REGIONAL EVALUATION,
MEASUREMENT & VERIFICATION FORUM

Request for Consultant Proposals (RFP) FINAL 9-4-14

Early Replacement Measure Project RE14-1: Phase II Study

Issued by:

Northeast Energy Efficiency Partnerships, Inc
September 5, 2014 (EST)

Notice of Intent to Bid Due:
September 15, 2014, 4:00 PM (EST)

Questions Due:
September 17, 2014, 4:00 PM (EST)

Proposals Due:
September 24, 2014, 4:00 PM (EST)

RFP WEBSITE

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EARLY REPLACEMENT MEASURE PROJECT:

PHASE II STUDY

1. EXECUTIVE SUMMARY AND PROJECT OBJECTIVES

On behalf of the Regional Evaluation, Measurement and Verification Forum (Forum), Northeast Energy Efficiency Partnerships, Inc. (NEEP) is issuing this request for proposals. The Forum is a regional project facilitated and managed by NEEP representing states in New England, New York and the mid-Atlantic. The Forum is undertaking a number of projects in 2014, including this effort to conduct a second phase of research on early replacement measures installed in Forum member Energy Efficiency (EE) programs.

This Project is one of many Forum projects intended to help improve and ensure the understanding, transparency, and credibility of energy efficiency resources implemented in the Northeast, New York and mid-Atlantic region. The Early Replacement Measure Project (ERMP) consists of two phases that were formulated as follows prior to the initiation of the Phase I Scoping Study:

- **Phase I** of the Early Replacement Measure Project was a Scoping Study to compile descriptive information about current EE programs that offer early replacement measures, including program design elements, measure savings and remaining useful life assumptions and program progress to date. An Early Replacement (ER) program is defined as any program that promotes the replacement of equipment prior to the assumed time of "normal replacement" (e.g., at the end of the useful life of the equipment) that would occur without the influence of the program. The scope of the survey therefore included "retrofit" programs that offer incentives or technical assistance to induce such early replacements regardless of savings or measure life assumptions. Normal Replacement (NR) in this context means that the time of replacement is not influenced by an EE program. A NR replacement program is accordingly one which seeks to influence the efficiency, but not the timing of equipment replacement. The information was documented and analyzed in order to compare and contrast program design elements and assumptions and to identify and prioritize the measures and program participant populations that could be candidates for study in the second phase of the ERMP. While the primary focus of the study was on early replacement programs, the survey also obtained information about program incentives that target "normal replacement" (NR), which will be used to define the survey population in Phase II. Information is necessary on these programs as there is some data showing that programs that are targeted at normal or end of life replacement are actually resulting in some level of early replacement. The Phase 1 Scoping Study has been completed. The methodology and findings are documented in the final report, "Early Replacement Measures Scoping Study Phase 1 Research Report", available on the Forum website at http://www.neep.org/early-replacement-phase-1. A spreadsheet version of the survey results is also available on the Forum website.

Phase II (this RFP) of the ERMP is intended to be an in-depth investigation of a limited number of program participant populations and measures. The scope of this, informed by the Phase I findings, is efficient residential boilers, furnaces and central AC. The primary data collection activity will consist of surveys of customers who have participated in EE programs offering early replacement incentives implemented by Forum member Program Administrators (PAs). A limited number of customers who received "normal replacement" incentives will be included in the survey population in order to investigate the possibility that such incentives may influence customers to replace equipment prior to the expected time of normal replacement. The data will be collected and analyzed in order to provide a deeper understanding of equipment replacement decisions and to develop a sound empirical and analytic basis for remaining useful life assumptions employed in the calculation of energy savings of early replacement measures. A secondary objective is to provide insights and recommendations to assist PAs in the assessment and qualification of measures as either early or normal replacement for the purpose of the determination of energy savings, incremental costs and program incentives. The Phase II study will be designed to produce various types of information, including independent estimates of the RUL, age and efficiency of equipment replaced by program participants, recommendations regarding methodology to estimate equipment age and RUL and use of single vs dual

baseline savings assumptions, etc. (See **Phase II Study Objectives** below for a full description of the information that will be produced by this research.)

This request for proposals is to procure contractor services for Phase II of the ERMP. As indicated above, the Phase II scope of work described below is informed by the results of the Phase I research and reflects the results. NEEP intends to enter into a contract with one or more consultants, selected on behalf of the Forum, as a result of this RFP process. A NEEP project manager, technical advisors, and a subcommittee of Forum members will provide oversight and guidance during the Project. However, the consultant will only report to the NEEP project manager.

The product of the Phase II research described in this request for proposals will be a final report. Other deliverables will include reporting on preliminary/draft findings, participation in several teleconferences and presentations of results at one or two Forum meetings. It is intended that this work be started in September or early October and completed within six months.

2. BACKGROUND

The Regional Evaluation, Measurement and Verification Forum (Forum) includes public and private sector representatives from the New England states, New York, Maryland, the District of Columbia and Delaware.

The objective of the Forum is to support the successful expansion of demand-side resource policies and programs, by:

- Providing for consistent, credible and accessible savings data from demand resources to support state and regional energy, climate change and other environmental policy goals,
- Reducing the cost of evaluation, measurement and verification (EM&V) activities by leveraging resources across the region for studies of common interest, and
- Removing barriers to the participation of demand-side resources in regional markets by establishing regional protocols to be adopted by the states.

The Forum serves five core functions:

1. Provide a framework for multi-state agreement on consistent EM&V protocols;
2. Develop common/consistent protocols;
3. Coordinate multi-state research and evaluation;
4. Aggregate and provide access to state and regional level demand-side resource data, and
5. Provide access to, and visibility and technical support for Forum products and results.

NEEP staff serves as facilitators, conveners, project managers and administrators for the Forum and its activities. A regionally representative Forum Steering Committee of stakeholders directs the Forum's agenda. Specific Forum projects are undertaken with the input and guidance of topical Project Committees, which recommend products to the Steering Committee for Forum adoption.

The three Project Committees are:

- Protocol Development Committee. Focus is to consider and develop a) common/consistent protocols for EM&V characteristics (e.g. EM&V methods, precision/accuracy guidelines); b) common energy and demand savings assumptions, including stipulated values for common measures, input assumptions (e.g. measure life/persistence), and coincidence factors, and potential supporting on-line database; and c) common reporting formats for savings data and associated cost and emission reductions.
- Research & Evaluation Committee. Focus is to undertake and support coordinated research and evaluation projects that serve as basis for protocol development (e.g. common assumptions). Examples of projects include savings load shape analyses (e.g. to inform coincidence factors); measure life and persistence studies; spillover and free-ridership approaches; and common measure cost input assumptions. Projects may include coordination of multi-state projects that involve a subset of the region.
- Education and Information Access Committee. Focus is to guide and help ensure Forum products and results (e.g. studies, reports, protocols, recommendations, references, etc.) are visible and readily accessible to stakeholders, while ensuring protection of any confidential information.

This Project falls within the purview of the Research and Evaluation Committee. For more information on the Forum, please see http://www.neep.org/initiatives/emv-forum

3. WORK SCOPE AND DELIVERABLES

While information in this Section is being provided to assist potential bidders, bidders are requested to propose their own approach to meeting the project objectives, including their recommendations with respect to appropriate report contents, the schedule and budget, and possibly modified or additional tasks, given the Project objectives.

A. Overview

The selected consultant's client will be NEEP, which will have final say on scope issues and deliverables approvals in consultation with the Forum project subcommittee, and the technical advisors. The subcommittee will be responsible for providing broader Forum participant input and comment; its support, interaction, and input will be critical to the success of the Project. NEEP will be responsible for managing an efficient interaction process between the Forum subcommittee, the Forum participants, and the consultant – where such process involves:

- Subcommittee reviews and provides input to initial draft documents; and
- Discussion and input provided by Forum members on final drafts.

Early Replacement Measure Project Background

All energy efficiency programs are designed to influence the decisions that determine the level of efficiency of energy-consuming equipment. Some programs also attempt to influence decisions regarding the timing of the equipment purchase. The design of such programs or program elements, variously described as "early replacement" (ER), "early retirement" or "retrofit", rests upon two critical baseline assumptions concerning the "normal replacement" (NR) decision that would hypothetically occur in the absence of the program: 1) the remaining useful life (RUL) of the existing equipment, that is, the elapsed time from the point of program intervention until the time of equipment failure or normal replacement, and 2) the efficiency of the equipment that would have been purchased at the time of NR absent the program.

Several key program design elements are informed by these two baseline assumptions, including incentive qualification criteria (e.g., existing equipment efficiency, operating condition,age), incentive amount, incremental measure cost, incremental measure savings and measure cost-effectiveness. The baseline assumptions are therefore important determinants of which measures and existing equipment qualify for incentives as well as the magnitude of the incentive payment and energy savings to be claimed.

The **objective** of the ERMP is to develop information to guide the design and analysis of ER program elements. The specific focus will be on data collection and analysis pertaining to the RUL assumptions employed in ER programs. The ERMP is being implemented in two phases. **Phase I,** which has been completed**,** consisted of a scoping study to characterize programs or program elements currently implemented by Program Administrators that are designed to promote early replacement of existing equipment with more efficient equipment. The purpose of the Phase I Scoping Study was to describe the baseline assumptions and procedures employed to qualify measures for early replacement incentives and the assumptions currently employed to determine energy savings, including assumptions or site-specific data pertaining to existing equipment remaining useful life, new equipment life, and other information used to estimate remaining useful life or to qualify measures, such as the efficiency of the existing equipment. The results of the Phase I research are summarized in the next section.

