Dynamis Energy, LLC

Mercury Best Available Control Technology Analysis
Ada County Landfill Waste-to-Energy Facility
Ada County, Idaho

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Table of Contents

List of Tables

1.0 INTRODUCTION

Dynamis Energy, LLC (Dynamis) performed a Mercury Best Available Control Technology (MBACT) analysis for the proposed Waste-to-Energy (WTE) facility at the Ada County Landfill, specifically the thermal conversion unit.

This MBACT analysis will follow the Environmental Protection Agency's (EPA) top-down approach consisting of the following steps:[1]

- Discussion of technically feasible options
- Ranking by control effectiveness
- Evaluation of most effective controls and documentation of results, with consideration of cost, energy and environmental analyses
- Selection of BACT

2.0 MERCURY

In this top-down MBACT analysis, the first step is to identify the processes (or emissions units) at the Dynamis facility and examine all available control options for each process.[2] Dynamis has one process applicable to this MBACT analysis, the thermal conversion unit. Natural gas combustion, emergency generator diesel combustion, and cooling tower emissions are not sources of mercury.

The New Source Review Workshop Manual addresses control strategies in three general categories:

- Inherently lower-emitting processes/practices, including the use of materials and production processes and work practices that prevent emissions and result in lower "production-specific" emissions
- Add-on controls, such as scrubbers, fabric filters (FF), thermal oxidizers, and other devices that control and reduce emissions after they are produced
- Combinations of inherently lower-emitting processes and add-on controls

Add-on control has been demonstrated for controlling mercury emissions from municipal waste combustors. If add-on control is necessary, several different air pollution control technologies (APCT) can be applied once exhaust streams are captured, to recover or destroy the pollutants.

[1] "New Source Review Workshop Manual, Prevention of Significant Deterioration and Nonattainment Area Permitting," EPA, DRAFT October 1990.
[2] A production process is defined in terms of its physical and chemical unit operations used to produce the desired product from a specified set of raw materials.

The Dynamis facility is specifically designed to combust municipal solid waste (MSW) and tires; utilizing raw materials with lower mercury content is not an option.

The analysis will start with the technology that has the highest degree of control. Three categories of mercury control options were identified for the BACT analysis: 1) The EPA RBLC[3], 2) technical journals, and 3) information received from emission control vendors which were sources of information for identifying these control technologies. Note that nearly all vendors contacted were unwilling to provide solid bids due to the time and expense involved in preparing a bid; however bids for budgetary purposes have been provided.

The basis for equipment cost estimates will be documented primarily with data supplied by the equipment vendor in the form of budget estimates. Cost estimates for selected control of each pollutant and process are shown in Appendix A. The names of the vendors have been redacted to protect competitive advantages. Cost estimates for the condensing economizer were provided verbally by the vendor; however specifications for the unit are included in Appendix A.

2.1 RACT/BACT/LAER Clearinghouse for Municipal Waste Combustion

A search was performed on BACT determinations from the EPA RBLC clearinghouse. The search was made based on municipal waste combustion. Table 1 displays the results from the RBLC search for mercury control of municipal waste combustion. Table 2 shows various APCDs along with the range of mercury removal efficiency for each device.

Table 1 – EPA RBLC Clearinghouse for Mercury Control for MSW Combustion

Company/Facility	Process Description	BACT for Hg
Solid Waste Authority of Palm Beach County/ Palm Beach Renewable Energy Park	Three Municipal Solid Waste Combustors	Activated Carbon/FF Baghouse
Department of Solid Waste Management/ Hillsborough County Resource Recovery Facility	Three Municipal Waste Combustors	Activated Carbon
City of Harrisonburg/ City of Harrisonburg Resource Recovery Facility	Resource Recovery Facility/Waste Combustion	Dry-Dry Flue Gas Scrubbing System Using a Hydrated Lime Sorbent or Other DEQ Approved Suitable Sorbent
Lee County Solid Waste Division/ Lee County Waste-to-Energy Facility	Waste-to-Energy Facility	Carbon Injection (CI)
Camden County Resource-Recovery Facility/ Camden Resource-Recovery Facility	Four Mass Burning Water Wall Incinerators	ESP/Scrubber

[3] RBLC is the RACT/BACT/LAER Clearinghouse or the Reasonably Available Control Technology (RACT), Best Available Control Technology (BACT), and Lowest Achievable Emission Rate (LAER) Clearinghouse.

Table 2 - Air Pollution Control Device Mercury Removal Efficiency

Control Device	Hg Removal Efficiency % Min	Max	Mean
Wet Scrubber (WS)	2.74	99.9	77.8
Electrostatic Precipitator (ESP)	1.30	98.3	20.4
Fabric Filter (FF)	0.70	98.0	53.0
Dry Sorbent Injection (DSI)/ESP	1.50	91.0	21.7
DSI/FF	2.00	99.0	74.9
DSI + Carbon Injection (CI)/FF	8.00	99.0	81.7

Source: Takahashi et al., Science of the Total Environment 408 (2010) 5472-5477

2.2 Technically Feasible Options

The tables above show that BACT options include wet scrubbers (WS), electrostatic precipitator (ESP), FF, dry sorbent injection (DSI) with ESP or FF, and activated carbon injection (CI) with FF.

2.2.1 Wet Scrubbers

WSs are typically used to control acid gas emissions from municipal waste combustion and are also capable of control particulate matter emissions. Wet scrubbing is also used for metals control at municipal waste combustion facilities in Europe and Japan. The wet scrubbing process typically involves ducting the flue gas into a spray tower where it is contacted with water and alkaline solution to remove acid gas. The process also saturates the gas stream and reduces flue gas temperatures. WS designs may also include a particulate collection system after the absorber stages to reduce aerosol and fine particulate emissions. Due to low absorber operating temperatures which promote mercury condensation, wet scrubbing technology achieves high mercury reduction (Nebel and White, 1991).

2.2.2 Electrostatic Precipitator

According to the EPA-CICA Fact Sheet (EPA-452/F-03-027):

"An ESP is a particulate control device that uses electrical forces to move particles entrained within an exhaust stream onto collection surfaces. The entrained particles are given an electrical charge when they pass through a corona. Electrodes in the center of the flow lane are maintained at high voltage and generate the electrical field that forces the particles to the collector walls. The collectors are knocked, or "rapped" by various mechanical means to dislodge the particulate, which slides downward into a hopper where they are collected. The hopper is evacuated periodically as it becomes full. Dust is removed through a valve into a dust-handling system, such as a pneumatic conveyor, and is then disposed of in an appropriate manner."

2.2.3 Fabric Filter/Baghouse

FFs are typically used to control particulate matter emissions. Flue gas or process emissions enter the baghouse compartment, where larger particles drop out while smaller dust particles collect on filters/filter bags. The filters may be in the form of sheets, cartridges, or bags. The operating conditions and incoming particulate matter generally dictate the type of fabric used; some fabrics are only useful at low temperatures, while higher temperature flue gas streams may require fabrics such as Teflon or fiberglass. When the dust layer thickness reaches a level where flow through the system is sufficiently restricted (called pressure drop or delta P), bag cleaning is initiated. Cleaning can be done while the baghouse is still online (filtering) or in isolation (offline). Once cleaned, the compartment is placed back in service and the filtering process starts over.

2.2.4 Dry Sorbent Injection/Electrostatic Precipitator

DSI systems, when combined with an ESP, are typically used for removal of acid gas and particulate. However, in some installations they have been shown to have some mercury control effectiveness. A DSI/ESP system removes mercury through two basic steps. In the first step, a powdered sorbent is injected into the flue gas to create a ‘sorbed’ particulate compound; the most common sorbents are trona, sodium bicarbonate and hydrated lime. In the second step, the particulate compound is removed by the ESP.

2.2.5 Dry Sorbent Injection/Fabric Filter

DSI systems, when combined with an FF, are typically used for removal of acid gas and particulate. However, in some installations they have been shown to have some mercury control effectiveness. A DSI/FF system removes mercury through two basic steps. In the first step, a powdered sorbent it injected into the flue gas to create a ‘sorbed’ particulate compound; the most common sorbents are trona, sodium bicarbonate and hydrated lime. In the second step, the particulate compound is removed by the FF.

2.2.6 Activated Carbon Injection/Fabric Filter

Activated CI systems involve injecting a sorbent such as powdered activated carbon (PAC) into the flue gas where the gas phase mercury in the flue gas contacts the sorbent and attaches to its surface. The sorbent with the mercury attached is then collected by a particle control device, either an ESP or FF.

One disadvantage to activated CI is that concentrations of HCl in the flue gas must be very low for effective removal of mercury by activated carbon. Based on the Dynamis facility design, layout and location restrictions, the ACI would occur prior to the removal of HCl by an acid gas control system. Therefore it is likely that the flue gas entering the ACI/FF system would contain high concentrations of HCl, and the system control efficiency would likely be well below the mean shown in Table 2.

2.3 Mercury Control Technologies Control Effectiveness and Discussion of Other Factors

2.3.1 Wet Scrubbers

2.3.1.1 Control Effectiveness

WS control is estimated to have a mean mercury control effectiveness of 77.8% based on literature sources.

2.3.1.2 Expected Emission Rate and Reduction

The expected controlled emission rate is 12.8 pounds/year (lb/yr) and the reduction is 44.9 lb/yr.

2.3.1.3 Energy Impact

Energy is required to operate the pumps and fans associated with the scrubber. Per the manufacturer the specified scrubber system requires 2.29 MMBtu/hr energy consumption.

2.3.1.4 Environmental Impact

WSs generate a wet waste product and may produce a visible plume.

2.3.1.5 Economic Impact

Dynamis currently plans to install a wet scrubbing system for control of HCl, SO_2, particulate, particulate metals, and energy capture. The capital equipment cost for the scrubber is $2,496,000 including shipping and installation. Operating costs are estimated at $57,000/year based on information from the manufacturer and include waste product treatment and disposal. The annualized capital cost is $222,144 based on the capital recovery formula:

Capital Recovery Factor:

CRF = capital recovery factor

i = interest rate

n = lifetime (yrs)

$$CRF = \frac{i \cdot (1 + i)^n}{(1 + i)^n - 1}$$

i = 4%

n = 15 years

With an interest rate of 4% and a 15 year lifetime, the capital recovery factor is 0.089. A 15 year lifetime is reasonable to assume for a wet scrubbing system.

2.3.2 Electrostatic Precipitator

2.3.2.1 Control Effectiveness

ESPs are estimated to have a mean mercury control effectiveness of 20.4% based on literature sources.

2.3.2.2 Expected Emission Rate and Reductions

The expected controlled emission rate is 46.0 lb/yr and the reduction is 11.8 lb/yr.

2.3.2.3 Environmental Impacts

Some disadvantages for ESPs include the risk of dioxin/furan generation if operating at incorrect temperatures. Also, particular care must be taken for ESPs to ensure that smaller particles are collected with maximum efficiency, as chlorinated organics such as dioxin/furans tend to be enriched in these smaller particles. Improper operation may cause fires or explosions to occur due to the buildup of combustible gases and electrical sparks. In addition, ozone may be produced by the negatively charged electrode during gas ionization (EPA Fact Sheet EPA 452/F-03-028).

2.3.2.4 Energy Impacts

Based on a general literature search, energy requirements for ESPs are approximately 50% of those required by wet scrubbing systems. This equates to an energy consumption of 1.15 MMBtu/hr.

2.3.2.5 Economic Impacts

From EPA Fact Sheets, EPA 452/F-03-027[4] and EPA 452/F-03-028[4]:

The capital cost for an ESP ranges from $13 to $156/scfm; the average is $84.5/scfm. Operations and maintenance costs range from $4 to $44/scfm (average $24/scfm). Based on an exhaust of 118,680 scfm, the capital cost is $10,028,460. Annual operating costs are $2,848,320. In addition, if an ESP is the utilized mercury control, it would also require the installation of a separate condensing economizer to cool the flue gas and recover energy after leaving the ESP. Estimated capital cost for a condensing economizer is approximately $1,000,000. The annualized capital cost for the entire system is $981,532 based on a capital recovery factor of 0.089 (shown calculated above).

