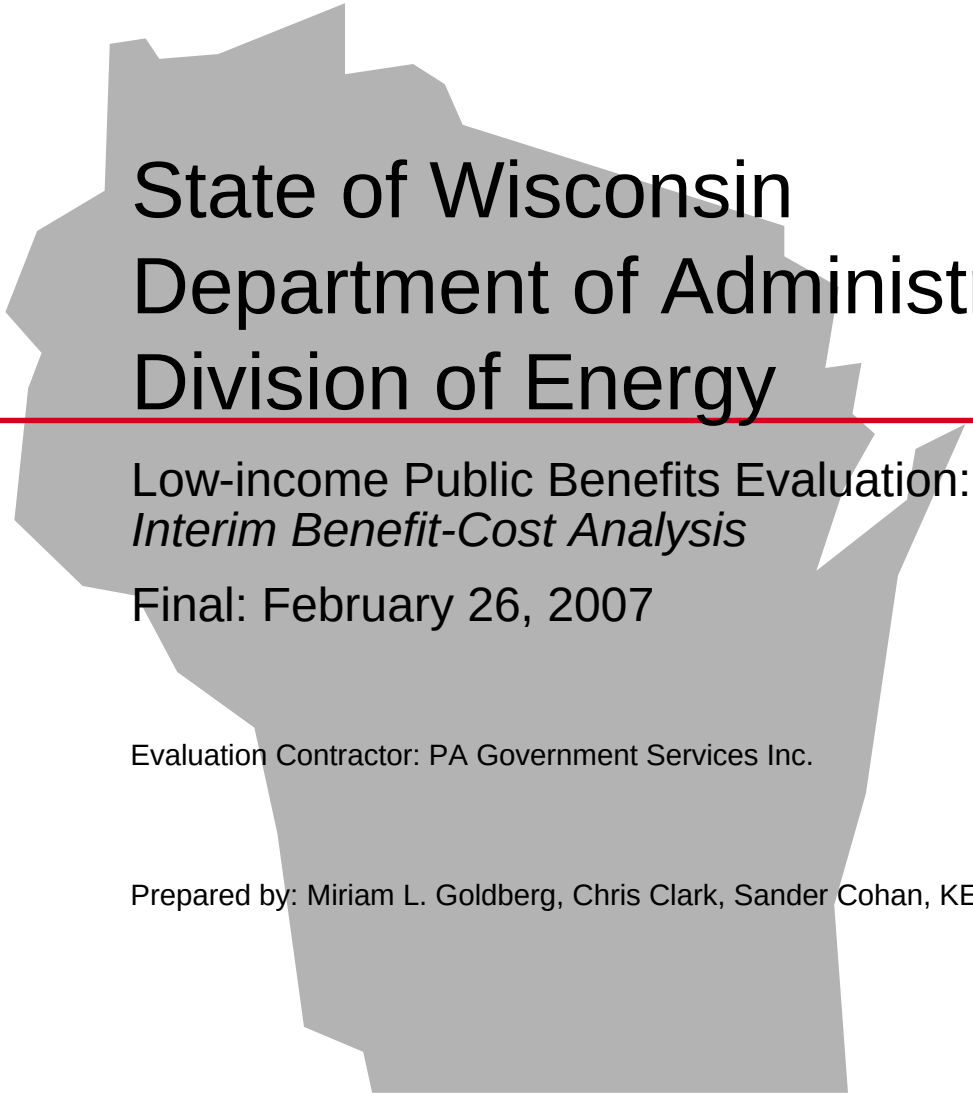
PA Consulting Group



State of Wisconsin Department of Administration Division of Energy

Low-income Public Benefits Evaluation: *Interim Benefit-Cost Analysis*

Final: February 26, 2007

Evaluation Contractor: PA Government Services Inc.

Prepared by: Miriam L. Goldberg, Chris Clark, Sander Cohan, KEMA Inc.

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1. EXECUTIVE SUMMARY

1.1 PURPOSE OF THIS REPORT

This report provides a benefit-cost analysis of Wisconsin's Weatherization Assistance Program (WAP).

The report is based on evaluation findings from the first five years of program operations. The objective of this study is to provide relevant information to Wisconsin policymakers, regulators, utilities, and other stakeholders on the potential savings to be gained from current and future investments in this program.

The analysis presented here focuses on the value to the state of Wisconsin of energy-efficiency measures implemented as a result of all funding sources that contribute to WAP, including Public Benefits funds.[1] This value includes savings on energy bills, associated benefits of the measures not related to energy bills, mitigation of environmental externalities, and economic impact.

1.1.1 Timeframe

For this report, the analysis assumes Public Benefits will provide funds and DOA will manage WAP for 10 years beginning in 2001 (Fiscal Year 2002, denoted FY02). The total impact of the program is measured for an additional 15 years after funding ends (FY26). Inputs and projections used for this analysis are based as much as possible on specific WAP funding plans and evaluation findings. All analysis is based on current operational policies and procedures, and any changes to the policies and procedures will affect the results of the benefit-cost analysis.

1.2 APPROACH

1.2.1 Benefit-Cost Tests

This analysis takes a societal perspective to counting WAP benefits and costs. The "simple" BC test presented here is somewhat conservative. It counts as benefits only the avoided costs of well documented energy savings. These avoided costs include the value of avoided emissions for which active offset markets currently exist. The simple test is comparable to Total Resource Cost or Societal tests typically done in other states.

The "expanded" test used here is intended to be more realistic by including a broader range of effects. However, including this broader set of effects requires using estimates not necessarily counted in other jurisdictions. Costs in both tests are program spending.

The expanded BC test expands upon the simple test in several ways.

[1] WAP funding comes from the Department of Energy, Low-income Home Energy Assistance Program (LIHEAP), and State Public Benefits Program. The percent of total WAP funding comprised of Public Benefits funds ranges by year (from a low of 42% in 2002 to a high of 71% in 2005). The initial benefit-cost analysis was also based on all funding sources that contribute to WAP.

- Non-energy benefits are included for the program.
- Avoided emissions externality costs for expected future emissions offset markets are counted as a benefit.
- Benefits are valued in terms of their net impact on the economy, using results from the separately reported the economic impact study.

The economic impacts take into account the economic ripple effects on the Wisconsin economy of energy savings and associated non-energy and emissions effects.

1.3 KEY FINDINGS

The benefit-cost ratio for the expanded test is just over 1.0, with net benefits of $14.6 million under the 25 year timeframe under consideration. Stated differently, the long-run total benefit based on quantifiable energy savings, associated mitigated emissions, and monetizable non-energy benefits is slightly more than the program spending.

The previous BC analysis conducted for this program indicated a BC ratio of 1.9 for this program under the expanded BC test. Reasons for a lower value in the present work are:

1. Energy savings values used in the present work are based on impact analysis completed after the prior BC analysis. The whole-premise impact analysis found lower unit savings than the deemed savings that had been assumed in the earlier work. The adjusted savings based on the impact analysis are 29 percent as large as the deemed savings. Appendix A provides further detail on the energy savings values used.

2. The present work counts non-energy benefits only if they result in dollar flows through the economy. NEBs that are based on participant perceptions but would not translate into economic exchanges are not included. The prior work did count “non-economic” NEBs.

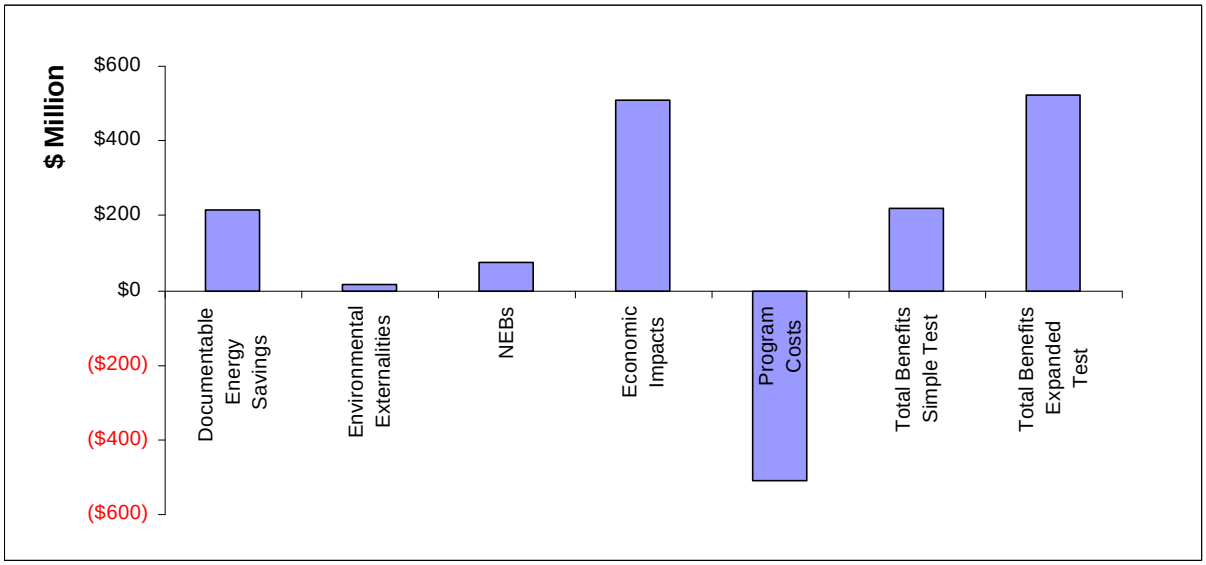
The more conservative simple test gives a BC ratio of 0.4. However, low-income programs are not necessarily expected to perform well using this type of test. The public policy rationale for these programs does not derive solely from the value of avoided energy costs, the only benefit counted in the simple test. Mitigated hardships to participants are key goals of these programs. Measures of these effects in the form of Non-energy benefits are valued in the expanded test, along with other secondary benefits to the economy.

1.4 CONTRIBUTORS TO PROGRAM BENEFITS

The value of each of the components that contributes to program benefits as well as the program costs are indicated in Figure 1-1. The value is shown in terms of the net present value[2] over the 25-year timeframe of the analysis.

[2] “Net present value” refers to standard financial terminology. This use is distinct from “net” in the sense of program attribution, net benefits (benefit minus cost), or net economic impacts.

Figure 1-1. WAP Benefit Components and Costs
Net Present Value of 25 Years of Benefits ($000,000)



All dollars are in 2007$

1.4.1 Value of Avoided Energy Costs

Documentable energy savings (observed or projected net verified savings based on documented impacts) are the foundation of the WAP's benefits. Over the timeframe of the analysis, the program is projected to provide $215.9 million in avoided energy costs.

1.4.2 Environmental Externalities

Externalities increase the value of every unit of energy savings by around 12 percent. The value of avoided externalities has been estimated based on active and planned emissions trading markets. Emissions offset markets provide an empirical basis for assigning a monetary value to emissions avoided through the program.