Phase I Findings

The Phase I Scoping Study produced a wealth of information about Forum member ER programs as well as selected non-Forum programs operated by PAs outside the Northeast Region. The study findings are documented in the report, "Early Replacement Measures Scoping Study Phase 1 Research Report", available at http://www.neep.org/early-replacement-phase-1. The major findings of the Phase I study are summarized below:

Definition of Early Replacement Measures

The findings reflect to some degree a want of conceptual clarity regarding the definition of ER measures. Some PAs whose participation was solicited expressed uncertainty as to whether they were operating any programs or program elements that qualify for the ER designation. This definitional confusion is understandable given the history of EE programs and the conventions that have been employed to categorize them. The first utility EE programs implemented in the 1980's promoted the replacement of equipment that was installed and operating at the time of program participation. The energy and demand savings imputed to these measures were quantified in terms of the difference between the consumption of the existing equipment and the more efficient equipment promoted by the programs. Such EE programs came to be categorized as "retrofit" programs to distinguish them from programs that were later developed to capture "lost opportunities" to influence market transactions at the time of "normal replacement" major renovation or new construction. Most of those programs assumed the savings lasted as long as the lifetime of the new measure without regard for the age of the measure being replaced.

A more recent development has been the identification of programs and measures as "early replacement" or "early retirement" that employ explicit baseline assumptions pertaining to the remaining useful life (RUL) of existing equipment in the determination of incremental energy savings and incremental costs of the ER measures. An important finding of the Scoping Study was that so-called "retrofit" programs that do not explicitly account for RUL in the baseline assumptions continue to represent a substantial portion of EE portfolio expenditures and savings.

This lack of clarity in terminology is further compounded by apparent inconsistencies between measure baseline assumptions and their corresponding classification as ER or NR. For example, some ER programs may apply an ER baseline (existing equipment efficiency) for the purpose of savings calculations but a NR baseline (current standard efficiency) in the calculation of rebates need to incentivize the early replacement of the measure.

In spite of these definitional issues, what all of the surveyed programs share is the defining baseline assumption that an ER measure is a replacement of equipment that would continue to operate except for the influence of the ER program.

ER Program Eligibility Criteria

PAs that explicitly differentiate between ER and NR measures utilize different baseline assumptions to calculate energy savings and typically offer higher financial incentives (rebates based on a portion of the total replacement cost not just the incremental cost going from a standard to high efficiency selection) to induce the customer to replace the existing equipment prior to the time of "normal replacement". Because ER program offer higher incentives some programs establish eligibility criteria to qualify measures for ER incentives. The Phase I research found that a number of different eligibility criteria are currently in use:

- **Functionality** – A majority of the ER programs (71%) require that the existing equipment be operational at the time of replacement.

- **Repair Cost** – A small number of ER programs establish a maximum repair cost to bring the existing equipment up to a higher efficiency level or to make the equipment functional.
- **Age** - A small number of ER programs establish a maximum age of the existing equipment.
- **Efficiency** - A small number of ER programs establish a maximum efficiency of the existing equipment.
- **Verification** – Less than half of the ER programs (42%) require some form of verification of the eligibility criteria in order to qualify for the ER incentive.
- **Other** – The surveys identified other eligibility criteria that are not ostensibly tied to the ER/NR distinction, e.g. minimum hours of use, minimum capacity, restrictions on fuel type, etc.

These restrictions are generally designed to disqualify measures that are in fact normal replacements that might be eligible for NR incentives offered through the same or a different EE program.

Baseline Assumptions

The programs surveyed in Phase I can be classified according to one of the following ER program models that employ different baseline assumptions:

- **Retrofit** model (RUL=EUL, Baseline Efficiency=Existing Efficiency)
- **Single Baseline** model (0<RUL<EUL, Baseline Efficiency=Existing Efficiency)
- **Dual Baseline** model (0<RUL<EUL, Baseline Efficiency=Existing for RUL and Current Standard Efficiency for EUL-RUL)

The Effective Useful Life (EUL) is typically defined to be the median age of replacement of a particular category of equipment. The Current Standard Efficiency is the assumed average or typical efficiency of discussed above, the Retrofit model does not make an explicit RUL assumption[1]. The Baseline Efficiency is assumed to equal the Existing Efficiency until the efficient equipment (measure) reaches the end of its EUL. This is equivalent to the implicit assumption that the RUL is equal to the EUL.

The Single and Dual Baseline models both employ the baseline assumption that the existing equipment would be replaced at some time in the future, i.e. the time of normal replacement, prior to the time of replacement of the measure. By assumption that the measure is an ER and not an NR, the RUL is greater than zero. The Dual Baseline model is distinguished from the Single Baseline model by the additional baseline assumption that at the end of the RUL the existing equipment would be replaced by equipment of the same efficiency as the current market standard. In other words, the standard level of efficiency is assumed to remain constant until the end of the RUL of the existing equipment.

The survey found that the ER programs can be classified as 32% Retrofit, 31% Single Baseline and 36% Dual Baseline. Another interesting finding is that this distribution varies substantially among measure categories. For example, Lighting is 31% Retrofit, 69% Single Baseline and 0% Dual Baseline, whereas Central AC and Heat Pumps are 0% Retrofit, 20% Single Baseline and 80% Dual Baseline.

Remaining Useful Life Assumptions

PAs which incorporated explicit RUL assumptions in their ER energy savings and measure cost calculations employed different methods to determine the assumed RUL values. The Phase I study identified the following methods that are currently in use:

[1] However, some retrofit models build in an implicit reduction in lifetime savings, such as programs that assign 13 vs 15 year measure life depending on early vs replace on burnout program assumptions.

- RUL=Stipulated Value
- RUL=EUL x Stipulated Factor
- RUL=EUL-Age of Existing Equipment (=0 if Age ≥ EUL)

The Phase I findings indicate that most ER programs (83%) employ a stipulated RUL or a stipulated fraction of the EUL, typically one half or one third of the EUL. Thus it appears that current practice does not explicitly take into account the age of the existing equipment in the determination of the value of the RUL. The one method that does take age into account is flawed because it has no logical relationship to an underlying survival function and will generally yield a negatively-biased estimate (see Appendix C).

Cost-Effectiveness Issues

The PAs who were interviewed in Phase I expressed concerns about the cost-effectiveness of ER programs and measures. For example, the issue was raised that there have been relatively few upgrades to efficiency standards in recent years for HVAC equipment and refrigerators. The consequence of a "stagnant baseline" is the convergence of the efficiencies of existing and new equipment. Incremental ER savings that are not much greater than NR savings may not be sufficient to justify the greater incremental cost of early replacement.

While most ER programs were reported to employ ER measure cost calculations based on the full cost of the new equipment, 15% were reported to utilize the difference between the cost of the measure and standard new equipment, which is the standard basis to determine NR incremental cost. There are different methods in use to perform the calculations that are based on the full cost of the new equipment:

- **Unadjusted Installed Cost** – Most PAs equate the incremental ER cost to the total installed cost of the measure. This is the conventional "retrofit program" approach.
- **Avoided Replacement Cost Adjustment** – The present value of the standard replacement cost (discounted by the RUL) is subtracted from the installed cost of the measure.
- **Deferred Replacement Cost Adjustment** - The present value of the real levelized carrying charges on the standard replacement cost over the age of the existing equipment (discounted by the RUL) is subtracted from the installed cost of the measure.

Assuming the RUL<EUL, the unadjusted cost method overstates the incremental cost because it does not account for the baseline assumption that the existing equipment would be replaced at the end of the RUL. On the other hand, the avoided cost method understates the incremental cost because it does not account for the cost of replacement of the measure at the end of the EUL (see Appendix C).

Phase II Study Objectives

The Phase I Scoping study provides a comprehensive and detailed characterization of ER programs currently operated by Forum members that promote a broad range of EE measures to Residential and Commercial/Industrial customers. The major findings summarized above raise a number of important methodological and program design questions that warrant further research in Phase II of the ERMP.

Phase II of the ERMP is an in-depth investigation of a limited number of program participant populations focusing on a targeted class of measures: efficient residential boilers, furnaces and central AC. The primary data collection activity will consist of surveys of customers who have participated in EE programs offering ER incentives implemented by Forum member PAs. The data will be collected and analyzed in order to provide a deeper understanding of equipment replacement decisions and to develop a sound empirical and analytic basis for remaining useful life assumptions employed in the calculation of energy savings of early replacement measures. A secondary objective is to provide insights and recommendations to assist PAs in the assessment and qualification of measures as either

early or normal replacement for the purpose of the determination of energy savings, incremental costs and program incentives.

Phase II data collection and analysis will focus on Residential programs that offer incentives for the early replacement of operating HVAC equipment. An independent assessment of RUL and Baseline Efficiency assumptions will be conducted using primary (customer and vendor/contractor survey) and secondary data sources, as necessary. Secondary sources may include Program Administrator program tracking data, Technical Resource Manuals, and other published information. Participant survey data will also be analyzed to provide insight into the equipment replacement decision process. The results of these analyses will inform the development of general guidelines to assist PAs in ER program design and the calculation of costs and savings of ER measures.

The Phase II study will be designed to produce the following information:

1. Independent estimates of the RUL, age and efficiency of equipment replaced by program participants.
2. Independent estimates of the incremental cost of early replacement by program participants under single and dual baseline assumptions.
3. Comparison of independent estimates with program assumptions and equipment incentives.
4. Conclusions and recommendations regarding methodology to estimate equipment age and RUL.
5. Conclusions and recommendations regarding the use of single vs. dual baseline savings assumptions.
6. Conclusions and recommendations regarding program eligibility criteria, incentive levels and other relevant design parameters.
7. General findings characterizing participating end user replacement decisions, based on participant and vendor survey data.

ERMP Phase II Technical Requirements

Data Collection

The contractor will conduct data collection activities necessary to provide information pertaining to a cross section of participants in Forum ER Programs that conform to the following criteria:

- The program offers incentives to Residential customers to replace existing HVAC equipment (Boilers, Furnaces, central AC) in single family dwellings.
- The program explicitly addresses the early replacement market and employs a baseline assumption that the existing equipment would continue to operate for some specified period of time (RUL>0).
- The baseline assumptions conform to either a Single Baseline or Dual Baseline program model (i.e. RUL<EUL).

