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Retro-Commissioning Process Manual

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Appendix A – Sample RCx RFQ

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Appendix H – Sample Final RCx Report

1 General

1.1 Introduction

Guidelines and Policy: Retro-Commissioning, or Existing Building Commissioning, is mandated for all “covered” Federal facilities according to the Energy Independence and Security Act of 2007 (EISA). The VA RCx Process Manual offers guidance in meeting this mandate. It provides guidance for the planning, the acquisition and the performance of Retro-Commissioning in VA facilities.

Executive Order 13423 – Strengthening Federal Environmental, Energy, and Transportation Management (January 2007) requires that Federal Agencies ensure that facilities are operated and maintained in accordance with the *2006 Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (MOU) with was signed by the Department of Veterans Affairs and other Federal Agencies. The MOU creates a sustainable Federal government and serves as a lynchpin for the sustainable building provisions contained in EO 13423 and EO 13514.*

Executive Order 13514 – *Federal Leadership in Environmental, Energy, and Economic Performance (April 2010)* mandates that Federal Agencies implement high performance sustainable Federal building design, construction, operations and management, maintenance and deconstruction.

Updated High Performance and Sustainable Building guidance was issued by the Office of Management and Budget in December of 2008. This update offered revised guidance and a new set of *Guiding Principles for Sustainable Buildings.*

Section 548(a) of National Energy Conservation Policy Act (NEPCA, 42 U.S.C. 8258(a)) requires each Federal Agency to submit to the U.S. Department of Energy an annual report describing activities to meet the energy management requirements of Section 543 of NECPA (42 U.S.C. 8253). The Department of Veterans Affairs is not exempt from this requirement.

Retro-Commissioning of covered facilities assists the Department of Veterans Affairs to meet its mandated obligations and its own *Sustainable Management Policy*. Retro-Commissioning helps VA facilities meet agency-wide directives covering Sustainable Practices with particular emphasis on *VA Directive 0055: VA Energy and Water Management Program and VA Directive 0057: VA Environmental Management Program.*

1.2 Resources

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1.3 Acronyms

Table 1.3 List of Acronyms

Acronym	Meaning
BAS	Building Automation System
CACO	Department of Veterans Affairs Central Office
CFR	Current Facility Requirements
CMMS	Computerized Maintenance Management System
CO	Contracting Officer (VA)
COR	Contracting Officer's Representative (VA)
COS	Change of State
COV	Change of Value
Cx	Commissioning
DDC	Direct Digital Control
EBCx	Existing Building Commissioning
ECM	Energy Conservation Measure
EMCS	Energy Management Control System
FCA	Facility Condition Assessment
FEMP	Federal Energy Management Program
FM	Facilities Management
FPT	Functional Performance Test
HVAC	Heating, Ventilating, and Air Conditioning
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
NEBC	National Energy Business Center (VA)
NTP	Notice to Proceed

Acronym	Meaning
O&M	Operations & Maintenance
OAEM	Office Of Asset Enterprise Management (VA)
OPR	Owner's Project Requirements
RCA	Recommended Corrective Action
RCx	Retro-Commissioning
RCx	Re-Commissioning
RFI	Request for Information
RFP	Request for Proposal
RFQ	Request for Quotation
SCA	System Condition Analysis
SOO	Sequence of Operation
SOW	Statement of Work
SPT	Systems Performance Testing
TAB	Testing, Adjusting, and Balancing
VA	Department of Veterans Affairs
VACO	VA Contracting Officer
VAMC	VA Medical Center
VISN	Veterans Integrated Service Network

1.4 Definitions

Baselining: The method of comparing current performance to a historical metric, or "baseline".

Benchmarking: The process of comparing a building's energy usage to other similar buildings and to the building itself prior to the RCx process.

Commissioning: An intensive quality assurance process that begins during the design of a new building and continues through construction, occupancy, and operation.

Continuous Commissioning®: A continuing process of existing building commissioning developed by Texas A&M System Energy Systems Laboratory.

Current Facility Requirements (CFR): Defines the Owner's current operational needs

and requirements for a building or space within a building. It typically includes items addressing temperature and humidity set points, operating hours, filtration, vibration, sound and/or specialty needs.

Dashboard/User Interface: User Interface Dashboards are “real time” systems that measure and display building performance metrics such as overall building comfort, energy use, operational and maintenance parameters.

Diagnostic Monitoring: A process that utilizes energy management control system (EMCS) trending, portable data logger trending, and energy and weather data to analyze the operation of equipment and systems in a building.

EPA Energy Star®: A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that provides a method for facilities of various types to benchmark energy consumption and compare their performance to a group of peer facilities.

Existing Building Commissioning (EBCx): A systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low/no cost and capital intensive Facility Improvement Measures.

Issues Log: A formal and ongoing record of problems or concerns – and their resolution – that have been raised by members of the RCx Team during the course of the RCx Process.

LEED® Project: A project that is certified under the US Green Building Council’s Leadership in Energy and Environmental Design (LEED) process.

Master Metering: A single utility meter for the entire property.

Owner’s Operating Requirements (OOR): A document that details the facility’s operating requirements including operating hours, process and equipment status during off-times, and requirements and limitations for temperature, humidity or air filtration.

Operations and Maintenance (O&M) Manuals: Written documents that provide the information necessary for properly operating and maintaining installed equipment.

Owner’s Project Requirements: A written document that details the functional requirements of a project and the expectations of how it will function.

Payback: The period of time required to recoup the funds expended in an investment, or to reach the point at which cost or expenses and revenue are equal.

Persistence: Firm or obstinate continuance in a course of action in spite of difficulty or

opposition. Persistence of the performance of implemented RCx measures.

Rate of Return: A profit on an investment over a period of time, expressed as a proportion of the original investment.

Recommissioning: The periodic re-occurrence of the commissioning process applied to an existing building.

Request for Information (RFI): A request made by contractors to clarify details in a Statement of Work or contractual relationship.

Retro-Commissioning (RCx): The application of the commissioning process to an existing building that has not previously undergone the commissioning process.

RCx Plan: A document that outlines the organization, responsibilities, schedule, methodologies, allocation of resources and documentation requirements of the existing building commissioning process.

Sequences of Operations (SOO): A narrative describing how the mechanical, electrical, energy management in a facility are intended to operate.

Supported RetroCommissioning™ (SRCx): A process that provides long term, remote monitoring of RCx project outcomes, and mentoring and training at building management and maintenance personnel levels.

Systems Manual: A system-focused composite document that includes the O&M Manuals and additional information of use to the owner and building staff in operating and maintaining the facility.

Systems (Functional) Performance Testing: Tests that evaluate the dynamic function and operation of equipment and systems using manual or automated monitoring methods and either passive observation or active testing of operation.

Trend Logging: A diagnostic method that uses data gathered at short intervals, such as every 15 minutes, to understand how a building or one of its systems is operating.

Turnover Phase: The phase of RCx where maintenance documentation and training are provided to O&M personnel.

2 Retro-Commissioning Process Overview

2.1 Defining Retro-Commissioning

The Retro-Commissioning (RCx) process, sometimes referred to as Existing Building Commissioning (EBCx), is *"…a systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low/no cost and capital intensive Facility Improvement Measures and ensuring their continued performance. The goal of RCx is to make building systems perform interactively to meet the Current Facility Requirements (CFR) and provide the tools to support the continuous improvement of system performance over time."*

RCx is not to be confused with Commissioning and/or Re-Commissioning. Where Commissioning takes place during the new construction phase of a building's life, and Re-Commissioning is performed periodically in a building that was previously commissioned, RCx always refers to the commissioning of a building that has never been commissioned.

Buildings that were not commissioned during original construction often lack comprehensive or updated reference documentation that is critical to understanding the design and operating intent of building components and systems. In many cases these buildings will also be suffering from system performance deficiencies that have lingered since original construction. The RCx process is useful in systematically providing solutions to these deficiencies.

In addition, it is common for areas within a building to be renovated over time in order to accommodate changes in space usage. These renovation projects do not always include consideration for alterations to the building systems that serve the renovated space. The result is that very often heating, ventilating and air conditioning systems that serve the reconfigured space fail to meet the new usage demands of that space.

2.2 The RCx Mandate

The RCx process is designed to reduce reactive repairs, improve building systems performance and maintain energy efficiency in an existing building. In addition to these practical benefits, this process is also mandated under Section 432 of the Energy Independence and Security Act of 2007 (EISA). Under this section, "covered" federal facilities must undergo Energy and Water Efficiency evaluations and RCx on a cyclical basis. This four year cycle of activity is intended to ensure the persistence of savings for implemented energy and water efficiency projects. RCx is a critical component of EISA Section 432 and it should be regarded as a necessary part of complying with this

important federal mandate.

2.3 Goals of RCx

The RCx process provides an opportunity to:

- Reduce the cost of building operations
- Maintain the performance of building systems and related equipment
- Create a platform for building operations and maintenance personnel, facility managers, and energy managers to:
  - reduce the number of deferred maintenance items
  - uncover opportunities to reduce energy use and costs
  - learn more effective methods of caring for building systems

The willing cooperation and participation in the RCx project work by VA staff and managers is critical to the success of this process.

2.4 Benefits of RCx

2.4.1 Energy Savings Benefits

RCx is a cost effective tool that can be used for discovering low cost energy savings potential in existing buildings. The magnitude of energy savings identified during the RCx process is dependent on the complexity and size of building systems, hours of operation, building system control strategies and the types of deficiencies encountered.

2.4.2 Non-Energy Saving Benefits

Although a major focus of the RCx process is energy conservation, non-energy benefits are available as well. These include:

- Helping to ensure that building systems operate as dictated by design or improving infection control
- Improving the building's overall performance by optimizing energy-efficient design features already installed
- Reducing operation and maintenance costs associated with reactive repair calls
- Improving building maintenance staff skills
- Identifying potential indoor environmental quality issues
- Improving the general comfort of the facility for veterans and their families

2.5 The VA RCx Team

Although the RCx team will include an RCx Contractor after a project is awarded, VA team members who come together during the project development phase play an important role in ensuring the success of any RCx project. Members of the VA RCx Team will generally include some or all of the following VA staff:

- Contracting Officer
- VISN Energy Manager
- VISN or VAMC Contracting Officer Representative
- VAMC Site Energy Manager
- VAMC Chief Facility Engineer
- VAMC Site Facility Maintenance Manager/Supervisor
- VAMC Site Electrical/Mechanical/Control System Shop Maintenance Staff

The Contracting Officer is responsible for collecting sufficient information from each VISN project site to produce effective RCx Request for Quote (RFQ) documents. The cooperation of VISN and VA site level personnel in providing this information is vital to creating an RFQ document that can be accurately bid by qualified RCx Contractors.

VA Contracting staff, VISN level Energy Managers & COR's, and VA site level Maintenance and Operations staff should refer to the Appendix section of this RCx Process Manual for additional information concerning ideal data requirements for RCx projects.

2.6 The RCx Team Contractual Relationship

For any RCx project, the Department of Veterans Affairs establishes contracts for the RCx Planning and Investigation phases. The contract is administered by a VA Contracting Officer and/or his/her designated representative. The authority to modify a contract is strictly limited to the Contracting Officer. The contract is managed and supervised by a designated COR whose authority and responsibilities are defined by the Contracting Officer.

In this structure, all communications on contractual issues are strictly limited to communications between the VA and the RCx Contractor. It is the practice of the VA to require that communication between other parties to the contract (A/E Sub-consultants, Subcontractors and Vendors) be routed through the RCx Contractor.

RCx is a process that relies upon high levels of communications and collaboration between all parties. Because of this, open communication and cooperation between the

RCx Contractor and the VA is essential to the success of the RCx effort.

With this in mind, this manual has been developed to recognize that, in the execution of the RCx process, the RCx Contractor must develop effective methods to communicate with every member of the team involved in delivering commissioned systems, while at the same time respecting the exclusive authority of the Contracting Officer and his/her designated representative. Procedures outlined in this manual must be executed within the following limitations:

a. The RCx Contractor must maintain a continuous open communication with all members of the RCx team, including Sub-consultants and VA site staff. All communications shall be copied to the VA COR.

b. Information from the RCx Contractor to any party to the project must be transmitted as follows:

- No communications (verbal or written) will be deemed to constitute direction that modifies the terms of any contract between the Department of Veterans Affairs and any party to the project.
- In the event that any RCx issue and suggested resolution are deemed to require an official interpretation, the Contracting Officer or the COR will issue an official directive to this effect.
- All parties to the RCx Process shall be individually responsible for alerting the COR of any issues that they deem to constitute a potential contract change, prior to acting on these issues.

2.7 The 6 Phases of the VA RCx Process

The RCx process consists of the following phases:

- Phase 1 - VA Contract Planning
- Phase 2 - RCx Planning
- Phase 3 - RCx Investigation
- Phase 4 - RCx Implementation
- Phase 5 - RCx Turnover
- Phase 6 - RCx Persistence

2.7.1 Phase 1 - VA Contract Planning Phase

VA contract planning phase activities cover tasks that take place at the Contracting, VISN and VA site levels. The VA Contract Planning Phase and the activities and actions within that phase are addressed in detail in Chapter 3 of this Manual.

2.7.2 Phase 2 - RCx Planning Phase

During the RCx planning phase the RCx Contractor will confirm the project scope, identify the operational needs for the campus, collect primary building system and equipment data, and discuss the RCx process steps with VA staff and facility management. At the same time the RCx Contractor will begin to gather the information necessary to develop a comprehensive RCx Plan for the facility.

Planning phase activities should commence with the RCx Contractor providing site facility staff with an agenda for a planning phase kick-off meeting, and an accompanying list of the information that will be collected during the planning phase visit to the site.

During the planning phase site visit the contractor will request a tour of the facility in order to evaluate the condition of the systems covered by the RCx project. In addition, the contractor will request information concerning any challenges that facility staff face relative to equipment maintenance and operations. At this time the RCx Contractor's staff will begin the process of establishing the current facility requirements (CFR) for important areas within the facility. Upon completion of the RCx planning meeting and site visit the RCx Contractor will develop an RCx Plan for the facility and provide a draft copy of that plan to VA COR for review.

Deliverables for this phase of the RCx project include the RCx Plan and the Scoping Meeting Minutes.

2.7.3 Phase 3 - RCx Investigation Phase

During this phase the RCx team identifies deficiencies and issues in current design, maintenance, and operations that may have an impact on the ability of existing building systems to meet current facility requirements and energy use reduction targets.

The Investigation Phase includes:

- Site visits to conduct a detailed tour of the facility, collect data, interview facility staff, and evaluate the capabilities of the BAS
- Review and analysis of collected data
- Collecting equipment information and developing an Equipment Inventory

- Using utility billing information to calculate the utility baseline and benchmarking the performance of the facility against comparable facilities
- Creating and executing a plan to perform diagnostic monitoring using trending data from the BAS and portable data loggers
- Performing systems testing of building systems and equipment
- Developing an Issues Log (Findings Log) which will identify and record corrective actions
- Identifying facility improvements, process (sequence of operation) changes, maintenance changes and the costs associated with implementing those improvements or changes

A group of deliverables are created during and at the conclusion of the RCx Investigation Phase including:

- New or updated CFR
- Bibliography of available documents; including drawings, O&M manuals, prior studies, schematics and sequences of operations
- Summary of personnel & occupant interviews
- Facilities Performance Report
- Equipment Inventory
- Condition Assessment Report
- Issues Log
- Diagnostic Monitoring Plan
- Diagnostic Monitoring Testing Report
- Systems Testing Plan
- Systems Testing Report
- Recommended Corrective Action Report
- Final RCx Report

2.7.4 Phase 4 - RCx Implementation Phase

The recommended corrective actions that result from the activities and tasks completed during the Investigation Phase are reviewed with facility staff and management while reviewing the Final RCx Report. While simple corrective actions, as defined by the RCx SOW are addressed during the Investigation Phase by the RCx Contractor, implementation of more costly items will need to be carried out by facility staff or contracted out to specialty contractors at a later date. Implementation of corrective actions by the RCx Contractor is not included in the SOW for RCx services. How these sorts of repairs can be addressed should be discussed at the RCx Planning Phase Scoping Meeting.

Doing so will enable the RCx Contractor to present and prioritize implementation items in a manner that realistically assists the site to execute corrective actions. These could be acted on by site staff, outside contractors or by the RCx Contractor under a separate contract.

2.7.5 Phase - 5 RCx Turnover Phase (Hand-Off Phase)

Assuming that recommended corrective actions are implemented, the operation and maintenance responsibilities for those are turned over to appropriate facility maintenance and operations staff.

Deliverables at this stage include maintenance procedural documentation and training, enacting new operations and maintenance procedures, alterations to existing service agreements, creating new utility baselines and developing the persistence strategies that support the continued performance of implemented corrective actions.

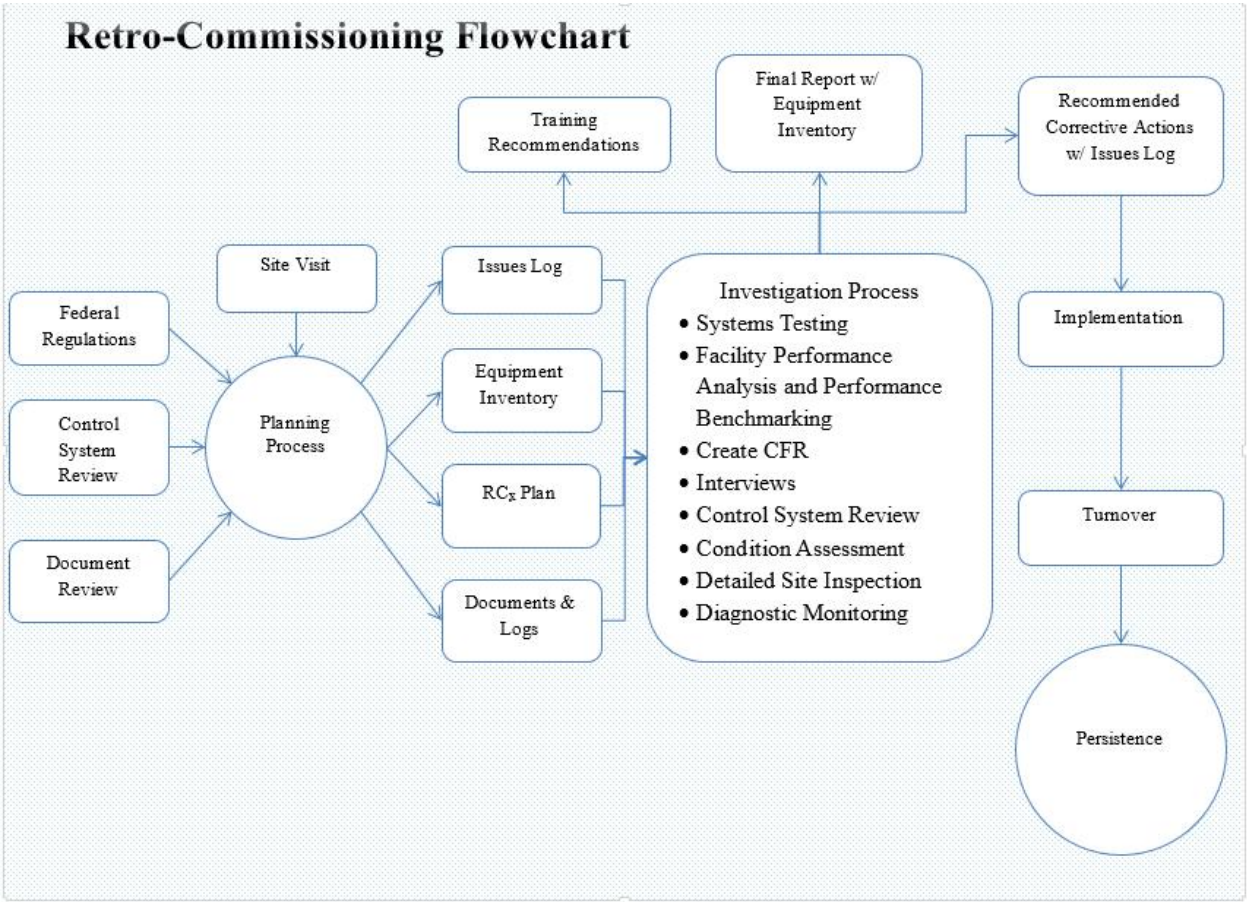
2.7.6 Phase 6 - RCx Persistence Phase

The objective of the Persistence Phase is to ensure that the investments in corrective actions made during the RCx process continue to deliver value beyond the completion of the project. The Persistence Phase includes critical skills training, particularly related to measure fault detection and monitoring, fine tuning of maintenance management procedures, and project measurement and verification functions.

The persistence of RCx measures is closely related to activities like Ongoing Commissioning, Monitoring Based Commissioning, Supported Retrocommissioning™ and Continuous Commissioning®. Deliverables at this stage of the project can take the form of any of these persistence approaches.

