CONF-7705189--Summ.



# SUMMARY OF PROCEEDINGS OF THE FIRST MEETING OF THE EXECUTIVE COMMITTEE ON BUILDING AND COMMUNITY SYSTEMS

ELECTRICITY COUNCIL RESEARCH CENTRE

Capenhurst, United Kingdom

May 3 - 5, 1977

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## AGENDA

May 3 Field trip to facilities of the Electricity Council Research Centre

May 4 Final meeting of Experts Group on Buildings and Community Systems;

May 4-5 First meeting of Executive Committee on Building and Community Systems



The International Energy Agency (IEA) meeting on Building and Community Systems was conducted in three phases. First, participants toured the Electricity Council Research Centre (ECRC) research facilities to observe the ECRC's building research activities, and to receive information on their ongoing research into energy usage in buildings.

The final meeting of the Experts Group on Building and Community Systems was then held on the morning of May 4. During this meeting, analysts discussed the progress of their analysis of office buildings that has been conducted since the October, 1976, Experts Group meeting in Stockholm.

## DISCLAIMER

In accordance with IEA rules, this Experts Group was then abolished and an Executive Committee on Buildings and Community Systems created to direct further work in this project area. This action reflects the signing in March of the Implementing Agreement on Building and Community Systems and Annex I on Thermal Characteristics by the United States, Canada, and Italy. The discussion of study activities, begun by the Experts Group, was continued at this Executive Committee meeting. Sections I and II describe the meetings of the Experts Group and Executive Committee. Section III describes the field trip at the ECRC.

## I. FINAL MEETING OF THE EXPERTS GROUP ON BUILDINGS AND COMMUNITY SYSTEMS: DISCUSSION OF ANALYSIS RESULTS - MAY 4, 1977

During the final meeting of the Experts Group on Building and Community Systems, held on the morning of May 4, members reviewed the results of the energy analyses of office buildings undertaken since the October, 1976, Experts Group meeting in Stockholm. This meeting was chaired by G.S. Leighton of the United States; participants are listed in Attachment A.

At the October meeting, it was agreed that participating analysts would apply analysis programs to three office buildings to be specified by ASHRAE. For study purposes, the buildings were assumed to be located in Wethersfield, U.K.; a tape of 1967 Wethersfield weather data was provided. The analysis programs used in the study were described in a document that contained summaries of questionnaires circulated to all participants, forwarded with the agenda for this meeting. However, since two participating analysts submitted questionnaires too late for inclusion in that document, questionnaires for their programs are presented in Attachment B. They will be included in an update to the previous document.

A chart was used to catalogue the analysts' results. The variables in the chart included:

1. Building peak thermal loads. The demand for heat extraction (cooling) or addition (heating) that occurs in the building shell if specified interior temperatures are maintained during assumed exterior weather conditions.

2. Actual peak heat extraction/addition by equipment. The peak heat demand extracted or supplied by the primary building equipment to meet the building loads described in 1 above. This demand is greater than the building peak thermal load due to the inefficiency of the secondary (ventilation and air handling) building equipment.

3. Total annual heat extraction/addition by equipment. The total annual energy supplied by the primary building heating and cooling equipment.

4. Annual fuel consumption. The total fuel (electricity and gas/oil) consumed by the primary and secondary equipment serving the building. This consumption can be larger than total annual heat extraction/addition by equipment, because of inefficiencies in the primary building equipment.

There was some confusion over these categories, particularly items 2 and 3. The Operating Agent agreed to develop clearer definitions, to be used in future building analyses.

Specific analysis program results were then considered. Although three buildings were analyzed in the study, only the results of the analysis of the first building (IEA I) were addressed. Each analyst presented results and briefly described his analysis. The summary, as completed, is included as Attachment C.

There was considerable discussion of the wide variation in the results. Ross Meriwether, one of the U.S. analysts, noted

that the differences appeared to be due to differences in three factors:

1. Analysts' methods of combining results for entry into the wall chart

2. Analysts' interpretations of the building specifications

3. Design of the analysis programs themselves.

Members agreed to defer discussion of the differences in interpretation of building specifications to the afternoon meeting of the Executive Committee.

In accordance with IEA procedures, members then abolished the Experts Group and formed the Executive Committee on Building and Community Systems.

## II. FIRST MEETING OF THE EXECUTIVE COMMITTEE ON BUILDING AND COMMUNITY SYSTEMS - May 4-5, 1977

Members reconvened as the Executive Committee on Building and Community Systems, recognizing that the Implementing Agreement and Annex I (Thermal Characteristics of Buildings) were signed by the United States, Canada, and Italy in March, 1977.

### INTRODUCTORY REMARKS AND IEA PROCEDURES

Neils de Terra of the IEA Secretariat opened the meeting and stated that Switzerland would soon sign the Implementing Agreement and that the United Kingdom would sign at this meeting. The United Kingdom had decided to endorse the Implementing Agreement by allowing each of its participating analysts to sign separately. Although the United Kingdom would have several members on the Executive Committee, it was agreed that it would continue

to have only one vote. U.K. participants then signed the Implementing Agreement and Annex 1. Mr. de Terra noted that countries interested in participating in IEA activities may send representatives to the initial meeting only of the Executive Committee. Observers from Austria, Germany, Sweden, and Denmark were present. Members of the Executive Committee are listed in Attachment D; Switzerland is included in the listing as it has announced its intention to sign the Implementing Agreement very soon.

Mr. de Terra then specified the guidelines for dissemination of information derived from cooperative activities that have been developed by the Secretariat. He explained that the Executive Committee may publish three types of documents through the IEA Secretariat:

- Project confidential - available to Annex I participants and the Secretariat only.
- IEA confidential - available to participants in other annexes and IEA member countries only
- Public - available to the general public.

The Operating Agent is responsible for submitting two recurring reports: a semi-annual report to the Annex I participants and the Secretariat, and an annual progress report, distributed also to nonparticipating IEA countries. The annual report will contain an executive summary suitable for use by the Secretariat in preparing its annual public report on IEA activities. These reporting requirements are described in more detail in Attachment E.

ELECTION OF OFFICERS

Gerald S. Leighton of the United States was elected Chairman and David Curtis of the United Kingdom, Vice Chairman of the Executive Committee, by unanimous vote. Mr. de Terra then turned the meeting over to Mr. Leighton.

PROPOSED MODIFICATIONS TO IMPLEMENTING AGREEMENT AND ANNEX I

Proposed changes to the wording of Annex I were then considered. First, the Secretariat proposed that the wording of the intellectual property provisions of the annex be made consistent with other IEA agreements (Attachment F). The Chairman then proposed a second change to the annex to clarify the conditions under which the CAL-ERDA ("LBL") program might be accessed from Europe (Attachment G).

In addition, the Secretariat proposed that the Executive Committee include the present IEA Ekistics project as a second annex under the Implementing Agreement (Attachment H). The Chairman distributed copies of the present Ekistics agreement so that members would be familiar with the project (Attachment I). The Chairman added that the United States and Germany may later propose to add their present bilateral agreement (the Wiehl and Esslingen projects) to the Implementing Agreement as a third project annex.

Since several members preferred to consult with their respective governments before agreeing to these three proposals, it was agreed that members would vote on these matters by mail or telex to the Secretariat, no later than the end of May, 1977.

The members then agreed to a clarification of the definition of "freely available" as it appears in paragraph 7(e) of the Annex. This paragraph specifies the type of software information, utilized in the study, that may be withheld as proprietary. The clarification is as follows:

"The Executive Committee feels that each case must be considered individually, but in general, it is agreed that, for example, users manuals for proprietary programs are freely available, but program listings of proprietary programs are not."

The Chairman requested and received permission to write a letter to the Secretariat commending its expeditious handling of the Implementing Agreement and Annex.

DIFFERENCES IN INTERPRETATION OF BUILDING SPECIFICATIONS

As a continuation of the earlier Experts Group meeting, the members discussed differences in interpretation of the building specifications used. Marx Ayres of ASHRAE, who had written the specifications, outlined seven areas in which differences may have arisen:

1. Weather
2. Architecture
3. Thermal Zone Definition
4. Operating Schedules
5. Secondary HVAC systems
6. Primary HVAC systems
7. Other

Actual variations in study results are detailed in Attachment C.

1. Weather

The major source of variation in study results was found in the methods used to calculate direct and diffuse solar radiation from the given information on cloud cover. Some analysts believed that the ASHRAE algorithm for deriving solar radiation is not the best technique for study purposes, and employed other approaches. It was agreed that this source of variation

should be removed in future analyses by adding specific hour-by-hour solar radiation values to the weather tape, thereby removing the need to calculate them. The U.K. representatives agreed to give the Operating Agent the algorithms developed at ECRC for use in calculating these values if additional analyses were to be performed.

One or two programs require information on cloud type, but this is not provided by the weather tape. The following default values were adopted by the members, based on discussions with the U.S. National Oceanic and Atmospheric Administration (NOAA):

| | |
|---|---|
| January - stratus | July - stratocumulous |
| February - stratus | Agusut - cumulous |
| March - stratocumulous | September - stratus |
| April - stratus | October - stratocumulous |
| May - stratocumulous | November - stratus |
| June - stratocumulous | December - stratus |

## 2. Architecture

The U.K. analysts stated that one major confusion stemmed from information provided on the amount of glass area in IEA I. The U.K. analysts had assumed that information contained in the specification applied to the interior wall area. In fact, the specification applies to the larger exterior wall area.

Other members voiced confusion over Table II of the specification dealing with glass characteristics. It was noted that the shading coefficients given do not isolate the shading effect of the venetian blinds (i.e., without the glass in front). In addition, the shading coefficients could be in conflict with the absorptance and transmittance coefficients. The members agreed that the data pertaining to absorptance for single glazing should be transposed with the data for transmittance. The ASHRAE representative agreed to revise and reissue the specification with these changes.

There was also concern that differences in the results may be attributable to variations in basic assumptions. For example, some participants had calculated outside air films from the weather tape data, while others merely assumed seasonal values. It was agreed that the error resulting from these differences is relatively small.

Basic assumptions on infiltration of air also differed. Some analysts assumed that infiltration during night shutdown (one-half air change per hour) would affect the entire building, while others assumed that only the perimeter zone of the building would be affected. Mr. Ayres noted that no infiltration of air should occur during periods when the fans are running and the building is pressurized.

3. Thermal Zone Definition

The problems arising from the given definition of thermal zones was also discussed. In developing models of the building, participants had assumed widely varying perimeter or exterior zones (see "ext zone" column

in Attachment C). Members agreed that these variations could introduce significant differences in predicting energy usage. The Operating Agent will undertake parametric analysis of the exterior zone (see below).

Some analysts modeled the plenums (area between a drop ceiling and next floor slab) as a separate zone; others included plenums with occupied space. The analysts discussed whether they had included return air loads in calculating the energy that must be extracted or added by the equipment. It was found that most analysts had included these loads in their analysis (see column "R.A. loads" in Attachment D).

In addition, confusion existed over whether the elevator shaft should be air conditioned. Some analysts had assumed that the shafts were not air conditioned; Mr. Ayres stated that they should be.

4. Operating Schedules

Although the building specification included a separate use schedule for domestic hot water, many analysts were unable to enter separate hot water use schedules, and had to use the lighting or elevators use schedules. Analysts from Lawrence Berkeley Laboratory stated that they had also established a separate use schedule for the lobby.

