

## Commercial Building HVAC Technology Screening Tools

by

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### Abstract

Commercial building owners and managers face a complex array of HVAC technology options. Economic analysis of the options requires consideration of technology characteristics, equipment operating strategies, and utility rates. The interaction among these factors is complicated, requiring structured analysis tools **that go well** beyond simple spreadsheets. To provide a uniform and well-tested approach, the Electric Power Research Institute (EPRI) has developed COOLAID, COOLGEN and COMTECH, which are PC analysis tools for commercial building technologies. The focus of both programs is to provide analysts and engineers with a method for understanding the economic impacts of alternative technologies on equipment costs and utility bills, and for conveying these impacts to decision-makers. These programs serve as a first-level screening tools, and provide the basis for more detailed evaluations with hour-by-hour building simulation models.

COOLAID deals explicitly with cool storage. It is being used around the country for evaluation and marketing of cool storage systems. It allows the direct comparison of a variety of cool storage equipment options and operating strategies with conventional electric cooling systems under a broad range of utility rates.

COOLGEN is a competitive assessment tool for gas cooling options. It allows evaluation of gas cooling technologies, cogeneration with heat recovery, and cogeneration with absorption cooling, and compares them with conventional cooling and heating systems.

With COMTECH it is possible to evaluate a variety of electric technologies, as well as gas-based alternatives. Included are high-efficiency chillers, heat-recovery chillers and heat pumps, heat-pump water heaters, cool storage systems, gas cooling options, and cogeneration packages with or without absorption cooling.

The purpose of this paper is to discuss the features and uses of these programs.

### Program Uses

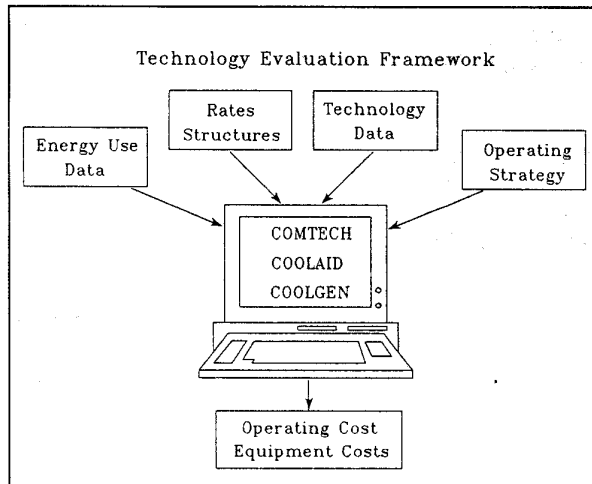
- Direct Marketing
- Training
- Market Analysis
- Rate Design

### Program Uses

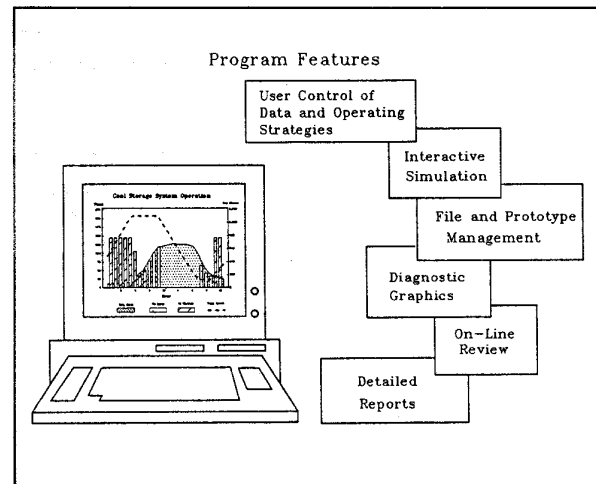
#### Program Uses

The technology screening tools are intended to serve four main purposes, as illustrated above. These are:

- **Technology Screening:** COOLAID, COOLGEN and COMTECH allow analysts and engineers to evaluate a variety of technology options for a particular site quickly and easily. These results can form the basis for more detailed hour-by-hour analysis.
- **Customer Information:** These programs can be used to develop information for specific customers, and to present analysis results to customers. Using prototype information, approximate estimates can be developed and customized quickly.
- **Market Analysis:** The screening tools can be used to analyze technology options for particular market segments, and to quantify the economics of the technologies in these segments.
- **Rate Design:** These programs can be used by utility analysts to evaluate the impact of alternative rates and incentives on customer costs.



