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Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

ENERGY & ENVIRONMENT DIVISION

COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT (CIRA™)

R.C. Sonderegger, J.-Y. Garnier, and J.D. Dixon

March 1982

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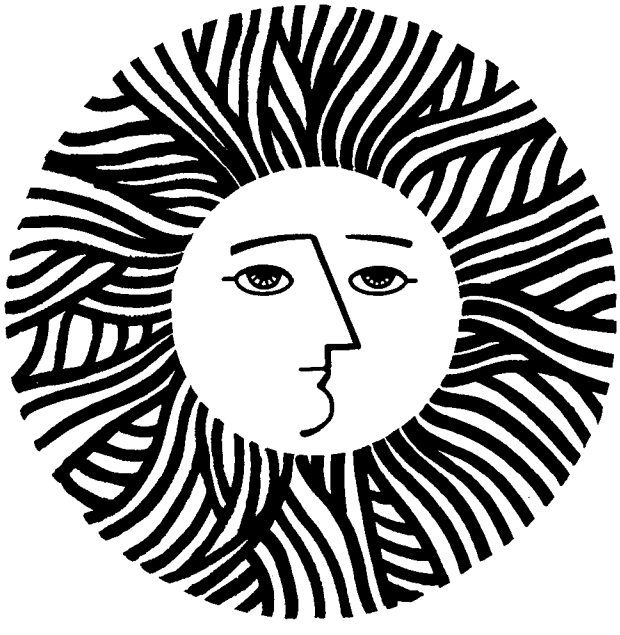

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PUB. 425
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COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT

C I R A™

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March 1982

TABLE OF CONTENTS

OVERVIEW..... 1

Microcomputer requirements for CIRA..... 6

GUIDE TO CIRA INPUTS..... 7

Sample input session..... 9

GUIDE TO CIRA OUTPUTS..... 23

Sample output sessions:

a) Design Energy Analysis..... 24

b) Retrofit Package..... 28

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OVERVIEW

What do a government official, an architect, an energy auditor, an engineer and a contractor have in common? Sooner or later, they all need to know projected energy use in a given house and sometimes they may need to maximize energy savings in an existing house within the constraints of a given budget.

Several paper-and-pencil procedures exist to do both of these tasks. Unfortunately, they always boil down to lengthy sheets of calculations. You've heard of computer programs developed to ease this task: you like their speed -- it's the inputs you could do without. Describing a building to a computer may require strict adherence to a particular format or the knowledge of a special language. Furthermore, you may lack access to a computer system that runs your favorite building energy analysis program.

Two recent trends appear particularly promising as a way out of the burden of calculating energy use in buildings: the introduction of microcomputers and the development of user-friendly programs. Microcomputers are cheap enough to be affordable by the smallest business, and many different brands are capable of running the same wide selection of programs. User-friendly programs don't expect you to tell them about your building in some rigid format or language; they ask questions in plain English and suggest possible answers -- you just point to the answer you like best.

Computerized, Instrumented, Residential Audit (CIRA)* is a user-friendly program developed for microcomputers. More precisely, CIRA is a collection of programs related to building energy analysis and designed for a wide variety of microcomputers. It couples the state-of-the-art in interactive features with the latest developments in simplified computer models of building energy analysis. For the novice, CIRA will provide exhaustive explanations of everything it needs, while for the experienced user the questions and responses are more terse.

Below you will find descriptions of how CIRA takes the headaches out of describing the house characteristics needed for energy analysis. For those interested in the more technical aspects of CIRA -- how it figures out heating and cooling energy consumptions or how it determines optimal energy-saving strategies -- we have included a section "Energy Calculations."

* The CIRA program is available from Lawrence Berkeley Laboratory. There is an order form at the back of this pamphlet.

Data entry

In developing CIRA, much effort was devoted to facilitating the tedious process of entering the appropriate building data. Prominent among the features that distinguish CIRA from other computer programs are:

Friendliness:

The user does not have to learn a language and does not have to remember any commands. CIRA does the work by asking about wall areas and types, heating system specifications, passive solar features, etc.; the user simply answers the questions displayed on a screen.

Helpfulness:

If the CIRA novice does not understand some of the questions, such as

"Terrain Class.....?",

he or she can call for help with a simple keystroke, to which the computer responds with a more detailed explanation of the question, together with examples when appropriate.

Multiple choice:

If the user understands the question, such as "Window Glazing.....?", but does not remember the possible answers, another keystroke displays a list of options in multiple choice style, in this case

S=Single Pane
D=Double Pane
T=Triple Pane

In fact, this list will appear automatically whenever more than two wrong answers are given.

Dynamic defaults:

Frequently, the user may not know the answer to technical questions, such as the R-value of a wall or the solar-gain factor of a window. What is, for example, the R-value of a 2' x 6' frame wall whose 5.5 inch cavity is insulated with 4 inches of Vermiculite and one inch of exterior insulating sheathing? CIRA provides the answer, in this case R-16.8, at the touch of another special key. We call the values provided by this keystroke dynamic defaults. Defaults, because they provide the most likely answer when the user hasn't a clue, and dynamic, because they usually depend on the user's answers to one or more previous questions. Beyond the lay user, the professional can use dynamic defaults to avoid leafing through voluminous handbooks in search of the heat-loss factor for a basement, for example.

Goof-proofing:

Often, the user may want to alter previous input, or correct mistakes, or re-use a house entered earlier, changing only details such as floor area, the city where it is located, and the window size. As soon as another simple keystroke is hit, the computer enters an editing mode, and displays the desired questions and the answers previously given on the screen, along with a request for the new answers. The computer even keeps track of things you may have forgotten in the process: if you change the city from Denver to San Francisco, for example, it will remind you that, as you leave the mile-high city, you may also want to change the altitude.

The computer accepts entries on a wide variety of house components and related features:

- Walls, windows, doors
- Roof and subfloor
- Active and passive solar features
- Heating and cooling system
- Information on how the house is oriented and shielded
- Occupant behavior related to energy use
- Prices for the various fuels used.

Some of these entries may require the use of specialized instrumentation, such as 1) a tape measure to obtain the relevant dimensions of the house, 2) a solar siting meter to measure the degree of obstruction to solar radiation by trees and adjacent buildings, 3) a combustion efficiency meter to measure furnace efficiency, 4) a blower door to pressurize the house, and 5) a few smoke sticks to find where the air leaks are. Incidentally, most of these instruments can be found in the kit of a "house doctor," who searches a house for hard-to-spot energy leaks and fixes the most conspicuous of them during his or her visit. CIRA was designed with the house doctor-approach in mind. The measurements performed by the house doctor feed directly into CIRA which translates them into practical retrofit recommendations. Thanks to dynamic defaults, however, these measurements and the attendant instruments are not indispensable -- CIRA can function as a "stand-alone" diagnostic program. After all questions about the house have been properly answered, the computer will automatically figure monthly and yearly heating and cooling energy consumptions or, on request, recommend several combinations of energy-saving measures suitable for low, medium and high budgets. Every

combination (e.g., storm windows, elimination of air leaks, basement insulation) is chosen to produce the highest energy savings for a given budget. Of course, interest and inflation rates, maintenance costs of the installed measures, and projected period of occupancy are taken into account.

Energy calculations

To calculate the energy consumed for any given house, CIRA uses heating and cooling algorithms developed at Lawrence Berkeley Laboratory, Princeton University, National Bureau of Standards, Los Alamos National Laboratory and the University of Wisconsin. A brief summary follows below.

