

ACEEE Emerging Technology Program

Analytical Methods

CRITERIA

By "emerging technology," we mean technologies and practices that are either commercialized but have less than about a 2% market share in the relevant market, or that are not yet commercialized but are likely to be commercialized within five years. For ACEEE's "continuous" annual reporting model launched in 2006, five to seven technologies were selected on the basis of several criteria, including greatest potential savings, a balanced portfolio among gas vs. electricity, new vs. retrofit, and residential vs. commercial; and a diversity of technology types. The final list was determined through a multi-stage ranking and feedback process with program sponsors.

INITIAL SCREENING

In order to develop a list of potential candidate measures meeting the project criteria, we compiled a short list based on the following sources:

- Sponsor Requests
- Lists of emerging technologies developed for previous ACEEE studies
[1993](#) | [1998](#) | [2004](#) |
- Recent conference proceedings and journals
- Measure recommendations from energy research organizations
- Product and research announcement information received at ACEEE

Using our initial list, we polled program sponsors to add or subtract measures according to their interests. With a list of qualifying measures, each sponsor was then asked to rank its top five priorities. Based on this input, ACEEE created a balanced portfolio of measures that addressed the needs of the sponsors and our own screenings of energy savings potential.

ACEEE allows each sponsor to assign a portion of their subscription to screenings or reports by special request. These may be specific to a particular state or region, and may take on a different format.

DETAILED DATA COLLECTION

For each of the measures selected for detailed analysis, over 30 pieces of data were collected, compiled, and calculated in a database. Based on these values, as well as a review of published literature on each measure and telephone conversations with researchers and manufacturers working on the different measures, written descriptions on each measure and their status and prospects were prepared.

Beginning in 2006, tabulated standard variables and written descriptions are combined into the following sections (click to jump to section):

[Section 1: Description](#)

[Section 2: Market Information](#)

[Section 3: Energy Study and Savings Information](#)

[Section 4: Market Success](#)

[Section 5: Next Steps](#)

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Section 1: Description

Definition	A one sentence definition of the emerging technology and practice.
Base case	<p>The specific features characterizing the current or dominant technology to which new measure is being compared.</p> <p>Our units of analysis are specific to each measure, depending on the most appropriate way to analyze it. For new construction and equipment replacement measures, the base case corresponds to typical new construction and equipment replacement practices as of the release date. However, in cases where future improvements in equipment efficiency are known due to finalized or near-finalized building code and equipment efficiency standards, we use the new standards to determine the base case.</p>
New Measure	The specific features of the new measure, as compared to the basecase, that are most relevant to our energy use and cost calculations.
Background and Description	Paragraph summary of the technology, history, applications, and potential value.

Section 2: Market Information

Market Sector(s)	Residential, Commercial, Industrial or a combination.
Market Segment(s)	Relevant subsets of the market sector where the measure is applicable (e.g. "offices, schools" in the commercial sector)
Application(s):	<ul style="list-style-type: none"> • New Construction - the construction of a whole building or major renovation/modernization projects. • OEM component - Equipment components (such as appliance motors and power supplies for consumer electronics) that are purchased by manufacturers rather than end-users. • Retrofit - Activity in an existing building except those covered under "replace-on-burnout," including new practices, networking systems, and upgrading functional equipment. • Replace on Burnout - Technology applies only when previous equipment or systems fail. "Long-life" means durable goods and building structures, typically with service life of at least a decade. "Short life" means devices expected to be replaced in about 5 years or less.
End-use(s)	All applicable equipment classes that best describe the new measure's prime functions, including heating, cooling, water heating, household appliances, lighting, electronics, drive components, and controls.
Fuel type(s)	Electricity, Natural Gas, Oil, Renewables, or any combination thereof
National/ Regional	New Measure is feasible on a national or regional basis
Regions	Designates specific regions, if measure is applicable on a regional basis
States	Designates specific states addressed by the study
Current status	<ul style="list-style-type: none"> • Commercialized - Product involving the technology is available on the

	<p>market</p> <ul style="list-style-type: none"> • Field Test - Performance of the technology is currently being evaluated • Prototype - Researchers or manufacturers have developed a prototype • Research - Technology has been conceived by researchers
Estimated date of commercialization	<ul style="list-style-type: none"> • Identifies the date that the product was commercialized or the expected time to market. May be a specific date, approximate date, or a range.
Major Market Players / Manufacturers	Lists major manufacturers of the technology, or research organizations and other associations that are a primary source of expertise on the technology.
Current Promotional Activity	Designates all that apply from a list of standard or common promotional activities. Examples include R&D, demonstrations, testing, education, training, financing, incentives, standards or promotional programs.
Current Status of Measure	Paragraph summary of the measure's market status, promotional activities, recent progress and expectations

