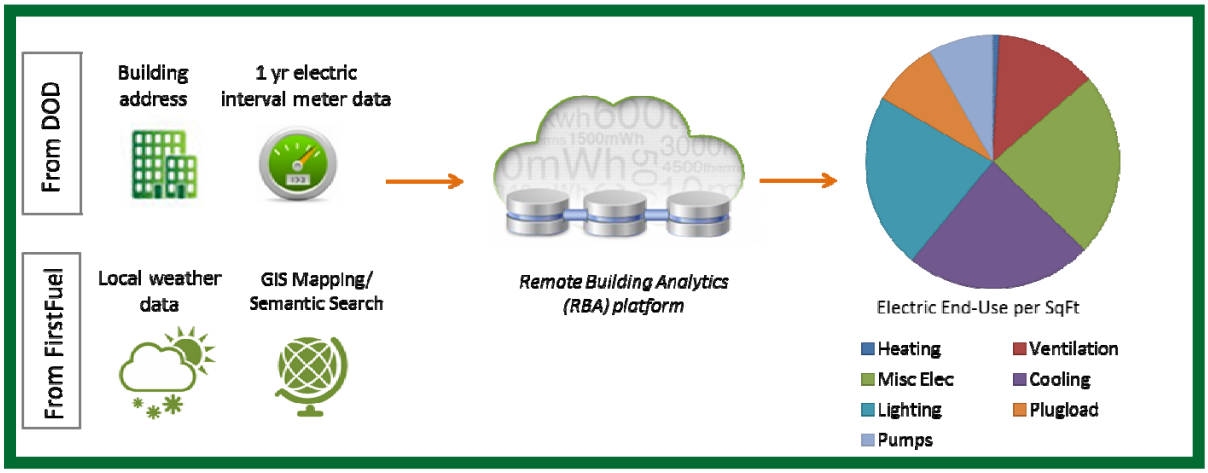
ESTCP
Cost and Performance Report

(EW-201261)



Rapid Building Assessment Project

May 2014

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ENVIRONMENTAL SECURITY
TECHNOLOGY CERTIFICATION PROGRAM

U.S. Department of Defense

COST & PERFORMANCE REPORT
Project: EW-201261

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ACRONYMS AND ABBREVIATIONS

AMI	Advanced Metering Infrastructure
ASHRAE	American Society of Heating Refrigeration and Air Conditioning Engineers
CVRMSE	Root-mean-square deviation
DoD	Department of Defense
DOE	U.S. Department of Energy
DPW OMD	Directorate of Public Works Operations Maintenance Division
ECM	energy conservation measure
EEB Hub	Energy Efficiency Buildings Hub
EISA	Energy Independence Security Act
EPRI	The Electric Power and Research Institute
ESTCP	Environmental Security Technology Certification Program
FTP	File Transfer Protocol
GIS	Geographical Information Systems
GSF	gross square footage
JCI	Johnson Controls Energy Services Group
kWh	kilowatt hour
LP	Linear Programming
MBE	mean bias error
NOAA	National Oceanic and Atmospheric Administration
OLS	Ordinary Least Squares
PG&E	Pacific Gas & Electric
R&D	research and development
RBA	Remote Building Analytics
REST	representational state transfer
sq ft	square foot

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EXECUTIVE SUMMARY

In recent years, the U.S. Department of Defense (DoD) has launched several initiatives to reduce its fossil fuel use by improving energy efficiency, i.e., reducing wasted energy. Reducing the amount of energy used and wasted across the DoD's portfolio of buildings is a significant opportunity and key to reducing emissions and energy consumption across the United States (U.S.). However, identifying and profiling the energy savings potential of individual buildings presents significant challenges for the DoD's large and diverse building portfolio.

FirstFuel Software is a Boston-based commercial energy analytics company that provides a breakthrough solution with the potential to address this large-scale challenge. The company's Remote Building Analytics (RBA) platform is an analytics-driven energy information service designed to help large government agencies and utilities to rapidly and cost-effectively target, prioritize, quantify, enable, and track energy savings in heterogeneous building portfolios, at scale. The platform utilizes advanced, proprietary statistical methods and data mining techniques to deliver an end-to-end efficiency solution that is being deployed at over 15 government agencies and utilities across North America and Europe.

Requiring only hourly utility electric meter data, the building type, and address, FirstFuel can produce a remote set of building-specific performance insights and customized recommendations at an end-use consumption level. These recommendations can be utilized by agencies, such as the DoD, at the management, site, and/or building level to identify opportunities, plan and execute efficiency projects. In addition, FirstFuel's analytics can track the efficiency measures enacted by building managers/operators and quantify their effectiveness over time. All of these services are performed remotely, and require no on-site visits or additional metering device installations. FirstFuel analytics have been independently and repeatedly validated by third-parties across many dimensions of performance (e.g., accuracy, speed, cost, scale, impact potential).

The Rapid Building Assessment demonstration project focused on determining whether FirstFuel's end-to-end solution can enable the DoD to scale energy efficiency initiatives across its large and varied building portfolio. FirstFuel analytics were applied to a total of 100 DoD buildings across five different DoD-specific building types. FirstFuel worked with 11 installations across the country to conduct the performance analysis.

The FirstFuel demonstration project was designed around three specific Performance Objectives: (1) cost, (2) scalability, and (3) accuracy. To support the DoD's evaluation of these primary Performance Objectives, a third-party engineering firm, The Cadmus Group, conducted American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Level II on-site audits across 16 of the DoD buildings.

The results of this project and achievement of the Performance Objectives suggest that the FirstFuel RBA can present significant advantages over the DoD's traditional approach to on-site energy audits and continuous performance monitoring. For example, traditional walk-through audits run between $5000 and $10,000, and take several weeks or more to complete, including multiple days on-site. These traditional audits are too costly and time consuming to deliver

savings at scale, and yield large reports that are often difficult to use as an efficiency prioritization and planning tool. In contrast, FirstFuel's remote audits can be accomplished in hours, regardless of size or type of building, and at a fraction of the cost without a site visit, while simultaneously yielding performance analysis results similar to ASHRAE Level II on-site audits (the comparison on-site used in this demonstration project).

Through this demonstration we have observed two potential limitations to the demonstrated approach. The first relates to building energy data. Buildings that do not have interval electric consumption data were not applicable for the remote auditing technology that FirstFuel had commercialized during the scope of this study. In conjunction, for those buildings with significantly less than 1 years' worth of interval electric consumption data, the remote analysis proved difficult or impossible to complete. The second limitation concerns buildings that are not occupied for months at a time, or buildings that have very low energy consumption. These buildings may present challenges to perform the end-use analyses.

The FirstFuel ESTCP demonstration suggests that DoD will find significant value in using FirstFuel's tool to launch, manage, and track major energy efficiency initiatives across its vast portfolio of buildings, primarily through the following:

- Immediately implementing low/no cost operational savings uniquely identified through the FirstFuel platform;
- Significantly reducing the time and cost relative to traditional on-site audits across a range of building types specific to the DoD;
- Providing DoD site energy managers with an insightful, intuitive tool to focus and refine energy savings efforts, and compare buildings to others within the portfolio; and
- Tracking energy performance and savings over time to track progress of long-term efforts, aid reporting, validate the effectiveness of energy conservation projects, and maintain the persistence of savings.

Because FirstFuel does not require any on-site devices or visits, the platform can be deployed rapidly and with no further installation cost to all DoD buildings with interval meters. Given the widespread deployment of such meters throughout both the Army and Navy branches, with extensive work underway for almost complete coverage of Advanced Metering Infrastructure (AMI) in all service branches, the FirstFuel RBA platform provides the optimal combination of effectiveness and leverage of existing or planned infrastructure investments.

1.0 INTRODUCTION

Energy efficiency is the "first fuel" the U.S. Department of Defense (DoD) is addressing, and FirstFuel's demonstration was designed to test the validity of its approach to conduct remote building audits while also helping the DoD to meet its energy efficiency goals.

1.1 BACKGROUND

In recent years, the DoD has launched several initiatives to reduce its fossil fuel use by improving energy efficiency (i.e., reducing wasted energy).[1] Reducing the amount of energy that is used and wasted across the DoD's portfolio of buildings presents a significant opportunity and is key to reducing emissions and energy consumption across the United States (U.S.). However, identifying and profiling the energy efficiency savings potential of individual buildings presents significant challenges for a building portfolio as large and diverse as that of the DoD.

Over the course of the 16-month project, FirstFuel worked with 11 DoD installations to perform remote audits on 100 buildings utilizing FirstFuel's Remote Building Analytics (RBA) platform. In order to evaluate the technology on a range of DoD specific buildings, FirstFuel divided the 100 buildings assessed into five building type categories. The first type consisted of 30 "Type 1" buildings, which were company headquarters and administrative buildings. The remaining 70 buildings made up the four other buildings types that are specific to the DoD. FirstFuel performed research and development (R&D) to customize the RBA software in order to provided end-use analysis for buildings of this type.

1.2 OBJECTIVES OF THE DEMONSTRATION

FirstFuel's demonstration examined how the DoD could measure the impact of energy audits across hundreds of buildings. To conduct each remote audit, FirstFuel utilized four pieces of information: (1) 1 year of historical electric interval consumption data, (2) weather data from the building's closest weather station, (3) geographical information systems (GIS) information from the building's location, and (4) a building information survey completed by DoD site energy managers. The weather and GIS data were sourced by FirstFuel, and not provided by the DoD.

