DEEP ENERGY RETROFITS USING ENERGY SAVINGS PERFORMANCE CONTRACTS:

SUCCESS STORIES

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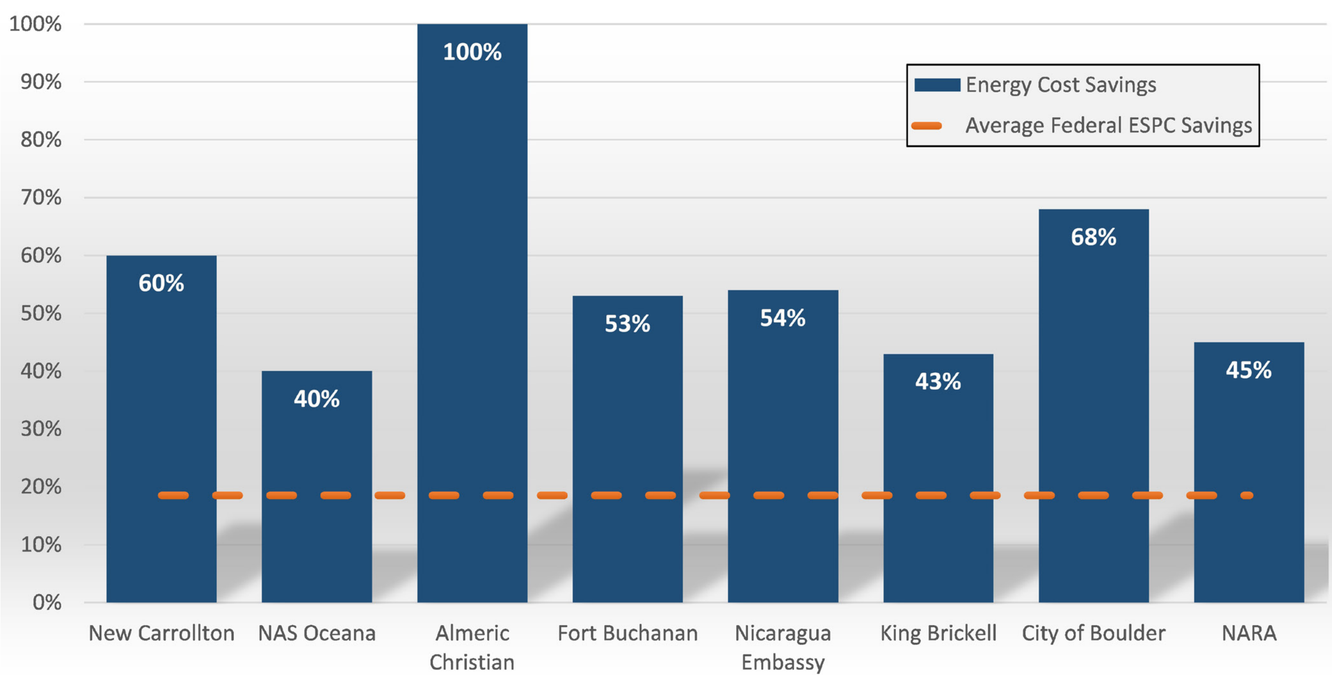
Front and back cover image courtesy of: *Mick Stephenson - John F. Kennedy Presidential Library and Museum*

DEEP ENERGY RETROFITS USING ESPCs: INTRODUCTION

Energy savings performance contracts (ESPCs) have become a key mechanism for energy efficiency upgrades in recent years, with the federal market now exceeding $1 billion in gross annual revenue.[1] ESPCs allow federal agencies to partner with an energy service company (ESCO) in order to complete energy savings projects without upfront capital costs or Congressional appropriations.

This report showcases eight case studies that highlight best practices in federal ESPCs. Highlighted projects—including seven federal and one municipal project—cumulatively exceed 600 billion BTUs in energy savings, with an average 58% energy use reduction.[2]

FIGURE 1: *PROJECT COST SAVINGS[3] FOR EACH CASE STUDY COMPARED TO AVERAGE FEDERAL ESPC SAVINGS[4]*



[1] Stuart, Elizabeth, Peter H. Larsen, Charles A. Goldman, and Donald Gilligan. Current Size and Remaining Market Potential of the U.S. Energy Service Company Industry., 2013.

[2] Best single-building savings used for NARA and City of Boulder portfolios, as these portfolios included both deep retrofits and lighter-touch building retrofits.

[3] Best single-building savings used for NARA and City of Boulder portfolios.

[4] Shonder, John, "Approaches to Deep Energy Retrofits in the US Federal Government" IEA Annex 61 Technical Day. Tallinn, Estonia. 22 September 2014.

While each project has a unique story, six key best practices emerged across all cases. These best practices include both those exemplified in the following case studies and those that project interviewees identified as an area for improvement. Federal agency and ESCO representatives can use these six best practices to push their next ESPC project to deeper levels of energy savings.

1) SET AGGRESSIVE LONG-TERM GOALS

Setting aggressive goals early is essential to planning a deep energy retrofit. Decisions made early in the project can have a significant influence on end results.

Key Considerations:

- Establish long-term goals and build a roadmap toward those goals. Determine ideal intervention points[5] and consider the interactive effects between projects along this roadmap to ensure that future intervention points are not mitigated by uncoordinated short-term projects. Multi-phase projects can be used to ensure consideration of long-term interactions.
- Clients should clearly state desired outcomes and constraints (including the intent to achieve deep savings) in requests for proposals (RFPs), and be prepared to be more engaged as an owner.[6] The project should entail a more rigorous audit process and a broader set of energy conservation measures (ECMs) than a conventional retrofit.
- Quantify the project's impact on non-energy benefits (e.g., greater resiliency and public image) when deciding how deep to push the project.[7] Include water and waste efficiency in the project scope to maximize impact.
- Use a bundled payback hurdle of 25 years, the maximum contract term stipulated by the federal government. Allowing the project team to bundle short- and long-term measures under minimal constraints maximizes synergy between measures and builds long-term value.[8]

[5] See RMI's "Specifying Triggers." Resource provided at the end of this report.

[6] See RMI's *The Path to a Deep Energy Retrofit Using an Energy Savings Performance Contract*. Resource provided at the end of this report.

[7] See RMI's *How to Calculate and Present Deep Retrofit Value*. Resource provided at the end of this report.

[8] Long-term ESPCs yield nearly double the ESCO-guaranteed cost savings to the government. See *Oak Ridge National Laboratory's Beyond Guaranteed Savings*. Resource provided at the end of this report.

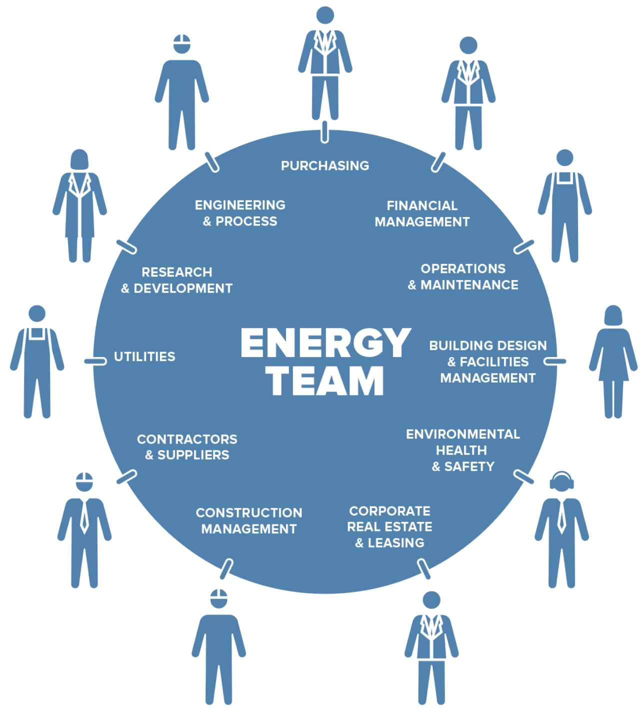
2) ENGAGE AND COLLABORATE WITH DIVERSE STAKEHOLDERS

Involving a diverse group of stakeholders in a deep retrofit project is critical to understanding each group's intrinsic needs and constraints as they relate to the project scope. Involving stakeholders also builds engagement, fosters collaboration, and helps to identify otherwise-hidden project pitfalls. Potential stakeholder groups include the project development team and construction team; agency representatives and building tenants; contractors and subcontractors; the operations and maintenance (O&M) team; measurement and verification (M&V) specialists; and marketing, security, human resources (HR), and information technology (IT) representatives.

