Offer and Acceptance

SOLICITATION NO.: ADSPO16-00005912 Request for Qualifications: 2016 Annual Professional Services List

PAGE 1 OF 1

Offeror: Energy Environment Economics, LLC

State of Arizona
State Procurement Office
100 N. 15th Ave. Suite 201
Phoenix, AZ 85007

OFFER

TO THE STATE OF ARIZONA:

The Undersigned hereby offers and agrees to furnish the material, service or construction in compliance with all terms, conditions, specifications and amendments in the Solicitation and any written exceptions in the offer. Signature also certifies Small Business status.

ENERGY-ENVIRONMENT-ECONOMICS INC.
Company Name

18818 N. 34th WAY
Address

PHX AZ 85050
City State Zip

ethree1@cox.net
Contact Email Address

Signature of Person Authorized to Sign Offer

MICHAEL LEDBETTER
Printed Name

PRESIDENT
Title

Phone: 602 570 4886

Fax: N/A

By signature in the Offer section above, the Offeror certifies:

1. The submission of the Offer did not involve collusion or other anticompetitive practices.
2. The Offeror shall not discriminate against any employee or applicant for employment in violation of Federal Executive Order 11246, State Executive Order 2009-9 or A.R.S. §§ 41-1461 through 1465.
3. The Offeror has not given, offered to give, nor intends to give at any time hereafter any economic opportunity, future employment, gift, loan, gratuity, special discount, trip, favor, or service to a public servant in connection with the submitted offer. Failure to provide a valid signature affirming the stipulations required by this clause shall result in rejection of the offer. Signing the offer with a false statement shall void the offer, any resulting contract and may be subject to legal remedies provided by law.
4. The Offeror certifies that the above referenced organization ✓ IS/ ___ IS NOT a small business with less than 100 employees or has gross revenues of $4 million or less.

ACCEPTANCE OF OFFER

The Offer is hereby accepted.

The Contractor is now bound to sell the materials or services listed by the attached contract and based upon the solicitation, including all terms, conditions, specifications, amendments, etc., and the Contractor's Offer as accepted by the State.

This Contract shall henceforth be referred to as Contract No. ADSPO16-00005912.

The effective date of the Contract is March 1, 2016.

The Contractor is cautioned not to commence any billable work or to provide any material or service under this contract until Contractor receives purchase order, contact release document or written notice to proceed.

State of Arizona Awarded this 29 **day of** February **20** 16

Procurement Officer

DEFINITIONS

Architect Services, Engineer Services, Land Surveying Services, Assayer Services, Geologist Services and Landscape Architect Services: Those professional services within the scope of the practice of those services as provided in ARS § 32-101.

Branch Office: A geographically distinct place of business or subsidiary office of a firm that has a key role on the team.

Discipline: Primary technical capabilities of key personnel, as evidenced by academic degree, professional registration, certification, and/or extensive experience.

Firm: Defined in ARS § 32-101(B.19.).

Key Personnel: Individuals who will have major contract responsibilities and/or provide unusual or unique expertise.

SPECIFIC INSTRUCTIONS:

1 . Complete this form for each branch office seeking work under this RFQ.

a . – e. **Firm (or Branch Office) Name and Address.** Self-explanatory.

f. **Year Established**. Enter the year the firm (or branch office, if appropriate) was established under the current name.

g. **Ownership**.

(g1). *Type*. Enter the type of ownership or legal structure of the firm (sole proprietor, partnership, corporation, joint venture, etc.).

(g2). *Small Business Status*. A firm is a small business if the firm has less than 100 employees **or** has gross revenues of $4 million or less.

h.-j. **Point of Contact**. Provide this information for a representative of the firm that the Customer can contact for additional information. The representative must be empowered to speak on contractual and policy matters.

k. **Name of Firm**. Enter the name of the firm.

2. **Employees by Discipline**.

a. Select disciplines from the List of Disciplines (Function Code) listed on Page 3 of 4 Instructions. For employees that do not qualify for any of the disciplines, select "Other". *Note: The intended searchable database indicated in the RFQ will be populated from the Qualifications Form I Excel attachment only.*

b. Each person can be counted only twice; once for his/her primary function and once for his/her secondary function. Primary and secondary functions should be indicated by including a "P" or an "S" in column b after the Description Title is given.

c-d. If the form is completed for a firm (including all branch offices), enter the number of employees by disciplines in column c. If the form is completed for a branch office, enter the number of employees by discipline in column d and for the firm in column c.

3. **Profile of Firm's Experience and Annual Average Revenue for Last Year**.

a. Enter the approximate number of projects the firm (or branch) has done attributable by Profile Code listed on Page 3 of 4 Instructions over the last year.

b. Enter the appropriate Profile Codes from Instructions Pages 3 of 4 that represent the type of work the firm (or branch) has done over the last year.

c. Using the Revenue Index Number on Page 3 of 6 Form, indicate the approximate revenue the firm has earned over the last year per Profile Code entered into the table.

4. **Resumes of Key Personnel Proposed for This Contract.** Complete this section for each key person who will participate in this contract.

   a. Self-explanatory.
   b. Self-explanatory
   c. Total years of relevant experience (block c1), and years of relevant experience with current firm, but not necessarily the same branch/office (block c2).
   d. Name, City and State of the firm where the person currently works, which must correspond with one of the firms (or branch office or a firm, if appropriate) listed in Section 1.
   e. Provide information on the highest relevant academic degree(s) received. Indicate the area(s) of specialization for each degree.
   f. Provide information on current relevant professional registration(s) and in which State(s) they are current.
   g. Provide information on any other professional qualifications relating to this contract, such as education, professional registration, publications, organizational memberships, certifications, training, awards, and foreign language capabilities.
   h. Provide information on no more than five (5) projects in the last year which the person had a significant role that demonstrates the person's capability relevant to her/his proposed role in this contract. These projects do not necessarily have to be any of the projects presented in Section 5 for the project team if the person was not involved in any of those those projects or the person worked on other projects that were more relevant than the team projects in Section 5. Use the check box provided to indicate if the project was performed with any office of the current firm. If any of the professional services or construction projects are not complete, leave Year Completed blank and indicate the status in Brief Description and Specific Role.

5. **Example Projects Which Best Illustrate Firms Qualification for this contract.** Select project where multiple team members worked together, if possible, that demonstrate the team's capability to perform work similar to that required for this contract. Complete one Section 5 for each project. List no more than five (5) projects.

   a. Title and Locations of project or contract. For an indefinite delivery contract, the location is the geographic scope of the contract.
   b. Enter the year completed of the professional services (such as planning, engineering study, or design), and/or the year completed if construction. If any of the professional services or the construction projects are not complete, leave Year Completed blank and indicate the status in Brief Description of Project and Relevance to This Contract (block f).
   c. Project Owner or user, such as a government agency or installation, an institution, a corporation or private individual.
   d. Provide the original budget or not to exceed dollar amount for the project.
   e. Provide the Total Cost of the Project. If any of the professional services or construction projects is not complete, indicate the percentage compete and whether this project will be on budget, over or under budget.
   f. Brief Description: Indicate scope, size, and length of project, principle elements and special features of the project. Discuss the relevance of the example project to this contract.

6. **Additional Information**. Use this section to provide additional information you feel may be necessary to describe your firm's qualifications for this contract.

7. **Annual Average Professional Services Revenues of Firm for Last 3 Years**. Complete this block for the firm or branch office for which this form is completed. In column a, enter an approximate percentage of total work attributable to State, Federal or Municipal Work. In column b, enter an approximate percentage of total work attributable to Non-Government work. Percentages should take into consideration work completed over the last 3 years.

8. **Authorized Representative**. An authorized representative of the firm or branch office must sign and date the completed form. Signing attests that the information provided is current and factual. Provide the name and title of the authorized representative who signed the form.

List of Disciplines (Function Codes) for Question 2

Aeronautical Engineer
Agricultural Engineer
Archeologist
Architect
Architectural Engineering
Biologist
CADD Technician
Chemical Engineer
Civil Engineer
Construction Manager
Construction Inspector
Control Systems Engineer
Cost Engineer/Estimator
Ecologist
Electrical Engineer
Environmental Engineer
Environmental Scientist
Fire Protection Engineer
Geodetic Surveyor
Geographic Information System Specialist
Geological Engineer
Geologist
Hydrographic Surveyor
Hydraulic Engineer
Hydrologist
Industrial Engineer
Landscape Architect
Mechanical Engineer
Metallurgical Engineer
Mining Engineer
Nuclear Engineer
Petroleum Engineer
Photogrammetrist
Project Manager
Sanitary Engineer
Soils Engineer
Structural Engineer
Technician/Analyst
Transportation Engineer
Water Resources Engineer

List of Experience Categories (Profile Codes for Question 3)