The project's objectives were designed around measuring the time, cost, and accuracy of FirstFuel's remote audits, as compared to American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Level II on-site audits. FirstFuel demonstrated the that remote audits could be done at one third the cost when compared to the on-site approach, and three to five times faster versus ASHRAE Level II on-site audits. While the energy conservation measures (ECM) between the two approaches did not match up to the expected success criteria of 80% in the Type 1 buildings, the FirstFuel approach did find 16% more savings compared to the on-site audits in these buildings, suggesting that number of ECMs as a metric may be a less important than the savings found. For example, ECMs recommended via on-site audits may not be uncovered by the FirstFuel RBA (or vice versa) because omissions may reflect a different set of energy management objectives or scope. By their very nature, on-site audits are more likely to

[1] "Fact Sheet: DoD's Energy Efficiency and Renewable Energy Initiatives. Environmental and Energy Study Institute. http://www.eesi.org/dod_eere_factsheet_072711

capture smaller value capital improvements, because they result from visual confirmation, whereas analytics based approaches, like FirstFuel, are just as likely to capture larger value operational ECMs.

1.3 REGULATORY DRIVERS

FirstFuel's ESTCP Rapid Building Assessment Proposal addresses the following drivers:

Driver		Explanation
Energy Policy Act, 2005, Section 103	Mandate for using advanced meters to reduce electricity in Federal buildings by October 2012.	FirstFuel's software platform provides a straightforward way for the DoD to use the data generated from the advanced meters to identify and encourage reductions in electricity consumption.
Executive Order (EO) 13123	"Greening the Government through Efficient Energy Management."	This executive order set energy management goals for the Federal Government. The inefficient use of energy wastes defense funds. The success of FirstFuel's project offers the DoD a way to identify areas to reduce energy waste in a manner that is cost effective and timely.
Strategic Sustainability Performance Plan, 2011; Pg I-14	"Decisions made at the facility level are not always in the best long-term interests of the Department as a whole, including its sustainability objectives. DoD needs to ensure that personnel working on-site-level projects bring a broad perspective to the decision-making process that considers objectives of the Department beyond those of the site alone."	The project may contribute to the driver by giving energy site managers insight into the energy consumption of different DoD buildings, thereby allowing DoD to make strategic decisions in their entire building portfolio and comparing the performance of buildings within the DoD.

2.0 TECHNOLOGY DESCRIPTION

2.1 TECHNOLOGY OVERVIEW

2.1.1 Core Technology

FirstFuel's RBA platform combines interval meter data with hourly weather and climate data and GIS mapped building characteristics to provide a consistent, reliable view of how energy is used inside a building. The platform utilizes advanced, proprietary statistical methods and data mining techniques based on FirstFuel's patent pending technology. The core technology utilizes a unique approach based on "inverse modeling," which examines each building and data set independently. The technology infers the building's energy use utilizing only its own unique consumption patterns and signatures. The platform infers the building's energy use breakdown without the use of outside databases/benchmarks of "like" buildings, traditional energy simulation models (e.g. eQuest, DOE-2, EnergyPlus), or the use models that compare a building's interval usage data to a simulated model of the building operating at 'optimal performance.'

This enables FirstFuel platform users to view energy analysis and recommendations that each have been individually verified based on actual building performance, as opposed to automated content based on how their building should be performing. The output from FirstFuel's inverse model is a highly accurate breakdown of the actual hour-by-hour consumption across end-uses for the building. This inverse-modeling approach enables a level of simultaneous individual building analysis customization, scale across portfolios, and accuracy of results that is unparalleled in the industry.

The only inputs that the FirstFuel RBA platform requires is 1 year of historical electrical interval data (5/15/30/60 minute building electric consumption data) and the building address. The data can be delivered to FirstFuel seamlessly through a variety of data transfer methods, including encrypted .csv files uploaded to a secure File Transfer Protocol (FTP) server, using representational state transfer (REST) services, and through Green Button Connect. The electric interval data must represent only the building being analyzed. For example, buildings that are served by a central heating/cooling plant cannot be analyzed unless the building's electric consumption is measured on an interval basis. From there, FirstFuel pulls in additional information about the building including hourly local weather data, GIS building data, and additional building data through semantic searches that are publicly available, including square feet, occupancy type, etc.

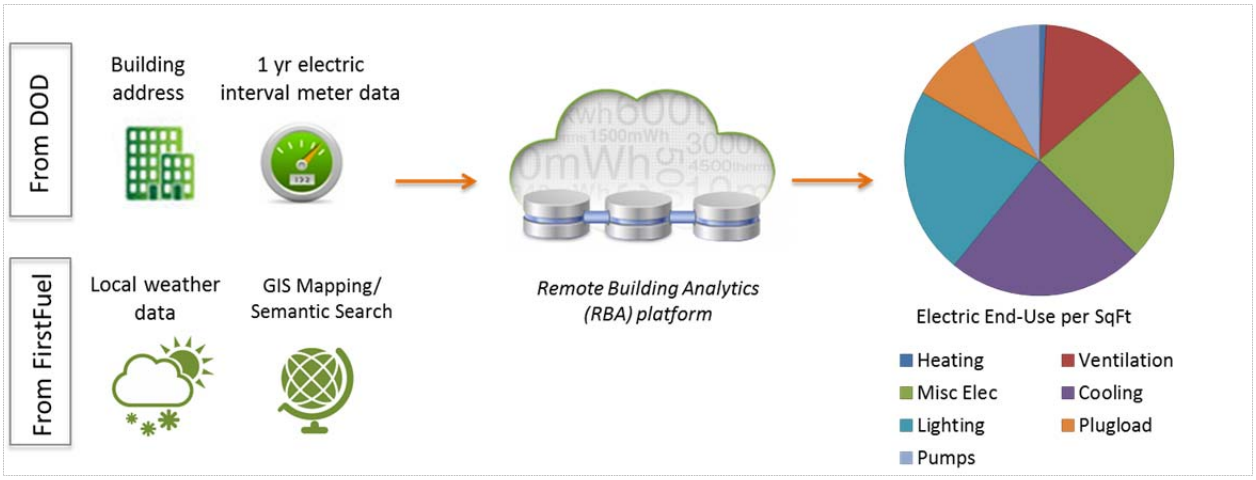


Figure 1. FirstFuel's inverse modeling remote audit process.

The analytics output includes building-specific performance benchmarks, base lining, load disaggregation, and customized recommendations for actions at the end-user level, as well as predictive projections of each building's potential for energy efficiency. FirstFuel's technology is particularly adept at detecting and detailing operational savings opportunities, and instructing energy administrators or building-level managers regarding how best to implement changes and track performance. When monthly thermal data (natural gas, fuel oil, etc.) is available for the building, FirstFuel is able to perform an analysis of the building's thermal use. The analysis includes a breakdown of the weather related and non-weather related thermal fuel consumption, and energy conservation measures related to thermal energy reductions.

To provide results more consistent with those of ASHRAE Level II equivalent audits, FirstFuel asked the energy site managers to complete a short building information survey for each building analyzed. These surveys provide asset-related information needed for FirstFuel building engineers to implement more refined costs and return on investment (ROI) estimates associated with the ECMs. While a large majority of the remote energy audit process is automated through analytics, FirstFuel's team of in-house energy engineers quickly verify each ECM to ensure the energy savings recommendations are relevant, customized, and actionable.

Through this approach, FirstFuel creates a level of detail about each building that was previously unavailable without going on-site, including end-use consumption profiles by hour, detailed building operational schedules, setpoints, equipment sequences, ventilation configurations, and more. FirstFuel is the only fully remote commercial energy analytics solution that has been independently and repeatedly validated by third parties across many dimensions of performance. FirstFuel's successful technical validations include a Scaled Field Placement completed by Pacific Gas & Electric (PG&E) in 2013, as an Emerging Technologies Coordinating Council initiative; the Fraunhofer Institute (a U.S. Department of Energy [DOE]-funded study); the Cadmus Group; The Electric Power and Research Institute (EPRI); Johnson Controls Energy Services Group (JCI); and the DOE's Energy Efficiency Buildings Hub (EEB Hub).

For this project, FirstFuel worked with 11 DoD installations across the country to identify buildings for remote audit participation. Participating sites provided just three pieces of information for the remote audits and remote performance monitoring: (1) 1 year of historical electrical interval data, (2) the building address, and (3) a completed building information survey.

2.1.2 Technology Application

FirstFuel's deploys its RBA platform to customers in an industry leading integrated approach – through an intuitive web-based portal, demonstrated to the end-user in a webinar by our skilled team of in-house energy engineers.

The engagement of building operators remains a critical step to accelerating energy efficiency across the federal sector. In this project, FirstFuel's team of in-house energy engineers directly engaged building operators through an Efficiency Planning Session. Conducted via webinar, FirstFuel discussed the full energy analysis and results, gained acceptance and buy-in around leading energy savings recommendations, and secured initial commitment to act through collaborative dialogue.

Following the webinar, FirstFuel energy engineers continued to provide on-going coaching to motivate and support action through regular engagement touch-points and by working with third party implementers to ensure that uncovered opportunities translated into projects and energy savings opportunities. The resulting remote audit and customer delivery process incorporated the best of analytics, building engineering experience, and local knowledge that cannot be accomplished with the "push of a button" alone.