5. Secondary HVAC System

Another major uncertainty in the specification was the placement of the minimum opening stop on the variable air volume (VAV) boxes. As shown in Attachment D (column "VAV stop"), analysts assumed percent minimum stops from 30% to 50%. Members agreed that this factor had significantly affected estimates of energy usage in the building.

In addition, since no data on fan efficiencies were given in the specification, analysts had developed different assumptions for fan efficiency. Because these assumptions varied, the energy requirement predicted for this equipment differed for each analysis program.

6. Primary HVAC Systems

It was noted that one of three assumptions were used in deciding how the cooling systems would also control the temperature of condenser water.

Analysts assumed widely differing plant sizes depending on whether they sized equipment based on assumed peak loads; required response time to reach design temperatures at the start of the work day; or peak loads on the 1967 weather tape. These differing assumptions contributed to the observed spread in analysis results.

7. Other

The Swedish participants noted that there are many ways to convert solar radiation entering windows into radiant and convective components, in addition to the ASHRAE algorithm. The Swedish members noted that this factor may have contributed to the disparity in study results.

The members agreed to address methods of resolving data inconsistencies when the meeting continued on May 5.

This meeting was therefore adjourned.

* * *

The discussions at the second session of the Executive Committee meeting centered around three areas:

- Activities to improve the consistency of results among analysis programs
- Future analyses of infiltration and opening windows
- Future analysis of real buildings

These discussions are summarized below.

## ACTIVITIES TO IMPROVE THE CONSISTENCY OF RESULTS AMONG ANALYSIS PROGRAMS

The Executive Committee agreed to analyze the building (IEA I only) again, using an improved and "tightened" specification. The specification will be more detailed and, in preparing it, the Operating Agent will attempt to remove much of the uncertainty remaining in the present specification. To remove further uncertainty in calculating solar radiation, the U.K. agreed to send the U.S. their algorithms for generating direct and diffuse solar radiation. The U.S. will use the algorithms to generate the data and integrate them into the 1967 Wethersfield tape. The U.S. will then send a new tape to all participants by July 15.

It was further agreed to expand the analysis to include a number of simpler variations of the IEA I building. By analyzing these simpler buildings, the Executive Committee may be able to identify that point in increasing building complexity where different analysis programs begin to give different results.

The Operating Agent will develop specifications for the following variations on IEA I:

1. Same as IEA I, but with constant inside temperatures, no HVAC systems (central plant and secondary HVAC), no internal loads and no windows.

2. Same as 1., but add windows

3. Same as 2., but add internal loads

4. Same as 3., but add secondary HVAC systems

5. Same as 4., but add central plant equipment

To aid in summarizing the analyses, the U.S. agreed to develop improved summary tables. These will be sent to participants along with the revised building specification, by July 15.

The Operating Agent also agreed to undertake parametric analyses to attempt to discover which areas of interpretation of the specification are most critical in determining the predicted energy usage of a building. The analysis will cover those variables that participants at the meeting believed were most important, including:

1. Depth of the perimeter zone (zones from 0 to 6 m. in depth will be studied)

2. U-factors for internal partitions

3. Assumed location of VAV minimum opening stops

4. Assumed amount of infiltration.

Participants agreed to forward to the Chairman one-page summaries of their assumptions on infiltration, especially the interior volume affected, by July 15.

The action items and schedule for these activities are shown in Attachments J and K. The schedule assumes that analysts will re-analyze IEA I and the five variations before the November meeting of the Executive Committee.

## ANALYSES OF INFILTRATION AND OPENING WINDOWS

There was much discussion of possible research activities in the area of opening windows analyses. The ECRC described some of their current work into the reasons why people open windows and passed out a document on it (Attachment L). Representatives of Switzerland, Sweden, Canada, and the U.S. also outlined their work in this area. The Swiss representatives, whose technique for measuring infiltration through opening windows was on the meeting agenda, said that this technique was not a general one and that we should look at others as well.

In general, the Executive Committee agreed that there are two components to the phenomenon of opening windows:

1. The amount that inhabitants open the windows (a function of the weather, the building design, the amount of other infiltration through cracks, and their own needs)

2. The amount of infiltration through the windows once they are opened.

The Executive Committee could not arrive at any specific research activities in this area. The Chairman proposed that the Operating Agent

develop a research program in the area for discussion at the November meeting of the Executive Committee. As an input to this, the other members of the Executive Committee agreed to send short abstracts of ongoing work in opening windows of which they are aware. The action items and schedule for these activities are shown in Attachments J and K.

ANALYSIS INVOLVING REAL BUILDINGS

There was great interest among all analysts in applying analysis programs to the design of a real building. This would allow analysts to compare their program results with the actual performance of the building. The British Dept. of the Environment proposed a building at Avon Bank, near Bristol, for this purpose. The British analysts will meet in the middle of June to discuss a research project based on this building. David Curtis asked to receive by May 31 any opinions on appropriate instrumentation for the building. Then, by July 15, they will send to the operating agent:

1. a description or specification of the Avon Bank building

2. a description of the weather data available at the site

3. a description of the present and planned instrumentation in the building

4. a proposed R&D program based on the building

The Operating Agent will send this material to the members of the Executive Committee who will return comments on it to the Operating Agent by September 15. The Operating Agent will then send the comments to all Executive Committee members. Then at the November meeting, the Committee will review the

materials and draft a R&D program in real buildings. The Committee will also further advise the U.K. as to what instrumentation to include in the building. Any analysis of the Avon Bank building will, therefore, occur after the November meeting.

It is likely that this future program will involve joint funding of R&D by the members of the Executive Committee. Mr. de Terra outlined the possible formulas that have been used for sharing the cost of joint projects in the IEA.

The action items and schedule for these activities are shown in Attachments J and K.

FINAL PROCEEDINGS

The next meeting of the Executive Committee was scheduled for November 16-17 near London. The Chairman asked for and received permission to send a letter on behalf of the Executive Committee to the ECRC thanking them for sponsoring the meeting.

The meeting was adjourned at 1300 on May 5.

## III. FIELD TRIP TO OBSERVE BUILDING RESEARCH AT THE ECRC

An introduction to ECRC energy research was given by Mr. G. W. Brundrett. Members were then taken on a tour of ECRC research facilities, during which ECRC staff briefed participants on various areas of research. A summary of each briefing, and the names of the ECRC personnel involved, are given below.

ENERGY IMPLICATIONS OF LIGHTING
(P. R. Boyce)

Mr. Boyce explained that lighting represents 4 percent of total energy usage in the United Kingdom. The ECRC has found that the use of task, rather than area, lighting can reduce lighting costs by a factor of 10, although some of the resultant savings are eliminated by greater space heating costs. In addition, these savings can be achieved without the reducing U.K.--recommended lighting levels shown below:

| | Task Level | Background Level |
|---|---|---|
| Wide building | 750 lux | 300 lux |
| Narrow building (more natural lighting) | 500 lux | 200 lux |

(These levels are about one-half of U.S.-recommended levels.)

The speaker indicated that fluorescent lamps are the most efficient lights available. ECRC research has shown that the most efficient installation for fluorescent lights is in parabolic ceiling recessions. High intensity mercury vapor lamps are next most efficient.

THERMAL COMFORT
(D. A. McINTYRE)

The speaker reviewed several issues in ECRC thermal comfort research. He noted that the optimum environment for worker efficiency (usually a combination of temperature, humidity, noise level) depends on the task to be performed. Studies have demonstrated that background music improves performance of routine tasks but reduces the performance of complex tasks. However, research thus far has failed to identify the optimum temperature levels for various tasks.

The ECRC representative stated that, in the past, comfort has been measured by asking subjects to assess their comfort levels on a scale of 1 to 7. At Kansas State, a linear relationship was observed between temperature (in the range of 20-35°C) and average comfort index, assessed by seated test subjects who were lightly clothed. However, the statistical scatter of the results is very large, and different subjects reported the same comfort index at widely varying temperatures. The ECRC representative noted that observations of people tend to give more accurate indications of comfort than the subjects' own assessment.

Participants also discussed Fanger's equation, which considers the different combinations of activities, amount of clothing, and environment that will produce the same comfort level.

## EXPERIMENTAL HOUSES
## (J. B. SIMONS)

The ECRC is measuring thermal performance of various types of wall construction, insulation, and glazing in a number of semi-detached single family units (about 80 square meters floor area each). The ECRC representative described the instrumentation systems and some of the unexplained changes in thermal performance of the walls.

## DOMESTIC HEAT PUMPS
## (R. D. HEAP/C. J. BLUMDELL)

The ECRC has found that heat pumps which are commercially available from the United States are poorly suited to residential application in the United Kingdom. The U.S. units are too large for average U.K. houses, and are designed more for air conditioning performance than for heating performance. The ECRC is building a prototype electric heat pump for space heating applications that may achieve a coefficient of performance of 2.7 to 2.8.

SOLAR CALCULATIONS
(P. BASNETT)

Weather data taken in the field do not usually include solar radiation; in general, only total cloud cover is measured. However, since a measurement of solar radiation is important when calculating energy use in buildings, most analysis programs calculate it from weather data. The ECRC has developed improved methods for estimating the direct and diffuse components of solar radiation from measurements of total cloud cover.

