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THE REAL ACID TEST OF TITLE IV OF THE CLEAN AIR ACT AMENDMENTS OF 1990: EXTERNAL COST JUSTIFICATIONS NOT RELATED TO ACID DEPOSITION CONTROL

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INTRODUCTION

IN 1990, Congress enacted the Clean Air Act Amendments of 1990.[1] One of the principal objectives of the Amendments Act, contained in Title IV, is to control acid deposition by reducing the air emissions of sulfur dioxides (SO_2) and nitrogen oxides (NO_x) released by many fossil fuel-fired steam-electric generating utility units.[2] Unfortunately, a comprehensive report recently issued by the National Acid Precipitation Assessment Program (NAPAP),[3] called the Integrated Assessment (NAPAP IA), casts formidable doubts upon Title IV's efficacy. Essentially, the NAPAP IA suggests that the relationship between Title IV and the mitigation of the adverse effects of acid deposition in environmentally sensitive areas is too attenuated to warrant the nationally pervasive regulatory nature of Title IV.[4] Consequently, some commentators have attacked the propriety of Title IV.[5]

The stated purpose of Title IV is acid deposition control. However, by reducing significant emissions of SO_2 and NO_x emissions in the United States, Title IV makes enormous strides at reducing the non-acid deposition-related human health and ecological (environmental) adverse effects attendant with fossil fuel-fired electric power generation.

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1. The Clean Air Act Amendments Act of 1990 (West Supp. 1990)(amending the Air Pollution Prevention and Control Act, commonly referred to as the Clean Air Act (CAA)), 42 U.S.C.A. §§ 7401-7671(q)(West Supp. 1990).
2. 42 U.S.C.A. § 7651b.
3. NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM, U. S. ENVTL. PROTECTION AGENCY, INTEGRATED ASSESSMENT REPORT (1990) [hereinafter NAPAP IA].
4. *See generally id.*
5. *See, e.g.*, Philip Shabecoff, *Acid Rain Report Confirms Concern, but Crisis is Discounted*, N.Y. TIMES, September 5, 1990, at A1; *see also Sixty Minutes: Acid Rain* (CBS television broadcast, Aug. 4, 1991) (discussing how tax dollars and congressional efforts were wasted because the NAPAP IA "confirmed" that Title IV was unnecessary).

Electric power generation has severe environmental impacts. These environmental impacts are known as "externalities" because they are not included in the price paid by customers for the use of electricity from the electric utility industry. The Pace University Center For Environmental Legal Studies reviewed all available studies monetizing the adverse external environmental effects resulting from the release of SO_2 and NO_x emissions from the electric utility industry. A principal purpose of the Pace Study was to determine how available studies quantify the environmental costs of SO_2 and NO_x emissions on a dollar per pound of emission basis. Correspondingly, the environmental benefits conferred by Title IV can be expressed in terms of dollars saved per pound of SO_2 or NO_x emissions eliminated by Title IV.

To comply with Title IV, the utility industry will have to limit their emissions of SO_2 and NO_x. This will require the utility industry to accrue compliance costs for various control devices, including flue gas desulfurization and low-NO_x burner technology. As the contraposition to externalities, the utility industry's costs of compliance with Title IV are known as "internalities" because these costs are generally included in the price consumers pay for electricity. Analogous to monetizing external environmental cost benefits, internal costs of compliance with Title IV can also be monetized.

The purpose of this article is to compare the non-acid deposition-related external environmental cost benefits of Title IV with the internal costs of compliance. This article does not address whether Congress should have enacted Title IV in the first place. Instead, this article argues that, notwithstanding the external effects of reducing acid deposition, the non-acid deposition-related external cost benefits made possible by Title IV far outweigh the internal costs of complying with Title IV. Therefore, regardless of the issue of whether the intended scope and focus of Title IV is appropriate to control damage due to acid deposition, Title IV clearly has viable non-acid deposition-related cost justifications.

BACKGROUND

The combustion of fossil fuels results in the release of significant amounts of airborne sulfur dioxide (SO_2) and nitrogen oxides (NO_x).[6] Ultimately, emissions of SO_2 and NO_x are deposited back on earth either directly as SO_2 and NO_x, or as chemical derivatives of SO_2 or NO_x.[7] These depositions of SO_2 and NO_x subsequently cause adverse environmental effects, including damage to humans, the aquatic ecosystem, agricultural production, forests, materials and visibility.[8]

Utility units are responsible for a lion's share of SO_2 and NO_x emis-

6. *See generally* NAPAP IA, *supra* note 3.
7. *Id.*
8. These precepts are codified in 42 U.S.C.A. § 7651a.

sions in the United States. In 1985, fossil fuel-fired[9] steam- electric generating units (hereafter utility units) accounted for over 16 million tons, or about 70 percent, of all emissions of SO_2 in the U.S.[10] Similarly, in 1985, utility units were responsible for almost 6.6 million tons, or about one-third, of all NO_x emissions in the United States.[11]

On November 15, 1990, President Bush signed into legislation the "Clean Air Act Amendments of 1990" (Amendments Act).[12] The amendments contains sweeping revisions which take the form of seven "titles" regarding: (1) attainment and maintenance of national ambient air quality standards,[13] (2) mobile sources,[14] (3) hazardous air pollutants,[15] (4) acid deposition control,[16] (5) permits,[17] (6) stratospheric ozone protection,[18] (7) enforcement,[19] and, (8) miscellaneous provisions.[20]

Title IV of the Amendments Act concerns reducing the emissions of SO_2 and NO_x from utility units.[21] The stated objective of Title IV is to control the emissions of SO_2 and NO_x because they are the main precursors to acid deposition.[22] However, by dramatically reducing overall emissions of SO_2 and NO_x in the United States, Title IV will have more profound environmental implications than simply thwarting acidic deposition.[23]

9. In this article, fossil fuel-fired will refer primarily to coal and/or oil fired facilities.

10. NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM, U.S. ENVTL. PROTECTION AGENCY, EMISSIONS INVENTORY: NATIONAL UTILITY REFERENCE FILE (VERSION 2 1985) [hereinafter NAPAP EMISSIONS INVENTORY].

11. *Id.*

12. 42 U.S.C.A. § 7401-7671(9)(West Supp. 1990).

13. 42 U.S.C.A. §§ 7501-7554.

14. 42 U.S.C.A. §§ 7581-7627.

15. 42 U.S.C.A. §§ 7412.

16. 42 U.S.C.A. §§ 7651-7651o.

17. 42 U.S.C.A. §§ 7661-7661f.

18. 42 U.S.C.A. §§ 7671-7671p.

19. 42 U.S.C.A. §§ 7413.

20. 42 U.S.C.A. §§ 767lq.

21. See 42 U.S.C.A. § 7651(a)(2) which provides that "the principal sources of the acidic compounds and their precursors in the atmosphere are emissions of sulfur and nitrogen oxides from the combustion of fossil fuels", and 42 U.S.C.A. § 7651(a)(7), which adds that "control measures to reduce precursor emissions from steam-electric generating units should be initiated without delay."

22. *See* 42 U.S.C.A. § 7651(a)(2). Incidentally, prior to the Amendments Act, the Clean Air Act only addressed acid deposition control tangentially in 42 U.S.C.A. § 7410(a)(2)(E) which allowed states to implement consensual interstate air pollution control agreements, including those to abate emissions of SO_2 and NO_x and provided a procedure by which a state believing itself the recipient of air pollution from another state in violation of 42 U.S.C.A. § 7410(a)(2)(E) could petition the EPA to force a revision of the offending state's State Implementation Plan, and 42 U.S.C.A. § 7415 pertaining to actions involving the prevention of international air pollution, including the transnational transportation of SO_2 and NO_x.

23. Besides the non-acidic deposition related beneficial effect of reducing SO_2 and NO_x discussed in this article, Title IV may help pave the way for international action. *See generally* HILARY F. FRENCH, WORLDWATCH INSTITUTE PAPER NO. 94, CLEARING THE AIR: A GLOBAL AGENDA (1990).

Title IV aims to reduce emissions of SO_2 and NO_x from affected utility units[24] by ten million[25] and two million[26] tons per year, respectively, by the year 2000.[27] Title IV implements acid deposition control in two phases. Beginning on January 1, 1995, Phase I restricts both SO_2 and NO_x emissions from large coal-fired utility units.[28] Beginning on January 1, 2000, Phase II limits both SO_2 and NO_x emissions from smaller coal and oil-fired utility units, as well as tightening the restrictions on the larger coal-fired utility units affected by Phase I.[29]

Title IV controls SO_2 emissions by setting limits and then distributing marketable licenses to pollute, known as "allowances", to utility units. Utility units may buy, sell, lease, or hold the allowances for future use. In contrast to the use of a market-based approach, Title IV regulates NO_x emissions primarily by restricting the emissions rates of affected utility units. These concepts will be discussed more thoroughly in Part I of this article.

Reduction of SO_2 and NO_x have various "external" cost benefits.[30] Many of these external benefits are not related directly to controlling acid deposition, and can be quantified in terms of the value of eliminating a unit of SO_2 or NO_x. These external non-acid deposition- related cost benifits will be addressed in this article in dollars per pound (1989$/lb of SO_2 or NO_x reduced). Further, to meet Title IV's SO_2 and NO_x emission reduction requirements, utilities must incur various "internal" compliance costs.[31] The quantifiable internal economic costs of Title IV are a function of many things, including the costs of installing new emission control technologies, switching fuels, developing cleaner technologies, or any other means of compliance.[32]

The remainder of this article is divided into six main parts. Part One describes Title IV of the Clean Air Act Amendments of 1990; Part Two discusses the non-acid deposition related external cost benefits achieved by Title IV's reduction of SO_2 emissions; Part Three addresses the non-acid deposition related cost benefits achieved by Title IV's reduction of

24. Affected utility units are any units subject to either SO_2 or NO_x restrictions. 42 U.S.C.A. § 7651a(2) (West Supp. 1990). In this article, I will refer to "affected units" simply as utility units.

