

FINAL TECHNICAL REPORT

AWARD NUMBER: DE-EE0002730 / 003

**TEXAS MEDICAL CENTER CENTRAL HEATING AND COOLING SERVICES
COMPANY**

**RECOVERY ACT: THERMAL ENERGY CORPORATION COMBINED HEAT AND
POWER PROJECT**

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EXECUTIVE SUMMARY

To meet the planned heating and cooling load growth at the Texas Medical Center (TMC), Thermal Energy Corporation (TECO) implemented Phase 1 of a Master Plan to install an additional 32,000 tons of chilled water capacity, a 75,000 ton-hour (8.8 million gallon) Thermal Energy Storage (TES) tank, and a 48 MW Combined Heat and Power (CHP) system. The Department of Energy selected TMC for a \$10 million grant award as part of the Financial Assistance Funding Opportunity Announcement, U.S. Department of Energy National Energy Technology, Recovery Act: Deployment of Combined Heat and Power (CHP) Systems, District Energy Systems, Waste Energy Recovery Systems, and Efficiency Industrial Equipment Funding Opportunity Number: DE-FOA-0000044 to support the installation of a new 48 MW CHP system at the TMC located just outside downtown Houston. As the largest medical center in the world, TMC is home to many of the nation's best hospitals, physicians, researchers, educational institutions, and health care providers. TMC provides care to approximately six million patients each year, and medical instruction to over 71,000 students.

A medical center the size of TMC has enormous electricity and thermal energy demands to help it carry out its mission. Reliable, high-quality steam and chilled water are of utmost importance to the operations of its many facilities. For example, advanced medical equipment, laboratories, laundry facilities, space heating and cooling all rely on the generation of heat and power.

As result of this project TECO provides this mission critical heating and cooling to TMC utilizing a system that is both energy-efficient and reliable since it provides the capability to run on power independent of the already strained regional electric grid. This allows the medical center to focus on its primary mission – providing top quality medical care and instruction – without worrying about excessive energy costs or the loss of heating and cooling due to the risk of power outages.

TECO's operation is the largest Chilled Water District Energy System in the United States. The company used DOE's funding to help install a new high efficiency CHP system consisting of a Combustion Turbine and a Heat Recovery Steam Generator. This CHP installation was just part of a larger project undertaken by TECO to ensure that it can continue to meet TMC's growing

needs. The complete efficiency overhaul that TECO undertook supported more than 1,000 direct and indirect jobs in manufacturing, engineering, and construction, with approximately 400 of those being jobs directly associated with construction of the combined heat and power plant.

This showcase industrial scale CHP project, serving a critical component of the nation's healthcare infrastructure, directly and immediately supported the energy efficiency and job creation goals established by ARRA and DOE. It also provided an unsurpassed model of a district energy CHP application that can be replicated within other energy intensive applications in the industrial, institutional and commercial sectors.

COMPARISON OF ACCOMPLISHMENTS WITH GOALS

The objective of this project is 1).the construction and operation of a high-efficiency combined heat and power (CHP) system at an existing district power plant that supplies the energy, heating, and cooling needs of the TMC. 2). The project would design, purchase, install, and operate the CHP system. 3). The system will include a natural gas-powered turbine, heat recovery steam generator (HRSG), a natural gas compressor, four chillers to be powered by the CHP system, cooling towers, and required balance of plant equipment (as defined in Attachment 2a Statement of Project Objectives).

This CHP project directly contributed to the job creation and energy independence goals and objectives defined in the Financial Assistance Funding Opportunity Announcement, U.S. Department of Energy National Energy Technology, Recovery Act: Deployment of Combined Heat and Power (CHP) Systems, District Energy Systems, Waste Energy Recovery Systems, and Efficiency Industrial Equipment Funding Opportunity Number: DE-FOA-0000044. Additionally, this project specifically supported the commercially available CHP technology implementation and system efficiency goals set under the Industrial Technology Program.

Goal 1: The TECO system was successfully completed ahead of schedule and has been in commercial operation serving the TECO's customers since June, 2010.

Goal 2: The design, procurement, installation, construction and commissioning has been successfully completed and the system is performing as intended.

Goal 3: The system has been installed and integrated into the TECO district energy plant as intended and is producing electricity, steam and chilled water for the TMC campus as intended.

Demonstrated Performance:

Goal: Identify jobs directly created jobs created in the engineering, manufacturing and construction sectors.

Accomplishments:

- 1,559,146 total person-hours (including design, construction management and subcontracted labor) worked to design, install and construct the project, with zero lost time incidents.
- 14,280 total person-hours of operations and maintenance training January 2010 through June 2011 completed.

Goal: New CHP system shall have an efficiency of at least 60%. Replacement of an inefficient existing system shall have at least 60% overall system efficiency and represent at least a 25% efficiency increase compared to system being replaced.

Accomplishments:

- TECO's new CHP system exceeds the requirement for 60% efficiency by consistently ranging between 71% and 82%.
- TECO's replacement of the inefficient system with the new CHP system and chilled water system increased overall system efficiency by 100%.

Goal: Project completed at or below the funded amount and on schedule.

Accomplishments: Project completed significantly under budget while meeting the desired schedule for operation of the system.

SUMMARY OF PROJECT ACTIVITIES

I. Project Management and Planning

- a. Maintain Project Management Plan – TECO revised and updated the Project Management Plan (PMP) on a periodic basis during project execution in accordance with DOE reporting requirements and as necessary to reflect significant project task adjustments. An initial update of the PMP was provided following DOE award and completion of subsequent negotiations with DOE and NETL. PMP maintenance included documentation of project progress and updates related to the WBS as broken down by task and sub task, the status of Risk issues identified in the Risk Management Profile, the status of critical project activities as identified in the Milestone Log, the status of project funding and cash flow against the projections provided in the Funding and Costing Profile, the status of the actual project schedule relative to the planned Project Timeline, and progress towards achievement of project objectives relative to the list of Success Criteria at Decision Points.
- b. Environmental and Regulatory Compliance – TECO completed all necessary construction and environmental permitting activities and possessed the necessary permits for the project. TECO and its design and installation team members ensured that the permitted project is installed as designed and that the operational system complies with all environmental and regulatory requirements.
- c. Execution of Required Financing Agreements – TECO obtained private sector financing for its proposed non-federal cost share. TECO also established contracts with major equipment vendors and the natural gas provider.
- d. Prepare Reports and Briefings – TECO provided all necessary reports and briefings to support the project kick-off meeting, quarterly technical and financial reports, annual technical and financial reports, project demonstration, and periodic DOE peer reviews.

