CMHC Project No. 6797-7 March 1993

EXPERT SYSTEM FEASIBILITY STUDY

A report submitted to the
Housing Innovation Division
CANADA MORTGAGE AND HOUSING CORPORATION
Ottawa

by
Wagner, Daigle, Revay Ltée
4333 St. Catherine Street West
Montréal, Québec H3Z 1P9

Affiliated with **Revay and Associates Limited**
Montréal-Ottawa-Toronto-Calgary-Vancouver-Hartford

CANADA MORTGAGE AND HOUSING CORPORATION

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part IX of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make widely available information which may be in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

DISCLAIMER

This study was conducted by Wagner, Daigle, Revay Limitée for Canada Mortgage and Housing Corporation under Part IX of the National Housing Act. The analysis, interpretations and recommendations are those of the consultant and do not necessarily reflect the views of Canada Mortgage and Housing Corporation or those divisions of the Corporation that assisted in the study and its publication.

ACKNOWLEDGEMENTS

WDR Ltée wishes to acknowledge the assistance provided by all the participants who responded to the questionnaire survey and of those who accepted our invitation to attend the seminars and shared their views.

WDR Ltée would also like to thank the CMHC for giving us the opportunity to investigate this most interesting area of computer technology as it relates to construction.

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

The purpose of this feasibility study was four-fold:

- to assess the need for knowledge-based expert systems, or similar computerized tools, in the residential sector of the construction industry;
- to assess the adequacy of EXPAIR, a shell dealing with indoor air quality, developed specially for CMHC;
- to assess a number of commercially available expert system shells and recommend a possible alternative to the shell used to develop EXPAIR;
- to assess the market potential of such tools and recommend a marketing strategy.

The answers to the first two tasks were obtained from a mail survey that resulted in approximately 150 completed questionnaires, from a series of over 50 interviews, and from approximately 80 demonstrations of the EXPAIR tool followed by discussions and written assessments.

The level of interest displayed by the attendees and the informal discussion that followed indicate that the residential sector is willing to try out this new technology. Considering the conservatism of the audience, this can be interpreted as a signal that this new technology is, in fact, needed.

The report identifies a number of possible uses of expert systems. The majority of the participants of the survey responded that the expert system could be used as a tool to **train personnel**. A significantly high number of respondents from each group who participated in the survey suggested the potential use of expert systems to **identify problems** and to give **guidance to designers**.

In addition, every group expressed the opinion that the issue of **material selection** should be addressed by expert systems. **Code compliance** is another issue that every group is interested in and there is significant support for this: 55% of the participants assigned a high priority to this issue, and only 9% gave it a low priority. A similar interest was shown for **regulatory compliance** in general. The report rates in order of importance some specific issues that can be related to **building science** (page 20).

The assessment of EXPAIR, both by the consultant and by the participants in the survey, was not favourable. The overall performance of EXPAIR was found to be inferior to currently available shells that have stood the test of time in a competitive environment.

The report evaluates a number of commercially available shells. All of them run on the PC platform and this was taken as a base requirement for any system that would be used in the field. In terms of the functionality that these systems currently offer, they all meet and generally exceed the criteria developed by CMHC.

Of the systems reviewed, the consultant has concluded that the system that best meets the requirements outlined by CMHC for their current needs is the KnowledgePro product that runs in both the DOS ($500) and WINDOWS ($700) environments. It provides both a satisfactory development environment and a good delivery environment with free run-time delivery mechanism.

In the area of marketing, the consultant suggests that CMHC develop a system to deal with residential building codes and "test the waters" with it. The system should be complete: it should deal fully and exhaustively with a narrowly focused topic. This will instill confidence and prepare the market for the new technology.

CMHC should not wait until a larger majority in the industry approves the development of such a system—electronic spreadsheets did not receive much appreciation when they were first introduced.

The dependence on computers will continue to grow as the world becomes more complex and technology more sophisticated. It is highly probable that, if the right tool is developed, the residential sector will embrace it and even be prepared to pay for it a price higher than the $500 maximum suggested by the survey. The potential of expert systems for saving time and money—and for avoiding mistakes—will prove of great persuasive power.

2.0 INTRODUCTION

2.1 BACKGROUND TO THE STUDY

In recent years, developments in computer technology have had a major impact on the use of computers by professionals in the housing sector such as Architects, Engineers, Property Managers, Builders and Inspectors. Developments in hardware have provided us with small and powerful desktop, laptop and hand-held microcomputers for use in the offices and on construction sites. Software developments have resulted in much improved user-friendly interfaces through the use of advanced graphics and systems based around windows with interaction through mouse and menus. Along with the above, a completely new family of software programs known as Knowledge-Based Expert Systems, has also emerged.

Expert Systems, a computer science terminology, refers to the emulation of human thought process in computers. They have emerged as practical problem solving tools that can reach the level of performance comparable to that of a human expert in some specialized problem domain.

They are called Knowledge-Based Expert Systems (KBES) because their performance depends critically on the knowledge stored in the system. KBES encapsulate specialist knowledge about a particular area or domain and are capable of making intelligent decisions within that domain. KBES approach is to choose from a set of strategies one that is most relevant to the current state of a problem, apply it to take a step closer to the solution and then reappraise the situation. Additional information is requested as required in order to choose the most suitable solution.

Application of this new technology in "real life" situations in several industrial sectors is beginning to show many benefits, including financial. The housing industry provides many application areas for this new type of software, both relating to the planning and engineering aspects of constructing new residential buildings through to the management and maintenance of existing residences.

2.2 KBES APPLICATION IN RESIDENTIAL SECTOR

Practitioners in the building industry are increasingly confronted with new complex problems for which they have no training. To deal with this problem in an effective manner, expert knowledge is required. Many factors such as cost and availability may discourage practitioners from calling upon experts to find the cause and proper remedy to these problems.

Hence, application of KBES in the housing industry has many benefits. The knowledge that is accumulated and preserved in the system becomes widely available. Thus users can be freed from the necessity of possessing detailed knowledge. Further, complex problems can be solved with such a computerized system. KBES can improve employees' service levels: less trained employees can provide high knowledge content services.

KBES can also improve the quality and consistency of decisions, and reduce employees' training time. Quality of work can be improved by considerably reducing expensive mistakes in complex processes. The quality of working conditions can be improved by relieving the employee from routine work. The present shortage of experts with rare and costly expertise can be ameliorated. Machine time can be better exploited; human productivity can be increased. All the above will translate into financial benefits.

2.3 FEASIBILITY STUDY ON THE USE OF KBES

Inasmuch as many companies in sectors other than housing have used these systems to help in the development of their products and in increasing the efficiency of their operations, the Canada Mortgage and Housing Corporation (CMHC) wished to conduct a feasibility study of expert systems to establish the demand and the marketability of such a system in the housing sector.

CMHC retained a consultant to perform a market survey within the residential sector , that is, among architects/designers, engineers, property

managers, builders and inspectors, to determine possible clients of expert systems and the type of application required by them.

As part of the above study the consultant was required to evaluate applicable expert system development tools and recommend the most suitable tool that would permit the optimal performance and ease of production of expert systems within the housing sector. The evaluation of suitable tools also included a particular tool called EXPAIR, developed for CMHC. Further, a suitable architecture and an operating environment had to be suggested for such development of expert systems.

Finally, the study was to include proposals as to the marketability of the product, the suggested price of sale and a suitable distribution scheme.

2.4 PROCEDURES FOLLOWED BY WDR

Wagner, Daigle, Revay Ltée, the consultant selected to conduct the study, discussed the Work Plan with the Project Officer and established administrative arrangements and project milestones. Background knowledge of the survey subject area was expanded by discussion with key players. Another meeting with the Project Officer was held to clarify the requirements of the project and to discuss the draft questionnaires and the mailing lists.

Based on these discussions, questionnaires in English and French were prepared. The mailing lists of survey participants were compiled from membership lists containing residential contractors, architects, engineers, property managers and building inspectors. About 1300 questionnaires were mailed out to participants across Canada, with the main focus being in the metropolitan areas of Montreal, Toronto and Calgary—principal concentrations of building activity and building stock in Canada.

Workshops were organized in Montreal, Toronto and Calgary to introduce expert systems and their application in residential sector to invited groups

of practitioners. Personal interviews were also conducted to elaborate on or augment the responses to the survey questionnaires.

The participants of the workshops were requested to provide their views on a prototype expert system on indoor air quality in high-rise residential buildings, EXPAIR, developed for CMHC. EXPAIR was demonstrated to the participants along with other applications. Further, a prototype knowledge base module on dampness in basements was developed by the consultant by utilizing the same tool, SCHL, that was used to develop EXPAIR, to evaluate the features of that tool.

A literature review on available expert system development tools was carried out and certain applicable tools were chosen for further study. Along with this study, discussions with some industry leaders on the application of these tools were carried out to determine the most suitable tool that is available in the market to develop applications in the residential sector. A similar study was conducted to establish the suitable marketing and distribution scheme for EXPAIR and related systems that would be developed under the guidance of CMHC.

Along with the results of the studies mentioned above, the survey material was analyzed and this report was prepared.

2.5 CONTENTS OF THE REPORT

The format of this report is designed to take the reader through the elements of the study that were required by the contract, the methodology employed by the consultant and the resulting conclusions.

Section 3.0, 'Questionnaire Survey' discusses the structure of the questionnaire and the selection of survey participants.

Section 4.0 of this report titled, 'Workshop on Expert Systems' presents the purpose of holding such seminars and the responses of the participants.

Section 5.0 provides the views of the interviewees who were selected from the a cross-section of the housing sector.

Section 6.0 analyses the results of the survey materials and presents the results as requested by CMHC.

Section 7.0 presents an evaluation of EXPAIR, the tool developed for CMHC.

Section 8.0 presents the evaluation of expert system building tools and consultant's recommendation.

Section 9.0 deals with the marketability of Expert Systems.

Section 10.0 contains the consultant's conclusions and recommendations.

Section 11.0 contains the exhibits used in this report: copies of the questionnaire in both official languages, background information mailed with the questionnaire, and statistical tables extracted from the responses to the questionnaire.

3.0 QUESTIONNAIRE SURVEY

3.1 PURPOSE OF QUESTIONNAIRE SURVEY

WDR was requested to conduct a market survey to determine the level of interest in the application of expert systems and their possible clients. In addition, this survey was to establish what expert system application is needed by each group.

As many professionals in the residential sector are not familiar with the application of expert systems, WDR wanted to elicit more information on the type of services provided by the participants and the type of expertise required in order to assess whether that service can efficiently and economically be provided with the assistance of an expert system.

Further, WDR wanted to make use of the questionnaire to extract information on participants' view on marketability, suitable price for expert system, etc. in order to augment its study on such items.

3.2 FORMAT OF QUESTIONNAIRE

The questionnaire consisted of a one-page 'backgrounder' along with six pages of questions. (See Section 11.0 **Exhibits**).

The backgrounder provided information on the CMHC-sponsored feasibility study. This included a brief introduction to expert system, followed by its relevance and possible application to residential sector and its advantages. The backgrounder clearly stated the purpose of the survey and provided telephone numbers of the members of the project team in major cities across Canada who could be contacted for any clarification.

The 6-page questionnaire had five different sections, each focusing on different aspects of the study.

Section A was designed to elicit information on how well the participant is automated or computer literate. The questions in Section B were used to determine whether the participant could benefit from an expert system in terms of time and money. As a follow-up, questions regarding the type of expertise required by the participant were included in Section C to establish the candidacy of that expertise to be part of an expert system.

Section D was incorporated to find out the demand or the acceptability of expert systems within the residential sector and the suitable price. Questions relating to possible area of development of expert systems as required by the residential sector was presented in Section E. This last section also included questions on the type or structure of expert systems preferred by the participant.

The questionnaires were distributed in both official languages.