1.4.3 Non-energy Benefits

Non-energy benefits are nearly equal to the direct value of the avoided energy. Only NEBs that result in monetary flows are counted in this analysis. By this method, the total value of WAP NEBs is $73.6 million over the 25-year timeframe.

1.4.4 Economic Multiplier

The net economic impact of the program benefits is about 1.5 times as great as the direct sum of these benefits. Examples of economic impacts include jobs produced from the WAP and increased household spending for other goods as a result of energy savings. Thus, counting the full economic impact adds substantially to the cost-effectiveness of the program.

2. INTRODUCTION

2.1 PURPOSE OF THIS REPORT

This report provides a benefit-cost analysis of Wisconsin's Weatherization Assistance program (WAP).

The report is based on evaluation findings from the first five years of program operations. The objective of this study is to provide relevant information to Wisconsin policymakers, regulators, utilities, and other stakeholders on the potential savings to be gained from current and future investments in this program.

The analysis presented here focuses on the value to the state of Wisconsin of energy-efficiency measures implemented as a result of all funding sources that contribute to WAP, including Public Benefits funds.[3] This value includes savings on energy bills, associated benefits of the measures not related to energy bills, mitigation of environmental externalities, and economic impact.

2.2 RELATIONSHIP TO OTHER FOCUS EVALUATION WORK

This report is similar in structure and intent to a previous benefit-cost analysis completed for Wisconsin's Low-income Public Benefits programs in 2003. The analysis draws on prior evaluation work to quantify in monetary terms the benefits and costs attributable to the program. The prior work includes:[4]

- Determination of verified energy and demand savings attributable to the program
- Assessment of non-energy benefits
- Assessment of emissions mitigation associated with energy savings.

Additional steps undertaken for the present analysis include:

- Compilation of program spending information
- Projection on and estimation of benefit-cost formulas.

In addition, an economic impact analysis is being conducted in parallel with this work using most of the same data streams.[5] The economic impact analysis traces WAP spending

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[3] The majority of WAP funding comes from the Department of Energy, Low-income Home Energy Assistance Program (LIHEAP), and State Public Benefits Program. The percent of total WAP funding comprised of Public Benefits funds ranges by year (from a low of 42% in 2002 to a high of 71% in 2005). The initial benefit-cost analysis was also based on all funding sources that contribute to WAP.

[4] *Low-income Public Benefits Evaluation, year 3 Low-income Program Evaluation – Volume 1. Report,* October 2004; *Low-income Non-energy Benefits for Inclusion in Economic Analysis – Final Report,* April 3, 2006; *Estimating Seasonal and Peak Environmental Emissions Factors – Final Report,* May 2004.

[5] *Draft Economic Development Benefits: FY07 Evaluation Report* (Focus Evaluation Team, 2006).

through the economy and measures the cumulative effects of that spending. A key step in the benefit-cost analysis is to incorporate products of that analysis into a benefit-cost test. The combination of these results provides an overall assessment of program costs and benefits to the state.

2.3 TIMEFRAME AND ASSUMPTIONS

For this report, the analysis assumes Public Benefits will provide funds and DOA will manage WAP for 10 years beginning in 2001 (Fiscal Year 2002, denoted FY02). The total impact of the program is measured for an additional 15 years after funding ends (FY26).

Inputs and projections used for this analysis are based as much as possible on specific WAP funding plans and evaluation findings. Documentable energy savings impacts and participation are projected based on spending levels and findings to date. Non-energy benefits are projected in proportion to participation levels.

2.4 APPROACHES

This study includes a series of benefit-cost tests designed to calculate not only the direct benefit of WAP, but also the benefit of the program to the economy as a whole, taking into account indirect benefits.

In all benefit-cost tests, benefits are compared with costs in terms of net benefit (the difference between benefits and costs) and in terms of the benefit-cost ratio. This report presents the results of two approaches, which we have called the “simple” and “expanded” benefit-cost (BC) tests.

The “simple” BC test is somewhat conservative. It counts as benefits only the avoided costs of well-documented energy savings. This test is comparable to those typically done in other states.

The “expanded” test is intended to be more realistic by including a broader range of effects beyond energy savings. However, including this broader set of effects requires using estimates that have somewhat less empirical certainty and that are not necessarily counted in other jurisdictions.

For both tests, the analysis here considers total benefits of a 10-year program rather than considering a single program year. We also consider a time frame of benefits that extends 15 years beyond the assumed end of the program. Analysis based on multiple program years provides more stable results less subject to fluctuation from particular program year circumstances. Extending many years beyond the end of the program allows the benefits of most measures to be counted for their full measure lives. The particular time-frames of 10 years of program plus 15 beyond the end were taken for consistency with similar analysis being conducted for the state’s Focus on Energy program.

Simple BC Test

The simple benefit-cost test is comparable to types of analysis conducted for other programs and states. The methodology combines elements of a Total Resource Cost (TRC) and Societal Test approach. The analysis calculates the total benefit of the program based on the most basic measure of benefits, the avoided energy costs attributable to the program. These

avoided costs include the value of avoided emissions for which active offset markets currently exist. Avoided energy costs are determined at the utility level. Costs are the simple sum of program and customer costs.

Expanded BC Test

The expanded BC test expands upon the simple test in several ways.

- Non-energy benefits (and costs) are included for the program.
- Avoided emissions externality costs for expected future emissions offset markets are counted as a benefit.
- Benefits are valued in terms of their total impact on the economy, as determined from the economic impact analysis.

The economic impacts take into account the economic ripple effects on the Wisconsin economy of energy savings and associated non-energy and emissions effects.

The same costs are counted in the expanded BC test as in the simple test.

2.5 SCENARIOS AND LEVELS OF ANALYSIS

Each benefit-cost test was evaluated under a single spending scenario. The funding scenario utilized for WAP in the benefit-cost analysis is representative of the current funding level, and is not expected to change or be reallocated on a moving forward basis. This funding scenario indicates the cost-effectiveness of WAP spending to date, but assuming a longer total funding period.

The benefit-cost analysis was conducted for WAP based on both the simple and expanded version of the benefit-cost test.

2.6 ORGANIZATION OF THE REPORT

The cost and benefit components counted in the analysis are described in Section 3. The findings from the analysis are presented in Section 4. The benefit-cost methodology is described in detail in Section 5.

Appendix A provides details of the development of projected savings and cost streams. Appendix B contains a memorandum describing the emissions modeling that is the basis for the externality valuation. Appendix C provides a comparison between the present results and those from the initial benefit-cost analysis produced in 2003. Appendix D lists the measure life assumptions used in the analysis.

3. ELEMENTS OF COSTS AND BENEFITS

This section provides an overview of the costs and benefits included in the analysis.

3.1 COSTS

Total program spending is counted as all money spent on WAP. This includes measure installation costs and administrative costs (both state and local agencies). There are no customer incremental costs for measure implementation associated with WAP.

In principle, non-energy costs associated with the measure implementation would also be counted on the cost side. These would be costs associated with the effect of the measure other than the direct costs of implementation. Examples of this type of cost include reduced productivity, lower amenity value, or increased operating costs. In practice, non-energy costs have not been identified for WAP. The non-energy benefits analysis did explore costs as well as benefits. However, all non-energy effects identified were positive benefits.

3.2 BENEFITS

Benefits counted in this analysis are the following:

- **Documentable energy savings.** These are the energy savings from energy-efficiency measures attributable to the program, based on the evaluation verified net savings reported in prior impact evaluations. These energy savings are counted as benefits over the measure lifetime, or the 25 year horizon of the benefit-cost analysis, whichever is shorter. The dollar value assigned is the avoided cost to the utility per kWh or therm of energy and kW of electricity demand.
- **Avoided externalities:** The avoided externalities considered in this analysis are the avoided air emissions associated with reduced electricity (kWh) and natural gas (therms) consumption. Avoided externalities are divided into two categories:
  - ***"Economic" externalities*** translate into dollar flows in the economy. These are externalities that have been "internalized" via trading markets or emissions caps. These externalities are counted in the simple b/c test as an additional avoided cost per unit of energy saved. They are also included in the economic impact model.
  - ***"Non-economic" externalities*** have values set by regulatory policy or public willingness to pay, but do not translate into flows through the economy. These externalities are not included in the economic impact model. However, they are counted in the expanded b/c test as an additional avoided cost per unit of energy saved.
- **Non-energy benefits.** Non-energy benefits are benefits to the measure implementer or in some cases the utility other than avoided energy costs associated with the measure. For use with the economic impact model, non-energy benefits (and costs) are divided into two categories:
  - ***"Economic" non-energy benefits and costs*** translate into dollar flows in the economy. Examples include reduced sick time, improved home safety,

and improved productivity. These effects are calculated on a per participant basis and are included in the economic impact model.[6]

- ***"Non-economic" non-energy benefits and costs*** have perceived value to implementers or other parties, but do not result in monetary flows. Examples include residents' higher or lower satisfaction with lighting quality. These effects would not be included in the economic impact model. The present analysis does not count any non-economic non-energy effects even outside the economic impact model.

Additional benefit-cost components that would be included if present but are assumed to be zero for this program are the following:

- **Added market effects energy savings.** Market effects savings are the energy savings due to additional measures implemented outside of the program by either participants or nonparticipants that would not have occurred without the program. For the Low-income Program, no market effects savings are estimated.
- **Incremental project costs to customers.** For the most part, there are no incremental costs paid by WAP recipients for their efficiency measures. The multi-family component of WAP does require a co-payment by the property owner for some projects. However, at this point in the program, this cost is quite small and is treated as zero for this analysis.

The simple BC test counts as benefits only the avoided energy costs and associated avoided economic externalities associated with the energy savings. The expanded test also counts non-energy benefits (NEBs) and non-economic externalities. The total economic value of the avoided energy is determined in the expanded BC test as the output from the economic impact model. We refer to the difference between this total economic benefit and the direct sum of the benefit components as the "economic impact adder."

3.3 USE OF NET VALUES

In this report, the term "net" is used in three essentially distinct ways, arising from standard terminology that applies to different components of the analysis. While these multiple uses of the same term can lead to some confusion, we use "net" in these different senses so that these analysis components will each be understandable in terms of its usual framework. Following is an explanation of the kinds of "netting" that occurs in the analysis.

1. Net Benefits

In the context of a benefit-cost analysis, the "net benefit" is simply the difference between the benefits and the costs counted. This "netting" is distinct from the use of "net-to-gross" or attribution factors in the determination of the benefits and costs.

[6] NEBs values used in the BC analysis are reported in *Low-income Non-energy Benefits for Inclusion in Economic Analysis,* Final report April 3, 2006.

2. Net Economic Impacts

The economic impacts used as a measure of overall program benefit are "net" economic impacts. That is, these impacts are the effect of the program on the economy over and above the "multiplier" effect that would result if the same money were spent without any direct productive effects.

