Emerging Technology Efficiency Market Share Needs Assessment, Feasibility, and Market Penetration Scoping Study

Submitted to:

The California Board for Energy Efficiency

and

Pacific Gas & Electric
123 Mission Street
San Francisco, California 94177

December 6, 1999

Prepared by:

TURNING DATA INTO INFORMATION

Regional Economic Research, Inc.
11236 El Camino Real
San Diego, California 92130
(858) 481-0081

Table of Contents

1

Introduction

1.1 Overview

This report presents the results of the Near-Term Emerging Technologies Needs Assessment, Feasibility, and Market Penetration Scoping Study conducted by Regional Economic Research Inc. (RER) for the California Board for Energy Efficiency (CBEE) under management of Pacific Gas and Electric Company (PG&E). This research is an extension to RER's Efficiency Market Share Needs Assessment and Feasibility Scoping Study (referred to as the "initial study" hereafter) completed in May 1999.[1] This study's primary purpose is to develop and recommend strategies for tracking the market shares of "near-term" emerging energy efficiency products and services in the California Market and to investigate possible methods for forecasting the market penetration of such measures.

The primary function of the CBEE is to oversee and promote market transformation in California. As an advisory board to the California Public Utilities Commission (CPUC), the CBEE is spearheading a major effort to transform markets for energy efficiency in California. This effort focuses on reducing and possibly eliminating a variety of market barriers to energy efficiency through a series of program interventions funded by a Public Goods Charge (PGC) and natural gas DSM funds. Assessing the effects of programs covered by this statewide effort will be critical from the perspective of both public policy and program planning. While success will be gauged by a variety of market effects indicators, tracking efficiency market shares of products and services will be an absolutely essential element of the market assessment and evaluation (MA&E) process.[2] Market shares of cost-effective, high-efficiency products and services reflect the economic efficiency with which markets are actually operating and act as the ultimate indicators of the effectiveness of specific programs as well as the overall market transformation process.

---

1 Regional Economic Research, Inc. *Efficiency Market Share Needs Assessment and Feasibility Scoping Study*. Prepared for the California Board for Energy Efficiency. May 1999.

2 In this context, we use the term market share to refer to the proportion of products/services that are "energy efficient," or to efficiency distributions, or to overall average efficiency levels of end uses.

1.2 Project Objectives

The primary objective of this study were to develop strategies for tracking the market shares of specific "near-term" emerging energy efficiency technologies and services. A secondary objective was to begin the assessment of alternative approaches to developing estimates of baseline market shares of emerging technologies.

1.3 Definition of "Near-Term" Emerging Technology

In order to focus the study, it was necessary to develop a working definition of near term emerging technologies. Recent literature reveals that there is no standard definition of an emerging technology. For example, one study defines emerging technologies as those that either "are not yet commercialized but are likely to be commercialized and cost effective to a significant proportion of end users by 2005" or "are commercialized, but have penetrated less than 2% of the appropriate market." [3,4] Another recent study considers an emerging technology as one that is currently available on the market but is not common or one that could be available on the market within the next five years (1998-2003).[5]

Both of these definitions imply that a product or service does not have to be "new" to be considered an emerging technology. Rather, the *market* for a particular technology or service has not reached some threshold of market penetration or development. While this condition is necessary, it is not sufficient in the context of this research. In particular, the market for any particular technology might be undeveloped for a variety of reasons. Perhaps a measure has been commercialized for a significant length of time but has not gained a perceptible market share because it is not cost effective enough for the mass market. Such a measure would be classified as emerging according to the definitions presented above. However, the goal of this phase was to identify key emerging technologies as priorities for tracking – including such a measure would not be wise. Thus, a measure with an undeveloped market is too broad a definition for an emerging technology for this study. One would first need to ascertain why the market is undeveloped before classifying a technology as "emerging."

---

3 American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* December 1998.

4 Note that to narrow the number of measures covered to a manageable number, this study did not cover measures with "only long-term potential as well as measures which have already shown significant acceptance in the market."

5 Daniel, Mann, Johnson, & Mendenhall. *Technical Assessment of Residential and Small Commercial Emerging Technologies.* Prepared for Pacific Gas and Electric Company. 1998.

Given the above discussion, in the context of this study, *an emerging technology is one that has been demonstrated but is not commercially available or has only recently been commercially available.*[6]

This definition ensured that as many measures as possible were initially considered. Further, RER did not attempt to narrow the definition using a criterion on a threshold requirement for a measure’s cost-effective savings potential. A measure’s potential for cost-effective savings was one of the four criteria for selecting technologies as final priorities, thus, this crucial information will not be ignored.

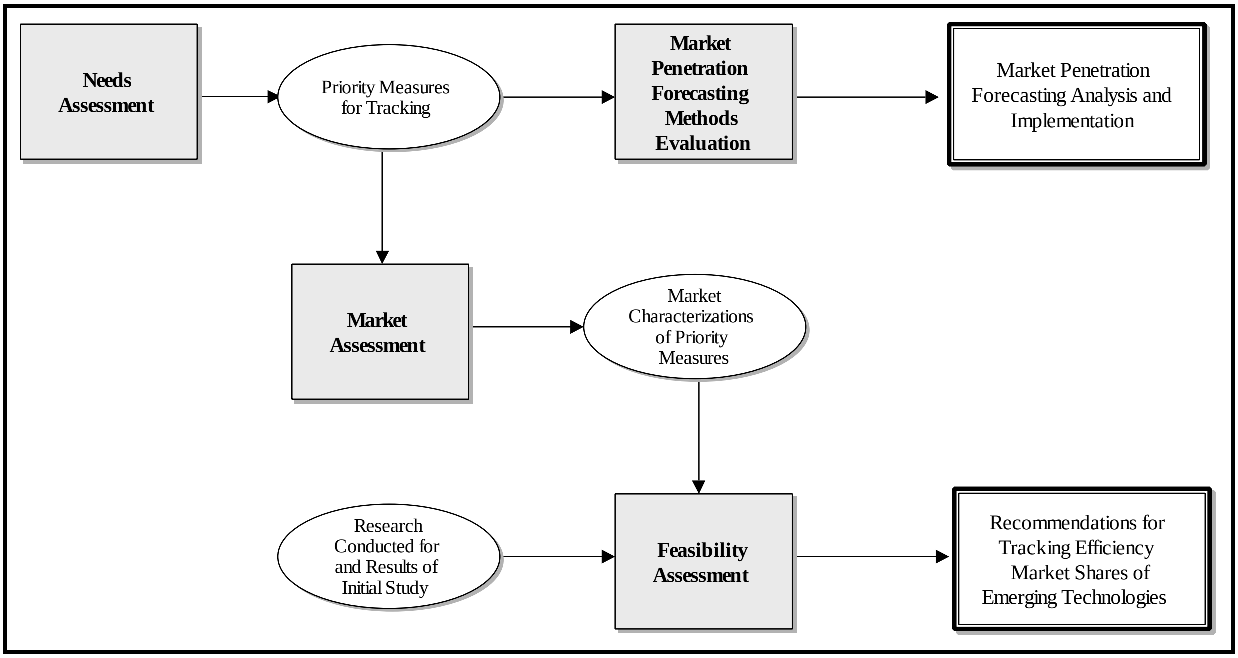
1.4 Overview of Study Methodology and Primary Results

Figure 1 provides an overview of this study. As shown, there were four major components to this project. First, RER conducted a Needs Assessment to identify priority emerging technologies and services for tracking in the California market. Next, during the Market Assessment, RER characterized the markets of priority measures to determine points in the distribution channel at which data for market share tracking can be obtained. Finally, recommendations for market share tracking were developed according to whether any given priority measure could be incorporated into an existing or recommended market share tracking effort. RER also conducted an evaluation of methods of forecasting the market penetration of emerging technologies and services and conducted a demonstration of a preferred method.

The elements of the study and the primary results of the analysis are discussed below.

[6] Also note that the renewable and self-generation technologies are not in the scope of this study.

Figure 1-1: Project Overview



Needs Assessment

The objective of the Needs Assessment was to identify specific emerging energy efficiency measures for which tracking systems should be developed. Twelve priority emerging technologies and services were identified based upon results of recent evaluations of the role of emerging technologies and services in market transformation programs and in-depth interviews with industry experts and participants. These technologies are: evaporative condenser air conditioning, indirect-direct evaporative coolers, aerosol-based duct sealing, integrated new home design, dedicated CFL floor and table lamps, high-efficiency horizontal axis clothes washers, electrodeless (induction) lamps, integrated lighting fixtures and controls, building commissioning and retro-commissioning, integrated commercial building design, supermarket refrigeration optimization, and advanced metering technologies.

Market Assessment

The objective of the second phase of this study was to identify and investigate alternative methods for tracking the market shares of the measures identified as priorities in the Needs Assessment. Because energy efficiency programs in the State are categorized and developed according to *market events*, including new construction, retrofit, and replace-on-burnout/net acquisition, it is also necessary to collect data that can distinguish these decision types. Thus, in the context of this research, data required for tracking efficiency market shares must meet the following requirements:

- Data represent unit sales, and
- Data are/can be segmented by efficiency level (if applicable), and
- Data are/can be segmented by geographic region, at least at the state level, and
- Decision type (new construction and replace-on-burnout/retrofit/net acquisition) must be identifiable, when applicable.

Keeping these data requirements in mind, the overall approach to this was to answer two key questions:

- At which point in the distribution channel does it make the *most sense* to collect market share data for the priority measures?
- What methods or strategies could be implemented to collect market share data at various distribution points?

To address the first research question, RER characterized the markets for the identified priority measures and determined the point(s) in the distribution channels where it makes the most sense to collect data required for tracking. Research completed for the initial study provided information to answer the second question and was not repeated here. In particular, the Methods Assessment of the initial study required the identification and review of a wide range of alternative data sources and data collection methods.[7] The methods and data sources reviewed include publicly available shipments data, consumer panel data, and scanner data; building department records; downstream market actor surveys; and sales data collection from upstream and midstream market actors.

Feasibility Assessment

RER utilized the results of the first two phases to determine the most feasible means for tracking market shares of emerging technologies and services. The Feasibility Assessment approach of this add-on study is significantly different than conducted for the initial study. In particular, the first priority was to incorporate emerging technologies and services into tracking efforts currently being developed or that were at least recommended in California. The three primary criteria used to determine if the measure could be covered in an existing effort include:

1. The emerging technology/service has or will have an identical distribution channel or service providers as existing measures covered by the initiative, and
2. Data for the additional measure could be obtained with out significantly altering the design of the planned or recommended initiative, and
3. The marginal cost for adding the measure is relatively low.

[7] See Section 5 of the initial study.

The final step of the Feasibility Assessment was to formulate recommendations for tracking the market shares of measures that did not meet the above criteria. Insofar as data for each of the remaining measures could realistically be obtained with only one method, the in-depth feasibility analysis for evaluating alternatives used for the initial study was not necessary here.

The result of the Feasibility Assessments is a set of recommendations and associated cost estimates for tracking the efficiency market shares of the priority emerging technologies and services in the California market. Table 1-1 summarizes RER's recommendations for tracking the priority near-term emerging technologies. As shown, RER recommends the following:

- Incorporate measures into tracking initiatives that are currently being developed or were at least recommended in the initial scoping study, and
- Develop new market share tracking initiatives. RER recommends the following methods for tracking priority measures that could not be covered by current activities:
  - Obtain records from Aeroseal, Inc. to monitor aerosol-based duct sealing applications,
  - Administer a survey of residential building designers to track shares of other high-priority emerging residential technologies, and
  - Administer a survey of nonresidential building designers to track shares of remaining high priority nonresidential measures.

RER estimates that the marginal cost of incorporating measures into efforts being developed will be very low. Cost increases will primarily result from longer on-site surveys needed to cover the additional measures, particularly if a survey of on-site building personnel is required. For example, the per unit cost increase needed to incorporate measures into the commercial new construction and existing building on-site survey will be roughly $25 to $50.

Table 1-2 provides a summary of the costs of the initiatives for tracking measures that could not be incorporated into other market share efforts. The estimated annual budget to develop and implement these three initiatives is $211,000 to $338,000 for the first year. Because development costs are not incurred in subsequent years, annual costs are reduced to roughly $172,000 to $278,000. *Note that the estimated costs presented in this study do not reflect any economies that can be realized by coordinating with other MA&E efforts.*

The costs of these tracking initiatives are substantial, but are necessary to achieve the assessment of market transformation efforts aimed at emerging technologies. RER strongly recommends coordination among utility program managers, MA&E project managers, and managers of market share tracking initiatives to identify opportunities for avoiding duplication of efforts and reducing the burden on market actors for participating in surveys. This is particularly relevant to initiatives IX and X, which require surveys of building designers to characterize and monitor standard building design practices.

Table 1-1: Summary of Market Share Tracking Recommendations

High-Priority Measure	Recommendation	Status
Evaporative condenser air conditioning	Incorporate into residential new construction market share tracking and distributor sales data collection efforts.	In development
Indirect-direct evaporative coolers	Incorporate into residential new construction market share tracking and distributor sales data collection efforts.	In development
Aerosol-based duct sealing	Obtain records from Aeroseal Inc.	New
Integrated new home design	Survey new home builders to characterize standard design practices.	New
Dedicated CFL floor and table lamps	Incorporate into residential new construction on-site surveys and retail data collection efforts.	In development
High-efficiency vertical-axis clothes washers	Incorporate into residential new construction on-site surveys and retail data collection efforts.	In development
Electrodeless (induction) lamps	Incorporate into nonresidential new construction/existing building on-site and telephone surveys.	Recommended
Integrated lighting fixtures & controls	Incorporate into nonresidential new construction/existing building on-site and telephone surveys.	Recommended
Building commissioning & Retro-commissioning	Incorporate into nonresidential new construction/existing building on-site and telephone surveys.	Recommended
Integrated commercial building design	Survey commercial building design professionals to characterize standard design practices.	New
Supermarket refrigeration optimization	Incorporate into nonresidential on-site and telephone surveys of existing establishments.	Recommended
Advanced metering technologies	Incorporate into nonresidential on-site and telephone surveys of existing establishments.	Recommended

Table 1-2: Summary of Annual Costs for Planning and Implementing Additional Market Share Tracking Initiatives

Recommended Initiative	First Year	Second Year
VIII. Obtain Records from Aeroseal, Inc.	$13,000 to $34,000	$8,000 to $24,000
IX. Survey of Residential New Construction Builders	$89,000 to $137,000	$72,000 to $112,000
IX. Survey of Commercial New Construction Design Professionals	$109,000 to $167,000	$92,000 to $142,000

Market Penetration Forecasting Analysis and Demonstration

The use of market penetration analysis on emerging energy efficient technologies and services to gauge the impact of market transformation initiatives is a relatively new and underdeveloped area. For measures with well established markets, assessing the success of market transformation programs is accomplished by comparing the actual market penetration of the emerging efficiency measures with market transformation programs to estimates of what the market penetration of these technologies would be without the market transformation initiatives (i.e., the hypothetical baseline conditions). However, baseline data does not exist for emerging technologies and services; thus, baseline conditions cannot be directly measured and can only be estimated through modeling.

Thus, the primary goal of this phase of the study was to identify, evaluate, and demonstrate alternative methodologies for forecasting the baseline market shares of emerging technologies. In the course of this element of the study, RER reviewed and evaluated the most commonly used market penetration forecasting approaches, including judgmental methods, consumer research, and methods of modeling by analogy, including simple historical analogies, diffusion models, and market share analysis. Each method was judged according to the *applicability* of the approach to forecasting baseline shares, the likely *accuracy* of the approach, the *availability of data* required to implement the approach, and the *cost* of implementation.

The results of the analysis are not particularly encouraging. While all of the methods covered by the review could in principle be applied the estimation of baseline market shares, each has serious drawbacks under current conditions. Judgmental approaches offer flexibility and minimal data requirements, but are not likely to provide the kind of accuracy that would be required for the assessment of market effects. More formal empirical approaches could be utilized, but (given the lack of data on the emerging technologies in question) would necessitate some means of modeling by analogy. Unfortunately, even this set of approaches, which would include variants of diffusion modeling and market share analysis, is severely handicapped by the lack of data on analogous existing mature technologies. Even our demonstration of these methods for electronic ballasts required the use of highly aggregated data, and was far from an ideal exercise. Modeling market shares of emerging technologies (or for that matter, mature technologies) will require a serious effort to track market shares over reasonably long periods of time. The CBEE has started this process of tracking, and this process will eventually enhance our ability to assess market effects.

1.5 Organization of the Report

The remaining Sections of this report include the following:

- Section 2 presents the methodology and results of the Needs Assessment,
- The third section includes the Market Assessment of the emerging efficiency measures identified as high priorities for tracking,
- Section 4 presents RER' s recommendations for tracking the market shares of the priority emerging technologies and services, and the approach for developing these recommendations,
- Section 5 presents the market penetration forecasting analysis and demonstration, and
- The final section summarizes the recommended tracking initiatives and results of the market penetration forecasting analysis and offers some concluding remarks.
- Appendix A includes the bibliography, and
- Appendix B and C include the interview materials developed for the Needs Assessment.

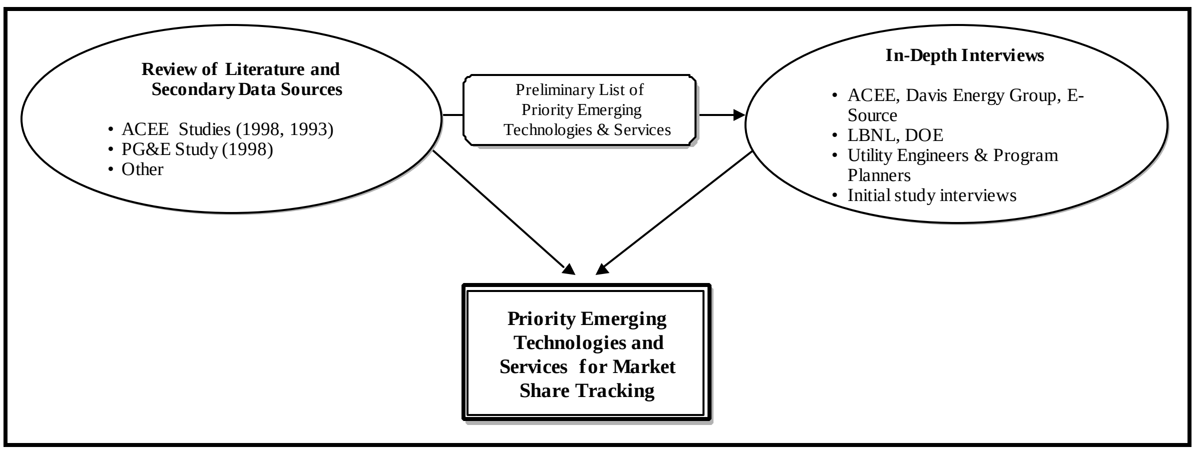
2

Needs Assessment

2.1 Overview and Objectives

The objective of the first phase of this study was to identify 10 to 15 "near-term" emerging technologies to be considered for tracking for the remainder of the project. Figure 2-1 depicts the general approach to identifying priority emerging technologies. As shown, the results of several studies pertaining to emerging technologies and the information obtained during in-depth interviews helped RER compile a list of 10 to 15 priority near-term emerging technologies for tracking that will be considered during the remaining phases of this study.

Figure 2-1: Overview of Needs Assessment



The remaining sections summarize the methodology and present the results of the Needs Assessment.

2.2 Needs Assessment Methodology

As shown above in Figure 2-1, three primary elements comprise the methodology for deriving the final priority measures:

1. Review prior research evaluating emerging technologies as targets for market transformation programs,

2. Compile a preliminary list of near-term emerging efficiency measures for consideration as priorities, and
3. Conduct interviews with experts and industry participants.

Reviews of Prior Research Evaluating Emerging Technologies as Targets for Market Transformation Programs

Several recent studies that evaluated emerging technologies and their role in market transformation programs were recently completed. An extensive analysis conducted by the American Council for an Energy-Efficient Economy (ACEEE), the Davis Energy Group, and E-Source identifies several emerging technologies as targets for market transformation initiatives. This study was national in scope and focused on technologies applicable to the residential and commercial sectors. Other studies conducted for PG&E focused on the potential emerging technologies in the residential and small commercial sectors in the PG&E service area. Reviews of these studies and their applicability to this study are presented below.

Emerging Energy-Saving Technologies and Practices for the Building Sector

The primary objectives of this study (referred to as the 1998 ACEEE ET study hereafter) were to 1) identify new research and demonstration projects that help promote high priority emerging technologies, 2) identify potential new measures for market transformation activities, and 3) provide information on emerging technologies.[1,2] In the context of this study, an emerging technology is defined as follows:

- A technology or practice that is not yet commercialized but is likely to be commercialized and cost-effective to a significant proportion of end-users by 2005, or
- A technology or practice that is commercialized but has penetrated no more than 2% of the appropriate market.

The 1998 ACEEE ET study ultimately resulted in a prioritization of emerging technologies and practices covered by the analysis. In particular, the study identified 12 high priority and 21 medium priority emerging technologies and practices from an extensive list of over 350 measures. The approach used to prioritize the measures is summarized below.

---

1 The 1998 ACEEE ET Study updates and extends the analysis of a similar study completed in 1993 by the same authors. See California Energy Commission, 1993.

2 American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* Draft Final Report. October 1998.

- ***Develop Initial List of Measures.*** First, the study team constructed an initial list of 352 measures based on an extensive literature search and numerous contacts with professionals from various organizations. The initial list of technologies and practices covered the residential, commercial, and industrial sectors as well as retrofit, new construction, replace-on-burnout, and original equipment manufacturers' decision types.
- ***Determine Savings Potential for Each Measure.*** To narrow the initial list, measures were categorized into high, medium, or low potential measures based on the cost of saved energy relative to national average energy prices. High potential measures have a cost of saved energy less than 50% of current national average energy prices or can reduce residential/commercial energy use by 0.5% or more. Low potential measures have a cost of saved energy greater than current national average energy prices, or can reduce residential/commercial energy use by no more than 0.25%. Medium potential measures are those that fit neither the high or low potential requirements. Roughly 40% of the initial list of measures fell into the high or medium potential categories.

  The study team conducted preliminary investigations on the medium potential measures by estimating their savings potential and cost of saved energy. As a result, some measures were re-labeled as high or low potential measures.
- ***Conduct Detailed Analysis.*** A more detailed analysis was then conducted for 73 high and medium potential measures. (Low potential measures were dropped either because their levelized costs were too high or because estimated energy savings were too low.) In particular, over 30 pieces of data were collected for each measure. These data were organized into eight categories: market information, base case information, new measure information, savings information, cost information, data quality assessment, likelihood of success, and recommended next steps.
- ***Prioritize Measures.*** Finally, the study team prioritized the measures based on three factors: potential energy savings, cost of saved energy, and likelihood of success.
  - ***High priority measures*** have potential energy savings of at least 1% of projected U.S. residential and commercial energy consumption in 2015, have a cost of saved energy less than half of current retail energy prices, and are judged to be very or somewhat likely to succeed.
  - ***Medium priority measures*** have potential savings of 0.25 to 1% of projected U.S. residential and commercial energy consumption in 2015, have a cost of saved energy less than current retail energy prices, and are judged to be very or somewhat likely to succeed.
  - ***Low priority measures*** have potential energy savings of less than 0.25% of projected U.S. residential and commercial energy consumption in 2015 but otherwise meet the criteria of a medium priority measure.
  - ***"Not a priority" measures*** have a cost of saved energy greater than current retail energy prices or are judged to be not very likely to succeed.

Table 2-1 presents the results of the 1998 ACEEE ET study. As shown, the study team identified 12 high priority measures and 21 medium priority measures covering residential, commercial, and industrial sectors. The measures that pertain to more than one market include aerosol-based duct sealing, dual source heat pumps, improved ducts and fittings, improved heat exchangers, reduced-cost high efficiency CFLs, metal halide replacements for incandescents, evaporative condenser air conditioning units, advanced metering/billing systems, and compact fluorescent floor and table lamps.

As noted by one of the authors of the 1998 ACEEE ET study, the results are generally transferable to the California market, though the weather sensitive measures would need careful consideration with respect to this issue.[3] Detailed analysis and results pertaining to most lighting, practice, power, shell, and appliance measures would be applicable to the California market, while analysis regarding HVAC and other weather sensitive measures would need to be reconsidered because of climate differences between California and national averages.[4]

---

3 One study author was interviewed during the Needs Assessment phase of the initial study. During this interview, the respondent was directly asked about the transferability of results of the 1998 ACEEE ET study to the California market.

4 In the 1998 ACEEE ET study, the estimated base case data, cost, and savings information in absolute terms are based on national averages. Therefore, cost effectiveness and savings potential estimates for some HVAC measures might not be accurate for the California market.

Table 2-1: Results of 1998 ACEEE ET Study

High Priority Measures	Medium Priority Measures
High efficiency vertical axis clothes washers	"Low leak" home electronics
Aerosol-based duct sealing	One (1) kWh/day refrigerator/freezers
Commissioning existing commercial buildings	High efficiency dishwashers
Dual source heat pumps	Improved efficiency AC compressors
Improved ducts and fittings	Improved efficiency refrigeration compressors
Improved heat exchangers	Adv. clothes washer and dishwasher controls
Integrated lighting fixtures and controls	Switched reluctance drives
Reduced-cost, high efficiency CFLs	Indirect-direct evaporative coolers
Metal halide replacements for incandescent	Evaporative condenser air conditioning
Integrated new home design	Commercial distribution system air sealing
Integrated commercial building design	Advanced metering/billing systems
Integrated space/water heating systems	One-lamp fixtures and task lighting
	Compact fluorescent floor and table lamps
	Improved fluorescent dimming ballasts
	Fuel cells
	Microturbines
	Dry-type distribution transformers
	Heat reflecting roof coatings
	High R (>4) windows
	Integrated space/H_20 heat systems (gas and oil)
	Residential heat pump water heater

The transferability of results of the 1998 ACEEE ET study can also be evaluated based on a similar study conducted for the CEC in 1993 (referred to as the 1993 CEC study hereafter).[5] In particular, 12 of the high and medium priority measures in Table 2-1 were also considered priorities for California energy efficiency programs in the 1993 CEC study. The overlapping high priority measures include the following:

- Reduced-cost high efficiency CFL,
- Integrated lighting fixtures and controls,
- Aerosol-based duct sealing, and
- Improved ducts and fittings.

[5] The objective of this earlier study was to identify new technologies that should be priorities for energy efficiency programs in California. This study only covered electric and gas technologies. See California Energy Commission, 1993.

The overlapping medium priority measures include the following:

- One (1) kWh/day refrigerator/freezers,
- Advanced clothes washers and dishwasher controls,
- High efficiency dishwashers,
- Compact fluorescent floor and table lamps,
- Improved fluorescent dimming ballasts,
- Evaporative condenser air conditioning,
- Heat reflecting roof coatings, and
- Switched reluctance drives.

Technical Assessment of Residential and Small Commercial Emerging Technologies

The primary objectives of this study (referred to hereafter as the 1998 PG&E ET study) were to 1) identify new measures for potential PG&E market transformation activities, and 2) evaluate emerging technologies.[6] In the context of this study, an emerging technology is defined as follows:

- A technology or practice that is currently available on the market but is not common, or
- A technology or practice that could be available on the market within the next five years (1998-2003).

The study identified and evaluated 10 potential emerging technologies in the residential and small commercial sectors according to several criteria, including the stage of market maturation, savings potential, and the market barriers impeding adoption. The approach of the analysis is summarized below.

- ***Determine Technologies to be Covered by the Analysis.*** First, the study team compiled a list of 10 technologies to be covered by the analysis of this study based on four criteria:
  - The technology is applicable in the residential or the light commercial sector,
  - The technology is not covered in other PG&E Market Transformation Initiatives,
  - The technology has been demonstrated but is not commercially available, has only recently been commercially available, or has not achieved significant market penetration, and
  - The technology offers significant energy savings potential.

6 Daniel, Mann, Johnson, & Mendenhall. *Technical Assessment of Residential and Small Commercial Emerging Technologies.* Prepared for Pacific Gas and Electric Company. 1998.

Selecting Targets for New Market Transformation Initiatives, prepared by ACEEE, Xenergy, and E-Source, was the primary source for developing the list.

- ***Conduct Literature Review and Collect Preliminary Information.*** Second, after reviewing numerous sources for technology research, the project team identified the following for each measure: energy savings potential, target market, current market availability, current and mature market costs, operating issues, and future development plans and issues in California.
- ***Conduct Economic Analysis.*** Third, an economic analysis was conducted for each measure, considering current costs and costs of a mature technology, from both a user's and a Total Resource Cost (TRC) perspective.
- ***Estimate Potential Net Impact.*** Fourth, the study team estimated the potential net impact that each technology might have on electricity or gas usage in PG&E's service area according to three scenarios: base use, moderate, and full penetration.
- ***Identify Market Barriers.*** Finally, the study team identified market barriers being faced by each technology and recommended ways that PG&E might address those barriers.

Table 2-2 below includes the 10 emerging technologies covered by this study and the analysis results. The study ultimately recommended that PG&E market transformation initiatives promote verified duct sealing with an aerosol sealing process and coin-operated horizontal axis clothes washers. "While there are technologies with greater potential savings, these two offer the combination of identifiable and addressable market barriers, cost effectiveness in many circumstances throughout the PG&E system, and significant savings potential."[7]

[7] Daniel, Mann, Johnson, & Mendenhall. *Technical Assessment of Residential and Small Commercial Emerging Technologies.* Prepared for Pacific Gas and Electric Company. 1998.

Table 2-2: Results and Recommendations of 1998 PG&E ET Study

Emerging Technology	Market Maturity	Cost-Effective	Savings Potential	Market Barriers
Verified duct sealing	Pilot testing	Often	High	Medium
Blower door assisted infiltration reduction	Available	Limited	Medium	High
Combined space/water heat: hydronic	Available	Often	Very high	Prohibitive
Combined space/water heat: forced air	Available	Often	Very high	High
Modulating furnaces	Available	No	Low	Medium
Efficient furnace blowers	Available [1]	Possibly	Low	Medium
Coin-op. horizontal axis washers	Available [1]	Very often	High	Medium
Clothes dryer: microwave	In develop.	No	High	Prohibitive
Clothes dryer: heat pump	Available in Europe	No	High	Prohibitive
Clothes dryer: thermostat	Available	Limited	Low	Medium
Low energy/water use dishwashers	Available	Limited	Low	Medium
Gas storage water heaters	Available	Limited	Medium	Medium [2] High [3]
High efficiency 10 ton packaged AC	Available [1]	Often	Medium	Medium

1 Components only.
2 Non-condensing.
3 Condensing.

The preliminary list of priority emerging measures and the interview respondent sample, protocol, and structure, and discussion topics are summarized below.

Compile Preliminary List of Priority Emerging Technologies

The second step of the Needs Assessment was to develop a preliminary list of emerging technologies. It is not in the interest of this study to duplicate previous research efforts, such as those reviewed above, but rather to assess the transferability of results to the California market and to incorporate results into this first study phase. In particular, the results of the 1998 ACEEE and PG&E ET studies were used to compile the list of preliminary measures to be discussed and evaluated during the in-depth interviews. The preliminary list served as a useful starting point and limited the number of technologies to a manageable size, which helped focus the interview discussions. Previous studies pertaining to emerging technologies and their role in market transformation initiatives were particularly useful to this phase of the study, as they have already prioritized emerging technologies from a market transformation perspective to some extent.

To compile a preliminary list of measures, RER combined the results of the 1998 ACEEE and PG&E ET studies, then eliminated duplicates across study results and the measures covered by the initial study. Suggested measures that were considered emerging technologies during the interviews of the initial study are also included. The resulting preliminary set of emerging technologies is presented in Table 2-3.

As explained below, RER staff attempted to interview utility research staff and program planners first to ensure that any emerging technologies covered by California energy efficiency programs were included in the preliminary list of measures. The preliminary list was then augmented with measures suggested by utility staff before other interview respondents participated.

Table 2-3: Preliminary List of Priority "Near-Term" Emerging Technologies

Residential	Nonresidential
HVAC and Water Heating	**HVAC and Water Heating**
Improved efficiency AC compressors	Dual source heat pumps
Improved heat exchangers	Evaporative condenser air conditioning
Indirect-direct evaporative coolers	Improved heat exchangers
Integrated space/H_20 heat pumps	**Shell**
Modulating gas furnaces	Blower door assisted infiltration reduction
Residential heat pump water heater	Commercial distribution system air sealing
Dual source heat pumps	Heat reflecting roof coatings
Combined space/water heat: hydronic	**Lighting**
Combined space/water heat: forced air	Compact fluorescent floor and table lamps
Evaporative condenser air conditioning	Improved fluorescent dimming ballasts and controls
Gas storage water heaters	One-lamp fixtures and task lighting
Efficient furnace blower motors	Sulfur lighting*
Shell	T-5 fluorescent lamps*
Blower door assisted infiltration reduction	Metal halide replacements for incandescent
Lighting	Integrated lighting fixtures and controls
Metal halide replacements for incandescents	**Other**
Compact fluorescent floor and table lamps	Light emitting diode traffic lights (3-color retrofit)*
Other	Integrated commercial building design
Integrated new home design	Commissioning existing commercial buildings
Improved efficiency refrigeration compressors	Switched reluctance drives
Appliances	
High efficiency vertical axis clothes washers	
Coin-op. horizontal axis washers	
One (1) kWh/day refrigerator/freezers	
Adv. clothes washer and dishwasher controls	
Clothes dryer: heat pump	
Clothes dryer: microwave	
Clothes dryer: thermostat	
"Low leak" home electronics	

* Suggested as a priority measure in the initial study.

In-Depth Interviews

The ultimate goal of the in-depth interviews was to obtain enough measure-specific information that would enable RER staff to identify priority emerging technologies for tracking. In particular, the following objectives were sought:

- Identify additional emerging technologies that should be included in the preliminary list of measures, such as those promoted by utilities or other organizations,
- Identify measures that should be considered priorities for market share tracking, and
- Obtain supporting measure-specific information, such as measure characteristics, promotion activities, applications, and current market status.

The interview sample, interview protocol, interview structure, and discussion topics suggested emerging technologies to be added to the preliminary list. Key observations and issues identified during the interviews are presented below.

Interview Sample and Interview Respondents

Table 2-4 presents the sample of respondents who were the initial targets for the interviews. As shown, the majority of respondents are involved in research and development and/or some engineering-related field and are likely to have knowledge of technologies that have not yet been commercialized or have not yet penetrated the market to a great extent. Because information about specific technologies and their potential for adoption is required to identify priorities for tracking, efforts were made to interview individuals who have an in-depth understanding of specific end-use technologies, a broad-based knowledge of new technologies and the markets in which they will enter, or both.

