Economic Impact Analysis
Virginia Department of Planning and Budget

9 VAC 5-140-10 et seq. – Regulations for Emissions Trading
Department of Environmental Quality

March 14, 2001

The Department of Planning and Budget (DPB) has analyzed the economic impact of this proposed regulation in accordance with Section 9-6.14:7.1.G of the Administrative Process Act and Executive Order Number 25 (98). Section 9-6.14:7.1.G requires that such economic impact analyses include, but need not be limited to, the projected number of businesses or other entities to whom the regulation would apply, the identity of any localities and types of businesses or other entities particularly affected, the projected number of persons and employment positions to be affected, the projected costs to affected businesses or entities to implement or comply with the regulation, and the impact on the use and value of private property. The analysis presented below represents DPB's best estimate of these economic impacts.

1) Summary of the Proposed Regulation

The U.S. Environmental Protection Agency (EPA) has promulgated a rule, known as the NOx SIP call rule, to reduce emissions of oxides of nitrogen (NOx) of man-made origin. The reductions called for in this rule are over and above the other requirements of Title I of the Clean Air Act (CAA) and are also over and above the reductions required under the acid rain provisions required by Title IV of the CAA.[1] The primary purpose of the rule as enunciated by EPA is to reduce the amount of NOx transported in the atmosphere between states in order to prevent NOx emissions by upwind states from causing violations of the National Ambient Air quality Standards (NAAQS) in downwind states. The mechanism that EPA has chosen to use to implement this rule is to assign an aggregate emission limit for specific source categories in the 22 affected states and to give the states wide latitude in fashioning their State Implementation Plans (SIPs) for keeping NOx emissions within the state below the mandatory cap.

[1] A good background discussion of federal NOx regulations may be found in Krolewski and Mingst (2000).

EPA has recommended that states implement the requirements with what is commonly referred to as a "cap and trade" program. Cap and trade programs operate as follows: the cap, or emissions budget, is established for a group of sources. The cap is then divided up into shares, or allowances, each of which gives the holder a conditional right to emit some amount of the limited emission. The allowances are distributed, or allocated, to the sources according to some formula. Any source wishing to emit the capped emission must have sufficient allowances in its possession to cover all of its emissions. If a source emits fewer units of effluent than the number of allowances it is allocated, then it can sell those allowances to other sources. A source with emissions greater than the number allowances it owns must buy enough allowances to cover the excess emissions. Emissions are carefully monitored. Any source emitting quantities not covered by allowances is subject to penalties.

Cap and trade programs have two very attractive qualities. First, they provide a high level of certainty that the program will actually achieve the environmental quality goal established. This is due to the program establishing a fixed cap on the physical quantity of emissions, generally in terms of mass per period of time and also to enhanced monitoring which is an integral part of these types of programs. The second attractive quality of cap and trade programs is that they provide the maximum amount of flexibility to the regulated community in deciding how to achieve the set cap on emissions.

This flexibility is accomplished by mimicking as closely as possible the structure of private markets for privately owned goods. Sources trade their allowances in this market Some sources will find that their cost of reducing emissions to a level below their allocation is less than the market price of allowances. These firms would profit form selling their allowances to those firms whose costs are higher than the allowance price. In this way, firms will trade their emission control responsibilities so that the emission reductions are accomplished in the cheapest possible way. It is not possible for a regulator to have enough information about sources to accomplish least cost reductions through regulatory mechanisms. Evidence from existing air emission trading programs strongly suggests that the closer the emissions market resembles markets for other private goods, the better the performance of the program for both protecting environmental quality and for doing so at the lowest possible cost. Evidence also suggests that

the details of design and implementation of emission trading programs can be critically important in determining how well they actually perform once implemented.[2]

EPA has determined that trading between any sources in the 22 state region will be allowed under NOx budget program. EPA has even has agreed to provide administrative support for the regional NOx market by operating the system for tracking ownership and use of allowances. EPA published a "model" trading rule for states to follow in establishing their own programs. Some of the items covered in the model rule are mandatory of all participating programs while other items in the model rule are discretionary and will vary from state to state.

This proposed regulation establishes a NOx Budget Trading Program, a cap and trade program, to implement requirements of the NOx SIP call in a way that will allow Virginia sources to participate in the multi-state regional market comprising hundreds of sources. In its background document accompanying this proposal, the Department of Environmental Quality (DEQ) has provided a clear and succinct description of both the EPA mandate and the Air Board's proposal in response to that mandate. DEQ also lists all of the areas where the Air Board proposal diverges from the EPA model rule.

2) Estimated Economic Impact

The reductions in NOx emissions from Virginia sources required by this regulation are mandated by federal law.[3] The economic benefits from the reductions will not depend greatly on the specific strategy chosen to implement the emissions reduction. The same may not be said for the costs arising from this rule. The cost of complying with air pollution regulations is known to vary widely depending on the type of regulation used to implement emissions reductions. The compliance cost estimates used in this report are derived from estimates made by EPA. These estimates are based on the assumption that the regulation is implemented with a cap and trade program very similar to that used under Title IV to control SO_2 emissions. Evidence suggests that, of the options available for NOx reductions, such a program is likely to achieve the greatest possible savings on compliance costs. The trading program proposed by the Air Board follows the SO_2 model in most respects, and, thus may be expected to come close to achieving the cost

[2] The economics literature in this area is becoming quite large. A good starting place would be Ellerman et al. (2000).

