SELECTING TARGETS FOR NEW MARKET TRANSFORMATION INITIATIVES IN THE NORTHWEST

Margaret Suozzo
Steven Nadel
Jeff Harris
Tom Eckman

June 1998

Prepared for:
Northwest Energy Efficiency Alliance
851 SW 6th Avenue, Suite 1100
Portland, OR 97204

1001 Connecticut Avenue NW, Suite 801, Washington, DC 20036 (202)429-8873

See our webpage at http://aceee.org

Table of Contents

Executive Summary

This report documents the results of a study conducted by the American Council for an Energy-Efficient Economy (ACEEE) for the Northwest Energy Efficiency Alliance (the "Alliance"). The study's primary purpose is to analyze a range of technologies and practices, collectively referred to as "measures" for their potential as regional market transformation initiatives.

Approach

The following multi-step process was taken to assess potential market transformation targets. First, we *developed a list of measures*, focusing on technologies and practices suitable for full-scale market transformation programs at some point in the near term (i.e., during the 1998-2000 period). Second, we *collected data,* and updated or modified data collected for a previous PG&E study to reflect new and regional information. Additional measure analyses were added based on prior assessments of measures in the Northwest and discussions with Alliance staff. And third, we *developed and implemented a method for ranking* and presenting comparative information on different measures.

Measure characterizations

Detailed measure characterizations are presented for each of the 36 measures selected for analysis. These characterizations include a one to two page write-up and a data sheet that documents the data and assumptions used in estimating key variables.

Ranking measures

From the data collected on each measure, three factors were selected as our principal means for comparing, ranking, and presenting potential measures for new market transformation programs: (1) potential energy savings, (2) cost effectiveness; and (3) likelihood that a market transformation initiative will be successful. A variety of rankings were then performed.

Weights were applied to the three factors and an overall ranking based on these weights performed. Weighting factors (45 percent for potential energy savings; 35 percent for likelihood of success; and 20 percent for cost of saved energy, i.e., the "basecase scenario") were chosen by ACEEE and the Alliance. For comparison, we conducted two sensitivity analyses on the basecase rankings. The first case weights each factor evenly (i.e., 33 percent each) and the second case reverses the weightings on energy savings potential and likelihood of success (energy savings potential is weighted 35 percent and likelihood of success 45 percent).

Results

The top 15 measures from the basecase ranking scheme as well as measures that made the top 15 under alternative scenarios are shown in Table E-1 below. This basecase ranking includes 8 residential measures and 7 non-residential measures; 10 of the measures are technologies and 5 are practices.

Table E-1: Summary of Rankings Under Alternative Weighting Schemes

		Base Weighting	Even Weighting	Reverse Weighting
	Potential Energy Savings	**45%**	**33%**	**35%**
	Cost of Saved Energy (CSE)	**20%**	**33%**	**20%**
	Likelihood of Success	**35%**	**33%**	**45%**
1	Tumble-action clothes washers*	1	1	1
2	High-efficiency electric storage water heaters	2	2	2
3	Commercial building retro-commissioning	3	5	5
4	Low energy/water residential dishwashers*	4	4	4
5	Optimization of microelectronics HVAC systems	5	6	6
6	Commercial/industrial exit signs*	6	3	3
7	Industrial pumps, fans & blowers	7	8	14
8	Residential duct sealing	8	10	10
9	High-efficiency packaged commercial refrigeration equipment	9	7	8
10	Screw-in compact fluorescent lamps	10	22	18
11	Premium efficiency motors	11	11	12
12	Manufactured housing	12	16	11
13	Industrial compressed air system improvements	13	14	15
14	Residential fluorescent lighting fixtures	14	15	16
15	LED traffic signals (red and green)	15	12	7
	LED traffic signals (red)	18	19	9
	Agricultural scheduling systems	19	13	17
	Improved building code implementation*	20	9	13

* Note: These measures have negative costs and have been ranked assuming a zero CSE.

Twelve of the 15 measures are common to all scenarios: the basecase, even weighting, and the reverse weighting scenarios, although their order differs somewhat. Thus, the high-ranking measures are quite robust across a wide range of weights.

The Alliance now has initiatives underway to promote several of the measures presented in Table E-1, including tumble-action clothes washers, building retro-commissioning, efficient microelectronics industry HVAC systems, residential duct sealing, compact fluorescent lamps and residential lighting fixtures, manufactured housing, premium efficiency motors, improved building codes, and agricultural scheduling. In addition, the Alliance is conducting market research to evaluate opportunities for an expanded building retro-commissioning initiative and for beginning new initiatives in the areas of industrial compressed air, pump, fan and blower systems.

Of the remaining measures, several are currently addressed by national initiatives, including the EPA and DOE ENERGY STAR® programs for efficient commercial and industrial exit signs and high efficiency dishwashers. EPA and DOE are also in the process of developing an ENERGY STAR® program for efficient refrigerated vending machines. The Consortium for Energy Efficiency (CEE) is developing qualifying levels for the very efficient dishwashers and is investigating the potential for a national LED traffic signals initiative. Finally, DOE is revising its minimum efficiency standards for electric storage water heaters.

Introduction

This report documents the results of a study conducted by the American Council for an Energy-Efficient Economy (ACEEE) for the Northwest Energy Efficiency Alliance (the Alliance) to identify and analyze potential new market transformation initiatives. This report characterizes a range of technologies and practices and ranks them in terms of specific criteria to enable The Alliance to identify market transformation initiatives to pursue.