II. Master Plan Implementation

1. Summary -TECO has been providing chilled water and steam to the Texas Medical Center (TMC) since 1969 with the goal of providing economical and reliable thermal services. During this time the chilled water and steam demands have continued to grow necessitating many additions to their systems. In anticipation of growth beyond their current capacity, TECO worked with Carter-Burgess and Burns & McDonnell to develop and finalize the 2006 Master Plan. The result of these efforts is a Master Plan that contains several inter-related projects taking place over many years so that TECO can continue to meet increased demand and maintain reliability.

The project objectives for the CHP1 Task Order Authorization was to design, purchase and install equipment for the new CHP system so that TECO can meet not only the stated goals of reliably meeting the TMC utility demands but also to actually decrease their effect on the environment while supplying a growing load. CHP1 can operate either isolated from or in parallel to the existing utility grid. This allows TECO to export excess power, reduce their load on the electrical system, or operate as a power island depending on the situation. In the event of a gas turbine generator (GTG) outage, whether planned or not, TECO's electricity provider (CenterPoint Energy) provides the source of the backup energy to operate the facility. TECO's own package boilers provide backup and peak steam production. The CHP1 system increases TECO's capability to supply steam and chilled water in the event of a breakdown in the electrical utility grid feeding the Central Plant (CP).

2. Scope - The Master Plan Implementation (MPI) scope was defined by the following design criteria: Addition of two GTG's that will allow TECO to become a more efficient CHP plant and allow TECO to meet the increased steam demand.
 - Addition of 80,000 tons of chilled water production that will allow TECO to meet the increased chilled water demands.
 - Addition of two thermal energy storage tanks that will allow TECO to shift chilled water demand to the evening when rates are lower and will provide limited chilled water capacity in the event of the loss of all chillers.
 - Expansion of the chilled water system to the west of Main Street that will allow TECO to meet the demands of the TMC growth to the north and west.
 - Crossing Bray's Bayou to the south with thermal services to meet the needs of the future Mid and South Campuses of the TMC.
 - Replacement of the existing West Cooling Tower that was built during the original construction.
 - In addition, there are several smaller projects that are a part of the overall master plan that are being performed in support of the main projects described above. These projects include an Operations Support Facility, upgraded electrical distribution system in the CP, demolition of the existing laundry facility and the replacement of some of the existing chilled water pumps.

a. MPI Phase 1 Projects

- i. Laundry Building Demolition (LPRP)
- ii. Operations Support Facility (OPSF)

- iii. West Distribution Loop (WDLO) (Not included in Burns & McDonnell scope)
- iv. Thermal Energy Storage Tank #1 (TES1)
- v. South Main Plant Electrical Interconnection (SMPE)(Delayed)
- vi. Central Plant Electrical Upgrade (CPEL)
- vii. Mid -Campus Distribution Bridge (MCDB)
- viii. Chilled Water Pump Replacement (CHWP)
- ix. Combined Heat and Power #1 (CHP1)
- x. Four (4) 8,000 ton chillers and East Chiller Building (ECHB)
- xi. West Cooling Tower Replacement (WCTR)(Delayed)

b. MPI Phase 2 Projects

- i. Addition of (6) 8,000 ton chillers and associated equipment
- ii. Thermal Energy Storage Tank #2 (TES2)
- iii. Combined Heat & Power #2 (CHP2)
- iv. New Boilers at the South Main Plant

III. Combined Heat and Power

Summary

The CHP1 Task Order is the second largest single project in MPI Phase 1 based on cost. The equipment produces 48 megawatts (MW) of electrical energy on a summer day and 135,000 pounds per hour (pph) of steam. The use of duct burners in the HRSG will increase steam production capacity to approximately 330,000 pph on the same summer day. TECO's critical role at the TMC mandates a plant built to "industrial" standards and a high level of automation to ensure its efficient operation.

Scope

- Demolition of Boiler #5 and relocation of the RSK Conference Center and the low pressure fuel gas metering (CenterPoint Gas) station
- GE LM6000 PD SPRINT Aeroderivative GTG
- Two pressure level Heat Recovery Steam Generator (HRSG) including Selective Catalytic Reactor (SCR) for NO_x emission reduction
- Fuel gas compressor for the new high pressure supply
- Pipe rack to connect the new equipment to the existing steam, feedwater, condensate return and utilities of the existing CP
- Aqueous ammonia unloading, storage and handling for operation of SCR

Schedule

The completion date for operation was June, 2010. The manufacturing lead times for the GTG and HRSG required a commitment to these contracts prior to the completion of the front end planning effort. CHP1 required a new low pressure (200 psig) fuel gas metering and regulating station and the removal of the existing fuel gas metering and regulating station. Therefore the fuel gas feed to the boilers was modified early in the CHP1 project compared to most other activities. This required the construction of a portion of a new pipe rack. The gas lines are installed above grade as much as possible in the vicinity of the gas turbine and HRSG. The

construction of CHP1 was closely coordinated with the Operations and Support Facility (OPSF) and Central Plant Electrical (CPEL) task orders. Due to its location in the heart of the project site, a key objective for the OPSF construction schedule was to minimize the impact on major construction activities related to CHP1.

IV. Future Expansion Considerations

The high pressure fuel gas system is sized to support a second GTG and HRSG. The planning at this point is that the CHP2 design be based on the higher pressure steam conditions and include a non-condensing steam turbine in order to optimize the usage of the recovered heat. Piping and electrical connections to existing systems will include provisions for connecting CHP2 if practical, expedient and/or cost effective to do so.

Procurement of Equipment, Controls, and Ancillary Supplies

TECO and its installation team procured all equipment required for the implementation of the new CHP system. Equipment specification for all major equipment was completed in early 2009. Additional procurement activities included: equipment supplier final contract negotiations, purchase order award, vendor document/drawing review, equipment expediting, and shipment coordination.

Installation and Integration

TECO and its installation team installed all equipment required for the new CHP system. This included installation of the combustion turbine, HRSG, natural gas compressor, associated balance of plant equipment, controls and interconnecting piping. The project also encompassed integration of both the CHP system steam output with the existing and expanded district thermal energy system and the CHP system electrical power output which serves the electric chiller equipment and local grid interconnection.

V. PROJECT DESIGN APPROACH

Process Description

CHP is the utilization of a fuel in a device or devices to produce both electric and thermal energy. The CHP for this project utilized a GTG to produce electricity and hot gas. The GTG exhaust gas passes to the HRSG which utilizes the heat via convective heat transfer to produce steam. The HRSG is fitted with natural gas fired Duct Burners (DB) to add heat to the GTG exhaust gas for additional steam production capacity at a higher efficiency than the other boilers at the facility. The HRSG was also fitted with a Selective Catalytic Reactor (SCR) to reduce Nitrous Oxide (NO_x), and space was provided for a future catalyst to reduce Carbon Monoxide (CO) emissions.