25. 42 U.S.C.A. § 7651(b).

26. *Id.*

27. Title IV does not presently affect the emissions from industrial sources. However, not later than January 1, 1995, and every 5 years thereafter, EPA must report to Congress as to the continued propriety of exempting industrial SO_2 emissions from Title IV. 42 U.S.C.A. § 7651e.

28. 42 U.S.C.A. § 7651c(a).

29. 42 U.S.C.A. § 7651d(a).

30. *See generally* RICHARD L. OTTINGER ET AL, PACE UNIVERSITY CENTER FOR ENVIRONMENTAL LEGAL STUDIES, THE ENVIRONMENTAL COSTS OF ELECTRICITY (1989) [hereinafter PACE STUDY]; Richard L. Ottinger, *Getting at the True Cost of Electric Power*, ELECTRICITY J., July 1990, at 14-23.

31. NAPAP IA, *supra* note 3, at 405-96.

32. *See infra* Part V.

NO_x emissions; Part Four examines why this article will not address the acid deposition related external cost benefits achieved by Title IV; Part Five lists some industry estimates of the internal costs of compliance with Title IV; and, Part Six compares Title IV's non-acid deposition-related external cost benefits with its internal costs of compliance.

I. Title IV of the Clean Air Act Amendments of 1990

Title IV sets limits on the emissions of both SO_2 and NO_x from utility units. A working knowledge of Title IV is essential to understand fully the thesis of this article; hence, the following sections will discuss how Title IV implements these reductions, as well as some of the Title's inherent problems.

A. *SO_2 Emission Limitations*

Title IV uses "allowances" to implement SO_2 emission restrictions. The following paragraphs summarize these restrictions pertaining to both existing[33] and new[34] utility units, and describe the allowance program.

1. Limitations Imposed Upon Existing Utility Units

The SO_2 emissions restrictions imposed by Title IV on existing units depend upon whether Phase I or Phase II of the legislation is in effect. Beginning on January 1, 1995, Phase I of Title IV establishes an annual SO_2 emission limitation (in tons per year) for 111 coal and oil- fired utility units which in 1985 had a generating capacity of at least 100 megawatts (MW) and emitted at least 2.5 pounds of SO_2 per million British Thermal Units of heat input (lb/MBtu).[35]

The annual SO_2 emission restriction Title IV imposes upon a utility unit is equal to the number of "allowances" allocated to the unit. The affected utility units are found in twenty-one states, the majority of which are located in the northeastern United States.[36]

Beginning after January 1, 2000,[37] Phase II of Title IV further restricts the emissions of the 111 utility units specified in Table A to 1.2 lbs NO_x/MBtu. Phase II also establishes methods of calculating SO_2 allowances

33. 42 U.S.C.A. § 7651a(8) defines "existing unit" as utility units that commenced commercial operation before November 15, 1990.

34. 42 U.S.C.A. § 7651a(10) provides that "new units" are those that commences commercial operation on or after November 15, 1990.

35. The utility units affected by phase one are set forth in the legislation as "Table A—Affected Sources and Units in Phase I and Their Sulfur Dioxide Allowances", found in 42 U.S.C.A. § 7651c. Eligibility for Table A was based upon data gathered in the NAPAP Emissions Inventory, *supra* note 10.

36. The states containing affected sources are: Alabama, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Tennessee, West Virginia, and Wisconsin. *See* 42 U.S.C.A. § 7651c.

37. 42 U.S.C.A. § 7651d(a)(1).

for: units with a capacity of at least 75 MW that emit 1.2 lbs/mmBtu or more of SO_2[38]; coal or oil-fired units with a capacity of less that 75 MW and SO_2 emissions greater than 1.2 lbs/mmBtu[39]; coal-fired utility units with SO_2 emissions less than 1.2 lbs/mmBtu[40]; oil and gas-fired units with SO_2 emissions between 0.6 and 1.2 lbs/mmBtu[41]; oil and gas-fired units with SO_2 emissions of less than 0.6 lbs/mmBtu[42] ; specified utility units that began operation between 1986 and December 1990[43]; oil and gas-fired utility units that consume less than 10 percent oil[44]; utility units in states experiencing at least a 25 percent population growth[45]; certain municipally owned units[46]; and, utility units in states with an average 1985 statewide emission rate of no more than 0.8 lbs/mmBtu.[47]

2. Limitations Imposed Upon New Utility Units

New utility units subject to SO_2 restrictions are those which commence operation after November 15, 1990.[48] Unlike existing utility units, and with the exception of some units commencing commercial operation between December 31, 1995 and January 1, 2000,[49] new utility units will not be allocated allowances by EPA.[50] Moreover, beginning on January 1, 2000, Title IV requires new units to obtain allowances equal to their annual SO_2 emissions from other sources which have been allocated allowances.[51]

3. Description of the Allowance System[52]

Title IV permits EPA to allocate "allowances" in an amount equal to the utility unit's annual SO_2 emission limitation.[53] An allowance is a license to emit one ton of SO_2 in a given year, and is allocated to affected

38. 42 U.S.C.A. § 7651d(b).
39. 42 U.S.C.A. § 7651d(c).
40. 42 U.S.C.A. § 7651d(d).
41. 42 U.S.C.A. § 7651d(e).
42. 42 U.S.C.A. § 7651d(f).
43. 42 U.S.C.A. § 7651d(g).
44. 42 U.S.C.A. § 7651d(h).
45. 42 U.S.C.A. § 7651d(i)(1)(A).
46. 42 U.S.C.A. § 7651d(j).
47. 42 U.S.C.A. § 7651e.
48. 42 U.S.C.A. § 7651a(10).
49. *See* 42 U.S.C.A. § 7651d(g).
50. 42 U.S.C.A. § 7651b(e).
51. *Id.*
52. Any discussion regarding the marketable allowance system would be remiss not to acknowledge the contributions of Dr. Daniel Dudek, Chief Economist on Air Issues, Environmental Defense Fund (EDF). Dr. Dudek was an early champion of the concept that acid deposition precursors could be regulated through the use of a market-oriented system of "allowances". For a colorful account of Dr. Dudek's efforts to propagate the market-based allowance approach, *see* ROBERT TAYLOR, AHEAD OF THE CURVE: SHAPING NEW SOLUTIONS TO ENVIRONMENTAL PROBLEMS 65-83 (1990).
53. 42 U.S.C.A. § 7651b(a).

utility units[54] by EPA.[55] A utility unit's annual SO_2 emission limitation is a function of the type of fuel used by the utility unit, as well as the unit's rated capacity, fuel consumption rate, actual and allowable emission rates, and other factors. A utility unit's SO_2 emissions may not exceed the number of allowances that the unit is holding in any given year.[56]

To meet emission limitations for subsequent years, utility units may carry unused allowances from year to year and from Phase I into Phase II.[57] Thus, a utility may accumulate allowances that it does not need to meet its own annual emission limitation.[58] Subject to EPA regulations scheduled for release by May 15, 1992,[59] utilities may dispose of accumulated allowances either by transferring them to their own units, or by selling them to other utilities.[60] The allowance program also provides incentives for early implementation of certain emission control technologies,[61] and for employment of energy conservation measures.[62]

54. Other utility and non-utility units not affected by Title IV, including industrial units, may "elect" to become "affected", and thereby receive SO_2 allowances. 42 U.S.C.A. § 7651 e(c); *see* 42 U.S.C.A. § 7651i(a). The impetus for doing this is that the affected unit may then transfer or sell the allowances it "frees up" by reducing its emissions beyond certain EPA-established limitations. 42 U.S.C.A. § 7651i(f). The number of units taking advantage by electing into the allowance program is speculative at this time; therefore, the environmental cost benefits of election for additional units will not be addressed in this article.

55. 42 U.S.C.A. § 7651b(d)(1).

56. The penalties for violating an annual emission limitation are found in 42 U.S.C.A. § 7651j.

57. 42 U.S.C.A. § 7651b(b).

58. *Id.*

59. *Id.*

60. *Id.* EPA must also establish a system to track allowances transactions by May 15, 1992. 42 U.S.C.A. § 7651b(d)(1).

61. Incidentally, Title IV provides incentives for utilities who reduce their SO_2 emissions before being required to do so by Title IV. Section 7651c(d) contains provisions for allocating "bonus" allowances to utilities using a "qualifying phase I technology" (as defined in § 7651a(19)). In the balance, the incentive program could have a beneficial impact upon the environment. The number of bonus allowances a utility unit may earn is dependant upon when and how much it reduces SO_2 emissions. The utility industry's reaction to Title IV's emission reduction incentives, however, will not be known until at least 1995; therefore, a discussion of the environmental impacts of the reserve would be premature at this time.