For each equipment category (e.g. boiler, AC), the participant sample will be stratified in order to represent, to the extent possible, a cross section of ER program attributes, including the following:

- Single Baseline and Dual Baseline assumptions, if both types of programs are represented in the target population.
- Programs that track site-specific estimates of the age of the existing equipment of each participant, if any such programs exist in the target population.

- A cross section of incentive amounts for similar equipment.
- Programs that offer different ER and NR incentives for the same equipment.

Data collection will address the following information requirements:

Program Information

- Program eligibility criteria
- Program verification procedures employed to determine compliance with eligibility criteria
- Program assumption/calculation of RUL of equipment that was replaced
- Program assumption of efficiency of baseline normal replacement at end of RUL
- Program assumption of installed cost of baseline normal replacement at end of RUL
- Method employed to calculate savings
- Method employed to calculate incremental cost

Participant Information

- Type and size of equipment that was replaced
- Age of equipment that was replaced
- Efficiency of equipment that was replaced
- Functional status of equipment that was replaced
- Repair costs required for continued operation of equipment that was replaced
- Incentive payment amount
- Efficiency of new equipment
- Installed cost of new equipment
- EUL of new equipment
- PA estimate of annual energy savings over RUL of equipment that was replaced
- PA estimate of annual energy savings over remaining life of measure (EUL-RUL)
- PA estimate of Incremental measure cost
- Participant subjective estimate of RUL
- Participant feedback on replacement decision process, including reasons for replacement, payback criteria, etc.

The contractor may utilize various sources to collect the required information, including but not limited to:

- Program tracking system files
- Technical Reference Manuals
- Other published information (e.g. program plans, EM&V reports, survival function data)
- Participant interviews
- Equipment Vendor/Implementation Contractor interviews
- Participant site visits

Data Priorities

Data collection activities should place the highest priority on the determination of the age of equipment that was replaced by each sampled participant. The Phase I findings indicate that most ER programs rely on stipulated assumptions about equipment age and RUL. Therefore the contractor proposal must include a detailed description of the proposed data collection approach that will be employed to form a reasonable site-specific estimate of equipment age. In ER programs that have tracked participant equipment age, the method and data sources employed by PAs to arrive at such estimates must be reviewed and revised if deemed appropriate. ER programs which have PA or vendor

documentation of data obtained via on-site verification of equipment information used to determine the age at the time of replacement may provide a calibration set to assist in the estimation process.

A high priority should also be placed on participant feedback about the replacement decision process. Feedback should be solicited regarding the factors that contributed to the decision to participate and in particular the decision to replace the existing equipment. The participant should also be queried about the "normal replacement" decision process. Did they have plans to replace the equipment at some time to be determined by certain factors, and if so what are those factors, etc.?

Data Analysis

The contractor will conduct the following analyses of the data:

- Frequency distributions and associated parameters of replaced equipment age, efficiency, functional status, incentive levels (% of installed cost) and participant payback criteria
- Analysis of sources of variation in age of replaced equipment, including replaced equipment efficiency, functional status, repair costs, incentive level, payback w/ incentive, program eligibility criteria
- Median residual life estimation of RUL for each sample participant (See Appendix C)
- Frequency distributions and associated parameters of estimated RUL
- Comparison of estimated and assumed RUL (bivariate frequency distribution and associated parameters)
- Independent assessment of baseline efficiency at time of normal replacement, taking into consideration known and projected future changes in codes and standards and market trends
- Comparison of contractor assessment of baseline efficiency with program efficiency assumptions
- Independent calculation of incremental measure cost using deferred replacement cost adjustment (see Appendix C)
- Comparison of contractor and PA estimates of incremental measure cost

The data analysis will be formulated in terms consistent with the analytical frame of reference described in Appendix C. Verification of annual energy savings and benefit-cost calculations are outside the scope of work of this study.

RUL Estimation

The median residual life estimate of the RUL of each sample participant will be calculated on the basis of the contractor estimate of the age of the equipment that was replaced and published survival function parameters (see Appendix C). The selection of the survival function data will be made in consultation with the project review team.

Statistical Precision

The program participant sample shall be designed to achieve 10% precision at a two-sided confidence level of 90% for the estimated age of the existing HVAC equipment.

Target Population

The target population consists of Forum member PAs who operate EE programs with Residential HVAC early replacement components. The Program Administrators and service territories are listed below in Table 1.

Table 1

2014: States Participating in EM&V Forum

(* denotes sponsorship of this project)

State	Program Administrator	State	Program Administrator
CT*	CL&P	NY	Central Hudson
	United Illuminating		Consolidated Edison
DE*	DE SEU	*	PSEG-NY
DC*	DC SEU		National Grid
MA*	Cape Light Compact		NYPA
	NSTAR/WMECo		NYSEG/RGE
	National Grid		NYSERDA
	Unitil		ORU
MD*	BGE	RI*	National Grid
	FirstEnergy	VT*	EVT
	PHI/Pepco		
	SMECo		
NH*	Liberty		
	NH Elec Coop		
	PSNH		
	Unitil		

Project Deliverables

The final report will present the following information:

1. Complete description of the data collection and analysis activities.
2. Presentation of the findings

   a. Results of the equipment age and RUL analysis
   b. Results of the equipment baseline efficiency analysis
   c. Results of the incremental measure cost analysis
   d. Results of the participant survey
3. Discussion of the implications of the findings
   a. RUL assumptions
   b. Baseline efficiency assumptions (program model)
   c. Incremental cost assumptions
   d. Program design (eligibility, incentive levels, etc.)

B. Project Tasks

Task 1: Kick Off Meeting.

The contractor will hold a kick off meeting or teleconference with NEEP's project manager, NEEP's technical and policy advisor, and a sub-committee of Forum members to: Discuss scope, schedule and approach; Review objectives and expectations for sub-committee participation in study; Review the proposed work plan and schedule; Review contractor data requirements, secondary data sources and information characterizing PA programs; and establish project management process.

Schedule: *within one week of contract signing*

Deliverable: *minutes of meeting*

Task 2: Final Work Plan

The work plan will be finalized and submitted to the Project Coordinator for review and approval by the Project sub-committee.

Schedule: *within two weeks of contract signing*

Deliverable: *Final work plan*

Task 3: Sample Design

The contractor will present the proposed sample design for review and approval by the Project sub-committee.

Schedule: *within four weeks of contract signing*

Deliverable: *Sample Design memorandum*

Task 4: Development of Program Participant Survey Instrument and Data Collection Protocol

The contractor will prepare a draft survey instrument and the proposed data collection protocol describing the procedure that will be employed to collect the data specified above for review and approval by the Project sub-committee.

Schedule: *within four weeks of contract signing*

Deliverable: *Draft Survey Instrument and Data Collection Protocol*

Task 5: Survey Scheduling

The contractor will schedule the participant surveys so that data collection can begin when the survey instrument is finalized.

***Schedule**: within six weeks of contract signing*

***Deliverable**: memorandum to report completion of survey scheduling*

Task 6: Data Collection

Upon approval and finalization of the survey instrument and data collection protocol by the Project sub-committee, the contractor will conduct the collection of primary and secondary data. The contractor may issue supplemental information requests before, during or after the completion of the survey to procure program documentation or to obtain clarification of information that has been collected.

***Schedule**: beginning within six weeks of contract signing and concluding within 10 weeks of contract signing*

***Deliverable**: memorandum to report completion of data collection*

Task 7: Data Analysis

The contractor will complete the analyses of the data specified above.

***Schedule**: within fifteen weeks of contract signing*

***Deliverable**: memorandum summarizing key findings*

Task 8: Draft Report

The contractor will submit a draft report for review and approval that includes a comprehensive description of the data collection and analysis methodology, study findings and discussion of the implications of the findings, as specified above.

***Schedule**: within seventeen weeks of contract signing*

***Deliverable**: Draft Report*

Task 9: Presentation of Findings

The contractor will present the methodology and results to the Project sub-committee.

***Schedule**: within nineteen weeks of contract signing*

***Deliverable**: Presentation of Findings*

Task 10: Final Report

The contractor will submit the final report for review and approval.

***Schedule**: within twenty weeks of contract signing*

***Deliverable**: Final Report*

4. Project Budget and Schedule

It is intended that this work be started in September and completed within six months.

Some notes on the budget and schedule:

- The amount of allocated funds is not being indicated in order to allow bidders to present their unbiased estimates.

SUMMARY OF TASKS AND DELIVERABLES

PROJECT TASKS	Schedule	DELIVERABLES
Task 1: Kick-off Meeting	*within one week of contract signing*	*Meeting Minutes*
Task 2: Final Work Plan	*within two weeks of contract signing*	*Final Work Plan*
Task 3: Sample Design		*Sample Design Memorandum*
Task 4: Development of PA Survey Instrument and Data Collection Protocol	*within four weeks of contract signing*	*Draft Survey Instrument and Data Collection Protocol*
Task 5: Survey Scheduling	*within six weeks of contract signing*	*Memorandum to report completion of survey scheduling*
Task 6: Data Collection	*within ten weeks of contract signing*	*Memorandum to report completion of data collection*
Task 7: Data Analysis	*within fifteen weeks of contract signing*	*Memorandum summarizing key findings*
Task 8: Draft Report	*within seventeen weeks of contract signing*	*Draft Report*
Task 9: Presentation of Findings	*within nineteen weeks of contract signing*	*Presentation of Findings*
Task 10: Final Report	*within twenty weeks of contract signing*	*Final Report*

5. GENERAL SUBMITTAL INFORMATION

This Section of the RFP provides information for bidders concerning the submittal process, general requirements, schedule, and qualifications. Specific requirements for the content and preparation of bids are contained in Section 5.

A. Contact and Communications

All communications between bidders and NEEP are to be directed to:

Elizabeth Titus, etitus@neep.org 781-860-9177 x111

Danielle Wilson, dwilson@neep.org 781-860-9177 x150

Any unauthorized contact may result in the disqualification of the contacting firm's proposal(s).