3. Net Present Value

The value today of a stream of future payments (or costs) based on a particular discount rate is the net present value (NPV). In this analysis, we determine streams of costs and benefits over the timeframe of the analysis, and express these in terms of their net present value. Total benefits and costs are calculated in net present value terms.

In the expanded test, the total program benefit is the *net* economic impact (i.e. impact beyond the base effect of program spending), plus the value of avoided emissions not captured in the economic model.

For both tests, each benefit and cost stream over the timeframe of the analysis is translated into its *net present value,* the financial value in 2007$ of the discounted stream. *Net* benefits are the difference between total program benefit and total (societal) cost associated with the program, where both benefits and costs are expressed in NPV terms.

3.4 RELATIONSHIP OF BENEFIT-COST ANALYSIS AND ECONOMIC IMPACT ANALYSIS

This BC analysis is conducted in conjunction with an economic impact analysis, separately reported. The two analyses use the same input streams of program spending and program effects. The expanded BC test uses an output of the economic impact analysis as a measure of program benefits. (Both the simple and expanded BC tests use the same measure of costs, as described under Section 3.1.)

In the simple analysis, documentable energy savings are counted as benefits. Program costs excluding incentives and customer net incremental costs are counted as costs. In the expanded analysis, NEBs are added to the list of benefits and all benefits are valued based on the output of the economic impact model. "Non-economic" externalities are added to this benefit value. Table 3-1 indicates the relationship among these elements.

Table 3-1. Relationship of Elements in Economic Model and Simple and Expanded BC Tests

Analysis Components Included in			General Category	Element	BC Tests	
Simple Benefit–Cost	Expanded Benefit-Cost	Economic Impact Analysis			"Benefit"	"Cost"
Yes	Yes	Yes	Direct costs and energy savings	Program operations		+
				Documentable energy savings (avoided cost of energy)	+	
				Added market effects energy savings (avoided cost of energy)	+	
				End-user implementation costs for direct and market effects energy savings		+
				Internalized externalities (NOx, SOx)	+	
No	Yes	Yes	Other direct effects on the state economy	Economic non-energy benefits	+	
No	Yes	Yes	Spin-off effects on the state economy	Business sales	+	
			Dynamic effects on the state economy	Business expansion and attraction	+	
No	Yes	No	Non-financial changes to WI households and businesses	CO2 and Hg emissions reductions	+	

\+ Added to the benefit or cost

The simple benefit-cost test incorporates all of WAP's documentable energy effects on the Wisconsin economy. This test does not include the spin-off and dynamic effects that are calculated by the economic impact model. These effects, along with economic non-energy benefits and non-economic emissions effects, are included in the more comprehensive expanded benefit-cost test. As indicated, the expanded BC test counts all these effects listed.

The benefits components counted in each test and considered in the economic analysis are displayed in condensed form Table 3-2. The simple analysis counts only the energy savings and direct costs. The expanded test counts these direct effects; other direct effects on the Wisconsin economy; the non-economic changes to state businesses and homes; and the economic "adders" that result from the economic impact model. The economic analysis described in a separate report determines the spin-off and dynamic effects on the economy that translate into economic adders. That analysis does not count the non-economic externalities and non-energy benefits.

Table 3-2. Benefits Components Included in the Simple and Expanded Tests, and in the Economic Analysis

<table>
<tr><th>Simple
Benefit-Cost Test</th><th>Expanded
Benefit-Cost Test</th><th>Economic Impact</th></tr>
<tr><td colspan="3">Direct costs and energy savings</td></tr>
<tr><td></td><td colspan="2">Other direct effects on the state economy</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Spin-off effects on the state economy</td></tr>
<tr><td colspan="2">Dynamic effects on the state economy</td></tr>
<tr><td></td><td>Non-financial changes to WI households and businesses</td><td></td></tr>
<tr><td></td><td></td><td>Transfer payment</td></tr>
</table>

These elements, their relationship, and how their values were determined are discussed further in Section 5.

3.5 VALUATION FACTORS

This benefit-cost analysis pulls together information from a number of sources. The projected streams of energy savings and costs were developed based on information provided largely by program-area evaluations. To monetize benefit and cost streams and to develop associated estimates of net present value, the following additional information was required:

- The discount rate
- The energy escalation factor
- The unit avoided cost of energy
- The unit avoided cost of externalities.

The assumptions underlying each of the above valuation factors used in the benefit-cost analysis are discussed below.

Net Present Value Discount Rate: Consistent with the previous study, the current BC analysis uses a discount rate of 3 percent to calculate the present value of net benefits.

The 3 percent rate is based on the real public cost of capital (i.e., long-term bond rate net of inflation). The U.S. Office of Management and Budget recognizes 3% as the real cost of government borrowing.[7] The public cost of raising money is lower than the private cost

[7] OMB Circular A-94, Appendix C, rev January 2007. http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

because it is subsidized by its special tax free status and it has government backing. This approach allows the relative benefits or payback from WAP to be evaluated on a basis that is consistent with the assessments being done for other public welfare programs.

Energy Escalation—Over the past several years, the cost of energy in Wisconsin has escalated at a rate higher than the rate of inflation. To compensate, the analysis includes an annual energy escalator of 1.0% to account for increases in the cost of all fuels used as inputs for electricity production.

Various forecasts from organizations such as the U.S. Energy Information Administration and the Wisconsin PSC estimate energy cost escalation factors from 0.3% to 1.5% above inflation, depending upon the assumptions used. Additionally, the PSC estimates that coal costs will increase at an average annual rate of 3.05% and natural gas a 3.55%, including inflation. Assuming the rate of inflation is approximately 2.5%, a 1% escalation factor for fuels is therefore warranted.

Avoided Costs—This analysis uses utility avoided cost as the basis for valuing kWh, kW, and therm savings. This approach is a departure from the prior benefit-cost analysis, which valued energy based on customer avoided cost, calculated as average customer spending per kWh and therm delivered. Valuation in terms of avoided utility or supply costs is more consistent with benefit-cost analysis conducted in other jurisdictions. Avoided cost values used here are based on published reports and tariffs and discussions with members of the Wisconsin Public Service Commission.

- **kWh—**An avoided cost of electricity of $.56/kWh is utilized for the benefit-cost analysis. This amount is based on an estimate of $0.52/kWh, increased by 8% to account for line loss. This avoided cost figure is based on the electric future market assessment for 12 months as reported in "Platt's Megawatt Daily." For comparison purposes, this amount was validated against the average marginal energy cost of $53.9 per MWh, projected in docket 6680-UR115 by Alliant Energy.
- **kW—**The cost of avoided kW has two components. The first component is the avoided cost of new generation capacity, valued at $60/kW. This calculation is derived based on a PSC buy-back rate of $50.82 plus an 18% reserve margin requirement. The second component is the avoided cost of transmission capacity, valued at $44/kW. This number is estimated by multiplying the per kWh cost of avoided transmission (from the Draft 2006 Wisconsin PSC Strategic Energy Assessment) by total kWh of electricity purchased by WI customers from EIA State Electricity Profiles.[8] The resulting total annual transmission cost is divided by total peak summer demand (kW, as reported in the Draft 2006 Wisconsin PSC Strategic Energy Assessment). The resulting total value of avoided demand is $104/kW.
- **therms—**The avoided cost of natural gas also has two components. The first component is a value of $0.84/therm, an estimate of the average cost of gas per therm delivered to Wisconsin. This value is derived by looking at the costs built into longer term forward gas contracts in 2005, while also accounting for Henry Hub

[8] Available at http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html

prices prior to Hurricane Katrina and the unusually warm winter of 2006. This amount was then adjusted further to account for differences in costs of transport within Wisconsin across customer segments. To account for transportation costs, the project team used an average of published gas transport tariffs from We Energies and Madison Gas and Electric, determining the basket of prices in accordance with the program under evaluation. The resulting residential rate utilized is $1.06/therm.

Avoided Emissions—Historical avoided emissions from WAP were developed from data provided by the Environmental Protection Agency (EPA). Forecast data for avoided emissions were developed based on output from a Multi-Pollutant Optimization Model. This model uses yearly plant-level data on fuels, emissions rates, capacity factors, and costs along with the total system hourly load curve to estimate emissions from marginal producers. The model is described further in Emissions Factors and Allowance Prices, included as Appendix B to this report. For the 2006 analysis, factors for NO_x, SO_x, CO_2, and mercury were included.

- **Generation Emissions Factors—**Emissions factors for electricity generation were estimated using an approach previously developed in 2004 reported in the Focus on Energy publication, *Estimating Seasonal and Peak Environmental Emissions Factors*. Emissions input data for these factors came from estimates of hourly emissions per hour per MWh of generation in marginal plants in the two NERC regions of Wisconsin in 2006. Marginal plants were plants that had the most change in MWh, increase or decrease, over the previous hour. For additional details, please see Appendix B.

- **Natural Gas On-Site Use Emissions—**Emissions factors for natural gas used in the analysis calculate the effect of energy efficiency on non-electric-related emissions at a customer's site. Values for this type of avoided emissions calculation were taken from the EPA's Technology Transfer Network Clearinghouse for Inventories and Emissions factors. While most factors were uniform, NOx emissions varied by size and configuration of the on-site boiler. Therefore, this type of emission required further delineation by equipment size. For NOx emissions, which are particularly sensitive to equipment size, we used the mid-range emissions factor shown in the table below.

- **Allowance Prices—**Historic and forecast allowance prices were taken from the Multi-Pollutant Optimization Model. The model, designed to evaluate environmental compliance options, explores the emissions costs and benefits of fuel choice, capital investment in pollution control equipment, allowance market purchases, and generating unit operating decisions.

Emissions factors and allowance prices utiltized for Years 1, 10, and 25 of the analysis are shown used for the BC analysis are shown in Table 3-3. Resulting avoided emissions values in $/kWh and $/therm are shown in Table 3-4.

Table 3-3. Emissions Factors and Allowance Prices

	Avoided Pollutant	Generation Factors (lbs/MWh)	Natural Gas On-Site Use Factors (lbs/therm)	Allowance Price ($/ton)		
				Year 1	Year 10	Year 25
Economic	NO_x	2.1	0.0000588	915	1468	2168
	SO_x	4.6	0.009804	186	773	2133
Non-Economic	CO_2	1746	11.76	1	7	24
	Mercury	0.0000179	2.55E-08	9,000,000	41,000,000	126,000,000

Table 3-4. Value of Avoided Emissions

	Avoided Pollutant	Year 1		Year 10		Year 25	
		$/kWh	$/therm	$/kWh	$/therm	$/kWh	$/therm
Economic	NO_x	$0.0010	$0.0000	$0.0015	$0.0000	$0.0023	$0.0001
	SO_x	$0.0004	$0.0009	$0.0018	$0.0038	$0.0049	$0.0105
Non-Economic	CO_2	$0.0009	$0.0059	$0.0061	$0.0412	$0.0210	$0.1411
	Mercury	$0.0001	$0.0001	$0.0004	$0.0005	$0.0011	$0.0016

3.6 COMPARISON WITH PRIOR REPORT

The analysis in this report is similar to that of the Initial Benefit-Cost report (*Initial Benefit-Cost Analysis: Final Report,* March 31, 2003.), but has some important differences. These differences, and their likely effect on the benefit-cost ratios, are detailed in Appendix C. Also presented in Appendix C is a re-calculation of the prior BC ratios using the current formula for a more meaningful comparison with the present work.