Analysis Framework



Program Features

### Program Logic

The logic of COOLAID, COOLGEN and COMTECH is straightforward as shown above. The user provides a compact set of information required to perform simplified sizing calculations and to determine equipment and operating costs for each technology scheme. These data include descriptions of:

- Building energy services delivered for up to six end uses,
- Electric rate structures,
- Gas rate structures,
- Equipment performance and cost parameters, and
- Equipment operating strategies.

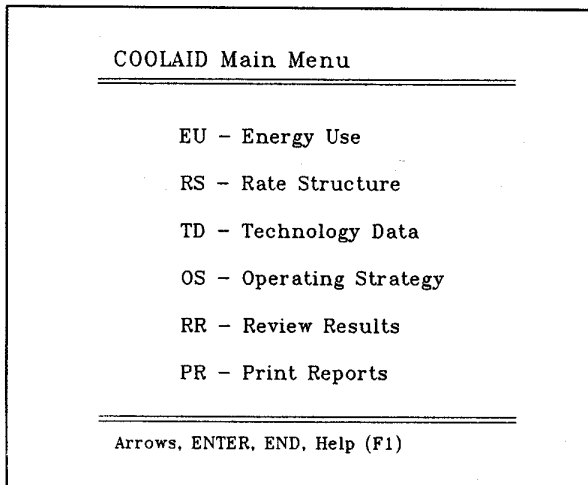
Each program combines this information and provides estimates of system costs, monthly energy bills and operating costs for each technology option.

COOLAID provides an automatic comparison of the specified cool storage option with a conventional cooling system. COOLGEN provides similar comparisons for cogen alternatives versus conventional systems. In COMTECH, a variety of equipment configurations can be evaluated individually for a single building. A compare feature gives financial comparisons of any two equipment schemes.

### Program Features

Program program features are illustrated above. All three programs take advantage of the capabilities of the PC environment. They are completely interactive and menu-driven program. They have complete file-handling abilities, allowing storage, retrieval, and editing of technology schemes. They give the user direct access to all data and parameters. They come with default energy use and technology data.

Intermediate results can be viewed both graphically and in tabular form throughout the programs. The user can preview and select from a variety of output tables. Each program is accompanied by a User's Guide that provides a discussion of technology parameters and estimated cost ranges for a variety of system types.

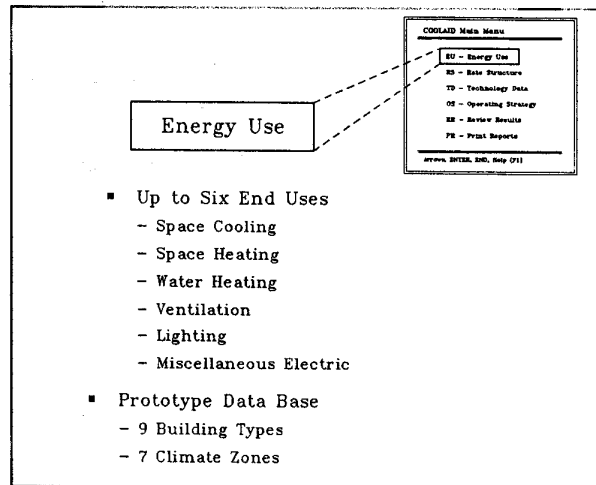


COOLAIID Main Menu

### COOLAIID Main Menu

The COOLAIID Main Menu, is shown above, and it is similar to the COOLGEN and COMTECH menus. Each Main Menu identifies the major input data and execution actions required by the program. These are as follows:

