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Extending the Reach of Campus Renovation through Combined Financing

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ABSTRACT

Federal government agencies are faced with significant budgetary challenges when trying to meet requirements for infrastructure renewal and mandates for increased energy efficiency. Much of the building stock owned and operated by the federal government is of the age where major renovation will be required to continue to meet the mission requirements. Additionally, there are numerous federal mandates requiring that agencies meet prescribed goals for energy efficiency and sustainability such as net zero energy. Major facility renovation projects have traditionally been funded with sustainment, restoration, and modernization (SRM) funds requiring large capital appropriations. These funds are becoming increasingly difficult to obtain under current budget constraints. Alternative financing vehicles for energy projects have significant limitations in the ability to fund large-scale renovations of buildings. These challenges require that the methods used to accomplish these requirements extend beyond what has traditionally been done.

This paper provides an example of how a major renovation of a federal government campus is being accomplished using a combination of traditional appropriated funds and private financing through energy performance contracting. The approach being used has been and continues to be successful in achieving significant energy usage reductions while relieving the constraints of the available funds. However, this approach also comes with the significant challenge of coordinating between multiple contract vehicles, design teams, and contractors along a very accelerated timeline. The paper provides background for why this approach was taken as well as the specific contract vehicles being used. The paper then discusses the different combinations of interactions between the contract vehicles and the project teams at various stages of the overall project. The paper also discusses engineering analysis and the design process required to develop and implement the project. Finally, the paper discusses "lessons learned" that could be applied to similar efforts in the future.

INTRODUCTION

Federal government agencies are faced with significant budgetary challenges when trying to meet requirements for infrastructure renewal and mandates for increased energy efficiency. Much of the building stock owned and operated by the federal government is of the age where major renovation will be required to continue to meet the mission requirements. Additionally, there are numerous federal mandates requiring that agencies meet prescribed goals for energy efficiency and sustainability such as net zero energy (NZE). Major facility renovation projects have traditionally been funded with sustainment, restoration, and modernization (SRM) funds requiring large capital appropriations. These funds are becoming increasingly difficult to obtain under current budget constraints. Alternative financing vehicles for energy projects have significant limitations in the ability to fund large-scale renovations of buildings. These challenges require that the methods used to accomplish these requirements extend beyond what has traditionally been done.

One example of where this combination of requirements is being addressed in an innovative manner is the Intelligence Community Campus–Bethesda (ICC-B). The Defense Intelligence Agency (DIA) is currently embarking on an extensive campus redevelopment at the request of the Office of the Director of National Intelligence. The 39 acre (0.16 km^2) campus will house several agencies of the intelligence

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community and had been previously occupied by the National Geospatial-Intelligence Agency (NGA) (from 1946 until 2011). The campus was previously made up of six buildings originally constructed between 1946 and 1988 (and a small Visitor Center built in 2005) with a weighted average age of approximately 56 years. The redevelopment calls for the demolition of three buildings. The remaining buildings are to have full-scale renovations of both the interior and exterior shells. A new 230,000 ft^2 (21,367 m^2) building (Centrum) is to be added to serve as the center of the campus, connecting the existing three buildings. The new construction and major renovation designs are required to meet aggressive energy and sustainability standards with a goal of achieving Leadership in Energy and Environmental Design® (LEED®) Silver certification.

The overall campus redevelopment project began as a traditional design/build construction project for the North Campus consisting of a 1800 car garage, a Visitor Control Center, and a Vehicle Inspection Station. All buildings on the North Campus were designed and built to be NZE buildings (designed to produce as much renewable energy on site as they consume during the course of one year). The South Campus is being delivered as a traditional SRM construction project under a single award task order construction contract (SATOCC) administered by the U.S. Army Corps of Engineers (USACE), Baltimore District. The project was to be funded entirely relying on appropriated funds. Yet it was quickly realized that budget constraints would significantly limit the ability to achieve the goals of the project. It was then decided to combine the traditional construction contract with an energy performance contract for the South Campus. This would allow a separate team to be brought on board to specifically focus on the core energy infrastructure. A separate utility energy service contract (UESC) was awarded by the USACE, Huntsville Engineer Center, to use this alternative financing vehicle, leveraging energy and energy-related savings to fund significant portions of the project. This approach comes with numerous complications arising from the separate contract mechanisms and contractor teams.

The chosen approach has been successful in combining public and private funding streams to achieve the goals of the project within available funding constraints. The challenges associated with this unique approach are being identified and mitigated to ensure overall success. This paper details the business and engineering approaches employed to date as the project has evolved. The "lessons learned" are also discussed in an effort to improve the implementation of this approach to other projects in the future. The results show that the combined approach provides a powerful mechanism for extending the reach of appropriated funds to achieve deeper energy savings and sustainability in federal buildings.

PROJECT EVOLUTION

As mentioned previously, the redevelopment of the ICC-B South Campus was originally planned to be executed under a SATOCC using appropriated funds. The contract was awarded through a competitive solicitation for a design-build team (DBT). The DBT was to be made up of a general contractor along with design and engineering services. The successful DBT was selected based on a combination of qualifications and the projected implementation budget for completing the campus redevelopment.

One of the principal motivations for considering the use of a private funding stream in conjunction with traditional appropriated funding was a shortfall in appropriated funds to accomplish the campus renovation. The original budget for the project was reduced, and the reduction would have delayed many of the programmed elements of the redevelopment effort and hampered efforts to achieve significant reductions in future energy consumption. It was at this point that use of alternative funding sources began to get serious consideration as a means to help keep the redevelopment effort on track.