Approach

The purpose of this project was to review a wide range of technologies and practices (hereafter collectively referred to as "measures") and to identify high priority measures for the Alliance to consider pursuing as new market transformation ventures. To select the measures, we implemented a multi-step process. First, we developed a list of measures, focusing on technologies and practices that will be suitable for full-scale market transformation programs in the next few years (i.e., at some point during the 1997-2000 period). Second, we identified data needs for each measure, conducted research to collect these data, and prepared a short write-up on each measure. Third, we developed and implemented a method for comparing or ranking different measures. And, following review and consultation with the Alliance staff on this methodology and on an initial ranking of measures, we revised the rankings. The approach taken to identify, characterize, and compare measures for this study is detailed below.

Develop List of Measures

The first step was to compile a preliminary list of measures for consideration as possible new market transformation initiatives. A subset of measures from a study ACEEE conducted for Pacific Gas & Electric company were selected for the list based on their perceived potential in the Northwest. These measures had been culled primarily from initiatives being targeted or considered by national and regional market transformation organizations (i.e., the Consortium for Energy Efficiency (CEE), the Alliance, the Northeast Energy Efficiency Partnership (NEEP), the EPA and DOE ENERGY STAR® programs, etc.). Additional measures were added based on prior assessments of measures in the Northwest and discussions with the Alliance staff. Only energy-saving measures were included; measures which generate electricity, such as fuel cells and renewable energy systems were considered beyond the scope of this study. The preliminary list was reduced to approximately 40 measures by eliminating those with very-limited impacts which were highly likely to rank near the bottom of the screening process. A few additional measures were dropped during the screening process for the same reason.

The measures selected are summarized in Table 1.

Screening and Ranking Criteria

As part of our research plan we identified three factors as our principal means for comparing, ranking, and ultimately prioritizing measures for new market transformation programs. These are: potential energy savings, cost effectiveness, and likelihood that a market transformation initiative will be successful. Potential energy savings estimates are important to justify the substantial work and effort to develop and implement a market transformation initiative. Initiatives with only small savings may not justify the costs of

Table 1. Measures Selected for Analysis

Residential Measures

HVAC
1. High-efficiency air-source heat pumps
2. Ground source heat pumps without water heating
3. Ground source heat pumps with water heating
4. Residential duct sealing

Water heating
5. Heat pump water heaters
6. Integrated space/water heating heat pump systems
7. High-efficiency electric storage water heaters (EF ~.93)

Building shell
8. Residential efficient windows
9. Residential new construction (shell measures beyond state codes)
10. Manufactured housing (efficiency improvements beyond current practice)

Lighting
11. Residential fluorescent lighting fixtures
12. Screw-in compact fluorescent lamps

Appliances
13. Low energy/water residential dishwashers
14. Tumble-action clothes washer or equivalent

Commercial/Industrial/Agricultural Measures

Lighting
15. Daylight dimming controls
16. Occupancy sensors
17. Commercial and industrial exit signs
18. Improved lighting design practices

HVAC
19. Optimization of chiller and tower systems
20. Optimization of microelectronics industry HVAC systems

Motor systems
21. Premium efficiency motors
22. Industrial pumps, fans and blowers -- selection & optimization
23. High quality motor repair practices
24. Industrial compressed air system improvements

Building shell, refrigeration, and other
25. Advanced commercial glazing
26. New commercial buildings (beyond current codes)
27. Commissioning of new commercial buildings
28. Improved implementation of building codes -- training, TA, etc.
29. Commercial heat pump water heaters
30. Commercial building retro-commissioning
31. Commercial refrigeration integrated design (for market not yet transformed)
32. High-efficiency packaged refrigeration equipment (e.g. vending machines)
33. Agricultural irrigation scheduling systems
34. Wastewater facility energy efficiency optimization
35. LED traffic signals
36. Dry-type distribution transformers

putting an initiative into place. All other things being equal, new market transformation initiatives with high savings will be more advantageous than those with small savings. Potential energy savings were assessed by comparing present market conditions to the market conditions that can be plausibly predicted after a market transformation initiative is implemented.

Potential energy savings need to be analyzed over a long enough time frame for the initiative to have substantial impact, but for a short enough time frame to be relevant in current planning efforts. For this study, we keyed in on savings achieved in 2010 on the assumption that 2010 is far enough away for new market transformation initiatives to have significant impact yet close enough to be within current resource planning time horizons. Potential energy savings were estimated on a regional basis, defined for the purpose of this study to include Washington, Oregon, Idaho and the portion of Montana west of the continental divide. For measures that are cost-effective in some parts of the region but not others, the energy savings potential was estimated for cost-effective applications. For this study, "cost-effective" was defined as a life-cycle cost of conserved energy less than 30 mills per kWh.[1]

Measure cost-effectiveness is important for several reasons. First, it is important for convincing consumers to implement a measure. If measures are very expensive relative to the benefits, achieving substantial market share will be near impossible. Second, prioritizing DSM programs has typically relied on the total resource cost (TRC) test; measure cost is a primary element in assessing TRC costs. Where measures are cost-effective (as defined above) in some applications but not in others, levelized costs were calculated for typical cost-effective applications (e.g., in the case of ground source heat pumps, the cost-effectiveness was calculated for homes greater than 2000 square feet in regions with greater than 6000 heating degree-days).