- **Energy Use:** This module allows the user to describe energy services delivered to the building.
- **Rate Structures:** This module allows the user to define a wide variety of electric and gas/fuel rate structures.
- **Technology Data:** This module contains technology parameters that describe equipment performance and installed costs.
- **Operating Strategy:** This module allows the user to size the equipment and to define the equipment operating profiles. In what follows, each module is described in greater detail.
- **Review Results and Print Reports:** In these modules, energy use, utility bills, and equipment costs for a selected scheme are calculated. The results may be viewed interactively or printed in report form.



Building Energy Use Data

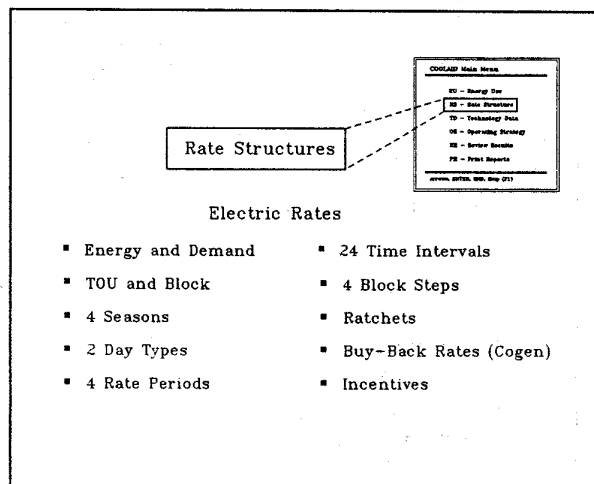
### Energy Use Data

These programs require data that describe the hourly profile of end-use services delivered to the building. For example, cooling profiles indicate the amount of heat removal required, which are expressed in tons. The amount of energy used to meet these cooling requirements depends on the cooling technology that is used, and the way it is operated.

For cooling and space heating, energy-use patterns are described using a top-down approach, beginning with annual energy amounts, and factors that spread these amounts to months, to days of the month, and to hours of the day. The result is called the 48-day format.

Profiles for the remaining end uses are described using peak intensities (energy use per square foot in the peak hour) and load shapes for the workday and the non-workday. The two load shapes are used for each month, but the peak intensity may vary by month. The result is called the modified two-day format.

This approach to describing building energy use offers an important advantage. It allows a particular set of load shapes to serve as a generic prototype. A specific building can be processed quickly and easily by changing only the annual or monthly intensities, while maintaining the hourly patterns of the generic case. A variety of data-entry features is provided, including the ability to copy profiles from month to month. A graph option allows viewing of load shapes.



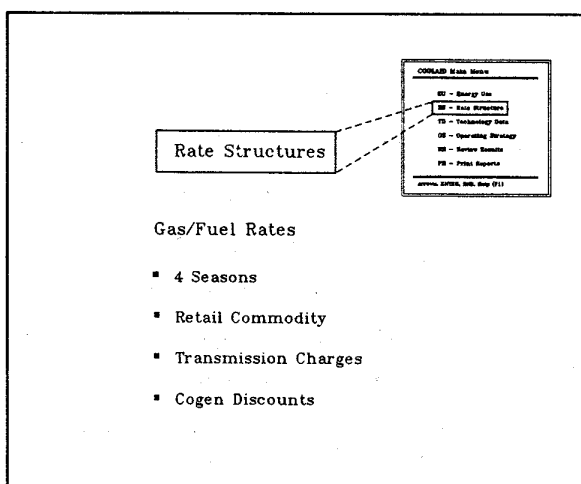
Electric Rate Structures

### Electric Rate Structure Data

As indicated above, these programs handle a large number of rate components that can be used independently or in combination with each other. This allows users to model a wide variety of rate structures, including:

- Time-of-use rates,
- Fixed block rates,
- Load-factor block rates,
- Tiered rates with dynamic block ranges, and
- Combinations of the above.

