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Sustainable Use of Local Resources for Improved Energy Security

Phase 2: Procurement and Installation of Waste-to-Energy System at Eielson AFB, Fairbanks, AK

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Tarek Abdallah

Construction Engineering Research Laboratory (CERL)
U.S. Army Engineer Research and Development Center
2902 Newmark Dr.
Champaign, IL 61822-1076

Renee Comly, Amir Rehmat, and Marc Goold

Biomass Energy Systems, Inc.
1285 N. Telegraph Road # 140
Monroe, MI 48162

Final Report

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Abstract: This ongoing project is developing small-scale distributed power generation for use at U.S. Air Force bases using locally available resources such as wood and generated wastes. The first such system is designated for installation at Eielson Air Force Base (AFB), Fairbanks, AK. The program entails the conceptualization, design, fabrication, and testing of this customized waste-to-energy system for the specific application to this Air Force base. The program will proceed to completion in three phases: (1) system design, (2) technical support for construction, system integration and power generation, and procurement of gasifier-related instrumentation and accessories, and (3) technology transfer to DOD facilities, and state and local agencies.

Executive Summary

The focus of the project is the development of small-scale distributed power generation for use at U.S. Air Force bases, using locally available resources such as wood and locally generated wastes. The direct benefits of this development to the bases include the reduction of the use of non-renewable energy, increased energy security, and less reliance on a central grid. The overall goal of the program is to develop the ability of any Federal, state, or private sector energy users to convert locally available energy resources and locally generated wastes into readily usable forms of energy that can be used to replace hydrocarbon fuels, such as natural gas or oil. The phased program is intended to engineer, procure, install, and test a system with 1 MW of net production capacity for distributed power generation, using local resources such as wood and locally generated wastes at Eielson AFB in Alaska. The system used here is universally applicable in nature and easily adaptable for additional Federal, state, and private energy users.

The U.S. Air Force, Advanced Power Technology Office (APTO) is the principal driver behind this system development. Through APTO, the Air Force is taking the initiative to fulfill the requirements of Executive Order 13423, which has clear mandates for Federal facilities. It sets forth goals for the Federal Government to achieve improvements in its energy management, thereby saving taxpayer dollars and reducing emissions that contribute to air pollution and global climate change. These goals also include the following measures:

1. Each agency shall strive to expand the use of renewable energy within its facilities and in its activities by implementing renewable energy projects and by purchasing electricity from renewable energy sources.
2. Through life-cycle cost-effective measures, each agency shall reduce the use of petroleum within its facilities. Agencies may accomplish this reduction by switching to a less greenhouse gas-intensive, non-petroleum energy source, such as natural gas or renewable energy sources by eliminating unnecessary fuel use or by other appropriate methods.
3. Through life-cycle cost-effective measures, each agency shall reduce its greenhouse gas emissions attributed to facility energy use by 30 percent by 2010, as compared to such emissions levels in 1990.

The participation of an Air Force base provides the optimum path for the implementation of the most critical areas of adaptation for the mandates of Executive Order 13423. Participation in this overall program and is subsequent planned deployment, will enable the Air Force to use all its renewable wastes to provide alternative energy that will:

- replace petroleum fuel
- significantly reduce greenhouse gases through the use of biomass (wood)
- help implement biomass-based alternative energy technology to displace the use of petroleum in civilian uses, thereby freeing up a large portion of the current demand for petroleum from this segment of the society
- help implement micro grid structures among small communities (as well as at DOD facilities), which will be powered by local resources, and will thereby increase energy security.

The first such system is designated for installation at Eielson AFB in Alaska. The program entails the conceptualization, design, fabrication, and testing of this customized waste-to-energy system for the specific application to this Air Force base. Eielson AFB is located in Fairbanks, AK, which adds the design challenge of addressing issues related to installation and operations of equipment in severe weather conditions. The selection of this particular Air Force base by APTO also addresses the interests of the State of Alaska, which shares a similar objective of independent energy security. The State of Alaska is well suited for this development, since wood waste is available in abundance all over the state throughout the year. The development at the Air Force base will be directly applicable for use throughout the State. With the deployment of this technology, the State can look forward to eliminating the use of diesel for power generation at remote villages.

The program consists of three phases:

1. Phase 1, which was completed in August of 2008, was comprised of the system design to the stage at which the system was ready for procurement.
2. Phase 2, Part 1, which began in August 2008, includes technical support for construction, system integration, and power generation, as well as the procurement of gasifier-related instrumentation and accessories.
3. Phase 3, which will involve technology transfer to DOD facilities, state, and local agencies.

Biomass Energy Systems, Inc. (BESI) leads the overall program, with logistic support provided by the APTO. BESI is a woman-owned waste-to-energy technology development company specializing in customized distributed generation systems. The genesis of the core system for this project is the result of many years of research, study, testing, and operations by the personnel that are involved in the program.

This final report covers the entire 9 months allocated to the Part I, Phase 2 of the project. It contains detailed information about the project progress and accomplishments during this 9-month period.

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Preface

This study was conducted for the U.S. Air Force (USAF) Advanced Power and Technology Office (APTO) under a reimbursable effort with the U.S. Army Engineer Research and Development Center (ERDC) under Contract W9132T-07-C-0020, and for the ERDC, under a Project titled “Vehicle to Grid Technology for Improved Grid Energy Efficiency and Security, Improved Grid Energy Efficiency and Security using Advanced Modular Lithium-Ion Energy Storage for Hybrid and Electric Vehicles.” Funding was provided through Military Interdepartmental Purchase Requests (MIPRs) F3QCDA7197G007 (FY07) and F3QCDA7193G003 (FY08), “Proposal for Improved Grid Efficiency and Security and Advanced Modular Lithium-Ion Energy Security Energy Storage for Hybrid and Electric Vehicles.”

The work was managed and executed by the Energy Branch (CFE), of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL principal investigator and technical monitor was Franklin H. Holcomb. Appreciation is owed to Mr. Michael Mead, Chief, U.S. Air Force Advanced Power Technology Office, and to Gregory Kaminski and Steven McTier, also associated with the U.S. Air Force Advanced Power Technology Office, for technical oversight support. Franklin Holcomb is Chief, CEERD-CF-E, and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director is Martin J. Savoie, CEERD-CV-T. The Director of ERDC-CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Gary E. Johnston, and the Director of ERDC is Dr. Jeffery P. Holland.

1 Introduction

Background

The development of small-scale distributed power generation at U.S. Air Force bases using locally available resources such as wood and locally generated wastes offers direct benefits including: (1) the reduction of the use of non-renewable energy, (2) increased energy security, and (3) less reliance on a central energy grid. This work was undertaken to develop the ability of any Federal, state, or private sector energy users to convert locally available energy resources and locally generated wastes into readily usable forms of energy that can be used instead of hydrocarbon fuels, such as natural gas or oil. The target wastes for this development includes wastes generated at the Air Force bases including, but not limited to municipal solid waste, municipal sewage sludge, food waste, construction wood debris, and packaging wastes.

