

Retro-Commissioning (RCx)

1. Projected Program Budget	\$	11,626,203
2. Projected Program Impacts		
MWh		39,040
MW (Summer Peak)		9.60
3. Program Cost Effectiveness		
TRC		1.47
PAC		2.11

4. Program Descriptors

Market Sector: Nonresidential
Program Classification: Local
Program Status: New

5. Program Statement

Most buildings have never gone through any type of commissioning or quality assurance process and are therefore performing below their potential. Many problems from the original construction may exist and may not manifest themselves in an obvious manner, although they may be causing unnecessary consumption of energy and increased electrical demand. Even if building staff members have been able to work out most of the “obvious deficiencies”, they are often forced to solve problems under severe time and budget constraints and without the benefit of proper documentation. Having to solve problems fast and without good information usually results in “quick and dirty” solutions which can lead to other problems that may be invisible yet costly.¹ As long as building systems maintain a reasonably comfortable or tolerable environment, nothing appears wrong. Many problems are noticed only when a catastrophic failure or a visible consequence occurs. For example, when unnecessarily large volumes of outdoor air are drawn into a building due to a failed economizer actuator, more heating and cooling energy are used. However, as long as heating and cooling systems have the capacity to handle this increased outdoor air volume, the problem goes unnoticed. Other common problems that drive energy costs up but may or may not cause comfort problems include:

- Variable speed drives that no longer modulate properly
- Time clocks circumvented or set up improperly
- Equipment running more than necessary or running inefficiently due to improper operating strategies
- Equipment cycling excessively due to improper sequences of operation and/or equipment operational problems

¹ PECI and Oak Ridge National Laboratory. 1998. A Practical Guide For Commissioning Existing Buildings. U.S. Department of Energy

- Equipment that is operated manually because the automated system operation is misunderstood or is causing operational problems
- Improperly sized equipment cannot meet the operational requirements as currently configured
- Airflow and/or water flows within the system are improperly balanced, leading to energy waste
- Energy management systems that were never installed or programmed to take full advantage of their capabilities or that have degraded over time
- Sensors and/or actuators that are out of calibration or have failed

Each of these problems can have a sizable effect on the economics of owning and operating a building. These types of problems are typical in many buildings.² The result is that significant savings are achievable for a majority of existing buildings. It may be surprising that market penetration is so low for building system optimization and RCx services. In general, there is a lack of demand for these services due to four main market barriers:

- There is a lack of awareness of building system optimization and RCx benefits.
- The first cost of building system optimization (BSO) and retro-commissioning (RCx) is too high to be funded through tight building operations budgets.
- The facilities staff lacks the time and/or initiative to implement this process.
- Inconsistent approaches to building system optimization and RCx do not give a sense of the service and value that owners receive.

In addition, previous RCx programs have revealed the following critical difficulties that have hindered success:

- Securing buy-in from building owners and facilities staff to participate in building system optimization and RCx programs has been difficult. In previous programs with short program cycles, the rush to secure participants and undertake field work has led to strategies that bypass owner and facilities staff involvement at the early stages of the process. This has caused difficulty and delay when moving from investigation results to the implementation of corrections. Prompt implementation requires owner and facilities staff commitment and the identification or cultivation of an internal champion for the process. This work should occur upfront in the process and is in fact an effective screening method to sort out participants that will help the project to succeed.
- Ensuring persistence of some savings measures in a cost-effective manner is challenging. Building owners must be interested and capable to make and sustain ongoing commitments of operating resources to ensure the implementation of and persistence of corrections. Because the savings are realized from a variety of operational interventions, their ongoing viability depends on the owner's readiness and ability to manage the systems effectively and oftentimes in new ways. Building facility staff must know and understand the consequences of the ir

² PEI and Oak Ridge National Laboratory. 1998. A Practical Guide For Commissioning Existing Buildings. U.S. Department of Energy

decisions as it impacts not only comfort, but energy usage. Again, candidates must be screened to ensure these qualities are present.

- Supporting large amounts of building system optimization and RCx is unmanageable when utilizing only a few service providers. The experience and skills required to quickly and efficiently diagnose and correct operating deficiencies is significant. The pool of service providers that can execute these tasks needs to be increased. Due to the wide variety of control systems and equipment likely to be found in the stock of existing buildings, flexibility in selecting vendors that have the appropriate experience for a particular retro-commissioning project is essential. Additionally defined assessment protocols to identify building system optimization opportunities and clearly defined processes for RCx will provide valuable operations diagnostic experience to new providers and allow experienced providers to participate efficiently.
- The amount of time required to implement an RCx project is often underestimated. Unlike new construction commissioning there is no natural implementation timeline. Other issues often come up that tend to extend the process including capital funding availability, trending of data, availability of in-house labor, and unforeseen problems encountered during implementation. Enhanced screening of potential sites may help with the funding and in house labor issues. However, other unforeseen factors should be carefully considered in developing a realistic timeline for each individual project.
- The projected amount of project expenditures at the onset is inherently difficult to project. There are several aspects of the process that make projection of

Building commissioning is increasingly recognized as a cost-effective process to improve building performance, reduce energy use, increase equipment life, improve indoor air quality, and improve occupant comfort and productivity.

expenditures from the onset difficult. These include the unknown state of the system(s) prior to the investigation phase, unknown building issues found during installation of equipment and/or software modifications, and the difficulty of getting good cost estimates for work from multiple vendors before the full scope of work is known.

6. Program Rationale

Building commissioning is increasingly recognized as a cost-effective process to improve building performance, reduce energy use, increase equipment life, improve indoor air quality, and improve occupant comfort and productivity. Over the past ten years, utilities in California and across the United States have been important supporters of the commissioning industry, and that support has led to significant energy savings. However, the majority of existing buildings have never undergone a commissioning or quality assurance process, and are therefore most likely to be performing well below their potential. In 1998, a study for the Department of Energy estimated that less than 0.03%

of existing buildings were retro-commissioned each year.³ Although that percentage has most likely increased since 1998, there remains substantial energy saving opportunities through RCx existing buildings.

Retro-commissioning (RCx) applies a systematic process for improving and optimizing larger sized building operations and for supporting those improvements with enhanced documentation and training. The process focuses on the operation of mechanical heating, ventilating, and air-conditioning (HVAC), refrigeration, lighting, domestic hot water (DHW) and related controls. The RCx process is intended to optimize how equipment operates as a system. Other specific equipment such as landscaping fountains may be included as well if they are applicable to a specific project and meet other program guidelines. RCx projects produce typical savings of 12-15% of total building energy costs, with a simple payback from energy savings alone averaging less than 2 years.⁴

Medium and large sized commercial, industrial, and institutional buildings represent a large proportion of the market potential that can be effectively realized using defined assessment protocols to identify building system optimization opportunities. In addition to significant energy savings, these practices can reduce maintenance costs, provide accurate building documentation, provide appropriate training to operating staff, aid in long term planning for retrofits, and increase the asset value of a building.

7. Program Outcomes

- Improve the ability of building operations staff to identify wasteful energy use
- Create persistent savings over the remaining lifetime of the affected equipment
- Prolong equipment life
- Optimize comfort in cases where the corrections rectify outstanding comfort issues
- Demonstrate a well-delivered RCx process so that building owners and operators realize the value inherent in this service
- Documentation and staff training on the optimized building system operations.

8. Program Strategy

The market barriers and programmatic difficulties described in the program statement are common limitations for incentive programs, and require innovative solutions. The program presented in this proposal is designed to overcome these issues by incorporating the following elements:

- **Careful building screening to reduce risk of ineffective RCx Activities.**
Successful building system optimization and RCx projects require buildings with high potential for realizable operational savings. Buildings may be less desirable candidates for building system optimization and RCx due to their small size, their age, general level of maintenance, equipment types and imminent need for a major retrofit, or a lack of an automated building control system. Screening

³ PECL. 1998. National Strategy for Building Commissioning. U.S. Department of Energy.

⁴ PECL. 2000. California Commissioning Market Characterization Study. Report prepared for Pacific Gas and Electric Company.

- requirements will assure that the program does not invest in buildings that are poor physical RCx candidates.
- **Owners will be involved early, and screened based on their willingness and ability to undertake initial program steps.** As mentioned above successful projects require owners willing to invest capital and human resources in the project. Early owner recruitment and participation steps involve some owner decisions and actions including review and approval of a project scope and support of the RCx provider. Owners that cannot or will not undertake these initial steps are not likely to follow through with the subsequent building system optimization and RCx requirements.
 - **Building operators will be involved early based on their willingness and ability to be an integral part of the RCx process.** If the building owner does not have the support of the facilities staff, the likelihood of successful RCx program and savings persistence is low. The facilities staff must eventually deal with any changes made, so they need to be supportive and understanding of any changes. The owners need to allocate appropriate time and/or budget so that the facilities staff can adequately support the RCx process. Along with the owner, the facilities staff should be involved in the decision of which measures should be implemented. A designated staff member will be the point of contact for this portion of the process. Owners that cannot get this degree of buy in from the facilities staff are not likely to be able to successfully follow through with the subsequent building system optimization and RCx requirements.
 - **Targeting owners that have already engaged in energy efficiency activities and experienced success.** To keep projects moving through owner's decision processes, the identification of an internal champion is helpful. These people are likely to exist within organizations that have already undertaken efficiency upgrades, participated in earlier utility or third-party programs or employ graduates of the Building Operator Certification program or employ staff with documented RCx training. These owners are excellent candidates for taking the next step and pursuing increased operating efficiencies. The program will target these owners as a priority. Targeting and recruiting good owner candidates will reinforce the building screening and owner involvement elements above.
 - **Ensuring the persistence of savings through carefully targeted requirements for building documentation, training, and energy tracking.** A challenge in the building system optimization and RCx process is how to prove that the benefits last. Verifying persistence of savings is a key goal of this program. The systems and methodologies developed to produce long-lasting results are a result of the most recent experience and research in monitoring building performance, working with building operators to understand their needs, and delivering building system optimization and RCx training to the appropriate audiences. Through these experiences, documentation and monitoring requirements will be streamlined to ensure the program delivers persistence of savings in a cost-effective manner.
 - **Building the building system optimization and RCx infrastructure by providing consistent protocols suited to different building sizes and complexity, and thoroughly training service providers on the program.** The SCE RCx Program will utilize the traditional trade ally design – a framework that

has worked well for California utilities' past programs. For medium sized buildings and less complex systems, specific defined assessment protocols to identify building system optimization opportunities will be developed from those currently in use in today's market. These protocols will allow quick efficient assessments of system components and functions to identify opportunities and then employ specific analyses to further qualify the measure, and quantify the savings potential and define the scope of the correction. For larger buildings and more complex systems, the program will utilize a uniform set of RCx protocols and templates that will allow skilled providers flexibility in the diagnostic approach while yielding consistent deliverables from the process that conform to program requirements. As practical, web based tools may be used to enhance the reporting and resolution of issues among the participants. Participating service providers will be extensively trained in the use of these tools and their deliverables will be monitored to ensure compliance with program requirements.