For each month, an energy balance is calculated separately for day and night. First, a heat-transmission coefficient is calculated, to determine how much heat the house loses per month and per degree of temperature difference between indoors and outdoors. To this coefficient is added the effect of infiltration, computed on a monthly basis using a method developed at Lawrence Berkeley Laboratory. This method uses information on the leakage area of the house, the type of terrain on which it is located, and the type of shielding surrounding the house, all of which is part of the information requested by CIRA. For terrain and shielding classes, CIRA will display descriptive tables on request. Leakage area is generally measured with a so-called "blower door", a fan-like device that creates an over- or under-pressure in the house and measures the amount of air flow through the fan necessary to reach several special levels of pressure. Alternatively, the leakage area can be estimated from information on the air tightness of windows, walls, doors, and all other building components. As usual, dynamic defaults are available to provide what the user may not know.

Of course, like most other aspects of heating and cooling energy requirements, air infiltration depends on the local temperatures and wind speeds. The user, however, never need be concerned with such tedious detail: the name of the nearest city in CIRA's files is all he or she ever will have to know about local weather patterns. And, naturally, the program will prompt for it and display the available options.

Solar gains are computed by taking into account weather-averaged solar radiation in the city chosen by the user, the shading effects of trees, nearby buildings and overhangs, and the optical characteristics of windows and walls. The shading effects of overhangs and the reflection of glazed surfaces are modeled by using correlation methods developed at Los Alamos National Laboratory. The solar gains, together with other internal gains and radiation losses to the sky, are used to compute an effective outdoor temperature, which is usually higher than the monthly average temperature. The monthly values of effective outdoor temperature, indoor thermostat setting, and heat-transmission coefficient are used to compute monthly heating and cooling loads for day and night. These loads are corrected if night and day thermostat settings are different. Seasonal heating and cooling efficiencies are figured for each month based on 1) heating and cooling loads, 2) specifications of the heating and cooling equipment, 3) part-load efficiencies, and 4) ambient-dependent output capacities. Finally, heating and cooling loads and efficiencies are

combined to arrive at monthly energy consumptions for heating and cooling.

The heating and cooling consumptions calculated by this load module were compared with those of the DOE-2.1 program for seven different cities and two thermostat schedules. In general, discrepancies between the two programs were found to be on the order of ±10%.

Viewing the results

After the minute or so that it takes to perform the heating and cooling calculations, CIRA displays monthly values and yearly totals (or means, where appropriate) of several quantities, such as:

- Daily and nightly heating and cooling energy consumption
- Daily and nightly heating and cooling loads
- Air infiltration
- Solar gains
- Dollar expenditures for heating and cooling
- Average and effective daily and nightly outdoor temperatures

These results can be displayed either in tabular form or graphically, depending on the user's wishes. By pressing the appropriate key from a menu displayed at the top of the screen, the user may also plot any arithmetic combinations of these figures (e.g., the sum of daily and nightly heating and cooling expenditures). For users with special needs, CIRA can be easily modified to display other types of output as, for example, infra-red radiation loss to the sky, or the percent change in energy consumption for every percent change in infiltration, in solar gains, or in similar parameters.

Energy-saving retrofits

For energy auditors and energy policy makers, the technical details about yearly energy consumption may be of less interest than determining the most cost-effective strategy to save energy. That is, for a given budget, what is the most energy-saving combination of retrofits or, what is the highest retrofit budget for which the dollar savings still exceed the expenditures (including maintenance costs)? CIRA is able to answer both of these questions in a mostly automated process consisting of two stages: the selection of retrofits, and their economic optimization.

Retrofit selection

The retrofit selection occurs as follows: First, CIRA scans an extensive list on a disk containing several hundred retrofit options and their respective costs per unit, as well as their figures of thermal merit (typically, added thermal resistance, decreased solar gain, decreased

leakage area, improved efficiency). CIRA will consider only those items appropriate to the structure in question; that is, cellulose insulation for cavity walls, not for solid masonry walls, and sliding storms for double-hung windows, not for casement windows. This reduced selection of retrofits is briefly shown on the screen for each house component (walls, windows, etc.).

Economic optimization

At the end of this retrofit selection process, the computer determines the best combination of retrofits for the whole house within the constraint of a budget. This process involves multiple yearly energy calculations, and takes about ten to fifteen minutes, depending on the size and complexity of the house, the climate and the number of retrofits involved. Dollar and energy savings in several different economic formats are shown for each retrofit based on the expected period of occupancy for the house under consideration.

Micro-computer Requirements to Run CIRA

Currently, CIRA can be run on any microcomputer with the following specifications:

- **Z80, 8080 or 8085 family of microprocessors.**
- **CP/M operating system (version 2.0 or greater).**
- **64 k of random access memory.**
- **Two 8" single density disk drives or equivalent (2x240k or 450k bytes total).**
- **80 column video terminal (cursor addressing is necessary).**
- **132 column printer for retrofit output.**

CP/M is a trademark of Digital Research Inc., P.O.Box 579, Pacific Grove, CA 93950.

Modifications may be performed by the user to accommodate most terminals. At the time of this writing (April 1982) a complete system with these specifications, including a terminal or a keyboard and monitor, can be purchased for around $4,000.

GUIDE TO CIRA INPUTS

CIRA does not use an artificial, buildings language. Information is input in response to questions, grouped by component. The components and the key letters used to identify them are:

G = General	E = Economic	W = Windows
D = Doors	O = Walls	R = Roof/Ceiling
S = Subfloor	P = Passive-Solar	N = Greenhouse
X = Active-Solar	H = HVAC-system	I = Infiltration
L = Landscape	A = Appliances	C = Continue

The user chooses a component by typing in one of the above keyletters when the computer asks:

"WHAT NEXT or Continue?"

The questions for the chosen component then appear on the screen; after one question is answered, the next question appears until the complete list, with answers, is on the screen. Take, for example, the questions for windows; the complete list is:

A) Name of the following windows.....?
B) Which window ORIENTATION.....?
C) Window TYPE.....?
D) GLAZING.....?
E) DRAPES & SHUTTERS.....?
F) Are window covers USED at DAYTIME.....?
G) U-value (Btu/sqft/F).....?
H) Average sash FIT.....?
I) Specific LEAKAGE AREA (sqcm/sqft).....?
J) Summer SOLAR GAIN factor (%).....?
K) Winter SOLAR GAIN factor (%).....?
L) Window AREA (sqft).....?

For every question there are a list of possible answers, a short explanation, and a default value (a value calculated on the base of previous answers, or a best estimate). Each of these can be called by a keystroke when the question appears. The list is called by <control-L> for List, the explanation by <control-H> for Help, and the default value by <control-D> for Default. A reverse polish notation (RPN) calculator can be used for any numerical question, as shown in the sample input to find window area. The operations that the calculator can do are listed on page 27 in the "Guide to CIRA Outputs" section.

If the user is not technically sophisticated, the computer can be set to automatically use either a default or a pre-set value, and not display the question. For example, the U-value could be automatically calculated using the answers for glazing, covers, and use. If desired, whole sections can be handled in this way; the data for the Economic section, for example, could be pre-set, and the questions on energy prices, discount rates etc. would never appear. Such questions are referred to as "ghost questions".

The answer to a question may be changed at any time. The first chance is immediately after the answer has been entered, when the computer asks for a yes/no confirmation. The second chance is in the middle of entering a component, when the user may interrupt the questions to edit the previous answers by typing <control-E> for Edit. Finally, once a complete component has been entered, and the computer asks "Which menu ITEM?", the user can choose the code letter next to a question and re-answer that question. This last method can be used at any point. The user is led through these steps by instructions which appear on the screen.

Once all the house components have been entered, the program can continue to the energy calculations. If the user attempts to continue with the inputs incomplete, a warning message appears giving the names of the missing components. The user decidess whether to proceed to the design energy calculations or the retrofit optimization calculations. As it calculates, it displays short messages to indicate the stage it has reached, e.g. "Entering ENERGY CALCULATION program", or it shows the savings from each retrofit it is considering. The complete flow diagram of the program set is shown in the "Program Organization and Glossary" section. The design energy calculation takes one or two minutes to complete; the retrofit optimization takes about ten. The exact times vary from house to house and from computer to computer.

