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Natural Gas Availability and Ambient Air Quality in the Baton Rouge - New Orleans Industrial Complex

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Abstract

Louisiana has been heavily reliant on natural gas to satisfy the spectrum of energy demand from electric power generation to home heating. The increasing shortage coupled with federal allocation policies will necessitate significant substitution of fuel oil and coal for power generation and industrial boiler fuel. Atmospheric emissions will increase dramatically and create the potential for violation of ambient air quality standards. The impact will be most keenly felt in the Baton Rouge - New Orleans corridor, containing the highest concentration of both people and industry.

Three 1985 scenarios have been postulated. The minimum natural gas scenario corresponds to just enough gas to supply the residential and commercial sectors plus chemical feedstock demand. Natural gas would supply approximately 8% of the stationary source demand compared to 1974's 80%. Two versions of the sceario, involving different stack dispersion characteristics were considered. The final scenario provided enough gas to supply 16% of the projected 1985 demand. The previous categories plus small boilers and process heaters ($< 3 \times 10^5$ scf/day) were allocated natural gas. The Climatological Dispersion Model was used to translate emission rates into ambient air concentrations.

It was concluded that continued industrial growth, fuel substitution, and air quality maintenance are compatible only if:

(a) Fuel oil and coal burning facilities are designed with adequate dispersion characteristics;

(b) Ambient air quality site studies are conducted prior to final site selection;

(c) Industry and regulatory agencies cooperate to promote industrial growth while insuring that air quality is maintained.

Introduction

The increasing shortage of natural gas has great potential for aggravating existing air pollution problems and creating problems where none have previously existed. The substitution of fuel oil, also in short supply, and coal for natural gas results in a dramatic increase in atmospheric emissions, particularly sulfur oxides. While the general problem exists nationwide, it is probable that the impact in the Baton Rouge - New Orleans complex will be most severe.

The banks of the Mississippi River between Baton Rouge and New Orleans are lined with petroleum refineries, inorganic and petrochemical plants, fertilizer manufacturers, food processors, and electric utilities (Figure 1). Most of the major United States corporations are represented and the majority of the industrial facilities are energy intensive. The average per capita energy consumption in Louisiana is about 65% above the national average [1] with the majority of this differential caused by the very high demand in the industrial sector as shown in Figure 2.

The region is also heavily dependent upon natural gas as the primary fuel (Figure 3). Essentially no coal is presently burned although the construction of several large coal fired power plants has been announced and it is known that many Louisiana industries are seriously considering either the construction of new coal fired boilers or the conversion of existing units to coal burning capability.

The population of the area is large (Table I), and growing at a higher rate than the United States average. The population centers of Baton Rouge and New Orleans are located at either end of the region with the remainder of the population rather evenly distributed in numerous small towns between.

The current production of natural gas in Louisiana far exceeds the intrastate demand even with most of the major industries utilizing natural gas. Approximately 80% of Louisiana's 1974 production was exported to other parts of the nation. Nevertheless, national policies which regulate natural gas distribution and which assign priorities to residential and commercial users are creating significant shortages within Louisiana borders. One measure of this shortage can be seen in the current price of new contracts for unregulated natural gas, approximately $2.00 per million Btu. On the other hand there are many contracts still in effect which provide natural gas boiler fuel at approximately $0.20 per million Btu.

Air Quality Implications

Table II was compiled from air pollution emission factors [2] to illustrate the amounts of each of the five criteria air pollutants emitted from boilers firing natural gas, fuel oil, and coal having the listed properties. Relatively small changes are expected in the total emission rates of carbon monoxide, nitrogen oxides, and hydrocarbons. Particulate emissions would increase dramatically if uncontrolled. High efficiency particulate control devices are expected to be installed where needed so that the actual increase in particulate emissions is expected to be small.

Sulfur oxides remain as an important pollutant. Both the fuel oil and coal specified in Table II satisfy New Source Performance Standards [3] without requiring stack gas treatment. At present, boiler fuels in the Baton Rouge - New Orleans area account for approximately 50% of the total SO_x emissions with process off-gases contributing most of the remainder. Total replacement of natural gas by fuel oil (0.7 wt %S) in all boilers would increase the boiler contribution to almost 98% of the total.

This study concentrated on the impact of fuel switching on ambient air quality. The scope of the original study was statewide. The Baton Rouge - New Orleans area was soon identified as the crucial area within the state, and this paper is restricted to that area.

The Climatological Dispersion Model (CDM) [4] was utilized to relate emissions to ambient air quality. Various natural gas substitution scenarios were postulated and areas particularly susceptible to air quality degradation were identified. The methodology developed is useful as a management tool for evaluating alternate energy policies with the aim of maintaining satisfactory air quality while encouraging economic growth.