2.3.3 Fabric Filter/Baghouse

2.3.3.1 Control Effectiveness

FFs/baghouses are estimated to have a mean mercury control effectiveness of 53% based on literature sources.

2.3.3.2 Expected Emission Rate and Reduction

The expected controlled emission rate is 27.1 lb/yr and the reduction is 30.6 lb/yr.

2.3.3.3 Environmental Impacts

Concentrations of some dusts in the FF/baghouse may represent a fire or explosion hazard if a spark or flame is accidentally admitted. In addition, dust collected from the system could possible contain hazardous materials requiring special handling and disposal.

2.3.3.4 Energy Impacts

Energy is required to operate the fans associated with a FF/baghouse. Rough energy consumption requirements based on the approximate size baghouse system required for the Dynamis system are approximately 3.052 MMBtu/hr.

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[4] Fact Sheet is in 2002 dollars. Annual inflation is estimated to be 2.5% on average, or 25% total for ten years since that time.

2.3.3.5 Economic Impacts

Based on quotes from vendors, the capital equipment cost is $1,580,230; annual operating costs are estimated at $156,000. In addition, if a FF/baghouse is the utilized mercury control, it would also require the installation of a separate condensing economizer to cool the flue gas and recover energy after leaving the FF. Estimated capital cost for a condensing economizer is approximately $1,000,000. The annualized capital cost for the entire system is $229,640 based on a capital recovery factor of 0.089 (shown calculated above).

2.3.4 Dry Sorbent Injection/Electrostatic Precipitator

2.3.4.1 Control Effectiveness

DSI combined with an ESP is estimated to have a mean mercury control effectiveness of 21.7% based on literature sources.

2.3.4.2 Expected Emission Rate and Reduction

The expected controlled emission rate is 45.2 lb/yr and the reduction is 12.5 lb/yr.

2.3.4.3 Environmental Impacts

Spent sorbent from the system could possibly contain hazardous materials requiring special handling and disposal. Also, ozone may be produced by the negatively charged electrode in the ESP during gas ionization (EPA Fact Sheet EPA 452/F-03-028).

2.3.4.4 Energy Impacts

Based on a general literature search, energy requirements for ESPs are approximately 50% of those required by wet scrubbing systems. This equates to an energy consumption of 1.15 MMBtu/hr. Sorbent injection is not expected to have significant energy impacts.

2.3.4.5 Economic Impacts

From EPA Fact Sheets, EPA 452/F-03-027[4] and EPA 452/F-03-028[4]:

The capital cost for an ESP ranges from $13 to $156/scfm; the average is $84.5/scfm. Operations and maintenance costs range from $4 to $44/scfm (average $24/scfm). Based on an exhaust of 118,680 scfm, the capital cost is $10,028,460. Annual operating costs are $2,848,320. In addition, if an ESP is the utilized mercury control, it would also require the installation of a separate condensing economizer to cool the flue gas and recover energy after leaving the ESP. Estimated capital cost for a condensing economizer is approximately $1,000,000. The annualized capital cost for the entire system is $981,532 based on a capital recovery factor of 0.089 (shown calculated above).

Costs for the sorbent injection system are based on sodium tetrasulfide as the sorbent. Annual sorbent costs are estimated to be approximately $88,000/year. Capital cost for the sorbent injection system is approximately $152,500 (Licata, et al, 2000). The annualized capitol cost of the injection system is $13,573, based on a capital recovery factor of 0.089 (shown calculated above).

2.3.5 Dry Sorbent Injection/Fabric Filter

2.3.5.1 Control Effectiveness

DSI combined with an FF is estimated to have a mean mercury control effectiveness of 74.9% based on literature sources.

2.3.5.2 Expected Emission Rate and Reduction

The expected controlled emission rate is 14.5 lb/yr and the reduction is 43.2 lb/yr.

2.3.5.3 Environmental Impacts

Spent sorbent from the system and could possibly contain hazardous materials requiring special handling and disposal.

2.3.5.4 Energy Impacts

Energy is required to operate the fans associated with a FF/baghouse. Rough energy consumption requirements based on the approximate size baghouse system required for the Dynamis system are approximately 3.052 MMBtu/hr. Sorbent injection is not expected to have significant energy impacts.

2.3.5.5 Economic Impacts

Costs for the sorbent injection system are based on sodium tetrasulfide as the sorbent. Annual sorbent costs are estimated to be approximately $88,000/year. Capital cost for the sorbent injection system is approximately $152,500 (Licata, et al, 2000).

Based on quotes from vendors, the FF capital equipment cost is $1,580,230; annual operating costs are estimated at $156,000. In addition, if dry sorbent injection/FF is the utilized mercury control, it would also require the installation of a separate condensing economizer to cool the flue gas and recover energy after leaving the FF. Estimated capital cost for a condensing economizer is approximately $1,000,000.

Total annualized cost for the system is $243,212 based on a capital recovery factor of 0.089 (shown calculated above). Annual operating costs are $244,000.

2.3.5.6 Activated Carbon Injection/Fabric Filter

2.3.5.7 Control Effectiveness

Activated CI combined with an FF is estimated to have a mean mercury control effectiveness of 81.7% based on literature sources.

2.3.5.8 Expected Emission Rate and Reduction

The expected controlled emission rate is 10.6 lb/yr and the reduction is 47.2 lb/yr.

2.3.5.9 Environmental Impacts

Mercury laden spent carbon requires special handling and disposal.

2.3.5.10 Energy Impacts

Energy is required to operate the fans associated with an FF/baghouse. Rough energy consumption requirements based on the approximate size baghouse system required for the Dynamis system are approximately 3.052 MMBtu/hr. Activated CI is not expected to have significant energy impacts.

2.3.5.11 Economic Impacts

Based on quotes from vendors, the capital equipment cost for the activated CI system is $142,825; annual operating costs are estimated at $156,000. The activated CI system would have to be coupled with an FF to remove the mercury laden carbon. FFs have a capital cost of $1,580,230 and annual operating cost of $156,800. In addition, if ACI/FF is the utilized mercury control, it would also require the installation of a separate condensing economizer to cool the flue gas and recover energy after leaving the FF. Estimated capital cost for a condensing economizer is approximately $1,000,000.

The annualized capital cost of the combination ACI/FF system is $242,351, based on a capital recovery factor of 0.089 (shown calculated above).

2.4 Top-Down MBACT Impact Analysis Results

Control Alternative	Emissions (lb/yr)	Emissions Reduction (lb/yr)	Economic Impacts			Environmental Impacts	Energy Impacts
			Total Annualized Cost ($/yr)	Average Cost Effectiveness ($/lb)	Incremental Cost Effectiveness ($/lb)	Adverse Environmental Impacts (Y/N)	Incremental increase over Baseline (MMBtu/yr)
ACI/FF	10.6	47.2	$555,151	$11,762	$120,000	Y	3.05
WS	12.8	44.9	$279,144	$6,217	($122,393)	Y	2.29
DSI/FF	14.5	43.2	$487,212	$11,278	$8,061	Y	3.05
FF	27.1	30.6	$385,640	$12,602	($195,899)	Y	3.05
DSI/ESP	45.2	12.5	$3,931,425	$314,514	$145,104	Y	1.15
ESP	46.0	11.8	$3,829,852	$324,563	$324,563	Y	1.15
Baseline (no control)	57.7	0	n/a	n/a	n/a	Y	n/a

ACI/FF – Activated carbon injection + fabric filter
WS – Wet scrubber
DSI/FF – Dry sorbent injection + fabric filter
FF – Fabric filter
DSI/ESP – Dry sorbent injection + electrostatic precipitator
ESP – Electrostatic precipitator
Total annualized cost – includes capital and operations and maintenance costs
Incremental cost effectiveness – the difference in annualized cost for the control option and the next most effective control option, divided by the difference in emissions reduction resulting from the respective alternatives.

3.0 MBACT CONCLUSION

The control technology chosen as MBACT is the WS. Although the activated carbon system has a slightly higher (3.9%) mean control efficiency than the WS, this represents only increased reduction of 2.3 lb/yr. However, as discussed in section 2.2.6, activated carbon system mercury control efficiency has been shown to be dependent on flue gas HCl concentration. Based on the Dynamis facility design, layout, and location restrictions, the ACI would occur prior to the removal of HCl by an acid gas control system. Therefore, it is likely that the flue gas entering the ACI/FF system would contain high concentrations of HCl, and the system control efficiency would likely be less than the WS's control efficiency.

The average cost effectiveness of the ACI/FF system is greater than $11,000 lb/pollutant removed, and also has an incremental cost effectiveness of approximately $120,000/lb. The WS system has an average cost effectiveness of less than $6,500 lb/pollutant removed, and also has a negative incremental cost effectiveness above the next most effective control technology. Both the ACI/FF system and WS system have the potential to have adverse environmental impacts due to by-product treatment and disposal. Both control technologies represent an increase in energy impacts over baseline, with energy requirements being slightly higher for an ACI/FF system.

Based on this analysis, and the discussion above, wet scrubbing technology represents the best available control technology for mercury emissions from the Dynamis WTE facility.

4.0 REFERENCES

Licata, Schüttenhelm, and Klein. Mercury Control for MWCs Using the Sodium Tetrasulfide Process. 8th Annual North American Waste to Energy Conference. Nashville. TN 2000.

Nebel and White. A Summary of Mercury Emissions and Applicable Control Technologies for Municipal Waste Combustors. Prepared for Walter H. Stevenson Standards Development Branch (MD-13) and Michael G. Johnston Industrial Studies Branch (MD-13) Office of Air Quality Planning and Standards, USEPA. September 1991.

Fumitake Takahashi, Akiko Kida, Takayuki Shimaoka. Statistical estimate of mercury removal efficiencies for air pollution control devices of municipal solid waste incinerators. Science of the Total Environment 408 (2010) 5472–5477.

USEPA. Air Pollution Control Technology Fact Sheet. EPA-452/F-03-027. Dry Electrostatic Precipitator (ESP) – Wire Pipe Type.

USEPA. Air Pollution Control Technology Fact Sheet. EPA 452/F-03-028. Dry Electrostatic Precipitator (ESP) – Wire Plate Type.

APPENDIX A

Cost Estimates

[redacted]

[redacted]

[redacted] **Proposal Number: [redacted] 2012-0112, Revision 1**
Customer Reference: ADA County

DATE: February 7, 2012

PROPOSAL AND SPECIFICATIONS

TO: Evergreen Engineering
P.O. Box 21530
Eugene, OR 97402-0409
Attn: John Solvason jsolvason@eeeug.com

FROM: [redacted]

copy:

I. System Design and Proposal Summary for one (1) 230,716 ACFM unit for a Syngas Fired Boiler

[redacted] is pleased to offer a fabric filter system consisting of on-line/off-line cleaning, 6-module, high volume intermediate pressure pulse-jet collector for filtration of the Syngas fired boiler flue gases. The system as offered below is complete from the baghouse inlet manifold flange through the fabric filter and to the outlet manifold discharge flange. 18' filter bags and split module arrangement is being offered in order to fit the 50' (10' lower than the stack) height restriction with no more than a 4' pit for the baghouse, we understand this will alleviate the confined space issue in the baghouse area.

Supply of equipment includes a [redacted] Split Module entry side design for flow distribution and inlet baffling array. This, in conjunction with 8.5" average bag spacing for elimination of can velocity, through cross-flow arrangement maximizes gas and particulate distribution as well as minimizing bag wear. Moreover, appropriate cross-flow design reduces re-entrainment aiding in cleaning efficiency and is far superior to hopper entry designs. Additionally, the proposed system includes the [redacted] high volume intermediate pressure cleaning system engineered specifically for long bag pulse-jet system application. Please note this is not a "typical hopper entry" baghouse design, the presented technology has been developed using Computational Fluid Dynamics modeling as well as much R&D and proven to perform exceptionally well in multiple installations.