Attachment A

Participants in the meeting of the Experts Group, Capenhurst, May 4, 1977

| NAME | ORGANISATION/ADDRESS | TELEPHONE/TELEX |
|---|---|---|
| Thomas W. Mayer )<br>J. A. Clarke ) | ABACUS, Dept of Architecture, University of Strathclyde<br>131 Rottenrow, Glasgow, UK | 041-552-4400 Ext.3021 |
| Stephen A. Lewis | American Gas Association<br>1515 Wilson Boulevard, Arlington, Virginia, 22209, USA | 703-524-2000 |
| Joseph F. Cuba | ASHRAE - USA<br>345 E 47 Street, New York, NY 10017, USA | 212-644-7853 |
| Peter R. Fish | Atkins Research and Development<br>Parkside House, Ashley Road, Epsom, Surrey | Epsom 26140, Ext.2870 |
| J. Marx Ayres | Ayres Associates<br>1180 South Beverly Drive, Los Angeles, CA 90035, USA | (213) 553 5285 |
| John Bennett | British Gas Corporation<br>Watson House, Peterborough Road, London SW6 | 01-736-1212 |
| E. Danter | Building Research Centre<br>Garston, Watford, Herts, WD2 7JR, U K | Garston 74040 |
| Jeremy P. Cockroft | Building Services Research Unit,<br>Glasgow University, 3 Lilybank Gardens, Glasgow G128RZ, Scotland | 041-334-2269 |
| G. Elias | CNR - MILANO<br>P.le Morandi 2, Italy | 780190 |
| Peter O'Neill )<br>Judith R. Stammers ) | Directorate-General of Research, Departments of Environment and Transport, 2 Marsham Street, London SWIP 3EB | 01-212-8457 (P.O'N)<br>01-212-7509 (JRS)<br>22601 (DOE Marsham London) |
| P. Bassett | Electricity Council Research Centre<br>Capenhurst, Chester CH1 6ES, UK | 051-339-4181, Ext.350 |
| Peter Hartmann | EMPA<br>Ueberlandstrasse, CH 8600 Duebendorf, Switzerland | 01 82081 31 |
| Gerald S. Leighton | ERDA, Washinton DC 20545, USA | 301-762-8266 |
| Kirtland C. Mead | ERDA - USA<br>44 Brattle Street, Cambridge, Ma 02140, USA | 617-661-1410 |
| Robert Henninger | Gard, Inc, 7449 N. Natchez, Niles, Ill 60648, USA | 312-647-9000 Ext. 242 |
| Jonathan J. Haigh | Haden Young Ltd, 141 Euston Road, London NW1 | 01-387-4377 |
| Peter KÜppers | KFA, Projektleitung Energieforschung<br>517 Jülich, Postfach 1913, Germany | 02461 - 613269 |
| Metin Lokmanhekim | Lawrence Berkeley Laboratory, University of California<br>Bldg 50, Room 228, Berkeley, California 94720, USA | (415) 843-2740, Ext.5711 |
| Frederick Winkelmann | Lawrence Berkeley Laboratory, Berkeley, CA 94720, USA | (415) 843-2740, Ext.5711 |
| B. Adamson )<br>Kurt Källblad ) | Lund Institute of Technology<br>Fack S-2207, Lund, Sweden | (46) - 124600 |
| Ross F. Meriwether | Meriwether & Associates<br>1600 Northeast Loop 410, San Antonio, Texas, USA 78209 | 512-824-5302 |
| L. Jones | National Research Council, Division of Building Research<br>(Energy & Services), Ottawa, Canada K1A 0R6 | (613) 993 1421 |
| Eugene Stamper | NJIT - USA, 323 High Street, Newark, NJ 07102, USA | 201-645-5354 |
| David Curtis | Oscar Faber & Partners, 18 Upper Marlborough Rd., St. Albans, Herts, U.K. | St. Albans 61222<br>Telex: (UK) 889072 |
| John Campbell | Ove Arup & Partners, 13 Fitzroy Street, London W1 | 01-636-1531 |
| Malcolm Barnett | Pilkington Brothers Ltd, West Park, St. Helens, Merseyside | 0744-28882, Ext.2626 |
| R. Eltschka | Technical University - Vienna, Austria<br>A-1010 Wien, Gusshausstrasse 25 | (0222) 657611 |
| E. Panzhauser | Technical University - Vienna, Austria<br>A-1040 Vienna, 13 Karlsplatz | (0222) 653785 Ext 225<br>Telex: 11000 TVFA |
| Hans Lund | Thermal Insulation Laboratory, Technical University of Denmark<br>Bld 118, DK-2800, Lyngby | (02) 88 3511, Ext.5286 |
| M. J. Austin | Welsh School of Architecture, 28 Park Place, Cardiff, UK | 0222-24731 |
| N. de Terra | International Energy Agency<br>2 rue Andre-Pascal, 75016 Paris, France | 524-9955<br>Telex: 630190 |

# IEA QUESTIONNAIRE
# FOR
# BUILDINGS ANALYSIS PROGRAMS

## Basic Information

1. Name of program: Energy System Analysis Series (ESA)

2. Developer of program: Ross F. Meriwether & Associates, Inc.

3. Proprietor or supporting agency: Ross F. Meriwether & Associates, Inc.

Contact person: Ross F. Meriwether

Address: 1600 N. E. Loop 410, Suite 241
San Antonio, Texas 78209

Telephone #: (512) 824-5302

Computer Information (if program computerized)

1. Computer (type, model): IBM 370/155 & up; UNIVAC 1108; CDC 6400 & up

2. Computer language in which program is written:

   FORTRAN IV

3. Core requirements: IBM: 380K bytes; UNIVAC : 33,000 decimal words

4. Storage requirements: Up to 500K bytes for program output file

5. Average time required per run (minutes)

   CPU time: Varies by program & machine type

   I/O time: _____

6. Cost per run ($): Varies by program: $5 to $70 per program

Descriptive Information

1. Does the program calculate loads, or energy consumption, or both?

   Loads: ZTL, DPR programs

   Energy Consumption: ERE,TCR,EEC programs

2. Does the program make estimates based on hour-by-hour calculations or on some other basis?

   Hour-by-hour: yes

   Other (please specify): _____

3. Are there any limitations on the types of buildings the program can analyze? YES: ____ NO: X

4. What building systems are analyzed by the program?

   Heating: yes

   Ventilating: yes

   Air Conditioning: yes

   Other (please specify): Heat pumps, heat recovery, total energy, selective energy.

5. What economic calculations are performed?

   Capital or first costs: uses as input to life cycle.

   Operating costs: yes

   Annual or life cycle costs: yes

6. What methods of computation are used?

Response factor: _____

U-factor: _____

Numerical difference: _____

Other (please specify): A combination of response factors, equivalent temperature differences, and ratio techniques.

Data Requirements

1. How many entry items are required for one zone (one external wall and one window)?

   Variable

2. For what entry items does the program provide default values?

   Almost none

3. What systems of physical units can the program use?

   Metric: No

   English: Yes

4. Are outputs available in a fixed format or can the format be modified as needed?

   Fixed output format: yes

   Flexible output format: some options available

5. What data bases are available with the program?

   Weather data (please specify which locations):
   about 80 U.S. locations, some overseas

   Types of weather data available (please specify):

   Mostly DB, DP, CC, but some files have other factors

   Cost data (please specify):

   No formal data base

   Characteristics of standard components (please specify):

   No formal data base

   Thermal characteristics of materials (please specify):

   No formal data base

IEA Program Comparison

1. Would you be willing to include your program in the IEA comparison? YES: X NO: ____

2. Would you be willing to run your program against test problems at your own expense, or would you require funding?
YES: X Require funding NO: ____

3. If funding is required how much would you need per run? _____
Cost estimate will be supplied for a specifically defined run

4. What types of buildings would you like the IEA to use as standard test problems? Any commercial or institutional

5. What types of equipment or components would you like to see included in standard test buildings? Any

6. What geographical locations would be acceptable to you for standard test problems? Any

Head of Department: Professor Dewi-Prys Thomas BArch DipCD FRIBA MRTPI
Professor of Architectural Science: Patrick O'Sullivan BSc PhD
Reader Alan Lipman BArch MA ARIBA
Director of Project Office: John G Roberts BArch FRIBA

THE WELSH SCHOOL OF ARCHITECTURE : Research & Development

UWIST
28 Park Place
Cardiff
CF1 3BA
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Dr. Kirtland C. Mead,
Resource Planning Associates, Inc.,
44 Brattle Street,
CAMBRIDGE,
Massachusetts 02138,
U.S.A.

8th March, 1977.

Dear Dr. Mead,

Gerald Leighton has asked me to send you the enclosed completed questionnaire.

I must stress that our computer program has been developed primarily as a research tool for our own use and not as a design package for commercial purposes.

Consequently, we are mainly interested in obtaining a realistic simulation of the heat transport processes occuring in the building and are not so concerned with running time requirements, presentation of results, or making life easy for an external user. Also, being a School of Architecture, we are mainly interested in the effect of basic building design decisions on thermal environment and energy requirements, and not in the design of heating and ventilating plant. In fact, hitherto, our program has only been used to simulate small non-air-conditioned buildings.

In order to participate in the present project, we have therefore had to carry out some hurried last-minute alterations to our program in an attempt to make it function as a commercial design package. Even so, we feel like someone entering a cat for a dog show!

We would be grateful if some comment on the above lines could be made in any future comparison of programs.

I hope to be sending you some results in the not-too-distant future, but I'm afraid this is not likely to be before March 31st.

Yours sincerely,

M. J. Austin

M. J. Austin.

# IEA QUESTIONNAIRE
# FOR
# BUILDINGS ANALYSIS PROGRAMS

## Basic Information

1. Name of program: HTB

2. Developer of program: M.J. AUSTIN

3. Proprietor or supporting agency: UWIST


Contact person: M.J. AUSTIN

Address: 28 PARK PLACE

CARDIFF

Telephone #: CARDIFF 24731

Computer Information (if program computerized)

1. Computer (type, model): ICL 4-70

2. Computer language in which program is written:

FORTRAN

3. Core requirements: 50K BYTES & upwards

4. Storage requirements: ?

5. Average time required per run (minutes)

CPU time: 75 mins. (To process 6 months weather data)

I/O time:

6. Cost per run ($): N.A.

Descriptive Information

1. Does the program calculate loads, or energy consumption, or both?

   Loads: ✓

   Energy Consumption: ✓

2. Does the program make estimates based on hour-by-hour calculations or on some other basis?

   Hour-by-hour: ✓

   Other (please specify): _____

3. Are there any limitations on the types of buildings the program can analyze? YES: ✓ NO: _____

4. What building systems are analyzed by the program? NONE

   Heating: _____

   Ventilating: _____

   Air Conditioning: _____

   Other (please specify): _____

5. What economic calculations are performed? NONE

   Capital or first costs: _____

   Operating costs: _____

   Annual or life cycle costs: _____

6. What methods of computation are used?

Response factor: _____

U-factor: _____

Numerical difference: ✓

Other (please specify): _____

Data Requirements

1. How many entry items are required for one zone (one external wall and one window)? N.A.

2. For what entry items does the program provide default values? NONE

3. What systems of physical units can the program use?

   Metric: ✓

   English: _____

4. Are outputs available in a fixed format or can the format be modified as needed?

   Fixed output format: ✓

   Flexible output format: _____

5. What data bases are ~~available~~ with the program?

   Weather data (please specify which locations): N.A.

   Types of weather data ~~available~~ (please specify):

   STANDARD MET. TAPES

   Cost data (please specify): NONE

   Characteristics of standard components (please specify): AREA, THICKNESS, MATERIAL TYPE

   Thermal characteristics of materials (please specify): THERMAL CONDUCTIVITY, SPECIFIC HEAT, DENSITY, REFLECTIVITY, EMISSIVITY