Climatological Dispersion Model

The model, developed by the Environmental Protection Agency, is one of several which relate continuous emissions to long-term average pollutant concentrations. Although no one dispersion model is superior in all situations, the CDM has provided a good estimate of both mean and maximum SO_2 concentrations in a number of test cases [5,6]. It is particularly important to note that CDM has provided excellent correlation in areas with flat terrain and relatively straight winds, conditions typically found in Louisiana.

Input to the CDM consists of historical meteorological data and an emissions inventory. The meteorological information includes annual average ambient temperature, mixing height, and the joint frequency distribution between wind speed, wind direction, and atmospheric stability class. This information was obtained from the National Climatic Center of the U. S. Department of Commerce based upon data obtained at the Baton Rouge and New Orleans airports. The airport data was assumed to be representative of the surrounding region. Low wind speeds and stable conditions prevail at both locations. New Orleans winds are predominantly from the north while the predominant wind direction in Baton Rouge is from the southeast.

The current emissions inventory was compiled from the National Emissions Data System (NEDS) of the EPA and from the files of the Louisiana Air Control Commission (LACC). Parameters consisting of emission rate, location, stack height and diameter, and gas exit velocity and temperature were compiled for each point source within the region. Area sources, including those having very small emissions or those not traceable to a single point source, were compiled in terms of the annual SO_x emission rate by parish (county). A summary of current emissions is presented in Table III.

The total emission rate of sulfur oxides in Louisiana in 1974 was 358,811 tons. Of this statewide total, almost 70% originated from the area of interest. While this emission rate is certainly significant it can be placed in the proper perspective by comparison with the emission rate in Indiana, a state roughly the same size, but more heavily dependent upon coal and fuel oil. Louisiana's statewide emissions are approximately 1/6 those of Indiana.

The number of individual point sources involved in a dispersion study of this magnitude is quite large and thus imposes severe limitations on computer memory and execution time.

Consequently, a procedure was developed whereby the individual sources within a plant were combined into no more than two effective sources. All combustion sources, including process heaters and boilers, were combined into one effective point source and all process off-gases were combined into the second effective point source. The separation was necessary since process emissions are largely independent of fuel type.

Two sets of weighted average stack parameters were calculated to correspond to the two categories of emissions using the following equations:

Pollutant Emission Rate:

$$Q_j = \Sigma Q_{ij}$$

Stack Height:

$$H_j = \frac{1}{Q_j} \Sigma Q_{ij} H_{ij}$$

Gas Volumetric Flow Rate:

$$V_j = \frac{1}{Q_j} \Sigma Q_{ij} V_{ij}$$

Stack Temperature:

$$T_j = \frac{1}{Q_j} \Sigma Q_{ij} T_{ij}$$

Stack Gas Exit Velocity:

$$v_j = \frac{1}{Q_j} \Sigma Q_{ij} v_{ij}$$

Stack Diameter:

$$D_j = \left(\frac{4v_i}{\pi V_j}\right)^{1/2}$$

In the above equations j = 1 or 2 with j = 1 representing combustion and j = 2 representing process emissions. The subscript i designates an individual source within a particular plant. This averaging procedure reduced the total number of "effective" sources to a number compatible with computer memory and execution time restrictions. The procedure was validated for the grid size of interest in this regional study by comparing predicted concentrations using effective sources to predicted concentrations considering each source individually. The validity of the procedure is subject to question when higher concentration resolution (finer grid size) is needed.

Predicted ambient air concentrations are, of course, highly dependent upon the meteorological data. New Orleans and Baton Rouge data, while similar in many respects, are sufficiently different that important variations in predicted concentrations result using the same emissions data. This problem was important when modeling that region approximately equal distance between the two cities. In order to more closely approximate the realistic case of a gradual change in meterological conditions between Baton Rouge and New Orleans, a new set of meteorological data was calculated as the arithmetic average of the Baton Rouge and New

Orleans data. This intermediate data was then applied when modeling the parishes (counties) of Ascension, St. James, and St. John the Baptist.

Fuel Substitution Scenarios

The first step in the modeling effort consisted of a base case study of the existing situation using the latest (1974) data available. A favorable comparison between base case predictions and experimental data is obviously necessary if the future scenarios are to be valid.

From this base case, additional scenarios were developed based upon reduced availability of natural gas, implementation of stack parameters suitable for the fuel being burned, and the assumption that process emissions not currently in compliance would be reduced to allowable values. The year 1985 was selected as the date of interest and energy demand calculations for this date were based upon historical growth rates from each of the demand sectors.

Emissions expected from this historical growth rate projection were included for the residential, commercial, transportation, and other area source categories. These categories, however, constitute only a small fraction of the total SO_2 emissions. The majority originate from point or industrial sources. Emissions resulting from new industry or expansions of existing industry were not