Major Equipment

1. New Equipment

a) Gas Turbine Generator (GTG)

The GTG is a General Electric (GE) LM6000 PD SPRINT unit. The LM6000 PD is a 48MW aeroderivative gas turbine with dry-low emissions combustion. The GTG has inlet air chiller coils for increased power production during hot ambient conditions.

Equipment and materials include:

- Gas turbine.
- Gas fuel system.
- Turbine Lube oil system.
- SPRINT water injection system.
- Water wash system (on-line and off-line capabilities).
- Enclosure ventilation system.
- Fire protection system.
- Hydraulic system.
- Hydraulic start system.
- Ladders and platforms.
- Turbine and Generator Sound enclosure.
- Instrumentation and controls.
- Insulation and lagging.
- High efficiency inlet air filter.
- Generator.
- Generator Lube oil system.
- Generator Cooling system.
- Turbine Enclosure ventilation system.

b) Heat Recovery Steam Generator (HRSG)

The HRSG will be a two-pressure steam generator. The HRSG receives feedwater from the existing CP Boiler Feedwater Pumps. All the feedwater is heated by the first economizer. A portion of the feedwater supplies the LP evaporator. The remainder of the feedwater is heated in a second economizer and then supplies the Intermediate Pressure (IP) evaporator. The High Pressure (HP) designation has been reserved for the future CHP2. The Low Pressure (LP) evaporator section further heats the LP feedwater to the saturation point. The low pressure steam system produces steam at the TMC supply header pressure and provides saturated steam. No low pressure superheater is provided. The LP system is designed to provide steam at pressures ranging between 150 psig and 250 psig.

The second economizer receives the remaining feedwater and heats the water to near saturation and then flows into the LP evaporator section. A superheater heats the steam to the final temperature. A steam desuperheater maintains maximum outlet temperature. The IP steam system is designed to provide steam at 400 psig and 600°F, plus pipe line losses. A DB is included to allow for additional steam production by burning natural gas in the GTG exhaust gas stream. The DB is capable of firing to a nominal heat input of 220 MMBtu/hr.

The HRSG includes a selective catalytic reduction (SCR) system for the reduction of NO_x emissions. The SCR is sized to attain permit emission levels at peak fired conditions with a margin to allow for system upsets. Space is included in the HRSG to allow for the future installation of a CO catalyst for the reduction of CO emissions.

Fresh air firing was not included in the HRSG design.

Equipment and materials include:

- Heat recovery steam generator.
- Economizer: First and Second.
- IP evaporator.
- LP evaporator.
- IP drum.
- LP drum.
- IP superheater.
- Steam temperature control equipment.
- Casing, insulation, and lagging.
- Sample connection for CEMS prior to SCR catalyst.
- Structural steel
- Duct burners and ignitors.
- Interconnecting steam and water piping.
- Motor-operated stop valve at superheater outlet.
- Electric aqueous ammonia vaporizer.
- Safety and blow-off valves, including vent stacks, silencers, and control accessories.
- Instruments and instrument connections.
- Combustion safeguard system.
- Electric motor drives.
- Miscellaneous trim, including the following:
 - (a) Trim valves.
 - (b) Gauges.
 - (c) Drum trim valves.
- Ductwork.
- Expansion joints.
- Structural and miscellaneous steel including the following
 - (a) Access platforms.
 - (b) Stairs.
 - (c) Ladders.
 - (d) Handrails.
 - (e) Walkways.
 - (f) Grating.
- Main exhaust gas stack including the following:
 - (a) Steel shell.
 - (b) Connecting ductwork.
 - (c) Walkways, platforms and ladders.
 - (d) Lighting and convenience outlet systems.
 - (e) Connections for emissions monitoring equipment.
 - (f) Dampener for heat retention.

c) Natural Gas Compressor

One 100% capacity natural gas compressor was installed to supply compressed natural gas to the GTG. The supply to this compressor will be the future high pressure pipeline TECO is negotiating to secure. The current design assumes this supply will enter the CP at the MCDB bridge over Brays Bayou. The compressor was designed for suction pressures between 550 psig and 725 psig with an outlet

pressure as required supplying the GTG with natural gas between 675 psig and 705 psig at the equipment nozzle connection.

The compressor is reciprocating type design. The compressor includes a variable frequency drive (VFD), full gas recirculation loop, and gas cooler as required by the compressor to meet the specified conditions. The compressor is rated for the following:

Future high pressure supply:

- Maximum capacity 482,100 scf/hr
- Suction pressure 550 – 725 psig
- Suction temperature 60 – 90 °F
- Discharge pressure approximately 715 psig (as required to supply GTG)
- Discharge temperature <250 °F

Equipment and materials include:

- Natural gas compressors.
- VFD capable electric drive motors.
- Packaged controls.
- Lube oil coolers.
- Natural gas coolers (as required).
- Inlet gas scrubbers.

The VFD is an addition that is not required for operation. The VFD provides a potential benefit to the Plant operations cost in the form of electrical power savings at reduced gas turbine loads and higher gas supply pressures. A constant speed compressor controls the compressor unit outlet by recycling gas. The VFD reduces the compressor motor load by reducing the rotating speed, thus reducing the flow gas at a given outlet pressure, which results in a lower power requirement relative to a constant speed compressor that relies on gas recirculation to reduce the flow output of the compressor unit. Burns & McDonnell bid the compression equipment both with and without a VFD. The final decision was to not incorporate a VFD in the gas compressor system.

d) Fuel Gas Conditioning Equipment

One skid-mounted fuel gas filter/separator unit is installed near the GTG. The conditioning system is designed to meet GE's natural gas requirements at the GTG with margin:

The fuel gas conditioning skid is rated for the following:

- Maximum capacity 482,100 scf/hr (plus additional 15% margin)
- Design inlet pressure 725 psig
- Operating pressure 675 – 715 psig
- Natural gas temperature <250 ° F

e) Ammonia Unloading, Storage, and Transfer

Aqueous ammonia unloading, storage, and transfer equipment is provided to supply ammonia for NO_x control to the HRSG. Aqueous ammonia at 19% ammonia concentration is used. The equipment consists of a truck unloading skid, a 10,000 gallon aqueous ammonia storage tank, and two 100% aqueous ammonia transfer pumps. Typical aqueous ammonia delivery trucks transport 7,000 gallons of aqueous ammonia. Assuming 90% usable volume in the 10,000 gallon storage tank provides 9,000 gallons of useable storage. The approximate maximum daily usage of aqueous ammonia will be 495 gallons per day. Assuming the truck fills the storage tank to the maximum usable volume, truck deliveries planned for every two weeks allow four days of margin at maximum load should the aqueous ammonia delivery be delayed. When CHP2 is installed the CHP1 storage tank will also be used as a holding and transfer tank for CHP2.

The ammonia delivery and storage equipment is located outdoors inside a spill containment area.