A flow schematic that graphically describes the RCx Process, Phases 2 through 6 is presented below.

Figure 1.0 RCx Process Flowchart



3 Phase 1 - VA RCx Contract Planning

3.1 Objectives

The objective of the contract planning phase is for the VA team to contractually procure the services of a contractor to perform the RCx work. Members of the VA team include the VA Program and Contracting Group, the VISN level CORs and Energy Managers, and site level O&M personnel. VA team member responsibilities are outlined below.

Table 3.1 - VA Project Team Roles

Designation	Team Member	Role Description
OAEM	RCx Program Office Staff	VACO Program Policy Office oversees energy and sustainability budget and compliance
CO	VA Contracting Officer	Contracting Officer is responsible for preparing the RFQ, executing the bidding process, selecting the contractor and issuing the Notice to Proceed, as well as executes and administers the executable project
VA-COR	Department of Veterans Affairs Contracting Officer's Representative	Technical Representative of the VA Contracting Officer - responsible for managing and supervising the contract
VAMC FM	VA Medical Center Facilities Management Team	Representatives of the local VA Medical Center responsible for Facilities Operation & Maintenance, Construction Coordination and/or other VAMC departments
RCx Contractor	RCx Contractor	Representatives of the independent 3rd party RCx Contractor responsible for RCx work as stated in the contract

3.2 Planning for the RCx Project

Planning for a VA RCx project begins with the selection of a site or sites to be Retro-Commissioned and confirmation that budget funding is available to complete the work. This selection must be done with the understanding that RCx is a compliance issue. Each VA site must undergo either RCx or Re-Commissioning every four years.

During the VA planning phase and in preparation for the development of contracting documents and Requests for Proposals, a variety of tasks and activities need to be completed. Generally these will include the collection of information concerning sites to be Retro-Commissioned, discussions with site personnel about specific equipment concerns, and potential schedules for project execution. The goal during this phase is to collect sufficient information to develop an effective solicitation for RCx services.

Table 3.2 - VA RCx Contract Planning Phase – Task/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Planning for the RCx Project	Planning for a VA RCx project begins with the selection of a site or sites to be RCx'd and confirmation that budget funding is available to complete the work. The performance of an RCx Process at each VAMC is mandated to occur every four years as directed by the Program Office.	n/a
Create a Scope of Work	A sample RCx statement of work (SOW) document is contained in **Appendix A**. This sample SOW should be edited to suit specific RCx project. If the site has previously received RCx much of the information required for the project will be readily available. If this is the first RCx project, the collection of information needed to prepare bidding documents will require additional effort and time. Guidance on that data collection is contained in this manual	Written Scope of Work List of required documents
RCx Project Budgets	Budgets for VA RCx projects will be created on a case-by-case basis and will be dictated by prevailing project costs. Funding is subject to prior approval.	Written & approved budget

RCx Task	RCx Task Description	RCx Deliverable
Site COR & Energy Manager RCx Project Preparations	In preparation for RCx activities at VA sites, CORs and Energy Managers should collect information that is commonly required for an RCx project. Information or documents that are not available should be recorded as missing and that information should be shared with RCx Contractors during and pre-proposal site visits.	List of available and unavailable documents and their location
Selection Process of RCx Contractor	Selection of an RCx Contractor should be based on factors as outlined in the RCx Request for Quotation documents prepared by the Contracting Officer. CO will send selected RCx Contractor a Notice of Award	RFQ and applicable Addenda Notice of Award
Submittals Prior to Notice to Proceed	The RCx Contractor must submit Proof of Insurance to the CO. Coverage normally includes requirements for general liability, professional liability (Errors and Omissions), and workman's compensation at levels dictated by VA standards. Prior to proceeding with project commencement the selected RCx Contractor should submit a project schedule that meets the project execution period outlined in the RFQ, and that indicates estimated completion dates for each project deliverable.	Pre-execution documents from RCx Contractor as required by contract
Notice to Proceed (NTP) Meeting	The CO will schedule a time and date to conduct the Notice to Proceed Meeting. This schedule and a meeting agenda will be sent to the RCx Contractor and other VA representatives. At a minimum this call should be attended by the Site COR or CORs, the Contracting Officer and Contracting Specialist and the VISN COR or Energy Manager, and RCx Contractor personnel. The meeting will be held via teleconference and afterwards the CO will issue the NTP. This meeting should establish a clear understanding of all	Notice of meeting time and date, meeting agenda. Notice to Proceed (NTP)

RCx Task	RCx Task Description	RCx Deliverable
	contractual requirements and identify and resolve potential project challenges.	

3.3 Create a Scope of Work Based on the RCx Process Manual

Although an RCx SOW document is contained in **Appendix A** of this manual, Contracting Officers and/or VISN CORs will need to collect additional, site specific information in order to prepare adequate project bidding documents.

The more relevant and complete the information about a VA site that can be provided when an RFQ is issued, the better the potential quality of the RCx Contractor response. Having this information available for the bidders during the RFQ process is the best way to avoid contract conflicts and possible change orders that increase project costs after award. When proper and complete information is provided with the RFQ, and a contractor site visit is performed before project closing, there is absolutely no reason why a bidder could not accurately estimate a fixed cost for an RCx project.

3.3.1 Information to Accompany RFQ Documents

As noted above, having accurate and appropriate information available during the solicitation process for an RCx project is critical to project success. Documents and information that will assist a potential RCx Contractor to create a realistic project bid are listed as follows:

- A site plan showing all buildings that are part of the project
- A brief description of each building with square footage, number of stories, age, construction type, building use
- Whether central plant buildings and equipment, co-generation facilities, solar PV arrays or site utility provider buildings and equipment are included or excluded from the project
- A list of the types of equipment and systems to be Retro-Commissioned. For example:
    - HVAC mechanical systems and controls
    - Electrical power distribution and grounding systems
    - Emergency & standby power, emergency lighting and controls
    - Solar PV systems
    - Combined heat & power
    - Domestic hot water systems
    - Building envelope – thermography only
- For sites where RCx has already taken place the equipment list

should be provided with the RFQ or made available to bidding contractors during the pre-proposal site visit

- If an equipment list is not available then the RFQ should clearly state what systems will be covered by the contract
- BAS control systems are an important part of any RCx project and the RFQ documents should include a detailed description of the system. This should include an outline of the system's ability to store data. This is particularly important because this determines how much trending capability a system will have. Many older BAS systems have little data storage space and this makes collecting trend data extremely difficult. In extreme cases this could cause the contractor to resort almost exclusively to installing stand-alone logging devices, which will have a significant impact on project costs
- For sites that have BAS control system service contracts, site personnel could potentially use the services of their controls contractor to provide detailed information about the BAS system

3.4 RCx Project Budgets

Budgets for VA RCx projects are created on a case-by-case basis and will rely on currently available funding. Program funding will vary from year to year and should be discussed and approved at the VISN or the VACO Asset Enterprise Management (OAEM) Program Office level.

3.5 Site COR & Energy Manager RCx Project Preparations

In preparation for overseeing the delivery of RCx services at VA sites, CORs and Energy Managers should collect information that is commonly required at the commencement of any RCx project. Once again the whereabouts of much of this information should be readily available if the site has previously undergone RCx. In cases where this will be the first RCx performed, Site CORs and Energy Managers should begin to locate and assemble RCx project supporting information and documents well before the pre-proposal site visit for the project. The Common RCx Document Requirements list found in Chapter 4 of this manual provides an overview of the information that the RCx Contractor will typically request.

Information or documents that are not available should be recorded as missing and should be shared with the RCx Contractors during the pre-proposal site visit. It is important that prospective project bidders are made aware of missing documentation so they can estimate for any related or additional costs.

Table 3.5 – VA RCx Contract Planning Phase - Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Planning for the RCx Project	Work with VA Program Office representatives to identify sites to be RCx'd	Assist CO as required during the preparation of documents	n/a
Create a Scope of Work Based on the RCx Process Manual	Create the SOW and accompanying solicitation documents	Review and assist CO with the assembly of pertinent site information	n/a
RCx Project Budgets	Create project budget	Review budget	n/a
VISN and Site COR & Energy Manager RCx Project Preparations	Coordinate with CORs & Energy Managers. Schedule and organize pre-bid site tours.	Confirm schedule for site visits. Assign site tour staff for each site. Arrange for meeting room at each site.	n/a
Selection Process of RCx Contractor	Prepare and post solicitation documents. Prepare and post addenda and coordinate contractor questions and RFIs. Receive quotes. Coordinate review and contractor selection. Select contractor and award project.	Conduct contractor site visits. Answer contractor questions and RFIs. Participate in bid reviews and contractor selection process.	Attend site visits, prepare RFIs and prepare bids.
Submittals Prior to Notice to Proceed (NTP)	Receive and review Notice of Award documents.	Assist CO as required.	Respond to Notice of Award.
Notice to Proceed Meeting	Prepare and distribute agenda. Schedule teleconference date and time. Conduct meeting and Issue Notice to Proceed.	Participate in Notice to Proceed meeting.	Full RCx Contractor Team participation.

3.6 Selecting an RCx Contractor

The VA selects an RCx Contractor through the competitive solicitation process. RCx Contractors are selected based upon a Best Value evaluation, which includes an assessment of the knowledge and experience of contractor team members and company, past performance ratings, Set Aside qualifications such as a Service Disabled Veteran Owned Small Business (SDVOSB), project approach, reasonableness of hours/costs assigned to tasks and deliverables, responsiveness to the SOW, and overall project price.

3.7 Submittals Prior to Notice to Proceed

3.7.1 Insurance

RCx Contractors must provide proof of insurance in accordance with VA standards and requirements.

3.7.2 Schedule

Previous to project commencement the selected RCx Contractor will submit a project schedule that indicates estimated completion dates for each deliverable required by the project and compliance with project duration.

3.7.3 Documentation of OSHA Training

OSHA 10 & 30 hour training certificates must be provided to VA Contracting personnel previous to commencement of the project. An OSHA 30 hour training is required for RCx Contractor Site Project Managers; an OSHA 10 hour training is required for all other RCx Contractor staff.

3.7.4 Safety Plan

RCx Contractors must provide VA Site and Contracting Level personnel with a copy of their site safety plan previous to commencing on-site activities.

3.7.5 QA/QC Plan

RCx Contractors must provide VA Site and Contracting Level personnel with a copy of their Quality Assurance/Quality Control plan previous to commencing on-site activities.

3.7.6. Security Clearance

Site security clearances must be coordinated with the COR prior to beginning site work. RCx Contractors should address this issue immediately after receiving the Notice of Award in order that schedule delays are minimized.

After the Technical and Price Quotes are reviewed, the CO will send selected RCx Contractors a Notice of Award.

3.8 Notice to Proceed Meeting

Previous to commencing work on site, a Notice to Proceed (NTP) conference call will be conducted with the RCx Contractor selected for the project and VA personnel. At a minimum this call should be attended by the Site COR or CORs, the Contracting Officer and Contracting Specialist and the VISN COR or Energy Manager. The RCx

Contractor staff attending this conference call should include the RCx Program Manager, overall Project Manager and the Site Project Managers.

Table 3.8 - VA RCx Contract Planning Phase - Notice to Proceed Checklist

RCx Task	RCx Task Description	RCx Deliverable
VA Kick-off Meeting	Prior to beginning the RCx project, the CO must conduct a kick-off meeting that concludes with the issuance of a Notice to Proceed. The Agenda for this meeting includes: 1. Welcoming of all stakeholders; CO, CO Specialist, Site COR(s), RCx Contractor's program manager, site project managers. 2. Discussion on the contractual aspects of the project and invoicing procedures 3. Deliverables: • Insurance • OSHA certificates • Safety Plan • CQCP Plan 4. Discussion on executing the project: • Statement of Work • Schedule • Coordination with site management • Site security • Simple repairs 5. Issue Notice to Proceed	Prepare agenda Formal Notice to Proceed document

The purpose of the Notice to Proceed Meeting is to brief the contractor on the VA's procedures and policies to be observed during the performance of the project work. The discussion and any information provided, supplements but does not supersede the project requirements as defined in the contract documents.

This meeting should establish a clear understanding of all contractual requirements and identify, and resolve, questions associated with the SOW or other contractual issues.

The Notice to Proceed conference call should be initiated by the Contracting Officer or Contracting Specialist responsible for the project.

4 Phase 2 - RCx Planning

4.1 Objectives

This section of the VA RCx Process Manual provides guidance for the early stage development of the RCx Project, responsible by the Contractor and the VA Team, after a project award has been made.

4.1.1 Objective One

Work with facility staff and management to identify and recommend potential site or equipment issues that should be evaluated during the RCx Investigation Phase.

4.1.2 Objective Two

Identify problems that will impact the ability of buildings or systems to satisfy the CFR.

4.1.3 Objective Three

Develop methods to better identify, categorize and manage equipment and systems.

4.2 RCx Contractor Activities Before the On-site Kick-off Meeting

The VA RCx contracting process includes two kick-off meetings. The first meeting is the Notice to Proceed teleconference noted in 3.8 above. The second meeting is held at the project site with the participation of the CO, the COR, the Facility Manager, key facility maintenance and operations staff members and the RCx Contractor team. Essentially, this meeting is the formal project commencement.

Previous to this meeting the RCx Contractor should provide the site COR with an information request form outlining the types of information that will be required to commence the RCx investigation.

A sample of the kick-off meeting Information Request Form can be found in **Appendix C** of this RCx Process Manual. An excerpt from that form is shown below.

Table 4.2 - Sample Information Request Form

Project Name:	**Project No:**	
COR Contact Info:	**Original Request Date:**	
Item Required	**Comments**	**Date Promised**
13 months Electric Bills w/Peak Demand and Consumption information		
13 months Electric Demand Interval Data or Utility Company Access		
Rate Schedule information for each electric account		
13 months Natural Gas, Fuel Oil, and/or Propane Bills with supplier information		
13 months Other Utilities – Steam/water/etc. with supplier information		
Copies of As-Built Mechanical & Electrical drawings		
Schematic of Central Plant Systems & Equipment		
Mechanical Equipment List		
Mechanical Equipment Operating schedules		
Copy of Control System Maintenance Contract		
Controls Contractor Contact Name & Phone Number		
Copy of Control System Drawings		
Copy of Control System Points List		
Copy of Control System Sequence of Operation – As Built & Current		
List of current Trend Logs & Archived Trend Logs		
Completed Owner's Operating Requirements (*form provided*)		

4.2.1 Schedule

The RCx Contractor will work with the site COR to schedule the kick-off site meeting. The timing for this meeting should provide the COR and facility staff with sufficient time to collect facility information requested by the contactor previous to the kick-off meeting. It is important that this meeting take place within five calendar days after the Notice to Proceed.

4.2.2 Kick-off Meeting Agenda

Depending upon the complexity and size of the RCx project site, the kick-off meeting will last between one and two hours although the RCx Contractor and select site staff will be occupied with the project for the entire day. The VA staff should expect the contractor to provide an agenda previous to the meeting. The agenda should include:

- Introduction of team members and their roles, including contact information
- A presentation by the contractor describing the RCx process schedule
- Identification of documentation gaps, if known - information requested by the contactor but not provided by the site
- Guidance concerning VA staff to be interviewed on-site
- Discussion of roles expected of the VA site controls contractor or other relevant service contractors
- Other agenda items that reflect the unique characteristics of the project site

4.2.3 Submittals

The RCx Contractor shall submit all project commencement deliverables requested in the RFQ. A listing of these deliverables can be found in Section 3.7 of Chapter 3 above and in the tables below.

Table 4.3.2.a – VA RCx Planning Phase – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
RCx Contractor activities before the Site Kick-off Meeting	The on-site kick-off meeting or scoping meeting occurs at the project site with the COR, the Facility Manager, key facility maintenance and operations staff members and the RCx Contractor. This meeting is the project commencement.	Agenda and Schedule for meeting
On-site Kick-off Meeting and Site Visit Facility Tour	***Site Visit Facility Tour*** - The facility tour is designed to familiarize the RCx team with the facility layout, the location of infrastructure systems, space usage and other relevant characteristics at the site. ***Document Review*** - VA facility staff will be asked by the RCx Contractor to provide access to important documents. These may include: • Site/building plans (as-built or record plans) • Specifications and equipment lists • O&M manuals and TAB Reports • Sequences of operations for control systems • Control system schematics • Training manuals • Prior engineering or energy efficiency reports and studies • Renovation history and future plans • Demand Maintenance logs and history • CMMS system capabilities and repair histories • Comfort complaint logs • Documentation of CFR ***Utility Billing Review*** – Where possible, 2 years of monthly bills should be provided. This quantity is required to adequately calculate the baseline and perform benchmarking calculations. ***Interview Key Staff Members*** - Coordinate with the site COR to identify key staff that should be interviewed. These interviews provide valuable insights into the operational performance of the facility and offer important information to the RCx Contractor about building systems deficiencies and particular areas of interest. ***Investigate Control System*** - During the first site visit the RCx team will focus attention on the BAS in order to determine its ability to gather critical information regarding the operation of major	None

RCx Task	RCx Task Description	RCx Deliverable
	mechanical and energy consuming systems. RCx Contractor team members will request copies of point lists, schedules and sequences of operation (SOO) for the BAS control system. At the same time the RCx Contractor will download screen shots from the BAS to help with the creation of an equipment inventory and to begin planning for diagnostic monitoring and systems testing.	
The RCx Plan	***Project Objectives*** - Based on the discussions that took place during the kick-off meeting and site tour, the RCx team will summarize important objectives for the project. Although the broad Retro-Commissioning objectives will be called out, the RCx Plan will also reflect the facility staff's specific desires relative to conducting the RCx investigation. ***General Facility Information*** - The Facility Information section of the RCx Plan provides a general description of the project site, a summary of the activities that took place during the kick-off site meeting and visit, preliminary utility information and the names, titles and duties of RCx team members. ***Building and System Descriptions*** - During the initial site visit the RCx Contractor and VA teams will collect information to assist with the preparation of a narrative describing the facility and its associated buildings. The information will include: • History of the facility • Location maps • Facility map Information on all utility providers • A detailed description of the buildings • Building number or other name • Function of building • Year built, year remodeled or renovated, or usage change • Number of floors • Size in square feet • A detailed description of the systems in the building to be RCx • Central plant details and description • BAS Controls (HVAC, fire suppression, lighting, security as applicable to scope) • Investigation priorities	Site and COR approved RCx Plan

RCx Task	RCx Task Description	RCx Deliverable
	Process and Scope - The process and scope section of the RCx Plan provides a detailed description of the work to be accomplished during the Planning and Investigation Phases of the RCx project. ***RCx Team – Roles and Responsibilities*** - This section of the RCx Plan will describe the note team members and their roles and responsibilities during the RCx process. Members of the RCx team will come from both the contractor and VA site personnel. ***Schedule*** - The RCx Plan will include a schedule that details the task and deliverables for the planning and investigative phases of the project, and the estimated completions dates for each of those tasks and deliverables. ***Available Documentation*** - The available documentation received, reviewed and requested section of the RCx Plan outlines the status of various documents required to complete the RCx Process. Typically this list will outline the status of documents requested previous to the site kick-off meeting or subsequent to that meeting. ***Investigation Scope and Methods*** - This section of the RCx Plan describes, in non-technical terms, the extensive activities involved with the investigation phase of the project. Delivered in a narrative form, the Scope and Methods section offers an explanation of the tasks and activities that will occur and provides a general description of the key site visits, associated deliverables, and the scope and method for each.	
Scoping Meeting	After the RCx Plan has been reviewed, a scoping meeting will be conducted to discuss comments on the Plan from the VA reviewers and to allow the RCx Contractor to discuss how the investigation phase will be conducted. The RCx Contractor will provide specific dates for site visits, installing data loggers and conducting systems testing. The RCx Contractor will also briefly describe the scope of the different investigative processes.	Meeting Minutes

Table 4.3.2.b VA RCx Planning Phase - Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Contractor Activities Before the On-site Kick-off Meeting	n/a	Reserves room and schedules facilities staff to attend the meeting.	Prepare agenda and presentation explaining the project, including key deadlines. Send out RFI.
On-site Kick-off Meeting and Site Visit Facility Tour	n/a	Attend meeting. Explain security issues. Explain photographic restrictions. Provide access to documents. Provide utility billings. Provide escort for site facility tour Schedule interviews Schedule controls contractor assistance	Present meeting. Take team to acquire security passes. Begin review of documents Begin review of utility billings Perform site tour Interview key staff members Interview controls contractor
The RCx Plan	n/a	Review RCx Plan	Write the RCx Plan Participate in review session with COR Write final RCx Plan
Scoping Meeting	n/a	Attend scoping meeting	Review RCx Plan with COR, Facilities Manager and facilities staff

4.3 On-site Kick-off Meeting and Site Visit

4.3.1 Facility Tour

Upon completion of the formal kick-off meeting a facility tour will take place. The facility tour is designed to familiarize the RCx Contractor with the facility layout, the location of infrastructure systems, space usage and other relevant characteristics at the site. The facilities department should expect to provide an experienced and knowledgeable facility staff member to direct this tour. The goals of the tour are:

- Identify the various space types and uses, occupancy loading and occupancy schedules
- Survey the mechanical rooms and HVAC equipment
- Survey the non-HVAC equipment that will be retro-commissioned, if any
- Assess the scope, reach and capability of BAS control systems
- Review documented control sequences of operation and points lists

4.3.2 Document Review

VA facility staff will be asked by the RCx Contractor to provide access to important facility documents. These may include:

- Site/building plans (as-built or record plans)
- Specifications and equipment lists
- O&M manuals and TAB Reports
- Sequences of operation for control systems
- Control system schematics
- Training manuals
- Prior engineering or energy efficiency reports and studies
- Renovation history and future plans
- Preventive Maintenance logs and history
- CMMS system capabilities and repair histories
- Comfort complaint logs
- Documentation of CFR

4.3.3 Utility Billings Review

The RCx team will request utility billing information and history from the facility. Two years of monthly bills is ideal to adequately calculate the baseline and perform benchmarking calculations. Thirteen months is the absolute minimum.