Background

The DIA was selected to be the executive agent for the campus redevelopment effort. The challenges imposed on the redevelopment program by the budget constraint forced the DIA to identify alternative approaches to meet the program goals under the revised conditions. Previous research conducted on the use of different private-financing-based performance contract vehicles seemed to provide a means of addressing many of the issues. As the budget constraints began to place the overall outcome of the redevelopment program in jeopardy, DIA's senior technical expert for facilities and construction and the ICC-B project executive researched alternative strategies for energy infrastructure development that could be used to maintain the project goals and leveraged appropriated funds.

One of the example projects researched involved the construction of a central utility plant (CUP) and associated utility distribution system at the Federal Research Center at White Oak (FRCWO) in Silver Spring, Maryland. FRCWO houses the headquarters and most of the centers of the U.S. Food and Drug Administration (FDA); the campus was redeveloped and is managed by the General Services Administration (GSA) on property that formerly housed the Naval Surface Warfare Center. This Navy property became available pursuant to the Base Realignment and Closure (BRAC) legislation of 1993. The primary energy infrastructure at FRCWO was developed over the course of several phases using the Department of Energy's energy savings performance contract (ESPC). In addition to providing the primary energy infrastructure that serves the 3.7 million gross ft^2 (374,000 m^2) campus, operations and maintenance (O&M) services for both the CUP and the supported campus buildings were also included by the energy service company (ESCO) as part of the ESPC contract.

The research also included a GSA redevelopment effort applying a similar approach in the development of the energy infrastructure at St. Elizabeth's, a property in the District of

Columbia that was to be redeveloped as the headquarters for the Department of Homeland Security and several of its subordinate agencies. This project was also implemented using an energy-performance-based contract vehicle. In this case, the project was developed under a UESC. The project team was made up of the same ESCO used at the FRCWO teamed with the local utility providing natural gas to the campus. Both projects were used to compare the benefits of the different contract vehicles as applied to the ICC-B project. The DIA ultimately decided to move forward with a UESC due to the greater flexibility and relatively quicker acquisition cycle time associated with that contracting vehicle in comparison with the ESPC approach.

Because the redevelopment program was originally planned based on a single contract award, the transition to executing the project using separate contract vehicles and multiple contractors required significant coordination. The overall scope of the redevelopment was reexamined to determine what portions of the construction project would be included in the UESC portion of the project. The UESC energy team (UET) was then required to identify energy conservation measures (ECMs) that would generate significant cost savings to be used to fund the implementation. The UET began examining the existing facilities and original design concepts while the DBT (including the designer of record) continued to develop the design for the component pieces of the redevelopment. The challenge became coordinating with the DBT to integrate the ECMs developed by the UET into the already mature design concepts without significantly impacting the overall project implementation schedule.

UESC Original Role

The original concept for the UESC project was to replace the primary energy infrastructure for the campus. This was to include a CUP and associated utility distribution system to provide chilled water and heating hot water to the campus. This approach was modeled after the projects at FRCWO and envisioned at St. Elizabeth's. This approach had the following goals:

- Extend the reach of appropriated funds in terms of providing program floor space by leveraging alternative financing to construct the site energy infrastructure (this was, and remains, the primary goal).
- Help meet federal energy conservation and sustainability mandates.
- Provide reliable/robust utilities service to the campus (enhance energy security at the site).
- Make energy-related improvements as unobtrusive as possible in response to community relations considerations.
- Evaluate the potential for achieving NZE consumption at all or part of the campus through a combination of renewable energy and a cogeneration component if economically viable.
- Have fixed accountability for energy systems performance.
- Provide phased implementation of energy infrastructure development to match the pace of construction/renovation of the campus buildings.

The DIA requested that the UET analyze various options for configuration of the site energy infrastructure. Factors that impacted this analysis included validation of loads to be serviced and when these loads are expected to materialize, location of the central plant (at the location of the existing boiler plant, in the basement underneath the Centrum building, as a free-standing plant somewhere on current surface parking lot, or other possibilities), equipment line-up, nature of utilities to be provided, schematics reflecting equipment layout and distribution system connection points with serviced buildings, etc.

The following items were originally considered to be included within the UESC project:

- Major items of HVAC CUP equipment, including boilers, chillers, and ancillary plant equipment (cooling towers, pumps, fans, variable-frequency drives on motors, piping and valves, plant controls, etc.)
- Building to house CUP equipment or floor slab with imbedded piping in basement portion of Centrum building, depending upon utility option selected
- Emergency generators
- Fuel cells
- Photovoltaic system
- Distribution system piping/wiring from CUP to supported campus buildings
- Advanced metering for individual buildings
- Integrated building management system to include building automation system (BAS), fire alarm system, physical security system, load management/load shedding hardware and software, facility information dashboard, etc.
- Campus-wide O&M services (including CUP and supported buildings)

UESC Role Variation by Project Phase

As mentioned in the preceding section, the development of the campus energy infrastructure was to be undertaken in phases. The centerpiece of the phase I/base portion of the proposed UESC project is the construction of a CUP to replace the existing decentralized plants on the ICC-B campus. The CUP ECM includes cooling, heating, and standby generation systems. Savings associated with the first two components (cooling and heating) of the CUP derive from a comparison of the energy usage, O&M, and equipment replacement costs of the new consolidated plant in comparison with the existing decentralized plants. CUP O&M services are also included as a part of UESC phase I.

Three additional phases that will impact the buildings to be renovated as a part of the ICC-B redevelopment effort are primarily composed of the following ECMs:

- Lighting upgrades and lighting controls
- Variable-air-volume (VAV) reheat air-handling unit (AHU) system with energy recovery dedicated outdoor air system (DOAS)
- Upgrade to campus-wide energy management system (EMS)
- New gas-fired water heaters
- Solar domestic hot-water generation

Photovoltaic (PV) systems, originally intended to be included as a part of phases II, III, and IV, are being combined into either phase III or phase IV to take advantage of economies that can be realized by waiting until all of the PV systems can be installed simultaneously.