Examples of all of these features of the CIRA input structure are shown in the sample input session which follows. In an actual input session, a video terminal would be used, and the input format has been designed for such a terminal. The format includes frequent redrawing of the screen to simplify the input. This is convenient and helpful on a screen, but appears rather clumsy when printed.

Note: The maximum permitted number of component entries is 30. If there are more than that, some will have to be consolidated. For example, if there are a lot of small windows the user will have to combine some of them into one large window.

A SAMPLE INPUT SESSION WITH CIRA

```
**********************************************************
****                                                  ****
**** COMPUTERIZED, INSTRUMENTED RESIDENTIAL AUDIT     ****
****                                                  ****
****           Version 1.0 - March 1982               ****
****                                                  ****
****                (c) 1982 LBL                      ****
****                                                  ****
****        Energy Performance of  Buildings          ****
****          Lawrence Berkeley Laboratory            ****
****            University of California              ****
****          Berkeley,  California  94720            ****
****                                                  ****
**********************************************************
```

Note: In an actual input session a video terminal would be used, and the input format has been designed for such a terminal. The format includes frequent redrawing of the screen to simplify the input. This is convenient and helpful on a screen, but appears rather clumsy when printed.

"L"ong, "S"hort or "N"o INSTRUCTIONS....? L Long instructio--> OK? YES

The user decides to read the long instructions. He/she types L, and confirms with a carriage return.

WELCOME to the CIRA audit...

In this audit you will be asked a number of questions about your house. Many questions are multiple choice. For them, all you have to do is enter the appropriate code letter. For example, the question might be:

Window GLAZING.....?

If you type "D", the computer responds

Window GLAZING.....? D Double Pane --> OK?

and waits for you to confirm your answer with a "Y" or reject it with an "N". (A carriage return at this point also means "Yes"). Other times, you will be asked for a quantity, such as:

Insulation thickness (inches).....?

In this case, after entering the number of inches, you have to press the "RETURN" key, to indicate your entry is complete. (The computer will

HIT <ANY KEY> TO CONTINUE

The screen is full of instructions and the computer waits for the user to ask to continue.

answer and ask you to confirm or reject it.

Insulation thickness (inches).....? 3 3 inches --> OK?

HELP

If you don't UNDERSTAND a question, ask for HELP by holding down the CTRL while pressing the H key at the same time (just like SHIFT and H). A short explanation will appear.

LIST

If you understand the question, but don't REMEMBER the possible answers, press CTRL and L at the same time for a LIST of possible answers.

DEFAULT

If you do not KNOW the answer to a question, e.g. the U-value of a single pane window, press CTRL and D at the same time. The computer will give the most likely answer, based on the information you have already given. In other words, it will answer for you by DEFAULT, since you don't know the answer.

HIT <ANY KEY> TO CONTINUE

End of the second screenful of instructions.

There are two main levels of questions. First comes the "WHAT NEXT?" question, that you will be asked as soon as this is over. This wants to know which section of the house you are ready to enter, e.g. WALLS, DOORS, or INFILTRATION. Then come more specific questions about each item. If you get frustrated answering questions about, say, WALLS, and want to quit and answer questions about some other item, press CTRL and Q (Q for quit). This will land you up at the WHAT NEXT? level again.

MISTAKES

If you make a mistake, there are a number of ways to correct it. First, when the computer repeats back your wrong answer, press N (for NO!). The computer will ask you the question again. Second, if you change your mind in the middle of any section, you can go back and change any answer by pressing CTRL and E (E for edit). Third, at any time you can go back to a section and re-answer any question, by asking for that "Menu item" again.

Suppose you want to change the glazing of the Bedroom Windows. To start, you ask for the component, WINDOWS, [by typing

HIT <ANY KEY> TO CONTINUE

End of the third screenful of instructions

the code letter W for windows] then you ask for the NAME [by typing the menu number next to the Bedroom Windows] then you ask for the menu item you want to correct [by typing the number next to the question about glazing]. If you make any changes, remember to SAVE the new answers, which erase the old ones.

If you want to eliminate a component completely, do exactly the same thing as for Bedroom Windows, but when the second menu comes on the screen, choose the number next to the DELETE question.

Finally, if a question is asked that you have already answered, and your answer is the same as last time, try pressing the "RETURN" key. Most of the time, your previous answer will have been retained.

HIT <ANY KEY> TO CONTINUE

A SUMMARY OF WAYS TO GET HELP

<ctrl H>.....Gives HELPful information
<ctrl L>.....LISTs all possible answers.
<ctrl D>.....Gives DEFAULT value for the answer.
<ctrl Q>.....QUITS, and lands you at WHAT NEXT?
<ctrl E>.....Lets you EDIT your answers to any question.
<RETURN>.....(Carriage return key) Repeats your last answer.
?.....(Question mark) Reprints this summary table.

Only this table is printed if you ask for the short instructions

HIT <ANY KEY> TO CONTINUE

End of the long instructions

NO current DISK DATA for this house.

There is no pre-existing data on this house. The user asks for a list of components by pressing <ctrl-L>. The computer confirms this by printing List

WHAT NEXT or Continue.....? List:

G = General
E = Economic
W = Windows
D = Doors
O = Walls
R = Roof/Ceiling
S = Subfloor
P = Passive-Solar
N = Greenhouse
X = Active-Solar
H = HVAC-system
I = Infiltration
L = Landscape
A = Appliances
C = Continue

WHAT NEXT or Continue.....? W Windows --> OK? YES

The user decides to start by entering data on the house windows.

NO previous WINDOWS data

NAME of the following windows.....? Front Front --> OK? YES

The user presses S for south

Which window ORIENTATION.....? S South --> OK? YES

The user asks for a list of possible window types.

Window TYPE.....? List:

D = Double hung
H = Horizontal Sliding
C = Casement
T = Tilting
J = Jalousie
F = Fixed
G = Greenhouse
S = Skylight
O = Dome

Window TYPE.....? C Casement --> OK? YES
GLAZING.....? S Single pane --> OK? YES
DRAPES & SHUTTERS.....? N None --> OK? YES
U-value (Btuh/sqft/F).....? Default: 1.1 Btuh/sqft/--> OK? YES

By pressing <ctrl-D> the user gets the default value.

Average Sash FIT.....? Help:

The user presses <ctrl-H> to ask for help about leakage area.

The average SASH FIT is how tightly the window sash fits in its frame. Do not confuse this sash fit with the size of cracks, if any, between the window frame and the wall! The options are:

Loose	if the sash rattles in the frame and/or if you can see light through or around the sash;
Tight	if outdoor noise decreases substantially when you close the window, and if it "feels" snug;
Average	for cases in between.

Average Sash FIT.....? List:

L = Loose
A = Average
T = Tight

Average sash FIT.....? A Average --> OK? YES

Specific LEAKAGE AREA (sqcm/sqft).....? Default: .19 sqcm/sqft --> OK? YES

The default is calculated for average sash fit.

Summer SOLAR GAIN factor (%).....? Help:

The SOLAR GAIN factor is the percentage of solar radiation which would get into the room if all the sunlight struck the glass at right angles. The default values are based on your previous answers about GLAZING, window COVERS and window cover USAGE. This factor will change from summer to winter if you use the window covers differently in the different seasons.

The default value you get by pressing <ctrl-D> is based on your answers to previous questions about GLAZING, COVERS, and USAGE.

Summer SOLAR GAIN factor (%).....? Default: 87 % --> OK? YES
Winter SOLAR GAIN factor (%).....? Default: 87 % --> OK? YES
Window AREA (sqft).....? 4!16* 64 sqft --> OK? YES

The user enters the window dimensions using an "RPN" calculator: 4 "enter", 16 "times". The computer responds with the result, 64.

