Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

Project Narrative

Project Objectives

The primary objective of the Project is to maximize the productive use of the substantial quantities of waste landfill gas generated and collected at the Central Landfill in Johnston, Rhode Island. An extensive analysis was conducted and it was determined that utilization of the waste gas for power generation in a combustion turbine combined cycle facility was the highest and best use.

The resulting Project reflects a cost effective balance of the following specific sub-objectives:

- Meet environmental and regulatory requirements, particularly the compliance obligations imposed on the landfill to collect, process and destroy landfill gas
- Ensure that adequate space is available for the required expansion of the Central Landfill
- Utilize proven and reliable technology and equipment
- Maximize electrical efficiency
- Maximize electric generating capacity, consistent with the anticipated quantities of landfill gas generated and collected at the Central Landfill
- Maximize equipment uptime
- Minimize water consumption
- Minimize post-combustion emissions

Merit Review Criterion Discussion

Criterion 1: Ability to Preserve or Create Domestic Jobs

Domestic job creation methodology:

- The Applicant has determined the number of jobs created by working in close collaboration with the Applicant's owner's engineer and major equipment vendors and service providers. A detailed headcount matrix is attached. The estimate of jobs created or preserved includes
    - o Employees of Applicant or its subsidiaries and affiliates that support the Project or to maintain and operate the resulting equipment and infrastructure. These employees include the categories set forth below.
        - Project development
        - Project management
        - Project engineering and design review
        - Accounting and financial analysis
        - Administrative
        - Legal
        - Landfill gas wellfield construction, maintenance and operation
        - Facilities management

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

    - Facilities maintenance and operation
  - Employees of Applicant's owner's engineer and identified major service providers, equipment vendors and their subcontractors *to the extent that* those employees will be working in support of the Project or to maintain and operate the resulting equipment and infrastructure. For certain major equipment (e.g. combustion turbines, gas treatment, etc.) maintenance will be performed by the vendor pursuant to long term (5 -10 years) service agreements. These agreements provide for regular maintenance of the equipment, together with performance guarantees. Accordingly, jobs associated with satisfying the obligations under the long term service agreements are included in the estimate of jobs created. The specific participants in this process were:
    - Jacobs Engineering Group
    - Solar Turbines
    - domnick hunter
    - Merichem
    - Rentech
    - Dresser-Rand
    - Stantec Engineering
    - GZA Geoenvironmental
    - EIG
    - Vanderweil
    - DBI
  - Employees of other major vendors, the construction contractor and its subcontractors. Because certain major vendors (e.g. compressors, steam turbine generating set, etc. . .) the construction firm has not yet been selected, an estimate of the associated construction jobs has been developed by Applicant's owner's engineer. This estimate is based on Jacobs considerable experience with the construction and commissioning of landfill gas and combined cycle combustion turbine projects.
  - Due to the legal intensive nature of project development work, in addition to its in-house legal resources, Applicant engages a large number of outside lawyers. Because Applicant's legal work is outsources to a variety of different firms, Applicant has estimated the consolidated legal resources associated with the Project.

- Methodology for Determining FTEs

  Applicant requested the major equipment suppliers to provide labor hours to manufacture their equipment and present it in the number of Full Time Equivalent ("FTE") employees (See Attachment). After receiving the data it was apparent to Applicant that some of the

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

suppliers had neglected to include the associated labor hours embedded in their material suppliers' cost. In most cases the detailed support for the FTE calculations indicated that they had only provided information on their shop and the shops of their major suppliers. In particular, there were no hours included for the next level of sub-suppliers and material providers. The conclusion that additional FTEs should be included for sub-vendors was reinforced by the fact that there were large discrepancies between the labor estimates provided by suppliers of similar equipment.
Accordingly, Applicant used the information provided by the major vendors to identify locations for the manufacturing and to establish the base number of FTEs at the vendor level. Applicant then increased the number of FTEs to reflect the FTEs associated with subvendors and materials providers, taking into account the nature of the product and the level of engineering, design and manufacturing required to produce the product.
By way of illustration, the calculation of FTEs for the heat exchanger manufacturer was as follows: The heat exchanger manufacturer's cost is comprised of 10% engineering, 35% shop labor, 45% material and buy-out items, and 10% profit. The base amount of FTEs would be calculated based on engineering and shop labor. However, all of the material and buy-out items also include a significant labor component and must be included to accurately reflect the total FTEs required to provide the heat exchanger. The major materials for a heat exchange are tubes and plate. The tubes are manufactured from strip material rolled and welded or hollows drawn down in stages to the required size. Furthermore, the strip material and hollows are manufactured in a mill. The same is true for the plate material. In the end, depending upon the alloy, the actual labor hours to fully manufacture the heat exchanger would be between 60% and 70%.

This specific calculation of associated FTEs is based upon an assessment of the labor component included in certain specified manufactured products. In particular, for the specified equipment listed, labor is assumed to be 63% of the total cost and $100,000 was conservatively assumed to be the fully loaded labor cost for one FTE. (To the extent that the fully loaded labor cost were less than $100,000, the number of FTEs could, in fact, be significantly greater than estimated in this Application.) Therefore, the FTEs associated with the major equipment was calculated by multiplying the major equipment suppliers bid price by 0.63 and dividing that result by $100,000. As an example, if the price quoted is $2,000,000 the labor embedded in that cost is calculated as $1,260,000 and the FTE employees is calculated as 12.6. This estimate appears to be reasonably accurate based on discussions with a variety of vendors and subvendors. A particular effort has been made to source equipment and materials from domestic suppliers. Accordingly, with

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

the possible exception of the large electrical switchgear, virtually all equipment will be produced in the United States. The headquarters and manufacturing, fabrication or other facilities for each of the major vendors are detailed in the attached headcount matrix.

- Domestic manufacturing jobs created or preserved in support of this activity will be 341 FTEs. These jobs include the following categories:
  - Designers
  - Machinists
  - Unskilled labor
  - Welders
  - Millwrights
- Domestic construction jobs created or preserved in support of this activity will be 112 FTEs. These jobs include the following categories:
  - Welders
  - Steel Workers
  - Carpenters
  - Mechanics
  - Millwrights
  - Electricians
  - Heavy Equipment Operators
  - Painters
  - Laborers
- Domestic skilled labor jobs created to maintain operation of equipment and infrastructure deployed under this activity include 25 FTEs. These jobs include the following categories:
  - Supervising Engineers
  - Managers
  - Technicians
  - Operators
  - Mechanics

Criterion 2: Project Management and Resources

- The Project is "shovel ready" and Applicant is well positioned and capable of initiating the project expeditiously and initiation of construction activities and equipment procurement within 120 days of award.

  The project development sponsor, Ridgewood Renewable Power is one of the oldest developers, owners and operators of renewable generating projects in the United States. Ridgewood has a long and successful track record of building and redeveloping projects, both domestically and internationally. In particular, Ridgewood, through its affiliates and subsidiaries, built and operated one of the largest portfolios of landfill gas fueled electric generating facilities in the United Kingdom. In addition, Ridgewood's clean energy and infrastructure portfolio has consisted of wood biomass facilities, hydroelectric generating plants, natural gas fired cogeneration facilities

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

and water desalination plants. Ridgewood also has demonstrated capability to raise equity funds. Since inception, Ridgewood's clean energy business raised more than $300 million and, together with its affiliated companies has raised more than $2.5 billion.

- The Applicant has already secured all of the major steps needed to proceed with the Project:
  - A detailed design basis document has been created that sets forth all major technical aspects of the Project and establish the conceptual framework for approaching the Project. A copy of the design basis document is available on request.
  - Applicant's owner's engineer is in the process of preparing the specifications for bidding the construction contract. It is anticipated that the contract will be ready for bid by beginning of the fourth quarter of this year.
  - A final air permit to construct has been received from Rhode Island Department of Environmental Management.
  - The Applicant has bid into the New England Independent System Operator's forward capacity auction and has been selected to sell capacity beginning in mid-2011.
  - The Applicant has identified a credit worthy offtake party and is in exclusive negotiations to secure a long-term power purchase agreement.
  - The Applicant has prepared and filed an interconnection application and the required feasibility and system impact studies have been successfully completed. Detailed engineering work is proceeding for the design and construction of the associated electrical substation and intertie and it is anticipated that a large generator interconnection agreement will be executed in the fourth quarter of this year.
  - The Applicant has completed the conceptual design work for the landfill gas collection system modification and upgrade. Detailed design work is proceeding and, weather permitting, construction could commence within 120 days of the grant award.
  - Equipment specifications for all major equipment have been prepared and indicative bids from major vendors have been solicited and received.
  - A wetlands application has been prepared and submitted. The final wetlands permit is anticipated by 11/1/09.
  - Most major vendors have been selected.
  - Phase I environmental studies have been prepared for all affected sites.
  - Landfill gas rights and site leases and electrical transmission easements have been secured.
  - The generating facility itself is exempt from State Energy Facility Siting Board approval. Siting Board approval may or may not

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

be required in connection with the intertie. A presentation and public hearing have been completed and confirmation from the Siting Board is anticipated shortly.