Phase II addresses measures to be implemented in Roberdeau Hall, phase III addresses measures in Erskine Hall, and phase IV addresses measures in Maury Hall. O&M activities associated with the Centrum building that are not covered as a part of phase I (i.e., O&M not directly related to the CUP) will be included in phase II. ECMs for phase II will generally be implemented through providing the materials associated with the ECMs to the SATOCC contractor as government furnished equipment (GFE) purchased as a part of the UESC project. One exception to the GFE concept is the EMS ECM, which will be a turnkey installation under the UESC project for all project phases.

While the GFE approach will be employed for elements of phases III and IV as well, some of the ECMs under these phases will also include installation of the ECMs due to the ability to separate the core mechanical/electrical infrastructure from the tenant fit-out in Erskine Hall and a different level of renovation contemplated for Maury Hall. As with phase II, full-building O&M services will be part of phases III and IV.

ORIGINAL CAMPUS EXISTING CONDITIONS

Facility Overview

The ICC-B is located in Bethesda, Maryland. The campus was originally occupied in 1946 by the Army Mapping Service and eventually the NGA, and it has recently been turned over to the DIA to transform the facility into a secure campus supporting U.S. intelligence community activities. The facilities were last fully occupied and functioning in 2008. In the years between 2009 and the present, the occupants of the buildings have been moved to other buildings. For these reasons, for the purposes of the energy analysis, the existing conditions used to establish the initial energy baseline for the buildings have been those of 2008; 2008 energy data from the utility companies was also chosen as the basis for modeling analysis and calibration. Table 1 shows the list of buildings on campus as of 2008 and their approximates sizes. The aerial photograph in Figure 1 shows the NGA campus prior to the start of renovations.

Baseline Energy Analysis

The approach taken to conducting the energy analysis for the project was to develop hourly building simulations for the buildings. The primary focus of the energy models was the three buildings to be renovated. However, the remaining buildings were included in the initial campus model to provide the ability to calibrate the model based on actual utility data for the baseline year. The information used to model the buildings was taken from a combination of facility drawings, interviews with facility personnel, and detailed surveys of the buildings. The information was gathered based on how the buildings were occupied and operated during the 2008 baseline year. It was learned from facility personnel that the facilities were all operated 24 hours per day, seven days per week. These buildings were also reported to have high-intensity plug loads. Several areas in the buildings were identified as computer rooms and modeled accordingly.

The components of the building envelope for each building were identified through existing drawings and visual inspection. The drawings indicated masonry façade construction (concrete masonry units, brick, terra-cotta, and cast

Table 1. Original Campus Building List

Building Name	Floor Area (Gross)	Year Built	Building Status
Erskine Hall	<400,000 ft^2 (37,160m^2)	1946	To be renovated
Abert Hall	<95,000 ft^2 (8826 m^2)	1962	To be demolished
Emory Building	<15,000 ft^2 (1394 m^2)	1963	To be demolished
Roberdeau Hall	<140,000 ft^2 (13,006 m^2)	1966	To be renovated
Maury Hall	<155,000 ft^2 (14,400 m^2)	1988	To be renovated
Visitor Center	<1500 ft^2 (139 m^2)	2005	To be demolished

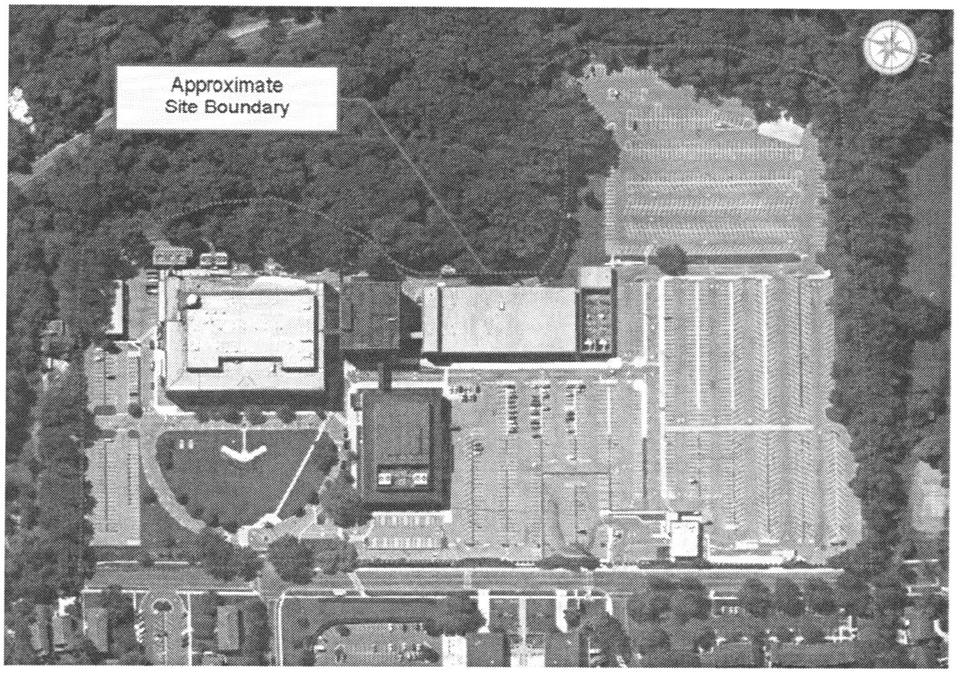

Figure 1 *Former NGA Sumner Campus. (Illustration provided by USACE, Baltimore District.)*

concrete) with various levels of batt or board insulation (including zero insulation) depending on the age of the building. Roofs are flat with layers of insulation and built-up roofing. The buildings were without windows (for security reasons) with the exception of Erskine Hall, which had a limited window-to-wall ratio. Windows were generally fixed sashes with double glazing in aluminum frames.