[3] See 40 CFR 51.121.

savings associated with cap and trade programs. The compliance cost discussion that follows will include a discussion of the specific design choices made by the Air Board in its proposal.

a) Costs

i) Compliance costs

The EPA estimates that, given currently available technology, it will cost, on average, $1,977 (year 2000 dollars) per ton of ozone season NOx emissions reduced. The average control costs for Virginia sources will probably not vary dramatically from the average for the control region, although the control costs for individual sources will show substantial variation. To estimate the compliance costs, we can multiply the average cost per ton by the number of tons. However, the number of tons reduced depends on which year you choose for your estimate since, under a cap, emissions cannot grow but under previous regulations emissions would have trended upward with economic activity. The figure used by DEQ in its background document reflects approximately a 45,000 ton reduction in ozone season NOx tons.[4] This results in an annual compliance cost for Virginia sources of $89 million (year 2000 dollars).[5]

There are a number of important uncertainties as to the magnitude of this number. For example, if the technology for NOx control improves, then these costs can be expected to fall. If economic growth is different from the expectations built into the cost model, then costs may be higher or lower depending on how actual growth differs from assumed growth. Dominion Generation (formerly Virginia Power) has argued forcefully that compliance costs will be significantly higher because the growth in electricity demand will, it believes, be much higher than projected in EPA's cost estimates. This means that in order to reduce emissions enough so that the cap is not exceed, sources will have to reduce average emission rates well below the 0.15 lb/mmBTU of heat input assumed in EPA's cost analysis. This would increase the average and

[4] This reduction reflects a choice to include only sources located in Virginia in calculating compliance costs. This does necessarily reflect the full compliance costs faced by Virginia utilities and their customers. Dominion Resources, Inc. owns a 1,500 megawatt facility located at Mt. Storm in West Virginia. Currently, this facility serves only Virginia customers. Thus, the compliance costs for this facility are paid by Virginians. There may be some facilities located in Virginia that sell significant amounts of power outside of Virginia. For those plants, compliance costs would be overstated.

[5] Dominion Resources, Inc. currently operates 8,100 megawatts of generating capacity serving the Virginia market. The company estimates it compliance costs to be $600 million in capital expenditures to be spent over the next two or three years and $30 million in operation and maintenance costs.

total costs above those estimated by EPA. According to EPA's regulatory impact analysis, EGU costs would rise by about 30% if average emission rates were to 0.12 lb/mmBTU of heat input.

One key uncertainty about costs concerns the type of market arrangement that is used to implement the NOx reductions. The costs estimated by EPA assume that the reductions are implemented through a regional trading program very similar to the national sulfur dioxide allowance trading program. As already noted, this program has been extremely successful in achieving the emission reduction requirement while greatly lowering the cost of control relative to what would have occurred under traditional regulatory instruments.[6]

ii) Trading program design choices

One recent report[7] estimates that a well-designed allowance trading program can reduce compliance costs for EPA's NOx SIP call by 40 to 47% below what they would be with the more traditional regulatory practice of specifying in source permits emission rate standards.[8] As discussed in an earlier section, the Air Board's proposal may be expected to achieve a large fraction of the potential savings. In this section, the particular design elements of the program will be outlined and discussed.

(1) Allowance definition and use

The definition of an allowance in the proposed regulation is: *an authorization for a source to emit up to one ton of nitrogen oxides during the control period of the specified year or of any year thereafter*. This definition is important since it clearly establishes the characteristics of the asset to be traded. A NOx allowance gives the owner a clearly delineated economic privilege and all allowances give exactly the same privilege. This clarity and uniformity in the definition of the asset eliminates uncertainty over the quality of the asset being traded in the market. This uncertainty can lower significantly the economic value created by the market.

Ambiguities in the delineation of an asset introduces significant risks into the transaction and will lead to defensive expenditures by parties to a trade. The buyer will not place as high a value on the purchase of such an asset because he will not know what value the right has to him until he has invested resources in determining the scope of the asset. The seller will be forced to

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6 See Ellerman et al. (2000).
7 See Farrell et al. (1999).
8 This type of rule is often referred to as "command and control" regulation.

place a lower value on the resource because of the expense of proving its characteristics to potential buyers.

This definition of an allowance will be consistent among the states participating in the regional NOx market. This consistency will facilitate the establishment of the regional market for allowances. Allowances from any one part of the region may be used in any other part of the region.[9] The large regional market will significantly increase the opportunities for cost saving trades among sources. The larger trading area also gives greater assurance that the market for allowances will be "liquid"; that is, there will always be willing buyers and sellers in the market. Assurances that the allowance market will be liquid will prevent firms from having to make significant defensive over-expenditures in allowances.