1 A Program Comparison

1. Would you be willing to include your program in the IEA comparison? YES: ✓ NO: ____

WITH RESERVATIONS

2. Would you be willing to run your program against test problems at your own expense, ~~or would you require funding?~~

YES: ✓ NO: ✓

3. If funding is required how much would you need per run? $ N.A.

4. What types of buildings would you like the IEA to use as standard test problems? ACTUAL BUILDINGS

5. What types of equipment or components would you like to see included in standard test buildings? ANYTHING REALISTIC

6. What geographical locations would be acceptable to you for standard test problems? ANY

SUMMARY OF BUILDINGS AND COMMUNITY SYSTEMS EXPERTS GROUP BUILDING ANALYSIS - IEA I

| PROGRAM NAME | BUILDING PEAK THERMAL LOAD | | ACTUAL PEAK HEAT EXTRACTION/ ADDITION BY EQUIPMENT | | DATE TIME OF ACTUAL PEAK | TOTAL ANNUAL HEAT EXTRACTION/ ADDITION BY EQUIPMENT | | | ANNUAL FUEL CONSUMPTION | | NOTES | EXT. ZONE | R.A. LOADS | VAV STOP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HEATING (MJ/h) | COOLING (MJ/h) | HEATING (MJ/h) | COOLING (MJ/h) | | HEATING (GJ) | COOLING (GJ) | OTHER (Mwh) | ELECTRICITY (Mwh) | GAS OR OIL - (GJ) | | | | |
| WELSH, SA | 12107 | 7877 | 12107 | 7877 | Jan 9/Jul 11 7 am /10 am | 2128 | 7459 | | | | Peak is not by equipment | 0 | Yes | N/A |
| PILKINGTON | 5110 | 6192 | 5110 | 6192 | Jan 21/Jul 22 7 am /11 am | 1375 | 9776 | | | | Does not consider equipment | None | No | N/A |
| FABER | 3220 | 7374 | 4294 | 2448 | | | | | 6499 | 23455 | | 5m | No | ? |
| AGA ECUBE 75 | -3620 | 7118 | 8329 | 8262 | Jan 2/Jul 17 7 am /4 pm | 8050 | 5834 | 4326 | 4519 | 10950 | | 6m | Yes | 50% |
| ECUBE III | -3308 | 4873 | 4410 | 6060 | Jan 8/Jul 10 11 pm/5 pm | 6131 | 1907 | 2700 | 1997 | 8719 | Peak dates for equipment loads (Program under-developed) | 6m | Yes | 50% |
| MERIWETHER | -4246 | 7709 | 4387 | 7609 | Jan 2/Jul 11 7 am /11 am | 4777 | 2745 | 3120 | 3305 | 6471 | | 4.5m | Yes | 19-49% dep. on zone |
| OFFICE (ECRC) | 4190 | 4919 | 4311 | 3215 | Jan / Jul | 1800 | 2554 | | | 3175 | 35% glass no equipment | 5m | Yes/ 2 | N/A |
| CAL-ERDA | 4197 | 3554(S) 4112(T) | 6878 | 5063 | Dec 9/Jul 12 8 am /10 pm | 3876 | 1251 | 3226 | 3523 | 5667 | | 3.7m | Yes | ? |
| REID CROWTHER (.RC) | - | - | 1366.5 | 6267 | Jan 9/Jul 11 8 am /5 pm | 662.8 | 2333 | 3008 | 3506.9 | 1096.72 | | 2.8m | Yes | 40% |
| BRITISH GAS | 7080 | 5591 | 7030 | 5591 | Jan 10/Jul 18 7 am /10 pm | 1380 | 4753 | | | | Does not consider equipment | 0 | Yes | N/A |
| SCOUT | 5198 | 6534 | 5644 | 7309 | Dec 10/Jul 20 2400 /1700 | 4586 | 2515 | 3168 | 4255 | 6072 | Peak heating only No setback | 3m | Yes | 30% |
| ESP | N/A | N/A | 8179.6 | 13140.0 | Jan 9/Jul 7 8 am /2 pm | 3166 | 8999 | N/A | N/A | N/A | | 0 | Yes | N/A |
| ATKOOL | -4235 | 7672 | - | - | Jan 9/Jul 10 8 am /5 pm | - | - | - | - | - | | 0 | No | N/A |
| ARKET | | | 6214 | 3560 | Jan 9/Jul 7 7 am /4 pm | 2659 | 2292 | | | | No equipment | 0 | Yes | N/A |
| FADEN YOUNG CO 11 | 3744 | 7177 | | | Winter/Aug 1100 | - | - | - | - | - | No equipment | 0 | Yes | N/A |

Attachment C

# MEMBERS OF THE EXECUTIVE COMMITTEE

## BUILDINGS AND COMMUNITY SYSTEMS

## May 4, 1977

| Name | Organization/Address | Telephone/Telex |
|---|---|---|
| Thomas W. Maver<br>J.A. Clarke | ABACUS, Dept. of Architecture,<br>University of Strathclyde<br>131 Rottenrow, Glasgow, UK | 041-552-4400 Ext. 3021 |
| Peter R. Fish | Atkins Research & Development<br>Parkside House, Ashley Road,<br>Epsom, Surrey, UK | Epsom 26140, Ext. 2870 |
| John Bennett | British Gas Corporation<br>Watson House, Peterborough Road,<br>London SW6 | 01-736-1212 |
| Jeremy P. Cockroft | Building Services Research Unit,<br>Glasgow University, 3 Lillybank<br>Gardens, Glasgow G128RZ Scotland | 041-334-2269 |
| G. Elias | CNR - MILANO<br>P. le Morandi 2, Italy | 780190 |
| Peter Hartmann | EMPA<br>Ueberlandstrasse, CH 8600<br>Duebendorf, Switzerland | 01 82081 31 |
| Gerald S. Leighton | ERDA, Washington DC 20545, USA | 301-7 62-8266 |
| Jonathan J. Haigh | Haden Young Ltd., 141 Euston Road,<br>London NW1 | 01-387-4377 |
| L. Jones | National Research Council, Division<br>of Building Research (Energy &<br>Services), Ottawa, Canada K1A 0R6 | (613) 993 1421 |
| David Curtis | Oscar Faber & Partners, 18 Upper<br>Marlborough Rd, St. Albans, Herts.,<br>U.K. | St. Albans 61222<br>Telex: (UK) 889072 |
| John Campbell | Ove Arup & Partners, 13 Fitzroy<br>Street, London W1, U.K. | 01-636-1531 |
| Malcolm Barnett | Pilkington Brothers Lrd., West Park<br>St. Helens, Merseyside, U.K. | 0744-28882, Ext. 2636 |
| M.J. Austin | Welsh School of Architecture, 28<br>Park Place, Cardiff, UK | 0222-24731 |

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

INTERNATIONAL ENERGY AGENCY

RESTRICTED

Paris, 14th February, 1977

IEA/CRD(77)48

English only

# COMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

## DISSEMINATION OF INFORMATION ON IEA CO-OPERATIVE R, D & D PROGRAMMES AND PROJECTS

(Note by the Secretariat)

## 1. INTRODUCTION

The conclusion by the Governing Board that significant co-operative activities in energy research and development can only be achieved through a commitment by the interested parties has resulted in the concept of an Implementing Agreement for all such activities.

All Implementing Agreements concluded so far make specific provisions for the dissemination of information derived from the co-operative activities in question. However, there are considerable variations in the policies on information included in the Agreements; some encourage the widest possible dissemination to all Agency Member States, subject notably to the need to protect intellectual property, while others restrict the dissemination of detailed technical information derived from the co-operative activities to the Contracting Parties only. Only one Agreement (on the Intense Neutron Source) makes specific provision for annual reporting to all Agency Member States.

The purpose of this note, therefore, is to attempt to set forth guidelines for reporting on IEA co-operative energy R, D & D programmes and projects.

2. OBJECTIVES OF INFORMATION DISSEMINATION

It is to be noted that there are several objectives to be achieved through information dissemination:

(a) Participants in a project require technical information to achieve their project purposes and management information to assure adequate project execution;

(b) To the extent permitted by the terms of individual project Agreements, non-participating IEA countries are entitled to information developed on individual projects;

(c) Information provided to both the technical and non-technical public can give important visibility to IEA activities.

3. PROPOSED REPORTING REQUIREMENTS

To achieve these objectives, the following reporting system is proposed:

A. Reports to be Prepared by the Project Operating Agent

(i) At a frequency to be determined by project participants, but no less than semi-annually, the Operating Agent (or other project entity as determined by the Executive Committee) shall prepare reports containing all significant technical information developed in the project and management information relating to the conduct of the project. Such reports are to be distributed to the project participants with a copy to the Secretariat. Unless

otherwise provided in the project Implementing Agreement or agreed to by the project Executive Committee, no further distribution is to be made of such reports.

(ii) A progress report suitable for distribution to non-participating IEA countries is to be prepared annually on each project on a calendar year basis. This report should contain as much technical information as the Implementing Agreement permits to be distributed to non-participants.

Each such annual report should include an executive summary in a form suitable for distribution to the press and other interested members of the public. To the extent appropriate, the summary should include illustrations and explanations to help public understanding of the project.

Thirty copies of each such annual report should be submitted to the Secretariat by 31st January of each year for the preceding calendar year, for distribution to Member countries.

At the conclusion of each project, a final report should be prepared suitable for distribution to all IEA countries. This report may be substituted for the final annual report.

(iii) While the contractual provisions of individual projects may limit the distribution of technical information, it should be recognised that the

issuance of technical reports for the technical/ industrial community when a body of work has been completed, can give added visibility to IEA activities. Executive Committees should, therefore, be alert to the possibilities for preparation of such reports.

B. Reports to be Prepared by the Secretariat

(i) The Secretariat will prepare an annual report of all IEA activities. It will consist of the executive summaries contained in each project's annual report /A(ii) above/, with such editing as is necessary to assure a cohesive document. This report will be distributed to all members of the Agency and will be available for public distribution.

(ii) A brochure will be prepared for those projects lending themselves to such treatment which describes the purpose and content of the project. It should be written in a form suitable for the general public with appropriate illustrations, and will be prepared by the Secretariat with assistance by the project Executive Committee.

4. REPORTING FORMAT

The format for project reports prepared for internal project distribution will be determined by the project Executive Committee.

A general format for the annual reports will be supplied by the Secretariat, based upon customary practice for annual progress reports on technical programmes.

A special cover will be designed for use by projects in preparing annual reports and the Secretariat in preparing the Agency annual report.

5. RECOMMENDATIONS

The Committee on Energy Research and Development is invited to discuss and approve or amend, as necessary, the foregoing guidelines and to authorise their transmission to the Executive Committees of all IEA co-operative R, D & D programmes and projects.

The Executive Committee,

decides to Amend the Implementing Agreement by replacing the word "or" in paragraph 7(c)(2) of Annex I with the word "and".

NOTE: This change is necessary because the three conditions 7(c)(1)(2) and (3) are not alternatives, but must all be met for proprietary information to qualify as such. This amendment will bring the Buildings and Community Systems Agreement into conformity with similar language in the Heat Pumps, Combustion and Solar Heating and Cooling Agreements. The Cascading Agreement is being similarly modified.

## Proposed Executive Committee Action

The Executive Committee decides

To amend Annex I Para.3(a) (3)

by deleting "Two participants ....."

and by adding "Any country wishing to access the LBL system shall provide a single computer link within that country. Organizations within that country desiring access to the LBL system shall access the system through such link. "

The Executive Committee of the IEA Implementing Agreement for a Programme of Research and Development on Energy Conservation in Buildings and Community Systems

NOTING that a bilateral agreement (Implementing Agreement For the Establishment of a Project to Demonstrate and Promote the Combined Application of the Science of Ekistics and Advanced Energy Systems,) was signed under IEA auspices in 1976 in the field of energy conservation in buildings and community systems; and further

NOTING that when the Ekistics Agreement was concluded it was foreseen that it would be brought in to the subject umbrella agreement signed on 16th March,

REQUESTS the IEA Secretariat to prepare a new annex to the Implementing Agreement that will integrate the R and D activities of this bilateral agreement into the umbrella agreement, such new annex and necessary legal instruments to be circulated to all present and proposed Contracting Parties by 31st August, 1977.

ANNEX A

# A G R E E M E N T

Between

THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION ( ERDA )
OF THE UNITED STATES OF AMERICA

And

THE NATIONAL ENERGY COUNCIL OF THE MINISTRY OF COORDINATION
OF THE REPUBLIC OF GREECE

For a Task

Titled: "Development of a Methodology for Combined Application of the Science of Ekistics and Advanced Community Energy Systems"

Under the

INTERNATIONAL ENERGY AGENCY
IMPLEMENTING AGREEMENT

For the establishment of a project to demonstrate and promote the combined application of the Science of Ekistics and Advanced Energy Systems.

# I. Introduction

## A. Background

In order to achieve maximum conservation of energy on a community scale, the analytical and design tools and methods traditionally used by the urban design and energy systems professions must be refocused upon the energy considerations in human settlements and combined for joint application by teams consisting of both professions to the problems of human settlements. This task will develop such a practical and widely applicable tool, consisting of a community design methodology and ekistic-energy analytical matrix. Ekistics is a Greek word for the science of human settlements as developed in its modern form by Constantine Doxiades. It offers a detailed analytical matrix of the functional and scale relationships in human settlements, ideal for correlation of energy parameters and synthesis of a generic design and analysis tool and methodology for use by urban designers and engineers to maximize energy conservation on a community scale.