Key Considerations:

- Kick off the project with a collaborative design charrette that assembles all stakeholder groups. Clearly define project roles, responsibilities, desired outcomes, concerns, and recommendations.
- Maintain stakeholder engagement throughout the project. Require an on-site prime contractor, dedicated project engineer, on-site meetings, and frequent project updates to increase exposure to stakeholder groups and enable a more iterative design process.
- Mitigate personnel turnover during the project. ESCOs should ensure continuity between the development and construction teams. Clients should address turnover through centralized support and potentially a memorandum of agreement (as discussed in the U.S. Embassy in Nicaragua case study).
- Build tenant engagement by incorporating non-energy upgrades into the project scope, minimizing the impact of construction on building operations, and implementing education programs and/or design-review processes around major or potentially sensitive measures.

FIGURE 2: *POSSIBLE ENERGY TEAM STRUCTURE*
SOURCE: WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (WBCSD)



3) ESTABLISH A SUPPORT SYSTEM

No successful project can reach completion without strong overarching support from the client and dedicated ESCO management.

Key Considerations:

- Foster project champions within your organization. Nearly every interviewee consulted for this report credited project success to the dedication and commitment of one or two key individuals. These individuals deserve recognition for their work, potentially through an award program or with financial incentives.

- Run project management, legal and procedural support, and information dissemination through a centralized project management office (PMO). This takes pressure off the project team and enables the bundling of projects across locations (when advantageous). Centralized management and support is especially important for smaller agencies and those less familiar with the ESPC process.

- Provide the early support necessary to identify and capture applicable utility rebates, federal grants, and appropriated capital-improvement funds to reduce project costs and enable more aggressive measures.

- Make use of federally supplied resources. The DOE Federal Energy Management Program (FEMP) offers ESPC education programs, technical assistance, and project guidance (including project facilitators and step-by-step project guidelines)[9]. Other organizations, including Lawrence Berkeley National Laboratory (LBNL) and the National Renewable Energy Laboratory (NREL), provide more specialized assistance.

- Support the development of policy mandates and federal programs that push for deep energy savings. The President's Performance Contracting Challenge, Army Net-Zero Initiative, and GSA's National Deep Energy Retrofit (NDER) Program have all successfully incentivized deep retrofits.

[9] See DOE's Federal Energy Management Program. Resource provided at the end of this report.

4) START WITH A CLEAN SHEET AND A BEGINNER'S MIND

Designers often succumb to "infectious repetitis," reproducing inefficient buildings by starting with a previous or familiar design. Repetitive design can be effective if the previous design was optimized but this is generally not the case. By starting the project without arbitrary design constraints, the development team has the opportunity to create the most efficient design possible.

Key Considerations:

- Develop the project around providing desired end uses (e.g., heat, light, and comfort) as efficiently as possible, rather than specifying a delivery method. This subtle change in mindset opens the project to measures that might otherwise have been overlooked.

- Avoid making unfounded assumptions about specific technologies and their application to a project. The energy technology field is developing quickly, and the economics for many ECMs (e.g., LEDs) have dramatically improved over the past several years.

- Provide the necessary time and resources to develop creative ideas. Some of the most effective measures noted in these case studies were also the most innovative (e.g., NAS Oceana's wastewater-effluent heat-rejection loop).

5) USE AN ITERATIVE, HOLISTIC DESIGN PROCESS

The strongest project designs are generally those that consider frequently neglected impacts, quantify synergies between project measures, and use a nonlinear design process to incorporate new information. By expanding the problem, these projects are more likely to reach a truly optimized outcome.

Key Considerations:

- Use a design-build project-delivery method, which allows for scope edits as new information is uncovered. Note that design-build projects are generally more complex and require a strong project-support system.

- Use a multi-phase project delivery method, which allows the project team to use lessons learned during earlier phases to inform designs in later phases. Multi-phase projects also allow the project team to build deep-cutting measures around ideal intervention points (e.g., equipment replacement) while also capturing easy savings up front (e.g., through recommissioning).

- Require an on-site prime contractor and on-site meetings, both of which help to uncover new project information through exposure to stakeholders and site processes.

- Use integrative design and consider the project's non-energy benefits (e.g., resilience and public image). The project team can only deliver a truly optimized design by considering the project's interactive effects within and across value streams.

6) INCORPORATE FEEDBACK AND ONGOING INVOLVEMENT

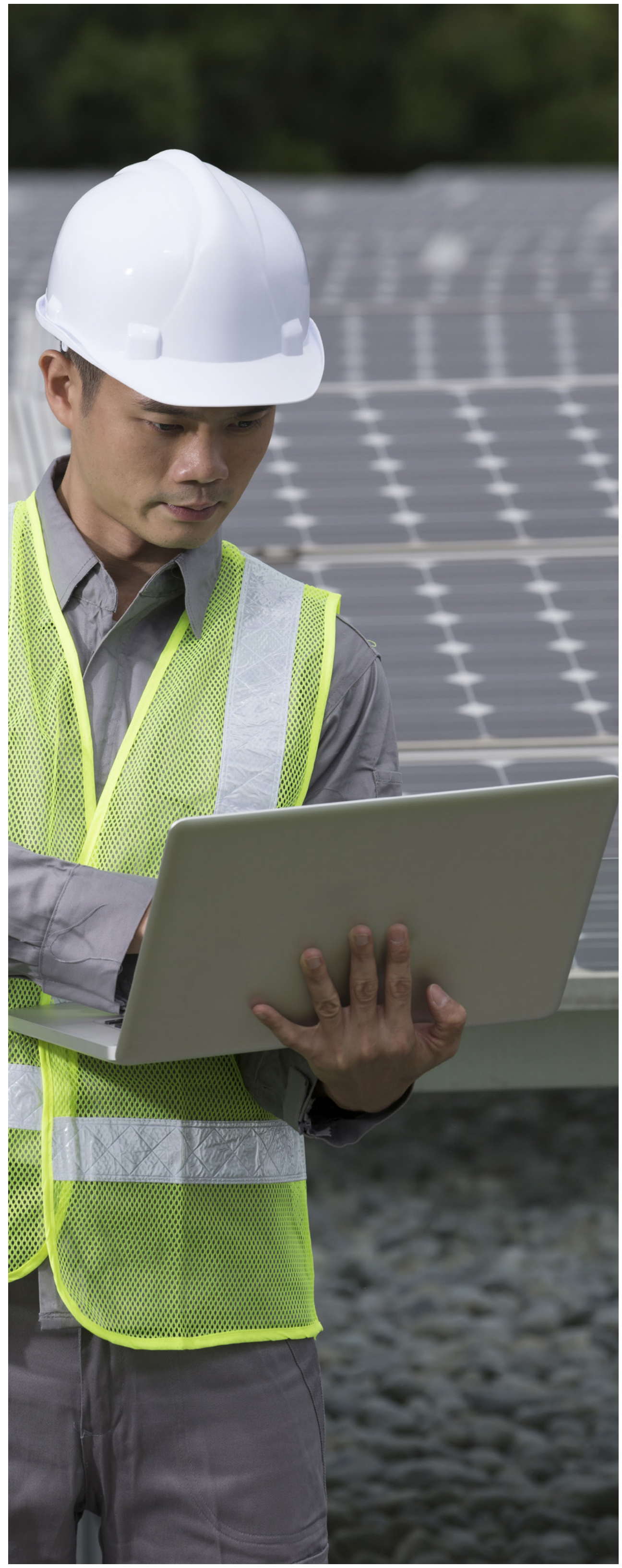
Even the most efficient building will not reach its full potential unless operated correctly. In ESPCs, ensuring the preservation of initial savings is paramount to justifying the project's investment and mitigating risk for both the ESCO and client.

Key Considerations:

- Incorporate building automation system (BAS) installation or upgrades into the project scope. These systems help facilities managers quickly identify and resolve inefficiencies that can otherwise go unnoticed. BAS data can also be used to inform future projects.

- Use targeted audits to discover information critical to building retrofits, including building equipment age and condition. This can be performed either before a project—potentially across a building portfolio—or as a part of the earliest phase in a multi-phase project delivery.

- Incorporate behavior-change and occupant-engagement programs into the ESPC. These programs are effective, low-cost insurance policies against savings losses due to occupant behavior. A wide range of strategies exist, including informational plaques near key building systems and regular emails providing occupants with operational recommendations.



COMPREHENSIVE BUILDING IMPROVEMENTS:

NEW CARROLLTON FEDERAL BUILDING

The New Carrollton Federal Building
Image courtesy of: *Rife International*

COMPREHENSIVE BUILDING IMPROVEMENTS: NEW CARROLLTON FEDERAL BUILDING

Energy service company Ameresco's deep energy retrofit at the GSA's New Carrollton Federal Building resulted in a projected 60% energy reduction and 56% water reduction, particularly impressive given the relatively efficient operation of the original building. The project hinged upon a 40% downsizing of the existing chiller system—made possible through integrative, whole-system design—and was bolstered by excellent local utility incentives.

