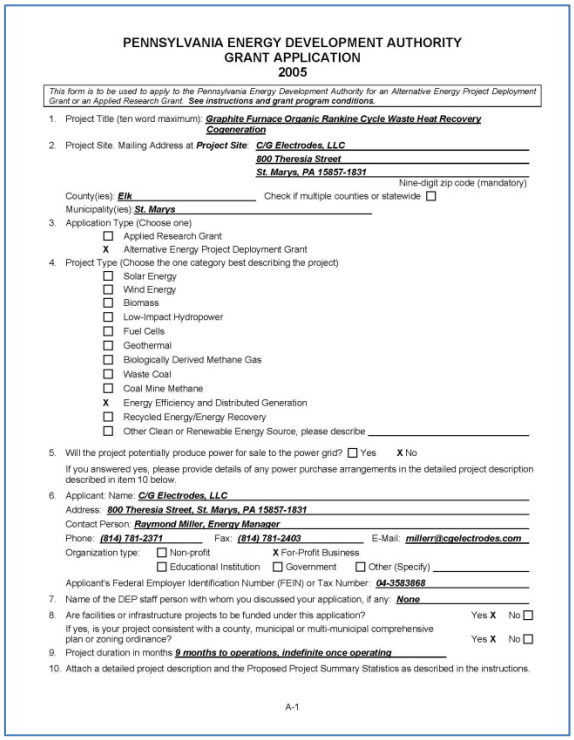
PROJECT SUMMARY

C/G ELECTRODES WASTE HEAT RECOVERY PROJECT
PROJECT DESIGN AND GRANT WRITING

PROJECT SUMMARY



PENNSYLVANIA ENERGY DEVELOPMENT AUTHORITY
GRANT APPLICATION
2005

This form is to be used to apply to the Pennsylvania Energy Development Authority for an Alternative Energy Project Deployment Grant or an Applied Research Grant. ***See instructions and grant program conditions.***

1. Project Title (ten word maximum): ***Graphite Furnace Organic Rankine Cycle Waste Heat Recovery Cogeneration***
2. Project Site. Mailing Address at ***Project Site***: ***C/G Electrodes, LLC***
   800 Theresia Street
   St. Marys, PA 15857-1831
   Nine-digit zip code (mandatory)
   County(ies): ***Elk*** Check if multiple counties or statewide ☐
   Municipality(ies) ***St. Marys***
3. Application Type (Choose one)
   ☐ Applied Research Grant
   X Alternative Energy Project Deployment Grant
4. Project Type (Choose the one category best describing the project)
   ☐ Solar Energy
   ☐ Wind Energy
   ☐ Biomass
   ☐ Low-Impact Hydropower
   ☐ Fuel Cells
   ☐ Geothermal
   ☐ Biologically Derived Methane Gas
   ☐ Waste Coal
   ☐ Coal Mine Methane
   X Energy Efficiency and Distributed Generation
   ☐ Recycled Energy/Energy Recovery
   ☐ Other Clean or Renewable Energy Source, please describe
5. Will the project potentially produce power for sale to the power grid? ☐ Yes X No
   If you answered yes, please provide details of any power purchase arrangements in the detailed project description described in item 10 below.
6. Applicant: Name: ***C/G Electrodes, LLC***
   Address: ***800 Theresia Street, St. Marys, PA 15857-1831***
   Contact Person: ***Raymond Miller, Energy Manager***
   Phone: ***(814) 781-2371*** Fax: ***(814) 781-2403*** E-Mail: ***millerr@cgelectrodes.com***
   Organization type: ☐ Non-profit X For-Profit Business
   ☐ Educational Institution ☐ Government ☐ Other (Specify)
   Applicant's Federal Employer Identification Number (FEIN) or Tax Number: ***04-3583868***
7. Name of the DEP staff person with whom you discussed your application, if any: ***None***
8. Are facilities or infrastructure projects to be funded under this application? Yes X No ☐
   If yes, is your project consistent with a county, municipal or multi-municipal comprehensive plan or zoning ordinance? Yes X No ☐
9. Project duration in months ***9 months to operations, indefinite once operating***
10. Attach a detailed project description and the Proposed Project Summary Statistics as described in the instructions.

