



Project Summary

Integrated Air Pollution Control System, Version 4.0

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The Integrated Air Pollution Control System (IAPCS) was developed for the U.S. Environmental Protection Agency's Air and Energy Engineering Research Laboratory to estimate costs and performance for emission control systems applied to coal-fired utility boilers. The model is capable of projecting a material balance, an equipment list, and capital investment and revenue requirements based upon user-specified input data. Included in the model are conventional and emerging technologies for controlling sulfur dioxide, nitrogen oxide (NO_x), and particulate emissions using pre-combustion, in-situ, and post-combustion emission controls. A variety of technology modules built into the model can be incorporated and combined. Cost and performance estimates can be analyzed in terms of integrated technologies. Conventional and emerging technologies included in the IAPCS Version 4.0 are overfire air/low NO_x burners, lime injection multistage burners, physical coal cleaning, coal switching and blending, spray humidification, electrostatic precipitator, fabric filter, lime spray drying, wet limestone flue gas desulfurization, dry sorbent injection, natural gas reburning, selective catalytic reduction, atmospheric fluidized bed combustion, pressurized fluidized bed combustion, integrated gasification combined cycle, and pulverized coal burning boiler.

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 three separate reports of the same title (see Project Report ordering information at back).

Introduction

The Integrated Air Pollution Control System (IAPCS) was developed for the U. S. EPA's Air and Energy Engineering Research Laboratory to estimate costs and performance for emission control systems applied to coal-fired utility boilers. The model generates a material balance and an equipment list from which capital investment and revenue requirements are estimated based upon user-specified input data. The model includes conventional and emerging technologies for controlling sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM) emission. The various technology modules can be combined with interaction and integrated effects for various control configurations reflected in the material balance, cost, and performance estimates.

Background

The IAPCS computer model was developed to estimate cost and performance of air emission control equipment for coal-fired utility boilers. The IAPCS model evolved over the years from a FORTRAN-coded mainframe computer model (the Shawnee Model) which was developed by the Tennessee Valley Authority. The first version (unpublished) of IAPCS (IAPCS-1), a mainframe computer model, was completed in November 1983 and was housed at U.S. EPA's National Computer Center (NCC). An IBM PC version of IAPCS



(IAPCS-2) was published in September 1986; this version incorporated a number of enhancements and upgrades to the various pollution control modules. A third version of IAPCS (IAPCS-3) was not published, but incorporated additional enhancements and added several new technology modules, including selective catalytic reduction (SCR), natural gas reburning (NGR), and gas conditioning (GC). The latest version (IAPCS-4) includes further enhancements to technology modules and a number of new technologies.

Model Description, Organization, and Capability

IAPCS-4 is a personal computer-based model for cost and performance estimates of pollution control systems for coal-fired utility boilers. In this current and latest version, a C language User Interface has been added to the original model to facilitate the input of data for the FORTRAN model.

IAPCS-4 consists of three volumes and three diskettes: Volume 1: User's Guide, Volume 2: Technical Documentation Manual, and Volume 3: Programmer's Maintenance Manual. Diskette 1 contains the Executable Files. Diskettes 2 and 3 contain the Source Code Files in FORTRAN and C language and other files required to create an Executable File.

Instructions for compiling the program to produce an Executable File from the Source Code Files are in Volume 3: Programmer's Maintenance Manual, Section 1.8, Procedures for Building the IAPCS Program.

The IAPCS-4 documentation format was selected to facilitate future maintenance and enhancement of the IAPCS model. This includes correction of software errors, correction of existing deficiencies, and enhancement of the modeling system with new capabilities.

Conventional and emerging technologies which are included in IAPCS-4 are:

- Physical coal cleaning/coal switching and blending (PCC/CS/B)
- Overfire air/low NO_x burners (OFA/LNB)
- Natural gas reburning (NGR)
- Lime injection multistage burners (LIMB)
- Advance silicate process (ADVACATE)
- Electrostatic precipitator (ESP)
- Fabric filter (FF)
- Gas conditioning (GC)
- Lime/limestone flue gas desulfurization (LLS/FGD)
- Lime spray drying/duct spray drying (LSD/DSD)

- Dry sorbent injection (DSI)
- Selective catalytic reduction (SCR)
- Atmospheric fluidized bed combustion (AFBC)
- Pressurized fluidized bed combustion (PFBC)
- Integrated gasification combined cycle (IGCC)
- Pulverized coal burning boiler (PCBB)

The program will accept any reasonable configuration of these technologies. Exceptions include:

- Spray humidification cannot be utilized with DSI or LSD.
- LSD or DSI is not to be preceded by a FF or an ESP.
- Identical control devices in series are not permitted.