Following completion of the Efficiency Planning Session, participants were given access to FirstFuel's web-based energy portal for on-going usage by DoD energy managers. This portal included all underlying building performance analysis (including leading energy conservation recommendations) and ongoing tracking of energy savings through FirstFuel's remote performance monitoring. The following screenshots provide a snapshot of FirstFuel's web-based energy portal:

Building Information and Current Energy Use:

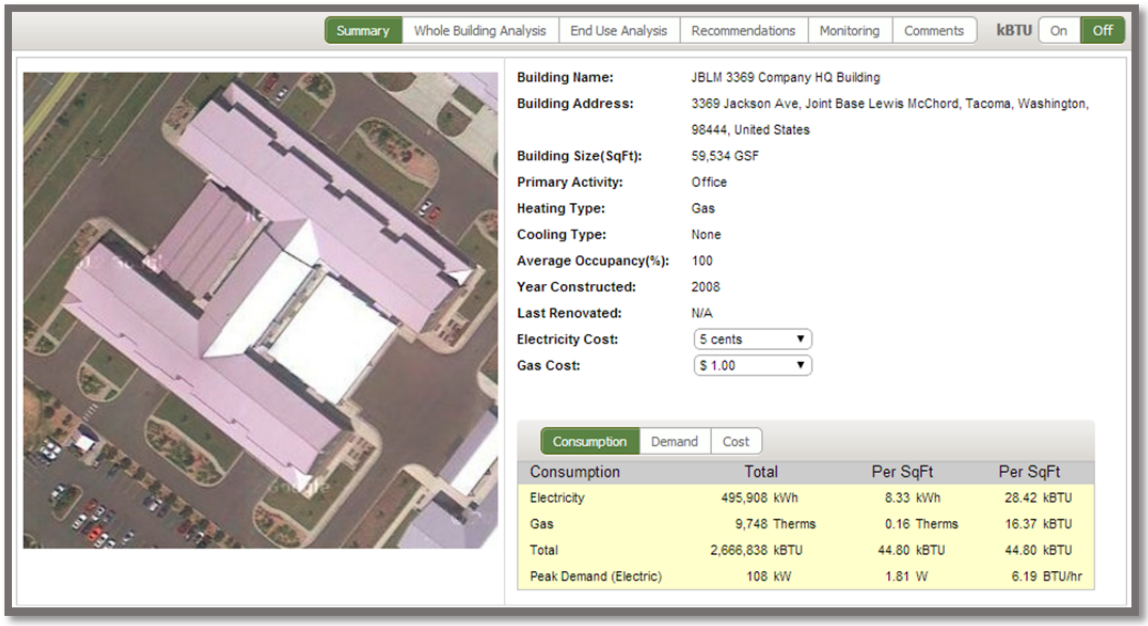
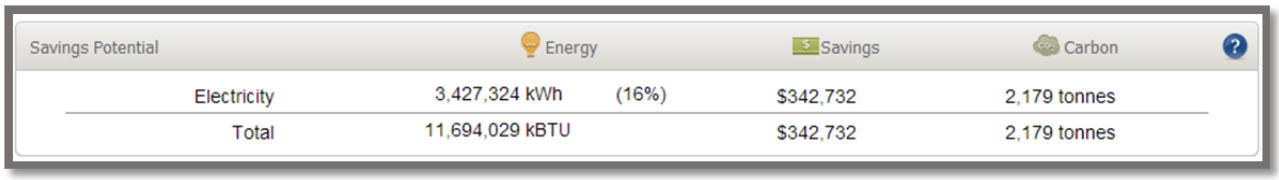


Figure 2. Sample building summary page (Part 1).

Savings Potential:



Savings Potential	Energy		Savings	Carbon
Electricity	3,427,324 kWh	(16%)	$342,732	2,179 tonnes
Total	11,694,029 kBTU		$342,732	2,179 tonnes

Figure 3. Sample building summary page (Part 2).

End-Use Analysis:

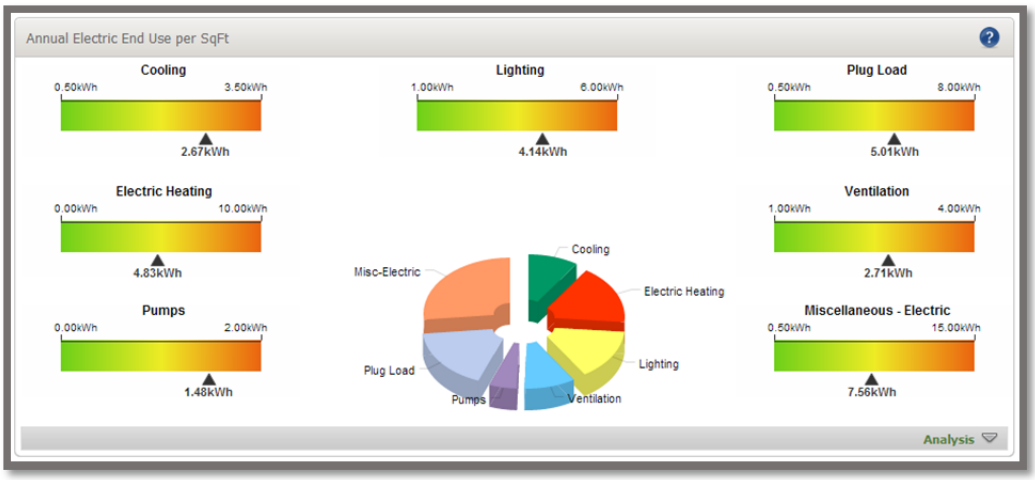


Figure 4. Sample end-use analysis.

ECMs:

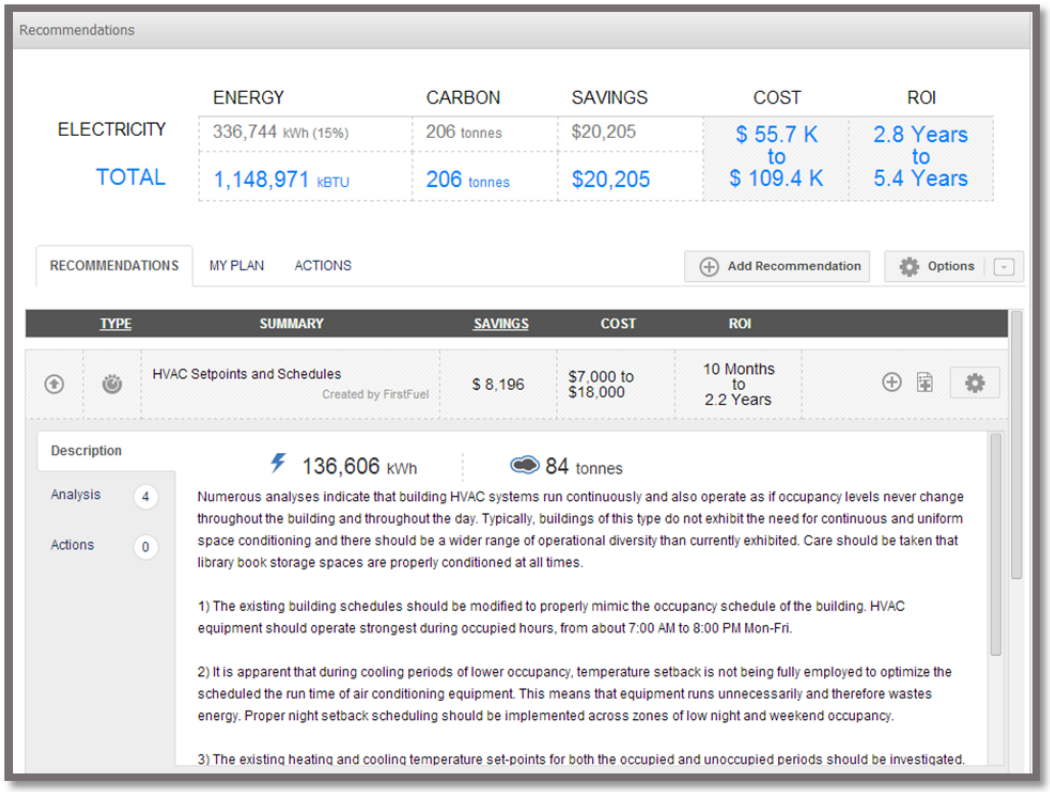


Figure 5. Sample recommendations.

FirstFuel portal users that oversee more than one building have portfolio viewing privileges. Portfolio users are able review the results of the assessments across multiple buildings to identify areas of highest opportunity, by building type, by location or by opportunity type (e.g., lighting, schedule changes, etc.). Below is an example of the DoD portfolio view for potential energy savings sorted by building type:

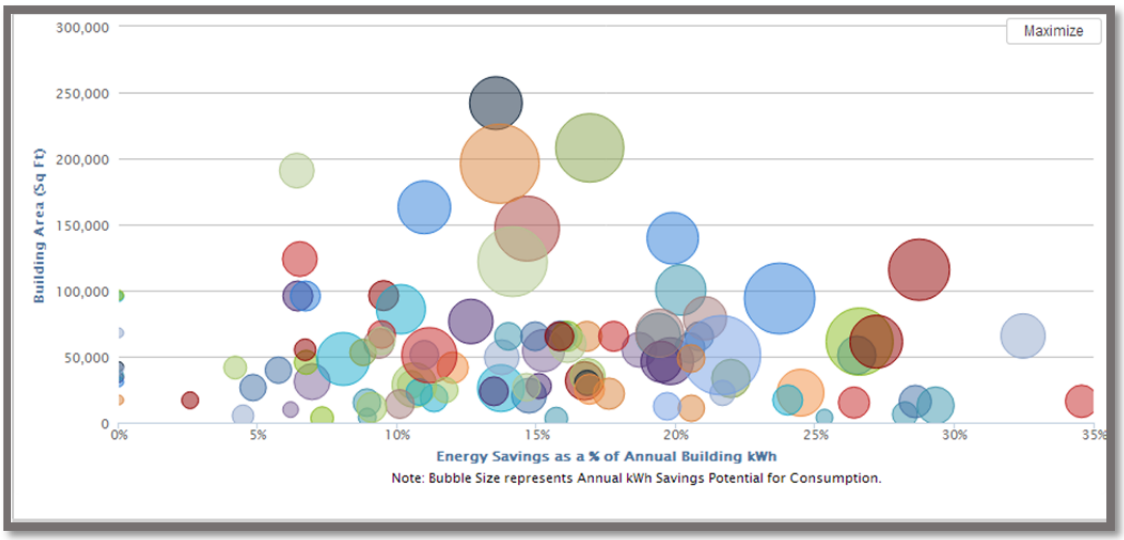


Figure 6. Portfolio view.