4.3.4 Interview Key Staff Members

The RCx team will coordinate with the site COR to identify key staff that should be interviewed. These interviews provide valuable insights into the operational performance of the facility and offer important information to the RCx Contractor about building systems deficiencies and particular areas of interest.

Candidates for interviews include:

- Facilities Department Manager
- Electrical Department Manager
- Mechanical Department Manager
- Maintenance Manager & Maintenance Personnel
- Control Systems Leader and/or Controls Contractor
- Mechanical & Electrical services providers
- Selected building occupants (COR approval)

4.3.5 Control Systems

Most VA facilities utilize a Building Automation System (BAS) to control the functionality of important mechanical systems. At times VA facilities will

contain control systems from a variety of manufacturers, all operating independently from each other. In some cases only major equipment will be controlled with more modern Direct Digital Control (DDC) systems and occupied spaces will utilize pneumatic control devices.

A typical BAS will control Heating, Ventilating and Air Conditioning systems. More advanced systems can include control for Lighting and Security systems as well. In either case, the BAS is an extremely important tool that will be used frequently throughout the RCx process.

During the first site visit the RCx team will focus attention on the BAS in order to determine its ability to gather critical information regarding the operation of major mechanical and energy consuming systems. RCx Contractor team members will request copies of point lists, schedules and sequences of operation (SOO) for the BAS control system in an effort to determine the operating characteristics of controlled equipment.

4.4 Contents of the RCx Plan

The RCx Plan is the roadmap that the RCx Contractor will use to complete the RCx project work. It is developed in cooperation with the COR and VA site O&M staff and it will contain the elements listed below.

4.4.1 RCx Plan Executive Summary

As its name implies, the Executive Summary for the RCx Plan provides a summary of the RCx process and project phases, an overview of the Plan content and a description of the exhibits and forms included in the plan.

4.4.2 Project Objectives

Based on the discussions that took place during the kick-off meeting the RCx Contractor will summarize particularly important objectives for the project that were suggested by site staff.

4.4.3 General Facility Information

The Facility Information section of the RCx Plan simply provides a general description of the project site, highlights of the activities that took place during the kick-off site meeting and visit, preliminary utility information and the names, titles and roles of RCx team members.

4.4.4 Building and System Descriptions

During the initial site visit the RCx Contractor and VA team will collect information to assist with the preparation of a narrative describing the facility

and its associated buildings. This section of the plan includes:

- History of the facility
- Location maps
- Facility maps
- Information on all utility providers
- A detailed description of the buildings
- Building number or other name
- Function of building
- Year built, year remodeled or renovated, or usage change
- Number of floors
- Size in square feet
- A detailed description of the systems in the building to be retro-commissioned
- Central plant details and description
- BAS Controls (HVAC, fire suppression, lighting, security as applicable to scope)
- Investigation priorities

A sample building description form is shown in the following table.

Table 4.4.4 - Sample Building Descriptions

Characteristic	Description
Building no./name	Building 1, Clinical Support Bldg.
Primary function	Hospital and Community Living Center
Conditioned area	107,157 square feet
Number of stories	Four plus attic
Schedule(s) of use	8:00 am to 4:30 pm, Monday through Friday. The kitchen runs on a separate operating schedule.
Type of HVAC system(s)	Four constant volumes four-pipe AHUs installed in 2010. Heating hot water and chilled water are supplied from central plant. Heating hot water in bldg. is glycol mixture and separated from central plant supply with heat exchanger.
Type of HVAC controls	Siemens Apogee BAS installed in 2010. VFD controls on AHU fans used for balancing, soft start, and filter loading compensation.
General comments	The chillers and chilled water distribution system are shared with Building 31. Siemens believes that buildings 1 and 31 account for 50% of the energy used.

This table can be expanded to include lighting, electrical, generation, building envelop

and other systems that may be included in the project.

4.4.5 Process and Scope

The process and scope section of the RCx Plan provides a detailed description of the work to be accomplished during the Planning and Investigation Phases of the RCx project. In many ways it represents the total RCx effort that will take place at the site, outlining key project milestone dates and all project deliverables.

4.4.6 RCx Team – Roles and Responsibilities

This section of the RCx Plan describes the roles and responsibilities of the different team members during the RCx process.

The goal of creating a roles and responsibilities matrix is to establish clear lines of communication and responsibility amongst team members from the contractor and VA staff. It is vitally important to the success of the project that each team member understands their role and their responsibilities in completing the work of the RCx project.

Table 4.4.6 - Sample Names and Contact Information

Area of Responsibility	**Name of Individual**	**E-Mail Address**	**Phone Number**
Pre-Award			
CONTRACTING OFFICER			
CONTRACT SPECIALIST			
Post Award			
CONTRACT SPECIALIST			
SITE COR			
FACILITIES MANAGEMENT			
HVAC & ELECTRICAL MAINTENANCE CONTACT			

Area of Responsibility	**Name of Individual**	**E-Mail Address**	**Phone Number**
BAS CONTACT			
CAD/CMMS CONTACT			
SAFETY MANAGER			
RCx Contractor Team			
PROGRAM MANAGER			
LEAD RCx CONSULTANT			
SITE PROJECT MANAGER			
SITE PROJECT MANAGER			
ENERGY ANALYST SUPERVISOR & BAS SPECIALIST			

4.4.7 Schedule

The RCx Plan will include a schedule that details the tasks and deliverables for the planning and investigative phases of the project. Estimated completion dates for each of those tasks and deliverables will be shown. Depending on the scope of the project, the schedule may include Phase 3 – Implementation, Phase 4 - Turnover, and Phase 5 – Persistence, as well.

Table 4.4.7 - Sample Project Schedule

GENERAL - The following table is the schedule of milestones for this project. Anticipated completion dates are based upon plans for carrying out the RCx investigation on or before the proposed end dates shown on the VISN XYZ RCx Schedule submitted on mm/dd/year. As the project proceeds, updates and revisions to the schedule may be presented to the VA COR for approval.

Task	Tasks and Deliverables	Completion Date
	TASK 1 – PLANNING PHASE	
1.1	Pre-kick-off Meeting Activities	Completed on month, date, year
1.2	Kick-off Meeting	
1.2.2	Interview Energy, Building, and O&M Management	
1.2.3	Perform a Cursory Walk-Through	
1.3	Documentation Review	
1.4	Review Current VA Standards	
1.5	Submit RCx Plan	
1.6	Conduct a Scoping Meeting and Issue Minutes	
	TASK 2 – INVESTIGATION PHASE	
2.1	RCx Coordination	Continuous
2.2	Site Review/Survey, Condition Assessment and Facility Information Documents Report	
2.3	Equipment Inventory with Photographs and IR Scans	
2.4	Building Staff & Management Surveys Interviews will be conducted during the detailed site visit.	
2.5	Facility Performance Analysis and Performance Baseline Establishment	
2.6	Create and update the CFR	
2.7	Systems Diagnostic Monitoring Plan	
2.8	Systems Diagnostic Monitoring Report	
2.9	Systems Test Procedures Plan	
2.10	Systems Test Procedures Report	
2.11	Simple Repairs and Prepare Report Summary	

Task	Tasks and Deliverables	Completion Date
2.12	Recommended Corrective Action Report	
2.13	Certified Final RCx Report	

4.4.8 Available Documentation

The available documentation received, reviewed and requested section of the RCx Plan outlines the status of various documents requested by the RCx Contractor. Typically this list will outline the delivery status of documents requested, previous to the site kick-off meeting, during that meeting or subsequent to that meeting.

Table 4.4.8 - Sample Documentation Description Table

Item Requested	Description	Requested	Status
Systems Operations & Maintenance Manuals	O&M Manuals for mechanical, electrical and controls		
Current Facilities Requirements (CFR) Report	Defines the current operational needs and requirements for a building or space. Typically includes temp/humidity set points, operating hours, filtration, etc.		
Basis of Design Documents	Basis of Design Documents for previous mechanical and electrical construction projects and site		
Preventative Maintenance Program	PMP Reports, Emergency Orders and listing of routine PM tasks and schedule		
Site Specific Health and Safety Requirements	A document that describes Health and Safety (H&S) Requirements		
Mechanical Equipment Schedules	Equipment Data Sheets that include Name Plate information		

Item Requested	Description	Requested	Status
Mechanical Drawings	Drawings of each of the buildings that show equipment schedules; equipment room layouts, duct and piping layouts; steam and chilled water piping schematics, riser diagrams. (Ideally a full set of HVAC drawings, including known changes, such as renovation drawings and updated as-built)		
Previous Studies and/or Evaluations Performed	Any energy studies, commissioning reports, TAB Reports or similar reports		
Utility Bills	Electric, Natural Gas, other fuel or energy sources		
Electric Demand Data	15 minute electrical interval load demand data		

4.4.9 Investigation Scope and Methods

Delivered in a narrative form, the Scope and Methods section of the RCx Plan offers an explanation of each of the tasks that will occur during the RCx project. It provides a general description of the key site visits and associated deliverables.

5 Phase 3 - RCx Investigation

5.1 Objectives

There are four objectives of the Investigation Phase:

5.1.1 Collect and Assemble Data

Collect and assemble available site data into a central repository for analysis. Collected data will include reports, studies, design documents, O&M manuals, billing histories, preventive maintenance plans, equipment inventories, schematics, Sequences of Operation, maintenance histories and even oral histories obtained through interviews.

5.1.2 Create CFR

Identify how building and spaces are intended to operate by creating or updating a Current Facilities Requirements (CFR). The data in the CFR is common also to the VA Design Guide (for HVAC).

5.1.3 Interviews, Diagnostic and Systems Testing Methods

Identify where and how the facility is not meeting the CFR through the use of diagnostic monitoring, systems testing and interviews.

5.1.4 Corrective Actions

Identify and describe the corrective actions that will be required to bring the building back into compliance with the CFR. The description will also include the costs for repairs and corrective measures, the energy saved, the amount of money saved, the rate of return and also the processes recommended to implement the corrective measures.

The table below describes many of these activities.

5.2 Site Visit

Table 5.2.a - RCx Investigation Phase, Site Visits – Tasks/Deliverables

RCx Task	RCx Task Description
Site Visit	***In-depth Investigation*** - The RCx Contractor will conduct an in-depth investigation of the building(s) to be RCx'd. There are several reasons for conducting this level of detailed investigation, including: • Documentation of how a building should operate • Developing a thorough knowledge of the systems to be investigated and how they interact • Identifying available control systems not only as part of the building investigation, but to ensure the building is operating efficiently • Understanding the condition of equipment • Gathering information sufficient to write a diagnostic monitoring plan and a systems testing plan RCx Deliverable - None ***Interviews -*** Interviews with key facility staff are an important element in understanding the current needs, issues and challenges related to system operations and maintenance. Facilities staff can provide insight into known design and space deficiencies, facility staff training and education needs, indoor air and environmental quality issues, and occupant comfort complaints. The interview process also helps to uncover potential improvement opportunities, confirm Current Facilities Requirements (CFR), and to develop consensus on RCx process activities and goals. RCx Deliverable – Interview Report ***System Condition Analysis -*** During the RCx Investigation the RCx Contractor will perform System Condition Analyses (SCA) on facility equipment to assess its current operational and maintenance conditions. The goal of SCA activities is the identification of O&M issues or physical conditions affecting the performance of equipment and systems, based on direct observation. Typical items to be checked include: • Cleanliness of coils, louvers, and other surfaces that could harbor contaminants and infection risks • Serviceability of filters, belts, valves, dampers, ducts, flex connections, insulation, door seals and glazing • Completion of required preventative maintenance actions • Overall equipment physical condition RCx Deliverable - Information collected will be included in Recommended Corrective Actions Report and the Issues Log ***Document Review -*** VA facility staff will be asked by the RCx Contractor to

RCx Task	RCx Task Description
	provide access to facility documents. These may include: • Site/building plans (as-builts or record plans) • Specifications and equipment lists • O&M manuals and TAB Reports • Sequences of operations for control systems • Control system schematics • Training manuals • Prior engineering or energy efficiency reports and studies • Renovation history and future plans • Demand Maintenance logs and history • CMMS system capabilities and repair histories • Comfort complaint logs • Documentation of CFR RCx Deliverable - None ***System Condition Analysis -*** The RCx Contractor will inspect the condition of the system as they conduct the site visit. Examples of items to be identified include: • Air and water leakage or flow blockage • Corrosion and wear • Manual overrides, such as throttled valves, motor control centers in "Hand" mode, disconnected valve or damper actuators, disconnected safety mechanisms, etc • Equipment operation when not required • Unusual noises or odors emanating from equipment or noticeable in occupied spaces • Lighting levels and control **Current Facility Requirements -** The Current Facility Requirements (CFR) document provides a description of the current space use of various areas within an existing building. RCx Deliverable – New or Updated CFR VA facility users and occupants have specific requirements for the various spaces in their facilities. Many of these requirements relate directly to the VA HVAC Design Handbook. The CFR should include the following information: • Identification and location of the room or area • Current occupancy information (space type) • Current usage information (space type) • Prior usage and change of use documentation • HVAC zone changes

RCx Task	RCx Task Description
	• Current required indoor climate requirements (temperature, air changes, pressure, etc.) • Owners sustainability and building rating requirements • Building system scheduling requirements • Energy and efficiency requirements • Operation and maintenance issues RCx Deliverable – Energy Benchmark/EUI ***Utility Billing Review*** - The RCx team will request utility billing information and history from the facility. Two years of monthly bills is the ideal quantity required to adequately calculate the baseline and perform benchmarking calculations. RCx Deliverable – Summary of Interview Info ***Interview Key Staff Members*** - These interviews provide valuable insights into the operational performance of the facility and offer important information to the RCx Contractor about building systems deficiencies and areas of interest. RCx Deliverable – - Issues Log ***Investigate Control System*** - Coordinate with site COR to identify key staff that should be interviewed. These interviews provide valuable insights into the operational performance of the facility and offer important information to the RCx Contractor about building systems deficiencies and areas of interest. ***Equipment Inventory*** - The Equipment Inventory developed as part of the RCx project should be maintained as a living document. It can be used to: • Manage assets for funding purposes • Help to plan, monitor and track O&M practices • As a tool to organize, record and track equipment condition • As a link to a Digital Issues Log RCx Deliverable – - Equipment Inventory update or creation ***Available Documentation*** - The available documentation received, reviewed and requested outlines the various documents required to complete the RCx Process. Typically this list will outline the status of documents requested previous to the site kick-off meeting, during that meeting or subsequent to that meeting. RCx Deliverable – Document Inventory

Table 5.2.b RCx Investigation, Site Visits – Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Site Visit – In-depth Investigation	n/a	Schedules facilities staff to escort and assist the RCx Contractor's team	Plan and execute in-depth investigation
Site Visit – Document Review	n/a	Assemble requested documents and make them available to RCx Contractor's team	Review and tabulate findings from document review
Site Visit – System Condition Analysis	n/a	Schedules facilities staff to escort and assist the RCx Contractor's team	Plan and execute systems condition assessment
Site Visit – Current Facility Requirements	n/a	Provide RCx Contractor with copy of existing CFR or other similar document Review updated CFR	Update or create CFR
Site Visit – Utility Billing Review	n/a	Provide RCx Contractor with monthly utility billings	Review monthly utility billings
Site Visit – Interview Key Staff Members	n/a	Schedules detailed interviews	Conduct interviews
Site Visit – Investigate Control System	n/a	Schedule controls contractor and site controls manager to work with RCx Contractor	Meet with controls contractor and site controls specialist to collect information for preparing the Diagnostic Monitoring and Systems Testing plans
Site Visit – Equipment Inventory	n/a	Provide RCx Contractor with copy of existing equipment inventory, Ames/Mers inventory or other similar document	Update or create an equipment inventory

The RCx investigation phase begins with a methodical collection and review of information about the facility including site surveys to assess the configuration of systems and condition of equipment. The contractor will review building drawings, trend

data from building automation systems and portable data loggers, test system operation to verify actual performance, and interview individuals with direct knowledge of the buildings, systems, and equipment found at the site.

5.2.1 In-Depth Building Investigation

The RCx Contractor will conduct a very detailed investigation of the buildings and systems covered by the contract. There are several good reasons for conducting this level of detailed investigation, including:

a. Documenting how the building should operate
b. Developing a thorough knowledge of the systems to be investigated and how they interact with each other
c. Identifying control system performance, not only as part of the building investigation, but to ensure that building systems run efficiently
d. Understanding the condition of the various pieces of equipment
e. Gathering sufficient information to be able to write a diagnostic monitoring plan and a systems testing plan

The in-depth building investigation can take between two to three weeks or even longer, depending on the size and complexity of the building(s).

5.2.2 Interviews

Interviews with key facilities staff are an important part of understanding the current needs, issues and challenges related to building system operations and maintenance. Facilities staff can provide valuable insight into known design and space deficiencies, training needs, indoor air and environmental quality issues, and the reliability of occupant comfort conditions. A sample Interview Form can be found in **Appendix F**.

Generally, two different groups are interviewed in the investigation phase; the facilities staff, and select building occupants. The operations and maintenance team has extensive knowledge of HVAC systems, and they are generally familiar with issues related to equipment operation. They interact with the occupants in each building and respond to complaints concerning mechanical equipment in order to resolve indoor environmental quality and comfort issues. Since this group is familiar with the systems contained in each building on a campus, they are able to provide very useful information related to design and space deficiencies and system operations and maintenance history.

Interviews with select hospital management staff and department heads should be conducted to assess occupant comfort/satisfaction and specific space requirements.

The interviews of this group should be scheduled through or by the COR or Energy Manager. The following rules should apply to the interview process: interview only those who 1) are willing to participate, 2) may have information beneficial to the investigation and 3) have the time to complete an interview.

A script should guide the interview process. There should be one type of interview script for the facilities staff and another for building occupants.

5.2.3 System Condition Analysis

During the RCx Investigation the RCx Contractor will perform System Condition Analyses (SCA) on facility HVAC equipment to assess its current operational and maintenance condition. The goal of SCA activities is the identification of O&M issues or physical conditions affecting the performance of equipment and systems, based on direct observation. Typical items to be checked include:

- Cleanliness of coils, louvers, and other surfaces that could harbor contaminants and infection risks
- Serviceability of filters, belts, valves, dampers, linkages, ducts, flex connections and insulation
- Completion of required preventative maintenance tasks
- Overall equipment physical condition
- Air and water leakage or flow blockage
- Corrosion
- Manual overrides, throttled valves, motor controls in “Hand” mode, disconnected valve or damper actuators, disconnected safety mechanisms
- Equipment operation when not required
- Unusual noises or odors emanating from equipment or noticeable in occupied spaces
- Lighting levels and controls

These SCA activities will initially be conducted with the assistance of VAMC O&M staff. This helps the RCx Contractor become acquainted with the characteristics of the facility and its principal energy consuming systems and equipment. This is an opportunity to note significant operational or maintenance issues and to gain a perspective on the maintenance and repair history of facility equipment.

An additional resource that can be useful for this process is the Facility Condition Assessment (FCA) report, which is a study produced approximately every 36 months by the VA’s Consulting Support Services (CCS) group, a part

of the office of Construction and Facilities Maintenance. The FCA contains estimates of the age, remaining lifetime, value, replacement cost, and general condition of the capital assets at each VAMC site. In some cases it may provide sufficient information on the state of equipment or systems to serve as a guide for more detailed analyses during the RCx investigation process.

Items noted during initial building walkthroughs will normally warrant additional investigation later in the RCx process. Observations of potential issues will be recorded and classified in the Issues Log (Section 5.5), and follow-up actions identified (Section 5.8).

As part of the walk-through, VAMC O&M staff should inform the RCx Contractor of any equipment warranties and service contracts that are active on equipment or systems. A warranty may become void if the installing contractors or manufacturer representatives are not called in to test or make modifications that affect equipment operation.

