Acid Rain Program Benefits Exceed Expectations

CLEAN AIR MARKET PROGRAMS

A new analysis[1] of the Acid Rain Program, established by Title IV of the Clean Air Act Amendments of 1990, estimates annual benefits of the program in 2010 at $122 billion and costs for that year at $3 billion(2000$)—a 40-to-1 benefit/cost ratio. This new analysis includes:

- *Previously unanticipated mercury reductions are quantified.*
- *Health benefits are based upon reductions of fine particle and ozone pollution, not just sulfates.*
- *The list of benefits categories is expanded, reflecting EPA's latest benefit quantification and valuation methodologies.*

Benefits are Due to Emissions Reductions

These quantified benefits are the result of improved air quality and lower acidic deposition in the U.S. and Canada. The Acid Rain Program not only reduced emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X) from U.S. power generation sources, as Title IV intended, but reduced mercury emissions, as well. To comply with the Acid Rain Program, power plants switched to low sulfur coals (which also contained less mercury) and installed scrubbers to control SO_2 (which also controlled mercury emissions).

Attainment Achievements

By reducing SO_2 and NO_X over a large geographic region, ambient levels of fine particulate matter (PM) and ozone also decline; thus the Acid Rain Program contributes to the National Ambient Air Quality Standards (NAAQS) attainment. In 2010 air quality improvements due alone to the Acid Rain Program:

- 92 counties will be in attainment with the fine PM NAAQS, and
- 110 counties will be in attainment with the 8-hour ozone NAAQS.

$122 Billion in Benefits for Human Health, Visibility, and Natural Resources

Annual health benefits in 2010 of the Acid Rain Program's reductions of fine PM and ozone, valued at $119 billion, are detailed in Figure 4, along with the Program's improvements in visibility and natural resources, valued at $2.6 billion. Other benefit categories quantified, but not yet monetized, include significant reduction in chronically acidified lakes and streams in the eastern United States.

Estimated Costs are Less Than Expected

Acid Rain Program Implementation and Compliance strategies that were not anticipated at the Program's inception have cut estimates of the Acid Rain Program's annual cost estimates to $3 billion in 2010, 50% of the Program's cost estimated by EPA in 1990. The current estimate recognizes that some switching to lower sulfur coal would have occurred in the absence of Title IV. Railroad deregulation lowered the cost of transporting coal from Wyoming's Powder River Basin to electric plants in the Midwest and adaptation of power plant boilers to use lower sulfur coal was less costly than projected.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

[1] *Lauraine G. Chestnut and David M. Mills, "A Fresh Look at the Benefits and Cost of the US Acid Rain Program," Journal of Environmental Management, Vol. 77, Issue 3 (November 2005), 252-266.*

FIGURE 1.
Annual SO_2 emissions from U.S. electric power industry by region.

Emissions from U.S. power generation	SO_2 (million tons)	NO_X (million tons)	Mercury (tons)
2010 without Title IV	17.3	7.6	52
2010 with Title IV	9.3	5.0	42
The difference Title IV makes*	8.0	2.6	10

**Differences do not exactly match 2010 totals due to rounding*

Source: Chestnut and Mills. Calculated using data provided by U.S. EPA.

FIGURE 2.
Annual benefits of projected reductions in $PM_{2.5}$ (annual average) with Title IV from estimated concentrations without Title IV in 2010.

Avoided health effects	Number of cases of avoided health effects*		Monetary value (millions U.S. 2000 dollars)	
	U.S.	Canada	U.S.	Canada
Mortality (adults)	17,000	1,000	$100,169	$6,002
Infant mortality (children less than 1)	100	5	$751	$28
Chronic bronchitis (adults)	10,400	600	$4,056	$218
Nonfatal heart attacks (adults)	22,800	1,200	$1,917	$101
Respiratory hospital admissions (all ages)	8,300	400	$123	$7
Cardiovascular hospital admissions (adults)	10,800	600	$233	$13
Emergency room visits for asthma (children)	14,100	600	$4	$0.2
Acute bronchitis (children)	26,600	1,100	$10	$0.4
Asthma exacerbations (children with asthma)	28,200	1,200	$1	$0.1
Upper respiratory symptoms (children with asthma)	338,200	15,200	$9	$0.4
Lower respiratory symptoms (children)	287,300	12,200	$5	$0.2
Minor restricted activity days (adults)	12,130,300	636,100	$643	$34
Work loss days (adults)	2,090,400	109,600	$228	$12
Total monetary value			$108,148	$6,416

** Rounded to nearest 100.*

Source: Chestnut and Mills. Calculated by the authors using REMSAD results provided by U.S. EPA.

FIGURE 3.
Annual benefits from projected reductions in 8-hour ozone concentrations (season average) with Title IV from estimated concentrations without Title IV in 2010.

Avoided health effects	Number of cases of avoided health effects*	Monetary value (millions U.S. 2000 dollars)
Mortality	700	$4,101
Respiratory hospital admissions (age ≥ 65)	1,500	$27
Respiratory hospital admissions (age ≤ 2)	1,800	$14
Emergency room visits for respiratory illness	400	$0.1
School loss days	785,500	$59
Acute respiratory symptoms, minor restricted activity	1,612,100	$161
Worker productivity loss	n.a.	$22
Total monetary value		$4,384

**Rounded to nearest hundred.*

Source: Chestnut and Mills. Calculated by the authors using BenMAP with CAMx results provided by U.S. EPA.