Acoustics, Noise Abatement
Aerial Photography; Airborne Data and Imagery Collection and Analysis
Activity Centers
Air Pollution Control
Airports; Navaids; Airport Lighting; Aircraft Fueling
Airports; Terminals and Hangars; Freight Handling
Agricultural Development; Grain Storage; Farm Mechanization
Animal Facilities
Anti-Terrorism/Force Protection
Area Master Planning
Auditoriums and Theaters
Automation; Controls; Instrumentation
Barracks; Dormitories
Bridge Design: Bridges
Cartography
Cemeteries *(Planning and Relocation)*
Chemical Processing and Storage
Child Care/Development Facilities
Codes; Standards; Ordinances
Cold Storage; Refrigeration and Fast Freeze
Commercial Building *(Low Rise)*; Shopping Centers
Community Facilities
Communications Systems; TV; Microwave
Computer Facilities
Conservation and Resource Management
Construction Management
Construction Surveying
Corrosion Control; Cathodic Protection Electrolysis
Cost Estimating; Cost Engineering and Analysis; Parametric Costing; Forecasting
Cryogenic Facilities
Construction Materials Testing
Dams *(Concrete; Arch)*
Dams *(Earth; Rock)*; Dikes; Levees
Desalinization *(Process and Facilities)*
Design-Build - Preparation of Requests for Proposals
Digital Elevation and Terrain Model Development
Digital Orthophotography
Dining Halls; Clubs; Restaurants
Dredging Studies and Design
Design & Planning Structured Parking Facilities
Detention Security Systems
Disability / Special Needs
Ecological and Archeological Investigations
Educational Facilities; Classrooms
Electrical Studies and Design
Electronics
Elevators; Escalators; People-Movers
Energy / Water Auditing Savings
Energy Conservation; New Energy Sources
Environmental Impact Studies, Assessments or Statements
Fallout Shelters; Blast-Resistant Design
Fire Protection
Fisheries; Fish Ladders
Forensic Engineering
Garages; Vehicles Maintenance Facilities; Parking
Gas Systems *(Propane; Natural, Etc.)*
Geodetic Surveying: Ground and Airborne
Heating; Ventilating; Air Conditioning
Highways; Streets; Airfield Paving; Parking Lots
Historical Preservation
Hospital and Medical Facilities
Hotels; Motels
Housing (Residential, Multi-Family; Apartments; Condominiums)

Hotels; Motels
Hydraulics and Pneumatics
Hydrographic Surveying
Industrial Buildings; Manufacturing Plants
Industrial Processes; Quality Control
Industrial Waste Treatment
Intelligent Transportation Systems
Infrastructure
Irrigation; Drainage
Judicial and Courtroom Facilities
Laboratories; Medical Research Facilities
Land Surveying
Landscape Architecture
Libraries; Museums; Galleries
Lighting *(Interior; Display; Theater, Etc.)*
Lighting *(Exteriors; Streets; Memorials; Athletic Fields, Etc.)*
Labs - General
Labs – Research – Dry
Labs – Research – Wet
LEED Accredited A/E
LEED Independent 3rd Party Building Commissioning
Mapping Location/Addressing Systems
Materials Handling Systems; Conveyors; Sorters
Metallurgy
Materials Testing
Measurement / Verification / Conservation Water Consumption Savings
Mining and Mineralogy
Medical Related
Modular Systems Design; Fabricated Structures or Components
Mold Investigation
Museums
Nuclear Facilities; Nuclear Shielding
Office Buildings; Industrial Parks
Outdoor Recreation
Petroleum and Fuel *(Storage and Distribution)*
Photogrammetry
Pipelines *(Cross-Country - Liquid and Gas)*
Phase I Environmental
Prisons & Correctional Facilities
Plumbing and Piping Design
Prisons and Correctional Facilities
Product, Machine Equipment Design Pneumatic
Structures, Air-Support Buildings Power Generation,
Transmission, Distribution Public Safety Facilities
Radar; Sonar; Radio and Radar Telescopes
Radio Frequency Systems and Shielding's
Railroad; Rapid Transit
Recreation Facilities *(Parks, Marinas, Etc.)*
Refrigeration Plants/Systems
Rehabilitation *(Buildings; Structures; Facilities)*
Research Facilities
Resources Recovery; Recycling
Roof Infrared Imaging to Identify Water Leaks
Roofing
Safety Engineering; Accident Studies; OSHA Studies
Security Systems; Intruder and Smoke Detection
Seismic Designs and Studies
Sewage Collection, Treatment and Disposal
Soils and Geologic Studies; Foundations
Solar Energy Utilization
Solid Wastes; Incineration; Landfill
Special Environments; Clean Rooms, Etc.
Structural Design; Special Structures
Surveying; Platting; Mapping; Flood Plain Studies
Sustainable Design
Swimming Pools
Storm Water Handling and Facilities
Specifications Writing
Toxicology
Testing and Inspection Services
Traffic and Transportation Engineering
Topographic Surveying and Mapping
Towers *(Self-Supporting and Guyed Systems)*
Tunnels and Subways
Traffic Studies
Transportation
Urban renewals; Community Development
Utilities *(Gas and Steam)*
Value Analysis; Life-Cycle Costing
Warehouse and Depots
Water Resources; Hydrology; Ground Water
Water Supply; Treatment and Distribution
Wind Tunnels; Research/Testing Facilities Design
Waste Water Treatment Facility
Water Well Rehabilitation; Water Well Work
Zoning; Land Use Studies

(If a firm has branch offices, complete for each specific branch office seeking work.)

1. ***Annual Request for Qualifications***

a. FIRM (OR BRANCH OFFICE) NAME:	Energy-Environment-Economics, L.L.C.
b. FIRM (OR BRANCH OFFICE) STREET:	18818 N. 34th Way
c. FIRM (OR BRANCH OFFICE) CITY:	Phoenix
d. FIRM (OR BRANCH OFFICE) STATE:	Arizona
e. FIRM (OR BRANCH OFFICE) ZIP CODE:	85050

f. YEAR ESTABLISHED:	1999

(g1). OWNERSHIP - TYPE:	L.L.C.
(g2) OWNERSHIP - SMALL BUSINESS STATUS:	Small Business

h. POINT OF CONTACT NAME AND TITLE:	Michael Ledbetter, P.E.
i. POINT OF CONTACT TELEPHONE NUMBER:	602-570-4886
j. POINT OF CONTACT E-MAIL ADDRESS:	Ethree1@cox.net

k. NAME OF FIRM *(If block 1a is a branch office)*:	

2. EMPLOYEES BY DISCIPLINE

a. Discipline Title	b. Function: Primary (P) or Secondary (S)	c. No. of Employees - Firm	d. No. of Employees - Branch
Mechanical Engineer	P	2	
Electrical Engineer	P	1	
Total	3		

3. PROFILE OF FIRM'S EXPERIENCE AND ANNUAL AVERAGE REVENUE FOR LAST YEAR

a. Approximate No. of Projects	b. Experience	c. Revenue Index Number *(see below)*
9	Energy (resource) conservation and management	3
1	Construction Management	1
8	HVAC Engineering	1
7	LEED Independent 3rd Party Building Commissioning	3
8	Energy (resource) conservation and management	3

PROFESSIONAL SERVICES REVENUE INDEX NUMBER

1. Less than $100,000
2. $100,000 to less than $250,000
3. $250,000 to less than $500,000
4. $500,000 to less than $1 million
5. $1 million to less than $2 million
6. $2 million to less than $5 million
7. $5 million to less than $10 million
8. $10 million to less than $25 million
9. $25 million to less than $50 million
10. $50 million or greater

4. Resumes of Key Personnel Proposed for this Contract (*Complete one Section #4 for each key person.*)

a. NAME	b. ROLE IN THIS CONTRACT	c. YEARS EXPERIENCE	
D. Michael Ledbetter, P.E.	Engineer in Charge	1. TOTAL 30	2. WITH CURRENT FIRM 16

d. LOCATION *(City and State) Phoenix, Az.*

e. EDUCATION *(DEGREE AND SPECIALIZATION)*	f. PROFESSIONAL TRAINING - REGISTRATIONS
B.S.M.E. Texas Tech University 1987	*#41041 State of Arizona, Mechanical*

g. OTHER PROFESSIONAL QUALIFICATIONS *(Organizations, Awards, etc.)*

Specialization in HVAC Systems Analysis and Design. Expert in HVAC Control Systems, Commissioning and Optimization of Commercial and Industrial HVAC Systems. Energy conservation (HVAC) expert,

H. RELEVANT PROJECTS

1.

(1) TITLE AND LOCATION *(City and State)*
R.R. Donnelley, Phoenix, AZ.

(2) YEAR COMPLETED 2015

Professional Services Engineering Analysis, Design, Commissioning and Optimization services

Construction (if applicable)

3) BRIEF DESCRIPTION *(Brief scope, size, cost, etc.)* AND SPECIFIC ROLE

X Check if project performed with current firm

EIC. Energy-Environment-Economics provided a detailed engineering study and report of the HVAC System's current (existing) condition and operation including: HVAC system design and DDC system deficiencies, potential energy conservation opportunities with budgeted project costs and economic analysis, and maintenance related operational and efficiency analysis. The result of this study became an approximately $500,000 Energy Conservation Project including Retro-Commissioning and Optimissioning^{SM} - a combination of HVAC system commissioning and optimization - of the facility. The project included the engineering required for the modernization and automation of the chilled water central plant, air distribution system, and DDC system complete. Also, project coordination and test & balance services were provided in addition to the commissioning and optimization services provided. The project was completed under the auspices of and in partnership with APS and resulted in energy savings of approximately $100,000/year and qualified for a rebate of approximately $110,000.

2.

(1) TITLE AND LOCATION *(City and State)*
AZ Heart Hospital, Phoenix, AZ.