62. Beginning January 1, 1995, 42 U.S.C.A. § 7651b(g), Title IV provides that for each ton of SO_2 avoided by an affected utility unit by the use of "qualified energy conservation measures," the EPA will allocate a single allowance to the unit. 42 U.S.C.A. § 7651c(f)(2)(A). The subsection also applies to SO_2 emissions avoided through the use of "qualified renewable energy." 42 U.S.C.A. § 7651c(f)(2)(B). Because emission reductions gained by use of conservation programs are offset by additional like-kind emissions from conventional power sources, the conservation initiatives will have no effect upon the overall amount of SO_2 and NO_x reduced by Title IV. For a helpful discussion of § 7651c(f), see Richard Cavanaugh, Natural Resources Defense Council, Clean Air Act Incentives For Energy Efficiency and State Regulatory Reform, Natural Resources Defense Council (unpublished paper presented at the "Clean Air Act Amendments and the Energy Industry Conference", in Washington, D.C. (February 21-22, 1991)); *see also*, HOWARD GELLER, ET AL., AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECON-

B. NO_x *Emission Restrictions*[63]

Another objective of Title IV is to reduce NO_x emissions by at least two million tons per year relative to 1980 levels. Title IV seeks to realize this goal by limiting the NO_x emission rates (on a lbs/MBtu heat input basis) of affected coal-fired utility units.[64] On the date that a coal-fired utility unit becomes affected by Title IV's SO_2 emission limitations, the unit correspondingly is required to meet NO_x emission rate limitations.[65] The NO_x emission rate restrictions are a function of the type of coal-fired boiler used by the affected utility unit.[66] Title IV restricts the NO_x emission rates for the following types of coal-fired boilers: tangential, dry-bottom wall-fired boilers and cell burners in existence after January 1, 1995[67]; and, wet-bottom wall-fired boilers, cyclones, boilers applying cell burner technology, and all other types of utility coal-fired boilers in existence after January 1, 1997.[68]

C. *Problems With Title IV*

Title IV is not without its problems. Some of these problems are especially troublesome when it comes to monetizing externalities. A few of Title IV's shortfalls are discussed in the following paragraphs.

1. Interpollutant Trading and the Uncertainties Regarding the Protection of Environmentally Sensitive Areas

NAPAP maintains that acidic lakes and streams that have been acidified by emissions from utility units and other anthropogenic sources are found primarily in the Southwest Adirondack Mountains, New England, small forested watersheds in the Mid-Atlantic Highlands, Mid-Atlantic Coastal Plains, Northcentral portion of the Florida Peninsula, and the Upper Peninsula of Michigan and northeastern Wisconsin. These areas are found to be particularly sensitive to acid deposition.[69]

The Achille's heel of Title IV may be that it does not restrict how a utility uses its allowances. For instance, utilities may transfer allowances

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OMY (ACEEE)/ENERGY CONSERVATION COALITION, ACID RAIN AND ELECTRICITY CONSERVATION (1987); ELLIOTT NIXON & CHARLES NEME, CENTER FOR CLEAN AIR POLICY, AN EFFICIENT APPROACH TO REDUCING ACID RAIN: THE ENVIRONMENTAL BENEFITS OF ENERGY CONSERVATION (1989).

63. 42 U.S.C.A. § 7651f(c) requires the EPA to revise its 111 New Source Performance Standards (NSPS) for NO_x emissions from fossil fuel- fired steam generating units by January 1, 1994. Any tightening of the NSPS for NO_x would have a beneficial effect upon the environment. It is impossible at this time, however, to know how EPA will revise the standards, and therefore how much any revision would reduce future emissions of NO_x. Hence, this article does not address the environmental cost benefits of revising the NO_x NSPS.

64. 42 U.S.C.A. § 7651f(a).

65. *Id.*

66. 42 U.S.C.A. § 7651f(b).

67. 42 U.S.C.A. § 7651f(b)(1).

68. 42 U.S.C.A. § 7651f(b)(2).

69. NAPAP IA, *supra* note 3, at 9-41.

from one unit to another unit they may own, or may trade or sell their allowances to another utility. As such, there is no way to ensure that utilities will reduce SO_2 and NO_x emissions from utility units located near environmentally sensitive areas.

For example, several utilities operate affected utility units near the Adirondacks, an environmentally sensitive area. However, simply by rearranging the displacement of their allowances, or by purchasing additional allowances, these utilities may emit as much, and possible more, SO_2 than at current levels in the Adirondacks. This is particularly troublesome considering the site-specific nature of the NAPAP findings. Consequently, Title IV is no guarantee that environmentally sensitive areas will be any better off than before.

2. Exemption of Simple-Cycle Gas Fired Combustion Turbines

Simple-cycle gas-fired combustion turbines (those that do not generate steam) are significant emitters of NO_x. Title IV, however, exempts simple-cycle gas-fired combustion turbines from the acid deposition control emission limitations.[70] Although new simple-cycle gas-fired combustion turbines will still be required to meet NSPS,[71] most agencies administering the Clean Air Act do not require simple- cycle generators to meet the more restrictive Best Available Control Technology.[72] Thus, by regulating primarily coal-fired utility units, and by exempting simple-cycle gas-fired utility units, Title IV may actually encourage the use of simple-cycle gas-fired combustion turbines. This may offset some of the gains to be made by reducing NO_x emissions from coal-fired plants.

3. Inapplicability to Emissions from Solid Waste Combustors

Individually solid waste combusting electric generation facilities (commonly known as waste-to-energy facilities) produce a significant amount of SO_2 and NO_x.[73] Although collectively they presently account for only a relatively small proportion of both SO_2 and NO_x emissions in the United States, their use is growing rapidly as landfill disposal sites are

70. 42 U.S.C.A. § 7651f(e).

71. 42 U.S.C.A. § 7511 (West Supp. 1990).

72. 42 U.S.C.A. § 7445 (West Supp. 1990) requires that a Best Available Control Technology (BACT) review be conducted before the construction of any "major emitting facility." Major emitting facilities include natural gas-fired utility units with the potential to emit at least 250 tons of NO_x per year. 42 U.S.C.A. § 7479(1). Many new simple-cycle gas-fired generators will not have the potential to emit at least 250 tons per year of NO_x, and therefore, will not trigger BACT review. Consequently, the reduction in NO_x emissions from Title IV could be lessened or even offset by the increased use of simple-cycle gas-fired combustion turbines. Unfortunately, this theory is merely speculative at this time; thus, this article will not consider the environmental costs impact of the increased demand for simple-cycle gas-fired combustion turbines resulting from the imposition of Title IV.

73. Waste-to-energy facilities produce about as much SO_2 and NO_x as a like-sized coal-fired steam-electric generation facilities. *See* PACE STUDY, *supra* note 30, at 456.

being exhausted.[74] Title IV, however, applies exclusively to *fossil-fuel* fired electric generators.[75] Therefore, non-fossil-fuel utility units,[76] such as municipal solid waste (MSW) combustion utility units,[77] are not subject to Title IV.[78] Thus, by not regulating MSW combustion utility units under Title IV, the Amendments Act may actually encourage their use. This may also offset some of the gains made by reducing emissions from fossil fuel-fired utility units.

II. EXTERNAL COST BENEFITS ACHIEFED BY TITLE IV'S REDUCTION OF SO_2 EMISSIONS (EXCLUDING ACID DEPOSITION EFFECTS)

As explained above, fossil fuel-fired utility units account for roughly two-thirds of all SO_2 emissions in the United States,[79] and one objective of Title IV is to reduce utility SO_2 emissions by about ten million tons per year.[80] The following sections: describe some of the adverse non-acid deposition related external impacts attributable to SO_2 emissions; determine the aggregate external cost benefits of Title IV's SO_2 reductions based upon figures provided by the Pace Study; and compare these external cost benefits with figures currently being used by various state regulatory agencies.[81]

A. *The External Cost Benefits Pertaining to Specific Media*

Emissions of SO_2 from fossil fuel-fired utility units have numerous adverse external impacts.[82] Emissions of SO_2 damage human health, materials, crops and visibility.[83] This section briefly describes how Title IV will result in external cost benefits to various environmental media (excluding the effects of acid deposition), as established by the Pace Study. This section concludes with an estimation of the aggregate annual non-acid deposition-related external cost benefits made possible by Title IV's reduction of SO_2 emissions.

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74. *Id.*

75. *See* 42 U.S.C.A. §§ 7651a(2), (7), (15) (West Supp. 1990).

76. Non-fossil-fuel utility units would also include, for example, wood and biomass (renewable generation resources), waste-to-energy, and nuclear utility units. *Id.*

77. A solid waste incineration unit will not be subject to Title IV if at least 80 percent of its annual average fuel consumption is from fuel other than fossil fuel. 42 U.S.C.A. § 7429 (h)(4) (West Supp. 1990).

78. 42 U.S.C.A. § 7429(h)(4). Title III of the Clean Air Act Amendments of 1990 contains a provision to regulate other aspects of solid waste combusting utility units. *See generally* 42 U.S.C.A. § 7429.

79. *See generally* NAPAP IA, *supra* note 3, at 236-46.

80. 42 U.S.C.A. § 7651(b) (West Supp. 1990).

81. Part Three of this article addresses the external cost benefits achieved by Title IV's reduction of NO_x emissions, excluding acid deposition effects.

82. *New Resources: Supply Curves and Environmental Effects*, STAFF ISSUE PAPER, (Northwest Power Planning Council), Feb. 1990.