Potential bidders are encouraged but not required to submit **a notification of intent to submit a proposal in response to this RFP by 4pm on September 15, 2014 to NEEP contacts listed above**. This information helps NEEP plan and administer the RFP.

B. Bidders' Q&A

Bidders may submit questions via e-mail for this RFP. A website has been established for this Project RFP: NEEP RFP Website. **All questions submitted prior to 4pm on September 17, 2014 will be posted and answered on the website as soon as possible**. All questions and answers will be available to all respondents.

C. RFP Submittal Format and Due Date

Bidders are required to submit electronic versions of their proposal to:

Elizabeth Titus, etitus@neep.org

Danielle Wilson, dwilson@neep.org

The proposals should be submitted in both Microsoft WORD and Adobe Acrobat format. An electronic receipt will be sent to those who submit proposals on time.

Late submittals will be rejected.

Bidders are not required to submit print copies of their proposals.

The transmittal letter contained in the proposal package must have an electronic signature and must be signed by a person who is authorized to bind the proposing firm.

NEEP reserves the right to reject as non-responsive any proposals that do not contain the information requested in this RFP. NEEP is not liable for any costs incurred by any person or firm responding to this RFP or participating in best and finals interviews.

D. RFP Schedule

RFP release	September 5, 2014
Intent to bid notice	September 15, 2014
Close of RFP question period	September 17, 2014
Electronic proposals due	September 18, 2014
Anticipated date of bidder selection	September 24, 2014
Anticipated contract start date	October 10, 2014

The above schedule is subject to change by NEEP.

E. Minimum Qualifications

A single firm or a team of firms under a single primary contractor may submit bids.

Key staff members must have demonstrated experience delivering high-quality EM&V services and/or studies for system benefit charge funded DSM programs. Changes in proposed key staff members may not be made during the execution of the work without written approval of NEEP.

F. Modifications to the RFP

NEEP may modify the RFP prior to the date fixed for submission of proposals by the issuance of an addendum to all parties who have submitted a notice of intent to bid by the required date.

G. Post Proposal Negotiation and Awarding of Contracts

NEEP reserves the right to negotiate both price and non-price factors during any post-proposal negotiations with a finalist. NEEP has no obligation to enter into an Agreement with any respondent to this RFP and may terminate or modify this RFP at any time without liability or obligation to any respondent.

H. Acceptance of Terms and Conditions

The submission of a proposal to NEEP shall constitute a Bidder's acknowledgement and acceptance of all the terms, conditions and requirements of this RFP.

NEEP will utilize its standard Services Agreement to contract for the services outlined in this RFP. **A list of exceptions to this document should be returned with bidder's response, see Section 5 of this RFP**. The Services Agreement is included as an attachment to this RFP, Appendix B.

I. All Submitted Proposals Become Exclusive Property of NEEP

All proposals submitted to NEEP pursuant to this RFP shall become the exclusive property of NEEP and may be used for any reasonable purpose by NEEP.

6. PROPOSAL SUBMITTAL REQUIREMENTS

A. Submission of Proposals

Proposals should provide straightforward and concise descriptions of the proposer's ability to satisfy the requirements of this RFP. Omissions, inaccuracies or misstatements will be sufficient cause for rejection of a proposal. Proposals not submitted as indicated may be rejected.

NEEP and the Forum are looking for proposals demonstrating creativity, expertise and experience in how bidders approach the work scope – recognizing that final sampling plan and design will be established in the course of the project. Once the consultant is selected, an initial task will be to review the scope and deliverables with the NEEP project manager, technical advisor, and a Forum subcommittee.

Bidders are invited to submit optional tasks and budgets if they believe there are additional or tangential tasks that they believe would benefit the objectives of the Project.

All proposals must include the documents identified in Appendix A "Required Proposal Checklist". **Proposals not including the Checklist may be deemed non-responsive**.

B. Proposal Format

Bidders are requested to provide concise yet complete description of the bidder's approach and capabilities for satisfying the required services outlined in this RFP. **Excessive length is discouraged.** In addition, bidders are encouraged to proactively present additional information and responses, not specifically requested, that help demonstrate understanding of this project's objectives and needs as well as bidder's creativity, experience, and/or expertise.

Proposals must adhere to the following set format (the numbers indicated are suggested maximum page limits):

- Proposal cover;
- Signed cover/transmittal letter;
- Table of Contents (include proposal date and page numbers on each page of proposal);
- Completed proposal checklist;
- Executive summary (2 pages);
- Work scope and schedule (10 pages);
- Staffing and subcontracting plan (2 pages);
- Qualifications and Experience (10 pages);
- Budget and Billing Rates (2 pages including tables);
- Exceptions to contract terms (if needed); and
- Appendix - Resumes (2 pages per resume).

The proposal cover must indicate the RFP name, the proposal date, bidder's name and list of subcontractors. The transmittal letter must also state that the person signing the letter is authorized to commit the bidding organization to the proposed work scope, budget and rates; that the information in the proposal is accurate; and that the proposal is valid for 90 days from the date of submittal.

For the checklist please use the form in Appendix A.

I. Section 1: Executive Summary

Section 1 of the proposal should contain a high level summary of the proposal including the approach to the tasks, key staff assigned to the effort, and the consultant's or bidding team's qualifications to perform the services sought through this RFP.

II. Section 2: Work Scope and Schedule

Section 2 of the proposal should discuss bidder's approach to Tasks defined in the RFP. Describe bidder's approaches to each of the work scope tasks with sufficient detail to distinguish the strengths and unique features of the bidder's team and approach. Section 2 must include a schedule for performing the work. The schedule should be presented graphically and supplemented with text explanations needed to provide a complete understanding of the proposed timeline.

III. Section 3: Staffing Plan

In Section 3 bidders are requested to provide a staffing plan. Note that assigned staff qualifications are more critical than firm qualifications and that staffing changes for key personnel are subject to approval by NEEP. In particular, a successful proposal will indicate one or more experienced principals that will direct and commit to the Project.

- Describe the roles of each of the positions listed in bidder's staffing plan.
- Identify the lead staff member assigned to manage the work, provide a short biography, and explain why he or she is qualified for this position. Describe this person's availability for the project, and the office where he or she will be based.
- Identify the key personnel to be assigned to this project, describe their responsibilities, and provide a paragraph biography for each person. Indicate availability and length of time commitment to project.
- Specify any anticipated subcontractors who will be used, roles, responsibilities, and proposed subcontractor mark-up percentage.

Include resumes for all individuals named in the staffing plan. Resumes and bios should describe relevant responsibilities from other projects that will help NEEP evaluate the qualifications and experience of key personnel. Please limit length of resumes to **two** pages and place in an appendix.

IV. Section 4: Firm Qualifications and Experience

Use this section to address bidding team's qualifications and experience, drawing on lessons learned and best practices experience. Bidders should also provide two to four references from current (preferred) or recent clients for whom they have performed projects that are relevant to the work scope. References should include a brief synopsis of specific services provided, company name and location, contact name, contact title, telephone number and, email address of the reference. In the event the bidder is forming a new organization to bid on this proposal, the bidder should provide the related references for the key staff members proposed for the project.

References should be included (two to four each) for any major subcontractors.

V. Section 5: Budget and Billing Rates

Using the two tables shown below bidders must provide labor and other direct costs proposed for this project.

Budget Table One – Billing Rates

Person	Title	2014 Hourly Billing Rate all inclusive)

Budget Table Two – Task by Task and Total Budget

Task	Personnel Assigned	Hours per Personnel Assigned	Labor Costs	Directs Cost (to be billed at cost to Consultant)	Per Task or Total Cost
1					
2					
3					
4					
5					
6					
7					
Total					

VI. Section 6: Exceptions to contract terms

Bidders must provide any requested exceptions to the Services Agreement included as Appendix B.

VII. Section 7: Conflicts of Interest

Bidders should identify, and address as they feel appropriate, potential situations that may be perceived as a conflict of interest in completing this work. Examples would be work performed implementing or evaluated programs in the Region. Such situations are not necessarily a conflict, and may speak to the bidder's qualifications, but should be disclosed.

VIII. Section 7 (Appendix): Resumes

7. Selection Process and Evaluation Criteria

NEEP and the project subcommittee will base their evaluation of proposals on a scoring matrix below. As noted above, the qualifications of key staff (principals) assigned to lead this Project and the amount of time (commitment) they commit to the Project will be weighed heavily.

RFP Evaluation Criteria/Scoring Matrix

Part A: Technical Approach
1. Proposal quality – comprehension and clarity regarding meeting project objectives and quality of proposed approach for meeting those objectives
2. Thoroughness and practicality of approach
3. Creativity of approach
Part B: Management Approach
1. Dedicated resources
2. Demonstrated management competence of key staff
3. Approach to use and management of subcontractors
Part C: Qualifications and Experience
1. Demonstrated competence and experience of key staff and firm(s)
2. References
Part D: Cost
1. Total costs
2. Billing rates and direct costs/subcontractor mark-up rates (if any)

APPENDIX A: REQUIRED PROPOSAL CHECKLIST

REQUIRED PROPOSAL CHECKLIST

Bidder Information		
Name of Bidder:		
Contact Name:		
Contact Phone:		
Contact Email:		
Subcontractors:		
Evaluation Scope		
Proposal Checklist & Locator	Included	Section/Page
Proposal Cover		
Transmittal Letter – signed original		
1. Executive summary		
2. Work scope and schedule		
Schedule figure		
3. Staffing and subcontracting plan		
4. Qualifications and Experience		
References		
5. Budget		
Budget Tables		
6. Exceptions to contract terms		
7. Resumes		

APPENDIX B: NEEP PROFESSIONAL SERVICES AGREEMENT

The NEEP Terms and Conditions and Non-Disclosure Agreements are available here.

