Benefit Cost Analysis of a Portfolio of Energy Efficiency Programs

B/C Ratios Calculated at the Program, Sector, and Portfolio Levels

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ABSTRACT

This report summarizes the benefit cost (B/C) model developed and used to estimate the cost-effectiveness of New York's public benefits programs. B/C ratios were calculated under a number of scenarios for 18 different **New York Energy $mart**[SM] Program initiatives. Results are presented at the program level, sector (*i.e.*, business/institutional, residential, and low-income) level, and the portfolio level. Although the B/C ratios for some programs are below 1.0, when all 18 programs are viewed as a portfolio, the B/C ratio is greater than 1.0 regardless of the scenario used. Since several programs in the portfolio are designed to have broad, non-specific impact on the energy efficiency market, it was expected that these programs in their own right might have B/C ratios less than one. It is also expected over time that B/C ratios will improve due to better-quality data, new data, and measuring of some market effects that heretofore were not quantified. A reported B/C ratio that is low today might become larger in the next update of this analysis as more is learned about the program's market effects.

The programs within the **New York Energy $mart**[SM] Program portfolio are diverse, have multiple objectives, and are designed to work interactively with one another to achieve the Program's broad public policy goals. As a result, it is inappropriate and can be misleading to compare B/C ratios across programs. However, combined with the evaluation results presented in the May 2005 **New York Energy $mart**[SM] Program Evaluation and Status Report, the B/C analysis may help improve understanding of how the **New York Energy $mart**[SM] Program portfolio is performing.

Introduction

Starting in 2003, a comprehensive effort was begun to more fully evaluate all of the **New York Energy $mart**[SM] programs. NYSERDA hired Nexant Inc. to verify the reported program savings. Summit Blue Consulting was hired to measure market effects and assess the degree to which NYSERDA might claim credit for the energy savings. Summit Blue also estimated non-energy benefits for selected programs. The benefit cost analysis was performed by the Heschong Mahone Group, Inc. in conjunction with Ridge & Associates, and Energy and Environmental Economics, Inc. The analysis was performed in late 2004 and updated in mid-2005. The B/C analysis also includes macroeconomic benefits attributed to the programs as estimated by Neenan Associates as well as the impact of the programs on the energy market price for electricity and the associated statewide reduction in customer bills.

B/C ratios were calculated at the program level, sector level, and the portfolio level. A total of 18 programs were included: nine business and institutional programs, six residential programs, and three

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low-income programs. The program spending and realized energy and demand savings through 2004 are shown in Table 1. Also shown are the program budgets through 2006 along with the anticipated energy and demand savings.

Table 1. Program Spending, Budget, Realized and Anticipated Energy and Demand Savings

	Program Spending (1999-2004) $ Million)	**Realized Annual GWh Savings**	**Realized Peak MW Savings**	**Program Budget (1999-2006)** $ Million	**Anticipated Annual GWh Savings (Through 2006)**	**Anticipated Peak MW Savings (Through 2006)**
Business/ Institutional Programs	$174.4	1,124	753	$359.1	2,314	1,550
Residential Programs	$130.0	249	93	$155.6	298	111
Low-Income Programs	$48.1	16	2	$128.4	43	5
Total	$352.5	1,389	848	$643.1	2,655	1,666

Note: The anticipated values are based on straight extrapolation and therefore are conservative estimates.

Benefits and Costs

Two different tests were used to calculate B/C ratios:

1. In the Total Market Effects Test (TMET), monetized benefits are compared to the total incremental costs, including customer costs.

2. In the Program-Efficiency Test (PET), the monetized benefits are compared only to NYSERDA program costs.

Four scenarios were constructed for each of the two tests with each successive scenario adding additional benefits that can be quantified and attributable to the **New York Energy $mart**[SM] Program. In Scenario #1, only the avoided costs associated with energy, capacity, natural gas, oil, and water savings arising from participant actions and from market spillover are included as benefits. In Scenario #2, the energy market price benefits from lowering the statewide energy requirements are added. In Scenario #3, non-energy benefits are added for each of those programs for which estimates are available. In Scenario #4, macroeconomic benefits are added, but only at the portfolio level. The methods used to calculate these benefits are described below. The benefits and costs included in each scenario for each test are depicted in Table 2.