83. *Id.*

1. SO_2-Related Human Health Cost Benefits of Title IV

Sulfur dioxide (SO_2) is one of many air pollutants adversely affecting human health.[84] Yet emissions of SO_2 are not generally believed to be a direct major cause of adverse human health effects.[85] Emissions of SO_2, however, contribute to the formation of particulate matter (PM10) by reacting in the atmosphere to form sulfates.[86] PM10 is more often recognized as a cause of adverse human health effects.[87] Consequently, SO_2 emissions contribute to cause impaired breathing, coughing, chest tightness, and mortality, as well as reduced productivity and activity.[88]

The Pace Study reviewed various external methods of assessing the damage to human health caused by the deposition of SO_2 and sulfates (excluding acid deposition effects).[89] For reasons explained in the Pace Study,[90] Pace suggests a "starting point" for the human health costs of SO_2 of $1.72/lb SO_2.[91]

Phase I of Title IV aims to reduce annual SO_2 emissions by about 3.5 million tons per year. Assuming human health cost savings of $1.72/lb SO_2 emitted, this translates into human health cost benefits of roughly $12 billion dollars per year. Phase I applies from January 1, 1995 until January 1, 2000. Thus, the total human health cost benefit of Phase I due to SO_2 reduction will be approximately 60 billion dollars. Phase II seeks to reduce annual SO_2 emissions by about ten million tons per year. At $1.72/lb SO_2 emitted, this equals human health cost benefits of about $34.4 billion dollars per year during Phase II.

2. SO_2-Related Agricultural Cost Benefits of Title IV

The direct deposition of SO_2 also results in acidification of soils, damage to plant foliage, and materials soiling.[92] Pace's review revealed that most studies evaluating the effect of the direct deposition of SO_2 on agricultural crops did not differentiate between the effects of the direct depo-

84. Dr. Morton Lippman, *Health Benefits from Controlling Exposure to Criteria Air Pollutants*, HEALTH BENEFITS OF AIR POLLUTION CONTROL: A DISCUSSION (John Blodgett, Congressional Research Service, ed., 1989).

85. JOHN GRAHAM, ET AL., U. S. ENVTL. PROTECTION AGENCY, DIRECT HEALTH EFFECTS OF AIR POLLUTANTS ASSOCIATED WITH ACIDIC PRECURSOR EMISSIONS, §§ 4, 5, 6, app. A (1989).

86. *Id.*

87. Various studies have reviewed the health effects of respiration of PM10. *See, e.g.*, JOHN CANNON, AMERICAN LUNG ASS'N, HEALTH COSTS OF AIR POLLUTION: A SURVEY OF STUDIES PUBLISHED 1978-1983 12-14 (1985); JEFF HALL, CALIFORNIA STATE UNIVERSITY FULLERTON FOUNDATION, ECONOMIC ASSESSMENT OF THE HEALTH BENEFITS FROM IMPROVEMENTS IN AIR QUALITY IN THE SOUTH COAST AIR BASIN (1989) (Report to the South Coast Air Quality Management District Under Contract No. 5685).

88. PACE STUDY, *supra* note 30, at 193.

89. *Id.* at 193-99.

90. *Id.* at 193-99.

91. *Id.* at 209.

92. *Id.* at 199.

sition of SO_2 and the effects of acid deposition.[93] Ultimately, though, the Pace Study embraces the reasoning of various studies[94] and assumes that the effects of the direct deposition of SO_2 on agricultural crops are negligible.[95]

3. SO_2-Related Material Cost Benefits of Title IV

When SO_2 combines with oxidants and moisture to form sulfuric acid, it corrodes metals, damages electrical contacts, deteriorates paper, textiles, leather, finishes and coatings, and erodes building stone strength.[96] The Pace Study could locate no material cost studies distinguishing between the effects of the direct deposition of SO_2 and acid deposition.[97]

The Pace Study determined that most studies assessing the material costs of acid deposition were difficult to apply because:[98] (1) many studies were national averages understating the damage in highly populated regions, while overstating the damage in other, less populous regions; and, (2) some studies were somewhat dated.[99] The Pace Study revealed the range of material costs from acid deposition to be between \$0.34lb/SO_2 and \$1.017lb/SO_2.[100] After suggesting that more research needed to be conducted, the Pace Study suggested a "starting point" materials cost of \$0.12lb/SO_2.

Accordingly, utility industry compliance with Phase I of Title IV would translate into materials cost benefits of roughly \$840 million dollars per year. Phase I applies from January 1, 1995 until January 1, 2000. Thus, the total materials cost benefits of Phase I due to SO_2 reduction will be approximately \$4.2 billion dollars. Moreover, if the utility industry complies with Phase II of Title IV, it would reduce annual SO_2 emissions by about 10 million tons per year, and translate into materials cost benefits of roughly \$2.4 billion dollars per year for the duration of Phase II.

4. SO_2-Related Visibility Cost Benefits of Title IV

Sulfur dioxide reacts in the atmosphere to produce sulfates (SO_4).[101] Besides harming human health, sulfates also degrade visibility.[102] Based

93. *Id.* at 199.
94. *See generally*, CHARLES RIVER ASSOCIATES, REPORT NO. 792, BENEFITS AND COSTS OF EXTERNALITIES AND INTANGIBLES ASSOCIATED WITH SOUTHERN CALIFORNIA EDISON'S 1985 AND 1986 CONSERVATION AND LOAD MANAGEMENT PROGRAMS (1984).
95. PACE STUDY, *supra* note 30, at 201.
96. *Id.* at 201.
97. *Id.* at 202.
98. *Id.* at 204.
99. *See e.g.*, Adam Gillette, *Sulfur Dioxide and Material Damage*, AIR POLLUTION CONTROL ASS'N J., Dec. 1975.
100. PACE STUDY, *supra* note 30, at 204.
101. *Id.* at 192-93.
102. *Id.* at 193.

upon studies using willingness-to-pay[103] valuation methodologies,[104] the Pace Study suggests a starting point cost for lost visibility due to sulfate formation to be \$0.14lb/SO_2.[105]

Phase I of Title IV aims to reduce annual SO_2 emissions by about 3.5 million tons per year. At \$0.14lb/SO_2, this translates into visibility cost benefits of roughly \$980 million dollars per year. Phase I applies from January 1, 1995 until January 1, 2000. Thus, the total human health cost benefit of Phase I due to SO_2 reduction will be approximately \$4.9 billion dollars. Additionally, during Phase II, an annual 10 million tons per year reduction of SO_2 emission would translate into visibility cost benefits of roughly \$2.8 billion dollars per year as long as Phase II remains in effect.

B. *Aggregate SO_2-Related External Cost Benefits of Title IV*

Phase I of Title IV will reduce annual SO_2 emissions by about 3.5 million tons per year. By combining the external costs from SO_2 emissions related to human health, material, and visibility costs, the aggregate external costs from SO_2 emissions are \$2.03lb/SO_2, this means that the total Phase I cost benefits during Phase I could be as much as \$14.21 billion dollars per year. Since Phase I applies from January 1, 1995 until January 1, 2000, the total human health cost benefit of Phase I due to SO_2 reduction (excluding damages due to acid deposition) could be approximately \$71.05 billion dollars.

Phase II of Title IV aims to reduce annual SO_2 emissions by about 10 million tons per year. This translates into total cost benefits (excluding damages due to acid deposition) of roughly \$40.6 billion dollars per year for the duration of Phase II.

C. *Comparison With SO_2 Externality Figures Used By State Regulatory Entities*

This article focuses primarily on the Pace Study. However, various state public utilities commissions have also attempted to monetize the unit value of reducing emissions of SO_2.[106] A detailed discussion of the foundation for the values used by the various state regulatory entities is

103. Willingness-to-pay surveys ask what people would be willing to pay to have vista visibility improved. PACE STUDY, *supra* note 30, at 65.

104. *See* ECO NORTHWEST ET AL., ECONOMIC ANALYSIS OF THE ENVIRONMENTAL EFFECTS OF A COMBUSTION-TURBINE GENERATING STATION AT FREDERICKSON INDUSTRIAL PARK, PIERCE COUNTY, WASHINGTON: FINAL REPORT (1984) (report commissioned by Bonneville Power Administration).

105. PACE STUDY, *supra* note 30, at 205. The Pace Study points out some of the inherent problems associated with willingness-to-pay studies. For example, most WTP studies ask people what they would be willing to pay to have visibility restored entirely, which is not currently a possibility. *Id.* at 65.

106. Telephone Interview with Emily Caverhill, Research Associate, Resource Insight, Inc. (April 11, 1991). Resource Insight-compiled table entitled "Comparison of Monetized Values of Externalities in the U.S.", updated April, 1991.

beyond the scope of this article.[107] Nevertheless, for the purpose of comparison with the cost figures generated pursuant to the Pace Study, Table 1 surveys the external non-acid deposition related external costs attributable to SO_2 emissions, being used by various state regulatory entities.

TABLE 1: COMPARISON OF MONETIZED SO_2 REDUCTION VALUES[108]

State Entity	Unit Cost ($/lb) Reduction Value	Annual Phase I Benefits (Billion 1989 $)	Annual Phase II Benefits (Billion 1989 $)
Cal. Enery Commission (Out-of-State values)	0.54	3.78	10.80
Mass. DPU	0.75	5.25	15.00
New York PSC	0.41	2.87	8.20
Nevada PSC[109]	0.78	5.46	15.60
BPA[110] ("East" values)	0.2025	1.42	4.06
Pace Study	2.03	14.20	40.57

Table 1 suggests that the figures generated pursuant to the Pace Study may emphasize the upper end of the external cost benefits of Title IV's reduction of SO_2 emissions.[111] Yet, considering orders of magnitude, it appears as if the Pace Study numbers are reasonably consistent with those used by state regulatory entities. Part Five of this article compares how these non-acid deposition-related external costs compare with the internal costs of complying with Title IV.

III. EXTERNAL COST BENEFITS ACHIEVED BY TITLE IV'S REDUCTION OF NO_x EMISSIONS (EXCLUDING ACID DEPOSITION EFFECTS)

Fossil fuel-fired utility units account for roughly one-third of all NO_x

107. For a brief critical discussion of the approaches taken by different state entities, see Emily Caverhill and Paul Chernick, *Accounting for Externalities*, PUBLIC UTILITIES FORTNIGHTLY, March 1, 1991, at 6.