The phased program is intended to engineer, procure, install, and test a system with 1 MW capacity for distributed power generation, using local resources such as wood and locally generated wastes at Eielson AFB, AK. The system developed in this work is universally applicable and easily adaptable to additional Federal, state, and private energy uses. The overall program consists of three phases:

1. Phase 1, which was completed in August 2008, was comprised of the system design to the stage at which the system was ready for procurement.
2. Phase 2 includes technical support for construction, system integration, power generation, and procurement of gasifier-related instrumentation and accessories.
3. Phase 3 will involve the technology transfer to DOD facilities, and to state and local agencies.

The project is currently in Phase 2, in which the primary activity is confined to the procurement and the installation of the 1 MW waste-to-energy system at Eielson Air Force Base (AFB). It is anticipated that Phase 2 will span over 2 years. This report describes the progress made during the first 9 months (Phase 2, Part 1) of the project.

Objectives

The overall goal of this project is to improve energy security and build the nation's alternative energy generation capacity by introducing small-scale power distribution systems that use renewable, local resources such as woody biomass and locally generated wastes to provide power. The specific objective of this phase of research is to procure and the install a 1 MW waste-to-energy system at Eielson AFB, AK.

Additional overall objectives are to:

1. Convert renewable solid wastes and other recurring solid wastes into a usable form of gaseous fuel that can readily replace, and therefore displace, petroleum-based fuels in a first-of-its-kind application of this system.
2. Implement an alternative energy demonstration to produce 1 MW of electrical power from solid wastes at the selected Air Force base facility in Alaska to develop and demonstrate a wider use of local resources, including wastes, to increase energy security.
3. Demonstrate the production of alternative energy from locally generated wastes at the Air Force base, as well as other locally available biomass, such as woody biomass, including the undesirable beetle-infested pine wood waste found in Alaska, thereby providing an additional benefit of healthy reforestation and the reduction of fire hazards, while increasing energy security.
4. Develop an effective technology deployment path through a public-private partnership with the active participation of industry, academics, government, and local population of Alaska.
5. Demonstrate the efficacy of distributed, alternative energy generation from a wide array of solid wastes and for an extensive array of end-use applications, by developing a broad operational database from the sustained operation of the 1 MW demonstration facility located at Eielson AFB, AK.
6. Develop a turnkey modular system for a wider application throughout DOD facilities, in addition to the prospect of global applications, to foster an export market for the alternative energy systems.

Approach

This work is developing and testing a modular 1 MW waste-to-energy system at Eielson AFB, AK that can ultimately be deployed at DOD facilities across the United States. Specific tasks of Part 1 of Phase 2 included:

1. Installation planning and procurement support
2. Permit support
3. Procurement of the instrumentation and accessories
4. Project management.

Mode of technology transfer

This report will be made accessible through the World Wide Web (WWW) at URL:

http://www.cecer.army.mil

2 Work Plans and Project Accomplishments

Phase 2 work plan

Phase 2 of the program consists of procuring and installing the waste-to-energy system at Eielson AFB, AK. This system will demonstrate waste-to-energy conversion in a real-world setting in Alaska, where the wastes generated daily will be converted into alternative energy for DOD applications. The full participation of Eielson AFB during this demonstration will help DOD work all the way through the integration of the change from petroleum to locally available renewable sources. This participation will also help facilitate the transition of the system into the broader government and civilian sectors. This demonstration will also improve on the feed preparation, if necessary, and also bracket new sets of operating conditions for Alaskan wastes, such as beetle-infested wood and nearby industrial wastes, such as sawmill wastes. BESI, in cooperation with its subcontractors, including a local Alaska engineering company, will provide installation and oversight. Depending on the staffing needs and availability, BESI and/or Air Force personnel will perform the shakedown and operations. Phase 2 will be carried out in several parts, based on the availability of funds. Overall, Phase 2 is scheduled to span 24 months.

This final report specifically addresses progress made during the 9 months allocated to complete Part 1 of Phase 2 of the project, for which partial funding had been made available in August 2008.

Phase 2, Part 1 work plan

Part 1 of Phase 2 was comprised of four tasks:

1. Task 1: Installation planning and procurement support
2. Task 2: Permit support
3. Task 3: Procurement of the instrumentation and accessories
4. Task 4: Project management.

The following sections describe each task in detail.

Task 1: Installation planning and procurement support

The objective of Task 1 is to provide technical support to Eielson AFB with planning for the installation of 1 MW waste-to-energy system at the base.

Task 1 will include technical support to Eielson AFB in the following specific areas:

- planning for the building to house the waste-to-energy system
- planning for the utilities for the waste-to-energy system
- planning for waste supply for the waste-to-energy plant
- planning for the power hook up to the base grid and for its optimal use
- planning for the optimal use of the waste-to-energy system
- identifying additional waste streams that would be suitable for use with the proposed waste-to-energy system
- planning for the disposal of waste streams from the waste-to-energy facility
- planning for monitoring air emissions from the plant.

BESI will manage the procurement of the instrumentation and accessories for the gasifier and work closely with the manufacturer to assure quality control and to assure workmanship in accordance with the BESI specifications.

Task 2: Permit support

The objective of Task 2 is to provide technical support to Eielson AFB for its application for permits for the installation and for the operation of the waste-to-energy facility.

In Task 2, BESI will provide technical support to Eielson AFB with their application for the installation and for the operation of the waste-to-energy facility. This support will include providing:

- estimates of air emissions from the plant
- design calculations for the gas flows through the system
- the bases for all calculations provided for permit applications
- any narratives that may be required of the application
- any other information that may be required from time to time for the procurement of all the necessary permits for the plant.

Task 3: Procurement of the instrumentation and accessories

Task 3 will begin the partial procurement of the waste-to-energy system. In this task, BESI will procure and deliver to Eielson AFB gasifier-related components (for Gasifier RX300). Because of the limited availability of the funding, only the instrumentation and accessories (shown in bold-italics in Table 1) will be procured.

Table 1. Procurement Items: Current Items Italicized.

SL #	Gasifier Component	U.S. Manufactured / Assembled Vendors	Value Vendors
1	Gasifier Shell (Kiln) (Attachment A) Shell Inlet End Cover/Hood Outlet End Cover/Hood Drive Motors	$904,040	$352,869
	Shipping/Handling	$10,000	$15,000
2	Refractory Material (Attachment B)	$129,600	$61,517
	Shipping/Handling	$3,000	$5,000
3	Air Distributor (Attachment C)	$66,080	$57,508
	Shipping/Handling	$2,000	$3,000
4	***Accessories: (Attachment D)*** ***Ash Handling System, Air Nozzles & Process Blowers, Startup Burner, Air Compressor, Support Structures, and Piping.***	$115,647	$112,501
	Shipping/Handling	$6,000	$7,000
5	Instrumentation (Attachment E) ***Sensors*** ***PLC, DCS, Software*** ***Motor Control Center (MCC)***	$370,357	$195,436
	Shipping/Handling	$7400	$4400
6	Valves & Actuators Attachment F)	$24,641	$20,534
	Shipping/Handling	$1500	$2190
	TOTAL GASIFIER PRICE (Includes Shipping & Handling for individual items)	$1,640,265.00	$836,955.00
All Prices in US Dollars Shipping/Handling is FOB Fairbanks, AK, USA.			