Table 2-4: Interview Sample

Organization	
American Council for an Energy-Efficient Economy	Lighting Research Center
California Energy Commission: Energy Technology Development and Energy Efficiency Divisions	Northwest Energy Efficiency Alliance
California Institute for Energy Efficiency	NAESCO
California Manufacturers Association	Pacific Energy Center
Consortium for Energy Efficiency	Pacific Gas & Electric
Davis Energy Group	San Diego Gas & Electric
E-Source	SMUD
Electric Power Research Institute	Southern California Edison
Lawrence Berkeley National Laboratory: Building Technologies Program, Energy and Environment Division	Southern California Gas Company
Lighting Design Laboratory	U.S. Environmental Protection Agency
	U.S. Department of Energy: Office of Building Technologies, Federal Energy Technology Center, Office of Energy Efficiency Renewable Technology, and Office of Industrial Technologies

Interview Protocol

The protocol for conducting the in-depth interviews consisted of the following steps:

- First, RER contacted potential interview respondents by telephone and/or e-mail, explained the study objectives, and arranged a time for the interview. Representatives from each organization in the sample included in Table 2-4 were contacted several times to participate in this research.[8]
- RER then provided each respondent with a short memorandum that briefly described the study, the list of preliminary priority measures, the working definition of an emerging technology adopted for this study, and brief descriptions of the criteria RER will use to select the final priority measures. Providing this information before the interview allowed the respondent to consider relevant

8 Because of the tight schedule and the need to identify the priority measures, RER set a deadline of April 30, 1999 for those contacted to respond and participate.

issues and obtain any required information to prepare for the interview. A sample memorandum is included in Appendix B.

- RER staff then conducted the interview according to the interview structure and discussion guide described below.
- RER attempted to interview utility staff first to ensure that any emerging technologies that are or will be covered by 1999 energy efficiency programs or that are being promoted by utilities are included in the preliminary list of measures. Any measures suggested by utility staff were added to the preliminary list of measures for the remaining interviews. RER attempted to conduct these interviews in person.

General Interview Structure and Discussion Topics

The in-depth interview was designed to obtain information pertaining to the following topics, questions, and issues.[9]

- ***Introduction and respondent background.***
- ***Discuss criteria for selecting priority emerging technologies.***
- ***Include emerging technologies to be covered by energy efficiency programs that are not included in the preliminary list.*** RER attempted to interview utility research staff and program planners first to ensure emerging technologies covered by California energy efficiency programs were included in the preliminary list of measures. The preliminary list was then augmented with any additional measures suggested by utility staff before the remaining interviews were conducted. Emerging technologies not in the preliminary list but identified by other interview respondents were also considered for the final set of measures.
- ***Identify measures that should be priorities for tracking.*** Interview respondents identified or "voted" for measures that they feel should be priorities for tracking. Other topics included discussions on how the respondent selected measures, how they met RER's criteria of an emerging technology, and the four selection criteria with respect to identified measures. Why were they chosen as priorities? Why were the others not chosen?
- ***Obtain additional information about chosen and rejected measures.*** Additional information answered the following research questions. Are there similarities to already commercialized measures? What distinguishes the emerging technology from existing measures? What is the expected success/failure of measures? Why? Are there any preliminary indications of this success/failure?

9 The in-depth interview guide is included in Appendix C.

Interview Respondents

Table 2-5 includes the affiliations of the respondents who participated in the in-depth interview task for this research. Interviews were conducted with 21 individuals representing 13 organizations. RER also conducted three in-person group interviews. These interviews were very productive "working sessions," during which a considerable amount of information and ideas were shared, not only with the RER team but also between the respondents themselves.

As shown in Table 2-5, representatives from three of the four investor-owned utilities in California participated (SDG&E, SCE, and the Gas Company), in addition to the Sacramento Municipal Utility District (SMUD) and statewide energy centers that are demonstrating emerging technologies. PG&E provided the results of several studies that recommended emerging technologies for market transformation initiatives. The results of these studies were incorporated into the Needs Assessment analysis. Other notable respondents included California Energy Commission staff (including PIER project managers and other staff from the Energy Technology Development and Energy Efficiency divisions), the Davis Energy Group, and representatives from state and national organizations (i.e., LBNL and DOE).

Some nonrespondents did not participate because they did not meet the response deadline, while a few felt unqualified to provide the input needed for this phase of the study. Furthermore, some referred RER staff to other individuals in the sample or to those who already participated. It should also be noted that many individuals (respondents and nonrespondents) did offer to provide input during the Methods Assessment.

Table 2-5: Interview Respondents

Organization	
California Energy Commission: Energy Technology Development Division Energy Efficiency Division	San Diego Gas & Electric
California Institute for Energy Efficiency	SMUD
Davis Energy Group	SMUD Energy & Technology Center
Electric Power Research Institute	Southern California Edison, CTAC Center
Lawrence Berkeley National Laboratory	Southern California Gas Company
Pacific Energy Center	U.S. Department of Energy: Office of Industrial Technologies

Note that ACEEE and E-Source representatives provided some input pertaining to emerging technologies during the interview phase of the initial study

Even though PG&E program staff were not able to participate in the interview process, they provided several studies conducted for PG&E pertaining to emerging technologies as targets for market transformation initiatives in the PG&E service territory. See Bevilacqua-Knight, Inc., 1998; Daniel, Mann, Johnson, and Mendenhall, 1998; and Daniel, Mann, Johnson, and Mendenhall, 1999.

Measures Added to Preliminary List

As mentioned above, one of the objectives of the in-depth interviews was to augment the preliminary list derived from the results of prior research with measures suggested by in-depth interview participants. As shown in Table 2-6 below, 25 measures were added for consideration as high priorities during the in-depth interviews. A few points about the measures in Table 2-6 are worth noting here. First, industrial measures were not covered by the 1998 ACEEE ET study; therefore, the preliminary list (Table 2-3) was biased toward residential and commercial building measures. As such, one of the objectives of the in-depth interviews was to identify industrial measures for consideration. Second, not all interview respondents were familiar with the priority measures covered by the initial study. As a result, some of the measures suggested were, in fact, covered by the initial study (i.e., high efficiency HVAC packaged units). Finally, some suggested measures may not appear in Table 2-6 because they were very similar to measures in the preliminary list (for example, card system HVAC and lighting controls were suggested, but were considered as advanced commercial building controls).

Table 2-6: Emerging Technologies Suggested by Interview Participants

Measure	Sector	End Use	Decision Type
Advanced metering technologies	All	-	-
Integrated building photovoltaics	Res, Nonres	Shell	NC, Retro
Advanced wall framing	Res, Nonres	Shell	NC
Radiant barriers	Res	Shell	NC
Light-emitting diodes (all applications)	Res, Nonres	Lighting	NC, Retro
Aerosol duct sealing	Res, Nonres	HVAC	NC, Retro
Home automation system	Res	HVAC Lighting	NC, Retro
Ventilative night cooling	Res	HVAC	NC, Retro
Improved ducts and fittings	Res, Nonres	HVAC	NC, Retro
Improved residential water distribution system	Res	Water heat	NC
Instantaneous (direct contact) water heater	Res, Nonres	Water heat	NC, ROB
Injection molding (all electric)	Nonres	Process	-
Advanced radiation technologies	Nonres	Various	-
Membrane filtration technology	Nonres	Process	-
Supermarket refrigeration optimization	Nonres	Refrig.	NC, Retro
Advanced motor rewinding techniques	Nonres	Various	Retro
Cool storage roof (night spray)	Nonres	HVAC	NC, Retro
Electrochromic glazing	Nonres	Shell	NC
Plastic downlight luminaires	Nonres	Lighting	NC, Retro
Advanced daylighting controls/devices	Nonres	Lighting	NC, Retro
Dimmable compact fluorescent lamps	Nonres	Lighting	NC, Retro
Electrodeless lamps	Nonres	Lighting	NC, Retro
Advanced commercial building controls (including card system controls	Nonres	Lighting HVAC	NC, Retro
High efficiency HVAC packaged units	Res, Nonres	HVAC	NC, ROB
High efficiency compressors/compressor systems	Nonres	Multi	NC, Retro

Res and Nonres denote residential and nonresidential sectors, respectively.
NC, ROB, and Retro denote new construction, replace-on-burnout, and retrofit decisions, respectively.

2.3 Needs Assessment Analysis and Results

The measures covered by the Needs Assessment analysis include those on the preliminary list of measures derived from the 1998 ACEEE ET and 1998 PG&E ET studies (Table 2-3) and the measures suggested for consideration during the in-depth interviews (Table 2-6).

Criteria and Rationale for Identifying Priority Emerging Technologies

The objective of the analysis was to evaluate each measure systematically according to a formal set of criteria similar to those adopted for the initial study. For review, the criteria used to identify the priority measures for the initial study are defined below:

- ***Cost-Effective Savings Potential.*** In general, it would be more logical to design a tracking system that focuses on measures with the greatest cost-effective energy and demand savings.
- ***Marketing Efforts.*** All else being equal, it would be more important to track the shares of measures that are being marketed and promoted by utilities and other organizations than to track measures receiving little attention.
- ***Severity of Market Barriers.*** Given other factors and the fact that the ultimate purpose of market share tracking is to evaluate market transformation initiatives, it would be judicious to focus efforts on those technologies and services to which market barriers are expected to be the most severe.
- ***Susceptibility of Barriers to Program Intervention.*** The effectiveness of targeting publicly funded market transformation programs at specific technologies and services depends partly on the susceptibility of key barriers to program influence.

RER recognized at the onset of this study that there would be differences in applying these criteria to near-term emerging technologies. The sources of these differences lie in the fact that 1) knowledge about emerging technologies is not widespread in the energy efficiency industry and tends to be concentrated among technology experts in research, development, and demonstration projects, and 2) because markets for these measures are in a nascent stage of development, information with respect to the measures' success is anticipatory. This is particularly true with respect to marketing efforts to promote the technologies, the market barriers that are likely to impede their success in the marketplace, and the susceptibility of barriers to program intervention.

Because of these issues, the in-depth interview discussions were quite different than those conducted for the initial study. First, respondents were better able to add to the preliminary list as opposed to narrowing the list for tracking. Second, because the markets for most measures on the preliminary list have not yet been established or developed, interview respondents found it difficult to provide input in terms of the four criteria and to choose the final priority measures. Third, most could not or would not rank measures as priorities for tracking. Instead, most provided a "yes/no" or "high/medium/low" vote. As a result, information obtained from the interviews was qualitative in nature, reflecting the fact that the interviews tended to be more discussion oriented and less structured than those for the initial study.

While the information obtained during the interviews was valuable, its qualitative nature presented a formidable obstacle for systematically evaluating and prioritizing measures for tracking. As such, it was not possible to quantitatively evaluate measures according to the criteria applied in the initial study and derive a priority ranking. To mitigate this problem, RER developed the following set of criteria that is more appropriate for evaluating emerging technologies in the context of this study:[10]

- Market status,
- Measure characteristics,
- Marketing and promotion efforts,
- Cost-effective savings potential (particularly in the California market),
- Coverage by existing tracking efforts, and
- Support by interview respondents.

Each criterion is discussed below.

Market Status. *Does the measure fit our definition of a "near-term" emerging technology?* According to the definition adopted for this study, the measure should be demonstrated but not commercially available, or the measure has only recently been made commercially available. If a measure did not fit this definition, it was dropped from further consideration.

Measure Characteristics. *Does the measure exhibit particular characteristics that could justify including or excluding it as a priority?* For example, interviewees considered components that are integral parts of existing measures (i.e., original equipment measures [OEMs] such as motors and compressors) not appropriate for statewide tracking initiatives. Furthermore, these technologies can be tracked implicitly by tracking the measure itself.

[10] Cost-effective savings potential and marketing efforts, two of the criteria applied during the Needs Assessment of the initial study, are also used here. The other two, severity of market barriers and susceptibility of barriers to program intervention, are not applied for reasons mentioned above. In particular, because markets have not yet developed for the technologies considered here, interview respondents generally did not comment on the expected severity of market barriers and success of program intervention. Barriers typically associated with emerging technologies include high first cost and those related to customer perception, availability of trained contractors, and information-related barriers.

Also note that renewables and self-generation technologies are not in the scope of this study. OEMs and renewables were excluded from further consideration.

Promotion Efforts. *Is the measure promoted by a California utility or energy center or by a regional or national organization?* As with the initial study, it makes more sense to track emerging technologies that are being promoted in California. While utility energy efficiency programs traditionally have not explicitly covered emerging technologies, utilities have demonstrated new technologies as part of their research, development, and demonstration programs. Organizations such as the California Energy Commission (CEC), the U.S. Department of Energy (DOE), and the Lawrence Berkeley National Laboratory (LBNL) are also active in promoting emerging technologies and services. RER relied heavily on information obtained during the in-depth interviews to learn of marketing efforts to promote emerging technologies over the next few years.

Cost-Effective Savings Potential (particularly in the California market). *Which emerging energy efficiency technologies and services are likely to have the highest cost-effective saving potential?* Considerations pertaining to this criterion include 1) the measure's potential to be adopted by a broad range of customers or if its adoption is limited to a specific application or customer, 2) if the measure represents "leaps and bounds" in energy efficiency or small improvements to existing measures, and 3) the cost-effective savings potential for some measures might be different in California than in the national market. Again, RER relied heavily on the results of recent studies pertaining to the role of emerging technologies in market transformation programs and interviews with technology experts to assess each measure's potential for cost-effective savings in California.

Existing Tracking Efforts. *Can the measure be incorporated into existing tracking efforts?* Even though this criterion was not used to include or exclude measures as priorities *per se*, it would be a serious oversight to ignore existing tracking efforts and not to take advantage of economies that could be realized by incorporating additional measures into existing tracking initiatives. As such, the extent to which emerging technologies can likely be incorporated into existing tracking efforts was seriously considered in this analysis.

Interviewee Support. *Of the interview respondents who felt qualified to discuss any particular measure, how many voted for that measure as a priority for tracking?* The extent to which the industry experts supported or "voted for" a particular measure as a high priority for tracking was also a critical factor in this analysis. Application of this criterion involved considerable subjective assessment of comments made during the interviews and consensus among interviewees for any particular measure to be a high priority for tracking. In general, measures strongly supported by interviewees are considered high priorities for tracking.

All measures included in Table 2-3 and Table 2-6 were evaluated according to the above criteria. The evaluation was based on information obtained during the in-depth interviews and results of recently completed studies reviewed above. Results of this analysis are discussed below.

Needs Assessment Results

The results of the Needs Assessment analysis are presented in Table 2-7 through Table 2-9. A summary of the analysis is provided in Table 2-10 through Table 2-12. As indicated, the analysis resulted in the grouping of measures into three categories, rather than the ranking of measures as in the initial study. The three categories are defined below.

- ***High priority near-term emerging technologies*** are recommended for tracking and will be covered under the two remaining phases of this study. In general, these measures received strong support across interview respondents, were being promoted in California, and have potential for cost-effective savings in the California market. As shown in Table 2-7, 12 measures were considered high priorities for tracking.
- ***Low priority near-term emerging technologies with potential to be incorporated into tracking initiatives recommended for the initial study*** are not considered high priorities for tracking, but can likely be covered by tracking initiatives recommended in the initial study for a low incremental cost. In general, measures included in this category received little support from interview respondents and/or were not viewed as having the potential for cost-effective savings in the California market. As shown in Table 2-8, 15 measures were included in this category.
- ***Low priority near-term emerging technologies*** are not recommended for tracking efforts. For the most part, these technologies were not supported by interview respondents but were added measures. Therefore, they were not reviewed by enough interviewees and/or can not likely be covered by initiatives recommended for tracking existing measures. Also included in this category are measures dropped for further consideration because they do not fit the definition of a near-term emerging technology adopted for this study, and measures considered OEMs or renewable technologies. As shown in Table 2-9, 29 measures were considered low priorities for tracking.

Note that measures applicable to the industrial sector and adopted by a wide range of industrial customers for a variety of applications, such as motor rewinding techniques and HVAC and lighting equipment, are included in the evaluation here. However, industrial process measures (injection molding and membrane filtration technologies) are addressed below.

Table 2-7: High Priority Near-Term Emerging Technologies

High Priority Measure	Sector	End Use	Decision Type
Indirect-direct evaporative coolers	Res, Nonres	HVAC	NC, ROB
Evaporative condenser air conditioning	Res, Nonres	HVAC	NC, ROB
Aerosol duct sealing	Res, Nonres	HVAC	Retro
Integrated new home design	Res	-	NC
Dedicated CFL floor and table lamps	Res, Nonres	Lighting	NA, ROB
High efficiency vertical axis clothes washers	Res	Appliance	NA, ROB
Electrodeless (induction) lamps	Nonres	Lighting	NC, Retro
Integrated lighting fixtures and controls	Nonres	Lighting	NC, Retro
Building commissioning and retro-commissioning	Nonres	-	NC, Retro
Integrated commercial building design	Nonres	-	NC
Supermarket refrigeration optimization	Nonres	Refrig.	NC, Retro
Advanced metering technologies	Nonres	-	-

Res and Nonres denote residential and nonresidential sectors, respectively.
NC, NA, ROB, and Retro denote new construction, net acquisition, replace-on-burnout, and retrofit decisions, respectively.

Brief definitions for each of the measures included in Table 2-7 are provided below.[11]

- ***Indirect-direct evaporative coolers*** differ from conventional evaporative coolers in that an indirect cooling stage is added upstream of the direct evaporative cooling stage. This allows cooler temperatures than conventional systems. Primary applications are in the new construction, residential sector, and hot and dry regions of California.
- ***Evaporative condenser air conditioning.*** Evaporative condensers can be used instead of air-cooled condensers in dryer climates to reduce condensing temperatures, which reduces the work a compressor system must do to reject heat. Although evaporative condensers are already commonly used for commercial applications, the key difference for this emerging technology is that outside units are similar to conventional, residential-type air-cooled condenser units. The technology is applicable to smaller commercial and residential markets in drier regions. This evaporative technology stands a better chance than indirect-direct design, especially if the unit is similar in size to a conventional air-cooled unit. However, a need for water and increased maintenance might prevent this from making considerable inroads.

[11] The 1998 ACEEE ET study is an excellent source for non-technical descriptions for most of the measures covered here.

- ***Aerosol duct sealing,*** developed by LBNL, is ideal for sealing duct leaks up to one-quarter inch in size. All vents in the building are sealed, and a duct blaster-type device is used to spray a latex aerosol sealer into the ductwork.
- ***Integrated new home design*** represents a process in which all aspects of a home (building orientation, building shell, HVAC design, lighting, appliances, etc.) would be accounted for and considered in its design, with one of the primary goals being to minimize energy use.
- ***Dedicated compact fluorescent floor and table lamps*** are lamps that would have pin-type sockets instead of screw-type sockets and could be used only with compact fluorescent lamps (CFLs). The need for these technologies is driven by the fact that the shape of screw-type CFLs often makes them incompatible with existing screw-type lamps. This category would also include the CFL replacements for halogen torchiere floor lamps. The market for these technologies is quite "diffuse," according to the 1998 ACEEE ET study.
- ***High efficiency vertical axis clothes washers.*** Vertical axis washers have benefits similar to those of horizontal axis washers, yet overcome design limitations that have impeded adoption of horizontal axis models. In these washers, the agitator of the conventional vertical washer is eliminated and other means are employed to wash the clothes in a partially filled washtub. This technology results in significant energy and water savings while accommodating consumer preferences for top-loading washers.
- ***Electrodeless (induction) lamps*** are fluorescent-type lamps that utilize microwaves to excite gas within the lamp instead of ballasts. Very long lifetimes are a special feature of this lighting technology.
- ***Integrated lighting fixtures and controls.*** This measure represents the process in which lighting fixtures and their controls (i.e., occupancy sensors, EMS systems, and dimmers) are designed as complete systems, which generally minimize energy use.
- ***Building commissioning and retro-commissioning*** refer to the process in which major building systems (HVAC, EMS, lighting, etc.) are analyzed and adjusted to optimize building energy usage. Commissioning can also include "continuous commissioning" in which a building's performance is regularly monitored and adjusted.
- ***Integrated commercial building design*** is a process in which all aspects of a building (orientation, shell, HVAC systems, operation, lighting, etc.) would be accounted for and considered in its design, with one of the primary goals being to minimize energy use.
- ***Supermarket refrigeration optimization*** refers to the optimization of commercial refrigeration systems to reduce energy use. Possible measures covered by the optimization process include EMS controls, high efficiency cases, and new compressor technologies. Optimization could include some or all of these.

- ***Advanced metering technologies.*** Advances in metering technologies enable commercial customers to more accurately measure and monitor energy usage real-time. Enhanced capabilities and presentation of data enable customers to better manage loads and identify opportunities for increased efficiency.

Table 2-8: Low-Priority Near-Term Emerging Technologies – Have Potential to be Incorporated into Recommended Initiatives of Initial Study

Measure	Sector	End Use	Decision Type
Integrated space/water heat pumps	Res, Nonres	HVAC Water heat	NC, ROB
Combined space/water heat	Res, Nonres	HVAC Water heat	NC, ROB
Residential heat pump waterheater	Res	WATER heat	NC, ROB
Modulating gas furnace	Res	HVAC	NC, ROB
Dual source heat pump	Res, Nonres	HVAC	NC, ROB
One (1) kWh/day refrigerators and freezers	Res	Appliance	NA, ROB
Improved ducts and fittings	Res, Nonres	HVAC	NC, Retro
Gas storage water heater	Res, Nonres	Water heat	NC, ROB
Clothes dryer: heat pump	Res	Appliance	NA, ROB
Clothes dryer: microwave	Res	Appliance	NA, ROB
Clothes dryer: thermostat (humidistat)	Res	Appliance	NA, ROB
Advanced commercial building controls	Nonres	HVAC Lighting	NC, Retro
Improved fluorescent dimming ballasts and controls	Nonres	Lighting	NC, Retro
T5 fluorescent lamps	Nonres	Lighting	NC, Retro
Instantaneous (direct contact) water heat	Res, Nonres	Water heat	NC, ROB

Res and Nonres denote residential and nonresidential sectors, respectively.
NC, NA, ROB, and Retro denote new construction, net acquisition, replace-on-burnout, and retrofit decisions, respectively.

Brief definitions for each of the measures included in Table 2-8 are provided below.

- ***Integrated space/water heat pumps*** provide space cooling, space heating, and water heating. In cooling mode, hot water is produced from heat rejected during space cooling.
- ***Combined space/water*** are systems (primarily non-electric) that provide combined space and water heating. Efficiency is obtained by reducing the number of separate components.
- ***Residential heat pump water heater.*** Water is heated by a heat pump rather than electric resistance heating.

- ***Modulating gas furnace.*** Furnace output is constantly monitored and adjusted to match a home's heating requirements more closely. Heating system output for a conventional furnace is constant/fixed.
- ***Dual sink/source heat pumps*** are air-source/ground-source heat pump hybrids. They can use either the air or ground (via a ground loop that is smaller than for a traditional GSHP) as the sink/source.
- ***One kWh/day refrigerators and freezers.*** Energy use at this level represents a significant decrease from the average energy use of refrigerators and freezers being manufactured today. An average energy use of 1.36 kWh/day will result from federal minimum efficiency standards to be implemented as of July 1, 2001.[12]
- ***Improved ducts and fittings.*** An air distribution ducting "system" would snap together and create a tight system without sealing by additional means (tapes, aerosols, etc.).
- ***Condensing gas storage water heaters*** increase water heater efficiency by extracting enough additional heat from the exhaust gases, enough to condense the water vapor.
- ***Clothes dryer: heat pump.*** A heat pump is utilized instead of an electric resistance heating element to dry clothes.
- ***Clothes dryer: microwave.*** Clothes are dried via microwaves instead of a gas burner or an electric heating element.
- ***Clothes dryer: thermostat (humidistat).*** A humidistat is used to measure the humidity in the dryer and determine when the load of clothes is dry
- ***Advanced commercial building controls.*** This technology group could include advanced EMS systems and card systems for hotels/motels that activate/deactivate equipment based on room occupancy.
- ***Improved fluorescent dimming ballasts and controls.*** This measure includes daylight dimming (dimming ballasts in response to available light), the adjustment of each lamp to optimize light availability across a space, and photosensors that compensate for the gradual reduction in light output that occurs over a lamp's lifetime.
- ***T5 fluorescent lamps*** are very small diameter fluorescent lamps that can be used in wall washers and uplight applications.
- ***Instantaneous (direct contact) gas water heat.*** Though electric units have been around for a long time, gas-fired units are emerging. Water is heated on demand, usually at the source of demand. As such, there is no water storage tank and, hence, no standby heating losses.

---

[12] American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* Draft Final Report. October 1998.

Table 2-9: Low-Priority Near-Term Emerging Technologies

Measure	Sector	End Use	Decision Type
Improved efficiency AC and refrigeration compressors	Res, Nonres	HVAC Refrig.	-
Improved heat exchangers	Res, Nonres	HVAC	-
Efficient furnace blower motors	Res, Nonres	HVAC	-
Ventilative night cooling	Res, Nonres	HVAC	NC, Retro
Advanced wall framing and engineering	Res, Nonres	Shell	NC
Coin-op horizontal axis clothes washer	Res, Nonres	Appliance	NC, ROB
Advanced daylighting controls/devices	Nonres	Lighting	NC, Retro
Blower door assisted infiltration reduction	Res, Nonres	Shell	NC, Retro
Commercial air distribution sealing	Nonres	HVAC	NC, Retro
Radiant barrier	Res	Shell	NC
Metal halide replacements for incandescents	Res, Nonres	Lighting	NC, Retro
Plastic downlight luminaires	Nonres	Lighting	NC, Retro
Home automation system	Res	HVAC Lighting	NC, Retro
Advanced clothes washer and dishwasher control	Res	Appliance	-
"Low leak" home electronics	Res	Appliances	NA, ROB
High efficiency HVAC package units	Res, Nonres	HVAC	NC, ROB
Heat reflective roof coating	Nonres	HVAC	NC, Retro
Cool roof storage (night spray)	Nonres	HVAC	NC, Retro
Electrochromic glazing	Nonres	Shell	NC
Dimmable compact fluorescent lamps	Nonres	Lighting	NC, Retro
One lamp fixtures and task lighting	Nonres	Lighting	NC, Retro
Sulfur lighting (molecular radiators)	Nonres	Lighting	NC, Retro
Integrated building photovoltaics	Res, Nonres	Shell	NC, Retro
Light emitting diode traffic lights (three-color retrofit)	Nonres	Lighting	Retro
Light emitting diodes (all applications)	Res, Nonres	Lighting	NC, Retro
Switched reluctance drives	Nonres	Motors	NC, Retro
Advance motor rewinding techniques	Nonres	Motors	-
High efficiency compressors, compressed air systems	Nonres	Multi	-
Improved residential water heat distribution system	Res	Water heat	NC
Advanced radiation technologies	Nonres	-	-

Res and Nonres denote residential and nonresidential sectors, respectively.

NC, NA, ROB, and Retro denote new construction, net acquisition, replace-on-burnout, and retrofit decisions, respectively.

Brief definitions for each of the measures included in Table 2-9 are provided below.

- ***Improved efficiency AC and refrigeration compressors.*** New technologies such as scroll compressors can be used to increase the efficiency of compressors by better matching demand to output.
- ***Improved heat exchangers.*** Improvements in heat exchanger materials and design, such as increased surface area, are reflected in higher overall efficiencies of HVAC, heat pump, and refrigeration systems.
- ***Efficient furnace blower motors.*** High-efficient motors, typically variable speed, are used in furnaces instead of standard efficiency motors.
- ***Ventilative night cooling***. Cool outdoor air can be drawn in at night through dampers and louvers to cool the residence or business to reduce morning cooling loads. This measure also eliminates the need to leave windows and doors open at night, making this an attractive option, particularly to residential customers.
- ***Advanced wall framing and engineering.*** Engineered wall framing, such as pre-assembled "panels" that can be used in lieu of conventional plywood/insulation construction, increase the R-value of the building shell.
- ***Coin-op horizontal axis clothes washers.*** Horizontal axis washing machines require only a partially filled washtub, thereby significantly reduce hot water and energy use.
- ***Advanced daylighting controls/devices*** are lighting controls specifically designed to utilize and optimize daylighting. These controls use photosensors to detect daylight and adjust lighting levels accordingly. Devices that can provide daylighting, such as Solatube for residential buildings, are also included here.
- ***Blower door assisted infiltration reduction*** involves the use of a blower door test to identify leaky ducts, which are then sealed to reduce infiltration.
- ***Commercial air distribution sealing*** refers to sealing leaky air distribution ducts in small commercial buildings. Methods would be similar to residential duct sealing.
- ***Radiant barriers*** are radiant/reflective barriers installed on the underside of roofs to reduce radiative heating.
- ***Metal halide replacements for incandescents*** are high lumen-to-watts metal halides with reflective fixtures that can replace incandescent lighting in both residential and commercial buildings. Metal halides can provide the brightness of incandescents at one-quarter the watts.
- ***Plastic downlight luminaires***, typically used for recessed downlighting, are plastic cans that can be shaped more easily to provide higher fixture efficiency than the metal "cans."
- ***Home automation systems*** provide control of HVAC, lighting, outside lighting, security system, and other equipment. Advanced HVAC controls enable

residential customers to separately control temperature and humidity, optimize variable speeds and balance heating and cooling zones, and even control night ventilation devices to reduce daytime cooling loads.

- ***Advanced clothes washer and dishwasher controls.*** "Fuzzy logic" controls are used to adjust wash cycles to minimize water and energy use based on measurements of key parameters.
- ***"Low leak" home electronics*** reduce or eliminate standby losses, such as the energy used in waiting for a signal from the remote control.
- ***High efficiency HVAC package units*** are more efficient than the minimums required by energy codes.
- ***Heat reflective roof coatings*** reduce cooling loads (but increase heating loads) by reducing the amount of solar gain though the roof of a building.
- ***Cool roof storage (night spray).*** Roofs/attic spaces are cooled through evaporation/radiation by spraying water (via sprinklers) on the roof at night.
- ***Electrochromic glazing.*** With special glass coatings, the transmissivity of the glass can be changed/varied with an electric charge.
- ***Dimmable compact fluorescent lamps*** are compact fluorescent lamps with integrated dimmers or the controls that make dimming possible.
- ***One lamp fixtures and task lighting*** refers to linear fluorescent lamps, since most fixtures of fluorescent linear lamps are a minimum of two fixtures.
- ***Sulfur lighting (molecular radiators)*** is an electrodeless lamp (active gas is sulfur) and is currently only available as a very high output device.
- ***Integrated building photovoltaics.*** Photovoltaics (PVs) are integrated into roof shingles, roof panels of residential and commercial buildings. PV panels generate electricity and can easily replace conventional roofing material.
- ***Light emitting diodes (all applications).*** A light-emitting diode (LED) is a "semiconductor technology that uses solid-state electronics to produce light."[13] LEDs offer significant energy savings over traditional incandescent lighting and can be used for numerous applications, particularly signage, outdoor lighting, and traffic lights.
- ***Light emitting diode traffic lights (three-color retrofit).*** LEDs are installed in traffic lights instead of incandescents.
- ***Switched reluctance drives*** are electronically commutated motors that offer variable speed regulation and precision control.
- ***Advanced motor rewinding techniques.*** Advanced technologies and techniques can be used to retrofit burned-out motors.

[13] Suozzo, M. *A Market Transformation Opportunity Assessment for LED Traffic Signals.* The American Council for and Energy-Efficient Economy. April 1998.

- ***High efficiency compressors and compressed air systems*** encompass high efficiency compressors and analysis of compressed air delivery systems to minimize losses and leaks.
- ***Improved residential water heat distribution system*** addresses the thermal losses incurred in delivering hot water from its source to its destination. This measure would cover both active and passive measures for improving the performance of water heating systems.
- ***Advanced radiation technologies,*** including ultrasonic disinfection and humidification (used by hospitals, for example), can be used in a variety of applications instead of traditional systems that require significantly more energy.

Table 2-10, Table 2-11, and Table 2-12 summarize RER' s analysis and the evaluation of measures according to the criteria described above. Abbreviated information is provided for each *relevant* criterion for each measure. Note that information about every criterion could not be obtained for every measure, particularly for those suggested by interview respondents. These summary tables include all information that was considered to categorize each measure as a high priority, a low priority that can be incorporated into an existing tracking effort, or a low priority.

Table 2-10: Needs Assessment Analysis Summary – High Priority Measures

Indirect-direct evaporative coolers Market status: Commercialized Promotion: CA Savings Potential in CA: Higher than national average Existing tracking: Yes Interviewee support: Strong	**Compact fluorescent floor and table lamps** Market status: Demonstrated, Commercialized Promotion: CA, Other Savings Potential in CA: Yes Existing tracking: Yes Interviewee support: Medium	**Building commissioning and retro-commissioning** Market status: Commercialized Promotion: CA, Other Existing tracking: No Interviewee support: Strong
Evaporative condenser air conditioning Market status: Commercialized Promotion: CA, Other Savings Potential in CA: Higher than national average Existing tracking: Yes Interviewee support: Strong	**High eff. vertical axis clothes washer** Market status: Commercialized Promotion: CA, Other Savings Potential in CA: Yes Existing tracking: Yes Interviewee support: Medium/Strong	**Integrated commercial building design** Market status: Commercialized Characteristics: Practice Promotion: CA, Other Savings Potential in CA: Yes Existing tracking: No Interviewee support: Strong
Aerosol duct sealing Market status: Commercialized Promotion: CA Savings Potential in CA: Yes Existing tracking: Yes Interviewee support: Added measure	**Electrodeless lamps (induction)** Market status: Commercialized Characteristics: Significant change from current technology Existing tracking: Possibly Interviewee support: Added measure, strong	**Supermarket refrigeration optimization** Market status: Commercialized Promotion: CA Savings Potential in CA: Yes Existing tracking: No Interviewee support: Added measure, not much feedback
Integrated new home design Market status: Commercialized Promotion: CA, Other Savings Potential in CA: Yes Existing tracking: No Interviewee support: Strong; "useless unless it has a verification component," "biggest potential, … hardest to track, … biggest barriers"	**Integrated lighting fixtures and controls** Market status: Commercialized Promotion: CA Existing tracking: Possibly Interviewee support: Medium/Strong	**Advanced metering technologies** Market status: Commercialized Savings Potential in CA: Yes Existing tracking: No Interviewee support: Medium; dropped from preliminary list, but was added by interview respondents.