KEY ENERGY CONSERVATION MEASURES (ECMs):

- Central chilled-water plant
- Integrative building controls and sensors
- 11,000+ LED replacements
- 808 kW solar PV
- Geothermal heat rejection
- Exhaust-to-Outdoor-Air heat-recovery loop

PROJECT SNAPSHOT:	
Location	New Carrollton, MD
Building Size	1.2 million ft^2
Original Construction	1994
Development & Construction Duration	38 months (2012–2015)
Investment Value	$40.0 million
Appropriated Funds	$586,000 (1%)
Contract Term	22 years
Cost Savings	$2.5 Million/year
Energy Savings	94,588 MmBtu/year (60%)
Energy Service Company	Ameresco, Inc.

"ANY TIME YOU HAVE A CHAMPION DRIVING THE PROJECT, THAT'S A KEY DIFFERENCE." - Nicole Bulgarino, Ameresco senior vice president

INTEGRATIVE DESIGN AND FOCUS ON END USE

An integrative approach was essential in maximizing efficiency gains at the New Carrollton Federal Building. A bulk of the project savings was achieved by a new chiller system, which was made possible by the building's seemingly unrelated lighting retrofit. The installation of LED fixtures, among other measures, reduced the chiller's required cooling capacity by over 40%. This massive downsizing of the replacement chiller system generated significant capital savings over business as usual, and supported investments in deeper-cutting ECMs.

The project team also intentionally focused on providing end-uses (e.g., warmth and comfort), rather than specific systems. This shifted the team away from pursuing basic component replacements and toward an in-depth exploration of more unique measures. This approach eventually yielded the geothermal heat-rejection loop and exhaust-heat recovery system that serve as essential components of the building's new HVAC system and were critical to achieving aggressive energy targets.

The team's integrative-design approach also shows in the building controls, which integrate the operation of the HVAC system (including a central chiller plant, cooling towers, geothermal loop, heat recovery system, and kitchen exhaust) with lighting and other building systems. The building-systems controls ECM was calculated to have the highest impact on energy and cost savings.

A three-year measurement and verification process using International Performance Measurement and Verification Protocol Option C (whole building-level) is currently under way on the majority of ECMs, with the solar PV array and water conservation measures being metered separately.

OVERARCHING SUPPORT

Ameresco credited the GSA's National Deep Energy Retrofit (NDER) Program with making smooth delivery of the project possible. National-level support and a clearly stated objective of achieving best-in-class energy savings set the project tone early on. Programmatic support from the national office under the NDER program also allowed the GSA's regional team to focus on measure development.

The use of a third-party project facilitator was also integral to pushing this project toward deep savings. This facilitator, a resource provided by the U.S. Department of Energy (DOE) Federal Energy Management Program, provided independent analysis to the regional GSA team regarding which project strategies best fit their goals and budget. The facilitator, as well as the DOE's step-by-step guidance on the energy savings performance contract process, helped the regional team make informed decisions to optimize the efficient use of taxpayer dollars.

BUILDING PROJECT BUY-IN

Ameresco and the GSA worked to build project buy-in by incorporating non-energy upgrades in the project, including a building roof replacement and rain gardens—the latter effectively met the GSA's stormwater management requirements. Rain gardens were installed concurrently with the neighboring parking lot canopy PV system in order to offset that system's aesthetic impacts, which had been a concern early in the project. The project team also found tenant engagement and education vital to maintaining a smooth construction process in a continuously occupied space.

Heat recovery coil installation
Image courtesy of: *Ameresco, Inc.*

South parking lot PV canopy
Image courtesy of: *Ameresco, Inc.*

THE NAVY BREAKS THROUGH:

NAVAL AIR STATION OCEANA

THE NAVY BREAKS THROUGH: NAVAL AIR STATION OCEANA

The Naval Air Station (NAS) Oceana deep energy retrofit is a four-phase endeavor that is unprecedented in both size and scope. The project—which kicked off in 2002 and is expected to be completed in 2017—is projected to reduce energy use by over 40% across more than 100 retrofitted buildings, saving the naval base over $6 million in annual energy costs.

KEY ENERGY CONSERVATION MEASURES (ECMs):

- Steam and chiller plant decentralization
- High efficiency HVAC equipment
- Renewables: solar thermal, ground-source heat pump (GSHP) with effluent heat rejection
- Digital controls: over 18,000 measurement points
- Lighting retrofits: over 40,000 fixtures
- Water conservation: over 10,000 fixtures

AWARDS AND ACCOLADES:

Phase 2 of the project earned the 2011 VSBN Green Innovation Award and the 2009 Presidential Award for Leadership in Federal Energy Management, and helped the Navy earn the 2009 Platts Green Energy Initiative of the Year award.

PROJECT SNAPSHOT:	
Location	Virginia Beach, VA
Building Size	5.38 million ft^2 (110 buildings)
Original Construction	1960–2000
Development & Construction Duration	15 years (2002–2017)
Investment Value	$89.6 million
Appropriated Funds	$0
Contract Term	13–19 years
Cost Savings	$6.07 million/year
Energy Savings	286,068 MmBtu (41%)
Energy Service Company	Trane U.S., Inc.

The project is centered on the decommissioning and decentralization of the base's out-of-date and inefficient steam plant, which had deteriorated beyond repair from corrosion (due to the plant's location in a coastal environment). This presented Navy and Trane personnel with an opportunity to leverage a major infrastructure investment as an enabler for deep energy savings. Load reduction measures such as lighting retrofits and the addition of high-efficiency HVAC equipment, together with system rightsizing, allowed the project team to downsize system components by up to 70%. Additional measures, including an extensive GSHP system that used graywater effluent from a nearby water treatment plant for heat rejection—one of the first systems of its kind—transformed the base's energy source from an outdated liability to a state-of-the-art example of efficiency.

Effluent heat exchange facility at the main base
Image courtesy of: *Trane U.S., Inc.*

The HRSD Treatment Plant, whose effluent pipeline was used in the Dam Neck GSHP system
image courtesy of: *Trane U.S., Inc.*

MULTIPLE PHASES AND A LONG-TERM OUTLOOK

Staging work across multiple phases allowed the Navy and Trane to capture easy, up-front savings while maintaining a long-term vision. Lessons learned during early phases were instrumental in shaping later work. The steam plant decommissioning implemented at the Dam Neck Annex in Phase 2, for example, was so successful that the measure was implemented at the main base as the cornerstone of Phase 3 work. Phase 2's successful lighting and water ECMs were also replicated and key systems were purposely over-sized with future expansion in mind.

In addition, the project team's long-term vision for the naval base was exemplified in operations and maintenance (O&M) procedures. The Navy decided from the project outset that O&M work would be contracted to Trane, allowing for Trane's O&M team to contribute to project development, thus avoiding a number of maintenance issues. The Navy also elected to consider O&M savings as a value stream, a significant decision considering corrosion issues at this coastal site. Some existing outdoor systems required replacement or retrofit every three to four years, a maintenance headache that the project team was able to address by installing all new equipment and piping indoors or underground.

MAKING OPPORTUNISTIC ADJUSTMENTS

During a routine site-walk late in Phase 2 of the project, a Trane engineer noticed a six-foot pipe running through the base. The pipe, which had not been previously considered, was an effluent pipeline stemming from the nearby Hampton Roads Sanitation District (HRSD) disposing 50 million gallons of graywater per day.

Project team members moved quickly to capitalize on the discovery. Navy and Trane quickly established a partnership with HRSD personnel, who allowed free use of their pipeline in exchange for a land easement to be used for future treatment plant expansion. The already-specified 450-ton ground-source heat pump and 4,400-ton condenser-cooling loop were redesigned to incorporate a heat-rejection loop utilizing the effluent pipeline. This allowed the project team to remove several cooling towers and other HVAC components from the original project scope. Using the massive effluent pipeline—where the internal temperature rises less than 1° F during use—was also significantly more efficient than traditional GSHP heat-rejection well fields (which generally reach 90–95° F) at a lower installation cost. This also significantly reduced the site's potable water use and steam-plant emissions.