Note that the "Buy American Act" requires these items to be procured from U.S. vendors. The combined value of the delivered components, which will be delivered on a fixed cost basis, is $499,404.

Task 4: Project management

Task 4 will provide effective procurement and project management so that the proposed activities are effectively conducted within the allocated time and budget. Task 4 will include:

- program liaison with APTO and CERL
- project reporting.

Project accomplishments

The accomplishments summarized here took place in Part 1 of Phase 2, during the performance period from August 2008 to April 2009.

Task 1: Installation planning and procurement support

1.1 Plant installation support

The research team worked with BAE Systems Inc. to help developing protocols for the installation of the 1 MW waste-to-energy system at Eielson AFB. BAE was furnished with the entire design, and with various schedules for component fabrication and delivery. A lack of specific information about the site for the project on the Base made it impossible to develop exact cost information for the installation. However, during the course of this exercise, it was possible to articulate the conditions that would provide a least-cost approach for the installation, some of which are:

1. The site should be prepared in terms of filling, leveling, strengthening, and clearing before installation activities begin.
2. Site preparation should also include connection with all of the necessary utilities, including water, fuel for startup, and electricity to the site.
3. The site owner should procure all of the related permits before installation begins.
4. The site preparation process should include decision made with the site owner on a strategy for waste collection, waste delivery, including sorting, and temporary storage.
5. The site owner and the technology provider must formulate power integration protocols to introduce power generated from the waste-to-energy facility before installation begins.
6. Note that, if the plant is designed for an indoor location, the building enclosure will not be considered as part of the installation. The cost of the building will need to be accounted for separately.

7. The installation drawings for the components, interconnecting ducts, piping, insulation, instrumentation, electrical, foundation, and structural steel, including platforms, should be complete and approved before installation begins.
8. All components, including vessels, major piping and ducts, compressors, gensets, tanks, blowers, instrumentation and controls, motor control center, programmable logic controller, manual valves, solenoid valves, conveyors, elevator conveyors, and motors should be all available at the site before installation begins.
9. The cost of the refractory lining should be incorporated into the cost of the components. The equipment supplier should coordinate installation of the refractory lining with the refractory supplier.
10. All activities outside the confines of the plant itself, such as landscaping, peripheral lighting, and construction of parking areas and access roads are considered separate from the actual installation should coordinate and shall be contracted separately.

These preparedness measures will help minimize costs. Additionally, keeping costs for the plant installation will require careful planning and scheduling of all construction activities, and prudent use of the work force and construction equipment. Figure 1 shows the planning, scheduling, and duration of each activity.

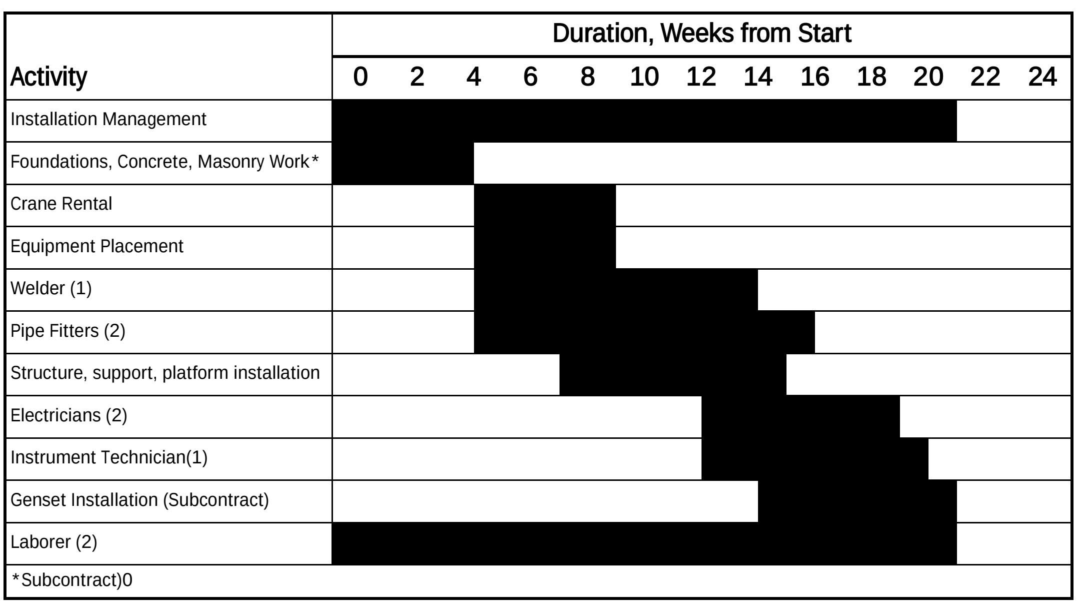


Figure 1. Schedule of installation activities.

Some of the higher costs associated with the installation are the materials required for civil and structural work. Estimation of civil work assumed a plant floor area of approximately 44,000 sq ft and an 8 in. slab thickness throughout. Estimates for structural steel usage will to use similar information from the actual installations of South Korean and Indian waste-to-energy facilities, which are similar in size to the Eielson project. Actual data from these installed plants will enable more accurate cost estimates of the steel structure, which will minimize the contingency allowances in the cost of installation.

Continued interaction with BAE Systems during subsequent contract modifications will ensure accurate feedback regarding accounting plant installation costs. The time allocated for installation activities has been capped at 24 weeks, of which the first 6 weeks will be dedicated to foundations, concrete, and masonry work.

The participants mutually agreed on the most favored conditions to minimize the cost for the plant installation. Further discussions were postponed until Eielson AFB could provide information regarding considerations that directly impact the cost of installation, such as:

- an exact location for the installation
- the condition of the site upon which the plant will be installed
- the time of the year when the plant will be installed
- the availability of local tradesmen
- the specification for overall integration of the waste-to-energy plant with the rest of the power grid on the Base.

It is anticipated that this information will become available as soon as the Memorandum of Understanding (MOU) is signed between APTO and Eielson AFB. Although technical support for this subtask of Part 1 of Phase 2 of the project concluded at the end of April 2009, it will resume in Part 2 of Phase 2 of the project when additional funding is made available.

1.2 Facility planning support

The activities in this subtask depend on information received from Eielson AFB, i.e., the exact location of the plant on the Base and its location in relation to the local electric grid. Again, this information will only be available after APTO has executed a MOU with Eielson AFB for the integration of the waste-to-energy project at the Base.

The activities in this subtask were also concluded at the end of April 2009 for Part 1 of Phase 2 of the project, but technical support for this subtask will be nonetheless included in Part 2 of Phase 2 of the project when additional funding is made available.