3.3 SELECTION OF PARTICIPANTS

Almost all the participants of the questionnaire survey were chosen within the residential sector. They were selected among architects/designers, engineers, property managers, builders and inspectors. Initially, WDR planned to mail out the questionnaire to about 600 participants. As the topic of expert systems was foreign to many in the residential sector and to give more credibility to the study, WDR increased the number of mailings by over 100%.

The responses of the participants are analyzed and presented in Section 6.0 of this report.

4.0 WORKSHOP ON EXPERT SYSTEMS

4.1 PURPOSE OF ORGANIZING WORKSHOPS

Many practitioners in the residential sector are not familiar with the application of expert systems to solve problems. Hence, workshops on expert systems and their application in the residential sector were organized in three major cities across Canada to invited groups of practitioners so that they would thereby gain a clearer idea of the survey objectives. These workshops were also used to get the participants' thoughts on the applicability of this technology.

At these workshops, an introduction to expert systems was presented and some applications were demonstrated to make the participants understand and appreciate the usefulness of this emerging technology. The workshops were conducted by professionals who are known for their research on expert systems and their application in the construction industry.

The system EXPAIR, a prototype expert system tool with a knowledge base on indoor air quality in high-rise residential buildings developed for CMHC, was demonstrated to the participants, in order to study their reaction to the system. The participants were requested to fill out a questionnaire related to the performance of EXPAIR. The presentations were followed by discussions.

It should be noted that even though a total of more than 600 people were invited to attend these workshops, only approximately 80 attended the three seminars. The seminars were free, and lunch was served following the presentations. This gives an indication of the level of interest regarding expert systems within the residential sector.

4.2 RESPONSES OF PARTICIPANTS

Even though 24% of the participants were aware of the applicability of expert systems, only a very small minority of them were familiar with the way the systems work. The general introduction provided by the speakers at these seminars made the participants understand this new technology and its applicability.

Participants showed their appreciation of some basic differences between the conventional software and the expert systems such as the explanation facility, ability to edit the knowledge base etc. Participants inquired about the availability of such systems that are useful in 'real world' applications. Concerns were expressed as to the cost of such systems and to the legal liability for the advice given by the system to the user.

Some participants expressed their opinions on possible applications, in their line of business, such as a learning tool, and were willing to give this new technology a chance.

Different expert tools were received with different degrees of enthusiasm, depending on their usefulness to the participants. As EXPAIR is not a complete advisory system, it failed to attract the interest of the participants. Other applications shown at these workshops, such as the system for sealant selection demonstrated in Montreal or a building code semi-expert system in Toronto, received greater appreciation.

Participants were requested to provide their responses to questions prepared by the consultant to evaluate the performance and the user interface of EXPAIR. Most of the participants in Toronto and Calgary responded to the request. The participants in Montreal did not feel that they were in a position to evaluate the system and hence refused the consultant's request.

4.3 CONCLUSION

The level of interest displayed by the attendees and the informal discussion that followed indicate that the residential sector is willing to try out this new technology. This represents a strong indication that new technology is, in fact, needed.

The important issue as to who will bear the liability for the advice provided by an expert system will have to be resolved to the satisfaction of the possible users before making further inroads. This should not present too much of a problem, since such issues have been successfully resolved in other areas of technology.

Further, if any workshop is to be organized in the future for participants from this sector, the system to be demonstrated must be a complete one, even if its domain should be narrow. The lack of availability of a complete system in a particular domain is the greatest obstacle which could prevent CMHC from building up the enthusiasm and the trust in expert system technology.

From a purely practical point of view, the selection of nomenclature can make a great deal of difference when presenting new technology to potential recipients who may not be quite ready for it. For example, introducing EXPAIR as an expert system generally led to long and intricate explanations; sometimes the audience or the interviewee seemed intimidated by the concept. On the other hand, presenting the same product simply as a computer tool designed to produce certain results helped induce a much more receptive attitude.

5.0 INTERVIEWS WITH PROFESSIONALS

5.1 PURPOSE OF INTERVIEWS

The interviews with some selected individuals were held to provide an introduction to KBES, if they have not been previously exposed to them, and to gather their views on the application of such systems. This was suggested by WDR to CMHC in order to enhance the findings of the questionnaire survey. A total of 56 interviews were conducted in Montreal, Toronto and Calgary.

Interviewees were selected from smaller and medium size organizations within the residential sector and from professionals who are familiar with expert systems in the construction industry.

The interviewees can be classified into following three distinct groups:

Group A: Persons who have had little experience in the use of computers; this group consisted mainly of builders.

Group B: Persons who are experienced computer users but had little or no knowledge of expert systems; members of this group are mostly architects and engineers.

Group C: Expert computer users, usually building scientists and academics, who have been previously exposed to expert systems.

5.2 VIEWS OF INTERVIEWEES

Views of the interviewees differed, depending on their level of utilization of computers in their work place and on their prior experience with new developments in computer technology. The reaction of the interviewees to this new technology can be summarized as follows:

Group A, which mostly consisted of home builders, showed a remarkable lack of interest not only in expert systems but also in computer technology in general. It was often difficult to even get them to listen to a brief presentation and it was very difficult to explain to them what it could do for them and what would be the benefits. The product must sell itself. It must be fully operational and user-friendly.

With this group, it is particularly important to bear in mind the importance of nomenclature. A much better reception of new ideas is experienced if computer jargon is avoided. Home-builders are interested in better and more efficient **tools**.

Representatives of **Group B** easily understood the concept of expert systems and the possible benefits. Their attitude, however, was generally one of mistrust of the technology. Their main concern is their exposure to liability. They would gratefully embrace an expert system if the system developer would accept the liability for the system's output. In the absence of such a warranty, members of this group remain uneasy. As one questioner put it: if the system embodies knowledge they do not possess, how can they check the validity of the answers?

Group C is just as familiar with computers as the preceding group, if not more so, but does not share the anxiety about professional liability. Even though some of the participants in this group are not directly involved with the housing sector, they see the value of expert systems and their potential. However, they express dissatisfaction with the systems now available.

5.3 CONCLUSIONS

WDR concludes that any attempt to raise the level of technology to the point where Group A would immediately embrace an expert system would be difficult. For this group, the best chance of success would be with a knowledge-based system that deals with an area of knowledge that they must have and presents the information in a user-friendly, pictorial, point-

and-click fashion. This reinforces the conclusion WDR arrived at after the demonstration workshops.

The tools that would be most useful to this group, it appears, would assist in code compliance (e.g. selection of joists or trusses for different spans and loading conditions), or assist in the selection of suitable building materials (e.g. roofing membranes or sealants).

Group B requires a system that not only provides answers, but also detailed guidance as to how and why it arrived at a particular answer. This suggests systems which are based on rigorous mathematical analysis, such as those used for structural design.

Group C is the most difficult to satisfy but their needs are not those of the construction industry. The value of the Group C members is that their expertise can be extremely useful in the development of new expert systems.

6.0 ANALYSIS OF RESPONSES TO QUESTIONNAIRES

6.1 OVERVIEW OF RESPONSES

As mentioned in Section 3.3, about 1,300 questionnaires were mailed out to professionals in the housing industry. WDR received almost 160 questionnaires. The response rate was comparatively low, about 12%. This is not unexpected, since only about 30% of respondents are aware of the concept and application of expert systems. Further, only 23% of the respondents have ever seen an expert system application and less than 2% use expert systems in their work place.

The following mix was found among the respondents:

Architects	24%
Engineers	11%
Contractors	24%
Building Owners	3%
Inspectors	18%
Property Managers	5%
Others	15%

Most of the respondents were from western and central regions of Canada. Only 3% came from the Maritimes. This is of little statistical significance because, for practical reasons, most of the mailings were addressed to Québec, Ontario and Alberta.

In the following paragraphs, the analysis of the responses is presented with a view to respond to CMHC's questions which are:

- is there an interest in expert systems in the housing sector?
- if so, what kind of expert system would be most useful?

6.2 LEVEL OF COMPUTERIZATION

The analysis of the responses shows that computer literacy among the respondents is acceptably high. All engineers and almost all architects who responded to the survey depend on computers for their daily work. The percentage of computer users among professionals, other than architects and engineers, is remarkably high already and will, no doubt, increase at a fast rate.

Personal computers (IBM or compatible) seem to be the most popular machines among the respondents. The use of Apple Macintosh computers is high among architects, but not as high as for IBM or compatible computers. This shows that the housing industry, at least, has the paraphernalia ready for the introduction of KBES.

The use of computers among companies that responded to question, *"What do you use computers for?"* is distributed as follows:

Accounting	20%
Word-processing	23%
Desktop Publishing	10%
CAD	11%
Database	13%
Project Management	10%
Estimating	7%
Construction controls	5%

Hence, the use of computers for tasks other than regular office work is about 33% to 46%. It is surprising to note that about 56% of the computers are being used by Designers/Executives/Inspectors and the Senior Management. This assures CMHC of an attentive audience who are familiar with the use of conventional software within the residential sector.

6.3 EXPERT SYSTEMS IN RESIDENTIAL SECTOR

The above analysis shows that the industry has the technology and consists of computer users who are knowledgeable in residential applications. Their attitudes towards expert system applications will be analyzed on the following pages.

Almost all the respondents wanted to examine an expert system. Their concerns about expert systems are listed below:

	Agree	Disagree
• The source of the expertise is unknown:	30%	15%
• There is no assurance that the expertise will lead to the right answer:	37%	10%
• Computers cannot replace experience:	33%	19%
• Nobody in our business uses them:	19%	31%
• Nobody in our business trusts them:	5%	33%
• The technology is too new:	13%	30%
• It will take too long to learn to use the system:	11%	37%
• It is easier and more reliable to phone someone you know to get expert advice:	21%	24%

The above shows that the industry is rather confused about the applicability of the expert system. But—significantly—67% of respondents think that a suitable expert system would make their operations more efficient and/or more profitable.

6.4 POSSIBLE USES OF EXPERT SYSTEMS

The majority of the participants of the survey had responded that the expert system could be used as a tool to **train personnel** (35% important, 15% not important). This particular use of expert system is reported mostly by the engineers.

A significantly high number of respondents from each group that participated in the survey had suggested the use of expert systems to

identify problems. Overall 51% expressed this opinion, versus 12% which gave low importance to this need.

The same is true for a system for **guiding designers** (46%/16%). In the above two needs, the most likely clients are the architects among whom 63% versus 13% consider **problem identification** and 61% versus 18%, **guiding designers** as the important uses of expert systems in the residential sector.

6.5 ISSUES FOR APPLICATION

Under issues for application of expert systems, the engineers want CMHC to address the issue of **design concepts** whereas the other groups do not show any interest in that topic. In engineering design, expert systems may be used, and are already used, to select most suitable solutions in the design of certain structures, mechanical and electrical systems, and so on.

But in the case of the issue of **material selection**, every group feels that this issue should be addressed. Overall, 44% of these respondent support this view and only 10% gave less priority to this issue.

Code compliance is another issue that every group is interested in and there is significant support for this. The overall percentage is 55% vs. 9%. A similar interest was shown for **regulatory compliance** (50% vs. 13%). The architects, engineers and inspectors, in great majority, feel that the issue of code/regulatory compliance should be addressed by an expert system.

The issue of **construction practice** seems to be popular among architects and slightly less popular among engineers, contractors and building inspectors. An expert system may, for example, be used to guide professionals in handling day-to-day site routine, or sudden emergencies. The overall percentage is 41% vs. 10%. Except for contractors (31% vs. 11%) no other group seem to consider the issue of **sources of material** as an important issue.

The rating of some specific **building science** related issues are given below. As reported above, only high and low priorities given by the participants who responded to this question are presented.