FIGURE 4.
Summary of annual benefits and costs of Title IV in 2010 (millions U.S. 2000 dollars)

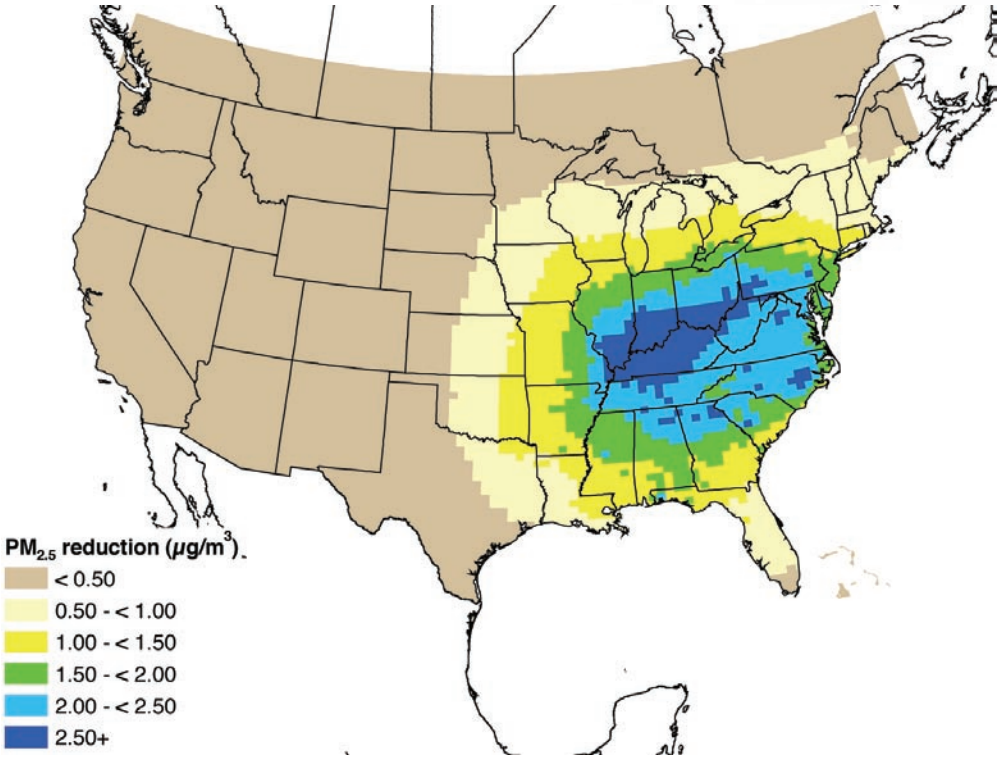
Quantified benefits*:		
$PM_{2.5}$ mortality (U.S. and southern Canada)	$107,000	
$PM_{2.5}$ morbidity (U.S. and southern Canada)	$8,000	
Ozone mortality (eastern U.S.)	$4,000	
Ozone morbidity (eastern U.S.)	$300	
Visibility at parks (3 U.S. regions)	$2,000	
Recreational fishing in NY	$65	
Ecosystem improvements in Adirondacks (NY residents)	$500	
Total annual quantified benefits		$122,000
Quantified costs for U.S. power generation:		
SO_2 controls	$2,000	
NO_X controls	$1,000	
Total annual quantified costs		$3,000

**These are central estimates but are subject to uncertainty and should not be interpreted as exact point values; we have therefore rounded for summary purposes. Many categories of expected benefits are not quantified due to insufficient data. Some, such as urban visibility, are quantified only as sensitivity tests due to uncertainty; these sum to about $4 billion. Other unquantified benefits include improved health and environment due to mercury reductions; improved health of natural forests and improved water quality in lakes, streams, and coastal estuaries from reductions in acid and nitrogen deposition; and increased longevity and reduced soiling of painted surfaces and stone materials.*

Source: Chestnut and Mills. Calculated using REMSAD results provided by U.S. EPA.

FIGURE 5.

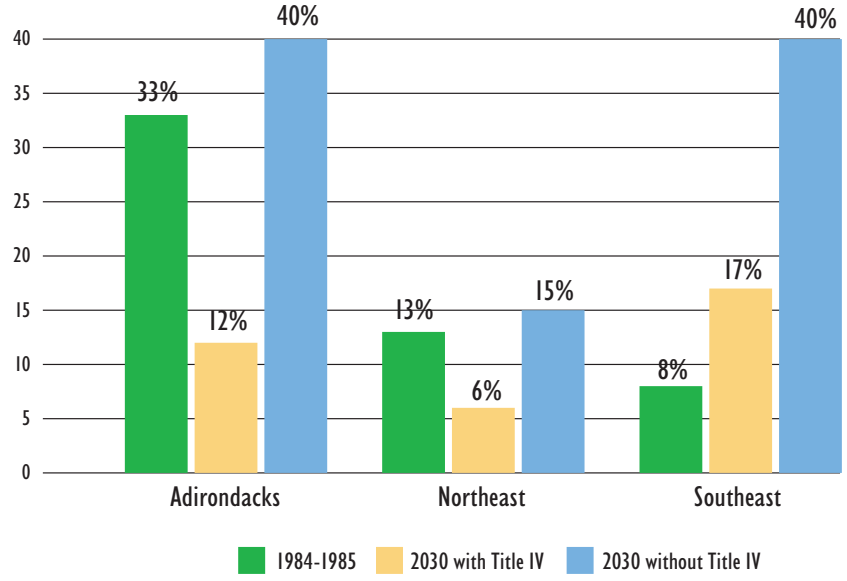
Projected reductions in $PM_{2.5}$ (annual average) with Title IV estimated concentrations without Title IV in 2010.



Source: Chestnut and Mills. Calculated using REMSAD results provided by U.S. EPA.

FIGURE 6.

Projected changes in percentage of lakes and streams with chronic acidification with and without Title IV.



Source: NAPAP Report to Congress (2005).