The Implication of Incorporating Environmental Costs in Utility Rate Setting

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Abstract

Electric and natural gas are the two major sources of energy for residents of Washington State. Several states have adopted a policy whereby utility companies decide on the choice of mixes of resources by incorporating cost effectiveness, conservation and externalities.

Externalities could include the direct and indirect environmental and human health cost of using resources such as electricity and gas that are not captured by market prices. Washington State possesses diverse resources that are susceptible to wastes and emissions originating from the consumption of energy. The impact of these wastes could be spatial, short-lived or cumulative. By most accounts the overall impact of pollution on ecosystems could be far-reaching and greater than the quantifiable and monetized impacts of environmental externalities. The need to account for environmental externality becomes even stronger in situations where inter-generational equity is used as a criterion for planning long term resource requirement.

Utility companies in Washington State are not required to explicitly incorporate or account for externality in the development and implementation of Integrated Resource Plan (IRP). IRPs are used by utility companies to facilitate the identification of the least-cost mixes of resources in the delivery of energy to their customers over a long planning horizon. In addition, there are no cases in which utility companies were ordered to incorporate costs of environmental externality in setting rates.

The present study is intended to show the implication of explicitly incorporating externality in rate setting on i) changes in the prices of energy or utility rates, and ii) its contribution toward reducing emissions of selected pollutants. The study will explore situations under which externality estimates from other studies could be utilized to develop energy policies. Furthermore, the study will discuss ways in which increases in costs of using energy as a result of accounting for externality may be shared or accounted.

The Implication of Incorporating Environmental Costs in Utility Rate Setting

1. Introduction

Energy is the single most important resource capable of sustaining life on earth. Energy not only is the engine of economic growth but also the cause of important life threatening outcomes. Its ubiquity, its role as life supporting resource as well as its potential to become a cause for the demise of human beings or living things at large makes it the most interesting area of research for public policy making.

The most commonly used sources of energy could be divided into fossil (e.g., natural gas and coal) and non-fossil (hydro, nuclear and geothermal). The extent to which the use of energy affects the environment and human health depends on the nature of the combustion process and the carbon content of the type of energy. This is particularly important in evaluating the impact of utilities such as those providing electricity because they are attributed as the major cause of several pollutants and thus targeted for significant reduction in emissions by the federal government. [1,2]

Reduction in emissions of pollutants from the energy sector would require the use of various strategies such as adoption of new control technologies, use of less polluting sources of energy, fuel substitution, etc. Regulations that require reducing emissions of criteria air pollutants using best available or end-of-pipe control technologies tend to increase the cost energy production and utilization. Increases in the cost of producing energy due to the implementation of emission reduction regulations may be passed onto the consumers via increased prices. It is possible that the net effect of stringent pollution reduction measures would result in reduced disposable income of consumers of energy. On the other hand, the use of renewable sources of energy, low-carbon content fuels such as natural gas, or fuel switching may be constrained by several factors (e.g., prices, supply, capacity, etc.).

The increased consciousness of the public for cleaner and healthier environment beginning in the early 80's has led to the enactment of environmental and energy laws and regulations. These regulations are expected to contribute toward greater investment in cleaner sources of energy, fewer energy intensive appliances or end use technologies, increased competition, etc. Federal energy and environmental regulations have also led to restructuring and deregulation of the energy sector.

Restructuring and deregulation of the energy sector are expected to lead to a cleaner environment and reduced energy bills for all consumers. The benefit of restructuring and deregulation would happen if there is fair competition; universal, reliable, and quality service is provided to consumers; presence of increased use of renewable energy and energy efficiency; fair and consistent allocation of the costs and benefits of restructuring; relatively no increase in environmental and human health risk; improved regulatory authority; transparency of the activities of utility companies, etc. However, whether or not restructuring and deregulation of the energy sector incorporate or internalize environmental costs and yet enable the attainment of the above benefits is to be seen.

The present study will attempt to explore the causes and importance of environmental externality, and the value or significance of incorporating environmental costs in the utility rate setting and resource allocation planning in light of the ongoing restructuring/deregulation of the energy sector. In addition, the study will review monetary estimates of environmental externalities from various studies with the view to assess the reliability and likelihood of using these estimates in energy policy planning.

1.1. Synergy between Energy, Environmental, and Regulatory Policies

In its comprehensive form, the environment is ought to include both the physical and non-physical resources inhabiting the earth, including the human being. Energy or natural resources are the primary components of the environment. Therefore, the most elementary form of the relationship between energy, the environment, human activities and/or regulations could be depicted as being bi-directional or reciprocal.[3]

In order to attain a "better" standard of living, human beings act in the exploration, extraction, processing, production and consumption activities. These activities will affect the environment in two ways: i) extract some of its endowment or resources, especially that of non-renewables and ii) treat it as a sink for wastes. Degradation of resources such as polluted air and water is indicative of the limited assimilative or carrying capacity of the environment with respect to some pollutants. Degradation of the environment will increase human health risks. Therefore, human beings engage in actions (e.g., development of regulations) that will constrain their activities and reduce the impacts of their activities on themselves and the environment. Because of these intertwined linkages, it is important to create synergy between energy, environmental and regulatory policies. [3]

The significance of synergism may vary from country to country. Countries such as USA not only utilize a large percentage of the world's energy resource but also release significant amounts of CO_2 to the atmosphere. In fact, the per capita CO_2 emissions of 35 U.S. states rank among the 50 highest national emitters in the world. [2] Several environmental and human health impacts are caused by emissions from the combustion of fossil fuels that accounts for nearly 70 percent of the total electricity generated in the United States. Therefore, the USA needs to explore ways in which energy, environmental and regulatory polices can be reconciled to make progress toward sustainable environment. [2]

