INTEGRATING AN ENERGY EVALUATION MODULE WITH A CAD PROGRAM:

A
FEASIBILITY STUDY

ENERGY EFFICIENT INDUSTRIALIZED HOUSING
RESEARCH PROGRAM

THE CENTER FOR HOUSING INNOVATION
UNIVERSITY OF OREGON

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1.0 EXECUTIVE SUMMARY

The U.S. housing industry appears to be on the brink of extensive computerization as a result of competitive pressures within the U.S.A., and from Europe and Japan. The Japanese lead the U.S. in computerizing the sales through design processes and the Swedes and Norwegians lead in the design through production processes. Computer-based tools for evaluating the energy performance of buildings have low levels of use throughout the industrialized housing field. If a computer-based energy evaluation tool is to be used, it must fit with the computers and software already used to produce and market industrialized housing. Therefore an energy tool which works with CAD systems, the most common non MIS computer use in industrialized housing, is more likely to be useful and actually utilized than one which does not.

The Energy / CAD tool must have access to information about a buildings thermal properties to perform energy calculations. If the evaluation process is to be as automatic as feasible, this data must be defined within the CAD tool as completely as possible, reducing the need for time consuming operator input of energy featurs and possible input errors.

The computer most likely to be in the industrialized housing setting is a personal computer running in the DOS environment. The CAD programs need to provide capabilities useful to the industrialized housing producer such as cut lists, production and permit drawings, estimating, and inventory control, while also providing the requisite data structure.

Few of the individual CAD packages marketed for PCs presently have all these capabilities; many lack industrialized housing production features. While many of the surveyed CAD tools could accommodate the Energy module, they would require intensive programming efforts to create the requisite data structure, and would still need industrial housing capabilities. Another area in which many CAD packages failed to meet the criteria was in not having true three-dimensional capabilities which are required for the Energy module to account for things like solar incidence, shading and stack ventilation.

The two most highly ranked CAD packages are SoftPlan and SolidBuilder. Both programs have the kind of data structure which allow extensive thermal definition of a buildings components and can generate Bills of Materials, cut lists, framing diagrams, elevations, sections and in the case of SolidBuilder, three dimensional views of the building or sub-assemblies (like stick framed roof structures). A third program, ASG, currently does not provide the requisite data structure, but is expected to release a new version in early 1992 which does. ASG does currently have features appropriate to the industrial production of housing.

SoftPlan is an architecturally specific CAD package created for light frame construction. It generates the third dimension (currently elevations only) from plan views and information entered by the user. one of its most attractive features is that it can run on a very simple PC and does not require a math coprocessor.

Solid-Builder is an architecturally specific front end for a general purpose 3D solid modeling CAD program (SilverScreen). SolidBuilder allows the user to focus on sets of design or drawing issues specific to architecture and light frame construction. It requires a slightly more sophisticated hardware platform, and the additional CAD program.

2.0 INTRODUCTION

Organization of the Report

This report is organized in three basic parts. The first part introduces and describes the Energy / CAD tool (Sections 1 and 2). The middle part presents and explains the criteria used in selecting a CAD package, and also identifies the CAD package chosen (Sections 3 and 4). The last part consists of reference material organized in a series of Appendices. These Appendices include a list of the kinds of information needed to make an energy analysis, the complete text of the individual CAD package evaluations (arranged by category).

2.1 THE NEED FOR A CAD-BASED ENERGY TOOL

In FY90 we completed the study "A Review of Computer Use in Industrialized Housing". Conclusions reached in that study are the basis for the objectives listed here. Japanese, Swedish and Norwegian housing companies are more industrialized and more computerized than U.S. companies. The Japanese lead the U.S. in computerizing the sales through design processes and the Swedes and Norwegians lead in the design through production processes. These foreign examples are illustrations of what U.S. industry may have to do to improve its domestic productivity and to remain competitive in the world housing market.

Given these foreign examples and what is currently taking place in the U.S. in software development and housing production, we believe the U.S. industry is on the brink of extensive computerization. Computerized energy tools have low levels of use within the industrialized housing arena because they are not directed to the stakeholders which have control over energy decisions and they are not specific to the decisions that those stakeholders make. The energy tools should be directed at housing production and consumption stakeholders who are motivated to make "good" energy decisions, like home owners and manufacturers that sell energy products.

In order for any energy tool to be used it must fit with other tools that are being used to design industrialized housing. Those tools are currently and in the near future will be industrialized housing CAD systems. Therefore, energy tools that

are integrated with these CAD systems will be most likely to be used. Consequently, our objective is to design an energy module which is integrated with a CAD system.

Methodology

This project commenced with deciding what inputs were necessary for a complete energy evaluation of a residential scale building (see 6.2). Next the existing CAD packages were surveyed for basic capabilities, and evaluation copies of CAD that met basic criteria were obtained. Of key importance were the language type, architecture of the CAD program, data structure, industrial housing features and possible working relationship. Of prime concern was the ability to define within and extract information relevant to energy calculations from the CAD package.

2.2 CAD AND THE INDUSTRIAL HOUSING MARKET

The producers of industrialized housing currently use two kinds of computer based tools to create files and documents for housing production (Brown, 1990). CAD packages will be the focus of this investigation. The other kind of tool is a more limited and specific software which performs a special task. Truss design and analysis packages and panel layout packages are both examples of this more specialized type. These specialized tools have primarily been designed and intended to be used as production tools. Consequently, their data structures in general to not have the potentially attribute-rich qualities which the energy evaluation module must have access to. The capabilities of these production tools have lately been approaching those of the CAD packages, but they have been excluded from consideration because they do not describe or account for the whole building. (see Appendix 5.4.4)

CAD System Characteristics

The current generation of mature CAD programs appear to be reaching limits imposed by their language, data structure and conceptual framework (Orr, June '90; Roberts, June '91). CAD vendors in general are in the process of preparing the next generation of CAD programs for release. These programs utilize advances in software and hardware design which have been standard in high end workstations.

Key features of the new CAD programs include the provision of an open architecture with a compiled language (usually 'C' or some variant of the 'C' language), and attribute-rich object orientation within extendible data structures. These features enable the programs to run quickly and allow the design file to hold information about the design in ways which are more easily accessed. The object oriented approach allows definition of building components within the CAD program improving the speed at which a designer can define a building. The extendible data structures allow attribute-rich definitions of and associations with the objects (Atwood, July 1990; van der Roest, July '90).

These next generation CAD packages also have high level hooks, allowing other developers to integrate other capabilities or create a customized application. In comparison, the older, more ubiquitous CAD packages often rely upon slower interpreted languages and less capable data structures.

The next generation CAD programs are making their way to the market. CadKey and DataCAD are working on the "Parthenon" project, and a version of that integrated package has been successfully introduced in Europe. VersaCAD has a similar project in development called the "Emerald Forest"(Falicoff, '91). The other major CAD vendors are reportedly preparing similar products. All of these advanced CAD products feature compiled languages using object oriented programming and advanced data structures. In addition, some vendors have been able to focus on new products (instead of support, maintenance and upgrading of old technology based CAD programs) and have released new generation CAD programs during the last two years.

Hardware System Characteristics

Hardware platforms are also evolving. Highend PCs (micro computers) are approaching workstation-like functionality, blurring the distinction between PCs and workstations. One of the major factors contributing to this performance improvement has been the decreased cost and increased use of sophisticated graphics control boards in the PCs to increase the rate at which operations are displayed. Other factors influencing the configuration of the hardware platform include the continually decreasing costs of memory as well as the processors and peripheral equipment.

2.2.1 Need Based Evaluation Issues

The selected CAD package should have features which can be applied immediately to the production of houses in the industrial setting. It also needs to have features which will allow a building to be defined in ways needed for energy evaluation, and have a means of sharing that information with the energy evaluation module. These technical features are explained further in Section 3.0.

Other key factors in making the Energy module available to the producer are its actual usability, and the investment necessary for acquisition. The actual usability of the energy tool addresses the needs of a user who probably does not have a very sophisticated understanding of thermal analysis, and may not have formal training in CAD or design. Investment acquisition includes not only the initial price of the Energy / CAD module, but whether the program requires the acquisition of new or additional hardware or software, and whether the CAD / Energy package is easily learned and efficient to use.

2.2.2 Design and Energy Code Certification Issues

Many state and local government agencies are now requiring some proof of a buildings compliance with either a prescriptive or performance based energy code (Pierce, 1991 p.7). Computer based programs for compliance certification exist, but apparently require effort and expense to maintain and upgrade as regulatory changes in the energy code occur. The Energy / CAD tool will not function as an energy code compliance or certification tool, as that endeavor is beyond the scope of this project (see the Appendix, Section 6.5). However, the CAD based program could summarize attributes of the structure (such as areas, R values, and etc.), and do so in in a format useful for input to energy compliance packages in the future.

3.0 DESCRIPTION OF THE PROPOSED ENERGY / CAD TOOL

The Energy / CAD evaluation tool is intended to dynamically evaluate residential scale design decisions within a CAD environment which supports the industrial production of dwellings. It will provide the designer with immediate feedback about the energy implications of design decisions. The Energy / CAD Tool is intended to be used by designers and building construction professionals who do not have extensive proficiency in thermal analysis, but do have knowledge and experience with building design and configuration. See the Appendix Section 6.1 for a more detailed description of the Energy / CAD tool.

3.1 CRITICAL ISSUES AND ASSOCIATED CRITERIA

In this section, the issues which must be resolved for the Energy / CAD tool to operate successfully are identified in a heading format and explained within the following paragraph(s). Criteria which address those issues are then formulated and expressed.

3.1.1 Ability to Extract Meaningful Data From The CAD Package
Ability of the CAD Package to Recognize / Define Thermal Objects

The ability to extract information about a structure from the CAD package is critical if the energy evaluation module is to furnish usable information in the design and pre-production stages. The Energy / CAD tool therefore needs to be able to define and/or differentiate between thermal and non-thermal building objects. For instance, a CAD package may include the projecting eave of a roof in its definition description of that roof, but the eave is probably unimportant in the energy calculation process. The Energy / CAD tool needs to include only those elements which contribute to energy gain or loss, and disregard the thermally neutral elements. (The degree to which this differentiation is dependent on system intelligence or user input is subject to definition.)

3.1.2 Intended User Characteristics

This CAD-based energy evaluation tool is intended to be used by people who do not have special knowledge or training in energy analysis, but do have specific knowl-

edge of building design and construction. These people are likely to utilize the tool to 'fine tune' the design of the building by evaluating its probable energy use while in the design and pre-production stages. The Energy / CAD tool is intended to furnish this information in a reasonably short time frame, and in ways which are useful to the client.

3.1.3 User Appropriate Inputs and Outputs

Different people and institutions need to utilize Energy / CAD tool in differing ways. The information which the tool is expected to provide will almost certainly vary in format according to the needs of the both the individual user and even according to individual product. For instance, one may wish to evaluate performance on an average day or a design day; or one may need to ascertain annual energy use, or annual energy cost, given a local utility rate structure. The evaluations furnished will also need to vary by period (day, month, year and life cycle).

This thermal analysis program will therefore need to provide output formats which can be specified by the user. These output formats will need to display both normalized and locally appropriate figures. The output period should be user selectable, and the specificity of contributing elements should depend on the period. For instance, when querying for a yearly summation, appropriate outputs would probably include total economic cost, breakdown by category (heating, cooling, gas, electric, etc.) and normalized data ($/SF, BTU/SF/DD, etc.).

3.1.4 Locally Specific Data

The ideal Energy / CAD tool should support the user by integrating locally specific information, enabling the evaluation to most closely simulate specific building performance. This locally specific information includes items such as building materials and processes (and their associated attributes), as well as local climate (weather) and economic (energy and materials cost) data. (Most CAD package already enable the user to define new objects and associated attributes, so this capability is simply an extension of an existing feature.)

Supplying this degree of local specific information is beyond the scope of developing the tool (i.e., it would be impractical for the developers to provide this data for

all possible localities), but affordances should be made which allow the individual user to import and utilize this kind of data. The importation of this data could perhaps be invoked as an auxiliary feature (i.e, provided as an optional program and supported in the documentation) in which the user is prompted by the program through the importation procedure.

3.1.5 Design Process and Dynamic Response Time

The Energy / CAD tool is intended to be a dynamic design tool with a quick response time, enabling a designer to spend more time making appropriate changes to the design, and less time in a wait state. Response times of less than a minute or two to complete the calculations for a residential scale building would be acceptable, and a range of 1-3 seconds ideal. This dynamic aspect will probably be a critical factor in choice of algorithm type.

3.1.6 Choice of Energy Calculation Algorithms

Many of the algorithms used by energy analysis programs try to simulate building performance as finitely and as accurately as possible. These calculations are often time consuming and provide a *precision* which is appropriate for research work, but inappropriate in the design setting. The Energy / CAD tool is not intended to be a specialized research tool, but a design evaluation tool supplying a relative degree of accuracy rather than an absolute degree of accuracy. This situation will allow the tool to use an energy algorithm type which is more appropriate to the setting. The faster energy algorithm will also enable the evaluation to be part of the dynamic process.