	High	Low
• Heating and Ventilation	55%	9%
• Fire Protection	51%	10%
• Foundation/Basement Design	48%	10%
• Roofing	46%	10%
• Safety	44%	13%

6.6 POSSIBLE CLIENTS AND APPROPRIATE AREAS

As mentioned in the preceding sections, expert systems in the residential sector can act as diagnostic systems, selection systems or guidance systems.

The survey shows that 55% of the architects who responded feel that there is a need for a diagnostic tool to deal with **roofing problems** as opposed to 18% who gave low priority to this need. Many contractors feel that there is a need for a system to diagnose **causes for cracks** in walls. With regard to **window problems**, no group seems to show an absolute need for a system. Each group is equally divided between low and high priority for this system.

In the application of expert systems as selection tools, architects and contractors feel that there is a need for a system to **select sealants**. Among those who responded, 47% of architects and 33% of contractors give high priority to the above against 13% of architects and 17% of contractors who consider it as a low priority. The architects, contractors and residential inspectors would like to see a system that helps in the selection of **roofing membranes**. The percentage of high versus low priority for each group are 47% to 21%, 36% to 11% and 33% to 4%. Only the contractors seem to show some interest for a system to **select windows**.

The architects, contractors and inspectors would like a system to guide them with **code compliance**. The architects overwhelmingly gave high priority to this system. The percentages are as follows: 61% to 16%, 39% to 8%, 41% to 26%. The engineers are divided equally. There was no clear consensus for a guidance system to deal with **compliance of labour laws** or to provide a guidance with **emergency procedures** among the respondents.

6.7 EXPERT SYSTEM ENVIRONMENT

The survey shows that stand-alone systems are not going to be popular among the participants. The 75 % of respondents to the survey prefer a modular system with add-on capability. Further, they would like to have their own in-house system, rather than bulletin board access.

The participants would like to receive the following services from the system supplier:

- training
- system maintenance
- user support
- regular updates.

They are not interested in user groups or in system support or, at least, they are not interested—**based on their experience to date**. It is quite likely that a significant percentage of the respondents never had any experience of user groups but simply rejected what they did not know. The same may be true of some other responses. However, to discover whether this was so was not of fundamental importance and would have made the questionnaire even longer and more complex than it was.

The DOS operating system seem to be the popular run environment for most of the software used by the respondents but this will most likely change in the future. We foresee two important developments that will prompt this change:

- the introduction of the user-friendly Windows NT operating system scheduled for the fall of 1993;
- the gradual phasing out of older computers which could only run DOS.

The consultant is confident that the buyers of new computers will choose Windows NT which will be greatly superior to DOS, both from the point of view of performance and of ease of use.

The general recommendation therefore would be to move towards the adoption of the WINDOWS-based products as the trend is now towards the wider use of this environment by end-users. Such systems have generally better end-user interfaces. In addition, the Windows based products are more likely to be subject to further development by the product developers as that is the direction that they see the market moving.

6.8 CONCLUSION

The analysis of the survey establishes the direction CMHC should take and the issues it should address for the development of expert systems. The survey also established specific areas and possible clients.

The immediate need within the residential sector seems to be for a system that deals with building codes and the rest of the regulatory framework. An expert system in the domain of roofing membrane selection / roofing problems is another area of immediate need.

No matter what expert system is developed, a great deal of thought must be given to the maintenance of the system for an indefinite period of time. Circumstances change, new materials are brought on the market, new facts emerge about old materials, progress is made in building science. If an expert system, and in particular a knowledge-based system, is not up-to-date it may be worse than useless.

This factor must be borne in mind not only in the development of the system but also in any budget considerations.

7.0 EVALUATION OF EXPAIR

7.1 EXPERT SYSTEM TOOL

A knowledge-based system has two primary and distinct components namely:

- the knowledge base (KB),and
- the inference engine.

The inference engine manipulates the KB by controlling the selection of rules to develop a desired solution, or to arrive at a conclusion. An expert system development tool consists of inference engine and other interfaces to ease the development and the use of KBES.

The first generation KBES were almost invariably written in declarative languages like LISP and PROLOG and in the Artificial Intelligence (AI) environment. Now, commercial derivatives of these AI systems are developed by various organizations to ease the development of KBES by those who are concerned with practical applications of these systems in their respective fields. These tools provide standard ways to represent and manipulate KB, convenient editing and debugging features, and come with various facilities.

The system, SCHL, is such a tool. This was developed for CMHC for its use to build KBES in domains within the residential sector. As part of this project, WDR was required to evaluate this tool against the features and facilities provided by similar tools that are available in the market.

The system SCHL was evaluated using two methods. It was demonstrated to participants of the workshops and participants' input was obtained as to the performance of it user interface. Its developer interface and other features, such as the method of knowledge representation, were evaluated by 'hands-on' experience. A prototype knowledge-base system on dampness in basements was developed with SCHL to evaluate its features and facilities.

7.2 EVALUATION CRITERIA

WDR, prior to commencement of the evaluation, developed a set of criteria in order to focus its evaluation on important factors.

Any expert system development tool which is designed to facilitate easy development of KBES should possess the following:

- **Structuredness**—a definite pattern of organization of its independent parts;
- **Consistency**—uniform notation, terminology, and symbology within itself, and content traceable to the requirements;
- **Accessibility**—an easy selective use of its components;
- **Completeness**—all of the software parts present and fully developed;
- **Reasoning Techniques**—a correct method of reasoning;
- **Communicativeness**—ease of input and output;
- **Understandability**—help capability and explanation facility;
- **Device-Independence**—portability of software from any one hardware configuration to another;
- **Self-Descriptiveness**—enough information for a reader to determine its objectiveness, assumptions, constraints, inputs, outputs, components, and status;
- **Augmentability**—ease of accommodating expansions in data storage requirements or component computational functions;
- **Modifiability**—ability to update;
- **Ease of Use**—clear understandability and user-friendliness.

The following paragraphs summarizes the consultant's evaluation of EXPAIR, based on the above considerations.

7.3 PERFORMANCE OF EXPAIR

EXPAIR's main menu contains four options, viz. to consult, to edit knowledge base, to view report and to exit from the system. These are independent of each other and function satisfactorily.

The main components of the knowledge base of EXPAIR system are **networks**, **variables** and **dialogs**. The networks represent certain elements of the KB expressed by nodes and logical links that form paths. The networks use the variables and dialogs as components in the commands of the nodes.

The techniques followed in this tool, including the symbols, terminology etc., to represent knowledge are easy to understand and apply. But the current method of representing knowledge limits its applicability to domains that require the use of other popular methods such as frames and objects. It should be noted here, that the tool is (upper/lower) case sensitive. (Note: A network MAIN should be present in the system to run the consultation; if it is created as 'main', EXPAIR would not identify this network).

Accessibility to different components of the tool is very limited. The user has to exit to the main menu to switch to a different function of the system even after choosing a particular KB to work with.

The tool is not complete, even though all the primary parts are present in the tool. It lacks several features that define an expert system, e.g. an explanation facility. The reasoning method that fits the available knowledge representation technique seems to perform as intended. The absence of other reasoning methods makes this tool insufficient for application in domains that may require those methods.

The method of inputting knowledge is very tedious. Even though the tool allows a graphical way to create its networks, creating a network which extends more than one screen is time consuming. The contents of a node cannot be 'copied' to create a similar one. Even though the tool uses window-like features, moving nodes within a network does not use the usual 'click-and-move' method.

While creating a network, the accidental pushing of the right button of the mouse will delete the highlighted node without even asking for user's confirmation. When deleting a node in a particular path EXPAIR does not

automatically bring the rest of the nodes in the path closer to fill the space created by the deleted node. This problem is also evident in inserting a node. The arrows that connect two nodes can be either a NORMAL arrow or an ELSE arrow. But visually, there is no way to distinguish between the arrows.

The purpose of the saving option, even when no changes are made in the knowledge base, is not apparent. The current version of EXPAIR does not provide any help or explanation facility. There is no on-line help and the manual is not easy to understand and is not complete.

A distinctive feature of an expert system is its ability to display the line of reasoning and to answer user's questions such as 'how' and 'why'. In the absence of this facility, EXPAIR will fail to inspire confidence in the user for any solution it provides.

The tool EXPAIR can only be run using a colour display screen. The consultant's attempt to use a monochrome screen gave unsatisfactory results. It requires a mouse as all selections must be made with one. These properties would eliminate a large number of older and cheaper computers which are monochrome and whose users are not familiar with input techniques using a mouse.

There is no way to abandon the EXPAIR consultation process once the input window sequence has been started. The consultant could not determine the augmentability of this tool or the ability to update. The manual does not make any reference to any limitations of this tool.

In user interaction formats, EXPAIR requires only a few key strokes and the user is expected to make choices through the use of a mouse. EXPAIR is efficient is this regard. EXPAIR also allows the system to rerun/replay a particular consultation without requiring the user to answer again all the system's questions (for 'what-if' situations) but it does not explain the reasoning behind a particular consultation. Further, no confidence factors are involved in the consultation and very little attempt is made in EXPAIR to incorporate graphics.

7.4 CONCLUSION

EXPAIR provides limited methods of knowledge representation and inferencing. Even with the available techniques, the consultant found the overall documentation poorly presented and there was no on-line help concerning matters of syntax and command usage. The absence of levels of confidence for a solution which are crucial to reach a valid conclusion or a result, especially if the knowledge used is overly complex and unclear, is a negative factor of this tool. Some may feel that this feature may weaken the entire advice or recommendation process.

Graphics can increase the user-friendliness, specially among home builders. They can be used in variety of ways to represent the structure of the knowledge within the system; to trace the logic of a particular consultation; to provide critical information to users in the form of on-screen windows; to capture and display visual images necessary to conduct a consultation or illustrate a result. The absence of this feature makes it inappropriate for the residential sector.

No matter how good the logic of the system or how complex its knowledge, if the user cannot effectively interact with the software, then the expert system will not achieve its primary goal of replicating human expertise. The consultant found the overall performance of EXPAIR inferior to currently available shells that were developed under competitive environment and had stood the test of time.

8.0 EVALUATION OF ES DEVELOPMENT TOOLS

8.1 COMMERCIAL TOOLS

There are several expert system development tools available in the market. These vastly vary in their quality and level of sophistication. Hence selecting the 'right' tool for particular applications within the residential sector becomes an important task. There are several factors that have to be considered in choosing the right shell to develop an expert system. Fit of the tool to the problem is very important. The following five factors are identified as important from both the user and the developer points of view:

- Effectiveness of the developer interface
- Effectiveness and friendliness of the user interface
- Integration capability with existing programs and databases
- Run-time licensing for delivered system
- Cost of the tool

As part of this project, WDR reviewed several tools that are available in the market against the requirement of CMHC. The following five tools were chosen for further study and the performance of these tools against the above listed considerations are presented below.

8.2 EVALUATION OF SUITABLE TOOLS

8.2.1 LEVEL 5 Object

Price: Approx. $995 but depends on run-time option chosen. They do provide for unlimited run-time copies of a completed system as well as for a single user option.

Vendor: Information Builders Inc.
1250 Broadway
New York, NY 10001 USA
Telephone: (212) 736-4433

Requirements: IBM or compatible running MicroSoft Windows. Versions are also available on IBM mainframes, DEC VAX, Apple Macintosh and UNIX work stations.

Comments: This basic system has been around for some considerable time and started out as just Level 5 and ran on a wide range of systems. The new version, level 5 Object, has adopted an object oriented approach to knowledge representation and inference control (procedural knowledge representation).

The system provides support for both backward and forward chaining inferencing techniques as well as Blackboard architecture type "Demon Rules" which monitor the occurrence of specific patterns, events or states before they fire. This mixed approach to the control of the inferencing mechanism provides for a powerful and highly flexible system.

There are a number of different options provided to deal with reasoning with uncertainty. The options include the use of Bayesian, averaging and product-space confidence techniques. There are some good tools for developing the user interface to a system and they provide for full control over the development of dialogues using check-boxes, buttons, and text windows. They also support the use of graphics and hyper-regions within the user interface.

