produce electricity. This hot water could be used to generate power directly, without impacting oil and gas production.

The Organic Rankine Cycle (ORC) is similar to the cycle of a conventional steam turbine, except for the fluid that drives the turbine, which is an environmentally friendly low boiling point organic fluid which allow the system to run efficiently on low temperature heat sources to produce electricity in a wide range of power outputs.

**Top:** IT30 With Air Cooled Condenser  
**Lower:** IT250  

**Operating Input Fluid Range:**  
70-110 °C and 80-150 °C

**Generator can be 50/60hz**  
Induction or Synchronous Grid Connect Power

Durable evaporator and condenser heat exchangers.

Skid has top lifting rings and forklift slots for ease of installation.

**1,800 RPM Shaft Horsepower Output for a generator, pump or compressor.**

Exit heat exchanger fluid can be used for additional CHP - hot water and chiller applications.

Entire unit is skid mounted and can additionally be mounted within a 20 or 40 foot ocean shipping container.

**MODULAR INSTALLATION**

The Global Energy Infinity Turbine was designed with the user in mind. The skid mounted units install easily, and can be mounted in a standard shipping container for remote, oil-rig, or shipboard deployment.
### GLOBAL ENERGY • INFINITY TURBINE • SPECIFICATIONS

#### Infinity Turbine • Thermal Fluid Heat Input Chart

<table>
<thead>
<tr>
<th>Infinity Turbine Model</th>
<th>110-150 Deg C Input</th>
<th>Flow Rate Gallons Per Minute 2 gpm per rated system kWe</th>
<th>Flow Rate Liters Per Minute 7.57 liter/minute per rated system kWe</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT 1 (For Illustrative Only)</td>
<td>30,000 btu</td>
<td>1 GPM</td>
<td>3.785 Liter/Min</td>
</tr>
<tr>
<td>IT 30</td>
<td>900,000 btu</td>
<td>60 GPM</td>
<td>227 Liter/Min</td>
</tr>
<tr>
<td>IT 250</td>
<td>7.5 mmbtu</td>
<td>500 GPM</td>
<td>1,693 Liter/Min</td>
</tr>
<tr>
<td>IT 500</td>
<td>15 mmbtu</td>
<td>1000 GPM</td>
<td>3,785 Liter/Min</td>
</tr>
</tbody>
</table>

Heat Rate = 30,000 - 42,000 btu/kWe

### Infinity Turbine • Exit Heat Available for CHP and Power Produced Chart

<table>
<thead>
<tr>
<th>Infinity Turbine Model</th>
<th>Evaporator Exit Temp - based on 100 Deg C (212 F) Evap Input Temp</th>
<th>Output Power per Hour - kWe</th>
<th>Output Power per Day - kWe</th>
<th>Output Power per Year - MWe</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT 1</td>
<td>65 C 172 F</td>
<td>1</td>
<td>24</td>
<td>9</td>
</tr>
<tr>
<td>IT 30</td>
<td>65 C 172 F</td>
<td>30</td>
<td>720</td>
<td>263</td>
</tr>
<tr>
<td>IT 250</td>
<td>65 C 172 F</td>
<td>250</td>
<td>6000</td>
<td>2190</td>
</tr>
<tr>
<td>IT 500</td>
<td>65 C 172 F</td>
<td>500</td>
<td>12000</td>
<td>4380</td>
</tr>
</tbody>
</table>

### Infinity Turbine • Exit Heat Available for CHP

<table>
<thead>
<tr>
<th>Infinity Turbine Model</th>
<th>Available for CHP</th>
<th>Condenser Flow - based on 10 C inlet and 18 C outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT 1</td>
<td>25,000 btu</td>
<td>2.5 gpm</td>
</tr>
<tr>
<td>IT 30</td>
<td>800,000 btu</td>
<td>150 gpm</td>
</tr>
<tr>
<td>IT 250</td>
<td>6 mmbtu</td>
<td>1,250 gpm</td>
</tr>
<tr>
<td>IT 500</td>
<td>13 mmbtu</td>
<td>2,500 mmbtu</td>
</tr>
</tbody>
</table>
### Infinity Turbine • Power Produced Savings and Revenue Chart • USA

<table>
<thead>
<tr>
<th>Infinity Turbine Model</th>
<th>Savings or Revenue per Year Usage at $0.10/kWe</th>
<th>Savings or Revenue per Year Usage at $0.15/kWe</th>
<th>Savings or Revenue per Year Usage at $0.20/kWe</th>
<th>Savings or Revenue per Year Usage at $0.25/kWe</th>
<th>Savings or Revenue per Year Usage at Euro $1.25 /kWe - In Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT 1</td>
<td>$876</td>
<td>$1,314</td>
<td>$1,752</td>
<td>$2,190</td>
<td>E 1,095</td>
</tr>
<tr>
<td>IT 30</td>
<td>$26,280</td>
<td>$39,420</td>
<td>$52,560</td>
<td>$65,700</td>
<td>E 32,850</td>
</tr>
<tr>
<td>IT 250</td>
<td>$219,000</td>
<td>$328,500</td>
<td>$438,000</td>
<td>$547,500</td>
<td>E 273,750</td>
</tr>
<tr>
<td>IT 500</td>
<td>$438,000</td>
<td>$657,000</td>
<td>$876,000</td>
<td>$1,095,000</td>
<td>E 547,500</td>
</tr>
</tbody>
</table>

### Infinity Turbine • Power Produced Chart • Europe • Carbon Credits

<table>
<thead>
<tr>
<th>Infinity Turbine Model</th>
<th>Savings or Revenue per Year Usage at Euro $1.25 /kWe - In Euro</th>
<th>Carbon Credit - Tons Per Year based on 2,000 kWe per ton</th>
<th>Carbon Credit per Year in Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT 1</td>
<td>E 1,095</td>
<td>4.38</td>
<td>E 99</td>
</tr>
<tr>
<td>IT 30</td>
<td>E 32,850</td>
<td>131.4</td>
<td>E 2,962</td>
</tr>
<tr>
<td>IT 250</td>
<td>E 273,750</td>
<td>1095</td>
<td>E 4,681</td>
</tr>
<tr>
<td>IT 500</td>
<td>E 547,500</td>
<td>2190</td>
<td>E 49,373</td>
</tr>
</tbody>
</table>

The Infinity Turbine is based on the Organic Ranking Cycle, which uses a thermal fluid heat exchanger to evaporate and pressurize and environmentally high molecular (low boiling point) working fluid. Specifications and performance may change without notice. Performance figures are approximate and for general information. For detailed performance, please commission a engineering study for your exact installation. Closed loop environmentally friendly working fluid (refrigerant) will vary in type according to the resource input temperature. Higher input temperatures may also allow the deployment of a multi-stage system which is more efficient. Chart prepared on October 14, 2008. Contact info: Greg Giese, Infinity Turbine LLC, PO BOX 5617, Madison, WI 53705 USA TEL(608) 238-6001 greg@infinityturbine.com