- **Processes will be developed to ensure that the process moves along at a reasonable rate and takes into account problems typically encountered.** A timeline that identifies typical milestones will be established. Allowances for typical delays (e.g. trending of data) will be included to ensure that realistic time expectations are created. Owners and RCx Service providers will need to meet their obligations with respect to the schedule to ensure that the project can be completed successfully.
- **A qualification process for service providers will be developed.** Due to the likely variation in building type, equipment, and control system, and location, it will be necessary to have a flexible process to obtain service providers for each individual project. This process will screen providers for required attributes including capability, cost, and experience with specific systems including controls, relationships with outside contractors, training capabilities and geographic location.

9. Program Objectives

The program will provide optimization of existing buildings within the SCE service territory. Program benefits include demand reductions and energy savings. Coordination with Southern California Gas Company will be included with projected therm savings as part of this

The program is designed to expand building system optimization and RCx capabilities in SCE's service territory with program features that directly address market barriers, as well as to ensure the persistence of the program benefits.

process. A total of 40 million square feet of space will be retro-commissioned as part of this program. Ancillary benefits include improved occupant comfort, increased equipment life, increased training of the building operators, and a training program for the RCx community.

10. Program Implementation

SCE's Retro-commissioning (RCx) Program is a unique energy efficiency effort aimed at cost-effective peak energy and demand savings. Incentives for gas based measures found as part of the RCx process will be coordinated with Southern California Gas Company. The program is designed to expand building system optimization and RCx capabilities in SCE's service territory with program features that directly address market barriers, as well as to ensure the persistence of the program benefits. These objectives are met through the development of building and owner/operator candidate screening protocols, use of specific building system optimization and RCx protocols, building operator and commissioning provider trainings, and building operation tracking systems. Additional management tools will be used to keep the project on schedule and to assist with program and project budgeting. Furthermore, to effectively market the program services, the program will leverage existing relationships among building owners, participation in other SCE retrofit programs, participants in the Building Operator Certification program, and local governments.

Overview of Program Process

The Program will provide the initial screening of the candidate buildings. Approved candidates will be required to enter into an agreement with the program to ensure dedication to the process.

The program will assist owners in selecting a commissioning provider from the pre-qualified provider list if they are not already working with one. The building system optimization and RCx provider will contract directly with the owner, and all incentive payments will be made to the owner with the exception of the investigation scope and bid payment.

After the investigation scope and bid, a customer with a building with non-functioning equipment will be directed to complete repairs that affect the ability to perform RCx services. Next, the building system optimization and RCx provider completes the investigation, helps the facility staff to select items for implementation, aids implementation when necessary, and sets up the tracking system.

Required or recommended retrofit items will be referred to applicable rebate programs if the owner is interested in implementing these measures. If applicable, these measures can be evaluated as part of the RCx process.

The program will tap into the existing commissioning industry in California for RCx services and will assure long-lasting benefits by completing the following tasks: Appendix A contains a program implementation flow chart that supports the followings process summarizes.

RCx Project Screening and Marketing

A comprehensive means will be used to screen buildings and their occupants for participation in the program. The goal of the screening process is to ensure that the proper buildings with interested owners and operators are selected for the program.

Considerations such as building EUI, equipment type and condition, building usage, funding, and building operator interest will all be considered.

Marketing of the program will be directed from a pre-screening of the applicants and through other vehicles such as a web site and project brochures.

RCx Provider Selection

The program will publish eligibility criteria for commissioning providers and will evaluate provider qualifications for eligibility. Eligibility criteria will include demonstrated experience in building lighting, HVAC and refrigeration systems, engineering, control systems, diagnostics, monitoring, data analysis, functional testing and energy savings calculations and approved pricing structure. These qualifications include work experience, training and/or education, and employee licenses or certifications. Additionally, the RCx provider will be required to have on staff or via subcontracts, personnel that are capable of operating and programming a variety of control systems, and have software and/or hardware keys and qualifications to use them. Requirements for liability insurance and appropriate licensing will also be required. Due to the expected diversity, sizes, and locations, multiple vendors for specific types of work and/or subcontracting of portions of the work may be considered as part of this process.

The program will pre qualify RCx contractors for participation in the program. An initial qualification process will be initiated at the start of the program to ensure that the contractors are pre-qualified prior to the initiation of the RCx process in order to expedite the RCx process. Although the pre-screening will be done at the program onset, the process will be left open so that buildings requiring special skills, specific controls contractors, or a vendor of the owner's choosing can be accommodated as required. Applicants will be qualified and identified by particular skill sets that they bring to the program. A pool of qualified contractors will be available for the program projects. The program will be able to drop an RCx provider from the RCx provider pool and or a job due to non-performance, inaccurate projections, poor quality work, lack of timelines, owner complaints, lack of cooperation, etc.

Upon acceptance of the RCx process, the owner will be able to choose an RCx contractor of their own choice or one from the pool. The program will match appropriate contractors to a particular site based upon such factors as controls capability, engineering capability, RCx provider workload, and geography. If a particular match does not exist, the existing contractors with the most similar background will be asked to see if they can expand their capabilities (e.g. add separate subcontractors for a different control systems) to match a particular site.

RCx Hardware Contractor Selection

In general, contractors to perform hardware related work (valves, control sensors, VFDs, etc.) will be approved by the RCx program. In general the contractors used or referred by the current building staff will be utilized as long as they meet basic requirements including appropriate licenses, insurance, and qualification for the particular job. The RCx program will approve these contractors.

In cases where the existing building staff does not have a contractor for a specific portion of the work, other contractors will be qualified and contacted as needed for specific work.

Building system Optimization and RCx Protocols

For medium sized buildings and less complex systems, specifically defined assessment protocols to identify building system optimization opportunities will be developed from those currently in use by RCx providers. Specialized types of buildings may also have specific types of templates. These protocols will allow quick efficient assessments of system components and functions to identify opportunities and then employ specific analyses to further qualify the measure, quantify the savings potential and define the scope of the correction. For larger buildings and more complex systems, the program will utilize a uniform set of RCx templates. While allowing for flexibility for individual commissioning provider styles, the protocol is a framework that will provide the requirements for the program, and shall create clear expectations for commissioning providers and customers. These templates shall also provide some level of quality control. Commissioning providers that qualify will complete a thorough RCx process using protocols that include candidate screening, building investigations, and implementation of deficiency corrections to achieve savings that persist over time.

Building system optimization, RCx Training and Orientation

To build the infrastructure for quality RCx process, a building system optimization and RCx orientation will be made available to potential and existing service providers. Qualified providers will be required to participate in a Program Orientation. The orientation will summarize how the retro-commissioning process will be operated in order to ensure consistent delivery and implementation. The Program Orientation will cover the required RCx program protocols and templates for the scoping studies, the RCx analyses, implementation of fixes, documentation, operator training, and operational tracking system.

Participants will benefit from working with an experienced commissioning provider in a well-developed framework for providing building system optimization and retro-commissioning services. Orientation topics include:

1. Scoping – tools and techniques
2. The system approach
3. Efficient methods for uncovering problems
4. Working with the building staff
5. Calculating the savings
6. Environmental impacts of reduced energy consumption
7. Implementing the findings
8. Providing a targeted Systems Manual
9. Building system assessment protocols

Participants will leave the orientation with an understanding of the building system optimization and RCx processes and how to apply that process in this program's building

stock. The emphasis of the orientation is on the operation of the program, not how to retro-commission a building.

A separate training component with more emphasis on the general process and less emphasis on the program specifics will be offered as a one time course for interested building owners, building operators, service providers and decision makers.

RCx Incentive and RCx Process

The Building RCx program will provide incentives to the owners as a means to get them to undergo the RCx process and to implement the recommendations in a timely manner. The incentive process is a multi faceted approach that is meant to provide value to the customer, to the utility and to the operators of the buildings.

Upon approval of the RCx process by the owner, an initial fee may be charged to the owner. This fee is meant to financially engage the owner in the process at the beginning. The RCx Provider may bill both the RCx Program and the owner (the owner will share a significant part of the RCx process cost) on a regular basis through the project duration.

The RCx Program will allocate an incentive value per building based upon size, Energy Usage Index (EUI), and building type. A funding cap will be set for both the RCx process and incentives. This total budget will be used to fund a significant portion of the RCx process and the approved controls programming changes, with the balance being used for hardware/labor buy downs that are not appropriate or funded by other programs. This split is meant to encourage owner financial involvement in the process and to encourage the funding of controls changes rather than major hardware changes (pure retrofit work) from RCx funds.

The RCx Program will develop a formula for doling out the hardware/labor buy downs for a given budget. In general, the following rationale will be used to allocate and approve measures for funding incentives that are not strictly controls based, although similar considerations will be use to approve control changes.