The secondary HVAC systems in the buildings were generally VAV AHUs with shut-off-style reheat terminal boxes. The systems were generally in fair condition. However, typical efficiency issues were persistent, such as simultaneous heating and cooling in VAV reheat systems. The computer room spaces were served by chilled-water computer room air-conditioning (CRAC) units. The primary HVAC systems consisted of chilled water and a steam plant. The chilled-water system consisted of three separate chilled-water plants located in the three campus buildings. The chilled-water distribution system was connected to all the campus buildings such that all chillers could be used to provide cooling capacity to the loop. Each of the three buildings was equipped with three water-cooled centrifugal chillers with a total nominal cooling capacity of approximately 6000 tons (21,101 kW). This level of connected capacity was due to each plant being made up of redundant chillers. Interviews with plant operators and review of chiller logs suggest that the peak cooling load for the campus was less than 2400 tons (8440 kW). The chilled-water system equipment varied in age from 12–24 years and was reportedly of degraded efficiency. Several of the chillers originally used R-11 and had been converted to use R-123.

Campus heating and domestic hot-water loads were met using two 500 hp (4905 kW) and one 200 hp (1962 kW) steam boilers located in Erskine Hall. The steam was distributed to the remaining buildings and generally converted to hot water for use in the buildings. The larger boilers were installed in 1975 and were in generally poor condition. The smaller boiler was installed in 2001 to provide steam capacity during the summer months. The steam system overall was found to have significant energy losses in the ancillary devices and distribution systems.

The buildings were equipped with BASs made up of a blend of pneumatic and direct digital control (DDC) systems that managed the operation of the HVAC equipment, including the central plant, air handlers, and terminal devices. Control panels located within each mechanical room provided operational control of the major equipment, such as air handlers, and pneumatic control valves to meet the space temperature requirements. The systems were integrated together for centralized control. No advanced control schemes for the purpose of energy optimization were reportedly in use.

The information gathered for the campus buildings was used to develop hourly energy simulation models for the buildings that were combined into an overall campus model. The model was refined and calibrated against the actual utility data for the 2008 calendar year. The hourly weather data was used for the period coincident to the available utility data. Figures 2 and 3 show comparisons of the actual utility data to the results of the campus energy model.

Figure 2 shows the monthly comparison of the predicted energy usage. The model predicts the annual electrical usage to be 38,048,968 kWh. A comparison with the actual electrical usage for the baseline year (37,929,452 kWh) results in a mean bias error of +0.7%. The electrical demand profile (kW/