There are several laws and regulations that affect the energy sector and environment. The present status of the utility industry is a product of the market place and regulations that were implemented since the early 60's. Often these regulations are designed either to protect consumers or ratepayers, stimulate economic growth, facilitate energy conservation or increase energy efficiency, and reduced environmental and human health risks. [1,2,4,5,6]

In order to address the environmental and human health concerns of pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOCs), carbon dioxide (CO_2), particulate matter (PM), etc., the Clean Air Act (CAA) of 1963 was passed by congress. By 1971, the United States Environmental Protection Agency (US-EPA) established New Source Performance Standards (NSPS) that required coal-fired utility boilers built after August 17, 1971, to emit no more than 1.2 pounds of SO_2 per million Btu of heat input. Similar requirements for NOx (limit emission within the range of 0.2 to 0.8 pounds per million Btu) were established. [1,2,4,5,6,7,8,9]

In 1977, the CAA was amended requiring States to set limits on existing sources in regions not attaining goals established in the Act. Within two years, the EPA established the Revised New Source Performance Standards (RNSPS). The major difference between RNSPS and NSPS is that new and modified boilers were required to reduce emissions by at least 90% so that the NOx or SO_2 limit was set to less than 0.6 pounds per million Btu. [1,5,6,7,8,9,10]

In the natural gas sector, the shortage of interstate markets led Congress to pass the Natural Gas Policy Act of 1978. The passage of the Pacific Northwest Electric Power Planning Act in 1980 required the development of a methodology for determining quantifiable environmental costs and benefits in determining the total system cost of energy resources. The Federal Energy Regulatory Commission (FERC) issued Order 380 and 636 to reform pipeline. [10,11,12,13] The order eliminated the variable-cost component of a local distribution company's (LDC's) minimum bill requirements that made it economically feasible for many LDCs to switch gas suppliers.

The latest amendment of the 1963 CAA was in 1990. In 1990, the Clean Air Act Amendments (CAAA) were instituted requiring electric utilities to reduce emissions of SO_2 and NOx by 10 and 2 million tons of emissions from 1980 levels respectively. In 1992, the Energy Policy Act was passed that requires development of a least-cost energy strategy to promote energy efficiency and limit the emission of carbon dioxide (CO_2) and other greenhouse gases. [3,10,11,12,13,14,15,16]

As a result of the passage of several laws and regulations over the past few decades, wellhead gas prices have declined by more than 20%. It is estimated that consumers may have saved a total of about $100 billion since the mid-1980 due to reduced retail gas prices. It is also estimated that labor productivity in the pipeline and distribution sector of natural gas may have increased by more than 20% and that operating and maintenance costs declined by about 20%.

Significant efficiency gains and lowered electricity prices were observed as a result of these laws and regulations. [3,10,11,12,13,14,15,16]

Within this context of technological and regulatory changes, factors such as demand for lower prices and retail access, implementation of the Energy Policy Act of 1992, and the presumption that increased competition produces greater energy efficiency have contributed to consideration of restructuring and deregulation of the energy sector. Full implementation of deregulation in the energy sector is expected to be characterized by computer-based dispatch of energy, open entry to buy, sell, and transmit power; demand-side bidding; contracts as financial instruments for hedging against risk; and prices that reflect the marginal cost of energy. Some of these features are being observed in the USA utility sector. [3,12,13,14,15,16]

Economic growth, the need to comply with laws, regulations and maintain competitive position has had some unintended consequences off energy production, distribution and consumption. The unintended consequences of energy (electricity and gas) consumption has to be borne by some portion of the society. Federal or State regulations had the objective of restricting using the environment as a repository for wastes or raising the cost of doing so to discourage unsustainable energy production and consumption activities. Often, costs of compliance with Federal and State regulations are passed to consumers via electric and gas bills. In some ways, therefore, federal and state laws may be viewed as strategies that have contributed toward internalizing of externalities.

Similarly, the increased costs of implementing regulations would be passed onto consumers. Therefore, the consumers or taxpayers are charged from two angles: to cover government costs to implement regulation and by companies to recover costs of implementing control technologies. As a result, recent government initiatives have shifted their emphasis from command and control to market-based, combination of regulations and market based, and voluntary approaches in order to implement energy saving or conservation and energy efficiency measures.

1.2. Summary

Many state and federal laws dealing with energy, environment, consumer protection, etc., were passed and implemented since the early 60's. The ultimate objective of these regulations and policies may include reduced energy consumption per unit of output produced and per capita, reduced releases of pollutants and wastes to the environment, reliable and lower price of energy, etc. In fact, regulators such as FERC are using an ex-ante evaluation of orders with respect to their likely impact on the environment before implementation of policies (e.g. FERC Order 888).

The latest development in the energy sector is restructuring and deregulation. Cleaner environment, fair, reliable and low energy price, and increased energy efficiency and conservation are the expected primary outcomes of these developments. Whether or not these processes eventually lead to the full functioning of the "invisible hand" is to be seen. There is, however, one concern. Despite the source and amount of energy used, there will be releases of waste and emissions. These byproducts will impact the environment and human health. The government has to interfere in the market system in order to ensure that prices of energy will take into account these undesirable consequences of energy utilization. These relationships between energy, environment and the need for government intervention (regulations) would and should justify synergy between policies targeted at each of these areas.