Section 3: Energy Study and Savings Information

Base Case Information

Efficiency	Efficiency is a measure of usable energy output divided by energy input. The units of efficiency are specific to each measure's end use category.
Annual energy use (electricity or fuel)	Energy use is calculated for typical operating conditions, which are determined using government documentation ¹
Summer/ Winter Peak Demand	<p>Given in kW, Peak demand gives the estimated power draw during peak hours. It is calculated using loads at the 0.4% design temperatures in ASHRAE 2003, or available load shapes.</p> <p>a. U.S. summer peak (2 pm, very hot summer day in St. Louis) b. U.S. winter peak (6 pm, very cold winter evening in St. Louis)</p>

New Measure Information

Efficiency	Efficiency is a measure of usable energy output divided by energy input. The units of efficiency are identified differently depending on each measure's end use category.
Annual energy use (electricity or fuel)	Energy use is calculated for typical operating conditions, which are determined using government documentation ¹
Summer/ Winter Peak Demand	Given in kW, Peak demand gives the estimated power draw during peak hours. It is calculated using loads at the 0.4% design temperatures in ASHRAE 2003, or available load shapes

¹ [EIA] Energy Information Administration. 2006. Annual Energy Outlook. Residential Energy Consumption Survey. Washington, D.C.: U.S. Department of Energy.

[EIA] Energy Information Administration. 2003. Commercial Buildings Energy Consumption Survey. Washington, D.C.: U.S. Department of Energy.

	a. U.S. summer peak (2pm, very hot summer day in St. Louis) b. U.S. winter peak (6pm, very cold winter evening in St. Louis)
Projected Incremental Cost	The additional retail cost to the consumer of the product relative to base case for a typical unit once the technology is established (e.g., mature market costs), including installation. Costs are in current U.S. dollars. For commercial sector measures, costs are in quantities used in a medium-sized office/retail building; for residential sector measures, costs are in single-unit quantities.
Estimated life (years)	These are service lives in commercial applications.. Available data (e.g., ASHRAE 2003, Chapter A36: "Applications," Table 3) are of limited accuracy, but are often the best available.

Savings Information

Electricity Savings	Annual electricity savings of the new measure is estimated by subtracting New Measure electricity use from Basecase electricity use.
Peak Demand Savings	Summer and Winter Peak Demand Savings are estimated by subtracting New Measure peak demand values from the Basecase peak demand values. For many technologies, there are better energy savings than demand savings data. In some cases, we have used available empirical correlations.
Gas/Fuel Savings	Annual fuel savings of the new measure is estimated by subtracting New Measure fuel use from Basecase fuel use.
Percent Savings	Percent Savings is calculated from electricity and gas/fuel savings. Where a measure affects both electric and fossil fuel use, the percentage reduction in energy use is based on source energy savings using the projected national average heat rate for electricity generation in 2020.
Feasible applications	Feasible applications are the approximate percentage of end-use applications for which the specific technology is likely to be appropriate for the target market. This figure includes both technical and economic feasibility. For most measures, this is done on a national basis. However, for example, if the target market is new construction in the Southeast, "percent feasible" applies to that percent of new construction in the Southeast that is feasible. Any restrictions (e.g., new construction only, limited regional applicability) were made as a coefficient in the calculated 2020 savings potential, not in the "feasible applications" parameter. Feasibility does not take into account the likely commercialization date of the technology nor the rate at which the equipment or building stock turns over.
Industrial savings Potential	A Yes/No variable indicates if savings in the industrial sector are likely to equal or exceed at least 25% of savings in residential and commercial sectors.
Savings Potential in 2020	Savings as Percent of 2020 Building energy use (see discussion below).
Cost of Saved Energy	See discussion below
Other Direct Costs/Savings	Other important costs included in the analysis (e.g., additional or avoided maintenance costs and additional or avoided operating costs such as water, detergent, or use of a secondary energy source). Specifics are included in notes and write-up for technologies and practices affected. This includes demand charge savings where these are significant. For fuel switching measures, the cost of the

	new fuel is included as a cost and the cost of saved energy is calculated in terms of the fuel that is displaced. For periodic costs in the future (e.g., maintenance every five years), costs were annualized, assuming a 4.53% real discount rate (Nadel, 2004).
Summary of Savings Potential and Cost-Effectiveness	Paragraph summary of the energy study data, including other details and analysis.