The equipment detailed in this proposal is a modular format (not panelized) minimizing field welding.

[redacted]

Additionally, the inlet and outlet manifolds are modular also to minimize field erection.

The proposed collector detailed in this proposal and attached general arrangement drawing is a lift-off door design with the pulse cleaning system integral to the door which has been quite well received in the coal fired boiler industry for several reasons: the first of which being the bags are accessed via removal of this lift-off door inside a penthouse which eliminates confined space since maintenance personnel do not need to enter the module, they simply step down onto the tubesheet. The second most pronounced reason for the lift-off door is the reduction of clean air plenum surface area for radiant cooling and subsequent acid gas condensation and corrosion. As a side note one of the proposed MACT standards contains a requirement for action to be taken within one hour should the system broken bag detector identify an emissions problem. With a walk-in plenum unit the module will not cool enough in one hour to enter and perform maintenance, but with a monolithic lift-off door the bag maintenance can commence as soon as the door is removed since the tubesheet is open to the penthouse with the door removed.

A common question associated with the monolithic lift-off door references potential for door seal leakage and cold spot corrosion resulting in the clean air plenum. [redacted] proprietary design utilizes a floating door pan which allows the heated surface of the insulated door to expand and contract independently from the structure exposed to ambient conditions. This results in a seal that does not leak and has not leaked on approximately 400 baghouse modules with this design that [redacted] has supplied.

II. Scope of Work

A. Equipment and Material Supplied by [redacted]

- Pulse-Jet Fabric Filter
- Top-removal snap-band filter bags with 12 wire A-36 CS cage with integral venturi
- Solid State cleaning controls in NEMA 4 enclosures
- Outlet manifolds with pneumatically actuated poppet dampers for module isolation during maintenance and cleaning cycle
- Bypass damper system
- Inlet manifolds with pneumatically actuated butterfly dampers for module isolation
- Baghouse system differential pressure transmitters
- Insulation and lagging
- Hopper heaters
- Capacitance type hopper level switches
- Individual module lift-off doors
- System penthouse structure with girts
- Monorail cranes and runway steel
- Structural steel
- PLC based control system
- Baghouse substructure to 4 feet below hopper discharge flange (deduct offered for incorporating 4' of the baghouse steel into the "pit" retaining walls)
- Penthouse vent fans

- Penthouse vent louvers
- Stair access from bottom of baghouse steel to penthouse elevation
- Secondary egress caged ladder from penthouse to bottom of baghouse steel
- One (1) broken bag detector

B. Equipment and Material Supplied by Customer

- Foundations
- Controls
- Ash conveying system
- Grounding grid
- Lighting
- Opacity monitors
- Installation services
    - *Field erection*
    - *Field wiring*

C. Services Supplied by [redacted]

- Engineering
    - *General Arrangement Drawings, Equipment Load Diagrams, Erection/Assembly Drawings, Process and Instrumentation Diagrams, Electrical Elementary Drawings, and Field Interconnection Drawings*
    - *Operation and Maintenance Manuals*
    - *Spare Parts List*
- Start-up
    - *Service Engineer for up to one (1) week*

D. Services Supplied by Customer

- Engineering
    - *Foundation Design*
- Electrical installation
- All State, Federal, and Local taxes
- 120 VAC power to control system equipment
- 480 VAC power to local disconnect for bridge crane
- 480 VAC power to hopper heater power distribution panel
- Concrete/Foundations
    - *All foundation work*
    - *Grouting of equipment as required*

III. Design Conditions

A. Process Design Conditions (normal)

- Application: Syngas Fired Boiler
- Volume: 230,716 ACFM
- Temperature: 348°F
- Inlet Dust Load: 2550 #/hr

B. Environmental Design Conditions

- Jobsite: Idaho
- Location: ADA County
- Approx. Elevation: 3050 ft
- Max. Ambient Temperature: 104°F
- Min. Ambient Temperature: -15°F

C. Structural Design Conditions

♦ Max. Gas Pressure:	+/-30" w.g.
♦ Max. Design Temperature:	425°F
♦ Basic Wind Speed:	112 MPH
♦ Exposure:	Outdoors
♦ Vertical Snow Load:	5 PSF
♦ Platform Live Loads:	100 PSF
♦ Seismic Load:	Ss 0.188, S1 0.078
♦ Dust Density, structural basis:	70 PCF
♦ Dust Density, volumetric basis:	45 PCF

D. Constructions Codes

- The fabric filter system will be designed in accordance with the following codes where applicable.

• *National Electrical Code*	*NEC*
• *International Building Code*	*IBC*
• *American Welding Society*	*AWS*
• *American Society for Testing and Material*	*ASTM*
• *American Institute of Steel Construction*	*AISC*

IV. Fabric Filter Equipment Description

A. Equipment Selection

♦ Design Type:	Modular
♦ Filter Type:	Intermediate Pressure Pulse-Jet
♦ Cleaning Mode:	On-line
♦ Number of Modules:	Six (6)
♦ Bags per Module:	375
♦ Total Number of Bags:	2,250
♦ Cloth Area:	63,912 SF net per system
♦ Air-to-Cloth Ratio based on normal MCR conditions:	3.6:1 with all modules on-line / 4.33:1 net with one module off-line

B. Materials of Construction

♦ Clean Air Plenum:	3/16" Carbon Steel
♦ Housing:	3/16" Carbon Steel
♦ Tubesheet:	1/4" Carbon Steel
♦ Hopper:	3/16" Carbon Steel
♦ Structural Steel:	3/16" Carbon Steel
♦ Cleaning System:	3/16" Carbon Steel
♦ Venturis:	A-36 Carbon Steel, integral to cage
♦ Filter Cages:	11 gauge, 12 wire, A-36 Carbon Steel

C. Clean Air Plenum

♦ Type:	Lift-off door with penthouse. Two (2) insulated monolithic door per module with integral cleaning system.

D. Hoppers (12 total hoppers, 2 per module)

♦ Slopes, End/Side/Valley (degrees):	64°/ 64°/ 56°
♦ Discharge Width/Length (inches):	10” 150# flange pattern
♦ Accessories	
• *Insulated Access Door:*	*24" rectangular hinged*
• *Vibrators:*	*Mounting plate provided*

- *Strike Plate:* — *One (1) per hopper*
- *Level Probes:* — *Capacitance type, 1 per hopper*
- *Hopper Heater:* — *480 VAC heating pad type, shop installed with thermostat*
- *Poke Holes:* — *2-4"Ø per hopper*

E. Filter Assemblies

- Bags: — (2250) 18' long, 16 oz. PPS (Ryton) + 3% spare bags
- Cages: — (2250) A36 Carbon Steel rolled collar cage with 12 vertical wires and girth rings on 8" spacing + 2% spare
- Venturis: — (2250) Carbon Steel, integral with cage

F. Cleaning System

- Cleaning Manifold: — 6" diameter, 11.5" long manifolds, one (1) per compartment with rigid pipe nipple connection of [redacted] pulse valve. Each manifold equipped with a pressure regulator and pressure relief valve.
- Blowpipe: — (180) 1.5" diameter Schedule 10 pipe with nozzles configured for cleaning 18' long bags
- Pulse Valves: — (180) 1.5" [redacted] high Cv diaphragm valves.
- Solenoid Valves: — (180) direct mounted electric solenoid valves
- Timer Cards: — The unit is provided with a Solid State timer for sequencing of the cleaning system. The Solid State timer provides for control of both the pulse duration and interval. This timer equipment is pre-wired and tested in the shop prior to shipment. Timer cards are assembled in NEMA 4 enclosures.
- Compressed Air Usage: — 60 cfm maximum usage

G. System Penthouse

- Framing: — Shop fabricated structural members supported from the collector modules
- Wind Girts: — Z-type girts from grade through penthouse level in order to enclose the entire system to grade with gutters and downspouts
- Traveling Monorail Crane Steel: — Prefabricated, supported from the penthouse
- Louvers and Ventilators: — Included
- Siding and Roofing: — 24 gauge box rib Kynar coated panels

H. Monorail Cranes

- Bridge Cranes: — Two (2) 3-ton, 480 VAC with powered trolley, disconnect switch included to be mounted in penthouse

I. Control System

The baghouse control system is based on a fully automated Allen-Bradley ControlLogix PLC based capable of cleaning the unit based on differential pressure across the entire 6-module baghouse system, for this quoted supply the PLC equipment and control panel is by others however the logic for the described operation is included. The primary operation mode is on-line cleaning; on-line cleaning operates the pulse cleaning system with flue gas flow through the respective module unrestricted. This practice works exceptionally will with the proposed collector design due to the cross flow characteristics of the design and sweep of particulate away from the filter media during a cleaning cycle significantly reducing re-entrainment.

Adjustment of the differential cleaning set point is available to operators via a password-protected keypad in the face of the control panel. In addition, a time based cleaning sequence is available if something associated with the differential pressure signal is not working properly.

PPS bags need to be protected from gas temperatures higher than 400°F. Baghouse control system shall bypass and alarm high and low inlet and outlet temperatures.

Operator interface shall be via color touch screen.

Appropriate alarms are provided to inform operators both audibly and visually of system malfunctions such as:

High Inlet Temperature
Low Inlet Temperature
High Differential Pressure
Loss of Compressed Air Supply
Damper Failure
Pulsing System Failure
Hopper Heater Failure
Excessive Temperature Differential across Unit
High Hopper Level

J. Electrical Service

- Control Panel: 120 VAC, 25 amp
- Hopper Heaters: 480 VAC, 4.6 kW per hopper, (12) hoppers total
- Monorail Crane: 480 VAC 3Ø 2 HP
- Motorized Trolley: 480 VAC 3Ø 1 HP max.

K. Inlet

- Size/Type: 2' x 9' rectangular, flanged, entry with pneumatically actuated butterfly dampers
- Diffuser: Multi-louver baffling in the side wall of each module resulting in a cross-flow design with gas distribution chamber in module prior to flue gas contacting bags

L. Outlet

- Type: Rectangular, flanged, tapered manifold
- Damper Design: Pneumatically actuated round poppet dampers at module discharge integral to outlet manifold. Damper shafts to be stainless steel in order to prevent cold gas interface corrosion

M. Bypass

- Type: Rectangular, flanged, bridging between the inlet and outlet manifolds
- Damper Design: Two (2) pneumatically actuated round poppet dampers

N. Structural Steel

- Discharge Clearance: 4 ft. under hopper discharge flange to accommodate Ash conveying system to be offered separately

O. Access Steel

- Stair Access: One (1) stair system is provided from hopper level to penthouse level.
- Platform: One (1) landing platform located at entrance to penthouse.
- Secondary Egress: One (1) caged ladder from penthouse to hopper level

P. Instrumentation

- System Pressure Drop: One (1) 4-20 mA output differential pressure indicating transmitter per system.
- System Inlet Temperature: One (1) 4-20 mA output thermocouple and indicating transmitter combination per system.
- System Outlet Temperature: One (1) 4-20 mA output thermocouple and indicating transmitter combination per system.
- Compressed Air Manifold: One (1) pressure gauge 0-125 psig.
- Compressed Air Supply: One (1) pressure switch for PLC acknowledgement and alarming of low compressed air supply per system.
- Module High Level: Two (2) RF capacitance type level probes per hopper; one for high level and one for High High level
- Broken Bag Detection: One (1) Broken bag detector located in the outlet manifold for system broken bag detection/alarming

V. Dust Handling System (provided by others)

VI. System Fan (provided by others)

VII. Compressed Air System (not included)

VIII. Insulation and Cladding

- 4" 6# mineral wool with 1" 6# mineral wool over stiffeners and 20 gauge aluminized steel on manifolds, hoppers, and module halves. Lift-off doors will be pre-insulated in fabrication shop.