5.2.4 Current Facility Requirements (CFR)

a. Introduction

The Current Facility Requirements (CFR) document provides a description of the current space use of various areas within an existing building. The CFR is similar to an Owner's Project Requirements (OPR) for a new building. The CFR is a key component of the RCx process because it establishes space conditioning requirements that can be easily impacted by the RCx process.

VA facility users and occupants have specific requirements for the various spaces in their facilities. Many of these requirements are guided by the VA Design Guide (HVAC). When a building is originally constructed, the specific requirements are defined based on the expected use of the space or facility. After occupancy, the specific functions of the facility or individual spaces may change when compared to original design.

Examples of changes that can occur over time include remodeling or repurposing of spaces and changes in the operation of systems that serve those spaces. Clear documentation within the CFR, which defines the facility's operational needs and requirements, should be completed prior to concluding this phase of the RCx process. The CFR should include the following information:

- Identification and location of the room or area
- Current occupancy/usage information (space category and type)
- Prior usage and any change of use documentation, if applicable

- HVAC zone changes
- Current required indoor climate requirements (temperature, air changes, return air, humidity, pressurization, etc.)
- Owners sustainability and building rating requirements
- Building system scheduling requirements
- Energy and efficiency requirements
- Operation and maintenance issues

The CFR should make note of integrated requirements such as controls, fire and life safety, warranty review, service contract review and other relevant systems. A sample CFR can be found in **Appendix D** of this manual.

The RCx plan must present an approach for documenting and verifying that CFR requirements are being met. If the building has experienced usage changes from the original design, which for VA facilities is very likely, or if a current CFR does not exist, the RCx Contractor, with assistance from the facility, should develop a detailed CFR as part of the RCx project.

b. Measurable Targets

Measurable targets within the CFR include metrics for determining how well the building systems and assemblies are actually performing. The RCx process will be used to identify areas where performance does not meet the CFR. With this information a plan to bring the performance of those areas into compliance with the CFR can be developed and solutions implemented. If the facility was commissioned when originally constructed, the original commissioning documents may be available to assist with this process.

The CFR must include an overview of facility use and general information regarding the specific environmental, functional, and operational conditions to be maintained in a given space. The CFR should identify any known issues with the building or building systems and assemblies. Once defined, the CFR provides the criteria from which scope, acceptance, and operational decisions are evaluated. The CFR document should define specific, measurable targets wherever possible, such as achieving a specific temperature or pressure.

c. CFR Workshop

Conducting a CFR Workshop with a stakeholder user group can be effective in developing and ranking a list of needs and requirements for a facility or space. Methods used to obtain information should allow the different user groups and building operators to interact. Workshops, interviews, surveys, and a brief walk-through of the facility can be used to obtain this input. Stakeholders

should be given an opportunity to review and comment on the draft CFR document.

The CFR is a living document and future revisions should be expected. The latest version of a CFR will be the standard for making decisions throughout the RCx process. Documentation of changes in each update of the CFR must be maintained along with an explanation of reasons for modification. This will help to prevent repetition of a prior requirement without appropriate review and justification.

5.2.5 Facility Information Documents and Inventory

The RCx investigation process begins with extensive information gathering, and yields an assessment of building and equipment operations. This should include quantitative analysis of issues identified during the investigation, recommendations for actions to correct discovered issues, and cost-benefit analysis of those recommendations. Collection of existing facility documents, including drawings, sequences of operation, maintenance records, equipment data, and operating logs is an important early step in the information gathering process.

When scoping a project, it is important to understand what building documentation is available for used during the RCx process. Clear, complete, up-to-date documentation expedites the investigation phase of any RCx project. Missing building information makes the project more expensive because the RCx Contractor must spend significant time recreating building documents. A list of common and important building documentation used during the RCx process includes:

- Utility bills and/or history including natural gas, fuel oil, steam, chilled water, electricity, etc. (Often this information is available from the utility provider)
- As-built mechanical and electrical drawings including piping and riser diagrams
- Specifications for the original construction and any renovations to the facility
- Testing, adjusting, and balancing reports for the original construction and renovations
- Control diagrams for the original construction and any renovations (see Control System section 5.2.7 for more information).
- Survey of the facility with a focus on the mechanical rooms, electrical rooms, and energy-consuming equipment and systems (see

equipment inventory, section 5.2.6) including nameplate information and dates of installation

- Trend data including automatic temperature control systems for water chillers, boilers, air terminals, air handler units, exhaust fans, domestic water heating equipment, and fan coil units
- Identified current sequences of operation, set-points and points lists
- Air Handler Zone Plans
- Operation and maintenance manuals
- Copies of current HVAC and Control system service contracts
- Equipment warranties still in effect
- Previous commissioning reports/energy studies

Where building documentation is limited, the RCx Contractor should be prepared to work with VA personnel to create that documentation.

Table 5.2.5 - Sample Drawing Inventory

Project #	Date of Project	Project Title & Description	Notes	Bldg. #	Floor	Drawer #
none	2000	Fire Protection				
none	2003	Fire Protection				
none	1997	Fire Protection				
none	1999	Fire Protection				
none	1999	Fire Protection First Draft				
537-99-955	1999	Fire Protection				
none	1998	Site Plan				
none	1996	First Floor Plan				
7-4126	1953	Plumbing				
7-4126	1953	Electrical				

5.2.6 Equipment Inventory

A key tool that is created during the RCx process is the equipment inventory. This is a required element of the RCx project as outlined in the Statement of Work.

Although most facilities will have some form of an equipment inventory, the RCx process formalizes the collection, sorting, storing and use of equipment data. The resulting documentation should be a significantly improved and more comprehensively populated inventory of exiting equipment and systems. A sample Equipment Inventory Form can be found in **Appendix B**.

a. Creating the Equipment Inventory

The system used to inventory equipment can be as simple as an Excel

spreadsheet or as complex as a web-based data management system. Whether it is complex or simple, the following information should be collected and stored in the data base for all equipment:

- Location (bldg. name, room #, floor)
- Equipment ID (i.e. AC-3, EF-6, CWP-1)
- Manufacturer's information (make, model, serial #)
- Equipment type (AHU, heat exchanger, pump)
- Installation date
- Overall condition
- Control (DDC/ pneumatic)
- BAS (whether or not it is on BAS)
- Operational information
- Operating conditions (flow, head, horsepower)
- Equipment photos

b. Compiling the Equipment Inventory

There are many sources of information for populating the equipment inventory. The most common methods for collecting this information are:

- Reviewing existing equipment schedules and verifying that equipment is in place
- Nameplate information
- Manufacturer's cut sheets, either in bid sets or equipment information binders
- As-built drawings, sometimes called record drawings
- Operations & maintenance manuals
- Preventive maintenance programs and data bases
- BAS screenshots

c. Layout of the Equipment Inventory

When preparing the equipment inventory it is important to keep the end user in mind. The inventory should be a tool that is readily updatable, easy to use in the field by maintenance and operations staff, and user friendly. The following table shows the information that is normally collected and stored in an equipment data list, which is later used to populate the equipment inventory.

Table 5.2.6.c - Sample Equipment Data List

Equipment Type	Information to Include in Equipment Inventory
Pumps	1. Pump type 2. Location

Equipment Type	Information to Include in Equipment Inventory
	3. Manufacturer 4. Equipment tags 5. Date installed 6. Motor power (horsepower, kW) 7. VFD (yes/ no) 8. Motor efficiency (%) 9. Flow rate 10. Head
Chillers/ Condensing Units	1. Chiller type 2. Location 3. Manufacturer 4. Equipment tags 5. Date installed 6. Chiller capacity 7. Efficiency 8. Refrigerant type 9. Outside air temperature enable set point 10. Flow rate 11. Entering water temperature 12. Leaving water temperature 13. Chilled water reset strategy (yes/no) 14. Design power input (kW) 15. Minimum power input (kW) 16. Stages of cooling
Cooling Towers	1. Tower Type 2. Location 3. Manufacturer 4. Equipment tags 5. Date installed 6. Number of cells 7. Condenser water flow rate 8. Entering water temperature 9. Leaving water temperature 10. Condenser water reset strategy (yes/no) 11. Fan power (horsepower/ kW) 12. Airflow
Air Handling Units and Fan Coils	1. Type 2. Location 3. Manufacturer 4. Equipment tags 5. Date installed 6. Supply & return fan motor power (horsepower/ kW) 7. Supply & return fan VFD (yes/ no) 8. Supply & return fan motor efficiency (%) 9. Total airflow 10. External static pressure 11. Total static pressure 12. Minimum outside air flow rate 13. Economizer (yes/ no) 14. Economizer control type 15. Economizer minimum position limit

Equipment Type	Information to Include in Equipment Inventory
	16. Heat recovery type 17. Heat recovery control 18. Preheat coil type 19. Preheat control 20. Heating coil type 21. Heating capacity (Btu/hr) 22. Cooling coil type 23. Associated chiller efficiency (kW/ ton) 24. Cooling capacity (tons) 25. Design static pressure set point 26. Supply air temperature control (constant, floating, reset) 27. Design supply air temperature set point 28. Terminal units

d. Using the Equipment Inventory

A comprehensive Equipment Inventory can be a valuable tool serving a variety of purposes, beyond the completion of the RCx project. Useful applications could include:

- Managing assets for funding purposes
- Helping to plan, monitor and track O&M practices
- As a tool to organize, record and track equipment condition
- As a link to a Digital Issues Log

The Equipment Inventory developed as part of the RCx project should be maintained as a living document. This means that new or replacement equipment should be recorded in order that a current inventory is always available.

5.2.7 Control Systems

The control system in any building is the most important element of the HVAC systems and it can be readily used to identify and implement energy conservation measures. Most HVAC systems are controlled by either DDC or by pneumatic controls. It is common to find both DDC and pneumatic controls in a facility. Depending on the facility, the control system may be referred to as an Energy Management Control System (EMCS) or a Building Automation System (BAS). For the purpose of simplicity, the term BAS is used throughout this manual.

a. BAS

A BAS can be used as a data acquisition and analysis tool during the RCx

investigation to collect historical and operational information in the form of control point trends.

The ability of a BAS system to collect trend data, and to store that data within short sampling frequencies (15 minutes or less) over long periods, without slowing down the normal control functions of the system, is an important consideration for the RCx Contractor. Without adequate trending and data storage capability, the RCx Contractor will need to rely more heavily on portable data loggers and handheld test equipment to gather required data. This will add time and significant expense to any RCx project.

b. Sequences of Operation

A key activity of RCx process is the detailed review of control sequences of operation. Sequences of operation describe how the control system should operate the building systems. In many cases, the original sequences were programmed into the BAS, but never put in writing for future review, or the existing written sequences lack sufficient detail to allow building staff to understand how the controls are integrated with building equipment. One of the roles of RCx is the “tuning” of existing controls to meet the needs of the CFR.

Any changes that are made to the control sequences as a result of RCx should be carefully documented, along with the reasons for the changes, and details of final values for all parameters and set-points recorded. Change information should be shared with building staff.

Improvements to sequences are more likely to persist when building operators understand the rationale for changes and agree with their implementation.

c. System Diagrams and Schematics

System diagrams, which are sometimes called one-line diagrams, enable the user to visualize the process of heating, cooling, and ventilation of spaces in schematic format. These one-line diagrams are typically produced during the initial part of the investigation process to help the RCx team better understand how the various systems are laid out and whether the current building documentation is correct. Once completed, the system diagrams can be incorporated into the BAS system operator workstation for future reference.

5.3 Facility Performance Analysis and Performance Baseline

Section 432 of the Energy Independence and Security Act of 2007 (EISA) outlines a framework for facility energy and water project management and benchmarking, including the following the requirements for Federal agencies:

- Designate “covered facilities” and assign “facility energy managers” for ensuring compliance of “covered facilities” subject to the requirements
- Conduct “comprehensive energy and water evaluations”
- Implement identified efficiency measures
- Follow up on implemented efficiency measures
- Use the FEMP-deployed web-based Compliance Tracking System to report facilities’ energy use, evaluations, projects, follow-up, and analysis
- Benchmark metered buildings that are, or are part of, covered facilities
- Disclose to congress and the public, agency progress in evaluating covered facilities, project implementation, follow-up status, and benchmarked building performance monitoring status

Specific to the RCx process, the requirement to create utility baselines and to then benchmark the current state of utility management at the VA facility, not only allows the facility to comply with Federal mandates, but provides tools to better manage utility usage.

Table 5.3.a - RCx Investigation Phase, Performance Analysis – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Facility Performance Analysis and Performance Baseline	Section 432 of the Energy Independence and Security Act of 2007 (EISA) outlines a framework for facility energy and water project management and benchmarking, including the following the requirements for Federal agencies: • Designate “covered facilities” and assign “facility energy managers” for ensuring compliance of “covered facilities” subject to the requirements • Conduct “comprehensive energy and water evaluations” • Implement identified efficiency measures • Follow up on implemented efficiency measures • Use the FEMP-deployed web-based Compliance Tracking System to report facilities’ energy use, evaluations, projects, follow-up, and analysis • Benchmark metered buildings that are, or are part of, covered facilities • Disclose to congress and the public agency progress in evaluating covered facilities,	none

RCx Task	RCx Task Description	RCx Deliverable
	project implementation, follow-up status, and benchmarked building performance monitoring status Specific to the RCx process, the requirement to create utility baselines and then benchmark the current state of utility management at a VA facility allows the facility to comply with Federal legislation.	
Facility Performance Analysis and Performance Baseline (continued)	***Utilities -*** The utilities that are regulated in EISA Section 432 are energy and water related. For the purpose of RCx only energy related utilities are examined. This would normally include: a. Natural Gas, Fuel Oil, Propane b. Electricity c. Steam and Chilled Water ***Analysis Tools and Strategies*** – a. EPA Energy Star EPA Energy Star allows the facility to establish a baseline rating on its historical utility consumption and also includes other facility specific information. b. Graphical Presentations Plotting the utility usage data will often provide an easier insight into utility usage patterns within the facility over time.	Baselines will be generated for natural gas, fuel oil, electricity, other utilities Document EUI and/or Portfolio Manager Rating

Table 5.3.b RCx Investigation Phase, Performance Analysis – Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Facility Performance Analysis and Performance Baseline	n/a	Provide RCx Contractor with any additional information not provided during the detailed site walk	Review and generate baselines for natural gas or fuel oil, electricity or other utilities

5.3.1 Utilities

The utilities that are regulated in EISA Section 432 are energy and water related. VAMCs use water for domestic purposes, for production of steam for heating hot water, irrigation and sterilization. Other utilities could include electricity, fuel oil or natural gas or propane for heating; and chilled water for cooling. Generally, RCx will focus attention on energy utilities only.

5.3.2 Creating Utility Baselines

As discussed previously, an objective of RCx is to establish a utility usage baseline. Annual usage provides the facility with a point of reference for year on year comparison purposes.

a. Natural Gas or Propane Baselines

Natural gas is used to directly heat the facility or to fuel a boiler which produces hot water or steam for heating. Most facilities only have master meters at this time.

For compliance reporting purposes, natural gas usage is merged with electrical usage. The baseline is measured in terms of Annual Energy Use, site delivered (Million Btu); Annual Energy Use, source (Million Btu), Annual Energy Intensity, site delivered (KBtu per Square foot); Annual Energy Intensity, source (KBtu per square foot); Annual Weather-normalized Energy Intensity, delivered (KBtu per square foot); Annual Weather-normalized Energy Intensity, source (KBtu per square foot); and Energy Star Rating (1-100). The RCx Contractor should review two to three years of natural gas usage.

b. Fuel Oil Baseline

Fuel oil is used to directly heat the facility or to fuel a boiler which produces hot water or steam for heating. Most facilities only have master meters at this time.

For compliance reporting purposes, fuel oil usage is merged with electrical usage. The baseline is measured in terms of Annual Energy Use, site delivered (Million Btu); Annual Energy Use, source (Million Btu), Annual Energy Intensity, site delivered (KBtu per Square foot); Annual Energy Intensity, source (KBtu per square foot); Annual Weather-normalized Energy Intensity, delivered (KBtu per square foot); Annual Weather-normalized Energy Intensity, source (KBtu per square foot); and Energy Star Rating (1-100). The RCx Contractor should review two to three years of fuel oil usage.

c. Electricity Baselines

Electricity is used throughout a VAMC for a variety of purposes. This includes interior and exterior lighting, heating and air conditioning, food preparation, water distribution, sound systems and outlet load. It is very often the largest utility cost in a VAMC.

For compliance reporting purposes, electricity usage is merged with the fuel source, either natural gas or fuel oil. The baseline is measured in terms of Annual Energy Use, site delivered (Million Btu); Annual Energy Use, source (Million Btu), Annual Energy Intensity, site delivered (KBtu per Square foot); Annual Energy Intensity, source (KBtu per square foot); Annual Weather-normalized Energy Intensity, delivered (KBtu per square foot); Annual Weather-normalized Energy Intensity, source (KBtu per square foot); and Energy Star Rating (1-100). The RCx Contractor should review two to three years of electricity usage.

d. Steam/Hot Water Baselines

Steam and hot water is mostly used for heating and is either produced by the facility with its own boiler or purchased from a third party.

For compliance reporting purposes, steam and hot water usage is merged with electrical usage. The baseline is measured in terms of Annual Energy Use, site delivered (Million Btu); Annual Energy Use, source (Million Btu), Annual Energy Intensity, site delivered (KBtu per Square foot); Annual Energy Intensity, source (KBtu per square foot); Annual Weather-normalized Energy Intensity, delivered (KBtu per square foot); Annual Weather-normalized Energy Intensity, source (KBtu per square foot); and Energy Star Rating (1-100). For energy management purposes, steam and hot water usage should be analyzed separately. The RCx Contractor should review two to three years of steam and hot water usage.

e. Chilled Water Baselines

Chilled water is mostly used for cooling and is either produced by the facility with its own chiller systems or purchased from a third party.

For compliance reporting purposes, steam and hot water usage is merged with electrical usage. The baseline is measured in terms of Annual Energy Use, site delivered (Million Btu); Annual Energy Use, source (Million Btu), Annual Energy Intensity, site delivered (KBtu per Square foot); Annual Energy Intensity, source (KBtu per square foot); Annual Weather-normalized Energy Intensity, delivered (KBtu per square foot); Annual Weather-normalized Energy Intensity, source (KBtu per square foot); and Energy Star Rating (1-

100). For energy management purposes, steam and hot water usage should be analyzed separately. The RCx Contractor should review two to three years of chilled water usage.

5.3.3 Documenting Data Fields

An example of the data entry field for entering Baseline and Benchmarking data is shown below.

Table 5.3.3 – Sample Baseline and Benchmarking Data

Field Name	Description	Date Type/Validation	Required/Optional
Annual Energy Use (site delivered)	Annual Energy Use in terms of site-delivered Btu	Numeric: (Million Btu)	Required
Annual Energy Intensity (site delivered)	Annual site-delivered energy intensity	Numeric: (KBtu/Sq Ft)	Required
Annual Weather-normalized Energy Intensity (site delivered)	Annual weather-normalized site-delivered energy intensity	Numeric: (KBtu /Sq Ft)	Required
Energy Star Rating	Energy Star Rating	Integer: (1-100)	If applicable
Annual Water Consumption	Annual Potable Water Use	Numeric: (Thou. Gallons)	Optional
Green House Gas Emissions	Equivalent CO2 emissions of source	Numeric: (Metric Tons of CO2e)	Optional

5.3.4 Analysis Tools and Strategies

a. EPA Energy Star

EPA Energy Star allows the facility to establish a baseline rating on its historical utility consumption. Many VA facilities have already initiated this process, but the RCx Contractor should review the inputs and results to verify the accuracy of results. Although a baseline rating can be determined from only 12 full months of data, a more extensive data set will provide the RCx Contractor with a better foundation for making decisions on the value of various energy conservation measures.

b. Graphical Presentations

Plotting utility usage data will often provide an easier insight into utility usage patterns within the facility. The following table presents a listing of typical graphs of utility data and what they will indicate. These graph types can be used for any facility utility or a combination of several utilities.

Table 5.3.4.b – Graphical Presentation Types

Plot Description	Indicates	Benefit to the RCx Process
Monthly energy consumption of the facility over a 2 to 3 year period. The graph can also be used to plot buildings with sub meters	This graph will show if there have been months of unexplained increases or decreases in energy usage.	The graph may not tell the RCx Contractor what the cause is, but will assist in the preparation of the Diagnostic Monitoring and Systems Testing plans.
Daily plot of the electrical demand profile (by facility or by building sub meter)	This graph will show the response of the facility as the facility begins to operate during the morning and how it changes during the day	The graph may show a high baseload that operates throughout the 24 hour period – reducing the baseload can produce large energy savings Many electrical providers are time of use billing – facilities pay more for electricity during peak demand periods. Reduce the demand = reducing the costs
Daily plot of the water demand profile (by facility or by building sub meter)	This graph will show the response of the facility as the facility goes through its daily operations.	Most water utilities have fixed schedules that show when a facility can/should irrigate. Irrigating during non-approved times may result in fines. Some water utilities are beginning to initiate time of use charges. These Demand Response charges can be substantial.
Monthly steam and chilled water consumption profiles	These profiles (multi-year) illustrate when a facility is using steam and chilled water. There should be a pattern.	Many facilities have specific schedules when they will shift from steam production to chilled water production and then returning to steam production. Anomalies from these schedules could indicate excess energy usage.