Overhang PROTRUSION (inches).....? Help:

An OVERHANG is any overhang above a window or solar wall, e.g. awnings, horizontal shades, balconies or the roof itself.

The OVERHANG HEIGHT is measured from the top of the sash to the height of the outer tip of the overhang.

The OVERHANG PROTRUSION is measured horizontally out from the plane of the window.

The OVERHANG PROTRUSION, the HEIGHT of the overhang above the window, and the AZIMUTH, all determine the shading effect of an overhang.

Overhang PROTRUSION (inches).....? 12 12 inches --> OK? YES
HEIGHT above top of window (inches).....? 12 12 inches --> OK? NO

The user slips, and enters 12 instead of 24, and corrects it immediately.

HEIGHT above top of window (inches).....? 24 24 inches --> OK? YES
Average window HEIGHT (feet).....? Edit...

The user notices that he/she should have entered 15 for the protrusion, and decides to edit the answer. The computer displays the present answers

```
 Current answers for WINDOWS named Front :

   A) NAME of the following windows.....? 'Front'
   B) Which window ORIENTATION..........? 'South'
   C) Window TYPE.......................? 'Casement'
   D) GLAZING...........................? 'Single pane'
   E) DRAPES & SHUTTERS.................? 'None'
   F) U-value (Btuh/sqft/F).............? ' 1.1' Btuh/sqft/F
   G) Average sash FIT..................? 'Average'
   H) Specific LEAKAGE AREA (sqcm/sqft).....? ' .19' sqcm/sqft
   I) Summer SOLAR GAIN factor (%)..........? ' 87' %
   J) Winter SOLAR GAIN factor (%)..........? ' 87' %
   K) Window AREA (sqft)....................? '64' sqft
   L) Overhang PROTRUSION (inches)..........? '12' inches
   M) HEIGHT above top of window (inches).....? '24' inches
   Y) < DELETE this Component >...
   Z) < RESUME questioning >...

Which menu ITEM(S).....................? L          L              --> OK? YES
```

The code letter for protrusion in the "menu" is L.

```
Overhang PROTRUSION (inches)...........? 15        15 inches      --> OK? YES
```

This is the only answer the user wants to change.

```
 Current answers for WINDOWS named Front :

   A) NAME of the following windows.....? 'Front'
   C) Window TYPE.......................? 'Casement'
   D) GLAZING...........................? 'Single pane'
   E) DRAPES & SHUTTERS.................? 'None'
   F) U-value (Btuh/sqft/F).............? ' 1.1' Btuh/sqft/F
   G) Average sash FIT..................? 'Average'
   H) Specific LEAKAGE AREA (sqcm/sqft).....? ' .19' sqcm/sqft
   I) Summer SOLAR GAIN factor (%)..........? ' 87' %
   J) Winter SOLAR GAIN factor (%)..........? ' 87' %
   K) Window AREA (sqft)....................? '64' sqft
   L) Overhang PROTRUSION (inches)..........? '15' inches
   M) HEIGHT above top of window (inches).....? '24' inches
   Y) < DELETE this Component >...
   Z) < RESUME questioning >...

Which menu ITEM(S).....................? Z          Resume/Complete--> OK? YES
```

The user decides that all the other answers are OK, and resumes questioning.

```
Average window HEIGHT (feet)...........? 4         4 feet         --> OK? YES
```

That is the last question.

```
 Current answers for WINDOWS named Front :

   A) NAME of the following windows.....? 'Front'
   B) Which window ORIENTATION..........? 'South'
   C) Window TYPE.......................? 'Casement'
   D) GLAZING...........................? 'Single pane'
   E) DRAPES & SHUTTERS.................? 'None'
   F) U-value (Btuh/sqft/F).............? ' 1.1' Btuh/sqft/F
   G) Average sash FIT..................? 'Average'
   H) Specific LEAKAGE AREA (sqcm/sqft).....? ' .19' sqcm/sqft
   I) Summer SOLAR GAIN factor (%)..........? ' 87' %
   J) Winter SOLAR GAIN factor (%)..........? ' 87' %
   K) Window AREA (sqft)....................? '64' sqft
   L) Overhang PROTRUSION (inches)..........? '15' inches
   M) HEIGHT above top of window (inches).....? '24' inches
   N) Average window HEIGHT (feet)..........? '4' feet
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

Which menu ITEM(S).....................? Z        Resume/Complete--> OK? YES
```

The answers are now complete and the user decides to save them. If not saved they are simply deleted.

```
SAVE this information..................? Y        Yes - save this--> OK? YES

  Current WINDOWS kinds are:

              1) 'Front'
              2) New WINDOWS...
         <ctrl Q> To quit WINDOWS...

Which menu ITEM (item no.).............?  QUIT !
```

At this point, all the other house components should be entered.

****

All the other components are now being entered

in a similar fashion to "WINDOWS"

****

```
 Current HOUSE data:

          GENERAL  ( 6435 Hazel )      ECONOMIC  ( MoneyStuff )
          WINDOWS  ( Kitchen)          WINDOWS  ( East side )
          WINDOWS  ( Back yard )       WINDOWS  ( West side )
            DOORS  ( Front )             DOORS  ( Back )
            WALLS  ( Front )             WALLS  ( Garage )
            WALLS  ( East side )         WALLS  ( Back )
            WALLS  ( West side )       ROOF/CEI  ( Above )
         SUBFLOOR  ( Below )           HVAC-SYS  ( Furnace )
         INFILTRA  ( Leaks )           LANDSCAP  ( Area )
         APPLIANC  ( Jim&Marilyn )     ACTIVE-S  ( Water )

WHAT NEXT or Continue.....................? O          Walls          --> OK? YES
```

The user decides he/she has made a mistake in WALLS and and asks to see them again, by typing the code letter o

```
  Current WALLS kinds are:

              1) 'Front'
              2) 'Garage'
              3) 'East side'
              4) 'Back'
              5) 'West side'
              6) New WALLS...
        <ctrl Q> To quit WALLS...

Which menu ITEM (item no.).............? 1          1 item no.      --> OK? YES
```

The mistake was thought to be in the front walls.

```
 Current answers for WALLS named Front :

   A) NAME for the following walls.............? 'Front'
   B) Which wall ORIENTATION...................? 'South walls'
   C) Wall TYPE................................? 'Two by Four Frame'
   D) Wall INSULATION..........................? 'None'
   E) INSULATABLE wall THICKNESS (inches)......? '3.5' inches
   F) Exterior INSULATING SHEATHING............? 'None'
   G) Wall R-VALUE (F-sqft/Btuh)...............? '4.64001' F-sqft/Btuh
   H) Wall AREA wo/ windows & doors (sqft).....? '103' sqft
   I) No. of WINDOWS (No.).....................? '2' No.
   J) No. of VENTS in wall (No.)...............? '0' No.
   K) No. of other PENETRATIONS (No.)..........? '2' No.
   L) Specific LEAKAGE AREA (sqcm/sqft).......? '.234466' sqcm/sqft
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

Which menu ITEM(S).....................? D          D               --> OK? YES
```

