Sustainability and the Valuation of Externalities from Electricity Generation in California

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1 Introduction

The economic rationale for the valuation of and accounting for externalities is that their presence in the production and consumption of goods and services causes markets to deviate from the socially optimal levels. Externalities are costs (or benefits) to society that result from interactions among firms and individuals which are not reflected in market prices. Proper accounting for externalities in planning and decision making can bring market outcomes closer to their optimal levels. A critical element of sustainability is a growth path that results from accounting for externalities to the environment and to future generations that result from current economic activities.

This paper discusses the conceptual basis of sustainability and its multi-dimensional application to the energy sector (section 2). It then describes the rationale and status of current efforts to quantify the value of air quality externalities as applied to the electricity sector in California (section 3).

2 The Analytic Foundations of Sustainability

The 1970s marked the beginning of the broad awareness of actual and potential conflicts between economic progress in production, consumption, and technology development on the one hand and the quality of the environment on the other. Since then, the environment has become the subject of intensive research in both developed and developing nations. In various countries, laws setting standards that regulate various types of environmental degradation -- notably air pollution, water pollution, solid waste pollution, and noise pollution -- have been enacted. Abatement policies and a large number of regulations have been introduced in the areas of power generation, transportation, industrial pollution, sewage treatment, protection of the scenic environment, and so on. In the past decade, however, a shift has taken place from partial environmental analysis to a focus on interactions among economic production and energy-environmental interactions and their spatial and dynamic impact. These interactions arise in general because concerted socioeconomic development requires a compromise between material growth and environmental constraints, including environmental quality, energy, and natural resources.

Proper measurement of the environmental impact is a major issue in the debate on the economic relation between growth and the environment. This measurement problem is closely linked to the question of the trade-off between economic growth and environmental protection. In the long-term, economic growth and environmental protection are being reconciled in the concept of sustainable development; the same cannot be said for the short-term. Two extreme and opposite lines of thought are:

(1) economic growth is essential in providing means for abatement of environmental damage;
(2) economic growth inevitably causes environmental damage so that economic de-cline (negative economic growth) is essential for a cleaner environment.

According to the second proposition, clearly a negative trade-off exists between economic growth and the state of the environment. However, the trade-off may also be negative under the first proposition when economic growth is needed to finance abatement costs and measures to protect the environment.[1]

The concept of sustainable development has been gaining endorsement in both developed and developing countries.[2] It has been discussed intensively at a global level in the past few years and a proliferation of research applying the concept to regions, countries and sectors has also emerged. In general, the concept is defined to encompass a time-path for the causality and impact of interactions among economic/energy and environmental decisions and management. More specifically, sustainable development explicitly incorporates the notion that the use of resources today should not impair the prospects for maintaining or improving future living standards.[3]

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[1] Butter, F.A. and H. Verbruggen 1994. Measuring the Trade-Off Between Economic Growth and a Clean Environment. Environmental and Resource Economics Vol. 4: 187-208.

[2] Nijkamp, P., van den Bergh C., and F. Soeteman 1990. Regional Sustainable Development and Natural Resource Use. Proceedings of the World Bank Annual Conference on Development Economics.

[3] World Commission Environment and Development. 1987. Our Common Future. New York: Oxford University Press.

The concept brings to the forefront the need to distinguish between stock and flow concepts in the national accounting systems of nations.[4] Until quite recently, environmental resources were treated in economic analysis as *a free gift of nature,* and the generation of income originated only at the point of extraction and harvest of natural resources. In other words, traditional methods of accounting allowed for the peculiar decoupling of environmental (ecological) and economic productivity. Sustainability analysis, on the other hand, explicitly incorporates the impact of an economy's productive activities on its wealth: production or generation of income is considered positive as long as the wealth that the society starts off with is maintained at the end of the time horizon. Wealth here encompasses natural (environmental) components including fresh air, water, ozone layer, etc. Any reduction in society's wealth in the process of producing goods and services must be explicitly taken into consideration in the national accounting system (as well as pricing at the micro level) to preserve the right of future generations to the same environmental and economic resources.

An important component of virtually all definitions of sustainable development is equity. Two types of equity considerations are embodied in the concept: equity for future generations, whose interests are not represented by standard economic analyses or market forces that discount the future, and equity for people living now who do not have reasonable access to natural resources or to social and economic goods".

The issue of *intergenerational* equity is complex. Failure to restrict the growth of emissions resulting from today's production and use of energy imposes costs on future generations. One may take the view that technological progress is likely to in-crease future levels of real income and reduce the cost of mitigating the damages arising from environmental impacts. However, this is by no means certain, and some ethical systems imply the need for compensating resource transfers in the absence of policies that succeed in eliminating these external effects across generations.

2.1 Dimensions

The literature suggests several dimensions to the concept of sustainable development. For the purposes of energy development, production, and use, one can identify four basic dimensions that are time-variant and causally interlinked. These are economic, energy, environmental, and technological dimensions. Other dimensions have been suggested, including human and international. Examples

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[4] Friend, A. 1993 Economics, Ecology and Sustainable Development: Are They Compatible? Environmental Values 2:158-170.

of the former include the horizontal equity of access and use of resources and energy services. An example of the latter includes equity in use across international borders. More specifically, pollutants resulting from energy use are "exported" across international boundaries to other countries whose well-being is impacted by the emissions. This may invite reciprocity leading to a situation that can be characterized as a "negative-sum game". Proper management of energy decisions, on the other hand, would invite cooperation through the institution of regulations that would be beneficial not only to the human agents and their economic systems, but also to the ecological system.

2.1.1 Economic Dimension

Production of energy requires the use of reproducible and irreproducible factors of production. Traditional economic analysis has focused on the reproducible factorssuch as labor, capital, organization, and technology. In the area of irreproducible factors, classical economists have focused on land to the neglect of other natural and environmental factors, including clean air and freshwater.

The standard economic problem at the micro level is set in terms of maximizing out-put given input availability and associated prices of factors of production. Reproducible factors carry a price while irreproducible ones do not. Obviously, irreproducible factors have shadow prices whose levels rise monotonically with environmental degradation and decreased energy security. For instance, as polluting activities accumulate, the social cost of production rises and less is producible than if environmental resources had been well managed and preserved.