In addition, the programs have technology-specific rates and incentives. For example, there are buy-back rates for the cogen technology options in COOLGEN and COMTECH, and there are incentives for the cool storage systems in COOLAID.



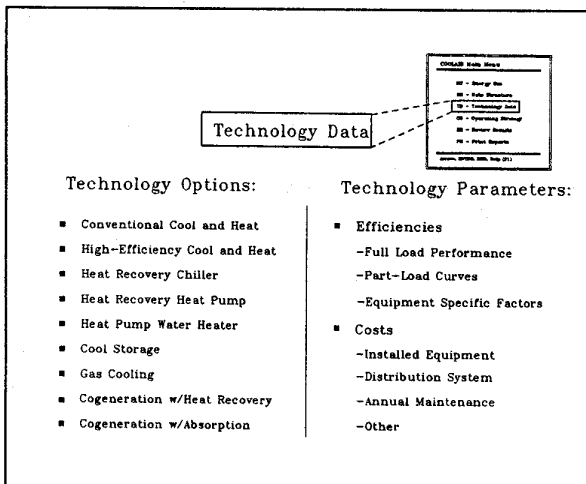
Gas/Fuel Rate Structures

### Gas/Fuel Rate Structure Data

In COMTECH and COOLGEN, which deal with gas technologies, the user specifies rates for natural gas (or other fossil fuels). These rates are described in the following terms:

- Up to four seasons,
- Volumetric charges, and
- Demand charges.

Also, the user may define discounts for cogeneration gas/fuel use.



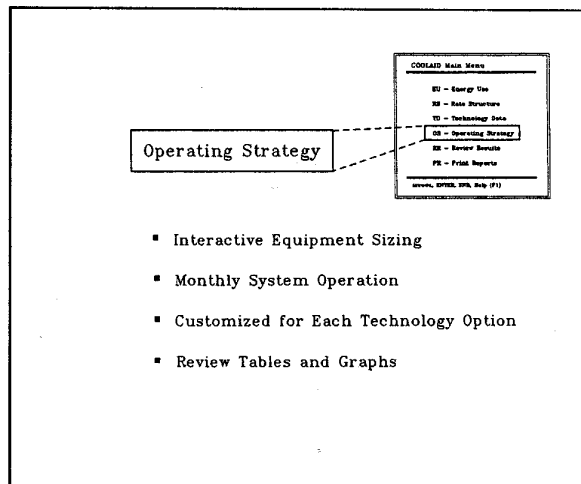
Technology Data

### Technology Data

COOLAID, COOLGEN and COMTECH allow evaluation of many types of cooling and heating systems, as shown above. The programs require equipment efficiency and cost parameters for each piece of equipment. These data include the following.

- Efficiency data consist of parameters that describe equipment performance, including full-load efficiencies and part-load curves. Additional performance factors specific to each equipment type are also defined.
- Installed cost values are entered for each piece of equipment, and may also be entered for the building distribution system and electrical system. Equipment-specific costs are also entered where appropriate.
- Annual maintenance costs can also be entered for each piece of equipment. In addition, for the cogeneration technologies in COOLGEN and COMTECH, maintenance downtimes are also specified.

The User's Guide for each program provide descriptions of various types of end-use equipment, and contain tabular data on equipment efficiency and installation cost ranges. Users may rely on these default technology data, or may input their own.