APPENDIX C: EARLY REPLACEMENT ANALYTICAL FRAMEWORK

As discussed in the RFP, the Phase I findings indicate a certain lack of definitional clarity, consistency and articulation of baseline assumptions and questionable remaining useful life (RUL) assumptions in ER program design which have important implications for program eligibility criteria, savings estimation and cost-effectiveness analysis. This appendix to the RFP is designed to establish consistent terminology, explicit definition of alternative ER models in terms of efficiency baseline and RUL assumptions and a description of an alternative approach to RUL estimation, the purpose of which is to provide a coherent analytical framework within which to formulate the research questions that will be addressed in Phase II of this project. The paradigm makes explicit the underlying assumptions and presents a critical analysis of those assumptions that leads to specific research questions.

The Baseline Replacement Decision Process

The equipment replacement decision can be formulated as a discrete event that occurs within a continuous decision process of ongoing review and evaluation of alternative options to minimize the cost of end-use service. By assumption, the time of ER precedes the time of NR and the difference is referred to as the "remaining useful life" (RUL). However the name should not be construed to necessarily mean the elapsed time until equipment failure, because NR may be determined by a number of other factors including:

- Degradation of performance below an acceptable threshold
- O&M cost of continued operation
- Capital cost of continued operation
- Building renovation cycle
- Change of occupancy
- Planned equipment replacement

The timing of replacement is essentially an economic decision determined by the opportunity cost of continued operation of the existing equipment.

Definitions

Replacement Event (R) is the removal of existing equipment from service and the installation of other equipment to provide equivalent service at a determinate point in time, the **Time of Replacement** (TR). The TR therefore marks the end of the life cycle of the existing equipment and the beginning of the life cycle of the new more efficient equipment (measure).

Age at Replacement (AR) is the elapsed time between the Time of Replacement and the **Time of Installation** (TI) of the existing equipment, i.e. AR=TR-TI.

A Replacement Event may be classified as one of two hypothetical event types:

Normal Replacement Event (NR) is a replacement for which the TR is decided independently of **Participation in an Energy Efficiency Program** (P).

Early Replacement Event (ER) is a replacement for which the TR is influenced by Participation in an Energy Efficiency program.

As Replacement Events, NR and ER are mutually exclusive: only one or the other can occur during the life cycle of existing equipment. In this sense the two event types represent "competing risks" of replacement. NR can occur at any time after equipment installation and for any reason, except EE program participation. ER can also occur at any time, but its occurrence is conditioned on program participation.

While the R by a participant is directly observable at the TR, the type of event (NR/ER) is unobservable. It is therefore possible that equipment replacement by a program participant identified as a "measure" can be either a NR or ER, depending on whether the TR is determined in part by the program intervention. The NR/ER distinction is of fundamental importance to the program planning and evaluation process because it determines the program baseline assumptions.

The program baseline refers to the hypothetical events that could be observed in the absence of a program intervention. If the individual had not entered the program, then the TR could be determined and the replacement would, by definition, be classified as a NR. Once the decision is made to enter the program, the type of replacement becomes indeterminate. If it is a NR, then the baseline TR is, by definition, equal to the observed TR. If it is an ER, then the baseline TR is equal to the hypothetical, but unobservable, **Time of Normal Replacement** (TNR).

An ER can only occur prior to the TNR because the impact of the program intervention is assumed to advance the TR. The magnitude of the ER impact of the program is quantified in terms of the **Remaining Useful Life** (RUL=TNR-TR):

TI ---------- TR ---------- (TNR)

|< - - - - - - AR - - - - - - - - - ->|< - - - - (RUL) - - - ->|

TNR and RUL are enclosed in parentheses to indicate that they represent latent (unobservable) variables. It is current practice to explicitly or implicitly adopt RUL assumptions which define the program baseline for the purposes of program planning and evaluation. Depending on the assumptions, alternative program models can be formulated to establish an analytical framework that can be used to determine program incentives, incremental measure costs and annual and lifetime energy savings. The following discussion formalizes the definition of the models, implicit or explicit, which characterize the current programs described in the Phase I research.

Program Models

The following alternative program models are classified according to assumptions pertaining to Remaining Useful Life (RUL) and the Baseline Efficiency at the Time of Normal Replacement (BE_TONR):

1. Normal Replacement (RUL=0, BE_TONR=Current Standard)
2. Early Replacement - Retrofit (RUL=EUL, BE_TONR is not specified)
3. Early Replacement – Single Baseline (0<RUL<EUL, BE_TONR=Efficient Equipment)
4. Early Replacement – Dual Baseline (0<RUL<EUL, BE_TONR=Current Standard)

The framework is illustrated in Figure 1. The figure represents the ER paradigm in the case of a commercial lighting measure, the replacement of T12 fluorescent lighting with high performance T8 (HPT8) lighting. In this example the RUL of the existing T12 lighting is assumed to be equal to 5 years and the measure life (EUL) of the new HPT8 lighting is assumed to be equal to 15 years. Annual energy

consumption is plotted against the number of years following measure installation. The designated areas A,B,C,D represent different components of lifetime energy savings.

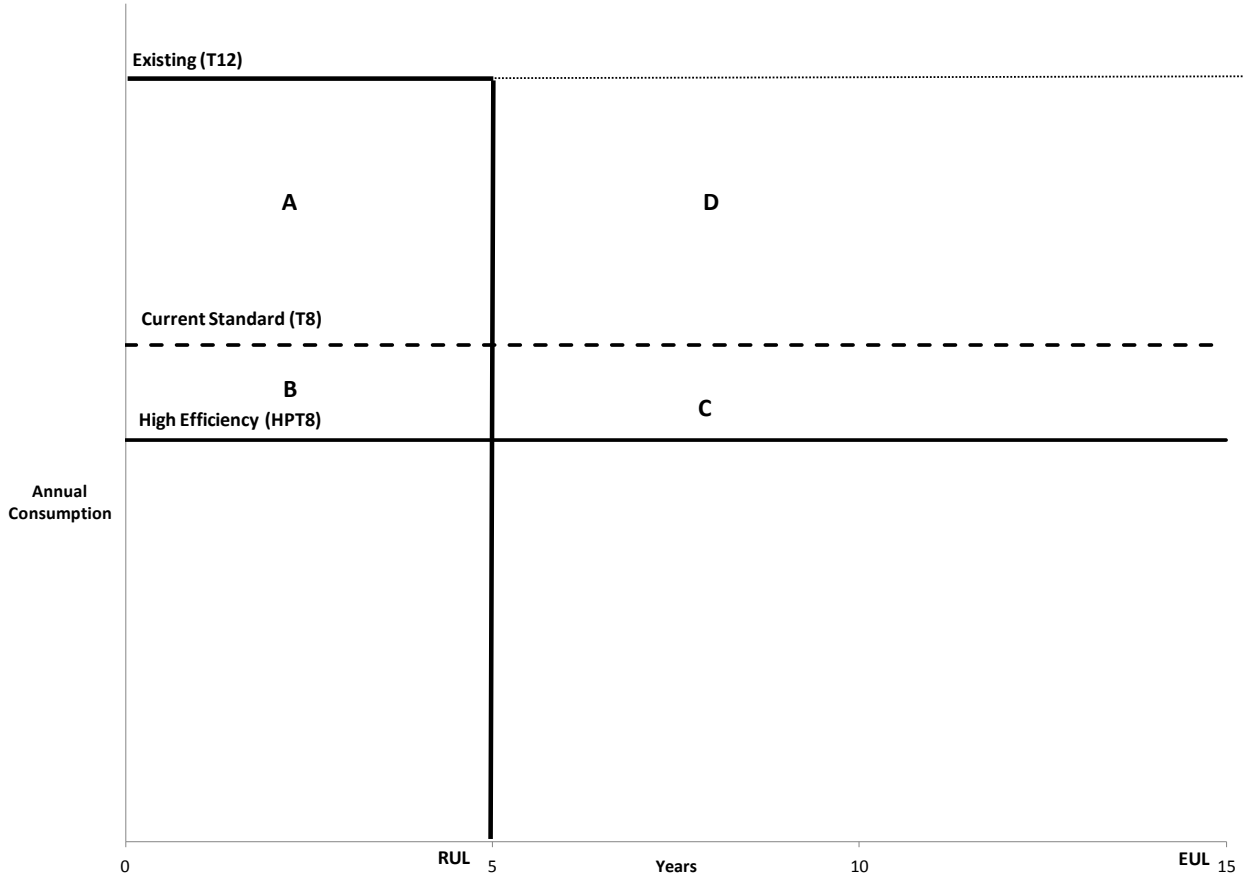

Figure 1: T8 Early Replacement Energy Savings

Model	Remaining Useful Life	Baseline Efficiency at Time of NR	Savings	Incremental Cost
Normal Replacement	RUL=0	Current Standard	B+C	B+C
Early Replacement - Retrofit	RUL=EUL	Unspecified	A+B+C+D	A+B+C+D
Early Replacement - Single Baseline	0<RUL<EUL	High Efficiency	A+B	A+B
Early Replacement - Dual Baseline	0<RUL<EUL	Current Standard	A+B+C	A+B+C

(NOTE: See Figure 3 for graphic representation of incremental cost components.)

Normal Replacement

The baseline time of normal replacement is assumed to be equal to the observed time of replacement (measure installation). Therefore the RUL=0 and the baseline efficiency is assumed to be equal to the current standard efficiency. The annual energy savings is equal to the difference between the corresponding annual consumption and the consumption of the efficient equipment (program measure). This level of savings persists for the effective useful life (EUL) of the measure. Note that Normal Replacement allows for the possibility that the current standard efficiency is the same as the efficiency of the existing equipment.

Early Replacement - Retrofit

The baseline time of normal replacement of the existing equipment is assumed to be equal to the time of normal replacement of the efficient equipment. Therefore the RUL=EUL and the annual energy savings is equal to the difference between the corresponding annual consumption and the consumption of the efficient equipment (program measure). This level of savings persists for the effective useful life (EUL) of the measure. The assumption that the RUL of the existing equipment equals the EUL of the efficient equipment implies that the EUL of the existing equipment exceeds the EUL of the efficient equipment. This assumption would generally be unwarranted unless the operational life of the existing equipment has been extended as a result of refurbishment or replacement of major components.