The user forgot the insulation in the walls, i.e. item D.

```
Wall INSULATION.....? List:

        N = None
        F = Fiberglass batts
        L = Fiberglass loose
        B = Fiberglass boards
        C = Cellulose fill
        U = UF-foam
        P = Polyurethane boards
        S = Polystyrene boards
        V = Vermiculite fill

Wall INSULATION.....? F          Fiberglass batt--> OK? YES

 Current answers for WALLS named Front :

   A) NAME for the following walls.....? 'Front'
   B) Which wall ORIENTATION.....? 'South walls'
   C) Wall TYPE.....? 'Two by Four Frame'
   D) Wall INSULATION.....? 'Fiberglass batts'
 * E) Insulation THICKNESS (inches).....? ' ' inches
 * F) INSULATABLE wall THICKNESS (inches).....? '3.5' inches
   G) Exterior INSULATING SHEATHING.....? 'None'
 * H) Wall R-VALUE (F-sqft/Btuh).....? '4.64001' F-sqft/Btuh
   I) Wall AREA wo/ windows & doors (sqft)....? '103' sqft
   J) No. of WINDOWS (No.).....? '2' No.
   K) No. of VENTS in wall (No.).....? '0' No.
   L) No. of other PENETRATIONS (No.).....? '2' No.
   M) Specific LEAKAGE AREA (sqcm/sqft).....? '.234466' sqcm/sqft
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

 * Has DEFAULT value referenced to ITEM 'D' above.

Which menu ITEM(S).....? EFH        EFH              --> OK? YES
```

The computer reminds the user that since there is now some insulation in the walls the defaults will have changed. The user reanswers those questions affected, EFH.

```
Insulation THICKNESS (inches).....? Default:    3.5 inches     --> OK? YES
INSULATABLE wall THICKNESS (inches).....? Default:    0 inches     --> OK? YES
Wall R-VALUE (F-sqft/Btuh).....? Default:    14.1242 F-sqft--> OK? YES
```

```
 Current answers for WALLS named Front :

   A) NAME for the following walls.....? 'Front'
   B) Which wall ORIENTATION.....? 'South walls'
   C) Wall TYPE.....? 'Two by Four Frame'
   D) Wall INSULATION.....? 'Fiberglass batts'
   E) Insulation THICKNESS (inches).....? ' 3.5' inches
   F) INSULATABLE wall THICKNESS (inches).....? ' 0' inches
   G) Exterior INSULATING SHEATHING.....? 'None'
   H) Wall R-VALUE (F-sqft/Btuh).....? ' 14.1242' F-sqft/Btuh
   I) Wall AREA wo/ windows & doors (sqft)....? '103' sqft
   J) No. of WINDOWS (No.).....? '2' No.
   K) No. of VENTS in wall (No.).....? '0' No.
   L) No. of other PENETRATIONS (No.).....? '2' No.
   M) Specific LEAKAGE AREA (sqcm/sqft).....? '.234466' sqcm/sqft
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

Which menu ITEM(S).....? Z          Resume/Complete--> OK? YES
```

Having entered those changes the user is finished.

```
SAVE this information.....? Y          Yes- save this---> OK? YES

  Current WALLS kinds are:

            1) 'Front'
            2) 'Garage'
            3) 'East side'
            4) 'Back'
            5) 'West side'
            6) New WALLS...
       <ctrl Q> To quit WALLS...

Which menu ITEM (item no.).....? QUIT !

 Current HOUSE data:

          GENERAL  ( 6435 Hazel )      ECONOMIC  ( MoneyStuff )
          WINDOWS  ( Front )            WINDOWS  ( East side )
          WINDOWS  ( Back yard )        WINDOWS  ( West side )
            DOORS  ( Front )              DOORS  ( Back )
            WALLS  ( Front )              WALLS  ( Garage )
            WALLS  ( East side )          WALLS  ( Back )
            WALLS  ( West side )       ROOF/CEI  ( Above )
         SUBFLOOR  ( Below )           HVAC-SYS  ( Furnace )
         INFILTRA  ( Leaks )           LANDSCAP  ( Area )
         APPLIANC  ( Jim&Marilyn )     ACTIVE-S  ( Water )

WHAT NEXT or Continue.....? C          Continue       --> OK? YES
```

The user decides to continue to the calculations.

Other house components missing:

PASSIVE-SOLAR
GREENHOUSE

The computer reminds the user that a couple of possible components are missing.

ENTER, CALCULATE, RETROFIT or QUIT.....? C

Calculate energ--> OK? YES

The user decides to continue to the energy calculations. The computer shows what it is doing as it proceeds.

Loading DATA COMPRESSION program

CIRA data compression 1.0

--READING DATA--
--COMPRESSING--
--WRITING--

Entering ENERGY CALCULATION program

CIRA energy calculations 1.0

--CALCULATING--
--WRITING--

Entering PLOTTING program

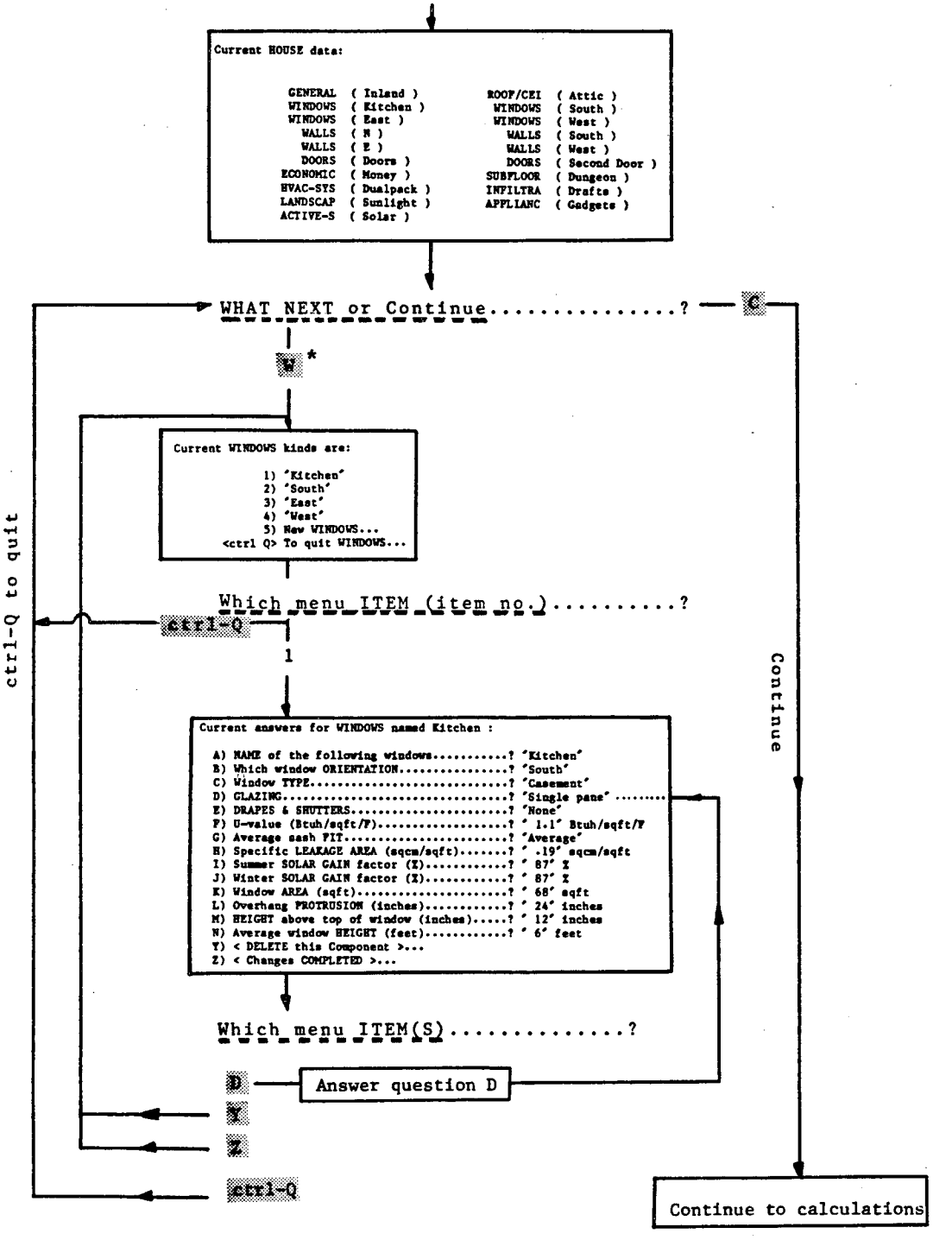
CIRA plotting program 1.0

--READING DATA--

****AT THIS POINT THE COMPUTER PRINTS OUT THE RESULTS****

Details of the output are given in the "Output Guide" section.