(2) Allowance allocation

Allowances must be allocated to sources. The methods for allocating allowances may be divided into two groups: methods which give firms incentive to change their behavior for the purposes of receiving future allowances and methods which do not give firms these incentives. It is well understood that, if the allowance market is reasonably liquid, allocation methods which firms incentive to "chase" or "earn" allowances by changing their behavior can result in significant economic losses relative to methods lacking those incentives.

There are two ways to allocate allowances so that firms do not have incentive to chase allowances. One way is to hold an auction for the allowances (or to sell them at the current market price, which amounts to the same thing.) In this case, a firm wishing to use an allowance, must pay the market price, and the market price is the best available measure of the social (economic) value of the allowance.[10] The other way of efficiently allocating allowances is to give them away permanently (once and for all) based on *past* behavior; this is often called grandfathering. Since the allowances are given out on the basis of past behavior, noting the firm can do now will affect its future grant of allowances. Future behavior will be efficient because firms will face the market price as the cost of obtaining or using an allowance.

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[9] This permission is subject to the restrictions contained in Title I of the Clean Air Act which prevent sources from using allowances if doing so would result in an exceedence of air quality standards.

[10] Note that a firm wishing to use an allowance it already owns faces exactly the same cost because to use the allowance is to give up the money the firm could have had from selling the allowance. This "loss" from using something rather than selling it is called opportunity cost.

In its "model" rule, EPA proposed that allowances be given out only three years in advance. Under this scheme, there will be a continuing reallocation of allowances usable in any ozone season at least three years in the future. At the end of each season, firms report their heat input (fuel use) to the state authority, and, based on heat input for this and the previous few years, a firm will receive a proportional grant of allowances at no cost. The total number of allowances granted must add up to the state budget. The Air Board chose to use a ten year continuing allocation window for this proposal. While this proposal is not as efficient as one containing a once-and-for-all allocation or an auction, the ten year window represents a significant improvement in economic efficiency over the three year window proposed by EPA.

(a) Reallocation

In private markets the government generally does not have a large role in reallocating ownership of goods. Goods are owned privately and reallocated through voluntary trading when one person values a good more than the current owner does. Anytime the government takes a role in reallocating private goods, there is a significant probability that the reallocation will be no better or even worse than the original allocation. This same observation holds true in emission markets. If allowances are allocated once and for all, like ownership interests in private goods, then the owners of these allowances will trade them when someone else values them more highly than the current owner. There is no apparent reason for the government to be involved in reallocating allowances.

The SO_2 market was established by granting existing sources a permanent stream of future allowances based on their current share of the market. These sources can use the allowances or sell them. They can sell one year of allowances or their entire future stream; just like leasing or selling a piece of real property. When firms enter the market, they must buy the allowances they need from existing owners; just like someone wanting to use land must buy or lease land before they can do whatever it is they wanted the land for. When sources leave the market, the owner sells their stream of allowances to some other firm; just like a landowner who sells land when they do not need it any longer.

Reallocating allowances based on current decisions introduces uncertainty in the market and gives firms incentives to do economically inefficient things solely for the purpose of increasing its share of future allowance allocations. It is hard to imagine the chaos that such a

rule would cause if it were applied to land or some other asset traded in private markets. At the end of each year, the government would examine how you used your land and decide how much land to give you to use in the year three years from now. This is exactly what EPA proposed doing in their model rule. This makes it extremely difficult for firms to plan for future expansions.

It would also be very expensive for firms write to contracts for future supply of allowances at a firm price because no one knows who will have what allocation just three years out. The cost of this uncertainty to the producers and users of electricity will likely be very high. For example, firms building large power plants routinely begin planning for increased expansion 10 years or more in advance of when they expect to bring the power on line. Contracting for a supply of NOx credits for the period when the plant is in operation will involve purchasing forward contracts on allowances before any determination has been made about who will receive the allocations for those allowances. Since no one owns the allowances, there is no one who can make a firm commitment to supply allowances. This would not be true under a one-time allocation of allowances. Ownership would be settled, and contracts for allowances could be made for any future periods. Under the reallocation rule, firms will face both high contracting costs and a high degree of residual uncertainty. And the shorter the advance allocation window, the more severe will be the impact of the reallocation rule.

One key problem with a reallocation rule is that, for firms, the least cost production plan is no longer the best plan. This is because the firm must always take into account the gain or loss in future allocations whenever it makes a choice about changes in production. For example, any time a firm is considering changing the level of heat input for a source, it must consider the gain or loss of a free unit of allowance allocation in the near future. Firm A has found that it is no longer profitable to run some facility at a high capacity so it is considering cutting back 10 units of heat input. However, the financial manager points out that if it does stop producing the unprofitable 10 units, it will lose allowance allocation 3 years from now.

The shorter the time horizon for allocation, the lower are a firm's incentives to shut down old, inefficient sources or to reduce the amount of fuel they use (heat input). This is because shutting down the source or reducing heat input causes the firm to lose future allocations. In considering whether to shut a facility down, the loss of these allocations is a cost of shutting

down the facility. It is much the same as if a firm operating a store could only keep the land and building as long as it kept the store open. The value of freeing up the land to go to its next best use is not included in the firm's decision and, hence, it will not have the proper incentive to shut down a marginal operation.