Plot Description	Indicates	Benefit to the RCx Process
Energy Utility Index (EUI)	A tool with tables and graphs to calculate the historical baseline energy usage by calculating the energy use per square foot over time (kBtu/ft2/year). The data can also be normalized to weather to more clearly reflect year to year performance (Btu/ft2/year/degree day).	The tool can be used to illustrate performance of the facility or of specific buildings within the facility. Comparing the EUI from one facility with another can indicate areas of potential energy savings.

5.4 Diagnostic Monitoring

5.4.1 Introduction

Diagnostic monitoring involves the collection and recording of operational data from a building system or systems over time, in order to assess system performance. Diagnostic monitoring provides the RCx Contractor with means to quantify already known operational issues and to uncover additional issues related to system performance and control functionality. Objectives of diagnostic monitoring include:

- Confirm apparent operating issues from empirical field observations
- Identify operating hours and cycling patterns of equipment
- Identify operating temperatures, pressures, humidity, speeds, and flow rates over time
- Determine correlations between system operating variables and other parameters (e.g., ambient temperature and occupancy) for the purposes of establishing long-term patterns
- Compare current operation with as-built control sequences of operation, if available. Infer current sequences of operation from trend data to the extent possible
- Identify when changes in load occur and how systems respond to those changes
- Identify systems that do not respond to control set-points or cannot reach set-points
- Identify unstable control loops
- Find incidents of simultaneous heating and cooling, inappropriate economizer operation, excessive variable frequency drive (VFD) speeds, and other operating parameters that indicate non-optimal operating conditions
- Identify sensors whose values do not correspond to actual operating conditions, indicating a need for calibration or replacement

- Identify extreme deviations from system parameters that may indicate operational problems

The RCx Contractor will develop a group of detailed testing procedures called the Diagnostic Monitoring Plan. The Plan will describe the method and scope of monitoring activities to be undertaken and be submitted to the VA COR for review. The methods and extent of monitoring that are most suitable for each facility or building system will be specified based on the types and capabilities of control systems present. Upon acceptance of the plan, the RCx Contractor will begin to implement the plan including, setting up trending on the BAS and installing portable data loggers. A sample Diagnostic Monitoring Plan can be found in **Appendix E**.

Table 5.4.1.a - RCx Investigation Phase, Diagnostic Monitoring – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Diagnostic Monitoring	Diagnostic monitoring involves the collection and recording of operational data from a building system or systems over time, in order to assess system performance. Diagnostic monitoring provides the means to quantify already known operational issues and to uncover additional issues related to system performance and control functionality. Some objectives of diagnostic monitoring include: • Confirm apparent operating issues • Identify operating hours and cycling patterns of equipment • Identify operating temperatures, pressures, humidity, speeds, and flow rates over time • Determine correlations between system operating variables and other parameters • Compare current operation with as-built control sequences of operation • Identify when changes in load occur and how systems respond to those changes • Identify systems that do not respond to control set points or cannot reach set points • Identifying simultaneous heating and cooling, inappropriate economizer operation, excessive variable frequency drive (VFD) speeds • Identify sensors whose values do not correspond to actual operating conditions • Identify extreme deviations from system	Diagnostic Monitoring Plan and Report

RCx Task	RCx Task Description	RCx Deliverable
	parameters that may indicate operational problems	

Table 5.4.1.b - RCx Investigation Phase, Diagnostic Monitoring – Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Diagnostic Monitoring Plan	n/a	Coordinate with controls contractor and RCx Contractor to identify the plan to assess the system performance Review and the Diagnostic Monitoring Plan	Write the Diagnostic Monitoring Plan
Diagnostic Monitoring Testing and Report	n/a	Assist RCx Contractor with installing the portable data loggers and the creation of the trends from the BAS Review Diagnostic Monitoring Testing Report	Install the portable data loggers Program the BAS to create trending data Write Diagnostic Monitoring Testing Report

5.4.2 The Diagnostic Monitoring Plan

A Diagnostic Monitoring Plan is meant to organize the activities that take place during the diagnostic monitoring portion of an RCx project. This includes addressing the systems and the parameters to be monitored, the duration and frequency of data collection, the devices used for monitoring, and the locations of portable data logging devices to be installed. Access and coordination issues that need to be addressed for the successful implementation of the plan are also included.

a. Roles and Responsibilities

RCx relies on comprehensive and quantifiable information about system operation in order to verify issues and quantify the results of corrective actions. Diagnostic monitoring is at the heart of these efforts.

During diagnostic monitoring, the primary role of the RCx Contractor is to identify what needs to be diagnosed and how accomplish that. The plan will include the coordination of Building Automation System (BAS) trending for key operational parameters. It will also identify when spot measurements will be needed and it will determine the extent to which portable data logging devices will be installed. Where portable data logging is required the RCx Contractor will outline how devices will be placed. When logging is complete the RCx Contractor will retrieve data logging equipment.

The VA facility staff must provide information on the BAS and its data collection and storage capabilities to the RCx Contractor. In most cases facility staff assistance will be required for the placement of ambient air data loggers in locations with access restrictions, or when diagnostic measurements require equipment to be temporarily shut off. Monitoring activities may require coordination to minimize disruptions to occupant activities, to inform occupants when data loggers need to be placed in occupied spaces, and to preserve health and safety standards.

In some instances, the facility's controls contractor may be tasked to provide assistance in identifying control points, verifying control hardware locations and functionality, setting up and retrieving trends, and accessing other BAS software capabilities. To the extent that these activities are outside their routine activities, the RCx Contractor may have to execute a subcontract with the controls contractor(s) in order to complete these tasks.

RCx team members most directly involved in diagnostic monitoring, and their contact information, should be clearly outlined in a table similar to the one shown below:

Table 5.4.2.a - Roles and Responsibility

Role/Title	Name	Role	Responsibility
VAMC Site COR			
VAMC Maintenance Manager			
VAMC BAS Contact			

Role/Title	Name	Role	Responsibility
RCx Contractor Site Program Manager			
RCx Contractor Site Project Manager			
RCx Contractor Senior Engineer			
RCx Energy Analyst Supervisor			
RCx Contractor Engineer/Tech			
BAS Contractor			

b. Approaches, Limitations and Priorities

This section describes the available approaches to monitoring, limitations that may apply, and criteria to consider in prioritizing what equipment data points to log.

The following are the types of monitoring that can be employed during an RCx project:

- **Building Automation System Trend Logs:** Trend logs set up in the BAS are data logs recorded at pre-programmed intervals for the duration of the trending period (typically a minimum of two weeks). Trend logs are ideal sources of data because they can be set up for any duration or interval and can be exported electronically for later analysis. A typical record interval is every 15 minutes.

- **Building Automation System Histories:** Building Automation Systems with limited trending capability are often still capable of storing brief histories within controller panels that can be downloaded or printed out. These histories are typically 24-48 readings at intervals of one to two hours, and although they are not ideal they do provide a useful profile of system operation over the course of one or more days.

- **Portable Data Loggers:** Portable data logging devices are capable of storing large quantities of data and exporting that data electronically for

use in analysis software. Most are small enough to be placed in occupied locations, or affixed to mechanical equipment without interrupting equipment operation or disrupting building occupants. Their limitations lie in the practicalities of accessing the equipment components or locations to be logged, and in the logistical schedule and budget constraints of each project.

An important aspect of deploying portable data loggers at a VA facility is the coordination with facility staff and communication with building occupants. Since data loggers will be left unattended for several weeks at a time, the intended time periods and locations for monitoring need to be identified well in advance to allow time for placement coordination and approval.

From the perspective of an employee or resident in the facility, an unfamiliar person (the RCx Contractor) placing a small electronic device in a discrete location will justifiably arouse suspicion. Thus, every effort should be made by the VA facility staff member coordinating RCx activities to disseminate pertinent information about the data logger deployments to building security staff and to the department managers.

The Diagnostic Monitoring Plan provided by the RCx Contractor must include a one-page digital flyer that contains VA facility staff and RCx Contractor contact information; deployment period; description of the data logger, including a picture of the data logger, what is being measured; and a map with the approximate location where the logger(s) will be placed. This flyer should be provided to the person responsible for the department or work area where logger(s) are being deployed.

- **Spot Measurements:** Spot measurements of temperature, air quality, pressure, flow, power, or other parameters may be sufficient for some types of equipment. This might include constant volume systems that run continuously or situations where schedules of operation can be easily verified. In these cases, it is generally safe to assume that throughout the hours of operation the measured parameter will not change significantly. Also, spot measurements are typically used for systems where trend logging is not available and where portable data logger application is impractical.

Ideally, data would be collected continuously for every parameter of HVAC system operation and control. However, there are almost always practical limitations to the number of variables that can be feasibly monitored during the

course of an investigation. Such limitations may include:

- BAS controller memory
- BAS network speeds
- Operator workstation memory
- Lack of BAS equipment connection and/or coverage
- BAS token-passing protocols and shared data processing priorities
- Lack of technical support for BAS to set up or retrieve trends
- Limited access to equipment for placement of loggers
- Limited access to occupied areas for placement of loggers, especially above ceilings
- Practical limits to the number of loggers that can be supplied, programmed, and placed simultaneously
- Security issues affecting portable data loggers left in occupied spaces

Due to these limitations, and where all the desired parameters cannot feasibly be monitored, priorities must be determined and sampling plans put in place. Priorities may be defined based on multiple factors, including:

- Relative energy use of system, which directly affects potential for energy savings
- Number of occupants or size of area affected
- Known operation or maintenance issues
- Persistent history of comfort or air quality complaints
- Compliance with codes and standards
- Infection control and IAQ concerns

In general, BAS trends will be preferred over the use of portable data loggers, both for efficiency of data collection and for the variety of data that can be acquired. Portable data loggers cannot record certain parameters such as set-point values or damper positions; however, they are useful for collecting more extensive measurements of space comfort conditions.

Based on the limitations and priorities of each system, the most comprehensive but feasible approach should be chosen for each piece of equipment.

c. Building Automation System Trending Plan

The RCx Contractor should develop a BAS Trending Plan. The Trending Plan should identify which systems and equipment at the facility are to be monitored using BAS trend logs, including the parameters or variables to be monitored, the minimum duration of monitoring, and the maximum interval for recording the

monitored variables.

A typical minimum duration of monitoring for RCx purposes at VA facilities is 14 days. Whenever possible monitoring should take place over a minimum of seven consecutive days to ensure capturing weekend operations within that timeframe. The maximum time interval for recording data will depend on the type of parameter being evaluated. Some trends can lead to inaccurate conclusions when logged at even time intervals whereas points such as fan or pump status, or temperature and pressure set-points, should be recorded when there is a change of value (COV). The table below shows some typical trending values for different systems.

Table 5.4.2.c - Example of Original Point List for Trend Logging

System Description	Point Description	Minimum Trend Duration (Days)	Maximum Trend Interval (Minutes)
Constant Volume AHU – SF/EF, Steam Coil, Chilled Water Coil, Humidifier, 100% OSA	Supply Air Temperature	14	5
	Heating Coil Air Temp	14	1
	Cooling Coil Air Temp	14	1
	Supply Fan Status	14	COV
	Exhaust Fan Status	14	COV
	Heating Coil Valve Command	14	1
	Cooling Coil Valve Command	14	1
	Supply or Exhaust Air Humidity	14	5
	Humidity Valve Command	14	5
	OSA Damper Position	14	COV
	EA Damper Position	14	COV

System Description	Point Description	Minimum Trend Duration (Days)	Maximum Trend Interval (Minutes)
	OSA Damper End Switch (if applicable)	14	COV
	EA Damper End Switch (if applicable)	14	COV
	OSA Damper Position	14	COV
	EA Damper Position	14	COV
	OSA Damper End Switch (if applicable)	14	COV
	EA Damper End Switch (if applicable)	14	COV

Note that relevant BAS information such as manufacturer, software version, and trend data capacities should also be accurately recorded.

d. Portable Data Logging Plan

The Portable Data Logging Plan lists the systems and equipment at the facility to be monitored using portable data loggers. This plan will include the parameters or variables to be monitored, the device or means used for monitoring, the minimum duration of monitoring, and the maximum interval for recording the monitored variables. A sample data logging table is provided below.

Table 5.4.2.d – Sample Point List for Portable Loggers

Building	System/Equipment	Parameters Measured	Monitoring Deice	Minimum Logging Duration (Days)	Maximum Logging Interval (Minutes)
1	Hot Water Convectors	Space Temperature	U12 data loggers	14	15
1	Finned Tube Radiators	Space Temperature	U12 data logger	14	15

Building	System/Equipment	Parameters Measured	Monitoring Deice	Minimum Logging Duration (Days)	Maximum Logging Interval (Minutes)
1	Exhaust Fans (not connected to DDC)	Fan Status	U9 data logger	14	COV
4	Packaged Rooftop Air Unit	Space Temperature, Fan Status	U12 data logger, U9 data logger	14	15, COV
6	PTAC Units	Space Temperature, Fan Status	U12 data loggers, U9 data logger	14	15, COV
14	Unit Heaters	Space Temperature	U12 data loggers	14	15

e. Additional spot measurements may be needed depending on the unique characteristics of the site. For example, comfort issues are site specific and calibrated sensors may not be close enough to the area in question. In this case spot measurements should be meticulously recorded and documented in tables similar to the one presented below.

Table 5.4.2.e - Spot Measurements

Building	System/Equipment or Location	Parameter Measured	Monitoring Device	Time of Day
2	Building	Building Pressure	Pressure Multi-meter	Any
3	Building Conference Room	CO_2 Levels	CO_2 Meter	During a large meeting

f. Diagnostic Monitoring Schedule

To facilitate coordination with the VA staff, the Diagnostic Monitoring Plan

should also set forth an intended, detailed schedule of each diagnostic monitoring task to be carried out at the facility. A sample schedule table is presented below.

Table 5.4.2.f - Sample Schedule

TASK	DATE COMPLETE	ON SITE	COMMENTS
Provide list of points to be trended to BAS Contractor			
Launch and place portable data loggers to supplement Trends			
Place CO_2 loggers			
Trend logs begin recording			
Verify proper trend log configuration			
Take spot measurements			
Remove portable data loggers			
Receive, process, and analyze [heating season] trend logs			
Download, process, and analyze portable logger data			
Prepare graphs and correlations from data			
Identify issues from diagnostic monitoring data			
Deliver Diagnostic Monitoring Report			

5.4.3 Diagnostic Monitoring Testing and Report

a. Data Collection and Analysis

The data gathered during the monitoring period must be prepared in graphical format and analyzed to discover potential issues and performance improvement opportunities. The analysis should be performed by someone who is familiar with the system control sequences, infection control requirements, and optimal control strategies for energy efficient operations, code compliance, air quality, and occupant comfort.

For an initial overview and familiarization with the BAS system, trends can often be assessed on the real-time screen graph. This can be accomplished either on location during the walk-through, or off-site, if remote access to the BAS is available. However, additional resolution is always needed in order to perform in-depth data analysis. Therefore data collected during the monitoring period should be graphed in such a way that correlating control points can be cross-referenced to evaluate how they vary as a function of each other. The stream of values for each control point should also be assessed as a function of outdoor weather conditions as well as occupancy patterns, sequences of operations, set points, and known system overrides.

The following are some of the primary reasons for equipment malfunctions. These are typically identified during diagnostic monitoring analysis:

1. Sensors out of calibration
2. Hardware malfunction
    a. Actuator positions
        i. Dampers
        ii. Valves
    b. Humidifier operation
    c. Pump operation
3. Improper sequences of operation or programming
    a. Improper set points
    b. Inaccurate occupancy schedules

For each component, the above possibilities should be considered. If there is evidence of potential issues or operational improvement opportunities, these should be added to the Issues Log for further examination during the Systems Performance Testing Phase.

b. The Diagnostic Monitoring Report

The Diagnostic Monitoring Report should provide a summary of the systems that were monitored during the data logging process, a summary of findings, the issues identified, and opportunities identified. Deviations between the Diagnostic Monitoring Plan, as it was originally designed and the actual execution of the equipment monitoring process should also be recorded.

The Diagnostic Monitoring Report presents key issues found during diagnostic monitoring. It should be subdivided into separate sections organized first by building, and then by major equipment system (Air Handling Unit, Heating Water System, Chilled Water System, etc.). Depending on the complexity of the systems and any special requirements for particular spaces, issues may

be further subdivided by floor, VAV zone, or specific room. Each section should present key issues identified during diagnostic monitoring, using clear and consistent data graphs and accompanying narrative descriptions.

Samples of the graphical formats used to identify particular issues should be provided in the body of the report, with additional graphs displaying different occurrences of the issues for various pieces of equipment, attached as appendices. All issues, including the locations and equipment affected, should be accurately summarized and added to the Issues Log.

5.5 Issues Log

An Issues Log, sometimes called a Findings Log, is a formal and ongoing record of problems or concerns within a facility and the recommended resolution of those problems and concerns. It is a living document that will be created by the RCx team and maintained throughout the course of the Investigation and Implementation Phases of the RCx project.

Table 5.5.a - RCx Investigation Phase, Issues Log - Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Issues Log	An Issues Log, sometimes called a Findings Log, is a formal and ongoing record of problems or concerns within a facility and the recommended resolution of those problems and concerns. Potential system or equipment issues may be recognized at numerous times during the investigation. Issues can be seen by the RCx contractor, heard during discussions with facility staff, observed during diagnostic monitoring and systems testing, or review of historical maintenance activities. VA personnel responsible for managing RCx site activities should participate in the design of the Issues Log to ensure that site specific information is included. The issues log should list the following categories as a minimum: a. Issue item number b. Building name or number c. Floor	Written and digital copies of the Issues Log

RCx Task	RCx Task Description	RCx Deliverable
	d. Location or room number e. Equipment tag f. Observation method g. Issue description h. Proposed resolution i. Repair category j. Issue categories: • Infection control • Energy usage • Maintenance • Comfort • Safety k. Recommended resolution l. Resolution responsibility m. Action taken n. Date of action taken o. Resolution status p. Verified by q. Verification date r. Comments	

Table 5.5.b - RCx Investigation Phase, Issues Log - Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Issues Log	n/a	Work with RCx Contractor to identify issues that are known by past experiences Review the RCx Contractor's issues log	Create an Issues Log Update Issues Log

The Issues Log is a useful tool to keep track of the status of equipment repairs and it should be maintained by the facility indefinitely. The log, in conjunction with the Equipment Inventory, can be used to track and manage issues associated with specific pieces of equipment or systems.

5.5.1 Identifying Potential Issues

There are a number of points during the RCx process when the RCx Contractor can discover building or equipment deficiencies. Below is a list of RCx process points where potential system or equipment issues may be discovered.

a. Pre-kick-off phase
   - As part of the pre-kick-off requests for information
b. Planning phase
   - Kick-off meeting and first site visit
   - Document reviews
   - Facility tours
   - Control system reviews with the controls contractor or engineer
   - Key staff interviews
c. Investigation phase
   - Site investigation
   - Medical staff interviews
   - Detailed review of documents
   - Benchmarking and baseline calculations
   - Equipment condition assessments
   - Diagnostic monitoring
   - Systems testing

Utilizing information gained throughout the RCx process over the long term is vital. Each activity listed above should be treated as an opportunity to discover opportunities to improve building performance.

5.5.2 Issues Log Requirements

VA personnel responsible for managing RCx site activities should participate in the design of the Issues Log to ensure that site specific information is included. The Issues Log summarizes each finding from the RCx Planning and Investigation Phases, including the “field fixes” made during the course of investigation. The log should list the following categories as a minimum:

a. Issue item number
b. Building name or number
c. Floor
d. Location or room number
e. Equipment tag
f. Observation method
g. Issue description
h. Proposed resolution
i. Repair category
j. Issue category
   - Infection control
   - Energy usage
   - Maintenance

- Comfort
- Safety

k. Recommended resolution
l. Resolution responsibility
m. Action taken
n. Date of action taken
o. Resolution status
p. Verified by
q. Verification date
r. Comments

A unique equipment tag (identification number) should be assigned to each finding to be used as a reference number throughout every RCx report and document. This will help to avoid confusion, especially during the implementation phase of the project.

5.5.3 The Issues Log Document

The RCx Contractor will prepare the initial RCx Issues Log that describes issues and observations identified during the RCx process. The Issues Log will identify and track issues as they are encountered, name the party responsible for resolution, outline any progress toward resolution, and document how the issue was resolved. The RCx Issues Log will also track the status of unresolved issues.