The key differences are as follows:

1. The current analysis values all energy savings in terms of 2007 avoided costs, while the prior analysis used average energy prices from 2001–2002. In addition, the present analysis explicitly values avoided capacity, in kW demand at system peak hours. In the prior analysis, capacity costs were included in the average price per kWh. The overall effect of these changes is to increase the total value of saved energy, and hence to increase the BC ratios.

2. An energy cost escalator of 1% is used. That is, energy costs rise 1% faster than inflation.

3. The value of avoided emissions has been reduced somewhat based on updated analysis using similar methods. In the prior report, avoided externalities added about 20 percent to the avoided energy cost. In the present analysis, avoided externalities add about 8 percent.

4. FINDINGS

4.1 PROGRAM BENEFITS

Benefits of the Weatherization Assistance program (WAP) are shown for Years 1, 10, and 25. Respectively, these are the first year of the program, (assumed) final year of the program, and the point 15 years after the assumed program close.

The benefits for each year are the total effects of all measures implemented as a result of the program up through that year. Thus, the documentable energy savings for Year 1 would be the annual energy savings due to measures implemented through WAP and attributable to it (first-year net savings). The documentable savings shown for Year 10 are the net annual energy savings resulting from all measures implemented through the program in Years 1 through 10 and persisting until Year 10. The documentable savings shown for Year 25 are the net annual energy savings due to measures implemented in Years 1 through 10, adjusted for persistence over the average measure life of the installed measures. For example, if the average measure life is 20 years, some measures will last longer, so that there are still savings in Year 25 from measures installed under the program 15 or more years prior.

Market effects savings are not applicable to WAP and are not included in the analysis. Under the simple benefit/cost test, only the value of documentable energy savings, including associated economic externality savings, are counted as benefits. For the expanded benefit-cost test (see Section 4.4 below), results of the economic impact analysis, which incorporate economic externalities and NEBs, are included among the benefits of WAP, together with non-economic externalities.

Historical savings for the current benefit-cost analysis are lower than in the previous benefit-cost analysis. The primary reason is that the initial analysis was conducted prior to the 2004 impact evaluation of WAP. That evaluation found a lower net-to-gross ratio than had previously been assumed for the same period. This effect is partly offset by the use of 2007 dollars for the analysis, together with an energy escalation factor.

4.2 PROGRAM COSTS

The costs associated with WAP for Years 1, 10, and 25 are also shown. Respectively, these are the first year of the program, (assumed) final year of the program, and the point 15 years after the assumed program close. For reasons described above, costs are shown for a single funding scenario only.

The same costs are utilized for both the simple and expanded tests. These include the program costs as well as the incremental cost to the customer. In the expanded test, the total value of these costs is determined as the output of the economic impact model with these costs as inputs.

4.3 BENEFIT-COST RESULTS—SIMPLE TEST

Benefit-cost analysis using the simple test was performed for the Weatherization Assistance program (WAP). Benefit-cost results are illustrated in Table 4-1 below.

Table 4-1. WAP Benefit-Cost Components ($000,000)

Year	FY	Select Individual Benefits				Total Benefits	Total Costs	Net Benefits	B/C Ratio
		Documentable Energy Savings	Economic Envt'l Externalities	Program Costs	Incremental Costs				
1	2002	$1.1	$0.0	$34.6	$0.0	$1.1	$34.6		
10	2011	$15.2	$0.2	$56.3	$0.0	$15.4	$56.3		
25	2026	$10.8	$0.2	$0.0	$0.0	$11.0	$0.0		
NPV Years 1 through 25		$215.9	$3.5	$508.2	$0.0	$219.4	$508.2	-$288.8	0.4

*All dollars are in 2007$; Program costs are exclusive of incentives

A benefit-cost ratio of 0.4 is calculated for the 25-year timeframe under consideration. That is, over a 25-year timeframe, the net present value at Year 1 of the stream of benefits is nearly one half that of the net present value of the stream of program spending.

The rationale for Low-income Programs derives from policy objectives to serve this population, so that the program justification goes beyond the value of avoided energy. Programs of this type are not necessarily expected to pass a benefit-cost test on this basis alone. The rationale for these programs does not derive solely from the value of avoided energy costs, the only benefit counted in the simple test. Mitigated hardships to participants are key goals of these programs.

The expanded test presented below, which values non-energy benefits as well as documentable energy savings, provides a more comprehensive measure of the program's cost-effectiveness.

4.4 BENEFIT-COST RESULTS—EXPANDED TEST

Benefit-cost results for the Low-income WAP using the expanded benefit cost test take into account the total change to the state economy resulting from the Program, as measured by the economic impact analysis. In addition to documentable energy savings, the economic impact analysis incorporates economic externalities and NEBs, along with non-economic externalities. Table 4-2 shows the inputs for the economic impact model, as well as the results of the economic impact analysis for the WAP program.

Table 4-2. WAP Benefits and Economic Impact for Expanded Test ($000,000)

Year	FY	Documentable Energy Savings	Economic Envt'l Externalities	NEBs	Economic Impacts	Economic Impacts Adder
1	2002	$1.1	$0.0	$0.8	$2.6	$0.7
10	2011	$15.2	$0.2	$7.3	$26.4	$3.7
25	2026	$10.8	$0.2	$0.7	$43.9	$32.2
NPV Years 1 through 25		$215.9	$3.5	$73.6	$426.2	$180.8

*All dollars are in 2007$

Results of the expanded benefit-cost test for WAP are shown in Table 4-3 below.

Table 4-3. WAP Benefit-Cost Components, Expanded Test ($000,000)

Year	FY	Benefit Components		Cost Components		Total Benefits	Total Costs	Net Benefits	B/C Ratio
		Economic Impacts	Non-Econ. Envt'l Externalities	Program Costs	Incremental Costs				
1	2002	$2.6	$0.0	$34.6	$0.0	$2.6	$34.6		
10	2011	$26.4	$0.7	$56.3	$0.0	$27.1	$56.3		
25	2026	$43.9	$1.5	$0.0	$0.0	$45.4	$0.0		
NPV Years 1 through 25		$508.9	$13.8	$508.2	$0.0	$522.8	$508.2	$14.6	1.0

*All dollars are in 2007$

Under the expanded benefit-cost test, net benefits for WAP are positive for the 25-year timeframe under consideration, resulting in a benefit-cost ratio of just over 1.0. When viewed through the broad economic perspective provided by economic impact analysis, WAP performs adequately from a strict cost-effectiveness perspective. In addition to documentable energy savings, NEBs and economic impacts constitute a large portion of total WAP benefits, as they are responsible for approximately 14 and 35 percent of total program benefits, respectively..

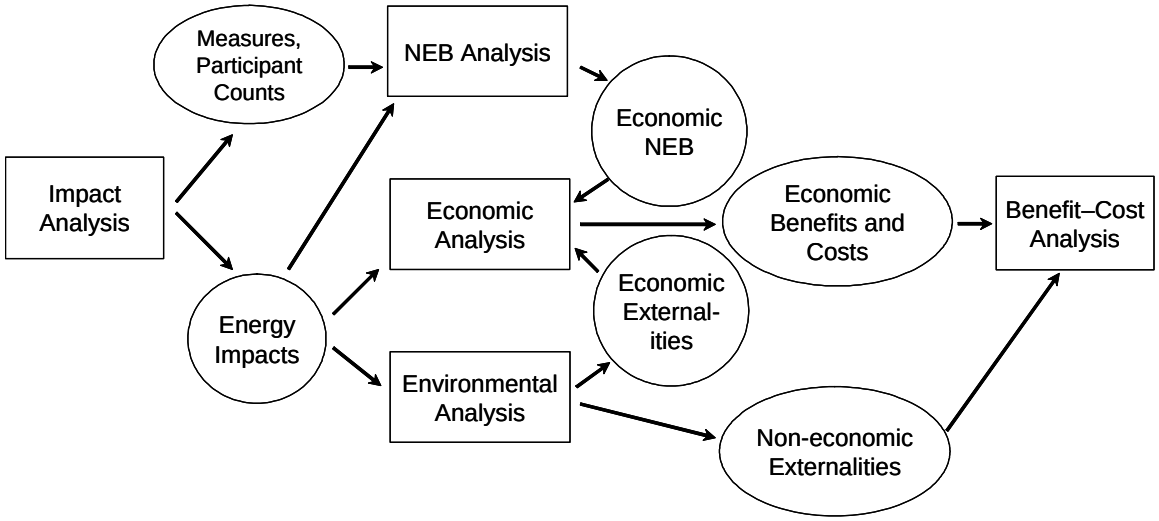
5. METHODOLOGY

This section describes the structure of the benefit-cost analysis. First, an overview of the key elements of the analysis is provided. The source of each of these elements is described in brief. The computation of the simple and economic development benefit-cost measures from these elements is then described.

5.1 ELEMENTS OF COSTS AND BENEFITS

The benefit-cost analysis combines quantified costs and benefits, as determined from a number of evaluation activities. These activities are referred to as "valuation" tasks because they assign values to distinct cost and benefit components. The relationship among the valuation tasks and cost and benefit components is illustrated in Figure 5-1.

Figure 5-1. Overview of Benefit-Cost Components and Valuation Activities



For all components, the results were projected out assuming operation of the program for a 10-year period, with additional projections made, as warranted for each program, over an additional 15-year timeframe extending beyond the end of the program. The analysis components and benefit-cost elements provided by each valuation task are described more fully in the table below.

Table 5-1. Analysis Components Contributing to the Benefit-Cost Analysis

Analysis Component	Input to BC Analysis Provided	Provided by	Extensions Required for BC	Level of Detail Used
Direct Impacts	Direct energy savings	Program Area Evaluation	Projection for future program years	Program
Non-energy Benefits	Economic non-energy benefits multipliers	NEBs Evaluation	None	Program Area
Economic Impact	Program net impact to state economy	Economic Evaluation	None	Program Area
Environmental Externality	Environmental multipliers	Environmental Evaluation	None	All Programs

5.1.1 Energy Impacts, Documentable Energy Savings

The impact analysis for WAP determines the documentable energy savings attributed to the program to date. As part of the economic and benefit-cost analysis, energy savings for future years are projected based on the projected spending levels. This analysis also determines avoided costs per kWh, kW, and therm saved, which is used to translate energy savings into dollar values.