The likelihood that a market transformation initiative will be successful is one of the most critical factors in selecting market transformation targets. If an initiative is unlikely to be successful, it is generally not worth pursuing. Likelihood of success in turn depends on an analysis of the major market barriers that are impeding each initiative and the likelihood that program interventions can overcome these barriers. Likelihood of success also depends on the how well the technology or practice addresses customer needs — does the measure have additional benefits besides energy savings, or is the measure less desirable than conventional measures from a consumer perspective? As described further below, likelihood of success was rated on a five-point scale by ACEEE and the Alliance staff.

Measure Data Collection and Analysis

In order to analyze these three factors, we collected a variety of information on each measure. This information is listed in Table 2. Most of the data in Table 2 are self explanatory, but a few key variables require further explanation:

[1]Thirty (30) mills per kWh was used as a rough approximation of the long-run avoided cost of new generation resources and includes cost savings from avoided transmission and distribution system improvements and a margin to account for non-energy benefits. This value was chosen primarily as a screening criteria, not as a strict avoided cost value.

Table 2. Information Collected on Each Measure

Market Information:

1. Measure name
2. Market sector (RES, COM, IND, AGR)
3. End use(s)
4. Energy types (ELEC)
5. Market segment (NEW, RETROFIT, REPLACEMENT, OEM)

Basecase Information:

6. Basecase description (typical unit size and characteristics of current practice to which new measure is being compared)
7. Base case efficiency
8. Base case annual energy use

New Measure Information:

9. New measure description (size and characteristics, for comparison to basecase)
10. New measure efficiency
11. New measure annual energy use
12. Measure life

Savings Information:

13. Electricity savings/year (of new technology relative to basecase)
14. Percent savings (of new technology relative to basecase)
15. Feasible applications (% of applications for which measure is feasible)
16. Savings potential in 2010 (avg MW)

Cost Information:

17. Current measure cost
18. Projected future measure cost (in mass use)
19. Other direct costs/savings
20. Cost of saved energy (mills/kWh)

Data Quality Assessment:

21. Data quality assessment (quality/accuracy of data on each measure, rated on an A-D scale, where A=very good, B=good, C=fair, and D=poor).

Likelihood of Success:

22. Major market barriers (brief list)
23. Effect of measure on customer utility (non-energy benefits and problems)
24. Current activity in NW
25. Available exit strategies
26. Likelihood of success rating (1-5 scale)
27. Rationale for likelihood of success rating

Other Factors:

28. Need for intervention (high, med, low)
29. Fuel share impact (yes, maybe, no)
30. Non electric fuel benefits (high, med, low):

Sources:

31. Savings estimates
32. Cost estimates
33. Measure life estimates
34. Other key sources
35. Principal contacts

36. Notes

Feasible applications (%) (#15)

Feasible applications represent the proportion of applications where the measure is likely to be technically feasible and cost-effective over the long-term. However, for measures with substantial current market share, we do not include the current market share in these estimates. In this way, we only include applications that can save energy relative to the present basecase situation. In this manner we attempt to estimate the long-term potential impact of a new initiative. Based on information from the Northwest Power Planning Council (NWPPC)'s *Fourth Northwest Conservation and Electric Power Plan*, feasible applications for most measures were capped at 85 percent, and for measures for which a Federal efficiency standard or state code is likely to go into effect prior to 2010, the feasible applications were capped at 95 percent (NWPPC 1997).

Savings potential in 2010 (avg MW) (#16)

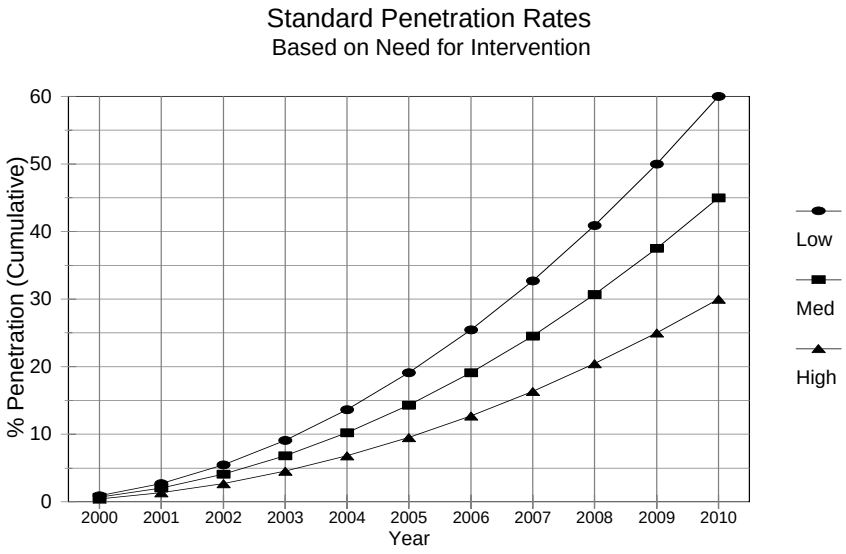
Potential energy savings were estimated using projected energy end-use data for the Northwest (see Appendix A). The general approach for estimating energy savings was to compute the product of projected energy use in 2010 for the specific end-use times the feasible applications times the proportion of the market that could be impacted by 2010. For retrofit measures, this latter figure was assumed to be 100%. For replacement measures (measures installed when existing equipment fails and must be replaced), this proportion was estimated to be 11 divided by the measure life (representing the proportion of equipment that will be replaced between 2002 and 2010) times an assumed penetration rate. For new construction measures, a similar approach was used based on construction during the 2000-2010 period divided by the total anticipated building stock in 2010.