Dam Neck Annex at NAS Oceana
image courtesy of: *United States Navy*

EXEMPLARY TEAMWORK

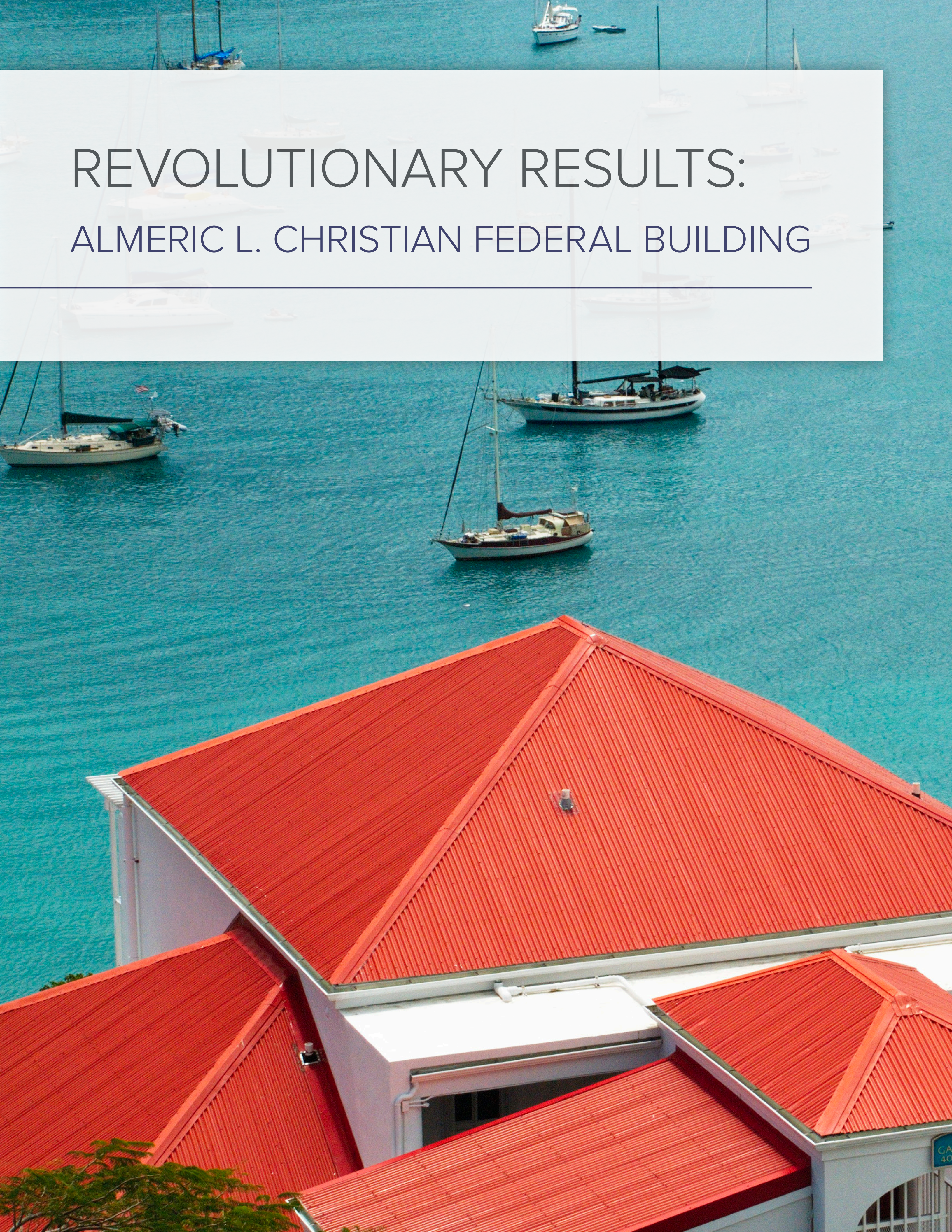
Project personnel credited their long-term vision and collaborative approach to trust between the Navy's deputy public works officer and a Trane federal executive. This trust was exemplified when the naval officer fought on behalf of Trane to recognize project savings that were taken off the table near the end of the project. Conversely, when Trane completed Phase 3 of the project over four months ahead of schedule (due in part to the excellent communication structure between Trane and the Navy), they elected to funnel $1.2 million in savings back into the site, retrofitting ancillary systems that had originally been left out of the project scope.

"BUILDING RELATIONSHIPS IN THE RIGHT PLACES IS ALL ABOUT INTEGRITY. YOU DON'T GET ANYWHERE WITHOUT A LEVEL OF TRUST." - Jody Wilkens, Trane director of federal contracting

VFA-81 and CVW-17 approach the virginia beach ocean front as they return to Naval Air Station Oceana
Image courtesy of: *clker.com*

REVOLUTIONARY RESULTS:

ALMERIC L. CHRISTIAN FEDERAL BUILDING



REVOLUTIONARY RESULTS: ALMERIC L. CHRISTIAN FEDERAL BUILDING

The Almeric L. Christian Federal Building on Saint Croix is the first known federal energy savings performance contract (ESPC) to achieve net-zero energy use. GSA partnered with Schneider Electric on the $6.4 million project, which resulted in savings exceeding $500,000 per year. International Performance Measurement and Verification Protocol Option C (whole-building level) is used on all efficiency measures.

KEY ENERGY CONSERVATION MEASURES (ECMs):

- Retro-commissioning
- Building automation system (BAS) upgrades and smart building integration
- Lighting upgrades
- Chiller, air handling unit (AHU), and pump replacements
- Window films
- 462 kW solar PV

PROJECT SNAPSHOT:	
Location	Saint Croix, Virgin Islands
Building Size	57,872 ft^2
Original Construction	1989
Development & Construction Duration	24 months (2012–2014)
Investment Value	$6.4 million
Appropriated Funds	$119,000 (2%)
Contract Term	19 years
Cost Savings	$510,000/year
Energy Savings	3,283 MmBtu/year (100%)
Energy Service Company	Schneider Electric

CLEAR AND AMBITIOUS GOALS

The Almeric Christian ESPC was part of the GSA's National Deep Energy Retrofit (NDER) program. The GSA's clear expectation for a deep energy retrofit to reduce the cost burden of high electricity rates led the project team to adopt an aggressive and revolutionary goal: net-zero energy use. Support for this goal came from all levels of the GSA, which provided the necessary resources and momentum to make the project successful.

By stipulating a net-zero energy project, the project team was able to reframe how energy measures were considered. Rather than confining ECMs to payback or internal rate-of-return thresholds, ECM's life-cycle costs were compared to the life-cycle cost of on-site energy production. This subtle difference gave the project team latitude to select deeper-cutting, longer-payback efficiency measures.

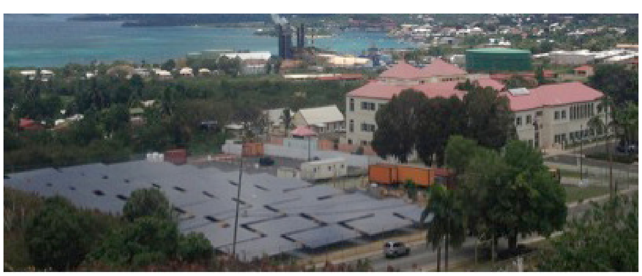
The Almeric L. Christian Federal Building's 462 kW solar array

COMPREHENSIVE STAKEHOLDER ENGAGEMENT

Schneider involved a diverse group of stakeholders from the project's outset. They maintained constant communication with key stakeholders through weekly on-site meetings involving local and regional staff (including tenant representatives), a three-week look-ahead during construction, and monthly check-ins with the national GSA Project Management Office.

Schneider noted that receiving the Task Order RFP during the beginning of the investment-grade audit allowed the project team to involve contractors and subcontractors early in development, a necessity due to the challenging nature of transporting a construction workforce to the island. Involving the construction team in the design process also helped the project team avoid costly change orders and identify low-cost capital improvements that could be easily incorporated into ECM delivery.

Understanding the unique requirements of the site and involving relevant personnel early were also essential to avoiding costly project delays. For example, new requirements regarding integration of the site's building automation system with GSA's Building Link system and relevant cybersecurity measures necessitated the early involvement of GSA's IT department. Schneider also had to move quickly to obtain necessary site-security clearances to avoid significant construction delays.