Likewise, energy use must be restrained to preserve the environment and allow future generations to enjoy the services provided by energy in adequate quantity and quality while preserving the environment. By contrast, current consumption patterns suggest a measurable amount of excessive use. For instance, consumption of energy from fossil fuels is 33 times higher in the United States than in India, and 10 times higher in countries of the Organization for Economic Cooperation and Development, on average, than in developing countries.[5] While some of the differences in per capita energy use are due to differences in stages of economic development; some is due to sheer waste or overutilization of energy resources. This is reflected in the ability of economies, given proper economic signals and institutional arrangements, to re-duce energy intensity without compromising economic growth. In California, for instance, per-capita energy use has declined noticeably over the period 1975-1990.[6] Based on state and country

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[5] World Resources, 1992-93. A report by: The World Resource Institute in collaboration with: The United Nations Environmental Programme and the United Nations Development Programme. Oxford University Press, New York.

[6] Energy Information Administration, 1992. Annual Energy Review. Washington, D.C.

experiences and international studies, one can argue that the economic dimension of sustainable development suggests steady reduction in wasteful levels of consumption of energy and other natural resources through improvements in technical and economic efficiency and through changes in life-style.

2.1.2 Energy Dimension

Energy is a resource that is used in the production of services demanded by economic agents, such as process heat, space heating and cooling, and movement of persons, freight, and information. Because of energy's centrality to production, economic growth, and modern living, policy makers consider courses of action that pre-serve it as *a sustainable resource.* Energy production and use are vital to the economy; the mix of energy use has profound consequences for environmental quality. Relying on least-cost energy planning that treats demand sources (demand-side management) on equal footing with supply sources is an important aspect of sustainable energy production and use. A dynamic world with volatile energy market diversification for the attainment of long-term energy security requires, among other things, the development of renewable energy sources. Fluctuations in oil markets and accompanying supply shocks, characterized in the past two decades, limit economic growth potential, subject production and consumption processes to unpredictable curtailments, and expose the economy to spells of inflation and unemployment that persist for several years.

Energy activities are either contributing factors to or the main cause of a significant number of environmental impacts. Major energy-related issues include global climate change, acid deposition, and urban air quality. Virtually every phase of energy production, delivery, and use imposes a burden on the environment: land disturbances from coal mining, toxic residues as a by-product of petroleum extraction, oil spillage from tanker operations, airborne emissions from power plants, buildup of radioactive nuclear wastes, and other impacts. The impact of energy production and use on the environment is remarkable given that the size of the energy sector in the total value added is estimated at only 4.5 percent, while value added of the non-energy sector represents 94.5 percent of GDP.[7]

Sustainable development suggests that the use of energy resources by the present generation should not impede the ability of future generations to use energy for their well-being. This implies that energy intensity, the energy use per one unit of GNP, must be improved. But empirically, energy use is rising as shown by the

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[7] Rotemberg, J. and M. Woodford 1993. Energy and Aggregate Economic Activity. NBER Working Paper No. 4576.

simple identity:

$$E=E/GNP*POP*GNP/POP$$

The annual energy use, E, is related to the three factors: energy intensity (E/GNP), population size (POP), and GNP per capita. Scientists have demonstrated that to keep global warming under one degree centigrade, E must be reduced by about 1/10.[8]

Central to the economic dimension of sustainable energy, as well as to the environmental dimension discussed below, is the intergenerational issue. Use of non-renewable energy sources by the current generation may reduce the ability of future generations to utilize non-renewables. Likewise, the future quality of renewable energy sources may deteriorate if not properly utilized and maintained by current users.

2.1.3 Environmental Dimension

Sustainable development requires protecting the natural resources needed for food production and cooking -- from soils to wood to fisheries. Sustainable development means limiting the global rate of increase of greenhouse gases and, eventually, stabilizing the atmospheric concentration of these gases. The most important greenhouse gas arising from human activity, carbon dioxide, accounts for about half of the atmospheric warming potential. Sustainable development also means not risking significant alterations of the global environment that might -- by increasing sea level or changing rainfall and vegetation patterns or increasing ultraviolet radiation -- alter the opportunities for future generations. Soil erosion and loss of soil productivity reduce yields and remove large areas of agricultural land from productivity each year. Overuse of fertilizers and pesticides pollutes surface and groundwater. Many freshwater and marine fisheries are already being harvested at levels that are close to becoming unsustainable.

The environmental dimension affects the system at both the micro and macro levels. To illustrate the impact at the micro level, assume that households desire a certain level of health given their socioeconomic conditions and their surrounding environmental quality. Assume further that the knowledge of health-related technologies is acquired cumulatively through direct experiences with these technologies and/or exposure to health education programs. Finally, assume that members of households acquire information regarding the health impacts of their environmental quality quite rapidly and dynamically. Under these circumstances, one can predict that environmental degradation will translate into higher marginal

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[8] Krupp, H. 1992. Energy Politics and Schumpeter Dynamics. Tokyo: Springer-Verlag.

costs of achieving the desired level of health. More specifically, environmental pollution increases the cost of maintaining the health level because individual members must spend more resources for "preventive" and "curative" health services. Examples of preventive measures include the purchase of heavy duty air filters for air conditioning at home or work; the purchase of water purification equipment to purify the water of certain pollutants; and the purchase of commercially bottled water to avoid using the kitchen water. Examples of curative measures include out-of pocket and time cost of clinic and hospital visits; laboratory tests; and doctor's and hospital fees for medical treatment.

Figure 2.1 illustrates the impact of environmental degradation on the expenditure required to attain the desired health level H*. Initially, given an environmental quality level, the marginal cost of health is assumed, for simplicity, to be constant -- i.e., increases in the cost of individual health cost are independent of the level of the individual's health stock. The curve labeled MB indicates the marginal benefit of in-vesting in individual health. The slope of the MB curve is based on the assumption that as the individual gets healthier, the marginal benefit received from increasing his/her health gets smaller. The equilibrium level of health services is at H* where the marginal costs and benefits are equal.