Table 2-11: Needs Assessment Analysis Summary – Low Priority Measures with the Potential to be Incorporated into Recommended Initiatives of Initial Study

Integrated space/water heat pumps Market status: Commercialized Promotion: CA (EPRI) Savings Potential in CA: Marginal Existing tracking: Yes Interviewee support: Mixed/weak. Some confusion on how this measure is differentiated from combined space/water heat and dual source heat pumps.	**1 kWh/day refrigerators and freezers** Market status: Commercialized, refrigerators covered by initial study Existing tracking: Yes Interviewee support: Medium/weak	**Clothes dryer: thermostat (humidistat)** Market status: Demonstrated, Commercialized, Existing Existing tracking: Yes Interviewee support: None
Combined space/water heat Market status: Commercialized ("but underutilized") Savings Potential in CA: Marginal Existing tracking: Yes Savings Potential in CA: Marginal; relatively high energy cost and gas savings Interviewee support: Mixed/weak; some confusion on how this measure is differentiated from dual source heat pumps	**Improved ducts and fittings** Market status: R&D, Demonstrated Promotion: Other Savings Potential in CA: Marginal Existing tracking: Possibly Interviewee support: Added measure, not much feedback	**Advanced commercial building controls** Market status: Commercialized Promotion: CA, Other Existing tracking: Yes Interviewee support: Added measure, not enough feedback
Residential heat pump water heater Market status: Existing; "been out there a long time" Savings Potential in CA: Marginal; high potential in significant cooling/heating climates, best if have electric resistance heat Existing tracking: Yes Interviewee support: Mixed/weak	**Gas storage water heater** Market status: Existing (covered by initial study) Existing tracking: Yes Interviewee support: Weak	**Improved fluorescent dimming ballasts and controls** Market status: Commercialized Promotion: CA, Other Existing tracking: Possibly Interviewee support: Weak

Table 2-11 (cont'd): Needs Assessment Analysis Summary – Low Priority Measures with the Potential to be Incorporated into Recommended Initiatives of Initial Study

Modulating gas furnaces Market status: Existing, covered by initial study Savings Potential in CA: Marginal; relatively low potential energy cost, electricity, and gas savings Existing tracking: Yes Interviewee support: Medium	**Clothes dryer: heat pump** Market status: R&D, Demonstrated, Commercialized Savings Potential in CA: relatively high electricity savings Existing tracking: Possible Interviewee support: Weak; not market ready, might have very high cost	**T5 fluorescent lamps** Market status: Commercialized Promotion: CA, Other Existing tracking: Yes Interviewee support: Mixed; "will gain market share anyway, no real market barriers"
Dual source heat pumps Market status: Commercialized Savings Potential in CA: Marginal; "gas units too expensive … not appropriate for residential sector" "potential only in certain climates" Existing tracking: Yes Interviewee support: Mixed/weak	**Clothes dryer: microwave** Market status: R&D, Demonstrated Savings Potential in CA: Marginal; limited applications Promotion: CA Existing tracking: Possibly Interviewee support: Weak	**Instantaneous (direct contact) water heat** Market status: Existing Existing tracking: Yes Interviewee support: Added measure, not enough info.

Table 2-12: Needs Assessment Analysis Summary – Low Priority Measures

Improved efficiency compressors (AC and Refrigeration) Market status: R&D, Demonstrated Characteristics: OEM Interviewee support: Weak; refrigeration compressors will be "important to watch, but not at the level of tracking."	**Metal halide replacements for incandescents** Market status: R&D, Demonstrated, Commercialized Promotion: No Interviewee support: Mixed; conflicting feedback; "Dead on arrival for residential applications," "cannot compete with current technology."	**One lamp fixtures and task lighting** Market status: Commercialized Characteristics: Practice Existing tracking: Possibly Interviewee support: Weak
Improved heat exchangers Market status: Existing, "measure has already been incorporated into current designs." Characteristics: OEM Interviewee support: Medium	**Plastic downlight luminaires** Interviewee support: Added measure, not enough feedback.	**Sulfur lighting (molecular radiators)** Market status: Demonstrated Promotion: CA (some) Existing tracking: Possibly Interviewee support: Added measure, "Another DOA technology, hard to control temperatures and color … limited applications"; "this one is dead and has been taken off the market …"
Efficient furnace blower motors Characteristics: OEM Interviewee support: Medium	**Home automation system** Market status: R&D Existing tracking: No Interviewee support: Added measure, not enough feedback	**Integrated building photovoltaics** Market status: Commercialized Characteristics: Renewable Promotion: Other Existing tracking: Possibly Interviewee support: Added measure, not enough feedback
Ventalative night cooling Interviewee support: Added measure, not enough feedback.	**Adv. clothes washer and dishwasher controls** Market status: Commercialized Characteristics: OEM Existing tracking: Yes Interviewee support: Medium/weak	**Light emitting diode traffic lights (three-color retrofit)** Market status: R&D, Demonstrated, Commercialized Promotion: CA, Other Existing tracking: No Interviewee support: Weak

Table 2-12 (cont'd): Needs Assessment Analysis Summary – Low Priority Measures

Advanced wall framing and engineering Interviewee support: Added measure, not enough info.	**"Low leak" home electronics** Market status: Commercialized Promotion: Other Interviewee support: Weak/none. "…these will take off on their own"	**Light emitting diodes (all applications)** Market status: R&D, Demonstrated, Commercialized Promotion: CA, Other Existing tracking: No Interviewee support: Added measure, not much feedback
Coin-op horizontal axis clothes washer Market status: Commercialized; existing ("these have been on the market for years") Promotion: CA, Other Savings Potential in CA: Limited (small market) Existing tracking: No Interviewee support: Medium/weak	**High efficiency HVAC package units** Market status: Existing, covered by initial study Interviewee support: Added measure	**Switched reluctance drives** Market status: Commercialized Characteristics: OEM, motors covered by initial study Promotion: Other Existing tracking: No Interviewee support: Low
Advanced daylighting controls/devices Market status: Commercialized Promotion: CA, Other Existing tracking: Possibly Interviewee support: Added measure, not enough feedback	**Heat reflective roof coating** Market status: Commercialized Promotion: Other Existing tracking: No Interviewee support: Weak	**Advanced motor rewinding techniques** Market status: Commercialized Existing tracking: No Interviewee support: Added measure, not much feedback
Blower door infiltration reduction Savings Potential in CA: Marginal Interviewee support: Weak. Other duct-related measures would be more appropriate for tracking	**Cool roof storage (night spray)** Market status: Commercialized Promotion: CA, Other Existing tracking: No Interviewee support: Added measure, not enough feedback	**High efficiency compressors, compressed air systems** Characteristics: OEM in some applications; compressed air optimization covered by initial study Promotion: CA, Other Interviewee support: Added measure

Table 2-12 (cont'd): Needs Assessment Analysis Summary – Low Priority Measures

Commercial air distribution sealing Market status: Commercialized Existing tracking: Possibly Interviewee support: None	**Electrochromic glazing** Market status: R&D, Demonstrated Savings Potential in CA: "problem is that the cost is prohibitive compared to alternatives… " Promotion: CA, Other Existing tracking: Possibly Interviewee support: Added measure, not enough feedback	**Improved residential water heat distribution system** Interviewee support: Added measure, not enough feedback
Radiant barrier Interviewee support: Added measure, not enough feedback	**Dimmable compact fluorescent lamps** Promotion: CA, Other Existing tracking: Possibly Interviewee support : Added measure, not enough info.	

2.4 Emerging Industrial Process Technologies

As explained above, one objective of the in-depth interviews was to solicit suggestions for industrial measures for market share tracking. Suggestions include the following:

- ***Membrane technologies.*** Membrane processes use a semipermeable barrier made of various materials (organic polymer, metal, or ceramic) to transport and separate components from one fluid to another. Membrane systems are typically less energy-intensive than conventional separation processes such as evaporation and distillation.
- ***Advanced injection molding machines/controls.*** Injection molding is a method of producing parts with a heat-meltable plastics material. Injection molding machines produce plastic parts by injecting heat-meltable plastic material into molds. Variable speed drive and other advanced electronic controls can be used to greatly improve the energy efficiency of fixed volume type machines.

Discussions during the in-depth interviews revealed that the introduction of new technologies in the industrial sector – process measures, in particular (such as those defined above) – tend to be driven by the need for a specific technology for a particular sector or application. This is corroborated with results of focus groups with industrial customers RER conducted in 1998 for the CEC.[14] Whether or not other customers adopt an emerging technology greatly depends on either the demand for the technology by customers with similar needs or the transferability of the technology to other applications.

Inclusion of the industrial process measures could not be justified based on the analysis criteria presented above. First, very few interview respondents were qualified to comment on industrial process measures outside of their expertise. Second, because these measures were added during the interview process, these measures did not appear on the preliminary list for all respondents to evaluate. Third, RER does not consider the above list of measures comprehensive or exhaustive of the industrial measures that might warrant market share tracking. However, the limited application of emerging industrial technologies should not necessarily exclude measures from consideration for tracking, particularly because of the potential for high energy savings typically associated with industrial measures.

[14] The objectives of these focus groups, each held with customers of a specific industrial end-use segment, were to identify key issues and challenges facing the industry, identify potential solutions that can be addressed through research, development and demonstration activities and to prioritize the identified issues and solutions. The technological solutions to the issues identified by the industrial customers were clearly delineated across sector lines, indicating that technologies with significant potential are/will be at least sector specific, if not customer specific.

3

Markets Assessment

3.1 Overview

The primary objective of the Markets Assessment is to identify and better understand the key market actors and primary channels of distribution. The results of these market reviews help identify points in the distribution channels where it makes the *most sense* to collect data to support market share tracking efforts in California.

One must consider the data requirements of market share tracking when determining the most sensible tracking possibilities. In the most general terms, the data sought must meet four criteria:

- Data represent unit sales, <u>and</u>
- Data are/can be segmented by efficiency level, <u>and</u>
- Data are/can be segmented by geographic region, at the state level as a minimum, <u>and</u>
- Decision type (new construction, replace-on-burnout, retrofit, and net acquisition) must be identifiable, when applicable.

This research reveals that, in most cases, unique measure characteristics as well as key features of their distribution networks help to identify logical market nodes for collecting market share data that meets these criterion.

Several points are worth noting here:

- First, the market reviews presented here are not intended to be comprehensive market characterizations, as doing so was not the objective of this study. These reviews are intended to provide enough depth for one to understand the basic market structure and distribution mechanisms to make inferences about the most logical means for collecting data for market share tracking.
- Second, this methods review will help identify those emerging technologies that can be incorporated into tracking initiatives currently being developed at a relatively low marginal cost. This and other tracking issues are discussed under the "implications for tracking" heading for each measure.

- These reviews focus on market actors that are or could be involved in the product distribution or service delivery. It is important to recognize that there are other market actors that are not involved in product distribution that could, in fact, participate in market share tracking. Because building departments, for example, collect data on specifications and installations in the residential and nonresidential new construction markets, they could possibly provide useful data for market share tracking.

For review, Table 3-1 includes the 12 priority near-term emerging technologies and services identified as priorities for tracking. The following subsections include reviews of the market for each measure.

Table 3-1: High Priority Near-Term Emerging Technologies

High Priority Measure	Sector	End Use	Decision Type
Evaporative condenser air conditioning	Res, Nonres	HVAC	NC, ROB
Indirect-direct evaporative coolers	Res, Nonres	HVAC	NC, ROB
Aerosol duct sealing	Res, Nonres	HVAC	Retro
Integrated new home design	Res	-	NC
Dedicated CFL floor and table lamps	Res, Nonres	Lighting	NA, ROB
High efficiency vertical axis clothes washers	Res	Appliance	NA, ROB
Electrodeless (induction) lamps	Nonres	Lighting	NC, Retro
Integrated lighting fixtures and controls	Nonres	Lighting	NC, Retro
Building commissioning and retro-commissioning	Nonres	-	NC, Retro
Integrated commercial building design	Nonres	-	NC
Supermarket refrigeration optimization	Nonres	Refrig.	NC, Retro
Advanced metering technologies	Nonres	-	-

Res and Nonres denote residential and nonresidential sectors, respectively.
NC, NA, ROB, and Retro denote new construction, net acquisition, replace-on-burnout, and retrofit decisions, respectively.

3.2 HVAC Equipment: Evaporative Condenser Air Conditioning and Indirect-Direct Evaporative Cooling

Evaporative condenser air conditioning and indirect-direct evaporative coolers, two of the 12 priority measures in Table 3-1 above, are relatively new applications of existing HVAC equipment technologies that have similar or identical distribution channels. As such, they are considered to be in the same market and are grouped together for the purpose of this study. Measure definitions, a market review, and implications for tracking these measures are provided below.

Evaporative Condenser Air Conditioning

Condensers are the heat rejection components of an air conditioning system. They are classified according to the cooling medium employed: air cooled, water cooled, or evaporative cooled. Evaporative condensers are inherently more efficient due to the increased heat transfer capacity of the evaporative process. In evaporative condensers, water is sprayed onto the surface of the condenser coil containing the hot, high-pressure vapor coming off the compressor. Air simultaneously blown over the coil causes some of the water to evaporate, thereby removing heat from the coil and condensing the refrigerant vapor. Evaporative condensers generally achieve higher levels of energy efficiency than air-cooled condensers because they can operate at lower condensing temperatures than air-cooled condensers. In particular, the heat rejection potential of the evaporative condenser is limited by the ambient wet bulb temperature, while the air-cooled condenser potential is limited by the dry bulb temperature. Because the wet bulb temperature can be 14 to 25 degrees lower than the dry bulb ambient temperature, this process can reduce condensing temperatures by 20 or more degrees in dry climates.[1]

While evaporative condensing units suitable for the large commercial and industrial sector have been commercially available, the introduction of an evaporative water-cooled condensing unit for the small commercial and residential sectors has brought this technology to the radar screen as a promising emerging technology in California. Refrigeration Technologies, Inc. (RTI), the only manufacturer of this technology, has developed an evaporative condensing unit that achieves considerably higher cooling efficiencies than air-cooled condensing units. This technology has moved out of the demonstration phase into commercialization and is now being shipped to California and other western and mid-western regions. Though sales volumes have been low since its introduction into the marketplace last

---

[1] American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* December 1998.
1996 ASHRAE Systems and Equipment Handbook.
American Society of Heating, Refrigerating and Air-Conditioning Engineers, In. *1996 ASHRAE Handbook. Heating, Ventilating, and Air-Conditioning Systems and Equipment.* Atlanta, GA. 1996.

year, the overall market response has been positive and is expected to increase as contractors become more familiar with installation practices and as the energy savings potential of this technology is realized.[2]

Indirect-Direct Evaporative Cooling

Indirect-direct evaporative coolers (IDECs) incorporate a two-stage cooling process consisting of a first-stage heat exchanger followed by a second-stage evaporative pad through which water flows continuously. The intake air is first cooled via an air-to-water heat exchanger. The air continues through the second stage evaporative pad, which further decreases the temperature while increasing humidity. The primary advantage of indirect-direct evaporative cooling versus direct-only evaporative cooling is that a lower level of humidification of the supply air occurs. IDECs supply air that is cooler than possible with the direct or indirect stage alone and produce a more comfortable humidity range than direct evaporative units. The emerging IDEC technology considered for this study is a *compact* two-stage cooler developed by CoolTech Industries that was covered in the 1998 ACEEE ET study.

Review of the Market

The markets for evaporative condensers and compact IDECs are still relatively small. There is considerable potential for increased market penetration of these measures in hot/dry climates in California if specific market barriers can be overcome. The barriers associated with these measures include contractor unfamiliarity, consumer perception, high first cost, and the fact that there are no major manufacturers producing these units yet.[3]

RTI and CoolTech Industries are the only manufacturers of the evaporative condenser and compact IDEC emerging technologies, respectively. These manufacturers sell the units through HVAC equipment distributors to HVAC contractors.[4] In addition to being producers and suppliers of equipment in the HVAC equipment market, manufacturers disseminate information to a variety of market actors regarding HVAC system design and equipment installation. This is a particularly crucial role with respect to emerging technologies, as contractors will not be as willing to promote, sell, and/or install unfamiliar equipment. Furthermore, contractors tend to increase their fees for installing "non conventional" equipment, which drives the initial cost to the consumer even higher.

---

[2] Rocky Baccus, Refrigeration Technology, Inc. Personal communication, July 14, 1999.

[3] American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* December 1998.
Rocky Baccus, Refrigeration Technology, Inc. Personal communication, July 14, 1999.

[4] RTI's evaporative condensing unit is sold only through two HVAC equipment distributors in California – one in Northern California and the other in Southern California.

As with all HVAC equipment installed in the residential new construction sector, builders and HVAC/mechanical contractors typically specify equipment type and efficiency parameters. The homeowner may have some input on the type of system placed in a custom home but not in a typical tract home. When replacing equipment, the consumer is the primary decision maker and interacts directly with the HVAC contractor.

Implications for Tracking

There are several options for obtaining data for tracking the efficiency market shares of evaporative condenser units and IDECs. Possible methods include obtaining data from manufacturers, HVAC equipment distributors, HVAC/mechanical contractors, and at the end-user level via an on-site survey.

Obtaining data from manufacturers is somewhat more plausible here than for the existing HVAC equipment covered by the initial tracking scoping study, primarily because there is only one small manufacturer of each technology. In fact, preliminary discussions indicate that these manufacturers might be willing to provide data of sales to California to be used for tracking purposes. There are two issues with implementing this method. First, obtaining sales data by decision type is not possible because manufacturers are not likely to be able to identify separately sales for new construction and replacement installations. Second, obtaining data from manufacturers might not be a prudent long-term solution. As the market penetration of these technologies increases, the likelihood that the technology will be purchased or adopted by other manufacturers also increases. Therefore, the data collection efforts will need to grow or change as the markets for these products expand.

Collecting distributor sales data is a very promising option, particularly since this method is currently being developed for tracking existing HVAC equipment and because these emerging technologies are commercially available through distributors.[5] Again, collecting market shares by decision type becomes a tracking issue in California, because manufacturers and distributors may or may not be able to separately identify sales for new construction and replacement installations. However, the HVAC contracting industry for new construction is fairly concentrated in California, with only a handful of contractors accounting for a very large percentage of installations in the new construction market. Because HVAC equipment distributors can identify sales to those contractors, sales by decision type should be obtainable with a fair level of confidence.

Another option is to collect data from HVAC contractors. This option is less attractive than the distributor option for two reasons. First, collecting data from HVAC contractors would require a much larger sample of "data suppliers" to cover the same portion of the market than

---

5 Regional Economic Research, Inc. *Efficiency Market Share Needs Assessment and Feasibility Scoping Study*. Prepared for the California Board for Energy Efficiency. May 1999. See Section 9 Initiative III.

if data were collected from distributors. It would also be necessary to ensure the collected data covered new construction and replacement installations in both residential and nonresidential sectors. Second, the Wisconsin experience reveals that HVAC contractors are relatively poor record keepers. If this is the case in California, it may be more difficult to collect data that meet the four key criteria than one would assume.

The final alternative is to collect data at the final end-user level from on-site surveys. This is also an attractive option, particularly for new construction. Residential new construction on-site surveys (including a short homeowner survey) are an element of the tracking initiatives currently being developed. Efficiency parameters of HVAC equipment will be recorded in this effort.

3.3 Aerosol Duct Sealing

Forced air distribution system leakage has received considerable attention as a major source of energy loss in recent years. Testing for duct leakage and properly sealing leaks, therefore, is viewed as one source of significant achievable energy and demand savings in the residential sector. Utility programs and recent revisions to Title 24 requirements are pushing the market in this direction. The new Title 24 Energy Efficiency Standards effective as of July 1, 1999 allow a compliance credit for third-party verification of tight ducts in residential buildings.[6]

Air ducts can be sealed with a variety of materials, including mastics, metal tape (foil back), butyl tape (clear plastic tape), and duct tape, which can be augmented with collars or clamps. A recent development in duct sealing is the advent of a sticky vinyl acetate polymer developed at the Lawrence Berkeley National Laboratory. Atomized particles of this liquid polymer are sprayed into ducts that have been pressurized with a machine similar to a duct blaster. The material automatically deposits and dries at leakage points in the duct work, covering areas that are small and/or inaccessible with conventional sealing methods. Thus, the aerosol sealant is ideal for sealing ducts in both residential and nonresidential buildings, particularly in existing buildings where ducts are often inaccessible.

Review of the Market

The key actors in the market for aerosol duct sealing include Aeroseal, Inc., HVAC/mechanical contractors, and homeowners or building managers/owners. Builders are currently not a primary actor in this market but might become more so in the future due to the recent Title 24 revisions that award points for tight air distribution ducts. In the new

[6] California Energy Commission. *Residential Manual for Compliance with California's 1998 Energy Efficiency Standards.* July 1999. See Chapter 4, entitled "Compliance Through Quality Construction."

construction market, the HVAC/mechanical contractor and the builder specify the HVAC system and the HVAC contractor primarily designs and installs the duct system. The builder will generally decide whether to test for duct leakage. Even though there is evidence of duct leakage in both new and existing homes, homeowners rarely request diagnostic testing and sealing services for new homes, as they typically assume equipment is installed properly. Thus, the primary market for the aerosol sealant is for duct retrofits. However, as awareness and experience of both contractors and builders increase, the new construction market for duct diagnostics and aerosol sealing is likely to expand.

In a retrofit situation (e.g., existing buildings), the homeowner contracts with an HVAC contractor to replace equipment and/or repair ducts. Duct diagnostics and repair are not a standard business of most HVAC contractors; they rarely verify that the unit is delivering the air according to equipment specifications. The industry, however, is changing as both contractors and homeowners realize the importance of a tightly sealed air distribution system.

Aeroseal, Inc. is the only company licensed to sell/use the aerosol duct sealant commercially. While the sealant itself is the technology covered by this study, it should be recognized that Aeroseal will not merely sell the aerosol material to contractors. Rather, Aeroseal offers a "franchise" to HVAC contractors who are willing to commit to offering duct services (diagnostics and sealing in addition to HVAC equipment installation) as a normal business practice. In particular, Aeroseal has developed a user-friendly diagnostic system that enables contractors to analyze duct leakage, air-flow performance, combustion safety, return air, and temperature of supply air in the ducts. Based on the results of this analysis, the contractor then makes recommendations to the homeowner for mitigating any identified problems. Should duck leakage, in fact, be a problem, the trained contractor will then proceed with the aerosol sealing process.[7]

Implications for Tracking

Market share tracking of aerosol-based duct sealing is somewhat problematic because the sealant itself is not marketed and sold in the same manner as other products. Instead, aerosol duct sealing is a service offered only by trained HVAC contractors. As such, the market share of aerosol sealants cannot be defined in the same way the market share of high efficiency air conditioning equipment. It is necessary to define the indicators of aerosol duct sealing that need to be obtained to compute the market share of aerosol duct sealing. Here, the market share is broadly defined as the number of homes that were aerosol sealed as a percentage of all "feasible applications." The number of feasible applications can refer to

7 Aeroseal, Inc. provides training (classroom and on-site) and support to all contractors offering the diagnostic services and the aerosol sealing process. Aeroseal also licenses the necessary equipment and materials to the contractor, including the injection equipment, diagnostic equipment and software, and marketing materials.

either the number of homes that have undergone some level of duct retrofit (irrespective of the sealing method used) or the number of homes that *should* be sealed in a specific time period. The number of contractors trained and licensed to use aerosol sealants is a secondary indicator of the market penetration of aerosol sealing.[8]

Data for tracking the market of aerosol sealing can be obtained through the following:

- ***On-Site Surveys.*** One option is to identify homes that have had ducts aerosol sealed via an on-site visual inspection or customer survey. Identifying homes that have been aerosol sealed would be relatively straightforward. In particular, the aerosol sealing process requires an injection hole in the plenum. The injection hole, sealed after the process is complete, would be easily identifiable during an on-site inspection. Though homeowners might or might not be able to identify the technology used to seal leaky ducts, each occupant is provided with the diagnostic results and/or pre- and post-sealing information after the aerosol sealing process. This certificate would serve as evidence of aerosol duct sealing. Even though the primary market for this technology is existing buildings, tracking the penetration of aerosol sealing in the new construction sector can be incorporated into the new construction on-site surveys already being planned for tracking existing measures.
- ***Aeroseal, Inc. Records.*** The other viable option is to obtain Aeroseal records. Because diagnostic data of each application is submitted to Aeroseal, the number of contractors offering the diagnostic testing and aerosol sealing services and the number of homes in which the aerosol-based sealant was applied would be available. This is a very attractive alternative for two reasons. First, obtaining Aeroseal Inc. records would be relatively straightforward. Preliminary discussions with Aeroseal Inc. indicate that some data fields could be made available for tracking purposes. Second, the Aeroseal Inc. database includes information on contractors and applications *nationwide*. Thus, comparison area data would be readily available for a relatively low or no marginal cost.

3.4 Integrated New Home Design

Integrated new home design refers to designing residential buildings as an integrated process that takes advantages of synergies between the building envelope and space conditioning systems that result in significant energy savings. The objectives of this process are to maximize the value for the homeowner by minimizing energy use and enhancing comfort and to increase the efficiency of the construction process. All aspects of home design – building location and orientation, building shell, HVAC design and sizing, lighting and appliance specification, construction quality assurance, etc. – would be considered in this

[8] Even though the number of contractors licensed and trained to use the aerosol sealant does not explicitly indicate *usage* of aerosol sealant, it is safe to assume that contractors who commit substantial resources to obtain a " franchise" and the necessary training for this technology/service but not apply it.

process. Furthermore, the key market actors involved in these tasks work together as a team headed by the builder to achieve these goals. Note that this measure encompasses not only the process of integrated design but also the tools and services required to facilitate the integrated home design.

Integrated new home design is considered an emerging technology because new homes are more typically designed by a variety of professionals with little or no coordination. The design and construction processes are a series of disjointed and separate tasks and equipment selection and measure specification. Furthermore, because builders have no stake in the operating costs of the home, their primary objective is generally to minimize costs subject to compliance with Title 24 energy efficiency standards and building codes.

Note that this measure relates to several other efficiency measures in residential market, some of which are or will be covered by tracking. High efficiency HVAC equipment, optimal HVAC system design, and duct sealing will undoubtedly result from the integrated design process.

Review of the Market

The builder is the ultimate decision maker and becomes the design "team leader" once the decision is made to pursue the integrated design approach. The builder selects an architect, window contractor, HVAC/mechanical contractor, and Title 24 consultant for the team. Preliminary plans for the proposed new homes are presented to all parties and interactive discussions for specifying the equipment, shell measures and other design features, and implementing and improving the designs would begin.

Government officials are also involved in this process, although indirectly via the building code and Title 24 compliance and approval/inspection process. They would not typically be involved in the design process *per se*. However, in the event that a new technology was implemented, they might be asked to participate to address any possible concerns before final submittal of the plans to the local building department.

The market for "quality assured" construction has shown signs of growth, as evidenced by the emergence of private firms that review building plans with an eye toward improving envelope tightness, HVAC equipment, and system design. After reviewing the plans, these professionals provide recommendations for design changes and equipment improvements that substantially reduce operating costs. In fact, some builders now offer an energy bill guarantee to homebuyers to promote high efficiency homes and differentiate their product from those that have not embraced the integrated design concept.

There are currently several programs that encourage the integrated design approach, one of which is the U.S. Department of Energy's (DOE's) Building America Program. The focus of this program is "cost effective integration." The systems-engineering approach that the DOE promotes recognizes that features of one component in the house can greatly affect others, so that designing the house as a system can result in additional benefits at no extra cost and often at reduced costs. For example, participating home builders might learn how to integrate the design and specification of the shell measures and the HVAC system, which not only reduces energy losses, but also allows for HVAC equipment downsizing. Having been in operation for the past five years, the Building America Program expects to have built more than 850 homes by the end of 1999. The average annual energy savings of homes built under the Building America Program are estimated to be 30% to 50%.[9]

Implications for Tracking

The difficulty in tracking this measure is that it is a process or practice rather than a product that can easily be counted and quantified. The market share for these measures is broadly defined as the number of actual applications as a percentage of all feasible applications. Thus, the market share of integrated new home design is defined as the proportion of all new homes designed with this technique. Another less accurate indicator of market share is the proportion of builders that have adopted the integrated design approach.

Compounding the problem of tracking the market share of this measure is the lack of a solid definition and universally accepted criteria that distinguish the integrated design approach from the traditional design process. A check list of conditions to be met to qualify as an integrated design process will need to be compiled as the first step to tracking this measure.

The only feasible means for obtaining information regarding the building design process is through a survey of one or more of the market actors involved in the design process. As mentioned above, the builder is the ultimate decision maker and central figure in this market; therefore, a survey of builders to characterize their standard design approach would be required. Other market actors, such as architects and firms offering building plan review services with the intent to improve building performance, should also be surveyed.

3.5 Dedicated Compact Fluorescent Floor and Table Lamps

Compact fluorescent lamps (CFLs) combine the efficiency of fluorescent lighting with the convenience of incandescent fixtures. CFL systems are classified as one of three basic types: integrated systems, modular systems, and dedicated systems. Integrated systems are one-piece units that consist of a lamp, ballast, and socket adapter. These lamps are usually sold

[9] http:\\www.eren.doe.gov\buildings\building_america.

with a medium screw base and are designed to replace incandescent lamps in existing luminaires. Modular systems are self-ballasted and are designed for use in an incandescent luminaire. Unlike integrated systems, modular systems contain a replaceable lamp socket.

Dedicated systems consist of a specially designed luminaire with a ballast and lamp socket that has been directly wired as part of the luminaire. Dedicated CFL floor and table lamps have pin-type sockets instead of screw-type sockets and can be used only with CFLs. The need for these technologies is driven by the fact that the shape of screw-type CFLs often makes them incompatible with existing screw-type incandescent lamps.

To mitigate these impediments to more widespread adoption of CFLs, some manufacturers are beginning to produce floor and table lamps "dedicated" to CFLs. That is, because of the design, the owner/user of the lamp cannot inadvertently replace a CFL with a less efficient incandescent. Because CFLs can replace incandescents that are three to four times their wattage and can last 10 to 15 times as long as an incandescent, these new dedicated CFL freestanding floor and table lamps provide the opportunity for significant energy savings in the residential market.[10]

Note that this measure includes the CFL version of the halogen torchiere floor lamp. The halogen torchiere consumes about 300 to 500 watts and can reach temperatures of 700 to 1,100ºF.[11,12] The CFL torchiere provides both energy savings and safety compared to its halogen counterpart. In particular, these lamps consume only about 20% of the wattage of the halogen torchiere.

Dedicated CFLs seem to overcome some of the barriers associated with the more conventional modular and integrated CFL systems. Until recently, a limiting factor for CFLs – particularly in residential applications – has been their size. The typical fluorescent lamp/ballast combination is somewhat larger than the incandescent lamp. Consequently, they may not fit properly in luminaires designed for incandescent light sources. Furthermore, use of CFLs in the residential sector is often limited to areas where aesthetics are not a primary concern, such as basements, garages, and utility rooms. From a conservation perspective this is unfortunate, as lighting in these areas is generally utilized infrequently, and the full energy savings potential of compact fluorescent lamps is not realized in these

---

10 American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* December 1998. http:\\www.eren.doe.gov\erec.

11 www.epa.gov\appdstar\fixtures

12 The heat produced by halogen torchieres poses serious safety hazards. It is estimated that halogen torchieres have caused at least 350 fires, 114 injuries, 30 deaths, and $2 million in property damage since 1991. As a result, many universities and colleges in the U.S. have banned the use of halogen torchieres from residence halls (www.lightsite.net).

applications. Availability of high quality, aesthetically pleasing CFLs are recognized as a prerequisite for widespread in-home use of compact fluorescent lamps. Similar barriers are present in commercial applications, such as decorative lighting for hotels/motels, dormitories, offices, etc.

Review of the Market

Several key players in the market for dedicated CFL lamps and fixtures include manufacturers, wholesale lighting distributors, mass-market retailers (i.e., Target, Wal-Mart, and Home Depot), specialty retailers, mail-order houses, and consumers. Dedicated CFL fixtures are typically sold by the manufacturer directly to retailers (especially mass-market or national chains) or to a wholesaler that services smaller retailers. With the exception of CFL torchieres, freestanding dedicated CFL fixtures are not yet widely available and are mainly sold through catalogs and specialty lighting distributors and retailers. Wal-Mart and Target began selling CFL torchieres only in the past few months. Sales through these large retailers are limited to states in which utilities are promoting the CFL torchieres, mainly in the California, Wisconsin, the Northwest, and the Northeast markets.

Contractors and lighting designers/specialists help to design and specify lighting equipment and fixtures in the commercial new construction sector, which may or may not include floor and table lamps. Building occupants are the primary decision makers for replacement and net acquisitions and homeowners are the primary decision maker for both replacement and net acquisition purchases in the residential sector.

Implications for Tracking

The market share of CFL floor and table lamps can be considered as the number of dedicated CFL floor and table lamps sold as a percentage of all floor and table lamps. This would require the collection of sales data on *all* freestanding luminaires – not a small task.

Unlike hard-wired CFL fixtures, the market of dedicated freestanding CFL floor and table lamps is less developed and there are fewer sales data collection alternatives. Though there are a relatively small number of manufacturers, they are not likely to have shipments data that meet the four requirements for tracking in California, nor are they likely to be willing to supply such data. Furthermore, as the market for dedicated freestanding fixtures expands, the number of manufacturers should rapidly increase. The tracking system would naturally need to expand accordingly. At this point, the effort and cost in monitoring and recruiting additional manufacturers cannot be foreseen.

Given that dedicated CFLs are not yet widely available through retailers, the most logical means of data collection at this point is at the end user level. A survey of consumers is a favorable option for several reasons. First, residential new construction on-site surveys (and a short resident interview) are currently being planned for tracking many measures covered by the initial scoping study. Freestanding lighting fixtures could be incorporated into this effort at a relatively low marginal cost. Second, the distribution channel for dedicated CFL floor and table lamps will likely expand and change over the next several years. Obtaining data at the consumer level will bypass the need to alter or expand tracking efforts in response to the changing marketplace. A telephone or mail survey of consumers will likely need to be implemented to obtain information on replacement purchases.

Note that it also might be possible to obtain sales data on residential lighting fixtures from ENERGY STAR® retail partners. The ENERGY STAR® retail data collection tracking initiative is currently being developed to track several residential measures covered by the initial study, including CFL fixtures and lamps. To the extent that dedicated CFL fixtures are sold through ENERGY STAR® retail partners they can also be incorporated into this existing initiative. Though Target and Wal-Mart are not yet ENERGY STAR® retail partners, it is quite possible that they will be in the next few months.

3.6 High Efficiency Vertical Axis Clothes Washers

Clothes washers generally fall into one of two design categories based on the axis upon which the washtub spins. The washtub in a conventional clothes washer spins on a vertical axis. These top-loading units typically require a large volume of water as the washtub must be filled with enough water to cover the entire load.[13] Horizontal axis (front-loading) clothes washers offer the potential for energy and water savings, as well as gentler treatment of clothes compared to the traditional vertical axis models. These washers feature a washtub turned on its side with the agitator removed. The clothes are gently lifted and plunged into the water approximately 50 times per minute. Electronic controls monitor the tumbling and spin speeds and automatically adjust the water levels to optimize water use. Despite these advantages, customer perceptions of front-loading washers and the higher first cost of the horizontal axis models have limited the adoption of these more energy efficient washers.