Operating Strategy

### Operating Strategy

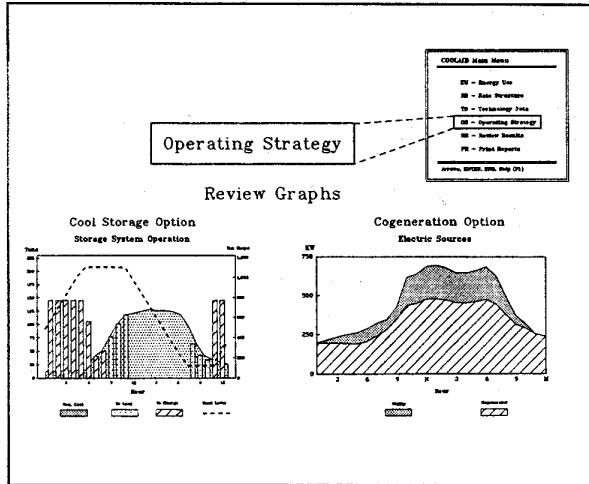
The Operating Strategy module in these programs has two main purposes:

- To size each piece of equipment in the technology package, and
- To specify a monthly operating strategy. This applies to the following technology schemes:
  - Heat recovery chillers and heat pumps,
  - Heat pump water heaters,
  - Cogeneration with heat recovery and/or absorption cooling, and
  - Cool storage.

Rather than imposing a "canned" sizing algorithm, the programs allow the user to size equipment directly. The programs provide a variety of information relevant to sizing decisions, and they provide default sizing values whenever they are appropriate.

For each technology scheme, the programs allow customized sizing and operating strategy procedures. In general, the user has complete control over equipment operation, but may use program defaults if desired. The approach is straightforward, and allows the analyst to experiment with "what-if" analysis.

The programs allow strategies to vary across months. The advantage of this is best described with the cool storage example. Monthly flexibility allows a system that is designed for partial storage in the summer to operate as a full-storage system in the winter, which increases the bill savings.

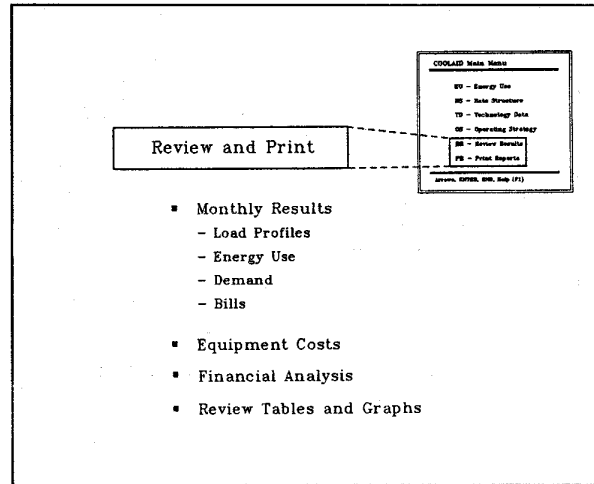


Operating Strategy -- Diagnostic Features

### Operating Strategy Features

COOLAID, COOLGEN and COMTECH provide a wide variety of tables and graphs in the Operating Strategy module. These diagnostic graphs allow the user to review the operating impacts of each technology scheme. Examples are presented above.

- **Cool Storage System Operation.** In COOLAID and COMTECH, operation of the cool storage system is illustrated. The shaded area in the background displays the cooling load. The bars in the foreground depict storage chiller operation. The dashed line represents the storage tank contents, which are measured on the right-hand axis in ton-hours.
- **Electric Sources with Cogeneration.** For the cogeneration case, COMTECH and COOLGEN illustrate the sources of electricity under a thermal load-following operating strategy. The majority of the electric load is being supplied by the cogenerator, with only the peak load supplied by the utility.



Calculate, Review and Print

### Calculate, Review and Print

In the remaining modules, the energy use, utility bills and equipment costs are calculated for a particular technology option. Execution time is about one minute, depending on the type of computer. A variety of review tables and graphs are available for visual inspection of the results.

Each program allows comparison of two technology options, and provides a financial analysis. In COOLAID, the cool storage system is compared with the conventional system. In COOLGEN, the gas technology options are compared with the baseline electric technologies. In COMTECH, the user may select and compare any two technologies.