Control technology interactions are shown in the material balance tabulation at the exit of each module.

Parameter files are an important feature of the IAPCS-4 program. The param-

eter file has specific default values for program operation and calculation. Based on a recent program, the user may then modify these default values for preference and site-specific needs.

System Flow Chart

Figure 1 is a System flow chart for the IAPCS program. The symbols and format are for a Yourdon Context Diagram. A single "bubble" represents an overview of the entire program, with external sources (permanent data files) and sinks (output files and reports) depicted as blocks. Data Stores (internal and temporary files) are shown.

IAPCS uses four permanent files (sources) to operate:

- 1) A User Screen Menu and Message Database used for all user screens and messages;
- 2) A Default Parameter File for TVA format runs;

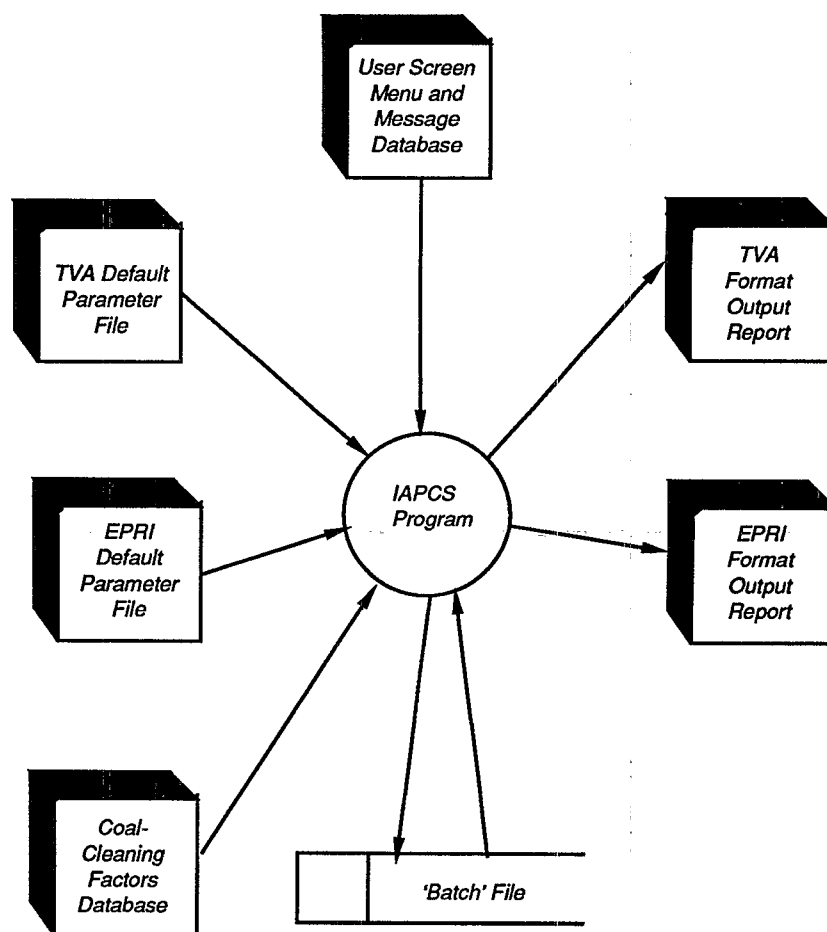


Figure 1. IAPCS system flow chart.

- 3) A Default Parameter File for EPRI format runs; and,
- 4) A Database of Coal Cleaning Factors.

The main data store is a file called the Batch File which contains the actual numeric parameters to use for each of a series of IAPCS runs. Each segment of the Batch File is derived from numeric values in the corresponding Default Parameter File.

Only one of the two Output Reports (Data Sinks) is produced for a given run: each run is specific to either the TVA or EPRI Format. Optionally, these Output Reports may be appended to previously created reports.

System Module Hierarchy Chart

Figure 2 is a system module hierarchy chart for IAPCS. For the purpose of interpreting this diagram, a module means a collection of functionally related subroutines. Figure 2 shows these functional areas further subdivided by the computer programming language used for each (C or FORTRAN).