2. Importance of Healthy environment

2.1. Linkages between Environment and Economy

The relationship between the economy/resources and environment or sustainable development has become an area of concern only very recently. As indicate earlier, the environment in its broadest sense encompasses terrestrial and aquatic ecosystems, including humans. [3]

The environment provides two types of functions: source function, to provide the economy with necessary resources, and sink function, to assimilate the waste released from the economic process. There are three types of linkages between the environmental and economic systems: inter-economy linkages, which include links that exist between consumers and producers, and among various producers; inter-environmental linkages, which include various links within the natural resources or the ecosystems; and the interdependencies between the environmental system and the economic system. The last category of linkages can be further divided into two types: environmental inputs (such as natural resources) to economy and waste flows from economy to the environment. One of the most valuable categories of supply provided by the environment is natural capital that includes natural resources, and other amenities (services). [3]

The production of economic goods and services has shown unprecedented increases, and has been accompanied by significant destruction of the most fundamental, scare and consequently economic good at human disposal, namely the environment. Natural capital is identified as one of the area of greater concern to ensure progress toward sustainable development. Progress toward sustainable development or environment implies that nonrenewable resources such as natural gas should be depleted at a rate equal to the rate of creation of renewable substitutes. It has also been suggested that the rate of use of renewable resources should do not exceed regeneration rates and rates of development of renewable substitutes. If these and related conditions are not satisfied, degradation of the environment is doomed to occur. [3]

The economic system is dependent on the environment for the necessary ingredients - energy and other non-energy inputs. These inputs along with other non-natural inputs are transformed into goods and services that are required to fulfill the growing needs of humans. However, the process used to generate these goods and services produce more than what is consumed for economic purposes; a part of the output is non-economic in nature, which includes waste. The impact of these wastes on the environment and human health has caused significant financial expenditures that are necessary to defend humans and the environment from the unwanted side effects of unsustainable production and consumption decisions. The present study reviews and presents an argument for situations in which estimates of damages to the environment from other studies can be used to draw inferences about ways in which the polluter should be held responsible for the damages or for the manner in which damage could be internalized. [3]

The ultimate objective of conservation measures is to save the consumption of resources, increase efficiency and reduce emission of pollutants. It is estimated that adoption of cost-effective energy efficiency improvement could lead to a 50 percent reduction in emissions of CO_2 at zero cost to the economy. Some studies have argued that full use of energy efficiency and other renewable energy options could result in savings of more than $2 trillion, and reduce CO_2 emissions by 71 percent below 1988 levels, despite doubling of the GNP. [11] Other studies have also attempted to relate economic growth with cleaner environment. A recent study found that as income per capita increases (increased economic prosperity), environmental quality deteriorates up to a point, beyond which environmental quality improves. [18] Despite these findings, the fundamental truth is that there need to be a mechanism to internalize externality.

2.2. Emissions of Pollutants (Economic Growth) and the Environment

Despite the fact that the environment served as value-less store or sink for wastes and byproducts of human activities, the ability of the environment to assimilate wastes without affecting the functioning of the fauna and flora would be limited to some "threshold" level. Beyond this level, the byproducts of human activities become destructive. These destructive consequences result from air emissions, wastes, etc., characterized by either long lasting cumulative or short-term impacts. [3]

The environmental impacts of energy consumption could be felt at local, national or international level. It could affect private or common property. Under situations where the impacts are localized and private, entities affected by the damage can pursue various avenues to be compensated for the damage. [3] However, the situation becomes complicated when the impacted resource has an attribute of common or public property, especially that of unmanaged common (e.g., air and ocean).[3,18]

In the USA, it is estimated that the electric utility industry now produces 68% of the sulfur dioxide emissions that cause acid rain, 20% of the gases linked to the atmospheric greenhouse effect, and more than 50% of all nuclear waste. In addition to the common byproducts or wastes of energy consumption, nearly 75% of the annual electricity production in the United States is wasted because the products, processes and practices are inefficient or energy intensive. [1,8,10,13] Thus, implementation of ways in which emissions and wastes from the electric utility or energy sector could be reduced might be vital the local, regional and national environmental quality.

Strategies such as increasing energy efficiency, conservation and use of renewable sources of energy are suggested alternatives to reduce emissions. Equally important is the identification of the stage within the fuel cycle where interventions would have the greatest impact with respect to reducing energy consumption and emissions of pollutants.

While increased competition and regulations may contribute to reduced emissions of criteria air contaminants, the estimated reduction is considered to be inadequate and not sustainable. [20,21] Amongst the components of the electricity system, end use offers the greatest potential for large increases in efficiency, and for reduction in emissions of pollutants including CO_2. Increases in efficiencies can be obtained by adoption of new energy saving technologies and appliances, changing mixes of management styles, etc. The increase in efficiency not only translates into increased avoided emission of pollutants but also lowered utility rates. Strategies such as demand side management with respect to end uses, renewable energy generation technologies (e.g., Photovoltaic, Wind power, Geothermal, Biomass, Solar Thermal, Waste Fuels and Hydro power), other technologies geared toward efficiency improvements and increased use of natural gas are expected to contribute to reduced emissions of pollutants. [1,18,19]

Despite being labeled as clean fuel, the exploration, extraction, production, processing and distribution of natural gas have some environmental consequences. Some of these impacts may be felt on wetlands, habitats, wilderness, recreation and national parks, etc. Production and end-use components of the natural gas processes account for 60 and 30% of total CO_2 emissions from the natural gas sector respectively. Efforts to reduce the impact of emission from the natural gas sector and to design a method of penalizing for the environmental damage from this sector has to concentrate in these two segments of the natural gas sector. [18,20]

Currently, natural gas represents twenty-four percent of the energy consumed in the United States. A projection by the Energy Information Administration (EIA) for 1999 indicates that the share of natural gas may increase to about 30% by 2020. [20] The reason for the anticipated increase in the share of natural gas could be due to i) its lower carbon content and thus release lower quantities of greenhouse gases and criteria pollutants per unit of energy and/or heat produced compared to other fossil fuels, and ii) is not a source of toxic spills. These benefits of natural gas are very important when viewed vis-à-vis the fact that in 1997 energy-related carbon dioxide emissions accounted for 83.8 percent of U.S. anthropogenic greenhouse gas emissions. [20] The inherent characteristics of natural gas for being less damaging to the environment and human health have been the major force for its increased consumption (about 60%) in the generation of electricity (See Table 1).[20]

Recent projection by Energy Information Administration (EIA) indicates that the gains made under the 1990 CAAA may be lost due to increased emissions of NOx which is a precursor for acid rain, ground-level ozone and inhalable particulate matter. On the other hand, emissions of CO_2 will decline by as much as 40% of what was agreed for global climate change agreement.