The faster thermal analysis techniques fall into a number of categories according to type, including parametric equations, frequency or harmonic analysis, and equivalent temperature differential methods. The methodology presented in the Passive Solar Design Handbook provides an example of parametric equations based upon detailed simulation. The British Research Establishment Admittance Method is an example of the frequency or harmonic analysis type. The ASHRAE calculation is an example of the equivalent temperature method. (See the Bibliography). A fourth technique utilizes empirical or physically derived direct solution equations, and is usually limited to steady state analysis. (Falicoff, 1991)

3.1.7 Interface Philosophy

Many energy calculation programs, demand either specialized or expert knowledge on the part of the operator for the definition of the building. The report (feedback) also furnishes a degree of accuracy which depends upon operator knowledge, assumptions and proficiency. These interface requirements decrease the use of the tool to relatively few persons and situations. The Energy / CAD tool should not place similar interface or knowledge related obstacles in the path of the operator. The Energy / CAD should instead either supply or elicit appropriate information from the user when necessary. For instance, if the user has not specified a schedule for artificial lighting in a given building zone, the tool should prompt the user for confirmation or specification.

3.2 REQUIRED INPUTS

The inputs required for complete building definition must include terrestrial data, building data and occupant activities and schedules. A complete list of inputs is located in the Appendix, section 6.2.

Terrestrial Data

Energy use calculations require a context for the building. The context includes the position and orientation of the building on the earth and the climate specific to that place. Allowing a degree of definition dependent on user input accommodates the range of condition which the user typically operates. Typical data includes hourly figures for solar radiation, temperatures , wind speed and direction, groundwater temperature and etc. (See the Appendix, section 6.2 for a more complete list.)

Building Data

Building elements and systems which have thermal implications need to be *accounted for* in evaluation process, but not necessarily defined. For instance, the Energy / CAD tool will not need to know *where* every stud in a 2x6 stick framed wall is, but will need to know the area, volume, and the individual and combined thermal characteristics of all the studs to in order to account for their contribution to the thermal performance of that wall.

The need to account for elements without definition has implications for the dynamic character of the to Energy / CAD tool. Data need not be duplicated: the definition of similar objects (a type and size of window, for instance) need only be defined once, and then applied as many times as that window model occurs. This passing of object attributes in a hereditary fashion is key to both limiting the buildings' file size and speeding the calculation procedure. This kind of structure is most likely to be found in object oriented CAD program, and not in point and line (graphics-based) CAD programs.

Occupant and Equipment Schedules
Conservation Strategy Priorities

The ways in which occupants use a building, and the desired environment within that building change over time. Time periods can be defined to include days (by hours), weeks (by days) and seasons and years. The definition of schedules by periods accommodates the desired changes in environment such as temperature setbacks, weekend vs. weekday schedules, summer vs. winter schedules, etc.

A related concept which needs to be accommodated in a similar fashion is the ability for a designer to prioritize energy use and conservation strategies. For example, a building in a hot arid climate may be designed to absorb energy during the day and remove it at night to take advantage of both natural cooling strategies and off-peak energy costs; in this case, the simulation process should be able to implement that sequence of events instead of a less desirable sequence.

3.2.1 Inputs: Minimal Information Requirements

A building needs to be defined as fully as possible for the energy evaluation to be useful. In cases where it is difficult or impractical to define a building completely, the Energy / CAD tool should account for that lack of definition and draw attention to that limitation in the report. Also, if a strategy is specified but not utilized, the program should note that fact as well. For instance, if a designer were modeling one half of a duplex having a mirror reverse plan, the contributing characteristics of the party wall should be noted and handled by the program without having to input the other part of the building. If the building was not able to cross ventilate and should have, the report could call out that discrepancy.

3.2.2 Default Values used in Calculations

Certain values and characteristics of the structure may not be known or need to be defined when an energy evaluation is desired. In this scenario, the Energy / CAD tool will supply values for the calculation. For instance, infiltration and air exchange figures may not be available; the tool would assign a probable value, enabling the calculation to proceed.

3.2.3 User Accessible and Definable Inputs

If the Energy / CAD tool is to function dynamically, it must allow the the user to enter or delete particular elements according to different modes. For instance, if the user has developed and evaluated the design, and then wishes to evaluate certain changes (e.g., increasing the area of north facing windows), those changes could be made in either the drawing of the design, or in the alphanumeric summary of the design.

In this scenario, rather than having to change the actual design, the user could simply change the area of the north-facing window alphanumerically, run the calculation again, and then make the more permanent change in the CAD file based on that feedback. The point is that the user needs to have control of the process and work in an intuitive fashion, especially if that means accommodating different modes of interaction.

The flexible nature of the interface can be extended to include specifying elements in whole groups. For instance, a design could be input entirely alphanumerically at first in order to test ideas about how much insulation, glass or mass might be appropriate. The program itself might extend the interactive nature by querying the user for additional information. In this case, if no north walls had been specified, the program might ask the user if the north walls were party walls or some other entity. This concept also has implication for output: if cross ventilation using a north opening were possible, but a north wall / window not specified, the program could draw attention to that mismatch.

3.3 OUTPUTS

Designers or people who make design decisions need information about the dwelling summarized in formats which differ according to individual circumstance. Information formats can include tabular summaries of materials and costs or graphic summaries. The summaries may need to be be organized by groups as well, including time period (lifetime, annual, monthly, weekly, daily or hourly for costs and energy), category of energy (source, type; e.g., electricity, solar gain, ventilation, etc.); or building element (north wall, north-facing windows or all the windows, etc.) In any case, if the program is to support the user, it must support user definable outputs and output formats.

3.3.1 Defaults

The Energy / CAD tool should provide a few standard summary formats by default. Possibly the most useful format would be a one or two page annual summary, divided according to building element (walls, windows, etc.) and energy use (source and type) categories and their associated cost. Other default formats could be monthly summaries and daily summaries (for representative seasonal periods).

3.3.2 User Definable Formats

The user should have the ability to specify an output format applicable to the design operation in process. For instance, when deciding on the exact size and place of a window and associated mass, a 24 hour summary for a heating or cooling season day may be more appropriate than a yearly summary.

4.0 CRITERIA USED FOR CAD PACKAGE SELECTION

General Criteria

The preceding section presented and discussed the attributes and requirements of the proposed CAD-based energy evaluation tool. Given these conditions, a set of selection criteria were developed to evaluate CAD packages.

The formulation and use of the selection criteria are intended to help answer the question "is it technically feasible to extract the data we need to perform an energy analysis from the CAD package?" Other questions which followed from this primary question addressed issues of if the data was even available, and if the CAD package allowed definition or extension of the data structure. Other selection criteria are based upon requirements of the Energy tool itself, and the performance criteria; the intended market of the tool; the identity and description of the end user; and the reason this tool is deemed necessary and desirable. The features for which the CAD packages were evaluated also had to be available within the currently released version of software.

The criteria have been developed in response to the above primary question. Some carry more weight than others - for instance, the kind of language used by CAD package(or by add-on packages) tends to control how fast an operation can be implemented and therefore the overall speed of the the program. Likewise a CAD package which has features useful to producers of Industrialized Housing but does not have an optimal data structure implemented would rank higher than a CAD package with optimal data structure and no Industrialized Housing production features. This distinction is critical because the Industrialized Housing feature is more difficult to implement, being the result of a special kind of rule-based knowledge, i.e., how to actually construct a building of a given design.

The data structure represents a more general kind of knowledge and creating an appropriate data structure can be implemented in different ways, depending on the specific situation (Tucker, June '91; Atwood, July '90; van der Roest, July '90). For instance a CAD package may be able to associate only 5 attributes with an object (e.g., a wall). One of those attributes could be a reference telling the Energy / CAD tool where more complete information about the wall is stored, in effect 'ex-

tending' the data structure. The important distinction here is that the specific kind of knowledge (how to build) is more difficult to implement than the general kind of (programming) knowledge (where more information can be found for use).

4.1 SPECIFIC CRITERIA: TECHNICAL CONSIDERATIONS

4.1.1 Hardware and Software Platforms

PC-based Software

Work Stations

Our previous research indicates that virtually all industrially based producers of housing have PCs in the office setting (even those without CAD), and the choice of CAD systems actually in use reflects this (Brown, 1990). The ability of the CAD package to run on a PC is therefore critical and assumes a high priority. Most of the CAD packages evaluated run on PCs and in some cases, work stations. While the functional differences between highend PCs and and work stations are becoming less apparent, workstations may not be as desirable because they generally require a larger investment to acquire and maintain, decreasing their availability in the IH marketplace as a whole. Workstations also require specialized knowledge (of a Unix-based operating system, for instance) and therefore often require dedicated resource people; consequently, work stations have been less likely to be found in the smaller setting.

In contrast, the lower acquisition investment of PCs does not limit them the the lower end of the market (as workstations tend to limit themselves to the upper) - but also makes them available in the middle and upper end as well. In fact, the PC is probably already present and utilized in the Industrialized Housing office setting already. Therefore a CAD-based energy tool which runs on PC platforms will likely have a larger potential marketshare, and consequently larger availability to the housing industry.

Finally, programs conceived and developed for PCs within the emerging CAD environment can be ported to workstations more easily than software written for workstations can be transported onto PC platforms (Falicoff, 91). In fact, at least

one new generation CAD program (SilverScreen by Schroff Development) already has been ported to the IRIS workstation (Silicon Graphics) (Schroff, '91). Given the lower initial cost and trends within the CAD field, the PC is the preferred hardware platform.

Software platforms

For the purposes of this evaluation, the CAD package can either stand alone or be associated with (run on top of) a general purpose CAD package, but it should be optimized or optimizable for architecture (i.e., help the user focus on sets of design or drawing issues specific to architecture) to qualify for consideration. Optimization for architecture is important because it allows productivity gains. General purpose CAD programs can be used to design many kinds of objects, and CAD programs only one. Architecturally specific CAD programs are usually standalone programs or utilize a general purpose CAD program.

4.1.2 CAD Capabilities

The CAD package must have complete CAD capabilities - the ability to assign attributes to an entity in some fashion, the ability to view the artifact in different ways, etc. The program needs to have a comprehensive set of both 2D and 3D primitives (lines, patterns, cubes, spheres, etc.) as well as symbolic entities of use and meaning to the building industry (symbols, arrows, schedules,cross hatching, and etc.). The third dimension is critical for a CAD package integrating an energy efficiency module because many factors (such as solar incidence and stack ventilation) require the third dimension to be integrated with the other two dimensions for calculation purposes.

4.1.3 Program Architecture & Language

Compiled vs. Interpreted Languages

Because the Energy / CAD tool is intended to perform in a dynamic and interactive manner, it really needs to be in a compiled language itself, and for best results, operating in a compiled language environment. (In general, compiled languages allow a program to run faster and transfer to other platforms.) If the CAD program is operating in an interpreted language environment (such as

AutoCADs AutoLisp) it will be more difficult to create the attribute-rich environment necessary for energy calculations, and it will be more difficult to extract , manipulate and present attribute based information. In this scenario, the extendibility of the data structure is probably more important than language (but in general the extendibility is associated with the compiled language anyway) .

Open vs. Closed Architecture

Open architecture is the ability to allow customization or modification of the program for specific purposes without requiring effort by the original vendor. In general, the creation of the attribute-rich data structure, and the input and extraction of those attributes will be more likely with a program having open architecture. Of interest here is not only if the architecture is open, but to whom the architecture is open and under what circumstances. For instance, a stand-alone CAD package probably has a proprietary, closed architecture - i.e., closed to third party development - yet be open to licensed development.

High level hooks, Binding

Some CAD packages use 'hooks' which allow an extendible language to be 'grafted' onto the CAD program itself as a means of enhancing the functionality of the program. Issues of language type and compilation apply to this criterion.
An additional factor to be considered is the characteristics of the program which has the hooks. The presence of high level hooks or C-binding does not confer immediate benefit: the bound language must interface well with , and the original language and still allow the richness expected of a modern language. For instance, in the case of AutoCAD, release 11 provides 'C' binding, enabling software developers to extend the capabilities of the CAD package. However, the CAD program itself is still running under control of AutoLisp using the same data structure and so is not truly 'C' bound (Falicoff, 1991).

4.1.4 Data structure and Attribute Handling

Object Orientation

A crucial factor for the functionality of the Energy / CAD Tool is the ability to query the CAD package for attributes of a building element (wall, window, etc.) CAD programs can associate attributes with objects in a few ways, and a most direct

association is possible with object oriented programming (OOP). OOP relies upon the creation, manipulation and aggregation of 2D and 3D primitives (squares and circles, cubes and spheres, etc.) into hierarchical objects. These objects are defined within sets of attributes (such as graphical dimensions and geometric relations, and according to application specific data (wall, window) and can be associated with given attributes (such as thermal qualities) (van der Roest, July '90). Therefore, OOP offers an attribute - rich environment more suitable for energy calculations than data-structure types. CAD packages which utilize OOP are more likely to successfully integrate the Energy / CAD tool.

