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IEA ANNEX 21 - CALCULATION OF ENERGY AND ENVIRONMENT PERFORMANCE IN BUILDINGS

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ABSTRACT

Software for analysing the thermal performance of buildings is becoming increasingly complex as it approaches the complexity present in the real world. This additional complexity is increasing the likelihood of software being used improperly, either due to misunderstandings or due to unwise approximations or errors. This problem could be addressed partially by the design of much better human computer interfaces and by a greater level of integration of analysis tools sharing common databases. However, it becomes increasingly necessary to explain and document the basis of the algorithms incorporated in the software and the methods for using programs for practical applications, and to evaluate the adequacy of the programs for addressing them.

This paper describes the approach being adopted to address the above issues in an International Energy Agency collaborative project - Annex 21 - Calculation of Energy and Environmental Performance of Buildings.

A description is given of a recent development to allow the systematic documentation of the theoretical basis of building analysis software using a prototype expert system. An important feature of this system is the ability it provides for the investigation of assumptions embodied in common algorithms and programs on a consistent and rational basis.

The work in developing and using this system has highlighted the need for a much greater level of agreement between researchers and program developers on the definition of many terms in common parlance in this field.

The approach adopted to establish and document procedures for using programs is described and progress to date is reported. This work should help to increase consistency of performance assessment, to aid in training, to allow improvement of procedures and to promote quality assurance.

Finally, a summary is given of progress to date in the evaluation of programs within IEA 21.

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 [1] and another one is in progress in the UK.

The North American study was a market survey energy of 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 tradeoffs.

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 Department of Energy (ETSU) by the Construction Industry Computing Association (CICA). Separate questionnaires were sent in 1990 to program vendors, known program users and designers. IN-DEPTH STRUCTURED INTERVIEWS were carried out in 1991 to supplement the information obtained from the questionnaires. 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
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 (PAM) 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 [2]. 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 and 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 AND ENVIRONMENTAL PERFORMANCE OF BUILDINGS

This project started in October 1989 and will finish in October 1992; 8 countries are participating.

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 (Figure 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 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

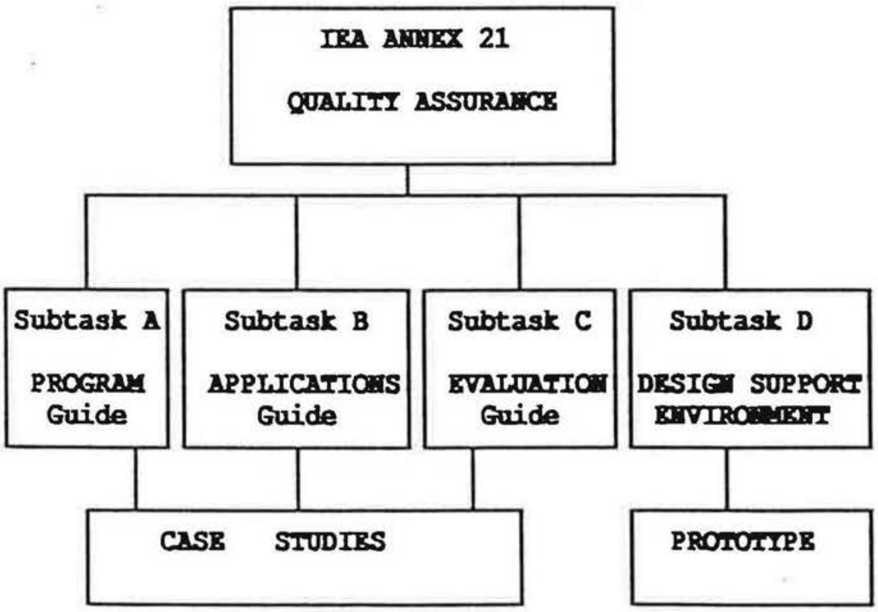

FIG. 1 IEA Annex 21

It is essential to be able to describe aspects of modelling in a simple clear fashion ie 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 Subtasks A & B.

SUBTASK A - DOCUMENTATION OF EXISTING METHODS

The objectives of Subtask A are to:

- produce documentation of existing programs and models
- develop standard methodology for documenting programs and models
- document explicit information on techniques used, assumptions, approximations made and definitions of input and output parameters
- document guidance on the range of applicability

This subtask is led by the University de Liege; they are concentrating on the documentation of existing models, making use of a proforma which has been under development in France and Belgium for some time [3].