Savings potential in 2020 Determination

The annual energy savings potential are estimated for on-site electricity consumption (GWh) and source energy (trillion Btu). The estimates assume "base case" values by end use for the United States as determined by the Energy Information Administration's Annual Energy Outlook from the report release year. The approach for estimating energy savings is to compute the product of projected energy use in 2020 for the specific end-use, multiplied by the feasible applications, multiplied by the proportion of the market that could be impacted by 2020. For retrofit measures, this latter figure was assumed to be 100%. For replacement measures (measures that are installed when existing equipment needs to be replaced), this proportion was calculated assuming that sales between one year after the release date and 2020 are affected.

For these calculations, we assumed gradually rising sales, with a 10% penetration rate for applicable markets in 2007, 20% in 2008, etc., rising to 100% in 2016 and continuing at 100% for subsequent years. For measures not yet commercialized, the savings potential only includes sales after the date of commercialization and thus for measures commercialized after 2005, the ramp-up begins in the year of commercialization. For new construction measures, the same approach was used as for replacement measures except that savings estimates include only buildings built in 2005 or thereafter. Thus, the energy savings estimates essentially are for the technical and economic savings potential. Such savings may be achievable for measures with a likelihood of success rating of five (the maximum score) and for which full turnover of the stock will take place by 2020. For measures with a lower likelihood of success, penetration rates will probably be lower, but this difference is captured in the likelihood of success score and not the energy savings score. For measures that save one fuel but use more of another fuel (e.g., gas air conditioning that saves electricity but uses gas), energy savings are expressed in Btu, valuing electricity at 10,010 Btu/kWh. It should be noted that savings often overlap between measures and that savings across measures are frequently not additive. Also, given the many assumptions made in the calculations, these estimates should be viewed as approximate and not absolute. For this reason, national savings estimates will be rounded to the nearest GWh or trillion Btu.

Cost of Saved Energy Determination

Cost of saved energy is calculated for the U.S. in both \$/kWh for saved electricity, and \$/million Btu for saved fuel. The estimates reflect both equipment costs and other direct costs/savings. The cost of saved energy is the levelized cost of a measure over its lifetime per unit of energy saved. It is calculated by assuming each measure is financed with a loan, with a term equal to the measure life and an interest rate equal to the discount rate, and dividing the annual loan payments by the annual energy savings.

These calculations are based on future measure cost estimates and a 4.53% real discount rate (Nadel, 2004), based on an average of utility discount rates used in 2004 DSM filings and plans. For measures that save both electricity and natural gas, we allocated costs proportionately to the two fuels based on the primary energy savings achieved and calculated costs of saved energy separately for electricity and gas. For measures that have annual operating costs or savings besides energy (e.g., reduced or increased maintenance costs), changes in annual maintenance costs were included in the costs calculations. For example, for a measure that increases maintenance costs, costs included in the total were annualized capital

costs and the incremental annual increase in maintenance costs. In some cases, savings in other costs are greater than annualized measure costs and the cost of saved energy is negative. For these measures, the cost of saved energy field is kept at zero, because once a cost of saved energy is negative, the exact value is immaterial and often misleading (for example, if costs are negative, the cost of saved energy declines as energy savings decline). For measures that save one fuel but use more of another fuel, cost of saved energy is calculated for the fuel being saved, but including the annual cost of the other fuel in the cost part of the calculations. For example, to calculate the cost of saved energy of gas air conditioning, costs include annual loan payments on capital costs, annual natural gas costs (valued at EIA projected values for 2020 but expressed in 2006 \$), and incremental annual maintenance costs. As with the energy savings estimates, these figures depend on many assumptions and estimates and are highly approximate. Given the many assumptions made in the calculations, these estimates should be viewed as approximate and not absolute. For this reason, cost of saved energy was rounded to the nearest cent.

Section 4: Market Success

Likelihood of Success Rating	The success rating is a qualitative determination on a scale of 1-5, 5 being assigned to measures with an excellent chance of success. See Discussion below
Rationale	The rationale presents a justification for the success rating selected, according to the criteria explained below.
Non-energy Benefits/ Drawbacks	Examples include “cleans clothes better,” “increases worker productivity,” or “more difficult to maintain,” etc.
Major market barriers	Designates all that apply from a list of standard or common barriers to market penetration. Examples include third-party decision makers, split incentives, high initial costs, and contractors unfamiliar with proper installation practices.
Market Barriers	Discussion of Market Barriers that currently effect or have the potential to effect the success of the new measure in the marketplace.

Likelihood of Success Determination

Success is defined as penetrating at least 50% of feasible applications by 2020. The rating is qualitatively determined for each measure according to the likelihood with which market and technical barriers can be overcome, using the 5-point scale indicated below. Significant non-energy benefits can also offset some of the barriers and improve the likelihood of success, so where these exist, the likelihood of success is increased by 1 point on the 5-point scale. The project team shares its initial estimates with the project Advisory Committee for review and comment in order to reflect a consensus judgment of the people working on the project.