(2) YEAR COMPLETED 2004

Professional Services Engineering Analysis, Design, Commissioning and Optimization services

Construction (if applicable)

(3) BRIEF DESCRIPTION *(Brief scope, size, cost, etc.)* AND SPECIFIC ROLE

X Check if project performed with current firm

EIC. *Energy-Environment-Economics* provided a detailed study and report of the HVAC System's existing conditions and operations including design and DDC system deficiencies, potential energy conservation opportunities with budgeted project costs and economic analysis, and maintenance related operational and efficiency analysis. The result of this study became an approximately $1,800,000 HVAC system redesign and modifications for the facility, including construction document preparation, commissioning and Optimissioning^{SM} of the entire facility. The central plant was converted to direct variable primary and a new plate/frame heat exchanger was installed. Fire/smoke dampers were replaced throughout the facility to shift the system curve so the air handling units could deliver the required airflows. Existing inlet guide vanes were removed and replaced with variable frequency drives. Airflow measuring stations were added among other measures to get positive control of the outside air quantities provided. DDC algorithms were completely rewritten and optimized. The entire scope of work was performed without shutting down the hospital.

3.

(1) TITLE AND LOCATION *(City and State)*
AZ DEMA – WAATS CMSB – L4525, Marana, AZ.

(2) YEAR COMPLETED 2003

Professional Services Engineering Analysis, Design, Commissioning and Optimization services

Construction (if applicable)

(3) BRIEF DESCRIPTION *(Brief scope, size, cost, etc.)* AND SPECIFIC ROLE

X Check if project performed with current firm

EIC. Energy-Environment-Economics provided a detailed engineering study and report on the HVAC System's current (existing) condition and operation including: HVAC system design and DDC system deficiencies, potential energy conservation opportunities with budgeted project costs and economic analysis, and maintenance related operational and efficiency analysis. The result of this study became an approximately $500,000 Energy Conservation Project, including Retro-Commissioning and OptimissioningSM - a combination of HVAC system commissioning and optimization - of the facility. The project included the engineering required for the repair, modernization and automation of the chilled water central plant, the air distribution system, and the critical Data Rooms' HVAC components.

4.	(1) TITLE AND LOCATION *(City and State)* ***AZ DEMA – WAATS Administration/Flight Training/Dorms – L4500, Marana, AZ.***	(2) YEAR COMPLETED 2014 Professional Services Retro-Commissioning	Construction (if applicable)
	(3) BRIEF DESCRIPTION *(Brief scope, size, cost, etc.)* AND SPECIFIC ROLE EIC. Complete Retro-Commissioning (RCx) of the HVAC and DDC systems. VAV boxes were re-calibrated; all sequences of operation developed and installed in 2010 (see below) were functional performance tested and corrected as needed, and critical system setpoints re-established. Existing deficiencies were reported and recommendations for improved system performance was provided in the detailed final RCx Repot.	X Check if project performed with current firm	
5.	(1) TITLE AND LOCATION *(City and State)* ***JCNTF Building, PPMR (National Guard) Phoenix, AZ***	(2) YEAR COMPLETED 2012 Professional Services Engineering Analysis, Design, Commissioning and Optimization services	Construction (if applicable)
	(3) BRIEF DESCRIPTION *(Brief scope, size, cost, etc.)* AND SPECIFIC ROLE EIC. HVAC system redesign and modernization including the central plant, air distribution system, and control system. Central plant converted to variable primary, chilled water coils replaced with higher capacities to extend use of new plate/frame heat exchanger, pneumatic control system replaced with DDC system, VAV boxes replaced with pressure independent type. Entire system was Commissioned and Optimized by *Energy-Environment-Economics$_{LLC}$*. Total project cost was approximately 400,000$.	X Check if project performed with current firm	

4. Resumes of Key Personnel Proposed for this Contract (*Complete one Section 4 for each key person.)*

a. NAME	b. ROLE IN THIS CONTRACT	c. YEARS EXPERIENCE	
Tripp Armstrong, B.S.E.E.	Electrical/Controls Engineer	1. TOTAL 24	2. WITH CURRENT FIRM 9

d. LOCATION *(City and State) Phoenix, Az.*

e. EDUCATION *(DEGREE AND SPECIALIZATION)*	f. PROFESSIONAL TRAINING - REGISTRATIONS
B.S.E.E. Arizona State University 1988	

g. OTHER PROFESSIONAL QUALIFICATIONS *(Organizations, Awards, etc.)*
Specialization in HVAC Controls Systems and DDC System Design, Expertise in Commissioning and troubleshooting of DDC Systems

4. Resumes of Key Personnel Proposed for this Contract (*Complete one Section 4 for each key person.)*

a. NAME	b. ROLE IN THIS CONTRACT	c. YEARS EXPERIENCE	
Brad Hindes, B.S.M.E.	HVAC Equipment Application Engineer	1. TOTAL 35	2. WITH CURRENT FIRM 7

d. LOCATION *(City and State) Phoenix, Az.*

e. EDUCATION *(DEGREE AND SPECIALIZATION)*	f. PROFESSIONAL TRAINING - REGISTRATIONS
B.S.M.E. Texas Tech University 1988	

g. OTHER PROFESSIONAL QUALIFICATIONS *(Organizations, Awards, etc.)*
Specialization in HVAC Systems Equipment and Control Systems, Commissioning Commercial and Industrial HVAC equipment. HVAC equipment application expert.

5. EXAMPLE PROJECTS WHICH BEST ILLUSTRATE PROPOSED TEAM'S QUALIFICATIONS FOR THIS CONTRACT *(Present no more than five (5) projects. Complete one Section 5 for each project.)*		
a. TITLE AND LOCATION *(City and State)*	b. YEAR COMPLETED	
	PROFESSIONAL SERVICES	CONSTRUCTION *(If applicable)*
RR Donnelley, Phoenix, Az.	2015	2015

23. PROJECT OWNER'S INFORMATION		
c .PROJECT OWNER Ed Ray	d .ORIGINAL BUDGET/NTE AMOUNT OF PROJECT 375,000	e. TOTAL COST OF PROJECT 375,000

f. BRIEF DESCRIPTION OF PROJECT AND RELEVANCE TO THIS CONTRACT (include scope, size, and length of project)

R.R. Donnelley, Phoenix, AZ.

Building Description

The 50,000 square feet of building operates 24/7 as a repository of promotional, financial and marketing reports that are distributed for printing (publishing). The facility originally operated as a printer for these materials, and the new role necessitated widespread changes to the original floor plans. Constructed in 1986, all of the original HVAC equipment – with the exception of a new chiller installed in 2006 – was original.

The HVAC system consists of:

- The central plant includes two water chillers with associated pumps and cooling towers, and is primary-secondary pumped and piped. The secondary pumps and the cooling tower fans are all equipped with variable frequency drives.
- There is a hydronic plate/frame heat exchanger to provide "free" cooling during the appropriate ambient conditions.
- 11 central station air handling units, most of which are VAV and serve the VAV boxes in the office/training areas.
- Complete direct digitally controlled energy management system (EMS).

Project Problems/Issues

- The entire energy management system was inoperative.
- Central plant pumping was poorly designed and unnecessarily wasteful.
- The new variable frequency drive equipped chiller would not operate with normal condenser water temperatures.
- Inability to utilize the existing waterside economizer
- Extremely high utility costs

Project Overview

Energy-Environment-Economics provided a detailed engineering study and report on the HVAC System's current (existing) condition and operation including: HVAC system design and DDC system deficiencies, potential energy conservation opportunities with budgeted project costs and economic analysis, and maintenance related operational and efficiency analysis. The result of this study became an approximately $500,000 Energy Conservation Project, including Retro-Commissioning and Optimissioning^{SM} - a combination of HVAC system commissioning and optimization - of the facility. The project included the engineering required for the repair, modernization and automation of the chilled water central plant, the air distribution system, and the DDC energy management system complete. The project qualified for a substantial (approximately $110,000) APS energy rebate.

Solutions Provided

The study identified that the central plant was poorly designed and that the relatively new variable frequency drive equipped high efficiency chiller could not operate with normal condenser water temperatures. Also, all control valves, used to isolate chillers and/or cooling towers and initiate plate/frame operation, were not functional. As a result, all central plant operations were controlled manually by facility staff in response to occupant complaints or recent history. Also, the variable frequency drives serving the cooling towers and secondary pumps operated at full speed (60 Hz) at all times due to non-functioning chilled water control valves and chiller issues. To correct these issues, the following measures were implemented:

- The central plant was converted to direct variable flow and now uses one chilled water pump in lieu of two previously. A flow meter controlled supply-to-return bypass valve modulates at low flow conditions to maintain acceptable chiller flow rates. Also, the newly installed differential pressure transmitter controls the chilled water pump speed to match the loads/flows, further reducing pump HP.
- New software specifically intended for direct variable systems and to correct condenser water temperature issues was installed on the variable frequency drive equipped Carrier chiller.
- A new central plant controller to control pumps, cooling towers, variable frequency drives etc. was added. The best practice sequences of operations were installed and critical system setpoints were established as discussed in the Controls Analysis section of this report. Critical setpoints include:
    - Differential pressure setpoint for control of chilled water pump variable frequency drive speed.

- Chiller<>plate/frame WB temperature based reset schedule.
- Condenser water temperature DB temperature reset schedule.
- WB temperature based chiller supply water temperature reset schedule.

- The central plant was tested and balanced and all sequences of operations were functional performance tested and optimized for performance.