Sites that provided FirstFuel with post-audit electric consumption data were given access to FirstFuel's continuous performance monitoring service. Similar to the remote audit service, FirstFuel continuous monitoring is conducted without the use of on-site devices or site visits, and requires only regular updates of interval data. With this data, FirstFuel is able to: (1) establish a weather and occupancy-normalized baseline of consumption based on the initial year of data; (2) measure the deviation, at a whole building level, between the baseline and actual consumption, i.e., measure energy savings at a whole building level; (3) correct for major non-efficiency changes in the building during either the initial year of data or in the following years; (4) alert customers on a monthly or quarterly basis to significant changes in the building's energy consumption profile; and (5) demonstrate persistence of operational measures for enhanced savings.

Figure 7 below is an example of FirstFuel's continuous performance monitoring:

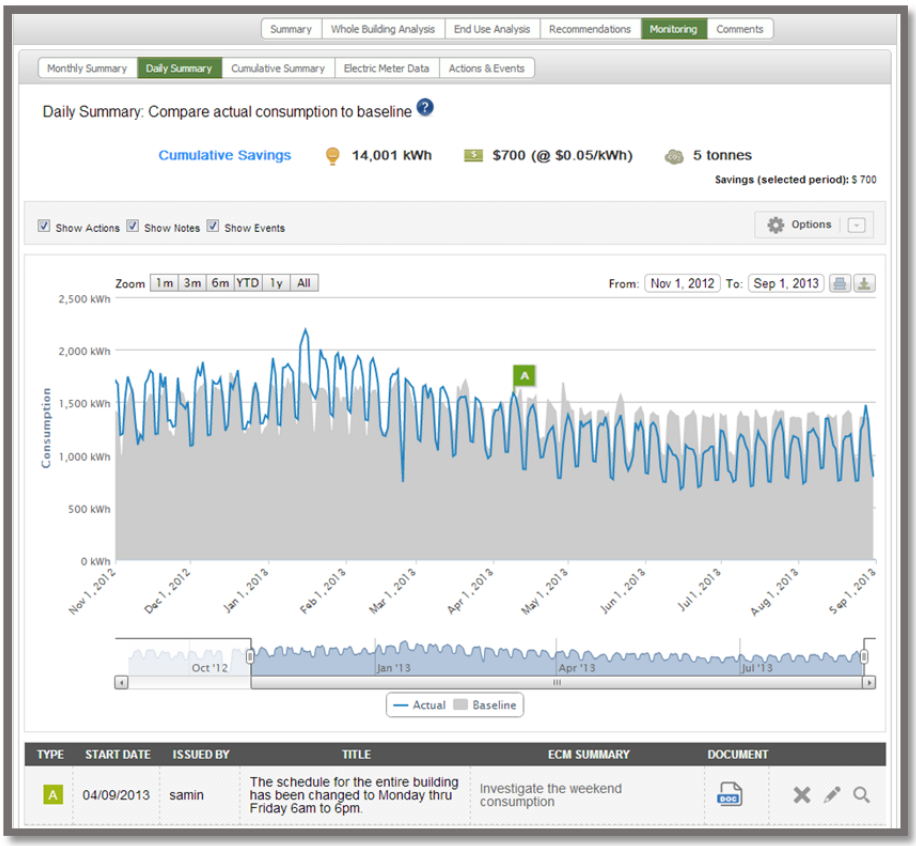


Figure 7. Continuous performance monitoring screenshot.

2.1.3 Technology Development

FirstFuel developed the remote audit technology, now called FirstAudit, through 2 years of intensive research and development. After launching FirstAudit in mid-2011, FirstFuel has added a suite of additional Software-as-a-Service analytics capabilities to support the entire energy efficiency lifecycle, including portfolio efficiency screening and energy audits to customer

engagement and performance monitoring and verification. The timeline below illustrates the chronological summary of the FirstFuel's deployment of the RBA technology to date.

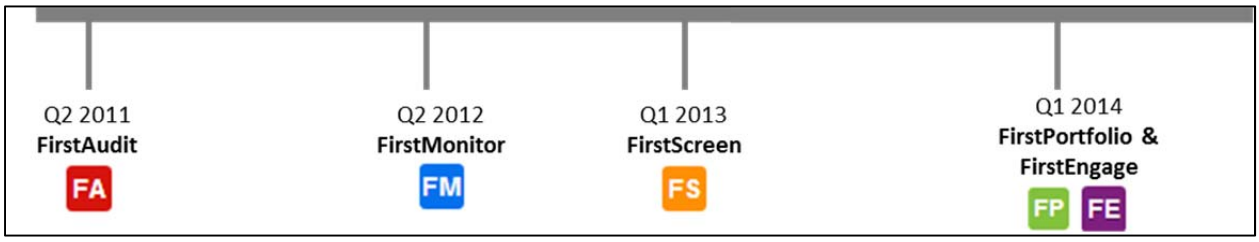


Figure 8. Chronological summary of FirstFuel's technology deployment.

2.1.4 Expected Application of the Technology

Following technical and field evaluation of FirstFuel's RBA platform, the software has been fully commercialized. FirstFuel is engaged in several deployments with customers, including several of the largest North American utilities, the U.S. General Services Administration, and the Washington D.C. Department of General Services. As of January 2014, FirstFuel customers were tracking over $250 million in potential savings on the FirstFuel RBA platform, which includes an identified 14% electricity savings potential across 5.5 million square feet of DoD buildings.

FirstFuel's demonstration involved conducting remote audits on DoD buildings and using FirstFuel's existing RBA technology. Research that occurred as part of the demonstration focused on optimizing the RBA platform for DoD's unique building types in addition to the common commercial building types that were previously available through the platform. Specifically, FirstFuel building engineers spent time researching how each new building type operates in order to incorporate that learning into the key algorithms and processes of the RBA platform, including the end-use disaggregation and other component analytics of the remote audit. To understand the unique features associated with DoD buildings, a team of FirstFuel building engineers conducted building walkthroughs at two sites—Fort Benning and Naval Station Everett—which each hosted several example buildings in the new types. The on-site walkthroughs consisted of visual inspection and discussions with on-site building operators to review the buildings' operational schedules, types of equipment, and overall design specifications.

The on-site review and study of DoD specific building types provided FirstFuel's team the necessary information to optimize the RBA platform, analytics, and disaggregation engine for these new buildings. The research also yielded the realization that not all DoD buildings can be analyzed using only FirstFuel's traditional RBA tool. A particularly unique feature of DoD buildings' energy consumption is that many buildings are not always occupied throughout the year (e.g., barracks). Because FirstFuel's original audit tool worked by analyzing a building's own unique consumption patterns and signatures over a 12 month period, those buildings with significantly different patterns within the year period required a slightly modified analytics approach. In order to provide end-use level consumption detail for these buildings, FirstFuel's traditional "inverse modeling" approach was supplemented by another proprietary approach, using a high-speed variant of traditional building models, such as DOE-2. The method was also

remote and meets similar cost, speed, and accuracy specifications to FirstFuel's core methodology, as it still incorporates most aspects of the inverse modeling approach.

2.2 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

There are three primary alternatives to FirstFuel's remote audit technology in the market today.

1. Traditional on-site energy assessments and audits
2. Remote energy analysis and benchmarking tools
3. Analytics tools requiring on-site devices

The FirstFuel RBA has been designed to present significant advantages over each, and these advantages have been demonstrated successfully in this project.

1. The traditional approach to building energy assessments begins with a walk-through audit. Typical on-site assessments run between $5000 and $10,000, and take several weeks or more to complete, including multiple days on-site. These audits are too costly and time-consuming to deliver savings at scale across the DoD's portfolio of buildings. FirstFuel's remote audits can be accomplished in hours regardless of the size or type of building and at a fraction of the cost, without a site visit, yielding results similar to ASHRAE Level II on-site audits (the comparison on-site used in this demonstration project) that can take weeks to complete.

   In addition to cost and speed advantages, the FirstFuel methodology suggested an advantage in overall effectiveness. Between the use of the online portal, interactive Efficiency Planning Sessions via webinar, and the remote monitoring tracking features, the FirstFuel approach creates a more interactive and ongoing engagement than a static audit. Early results suggest that this engagement will increase building managers' ability and propensity to act on the recommended ECMs provided. Key interactive features not available from on-site audits include:

   - Easy access via web portal by multiple stakeholders;
   - Updateable and easy to understand dynamic charts, graphs, and analysis describing energy performance and ECMs;
   - Tracking of overall building performance over time;
   - Impact measurement of enacted ECMs; and
   - ECM recommendation, personalized plan creation and documentation features.

2. Other remote technologies currently available in the market are inexpensive but do not offer the same level of scalability, accuracy or actionable results as FirstFuel's RBA platform. Although many bill themselves as "remote audits," FirstFuel's inverse modeling approach is the only one to examine each building utilizing only its own unique consumption patterns and signatures. This is analogous to an on-site audit that bases its conclusions on observation and analysis of the actual building in question, rather than on a series of comparisons to other buildings. Using its proprietary

approach, FirstFuel analysis is able to include: end-use consumption profiles by hour, detailed building operational schedules, setpoints, equipment sequences, ventilation configurations, and more. The net result is a series of ECMs, cost, and savings estimates that are uniquely verified for each building. In contrast, other remote technologies offer results that rely only partially on building data, and instead make recommendations based on comparisons to "like" buildings or models that simulate the performance of a particular building operating at maximum efficiency. This approach especially falls short when analyzing DoD type buildings, as the unique building types make "like building" comparisons less accurate or insightful due to the lack of "like buildings" available for comparison.

Taking into consideration the above, it is notable that FirstFuel offers the only remote technology that has been extensively validated by third parties, now including this demonstration project, for its accuracy and comparability to on-site audits. As the DoD investigates the use of tools now and in the future, this demonstration underscores the importance of such validation of both accuracy and actionability of results.