Other tools provided within the system include some powerful debugging tools in the form of knowledge visualization and graphical tracing aids. The total system is very well integrated into the Windows environment and has excellent facilities for

integration with other applications such as Lotus 1-2-3, DBASE III, SQL as well as accessing simple ASCII files.

8.2.2 VP-Expert

Price: Approx. $250 for the developers system and a small additional cost for developers to distribute unlimited run-time versions of their developed system.

Vendor: Paperback Software International
2830 Ninth Street
Berkeley, CA 94710 USA
Telephone: (415) 644-2116

Requirements: IBM or compatible running MS-DOS or PC-DOS

Comments: This is a relatively inexpensive system although there is a small additional charge to distribute unlimited run-time versions of the system. The system is based upon the use of production rules as the primary form of knowledge representation and uses backward-chaining as the dominant inferencing technique.

One of its interesting features is the ability to INDUCE a knowledge base from a well selected collection of example cases. The system is able to translate the examples into rules, at this stage are not necessarily optimized, which can then be used by the system to form a knowledge base. Another interesting feature of the system is a hypertext command, which provides for the creation of hypertext windows when certain variables in the system have a specified value. The text within these windows can themselves contain hypertext links to other text.

In addition to the ability to access ASCII files, the system is also able to link to dBase II, III and III+ files as well as files created using Lotus 1-2-3. An add-on product also enables the system to use SQL.

8.2.3 KnowledgePro

Price: $500 (DOS version), $700 (Windows version)

Vendor: Knowledge Garden Inc.
473A Malden Bridge Road
Nassau, NY 12123 USA
Telephone: (518) 766-3000

Requirements: IBM or compatible under MS-DOS or running MicroSoft Windows

Comments: This product provides a number of different approaches to the representation of information ranging from classical production rule type representation, through to frame type representations. The system has not been designed to deal with uncertainty through the use of confidence factors etc., preferring instead to force the knowledge engineer to structure their knowledge base in such a way as to resolve the uncertainty issue.

Construction of a rule base can be facilitated by the use of a companion product, Knowledge Maker, which can induce rules from a set of well selected example cases from the problem domain.

The primary inference method within the system is backward chaining although it is possible to adopt a forward chaining approach. In many ways the Knowledge Pro product is similar to a high level programming language which provides in excess

of 100 keywords with their associated syntax. It provides good support for mathematical calculations and string manipulation functions (very similar to the LISP language).

The end user interface to the system can be designed to support hypertext type functionality for the capture of user responses and for the provision of detailed explanation and Help facilities. There are good debugging facilities and a trace capability which allows the knowledge engineer to examine the step-by-step execution of a knowledge base. There is also support for the user to examine the state of any of the variables during the running of a knowledge base.

Finally, this system is able to interact with other programs running in the same environment. These include, Lotus 1-2-3, dBase, PC Paint, Turbo Pascal and C functions.

8.2.4 1st-Class

Price: $1,000 with one run-time license, for additional run-time licenses contact vendor for current prices.

Vendor: A1 Corp. Inc.
100 Fifth Avenue
Waltham, MA 02254 USA
Telephone: (617) 890-8400

Requirements: IBM or compatible under MS-DOS or OS/2

Comments: This system has some interesting features to aid the development of a knowledge base. This includes a system that supports the use of examples to bootstrap the system using a spread sheet type interface. Although the system is not designed around the use of confidence factors there is support for various statistical techniques to fine tune the knowledge

base. The system is based around the development of a decision tree and there is support for a decision tree editor. An alternative method for setting up the knowledge base is by directly entering the decision tree editor and to build the decision tree within that environment. There is fairly extensive support for mathematical calculations within 1st-Class so that various techniques can be applied to the knowledge base to deal with areas of uncertainty in the knowledge base.

The lst-Class system supports the use of both backward and forward chaining. This is achieved through the use of small modular knowledge bases which are executed either as the reporting of a conclusion from the knowledge base (a forward chain) or as a link to another knowledge base whose conclusion acts as an answer to a query from the original knowledge base (backward chain).

There are a number of low level commands within the 1st-Class system which allows the branching to external programs and the putting and getting of information from various files and programs (dBase, ASCII, etc.). A useful utility is the ability to convert rules within the system into "C" or Pascal source code for use in other systems which allows for the porting of the knowledge base logic to another system/application.

8.2.5 Intelligence/Compiler

Price: $500

Vendor: Intelligence Ware Inc.
5933 West Century Boulevard
Los Angeles, CA 90045 USA
Telephone: (213) 216-6177

Requirements: IBM PC AT

Comments: This system has a number of different knowledge representation methods; Production rules, Frames and Logic. There is considerable support for the use of uncertainty within the knowledge base and the system supports both confidence factor and semi-exact reasoning methods.

The system includes a sophisticated knowledge based editor which has a certain degree of intelligence built into it so that it is able to support the user in creating the knowledge base. The system is based around the concept of interactively developing the knowledge base through the rule creation, test and then loop-back to modify/add, re test etc. Tools are supplied to aid the tracing and debugging of the knowledge base as well as an extensive explanation tree facility.

Support for external files and programs are provided including the ability to directly reference data cells within Lotus 1-2-3 spreadsheet files. For other databases there are various conversions required prior to their use by the intelligence/ compiler.

One useful facility for the system developer is the intelligent dialogue generator which provides some excellent support for the design and construction of dialogues between the user and the system. There are two modes of use for the system, expert and novice, which provides for different levels of defaults in the generated dialogue screen. Systems developed using this tool can be distributed as stand alone compiled knowledge bases without the payment of any further royalties to the product vendor. Finally, the compiled knowledge base file is encrypted to ensure security of the final system.

8.3 RECOMMENDATION

All of the systems reviewed above run on the PC platform and this was taken as a base requirement for any system that would be used in the field. In terms of the functionality that these systems currently offer, they all show very good qualities. This is not generally surprising as they have been developed within the commercial market place where the competition has forced out all but the well-designed systems.

Of the systems reviewed, the one that best meets the requirements outlined by CMHC for their current needs is the KnowledgePro product which runs in both the DOS ($500) and WINDOWS ($700) environments. It provides both a satisfactory development environment and a good delivery environment with free run-time delivery mechanism.

With systems developed using Knowledge-Pro, a complete stand-alone runtime version of each developed system would be sent to the end user. This would be to ensure the security of the knowledge base. Although it is possible to deliver knowledge base shells, it is often simpler and less of a problem for the end user to just copy a complete system onto their computer.

8.4 GLOSSARY OF COMPUTER TERMS

Bayesian Probability. Statistical approach to the calculation of the probability of an event which takes into account various information regarding prior probability of events occurring and the conditional probabilities between various events.

Button, see User Interface

Check-box, see User Interface

Development system. A development system provides a complete environment in which a knowledge engineer is able to develop a knowledge based system.

such a development system typically provides tools for the development of a knowledge base, tracing of the inference mechanism in operation, user interface design and editing tools and in a number of cases tools to aid the development of a knowledge base using "learning from examples" techniques.

Hyper region, see User Interface

Hypertext. A non-linear version of a text document which provides for the individual to move directly from one point in the text to another. In such systems a user is able to select specific points within the text (words, phrases or markers) and is taken directly to the associated information. For example, a user may select a technical term in the document and immediately be presented with a definition of the term. In a Hypermedia document the link may take the user to a graphic, a video segment or an audio segment of the document.

Runtime. In the current context, a runtime version of an application consists of a version of the application which:

- contains the complete knowledge base;
- is in a form in which the end user is unable to modify the knowledge base (usually) and ensures the security of the knowledge base;
- inhibits the end user from accessing certain functionality of the development version of the system;
- is of a smaller size than the development system.

In some contexts this type of system would be called an executable file/system or application.

Text-window, see User Interface

User Interface. Buttons, check-boxes, hyper regions and text windows are all various types of attributes of a user interface to a hypermedia/hypertext environment.

A **button** can be an indicator of the existence of a link between a point in a document and some other information. Often the additional information is

provided in a separate **text window** so that the user is able to view both the source document and the linked information simultaneously.

In the case of a graphic or picture, a **hyper region** of that source may be designated to act as a linking button to some other information. For example, on the schematic picture of an engine various components, such as the distributor, alternator etc. would be defined as hyper regions and if the user selected one of these he/she could be presented with associated information.

Check-boxes are often used in a dialogue between the system and the users when the users are asked to indicate their response to a question by selecting one of a number of boxes to indicate their decision.

9.0 ISSUES OF MARKETABILITY

This chapter deals with the issues relating to marketability of knowledge-based systems generally, and the EXPAIR system in particular. The issues discussed in the first part of the chapter include the following:

- Market definition (who are the potential buyers?)
- Product acceptance (why should someone buy this product?)
- Marketing issues (how is product awareness to be created?)
- Competitive issues (is there competition, and in what form?)
- Product pricing (how much should a user pay, and when?)
- Product sales and distribution (how is the buyer to acquire this product?)
- Product maintenance and support (who will look after the customer?)

9.1 SURVEY RESULTS

Following is a summary of the survey findings that bear on the issues of marketability. Charts 8-A to 8-H at the end of this chapter summarize the responses to questions asked in Section D of the survey.

9.1.1 KEY FINDINGS

The key findings of the marketability section of the survey are as follows.

- Less than 25 % of the respondents had seen an expert system before.
- For most of the concerns that respondents were asked to react to, about 40% felt unable to comment.
- The source of the expertise embodied in an expert system did not seem to cause excessive concern.
- Of those who commented, the majority agreed or were neutral on the statement that computers cannot replace experience.

- There was a high degree of uncertainty on whether others in their business used expert systems.
- There was little agreement that nobody in the business trusted expert systems.
- There were no strong indications that respondents felt the technology was too new.
- Time required to learn how to use an expert system does not appear to be a significant issue.
- Though some felt that it was easier and more reliable to phone someone they knew to get expert advice, the majority did not comment or were neutral on the subject.
- A small majority of respondents felt that there was no need to wait for the technology to mature and stabilize further.
- A significant majority of respondents (67%) felt that a suitable expert system would help them in their businesses.

9.1.2 CONCLUSIONS

The respondents were likely to be the people in the survey most interested in expert systems. If this is true, the results will be skewed in favour of implementation of expert systems. Yet the results are not particularly encouraging, suggesting a lack of knowledge of the potential for expert system applications, and the need for "missionary sales."

The technology is still in the pioneering stage in the construction industry generally and in home building in particular. To persuade potential users to take advantage of the technology, they must be exposed to a system for which they can see an immediate beneficial use. Such a use will need to do two things: address a real, **and perceived**, need and demonstrate a good potential to save the user money.

9.2 BASIC MARKETING ISSUES

9.2.1 MARKET DEFINITION

Who are the potential buyers?

The product line that is being contemplated is a series of expert systems that deal with topics related to residential buildings. The potential users of such systems would include a broad range of individuals and businesses connected with new residential construction and with renovation of existing residential buildings. Potential users would include, depending on the application, the following:

- developers;
- building owners;
- builders: prime contractors and specialty trades;
- building materials suppliers and manufacturers;
- designers;
- inspectors and regulators.

The questions which will help identify whether or not a potential buyer will purchase the product include the following.

- Does the product address an area of expertise relevant to my business?
- Will the product answer frequently asked questions that I cannot answer using my existing resources?
- Will using this system save me time or money in the normal operation of my business?
- Is the expertise embodied in the system reliable and current?

Using the survey results to assist in understanding the size of the marketplace, the following filter process is helpful. Note that the figures are based on a number of assumptions.