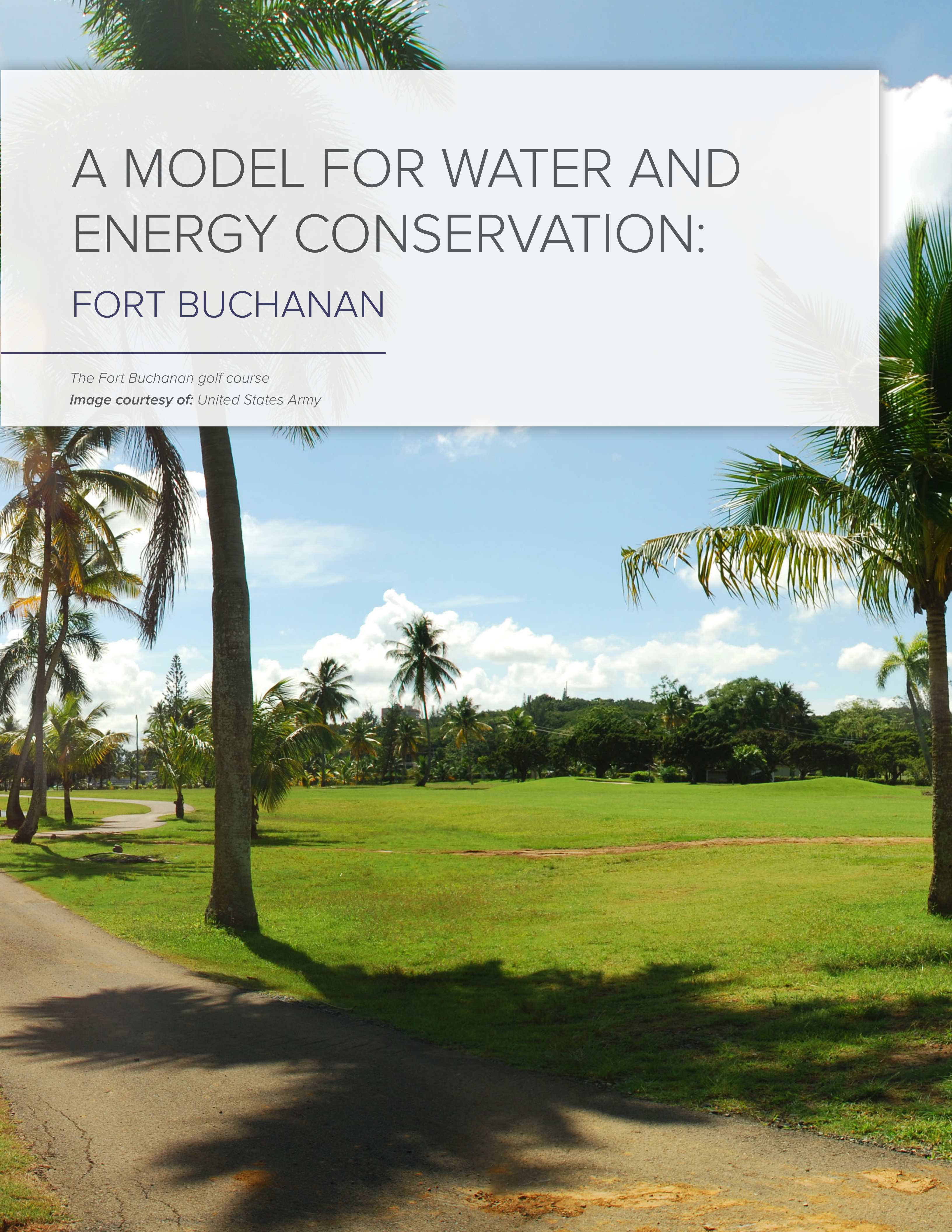
Almeric L. Christian Federal Building
image courtesy of: *Schneider Electric*

BUILDING TRUST IN THE PROJECT

Schneider built project buy-in by incorporating low-cost, non-energy benefits; involving stakeholders in the design process; and swiftly addressing tenant concerns. Almeric Christian's building manager, who was involved early in the development process, became a proponent for the design team and frequently proposed practical methods to address tenant concerns and needs. Examples include replacement of worn perimeter fencing, which was framed in the ESPC as a necessary security measure for installation of new transformers, and site re-grading, which was incorporated into the ground-mounted solar PV installation and effectively solved existing runoff issues. Schneider recognized that the stakeholder engagement and trust built through these measures was more valuable to the project's success than energy savings, and therefore justified the cost.

The project team also used tenant engagement to proactively address potential conflicts. When tenants presented aesthetic concerns about an ECM, they were brought into the design process through a collaborative mock-up review (done for lighting and window films) or educated about the effects of the final product (e.g. through solar-PV glare analysis).

By showing a clear commitment to their client, the ESCO built relationships that have endured well beyond project completion. Schneider has already been selected for two additional ESPCs with the GSA regional team, and both parties have collaboratively applied insights gained on Saint Croix to new projects and engagements.



A MODEL FOR WATER AND ENERGY CONSERVATION:

FORT BUCHANAN

The Fort Buchanan golf course
***Image courtesy of:** United States Army*

A MODEL FOR WATER AND ENERGY CONSERVATION: FORT BUCHANAN

The United States Army achieved 53% energy savings and 70% water savings at Fort Buchanan through a multi-phase energy savings performance contract with Johnson Controls. The first two phases of the project were implemented between 2010 and 2015, and a third phase targeting further energy and water reductions is currently underway.

KEY ENERGY CONSERVATION MEASURES (ECMs) AND WATER CONSERVATION MEASURES (WCMs):

- HVAC improvements
- LED lighting replacements and controls
- Solar PV, solar thermal, and wind generation
- Rainwater harvesting
- Weather-integrated irrigation
- Plumbing retrofits and leak detection

PROJECT SNAPSHOT:	
Location	San Juan, Puerto Rico
Building Size	1.7 million ft^2 (73 buildings)
Development & Construction Duration	38 months (2010–2013)
Investment Value	$71.1 million
Appropriated Funds	$0
Contract Term	17–20 years
Cost Savings	$4.8 million/year
Energy Savings	77,803 MmBtu/year (53%)
Energy Service Company	Johnson Controls, Inc.

AGGRESSIVE GOALS: THE ARMY NET-ZERO INITIATIVE

Fort Buchanan is a net-zero-water pilot site under the Army Net-Zero Initiative, which assesses the feasibility and best path forward for net-zero energy use, water use, and waste on army bases. The initiative builds upon the strategic importance of resource management to the Department of Defense's mission, which recognizes that reliance on energy, water, and material imports is a significant security concern. Reduced consumption and on-site generation of these resources enhances mission effectiveness, improves resiliency, and protects bases against unexpected cost spikes.

Within this context, the team successfully created early alignment and support for best-in-class savings at Fort Buchanan. Rather than searching for "easy win" conservation measures, the project team was directed to find the best long-term pathway toward net-zero resource use. This mindset shift led to the implementation of such innovative water conservation measures as rainwater harvesting, weather-integrated irrigation systems, and potable water generation. Future projects aim to make the base's water requirements entirely self-supplied.

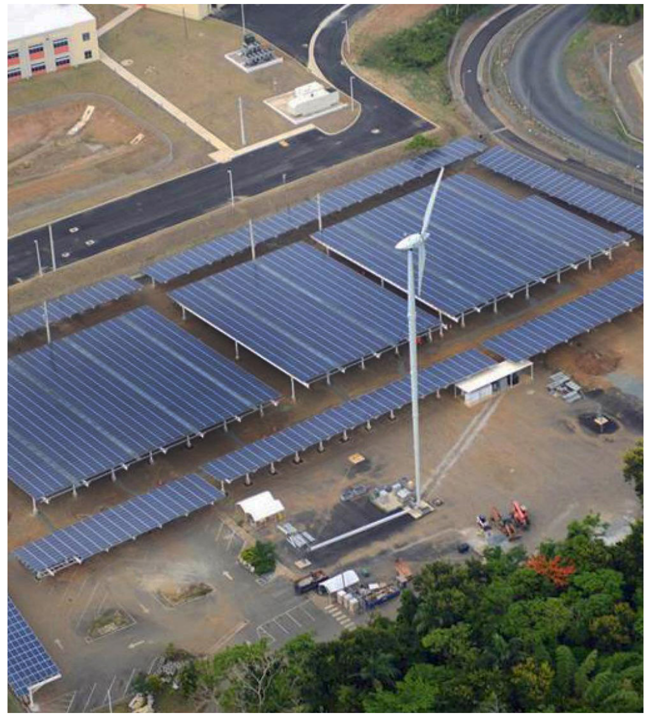
Project team members noted that the "best long-term path" philosophy established at this Net-Zero Water facility percolated well beyond water conservation. Stakeholders were motivated by the installation's aggressive goals, forward-thinking strategy, and overarching support from superiors. This backing also resulted in the project cutting energy use by over 50% despite a focus on water savings.

LONG-TERM VISION: MEASURE BUNDLING AND PROJECT STAGING

The scope of ECMs and WCMs implemented at Fort Buchanan exceeded the norm because of measure bundling. A $23.5 million investment in measures with 7–12 year paybacks (e.g., lighting upgrades, controls, and retro-commissioning) was combined with a $38 million investment in longer-term payback items (18–33 years). This bundling enabled the implementation of several uncommon ECMs such as reflective roof membranes and wind generation, many of which would not have been financially viable when considered in isolation.