IX. Surface Preparation and Painting

A. Exterior Fabricated Steel Surfaces, Low Temperature, Uninsulated, i.e. structural steel

- Surface Preparation: SSPC-SP-6
- Prime Paint: Red oxide alkyd primer @ 1.5-2.0 mils D.F.T.
- Finish Paint: Alkyd enamel finish @ 1.5-2.0 mils D.F.T.

B. Interior Fabricated Steel Surfaces

- Interior surfaces are not primed or painted

C. Vendor Supplied Equipment

- Vendor supplied equipment is provided with Vendor’s standard paint system.

X. Sodium Bicarbonate Injection System

A. System Design and Proposal Summary for one (1) Sodium Bicarbonate Injection System

This proposal is for the design and supply of a Sodium Bicarbonate Injection System for installation upstream of the [redacted] supplied baghouse to aid in reduction of HCl, SO_3 and SO_2 present in the flue gas stream for the biomass fired fluid bed boiler. The system as offered below includes the complete supply of the bulk bag discharging station, Sodium Bicarbonate feed equipment, pneumatic tubing for transport to the injection point, and injection lance. Instrumentation, Allen-Bradley ControlLogix PLC controls, and power distribution panel for the system are also included for the system.

B. Scope of Work

- Equipment and Material Supplied by [redacted]
  - *Bulk Bag discharging station, non-enclosed (anticipated installation under the baghouse system)*
  - *PLC based Control system integrated in the Baghouse PLC panel for automation of all injection equipment and annunciating system conditions. Control system to be capable of being tied into existing plant system.*
  - *Sodium Bicarbonate loss in weight feed system*
  - *Sodium Bicarbonate conveying blower and eductor*
  - *Sodium Bicarbonate conveying stainless steel tubing (3")*
  - [redacted] *proprietary injection lance/nozzle*
  - *480 VAC power panel*
  - *480 VAC: 120 VAC transformer for controls*
  - *Tuning fork type hopper level switch*
  - *Bag lifting hoist and rail*

- Equipment and Material Supplied by Others
  - *Monitoring equipment*
  - *Supply of Sorbent*
  - *480 VAC power feed from MCC to* [redacted] *Panel*
  - *Foundations*
  - *Equipment to tie into plant DCS*
  - *Compressed air piping from plant system to Sodium Bicarbonate system*
  - *Injection system enclosure*

- Services Supplied by [redacted]
  - *Engineering*
    - *General Arrangement Drawings, Equipment Load Diagrams, Erection/Assembly Drawings, Process and Instrumentation Diagrams, Electrical Elementary Drawings, and Field Interconnection Drawings.*
    - *Operation and Maintenance Manuals*
    - *Spare Parts List*
  - *Start-up services included with the baghouse startup*

- Services Supplied by Others
    - *480 VAC power feed from MCC*
    - *DCS Integration of* [redacted] *control system*
    - *Foundation Design*
    - *Compressed Air*
    - *Erection of System*

C. Design Conditions

- Control System

The control system is designed to be fully automated through the baghouse system PLC, capable of receiving an adjustable "feed set point" signal for determination of Sodium Bicarbonate demand in conjunction with some sort of unit load signal from the plant control system.

Manual control of all the conveying and metering equipment is available through the [redacted] supplied HMI.

Appropriate alarms are provided to inform operators both audibly and visually of system malfunctions such as:

Loss of conveying air/line pluggage
Metering screw malfunction
Metering screw fill malfunction
Pneumatic slide gate malfunction
Weighing system malfunction
Bulk Bag low level
Bulk Bag ready to be replaced

Key control points as well as indication of equipment status will be programmed and available across Ethernet link to Owner's DCS. PLC cabinets are built by [redacted]

The [redacted] Controls operate on a loss in weight principal. The Reagent is fed from the bulk bag discharge into the metering screw/volumetric feeder through a rotary valve. Sodium Bicarbonate is discharged until high level switch is met. The volumetric feeder is also mounted on load cells and is used as the primary feed rate control for the loss in weight system.

- Electrical Service
  - *Control / Starter Panel: 480 VAC, 50 amp*
  - *Metering Screw: 480 VAC 3Ø 0.75 HP VFD driven*
  - *Pneumatic Conveying Blowers: 480 VAC 3Ø 6 HP*

- Instrumentation
  - *Compressed Air Supply: One (1) pressure switch for PLC acknowledgement and alarming of low compressed air supply per system*
  - *Pneumatic Conveying/Injection Line: Flow switch, one (1) per injection line for loss of blower or line pluggage*
  - *Load Cell Weighing System: One (1) system (4 cells) with 4-20 mA output under metering screw*
  - *Level Probe: One (1) installed in metering screw top for verification of fill, tuning fork type*

D. Reagent Feeding System

- Bulk Bag Discharge, single discharge, single train
  - *Bag Discharge Un-tying Station: Sealed access "glove box" with a hinged gasketed access door. System is designed to allow untying of bag through gloves*
  - *Massaging Pads: Due to the fine nature of Sodium Bicarbonate, agitation of the bulk bag is accomplished through air cylinder massaging system as opposed to fluidization pads*
  - *Bottom of Bulk Bag Isolation: Teflon seal pneumatically actuated slide gate, Quantity (1)*

- Metering Screw Conveyor
  - *Quantity:* *One (1) per feed train*
  - *Manufacturer:* *Acrison or equal*
  - *Design Conditions*
    - *Trough Loading:* *100%*
    - *Metering Screw Trough/Dutchman Size:* *2 cubic foot minimum*
    - *Metering Screw Fluidizing Nozzles:* *Two (2)*
  - *Construction*
    - *Diameter:* *1.5"*
    - *Flighting Type:* *Stainless steel*
    - *Turndown:* *10:1*
  - *Venting:* *Vented to eductor inlet*

Note: Familiarity with how to configure the loss in weight system as well as expansion and contraction issues is paramount for system performance and accuracy. Many organizations are not familiar with the pitfalls.

E. Reagent Injection System General Description

The [redacted] Reagent Feeding System is a loss in weight system designed for extraordinary accuracy. The system starts with a rotary valve charging a "Loss in Weight" feed metering screw supported by four (4) load cells, the main feeder is a volumetric feeder that is mounted on a weigh scale/load cells described above. The speed of the feeder screw is then adjusted to achieve the desired loss in weight material feed. By use of this dual weighing system, the system can achieve a high level of feed accuracy over many different carbon types. Over a time adjusted average, this system can achieve 1% accuracy. Injection system consists of the following:

- One (1) Bulk bag discharge station with a dual discharge
- One (1) Hopper discharge Salina vortex (or equal) slide gate
- One (1) Regenerative blower
- One (1) Metering feeder screw for metering Sodium Bicarbonate
- Loss in weight feed system for gravimetric metering of Sodium Bicarbonate
- One (1) Fox eductor and injection nozzle
- Power panel with starters and variable frequency drives for Sodium Bicarbonate feeding system motor controls
- 304 SS injection lance
- Tubing for connection of lances to feeding equipment
- Sized for injection rate of 551 #/hr, expected usage 404 #/hr
- Bulk Bag discharge station (Note: Silo and on-site grinding equipment can be quoted as an option)
  - *Glove box for untying bulk bag*
  - *½ ton hoist for lifting bulk bag*
  - *IEC style starters*
  - *2200# bulk bag design*

XI. Contract Pricing

A. The price for all equipment and services as described above is: $1,580,230

B. Deduct for shortening baghouse steel by incorporating the perimeter with the 4" pit retaining wall: .... ($9,800)

C. Option for bulk bag unloader / injection system as described above: $142,825

D. Option for Freight to jobsite: $126,900

E. Option for positive pressure pneumatic conveying system: .... $To Follow

F. Project Schedule

- To follow

G. Payment Terms

- 10% of total contract price due upon submittal of approval drawings.
- 80% of total contract price for estimated work in progress. Work in progress is inclusive of engineering, work on Seller's premises, and work by subcontractors.
- 10% retainage of final payment is due upon successful performance testing or acceptance of performance by purchaser. Acceptance actions by purchaser should be completed within 30 days after start-up. If acceptance is delayed at no fault of seller, then final payment shall become due no later than 60 days after shipment.
- All payments are based on Net 30 days payment schedule.

H. All equipment quoted in this proposal is Ex-Works; freight is not included to jobsite.

I. Taxes or duties are not included.

J. Upon award of contract, please submit tax exemption certificate to [redacted]

K. Prices quoted are valid for <u>30</u> days from date of issue unless extended in writing.

XII. Performance Guarantees

A. Emissions Guarantee

- [redacted] will guarantee 0.007 gr/dscf and 50% SOx reduction and 95% HCl reduction based on design conditions as specified in this proposal. The system shall be tested within 60 days after start-up. Testing shall be performed in accordance with the U.S. EPA Method 5 procedure evaluating "front-half" of train capture for determination of compliance with particulate emissions. This guarantee does not include solid particulate matter which may condense in either the outlet ductwork or emission train.
  - *If emissions are not met due to bag failure, [redacted] shall retain the right to replace bags on a one for one basis until this guarantee is met.*
  - *Dustex shall bring the equipment in compliance within 45 days of written notification of failure.*
  - *This guarantee is only valid per all the conditions outlined in the Emissions Guarantee Appendix and the system is operated in accordance with the manufacturer's instructions.*
  - *Emission testing is to be performed by others per the above EPA Method upon successful operation of the system. [redacted] shall be notified two (2) weeks prior to testing and shall reserve the right to observe the test*
  - *Pressure drop shall not exceed 6" w.c. with all modules on-line and 7.8" with one module off-line.*

XIII. Schedule

*A. **Submittal drawings for review shall be submitted five-six (5-6) weeks after receipt of order and consist of the following:***

- P&ID's
- General Arrangements (in 3D format, [redacted] uses SolidWorks 3D as a standard design tool)
- Structural Loads

B. Submittal drawings will be finalized one (1) week after receipt of comments.

C. Equipment delivery anticipated to be December 2012.

D. LNTP amount for engineering $94,500.

XIV. Attachments

A. Appendices A, B & C

B. Proposal General Arrangement Drawings (to follow)

C. Field Supervision Rates

Appendix A

Optional Activated Carbon Injection for Heavy Metals Control

I. System Design and Proposal Summary for one (1) PAC Injection System for the following Syngas fired boiler, baghouse installation

This proposal is for the design and supply of a Powder Activated Carbon (PAC) injection system for installation into the [redacted] supplied scrubber to aid in reduction of heavy metals present in the flue gas stream for the incineration project. The system as offered below includes the complete supply of the bulk bag discharging station, PAC feed equipment, and injection lance. Instrumentation, Allen-Bradley ControlLogix PLC controls, and power distribution panel for the system are also included for the system.

II. Scope of Work

A. Equipment and Material Supplied by [redacted]

- Bulk Bag discharging station, non-enclosed (Intended to be installed in the scrubber enclosure)
- PLC based Control system for automation of all injection equipment and annunciating system conditions integrated with scrubber controls system.
- Activated Carbon loss in weight feed system
- Activated Carbon conveying blower and eductor
- 480 VAC power panel
- 480 VAC: 120 VAC transformer for controls
- Tuning fork type hopper level switch
- Bag lifting hoist and rail

B. Equipment and Material Supplied by Others

- CEMS Monitoring equipment
- Supply of Sorbent (PAC)
- Activated Carbon conveying stainless steel tubing (1")
- 480 VAC power feed from MCC to [redacted] starter panel
- Foundations
- Equipment to tie into plant DCS
- Compressed air piping from plant system to ACI system

C. Services Supplied by [redacted]

- Engineering
  - *General Arrangement Drawings, Equipment Load Diagrams, Erection/Assembly Drawings, Process and Instrumentation Diagrams, Electrical Elementary Drawings, and Field Interconnection Drawings.*
  - *Operation and Maintenance Manuals*
  - *Spare Parts List*
- Start-up services for three (3) days (priced separately)

D. Services Supplied by Others

- 480 VAC power feed from MCC
- DCS Integration of [redacted] control system
- Foundation Design
- Compressed Air
- Construction Water and Power
- Erection of System

III. Design Conditions

A. Process Design Conditions

- Application: MSW Boiler

B. Environmental Design Conditions

- Jobsite: Idaho
- Location: ADA County
- Approx. Elevation: 3050 ft.
- Max. Ambient Temperature: 104°F
- Min. Ambient Temperature: -15°F

C. Control System

The control system is designed to be fully automated through connection to owner's system, capable of receiving a "feed set point" signal for determination of carbon demand.