This implies that significant effort needs to be made by state and federal governments, as well as the utility sector toward ways of reducing emissions of criteria air contaminants, including CO_2.[1,3,9,18,19]

2.3. Summary

USA utilities account for a large percentage of total energy consumed and pollutants emitted by the Organization for Economic Cooperation and Development (OECD) countries. Progress due to the implementation of regulations has brought about inconsistent results. In an era of increased competitiveness, internationalization, greater emphasis for environment protection, and financial prudence, it is important to explore ways of creating synergy among policies and regulations directed at the energy sector, the environment, and emissions of criteria air pollutants. It is only with a holistic view of the intricate and delicate balance between environmental and economy that it would be feasible to develop strategies, policies and regulations that would produce the maximum benefit to the environment and the public. Until it is time to use a full-fledged integrated-assessment-modeling platform depicting the linkages between energy/economy, environment and regulations in the formulation of sound synergistic policies, the role of the government in the energy sector will continue to be important. That is, the government has to explore for ways of reducing emissions, implement strategies that will minimize the use of resources especially non-renewables and developing methods of accounting for environmental externality. In order to implement ways of accounting for externality, it is essential to identify the causes of environmental externality, and whether or not there are non-market forces that may have contributed to the unsustainable production and consumption of energy.

3. Externalities and Market Failure

3.1. Market Failure and Externality

.1.Market Failure and Externality The most critical requirement to attain maximum social welfare is the existence of perfect competition in all economic activities in all markets so that the value at the margin of any class of factor (i. e., land, labor, and capital) is the same in all occupations in which it is employed. [3] Optimal welfare is attained when resource allocated lead to maximum efficiency. The attainment of economic efficiency in the allocation of resources is based on the equivalence between marginal costs and prices. Market failures attributable to the divergence between social costs/benefits and private costs/benefits lead to an inefficient allocation of resources. To move toward efficient allocation of resources, therefore, strategies have to be designed so that price of goods or products and processes will internalize costs of externality.

Attainment of allocative efficiency does not necessarily mean highest level of welfare. This is because some goods and services may be produced outside the market system (e. g., many environmental services) and that the distribution of income may be inequitable. [3] Absence of allocative efficiency means that there is room for improving social welfare. That is, at least one person could be made better off without making someone else worse off. [3]

Much of the literature identifies market failure as the primary cause of externality or environmental problems. [3,24] When markets fail, prices of goods and services fail to reflect their social scarcity-values. Market failure related to the environment may be caused by several factors. For instance, many environmental resources do not have markets. For some resources, transaction or negotiation costs are too high. For others, the physical feature makes it impractical to (e.g., atmosphere) define private property rights. In other situations the property rights are not properly defined or are unprotected (e.g. bio-diversity) preventing their existence or force them to malfunction. Environmental externalities are observed through the changes in the functioning of the physical-biological environment.

Besides market failure, government may also be responsible for distortion and cause of environmental externality. Subsidies or tax incentives, direct price controls, foreign exchange controls, and international trade restrictions may contribute toward distortion of the market or externality. It is essential to identify whether externality or market failure is caused by policy or market failure. Examples of policy failure include low or reduced rent, taxes or prices on natural resources; subsidies for environmentally damaging activities; controlled agricultural prices and agricultural taxation, etc. [3]

There are three types of environmental market failure: public good failure; open access failure; and inter-temporal failures. Each of these externalities may have global, transnational and/or local impacts. The essential feature of a public good is that it is non-rival in consumption, and non-excludable in its supply (e.g., air). [3]

Utility plants that burn fossil fuels to generate energy and emit several pollutants whose impacts are felt at local, regional and global level (acid rain, urban ozone, and global climate change). Although the operations of utilities damage the environment and affect human health, the full cost of the damage is not compensated for. In as long as polluters did not pay for the damage inflicted on the environment and consumers do not pay for the full cost of energy; it is plausible to argue that resources are allocated inefficiently.

Government often attempts to correct market failure by creating provisions to internalize externalities. Some state regulatory agencies are trying to develop methodologies to valuate environmental externalities and incorporate these costs in determining the demand for energy. If the market fails and that the marketplace does not capture these costs, the involvement of the government may be required to "internalize" costs of externality of using energy. [21,22,23,24,25]

3.2. Internalizing Externality

State utility commissions regulate energy prices charged by utilities. The basis for the rate setting is that customers would have to pay the cost required to deliver energy plus an acceptable rate of return to ensure profitability of the utility as a business entity. The cost of providing the service, however, accounts only for those inputs and outputs for which there are markets and prices, and those whose benefits/costs are shared by owners.

Utility commissions and regulators are expected to ensure that resources are not used in an inefficient manner and that defensible approach or procedure is utilized in choosing the least-cost, less resource intensive and less environmentally polluting mix of resources for long term operations or planning. Federal and State agencies review whether or not appropriate measures are incorporated in the IRP to ensure that environmental externality caused by the choice of polluting resources, use of non-renewable resources, and strategies to conserve energy are part of the comprehensive working plan. However, utilities will loose revenue since conservation or energy efficiency programs reduce sales. The loss in revenue will have to be collected by spreading investment across smaller sales volume to allow the utility to function as a business entity.