The project was staged in a series of distinct phases, a strategy now common at many military installations. Project staging has allowed the development team to capture easy savings up-front, while scheduling other ECMs to coincide with right-timed opportunities (e.g., planned equipment replacement). Project staging has also enabled the team to reconsider measures that were originally uneconomical (including LED lighting) and apply lessons learned in early phases during subsequent design stages.

Project staging and measure bundling were both made possible by the long-term project vision to achieve net-zero water and energy use at Fort Buchanan. By contextualizing work as one step in a long-term, multi-stage process building toward an unwavering goal, the Army gave Johnson Controls latitude to build around the measures that best fit that path forward rather than incentivizing those with quick and easy returns.



Parking lot PV canopy and neighboring wind turbine
Image courtesy of: *United States Army*

Solar powered street lights
Image courtesy of: *United States Army*

BUILDING BUY-IN FOR AMERICAN EMBASSIES:

U.S. EMBASSY IN NICARAGUA

The Embassy's ground-mounted solar PV system
Image courtesy of: *Lockheed Martin*

BUILDING BUY-IN FOR AMERICAN EMBASSIES: U.S. EMBASSY IN NICARAGUA

In 2014, Lockheed Martin completed an energy savings performance contract (ESPC) at the U.S. Embassy in Nicaragua that will achieve a 54% energy reduction across nine buildings. This project was unique as it achieved deep energy savings in relatively new buildings despite the unique communication issues inherent in international embassies (management rotates every two years) and a lack of local utility incentives for renewables. An additional project phase currently in development will build toward net-zero energy use.

KEY ENERGY CONSERVATION MEASURES (ECMs):

- 2,238 LED replacements
- Chiller-plant optimization with staged loading
- Variable-refrigerant, multistage, direct-expansion cooling systems
- Building-automation-system retro-commissioning and sequence optimization
- High-efficiency transformer upgrades
- 956 kW high-efficiency solar PV

PROJECT SNAPSHOT:	
Location	Managua, Nicaragua
Building Size	193,000 ft^2 (9 buildings)
Original Construction	2007
Development & Construction Duration *	34 months (2012–2014)
Investment Value	$15 million
Appropriated Funds	$0
Contract Term	25 years
Cost Savings **	$1.6 million/year
Energy Savings	8,760 MmBtu/year (54%)
Energy Service Company	Lockheed Martin

* From PA kickoff to final acceptance

** Savings are recouped by energy service company through contract term

MAKING SOLAR WORK

Despite Nicaragua's abundant year-round sunshine and high electricity rates, a lack of local utility incentives impeded the implementation of solar PV on this project. Without an available utility net-metering program or other local financial incentives, solar PV would have a high capital cost and any excess generation (e.g., that planned for phase 2) would be lost. Additionally, embassy staff members were concerned that a large, ground-mounted solar installation would negatively affect the aesthetics of their work environment.

Lockheed Martin and the Department of State (DOS) Bureau of Overseas Buildings Operations (OBO) worked hand-in-hand with renewable-energy specialists from Lawrence Berkeley National Laboratory (LBNL) and the Department of Energy (DOE) to build confidence around the solar installation by comprehensively modeling the financial impacts of various simulations, including a potential battery-storage system to capture excess generation (now being considered for phase 2). LBNL and DOE specialists provided the independent third-party expertise necessary to build project buy-in, and the Department of State now utilizes third-party specialists for prospective overseas ESPCs with renewable installations. Tenant concerns were addressed by specifying a carport canopy installation on existing parking lots, which reduced the ground-mount system size by nearly half and provided the added benefit of vehicle protection to employees. The resulting 956 kW PV installation, the State Department's largest overseas system, is projected to offset 37% of the retrofitted site's energy consumption. Studies for a second ESPC include additional PV capacity and battery storage.

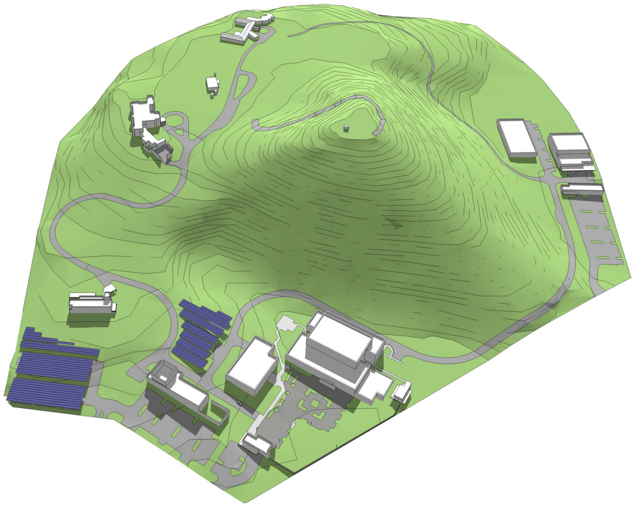
POTENTIAL IN NEW BUILDINGS

Despite an average building age of seven years, project engineers were able to find significant savings through integrative design and by installing higher efficiency equipment. Savings hinged on a comprehensive LED-lighting retrofit and HVAC unit replacements, saving over 460 MWh and 390 MWh per year, respectively. Lighting savings were compounded by LEDs' superior color rendering, which improve conditions for visual security even under reduced lighting levels. The lighting retrofit's significant effect on building-cooling loads also allowed for replacement HVAC equipment to be downsized, creating up-front capital savings.

Project engineers noticed early in the development process that the existing central chiller system was oversized for periods of low occupancy, and that frequent system cycling during off-hour loads had forced facility managers to lower cooling set points during nights and weekends to false-load the system. Because existing chillers were in good condition, the project team opted to install an additional lower-capacity unit to meet off-hour loads. This reduced equipment wear and increased runtime efficiency in buildings connected to the central HVAC system. In other buildings, split-system AC units were replaced with variable-refrigerant-volume direct-expansion systems.

"THROUGH [THESE PROJECTS] WE SHOW THAT WE STAND WITH THE MANY NICARAGUANS FROM ALL WALKS OF LIFE WHO ARE WORKING TO PROTECT THE ENVIRONMENT."
- Phyllis Powers, U.S. Ambassador to Nicaragua

Carport canopy solar PV system
Image courtesy of: *Lockheed Martin*



The United States Embassy site model
Image courtesy of: *Lockheed Martin*

THE POWER OF EFFECTIVE COMMUNICATION AND A MOTIVATED TEAM

Because embassy management turns over every two years, maintaining a consistent knowledge base and ensuring continuity of communication and project management were particularly challenging. With a diverse set of stakeholders based in both the U.S. and abroad, keeping an active line of communication open was central to achieving each entity's goals.

Both Lockheed Martin and the State Department attributed the project's success to the OBO project manager, who addressed communication concerns by developing a memorandum of agreement (MOA) that memorialized approvals and allowed knowledge about the project to live beyond staff turnover. The document, which summarized the intent and details of the ESPC and described project roles, was required reading for all incoming Managua staff and supplemented centralized project management out of OBO's D.C. office. The Department recognized the MOA as an essential tool in the communication and implementation of ESPC projects overseas.

The momentum for this project stemmed from the 2011 Presidential Performance Contracting Challenge and the State Department's Greening Diplomacy Initiative, whose view is that embassy sustainability projects provide an excellent opportunity to improve the United States' image abroad and enhance the security of overseas operations. This diverse support set the project's tone and set an expectation for exemplary savings, leading agency representatives to tell Lockheed to "leave no stone unturned" during the PA phase rather than strictly focus on a few ECMs. Team members credit this fully optimized approach with forging a cutting-edge efficiency project now used as a case study throughout Nicaragua.

The United States Embassy main building
Image courtesy of: *Lockheed Martin*

SEIZING OPPORTUNITY:

KING AND BRICKELL FEDERAL BUILDINGS

SEIZING OPPORTUNITY:
KING AND BRICKELL FEDERAL BUILDINGS

The GSA's King and Brickell federal office buildings, located in Miami, Florida, achieved 43% energy savings and 40% water savings with a 15-year contract term through an energy savings performance contract (ESPC) with FPL Energy Services, Inc. (FPLES). This $4 million project focused on cooling-load-reduction measures that enabled the downsizing of planned HVAC system replacements.

KEY ENERGY CONSERVATION MEASURES (ECMs):

- Packaged water AC units
- Lighting upgrades and controls
- Variable air volume controls
- Water conservation and on-site treatment
- Energy recovery ventilation

PROJECT SNAPSHOT:	
Location	Miami, Florida
Building Size	581,000 ft² (2buildings)
Original Construction	1972 (Brickell) and 1993 (King)
Development & Construction Duration	32 months (2012–2015)
Investment Value	$4.4 million
Appropriated Funds	$2.2 million (51%)
Contract Term	15 years
Cost Savings	$249,000/year
Energy Savings	13,326 MmBtu/year (43%)
Energy Service Company	FPL Energy Services, Inc.