Object oriented programs can also decrease the amount of object definition directly required of the user through the passing of attribute within an object hierarchy or 'family' group. This feature allows a program to account for all of an objects attributes with out having to define all of them, saving data structure space and access time, and hence energy calculation time. A good example of this is the capability of the CAD package to know the combined area, volume and thermal performance of framing members and other elements within a wall or floor, but need not have calculated the exact position of those elements at this stage of design.

Other advantages of OOP are found in both the identification of an object as both an independent object as well as an object within a hierarchy (part of an assemblage of objects creating a larger object) (van der Roest, July '90). In this case, a window can be defined as either one of a class of windows having similar characteristics for cost estimation; a part of a wall assemblage for image viewing (elevations, etc.) or energy calculations; or as an individual entity. When an object is defined in OOP it can be more easily identified (chosen) and manipulated, often within a relative, independent coordinate system rather than a global and arbitrary coordinate system.

Attribute Glued Graphics

Another way CAD packages can associate meanings and attribute to designed objects without the use of OOP is by associating attributes with a graphic object - usually an assemblage of points, lines, polygons and cubes. This kind of Attribute Glued Graphics (AGG) is exemplified by older CAD packages which were primarily intended to be drawing environments.

The CAD packages reviewed which used AGG often included 'hooks' or pointers' which allowed attributes to be associated with the drawn entity in an associated file. The drawbacks inherent in this system are the possible remoteness of the associated attribute, increasing data access time and raising the possibility of losing relations between the CAD and data files.

Symbology

Another type of CAD program focuses upon the creation of graphic entities symbolizing objects. These symbolic graphic entities may or may not have any intelligent features, such as rule-based formulations or parametric capabilities. The symbols may be arranged in hierarchical groups (as with AutoCADs 'blocks') or in non-hierarchical assemblages.

As a general rule, this kind of environment poses greater difficulty in performing attribute dependent operations such as changing an objects scale. In this operation, a stick-framed wall which is lengthened by 50 % will also increase the distance between studs by 50%. As a result, CAD packages which use AGG will may have difficulty supporting the Energy / CAD tool because of inaccuracies between assumption and operation.

Attribute Field Constraints

The number of attributes which a designer can associate with an object is a constraint posed by any given CAD package. The number of attributes need to be large enough to allow the complete description of an object - its physical and thermal properties, any associated properties such as economic data and references to other objects are of key interest here. To keep the CAD file size manageable, most CAD packages limit the number of fields (the places attributes are stored) available within the CAD file.

The language which accesses the attributes is again of importance: interrogation of attribute fields is a slower process with interpreted languages than with compiled languages. However, compiled languages generally have extendible data structures, negating the field number constraint as well. Constraints posed by language or data structure may (or may not) be overcome by clever programming, but the effort is greater than with unconstrained situations.

Another issue of interest is the way in which the links between object and field operate. Most CAD packages can access a database, but accessing the CAD object from the database is more rare, though useful. For instance, if one wished to delete a window from a wall, one could do so in the graphic display portion of the CAD program or simply delete it from a schedule. Sub issues include the nature of the link - whether changes are updated immediately or in some other fashion, and where the attributes are stored and how they can be manipulated (Tucker, June '91; van der Roest, July'90). In general, the CAD package which the kind of data structure and functionality which the Energy / CAD tool requires, probably has the capability to allow the user to change the design either graphically or alphanumerically (though this capability my not be currently implemented).

4.2 APPLICABILITY TO INDUSTRIAL HOUSING PROCESSES

The applicability of a CAD program to industrial housing process is probably the single most important consideration in this evaluation, as discussed previously. Applicability can be defined within two areas of functionality - the ability to create documents and files for utilization within contexts either external or internal in relation to the producer. For the purpose of this report, externally oriented documents or files are necessary for communicating with clients, vendors and regulatory agencies. Internally oriented documents are utilized for the actual production of the dwelling.

4.2.1 Externally Oriented Documents: Drafting and Drawing Features

Any mature CAD package has the necessary drafting and drawing features required for the production of documents necessary for communicating with clients, vendors and regulatory agencies. Differences are found within the degree to which those features are automated, or contained within single or multiple CAD modules. In general, the more attractive CAD package will have the ability to produce the document elements necessary for these kinds of drawings, given a construction type, a defined view and specific information needs. For instance, one may need a framing diagram of a building plan, along with plumbing layout diagrams; an efficient CAD package should reduce the amount of input required of the human operator to produce the document.

A CAD package need not have all possible drawing facilities (for animated 'walk throughs' or rendering, for instance), but the ability to import and export files in some standard format is essential. The basic and desirable drawing capabilities are noted below.

- Plans, Elevations, Sections, Other Views
- Floors, Walls, Roofs, Sections, Details
- Schedules, Notes, Finish Materials and Rendering
- Libraries of objects

  Creation or modification or deletion of library objects
- Estimation, Reports

A CAD package may have other capabilities which would make it attractive to a producer of industrial housing. For instance, the ability to help create massing or presentation models might be a desirable feature in the design and marketing phase.

4.2.2 Production Drawings and/or Features

Internally oriented documents are utilized for the actual production of the dwelling. As such, the user must be able to generate and convey specific kinds of specialized information within the CAD environment, and may need to do so in either hardcopy or soft (electronic) formats.

Automatic Production of Construction and/or Manufacturing Documents

The CAD package needs to have the ability to produce documents or files necessary to the manufacturing process. If these documents can be produced automatically, so much the better. The basic and desirable drawing capabilities are noted below.

- Floor Framing Drawings, Diagrams and/or Details
- Wall Framing Drawings, Diagrams and/or Details
- Roof Framing Drawings, Diagrams and/or Details
- Component Construction Drawings, Diagrams and/or Details

(all or any of the above in 2D, axonometric and sectional views)

Other Applications for Industrialized Housing

CAD packages may offer specialized kinds of documents necessary for specific manufacturing processes. This capabilities may include the generation of:

- Cut Lists (lists of individual building components size and shapes);
- Materials Takeoffs (lists of areas, numbers of components, etc.);
- Estimating (preparing estimates of cost of production and delivery);
- Inventory control;
- NC and CNC files ;

  (files which can be used to control Numerically Controlled (NC) or Computerized Numerically Controlled machines. These machines can range from automatic saws to robotic assemblies. Depending on use, the files could be lists on paper or digital files which can be transferred to the machine electronically.).

4.3 RESEARCH AND DEVELOPMENT CONSIDERATIONS

4.3.1 CAD Vendor Qualities

Larger companies have in general exhibited less ability to respond quickly and fluidly to this research project. Many of the larger vendors are willing to support this endeavor as for any third party developer. The smaller companies seem to be more willing to work with us in a more direct manner, and have usually been more responsive, following up and even extending commitments and opportunities.

Inertia, Upgrade Commitment

With the already occurring changes in the CAD field, some vendors are not or may not be interested in developing products for their older CAD packages. Other vendors may not be implementing new generation CAD programs; and the older CAD packages are problematic, as discussed above. The development of new generation CAD programs apparently demands a significant commitment, and some vendors have been very direct in saying that they cannot divert programming resources from that effort at this time to support older, outmoded CAD packages.

Market Share

The Energy tool will be developed to integrate with a currently used CAD package. Some CAD packages are more ubiquitous than others, but market share alone is not a defensible or singular criterion. For instance, the larger volume producers may have one or more CAD packages which were modified or developed for their own specific purposes and are maintained in house. Utilization factors also figure into the market share issue, and include the actual use and usability of the product; there may be many copies of a program sold, but whether they are actually in use or of use for the purpose of creating dwellings in the industrial setting is a critical issue.

Possibly the key factors in the availability of the Energy / CAD tool (as opposed to the CAD package it will be integrated with) is its actual utility, its acquisition investment and potential marketshare. The usability of the Energy / CAD tool should address the needs of the user who probably does not have a very sophisticated under-standing of thermal analysis, but understands building production very well.

Investment Required for Acquisition

The investment for acquisition is a crucial factor to be considered. CAD packages which require large initial investments (including personnel commitment and capital resources) may in fact have a smaller market share than expected. Large volume producers who already have workstations, minicomputers or mainframes tend to dedicate those resources and modify or develop their own computer-based tools. A sophisticated and cost effective energy evaluation tool will be just as available and of use to these producers as to a less elaborate corporate entity.

A final facet of the market share question is the purpose of the project. This project is intended to transfer evaluative technology into the design and production setting and in doing so, either fill a niche or act as a market catalyst. As such, this tool has the potential to be developed as an elegant and successfully integrated product, negating concerns about whether the tool runs on the larger software platform(s). The larger context of the EEIH project is to create more energy efficient housing; if the Energy tool were of use to others (such as remodelers, students, or researchers) the potential impact of the tool would be increased.

4.4 SUMMARY: THE CAD PACKAGE OF CHOICE

Three CAD packages either meet or will probably meet all of our criteria. The two which currently meet our criteria are SoftPlan and SolidBuilder; the third, ASG, currently does not meet the criteria, but is expected to with its next release (scheduled for January of 1992). All three have very different strengths and weaknesses which makes the choice of a CAD package somewhat difficult, as all three could probably integrate the Energy evaluation module successfully.

SoftPlan would fit into any industrialized housing setting. It has the most minimal hardware configuration requirements of all three, and is an architecturally-specific standalone package as well (i.e., it does not require another CAD package to run). The minimal PC is likely to already be in the office setting, even those which do not currently utilize CAD. The other two programs do require (or recommend) more sophisticated hardware and a second CAD package: ASG requires AutoCAD and SolidBuilder requires SilverScreen (see sections 5.2 and 5.3). Supporting and maintaining the second CAD program of course involves additional commitment of resources.

SoftPlan however, has a closed architecture: situation specific changes to the basic program can only be made by the vendor. A CAD package with open architecture could allow a producer to modify it to accommodate the construction of mass walls, for instance. Both ASG and SolidBuilder can be modified because their base CAD programs have open architectures. SoftPlan also handles the critical and necessary third dimension less adroitly - currently only generating 2D elevational views.

SoftPlan and SolidBuilder (and the associated Silverscreen) have been developed in the "C" family of programming languages. ASG's upcoming release will apparently utilize the 'C' hooks provided by AutoCAD in its last release to extend its capabilities. In contrast, the core of AutoCAD is still in the LISP programming language. The programs written in "C" are apparently more extendible and portable, allowing the programs to accommodate changes in hardware or software more easily

ASG has a potentially large installed base due to the ubiquity of AutoCAD. It has demonstrable expertise in both utilizing AutoCAD features to accommodate and resolve architectural issues. ASG also offers the most extensive architectural CAD capabilities of the three packages, including optional HVAC and Mechanical engineering modules. However, it still operates in a non-object oriented CAD environment which is being discarded by other CAD vendors seeking improved performance, design capability, operational functionality and speed. Despite all the positive features of ASG's Architectural CAD package, one must be concerned about the underlying platform. The mitigating factor is of course, ASG's ability to capitalize on the "C" hooks and transform itself into a more portable package.

One of the most difficult operations in creating the Energy / CAD package will be the capability of the program to recognize and make a distinction between the constructional object (as represented in the CAD drawing) and the thermal object. For example, given a design which has a roof with overhanging eave, the program must in some way distinguish between the thermally less significant eave and the more critical roof structure over the inhabited space. The 3D modeling capabilities provided by SilverScreen for SolidBuilder make this a more probable capability than the other two. Likewise, the ability to create other constructional entities as objects and associate thermal (and other kinds of) attributes with that object make it more likely that a user could include such things as a mass wall made of adobe, or a rockbed having a certain thermal capacity for passive cooling.

SolidBuilder is the most likely candidate for successfully integrating the Energy module. All three would probably do well, but SolidBuilder has good short term and long term prospects. It can probably be extended and ported to any CAD environment likely to evolve.

5.0 CAD PACKAGE EVALUATIONS

5.1 SUMMARY

Nearly all the CAD packages reviewed could probably integrate an energy evaluation tool, given modification and programming effort. Nearly all incorporate at least one or two features of use to industrialized producers of housing - usually a Bill of Materials and an associated cost estimation facility. Given the range of choices, weight was given to two main factors - the provision of more sophisticated Industrialized Housing features, and the extendibility of the basic CAD package (based on its language, etc.). A less tangible, but important consideration was how serious the vendor seemed to about including an energy evaluation module with their product, and under what conditions.

The evaluation process utilized searches of both evaluative and product literature (often published by the vendor), conversations with people who develop or have experience using CAD products, and evaluations of actual products provided by CAD vendors. In some instances, the data was not comprehensive enough to allow an evaluation, and those products were either eliminated from consideration or noted as not evaluated (Section 5.6).