The same incentives apply to using energy conservation to reduce heat input per unit of output. Using additional fuel has both a cost and a benefit associated with it. The cost is the price of the fuel. The benefit of using additional fuel (heat input) is that it qualifies the source for a larger share of the NOx allocation at the end of the allocation horizon. This reduces the incentives that the owner has to reduce fuel use.[11]

The Air Board's technical advisory committee for this regulation proposed a ten year reallocation horizon. While this is still inefficient relative to a permanent allocation, the longer the allocation horizon, the less inefficiency from uncertainty and from giving firms incentives to change production in response to future free allocations.[12]

One reason given for the reallocation rule is that buying NOx allowances would be a *barrier to entry* for new sources. While buying allowances is a cost of entry, it is not in any significant sense a barrier to entry any more than buying a lease, paper clips, and computers is a barrier to entry to starting an accounting business. These are costs of doing business. They are **not** barriers to entry. Similarly, using NOx allowances imposes real costs on other firms since any allowances that one firm uses cannot be used by others. If firms are given allowances for free, then they are not forced to consider the costs that their activity imposes on society, because they do not take into account the higher value that another firm might be able to produce with the allowances.

A barrier to entry exists when an input necessary for entering a business is not available for purchase in a competitive market.[13] This is definitely not the case for the proposed NOx

[11] Some have suggested basing allocations on output rather than heat input. While this would increase incentive to conserve energy, it would have its own difficulties. Most troublesome among these is the problem of measuring output for different types of sources.

[12] A shorter *initial* allocation period, one that applies only to the allocation made at the beginning of the program, will not have any efficiency cost since this initial allocation depends only on behavior predating the program, not current or future behavior.

[13] Barriers to entry come in essentially three flavors: (1) the unavailability of some resource, information or knowledge essential for production, (2) government granted monopoly, or (3) a minimum efficient scale of production that is large relative to the size of the market. Electricity deregulation (the elimination of barrier type 2)

market. In fact, there is already an active allowance trading market for NOx covering 9 northeastern states. This market will be a part of the 22 state regional market once it is in place. NOx allowances are already for sale and can be purchased by visiting the web site of the Cantor Fitzgerald brokerage firm, among others. Independent power producers have not had difficulty purchasing the allowances they need to enter the market. Once the 22 state market is in place, opportunities for trading will increase dramatically. There is every reason to believe that the NOx market will be at least as liquid as the SO_2 market has turned out to be.

The free allocation of allowances to firms based on heat input will result in firms entering the market even if it is inefficient for them to do so. For example, suppose that an existing firm is producing electricity and using allowances for its NOx emissions. A new firm wishing to enter the market will be granted some fraction of its allowance requirements for free. The new firm can enter the market even if it can't produce power at a competitive rate. This is because, for every unit of heat input, it will be given some allowances for free in three years; the value to the firm of producing a unit of output is equal to the price of its output plus the value of what is given to it for free. The cost of these free allowances is paid by existing companies who must go and buy the allowances on the market. That existing sources must buy allowances at the market price is not a source of inefficiency. It is the granting of free allowances to new or expanding sources that is inefficient because their apparent cost of doing business is lower than the real cost since they do not need to take into account the costs they impose on others.

Arguments for a reallocation rule often frame the issue as one of fairness. The firms already in the market receive a windfall when the allocations are initially given out. It is true that existing firms receive a windfall when allowances are given out for free. It is important to point out that this windfall does not produce economic inefficiency. The shareholders and employees of the firms receiving the allowances are better off, however these firms face an opportunity cost of holding on to the allowances. The opportunity cost is the money the firms could receive for selling the allowances. If firms entering the market value the allowances at or above the market price, there are firms that will sell them. In this case, both the entering firms and the existing firms face an efficient set of incentives.

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was made possible by changes in technology that eliminated barrier type 3. As described in the text, given the size of the NOx market already in existence, it is not correct to describe the requirement that firms purchase NOx

One way of getting around the fairness issue is to charge existing firms the market price for the allowances received. Another way would be to allocate the allowances in a way that takes account of what some potential entrants have already spent on entering the market. The first strategy may work as long as the charge is not enough to cause existing firms to effectively oppose the formation of the market. The second strategy, while superficially appealing, may be difficult to administer. Any effort to eliminate the appearance of unfairness between firms is likely to impose significant costs on the public. One might ask why imposing increased compliance costs on the public is somehow more fair than requiring new firms to purchase the resources they need to enter a business even though the existing firms didn't have to.

(3) Opt-in sources

EPA's rule establishing the regional NOx market automatically applies to large sources of NOx emissions. States may allow other sources to opt-in to the emissions market program. Under EPA rules, states choosing to add opt-in provisions must adopt EPA's opt-in provisions without modification. Thus, the decision for the Air Board is whether or not to use opt-in provisions; if the decision is made to do so, then the state has no discretion about how to implement the provision.