108. All units are in 1989 dollars unless otherwise specified.

109. Nevada PSC figures are in 1990 dollars.

110. Bonneville Power Authority (BPA) figures are in 1990 dollars.

111. Note that the Pace Study used damage cost estimates while the state figures cited herein use control cost figures. Both techniques probably underestimate the external costs of producing electricity. For example, the figures used in the Pace Study are conservative because they do not include the front-end external costs associated with fuel procurement, i.e., oil drilling, spill abatement, transportation, mining and national security (such as the Persian Gulf War) efforts. In addition, Caverhill & Chernick, *supra* note 107, at 6, suggest that many of the figures used by state regulatory agencies are also too low.

emissions in the United States.[112] Emissions of NO_x are responsible for various adverse non-acid deposition related external impacts. As stated above, one objective of Title IV is to reduce emissions of NO_x from utility units by approximately 2 million tons per year.[113] The following sections: describe some of the adverse non-acid deposition related external impacts attributable to NO_x emissions; determine the aggregate external cost benefits of Title IV's NO_x reductions pursuant to figures provided by the Pace Study; and compare these external cost benefits with figures currently being used by state regulatory agencies.

A. *The External Cost Benefits Pertaining to Specific Media*

Emissions of NO_x adversely affect the environment on many fronts. NO_x reacts in the atmosphere to form tropospheric ozone and acid aerosols. Tropospheric ozone harms human health,[114] damages ornamental plants and forests, damages crops, and contributes to regional haze and loss of visibility.[115] Acid aerosols also harm human health.[116] NO_x may also cause damage to flora, fauna, and livestock.[117] Moreover, NO_x is also a significant contributor of "greenhouse gases"[118] (which may contribute to global warming[119]). Finally, NO_x may promote the cancer growth.[120]

This section briefly describes how Title IV will result in external cost benefits to various environmental media (excluding the effects of acid deposition), using figures generated by the Pace Study. The section concludes with an estimation of the aggregate annual external cost benefits made possible by Title IV's reduction of NO_x emissions.

1. NO_x-Related Human Health Cost Benefits of Title IV[121]

Tropospheric ozone (ozone) is created by a reaction of NO_x with at-

112. *See generally* NAPAP IA, *supra* note 3, at 236-46.
113. 42 U.S.C.A. § 7401(b)(1)(West Supp. 1990).
114. PACE STUDY, *supra* note 30, at 214-15.
115. *Id.* at 215.
116. *Id.* at 215.
117. *Id.* at 215.
118. NO_x reacts in the atmosphere to form Nitrogen Oxide (N_2O). Although N_2O accounts for only about 5 percent of all greenhouse gases, it is major greenhouse gas because it absorbs approximately 180 times as much infrared radiation as does CO_2 on a volumetric basis. Daniel A. Lashof & Dilliph Ahuja, *Relative Contributions of Greenhouse Gas Emissions to Global Warming*, NATURE, April 5, 1990, at 529-31.
119. U.S. ENVTL. PROTECTION AGENCY, POLICY OPTIONS FOR STABILIZING GLOBAL CHANGE, (1989) (Office of Policy, Planning and Evaluation Draft report to Congress), *citing Mark Hansen, et al., Evidence for Future Warming: How Large and When, in* THE GREENHOUSE EFFECT, CLIMATE CHANGE AND U.S. FORESTS, 19 (Eric Shands & Michael Hoffman eds., 1987).
120. Kathy Fackelmann, *Air Pollution Boosts Cancer Spread*, SCIENCE NEWS, April 7, 1990.
121. Tropospheric ozone is not to be confused with the stratospheric ozone layer. The stratospheric ozone layer is essential to protect terrestrial life from cosmic UV radiation. The troposphere is roughly the first 10 kilometers (km) in altitude; the tropospause is

mospheric oxygen in the presence of sunlight.[122] Human exposure to NO_x-induced ozone results in many adverse health effects.[123] Acute, short-term human exposure to high levels of ozone can cause temporary ailments such as lung irritation, hyperactivity, minor eye irritation, inflammation of respiratory cells, coughing, reduction of lung function, and pain upon inhalation.[124] Moderate to intermediate human exposure to ozone can cause a reduction or loss of worker productivity, an increase in health care costs, and discomfort, pain and suffering.[125] Chronic, long-term exposure to ozone may cause structural lung damage, leading to chronic lung disease, lung cancer, and increased susceptibility to respiratory infections such as bronchitis and pneumonia, all of which may cause early mortality.[126]

The Pace Study reviewed various external cost studies assessing the damages to human health caused by NO_x-induced ozone.[127] For reasons described in the Pace Study,[128] the starting point for human health costs of NO_x-induced ozone is estimated to be \$0.63lb/NO_x.[129] Beginning on January 1, 1995, Title IV seeks to reduce annual NO_x emissions by approximately 2 million tons per year.[130] At \$0.63lb/NO_x, this translates into human health cost savings of roughly \$2.5 billion dollars per year.

2. NO_x-Related Flora Cost Benefits of Title IV

NO_x and ozone cause damage to agricultural crops, commercial timber and natural forests, ornamental plants, and other natural flora.[131] Due to the paucity of data evaluating the economic costs of NO_x on commercial

from 10-20 km; and the stratosphere is from about 20-50 km. PACE STUDY, *supra* note 30, at 214 N.6.

122. ANTHONY WELLBURN, AIR POLLUTION AND ACID RAIN, 1988. The process of converting NO_x to ozone is exacerbated when Volitile Organic Compounds (VOCs), aldehydes, and carbon monoxide are present. VOCs, aldehydes, and carbon monoxide provide the free radicals necessary for conversion of Nitrogen Oxide (NO), which is produced by the combustion of fossil fuels, to NO_2, a component of tropospheric ozone. The Pace Study assumes that a reduction in NO_x emissions will result in a correlative reduction in tropospheric ozone-related environmental damages. PACE STUDY, *supra* note 30, at 214.

123. *See generally* John Cannon, American Lung Ass'n, The Health Costs of Air Pollution: A Survey of Studies Published 1984-1989, (1990); and Aaron Allen, *Poisoned Air*, Environmental Action, Jan./Feb. 1988.

124. U.S. OFFICE OF TECHNOLOGY ASSESSMENT, CATCHING OUR BREATH: NEXT STEPS FOR REDUCING URBAN OZONE, (1989).

125. PACE STUDY, *supra* note 30, at 215.

126. John Last, *Modification by Ozone of Lung Tumor Development in Mice*, 78 J. NATL. CANCER INST. 149, 1987.

127. *See* PACE STUDY, *supra* note 30, at 213-20.

128. *Id.*

129. *Id.* at Table 3. This article takes the liberty of combining the mortality and morbidity health effects. Unfortunately, the Pace Study does not address the medical costs attendant with NO_x-induced smog. *See e.g.*, John Mathews, *Smog-control Study Targets Medical Costs*, WASH. POST, July 11, 1989 at A10.

130. 42 U.S.C.A. § 7651(b)(West Supp. 1990).

131. PACE STUDY, *supra* note 30, at 221.

timber, natural forests, ornamental plants, and other natural flora, the Pace Study evaluated only the economic costs of NO_x and ozone pertaining to lost agricultural productivity.[132]

Damage to agricultural crops from ozone pollution may include leaf necrosis, depreciation in plant growth and vigor, reduction in plant yield, and increased susceptibility to biotic and abiotic stresses.[133] Based upon the findings of various studies,[134] the Pace Study established a "starting point" for valuing the economic losses of NO_x- induced agricultural crop reduction of \$0.01lb/NO_x. Beginning on January 1, 1995, full compliance by the utility industry with Title IV would reduce annual NO_x emissions by about 2 million tons per year.[135] At \$0.01 lb/NO_x, this translates into human health cost benefits of roughly \$40 million dollars per year.

3. NO_x-Related Material and Property Cost Benefits of Title IV

NO_x-induced ozone damages, *inter alia*, dyes and paints,[136] plastics, elastomers (including natural or synthetic rubber substances), electrical components,[137] and textile fabrics.[138] The Pace Study considered the various methodologies for assessing the economic costs of material and property damage due to NO_x-induced ozone, including: (1) material replacement costs; (2) the cost of periodic repainting or cleaning; (3) the loss of consumer perceived value of the material; and, (4) the cost of developing ozone and NO_x resistant materials, such as fade-resistant dyes.[139] Based upon the findings of various studies,[140] and because it is generally believed that SO_2 causes far more damage to materials than does NO_x,[141] Pace established a nominal "starting point" for assessing the material and property costs associated with NO_x emissions of \$0.01lb/NO_x. Beginning on January 1, 1995, Title IV aims to reduce

132. *Id.*

133. ENERGY AND RESOURCE CONSULTANTS, INC., THE BENEFITS OF AIR POLLUTION CONTROL IN CALIFORNIA 2-28 (1986) [hereinafter BENEFITS OF CONTROL] (Prepared for the California Energy Air Resources Board).

134. *E.g.*, ECO NORTHWEST ET AL., FINAL REPORT: ECONOMIC ANALYSIS OF THE ENVIRONMENTAL EFFECTS OF THE COAL-FIRED ELECTRIC GENERATOR AT BOARDMAN, OREGON (1983) [hereinafter ECO 1983], (report commissioned by the Bonneville Power Administration (BPA));ECO NORTHWEST ET AL., GENERIC COAL STUDY: QUANTIFICATION AND VALUATION OF ENVIRONMENTAL IMPACT (1987) [hereinafter ECO 1987] (Report commissioned by the BPA). *See* PACE STUDY, *supra* note 30, at 217 n.16.