Task 2: Permit Support

At the time of this writing, Eielson AFB has not provided complete data on either the quantity of the waste that would be available for the project, or for the final composition of this waste. Nonetheless, available information on typical municipal solid waste generated in the United States and partial information from Eielson AFB was used to estimate emissions data that would be useful for developing permit information for the proposed waste-to-energy facility.

This typical Municipal Solid Waste (MSW) is comprised of a number of combustible components, such as paper, plastics, textiles, rubber, wood, yard waste, and food waste. The noncombustible inorganic component is primarily made up of glass and metals. The chemical composition, amounts, and physical nature of each of these organic components (listed in Table 2) vary significantly between components. The last row of Table 2 lists baseline average composition of MSW.

Table 2. Ultimate analysis of MSW based on typical U.S. MSW composition.

Components of Waste Stream	% in MSW	Percent by Weight (Dry Basis)						
		C	H	O	N	S	Cl	Ash
Paper and Cardboard	35.7	43.5	6	44	0.3	0.2	0.071	6
Plastics	11.1	60	7.2	22.8	0	0	0.278	10
Textiles	4.3	55	6.6	31.2	4.6	0.2	0.054	2.5
Rubber & Leather	4.6	69	9	5.8	6	0.2	0.058	10
Wood	5.7	49.5	6	42.7	0.2	0.1	0.224	1.5
Yard Waste	12.2	47.8	6	38	3.4	0.3	0.224	4.5
Glass & Metals	13.4	2.5	0.35	2.9	0.1	0	0.008	94
Food Waste	11.4	48	6.4	37.6	2.6	0.4	0.034	5
Others (dirt, ash, etc.)	1.6	26.3	3	2	0.5	0.2	0	68
Composite MSW		42.3	5.5	31	1.3	0.18	0.72	18.6
(Based on U.S. EPA (2003) "Municipal Solid Waste in the United States: Facts and Figures", Office of Solid Waste and Emergency Response, EPA 530-R-03011, Washington, DC)								

Table 3 lists the heat and material balance for the gasification of MSW with air. Two cases of material balances are presented below. The first case is based on processing 1 t/h of MSW containing 20 percent moisture. The second case is based on producing 1.3 MW gross or 1 MW of net power, assuming a very conservative overall efficiency number of 20 percent. In both cases, the gasification temperature is 1800 °F and the gasifier is operating at near atmospheric pressure.

Table 3. Energy and material balances for the gasification of MSW with air.

Criteria	MSW Processing Rate of 1 Ton	Production of 1 MW of Net Power
Gasification Mode, Air/Enriched Air/O_2	Air	Air
Waste Composition (Dry Basis)		
wt %		
C	42.61	42.61
H	5.54	5.54
O	31.52	31.52
N	1.32	1.32
S	0.18	0.18
Cl	0.1	0.1
Ash	18.73	18.73
Moisture %	20.00	20.00
HHV, Btu/lb (Dry) (Dulong)	7200.83	7200.83
HHV, Btu/lb (Wet) (Dulong)	5760.66	5760.66
Total Feed Rate, lb/h	2000.00	3861.00
Dry Feed Rate, lb/h	1600.00	3089.00
Moisture Feed Rate, lb/h	400.00	772.00
Gasification Temperature, °F	1800.00	1800.00
Heat Loss, % of heat input	5.00	5.00
Air Composition, mol %		
O_2	0.21	0.21
N_2	0.79	0.79
CO_2		
Ar		
Air Feed Rate, mols/h	171.228	330.54
Air Feed Rate, lb/h	4940.00	9536.00
Syngas Produced, mol/h	254.44	491.17
Syngas Produced, lb/h	6640.31	12818.69
Syngas Mol Wt, lb/mole	26.09	26.09
Syngas Composition, mol %		

Criteria	MSW Processing Rate of 1 Ton	Production of 1 MW of Net Power
CO	10.07	10.07
H_2	7.56	7.56
CH_4	0.89	0.89
CO_2	11.34	11.34
H_2O	16.62	16.62
H_2S	0.04	0.04
N_2	53.46	53.46
HCl	0.02	0.02
Total	100.00	100.00
Ash Produced, lb/h	299.68	578.50
HHV of Syngas, Btu/SCF (Wet)	66.20	66.20
HHV of Syngas, Btu/SCF (Dry)	79.40	79.40
Total Heat Input, Btu/h	1.15E+07	2.22 E+07
Heat Loss, Btu/h	576066.00	1.1 E+06
Sensible Heat, Btu/h	3,124,276	6,031,211
Heat in Syngas, Btu/h	6.37E+06	12.27 E+06

According to the values listed in Table 2, the gross output of 1.3 MW of electrical power will require 1.931 t/h of MSW, or 46.34 t/d. Production of 1 MW gross power instead of 1.3 MW drops the MSW requirement to 35.6 t/d. On a unit basis, each ton of MSW per hour containing 20 percent moisture yields approximately 0.674 MW of power.

The positive environmental impact of MSW gasification

Solid residue

The solid residue from a MSW waste-to-energy plant using gasification largely depends on the presorting of MSW performed before processing. Glass and metals form almost 90 percent of the noncombustible portion of the MSW. If these materials are removed before processing, then the solid residue from the waste-to-energy system is reduced from 579 lb/h to about 60 lb/h, or ~0.72 t/d. Without the glass and metals, the volume reduction of MSW is greater than 98 percent for the remaining quantity of solid residue. In addition to the solid residue left behind by the incombustible inorganic component of MSW, more solid residue is generated from the capture of sulfur during the processing.

The preferred mode for sequestration and thus the avoidance of SOx emissions into the atmosphere is the addition of limestone into the gasifier. Alternatively, lime can be injected into the baghouse for the same purpose. If the presorting of MSW has already reduced the amount of inorganic materials, then the preferred mode will be the in-situ capture in the gasifier. If presorting is not done, then the preferred mode will be the injection of lime into the baghouse. The objective is to minimize the overall quantity of sulfur-containing solid residue from the process. Experience shows that target capture for sulfur during the processing is about 90 percent.

The amount of calcium required by the gasification process in the form of either limestone or lime is dictated by the amount of sulfur present in the MSW. The proposed 1.3 MW system would introduce approximately 0.174 moles of sulfur, which would then require 0.348 moles of limestone or 0.348 moles of lime. This amounts to using 0.42 t/d of limestone or 0.24 t/d of lime. The additional solid residue resulting from this sulfur capture is 0.27 t/d.

SO_2 emission

With 90 percent removal of sulfur during processing, the amount of sulfur left in the clean fuel gas is 0.0174 moles. When the fuel gas is used in the genset, the NOx content of the flue gas will amount to 0.0174, compared to 815 moles of total flue gas adjusted for 7 percent oxygen. Thus on a volumetric basis, SOx in the flue gas will be approximately 21 ppm, which is 33 percent less than the value of 30 ppm, the amount allowable under New Source Performance Standards (NSPS) for controlled MSW combustion.