3. Analytics tools that utilize on-site devices are typically more expensive than the FirstFuel solution—ranging from $5000 installed cost for the lightest devices to over $100,000 for high-end BMS systems or building sub-meters. The "light-device" solutions tend to lack the diagnostic detail found in the FirstFuel RBA, for example end-use level benchmarking and detailed recommendations. These light-device solutions are often classified as a "dashboard" or "energy monitoring" and provide few actionable insights. At the higher end, more detail is provided, but at much higher price, and often foregoing the "whole building" view in favor of much higher detail and control of a few key systems. However, the key advantage of the FirstFuel platform relative to systems that require on-site devices is the speed, cost, and ease of implementation—all of which enable scale across of a multitude of building types and sizes. The FirstFuel platform can be deployed rapidly, with no further installation cost, to all DoD buildings with interval meters. Given the already widespread deployment of such meters in both the Army and Navy, with extensive work underway for almost complete coverage of Advanced Metering Infrastructure (AMI) in all service branches, the FirstFuel RBA platform provides the optimal combination of effectiveness and leverage of existing or planned infrastructure investments.

We have observed two potential limitations to the demonstrated approach through this ESTCP demonstration. The first relates to building energy data. Buildings that do not have interval electric consumption data are not applicable for the remote audits. Additionally, for those buildings with significantly less than one years' worth of interval electric consumption, the remote analysis can be difficult or impossible to complete. Such meter data issues are often not discovered until those 12 months are requested, and the undetected problem means the building's analysis cannot be completed until either more data is gathered by the meter or more complete data is gathered from an earlier time period. The second limitation concerns buildings that are not occupied for months at a time, typically while troops are deployed, or buildings that have very low energy consumption. These buildings may present challenges to perform the end-use

analyses. However, the impact of this limitation is partially mitigated by the finding that these types of buildings often have lower consumption and/or limited energy efficiency opportunities.

One final issue to consider regarding FirstFuel platform advantages and limitations is the total cost of ownership and return to the DoD. When conducting an audit- either on-site or remotely, one of the major cost considerations is the resources that the DoD must offer to complete the assessment. On-site audits typically require a site manager to accompany the building engineers to each of the buildings. This can mean that a DoD employee is occupied for an entire day for one building walkthrough. In addition, the DoD resource often is asked to pull building drawings and building automation system data. Alternative remote energy analysis and benchmarking solutions bill themselves as "push button," but return results that require extensive additional work to detail actual savings opportunities.

FirstFuel's remote audits require only the time of the site manager to collect the building's data (including completing a building information survey) and participate in a webinar-based Planning Session. As such, a significant advantage of FirstFuel's approach is that it helps to reduce the time and burden that the DoD energy site manager, or their staff, must devote to energy audits.

3.0 PERFORMANCE OBJECTIVES

Table 1. Performance objectives.

Performance Objective	Metric	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives				
Cost of the RBA	RBA price per building and per square foot (sq ft)	• 12 months of historical electric data in interval format for each building • Building Information Survey for each building	• The average cost for the RBAs performed on the 16 ASHRAE Level II audited buildings (Types 1-5) will be less than or equal to $3000/building, or $0.12/sq ft (whichever is higher)	The RBA met or exceeded this criteria
Scalability of the RBA	Hours per engineer per RBA	• 12 months of historical electric data in interval format for each building • Building Information Survey for each building • Results from 12 Cadmus ASHRAE Level II audits	• RBAs for Type 1 buildings completed in 25% of the time of Cadmus ASHRAE Level II Audits • RBAs for Type 2-5 completed in 50% of the time of Cadmus ASHRAE Level II Audits	The RBA met or exceeded this criteria
Accuracy of the RBA	• # of RBA ECMs identified • # of ASHRAE Level II ECMs	• Outputs from the FirstFuel RBAs • Results from 12 Cadmus ASHRAE Level II audits	• RBA finds 80% of the ECMs found in Building Type 1 ASHRAE Level II audits • RBA finds 60% of the ECMs found in Building Types 2-5 • RBA finds recommendations NOT found in Type 1 Building ASHRAE Level II on-site audits	• RBA found 61% of the ECMs found in Building Type 1 ASHRAE Level II audits (1), which accounted for 16% more savings than the savings found in the same on-site audits.[2] • RBA found 65% of the ECMs found in Building Type 2-5 ASHRAE Level II audits, which accounted for 37% more savings than the savings found in the same on-site audits[3] • RBA found 18 recommendations NOT found in Type 1 building ASHRAIE Level II on-site audits

[2] The ASHRAE LII onsite audits identified 421,909 kilowatt hours (kWh) of savings in the 6 Type 1 buildings. FirstFuel RBA identified 491,196 kWh of savings in the same buildings.
[3] The ASHRAE LII onsite audits identified 289,561 kWh of savings in the 6 Type 2-5 buildings. FirstFuel RBA identified 396,220 kWh of savings in the same buildings.

Table 1. Performance objectives (continued).

Performance Objective	Metric	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives				
Accuracy of the Continuous Performance Monitoring	FirstFuel's predictions compared to actual consumption during the monitoring period	3 months of interval data from the 12 ASHRAE Level II buildings	FirstFuel's continuous performance monitoring satisfies ASHRAE Guideline 14	FirstFuel's continuous performance monitoring satisfies ASHRAE Guideline 14
Qualitative Performance Objectives				
Customer Satisfaction	Degree of Satisfaction	Standard, web-based Likert Scale Survey to include criteria such as: RBA invasiveness, speed, opinion on applicability of results, and recommendations, portal ease of use, among others	75% overall customer satisfaction compared to the Cadmus ASHRAE Level II audits	• Greater than 75% customer satisfaction compared to the ASHRAE Level II audits for 1 of the 2 sites visited[4] • Responding sites had 39 buildings with remote audits

[4] Survey was not completed by the second of the two sites visited.

4.0 FACILITY/SITE DESCRIPTION

4.1 FACILITY/SITE LOCATION AND OPERATIONS

FirstFuel performed the remote audit (through the RBA platform) on 100 DoD buildings. Of the 100 buldings, 30 buildings consisted of offices, municipal/community buildings and schools. The remaining 70 buildings were prevalent types across the broader DoD portfolio, such as barracks, training facilities, and warehouses.

In addition to identifying building types relevant to the DoD, FirstFuel focused on incorporating buildings from sites that represented a range of climate zones. The following map illustrates the 11 DoD sites that participated in the demonstration project:

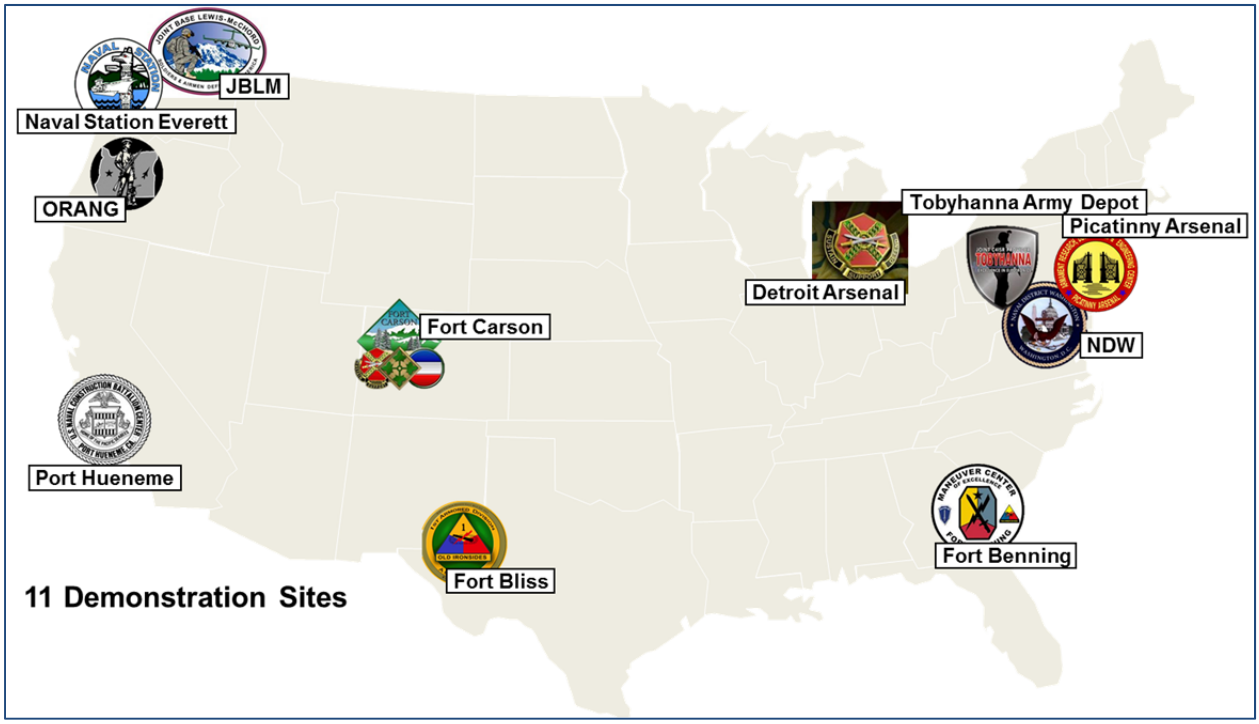


Figure 9. Map of host DoD installations.

To meet the participation criteria, each site needed to provide FirstFuel 12 months' worth of historical electric interval data for its building. The interval data had to represent the entire electrical consumption of the building. The table below outlines the number of buildings, by type, from each installation.

Table 2. Host installations and building count.

