APPLICATION OF SIMULATION PROGRAMS TO THE ASSESSMENT OF OVERHEATING RISKS IN BUILDINGS AND THE WORK OF IEA ANNEX 21

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ABSTRACT

This paper describes the objectives of International Energy Agency (IEA) Annex 21 and the ongoing work of Subtask B which deals with how programs should be used for particular applications. Well documented procedures for using programs need to be developed to fulfill a real need by increasing consistency of performance assessment, aiding in training, allowing improvement of procedures and promoting quality assurance.

The emphasis in this work is on how programs are applied, so that the programs are taken as 'given'. The assumptions embodied in programs are relevant to the choice of program for a particular purpose and application, but the immediate focus here is on how best to use them rather than on how their design might be improved.

The way programs should be used to address a particular purpose has been termed a Performance Assessment Method (PAM) and an attempt has been made to structure these using a documentation proforma, or 'Shell'. A prototype expert system has also recently been developed as an aid to systematic documentation and information retrieval.

It is expected that many different PAMs will be in use by practitioners and researchers, but that there will be common elements which will become clear once a number of PAMs have been documented. Documentation is essential so that, firstly, the assumptions in currently adopted methods can be made explicit and thus open to analysis, secondly, that quality assurance can be carried out, and thirdly, that portions of the assessment method for one application can be re-used for different applications. Thus part of the data selection/analysis procedure can be applied equally well to an overheating investigation as to an energy retrofit. The development of a library of accredited PAMs could lead to an important increase in the quality and credibility of the use of prediction programs in the building field.

INTRODUCTION

Procedures for calculating the energy and environmental performance of buildings have been in existence for a considerable time and a great deal of research and development has taken place. Increasingly complex software packages **(PROGRAMs)** have been developed and used within the research community. They are now finding their way into the construction industry and are being used to address real world problems.

Very little information exists on what sort of performance assessments are actually carried out. one survey was carried out in North America [Seth, 1987] and another one is in progress in the UK.

The North American study was a market survey of energy analysis programs. This showed that engineering consultants were the main purchasers, with the market having reached a fairly low growth situation. A relatively small number of programs dominated the market (11 programs accounting for 92% of reported sales). The main reasons given for using energy analysis programs were either:

because their use was mandated, or
in order to compare options and evaluate trade-offs

The characteristics most frequently mentioned by survey respondents as important when deciding on purchases were ease-of-use, adequate documentation and a good manual.

The UK survey was carried out for BRE and Dept. Energy (ETSU) by the Construction Industry Computing Association (CICA). Separate questionnaires were sent in 1990 to program vendors, known program users and designers. The responses have not been fully analysed and in-depth structured interviews will be carried out in 1991 to supplement the information obtained. The preliminary conclusions suggest that the most common performance assessments carried out using computer programs are:

Architects	Building Regulations checking
	Condensation risk
Local authorities	Plant sizing
	Building Regulations checking
	Temperature and humidity levels
	Annual energy
Building Services Consultants	Annual energy
	Condensation risk
	Temperature and humidity levels

Again, one of the factors that received frequent mention was the importance of ease-of-use of programs. It is regarded as very likely that this applies as much to the performance assessment method as to the program itself. If clear guidance on how to perform an assessment was available, assessments would be carried out much more often.

Initiatives from local authorities and from the UK Government and the European Community are encouraging the use of programs for both design and retrofit applications. There are, however, major problems in their use as demonstrated by the study carried out by the Joint Research Centre of the European Community at Ispra to compare different methods of conducting an energy audit [Helcke, 1990]. Four companies were commissioned to carry out audits of the same set of buildings - 6 apartment blocks, a school and a single family house. The type of audits conducted ranged from a non-instrumented walk through, with the use of a simple steady state program, to an infra-red envelope study with computer processing of images and using a detailed simulation program.

The dispersion (100*range/mean) between the input values used by the four companies varied from 15 -155% and in the calculated energy flows from 25 - 245%. The auditors examined the cost-effectiveness of several Energy Conservation Options and came to quite different conclusions. These discrepancies stem from a variety of different causes, including different user assumptions and differences in level of program detail. This illustrates the need for documenting the method that is to be used for a PAM, in this case an Energy Audit PAM, so that they can be reliably carried out and can be compared and evaluated. The Ispra exercise showed that there was little correlation between the cost of the audits investigated or of the quality of the information provided.