Given these circumstances, the software packages evaluated fall into and are presented according five broad categories:

- those which meet the criteria (Section 5.2);
- those which could meet the criteria (Section 5.3)
  (if the criteria included Unix based computers);
- those which do not provide more than minimal features of use to industrialized producers of housing (Section 5.4)
  and those which do not meet the criteria.
- the package which does not fit the above categories(Section 5.5)
- those which were not evaluated(Section 5.6)

A tabular overview is presented at the end of the evaluations (Section 5.8).

5.2 SOFTWARE PACKAGES WHICH MEET THE CRITERIA

Two software packages currently meet all the criteria identified as crucial to the successful integration of an energy evaluation module for a CAD package in or of use to industrialized producers of housing. A third CAD package does not currently meet the criteria, but probably will with release of the next version (expected early 1992). The two packages which currently meet the criteria are:

SoftPlan and
SolidBuilder (with SilverScreen).

These packages run on DOS based PCs. SoftPlan is a standalone CAD package and SolidBuilder requires SilverScreen, a general purpose 3D solid modeling CAD program. Both SoftPlan and SolidBuilder have features created especially for light frame residential construction. Both have the capability to incorporate other building processes, systems and materials because of their open data structure. The evaluations follow (SilverScreen's evaluation is in section 5.4.3).

The alternative package is ASG's Architectural package which utilizes AutoCAD. While its currently released version does not have the ability to associate more than geometric data with walls (length, height, thickness), the next version is expected to have the capability to associate many attributes with the wall, and provide framing diagrams and drawings of floors, walls, and roof structures. ASG's product is provisionally included in this section, but the actual evaluation is printed in the next section.

5.2.1 SoftPlan

SoftPlan Systems Inc.
168 Lexington Court, Unit H
Waterloo Ontario, Canada N2J 4R9
519/886-9750

Technical Considerations

Hardware and Software Platforms

SoftPlan can run with a 80286 CPU under MS DOS with only 640K RAM. A math coprocessor is *not* required. SoftPlan is an architecturally specific standalone CAD package created especially for light frame construction.

CAD Capabilities

SoftPlan generates the third dimension (currently elevations only) from plan views and information entered by the user. This capability is based on an additional module. The process of creating sectional views of structures is unique in that architectural symbols (e.g., for insulation, framing members, etc.) can be placed automatically.

Program Architecture & Language

The architecture is closed and proprietary, but written in a 'C' type language. Its execution speed is very fast.

Database and Attribute Handling

SoftPlan uses object oriented programming; its data structure is extendible.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

SoftPlan produces many of the details necessary for externally oriented documents (plans, dimensions, sections, symbols, elevations) automatically.

Production Drawings and/or Features

Bills of materials (BOMs), estimating and cut lists are the primary features provided by SoftPlan. Framing diagrams of roofs, floors and walls are generated according to standard stick framing practices; trusses are not designed automati-

cally. Libraries of individual objects can be created and expanded. Objects in the drawing files can be grouped as well.

Research & Development Considerations

CAD Vendor Qualities

SoftPlan Systems is a small, privately held Canadian business. It is apparently growing rapidly, and is interested in adding energy evaluation capabilities. SoftPlan also provides exceptionally high quality, extensive documentation, accessible for the both the novice computer and CAD user as well as the experienced.

Summary

SoftPlan is a well regarded residential design package which very closely fits our criteria. Its main drawback may be that it is a proprietary system. SoftPlan has good production document capability and its software documentation is exceedingly good accommodating novice DOS and CAD users. Its greatest asset, however, is that it performs well on a very common and relatively unsophisticated hardware platform which is very likely to be in the office setting already.

5.2.2 SolidBuilder

Computer Integrated Building Corp.
P.O. Box 222
Occidental CA 95465
707/874-2826
with: **SilverScreen**
Schroff Development Corp.
P.O. Box 1334
Mission KS 66222
913/262-2664

Technical Considerations

Hardware and Software Platforms

SolidBuilder utilizes the extended version of SilverScreen, a standalone 3D solid modeling CAD package, and shares its hardware and software requirements. SilverScreen requires an 80386 CPU with math coprocessor and 4MB of RAM is

recommended. MS DOS is necessary. The extended version has been ported to aUnix (Silicon Graphics Personal Iris) system.

CAD Capabilities

SolidBuilder uses SilverScreen's CAD capabilities. SilverScreen offers full three dimensional CAD capabilities, including multiple user definable 2D views. Though primarily a 3D modeling program, it has fully functional 2D capabilities.

Program Architecture & Language

SolidBuilder uses SilverScreen's CAD capabilities. SilverScreen is open to developers writing in 'C'. It is written in 'C' and is fully compiled.

Database and Attribute Handling

SolidBuilder extends SilverScreen's 2 and 3D CAD capabilities by optimizing it for architecture, especially light frame construction. As such it shares the same CAD capabilities, program architecture, language, database and attribute handling: i.e., it is open, extendible, and object oriented. Objects and attributes are hierarchically arranged and attributes can be inherited among groups of objects. (Inheritance enables the program to account for attributes with having to define them all the time).

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features
In addition to the normally found 2D depictions, the 3D solid modeling functions of Silverscreen enable SolidBuilder to have good visualization and rendering capabilities.

Production Drawings and/or Features

SolidBuilder can automatically produce cut lists for stick framed walls, floors and roofs which include individual member dimensions and angles. It can also produce dimensioned framing drawings keyed to those lists. Presumably it can utilize SilverScreen's ability to produce standard CNC files as well for CAM (computer aided manufacturing) applications.

Research & Development Considerations

CAD Vendor Qualities

CIB has been very eager, helpful and is very interested in adding the energy evaluation capability to its package. CIB is currently working on adding structural analysis and truss design capabilities as well.

Summary

SolidBuilder (together with Silverscreen) seems to have the most precise fit to the criteria. The program has a fast language, open architecture, an extendible data structure and object orientation. Its biggest drawback may be its relatively small installed base, but given SilverScreen's file transfer capability, it can interface with virtually any CAD package. Both SilverScreen and SolidBuilder have clear support documentation which is useful to user unfamiliar with CAD. SolidBuilder's biggest asset is its sophisticated production document capability, which is applicable to both manual and automated production facilities.

Section Summary

The evaluation of ASG (which is provisionally included in this section) is found in section 5.3. ASG's currently released version does not meet the criteria, but a beta version apparently has the capability to meet the criteria. ASG has extensive architectural, HVAC and mechanical capabilities, and could probably integrate the energy tool.

SoftPlan or SolidBuilder both appear to be capable of successfully integrating the energy evaluation module. SoftPlan has the disadvantage of being a non U.S. company (with customs delays, etc.) and is in a different time zone from the University. SoftPlan has market appeal with its relatively unsophisticated PC platform requirements, good documentation and standalone quality.

SoftPlan's minimal hardware and software requirements could make it the best choice in this category. However, SolidBuilder has the same capabilities, plus the advantage of the open architecture and SilverScreen's other CAD capabilities as well. Both SilverScreen and SolidBuilder are very eager to bring the energy module into their products and have actively sought our opinion and supported requests for further information.

5.3 CAD PACKAGES FOR UNIX BASED COMPUTERS

The dividing line between PCs and workstations is becoming less distinct. Some higher-end PCs are approaching workstation-like performance and functionality, especially when the PC uses a Unix / Xenix operating system. In this category are those CAD packages which could probably integrate the Energy / CAD successfully, but technically do not meet the criteria because they run primarily on workstations or workstation like PC platforms.

5.3.1 Builders CAD

Integrated Computer Graphics Inc.
1120 Hope Road, Suite 100
Atlanta GA 30350
404/552-8800

Arris

Sigma Design Inc.
6251 S. Greenwood Plaza Blvd.
Englewood CO. 80111
303/741-5700 800/525-7050

Technical Considerations

Hardware and Software Platforms

Builders CAD requires hardware platforms capable of supporting Arris, typically Unix or Xenix environments such as workstations and some of the higher-end PCs (e.g.,those with Intel 486 chips running at 33 Mhz). Additional hardware requirements include a math coprocessor, an appropriate mouse. Builders CAD utilizes Arris, an architecturally specific CAD program and has features especially appropriate to residential scale design and construction.

CAD Capabilities

Builders CAD provides a full complement of CAD capabilities, including 3D solid visualization and shadow casting. Arris provides a wide range of support features, including file transfer capabilities with other CAD, presentation and analysis programs.

Program Architecture & Language

The architecture of the CAD program could be described as medium open; currently the program links objects to a text file for the materials analysis functions, and to user definable templates for more sophisticated applications. A more fully featured database is in development. Builders CAD is written in 'C.' Arris provides SIGMAC - a 'C'-based compiled macro and programming language for customizing, extending or creating special features or applications.

Database and Attribute Handling

Builders CAD apparently handles object attributes in two ways. The package assigns values or descriptions to an object in a direct correspondence, or assigns specifications to groups of objects in a template format. This latter method allows objects to be accounted for without having to be defined individually. For instance, the position and existence of every stud (or another element) in a wall need not be defined and made part of the drawing file, but can be calculated and displayed as necessary. Objects can be part of hierarchies, and pass attributes, again allowing attributes to be accounted for without redundant definition.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

Builders CAD supports the full range of drafting and drawing features necessary to produce documents for permit and marketing features.

Production Drawings and/or Features

Key production features include automatic framing generation for walls, floor and roof in both 2D and 3D views, complete with dimensioning. Materials optimization, requirement lists and cost estimates are also generated automatically.

Research & Development Considerations

CAD Vendor Qualities

ICG has been consistently helpful and quick to respond to questions. A working relationship seems possible and positive. They appear to support their product well, including a week of training with purchase, toll-free telephone support and a lease/purchase plan for acquisition.

Summary

Builders CAD is a sophisticated and powerful package having all the features which are technically desirable. It is unclear whether we would work closely with ICG or simply as a third party developer for their third party product. Possible drawbacks include the need for sophisticated hardware platforms and an additional CAD program.

5.3.2 DesignBid

Dickens Data Systems
250 Williams Street, Suite 1110
Atlanta GA 30303
404/448-6177

Technical Considerations

Hardware and Software Platforms

DesignBid will run on Xenix capable PCs, and on Unix based workstation (specifically the IBM RS 6000, Silicon Graphics and Sun Sparcstations). DesignBid is a standalone CAD program created especially for architectural applications.

CAD Capabilities

DesignBid generates the third dimension from plans, based on information given in the database which defines attributes of objects.

Program Architecture & Language

Currently the architecture of DesignBid is closed except to third party developers. DesignBid is written and extendible within the Xenix and Unix languages.

Database and Attribute Handling

The data structure is open to approved third party developers and can be extended. Extensions within the relational database can be according to item, assembly or packages of assemblies, utilizing inherited attributes. The database and drawing are fully interactive: manipulating an item in the database will change the object visualized. Some values with in the database are not currently accessible as more than text, i.e., the R-value of an object cannot currently be used in a calculation, but could be if the data structure were redesigned. Redesign of the data

structure is possible, and would be done by Dickens in conjunction with the developer.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

DesignBid is capable of producing 2D and 3D drawings as needed. Hidden line, rendered views, walk-throughs and fly bys are possible.

Production Drawings and/or Features

DesignBid automatically generates cut lists and materials lists. Labor costs and purchase orders can be accounted for as well.

Research & Development Considerations

Dickens Data Systems is very interested in expanding their third party development program at this time, but only in strategic directions (of which energy is one).

CAD Vendor Qualities

DesignBid has a small but significant installed base. The director of product development is articulate and perceptive, and willing to work with the University, under the right conditions.

Summary

DesignBid is a program which seems to have all the qualities necessary for successfully implementing the Energy / CAD tool. Their major drawback is the operating environment which may require substantial commitment to learn and work within.

5.4 CAD PACKAGES WHICH DO NOT MEET THE INDUSTRIALIZED HOUSING CRITERION

In this category are those packages which could probably successfully integrate of the Energy / CAD tool, but do not have production support capabilities beyond a Bill of Materials or equivalent. The lone exception is ASG, which does have those capabilities but not for walls. The degree to which integrating the Energy module with these programs varies individually, but all would probably require very clever or unwieldy programming strategies.

5.4.1 ArchiCAD v3.43

Graphisoft
400 Oyster Point Blvd., Suite 520 So.
San Francisco CA 94080
415/226-8720

Technical Considerations: Hardware and Software Platforms
Macintosh II family (Motorola 68020 CPU or better), 2 MB RAM (minimum), hard disk, math co-processor. Standalone Program

CAD Capabilities
ArchiCAD has complete 2D and 3D design and drafting capabilities

Program Architecture & Language
Proprietary system with GDL (Graphics Description Language) macros available to user/programmer. The GDL appears to be an interpreted language.

Database and Attribute Handling
Object Oriented Programming. Extendible data structure.

Applicability to Industrialized Housing Processes
Externally Oriented Documents: Drafting and Drawing Features
Details for externally oriented documents must be created manually.

Production Drawings and/or Features

Bill of Materials and spreadsheet format output of BOM.

Research and Development Concern

CAD Vendor Qualities

Graphisoft has not implemented features which would make it more attractive to the industrialized housing producer, apparently preferring to leave special implementations to the user.