The use of IRP enables utilities to evaluate the impact of adding or incorporating externalities, conservation measures, etc., on utility rates in a holistic manner. In a regulated environment, conventional rate design practices lead to energy and demand charges substantially in excess of utility's short-run marginal costs or prices. The difference between a utility's energy charges and marginal costs reflects a contribution to the recovery of the utility's fixed costs. [8,26,32]

With increases in competition, the energy prices will be driven toward marginal costs. In fact, some utilities have started to offer lower rates to their largest customers in order to ensure higher incremental sales. With the spread of restructuring, rates are likely to be unbundled with the price of competitive services separated from other components of the customers' bills and pushed toward their marginal costs. However, the negative impact of efficiency programs on rates may not be lowered over a longer time.

3.3. Methods of Estimating Externality

Internalizing externalities may pose difficulty depending on whether the affected resource is global or local common, or whether it is caused by market or policy failure. For public good such as air, it is essential to design ways of non-rivalry while at the same time provide an [dis]incentive for the production of the bad or good. Examples of this nature are commodities such as fish, oil, natural gas, & forests. For some goods it is difficult to impose exclusion (e.g., air).

In order to internalize externalities, it is necessary to value or monetize the costs and benefits of damages to the environmental and risks to human health. Damages because of externality can be estimated in two ways: "direct damage estimation" and "cost of abatement." Damages due to a given pollutant are estimated using causal attribution. [24,25,26,27,28,29,30,31] In the damage cost approach, three steps are involved in determining the manner in which externalities are internalized. First, the causal relationship for the damage has to be empirically determined. Then, using emissions, output from atmospheric transport model and dose-response relationship, the quantitative impact of the emission would be determined. Finally, these estimates will be monetized. Valuation using the damage function approach utilizes either willingness to pay to avoid damages or compensation for willingness to accept in lieu of the damages. [2,3,4,5] Cost of abatement (control costs) attempts to estimate cost of reducing/ emissions of a given pollutant. Methods such as "indirect cost estimation (e.g., hedonic)," and "contingent valuation" are utilized to value damages.

Several ways of incorporating externalities are suggested. These include, but not limited to, the assignment of property rights; quantity restrictions; performance bonds; deposit-refund systems; tradable pollution permits; Pigouvian taxes and subsidies. [3]

In order to internalize externalities, some states have adopted "adders" to be used in resource planning. Adders are monetary instruments similar to an emissions tax, except no revenue is collected. Adders are expected to serve as a shadow price representing society's opportunity costs that are external to the private financial decisions of the utility but that should be considered by the firm if it is to make socially beneficial investment decisions. [3,4]

Several state policies require that utilities consider environmental costs in choosing among available supply options. Nineteen states require utilities to use quantitative estimates of environmental costs. In addition, about 10 states and DC, require the use of qualitative criteria that attempt to account for environmental costs. Some of the states are in the processes of developing policies that may require quantitative or qualitative consideration of environmental costs. [4,5,14,21,22,23,24,26,31,33]

Often, the regulatory environment involves other pre-existing policies and distortions that may have contributed to the divergence of social and private cost, and marginal cost. The magnitude of distortions that account for these effects could be substituted as "second-best" efficient adder. In addition to the determination of adders, it is essential to determine how the adders would be implemented. Adders could be applied to investment or dispatch, and decision has to be made on whether consumers interest is to see prices reflect costs of externality. [4,5,14,21,22,23,24,26,31,33]

4. Methodology and Study Design

Methodology and Study Design4.1. Empirical Model

Determination of the magnitude of externality and internalizing in the choices of resources can be accomplished using either econometric or mathematical modeling techniques. Most utilities prefer operations research or mathematical optimization routine to incorporate environmental externalities in the choice of resources. The essential feature of the mathematical model to be used for long term integrated resource plan should include:

i) flexible in state and space in that it must have enough flexibility to accommodate the mixes of resource over a cross-section of uses and time (dynamic programming); ii) capable of producing or incorporating the most likely energy, environmental and regulatory (rate) policies; iii) able to incorporate discrete, continuous, and non-linear functions; iv) able to generate the probability or expected value of occurrences of mixes of resources or supplies, likely patterns of consumption of demand related activities, and maintain a reasonable rate of return for the utility; and v) other constraints depending on the specific objective of the utility.

Given the objective function of maximizing net revenue or income (R), and expenditure or budgetary (M), supply (S), demand (D), price (P), non-zero or non-negativity constraints, etc., for utility i, resource j and time t, the resource optimization routine can be written as: [28,32,34,35]

$$
\begin{aligned}
&Maximize = R_t \\
&Subject \\
&\sigma M_{ijt} \le \varpi\,(budget) \\
&\alpha S_{ijt} \le \delta \ge 0(Supply) \\
&\beta D_{ijt} \le \theta \ge \pi\,(Demand) \\
&P_{energy,\,t} \le \Phi \ge \lambda\,(\mathrm{Pr}\,ice) \\
&. \\
&etc. \\
&R, M, S, D, P, \ldots \ne 0(non - zero)
\end{aligned}
$$

The optimization algorithm could be specified as a single or multi-objective routine. For example, the utility can maximize revenue normalized for emissions or by the value of externality. Due to lack of the software for use by the public, it was not possible to run the resource optimization routine. However, the findings of various studies dealing with externality or adders are compiled and subjected to selected statistical analysis to ascertain their form of distribution, variability and the likelihood of using these values in developing energy policies or plans . In addition, the results of incorporating externality and its impact on rates of utility companies operating in the state of Washington are presented.

