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Investigating the Environmental Pollution of Electrical Power Plants

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ABSTRACT

Nowadays, the environmental pollutions are always increased due to industrial units such as electrical power plants. The electrical power plants produce different gases such as carbon, oxide nitrogen, and natural gases. In many countries, the environmental protection agency (EPA) provides some regulations to control and limit these gases. In this regard, it can be very useful to study and analysis the environmental pollution and emissions of electrical power plants. This paper addresses a comprehensive investigation of different emissions provided by electrical power plants.
Keywords: Environmental Protection Agency, Carbon, Oxide Nitrogen, Natural Gases, Electrical Power Plants, Environmental Pollution

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INTRODUCTION

In recent decays, along with the rapid development of industry and increasing the industrial units in all round the world, the environment pollution has been rapidly increased and this issue has led to a new challenge. The environmental pollution plays a major role in the political and economical decisions of the companies and governments [1-6]. One of the most important industries, which produce different emissions and gases, is power plants. The generation of electric power produces more pollution than any other single industry in the world. The energy sources most commonly used for electricity production are fossil fuels such as coal, oil, and natural gas, which are known as non-renewable resources. They take Millions of years to be formed in the crust of the earth by natural processes. Once burned to produce electricity, they are gone forever. Burning fossil fuels such as coal or oil creates unwelcome by-products that pollute when released into our environment, changing the planet's climate and harming ecosystems. The U.S. electricity production industry is responsible for, 62.6% of U.S. sulfur dioxide emissions that contribute to acid rain, 21.1% of U.S. nitrous oxides emissions that contribute to urban smog, 40% of U.S. carbon emissions that contribute to global climate change. Among the other major environmental issues linked to electricity are water impacts, generation of wastes, and the disruption of land uses. Nitrous oxides emissions contribute to ground-level ozone, particulate matter pollution, haze pollution in national parks and wilderness areas, brown clouds in major western cities, acid deposition in sensitive ecosystems across the country, and the eutrophication of coastal waters. Elevated ozone levels persisting throughout the country have also led to the adverse health effects of smog and millions of dollars in agricultural damage. A compelling body of scientific evidence links fine particle concentrations with illness and thousands of premature deaths each year. Children and the elderly are particularly at risk. The other sources of electricity production are nuclear resources. Like coal, nuclear power causes some of the most serious environmental impacts, albeit indirectly. While nuclear power plants do not release toxic chemicals like traditional power generation plants, nuclear fuel systems create hazards that may threaten people and the environment now and for generations to come, as well as pose risks of catastrophic accident. Mining, processing and transporting nuclear fuel produce significant pollution, including air pollution. After decades of nuclear power plant operation, our nation as not yet decided how to solve the problem of safely storing hazardous nuclear wastes for centuries to come [7].

The effects of environmental pollutions in electric power systems

Many studies have been carried out to assess the environmental pollutions of electrical generation systems. Paper [8] addresses an adaptive resource allocation for the electric environment pollution control through the web-based GIS. This paper provides an optimization problem for a general utility function such that it could be non-concave and non-differentiable. To solve this problem, the paper decompose the original optimization problem into the dual optimization problem, which can be easily solved by a simple iterative bisection algorithm to adaptively control the electric environmental pollution through the web-based GIS. Paper [9] provides an interval-parameter full-infinite joint-probabilistic mixed-integer programming for supporting electric power systems management. The proposed model is applied to electric power systems of Beijing for planning within a multi-energy resource, multi-electric power plant, and multi-period context, where mixed integer linear programming technique is employed to facilitate dynamic analysis for decisions of facility-capacity expansion. In the proposed method, tradeoffs among system costs, electricity-supply security, and air-pollution control can be obtained under joint probabilities. The results can be used to help managers to identify desired system designs and to determine which of these designs can most efficiently accomplish optimizing the system objective under uncertainty. The results can also address the challenges generated in the processes of electric-power production (such as imbalance between electricity supply and demand, the contradiction between air pollution emission and environmental protection). Paper [10] discusses that green electricity generation can provide an indirect route to cleaner air: by displacing generation from fossil fuels, green electricity can reduce emissions of CO2 and conventional air pollutants. Several types of voluntary markets have emerged in the United States to take advantage of this relationship, including green electricity programs, carbon offsets, and renewable energy certificates. At the same time, regulators are favoring cap-and-trade mechanisms for regulating emissions. This paper describes the appropriate framing of environmental claims for green electricity products. This paper applies an accounting framework for evaluating claims made for capped pollutants, with entries for emissions, avoided emissions due to green electricity, and unused emission permits. This framework is applied in case studies of two major electric utilities that operate with green electricity programs and capped pollutants. The cases demonstrate that the relative magnitude of “unused permits” and “emissions avoided” is a key relationship for evaluating an emissions reduction claim. Lastly, this paper considers the evolution of the green electricity marketplace given the reliance on cap-and-trade. In this setting, pollution-emission products could be decoupled from one another and from the various green electricity products. Paper [11] discusses that anthropogenic activities such as the use of fossil energy sources for electricity generation, are the main contributors to the pollution of the environment. The main energy source used in the Greek electricity generation sector is lignite as there are large reserves in the country. Petroleum is also used at a great extent mainly in the islands in the autonomous power generation systems, while the use of natural gas is also increasing. Although lignite is a “cheap” energy source, the environmental impacts associated with its use are high, something that applies also for petroleum and in a lower extent with natural gas. The total net production of electricity from thermal power plants in Greece accounts for almost 90% of the total electricity production, while only 10% derives from hydroelectric energy and other renewable energy sources (RES). A typical example of the significance of the environmental impacts associated with the electricity generation sector is the fact that almost 74% of the total CO2 emissions in the country derive from this sector. Paper [11] focuses in investigating the environmental impacts associated with the atmospheric emissions and other wastes that are produced during the life cycle of the energy sources used for electricity generation in Greece. The environmental evaluation of the different energy sources is performed through the life cycle analysis methodology and the Eco-indicator 99 method and the results are used for comparison purposes. Paper [12] describes a methodology to incorporate the environmental costs associated to the construction and operation of power plants in the long-term expansion planning process of hydrothermal generation systems. These external costs are estimated in terms of monetary values, according to the nature of their impacts and endogenously included in the formulation of the expansion planning model. The minimization of the maximum regret framework used in the modeling process enables the development of a single expansion strategy that allows for corrections in the expansion trajectory, according to the behavior of electricity demand. Paper [13] argues that Thailand has a high potential to utilize renewable energy for electricity generation especially from agricultural waste; however, at present only a small fraction of biomass is used for energy purposes. Paper [13] aims to estimate the potential of biomass power generation and its impact on power generation expansion planning as well as mitigating carbon dioxide emission from the power sector. The harvest area and crop yield per area are taken into consideration to estimate the future biomass availability. The supplies of biomass are then applied as a constraint in the least cost electricity generation expansion-planning model. The cost of CO2 emissions is also added to the fuel costs as carbon taxation to make biomass power generation competitive to fossil fuels, then the optimum value of CO2 charge is found out. In addition, levels of CO2 limitation from power generation are also introduced to mitigate CO2 emissions.