C.I.R.A.



User inputs * Code letter. For a complete list, press ctrl-L

GUIDE TO CIRA OUTPUTS

CIRA produces two distinct types of output. The first is a design energy analysis of the building, i.e. data on month by month heating and cooling loads, energy use, infiltration rates and so on. This data is presented in both tabular and graphic forms. The second type of output is a retrofit package. This is the best set of retrofits for the building under consideration, given the investment limit, interest rate etc. that the user has chosen.

Design Energy Analysis

The output from the design energy analysis is tailored to the needs of the more technical user. A typical set of output data would be month by month values for the following parameters:

Daytime load (Mbtu)	Nighttime load (MBtu)
Daytime energy (MBtu)	Nighttime energy (MBtu)
Sky radiation loss (MBtu)	Free Heat (MBtu)
Infiltration (cfm)	Solar Savings Fraction (%)
Average temperature, day (F)	Average temperature, night (F)
Overall gas use (therms)	Overall gas use ($)
Overall electric use (kWh)	Overall electric use ($)
Solar gain (MBtu)	Space conditioning cost ($)

where M means "mega", that is 10^6, and k means "kilo" that is 10^3.

The output may either viewed in tabular form, or plots of either one or two parameters may be made. Printouts can be made of both plots and tables. A calculator adds flexibility; arithmetic calculations may be made on the data, and the results placed either in a table or displayed as a plot. For example, cooling loads, which are presented as negative heating loads, may be extracted from the heating loads and plotted on the same graph as infiltration rates. A separate file stores related data on the house, including the city in which it is located, its altitude and latitude, and its UA-value.

The sample output session below illustrates some of the capabilities of this interactive output program.

A SAMPLE OUTPUT SESSION WITH THE CIRA DESIGN ENERGY PROGRAM

ENTER COMMAND
Command/Code choices are as follows:

'R' - REVIEW/TRANSFER data	'C' - CALCULATE between columns
'D/T' - DISPLAY related data	'L/F' - LIST at printer/file
'P' - PLOT 1 or 2 columns	'Q' - TERMINATE program

	a Dload	b Nload	c D egy	d N egy	e Infil	f Sgain	g Rloss	h Spce$	
Jan:	15.1	12.3	26.9	22.0	391	0.96	1.4	272.8	:Jan
Feb:	9.2	7.3	16.5	13.0	351	1.34	1.2	164.7	:Feb
Mar:	7.2	6.2	12.9	11.1	359	2.32	1.4	133.9	:Mar
Apr:	1.9	1.3	3.3	2.4	294	2.91	1.2	32.0	:Apr
May:	-1.9	-0.0	-1.2	-0.0	270	3.70	1.2	24.9	:May
Jun:	-4.9	-0.8	-3.1	-0.5	251	3.97	1.0	73.9	:Jun
Jul:	-6.0	-1.2	-3.9	-0.8	229	3.73	1.1	95.1	:Jul
Aug:	-4.0	-0.7	-2.6	-0.4	232	3.17	1.1	61.0	:Aug
Sep:	-1.8	-0.2	-1.1	-0.1	232	1.97	1.0	26.4	:Sep
Oct:	3.5	2.4	6.2	4.3	295	1.60	1.3	58.3	:Oct
Nov:	6.4	4.4	11.4	7.8	324	0.85	1.2	107.2	:Nov
Dec:	11.2	8.2	20.0	14.6	384	0.68	1.4	193.2	:Dec
yr(sum):	35.8	39.2	85.4	73.3	3612	27.20	14.5	1243.4	
yr(mean):	3.0	3.3	7.1	6.1	301	2.27	1.2	103.6	

The above is the table which is the first output of the program. The options available to the user are:

a) to review or transfer data, that is, to look at any of the other output parameters which are not displayed here;

b) to display related data, such as location, UA-value and solar apertures;

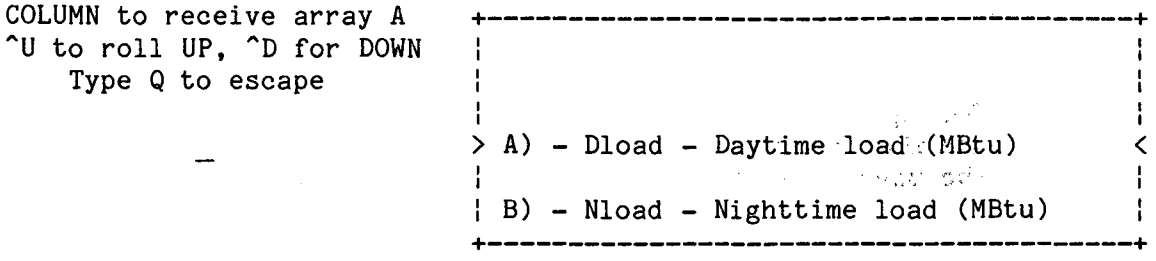
c) to plot either one or two columns (either from this data set or from any of the other parameters; once they have been transfered to the screen)

d) to calculate using this data set, e.g. extracting the cooling load from the total space heating loads;

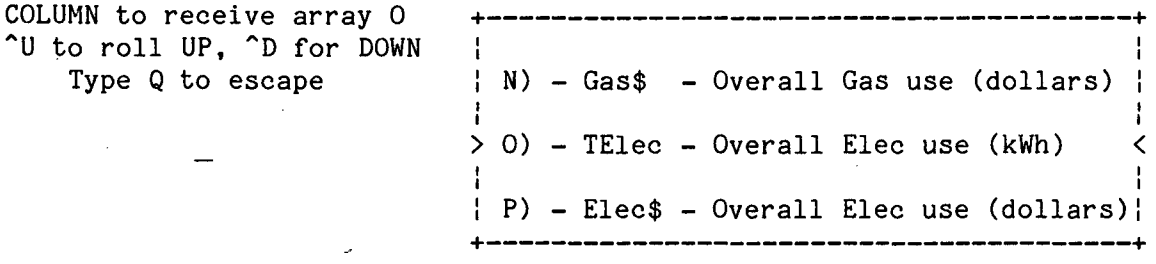
e) to send the information displayed on the screen either to a line printer (L) or to save it temporarily in a file (F) with other screenfuls of data and only print the whole file when it has been edited to suit the user's requirements;

or f) to terminate the program.