- Does the measure have a payback from 1-3 years?
- Does the measure help meet the energy goals for the program?
- Will the measure improve occupant comfort?
- Will the measure improve equipment lifetimes?
- Does it make sense to and is their project time to fund this measure from another incentive program (The emphasis on this program is RCx and not pure retrofit measures)?
- Will this measure help other measures save more?

For measures with outstanding paybacks (after incentive) of less than one year, the owner will be expected to contract for this work and pay for the amount not covered by the incentive as a requirement of the program. For measures with outstanding paybacks over 3 years, the owner will be given incentives to take advantage of the measure, but is not required to do so as part of the program contract. The RCx provider will provide an

estimated payback prior to the implementation phase. Rebates will be calculated based upon installed costs and any quantification of energy cost savings that is done after installation. All hardware incentives will be paid to the owner by RCx Program at the successful completion of the program.

For the purposes of evaluation, measures are split into three groups.

- O&M and minor repairs (Fan belts, equipment tune ups, filters, broken gauges, etc.)
- Control repairs/enhancements (programming effort, broken sensors, broken actuators, etc)
- Major repairs (VFDs, major hardware repairs or replacements)

Both during the program and during the evaluation of the measures, the RCx Program will group the measures into the appropriate category using the basic strategy indicated below. For items in all categories, the RCx provider will provide an engineering estimate of cost savings and implementation cost that yields a payback value.

Incentives for each type of measure will be paid as indicated for measures that have been approved by the building operator, building owner, and the RCx Program. Non approved measures will not be funded, but may be implemented at the owner's expense if desired.

For O&M and minor repair items, these items will be identified during the RCx process by the RCx Provider. Per the RCx contract terms, these items will probably be limited to \$500 or less (each) and the cost and labor for the repair will be the full responsibility of the owner. The intent is that this will be covered by the owner's O&M budgeting and personnel. The RCx Provider will review and approve these fixes and coordinate any related programming with the owner's contractor.

For control repairs, these items will be identified during the RCx process by the RCx provider. For typical programming issues, the cost will be shared between the RCx process and the owner with a significant cost share. For control hardware costs, the owner will contract with a separate contractor to perform the installation/repair work. SCE/Admin will rebate the owner for this work based upon the guidelines indicated previously. The RCx provider will review and approve the hardware installation/repair.

For major repairs, these items may be identified both initially and during the RCx process. For critical problems that impact the RCx process near the onset (first portion of the RCx timeline), the owner will be required to pay the non-incentivized portion of the cost. If the owner refuses/cannot pay, the RCx will be stopped at this point, with the owner required to pay their share of any outstanding monthly fees to the RCx provider. For other major repairs found late in the process, the incentives will be evaluated using the criteria indicated previously. The owner may or may not decide to approve these measures.

At the completion of the project, interested building operators will be eligible for a rebate for the BOC class. At the completion of a successful course, the owner of each building with an operator will be paid for a maximum of two operators per building attending the courses. Because of the program and course timing issues, the program will be limited to 60 trainees that would most likely come from the first buildings that are RCx'd.

Program Completion

At the end of the program, the full process will be evaluated for as built conditions and documentation will be provided to the building owner. This documentation shall consist of training information, final performance and costs, targeted documentation of the RCx'd systems and a final report.

As indicated above, operators will become eligible for the BOC program incentives at the completion of the project. If applicable, after one year, the building may be reviewed for Energy Star[®] qualification by the RCx provider. Alternately, if interested, the owner will be provided with the documentation required by the RCx process of the LEED-EB program.

Ongoing RCx Program Operations

To ensure success of the RCx program, a quality control process will be established. The program will provide oversight and technical assistance to the commissioning providers and modify the program procedures to ensure that owner/management firms are being well served by the commissioning providers.

Oversight

Throughout the program, documentation from each step of the RCx project will be reviewed. The table below lists the documents that will be reviewed.

RCx Phase	Quality Control Documentation
Screening	Screening report and Owner agreement
Scoping	Investigation scope and bid
Investigation	Findings list with energy savings calculations and cost estimates Owner and operator approval of proposed measures form
Implementation	Confirmation of implemented measures
Persistence of Savings	Targeted Building Systems Manual Integrate RCx process with Building Energy Monitoring System. Tracking System Documentation Training Documentation Final Report

Ensuring Persistence Through Performance Tracking

Recently conducted studies of RCx persistence have found a greater persistence of commissioning benefits when building operators were well-trained and tracked building

performance⁵. Experience has shown that well-informed owners and operators not only ensure that RCx savings persist, but they also work to create additional savings. Savings need to be monitored and actions need to be taken periodically to fine tune building performance.

The commissioning providers will propose and implement a tracking system to monitor the improvements implemented in each building. The program will assist in the

development of
where needed.
will track
for verification
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of
and will

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critical points
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improvements,
provide that

information to the program and the building operators. This approach ensures a high level of confidence in the realization of the savings from this program.

11. Customer Description

Nonresidential medium and large customers in the commercial & industrial, government and institutional segments are the primary customer groups. Office buildings, retail malls, supermarkets, hotels, institutional facilities, and public buildings would all be eligible under this program. The common portions of residential occupancy that has commercial meters would also be eligible (e.g. condos with central HVAC). The primary market actors targeted will be the building owners and key financial decision-makers.

Desirable characteristics we look for in buildings include:

- Greater than 100,000 square feet - smaller areas may be justified for applications with higher potential energy savings that meet other criteria
- Owner occupied
- Owner able to commit to capital expenditures within 6 months or less of agreement
- Owner maintained
- Utilizes direct digital controls (DDC) for the primary operation of building systems to undergo RCx
- DDC system values can be readily trended using existing software and hardware
- HVAC and/or refrigeration systems primarily consist of built-up equipment or central plants rather than unitary equipment.
- High electricity and gas consumption
- Mechanical equipment in relatively good condition
- Building not commissioned or retro-commissioned within the last five years

12. Customer Interface

⁵ H. Friedman, A. Potter, T. Haasl, D. Claridge, S. Cho, "Persistence of Benefits from New Building Commissioning", Proceedings of 11th National Conference on Building Commissioning, May 20-22, 2003.

Although the RCx process is somewhat more complex than many energy efficiency programs, this program is designed to act as a single point of contact for a building retro-commissioning process. This feature will allow the customer to go to a respected entity (SCE) that will be dealing with many of the complexities of the process including defining a process, qualifying providers, overseeing the implementation and providing estimates of energy savings and cost impacts. This will relieve the customer from having to investigate many of the activities that they may not be familiar with. Typically, the program will be presented to the customer via SCE's marketing process. Alternately, the customer may get information about the program through a website.

Screening will be done to ensure the customer meets the program guidelines, which will consist of quick facility walkthrough and some brief questions. Once the customer has been approved via the screening process, an agreement will be developed that summarizes the program scope including likely customer costs, customer time commitments, likely sources of inconvenience, and work being done by the RCx provider. Upon the completion of the investigation phase of work, the RCx provider will present a list of recommended measures to the Customer and to the RCx program. The customer and the customer's facility operator will need to review and approve any proposed measures to ensure they are comfortable with the operational and cost ramifications (including incentives). During the implementation phase, the RCx program and the RCx provider will work with the owner to ensure that the measures are installed and operate properly prior to being accepted.

One feature of this program is that appropriate retrofit measures identified as part of this process will be referred to the appropriate retrofit measure efficiency programs, which should make the identification, qualification, rebating and evaluation of these measures less intrusive for the owner and more integral to the retro commissioning process. Conversely, demand response opportunities identified as part of this process will be referred to the appropriate demand response efficiency programs, which should make the identification, qualification, rebating and evaluation of these measures less intrusive for the owner and more integral to the retro commissioning process.

13. Energy Measures and Program Activities

13.1. Measures Information

If the owner expresses an interest, appropriate demand response items will be identified as part of the energy efficiency review process.

Typical HVAC Measures Information

Measure information is provided in the corresponding cost-effectiveness calculator and portfolio workbook.

The SCE RCx Program will target common problems found in HVAC, DHW and lighting systems, and will include measures to address the following systems:

Chillers – Chillers are often the single biggest equipment loads in commercial and institutional buildings and almost always set the peak summer demands. Operators tend to be more concerned with maintaining comfort than they are about the energy efficient

operation of the equipment. Consequently, three operating scenarios commonly occur that result in excess energy use. These are usually easy to remedy by reprogramming the building automation system. The three common scenarios are described below:

- **Chilled water set-point too low.** Operators often lower the chilled water set-point during periods with peak cooling loads. However, they forget to reset it and it remains at the low value continuously or until they receive complaints of discomfort. Raising the set-point by a few degrees during periods of smaller loads can save substantial amounts of energy. Often automatic chilled water reset controls have been overridden or were never employed during the initial start-up of the chiller system.
- **Improper staging.** Most electric chillers are more efficient operating at higher loads. Many buildings will have more than one chiller. Quite often two chillers will operate at low loads, when one has sufficient capacity to meet the load. For more energy efficient operation (as indicated by the IPLV of the chillers), a single smaller chiller should be used to meet lower loads, and multiple chillers used to meet the higher ones.
- **Chillers energized when unnecessary.** Chillers are often operated when outdoor air can meet cooling loads with airside economizers. This results in the chiller being operated at low loads when they are not needed. Carefully determining the “balance point” of the building and then setting an appropriate ambient lockout temperature can reduce the number of hours a chiller is operated.

Collecting and analyzing chiller performance data is the only way to determine if their dynamic performance is optimal. Potential chiller problems that are investigated using time series data include: proper staging, proper temperature resets, meeting load or drifting, maintaining proper temperature differentials, short cycling, and calculated efficiency (kW per ton).

Cooling Towers – Cooling towers are a key component of most large cooling systems and their performance and operation can have a large impact on the efficiency of the chillers and the total energy use and peak demands of the entire cooling system. The following four common operational characteristics of cooling towers can cause excess energy consumption:

- **High condenser water temperatures.** Similar to the condition for chilled water temperature discussed above for chillers, the condenser water temperature is often set too high. Chillers run more efficiently at low condenser temperatures. Chillers will operate with lower temperatures than are typically programmed.
- **Excessive cycling of fans.** This condition is most common on large towers with single, constant speed fans. Excessive cycling is common at low loads and causes wear on motors and drive systems (belts, pulleys, etc). This condition can be reduced by slightly increasing the control deadband of the condenser water setpoint or installing two-speed motors or variable speed drives.