The opt-in provision requires that a source monitor emissions for one full control period before entering the program. Emissions during this period constitute the source's baseline emissions. At the end of the baseline year (and for each year thereafter), the source receives an allowance allocation based on heat input times an emission rate. The heat input used is the lesser of last year's input and the baseline input. The emission rate is the lesser of the baseline emission rate and the most stringent applicable rate.

While opt-in provisions do expand the potential market and hence the potential savings from the market, they carry an economic cost as well. There is little doubt that firms will take the future allocation of emissions into account when making choices about production in the current year. As a result, firms will have incentive to move away from the least-cost method of production and the most profitable level of output. In addition, since firms have incentive to manage their emissions to maximize future allowance allocations, there are incentives to actually

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allowances as a "barrier to entry." It is no different than the requirement that firms buy the concrete or steel they need to produce electricity.

increase emissions in establishing a baseline. Opt-in provisions in the SO_2 program have had similar problems.[14]

(4) Compliance supplement pool and early reduction credits

The Air Board proposal can, provide up to 6,990 extra allowances for the first two years of the program for sources facing particular difficulty in achieving the reductions required under this proposal. These extra allowances are referred to as the compliance supplement pool. The compliance supplement pool (CSP) will primarily be allocated as "early reduction credits" (ERCs) to sources that reduce their emission rate to below both 0.35 lbs/mmBTU *and* lest than 80% of 2001 emission rate. ERCs may be used only in the 2004 and 2005 ozone seasons. Any remaining CSP allowances will be allocated to firms making a clear demonstration of hardship in meeting the reduction requirements imposed by this rule.

The CSP adds to the flexibility of the program and has the added benefit of encouraging firms to reduce NOx emissions earlier than is required. Any earlier reductions increase the value of the reductions by making the initial reductions happen sooner.[15] The increased flexibility will tend to reduce the costs of compliance for existing sources. If there is an over-production of reductions, the ERCs will be distributed *pro rata* among the sources qualifying.

(5) Banking

Banking of unused allowances encourages sources to delay emissions and gives sources additional flexibility for smoothing their demand for allowances. Since a substantial portion of the damage from NOx emissions is due to periods when emissions and weather conditions combine to exceed health standards, it is important that banked allowances not accumulate to the point where their use could result in periods of significant health effects. In order to balance these two opposing interests, the proposal includes a provision for “flow control” which reduces the NOx value of an allowance if the total stock of banked allowances exceeds 10 per cent of the total allowance allocations.

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[14] For a discussion, see Ellerman et al. (2000).

[15] This will, in turn, delay somewhat the achievement of the final budget relative to what would have happened otherwise, but the net impact is a gain in the value of NOx reduction benefits and a reduction in costs.

[16] Some have suggested basing allocations on output rather than heat input. While this would increase incentive to conserve energy, it would have its own difficulties. Most troublesome among these is the problem of measuring output for different types of sources.

While banking is a valuable option for firms, it is less so when there is a liquid market for allowances. This is because banked allowances do not earn a rate of return; they only allow a source to avoid entering the market for allowances in order to make up for a shortage in a given season. If the market is liquid, then sources will prefer to sell allowances today and have the cash in the bank rather than hold a non-producing asset for more than a year or so. Since there is a risk that banked allowances will be discounted by flow control when a firm wishes to use them, then there is more incentive to use banked allowances early and to not hold a large stock of banked allowances.

A short allocation window or a set-aside provision (discussed in the next section) increases the uncertainty over future allocations. The increased uncertainty may induce firms to choose to bank more allowances than they would in the absence of this uncertainty. Whether the banked allowances poses a risk of exceeding air quality standards depends on the size of the stock of banked allowances. The level of banking, in turn, depends to a significant extent on the level of risk firms face in future allocations. By increasing these risks, set-asides and short allocation windows could contribute to an increased risk from a large stock of banked allowances.

(6) Set-asides

The EPA model rule contains provisions for a n allowance set-aside for new sources. Each season the state would take a percentage of each source's allowances[17] for that season and make those available to new sources. The Air Board chose not to implement a set-aside in the proposed regulation.

In the EPA model rule, these set-aside allowances would be handed out for free. This set-aside is equivalent to a cash subsidy for firms bringing new NOx sources on line; paid for by a tax on the owners and users of existing sources. A set-aside program such as this would do substantial violence to the operation of the market. A set-aside gives firms incentives to build new sources even if those sources would represent a net economic loss to the Commonwealth and leads to over-investment in new facilities. In addition, a set-aside provision exacerbates the effects of the periodic reallocation rule discussed in the previous section. Since set-aside

[17] Five percent for the first five years of the program and two percent per year thereafter.

provisions are not part of the Air Board proposal, the discussion of set-asides was not included here but may be found in Appendix A.

b) Benefits

Nitrogen oxide emissions have a wide range of environmental effects. These effects arise through three main pathways: (1) direct effects of NOx, (2) the effects of reduced NOx emissions on ground-level ozone formation, and (3) the contribution of NOx emissions to the formation of fine particulate matter (PM). Most of these impacts are harmful to people and to a variety of valuable environmental services. Thus, reductions in NOx emissions below the levels specified by other provisions of the CAA can be expected to produce benefits for Virginia.