Simplified uniform penetration rates were developed to represent a plausible estimate of market penetration of each measure in the analysis period. Penetration rate was not customized for each measure; instead we assigned measures one of three standard penetrations rates. These rates were tied to assumptions about the level of market intervention required for the measure to be successful. In general, the penetration figures assume successful programs. Thus, where market intervention required is high, market penetration was assumed to be 5 percent in the year 2000, 10 percent in 2001, 15 percent in 2002, and so on, for a cumulative market penetration by 2010 of 30 percent. For measures where the need for intervention is medium, market penetration was assumed to be 7.5 percent in 2000, 15 percent in 2001, and so on, for a cumulative market penetration of 45 percent in 2010. Finally, where the need for intervention is low (i.e., where market transformation is likely to occur without much intervention), penetration rates were expected to be higher: 10 percent in 2000, 20 percent in 2001, 30 percent in 2002, for a cumulative penetration of 60 percent by 2010.

These penetration rates served as the general case, however, for certain measures with codes and standards likely in the near future, we estimated an effective date of the standard and assumed the penetration of the measure would be 100% as of this date. For example, the effective year for efficient water heaters was assumed to be 2003; for distribution transformer standard and clothes washers, it was assumed to be 2005; and for high efficiency heat pumps and low energy dishwashers, 2006. In these cases, the rate at which penetration was assumed to ramp up, varies with the product. For example, high efficiency heat pumps are not likely to achieve a significant level of penetration in the absence of standards, so a non-regulatory market transformation initiative is assumed to result in a penetration of no more than 30 percent. For these products, the ramp up is modeled as

follows: 10% in 2000, 20% in 2002, 30% of the market in years 2003 through 2005, and 100% in 2006, when the new standard is assumed to go into effect.

These rates are somewhat aggressive and are more likely to be achievable for measures with a likelihood of success rating of five (the maximum score). For measures with a lower likelihood of success, penetration rates will probably be lower, but this difference will be captured in the likelihood of success score and not the energy savings score.



Cost of saved energy (mills/kWh) (#20)

The cost of saved energy is the present value of the costs of a measure levelized over its lifetime and expressed 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 were based on the future measure cost estimates and a real discount rate of 4.75 percent per discussions with the Alliance staff. For measures that have annual operating costs or savings in addition to energy (e.g., reduced or increased maintenance costs), changes in annual maintenance costs are included in the calculations. For example, for a measure that increases maintenance costs, the cost of saved energy calculation includes total capital costs and the incremental increase in maintenance costs. Likewise, for measures that reduce maintenance costs, incremental cost reductions were subtracted from total capital costs. The cost of saved energy calculations do not include non-quantifiable benefits or environmental externalities, such as carbon dioxide offset credits.

Likelihood of success (1-5 scale) (#26)

Likelihood of success was determined on a qualitative basis by evaluating a given measure along four dimensions: (1) the likelihood with which market and technical barriers can be overcome; (2) the amount of progress that has been made to date in transforming the market for the measure; (3) the magnitude of the benefits of the measure; and (4) whether there is a clear exit strategy. Likelihood of success was assessed using the following five point scale:

> 1 = Will be very difficult to succeed; there are many large barriers to overcome, the benefits are limited, and little work has taken place thus far.

2 = Will be hard to succeed; there are many large barriers and not all are likely to be significantly reduced overtime; however, there can be substantial benefits or some progress has already been made.

3 = Moderate chance of success; there are substantial barriers to overcome, but also substantial benefits; some progress has already been made; but there is no clear exit strategy.

4 = Good chance of success; the barriers appear surmountable and the benefits are large. Significant progress has already been made; so trade allies and other interested parties are familiar with the measure; however, the obvious exit strategy is controversial (e.g., a mandatory efficiency standard for horizontal-axis clothes washers).

5 = Excellent chance of success; the measure has been proven technically and has significant benefits. Extensive work has taken place already, and the measure lends itself to a clear exit strategy such as codes, mandatory standards, or an easy to meet voluntary standard as with power management in PCs.

Below, Table 3 summarizes how each likelihood of success score compares along these four dimensions.

Table 3. Evaluating Likelihood of Success

Dimension\ Rating	1	2	3	4	5
Barriers	Very difficult to overcome	Difficult to overcome	Some but not all barriers can be significantly reduced over time	All can be overcome	All can be overcome
Progress to date	Very limited	Some	Significant	Significant	Significant
Benefits	Limited	Can be substantial	Substantial	Substantial	Substantial
Exit strategy	None	None	Not clear	Difficult or controversial	Clear

Need for intervention (high, med, low) (#28)

The “other factors” including need for intervention, fuel share impact, and non-electric fuel benefits were rated on a subjective scale, in communication with the Alliance staff. The need for intervention was determined to be high, medium, or low, depending on the level of effort likely to be required for a successful market transformation initiative. Measures where only minor intervention is likely to be required, such as LED traffic signals and high efficiency electric water heaters, were rated “low” on the need for intervention scale. In contrast, measures requiring significant intervention (e.g., retail incentives, in-field training, demonstrations), were rated “high.” As mentioned above in the discussion on savings potential in 2010, the value of this factor (high, medium, or low) determines the penetration rate assumed for the measure.