- The availability of water and sewer service has been confirmed.

- Because of the advanced stage of this Project development, there are no significant implementation barriers or risks that have not already been resolved or mitigated. Given the complexity and challenges of utilizing a waste fuel source like landfill gas, the area of greatest focus has been on the selection of appropriate and adequate gas clean up technologies. Significant research and analysis has been done to evaluate the landfill gas quality and composition and the expected performance of the equipment. Reputable gas treatment companies with proven technologies and the financial strength to provide meaningful performance guarantees have been selected. In addition, redundant systems have been designed to ensure that all problematic constituents will be removed from the gas.
- Application of sound methodology in the Project Management Plan including:
  - Identification of, and criteria for go/no-go decisions
  - Interim milestones
  - Identification of success/failure metrics to enable effective project management. The achievement of schedule milestones related to Permitting, Electrical Interconnection, Major Equipment Procurement and Delivery, Construction, Commissioning and Performance Testing have been selected as the measure of Project success.
- The proposed work and budget has been distributed among the team members in manner intended to maximize the efficient accomplishment of the Statement of Project Objectives (SOPO). Project development tasks have been largely allocated to employees of the Applicant and its affiliates. Where advisable based on technical expertise and/or resource constraints, work and budget have been allocated to Applicant's owner's engineer and various other consulting engineers, lawyers and service providers.
- The roles and contributions of each team member in deployment of the technology are described in detail in the Roles of Participants section below.
- As directed in the grant application instructions, evidence of team's experience and success in similar projects has been submitted as part of the Facility and Other Resource information.
- The suitability of experience and availability of key personnel to complete the proposed project is set forth in the Research and Related Senior/Key Person Profiles. The Project Manager, three key individuals employed by the project development sponsor and three employees of the owner's engineer will have primary responsibility for the Project. These key personnel have all of the skills and ample experience with similar assignments to successfully implement the Project.

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

- Due to the advanced stage of the Project, environmental and other regulatory requirements for the Project have already been addressed or are well underway. A complete list of all environmental and regulatory permits required, together with an identification of the parties responsible for implementation and the current status is attached.

Criterion 3: Energy Benefits -

- The Project will be the second largest landfill gas to electric generation facility in the United States. It will produce sufficient renewable energy to meet the entire Rhode Island renewable portfolio standard for 2009. The design specifications for the Project, as detailed in the design basis document, are as follows:
  - Gross MW: 41.7
  - Net MW: 37.3
  - Gross Heat Rate: 8,231 Btu/KWhr (LHV)
  - Net Heat Rate: 8,378 Btu/KWhr (LHV)
  - Annual MWh: 365,292
  - Electric Efficiency: 45.6%
- The energy savings relative to baseline equipment and infrastructure is based on the productive use of the waste landfill gas that is, or will be flared to atmosphere. This savings is equal to the Btu's consumed by the new combined cycle plant and is 2,733 TBtu/year.[1]
- Because of the size of the Project it was possible to utilize a combined cycle to recover a portion of the waste exhaust heat and thereby maximize the overall efficiency of the technology. Ordinarily, landfill gas projects, which average about 3 MWs, are too small to justify the implementation of a steam bottoming cycle. The 45.6% electrical efficiency of the Project is perhaps the most efficient landfill gas application in the country. The state-of-the-art landfill gas combustion turbine (Solar's Mercury 50) only has an efficiency of 38.5%. While reciprocating engines fueled by landfill gas can have efficiencies in the range of 34%, increasingly stringent air regulations make installation of reciprocating engines difficult, if not impossible, in many jurisdictions. In addition, the power density of combustion turbines was a critical requirement in this application since there was insufficient space at the Central Landfill to permit the installation of reciprocating engines.

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[1] The Applicant currently owns three generation facilities located at the Central Landfill: (1) 12 MW Waukesha reciprocating engine plant; (2) 2.4 MW Deutz reciprocating engine plant; and (3) 6 MW Caterpillar reciprocating engine plant. The Waukesha and Deutz plants are directly in the path of the landfill expansion and must be decommissioned and demolished regardless of the implementation of the Project. In addition, both Deutz engines recently experienced catastrophic failures and are unlikely to be recomissioned. Accordingly, for the purposes of this calculation it has been assumed that the landfill gas that is currently utilized by these plants will be flared in the absence of the Project.

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

- The construction costs of the needed gas collection systems, pretreatment, compression and generating equipment are substantial, but can be cost effective, depending upon the price of energy, capacity and environmental attributes. In particular, the fact that the plant is fueled by waste landfill gas, which would otherwise be flared helps the economics of the Project. In addition, the relatively high energy prices in the ISO-NE region combined with the additional revenue stream associated with the sale of renewable energy credits help to support the economics of the Project.
- In addition to the energy benefits, the environmental benefits are substantial as well. Attached is a summary of the greenhouse gas benefits of the project, using the environmental benefits calculator developed by the landfill methane outreach program (LMOP) of the federal EPA. Landfill gas consists largely of methane, which is a very harmful greenhouse gas. The potential destructive capacity of methane is 22 times worse than CO2. As outlined in the calculation, there are both direct and indirect environmental benefits. The direct benefits are associated with the destruction of the methane, while the indirect benefits are associated with supplanting fossil fuel based electric generation at the emissions produced by the average system mix.

Relevance and Outcomes/Impacts

The objective of the FOA is "to solicit applications for cost-shared projects that will deploy sustainable energy infrastructure projects and energy efficient industrial technologies". Specific to Waste Energy Recovery (Area of Interest 3), is the objective to utilize waste gas that would otherwise be flared in new efficient systems with efficiencies greater than 30%. This Project will result in the construction of a facility with a projected life in excess of 25 yrs, utilizing combustion turbine-combined cycle technology operating at efficiencies greater than 40%. In addition, the construction and operation of this facility will result in the creation of a significant number of short and long term job opportunities, and ultimately producing 40+ MW of renewable energy.

Role of Participants

This application is submitted by a single Applicant, Rhode Island LFG Genco LLC, which will have ultimate responsibility for meeting the requirements of the Project. However, given the scope of the Project and the Applicant's limited internal resources and capabilities, the Applicant will rely on a number of organizations to support its efforts. This section will identify the key organizations that will also participate in the Project and describe the role of each.

- Ridgewood Renewable Power is the project development sponsor. It will be responsible for the executive management level development

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

decisions and for securing the funds required for the Project. In addition, the resources of its affiliates and subsidiaries (e.g. financial analysts, administrative staff, consulting engineers, etc. . .) can be used to supplement the Project requirements.

- Jacobs Engineering is the owner's engineer. It will be responsible for the engineering design, equipment specifications, and preparation of construction documents. In addition, Jacobs will run the bidding process, assist in the selection of construction contractor and provide permitting and regulatory support on an as needed basis.
- Stantec Engineering is the landfill gas collection system consulting engineer. Stantec will be responsible for the design development and equipment specifications for the upgrade of the landfill gas collection system and the associated flares. Stantec will also oversee the construction of the collection system upgrades.
- Energy Initiatives Group provides electrical consulting engineering services associated with interconnecting the generating facility with the local transmission system.
- Vanderweil Engineering will be responsible for the engineering design and construction of the electrical substation and the intertie.
- GZA GeoEnvironmental is the environmental consulting engineer. GZA will be responsible for all environmental permitting, including air, wetlands, storm water permits.
- Major Vendors
    - Solar Turbines will provide the combustion turbine generator sets, including turbine inlet chilling systems.
    - Rentech will provide the heat recovery steam generators, including the integrated selective catalytic reduction systems
    - Merichem will provide a comprehensive sulfur removal gas pretreatment system.
    - domnick hunter will provide a comprehensive siloxane removal gas pretreatment system.
    - John Zink will provide the back-up landfill gas flares as well as the thermal oxidizer required to destroy the off-gases produced by the siloxane removal system.
    - Legal – A variety of law firms provide legal support for the Project depending upon the specific expertise required.
    - Other major vendors have not yet been definitively selected, although a short list of prequalified providers has been completed. These include:
        - Steam turbine generator set
        - Landfill gas compressors
        - Construction contractor

Tab 31

PERMITS REQUIRED FOR: Johnston Combined Cycle LFG Plant

Jacobs Carter Burgess		Document no:	27-00-001
Client:	Ridgewood	Revision:	E
Project:	Area 3:Johnston Combined Cycle LFG Plant	Date:	4/9/2008
Project No:	CB170365	Prepared by:	David Bibayan
		Checked by:	