BRE has been working together with Tsinghua University, Beijing to develop a prototype 'expert system' to aid with the investigation of documentation issues [4]. This 'Management of Information System' (MIS) is being used to facilitate the collection and analysis of information relating to modelling the environmental performance of buildings. It could be used for the documentation of program assumptions, for documenting the way in which a program is used for addressing a particular problem ('**Application**') or for documenting input/output data requirements etc. So far most thought has gone into its use for documenting programs. This work is described in more detail below.

Management of Information System (MIS)

The MIS is intended to allow documentation of an object in such a way that there are no 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. Additionally, to ensure consistency between information provided by different documentors, the decision was made that it be provided in the form of choices made between a finite set of possibilities (i.e. 'multi-choice' menus) rather than in a free format as is conventional.

The MIS has been implemented on a PC 386 machine using Turbo Prolog. The terms used have been defined in accordance with a glossary that is being prepared within IEA Annex 17 and 21, and the UK Industry/Research Club BEPAC (Building Environmental Performance Analysis Club [5]). It is very important that strict definitions of terms are adhered to if the information is to be suitable for analysis by computer. Users of the MIS are required to add new definitions where necessary via a **"help" facility**. These definitions can then be used to improve the draft IEA glossary.

Facilities for documenting, editing and analysing information are provided.

In addition to selecting terms from menus of options, **'Links'** also need to be specified between terms and successive menus so that the MIS user, has to supply a minimum of information, i.e. the menus displayed to the documentor will be logically dependent on the user's previous responses. The set of 'menus' and the logical 'links' between menus form a **'tree'** structure (see Fig. 2).

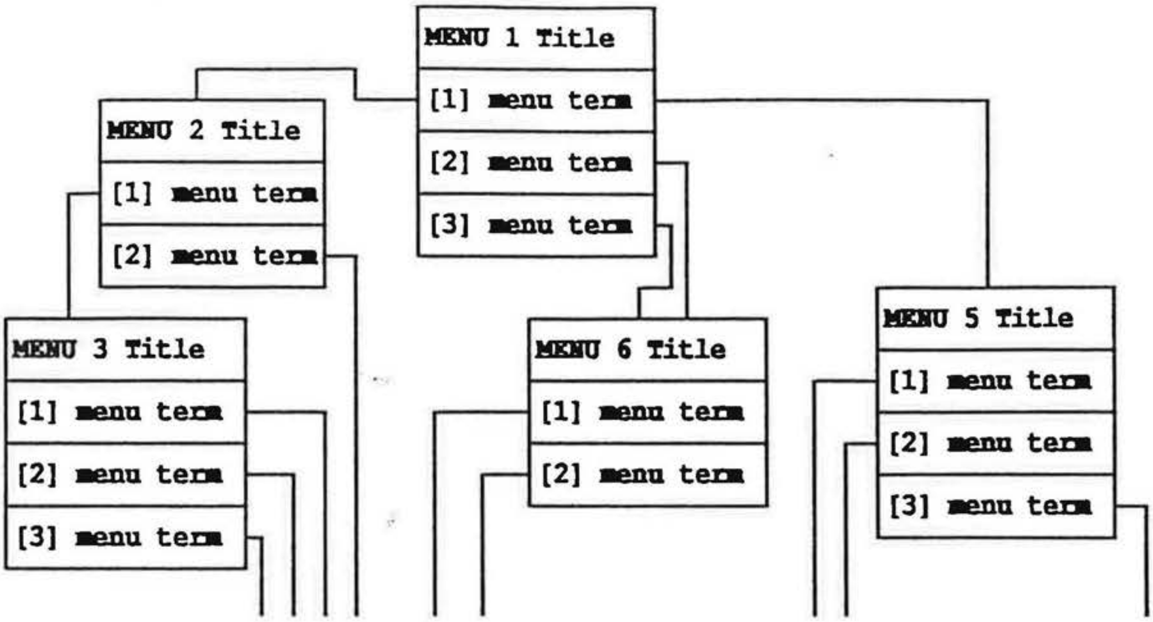

FIG. 2 Menu Structure in the MIS

A collection of such responses can be stored in a **'library'** (e.g. WALL, ZONE, MODEL, APPLICATION).