Ranking Procedure

In ranking measures, we used objective analysis where possible; however, since much of the data going into the analysis is subjective in nature, any objective process will not capture the full range of issues that need to be balanced in order to select the best program targets. In order to address this problem, a three-step ranking process was used: (1) objective ranking as discussed below; (2) review of initial rankings by ACEEE and the Alliance including review and adjustment for consistency of subjective factors in the rankings (e.g., likelihood of success); and (3) review of revised rankings by other regional energy efficiency experts, resulting in further adjustments of the types noted in the previous step.

For the first step, each of the three key criteria (potential energy savings, cost of saved energy, and likelihood of success) were ranked from lowest to highest and points assigned, with zero points to the lowest-ranked measure and 100 points assigned to the highest ranked measure. For measures in between, points were prorated based on their score. Measures with the same score received the same number of points.

A total measure score was determined by weighting each of the three factors. Initial weighting factors were chosen by ACEEE and the Alliance staff. These are indicated below:

Factor	Weight
Energy savings potential	45%
Likelihood of success	35%
Cost of saved energy	20%

The Alliance has as its mission “to promote cost-effective electricity efficiency through the tool of market transformation.” Thus, energy savings potential was most heavily weighted because saving energy is the primary objective of these market transformation programs. Likelihood of success was also heavily weighted because we are interested in savings that can be achieved in practice and not just in theory. This factor depends on barriers inhibiting each measure, chances of overcoming these barriers, non-energy benefits of each measure, and previous work done to foster market transformation. Cost of saved energy was weighted less than the previous two factors because measures with a high cost of saved energy will generally have a low likelihood of success score (due to the barriers of high measure costs and/or limited measure benefits) and we do not want to overweight this factor. In addition, measures with costs above 30 mills per kWh were screened out prior to the ranking process.

For comparison, we conducted two sensitivity analysis on the rankings. The first case assumes that each factor is weighted evenly (i.e., 33 percent each) and the second one reverses the weightings on energy savings potential and likelihood of success (energy savings potential is weighted 35 percent and likelihood of success 45 percent).

Regarding the second step in the selection process, ACEEE and the Alliance staff compared rankings of the different measures, and where scores and rankings appeared inconsistent with each other, appropriate adjustments were made to some of the scores, resulting in some adjustments to the rankings. For example, during this step we compared likelihood of success and other factor scores for relative consistency with each other. We also examined energy savings and cost of saved energy figures with regard to the other measures and to prior analyses of these measures. Where scores appeared aberrant,

ACEEE and the Alliance conducted some additional research, revised data where appropriate, and prepared revised rankings.

Measure Rankings

Based on the ranking scheme discussed above, measures were scored and final rankings prepared. These rankings are summarized in Table 4 below. In examining the rankings, it is obvious that scores between adjoining measures are close together, and given the inexact nature of the scores and rankings, small differences between ranks are not significant. Thus, the primary purpose of this exercise is to separate highly ranked measures (those near the top of the list) from lower ranked measures. The top 15 ranked measures, listed below, include 7 residential measures and 8 non-residential measures; 9 of the measures are technologies and 6 are practices:

1 Tumble-action clothes washers
2 High-efficiency electric storage water heaters
3 Commercial building retro-commissioning
4 Low energy/water residential dishwashers
5 Optimization of microelectronics HVAC systems
6 Commercial/industrial exit signs
7 Industrial pumps, fans & blowers
8 Residential duct sealing
9 High-efficiency commercial packaged refrigeration equipment
10 Screw-in compact fluorescent lamps
11 Premium efficiency motors
12 Manufactured housing
13 Industrial compressed air system improvements
14 Residential fluorescent lighting fixutes
15 LED traffic signals (red and green)

The results of the sensitivity analysis of the top 15 basecase measures are shown in Table 5 below. Measures that rank within the top 15 under the alternative scenarios are also presented. Twelve measures are common to all rankings. Common residential measures include efficient clothes washers, storage water heaters, efficient dishwashers, and improved duct sealing. Commercial and industrial measures common to all scenarios include building retro-commissioning, microelectronics industry HVAC system optimization, efficient exit signs, better industrial pumps, fans, and blowers, improved commercial packaged refrigeration equipment, premium efficiency motors, industrial compressed air system improvements, and LED exit signs (red and green retrofits).

The high-ranking measures are relatively robust across a wide range of weights. But there are a few notable results of the sensitivity analysis. First, industrial fans, pumps and blowers move down the list in the alternative weighting scenarios. This measure is characterized by very high potential energy savings achievable at a relatively high cost of saved energy (20 mills per kWh). Second, two measures in the top 15 under the base weighting scheme, screw-in compact fluorescent lamps and manufactured housing, do not make the top 15 ranked measures under the even weighting scenario. For the first, this is likely the result of its relatively high cost of saved energy (30 mills per kWh). Instead, measures characterized by low potential energy savings but attractive costs of saved energy take their place, including improved building code implementation and agricultural scheduling systems. Third, under the reverse weighting scheme, LED traffic signals (red-only retrofits) also make the list of the top 15 (as number 9), as does improved building code implementation, displacing screw-in compact fluorescent lamps and residential fluorescent

fixtures, which do not make the top 15 in this scenario. For the rankings of all measures under each scenario, see Appendix B.