Environmental benefits such as reductions in emissions of sulfur dioxide, nitrogen oxides, and carbon dioxide were not included as a benefit primarily because the monetary value of these reductions are too uncertain at this time. Furthermore, with respect to sulfur dioxide and nitrogen oxides, since there are statewide regulatory emission caps as well as emission trading markets, emission credits may likely be sold in the marketplace, allowing generators to reduce operating costs (*e.g.*, through less stringent pollution controls) or expand generation (*e.g.*, to meet economic growth) without exceeding the caps. The net effect of this would be that statewide emissions meet the caps for sulfur dioxide and nitrogen oxides with no real reduction benefits.

Table 2. Benefits and Costs Included in the Scenarios for the TMET and PET

	TMET				PET			
	Scenario				Scenario			
	#1	#2	#3	#4	#1	#2	#3	#4
Benefits								
Avoided costs for kWh and kW and other avoided costs *(e.g.*, water, natural gas, oil)	X	X	X	X	X	X	X	X
Energy market price effects (reduction in wholesale price of electricity due to reduced requirements)		X	X	X		X	X	X
Non-energy benefits (*e.g.*, health , safety)			X	X			X	X
Macroeconomic impacts				X				X
Costs								
Incentives, implementation costs, administration and evaluation costs	X	X	X	X	X	X	X	X
Customer contributions to the incremental costs	X	X	X	X				

X: included in analysis

Realization Rates, Net Factor, and Market Effects Factor

Nexant assessed program-reported savings using file reviews, review of calculation methods, and on-site visits to determine that the energy savings reported by the programs were accurate and that measures have been installed and are operating as expected. For each program, Nexant estimated a realization rate that adjusted the NYSERDA-reported annual energy savings through year-end 2004. For example, a realization of 100% indicates no difference between NYSERDA-reported and M&V verified savings. The verified gross annual energy savings were then adjusted by a Net-To-Gross (NTG) multiplier, estimated by Summit Blue, to yield net savings. The NTG multiplier has two components: (1) a net factor, and (2) a market effects factor.

1. Net Factor - The net factor is the percentage of gross savings attributable to the program. One minus this factor equals the percentage of savings attributable to the freerider effect, *i.e.,* the effect that would have occurred regardless of any intervention or incentives provided by the program. Savings attributable to freeriders are subtracted from the gross savings.

2. Market Effects Factor - The market effects factor captures program effects that go beyond the measures installed through the programs. Many programs are designed to influence the broader market by increasing awareness of strategies to increase energy efficiency. The market effects factor captures the energy and demand savings that participants and non-participants achieve as a result of actions taken beyond program participation. These effects are referred to as spillover.

Net factors and market effects factors were calculated for those programs that received a thorough review – for all others, a net factor and a market-effects factor were assigned based on similar programs that have been implemented elsewhere in the U.S. At the portfolio level, the reported gross energy savings were equal to the verified gross savings. The net energy savings at the portfolio level were about 8% lower than the reported savings.

Avoided Electricity and Demand Costs

A forecast of future energy prices for six time periods (summer on-peak, summer off-peak, summer shoulder, winter on-peak, winter off-peak, and winter-shoulder) was developed based on the annual real rate of energy price increase predicted using the Multi-Area Production Simulation (MAPS)[2] model which simulates the operation of the electricity system in New York. MAPS analyses of annual energy production cost escalation rates were conducted by NYSERDA staff. Future energy prices were obtained by applying these escalation rates to the average hourly New York Independent System Operator (NYISO) energy price data by location and time period. Generation-level kWh savings for each program, distributed by location and time period, were multiplied by the corresponding average avoided energy price in cents per kWh to get a total dollar value of avoided energy costs for each year over the expected life of the measures implemented by each individual program. The present value of the stream of annual avoided energy costs, in total dollars over the expected life of the measures, was then calculated.

Energy Market Price Effect

The energy market price effect is the savings that result from lower market clearing prices for electricity when the demand for electricity is reduced. Lower prices occur because the price bids from the most expensive generating units are not needed when the system requirements are lowered. When the most expensive units are backed out because of lower requirements, the market clearing price for all kWh generated is lowered. This benefit accrues to all electricity customers regardless of whether they participate in the **New York Energy $mart^{SM}** Program.