NOx resulting from MSW-bound N_2

In MSW incineration, all nitrogen bound with MSW ends up as NOx. In fact, if the direct combustion of MSW were used in the proposed process, the resulting NOx would amount to 3600 ppm, which far exceeds the NSPS limit of 100 ppm, and which would require expensive reduction techniques for mitigation. One of the major advantages of gasification over incineration is that the reducing conditions in the gasifier cause all nitrogen bound with MSW to be converted into elemental nitrogen; the proposed use of gasification will create no NOx from MSW-bound nitrogen.

Fate of chlorine

All chlorine entering the gasifier with MSW ends up as hydrogen chloride. Since this compound is extremely soluble in water, all the hydrogen chloride is removed from the gas when the syngas is scrubbed before use. This is very different from incineration. During MSW incineration, in which oxidation conditions prevail, most of the chlorine in the MSW ends up as elemental chlorine, which then reacts with stray hydrocarbon species to form highly toxic and carcinogenic compounds commonly known as dioxins and furans. The abatement of these harmful compounds during the gasification of MSW makes this process safer and more palatable.

Avoidance of methane emissions

The diversion of MSW from landfills and its use to produce clean alternative energy via the gasification technology avoids a significant quantity of uncontrolled methane emissions. Generally, 50 percent of all energy contained in the MSW ends up as methane released into the atmosphere. In this case, the total heat input when producing 1.3 MW of power from MSW is 22.2 million Btu/h. Processing MSW in this manner will prevent the release of at least 11.1 million Btu in the form of methane (for a methane emission reduction of 11,100 SCF/h). This is a very significant greenhouse gas reduction from the landfill, particularly when methane is an especially potent greenhouse gas (more than 20 times more potent than CO_2).

Since the information regarding the exact nature of the waste generated by Eielson AFB will only be known after APTO has executed the MOU with Eielson AFB, formal estimations for the actual waste will be made only after the Memorandum of Understanding is in place.

During the course of the Part 1 Phase 2 of the project, I was not possible to obtain the information regarding the existing Title V permit at the Base and regarding all point sources of emissions. This information would be useful in superimposing point source emissions from the proposed waste-to-energy facility and in assessing direct benefits derived from using this improved alternative energy generation techniques over the direct combustion of coal in the PC boiler.

The activities in this task were also concluded at the end of April 2009 for Part 1 of Phase 2 of the project. The continuation of the technical support for this task will be nonetheless included in Part 2 of Phase 2 of the project when additional funding is made available.

Task 3: Procurement of the instrumentation and accessories

Equipment procurement

All of the components that were included in the partial procurement in Part 1 of Phase 2 of the project have been procured.

3 Components

Table 4 lists all the components included in this partial procurement along with their specifications. Table 4 also includes photographs of the individual components or for the component groups.

Table 4. Plant components procured during Part1 of Phase 2.

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Startup Burner & Controls BRN-310	One Kiln Burner including: § Burner (with refractory lined sleeve) heat release of 10 Million Btu/hr § Diesel fuel train and pilot train including modulating actuator and approved shutoff valves. Control panel including: § Flame safeguard with UV flame scanner, conventional start with automatic reset valves, automatic fuel air control, electric ignition and low fire purge safeguard. § Capability of integrating process combustion with and air blower and motor.	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Ash Surge Hopper H-350	1-ton capacity hopper to receive hot ash from kiln. Fabricated in high temperature Stainless Steel	
		

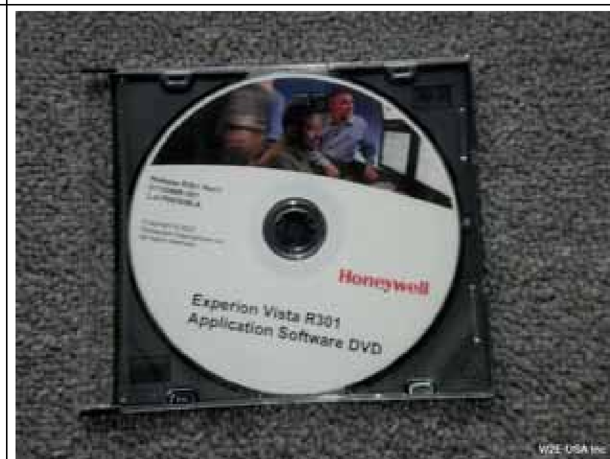
Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Rotary Airlock RV-320	High temperature (800 °F) rated airlock valve to discharge ash from kiln. All material contact surfaces fabricated of stainless steel.	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Air & Process Nozzles RX-300-PN50NB1 RX-300-PN50NB2 RX-300-PN200NB	Air and process nozzles specified by the client will be provided. Suitable flanges will be provided in the inlet and outlet covers to accommodate these nozzles. Fabricated in high temperature stainless steel.	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Process Blowers BL-330A BL-330B	Process blower capable of delivering 3000 CFM at 3550 RPM. Motor: 40HP, 3PH, 60Hz, 230/460V, TEFC, Insulated. Cast iron frame. Motor operated with variable frequency drive. V-ring shaft seal, drill inlet flange standard bolt circle. Wire inlet filter. Drill discharge flange standard bolt circle. AMCA C construction.	
	Process blower capable of delivering 1000 CFM at 3524 RPM. Motor: 15HP, 3PH, 60Hz, 230/460V, TEFC, Insulated. Steel frame. Motor operated with variable frequency drive. V-ring shaft seal, drill inlet flange standard bolt circle. Wire inlet filter. Drill discharge flange standard bolt circle. AMCA C construction.	