Generation expansion planning and air emissions

Generation expansion planning is a planning which denotes the place, time, capacity and technology of new installed technologies in electric power systems. In this planning, many objectives are defined as objective function of the planning such as minimizing cost, maximizing profit, satisfying reliability, minimizing air emissions, etc. A general planning which consider air emissions can be mathematically formulated as follows:

$$\text{Min } (IC + \omega_1 \times CO2 + \omega_2 \times NOx) \quad (1)$$

$$\text{Subject to System constraints} \quad (2)$$

Where, IC shows the investment cost of new installed generation units, CO2 indicates the produced carbon dioxide by generation units and NOx shows the nitrogen oxide produced by generation units. The coefficients ω_1 and ω_2 are used to calculate the emissions (CO2 and NOx) per money. In other words, a forfeit cost is defined for different levels of emissions and these emissions are calculated per money. The proposed approach has been widely used in different papers and they have considered the emission in their planning. For instance, paper [14] provides an method to the electricity generation expansion problem for minimizing cost and air emissions, including CO2and NOx. In this paper, several types of generation systems such as coal, nuclear and wind are included. This paper manages the problem as a constrained optimization programming. The different objectives are combined using dimensionless weights and a Pareto front can be determined by varying these weights. Paper [14] consider different cases and weights to show the effects of emissions on the planning. Figure 1 shows a tradeoff between planning cost and air emissions. It is clearly seen that by increasing the investment cost, the emissions are reduced and vice versa. Therefore, it can be concluded that, in order to reduce the environmental emissions, the power system planner should invest on the new and modern technologies which are expensive and have less emissions. Figures 2 and 3 show the tradeoff between cost, CO2, and NOx respectively. The mentioned issues are significantly seen in these figures.

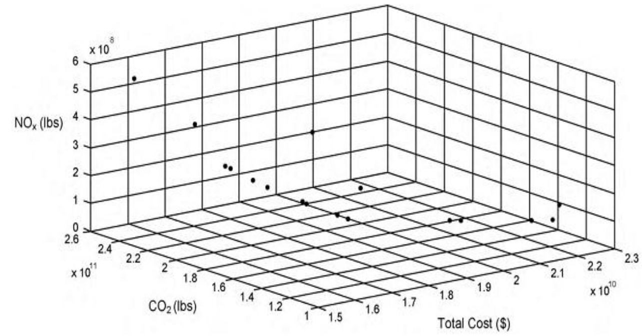

Figure 1: Tradeoff between planning cost and air emissions [14]

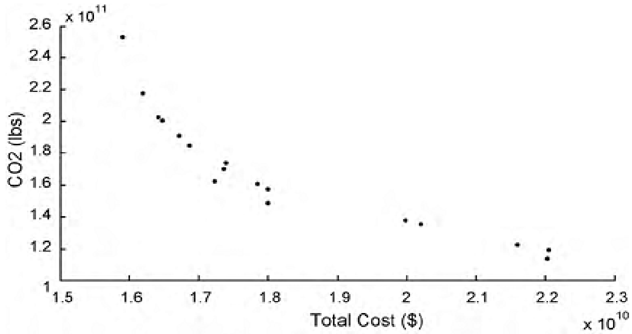

Figure 2: Tradeoff between cost and CO2 [14]

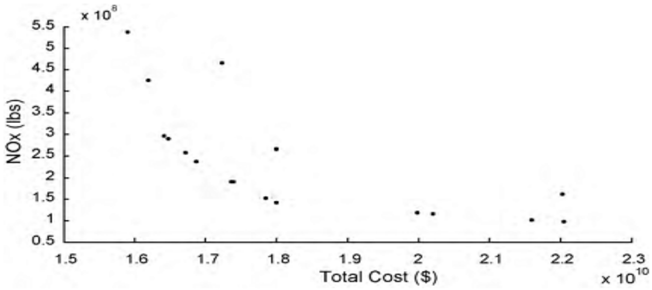

Figure 3: Tradeoff between cost and NOx [14]

CONCLUSION

In this paper the effects of electric power plants on the environmental pollutions were investigated. It was shown the electric power plants produce different pollutions such as CO2, NOx, natural gases, and so forth. These gases can be limited by installing modern technologies such as wind and nuclear, but these technologies are high cost and expensive. Therefore, the power system planner has to make a tradeoff between cost and emissions.

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