4.2. Implications of Incorporating Externality in Utility Rate Setting

4.2.1. Impact of Incorporating Externality in Utility Rate Setting.2.Impact of Incorporating Externality in Utility Rate Setting

Most countries around the world are struggling to minimize the environmental and human health impacts of emissions or wastes. These unwanted byproducts are the results of human activities. Assuming an elastic demand for essential non-renewable resources such as natural gas, and limited availability of substitute resources, it can be argued that increasing the price of the non-renewable resource may contribute to reduced usage and damage to the environment. However, under situations where alternatives exist, transaction costs are minimal and enforcement is loose, it may not possible to attain the objective of reducing emission of toxic pollutants and/or conserve energy or improve energy efficiency.

Due to the increased importance and recognition of ways in which segments of a society or the public has to be compensated for the damages caused by economic entities, policy makers are struggling with finding ways of not only how damages should be quantified but also how to allocate the value of the damages among various damaging activities.

A large percentage of emissions of criteria air pollutants in the USA is attributed to activities of the utility sector. Public Utility Commissions (PUCs) in several states have attempted accounting for environmental externality through the use of adders in IRPs. These adders are derived from State or agency specific research studies. The inclusion of adders in IRPs is intended to influence the choice of technology or resources in investment decisions on the basis of least social cost rather than least private cost.

There are, however, some flaws associated with adders. If adders are added to price of energy, then it is possible that customers could switch to energy sources that are cheaper and yet environmentally damaging. Alternatively a utility company may change the service territory from state with stringent regulation to one with loose or minimal regulation; thus resulting in resource allocation that is not socially optimal. It is also possible that large customers may contract supply from non-utility generators or utilities located out of state.

Despite the efforts and interest in using adders as a substitute in accounting for environmental externality, recent studies suggest that they may not be as effective as was thought in reducing damages to the environment. The study sponsored by EIA found that the practices of incorporating adders in the IRP were found to have had negligible impacts on electric utility resource (supply side options, demand-side methods, etc.) planning decisions. [35] Furthermore, the choice of demand side management (DSM) options were found to be unaffected by consideration of externality.

Bernow et al. (1991) found that adding emissions costs to the normal costs of operating different types of power plants resulted in reduction of emissions of SO_2, NOx, PM and CO_2 by 67%, 26%, 65% and 19% respectively. [2,3,4,5] Therefore, it may be possible to argue that the incorporation of externality or cost of emissions in planning the choice of resources mixes may contribute to reduce emission of pollutants.

In situations where externalities are not incorporated in energy pricing, energy prices will not equal marginal cost. The incorporation of externality may exacerbate allocative inefficiency or may improve allocative efficiency. If the inclusion of externality exacerbates the gap, the loss in welfare could be significantly higher than the cost of providing energy. [36] Burtraw, et al (1996) found that the value of the adders should be greater than externality when prices are less than marginal cost. However, adders should be less than externalities if it is possible to substitute the source of energy (e.g., electricity) and that externalities from unregulated supplies are larger, and marginal cost pricing effects are more important. It was also found that given the existing regulatory environment, methods to estimate externality and the data required to aid the analysis, the difference between efficient adders and externality estimates is about 10-20%. [36,37] Therefore, adders that are equal to estimates of externality may fail to achieve economic efficiency.

The method of incorporating externality takes existing environmental and social regulation as given. In addition, deregulation of the energy sector implies that regulated utilities are facing increasing competition from utility companies outside their service territory who may not be affected by social costing. Therefore, appropriate methods should be designed to estimate cost of environmental externality that is socially optimal.

4.3. A Case study from Washington Utility Companies

Several states have required utility companies to incorporate adders in their IRPs (see Table 2a). However, few have tried to examine the impact of incorporating adders on prices of energy and revenue, nor monitored whether or not these estimates are used in the choice of resources in each planing period.

The state of Washington doesn't require utility companies to incorporate adders in IRPs. However, IRPs developed by companies operating in other States that require the use of adders and also operate in Washington State were used as a case study to examine the impact of incorporating adders in rate setting. The result of incorporating adders showed that gas prices per therm could increase by 20 to 70% (or 140%) compared to a situation where externality is not considered (see Table 2b). The data for Table 2b also show that inclusion of DSM options such as weatherization did not substantially contribute to reducing gas prices. This may be due to the fact that DSM strategies reduce volume of sales and revenue of utility companies resulting in higher prices per unit of energy (therm or kWh). On the other hand, due to rising gas and pipeline charges, the average gas bills to customers are estimated to increase by about 10%.

To ensure that accounting for externality will make a difference, the adders must be incorporated into the utility bill or proper auditing should be conducted to determine whether or not utility companies have implemented the results of long-term optimization plan with respect to the choice of mixes of resources. If adders are incorporated in the utility rates, it will likely result in an average bill increase of about 30 to 50%, in addition to annual increases in cost of energy. This level of increase may not be affordable by an average energy customer. Therefore, the federal and state government should design a strategy by way of which the social costs of environmental externality will be properly accounted. For example, the benefit of internalizing environmental externality is shared by all. Therefore, methods could be explored whereby these costs could be shared by all who may enjoy clean air, water, etc. Alternatively, State and federal governments could utilize economic instruments (e.g., taxes, subsidies, etc.,) to reduce emission of pollutants, implement polluter-pays or precautionary principles, or mixes of various strategies. If environmental externality is not properly accounted, it will result in a much greater increase in the extraction of resources such as natural gas and emission of pollutants from the use of cheap fuels such as coal.

4.4. Review of Estimates of Environmental Externality

Reviews of empirical estimates of environmental externality by pollutant and fuel cycle are presented in Tables 3a and 3b respectively. Analysis of methods used to estimate externality or adders indicated that i) variation in assumption with respect to the impact of CO_2 could lead to estimates that may differ by a factor of up to 100, and ii) uncertainty in dose-response relationship were found to be more important than regional variation in ambient concentrations. Uncertainty in dose-physical effect modeling and economic valuation could differ by as a factor of ten, and site-specific factors may contribute to variation in estimates by a factor of up to three or less. [37] If dose-response relationship and site-specific factors contribute to this level of variability in estimates of adders, direct use of these estimates in other policy planning exercise may result in erroneous conclusion. It is also important to explore whether or not similar results hold true for other pollutants. Review of the literature indicated that the variability in externality estimates for criteria air contaminants such as SO_2, NOx and PM is not as high as that of CO_2. Thus, it may be possible to develop some pollutant and site-specific adjustment factor in situations where adders need to be used and there are no site-specific studies dealing with environmental externality.