- **Improper staging of fans.** Multiple sets of fans are not programmed in a manner that provides the most cooling for the least energy.
- **Poor maintenance.** This reduces heat transfer efficiencies and requires excess fan energy to reject heat from a tower. It is often a result of poor water treatment.

Time series performance data collected on cooling towers is used to investigate: approach to wet bulb temperatures, condenser water temperature differential, condenser water reset, and fan cycling and staging. Static tests are not sufficient to investigate these parameters over a range of operating conditions.

Boilers – Boilers are a key component of most large heating systems and their performance and operation can have a large impact on the efficiency of the entire heating system. The following four common operational characteristics of pumps can cause excessive energy consumption:

- **Excessive hot water temperatures.** Boilers are often set to run at 180 F, which is often higher than required. Enabling of temperature resets can be used to optimize the hot water temperature to the load.
- **Excessive cycling of boilers.** Sequences of operations may not properly turn the boilers on and/or off due programming.
- **Improper staging of boilers.** Multiple sets of boilers are not programmed in a manner that provides the most heat output for the least energy.
- **Boilers when not required.** Due to the limited RH requirements in Southern California, re-heat systems do not typically need to be active during many periods of the year. Controls will be checked to ensure that appropriate lockouts are enabled and operable.

Time series performance data collected on pumps is used to investigate hot water supply and return temperatures, boiler enable and outdoor air temperature. Coordination with Southern California Gas Company will be done for gas boilers.

Pumping – Pumps are a key component of most large central plant systems and their performance and operation can have a large impact on the efficiency of the entire cooling system. The following three common operational characteristics of pumps can cause excessive energy consumption:

- **Unnecessary balancing valves.** Pumps are often over designed, resulting in the use of balancing valves to cut back flow. This wastes a lot of energy. Trimming impellers and/or adding variable speed drives can replace the need for the major balancing valves. Additionally, the replacement of two way valves at airhandlers will result in enhanced savings with variable pump flow.
- **Excessive cycling of pumps.** Sequences of operations may not properly turn the pumps on and/or off due programming.
- **Improper staging of pumps.** Multiple sets of pumps are not programmed in a manner that provides the most pumping for the least energy.

- **Pumps run when not required.** For various reasons, pumps often run when not required, consuming considerable amount of energy. Re-programming can quickly solve this problem.

Time series performance data collected on pumps is used to investigate: pump cycling and staging.

Economizers – Economizers are designed to reduce the need for mechanical cooling when outside air conditions can provide “free cooling.” Only a small percentage of the economizers we have studied actually work properly. The following four common operational faults in economizers can cause excess energy consumption and increased peak demand:

- **Outside air damper at minimum.** Outside air dampers are locked in the minimum air setting and “free cooling” is never realized. Mechanical cooling is necessary at times when free cooling should be available. This increases the cooling requirements in morning and evening hours, as well as during the cooler swing months.
- **Outside air damper open.** Outside air dampers are locked in the maximum air setting and free cooling is realized, but the peak loads are increased. These excess loads are particularly prevalent during the hottest hours on summer months.
- **Actuator failure.** Either of the two conditions above may result if the actuator has failed. Additionally, temperature and RH sensors may have failed or be out of calibration, resulting in improper operation.
- **Improper logic.** Economizer has not been configured as an integrated economizer and thus does not sequence properly with the chilled water valve. This additional programming can save significant energy.

Air Side Delivery – Air handlers (AHUs) are the key to climate delivery and efficiency. The following five common operational faults in AHUs can cause excess energy consumption and increased peak demand:

- **Poor Balancing.** Either the result of a poor initial air balance or the result of changes, air balance is not proper. Resulting in comfort and performance problems. In some cases, there may be inadequate airflow which causes comfort problems.
- **Variable flow not properly operating.** For older units with vane axial controls, these controls have often failed. Newer units with VFDs may not be operating properly due to VFD failure, sensor miscalibration, etc.
- **Inefficient Power transfer.** Belts are worn, rubbing or not properly aligned. Simple fixes can improve system operation and reduce wear and tear.
- **Valve actuator failure.** Chilled water and/or hot water valve controls may have failed, resulting in limited temperature control and /or comfort problems. Repair or replacement of the actuator and/or valve will yield better temperature control and reduced energy usage.
- **Improper logic.** Misunderstanding of damper controls and speed control algorithms results in dampers being closed or modulated improperly, thereby driving up the amount of fan energy required.

Restoring economizers to proper operation reduces energy consumption. Only time series data will reveal these problems over a range of operating conditions. It will also clearly show the interaction between the operation of system components, such as the economizer and chiller or compressor.

Zonal Terminals and Controls – Often, heating and cooling are supplied to spaces at the same time when not required for humidity control. This can happen if a space is cooled and heated using independent controls. The heating and cooling systems can run simultaneously without causing perceptible comfort problems, so these conditions are rarely reported to maintenance personnel. Eliminating simultaneous heating and cooling is often a matter of the following inexpensive changes:

- Coordinating setpoints and educating staff on their impact for energy savings
- Locking out the heating during summer months or via temperature controls
- Reducing over ventilation
- Repair or replace zonal sensors or actuator controls that may have failed
- Add zonal supply air temperature resets that may reduce the need for re-heat during dry periods of operation or low load
- Changes to control logic

Controls – Control systems are often the most problematic system in a building. Improving and changing the controls to a building can result in significant energy savings. The following strategies are commonly implemented during retro-commissioning:

- Scheduling for HVAC systems according to demand and required warm-up/cool down
- Correctly programming reset schedules for supply air and hydronic systems
- Recalibrate or repair sensors that are not functioning properly. For outdoor sensors, ensure that the sensor is properly shielded from the sun
- Correcting operation when VFD turndown is limited
- Configure VFDs to operate in variable torque mode
- Improving the ability to meet setpoints without valve hunting or cycling of equipment
- Reducing leaks in pneumatic control systems
- Addressing interactions between systems to avoid cascading instability

Control problems can be found through observation and analysis of time series data. Retro-commissioning addresses the root cause rather than a work-around that may have been implemented if a resultant symptom was being addressed.

Typical Lighting Measures Information

Measure information provided in corresponding cost-effectiveness calculator and portfolio workbook.

Luminaires – Improving and changing the luminaires in a building can result in significant energy savings. The following strategies are commonly implemented during retro-commissioning:

- For applications where lighting runs continuously and is inefficient retrofit measures are recommended (the rebates would be offered via other existing programs)
- Address any maintenance issues that impact existing lighting systems (relamping, cleaning, etc.)

Controls – Lighting control systems are often the most problematic part of the lighting. Improving and changing the controls to a building can result in significant energy savings. The following strategies are commonly implemented during retro-commissioning:

- Scheduling for lighting systems according to usage
- For older buildings, no easy way to turn lighting off when not needed
- Recalibrate or repair sensors (occupancy and photocell) that are not functioning properly.

Control problems can be found through observation and analysis of time series data. RCx addresses the root cause rather than a work-around that may have been implemented if a resultant symptom was being addressed.

Typical DHW Measures Information

Measure information is provided in the corresponding cost-effectiveness calculator and portfolio workbook.

Heaters and Re-circulation – Heaters are a key component of most large DHW systems and their performance and operation can have a large impact on the efficiency of the entire DHW system. The following four common operational characteristics of pumps can cause excessive energy consumption:

- **Excessive hot water temperatures.** Heaters are often set to run at 140 F, which is often higher than required or allowed by code if there is no tempering. Lowering set-points will save energy.
- **Re-circulation controls not configured properly.** Times and/or setting may not be appropriate, wasting energy and/or keeping the system from providing hot water at the required times.
- **Aquastat Controls.** Aquastat controls may be set inappropriately or have failed, wasting energy and/or keeping the system from providing hot water as required.

Typically on site measurements can be used to diagnose these issues. Coordination with Southern California Gas Company will be done for gas heaters.

13.2. Energy Savings and Demand Reduction Level Data

Energy savings and demand reduction information is provided in the corresponding cost-effectiveness calculator and portfolio workbook. Assumptions are indicated below.

Although several other RCx programs have been implemented in various locales, the type, scope and mechanism of delivery has varied substantially. Although some of the programs are in California, some of them are on the East coast (NYSERDA) or Pacific Northwest (Northwest Energy Alliance, 2003), with different energy costs, climate, and equipment types. Some programs are utility incentive programs, some are utility partnership programs, and some are third-party programs that cost share identified measure costs. Program scopes have varied from HVAC to multiple system types. This program is intended to address some items that have been adopted in some of the other programs. The reasoning behind this is that the cost and effort on the part of the customer to evaluate these other items is lower than if multiple evaluations are done. Among these are the inclusion of lighting and DHW as part of the standard scope, including gas system evaluation. Additionally, the scope is to contain some evaluation of demand response potential, water savings measures, and enhancement of the current building control system to allow for “monitoring based commissioning.”

As a result of the variation in the programs, there is no clear best set of numbers upon which to base the program costs and savings from. However, there is a range upon which these assumptions are built. The two most relevant programs which are both in SCE territory are not far enough along to fully substantiate completed costs and savings. Additionally, the delivery mechanisms of the two programs are substantially different. The BTU program is a third-party program that has a scoping phase, a detailed investigation phase, and an implementation phase. This program relies heavily upon walkthroughs and data collection to identify problem issues. The SCE/Los Angeles County Partnership program is formed much as the construction phase of a new building commissioning program would be with pre-functional, functional and re-testing phases. Additionally, the county is devoting considerable resources and commitment to the program that may not be available on a general program basis. Consequently, the program cost for the partnership would be larger than the BTU program. It is planned that the proposed program’s scope will fall midway between the two programs with more scope and incentives than the BTU program, but less testing of equipment than the partnership program.