Filter process to evaluate market size

Total Canadian Market:	180,000	*Assumes that each company in the construction industry is a potential buyer of the product. [Source of market size: CCRB Report]*
Portion of market in the Home Building Industry @ 40%	72,000	*Estimated*
Portion of market interested in using this technology @12%	8,640	*Based on approximately 12% response to surveys and demonstrations' invitations.*
Portion of market that may pay $1,000.00 or more @ 35% (see below)	3,034	*$1,000.00 price based on calculation for product pricing (see below).*

These questions should be asked in relation to any expert system. On the basis of the first question, the potential users are likely to be restricted to owners of existing high-rise residential buildings whose tenants experience air quality problems on a regular basis. This group would include condominium corporations and owners of apartment buildings, but would be smaller than the 3,034 potential market identified above.

On the basis of the second question, the potential purchasers will likely be ones with buildings where the problems are both severe and commonplace. This is a relatively small market. Individual tenants or condominium owners are unlikely to purchase the system. A likely user would be the building manager, looking for a quick answer to an air quality problem. The majority of the recommendations currently offered by EXPAIR require special testing and the solutions offer no guarantee of success. It is highly likely that the owner of the building will require a consultant to inspect the building and perform the tests whether or not the system has been used. Thus the answer to the third question will reduce the potential market to a clearly non-viable size.

The fourth question is, at this point, irrelevant. However, the use of any one product will influence the customer's inclination to purchase another one in the future. EXPAIR, in its current form, offers the advice that the temperature and relative humidity should be lowered in almost all circumstances. If this advice is followed repeatedly, then the indoor temperature and relative humidity will, presumably, approach zero. Although this may indeed resolve most indoor air quality problems, it does not inspire confidence with the user.

The consultant retained to do the inspection may also be a potential user of the system. The second question will likely disqualify this potential buyer: If the answer is YES, then the consultant should arguably not be in that business, and if the answer is NO, he/she is not likely to buy the product.

> It is likely that the market for any one product in a line of Expert Systems for the residential construction market will be very restricted.
>
> To overcome the market size problem, the potential product needs to be repositioned to be attractive to a broader population.

9.2.2 PRODUCT ACCEPTANCE

Why should someone buy an expert system?

The construction industry as a whole is slow to accept change. The adoption of computers for any purpose was (and still is) slow. The prime use of computer technology in the industry is for accounting and word-processing. Both applications are well-proven and served by a broad range of suppliers with proven and rigorously tested systems that have set a standard of reliability that must be met by today's new products.

There must usually be a measurable (or at least discernible) advantage to be had out of use of a computer system before a business will invest in it. The investment in the system includes all marginal additional costs of

operating the system. These costs include license charges, maintenance costs, cost of any additional hardware requirements, training and the time required to use the system.

The purchaser needs to be assured that the system will answer questions that currently cost money to answer, and will do so often enough to justify the cost of purchasing, maintaining and using the product.

> Frequency of potential use of the product is an important issue in determining the price to be charged for the product.

The Marketability section of the survey sought to identify the "threshold price" for a knowledge-based system. The results are repeated here.

Price v % prepared to pay it	No Interest at all	$100	$500	$1,000	$2,000	$5,000
Percent	17.7	6.5	40.5	24.2	4.6	6.5
Reverse Cum.%	100	82.3	75.8	35.3	11.1	6.5

From this table, it can be seen that 82% of the respondents would consider paying up to $100 for an expert system product. This reduces to 76% at $500 and 35% at $1000. The threshold price is therefore about $500.

9.2.3 MARKETING ISSUES

How is product awareness to be created?

One of the advantages of selling into a niche market is that the market is often represented by special interest or trade groups. There are associations and professional and technical groups that represent home builders, developers, construction trades and professions involved in the residential building industry. Access to these groups and their regular

meetings and publications will afford good opportunities to create awareness of the proposed software. The challenge is to create a sufficiently receptive audience response. This is usually achieved through identification of immediate benefits... usually financial ones!

Considering EXPAIR in this context, some indication of the response of industry groups may be gleaned from the survey conducted for this report. Nearly 60% of survey respondents were neutral or agreed with the statement that there was no assurance that the expertise (in the system) will lead to the right answer.

The utility of the product is seen as relatively low, particularly given the litigious nature of the industry. 60% of respondents also felt that computers cannot replace experience. This suggests that the time for this technology has not reached the majority of the marketplace. This is borne out further by interview results. Mr. John Ink of the Alberta Construction Technology Centre commented strongly on this point based on a relatively recent attempt to bring knowledge-based systems to the Alberta construction industry.

9.2.4 COMPETITIVE ISSUES

Is there competition, and in what form?

The current perceived competition for expert systems is the experts who are selling their expertise. The basis on which such expertise is sold is the reputation of the expert. These experts will not encourage the use of expert systems when their use is perceived to reduce their own market.

The real advantages of an expert system need to be emphasized. These advantages include the following important features.

- consistency of response;
- the ability to capture experience and knowledge that might otherwise be lost through retirement or other event;
- provide expertise at any time;

- reduce cost of, and access time to, expertise;
- make expertise more available, so that it may be used by a broader group and provide useful training or education to those users;
- supplement the knowledge of other experts.

As the technology becomes more robust and is accepted by the community, it is likely that a broad range of knowledge based information systems will become available. Their usability, depth of knowledge, and ability to 'learn' will likely be features that will be important to users in making their selection of such systems.

9.3 PRODUCT PRICING, DISTRIBUTION AND SUPPORT

9.3.1 PRODUCT PRICING

How much should a user pay, and when?

The cost of product development is only one factor in the overall cost of a software product. Other costs include product maintenance, user support, product distribution, retailer profit, marketing, sales and distribution costs, production costs (packaging, manuals and disks) and product development. Any product that is not continually developed and upgraded on a planned basis will not survive in today's high-tech competitive market. The next upgrade(s) should be in development as the current version hits the market. Plans need to be in place for the strategic development of the product if it is to maintain a market presence.

Pricing should maximize the return on investment. To illustrate this, the following simplified calculation is offered. (Please note: **the figures in the example are intended only as an illustration**)

INITIAL DEVELOPMENT COSTS:

Prototype (current version)	50,000.00
Complete prototype	100,000.00
Alpha test	50,000.00

Prepare for beta test, and complete documentation	50,000.00
Legal agreements etc.	50,000.00
SUB-TOTAL	**300,000.00**
PRODUCTION COSTS (assume 1000 copies)	
Printing	20,000.00
Disks	5,000.00
Packaging	10,000.00
MAINTENANCE COSTS (assume staff of two)	
Payroll for 1 year	100,000.00

With linear amortization of initial development cost over 3 years, the cost per copy, assuming 1,000 were sold each year, CMHC would need to recover:

Development cost contribution	100,000.00
Production Cost	35,000.00
Maintenance cost	100,000.00

... or **$235.00** per copy.

This is only the beginning. Other costs will include the following:

Distribution costs @ $20.00 per copy	20,000.00
Marketing costs (advertising etc.) @ $50,000.00 per year	50,000.00
Sales costs (direct sales force or retailer mark-up) @ 70%	164,500.00
Shell license (e.g. run-time version costs) @$100.00 per copy	100,000.00
On-going product development @ $100,000 per year	100,000.00
SUB-TOTAL	**434,500.00**

This would bring the break-even cost to about $670.00 per copy.

If other factors, such as on-going development of the product, administrative costs, the cost of a 1-800 hot-line, financing costs and so on are considered as well, a likely minimum price, assuming sales of 1,000

copies in the first year would approach $1,000.00 per copy. At $1,000.00 per copy, the potential market is reduced by about 65%.

After the first year, sales would have to increase substantially to cover price erosion. As other products reach the market, price cutting will be inevitable. A 50% drop in price over the first 3 years is not uncommon.

Another issue to be considered in the pricing is the likelihood of not reaching the first year quota of 1,000 sales. These sales equate to about 20 copies per week throughout the year. For a product of this nature, this may be ambitious.

Backing into the price, from the survey results, and comparing other utility products that are on the market, we have an indication that a price of greater than $500 per copy will discourage many potential users from acquiring the product.

There are different ways of altering the pricing structure. The product could be offered as a bulletin-board service with a "user pays" policy. It could be offered to local associations at a higher cost, with permission to copy and distribute to their membership. Subscriptions to periodic upgrades or expertise update may generate revenue.

The initial review, however, suggests that, using the illustrative figures shown above, the venture into producing, marketing and supporting a product like EXPAIR is very risky.

9.3.2 PRODUCT SALE AND DISTRIBUTION

How is the buyer to acquire this product?

The distribution of expert systems should be through an existing network. There are two basic options available. The first is to use industry associations to disseminate information on the product, and to sell and support the product through CMHC's offices.

The second option is to use a commercial outlet. This second option would involve identifying a suitable candidate business with offices across Canada and with good access through its existing client base to the target market for the product. Such a company would need to be interested in taking on the distribution and sale of expert systems. It would need to operate closely with CMHC in the development of future products and upgrades as it will have direct access to the market and its needs.

9.3.3 PRODUCT MAINTENANCE AND SUPPORT

Who will look after the customer?

The EXPAIR product and any subsequent products or upgrades will need to be maintained and supported. Users have expectations created by existing software producers. These expectations must be met by providing a service that addresses customer support, debugging and on-going product enhancement and development.

This service is best provided by the system development team in the first instance, until sales and install base require more time than this group can provide in addition to on-going development work. Sometimes the development team's skill set and the skills required for customer support are not the same. In this case additional staff may be required, adding to the cost of supporting the product. A voice (telephone) and a BBS (Bulletin Board Service) should be considered as a vehicle for offering support for the product(s).

9.4 RECOMMENDATIONS

9.4.1 PRODUCT POSITIONING

Selecting the right first product, and positioning and packaging it to address market needs is of paramount importance for its success. The market currently requires missionary sales which are best effected through professional services companies. The market for the current EXPAIR product is probably too small for it to be viable if restricted to Canada.

9.4.2 PRICING POLICY

It would appear that a price of more than $500 would be an obstacle for many users. A study of the likely cost of completing development and setting up production and support of the product should be undertaken to verify that such a price would sustain the business and provide sufficient return on investment.

9.4.3 SALES AND DISTRIBUTION

The product will need to be focused on a clearly identified market. Sales would likely be too small and too specialized to attract the interest of software retailers, unless they could carry the product on a consignment basis. This is risky and makes receivables difficult to predict. The better option is to sell and support the product through professional services companies who have offices located in major Canadian population centres.

9.4.4 SUPPORT SERVICES

Expectations for support must be addressed. A balance between oversupporting the product and meeting minimum expectations must be established. This may be done by budgeting for a higher level of service than the expected minimum, and then increasing the service level if required.

Another important step is to conduct a rigorous beta-testing program. This program should encourage comments and suggestions from beta users. All such comments and suggestions should be carefully considered. Corrective action should be taken where appropriate before product launch.

9.4.5 PRODUCT DEVELOPMENT

To maintain market share and to support existing users as well as to expand the user base, a detailed plan for product development must be established **before** product launch. Many users expect upgrades, changes and new material. It is often an indication that the software producer intends to remain in the business, and serves the purpose of developing user confidence at this delicate stage.

9.4.6. FURTHER MARKET STUDY

A more detailed market study will likely be required to direct the development of the CMHC expert system venture. There is a potential market for the EXPAIR product but the product will need to be completed first. Potentially, other areas of expertise should be reviewed and developed. Timing of product releases will also need to be investigated further.

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 CONCLUSIONS

The purpose of this assignment was to identify the level of interest among the survey participants and to identify the possible clients and the area of applications. The level of awareness among the home builders is, as expected, very low.

The results of workshops, interviews and the questionnaire survey indicate that the professionals are very eager to find out the real advantages of expert systems. Even though their attitudes towards the applicability is rather mixed, there is willingness among the participants to 'give it a try.' Possible clients and areas of application are identified and the marketing issues are addressed in this report.