As the user base becomes wider, it is inevitable that the average level of user expertise and understanding of building physics and simulation techniques becomes lower. There is therefore an increasing chance that a program will be used improperly or outside the range of applicability dictated by the assumptions and approximations within the program. Options are often provided within a single program to allow the user a choice between different **MODELs**, each having differing levels of modelling detail. This further complicates the task of the non-expert user and increases the need for guidance on program use to be set down unambiguously. The international collaborative project, IEA Annex 21, is addressing this need.

IEA Annex 21 - CALCULATION OF ENERGY & ENVIRONMENTAL PERFORMANCE OF BUILDINGS

This project started in October 1989 and will finish in October 1992; 8 countries are participating fully with other countries having Observer status.

The objectives of the Annex are:
(i) to develop quality assurance procedures for calculating the energy and environmental performance of buildings by providing guidance on:

program and modelling assumptions
appropriate use of programs for a range of applications
evaluation of programs

(ii) to establish requirements and market needs in building and environmental services design

(iii) to propose policy and strategic direction for the development of calculation procedures

(iv) to propose means to effect technology transfer of calculation procedures into the building and environmental services design profession.

The Annex seeks to address some of the obstacles (Table 1) to the use of prediction programs; it is divided into four subtasks (Fig. 1) with one major theme running through the Annex - the need to improve **quality assurance** to give greater confidence in the use of prediction methods in building and environmental services design.

A clear statement of the assumptions and simplifications made in the program is seldom available

Well-documented, reliable input data are hard to find

Guidance on how to translate a real building description into the simplified form required by the program is almost totally lacking

Rules for the selection of climatic, occupancy and other user data are needed

Guidance is needed on the choice of performance parameters to be output from the program and their interpretation for particular applications

Much improved user interfaces are needed; these should be matched to the type of program user and have facilities to help trap errors

Reliable and accepted methods for judging the adequacy and accuracy of programs are needed if issues such as professional liability are to be satisfactorily addressed.

Table 1
Obstacles to the use of performance calculation methods

It is essential to be able to describe aspects of modelling in a simple clear fashion i.e. these aspects must be documented.

You must be able to define in order to understand; to understand in order to be able to assess; to assess in order to be able to improve.

Accordingly, in this paper the major emphasis is laid on the documentation issues and tasks in Annex 21, concentrating on the work of Subtask B, **Appropriate use of programs**, which has as objectives:

- provide guidance on how to select an appropriate program and data for a specific application
- provide guidance on how to apply these to specific applications.

The main outputs of the subtask will be a series of guides illustrating the proper use of an ideal program, and will include Case Studies to help quantify the importance of different assumptions and levels of modelling detail. To date the emphasis of the subtask has been on providing guidance for specific applications.

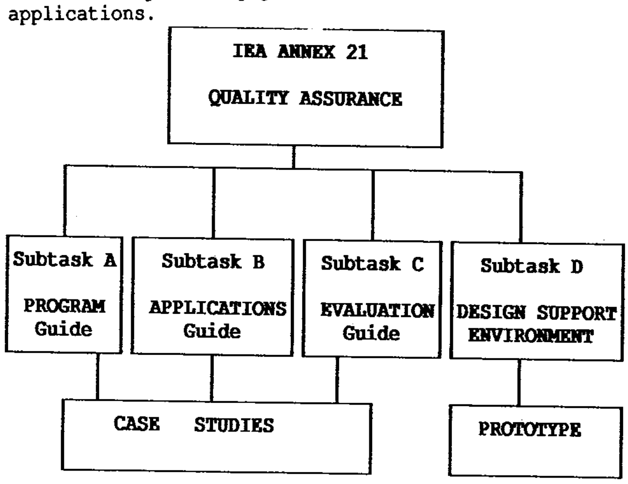

FIG. 1 IEA Annex 21

NEED FOR DOCUMENTATION

In past attempts to compare results obtained by different people, either using the same or different programs [Jones, 1979; Allen, 1985], insufficient attention has been paid to the distinctions made between Program, Model, Method, etc. Indeed, there are no universal terms in common use within the modelling community. The overall effect of this has been to impede critical comparison or assessment of the research work that has been performed and this, in turn, has prevented rapid progress. A glossary defining some of the terms used in this paper is included as Appendix A.