The air handling units are equipped with 100% outside air economizers but the damper actuators were not functional, and neither were the chilled water coil control valves. Facility staff manually opened/closed the control valves to adjust the supply air temperatures, resulting in unnecessarily low supply air temperature and requiring substantial VAV box electric reheat to satisfy the zone temperature setpoints. Outside air quantities were in no way representative of requirements, and were but another contributor to excessive energy consumption. Finally, the supply air fans were equipped with inlet guide vanes (original) to vary supply air quantities, but the actuators were not functional. The inlet guide vanes were therefore actually increasing energy use due to the additional pressure losses thru the vanes.

All of these deficiencies were corrected, including:

- New supply air fan variable frequency drives were installed, and new static pressure sensors were installed for control.
- The outside air damper actuators were replaced at all air handling units, and return air duct CO2 sensors were added to allow for demand controlled ventilation (DCV). Also, because the air handling unit are not equipped with a relief/return fan to relieve outside air when in economizer mode so as to maintain acceptable space pressure conditions, during the RCx of the air handling units maximum outside air damper positions were established for outside air economizing operation.
- New pressure independent chilled water control valves were installed.
- New air handling unit and VAV box controllers were installed, and best practices sequences were implemented including:
  - Supply air temperature and supply air static pressure reset schedules based upon greatest zone demand.
  - Enabling outside air economizing when ambient conditions permit.
  - Using outside air economizing to dehumidify high occupancy spaces when certain space and ambient conditions exist regardless of outside air economizing parameters.
  - Using CO2 sensors to control outside air flow rates to all occupied spaces.
- The entire air distribution system was tested and balanced (TAB) and Commissioned including functional performance testing of all components and calibration of all VAV boxes.

The original energy management system was in a total state of disrepair and providing no temperature control much less energy management. A completely new direct digitally controlled (DDC) energy management system was installed and state of the art control sequences were developed and installed. In several areas motion sensors were installed to control lighting and were integrated into the HVAC system to enable "mini-reset" schedules to be used during no occupancy periods when scheduled OCCUPIED. In general, the new DDC system included:

- Installed a new Automated Logic (ALC)/Easy IO DDC energy management system for all HVAC components and lighting systems where reasonable. New pressure independent chilled water control valves, new damper actuators, new air handling unit and VAV box controllers, and central plant control valves and controllers were provided.
- Each individual air delivery system was placed in a static (steady state) condition and all input and output points be Retro-Commissioned and recalibrated.
- Developed and installed new sequence of operations for the central plant, and Commission those sequences. The new sequences will include chilled water reset, optimized chiller < > heat exchanger modes, and a heat exchanger changeover temperature reset schedule.
- Commission the DP setpoint and all VAV air handling unit setpoints including supply air static resets to minimize pumping and air handling unit energy costs.
- Replaced the outside air temperature/humidity sensor used to calculate ambient wet-bulb and initiate plate/frame operation.
- Retro-Commission all VAV boxes and establish minimum damper positions.
- Established deck temperature reset schedules for all air handling units and supply air static pressure reset schedules for all VAV air handling units.
- Commission the static pressure setpoint for all VAV air handling units in conjunction with the replacement of the units using inlet guide vanes with variable frequency drives.
- New front-end graphics for the entire HVAC system were provided.

The magnitude of the project and the potential for energy savings were of interest to APS, and the entire process was conducted under their purview and guidelines to qualify for an owner incentivizing rebate. The rebate amount is conditional on the agreed upon energy savings potential, so the entire process is very stringent and regulated. The following tables (1 and 2) show actual utility data and then the computer simulated utility consumption for the pre-project (Baseline) conditions. A closely calibrated Baseline Model allows the proposed energy conservation measures to be accurately modeled for their impact on future energy use.

Table 1 Actual Utility Data – Average from 2011-2013

Billing Period	Total Charges ($)	Total Consumption (kWh)	Avg Price ($/kWh)
Jan	$13,142.78	170,133	0.1294
Feb	$13,286.37	164,533	0.1238
Mar	$14,399.16	181,733	0.1262
Apr	$15,364.19	199,067	0.1296
May	$19,091.52	202,533	0.1067
Jun	$20,399.01	210,933	0.1034
Jul	$22,458.98	237,067	0.1056
Aug	$21,420.97	226,267	0.1056
Sep	$21,368.70	224,800	0.1052
Oct	$20,284.16	216,267	0.1066
Nov	$16,270.40	207,333	0.1274
Dec	$14,708.05	188,933	0.1285
Totals	**$212,194.29**	**2,429,600**	**0.1145**

Table 2 Computer Simulation of Current Operations (2012 Baseline)

Billing Period	Total Charges ($)	Total Consumption (kWh)	Avg Price ($/kWh)
Jan	16,354	191,502	0.1171
Feb	14,387	168,460	0.1171
Mar	15,337	179,594	0.1171
Apr	14,778	173,041	0.1171
May	15,715	184,016	0.1171
Jun	16,357	191,540	0.1171
Jul	17,886	209,440	0.1171
Aug	17,520	205,158	0.1171
Sep	16,188	189,551	0.1171
Oct	15,405	180,385	0.1171
Nov	15,214	178,145	0.1171
Dec	16,538	193,652	0.1171
Totals	**$191,679**	**2,244,483**	**0.1171**

Numerous iterations of the Baseline Model resulted in a very closely calibrated model when compared to actual energy use. Table 3 below is the computer generated simulation for future energy use when all of the energy conservation measures were installed including:

- New facility wide energy management system: new controllers at all VAV boxes and air handling units; new zone sensors; new air and water temperature sensors; central plant controller; new differential pressure sensors; new WB temperature sensor; optimized sequences of operations with operating and reset schedules, changeover setpoint reset schedules and supply chilled water temperature reset schedule
- Central plant conversion to direct variable piping
- Automatic central plant control valves

- New pressure independent chilled water control valves
- New variable frequency drives at air handling units/cooling towers
- Demand controlled ventilation
- Lighting schedules, occupancy sensors used for disabling lights as well as utilizing zone "mini-reset" schedules during extended periods of inactivity during Occupied hours of operations.

The relevant number is the kWh saved because the total utility cost ($/kWh) will change over time. This analysis was verified and endorsed by APS and resulted in a rebate to the Owner of approximately $110,000. To date, the actual post project energy use closely mirrors the computer simulated usage shown in Table 3 below.

Table 3 Computer Simulated Projected (Future) Monthly Energy Costs

Billing Period	Total Charges ($)	Total Consumption (kWh)	Avg Price ($/kWh)
Jan	8,233	96,406	0.1171
Feb	7,410	86,763	0.1171
Mar	9,062	106,110	0.1171
Apr	9,441	110,555	0.1171
May	10,869	127,269	0.1171
Jun	12,227	143,173	0.1171
Jul	13,413	157,062	0.1171
Aug	12,985	152,043	0.1171
Sep	11,745	137,535	0.1171
Oct	10,044	117,606	0.1171
Nov	8,523	99,797	0.1171
Dec	8,528	99,862	0.1171
Totals	**$122,479**	**1,434,181**	**0.1171**

5. EXAMPLE PROJECTS WHICH BEST ILLUSTRATE PROPOSED TEAM'S QUALIFICATIONS FOR THIS CONTRACT

(Present no more than five (5) projects. Complete one Section 5 for each project.)

a. TITLE AND LOCATION *(City and State)*	b. YEAR COMPLETED	
	PROFESSIONAL SERVICES	CONSTRUCTION *(If applicable)*
JCNTF Building, Phoenix, Az.	2012	2012

23. PROJECT OWNER'S INFORMATION

c .PROJECT OWNER	d .DOLLAR AMOUNT OF PROJECT	e. TOTAL COST OF PROJECT
DEMA – WAATS – Jeff Seaton	$105,000	$521,000

f. BRIEF DESCRIPTION OF PROJECT AND RELEVANCE TO THIS CONTRACT (include scope, size, and length of project)

JCNTF Building, PPMR (National Guard)

Building Description

Located in Phoenix, AZ., the JCNTF facility consists of approximately 50,000 square feet square feet. It appears that the original HVAC system was designed to the highest energy efficiency standards and capabilities available circa 1977. The system incorporated renewable energy sources in addition to these cutting edge efficiency technologies. However, the system has fallen into disrepair, perhaps due to the inability of the original pneumatic control system to manage such a complex HVAC system. The pneumatic controls are completely inoperable at this time, so it should come as no surprise that numerous supplemental heating/cooling units – ductless "mini" split systems – have been installed throughout the facility.

Project Overview

Central Plant Scope of Work:

A new cooling tower (as specified and scheduled) was provided and installed, a new plate/frame heat exchanger (as specified and scheduled was provided and installed, a new chilled water pump and a new condenser water pump (as specified and scheduled) were provided and installed, new central plant control valves (provided by the controls contractor, installed by the mechanical contractor) were installed, and new variable frequency drives (provided by the controls contractor, controls contractor installed)) were installed for the new cooling tower and chilled water pump as shown on the construction documents. To accomplish this work required:

1. A chilled water system shutdown and subsequent demolition of the existing cooling tower and piping, demolition of the existing chilled water and condenser water pumps and piping, and demolition of the existing chilled water and hot water piping coil connections serving air handling units #1-3.

2. Installation of the new cooling tower including all required piping, installation of the new chilled water and condenser water pumps complete with piping and accessories as detailed, installation of the new plate/frame heat exchanger including all piping and controls contractor furnished control valves, and installation of the new hot water and chilled water piping and controls contractor furnished control valves serving air handling units #1-3. NOTE: Refer to Air Distribution System Scope of Work for coordination requirements of piping work required and related chilled water coil replacement work required.