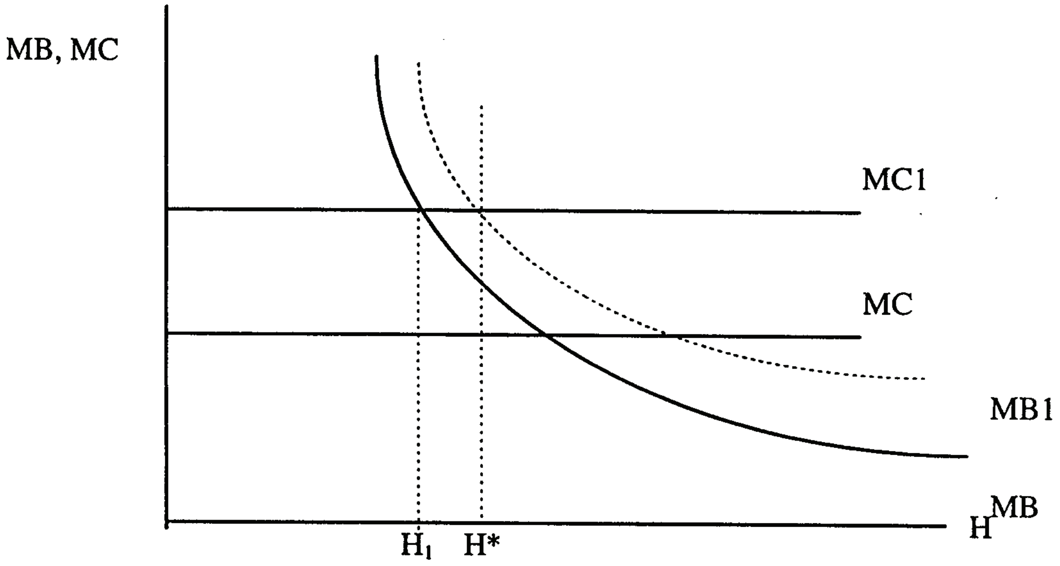

Figure 2.1: The impact of environmental degradation on the desirable level of health investment

If the quality of the environment is degraded, then maintaining the desired level of health H* becomes more costly, as reflected in higher marginal cost (MC1). The individual must now incur extra costs to maintain his/her health at the desired level. Economic theory suggests that the individual's health level would deteriorate to H1 (where the MC 1 and MB are equal at the higher cost due to environmental degradation). If the socioeconomic conditions of the individual were improved through a rise in income or wealth due to an extraneous force (as represented by the marginal benefit curve MB 1), then he/she could still return to the desired health level, albeit at higher costs.

At the macro level, the relationship between natural resources conservation and out-put growth can be shown graphically in Figure 2.2. The extent of resource conservation increases the output per period of goods and services. The output is maximized at level of conservation $x_{i,}$ beyond which negative returns to conservation set in. This implies that it is economically not feasible to preserve all aspects of the environment. For example, it is not possible to preserve every forest or tree. Attempting to preserve all aspects of the natural environment including fresh air and water would be too costly. The relationship can be altered by technological developments that result in an upward shift in the production function. This implies that technological development can increase the output of goods and services for any given level (and quality) of environmental resources.

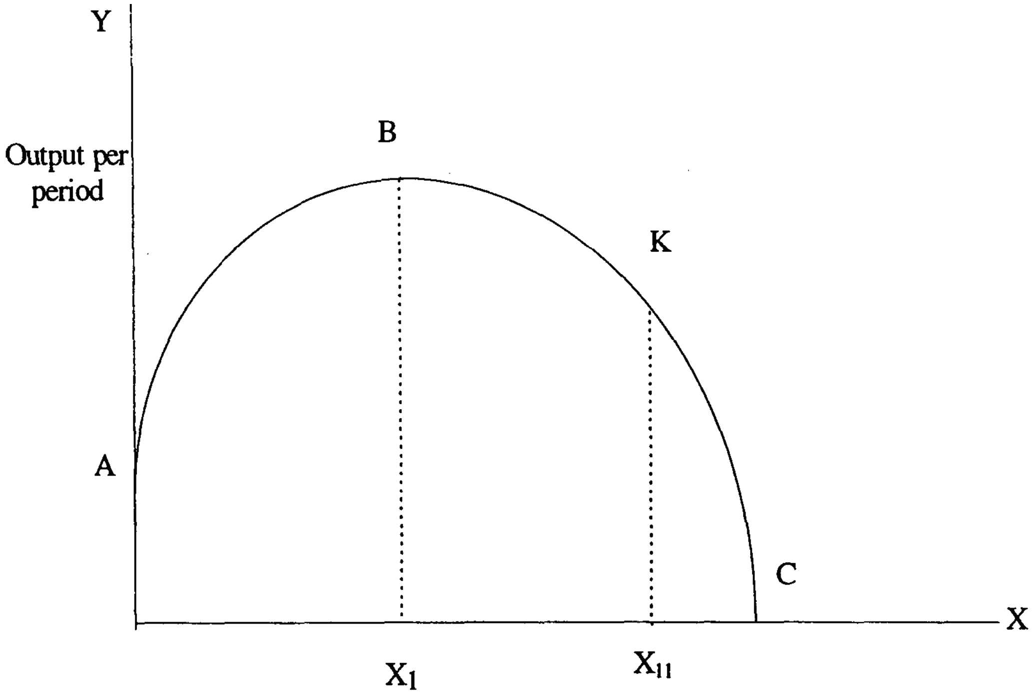

Figure 2.2: Extent of conservation of the natural environment. Up to a point, conservation of the natural environment is necessary to increase or maintain the output of goods and services

The relationship that Figure 2.2 depicts can be analyzed more systematically with reference to a particular aspect of the environment. Nordhaus, for instance, discussed the relationship between climate change and economic productivity.[9] For example, economies that are subjected to climatic shocks because of mismanagement of energy production and use undergo productivity loss in the short run. In the long run, however, these economies have time to adapt and develop modes of production and use that may eliminate the impact of the shock. This situation is portrayed in Figure 2.3; the long-run productivity level is assumed to be horizontal line P* connoting the productivity that corresponds to a long-run average temperature level, suggesting that in the long-run productivity may be independent of the temperature level. In the short-run, however, productivity will be maximized at the "design climate;" that is, corresponding to capital, technology, management, energy that are designed for the climate To. If climate were to change to $T_{I,}$ cool weather crops would wilt, ski areas would fail, and other signs of an ill-adopted technology would emerge, with the equilibrium moving from A to B and productivity falling from P* to $P_{t.}$ Once all adaptations had taken place, productivity would rise to point C, with productivity equal to the initial level and with new short-run productivity curve $SR_{I.}$ The speed of adjustment might be as short as two years or as long as two decades or longer.