## B. Task Objectives

1. Sponsor international cooperation in the area of community development based on the combined application of the science of ekistics and advanced community energy systems.

2. Develop a practical and widely applicable methodology for community design and analysis as a tool for achievement of maximized energy conservation in a resources-limited environment. This methodology in its generic form and through the accompanying guidelines must be suitable for immediate transferability and use in the U.S. environment.

3. Organize and conduct an international conference in the summer of 1977 on ekistics and innovative community energy systems to encourage on-going international exchange of information and collaboration in this field.

4. At a future time, by mutual agreement, the methodology and related outputs developed under this task may be applied for a demonstration of the ekistic-energy development of a specific site.

## II. Specification of Task

Develop a Methodology for Combined Application of the Science of Ekistics and Advanced Community Energy Systems.

### A. Subtask 1: Development of Methodology, Scope of Work

#### 1. General Requirements

The designated Operating Agent will develop a practical and universally transferable methodology for energy conserving community planning in a resources-limited environment based on ekistics and the use of advanced community energy systems. Practicality and transferability shall be assured by development of the methodology through step-by-step application of the ekistic matrix, and the energy parameters thereof, to the generic realities and potentials of a test-case site translated to the general case for widespread transferability. The Operating Agent shall prepare a report of all work covered in this Scope of Work, with particular emphasis on a clear presentation of the practical and transferable methodology developed, within 12 months from the entry into force of this Annex as a deliverable to the U.S. ERDA.

2. Specific work items in Subtask 1 include:

   a. Detailed work management plan and budget for subtasks 1 and 2 and test-case site selection rationale recommendation. A report on these items shall be submitted to the Joint Working Party for review and approval prior to proceeding with other work items.

   b. Preliminary formulation of the methodology to be used and refined during application to the site. The methodology will include the use of -

      (1) ekistic matrixes, including energy parameters
      (2) parameters of advanced energy systems
      (3) socio-economic feasibility criteria
      (4) engineering-economic feasibility criteria
      (5) planning framework for economic and ekistic land-use development
      (6) procedures for choosing a balanced ekistic-energy economic development

c. Methodology development tasks:

(1) Inventory and evaluation of potential natural resources of the site, including hydrological and insolation surveys; define process for the general case.

(2) Societal definition of human resources and needs, including analyses of local socio-economic structure; define process for the general case.

(3) Analysis and definition of economic development potentials of the site; define process for the general case.

d. Development of socio-economic and engineering-economic feasibility criteria, guidelines, and limiting conditions for the general case and the site.

e. Application of the preliminary methodology to the site to produce alternative preliminary land-use and economic development master plans. These plans will display alternative ways of using natural and human resources to exploit economic development potential, assuming availability of required energy and water at the site. Energy consuming end-use services required will be specified by amount and type. Refine preliminary methodology for the general case.

f. Development of a community energy and utilities supply system that fully supports each alternative master plan. These systems will give full coverage to traditional energy sources and to use of solar and other non-depletable forms of energy. They will be based on maximum community-wide energy efficiency from energy production through conversion, distribution, and end-use. In this work item the Operating Agent will borrow and adapt ongoing work under ERDA's Advanced Technology Mix Energy Systems (ATMES) Program. Refine preliminary methodology for the general case.

g. Development of a recommended master plan for full development of the site, including cost estimates and a preliminary engineering description of the energy system which will serve it. Define process for the general case.

h. Development and presentation of a phased development plan for implementation of the master plan, complete with budget for economic and social investment for each phase and with recommended organizational approaches. Define process for the general case.

i. Documentation of the complete methodology as refined by application to the site, including illustrations, examples and instructions adequate for generalized use by urban planners, engineers and related professionals.

B. Subtask 2: International Conference on Ekistics and Innovative Community Energy Systems

1. The Operating Agent, shall undertake and carry out an international conference on ekistics and innovative community energy systems in Athens, in the summer of 1977. The conference shall be co-sponsored by the National Energy Council and ERDA. This conference will encourage international exchange of information and collaboration on applications of ekistics and advanced energy systems to new and old communities. Subjects to be covered include -

   a. Technological and scientific developments in ekistics, urban planning, and community energy systems.

   b. Government projects for regional economic development which can profit from ekistics planning techniques and advanced energy systems.

2. The widest possible participation by countries in the conference shall be sought, and a wide scope of presentations by these representatives shall be encouraged as long as they relate to the main subjects of the conference.

3. The Operating Agent, shall undertake all activities required to successfully convene and carry out the conference, including the preparation and dissemination of printed proceedings of the conference. The Executive Committee shall approve the detailed budget for the conference, the guidelines for international participation and the detailed agenda of the conference.

III. Designation and Specific Duties of the Operating Agent

A. The National Energy Council of the Ministry of Coordination of the Republic of Greece is designated the Operating Agent for this Task.

B. The specific duties of the Operating Agent are as follows:

1. Provide full project management services for accomplishment of work as specified in the Task Specification and the Task Schedule.

2. In accordance with the Task Schedule, submit to the Executive Committee for approval a detailed work management plan and budget including identification of energy and ekistics consultants to be used in Subtask 1 and organization to be assigned execution of Subtask 2.

3. Ensure delivery of the work products to the Participating Parties in accordance with the Task Schedule. Submit the Subtask 1 final report and the conference proceedings to the Executive Committee.

IV. Obligation of the Energy Research and Development Administration (ERDA) of U.S.A.

A. ERDA shall, within two months from the signing of this Agreement provide the Operating Agent with relevant information on those advanced community energy systems, derivable from ERDA RD&D programs, which could have potential application compatible with the nature and general requirements of the test-case site.

B. During the course of the Project ERDA will provide information, guidance and comments concerning the energy systems considered under the Task.

C. Following completion of work item II.A.2.e, ERDA personnel associated with the ATMES program shall consult with counterpart personnel of the Operating Agent with the objective of selecting and defining the community energy system to serve each of the alternative land use/development plans.

## V. Task Management and Task Schedule

### A. Task Management

1. Supervision of the Task shall be vested in a Executive Committee as constituted herein and decisions reached by the Executive Committee shall be binding on the Operating Agent and each Participating Party.

2. The Executive Committee shall consist of one representative designated by each of the Participating Parties. Each member of the Executive Committee may appoint technical or other advisers. Each Participating Party shall inform the other Participating Parties in writing of all designations under this paragraph.

3. The Executive Committee shall evaluate performance of work and Task results by the Operating Agent, and shall take such actions as are necessary for the effective management of the Task in accordance with the Task Schedule.

4. The Executive Committee shall adopt the detailed Task Budget and detailed work management plan and shall make such rules and regulations as may be required for the sound management of the Task.

5. Members of the Executive Committee shall be remunerated by their respective employers and shall be subject to their employers conditions of service.

6. Each member of the Executive Committee shall have one vote, and all decisions shall be by unanimity.

7. The Executive Committee shall meet in regular session at least twice annually during the duration of the Task; each Participating Party shall have the right to request additional sessions. Meetings of the Executive Committee shall be held at such locations as may be mutually agreed upon. All members of the Executive Committee shall be present to produce a quorum for the transaction of business in meetings of the Executive Committee. With the agreement of each representative in the Executive Committee, a decision or recommendation may be made by Telex or cable without the necessity for calling a meeting.

B. Task Schedule

The Operating Agent undertakes the obligation to complete and submit to the Participating Parties all work related to the Project within twelve (12) months from the signing of this Task Agreement.

The Operating Agent will follow the following time schedule:

1. PHASE 1

Within thirty (30) days from the signing of the respective contract the Operating Agent must submit to the Executive Committee.

a. A detailed work management plan and budget for the Task.

b. Data and recommendations for the selection of a specific test-case site for the development of the Methodology.

The approval and/or any comments by the Executive Committee on the first phase must be communicated in writing to the Operating Agent no later than thirty (30) days from the date of its submission.

2. PHASE 2

Within four (4) months from the date of the written approval to the Operating Agent of the work of Phase 1 the Operating Agent must complete and submit the following items of work to the Executive Committee.

a. Complete definition of the preliminary methodology for the combined Ekistic-Energy methods with a brief description of it.

b. Alternative land-use and economic development schemes.

c. Definition of necessary end-use energy consuming services by type and quantity and of other services required by the community.

d. Presentation of Alternative Plans for joint selection of the suitable energy system that covers the requirements of each land-use and economic development plan.

e. Preparation and Program for the organization of an International Conference on Ekistics and Innovative Community Energy Systems.

The approval and/or any comments by the Executive Committee on the material of the Second Phase must be communicated in writing to the Operating Agent within twenty (20) days from the fulfillment by the Operating Agent of all the obligations of the Second Phase.

3. PHASE 3

Within four (4) months from the date of the written approval or of any comments by the Executive Committee to the Operating Agent on the material of the second phase the Operating Agent must complete and submit the following items of work:

a. Complete workable, analytic ekistic-energy matrix and methods and design methodology to incorporate complete, specific, community energy and recycling systems, for the land-use economic development schemes.

b. Justified choice of the preferred land-use economic development scheme and ekistic-energy development master plan.

c. Organize and hold International Conference in Greece on ekistics and innovative community energy systems.

The approval and/or any comments of the Executive Committee on the material of the Third Phase must be communicated in writing to the Operating Agent within twenty (20) days from the fulfillment by the Operating Agent of all the obligations of the Third Phase.

4. PHASE 4

Within one (1) month from the date of the written approval or of any comments by the Executive Committee to the Operating Agent on the material of the Third Phase the Operating Agent must:

a. Submit the Final Text of the Subtask No. 1 Report as particularly called for in subparagraphs II.A.1 and II.A.2.i above in English and Greek and in thirty (30)

copies in each language. Also the Operating Agent must within thirty (30) days from the date of the submission of the Final Text of this Report submit to the Executive Committee thirty (30) copies in English and thirty (30) copies in Greek of the Final Text of this Report in the form of a General Report including the drawings developed under the Task as well as thirty (30) copies of a Summary Report with respective drawings in English and thirty (30) copies in Greek of the same Summary Report.

b. Within two (2) months from the date of the end of the International Conference the Operating Agent must publish and distribute to the participants the Proceedings of the Conference in English.

VI. Financial Terms for the Task

1. The expenditure incurred in the operation of this Task for one year shall be borne by the Participating Parties in the proportions appearing below. Such expenditure is not expected to exceed $200,000 at October, 1976, price levels and exchange rates, and may not exceed such level except upon the unanimous agreement of the Executive Committee. The Executive Committee acting by unanimity, shall adjust the figure referred to in this paragraph at half-yearly intervals to take account of changes in exchange rates and changing price levels in the country of the Operating Agent to ensure that the necessary real resources will continue to be available to perform the task. If significant changes in such exchange rates or price levels occur, the Executive Committee, acting by unanimity, shall consider whether to adjust the program of work to the available funds. The financial year of the Task shall correspond to the financial year of the U.S. ERDA.

2. Specific financial proportions for each Contracting Party to the Task.

| Participating Party | Proportion |
|---|---|
| U.S. Energy Research & Development Administration (ERDA) | 75% |
| National Energy Council of the Ministry of Coordination of the Republic of Greece | 25% |

3. The percentages above will be revised if other IEA member countries express interest in participating in this Annex.

4. The payment of the expenses for each phase of this Project will be prepaid by the Participating Parties in their proportion to a special account of the Public Investments of the Ministry of Coordination of the Republic of Greece. Prepayment of the U.S. ERDA financial proportion shall be made as follows: 20% of the proportion within fifteen (15) days following signing of this agreement; 80% of the proportion within fifteen (15) days following approval of the detailed work management plan and budget by the Executive Committee.