3. Pipe hangers shall be installed as required for support of the new plate/frame heat exchanger piping. All disturbed chilled water piping insulation shall be repaired to match existing insulation. All new chilled water piping, pump accessories and control valves shall be insulated to match the existing insulation.

4. The existing cooling tower, pumps and associated piping shall be removed as shown on the construction documents.

5. New cooling tower, pumps, plate/frame heat exchanger, control valves, variable frequency drives, and associated piping shall be installed as detailed on the construction documents.

Air Distribution System Scope of Work:

Install new chilled water coils (as specified and scheduled) one each for the three existing air handling unit chilled water coils to be replaced. Air handling unit chilled water coils must comply with the specific dimensional requirements as required by the physical size and installation requirements of the existing

Carrier air handling units. Also, the existing VAV boxes shall be removed and replaced with new pressure independent, single duct VAV boxes as shown on the construction documents. Finally, the existing sir-to-air heat exchangers serving the air handling units and associated ductwork is to be removed. Refer to the construction documents for specific requirements. To accomplish this work will require:

6. Replace the existing chilled water coils at air handling unit #1-3 with new chilled water coils as specified and scheduled. Ideally, this work would be done in conjunction with the new chilled water and hot water coil piping complete with new control valves (controls contractor furnished, mechanical contractor installed) and accessories as shown on the construction documents.

7. Remove and replace air handling unit sections and existing ductwork as required to provide sufficient access for coil removal and coil installation.

8. Remove existing VAV boxes and install new VAV boxes as specified and scheduled. Contractor bidders should expect that some inlet (primary) air connection transition to the new VAV box will be required. VAV boxes and hot water piping packages (if required) shall be supported and hung per manufacturer's recommendations and all applicable Codes.

9. Remove air-to-air heat exchangers as shown, cap and provide insect screens as shown on the construction documents.

10. Provide a general and thorough "clean-up" of the air handling units including power washing of the air handling units and existing hot water coils, new fan motor belts, sheaves and new filters.

DDC Scope of Work

The scope of the DDC work required for this project included:

1. Provide main and control power to the twenty-three (23) new VAV boxes provided by the controls contractor and installed by the mechanical contractor in the facility. Provide the necessary programming and graphics to incorporate the new VAV boxes into new sequences of operations.

2. Provide new modulating motorized control valves (installed by the mechanical contractor) in the central plant and provide control power. Provide the necessary programming and graphics to incorporate the new valves into the new DDC sequences of operations.

3. Provide new chilled water (3 total) control valves and new hot water (3 total) control valves serving air handling units #1-3 to be installed by the mechanical contractor. Valves shall be pressure independent type. Install new DDC system communication wire to all new valves. Terminate new control valves as required.

4. Install new DDC system communication wire to all air handling units, chiller, cooling tower, pumps, VAV boxes and associated control valves.

5. Provide and install five new variable frequency drives for the three air handling units, new chilled water pump, and new cooling tower including main and control power and disconnecting means requirements.

6. Provide and install three new premium efficiency (inverter duty) fan motors at each air handling unit (3 total).
7. Provide and install new temperature (air and water) sensors serving the central plant and at the air handling units and VAV boxes as shown on the construction documents; provide and install new outside air temperature sensor and humidity sensor used for wet-bulb calculation. Integrate all new devices into the new DDC system and new sequences of operations.

8. Provide the necessary programming to support revised central plant/air handling unit sequences of operations as developed by the Optimissioning^{SM} team. Provide all updates to front-end graphics.

Solutions Provided

Energy-Environment-Economics provided a detailed engineering analysis and report of the HVAC System's existing conditions and operations including original design and DDC system deficiencies, potential energy conservation opportunities with budgeted project costs, economic analysis, and maintenance related operational and efficiency analysis. The result of this study became an approximately $800,000 HVAC system redesign and modifications for the facility, with *Energy-Environment-Economics*$_{LLC}$ providing Design (Construction) Document preparation, Commissioning and Optimissioning^{SM} services for the entire facility. The designed and implemented renovations and energy conservation measures has resulted in a fully functional and highly efficient HVAC system that has eliminated the need for the previously existing ductless split systems and reduced the facility's total energy costs by approximately 33%.

5. EXAMPLE PROJECTS WHICH BEST ILLUSTRATE PROPOSED TEAM'S QUALIFICATIONS FOR THIS CONTRACT

(Present no more than five (5) projects. Complete one Section 5 for each project.)

a. TITLE AND LOCATION *(City and State)*	b. YEAR COMPLETED	
	PROFESSIONAL SERVICES	CONSTRUCTION *(If applicable)*
Az Heart Hospital, Phoenix, Az.	2004	2004

23. PROJECT OWNER'S INFORMATION		
c .PROJECT OWNER	d .DOLLAR AMOUNT OF PROJECT	e. TOTAL COST OF PROJECT
Arizona Heart Hospital	$455,000	$1,800,000

f. BRIEF DESCRIPTION OF PROJECT AND RELEVANCE TO THIS CONTRACT (include scope, size, and length of project)

Arizona Heart Hospital

Building Description

The facility is a 54-bed heart hospital with four operating theaters; Cath and diagnostic labs, ICU, CCU, and an around the clock emergency room serviced by air and ground transportation. The facility is approximately 160,000 square feet multi-story (basement and two floors above grade) building. The heating, ventilating and air conditioning (HVAC) system consists of:

- Constant flow chilled water/hot water systems including 2 parallel piped water cooled water chillers, approximately 320 tons each.
- 8 central station air-handling units, all of which equipped for variable volume (VAV) using either variable frequency drives or inlet guide vanes, all having both supply and return fans and 100% outside air economizer capabilities.
- Approximately 240 constant and variable volume boxes, most with reheat coils.
- Complete direct digitally controlled Energy Management System (EMS).

Project Problems/Issues

- Inability to satisfy all of the facility's temperature, humidity requirements, including ICU areas due to original HVAC system design and installation
- Space pressure problems, i.e. pressures between sterile areas inverse from required
- Questionable design practices
- Risk management and regulatory agency compliance issues due to the above
- Excessive utility costs

Project Overview

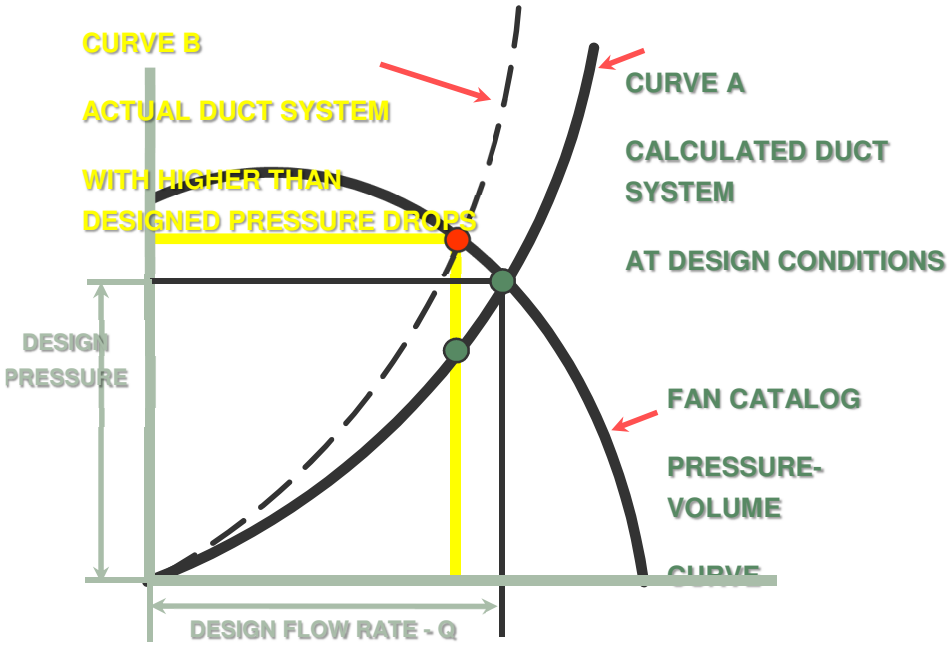
Energy-Environment-Economics provided a detailed study and report of the HVAC System's existing conditions and operations including design and DDC system deficiencies, potential energy conservation opportunities with budgeted project costs and economic analysis, and maintenance related operational and efficiency analysis. The result of this study became an approximately $1,800,000 HVAC system redesign and modifications for the facility, including construction document preparation, commissioning and Optimissioning^{SM} of the entire facility.

Solutions Provided

The modifications included replacement of numerous in-duct fire/smoke dampers (FSD) and air handling unit supply air discharge ducts to reduce the air distribution system's total pressure drop. The analysis determined that the total system pressure drop was significantly higher than the design intent, and as a result the air handling units did not have the capability to provide the airflow required to all zones, especially those distant from the air handling units. The higher than design system pressures were also causing serious duct leakage, up to 25% on some systems, exacerbating the comfort issues. The following graph illustrates the design and calculated (actual) conditions:

System Pressure Drops

- high static supply fans designed at 6.5", returns at 2"
- systems operating at approximately 10.5" total static
- extreme – up to 1" - FSD pressure drops
- high pressure drops at discharge plenums, i.e. system effect
- high losses at elbows due to high velocities



This lack of capacity, even at 100% fan speeds, resulted in an inability to maintain temperature/humidity requirements as well as poor ventilation control and indoor air quality. Also, with these conditions there was no way to capitalize on the energy management capabilities (VAV) of the air handling units. To complicate matters, large space pressure differences were existing between sterile areas due to return air fan control schemes and the original outside air system design criteria.