A-1

Bridgestone Associates was initially engaged to prepare a detailed application to the Pennsylvania Energy Development Authority (PEDA) for capital grant funding of an Organic Rankine Cycle (ORC) waste heat recovery system to generate electricity from waste heat recovered from car bottom furnaces. Upon successful approval of the grant funding, Bridgestone Associates was then engaged to prepare the complete detailed design of the ORC waste heat recovery plant. During the design process, the ORC vendor determined that their equipment required additional development and design work and withdrew it from the market. Bridgestone Associates then continued with the design now based on a steam turbine as the prime mover. The final design incorporated a waste heat steam generator to recover heat from the 1,200 – 2,000 ^{o}F car bottom furnace and thermal oxidizer exhaust and a 2.3 MW steam turbine. Bridgestone Associates' work included preparing the complete designs; equipment selection; detailed cost estimates; drawings including structural, general arrangement, electrical, instrumentation and control, and piping drawings; financial analysis of the project; discussions with the local utility and the grant provider; and development of permitting requirements.

PROJECT STATISTICS

Client:	C/G Electrodes, UTC Power Corporation
Project Type:	Waste heat recovery generation with Organic Rankine Cycle or steam turbine generator
Size:	2.3 MW with steam turbine design 370 kW with Organic Rankine Cycle design
Unit Sizes:	2 x 200 kW UTC Power PureCycle Organic Rankine Cycle systems or 1 x 2.3 MW steam turbine
Estimated Project Cost:	US$1.05 million for ORC system

Grant Funding:	US$491,114 capital grant approved from PEDA
Plant Location:	St. Marys, Pennsylvania, USA
Plant Elevation:	1,666 feet above sea level
Energy Generated:	3.1 million kWh/year for ORC system
Electricity Sales:	Internal C/G Electrodes use
Existing Client Electricity Use:	26 MW
Primary Fuel:	Waste heat recovery from car bottom furnaces
Waste Heat Temperature:	1,200 – 2,000 °F
Back-up Fuel:	Natural gas
Water Savings:	13.8 million gallons per year for ORC system
Carbon Emissions Reduction:	7.3 million pounds per year

PROJECT DESCRIPTION

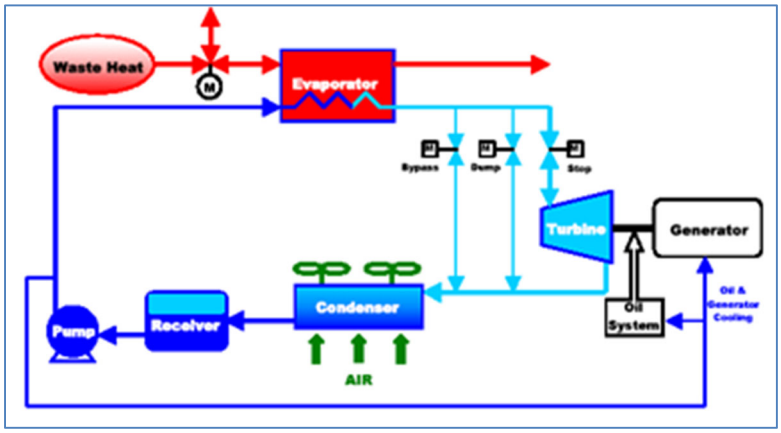
In the initial phase of the work performed by Bridgestone Associates, Bridgestone prepared a detailed application for a capital grant for an Organic Rankine Cycle waste heat recovery system. This system would generate 370 kW net from waste heat resulting from manufacturing processes at C/G Electrodes in St. Marys, Pennsylvania.

C/G Electrodes manufactures graphite electrodes used in electric arc furnaces in steel manufacturing worldwide. The manufacturing process starts with weighing of the appropriate ingredients which are then mixed and extruded into the rough shapes required. The extruded material is then baked after which it is pitch treated to fill any voids and then baked again to densify. This baking is performed in natural gas fired car bottom furnaces. After this baking, the un-machined electrodes are heated in electric furnaces to approximately 3,000 °C to graphitize the carbon. The cooled graphite blocks are then machined to customer specifications, packed and shipped. C/G Electrodes ships approximately 42 million pounds of finished products each year.