In the previous version of the benefit-cost analysis, avoided energy cost was based on the avoided energy bill of the ratepayer. Avoided energy was calculated from average customer spending per kWh and per therm delivered. In the present version of the benefit-cost analysis, utility avoided cost is used to develop energy impact estimates. In addition, whereas the prior benefit-cost analysis considered only kWh and therms in its analysis, the current analysis also includes a separate value for avoided demand (system peak day), or kW. In previous work, the demand cost was embedded in the customer's average cost per kWh.

5.1.2 Market Effects

No market effects are assumed for this program.

5.1.3 Non-energy Benefits

The non-energy benefits (NEBs) analysis provides multipliers in the form of incremental dollar value per participant for each of several non-energy benefits. NEBs are separated into "economic" and "non-economic" benefits. "Economic" NEBs result in dollar flows in the economy. These additional benefits are included in the economic input-output model, but not the simple model. "Non-economic" NEBs have value to customers, but do not affect dollar flows. These benefits are sometimes viewed as more subjective and less concrete than the "economic" NEBs. For this reason, non-economic NEBS have not been included in this benefit-cost analysis.

5.1.4 Environmental Benefits (Externalities)

Environmental benefits in the form of avoided emissions are included to varying degrees in the simple and expanded benefit cost tests. In the simple test, we include the well documented value of avoided emissions based on existing cap and trading markets. These values are available for NO_x and SO_x. These prices reflect the costs of mitigating these emissions associated with delivering electricity. For gas, the emissions mitigation cost is not an explicit cost of delivering the fuel. However, we take the trading price as the societal value of the avoided emissions from the gas consumption.

In the expanded test, we also count as benefits avoided carbon (CO_2) and mercury (Hg). These benefits are valued based on projected markets. Because these values are less well defined at this stage, we do not include them in the simple test.

Evaluation's environmental analysis developed emissions factors for electricity and gas saved in terms of pounds of emission per kWh and per therm. As described in Section 3, the emissions model used defined emissions factors for SO_x, NO_x, CO_2, and mercury (Hg) emissions. The analysis also developed dollar values for each of these emissions based on current and projected emissions trading markets. For SO_x and NO_x, current emissions offset markets exist, and present emissions values were forecast for 25 years. For CO_2 and Hg

emissions, regulatory markets are not expected to exist until 2009 and 2010, respectively. Projected emissions values for the onset of these markets were both forecast for 25 years to 2026. In addition, to enable valuation of avoided CO_2 and Hg emissions in program years FY02 to FY09, emissions values were developed based on a regression methodology developed expressly for this purpose. Since the economic impact benefit-cost test is a societal test, it was our intent to capture the value of these emissions in the expanded benefit-cost model irrespective of whether or not they have been prescribed a market value in an existing emissions trading marketplace.

The previous version of the benefit-cost analysis utilized the avoided bill of the customer to value avoided energy. As a result, the values of avoided SO_x and NO_x emissions were captured by active emissions trading markets, internalized in the customer's bill, and were therefore captured by the economic input-output model. The value of avoided CO_2 emissions was developed by the Wisconsin Public Service Commission and was not valued by a functional emissions trading market. Thus, avoided CO_2 did not translate into dollar flows in the Wisconsin economy. The value of CO_2 emissions was therefore counted in the benefit-cost analysis, but not in the economic input-output analysis. Mercury was not included in the original benefit-cost analysis.

The current version of the benefit-cost analysis uses utility avoided cost. SO_x and NO_x emissions, which are subject to active cap and trade regulations in Wisconsin, are included in the simple benefit-cost test, as well as in the economic input-output analysis. The value of these avoided emissions would be monetized by the PSC and would ultimately be passed onto the customer in the form of reduced rates. Avoided SO_x and NO_x emissions are therefore representative of dollar flows in the economy. In contrast, emissions values for CO_2 and Hg are not currently regulated in Wisconsin and therefore are not captured in the economic input-output analysis. They are, however, included in the expanded benefit-cost tests.

5.1.5 Economic Model

The economic input-output model counts the direct and indirect effects of all dollar flows into the Wisconsin economy resulting from the program. The model counts the effects of documentable energy and demand savings; economic NEBs; and any internalized externalities, namely avoided NO_x and SO_x emissions.

5.1.6 Costs

Both the benefit-cost analysis and input-output analysis required development of projected program spending for each year. Program spending projections were developed in consultation with Department of Administration (DOA) staff. Consistent with the economic impact report, the current benefit-cost analysis assumes operation of the program for a 10-year period (beginning in FY02) and includes impacts that extend 15 years beyond the end of the program. Analysis for this timeframe requires projections of program spending, in addition to direct impacts several years forward.

Program Incentive Payments

This program does not involve incentive payments to participants.

Incremental Project Costs

This program involves almost no customer incremental costs. Such costs are assumed to be zero in the analysis.

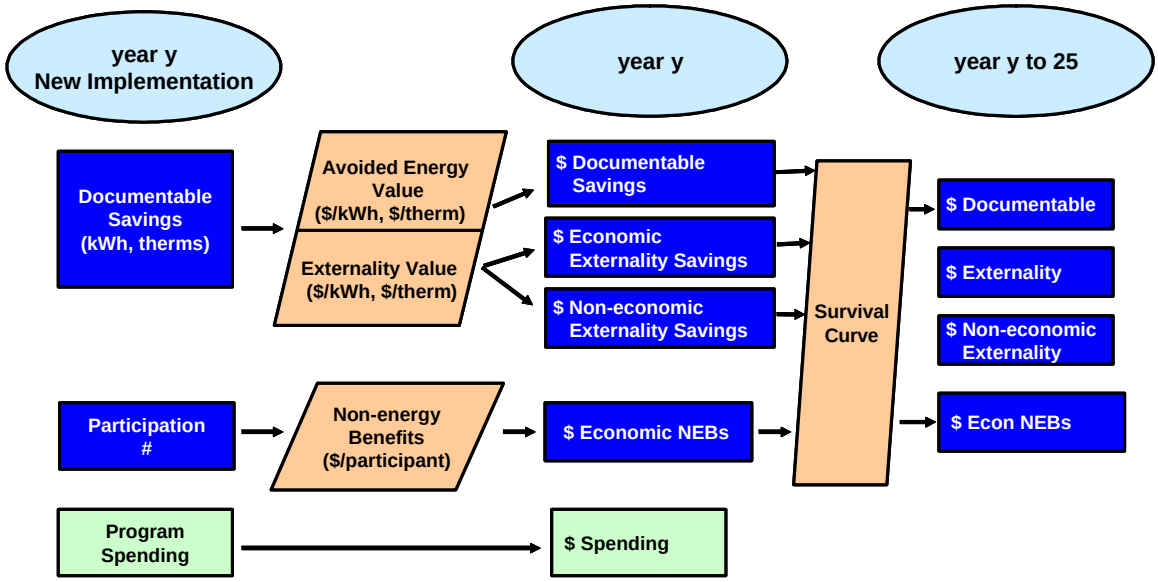
5.1.7 Relationship between the Economic Input-Output Model and the Expanded Benefit-Cost Analysis

The expanded benefit-cost analysis and the economic input-output analysis reported on separately are closely related. Many of the inputs required for the two analyses are the same. Like the economic input-output model, the expanded benefit-cost analysis counts: documentable energy savings; market effects energy savings; economic non-energy benefits; and internalized environmental externalities. The expanded benefit-cost analysis also counts the value of non-internalized externalities. In the expanded benefit-cost analysis, the output of the economic input-output model provides the total value of the elements counted in that model.

5.1.8 Developing the Input Streams

Figure 5-2 shows how the benefit streams for 25 years are developed in the benefit-cost analysis. In each of Years 1 through 25, the new implementation of energy efficient measures through the program is projected. Corresponding estimates of the numbers of program participants and their associated implementation costs are also projected. First-year dollar savings, in terms of avoided energy costs and avoided externalities are calculated from the first-year energy savings. First-year economic NEBs are calculated based on the participant counts. For each year after Year *y*, these benefits are degraded according to an assumed decay curve. The decay curve is an exponential decay, with median lifetime equal to the savings-weighted average measure life for each program area. This decay rate applies to all components of the benefits stream.

Figure 5-2. Development of Benefit Streams



5.2 BENEFIT-COST MEASURES

The benefits and costs of a program like WAP can be compared in a variety of ways. This report presents the results of two approaches, which we have called the "simple" and "expanded" benefit-cost tests. The simple benefit-cost test we use is similar to a Total Resource Cost (TRC) or Societal Test approach. The expanded benefit-cost test incorporates additional benefits, including economic impacts, avoided air emissions, and non-energy benefits (NEBs). Both tests are based on a long-term time frame, rather than assessing program effectiveness for any single year.

5.2.1 Total Resource Cost Test

The TRC test measures the net costs of a demand-side management program as a resource option based on the total program costs, both to the participants and the utility. The Societal Test, a variant of the Total Resource Cost Test, compares the avoided cost of energy supply with the combined program and participant costs. This framework has its origins in an Integrated Resource Planning process for regulated retail electricity supply. In this framework, investment in energy efficiency is justified if it is cheaper than investing in additional generation/energy supply. The Societal Test also counts avoided externalities among the benefits of energy efficiency and uses a societal discount rate (CEC, 2001b).

The benefits included in the TRC test are the avoided supply costs—the reduction in transmission, distribution, generation, and capacity costs valued at marginal costs for periods when there is a load reduction. Avoided supply costs are calculated using net program savings, or savings net of changes in energy use that would have happened in the absence of the program. The costs included in the TRC test are the program costs paid by both the utility and the participants.

5.2.2 California Public Purpose Test

The California Public Purpose Test is an extension of the Societal Test (CEC, 2001b). The primary differences between the PPT and the Societal Test are that the PPT explicitly allows for counting of non-energy benefits and also allows for consideration of a multi-year timeframe for the analysis of costs and benefits. The PPT counts the following benefits and costs.

A. BENEFITS

- Customer avoided energy costs, based on direct net energy savings. Savings net of free-ridership are valued at the average cost per kWh or therm.
- Customer avoided energy costs, due to market effects energy savings. Market effects energy savings are valued at the same avoided cost as the direct energy savings.
- Customer non-energy benefits value, based on net energy savings. Non-energy benefit multipliers are applied to the net energy savings.
- Avoided externality value, based on net energy savings. Externality multipliers are applied to the net energy savings.