The Documentation Process

A library is selected - e.g. a WALL library, a library containing information about PLANT modelling, or one containing methods of assessing OVERHEATING.

The documentor is requested to describe the program, model, application etc by 'marking' each option that applies in the current menu displayed on the screen. If none of the menu options applies then a new term can be added, the new term marked and a Help file edited to explain the new term if necessary.

If the whole menu (M) is inapplicable, the existing links (i.e. logical conditions which determined that the menu should be presented to the documentor) must be incorrect. The user can correct this, i.e. improve the system, by providing information on why the menu M was not applicable.
In this way, the MIS allows objects to be documented by experts and, at the same time, 'learns' how to improve the information collection process for subsequent users.

Evolution of MIS structure

Initially, when an MIS user creates a new library no structure exists - at most there will be one introductory menu. After the library has been used for some time to document several different objects a tree structure will exist and the MIS user documenting a new object within this library will be presented with one of the menus created by previous users who have documented similar objects.

Rather than allowing the structure to evolve in this way, it is possible and, indeed, advisable to impose greater order by using the Edit Group Structure pop-up menu option directly after creating a new library. This allows the menus to be displayed on the screen or printer as belonging to user-defined, logically connected groups.

Workplan & Outputs from IEA 21 Subtask A

One purpose of the MIS is to document assumptions in programs. One of the major outputs will be the development of a manual structure for future programs.

The IEA 21 working procedure is to:

a) provide a basic, logically sound structure for component parts of programs, developed separately in "COMPONENT" libraries (e.g. WALL, ZONE, WINDOW).

b) use this to document actual programs (still using component libraries) - to test the basic structure and to add/improve it as more programs are documented.

c) merge the libraries so as to form complete documentation of program assumptions.

d) use this structure to define a user manual.

SUBTASK B - PERFORMANCE ASSESSMENT

The objectives of Subtask B are:

- 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.

This subtask is led by the University of Newcastle, UK.

In order to use a program competently, the user must have a good understanding of the program assumptions and model options. In addition to this, the choice of what input data to use and how to make the building fit the internal representation used by the program is extremely important and can give rise to major difficulties. Many possibilities exist and different choices of e.g. climatic data, the number of separate zones to be explicitly modelled etc., might lead to very 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 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. How programs should be used must be documented.

A **Performance Assessment Method (PAM)** is defined as the combination of program and method of use to encompass all these aspects.

PAM = METHOD + PROGRAM

PAMs exist for many different purposes, eg energy auditing, overheating risk assessment, lighting level evaluation, etc.

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.

If PAMs actually in use are to be analysed in terms of their suitability to achieve the particular objectives of the user, they 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.