VII. Procurement Procedures

The Operating Agent shall competitively procure necessary contractor services for Subtasks 1 and 2 in accordance with the standard procurement procedures normally required for procurement of similar services by the Operating Agent. The laws of Greece shall be applicable.

VIII. Time Period for which this Annex will Remain in Effect

One year, subject to extension by the Executive Committee for work slippage as approved by the Executive Committee.

IX. Patents and Intellectual Property

A. The publication, distribution, handling, protection and ownership of information and intellectual property arising from this task shall be determined by the Executive Committee in conformity with this Agreement.

B. Subject only to restriction applying to patents and copyrights, the Participating Parties shall have the right to publish all information provided to or arising from this task except proprietary information. Proprietary information shall not be accepted for or utilized in this Task without express approval of the Executive Committee.

For the purpose of this Section IX, proprietary information shall mean information of a confidential nature such as trade secrets and know-how (for example, computer programmes, design procedures and techniques, chemical composition of materials, or manufacturing methods, processes, or treatments) which is appropriately marked, provided such information:

1. Is not generally known or publicly available from other sources;

2. Has not previously been made available by the owner to other without obligation concerning its confidentiality; and

3. Is not already in the possession of the recipient Participating Parties without obligation concerning its confidentiality.

The Operating Agent and the Participating Parties shall take all necessary measures in accordance with this Section IX, the laws of their respective countries and international law to protect proprietary information.

C. The Operating Agent shall provide the reports required in this Annex without restriction to each Participating Party. Each Participating Party shall be entitled to the following additional information:

EPt prior to the beginning of the task,

1. Information related to the task which has not been held confidential by the Operating Agent, its subcontractors, or the Participating Parties without restriction; and

2. Proprietary information of the Operating Agent or the Participating Parties related to the task for use only in relation to each Participating Party's research and development programmes.

EPt Subject to the approval described in IXB, QDM 10/25/78

D. The U.S. ERDA shall license proprietary information related to the task and which has been utilized in the task:

1. Royalty-free to the Government of each Participating Party for governmental use in its country only; and

2. On reasonable terms and conditions to the Participating Parties, their Governments and nationals of their countries designated by the Participating Parties for use in all countries.

E. Each Participating Party agrees to license, on reasonable terms and conditions, all patents owned or controlled by it which are useful in practicing the results of the task and have been utilized in the task, to the Participating Parties, their Governments and the nationals of their countries designated by the Participating Parties for use in all countries.

F. Patents owned or controlled, in whole or in part, by parties other than Participating Parties may be procured by or licensed to the Operating Agent for use in the task only with express approval of and under terms and conditions stipulated by the Executive Committee.

G. Inventions made or conceived in the course of or under the Task (arising inventions) shall be identified promptly and reported by the Operating Agent along with a recommendation of the countries in which patent applications should be filed. The Executive Committee shall establish procedures for processing such recommendations to determine where and when patent applications will be filed at the expense of the task.

Information regarding inventions on which patent protection is to be obtained shall not be published or publicly disclosed by the Operating Agent or the Participating Parties until a patent application has been filed in any of the countries of the Participating Parties, provided, however, that this restriction on publication or disclosure shall not extend beyond six months from the date of reporting of the invention. It shall be the responsibility of the Operating Agent to appropriately mark task reports which disclose inventions that have not been appropriately protected by the filing of a patent application.

H. Patents obtained on inventions arising from the task shall be owned by:

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2. U.S. ERDA in all countries, subject to a nonexclusive, irrevocable, royalty-free licence to the other Participating Parties and their Governments, and on reasonable terms and conditions to the nationals of their countries designated by the Participating Party.

I. The Operating Agent shall take appropriate measures necessary to protect copyrightable material generated under the Task. Copyrights obtained shall be the property of the Operating Agent for the benefit of the Participating Parties, provided, however, that the Participating Parties may reproduce and distribute such material, but shall not publish it with a view to profit.

J. Each Participating Party and the Operating Agent will, without prejudice to any rights of inventors or authors under its national laws, take all necessary steps to provide the cooperation from its authors and inventors required to carry out the provisions of this Section. Each Participating Party will assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

K. The Executive Committee may establish guidelines to determine what constitutes a "national" of a Participating Party. Disputes that cannot be settled by the Executive Committee shall be settled under Article 9(d) of the Implementing Agreement for the Establishment of a Project to Demonstrate and Promote the Combined Application of the Science of Ekistics and Advanced Energy Systems.

EXECUTIVE COMMITTEE ON
BUILDING AND COMMUNITY SYSTEMS
CAPENHURST MEETING
May 4-5, 1977

## Resulting Action Items

### A. Consistency of Results Among Analysis Programs

1. By May 15 the U.K. will send the operating agent their algorithm for calculating direct and diffuse solar radiation.

2. The operating agent will use the U.K. algorithm to generate solar radiation data. The operating agent will add these data to the 1967 Weathersfield weather tape and send a new copy of the weather tape to each participant by June 15.

3. The operating agent will revise the building specification for IEAI to remove analyst's choice as far as possible. The reviewed spec will also contain the five building variations discussed in the minutes of the Capenhurst meeting. The revised spec for IEAI and 5 variations will be issued to the Executive Committee (E.C.) and participating analysts for comments by June 7.

4. Participants will return comments to the operating agent by the end of June.

5. The operating agent will issue the final specification by July 15.

6. The operating agent will develop a document proposing and explaining definitions and formats for building analysis summaries. This document will be circulated to building analysts by July 15.

7. Analysts will run the reviewed IEAI and 5 variations in time to send summary results to the operating agent by September 15.

8. The operating agent will summarize all the results and distribute them to the E.C. for comment by October 15.

9. Analysts will send the operating agent by July 15 one page summaries of the assumptions they made in treating infiltration in the IEAI building.

10. The operating agent will perform a parametric analysis of the factors in a building specification whose interpretation most affects the energy loads and usage predicted by an analysis program. The results of this analysis will be presented at the November meeting of the E.C.

B. Analysis of Infiltration and Opening Windows

1. All E.C. members will send abstracts of ongoing work in this area of which they are aware to the operating agent by August 1.

2. The operating agent will develop a proposed research program in this area and send it to the members of the E.C. by October 15 for review. The program will be discussed at the November meeting.

C. Analyses Involving Real Buildings

1. E.C. members and participating analysts will, by May 31, send the U.K. (David Curtis) information on how real test buildings should be instrumented.

2. E.C. members from the U.K. and other participants will meet on or about June 15 to discuss a research program based on a building at Avon Bank, near Bristol. The building will be administrated by the Department of the Environment in the U.K.

3. By July 15 the U.K. will send the operating agent:

   a. a description or specification of the Avon Bank building

   b. a description of weather data available at the site

   c. a description of present and planned instrumentation of the building

   d. a proposed R&D program based on the building.

   The operating agent will send this material to the E.C. for comment.

4. Members of the E.C. will send comments to the operating agent by September 15.

5. The operating agent will then integrate these comments and send them to all E.C. members by October 15.

6. The Avon Bank program will be discussed at the November meeting. The E.C. will draft a final R&D program, decide on a funding scheme for the program, and further advise the U.K. on appropriate instrumentation for the building.

EXECUTIVE COMMITTEE ON BUILDING AND COMMUNITY SYSTEMS

SCHEDULE PRIOR TO NOVEMBER 1977 MEETING

| Activity | April | May | June | July | August | September | October | November |
|---|---|---|---|---|---|---|---|---|
| cutive Committee Meetings | | 5 | | | | | | 16 |
| Consistency of Results | | | | | | | | |
| 1. U.K. send Oper. Agent solar algorithm | | 15 | | | | | | |
| 2. Oper. Agent generate solar data, add to weather tape and send to all participants | | 15 | —— | 15 | | | | |
| 3. Oper. Agent revise building spec for IEAI, include 5 variations, circulate for comment | | 5 —— | 15 | | | | | |
| 4. Participants return comments | | | —— 30 | | | | | |
| 5. Oper. Agent issue final spec. | | | | — 15 | | | | |
| 6. Oper. Agent develop improved summary definitions and circulate | | 5 —— | | 15 | | | | |
| 7. Participants run IEAI and 5 variations, send results to Oper. Agent | | | | 15 | —— | 15 | | |
| 8. Oper. Agent summarize results and distribute | | | | | | 15 —— | 15 | |
| 9. Participants send Oper. Agent infiltration assumptions | | | | 15 | | | | |
| 0. Oper. Agent perform parametric analysis | | | | 15 | —— | | | 16 |

Attachment K

| Activity | April | May | June | July | August | September | October | November |
|---|---|---|---|---|---|---|---|---|
| cutive Committee Meetings | | 5 | | | | | | 16 |
| Infiltration & Opening Windows | | | | | | | | |
| 1. Exec. Comm. members send abstracts of ongoing work | | 5 —— | —— | —— | 1 | | | |
| 2. Oper. Agent devel. research program and circulate to E.C. for review | | | | | 1 —— | —— | —— 15 | |
| Real Buildings | | | | | | | | |
| 1. Participants send U.K. info on building instrumentation | | 5 —— 31 | | | | | | |
| 2. U.K. participants meet to discuss Avon Bank building | | | 15 | | | | | |
| 3. U.K. devel. info. on Avon Bank and send to Oper. Agent for circulation to E.C. | | | 15 —— | —— 15 | | | | |
| 4. E.C. members send comments to Oper. Agent | | | | 15 —— | —— | —— 15 | | |
| 5. Oper. Agent integrate comments and circulate | | | | | | 15 —— | —— 15 | |
| 6. Discuss Avon Bank program at Nov. meeting, draft final program | | | | | | | | 16 |

ECRC/M902

THE ELECTRICITY COUNCIL RESEARCH CENTRE
CAPENHURST CHESTER CH1 6ES

# VENTILATION: A BEHAVIOURAL APPROACH

by G. W. Brundrett

February, 1976

ELECTRICITY COUNCIL RESEARCH
ECRC/M902

THE ELECTRICITY COUNCIL RESEARCH CENTRE ECRC/M902

# VENTILATION: A BEHAVIOURAL APPROACH

by

G.W. Brundrett

SUMMARY

Behavioural studies of the window opening habits of families in one hundred and twenty three houses show a strong seasonal pattern. During winter window opening is closely related to moisture level in the external air. In summer it is more closely linked to mean daily temperature. There are wide differences between families, with larger families having more open windows. Re-examination of ventilation criteria suggests three seasons, one in deep winter which needs minimum adequate air for body odour removal, the second in spring/autumn for controlling moisture and the third in summer for cooling.

Paper to be presented at the CIB Conference, London, April, 1976.



February, 1976

CONTENTS

## 1. INTRODUCTION

Energy calculations for space heating involve two heat loss mechanisms. The first is heat conducted through the building fabric. The second is heat loss through casual air infiltration. Recent improvements in fabric insulation make this ventilation factor proportionately more important since it can represent 50% of the total loss.

In given weather conditions the minimum air change rate is controlled by the size and disposition of gaps in the building envelope particularly those around doors and windows. Surveys of modern houses by Warren 1975 revealed air change rates of 0.45-1.25 per hour in average winter weather conditions when the house windows and doors were closed. In practice the occupants of houses often find they prefer more ventilation than this minimum and they achieve it by opening the windows. Dick & Thomas 1951 observed the windows opened in twenty occupied experimental houses. They showed a linear relationship between the number of windows open and the mean outdoor temperature, fig. 1. This accounted for 70% of the observed variance in the number of windows open. A further 10% variance could be attributed to wind speed with higher wind speeds associated with smaller numbers of open windows. The houses were carefully calibrated and the air change rate was linearly linked to outdoor temperature. However these houses only contained different types of local heating and did not include central heating.