To address the limitations relating to front-loading horizontal axis washers, some manufacturers have developed vertical axis models with energy saving features comparable to the horizontal axis washers. New features, such as temperature sensors and special rinse systems are significant design changes that reduce energy and water usage of vertical axis models. Examples of high efficiency units that are commercially available are offered by Whirlpool (Resource Saver Wash System) and General Electric (with SensorWash™ feature).

[13] Because energy is required to heat wash and/or rinse water, the energy efficiency of a clothes washer is directly related to the amount of water used.

Review of the Market

The typical distribution channel of clothes washers consists of manufacturers, distributors, builders, retailers, and consumers.[14] In general, major appliance manufacturers have their own distribution centers or sell their products to independent distributors. There has been considerable consolidation in the distribution channels for clothes washers in recent years. This market trend has resulted in manufacturers fostering direct relationships with retail outlets; distributors in the clothes washer market are virtually nonexistent.

Because clothes washers are not typically standard equipment in new construction, the consumer is the only decision maker with respect to the brand and model purchased; replacements are also purchased at a retail establishment by the consumer.

Implications for Tracking

Alternative distribution points for collecting data for tracking the market share of high efficiency vertical axis clothes washers include manufacturers, retailers, and consumers. Data by decision type are not available from manufacturers since they do not have the mechanism (nor do they have an interest) to track sales past the first distribution point. Collecting data at either the retail or end-user level (or both) is more sensible because the residential appliance market is dominated by retail distribution, and end users purchase appliances for both new construction, net acquisition, and replacement installations. Furthermore, collecting data for tracking high efficiency washers directly from consumers is more feasible than other measures because consumers are familiar with these products and the brand/model numbers of these appliances are easily accessible. This can be done via mail or telephone survey or during an in-person on-site survey. The retail and consumer options are particularly attractive options because tracking initiatives currently being developed involve obtaining retail sales data for residential appliances from ENERGY STAR® and non-ENERGY STAR® retailers, as well as on-site surveys of newly constructed homes.

3.7 Electrodeless Induction Lamps

Electrodeless lamps are fluorescent-type lamps that utilize an induction coil instead of conventional electrodes to excite the gas sealed inside the lamp. The induction coil creates a magnetic field inside the gas, causing it to emit ultraviolet (UV) light. The UV light excites a phosphor coating on the inside surface of the tube that then glows with visible light. In contrast, electrode-based lamps use an *electric arc* to stimulate the gas to give off UV light. This measure specifically excludes sulfur lighting, which is another type of electrodeless lamp.

14 Major manufacturers of clothes washers in the U.S. include Maytag, Whirlpool, General Electric, and Frigidaire.

Although electrodeless lamps save energy, their biggest advantage versus conventional electrode-based lamps is a long life. Because there is no filament or electrode to break these lamps cannot fail by shock or other electrode-related phenomenon. Also, they will not just burn out but will fail gradually, becoming dimmer to the point of providing inadequate light. Currently, their primary application is in outdoor lighting or locations where extremely low maintenance is desired.

Electrodeless lamps are currently only available from three major manufacturers, each with their own unique lamp design. The Phillips' QL line is a globe-shaped lamp, GE's Genura is a replacement for incandescent R lamps, and OSRAM Sylvania's Icetron is a dual-tube, compact fluorescent-type lamp.

Review of the Market

The key participants in the market for electrodeless lamps are lighting equipment manufacturers and distributors, builders, building owners and tenants, architects and/or lighting designers (for new buildings), ESCOs (for retrofit applications), and electrical contractors. Because these lamps are so new and available in such limited styles and wattages, they are typically sold only through distributors. Even though a manufacturer's sales team might seek potential applications for the lamps, the actual sale transaction occurs between the customer, contractor, or ESCO and a distributor.

In new construction, use of electrodeless lamps would typically be specified by either the architect or the lighting designer. For retrofit applications, the customer or possibly an ESCO would typically request electrodeless lamps. However, any market actor who is knowledgeable about the technology could recommend its use for new or retrofit applications. Regardless of the market actor that recommends or specifies electrodeless induction lamps, the electrical contractor always performs the installation.

Implications for Tracking

Data for market share tracking could theoretically be obtained at several points in the distribution channel: manufacturer, distributor, designer, contractor, ESCO, and end-user level. Few options, however, can provide data that meet the requirements for market share tracking in California.

Data collection at the manufacturer level might be a viable alternative for several reasons. First, there are currently only three manufacturers of electrodeless lamps, and these companies have a small number of branch offices serving California. Second, the market is still very small. Some manufacturers initially are scoping out potential applications/customers to hand off to the distributors. Therefore, the manufacturers should be intimately familiar with all current and potential applications. Thus, data by region and decision type *might* exist at the manufacturer level. There are two disadvantages to this approach. First, preliminary discussions indicate that manufacturers are likely to be unwilling to release sales data. Second, as the market for electrodeless induction lamps expands, obtaining data from manufacturers would also need to expand. For example, this effort would also require that the list of manufacturers be constantly updated. Although there are currently only three manufacturers identified from reports and searches, that number is expected to increase as awareness of these lamps increases.

Another alternative would be to obtain sales information directly from the distributors or lighting contractors. However, because of the larger number of distributors and contractors, this could be a much more difficult and costly effort. A problem similar to obtaining manufacturer sales data also applies here. Mainly, a distributor/contractor tracking effort would need to accommodate expansion in the manufacturing industry, and the distributors and contractors supplying the required data would also need to be monitored closely.

In light of the above potential difficulties and obstacles, the most realistic option for obtaining data for market share tracking is at the site level via an on-site survey. Because commercial on-site surveys are likely to be an integral element of market share tracking in the nonresidential sector, incorporating electrodeless induction lamps into the effort could be done for a very low marginal cost. However, identifying electrodeless lamps during an on-site visit would require access to the fixture – something that might not be possible, particularly with outdoor lighting fixtures. Thus, a survey of the building manager or facility/engineer should accompany the on-site inspection to determine and confirm lamp types.

3.8 Integrated Lighting Fixtures and Controls

Integrated lighting fixtures and controls refers to advanced lighting systems in which controls are directly integrated into the fixtures and the assembly is designed, sold, installed, and warranteed as a complete lighting system. The installation of an integrated lighting system rather than separate components encourages the use of energy efficient equipment and helps to eliminate concerns/perceived risk of component compatibility, installation, and operation by providing the opportunity to offer a single-source warranty.[15] Control functions, including occupancy sensors, dimming controllers, etc., are typically incorporated into the

[15] This measure is not to be confused with and is distinct from the *integrated lighting system design* measure, which would be the process of taking a system approach rather than a component-based approach to designing the lighting for a building. Although similar, the distinction is that this measure is a practice while the *integrated fixture/controls lighting system* is a product. However, this product could certainly be an important part of the integrated lighting-system design approach.

wallbox for accessibility from the floor. An energy management system connection capability is usually provided as well. This measure also encompasses integrated systems designed to meet critical lighting applications requiring relatively high lighting levels. For example, Lightolier and EPRI jointly developed a system that provides optimal light for spaces with computer monitors.

Review of the Market

The key participants in the market for integrated lighting fixtures and controls are lighting equipment and control manufacturers, lighting equipment distributors, builders, architects, lighting designers, electrical contractors, building owners and occupants, and ESCOs.[16] For new construction installations, the architect leads the "specification team," though the actual specification/design of the lighting systems and the degree of interaction between market actors will typically vary by building type.

- For a concert hall or public space, the architect would typically defer to the lighting designer for design and specification of equipment, with the electrical contractor being responsible for installation and testing.
- In a high-end office, the architect would take the lead but work closely with the lighting designer on design and specification of the system, again with the electrical contractor being responsible for installation and testing
- In a low-end or "spec" office, the architect might create a concept design of the lighting system and then hand it off directly to the electrical contractor to finalize the design and specification.

For retrofit applications, the process would be similar to that outlined above, except that the primary decision maker would be an ESCO or other general contractor who would handle replacement of existing lighting equipment. Building occupants might have some input but will rely heavily on the expertise of other market actors for retrofit specifications.

Electrical contractors purchase the equipment from a distributor and install and test the lighting systems, regardless of decision type.

Implications for Tracking

Defining a market share of integrated lighting fixtures and controls in the context of this study is problematic because there are no efficiency levels associated with integrated lighting fixtures and controls. Therefore, the market share for this measure is defined in a manner similar to an energy efficiency service or practice – the number of integrated fixture and control installations as a percentage of all feasible applications. The number of feasible

[16] There are currently only a few manufacturers of these types of systems (Lightolier, U.S. Prescolite, Mitsubishi).

applications will need to be estimated and would consist of those having specific building characteristics (square footage, building type, etc.).

Alternative points in the distribution channel for obtaining market share tracking data include lighting designers, electrical contractors, and at the end-user level, via an on-site survey. However, as with most other measures sold through distributors, manufacturers are not likely to have access to or maintain sales records by decision type and/or small geographic regions. A similar problem exists with data from lighting equipment distributors. Though distributor data will be representative of a specific sales region, data are not likely to be available by decision type.

The most viable options for obtaining market data include a survey of electrical contractors or an on-site inspection. The latter is favorable here, primarily because commercial on-site surveys are likely to be a major market share tracking initiative in the nonresidential sector. Incorporating integrated lighting fixtures and controls in such an initiative would be straightforward, particularly since lighting equipment will likely already be covered.[17]

3.9 Building Commissioning and Retro-Commissioning

Building commissioning of new and existing buildings helps to ensure building systems operate at their optimal efficiency.[18] More specifically, commissioning is the process of ensuring that new building systems are operating efficiently and as designed while satisfying the buildings occupants. This process identifies imperfections and peculiarities of building systems, as well as the occupant's requirements, and usually occurs during the first year of building operation. Retro-commissioning is the process of optimizing the performance and efficiency of systems in *existing* buildings. In contrast to commissioning, retro-commissioning is the periodic fine tuning, calibration, and equipment improvement process. System operation history (i.e., maintenance records and billing history) usually aid in achieving these goals. The realized benefits of commissioning/retro-commissioning practices include improved system control, increased energy efficiency, improved equipment performance, improved indoor air quality, and reduced operation and maintenance costs.

Although building commissioning has been available for nearly a decade, the market for commissioning and retro-commissioning services remains small. ACEEE estimates about

---

[17] Regional Economic Research, Inc. *Efficiency Market Share Needs Assessment and Feasibility Scoping Study*. Prepared for the California Board for Energy Efficiency. May 1999. See Secion 10, Initiatives V and VI.

[18] Commercial building commissioning and retro-commissioning is actually two different but related measures combined into one here due to their common emphasis on the efficient operation of building systems (HVAC, lighting, refrigeration, etc.).

2% of all commercial building floor area each year is commissioned.[19] Another study estimates that less than 5% of newly constructed buildings and less than 0.03% of existing buildings are commissioned each year.[20] Buildings with larger, more complex building systems , such as institutional buildings, such as government complexes and universities, have the highest potential for energy savings from commissioning and retro-commissioning services.

Review of the Market

The key participants in the building commissioning/retro-commissioning market include builders, building owners and/or tenants, contractors (HVAC, lighting, etc.), facility engineers, and ESCOs. Sometimes a "commissioning agent" or an outside consultant specializing in the issues of building commissioning is also retained.

Building commissioning is typically initiated by the building owner. For newly constructed buildings, the system contractor(s) is(are) responsible for making sure that the building systems are installed, tested, and function as designed after completion. The system contractor(s) would inspect individual components and start up the whole system to make sure it operates properly. The contractor(s) might also retain a commissioning agent to help balance or fine tune the building systems. System performance would then be monitored and adjusted over the course of a year to validate operation through all seasons and parameters would be set for optimal operation. Optimal operation in this case would be defined as that which minimizes energy use while maintaining occupant comfort, which is the overriding objective for all building systems. Once the building systems are optimized, operation would be transferred to the facility engineer, who would receive extensive training and documentation for the system that would allow him/her to maintain this optimized state.

The facility engineer, and sometimes the building owner, initiates the retro-commissioning process. Approval from the building owner, tenant, or manager is generally required. Once approved, the facility engineer would hire a commissioning service provider (sometimes a system contractor) or ESCO to provide retro-commissioning services. The commissioning team will first conduct a site assessment and develop monitoring and test plans. A prioritization of improvements will then be presented to the building owner or facility engineer. After performing the desired services and selected improvements, the commissioning team will retest and monitor the systems as needed. Once the system is optimized, the facility engineer might take over day-to-day operations, but typically the

---

[19] American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* December 1998.

[20] Dodds, D., C. Dasher, and M. Brenneke. "Building Commissioning: Maps, Gaps & Directions." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* American Council for an Energy-Efficient Economy. Washington, DC. 1998.

commissioning service provider would still be involved in monitoring and fine tuning the system and verifying energy savings.

Although building commissioning/retro-commissioning is not new, the markets for these services are still in their infancy. The development of procedures, guidelines, and analytical tools will be key to further adoption of these procedures. Many of the tools and procedures being developed for integrated commercial building design (see Section 3.10) can also be applied to commissioning and retro-commissioning.

Implications for Tracking

As with other services or practices, market share tracking of building commissioning and retro-commissioning poses a formidable obstacle. Before developing a tracking initiative, it will be first necessary to define appropriately a market share of this measure and to identify the parameters that will be tracked as indicators of market share. Ideally, the market share could be defined as the number of buildings that *are* commissioned/retro-commissioned as a percentage of all buildings that *should be* commissioned/retro-commissioned. Tracking this measure also necessitates the development of a universally acceptable set of specific criteria that must be met in order for a site to be considered commissioned.[21] A secondary indicator of the market share of building commissioning could be the existence of firms providing commissioning services. Presently a small number of firms provide commissioning services as a primary business. Monitoring the growth of the infrastructure for the provision of commission services will provide solid evidence of increased demand for commissioning of both new and existing buildings.

Estimating the incidence of building commissioning/retro-commissioning could best be determined through a survey of decision makers (building owners and facility engineers) and/or commissioning service providers (contractors, commissioning agents, ESCOs). A survey of building owners and/or facility engineers is an attractive option for several reasons. First, an on-site survey and/or mail survey of commercial sites will likely be a primary initiative for tracking nonresidential measures covered by the initial study and the cost of including questions to identify sites that are commissioned/retro-commissioned would be very small.[22] Second, surveying these market actors would ensure the most accurate market coverage. Information from contractors, ESCOs, or commissioning agents, by themselves, might not provide adequate market coverage.

---

[21] For elements essential for commissioning see the following:
American Society of Heating, Refrigerating and Air-Conditioning Engineers, In. *1995 ASHRAE Handbook. Heating, Ventilating, and Air-Conditioning Applications.* Atlanta, GA. 1995. See Section 39.
PECI. *Commissioning for Better Buildings in Oregon.* Prepared for the Oregon Office of Energy. (No date provided.)

[22] Our assumption here is that an interview with the facility manager would be part of the on-site survey.

Determining the number of buildings that *should be* commissioned/retro-commissioned (the denominator of the market share formula) would be a far more difficult task. One method would be to determine the population of applicable buildings according to square footage and HVAC system and/or system control type.

3.10 Integrated Commercial Building Design

Integrated commercial building design is the concept of designing the building as a system to minimize energy use and optimize performance. This process is characterized by an integrated team approach to building design through which market actors work together during the design phase of development rather than individually. Building design tools and energy use simulation software help the design team identify and evaluate design trade-offs. In general, integrated commercial building design can lead to more efficient air distribution system design, HVAC equipment downsizing, and better utilization of monitoring and control devices, which will invariably reduce building operating costs. Because of the higher up-front construction and/or equipment costs that could be associated with the integrated approach, this measure is generally more applicable to larger, more energy intensive buildings with complex HVAC systems.[23]

A key element of the integrated building design process is the availability of software design tools that enable the market actors to analyze and evaluate the design team's concepts for optimizing building operation. There are numerous public and private resources available for analyzing and designing everything from whole-building simulations to specialty analyses such as daylighting, window performance, and motor analysis/selection. Development of new software and refinement of existing tools are continuing as the market for them (and the market for integrated design) grows. There has also been an explosion in the development of new tools spurred by programs such as ENERGY STAR® and Green Building, and market events such as deregulation of the electric power industry.

Note that integrated commercial building design relates to several other efficiency measures in the nonresidential market, some of which are (or will be) covered by tracking. Integrated lighting fixtures and controls, energy management systems, and high efficiency windows, for example, are likely to be specified as a result of the integrated design approach.

[23] The new statewide "Savings by Design" program being offered jointly by PG&E, SCE, and SDG&E is the embodiment of this measure. This program supports the team approach to building design and offers incentives to both building owners and design teams for participating.

Review of the Market

The commercial building market is complex; the sometimes lengthy design and construction process involves a variety of market actors and transactions. Furthermore, the decision making process and interactions among key market actors tend to vary according to building type, ownership structure, and preferences unique to each developer and other planning team members. The goal here is not to characterize the commercial building market in detail, but rather to identify key decision makers in the overall design process.[24]

Generally, commercial building design falls into one of two categories: "speculation" (spec) or "build-to-suit." In either case, the facilitator is a landholder, developer, development corporation, or a broker who specifically develops commercial facilities. In the spec design approach, the landholder, developer, or development corporation develops a concept (i.e., office park, corporate campus, mixed use) that is to be designed for a target "tenant." At a certain point in the construction process, the developer's brokers must secure leases based the concept. Selling points focus on the developer's business plan, amenities, and a description, representation, or model of the building and surrounding grounds. (At this point, all specifications are for shell and core buildings; tenant improvements differ.)

In the "spec" building, the extent that the developer will specify building design parameters varies depending on the effort needed to secure leases. It depends largely on the developer. The more experienced developers generally have a design team already on board. It is also not uncommon for the lender and the prospective tenant to want enough knowledge of the design concept that the developer is forced to hire the designer and prepare a concept. Some tenants might dictate a certain architect and radically alter the design.

Under a "build-to-suit" design approach, the developer secures a tenant, or at least a primary tenant, and produces a plan and design tailored specifically for that tenant. In most cases, the tenant drives the selection of the designer.

The key market actors in the commercial building market can be considered as either part of the design team or the construction team. The design team consists of architects and engineers, including structural, mechanical, acoustical, and lighting. Large property owners are likely to have an in-house design staff while smaller developers contract these services to other firms. The decision-making power of architects and engineers depends largely on owner preferences. The contractor would typically determine efficiency characteristics of a speculation building. In contrast, for a custom designed structure, a more traditional design approach is likely to be used where the architects and engineers can have significant

[24] See Reed, John H. and Nicholas P. Hall (1998) and Reed, John H., Mary O'Drain, and Jim Chace (1999) for more detailed characterization of this market.

influence. Regardless of their weight in the decision-making process, architects are the central figure in commercial building design.

Building design professionals often use design tools, mainly computer simulation software, to facilitate and aid the design process and will purchase a program that best meets their needs. For example, mechanical engineers would most likely be responsible for the overall building simulation, while evaluations for building sub-systems would most likely be performed by other market actors. Architects or lighting designers might use a computer program to optimize the lighting system design. A utility energy consultant might also provide or assist with this service. Software tools can be purchased from software vendors, government organizations, energy centers, mail/website order houses, etc.[25]

The construction team includes the general contractor and subcontractors (electrical, HVAC, plumbing, window, etc.). The general contractor hires subcontractors and oversees all aspects of building construction. Sometimes, the building owner also hires a construction manager to manage the process and serve as a liaison between the owner, design team, and the construction team.

Implications for Tracking

As with integrated new home design, the difficulty in tracking this measure is that it is a process rather than a product that can easily be counted and quantified. Two obstacles must be addressed in order to monitor the market penetration of integrated commercial building design. First, an appropriate definition of the market share of integrated commercial building design must be developed. Second, the broad measure description needs to be operationalized and the parameters that will be tracked as indicators of integrated commercial building design need to be determined.

The market share of a practice or service is broadly defined as the number of installations or applications as a percentage of all feasible applications. For tracking integrated commercial building design, the market share is equal to the number of buildings where an integrated design approach was adopted as a percentage of all newly constructed buildings. One also might want to consider imposing a constraint on the type of buildings that could qualify as a "feasible application." For example, the population of all feasible applications could be restricted to specific building types, those that exceed a specified square footage, or those that have/not have a specific HVAC equipment type, etc.

[25] Often software vendors offer services that are applications of the design/simulation tools. For instance, vendors of Title 24 compliance software packages would also offer Title 24 compliance services.

Alternatives for obtaining data that could reveal the adoption of an integrated design approach include a survey of building design professionals, primarily architects who specialize in the commercial market.

3.11 Supermarket Refrigeration Optimization

Refrigeration system energy use typically accounts for 50% of a supermarket' s total energy use. Therefore, optimization of these systems can yield significant energy savings. However, lack of commissioning or ongoing monitoring and poor maintenance can undermine about two-thirds of energy efficiency investments within two years.[26]

Typically, supermarkets use rack refrigeration systems (a group of small interconnected compressors) to service the numerous types and temperatures of display cases and storage coolers present. Supermarket refrigeration system optimization refers to the process of tuning and adjusting supermarket rack refrigeration systems to minimize energy use. System improvements employed as part of this process could include, but are not limited to, floating head pressure control, variable speed drives on compressors and condensers, variable condenser set points, and gas defrost or time controls on electric defrost. Continuous maintenance to ensure proper operation of these measures is a key element of refrigeration system optimization.

Review of the Market

The key actors in the refrigeration system market include equipment manufacturers; supermarket chain corporate headquarters, regional offices, and individual establishments; in-house maintenance departments; supermarket energy resource technicians; local refrigeration contractors; ESCOs; and utility energy consultants. Only a handful of manufacturers produces refrigeration systems for the supermarket industry – Hussman, Tyler, Kysor-Warren, and Hill-Phoenix dominate the market. These manufacturers maintain close relationships with large supermarket chains and often have considerable influence in equipment selection decisions.

Newly constructed stores within supermarket chains typically have a refrigeration configuration that will not vary from store to store any more than necessary. The design and layout of the refrigeration system is developed by a refrigeration engineer who is generally hired by the corporate office and is part of a design team comprised of corporate managers, architects, and system engineers. In-house and external designers, contractors, and equipment vendors might provide input in the specification process. Final decisions

[26] Refrigeration system energy use is not covered by Title 24, so the only reasonable baseline reference to use for these systems would be the current, "standard" industry practice for a given region of the state.

regarding energy using equipment are typically made by the chain's regional engineering department.

For existing establishments, the majority of energy-related issues (such as energy bill review and approval) is often deliberated at the corporate level, though on-site store managers and owners might provide input in energy-related decisions. Supermarket chains might have an energy manager, operations officer, or other individual who is the primary decision maker with respect to all energy-related aspects of the corporation, including monitoring energy usage and negotiating for and purchasing energy for the company. Interestingly, decisions pertaining to equipment purchases/retrofits can be made at the corporate, division, or establishment level, depending on the corporate structure of the chain. Note that energy managers have very little decision-making power.

Contractors and in-house maintenance departments are generally responsible for the installation and operation of energy using equipment and have an increasing role in the specification and optimal operation of equipment. In-house facility or energy managers are typically the primary decision makers with respect to ongoing refrigeration system optimization. Once such a decision is reached, a local refrigeration consultant or contractor is hired to provide such services.[27] The refrigeration contractor or other service provider would then determine and assess possible options for optimizing the refrigeration system and develop cost and savings estimates for each one. The utility energy consultant might also provide input for this step. The on-site store manager or owner, or the appropriate decision maker at the corporate/regional office, would then decide which measures to implement.[28]

Supermarket chains often have an annual specification review with representatives of equipment suppliers, engineering firms, etc., and decision makers of the chain where new ideas are introduced and reviewed and problems with current systems are addressed. First-cost reduction and meeting construction schedules are generally more important than energy use and tend to drive equipment and energy-related decisions. The large variables (deregulation and corporate restructuring) typically overshadow small technology decisions. Note that most chains implement major changes, especially cost-cutting ones, on at least a regional basis and also play "follow the leader" in terms of new equipment purchases and other major changes in business and operational practices. Therefore, adoption of

[27] ESCOs also provide refrigeration services, but they are more likely to approach supermarkets to promote their services, rather than wait to be contacted by a customer that needs such services. A utility energy consultant might also become involved to facilitate the process and provide advice, since all investor owned electric utilities in the State currently offer and promote this service.

[28] For a detailed characterization of the supermarket industry see the following: Quantum Consulting, Inc. *Study of Market Effects on the Supermarket Industry.* Prepared for Pacific Gas & Electric Company. Berkeley, CA. 1998.

optimization practices by industry giants could have a big influence on the industry as a whole.

Implications for Tracking

The difficulty in tracking this measure is that it is a service rather than a product that can easily be counted and quantified. The market share of a practice or service is broadly defined as the number of installations or applications as a percentage of all feasible applications. For tracking supermarket refrigeration optimization practices, the market share is equal to the number of establishments that conduct refrigeration optimization as a normal business practice as a percentage of all establishments.

Because this measure is a practice, it will also be necessary to compile a set of criteria that need to be met in order for the establishment to qualify as a site that conducts refrigeration optimization. Indicators of refrigeration optimization include, but are not limited to, the following:

- EMS for refrigeration system is present *and in use,*
- Maintenance log revealing periodic servicing of refrigeration system, and
- Presence of high efficiency measures including (but not limited to):
  - Mechanical sub-cooling,
  - Floating head pressure control,
  - Variable speed drives,
  - Anti-sweat heater control,
  - Hot gas defrost,
  - High efficiency case fans and/or lighting, and
  - Night-cycling of case lights.

The best sources for information on the above indicators are those market actors that are specifying or implementing optimization services. These individuals include on-site store managers or maintenance managers and refrigeration contractors. The large number of contractors and the perception of their unreliable record keeping practices make a survey of store owners and managers, including maintenance managers, a more realistic source of information for tracking this measure.

3.12 Advanced Metering Technologies

Advanced metering technologies refer to electric meters that give customers the ability to obtain highly detailed information about their energy usage. In contrast to conventional meters, advanced technologies have information feedback features that enable the customer to monitor energy use of the site and/or specific components/end uses. Typical features might include real-time monitoring of the following parameters:

- Energy use and demand,
- Power quality,
- Power factor,
- Power outage information, and
- Operating load shape.

Other capabilities/features available include data storage, time-of-use information, and real-time pricing. Most models have modem capabilities and software interfaces that enable the customer to analyze metered data. In particular, advanced meters are typically part of a complete energy analysis and control system package, since the detailed metered data are useless without a system that can easily analyze the data and apply controls.

There are two primary advantages of advanced metering technologies. First, they help facility managers understand their building's/facility' s energy usage, operation inefficiencies, and source of power quality problems. Second, these systems also enable the customer to take advantage of hourly pricing of the California Power Exchange. Deregulation of the electric industry has been a big driver of this market, especially for large power consumers, such as those in the Major Energy Users Group (MEUG). In order to purchase electricity, large customers must have access to their energy use parameters that are provided by these advanced meters. As deregulation continues to unfold, meters are expected to become even more sophisticated.

Review of the Market

The primary actors in the market for advance metering technologies include the customer (facility or energy managers), utilities, meter manufacturers, meter service companies, and ESCOs. Major meter manufacturers have several divisions each selling a variety of meters to different customers for different uses. For example, one major manufacturer has a utility division, a sub-metering division, etc. Utilities generally own the meters that they are responsible for setting and reading to determine customer usage. The type of meter installed at the site generally depends upon the customer rate.

The site facility/energy manager is responsible for determining the need for advanced meters. If the customer prefers a meter with additional capabilities beyond those available with the utility-owned meter, the customer is responsible for all costs of purchasing and installing the new meter. Facility managers typically purchase meters directly from the manufacturer, though meters are also available from the electric utility or ESCOs. The meters and their associated data storage and retrieval systems are then operated by the facilities manager, utility, or ESCO, with the facility manager being the ultimate recipient and user of resulting data.

All meter installations must be coordinated through and approved by the utility for all customers except direct access customers and sub-meters purchased by the customer. Utilities generally have a "meter department" that coordinates all meter installations, change-outs, and meter reading. As part of the meter hook-up process, utilities obtain information about the installed meter, including manufacturer and model numbers.

Implications for Tracking

The primary issues associated with tracking the market share of advanced metering technologies are that 1) metering technologies do not vary by efficiency level, and 2) defining the market share and indicators to be tracked. As with measures of similar characteristics, the market share of advanced metering technologies is defined as the number of installations as a percentage of all feasible applications. The former should refer specifically to the number of customers using advanced metering technologies, not the total number of meters in the marketplace. The denominator of the market share formula, then, is equal to the number of establishments in which advanced metering could be installed.

The market share of advanced metering technologies should be segmented by building type or business type (i.e., two- or three-digit SIC code). Even though the current market for advanced meters is comprised of large commercial and industrial customers, meter manufacturers are working to develop affordable advanced meters for the small commercial and residential sectors. Obtaining data for various market segments will indicate penetration into these markets in the future.

Data for tracking advanced metering technologies can be obtained from a variety of market nodes: the customer (facility manager/engineer), meter installers, metering service companies, utilities, and/or meter manufacturers. Utility records will provide data with the fairly complete market coverage and would presumably involve the least amount of effort and, therefore, be the least-cost alternative. However, as explained above, utilities are not likely to have information on direct access customers or sub-meters. As these are two critical segments of the advanced meter market, utility data is not likely to capture a significant portion of advanced meter installations.

Obtaining data from meter manufacturers is not a viable alternative for two primary reasons. First, preliminary discussions with the utility division of a major manufacturer indicate that they would not be willing to release their meter sales data. Second, the organizational structure of major manufacturers complicates data collection efforts. In particular, in order to obtain data on all meter sales, one would need to collect sales data from multiple divisions of one manufacturer. This might be very difficult, depending on the extent to which divisions communicate, and could result in incomplete data if all divisions are not willing to release its data.

Because of the above issues, customers are likely to be the best information source for tracking market shares of advanced metering technologies. Obtaining information on the types of meters and sub-meters could be obtained through a customer telephone survey or on-site visit.

Secondary indicators of market penetration, such as the number of metering service companies, availability of competing products, etc. could be solicited through surveys of meter manufacturers, customers, and other market research and analysis.

3.13 Summary

Table 3-2 summarizes the alternative data collection methods for obtaining market share tracking data for each of the 12 high priority emerging technologies. Because emerging technologies should be incorporated into planned or recommended tracking initiatives to the extent possible *prior* to the development of new initiatives, applicable planned or recommended initiatives developed for the initial study are also included. As shown, many of the high priority measures can be incorporated into existing initiatives. Collecting data for tracking the remaining measures generally requires surveys of market actors, consumers, builders, architects, facility managers/engineers, etc., who either request or conduct those services. Measures that cannot be incorporated into planned or recommended initiatives are somewhat unique with relatively undeveloped markets. There are few alternatives for tracking these measures.

RER' s recommendations for and a short discussion of general issues associated with tracking these high priority measures are presented in Section 4.

Table 3-2: Summary of Viable Methods for Tracking Priority Near-Term Emerging Technologies

Measure	Alternative Data Collection Methods	Planned or Recommended Tracking Initiative(s)
Evaporative condenser air conditioning and indirect-direct evaporative coolers	Distributor sales data, On-site inspection	Initiatives I and III
Aerosol duct sealing	On-site inspection, Aeroseal Inc. records	Initiative I
Integrated new home design	Builder survey	None
Dedicated CFL floor and table lamps	Consumer survey/on-site inspection, ENERGY STAR® retail data	Initiatives I and IV
High efficiency vertical axis clothes washers	ENERGY STAR® retail data, Consumer survey during on-site	Initiatives I and IV Consumer survey during on-site
Electrodeless lamps	On-site inspection w/ building owner/facility manager survey	Initiatives V and VI
Integrated lighting fixtures and controls	On-site inspection	Initiatives V and VI
Building commissioning and retro-commissioning	Building owner/facility manager survey	Initiatives V and VI
Integrated commercial building design	Survey of commercial building design professionals	None
Supermarket refrigeration optimization	Survey of on-site store managers or maintenance managers	Initiatives V and VI
Advanced metering technologies	Customer survey	Initiatives V and VI

4

Feasibility Assessment and Market Share Tracking Recommendations

4.1 Overview

This section presents the approach RER used to develop recommendations for tracking the market shares of the 12 priority near-term emerging technologies, and the final results of this process. Because of overlaps with the initial study and uniqueness of several of the priority measures, the feasibility analysis portion of this study differed considerably from the feasibility assessment of the initial study. As will be explained below, the crucial first step in developing recommendations was to identify measures that could be incorporated into tracking efforts that are currently being developed or that RER recommended in the initial study. RER then formulated new tracking initiatives for the remaining measures based upon the results of market reviews provided in Section 3 and the review of alternative tracking methods conducted for the initial study.

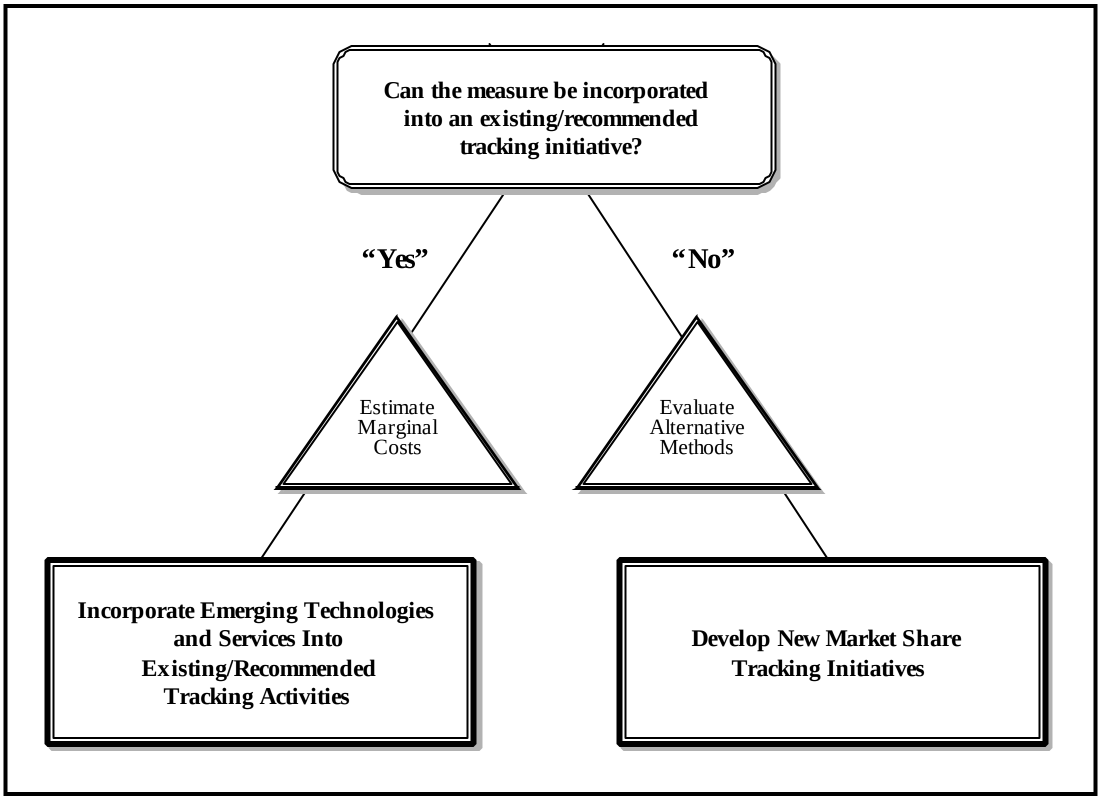
4.2 Feasibility Assessment: Approach for Developing Recommendations

As shown in Figure 4-1, the overall approach for developing the recommendations is fairly logical and is based upon whether or not the priority measure can be incorporated into an existing or recommended tracking initiative. As in the initial study, taking advantage of available economies in data collection methods and tracking multiple measures with the same initiative was a primary consideration here.