Some minor issues identified during the RCx process can be easily resolved by the RCx team. These are often referred to as simple repairs. However, even if the resolution is made, the issue should always be logged.

Table 5.5.4 Sample Issues Log

Site Specific Criteria	Category
	Issue Item No.
	Building Name or Number
	Floor
	Location/Room #
	Equipment Tag
	Observation Method
	Issue Description
	Proposed Resolution
	Repair Category*
	Issue Category*
	Simple Repair Implemented Under RCx Scope (Y/N)
	Repair Approved by VA (Y/N)
	Repair Responsibility
	Repaired By
	Repair Date
	Repair Actions Taken
	Verification Initials
	Verification Date

*__Issues Categories__
IF = Infection Control Co = Comfort EU = Energy Usage Sa = Safety
Ma = Maintenance

5.6 Systems Testing Plan

5.6.1 Definition and Purpose

Systems Testing is defined as the measurement of component or system performance under a range of expected operating conditions. In regard to Systems Testing of control systems, it is further defined as the verification of control operation in conformance with the Sequence of Operations.

The purpose of Systems Testing is to identify existing operating parameters, so that the system tested can be evaluated in regard to its capacity, proper performance, and control. Systems Testing is carried out to determine operating conditions that cannot be discerned by empirical observation or by diagnostic monitoring alone. Many elements of building operations, such as the existing Sequence of Operations, can usually be ascertained with diagnostic monitoring. Systems testing may include verification of equipment operability and control, device calibration, air and hydronic flow balancing, and systems testing. Testing has the potential to disrupt regular operations and can be time-intensive. Therefore, it is typically only used in existing buildings to determine aspects of system operation that cannot be determined by other means.

A Systems Testing Plan should be developed by the RCx contractor prior to engaging in testing. The plan should reflect the priorities of the facility and the requirements of the contract.

Table 5.6.1.a - RCx Investigation Phase, Systems Testing – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Systems Testing Plan	The purpose of Systems Testing is to identify existing operating parameters, so that the system tested can be evaluated in regard to its capacity, proper performance, and control. Systems Testing is carried out to determine operating conditions that cannot be discerned by empirical observation or by diagnostic monitoring alone. Testing has the potential to disrupt regular operations and can be time-intensive. Therefore, it is typically only used in existing buildings to determine aspects of system operation that cannot be determined by other means. ***Sampling Approach*** - In existing buildings, the extent	Systems Testing Plan and Report and updated Issues Log

RCx Task	RCx Task Description	RCx Deliverable
	of systems testing may be determined by a variety of factors, including but not limited to: • Areas of known problems or deficiencies • Size of systems • Systems serving critical operations (e.g. OR, laboratory) • Systems that are monitored by the building automation system (BAS) • Project budget • Project timeline While it may be ideal from the viewpoint of having a comprehensive evaluation of all systems to have every single system and component tested, it is often not practical or cost-effective to do so.	
Systems Test Procedures	***Systems Test Procedures*** - Systems test procedures are developed based on documented and ideal sequences of operation, manufacturer data and O&M instructions, and established testing procedures from the commissioning industry. a. Point-to-Point Testing Point-to-point checkouts should be used to verify displayed values on DDC systems, as well as to verify accuracy of stand-alone control devices. b. System Testing Operation of equipment should be verified visually by testing the equipment designated in the RCx Plan. Access to the BAS, local DDC panels, and local controls such as thermostats and pneumatic receiver-controllers will be needed to accomplish the testing. All deficiencies in design, maintenance, and control identified through Systems Testing should be documented in a log as each systems test is carried out. The findings from Systems Testing may be included in the overall project Issues Log.	

Table 5.6.1.b - RCx Investigation Phase, Systems Testing – Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Systems Testing Plan – Sampling Approach	n/a	Review and approve the RCx Contractor's sampling approach and plan	Develop sampling approach and plan for selecting systems and equipment to test
Systems Testing Plan – Systems Testing Procedures	n/a	Review and RCx Contractor's system test procedures	Develop systems test procedures plan

5.6.2 Sampling Approach

For new construction commissioning, Systems Testing is typically performed on all critical systems, and on a statistically significant sample of all other systems. In existing buildings, the extent of testing may be determined by a variety of factors, including but not limited to:

- Areas of known problems or deficiencies
- Size of systems
- Systems serving critical operations (e.g. OR, laboratory)
- Systems that are monitored by the building automation system (BAS)
- Project budget
- Project timeline

While it may be ideal from the viewpoint of having a comprehensive evaluation of all systems to have every single system and component tested, it is often not practical or cost-effective to do so. Furthermore, for components that are present in very large quantities (e.g. terminal boxes, radiators/convectors, unitary HVAC equipment such as window air conditioners, small exhaust fans, steam traps, lighting controls) testing a sample of components will usually yield results that are relevant to the vast majority of the remaining components.

In the case of larger systems, the scale of potential benefits from even small corrections to performance makes testing important in order to be able to accurately assess any deficiencies and quantify the effects of recommended changes.

In general, it is recommended that in most cases where there is not a specific target issue to be addressed, all of the following systems, not just a sample, be tested in order to identify potentially significant issues, due to the scale of

potential benefits:

- Central plant equipment serving multiple airside systems, including chillers, boilers, pumps, and cooling towers
- Built-up air handlers with rated air volumes of 4,800 CFM or above
- Packaged HVAC equipment with cooling capacity of 15 tons or above
- Exhaust systems that operate more than 2,000 hours/year with rated HP of 10 HP or more
- Pumping systems that operate more than 2,000 hours/year with rated HP of 10 HP or more
- Combustion heating equipment with rated fuel input of 750,000 Btu/hour or more
- Heat exchangers with rated heat transfer of 750,000 Btu/hour or more

Sample size for smaller devices must be large enough to be statistically significant. In other words, while 50% of a population would be an accurate representation of the total population in most cases, if the total population is only 10, a sample of 5 may be too small a number in absolute terms (depending on potential diversity of the component or system) to be statistically valid. Very small populations of devices (< 10) require sample rates at or near 100%. Generally for populations of more than 125 a sample size of 10-12% is sufficient to provide an accurate representation with precision of ±20% and 90% confidence. The Federal Energy Management Program has defined sample sizes for varying levels of precision and confidence, as shown in Table 5.6.2 and it is recommended that sampling plans correspond to the statistical formulas provided in FEMP *M&V Guidelines*.

Sampling sizes and sampling characteristics will vary according to the types of equipment present. In any event the RCx Contractor must comply with sampling rates that have been established for RCx in VA facilities. At this writing the minimum sampling size for terminal systems or non-primary systems is 30% of the total identified population. VA CORs and facility staff should be careful to determine the total population of such systems and this information should be provided to the RCx Contractor.

Table 5.6.2 - First Year (Cv-0.5) Sample Size Table based on Usage Group Sampling[1]

Precision	20%	20%	10%
Confidence	80%	90%	90%
Z-Statistic	1.282	1.645	1.645
Population Size, N	Sample Size, n4		
4	3	4	4
8	5	6	8
12	6	8	11
16	7	9	13
20	8	10	16
25	8	11	19
30	9	11	21
35	9	12	24
40	9	12	26
45	9	13	28
50	10	13	29
60	10	14	32
70	10	14	35
90	10	15	39
100	10	15	41
125	11	16	45

5.6.3 Systems Test Procedures

This section describes the testing procedures expected for major equipment types. Systems test procedures are developed based on documented and ideal sequences of operation, manufacturer data and O&M instructions, and established testing procedures from the commissioning industry. Sample testing forms can be found in **Appendix G**.

In order to test some devices, control outputs may need to be overridden, wiring temporarily disconnected, or sensors moved from their intended locations. In all such cases, the procedures must include what alarms should be disabled related to the altered I/O point to avoid nuisance alarms and must include steps to restore normal operation after the testing is complete,

[1] Table 5.6.2 – Table B-1 from *M&V Guidelines: Measurement and Verification for Federal Energy Projects, Version 3.0*

including removing all overrides, restoring alarms, and verifying proper operation or monitoring.

a. Point-to-Point Testing

Point-to-point checkouts should be used to verify displayed values on DDC systems, as well as to verify accuracy of stand-alone control devices. Point-to-point testing confirms three factors:

- That the control input or output (I/O) is functional
- That the control I/O is properly identified and corresponds to the equipment or sensor portrayed
- That the controlled device operates as indicated or sensed variable is accurate

In regard to control I/O, the testing can often be determined from a BAS operator's workstation by simply verifying that a change of command results in a change of state. This is only possible if there is feedback for the control output, e.g. current switches or transducers, flow sensors, damper position indicators, and temperature sensors that show change of temperature across a coil.

On systems that have not been properly commissioned at the time of installation, it is not unusual for a small portion of devices, especially terminal devices, to be mis-addressed in the system. These identification errors can sometimes be spotted from the operator's workstation by changing a control output and verifying a corresponding condition change. They should also be field-verified, as the most common error is in mixing up zone controller IDs in the field. Adding heat to a zone sensor or viewing an actuator while a second person views the BAS display or commands a point allows quick verification of proper point ID.

Failure of an output device to perform as designed may be caused by one or more of the following:

- Improper programming of control output loop
- Loss of connection
- Loss of power to relay, contactor, motor starter or VFD or failed electrical component
- Failure of actuator
- Mechanical failure or obstruction of damper or valve

A sensor that does not read accurately may be caused by one or more of the following:

- Improper location of sensor (e.g. space temperature sensor in contact with exterior masonry wall or in direct sunshine, mixed air temperature sensor with inadequate coverage of mixing plenum where airflow is stratified, hydronic sensor downstream of bypass piping, etc.
- Sensor out of calibration
- BAS sensor signal scaling incorrect

All of these factors should be verified when testing control sensors, whether connected to the BAS or part of a stand-alone control system.

When calibrating sensors, a calibrated field meter should be used to verify that the reported value is accurate, and if not, the input should be calibrated to conform to the sensed conditions. Temperatures should be measured as close to the existing sensor as possible. If pressure/temperature (P/T) taps are not available near existing immersion well temperature sensors, pipe temperatures may be taken using contact probes, but contact probes should not be used for calibration. In practical terms, in some cases it is difficult to match the exact conditions of the sensor with the field meter. When in doubt, limit any calibration adjustments to within the margin of error of the sensing position of the calibrated meter.

Calibration of flow sensors should be performed wherever flow is used as a control loop variable and the existing flow measurement device was never calibrated. In addition, turbine-type hydronic flow sensors should be calibrated at least once every 3 years. Where hydronic flow measurement devices such as balancing valves with differential pressure ports are installed in the system, calibration can be done based on differential pressure. In all other cases for hydronic flow measurement, a portable ultrasonic flow sensor is recommended for calibration.

Electrical measurements, where needed, should be taken with a three-phase true RMS power meter. Electrical safety procedures should be adhered to at all times.

Valve and damper actuators and linkages should be physically inspected and operated through their full range to verify control functionality and operable condition. Dampers and valves may be tested through their full ranges (open to closed) by overriding control points. Where linkages are disconnected or controlled devices are stuck or in need of repair, repairs should be performed if practical, and outstanding repair needs should be documented.

1. **Air Handling Units**

Sensors included in the point-to-point testing will vary for each equipment type and can be found in the testing plans in **Appendix G**. The following control points are typically included in the point-to-point testing of air handling units, where present:

- Supply air temperature
- Return/exhaust air temperature
- Return/exhaust air humidity
- Mixed air temperature
- Preheat air temperature
- Outside air temperature
- Duct static pressure
- Zone temperature (where applicable as a controlling point for system)
- Fan speed command
- Fan start/stop
- Fan speed or status feedback
- Damper actuator(s)
- Valve actuators(s)
- Humidifier valves or switches
- Heat recovery wheel

2. **Chilled Water Plants**

Sensors included in the point-to-point testing will vary for each chilled water plant. The scope of testing varies between water-cooled chillers and air-cooled chillers, as indicated by the two separate testing procedures that can be found in **Appendix G**. The following control I/O points are typically included in the point-to-point testing of chilled water plants, where present:

- Chilled water supply and return temperatures
- Condenser water supply and return temperatures
- Chiller start/stop and staging
- Chiller status
- Cooling tower fan start/stop
- Cooling tower fan speed or status
- System differential pressure
- Isolation valve operation
- Bypass valve operation
- Pump start/stop
- Pump speed or status

- VFD speed control command
- Remote set point commands
- Flow meters

3. **Heating Plants**

   Sensors included in the point-to-point testing will vary for each heating plant, depending on the number and types of devices comprising the heating system. The following control points are typically included in the point-to-point testing, where present:

   - Steam supply pressure(s)
   - Hot water supply temperature
   - Hot water return temperature
   - Boiler start/stop
   - Boiler status
   - Pump start/stop
   - Pump status or speed
   - Heat exchanger valve operation
   - Isolation valve operation
   - Mixing valve operation
   - Flow meters
   - System differential pressure
   - VFD speed control and feedback

4. **Terminal Units**

   Sensors and components included in the point-to-point testing can be found in the testing plans in **Appendix G**. The following sensor points, where present, are typically included in the point-to-point testing, where present:

   - Space temperature
   - Discharge air temperature
   - Heating valve position
   - Damper position
   - Airflow (typically a conversion of velocity pressure)
   - Fan operation (for cabinet units, fan coil units and fan-powered boxes)

b. System Testing

Operation of equipment should be verified visually by testing the equipment

designated in the RCx Plan. Access to the BAS, local DDC panels, and local controls such as thermostats and pneumatic receiver-controllers will be needed to accomplish the testing.

One of the principal objectives of system testing is to determine if the Sequence of Operations is performing as designed, and to verify if the sequence of operation is optimal for the system. In order to test Sequence of Operations, as-built documentation of the sequences must be made available to the RCx contractor in advance, and testing forms may have to be modified to adequately address the intended Sequence of Operations.

1. **Air Handling Units**

   A sample test procedure form can be found in **Appendix G**. The actual testing may need some variances from the sample, depending on the equipment and Sequence of Operations at each campus. The following features are typically included in the system testing:

   - *Schedule and lockout control:* Verify that equipment turns on and off in accordance with schedule and lockout set points in the control system.
   - *Economizer control:* Verify that economizer dampers operate per programmed Sequence of Operations, that dampers move proportionally, that minimum ventilation rates are maintained, and determine if control sequence is optimal.
   - *Temperature control:* Verify that heating and cooling valves are controlled to maintain set points, reset schedules, and lockouts per Sequence of Operations, and that there is no simultaneous heating and cooling.
   - *Fan speed control:* Verify fan speed control modulates to maintain static pressure or other set point per Sequence of Operations, and where available, review zone terminal device operation to determine if set point is optimal.
   - *Humidification (where applicable):* Verify the humidity sequence is functioning and the humidity set point is being maintained.
   - *Heat Recovery (where applicable):* Verify that the heat recovery system is operating as commanded by the BAS and that the control sequence is optimal.

2. **Chilled Water Plants**

   A sample test procedure form can be found in **Appendix G**. The actual

testing may need some variances from the sample, depending on the equipment and Sequence of Operations at each campus. The following features are typically included in the system testing:

- *Start/stop operation:* verify that equipment turns on and off and isolation valves open and close when commanded by the scheduling and temperature control parameters in the sequence of operation.
- *Cooling lockout:* Verify that chiller, cooling tower and associated pumps turn off when outside air temperature is below lockout temperature.
- *Chilled water temperature control:* Verify that chiller stages or modulates to maintain the chilled water set point.
- *Cooling Tower Control (if applicable):* Verify that valves and fans stage and that fans vary speed to maintain condenser water set point.
- *Resets:* Verify that programmed resets for chilled water and condenser water supply temperatures and differential pressure work in accordance with the programmed Sequence of Operation.
- *Pump lead/lag control:* Verify that pumps lead/lag per sequence of operation.
- *Pump speed:* Verify that pump speed modulates to maintain differential pressure, temperature difference set point, or refrigeration pressure set point (condenser control) per Sequence of Operations.

3. **Heating Plants**

A sample test procedure form can be found in **Appendix G**. The actual testing may need some variances from the sample, depending on the equipment and Sequence of Operations at each campus. The following features are typically included in the system testing:

- *Start/stop operation:* Verify that equipment turns on and off and isolation valves open and close when commanded by the scheduling and temperature control parameters in the sequence of operation.

- *Heating lockout:* Verify that boiler or converter and associated pumps turn off when outside air temperature is above lockout temperature.

- *Hot water temperature control:* Verify that boiler stages or modulates or that converter valves modulate to maintain the hot water set point.
- *Resets:* Verify that programmed resets for hot water supply temperature and differential pressure work per the programmed Sequence of Operation.
- *Pump lead/lag control:* Verify that pumps lead/lag per sequence of operation.
- *Pump speed:* Verify that pump speed modulates to maintain set point per sequence of control.

4. **Terminal Units**

   VAV boxes, cabinet heaters, and dual duct mixing boxes are all included under the sample test procedures for terminal units. Access to terminal boxes is limited due to location above ceilings. The test procedure should be developed to prevent conflicts with infection control and to cause minimum disruption to occupant activities. Typical tests include:

   - *Call for heating/ cooling:* Adjust space temperature set point at zone thermostat to verify dead bands and to verify that reheat valves and dampers modulate to meet the new set point.
   - *Minimum air flow:* Verify that minimum airflow settings are maintained by damper position (VAV boxes only). Evaluate if minimum airflow settings are appropriate for the occupancy and control sequence.
   - *Fan operation:* Verify that fan starts and stops or changes speed in accordance with the Sequence of Operations.

c. Systems Test Schedule

The Systems Testing Plan should include a schedule of testing activities. The schedule should indicate start and end dates, and expected order of testing, typically by system or building.

Note that for systems that are sampled, if test results indicate recurring issues, it may be necessary to conduct follow-up testing. The schedule should allow time for follow-up testing. In addition, follow-up testing may be required for any devices that could not be completely tested because of seasonal weather

variations (i.e. cooling or heating not active) or because certain components were not functional or needed repair at the time of initial testing. Ideally, testing should occur during the shoulder season (spring or fall) so that both heating and cooling operation are available for testing and so that part-load operation, when heating/cooling conflicts are most likely to occur, can be observed. In some cases, testing might be required in both the heating and cooling periods.

In order to test some devices or components, it may be necessary to manually override a control output, temporarily remove a sensor from its intended location, disconnect wiring, or otherwise alter ordinary operation. In these cases, it should be determined if the test needs to be scheduled for a specific time and/or if affected occupants need to be given notice, if backup services will be needed for the duration of the test, or other precautions need to be taken in advance. All such systems requiring advance arrangements should be identified in the plan, and responsible parties identified who will be accountable for communication and coordination of necessary arrangements to allow testing.

Table 5.6.3.c - Sample Schedule

Task	Date(s)	On-Site
Coordination meeting; scheduling of shutdowns		
System Testing, Buildings 4-10		
System Testing, Buildings 1-3		
TAB Measurements, Buildings 1, 2, 7		
Prepare Issues Log		
Prepare Systems Testing Report; deliver to VA for approval		

5.7 Systems Testing Report

This section includes a review of the approach to systems testing, criteria to be met in the testing process, and requirements for documentation and presentation of findings.

Table 5.7.a RCx Investigation Phase, Systems Testing Report –Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Systems Testing Report – Summary of Findings	All deficiencies in design, maintenance, and control identified through Systems Testing should be documented in a log as each systems test is carried out. The primary log is the Issues Log.	Summary of Findings
Systems Testing Report – Contents	A report presenting the findings from Systems Testing will form part of the overall RCx Report or may be broken out as a separate deliverable. It should contain: • Summary of key issues identified with benefits • Scope and schedule of Systems Testing (typically as presented in the FT Plan) • Issues Log with recommended corrective actions • Record of any repairs or modifications made during the course of the testing	Listing of contents

Table 5.7.b RCx Investigation Phase, Systems Testing Report –Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Systems Testing Report – Summary of Findings	n/a	Review summary of findings section of the report	Prepare summary of findings section of the report
Systems Testing Report – Contents of Report	n/a	Review Contractor's system test report	Write completed report

5.7.1 Summary of Findings

All deficiencies in design, maintenance, and control identified through Systems Testing should be documented in a log as each systems test is carried out. The findings from Systems Testing may be included in the overall project Issues Log, but the finding should always include a record of the date of the finding, how the finding was made (e.g. empirical observation, interview, diagnostic monitoring, and systems testing) and who recorded the observation.

In addition to the information included in the Summary of Findings, it is helpful if the findings are divided into component test results and control test results. The component level tests will typically identify maintenance issues or design issues related to equipment capacity or for application appropriateness, while control tests will identify problems with the Sequences of Operations, either in the design or execution of the control system installation.