The analysis compared the average annual electricity production costs of electricity in the 2004 MAPS base case (which includes the impacts of the **New York Energy $mart^{SM}** Program) to the costs predicted in a sensitivity case without the Program. The difference in average annual electricity production costs between the two scenarios was used to calculate the amount by which the average price of electricity would be higher in the absence of the **New York Energy $mart^{SM}** Program.

The electricity price output of MAPS reflects production costs only (fuel costs, fixed and variable operation and maintenance (O&M) costs, and emission allowance costs). To convert MAPS production costs to estimates of market clearing prices, MAPS production costs were increased by a factor of 1.33 to account for ancillary services, congestion costs due to transmission outages, electricity price spikes due to short-term fuel price spikes and/or extreme weather, and other factors that contribute to actual market bidding behavior. This factor was estimated by comparing backcasted MAPS output prices for 2002 and 2003 to historical electricity clearing prices in the same years. The present value of the energy market price effect was estimated, using the annual wholesale electricity price differential multiplied by the total kWh expected to be generated in New York each year over the expected life of the measures implemented by the **New York Energy $mart^{SM}** Program.

Non-Energy Benefits

Non-energy benefits (NEBs) can be viewed from various perspectives:

[2] The MAPS model, proprietary software developed by General Electric, simulates the operation of New York's electricity system on an hour-by-hour basis. The objective of the model is to meet the hourly electric load with the available user-defined generation units, while minimizing production costs, subject to generation and transmission constraints, operating reserve, and other system requirements.

1. Participant NEBs - Impacts that are realized and recognized by program participants. For residential programs, these benefits include increased comfort, ease of selling a home, personal satisfaction, environmental benefits, and other benefits for participants. For business/institutional programs, these benefits include increased productivity, equipment longevity, reduced noise, and increased safety. These effects are measured using valuation methods appropriate to the owner.

2. Utility/Agency NEBs - Net benefits accruing to the utilities or program-sponsoring agency, including fewer billing-related calls and other follow-ups, lower bad debt amounts from unpaid bills, lower transmission and distribution losses, and other benefits, which result in lower revenue requirements for the agency, and are appropriately valued at the agency's marginal cost and discount rates.

3. Societal NEBs - Net benefits beyond those accruing to the utilities/agencies or directly to participants, including economic multipliers or job creation benefits, reduced environmental impacts from emissions, and other benefits valued at societal costs and discount rates.[3]

Summit Blue's subcontractor, Skumatz Economic Research Associates (SERA), concentrated on estimating NEBs for the first category – participant NEBs. SERA noted that while many of these participant benefits are hard to measure (*e.g.* "comfort"), it is important to estimate dollar values for these benefits in order to allow comparison with direct energy benefits and to provide more comprehensive information for cost-effectiveness assessments of programs. Several steps were used to derive the dollar estimate of participant NEBs for each program.

Based on the literature and past research, a list of categories of NEBs was assembled that are relevant to the programs. For each of the NEB categories, respondents were asked whether the energy-efficient equipment or design features led to a positive or negative effect or no effect compared to standard equipment or design features. The same was asked for the overall or total of all the individual NEB categories.

For those NEB categories with an effect, respondents were asked how valuable – or costly – the effect was on a scale of 1 to 5, where 1 = slightly valuable and 5 = very valuable. They were asked the same question for the overall or total of all the individual NEB categories. Respondents were then asked whether the overall total NEBs were more valuable or less valuable than (or the same value as) the energy savings from the measures installed. The respondents were also `` asked the extent to which the NEBs were more or less valuable than the energy savings.

These expressed "relative" values (*e.g.*, much more valuable, somewhat less valuable, etc.) were translated into numeric multipliers using information from the surveys, past research, and relevant literature. The numeric multiplier was multiplied by the energy savings to obtain an estimate for each individual NEB category and for the overall net NEBs.[4] The sum of the individual benefit categories exceeded the value assigned to "total/overall" benefits, which is common. The values for the individual

[3] Macroeconomic benefits were estimated in a study conducted for NYSERDA (Neenan Associates, 2004, *Macroeconomic Impact Analysis of the* ***New York Energy $mart^{SM} Program****: An analysis of short-term and longer-term impact*). Emissions benefits are not being valued at this time. Other NEBs may be estimated at a later phase of the B/C project.