LAND USE PERMITS

PERMIT	REQUIRED FOR	ISSUED BY	IN SCOPE OF	DUE DATE
Lease Agreement		State of RI (Landfill Owner)	Ridgewood	Completed
Land use permit		Local Municipality	GZA	
Plant Site Licensing	Not required (methane energy exempt project)			-
wetland permit		RIDEM	GZA	In Progress
Transmission line licensing		R. I. Energy Facility siting Board	Ridgewood	Notice of Intent to Construct entered 2/10/09
Pre-application (10%)	Not required by City/State		N/A	-
Master Plan (30%)	Not required by City/State	Through State Fire Marshal to Johnston Fire Marshal	N/A	Before Development of Construction Documents
Preliminary plan (65%)	Not required by City/State		N/A	-
Final plan (100%)	Not required by City/State		N/A	-
Zoning/Special use permit	Not required by City/State		N/A	-
Dimensional variances	Not required by City/State		N/A	-

CONSTRUCTION PERMITS

PERMIT	REQUIRED FOR	ISSUED BY	IN SCOPE OF	DUE DATE
Air Permit	Any above ground work	RIDEM	GZA	Before Construction
Building Permit (mechanical, electrical, structural, Fire Department)	Any On-Site Construction	1. State of RI 2. City of Johnston (coordination)	Jacobs	Before Construction
Electric utility 23kV	Design development	NARRAGANSETT ELECTRIC	EIG	Before Development of Construction Docs
Electric utility 115kV	Design development	New England ISO	EIG	Before Development of Construction Docs
Water Service	Off site U/G work	City of Johnston	GZA	Before Construction
Sewer Service	Off site U/G work	City of Johnston & Cranston	GZA	Before Construction
Stormwater	Design Development	RIDEM	GZA	Before Development of Construction Docs
Telecom Utility	Off site U/G work	Verizon	Jacobs	Before Construction
Natural Gas	Not required	N/A	N/A	
Fire Protection (Including Alarm)	Design development, Hazardous material handling	Through State Fire Marshal to Johnston Fire Marshal	Jacobs	Before Development of Construction Docs
Electrical Interconnection permit	Construction of 115kV tieline	1. Energy Facilities Siting Board 2. Reliability Council of NE ISO	Neil Solomon	Before Construction
Permit for LFG line to cross road	U/G work	Town of Johnston	Jacobs	Before Construction
Permit for 23KV line to cross road	Construction of road crsng	Town of Johnston	Jacobs	Before Construction

Revised 7/13/2009

LANDFILL METHANE OUTREACH PROGRAM

Emission Reductions and Environmental and Energy Benefits for Landfill Gas Energy Projects

For electricity generation projects, enter megawatt (MW) capacity [ ] - OR - For direct-use projects, enter landfill gas utilized by project: [ ] million standard cubic feet per day (mmscfd) or [12,000] standard cubic feet per minute (scfm)

Direct Equivalent Emissions Reduced [Reduction of methane emitted directly from the landfill]		Avoided Equivalent Emissions Reduced [Offset of carbon dioxide from avoiding the use of fossil fuels]		Total Equivalent Emissions Reduced [Total = Direct + Avoided]		
$MMTCO_2E/yr$ million metric tons of carbon dioxide equivalents per year	tons CH_4/yr tons of methane per year	$MMTCO_2E/yr$ million metric tons of carbon dioxide equivalents per year	tons CO_2/yr tons of carbon dioxide per year	$MMTCO_2E/yr$ million metric tons of carbon dioxide equivalents per year	tons CH_4/yr tons of methane per year	tons CO_2/yr tons of carbon dioxide per year
1.2707	66,699	0.1496	164,938	1.4203	66,699	164,938

Equivalent to any one of the following annual benefits: (Direct)		Equivalent to any one of the following annual benefits: (Avoided)		Equivalent to any one of the following annual benefits: (Total)	
Environmental Benefits		Environmental Benefits		Environmental Benefits	
• Annual greenhouse gas emissions from __ passenger vehicles	232,727	• Annual greenhouse gas emissions from __ passenger vehicles:	27,405	• Annual greenhouse gas emissions from __ passenger vehicles:	260,132
• Carbon sequestered annually by __ acres of pine or fir forests	288,793	• Carbon sequestered annually by __ acres of pine or fir forests	34,007	• Carbon sequestered annually by __ acres of pine or fir forests:	322,800
• CO_2 emissions from __ barrels of oil consumed	2 955,091	• CO_2 emissions from __ barrels of oil consumed	347,982	• CO_2 emissions from __ barrels of oil consumed:	3,303,073
• CO_2 emissions from __ gallons of gasoline consumed:	144,232,591	• CO_2 emissions from __ gallons of gasoline consumed:	16,984,343	• CO_2 emissions from __ gallons of gasoline consumed:	161,216,935

View Calculations and References

Energy Benefits (based on project size entered):

• Heating __ homes: 40,783

For additional environmental benefit options, view the Greenhouse Gas Equivalencies Calculator on the EPA Clean Energy Web site.

Calculations and References

Return to Tool

Factors Used in the Calculations:

Conversion Factors

8,760 hours/year
365 days/year
24 hours/day
60 minutes/hour
1E+03 kilowatts/megawatt
2,000 pounds/short ton
0.9072 metric tons/short ton
1E+06 metric tons/million metric tons
1E+06 standard cubic feet/million standard cubic feet

Methane Conversions

0.0423 pounds methane/standard cubic foot methane
0.50 standard cubic feet methane/standard cubic foot landfill gas

Heating Values and Heat Rates

1,012 Btu/standard cubic foot methane [Ref: *Chemical Engineers' Handbook*. John H Perry, ed. McGraw-Hill Book Company: New York, 1963. Pg 9-9.]
1,050 Btu/standard cubic foot natural gas [Ref: *Compilation of Air Pollutant Emission Factors (AP-42)*. US EPA. Volume 1, Fifth Edition. Sept 1985. Appd A, Pg A-6.] http://www.epa.gov/ttn/chief/ap42/appendix/appa.pdf (PDF, 32 pp., 104 KB)
11,700 Btu/kilowatt-hour (weighted average for engines, gas turbines, and boiler/steam turbines)

Emission Factors

1.41 pounds carbon dioxide/kilowatt-hour (estimated average electric power plant emission rate for 2009)
0.12059 pounds carbon dioxide/standard cubic foot natural gas [Ref: *Instructions for Long Form EIA-1605, Voluntary Reporting of GHGs*. US DOE/EIA. May 2005 Appd B.] ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/FormEIA-1605_2004_Instructions.pdf (PDF, 72 pp., 354 KB)

Capacity and Other Factors

0.93 gross capacity factor for generation units of electricity projects (to account for availability and operating load)
0.85 net capacity factor for generation units of electricity projects (to account for availability, operating load, and parasitic losses)
0.91 factor for power delivered to households for electricity projects (to account for transmission and distribution losses)
0.90 gross capacity factor for direct-use projects (to account for availability of landfill gas)

Global Warming Potentials (GWPs)

21 GWP of methane

Tab 31

Calculations and References

Return to Tool

Direct Equivalent Emissions Reduced Calculations for Electricity Generation Projects:
$MMTCO_2E$/yr = megawatts (MW) of generating capacity * 0.93 [gross capacity factor] * (8,760 hours/year) * (1,000 kilowatts/megawatt) * (11,700 Btu/kilowatt-hour) / (1,012 Btu/standard cubic foot methane) * (0.0423 pounds methane/standard cubic foot methane) / (2,000 pounds/short ton) * (0.9072 metric tons/short ton) / (1E+06 metric tons/million metric tons) * 21 [GWP of methane]

tons CH_4/yr = $MMTCO_2E$/yr * (1E+06 metric tons/million metric tons) / (0.9072 metric tons/short ton) / 21 [GWP of methane]

Avoided Equivalent Emissions Reduced Calculations for Electricity Generation Projects:
$MMTCO_2E$/yr = megawatts (MW) of generating capacity * 0.85 [net capacity factor] * (8,760 hours/year) * (1,000 kilowatts/megawatt) * (1.53 pounds carbon dioxide/kilowatt-hour) / (2,000 pounds/short ton) * (0.9072 metric tons/short ton) / (1E+06 metric tons/million metric tons)

tons CO_2/yr = $MMTCO_2E$/yr * (1E+06 metric tons/million metric tons) / (0.9072 metric tons/short ton)