The retrofit model is also consistent with the alternative assumption that the RUL is less than the EUL of the efficient equipment but the savings persist beyond the time of normal replacement because the existing equipment would be replaced by equipment of the same efficiency. This assumption is generally implausible because existing equipment is typically less efficient than the current standard of efficiency and the general trend is for the current standard to increase over time.

Early Replacement – Single Baseline

The baseline time of normal replacement is assumed to be after the time of measure installation but before the expected time of replacement of the energy efficient equipment. Therefore the RUL is greater than zero but less than the EUL. The baseline efficiency at the time of normal replacement is assumed to equal the efficiency of the energy efficient equipment at the time of measure installation and the annual energy savings is equal to the difference between the corresponding annual consumption and the consumption of the existing equipment. This level of savings persists for the remaining useful life (RUL) of the existing equipment.

The Phase I research found that some ER programs employ a “blended” measure life (<EUL) to calculate lifetime savings based on the difference between existing and high efficiency equipment. While formally identical to the Single Baseline model, this practice can also be interpreted as a shortcut calculation designed to represent a Dual Baseline model, via the implicit equation of the Single Baseline and Dual Baseline lifetime savings. The use of such a shortcut, however, would incur inaccuracies in annual energy savings and measure cost-effectiveness, because the present value of benefits over the weighted average (blended) measure life would not reflect the time of normal replacement and the corresponding reduction in annual energy savings.

Early Replacement – Dual Baseline

The dual baseline model differs from the single baseline in the assumption that the baseline efficiency at the time of normal replacement is equal to the efficiency of the current standard efficiency at the time of measure installation. Therefore the annual energy savings before the time of normal replacement is equal to the difference between the annual consumption of the existing equipment and the consumption of the efficient equipment, but after the time of normal replacement the savings is based on the current standard efficiency. Thus the projected annual savings consists of a constant value (AES1) based on the existing efficiency baseline that persists until the time of normal replacement, followed by a different constant value (AES2) based on the current standard efficiency that persists until the time of replacement of the efficient equipment. The lifetime energy savings is equal to AES1*RUL+AES2*(EUL-RUL).

The program model assumptions have obvious implications for the calculation of annual and lifetime energy savings and the corresponding program benefits (avoided costs).

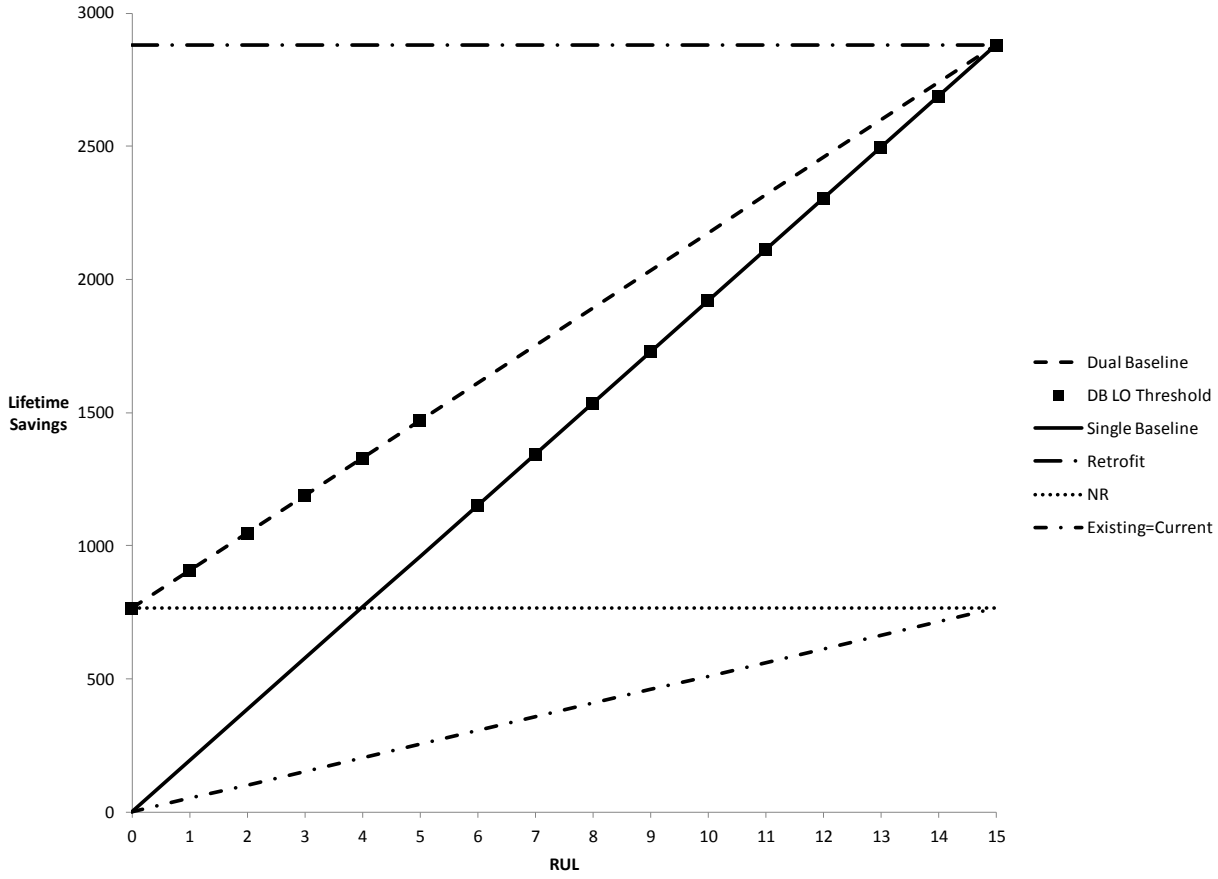

Figure 2: T8 Lifetime Energy Savings

Figure 2 presents the lifetime savings for different values of RUL in the range 0 to EUL=15 for the program models. The NR savings value is equal to the intercept of the Dual Baseline function (=AES2*EUL). The slope of the Single Baseline function is equal to AES1. The Dual Baseline slope is equal to the difference between ER and NR annual savings (=AES1-AES2), which is the difference between the existing and current standard consumption values. The Retrofit savings is equal to the Single and Dual Baseline values at RUL=EUL (=AES1*EUL).

The figure indicates the substantial range of variation in savings among the alternative program model assumptions. In this example the magnitude of lifetime savings varies from close to 0 kWh to 2,880 kWh, depending on the RUL assumption. The Retrofit and NR models represent upper and lower bounds on the Dual Baseline lifetime savings, depending on the assumed RUL. As the RUL approaches 0, the savings approach the NR value and as the RUL approaches EUL, the savings approach the Retrofit value. The Single and Dual baseline models converge to the same value as the RUL approaches EUL.

Threshold of Lost Opportunity

As noted above, a serious flaw in the Retrofit program model is the implicit assumption that the RUL=EUL. The Dual Baseline model addresses this problem via the assumption that the savings at the time of normal replacement is equal to the NR savings. However this assumption becomes more tenuous with increasing values of the RUL. Given current trends in building codes and equipment standards, as well as future implementation timetables determined by existing enactments, it is reasonable to assume that there is a threshold RUL beyond which the savings component AES2, corresponding to area C in Figure 1, goes to zero. This adjustment to the Dual Baseline model baseline

efficiency assumption is depicted in Figure 2 for an assumed threshold of RUL=5. For values of RUL<6 the lifetime savings are assumed equal to the Dual Baseline value. If the assumed RUL>5, then the lifetime savings are assumed equal to the Single Baseline value. For example, the Massachusetts Technical Reference Manual states: "the lifetime for measures replacing T12s has been reduced for the years 2013-2015 to 5.52, 4.98, and 4.57 which accounts for the effects of EISA (Energy Independence and Security Act of 2007)."

Stagnant Baseline

The line below the horizontal NR line in Figure 2 corresponds to the situation in which the efficiency of the existing equipment is equal to the current standard efficiency. In this case the ER assumption results in lifetime energy savings that are less than the corresponding savings under the NR assumption. This scenario was characterized by PAs interviewed in Phase I as a problem that arises from "stagnant baselines", i.e. measures for which "there have been relatively few upgrades to efficiency standards in recent years, so that new equipment is sometimes not that much more efficient than what is being replaced."

Existing Efficiency-RUL Tradeoff

Another factor to consider is the tradeoff between existing efficiency and RUL. Older existing equipment will tend to be less efficient, so that annual ER savings and RUL will be inversely related. This relationship implies that replacement of older equipment may be more cost-effective than replacement of equipment with a longer RUL, given consistent treatment of costs and benefits, as explained in the following section.

Cost Effectiveness

The RUL is also an important factor in the determination of incremental ER measure costs. Returning to the commercial lighting example, Figure 3 presents the parallel view of incremental measure costs for NR and ER measures. The installed cost of HPT8 lighting (A+B+C+D) is assumed to be $60. This amount is equal to the real levelized carrying charge (RLCC) multiplied by the present worth factor (PWF), assuming a ML of 15 years and a real discount rate of 3%. The incremental NR cost (B+C) is equal to $25, the difference between the installed cost of HPT8 and standard T8 lighting. The incremental Dual baseline ER cost (A+B+C), equal to $38.43, includes an additional component (A) equal to $13.43, which represents the incremental cost of replacement of the standard T8 lighting 5 years in advance of the time of NR. The incremental ER cost therefore amounts to 64% of the total installed measure cost, whereas the incremental NR cost is 42%.

The uncertainty concerning future standard baseline efficiency discussed above in the context of ER savings must be addressed in a consistent fashion on the cost side of the equation. If the future standard is expected to equal the current high efficiency level, then the incremental ER cost is equal to A+B, i.e. the Single Baseline amount. The value in this example is $23.02, or 38% of the installed cost of the measure. It is interesting that under these assumptions the incremental NR and ER costs are very close in value, so that an incentive of $25 would reimburse the customer for the cost regardless of whether the measure was an early or normal replacement. An implicit RUL can be determined that equates the incremental ER cost to the ER incentive amount. The level of acceptance of the ER incentive may indicate whether the true RUL is greater or less than the implicit RUL associated with the current incentive.