FirstFuel RBA Site Partners	Type 1 Admin	Type 2 Barracks, Dining	Type 3 Warehouses	Type 4 Recreation Centers/ Auditoriums	Type 5 Buildings with special process loads	Total
Naval Station Everett	7	4	6	3	3	23
Fort Benning	5	22	3	6	3	39
Joint Base Lewis-McChord (JBLM)	1	1	1	-	-	3
Oregon Army National Guard	2	-	-	-	-	2
Picatinny Arsenal	5	-	-	-	-	5
Port Hueneme	4	-	-	-	-	4
Naval District Washington	1	-	-	-	-	1
Tobyhanna Army Depot	2	-	-	-	-	2
Fort Carson	2	4	2	-	1	9
Fort Bliss	1	1	5	2	2	11
Detroit Arsenal			1			1
Total	**30**	**31**	**19**	**11**	**9**	**100**

Cadmus's on-site audits were performed on 16 of the RBA buildings at two sites: Naval Station Everett and Fort Benning.

4.2 FACILITY/SITE CONDITIONS

As long as the buildings satisfy the data criteria (12 months of historical interval [5/15/30/60 minute] electricity data), and they fall under one of five buildings types indicated in Table 3, then the FirstFuel RBA tool will be able to provide useful outputs, regardless of the climate or other infrastructure on the installation.

5.0 TEST DESIGN

5.1 CONCEPTUAL TEST DESIGN

FirstFuel conducted remote audits on 100 buildings that were representative of the DoD's diverse building portfolio. To conduct each remote audit, FirstFuel utilized four pieces of information: (1) 1 year of historical electric interval consumption data, (2) weather data from the building's closest weather station, (3) GIS information from the building's location, and (4) a building information survey completed by DoD energy managers.

The conceptual test was designed around measuring the time, cost, and accuracy of FirstFuel's 100 remote audits. FirstFuel tracked the time to complete the remote audit (also referred to as the RBA) for each building. The results of 12 of the 16 ASHRAE Level II on-site audits conducted by The Cadmus Group were used to compare energy savings recommendations and help prove the accuracy of the remote audit. The remaining four audits (one for each building Type 2-5) were used to aid the R&D effort associated with optimizing the FirstFuel RBA for those building types.

The buildings included in the demonstration were divided into five types:

Table 3. Building types.

Building Types		Percent of DoD's Building Stock[5]
1	Offices, municipal, schools, training facilities	11%
2	Barracks, dining facilities, mess halls	12%
3	Warehouses, shipping centers, commissaries	24%
4	Recreation centers and auditoriums	Unknown
5	Facilities with lighter process and specific equipment loads (e.g., large data centers and light manufacturing processes)	13%

While all the building types selected represent the DoD's diverse building portfolio, it is the Type 2-5 building that FirstFuel's platform was not yet optimized for at the start of the demonstration. FirstFuel's team spent time optimizing the process so that the remote audits could be performed effectively.

Design Steps:

Step 1: Data Quality Assurance

The energy manager at each site was responsible for transferring 12 months of historical interval (5/15/30/60 minute) electricity data to FirstFuel. In addition, they were asked to complete a building information questionnaire that took less than 40 minutes to complete.

Step 2: FirstFuel Remote Audits

The first 30 RBAs were Type 1 buildings. FirstFuel analytics were already optimized for these building types, and therefore required no additional research and development resources to

[5] http://www.arpa-e.energy.gov/sites/default/files/documents/files/AdvancedBuildings_DOD.pdf

complete. For building Types 2-5, FirstFuel used site visits and building walkthroughs to refine its analytics platform and complete the remote audits for these types of buildings. FirstFuel tracked the time involved to complete the RBA for each building in the deployment.

Step 3: Efficiency Planning Session

Following the completion of each RBA, FirstFuel published the results of the analysis on the online, DoD-specific portal and led an Efficiency Planning Session via webinar for the site's energy manager. The webinar covered the results of the remote audit, focused the energy managers on an initial set of recommendation to consider, and included training on how to use the web portal.

The efficiency planning session was also used to get feedback from the building team regarding assumptions made to complete the analysis. Any necessary changes discovered during the webinar were made to the audit by FirstFuel's building engineers after the call, and the updated audit was made available directly to the site's building team via the online portal.

Step 4: ASHRAE Level II On-site Audits

Simultaneously, Cadmus performed the ASHRAE Level II on-site assessments on 16 of the buildings at Fort Benning and Naval Station Everett.

While on-site, Cadmus' field staff gathered data, such as operating schedules, trend data, and other building characteristics and parameters. After the site visits, Cadmus wrote an assessment report for each building. The final reports were made available to the sites' energy managers, and the final ECMs were used to compare against the results of the FirstFuel RBA.

Step 5: Data Analysis and Comparison

FirstFuel compiled the time it took to complete each RBA, along with the associated cost and compared it to the time and cost it took to complete the on-site Level II assessments. During this analysis phase, FirstFuel also compared the number of similar recommendations for saving energy between the RBA and the on-site ASHRAE Level II audit.

5.2 BASELINE CHARACTERIZATION

The Cadmus Group followed ASHRAE Level II guidelines to conduct the 16 on-site audits. Cadmus's data collection included operating schedules, trend data, and other building characteristics and parameters. Site visits were used to confirm equipment was working as expected, and to interview building operators to better understand how equipment performance and pre-identified technical issues.

For each building, Cadmus obtained square footage data, using site visit data, reported program values, or secondary sources. Then, using available data, Cadmus determined each building's energy-use intensity. The final analysis included trends in building performance and offered potential explanations for outliers.

In contrast, FirstFuel's remote audit process used each building's historical high frequency (5/15/30/60 minutes) consumption data, the corresponding local historical weather data (gathered by FirstFuel via National Oceanic and Atmospheric Administration [NOAA] and other weather agencies) and physical building characteristics (extracted by FirstFuel via online mapping

sources) and the building's information survey (as completed by the site manager). Most often, each building's energy data was downloaded from the meter data management system by the person at the site most familiar with the site's advanced metering system. From site to site, the role of who was most familiar with the advanced metering system was not consistent, but it commonly was the person who oversaw building operations and the site's energy service provider contractors. No on-site presence or device installation/tracking was needed to establish the consumption baseline.

To complete the remote audit, FirstFuel used core statistical modeling methodology to disaggregate a building's end-uses by employing a combination of Neural Networks, Linear Programming (LP), Ordinary Least Squares (OLS) and other proprietary optimization techniques. The cost estimations associated with the ECMs were derived using the building's completed information survey and recognized facilities' cost data (e.g., RS Means).[6]

5.3 DESIGN AND LAYOUT OF SYSTEM COMPONENTS

FirstFuel's RBA platform is a "cloud-based" service, meaning it is accessed remotely on via the Internet and is hosted by FirstFuel.

5.4 OPERATIONAL TESTING

To test cost, speed and performance of the RBAs, FirstFuel first collected data files containing 12 months of electric interval data for each DoD building. FirstFuel used the building's high frequency electrical data, GIS information, and building questionnaire responses to perform the RBA. The time to complete the RBA was officially tracked to properly account for the resources associated with the demonstration activities.

Please see Appendix B in the Technical Report for a Gantt chart showing the timeline of project activities.

5.5 SAMPLING PROTOCOL

The test approach measured five dependent pieces of data:

1) *Time to complete* – All buildings that had on-site audits
2) *Cost* – All buildings
3) *Accuracy* (# of recommendations relative to ASHRAE Level II audits) – 12 buildings that had on-site audits
4) *Remote Monitoring* – 11 buildings with sufficient monitoring data
5) *Customer satisfaction* – one online survey[7]

[6] RS Means is an industry standard for facility construction cost data, updated annually.
[7] While customer satisfaction surveys were distributed to the two sites with the ASHRAE Level II onsite audits, only one completed the survey.

Time to complete – The time to complete each RBA was tracked in FirstFuel's project management system. FirstFuel also tracked the time it took for the site manager to complete the building information, attend the RBA webinar, and to supervise the ASHARE Level II audits. The time to complete the ASHRAE Level II audits, including writing the reports, was tracked by Cadmus and sent to FirstFuel.

Cost – FirstFuel used its standard pricing schedule.

Accuracy – FirstFuel collected the results of the ECMs from Cadmus' reports and recorded them in a spreadsheet that also contained the FirstFuel RBA recommendations.

Continuous Performance Monitoring – FirstFuel's continuous performance monitoring solution relies on electric interval data (5/15/30/60 minute) for each of the 3 months following the remote audit and the predicted monthly consumption data that FirstFuel generates using a variety of statistical methodologies including, but not limited to, mean bias error (MBE), R-squared, tests of significance including p-value and confidence interval measures, root-mean-square deviation (CVRMSE), etc. to demonstrate the accuracy of both in-sample and out-of-sample fits. The results of the monitoring, both the predicted and the actual consumption, are displayed on the web portal for each DoD building that submitted data.

FirstFuel demonstrated the value of the baseline model used for continuous performance monitoring by proving the accuracy of the predictions for 11 buildings (Types 1-5) compared to the buildings' actual consumption data. These buildings were selected because they represent the range of buildings in the sample set and they provided sufficient data from which to compare the predictions and actual performance data after the initial baseline period. FirstFuel's model used for continuous performance monitoring meets or exceeds the criteria established in ASHRAE Guideline 14. Guideline 14 was developed by ASHRAE to fill a need for a standardized set of energy (and demand) savings calculation procedures.

For additional information on the continuous performance monitoring results, see Section 6, "Accuracy of FirstFuel Models for Continuous Performance Monitoring."

Customer Satisfaction – A customer satisfaction survey was designed via web-based survey service, using a Likert scale style. The responses were scored along a range of "agree" to "disagree." FirstFuel captured the results/data from the online survey via Excel spreadsheet.

5.6 SAMPLING RESULTS

The following section provides the results for each of the samples collected and additional information about the remote audit results.

Time to Complete

The graph below demonstrates the average amount of time involved on the part of the installation's energy site manager to contribute to the completion of the audit.