Direct Equivalent Emissions Reduced Calculations for Direct-Use Projects:
$MMTCO_2E$/yr = million standard cubic feet per day (mmscfd) of LFG utilized * (365 days/year) * (1E+06 standard cubic feet/million standard cubic feet) * (0.5 standard cubic feet methane/standard cubic foot landfill gas) * (0.0423 pounds methane/standard cubic foot methane) / (2,000 pounds/short ton) * (0.9072 metric tons/short ton) / (1E+06 metric tons/million metric tons) * 21 [GWP of methane]

tons CH_4/yr = $MMTCO_2E$/yr * (1E+06 metric tons/million metric tons) / (0.9072 metric tons/short ton) / 21 [GWP of methane]

Avoided Equivalent Emissions Reduced Calculations for Direct-Use Projects:
$MMTCO_2E$/yr = million standard cubic feet per day (mmscfd) of LFG utilized * 0.90 [gross capacity factor] * (365 days/year) * (1E+06 standard cubic feet/million standard cubic feet) * (0.5 standard cubic feet methane/standard cubic foot landfill gas) * (1,012 Btu/standard cubic foot methane) / (1,050 Btu/standard cubic foot natural gas) * (0.12059 pounds carbon dioxide/standard cubic foot natural gas) / (2,000 pounds/short ton) * (0.9072 metric tons/short ton) / (1E+06 metric tons/million metric tons)

tons CO_2/yr = $MMTCO_2E$/yr * (1E+06 metric tons/million metric tons) / (0.9072 metric tons/short ton)

Calculations and References

Return to Tool

Environmental and Energy Benefit Equivalencies:		
5.46	metric tons carbon dioxide equivalent per vehicle per year	Environmental factors are from the Greenhouse Gas Equivalencies Calculator on the EPA Clean Energy Web site at http://www.epa.gov/cleanenergy/energy-resources/calculator.html
4.4	metric tons carbon dioxide per acre of pine or fir forests per year	
191.5	metric tons carbon dioxide per railcar of coal	
0.43	metric tons carbon dioxide per barrel of oil	
0.00881	metric tons carbon dioxide per gallon of gasoline	
11,476	kilowatt-hours per household (average annual electricity usage)	
67,075	cubic feet of natural gas per household (average annual household heating usage; transmission and distribution losses considered negligible)	

References

- For passenger vehicles: (1) *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*. U.S. Environmental Protection Agency, Washington, DC. Table 3-7 (p.3-9) http://www.epa.gov/climatechange/emissions/downloads06/07Energy.pdf (PDF, 59 pp., 1.47MB) and Table A-108 (p.A-127). http://www.epa.gov/climatechange/emissions/downloads06/07Annex3.pdf (PDF, 169 pp., 1.27MB)
(2) *Highway Statistics 2005*. Office of Highway Policy Information, Federal Highway Administration. Table VM-1 http://www.fhwa.dot.gov/policy/ohim/hs05/htm/vm1.htm
- For acres of forest.
(1) Nabuurs, G.J. and G.M.J. Mohren. 1995. *Modelling analysis of potential carbon sequestration in selected forest types*. Canadian Journal of Forest Research 25(7):1157-1172.
(2) Shan, J.P., L.A. Morris, and R.L. Hendrick. 2001. *The effects of management on soil and plant carbon sequestration in slash pine plantations*. Journal of Applied Ecology 38(5):932-941.
- For coal, oil, and gasoline: (1) *Inventory of U.S. Greenhouse Gas Emissions and Sinks: Fast Facts 1990-2005. Conversion Factors to Energy Units (Heat Equivalents) Heat Contents and Carbon Content Coefficients of Various Fuel Types*. U.S. Environmental Protection Agency, Washington, DC. USEPA #430-R-07-002. http://www.epa.gov/climatechange/emissions/downloads/2007GHGFastFacts.pdf (PDF, 2 pp., 216K).
(2) *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Intergovernmental Panel on Climate Change, Geneva, Switzerland. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm
- Additional source for coal: (3) Hancock, Kathleen and Sreekanth, Ande. *Conversion of Weight of Freight to Number of Railcars*. Transportation Research Board, Paper 01-2056, 2001.
- For households: *2005 Residential Energy Consumption Survey: Consumption and Expenditures Tables*. US DOE/EIA. Tbls US2 & US3. http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html

Notes: Equations used to estimate the equivalent number of homes heated were corrected in the version updated on 4/17/07 to reflect the impact methane content of LFG has on the offset of natural gas.
In the version updated on 3/14/08, the environmental equivalencies were changed to reflect those in the Greenhouse Gas Equivalencies Calculator on the EPA Clean Energy Web site.

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

Other Selection Factors

1. Optimization of Federal Funds - This application could qualify to receive as much as $49 M based on the required 50% non-federal cost sharing requirement. However, in order to optimize the federal funds available, the Applicant has chosen to provide 85% non-federal cost sharing by limiting the application of federal funds to the payment of selected major equipment (see Project Management Plan-Funding and Costing Profile). It is anticipated that the ability to increase the leverage on the federal funds deployed should enhance the attractiveness of this application.
2. Omitted
3. Diversity of Technologies - This Project represents a unique technology application that enhances its attractiveness for receiving a federal grant. First, due to the fact that it is ten times larger than the average landfill gas-to-electricity facility in the United States, waste heat recovery units will be deployed to maximize the productive use of the landfill gas that would otherwise be flared. Second, the Project will be a cutting edge application of post combustion emissions treatment (i.e. selective catalytic reduction) on landfill gas turbines. The successful demonstration of this technology will establish a new national standard for best available control technology and, accordingly, will dramatically further the EPA's goals of improving air quality.
4. ARRA 2009 Application Review Information Criteria - This application promotes and enhances the objectives of the ARRA 2009, especially recovery in an expeditious manner by promoting economic recovery, assisting those most impacted by the recession, and stabilizing key state budgets. In particular, Rhode Island has been one of the states most adversely impacted by the recession. Its unemployment rate of well over 10% is one of the highest in the country and it is facing a budget deficit of many hundreds of millions of dollars. The $15 million that Applicant will invest in this Project and the associated jobs will ameliorate the current adverse economic circumstances. In addition, the Project will also have substantial benefits for the California economy since the prime movers will be manufactured by Solar Turbines in its San Diego facilities. California's state deficit is the largest in the country. Targeting the creation or retention of manufacturing jobs in California will advance the key objectives of ARRA 2009.

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

Identification of Potential Conflicts of Interest or Bias in Selection of Reviewers Appendix

Collaborators and Co-editors
N/A

Graduate and Postdoctoral Advisors and Advisees
N/A

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

Bibliography & References Cited Appendix

N/A

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

Facilities & Other Resources Appendix

Participant Experience

Ridgewood Renewable Power (www.ridgewoodrenewablepower.com)
Jacobs Engineering (See Attached) (www.jacobs.com)
Stantec Engineering (www.stantec.com)
Energy Initiatives Group (EIG) (www.eig-llc.com)
Vanderweil Engineering (www.vanderweil.com)
GZA GeoEnvironmental (www.gza.com)

Vendor Experience

Solar Turbines
The Taurus 60 gas turbine is a proven product with 1540 units in service worldwide. For landfill gas applications, the turbine is guaranteed to achieve low emission levels which typically meet BACT levels in the United States. The Taurus 60 is packaged on a standard frame with standardized components to ensure maintainability and typically resulting in very high levels of availability. Solar has provided 101 turbines for landfill applications 28 of which were Taurus 60 models.

Qty	Model	EndUser	Site
1	Taurus60	Colari	Roma
1	Taurus60	SAIOD	Colombier
1	Taurus60	Air Products	Monmouth Landfill
1	Taurus60	Air Products	Monmouth Landfill
1	Taurus60	Middlesex County Generating Company	Sayreville
1	Taurus60	Middlesex County Generating Company	Sayreville
1	Taurus60	Colari	Rome
1	Taurus60	NEO Corporation	Bkk Landfill

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

1	Taurus60	BFI Charlotte	Charlotte
1	Taurus60	BFI Fall River	Fall River
1	Taurus60	BFI	Zion Landfill
2	Taurus60	Fort Worth Water Department	Fort Worth
3	Taurus60	Network Electric Company	Pontiac
3	Taurus60	Network Electric Company	Hillsdale/congress
1	Taurus60	Network Electric Company	Beecher
1	Taurus60	Pepco	Boyerstown
1	Taurus60	Santee Cooper	Richland
1	Taurus60	Santee Cooper	Anderson
1	Taurus60	City of Toledo	Toledo
2	Taurus60	CES Landfill	CES Landfill
1	Taurus60	BMW Manufacturing	Spartanburg
1	Taurus60	BMW Manufacturing	Spartanburg
1	Saturn20	Klarwerk Leipzig	Leipzig
1	Saturn10	Waste Management	Settler Hill
1	Saturn10	Santa Cruz Landfill	Santa Cruz
1	Saturn10	Land & Development Company	Mt Holly
2	Saturn10	Cat Capital Company	San Marcos Landfill
2	Saturn10	Cat Capital Company	Sycamore Canyon
3	Mercury50	Los Angeles County Sanitation	Calabasas Landfill
2	Mercury50	Ameresco Inc.	Chiquita Canyon
1	Mercury50	DTE Energy	Sunshine Canyon Landfill
2	Mercury50	PEI Power	PEI Power
1	Mercury50	East Bay MUD	EBMUD