IAPCS can be generalized into three components:

- 1) A small C language control routine;
- 2) A mixed language user-interface component (C and FORTRAN); and,
- 3) A FORTRAN cost modeling component.

Looking at the top of Figure 2, the Main Control Routine is the top-most module. Proceeding in a top-down fashion, the User-Interface is represented by the entire subtree shown at the left below the Control Routine. The Cost Modeling Component MODEL, appears as the right sub-tree below the Control Routine, and also as a sub-component of the User-Interface.

The FORTRAN Cost Modeling Component (MODEL) is invoked directly by the main Control Routine for batch mode execution, or indirectly from the User-Interface component for interactive mode execution.

IAPCS uses a set of files called Parameter Files, alternatively called Input Files. Two special Parameter Files called PARMFILE.TVA and PARMFILE.EPR contain the default values for the TVA and EPRI constants used in the costing model. These default parameter files (or any other user-specified parameter files) may be loaded into the input screen of the interactive user interface and modified. Parameter file data from the user interface may then be used to create new parameter files or may be passed directly to the cost modeling subsystem. Parameter file data from the user interface may also be stored in

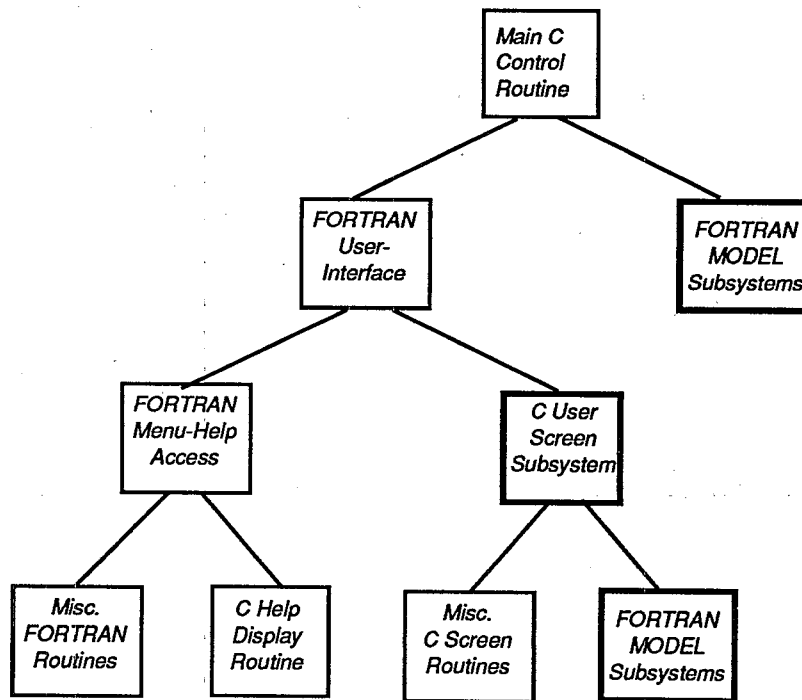


Figure 2. IAPCS system module hierarchy chart.

the form of Batch Mode Data Files for later use, as shown in Figure 1.

Model Cost Results

IAPCS-4 can present estimates for capital costs, levelized costs, and unit costs. These costs can be presented in constant or current dollars for any specified year.

To demonstrate this capability, FGD cost estimates were generated for a 500 MW unit having a capacity factor of 65% and burning Illinois No. 6 coal. The capital cost estimate was \$180/kW. The levelized annual cost was 8.0 mills/kWhr, and the unit cost was \$220/ton of SO₂ removed. Costs presented were in constant 1988 dollars.

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Norman Kaplan is the EPA Project Officer (see below).

The complete report consists of three volumes entitled "Integrated Air Pollution Control System, Version 4.0" and three diskettes:

Volume 1 is the User's Guide.

Volume 2 discusses technical documentation.

Volume 3 discusses programmer's maintenance.

Disk 1 is the executable file.

Disks 2 and 3 contain the source code.

Costs (subject to change) and PB numbers are:

PB91 133512, cost \$17.00: Volume 1.

PB91 133520, cost \$31.00: Volume 2.

PB91 133538, cost \$23.00 : Volume 3.

PB91 506469, cost \$80.00: Volumes 1 and 2 and Disk 1.

PB91 506477, cost \$130.00 Volumes 1, 2, and 3, and Disks 1, 2, and 3.

Volumes and disks of this report will be available only from:

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The EPA Project Officer can be contacted at:

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