Table 1 lists the areas where NOx reductions may have significant benefits. This table breaks benefits down into two important categories: quantified and unquantified benefits. The quantified benefits are those benefits for which the EPA has provided some numerical estimate of the overall economic value of the improvements resulting from the NOx reductions required by this rule. The unquantified benefits, being more difficult to measure, are not given any numerical value estimates. That these benefit streams are unquantified should not be interpreted to mean that the benefits are small, only that they are hard to measure, and that the time and resources available did not permit scientifically defensible measures of value.

Table 1
Ozone, NOx, and PM Benefits from the NOx SIP Call

	Benefits of Ozone and NOx Reductions-- Reductions in:	Benefits of PM Reductions-- Reductions in:
	Quantified	
Health	Mortality (short-term exposures) Hospital admissions for all respiratory illnesses Acute respiratory symptoms	Mortality (long- and short-term exposures) Hospital admissions for: all respiratory illnesses congestive heart failure ischemic heart disease Acute and chronic bronchitis Lower and upper respiratory symptoms Minor restricted activity days Work loss days
Welfare	Commodity crop yield losses Commercial forest yield losses Worker productivity losses	Household soiling Impaired visibility Nitrogen deposition to estuarine and coastal waters
	Unquantified	
Health	Airway responsiveness Pulmonary inflammation Increased susceptibility to respiratory infection Acute inflammation and respiratory cell damage Chronic respiratory damage/Premature aging of lungs UV-B (cost due to NOx reduction)	Changes in pulmonary function Morphological changes Altered host defense mechanisms Other chronic respiratory disease Cancer
Welfare	Ecosystem and vegetation effects in Class I areas (e.g., national parks) Damages to urban ornamentals (e.g.,grass, flowers, shrubs, and trees in urban areas) Fruit and vegetable crop losses Reduced yields of tree seedlings and non-commercial forests Damage to ecosystems Materials damage (other than consumer cleaning cost savings) Nitrates in drinking water Brown clouds Passive fertilization (cost due to NOx reduction)	Materials damage (other than consumer cleaning cost savings) Damage to ecosystems (e.g., acid sulfate deposition) Nitrates in drinking water Brown clouds

Source: EPA 1998

The EPA has reported its estimates of the economic value of the quantified portion of these benefits. EPA did not report the benefits by state. Since different states will receive different mixes of benefits, the aggregate dollar benefit estimates are not helpful for determining the level of benefits to be expected in Virginia. Based on these estimates, Table 2 reports the *average* benefit per ton of reductions throughout the 22 state region affected by this rule. The two columns represent two different scenarios reported by EPA: (1) a set of low range benefits assumptions and (2) a set of high range benefits assumptions. The benefits per ton are broken

out into four categories of effect. This is only a first-order approximation to the benefits per ton that Virginia would expect to receive. There are some reasons to believe that Virginia's share of the benefits in some categories will be higher than average and in other categories will be lower than average.

For the categories of ozone effects and PM effects more of the benefits are likely to occur in the northeastern states than in the upwind states including Virginia. Virginia does have one non-attainment area and there may be greater benefits there from regional NOx reductions than for other parts of the Commonwealth. The opposite is the case for agriculture and forestry, and for nitrogen deposition. In particular, the NOx emissions are responsible for a substantial fraction of the nitrogen entering the Chesapeake Bay and other coastal estuaries each year. This nitrogen deposition is known to contribute to a number of serious water quality problems in estuarine waters. Although the estimates are highly uncertain, recent studies indicate that the NOx SIP call emission reductions could add up to 20% of the reductions in Chesapeake Bay nitrogen loads that the Commonwealth has agreed to make as part of its multi-state agreement to improve water quality in the Bay.

Table 2
Summary of Quantified Benefits in 2007 by Major Category for the Selected Regulatory Alternative (Dollars per ton reduced, $1990)

Category	Low	High
Ozone Health and Welfare	$23	$1,128
Agriculture & Forestry	$217	$478
Nitrogen Deposition	$198	$198
PM Health and Welfare	$479	$1,671
Total	**$917**	**$3,475**

Source: EPA, 1998

One way to estimate the benefits of these reductions is to estimate the cleanup costs avoided by the reduction in airborne deposition. Assuming average avoided costs in the range of $2 to $20 per pound per year of nitrogen, and a 20% contribution to nitrogen removal targets for the Bay, the Bay states could receive (undiscounted) benefits of from $26 million to $260 million over the next several years from reduced effluent control costs.[18] In addition, there would be

[18] These cost figures are not discounted because the timing of savings is very uncertain.

significant benefits in avoided costs of cleanup for other Virginia estuarine waters. Not enough is known to quantify these benefits with any precision.