The original design for outside air included a large, passive (not forced air) outside air "plenum" to which individual outside air ducts attached to all air handling units. Preliminary testing showed that this "sharing" of the main outside air duct was resulting in some air handling units actually introducing return air from other air handling units via the outside air system. In other words, among other noted problems, sterile (surgery, etc.) areas were introducing air from less sterile areas. The entire outside air deliver system was egregiously deficient.

Part of the HVAC system redesign required that the outside air ducts to each air handling unit be replaced with smaller ducts and were equipped with outside air flow measuring stations. The smaller sizes provided the minimum velocities necessary to make the stations work correctly and to permit outside air control and monitoring. Also, *Energy-Environment-Economics* designed and implemented innovative outside air/return air/mixed air damper control algorithms, combined with a revised supply air fan/return air fan tracking algorithm, that solved the outside air delivery issues.

Through exhaustive field work, the engineering study also identified select areas where space was available to increase the size and lower the subsequent pressure drops of the FSD's that had especially high pressure drops and would have the most effect on shifting the system curve back to design as shown above. Affected areas were systematically taken off-line during low census and off-hour times, and these FSD's were replaced and the system brought back on-line in the morning. Accurate construction documents were mandatory, as was scheduling of all related shutdown activities. During this process, the ductwork was also re-sealed to minimize the extreme leakage.

System testing during analysis also revealed large pressure drops at the supply air discharge ducts at each air handling unit, caused by system effect pressure losses due to duct configurations. New designs were developed, and these changes were made simultaneously during the system shutdowns. Finally, to maximize the system shift, existing inlet guide vanes were removed and replaced with variable frequency drives. The net result of the air distribution system modifications was to shift the system curve within design, allowing sufficient air at required temperatures to be supplied to all zones.

The outside air delivery system corrections, combined with the modifications to the EMS, solved the IAQ and space pressure control issues. All corrections

to the air distribution system collectively solved the very serious problems, and were also very successful in reducing the energy consumption of the system.

System performance and efficiency was vastly improved through the proper application of variable air technologies and converting the constant volume chilled water system to variable primary. Inefficient equipment such as 3-way control valves and fan inlet guide vanes were replaced with pressure-independent 2-way control valves and variable frequency drives respectively. The installation of properly sized cooling towers and plate frame heat exchanger provided non-existent redundancy and reduced operating costs. All new devices - variable frequency drives, outside air flow measuring and control devices, et. al. – were integrated into the Energy Management System (EMS) sequences of operations.

The sequences of operations were completely rewritten for maximum performance and efficiency during the Optimissioning^{SM} process, including reset schedules for the air handling units. EMS communication with the chillers was established, enabling reset schedules to be established and more reliable control over central plant operations. Space pressure sensors and control algorithms were incorporated, as were air handling unit outside air control algorithms. Differential pressure sensors were installed into the revised chilled water system, and all facets of the new system's controls requirements were designed, implemented and optimized. All critical EMS setpoints, including economizer changeover, chilled water supply, supply air temperature, and air handling unit static were painstakingly established for maximum energy efficiency. All VAV/FPVAV boxes were calibrated during the HVAC system wide Test & Balance process.

Results

These system improvements were completed with no interruption in services, as affected areas were systematically taken off-line during low census periods and returned to operation the following morning(s). the new control algorithms for the entire system(s), coupled with the installation of new and/or relocated controls devices, allowed us to properly monitor, control and most importantly satisfy all space temperature and pressure and outside air flow requirements throughout the entire facility at all times and any conditions. The project resulted in eliminating all deficiencies associated with the HVAC system and reduced energy costs by approximately $100,000/year, but most importantly all compliance and risk management issues were addressed and corrected.

5. EXAMPLE PROJECTS WHICH BEST ILLUSTRATE PROPOSED TEAM'S QUALIFICATIONS FOR THIS CONTRACT

(Present no more than five (5) projects. Complete one Section 5 for each project.)

a. TITLE AND LOCATION *(City and State)*	b. YEAR COMPLETED	
	PROFESSIONAL SERVICES	CONSTRUCTION *(If applicable)*
WAATS CMSB, Marana, Az.	2003	2003

23. PROJECT OWNER'S INFORMATION

c .PROJECT OWNER	d .DOLLAR AMOUNT OF PROJECT	e. TOTAL COST OF PROJECT
DEMA – WAATS – Jeff Seaton	$74,000	$366,000

f. BRIEF DESCRIPTION OF PROJECT AND RELEVANCE TO THIS CONTRACT (include scope, size, and length of project)

AZ DEMA – WAATS CMSB – L4525, Marana, AZ.

Building Description

The building is a Mission Critical 24/7 Flight Simulator Training Facility with three full-motion Simulators and two supporting Data (Computer) Rooms. The devices provide flight training to the military of the U.S. and numerous allied countries. Training, office and conference areas make up the balance of the facility.
The HVAC system consists of:

- The central plant includes three water chillers with associated pumps and cooling towers, and is primary-secondary pumped and piped. The secondary pumps and the cooling tower fans are all equipped with variable frequency drives.
- There is a hydronic plate/frame heat exchanger to provide "free" cooling during the appropriate ambient conditions.
- The hot water system is comprised of one boiler and associated pumps and provides space heating used for Data Rooms' humidity control (reheat) and zone heating.
- 4 central station air handling units, one of which is VAV and serves the VAV boxes in the office/training areas.
- 10 chilled water/hot water computer room a/c (CRAC) units serving the Data Rooms
- Complete direct digitally controlled EMS.

Project Problems/Issues

- Inability to maintain temperature and humidity control in the Data Rooms
- Central plant was suffering from reverse decoupling due to original design
- All three 110-ton chillers had 30,000+ hours of operation, building peaks at 110 tons
- Inability to utilize the existing waterside economizer
- Outrageous (approximately 6$/s.f./year) utility costs

Project Overview

Energy-Environment-Economics provided a detailed engineering study and report on the HVAC System's current (existing) condition and operation including: HVAC system design and DDC system deficiencies, potential energy conservation opportunities with budgeted project costs and economic analysis, and maintenance related operational and efficiency analysis. The result of this study became an approximately $500,000 Energy Conservation Project, including Retro-Commissioning and Optimissioning^{SM} - a combination of HVAC system commissioning and optimization - of the facility. The project included the engineering required for the repair, modernization and automation of the chilled water central plant, the air distribution system, and the critical Data Rooms' HVAC components.

Solutions Provided

The study identified that the central plant was incorrectly piped and as a result was suffering from "reverse" decoupling. This condition is actually quite common in primary-secondary systems, and under various operating conditions elevates the supply chilled water temperature above what is required. The elevated water temperatures prevented the Data Rooms from maintaining temperature and humidity setpoints that were critical to operations. To compensate, additional chiller systems must be started and operated.

This central plant, intentionally or not, was equipped with 200% redundant capabilities. The Data Rooms were equipped with approximately 200%

redundancy as well, yet not even this massive amount of available capacity could overcome the poor design and lacking EMS practices and setpoints. Naturally, HVAC related energy costs were extreme as a result. During Optimissioning^{SM} the central plant was re-piped to eliminate this reverse decoupling, and valves were added to allow the secondary pumps alone to provide the necessary chilled water to the facility during heat exchanger mode of operation.

An inability to ever use the heat exchanger was cited by one consultant as a root cause of the excessive utility costs, and a recommendation to add an additional air-cooled water chiller dedicated to the CRAC units so as to enable the heat exchanger to serve the balance of the facility – and thereby save energy – was provided to the client. Our study and the subsequent Optimissioning^{SM} now allows the chilled water system to operate in heat exchanger mode approximately 4 months of the year, sans any additional chiller, saving energy and wear and tear on the chiller systems.

The study proposed using the available excess capacity of the CRAC units to satisfy the Data Rooms cooling needs during heat exchanger mode, as the warmer than design chilled water temperature delivered during this mode results in elevated supply air temperatures. Ambient conditions suitable for heat exchanger operation are low humidity, making humidity control of the Data Rooms a non-issue at these times. Iterations of the chilled water coils and load analysis of the Data Rooms showed that up to 62-degree supply air temperatures were sufficient to satisfy cooling demands, so the CRAC's were equipped with staging (on-off) controls that enable units to be cycled as needed to meet need, saving significant energy without affecting temperature/humidity requirements. The analysis also allowed the chiller-heat exchanger wet-bulb (WB) temperature changeover setpoint to be established and optimized for maximum energy efficiency.