The cost range for programs has varied from approximately \$0.09 to \$1.42/ sf. A figure of \$0.50/sf was selected based upon it being slightly higher (6%) than the high end of the range of programs that account for buildings of similar type and location (PECI “California Commissioning Market Characterization Study, 2002). The increased cost is included to deal with additional scope items indicated above and is about 10% less than the buildings in the Northwest Energy Efficiency Pilot Program (2003).

Energy savings across the various programs also varied dramatically, depending upon many factors, including the scope of work and building type. As there will not be a fixed building type for this program, it is assumed that a wide variety of buildings will be encountered. A figure of 1.22 kWh/sf-year was selected as the projected energy savings in kWh/SF-year. This figure is consistent with the North West Energy Alliance program. Likewise, gas savings of 0.056 therms /SF was based upon the same study. Although the

SMUD study (Evaluation of the Persistence of Savings from the SMUD Retro-commissioning Program, 2004) shows considerably lower savings, it should be noted that many of the buildings were less than 10 years old or recently renovated, which is considerably newer than the mean age of buildings anticipated for this program.

The projected incentive cost is \$0.18/sf. This is 20% higher than the current figure being used in the BTU program. The reason to increase this cost was to help get owners committing to the process quicker (which has been an issue in the BTU program) and to allow increased cost for more implementation scope and support including documentation, training, and monitoring based commissioning. This incentive consists of several components including the investigation (cost shared), programming measures (cost shared), and incentives for major measures that are not incentivized through other sources.

The established effective useful life (EUL) for many of the defined measures is 14 years (Energy Management System). It has been assumed that most of the equipment in the affected building has no more than 10 years of life on average remaining. Thus the baseline EUL was lowered from 14 to 10 years or roughly 70% of the standard value to account for the fact that the equipment is not new (except for some hardware replacements).

NTG was assumed to be 0.80. This is the default for programs that do not have other supporting evidence for an NTG value. Although the bulk of building owners will not currently pursue RCx unless given incentives or enticed, because of the growing use of LEED-EB (LEED for existing buildings), it is assumed that a small portion of the RCx work would be applied for buildings that are pursuing this certification.

13.3. Non-energy Activities

The program activities that support the energy savings achieved, but do not directly achieve energy savings by themselves are as follows:

- Investigation scope and bid
- RCx investigation, including a findings list and simple payback analysis
- Service provider orientation on building system optimization and RCx
- Optional incentives will be provided to interested participant building operators that are interested in pursuing Building Operator Certification.

Each of these activities is described in detail under Program Implementation.

13.4. Subcontractor Activities

The RCx provider will provide the full retro-commissioning support for the process. This includes activities detailed elsewhere including on-site scoping and investigation work, data collection and analysis, evaluation of cost and energy savings, modifications of controls and implementation of controls based measures.

Additional subcontractors will be used as needed for major repair or retrofit items discovered during the RCx process and not funded otherwise.

13.5. Quality Assurance and Evaluation Activities

Initial inspections will be randomly inspected upon completion of the retro-commissioning by the service provider. The installation verification will be done by confirming if the installed measures match the measures indicated in the report. Inspections will be made prior to payment.

13.5.1. Expected Number/Percent of Inspections

Approximately 10% of the sites will be inspected. At each site, approximately 1/3 of the total measures will be verified, including at least one for lighting and DHW measures, as applicable.

13.6. Marketing Activities

Currently, market demand for RCx services is still low, except in certain markets where long-term ownership interests are high, such as government buildings and schools.

The RCx program will identify potential new candidates using customer billing data. This will provide a list of possible sites for the screening process. In addition, the marketing plan is designed to recruit and leverage existing customer contacts and networks from within previous utility programs as well as from local governments. The target audience is best approached through existing relationships. SCE and local governments are the best source of existing relationships that can be tapped for recruitment. Commissioning providers and the program itself will also recruit owners.

A separate training course will be made available to train the decision makers about the retro-commissioning process. This will be tied into the marketing program.

The marketing messages will be designed to inform owners about building system optimization and RCx and to spur them to take advantage of the energy saving opportunities offered by the program. The marketing plan provides materials that have consistent messaging from credible sources and can be used by the providers, SCE, local governments, and program staff to build awareness and enroll participants. Marketing materials will be designed with a consistent look and message. Materials will include a brochure, fact sheets, and presentations that can be customized. The materials will explain the program approach, the energy savings potential, and available financial assistance, and include brief case study information. SCE, local governments and RCx providers may use the materials to aid in project recruitment.

A program webpage will be an integral part of promoting the program. It will contain all the marketing materials in an easy to download format. In addition, it will contain the program requirements, the RCx protocols and RCx resources for providers and owners. Means to share information among the various parties may also be integrated into this site.

14. Program Changes

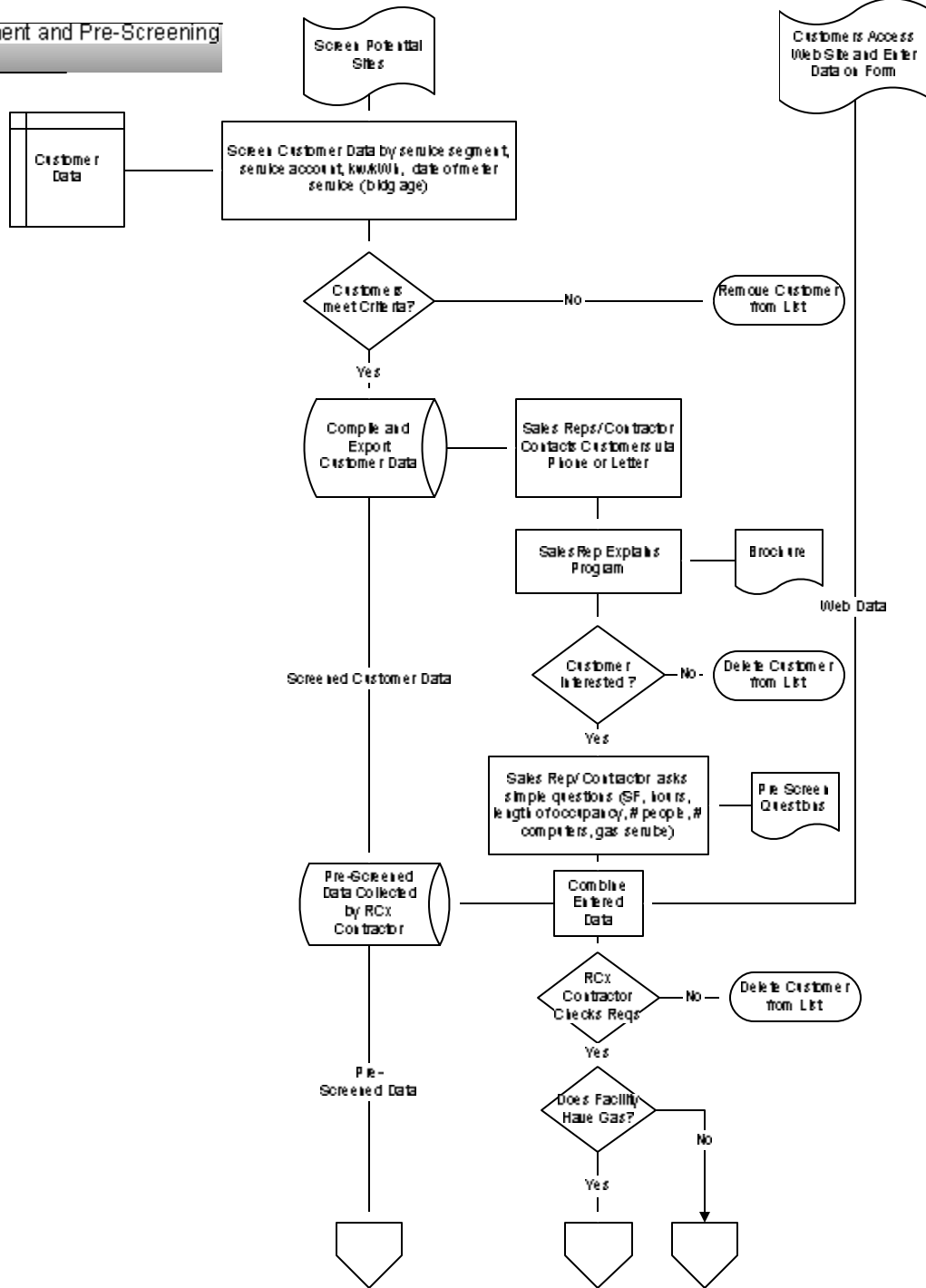
The following summarizes the major changes made since the June Filing:

1. Refrigeration was explicitly added as a measure type option.
2. The scope of area was corrected to be 40 million square feet.
3. Added the allowance that specialized types of buildings may also have specific types of templates.
4. The requirement for a length of one-day orientation was dropped to allow for more flexible delivery methods such as online delivery.
5. The requirement for an upfront delivery fee and monthly cost share with owner was loosened to allow for flexibility in cost share.
6. The specific cost share for the BOC class was loosened to allow for flexibility in cost share.
7. Added clarification to the targeted customers to explicitly include supermarkets and multi-family housing with commercial service.
8. Added flexibility to the targeted building square footage to allow buildings with high energy usage and small areas to be targeted.
9. Corrected the incentive levels to be consistent with the E3 calculator.
10. Updated EUL discussion to be consistent with the latest update to the DEER database.
11. In the program process and diagrams: Clarified the program process to have a single prime contractor that implements the program with a possible implementing subcontractor and RCx provider subcontractors. The use of a separate screening subcontractor has been deleted.