5.7.2 Systems Testing Report Contents

A report presenting the findings from Systems Testing will form part of the overall RCx Report or may be broken out as a separate deliverable. It should contain at least the following:

- A summary of key issues identified, and of the potential benefits of recommended corrective actions
- The as-executed scope and schedule of Systems Testing (typically as presented in the FT Plan, but modified to reflect any changes from the plan to the actual execution.)

- The Issues Log (Summary of Findings) from Systems Testing, with recommended corrective actions identified
- A record of any repairs or modifications to components or control programs made during the course of the testing
- An Appendix with copies of all completed test forms and copies of any TAB reports produced in conjunction with Systems Testing

5.8 Recommended Corrective Actions

Recommended Corrective Actions should be labelled as one of four corrective action categories:

- Simple mechanical repairs and adjustments
- Recommended simple mechanical measures
- Recommended control programming measures
- Utility efficiency opportunities

The following table presents the RCx Tasks/Deliverables for preparing the Recommended Correction Actions Report.

Table 5.8.a RCx Investigation Phase, Recommended Corrective Actions – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Recommended Corrective Action Report - Simple Mechanical Repairs and Adjustments	Define the scope of simple mechanical repairs and adjustments that may be implemented by RCx team personnel and have the VA site CIR authorize such work. Define Simple Repairs • Operational • Mechanical • Maintenance • Housekeeping	Written description of scope of simple mechanical repairs Written definition of simple repairs
Recommended Corrective Action Report - Recommended Simple Mechanical Measures	Identify recommended simple mechanical measures are repairs and adjustments which are outside of the agreed upon scope of simple measures outlined in the statement of work for the project - restricted to measures which are not controls oriented.	Identification of simple mechanical measures

RCx Task	RCx Task Description	RCx Deliverable
Recommended Corrective Action Report - Recommended Control Programming Measures	Identify control programming opportunities for improved efficiency or discrepancies between current operations and the CFR. Control programming measures should be implemented by the controls specialist or controls contractor for the site, and not by the RCx Contractor.	Listing of recommended control programming opportunities that will be presented in the Issues Log
Recommended Corrective Action Report - Utility Energy Efficiency Incentives and Opportunities	Research and verify potential utility rebates and incentives. Identify opportunities to reduce energy costs through adjusting tariffs	Listing of potential rebates with applications. Create list of tariff reducing opportunities

Table 5.8.b VA RCx Investigation Phase, Recommended Corrective Actions –Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Recommended Corrective Action Report - Simple Mechanical Repairs and Adjustments	n/a	Coordinate the scope of simple mechanical repairs with RCx Contractor	Coordinate the scope of simple mechanical repairs with the COR
Recommended Corrective Action Report - Recommended Simple Mechanical Measures	n/a	Review the simple mechanical measures identified by the RCx Contractor	Identify simple mechanical measures
Recommended Corrective Action Report - Recommended Control Programming Measures	n/a	Review listing of control programming opportunities prepared by RCx Contractor	Prepare listing of control programming opportunities
Recommended Corrective Action Report - Utility Energy Efficiency Incentives and Opportunities	n/a	Review submittal from RCx Contractor of utility rebates and incentives	Research and identify utility rebates and incentives

The corrective action categories are defined in sections 5.8.1-5.8.5, below:

5.8.1 Simple Mechanical Repairs and Adjustments

The scope of simple mechanical repairs and adjustments that may be implemented by RCx team personnel will be discussed with VA staff, including HVAC maintenance personnel, at the project kick-off meeting. The VA site COR must authorize in writing the specific measure types the RCx Contractor may implement prior to any mechanical repairs or adjustments being made. Simple mechanical repairs and adjustments will be limited to those that take up to 30 minutes to complete and a material cost that is outlined in the solicitation documents. Simple repairs may include the following typical measures:

- Operational:
  - Restoring automatic control, where feasible
- Mechanical:
  - Actuator linkage adjustment or reattachment
  - Sealing air leaks from holes or seams in ducts
- Maintenance:
  - Airflow sensor cleaning
  - Air filter replacement
  - Clean strainers
- Housekeeping:
  - Securing latch hardware on air handling unit doors

a. Procedure

Simple mechanical repairs and adjustments will be performed in the course of the investigation only after evaluating any *limiting factors* that may affect their current condition, and the *potential safety impact* of any changes.

The RCx Contractor will carefully *describe as-found and as-left conditions, and justifications* for all implemented simple mechanical repairs and adjustments in the Issues Log.

The RCx Contractor will document each modification by taking before and after digital photographs of the equipment item to be included with the electronic copy of the Issues Log.

b. Digital Photo Standards

Before and after photographs of simple repairs should be consistently taken from the same orientation and reviewed immediately to ensure the scene is sufficiently lit and in focus. Submitted photos will be no more than 300 kB in size. Each pair of photos will correspond to a specific entry in the Issues Log, and will be consistently labeled in a way that clearly identifies the issue it is documenting.

c. Energy Savings Calculations

Estimated energy savings stemming from simple mechanical repairs or adjustments will generally not be calculated, since they are intended to be resolved quickly and generally improve system condition or performance.

5.8.2 Recommended Simple Mechanical Measures

Recommended simple mechanical measures are repairs and adjustments which are outside of the agreed upon scope of simple measures outlined in the Statement of Work for the project. This category is restricted to measures which are predominately non-controls oriented.

These measures can typically be implemented by a contractor, by VA maintenance staff, under an existing mechanical services agreement or through annual funding provided for this purpose. Recommended simple mechanical repairs and adjustments may include the following:

- Operational:
  - Restore automatic control
- Mechanical:
  - Actuator repair or replacement
  - Valve repair or replacement
  - Damper blade replacement
  - Small pump repair or replacement
  - Pneumatic system component tuning, repair or replacement
  - TAB analysis of air, hydronic systems
- Maintenance:
  - Replace dirty air filters
  - Replace leaky damper blade seals
  - Replace worn, defective, or corroded hardware, wiring, relays, pneumatic tubing or fittings
  - Corrosion control

- Lubricate moving parts and mechanisms
- Caulk, seal, or insulate ductwork, damper frames, piping
- Caulk, seal, repair building exterior doors, windows, joints

The RCx Contractor will list these items in the Issues Log under the simple mechanical measures corrective action category. Entries will describe the issues in sufficient detail to be easily identifiable by a different party addressing the issues at a later date, including third-party contractors who may not be familiar with the facilities and systems.

The COR will review the measures, choose those to be implemented, and the party responsible for implementation. Some measures in this category may have calculable energy savings. The RCx Contractor should make recommendations to the COR on which measures may be the most appropriate to pursue calculations for, prioritizing and bundling of measures, and recommendations for contractors best suited to addressing different groups of measures.

5.8.3 Recommended Control Programming Measures

The CFR document should clearly define the operational requirements of all systems and it should be the standard to which systems are evaluated. The updated CFR should reflect space temperature, humidity, and ventilation requirements, as well as operating hours for all of the spaces served by the major mechanical systems.

The RCx Contractor will identify control programming opportunities for improved efficiency or discrepancies between current operations and the CFR, and record them in the Issues Log. Control programming measures should be implemented by the controls specialist or controls contractor for the site, and not by the RCx Contractor. The RCx Contractor can assist VA site personnel in presenting recommendations to the controls contractor and if necessary, provide follow up clarification on control programming recommendations.

a. Runtime Reduction

Most control programming measures can be generally categorized as runtime reduction or load reduction measures. The most common strategies for accomplishing these measures are through:

- Set point adjustments
- Set point reset implementation or adjustment

- Scheduling adjustments

The most effective energy conservation measure is to ensure equipment only operates when it is required to.

Scheduling - An accurate CFR will set the standards for time of day control, which should be designed to minimize equipment runtime. Some examples of scheduling that could be implemented as simple repairs include:

- Optimizing the occupancy schedule for HVAC equipment
- Reducing or shutting off ventilation to unoccupied spaces
- Scheduling domestic hot water recirculation pumps
- Adding optimal start and stop controls
- Weather-based lockout strategies

Weather-based controls use predicted or measured weather conditions to determine when equipment should be enabled, disabled, or set to standby. Most existing BAS systems are capable of some form of weather-based controls, but it is often discovered that this feature is not fully or optimally utilized. If weather-based controls are available but routinely disabled or bypassed, the RCx Contractor should discuss the matter with the facility operations staff to understand the context and reasoning behind this procedure.

Examples of weather-based lockout control strategies that could be implemented or optimized as a minor adjustment include:

- Enabling and disabling the heating and cooling systems based on outside air dry bulb temperature or enthalpy
- Start and stop dates or conditions for heating and cooling systems availability
- Start and stop dates or conditions for humidifier availability

b. Load Reduction

Load reduction can often be accomplished by altering operational practices or by implementing low-cost or minor repairs and adjustments to existing systems, yielding reductions in energy demand and consumption. To ensure that HVAC systems are able to continuously meet facility requirements, systems are designed using extreme minimum or maximum occupancy and ‘design temperature’ conditions to simulate worst case conditions. Cooling design temperature for a location is the outdoor dry-bulb temperature equal to

the temperature that is exceeded by 1% of the number of hours during a typical weather year. Similarly, heating design temperature is the outdoor dry-bulb temperature equal to the temperature that is exceeded by 99.6% of the number of hours during a typical weather year.

c. Base Load Operations

- Air and Water Distribution Systems

  As noted above, air and water distribution systems may be sized and configured to deliver pressures and flows which are greater than required for the optimal functioning of the system. Reducing operating pressures or flow rates can have a significant impact on energy consumption.

Typical programming measures associated with distribution systems base load reduction include:

- Duct static pressure set point reduction
- Fan speed reduction
- Pump speed reduction
- Reduce domestic hot water supply temperature set-point

Note: If the speed is adjustable or there is a set-point reset, these measures refer to reducing the maximum speed or the upper limit of the reset range.

d. Space Environmental Control

The CFR establishes environmental standards, such as heating, cooling, humidification, pressurization, and air change requirements of each space type in a VA facility. Standardizing an acceptable range of set points reduces overheating, overcooling, simultaneous heating and cooling, and unnecessary humidification or dehumidification. Modern BAS systems may allow occupants in some spaces to control local thermostats across a specified range, and the limits of this range should be verified to ensure they fall within the range specified in the CFR.

While certain critical spaces in a VA medical facility, such as operating rooms, procedure rooms and laboratories require more precise control of pressure, humidity and temperature, the RCx Contractor should ensure that systems serving less critical spaces are configured to deliver conditions that are less stringent, space-appropriate standards. When requirements for hygiene or comfort are less strict, efficiency can be gained, but the reverse is also true.

The following are examples of minor adjustments that can be considered:

- Space heating set point reduction
- Space cooling set point increase
- Reduce excessive humidification or dehumidification

Note: set point adjustments should be implemented with caution by making gradual incremental changes, allowing time between adjustments to observe how the system reacts before proceeding. Additionally, adjustments to set points can sometimes reduce energy used in one location while increasing it in another, potentially negating savings or destabilizing the performance of other parts of the system. RCx Contractors should consult with building operators to identify known factors that could limit the feasibility of set point adjustments.

e. Partial Load Operations

The extreme climate and occupancy conditions used to size equipment are also the most rarely occurring, so systems typically operate within a wide range of partial load conditions. If the system is not designed to reduce energy consumption proportionately to match the actual building needs under partial load conditions, these periods can have a large negative effect on energy consumption and costs.

The RCx Contractor should investigate the system's ability to operate efficiently and reliably under a wide range of load conditions, ideally spanning the peak winter heating season, a shoulder season, and the peak summer cooling season. Proposed and existing partial load control strategies must be validated against the CFR and verified during the systems testing.

Programming measures related to HVAC partial load operation can be divided into the following sub categories:

- Reset Controls

  The term "reset control" applies to the primary control parameters of central air handling systems, heating water systems, and chilled water systems. The basic premise of a reset is to allow the system to respond to changing conditions by providing a range of possible values for a set point, which is calculated based on feedback from the system. Common strategies include weather-based resets that use input from an outdoor weather sensor as a proxy for load, zone temperature versus set-point, or equipment loading to determine if the system is operating under partial load conditions. Example reset measures

include:

- Heating water temperature set-point reset
- Chilled water temperature set-point reset
- Supply air temperature reset
- Airside and waterside static pressure reset

Creating a reset strategy may be outside of the scope of simple repairs and adjustments due to BAS programming restrictions, or the amount of time that would be required for full investigation and implementation. In less complex situations, however, optimizing these resets can be a fairly straight forward operation.

- Setback/Setup Controls

While reset controls react to partial load conditions by resetting set-points for central air and water supply systems, setback/setup controls create reduced load conditions by lowering heating, cooling, ventilation, or humidity requirements in a space, dependent on usage, time of day or occupancy. The control is based on a sensor located in a space or the return vent, such as a BAS temperature or humidity sensor, programmable thermostat, CO_2 sensor, or occupancy sensor. Example setback/setup measures include:

- Reduce unoccupied heating space temperature set-point
- Increase unoccupied cooling space temperature set-point
- Demand controlled ventilation
- Kitchen or laboratory exhaust hood controls.

5.8.4 Utility Energy Efficiency Incentives and Opportunities

Often local utilities offer incentives to encourage their customers to use or install the most energy efficient equipment and methods. These incentives vary by state and utility, and are summarized on the DSIRE database (http://www.dsireusa.org). The RCx Contractor should deliver to the VA a list of potential energy measure incentives offered by the local utilities along with the requirements to obtain them.

In addition to actually reducing the energy impacts through energy conservation measures, there are opportunities to reduce energy use and cost through tariff rate changes. In some cases using a different utility provider or a different tariff can result in a lower cost structure.

Many utilities offer assistance to customers in finding the most cost effective way to consume the resources that they provide. Most VA facilities consume enough energy that they fall into the larger user categories. When a customer uses this amount of energy, it will usually be considered a managed account and have an individual assigned to assist the customer with cost management. This person will also provide useful forecasting information, such as anticipated cost increases, and how best to plan and budget for these changes.

To better understand how energy is being consumed on a VA complex, local metering for individual buildings has been required with EPACT 2005. All buildings over 50,000 square feet must be individually metered for electric and gas use. When available, this data should be summarized and used to better understand the facility's operation.

- Electrical Services and Tariffs

Tariff structures define how the customer will be billed. They are tailored to provide both the customer and utility with the best compromise on usage and generation. Larger electrical energy tariffs usually include the following factors:

  - Time of use structure, charging higher rates for daytime energy consumption
  - Demand charges relative to the peaks that are consumed during a month
  - Demand charges relative to the highest usage in a year
  - Service charges related to providing meters and transformers to deliver energy
  - Additional charges for poor power factor.
  - Incentives to being able to curtail usage during very high system loads
  - Incentives or charges for providing or using renewable energy

VA sites should be aware of these factors and plan for how to best adjust their usage to minimize their costs. Some strategies that may be considered, depending on the cost structure and feasibility, include:

- Evaluating 15 minute utility usage data and identifying usage patterns that may be shifted to minimize demand charges
- Using backup generators during times of peak demand to curtail portions of the electrical load
- Adding energy storage equipment, such as ice storage

- Shifting scheduled operation of HVAC equipment to run at the lowest energy cost times, such as over cooling buildings at night when free cooling is available and energy costs are less
- Adding combined heat and power generation capability, as it can provide electrical backup and the waste heat can be used to meet local needs
- Adding a system to dynamically add or subtract power factor correction capacitors if the campus is currently being assessed charges for poor power factor
- Redistributing the load if the three phase voltage and current being supplied to the campus shows an imbalance

Some states have allowed the deregulation of electricity, allowing customers to pay the local utility only for the infrastructure to deliver the energy and contract with another supplier for energy consumed.

a. Natural Gas Service

Natural gas is often consumed locally to provide space heating, domestic water heating, humidification, and sometimes backup generation. The tariff that defines this utility usually has the following factors:

- Units billed (therms, CCF, decatherms)
- Energy content of the delivered product (BTU per CCF)
- Degree heating days

Natural gas costs a fraction of the equivalent energy cost of electricity. This makes it a much more attractive source for uses where heating is involved. Modern equipment can be as efficient as 94+% at converting the available energy into heat. Thus, any heating uses that can be fueled by natural gas should be considered. Any equipment using electricity to provide heat, such as electric water heaters, should be considered for replacement.

b. Other Utilities

VA campuses may have access to other utility services, like steam and chilled water prepared by central services or independent contractors.

Steam can provide a very large transfer of heat in a compact piping system. Usually billed by the pound, it can be generated locally in boilers or as a by-product of generating electricity. Steam cannot be generated as efficiently as hot water, and thus should not be used when the alternative is available.

Steam pipes operate at a temperature that requires good insulation to minimize piping losses. Steam systems also use steam traps to keep the condensing equipment from accumulating water. Steam traps are difficult to maintain and can waste energy when they leak. Periodic surveys of steam traps in a steam system should be conducted. When steam is used year round for purposes other than heating, smaller boilers, located closer to the area of demand should be considered rather than leaving a large boiler operating under light load conditions.

Chilled water as a utility is also usually generated by a central plant, often using technologies that can benefit from the utilization of waste heat from another process. When available, this method can be less expensive than providing this same cooling energy using mechanical systems.

5.9 Final RCx Report

The RCx Contractor will submit to the COR the Final RCx Report summarizing findings of Phases 2 and 3, Planning and Investigation. The RCx Report should include the following sections. A sample of the Final RCx Report can be found in **Appendix H**.

Table 5.9.a RCx Investigation Phase, Final RCx Report – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Final RCx Report	Summarize all of the findings from the Investigation phase into a Final RCx Report. The Report shall include the following sections: • Report Title Page • Report Certification Page • Table of Contents • Executive Summary • RCx Plan with Scoping Meeting Minutes • Project Current Facility Requirements (CFR) • Facility Information Documents Report • Equipment Inventory • Interviews • Facility Performance Analysis and Performance Baseline • Diagnostic Monitoring Plan • Diagnostic Monitoring Report	Written Final RCx Report

RCx Task	RCx Task Description	RCx Deliverable
	• Systems Testing Plan • Systems Testing Report • Recommended Corrective Action Report • Out-briefing Minutes	

Table 5.9.b RCx Investigation Phase, Final RCx Report – Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Contractor
Approve Final RCx Report	n/a	Review and approve the Final RCx Report	Write the Final RCx Report
Out-briefing Assistance		Coordinate and assist the RCx Contractor with the Out-briefing	Conduct the Out-briefing

6 Phase 4 - RCx Implementation

The VA's RCx contract SOW dos not include implementation of Corrective Measures or Energy Conservation Measures beyond the Simple Repairs completed as part of an RCx Investigation. The final deliverable of an RCx project is the Final RCs Report. Actual RCx implementation should be carried out according to standard VA procedures used for acquiring services and repairs. Implementation could be completed using internal staff resources or an outside contractor.

The work of planning and executing more expensive and complex measures begins in the Implementation Phase. A Contractor will have provided the VA site with an Issues Log and Corrective Measures list. These documents will be provided to the site in a format t that supports the eventual implementation of the measures discovered during the RCx Investigation. The Implementation Section of this RCx Process Manual is provided to offer general guidance in completing the work of an RCx project, beyond the Investigation Phase.

6.1 Objectives

The main objective of this phase is to maximize the effectiveness of available funding by executing the highest priority measures among those previously identified. A prioritized list was generated during the Investigation Phase that allows the VA site to choose items that will provide the largest return on investment, and to estimate the magnitude of effort and cost involved in implementation. Factors that can affect the prioritization of implementation often include:

- Size of action - Smaller items may be aggregated to optimize the use of available resources.
- Return on investment (ROI) - In some cases, items with larger ROIs (longer payback) might need to be deferred due to limited availability of funds or scheduling conflicts.
- Disciplines available to do the work - Items involving special disciplines, like control programming, require specialized resources which are often scarce and may impact the order of execution.
- Seasonal impacts - Some items may have seasonal impacts, like working on heating and cooling systems in the shoulder months.
- Lead time impacts - Some items involving equipment purchases may be impacted by lead times. Many facilities will need to have changes done while equipment is operating, and consideration for minimizing disruptions while also trying to keep the costs under control is a concern.

Once energy conservation or corrective measures have been chosen, their potential

interactions assessed, and the magnitude of required effort determined, a detailed schedule of events can be prepared and reviewed with all involved parties. A level of buy-in and agreement on what successful completion will mean needs to be established. Sufficient detail should to be included to allow for the generation of statements of work for execution either internally or externally.

By the end of the Implementation Phase, the VA facility should have executed as many of the identified energy conservation and corrective measures as possible and should have a plan prepared to follow up on measures that were either deferred or need to be contracted externally.