135. 42 U.S.C.A. § 7651(b).

136. *See generally* NATIONAL ACADEMY OF SCIENCES, EFFECTS OF PHOTOCHEMICAL OXIDANTS ON MATERIALS, OZONE AND OTHER PHOTOCHEMICAL OXIDANTS, 653 (1989). [hereinafter EFFECTS OF OZONE].

137. *Id.* at 665.

138. BENEFITS OF CONTROL, *supra* note 133, at 2-24.

139. PACE STUDY, *supra* note 30, at 222.

140. *E.g.*, ECO 1987, *supra* note 134.

141. PACE STUDY, *supra* note 30, at 202.

annual NO_x emissions by about 2 million tons per year.[142] At \$0.01lb/ NO_x, this translates into materials and property cost benefits of roughly \$40 million dollars per year.

4. NO_x-Related Visibility Cost Benefits of Title IV

Suspended atmospheric NO_x emissions contribute both to regional and international haze,[143] and to the loss of visibility.[144] Generally, studies which have evaluated the visibility damage costs associated with NO_x emissions employ willingness-to-pay assessments (WTP).[145] Consistent with leading WTP investigations, the Pace Study established a "starting point" assessing visibility damage costs associated with NO_x emissions of \$0.17lb/NO_x.[146] Assuming full compliance by the utility industry, beginning on January 1, 1995, Title IV will reduce annual NO_x emissions by about 2 million tons per year.[147] At \$0.17lb/NO_x, this translates into visibility and property cost benefits of roughly \$680 million dollars per year.

5. NO_x-Related Ecosystems Cost Benefits of Title IV

There are many difficulties attendant with attempting to assess the environmental costs of NO_x emissions upon ecosystems and wildlife.[148] As of yet, no study has successfully monetized the NO_x-induced ozone damages to ecosystems and wildlife[149]; accordingly, at this juncture this aticle will not attempt to monetize these damages. Of course, this by no means suggests that NO_x-induced ozone has no detrimental effect upon ecosystems and wildlife; in fact, all indications are that the impacts are substantial.[150] Therefore, the reader should acknowledge that the external costs associated with NO_x emissions are undervalued because they do not include the effects upon ecosystems and wildlife.

B. *Aggregate NO_x-Related External Cost Benefits of Title IV*

One goal of Title IV is to reduce annual NO_x emissions by about 2 million tons per year.[151] Considering the impacts of NO_x emissions on human health, flora, material and property, and visibility, the Pace Study estimates the starting point aggregate external cost of NO_x emissions (excluding acid deposition) to be \$0.82lb/NO_x. Full compliance would

142. 42 U.S.C.A. § 7651(b)(West Supp. 1990).
143. The transboundary nature of haze is highlighted in Jost Heintzenberg, *Arctic Haze: Air Pollution in Polar Regions*, 18 AMBIO 50, 50 (1989).
144. PACE STUDY, *supra* note 30, at 215.
145. *See, e.g.*, ECO 1984, *supra* note 134; PACE STUDY, *supra* note 30, at 225.
146. *See* PACE STUDY, *supra* note 30, at 228.
147. 42 U.S.C.A. § 7651(b)(West Supp. 1990).
148. Some of these reasons are discussed in ECO 1987, *supra* note 134.
149. PACE STUDY, *supra* note 30, at 225.
150. *See generally* Gene Likens, *Some Aspects of Air Pollutant Effects on Terrestrial Ecosystems and Prospects for the Future*, 18 AMBIO, 156 (1989).
151. 42 U.S.C.A. § 7651(b).

mean a total external cost benefit for reducing NO_x emissions (excluding the costs of acid deposition) of approximately $3.26 billion dollars annually.

C. *Comparison of NO_x Externality Figures Used By State Regulatory Entities*

As discussed previously,[152] although this article focuses primarily on the Pace Study, various state public utilities commissions have also attempted to monetize the unit value of reducing emissions of NO_x.[153] For the purpose of comparison with the cost figures generated pursuant to the Pace Study, Table 2 lists the external non-acid deposition related external costs attributable to NO_x emissions, as recognized by various state regulatory entities.

TABLE 2: COMPARISON OF MONETIZED NO_x REDUCTION VALUES

State Entite	Unit Cost ($/lb) Reduction Value	Annual Cost Benefits After Jan. 1, 1995 (Billion 1989$)
California Energy Commission (Out-of-State values)	1.46	5.840
Massachusetts DPU	3.25	13.000
New York PSC	0.89	3.560
Nevada PSC[154]	3.40	13.600
BPA[155] ("East" values)	0.0344	0.137
Pace Study	0.82	3.26

Table 2 suggests that the figures generated pursuant to the Pace Study are somewhat on the lower end of the external cost benefits of Title IV's reduction of NO_x emissions.[156] Therefore, it appears as if the Pace Study is clearly a conservative estimate when compared with those figures used by state regulatory agencies to assess the external impacts of NO_x emissions.

152. *See supra* Part II(C).

153. Telephone Interview with Emily Caverhill Resource Associate, Resource Insight, Inc.; *See supra* note 103.

154. Nevada PSC figures are in 1990 dollars.

155. BPA figures are in 1990 dollars.

156. Again, note that many of the figures used herein are probably too low. *See supra* note 111.

IV. INABILITY TO ASCERTAIN THE EXTERNAL COST BENEFITS ACHIEVED BY TITLE IV'S REDUCTION OF ACID DEPOSITION

Emissions of SO_2 and NO_x react with moisture in the atmosphere to form sulfuric acid and nitrous acid, respectively.[157] Ultimately, sulfuric and nitrous acid return to the earth as acid rain, acid fog, or dry acid deposition, collectively referred to as acid deposition.[158] The following sections briefly discuss: how acid deposition is formed, the adverse effects of acid deposition upon various environmental media, why neither this paper nor the Pace Study attempts to monetize the adverse environmental effects of acid deposition, and a major obstacle to future attempts to monetize the external effects of acid deposition.

A. *The Formation of Acid Deposition*[159]

As discussed previously, fossil fuel-fired utility units account for approximately 70 percent of all SO_2 emissions,[160] and one-third of all NO_x emissions,[161] in the United States. Accordingly, emissions from fossil fuel-fired utility units are suspected to be responsible for about 70 and 33 percent of the deposition of sulfuric and nitrous acid, respectively.[162]

Sulfur dioxide and nitrogen oxides are transported in the atmosphere (usually in the troposphere), for one to ten days before being deposited.[163] Moreover, because SO_2 typically ascends higher into the atmosphere than does NO_x, sulfuric acids may be deposited 1000 kilometers or more from the source.[164]

Unaffected rainwater typically has a pH of about 5.6.[165] Emissions of SO_2 and NO_x, however, may acidify the rainfall, resulting in a lower pH. In fact, the average pH over some of the eastern United States has been recorded to be as low as 4.1.[166] As a frame of reference, recall that the pH scale is logarithmic[167]; thus a pH of 4 is ten times more acidic than a

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157. NAPAP IA, *supra* note 3, at 13.

158. *Id.* at 13-31.

159. For a comprehensive account of the formation of acid deposition, see generally U.S. ENVTL. PROTECTION AGENCY ET. AL., NAPAP, STATE OF SCIENCE/ TECHNOLOGY (SOS) REPORTS (1989).

160. *See supra* note 79 and accompanying text.

161. *See supra* note 111 and accompanying text.

162. *See, e.g.*, Frederick W. Lipfert, *Effects of Acidic Deposition on the Atmospheric Deterioration of Materials*, MATERIALS PERFORMANCE, July, 1987, at 12-19.

163. ELIZABETH KAY BERNER & ROBERT A. BERNER, THE GLOBAL WATER CYCLE: GEOCHEMISTRY AND ENVIRONMENT 113 (1987).

164. NATIONAL RESEARCH COUNCIL, ACID DEPOSITION ATMOSPHERIC PROCESSES IN EASTERN NORTH AMERICA 57 (1983). The transboundary nature of SO_2 and NO_x is also a function of the emission source's emission stack height. *Id.*

165. BERNER & BERNER, *supra* note 163, at 121.

166. *Id.* at 126-27.