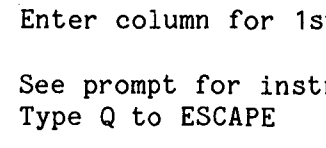
If the 'R' option is called, by pressing "R", the table remains on the screen but the command/code choices are replaced by the following:



The box on the right should be imagined as a roller which contains the names of all available parameters. Pressing <ctrl-U> moves the roller up (pressing <ctrl-D> moves it down), and the Nighttime load advances to the center position. The item which is in the central position can be transferred to any of the columns in the table by typing the letter that is above that column. For example, imagine the user wants to display and plot overall electricity use. By pressing <ctrl-U>, the roller is advanced to show:



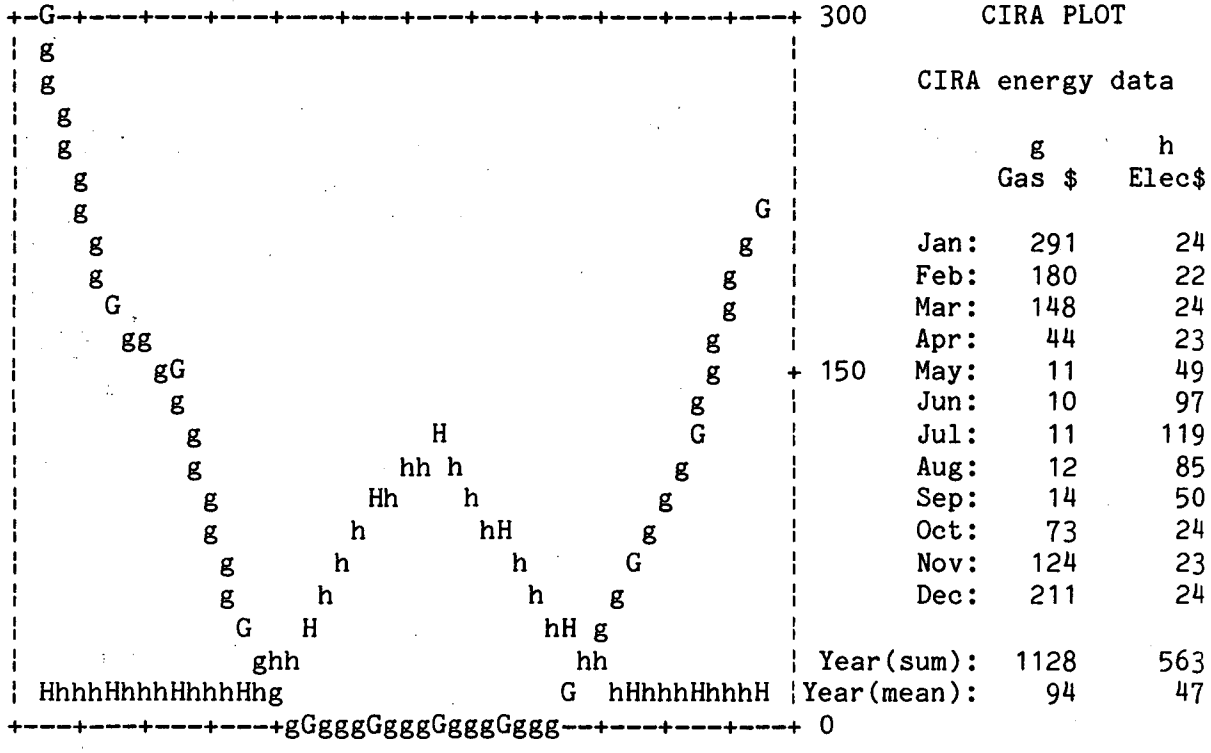
and by pressing, for example, "A", the monthly overall electric use data will be transferred to column "a". To plot data, the user must first escape from the review/transfer mode by pressing "Q". The original set of command/choices will be displayed at the top of the screen. The user can choose the plot mode by pressing "P". The set of command/choices will be replaced by the following:



If the user has already transferred $ cost data into columns "g" and "h", they can be plotted by first pressing "G". Then the prompt says:

```
2nd PLOT or <CR> for none                    g _
```

The "g" indicates that the figures in column "g" will be plotted, and the computer is awaiting instructions for the second plot. If the user types "H", the following plot appears:



The user may now make a printed copy of this plot by pressing "L" (for line printer), or by pressing "F" he/she may choose to store this plot in a file until it is convenient to print it. If the user presses "L", the computer will ask if the printer is ready; if the user presses "F" the computer will replace "<L>print <F>ile <ANY>" with "<Adding to HOUSE.PRN>". If any other key is pressed, the screen will return to the command/choice options.

The calculator is called by pressing "C". This replaces the command/choice options with the matrix of operators:

! enter	* multiply	/ divide	+ plus
- minus	¦ invert	@ change sign	^ y^x
> is x > y?	< is x < y?	= is x = y?	L $\log_e(x)$
) is x $\geq$ y?	(is x $\leq$ y?	# is x $\neq$ y?	X exp(x)
~ exchange x and y	' absolute value		

These are standard reverse polish notation (RPN) operators (similar to those used on Hewlett Packard calculators). The logic operators like ">" put +1 in the x register if the statement is true, 0 if it is false, and "roll down" the registers y, z, t into x, y, z, respectively. These operators may be used to carry out arithmetic manipulations of the data in one or more columns. As an example of the use of the logic operators, imagine the user wishes to extract the cooling load from the daytime space conditioning load. The total load is in column "a", so the operation to do this is a!!0>*. This asks if 0 is greater than "a"; if it is, the resulting +1 is multiplied by "a", otherwise the result is zero.

In this way, the data output may be manipulated to obtain the desired outputs from the standard ones, plots and tables made and the output formatted to suit.

Retrofit Package

If the retrofit option is chosen at the end of the inputs the computer will perform the retrofit optimization. When it is ready to print the output on the printer, the menu below appears on the screen. The output of the retrofit program consists of four pages of data; the user chooses which ones to print.

CIRA report generation -1.0-

--READING--

You have the following report options...

1. General HOUSE summary
2. Retrofitting PERCENTAGE CHANGE summary
3. 1st Retrofit ECONOMIC summary
4. 2nd Retrofit ECONOMIC summary

Your choice or 'Q' to quit []

The first page presents general data for the house: its location, floor area, infiltration rate etc. The name at the top of this page (and of the others) is the name given to the house in the "GENERAL" component of the input.

The second page presents the chosen package of retrofits, ordered by decreasing net savings-to-cost ratio. There is a brief description of each retrofit, followed by the effect it has on the energy used for heating, cooling, water heating, and for miscellaneous appliances (e.g. the refrigerator). The reductions are all given as percentages of original use, and so the reduction from the whole package is the sum of the individual reductions. This page also shows the energy use of both the house as it now is and of the house as it would be with all the retrofits installed. The units are millions of British thermal units per year (MBtu/yr). To get Therms per year, multiply by ten; to get Gigajoules per year, multiply by 1.055; to get kilowatt-hours per year, multiply by 292.9.

Pages three and four contain the bulk of the economic data. They give such parameters as initial and maintenance costs, first year and life-cycle savings, discounted payback, and internal rate of return. Again, the retrofits are listed in order of descending net savings-to-cost ratio. Several economic input variables are listed at the top of this page, such as the dollar limit on the cost of the retrofit package and the real increase (i.e. excluding general inflation) in the price of energy.

Once the chosen reports have been printed, the following menu appears on the screen:

CIRA report generation -1.0-
--READING--
At this point you can....

P: Run CIRA PLOT on the original house
R: RESTART with the original house
Q: Quit CIRA and return to CP/M

Your choice []

The following pages present a sample retrofit output from the CIRA program.

Seasons: '6435 Hazel' house in WASH-DC at 14 feet.

The HEATING season is from October thru April.

The COOLING season is from May thru September.

Physical:

Floor AREA (sqft):	864	House VOLUME (cuft):	6912
Real DISCOUNT rate (%):	3.00	Real MAINT ESC rate (%):	4.00
Azimuth of NORTH face:	17 deg E of NORTH	Economic HORIZON (yr):	20

	Heating	Cooling
Seasonal INFILTRATION (cfm)	111.4	37.4
AIR EXCHANGE RATE (ach)	0.97	0.33

	Overall	Ceiling	Wall	Floor
UA value (Btu/hr/degF)	498.7	45.3	276.4	177.0
Leakage area (sqin)	104.9	41.9	29.2	33.8

	North	East	South	West	Horizontal
Heating SOLAR APERTURE (sqft)	32.51	34.92	15.63	15.19	10.75
Cooling SOLAR APERTURE (sqft)	32.51	34.92	15.63	15.19	10.75

System & Economics:

	Heating	Cooling	Water	Electric
Type of EQUIPMENT	Unit Gas	Room AC	Gas	-na-
Day/night THERMOSTAT (deg F)	68 / 63	78 / 83	130	-na-
Fuel PRICES ($/MBtu)	4.71	17.52	4.71	17.52
Real ESCALATION rate (%)	2.80	1.50	2.80	1.50

CIRA----------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT----------CIRA

'6435 Hazel' house in WASH-DC at 14 feet.