Three primary criteria were considered to determine if the measure could be covered by an existing/recommended effort:

1. The emerging technology/service has or will have an identical distribution channel or service providers as existing measures covered by the initiative, and
2. Data for the additional measure could be obtained with out significantly altering the design of the planned or recommended initiative, and
3. The marginal cost for including the measure in the initiative is very low.

Figure 4-1: Approach for Developing Recommendations



The information sources utilized to assess the above criteria for each priority measure include the following:

- The review of markets for emerging technologies and services presented in Section 3.
- Efforts currently being developed to track market shares of residential measures. In particular, market share tracking activities in the residential sector are currently being developed and are primarily based upon RER' s recommendations in the initial scoping study.
- RER' s recommended initiatives for tracking nonresidential measures in the initial study. Unlike the residential sector efforts, market share tracking in the nonresidential sector are not yet in the development stage. Thus, the recommendations for incorporating emerging nonresidential measures must be based upon RER' s recommendations in the initial study rather than actual planned tracking activities.

As indicated in Table 4-2, RER determined that nine of the 12 priority measures could, in fact, be covered by existing or recommended tracking initiatives for a low additional cost and without much difficulty. These measures include:

- Evaporative condenser air conditioners,
- Indirect-direct evaporative coolers,
- Dedicated CFL floor and table lamps,
- High efficiency vertical axis clothes washers,
- Electrodeless lamps,
- Integrated lighting fixtures and controls,
- Building commissioning and retro-commissioning,
- Supermarket refrigeration optimization, and
- Advanced metering technologies.

The final step in developing recommendations was to determine how to best obtain data for the three remaining measures:

- Aerosol-based duct sealing,
- Integrated new home design, and
- Integrated commercial building design.

As shown in Figure 4-1, this theoretically entailed the evaluation of all viable tracking methods. The intention here was to do so according to the nine criteria developed for the feasibility analysis of the initial study.[1] However, insofar as each of these measures is unique in terms of its distribution or service provision, RER determined that there is only one viable alternative for tracking each measure. These methods were identified as a result of the market assessment presented in Section 3. In particular, a survey of design professionals to characterize standard building design approaches and practices is the only means to obtain market share tracking information for integrated new home design and integrated commercial building design. Obtaining data from Aeroseal Inc, is the only means for tracking market shares of aerosol-based duct sealing, particularly for applications in existing buildings.

The point to be made here is that because of the lack of competing data collection alternatives to track these unique measures, an in-depth feasibility analysis to compare and evaluate alternatives was not necessary.

RER's recommendations for tracking the priority near-term emerging technologies are:

- Incorporate measures into tracking initiatives that are currently being developed or were at least recommended, and
- Develop new market share tracking initiatives. RER recommends the following methods for tracking priority measures that could not be covered by current activities:

[1] See Section 7 of the initial study.

- Obtain records from Aeroseal Inc, to monitor aerosol duct sealing applications,
- Administer a survey of residential building designers, and
- Administer a survey of nonresidential building designers.

The remainder of this section details these recommendations.

4.3 Incorporate Emerging Technologies and Services Into Existing or Recommended Tracking Initiatives

As shown in Table 4-1, nine of the twelve priority near-term emerging measures covered by this study can be incorporated into tracking initiatives that are either being developed or at least have been recommended by RER in the initial scoping study. Three tracking initiatives currently in development - on-site surveys, distributor sales data collection, and retail data collection through a collaborative effort with the ENERGY STAR® program can also be used to track several emerging efficiency measures in the residential sector. Furthermore, two of the recommended initiatives of the initial scoping study for tracking nonresidential measures can accommodate several priority emerging technologies covered here.

Table 4-1: Summary of High-Priority Emerging Technologies and Services Covered by Planned or Recommended Tracking Initiatives

High-Priority Measure	Applicable Tracking Initiative(s) from Initial Study	Primary Activity	Status
Evaporative condenser air conditioning	I and III	New construction on-site surveys and distributor data collection	In development
Indirect-direct evaporative coolers	I and III	New construction on-site surveys and distributor data collection	In development
Dedicated CFL floor and table lamps	I and IV	New construction on-site surveys and retail data collection	In development
High-efficiency vertical-axis clothes washers	I and IV	New construction on-site surveys and retail data collection	In development
Electrodeless (induction) lamps	V and VI	New construction and existing building on-site and telephone surveys.	Recommended
Integrated lighting fixtures & controls	V and VI	New construction and existing building on-site surveys	Recommended
Building commissioning & Retro-commissioning	V and VI	New construction and existing building on-site and telephone surveys.	Recommended
Supermarket refrigeration optimization	VI	Existing building on-site and telephone surveys.	Recommended
Advanced metering technologies	V and VI	New construction and existing building on-site and telephone surveys.	Recommended

Residential New Construction On-Site Surveys

Data for tracking the market shares of several existing residential measures will be collected at the end user level - through data collected via on-site surveys. The feasibility of obtaining building department records will also be explored as a long-term source for new construction installation data. The "existing" measures covered by this initiative include duct sealing (practices), central air conditioning equipment, compact fluorescent fixtures, windows, gas furnaces, gas water heating equipment, and dishwashers.

RER recommends incorporating the following emerging efficiency measures into this tracking activity:

- Evaporative condenser air conditioning,
- Indirect-direct evaporative coolers,
- Dedicated CFL floor and table lamps, and
- High efficiency vertical-axis clothes washers.

On-site surveys of residential new construction can also serve as a secondary data source for aerosol duct sealing applications in the residential new construction sector.

RER estimates the marginal cost of including the above measures into the new construction tracking system would be very low to zero cost.

Distributor Sales Data Collection

Data for tracking market shares of replace-on-burnout and net acquisition purchases of residential HVAC and water heating measures will be obtained at the distributor level. In particular, sales data from both HVAC and water heating equipment distributors throughout the State will be used to estimate efficiency market shares of central air conditioning equipment, gas furnaces, gas water heating equipment, and packaged air conditioning equipment.

RER recommends incorporating the following emerging efficiency measures into this tracking activity:

- Evaporative condenser air conditioning, and
- Indirect-direct evaporative coolers.

RER estimates the marginal cost of including the above measures into the HVAC and water heating distributor tracking system would be very low to zero cost.

Retail Data Collection with ENERGY STAR® /EGIA Collaboration

Data for tracking the market shares of replace-on-burnout and net acquisition purchases of several residential measures will be collected at the retail level. This initiative is an integrated approach involving current ENERGY STAR® data collection efforts and the Electric and Gas Industries Association to obtain sales data from lighting and appliance retailers throughout California. This initiative would be the primary data source for replace-on-burnout and net acquisition purchases of compact fluorescent fixtures and lamps, clothes washers, refrigerators, and dishwashers.

RER recommends incorporating dedicated CFL floor and table lamps (torchieres, in particular) into this tracking activity.

RER estimates the marginal cost of including the above measures into the retail tracking system would be very low to zero cost.

Commercial New Construction On-Site Surveys with Building Department Data

RER recommended tracking new construction installations of several nonresidential measures at the end-user level with data obtained through commercial on-site surveys (with or without collaboration with CEC efforts) and with data retrieved from building department compliance forms. This initiative was the recommended primary data source for new construction installations of nonresidential windows, packaged air conditioning, adjustable speed drive pumps and fans (HVAC and water heating applications), 32 watt T8s with electronic ballasts, and energy management systems.

RER recommends incorporating the following emerging efficiency measures into this tracking activity:

- Electrodeless induction lamps,
- Integrated lighting fixtures and controls, and
- Building commissioning.

A few points about obtaining data on building commissioning are worth noting here. First, as explained in Section 3, the first step to tracking the market share of building commissioning is the development of an operational definition and a set of criteria that need to be met to affirm adoption of this practice. RER recommends consulting a recently completed study on building commissioning practices conducted for the Northwest Energy Efficiency Alliance (NEEA).[2] The study characterized baseline building commissioning practices in the Northwest for the development of strategies to encourage growth of the practice in the private sector. To assess baseline practices, it was necessary to first develop a metric by which commissioning levels could be determined. A similar approach could be adopted for characterizing baseline practices and the market share of building commissioning in California. RER also recommends coordination with the statewide MA&E effort relating to Codes and Standards (under PG&E management), as this study covers building commissioning practices.

Second, obtaining information on building commissioning requires a customer survey rather than equipment inspection. RER assumes that any on-site survey conducted for market share tracking (particularly in the nonresidential sector) will include a short interview with the appropriate building personnel, such as the building owner or facility manager.

---

2 Northwest Energy Efficiency Alliance. *Building Commissioning Practices in New Construction and Existing Building Markets in the Pacific Northwest*. Prepared by SBW Consulting, Inc. October 1998.

RER estimates the marginal cost of including the above measures into the commercial on-site survey would be very low – in the $25 to $50 range per survey, assuming these additional measures increase the survey time by a maximum of 30 minutes.

On-Site Commercial Surveys and Commercial and Industrial Sector Telephone Surveys

This recommended initiative integrates commercial on-sites surveys (with or without collaboration with CEC efforts) and a telephone survey of commercial and industrial customers to collect data on retrofits of several priority measures. This initiative is the recommended primary data source for retrofits of adjustable speed drive pumps and fans (HVAC applications), 32 watt T8s with electronic ballasts, energy management systems, and compressed air optimization.

RER recommends incorporating the following emerging efficiency measures into this tracking activity:

- Electrodeless induction lamps,
- Integrated lighting fixtures and controls,
- Building retro-commissioning,
- Supermarket refrigeration optimization, and
- Advanced metering technologies.

Obtaining information on these measures requires a survey of the customer – particularly for building retro-commissioning, supermarket refrigeration optimization, and advanced metering technologies. Again, RER assumes that any on-site surveys will include a short survey of the appropriate building personnel, such as the facility manager or engineer. Also note that advanced meters are primarily an industrial measure at this point; questions regarding meter and sub-meter types could easily be added to the industrial customer telephone survey.

In the cases of building retro-commissioning, supermarket refrigeration optimization, operational definitions of these measures as well as a set of criteria that need to be met to affirm adoption of these practices will need to be developed. Some suggestions were provided in Section 3.

RER estimates the marginal cost of including the above measures into the existing nonresidential building on-site and telephone surveys would be minimal. The additional costs would result from an increase in the on-site survey time and/or questions added to the customer interview or survey. Assuming an additional 30 minutes per on-site survey, RER estimates that incorporating these items would cost and additional $25 to $50 per unit. The marginal cost of adding advanced metering technologies to the industrial customer telephone survey will be very low.

4.4 Develop New Market Share Tracking Initiatives

As shown in Table 4-2, RER recommends that new initiatives be developed for tracking the market shares of the following:

- Aerosol duct sealing,
- Integrated new home design, and
- Integrated commercial building design.

Table 4-2: Summary of Additional Recommended Initiatives

High-Priority Measure	Recommended Initiative*	Primary Activity
Aerosol duct sealing	VIII Obtain Records from Aeroseal, Inc.	Obtain records from Aeroseal Inc., including number of practicing contractors and number of homes treated by region.
Integrated New Home Design	IX Survey of Residential New Construction Builders	Survey residential building designers to characterize standard design practices.
Integrated Commercial Building Design	X Survey of Commercial New Construction Building Design Professionals	Survey commercial building designers to characterize standard design practices.

* The numbering of these new initiatives continues from the numbering of initiatives recommended in the initial study.

Initiative VIII: Obtain Records from Aeroseal, Inc.

As indicated in Table 4-2, RER recommends tracking the market share of aerosol duct sealing with data obtained from Aeroseal, Inc., the only company commercially licensed to sell the aerosol sealant and injectors and train contractors. As explained in Section 3, Aeroseal Inc. receives data on <u>all</u> aerosol-based sealing applications from each licensed contractor. Preliminary discussions with Aeroseal Inc. representatives indicate that the number of applications by region, decision type (new construction, retrofit), and the number of practicing contractors could be made available for market share tracking purposes. Also note that a benefit to obtaining records from Aeroseal, Inc. is the availability of data on aerosol sealing applications nationwide, allowing comparison area tracking.

<u>Development</u>

The development of this initiative entails three primary steps:

- Determine data needs,
- Assess data availability, and
- Forge a data collection agreement and protocol with Aeroseal, Inc.

Determine Data Needs. Determining data needs for market share tracking is a critical first step to this tracking initiative. As mentioned in Section 3, because aerosol duct sealing is an emerging *service* that does not vary by efficiency level, computing a market share can be somewhat problematic. The broad definition of market share – the number of homes that were aerosol sealed as a percentage of all "feasible applications" – will need to be refined to determine the specific parameters of aerosol duct sealing that need to be collected to compute a market share.

Assess Data Availability. Data availability will also need to be assessed as a primary step in developing this initiative. Discussions with Aeroseal, Inc. to determine data availability should begin as soon as (or during) data needs have been determined. At a minimum, data requirements include the number of aerosol sealing applications by region, decision type (new construction, retrofit), and the number of practicing contractors. Preliminary discussions with Aeroseal Inc. representatives indicate that this, and possibly other "non-confidential" data could be available for market share tracking.

Forge Data Collection Agreement and Protocol. The final step in developing this initiative is to forge data collection agreement and determine a protocol with Aeroseal, Inc. Issues to be addressed at this stage include the data fields to be obtained, needs for a confidentiality agreement, and the compensation requirements of Aeroseal Inc.

Timing and Schedule

Table 4-3 summarizes the timing and recommended schedule for implementing this tracking initiative. As shown, the development of this initiative is expected to take roughly two to 3 weeks. After the initial development, the ongoing operation of this effort would entail roughly one to two weeks per quarter.

Table 4-3: Summary of Timing and Scheduling of Initiative VIII

Task	Timing	Scheduling
Development	4 – 6 Weeks	4th Quarter 1999
Quarterly Data Collection from Aeroseal Inc.	1 Week	Quarterly from 4th Quarter 1999
Integrate with and Update Market Share Tracking Database	1 – 2 Weeks	Quarterly from 4th Quarter 1999

Cost Estimate

Table 4-4 presents a summary of the estimated costs by task to develop and operate this tracking initiative. Ranges of costs are provided as a guideline; actual costs would greatly depend on any compensation requirements of Aeroseal, Inc. The actual costs for implementing this initiative will be apparent during its initial development.

Table 4-4: Summary of Costsof Initiative VIII, by Major Task

Task	Estimated Cost
Development and First Quarter:	
Development	$5,000 - $10,000
First Data Collection from Aeroseal, Inc.	$1,000 - $3,000
Incorporate Data into Market Share Tracking Database	$1,000 - $3,000
Subsequent Quarters:	
Quarterly Data Collection of Data from Aeroseal, Inc.	$1,000 - $3,000
Quarterly Market Share Tracking Database Update	$1,000 - $3,000
First Year Cost	**$13,000 to $34,000**
Subsequent Year Cost	**$8,000 to $24,000**
Fixed Costs	**$5,000 to $10,000**

Initiative IX: Telephone Survey of Residential New Construction Building Designers

RER recommends the development and implementation of a telephone survey of building designers involved in residential new construction for tracking the market share of integrated new home design. As indicated in Section 3, the builder and architect are primarily responsible for residential building design. Because there are currently no record keeping practices with respect to the design approach used for residential new construction, a survey of builders and possibly other market actors involved in the design process is the only alternative for obtaining information for tracking the market share of integrated new home design.

The initiative proposed here is a quarterly telephone survey of builders to characterize standard design practices in residential new construction, which will then need to be judged as "integrated" or "non-integrated" according to a predetermined definition and set of criteria. In formulating this recommendation, RER recognizes that there are likely to be other MA&E efforts targeting builders and other design professionals. As with other tracking activities, it will be critical to coordinate tracking efforts with other MA&E work. A survey of builders designed for tracking integrated new home design can certainly include a variety of other questions designed to meet the needs of other evaluation efforts. The cost estimate presented here does not account for such economies, and can be thought of as an upper limit of budget requirements.

Development

The development of this initiative entails the following:

- Develop criteria that need to be met to affirm adoption of integrated new home design as a standard business practice,
- Develop telephone survey instrument, and
- Develop sample design.

Develop Criteria that Need to be met to Affirm Adoption of Integrated New Home Design. As mentioned in Section 3, the critical first step to tracking the market share of integrated new home design is the development of an operational definition of the measure and the development of key criteria that need to be met in order to affirm adoption of integrated new home design as a standard business practice. RER recommends that the appropriate utility program managers help to develop these criteria to ensure that tracking efforts are consistent with program design.

Develop Telephone Survey Instrument. After determining key criteria that define adoption of the integrated new home design approach. The survey instrument should be based upon the results of the first step described above. Second, it is highly likely that other MA&E studies in California will require telephone surveys or interviews with builders and other key market actors in the residential new construction market. As such, coordination with other MA&E efforts will be critical to avoid duplication of efforts and unnecessary burden on market actors. Two factors will need to be carefully balanced – keeping the survey as brief as possible while still soliciting the information needed to characterize design practices and any other information required for other MA&E efforts. RER recommends a maximum length of 15 to 20 minutes.

Develop Sample Design. The initial step of developing the sample design is to identify the population of market actors responsible for residential building design. Based upon previous characterizations of the residential new construction market, builders are most often the central figure and decision makers in this market. Information needed to develop the population and sample frame include Builder Magazine, California real estate internet websites, trade organization membership rosters, and other internet resources.[3]

The builder sample should be stratified by geographic region and builder type (i.e., tract/production housing or custom home builder). In order to estimate costs of this initiative, RER developed the following simplifying assumptions:[4]

- Roughly 80% of all new single family homes in the State are production homes.
- Approximately 100,000 new housing permits are issued per year.[5]
- On average, tract developers complete an average of 750 homes per year and custom home builders complete and average of 70 homes per year.

These data lead to the conclusion that there are roughly 80 to 100 large tract builders and 225 to 275 small builders operating in the state of California. Given these data, RER recommends an overall completed sample size of 200 telephone surveys per quarter. These 200 surveys should include 1) a census of large tract builders should be attempted, and 2) surveys with custom builders to complete the sample. For example, assuming a response rate of 60% for tract builders, this would call for a completed sample of 140 custom builders.

---

3 Examples include http://www.nhc-homesource.com; http://www.builderonline.com; http://www.builder.hw.net.

4 These assumptions are based upon information obtained from builders for new construction program evaluations in both Northern and Southern California. See Regional Economic Research, Inc. *Residential Market Effects Study* and Regional Economic Research, Inc. *Comfort Home Program Evaluation*

5 Actual new housing starts by region are available from the Construction Industry Research Board.

Timing and Schedule

The timing and schedule of this initiative is relatively straightforward. Developing the builder survey is estimated to take four to six weeks. RER estimates roughly four to six weeks should be allocated per quarter to implement the survey, process the data, and update the market share tracking database.

Table 4-5: Summary of Timing and Scheduling of Initiative IX

Task	Timing	Scheduling
Development	4 – 6 Weeks	4th Quarter 1999
Quarterly Telephone Survey	3 – 4 Weeks	Quarterly from 4th Quarter 1999
Data Processing and Update Market Share Tracking Database	1 – 2 Weeks	Quarterly from 4th Quarter 1999

Cost Estimate

As shown in Table 4-6, RER estimates the cost of this initiative to be $89,000 to $137,000 for the first year and $72,000 to $112,000 for all subsequent years. This estimate assumes a per survey cost of $50 to $75 that includes a $25 incentive payment for respondents to encourage participation. *Note also that the estimated costs presented in Table 4-6 do not reflect any economies that can be realized by coordinating with other MA&E efforts.*

Table 4-6: Summary of Costsof Initiative IX, by Major Task

Task	Estimated Cost
Development and First Quarter:	
Survey Design	$10,000 - $15,000
Sample Design	$5,000 - $8,000
First Survey Implementation	$10,000 - $15,000
Development of Market Share Tracking Database	$10,000 - $15,000
Subsequent Quarters:	
Update Sample Design	$3,000 - $5,000
Quarterly Survey Implementation	$10,000 - $15,000
Quarterly Data Processing and Market Share Tracking Database Update	$5,000 - $8,000
First Year Cost	**$89,000 - $137,000**
Subsequent Year Cost	**$72,000 - $112,000**
Fixed Costs	**$25,000 - $38,000**

Initiative X: Telephone Survey of Commercial New Construction Building Designers

RER recommends the development and implementation of a telephone survey of building designers involved in commercial new construction for tracking market share of integrated new home design.

Development

The development of this initiative is similar to that of initiative IX discussed above.

- Develop criteria that need to be met to affirm adoption of integrated commercial building design as a standard business practice,
- Develop telephone survey instrument, and
- Develop sample design.

Develop criteria that need to be met to affirm adoption of integrated commercial building design. As mentioned in Section 3, the critical first step to tracking the market share of integrated commercial building design is the development of an operational definition of the measure and the development of key criteria that need to be met in order to affirm adoption of the integrated design approach as a standard business practice. RER strongly recommends that the appropriate utility program managers help to develop these criteria to ensure that tracking efforts are consistent with program design.[6]

Develop Telephone Survey Instrument. The telephone survey instrument should be based upon the results of the first step described above. Again, it is highly likely that other MA&E studies in California will require telephone surveys or interviews with builders and other key market actors in the commercial new construction market. As such, coordination with other MA&E efforts will be critical to avoid duplication of efforts and unnecessary burden on market actors. Two factors will need to be carefully balanced – keeping the survey as brief as possible while still soliciting the information needed to characterize design practices and any other information required for other MA&E efforts. RER recommends a maximum survey length of 15 to 20 minutes.

Develop Sample Design. The initial step of developing the sample design is to identify the population of market actors responsible for commercial building design. Information needed to develop the population and sample frame include trade organization membership rosters, and other internet resources.[7]

---

6 PG&E' s " Savings by Design" program, for example.

7 Examples include the California chapters of the Associated Builders and Contractors (www.abc.org) and the Associated General Contractors (ww.age.org), and www.aecinfo.org.

RER recommends a completed sample of 150 commercial builders/general contractors and 150 commercial architectural firms. The sample should be stratified by size, oversampling larger dominant firms in the California market.[8]

Timing and Schedule

The timing and schedule of this initiative is relatively straightforward. Developing the survey is estimated to take four to six weeks. RER estimates roughly four to six weeks should be allocated per quarter to implement the survey, process the data, and update the market share tracking database.

Table 4-7: Summary of Timing and Scheduling of Initiative X

Task	Timing	Scheduling
Development	4 – 6 Weeks	4^{th} Quarter 1999
Quarterly Telephone Survey	3 – 4 Weeks	Quarterly from 4^{th} Quarter 1999
Data Processing and Update Market Share Tracking Database	1 – 2 Weeks	Quarterly from 4^{th} Quarter 1999

Cost Estimate

As shown in Table 4-8, RER estimates the cost of this initiative to be $109,000 - $167,000 for the first year and $92,000 to $142,000 for all subsequent years. This estimate assumes a per survey cost of $50 to $75 which includes a $25 incentive payments for respondents to encourage participation. *Note also that the estimated costs presented in Table 4-8 do not reflect any economies that can be realized by coordinating with other MA&E efforts.*

[8] According to estimates presented by Reed, O' Drain, Chace (1999) there are roughly 8,000 new commercial buildings are built each year, and there are 2,000 architectural firms specializing in commercial buildings in California.

Table 4-8: Summary of Costs of Initiative X, by Major Task

Task	Estimated Cost
Development and First Quarter:	
Survey Design	$10,000 - $15,000
Sample Design	$5,000 - $8,000
First Survey Implementation	$15,000 - $22,500
Development of Market Share Tracking Database	$10,000 - $15,000
Subsequent Quarters:	
Update Sample Design	$3,000 - $5,000
Quarterly Survey Implementation	$15,000 - $22,500
Quarterly Data Processing and Market Share Tracking Database Update	$5,000 - $8,000
First Year Cost	**$109,000 - $167,000**
Subsequent Year Cost	**$92,000 - $142,000**
Fixed Costs	**$25,000 - $38,000**

5

Alternative Methods to Forecast Market Penetration of Emerging Technologies and Services

5.1 Overview

This section presents the analysis results of the Market Penetration Forecasting Analysis component of this study. The primary goal of this effort is to identify and evaluate alternative methodologies to forecast the baseline market shares of new products. In evaluating each methodology, RER used the following criteria:

- The *applicability* of the approach to forecasting baseline shares,
- The likely *accuracy* of the approach,
- The *availability of data* required to implement the approach, and
- The *cost* of implementation.

Before discussing the forecasting methodology, it is beneficial to review several important issues associated with the development of the baseline shares of emerging energy efficient technologies.

Key Issues

The use of market share analysis on emerging energy efficient technologies to gauge the impact of market transformation initiatives is a relatively new and underdeveloped area. It is particularly important to address several aspects of this approach when reviewing potential methodologies. This section touches upon the major ones.

Defining Near-Term Technologies

While the list of "near-term" energy efficient technologies and services to be addressed by this study has yet to be completely resolved, it is likely that many of these technologies will not represent completely new products. These technologies are existing products but with significant improvements in efficiency. In contrast, other emerging technologies represent radical changes in product design. For the former technologies, the issue is one of technological substitution—a superior technology replaces an existing one. For completely new technologies, the issue involves the spreading of innovation within a market. As described in the next section, this distinction could have important implications for both the choice of market share model as well as the implementation of the model.

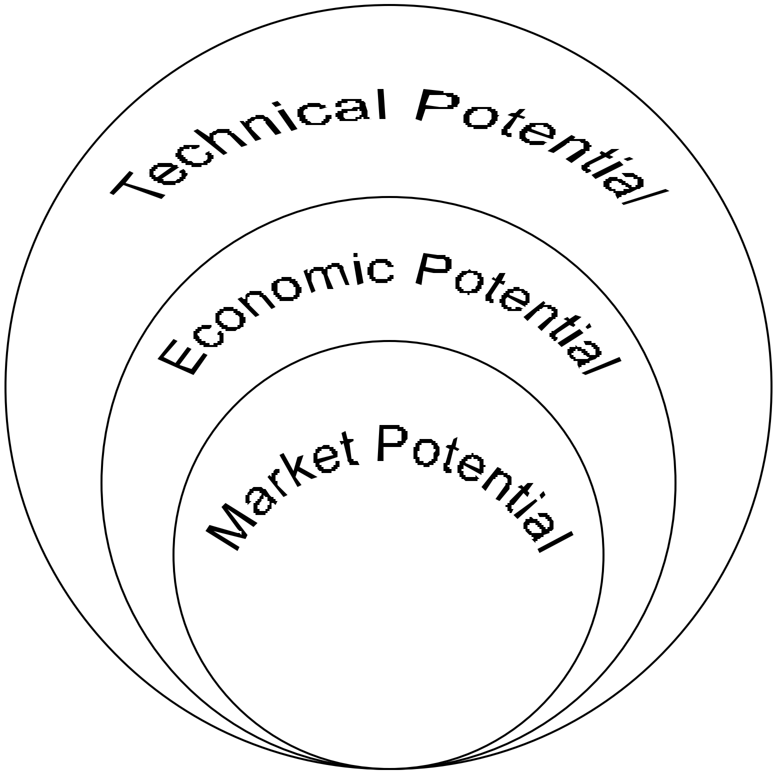
Potential and Penetration

Much of the applicable literature is cast in terms of market penetrations and market potentials (rather than directly in terms of market shares). When addressing the issue of market forecasting new technologies, the distinction must be made between potential and penetration. A product' s potential is essentially the size of the market for the product. There are three general definitions of potential. The broadest is termed *technical potential* and is equal to the market size if the most efficient equipment option is selected at each decision point. Thus, the measures are installed regardless of measure cost or acceptability to the customer. Technical potential represents the largest possible market for a technology. Notice that technical potential is not affected by the presence of a market transformation program.

The second type of potential is *economic potential.* Here, technologies are implemented only if they meet a stated economic criterion. This criterion typically compares the cost of a technology with the benefits that result from adopting the technology. In defining economic potential, the costs do not include information costs or costs associated with the decision-making process. The economic potential is less than the technical potential for any specific technology. The presence of a market transformation program can have a significant impact on economic potential if the program includes some type of incentive.

The final type of potential is *market potential*. This is the maximum number of actual installations of the technology. Market potential is a subset of economic and technical potential, as it is those customers who actually adopt the technology. Figure 5-1 shows the relationship between technical, economic, and market potential. Market potential should be significantly impacted by market transformation programs, since these programs reduce market barriers and thus increase market potential.

Figure 5-1: Technical, Economic, and Market Potential



Source: RTI, 1991

Market penetration, on the other hand, is the fraction of total potential achieved at a given time.[1] Thus, market penetration is dynamic as it can change over time. It can also be thought of as the ratio of cumulative sales (net of replacements, nonreplaced decay, and removals) achieved by a given time to the estimated potential. When the technology is first introduced, the market penetration is 0 since no one has installed the technology. Over time, as more of the technology is installed, the market penetration increases until it reaches its total potential. If M is defined as the total potential of the technology, and N_t as the net sales of the technology at time t, the market penetration at time t will be N_t/M. Since penetration is a function of time, a penetration time-path can be developed that shows how penetration changes over time. This change in penetration over time can also be termed the adoption rate.

1 Some researchers also refer to this as the saturation of the technology. Under that framework, penetration is defined as the change in saturation. Our definition of penetration is consistent with much of the literature, and this report is internally consistent with defining penetration as the ratio of cumulative sales to estimated potential.

This is contrasted with *market share*, which is the ratio of the net sales of the technology in question to the total net sales of similar (less energy efficient) technologies at one point in time. If the total net sales of the technology at time t are S_t, then the market share of the energy efficient technology at time t is N_t/S_t . If the new technology is a perfect substitute for the less energy efficient technology, then it can be expected to achieve, eventually, a 100% market share. This will be, by definition, the same point where market penetration equals 100%. Market share and market penetration are highly related concepts and, as will be discussed later in this report, one can go from one to the other fairly readily. For most of the discussion, we will focus on market penetration.

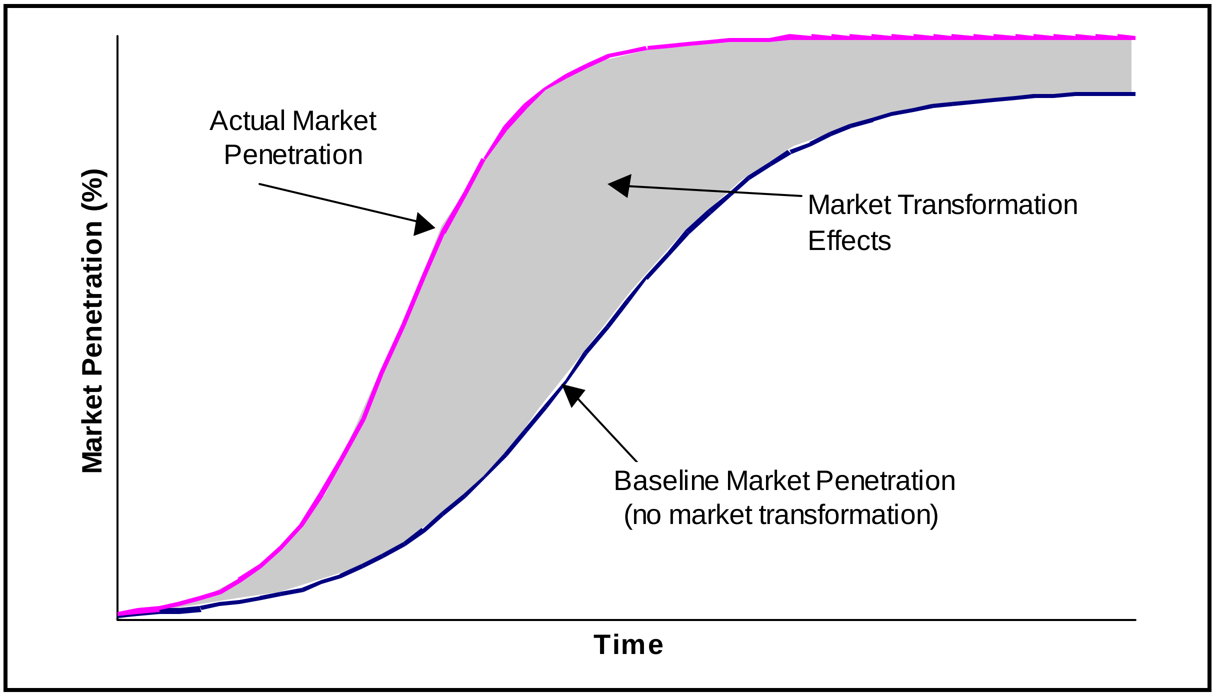
Given the dynamic definition of market penetration, to estimate market penetration, one must be able to model the variation in technology adoptions over time. Hence, market penetration modeling must be a dynamic process incorporating assumptions about how information spreads through the market over time. Potential, on the other hand, tends to be a static concept. Techniques that are viable for determining technical, economic, and market potential may have little use in determining market penetration.

In determining the baseline market performance of a new technology, one can either express it in terms of the relative total sales (i.e., the market share), or in terms of the proportion of total potential (i.e., market penetration). As discussed later in this report, each approach has both benefits and drawbacks. If one uses a market penetration approach, then it is important to define carefully the total market for the technology in question. Market potential can serve as the base, but programs significantly affect market potential. The same is also true for economic potential, though the program impact is through incentives, which can be readily measured and controlled. Therefore, the most straightforward approach is to use technical potential as a base. There will be some instances, however, where economic potential may be more appropriate. Throughout this report, we will use the term market potential to refer collectively to technical, economic, and market potential. We will make the distinction between types when it important to do so.

Impacts of Market Transformation Initiatives

As stated previously, the purpose of the market penetration forecasting analysis is to assess market transformation initiatives. This is done by comparing actual market penetration of emerging energy efficient technologies with market transformation initiatives to what market penetration of these technologies would be without the market transformation initiatives (i.e., the hypothetical baseline conditions). Because no baseline data exist for emerging technologies, the baseline conditions cannot be directly measured and can only be estimated through modeling. Figure 5-2 shows the relationship between the baseline and the actual market penetration under the market transformation initiative.