Evaluation of EXPAIR did not provide satisfactory results. EXPAIR is only a prototype of a shell. This needs a lot of developmental effort to bring it up to the level of the currently available commercial tools.

The choice of a vehicle to introduce expert systems to the residential sector is a difficult one. It is suggested that the initial product should deal with comparatively simple problems that can be easily managed and easily understood. A tool for diagnosing and solving air quality and moisture problems should be the culmination of a long line of simpler expert systems—air quality and moisture problems are complex, difficult to diagnose, and depend on a very large number of variables.

10.2 RECOMMENDATIONS

The current awareness among the participants indicates that the overall majority in the residential sector consider the issue of code compliance as the most important area that has to be addressed by an expert system.

The consultant would suggest to CMHC to develop a **complete** system to deal with residential building codes and test the waters. CMHC should not wait until a larger majority approves the development of such a system. It should be noted that the software development in electronic spreadsheets did not receive much appreciation when it was first introduced. With a complete system, CMHC can embark on a awareness level raising campaign.

Expert systems should be kept in perspective. They are only computer programs and are certainly not yet true experts capable of a leap in the dark. CMHC should take a positive outlook into the future. The dependence on computers will continue to grow as the world becomes more complex and technology more sophisticated.

Though in many ways the professionals in the residential sector may think that they are never going to reach for the more sophisticated tools, experience has shown that they do adapt to their technological surroundings and readily adopt whatever computing tools make their lives easier. The established commitment to the personal computer coupled with word-processing or spreadsheet software is but one example.

It is quite likely that, if the right tool is developed, the residential sector would embrace it and even be prepared to pay a higher price than the limit indicated in the survey.

11.0 EXHIBITS

11.1 RESPONSES TO QUESTIONNAIRE

Number of Responses:

Architects	38	(24%)
Engineers	17	(11%)
Contractors	36	(24%)
Building Owners	4	(3%)
Inspectors	28	(18%)
Property Managers	7	(5%)
Others	23	(15%)
TOTAL	**153**	(100%)

Responses by Province

	Canada	**B.C.**	**Alta**	**Sask.**	**Man.**	**Ont.**	**Que.**	**Marit.**
Architects	38	8	5	2	2	13	7	1
Engineers	17	1	6	-	1	9	-	-
Contractors	36	-	19	1	-	11	4	1
Building Owners	4	-	1	-	-	2	1	-
Inspectors	28	2	2	1	2	15	5	1
Property Mgrs	7	-	-	-	-	3	4	-
Others	23	-	8	1	-	11	2	1
TOTAL	**153**	**11**	**41**	**5**	**5**	**64**	**23**	**4**
Percent		7%	27%	3%	3%	42%	15%	3%

A3 To what extent do you depend on computers in your work?

	Totally	**Much**	**Not much**	**Total**
Architects	15	18	4	37
Engineers	3	14	-	17
Contractors	4	23	7	34
Building Owners	0	4	-	4
Inspectors	3	15	10	28
Property Managers	2	5	-	7
Others	9	12	2	23
TOTAL	**36**	**91**	**23**	**150**
Percent	24%	61%	15%	100%

A4 How many computers does your organization own/lease?

	Main Frame	Workst'ns	PC	Macintosh
Architects	1	8	26	16
Engineers	-	2	12	2
Contractors	1	9	22	4
Building Owners	-	-	4	-
Inspectors	2	8	23	2
Property Managers	-	3	6	1
Others	4	3	19	8
TOTAL	**8**	**33**	**112**	**33**
Percent	4%	18%	60%	18%

A6 What do you currently use computers for?

	Number of entries	Percent
Accounting	119	20 %
Word Processing	136	23 %
Desktop publishing	62	10 %
CAD	65	11 %
Database/Mailing list	78	13 %
Project Management	58	10 %
Estimating	44	7 %
Construction controls	30	5 %

A8 Who uses computers in your organization?

	Number of entries	Percent
Administrative staff	122	39 %
Designers/Execut./Inspector	85	27 %
Senior Management	92	29 %
Other	14	5 %

D1 Have you ever seen an expert system in use? Yes

Architects	9 out of 38	24%
Engineers	7 out of 17	41%
Contractors	6 out of 36	17%
Building Owners	0 out of 4	0%
Inspectors	6 out of 28	21%
Property Mgrs	0 out of 7	0%
Others	8 out of 23	35%
TOTAL	**36 out of 153**	**24%**

D4 The following concerns have been expressed regarding use of ES. To what extent do you agree/disagree with the statement?

(1 Strongly Agree, 2 Agree, 3 Neutral, 4 Disagree, 5 Strongly Disagree, 0 No comment)

A The source of the expertise is unknown.

Rating	**0**	**1**	**2**	**3**	**4**	**5**
Architects	10	5	10	6	5	1
Engineers	5	2	4	5	1	-
Contractors	8	3	5	13	4	3
Building Owners	1	-	1	2	-	-
Inspectors	10	1	4	8	4	1
Property Mgrs	5	1	-	1	-	-
Others	4	3	8	4	3	1
TOTAL	**43**	**15**	**32**	**39**	**17**	**6**
Percent	28%	10%	21%	26%	11%	4%

B There is no assurance that the expertise will lead to the right answer.

Rating	**0**	**1**	**2**	**3**	**4**	**5**
Architects	11	1	12	11	3	-
Engineers	5	3	6	3	-	-
Contractors	8	3	12	10	3	-
Building Owners	1	-	2	1	-	-
Inspectors	11	2	3	8	3	1
Property Mgrs	4	1	1	1	-	-
Others	3	4	6	5	4	1
TOTAL	**43**	**14**	**42**	**39**	**13**	**2**
Percent	28%	9%	28%	26%	9%	1%

C Computers cannot replace experience.

Rating	0	1	2	3	4	5
Architects	11	2	11	8	4	2
Engineers	5	4	5	3	-	-
Contractors	8	4	8	7	8	1
Building Owners	1	-	-	2	1	-
Inspectors	8	2	3	10	4	1
Property Mgrs	4	1	1	1	-	-
Others	3	2	7	3	7	1
TOTAL	**40**	**15**	**35**	**34**	**24**	**5**
Percent	26%	10%	23%	22%	16%	3%

D Nobody in our business uses them.

Rating	0	1	2	3	4	5
Architects	14	2	7	8	4	3
Engineers	5	2	1	4	5	-
Contractors	9	3	3	7	9	5
Building Owners	1	-	-	2	1	-
Inspectors	11	4	2	3	7	1
Property Mgrs	4	2	-	1	-	-
Others	3	1	2	3	7	5
TOTAL	**47**	**14**	**15**	**28**	**33**	**14**
Percent	31%	9%	10%	18%	22%	9%

E Nobody in our business trusts them.

Rating	0	1	2	3	4	5
Architects	13	1	2	11	8	3
Engineers	5	-	2	5	4	1
Contractors	9	1	-	13	10	3
Building Owners	1	-	-	1	2	-
Inspectors	11	-	-	7	8	2
Property Mgrs	4	-	1	2	-	-
Others	4	-	1	8	6	4
TOTAL	**47**	**2**	**6**	**47**	**38**	**13**
Percent	31%	1%	4%	31%	25%	8%

F The technology is too new.

Rating	0	1	2	3	4	5
Architects	13	0	3	10	11	1
Engineers	5	1	2	4	5	-
Contractors	9	3	2	11	11	-
Building Owners	1	-	-	2	1	-
Inspectors	10	4	1	5	7	1
Property Mgrs	4	-	1	2	-	-
Others	3	1	2	7	7	3
TOTAL	**45**	**9**	**11**	**41**	**42**	**5**
Percent	**30%**	**6%**	**7%**	**27%**	**27%**	**3%**

G It will take too long to learn to use the system.

Rating	0	1	2	3	4	5
Architects	12	1	2	6	13	4
Engineers	5	-	1	6	5	-
Contractors	9	1	4	10	11	1
Building Owners	1	-	1	1	1	-
Inspectors	9	3	2	6	5	3
Property Mgrs	4	-	-	3	-	-
Others	4	-	-	3	-	-
TOTAL	**43**	**5**	**12**	**37**	**44**	**12**
Percent	28%	3%	8%	24%	29%	8%

H It is easier and more reliable to phone someone you know to get expert advice.

Rating	0	1	2	3	4	5
Architects	12	1	5	13	7	-
Engineers	5	2	5	3	1	1
Contractors	9	1	4	12	10	-
Building Owners	1	-	-	2	1	-
Inspectors	9	3	3	4	8	1
Property Mgrs	4	1	-	1	1	-
Others	3	3	4	6	5	2
TOTAL	**43**	**11**	**21**	**41**	**33**	**4**
Percent	28%	7%	14%	27%	22%	3%

D5 Do you feel you should wait a few years until they get the bugs out of these new toys, no matter what the price?

	Yes	No	No Opinion
Architects	18	18	2
Engineers	5	11	1
Contractors	13	17	6
Building Owners	2	2	0
Inspectors	10	16	2
Property Managers	3	3	1
Others	6	12	5
TOTAL	**57**	**79**	**17**
Percent	37%	52%	11%

D6 Do you think that a suitable expert system would make your operations more efficient and/or more profitable?

	Yes	No	No Opinion
Architects	26	7	5
Engineers	8	7	2
Contractors	22	7	7
Building Owners	4	0	0
Inspectors	23	3	2
Property Managers	4	2	1
Others	15	4	4
TOTAL	**102**	**30**	**21**
Percent	67%	20%	14%

D7 Would you be prepared to purchase such a system if the price was less than:

	$100	$500	$1000	$2000	$5000	No Opinion
Architects	2	21	7	-	2	6
Engineers	-	6	4	-	2	5
Contractors	2	15	9	2	2	6
Building Owners	-	-	3	1	-	-
Inspectors	4	11	8	-	1	4
Property Managers	1	1	2	2	-	1
Others	1	8	4	2	3	5
TOTAL	**10**	**62**	**37**	**7**	**10**	**27**
Percent	7%	41%	24%	5%	7%	18%

E1 **Rate in order of priority the areas in which you feel there is a need for diagnostic aids for the practitioner:**
(1 low priority, 5 high priority; 0 is no response)

WINDOW PROBLEMS

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	6	8	7	6	6	5
Engineers	2	1	3	2	1	8
Contractors	5	4	9	4	3	11
Building Owners	1	1	1	1	-	-
Inspectors	5	1	4	3	4	10
Property Managers	1	-	1	1	1	3
Others	2	6	6	1	2	7
TOTAL	**22**	**21**	**31**	**18**	**17**	**44**
Percent	14%	14%	20%	12%	11%	29%

ROOFING PROBLEMS

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	14	7	5	2	5	5
Engineers	2	1	3	-	3	8
Contractors	9	3	6	3	4	11
Building Owners	2	1	-	-	1	-
Inspectors	8	3	4	-	3	9
Property Managers	2	-	1	-	-	4
Others	3	4	5	1	4	7
TOTAL	**40**	**19**	**24**	**6**	**20**	**44**
Percent	26%	12%	16%	4%	13%	29%

WALL CRACKING

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	4	6	6	7	9	6
Engineers	1	-	4	1	2	9
Contractors	12	2	5	2	3	12
Building Owners	-	1	-	1	1	1
Inspectors	5	3	4	2	3	10
Property Managers	2	-	-	-	1	4
Others	4	-	6	2	3	9
TOTAL	**28**	**12**	**25**	**15**	**22**	**51**
Percent	18%	8%	16%	10%	14%	33%

E2 **Rate in order of priority the areas in which you feel there is a need for selection tools for the practitioner:**
(1 low priority, 5 high priority; 0 is no response)

SEALANTS

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	9	9	6	1	4	9
Engineers	1	2	3	1	3	7
Contractors	6	6	2	5	1	16
Building Owners	1	1	-	-	-	5
Inspectors	3	1	4	1	3	15
Property Managers	1	-	1	-	-	5
Others	7	4	3	1	1	8
TOTAL	**28**	**23**	**19**	**11**	**12**	**60**
Percent	18%	15%	12%	7%	8%	39%