Table 4. Measure Rankings

Rank	Measure/Practice	Svngs	CSE	Success	Score
1	Tumble-action clothes washers*	177	$0.000	4	93.00
2	High-efficiency electric storage water heaters	96	$0.006	5	75.33
3	Commercial building retro-commissioning	136	$0.021	3	65.41
4	Low energy/water residential dishwashers*	54	$0.000	4	59.96
5	Optimization of microelectronics HVAC systems	100	$0.013	3	59.45
6	Commercial/industrial exit signs*	25	$0.000	5	59.30
7	Industrial pumps, fans & blowers	131	$0.020	2	57.69
8	Residential duct sealing	106	$0.024	3	56.52
9	High-efficiency packaged commercial refrigeration equipment	56	$0.010	3.5	52.61
10	Screw-in compact fluorescent lamps	99	$0.030	3	51.61
11	Premium efficiency motors	63	$0.013	3	49.63
12	Manufactured housing	51	$0.023	4	49.17
13	Industrial compressed air system improvements	60	$0.015	3	47.91
14	Residential fluorescent lighting fixtures	61	$0.016	3	47.86
15	LED traffic signals (red and green)	15	$0.020	5	47.72
16	Improved lighting design practices	70	$0.022	3	47.69
17	New commercial buildings -- integrated design	77	$0.029	3	46.24
18	LED traffic signals (red)	10	$0.024	5	44.87
19	Agricultural scheduling systems	30	$0.007	3	43.61
20	Improved building code implementation*	18	$0.000	3	43.41
21	Residential new construction	36	$0.011	3	43.04
22	Optimization of chiller and tower systems	30	$0.008	3	42.90
23	Dry-type distribution transformers	32	$0.027	4	42.14
24	New building commissioning	30	$0.011	3	41.86
25	Residential efficient windows	38	$0.024	3	37.98
26	Wastewater facility energy efficiency optimization	10	$0.024	4	37.68
27	High quality motor repair practices	20	$0.017	3	36.58
28	Commercial heat pump water heaters	23	$0.019	3	36.53
29	Advanced commercial glazing	34	$0.016	2	33.57
30	Commercial refrigeration integrated design	10	$0.013	2	28.24
31	Ground source heat pumps	9	$0.020	2	24.93
32	Ground source heat pumps w/water heating	10	$0.021	2	24.87
33	Integrated space/water heating heat pumps	88	$0.032	3	48.11
34	Occupancy sensors	95	$0.034	3	48.99
35	Heat pump water heaters	162	$0.034	2	59.64
36	Daylight dimming controls	59	$0.038	2	30.27
37	High-efficiency air-source heat pumps	32	$0.045	3	27.26

* Note: These measures have negative costs and have been ranked assuming a zero CSE.

The Alliance now has initiatives underway to promote many of the measures identified in the Table 4 above. These include tumble action clothes washers, building retro-commissioning, efficient microelectronics industry HVAC systems, residential duct sealing, compact fluorescent lamps and residential fluorescent fixtures, manufactured housing, premium efficiency motors, improved building codes, and agricultural scheduling. The Alliance is also conducting preliminary market research to determine if it will expand its work on building retro-commissioning and/or develop new initiatives for industrial compressed air, pump, fan and blower systems.

Of the remaining measures, several are currently addressed by national initiatives. The EPA and DOE ENERGY STAR® programs for, example, promote efficient commercial and industrial exit signs and high efficiency dishwashers. EPA and DOE are also in the process

of developing an ENERGY STAR® labeling program for efficient refrigerated vending machines (with other high efficiency packaged refrigeration equipment likely to follow). Similarly, CEE is in the process of developing qualifying levels for very efficient dishwashers through its Super Efficient Home Appliances (SEHA) Initiative and is also investigating the opportunities for developing a national initiative to address LED traffic signals. For high efficiency electric storage water heaters, DOE is in the midst of a rulemaking on new minimum efficiency standards, scheduled for completion in late-1999.

Finally, it is important to note that four of the five measures that were screened out due to a cost of saved energy of more than 30 mils represent substantial energy savings potential (more than 50 average MW) and had costs of conserved energy less than 40 mils per kWh. If carbon credits were included, it is likely that these measures would have made the cost-effectiveness cutoff and might have ranked fairly high due to their large energy savings. However, for the largest of these (heat pump water heaters), substantial institutional and technical market barriers exist, making the likelihood of success relatively low.

Table 5. Comparison of Rankings with Different Factor Weights

		Base Weighting	Even Weighting	Reverse Weighting
	Potential Energy Savings	**45%**	**33%**	**35%**
	Cost of Saved Energy (CSE)	**20%**	**33%**	**20%**
	Likelihood of Success	**35%**	**33%**	**45%**
1	Tumble-action clothes washers*	1	1	1
2	High-efficiency electric storage water heaters	2	2	2
3	Commercial building retro-commissioning	3	5	5
4	Low energy/water residential dishwashers*	4	4	4
5	Optimization of microelectronics HVAC systems	5	6	6
6	Commercial/industrial exit signs*	6	3	3
7	Industrial pumps, fans & blowers	7	8	14
8	Residential duct sealing	8	10	10
9	High-efficiency packaged commercial refrigeration equipment	9	7	8
10	Screw-in compact fluorescent lamps	10	22	18
11	Premium efficiency motors	11	11	12
12	Manufactured housing	12	16	11
13	Industrial compressed air system improvements	13	14	15
14	Residential fluorescent lighting fixtures	14	15	16
15	LED traffic signals (red and green)	15	12	7
	LED traffic signals (red)	18	19	9
	Agricultural scheduling systems	19	13	17
	Improved building code implementation*	20	9	13

* Note: These measures have negative costs and have been ranked assuming a zero CSE.

Appendix A: Energy End Use Breakdown for the Northwest

Below are projections of residential and commercial end-use energy consumption. In addition, relevant end-use data for the industrial sector is included.