[4] For more information on these steps and multipliers, see Skumatz, Lisa A. 2001. "Non-energy Benefits (NEBs) – The New Standard in Comprehensive Estimation and Modeling of NEBs for Commercial and Residential Programs." *Proceedings of the 2001 International Energy Program Evaluation Conference*, Salt Lake City, UT.

categories were then scaled down proportionally to ensure they added to the total/overall benefit provided by the respondent. The following is a list of the non-energy benefits included in the analysis: (1) equipment maintenance costs, (2) appliance/equipment performance, (3) appliance/equipment lifetimes, (4) improved occupant productivity, (5) tenant/personal satisfaction, (6) comfort, (7) building aesthetics/appearance, (8) noise levels, (9) building/equipment safety, (10) lighting/quality of light, (11) ease of selling/leasing home or building, (12) ability to stay in home/avoided moves, (13) doing good for the environment/environmental effects, (14) number of sick days lost from work, (15) number of calls to utility on bill issues, and (16) operating cost.

Macroeconomic Impact

Purchases of goods and services through the **New York Energy $mart^{SM}** Program set off a ripple effect of spending and re-spending that influences many sectors of the New York economy and the level and distribution of employment and income in the State. A macroeconomic impact analysis of the **New York Energy $mart^{SM}** Program was conducted by Neenan Associates to compare the impacts of program expenditures and energy savings to the impacts that would have resulted had the program not been implemented and the money not paid by ratepayers into the System Benefits Charge fund. This type of analysis required the use of an input/output model to characterize the myriad of interdependencies in the New York economy and how the expenditures within the State's economy differ between these two cases. The net macroeconomic impacts are expressed in terms of annual employment, income, and gross state product.

Results of the analysis indicated that the **New York Energy $mart^{SM}** Program provides a substantial net macroeconomic benefit to New York in the form of increased employment and labor income. The additional jobs and labor income during the Program implementation years (1999-2006) are primarily due to Program expenditures. The additional jobs and labor income in the years following Program implementation are entirely driven by the continuing stream of energy bill savings that results from the energy efficiency and demand reduction measures installed under the Program. During the Program implementation years (1999-2006), average annual net gain in jobs was estimated to be 4,800 and the average annual value added was estimated to be about $205 million (2000$). In the years following Program implementation (2007-2016), the net annual gain in jobs was estimated to be 4,100 and the annual value added was estimated to be about $5 million (2000$). Benefits used for the B/C analysis is the value added per year as shown in Table 3.

Table 3. Macroeconomic Impacts of the New York Energy $mart^{SM} Program: Average Value Added Per Year

	During Program Implementation Years 1999-2006		During Years Following Implementation 2007-2016	
	Annual Jobs	Annual Value Added (2000$)	Annual Jobs	Annual Value Added (2000$)
Program Case	7,580	$488 Million	4,298	$274 Million
Base Case (w/o Program)	2,800	$283 Million	188	$269 Million
Net Impact	4,780	$205 Million	4,110	$5 Million

Summary of Results

Portfolio-Level Ratios

As shown in Table 4, the portfolio-level TMET ratios ranged from a low of 2.1 to 7.2 depending on the scenario. Two sets of calculations for the TMET and PET are shown: first, only the costs associated with programs for which B/C ratios are calculated are included; second, all sector-level costs are included, including costs for programs that do not have associated energy savings.[5] In general, adding the additional sector costs did not significantly affect the TMET ratios. The PETs were impacted more by the additional program costs because these costs were a larger percentage of the total program cost compared to the total costs for the TMET analysis which included customer costs. The B/C ratios in Scenarios 3 and 4 (which are the two scenarios that include the non-energy benefits) are expressed as a range, which results from using either 50% or 100% of the non-energy benefits. The low end of the estimate approximates the value recommended for use by Summit Blue. The upper end of the estimate is the value obtained from the survey data.

Table 4. Portfolio-Level B/C Ratios

	TMET		PET	
	Without Additional Sector Costs	**With Additional Sector Costs**	**Without Additional Sector Costs**	**With Additional Sector Costs**
Scenario #1	2.3	2.1	5.1	4.2
Scenario #2	2.5	2.3	5.8	4.7
Scenario #3*	3.8 – 5.0	3.4 – 4.6	8.5 – 11.4	7.0 – 9.3
Scenario #4*	5.9 – 7.2	5.4 – 6.6	13.5 – 16.4	11.0 – 13.4

* The lower bound of the ratio is based on using 50% of the non-energy benefits; the upper bound is based on using 100% of the non-energy benefits.