167. pH is a logarithmic measure of the concentration of hydrogen ions, i.e., $pH=-\log[H+]$. PACE STUDY, *supra* note 30, at 233 N.8.

pH of 5, for instance.[168]

B. *Adverse Effects of Acid Deposition*

Acidic deposition adversely affects aquatics and ecosystems,[169] forests,[170] agriculture,[171] and materials,[172] among other things. Due to its transboundary nature, acid deposition is especially pernicious.[173] Unfortunately, though, neither the Pace Study,[174] the NAPAP Integrated Assessment, nor any other study, has yet to attempt to determine satisfactorily the nationwide environmental costs of acid deposition on a $lb/pollutant basis.[175] Therefore, this section describes environmental effects on a qualitative basis only, and also attempts to identify areas in need of quantitative future discussion and valuation studies.[176]

1. Qualitative Assessment of the Effects of Acid Deposition Upon Aquatics

Lakes and streams are acutely susceptible to the effects of acid deposition.[177] Lakes and streams receive acidic compounds from several key sources, namely, the atmosphere (acidic deposition), naturally produced organic acids (runoff from the surrounding watershed), and acid mine drainage.[178] Depending upon the pH buffering capacity of the lake or stream, acidic deposition from anthropogenic SO_2 and NO_x emissions can acidify the water body.[179] The primary result of the acidification of lakes and streams is the adverse affect on fish populations.[180] Acidic waters have been linked to reproductive failure and decline in fish populations.[181]

Due to the localized nature of current valuation studies, and for other

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168. *Id.*
169. *Id.* at 241-49.
170. *Id.* at 249-52.
171. *Id.* at 252-55.
172. *Id.* at 255-57.
173. *See, e.g.*, Henning Rodhe, *Acidification in the Global Perspective*, 18 AMBIO 155, 155 (1989); Marlise Simons, *High Ozone and Acid-Rain Levels Found over African Rain Forests*, N.Y. TIMES, June 19, 1989, at Al.
174. PACE STUDY, *supra* note 30, at 231-259.
175. Some of the problems associated with establishing a dollar per pound pollutant environmental cost for acid deposition are discussed in the PACE STUDY, *Id.* at 232-36.
176. For a discussion of some of the divisive political considerations attached to the acid deposition controversy, *see generally*, U.S. OFFICE OF TECHNOLOGY ASSESSMENT, ACID RAIN AND TRANSPORTED AIR POLLUTANTS: IMPLICATIONS FOR PUBLIC POLICY (1984).
177. D. W. Schindler, *Effects of Acid Rain on Freshwater Ecosystems*, SCIENCE, 56 January 8, 1988. *See also*, HENNING RODHE, ACIDIFICATION OF TROPICAL COUNTRIES SCOPE, 36 (1988).
178. NAPAP IA, *supra* note 3, at 9-41.
179. *Id.*
180. *See generally* PACE STUDY, *supra* note 30, at 241-42; NAPAP IA, *supra* note 3 at 9-41.
181. *Id.*

reasons described at length by both the Pace Study[182] and NAPAP's Integrated Assessment,[183] there does not exist sufficient information at this time to assign the costs of SO_2 and NO_x emissions which result in the acidification of aquatic systems (on a $lb/acid precursor emitted basis). Of course, this does not suggest that acid deposition has no adverse economic effect upon aquatic ecosystems; in fact, studies clearly suggest that aquatic ecosystems are adversely affected.[184] Therefore, future studies need to be conducted to determine the acid deposition-related economic impact on aquatic resources of each pound of SO_2 and NO_x emitted by fossil fuel-fired utility units.

2. Qualitative Assessment of the Effects of Acid Deposition Upon Forests

Acid deposition potentially has many adverse effects upon forest ecosystems,[185] including damaging leaf surfaces, interfering with the normal operation of plant guard cells, poisoning other plant cells, disturbing normal metabolic or growth processes, interfering with reproduction, accelerating the leaching of toxic chemicals, and interacting with other environmental stresses.[186] However, after acknowledging many uncertainties, the NAPAP Integrated Assessment asserts that "[t]here is no evidence of widespread forest damage from current ambient levels (pH 4.0-5.0) of acidic deposition in the United States."[187]

Therefore, due to the lack of evidence suggesting that acid deposition is adversely affecting forests in the United States,[188] and for other reasons described at length by both the Pace Study[189] and NAPAP's Integrated Assessment,[190] there does not exist sufficient information at this time to assign the costs to forest systems (on a $lb/acid precursor emitted basis) of acid deposition.

3. Qualitative Assessment of the Effects of Acid Deposition Upon Agriculture

Acid deposition was once believed to result in decreased crop yields.[191]

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182. PACE STUDY, *supra* note 30, at 242-49.
183. NAPAP IA, *supra* note 3, at 9-41, 157-61, 385-90.
184. PACE STUDY, *supra* note 30, at 242-49, and NAPAP IA, *supra* note 3, at 9-41, 157-61.
185. *See generally* SIMON POSTEL, WORLDWATCH INSTITUTE, WORLDWATCH PAPER 58, AIR POLLUTION, ACID RAIN, AND THE FUTURE OF FORESTS (1984); JOHN MACKENZIE, ILL WINDS: AIRBORNE POLLUTION'S TOLL ON TREES AND CROPS, (1988); ECONOMIC COMMISSION FOR EUROPE (ECE), AIR POLLUTION ACROSS BOUNDARIES (1985).
186. *See* PACE STUDY, *supra* note 30, at 249; NAPAP IA, *supra* note 3, at 50-73.
187. NAPAP IA, *supra* note 3, at 69.
188. For reasons which are not entirely understood, the impact of acid deposition upon European forests seem to be much more deleterious. PACE STUDY, *supra* note 30, at 249.
189. *Id.* at 250-51.
190. NAPAP IA, *supra* note 3, at 50-73, 161-64, 392-97.
191. Some of the earlier findings are discussed in DOUGLAS PETERSON, ET AL., OF-

More recent studies, however, have determined that acid deposition does not adversely affect crop yields.[192] In fact, NAPAP's Integrated Assessment concludes that "acidic deposition at ambient levels in the United States is not responsible for regional crop yield reduction."[193]

Therefore, due to the lack of evidence suggesting that acid deposition is adversely affecting crop yields, and for other reasons described at length by both the Pace Study[194] and NAPAP's Integrated Assessment,[195] there does not exist sufficient information at this time to assign the costs to agricultural crops (on a $lb/acid precursor emitted basis) attributable to acid deposition.

4. Qualitative Assessment of the Effects of Acid Deposition Upon Materials

Acid deposition also has an adverse effect upon materials,[196] and may corrode both stone and metals.[197] The rate of corrosion from acid deposition is a function of the relative reactivity of the material to acid, delivery of moisture, ambient gases, physical force of delivery, and the intensity, duration and amount of rainfall, among other factors.[198]

Acid deposition has an adverse impact upon both cultural materials (such as man-made sculptures and monuments) and construction materials (such as bridges and buildings).[199] The adverse impact of acid deposition on cultural materials is reflected in terms of physical damage, particularly the time it takes to reach a point where the material object has lost its unique qualities.[200] Cultural materials made of limestone are particularly susceptible to acid deposition.[201]

Likewise, the impact of acid deposition on construction materials is reflected in the amount of expenditures undertaken on a lifecycle basis to maintain either functionality or appearance.[202] This may include expenses incurred for more durable materials or for increased maintenance requirements.[203]

FICE OF POLICY, PLANNING AND EVALUATION, U.S. ENVTL. PROTECTION AGENCY, IMPROVING ACCURACY AND REDUCING COSTS OF ENVIRONMENTAL BENEFIT ASSESSMENTS, (1987).

192. PACE STUDY, *supra* note 30, at 252.

193. NAPAP IA, *supra* note 3, at 69.

194. PACE STUDY, *supra* note 30, at 253-55.

195. NAPAP IA, *supra* note 3, at 50-73, 151-54, 398-402.

196. *Acid Rain Control Proposals, Hearings on H.R. 144 and H.R. 1470 Before the Subcomm. on Health and the Environment of the House Comm. on Energy and Commerce*, 101st Cong., 1st Sess. (1989) (statement of Henry Magaziner, American Institute of Architects).

197. PACE STUDY, *supra* note 30, at 256.

198. *Id.*

199. NAPAP IA, *supra* note 3, at 75-110.

200. *Id.*

201. *See e.g.*, Paul Hofmann, *Italy's Endangered Treasures*, N.Y. TIMES, July 30, 1989, at § 5 at 35.

202. NAPAP IA, *supra* note 3, at 75.

203. *Id.*

Due to the lack of a national standard for assessing the economic impact of acid deposition on materials, and for other reasons described at length by both the Pace Study[204] and NAPAP's Integrated Assessment,[205] there does not exist sufficient information at this time to assign the costs to materials (on a $lb/acid precursor emitted basis) of acid deposition. Of course, this does not mean to suggest that acid deposition has no adverse economic effect upon material; in fact, studies categorically suggest that cultural and construction materials are adversely affected by acid deposition.[206] Therefore, future studies need to be conducted to determine the economic impact on materials of each pound of SO_2 and NO_x emitted by fossil fuel-fired utility units.

C. *Future Problems Imposed By Nonlinearity*

This article invites future studies attempting to monetize the external effects wrought by acid deposition. One major obstacle, however, may impede future assessments. Many commentators have questioned whether a specific quantitative reduction of emissions of SO_2 and NO_x from utility units can be directly correlated with a proportionate reduction of acid deposition.[207] Stated conceptually, does a 40 percent reduction in acid deposition precursors result in a 40 percent reduction in acid deposition?

To attempt to resolve this linearity issue,[208] NAPAP employed the Regional Acid Deposition Model, Version 2.1 (RADM).[209] The main purpose of the RADM was to determine how a change in emissions of a particular pollutant affects a change in the quantity and distribution of a deposited substance.[210]

The RADM determined that if emission reduction is applied uniformly to all major sources of SO_2 (as is the case with Title IV), then the percentage reduction in annual total sulfur deposition would be between 10 - 15 percent less than the overall reduction in SO_2 emissions.[211] For instance, a uniform annual reduction of SO_2 emissions of 50 percent would correspond to a 44 percent decrease in the deposition of sulfuric acid.[212] This phenomenon is largely due to atmospheric oxidant limitations.[213] Thus, reductions of SO_2 are not linearly related to reductions in

204. PACE STUDY, *supra* note 30, at 256-57.
205. NAPAP IA, *supra* note 3, at 75-110, 161-64.
206. PACE STUDY, *supra* note 30, at 256-57; NAPAP IA, *supra* note 3, at 75-110, 161-64.
207. PACE STUDY, *supra* note 30, at 233.
208. NAPAP IA, *supra* note 3, at 251-67.
209. NAPAP IA, *supra* note 3, at 252.
210. *Id.*
211. *Id.* at 254-55.
212. *Id.* at Figure 4.3-2.
213. *Id.* at 254. "Oxidant limitation" refers to the localized depletion of ambient hydrogen peroxide (H_2O_2). H_2O_2 facilitates the oxidation of SO_2 into sulfuric acid (SO_4). Production of H_2O_2 occurs by atmospheric photochemical reactions. In areas immediately downwind of large fossil fuel-fired utility units, an abundance of SO_2 will essentially

acid deposition. In constrast, NAPAP determined that reductions of NO_x are linearly related to reductions in acid deposition.[214]

It will take time to verify RADM's predictions; in the meantime, it will be subject to critisism.[215] Nonetheless, future attempts to monetize the external costs of acid deposition will have to grapple with the problem of nonlinearity. To be sure, the nonlinearity issue will probably forestall the task of assessing the external impacts of acid deposition for some time to come.