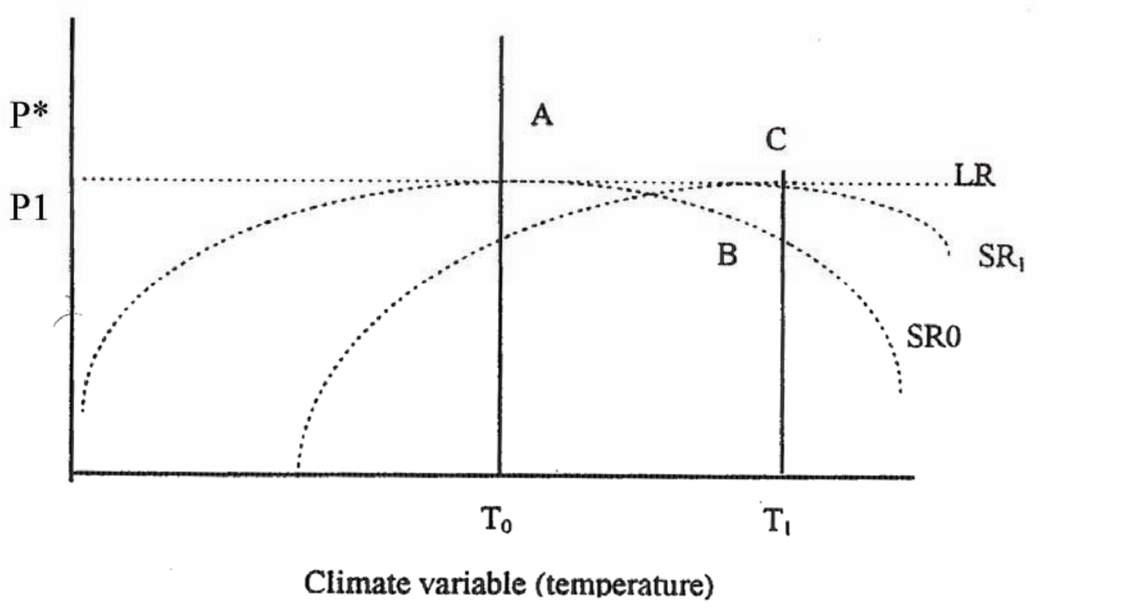

Figure 2.3: Economic productivity and climate change.

2.1.4 Technological Dimension

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[9] Nordhaus, W. D. 1993. Climate and Economic Development: Climate Past and Climate Change Future. Proceedings of Annual Conference on Development Economics. Supplement to the World Bank Economic Review and the World Bank Research Observer: 355-377.

Sustainable development requires the encouragement of technologies that have the potential to provide cleaner energy services, such as zero emissions technologies. The private sector can play a major role in the research and development activities leading to the evolution of new technologies. The public sector has a critical role in R&D in that virtually all long-term "knowledge-building" investment processes are in the nature of public goods. The public sector's role is also critical in demonstrating and commercializing the output of R&D activities.

Technological progress could be characterized as *capital-saving.* Capital here refers to both natural (or environmental) and man-made capital. While the two stocks of capital are substitutable within a certain range in the production process, capital-saving technical progress allows for conserving both types. Figure 2.4 shows that with the present technical knowledge and skills, different combinations of the two types of capital yield the same level of production and define the isoquant qo of production. Initially, the economy may be at a point, Po, corresponding to the initial stock of nature, No and accumulated capital, $K_{a.}$ The two types of capital are substitutable and sustain output within a certain range as can be seen from the curvature of the isoquants.

With the advent of capital-saving technical progress, the isoquant shifts leftwards indicating that less of both man-made and environmental or natural capital is needed to attain or sustain the same output level q_0. This points to the critical role that research and development and resultant human skills and knowledge play in sustaining economic progress. Figure 2.4 illustrates the possibility of postponing (or mitigating) the need to make a trade-off between man-made and environmental capital as long as technological progress proceeds at rates that dynamically succeed in introducing capital-saving innovations.

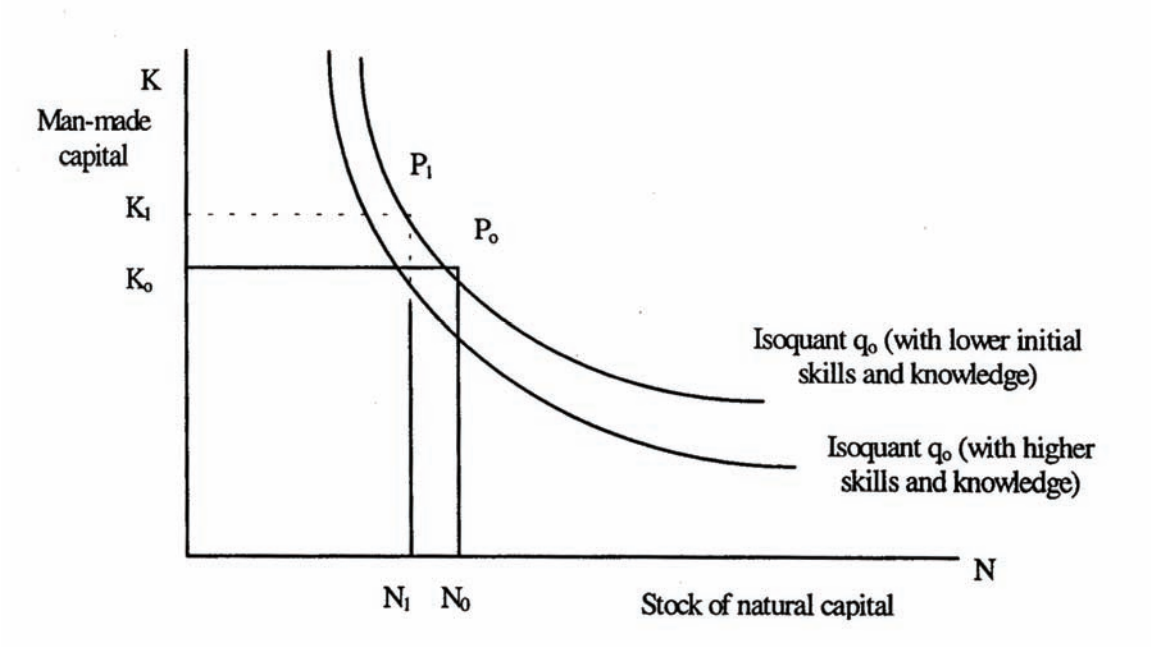

Figure 2.4: Technical progress and substitution between man-made and nature's capital.