The reliability of externality estimates derived from other studies can be examined based on the magnitude of variance and form of distribution from which the data may have been generated. Kolmogorov-smirnov tests were applied to estimates of externality data gathered from the literature to examine whether or not these estimates could be characterized by known distributions so that conventional statistical procedures could be employed to make adjustments to these estimates. The results indicated that the externality estimates for NOx, SO_2, PM and VOCs can be assumed to have come from a normal distribution at 90% level of confidence.

However, the test also showed that all the data for all the pollutants could be assumed to come from a uniform distribution. The results seem to indicate that with exception of externality estimates for CO_2, the properties of a normal or uniform distribution can be applied in transforming and utilizing these data to develop energy policies in other situations. Furthermore, estimates NOx, SO_2 and PM showed a coefficient of variation less than 50% while VOCs and CO_2 resulted in coefficient of variability greater than 100%. This may imply that, holding other things constant, it is possible to make use of externality estimates from other studies related to SO_2, NOx and PM in developing energy or environmental policies with more confidence compared to using estimates for VOCs and CO_2.

The studies also explored whether or not externality estimates derived from various studies at different time periods are correlated. The empirical estimates of correlation analysis are presented in Table 4. The results of correlation analysis of the damage estimates or costs of externality for different pollutants indicated that pollutants that are often precursors for the formation of chemicals that pose several environmental and human health risks tend to be statistically and significantly correlated. The results of correlation analysis showed that estimates of NOx and SO_2; NOx and VOCs; PM, SO_2 and NOx are statistically significant either at 5 or 10% level (Table 4). However, estimates of CO_2 are not statistically significant with any of the other estimates. These findings also support the empirical evidence that estimates of CO_2 may not have come from the same parent distribution as those for NOx, VOCs, SO_2 and PM. Given these findings, therefore, it would be possible to make adjustments to externality estimates of criteria air contaminants (e.g., NOx, SO_2, and PM) from other studies for specific application. Specifically, it would plausible to derive an adjustment factor for estimates of damages from criteria air pollutant compared to estimates for CO_2 in order to assist the development of specific energy policy plans or programs. Finally, review of the literature indicated that incorporation of externality might contribute toward reducing emission of pollutants (see pp. 15-16).

5. Conclusions and Recommendations

The USA utility sector accounts for a significant portion of energy consumption and emission of criteria air pollutants. By the same token, it is argued that this sector causes the greatest damage to the environment and human health. Therefore, it is important to examine ways in which environmental externality could be internalized in products and outputs of energy producing and consuming entities.

The state utility commissions have the primary and more frequent interaction with utility companies. It is expected that if successful strategies are to be implemented to internalize externalities, utility commissions will have the greatest chance of success because there is a mechanism that will set the prices of energy charged by the utility companies.

Review of literature indicates that there are several methods of estimating externalities. Analysis of externalities caused by utility companies requires the use of atmospheric dispersion modeling, surveys or other techniques to determine values, determination of least cost abatement technologies, etc., and that conducting these kinds of studies require longer time as well huge financial spending. Therefore, available literature could be used to transfer estimates derived for other regions, territories, etc.

Despite the variation in methods of estimation, estimates for pollutants that pose the greatest environmental and human health in North America (e.g., criteria air pollutant) show higher degree of correlation and seem to be derived from known distributional forms. Furthermore, the coefficient of variability of externality estimates derived for SO_2, NOx and PM was less than 50%. Therefore, minor adjustments can be applied to derive estimates for use in developing energy policy planning.

Analysis of the significance of incorporating estimates of environmental externality (adders) in utility rate setting indicates that energy prices could increase by at least 40%. The incorporation of adders in the choice of resources was also found to result in significant reduction in emission of selected pollutants. Incorporation of externality in energy prices will increase rates significantly. On the other hand, the benefits of reducing externality are shared by all. Therefore, state and federal agencies have to design a method so that the increased cost of protecting the environment and human health will be shared by all that may benefit from incorporation of externality in energy prices. These measures could include, among other things, the spread costs across beneficiaries, implementing of mixes of economic instruments and regulations, etc.

The ability of IRPs to produce sustainable results with respect to the choices of resource that results in minimal damages to the environment may not be materialized because of other factors that may influence the choice of resources, and limited monitoring activities by state agencies. If incorporation of externality is expected to successfully change behavior of utility companies so that damages to the environment and human health are minimized, then methods have to be explored to incorporate externality estimates in setting energy prices and in the choice of mixes of resources for long term planning.