Equipment and materials include:

- Truck unloading connections.
- Ammonia storage tank.
- Ammonia transfer pumps.
- Piping, valves and fittings.
- Instrumentation and controls.
- Accessories.

f) Feedwater Heat Exchanger

A feedwater heat exchanger was provided to exchange heat between the cold condensate return supplied to the existing deaerators and the hot boiler feedwater supplied from the existing deaerators. The function of the heat exchanger is to cool the feedwater to the HRSG for total thermal plant efficiency gains. The heat exchanger is a plate-and-frame type designed for an approach temperature of 10°F between the cold condensate return in and the hot feedwater out. This design was selected by TECO in lieu of a 5°F approach temperature due to the large increase in capital cost to achieve the 5°F approach. The feedwater heat exchanger is sized for the full CHP1 flow in full duct fired mode plus one CP Boiler at standby, approximately 340,000 lb/hr flow.

g) Miscellaneous Pumps

Miscellaneous pumps are provided as necessary. In general, pump impellers are not the minimum or maximum size for pump casing furnished. The TDH for the maximum impeller, at the design flow rate, is generally 10% higher than the design head.

h) Electrical Support Equipment

An electrical equipment enclosure was provided to house the 4160 volt and 480 volt motor control centers and switchgear which supports the GTG operations. The 4160 volt motor control center was manufactured by Powell Industries Inc.

The 480 volt support equipment is powered by a single 2000/2666kVA, 4160-480 volt transformer which, in turn, powers draw-out switchgear located in the equipment enclosure mentioned above. The equipment enclosure also houses the 125VDC system components which are utilized to control the 4160 volt and 480 volt switchgear. Other miscellaneous electrical equipment housed in the equipment enclosure includes 480 volt panelboards, 480-208/120 volt transformer and low-voltage panelboards.

Plant Layout

The CHP1 Task Order consists of two major pieces of equipment: the GTG and the HRSG. The GTG and the HRSG are arranged in a straight line configuration. The layout required the demolition of a single existing boiler (#5) and maintains vehicle access and turn around areas. Turbine and generator maintenance pull spaces are allowed to encroach upon vehicle access areas. A pipe rack originates at the boiler #5 location and runs adjacent to the GTG, parallel to the HRSG, then over to the TES1 task order pipe rack. A branch line runs north along the west side of Cooling Tower #10 and turns west to connect with the south eastern wall of the chiller building. Some GTG auxiliary and balance of plant (BOP) equipment is located under the pipe rack for space conservation. Access rails are provided as necessary. Fork lift truck access was maintained so that motors, pumps, compressors, large valves, etc. can be moved in and out for maintenance. Ladders, stairs and platforms were included to elevated equipment, valves and instruments.

The GTG circuit breaker is located on an elevated platform above the boiler alley vehicle entrance drive relative to the GTG. Non-segregated phase bus is routed on the top level of the pipe rack from the circuit breaker to the ECHB transformer.

Site Plan

The CHP1 is located within the original TECO CP lease area bounded by the Bray's Bayou to the south, Braeswood Boulevard to the east, Pressler Street to the north, and Bertner Avenue to the west.

VI. PROJECT EXECUTION PLAN

Administration and Project Management

The Front End Planning (FEP) studies and design documents were the basis for the detailed design of TECO's CHP1 Project at the CP. The primary measures of success for this project were the commissioning and startup of the facility and a total project cost that met budget keeping safety as the highest priority.

- **Cost Estimating:** The purpose of FEP3 activities was to produce a definitive cost estimate ($\pm 15\%$) and scope definition package that defines what will be constructed.

The FEP3 effort was the basis from which a Task Order Authorization for detailed design, procurement, and construction can be executed. The goal of FEP estimating was to clearly define the project scope and obtain scope buy-in from all affected parties. Burns & McDonnell used proven estimating techniques and provided experienced estimating resources throughout the process.

- **Project Management:** The Burns & McDonnell Project Management team worked closely with the TECO Project Management team on all phases of the project. The Burns & McDonnell Task Order Engineering Project Manager had the responsibility for the overall execution of the FEP work. The Task Order Engineering Project Manager was the key interface with TECO and coordinated the efforts of the lead discipline engineers, estimating and procurement staff and construction support personnel within the home and field offices.

Front End Planning Step 3 (FEP3) Detailed Scope Engineering

1. System Engineering

The Mechanical, Electrical and Controls Engineering staff worked both independently and together to refine the system design criteria presented in the FEP3 report. In some cases, these systems crossed Task Order boundaries and were coordinated with the respective discipline Engineers working on other Task Orders.

2. Mechanical Engineering

The Mechanical team developed a thermodynamic model for developing the Heat and Material balance presented in the FEP3 report. The performance of the primary equipment for CHP1 is derived from this model. The balances presented here are based on the final HRSG design that was selected in awarding that contract. The temperature, pressure and flows of gases, steam, condensate and feedwater in that model were the basis of calculations to evaluate and determine equipment and pipeline capacities for pumps, tanks, blowers, sample analysis, water filtration, and chemical treatment requirements within the agreed scope. The Mechanical team developed abbreviated equipment specifications all primary and most auxiliary equipment within the defined scope. These specifications were sent to prospective bidders to solicit costs for the equipment for the estimate. The responses to these equipment quotations were used for the estimate. The Mechanical team laid out the equipment and piping systems in a manner that allows adequate access for maintenance and repair activities within the constraints of the space available.

During the execution of the detailed design and construction Task Order, Burns & McDonnell's mechanical engineers finalized the process design after TECO reviewed the FEP3 report, refined the Heat and Material balance as necessary, Process and Instrumentation Diagrams (P&ID's) and equipment data information that were begun in FEP2 and FEP3 were completed. Any changes that affect equipment or cost were identified and a Task Order to begin detailed design was executed.

Burns & McDonnell's mechanical engineers completed piping documents that tracked the P&ID's. Piping design was closely coordinated with the structural team to effectively route piping on throughout the facility. A preliminary pipe rack and pipe layout was

prepared which was used to develop the piping material take-off (MTO) to support the development of the FEP3 estimate.

3. Civil Engineering

The Civil team will use a survey and benchmark information gathered during FEP3 to plan the CHP1 area, indicating all information obtained through work completed by the Surveyor. The final design of the pipe rack foundations determined the necessity to reroute existing underground utilities. The Civil team determined applicable permits needed for construction of Civil related issues. The area immediately south of cooling towers 7, 8 and 9 required close coordination to avoid and relocate the electrical and communications below grade for the foundations of the pipe rack and gas meters.

4. Structural Engineering

The Structural team reviewed the geotechnical reports, survey, existing site conditions and utilities, and adjacent foundations. The structural team performed preliminary calculations to determine preliminary structural element sizing and orientations, including piling, pile caps, columns, beams, girders, slabs, walls, and lateral force resisting systems. Detailed design included coordination with the piping layout, mechanical, and electrical equipment for interference checks, supports, and clearances. The structural team worked with the project estimators to furnish concrete and steel material take-offs to support the FEP3 estimate.