Residential End-Use Energy Consumption, in 2010

End-Use	Electric (avg MW)
Space Cooling	54.29
Space Heating	2,706.96
WH Dishwasher	338.24
WH Clotheswasher	493.47
WH Basic	1,045.13
WH Total	1,877.03
Drying	325.77
Lighting	387.82
Refrig/Freezer	1,016.08
Cooking	473.14
Miscellaneous	907.49
TOTAL	**9,625.42**

Source: NWPPC (1996); CEC (1995) was used to estimate water heating end-use breakdown.

Commercial End-Use Energy Consumption, in 2010

End-Use	Electric (avg MW)
Space Heating	1,583.77
Space Cooling	372.03
Ventilation	744.05
Water Heating	122.24
Cooking	159.44
Refrigeration	350.77
Indoor Lighting	1,679.43
Miscellaneous	403.91
TOTAL	**5,415.65**

Source: NWPPC (1996)

Industrial End-Use Energy Consumption, in 2010

End-Use	Electric (avg MW)
Chemicals	868.32
Pulp & Paper	1,664.28
Food	361.80
Petroleum & Coal	144.72
Primary metals	2,677.32
Transport Equip	217.08
Wood Products	434.16
Other	868.32
	7,236.00

Source: NWPPC (1996)

Other Assumptions and Data Inputs

New Construction Rates

Residential New Construction -- 16% of 2010 stock; based on annual growth of 1.6% over the 11-year period from 1999 through 2010 from NWPPC (1996).

Commercial New Construction -- 30% of 2010 stock; based on annual growth rate of 3.3% (from 1994- 96 figures) over the 11-year period from 1999 through 2010 from NWPPC (1996).

Discount Rate

Assumed to be 4.75 percent.

Appendix B: Alternative Sorting and Ranking Scenarios

As noted in the discussion of the methodology used in analyzing measures, several different ranking schemes were analyzed and compared with the “base” ranking scheme which weights potential energy savings, cost of saved energy, and likelihood of success at 45, 20, and 35 percent, respectively. Of the two alternative rankings, the first, which we call the “even-weighting” ranking, assumes that each factor is weighted evenly (i.e., 33 percent each) and the second one, the “reverse” ranking, reverses the weightings on energy savings potential and likelihood of success (energy savings potential is weighted 35 percent and likelihood of success 45 percent). Presented in the following tables are the results of each of the alternative rankings.

Basecase Weighting

Potential Energy Savings: 45%
Cost of Saved Energy: 20%
Likelihood of Success: 35%

Rank	Measure/Practice	Svngs	CSE	Success	Score
1	Tumble-action clothes washers*	177	$0.000	4	93.00
2	High-efficiency electric storage water heaters	96	$0.006	5	75.33
3	Commercial building retro-commissioning	136	$0.021	3	65.41
4	Low energy/water residential dishwashers*	54	$0.000	4	59.96
5	Optimization of microelectronics HVAC systems	100	$0.013	3	59.45
6	Commercial/industrial exit signs*	25	$0.000	5	59.30
7	Industrial pumps, fans & blowers	131	$0.020	2	57.69
8	Residential duct sealing	106	$0.024	3	56.52
9	High-efficiency packaged commercial refrigeration equipment	56	$0.010	3.5	52.61
10	Screw-in compact fluorescent lamps	99	$0.030	3	51.61
11	Premium efficiency motors	63	$0.013	3	49.63
12	Manufactured housing	51	$0.023	4	49.17
13	Industrial compressed air system improvements	60	$0.015	3	47.91
14	Residential fluorescent lighting fixtures	61	$0.016	3	47.86
15	LED traffic signals (red and green)	15	$0.020	5	47.72
16	Improved lighting design practices	70	$0.022	3	47.69
17	New commercial buildings -- integrated design	77	$0.029	3	46.24
18	LED traffic signals (red)	10	$0.024	5	44.87
19	Agricultural scheduling systems	30	$0.007	3	43.61
20	Improved building code implementation*	18	$0.000	3	43.41
21	Residential new construction	36	$0.011	3	43.04
22	Optimization of chiller and tower systems	30	$0.008	3	42.90
23	Dry-type distribution transformers	32	$0.027	4	42.14
24	New building commissioning	30	$0.011	3	41.86
25	Residential efficient windows	38	$0.024	3	37.98
26	Wastewater facility energy efficiency optimization	10	$0.024	4	37.68
27	High quality motor repair practices	20	$0.017	3	36.58
28	Commercial heat pump water heaters	23	$0.019	3	36.53
29	Advanced commercial glazing	34	$0.016	2	33.57
30	Commercial refrigeration integrated design	10	$0.013	2	28.24
31	Ground source heat pumps	9	$0.020	2	24.93
32	Ground source heat pumps w/water heating	10	$0.021	2	24.87
33	Integrated space/water heating heat pumps	88	$0.032	3	48.11
34	Occupancy sensors	95	$0.034	3	48.99
35	Heat pump water heaters	162	$0.034	2	59.64
36	Daylight dimming controls	59	$0.038	2	30.27
37	High-efficiency air-source heat pumps	32	$0.045	3	27.26

* Note: These measures have negative costs and have been ranked assuming a zero CSE.