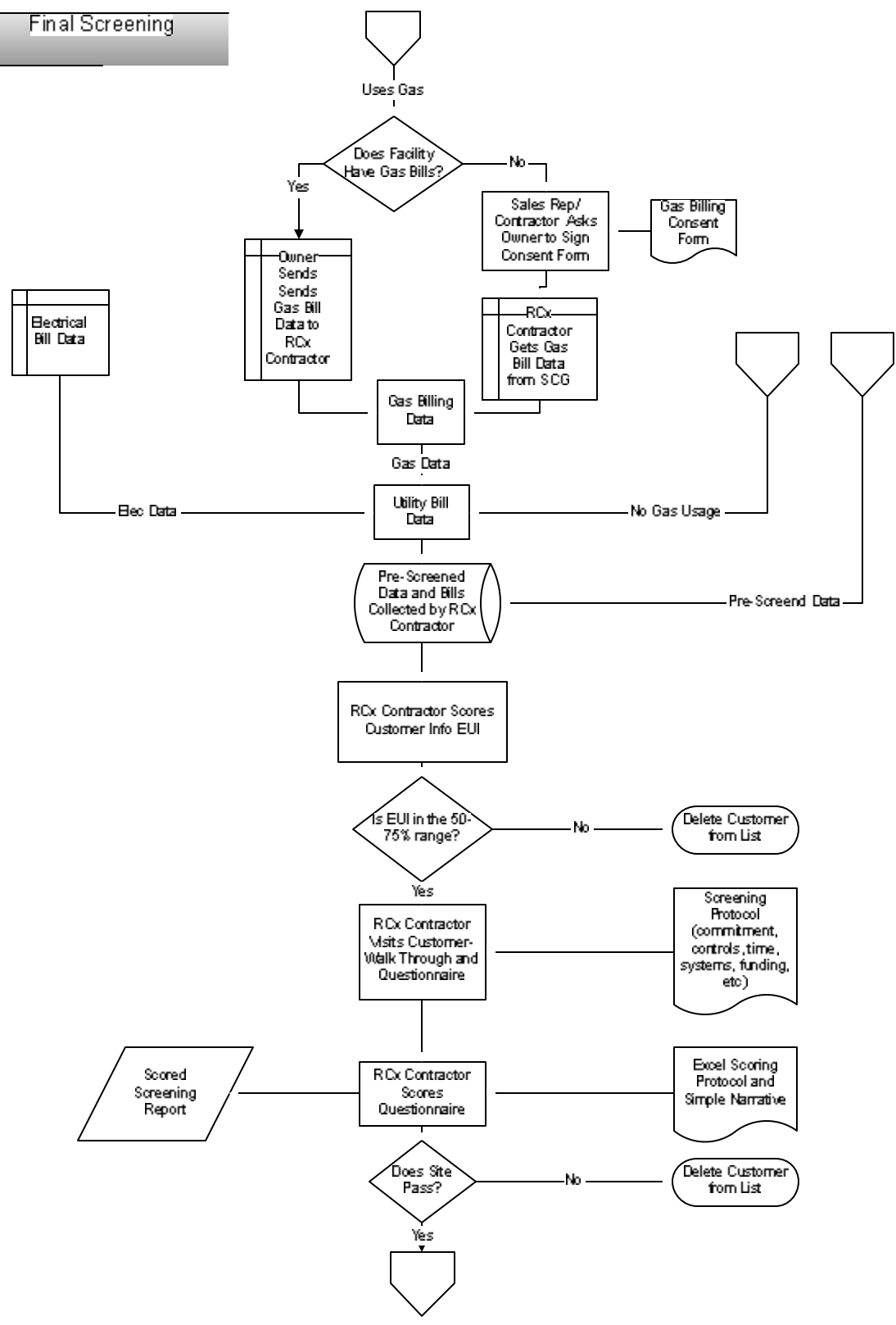
Appendix A

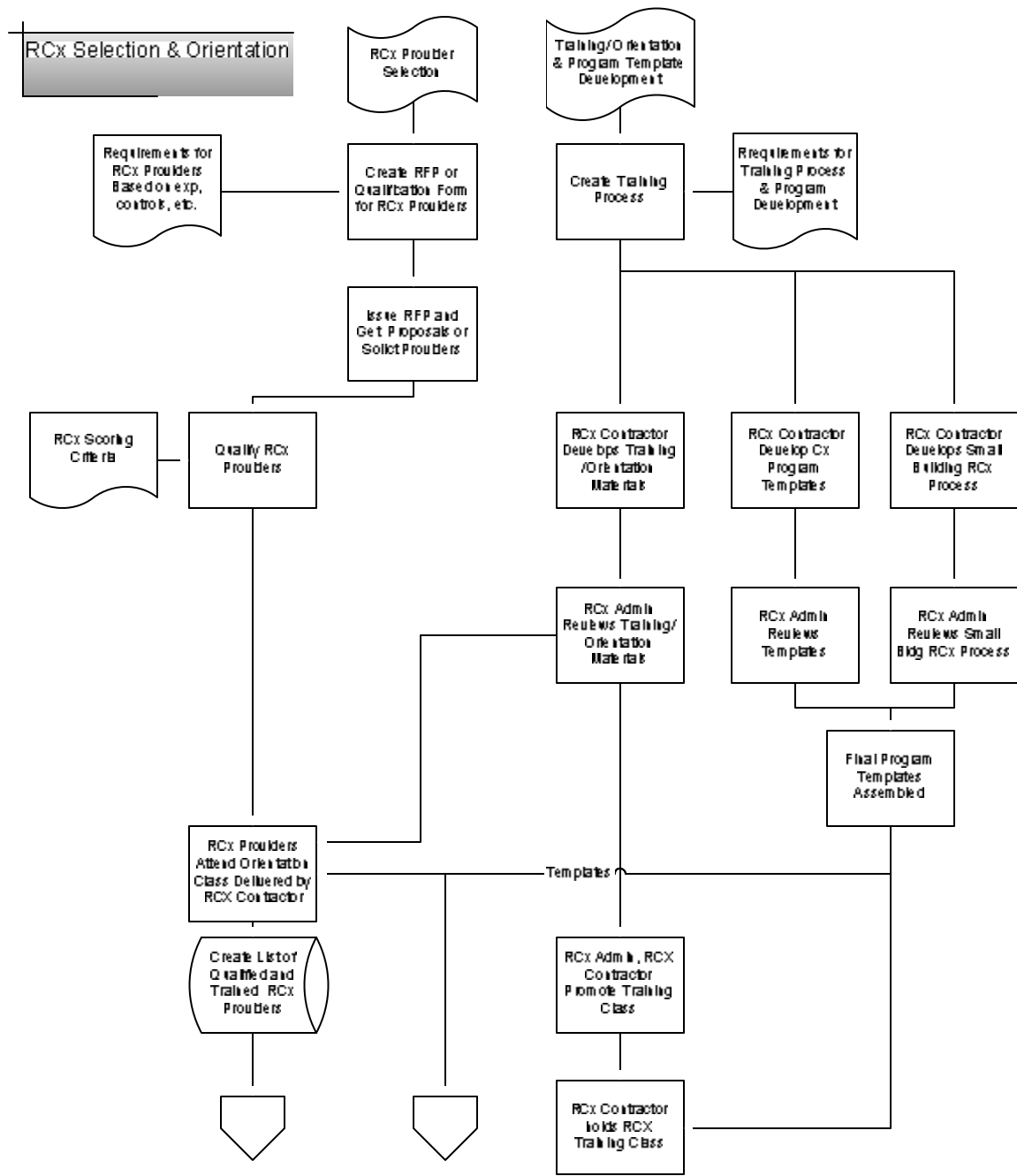
Program Implementation Flow Chart

Recruitment and Pre-Screening