If it can be assumed, to a first approximation, that avoided costs are constant in real terms, then an interesting aspect of the Single Baseline model, assuming consistent treatment of incremental costs and benefits, is that the TRC Benefit-Cost Ratio (BCR) will not depend significantly on the assumed RUL, and will therefore equal the Retrofit model BCR. In this case the Single Baseline ER measure will be cost-effective if the Retrofit ER measure is. Of course the magnitude of the TRC net benefit and the lifetime energy savings still depend on the value of the assumed RUL. This point demonstrates the

importance of consistent treatment of costs and benefits in the determination of measure cost-effectiveness, regardless of the assumed model.

Consistency of cost and savings calculations is indicated in Figures 1 and 3 for the alternative models. It is important to employ the correct formula. For example the cost of Dual Baseline early replacement should not be calculated by subtracting the discounted installed NR cost from the installed measure cost (=$29.81 instead of $38.43, for RUL=5), because this formula does not account for the cost to replace the efficient measure. If new equipment were replaced (RUL=EUL), this method would calculate an incremental cost of $37.53 instead of $60.

To summarize, the RUL is a critical baseline assumption that has important implications for program design and for the determination of measure savings, incremental cost and cost-effectiveness. The Phase I study has determined that most ER programs employ a default assumption determined by program design. Few programs utilize site-specific information to make a determination of the RUL. Even in these situations the RUL estimate is usually equated to the difference between the estimated age of the existing equipment and the assumed measure life (EUL), a formula which is likely to underestimate the RUL, as discussed in the following section.

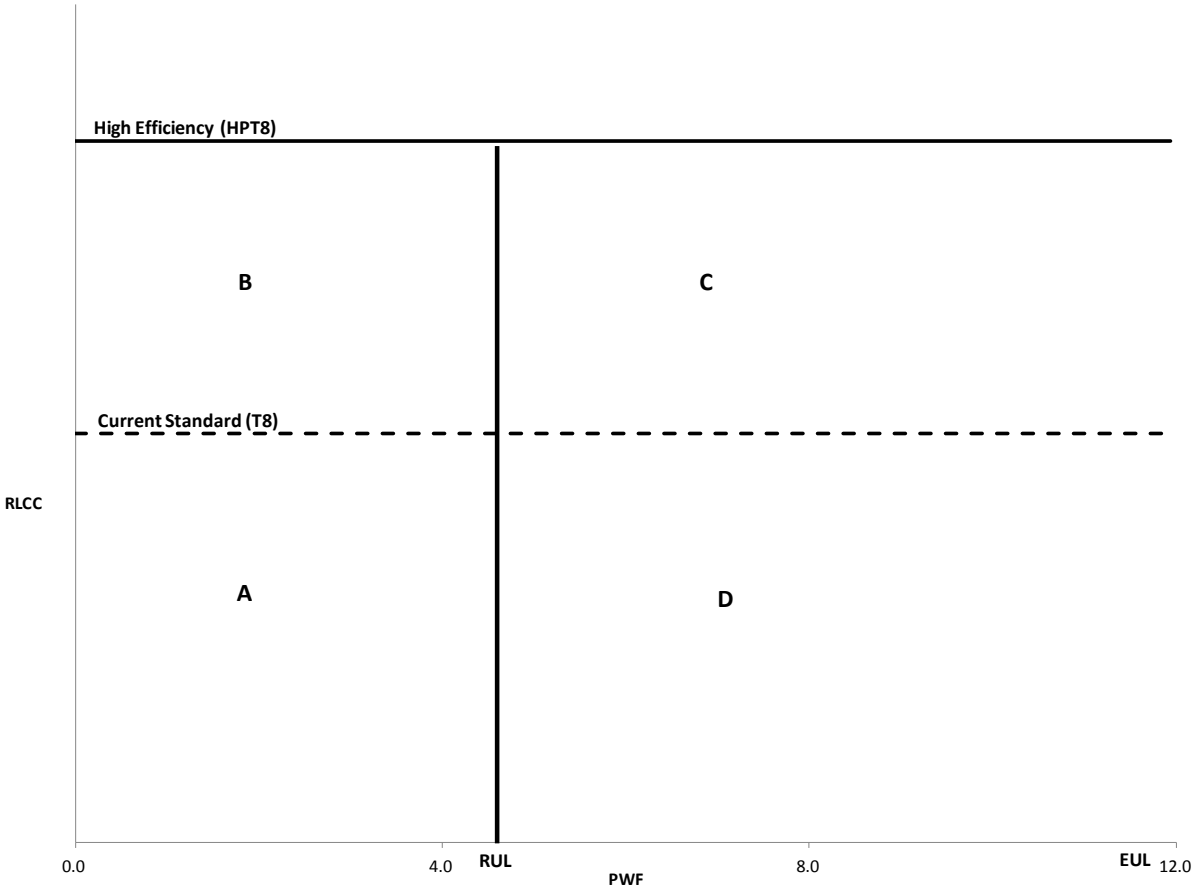

Figure 3: T8 Early Replacement Incremental Cost

(Real Discount Rate = 3%)

RUL Assumptions

As noted above, the Retrofit program model assumption that RUL=EUL is difficult to maintain unless measures have been taken to extend the life of the existing equipment, based on the implicit assumption that the RUL decreases with increasing age. It is generally assumed that the RUL is a declining function of the age of existing equipment because the probability of failure and the cost of continued operation increase with equipment age. An increasing replacement rate is supported by the results of survival analyses that have been conducted on different types of equipment.

The formation of a reasonable assumption for the value of the RUL is tricky, to say the least. Three different methods are currently in use:

Stipulated Value – The most common approach is to stipulate a value[2] that has no, or at best, a weak empirical foundation. While easy to apply, a stipulated value is inherently biased because it does not take into account the age of the existing equipment or other site-specific factors.

EUL-Age – Another common method is to equate the RUL to the difference between the effective useful life (EUL) and the age of the existing equipment, if positive, and otherwise to zero. This method may in certain instances be more accurate than a stipulated value, but is generally susceptible to significant negative bias (as explained below). In particular, its use implies that the replacement of equipment with an estimated age greater than the EUL would not qualify as an ER measure. This assumption is false by definition of the EUL, the age at which 50% of all equipment will continue to operate.

Residual Life – Much less common is the use of the median or mean residual life, based on the conditional probability of replacement given the age of the existing equipment. This method relies on an estimated survival function that determines the probability distribution of the age at replacement of a designated category of equipment. Given the applicability of the survival function to the population of ER participants, the residual life method can provide the most accurate estimate of RUL.

It is generally assumed that the RUL is a declining function of the age of existing equipment because the probability of failure and the cost of continued operation increase with equipment age. The three methods listed above differ fundamentally in the functional dependence of the calculated RUL on equipment age. As noted already, the Stipulated Value does not take age into account.[3] The EUL-Age estimate of RUL decreases with increasing age, but it does not reflect the fact that the probability that the existing equipment will reach a given age before replacement increases with current age. The following figure illustrates this point.

Figure 4 depicts the probability distribution of the age at replacement of T8 lighting, derived from an empirical estimate of the survival function (Figure 5) produced in a study of the persistence of high efficiency commercial lighting products installed by participants in energy efficiency programs.[4] The estimated median (EUL) of the distribution is equal to 16.2 years. If the current equipment age is 10 years, then the median age of replacement, conditional upon the knowledge of its age, is greater than the EUL, in this case equal to 20.5 years. Therefore the median residual value estimate of the RUL is 10.5 years (=(EUL| Age> Current) – Current Age). This value is commonly referred to as the Median Residual Life function (Med RL), which varies as a function of the current age.

[2] The California DEER employs a stipulated value of RUL=EUL/3.

[3] This would only be appropriate under the unrealistic assumption that the rate of failure is constant, independent of age, in which case the RUL=EUL, not EUL/3, the stipulated value employed by DEER.

[4] The data represent the probability density function associated with a modeled Weibull survival function fit to persistence data. See *Final Report C&I Lighting Measure Life and Persistence Project*, Prepared for the Regional Evaluation, Measurement & Verification Forum, June 2011.

The Med RL at a specified current age is determined from the survival function by calculating the difference between the age at which the survival function is equal to one half the survival function value at the current age (=(EUL| Age> Current) and the current age: Med RL (AR) = $S^{-1}(S(AR)/2)$ - AR. This formula is illustrated in Figure 5 for the value AR=10. S(AR) is the area under the curve to the right of vertical line at AR=10 in Figure 4 and $S^{-1}(S(AR)/2)$ is the age at which that area is divided in half (labeled EUL| Age> Current), which is the median age of the residual probability distribution, conditional upon AR>10. Figure 5 exhibits the dependence of the Med RL function on the shape of the survival function.