"IT COULD HAVE BEEN A TOUGH PROJECT WITHOUT THAT [TENANT] ENGAGEMENT." - Louie DiDonna, FPLES project manager

RIGHT TIMING AND RIGHTSIZING

This ESPC was timed to coincide with the planned replacement of two 385-ton chillers in the King Federal Building. The GSA had previously committed to replace the HVAC system, and was able to contribute over $2.2 million in appropriated funding to the project cost. These funds allowed FPLES to devote resources to pursue deeper-cutting measures, including an HVAC upgrade at the Brickell building.

FPLES was able to take further advantage of appropriated funds by downsizing specified HVAC replacements. By rightsizing load calculations and pursuing an aggressive lighting retrofit to further reduce cooling loads, the team could install smaller capacity units. The effect of this integrative design approach was an 8% downsizing of Brickell HVAC units, which saved a significant amount of energy and capital while minimizing construction complications (resulting from a lack of access at the site).

James L. King Federal Building
Image courtesy of: *General Services Administration*

BUILDING TRUST THROUGH COMMUNICATION

FPLES personnel noted that the GSA-stipulated requirement for an on-site prime contractor was a major benefit to this project, allowing the team to quickly resolve issues that arose during construction. Having an on-site presence also allowed FPLES to continue to identify design improvements through project completion, including a lighting retrofit expansion to incorporate existing fixtures not originally identified on as-built drawings.

FPLES' on-site presence also significantly increased the project team's exposure and engagement with building tenants. Consistent communications through daily construction updates and consistent ECM reviews built project buy-in amongst tenants, which was leveraged to save a number of ECMs. Most notably, a courtroom lighting retrofit that tenants initially opposed (because previous contractors had damaged antique fixtures) was later embraced and successfully implemented after FPLES educated tenant representatives about the retrofit and negotiated a staged installation and review process.

LEVERAGING RESOURCES

The National Deep Energy Retrofit (NDER) Program laid a strong foundation for deep savings by setting clear goals and providing a variety of educational resources—many of which helped guide regional team members who were not well versed in ESPCs through the process. The regional team shared an appreciation for DOE-sponsored resources, including an ESPC training course and access to an experienced ESPC contractor for independent guidance throughout the project. Regional team members also benefitted from frequent calls held between regional offices, which consistently aligned the team around common goals, and helped everyone understand their individual goals within the broader project scope.

"WITHOUT [SUPPORT FROM THE NATIONAL GSA OFFICE], THIS PROJECT WOULDN'T HAVE HAPPENED." - Michael Fifty, GSA project manager

An on-site prime contractor facilitated project communication and client exposure

RESPONSIBLE TO PAST, PRESENT, AND FUTURE CONSTITUENTS:

THE CITY OF BOULDER

Boulder, Colorado
Image courtesy of: *aboutboulder.com*

RESPONSIBLE TO PAST, PRESENT, AND FUTURE CONSTITUENTS: THE CITY OF BOULDER

The City of Boulder achieved a 25% energy savings across 66 buildings through a three-phase energy savings performance contract (ESPC) with McKinstry Essention, LLC. Retrofitted buildings accounted for more than 90% of the city's pre-project energy use, and the project savings single-handedly fulfilled Boulder's commitment to the Kyoto Protocol. The city received an exemplary award from the American Council for an Energy Efficient Economy and the Alliance for Water Efficiency for their efforts to optimize efficiency through the energy-water nexus.

KEY ENERGY CONSERVATION MEASURES (ECMs):

- Lighting retrofits and controls
- Replacement chillers, boilers, and air-handling units
- Smart building systems
- Water conservation measures
- Demand response via electric-vehicle battery storage
- Solar PV and solar thermal systems

PROJECT SNAPSHOT:	
Location	Boulder, Colorado
Building Size	1.5 million ft^2 (66 buildings)
Development & Construction Duration	4 years (2010–2013)
Investment Value	$16.2 million
Appropriated Funds	$2.4 million (15%)
Contract Term	15 years
Cost Savings	$668,000/year
Energy Savings	26,710 MmBtu/year (25%)
Maximum Building Savings	68% (OSMP Foresberg Building)
Energy Service Company	McKinstry Essention, LLC

INTERNAL MOTIVATION

Boulder is a city with a strong culture of environmental concern and a history of leadership in energy and the environment. In 2006, they implemented the first carbon tax in the U.S. Therefore it's no surprise that competition was a central motivator to pursue this ambitious project. According to city personnel, it all started with a presentation from the Colorado Energy Office, where city staff were shown how many other Colorado municipalities had achieved significant energy savings through ESPCs. The city quickly rallied behind an effort to maintain their leading status, generating an extraordinary level of support and involvement in the effort early on. Effective teamwork and dedication were especially important in navigating the budgetary disconnects between the various departments involved in the project.

The City of Boulder's commitment to supporting its community's values and adopted climate goals was a significant motivating factor for the McKinstry project team. In alignment with the city's sustainability goals, the project's core goal was to achieve carbon emissions reductions, rather than pure energy savings. Therefore, carbon-neutral measures (e.g., solar PV) were prioritized over more cost-effective but carbon-intensive measures (e.g., natural gas systems).

The North Boulder Recreation Center was a key building in the portfolio

FINANCING: MAKING IT WORK

Finding external funding sources was key to collecting the necessary capital funds for the project. A $360,000 ARRA grant was credited as a “spark” for the $16 million project, and the project team was able to capture an additional $4.4 million from utility rebates and appropriated capital-improvement funds. These three sources reduced overall project costs by nearly 30%.

However, identifying and allocating additional funding represented a major challenge. Because all departments in the city government have independent capital budgets and energy bills, each piece of the project was funded individually by the affected department (despite measures being determined at the city level). The facilities manager mitigated conflicts that arose by putting individual measures in the context of the community’s larger goals and commitments.

The facilities manager noted that, while some departments were reluctant to devote funds to the project, the funding split also allowed more ambitious departments to drive the project deeper. One standout department, Open Space and Mountain Parks, is now a net-positive energy producer. This push beyond net zero was motivated by employees within the department.

AN INNOVATIVE BEHAVIOR-CHANGE PROGRAM

McKinstry’s PowerED program, a behavior-change program originally developed for K–12 school districts, was adapted for a municipal setting at the City of Boulder’s request. The program was implemented with the goal of generating a 10% energy savings in addition to the technological retrofits. Project personnel noted that building stakeholder ownership and involvement through the program serves two functions: providing the city with a source of additional savings and insuring against savings degradation.

The PowerED program focuses on three areas of impact: people, process, and performance.

- The people component develops educational programs and competitions encouraging city employees to incorporate energy conservation into their personal and workplace habits.
- The process component targets the continuing education of building operators, a key factor in a project incorporating improved building-automation systems and smart controls.
- The performance component incorporates energy-use feedback, primarily through an interactive energy dashboard.

All three pieces engage stakeholders through proven social-science principles and represent an integrated approach to maintaining energy savings.

“THE CITY OF BOULDER WAS ONE OF THE MOST MOTIVATED PARTNERS WE’VE EVER WORKED WITH.” - Leslie Larocque, McKinstry regional director

EV charging stations were used to facilitate building demand response

SAVING ENERGY AND PRICELESS DOCUMENTS:

THE NATIONAL ARCHIVES AND RECORDS ADMINISTRATION PORTFOLIO

Richard Nixon Presidential Library and Museum
Image courtesy of: *Sorcha*

SAVING ENERGY AND PRICELESS DOCUMENTS: THE NATIONAL ARCHIVES AND RECORDS ADMINISTRATION PORTFOLIO

The National Archives and Records Administration (NARA), in collaboration with Honeywell Energy Services Group, achieved 27% energy savings across a portfolio of 12 presidential libraries in 2015. Select sites, such as the Gerald Ford Museum, achieved over 40% energy savings. Savings are particularly impressive given NARA's stringent thermal and lighting requirements for historic-document preservation.