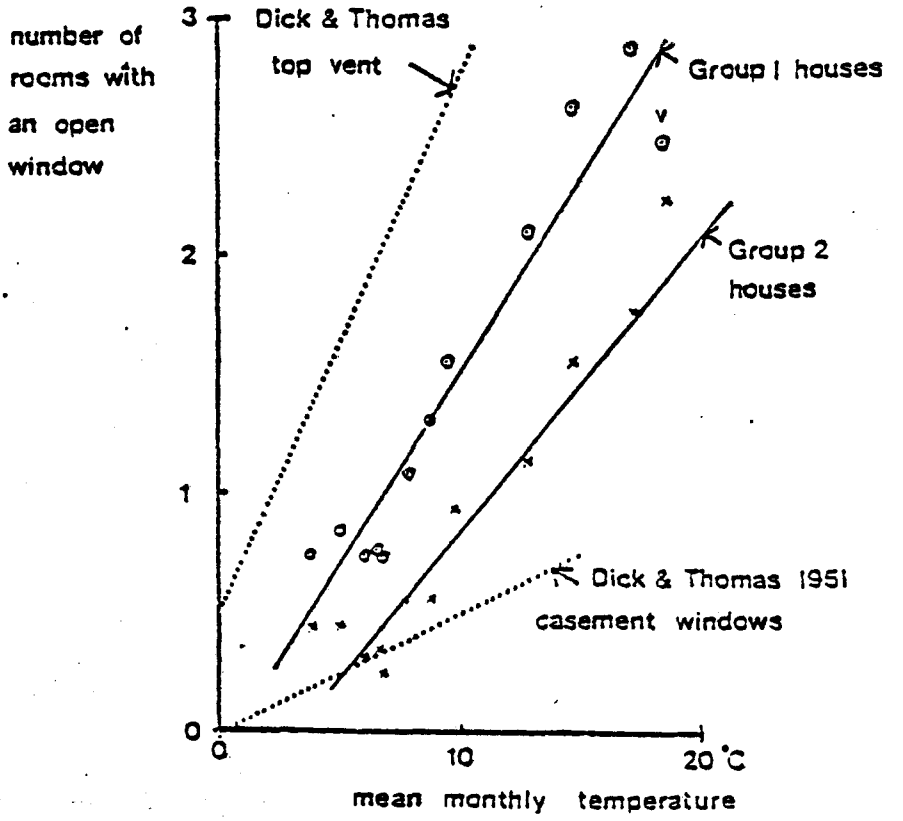



Figure 1 Relationship between open windows and temperature

Detailed field trials on modern central heating equipment were undertaken at Bromley over the 1968/1969 heating season. While no window observations were recorded, estimates of ventilation rates were made from energy balance considerations. This suggested a very similar user pattern to that of the earlier study. However a more positive identification of the modern housewife's window opening behaviour was needed. This paper describes the experiment to quantify and understand this behaviour.

## 2. OUTLINE OF SURVEY

The window opening pattern which a family adopts in a house was expected to be influenced by two major factors. One was the weather, the other was the personal characteristics of that family. To identify the key features in these two independent factors we needed three surveys. The first and most important was the regular observation of a number of houses over a long period of time. The second was the systematic recording of the weather over the same period. The third was an interview with the husband or housewife in each family. This was necessary to ascertain basic parameters such as the number and age of people in the house, and whether they smoked and to record habits such as whether they were in the house during the day or not. Finally such an interview could also elicit the person's own opinions and reasons for opening windows.

The analysis of the window opening observations was undertaken in two parts. The changes in average window opening behaviour from day to day were correlated with the weather factors. In contrast to this the differences between families were analysed in terms of their personal characteristics.

The houses in this survey were located at Connahs Quay. Two estates were chosen to represent modern housing practice. Both groups were built between four and ten years ago. The sites were adjacent to each other. Weather data was recorded at Capenhurst some six miles north east of the site. The open windows were recorded each weekday for a year from October 1974 to September 1975 in all of the houses. Observations were equally divided between mid-morning and mid-afternoon. Since the size, number and shape of the windows differed widely between houses the survey noted which rooms had an open window. For convenience this was the unit measure of open windows.

The householders were individually informed of the experiment at the start of monitoring. After six to nine months each householder was invited to give his or her views on window opening and to supply details about their family.

## 3. BACKGROUND DATA OF THE PEOPLE AND THEIR HOUSES

A high proportion of the people (82%) living in these houses were interviewed. This showed the two housing groups to contain people similar in age and family size. Both groups were predominantly in the younger part of the population with more than three quarters of them under 34 years old. There was only a small proportion of older people and none above retirement age. Social rankings for Group 1 were spread evenly, while Group 2 were weighted towards $C_2/D$. More of the Group 2 housewives went out to work.

The types of houses differed between the two Groups. Group 1 was essentially semi-detached (26) with some detached houses (15). Group 2 comprised terraced town houses (73) with some semi-detached (18) and a few detached (4). The architect's choice of windows differed between the two groups. Group 1 had a much higher proportion of smaller windows than Group 2.

These results are summarised in Table 1.

Table 1 Background data of the people and their houses

(a) Houses

| | | House Group 1 | | House Group 2 | | Total |
|---|---|---|---|---|---|---|
| | | No. | % | No. | % | |
| Type | Detached | 15* | 37 | 4* | 5 | 19 |
| | Semi-detached | 26 | 63 | 18 | 22 | 44 |
| | Town houses | 0 | 0 | 60 | 73 | 60 |
| | Total | 41 | 100 | 82 | 100 | 123 |

*four were four bedroom, all other houses were three bedroom

Table 1 Background data of the people and their houses

(b) Windows: estimated sizes and number

| Room | Group 1 | | | Group 2 | | |
|---|---|---|---|---|---|---|
| | Av. windows/room | | | Av. windows/room | | |
| | Large* | Medium* | Small* | Large | Medium | Small |
| Lounge | 0.51 | 0.49 | 0.49 | 1.0 | 0.61 | 0.16 |
| Dining room | 0.54 | 0.49 | 1.0 | 0.88 | 0.13 | 0.07 |
| Kitchen | 0 | 0.95 | 0.54 | 0.67 | 0.33 | 0.15 |
| Bedroom 1 | 0.51 | 1.34 | 0.98 | 0.84 | 0.72 | 0.13 |
| Bedroom 2 | 0.51 | 0.49 | 0.49 | 0.54 | 0.51 | 0 |
| Bedroom 3 | 0 | 1.0 | 1.0 | 0.90 | 0.74 | 0 |
| Bathroom | 0 | 1.44 | 0.98 | 0.66 | 0.34 | 0.05 |

*large is greater than $\frac{1}{3}m^2$ medium is approx. $\frac{1}{3}m^2$ small is approx. $\frac{1}{10}m^2$

(c) Family details (of those who were interviewed)

| | | House Group 1 | | House Group 2 | | Total |
|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. |
| Size of family | one | 1 | 3 | 1 | 1 | 2 |
| | two | 5 | 15 | 14 | 21 | 19 |
| | three | 8 | 24 | 18 | 26 | 26 |
| | four | 13 | 39 | 26 | 57 | 39 |
| | five | 6 | 18 | 6 | 9 | 12 |
| | six | 0 | 0 | 2 | 3 | 2 |
| | seven | 0 | 0 | 1 | 1 | 1 |
| | Total | 33 | 100 | 68 | 100 | 101 |
| Social groupings | AB | 6 | 18 | 3 | 4 | 9 |
| | C1 | 9 | 27 | 11 | 16 | 20 |
| | C2 | 12 | 36 | 25 | 37 | 37 |
| | D | 6 | 18 | 28 | 42 | 34 |
| | Total | 33 | 100 | 67 | 100 | 100 |
| Age of respondent | 16-24 yrs | 8 | 24 | 16 | 24 | 24 |
| | 25-34 yrs | 17 | 52 | 44 | 65 | 61 |
| | 35-44 yrs | 6 | 18 | 6 | 9 | 12 |
| | 45-54 yrs | 2 | 6 | 1 | 1 | 3 |
| | 55-64 yrs | 0 | 0 | 1 | 1 | 1 |
| | 65 + years | 0 | 0 | 0 | 0 | 0 |
| | Total | 33 | 100 | 68 | 100 | 101 |
| Women respondents | full time h/wife | 20 | 83 | 30 | 73 | 50 |
| | pt time employed | 3 | 12 | 3 | 7 | 6 |
| | full " " | 1 | 4 | 8 | 20 | 9 |

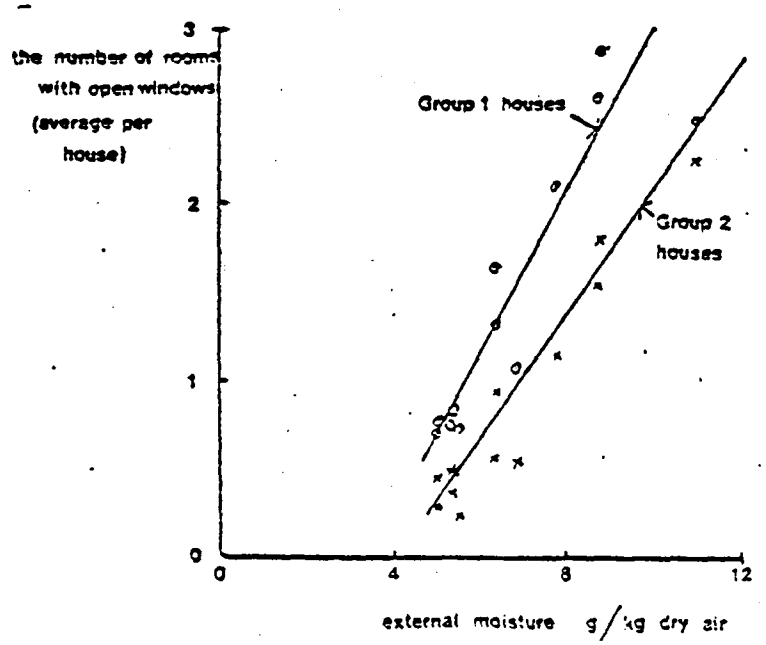
## 4. WEATHER SENSITIVITY

The observations showed a strong seasonal pattern with windows progressively closing with the approach of winter and then re-opening with the warmer weather. It was common to find open windows during the heating season, Table 2. Approximately twice as many rooms had open windows in the Group 1 houses as in the Group 2 houses.