B. COSTS

- **Program costs excluding incentive payments**. Incentive payments are not counted as either a program benefit or a program cost. The incentives are a transfer payment, and represent a net difference of 0.
- **Customer non-energy costs based on net energy savings**. The PPT does not explicitly mention non-energy costs. However, consistent with considering non-energy benefits, non-energy costs should also be considered and would be assigned to the cost side of the equation.
- **Customer incremental costs, net of free-ridership**. The same attribution factor used to adjust energy savings for free-ridership is applied to the in-program customer incremental costs. Only the incremental costs of measures that would not have been implemented in the absence of the program are counted. Incremental costs for market effects implementation are also counted.

5.2.3 Simple Benefit-Cost Test

The simple BC test used in this study is based on the TRC or Societal test, but with a multi-year time frame. Using this type of approach allows comparison of the WAP with similar programs around the country. The test counts as benefits net (attributable to the program) energy and demand savings, and documented market effects savings only. The simple test also counts as benefits the avoided value of economic environmental externalities. NEBs, non-economic environmental externalities, and economic multiplier effects are excluded. On the cost side, program costs are included, exclusive of incentives.

The simple test is carried out for each program portfolio (e.g., Renewable, Residential), as well for each individual program within the program portfolio. The simple test is summarized below.

A. BENEFITS

- Customer avoided energy costs based on net (i.e., program attributable) energy savings
- Avoided energy costs attributable to documented market effects.
- Economic environmental externalities for NOx and SOx

B. COSTS

- Total program spending, excluding incentive payments
- Net (i.e., program attributable) customer incremental costs.

C. RATIONALE FOR THE SIMPLE TEST

The simple test is based on direct valuation of energy savings in comparison with the total direct cost of achieving those savings.

5.2.4 Expanded Benefit-Cost Test

The expanded benefit-cost test counts benefits more broadly than the simple test. The expanded test includes NEBs and the full range of environmental benefits in addition to the same benefit elements included in the simple test. In addition, whereas the simple BC test counts the economic benefit by considering only the direct value of the benefit and cost components, the expanded benefit-cost test counts the total change to the state economy resulting from the benefits. This economic impact is calculated by running an economic input-output model for the state of Wisconsin with the expanded list of benefits as inputs.

The same costs are counted in the denominator for both the simple and expanded tests. Thus, the expanded test:

- Counts avoided non-economic externalities and NEBs in addition to the avoided energy benefits and economic externalities
- Values benefits in terms of the total economic impact of the benefits on the state economy
- Uses the same denominator (costs) as in the simple test.

The total change to the state economy is measured by the economic impact as determined by the economic input-output model. This impact captures the effects of documentable energy savings, as well as those environmental externalities and NEBs that result in dollar flows through the economy.

Benefits that do not result in dollar flows through the economy are not captured by the economic impact model. We refer to these benefits as “non-economic” benefits. These benefits are added to the economic impact calculated from the “economic” benefits to determine the total benefit for this test. In this analysis, NO_x and SO_x costs are internalized via emissions trading markets, and are counted in the economic model. CO_2 and Hg are not internalized and are not counted in the model; these benefits are added to the economic impact of the “economic” benefits to determine the total benefit. This analysis counts only “economic” NEBs.

The primary gains to the economy captured in the economic impact that are not captured by simply summing benefits as in the simple test include:

- Substitution of in-state purchases (such as for locally produced energy-efficiency products and services) for out-of-state purchases (such as for fossil fuel).
- Increased competitiveness of Wisconsin businesses as a result of increased in-state purchases.

The economic development benefits of interest to the analysis of this program are:

1. Added worker earnings
2. Corporate net profits
3. Beneficial changes in the cost of living.

Program savings explicitly benefiting Wisconsin households are best evaluated using the real disposable income impact. This impact captures both the underlying earnings creation as the

Wisconsin economy benefits under the program, and the reduction in the cost of living to households. Thus, the measure of economic impact used to quantify the benefits for the Low income Program for the expanded BC test is the real disposable income impact.

Distinct elements of the expanded benefit-cost test are summarized below.

A. BENEFITS

- Economic impacts from the Economic Input-Output Model, where the model inputs are:
  - Avoided energy costs attributable to documented market effects
  - Economic environmental externalities for NOx and SOx
  - Economic NEBs.
- Plus elements not included in the Economic Input-Output Model:
  - Environmental externalities for CO_2 and Hg, which are not internalized in the Economic Input-Output Model.

B. COSTS

- Total program spending.

C. RATIONALE FOR THE EXPANDED TEST

The expanded test is intended to capture the full effects of the program on the state's economy. The test incorporates the flow-through effects of the program spending and savings in the economy. The test also looks at the broader array of benefits resulting from the program, including well-documented savings, as well as non-energy benefits.

5.2.5 Comparison of Tests

Table 5-2 compares key components of the standard TRC and Societal tests with those of the simple and expanded tests used here. Also shown are the elements included in the economic impacts. The TRC and Societal Test components are based on the definitions in the California *Standard Practice Manual* (SPM).[9]

All the tests considered count the avoided cost of energy supply as a benefit. The Societal Test also counts the value of all avoided emissions associated with the energy savings. The TRC test counts avoided emissions only to the extent that the cost of those emissions has been internalized, for example through mitigation requirements or cap and trade markets.

Effectively, emissions costs for NO_x and SO_x are internalized for electricity generation, but not for most gas consumption. Our simple test counts avoided NO_x and SO_x values for both

[9] California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects, July 2002.

electricity and gas savings. Our expanded test also counts avoided CO_2 and Mercury emissions, which are not currently internalized.

Non-energy Benefits resulting in monetary flows are counted in the Societal Test and in our Expanded BC Test, but not in the TRC or simple test. The Societal Test would also count Non-Energy Benefits that do not result in monetary flows. However, our expanded test considers only the more easily quantifiable monetary NEBs.

Secondary economic benefits related to the stimulus effects of program-related spending and savings are not explicitly identified in the SPM for the Societal Test, but are often counted in the form of "economic multiplier" effects as a form of Non-energy Benefit. Our expanded test includes these secondary economic effects as reflective of the overall impact of the program on the economy.

Tax credits are handled differently in the TRC test than in the Societal test, but are not relevant to this program.

The TRC test uses a non-societal discount rate, such as the utility's. The Societal Test uses a societal discount rate. Both our simple and expanded tests use a societal discount rate of 3 percent.

In total, we view both the simple and expanded tests as taking a societal perspective. The expanded test is more comprehensive, and includes some effects that cannot be as rigorously quantified. The expanded test is derived from the economic impact, together with the non-monetized externalities that are not reflected in the economic impact.

Table 5-2. Comparison of Test Components

Analysis Component	TRC	Societal Test	Simple BC Test	Expanded BC Test	Economic Impact
Benefits Counted					
Avoided supply costs of kWh, kW, therm	X	X	X	X	X
Avoided emissions costs included in electric delivery	X	X	X	X	X
Avoided externality value of market-valued emissions costs associated with customer gas use		X	X	X	X
Avoided externality value of projected market value of emissions costs associated with electricity delivery		X		X	
Avoided externality value of projected market value of emissions costs associated with customer gas use		X		X	
Non-energy Benefits resulting in monetary flows ("economic")		X		X	X
Non-energy Benefits not resulting in monetary flows ("non-economic")		X			
Secondary economic benefits		X		X	X
Tax credits treated as reduction in customer costs	X				

Analysis Component	TRC	Societal Test	Simple BC Test	Expanded BC Test	Economic Impact
Discount rate	utility	societal	societal	societal	not applicable

5.2.6 Comparing Benefits and Costs

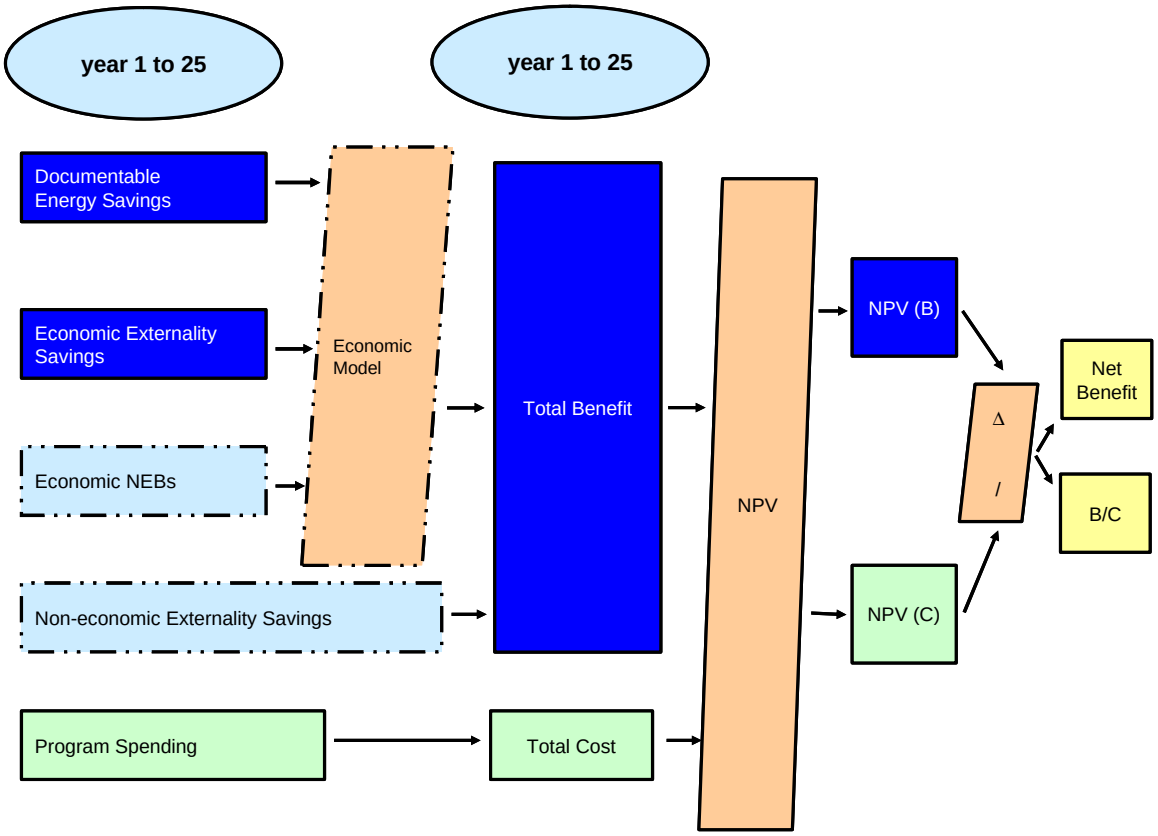
Benefits and costs are compared in this study in terms of the net benefit (total benefits minus total costs) and the benefit-cost ratio. Both the net benefit difference and benefit-cost ratio are calculated based on the net present value of a 25-year stream of costs and benefits. Results are all presented in 2007 dollars. Savings and other projections assume that the program continues for a period of 10 total years, through FY11. A real discount rate of 3 percent is assumed.