Summary

ArchiCAD is a sophisticated, high-end architectural CAD package which is easy to learn and use; it is upgraded consistently and is well supported. The data structure seems to be capable of supporting attribute-rich object definitions and development of the Energy / CAD tool within the ArchiCAD environment may be possible. However, more comprehensive production features may need to be developed concurrently if the package is to be more attractive to the designers and marketers of industrially produced housing. Given the lack of industrial production features (other than the BOM/cost estimating function) this package cannot be considered a potentially successful candidate for integrating the Energy tool.

5.4.2 ASG: Core , Architectural, & Mechanical / HVAC

ASG
4000 Bridgeway, Suite 309
Sausalito CA 94965-1451
415/332-2123

ASG with: AutoCAD r.10 or 11

Autodesk Inc.
2320 Marinship Way
Sausalito CA 94965
415/331-0356

Technical Considerations

Hardware and Software Platforms

IBM compatible w/VGA, 2MB RAM, mouse or digitizer.
AutoCAD release 10 or 11.

CAD Capabilities
Full complement of 2D and 3D CAD features.

Program Architecture & Language
Compiled language. Runs on top of AutoLisp (interpreted). 'C' hooks for compiled language extensions are available with AutoCAD release 11, but apparently have not yet been utilized by ASG in this release, although they probably will be in a future release.

Database and Attribute Handling
Glued-attribute graphics (attaches attributes to point and line based objects). Apparently walls cannot currently be defined as more than 3D geometric objects, limiting their usefulness for energy calculation purposes.

Applicability to Industrial Housing. Processes
Externally Oriented Documents: Drafting and Drawing Features
Manual creation and insertion of details.

Production Drawings and/or Features
Roof and floor design and framing features are in development. Similar features for walls will apparently not be implemented due to restrictions in data structure and processing speed. Creation of both schedules and BOMs is supported.

Research & Development Considerations:
CAD Vendor Qualities
ASG responded quickly and effectively to requests for further information and support.

Socio/Political/Economic Concerns
EEIH would probably be working as a third party developer to a third party developer for this AutoCAD-based product.

Summary

The present lack of wall-defining attributes by ASG is a serious drawback; the interpreted language the program runs under (i.e., AutoLisp) is also a cause of concern, as it may cause computational delays (in comparison to a compiled language). Given that major CAD vendors will or have already implemented new generation CAD packages with object oriented programming and other desirable features (see the report Section 1.2), one should question and be very clear about whether a product based on current versions of AutoCAD is desirable for its own attributes or for AutoCADs currently installed base. See also Thumbnail 3D in the next section.

5.4.3 **CADVANCE** (PRISMA)

ISICAD, Inc.
1920 West Corporate Way, P.O. Box 61022
Anaheim CA 92803-6122
714/533-8910

Technical Considerations

Hardware and Software Platforms

Isicad offers two standalone architectural CAD packages which run on different platforms: PRISMA is a workstation based program, and CADVANCE is designed for DOS based PCs. Digitizers and/or mice are supported as necessary input devices. CADVANCE is currently being revised to run under Microsoft Windows, and third party developers are being solicited and supported.

CAD Capabilities

CADVANCE has a full complement of CAD tools.

Program Architecture & Language

CADVANCE provides an open architecture: features are accessible via a compiled language for third party developers, and in a different format for users developing macros.

Database and Attribute Handling

While providing database accessibility in a dBase format, CADVANCE does not

provide true object oriented data structure. Instead, attributes seem to be attached to graphic elements (points and lines), decreasing its applicability for the Energy / CAD project. The CAD file and database seem to have only a one way link, i.e., they do not interactively edit each other. Manipulation of the database is open to the user.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features
Details for these kinds of documents require manual placement and revision.

Production Drawings and/or Features

CADVANCE provides a database which can be manipulated according to the users need and skill. Features such as framing or cut lists are not available.

Research & Development Considerations

CAD Vendor Qualities

ISICAD is currently supporting third party developer efforts by providing access (open architecture) and a software development kit.

Summary

CADVANCE has some attractive aspects (apparently it provides a most capable networking facility as well as running within MicroSoft's Windows (Yares, 1991). ISICAD is receptive to the idea of including an energy evaluation package and a major rewrite of the program is available in alpha for third party development. However, the current lack of facilities with specific application to industrial production of housing disqualifies CADVANCE at this time.

5.4.4 DataCAD

CADKEY, Inc.
4 Griffen Road North
Windsor CT 06095-1511
203/298-8888

Technical Considerations

Hardware and Software Platforms

DOS-based: IBM AT, PS/2 or compatibles, 3MB RAM , 20MB hard disk, math co-processor, mouse and/or digitizer. DataCAD is also available on three Unix stations (the Sun Sparcstation, the Sony NEWS and Silicon Graphics' Personal Iris). DataCAD is a stand-alone CAD package.

CAD Capabilities

DataCAD provides a full complement of 2D and 3D CAD functions and operations.

Program Architecture & Language

DataCAD is open to third party development, and provides compiled language access with a Pascal/Modula 2-like language called DCAL.

Database and Attribute Handling

The data structure is extendible and based on objects; the database is open to assigning values and data to objects.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

DataCAD can produce any necessary documents. Walk-through and fly-by functions are also available.

Production Drawings and/or Features

Bills of materials can be derived from the database associated with the CAD file. Apparently no other features which apply directly to industrial production settings (cut lists, framing diagrams, etc.) are provided.

Research & Development Considerations (DataCAD)

CAD Vendor Qualities

Cadkey is interested in and soliciting third party development. Their recent reorganization, release and support of the 'C' based current version is apparently utilizing all of their resources.

Socio/Political/Economic Concerns

DataCAD is one of the largest CAD vendors outside the USA for PC-based products . Their more sophisticated European packages include features such as framing for roofs, stairs and other structures; whether these features will be released in the U.S. soon is not clear. (Falicoff,1991)

Summary

DataCAD was created especially for use by architects, but currently does not have much emphasis on housing production, except for the generation of a bill of materials. Cadkey, however, does have the expertise to include more production-oriented features (but has denied intentions to do so for the USA in the near future). As an architectural design package in general, DataCAD is one of the more sophisticated and potentially capable CAD packages reviewed

5.4.5 **Drafix CAD** (Ultra, Windows)

Foresight Resources Corporation
10725 Ambassador Drive
Kansas City MO 64153
816/891-1040

Technical Considerations

Hardware and Software Platforms

WindowsCAD supports DOS capable compatibles; mice and digitizers are supported. Drafix is an architecturally specific, standalone CAD system.

CAD Capabilities

Drafix CAD is available in various configurations and with optional modules to extend its capabilities. 2D functions are provided and seem to be the strongest feature. The 3D features are accessories to the 2D. IGES and DXF formats are supported.

Program Architecture & Language

The architecture is closed, but open to third party developers. A macro language is provided.

Database and Attribute Handling

The data structure is proprietary, but could be extended. Attributes seem to be associated with graphical entities, not objects.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

Details are obtained from libraries or created and manually placed. The third dimension is an option,, i.e., elevations would need to be generated.

Production Drawings and/or Features

Drafix CAD programs are general purpose CAD programs, and not optimized for architecture, or industrial production of housing. The data structure allows creation of BOMs, or other user definable reports which can be manipulated in a spreadsheet.

Research & Development Considerations

CAD Vendor Qualities

Foresight Resources enjoys a comfortable reputation for making a sophisticated yet inexpensive CAD program. They are quick to respond to requests and have listened carefully to concerns. They do not seem interested in aiming features at a special market, but are willing to work with us in developing such a product as third party developer.

Summary

Drafix is a sophisticated drawing program with a good user interface. However, its lack of architecturally specific applications eliminate it from consideration.

5.4.6 MacArchitrion

Gimeor, Inc.
1815 H St.
Washington D.C. 20006
202/546-8775

Technical Considerations

Hardware and Software Platforms

Architrion utilizes the Macintosh II family of computers (Motorola 68020 and better CPUs) and operating systems. A math coprocessor is recommended. Architrion is a standalone architectural CAD program.

CAD Capabilities

Architrion has complete 3D CAD capabilities. 2D representations are accessed via projection of the 3D object into section or elevation and addition of 2D elements.such as lines, patterns and text.

Program Architecture & Language

The architecture is proprietary and closed. The language appears to be compiled.

Database and Attribute Handling

The data structure appears to be extendible. Attributes are associated with objects.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features
Details for externally oriented documents (permit drawings, reports, etc.) are manually created and positioned; they may be stored in libraries.

Production Drawings and/or Features

Materials lists can be derived from the object oriented database. Framing diagrams and other features of interest to industrially based housing producers are not manifest.

Research & Development Considerations

CAD Vendor Qualities

Gimeor has constantly upgraded its product, enabling it to be one of the more sophisticated design oriented CAD tools available. Gimeor has responded quickly and effectively to concerns and requests for support.

Summary

Gimeor is a European company. Architrion provides an object oriented, 3 dimensional architecturally specific CAD environment. However, its closed architecture and lack of sophisticated production features (in comparison to Builders CAD or SoftPlan, for instance) remove it from consideration.

5.4.7 MicroStation

(MicroStation Mac, MicroStation PC)
Intergraph Corporation
Huntsville AL 35894-0001
205/730-2000 800/345-4856

Technical Considerations

Hardware and Software Platforms

Intergraph provides general purpose CAD packages which run on Macintosh, IBM (and compatible) PCs and workstations. Digitizers are recommended, and mice are supported. n general MicroStation requires a more sophisticated hardware platform. Microstation is a standalone general purpose CAD package.

CAD Capabilities

Microstation provides a full range of CAD functions.

Program Architecture & Language

MicroStation provides an architecture open to third party developers which uses a compiled 'C' type language. Modifications by the capable user can be written in an interpreted 'C' type language. The complexity of the program apparently makes writing additional features a difficult and demanding process. (Falicoff, 1991).

Database and Attribute Handling

The data structure is extendible. Attributes are attached to graphic objects within a hierarchical structure.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

MicroStation is capable of producing requisite documents. with manual placement of details.

Production Drawings and/or Features

Various reports are possible, if specified by the user. Framing diagrams, cut lists and other applicable capabilities are apparently not available.

Research & Development Considerations

CAD Vendor Qualities

Intergraph is a large corporation whose interest seems to be in upgrading and improving their product, not necessarily optimizing it for special market niches.

Summary

Despite its large base and general acceptance in the design/engineering fields, MicroStation has not been optimized for residential architectural use, much less the industrial production of housing.

5.4.8 MiniCad + 3.0v2

Diehl Graphsoft, Inc.
8370 Court Avenue, Suite 202
Ellicott City MD 21043
301/461-9488

Technical Considerations

Hardware and Software Platforms

MiniCad + runs on Macintoshes having 2 MB of RAM and a hard drive. It is a standalone, general purpose CAD program.

CAD Capabilities

MiniCad offers 2D and 3D CAD capabilities; drawing in 3 dimensional views is possible, but simultaneous multiple views of the same object are not possible. Some third dimensional capabilities require an additional software module.

Program Architecture & Language

The architecture is best described as semi-closed: a Pascal-type language is available to the programming-literate user for creating macros or modifying the database. This interpreted language is probably not as fast as the compiled language of the program itself.

Database and Attribute Handling

The data structure is extendible within the relational database. Attributes can be attached to graphical or three dimensional objects, and manipulated by the integrated spreadsheet. Macros for specific purposes are available from third party sources.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

No automated architectural functions are provided. Objects, symbols and details can be stored in hierarchical libraries, and manually placed in drawings.

Production Drawings and/or Features

With the exception of reports generated from the relational database, MiniCad has not been optimized for industrial production.

Research & Development Considerations

CAD Vendor Qualities

Diehl Graphsoft has consistently improved and upgraded this program. Whether they are interested in developing more specialized capabilities is unknown.

Summary

MiniCad is a well-regarded middle range general purpose CAD program. Its lack of automated production features beyond the database and the interpreted language hooks make it less likely to successfully integrate the Energy package.

5.4.9 Point Line

Robi Graphiks, Ltd.
122 E. Olin Avenue, Suite 270
Madison WI 53713
608/256-3025

Technical Considerations

Hardware and Software Platforms

Point Line runs on MS-DOS capable machines. Digitizers and mice are supported and recommended. Special graphics cards (engines) are recommended for speeding up onscreen redraws. Point Line is a standalone general purpose CAD package which seems to be primarily used for architecture.

CAD Capabilities

Point Line is a fully featured 2D CAD program. The third dimension, solid modeling, rendering and fly-by / walk-through features are accessible via other software modules.

Program Architecture & Language

Point Line is open to third party developers, and is written in a 'C'-type compiled language. Other access is available via a Pascal-like language.

Database and Attribute Handling

The data structure is extendible and manipulatable.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features
Wall entities (types, intersections, etc.) are available, an apparently make producing documents a little easier. Libraries for symbols and details exist and are extendible.

Production Drawings and/or Features

Point Lines database enables BOMs and estimating reports to be generated.