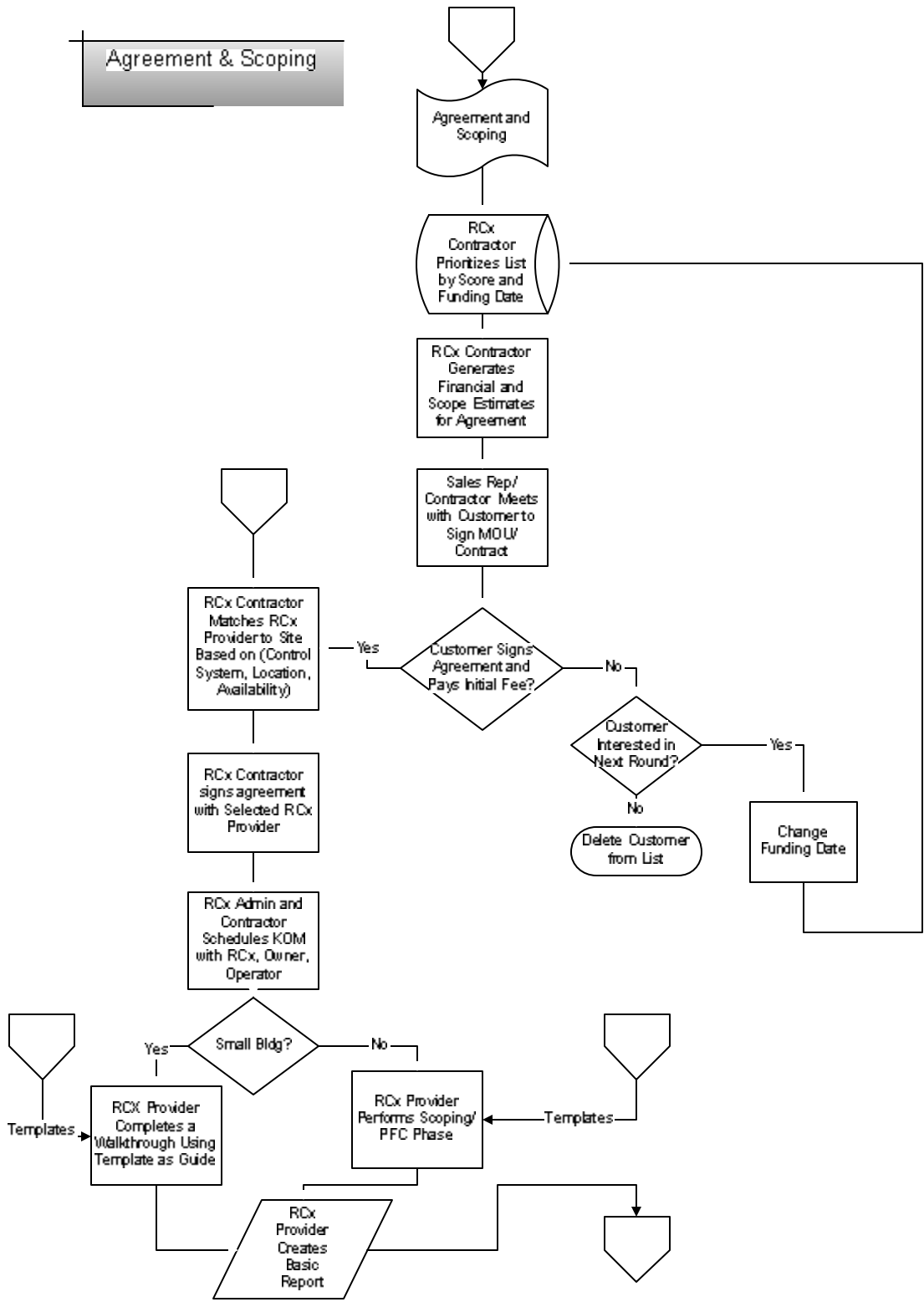


Final Screening

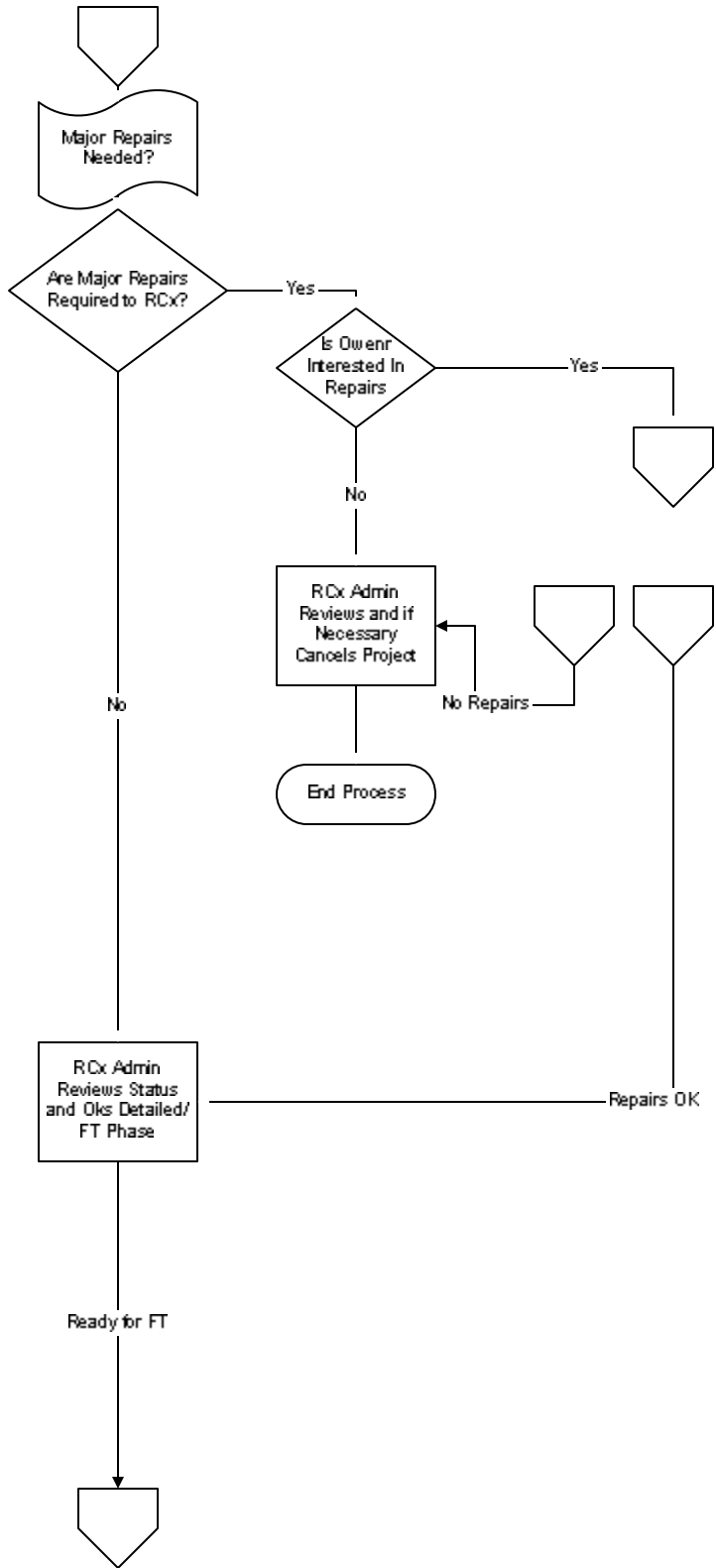


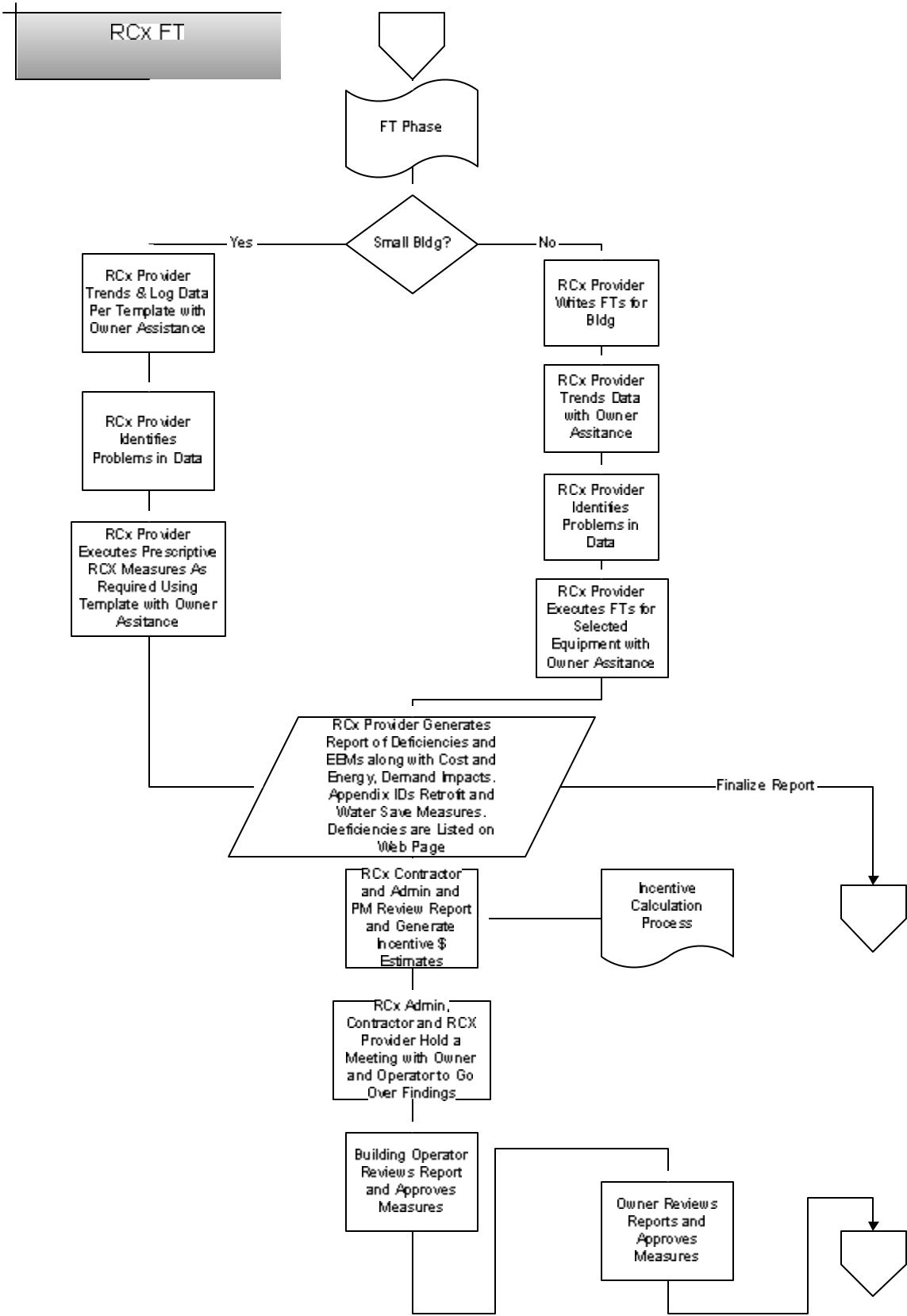


Agreement & Scoping

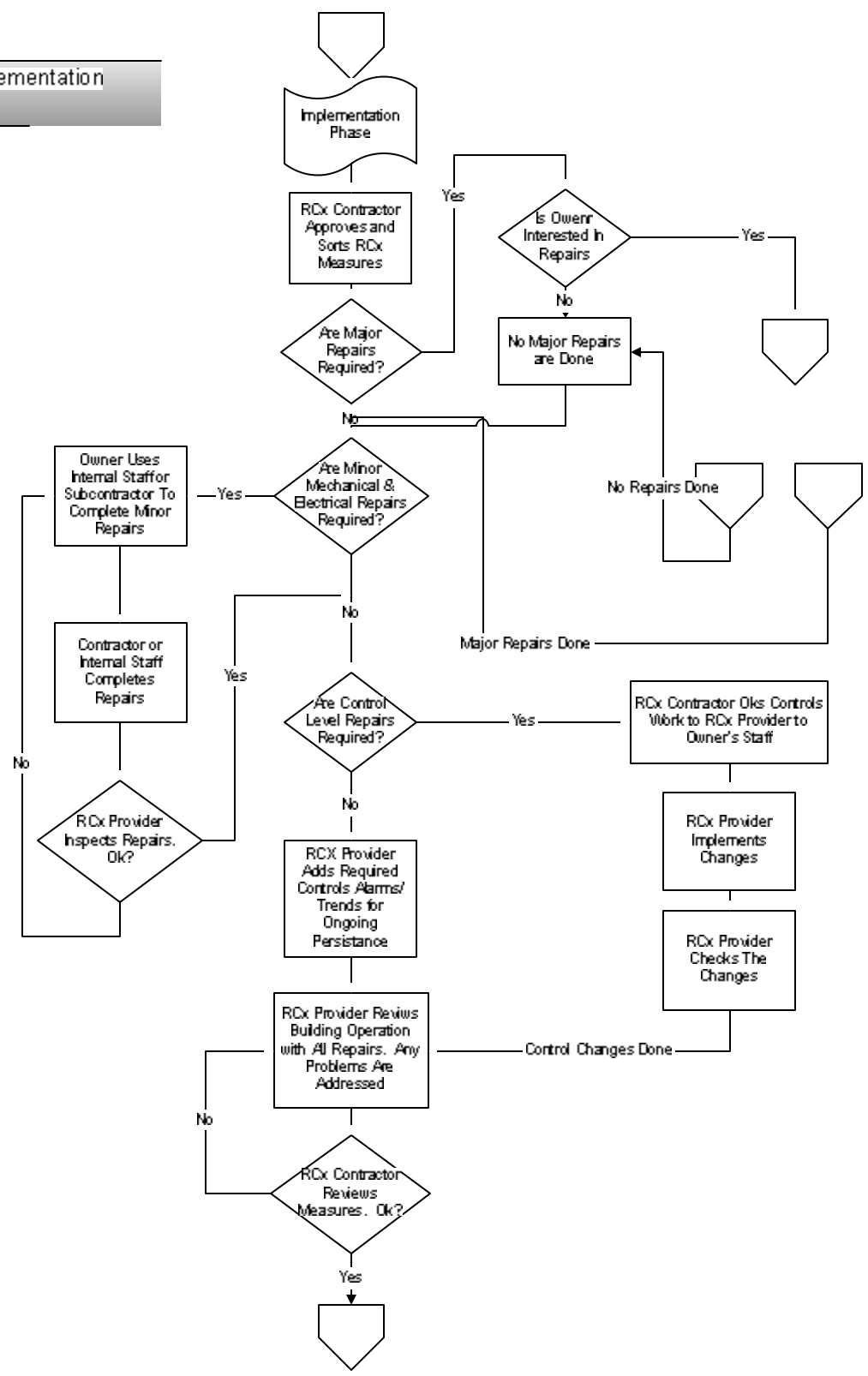