Figure 5-2: Baseline and Market Transformation



In order to develop meaningful models of baseline shares, one must first understand how these initiatives are designed to change the market for a technology. For this analysis, we assume that a market transformation initiative generally has three effects. First, the initiative increases market participants' awareness of the emerging technology, either directly through program materials or indirectly through demonstration effects. Second, it reduces many of the other adoption/market barriers for many of these technologies. Finally, these initiatives may alter the relative costs (i.e., payback) of the emerging technology if they offer some type of direct or indirect subsidy, or drive down costs through some other method. The net results of these effects are to increase the market potential for the emerging technology and to increase the rate of adoption. Therefore, in order to develop a meaningful baseline, the market penetration analysis must be able to account for these effects. Otherwise, the baseline forecast may not be meaningful relative to the actual market share under a market transformation initiative.

Ex Ante versus Ex Post Analysis

In reviewing the various methods available for market penetration forecasting, RER assumes that the models will be used to develop forecasts of baseline shares before the implementation of program interventions—in other words, an *ex ante* analysis of the market transformation initiatives. Alternatively, one could wait until the emerging technology market has developed and conduct an *ex post* analysis of the program impacts. There are two significant drawbacks to an *ex post* approach. First, it could take years for the markets to develop enough for this type of approach, at which time substantial resources already will have been devoted to the programs. Second, an estimate of baseline market shares still needs to be developed. Therefore, the issues associated with an *ex ante* analysis remain.

Data Driven Forecast

When reviewing the various approaches that can be used to forecast market penetration for emerging technologies, it is important to keep in mind that the "best" approach may not be feasible because of data constraints. For example, the most satisfying approach may involve modeling customer's awareness of a technology over time. However, this is only possible by repeatedly surveying a sample of potential adopters over time to see if they are aware of the technology. This is not practical, or even possible, for an *ex ante* analysis. Therefore, in determining the best approach, one must balance the data requirements against the attractiveness of the model.

The remainder of this section discusses essential issues relating to the impact of market transformation initiatives. Subsection 5.2 reviews the market penetration forecasting approaches discussed in the literature. This review summarizes the main features of each approach, and gives a general indication of the applicability of each approach for the development of baseline shares. It concludes by evaluating each approach based on applicability, accuracy, availability of data, and cost of implementation. Subsection 5.3 discusses the application of two of the methodologies showing some future promise for implemention and Subsection 5.4 demonstrates these forecasting methods for a selected technology.

5.2 Review of Market Penetration Forecasting Methods

This section reviews the most commonly used market penetration forecasting approaches. These include the following:

- Judgmental methods,
- Simple modeling by analogy,
- Consumer research,
- Diffusion models, and
- Market share analysis.

A general overview of the approach is presented for each of these methods, as well as its strengths and weaknesses relative to the forecasting of market penetration of emerging energy efficiency. In advance of this discussion, it should be noted that the individual methods are strongly overlapping. That is, each of the methods listed below tends to incorporate some elements of the others.

Judgmental Methods

Judgmental methods for forecasting market penetration generally involve subjective estimates of the performance of the technology. This is probably the most common approach used to develop market potential forecasts. The development of these subjective estimates can vary markedly in the amount of structure involved, ranging from informal discussions/meetings to Delphi methods, chain ratio models, or hybrid approaches. The more formal approaches are discussed below.

Delphi Method. The Delphi method interrogates a panel of experts through sequential questionnaires. First, a group of experts in the field is asked individually to predict the future course of a technology. The results of this first survey are then distilled to produce a second survey summarizing the thoughts of the entire group. Thus, the Delphi approach is based on the intuition of experts, which is later refined using the results of the panel as a whole. Armstrong (1985) concludes that the feedback and iterative rounds may increase accuracy, though the gains are slight. Overall, this approach is more accurate than traditional meetings or interviews. The Delphi method is most effective when used to determine market potential or choice probabilities, as it can, at best, only suggest ranges of adoption rates (Bolt, 1972).

Judgmental Chain Ratio Approach. The chain ratio approach can be considered a type of judgmental approach if the transition probabilities (the probabilities of moving from one event to another) are based on judgmental estimates. Essentially, this procedure involves the development of a sequence of likely events that culminate in a forecast of the final result. Many of the links in the chain can be estimated or known with certainty, though some links will need to be developed using judgment. Additionally, for any given result, one can develop a variety of chains following slightly different sequences of links, each of which might produce a different result. The chain ratio approach is often used for forecasting market potential, though it may be used to forecast market penetration. One of the strengths of this approach is that there is no "black box" involved—it is clear how the final estimate of market potential was obtained (Research Triangle Institute, 1991).

Hybrid Judgmental/Diffusion Approach. Another common judgmental approach for determining market penetration is a combination of judgment and the basic diffusion model (discussed in detail below). In essence, the researcher assumes that the cumulative market penetration of the technology will follow an S-shape over time. The researcher then uses judgment and/or literature review to define the parameters of the model. More often than not for emerging technologies, this approach amounts to little more than guessing the essential parameters. However, this approach does capture the diffusion character of market penetration and can be done using spreadsheet tools.

Benefits and Drawbacks

Depending upon the amount of formality, the judgmental approach can be cost effective and relatively easy to implement. Generally, the amount of data collection involved varies from none for informal meetings to significant surveying of experts or consumers.

The obvious major drawback to this approach is that the estimates are subjective, so results might change depending upon who conducts the analysis, the individuals included as expert judges, or the assumed values of key variables. Therefore, the results of a judgment approach can be criticized as being arbitrary. In addition, while most judgmental methods might be a reasonable approach for estimating *market potential*, they are not designed to forecast *market penetration*. Specifically, these approaches can give reasonable estimates of the total number of installations of the technology, they cannot give reasonable estimates of the time-path of installations. A notable exception is the hybrid approach, but this is more in the family of diffusion modeling. Finally, judgmental approaches are ill suited for sensitivity analysis and generally there is little possibility of statistical hypothesis testing.

Simple Historical Analogy

Another method to determine the likely penetration path of a new technology is to use the observed paths of technologies with the same general characteristics in similar markets. This is a purely heuristic approach, where the penetration time-path for the existing technology is assumed to apply to the emerging technology with no alterations. This contrasts with a model-based historical analogy approach, where the penetration pattern of the existing technology is used to parameterize the model for the emerging technology. Model-based historical analogy approaches are discussed later.

Benefits and Drawbacks

If the match between the new and existing technology is close, then using a historical analogy can produce accurate forecasts of both market penetration and market potential. Since there is little processing of the data, the analysis cost of this approach (assuming historical data are available) can be low.

There are several significant drawbacks to this approach. Data availability is a serious concern, as the data either are not currently being collected, are extremely expensive to obtain, or there is no clearly analogous existing technology. In addition, it is easy to assume false analogies, so that the market penetration for the emerging technology may not look at all like the penetration of the historical technology.

For the analysis of market penetration of new energy efficient technologies, the major drawback with using this heuristic approach is that most of these technologies are promoted by some type of program. Thus, the historical market penetration path cannot be used to estimate baseline for emerging technologies. However, it may be possible to use modeling techniques to control for the impact of these programs. This issue is addressed in Subsection 5.4.

Consumer Research

Consumer research approaches tend to use some form of concept testing to establish consumers' valuation of product attributes and their likely choices of product offerings with various mixes of these attributes. Some approaches use consumer responses to develop explicit choice models relating the likelihood of adoption to the range of product features. An example of one such approach is a conjoint analysis, where consumers are presented with various combinations of product attributes and are asked to rank the combinations. With this relative ranking, it is then possible to develop forecasts of total installations of the actual technology.

Other types of consumer research models include discrete choice models and preference regressions. This type of approach also includes the critical payback approach, where the paybacks associated with the technologies are combined with consumer research on required paybacks to predict total adoptions. In this case, consumers are surveyed on their requirements, in terms of payback, for adopting a new technology. Comparing the results of the survey to the actual payback of the technology gives an estimate of the total adoptions.

In general, these models are used to investigate consumers' preferences, opinions, valuations, perceptions, and choices about the technology through some type of survey mechanism. The focus is usually on developing estimates of the total number of consumers likely to adopt the technology, i.e., the market potential.

Benefits and Drawbacks

Consumer research approaches provide extensive details about consumer's preferences, attribute valuations, and decision-making processes. This type of information can be invaluable for program design. Consumer research approaches do not directly forecast market potential or market penetration (Research Triangle Institute, 1991). Further, these approaches tend to assume full awareness, so these models are unable to capture the penetration of new technology and are incapable of producing estimates of market penetration over time. However, they can be used in the development of choice probabilities for chain ratio models, or in adoption/awareness probabilities within a diffusion model.

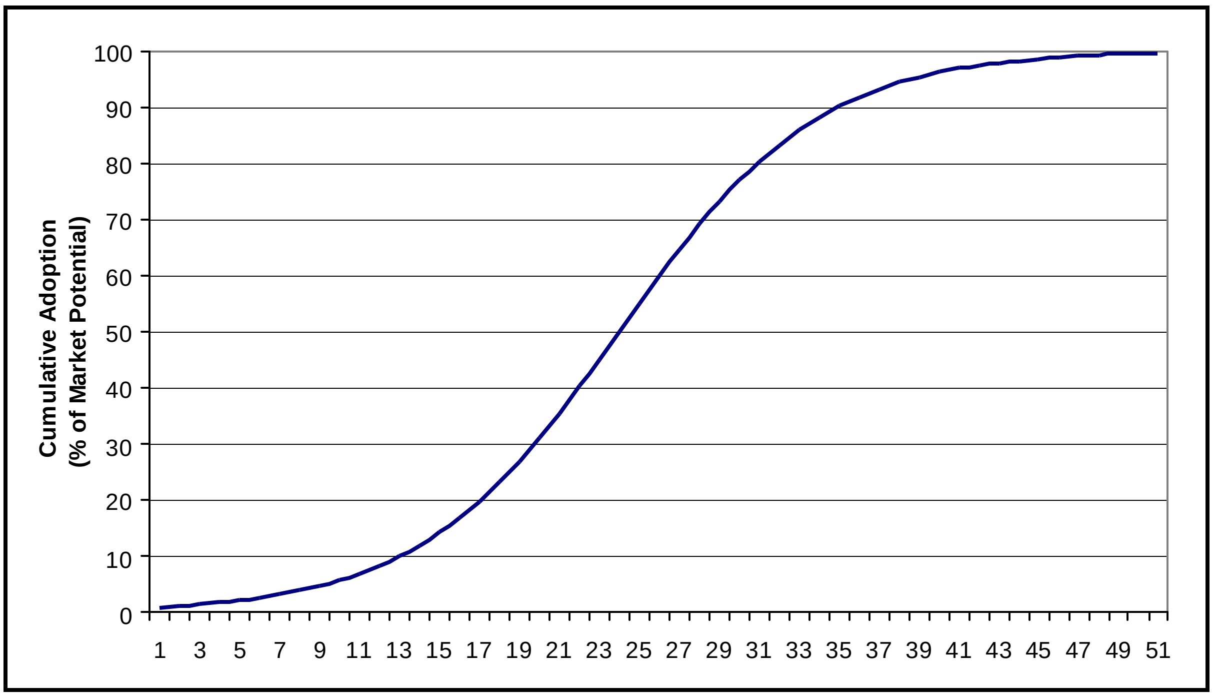
These approaches are often criticized because they are based on hypothetical circumstances, and may produce misleading results. Also, this type of research is generally difficult to conduct in commercial and industrial markets because there may not be a single decision maker for the firm, and companies might be secretive in their responses.

In general, these approaches are both expensive and time consuming. In addition, they can be very complicated, requiring significant technical skills to interpret and apply the results.

Diffusion Models

The essential foundation of diffusion models is to predict how an innovation is spread through a market over time. The basic tenet of diffusion models is that the time-path of cumulative adoptions is an S-shaped (sigmoidal) curve. Figure 5-3 presents a typical S-shaped diffusion/penetration curve (both curves look similar, though for a diffusion curve the vertical axis measures cumulative net sales, whereas for a penetration curve the vertical axis is the ratio of cumulative sales over market potential). This shape results from the fact that originally only a few individuals install the new technology. In subsequent periods, more individuals install the innovation as it starts to spread, or diffuse, through the market. Finally, the rate of installations tapers off as the number of non-installers falls. Eventually, the diffusion is complete, asymptotically approaching the technical/economic/market potential.

Figure 5-3: Diffusion Curve



The issue in diffusion modeling is determining the parameters of the S-shaped curve. Since data will not be available for the subject emerging technology (at least in the ex ante application of the analysis*), it will be necessary to use data on analogous technologies to develop estimates of these model parameters.* The choice of an analogous technology must be made carefully, insofar as some technologies start steeply, indicating rapid diffusion, while other technologies may be very flat, indicating slow diffusion. The model itself must also be designed carefully in order to account for the many factors that affect diffusion over time—both of the subject emerging technology and its representative analogous technology. This section summarizes the most widely used types of diffusion models.

Note that the diffusion curve is asymptotic to the technology' s potential. One can define diffusion relative to technical, economic, or market potential. Most studies use diffusion relative to market potential. For the problem of determining the impact of market transformation programs, market potential may not be appropriate. Since market potential reflects barriers, and a market transformation program eliminates barriers, then the diffusion must be able to account for this effect. However, modeling the elimination of barriers is complex and difficult to measure. Therefore, for determining the impact of market transformation programs, it may be best to define the diffusion relative to technical or economic potential. For this discussion, however, we assume that market potential is used as the base, as this follows the discussion in the diffusion literature.

The basic formula for a diffusion model can be expressed as the following differential equation:

$$\frac{dN(t)}{dt} = g(t)\left[M - N(t)\right]$$

where:

$N(t)$	= the cumulative number of installation at time t,
$\frac{dN(t)}{dt}$	= the diffusion rate at time t,
$g(t)$	= the coefficient of diffusion, and
M	= the market potential (i.e., the total number of potential installations).

There are three main types of basic diffusion models, which vary in terms of how they define the coefficient of diffusion (the $g(t)$ function):

1. External influence model,
2. Internal influence model, and

3. Mixed influence models.

Note that in all these models, there is no method to capture decay and replacement. This issue is addressed later in this section.

External Influence

In the external influence model, the coefficient of diffusion is a constant term. Thus, it is independent of prior adoption and, therefore, represents the influence of an external source (such as government agencies or mass media) on the adoption of the technology. The constant coefficient of diffusion implies that over time the cumulative number of adopters increases, but at a constant decreasing rate. Thus, the cumulative adoption curve is an arc, where the rate of diffusion at time *t* is dependent only upon the number of potential adopters remaining in the market.

Internal Influence

With the internal influence model, the coefficient of diffusion at any time *t* is a function of the cumulative number of adopters at that time, specifically a constant term times the cumulative adoption. This can be interpreted as diffusion only occurring through interpersonal contacts. The general form of the model results in a logistic diffusion curve, with the inflection point when 50% of the total market potential has adopted the technology. Another form of the internal influence model uses the Gompertz function (an asymetric function widely used in technical forecasting, which has a steeper initial curve relative to the logit curve). In this specification, the point of inflection for the S-shaped cumulative adoption curve occurs when 37% of the total market potential has adopted the technology.

Mixed Influence

The mixed influence model, as one would expect, is a combination of the external and the internal influence models. In this case, the coefficient of diffusion is a constant term plus another constant times the cumulative adoption. Therefore, it captures the effects of both external and internal influences. This is the most common type of diffusion model used, since rarely can one define a situation where it displays strictly external or internal influences, and is often termed the Bass model (Bass, 1969):

$$\frac{dN(t)}{dt} = \left[b_0 + b_1 N(t)\right]\left[M - N(t)\right]$$

where:

N(t) = the cumulative number of installation at time *t*

$\frac{dN(t)}{dt}$ = the diffusion rate at time t,

b_0 and b_1 = parameters

M = the market potential (i.e., the total number of potential installations).

These basic diffusion models offer limited flexibility in changing the shape of the diffusion curve, specifically in terms of symmetry and the point of inflection. The point of inflection represents the maximum rate of diffusion of an innovation. The diffusion curve is said to be symmetric if the diffusion pattern after the point of inflection is the mirror image of the pattern before the point of inflection. To increase the flexibility of the diffusion model, several researchers have proposed diffusion models that have parameters for the point of inflection (i.e., it is determined by the data rather than *a priori*) and allow for both symmetric and asymmetric diffusion patterns.

In general, there are several assumptions implicit in the basic diffusion model approach, which have significant impacts on the applicability of these models (Mahajan and Peterson, 1985).

- First, these models do not account for stages in the adoption process (e.g., awareness, investigation, etc.).
- Second, the market potential is assumed to be distinct and constant over time (i.e., the market is static).
- Third, adoption cannot be rescinded or repeated.
- Fourth, there is a complete mixing of individuals in the market for internal influences. In addition, the innovation itself does not change over the diffusion period (i.e., there can be no changes in technology). Further, the innovation is assumed independent from other innovations.
- Finally, the basic models do not capture diffusion across geographic areas (contrasted to penetration over time).

In order to address these drawbacks of the basic model, researchers have developed more extensive diffusion models. Perhaps more germane to this discussion is the development of diffusion models that allow for successive generations of a technology. These models essentially entail a system of linked diffusion models (Islam and Meade, 1997, Mahajan and Muller, 1996, and Norton and Bass, 1992).

The key to using a diffusion model to forecast baseline market penetration of emerging energy efficient technology is the ability to account for the effects of programs. In the ex ante application of the model, which entails the use of data on an analogous mature technology, this means that the impacts of past programs on the analogous technology must be recognized and that the baseline penetration path must be simulated in the absence of these impacts. As stated in the introduction, a program produces several effects including increasing awareness and lowering relative costs. A natural analogy to the marketing research literature on diffusion modeling is the incorporation of marketing mix variables within the diffusion model framework. Specifically, advertising is used to increase awareness, and pricing is used to alter relative costs. Therefore, it may be beneficial to address in detail models that incorporate marketing mix and pricing.

Horsky and Simon (1983) extend the Bass model by making the external coefficient a function of advertising. Specifically, they choose a natural log function of advertising expenditures, though a linear specification may also be valid:

$$\frac{dN(t)}{dt} = \left[b_0 + b_1 \ln(A_t) + b_2 N(t)\right]\left[M - N(t)\right]$$

where:

$N(t)$	= the cumulative number of installation at time t
$\frac{dN(t)}{dt}$	= the diffusion rate at time t,
b_0 , b_1 and b_2	= parameters
$A(t)$	= the level of advertising expenditures at time t, and
M	= the market potential (i.e., the total number of potential installation).

In terms of incorporating price within the diffusion model, it is possible to combine the Horsky and Simon model above with the model proposed by Mahajan and Peterson (1978). In this model, they assume that the market potential is a function of price $P(t)$:

$$\frac{dN(t)}{dt} = \left[b_0 + b_1 \ln(A_t) + b_2 N(t)\right]\left[M e^{-b_3 P(t)} - N(t)\right]$$

The price in this model should include both capital and operating costs. If the potential used in the model is technical potential (rather than market potential), then this is independent of price. In this case, one can incorporate price into the model just as with advertising:

$$\frac{dN(t)}{dt} = \left[b_0 + b_1 A_t + b_2 N(t)\ b_3 P_t\right]\left[M - N(t)\right]$$

Kalish (1984) also presents a model that incorporates both price and advertising in a two-step adoption and awareness model. Application of this model is impractical for this *ex ante* research, as it requires time series data on awareness of the technology.

Benefits and Drawbacks

Most importantly, diffusion models explicitly model how an innovation performs over time in the marketplace. They are ideal for estimating baseline forecasts of market penetration. Basic diffusion models, since they assume that penetration is a function of time only, can be used when there are little or no historical sales data available. The more detailed models that allow for the incorporation of advertising and pricing, such as the Horsky and Simon and the Mahajan and Peterson models, are more useful for the modeling of emerging energy efficiency technology since they can control for program effects.

As discussed above, the basic diffusion model suffers from several significant drawbacks, including the inability to model repeated purchases over time. The repeated purchase issue should only be significant for those technologies with short lives. In addition, the basic diffusion model cannot be used for sensitivity analysis since time is the only variable in the model. This is not true for the marketing mix models of as the Horsky and Simon and the Mahajan and Peterson models.

However, these models require an extensive amount of data to calibrate the parameters, as they are capable of incorporating a variety of explanatory variables. As noted above, one option (which would be necessary in the ex ante application of the model) is to use historical data on a similar technology to calibrate the model (see, for example, Lawrence and Lawton, 1981 and Thomas, 1985). Unlike the simple informal historical analogy approach discussed above, this approach is model based, so differences between the historical technology and the emerging technology can, in theory, be controlled for within the model. This includes the ability to control for program impacts on the historical analog. A viable option is to use, as an example, historical data on the penetration of "somewhat" efficient compact fluorescent lamps to calibrate a dynamic diffusion model for high-efficient compact fluorescent lamps. We will term this type of model an *analogical diffusion model* after Thomas, 1985.

As we will discuss below, the application of even the analogical diffusion model is hindered by the lack of decent market data on analogous technologies. In general, adequate data on market shares/penetrations are extremely difficult to find. Moreover, data on some of the explanatory variables may be virtually impossible to assemble. For instance, it may be impossible to collect some types of information like program marketing expenditures.

Adoption Process Models

The common assumption of the adoption process model is that prospective consumers go through a sequence of stages, usually beginning with unawareness and ending with rejection or adoption. A variety of adoption process sequences can be found in the literature depending on market and product type. Among them, one widely cited sequence for certain products is as follows (Rogers, 1995):

1. Awareness
2. Interest
3. Evaluation
4. Trial
5. Adoption

Operational adoption process models can be structurally complex, with simulated parameters set up as functions of time and market-mix variables. They are typically simulation models mapping dynamic behavior of a real system. Operational simulation of adoption process models usually uses one of two forms: 1) micro-simulation, or 2) discrete simulation. Discrete simulation is a stronger option than micro-simulation (Research Triangle Institute, 1991).

Micro-simulation models simulate the behavior of an individual consumer in a market. These models tend to be highly complex, since a dynamic system including structural models of individual choice, market interaction, and environmental parameters is required. Market forecasts are obtained by aggregating over the individual consumers in the model.

Discrete simulation models simulate potential consumers passing from one stage to the next in a specified adoption sequence. The model produces a period-by-period forecast by recording when prospective consumers enter and leave each stage. Consumers are assumed to pass from one stage to the next according to a simulated time sequence. The time sequence in discrete simulated models may be specified using periodic transition probabilities or using transition functions.

Benefits and Drawbacks

The micro-simulation model allows rich details and realism within the system and is compatible with direct segment and sensitivity analysis.

The discrete simulation model has major advantage in modeling dynamic systems with variables that change abruptly at each stage of adoption sequence. The discrete simulation process also has benefits of structural richness, and the effects of programs can be included and controlled within the process.

The major disadvantage of the adoption process models, at least for some models, is that the adoption process generally has many parameters to be calibrated, either judgmentally or using data-oriented methods. Data-based calibration requires extensive primary market research data, which can make adoption process modeling expensive. It also requires extensive computing with structurally complex models.

Market Share Analysis

Market share analysis is essentially an econometric analysis where the dependent variable is the market share of a product. While the main driving force of these models has been to investigate the market shares of different brands, it can easily be extended to investigate the market share of different technologies. Again, however, if it is to be used to forecast market shares of emerging technologies on an ex ante basis, it must be applied as a form of modeling by analogy. That is, its parameters must be estimated using data on an analogous technology, then applied to the development of baseline forecasts of the shares of the emerging technology.

The special aspect of a market share analysis over the more general econometric analysis is that by using market share as the dependent variable, structure is introduced into the econometric model. Specifically, the market share must lie between 0 and 1, and the estimated market share for all technologies must sum to 1. Several market share model specifications are available, including the familiar binary, multinomial and nested logit models used frequently in technology-related choice analysis. Another common type of market share model that is less familiar in energy efficiency literature but that meets these conditions is the Multiplicative Competitive Interaction (MCI) model, or attraction model (Cooper and Nakanishi, 1988).

The MCI model assumes that market shares are equal to the shares of attraction of respective brands, and that marketing instruments partially determine the attraction of each brand (Cooper and Nakanishi, 1988). Thus, the MCI model has the following structure:

$$m_{jt} = \frac{A_{jt}}{\sum_{i=1}^{n} A_{it}}$$

where:

$$A_{jt} = a_j \prod_{k=1}^{m} \left(X_{jkt}\right)^{b_{jk}} e_{jt}$$

m_{jt} is the market share of brand j in period t,

X_{jkt} is the explanatory variable k for brand j in time t,

α and β are coefficients, and

ε is the random disturbance term.

The A_{jt} terms represent that brand' s attractiveness based upon its characteristics.

While attraction models ensure that the market shares for all brands sum to 1, and that the market shares for each brand lies between 0 and 1, they do this at a rather steep cost. Often, the models will have a large number of parameters relative to the size of the sample. That is, they are over-parameterized. Consequently, linear or multiplicative market shares are more often used in practice. The linear model assumes that a brand' s market share is a linear function of marketing variables and other relevant variables. In the multiplicative model, the market share is a function of the product of the relevant variables raised to a suitable power. Recent investigations show that the attractive model is only marginally better than linear or multiplicative models (see Brodie and de Kluyver, 1984 and Leeflang and Reuyl, 1984). In general, the attraction model is a cross-sectional time-series model, while the linear and multiplicative models tend to be time-series models.

It is important to note that the distinction between econometric, market share, and diffusion models is somewhat arbitrary. A market share model is an econometric model. In addition, a diffusion model that incorporates marketing data is not much different from a logistic time-series model incorporating the same explanatory variables.

There are only two essential differences between a diffusion model and a market share model. First, the diffusion model investigates cumulative sales, while the market share model investigates the technology' s share of the market (i.e., sales over a given period). Depending upon the characteristics of the market (specifically market size and the decay/replacement rates), one can readily convert from diffusion to market share. Second, the diffusion model implicitly incorporates time within its framework, whereas the market share approach does not. One can explicitly incorporate time within the market share model by including it as an independent variable.

Benefits and Drawbacks

The benefits of a market share model in particular, and econometric models in general, are that it explicitly relates structural cause-effect relationships. This can help determine the role of various marketing initiatives on measure adoption, particularly market transformation initiatives.

While a market share model has the benefit of including explanatory variables within the model, thus allowing for sensitivity analysis, it has two significant drawbacks for this analysis. First, there are generally no time dynamics implicit within the model, in that the market share is assumed to follow a specific time-path like the diffusion model. That is, there is no assumption about how a new product will behave over time due to penetration. Rather, the model assumes that market shares are in equilibrium, and that changes in market shares over time are due to changes in marketing efforts, prices, or other explanatory variables. However, one can incorporate time dynamics into the model by including time or lagged values of market share explicitly as a regressor.

The second drawback to using this model is that it requires data to develop parameter estimates. As noted earlier, historic data from an analogous technology may be used to parameterize the model. However, as we will emphasize later, these data are not always readily available.

Evaluation of Methods

The previous section presented a broad-brush review of the most common types of models used to forecast market penetration. In this section, each alternative is evaluated on the basis of *ex ante* forecasting market penetration rates of emerging energy efficient technologies.

Each forecast methodology was evaluated according to the following criteria:

- The *applicability* of the approach to forecasting baseline shares,
- The likely *accuracy* of the approach,
- The *availability of data* required to implement the approach, and
- The *cost* of implementation.

Table 5-1 summarizes the evaluation of the various approaches based upon the above criteria.

None of the approaches is without serious drawbacks. At least in theory, the most reasonable approach for developing *ex ante* baseline shares is an analogical model based on either the diffusion or market share framework. This type of model must incorporate marketing mix (i.e., advertising and price) variables to control for the influence of such things as DSM programs and state and federal energy efficiency standards. Examples of this model include the Horsky and Simon and the Mahajan and Peterson models. Most of the other approaches do not account for the spread of a new technology over time through the marketplace. In addition, judgmental, informal historical analogy, and consumer research approaches are not well-suited for controlling for program effects.

The choice between using a diffusion model or a market share model depends upon the characteristics of the market and the focus of the analysis. The goal of a diffusion model is to analyze the time-path of cumulative installation, whereas the goal of the market share model is to investigate the technology' s share of the total market. In many cases, it is easy to convert from one to the other given knowledge of the total sales and the rate of decay and replacement, and if the technical potential is used rather than the market potential. Another difference is that the diffusion model implicitly incorporates time within its framework, whereas one must explicitly incorporate time in the market share model using independent variables. In essence, there is no strong reason to choose one model over the other, so we will demonstrate both approaches in below in Subsection 5.4.

Table 5-1: Evaluation of Possible Modeling Approaches

Market Penetration Forecasting Methodology	Applicability to Forecasting Baseline Shares	Likely Accuracy	Availability of Data	Approximate Cost of Implementation
Judgmental Approaches	Low applicability, as it is difficult to incorporate dynamic market performance. Better suited to determining market potential.	Low level of accuracy, as it is a subjective approach. May give reasonable results for near-term forecasting.	Can require little data collection or some amount of surveying, depending upon which approach is used.	Relatively inexpensive, depending on the level of formality
Historical Analogy	If the comparison technology is an appropriate match, the penetration path may be close to the emerging technology. However, this approach alone cannot control for program effects.	Can be very accurate if the comparison technology is well matched to the emerging technology.	Data may be expensive and difficult (if not impossible) to obtain.	Relatively inexpensive, though may have high data costs.
Consumer Research	Assumes complete knowledge, thus eliminating the issue of penetration over time. Is only suitable to provide input into other approaches.	Results may be inaccurate, as they are based on hypothetical situations.	Data are readily available, but must be collected through surveys.	Expensive due to survey costs.
Diffusion Models	Specifically designed to address the diffusion of new technologies. Can control for program effects.	May accurately measure penetration.	For the basic models, very little data are needed. For more complicated models, data may be expensive and difficult (if not impossible) to obtain.	Basic models using judgmental calibration are inexpensive. Advanced models are expensive
Adoption Process Models	Designed to model penetration. Can control for program effects. Not appropriate for an *ex ante* analysis.	May have higher accuracy than diffusion model.	Requires estimation of many parameters, and rounds of surveys. Other data expensive and difficult to obtain.	Expensive
Market Share Models	Applicability depends upon model specification. Can be identical to diffusion models. Can control for program effects.	Can accurately measure the cause-effect relationship between market share and marketing activities.	Requires pooled cross-section and/or time-series data of actual market performance. Therefore, can only be used once the market for the technology has been developed or by using historical analogy.	Expensive

However, while an analogical diffusion/market share model is attractive, it does require data for calibration. For many of the technologies in question, it might be possible to use the penetration time-path for similar technologies. However, there are still some unanswered practical questions with this approach:

- First, how can the program activities for the technologies used to calibrate the model be quantified?
- Second, how can the program activities be incorporated within the model?
- Third, is there enough consistency across time-paths to warrant this historical analogy calibration?

It may not be possible to answer these questions until a forecast of the market penetration for a specific emerging technology is implemented and the results compared to the actual penetration of the technology.

For some emerging technologies, there may be no reasonable existing similar technology. In this case, the only alternative would be a basic model that is calibrated using expert judgment to provide estimates of the penetration.

Finally, it should be noted that, in spite of the potential application of the diffusion and market share models using data on analogous mature technologies, this type of analysis is severely handicapped by the difficulty of obtaining data on even mature technologies. While historical data on mature technologies *should* be available, the energy efficiency community has not done a particularly good job in providing for the types of time series data needed for this application.

5.3 Implementation Approach

Based on the previous discussion, we have concluded that the best approach for developing baseline market penetration forecasts of emerging technologies is to use an analogical diffusion/market share model approach. In this section of the report, we review the steps involved in developing this model.

There are six steps involved in the implementation of an analogical diffusion/market share model:

1. Determine analogous existing technology,
2. Collect data on market shares/sales,
3. Collect data on factors (including programs) impacting existing technology,
4. Determine potential of the technology,

5. Estimate parameters of the model, and finally
6. Forecast baseline market shares/sales.

These steps are discussed in detail below. Section 4 demonstrates this technique on electronic fluorescent lamp ballasts.

Determine Analogous Technology

The first step in the development of the diffusion/market share model is determining the existing technologies that will be used to develop the estimates of the model. Thomas (1985) presents a systematic approach for determining appropriate technologies by using comparisons of the environmental situation, market structure, buyer behavior, marketing strategy, and characteristics of innovation. However, for many emerging energy efficient technologies, a formal systematic comparison is not necessary, as the new technology represents an improvement in the energy efficiency of an existing product rather than a complete new product.

For other emerging technologies, the match with existing technologies may be difficult. In these cases, it is probably better to loosen the criteria used to define the "similar" technologies rather than to use judgment to develop the model parameters arbitrarily. For example, using the penetration path of electronic ballasts may give insight into the penetration of high efficiency refrigerators.

Collect Market Data

Once the appropriate existing technology has been determined, the next step is the collection of market data. This data can take the form of either market share data or cumulative sales data. As was discussed previously, one can conceivably go from market share data to sales data. As discussed in Section 4, obtaining sales/shipment data is the most difficult part of modeling penetration. Two possible sources include the Census Bureau's Current Industry Reports and ENERGY STAR® tracking data. ENERGY STAR® is a joint program of the U.S. Department of Energy (DOE) and the Environmental Protection Agency (EPA). The purpose of this program is to encourage the development of a sustainable consumer market for energy efficient technologies by educating consumers and creating partnerships with manufacturers, retailers, and utilities. The important aspect of the ENERGY STAR® program relating to market data is the retail partnership arrangement. ENERGY STAR® Retail Partners provide sales data for tracking and other analytical purposes to ENERGY STAR®.

If sales/shipment data are used to estimate the model, then the next step is to develop sales net of decay and replacement. Since information on replacement sales is probably impossible to obtain, the average life of the measure can be used. Estimates of replacement sales are generated by moving the original sales forward into time by the average lifespan.

An example may help to clarify this approach. Assume that the average lifespan of a technology is three years and the sales for Year 1 are 5 units, all of which are original purchases. Table 5-2 shows how net cumulative sales can then be constructed by removing estimated replacements from actual sales.

Table 5-2: Developing Net Cumulative Sales

Year	Gross Sales	Replacement	Cumulative Net Sales
1	5		5
2	6		11
3	11	5	17
4	13	6	24
5	15	6	33
6	17	7	43
7	20	9	54
8	22	10	66

Collect Data on Factors Influencing the Technology

It is expected that the existing high efficiency technology is likely to be the subject of some type of energy efficiency program during its life cycle. In order to develop meaningful baseline forecasts of the emerging technology, we must eliminate the effects of these programs on the existing technology’ s penetration path. As discussed in Section 5.2, the diffusion/market share model is capable of controlling for the program effects, once appropriate independent variables are included in the model. This step in the process involves collecting the appropriate program data.