Research & Development Considerations

CAD Vendor Qualities

Robi Graphics provides a well-regarded CAD package, and upgrades and improves it frequently. They are quick to respond to questions and concerns about their hardware or software, and appear interested in expanding their capabilities, having few third party applications on the market (perhaps because their CAD package is so complete).

Summary

Pointline is one of the first of the new-generation CAD packages, providing object orientation and an extendible data structure with a compiled language. Pointline appears to be growing steadily and consequently appears to have few resources to support third party or special market niche concerns. Despite its strengths, it offers only the estimating package and database as features attractive to industrial producers of housing. The development of the Energy module would probably rest almost entirely with EEIH.

5.4.10 SilverScreen

Schroff Development Corp.
P.O. Box 1334
Mission KS 66222
913/262-2664

Technical Considerations

Hardware and Software Platforms

SilverScreen requires an 80386 CPU with math coprocessor and 4MB of RAM is recommended for the extended version (evaluated). Another version is available for the 80286, and requires a coprocessor as well, but only 640K of RAM. MS DOS is necessary. The extended version is also available for Unix (Silicon Graphics Personal Iris) systems. SilverScreen is a standalone CAD program created especially for 3D solid modeling.

CAD Capabilities

SilverScreen offers full three dimensional CAD capabilities, including multiple user definable 2D views. Though primarily a 3D modeling program, it has fully

functional 2D capabilities.

Program Architecture & Language

SilverScreen is open to developers writing in 'C'. It is written in 'C' and is fully compiled.

Database and Attribute Handling

The data structure is open, extendible and object oriented. Objects and attributes are hierarchically arranged and attributes can be inherited.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

Like most other CAD packages, Silverscreen requires manual placement of details or symbols which are not objects themselves. Dimensioning is parametric and associative.

Production Drawings and/or Features

SilverScreen's database can be manipulated to provide schedules (for inclusion in the drawing or other documents), BOMs, and CNC files (*for Computerized Numerical Control machines such as computer guided saws; an example of this would be PF Cutting microcomputer-based touchscreen controlled saw). Cut lists can include dimensions and angles.

Research & Development Considerations

CAD Vendor Qualities

Schroff Development has been very helpful and quick to respond to questions and concerns. They are interested in enlarging the capabilities of Silverscreen and are eager to work with us. They have indicated they would be willing to incorporate the basic energy algorithm and tool design, adapting it to their program.

Summary

SilverScreen is nearly exactly what we are looking for: it is object oriented, has an extendible data structure, and has sophisticated 3D capabilities. It is also a new product with a relatively small installed base and requires a moderately highend PC to run. However, Silverscreen does not currently have wall or roof framing ca-

pabilities,(but has an interactive deck design package which does exhibit the potential to do so for complete structures) and that is what moves it out of the most acceptable category to this one. Please see SolidBuilder as well (Section 5.4.1).

5.4.11 VersaCAD Mac 4.0

Computervision
100 Crosby Drive
Bedford MA 01730
617/275-1800

Technical Considerations

Hardware and Software Platforms

VersaCAD runs on many PC and workstation (Unix) platforms; this version requires a Macintosh with a 68020 CPU (or better) with a math coprocessor, and 2MB RAM minimum. VersaCAD is a standalone general purpose CAD package.

CAD Capabilities

VersaCAD provides a full range of 2D and 3D CAD capabilities. File translation in both IGES and DXF formats are supported as well as PICT (paint) and EPS (Encapsulated Postscript). Parametric design functions are provided.

Program Architecture & Language

VersaCAD is developed in a compiled language environment with 'C' binding. It is open to developers, and to users via the API (Application Program Interface) which allows customization of the program and integration of third party software.

Database and Attribute Handling

The data structure is open, and extendible to limits of the system by the use of pointers (to other data structures not located within the CAD file). Object hierarchies can be created, and attributes are attached to graphical entities. The database is accessible to and manipulated in HyperCard; a BOM is the standard report format, and other formats can be created.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

These kinds of documents can be created manually within VersaCAD. Hidden line and rendering capabilities make 3D views possible. Symbols and objects can be created or imported and stored in libraries. Objects can be grouped hierarchically and saved.

Production Drawings and/or Features

Excepting the Bill of Materials and the manipulatable database, VersaCAD does not provide production features such as dimensioned framing diagrams or cut lists.

Research & Development Considerations

CAD Vendor Qualities

VersaCAD and Computervision are part of Prime, the second largest CAD software company. They have been quick to respond to questions and concerns.

Summary

VersaCAD meets most of our criteria, but we must question whether the BOM and other potential database features are sufficient, given that other programs do provide more attractive features as well as the BOM. In addition, the energy module would probably need to be developed with the EEIH acting as a third party developer, with full project responsibility; VersaCAD has already supplied the open architecture, and it is not clear what other support is available.

5.5 CAD PACKAGES WHICH DO NOT MEET THE CRITERIA

These software packages simply do not have the data structure which can support the kind of information we need, and / or do not have production features. The packages(s) presented here were evaluated because of they had 3D capabilities. Many other products could have been listed here, but were eliminated from consideration in the initial survey.

5.5.1 Thumbnail 3D

Integrated Computer Graphics Inc. (ICG)
1120 Hope Road, Suite 100
Atlanta GA 30350
404/552-8800

AutoCAD
Autodesk Inc.
2320 Marinship Way
Sausalito CA 94965
415/331-0356

Technical Considerations

Hardware and Software Platforms

Thumbnail will run on any platform which supports AutoCAD releases 10, 10/386 or 11; the optimal configuration is an 80386 CPU with math coprocessor, hard drive and at least 6 MB of extended memory (RAM or virtual (hard disk) RAM).

Mice are supported and recommended, and digitizers are not (the package uses pull down menus). The latest available version of AutoCAD is preferred.

CAD Capabilities

Thumbnail is predominantly a 2D package which creates a three dimensional model based on plan based information and user inputs (for eave / roof heights, configuration and etc.).

Program Architecture & Language

The architecture is as open as AutoCAD, and takes advantage of the high level 'C'

binding hooks provided by AutoCAD release 11, but is apparently still constrained by AutoDesk's LISP-type interpreted.language.

Database and Attribute Handling

The data structure is extendible via the AutoCAD R11 hooks, but within the limitations of AutoCAD itself. Attributes are derived from and glued to graphical representations of volumetric zones (bedroom, living room, etc.), and can be reported. However, manipulation of these volumetric attributes (area, lengths, numbers of items) needs to be done within another application.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

Details can be created and stored in libraries for use in creating drawings manually.

Production Drawings and/or Features

No production facilities other than the material and area takeoffs are supported.

Research & Development Considerations

CAD Vendor Qualities

ICG has been quick and conscientious in responding to requests and concerns. They have been forthright in expressing doubts that this AutoCAD based package can support the data structure required to be of use in energy calculations or industrial production scenarios. Given they have implemented some of these features in their higher-end product (Builders CAD), that judgment is accepted.

Summary

Given the lack of industrial production features and the limitations of the underlying CAD package, and ICG's own assessment, this program will probably not be able to successfully integrate the Energy tool.

5.6 CAD PACKAGES NOT FITTING PREVIOUS CATEGORIES

This last category is for a CAD package which does not really fit in any of the preceding categories because it is in some ways more like a black box than a graphically oriented CAD package. It offers an array of unique features including the ability to integrate with other CAD packages and databases.

5.6.1 D++

Design Power, Inc.
10020 North De Anza Boulevard
Cupertino CA 9501
408/366-6600

Technical Considerations: Hardware and Software Platforms
Many CAD hardware or software platforms could be supported by this program.

CAD Capabilities
D++ is an object oriented, knowledge based tool intended to complement existing CAD packages, but is not limited to graphical manipulations. Basically, this program enables one to add knowledge in the form of rules or processes which aid in handling data. CAD packages in general are becoming 'fronts' or graphical means of viewing data which is used by many kinds of applications (such as financial and structural analyses, inventory control, relational databases, etc.).

Program Architecture & Language
D++ is open to definition by the user; it furnishes SQL links to relational databases as well as links to libraries, desktop publishing programs and other CAD systems.

Database and Attribute Handling
The data structure is open to extension, and attributes are only limited by choices of database and / or CAD packages. 'Intelligence' can be added by description (of an object), inheritance of attributes and by modeling processes; design rules can be specified and implemented.

Applicability to Industrial Housing. Processes

Externally Oriented Documents: Drafting and Drawing Features

Production Drawings and/or Features

D++ could be limited by the choice of CAD package(s) for which it is optimized to complement. As concurrent engineering practices become more widespread (BusinessWeek, 30 April 1990,) the ability to model processes may become as important a feature for designers and manufacturers as modeling products or the production of cut lists, framing layouts or links to inventory control are currently.

Research & Development Considerations

CAD Vendor Qualities

Design Power is a small and seemingly eager company with a unique product. They seem able and willing to work with us, and appear to have strong ties to the academic setting (i.e., the engineering program at Stanford) (Axworthy, 1991).

Summary

D++ may be the perfect 'black box' for the Energy / CAD tool. But it is not in use by the housing industry, has no directly applicable features, and seems to require a high level of understanding of design and engineering process to really be well applied.

However, because of D++'s ability to incorporate rule-based 'intelligent' processes, it may be a good platform for developing a comprehensive conceptual design / energy strategy and assessment tool which complements other more traditional CAD tools. The Energy / CAD tool in this case would probably be a generic energy evaluation product which DP Inc. would optimize for a given CAD package upon a customers request.

5.7 CAD PACKAGES NOT EVALUATED

Some software packages were of interest, but either not truly applicable, or not evaluated with a degree of rigor sufficient to place accurately within a given category. These packages are noted here.

5.7.1 Draw

HOK/CSC
1831 Chestnut St., Suite 601
St. Louis MO 63103
314/621-4700

5.7.2 MegaCADD

MegaCADD
65 Marion St., Suite 301
Seattle WA 98104
206/623-6245

5.7.3 Memsco Systems

P.O.Box 389
Saco ME 04072
207/934-5645

Note: Memsco Systems appears to be a rule-based panel building system with both computer hardware / software and manufacturing components. It does not appear to be a full CAD environment. (Maloney, 1991) Like other panelizing software, Memsco appears to develop framing information from designs developed elsewhere.

5.7.4 The Plan

Ted Dasher & Assoc.
4117 Second Ave. S.
Birmingham AL 35222
205/591-4747

5.7.5 ProfitCAD

Construction Data Control, Inc. (CDCI)
3675 Crestwood Parkway, Suite 400
Duluth GA 30136
404/279-0304

5.7.6 UniStar (WallStar, TrusStar, TrakStar)

On-Line Data, Inc.
P.O. Box 832750
Richardson TX 75083-2750
214/238-9609

Please turn page for Tabular Summary

CAD Packages Meeting Criteria

	SolidBuilder & SilverScreen	SoftPlan	ASG & AutoCAD	Builders CAD ICG & Arris	DesignBid Dickens Data System
Applicability to Industrialized Housing					
- Automated Production Features: Dwgs, Documents, Files	Wall, Roof Framing, Cut Lists, NC Files	Wall, Roof Framing, Cut Lists	Wall, Roof Framing, Cut Lists	Wall, Roof Framing, Cut Lists	Wall, Roof Framing, Cut Lists
- Automated Permit Dwgs, Drafting, Estimating	Yes	Yes	Yes	Yes	Yes
Programmatic & Technical Capabilities CAD / Design Features	Yes	Yes	Yes	Yes	Yes
Language Dependant Features: Compilation, Hooks, Open/Closed Architecture	Compiled 'C' Open Arch. Hooks in 'C'	Compiled 'C' Closed Arch.	AutoLisp, 'C',	'C' Partly open	'C' Partly open
Data Structure, Types, & Extendability	Object Oriented Programming, Extendable structure	Object Oriented Programming, Extendable structure	Attribute glued graphics, Extendable structure	Object Oriented Associations, Extendable structure	Object Associations, extendible
Attribute Field Constraints and Opportunites	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained
Comments Please also refer to the complete description / evaluation in the Appendix	Sophisticated solid modeling & light construction packages	Requires only a very simple DOS PC to run	DOS, 386 w/ co-processor	Unix Platform req.	Unix Platform req.
Prices / Installed Base	$5,000 (incl. SilverScreen) / Just Released	$4,500 / 10 pk.	A'CAD: $3,500 (R 11) / NA ASG: $3,255 (all opts.) / NA	Basic: $10,000 Framer: $15,000 />100	$17,500 / N/A

CAD Packages Not Meeting All Criteria

ArchiCAD	CADvance	DataCAD	WindowsCAD (Drafix CAD)	InterGraph Microstation	Mac-Architrion II	MiniCAD+
BOMS, other reports	BOMS, other reports	BOMS, other reports	BOMS, other reports	BOMS, other reports	BOMS, other reports	BOMS, other reports
No	No	No	No	No	No	No
Yes	Yes	Yes	Yes 2D (+3D)	Yes	Yes	Yes 2D (+3D)
Compiled; Open with Macros.	Open Architecture Open to 3rd party dev.	DCAL (compiled) Open to 3rd party dev.	Open to 3rd party dev.	Open to 3rd party dev.	Closed	Semi - closed: macro capabilities.
Object Oriented, structure extendable w/ macros	Attribute glued graphics; extendible	Object Oriented; extendible	Attribute glued graphics; extendible	Attribute glued graphics; extendible	Object Oriented; Extendible	AGG and OOP; extendible
Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained
Sophisticated arcitectural CAD for Macintosh	Sophisticated arch. CAD for PCs	Sophisticated arch. CAD for PCs	Midrange general CAD capabilites	Diverse Capabilities; Hardware available	Sophisticated arcitectural CAD for Macintosh	Midrange general CAD capabilites
$4,450 / 5,700 (worldwide)	$3,495 / 25,000	$3,495 / >75,000	$695 / approx. 40,000	$3,450 / N/A	$3,950 / 1,450 (US) 7,000 (world)	$795 / N/A

CAD Packages Not Meeting All Criteria, cont.