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

3	Mars90	LA County Sanitation	Carson
1	Mars100	Routiere de L Est Parisien	Claye Souilly
2	Mars100	Klickitat PUD	HW Landfill
1	Centaur50	Acheres V	Archeres
1	Centaur50	ISKI Waste Water Ruzia Plant	ISKI Waste Water Ruzia Plant
1	Centaur50	ISKI Waste Water Ruzia Plant	ISKI Waste Water Ruzia Plant
1	Centaur50	S.I.A.A.P.	Acheres
1	Centaur50	S.I.A.A.P.	Acheres
1	Centaur50	ISKI Atakoy	ISKI Waste Water Atakoy Plant
1	Centaur50	ISKI Atakoy	ISKI Waste Water Atakoy Plant
1	Centaur40	LA County Sanitation	Puente Hills
3	Centaur40	Waste Management	Milwaukee
3	Centaur40	Waste Management	Grows/wdlnd
2	Centaur40	Riverview Enrgy Part	Riverview
1	Centaur40	Kapaa Energy Partners	Kailua Oahu
1	Centaur40	Waste Management	Lewisville
1	Centaur40	Cat Generating Partners	Goshen Ny
2	Centaur40	Waste Management	Lake Lndfill
2	Centaur40	Waste Management	Altmont Pass
1	Centaur40	Waste Management	Settler Hill
1	Centaur40	Waste Management	Omega Hills
3	Centaur40	Waste Management	Calumet City
1	Centaur40	Land & Development Company	Mt Holly

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

1	Centaur40	Waste Management	Pottstown
5	Centaur40	Waste Management	Florida
1	Centaur40	Holsteiner Gas	Hamburg
1	Centaur40	County Of Winnebago	Oshkosh
1	Centaur40	Sca Services Of Pennsylvania	Pottstown
1	Centaur40	New Milford Landfill	New Milford
1	Centaur40	Waste Management	Lake Recycling Fac
1	Centaur40	Dortmunder Stadtwerke	Dortmund
1	Centaur40	DFW Recycling	Lewisville
1	Centaur40	Greene Valley Landfill	Woodridge
1	Centaur40	Greene Valley Landfill	Woodridge
1	Centaur40	Waste Management	Rochester
1	Centaur40	Rust E&i	Green Valley
2	Centaur40	Metro Waste Water Treatment	Denver
1	Centaur40	SC Johnson	Racine
1	Centaur40	Laurel Highlands Landfill Energy Ctr	Somerset

Rentech HRSG

Rentech is a well renowned name in package boiler and HRSG manufacturing. Of the 56 successful HRSG projects, 54 were with Solar Turbines. One project is a landfill gas project. In addition, another landfill gas HRSG is in fabrication and scheduled for delivery the 4th quarter of this year.

User Location	Purchaser Location	Rated HRSG Capacity – lb/hr	Design Pressure - PSI	Gas Turbine Model	Application

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

City of Toledo – Toledo, OH	Solar Turbines – San Diego, CA	77,000	650	Solar Taurus 60	Waterwall Boiler, Economizer, Feedwater Heater, Gas Duct Burner, Fresh Air Firing System

Vilter Manufacturing LLC
Vilter is the one of the best gas compressors manufactured in the world. Below is a list of 112 compressors provided by Vilter for Landfill projects. This list does not include project where others purchased Vilter compressors as part of their compressor system for landfill gas projects.

QTY	MODEL	CUSTOMER	LOCATION
1	VSG-361	A&B Enviromental	Emerald, WI
2	VSG-1801	Air Products (D-R)	New Jersey
2	VSG-1801	Ameresco - Mccarty	Houston, TX
2	VSG-2101	Ameresco - Chiquita Canyon	Valencia, CA
1	VSG-1201 Bare	City of Fresno	Fresno, CA
1	VSG-301	Cryofuel Systems	Monroe, WA
1	VSG-361	Cryofuel Systems	Monroe, WA
1	VSG-751	Cryofuel Systems	Monroe, WA
2	VSG-751	Cryofuel Systems	Monroe, WA
1	VSG-1501	Cryofuel Systems	Sultan, WA
1	VSG-601	Cryofuel Systems	Sultan, WA
1	VSG-1051	Cryofuel Systems Inc	Sultan, WA
2	VSG-401	Cryofuel Systems Inc	Sultan, WA
1	VSG-1501 Bare	David H. Johnson/DTE/Honeywell	Hopewell, VA
1	VSG-1801	Energy Systems Group	Johnson City, TN
1	VSG 1801 Reman	Energy Systems Group	Kingsport, TN
5	VSG-1201	Energy Systems Group	Johnson City, TN
5	VSG-2101, (2)VSSG451	Energy Systems Group	Conley, GA
1	VSSG 601 - Bare	Exterran Energy Solutions	Oak Hill, WV
8	VSG-1201	Four Hills Landfill	Nashua, NH
6	VSG-1801	Johnstown Regional	Caimbrooke, PA

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

2	VSG-301	Johnstown Regional	Caimbrooke, PA
1	VSG-1801 Bare	Johnstown Regional	Caimbrooke, PA
6	VSG-1801	Keystone	Pensylvania
3	VSG-1801	Merichem-Gas Technologies	GTP/Chevron
8	VSG-2101, (6) VSG-751,	Merichem-Gas Technologies	Washington
2	VSSG 341, (1) VSG 1801	Merichem-Gas Technologies	Washington
8	VSG 1801	Phase 3 Development	Sioux Center, IA
2	VSG-451	Phase 3 Development	Sioux Center, IA
1	VSG-301	Phase 3 Development	Hilarides, IA
3	VSG 1801 (1)VSSG341	Renewable Solutions Group	Winder, GA
1	VSG-1501	SEECO - Colorado	Colorado
1	VSG-1801	SEECO - Oklahoma Landfill	Oklahoma City, OK
1	VSG-1501	SEECO	Ventura, CA
1	VSG-401	SEECO	Turlock, CA
4	VSG-1201	Waste Management	Chicago, IL
1	VSG-1201	Waste Management	Dallas, TX
1	VSG-1201 / Roots Blower	Waste Management	Milw, WI
1	VSG 1201 - Rebuild	Waste Management	Northbrook, IL
4	VSG 1851	Waste Management	Virginia
4	VSG 1851	Waste Management	Pensylvania
6	VSG 601 & 2101	LA County	California
1	VSG 751	LA County	California
4	VSG 2101 & 451	Keystone	New Orleans

Merichem

Merichem is a proven supplier of gas treatment systems. They have over 160 systems in operation for multiple types of treatments and processes such as natural gas, acid gas in a refinery, amine gas, coal gas, biogas, carbon dioxide, Syngas, nitrogen and well head gas. The following four systems are landfill gas projects.

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

Company	Application Information	Plant Performance
New Jersey **Landfill** S/U October 2006	Landfill Gas 3.13 MMSCFD 8,500 ppmv H2S 36.8 vol% CO2 1.0 psig	1.0 LT/D < 170 ppmv outlet H2S 98.0% H2S removal efficiency
Delaware **Landfill** S/U Dec 2006	Landfill Gas 12.96 MMSCFD 2,000 ppmv H2S 36.8 vol% CO2 2.0 psig	1.0 LT/D < 20 ppmv outlet H2S 99.0% H2S removal efficiency
Florida **Landfill** S/U January 2003	Landfill Gas 13.2 MMSCFD 3.325 vol% H2S 40.0 vol% CO2 12.0 psig	10.83 LT/D < 50 ppmv outlet H2S 99.85% H2S removal efficiency
Florida **Landfill** S/U June, 1994	Landfill Gas 13.2 MMSCFD 0.5 vol% H2S 50.0 vol% CO2 12.0 psig	2.5 LT/D < 50 ppmv outlet H2S 99.0% H2S removal efficiency

Dresser-Rand

The Dresser-Rand organization as a whole has produced tens of thousands steam turbines worldwide, attached is a list of steam turbine generator sets specifically between 8,000 and 20,000 KW produced by the Burlington plant. It's estimated this particular plant has built 4,000 plus turbines since starting in 1927.