Table 6.a RCx Implementation Phase, Objectives – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Operations and Maintenance Training	***Building Systems Operations Manual –*** Create a Building System Operations manual that focuses on changes that resulted from the implementation of energy conservation measures. ***Presentation and Discussion*** – Create training presentation based on the Building Systems Operations Manual	Building Systems Operational Manual Training presentation
Funding Corrective Actions	***Warranties –*** Identify any existing warranty restrictions or funding opportunities for new corrective actions. ***Active Contracts*** - The RCx Contractor should have access to the BAS system to set up and download trends for monitoring purposes, but the site controls contractor will implement BAS control programming measures. There may be other existing maintenance and operations contracts. These will have been identified in the RCx Planning Phase. ***Facility Staff Expertise and Availability*** – Based on workload the VAs in-house engineering and maintenance staff may be available to manage some of the corrective actions identified in the Issues Log. If workload does not permit the on-site staff to make the corrections, then it will need to be packaged into a project that must go out for bid.	None

RCx Task	RCx Task Description	RCx Deliverable
	Available Funding Sources - The Energy conservation measures itemized by the RCx Contractor in the Issues Log should be evaluated by the Facilities Manager, COR or Energy Manager of the facility and prioritized by performing life cycle cost analyses. Repairs that cannot be performed by VA engineering and maintenance personnel, can be addressed with pre-approved O&M funding, provided that the cost of the repair does not exceed a predetermined amount. Executive Order 13514 mandates renewable energy options and other greenhouse gas (GHG) mitigation strategies be included in projects. The Executive Order also instructs agencies to "take into consideration environmental measures as well as economic and social benefits and costs in evaluating projects and activities based on lifecycle return on investment." (74 FR 52117; Oct. 5, 2009). Individual energy conservation measures that are less cost-effective may be bundled with those that are more cost-effective into projects that generate a better return on investment to increase the likelihood of receiving funding. Larger capital-intensive projects or projects from decentralized operating budgets are financed by appropriations or other funding from the Central Office	

Table 6.b RCx Implementation Phase, Objectives – Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Implementation Contractor
Operations and Maintenance Training - Building Systems Operations Manual	n/a	Coordinate with RCx Contractor to identify the training needed. Review training materials	Prepare training materials
Operations and Maintenance Training -	n/a	Assist with presentation and facilitate	Present the training and work with COR to facilitate

Activity	CO	COR/Other VA Staff	RCx Implementation Contractor
Presentation and Discussion		discussions	discussions
Funding Corrective Actions - Warranties	n/a	Review recent warranties for ESPC or other projects	Work with COR to review recent warranties for ESPC or other projects
Funding Corrective Actions - Active Contracts	n/a	Review existing contracts(BAS) to identify opportunities for implementing control improvements	Work with COR and controls contractor to initiate specific control changes
Funding Corrective Actions - Facility Staff Expertise and Availability	n/a	Identify qualified staff who are available that could work on ECM projects	Work with COR to identify projects that can be completed at the local level
Funding Corrective Actions - Available Funding Sources	Work with COR to identify funding opportunities from the VA and other funding Opportunities	Work with CO to identify funding opportunities from the VA Work with the RCx Contractor to identify other funding opportunities	Work with the COR to identify other funding opportunities
Commissioning	Contract with a Commissioning Agent in accordance with the Whole Building Commissioning Process Manual	Assist CO with contracting for a commissioning agent.	none

6.2 Operations and Maintenance Training

During the Investigation Phase it is likely that many repairs were made to systems that affect operations and maintenance. Many of these changes likely involved scheduling and control strategies. Previously the focus was on keeping the existing equipment running as specified in the past. With the beginning of the RCx Implementation Phase, the focus should shift to maintaining changes that were made and ensuring their persistence.

VA maintenance and operations staff will play a critical role in creating RCx measure persistence. Thus, it is important that improvements in the building's

systems are fully understood by facility O&M staff. Failure to fully educate O&M staff in the nature of repairs or changes made to building systems as part of the RCx project may lead to O&M staff inadvertently returning those systems to their original inefficient operation.

6.2.1 Building Systems Operations Manual

A key work product of the Implementation Phase is the preparation of a Building Systems Operations Manual. This may involve updating an existing systems manual, or the creation of an original document. The Building Systems Operations Manual will include:

- The updated CFR, which includes a list of occupancy schedules and temperature, humidity, and ventilation requirements for different spaces, and identification of the mechanical systems which serve them. The updated CFR will include 1) a schedule to periodically review and update the occupancy times and IEQ requirements for each space, 2) a list of points of contacts (e.g. supervisors, managers) for each department in the facility to discuss any changes in occupancy and space usage, and 3) to note recent occupant comfort or IEQ issues.
- A brief design narrative of all systems investigated, including a brief description of the system, its purpose and general operation, and operational factors that impact energy and water usage.
- A description of and rationale for all recommended measures, including proposed changes to automatic and manual control strategies, noting special operating and maintenance caveats.
- Recommendations for calibration frequency of critical control sensors and actuators by type and use. Discuss the option of including a critical point calibration log and schedule for tracking sensor performance and planning for replacement.
- Specific recommendations regarding seasonal operational issues that affect energy use.
- A list of all user adjustable set-points and reset schedules with a discussion of the purpose of each and the range of reasonable adjustments with energy implications. Include a schedule to periodically review the various set-points and reset schedules, and a log to document changes for longer-term study.

6.2.2 Presentation and Discussion

The Building Systems Operations Manual will serve as the text for the training presented to the building O&M staff. The training will include:

- Safety
- Familiarization with all building systems
- Discussion of changes that have been made to the equipment and operations
- Review of schedules that will require periodic updating
- Introduction to anticipated overrides, along with discussion of the impact on building operation and energy consumption and the need to document and correct root causes and remove them
- Tracking energy consumption
- Alarms and potential causes
- Contact list of vendors and responsibilities

A comprehension test should be administered to ensure training has been effective. A periodic refresher training schedule, along with a plan to train new employees will be prepared by the RCx Implementation Contractor.

6.3 Funding Corrective Actions

Corrective actions that are more intensive than the small repairs performed by the RCx Contractor during the investigation usually involves some combination of facility staff and outside contractors, depending on the nature of the measures being implemented. There are a number of factors to consider when determining who should perform the implementation of a measure, or group of measures, including:

- Existing equipment warranties
- Active contracts (e.g. controls or mechanical service contracts)
- Facility staff expertise and availability
- Available VA funding sources

6.3.1 Warranties

The Facility Manager or RCx Contractor should check to see if any recommended repairs could fall under a warranty. If the equipment is still under warranty, the repairs should only be provided by the manufacturer, as any adjustments made by third parties would likely void the warranty.

6.3.2 Active Contracts

Most VAMC campuses have on-going contracts with HVAC controls vendors or service companies for installation, periodic maintenance, and upgrades to the BAS systems in the facilities. The RCx Contractor should have access to the BAS system to set up and download trends for monitoring purposes, but

they will not implement any of the recommended BAS control programming measures. The site controls contractor will bear the responsibility and liability for implementing BAS control programming measures.

The VA may also have established relationships with other service contractors who can implement recommended RCx measures under an existing service contract. The RCx Contractor may be able to assist VA staff in requesting an accurate estimation of the cost for a contractor to implement recommended measures. Important factors that can affect the cost of implementation include:

- Clarity, specificity, and accuracy of the request presented to the contractor. How well-defined is the recommended measure, and how well is the intent conveyed to the contractor?
- Limitations of the existing BAS system. Depending on the age, condition, configuration, and capabilities of the existing BAS, the controls contractor may require certain software or hardware upgrades be included to accomplish the implementation, or they may recommend that the measure is not practical or possible to implement as requested.
- Scope of services of existing controls contract. Some measures that involve more complex or unusual tasks may incur additional costs.

6.3.3 Facility Staff Expertise and Availability

The VA has highly capable in-house engineers and maintenance staff that may be available to manage a significant number of the corrective actions identified in the Issues Log. This approach requires substantial commitment on the part of the staff, which can prove a challenge if the staff currently has a full work load. Prioritizing and gradually incorporating RCx measure implementation with existing work orders has proven to be a successful approach for some facilities. The Issues Log is designed to allow VA facility staff to track the implementation and resolution of measures, if necessary over an extended period of time.

6.3.4 Available Funding Sources

a. Executive Order 13514 mandates renewable energy options and other greenhouse gas (GHG) mitigation strategies be included in projects. The Executive Order also instructs agencies to “take into consideration environmental measures as well as economic and social benefits and costs in evaluating projects and activities based on lifecycle return on investment.” (74 FR 52117; Oct. 5, 2009).

Thus, the VA allocates annual funding to energy conservation measures that the facilities have access to for specific energy related projects. This budget is necessary to meet statutory requirements, achieve Presidential goals, and capture efficiencies and savings that can be reinvested in the growing mission

b. Individual energy conservation measures that are less cost-effective may be bundled with those that are more cost-effective into projects that generate a better return on investment. This method aids in the implementation of energy conservation measures that achieve other mandated sustainability goals such as water efficiency, renewable energy generation, and greenhouse gas reduction, even though they may have longer return on investment periods.

   The Energy conservation measures itemized by the RCx Contractor in the Issues Log should be evaluated by the Facilities Manager, COR or Energy Manager of the facility and prioritized by performing life cycle cost analyses.

c. Capital improvements are financed by appropriations or other funding from the Central Office allocated to larger capital-intensive projects or from decentralized operating budgets for smaller projects.

7 Phase 5 - RCx Turnover

The current VA Statement of Work for RCx does not include Turnover services. The final deliverable of an RCx project is the Final RCx Report. Turnover activities are regarded as an additional service and they will need to be acquired outside of the RCx Planning and Investigation project. This can be done through the contractor that performed the RCx Planning and Investigation, under a separate contract, through the implementation contractor or by another RCx contractor that the site chooses to work with. In either case, acquisition of additional services beyond the end of the RCx Investigation phase must be conducted according to standard VA practices.

A successful turnover would require that all documentation and knowledge is transferred to the operational staff at the facility. The Turnover Phase should include the following elements:

- Final Report
- O&M Manual(s)
- Systems Manual
- Operational Persistence Plan
- Training Plan

The following table presents the description of the tasks and deliverable in the RCx Turnover Phase.

Table 7.a RCx Turnover Phase, Objectives – Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Final Turnover Report	A Turnover Report is prepared that summarizes the work that has been accomplished through all prior phases of the RCx project.	Final RCx Turnover Report
Turnover Operations and Maintenance Manual	A new operations manual is created at the beginning of the Turnover Phase. This manual describes the operations and maintenance requirements that resulted from the work accomplished during the RCx process.	New Turnover Operations and Maintenance Manual
Systems Manual	The System Manual addresses the changes made to the systems in the facility during the RCx process. It	Manual describing how

RCx Task	RCx Task Description	RCx Deliverable
	includes documentation that confirms that implemented measures still comply with the CFR. Items include: • Copy of the CFR, with any revisions highlighted • As-built drawings or record drawings • Record keeping programs • O&M Manuals • Training materials • Descriptions for maintaining efficiencies of operation	the systems function alone and together.
Operational Persistence Plan	An operations plan must be created to ensure the continued persistence in efficiencies and utility savings that result from RCx implementation.	Written Operational Persistence Plan
Training Plan	As the RCx process proceeds, the focus of training will shift from maintaining the equipment and systems to learning about how efficiency issues are found and how they are remedied. Items in the training plan will likely include: • How does building function (CFR)? • Where are the inefficiencies? • How do you recognize the inefficiencies? • What were the implementation strategies to correct the inefficiencies? • What do the improvements in efficiency mean for reducing operating costs? • How do we maintain the improvements?	Written Training Plan

Table 7.b RCx Turnover Phase, Objectives – Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Turnover Contractor
Final Turnover Report	Review report	Work with the RCx Turnover Contractor (if, utilized) to prepare the report. Review report	Coordinate with the COR the preparation of the report

Activity	CO	COR/Other VA Staff	RCx Turnover Contractor
Turnover Operations and Maintenance Manual	Review manual	Assist with preparation of the Turnover Operations and Maintenance Manual Review manual	Prepare the Turnover Operations and Maintenance Manual.
Systems Manual	Review manual	Assist with preparation of Systems Manual Review manual	Work with COR to prepare the Systems Manual
Operational Persistence Plan	Review manual	A member of the COR staff or the RCx Turnover Contractor will write the Operational Persistence Manual Review manual	Work with COR to write the Operational Persistence Manual
Training Plan	Review plan	Coordinate the preparation of a Training Plan that focuses on how the efficiency issues are found and how to maintain them Review plan	Work with COR to prepare a Training Plan that focuses on how the efficiency issues are found and how to maintain them

7.1 Final Turnover Report

The Turnover Report summarizes the work that has been accomplished through all prior phases of the RCx project. It discusses the planning that occurred to prepare for the investigation, the results of the investigation and how the recommended improvements were implemented. It will not be a word-for-word copy of the Investigation Phase Final Report, but will be a supplement that summarizes additional activities, tasks and plans.

7.2 Turnover Operations and Maintenance Manual

Unlike a common O&M manual, the Turnover O&M Manual focuses on how to maintain the RCx measures and resulting reductions in utility costs. It will contain schedules for testing the improvements and describe the desired results. It will also prescribe corrective measures to bring the system back into compliance if it has strayed from desired performance.

7.3 Systems Manual

As the name implies, the System Manual addresses the changes to the systems in the facility. It will also include documentation that confirms implemented measures still comply with the CFR. It should also document any changes to building usage that will change the CFR. Items that should be included in the Systems Manual are:

- Copy of the CFR, with any revisions
- As-built drawings or record drawings
- Record keeping programs
- O&M Manuals
- Training materials
- Descriptions for maintaining efficiencies of operation

7.4 Operational Persistence Plan

The RCx process is centered on making behavioral and operational changes that result in increased efficiencies and utility savings. Some implementation activities require repairs or changes to equipment and others require changes in how operations and maintenance is conducted. The continued persistence in efficiencies and utility savings that result from RCx implementation will not continue without a determined effort to maintain performance (Operational Persistence). In the Turnover Phase the RCx contractor or a senior member of the facility staff will write a plan that directs the operations and maintenance staff on how to monitor and evaluate the performance of facility improvements. Often, this is a mind-set change that requires training and mentoring.

7.5 Training Plan

Operations and maintenance staff in a VA facility are provided with training, but it doesn’t necessarily focus on the RCx process. Retro-Commissioning specific training should be ongoing, beginning with the Planning Phase in order to set the appropriate expectations. As the RCx process proceeds, the focus of training will shift from maintaining the equipment and systems to learning about how efficiency issues are found and how they are remedied. This evolution in approach will help operations and maintenance organization recognize that they are owners of the improvements and it is their responsibility to ensure that improvements persist. The training plan should include the following topics:

- How does the building function (CFR)?
- Where are the inefficiencies?
- How do you recognize the inefficiencies?

- What were the implementation strategies to correct the inefficiencies?
- What do the improvements in efficiency mean for reducing operating costs?
- How do we maintain the improvements?

The training plan should be formalized and it should include well prepared teaching materials. The training materials should be flexible enough so they can be altered with changes made during the implementation phase.

8 Phase 6 - Monitoring the Persistence of Energy Savings

8.1 Understanding Persistence

The current VA Statement of Work for RCx does not include Persistence services. The final deliverable of an RCx project is the Final RCx Report. Persistence activities are regarded as an additional service and they will need to be acquired outside of the RCx Planning and Investigation project. This can be done through the contractor that performed the RCx Planning and Investigation, under a separate contract, through the implementation contractor or by another RCx contractor that the site chooses to work with. In either case, acquisition of additional services beyond the end of the RCx Investigation phase must be conducted according to standard VA practices.

Persistence of energy savings associated with implemented RCx measures is an often overlooked consideration within an RCx project. Unfortunately without a formalized persistence program that includes measure surveillance via some form of a fault detection system, and an accompanying O&M staff response, most RCx based energy savings will degrade over time. The result is a need to repeat the RCx process or re-commission building systems on a 4 to 5 year cycle. This is a common occurrence across all types of RCx projects and it can be easily prevented by applying practical persistence monitoring and response.

Table 8.1.a RCx Monitoring the Persistence of Energy Savings, Understanding Persistence– Tasks/Deliverables

RCx Task	RCx Task Description	RCx Deliverable
Fault Detection & Monitoring	A program must be prepared to monitor the operations of the system to recognize when a change of state or anomaly has occurred. The plan will include pre-designed responses to the faults detected. The plan will also include a program to monitor the changes in the system so as to recognize when the system is going out of optimum performance.	Prepare a Fault Detection and Monitoring program
O&M Staff Response and Training	The training program that was prepared for the Turnover Phase will be revised to include a clear definition of Operations and Maintenance procedures that must be followed to guarantee the continued performance of the building. It must be geared to the	New written training program that includes response programs for the O&M staff

RCx Task	RCx Task Description	RCx Deliverable
	existing staff with refresher courses and for the new employee.	
Contracting with Third Parties to Manage Persistence	If necessary or desirable, the facility will contract with a third party to manage the persistence program. The third party may be the person or group that prepares the Fault Detection and Monitoring program and the O&M Staff Response and Training.	none

Table 8.1.b RCx Monitoring the Persistence of Energy Savings, Understanding Persistence– Team Member Responsibilities

Activity	CO	COR/Other VA Staff	RCx Persistence Contractor
Fault Detection & Monitoring	Review program	Work with the RCx Persistence contractor to develop the program. Review program	Coordinate the creation of the program with the COR
O&M Staff Response and Training	Review program	Assist with preparation of the O&M Staff training program Review manual	Coordinate with COR on the preparation of the O&M staff training program
Contracting with Third Parties to Manage Persistence	Review contracting procedures	Assist with developing the Statement of Work for contracting to hire someone to develop the persistence programs	Respond to the solicitation

8.2 Fault Detection & Monitoring

Fault detection for implemented RCx measures can be as simple as creating, and responding to, “change of state” or “limit” alarms within an existing BAS control system that is connected to equipment where RCx measure implementation has occurred. A more complex approach might include standalone, web addressable logging devices to cover measures that cannot be reported on within the existing BAS control system. Or, a low tech or hands on program may simply employ the regular, visual inspection of the operating parameters of implemented RCx measures by O&M staff to ensure they continue to operate as intended. Ultimately though, a fault detection process or system should provide feedback sufficient to help building maintenance and operations staff

respond to conditions that contribute to RCx measure energy savings degradation. The rigor and regularity to which RCx energy saving measures are covered by a monitoring process will directly determine measure persistence. In other words, the more RCx energy saving measures can be maintained in their original operating condition, the less degradation that will occur. Determining which RCx measures receive the greatest attention and response should be guided by the relative contribution of savings. Generally, the implemented RCx measure with the greatest impact on energy savings will receive the greatest attention.

8.3 O&M Staff Response and Training

The importance of O&M staff within the RCx measure persistence challenge cannot be overstated. The active participation of this group, especially in large buildings with complex building systems is absolutely critical if RCx energy savings are to be maintained over the longer term. Simply assuming that a fault detection system will ensure that RCx energy savings remain persistent is a recipe for disaster. Rather, the combination of the information gathered from a detection system, AND a firm and coordinated response from O&M staff to a particular situation is the only combination that will effectively maintain RCx energy savings. For this reason, it is very important to consider the skills, experience and the abilities of maintenance staff in appropriately responding to RCx persistence demands.

Because a very high percentage of RCx energy savings are control systems related, it is important that O&M staff that are responsible for responding to changes of state or alarms generated by an RCx measure monitoring or fault detection system be well versed in trouble shooting control related issues. For this reason O&M staff must be thoroughly trained on how new or renovated equipment and systems are designed to work, how to properly operate and maintain those systems, and how to maintain operational and energy efficiency results of all implemented RCx measures.

Training that supports the persistence of RCx measures should not be a single event provided at the conclusion of the RCx project. To be truly effective, RCx measure persistence training should be an ongoing activity delivered over a period of time and it should focus directly on those tasks that help the O&M group maintain the gains they have achieved through the RCx measure implementation. Guidance on the appropriate forms of maintenance, the structure that maintenance training should be delivered under and skill level improvements expected from such training are described in more detail in the US Department of Energy publication “Commissioning for Federal Facilities”.

8.4 Contracting with Third Parties to Manage Persistence

Managing the persistence of energy savings that result from an RCx Project requires a commitment of O&M and technical resources that may not be readily available in every VA facility. In such cases it may be more practical, and more economical, to approach the monitoring and notification of RCx measure persistence using resources provided by a third party. Such arrangements should include ongoing O&M staff training, remote monitoring of selected RCx energy measures and notification of anomalies to site O&M staff as they occur.

Contracting for support in maintaining RCx measure persistence recognizes that most RCx projects do not include sufficient funding to provide the training necessary to effectively avoid RCx measure degradation. By contracting with a third party O&M staff is provided with the ongoing support required alter their approach to maintaining the systems in their facility and become conversant on how to interface with their fault detection process.

Third party approaches to supporting the persistence process are varied. They can include an approach like Supported RetroCommissioning™, a proprietary process, where monitoring, anomaly notification and on-site training and mentoring are bundled as a single approach or Continuous Commissioning® where on-site training is the primary focus. In either case the objective is to provide the O&M staff with the skills necessary to avoid the degradation of RCx energy savings and equip them with the expertise to address this challenge over the longer term.