Figure 5-3 illustrates how the benefits and costs are aggregated by the benefit-cost tests applied here. For each year of the analysis, simple or expanded test, the applicable benefits are combined. For the simple benefit-cost test, the combination is simply the sum of program benefits. For the expanded benefit-cost test, the benefit is the output of the economic impact model, using the expanded list of benefits as inputs, plus the non-internalized avoided externalities.

The costs are also combined for each analysis year. In both tests, the same cost elements are counted, and are summed to produce the total cost.

The 25-year net present value (NPV) is calculated for the total benefit and the total costs. The difference between total benefit and total cost yields the net benefit (also in NPV). The ratio is the benefit-cost ratio.

Figure 5-3. Combining the Benefit and Cost Streams



Benefit-cost results are calculated for a 25-year horizon. The projections used in the 25-year analysis are grounded in the historical performance of the program in the early years, FY02 to FY06.

5.3 PROJECTIONS

This analysis required a 25-year stream of all the benefit and cost components. The general approach to developing these projections for each program area is described below. Specific analysis to develop the inputs described in Appendix A.

5.3.1 Program Spending

Program spending projections were developed in consultation with Department of Administration (DOA) staff. Consistent with the economic impact report, the current benefit-cost analysis assumes operation of the program for a 10-year period (beginning in FY02) and includes impacts that extend 15 years beyond the end of the program.

Assumptions used to develop the spending projections for the high and low scenarios are as follows:

- FY02–FY06 spending levels are based on actual invoices submitted to DOA;

- FY07 budget numbers were provided by DOA, with spending based on percentage of actual budget spent in FY06;
- Unspent budget in each year is carried over to the following year.

5.3.2 Documentable Savings

Documentable savings for the first few program years are taken from the prior evaluation reports, in particular the most recent year-end report. Break-downs into subcategories needed for the analysis were developed as described in Appendix A. As discussed further in Appendix A, projected funding and associated program savings are assumed to remain flat at FY06 levels through the projected years.

5.3.3 Measure Life and Decay Rates

Measure life was assessed by the WAP evaluators, primarily based on secondary sources. This measure life is interpreted as the median measure life. Measure lives for all program measures included in this analysis are provided in Appendix D. The savings implemented in each program year is extended into the future with an exponential decay rate, such that half the savings remains after the measure life.

That is, we interpret the measure life identified from the literature as the time until half the units would be expected to have failed or been removed. This interpretation is consistent with the persistence study framework used in California and elsewhere. Under those rules, the "expected useful life" is the median survival time, where "surviving" means remaining in place and operable.

With this interpretation and an assumed exponential decay, the fraction f of savings that survives from one year to the next is given by

$$f = 2^{-(1/L)}$$

where L is the measure life. For example, if the measure life is 15 years, the surviving fraction each year is

$$f = 2^{-1/15} = 95.5\%.$$

The decay rate is

$$d = 1-f = 4.5\%.$$

Thus, in this example, the surviving savings from the prior year is calculated as 95.5% of the prior year's amount; 4.5% of the prior year's savings is lost. Associated non-energy and environmental benefits decay at the same rate.

The exponential decay formula implies a constant failure rate over time. This assumption is not necessarily realistic for many measures. Experience from numerous persistence studies conducted in California indicates that the failure process is often a mixture of two phenomena—in the short term, removal due to defect or dissatisfaction, and In the longer term, more or less steady wear-out patterns. This mixture suggests a "hazard rate" that is

high in the early years, then declines, becoming stable (exponential) or eventually rising again in much later years.

The Weibull function is commonly used for survival analysis. This form can give either an increasing or decreasing hazard rate, but not one that starts high, drops, then stabilizes or climbs. For a fixed median measure life, we considered a Weibull with shape parameter 1/2 (decreasing hazard) and one with shape parameter 2 (increasing hazard). The first gives 5-10% lower NPV and the second gives 5–10% higher NPV compared to the exponential. A mixture of the two distributions, representing a combination of the two contributing phenomena, would give NPV somewhere between, or close to that from the exponential itself. Thus, the exponential assumption, which is computationally convenient, appears to yield appropriate end results for purposes of this analysis.

5.3.4 Non-energy Benefits

Non-energy benefits were estimated based on values provided in the non-energy benefits reports.[10] The low-income NEBs reports identified some NEBs that do not result in dollar flows in the economy, but are based on customer reported value. For purposes of this analysis, only those NEBs that result in economic flows, or "economic" NEBs, are included. While customer perceived value was also used for the business NEBs assessments, the values reported involved financial effects on businesses.

[10] *Low-income Non-energy Benefits for Inclusion in Economic Analysis,* Final report April 3, 2006; *Non-energy Benefits Crosscutting Report Year 1 Efforts*, Final report January 30, 2003;

APPENDIX A: DEVELOPMENT OF PROJECTIONS

A.1 FUNDING LEVELS AND PROJECTIONS

DOA provided the funding levels and streams for FY02 through FY06. The funding included in the inputs represent full program spending. The categories are the same as DOA's reporting categories.

Per a discussion with Jim Cain of DOA, the public benefits funds are not expected to increase much, if at all, in the future years. Additionally, the funding levels for the federal funding is variable depending on market conditions, weather, and demand, and are not easily projected from one year to another. Therefore, the projected funding, and subsequent savings, remains flat from FY06 through the projected years.

A.2 DOCUMENTABLE SAVINGS

To arrive at documentable savings, the impact analysis was used as the proxy to which the deemed savings were adjusted. We have seen that deemed savings, when aggregated across a program, over-represents the total savings. The impact analysis, however, provides estimates based on over 7,000 households state-wide, and includes a comparison group. Table A-1 below shows the savings reported in the WAP impact analysis from 2003[11].

Table A-1. Savings Estimates from WAP Impact Analysis

Housing Type	Average Annual kWh Savings per Unit	Average Annual Therms Savings per Unit
Single family/shelter	924	169
Trailer/mobile home	1,167	59
2–4 unit building	783	185
Multifamily (5+ units)	46	94

The easiest solution would have been to estimate the savings, per year, based on number of units and types of units served. However, the BC input task required we estimate savings by end-use. To do this, we needed to extrapolate the overall savings to each end-use through the following steps.

1. Identify deemed savings for measure categories represented in the database
2. Assign a deemed savings estimate for each measure category for which we have an estimate
3. Compute the total savings by multiply the quantity installed by the deemed savings where appropriate. There are instances when the deemed savings is meant to be applied on a per install basis; for these cases we simply used the deemed savings.
4. Sum the total savings by housing type for each year

[11] Estimates produced by KEMA, report prepared by Lark Lee, Pam Rathbun, and Laura Schauer, "Low-income Public Benefits Evaluation, year 3 Low-income Program Evaluation – Volume 1. Report." Prepared for the State of Wisconsin Department of Administration Division of Energy. Final Submission: October 13, 2004.

5. Determine an adjustment factor using the impact analysis (AdjFactor=ImpactSavings/DeemedSavings)
6. Apply the adjustment factor to the deemed savings for each measure to establish an adjusted savings estimate
7. Verify the adjusted savings estimate is consistent with the impact analysis by summing the total savings by housing type and dividing that total by number of units served in that housing type
8. Determine the savings by end-use by aggregating and summing the savings data by end-use

As noted earlier, we did not the data to employ this method with FY03 applications. For FY03, we used FY02 estimates and simply adjusted those estimates upward to represent the increase in housing units served.

Table A-2 provides a simplistic example of the methodology to create the estimates. Household A, a single family home, received the following measures with associated deemed savings values.

Table A-2. Simple example of method to determine savings

Measure	A. Deemed therms savings	B. Quantity	C. Total Savings	D. Adjustment Factor	E. Adjusted Savings
Heating system replacement	405	1	405 therms	.29	117.60
Wall insulation	0.2/Sq Ft	800	160 therms	.29	46.46
Tank insulation	17	1	17 therms	.29	4.94
Total Savings			582 therms	.29	169.00

The total deemed therms savings, is 582. The total average therms savings for a single-family household, as identified through the impact analysis, is 169. The adjustment factor is calculated as:

Total impact analysis savings/ deemed savings
= 169 therms / 582 therms = .29

Next, the adjustment factor is applied to the deemed savings at a measure level to achieve an adjusted savings. This result of this calculation is represented in Column E in Table 2.

A.3 END-USES AND RELATED MEASURES

Table A-3 outlines the end-use categories, and major measure category assigned to each end-use category.

Table A-3. End-Use and Measures in Study

End-use	Measure Category
Air Conditioning	Health and Safety Cooling
Air Conditioning	Air Conditioning
Air Sealing	Air Sealing
Appliance	Refrigerator

End-use	Measure Category
Appliance	Health and Safety Appliance
Appliance	Freezer
Boiler Modifications	Boiler modifications and repairs
Heating System	Health and Safety Heating System
Heating System	Repair Heating System
Heating System	Heating System Modifications
Heating System	Heating System Replacement
Insulation	Floor Insulation
Insulation	Foundation Insulation
Insulation	Sillbox Insulation
Insulation	Wall Insulation
Insulation	Attic Insulation
Lighting	Lighting
Structure and Electrical	Health and Safety Alarms
Structure and Electrical	Health and Safety Structure
Structure and Electrical	Repair Electric Service
Structure and Electrical	Repair Structure
Structure and Electrical	Health and Safety Electrical
Ventilation and Air Quality	Health and Safety Air Quality
Ventilation and Air Quality	Health and Safety Ventilation
Ventilation and Air Quality	Repair Air Quality
Water Heater	Hot Water Treatments (water wraps, faucet aerators, low flow showerheads)
Water Heater	Repair Hot Water
Water Heater	Water Heater Conversion
Water Heater	Water Heater Replacement
Water Heater	Health and Safety Hot Water
Windows and Doors	Window Replacement
Windows and Doors	Door Replacement

Source: WisWAP Database

APPENDIX B: FINAL EMISSIONS MEMO

Subject **EMISSIONS FACTORS AND ALLOWANCE PRICES - DRAFT**

To	Mimi Goldberg, KEMA Chris Clark, KEMA Glen Weisbrod, EDRG	Oscar Bloch, WDOA David Sumi
From	Bryan Ward Eric Rambo	
Date	December 4, 2006	

This memo provides current emissions factors based on the Environmental Protection Agency's Office of Air and Radiation "Acid Rain Hourly Emissions Data" from 2005 and actual (2001–2006) and forecast (2007-2026) allowance prices for avoided emissions to be used for the Focus on Energy benefit cost and economic impact analysis based on PA Multi-Pollutant Optimization Model (M-POM). This memo will be followed by a report that provides additional discussion around the values, especially regarding the significant reductions in the estimates of the pounds/MWH for NOx and SOx from the previous analysis based on 2000 EPA data.