V. INTERNAL COSTS OF COMPLYING WITH TITLE IV

To meet Title IV's SO_2 and NO_x emission reduction requirements, utilities must incur various "internal" compliance costs.[216] The internal economic costs of Title IV are a function of the cost of: installing new emission control technologies ("scrubbers" or low-NO_x burner technologies); switching fuels, developing new cleaner technologies ("clean coal technologies", for instance); and other compliance options.[217]

Both the utility industry and NAPAP have made various estimates regarding the internal costs of complying with Title IV.[218] A detailed discussion of the basis for the industry figures cited herein is beyond the scope of this paper; nonetheless, the raw figures are provided and analyzed as points of reference for comparison with the external economic benefits of Title IV discussed thus far. NAPAP cites the following studies monetizing the utility industry's costs of compliance with Title IV:

(1) The Edison Electric Institute (EEI)[219] estimates the levelized cost in 1989 dollars of Phases I and II of Title IV to be between $ 4.5 and 5.5 billion dollars per year[220];

(2) The Electric Power Research Institute (EPRI)[221] estimates the compliance cost in 1988 dollars of Phase II to be up to $6.5 billion dollars per year[222];

(3) NAPAP's Summer Gas Scenerio[223] estimates compliance costs to

deplete the level of atmospheric H_2O_2, and limit or stop the conversion of SO_2 into SO_4. *Id.* at 179 box 3.2-1.

214. *Id.*

215. PACE STUDY, *supra* note 30, at 234, n.13.

216. NAPAP IA, *supra* note 3, at 405.

217. *Id.* at 423-27.

218. These studies were conducted at different times in the ratification process, and consequently are not directly compatible with each other or with the final version of Title IV. Before any of the studies were conducted, however, the basic agenda of Title IV was firmly in place, i.e., to reduce SO_2 and NO_x emissions by approximately 10 and 2 million tons per year, respectively. *Id.* at 405-96. Therefore, the internal cost figures from the cited studies should not deviate substantially from the figures used in this article.

219. The EEI study was conducted by Temple, Barker and Sloane, Inc. *Id.* at 424-26.

220. *Id.* at 425.

221. The EPRI study was conducted by Energy Ventures Analysis, Inc. *Id.* at 423-24.

222. *Id.* at 426.

223. NAPAP hypothesizes controlling acid deposition precursors by generating more natural-gas fired electricity during the summer months. NAPAP IA, *supra* note 3, at 427-28.

be between $2.7 and $7.3 billion dollars per year.[224]

Thus, various estimates place the utility industry's annual costs of compliance with Title IV at between 2.7 and 7.3 billion dollars per year. For the sake of a conservative comparison, Part Six will assume that it will cost the utility industry $7.3 billion dollars annually to comply with Title IV during either Phase I or Phase II.

VI. COMPARISON OF EXTERNAL AND INTERNAL COSTS OF TITLE IV

Phase I of Title IV will result in external cost benefits of $14.2 and $3.26 billion dollars annually ($1989) for reducing emissions of SO_2 and NO_x, respectively. Phase II will result in external cost benefits of $40.57 and $3.26 billion dollars annually ($1989) for SO_2 and NO_x emission reductions, respectively. In contrast, a review of relevant studies indicate that the maximum cost of industry's costs of compliance with Title IV will be $7.3 billion annually in both phases of Title IV.

A comparison of Title IV's non-acid deposition related external cost and the internal costs of compliance is broken down by Table 3.

TABLE 3. COMPARISON OF EXTERNAL BENEFITS AND INTERNAL COSTS

	External Cost Benefits (SO_2 + NO_x = Total) (Annual $1989) (Billions)	Internal Costs of Compliance (Annual $1989) (Billions)
Phase I	14.00 + 3.26 = 17.26	7.30
Phase II	40.57 + 3.26 = 43.83	7.30

Therefore, notwithstanding the external cost benefits of reducing acid deposition, the external cost benefits of Title IV far exceed the utility industry's internal costs of compliance. During Phase I, the external costs benefits conferred by Title IV will exceed the internal costs of compliance by almost two and one-half times. Furthermore, during Phase II, the external cost benefits made possible by Title IV will exceed the internal costs of compliance by more than six times.

CONCLUSION

The stated purpose of Title IV of the Clean Air Act Amendments of 1990 is to control acid deposition. To fulfill this notion, Title IV is targeted at reducing emissions of sulfur dioxide and nitrogen oxides from fossil-fuel burning plants within the electric utility industry.

Title IV is divided into two phases. During the first five years of the

224. *Id.*

program, Phase I will reduce emissions from 111 large, essentially coal-fired, units in 21 eastern and midwestern states. During Phase II and thereafter, Title IV will further reduce emissions from the units already affected by Phase I, and impose limitations upon many other existing fossil-fuel fired utility units not affected by Phase I. The electric utility industry estimates that it will cost up to $7.3 billion per year to comply with Title IV.

NAPAP's IA suggests that the societal and ecological problems associated with acid deposition are endemic, do not occur through out the United States, and are in any event not as severe as Congress presumed. Therefore, the NAPAP IA intimates that a pervasive national scheme of regulation is probably not the best way of addressing the acid deposition issue.

Unfortunately, Congress enacted Title IV before NAPAP released the IA. At best, therefore, Congress acted prematurely, i.e., it should have waited for the results of the NAPAP IA before enacting Title IV; and at worst, it acted improvidently without ensuring that there was an objective scientific foundation for national regulatory control of acid deposition. Accordingly, many in the electric utility industry and elsewhere maintain that the use of Title IV to control acid deposition is tantamount to "using a body cast to mend a broken finger." Hence, it is conceivable that the electric utility industry will clamor for Congress to revisit Title IV in the near future, or that the Environmental Protection Agency will be somewhat reluctant to implement the Title to its full extent.

In the very least, the NAPAP IA underscores the difficulty of ascertaining the societal and ecological cost benefits of Title IV. There is little doubt that acid deposition results in substantial external costs on human health, crops, materials, the national infrastructure, fisheries and the ecosystem. The problem, however, is one of identifying both the scope and the extent of acid deposition damage. To be sure, neither the NAPAP IA nor the Pace Study monetizes the environmental benefits of controlling acid deposition. Therefore, there is no quantitative basis for comparing the utility industry's internal compliance costs with the external benefits imposed by controlling acid deposition.

There is, however, less conjecture about the non-acid deposition- related external damages than of the acid deposition-related external damages of SO_2 and NO_x emissions. Excluding acid deposition effects, SO_2 emissions have a harmful impact on human health, materials, and visibility. Likewise, and also excluding acid deposition effects, NO_x emissions have a detrimental impact on human health, flora, materials and property, visibility and ecosystems. Thus far, the scientific community has found it easier to quantify monetarily these impacts than those associated with acid deposition.

Using conservative figures generated by the Pace Study, the non-acid deposition-related cost benefits of Title IV may exceed $17 billion per year, and $43 billion per year, during Phases I and II, respectively.

Thus, comparing these figures with the utility industry's internal compliance costs, the net economic benefit of Title IV may be $10 billion per year during Phase I, and $36 billion per year during Phase II.

Furthermore, assuming that the electric utility industry will be able to simply "pass-on" internal costs to ratepayers, the net economic benefits to ratepayers (and society) of Title IV will be about $3 billion and $29 billion per year for Phases I and II, respectively. Again, it is important to note that these figures do not even include the external costs of acid deposition. Consequently, it is conceivable that the external cost benefits conferred by Title IV will outweigh the utility industry's internal costs of compliance to an even greater extent than described above.

Therefore, there is a countervailing reason, having nothing whatsoever to do with acid deposition control, which provides independent justification for the methods of controlling SO_2 and NO_x emissions in the manner set forth in Title IV. This is because the electric utility industry is still the primary emitter of both SO_2 and NO_x, destroying both human and natural resources. Accordingly the non- quantifiable external costs benefits regarding the control of acid deposition, Title IV will have enormous societal net cost benefits.

The author acknowledges that comparing internal and external costs in such a mechanical and facile fashion is somewhat problematic. The science of assigning dollar amounts to the cost of emission of SO_2 and NO_x is in its infancy. Hopefully, the natural resource damage assessments in the wake of the Exxon Valdez disaster in Prince William Sound, Alaska may provide the imprimatur for the scientific community to develop more practical paradigms for monetizing the impact of other types of pollution, including SO_2 and NO_x emissions. In the meantime, despite valuation uncertainties, it seems clear that Tile IV provides society with a formidable net ecomonic benefit independent of the societal benefits conferred by reduing acid deposition. Therefore, Title IV should remain intact and be implemented to the full extent envisioned by Congress.