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Project Summary

Description of the Industrial Combustion Emissions Model (Version 6.0)

T. Hogan

The Industrial Combustion Emissions (ICE) Model is one of a number of National Acid Precipitation Assessment Program emission forecasting models. The ICE Model projects air pollution emissions (sulfur dioxide, sulfates,and nitrogen oxides), costs,and fuel mix for industrial fossil-fuel-fired (natural gas, distillate and residual fuel oil,and coal) boilers by state and year (1985, 1990, 1995, 2000, 2010, 2020, and 2030).

This document describes the model methodology, key assumptions, data sources, and user options for Version B of the ICE Model. Future ICE Model runs may include model modifications recommended by EPA.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Industrial Combustion Emissions (ICE) Model is a highly disaggregated and detailed process engineering model covering the consumption of fossil fuels (coal, distillate and residual fuel oil, and natural gas) in industrial boilers. It was developed to help decision makers assess a wide range of energy, environmental, and cost impacts resulting from policy alternatives.

The basic approach in the ICE Model is to project the characteristics of the industrial boiler population and to make a fuel choice decision for each group of boilers. The major industrial boiler characteristics include:

- New or existing unit.
- Size (MW, 10^6 Btu/hr heat unit)
- Average annual capacity utilization rate.*
- Local and Federal sulfur dioxide (SO_2), particulate matter (PM), and nitrogen oxide (NO_x) emissions standards.

Key input assumptions include:

- Base year (currently 1980) boiler population characteristics.
- Projected fuel prices and total industrial boiler fossil fuel demand.
- Boiler and pollution control equipment cost estimates.
- Local and Federal air emissions regulations.

Major model outputs include:

- Projected emissions of SO_2, sulfates, and NO_x
- Projected industrial boiler fossil fuel demand by fuel type (coal, distillate and residual fuel oil, and natural gas).
- Projected total capital and annual operating, maintenance, and fuel expenses.

*Expected annual fuel consumption/(design firing rate times 8,760 per year)

Model outputs are available by State (excluding Alaska and Hawaii) and year (1980 baseline, 1985, 1990, 1995, 2000, 2010, 2020, and 2030).

Approach

Inputs to the ICE Model are determined from an analysis of macroeconomic factors. Analysis of overall economic activity identifies critical trends in macroeconomic variables. Macroeconomic models thus provide key economic "drivers" of energy demand, such as industrial production growth. These drivers then serve as key inputs to a model of the U,S. energy markets to determine energy demand in the energy"using sectors of the economy. The energy markets essentially involve the interplay of demand and supply for alternative sources of energy (e.g., oil, coal), resulting in the determination of the price and level of use of various energy forms.

In turn, the energy market trends provide the costs of energy back to the macroeconomic framework, through such variables as the Consumer Price Index and costs of energy inputs to the industrial sectors. These energy cost impacts can, in turn, alter macroeconomic trends. For example, world oil price inflation (deflation) results in major cost increases (decreases) which in turn affect industrial production growth, consumer behavior,and real income.

Industrial energy demand is an important element of the energy market. This effort focused separately on industrial energy demand because:

- The ICE Model has not been used as a portion of a "general equilibrium" system which simultaneously reflects the interactions between the economy and energy markets.
- The ICE Model is not a complete energy demand model.

Logically, an industrial demand model addresses the following issues:

- The relationship between industrial production and the overall level of the energy inputs required to perform various industrial process operations.
- Energy demand in all industrial uses (e.g., boilers, process heat, feedstock),
- The mix of energy sources selected to provide the full range of energy services.

The major (exogenous) inputs to a complete energy demand model are industrial production growth trends and the prices of various forms of energy.

The ICE Model covers only a portion of industrial energy demand. Specifically, it does *not* address in any detail:

- The relationship between overall industrial production and energy demand (e.g., conservation, process efficiency trends).
- The demand for energy in non-boiler industrial uses.
- The demand for energy forms other than conventional fossil fuels (fuel oil, natural gas, coal).

Projections of total fossil fuel demand in industrial boilers by state and year and forecasts of industrial fuel prices by Federal region and year are key ICE Model input parameters. The Energy and Environmental Systems Division of Argonne National Laboratory has developed alternative ICE Model input scenarios. These ICE Model input assumptions are based on DOE National Energy Policy Plan projections.