Because some of the costs of NOx emissions are caused by sources outside Virginia and some are more the result of emissions inside Virginia, it would not be appropriate to take the level of reductions required by Virginia and simply multiply by the average benefits. Since the EPA did not separate benefits out by state, it would be overly speculative to give an estimate of aggregate benefits received by Virginia without substantial further research.

c) Uncertainties

Any attempt to estimate the costs and benefits of a major, regional pollution control effort such as that represented by this proposal must necessarily produce results subject to a high degree of uncertainty. Modeling the dispersion of emissions is very difficult. This makes it difficult to estimate accurately how and where the emissions contribute to ozone and PM exposure, nitrogen deposition in estuarine waters, and other eco-system dose-related problems. Second, understanding the effects of exposure and deposition on health and on environmental services is still relatively rudimentary. Measuring the economic value of any actual damages is costly and difficult, resulting in considerable uncertainty. Finally, there are a number of effects that are simply too difficult to arrive at numerical estimates for the physical and economic impact. These difficulties require that any cost and benefit estimates be taken as subject to huge margins of error. EPA's own estimates vary widely enough so that a net loss and a net gain are both within the reasonable range of outcomes for this regulation.

3) Businesses and Entities Affected

The primary impact of this regulation will fall on the firms owning sources of NOx emissions and on those firms planning to build NOx sources in Virginia. There are 64 individual electricity generating units representing 13 different firms. There are 13 units that are not classified as electricity generating units, and these represent 7 firms. This rule also has a significant impact on firms planning to build NOx sources in Virginia in the future. Although it is not known at this time how many firms have such plans at this time, there is expected to be a significant increase in electrical generation capacity as the market for electricity is deregulated.

Because this regulation has such a large effect on these sources, there are very significant secondary effects on prices and rates of return in the electric industry. A liquid market for NOx allowances will reduce the cost of entry for new sources relative to entry costs under the more traditional style of regulation. A smoothly operating market also reduces the total cost of providing electricity to consumers since emission markets lower the costs of achieving pollution control targets. The combination of these two effects is that prices for electricity will be lower than they would under regulations with less effective trading provisions, as new firms enter the market. The lower cost of electricity will reflect both lower costs and increased competition in the newly deregulated electricity market.

Lower electricity prices (relative to prices in the absence of the regional market for NOx) will tend to lower costs in businesses throughout Virginia. It will also cause a higher quantity of electricity demanded as firms with lower electricity costs expand and as firms and consumers shift their energy consumption toward electricity.

As indicated in an earlier section, the reallocation of allowances acts as a subsidy for the building of new NOx sources with the subsidy being paid by the owners and customers of existing sources. This will increase the entry of new sources to a level higher than is economically efficient. Since entering firms receive a costly input to production for free, they will not take into account the cost that the use of that resource imposes on others in the economy. Some sources will find it profitable to enter even though their entry will generate a net loss to Virginia's economy. This entry will drive electricity prices below their efficient level and will result in a reduction in the rate of return on capital for existing sources. This fall in rate of return will, in turn, result in a loss in income for existing source workers and shareholders to a level below that which is economically efficient. Lower electricity prices for electricity from fossil fuel fired boilers will also tend to increase carbon emissions relative to what would otherwise occur. The reduced economic value resulting from the inefficient incentives for entry is known as deadweight loss. The magnitude of this loss cannot readily be estimated at this time.[19]

[19] The estimation of this loss is greatly complicated by the possibility that the reduction of electricity prices below the market rate may offset some of the existing efficiency loss caused by labor taxes. Any such effect would be offset by the loss of labor income due to the lower rate of return in the industry. As a matter of policy, it would probably not be appropriate to use an induced inefficiency in one market to attempt to address inefficiencies in other markets. Since very little is known about these "general equilibrium" effects, it will probably often be the case that such policies will result in lower income for everyone.

4) Localities Particularly Affected

The costs of this regulation will not vary much between localities across Virginia. The direct costs will fall on electricity users and on shareholders of electric utilities and other affected firms. The indirect costs on other goods and services will also fall proportionately across the Commonwealth. The benefits of this rule will also be distributed proportionately with population across Virginia with a few notable exceptions. Since northern Virginia is the location of the only non-attainment area in Virginia, further NOx reductions under the SIP call may reduce some of the other expenditures that would otherwise be required for the non-attainment area to achieve attainment status. Higher elevation woods in western Virginia will probably receive a greater than proportional benefit to timber resources from reductions in acid precipitation damage. Finally, a large share of the environmental benefits of these NOx reductions will come from reduced nitrogen deposition in estuarine waters in the eastern part of the Commonwealth. In particular, water quality in the Chesapeake Bay will improve more quickly than would be the case without this rule. Savings resulting from avoided cleanup costs will fall partly on people in the Bay watershed and partly on all taxpayers. Other coastal watersheds will be similarly affected.

5) Projected Impact on Employment

The net impact of this regulation on employment cannot be known with any certainty although the EPA estimates that the implementation of this regulation with an allowance trading program could result in a net increase in employment because the additional jobs gained in the pollution control industry would more than offset any losses due to the higher costs due to the tighter environmental regulations.[20] In the long run, an efficient and competitive electric industry should provide the best environment for improving worker productivity an enhancing opportunities for employment.