5. Electrical Engineering

The Electrical team developed abbreviated equipment specifications for all primary and most auxiliary equipment within the FEP3 agreed scope. These specifications were sent to prospective bidders to solicit budgetary costs for the equipment. The responses to these equipment quotations were used to support the estimate. The Electrical team developed preliminary plans for power distribution and control signal management to support CHP1. The team developed preliminary protective relaying schemes for all of the medium and low voltage switchgear. Grounding plans were also developed. Equipment plans were provided for all electrical equipment to support the overall equipment arrangement drawing developed by the Mechanical team.

6. Instrumentation & Controls

The I&C team coordinated controls requirements with TECO and other Task Orders. The team provided instrument quantities and control systems scope to Estimating for inclusion in the FEP3 Estimate. The team established the I&C design basis and prepared specifications, an instrument index and interface plan with TECO's existing control system.

Computer Software

1. Drafting

Creation of the general arrangement drawings as well as other preliminary sketches for the CHP1 were accomplished in plan view only. For detailed design, the software used for modeling was Intergraph's *SmartPlant® 3D*. Piping isometrics for pipelines larger

than 2.5 inches were extracted from this model. Piping plans, cable tray plans and elevations were extracted from this model also. Final delivery for Conforming to Construction Records was in *AutoCAD* format per TECO's requirements.

2. Modeling

As described above, Burns & McDonnell developed a computer model of the thermodynamic cycle that has been chosen. The software utilized by Burns & McDonnell for this activity was GE's *GateCycle*®. Burns & McDonnell also utilized Applied Flow Technology (AFT's) *Fathom* fluid modeling program for the analysis of flows and pressure drops in the piping systems supporting CHP1. The results of these analyses were used to finalize pipe line sizing.

Procurement

A Procurement Manager coordinated activities required to purchase equipment and materials for the project. The Procurement Manager supported the definitive estimate effort by obtaining equipment and materials pricing and delivery information based on the abbreviated specifications developed by Engineering. In the execution phase of the Task Order, procurement activities included preparation of commercial terms and issuing of bid documents, and tabulation and evaluation of supplier proposals.

A Program Procurement Plan was prepared and defined purchasing, expediting, source inspection, logistics, receiving and inventory management activities. The Program Procurement Plan addressed the following:

- Any special procurement requirements and/or processes required by TECO and/or by law.
- Any approvals required by TECO.
- Specific Program guidelines for bid evaluation criteria, quality assurance, invoice validation, payment certification, data exchange, warranty requirements, and contract closeout.
- Identification of the planned procurement packages including a general scope description and responsibility matrix for each.
- TECO and Program or Task Order specific commercial terms and conditions.
- Required supplier documents for approval and for records.

A Program Approved Vendor list was established. Burns & McDonnell purchased from suppliers that are on the Program Approved Vendor list. Burns & McDonnell submitted recommendations and justification to TECO requesting written approval of exceptions. Bid documents were not issued to any potential supplier that was not approved by TECO as a qualified and approved supplier.

Procurement ensured that TECO's requirements for certified material test reports, Positive Material Identification, ultrasonic baseline thickness measurements, special inspections, and other items required by the TECO specifications were included in the procurement documents.

A bid evaluation and recommendation was prepared jointly by Procurement and the various Task Order Engineering disciplines to determine which supplier proposal had the lowest evaluated price and met the specified commercial and technical requirements.

The Procurement Manager directed the commercial evaluation and Engineering performed the technical evaluation. Upon receipt of the technical evaluation from Engineering, the Procurement Manager finalized the overall bid tabulation/evaluation for review by Program Management. The completed bid tabulation/evaluation and an award recommendation was submitted to TECO for review and approval.

Procurement Packages

Burns & McDonnell utilized the following procurement packages for the following primary and auxiliary pieces of equipment:

Table 5- 1 Procurement Packages

Contract No.		Contract Name
CHP1-	1120	Gas Turbine Generator
CHP1-	1210	Heat Recovery Steam Generator
CHP1-	2190	Miscellaneous Pumps
CHP1-	2280	Heat Exchangers
CHP1-	2320	General Service Pipe
CHP1-	2330	Pipe Supports
CHP1-	2530	General Service Control Valves
CHP1-	2540	Valves
CHP1-	2750	Fuel Gas Compression and Conditioning
CHP1-	2751	High Pressure Fuel Gas Regulation and Metering
CHP1-	2920	Ammonia Storage and Supply
CHP1-	4520	Pipe Rack Steel
CHP1-	5310	Medium Voltage Metal-Clad Switchgear
CHP1-	5311	Hybrid Generator Grounding System (if selected by TECO)
CHP1-	5320	480V Switchgear and Transformers
CHP1-	5330	480V Motor Control Centers
CHP1-	5340	Non-Segregated Bus Duct
CHP1-	5350	Relay and Metering Panels
CHP1-	6110	Plant Control System
CHP1-	6210	Instruments
CHP1-	6310	Continuous Emissions Monitor

Long Lead Procurement Packages

The Project schedule required long-lead time equipment purchases be made prior to the completion of the FEP3 level work. This was done for the GTG and HRSG for this Task Order. Some electrical equipment was purchased during the detailed design process of another Task Order at the CP, specifically, the Central Plant Electrical Distribution (CPEL) Task Order. Equipment costs were still tracked by Task Order.

Revisions to executed Purchase Orders, such as changes in schedule, scope of work, terms and conditions, or technical requirements were documented. Changes, additions, or deletions to the Purchase Order required written consent of Burns & McDonnell and the supplier.

Construction and Subcontracts

Burns & McDonnell implemented the construction work following terms and conditions of the Engineering, Procurement, and Construction (EPC) Agreement between TECO and Burns & McDonnell using a multiple subcontract approach. A separate Subcontracting Plan was developed for each of the identified EPC Task Orders. Although developed independently as if for separate projects, the Subcontracting Plans were coordinated with each other to address challenges inherent with the TECO CP Facility, such as on-site congestion, limited off-site space for jobsite offices and material staging, and systems that cross physical TO boundaries. Each Subcontracting Plan followed guidance provided in this Subcontracting Strategy

The overall subcontracting goal for the TECO project was to engage subcontractors on a per-TO basis and by craft discipline (or assembly of disciplines) in a way that maximized value to TECO. Best value was achieved by making sound economic and logistical decisions regarding lower tier subcontractors, generally seeking to minimize their numbers, and by packaging scopes of work in a way that was aligned with engineering workflow for reduction of overall schedule duration. Another critical factor was consideration of the following credentials of candidate subcontractors:

- Safety performance as represented by valid statistics
- Quality of work as demonstrated by successful completion of recent similar projects and by references
- Ability to staff the work as presented in backlog information
- Expertise of key personnel as demonstrated by resumes and references
- Price as determined by multiple competitive proposals

The following general process was utilized for identification, evaluation, solicitation, approval, and ultimately procurement of subcontractors:

- Burns & McDonnell identified and list candidate subcontractors based on successful past experience with Burns & McDonnell (Houston/Gulf Coast area), TECO, Texas Medical Center, and individuals within any of these organizations who may have further recommendations. Lesser or unknown firms expressing unsolicited interest were scrutinized carefully.
- Burns & McDonnell screened the initial list of candidate subcontractors, organized them by discipline, made initial contacts, and requested their completion of pre-qualification questionnaires developed by Burns & McDonnell.
- Based on evaluation of pre-qualification questionnaires, Burns & McDonnell further screened some subcontractors and requested additional qualification data.
- Burns & McDonnell condensed the candidate subcontractor list to 5 or 6 per discipline and made this recommendation to TECO for approval.
- Burns & McDonnell engaged certain subcontractors from the approved list for pricing and constructability input during the FEP stages of each TO.
- Burns & McDonnell requested competitive proposals from approved subcontractors and managed the bid processes; bids were preferably based on detailed design "Issue for Bid" technical documents.
- For each subcontractor procurement effort, Burns & McDonnell received proposals, performed technical and commercial evaluations, conducted bid conditioning meetings, and provided a recommendation to TECO.

Burns & McDonnell conformed technical and commercial documents to selected subcontractor final proposals and negotiated and executed the subcontract agreements.

Most subcontracts were solicited and awarded on a competitive lump sum basis. Scopes of work that pertained to the uncertainties of existing underground utilities and infrastructure were executed on a time and materials or unit price basis.

Subcontract Packages

Table 5- 2 Subcontract Packages

Contract No.		Name
CHP1	8000	Environmental Remediation (if authorized by TECO in accordance with Master Agreement). Asbestos has been identified on Boiler 5 along with some lead paint.
CHP1	8001	Hydro-excavation: Determine exact location of underground utilities which may impact detailed design.
CHP1	8015	Hazardous Waste Disposal (if authorized by TECO in accordance with Master Agreement)
CHP1-	8051	Demolition: Boiler #5 Dismantlement/Removal, Relocate RSK Conference trailers and low pressure gas metering station piping and concrete.
CHP1-	8211	Civil and Foundations Early CHP1 Pipe Rack: To support relocated fuel gas lines from low pressure meter station to boiler and Cooper gas headers.
CHP1-	8213	Civil and Foundations CHP1 Equipment and Pipe Rack: Relocate underground utilities as necessary, prepare and install piling and foundations for remaining pipe rack and all other CHP1 equipment.
CHP1-	Later	Early Pipe Rack Structural Steel Fabrication
CHP1-	Later	CHP1 Pipe Rack Structural Steel
CHP1-	Later	Low Pressure Natural Gas Pipe Fabrication
CHP1-	Later	Pipe Fabrication

Contract No.		Name
CHP1-	8216	CHP1 Early Pipe Rack Erection: Install pipe rack To support relocated fuel gas lines from low pressure meter station to boiler and Cooper gas headers. Includes the installation of that piping.
CHP1-	8301	Mechanical: Complete installation of GTG, HRSG and all auxiliary equipment provided with those contracts. Also install and connect other mechanical equipment necessary to complete the project. Compl
CHP1-	8316	Heavy Haul / Lift: For the GTG, receive equipment at GE factory and place in storage. Remove from storage, transport to site and set on foundations. For HRSG, receive equipment either at site or storage and unload. If stored, reload and transport to site and set on foundations. If sent directly to site, receive and set on foundations
CHP1-	8401	Electrical/Instrument/Control: Install electrical equipment, instruments, cable tray, conduit, cables and non-segregated bus to ECHB transformer. Terminate all cables.
CHP1-	9052	Construction Testing
CHP1-	9060	Electrical Testing: Check all electrical conductors prior to energizing.
CHP1-	9080	First Fills: Lubricants for GTG and other mechanical equipment.
CHP1-	9102	Surveying: Control of foundation elements and control points for equipment installation.
CHP1-	9701	Pre-Operational Cleaning: Clean HRSG and piping systems prior to initial operation.
TECO	5311	Major Electrical Equipment for CHP1 Task Order including Electrical Equipment Enclosure
TECO	6110	Plant Control System including interface to CHP1 turbine

Demolition and Site Development

The demolition and site development activities for the CHP1 were done in phases to accommodate the construction of the pipe support rack between the interface with the TES1 pipe rack and the existing boilers. This work was coordinated with the OPSF Task Order construction so to not adversely impact that project. Any additional underground utility relocation that was necessary was also addressed at that time. These were limited to the rerouting of storm and sanitary sewers.

Boiler No. 5 was demolished to make room for an electrical substation (5 kV to 480 V) along with the western end of the CHP1 pipe rack. A portion of CHP1 pipe rack was one of the first items constructed for this project. The existing low pressure natural gas metering station was replaced by a new meter station immediately south of cooling towers 7, 8 and 9. The gas pipe then installed on the new pipe rack to feed the existing users. TECO had established a date of March 15, 2009 before which hot taps of the existing gas line feeding the site were not allowed. The existing meter station was then demolished after the switchover. The demolition of the gas metering station allowed the full preparation of the CHP1 area to begin.

Quality

Burns and McDonnell's standard six step design quality program was implemented for the detailed engineering of the Program and individual Task Order projects. The quality program called for establishment of an independent Quality Review Team to review and document individual and team reviews of all key project documents. Final review steps included review of contracts and constructability of work packages.

Burns & McDonnell developed a Program Construction Quality Manual to guide inspections and testing conducted or otherwise managed by Burns & McDonnell's designated on-site Construction Quality Assurance Manager. This Construction Quality Manual addressed issues related to vendor fabrication and inspection of manufactured goods, transportation/handling of equipment, receiving of material and related inspection requirements, installation of goods, third party inspections responsibilities, testing and close out process.

Subcontractors were responsible for their own quality control (QC) and were required to provide project-specific QC Manuals and procedures, in compliance with project specifications, for Burns & McDonnell's review and approval.

Safety

Burns & McDonnell Safety & Health Services address client needs in the management of chemical, physical and biological exposure that may develop within occupational and environmental settings.

Burns & McDonnell developed a Health and Safety Manual applicable to all TOs that was implemented at TECO's facilities and applicable to all on-site personnel whether directly employed or subcontracted. It was the responsibility of all Burns & McDonnell staff to comply with and enforce the requirements of this Health and Safety Manual. Burns & McDonnell's field staff included a designated Safety Coordinator who in addition to enforcement provided support for training, planning, reporting, and record keeping.