Manual control of all the conveying and metering equipment is available through the [redacted] supplied HMI.

Appropriate alarms are provided to inform operators both audibly and visually of system malfunctions such as:

Loss of conveying air/line pluggage
Metering screw malfunction
Metering screw fill malfunction
Weighing system malfunction
Bulk Bag low level
Bulk Bag ready to be replaced

Key control points as well as indication of equipment status will be programmed and available across Ethernet link to Owner's DCS. PLC cabinets are built by [redacted]

The [redacted] Controls operate on a loss in weight principal. The PAC is fed from the bulk bag discharge into the metering screw/volumetric feeder through a rotary valve. PAC is discharged until high level switch is met. The volumetric feeder is also mounted on load cells and is used as the primary feed rate control for the loss in weight system.

D. Electrical Service

- Control / Starter Panel: 480 VAC, 50 amp
- Metering Screw: 480 VAC 3Ø 0.75 HP VFD driven
- Rotary Valves: 480 VAC 3Ø 1 HP
- Pneumatic Conveying Blowers: 480 VAC 3Ø 0.5 HP

E. Instrumentation

- Compressed Air Supply: One (1) pressure switch for PLC acknowledgement and alarming of low compressed air supply per system
- Pneumatic Conveying/Injection Line: Flow switch, one (1) per injection line for loss of blower or line pluggage
- Load Cell Weighing System: One (1) system (4 cells) with 4-20 mA output under metering screw
- Level Probe: One (1) installed in metering screw top for verification of fill, tuning fork type

IV. Carbon Feeding System (one feed train only)

A. Bulk Bag Discharge

- Bag Discharge Untying Station: Sealed access "glove box" with a hinged gasketed access door. System is designed to allow untying of bag through gloves
- Massaging Pads: Due to the fine nature of PAC, agitation of the bulk bag is accomplished through air cylinder massaging system as opposed to fluidization pads
- Bottom of Bulk Bag Isolation: Teflon seal pneumatically actuated slide gate
- Capacity: 2.5 days/bulk bag (worst case)

B. Hopper Rotary Valve

- Quantity: One (1)
- Manufacturer: [redacted] or equal
- Size: 6"
- Construction: Heavy duty fabricated housing complete with packing glands and outboard bearings and rotor adjustable tips
- Drive: 1/2 HP TEFC motor

C. Metering Screw Conveyor

- Quantity: One (1)
- Manufacturer: Acrison or equal
- Design Conditions
  - *Trough Loading:* *100%*
  - *Metering Screw Trough/Dutchman Size:* *2 cubic foot minimum*
  - *Metering Screw Fluidizing Nozzles:* *Two (2)*
- Construction
  - *Diameter:* *1"*
  - *Flighting Type:* *Stainless steel*
  - *Feed Rate:* *3 - 30 #/hr*
  - *Turndown:* *10:1*
- Venting: Vented to eductor inlet

Note: Familiarity with how to configure the loss in weight system as well as expansion and contraction issues is paramount for system performance and accuracy. Many organizations are not familiar with the pitfalls.

V. Powdered Activated Carbon Injection System General Description

The [redacted] PAC Feeding System is a loss in weight system designed for extraordinary accuracy. The system starts with a rotary valve charging a "Loss in Weight" feed metering screw supported by four (4) load cells, the main feeder is a volumetric feeder that is mounted on a weigh scale/load cells described above. The speed of the feeder screw is then adjusted to achieve the desired loss in weight material feed. By use of this dual weighing system, the system can achieve a high level of feed accuracy over many different carbon types. Over a time adjusted average, this system can achieve 1% accuracy. Injection system consists of the following:

- One (1) Bulk bag discharge station with a single discharge

- ♦ One (1) Hopper discharge Salina vortex (or equal) slide gate
- ♦ One (1) Regenerative blower
- ♦ One (1) Metering feeder screw for metering Activated Carbon
- ♦ Loss in weight feed system for gravimetric metering of Activated Carbon
- ♦ One (1) Fox eductor and injection nozzle
- ♦ Power panel with starters and variable frequency drives for PAC feeding system motor controls
- ♦ 304 SS Tubing for connection of lances to feeding equipment
- ♦ Bulk Bag discharge station
    - *Glove box for untying bulk bag*
    - *1 ton hoist for lifting bulk bag*
    - *IEC style starters*
    - *1500# bulk bag design*

VI. Surface Preparation and Painting

A. Exterior Fabricated Steel Surfaces, Low Temperature, Uninsulated, i.e. structural steel

♦ Surface Preparation:	SSPC-SP-6
♦ Prime Paint:	Red oxide alkyd primer @1.5-2.0 mils D.F.T. Alkyd enamel finish @ 1.5-2.0 mils D.F.T.

B. Vendor Supplied Equipment

- ♦ Vendor supplied equipment is provided with Vendor’s standard paint system.

VII. Contract Pricing (Appendix A)

A. The option price for the Activated Carbon System as described above is:......$142,825

DIRECT CONTACT LLC
P.O. Box 2969 Renton, WA 98056 ♦ Ph (425) 235-1723 ♦ Fax (425) 277-5780

May 17, 2012

Dynamis Energy, LLC
776 E. Riverside
Eagle, Idaho 83616

Attention: **Chris Durand, PE Project Engineer**

Reference: **DC062 ADA County, ID – MSW to Energy Project's Heat Recovery/pollution Abatement System**

Subject: **Equipment Supply and Engineering Proposal Revision A**

Dear Chris,

Direct Contact LLC (**DC**) appreciates the opportunity to work with Dynamis Energy LLC (**DE**) on the ADA County MSW to Energy Heat Recovery/Pollution Abatement System.

Background

DE is converting Municipal Solid Waste to Energy in ADA County, ID. The facility generates a bio-syngas via pyrolysis; the syngas is burned in a boiler to produce steam with the steam used to spin a turbine and generate electric power.

The steam exhausting the turbine is condensed and returned to the boiler. The condensate leaving the condenser needs to be heated substantially before returning to the boiler.

The syngas includes some entrained particulate, with a small fraction of acid gases (hydrochloric acid and sulfur dioxide).

DC has the technology and experience to capture a great deal of the waste heat leaving with the flue gas and returning its energy to the plant. In addition to recovering heat, DC can absorb a portion of the acid gases and scrub a portion of the particulates.

Design Conditions

Dynamis and Evergreen Engineering (EE) have developed three cases to be considered: Peak, Normal and Off Peak. These conditions are thoroughly described below. The Site Elevation is 3000-feet above sea level. The Peak condition is the design condition. The gross pollutant loading is proportional to the flue gas mass flow rate for the Normal and Off Peak Conditions using the Peak as a basis.

Case #1-Peak
Flue Gas Generated - Mass Flow Rate = 542,257.91-lb/hr
Flue Gas Stack Temperature = 350°F

<u>Design Conditions (Continued)</u>

Flue Gas Analysis: (Mole-fraction)

Oxygen	0.0579
Nitrogen	0.6797
Carbon Dioxide	0.1058
Argon	0.0083
Water Vapor	0.1484

Gross Pollutants

Sulfur Dioxide	40-lb/hr
Hydrochloric Acid	10-lb/hr
10 Micron & Smaller	7-lb/hr
2.5Micron & Smaller	7-lb/hr

Turbine Exhaust Condenser Condensate
Volumetric Flow = 433-gpm @105°F
Mass Flow = 215,042-lb/hr

Boiler Makeup Water
Volumetric Flow = 6-gpm @60°F
Mass Flow = 3,045 lb/hr

<u>Case #2 Normal</u>
Flue Gas Generated - Mass Flow Rate = 464,314.42-lb/hr
Flue Gas Stack Temperature = 350°F

Flue Gas Analysis: (Mole-fraction)

Oxygen	0.0680
Nitrogen	0.6987
Carbon Dioxide	0.1004
Argon	0.0084
Water Vapor	0.1244

Gross Pollutants

Sulfur Dioxide	34.3-lb/hr
Hydrochloric Acid	8.5-lb/hr
10 Micron & Smaller	6-lb/hr
2.5Micron & Smaller	6-lb/hr

Turbine Exhaust Condenser Condensate
Volumetric Flow = 433-gpm @105°F
Mass Flow = 215,042-lb/hr

Boiler Makeup Water
Volumetric Flow = 5.6-gpm @60°F
Mass Flow = 2,787 lb/hr

Design Conditions (Continued)

Case #3-OFF Peak
Flue Gas Generated - Mass Flow Rate = 127,350.73-lb/hr
Flue Gas Stack Temperature = 350°F (assumed)

Flue Gas Analysis: (Mole-fraction)

Oxygen	0.0573
Nitrogen	0.6889
Carbon Dioxide	0.1068
Argon	0.0084
Water Vapor	0.1386

Gross Pollutants

Sulfur Dioxide	9.4-lb/hr
Hydrochloric Acid	2.3-lb/hr
10 Micron & Smaller	1.6-lb/hr
2.5Micron & Smaller	1.6-lb/hr

Turbine Exhaust Condenser Condensate
Volumetric Flow = 100-gpm @105°F
Mass Flow = 50,000-lb/hr

Boiler Makeup Water
Volumetric Flow = 1.7-gpm @60°F
Mass Flow = 856-lb/hr

Scope

DC will provide equipment for a 'heat recovery/pollution abatement system' (HRPAS) that will use the exhaust flue gas as a heat source to add thermal energy to the condensate and boiler makeup water feeding the DA tank. The HRPAS will remove acid gases and particulate from the flue gas. Caustic soda will need to be added to the HRPAS to neutralize hydrolysis products generated or the absorption of acid gases will be limited. Water must be added to the HRPAS. The HRPAS will be a net evaporator of water and liquid water blow down will be necessary to purge salts generated in the hydrolysis of acid gases and the solid particulates scrubbed from the flue gas. The boiler blow down is directed through the vessels (V-01 and V-02) which should be enough water to adequately maintain salt concentrations in the contact water to a point that viscosity and surface tension does not affect mass transfer coefficients adversely. The method of achieving this heat recovery is described below. Please use the process flow diagrams D062-F-01A, -F-01B & -F-01C (for Peak (Design), Normal & Off Peak Conditions respectively) and the Piping & Instrumentation Diagram provided (drawings D062-F03 through F-05) as well as the General Arrangement drawings (D062-G-01 & G-02) to help with the process description.

DC's HRPAS will consist of several unit operations, duct & piping systems, instrumentation with control logic & interlocks performed in a PLC with a HMI. The system will be transparent to the operation of the Boiler.