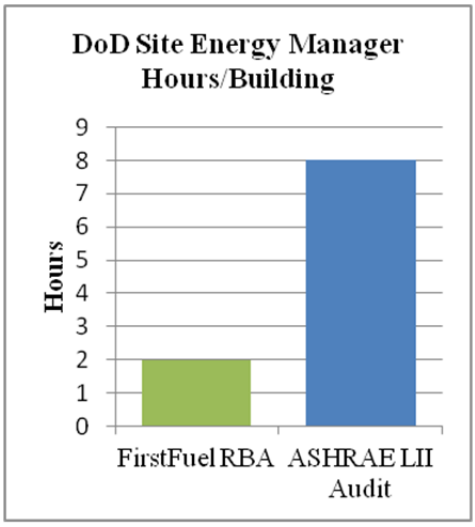


Figure 10. Energy site manager time for FirstFuel RBA time versus ASHRAE Level II audit time (in hours) for one building.

Accuracy

FirstFuel's RBAs identified 61% of the ECMs that the ASHRAE Level II audits found in the Type 1 buildings, which accounted for 16% more energy savings compared to the ASHRAE Level II audits in the same buildings. For the Type 2-5 buildings, FirstFuel's RBAs identified 65% of the ECMs that the ASHRAE Level II audits found, which accounted for 37% more savings compared to the savings found in the same on-site audits. The RBA also identified 18 ECMs that were not found in the Type I ASHRAE Level II audits, and a higher percentage of savings potential overall.

Reasons for ECMs not matching often was a result of different approaches to the audits. For example, in one audit, the ASHRAE Level II audit recommended implementing a supply air temperature reset strategy for each air handling unit. FirstFuel's RBA did not make this recommendation because of the humidity levels in the climate zone. In another case, the ASHRAE Level II audit recommendation de-lamping fixtures to reduce lighting density and installing motion sensors. The FirstFuel RBA for the same building did not include a lighting recommendation because based on the disaggregation, the lighting levels were found to be relatively low.

Remote Audit Results

Of the 100 buildings analyzed, FirstFuel successfully disaggregated the buildings' energy consumption into its building level end-uses of 91 of them. FirstFuel provided targeted energy conservation recommendations for nine buildings that could not be disaggregated; however, savings calculations are not provided, as they are partially dependent on the facility's energy end-use breakdown. The primary challenges of the nine buildings without end-use disaggregation were either a) very low annual energy consumption, or b) intermittent occupancy leading to highly irregular data. It should be noted that buildings with very low energy consumption present limited energy efficiency opportunity, by definition, and that buildings with intermittent occupancy also present challenges for accurate on-site audit calculations.

Across these 100 buildings, FirstFuel's RBA tool identified approximately 8.6 million kilowatt hours (kWh) in energy savings, which represents a potential 14% reduction in energy spending. To view the end-use analysis breakdowns and recommendations identified by building, please refer to Appendix E in the Technical Report.

The charts below show the outcome of the kWh savings per building and per square foot.

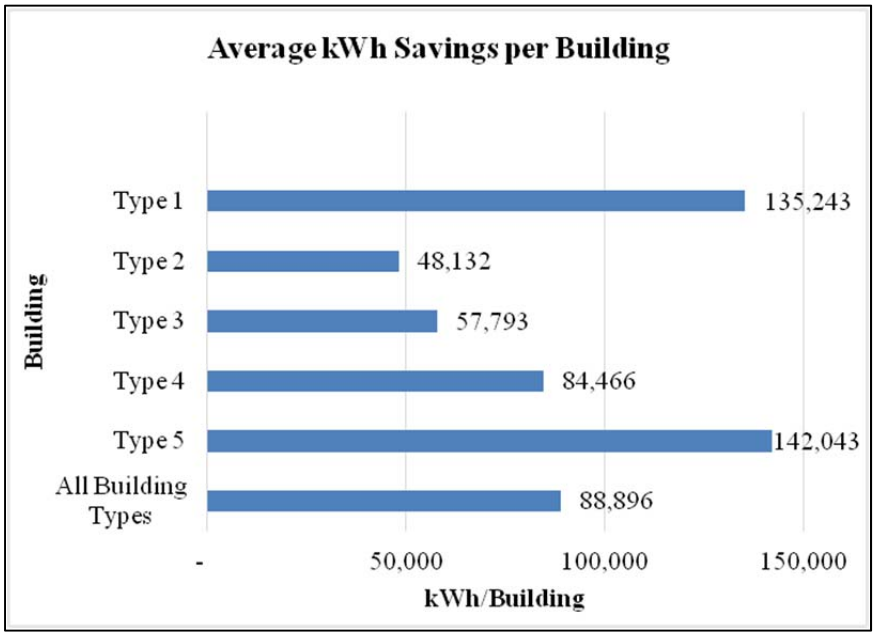


Figure 11. Average kWh savings per building.

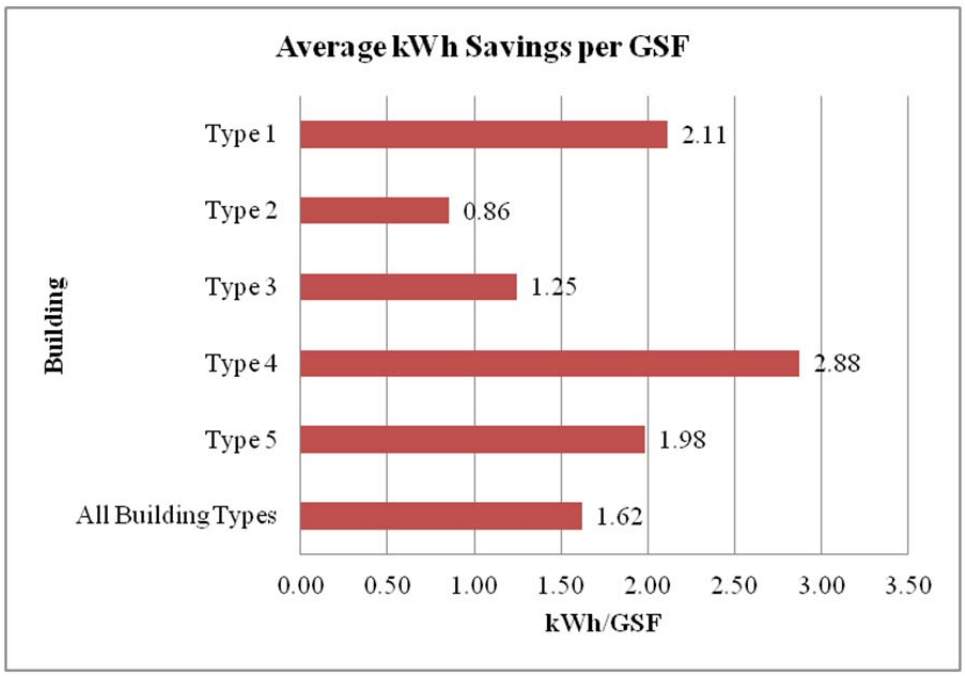


Figure 12. Average kWh savings per gross square footage (GSF).

6.0 PERFORMANCE ASSESSMENT

FirstFuel chose each Performance Objective with the major project goals in mind: cost, scalability, and accuracy. Tools like FirstFuel's RBA platform can help the DoD more rapidly and cost-effectively achieve energy efficiency at scale across its unique portfolio of buildings.

The individual Performance Objective subsections below include the data and graphs obtained during the demonstration to illustrate how the objective was met.

6.1 COST OF FIRSTFUEL RBA

Performance Objective: FirstFuel will demonstrate its applicability to the large and disparate DoD building portfolio by showing that its process can be executed much more cost effectively than traditional ASHRAE Level II on-site building energy assessments.

Success Criteria: FirstFuel's cost per RBA per building would be less than or equal to $3000/building.

FirstFuel's standard pricing sheet was utilized to the cost of an RBA to the cost of an on-site ASHRAE Level II audit the Cadmus performed on the same DoD building.

Results: FirstFuel's cost per RBA met or exceeded this success criterion.

6.2 SCALABILITY OF FIRSTFUEL RBA

Performance Objective: FirstFuel will demonstrate its applicability to the large and disparate DoD building portfolio by demonstrating that building energy assessments can be performed much more rapidly than traditional methods, providing a scalable solution for a large portfolio of buildings.

Success Criteria: 1) RBAs for Type 1 buildings completed in 25% of the time of Cadmus ASHRAE Level II Audits; 2) RBAs for Type 2-5 completed in 50% of the time of Cadmus ASHRAE Level II Audits.

In order to measure the scalability of FirstFuel's RBA platform, we compared the time to complete the remote audits to the time for on-site audits. The time to complete each RBA was tracked in FirstFuel's project management system. FirstFuel also tracked the time it took for the site manager to complete the building information, attend the RBA webinar, and to accompany the ASHRAE Level II auditors on-site. The time to complete the ASHRAE Level II audits was tracked by Cadmus and sent to FirstFuel.

Results: The FirstFuel RBA exceeded these criteria.

6.3 ACCURACY OF FIRSTFUEL RBA

Performance Objective: FirstFuel will demonstrate the validity of its remote audits by comparing the recommendations and energy conservation measures identified in 12 Cadmus ASHRAE

Level II audited buildings to the recommendations (both operational and retrofit) uncovered by FirstFuel RBAs.

Success Criteria: 1) The RBA identifies 80% of the measures/recommendations found in the Cadmus on-site audits for type 1 building, and 60% of the measures/recommendations found in the Cadmus on-site audits for building Types 2-5. 2) The RBA identifies measures/recommendations NOT found in the Type 1 Cadmus on-site audits.

Through FirstFuel's technology advancements and customer deployments across the 18 months since the DoD demonstration project, the company has learned that this performance metric is less important and relevant than other metrics. For example, ECMs recommended in on-site audits may not be uncovered by the FirstFuel RBA (or vice versa) because omissions may reflect a different set of energy management objectives or scope.