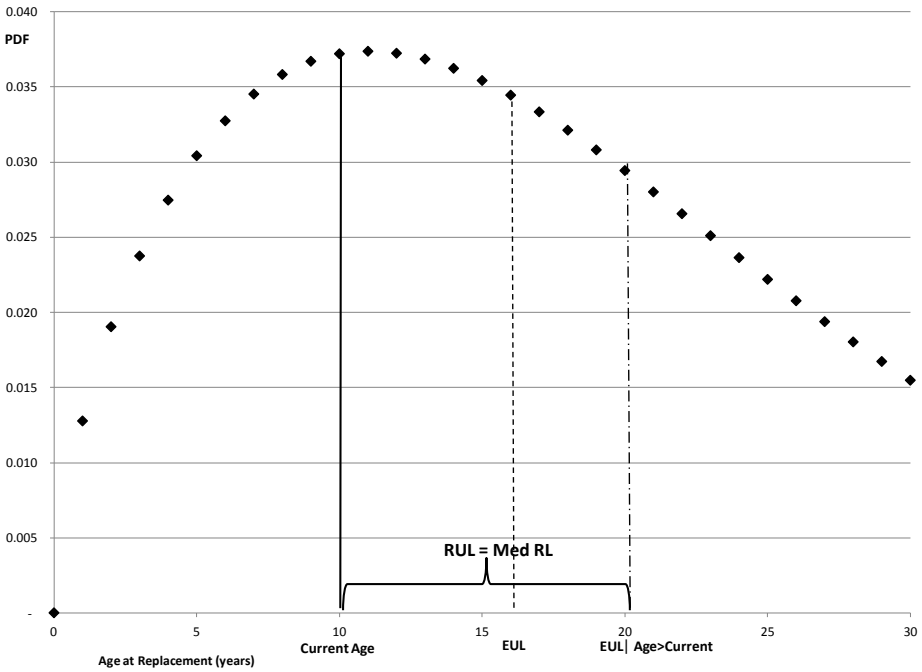

Figure 4: T8 Survival Distribution

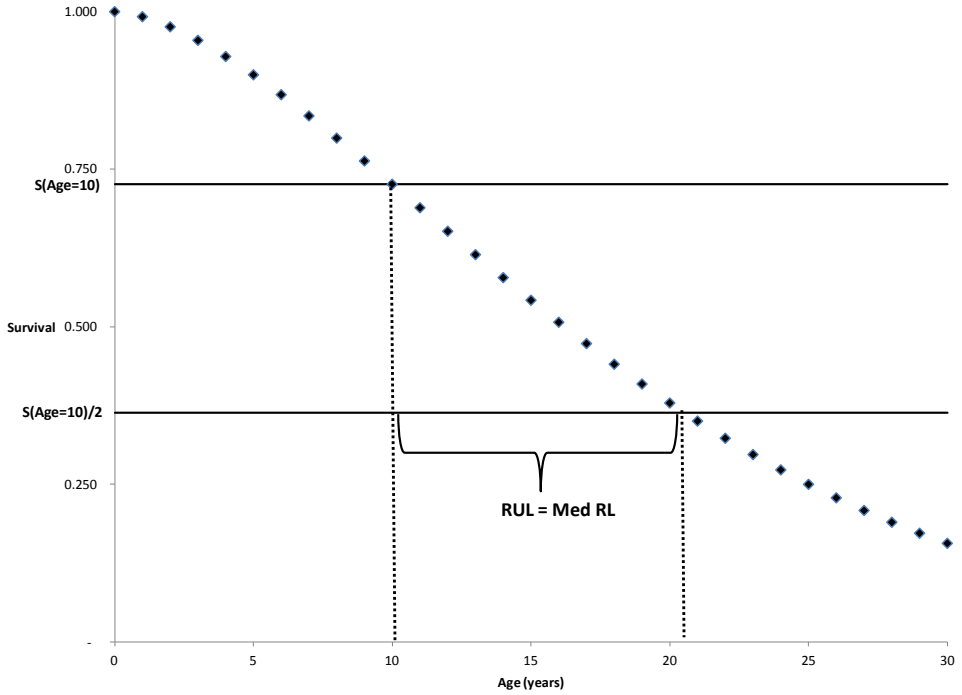

Figure 5: T8 Survival Function

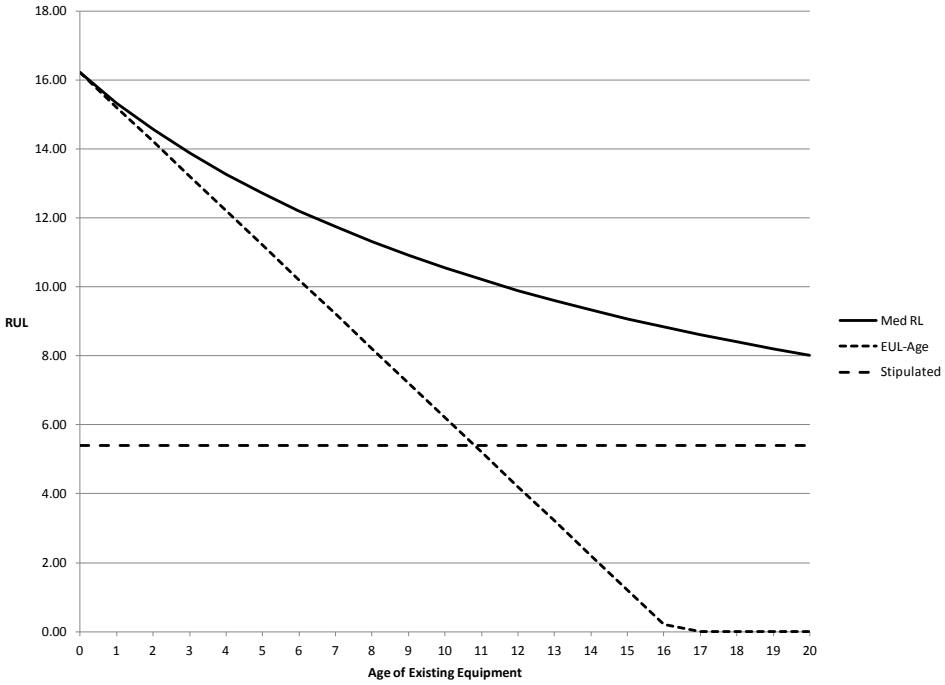

Figure 6: T8 Remaining Useful Life

The Med RL function corresponding to the T8 survival function is represented by the solid line in Figure 6. As expected, it declines with age but the rate of decline is also a decreasing function of age. The two dashed lines represent alternative RUL assumptions corresponding to the Stipulated (=EUL/3) and EUL-Age methods defined above.

The divergence of the three estimates is pronounced over the reported age range. The degree of divergence will generally depend on the shape of the survival function. For comparison the same relationship is presented for data derived from an estimated residential refrigerator survival function.[5]

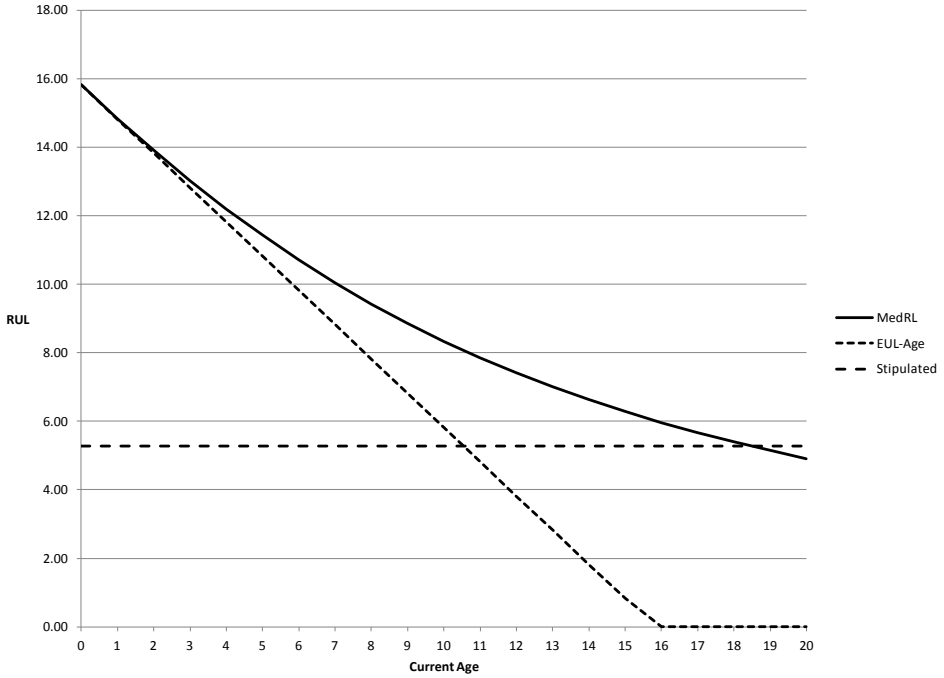

Figure 7: Refrigerator Remaining Useful Life

The Med RL, like the EUL and survival function, describes a population of equipment. For example, the survival function determines that a certain percent of the units are expected to be in service 10 years after installation, and that 50 percent of those that are still in service will continue to operate for another 10.5 years. The Med RL is the median (50th percentile) of the residual age distribution for all units of that age, but replacement of any unit could occur at any age greater than 10 years.

Figures 6 and 7 illustrate the following points:

1. The negative bias of the stipulated RUL value (=EUL/3) decreases with increasing age whereas the negative bias of RUL=EUL-Age increases with age and then decreases when Age>EUL.
2. Increasing age implies decreasing Med RL, but the decreasing rate of decline compresses the range with increasing age.
3. The accuracy of ER program RUL assumptions is highly dependent on an accurate assessment of the distribution of the age at replacement by program participants.

[5] Survival parameter estimates were taken from Welch and Rogers, *Estimating the Remaining Useful Life of Residential Appliances*, 2010 ACEEE Summer Study on Energy Efficiency in Buildings.

The figures do not illustrate the range of the residual life distribution at each age. For example, the first and third quartiles at age 10, associated with the T-8 Med RL of 10.5, are approximately 5 and 18 years, so that 25% of the units 10 years or older are not expected to be operating after 5 years and 25% are expected to be operating after 18 years.

Application of the residual life method to estimate RUL requires two types of data:

1. Baseline survival data are required to estimate the Med RL for a given AR.
2. AR data are required for program participants.

The validity of the residual life method is based on certain conditions:

1. The RUL>0.
2. The baseline survival data are representative of the population of program participants.
3. The baseline survival data conform to a reasonable standard of statistical accuracy.
4. The AR data conform to a reasonable standard of measurement accuracy.

RUL>0 represents the fundamental baseline assumption that the program measure is ER and not NR. Assumption 2 implies that the Med RL function can provide a reasonable estimate of the RUL of the ER measure given the AR. Assumption 3 concerns the method that was employed to estimate the survival function from empirical data and Assumption 4 refers to the validity and reliability of the measurement of equipment age.