The type of program data that needs to be collected depends upon both the histories of the programs and the available data. For example, if there has only been one program, and it only covered a fraction of the period for which market share data is available, then a simple indicator variable should be sufficient to control for the program’ s effects. If, however, there are many programs covering the entire period, a more detailed variable is needed. A natural candidate is the time series of program expenditures (prorated to capture share of the total program budget devoted to the particular technology). This proxies the “ level of effort” by the programs and serves much the same purpose as advertising expenditures in the marketing diffusion/market share models.

Note that if there has been no change in the programs during the period for which there is market data, then it is impossible to control for the program effects.

Determine Potential

Since diffusion is defined as the achievement of the total market for the technology over time, one of the key variables in the diffusion model is the size of this total market (i.e., the potential). As stated previously, one can define diffusion relative to technical, economic, or market potential. While most diffusion models use market potential, it is not appropriate for researching new technology diffusion by using an analogical diffusion model approach. The reason for this is that market potential reflects market barriers, so programs will affect both market penetration and market potential. This makes the use of an analogous technology difficult, as we would need to quantify the impacts of market barriers on the market for the technology as well as the impact of the program on these barriers. Therefore, to use the approach to determine the impact of a market transformation program, it will be best to use technical potential as a base for diffusion.

It may be possible to obtain the technical potential for the new technology through program planning documents or other literature. If this is not possible, it may be reasonable to use the technical potential for the existing technology as the technical potential for the emerging technology.

Note that it is also possible to treat the potential as a parameter to be estimated in the diffusion/market share model. This approach is attractive since the resulting diffusion/market share model will be internally consistent. However, the mechanics of this estimation is difficult and it requires an extensive time series of data to avoid degrees of freedom issues. Therefore, many researchers (Heeler and Hustad, 1980, Thomas, 1985, and Mahajan and Wind, 1986) suggest that potential be estimated outside the estimation of the model parameters.

Estimate Parameters

Once all the appropriate data have been collected, the next step is to estimate the parameters of the model. As previously discussed, if there is no readily available price data, the model should at least account for the awareness/adoption effects of the program. This can be done by including the program data within the model. While the best situation would have a complete time series of market share data starting at the product introduction ($t = 0$), this may not always be possible. It is still possible to develop meaningful parameter estimates by noting within the estimation process the period of time between when the product was introduced and when the market share and program data begin, essentially moving the estimation point up the penetration curves.

Forecast Baseline Market Share/Sales

The final step is the development of the forecast of the baseline market share/sales for the emerging technology. This is a simple matter once the model has been parameterized. Essentially the forecast is produced by simulating the market penetration path using the estimated model and setting the program variable to 0 (to eliminate the program effect). Under this approach, a forecast can be obtained of the cumulative number of installations for the entire life cycle of the emerging technology. To determine the impact of the market transformation initiative, either an *ex ante* or *ex post* analysis can be conducted. In an *ex ante* analysis, the expected program effects are included into the estimated model to obtain a forecast of the program effect prior to implementation, and to forecast the program expenditures. In an *ex post* analysis, conducted after implementation, the observed market share for the emerging technology at a given time is compared to the *ex ante* baseline forecast.

5.4 Demonstration

In this section of the report, we follow the steps presented in the previous section and demonstrate the estimation of both a diffusion model and a market share model using data for an existing energy efficient technology. The results of this analysis can be used to predict the market penetration of emerging energy efficient technologies.

Determine Analogous Technology and Collect Market Data

As stated in the previous section, the first steps in developing the penetration model are determining the existing technologies that will be used to develop the model and then collecting the necessary data. Our experience in this analysis has shown that this not an easy task. We found very few public sources of data on the sales of energy efficiency technologies. Most of the data had no time series component (i.e., the sales data was only collected at one point in time) or there was not enough detail to determine the efficiency of the technology. For example, the U.S. Bureau of the Census (Census Bureau) has information on electric lamp shipments, but there is only a single line item for fluorescent lamps.[2]

Given the problems in collecting data, it was decided to determine which technology to model based solely on available data. The only technology with sufficient data was electronic ballasts for fluorescent lamps. Electronic ballasts use integrated electronic circuitry rather than the magnetic components found in other ballasts. Electronic ballasts operate at the same input frequency as magnetic ballasts. However, they increase lamp

[2] In 1992, the Census Bureau started disaggregating shipments, so data are available for shipments of T-8 bulbs starting in 1992.

efficiency by operating the lamps at a higher frequency and by being less sensitive to ambient temperature (Vorsatz et. al., 1997). Therefore, electronic ballasts are a reasonable substitute for magnetic ballasts.

The Census Bureau, in their annual *Current Industrial Reports: Fluorescent Lamp Ballasts* (MQ36C), tracks quarterly shipments of electronic and magnetic ballasts. The shipments data for electronic ballasts were collected beginning in 1986, though these ballasts first became available in 1981 (PGE, 1999). In addition to the quantity shipped, the Census data also include the value of these shipments. This information was used to approximate the cost per unit for these ballasts. While these data are available on a quarterly basis, other data used in the analysis are only available annually. Therefore, the quarterly Census data were aggregated up to an annual basis.

The average life span of these ballasts is between 15 and 20 years (NLPIP, 1997). Therefore, it was assumed that, for the period of our model, there were effectively no replacement purchases. Thus, the Census data represent first purchases of electronic ballasts.

Collect Data on Factors Impacting the Technology

The factors that affect the diffusion of electronic ballasts include the price of electricity, the price of ballasts (discussed above), DSM program expenditures related to ballasts, and the various state and federal standards for ballasts. Data on the average retail price of electricity were obtained from the EIA Annual Electric Utility Report (EIA, 1986-1998). This source was also used to develop the total expenditures on DSM programs by utilities. While a preferred variable would have been the DSM expenditures on lighting/ballasts only, these data were unavailable. Therefore, it was implicitly assumed that the proportion of total expenditures devoted to ballasts remained constant over time.

Information about the various state and federal standards for ballasts, as well as technical information (such as operating life) was obtained from *Lighting Market Sourcebook for the U.S.* (Vorsatz, et al., 1977) and the National Lighting Product Information Program's *Specifier Reports : Electronic Ballasts* (NLPIP, 1997). Of note is the federal standard for *magnetic* fluorescent ballasts, which was added to the National Appliance Energy Conservation Act. This standard prohibited the manufacture of "standard" magnetic ballasts after January 1, 1990, and prohibited the sale of non-replacement units after April 1, 1991 (Koomey et. al., 1995). This standard targeted efficient magnetic ballasts as a replacement, rather than electronic ballasts (Koomey et. al., 1995).

Determine Potential

Information on the total possible market for electronic ballasts (i.e., the technical potential) was obtained from the ESource Report *How Far Have We Come ? Remaining Opportunities* *for Upgrading Fluorescent Ballasts and Lamps* (ESource, 1998). They estimate the potential for these ballasts to be 722 million units.[3]

Table 5-3 summarizes the data used in the analysis.

Table 5-3: Data for Penetration of Electronic Ballasts

Year	Shipment of Electronic Ballasts (in thousands)	Per unit cost of Electronic Ballasts ($ nominal)	Average Electricity Price, Commercial Sector (¢/kWh, real)	Annual DSM Expenditures (thousand $ nominal)
1986	421	28.11	8.9	69,946
1987	652	24.72	8.5	209,840
1988	1,064	23.97	8.1	419,680
1989	1,426	27.92	8.0	671,488
1990	3,001	23.09	7.8	872,935
1991	8,343	21.58	7.7	1,117,457
1992	13,292	20.66	7.7	1,803,773
1993	22,488	19.86	7.5	2,348,094
1994	24,606	15.88	7.3	2,715,657
1995	32,894	15.41	7.1	2,421,261
1996	30,342	14.88	6.9	1,902,197
1997	36,543	13.52	6.8	1,636,020
1998	39,782	12.88	7	1,586,211

Subsection 4.4 presents the results obtained when these data were used to estimate the diffusion and market share models.

Estimation Parameters

This section reviews the estimation results for the penetration models recommended in Section 2. As stated there, the recommended approach for forecasting market penetration is using either diffusion models or market share models of analogous technology. In this section, both these models are estimated for the electronic ballast market.

[3] During the estimation of the model, we tested the viability of this number by altering it and observing what occurs to the R-squared in the model. In general, this number appears to fit the data quite well.

Diffusion Model

A diffusion model estimates the time-path of the cumulative penetration of a technology. The specific model estimated in this analysis is:

$$\frac{dN_t}{dt} = \left[b_0 + b_1 N_t + b_2\ DSM_t + b_3 BP_t + b_4\ EP_t + b_5\ FS_t \right] \left[M - N_t \right]$$

where:

N_t = the cumulative number of sales/shipments of electronic ballasts at time t,

$\frac{dN_t}{dt}$ = the diffusion rate at time t,

b = parameters,

DSM_t = the level of DSM expenditures at time t,

BP_t = the unit price of the ballast at time t,

EP_t = the price of electricity at time t,

FS_t = an indicator for the 1990 federal standard for ballasts, and

M = the technical potential (i.e., the total number of potential adopters).

While it is possible to integrate the above equation and estimate the model using nonlinear least squares, this was not done in this analysis. There are two reasons for this. First, there are four terms in addition to N_t that are a function of time. Thus, integrals for each of these terms would need to be developed. Since there are no equations for these terms, the integrals would need to be approximated by summations, thus defeating the benefits of integration. Second, the sample size is limited, so it may not be able to meet the demands of a nonlinear estimation. Therefore, the discrete analog of this equation was estimated (which essentially involves changing the left side of the equation to ΔN_t):

$$N_{t+1} - N_t = \begin{bmatrix} b_0(M-N_t) + b_1 N_t (M-N_t) + b_2\ DSM_t (M-N_t) \\ + b_3 BP_t\ (M-N_t) + b_4\ EP_t\ (M-N_t) + b_5\ FS_t (M-N_t) \end{bmatrix}$$

This equation can then be estimated using ordinary least squares. These results are presented in Table 5-4.

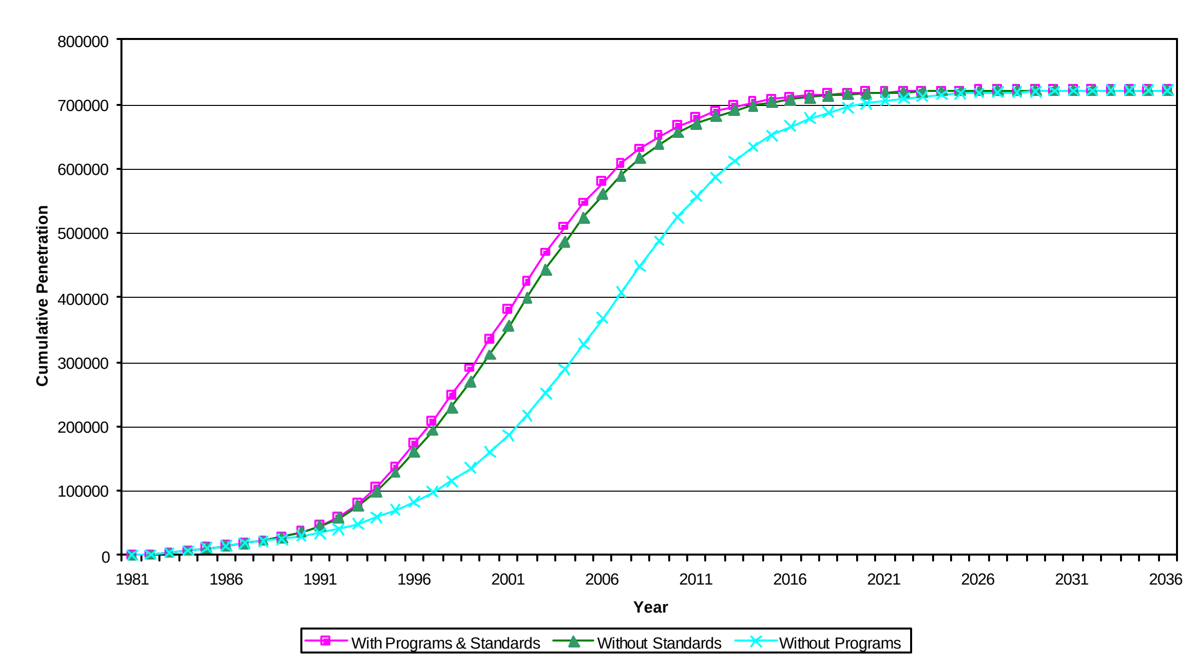
Table 5-4: Diffusion Model Estimation Results

Dependent variable: Change in cumulative electronic ballast shipments	
Independent Variables: **(all variables interacted with outstanding adopters, ($M-N_t$))**	**Estimated Coefficient** **(t-value)**
Constant	-0.03022 (-1.02)
Cumulative adoptions (N_t)	3.25e-7 (11.67)
DSM expenditures (DSM_t)	5.19e-9 (3.53)
Unit Cost of Ballasts (BP_t)	3.41e-5 (0.08)
Price of Electricity (EP_t)	0.003 (1.12)
1990 Federal Standards (FS_t)	0.003 (0.92)
R-squared F(6,7)	99.3% 167.55

This model shows that as DSM expenditures increase, or if new standards are in place, the cumulative diffusion increases. This is as expected. Notice that as the unit cost of ballasts increases, the cumulative diffusion also increases, contrary to expectations. However, this variable has a very low t-statistic so the coefficient is not precisely estimated.

These results can be used to forecast the adoption of electronic ballasts over time. They also can be used to estimate the effect of the changing or elimination of DSM programs or the 1990 federal standards. Figure 5-4 presents an example of this technique. To forecast penetration over time, it was assumed that the values for all the independent variables remain at 1998 levels. In this case, the penetration of electronic ballasts approaches its technical potential in 2014. Notice that eliminating DSM programs (i.e., setting the variable equal to 0) causes a large change in the diffusion rate, while eliminating the federal standard had a much smaller effect.

Figure 5-4: Forecast of Electronic Ballast Penetration



<u>*Market Share Model*</u>

The market share model is very similar to the diffusion model, except that it models the percentage of market share over time rather than the cumulative penetration. In equation form, the market share model can be expressed as:

$$\frac{S_t}{TS_t} = f(\, b_0 + b_1 T_t + b_2\, DSM_t + b_3 BP_t + b_4\, EP_t + b_5\, FS\,)$$

where:

S_t = the sales/shipments of electronic ballasts at time *t*,

TS_t = the total sales/shipments of lamp ballasts at time *t* (i.e., electronic and magnetic ballasts,

b s = parameters,

T = the time since the introduction of the electronic ballasts,

DSM_t = the level of DSM expenditures at time *t*,

BP_t = the unit price of the ballast at time *t*,

EP_t = the price of electricity at time *t*, and

FS_t = an indicator for the 1990 federal standard for ballasts.

In order to insure that the market share lies between zero and 100 percent, the above equation was estimated using a logit specification for *f*(). Thus, the estimated equation is:

$$ln\left(\frac{MS_t}{1-MS_t}\right) = b_0 + b_1T_t + b_2\,DSM_t + b_3BP_t + b_4\,EP_t + b_5\,FS$$

where MS_t is the market share of electronic ballasts at time t. The estimation results for this equation are presented in Table 5-5.

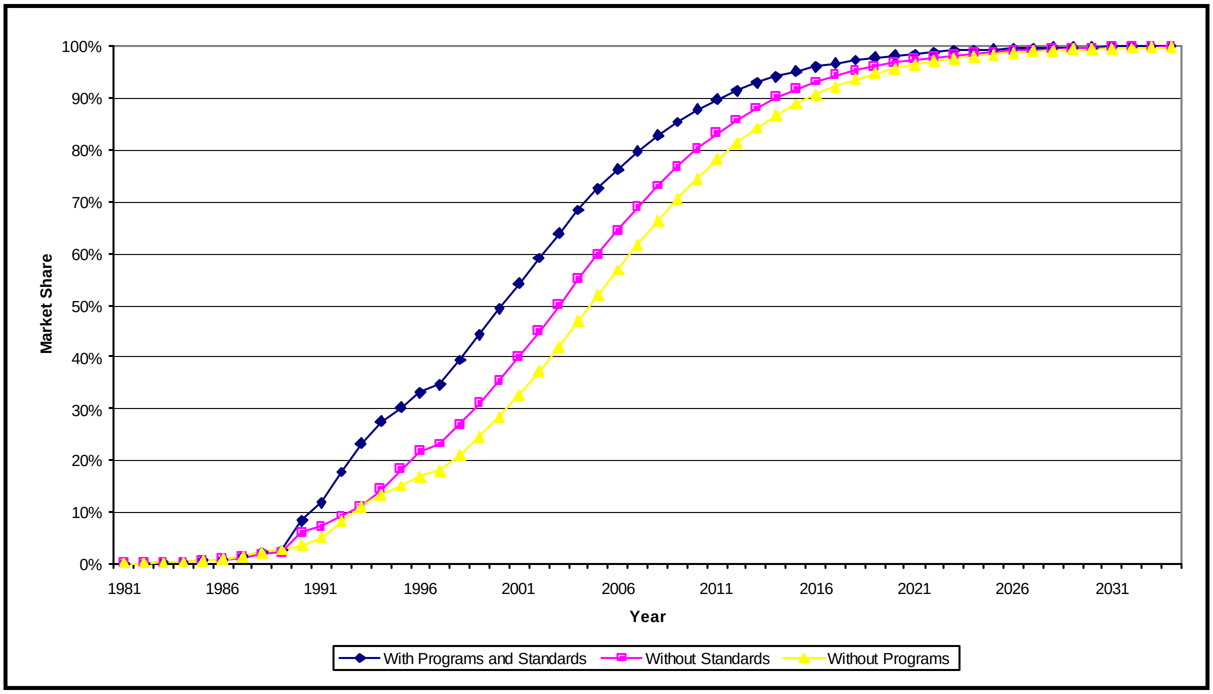
Table 5-5: Market Share Model Estimation Results

Dependent variable: Market Share	
Independent Variables:	**Estimated Coefficient (t-value)**
Constant	-2.253 (-0.75)
Time since ballasts first available (T_t)	0.199 (3.48)
DSM expenditures (DSM_t)	2.42e-7 (3.00)
Unit Cost of Ballasts (BP_t)	2.57e-2 (1.22)
Price of Electricity (EP_t)	-0.514 (-1.78)
1990 Federal Standards (FS_t)	0.89 (4.43)
R-squared F(5,7)	99.3% 324.4

The coefficient on the time since introduction of the electronic ballasts shows that as time increases, market share increases. This is also true for DSM program expenditures. The coefficients on the unit cost of the ballasts and the price of electricity both have wrong signs, with the coefficient on the electricity price variable being statistically significant.

As was the case for the diffusion model, these results can be used to forecast the adoption of electronic ballasts over time in the form of market share. They also can be used to estimate the effect of changing or eliminating DSM programs and the 1990 federal standards. Figure 5-5 presents these results. Notice that the curve is not as "smooth" over time as the diffusion model. This is a result of the feature of market share models where the time-path is not inherent within the model, but is simply an explanatory variable. Consequently, the time-path can be expected to be "lumpy" because the time-path of the other (i.e., non-time) explanatory variables may not be smooth.

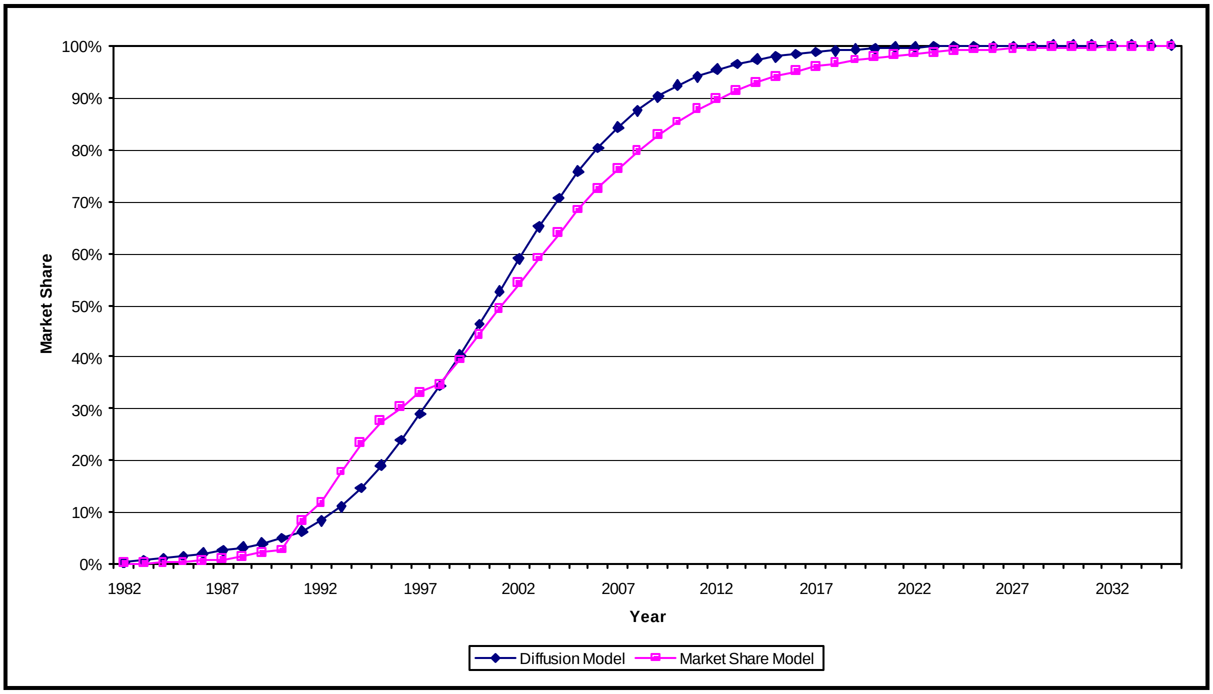
Figure 5-5: Market Share Forecast



The obvious question is which approach is appropriate for forecasting the penetration of new energy efficient technology. In one sense, there is no difference between the two approaches. The diffusion model essentially investigates the time-path of cumulative sales while the market share model investigates the time-path of market share. One can readily go from one to the other if there is information on sales of all types of the technology as well as their decay and replacements. For the fluorescent ballast market, the market has existed long enough to assume a steady state (i.e., decay and replacements of the older technologies are constant over time, and the total shipments is fairly constant at 1,000,000 units per year). Thus, market share can be obtained easily from the cumulative penetration. Figure 5-6 shows the forecasted market share from the diffusion model compared to the market share model. Here, the diffusion model predicts electronic ballasts capturing market share slightly faster than the market share model and produces a smoother time-path.[4] For this type of market, the diffusion model may be more useful since the time-path is implicit in the model and is less sensitive to the uneven time-path of the explanatory variables.

4 Note that these models assume that electronic ballasts will eventually capture the entire market. If this is not to be the case, the 100% market share can be simply interpreted as 100% of the possible market share and the models adjusted accordingly.

Figure 5-6: Comparisons of Market Share Forecasts

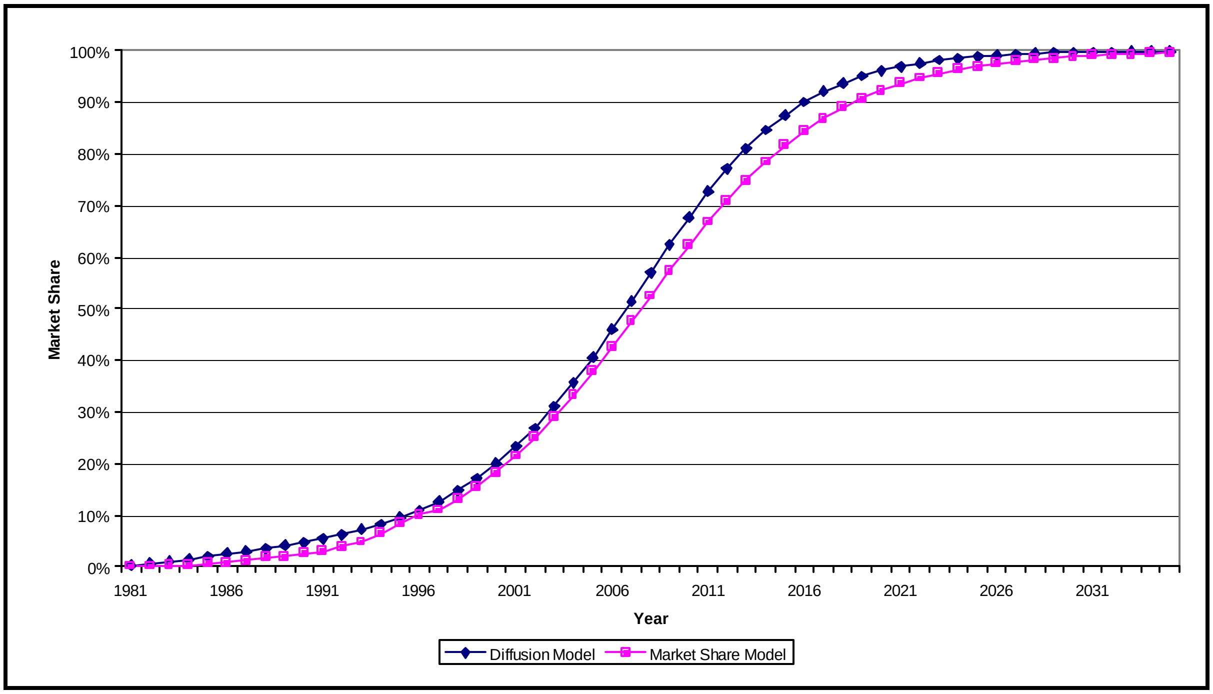


If the decay/replacement rate is not known, it may be more difficult to convert from penetration to market share. In such a case, the market share model may be preferred since it directly models market share.

Forecasting Emerging Technology Baseline

To apply the results of this modeling to forecasting penetration of emerging technology, it is necessary to develop the forecast of the baseline market share (i.e., the diffusion path associated with no DSM programs and no federal standards). As described above, this involves setting the DSM program expenditures and federal standard variables to zero and using the estimated parameters to forecast the market share over time. Figure 5-7 presents this baseline market share forecast using both the diffusion approach and the market share approach. This curve can be tuned to a particular technology by adjusting the technical potential and the forecasted prices (both unit and electricity).

Figure 5-7: Forecasted Baseline Market Share



As stated previously, either an *ex ante* or *ex post* analysis can be conducted to determine the impact of a market transformation initiative. In an *ex ante* analysis, the estimated coefficient on DSM expenditures can be used to forecast how the market share curve will look with the planned program expenditures. This approach assumes that a dollar spent by the market transformation program on the emerging technology will have the same effect as did a dollar spent by DSM programs on electronic ballasts. In an *ex post* analysis, conducted after implementation, the observed market share for the emerging technology at a given time is compared to the *ex ante* baseline forecast presented in Figure 5-7**.**

5.5 Conclusions

This phase of the study identified and evaluated alternative methodologies to forecast *ex ante* baseline market shares for emerging energy efficient technologies. Such as forecast will aid in the assessment of market transformation initiatives. The approaches reviewed include judgment, simple modeling by analogy, consumer research, diffusion, adoption process, and market share models. While the most appropriate approach for determining baseline shares was found to be modeling by analogy with diffusion or market share models, all models suffered from significant drawbacks. The use of any type of market penetration model to determine *ex ante* impacts from market transformation programs is a relatively uncharted research area. This, combined with the inherently unknowable nature of the market performance of emerging technologies even without market transformation programs, implies that all approaches involve some type of compromise.

In developing the demonstration of the recommended forecasting methods, the ability to obtain meaningful data was a major constraint in the development of meaningful market penetration models. There is an insufficient amount of publicly available sales or market share data. For those rare cases where data exist, the level of aggregation is such that one cannot have a particularly high level of confidence in the modeling results.

There are several implications of this data limitation. First, one energy efficient technology might need to serve as the analogous technology for several diverse emerging technologies, some of which may have little in common with the existing technology. For example, the most appropriate analogous technology for an ultra-efficient refrigerator may be the market penetration of energy efficient refrigerators. However, if no data are available on the market penetration of these refrigerators, one must use the penetration path of other much less closely related technologies.

Second, the ability to validate a model is also severely limited by the lack of data. For example, one test of the diffusion model' s ability to forecast market penetration is to estimate the model for a mature energy efficient technology. Those results are then used to forecast penetration of an existing, though less mature, technology. One can then check the accuracy of the forecast by comparing it to the actual market penetration data. However, since data are not typically available on the emerging technology, this comparison is not possible.

Third, even if sales data are available, there may be no information on other key variables such as program expenditures. In the electronic ballast models estimated above, data could not be obtained on program expenditures specific to lighting/ballasts. Therefore, we were forced to use total DSM expenditures. While this assumption seems reasonable given the estimation results, it may not be for other technologies.

Finally, even for cases such as electronic ballasts, the lack of extensive cross-sectional data (i.e., sales by region) and short time periods significantly reduces the sample size. This reduces the flexibility of the model. For example, in the case of the models presented above, the limited sample size prevents market size from being a parameter in the model, or the modeling of unit price as a function of program expenditures and market scale.

Therefore, it is not possible at this point to develop a library of market share curves of energy efficiency technologies to apply to emerging technologies. However, there is potential for doing this in the future. Transaction data from ENERGY STAR® appears to hold much promise for penetration modeling of energy efficiency appliances such as compact fluorescent fixtures and lamps, clothes washers, refrigerators, dishwashers, central air conditioning equipment, residential windows, and gas furnaces. However, sine the data only go back to 1998, the time series dimension of the data is small (but the cross-sectional dimension is quite large). This drawback will of course diminish over time. Further, data is only being collected from ENERGY STAR® participating dealers, which means it will be impossible to control for the bias introduced by the ENERGY STAR® program.

Even without these problems, ENERGY STAR® data will not completely resolve all the data issues. In addition to sales data, these models also require information on program activity focused on the technology and the market conditions relating to the market for the technology (e.g., energy prices, prices of competing goods, etc.). These data must be collected both over time and over each cross-sectional unit. For example, in trying to model the penetration of a technology in California, Washington, and Oregon, one would need not only the sales of the technology over time in these areas, but also the time series of program activity and market conditions for these areas. Development of this type of database will be expensive.

For those technologies not covered by ENERGY STAR® data, there are little sales data aside from those collected by the Census Bureau. Manufacturers and their trade groups (such as the National Electrical Manufacturers Association) have these types of data. However, they are very reticent about sharing this data with anyone. EPRI attempted to obtain some data from NEMA as part of their National Sales Tracking report, but was unsuccessful. Obtaining sales data from manufacturers would go a long way towards minimizing data issues.

In conclusion, the current availability of data does not allow us to meaningfully develop, validate, and apply market penetration models. However, by building upon the work performed by ENERGY STAR® and working with manufacturers, it may be possible to develop a database in the near future that will allow for meaningful model development. Until then, the models presented in this report represent perhaps the best available estimate of the market penetration of energy efficient technologies.

6

Summary and Conclusions

6.1 Project Overview

The primary purpose of this study is to develop and recommend strategies for tracking the market shares of key "near term" emerging technologies and services in California. In addition, RER investigated alternatives for forecasting the market penetration of emerging efficiency measures. This study was comprised of four primary components:

- A Needs Assessment to identify priority emerging technologies and services for which tracking systems should be developed,
- A Market Assessment to determine all possible points in the marketplace at which data for market share tracking could be obtained for each priority measure,
- A Feasibility Assessment to determine if a measure could be incorporated into an existing market share tracking effort, and to formulate new tracking initiatives for those that could not, and
- A Market Penetration Forecasting Evaluation and Demonstration.

The Needs Assessment resulting in the identification of 12 priority measures for which market share tracking initiatives should be developed. As shown in Table 6-1, these measures cover a variety of end uses in the residential and nonresidential sectors. RER utilized information obtained from interviews with engineers, research organizations, and utility staff in addition to results from recently completed evaluations of emerging technologies for market transformation initiatives to identify the priority measures.

Table 6-1: High-Priority "Near-term" Emerging Technologies and Services for Market Share Tracking

High Priority Measure	Sector	End Use	Decision Type
Indirect-direct evaporative coolers	Res, Nonres	HVAC	NC, ROB
Evaporative condenser air conditioning	Res, Nonres	HVAC	NC, ROB
Aerosol duct sealing	Res, Nonres	HVAC	NC, Retro
Integrated new home design	Res	-	NC
Dedicated CFL floor and table lamps	Res, Nonres	Lighting	NA, ROB
High efficiency vertical axis clothes washers	Res	Appliance	NA, ROB
Electrodeless (induction) lamps	Nonres	Lighting	NC, Retro
Integrated lighting fixtures and controls	Nonres	Lighting	NC, Retro
Building commissioning and retro-commissioning	Nonres	-	NC, Retro
Integrated commercial building design	Nonres	-	NC
Supermarket refrigeration optimization	Nonres	Refrig.	NC, Retro
Advanced metering technologies	Nonres	-	-

Res and Nonres denote residential and nonresidential sectors, respectively.
NC, NA, ROB, and Retro denote new construction, net acquisition, replace-on-burnout, and retrofit decisions, respectively.

The next step required investigating the markets of the priority measures to identify all possible point(s) in the distribution channels where it makes the most sense to obtain the data required for market share tracking. This exercise also helped RER determine which priority measures could be readily incorporated into existing or recommended market share tracking efforts. This was, in fact, the case for nine of the 12 measures. In particular, the measure characteristics and/or distribution channels of these emerging technologies and services were similar enough to measures covered by the initial study that they could be incorporated at a very low marginal cost and without significantly altering the market share tracking effort.

In the final phase of the study, RER developed new market tracking initiatives for the remaining three priority measures that could not be tracking with methods already in development. Because of their uniqueness in terms of delivery channels and/or overall characteristics, the review of markets revealed only on realistic alternative for obtaining data for tracking the market shares of these measures.

Another substantial component to this study was the identification and evaluation of methods for forecasting the market penetration of emerging technologies and services. While several methods were considered, most could not account for the spread of a new technology over time into the marketplace. Furthermore, most methods do not allow for the control of program effects – an essential component for the intended use with respect to market transformation evaluation.

RER determined that the most appropriate approach for developing baseline market penetration forecasts of emerging technologies and services is the analogical diffusion and market share model approaches. Recommendations are summarized below.

6.1 Summary of Recommendations

Tracking Market Shares of Emerging Technologies and Services

Table 6-2 summarizes RER’ s recommendations for tracking the market shares of the priority emerging technologies and services. Initiatives I through VI were recommended initiatives for tracking existing efficiency measures covered by the initial study. As shown, nine of the 12 emerging technologies and services can be incorporated into those initiatives with relative ease and for a minimal cost. RER formulated the remaining initiatives – VIII through X – to track the market shares of the remaining three measures. Because these measures were fairly unique, these methods are essentially the only realistic data collection alternatives.