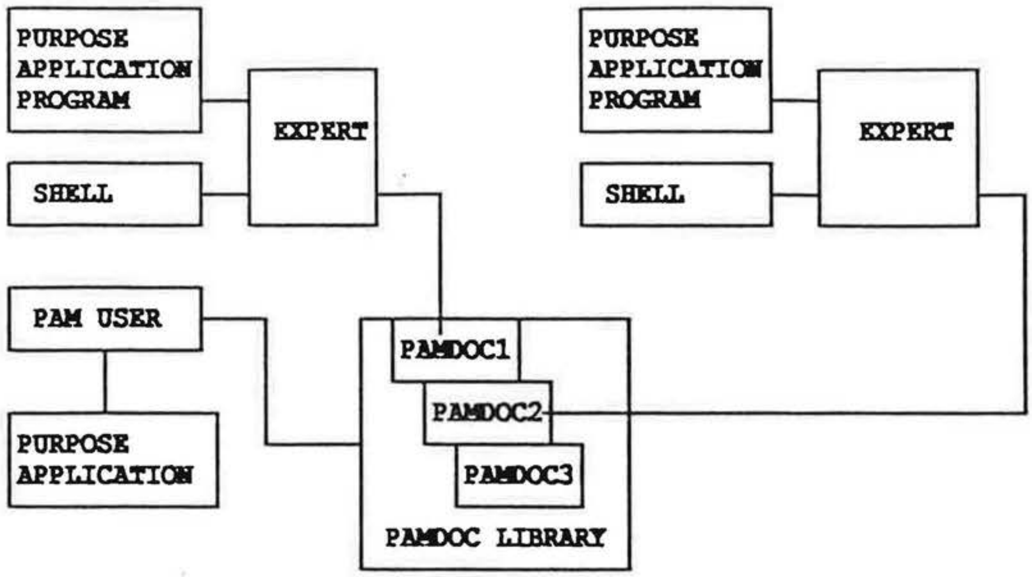

FIGURE 3 PRODUCTION AND USE OF DOCUMENTATION

Figure 3 illustrates the process of producing and using a documented PAM (PAMDOC). An 'expert' possesses a PROGRAM which may be used for a particular PURPOSE and APPLICATION. With the aid of a documentation SHELL (Fig. 4), which provides the necessary guidance for documentation, the PAM is documented.This documentation is transferred to a LIBRARY which may be accessed by a potential PAM user who has a particular purpose and application.

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. 4 DOCUMENTATION SHELL

The key element in this process is the documentation 'SHELL' which controls the content and format of the documentation.

The SHELL should be:

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

(b) COMPREHENSIVE in order that it may take account of 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 documentation for different PAMs may have common sections which only need to be completed for one PAM and then are referenced by the others. It is hoped that, having fully documented one 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 60% will be common.

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 that contain the information required.

CONTEXT DESCRIPTION	SITE DESCRIPTION	LOCATION	DESCRIPTION
		SITE EXPOSURE	PARAMETER DEFINITION LIST
		GROUND REFLECTANCE	ASSIGN VALUES
		GROUND TEMPERATURE	
			ETC
		EXTERNAL SHADING	
	CLIMATE DESCRIPTION	DESCRIPTION	
		CLIMATIC VARIABLES LIST	
		ASSIGN VALUES	
		RATIONALE	
		REFERENCES	
		QUALITY ASSURANCE	
		FURTHER INFORMATION	

FIGURE 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.

In this paper how a program should be used to address one particular 'application' - that of assessing overheating risk - is addressed. Further details can be found in [6].

The Evaluation of PAMs

A clear distinction must be drawn between the Performance Assessment Method itself and the PROGRAM which is 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 they might affect the PAM. For example, while a PAM might be concerned with the selection of the appropriate option for the treatment of solar processes, it would not be concerned with whether the option selected was correctly implemented within the program. This is a program verification problem (dealt with in Subtask C). 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. The appropriateness of program capabilities for the intended purpose does fall within the scope of PAM evaluation.

A PAM has to be evaluated in terms of how well it fulfils the purpose for which it was intended. Evaluation can be considered to be a QA process 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 questions such as:

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 its 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?

In IEA 21 Subtask B evaluation is limited to establishing that a PAM is:

Technically sound
Free of user uncertainty
Applicable
Credible

Technically sound: this cannot 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, eg inter-PAM comparisons, or quality assurance milestones, which a PAM should pass.

User uncertainty: The uncertainty or variation in the output from a PAM generated by differences in different users' implementations of the PAM.

This has nothing to do with 'correctness' of the PAM. There may be no user uncertainty but the PAM may nevertheless be invalid. A well written PAMDOC should ensure that adequate guidance is available so that all users will implement the PAM in exactly the same way.

Applicability: This is concerned with determining the limits, or the scope of application of a PAM; issues include:

can it be applied without making additional assumptions?

does the technical basis break down for some combination of conditions?

APPLICABILITY can be assessed by applying it to a wide range of 'realistic' as against 'abstract and simplified' case study buildings representing real world conditions.

User credibility: users in practice believe results produced and are prepared to base their design decisions on them.

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 suspicion.

Workplan and Outputs from IEA 21 Subtask B

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, IEA 21 B starts with relatively simple PAMs such as 'Overheating Risk' rather than more complex ones such as 'Optimising window size' or 'Retrofit studies'.

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 from 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 is being evaluated by implementing PAMs for a well defined case study by at least two or more independent users 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.

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 to determine whether a spread in results occurs which could indicate major differences between the PAMs.

Understanding and attributing the causes of the observed differences between the results generated by the PAMs is not easy. However, providing user uncertainty has been addressed, the effect of the USER should be eliminated. features of pams (such as zoning strategy) will have to be examined in order to understand differences between results generated by different PAMs. This will be done through sensitivity studies and a series of graded Case Studies to stress different aspects of the PAMs.