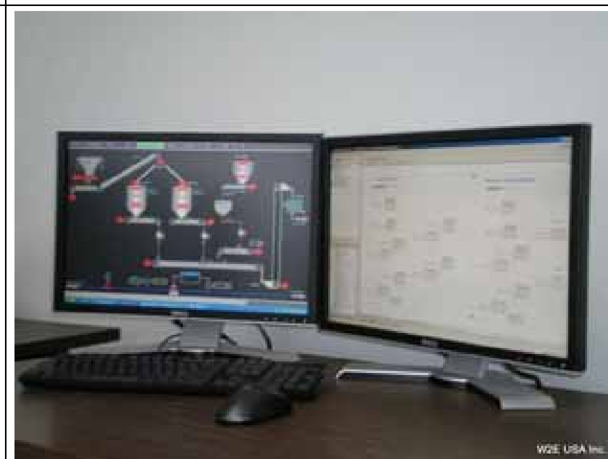
Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Air Compressor C-900 / C-930 / C-940	Air compressor with rated capacity of 500 CFM (+/-50 CFM) of compressed air at 100 psig. 460V 3Ph 60Hz. Open frame unit for indoor use only. Oil free type compressor or equipped with Oil vapor removal filters capable of reducing levels to less than 0.003 mg/m3 when challenged with 40 mg/m3 of oil vapor. Air discharge 1-1/2" to 2". 115V control voltage Rigid base with forklift slots Heavy duty intake air filter EPAct efficiency motor Multilevel safety systems Pressure relief valve Rated for 24/7 operations Automatic start/stop capable of remote monitoring and control.	
	Includes 500cfm@100psig capacity heated regenerated dryer with low purge (less than 10%) and low power consumption (less than 10kw) with pre and after filters capable of delivering compressed air with a dew point of -40F. Air receivers, minimum 400 gallon, 125 psig, ASME rated, with gage, pressure relief valve and drain – 2pcs	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Motor Control Center (MCC) MCC-M016/M017/M019/M020/M021	Control Center Panel to accommodate controls for the following motors: Process Air Blower-A Process Air Blower-B Rotary Air lock valve Gasifier Main drive Gasifier Auxiliary drive 20-in. Deep, Front Only, Circuit Breaker, 480V, 3 Phase, 4 Wires, 60 Hz, 42K AIC, NEMA1 Enclosure, Horizontal Bus: 600A Tin plated Copper, Vertical Bus: 300A Copper, Wiring Class I Type B 2 - 20-in. Deep, Front Only, 20-in. Wide Enclosure HLD6 Main TM CB, Standard, 3 Pole, 600A Frame @ 65KAIC, 600A Trip 1 - FVNR, CB, Size 1, 10 HP, Class I, Type B 1 - Electronic OL Type ESP Overload XClass 20 1 - Control Circuit Transformer, 480V, 50VA, 1 - Pilot light (R), Label: Running, Size:22mm 1 - FVNR, CB, Size 1, 3 HP, Class I, Type B 1 - Electronic OL Type ESP Overload XClass 20 1 - Control Circuit Transformer, 480V, 50VA, 1 - Pilot light (R), Label: Running, Size:22mm 1 - FVNR, CB, Size 1, 2 HP, Class I, Type B 1 - Electronic OL Type ESP Overload XClass 20 1 - Control Circuit Transformer, 480V, 50VA, 1 - Pilot light (R), Label: Running, Size:22mm 2 - FVNR, CB, Size 2, 20 HP, Class I, Type B 1 - Electronic OL Type ESP Overload XClass 20 1 - Control Circuit Transformer, 480V, 50VA, 1 - Pilot light (R), Label: Running, Size:22mm	

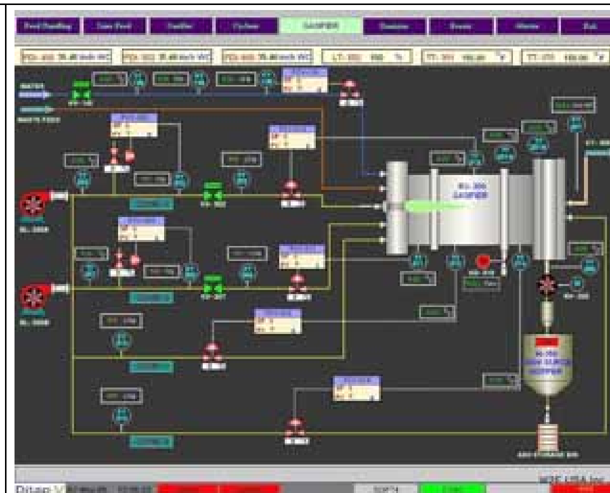
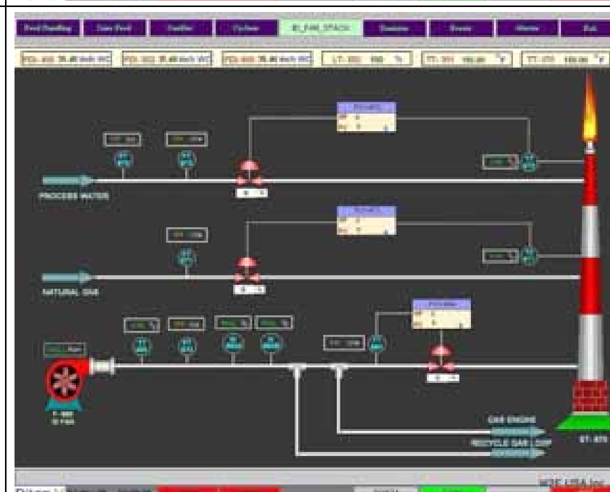
Component With ID No.	Specification	Photograph(s) of the Received Component(s)
Server Workplace CS-SWP-COMP CS-SWP-SOFT	Includes personal computer (without monitor) with following preloaded SW: Windows XP, One Engineering Workplace and Microsoft Office. PC: Minimum 486CPU, 1GB RAM, 500GB HDD, 256MB Graphics Card, Network adapter, USB ports., DVD R/W Drive, keyboard, mouse. Engineering Workplace supports Programmable Logic Controller.	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
Operator Workplace Client CS-OWP1-COMP CS-OWP1-SOFT	Includes PC (without monitor) with the following preloaded SW: Windows XP & one Operator Workplace. PC: Minimum 486CPU, 1GB RAM, 500GB HDD, 256MB Graphics Card, Network adapter, USB ports., DVD R/W Drive, keyboard, mouse. Operator Workplace supports Programmable Logic Controller.	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
PLC Cards and Accessories CS-PLC-C1 CS-PLC-PS1 CS-PLC-PS2 CS-PLC-AI (1-7) CS-PLC-AO (1-3) CS-PLC-DI (1-5) CS-LVTB CS-HVTB CS-FBTC CS-RACK (1-2) CS-MON (1-2) CS-PRN1	1- Programmable Logic Controller, 24 VDC, RS-232/485, integrated Ethernet TCP/IP Capacity: Analog In – 256 Analog Out – 64 Digital In – 960 Digital Out – 960 Function Blocks – 2000 PID Loops – 32 2 - 12 I/O Slot Rack 1 - I/O Scanner (for remote rack) 2 - Power Supplies 120/240VAC, 60W **I/O Modules** 7 - Analog Input hi level (16 ch) 3 - Analog Outputs 0 to 20mA (16 channel, 3 modules per rack) 5 - Digital Input, 24VDC (32 channel) 1 - Digital Input, 120/240 VAC, (16 channel) 3 - Digital Output, 24VDC (32 channel) **I/O Components** 18 - Low Voltage Terminal Block (36 channel) 1 - High Voltage Terminal Block (Barrier Style) **Accessories** 5 - Filler Block Terminal Cover 1 - Ethernet Cable (10 feet) 1- Serial Cable (PC to HC900 serial port) 2 - 250 ohm Shunt Resistor Kit (8/pkg.) 2 -19-in. TFT monitors 1 -8 Port Ethernet Switch 1 -Laser Jet A4 Printer	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
PLC Panel CS-PLC-PNL1	Suitable to accommodate above cards and accessories. Suitable access doors at front and rear.	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
SENSORS		
DCS and Control Software CS-PLC-CTRL CS-SCADA	Engineering, Software Development as per the control philosophy & logic provided by the P&ID for the RX-300 gasifier system only. SCADA software used is compatible with the Programmable Logic Controller selected above. Includes assembly and testing of the control system.	
		