RER strongly encourages the coordination of other MA&E efforts, particularly with respect to Initiatives IX and X, which require surveys of residential builders and commercial building designers. There will undoubtedly be other statewide evaluation plans that require surveys of these market actors. As with all other initiatives, coordinating market share tracking with other data collection efforts will prevent the unnecessary duplication of efforts, allow funds to be shifted to other more productive uses, and will prevent critical market actors from being inundated with telephone and mail surveys by evaluators.

Market Penetration Forecasting Method Evaluation and Demonstration

The primary goal of this phase of the study was to identify, evaluate, and demonstrate alternative methodologies for forecasting the baseline market shares of emerging technologies. The use of market penetration analysis on emerging energy efficient technologies and services to evaluate the success of market transformation initiatives is a relatively new and underdeveloped area. For measures with well established markets, assessing the success of market transformation programs is accomplished by comparing the actual market penetration of the emerging efficiency measures with market transformation programs to estimates of what the market penetration of these technologies would be without the market transformation initiatives (i.e., the hypothetical baseline conditions). However, baseline data does not exist for emerging technologies and services; thus, baseline conditions cannot be directly measured and can only be estimated through modeling.

The results of RER' s analysis are not particularly encouraging. While all of the methods reviewed could, in principle, be implemented to estimate baseline market shares, each has serious drawbacks under current conditions. These are likely to diminish as efforts to track market shares of energy efficient technologies are well underway.

While the most appropriate approach for determining baseline shares was found to be modeling by analogy with diffusion or market share models, all models suffered from significant drawbacks. Variants of diffusion modeling and market share analysis, in particular, are severely handicapped by the lack of data on analogous existing mature technologies.

In developing the demonstration of the recommended forecasting methods, the ability to obtain meaningful data was a major constraint in the development of meaningful market penetration models. Some implications of this data limitation include the following:

- One energy efficient technology might need to serve as the analogous technology for several diverse emerging technologies, some of which may have little in common with the existing technology.
- The ability to validate a model is also severely limited.
- In addition to sales data, information on program activity focused on the technology and the market conditions relating to its market is required (e.g., program expenditures energy prices, prices of competing goods, etc.). These data must be collected both over time and over each cross-sectional unit.
- The lack of extensive cross-sectional data (i.e., sales by region) and short time periods significantly reduces the sample size and in turn, the flexibility of the model.

In essence, the current availability of data does not allow us to meaningfully develop, validate, and apply market penetration models. Modeling market shares of emerging technologies (or for that matter, mature technologies) will require serious, long-term market share tracking efforts.

Table 6-2: Summary of Market Share Tracking Recommendations

Tracking Initiative	Measure Coverage	Primary Activity	Estimated Cost
I. Residential New Construction Tracking *(In Development)*	• Evap. condenser air conditioning • Indirect-direct evap. coolers • High-efficiency vertical-axis clothes washers • Aerosol-based duct sealing (secondary only)	On-site surveys of residential new construction buildings and possibly building department data.	Minimal.
III. Distributor Sales Data Collection *(In Development)*	• Evap. condenser air conditioning • Indirect-direct evap. coolers	Obtain sales data from HVAC and water heating equipment distributors.	Minimal.
IV. Retail Sales Data Collection *(In Development)*	• High-efficiency vertical-axis clothes washers • Dedicated CFL floor & table lamps	Coordinate with ENERGY STAR® and other retailers to obtain retail sales data.	Minimal.
V. Nonresidential New Construction Tracking *(Recommended)*	• Dedicated CFL floor & table lamps • Electrodeless (induction) lamps • Integrated lighting fixtures & controls • Building commissioning	On-site surveys of commercial new construction buildings.	\$25 to \$50 additional per on-site survey.
VI. Nonresidential Existing Building Tracking *(Recommended)*	• Dedicated CFL floor & table lamps • Electrodeless (induction) lamps • Integrated lighting fixtures & controls • Building retro-commissioning • Supermarket refrigeration optimization • Advanced metering technologies	On-site surveys of existing commercial buildings and a telephone survey of existing commercial and industrial sites.	\$25 to \$50 additional per on-site survey. Minimal additional cost of for telephone survey.
VIII. Obtain Records from Aeroseal, Inc. *(New)*	• Aerosol-based duct sealing		\$13,000 to \$34,000
IX. Survey Residential Builders *(New)*	• Integrated new home design	Telephone survey of residential new construction builders to characterize standard design practices.	\$89,000 to \$137,000 (first year costs)
X. Survey Commercial Building Design Professionals *(New)*	• Integrated commercial building design	Telephone survey of commercial building design professionals to characterize standard design practices.	\$109,000 to \$167,000 (first year costs)

6.2 Unique Issues Associated with Tracking Emerging Technologies and Services

For several reasons, emerging technologies are unique with respect to market share tracking. The fact that many emerging efficiency measures have undeveloped markets and/or because they are practices and services rather than "widgets" poses particular challenges for market share tracking. Recognizing these factors in developing a market share tracking system will undoubtedly enhance the information gleaned from tracking efforts. Such factors and issues identified throughout the course of this project include the following:

- Tracking emerging technologies is a dynamic process,
- Monitoring secondary indicators of market development and penetration could be very valuable,
- Many emerging efficiency measures are services and practices that pose a challenge, and
- It is important to recognize program design features that might influence market behavior and in turn, market share tracking data collection alternatives.

Each of these issues is discussed briefly below.

Identifying and Tracking Emerging Technologies is a Dynamic Process

It is important to recognize that market share tracking of emerging technologies is a dynamic process in the sense that new or improved efficiency measures are always on the horizon of being commercially available. To the extent that market share tracking will be an ongoing effort to evaluate market transformation initiatives, near-term emerging technologies will need to be periodically identified and incorporated into existing tracking initiatives.

Monitoring Secondary Indicators of Market Development and Penetration

In addition to the market share of an emerging technology or service, there are several secondary indicators that could be monitored to infer the extent of market development and penetration. Examples of these indicators include, but are not limited to:

- The number of manufacturers producing the product,
- The number of firms offering the service as its primary business,
- The number of firms that have adopted the practice as a standard business practice,
- The number of competing products available in the marketplace,
- The number of distributors and/or retailers that stock the product on a regular basis, and
- The level of development of the distribution channel.

Issues Associated with Tracking Emerging Efficiency Practices and Services

Unlike the priority measures covered by the initial study, many of the emerging efficiency measures covered here represent a practice or service rather than a "widget" having a traditional distribution channel. While this is not surprising, energy efficiency practices and services pose particular challenges with respect to market share tracking. For review, these issues are presented below.

- ***Defining a market share of the measure.*** Defining a market share of a practice or service is difficult for several reasons. As explained previously, the general market share formulae for this type of measure would be the proportion of actual applications of all feasible applications. The primary difficulty is defining measuring all feasible applications. In the absence of the denominator of the equation, it will not be possible to track the market share of the measure relative to other alternatives. Rather, it will only be feasible to monitor the number of applications in absolute terms.

- ***Operationalize measure definition and develop criteria to affirm adoption of practice.*** By definition, emerging efficiency services and practices have relatively undeveloped markets. As such, consistent, operational definitions have not yet been developed and/or universally accepted in the industry. As efforts to promote such services and behaviors increases, the need for a more concrete measure definition and criteria to affirm adoption of the measure also increases. This has been the case with building commissioning and retro-commissioning. National and regional efforts to promote commissioning practices have resulted in the development of metrics or key elements that distinguish commissioning from standard maintenance practices.

  A first, crucial step to developing market share tracking strategies for behaviors, practices, and services is the development of a standard measure definition and criteria to affirm its adoption. RER recommends that metrics for market share tracking in California be consistent with those developed in other regions or by other organizations promoting the measure(s).

- ***Records of standard practices do not generally exist.*** Records useful for the purposes of tracking the market shares of equipment and efficiency products are primarily inventory or sales records, and/or building department records of the equipment installation. Records can also be created during an on-site visual inspection of installed equipment and products. Unfortunately, such records are generally not available for practices or behaviors. This substantially limits the number of feasible alternatives for market share tracking. For example, building design approaches are not recorded by building department inspectors, nor can they be observed during an on-site visit. In general, the level of adoption of certain behaviors and practices can only be ascertained by surveying the market actors that could adopt the practice.

Recognize Market Transformation Program Design

Insofar as the ultimate goal of market share tracking is to evaluate the success of market transformation programs in the State, it is important to be aware of and consider program design features when developing market share tracking. For example, California's statewide Residential Contractor program allows lighting contractors to purchase equipment directly from distributors (particularly CFL fixtures). Thus, relying solely on retail data for market share tracking will exclude a crucial portion of the market if data is not collected from lighting contractors or distributors.

Appendix A

Bibliography

Adelman, L., and J. Mumpower. "The Analysis of Expert Judgment." *Technological Forecasting and Social Change* 15:191-204. 1979.

Akbari, H., L. Gartland, and S. Konopacki. "Measured Energy Savings of Light-colored Roofs: Results from Three California Demonstration Sites." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

American Council for an Energy-Efficient Economy, Davis Energy Group, and E-Source. *Emerging Energy-Saving Technologies and Practices for the Buildings Sector.* December 1998.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, In. *1995 ASHRAE Handbook. Heating, Ventilating, and Air-Conditioning Applications.* Atlanta, GA. 1995.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, In. *1996 ASHRAE Handbook. Heating, Ventilating, and Air-Conditioning Systems and Equipment.* Atlanta, GA. 1996.

Armstrong, S.J. *Long-Range Forecasting: From Crystal Ball to Computer.* Wiley-Interscience, New York, NY. 1978.

Assmus, G. "New Product Forecasting." *Journal of Forecasting* 3:121-138. 1984.

Baccus, Rocky. Refrigeration Technologies, Inc. Personal Communication, July 14, 1999.

Bass, F.M. "A New Product Growth Model for Consumer Durables." *Management Science* 15:215-227. 1969.

Bernhardt, I., and K.D. Mackenzie. "Some Problems in Using Diffusion Models for New Products." *Management Science* 19:187-200. 1972.

Berry, L. *The Market Penetration of Energy-Efficiency Programs.* ORNL/CON-299. Prepared for the Bonneville Power Administration. 1990.

Bevukacqua-Knight, Inc. *CPUC Milestone Report. Non-Residential Emerging Technologies.* Prepared for Pacific Gas & Electric. 1998.

Blackman, A.W., Jr. "The Market Dynamics of Technological Substitutions." *Technological Forecasting and Social Change* 6:41-63. 1974.

Bolt, G.J. *Market and Sales Forecasting-A Total Approach.* John Wiley, New York, NY. 1972.

Brady, R.C., and C. Dasher. "Building Commissioning as an Insurance Loss Prevention Strategy." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Brodie, R., and C.A. de Kluyver. "Attraction versus Linear and Multiplicative Market Share Models: An Empirical Evaluation." *Journal of Marketing Research* , 21:194-201. 1984.

Brown, L.A. *Innovation Diffusion: A New Perspective.* Methuen, Inc. New York, NY. 1981.

Brown, M.A. "Change Mechanisms in the Diffusion of Residential Energy Conservation Practices: An Empirical Study." *Technological Forecasting and Social Change* 25:123-138. 1984.

Cabone, R., and W.L. Gorr, 1985. "Accuracy of Judgmental Forecasting of Time Series." *Decision Sciences* 16:153-164. 1985.

California Energy Commission, California Conservation Inventory Group. *Emerging Technolgies to Improve Energy Efficiency in the Residential and Commercial Sectors.* Prepared by the American Council for an Energy-efficient Economy, the Davis Energy Group, and E-Source. 1993.

California Energy Commission. *1996 Energy Technology Status Report – Report Summary*. P500-96-006. California Energy Commission. Sacramento, CA. 1997.

California Energy Commission. 1998 Annual Report Concerning the Public Interest Resesearch Program. Sacramento, CA. 1999.

Case, M.E., and J. Wingerden. "Incentive Program for the Energy Efficient Design of State Buildings." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Cattin, P., and R.R. Wittink. "Commercial Use of Conjoint Analysis: A Survey." *Journal of Marketing* 46:44-53. 1982.

Chapp, T., M. Voss, and C. Stephens. "Waking the Sleeping Giant: Introducing New Heat Exchanger Technology into the Residential Air-Conditioning Marketplace." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Cooper, L.G., and M. Nakanishi. *Market-Share Analysis.* Kluwer Academic Publishers, Boston MA. 1988.

Daniel, Mann, Johnson, & Mendenhall. *Super Efficient (Horizontal Axis) Coin-Operated Clothes Washers Implementation Plan.* Prepared for Pacific Gas & Electric Company. 1999.

Daniel, Mann, Johnson, & Mendenhall. *Technical Assessment of Residential and Small Commercial Emerging Technologies.* Prepared for Pacific Gas and Electric Company. 1998.

Darley, J.M. "Energy Conservation Techniques and Innovations, and their Diffusions." *Energy and Buildings* 1:339-343. 1977.

Darley, J.M., and J.R. Beniger. "Diffusion of Energy-Conserving Innovations." *Journal of Social Issues* 37:150-171. 1981.

Dixon, R. "Hybrid Corn Revisited." *Econometrica* 48:1451-1465. 1980.

Dodds, D., C. Dasher, and M. Brenneke. "Building Commissioning: Maps, Gaps & Directions." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* Washington, DC. 1998.

Dodson, J.A., Jr., and E. Muller. "Models of new Product Diffusion through Advertising and Word-of-Mouth." *Management Science* 15:1568-1578. 1978.

Energy Information Administration (EIA). "*Annual Electric Utility Report*." Form EIA-861. 1986-1998.

Eskin, G.J. "Dynamic Forecasts of New Product Demand Using a Depth of Repeat Model." *Journal of Marketing Research* 10:115-129. 1973.

E-Source. "How Far Have We Come? Remaining Opportunities for Upgrading Fluorescent Ballasts and Lamps." SM-98-4. 1998.

Felts, D., and D.A. Jump. "Energy Savings from Indirect Evaporative Pre-Cooling: Control Strategies and Commissioning." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Fourt, Louis A. and Joseph W. Woodlock. "Early Prediction of Market Success for New Grocery Products." *Journal of Marketing* 25:31-38. 1960.

Grover, S. "Market Penetration: How to Predict the Future." ACEEE Proceedings. Summer 1998.

Hageman, Robert. Aeroseal, Inc. Personal Communication, July 22, 1999.

Hanssens, D.M., L.J. Parsons, and R.L. Schultz. *Market Response Models: Econometric and Time Series Analysis.* Kluwer Academic Publishers, Boston MA. 1990.

Hassl, T., and D. Dodds. "O&M Best Practices for Energy-Efficient Buildings." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Heeler, Roger M. and Thomas Hustad. "Problems in Prediction New Product Growth for Consumer Durables." *Management Science* 26:1007-1020. 1980.

Hoeschele, M.A., M.J. Berman, L.E. Eberling, and M.B. Hunt. "Evaporative Condensers: The Next Generation in Residential Air Conditioning?" *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Horsky, Dan and Leonard S. Simon. "Advertising and the Diffusion of New Products." *Marketing Science* 2:1-17. 1983.

Islam, T., and N. Meade. "The Diffusion of Successive Generations of a Technology: A More General Model." *Technological Forecasting and Social Change* 56:46-90. 1997.

Juster, F.T. "Consumer Buying Intentions and Purchase Probability: An Experiment in Survey Design." *American Statistical Association Journal* 61:658-696. 1966.

Kalish, S. "A New Product Adoption Model with Price, Advertising, and Uncertainty." *Management Science* 31:1569-1585. 1985.

Koomey, Jonathan G., Alan H. Sanstad, and Leslie J. Shown. "Magnetic Fluorescent Ballasts: Market Data, Market Imperfections, and Policy Success." Lawrence Berkely National Laboratory. LBL-37702. Berkeley, CA. 1995.

Krepchin, Ira and Ned Nisson. *Energy-Efficient HVAC Systems*. Cutter Information Corp., Arlington MA. 1996.

Kumar, V. "Forecasting Performance of Market Share Models: An Assessment, Additional Insights, and Guidelines." *International Journal of Forecasting* 10:295-312. 1994.

Lawrence, K.D., and W.H. Lawton. "Applications of Diffusion Models: Some Empirical Results," in Y. Wind, V. Mahajan, and R. Cardozo, (Eds). *New Product Forecasting*. Lexington Books. Lexington, MA., pp. 529-541. 1981.

Leeflang, P.S., and J.C. Reuyl. "On the Predictive Power of Market Share Attraction Models." *Journal of Marketing Research*, 21:211-215. 1984.

Lilien, G., and P. Kotler. *Marketing Decision Making: A Model-Building Approach.* Harper and Row, New York, NY. 1983.

Linstone, H., and M. Turoff. *The Delphi Method: Techniques and Applications*. Addison-Wesley, Reading MA. 1975.

Mahajan, V. and E. Muller. "Innovation Diffusion and new Product Growth Models in Marketing." *Journal of Marketing*. 43:56-68. 1979.

Mahajan, V. and E. Muller. "Timing, Diffusion, and Substitution of Successive Generations of Technological Innovations: The IBM Mainframe Case." *Technological Forecasting and Social Change*. 51:109-132. 1996.

Mahajan, V., E. Muller, and F.M. Bass. "New Product Diffusion Models in Marketing: A Review and Directions for Research." *Journal of Marketing*. 54:1-26. 1990.

Mahajan, V. and R.A. Peterson. "Innovation Diffusion in a Dynamic Potential Adopter Population." *Management Science.* 15:1589-1597. 1978.

Mahajan, V. and R.A. Peterson. "First-Purchase Diffusion Models of New-Product Acceptance." *Technological Forecasting and Social Change* 15:127-146. 1979.

Mahajan, V. and R.A. Peterson. *Models for Innovation Diffusion.* Sage University Paper Series on Quantitative Applications in the Social Sciences. 07-048. Sage Publications. Beverly Hills, CA. 1985.

Mahajan V. and Yoram Wind, eds. *Innovation Diffusion Models of New Product Acceptance*. Ballinger Publishing Company. Cambridge, MA. 1986.

Mansfield, E. "Technical Change and the Rate of Imitation." *Econometrica*, 29: 741-766. 1961.

Midgey, D.F. *Innovation and New Product Marketing.* John Wiley & Sons. New York, NY. 1977.

Northwest Energy Efficiency Alliance. *Building Commissioning Practices in New Construction and Existing Building Markets in the Pacific Northwest.* Prepared by SBW Consulting, Inc. October 1998.

Northwest Energy Efficiency Alliance. *Enhanced Baseline Assessment of Public Building Commissioning in the Pacific Northwest* Prepared by Quantum Consulting, Inc. July 1999.

National Lightng Product Information Project. *Specifier Reports: Electonic Ballasts*. 1997.

Norton, J.A., and F.M. Bass. "A Diffusion Theory Model of Adoption and Substitution for Successive Generations of High-Technology Products." *Management Science* 33:1069-1086. 1987.

Parker, P.M. "Aggregate Diffusion Forecasting Models in Marketing: A Critical Review." *International Journal of Forecasting* 10:353-380. 1994.

Parsons, L.J., and R.L. Schultz. "Forecasting Market Response." *International Journal of Forecasting* 10:181-189. 1994.

Parsons, L.J., and R.L. Schultz. *Marketing Models and Econometric Research.* North-Holland, New York, NY. 1976.

PECI. *Commissioning for Better Buildings in Oregon.* Prepared for the Oregon Office of Energy. (No date provided.)

Pacific Gas & Electric (PG&E). *SmartEnergy Equipment Guides.* Web page at http:www.pge.com/customer_services/business/energy/smart/index.html. 1999.

Philipson L.L. "Market Penetration Models for Energy Production Devices and Conservation Techniques." *Technological Forecasting and Social Change* 11:223-236. 1978.

Quantum Consulting, Inc. *Study of Market Effects on the Supermarket Industry.* Prepared for Pacific Gas & Electric Company. Berkeley, CA. 1998.

Reed, John H., Mary O' Drain, and Jim Chace. "Transforming Market Through Education and Information – A Study of the Pacific Energy Center." 1999 International Energy Program Evaluation Conference. August 1999.

Reed, John H. and Nicholas P. Hall. *PG&E Energy Center Market Effects Study*. Prepared for Pacific Gas & Electric Company. May 1998.

Regional Economic Research, Inc. California Energy Commission Public Interest Energy Research Program/Efficiency Division Industrial Sector Focus Groups, Conducted January 1998 through February 1998.

Regional Economic Research, Inc. *Active Solar Cooling Market Assessment Actions Identification.* Prepared for California Energy Commission. San Diego, CA. 1995.

Regional Economic Research, Inc. *Advanced Gas-Fired Combustors Market Assessment Actions Identification.* Prepared for California Energy Commission. San Diego, CA. 1996.

Regional Economic Research, Inc. *Daylighting Market Assessment Actions Identification.* Prepared for California Energy Commission. San Diego, CA. 1996.

Regional Economic Research, Inc. *Efficiency Market Share Needs Assessment and Feasibility Scoping Study.* Prepared for the California Board for Energy Efficiency. May 1999.

Regional Economic Research, Inc. *Ground Source Heat Pump Market Assessment Actions Identification.* Prepared for California Energy Commission. San Diego, CA. 1996.

Regional Economic Research, Inc. *High Performance Wall Systems Market Assessment Actions Identification.* Prepared for California Energy Commission. San Diego, CA. 1996.

Regional Economic Research, Inc. *Passive Solar Heating & Cooling Market Assessment Actions Identification.* Prepared for California Energy Commission. San Diego, CA. 1996.

Regional Economic Research, Inc. *Thermal Energy Storage Market Assessment Actions Identification.* Prepared for California Energy Commission. San Diego, CA. 1996.

Research Triangle Institute. *Market Penetration of New Technologies, Programs, and Services.* EPRI CU-7011. 1991.

Robinson , Bruce and Chet Lakhani. "Dynamic Price Models for New Product Planning." *Journal of Marketing* 21:1113-1122. 1975

Rogers, E.M. *Diffusion of Innovations.* Free Press. New York, NY. 1995.

Rosegger, G. *The Economics of Production & Innovation.* Butterworth Heinemann, Oxford. 1966.

Sachs, H., A.I. Lowenstein, H.I. Henderson, Jr., S.W. Carlson, and J.E. Risser. "Innovative Commercial 'Ground Source' Heat Pump System Sources and Sinks: Engineering and Economics." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Sai-Chew, D., L. Azar, M. Fraser, and C. Montross. "Architectural Conservation Techniques." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Schultz, R.L., and A.A. Zoltners. *Marketing Decision Models*. North Holland. New York, NY. 1981.

Siminovitch, M., E. Page, and D. Driscoll. "Energy Efficient Torchieres: From the Laboratory to the Marketplace." *Proceedings from the 1998 ACEEE Summer Study on Energy Efficiency in Buildings, Proceedings.* ACEEE Electronic Library. American Council for an Energy-Efficient Economy. Washington, DC. 1998.

Stoneman, P. *The Economic Analysis of Technology Policy.* Oxford University Press, New York, NY. 1987.

Suozzo, M. *A Market Transformation Opportunity Assessment for LED Traffic Signals.* The American Council for and Energy-Efficient Economy. April 1998.

Thomas, Robert J. "Estimating Market Growth for New Products: An Analogical Diffusion Model Approach." *Journal of Product Innovation Management* 4:225-237. 1985.

U.S. Department of Commerce, Bureau of the Census. *Current Industrial Reports : Fluorescent Lamp Ballasts.* MQ36C. 1986-1999.

U.S. Department of Energy. *Building Ready Inventions.* Inventions and Innovations Program, Office of Industrial Technologies. (No publication date provided.)

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. *Impacts. Office of Industrial Technologies: Summary of Program Results*. DOE/EE-0184. January 1999.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. *Sensors and Controls Program Plan.* Office of Industrial Technologies. August 1998.

Vorsatz, Diana, Leslie Shown, Jonathan Koomey, Mithra Moezzi, Andrea Denver, and Barbara Atkinson. "Lighting Market Sourcebook for the U.S." Lawrence Berkeley National Laboratory. LBNL-39102. Berkeley, CA. 1997.

Wind, Y. "A Framework for Classifying New-Product Forecasting Models," in Y. Wind, V. Mahajan, and R. Cardozo, (Eds). *New Product Forecasting*. Lexington Books, Lexington, MA., pp. 3-45. 1981.

Wind, Y., V. Mahajan, and R.N. Cardozo (eds). *New Product Forecasting*. Lexington Books, Lexington, MA. 1981.

Wood, L., and J. Mauskopf. "Forecasting Market Potential and Market Penetration of Residential Water Heater Load Control Programs." *Journal of Forecasting* 10:147-163. 1991.

Wright, G., and P. Ayton. *Judgemental Forecasting*. John Wiley and Sons. New York, NY. 1987.

Appendix B

Interview Memorandum

TURNING DATA INTO INFORMATION

(619) 481-0081
FAX (619) 481-7550

Regional Economic Research, Inc.

11236 El Camino Real, Suite A
San Diego, California 92130-2650

MEMORANDUM

Date

To:

From:

Re: Emerging technology efficiency market share scoping study

Thanks for taking time to discuss the scoping study we are conducting for the CBEE. The ultimate objective of this study is to make recommendations to the CBEE on which emerging technologies should be tracked over the next few years and the "best" methods for doing so. In general, the results of tracking efforts will help to evaluate (ratepayer funded) statewide market transformation efforts as well as the success of specific energy efficiency programs.

There are 3 phases to this study: 1) a needs assessment to determine 10 to 15 emerging technologies that will be covered by the remaining phases, 2) a methods assessment to characterize the markets for the identified technologies and identify possible tracking alternatives, and 3) a feasibility assessment to formulate the optimal tracking strategy and associated costs. There is also an additional task in which we investigate and demonstrate methods for forecasting the market penetration of emerging technologies.

We are in the needs assessment phase of this study and need input from technology experts, utilities, and other industry participants to identify the technologies that we should focus on for the remainder of the project. The table below includes the "preliminary list" of priority emerging technologies that I have compiled as a starting point to this process. This list is based upon results of recent ACEEE studies, an earlier study conducted for the CEC, and input received during the initial tracking study on existing measures. I should note the following:

- We are not limiting our scope to equipment but are considering services and practices as well.
- Renewables and self-generation technologies are not in the scope of this study.
- We are also looking at new construction, retrofit, replace-on-burnout, and net acquisition market events for each measure when applicable.
- We are considering measures in all sectors. The preliminary list is probably biased toward measures in the building sector because the ACEEE study covered only those measures.
- The measures on the list may or may not fit into our definition of an emerging technology - we'll need your help to determine this.

- The measures on the list might be existing, but can be considered an emerging technology if they have a new design or feature that represents an improvement from a previous model.

Preliminary List of Priority Emerging Technologies and Practices

Residential	Nonresidential
HVAC and Water Heating	HVAC and Water Heating
Improved efficiency AC compressors	Dual source heat pumps
Improved heat exchangers	Evaporative condenser air conditioning
Indirect-direct evaporative coolers	Improved heat exchangers
Integrated space/H_20 heat	Shell
Modulating furnaces	Blower door assisted infiltration reduction
Residential heat pump water heater	Commercial distribution system air sealing
Dual source heat pumps	Heat reflecting roof coatings
Combined space/water heat: hydronic	Lighting
Combined space/water heat: forced air	Compact fluorescent floor and table lamps
Evaporative condenser air conditioning	Improved fluorescent dimming ballasts
Efficient furnace blower motors	One-lamp fixtures and task lighting
Shell	Sulfur lighting
Blower door assisted infiltration reduction	T-5 fluorescent lamps
Lighting	Metal halide replacements for incandescent
Metal halide replacements for incandescents	Integrated lighting fixtures and controls
Compact fluorescent floor and table lamps	Other
Other	Integrated commercial building design
Integrated new home design	LED traffic lights (3-color retrofit)
Improved efficiency refrigeration compressors	Commissioning existing commercial buildings
Appliances	Switched reluctance drives
High efficiency vertical-axis clothes washers	
Coin-operated horizontal axis washers	
1 kWh/day refrigerator/freezers	
Adv. clothes washer and dishwasher controls	
Gas storage water heaters	
Clothes dryer: heat pump	
Clothes dryer: microwave	
Clothes dryer: thermostat	
“Low leak” home electronics	

I need your input on the following:

1) Are there any emerging technologies or practices that you feel should be added to this preliminary list of emerging technologies? Why? What emerging technologies and practices will PG&E be promoting?
2) Which technologies do you feel should be tracked over the next few years? Why? (We will need to provide a fairly in-depth rationale for the measures we select.)

To facilitate our discussion, I've provided the definition of an emerging technology we have adopted for this study, and the criteria that we will use to select the final list of technologies. Please keep these in mind when considering the measures that you feel we should cover through the remainder of the project.

Definition of "Emerging Technology"

In the context of this study, an emerging technology is one that:

- Has been demonstrated but is not commercially available, or
- Has only recently been commercially available.

Criteria for Choosing "Finalists"

Based upon the following, which technologies should we choose as the finalists? Why or why not? (e.g., what are the characteristics of each measure that led you to choose it or not choose it as a finalist?

1. Which emerging energy efficiency technologies and services are likely to have the highest cost-effective saving potential?
2. Which emerging energy efficiency technologies and services are likely to be subject to the most extensive marketing efforts (such as coverage by utility programs or promotion by other entities) over the next few years?
3. For which emerging energy efficiency technologies and services are market barriers likely to be most severe?
4. Which barriers are likely to be most susceptible to mitigation through market intervention?

Thanks again for your time. I'll look forward to discussing this with you soon.

Appendix C

In-Depth Interview Guide

C.1 Introduce the Study and Identify Appropriate Respondent

The following is a general outline of the approach that will be used to recruit and screen individuals within the identified target organizations. The recruitment and screening process might be accomplished in a single telephone call, but could possibly involve two or more telephone calls to identify the appropriate respondent and to schedule a convenient interview appointment.

Hello, my name is ___________ with Regional Economic Research, Inc. We have been retained by the California Board of Energy Efficiency and Pacific Gas & Electric to conduct a scoping study on tracking the efficiency market shares of key energy efficiency measures in California. Market share tracking will ultimately be used to assess the success of market transformation initiatives. RER recently completed a study that covered existing measures, and is now conducting a similar study that specifically addresses emerging technologies and their role in market transformation programs.

One of the first steps is to identify a set of key emerging technologies for which tracking systems should be developed. We have developed a preliminary list of emerging technologies from results of recent studies on priority emerging technologies for market transformation programs, but need input from a variety of technology experts and other industry participants to narrow the list to roughly 10 to 15 measures.

We are asking for your participation in this study because ___________________________.

Are you the appropriate person with whom I should speak?

☐ Yes ☐ No → *If not appropriate person, obtain contact information:*

Name:	____________	Name:	____________
Title:	____________	Title:	____________
Phone:	____________	Phone:	____________
Email:	____________	Email:	____________
Fax:	____________	Fax:	____________

We would greatly appreciate your participation in this research. Your participation involves in-depth interview during which I will ask you specific questions about emerging technologies we have already identified as potential candidates for tracking. The interview will take about 30 minutes of your time. When would be a good day/time for a telephone interview?

Date/Time: ____________________

I' d like to address a few points now that will facilitate our discussion. First, in the context of this study we are defining emerging technologies as one that has been demonstrated but is not commercially available, or has only recently been commercially available. Second, renewable and self-generation technologies are not covered by this study.

Prior to our conversation, I will fax or email you the preliminary list of priority emerging technologies we have derived from results of recent studies and a brief description of the criteria we will be using to choose the final 10 to 15 measures. Having the list of measures ahead of time will help you prepare for our discussion and give you some time to think about how the measures meet or do not meet our criteria.

The objective of the interview is to get your input as to which of the emerging technologies on the preliminary list should be priorities for tracking. Before our discussion, it would be helpful if you identified 10 or so measures from the list that you feel should covered by the remainder of our study.

The preliminary list of priority emerging technologies and additional information will be e-mailed or faxed to the respondent prior to the scheduled interview.

E-Mail: ____________________

Fax: ____________________

Is there anyone else who you feel should be participate of the interview?

Name:	____________	Name:	____________
Title:	____________	Title:	____________
Phone:	____________	Phone:	____________
Email:	____________	Email:	____________

Thanks, we greatly appreciate your participation. I will [email/fax] the a backround memorandum with the preliminary list of technologies, and other information that will help you prepare for our discussion. If you have any questions before the interview, please feel free to reach anytime me at 1-800-755-9585.

C.2 In-Depth Interview

Introduction and Respondent Background

What is your primary role in the energy efficiency market?

Do you have expertise in a particular end use, sector, or technology?

What activities regarding emerging technologies have you been involved in recently?
i.e., research, development, demonstration, program planning, marketing, etc.

Throughout the remainder of our discussion, please keep our definition of an emerging technology and the four criteria for choosing 10 to 15 final measures in mind.
Interviewer will review these with the respondent if necessary.

Identify Emerging Technologies Not Included in Preliminary List

If respondent is utility staff:

One of the primary reasons for obtaining input from utility staff is to ensure that any emerging technologies covered by utility energy efficiency programs will be considered for this study.

Please list and describe the emerging technologies that will likely be promoted by your organizations.

Should any or all of these technologies be added to our preliminary list of measures?
Interviewer will probe for reasons why or why not the measure should be included in the preliminary list.

- ☐ No → Why not?
  Interviewer will prompt the respondent to explain their logic for not including measures according to the criteria defined for this study.
- ☐ Yes →
  Please specify and describe each measure.
  Can you suggest and information sources for the measure(s)?

From now on, please also consider __*[list measures respondent wanted to add to the list]*__ as measures on the preliminary list.

Go to next interview topic.

If respondent is not utility staff:

Now that you have reviewed the list of emerging technologies and are familiar with our definition of an emerging technology and the criteria we are using to prioritize the measures for tracking, are there any emerging technologies would like to added to the list?

- ☐ No
- ☐ Yes →

Please specify and describe each proposed measure.

Can you suggest and information sources for the measure(s)?

From now on, please also consider ___*[list measures respondent wanted to add to the list]*___ as measures on the preliminary list.

Identify and Discuss 10 to 15 Measures That Should be Priorities for Tracking

As I mentioned earlier, the primary objective of this interview is to identify 10 to 15 measures as priorities for tracking.

After reviewing the list of measures and the criteria we are using to compile a final list of 10 to 15 priorities, which measures have you identified that should be on the final list?

What are your primary reasons for selecting this measure?
(Or, conversely, how did the respondent eliminate the rejected measures?)

How does this measure meet our selection criteria?

Please rank you selected measures, with 1 being the highest rank.

Obtain Additional Information About Selected and Rejected Measures

What distinguishes this emerging technology from existing, commercialized measures?
Probe: Is this an improvement on an existing, commercialized measure? Is this a "brand new" technology?

What is the expected success or failure of this measure?
Probe: What are the preliminary indications of this measure's success/failure? Is it based upon the market penetration of an existing or similar technology?

Can you suggest any sources of information for this measure or other individuals that could provide input for this research?