Quite apart from the understanding of the program and model options that a user needs to have, the choice of what input data to use and how to make the building fit the internal representation used by the program can give rise to difficulties. Many possibilities exist and different choices of e.g. climatic data, number of separate zones to be explicitly modelled, might lead to quite different results. In order to answer a particular design question, say 'will the building as currently designed lead to unacceptable overheating?', even the definition of appropriate outputs to be provided by the program is far from simple.

It is clear that even if a 'perfect' program (defined in Introduction and in Glossary) exists, the way in which that program is used and the results interpreted may still lead to inconsistent or even erroneous conclusions.

If any real progress is to be made, the entire process of program selection, input data selection, program-specific modelling decisions, output data specification and the interpretation process, needs to be examined. The ways in which programs are used must be documented.

This paper addresses the issue of how a program should be used to address one particular 'application' - that of assessing overheating risk.

Before any analysis of Performance Assessment Methods can be attempted, a clear definition is required of what we mean by a PAM. There are many aspects of building performance which may need to be evaluated, including the thermal, acoustic and lighting fields. A variety of ways of assessing each of these performance aspects also exists. The ways of determining the annual heating energy consumption of a building may range, for example, from using the degree day method and a pocket calculator, to a dynamic simulation using a computer program.

The results produced depend on the program used, the models selected within the program, the input data involved, the output data produced and its interpretation. A **Performance Assessment Method (PAM)** is defined as the combination of program and method of use to encompass all these aspects.

A PAM is therefore defined as the combination of Method and Program. (PAM = METHOD + PROGRAM)

A wide range of PAMs exists, each having a different purpose, eg energy auditing, overheating risk assessment, lighting level evaluation, etc.

In addition, the application of these PAMs to a particular building may not always be straightforward. A PAM suitable for domestic buildings may not, for example, be suitable for factories since its program may not successfully deal with large single volume spaces.

Many combinations of Purpose, Program and Applications exist which, if they are to be analysed in terms of their suitability to achieve the particular objectives of the user, must be documented in a structured way. It must be made clear here that analysis of the PAM is not concerned with the methodology or correctness of the programs which are dealt with by other Subtasks of IEA Annex 21. It is directed more at those features of input and output necessary to ensure that the user's requirements are met in a consistent and unambiguous way.

A FRAMEWORK FOR DOCUMENTATION - THE 'SHELL'

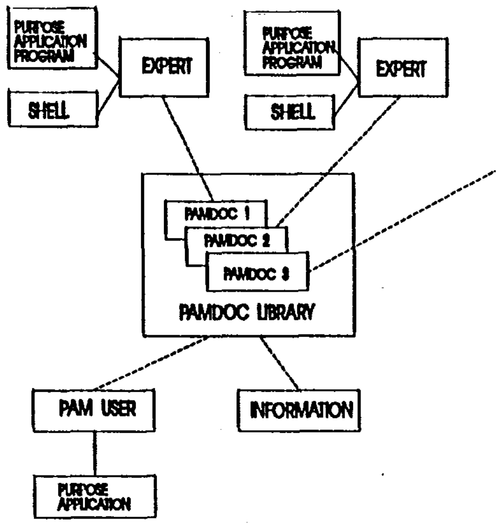

FIG. 2 PRODUCTION & USE OF DOCUMENTATION

Before considering the form and content of the PAM documentation (PAMDOC), it is helpful if one considers how the documentation may be produced and utilised. This then leads to the form the documentation may take. Figure 2 illustrates this. It is assumed that an 'expert' possesses a PROGRAM which may be used for a particular PURPOSE and APPLICATION. With the aid of a documentation SHELL, which provides the necessary guidance for documentation, the PAM can be documented, ie a PAMDOC is produced. Documentation produced is then transferred to a LIBRARY which may be accessed by a potential PAM user who has a particular purpose and application.

To make this process possible, the key element is the documentation 'SHELL' since this controls the content and format of the documentation.

What features then should the SHELL embody if it is to be used to produce meaningful information which can be easily accessed and analysed? It must be:

a) FLEXIBLE since, in theory, it should be capable of dealing with all known PAMs.

b) COMPREHENSIVE in order that it may take into account all situations likely to arise when documenting a PAM.

c) applicable to all the programs likely to be dealt with and must therefore be INDEPENDENT of the Program.

d) EASY TO USE from the point of view of the document compiler.

e) in a MODULAR form so that the information produced can readily be held in a computer database so that any documented aspect of a PAM may be retrieved for analysis of information purposes.