	Pointline	SilverScreen	VersaCAD Mac	Thumbnail 3D ICG & AutoCAD	D++
Applicability to Industrialized Housing					
- Automated Production Features: Dwgs, Documents, Files	BOMs, other reports	Various Reports	Various Reports	Schedules, Reports	See Notes and Evaluation
- Automated Permit Dwgs, Drafting, Estimating	No Some Yes	No Some See notes	No Some See notes	No Some See notes	See Notes and Evaluation
Programmatic & Technical Capabilities CAD / Design Features	Yes 2D & 3D	Yes 3D solid modeling	Yes 2D & 3D	See notes; 2D & 3D	See Notes and Evaluation
Language Controlled Features: Compilation, High level hooks, Open/Closed Architecture	'C' Open to 3rd party dev.	'C' Open	'C' Open to 3rd party & individual dev.	See notes	See Notes and Evaluation
Data Structure, Types, & Extendability	OOP Extendible	AGG w/ object hierarchies and associations	OOP Extendible	See notes	See Notes and Evaluation
Attribute Field Constraints and Opportunites	Virtually Unconstrained	Virtually Unconstrained	Virtually Unconstrained	Constrained	See Notes and Evaluation
Comments Please also refer to the complete description / evaluation in the Appendix	Sophisticated architectural CAD package	Sophisticated 3D solid modeling / CAD package	Sophisticated general CAD package	See notes	See Notes and Evaluation
Prices / Installed Base	N/A N/A	$2,995 ($ 5,000 Unix) / 400 users @ 270 sites	$3,495 / approx. 100,000	$749 / 80	$38,500 / 75 world-wide

Computer Based Tools Not Evaluated

Draw	MegaCADD	Memsco Systems	The Plan	ProfitCAD	UniStar	
Yes	Yes	See notes	Yes	See notes	Yes	
Yes	See notes	See notes	See notes	See notes	See notes	
2D & 3D	2D & 3D	Production Package	Production Package	See notes	See notes	
Under Revision	N/A	N/A Closed	N/A Closed	N/A Closed	N/A Closed	
Under Revision	N/A	N/A	N/A	N/A	N/A	
Under Revision	N/A	Constrained; see notes	N/A	N/A	N/A	
Currently not in release while being revised.		Production software; hardware (computing and production) available.			Production software; computing hardware available.	
N/A N/A	N/A N/A	$15,000 (comp.system) / 40-50 world wide	$500/mo.(1 user) $700/mo.(site); Inst.Base N/A	$3,000 - 8,000 / 9,000 users	$995 / mo. (3 user) / 150 sites	

6.0 APPENDICES

6.1 PERFORMANCE CRITERIA FOR THE ENERGY TOOL

In this section, the ideal Energy / CAD tool is conceptually described. Given the nature of the tool and the setting, the Energy / CAD tool is subject to redefinition, according to the capabilities of the actual CAD package with which it will be integrated. Consequently, the following description may turn out to be inaccurate. Nevertheless, certain features are critical to have if the tool is to meet the needs of its intended user base (Riddle, June, '90). These features are primarily issues of interface design and functionality, both of which are interrelated and interdependent. The Energy / CAD tool must meet the varied needs of the many CAD-based design environments, from large corporations to small semi-custom builder.

Some key concepts bear repeating: the Energy / CAD tool is not intended to be a certified energy code compliance tool (see Section 6.4), nor is it intended to supply an absolute degree of precision in predicting actual energy use. However, it is intended to function as comprehensively as possible throughout the design / evaluation process while providing relatively accurate energy use predictions.

6.1.1 Who & What Tool is for

The energy / CAD tool is intended to dynamically evaluate residential scale design decisions within a CAD environment which supports the industrial production of dwellings. It will provide the designer with immediate feedback about the energy implications of design decisions. The Energy tool is intended to be used by designers and building construction professionals who do not have extensive proficiency in thermal analysis, but do have knowledge and experience with building design, configuration and construction.

In its most developed form, the tool will use data as it is developed in the CAD environment to dynamically prepare an evaluation of energy implications. The dynamic nature of the tool lends itself to immediate feedback for the designer, who can use it to do iterative, what-if kinds of explorations. For instance, if the designer adds, deletes or changes a window in a given wall, she or he will be able to see the effect immediately (within a few seconds).

6.1.2 Conceptual and Functional Guidelines

Given the dynamic nature of the tool, the evaluation process should be fairly streamlined and as efficient as possible. For instance, after the initial calculation, the contribution of individual assemblies (such as walls or rooms) need not be recalculated until changed,if this strategy is faster than recalculating the whole structure. Likewise, calls to slow memory (i.e., hard drives) should be minimized as a means of minimizing the calculation process and decreasing the feedback time.

6.1.3 General Areas of Functionality

Components (such as pre-designed rooms, equipment or constructional assemblies) can be drawn, selected from libraries, or entered via fill in the blank processes. Non-envelope loads which can be applied to the the equation will probably include generic appliances (DHW heater, stove, range, AC, etc.). These components could include variables (such as energy input type: gas, electric; and relative efficiency: high, medium and low) and conditions of use (# of persons in household) which are selected by the user through the prompted interface.

The appropriate, already calculated energy figures for these stock components can then be applied immediately to the energy calculation. For instance, a pre-designed bathroom with an exterior wall of a given construction type will provide a known energy contribution which need not be recalculated each time it is placed into a design.

Through a summation and transformation process, the tool will present a summary of energy use to the user. The summation process will probably include calculation of both known and new design data in some combination. Transformation of energy data will include changing raw energy use figures e.g., MBTUS) to normalized figures (BTUs/SF, $/SF, etc.). The tool should also be able to predict periodic costs of the buildings energy requirements given the local utility rate structure and chosen energy source(s).

The periodic duration should be user definable. Other user defined attributes will include variables such as climate, insulation values, and credits / inputs for alternative energy sources such as passive solar gain, or passive cooling techniques.

Output formats should include tabular and graphic summaries (at the users discretion). Comparative outputs will be an optional output format, and will be based upon iterations which have different conditions - for instance, in one case the user may wish to see the implications of using gas for heating, and in another case using electricity. Case A could be displayed in one column and case B in the next. Because the envelope characteristics have not changed in this case and the envelope load is already calculated for that location, only the appropriate part of the calculation need be redone. For purposes of comparison, output will include area and climate normalized figures ($/SF, BTU/SF/DD etc.) as well as absolute figures.

In its most developed form, the tool should be able to prepare other-case scenarios using trend data - for instance, knowing that the local utility is planning on or has raised rates at n%/yr., the program could calculate future scenarios and payback periods for various configurations. In the tools most developed form, it should account for other energy systems such as photovoltaic energy production and consumption, and could even compare whole alternative energy systems with 'traditional' systems. When information of this nature becomes available, it should be entered via a structured input sequence by a user who can obtain this kind of data, yet need not understand how to input it.

Another kind of the input which should be available is the local cost and availability of both conservative and productive resources. For instance, the cost/ square foot (SF) of fiberglass and the cost of blown cellulose or airkrete may be a known variable (known to, input and modifiable by a local user; again through a prompted process).

The interface should allow the user to make both global and local changes to the design - for instance seeing the cost/benefit implication of using an all fiberglass insulated structure; changing it to an all cellulose insulated construction system; then checking to see if some combination of construction types is more effective.

Likewise, if a contribution of solar heat for DHW use or space heating is known, one ought to be able to enter those contributions via a similar structured input sequence.

One should be able to enter values directly into a table for a feed-forward kind of calculation which could then inform the design process. Given a certain climate, the program calculates a simple envelope load, disregarding other factors (orientation, user and equipment schedules, etc.). In this scenario, the designer should have the ability to adjust floor area, construction type and glazing attributes to fit a certain design program, before actually drawing the building. At a more advanced stage of design, the graphic and alphanumeric data should be linked and the user should have the ability to edit the tabular data alphanumerically. Tabular changes should either change the graphic or prompt the user to change the graphic.

This tool should display a kind of "intelligence" in that it 'knows' about and can apply attributes of materials to the evaluation equation as the design data is developed, or prompt the user for more information about the project. In effect, it does not need to be expert itself but prompts the user to provide the intelligence. For instance, as one draws a wall, the program knows the area and thermal characteristics which the wall is contributing to the building, but need not itself 'know' or decide what the wall is made of; these attributes can be automatically generated or input manually (following prompts).

If local climate data (or other kinds of data) are available, the program should have a facility which prompts the user to enter data with the correct format, and check it for anomalous conditions (such as a solar contribution when the sun is below the horizon). In this case, 'local' means geographically or climatalogically closer to the site than default climate data; the program could even prompt the user to make such a determination by comparing the buildings local terrestrial variables (latitude, longitude, altitude) to the default climate's terrestrial attributes.

Probably the most important functional requirement for the Energy tool is that it have the ability to meet the requirements of its user - both in terms of flexible

input methods and definable output formats. While the features noted above pose very difficult software design challenges, the sophisticated user / computer interface is not optional, given the nature of the probable user, and need to perform dynamic calculations with a relative degree of accuracy (Riddle, June '90; Kim, June '91).

6.2 INPUTS REQUIRED FOR THE ENERGY TOOL

This section contains information about the kinds of inputs an energy evaluation program requires to perform building and context specific energy use calculations. The actual inputs which would be used are dependent upon the level of precision the calculation is intended to achieve. Therefore, some of the inputs presented here may actually be too specific for the a calculation early in the design phase, but may be appropriated given another situation.

6.2.1 LIST OF GENERAL INPUTS

Materials Attributes

- R-Value
- U-value
- DHC
- Embodiment
- People: Occupancy variables
  - Number of people
  - Time / hours present during day
  - Activity levels
  - Zones (Square feet area: SF)

Lighting inputs

- (on, off, on as needed)
- Lighting levels required
- (interior, exterior)
- (when occupied, when not)
- (project/Energy consumption)
- Hours / time in use
- Zones (SF) (schedule)

Equipment Inputs

- (on, off, on as needed)
- (which / how many hours)
- Type of units
- # of units (each type)
- BTUs prod./unit, ea.
- BTUs cons./unit, ea.

Zones

(SF) (schedule)
Shades (interior) [(on, off,as needed)
(which/how many hours)(priority)]
Shades (exterior) [Variables same]
Cross Ventilation [Variables same]
Stack Ventilation [Variables same]
Night Ventilation / Mass [Variables same]
Night Insulation [Variables same]
Allowable Temperature (interior)
Maximum Temperature (Variables: what temp., which hours)
Minimum Temperature (Variables: what temp., which hours)
Ventilation Temp. (Variables: what temp., which hours)

Climate Data

Data source:
City /Region Name
Latitude (degrees N / S)
Longitude (Greenwich West)
Standard Meridian
DD65 (degree days for 65°F)
SWWT
Month #
Day, day type (clear, cloudy)
Hour (1-24); for each hour:
Temperature
avg. max.
design max.
avg. min.
design min.

Climate Data, cont.

Default days

- Rel.Humidity
  - avg. max.
  - design max.
  - avg. min.
  - design min.
- Wind
  - direction
  - Speed
- Radiation(daily /hourly total)
- Cloud coverage%)
- Altitude / air density(std. day)

6.2.2 Building Elements Used for Energy Use Calculations

Elements Perceived in Plan Views

Note: Units are not provided in this section. For a more complete definition of elements and units, see literature associated with products mentioned in Section 6.3.2 'Energy Evaluation Software.'

Roofs

- Area
  - pitch value
  - Area/pitch algorithm
- orientation
  - Nominal (NESW, etc.)
  - Angular (azimuth)
- Materials
  - reflectance
  - R value (gain)
  - R value (loss)
  - R value (per position)

Elements Perceived in Plan Views, cont.