Generation Emission Factors

Annual emissions factors were estimated from the Environmental Protection Agency's Office of Air and Radiation "Acid Rain Hourly Emissions Data" from 2005, using an approach developed in 2004 using data from the year 2000 and reported in the Focus on Energy publication, *Estimating Seasonal and Peak Environmental Emissions Factors.*

In 2004, emissions factors for NO_x. SO_x, CO_2 and HG were based on the mass of emissions per hour, per MWh of generation. Emission factors were calculated on marginal plants only, summed over the two NERC regions that supply Wisconsin. A marginal plant was defined as the plant with the most change in MWh, increase or decrease, since the previous hour.

In 2006 we have estimated emissions factors using the same rationale, and in addition have added two refinements. In the table "2005 Annual Emissions Factors," below, we provide three different numbers. In the rows labeled "2006 Report":

1. The row marked "Single Marginal Unit" reproduces the methodology from 2004 exactly, except for some minor cleaning of code that restored data considered missing in 2004.

2. The row marked "Marginal Unit= 99th percentile" redefines as marginal any unit that increases generation from the previous hour by 19% or more of its rated maximum. This represents the 99th percentile of movement over the year.

The row marked "Weighted by Region" retains the refinement of the previous row and additionally weights emissions factors by the mix of energy consumed within Wisconsin, with

about 82% generated within the state and 18% imported; and of the imports about 47% originates in the MAIN NERC region and 53% originates in the MRO NERC Region.

2005 ANNUAL GENERATION EMISSIONS FACTORS

			Pounds /MWh			Pounds /GWh
Source	**Year of Data**	**Type**	**NO_x**	**SO_x**	**CO_2**	**Mercury**
1999 Report	1999	By Marginal Cost	6.4	10.8	2,400	
		By Capacity Factor	5.9	10.0	2,035	
1998 EPA	1998					0.0373
2004 Report	2000	Single Marginal Unit	5.7	12.2	2,216	0.0489
2006 Report	2005	Single Marginal Unit	3.0	4.9	2,419	0.0262
		Marginal Unit = 99th Percentile	2.1	4.3	1,718	0.0198
		Weighted by Region	2.1	4.6	1,746	0.0179

Sources:
1999 Report: *Development of Emissions Factors for Quantification of Environmental Benefits*, June 25, 2001. Focus on Energy Pilot Evaluation Report.
1998 EPA: *EPA's E-Grid 2000 Database* for MAIN and MAPP for 1998.
2004 Report: *Estimating Seasonal and Peak Environmental Emissions Factors*, May 21, 2004. Focus on Energy Public Benefits Evaluation.
2006 Report: This report.

NATURAL GAS ON-SITE USE EMISSIONS FACTORS[12]

The emission factors discussed above are for emissions savings at the electric generator. Other emissions savings occur when energy efficient projects reduce the use of non-electric fuels at the participant's site. The primary site-based fuel (burned at the participant's site rather than at the power generation plant) saved under the WAP is natural gas. Combustion of natural gas produces a variety of pollutants including CO_2, NO_x, N_2O, SO_x, PM10, VOC, and CO. With the exception of CO_2, these pollutants are emitted in fairly small quantities.

According to the EPA's Technology Transfer Network Clearinghouse for Inventories & Emission Factors, the emission factor for CO_2 is 11.76 pounds of CO_2 per therm. The Clearinghouse provides a single emission rate for SO_x and mercury, as it does for CO_2. (Both the SOx and mercury values are quite small, particularly compared to coal, and as a result are often ignored.) The Clearinghouse provides a range of estimates for NO_x that depend on the size and configuration of the boiler. NO_x emissions are particularly sensitive to the size, design, and operating conditions of the boiler. Three representative emission rates for NO_x are presented in the following table.

[12] Taken from *"State of Wisconsin Department of Administration Division of Energy Focus on Energy Public Benefits Evaluation Estimating Seasonal and Peak Environmental Emissions Factors—Final Report May 21, 2004"*

NATURAL GAS ON-SITE USE EMISSION FACTORS

Substance	Pounds Per Therm
CO_2	11.76
SO_x	0.0000588
Mercury	0.00000002549
NO_x Lower Bound	0.003137
NO_x Mid-range	0.009804
NO_x Upper Bound	0.027451

Sources: (1) Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area.
(2) EPA Technology Transfer Network Clearinghouse for Inventories and Emission Factors.

ALLOWANCE PRICES

The historic and forecast allowance prices were provided by PA's Multi-Pollutant Optimization Model (M-POM). This model was designed to find optimal market-driven, environmental compliance options, given multi-pollutant compliance requirements. It is designed to explore emission costs and benefits in terms of fuel choice, capital investments in pollution control equipment, allowance market purchases and generating unit operating decisions.

M-POM is a dynamic, inter-temporal model that simultaneously selects technology (new units and compliance technology) and dispatches units over a 30-year horizon. PA models two seasons and typically 6 load segments per season. M-POM is set up to operate with 23 US regions.

The table below presents the historic and forecast prices for the relevant emissions allowances for the years 2001–2026.

HISTORICAL/FORECAST ALLOWANCE PRICES

	SO_2 Acid Rain/CAIR	NO_x SIP Call	NO_x CAIR - Annual	NO_x CAIR - Ozone	Hg CAMR*	CO_2**
Year	$/Ton, Nominal	$/Ton, Nominal	$/Ton, Nominal	$/Ton, Nominal	$M/Ton, Nominal	$/Ton, Nominal
2001	186	915			2	0
2002	152	778			6	0
2003	176	4,602			9	0
2004	441	2,236			13	1
2005	901	2,760			18	1
2006	790	2,069			22	2
2007	637	1,847			27	3
2008	674	1,693			32	3
2009	713		1,376	393	37	6
2010	773		1,042	426	41	7
2011	844		1,138	465	45	8
2012	918		1,238	506	49	8
2013	995		1,342	548	53	9
2014	1,075		1,450	593	57	10
2015	1,158		1,563	639	61	13
2016	1,261		1,700	695	67	15
2017	1,367		1,844	753	73	16
2018	1,477		1,993	814	78	18
2019	1,570		1,497	884	85	20
2020	1,665		978	957	92	22
2021	1,765		1,000	979	100	22
2022	1,868		1,023	1,002	107	23
2023	1,975		1,047	1,025	115	23
2024	2,085		1,071	1,049	123	24
2025	2,133		1,095	1,073	126	24
2026	2,183		1,121	1,097	129	25

* 2001–2010 based on trend in forecast market based value

** 2001–2009 based on trend in forecast market based value
2010–2014 based on forecast for the RGGI market
2015–2026 based on forecast for a national market

APPENDIX C: COMPARISON WITH PRIOR BC REPORT

C.1 ANALYSIS DIFFERENCES

As described in Section 3, the analysis of this report has several differences from that of the Initial Benefit-Cost Report. These differences, and their effect on the BC ratios compared to those of the initial report are indicated in the table below.

Table C-1. Comparison of Current Analysis Method with Initial BC Analysis

Benefits and Costs Counted			
In-program energy savings	Benefit	Benefit	None
Avoided emissions externalities--NO_x and SO_x	Benefit	Benefit	None
Avoided emissions externalities--Hg and CO_2	Benefit	Benefit only in expanded test	Decrease for simple tests
Non-energy effects	Economic and Non-economic NEBS counted	Only Economic NEBS counted	Decrease

Parameters	**Basis**	**Value**	**Basis**	**Value**	**Effect on BC ratio**
Analysis time frame	Assumed program life plus long measure life	25 years	Assumed program life plus long measure life	25 years	None
NPV discount rate	Average yield on 20-year US treasury bond	3%	Public sector cost of borrowing consistent with state of WI valuations	3%	None
Fuel escalator	None	0%	Analysis of historic fuel price increases compared to consumer price index	1%	Increase
Avoided kWh	Calculated from average customer bill	$.081/kWh	Estimated from forward electricity contract, Alliant Energy Docket 6680-UR115 , with 8% added to adjust for line loss	$0.056/kWh	Decrease
Avoided therms	Calculated from average customer bill	$.671/therm	Calculated based on long-term Wisconsin forward gas contracts and Utility rate cases	$1.061/therm	Increase
Avoided demand	Assumed included in average cost per kWh	0	Wisconsin PSC avoided generation figures, adjusted for avoided transmission using EIA data.	$104/kW	Increase
SO_x, NO_x valuation	Estimated from emissions market model	SOx: $0.0009/kWh NOx: $0.0008/kWh	Estimated from emissions market model, initial value	SO_x: $0.0004/kWh NO_x: $0.0010/kWh	Decrease
CO_2, Hg valuation	Not counted	0	Estimated from emissions market model, initial value	CO_2: $0.0009/kWh Hg: $0.0001/kWh	Increase

C.2 COMPARISON OF RESULTS USING CONSISTENT FORMULA

Re-calculating the Initial BC ratios with all the current assumptions is beyond the scope of this analysis. However, it is straightforward to apply the simple BC formula of the present report to the benefit and cost elements developed in the prior work. That is, we use the net present

value of the benefit and cost streams determined in the earlier work, based on the valuation factors used there, but apply the current formula to calculate the BC ratio. The current formula, as shown in Table C-2 would yield a BC ratio of 0.7 using the results from the prior work.

Table C-2. Simple BC Test Results from Initial BC Analysis Using Current Formula

Initial BC Results	Benefits		Costs	BC Results	
	Documentable Savings	Economic Environmental Externalities	Program and Other Costs	Net Benefits	Simple BC
Low Income	$125.2	$0.8	$208.6	-82.6	0.7

Table C-3. Simple BC Test Results from Present Analysis

Initial BC Results	Benefits		Costs	BC Results	
	Documentable Savings	Economic Environmental Externalities	Program Costs	Net Benefits	Simple BC
Low Income	$215.9	$3.5	$508.2	-288.8	0.4

The primary reason for the lower current BC ratio is that energy savings values used in the present work are based on impact analysis completed after the prior BC analysis. The impact analysis found lower unit savings than had been assumed in the earlier work.

While it is not possible to re-calculate the current expanded test from the prior findings, it is nonetheless worth noting key reasons the present result would be expected to be lower than that from the prior "economic multiplier" test. In addition to the reasons the savings value is lower in the present analysis, two factors would make the current expanded test yield a lower BC ratio than the prior work would have.

1. The present work counts only economic NEBs. The prior work counted both economic and non-economic NEBs.

2. Avoided emissions values are somewhat lower in the current work, based on revised analysis using similar methods. Economic externalities valued in the simple test are higher than in the previous work, but the total externality value is lower.

APPENDIX D: MEASURE LIVES

Measure lives for all program measures considered in the WAP benefit cost-analysis are listed below.

Measure	Measure Life in Years
Air Conditioning	20
Air Sealing	25
Appliance	12
Heating System	23
Insulation	25
Lighting	6
Structural and Electrical	20
Ventilation and Air Quality	15
Water Heater and Water Treatments	15
Windows and Doors	20