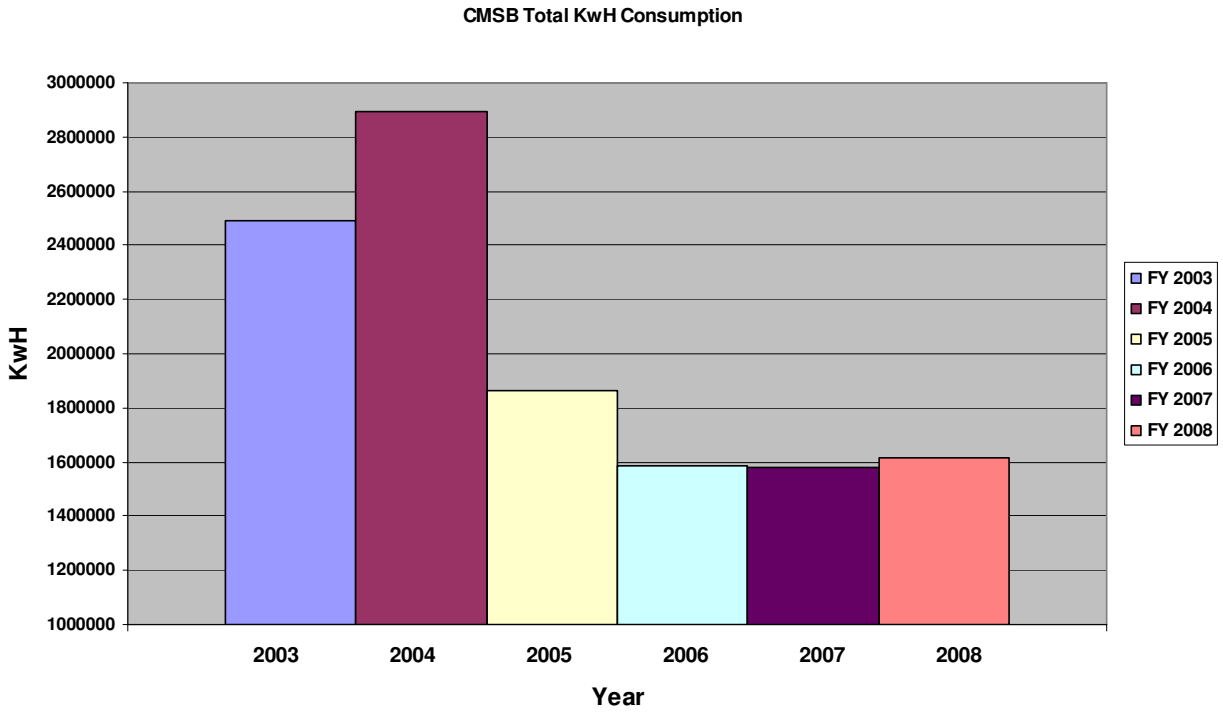
All critical EMS setpoints were similarly established and optimized, and all central plant algorithms were revised. Notably, the differential pressure setpoint used to control the speed of the secondary pumps' variable frequency drives, was eventually lowered from 12.5 PSI to 4 PSI. A combination of factors enabled this dramatic reduction, including an engineering innovation devised to force the CRAC units' chilled water control valves closed when the unit was off. This capability did not exist previously, and manufacturing engineers had stated that it was impossible to accomplish without a control valve replacement.

To maintain 4 PSI one secondary pump easily satisfies the demand of the facility. At 12.5 PSI both secondary pumps (one is intentionally redundant) operated – usually at 60 Hz – in an attempt to meet the setpoint. All of the electrical loads that were shed as a result of this Optimissioning^{SM} project, chillers, pumps, cooling tower fans, and CRAC units, resulted in outstanding energy savings and corrected all existing deficiencies. The Optimissioning^{SM} project consisted of the study, the engineering, the commissioning, the Test & Balance and the optimization of the facility. Also, project coordination services were provided by *Energy-Environment-Economics* in addition to the HVAC commissioning and optimization services provided.

Results

Results of the project reflected a 70% reduction in HVAC related energy costs with improved reliability and space conditions. After commencing in November of 2004 and being released to full control March of 2005, the project has had an immediate and staggering impact on energy consumption and utility costs. Space comfort has improved, including the Data Rooms' ability to maintain temperature and humidity within specified limits. The project has conserved approximately 1.5 million KwH every year in fully automatic operation. The Kw demand has almost been cut in ½, from approximately 620 Kw to 350 Kw.

Considering that only the HVAC system was Optimissioned^{SM}, and that lighting and approximately 400 HP of hydraulic pumping (serving the simulators) capability was left untouched, these results are nothing short of spectacular. Due to the concerted efforts of the Optimissioning^{SM} team, including Mr. Jeff Seaton (Energy Manager, State of AZ., NGB), approximately 2/3 of all major HVAC equipment was turned off, thereby generating these savings, extending the life expectancy of the existing equipment, and reducing their associated maintenance requirements and costs. The following charts were created from actual utility data provided by Mr. Seaton, and generated by his Utility Manager software:


CMSB Total KwH Consumption
3000000
2800000
2600000
2400000
2200000
2000000
1800000
1600000
1400000
1200000
1000000
KwH
2003
2004
2005
2006
2007
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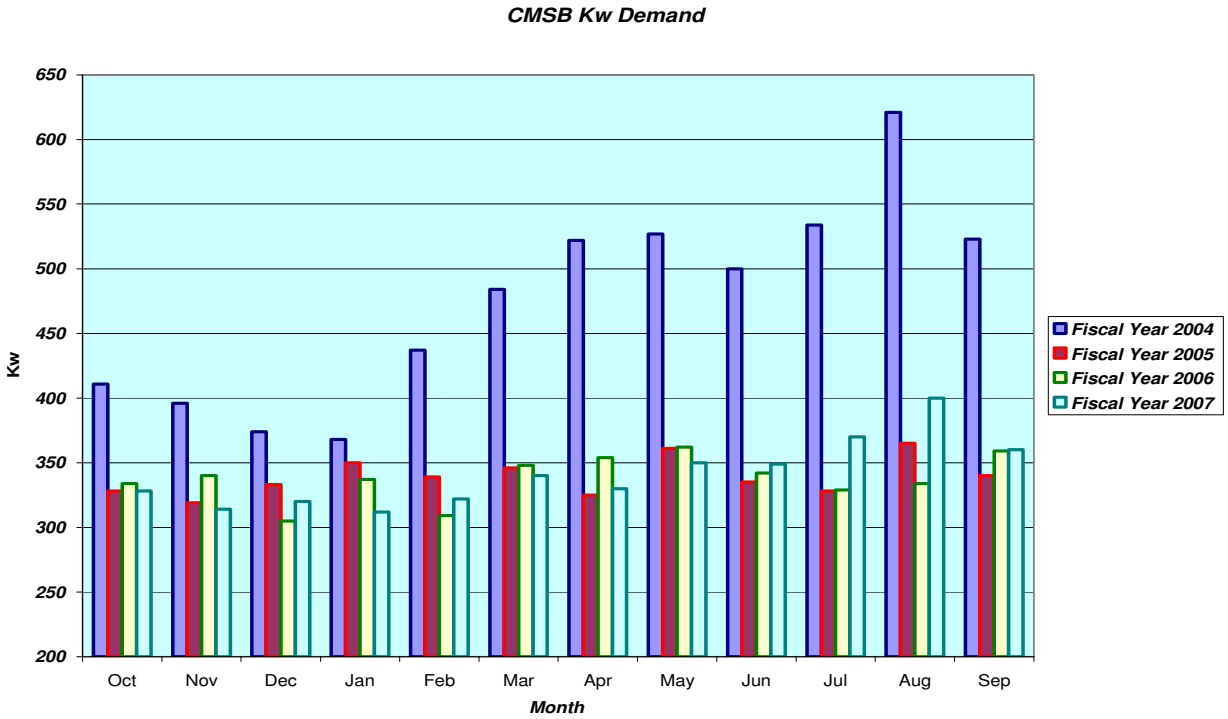
FY 2004
FY 2005
FY 2006
FY 2007
FY 2008


CMSB Kw Demand
650
600
550
500
450
400
350
300
250
200
Kw
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month
Fiscal Year 2004
Fiscal Year 2005
Fiscal Year 2006
Fiscal Year 2007

5. EXAMPLE PROJECTS WHICH BEST ILLUSTRATE PROPOSED TEAM'S QUALIFICATIONS FOR THIS CONTRACT

(Present no more than five (5) projects. Complete one Section 5 for each project.)

a. TITLE AND LOCATION *(City and State)*	b. YEAR COMPLETED	
	PROFESSIONAL SERVICES	CONSTRUCTION *(If applicable)*
Biltmore Medical Mall, Phoenix, Az.	2014	

23. PROJECT OWNER'S INFORMATION

c .PROJECT OWNER	d .DOLLAR AMOUNT OF PROJECT	e. TOTAL COST OF PROJECT
Biltmore Medical Mall – Elizabeth Bolden	$130,000	130,000

f. BRIEF DESCRIPTION OF PROJECT AND RELEVANCE TO THIS CONTRACT (include scope, size, and length of project)

Biltmore Medical Mall (BMM) – Phoenix, Az.

Building Description

The Biltmore Medical Mall (BMM) is located at 2222 E. Highland in Phoenix, AZ., in the fashionable Camelback Corridor. The facility comprises approximately 152,000 square feet of medical related office suites and includes an outpatient surgery center (OSC), orthopedic surgery service providers (TOCA), and oncology services provided by Arizona Oncology in their approximately 35,000 square feet of space. There is also an Eye Surgery Center, a Sports Medicine Center, a Radiology Center and a number of other outpatient related service providers. The facility was constructed in 1998 and has been almost continually tenant improved, most recently in 2010 for the approximately 15,000 square feet OSC that included five modernized ORs, procedure rooms, a PACU, a waiting room and staff facilities.

Project Overview

The heating, ventilating and air conditioning (HVAC) system serving these tenants has also been upgraded since 1998, most recently with the replacement of all of the rooftop mounted HVAC units. These units are direct expansion (DX), evaporative condensed, variable air volume (VAV) packages/split systems that provide conditioned air to the VAV boxes located in the tenant spaces. The VAV boxes are a mixture of series fan powered, parallel fan powered, and single duct (no fan) VAV boxes, most of which are equipped with electric heating elements. The original direct digital controls (DDC) system was also upgraded throughout the facility in 2010.