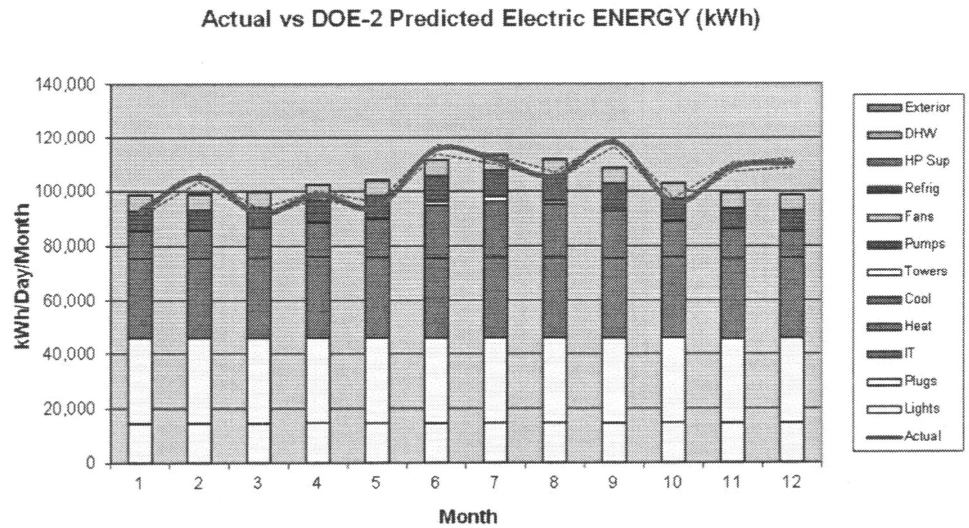

Figure 2 *Actual versus predicted electrical energy usage.*

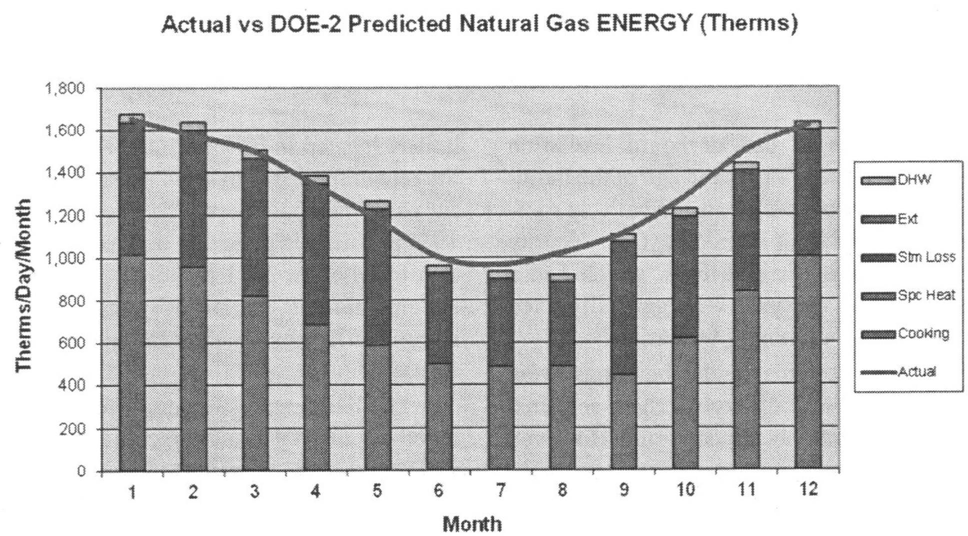

Figure 3 *Actual versus predicted natural gas usage.*

month) predicted by the model would normally be compared to the historical demand profile as well. However, in this case, historical demand data were not available for the baseline period. Figure 3 shows a similar comparison of the natural gas usage for the campus. The resulting model predicts the annual natural gas usage to be 480,984 therms (14,092,831 kW). A comparison with the actual natural gas usage for the baseline year (478,575 therms [14,022,248 kW]) results in a mean bias error of –0.2%. The calibrated model slightly underpredicts the gas consumption. However, this includes overall parasitic losses of approximately 47%. It should be noted that the previous analysis undertaken by USACE found similar results with respect to gas usage not directly attributable to useful heating loads.

The results of the calibration analysis were used to verify that the energy model was accurately simulating the energetic performance of the buildings and energy systems on the campus. Once calibrated, the energy model was then modified to conduct the required energy analysis for the campus redevelopment project.

CAMPUS REDEVELOPMENT DESIGN AND ENERGY ANALYSIS

The campus redevelopment involves the renovation of the three largest buildings on the existing campus. The three smaller buildings are to be demolished and a new building is to be constructed. The new Centrum building will be an approximately 230,000ft^2 (21,367 m^2) structure designed to provide interconnection between the Erskine Hall, Roberdeau

Hall, and Maury Hall buildings. The overall goal for the campus redevelopment is to achieve significant improvements in overall energy efficiency and sustainability for the buildings and campus overall. The renovation of the existing buildings seeks to minimize the internal and external load components and then meet them as efficiently as possible. The building façade of each structure is being replaced to increase the introduction of natural light while reducing the thermal loads from outdoor conditions. State-of-the-art light-emitting diode (LED) lighting is being used predominantly throughout the buildings with an extensive intelligent lighting control system. These types of design features are designed to allow for significantly reduced mechanical equipment capacity and energy infrastructure. The campus and individual buildings will make use of extensive submetering to isolate energy usage into end-use components. The submetering will allow continuous tracking of energy usage and direct billing of tenant organizations to raise occupant energy consumption awareness. All of these design elements combine to create the synergistic effect of substantial reductions in both implementation costs for the project and operational costs for the buildings going forward. The design standards for the construction and renovation projects called for achieving LEED Silver certification. The long-term goal is to achieve NZE consumption for as much of the campus as possible.

A site plan of the campus upon completion of renovation is shown in Figure 4.

As discussed previously, the design and implementation of the campus redevelopment is being conducted in phases. The DBT is responsible for developing the design of the buildings with respect to the new building structure (Centrum) as well as the façade and interior renovations of the existing buildings that will remain. The design is also to include the secondary HVAC systems within the buildings. The UESC team is to use the information provided by the DBT to design and construct the CUP, conduct energy analysis, and provide GFE equipment for installation by the DBT during the renovation of the existing buildings.

Adjusted Baseline Energy Analysis

The energy analysis for the campus redevelopment was complex in that it was required to properly isolate the energetic impacts of various portions of the project. This segregation is required to properly identify the energy and cost savings associated with the UESC portions of the project. Examples include the changes in space-use programming, such as adding instruction spaces, as well as the improved performance of the building envelope accomplished through the SATOCC portion of the redevelopment. This segregation was achieved through the use of an adjusted baseline model. The