Permitting

The primary permit required for CHP1 is the Air Permit from Texas Commission on Environmental Quality. This permit was granted by the TCEQ in July 2008.

VII. Commissioning, Shakedown and Start-up

Following completion of CHP system installation and integration with the existing district energy system, TECO and the installation team completed quality assurance checks, operator training, major equipment and balance of plant equipment start-up under this task. The end result of this task effort was a fully commissioned and commercially operational CHP system serving the TMC campus.

VIII. Operational Data Collection

Following commissioning and initiation of commercial operations, TECO committed to a 3-month CHP system demonstration for the purpose of documenting project technical goals and system performance assessment, with particular emphasis on assessing and documenting the system efficiency.

Operational Data

The CHP system is designed to be run base loaded twenty four hours a day, seven days a week and 365 days a year (24/7/365) and sized to meet the projected minimum summer steam load, with the exception of time required for equipment maintenance and periodic overhauls as recommended by the suppliers. TECO has conducted performance testing of the integrated system upon completion of the startup activities to insure safety, reliability and collected performance data over a period of three consecutive months from July 1, 2011 through September 9, 2011.

TECO is in the ERCOT marketplace and utilizes a day-ahead pricing scheme for electricity. TECO has a process in place that determines how many hours to run the CHP system on any given day based upon the local market conditions, the need to generate their own electricity and when it is economically viable to produce their own power. If the market conditions are favorable, or grid power is at a higher cost than TECO can generate power on-site, the operators will operate the CHP system and generate electricity on-site for use in electric centrifugal chillers, cooling towers, distribution pumps, and other auxiliary electrical loads in the central plant.

The CHP system design includes combustion turbine inlet cooling to lower the inlet air temperature to the combustion turbine to approximately 45° F allowing the maximum power output during the hottest weather conditions. The inlet cooling system can use either use chilled water supply water or chilled water return water depending upon ambient conditions and the power output required. When using chilled water, it is also possible to use the chilled water storage tank as the source minimizing electric consumption during peak demand periods which also increased overall savings and system efficiency.

The waste heat from the combustion turbine is ducted to the waste Heat Recovery Steam Generator (HSRG) to produce steam, in place of the natural gas fired boilers. All of the steam and chilled water produced is sent to TECO customers located in the TMC campus. If the market conditions do not warrant operation of the CHP, TECO purchases electricity from the grid and produces steam with its packaged natural gas fired boilers. TECO also has the option of using supplemental duct burners installed in the HRSG to meet the seasonal steam peak loads. Supplemental firing increases the overall efficiency of the CHP system to over 80%.

Operational Performance

- Time Frame: 07/01/2011 – 09/30/2011
- CHP1 Run Hours: 967
- Power Produced by CHP1: 40,442 MWh
- Steam Produced by CHP1: 123,224 k/lbs
- Emission Reduction (CO2): 25,007 tons (Note 1)
- Emission Reduction (CO2): 52% (Note 1)

Note 1 This analysis compares the actual CO₂ produced by CHP1 during June, July and August of 2011 to the CO₂ that would have been produced if TECO's commodities had been generated during the same operating hours by:

- 1) Electricity generated by a large-scale electric utility provider and
- 2) Natural gas burned in TECO's package boilers.

The assumed heat rate for utility power is 15,200, which is consistent with natural gas fired simple cycle combustion turbines in the ERCOT market and includes 7% voltage distribution system loss.

CHP1 Efficiency

- Time Frame: 07/01/2011 – 09/30/2011
- CHP1 Efficiency: 72%
- Percent Improvement with CHP: 108% (utility heat rate of 15,200 with 7% line loss)

CHP Central Plant 3-Month Operation

NG Input (MMBTU)	378,350
Electricity Output (MWh)	40,442
Steam Output (MMBTU)	133,082
CHP Efficiency	71.7%

Conventional Central Plant 3-Month Operation

Electricity Required (MWh)	40,442	40,442	40,442	40,442	40,442
Utility Plant Heat Rate HHV (BTU/kWh)	11,000	12,000	13,000	14,000	15,000
Utility Plant Fuel Input (MMBTU)	458,621	500,313	542,006	583,699	625,392
Steam Required (MMBTU)	133,082	133,082	133,082	133,082	133,082
Central Plant Package Boiler NG (MMBTU)	162,295	162,295	162,295	162,295	162,295

Conventional Plant Efficiency	43.7%	40.9%	38.5%	36.3%	34.4%
Percent Improvement with CHP	64.1%	75.1%	86.2%	97.2%	108.2%

Notes:

1. Data from actual CHP operation - July, August, September 2011.
2. Electricity Output is Gross Generator Output.
3. A portion of the CHP electricity output was exported (approximately 11 %).
4. Assumed 7% of electrical losses for imported power.
5. CHP Steam output production and steam required in conventional plant is assumed to be consumed by customers.
6. Package boiler efficiency is 82%

East Chiller Building (ECHB) Chiller Efficiency

- Time Frame: 07/01/2011 – 09/30/2011
- Production: 48.5 x 10⁶ ton-hour
- Efficiency: 0.591 kW/ton (compressor only)
- Efficiency Improvement: 0.094 kW/ton

Month	Total Tons Produced	Total Power Consumed	kW per Ton	Total Power Saved	Net kW per Ton Saved
	Ton-Hour	kWh	kW/ton	kWh	kW/ton
July 2011	16,400,505	9,687,595	0.591	1,557,799	0.095
August 2011	17,380,644	10,531,283	0.606	1,429,960	0.082
September 2011	14,711,297	8,418,208	0.572	1,569,556	0.107
Total	48,492,446	28,637,087	0.591	4,557,315	0.094

IX. PROJECT RISK MANAGEMENT PLAN

TECO implemented project risk analyses to identify potential project risks, anticipate their likelihood of occurrence and mitigate their impact on the team's ability to achieve the project objectives. The project team assessed and monitored several major risk areas throughout the project. These included the risk items listed below that are typical to a large energy infrastructure project. Where the project team had already taken steps to evaluate and/or mitigate the enumerated risk, that amplifying information is also provided.

Non-Engineering and Miscellaneous Risks

- Timely site acquisition and access – This was not an issue since the installation site is located within TECO's current facility boundaries and does not require demolition or remediation prior to commencing with the project.
- Insurable accidental risk
- Inflation
- Environmental concerns – TECO had already obtained all necessary construction and environmental permits for the proposed project.

- Coordination with municipal agencies and other third parties – As part of its overall master plan implementation efforts, TECO was already working with TMC member institutions, the local municipality, the local utility and appropriate regulatory agencies to ensure all project impacts are understood and documented. There were no known regulatory issues or third party / public dissent issues that would impede the immediate implementation of this project.
- Changes in conditions in the regional construction industry (demand/supply)
- Terrorist acts, Force majeure events or other acts of God
- Natural gas fuel availability and pipeline interconnection – TECO already has a natural gas supply contract in place.