KW	Final User	Location
9,250	DEXZEL COGENERATION	OILDALE CA US
13,000	SERAM PLYWOOD	SERAM . ID
10,000	BROWNING FERRIS GAS	NORTHVILLE MI US
10,000	BROWNING FERRIS GAS	MALLARD LAKE IL US
9,713	GENERATOR UNIVERSITY OF WI	MADISON WI US
9,133	GENERATOR UNIVERSITY OF NOTRE DAME	NOTRE DAME IN US
9,421	GENERATOR GAMA	TR
8,964	GENERATOR MILLER BREWING COMPANY	TRENTON OH US
12,500	GENERATOR UNIVERSITY OF ILLINOIS	CHAMPAIGN IL US
12,500	GENERATOR UNIVERSITY OF ILLINOIS	CHAMPAIGN IL US
9,207	GENERATOR IBERESE EXTRAGOL	MALAGA . ES
8,163	GENERATOR SIEBERDEEN VILLACANAS	VILLACANAS . ES

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

15,000	GENERATOR IOWA STATE UNIVERSITY	AMES IA US
12,000	GENERATOR JIANGXI COPPER COMPANY	JIANGXI . CN
18,222	GENERATOR UNIVERSITY OF ROCHESTER	ROCHESTER NY US
12,835	GENERATOR AREVA	BZ
9,362	GENERATOR PERTAMINA UPV	BALIKPAPAN ID
12,832	GENERATOR AREVA	BZ
12,995	GENERATOR AREVA .	BZ
12,995	GENERATOR AREVA	BZ
12,995	GENERATOR AREVA .	BZ
12,995	GENERATOR AREVA .	BZ
9,560	GENERATOR HULUDAO NON FERROUS	HULUDAO CITY . CN
11,415	GENERATOR PT PERTAMINA	SUMATRA . ID
9,341	GENERATOR HONEYWELL	HAMILTON OH US
9,341	GENERATOR HONEYWELL	HAMILTON OH US
14,200	GENERATOR PALMET DELTA	ENERJI KIRKLARELI . TR
10,722	GENERATOR AKSA MANISA POWER	MANISA . TR
9,167	GENERATOR YUNNAN TIN COMPANY	GEIJU CITY, . CN
10,499	GENERATOR YOUNG POONG	SEOUL . KR

Waukesha

Waukesha® Transformers are synonymous with quality and reliability and are manufactured at the company's modern transformer plants in Waukesha, WI and Goldsboro, NC according to the latest ISO 9001:2000 quality system standards.

The company's U.S. manufacturing operations utilize sophisticated computer-controlled equipment and test systems complemented by a well-trained, experienced work force to produce high quality power transformers that meet stringent customer requirements. The list below of 94 transformers reflects just transformers that Waukesha has provided over 70 MVA.

CUSTOMER NAME	UNIT MVA
ASSOCIATED ELECTRIC COOPERATIVE, INC.	80 / 106.67 / 133.33
E.ON CLIMATE & RENEWABLES NA INC.	84 / 112 / 140
WE ENERGIES	105 / 140 / 175
EL PASO ELECTRIC CO.	155 / 206.67 / 258.33
BRUNSWICK ELECTRIC MEMBERSHIP CORP.	75 / 100 / 125
THIRD PLANET WINDPOWER	90 / 120 / 150
OVERTON POWER DISTRICT NO. 5	120 / 160 / 200
ONCOR ELECTRIC DELIVERY CO ., LLC	90 / 120 / 150
AMEREN UE	84 / 112 / 140
PIONEER PRAIRIE WIND FARM I LLC	72 / 96 / 120
NIAGARA MOHAWK POWER CORP	75 / 100 / 125
BASIN ELECTRIC POWER COOPERATIVE	90 / 119.7 / 150.3
FIRSTLIGHT POWER RESOURCES INC.	100 / 133.33 / 166.67

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

MORENCI WATER & LIGHT	120 / 160 / 200
WOLVERINE POWER SUPPLY COOPERATIVE, INC.	90 / 120 / 150
INTERMOUNTAIN REA	90 / 120 / 150
AES WIND GENERATION, INC.	111 / 148 / 185
IDAHO POWER CO	180 / 240 / 300
IDAHO POWER CO	180 / 240 / 300
PLATTE RIVER POWER AUTHORITY	114 / 152 / 190
ELECTRICAL DISTRICT #2	90 / 120 / 150
WE ENERGIES	105 / 140 / 175
GILA RIVER INDIAN COMMUNITY UTILITY AUTHORITY	90 / 120 / 150
SOUTHWEST TRANSMISSION COOP.	75 / 100 / 125
COLORADO SPRINGS UTILITIES	79.8 / 106.4 / 133
CITY OF COLUMBIA	90 / 120 / 150
MIDWEST ENERGY INC.	100 / 133.33 / 166.67
INTERMOUNTAIN REA	120 / 160 / 200
GLOBAL ENERGY SERVICES, USA, INC.	76 / 101.33 / 126.67
BLUE RIDGE MOUNTAIN EMC	75 / 100 / 125
BLUE RIDGE MOUNTAIN EMC	75 / 100 / 125
AES WIND GENERATION, INC.	75 / 100 / 125
AES WIND GENERATION, INC.	75 / 100 / 125
PUBLIC SERVICE CO. OF NEW MEXICO	100 / 133.33 / 166.67
MIDAMERICAN ENERGY	72 / 96 / 120
MIDAMERICAN ENERGY	72 / 96 / 120
MIDAMERICAN ENERGY	72 / 96 / 120
MIDAMERICAN ENERGY	72 / 96 / 120
MIDAMERICAN ENERGY	72 / 96 / 120
MIDAMERICAN ENERGY	72 / 96 / 120
ARCHER DANIELS MIDLAND CO. - CEDAR RAPIDS	72 / 96 / 120
MIDAMERICAN ENERGY	75 / 100 / 125
SOUTHWEST TRANSMISSION COOP.	75 / 100 / 125
PROGRESS ENERGY (FLORIDA)	90 / 120 / 150
PLATTE RIVER POWER AUTHORITY	100 / 133.33 / 166.67
PLATTE RIVER POWER AUTHORITY	100 / 133.33 / 166.67
PLATTE RIVER POWER AUTHORITY	100 / 133.33 / 166.67
PLATTE RIVER POWER AUTHORITY	100 / 133.33 / 166.67
PLATTE RIVER POWER AUTHORITY	100 / 133.33 / 166.67
ALLIANT ENERGY - INTERSTATE POWER AND LIGHT CO.	100 / 0 / 0
AMEREN UE	77.4 / 103.2 / 129
AMEREN UE	77.4 / 103.2 / 129
POWER SYSTEMS DEVELOPMENT	90 / 120 / 150
MCKINLEY SALES COMPANY, INC.	120 / 160 / 200
TIC - THE INDUSTRIAL COMPANY	72 / 96 / 120
TRC ENGINEERING, INC.	96 / 128 / 160
TRC ENGINEERING, INC.	96 / 128 / 160
AMES MUNICIPAL ELECTRIC SYSTEM	100 / 133.33 / 166.67

Area 3: Johnston Rhode Island Combined Cycle Electric Generating Plant Fueled By Waste Landfill Gas

AMES MUNICIPAL ELECTRIC SYSTEM	100 / 133.33 / 166.67
JOHNSON CITY POWER BOARD	75 / 100 / 125
JOHNSON CITY POWER BOARD	75 / 100 / 125
POWER SYSTEMS DEVELOPMENT	75 / 100 / 125
ONCOR ELECTRIC DELIVERY CO ., LLC	90 / 120 / 150
JEA	78 / 104 / 130
JEA	105 / 140 / 175
JEA	78 / 104 / 130
GREAT RIVER ENERGY	84 / 112 / 140
GREAT RIVER ENERGY	84 / 112 / 140
GREAT RIVER ENERGY	84 / 112 / 140
MIDAMERICAN ENERGY	75 / 100 / 125
BRUNSWICK ELECTRIC MEMBERSHIP CORP.	75 / 100 / 125
BRUNSWICK ELECTRIC MEMBERSHIP CORP.	75 / 100 / 125
CALPINE - CONSTRUCTION MANAGEMENT GROUP	72 / 96 / 120
ENTERGY SERVICES INC	90 / 120 / 150
EXXONMOBIL CORPORATION	94 / 125.33 / 156.67
XCEL ENERGY	171 / 228 / 0
EXELON GENERATION	100 / 133.33 / 166.67
EXELON CORPORATION/PECO	120 / 160 / 200
OMAHA PUBLIC POWER DISTRICT	72 / 96 / 120
ALLEGHENY ENERGY	75 / 100 / 125
ALLEGHENY ENERGY	75 / 100 / 125
ALLEGHENY ENERGY	75 / 100 / 125
ALLEGHENY ENERGY	75 / 100 / 125
WILLIAMS ENERGY	70 / 93.33 / 116.67
EXELON GENERATION	72 / 96 / 120
EXELON GENERATION	72 / 96 / 120
EXELON GENERATION	72 / 96 / 120
EXELON GENERATION	72 / 96 / 120
MONTANA-DAKOTA UTILITIES CO.	90 / 120 / 150
MONTANA-DAKOTA UTILITIES CO.	90 / 120 / 150
VECTREN ENERGY DELIVERY OF INDIANA	77.7 / 103.6 / 0
SOUTH RIVER ELEC MEMBERSHIP CORP.	75 / 100 / 125
AIR LIQUIDE AMERICA CORPORATION	80 / 106.7 / 0