While the role of technology in augmenting natural and man-made capital is probably significant, there are areas where technical progress has not been able to overcome nature's constraints. For instance, while many of our economic and resource problems have been solved by technology, water is not solely a technological issue. If technology makes it possible to produce rain over one country, a neighboring country is deprived of its rainfall. If Ethiopia builds a dam near the source of the Nile and withdraws water for agriculture and other uses, the supply of water for Egypt, thou-sands of miles downstream, will diminish.[10] The limitations of technology in solving at least some of nature's constraints and the uncertainty regarding the speed and timing of technical progress add more urgency to the concept of sustainable development.

2.2 Role of Market and Regulatory Institutions

To attain sustainable development, the market and government institutions must be jointly utilized in order to provide proper signals for the producers and consumers. At the micro-level, the government could help the market develop a set of market-based instruments. These instruments would attempt to reflect the true cost of production in market prices. Symbolically, the price of energy service that reflects social cost can be measured as:

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[10] Falkenmark M. And Widstrand, C. 1994. Population and Water Resources: A Delicate Balance. Population Bulletin: 2-36.

$$P = MPC + MEC + MUC$$

where

P = price
MPC = private marginal cost of production
MEC = marginal external cost of production
MUC = marginal user cost, i.e., the value of future benefits foregone by using a resource now.

Notice that the impact of energy research and development can be traced out in Figure 2.5 by allowing the marginal external and use curves to shift downwards. Technological improvement can bring costs downwards -- e.g., zero emission technologies -- thereby allowing current generations to produce and use more energy now without infringing upon the ability of future generations to harvest the "gifts" of nature and enjoy the quality and quantities of goods and services including energy. But for research and development that enhances the welfare of current and future generations to proceed at adequate levels and timing, the public sector must provide economic support in the form of prices, joint R&D ventures and seed money for commercialization and demonstration projects.

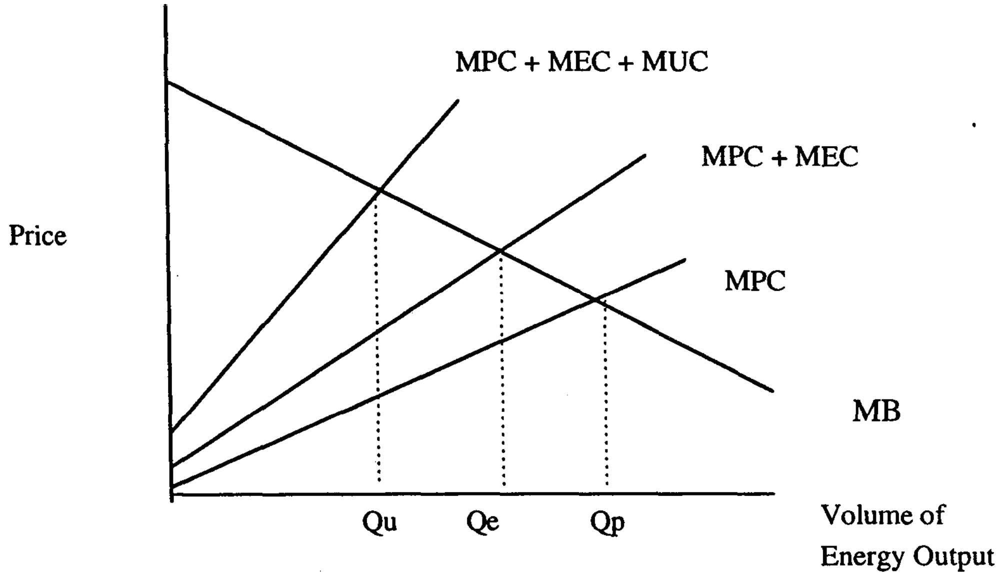

Figure 2.5: Optimum level of production and price in the presence of environmental and intergenerational costs.

3 Valuing Air Quality Impacts From Electricity Generation In California

Prior to 1990, economic analyses to determine the amount, type, and timing of electric capacity additions in California were based solely on private cost considerations. Some internalization of externalities took place implicitly during the permitting phase of power plant construction and operation. Often, the permit to construct and operate a power plant was issued with conditions requiring mitigation of the impacts of the plant on the local economy and environment.

In 1989, the California Energy Commission (CEC) staff retained the consulting firm Regional Economic Research, Inc. (RER) to investigate the feasibility of designing and implementing a model for quantifying the damages or benefits to air quality from changes in emissions from power plants. The model was to be based on data and information that already existed in the literature. This work concluded that there existed sufficient and readily available information to allow for the conversion of air quality impacts into monetary values that could then be explicitly incorporated into economic analysis of electricity generation.[11]

Following this finding, the CEC staff and RER proceeded to construct the Air Quality Valuation Model (AQVM) phases corresponding to the availability of funding. In 1990, legislation was enacted that required the CEC and the California Public Utilities Commission (CPUC) to incorporate values for the benefits and costs to the environment when conducting energy-economic analyses.[12] In the 1990 Electricity Re-port (ER 90),[13] the CEC utilized the cost of pollution abatement as a proxy for the value of air quality due to the simplicity of this approach and the fact that the AQVM was still being constructed. The CEC first employed the damage function approach using the AQVM in ER 92. The approach was again utilized in ER 94.

The AQVM consists of specifying and estimating four relationships.[14] In the first step, the generation technology is specified and its impact on emissions are estimated using generic technology or plant-specific emission rates. In the second step (which proved to be the most complex and controversial) the changes in emissions are translated to changes in ambient air quality. For example, in this step changes in ozone (0_3) resulting from changes in its precursors nitrogen

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[11] Thayer, et al., 1994. The Air Quality Valuation Model, Regional Economic Research.

[12] See California Public Resources Code 25000.1, statuettes of 1990.

[13] The CEC issues the Electricity Report (ER) biennially in even numbered years in response to legislative direction. Among other things, the ER forecast loads and resources over a 20 year horizon and identifies the least cost capacity additions to each major electric utility system.