The major sections of the SHELL are shown in Figure 3. Section 0.0 PAM IDENTIFICATION is effectively the 'cover sheet' of the documentation with brief details as to the PAM's purpose, application, program used and the source.

In SECTION 1.0, the PAM is defined in detail, enlarging on the brief information provided in SECTION 0.0 and covering such aspects as the type of environmental control system and climatic zones for which the PAM is suitable, together with the crucially important definition of the purpose of the assessment method.

A PROCEDURE section follows which describes the steps to be followed if one were actually using the PAM and identifies those sections of the PAMDOC in which the relevant information is embodied. The PROCEDURE section of the SHELL is the only section where the order, description and possibly number of sub-sections may be changed since PROCEDURES may vary depending on the program being used.

The remaining sections, 3.0-10.0 of the SHELL are concerned with providing all the information a user would require to describe his problem to the program.

A	**NOTES FOR GUIDANCE**
0.0	**PAM IDENTIFICATION**
1.0	**DEFINITION OF PERFORMANCE ASSESSMENT**
2.0	**PROCEDURE**
3.0	**INFORMATION DEFINITION**
4.0	**PROGRAM DEFINITION**
5.0	**CONTEXT DESCRIPTION**
6.0	**ZONING DESCRIPTION**
7.0	**BUILDING DESCRIPTION**
8.0	**BUILDING OPERATION DESCRIPTION**
9.0	**PLANT DESCRIPTION**
10.0	**PLANT CONTROL DESCRIPTION**

FIG. 3 DOCUMENTATION SHELL

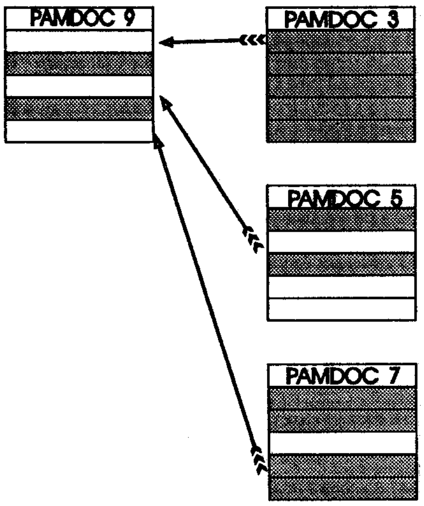

FIG. 4 MODULARITY OF DOCUMENTATION

The documentation for different PAMs, especially if using the same PROGRAM, may have common sections which only need to be completed for one PAM and then are referenced by the others. This is illustrated in Figure 4. It is hoped that, having fully documented a PAM, other PAMs dealt with by the same PROGRAM will only require a small amount of new documentation. If for example a program is capable of carrying out overheating risk and energy audit assessments, it is likely that only Sections 0.0 to 3.0 will need to be changed.

The major sections of the SHELL are themselves broken down into sub-sections. Section 5.0, for example, CONTEXT DESCRIPTION, is comprised of Site Description 5.1 and Climate Description 5.2, which themselves break down into individual topics so developing a 'tree' structure for each major section (Figure 5). It is these lower topic levels which contain the information required.