BIO-GAS
POWER GENERATION PROJECTS

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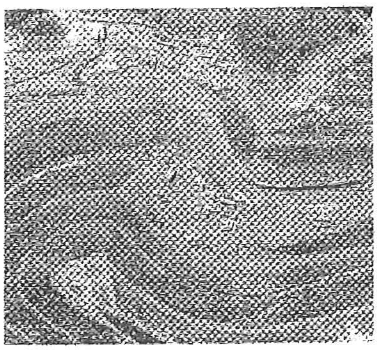
Calabasas Gas-to-Energy Project
Calabasas, California



Completion Date: 2009
Cost: $30,000,000

Jacobs is responsible for providing project management support, front-end engineering and detailed design services, technical procurement support, construction administration, inspection, startup, commissioning and testing services for a new 13 MW simple cycle Gas-To-Energy power facility for Los Angeles County Sanitation District.

The system is designed to provide renewable electricity to the California ISO grid via SCE transmission system. The project scope also includes coordination with landfill operations, site grading and storm water management permitting; air permitting compliance; natural gas/landfill gas blending, flare design and utility interconnections; siloxane removal system selection and landfill gas compression; and overall supervision of technical permitting issues to insure commercial operation in winter 2009.

The equipment configuration includes:

- **Three Solar Mercury 50 combustion gas turbine generators (CTG)** generators rated at 4.5 MW.
- **The project is fired on up to 100% landfill gas** and includes gas cleanup and compression with natural gas blending up to 25%.
- Electrical switchgear and utility interconnection including a new step-up transformer, medium and low voltage motor control centers.
- Complete plant control system (PCS) design.
- New plant control/electrical equipment building.
- Complete interconnection and installation of process piping inside the plant and tie-ins to existing service utilities for condensate, natural gas, landfill gas, water and sewer.

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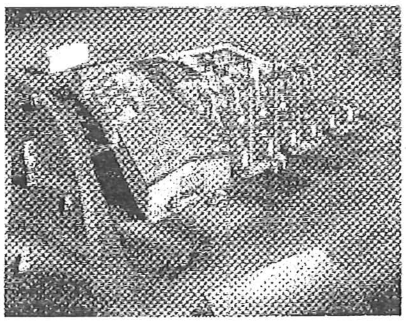

Completion Date: 2010
Cost: $80.000.000

Rhode Island LFG GENCO Project
Johnston, Rhode Island

Jacobs is responsible for providing all engineering and detailed design services, air emissions permit support, major equipment procurement, construction management, general contractor services, inspection, startup, commissioning and testing services for a new 46 MW combined cycle power facility for Rhode Island LFG GENCO at the Landfill in Johnston, Rhode Island.

The system is designed to provide renewable electricity to the National Grid system. The project scope also includes site selection; coordination with landfill operations, site grading and storm water management permitting; cycle optimization and selection including combined-cycle; air permitting and provision for SCR/CEMs system selection to meet air quality requirements; landfill gas, flare and utility interconnections; siloxane removal system selection; and overall supervision of technical and permitting issues to insure commercial operation in summer 2010.

The equipment configuration includes:

- **Six Solar Taurus 60 combustion gas turbine generators (CTG)** generators rated at 5.5 MW.
- Single pressure heat recovery steam generators (HRSG) capable of producing a combined capacity of 160,000 lbs/hr of steam at 350 psig, 550°F.
- Aqueous ammonia based selective catalyst reduction (SCR) system to reduce emissions.
- **The project is fired on 100% landfill gas and includes gas cleanup and compression.**
- One 13 MW condensing steam turbine generator (STG).
- One steam condenser with air extraction and hotwell pump package.
- Electrical equipment including a new step-up transformer, plant switchgear, medium and low voltage motor control centers.
- The complete compliance with State of Rhode Island Department of Environmental Management requirements.
- Complete interconnection and installation of process piping inside the plant and tie-ins to existing service utilities for condensate, landfill, water, and gas sewer.

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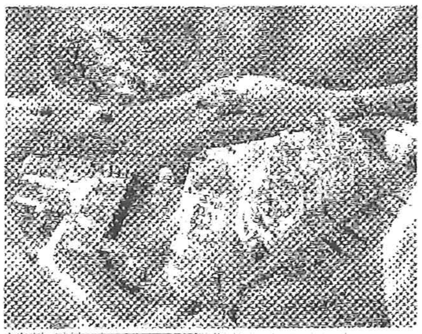
Olinda Renewable Power Project
Brea, California



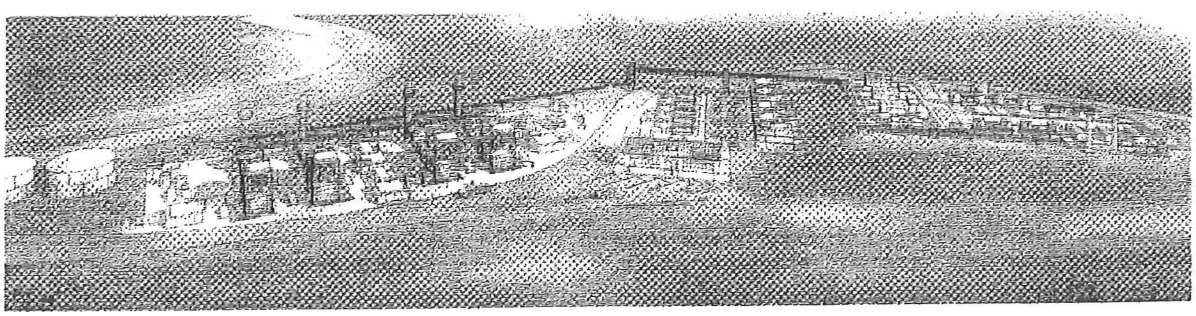
Completion Date: 2010
Cost: $52,000,000

Jacobs is responsible for providing all engineering and detailed design services, air emissions permit support, major equipment procurement, construction management, general contract services, inspection, startup, commissioning and testing services for a new 37 MW combined cycle power facility for Ridgewood Renewable Power at the Olinda Landfill in Brea, California.

The system is designed to provide renewable electricity to the City of Anaheim via SCE transmission system. The project scope also includes site selection; coordination with landfill operations, site grading and storm water management permitting; cycle optimization and selection including combined-cycle; air permitting and provision for SCR/CEMs system selection to meet SCAQMD requirements; landfill gas, flare and utility interconnections; siloxane removal system selection; and overall supervision of technical and permitting issues to insure commercial operation in summer 2010.

The equipment configuration includes:

- **Five Solar Taurus 60 combustion gas turbine generators (CTG)** generators rated at 5.6 MW at ISO.
- Single pressure heat recovery steam generators (HRSG) capable of producing a combined capacity of **110,000** lbs/hr of steam at 250 psig, 408°F.
- **The project is fired on 100% landfill gas and includes gas cleanup and compression.**
- One 8.5 MW condensing steam turbine generator (STG) .
- One steam condenser with air extraction and hotwell pump package.
- Electrical equipment including a new step-up transformer, plant switchgear, medium and low voltage motor control centers.
- The complete compliance with Southern California Air Quality Management District (SCAQMD) requirements.
- Complete interconnection and installation of process piping inside the plant and tie-ins to existing service utilities for condensate, landfill, water, and gas sewer.



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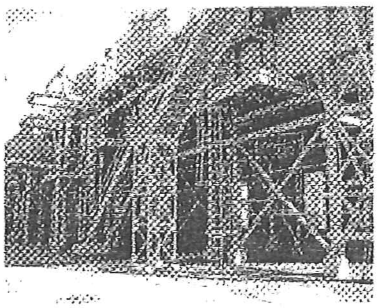
Carson Repower Project
Carson, California



Completion Date: 2009
Cost: $35,000,000

Jacobs is responsible for providing as-built of the existing plant, detailed engineering and design, technical procurement support, construction administration, startup, commissioning and testing support services for the removal, retrofit and replacement of the 40 MW combined-cycle cogeneration system at the Joint Water Pollution Control Plant in Carson, California for Los Angeles County Sanitation District.

The system will replace an existing HRSG/STG package with all associated balance of plant equipment. The new system is designed to provide electricity to the sanitary waste water treatment facility and the steam to the plant digesters.