The project scope for DC is broken into two categories: Engineering and Equipment Supply. Using the process flow diagram as a reference, the scope breaks down as follows:

Component Description	Engineering Responsibility	Equipment Supply
Inlet Gas Duct	DC	Others
HA-01	DC	DC
HA-01's Associated Components Duct and Plenum with wash headers	DC	Others
HX-01	DC	DC
HX-02	DC	Others
F-01 & F-02 Induction Fan & 4160-VAC motors	DC	DC
V-01 & V-02 HRPA	DC	DC
Interconnecting Duct between V-01& V-02 Stack	DC	Others
Pump P-01	DC	Others
Pumps P-02, P-03 & P-04	DC	DC
Valves: All shown on P&I Ds	DC	DC
Piping System inside target shown on P& I Ds	DC	DC
Stack	DC	Others
S-01 Filtration Equipment	Others	Others
All HRPAS Associated Supports and Platforms, Hand Rails & Ladders &/or Stairs	DC	Others
All Concrete Foundation and below grade systems	Others	Others

Electrical: All motor control and Variable Speed driver and lighting Conduit routing	Others	Others
Controls and Instrument (including modulated control valves) Package including PCL and HMI	DC	Others
CEMS Flow and Opacity Meters	Others	Others

Gas Flow

Syngas is generated in pyrolysis modules, then combusted in a second combustion unit (by-others). The very hot flue gas passes through a diversion stack (by-others). The flue gas then passes through a boiler with an economizer (by-others). The cooled flue gas leaves the economizer passes through a duct which directs the flue gas to the HRPAS. The flue gas first flows into transition TR-01 where it is evenly distributed, then passes through the washdown header and then enters the indirect heating coil (HA-01), which heats condensate while cooling the exhaust gas. The gas is only cooled to within 30°F or 40°F of its dew point; hence, although very cool, there is no concern of condensation occurring in normal operation. Downstream of HA-01, there is an exhaust wash water separation plenum, which splits the gas flow into two equal streams which are drawn into the induction Fans (F-01 and F-02). From the fans, the exhaust gas passes into two (2) [12.5 ft diameter x 33 ft straight wall with their major axis vertical] DCLLC Hydrothermal Recovery Vessels, (V-01 and V-02).

These vessels are of a special design as not only do they recover heat but they also absorb acid gases & remove particulates. First the flue gas is saturated and adiabatically cooled before entering the gas absorption section of the vessel. Then it passes to the heat recovery section of the vessel and the gas is further cooled before entering the scrubbing section where solid particulate is combined (via impaction and interception) in a coalescing mesh pad that captures solid material within liquid droplets. Most of these droplets are entrained in the gas flow leaving the coalescing mesh pad but captured in the mist elimination mesh pad above. The flue gas leaving the vessel is saturated with most of the acid gases and particulate removed. This cool saturated and relatively clean flue gas from each vessel recombines in the stack and is discharged to atmosphere. As the flue gas flows out the stack, it is monitored for effluent conditions (CEMS, flow and opacity meters are beyond the scope of DC).

Liquid Flow

The heat recovery system heats both turbine condensate (softened water - SW) and reverse osmosis water (RO - boiler feed water). Contact water (named because it is in direct contact with the exhaust gas) is a third flow stream that is part of the system. The contact water (CW) is initially made up of DI water, but as described above, water vapor generated in the combustion of syngas that drives the turbine, condenses in the vessels becoming a major constituent of CW. The contact water will have sodium hydroxide added to maintain a specific pH, approximately 10.5. The acid gas will absorb into the contact water and hydrolyze. The formation of sodium chloride and sodium sulfite will occur as well as sodium carbonate. Although makeup water (boiler blow down) will vaporize and leave with the flue gas, most of the makeup will flow out of the system purging the salts.

Contact water is circulated around & through the DCLLC Hydrothermal Recovery Vessels. The level of contact water in each vessel's reservoir is equalized using a 10" diameter line between vessels which maintains a common level in both vessels. One vessel has a 'common' overflow and the other vessel has a common reservoir level sensor. The two (2) circulation pumps draw water from both vessels via the equalization line. While either P-02 or P-03 can draw and circulate contact water to either vessel at off peak conditions, at normal flow conditions both pumps operate together. A portion of the contact water is circulated directly to the lower spray headers on the vessels absorption section. The remainder of the circulated contact water passes through a plate & frame heat exchanger (HX-01), cooling the contact water and heating condensate. The cooled contact water is again split: a portion going directly to the spray header on the heat recovery section on the vessels, and the remainder going to the filtering (S-01) system. The filtering system (by others) removes most of the collected particulates. The filtered contact water is used to wash the mist eliminator mesh pad & periodically washing the coalescing mesh pad with its waste stream being directed to the cooling tower (piping, etc is beyond the scope of this offering) . The coalescing mesh pad wash cycle is initiated on high differential pressure across the coalescing mesh pad.

Equipment Details

The heat recovery vessels are designed for non-pressurized service. The vessel's internals will be accessible via standard manways. The vessel shell is to have 1.5-inches of field-installed insulation covered with aluminum sheathing (insulation and sheathing is considered part of the installation service installed in the field by others and is outside the scope of this equipment proposal). All ductwork upstream of HA-01 is carbon steel (between HA-01 & F-01 it is stainless steel). All materials downstream & including the fan's casings & wheels are stainless steel. All piping material for RO water and contact water are stainless steel while softened water piping is carbon steel.

A skid will be located in the vicinity of the heat recovery vessels. The proposed skid system includes: one (1) 50-HP circulating water pump (P-02), one (1) 50-HP circulating water pump (P-03), with associated inlet & outlet piping. It is recommended a plate & frame heat exchanger (HX-01) be located indoors or be insulated completely. The contact lines running between V-01 & V-02 and the skid will be supplied be others.

The boiler makeup water heater HX-02 its condensate circulation pump P-01 are a part of the heat recovery system, but remote to the vessel's and skid. All items associated with boiler makeup heating will be supplied by others. DC will have process design responsibility, but piping design for freeze protection and maintenance accessibility is the responsibility of others.

The contact water in the reservoir of the vessels is maintained at a pH of 10.5 to 11. This is achieved by continuous sampling the pH of contact water exiting the circulation pumps and adding sodium hydroxide solution at P-02 and P-03 suction. The sodium hydroxide solution is presumed at a concentration of 50% water. Others will provide insulated/heat traced piping between the sodium hydroxide storage tank (by others) and the metering pump (P-04). P-04 and the pH sensor will be mounted on the DC skid. The pH sensor will be supplied by others and the pump will be supplied by DC.

The instrumentation & controls process design will be by DC. DC will generate a process description & loop list so the customer's PLC integrator/provider can specify, design & program the PLC. The Motor Control Center and Control Panel, PLC and HMI will be designed and supplied by others. The electrical equipment shall include motor starters for the pumps (P-01 (1-Hp motor @ 460-VAC), P-02 (50-Hp motor

@ 460-VAC), & P-03 (50-Hp motor @ 460-VAC)) and variable speed drives for the fans (F-01 (400-Hp motor @ 4160-VAC) & F-02 (400Hp motor @ 4160-VAC)) & metering pump P-04 (.333-Hp motor @ 460-VAC). Others will provide a control panel will include an RS View HMI providing supervisory & process control with the associated PLC (AB Contrologix) and DC will assist in theses efforts. The location of loop tuning will be decided by the provider.

Power distribution and local disconnects will be supplied (by others) for field distribution to the six (6) usage points: the pumps P-01, P-02, P-03 and P-04 at 480 VAC, the induced draft fans F-01 & F-02 (both of which are 400 HP) at 4160-VAC and 120-volt single phase transformer (30 amps) to be field routed to the control panel.

Process Engineering:
DCLLC will select, size or specify all components shown on the flow diagram with the exception of the filtration system.

Mechanical Engineering:
DCLLC will design / layout all equipment components with the exception of the filtration system and the remote skid for HX-02 & P-01.

Specific Exclusions

- *Electrical:* Supply of specified power requirements to the customer's Motor Control Center (MCC) with its associated motor starters/VFDs for P-01, P-02, P-03, P-04, F-01 & F-02 and from there to the motors, local controls and monitoring instrumentation is by others. All power wiring, conduit, tray, etc. and installation of same is by others.
- *Controls:* Supply of the PLC, HMI, any local control panels and all local instrumentation is by others. All control wiring & conduit as well as all installation of same is by others.
- *Foundation:* Design & supply of the foundation(s) required for the heat recovery vessels, equipment skid(s), etc are by others.
- *Structural:* All structural supports other than the unitary skid underneath the pump/heat exchanger module are by others. This includes vessel access ladders & platforms.
- *Mechanical:* Field items required as part of a complete installation will include the following items by others:
    - Insulated pipe lines used for supply and return hot condensate. The design requires isolation & check valves at the loop connection points, which are to be supplied by the installing contractor.
    - Insulation of V-01 & V-02 (described earlier).
    - Insulated pipe lines used for cool supply and hot return RO water. The design requires isolation & check valves at the connection points to the makeup supply & these are to be included by the installing contractor.
    - Drain/overflow lines from V-01 & V-02 to a client-specified sewer connection.
    - Design & supply of the S-01 Filtration system for contact water with the associated interconnecting piping, vales, etc.
    - Supply of the P-01, HX-02 and all interconnecting piping & valving, etc.

- Low-pressure flue gas inlet ducting for:
  - 1) hot flue gas from the economizer to DCLLC system inlet (with insulation),
  - 2) Cool flue gas from the V-01 & V-02 discharge to atmosphere (via the stack).
- *Permits:* All required permits (building, etc.) are specifically outside the scope of this proposal and to be provided by the client.

Utility Requirements

- Makeup water (RO) must have sufficient pressure to overcome 12-psi across the DCLLC system.
- RO & Softened Water must have sufficient pressure to overcome 20-psi across the DCLLC system's piping & heat exchangers.
- Electrical power (see scope): Transfer Pump P-01: 1-HP, Circulation Pump P-02: 50 HP, Circulation Pump P-03: 50-HP: Sodium Hydroxide Pump P-04: 1/3 HP, Induced Draft Fans F-01 & F-02: 400 HP each.
- Clean (low volume), dry air (90-psig) for pneumatic actuation for control dampers and valves.

Summary of Conditionally Guaranteed Emissions to Atmosphere with operational notes:

Peak Load:

Heat Recovery	31.00-Million BTU/hr
Volumetric Flow	150,865-ACFM @ 125.4°F
Sulfur Dioxide	11.50-lb/hr
Hydrochloric Acid	0.95-lb/hr
2.5 Micron Particle & Small	4.13-lb/hr

Normal Load:

Heat Recovery	30.00-Million BTU/hr
Volumetric Flow	140,935-ACFM @ 124.4°F
Sulfur Dioxide	9.86-lb/hr
Hydrochloric Acid	0.89-lb/hr
2.5 Micron Particle & Small	3.54-lb/hr

Off Peak:

Heat Recovery	8.43-Million BTU/hr
Volumetric Flow	39,100-ACFM @ 134.5°F
Sulfur Dioxide	2.47-lb/hr
Hydrochloric Acid	0.24-lb/hr
2.5 Micron Particle & Small	0.94-lb/hr

Direct Contact LLC will conditionally guarantee the above removal rates at stated Loads (steam generation rates). It is assumed that the constituents, noted above, exist proportionally to the mass flow of flue gas leaving the boiler. We have assumed that the particulate material in the flue gas is generally a solid material, and is not gelatinous or tacky.

Pricing Equipment & Engineering:
One (1) *DCI-HTR*™ Special System with integral acid gas absorption and particulate scrubbing engineering included (shipped loose for field installation) as described above:

Equipment Price: $**2,496,000.00**
F.O.B.: Point of Manufacture, Freight Prepaid & Add
Availability: 36 wks ARO for equipment delivery to site.
Payment Terms: 40% upon receipt of order to be paid upon receipt of invoice
30% upon receipt of materials at the fabrication facility (net 30)
20% upon shipment of equipment to site (net 30)
10% upon successful testing of system (or 90days after completion of DCLLC equipment installation if testing does not occur, whichever occurs first) (net 30)
Taxes: The above pricing includes no duties, taxes, etc. If any are applicable, they are to the account of others.

<u>Start-Up and Training</u>:
DCLLC has included five (5) days for equipment startup as well as five (5) days of training to plant personnel prior to leaving the completed job. As the installation of the equipment is by others, if additional time is required for startup and found not to be due to DCLLC, then the additional time & expenses will be billed at DCLLC's Standard Rates for Field Service then in effect.