ROOFING MEMBRANES

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	8	10	4	4	4	8
Engineers	1	-	4	2	3	7
Contractors	6	7	4	3	1	15
Building Owners	1	2	-	-	1	-
Inspectors	6	3	2	1	-	15
Property Managers	1	-	-	1	-	5
Others	3	6	2	2	3	8
TOTAL	**26**	**27**	**16**	**13**	**12**	**58**
Percent	17%	18%	10%	8%	8%	38%

WINDOWS

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	1	7	10	10	1	9
Engineers	1	-	5	3	1	7
Contractors	6	4	7	2	2	15
Building Owners	1	1	1	-	1	-
Inspectors	5	1	4	-	2	15
Property Managers	-	-	-	-	2	5
Others	2	3	8	1	2	8
TOTAL	**16**	**16**	**35**	**16**	**11**	**59**
Percent	11%	11%	23%	10%	7%	39%

E3 **Expert systems can be designed to guide a user through the process of completing a difficult task. Rate in order of priority the areas in which you feel there is a need for for the practitioner, and suggest other topics that you believe would be of interest:**
(1 low priority, 5 high priority; 0 is no response)

CODE COMPLIANCE

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	18	5	3	2	4	6
Engineers	5	3	1	3	5	5
Contractors	12	2	6	1	2	13
Building Owners	1	-	1	1	-	1
Inspectors	8	3	2	1	6	7
Property Managers	-	-	-	1	1	5
Others	10	2	1	-	4	7
TOTAL	**54**	**15**	**14**	**9**	**22**	**44**
Percent	34%	9%	9%	6%	14%	28%

COMPLIANCE WITH LABOUR LAWS

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	4	3	11	4	10	6
Engineers	-	2	2	3	2	3
Contractors	7	3	3	6	1	16
Building Owners	-	2	-	-	1	1
Inspectors	3	1	6	3	2	12
Property Managers	-	-	1	-	1	5
Others	1	3	7	1	2	10
TOTAL	**15**	**14**	**30**	**17**	**19**	**58**
Percent	10%	9%	20%	11%	12%	38%

EMERGENCY PROCEDURES

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	3	5	9	6	8	7
Engineers	1	1	5	1	2	7
Contractors	8	1	5	2	2	18
Building Owners	-	1	1	-	1	1
Inspectors	3	2	6	1	3	12
Property Managers	2	-	1	-	-	4
Others	1	3	7	1	2	10
TOTAL	**22**	**11**	**29**	**13**	**17**	**61**
Percent	14%	7%	19%	8%	11%	40%

E5 Rate the following uses of an expert system in order of importance:

(1 not important, 5 very important)

TRAINING PERSONNEL

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	3	8	11	3	1	12
Engineers	5	1	3	1	1	6
Contractors	9	4	4	4	4	11
Building Owners	2	-	1	-	1	-
Inspectors	5	8	5	-	1	8
Property Managers	1	-	-	1	-	6
Others	2	6	4	3	3	5
TOTAL	**27**	**27**	**28**	**12**	**11**	**48**
Percent	18%	18%	18%	8%	7%	31%

IDENTIFYING PROBLEMS

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	12	12	2	1	4	7
Engineers	7	1	2	1	1	5
Contractors	14	5	2	2	5	8
Building Owners	1	1	1	-	-	1
Inspectors	10	3	6	-	-	9
Property Managers	2	-	-	-	1	4
Others	7	3	2	3	1	7
TOTAL	**53**	**25**	**15**	**7**	**12**	**41**
Percent	35%	16%	10%	5%	8%	27%

GUIDING DESIGNERS

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	13	10	2	5	2	6
Engineers	9	-	1	-	3	4
Contractors	11	8	3	2	4	8
Building Owners	-	-	2	1	-	1
Inspectors	5	5	2	1	1	14
Property Managers	2	-	-	-	1	4
Others	5	2	5	3	2	6
TOTAL	**45**	**25**	**15**	**12**	**13**	**43**
Percent	29%	16%	10%	8%	8%	28%

E6 Rate the following types of issues to be addressed

(1 not important, 5 very important)

DESIGN CONCEPT

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	2	7	7	5	5	12
Engineers	5	1	3	-	2	6
Contractors	4	9	6	1	2	14
Building Owners	1	2	-	-	-	1
Inspectors	1	6	5	1	2	13
Property Managers	1	-	1	1	1	3
Others	5	4	5	-	1	8
TOTAL	**19**	**29**	**27**	**8**	**13**	**57**
Percent	12%	19%	18%	5%	8%	37%

MATERIAL SELECTION/USAGE

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	7	14	5	2	2	8
Engineers	6	2	2	1	1	5
Contractors	5	10	4	2	1	14
Building Owners	1	-	2	-	-	1
Inspectors	3	6	7	1	1	10
Property Managers	-	-	2	-	2	3
Others	5	8	2	1	2	5
TOTAL	**27**	**40**	**24**	**7**	**9**	**46**
Percent	18%	26%	16%	5%	6%	30%

CODE COMPLIANCE

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	19	6	1	2	1	9
Engineers	5	4	2	-	-	6
Contractors	11	4	5	1	2	13
Building Owners	1	-	1	1	-	1
Inspectors	13	5	1	1	1	7
Property Managers	2	2	-	-	-	3
Others	8	4	1	3	2	5
TOTAL	**59**	**25**	**11**	**8**	**6**	**44**
Percent	39%	16%	7%	5%	4%	29%

REGULATORY COMPLIANCE

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	14	9	1	3	3	8
Engineers	4	3	3	1	1	5
Contractors	7	6	4	2	2	15
Building Owners	-	3	-	-	-	1
Inspectors	13	5	2	1	-	7
Property Managers	2	1	-	1	-	3
Others	6	3	3	4	2	5
TOTAL	**46**	**30**	**13**	**12**	**8**	**44**
Percent	30%	20%	8%	8%	5%	29%

CONSTRUCTION PRACTICES

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	8	11	4	1	-	14
Engineers	4	-	5	-	2	6
Contractors	8	7	2	3	1	15
Building Owners	-	1	-	-	2	1
Inspectors	5	7	2	2	1	11
Property Managers	2	-	1	-	-	4
Others	3	7	5	2	1	5
TOTAL	**30**	**33**	**19**	**8**	**7**	**57**
Percent	19%	21%	12%	5%	5%	37%

SOURCES OF MATERIAL

Rating	**5**	**4**	**3**	**2**	**1**	**0**
Architects	4	5	9	3	5	12
Engineers	1	2	5	-	2	7
Contractors	4	7	6	3	1	15
Building Owners	1	1	1	-	-	1
Inspectors	3	4	7	1	1	12
Property Managers	-	-	-	-	4	3
Others	5	5	2	2	3	6
TOTAL	**18**	**24**	**30**	**9**	**16**	**56**
Percent	12%	15%	20%	6%	11%	37%

E7 Rate the following building science and related issues to be addressed

(5 high priority, 1 low priority)

Rating	5	4	3	2	1	0
Heating and ventilating	51	33	20	11	3	35
Fire protection	50	28	21	12	4	38
Found'n/basem't design	44	30	23	11	5	40
Roofing	42	29	26	10	6	41
Safety	40	27	18	14	6	48
New technologies	46	21	15	13	7	51
Framing	33	28	28	11	8	45
Drainage	24	25	31	17	11	45
Site investigations	32	16	25	19	15	46
Glazing	17	29	39	21	5	42
Electrical power/wiring	22	24	25	22	11	49
Lighting	19	25	35	18	10	46
Plumbing	18	25	36	19	8	47
Cladding	16	26	41	16	10	44
Security systems	14	21	28	23	21	46
Flooring	17	17	39	23	14	43
Interior design	12	20	25	22	23	50
Utilities/siteservicing	10	18	24	27	24	50
Kitchen design	8	14	25	20	36	50
Millwork	9	9	33	26	29	47
Gypsum board	7	11	37	23	26	49
Landscaping	5	8	30	23	36	51

Important:
Table E7 has been sorted in order of importance, as perceived by participants. This was done by adding the values in columns 1 and 2, then sorting in descending order.

E8 Which of the following software support services would you expect to receive from a system supplier

	Train'g	System Support	System Maint'ce	User Support	Regular Update	User Groups	System Upgrades	None
Architects	23	14	31	26	32	14	25	1
Engineers	9	8	10	11	13	7	10	4
Contractors	30	22	29	25	29	9	24	-
Building Owner	3	2	2	3	4	1	3	-
Inspectors	21	14	15	17	21	4	16	4
Prop'y Mgrs	3	2	4	4	4	-	3	1
Others	14	12	13	14	15	5	12	5
TOTAL	**103**	**74**	**104**	**100**	**118**	**40**	**93**	**20**
Percent	16%	11%	16%	15%	18%	6%	14%	3%

E9 What type of expert system(s) would you prefer ?

	Stand-alone Systems	Intg. Modular Systems	Add-on Capability	No Comment
Architects	10	16	29	2
Engineers	2	6	7	5
Contractors	5	21	13	6
Building owners	-	3	2	-
Inspectors	6	10	12	5
Property Managers	-	3	5	1
Others	4	12	11	4
TOTAL	**27**	**71**	**79**	**23**
Percent	14%	36%	40%	12%

E10 Would you prefer... ?

	In-house Software	Bulletin board Access	Hard to say	Both	No Comment
Architects	19	10	2	4	3
Engineers	10	2	-	4	3
Contractors	22	4	2	1	7
Building Owners	2	1	-	-	1
Inspectors	20	2	-	-	6
Property Managers	5	-	-	-	2
Others	9	6	1	2	5
TOTAL	**87**	**25**	**5**	**11**	**27**
Percent	56%	16%	3%	7%	17%

11.2 SURVEY QUESTIONNAIRES

AN "EXPERT SYSTEM" FOR THE HOUSING SECTOR?
Background Information on CMHC-Sponsored Feasibility Study

What is an "Expert System"? In recent years, a new family of software programs has emerged. They are known as **expert systems**. In computer language, these refer to systems which emulate human thought processes and can serve as practical problem-solving tools. In other words, they can act as an expert for the user.

Knowledge-based expert systems (KBES) contain, in addition, specialist knowledge about a particular subject area and are capable of making intelligent decisions.

Residential Sector Applications? Practitioners in the housing industry can be confronted with technical problems that are beyond their capacity to deal with effectively. Factors such as expense and availability may discourage them from calling upon experts to find the problem's cause and proper remedy. Can the computer, when loaded with a knowledge-based tool, fill the bill instead?

We're talking here about practitioners such as:

- builders and their sub-trades;
- architects, designers and consulting engineers;
- residential property managers;
- building officials and inspectors.

And we're talking about a wide variety of subject areas—for example, indoor air quality, water infiltration, sealants, insulation, windows, HVAC, roofing systems, energy efficiency, regulation compliance—you name it! The housing industry offers many potential applications throughout the whole gamut of the building sciences in planning, design, construction, management, maintenance and inspection activities.

Large or Small. Expert systems can be equally valuable to organizations of all sizes. Smaller outfits usually have fewer experts on staff or resources to hire consultants. On the other end of the scale, large organizations tend to encounter a greater variety of problems. Regardless of size, the use of an expert system can improve productivity. Also, as new knowledge is accumulated, it can be preserved in the system.

Why The Survey? Your input is needed to identify possible areas of application for expert systems in the housing sector and to assist the consultant in determining if there is a viable market. The enclosed questionnaire is also designed to give guidance on the future scope for expert systems or other computerized knowledge-based tools in the housing sector.