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		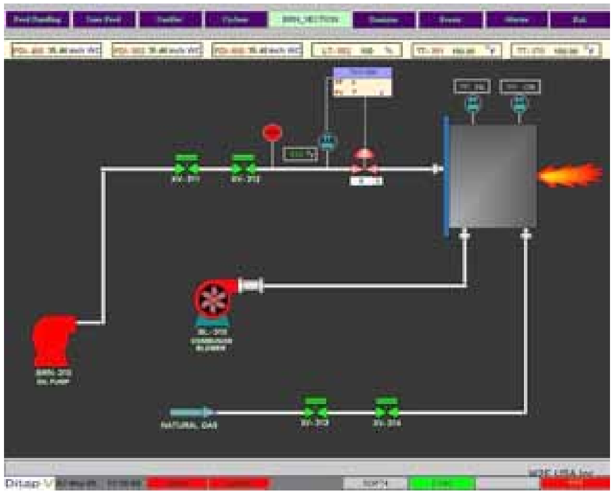
		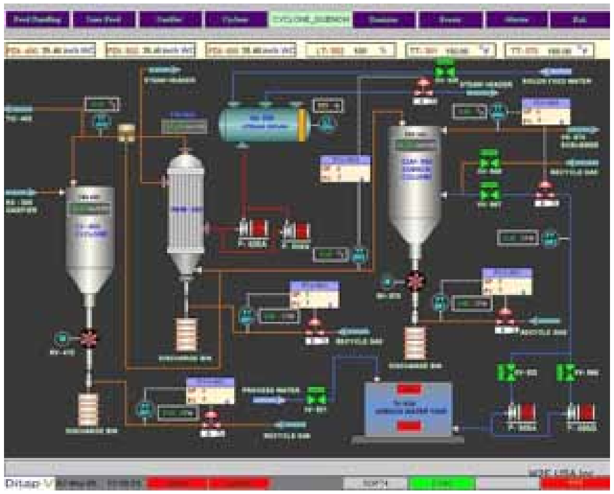

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		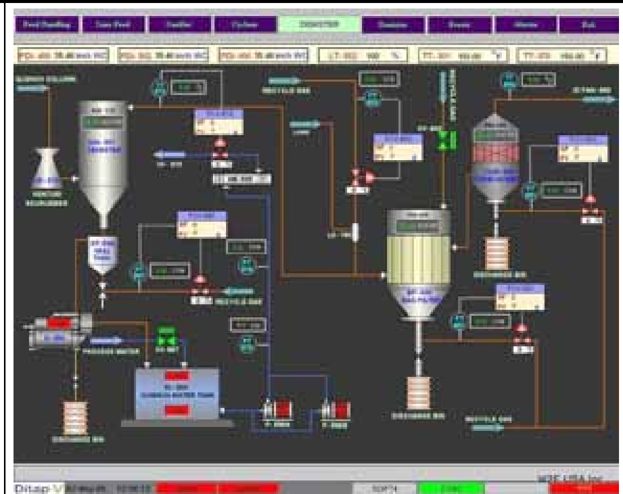
		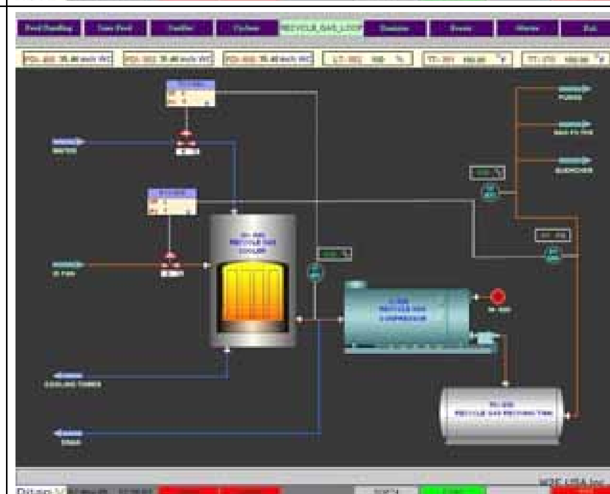

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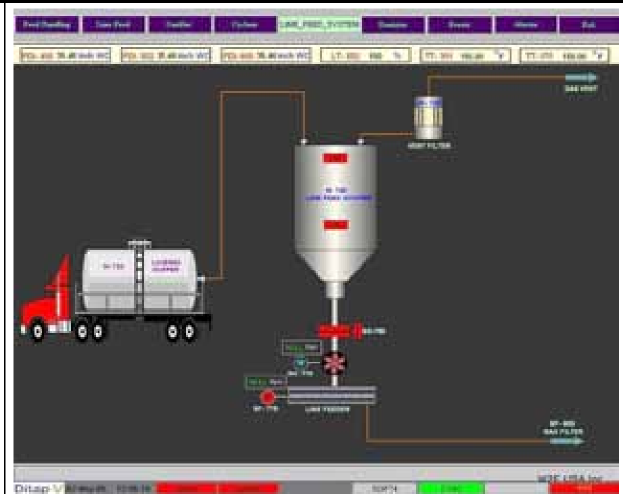
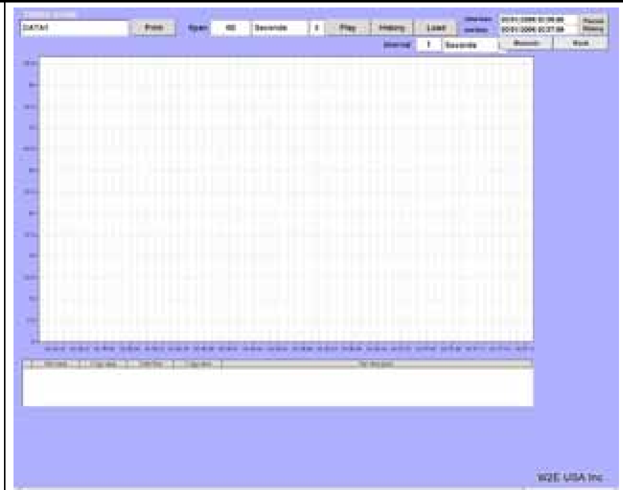
		
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
FE- 303	Process air to gasifier combustion zone: Orifice plate assembly	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
FE- 304	Process Air to gasifier combustion zone: Orifice plate assembly	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
FE- 312	Process air flow to gasifier zone 2: Orifice plate assembly	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
FE- 314	Process air flow to gasifier zone 4: Orifice plate assembly	
LSH 350	Ash surge hopper level RF Admittance Level switch	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
PI 1	Pump pressure gauge — Diaphragm type	
PI 136	Process water pressure: Diaphragm type with silicon pressure sensor	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
PI 2	Spill pressure gauge Diaphragm type	
PI 303	Process air header pressure: Diaphragm type with silicon pressure sensor	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
PI 304	Process air header pressure: Diaphragm type with silicon pressure sensor	
PI 307	Syngas pressure at gasifier exit: Diaphragm type with silicon pressure sensor	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
PI 312	LDO header pressure: Diaphragm type with silicon pressure sensor	 