<u>Corrosion Guarantee</u>:
All stainless steel non-rotating components are guaranteed for a period of two years from the date of startup or 30 months from date of delivery, whichever is shortest, based on the attached customer provided flue gas chemistry. This guarantee is applicable should significant evidence of corrosion appear while performing its intended purpose. DCLLC will repair or replace these items including parts and labor. The repair and or replacement of the items is the sole remedy provided in this Corrosion Guarantee. All repaired or replaced parts will have the balance of the initial warranty period remaining. All rotating equipment will be limited to the manufacturer's Corrosion Guarantee language, which will be provided upon final selection.

Direct Contact LLC is uniquely qualified to provide our patented equipment designs and complete engineering and project oversight experience as proven at other operations. I look forward to furthering this discussion as soon as your schedule allows. Should you have any questions, please don't hesitate to contact my office.

Thank you for your interest and continued consideration of **Direct Contact LLC.** We look forward to working with you and your colleagues on a project that will enable you to maximize the energy efficiency of the customer's operation.

With *Warmest* Regards,

Bill Carson

Chief Engineer
Direct Contact LLC

Cc: Curt Rothman (DCLLC)
Jim Shields (DCLLC)

[redacted]

Presents the

[redacted]

To:

EVERGREEN ENGINEERING

Engineering and Construction Services

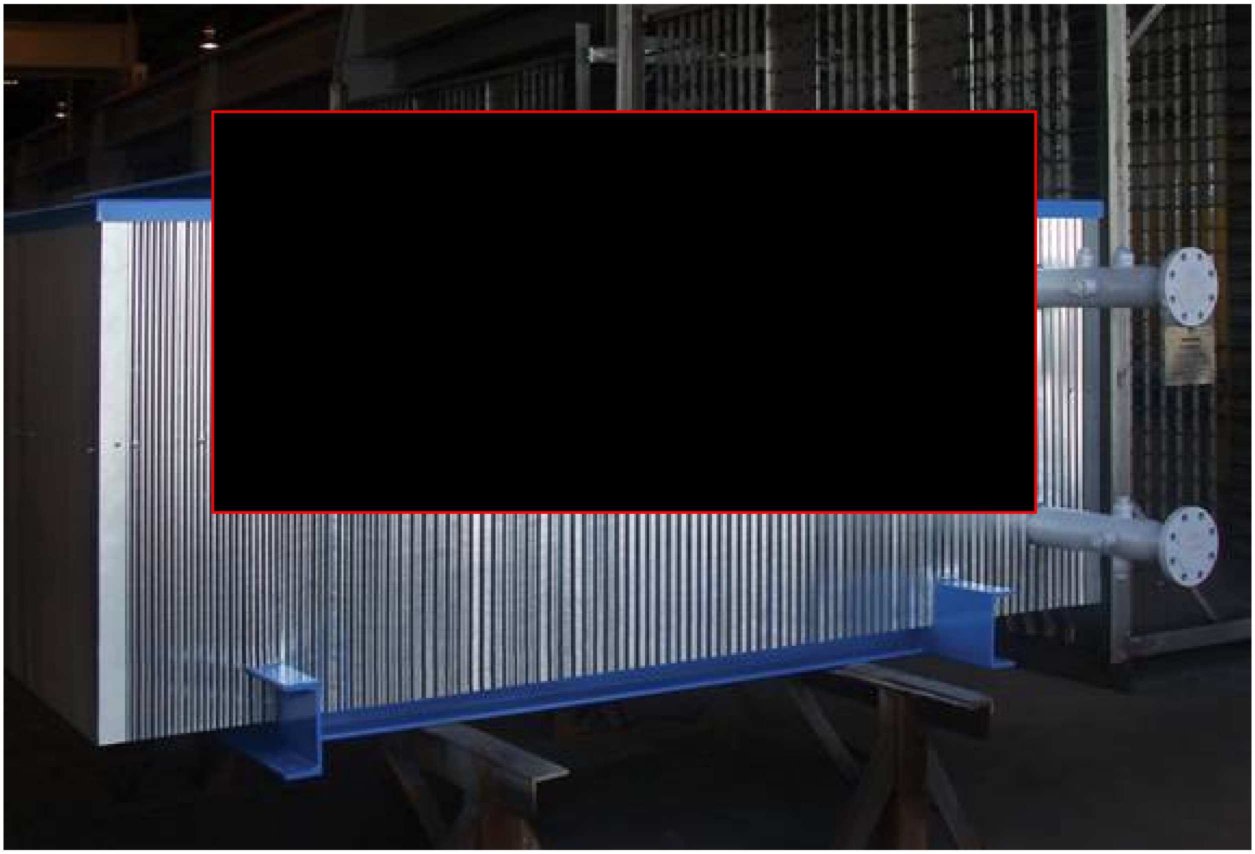
Proposed for

DYNAMIS ENERGY

Date: June 12, 2012

[redacted]

[redacted]



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[redacted]

May 18, 2012

Mr. John Solvason, PE
Evergreen Engineering
1740 Willow Creek Circle
Eugene, Oregon 97402

Subject: Condensing Economizer

SECTION 1.0 EXECUTIVE SUMMARY OF PROPOSAL / TERMS

1.1 Equipment Description and Pricing

[redacted] is pleased to offer our proposal for a Condensing Economizer for the above referenced project.

The unit is designed to cool 461,314 lb/hr of flue gas from 351 °F to 140 °F using 203,561 lb/hr of water at 105 °F. This water inlet temperature is below the water dew-point (119 °F) as well as the sulfuric acid dew-point (237 °F) of the flue gas. There will be condensation of moisture as well as acid on to the tube surfaces. The pressure part metallurgy has therefore been selected to be Duplex stainless steel. Tubes are also bare, given presence of particulates in the flue gas. Provisions have been made for soot-blower lanes.

The unit has been designed to be modular in construction for shipping ease. There will be four (4) identical modules. The unit has horizontal tubes with horizontal gas flow. Units will have to be jumpered across headers in the field. If layout horizontally takes up space, design can be revised to minimize foot-print by having units arranged to have gas flow vertically down in one pass or have gas flow in two passes.

1.3 Warranty Protection, Start-up, and Training

[redacted] can provide installation service, start-up assistance as well as training to the purchaser. Field Services are typically invoiced at published T&M rates, attached to this proposal.

1.4 Terms & Conditions

Any order resulting from this proposal will be in accordance with the attached [redacted] General Terms and Conditions of Sale.

Prices quoted above are [redacted] In the event [redacted] costs for steel, tubing, or related alloys materially increase based on information available at the time of this proposal compared to the actual cost of steel at the time of order placement, [redacted] will be entitled to an additional sum equal to the difference between the steel costs.

Prices do not include sales/use or any other applicable taxes.

1.5 Lead Times

Based on current shop loading and Duplex material availability

G.A. drawing for approval	6 weeks after order acceptance
Customer approval and release to fabricate	2 weeks after G.A. drawing submittal
Ready to ship – first module	20 weeks after release to fabricate
Each subsequent module	2 weeks after previous module

[redacted]

1.6 Milestone Payment Schedule

- To be negotiated prior to order acceptance

We certainly appreciate the opportunity to present our proposal, and trust that it meets with you approval. If you should have any questions or comments, please do not hesitate to contact the undersigned at your convenience.

Very Truly Yours,

[redacted]

SECTION 2.0 [redacted] ECONOMIZER DESCRIPTION

2.1 GENERAL INFORMATION

General Information					
Fuel	MSW		Proposal Number	[redacted] Cond HX	
			Proposal Revision	0	
			Date	6/12/2012	
Elevation	500	fasl	Unit Location	Outdoors	
Design Code	ASME Section 1		Radiography	10%	
Design Parameters			**Thermal Performance**		
Gas Flow Direction	Horizontal		Heat Exchanged	24.8500	MMBtu/hr
Tube Direction	Horizontal		Overall U	12.95	Btu/ft^2-hr-°F
Drainable	Yes		LMTD	71.30	°F
Design Pressure	490	psig	Total Heat Transfer Area	29,941	ft^2
Design Temperature	600	F	Max. Fin Temp	N.A.	°F
Tube Corr. Allowance	0	in	Max. Tube Wall Temp.	233	°F
Header Corr. Allowance	0	in	Min. Tube Temp	107	°F
Tube-side Process Information			**Shell-side Process Information**		
Fluid	Water		Fluid	Flue Gas	
Water Quality	Un-deaerated				
Mass Flow Rate	203,561	lb/hr	Mass Flow Rate	461,314	lb/hr
Inlet Temperature	105	°F	Inlet Temperature	351	°F
Outlet Temperature	227.0	°F	Outlet Temperature	141.00	°F
Operating Pressure	100	psig	Operating Pressure	10	in WC
Average Velocity	2.8	ft/s	Average Velocity	36.8	ft/s
Pressure Drop	28.0	psi	Draft Loss	5.80	in WC
Fouling Factor	0.001	hr-ft^2-F/btu	Fouling Factor	0.005	hr-ft^2-F/btu

Tube Bundle Configuration					
Tube Type	Bare		Tube Specification	SA790-2205 Welded	
Tube Layout	Inline		Effective Tube Length	19	ft
Flow	Counter		Tube OD	1.90	in
Tubes Wide	36		Tube AW	0.109	in
Tubes Deep	88		Fin Material	N.A.	
Streams	22		Fin Type	Bare	
Total Number of Tubes	3168		Fin Height	0	in
Transverse Pitch	3	in	Fin Thickness	0	in
Longitudinal Pitch	4	in	Fin Pitch	0	fpi
Bend Type	Hot		Fin Segment Width	N.A.	in

[redacted]

Structural Design					
Casing Design Pressure	20	in WC	Maximum Dead Load	2,500	lbs
Casing Design Pressure	600	°F			
Casing Material	Carbon Steel		Tube Sheet Type	Lattice	
Casing Thickness	3/16" Plate		Intermediate Tube Sheets Qty	1	
Sootblower Lane Qty	4		Access Door Qty	8	
Sootblower Lane Height	18		Access Door Size	16" x 16"	

Dimensions and Weight - PER MODULE			Flue Gas Analysis	% vol
Estimated Nozzle Center-Cente	7'-0"		H20	13.40
Estimated Overall Depth	10'-6"		CO2	7.20
Estimated Overall Height	10'-2 15/16"		N2	72.50
Estimated Overall Length	22'-7 1/2"		O2	6.80
Estimated Duct Height	9'-0"		SO2	0.10
Estimated Duct Length	19'-0"		Total	100.00
Estimated dry weight	66,150	lbs		
Estimated flooded weight	84,902	lbs		

Overall depth if all modules are arranged horizontally will be four times the individual module depth.

[redacted]

2.5 Scope of Supply

Supply		ITEM	Installation	
[redacted]	*Others*		[redacted]	*Others*
√		[redacted] Economizer	√	
	√	Economizer Insulation and Lagging		√
	√	Field Installation		√
√		Sootblower Wall-Boxes and Distal Bearings	√	
	√	Sootblowers		√
	√	Safety Valves		√
	√	Feedwater Pressure Gauges		√
	√	Feedwater Temperature Gauges		√
	√	Economizer By-Pass System		√
	√	Any Interconnecting Wiring or Cabling		√
	√	Interconnecting Piping External to Economizer		√
	√	Support Structure		√
	√	Expansion Joints		√
	√	Inlet Transition with Insulation, Lagging		√
	√	Outlet Transition with Insulation, Lagging		√
	√	Platforms and Walkways		√
√		Loading Equipment at Shop	√	
	√	Unloading Equipment at Site		√
	√	Site Storage Prior to Installation		√
√		Erection Consultant (Per diem / T & M rates)		
√		Class Room Training (Per diem / T & M rates)		
√		Field Testing Labor, Equipment and Consumables (Per diem / T & M rates)		
√		Start-Up Consultant (Per diem / T & M rates)		
√		Documentation		
√		O & M Manuals		

[redacted]

TERMS AND CONDITIONS OF SALE
March 19, 2010

DEFINITIONS

Where the context permits, the following words shall have the meanings indicated:

"Buyer" means the person, partnership, company, or corporation procuring the Products from the Company.