[14] For a detailed documentation of the AQVM see Thayer, et al., 1994.

oxides (NO,,) and reactive organic gases (ROG) are estimated using air quality models. The AQVM utilizes two air quality models. The SCREEN model is used to estimate changes to air quality from non-reactive pollutants, and the EKMA model for reactive pollutants. The third step uses the output of the air quality models to estimate the physical responses (damages) in the target population using dose-response functions that have been estimated in the literature. The AQVM incorporates dose-response functions to estimate the effects of air quality changes on human health, materials, agriculture and non-agriculture vegetation, and visibility. In the final step, the monetary value of the physical responses to changes in air quality are estimated. Values are estimated for the following primary and secondary criteria pollutants: nitrogen oxides (NO_x), sulfur oxides (SO), particulate matter (PM 10), reactive organic gases (ROG), and carbon monoxide (CO).

3.1 Estimates of Air Quality Values

The results of estimating the AQVM for the above mentioned pollutants are displayed in Tables 1.1 through 1.5 which are attached. The model was estimated for the years 1994, 1997, 2000, 2005, and 2010. Values for other years are obtained by linear interpolation and extrapolation. The differences in values among the years modeled reflect differences in the representative power plant and the corresponding plant characteristics, the target populations, and escalation in health cost. The values are presented in real 1991 dollars per ton per year obtained from modeling a sample of currently operating natural gas fired plants and the air basin in which they are located. The AQVM produces total damages per year for a base year resulting from a given change in emissions that can also be expressed in dollars per kWh. Expressing the results in $/ton is necessitated by the requirements of the electricity production cost models that use the output of the AQVM. To estimate future damage values that take into account growth in target populations and the cost of health care and translate them into $/ton, the staff developed a post AQVM processor described in Figure 3.1.

3.2 Application of the Air Quality Values

The sole intended use of the AQVM results is in the capacity expansion modeling that the staff uses to determine the least social cost capacity additions to California's major electricity systems. To be added to the system the new plant's social benefits must exceed its social costs. On the cost side, the main components are: capital, operation and maintenance costs, fuel cost and the cost of acquiring emission offsets, if applicable. In many areas of California new sources of air pollution are required to offset their emissions by at least 100 percent by reducing emissions from another source. The cost of obtaining such offsets is included in the new plant's cost. On the benefits side, the main components are: the value of fuel and emission reductions from reduced operation of old and relatively inefficient plants, and increased system reliability resulting from adding the new plant. The values of emissions reductions are estimated using the AQVM.

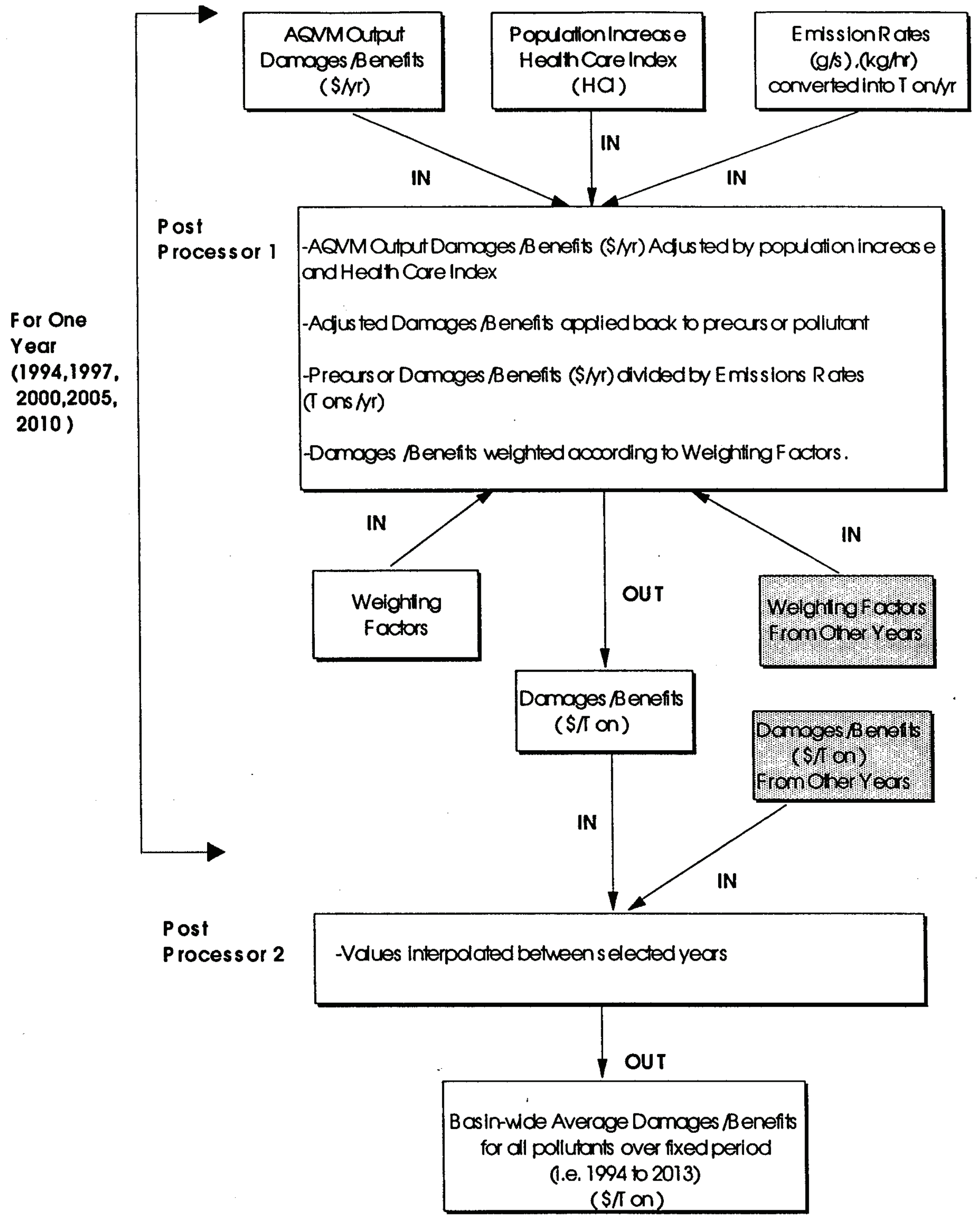

Figure 3.1: Post Processor Flow Chart

These values are location and application specific. Values for other locations or applications must be computed using appropriate data and assumptions. In particular, the applications of these results to the transportation sector is not technically correct since mobile emission sources require different air quality modeling than do stationary sources such as power plants. Given the required resources, the staff plans to expand the AQVM to the transportation sector by adding a mobile source air quality modeling component. Other planned future activities include improving the air quality modeling component for stationary sources, accounting for inter-basin transport of emissions and incorporating new findings from the literature as they become avail-able.