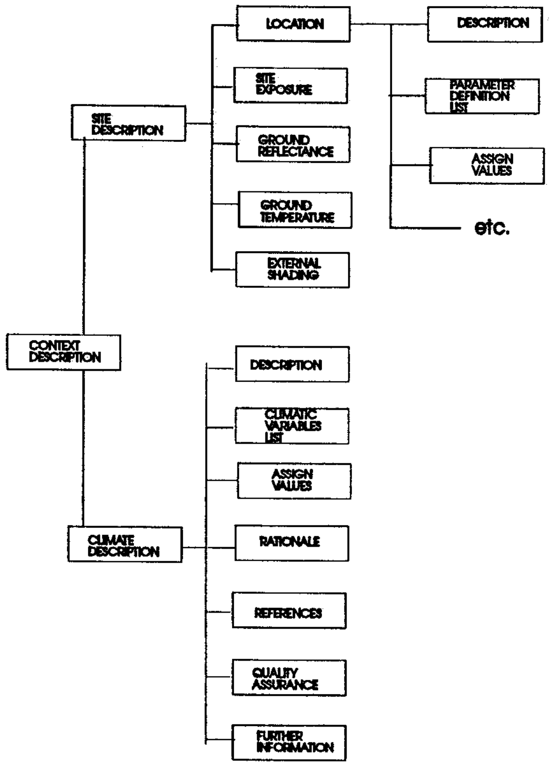

FIG. 5 TREE STRUCTURE OF DOCUMENTATION

A structured way of organising the information has been developed to facilitate analysis of the documentation produced for different PAMs. This has meant ensuring that the provision of information at each topic level follows a defined pattern. The information that needs to be set down not only describes how things are done, but also consists of the Rules for doing things and the Rationale behind these rules. This is to highlight areas of uncertainty and lack of knowledge as well as providing a measure of confidence, or lack of it, in the quality of the information.

Quality Assurance is the major theme of the work and a heading is provided to describe any methods used to ensure that when a PAM user provides data for a PAM, there is a check on the quality and consistency of the data provided.

The starting point for producing a 'library' of documented PAMs is to fully document a sample PAM for a simple application. This provides the formulation on which to base further documentation.

The assessment of overheating risk has been chosen as a starting point for a number of reasons, amongst which are that it is an assessment commonly carried out, it can have major design implications, e.g. whether to use air conditioning, and overheating represents a problem perceived as important by designer, builder owner and building occupier. In addition, there exists a variety of programs for dealing with overheating risk. Currently a number of 'experts' are preparing documentation for overheating risk using a test case building and the same weather data.

MANAGEMENT OF INFORMATION SYSTEM (MIS)

A computerised system to aid in the documentation tasks was developed principally for Subtask A [Bloomfield & Jiang, 1990]. This Management of Information System (MIS) could also be applied to the documentation of PAMs in Subtask B by implementing the shell described above.

The MIS aims to allow documentation of an object whilst avoiding ambiguities - the terms used must have unique meanings so that the information can be stored, and subsequently analysed, by computer. One way to ensure this is to produce the documentation using a computer in the first place. To ensure consistency between information provided by different documentors, the information is provided by making choices between a finite set of possibilities, rather than in a free format as is conventional.

The documentor describes the program, model, PAM etc by 'marking' each option that applies in a menu displayed on the screen. If none of the menu options applies then a new term can be added. After the system has been used for some time to document different objects, an extensive set of options and a logical structure will have been created for use by new documentors, i.e. the system has improved itself by learning from the experts performing the documentation.

THE EVALUATION OF PAMs

In developing an evaluation strategy for Performance Assessment Methods, a clear distinction has to be drawn between the Performance Assessment Method itself and the PROGRAM which is used as an integral part of the PAM.

Performance Assessment Methods are concerned with how programs are used. In this respect, the internal workings of the program need only be considered to the extent that it might affect the PAM. For example, while a PAM might be concerned with the selection of the appropriate option for the treatment of solar process, it would not be concerned with whether the option selected was correctly implemented within the program. This is a program verification problem. The evaluation of a PAM begins by taking the program as 'given' so that the evaluation process is not side-tracked into program development and verification. IEA Annex 21 Subtask C is dealing separately with program evaluation. The appropriateness of program capabilities for the intended purpose does fall within the scope of PAM evaluation.

If a PAM is selected (or developed) for a purpose, then it has to be evaluated in terms of how well it fulfils that purpose i.e. how well it performs the required Performance Assessment. In this context, evaluation can be considered to be a QA process applied to a Performance Assessment Method to determine fitness for purpose.

Unfortunately 'fitness for purpose' is open to interpretation and dependent upon the particular viewpoint taken at a given time. For example, evaluation might be seen as needing to address at least the following questions:

How do we know a PAM is good enough?
Is its scientific basis correct?
Is its implementation correct?
Does it consistently produce plausible results?
Is it economical in use of resources?
Will it produce repeatable results with different users?
Is it applicable to a wide range of building descriptions?
Does it produce 'credible' answers?

While such lists are thought provoking, if progress is to be made, they need to be better defined, structured and reduced to manageable proportions. In IEA 21 Subtask B evaluation will seek to establish that a PAM is:

Technically sound
Free of user uncertainty
Applicable
Credible

These terms are defined and expanded upon below.