Table 2 Monthly averages for weather and window opening. Connahs Quay 1974/75

| Month | Group 1 | Group 2 | Mean temp. $t\ ^oC$ | Av. humidity g/kg dry air | Av. temp. swing $\Delta t^oC$ | Av. wind speed m/s | Av. cloud cover overcast = 1 | Rain-fall mm |
|---|---|---|---|---|---|---|---|---|
| Oct. | 1.31 | 0.56 | 8.7 | 6.4 | 6.9 | 3.2 | 0.5 | 4 |
| Nov. | 0.71 | 0.29 | 6.0 | 5.1 | 5.2 | 4.2 | 0.5 | 5 |
| Dec. | 0.71 | 0.25 | 6.8 | 5.4 | 6.0 | 6.9 | 0.6 | 2 |
| Jan. | 0.74 | 0.33 | 6.5 | 5.3 | 6.1 | 4.7 | 0.5 | 2 |
| Feb. | 0.73 | 0.42 | 3.7 | 5.0 | 7.2 | 1.7 | 0.4 | 2 |
| Mar. | 0.82 | 0.44 | 5.0 | 5.4 | 7.5 | 5.4 | 0.5 | 2 |
| Apl. | 1.09 | 0.54 | 7.9 | 6.9 | 8.2 | 6.1 | 0.5 | 2 |
| May | 1.64 | 0.91 | 9.6 | 6.4 | 10.0 | 5.1 | 0.4 | 2 |
| June | 2.61 | 1.53 | 14.8 | 8.7 | 14.6 | 5.5 | 0.3 | 1 |
| July | 2.89 | 1.76 | 17.2 | 8.8 | 16.8 | 4.6 | 0.4 | 2 |
| Aug. | 2.49 | 2.23 | 18.5 | 11.0 | 18.7 | 5.3 | 0.3 | 2 |
| Sept. | 2.10 | 1.12 | 12.9 | 7.8 | 12.6 | 5.5 | 0.4 | 2 |

The relationship of open windows to daily mean external temperature was similar to that of Dick and Thomas 1951, fig. 1. However for Britain there is a strong link between mean daily temperature and mean daily humidity. The window opening behaviour could therefore be temperature or moisture motivated. (fig. 2)



Correlation of the window opening behaviour with winter weather showed Group 1 to be associated with mean daily temperature, then to a lesser extent daily temperature swing and to a small extent by wind speed. Group 2 was associated primarily with external moisture levels, to sunshine and wind and to a small extent to daily temperature swing. Selecting those houses where the housewife did not go out to work resulted in a similar result to those houses in Group 2, i.e. more strongly linked to moisture than temperature, Table 3.

Table 3 Winter: multiple correlation of window opening with weather (October-April inclusive: 127 days)

| Group | No. of houses | Equation for daily no. of rooms with open window/house (in order of importance) | Multiple correlation coefficient r | Statistical significance * |
|---|---|---|---|---|
| House Group 1 | 41 | constant -0.02<br>+0.1 x mean temperature ($^{o}$C)<br>+0.06 x temperature swing ($^{o}$C)<br>-0.02 x wind speed (m/s) | 0.68 | $p < 0.01$ |
| House Group 2 | 82 | constant -0.04<br>+0.09 x humidity (g/kg dry air)<br>-0.02 x cloud cover (tenths)<br>-0.1 x wind speed (m/s)<br>+0.02 x temperature swing ($^{o}$C) | 0.67 | $p < 0.01$ |
| All houses with housewife at home | 53 | constant 0.22<br>+0.16 x humidity (g/kg dry air)<br>-0.04 x cloud cover (tenths)<br>+0.04 x temperature swing ($^{o}$C) | 0.64 | $p < 0.01$ |

*F ratio test, significance of extra factor

The distribution of rooms containing open windows is shown in fig. 3. Bedrooms are the most common places for open windows. Other rooms, except kitchens, follow the same pattern though to a small magnitude. Kitchens are much less sensitive to the weather.

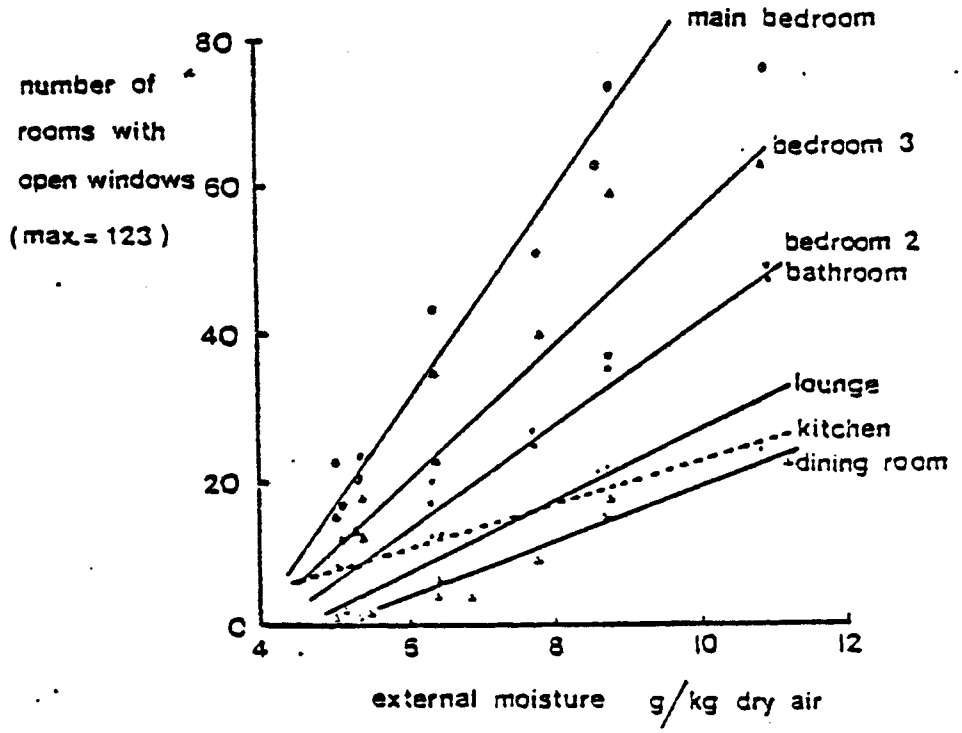



Figure 3 Which rooms have open windows

A similar analysis for the summer weather showed mean daily temperature to be the main associated factor for all three categories of Group 1, Group 2 and those houses with the housewife at home.

## 5. FAMILY FACTORS

Two important family characteristics influenced window opening behaviour. The first was whether the housewife had a job. Those housewives out at full time employment had only half the windows open of those who stayed at home.

The second characteristic was size of the family. Analysis of the habits of those housewives who stayed at home showed that the number of rooms with open windows increased with the number in the family.

These relationships are summarised in Table 4.

Table 4 Family factors: influence on rooms with open windows in winter

| Factor | Characteristic | Daily winter average of rooms with open windows |
|---|---|---|
| Employment of housewife | In full time employment (30 hrs +) | 0.36 |
| | In part time employment (8-29 hrs) | 0.71 |
| | Full time housewife (< 8 hrs paid) | 0.74 |
| Housewives at home | With two in family (sample of 2) | 0.34 |
| | With three (sample of 15) | 0.59 |
| | With four (sample of 22) | 0.60 |
| | With five (sample of 11) | 1.30 |
| | With six (sample of 2) | 1.06 |

Each family who believed windows were opened in winter was given the opportunity of saying why this may be. The distribution of these spontaneous reasons is given in Table 5.

Table 5 Spontaneous reasons for open windows in winter

| Factor | To freshen | To avoid condensation | To avoid stuffiness | To remove smoke | Too hot | Cooking smells | Air room |
|---|---|---|---|---|---|---|---|
| No. of mentions (max = 100) | 68 | 31 | 20 | 14 | 9 | 9 | 5 |

## 6. MOTIVATION

The survey has established that there is a strong association between temperature or external humidity and window opening. In the most sensitively controlled houses where the housewife is at home the major winter factor is humidity, while in summer it is mean temperature. In Britain, particularly over winter, there is a close relationship between outdoor temperature and humidity since the air is nearly always saturated, (Heap 1973). There is also a positive relationship between the number in the family and windows open.

The three most probable reasons for wanting fresh air are odour dilution, moisture control and convective cooling. Body odour dilution is a function of personal space and elapsed time between baths. An adult needs approximately 14m$^3$/h but this is independent of weather (Yaglou 1936). It would be a function of family size though Becher and Evensen 1961 found air quality in Danish flats was more related to the cleanliness and habits than fresh air supply. Body odour dilution would therefore define the minimum flow but not explain weather sensitivity.

Moisture control in buildings is generally the key factor for ventilation. Adequate ventilation will prevent condensation on the wall surfaces or windows. Dreyfus and colleagues 1958 estimated the moisture load in French dwellings to be 120-150 g/h/person on average. Loudon 1971 estimates a similar amount for British houses. Ward 1974 found ventilation problems to be particularly important in modern kitchens particularly with respect to condensation. In public sector houses 45% of the sample complained of inadequate ventilation in kitchens, with 42.5% reporting condensation troubles. Small amounts of dry air in winter may remove internally generated moisture but the quantity will have to be increased in milder weather when the outdoor moisture level is higher. Ventilation rates would also have to be higher in those houses containing bigger families. This therefore is the most likely winter motivation.

Cooling air is also a popular use for ventilation. In winter poor heating control could be compensated by personal adjustment of windows. Since overheating was only spontaneously reported by a very small proportion of the respondents then it does not appear to be a frequent occurrence. Summer cooling however would be necessary and it is likely to require a large air flow. This is reflected in the window opening behaviour being more closely linked with mean daily temperature than with humidity during summer.

Borel 1974 has already proposed a two season controlled ventilation system. Winter needs for body odour control are separated from the summer needs of cooling. Perhaps the introduction of a third element is particularly appropriate for houses, namely moisture control. The principle is outlined in fig. 4.

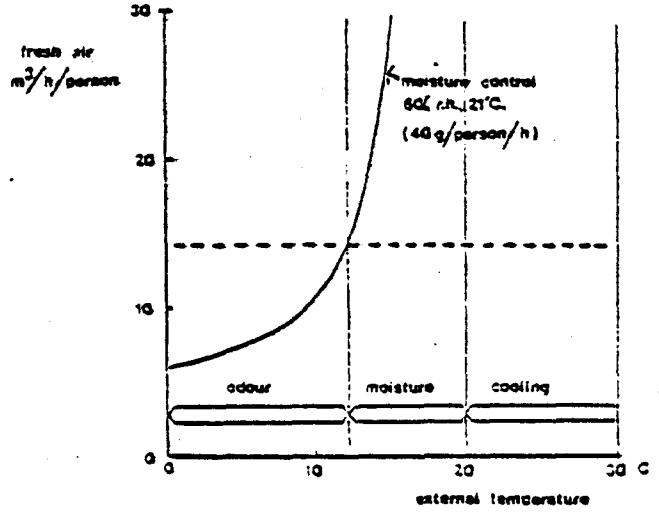



Figure 4 Proposed ventilation seasons

## 7. CONCLUSIONS

1. It is common to find open windows in Britain throughout the year. The number of open windows is strongly linked to weather with external moisture being most clearly associated in winter and mean temperature in summer.

2. The most popular rooms to have an open window are the bedrooms. The windows in other rooms are much less often open, though with the exception of the kitchen they follow similar behaviour. The kitchen windows are more often open in the coldest weather.

3. The two family factors which influence window opening behaviour are whether the housewife goes out to work and the size of family. Houses where the housewife is at home are much more likely to have an open window. Houses which contain larger families are also more likely to have an open window.

4. The energy implications of this behaviour require more research.

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## 9. ACKNOWLEDGMENTS

The success of this experiment is due to the large amount of assistance provided by many colleagues. Specifically, the weather data was generously supplied by British Nuclear Fuels Limited; the questionnaire design was drawn up with Mr. Ian Griffiths of Atkins Research and Development; the family data was skilfully collected partly through Atkins R. & D. and partly through Gordon Simmons Fieldwork Limited and the window observations were patiently made by staff of the Electricity Council Research Centre. All the computer analysis of results was obligingly done by Mr. J. Waddington of the Mathematics Section, ECRC.

Finally I must acknowledge the co-operation and tolerance of the householders involved in the project since without it the experiment could not have proceeded.