Even Weighting

Potential Energy Savings: 33%
Cost of Saved Energy: 33%
Likelihood of Success: 33%

Rank	Measure/Practice	Svngs	CSE	Success	Score
1	Tumble-action clothes washers*	177	$0.000	4	93.24
2	High-efficiency electric storage water heaters	96	$0.006	5	78.97
3	Commercial/industrial exit signs*	25	$0.000	5	69.78
4	Low energy/water residential dishwashers*	54	$0.000	4	68.79
5	Commercial building retro-commissioning	136	$0.021	3	62.49
6	Optimization of microelectronics HVAC systems	100	$0.013	3	61.43
7	High-efficiency packaged commercial refrigeration equipment	56	$0.010	3.5	58.41
8	Industrial pumps, fans & blowers	131	$0.020	2	55.89
9	Improved building code implementation*	18	$0.000	3	55.07
10	Residential duct sealing	106	$0.024	3	54.95
11	Premium efficiency motors	63	$0.013	3	54.13
12	LED traffic signals (red and green)	15	$0.020	5	52.89
13	Agricultural scheduling systems	30	$0.007	3	52.47
14	Industrial compressed air system improvements	60	$0.015	3	52.20
15	Residential fluorescent lighting fixtures	61	$0.016	3	51.80
16	Manufactured housing	51	$0.023	4	51.50
17	Optimization of chiller and tower systems	30	$0.008	3	51.26
18	Residential new construction	36	$0.011	3	50.04
19	LED traffic signals (red)	10	$0.024	5	49.40
20	New building commissioning	30	$0.011	3	49.35
21	Improved lighting design practices	70	$0.022	3	49.22
22	Screw-in compact fluorescent lamps	99	$0.030	3	48.61
23	New commercial buildings -- integrated design	77	$0.029	3	45.02
24	Dry-type distribution transformers	32	$0.027	4	44.38
25	High quality motor repair practices	20	$0.017	3	43.09
26	Wastewater facility energy efficiency optimization	10	$0.024	4	42.57
27	Commercial heat pump water heaters	23	$0.019	3	42.30
28	Residential efficient windows	38	$0.024	3	41.06
29	Advanced commercial glazing	34	$0.016	2	39.57
30	Commercial refrigeration integrated design	10	$0.013	2	36.83
31	Ground source heat pumps	9	$0.020	2	31.52
32	Ground source heat pumps w/water heating	10	$0.021	2	31.22
33	Integrated space/water heating heat pumps	88	$0.032	3	45.46
34	Occupancy sensors	95	$0.034	3	45.23
35	Heat pump water heaters	162	$0.034	2	51.44
36	Daylight dimming controls	59	$0.038	2	27.99
37	High-efficiency air-source heat pumps	32	$0.045	3	24.61

* Note: These measures have negative costs and have been ranked assuming a zero CSE.

Reverse Weighting

Potential Energy Savings:	35%
Cost of Saved Energy:	25%
Likelihood of Success:	45%

Rank	Measure/Practice	Svngs	CSE	Success	Score
1	Tumble-action clothes washers*	177	$0.000	4	91.00
2	High-efficiency electric storage water heaters	96	$0.006	5	81.86
3	Commercial/industrial exit signs*	25	$0.000	5	72.87
4	Low energy/water residential dishwashers*	54	$0.000	4	68.98
5	Commercial building retro-commissioning	136	$0.021	3	62.69
6	Optimization of microelectronics HVAC systems	100	$0.013	3	60.83
7	LED traffic signals (red and green)	15	$0.020	5	59.90
8	High-efficiency packaged commercial refrigeration equipment	56	$0.010	3.5	59.26
9	LED traffic signals (red)	10	$0.024	5	57.13
10	Residential duct sealing	106	$0.024	3	56.15
11	Manufactured housing	51	$0.023	4	55.91
12	Premium efficiency motors	63	$0.013	3	54.26
13	Improved building code implementation*	18	$0.000	3	53.61
14	Industrial pumps, fans & blowers	131	$0.020	2	53.58
15	Industrial compressed air system improvements	60	$0.015	3	52.70
16	Residential fluorescent lighting fixtures	61	$0.016	3	52.44
17	Agricultural scheduling systems	30	$0.007	3	52.01
18	Screw-in compact fluorescent lamps	99	$0.030	3	51.18
19	Optimization of chiller and tower systems	30	$0.008	3	51.11
20	Improved lighting design practices	70	$0.022	3	50.78
21	Residential new construction	36	$0.011	3	50.37
22	Dry-type distribution transformers	32	$0.027	4	50.02
23	New building commissioning	30	$0.011	3	49.70
24	Wastewater facility energy efficiency optimization	10	$0.024	4	47.98
25	New commercial buildings -- integrated design	77	$0.029	3	47.84
26	High quality motor repair practices	20	$0.017	3	44.69
27	Commercial heat pump water heaters	23	$0.019	3	44.18
28	Residential efficient windows	38	$0.024	3	43.69
29	Advanced commercial glazing	34	$0.016	2	38.47
30	Commercial refrigeration integrated design	10	$0.013	2	35.67
31	Ground source heat pumps	9	$0.020	2	31.67
32	Ground source heat pumps w/water heating	10	$0.021	2	31.46
33	Integrated space/water heating heat pumps	88	$0.032	3	48.49
34	Occupancy sensors	95	$0.034	3	48.52
35	Heat pump water heaters	162	$0.034	2	51.17
36	Daylight dimming controls	59	$0.038	2	30.50
37	High-efficiency air-source heat pumps	32	$0.045	3	31.17

* Note: These measures have negative costs and have been ranked assuming a zero CSE.