TECHNICALLY SOUND: A judgement that the basis of a PAM is technically sound.

As the definition implies, 'technically sound' can not be a fully quantitative measure. It is not practical to measure a PAM against an absolute 'TRUTH' model since none are available in practice. There is no analytical test or field data against which the PAM can be compared. Rather, there can only be a series of checks, e.g. inter-PAM comparisons, or quality assurance milestones, which a PAM should pass before it is released for use.

USER UNCERTAINTY: The uncertainty or variation in the output from a PAM generated by differences in the user's implementation of the PAM.

It is important to note that this has nothing to do with the 'correctness' of the PAM. There may be no user uncertainty but the PAM may nevertheless be invalid. The ideal situation is that a well written PAM should ensure that adequate guidance is available so that all users will implement the PAM in exactly the same way. That is, the PAM is understandable, comprehensive and applicable and consistently produces repeatable results.

The extent to which this is not the case can be construed as user uncertainty and may be caused by factors such as misunderstanding of the documentation, too much freedom of interpretation or the limited applicability of the PAM. Consistency between users does not necessarily mean that the users have correctly interpreted the guidance contained within the PAM. It is conceivable that all users may carry out the PAM in a repeatable fashion due to a misinterpretation of the documentation.

APPLICABILITY: The determination of scope of PAM.

Applicability is concerned with determining the limits, or viewed more positively, the scope of application of a PAM. There would appear to be at least two distinct aspects to this relatively simple proposition:

Can the documentation be applied without the need to make additional assumptions.

Does the technical basis of the PAM break down at the limits of application of the PAM for some unforeseen combination of conditions.

Applicability in this context can be viewed as determining the range of situations for which the PAM can be used, whilst being technically sound and free of user uncertainty. The distinct feature of applicability studies in this context is to stress the PAM by applying it to a wide range of 'realistic' as against 'abstract and simplified' case study buildings which are seen to represent real world conditions. The role of Applicability would be to extend the testing of the PAM to a wider range of situations and to rely on sensitivity studies and inter-PAM comparisons to detect whether there is a radical change in the behaviour of the PAM.

USER CREDIBILITY; The PAM produces results which the users of PAMs in practice believe and upon which they are prepared to base their design decisions.

A PAM might be viewed by its author as being technically sound, free of user uncertainty and of demonstrated applicability. However, there is no guarantee that practitioners in design offices will necessarily adopt a PAM unless it has some track record of being used to successfully address real world problems.

This might be termed verification in use. If the PAM produces results which do not accord with established practice, or at the very least are not explicable in terms of current design knowledge they are likely to be viewed with some suspicion.

Evidence for the credibility of PAMs might be:

a) consistent design advice results from use of different PAMs;
b) PAM produces a result which agrees with, or is at least explicable in terms of, best current design practice;
c) risks associated with using the PAM due to e.g. incorrect design decision, under/over estimation of predicted value are acceptable. This would require a serious look at areas such as risk analysis.

WORKPLAN

The evaluation of PAMs is a relatively new area and the complexities introduced by the method of use, the program and the user offer a rich ground for misunderstandings and abortive work. For this reason, it is felt important to start with relatively simple PAMs such as 'Overheating Risk' rather than more complex PAMs such as 'Optimising window size' or 'Retrofit studies'. These more complex PAMs are likely to contain the relatively simple PAMs as elements.

It is necessary to proceed in a staged way. While establishing User Credibility must be the eventual goal, it is a formidable task. Until a PAM has been demonstrated to be technically sound, free of user uncertainty and applicable, it is impossible to tackle this problem. Subtask B will concentrate on assessing technical soundness and user uncertainty associated with implementing a documented PAM and will introduce the element of applicability.

Documented PAMs for overheating risk assessment were subjected to peer review to determine whether the PAMs can be seriously questioned on technical grounds and whether they were unambiguous and free of user uncertainty. This led to a clarification of technical issues in the documented PAMs and the identification of areas where guidance is inadequate. This, in turn, led to a revision of the PAM documentation.

User uncertainty will be evaluated for each individual PAM by implementing it for a well defined case study by at least two or more independent users (Figure 6) to determine whether:

a) additional information needs to be requested from the PAM author indicating inadequate guidance,
b) there is a spread in the results from the simulation indicating different user interpretations of the PAM documentation,
c) the results of the simulations differ from that produced by the PAM author, indicating that the users have incorrectly interpreted the PAM.