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Table 1. U.S. Carbon Dioxide Emissions from Energy & Industry, 1990-1997 (million metric tons of C)

Fuel Type or Process	1990	1991	1992	1993	1994	1995	1996	1997P
Natural Gas Consumption	273.2	278.1	286.3	296.6	301.5	319.1	319.7	319.1
Gas Flaring	2.5	2.8	2.8	3.7	3.8	4.7	4.5	4.3
CO in Natural Gas	3.6	3.7	3.9	4.1	4.3	4.2	4.5	4.6
CO2	5.4	5.6	5.8	6.1	6.3	6.2	6.5	6.7
Total	279.3	284.6	293	304.4	309.6	323	328.1	328
Petroleum	591.4	576.9	587.6	588.8	601.3	597.4	620.6	627.5
Coal	481.5	475.7	478.1	494.4	495.6	500.2	520.9	533
Geothermal	0.1	0.1	0.1	0.1	*	*	*	*
Total	1073	1052.7	1065.8	1083.3	1096.9	1097.6	1141.5	1160.5
Cement Production	8.9	8.7	8.8	9.3	9.8	9.9	9.9	10.1
Other Industrial	8	8	8	8	8.1	8.9	9.1	9.2
Total	3.7	3.5	1.9	6	7.2	7.6	9.2	12.2
Total: Energy & Industry	1355.9	1340.8	1360.6	1393.6	1413.8	1428.1	1478.8	1500.8
Percent Natural Gas of Total	20.6	21.2	21.5	21.8	21.9	22.6	22.2	21.9

*Less than 0.05 million metric tons; P = Preliminary data.

Source: EIA, Emissions of Greenhouse Gases in the United States 1997 (October 1998).

Table 2a: Estimates of Adders by States

Adders/therm	CO_2, NOx, CO & CH4	CO_2 and NOx	NOx	CO_2
Washington 1		0.152		
Washington 2			0.0192	0.1475
Washington 3	0.15124			
Califonia[1]				9
Massachustes[1]				22
Minnesota[1]				10
Nevada[1]				22
Newyork[1]				1.1
Oregon[1]				25
Wisconsisn[1]				15

1- indicates that estimate are in $/t of CO2

Source: Compiled from Hohmeyer, et al., 1997; Ottinger, et al., 1990; Wang, et al., 1995; & Cohen, et al., 1990.

Table 2b. Percentage Increase in the Prices of Gas due to Incorporation of Environmental Externality and Conservation Measures

	Percentage Increases Compared to Base Case					
Scenario	Year1	Year2	Year3	Year4	Year5	Upper Range
Adder1	20.53	20.56	20.43	20.2	20.07	39.31
Adder2	47.26	47.34	47.3	46.63	46.18	89.3
Adder3	74.02	74.08	74.62	73.01	72.95	138.72
Adder1+washer	20.53	20.56	20.47	20.29	20.16	
Adder2+washer	47.26	47.41	47.06	58.39	57.82	
Adder3+washer	74.02	74.08	74.62	73.01	72.95	
Adder1+weatherization	20.53	20.63	20.56	20.46	20.39	
Adder2+weatherization	47.26	47.3	47.26	46.67	46.46	
Adder3+weatherization	73.95	73.97	74.46	72.88	72.91	

Adder1- Assumes that abatement cost for NOx and CO2 is $2000 and $10 per ton; Adder2- Assumes that abatement cost for NOx and CO2 is $2000 and $25 per ton; and Adder3- Assumes that abatement cost for NOx and CO2 is $2000 and $40 per ton. In all cases it is assumed that the amount of emissions per therm of gas used is $0.008 and $11.520 pounds respectively. Sources: Draft IRP reports and WUTC reports, 1995-1999.

Table 3a. Summary of Externality Values ($/ton)

Source/Pollutants	NOx	SO2	PM	CO2	VOCs
California	8196	4664.5	25092	9	1981
Massachusetts	7200	1700	4400	22	5900
Minnesota	854.5	300	1273.5	10	1190
Nevada	6800	1560	2380	22	1200
New jersey	1640	4060	2380	13.6	
New York	1832	832	333	1.1	
Newyork2	4510	921	2645	6.2	3188
Oregon	3500		3000	25	
Wisconsin				15	
BPA	477	1500	853		
California2	26397	19717	5710	7.64	18855
Nevada2	196	188.5	808		
W&S 95, literature	8945.5	183.75	378.7		4262.5
Leach 97 literature	17414	13060	290		11754.5
Literature, min &		16817	206.65	244.95	
Lit. mean	13180	8875.75	240.25		8008.5
Tellus	7480	1716	4598	26.4	6094
CEC	10230	19954	13442	8.8	5742
NYS	2112	946	374	1.32	
SCAQMD	301400	86240	50600		33440
PACE	1892	4664	2728	15.4	
BPA	473	2200	968	6.6	
Sweden	6996	2618		44	
NREL	7308	1686	4497		5959

Sources: Compiled from Hohmeyer, et al., 1997; Ottinger, et al., 1990; Wang, et al., 1995; and Cohen, et al., 1990

Table 3b. Social Costs of Externality by Fuel Cycle ($/ton)

Study sources	Coal	Oil	Gas	Nuclear	Biomass	Hydro	Solar	Wind
EC	15.28	17.10	1.04	1.86	NA	3.29	NA	2.43
Hohmeyer	64.95	64.95	64.95	156.30	NA	NA	122.35	91.70
Ontario Hydro	7.58	0.43	NA	0.03	NA	NA	NA	NA
ORNL/RFF	0.93	0.20	0.12	0.28	1.86	0.08	NA	NA
Ottinger	67.40	54.65	14.00	33.70	4.07	NA	2.33	0.58
Pearce	51.85	93.20	6.37	2.93	NA	0.67	1.17	0.67
RCG/Tellus	2.76	1.47	0.22	0.12	3.20	NA	NA	0.01

NA- refer to not available

Source: Compiled from Hohmeyer, et al., 1997; Ottinger, et al., 1990; Wang, et al., 1995; and Cohen, et al., 1990

Table 4. Correlation Analysis of Estimates of Environmental Externality

Pollutants	NOx	SO2	PM	CO2	VOCs
NOx	1	.772(**)	0.393	0.099	.937(**)
SO2	.772(**)	1	0.429	0.084	.691(*)
PM	0.393	0.429	1	0.004	0.086
CO2	0.099	0.084	0.004	1	0.045
VOCs	.937(**)	.691(*)	0.086	0.045	1

**, * Significant at 10%, and 5%