The scope includes the preliminary layout of equipment and a cost estimate to confirm the project's viability and the detailed engineering for mechanical and civil structural, FEED engineering, procurement support, and construction, commissioning and startup support services necessary for the installation of new equipment in existing buildings along with necessary building modifications.

The equipment configuration includes:

- **Three Solar Mars 100S combustion gas turbine generators (CTG)** rated at 10.0 MW each equipped with water injection combustion system and an inlet air evaporative cooler.
- Three single pressure heat recovery steam generators (HRSG) capable of producing 34,000 lbs/hr of 460 psig, 750°F super heated steam.
- **The project is fired on 100% digester gas and includes Siloxane gas cleanup.**
- One 10 MW condensing steam turbine generator (STG) with an extraction port for low pressure steam to meet plant demands.
- One steam condenser with air extraction and hotwell pump package.
- Electrical gear including a new step-up transformer, medium and low voltage motor control centers and a new blackstart emergency diesel generator
- Connection to the existing plant control system and necessary modifications to the continuous emissions monitoring system (CEMS) in compliance with Southern California Air Quality Management District (SCAQMD) requirements.
- Complete interconnection and installation of process piping inside the existing buildings and tie-ins to existing service for condensate, feedwater, steam, fuel gas and compressed are services.

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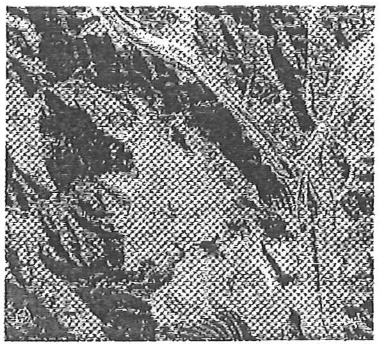
Sunshine Canyon Renewable Power Project
Sylmar, California



Completion Date: 2008
Est. Cost: $46,000,000

Jacobs is responsible for providing owners engineering and preliminary design services, air emissions permit support, major equipment procurement, construction management, inspection, startup, commissioning and testing services for a new 23 MW simple cycle power facility for DTE Biomass Energy at the Sunshine Canyon in Sylmar, California.

The system is designed to provide renewable electricity to the ISO SCE transmission system. The project scope also includes site selection; coordination with landfill operation, site grading and storm water management permitting; air permitting and CEMs system selection to meet SCAQMD requirements; natural gas, landfill gas, flare and municipal utility interconnections; siloxane removal system selection; and overall supervision of technical and permitting issues to insure commercial operation in summer 2010.

The equipment configuration includes:

- **Five Mercury 50 combustion gas turbine generators (CTG)** turbine generators rated at 4.67 MW.
- The project is fired on up to 100% landfill gas and includes gas cleanup and compression.
- Electrical gear including a new step-up transformer, medium and low voltage motor control centers.
- The continuous emissions monitoring system (CEMS) in compliance with Southern California Air Quality Management District (SCAQMD) requirements.
- Complete interconnection and installation of process piping inside the plant and tie-ins to existing service utilities for condensate, feedwater, steam, fuel gas and compressed air services.

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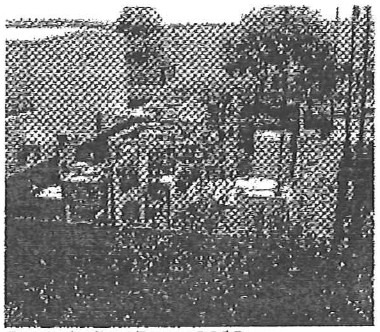

Completion Date: 2006
Cost: $4,000,000

Otay Gas-to-Energy Project
Chula Vista, California

Jacobs is responsible for providing preliminary engineering and detailed engineering, air emissions permit support, technical procurement support, construction support, startup, commissioning and testing support services for a retrofit 3.5 MW gas engine generator relocation for Covanta Energy at the San Diego County Landfill near Chula Vista, California.

The system will expand an existing 3.4 MW plant to 6.9 MW. The system is designed to provide renewable electricity to the SDG&E Utility distribution system.

The scope includes the preliminary layout of equipment and a cost estimate to confirm the project's viability and the detailed engineering, procurement support, and construction, commissioning and startup support services necessary for the installation of new equipment in existing buildings along with necessary building modifications.

The equipment configuration includes:

- Two 1,750 kW gas engine generators fired on 100% landfill gas.
- New power generator building and bridge crane.
- Electrical gear including a new step-up transformer, medium and low voltage motor control centers.
- One new reciprocating fuel gas compressor to provide 375 psig gas service to the CTG.
- Connection to and expansion of the existing plant control system and necessary modifications to the continuous emissions monitoring system (CEMS) in compliance with San Diego Air Pollution Control District (SDAPCD) requirements.
- Complete interconnection and installation of process piping inside the existing buildings and tie-ins to existing services for condensate, feedwater, steam, fuel gas and compressed air services.
- Modifications to existing buildings to accommodate the new equipment configuration.

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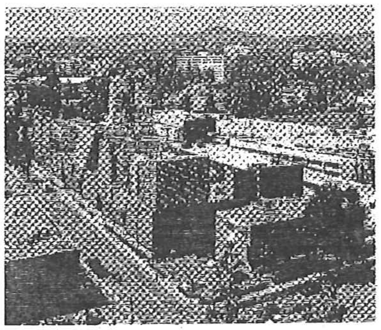
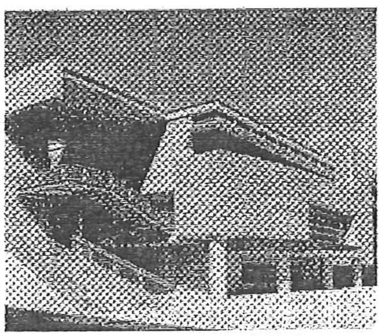
UCLA Cogeneration & Chiller System Expansion
Los Angeles, California





Completion Date: 2001/2002
Cost: $13,000,000

Jacobs is responsible for providing engineering services for the expansion of the campus district energy system at the University of California, Los Angeles. The three projects include adding 10,000 tons of cooling towers with associated downcomer and pumps; an underground concrete, 30,000 ton-hour thermal energy storage (TES) tank; and conversion of the anhydrous ammonia system to Urea. **Jacobs was selected because key project management and engineering staff served on the original plant design/construction team.**

The new system configuration includes:

- Three 9,580 gpm, induced draft, fiberglass, field erected cooling towers.
- Two 13,920 gpm 100 ft. horizontal split case circulating water pumps.
- Upgrade and conversion of the Fisher-Provox distributed control system (DCS) to a Delta V system.
- Cast-in-place concrete, 5.2 million gallon, 72 ft. deep chilled water storage tank co-developed as the basement of a new auditorium building.
- Complete interconnecting process piping, electrical and controls inside the existing central plant.
- Install new Urea-based ammonia system for NOx control on the two CTG's to replace existing anhydrous system.

This expansion project provides additional power and chilled water capacity to the original $155 million district energy system. The system includes 43 MW of combined cycle cogeneration; 360,000 lbs/hr of steam production; 32,000 tons of steam, electric and absorption chillers; 270,000 sq. ft. of office and shop space; 2.5 miles of new chilled water and high temperature heating distribution piping; and interconnection to 17 buildings and 3 major medical hospitals. **The cogeneration system is fired on 30% landfill gas.** The electrical distribution system features a new, state-of-the-art, SF6 switchgear substation and a complete reconfiguration of the campus underground electrical

The plant was selected as the *International District Energy Association (IDEA)* "System of the Year" in 1998.

EQUIPMENT APPENDIX

Jacobs:	Power and Energy Group	Document no:	H/J/01-1/GENERAL/DOE/JOHNSTON/EQ APP
Client:	Ridgewood Renewable Power	Revision:	A
Project:	Johnston Combined Cycle LFG	Date:	6/30/2009
Project No:	CB170365	Prepared by:	Jesus Cuchet
		Checked by:	David Bibayan

Equipment	Proposed Supplier	Quantity	Equipment Cost	Total Cost
CTG Solar Taurus 60	Solar	5	$ 2,894,349	$ 14,471,745
Fuel Gas Compressor	Vilter	Package	$ 4,313,457	$ 4,313,457
HRSG	Rentech	5	$ 1,470,621	$ 7,353,104
Steam Turbine Generator	Dresser-Rand	1	$ 4,211,014	$ 4,211,014
LO-CAT H2S Removal (Note 1)	Merichem	Package	$ 4,321,000	$ 4,321,000
Step-up Transformer	Waukesha	1	$ 1,132,860	$ 1,132,860
			TOTAL	35,803,180

Notes:

1. Cost of H2S Removal by Merichem includes $ 4,321,000 for a single train without any redundant equipment. Equipment redundancy to be evaluated.