6) Effects on the Use and Value of Private Property

The effects that this rule will have on private property are very difficult to estimate. There are some property owners who will definitely benefit. Landowners and business owners near the Chesapeake Bay will benefit from reduced nitrogen deposition in the Bay and the consequent improvement in water quality. Some landowners will benefit from reduced timber and

crop damage attributable to atmospheric NOx. In addition, there will be an increase in demand for pollution control services, which will increase the value of some firms in this industry.

There will be a significant loss to existing utilities and their shareholders due to increased costs of emission control and to increased entry of new sources who will garner a share of allowances held by existing utilities. The cost of electricity for many firms and consumers will rise as rates begin to reflect the value of scarce NOx allowances needed for the production of electricity. This could have a significant effect on the value of particularly energy intensive firms.

[20] See EPA (1999).

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Appendix A: Set-asides

The EPA model rule proposes a continuing set-aside program. As noted in an earlier section, set-aside provisions that reallocate allowances at anything less than the market price may be expected to increase the costs associated with this regulation. One way of avoiding the inefficiency is to auction set-aside allowances. If this is done, then sources still face the full cost of obtaining or using the allowances. The revenues from the auction can be used in a number of different ways. Auction revenues could be returned to the firms relinquishing the set-aside allowances. This is the strategy used in the SO_2 program. This scheme is known as a zero-revenue auction.

Alternatively, the auction revenues could be used for other purposes. There is the potential of a significant economic gain if auction revenues are used to offset other taxes. In particular, some economic studies suggest that an efficiency gain can be achieved by using auction revenues to reduce labor taxes.

The choice of what to do with auction revenues is probably much less important than the choice to charge for the set-aside. Unless the sources receiving the set-aside pay for the use of the set-aside allowances, then there will be an efficiency cost arising from the set-aside provisions.

For example, suppose that a firm is considering building a new source. If NOx allowances have a market price of $1,000, then taking an allowance from an existing firm will have an economic cost of $1,000. If the new source would not make a profit if it had to pay for the allowance, then the firm is generating less than $1,000 for the economy and taking the allowance from the firm that values it at $1,000 and giving it to a firm that will generate less than $1,000 in value represents a net economic loss for the Commonwealth paid for by owners and customers of the existing sources. On the other hand, if the firm can make a profit after paying for the allowance, then it will enter even if it has to pay for the allowances. Thus, the set-aside will not increase the number of efficient firms who enter since those firms would enter anyway. Only inefficient firms would base their entry decision on whether they receive a grant of free allowances. Consequently, a set-aside rule will increase the average cost of electricity generated in Virginia.

To give a better idea of how inconsistent this set-aside provision is with market incentives, suppose that a government wanted to encourage the growing of Brussels sprouts. To implement this policy the government offers any *new* growers free land for growing the sprouts. The land to be given to the new growers will come from a five per cent *set-aside*. In this example, it is obvious that the term *set-aside* is simply a euphemism for the confiscation of a portion of the land owned by existing farmers. While the policy will definitely increase the production of Brussels sprouts, it will do so at the expense of considerable economic damage by attenuating the ownership interest that existing farmers have in their property. It will also result in the production of Brussels sprouts that cost more to produce than their value in the marketplace. For these costly sprouts, every bushel produced represents a net reduction in economic well being. Such a policy sounds silly, but it is exactly analogous to the set-aside policy in the model rule. It is an extremely inefficient way to encourage new generation facilities.

There is an additional source of costs arising from the set-aside. Whatever method is chosen to allocate the set-aside allowances free to new sources, it will cause firms to change their production plans solely for the purpose of capturing the free set-aside. These changes will increase the costs of production relative to what the firm would have done if it had not had the incentive to capture part of the set-aside. If the set-aside is allocated on a first-come/first-served basis, firms will have strong incentive to arrange it so their sources come on line at the beginning of the relevant period chosen by DEQ rather than at the time that provides the greatest net economic benefits. On the other hand, if the allocation is for a *pro rata* share of the available set-aside, firms will try to arrange it so that their sources come online in years when few other sources are planning to start up.

If the set-aside is only for the first year a source is online, then firms building boiler units will want to space them out over several years so that each new boiler can get free set-asides. If, on the other hand, the set-aside continues until the source can use its advance allocation, then only the first few firms to enter at the beginning of each five-year period will get any allocation and the incentive to arrange start-up timing to capture a block of set-aside allowances will be very great indeed. Either way there is a significant economic loss associated with the firm efforts to gain set-aside allocations

Allowance reallocation also affects a firm's decision about what type of fuel to use to fire the boiler. First, only fossil fired generation receives the allowance allocation, so there is differential treatment of sources giving a preference to fossil fired sources. Also because coal generally results in more NOx per unit of heat input than does gas, the granting of free allocations will result in a larger subsidy for new coal-fired facilities than for new gas-fired facilities. Once again, a business decision will be made partly on the basis of gaining a free allocation of allowances rather than solely on the basis of the least cost production. One unintended consequence of the preferential treatment of fossil-fired, and specifically coal-fired, boilers is an increase in the carbon dioxide emissions over what would be expected under a market program without set-asides and reallocations.