Shown in Table 5 are the sector-level ratios for scenarios 1, 2 and 3. The Business/Institutional sector TMET ratios ranged from 2.7 to 6.5 depending on the scenario. The Residential sector TMET ratios ranged from 1.1 to 2.6 for the different scenarios. The Low-Income sector TMET ratios ranged from 0.9 to 2.0 for the different scenarios. This table does not have a scenario 4 because macroeconomic impacts were added at the portfolio level only.

[5] Additional sector level spending represented about 8% of the Business/Institutional Program spending, 17% of the Residential Program spending, and 10% of the Low-Income Program spending.

Table 5. Sector-Level B/C Ratios

		TMET		PET	
		Without Additional Sector Costs	**With Additional Sector Costs**	**Without Additional Sector Costs**	**With Additional Sector Costs**
Scenario #1	Business/ Institutional	2.8	2.7	6.5	6.0
	Residential	1.3	1.1	3.4	2.2
	Low-Income	1.0	0.9	1.2	1.0
Scenario #2	Business/ Institutional	3.2	3.1	7.4	6.8
	Residential	1.5	1.2	3.7	2.4
	Low-Income	1.1	1.0	1.3	1.1
Scenario #3*	Business/ Institutional	4.8 – 6.5	4.6 – 6.2	11.0 - 14.9	10.1 – 13.7
	Residential	2.0 - 2.6	1.7 – 2.2	5.2 - 6.7	3.4 – 4.4
	Low-Income	1.6 - 2.0	1.3 – 1.7	1.8 - 2.2	1.5 – 1.9

* The lower bound of the ratio is based on using 50% of the non-energy benefits; the upper bound is based on using 100% of the non-energy benefits.

Program-Level Ratios

The TMET and PET ratios for the Business/Institutional programs are shown in Table 6. The ratios for the residential programs are shown in Table 7. The ratios for the Low-Income programs are shown in Table 8. For those programs with non-energy benefits, a range of ratios is provided; the lower bound represents the inclusion of only 50% of the non-energy benefits and the upper bound represents inclusion of 100% of the non-energy benefits.

Table 6. Business/Institutional Sector Total Market Effects Test (TMET) and Program Efficiency Test (PET) Ratios

	TMET			PET		
Program	Scenario #1	Scenario #2	Scenario #3*	Scenario #1	Scenario #2	Scenario #3*
C/I Performance Program	2.9	3.5	5.1 - 7.0	5.1	6.1	8.9 - 12.2
New Construction Program	1.5	1.8	3.2 - 4.6	2.9	3.5	6.2 - 8.9
Curtailable Load Programs	1.6	1.6	Not Available	4.1	4.1	Not Available
Peak Load Reduction Program: Permanent Measures	6.4	7.5	Not Available	9.2	10.7	Not Available
Technical Assistance	3.5	3.9	6.5 - 9.0	36.4	40.6	66.6 - 92.8
New York Energy $mart[SM] Loan Fund (Includes residential sector)	2.1	2.3	Not Available	5.2	5.6	Not Available
Smart Equipment Choices	3.6	4.3	7.3 - 10.4	4.8	5.8	9.9 - 14.0
Small Commercial Lighting	1.4	1.7	2.8 - 4.9	1.6	1.9	3.2 - 5.7
Premium Efficiency Motors	1.9	2.3	Not Available	2.3	2.7	Not Available

* The lower bound of the ratio is based on using 50% of the non-energy benefits; the upper bound is based on using 100% of the non-energy benefits.

Table 7. Residential Sector Total Market Effects Test (TMET) and Program Efficiency Test (PET) Ratios

	TMET			PET		
Program	Scenario #1	Scenario #2	Scenario #3*	Scenario #1	Scenario #2	Scenario #3*
ENERGY STAR® Products	1.2	1.4	1.9 - 2.4	6.1	7.0	9.7 – 12.5
ENERGY STAR® Bulk Purchase	2.9	3.3	Not Available	5.1	5.8	Not Available
ENERGY STAR® Labeled Homes	2.0	2.0	3.1 - 4.2	3.5	3.5	5.4 - 7.3
Home Performance w/ENERGY STAR®	1.4	1.4	2.2 – 2.9	2.4	2.4	3.8 - 5.1
Keep Cool	0.8	0.9	1.4 – 1.9	0.9	1.0	1.5 - 2.0
Residential Comprehensive Energy Management	0.3	0.4	0.6 - 0.8	0.5	0.6	0.9 - 1.2

* The lower bound of the ratio is based on using 50% of the non-energy benefits; the upper bound is based on using 100% of the non-energy benefits.