A predecessor model, the Industrial Fuel Choice Analysis Model (IFCAM), provided the initial framework for development of the ICE Model. Key improvements incorporated in the ICE Model include the capability to:

- Update base year data to 1980.
- Generate projections by state (excluding Alaska and Hawaii) out to the year 2030.
- Provide pollution control retrofit options for existing industrial coal-fired boilers.
- Select fuel types in new industrial boilers using statistical decision criteria based on a sample of recent sales data.

Many of the remaining key assumptions in the ICE Model, which are presented in this report, were developed by EPA for IFCAM. IFCAM has been used by EPA to project the environmental, cost, and energy impacts of alternative New Source Performance Standards (NSPS) for industrial boilers.

Model Capabilities

The ICE Model is a process engineering/simple accounting industrial boiler fuel choice model. This modeling technique simulates the effects of specific policies on technical alternatives by applying direct engineering information at a disaggregated level.

The ICE Model structure had been designed to evaluate alternative fuel price projections, government energy and environmental policy proposals, the costs associated with firing alternat fuels, and other key model parameters The fuel choice decision criterio includes a comparison of after-tax discounted cash flows. Therefore, variety of proposed tax credits an changes in the tax treatment of capit that provide incentives to invest in coa related equipment can be analyzed usin the model.

Environmental regulatory policies ca affect fuel choice by altering the relativ costs of burning alternative fuels Regulations relating to PM, SO_2, an NO_x emissions from fuel-burnin sources include state and loca regulations and Federal NSPS.

The ICE Model is capable of modelin alternative industrial boiler NSPS. Th ICE Model can simulate the use various types of flue gas desulfurizatic (FGD) systems (some with combine SO_2/PM emissions control), various type of post-combustion PM emissior control, and two types of combustic modifications to control NO_x emissions.

Several types of alternative NSP specifications of SO_2 emissions contr for new industrial residual fuel oil coal-fired boilers can be analyzed. F example, the regulation can vary t boiler size and can be specified as:

- A ceiling emission rate (lb pollutant/10^6 Btu of fuel burned).
- A recommended percentag removal (e.g., 90% removal uncontrolled SO_2 emissions).
- A recommended percentag removal and a "floor" emissio rate (e.g., 90% removal but lower than 258 ng/J [0.6 lb/1 Btu]).
- A minimum percentage removal be applied if the recommend percentage removal results controlled emission rates low than the floor.

The ICE Model can simulate t impact of alternative fuel pri projections on industrial fuel m Regional fuel priced for distillate a residual fuel oil (four sulfur classe natural gas, and coal (up to 11 types) considered in the model.

The fuel choice decision is sensitive non-fuel costs of burning alternate fu While the best available cost data used, the model can evaluate the imp of any alternative cost estimates.

The ICE Model's fuel choice decisi are a function of technical, economic, regulatory factors. The ICE Mo evaluates fuel switching in exist boilers and fuel type selection in n

boilers. For existing boilers, fuel choice is determined by comparing the after-tax net present value of retrofit or fuel conversion capital costs and O&M and fuel expenses. For new units, fuel choice is determined by comparing boiler and pollution control capital, O&M, and fuel costs, as well as other factors.

The ICE Model selects from a wide range of fuel quality options (multiple residual fuel oil and coal types) and alternative pollution control strategies. Table 1 lists alternative industrial boiler pollution control technologies in the ICE Model.

Table 1. *Industrial Boiler Pollution Control Equipment Options in the ICE Model*

Pollutant	*Technology*
SO_2	*Flue gas desulfurization*
	Dual alkali
	*Lime spray drying**
	Sodium once-through
PM	*Single mechanical collector*
	Dual mechanical collector
	Side stream separator
	Electrostatic precipitator
	Fabric filter
NO_x	*Combustion modification*
	Low excess air
	Staged combustion air

**Combined SO_2/PM emissions control system; includes a fabric filter.*

T. Hogan is with Energy and Environmental Analysis, Inc., Arlington, VA 22209.
***Larry G. Jones** is the EPA Project Officer (see below).*
The complete report, entitled "Description of the Industrial Combustion Emissions Model (Version 6.0)," (Order No. PB 88-212 287/AS; Cost: $19.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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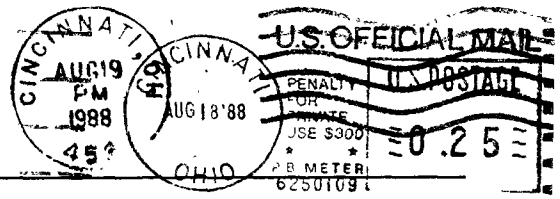

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