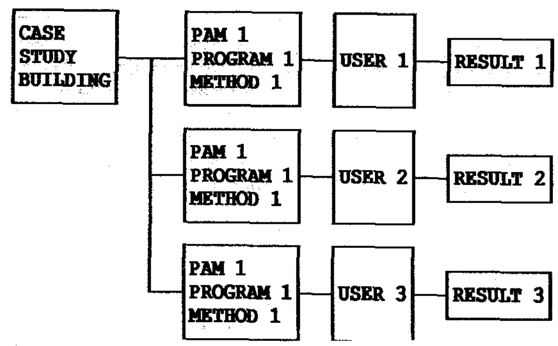

FIG. 6 TEST OF LEVEL OF AGREEMENT BETWEEN PAM RESULTS

The technical soundness of the PAM will be subsequently investigated by implementing a number of PAMs for the same purpose for a well defined and relatively simple Case Study (Figure 7) to determine whether a spread in results occurs which could indicate major differences between the PAMs.

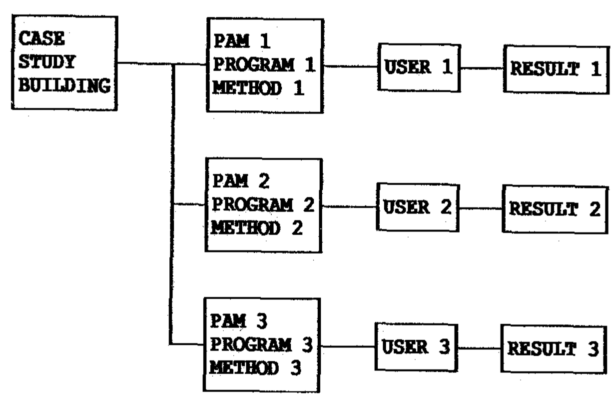

FIG. 7 TEST OF LEVEL OF AGREEMENT BETWEEN PAM RESULTS

Understanding and attributing the causes of the observed differences between the results generated by the PAMs will not be easy. However, providing user uncertainty has been addressed, the effect of the USER should be eliminated. However, features of PAMs (such as Zoning Strategy) may well have to be examined to understand the differences in results generated by different PAMs. This may require sensitivity studies and, as in earlier IEA work, a series of graded Case Studies to stress different aspects of the PAMs.

While this inter-PAM comparison is similar to the inter program comparison study carried out as part of previous IEA activities [Bloomfield, 1989], it is acknowledged that this exercise will be extremely difficult. The observed differences will be partly due to the Programs, partly to the user and partly due to the method. Whether these different sources of variation can be identified and isolated is a major research element in the work. Nevertheless, while inter PAM comparison can never deliver the 'TRUTH', if different PAMs for the same purpose give widely different results, their technical basis must be open to question.

Applicability will be addressed by extending the work to cover increasingly complex Case Study Buildings. The intention is to begin with the relatively simple and abstract case study buildings 9 and 10 from IEA Annex 8 and to gradually extend these to case studies which are more representative of real buildings.

ASSESSMENT OF OVERHEATING RISK

As part of the UK contribution to IEA subtask B, two PAMs for the assessment of overheating risk have been documented using the draft 'shell':

(a) BRE's method using a program BREADMIT, which uses the BRE/CIBSE procedures
(b) the method used in the Dept. Energy's Passive Solar Programme which employs the simulation program SERIRES.

These two PAMs employ prediction programs of very different levels of detail - a harmonic, admittance based program and a finite difference simulation program respectively. A comparison of the two PAMs to identify areas of similarity therefore forms a good test of the hypothesis that PAMs can be split up into re-usable modules. The work is not yet far enough advanced to draw any firm conclusions but preliminary results are described briefly here.