4 Conclusions

A sustainable development path requires the quantification and explicit accounting for externalities in energy production and consumption. This task is by no means simple. The work completed to date by CEC, extensive as it is, accounts only for air quality externalities from marginal additions to the electricity generation system. However, the complexity of the task should not deter attempts at quantification de-spite the large uncertainties associated with such attempts. The perceived complexity and data intensity of estimating externalities has in effect lead to assigning them a value of zero. Although current efforts at quantifying externalities have large modeling and data uncertainties, they represent important first steps in a long term effort to quantify externalities and reflect them in energy prices and/or the decision making process.

Table 1.1: Benefits from Displaced Emissions (for Year 1994)

Plant	Cell	NOx*	ROG*	CO	SO2	PM10	Total Damages ($1991/yr)
				($1991/ton/yr)			
San Diego Air Basin	**Average**	**2,470**	**652**	**2**	**6,139**	**21,346**	
Encina 5	Cell 1	2,403	55	1	5,820	9,890	$2,092,277
South Bay I	Cell 10	2,507	744	2	6,146	24,264	$1,787,091
San Francisco Air Basin	**Average**	**5,906**	**3,225**	**3**	**13,442**	**22,746**	
Pittsburg 6	Cell 6	5,913	468	3	13,412	27,557	$2,026,862
Hunter's Point 3	Cell 7	5,859	4,522	2	13,444	17,739	$468,547
North Coast Air Basin	**Average**	**621**	**19,913**	**0**	**1,245**	**2,287**	
Humboldt 2	Cell 6	621	19,913	0	1,245	2,287	**$15,681**
North Central Coast Air Basin	**Average**	**844**	**28**	**0**	**2,192**	**5,826**	
Moss Landing 7	Cell 3	844	28	0	2,192	5,826	$1,796,835
South Central Coast	**Average**	**1,385**	**163**	**0**	**3,385**	**5,494**	
Morro Bay 3	Cell 4	1,384	337	0	3,380	4,591	$537,360
Mandalay 2	Cell 15	1,387	60	0	3,388	6,001	$560,328
South Coast Air Basin	**Average**	**14,881**	**2,297**	**5**	**31,550**	**39,606**	
Valley 3	Cell 3	15,628	3,851	6	32,658	55,611	$1,263,739
Scattergood 3	Cell 7	14,694	1,499	4	31,845	35,894	$3,322,597
Etiwanda 3	Cell 8	15,138	1,875	5	32,130	45,648	$2,731,469
High Grove 4	Cell 9	17,482	55,791	4	35,377	0	$231,592
Huntington Beach 4	Cell 11	14,375	208	4	31,882	39,691	$5,299,823
South East Desert Air Basin	**Average**	**1,040**	**32**	**0**	**2,210**	**599**	
Cool Water 3	Cell 10	1,040	32	0	2,210	599	$932,566

*** 75 % of Ozone is allocated back to NOx and 25 % is allocated back to ROG**

Table 1.2: Benefits from Displaced Emissions (for Year 1997)

Plant	**Cell**	**NO, ***	**ROG***	**CO**	**SOz**	**PM10**	**Total Damages**
			($1991/ton/yr)				**($1991/yr)**
San Diego Air Basin	**Average**	**2,637**	**59**	**2**	**6,612**	**23,371**	
Encina 5	Cell 1	2,565	61	1	6,206	10,818	$1,229,530
South Bay 1	Cell 10	2,668	59	3	6,618	26,240	$1,270,563
San Francisco Air Basin	**Average**	**6,217**	**10,978**	3	**13,756**	**19,670**	
Pittsburg 7	Cell 6	6,204	514	3	14,023	22,820	$3,979,836
Hunter's Point 3	Cell 7	6,270	17,123	2	13,726	15,820	$295,221
North Coast Air Basin	**Average**	**802**	**23,604**	**0**	**1,513**	**0**	
Humboldt 2	Cell 6	802	23,604	0	1,513	0	$13,073
North Central Coast Air Basin	**Average**	**909**	**29**	*0*	***2,355***	**6,280**	
Moss Landing 7	Cell 3	909	29	0	2,355	6,280	$1,546,201
South Central Coast	**Average**	**1,511**	**46**	**0**	**3,613**	**6,315**	
Morro Bay 1	Cell **4**	1,485	39	0	3,627	4,592	$129,831
Ormand Beach 2	Cell 15	1,528	49	0	3,662	6,502	$306,155
South Coast Air Basin	**Average**	**19,039**	**13,596**	**6**	**34,826**	***45,585***	
Valley 3	Cell 3	17,348	5,178	7	34,999	57,414	$1,178,886
Long Beach 8	Cell 7	18,181	8,030	5	34,961	39,715	$720,603
Etiwanda 1	Cell 8	29,740	42,038	9	34,260	63,525	$449,426
High Grove 4	Cell 9	16,998	23,329	6	35,529	0	$399,463
Huntington Beach 3	Cell 11	15,678	507	5	34,576	40,369	$6,227,476
South East Desert Air Basin	**Average**	1,233	**43**	**0**	**2,605**	**705**	
Cool Water 3	Cell 10	1,233	43	0	2,605	705	$1,063,648

*** 75 % of Ozone is allocated back to NOx and 25 % is allocated back to ROG**

Table 1.3: Benefits from Displaced Emissions (for Year 2000)