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
TI 136	Process water temp: Pt 100 Resistance temperature detector with transmitter	 

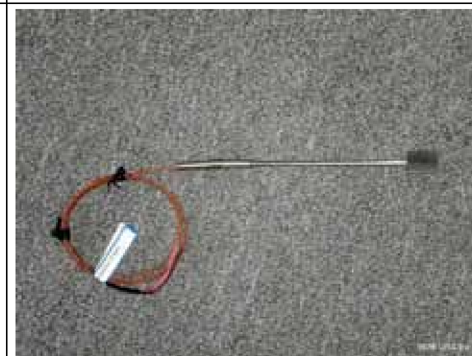
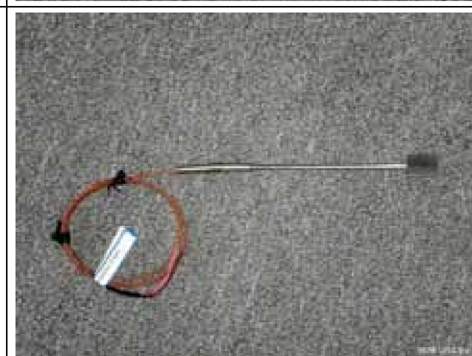
Component With ID No.	Specification	Photograph(s) of the Received Component(s)
TI 301	Gasifier skin temperature IR temperature detector	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
TI 302	Process air header temperature: Pt 100 resistance temperature detector with transmitter	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
TI 307	Process air header temperature: Pt 100 resistance temperature detector with transmitter	
TI 311	Gasifier zone 1 temperature: K type Thermocouple with transmitter	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
TI 312	Gasifier zone 2 temperature: K type thermocouple with transmitter	
TI 313	Gasifier zone 3 temperature: K type thermocouple with transmitter	
TI 314	Gasifier zone 4 temperature: K type thermocouple with transmitter	

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
TI 350	Ash discharge temperature: K type thermocouple with transmitter	
		

Component With ID No.	Specification	Photograph(s) of the Received Component(s)
		
TI 314 GF	Gasifier drive motor temperature: Pt 100 resistance temperature detector with transmitter	
TI 314PB	Pinion bearing temperature: Pt 100 resistance temperature detector with transmitter	

4 Project Management

Part 1 of Phase 2 of the project was completed within the allocated time and allocated budget. During the performance, no technical difficulties were encountered.

The partial procurement activity was completed as scheduled. All of the components included in the partial procurement have been received. The receipt of all the components was verified 4 June 2009. These components are awaiting shipment pending instructions from the government.

All deliverables for Part 1 of Phase 2 were received in a timely manner. (Table 5 lists the status of the project deliverables.) The technical part of this portion of the project began in August 2008 and concluded in May 2009. The reporting part of this portion of the project began in August 2008 and continued until June 2009.

At the time of this writing, the components procured during this phase of the program are being held at third party bonded warehouse and are awaiting shipment to the destination address.

Table 5. Status of reports and deliverables.

Deliverable	Due	Date Performed or Expected
Monthly Reports	Within five (5) days before the end of each month after award of contract	Submitted: 8 September 2008 25 September 2008 27 October 2008 24 November 2008 31 December 2008 27 January 2009 23 February 2009 26 March 2009 24 April 2009 27 May 2009
Draft Quarterly Reports	Within ten (10) days after completion of each three (3) months of the project.	Submitted as Draft: First Quarterly: 10 December 2008 Second Quarterly: 27 February 2009 Third Quarterly 15 May 2009

Deliverable	Due	Date Performed or Expected
Final Quarterly Reports	Within one (1) week after receiving comments from the Government.	Submitted as Final: First Quarterly: 5 January 2009 Second Quarterly 27 March 2009 Third Quarterly 29 May 2009
Monthly Teleconferences	No later than the last day of each month after each contract amendment	11 August 2008 4 September 2008 1 October 2008 3 November 2008 31 December 2008 27 January 2009
Project Review Meeting 1 at ERDC-CERL	Within nine (9) months after amendment of contract.	28 February 2009
Project Review Meeting 1 Draft Minutes	Within one (1) week after Project Review Meeting 1.	31 March 2009
Project Review Meeting 1 Final Minutes	Within one (1) week after receiving comments from the Government.	30 June 2009
Draft Final Report	Within eleven (11) months after award of first contract amendment.	30 May 2009
Final Report	Within two (2) weeks of receipt of ERDC-CERL's comments.	30 June 2009

5 Conclusion and Recommendations

This work has successfully completed the tasks of Part 1 of Phase 2 in developing and testing a modular 1 MW waste-to-energy system at Eielson AFB, AK which may ultimately be deployed at DOD facilities across the United States. Specific tasks of Part 1 of Phase 2 included:

1. Installation planning and procurement support
2. Permit support
3. Procurement of the instrumentation and accessories
4. Project management.

At the time of this writing, ERDC-CERL has completed the transition of this program to the Air Force Advanced Power Technology Office (APTO). Once the Memorandum of Understanding is executed between APTO and Eielson AFB, it is recommended that APTO facilitate direct communication between BESI and Eielson AFB personnel to discuss and resolve issues relating to the actual site, actual waste stream, and the permits. It is also recommended that the task relating to developing exact costs for the plant installation continues in the later parts of Phase 2 of the project, to optimize the use of future funding.

Acronyms and Abbreviations

Term	**Spellout**
APTO	Advanced Power Technology Office
AFB	Air Force Base
BESI	Biomass Energy Systems, Inc.
BAE	British Aerospace Systems
BAA	Broad Agency Announcement
CERL	Construction Engineering Research Laboratory
DCS	Distributed Control System
DC	District of Columbia
ERDC	Engineer Research and Development Center
EPA	Environmental Protection Agency
FY	fiscal year
FOB	forward operating base
MOU	Memorandum of Understanding
MW	megawatt
MSW	Municipal Solid Waste
NET	New Equipment Training
PLC	programmable logic controller
TR	Technical Report
USAF	U.S. Air Force
USACE	U.S. Army Corps of Engineers
CEERD	U.S. Army Corps of Engineers, Engineer Research and Development Center
DOD	U.S. Department of Defense
U.S.	United States

REPORT DOCUMENTATION PAGE

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5a. CONTRACT NUMBER

5b. GRANT NUMBER

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14. ABSTRACT
This ongoing project is developing small-scale distributed power generation for use at U.S. Air Force Bases using locally available resources such as wood and generated wastes. The first such system is designated for installation at Eielson Air Force Base (AFB), Fairbanks, AK. The program entails the conceptualization, design, fabrication, and testing of this customized waste-to-energy system for the specific application to this Air Force Base. The program will proceed to completion in three phases: (1) system design, (2) technical support for construction, system integration and power generation, and procurement of gasifier-related instrumentation and accessories, and (3) involve technology transfer to DOD facilities, and state and local agencies.

15. SUBJECT TERMS
renewable energy, sustainable facilities, security, Eielson AFB, waste-to-energy system

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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