Roofs

- Materials
  - DHCs
  - lag time
  - decrement values
  - absorptivity / conductance
  - Embodiment
- Mass (present / not present)
  - mass type
  - mass thickness
  - Mass thermal qualities
  - R-Value
  - U-value
  - DHC
  - Embodiment

Floors

- area
- Materials
  - reflectance
  - R value (gain)
  - R value (loss)
  - R value (posit)
  - DHCs
  - lag time
  - decrement values
  - absorptivity / conductance
  - Embodiment
  - solar zone
- mass (present / not present))
  - mass type
  - mass thickness
  - mass thermal qualities
  - R-Value
  - U-value

DHC

Embodiment

perimeter length

perimeter conditions

Relation to other spaces

slab on grade

vented crawl space

Unvented crawl space

conditioned basement

unconditioned basement

above conditioned space

Daylight Zones

Area

Reflectance

light levels required

schedule

(which / how many hours)

Occupant Zones

Area (repeat as necessary)

occupant density

activity level: gain/person/hr.

schedule

(which / how many hours)

Equipment Zones

Area / zone (repeat as necessary)

Schedule

(on, off, as needed)

(which / how many hours)

Equipment Types (repeat as necessary)

# of units (each type)

BTUs prod./unit, ea.

BTUs cons./unit, ea.

Elements Perceived in Plan Views, cont.

Roofs Lighting Zones (artificial)

Area / zone (repeat as necessary)

lighting level

Lighting Zones (artificial), cont.

Schedule

(on, off, as needed)

(which / how many hours)

Fixture Types (repeat as necessary)

# of units (each type)

BTUs prod./unit, ea.

*BTUs cons./unit, ea.

embodiment/fixture

Heating Zones

Area / zone (repeat as necessary)

(on, off, as needed)

Max temp.

(which / how many hours)

Min. temp.

(which / how many hours)

ELEMENTS PERCEIVED IN ELEVATIONAL VIEWS

Walls

(repeat as necessary)

Grade line (above / below)

Area: gross

Area: net

Orientation

Solar zone (present / not present)

Shaded portions

Color (reflectance)

Mass (present/not present)

Mass type

Mass thickness
Mass thermal qualities
R-Value
U-value
DHC
Embodiment
Materials
reflectance
R value (gain)
R value (loss)
R value (position)
DHCs
lag time
decrement values
absorptivity / conductance
Embodiment
Orientation
Area: gross or net
Area pitch value
Area/pitch algorithm
Solar zone (present / not present)

Walls

Grade line (above / below)
Shading
Color (reflectance)
Orientation
Solar zone (present / not present)
Type
Materials
reflectance
R value (gain)
R value (loss)
R value (position)
DHCs

ELEMENTS PERCEIVED IN ELEVATIONAL VIEWS, cont.

Walls, cont.

- Materials, cont.
  - lag time
  - decrement values
  - absorptivity / conductance
  - Embodiment
- Mass (present / not present)
  - Mass type
  - Mass thickness
  - Mass thermal qualities
  - R-Value
  - U-value
  - DHC
  - Embodiment
  - Area: gross or net

Windows

- Operable (yes/no) (%)
- Shading internal device
  - (coefficient)
  - (priority)
  - (on, off, on as needed)
  - (which/how many hours)
  - R-value
- Shading external device
  - (coefficient)
  - (priority)
  - (on, off, on as needed)
  - (which/how many hours)
  - R-value

Windows

- Glazing Plane
  - Transmittance
  - R-value / glazing
  - (U-value)

R-value / night insulation
(U-value)

Cross Ventilation:
Strategy Priority
Inlet area
CV inlet orientation
CV outlet area
CV outlet orientation
CV obstructions
CV Temp. max.
CV Temp. min.
CV schedule
associated mass

Stack ventilation
Strategy Priority
SV inlet height
SV inlet area
SV outlet height
SV outlet area
associated mass

Night Insulation
Strategy Priority
area
R-value
Schedule
(on, off, on as needed)
(which/how many hours)

Doors

Area: gross or net
U-value
Infiltration factor

6.2.3 OTHER RESOURCES

This section includes elements of a buildings context which are not traditionally considered part of an energy use calculation, but have influence on the energy use and resource consumption of a building. Like the item 'embodiment' in the preceding sections, these items could be part of the database associated with a building in an ideal CAD environment which incorporates more than geometric data.

Inclusion of these elements could enable the CAD design environment to move from quantitative issues (such as energy use) into qualitative design issues. This is arguably as realistic and useful a goal for a CAD environment as quantitative calculations (such as energy use), because qualitative concerns (such as quality of light, thermal comfort, etc.) are often closely related to quantitative issues.

CONTEXT (microclimate, geopolitical climate)

albedo values, orientation
Other elements: trees, other vegetative tempering devices.
Other elements: open porches,other constructed tempering devices.
Other elements: buildings, topography which affect microclimate.

WATER UTILIZATION

Volume Requirements

Equipment by type (repeat as necessary)
# of units (each type)
Volume consumed /unit, each
Volume produced /unit, each
(on, off, as needed)
(which / how many hours)
Recycling
Equipment by type (repeat as necessary)
# of units (each type)
Volume consumed /unit, each
Volume produced /unit, each
(on, off, as needed)
(which / how many hours)

HEAT RECOVERY (from water or air)

Equipment by type (repeat as necessary)

# of units (each type)

Energy consumed /unit, ea.

Energy produced /unit, ea.

(on, off, as needed)

(which / how many hours)

Indoor Air Quality Concerns

Heat Recovery Ventilation

Equipment by type (repeat as necessary)

# of units (each type)

Volume exchanged /unit, ea.

(on, off, as needed)

(which / how many hours)

Toxicology

Material (repeat as necessary)

(such as particleboard)

Substance(s)

Dangers

Alternative

Mitigation

Humidity Control

External Air Quality Concerns

Material (repeat as necessary)

(e.g., paint)

Substance(s) produced

(e.g., volatile organic compounds (VOCs))

Dangers

Mitigation

Alternative

External Air Quality Concerns, cont.

Equipment (repeat as necessary)
(such as a fireplace)
Energy cons. /unit, ea.
Energy prod. /unit, ea.
Substance(s) produced
Dangers
Mitigation
Alternative

Sound / Noise

Ambient value(s)
Source direction
Production (by bldg.)
Attenuation
Mitigation

6.3 SOFTWARE LISTS

6.3.1 CAD Packages (arranged alphabetically)

In this Appendix are the names and addresses of those CAD packages reviewed in the report. This is not intended to be a comprehensive list of all available CAD programs, but simply represent those programs which were initially expected would meet some of the criteria. For instance, 2D CAD programs are not represented because the lack of the third dimension disqualifies them from use in energy calculations.

ASG: Core , Architectural, & Mechanical / HVAC
(with AutoCAD r.10 or 11)
ASG
4000 Bridgeway, Suite 309
Sausalito CA 94965-1451
415/332-2123

ArchiCAD v3.43
Graphisoft
400 Oyster Point Blvd., Suite 520 So.
San Francisco CA 94080
415/226-8720

Arris (see Builders CAD)
Sigma Design Inc.
6251 S. Greenwood Plaza Blvd.
Englewood CO. 80111
303/741-5700 800/525-7050

AutoCAD r.10 or 11
Autodesk Inc.
2320 Marinship Way
Sausalito CA 94965
415/331-0356

Builders CAD (with Arris)
Integrated Computer Graphics Inc.
1120 Hope Road, Suite 100
Atlanta GA 30350
404/552-8800

D++
Design Power, Inc.
10020 North De Anza Boulevard
Cupertino CA 95104
408/366-6600

DataCAD
CADKEY, Inc.
4 Griffen Road North
Windsor CT 06095-1511
203/298-8888

DesignBid
Dickens Data Systems
250 Williams Street, Suite 1110
Atlanta GA 30303
404/448-6177

Drafix CAD (Ultra, Windows)
Foresight Resources Corporation
10725 Ambassador Drive
Kansas City MO 64153
816/891-1040

MacArchitrion
Gimeor, Inc.
1815 H St.
Washington D.C. 20006
202/546-8775

MegaCADD
MegaCADD
65 Marion St., Suite 301
Seattle WA 98104
206/623-6245

Memsco Systems
P.O.Box 389
Saco ME 04072
207/934-5645

MicroStation
(MicroStation Mac, MicroStation PC)
InterGraph Corporation
Huntsville AL 35894-0001
205/730-2000 800/345-4856

MiniCad + 3.0v2
Diehl Graphsoft, Inc.
8370 Court Avenue, Suite 202
Ellicott City MD 21043
301/461-9488

Point Line
Robi Graphiks, Ltd.
122 E. Olin Avenue, Suite 270
Madison WI 53713
608/256-3025

ProfitCAD
Construction Data Control, Inc. (CDCI)
3675 Crestwood Parkway, Suite 400
Duluth GA 30136
404/279-0304

SilverScreen (see SolidBuilder)
Schroff Development Corp.
P.O. Box 1334
Mission KS 66222
913/262-2664

SoftPlan
SoftPlan Systems Inc.
168 Lexington Court, Unit H
Waterloo Ontario, Canada N2J 4R9
519/886-9750

SolidBuilder (with SilverScreen)
Computer Integrated Building Corp.
P.O. Box 222
Occidental CA 95465
707/874-2826

The Plan
Ted Dasher & Assoc.
4117 Second Ave. S.
Birmingham AL 35222
205/591-4747

Thumbnail 3D
Integrated Computer Graphics Inc. (ICG)
1120 Hope Road, Suite 100
Atlanta GA 30350
404/552-8800

UniStar (WallStar, TrusStar, TrakStar)
On-Line Data, Inc.
P.O. Box 832750
Richardson TX 75083-2750
214/238-9609

VersaCAD Mac 4.0
Computervision
100 Crosby Drive
Bedford MA 01730
617/275-1800

6.3.2 Energy Evaluation Software

These energy evaluation programs were reviewed for input, output and interface reference. They have not been assessed in terms of functionality or applicability for the Energy / CAD tool or for this report.

CALPAS 3
Berkeley Solar Group Software
760 Gilman Street
Berkeley, CA 94710
415 / 525-6675

DOE 2
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

Energy Scheming
Department of Architecture
School of Architecture and Allied Arts
University of Oregon
Eugene OR 97402
503/346-5647

MicroPas 3
Enercomp, Inc.
123 C Street
Davis, CA 95616
916/753-3400

PSIC Passive Solar Design Strategies: Guidelines for Home Builders
Passive Solar Industries Council
1090 Vermont Avenue NW, Suite 1200
Washington, D.C. 20005
202/371-0357

REM Design
Architectural Energy Corporation
2540 Frontier Street, Suite 201
Boulder, CO 80301
303/444-4149

WattSun
Washington State Energy Office
809 Legion Way, S.E., FA-11
Olympia, WA 98504-1211
206 / 956-2031

6.4 ENERGY CODE ISSUES

The CAD-based energy evaluation tool is intended to support the designer / manufacturer in their ability to create energy efficient housing. One of the major hurdles in creating housing is the need to meet local building code requirements, including locally specific energy codes. The problems posed by multiple codes are compounded because individual codes use different methods for ascertaining code compliance, ranging from simply meeting prescriptive criteria (such as minimal R-values for building components), to meeting a performance criteria, often using an approved analysis tool to model actual performance. (Pierce, 1991)

Climate definition also plays an important role in determining the difficulty of meeting or proving code compliance; for instance, while Oregon has only one officially defined climate zone, California has sixteen defined climate zones. While a computerized energy evaluation tool probably needs to be flexible enough to accommodate more than one climate zone, the actual number or limit of zones is an open issue. The implication for both housing manufacturers and functionality of the Energy tool are significant, as many issues must be engaged and resolved concurrently.

Two even larger problems in designing a computer-based code compliance tool are certification for use and maintenance. Certification involves proving that tool is reasonably accurate, and maintenance encompasses keeping the program up to date with the code and certifying the program under those changes. These processes are resource and capital-intensive, as well as difficult to initiate and maintain. (Pierce, 1991)

While the desirability of introducing energy conservation techniques into the design process as early as possible is unquestionable, trying to meet all or any possible code provisions is problematic on three counts: that of deciding which individual codes to calculate compliance, certifying the tool, and maintaining the tool for all revisions of any supported energy code. Given the difficulties inherent in simply integrating the Energy tool with a CAD program,attempting to simultaneously develop a concurrently functioning code compliance tool would probably complicate the development of the Energy / CAD tool beyond necessity.

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Ms. Debbie Stamper
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Mr. Malcolm Davies, VP
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2320 Marinship Way
Sausalito CA 94965
415/331-0356

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Mr. Mike Stewart
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Waterloo Ontario, Canada N2J 4R9
519/886-9750

Mr. Pat Murphy, President
Mr. Bruce Wicinas, Product Development
Computer Integrated Building Corp. (SolidBuilder)
P.O. Box 222
Occidental CA 95465
707/874-2826

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Ms. Vicki Greist,
Marketing Representative
Integrated Computer Graphics Inc. (ICG: Builders CAD, Thumbnail 3D)
1120 Hope Road, Suite 100
Atlanta GA 30350
404/552-8800

Mr. Tim Donar
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100 Crosby Drive
Bedford MA 01730
617/275-1800

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