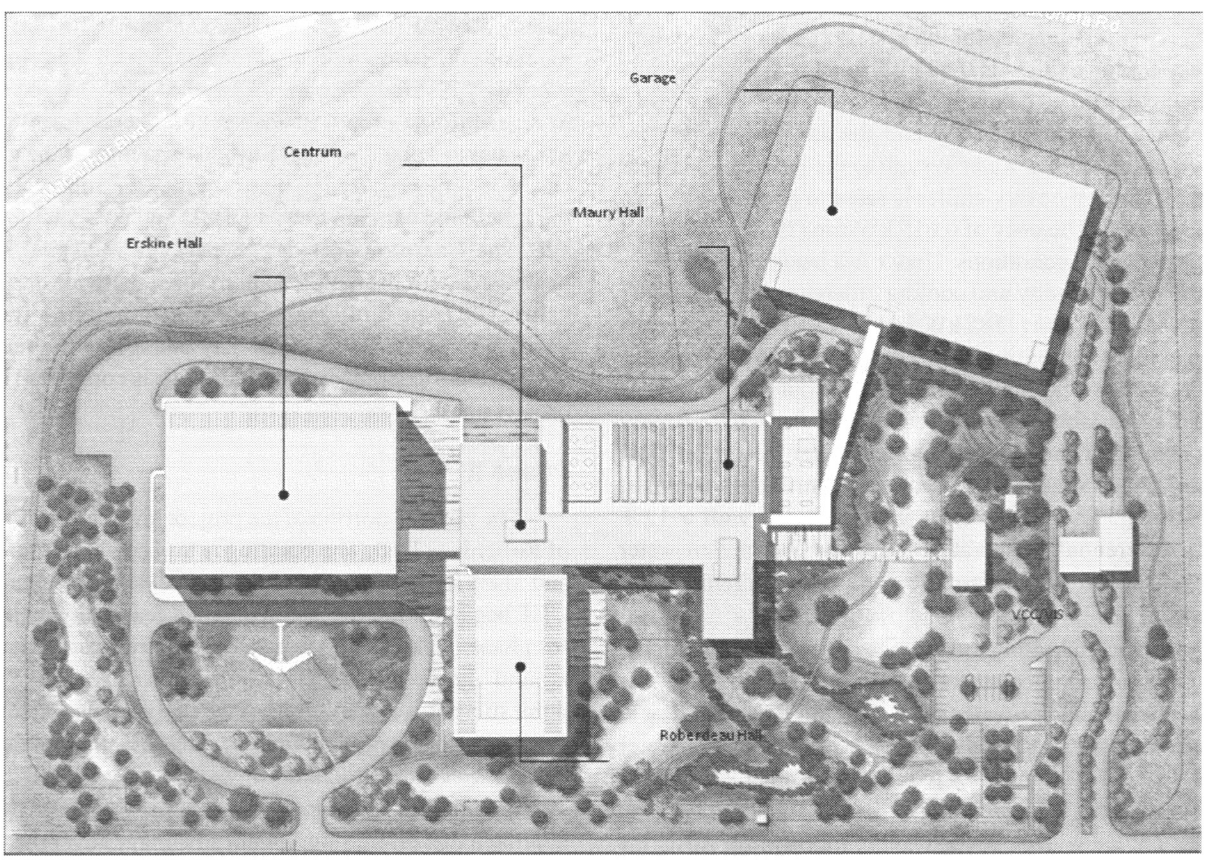

Figure 4 *ICC-B campus vision. (Illustration provided by USACE, Baltimore District.)*

model was initially developed using the information provided by the DBT for the Centrum Basis of Design (BoD) and 65% design package. The renovation of Roberdeau Hall and Erskine Hall was based on conceptual design information provided by the DBT as well as information gathered from the DIA regarding the projected space use of the renovated buildings. Once the information had been incorporated into the model, the impact of the UESC portions of the project could be properly measured against the performance of the adjusted baseline model.

Phase I

The phase I portion of the project involves the design and construction of the CUP to be used to provide chilled water and heating hot water to the campus buildings. As mentioned previously, the UET designed the CUP based on projections of the campus design cooling and heating loads provided by the DBT. As a result, the CUP was designed to provide sufficient capacity to meet the prescribed design loads while remaining highly efficient during low part-load operation.

The projected cooling load for the campus was calculated by the DBT to be approximately 1890 tons (6645 kW). This projected cooling load excludes specialized mission-critical cooling loads required to be met by systems with redundancy of both capacity and electrical power source. As a result, the chilled-water system design for the CUP was based on three 1100 ton (3868 kW) variable-speed chillers to meet the required $N+1$ redundancy for the system. The design cooling efficiency for the chillers is 0.593 kW/ton (20.2 EER) at full-load rated conditions. A fourth chiller was added to provide a combination of swing capacity and the ability to shift heat absorbed in the chilled-water system to the heating hot-water system. The heat recovery chiller is rated to provide 340 tons (1195 kW) with efficiency of 0.615 kW/ton (19.5 EER) at full cooling-load rated conditions. Under full heat recovery operation, the rated capacity and cooling efficiency change to 337 tons and 0.853 kW/ton (1185 kW and 14.1 EER), respectively, while providing approximately 5000 MBH (1465 kW) of heating hot water. The chilled-water distribution system is designed as variable primary flow, where the CUP primary pumps modulate the flow of chilled water based on flow demands of the variable-flow secondary distribution pumps at each building. The chiller units were selected with a 12°F (6.7°C) differential temperature between the chilled-water supply and return to decrease the pumping requirements for the system.

The projected heating load for the campus was calculated by the DBT to be approximately 10,320 MBH (3023 kW). As a result, the heating hot-water system design for the CUP was based on three 4000 MBH (1172 kW) condensing hot-water boilers. The $N+1$ redundancy requirement is met through the use of the heat recovery chiller discussed previously. The heat recovery chiller will be used to meet the heating loads the majority of the year, with the condensing boilers providing any required additional capacity. The thermal efficiency of the condensing boilers is in excess of 90% based on the design supply and return temperatures of the system.

The adjusted baseline model was modified to serve the campus buildings with the new CUP design, and operating parameters were entered into the campus energy model. The campus energy model estimates the total annual energy usage for the campus to be reduced by approximately 27% from the adjusted baseline model. This is made up of a 7% reduction in campus electrical usage and a 58% reduction in natural gas usage. The annual energy cost savings was estimated as approximately $580,000/yr based on projected electric and natural gas rates for the campus going forward. The energy cost savings were also augmented by avoided capital costs for the existing steam and chilled-water plants as well as reduced O&M costs.

The phase I portion of the UESC project was awarded based on a 35% design package for the CUP. After award, the UET moved toward completing the CUP design in coordination with the evolving design of the DBT for the Centrum building as well as existing building renovation designs. Significant design coordination issues have arisen that could have an impact on the efficiency of the systems, the cost of the program, and the ability to properly achieve the construction requirements of the project. One such issue is the selection of cooling coils for the Centrum building. The DBT selected cooling coils for the building based on a 10°F (5.5°C) temperature differential. The UET designed the chilled-water system based on a 12°F (6.7°C) chilled-water temperature differential to reduce the pumping requirements for both the primary and secondary distribution pumps. Another issue that has arisen is in regard to the projected load requirements for the heating hot-water system. The total heating capacity for the CUP was based on projected design loads for the Centrum building and the remaining campus from the BoD and 65% drawing package. The Centrum final design package indicated a design heating load for the building approximately twice the previous value. The issue further raises the question of how the design heating loads for the campus may change as the renovation design of the existing campus buildings is completed in future project phases.