KEY ENERGY CONSERVATION MEASURES (ECMs):

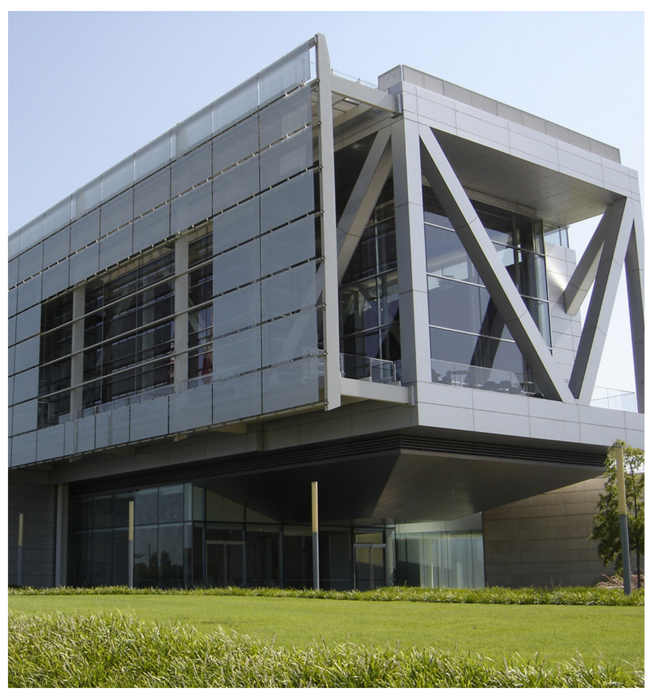
- LED and other lighting upgrades
- Controls upgrades
- Variable-frequency drives
- Chiller upgrade with staged loading (Gerald Ford Museum)

PROJECT SNAPSHOT:	
Location	Various
Building Size	1.3 million ft^2 (12 buildings)
Development & Construction Duration	29 months (2013–2015)
Investment Value	$11.1 million
Appropriated Funds	$0
Contract Term	16 years
Cost Savings	$977,000/year
Energy Savings	98,905 MmBtu/year (27%)
Maximum Building Savings	45% (Gerald Ford Museum)
Energy Service Company	Honeywell Energy Services Group

A COMPLEX CHALLENGE CALLS FOR CREATIVE SOLUTIONS

NARA's paramount concern in this project was maintaining (or enhancing) functionality of the libraries, which house priceless documents and artifacts from our nation's history. Preservation areas are required to remain below 65 degrees and maintain 50% relative humidity, while exhibit lighting must avoid high lumen levels. Meeting these requirements while maintaining thermal-comfort needs in visitor areas presented a complex and difficult-to-retrofit set of building systems. Adding to these complications was the fact that most document-storage areas had to remain occupied, and thus rigidly conditioned, during the construction process.

NARA employees were particularly concerned about retrofit measures that reduced air-flow rates in document storage areas. Honeywell was able to address concerns by conducting indoor air quality assessments and monitoring document decay. This quality-assurance measure, which included reports of the pollutant levels before and after the retrofits, allowed Honeywell to move forward with the optimal conditioning strategy and avoid major prescriptive constraints. Honeywell's strategies often reduced document-decay rates, enhancing the effectiveness of library operations and providing NARA with an additional (though unquantified) project benefit.



William J. Clinton Presidential Center
***Image courtesy of:** Zereshk*

STARTING RIGHT

Because of the complexity inherent in this project, NARA personnel employed an in-depth interview process including a proposal, interview, and site visit to vet energy service company (ESCO) candidates. This was preceded by an in-depth analysis of the portfolio, which NARA used to evaluate proposals. NARA knew, for example, that a chiller replacement at the Ford Library would best serve building functions by specifying two small chillers for ideal part-load efficiencies. Honeywell was one of the few ESCOs to propose that system, signaling their intelligent approach to the project and alignment with NARA's priorities.

NARA also acknowledged how important it was to clearly articulate goals and requirements before initiating the energy savings procurement contract, as a failure to provide ESCOs with clarity regarding desired outcomes and limitations could easily lead to proposals that do not align with priorities. By providing clarity on desires (e.g., the chiller-replacement-system specifications) and limitations (e.g., stringent climate control) before project implementation, NARA enabled Honeywell to move quickly and avoid costly changes to the project's scope.

> *"THE MAIN INGREDIENT FOR SUCCESS ON THIS PROJECT WAS THE PEOPLE... IF YOU GET THE RIGHT PEOPLE—THE RIGHT TEAM PLAYERS, THE RIGHT PERSONALITIES —[THE PROJECT] IS ALREADY A WINNER."* - Ngan Pham, NARA agency energy manager

John F. Kennedy Presidential Library and Museum
Image courtesy of: *Sharon Mollarus*

PROACTIVE STAKEHOLDER MANAGEMENT

The project involved a complex web of local facility managers, NARA leaders working out of Washington, D.C., document directors and curators, contractors, and ESCO personnel. Understanding the unique priorities, ideas, and leadership structure of each stakeholder group, as well as the interplay between each, was key to the project's success. Recognizing this challenge, Honeywell kicked off the project with an interactive charrette to foster early collaboration and develop a document outlining facility requirements at each site. The charrette brought together parties that had not previously interacted and established an "all-for-one" mindset at the project outset.

Both NARA and Honeywell personnel also credited the project's success to proactive management from project leaders. NARA's agency energy manager served as the primary spokesperson and organizer throughout the process, supporting both facility managers and Honeywell and helping to navigate the conflicting priorities that sometimes arose. The Honeywell team found his expertise and unwavering presence invaluable, especially with facility-manager turnover at four of twelve sites. NARA team members, on the other hand, consistently credited the project's success to a Honeywell project manager. His organization, responsiveness, and attention to detail was instrumental in building trust and engagement among stakeholders.

The Honeywell project manager also helped maintain continuity and communication between project sites by holding a weekly series of project meetings with facility managers. Because project implementation was staggered across 12 NARA sites, the project team was able to use these meetings to transfer insights among sites and avoid potential pitfalls in later projects. This was supplemented by staging deep-cutting, complex projects (e.g., the Gerald Ford Library) early on.

Richard Nixon Presidential Library and Museum
***Image courtesy of:** Stuart Seeger*

RESOURCES

DEEP ENERGY RETROFITS:

Rocky Mountain Institute:

- *Specifying Triggers*
- *The Path to a Deep Energy Retrofit Using an Energy Savings Performance Contract*
- *How to Calculate and Present Deep Retrofit Value*
- *Retrofit Resources*

ASHRAE:

- *Advanced Energy Design Guides*

General Services Administration (GSA):

- *Energy Savings from GSA's National Deep Energy Retrofit Program*
- *Deep Energy Retrofits in GSA Buildings*

New Buildings Institute (NBI):

- *Existing Buildings - Path to Zero Energy Buildings*

NET-ZERO-ENERGY BUILDINGS:

GSA:

- *Sustainable Facilities Tool (SFTool)*

Whole Building Design Guide:

- *Net Zero Energy Buildings*

NBI:

- *Zero Net Energy*

International Living Future Institute:

- *Net Zero Energy Building Certification*

ENERGY SAVINGS PERFORMANCE CONTRACTING:

Industry Organizations:

- *Energy Services Coalition*
- *National Association of Energy Service Companies*

Department of Energy:

- *Energy Savings Performance Contracts for Federal Agencies*

Oak Ridge National Laboratory:

- *Beyond Guaranteed Savings*

GLOSSARY OF ABBREVIATIONS

ACEEE: American Council for an Energy-Efficient Economy
AHU: Air Handling Unit
ARRA: American Recovery and Reinvestment Act
AWE: Alliance for Water Efficiency
BAS: Building Automation System
DOE: Department of Energy
DOS: Department of State
DX: Direct Expansion
ECM: Energy Conservation Measure
ESCO: Energy Service Company
ESPC: Energy Savings Performance Contract
FEMP: Federal Energy Management Program
FPLES: Florida Power and Light Energy Services
GSA: General Services Administration
GSHP: Ground Source Heat Pump
HRSD: Hampton Roads Sanitation District
HVAC: Heating, Ventilation, and Air Conditioning
IGA: Investment Grade Audit
IPMVP: International Performance Measurement and Verification Protocol
IRR: Internal Rate of Return
IT: Information Technology
LBNL: Lawrence Berkeley National Laboratory
LED: Light-Emitting Diode
M&V: Measurement and Verification
MmBtu: Million BTU
MWh: Megawatt-Hour
NARA: National Archives and Records Administration
NAS: Naval Air Station
NDER: National Deep Energy Retrofit Program
NREL: National Renewable Energy Laboratory
O&M: Operations and Maintenance
OA: Outdoor Air
OBO: Bureau of Overseas Buildings Operations
OSMP: Open Space and Mountain Parks
PA: Preliminary Audit
PM: Project Manager
PMO: Project Management Office
PV: Photovoltaic
RFP: Request for Proposals
VAV: Variable Air Volume
VFD: Variable-Frequency Drive
VRV: Variable Refrigerant Volume
VSBN: Virginia Sustainable Building Network


John F. Kennedy
PRESIDENTIAL LIBRARY AND MUSEUM