Plant	Cell	NO,, *	ROG*	CO	SO$_2$	PM10	Total Damages ($1991/yr)
		($1991/ton/yr)					
San Diego Air Basin	**Average**	**2,636**	**4,064**	**2**	**6,822**	**20,415**	
Encina 5	Cell 1	2,722	72	1	6,601	11,275	$718,964
South Bay 4	Cell 10	2,912	4,888	3	6,831	23,744	$512,585
San Francisco Air Basin	**Average**	**6,633**	*3,535*	3	**14,610**	**20,092**	
Pittsburg 7	Cell 6	6,548	1,683	3	14,678	23,841	$5,228,171
Hunter's Point 4	Cell 7	6,890	4,512	2	14,605	17,487	$292,719
North Coast Air Basin	**Average**	**570**	**8,040**	**0**	**1,348**	**1,822**	
Humboldt 2	Cell 6	570	8,040	0	1,348	1,822	$18,999
North Central Coast Air Basin	**Average**	**972**	32	**0**	**2,514**	**6,759**	
Moss Landing 7	Cell 3	972	32	0	2,514	6,759	$1,932,405
South Central Coast	**Average**	**1,641**	**893**	**1**	**3,886**	**6,378**	
Morro Bay I	Cell 4	1,663	2,831	0	3,948	4,863	$181,420
Ormand Beach 2	Cell 15	1,615	98	1	3,923	6,929	$3,599,777
South Coast Air Basin	**Average**	**21,155**	**10,497**	**6**	**37,930**	**56,445**	
Haynes 3	Cell 7	25,265	12,095	6	37,290	46,260	$1,178,594
Etiwanda 1	Cell 8	22,481	16,234	10	40,387	102,206	$456,933
High Grove 4	Cell 9	20,011	55,356	6	37,880	87,590	$695,986
Huntington Beach 4	Cell 1	16,896	553	6	37,164	45,676	$10,116,468
South East Desert Air Basin	**Average**	**1,434**	**60**	**0**	**3,005**	**813**	
Cool Water 3	Cell 10	1,434	60	0	3,005	813	$1,207,725

*** 75 % of Ozone is allocated back to NOx and 25 % is allocated back to ROG**

Table 1.4: Benefits from Displaced Emissions (for Year 2005)

Plant	Cell	**NO_x ***	**ROG***	**CO**	**SOz**	**PM10**	**Total Damages**
			($1991/ton/yr)				**($1991/yr)**
San Diego Air Basin	**Average**	**3,138**	7,972	**2**	**7,529**	**18,935**	
Encina 5	Cell 1	2,968	82	2	7,196	12,041	$673,580
South Bay 4	Cell 10	3,328	11,195	3	7,566	24,116	$500,341
San Francisco Air Basin	**Average**	**7,089**	**2,589**	**3**	**15,429**	**20,144**	
Pittsburg 7	Cell 6	7,200	1,295	4	15,595	25,514	$1,628,007
Hunter's Point 4	Cell 7	7,068	2,716	3	15,425	18,966	$294,002
North Coast Air Basin	**Average**	**656**	**10,931**	**0**	**1,457**	**1,241**	
Humboldt 2	Cell 6	656	10,931	0	1,457	1,241	$35,304
North Central Coast Air Basin	**Average**	**1,487**	**1,637**	**0**	**2,798**	**7,623**	
Moss Landing 6	Cell 3	1,487	1,637	0	2,798	7,623	$281,154
South Central Coast	**Average**	**1,805**	**185**	**1**	**4,282**	**6,667**	
Morro Bay 3	Cell 4	1,843	442	1	4,271	5,697	$112,289
Ormand Beach 2	Cell 15	1,801	116	1	4,362	7,636	$3,742,831
South Coast Air Basin	**Average**	**31,057**	**11,219**	**8**	**41,464**	**58,453**	
Haynes 1	Cell 7	42,629	11,149	7	41,674	54,635	$933,794
Etiwanda 1	Cell 8	25,892	20,868	12	43,177	77,103	$743,881
High Grove 4	Cell 9	19,245	7,264	6	41,283	62,462	$986,607
Huntington Beach 4	Cell 11	18,902	970	7	41,369	48,567	$11,844,850
South East Desert Air Basin	**Average**	1,709	**55**	**0**	**3,606**	**978**	
Cool Water 3	Cell 10	1,709	55	0	3,606	978	$1,094,739

*** 75 % of Ozone is allocated back to NOx and 25 % is allocated back to ROG**

Table 1.5: Benefits from Displaced Emissions (for Year 2010)

Plant	Cell		NO.*	ROG*	CO	S0$_2$	PM10	Total Damages
					($1991/ton/yr)			($1991/yr)
San Diego Air Basin	Average		**3,276**	**615**	**3**	**7,818**	**18,482**	
Encina 5	Cell	1	3,197	79	2	7,711	12,927	$428,482
South Bay 2	Cell	10	3,431	3,367	4	8,155	34,129	$452,504
San Francisco Air Basin	Average		**7,948**	**2,958**	**3**	**16,326**	**21,383**	
Pittsburg 7	Cell	6	7,644	1,514	4	16,445	26,881	$1,658,780
Hunter's Point 4	Cell	7	7,982	3,050	3	16,325	20,703	$458,165
North Coast Air Basin	Average		**702**	**7,593**	**0**	**1,668**	**1,178**	
Humboldt 2	Cell	6	702	7,593	0	1,668	1,178	$43,507
North Central Coast Air Basin	Average		**1,242**	**236**	**0**	3,063	**8,286**	
Moss Landing 6	Cell	3	1,242	236	0	3,063	8,286	$474,867
South Central Coast	Average		**2,022**	**335**	**1**	**4,787**	**7,798**	
Morro Bay 3	Cell	4	2,145	947	1	4,695	6,227	$128,682
Ormand Beach 2	Cell	15	1,989	131	1	4,808	8,545	$3,283,947
South Coast Air Basin	Average		**32,022**	**8,966**	**9**	**45,419**	**62,873**	
Haynes 2	Cell	7	36,552	6,859	8	45,634	58,780	$783,691
Etiwanda 1	Cell	8	25,953	14,909	13	47,363	83,107	$753,341
High Grove 4	Cell	9	21,702	15,604	9	44,983	64,881	$1,187,883
Huntington Beach 1	Cell	11	31,886	6,143	8	45,655	55,880	$630,999
South East Desert Air Basin	Average		**2,023**	73	**0**	**4,245**	1,137	
Cool Water 3	Cell	10	2,023	73	0	4,245	1,137	$790,502

*** 75 % of Ozone is allocated back to NOx and 25 % is allocated back to ROG**