Results: FirstFuel's RBAs identified 61% of the ECMs that the ASHRAE Level II audits found in the Type 1 buildings, which accounted for 16% more energy savings compared to the ASHRAE Level II audits in the same buildings. For the Type 2-5 buildings, FirstFuel's RBAs identified 65% of the ECMs that the ASHRAE Level II audits found, which accounted for 37% more savings compared to the savings found in the same on-site audits. The RBA also identified 18 ECMs that were not found in the Type I ASHRAE Level II audits, and a higher percentage of savings potential overall.

Reasons for ECMs not matching often was a result of different approaches to the audits. For example, in one audit, the ASHRAE Level II audit recommended implementing a supply air temperature reset strategy for each air handling unit. FirstFuel's RBA did not make this recommendation because of the humidity levels in the climate zone. In another case, the ASHRAE Level II audit recommendation de-lamping fixtures to reduce lighting density and installing motion sensors. The FirstFuel RBA for the same building did not include a lighting recommendation because based on the disaggregation, the lighting levels were found to be relatively low.

6.4 ACCURACY OF FIRSTFUEL MODELS FOR CONTINUOUS PERFORMANCE MONITORING

FirstFuel's continuous performance monitoring solution relies on electric interval data (5/15/30/60 minute) for each of the 3 months following the remote audit. The predicted monthly consumption data that FirstFuel generates using a variety of statistical methodologies, including but not limited to, MBE, R-squared, tests of significance including p-value and confidence interval measures, CVRMSE, etc. to demonstrate the accuracy of both in-sample and out-of-sample fits. The results of the monitoring, both the predicted and the actual consumption, are displayed on the web portal for each DoD building that submitted data.

Performance Objective: FirstFuel will demonstrate the value of our baseline model used for continuous performance monitoring by proving the accuracy of our predictions for 11 buildings (Types 1-5) compared to the buildings' actual consumption data. These buildings were selected because they represent the range of buildings in the sample set and they had sufficient data.

Success Criteria: FirstFuel's model used for continuous performance monitoring meets or exceeds the criteria established in ASHRAE Guideline 14.

Results: FirstFuel demonstrated the value of our baseline model used for continuous performance monitoring by proving the accuracy of our predictions for 11 buildings (Types 1-5) compared to the buildings' actual consumption data. These buildings were selected because they represent the range of buildings in the sample set and they provided sufficient data from which to compare the predictions and actual performance data after the initial baseline period. FirstFuel's model used for continuous performance monitoring meets or exceeds the criteria established in ASHRAE Guideline 14. Guideline 14 was developed by ASHRAE to fill a need for a standardized set of energy (and demand) savings calculation procedures.

6.5 CUSTOMER SATISFACTION

Performance Objective: FirstFuel will prove the customer value and satisfaction of FirstFuel's RBA platform compared to ASHRAE Level II on-site audits.

Success Criteria: 75% customer satisfaction compared to the Cadmus ASHRAE Level II site audits.

Results: Only one site responded to the survey provided. That site expressed satisfaction with the FirstFuel RBA approach compared to the ASHRAE Level II on-site audits, however, the results for this performance objective are considered inconclusive. Anecdotally, the FirstFuel approach also received positive feedback or expressions of interest and enthusiasm during the web-based Efficiency Planning Sessions, with few, if any, exceptions.

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7.0 COST ASSESSMENT

Since beginning the ESTCP demonstration, FirstFuel has significantly advanced its analytics platform. The advancements include better capabilities and more commercial proof points working across more than 15 large utilities and government agencies. With the new platform, FirstFuel has updated names for each specific analytics product, or module. These names are as follows:

- **FirstAudit:** Building specific remote audits that deliver customized, actionable energy savings recommendations.
- **FirstMonitor:** Advanced predictive analytics for efficiency savings monitoring, measuring, and alerting.
- **FirstPortfolio:** Advanced tools for managing building efficiency performance across portfolios.

FirstFuel's RBA platform costs typically range by the number of buildings that will be included in the project and by the buildings' size. The low end costs assume the installation has less than 50 buildings participating in the FirstFuel RBA deployment and their sizes range from 20,000 to 100,000 GSF. The high range assumes that there are 100 buildings in the deployment, and they are between 50,000 and 300,000 GSF. On a per building basis, typical remote audits range between $1000 and $7000, depending on building size.

7.1 COST MODEL

Table 4. Cost Model.

Cost Element	Description	Estimated Costs 50-100 buildings
FirstAudit Costs	Costs to develop the FirstAudit report	$50,000-$350,000
Hardware capital costs	None	$0
Installation costs	Labor to complete building data survey (about one hour), and set-up costs	$14,000-$29,500
Consumables	None	$0
Facility operational costs	None	$0
Annual FirstMonitor	$1000 per building per year	$0-100,000/yr.
Maintenance & Support	Annual Integrated Support $1000 per building per year	$50,000-$100,000/yr.
Hardware lifetime	None	$0
Operator training	None, included in above	$0
Salvage Value	None	$0
Estimated Total Cost of Deployment	For Year 1	$114,00-$579,500

7.2 COST DRIVERS

In addition to the RBA platform costs, there are two additional cost drivers that should be considered when selecting FirstFuel's technology for future implementation: data collection and data security. The time and resources required to collect the buildings' data can be minimal, if

the site's meter data management system is functional and well-understood. However, if the meter data collection is challenging or not well-understood, additional DoD resources may need to be devoted to data gathering. The second driver to be considered is data security & privacy. Should DoD require hosting FirstFuel's servers behind a DoD firewall (or some other alternative), this will increase the costs and resources necessary to maintain the system.

7.3 COST ANALYSIS AND COMPARISON

This report illustrates the significant cost advantages that FirstFuel's RBA platform holds over traditional on-site audit methods. While ASHRAE Level II audits vary in terms of approach and rigor, FirstFuel's remote audit technology has been designed to replace these on-site evaluations under certain circumstances. The General Services Administration, for example, utilizes the FirstFuel RBA as an ASHRAE Level II replacement to meet their Energy Independence Security Act (EISA) 432 audit requirement. Rather than sending energy auditors on-site to walk through hundreds of buildings as a means to identify potential energy efficiency projects, which cannot scale, FirstFuel's RBA platform offers DoD installations a highly scalable approach to targeting and driving energy savings projects.

A DoD installation can expect to pay around $0.10-$0.15/sq ft for an ASHRAE Level II audit. FirstFuel's remote audits have been shown to cost significantly less, and have the potential to offer additional benefits, including a more interactive approach and ongoing engagement. Key interactive features not available from on-site audits include:

- Easy access via web portal by multiple stakeholders;
- Updateable and easy to understand dynamic charts, graphs and analysis describing energy performance and ECMs;
- Tracking of overall building performance over time;
- Impact measurement of enacted ECMs; and
- ECM recommendation, personalized plan creation and documentation features.

8.0 IMPLEMENTATION ISSUES

The biggest issue that FirstFuel encountered during the demonstration was selecting buildings that had sufficient quality meter data. In order to perform the remote analysis, FirstFuel relies on the building's actual consumption data for the entire assessment period (12 months). Often times, meter data would be requested and issues with the data would not be discovered until FirstFuel performed the standard Data QA checks. The most common data issues were as follows:

- Meters scaled incorrectly;
- Data not properly labeled, and units unclear;
- Zero readings;
- Random recording resets;
- Random Spikes (unrelated to real kW consumption);
- Negative readings;
- Repeated readings; and
- Blank readings.

Because the meter data issues were often not discovered until FirstFuel reviewed the data, there was no way to go back and recover sufficient data for the particular buildings. As a result, time was added to the project to identify alternative buildings. Another issue was facility personnel were sometimes unaware of how to interpret the data or how it was scaled. At many sites, the lack of a centralized resource for building meter data management made it challenging to address questions or issues with the meter data.

To gain better value out of the meters deployed across the DoD, FirstFuel recommends training personnel on-site to manage the meter data system. Furthermore, FirstFuel recommends DoD adopt a standard across the branches for meter data collection and storage. The standardization may help to reduce the bottleneck of meter data collection efforts as well as the amount of concerns and questions regarding the integrity of the readings. In our professional opinion, these recommendations are important not just for the future success of the FirstFuel project, but for any endeavors seeking to obtain value from the advanced metering investments.

As site managers were made aware of the data discrepancies, they often asked what other installations were doing to address this prevalent issue. While researching solutions for DoD, FirstFuel came across a United States Department of Energy document called *Metering Data Best Practices: A Guide to Achieving Utility Resource Efficiency*.[8] The most helpful and relevant section is Chapter 6 "Meter Communications and Storage." This chapter outlines meter data storage standards that are in line with FirstFuel's experience of "good" practices. FirstFuel specifically recommends that the DoD adopt the following key guidelines related to meter data recording and storage:

- Interval meter data (5/15/30/60 minutes) be collected and stored for a period of at least 24 months;

[8] Full report is available via the Federal Energy Management Program's website: http://www1.eere.energy.gov/femp/pdfs/mbpg.pdf

- Date/time/unit fields should be standard across all meters, buildings, and sites;
- Data should be contained in a single, flat file;
- Meter communications issues should signal an alert to facility or energy manager so blank values do not go undetected;
- Meter database shall allow other applications to reach and access the data; and
- Applications that access the data should be straight-forward to allow non-technical users to monitor the building's consumption, and download and send files.

While the U.S. General Services Administration is not immune to data issues, our experience working with their buildings' data has been less prone to delays or roadblocks, thanks, in part, to their centralized management of the meter data collection. Resources throughout the GSA's energy division are trained on how to manage and interpret the building's advanced meter data, and as result, issues with recordings are identified in a timely manner and FirstFuel is able to provide the GSA with high quality remote audits and monitoring with minimal time spent on data QA. While the DoD may be constrained in adopting a policy that all branches can adhere to, standardizing the approach to meter data collection and meter data storage at least within the branches will go a long way toward helping to achieve the full value of the advanced meter deployment.

APPENDIX A

POINTS OF CONTACT

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