Technical Design Risks

- Delays in design works.
- Additional safety and unforeseen regulatory requirements
- Impact of requested modifications to completed design
- Timely coordination of design activity with construction activity – As noted, TECO and its project design and installation team members were already collaborating on related master planning projects at the site and had a well established communication and coordination protocol.
- Impact of excessive construction change directives and construction change orders

Installation Risks

- Work schedule shifts
- Overlap of construction trades
- Major construction incidents
- Impact of multiple prime contractors working concurrently due to fast track implementation (if required)
- Appropriate scheduling of construction submittals and materials
- Cost escalations
- Major equipment delivery delay – TECO had already verified the availability of the commercially available major equipment and had received commitments from the vendors that they had capacity to support the proposed project installation schedule.
- Major equipment malfunction and/or warranty issues
- Monitoring of project close out procedures including operational training, supply of operating manuals and completion of record documents

As noted above, many of the typical risk components for a project of this nature were already addressed by the project team, providing DOE with further assurance that the proposed project would achieve the stated energy efficiency and job creation objectives. Through ongoing, rigorous analysis of the remaining potential risks and application of strong management controls at an early stage in the project, TECO and its project team substantially reduced the likelihood of occurrence and impact of these risks.

PROJECT MILESTONE LOG

Periodic, topical and final reports were submitted in accordance with the Federal Assistance Reporting Checklist. On a quarterly basis, Federal Assistance Program/Project Status Reports and financial Status Reports were prepared and submitted to DOE/NETL. TECO also committed

to supporting DOE project peer reviews and technical industry events to disseminate the benefits of the project.

The following table is a schedule of additional deliverables and key milestones associated with the project, based on a nominal start date of October 2009.

Milestones (DE-EE000730 / 003)

Milestone/Deliverable	Date
CHP System Final Design	COMPLETE PRIOR TO AWARD
CHP System Permitting	COMPLETE PRIOR TO AWARD
Project Kickoff Meeting/Scope Refinement	October 2009 (COMPLETE)
Revise Project Management Plan	October 2009 (COMPLETE)
Procure Long Lead Equipment	November 2009 (COMPLETE)
150 Day Go/No Go Decision Point	February 2010 (COMPLETE)
Equipment Delivery to Site	March 2010 (COMPLETE)
Equipment Installation Complete	December 2010 (COMPLETE)
Installed System Shakedown Complete	May 2011 (COMPLETE)
Full Scale System Verification Complete	December 2011 (COMPLETE)
Project Complete	December 2011 (COMPLETE)

FUNDING AND COSTING PROFILE

The following table shows, by budget period, the amount of government funding going to each project team member. The funding amounts are rounded to the nearest one thousand dollars. A detailed breakdown of the proposed government funding by task is provided in the Budget Justification section of this proposal.

Project Funding Profile

Team Member	Planned Government Funding
Year 1 (OCT 2009 – SEP 2010)	
TECO	\$8,000,000
Year 2 (OCT 2010 – DEC 2011)	
TECO	\$2,000,000
Total:	\$10,000,000

The following table projects, by month, the expenditure of government funds for the first budget period. The cost amounts are rounded to the nearest one thousand dollars. A detailed breakdown of the proposed government costs by task and annual budget period is provided in the Budget Justification section of this proposal.

Project Costing Profile

Year 1 - Months After Award	Planned Government Cost
------------------------------------	--------------------------------

Month 1	\$700,000
Month 2	\$700,000
Month 3	\$700,000
Month 4	\$700,000
Month 5	\$700,000
Month 6	\$700,000
Month 7	\$700,000
Month 8	\$700,000
Month 9	\$700,000
Month 10	\$700,000
Month 11	\$500,000
Month 12	\$500,000

PROJECT TIMELINE

The schedule shows the start dates and end dates for each task and interdependencies between tasks.

**TECO Combined Heat and Power Project
Schedule of Project Activities (DE-FOA-0000044)**

Task	Description	Months After Start of Project																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Project Management and Planning	[Gantt bars for sub-tasks 1.1-1.4]																	
	1.1 Maintain Project Management Plan	[Gantt bar from month 1 to 16]																	
	1.2 Environmental and Regulatory Compliance	COMPLETE (Note 1)																	
	1.3 Execution of Required Financial Agreements	COMPLETE (Note 1)																	
	1.4 Prepare Reports and Briefings	[Gantt bars from month 3-4, 6-7, 9-10, 12-13, 15-16]																	
2	Procurement of Equipment, Controls, and Ancillary Supplies	[Gantt bar from month 1 to 4]																	
3	Installation and Integration	[Gantt bar from month 3 to 12]																	
4	Commissioning, Shakedown, and Start-up	[Gantt bar from month 11 to 13]																	
5	Operational Data Collection	[Gantt bar from month 13 to 16]																	

Notes

1. Project final design was completed in early 2009. TECO non-federal cost share financing already in place.

SUCCESS CRITERIA AT DECISION POINTS

The following table summarizes the success criteria for the proposed project in the form of expected outcomes and associated measures and critical decision points. These criteria will enable TECO and the project team to evaluate progress towards and accomplishment of project objectives. These criteria are specific, observable, measurable, and attainable.

Expected Project Outcomes	Measures	Timeframe Outcomes/Decision Points
<p>1) Safe and effective installation and demonstration of a high efficiency district energy system</p>	<ul style="list-style-type: none"> • Safety – Zero recordable injuries • Schedule – Milestones achieved as outlined above and commercial operation achieved by December 2011 • Cost – Procurement and installation costs tracked continuously against project management Funding and Costing profile; Final Total Installed Cost (TIC) under proposed budget • Reliability – Vertical start-up and successful system commissioning; system performance and efficiency targets achieved • Environmental – 100% compliance with emission targets • Performance – System energy efficiency exceeds 78% 	<p><u>End of Year 1 (Oct 2010)</u></p> <ul style="list-style-type: none"> • Procurement complete. • Installation complete. • Go/No-Go Decision at 150 Days. <p><u>End of Year 2 (Dec 2011)</u></p> <ul style="list-style-type: none"> • System shakedown and commissioning complete. • CHP system fully operational. • 3-month system demonstration complete.
<p>2) Contribute to the creation and preservation of domestic jobs</p>	<ul style="list-style-type: none"> • Estimated 1,069 domestic engineering, manufacturing and construction jobs created 	<p><u>End of Year 1</u></p> <ul style="list-style-type: none"> • Periodic documentation of jobs created per ARRA guidance. • Documentation of total jobs created by October 2010. <p><u>End of Year 2</u></p> <ul style="list-style-type: none"> • Periodic documentation of jobs created per ARRA guidance. • Documentation of jobs created by December 2011.