This inter-PAM comparison is similar to the inter program comparison study carried out as part of previous IEA activities [7]. However, it will be more complicated as observed differences will be due partly 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

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, eg whether to use air conditioning, and overheating represents a problem perceived as important by designer, builder owner and building occupier. In addition, there is a variety of programs for dealing with overheating risk. IEA 21 'experts' have prepared documentation for overheating risk using a test case building and the same weather data.

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 Department of 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. (0.5 x Tair + 0.5 x Tmrt)	Zone temperature defined as area- and 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-analytical; 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.
combined radiant/convective surface resistance 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/m^2K; 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, eg in the basic definition of what overheating is, surface coefficients, specification of geometry, ..., but with some important differences of detail, eg 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.

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.

SUBTASK C - EVALUATION OF PROGRAMS FOR CALCULATING ENVIRONMENTAL AND ENERGY PERFORMANCE IN BUILDINGS

The objectives of Subtask C are to:

(a) produce and document a methodology for evaluating programs

(b) produce reerence cases

(c) propose a program-independent standard description of a building and its operating conditions

This work is conducted jointly by the Buildings and Community Systems Annex 21 and the solar Task 12 (subtask B) groups and is led by the Solar Energy Research Institute, USA.

Much work has been conducted in the past to 'validate' thermal programs, but recent reviews conducted in the UK [8] and subsequently by the CEC group PASSYS [9] have concluded that these studies are of limited use in detecting program errors. Indeed, it is now increasingly being accepted that there is no such thing as 'validation' in the absolute sense.

The following techniques have been recommended to be used as part of a validation methodology:

review of theory
code checking
analytical tests
inter-model comparisons
empirical validation.

Reviewing theory and code checking are extremely useful but very time consuming and imply a high level of expertise on the part of the checker and an extremely high standard of documentation on the part of the program developer.

Analytical tests involve testing program predictions against solutions derived by theoretical means; it is only possible to derive solutions for very simple test cases, so such tests are limited in their scope. Two sorts of analytical tests can be distinguished:

(a) those designed to test extreme conditions - intended to expose any coding errors;

(b) those intended to match some sort of realistic or representative conditions - intended to give a measure of how good the program would be in practice.

It is very important when designing and performing analytical tests to keep this distinction firmly in mind.

Inter-model comparisons cannot answer the question of how accurate a program is directly; however, they can be very useful in identifying probable errors, if designed carefully and if the tests are carried out in a careful and controlled manner.

Empirical validation involves comparing experimentally derived results against program predictions and many such exercises have been carried out. This technique is difficult to carry out for many reasons, including:
(a) there are very few datasets of sufficiently high quality and sufficiently well documented for use by a third party;

(b) even in the best datasets uncertainties remain in many of the data that must be supplied as input to the program; the process therefore corresponds to comparing one unknown with another;

(c) it follows from (b) that very careful statistical analysis is needed if any meaningful conclusions are to be drawn from Empirical Validation studies;

(d) apart from the technical difficulties above, the issue of vested interests on the part of the tester is hard to resolve.

In the UK work [10] analytical tests for the conduction process were devised. These have been reviewed by the IEA 21/12 group and accepted as a valuable part of a validation methodology. Further work has been devoted to developing tests for solar processes; these have yet to be implemented.

Most of the work of the IEA Evaluation group has so far been devoted to developing a set of 'benchmark' tests based upon previous work conducted in IEA Solar Task 8 [7]. This is an inter-model comparison technique in which well respected detailed dynamic simulation programs are used to predict the performance of a range of simple buildings. The set of building descriptions are documented in great detail to help avoid user errors, and are graduated in level of complexity. Comparison between results obtained from different tests allows several physical processes to be isolated (eg compare results for tests with/without infiltration, with/without window etc). For each test case, a range of results is obtained and this range can be used as a target for other programs to be tested against.

The Evaluation subtask will conduct reviews of the methodology for conducting Empirical Validation (EV), seek to establish criteria for selecting datasets and make recommendations on how to conduct a scientifically rigorous Empirical Validation project.

As IEA Solar Task 12 continues beyond the end date of Annex 21, it is possible that this work will be carried to its logical conclusion within that group.

CONCLUSIONS

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

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.

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 responsibility of the professional designer or engineer to select appropriate tools, although they may, in turn, rely upon the expert certifying body.

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

International Energy Agency Annex 21 is addressing this need for documentation by developing proformas and by the use of a prototype expert system.

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 Department of Energy who are using dynamic simulation programs.

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 and it can only be carried out after the documentation stage.

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