BRE/BREADMIT/OVERHEATING	ETSU/SERIRES/OVERHEATING
Overheating defined as zone temperature above a specified value for longer than a specified period of time	Overheating defined as zone temperature above a specified value for longer than a specified period of time
Zone temperature defined as dry resultant (0.5xTair + 0.5xTmrt)	Zone temperature defined as area- & conductance-weighted internal surface temperatures
Specified value of temperature (see above) is 27°C	Specified value of temperature (see above) is 27°C
Specified time period is 1 day corresponding to Summer conditions so that temperatures are likely to be exceeded for design risk of 10, 20, 50 or 100 working days in 10 years	Specified time time is user-defined, simulation being performed using hourly values of weather representing the average weather over the last 20 years
Initial temperatures for walls etc not specified explicitly as method is semi-analytic; mean values over the period simulated are used implicitly	Initial values for all mass and air nodes are set at a 'suitable' value of 18.3°C

BRE/BREADMIT/OVERHEATING	ETSU/SERIRES/OVERHEATING
combined radiant/convective surface resistances obtained from CIBSE Guide: 0.12, 0.14, 0.10 m^2K/W for walls floors, ceilings	combined radiant/convective heat transfer coefficients specified as 8.3, 7.1, 10.0 W/m^2K (equivalent to 0.121, 0.141, 0.10 m^2K/W)
Single-glazed window conductance U=5.6 W/m^2K; wood frames modelled separately; area of glass specified	Single-glazed window conductance U=5.3 W/m2K; includes wood frames; area of whole window specified; shading coefficient used to account for obstruction of solar radiation by frame
Only 1 zone modelled explicitly; zone most likely to overheat is selected for analysis	All zones which are part of the design are modelled

Clearly, from the above limited excerpts from the information described in the shells (PAMDOCs) documenting PAMs, there are considerable areas of similarity, e.g. in the basic definition of what overheating is, surface coefficients, specification of geometry,..., but with some important differences of detail, e.g in the definition of zone temperature, selection of climatic data. The presentation of information in this way should allow specific parametric studies to be conducted to establish under what circumstances these differences might be important in the sense of affecting the design decisions that would result from the use of different PAMs.

Simulations performed both with SERIRES and ESP, both of which are capable of modelling multiple zones explicitly, were performed to quantify the issue of single versus multi-zone modelling. These preliminary sensitivity studies were conducted for a range of typical BRE houses and suggested that the peak temperature can vary from 35 to 50°C depending on the number of zones modelled.

FUTURE WORK

Much more work needs to be done in order to fully test the usefulness of the proposed structure for documenting PAMs. Within IEA Annex 21 other PAMs will be documented and it is expected that the documentation shell itself will need to be amended. Future work will concentrate on the analysis of the completed shells, evaluation of PAM assumptions and further evaluation of alternative PAMs for the main applications identified above. In order to achieve greater consistency and more speedy evaluation, the use of a computerised documentation and analysis system such as the MIS will be explored. An attempt will be made to devise a list of definitions of key words and concepts. This glossary will be circulated widely through the French Proforma Club and the European Community COMBINE project group as well as to other Annex groups within the IEA Buildings and Community Systems Implementing Agreement.

CONCLUSIONS

1. Quality assurance is of paramount importance in the field of building performance prediction. This implies a need for documentation.

2. The assumptions made in a performance prediction program must be clearly stated and available for inspection, if not by every program user, at least by a qualified expert capable of certifying the program. This is necessary in order to cope with the issue of professional liability. It is the reponsibility of the professional designer or engineer to select appropriate tools, although they may, in turn, rely upon the expert certifying body.

3. Even if a suitable program has been selected, the way in which it is used, the input data selected and the interpretation of the outputs, is all important. This constitutes a performance assessment method which needs to be documented, evaluated and be open to inspection by a quality assurance manager.

4. There is an urgent need to establish a glossary of agreed definitions of terms in order to promote consistency and avoid confusion and user errors.

5. International Energy Agency Annex 21 is addressing this need for documentation by developing documentation proformas (or 'shells') and by the use of a prototype expert system.

6. There is an urgent need for the implementation of a strategy for the evaluation of PAMs. Evaluation is central to the issue of future PAM development.

7. A first attempt has been made to document performance assessment methods for overheating risk. The method recommended by the UK CIBSE Guide shows some significant differences between that adopted by contractors operating the Performance Assessment Service for the UK Dept. Energy who are using dynamic simulation programs.

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APPENDIX A - GLOSSARY

Model - mathematical	a set of algorithmic relationships forming a mathematical representation of an object
Model - physical	a simplified physical description of a real-world problem; possibly implemented as part of a program
Performance Assessment Method (PAM)	program & method for using it, including procedure for selecting inputs and interpreting outputs
Program	software package
Shell	framework for documenting a PAM