Below are the criteria for each of the five likelihood of success rating levels. In the report, a written rationale follows the assigned rating to justify the selected level.

1	Will be very difficult to succeed; there are multiple major barriers that will be difficult to overcome.
2	Will be hard to succeed; there are major barriers to overcome and while some progress can be made, substantial barriers will likely remain.
3	Moderate chance of success; there are substantial barriers to overcome, some major barriers can be overcome, but others will likely remain.

4	Good chance of success; the barriers appear surmountable but will take require extensive effort and time to overcome.
5	Excellent chance of success; barriers appear to be clearly surmountable.

Section 5: Next Steps

Priority Level	Measures are divided into "high," "medium," "lower," "not a priority" and "special" categories, based on three factors: potential energy savings, cost of saved energy, and likelihood of success. The process for determining these categories is summarized further below.
Recommended Next Steps	Designates all that apply from a list of standard or common activities that are possible and would bring about market transformation for the measure. Examples include R&D, demonstrations, testing, education, training, financing, incentives, standards or promotional programs.
Summary of Next Steps	Paragraph summary of market barriers and some recommended educational, programmatic, or policy-related steps that would best address them.

Priority Determination

In ranking measures we recognize that measure scores are inexact and that small score differences are meaningless. We also recognize that no objective ranking process can capture the full range of issues that need to be balanced in order to fully assess potential initiatives. However, ranking measures helps separate high priority measures from low priority ones. Ranking also allows consideration of other issues to be focused on a limited number of measures that appear to be high priority.

For this study, measures were divided into "high," "medium," "lower," "not a priority" and "special" categories, based on three factors: potential energy savings, cost of saved energy, and likelihood of success. The differences among these priority categories are summarized in the two tables below.

Criteria for the Five Priority Levels

High priority	Potential energy savings of at least 1% of projected U.S. residential and commercial energy consumption in 2020; a cost of saved energy less than half of current U.S. retail energy prices; and a likelihood of success rating of 3 or more.
Medium priority	Potential energy savings of 0.25 to 1.0% of projected residential and commercial energy use in 2020; a cost of saved energy less than current retail energy prices; and a likelihood of success rating of 3 or more.
Low priority	Potential energy savings of less than 0.25% of projected U.S. residential and commercial energy consumption in 2020, a cost of saved energy less than current retail energy prices; and a likelihood of success rating of 2 or more.

Special measures	Those that will not save as much as 0.25%, but are included because they are particularly important for new construction or in specific regions.
Not a priority	Those with a cost of saved energy greater than current retail energy prices or a likelihood of success of 1.

Priority Levels and Distribution of Measures by Classification Parameters

Priority	Threshold for Savings	CSE, \$/kWh	CSE, \$/MMBtu (source energy)	Likelihood of Success
high	≥ 1.0%	≤ \$0.0405/kWh	≤ \$3.16/MMBtu	3–5
medium	≥ 0.25%	≤ \$0.081/kWh	≤ \$6.33/MMBtu	3–5
low	NA	≤ \$0.081/kWh	≤ \$6.33/MMBtu	2–5
special	>~0.05%	≤ \$0.081/kWh	≤ \$6.33/MMBtu	2–5
not a priority	--	>\$0.81/kWh	>\$6.33/MMBtu	1-5
total				

Note: To earn a "high" or "medium" priority, a measure must meet all the thresholds in the row. For example, high priority measures are those that show potential energy savings of at least 1% of projected U.S. residential and commercial energy consumption in 2020; a cost of saved energy less than half of current U.S. retail energy prices; and a likelihood of success rating of 3 or more. If a measure fails to meet one or more of these thresholds, it slips to the next lower priority.

Section 6: Assumptions

Data Quality Assessment	Quantifies the quality and accuracy of data on each measure, rated on an A-D scale, where A=very good, B=good, C=fair, and D=poor. See discussion below for details.
Key Assumptions used in Analysis	A paragraph summary explaining conditions of data collection not made apparent in the rest of the report.

Data Quality Determination

A	Very good. Data is available from several sources, with general agreement among these independent sources on specific values. Many of these cases include data obtained from independent analysts who do not have a vested interest in promoting a product.
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B	Solid estimates from one source, or less precise estimates from several sources.
C	Preliminary estimates were available from only one source, often a source with a vested interest in promoting the product.
D	Data are essentially a "guesstimate" with no source willing to support a firm number.