Any questions should be directed at the following offices of the consultant, **Wagner Daigle Revay Ltée**, and the **Revay Group**:

■ Montreal	(514) 932-9596	Matthew Nicholas, Carol Wagner
■ Toronto	(416) 498-1303	Paul Sandori
■ Ottawa	(613) 238-7184	Don Chutter
■ Calgary	(403) 259-5056	George Jergeas
■ Vancouver	(604) 984-8666	Max Wideman

The CMHC Project Officer in Ottawa is **Pierre-Michel Busque** (613) 748-4671.

AN "EXPERT SYSTEM" FOR THE HOUSING SECTOR?

A Survey for the Canada Mortgage and Housing Corporation

Please tick the appropriate box(es) or answer the question where applicable; if the question requires a numerical answer, please place the number in the box.

The completed questionnaire should be sent to:

Revay and Associates Limited
Attn. Paul Sandori
Suite 1001, 505 Consumers Road
North York, Ont. M2J 4V8

A self-addressed, postage-paid envelope is provided.

A Participant Information

Name of Company/Organization .....
Name of Contact.....
Title .....
Street.....
City .....Prov. .....Postal Code.....
Phone Number:.....
Fax Number.....

A1 How would you categorize your company?

- ☐ Architects/Designers
- ☐ Contractors
- ☐ Inspectors
- ☐ Engineers
- ☐ Building Owners
- ☐ Property Managers

Other (Please specify) .....

A2 Please explain the type of service(s) you provide:

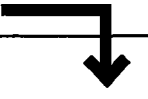
.....

.....

A3 To what extent do you depend on computers in your work:

☐ Totally ☐ Much ☐ Not Much

If you do not use computers, please skip to Section B



A4 How many computers does your organization own/lease?
If you don't know the exact number, please make an estimate.

- ☐ Workstation(s)
- ☐ PC (IBM or compatible)
- ☐ Apple Macintosh

Other (Please specify) .....

A5 What is the most powerful personal computer in your company?

☐ 486 ☐ 386 ☐ 286 ☐ XT
☐ Macintosh ..... ☐ Don't know

A6 What do you currently use computers for?

☐ Accounting ☐ Word Processing
☐ Desktop publishing ☐ CAD
☐ Database/Mailing list ☐ Project management
☐ Estimating ☐ Construction controls

Other (Please specify) .....

A7 What sort of price do you consider affordable for software packages?

☐ Accounting System .....
☐ Word Processing .....
☐ Spreadsheet .....
☐ CAD .....

A8 Who uses computers in your organization?

☐ Administrative staff
☐ Designers/Executives/Inspectors
☐ Senior Management

Other (Please specify) .....

A9 Do you currently use an expert system in your company? If so, which one:

Name and source: .....
Application: .....
Is the system useful:
☐ Yes ☐ No ☐ Somewhat useful

If you do **not** use an expert system:

☐ Do you have members who are aware of the application of expert systems?
☐ Would you be interested in examining an expert system?

B Would your company benefit from an expert system?

B1 How often do you need expertise that is not available in your organization?

☐ Often ☐ Sometimes ☐ Almost never

B2 Where do you get this information? Please indicate all sources used:

☐ Friends or colleagues ☐ Suppliers
☐ Trade contractors ☐ Consultants
☐ Books ☐ Technical journals
☐ Catalogues ☐ Government publications

Other (Please specify) .....

B3 Is the expertise required to provide the service(s) expensive?
☐ Yes ☐ No

B4 Do you have feed-back information from past projects readily available?
☐ Yes ☐ No

B5 Do you spend a large proportion of time on routine decision making?
☐ Yes ☐ No

B6 Do your experts have to make critical judgments in a short time?
☐ Yes ☐ No

B7 Do you consider that services you provide are bottle-necked by the difficulty in finding knowledgeable staff?
☐ Yes ☐ No

B8 What are the topics you would seek external expertise on? (Please list)

.....
.....
.....

C Could your knowledge be made part of an expert system?

C1 How would you categorize the knowledge required for your services(s)?
☐ Common sense and experience
☐ Data/numerical intensive
☐ Scientific knowledge

C2 Can the knowledge required to provide your service(s) be well-defined?
☐ Yes ☐ No

C3 Is this knowledge

reliable?	☐ Yes	☐ No
relatively stable?	☐ Yes	☐ No
generally accepted?	☐ Yes	☐ No
available?	☐ Yes	☐ No
complete?	☐ Yes	☐ No
formalized?	☐ Yes	☐ No

C4 Can this knowledge be broken down into various modules?
☐ Yes ☐ No

C5 Do you follow a set of standard procedures to solve problems?
☐ Yes ☐ No

C6 Do you see advantages in having the expertise required by your company computerized and provided by an expert system?
☐ Yes ☐ No

C7 Do you think that the value of tasks solved for your services would be sufficient to repay the cost of developing/purchasing an expert system?

☐ Yes ☐ No ☐ Don't know

C8 Would you invest time and money in the development of an expert system?

☐ Yes ☐ No
☐ Only with financial assistance
☐ Only with specialist assistance
☐ Only if I could recover the cost through sales

D Marketability of expert systems

D1 Have you ever seen an expert system in use?

☐ Yes ☐ No

D2 If so, which one(s)?

.....

D3 What was your overall impression of the expert system(s)?

.....

D4 The following concerns have been expressed regarding use of expert systems. To what extent do you agree/disagree with the statements?
(1 Strongly Agree, 2 Agree, 3 Neutral, 4 Disagree, 5 Strongly Disagree)

☐ The source of the expertise is unknown.
☐ There is no assurance that the expertise will lead to the right answer.
☐ Computers cannot replace experience.
☐ Nobody in our business uses them.
☐ Nobody in our business trusts them.
☐ The technology is too new.
☐ It will take too long to learn to use the system.
☐ It is easier and more reliable to phone someone you know to get expert advice.

D5 Do you feel you should wait a few years until they get the bugs out of these new toys, no matter what the price?

☐ Yes ☐ No

D6 Do you think that a suitable expert system would make your operations more efficient and/or more profitable?

☐ Yes ☐ No

D7 Would you be prepared to purchase such a system if the price was less than:

☐ $100 ☐ $500 ☐ $1,000 ☐ $2,000 ☐ $5,000

E Applications of Expert Systems

E1 Rate in order of priority the areas in which you feel there is a need for **diagnostic aids** for the practitioner:
(1 low priority, 5 high priority)

☐	window problems	☐	.....
☐	roofing problems	☐	.....
☐	wall cracking	☐	.....
☐	.....	☐	.....

E2 Rate in order of priority the areas in which you feel there is a need for **selection tools** for the practitioner:

☐	sealants	☐	.....
☐	roofing membranes	☐	.....
☐	windows	☐	.....
☐	.....	☐	.....

E3 Expert systems can be designed to guide a user through the process of completing a difficult task. Rate in order of priority the areas in which you feel there is a need for **guidance systems** for the practitioner, and suggest other topics that you believe would be of interest:

☐	code compliance	☐	.....
☐	compliance with labour laws	☐	.....
☐	emergency procedures	☐	.....
☐	.....	☐	.....

E4 Rate the areas in which you feel there is a need for computer **support tools** for the practitioner. These systems may, for example, support a user in intelligent directory/file maintenance, document/drawing management system, etc.

☐	.....	☐	.....
☐	.....	☐	.....
☐	.....	☐	.....
☐	.....	☐	.....

E5 Rate the following uses of an expert system in order of importance:
(1 not important, 5 very important):

☐	Training personnel	☐	.....
☐	Identifying problems	☐	.....
☐	Guiding designers	☐	.....
☐	.....	☐	.....
☐	.....	☐	.....
☐	.....	☐	.....

E6 Rate the following types of issues to be addressed:

- ☐ Design concepts
- ☐ Code compliance
- ☐ Construction practices
- ☐ .....
- ☐ .....
- ☐ .....
- ☐ .....
- ☐ Material selection/usage
- ☐ Regulatory compliance
- ☐ Sources of materials
- ☐ .....
- ☐ .....
- ☐ .....
- ☐ .....

E7 Rate the following building science and related issues to be addressed **(1 low priority, 5 high priority):**

- ☐ Site investigations
- ☐ Utilities-site servicing
- ☐ Cladding
- ☐ Glazing
- ☐ Flooring
- ☐ Millwork
- ☐ Plumbing
- ☐ Lighting
- ☐ Interior design
- ☐ Drainage
- ☐ New technologies
- ☐ .....
- ☐ .....
- ☐ .....
- ☐ .....
- ☐ Foundation and basement design
- ☐ Framing
- ☐ Roofing
- ☐ Heating and ventilating
- ☐ Gypsum board
- ☐ Fire protection
- ☐ Electrical power/wiring
- ☐ Security systems
- ☐ Landscaping
- ☐ Kitchen design
- ☐ Safety
- ☐ .....
- ☐ .....
- ☐ .....
- ☐ .....

E8 Which of the following software support services would you expect to receive from a system supplier?

- ☐ Training
- ☐ System support
- ☐ Regular updates
- ☐ System upgrades
- ☐ System maintenance
- ☐ User support
- ☐ User groups
- ☐ .....

E9 What type of expert system(s) would you prefer?

- ☐ Stand-alone systems for each topic covered
- ☐ Integrated Modular systems
- ☐ Add-on capability as needs increase

E10 Would you prefer:

- ☐ In-house software?
- ☐ Bulletin board access?

Thank you for your assistance

11.3 QUESTIONNAIRE FOR EVALUATION OF EXPAIR

EVALUATION OF THE "EXPAIR" EXPERT SYSTEM

Your response is needed to assess EXPAIR for future applications and further enhancement. Please grade each factor.

1. Is Expair efficient?
In user interaction formats, those with the fewest key strokes are the most efficient. The more "visual" the choice, the easier the system will be to use.

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

2. Is Expair understandable?
The user should make sense of what the system is asking for and what it is saying in its advice.

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

3. Is Expair "user friendly"?
No matter how good the logic of the system or how complex its knowledge, if the user cannot effectively interact with the software, then the expert system will not achieve its primary goal of replicating human expertise.

☐ Most Friendly ☐ Very Friendly ☐ Friendly ☐ Fairly Friendly ☐ Not Friendly

4. How good would Expair be as a tool in your business/occupation?
Expair is still being developed and its knowledge base is far from complete. However, it should still be possible to assess its potential as a tool that may help you do your job better or more easily. Please let us know how you rate Expair in this regard.

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

5. How long would it take to learn to use Expair?
An expert system is useful only if a potential user can become familiar with the system within a reasonable period of time. Please give us a rough estimate of how long you think it would take you to learn Expair and use it with confidence:

☐ Under 1 hr ☐ 1 to 3 hrs ☐ 3 to 6 hrs ☐ 1 day ☐ Wouln't even try!

6. How important is it for you to be able to follow the system's reasoning?
Some users have more confidence in the system's reasoning process if they have some means of following the reasoning behind a particular consultation. Other users just want results and trust the software developers to take care of the validity of the answers. How important would such a feature be to you?

☐ Essential ☐ Very important ☐ Moderately important ☐ Not very important

7. How important are graphics?
Assuming that you would wish to follow the computer's reasoning. How important would it be for you to have a graphical representation of the knowledge base and the decision process?

☐ Essential ☐ Very important ☐ Moderately important ☐ Not very important

8. How much importance do you attach to expert systems in general?
Now that you have seen Expair in operation, you can probably visualize other applications of this technology to your work. Of course, time and resources would have to be allocated to develop these additional tools. What degree of priority would you attach to the development of new expert systems?

☐ Top Priority ☐ High Priority ☐ Medium ☐ Low Priority ☐ Forget it!

9. What expert systems would you find most useful?
If an expert system such as Expair were available in the market at the present time, which information modules would you be particularly interested in? If possible, please list them in order of priority:

☐ .....

☐ .....

☐ .....

☐ .....

☐ .....

☐ .....

SUGGESTIONS AND COMMENTS

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....