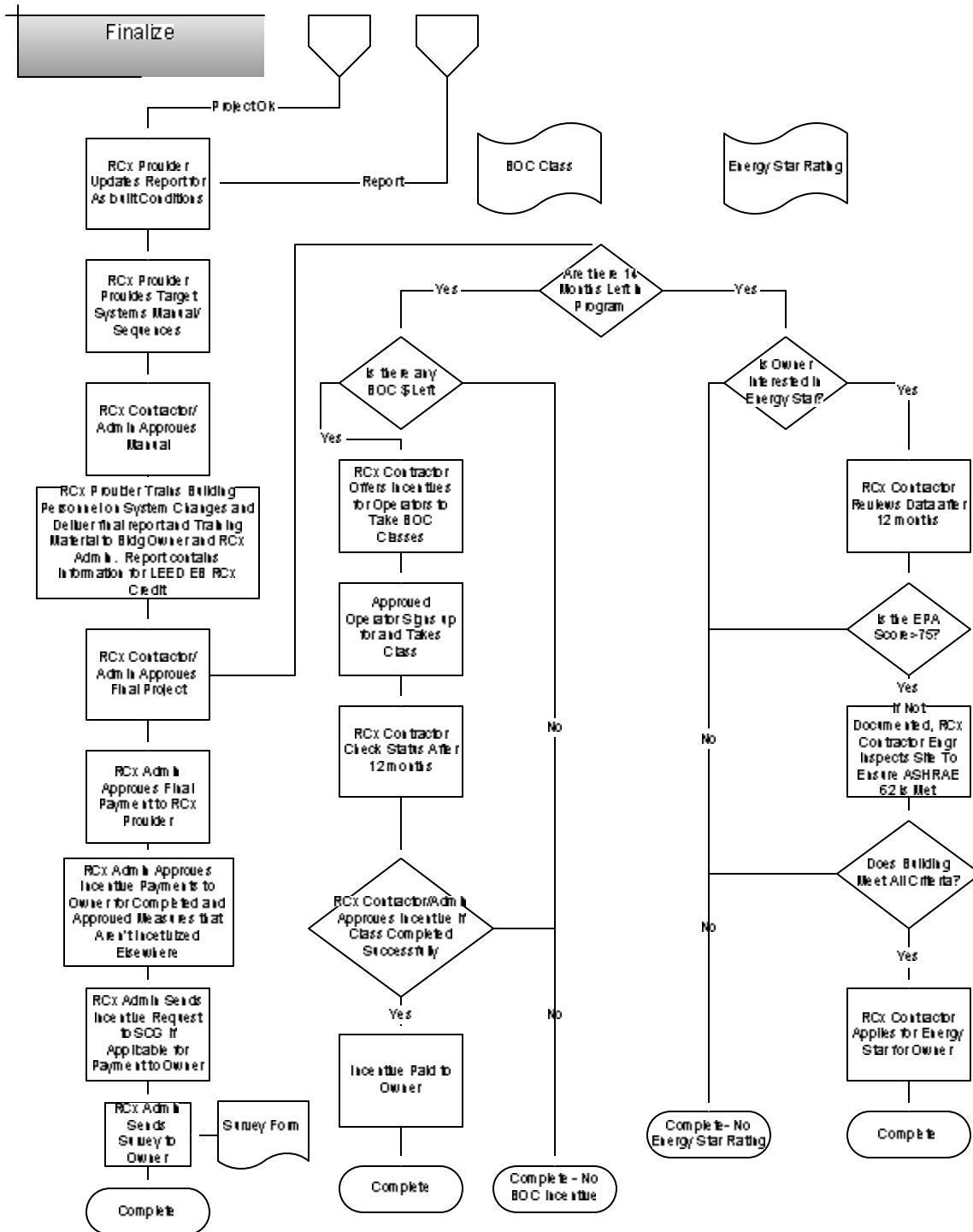
Scoping Review & Major Repairs



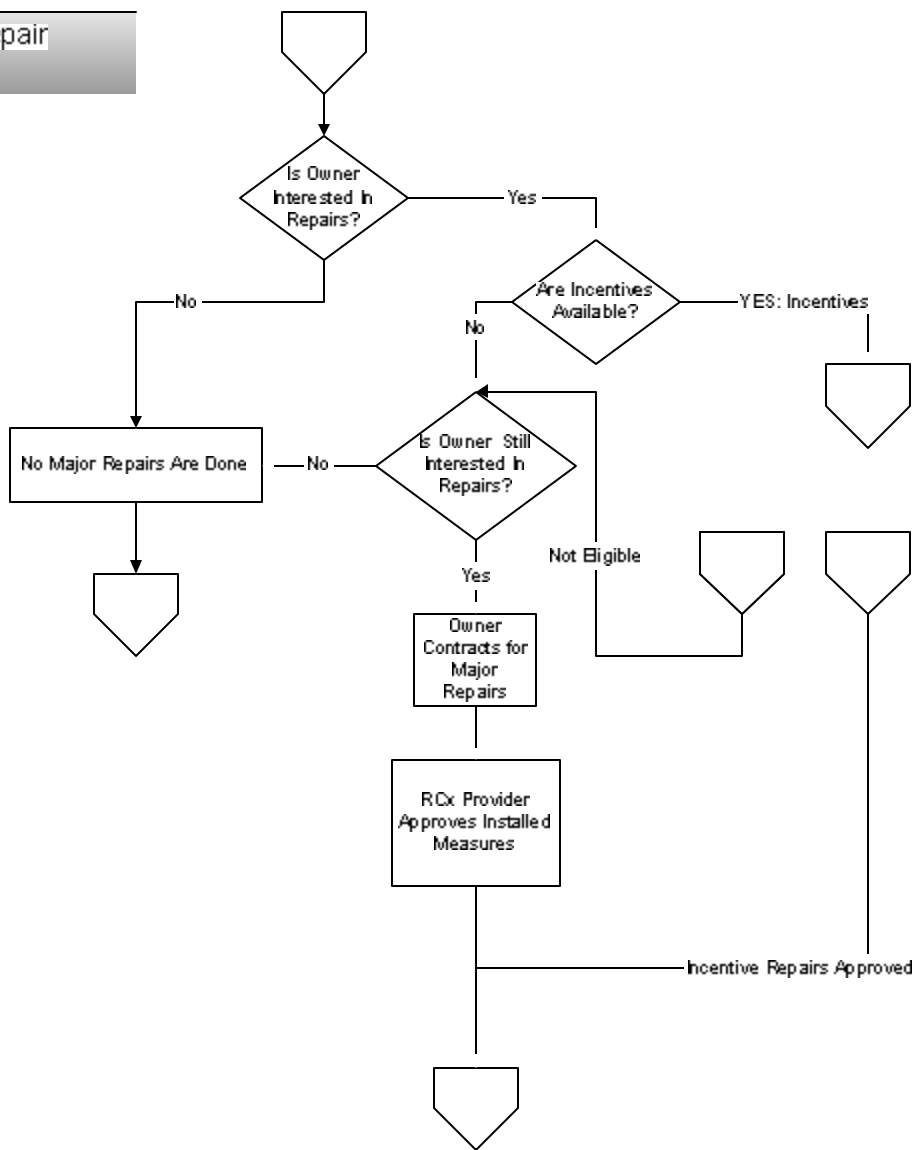


Implementation





Major Repair



Other Incentives