Exhaust gas from the 10 existing car bottom furnaces at approximately 1,400 °F is ducted to a common manifold and then to either one of two incinerators (thermal oxidizers). Natural gas is consumed in these incinerators (thermal oxidizers) to elevate the temperature of the entrained contaminants from the car bottom furnace to their oxidation temperature to affect their destruction. These oxidation temperatures often exceed 1,600 °F. The gasses and oxidized contaminants are then cooled and the sulfur dioxide is removed in a wet limestone slurry scrubber. The cooled gases are then exhausted to the atmosphere. The

thermal energy contained in the 1,400 °F exhaust gas from the thermal oxidizer is considerable. The cooling of these gases going into the scrubber consumes approximately 50,000 gallons of makeup water per day.

Through the implementation of the ORC system (UTC Power PureCycle™ 200 system) technology, the wasted thermal energy from the oxidation process may be recovered and utilized to generate some of the electric power that is required to operate the systems associated with the process. A significant portion of the exhaust gases from the oxidation chamber may be directed to the ORC system. This system will generate electricity and during the process, will provide cooling of the exhaust gases. As a result, approximately 75% less water will be consumed in the scrubber.



The ORC system will generate approximately 3,100 MWh annually from the waste heat from the car bottom furnaces and save approximately 13.8 million gallons of cooling water each year. In addition, because of the avoided electricity purchases, the estimated emissions savings resulting from reduced fossil fuel use by the local utility include the following:

NOx	>8,500 lb/year
SO2	>6.0 tons/year
CO	>14,000 lb/year
CO2	>3,600 tons/year
Particulates	>1,400 lb/year

The grant application to the Pennsylvania Energy Development Authority was successful and C/G Electrodes were awarded a $491,114 capital grant towards the project. PEDA commented that the grant application they received was “by far the best and most comprehensive they had ever seen”.

Upon award of the grant, Bridgestone Associates was engaged by C/G Electrodes to prepare a detailed design for the ORC waste heat recovery plant. The work requested by the client included structural, mechanical, electrical, and control system design, selection of equipment, all drawings, and development of a detailed cost estimate and financial model.

Waste heat was to be extracted from the high temperature duct connecting the exhaust of the thermal oxidizer to the wet scrubber. This exhaust duct was approximately 75 feet in the air and approximately 10 feet in diameter, posing significant structural and mechanical problems for an interconnection and bypass to the waste heat recovery system. Bridgestone Associates did however successfully develop a complete, structurally and mechanically sound solution that allowed waste heat to be bypassed to the recovery system or, in an emergency or during maintenance, to follow its original path.

Bridgestone Associates also completed all the electrical and mechanical design, and drawings for the ORC system and its installation. Unfortunately however, the ORC manufacture (UTC Power Corporation) determined there were performance and reliability issues with their equipment and withdrew it from the market after the project design was approximately 80% complete. This left the client with a continued desire to develop this waste heat project but no ORC equipment to use to convert waste heat to electricity. At the client's request Bridgestone Associates investigated alternatives and recommended a more traditional waste heat recovery steam generator and steam turbine. After discussions and agreement with PEDA on continued use of the capital grant funds, Bridgestone Associates modified the design to use this more traditional approach.

In addition to the complexities of connecting to and extracting the waste heat from ductwork over 75 feet in the air, the design also had to handle significant variations in waste heat temperature from 1,200 to 2,000 ^{o}F, variations in flow, and entrained particulate matter in the gas stream potentially causing fouling of the heat exchangers. All of these issues were examined and evaluated in detail, and satisfactory solutions developed to ensure long-term, reliable operation.

The design and equipment selection was completed for the client. Due to other critical plant investments that were required, the construction of the project was postponed by the client. As subsequent financial conditions for the client, a leveraged buyout, did not improve, the project was shelved indefinitely.