Table 8. Low-Income Sector Total Market Effects Test (TMET) and Program Efficiency Test (PET) Ratios

	TMET			PET		
Program	Scenario #1	Scenario #2	Scenario #3*	Scenario #1	Scenario #2	Scenario #3*
Low-Income Assisted Multifamily Progam	1.3	1.4	2.4 - 3.4	1.6	1.8	3.1 - 4.4
Low-Income Direct Installation	0.8	1.0	Not Available	1.0	1.1	Not Available
Assisted Home Performance w/ ENERGY STAR®	1.1	1.2	1.8 - 2.6	1.2	1.2	1.9 - 2.6

* The lower bound of the ratio is based on using 50% of the non-energy benefits; the upper bound is based on using 100% of the non-energy benefits.

Conclusions

Because the **New York Energy $mart**[SM] Program is a public benefits program, diverse objectives and benefits are sought. These additional benefits, in most cases, cannot be easily quantified. Therefore, individual B/C ratios alone should not be used as evidence to support or curtail program efforts – NYSERDA uses other broader decision criteria for this purpose, with B/C ratios being just one. The following are factors that should be considered when applying the B/C ratios:

- Different programs target different markets in which the technologies, customer characteristics, and magnitude of market barriers all may vary. Thus, a program with a lower B/C ratio may be addressing more significant market barriers than a program with a higher B/C ratio.

- Some programs place a much greater emphasis on certain objectives that are difficult, if not impossible to monetize. For example, low-income programs emphasize equity and the C/I Performance Program was designed specifically to strengthen the energy services infrastructure. The extent to which such benefits cannot be monetized will understate the B/C ratios.

- There are other programs that have up-front costs, such as the Small Commercial Lighting Program, that supports training of lighting contractors, with most of the benefits expected to

materialize in the future. For these programs, while there are relatively small energy and capacity impacts through 2003, more substantial impacts are expected in the future with B/C ratios increasing over time.

- Programs are continually reviewed and revised by NYSERDA in response to customer feedback and evaluation findings; therefore, final judgment of a program's cost-effectiveness, especially in its early stages, should be avoided particularly for market transformation programs.

- Estimating program spillover through the use of participant and non-participant surveys requires that respondents attribute installations of efficiency measures outside the program to awareness of the program and its message. It is very likely, however, that survey respondents may be unaware that NYSERDA's market transformation programs have brought about broad market changes such as stocking practices and more knowledgeable retail sales staff. Therefore, the market effects of many of NYSERDA's programs are likely to be underestimated. The best available estimates were used in the first-year report to capture the full market effects of the programs. Efforts to capture market share data for key measures in key programs should be increased so that more accurate market effect multipliers can be calculated.
- Efforts to quantify the non-energy benefits (*e.g.*, increased/improved energy affordability, comfort, safety, reliability, quality of living) should be continued and refined. In particular, the primary focus of these efforts should be on quantifying those benefits that are more easily quantifiable, such as increases and decreases in operation and maintenance costs.

Next Steps

Nexant has reviewed and adjusted nearly all of the savings estimates for the pre-qualified measures in NYSERDA's Deemed Savings Database. However, the incremental costs associated with each measure need to be reviewed and updated as necessary. The Deemed Savings Database will ensure that the correct savings and incremental costs are being used by program staff for pre-qualified measures.

Market transformation programs that front-load costs in anticipation of realizing future benefits will not fare as well under the B/C analysis as programs that deliver immediate savings (*e.g.*, resource procurement programs). The real value of public support for these activities and their resulting long-term impacts should be compared to what would have likely occurred absent the program by comparing the "base case" to forecasted longer-term market effects case. Efforts are currently underway to develop data collection and analysis procedures that will allow the inclusion of these future benefits in the benefit-cost analysis.

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