Spent: $2366.00 Limit: $10000.00

ORIGINAL operating cost: $824.59/yr RETROFITTED op cost: $528.92/yr

	Heating	Cooling	Water	Electric
ORIGINAL house (MBtu/yr)	59.75	8.31	28.47	15.04
RETROFITTED house (MBtu/yr)	25.56	6.23	19.24	11.92
CHANGE in energy	-57.2%	-25.1%	-32.4%	-20.7%

	Retrofit DESCRIPTION	NAME & LOCATION	change in HEATING	change in COOLING	change in WATER HEATER	change in ELECTRIC
1	Lower Htg. THERMOSTAT by 3 F always	6435 Hazel GENERAL	-18.2%	0.0%	0.0%	0.0%
2	Set water htr. thermostat to 120 F	Jim&Marilyn APPLIANC	0.0%	0.0%	-5.7%	0.0%
3	Install R-6 water htr. blanket	Jim&Marilyn APPLIANC	3.2%	-6.7%	-13.7%	0.0%
4	Install LOW FLOW SHOWERHEAD	Jim&Marilyn APPLIANC	0.0%	0.0%	-13.0%	0.0%
5	AUTO. 5 F Htg. & Clg. NIGHT SETBACK	6435 Hazel GENERAL	-9.8%	-0.3%	0.0%	0.0%
6	Hang inside REFLECTIVE DRAPES	Back yard WINDOWS	-2.7%	-6.0%	0.0%	0.0%
7	Hang inside REFLECTIVE DRAPES	East side WINDOWS	-3.1%	-2.6%	0.0%	0.0%
8	Buy new EFFICIENT REFRIGERATOR	Jim&Marilyn APPLIANC	2.6%	-4.2%	0.0%	-20.7%
9	Put 5.5" fiberglass batts und. floor	Below SUBFLOOR	-23.4%	-3.7%	0.0%	0.0%
10	INSULATE with 3.5" blown-in cellulose	West side WALLS	-5.8%	-1.6%	0.0%	0.0%

CIRA----------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT----------CIRA

CIRA----------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT----------CIRA

'6435 Hazel' house in WASH-DC at 14 feet.

Spent: $2366.00 Limit: $10000.00

Real DISCOUNT rate (%): 3.00 Real MAINT ESC rate (%): 4.00

	Heating	Cooling	Water	Electric
Type of EQUIPMENT	Unit Gas	Room AC	Gas	-na-
Fuel PRICES ($/MBtu)	4.71	17.52	4.71	17.52
Real ESCALATION rate (%)	2.80	1.50	2.80	1.50

	Retrofit DESCRIPTION	NAME & LOCATION	Initial COST	1st Year SAVINGS	Annualized MAINTENANCE	Net SAVGS to COST R
1	Lower Htg. THERMOSTAT by 3 F always	6435 Hazel GENERAL	$0.50	$51.11	$0.03	999.9
2	Set water htr. thermostat to 120 F	Jim&Marilyn APPLIANC	$0.50	$7.65	$0.10	294.9
3	Install R-6 water htr. blanket	Jim&Marilyn APPLIANC	$30.00	$19.22	$3.13	9.5
4	Install LOW FLOW SHOWERHEAD	Jim&Marilyn APPLIANC	$30.00	$17.39	$3.13	9.0
5	AUTO. 5 F Htg. & Clg. NIGHT SETBACK	6435 Hazel GENERAL	$120.00	$28.17	$6.57	3.4
6	Hang inside REFLECTIVE DRAPES	Back yard WINDOWS	$123.00	$16.28	$3.21	1.8
7	Hang inside REFLECTIVE DRAPES	East side WINDOWS	$123.00	$12.59	$3.21	1.4
8	Buy new EFFICIENT REFRIGERATOR	Jim&Marilyn APPLIANC	$700.00	$53.45	$0.00	1.3
9	Put 5.5" fiberglass batts und. floor	Below SUBFLOOR	$904.00	$71.28	$11.78	1.2
10	INSULATE with 3.5" blown-in cellulose	West side WALLS	$335.00	$18.54	$0.00	1.1

CIRA----------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT----------CIRA

CIRA----------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT----------CIRA

'6435 Hazel' house in WASH-DC at 14 feet.

Spent: $2366.00 Limit: $10000.00

Real DISCOUNT rate (%): 3.00 Real MAINT ESC rate (%): 4.00

	Heating	Cooling	Water	Electric
Type of EQUIPMENT	Unit Gas	Room AC	Gas	-na-
Fuel PRICES ($/MBtu)	4.71	17.52	4.71	17.52
Real ESCALATION rate (%)	2.80	1.50	2.80	1.50

	Retrofit DESCRIPTION	NAME & LOCATION	Discounted PAYBACK	Cost CONSV FUEL (/MBtu)	Int RATE of RETURN	Net LIFE SAVINGS
1	Lower Htg. THERMOSTAT by 3 F always	6435 Hazel GENERAL	0.0yr	$0.01	999.9%	$999.63
2	Set water htr. thermostat to 120 F	Jim&Marilyn APPLIANC	0.1yr	$0.08	999.9%	$146.94
3	Install R-6 water htr. blanket	Jim&Marilyn APPLIANC	1.9yr	$1.32	56.4%	$253.83
4	Install LOW FLOW SHOWERHEAD	Jim&Marilyn APPLIANC	2.1yr	$1.39	51.2%	$241.12
5	AUTO. 5 F Htg. & Clg. NIGHT SETBACK	6435 Hazel GENERAL	5.7yr	$2.45	20.0%	$284.84
6	Hang inside REFLECTIVE DRAPES	Back yard WINDOWS	10.1yr	$3.50	10.3%	$103.81
7	Hang inside REFLECTIVE DRAPES	East side WINDOWS	14.3yr	$4.42	6.3%	$43.28
8	Buy new EFFICIENT REFRIGERATOR	Jim&Marilyn APPLIANC	14.9yr	$4.64	5.8%	$202.33
9	Put 5.5" fiberglass batts und. floor	Below SUBFLOOR	15.9yr	$4.83	5.3%	$217.51
10	INSULATE with 3.5" blown-in cellulose	West side WALLS	18.7yr	$5.79	3.7%	$22.65

CIRA----------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT----------CIRA

COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT

CIRA™

CIRA is a set of computer programs to predict the energy consumption of small buildings. It can also provide an optimized list of retrofits to help improve the energy efficiency of a building. No specific knowledge of building science or of computer systems is needed to use CIRA. However to run the program as distributed by LBL, certain hardware requirements must be met.

The hardware requirements are as follows:

- Z80, 8080 or 8085 family of microprocessors.
- CP/M operating system (version 2.0 or greater).
- 64k of random access memory.
- Two 8" single density disk drives or equivalent (2×240k or 450k bytes total).
- 80 column video terminal (cursor addressing is necessary).
- 132 column printer for retrofit output.

The price for the manual and three 8" single density disks (two CIRA and one utility) is $240. The manual is approximately 350 pages and is enclosed, with the disks, in a 2" loose leaf binder. Please take this into consideration when specifying a mailing address.

CIRA ORDER FORM

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Technical Information Department
Lawrence Berkeley Laboratory
University of California
Berkeley, Ca 94720

Manual @ $80.* each _____

Disks(set of 3)$180.* _____

Manual & Disks @ $240.* _____

TOTAL _____

Enclosed please find $_____ for material marked above. (Please make check payable to: Regents University of California)

SHIP TO:

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*Prices reflect printing and book rate shipping charges and are subject to change without notice.

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