Phase II

The phase II portion of the project involves the renovation of Roberdeau Hall. The building is to receive a complete core and shell renovation. The energy analysis conducted by the UET began during the initial detailed feasibility study (DFS) for phase I. The UESC was to develop recommended ECMs around the secondary HVAC systems, BAS, lighting, and domestic hot-water systems. The analysis also included the use of on-site energy production using solar thermal hot-water and PV electrical production.

The UET developed an alternative HVAC design approach that offered significant advantages over the standard VAV design used in the existing building and the 35% design from the DBT. The proposed system uses DOAS AHUs to provide cooled and dehumidified primary air to the spaces. The DOAS unit will be equipped with a heat recovery wheel, chilled-water cooling coil, and direct-expansion (DX) cooling coil (with hot-gas reheat). The conditioned primary air will then be delivered via series fan-powered terminal units in the zones throughout the building. The terminal boxes draw return air from the plenum and blend it with a small percentage of conditioned primary air (10%–25%). The terminal unit is equipped with a cooling coil to meet the sensible cooling loads in the space. The amount of primary air introduced will be modulated based on a combination of zone humidity and carbon dioxide levels. The total flow of air to the space will be modulated based on zone temperature requirements using variable speed electronically commutated motors (ECMs).

The proposed design has several significant advantages over the standard VAV design. The proposed design greatly reduces the overall fan power requirements by eliminating the need for local AHUs and ductwork to distribute the full flow of air to the spaces. The majority of the latent cooling will be handled in the DOAS units with combination cooling coils. The system provides outdoor air to each zone based on the specific requirements for occupancy and space humidity. The combination of these and other factors were shown in the energy model to provide an increase in energy savings of approximately 69% over the standard VAV design. In addition to increased energy efficiency, the proposed design is expected to provide benefits for implementation cost and building design. The design eliminates the need for separate AHUs and large duct runs throughout the building. This reduces the cost to provide and install this equipment and frees up mechanical space for other space allocation. The UET proposed this alternative HVAC design along with the projected energy savings that would result from using this approach for the renovated buildings. The DBT had continued to progress the design of Roberdeau Hall to the 65% level based on the standard VAV system design. While the UET's proposed design approach would result in a significant increase in energy savings, changing the BoD fundamentally at 65% would significantly increase the time and expense required to complete the design. The decision was made to continue with the standard VAV HVAC design in an effort to maintain the projected occupancy date.

The detailed energy analysis for phase II began with updates to the adjusted baseline model based on the design details provided for the interior design and 35% façade renovation. The largest adjustments were based on increased window-to-wall ratio and increased specificity on the window and wall types. The energy model for the building was then modified in a series of parametric runs to account for the energy savings associated with each component ECM for the UESC. The initial change was connecting the building to the new CUP chilled-water and heating hot-water systems. The UET then modified the Roberdeau Hall model to account for the proposed lighting system design. The proposed lighting system uses LEDs extensively throughout the building, including where linear fluorescent tubes would more traditionally be used. The UET provided the design requirements to the DBT for use in their development of the detailed design. The overall result shows the lighting connected load density of approximately 0.50 W/ft^2 (5.4 W/m^2). The design also includes an advanced integrated lighting control system to account for items such as scheduling, occupancy, daylight harvesting, and light-level tuning. The UET integrated the DBT standard VAV HVAC design into the Roberdeau Hall building energy model along with advanced control schemes and scheduling around the projected operating schedule. Advanced control schemes included supply air temperature reset, static pressure reset, and outdoor air economizer. The energy model estimates the total annual energy usage for Roberdeau Hall to be reduced by approximately 69% from the adjusted baseline model. This is made up of a 41% reduction in building electrical usage and an over 80% reduction in natural gas usage when including the impact of the CUP and building energy improvements. The annual energy cost savings was estimated as approximately $130,000/yr based on projected electric and natural gas rates for the campus going forward. The energy cost savings are those attributable to Roberdeau Hall alone. The energy savings attributable to the CUP were taken as part of the phase I energy analysis.

Phase III

The phase III portion of the project involves the design and construction of Erskine Hall. This phase is similar to phase II, where the building will receive a core and shell renovation while converting the use of the building to intelligence-community agency tenant fit out.

Recent developments for phase III have shifted additional scope to fall under the UESC. Financial shortfalls for unforeseen scope requirements such as asbestos and lead paint remediation have risen under the current SRM contract. This will limit the campus renovations unless more scope is shifted to the UESC. Under negotiations at this time, the UESC may take over the entire base building design and installation for the mechanical and electrical systems related to the ECMs defined in the DFS. The UET will take the DBT's 65% design for phase III and develop the remaining design to 100% construction documents.

In addition to designing and installing the base building mechanical and electrical systems, the UET would also provide equipment as *government furnished/contractor installed (GFCI)* to the DBT for the two floors currently being programmed, designed, and installed by the DBT, similar to phase II as mentioned previously. The contract modification and scope have not been finalized at the time of this writing, but all stakeholders agree this is a viable option to keep the campus renovations on track to meet the ultimate mission. The underlying challenges of phase III will remain as they did for phase II due to construction schedule constraints. Moving forward with the UESC team's HVAC system design approach, outlined in the DFS, would jeopardize the schedule and burden the project with additional design fees. As in phase II, the decision was thus made to continue with the standard VAV HVAC design that was outlined in the DBT conceptual design for phase III in an effort to maintain the project completion date.

Phase IV

The phase IV portion of the project involves the design and construction of Maury Hall. At this time it is unknown how extensive the design and renovations will be. It is currently occupied and will remain occupied during the duration of the campus renovations until possible swing space is made available. The UET has assumed the same ECMs will be carried out on Maury Hall as in the other phases in order to maximize energy savings for the overall campus.