"Company" means [redacted] or the subsidiaries and affiliates.

"Products" means all goods, materials, chattels, equipment, and machinery to be provided pursuant to this Order.

"Order" means Buyer's purchase order or contract and documents and data referenced therein.

TERMS AND CONDITIONS

THE ORDER IS EXPRESSLY LIMITED TO ACCEPTANCE UPON THE TERMS AND CONDITIONS CONTAINED HEREIN.

A. PAYMENT

The Order is subject to progress billing in accordance with payment terms as stated therein. Company may invoice for payment, upon verifiable completion of the milestones for the amounts specified therein. In the absence of any payment terms, payment terms as stated within Company's proposal shall apply. The payment terms are Net 30 days from date of invoice. Late payment(s) beyond the terms as stated within the Order or in the absence of the Order as stated herein shall extend the delivery of the Products as determined by the Company.

B. PAST DUE ACCOUNTS

A finance charge of the lesser of 1.5% per month (18% APR) or the highest rate permitted by law will be assessed on all past due accounts. The parties intend to comply with all relevant usury laws. Should the finance charge paid exceed the legal limit, any excess will be deemed a payment of principal. An invoice is past due if the net amount is not paid within 30 days from date of invoice. Interest charged on a past due invoice will be assessed from the date on which that invoice was due. The above charges will be billed on the date that the invoice becomes 30 days past due, and on each monthly period thereafter.

C. BREACH

In the event of failure of Buyer to make any payment to the Company when due, the Company shall be entitled, at its sole option, to; extend the shipment of the Products in proportion to the date payment is received by the Company or suspend shipment of any or all goods to such defaulting Buyer, whether or not the contract covering said goods has been accepted by the Company; cancel any contracts then outstanding for the sale of goods to such defaulting Buyer; and to the extent permitted by law receive all expenses incurred by it in the collection of said payment, including reasonable attorneys' fees.

D. PRICES

Prices quoted by the company herein are firm for 30 days from the date of the quotation and are subject to adjustment as stated in the Company's quotation. After 30 days from the date of the quotation, all quoted prices are subject to change by the Company without prior notice to Buyer.

E. CANCELLATION

This Order may be canceled by Buyer only upon (1) written notice to the Company subsequently accepted in writing by the Company and (2) payment to the Company of cancellation charges as determined by the Company to include overhead and profit.

F. TAXES AND CHARGES

Taxes are not included within the Order price unless expressly stated therein.

G. FREIGHT

Unless otherwise stated within Buyer's Order, Company shall deliver the [redacted] manufacturing facility with loading allowed onto Buyers trailers. Should Company be responsible for freight DDP jobsite, the following provisions shall apply:

Truck Shipments

All truck shipments are subject to route survey and permit approval and changes in routing required by government authorities. All of the foregoing may require price and schedule adjustments. Off loading of the Economizer is the responsibility of the Buyer, four (4) hours of free time for off loading Economizer has been provided. Additional time is subject to demurrage.

Rail Shipments

[redacted]

Rail shipments will be delivered to the nearest rail siding that the carrier can and will deliver and are subject to route survey and permit approval and changes in routing required by government authorities. All of the foregoing may require price and schedule adjustments. Buyer is responsible for off loading of the glycol heaters components after delivery. Upon delivery Buyer will be granted two (2) free days to allow for off loading of the glycol heaters components. Additional time is subject to demurrage at the prevailing rates. Heavy duty rail car shipments are subject to demurrage and detention costs.

H. SHIPPING DATES

The Products will be shipped in accordance with the shipping date(s) as stated within Order. In the absence of such information the Products will be shipped in accordance with the dates specified within the Company's proposal. If delivery of the Products is delayed by Buyer, payment shall be made to Company upon completion of the Products or readiness to ship.

I. TRANSPORTATION RISK

Buyer assumes all risks of loss or damage upon the Company's delivery of the Products in accordance Article G.

J. DELAYS IN DELIVERY

The Company shall not be liable for any delay or failure in the delivery or shipment of the Products, or for any damages suffered by reason thereof, in the event that such delay or failure is, or such damages are, directly or indirectly due to either accident in manufacture or otherwise, fire, flood, riot, war, embargo, labor stoppages, inadequate transportation facilities, shortage of materials or supplies, delay or default on the part of its vendors, regulation by any governmental authority, or any cause or causes beyond its control.

K. STORAGE

If shipment is delayed due to any cause within Buyer's control, the Products may be placed in storage by the Company for Buyer's account and risk, and regular charges therefore and expenses in connection therewith shall be paid by Buyer. If, in the sole opinion of the Company, it is unable to obtain or continue such storage, Buyer will, on request, provide or arrange for suitable storage facilities and assume all cost and risk in connection therewith.

L. CLAIMS

The Company shall not be liable to Buyer for loss or damages to Products after of delivery. Shortages or damage of Products must be brought to the attention of the carrier at the time of delivery and stated in writing on the delivery papers in Order to initiate a claim.

M. WARRANTIES

The Company warrants the Products to be free from defects in workmanship and material, under normal use and service the earlier of, 12 months from initial operation of the Products or 18 months from the date of shipment (the "Warranty Period"). No warranty of any kind, express or implied, is extended by the Company. This warranty does not cover the effects of normal wear, tear or deterioration of the Products; damages caused by improper treatment of feedwater and or/conditioning of glycol heaters water, or the effects of abrasion, erosion, or corrosion; the effects of improper storage or erection; or abuse of the Products or operation or maintenance not in accordance with Company's operating instructions. If at any time prior to expiration of the Warranty Period, Buyer or Owner shall discover any defect or other failure of the Products, to conform to the Warranties, Company, upon written notice from Buyer, given within a reasonable time after discovery, shall correct the defect or nonconformity or replace the defective Product to comply with the Order requirements. Notwithstanding the foregoing, the Company's obligation to correct or replace any defect or nonconformity shall only occur during the Warranty Period and no such corrections or replacements shall occur upon expiration of the Warranty Period. Any defects or nonconformities not corrected or replaced during the Warranty Period shall be deemed accepted by Buyer. Further, if the Company has not received prior written notification, then the Company shall not be responsible for any repairs, parts, equipment supplied by others unless the same was specifically ordered by the Company. Any substitution of parts not provided by the Company or not authorized by the Company or modification, tampering, or manipulation of Company's product shall void any and all Warranties. Alteration of any parts without express written permission of the Company for a purpose other than that intended shall void any and all Warranties. The warranty shall not be effective unless the Buyer has fully paid for the Products.

N. THERMAL PERFORMANCE

[redacted]

Performance tests shall be run within sixty (60) days of the date of initial operation of the Products not to exceed three (3) months from delivery of the Products or shall be deemed satisfied. Satisfactory completion of performance tests satisfies Company's obligation with respect to Product operation, and Company's sole obligation is restricted to the material and workmanship warranty as stated within these terms. Tests shall be conducted in accordance with the applicable ASME test code including measurement uncertainties for the equipment.

O. BACKCHARGES

In the event the Products furnished by the Company under this Order are found to be defective as to workmanship or materials in accordance with Paragraph M. Warranties, or not to be in conformance with the Order documents, Buyer will take reasonable measures to discover such noncompliance as quickly as practical and provide written notice to Company. Company shall be allowed to correct the defect or nonconformity in accordance with the provisions of Paragraph M, Warranties but only to the extent such corrections are made during the Warranty Period.

The accepted procedure for dealing with the resolution of field problems under Paragraph M. Warranties is as follows:

1) Buyer will provide written notice to Company of specific problem(s) and deficiencies before any corrective action is taken.
2) Company will initiate reasonable action to remedy the nonconformity.
3) In a timely manner, which is mutually agreeable to Buyer and Company, Company will either undertake the corrective work or Company will authorize Buyer in writing to proceed with the rework at an agreed upon cost.

Final acceptance by Company of Buyer's invoices, pursuant to paragraph 3) above, for corrective work performed by Buyer will be contingent upon proper documentation such as accurate time records, material invoices, etc.

P. CHANGES

This Order shall not be changed or otherwise modified except upon the prior written authorization of a duly authorized representative of Buyer and the Company. Notwithstanding the foregoing, Buyer may, at any time, in writing, make changes within the general scope of the Order.

Q. ASSIGNMENT

Any assignment of the rights accruing hereunder shall be void without the prior written consent of the Company.

R. WAIVER

The Company's waiver of any breach by Buyer of any of the provisions of the Order shall not constitute a waiver of any other breach of the same or any other provision. The Company's rights and remedies under any provision of the Order shall be in addition to and not in substitution of any other rights and remedies available to the Company under applicable law.

S. GOVERNING LAW AND ARBITRATION

This Order is to be interpreted in accordance with, and its administration and performance governed by, the laws of the State of [redacted] The parties hereto agree that [redacted] shall be the exclusive forum for any cause of action filed in any court of law or equity arising out of the execution of or performance under this Order. Notwithstanding the foregoing, in the event Buyer is located outside the United States of America and purchases Products pursuant to the terms hereof for use outside the United States of America, any dispute between such Buyer and the Company respecting the Products shall be finally resolved by arbitration in the English language in [redacted] U.S.A. in accordance with the rules then obtaining of the American Arbitration Association, and judgment upon the award rendered may be entered in any court having jurisdiction thereof.

T. SEVERABILITY

In the event that any provision contained herein is held to be invalid or unlawful, such provisions shall be severable from the remaining provisions of these terms and conditions shall remain in full force and effect.

U. CONFIDENTIAL AND PROPRIETARY INFORMATION

Buyer shall keep confidential any technical, process or information derived from drawings, specifications and other data furnished by the Company in connection with this Order and shall not divulge, directly or indirectly, such information for the benefit of any other party without obtaining Company's prior written consent and shall maintain as secret such information except as otherwise provided herein.

V. LIMIT OF LIABILITY

[redacted]

Company shall not be liable for any special, indirect, incidental or consequential damages or lost profit, whether arising under warranty, contract, negligence, strict liability, indemnification, or any other cause or combination of causes whatsoever. Company's liability for personal injury will be $1,000,000 and the limits for property damages will be $1,000,000 with an overall aggregate of $2,000,000. All other liabilities will be limited to the Purchase Order value. These limitations shall prevail over any conflicting or inconsistent provisions stated elsewhere.

W. INDEMNIFICATION

Buyer shall at all times indemnify, defend Company and their respective affiliates, employees, officers, directors, and agents harmless from and against any and all costs, liabilities, losses and expenses resulting from and against all claims for personal injury, property damage, wrongful death or other damages, losses, and expenses, including attorney's fees arising out of, or resulting from, performance of the work or any services on behalf of the Buyer, whether commenced pursuant to this Order. It is expressly understood and agreed that this obligation to completely indemnify, defend and hold harmless shall apply and be enforceable for all claims without regard to whether or not Buyer is claimed to be negligent or otherwise liable for any such damages, losses and expenses.

X. INDEPENDENT CONTRACTORS

Neither the Order nor any other agreement made pursuant to or otherwise in connection with the Order shall be deemed to create or constitute a relationship of principle and agent, partnership, joint venture or business organization of any kind or nature whatsoever between Buyer and Company.

Y. SECURITY INTEREST IN THE PRODUCTS

To secure Buyer's obligation in connection with this Order, Buyer hereby grants Company a continuing lien on and first priority purchase money security interest in all of Buyer's right, title, and interest in and to the Products purchased under this Order (the "Collateral") and any proceeds thereof. Company's security interest in the Collateral shall terminate upon full payment of the purchase price including any subsequent change orders and related charges. If Buyer fails to pay amounts owed under the Order or otherwise breaches its obligations to Company hereunder, Company shall be entitled to foreclose on the Collateral and shall have all remedies available to secured parties under the Uniform Commercial Code in the State in which the Collateral is located. Buyer authorizes Company to file in the appropriate records a financing statement and any continuation statement, as Company deems appropriate to perfect Company's security interest in the Collateral, and to notify Buyer's creditors of Company's security interest.