Although the facility caters to health care professionals, the occupancy closely mirrors that of a typical office building, i.e. Monday-Friday from 7 A.M. to 6 P.M. Considering that the HVAC system and DDC system should provide for well above average operating efficiency, the building's utility costs were surprisingly exorbitant. Thus began the concerted HVAC system Retro-Commissioning (RCx) effort. Initiated by Mrs. Elizabeth Bolden of Health Care REIT and using incentives provided by SRP, the RCx process began with The ETC Group of Salt Lake City generating a preliminary HVAC system audit that resulted in a number of recommendations for improved energy efficiency.

Solutions Provided

Complete 3rd party independent HVAC Commissioning services – per the requirements spelled out by the Arizona School Facilities Board (SFB) for the entire district including DDC system point-to-point verification and DDC sequences of operations vetting. Part of the SFB's requirements included a thorough review, comment and approval of the investment grade audit (IGA) that was prepared by the performance contractor. The reviewed documentation included HVAC and lighting systems description, current utility data, projected utility consumption for the proposed energy conservation measures (ECM's), description of the proposed ECM's, and a financial summary. The information provided served to support the conclusion that the anticipated savings that can be realized upon implementation of the ECM's.

Retro-Commissioning Measure (RCM) #1 addressed concerns with the air handling units' operation including economizer operation, damper operability, and temperature and fan speed setpoint control. We will discuss the findings of our RCx effort in detail later in this document, but in general:

- Damper issues were corrected and verified for functionality.
- The economizers are not capable of 100% outside air as designed and are equipped with gravity type relief air dampers. Also, air handling unit 3 return air (exhaust) fan is controlled as a percentage of speed of the supply air fan while air handling units 4, 5 return air (exhaust) fans are controlled from a space pressure setpoint. It appears that the original sequences of operations used a differential enthalpy (between outside air

and return air) to enable/disable the economizers but the ability to calculate return air enthalpy does not exist so currently the economizers are enabled/disabled from an outside air dry-bulb temperature. All of these conditions make economizer operations problematic.

- The air handling units are equipped with varying but in all cases several stages of DX cooling. Each contains multiple supply air fans installed in fan walls and multiples of return air/exhaust air fans (housed and unhoused). The design of the fan walls creates a wide discrepancy in the face velocity across different sections of the DX coil. These conditions lead to deviations in the supply air temperature and are not feasibly "correctable".
- Air handling units 3-5 serve floors 2-4 and have interconnected ductwork on each floor. Each air handling unit senses a dedicated static pressure, but the zones served by each air handling unit are not typical so controlling the fan speeds from a single supply air static pressure setpoint does not produce the result of all fans operating at the same speed.
- Air handling units 1 and 3 control their return air fans as a percentage of the supply fan speed, and air handling units 4 and 5 control the return air fans from a building pressure setpoint. Also, the supply fan variable frequency drive speeds are limited to their maximum over-current protection rating, and that differs from air handling unit to air handling unit. The supply and return fan curves also vary, and this is another contributing factor why the supply fans operate at different speeds.

Retro-Commissioning Measure #2 instituted supply air temperature and supply air static pressure reset capability for air handling units #1, 3-5. The temperature reset is based upon the polling of each VAV box percent cooling request and adjusted up/down accordingly. The supply air static is also adjusted up/down when a nominal (20%) of VAV box damper positions are requesting more/less airflow. In general:

- Air handling units 3-5 share supply ductwork on floors 2-4, so the static pressure reset is based on a 20% (adjustable) average of all VAV boxes on floors 2-4. Considering that most suites contain several VAV boxes and that zone temperature setpoints – and therefore airflow requests - can vary substantially between even adjacent zones in any given suite, the ability to reset and the effectiveness of the reset is a significant unknown.
- The supply air temperature reset for air handling units 3-5 also polls all boxes on floors 2-4 and resets the supply air temperature up/down when 20% of the boxes' cooling request is below/above 99%. Because floors 2-4 must be polled together and not individually, the reset may not be as effective as possible if individual floors could be polled. However, any ability to reset the supply air temperature will reduce air-conditioning and electric reheat costs.
- Air handling unit 1 has special requirements – serves the Operating Rooms – so the ability to reset airflows and temperatures is limited.

Retro-Commissioning Measure #3 created occupancy schedules for the air handling units, as well as an optimal start/stop sequence wherein the air handling units will "learn" over a period of time when the air handling units must be started/can be stopped to achieve/maintain temperature setpoints of the zones. In general:

- Any zone can initiate a call for occupancy during unoccupied mode by pushing the zone over-ride button on the thermostat. When initiated that zone is commanded to occupied status, and in the case of floors 2-4 air handling units 3-5 are commanded to run in occupied mode with the appropriate resets. Outside air dampers remain closed.
- An occupancy schedule for each suite's VAV boxes was required to accomplish this RCM. The air handling units are commanded based upon each individual suite's requirements.
- The air handling unit(s) will be commanded to run during unoccupied mode if the average floor temperature is above or below their unoccupied temperature setpoints and will continue to run for 30 minutes once the average of the unoccupied floor temperature is satisfied.
- The optimum start/stop schedule was enabled but our history is that these sequences are of little benefit and can be problematic.

Retro-Commissioning Measure #4 involved the commissioning of the VAV boxes including correcting all found deficiencies, scheduling and setpoint control. During this phase of the project, the VAV boxes were also calibrated to ensure that sensed (via the pressure transducer) airflow was representative of actual airflow. In general:

- There are four types of VAV boxes within the facility: cooling only no fan, no fan with electric reheat, series fan powered with electric reheat and parallel fan powered with electric reheat. Numerous boxes were operating with the incorrect VAV box controller application and were corrected.
- The room setpoints vary throughout the facility due to the variations in max/min setpoints and slide adjustment positions.
- The majority of fan powered VAV boxes have/had mis-matched primary air/fan (plenum) airflows causing potentially uncomfortable space conditions and excess energy consumption. Numerous boxes were found to be out of balance or the fans were incapable of delivering more or less air (at max/min fan speeds) to achieve the desired condition. Those boxes were setup for the best energy efficiency possible.

Calibrating the fan powered boxes is a time consuming, 2-step process where initially the fan speed is set to the maximum cooling CFM with the primary air damper closed, and then the primary air damper is opened and its position set to the maximum cooling CFM where the plenum air inlet is neutral (no plenum air introduced). This is the optimal operating condition whereas no plenum air is introduced when the box requires full cooling CFM. Detailed

reports of the VAV box Commissioning/calibration results are included in this Final Commissioning Documentation.

It appears that the original Test & Balance was shoddy at best, and the facility would benefit from a complete re-balance. We also encountered frequent installation/maintenance/service issues: poor inlet conditions to VAV boxes, inaccessible boxes, inoperable heat, dirty filters, blown fuses, and faulty controllers among them. And although it is highly unusual, there is a dearth of controls capabilities for the air handling units. Considering that air handling units 3-5 share common ductwork on floors 2-4 and operate in concert this is an important condition to note.

It is likely that the original designers were concerned about potentially deleterious effects on static pressures throughout the facility that this ductwork design may have, and may have used fan-powered VAV boxes as a hedge against the possibility. It is unusual that this type of facility – designed circa 1998 - would be designed with so many fan-powered boxes otherwise. Series type fan-powered VAV boxes, where the fan operates continuously, obviously consume more energy than VAV boxes without fans. But they also are notoriously difficult to balance (referenced above) and will almost always have mismatched primary and plenum airflow rates that creates more energy wasting possibilities.

The overall impact that this Retro-Commissioning effort has upon the facility's energy used will undoubtedly be positive, and space conditions should likewise improve. But there is always a trade-off between energy efficiency and comfort, so we expect somewhat of a "learning curve" period wherein the new reset schedules may create temporarily uncomfortable space conditions for some tenants. It will be interesting to see the final results - i.e. energy savings – from this effort, but it will be impossible to ascertain the actual impact of individual measures because of the very inter-dependent nature of the HVAC system complete.

Results

The project resulted in an approximately $100,000 per year reduction in annual utility costs, and Mrs. Bolden was presented with an Excellence Award from the Building Owners and Managers Association (BOMA).

6. ADDITIONAL INFORMATION

a. PROVIDE ANY ADDITIONAL INFORMATION YOU FEEL MAY BE NECESSARY TO DESCRIBE YOUR FIRMS QUALIFICATIONS. *(ATTACH ADDITIONAL SHEETS AS NEEDED.)*

Energy-Environment-Economics$_{LLC}$ is a specialty energy engineering firm, focusing exclusively on energy conservation services for existing facilities. we have attached marketing brochures that communicate the types of projects we have executed very successfully over the past 15 years as well as to solicit similar types of projects.

7. ANNUAL AVERAGE PROFESSIONAL SERVICES REVENUES OF FIRM FOR LAST 3 YEARS

a.	Percentage of Total Work Attributable to State, Federal and Municipal Government Work:	50%
b.	Percentage of Total Work Attributable to Non-Government Work:	50%

8. AUTHORIZED REPRESENTATIVE. The foregoing is a statement of facts.

Signature:_____*D. Michael Ledbetter, P.E.* _____ Date:_____12/17/2015_____

Name: _____D. Michael Ledbetter _____ Title: _____President_____