In this phase, the UET will move forward with the campus-wide PV system as addressed in the DFS. Stakeholders agreed that installing the PV system in the later phases will minimize impacts on site logistics and construction activities. It is also more economical since the PV DBT would mobilize and demobilize once, in lieu of waiting for phases to be completed so the team could start construction. The estimated on-site production is approximately 1 MW. This is based on utilizing roof-mounted PV systems on all four buildings (Centrum, Roberdeau Hall, Erskine Hall, and Maury Hall). One goal of the PV system's production capacity is to offset Roberdeau Hall's electrical demand, possibly resulting in a NZE building. Whether this can be achieved is currently still under evaluation, and the UET is exploring other potential areas on campus that could be viable locations to harness additional solar energy to maximize the on-site energy production from solar PV systems.

LESSONS LEARNED

As the renovation of the ICC-B campus has progressed, lessons learned have surfaced over the course of the project. Unfortunately, the UESC team experienced obstacles that could have been prevented if earlier calibration with all stakeholders had taken place during the conceptual phase of the project. Coupling the traditional SRM contract with the UESC from the beginning would have required additional up-front planning but would have resulted in a more cohesive product and potential for additional energy saving opportunities. One apparent hurdle was the contractual and scheduling constraints that limited the influence that the UESC team could have on the DBT's designs. As mentioned previously, the DBT had obligations and specific schedules for delivery of completed phases of the campus. Therefore, it was necessary for them to continue progressing forward to meet their contractual obligations. In parallel, the UET was developing the DFS, which demonstrated viable ECMs. The parallel engineering development along a condensed timeline created insurmountable issues when seeking to integrate solutions from both teams.

Throughout the development and completion of the UET DFS, the DBT progressed forward with their design obligations. When the two efforts reached maturity, stakeholders were in a position that left them few options. One option was to extend the schedule and pay for additional design fees to implement all of the UESC team's ECMs and not sacrifice any potential energy savings demonstrated by the UET's DFS. A second option was to take a hybrid approach, which was to pursue ECMs that had little impact on the overall schedule but would reduce the campus's carbon footprint and minimize additional cost to the project. As a result, all stakeholders agreed to move forward with the hybrid approach, which fine-tuned the UET's ECMs to fit within the current DBT's design without impeding progress toward the ultimate goal of providing a state-of-the-art campus by a contractual project completion date.

In future efforts such as this, the two contract teams should be identified and begin collaborating from the very beginning of the project development. Under this model, the energy project development team would work directly with the design team to integrate the ECMs into the BoD. This will allow the systems to be designed in a manner that maximizes the benefits achieved in both energetic performance and constructability. This integrated design team approach would also decrease the overall development costs over separately engineered solutions competing for schedule and budget resources. As the project moves from design into construction, the integrated team approach would greatly reduce the likelihood of coordination issues and scope gaps. The largest benefit may be that an integrated team approach would foster a more collaborative working environment for achieving the best possible common result.

Projects such as these are highly complex and require instant communication between the team members. Regular and open communication will ensure scope-gap conflicts are identified early. The complexity of the ICC-B project led the team to decide early on that weekly meetings would be necessary. Some weeks the teams met more than once, and all meetings were held on site, away from home-office distractions. The communication between all stakeholders is likely the single most important component to a successful project of this magnitude and complexity.

SUMMARY AND DISCUSSION

The combination of the advancing age of the building stock and federal mandates for energy efficiency and sustainability are creating increased strain on agency budget planning. Federal agencies will continue to have a need to recapitalize aging facilities in order to meet new and evolving missions. Efforts to improve energy efficiency and sustainability of the federal building inventory will continue. Addressing these requirements will need to be accomplished in an environment of increased budget pressures. Navigating this new reality successfully will require the innovative application of tools and resources available to the stewards of federal facilities. Blended contract approaches leveraging alternative financing to enhance the energy performance of renovated facilities represents a viable option that could be applied elsewhere within the federal government to help address these challenges.

In the case of ICC-B, the project began as a traditional SRM contract and was met very early on with significant budget limitations. The DIA senior technical expert recognized the need to take an innovative approach combining the SATOCC with a UESC. This approach allowed the UESC to ensure that many of the aging energy systems, such as HVAC, lighting, and electrical infrastructure, were funded through energy cost savings. The combination of subject matter expertise allows the energy project team to remain focused on developing ECMs while the design-build team focused on the larger design development.

Innovation is not without its own set of challenges, however. Doing things differently impacts each of the stakeholders in an endeavor of the nature described in this paper. Many of the stakeholders were naturally resistant to change processes and behaviors that had served them well in the past. The value of continuously emphasizing the benefits that can be derived from deviating from normal practice is key to better ensure buy-in from stakeholders. Additionally, the sooner that alternative practices such as the one described in this paper can be introduced, embraced, and integrated into the facility acquisition process, the greater the likelihood that the highest degree of benefits will be achieved.

There are several reasons beyond the energy and environmental benefits that recommend the blending of alternative financing with the capital funding approach to wider application in the federal government, including the following:

- Reduced first and recurring costs to the government
- A more energy-efficient campus
- Fixed accountability for systems performance
- Flexibility to meet evolving program requirements

In addition to installing and/or supporting the installation of the ECMs that compose the UESC project and operating the CUP, the UET will provide O&M services to the entire ICC-B campus. This provides the benefit of establishing a single point of accountability for energy performance at the site which, in turn, enhances energy security by reducing opportunities for conflict that could negatively impact the delivery of utilities service to the supported buildings.

Finally, one of the significant benefits of the UESC approach specifically has been the ability to adapt the use of that contract vehicle to support the campus redevelopment effort in what has proven to be a relatively dynamic funding environment.

DISCLAIMER

The views expressed in this briefing are those of the authors and do not reflect the official policy or position of the intelligence community, Defense Intelligence Agency, the Department of Defense or any of its components, or the United States Government.