STANDARD DATA FILES

FOR COMPUTER THERMAL SIMULATION OF SOLAR LOW ENERGY NON-RESIDENTIAL BUILDINGS

Ian van der Werff
Robert Amor
Michael Donn

Energy Research Group
School of Architecture
Victoria University
Box 600
Wellington

November 2003

REPORT PREPARED AS PART OF RESEARCH CONTRACT WITH MARKET INFORMATION AND ANALYSIS GROUP MINISTRY OF COMMERCE ENERGY AND RESOURCES DIVISION

ABSTRACT

Standard data on building materials used in commercial buildings in New Zealand has been collected into computer files in a form for entry into two thermal simulation programs, DOE2.1D and SUNCODE. The materials data has been collated into descriptions of standard buildings to provide starting points for designers modelling their own buildings. As a further aid to the use of these two simulation programs in New Zealand, standard weather files have been developed for 22 locations in New Zealand and the South Pacific.

ISSN 0111-4166
ISBN 0-475-10079-4

CONTENTS

STANDARD DATA FILES

Project Objective

The objective of the research was:

"to develop two energy thermal simulation programs as design tools for New Zealand buildings."

The two simulation programs are SUNCODE [i] and DOE2.1C[ii]. They have been available for a number of years, originally on main-frame and latterly on personal computers. However, successful use of these programs has not been a simple task. They have been used primarily by researchers. Designers generally have not had the time to learn how to use the program, to find all the data required (building, weather and location) and then to model successfully the building that is to be tested.

The research is predicated on the notion of the numerate designer: the member of the design team who can manipulate mathematical models of a building in order to study its performance. As such, the results are not targetted exclusively at any particular member of the building design team. Rather, they provide the team with easy access to two programs which can simulate the energy performance of alternative design ideas at an early stage in the design process.

In order to simplify the use of these programs, and thereby assist designers to include these design tools in their design process, the tasks of this project were to:

a)Provide standard data on building materials used within New Zealand, applicable to both programs.
b)Develop standard weather files for extreme and typical design conditions in all the climate regions of New Zealand.
c)Define and provide computer models of standard building types as a starting point for designers modelling their own buildings.
d)Test all three data sets (separately and combined) for consistency and ease of use.

The architect, engineer or scientist involved in the early strategic design decisions for a building will find the files from this project of most use. This designer must still learn to operate and understand the limitations of whichever of the programs they decide to use as a design tool.

In this report an overview is presented of the data files and the principal assumptions on which they are based. Detailed Appendices delineate these assumptions and the process of data file creation. The data files are available on disk in IBM PC format.

The Building Simulation Programs

Both DOE2.1C and SUNCODE were originally written for main-frame computers, which were required to process both the large amount of calculation and the large amount of data needed by each program. Recent advances in technology have enabled both of these programs to be adapted to run on personal computers.

Both programs are accepted as state of the art in the field of building simulation, having undergone extensive validation by the International Energy Agency[iii]. They have been widely accepted by the international research and design communities.

The two programs approach the modelling of buildings in different ways. SUNCODE uses a relatively simple building model compared to DOE2.1C[iv].

Two of the main differences between the programs are:

HVAC Systems

SUNCODE assumes that an HVAC system provides what energy is needed by the building (as specified in the building input model), but does not concern itself with the details of what that system is. A services engineer or the designer must ensure that a suitable system is incorporated into the building design.

DOE2.1C provides the option of including plant and systems simulation when modelling the building. However, the base buildings have not utilised this option because the aim of this project has been to assist building designers, rather than services engineers. Adequate definition of a detailed HVAC system was not within the range of expertise of the research team because emphasis was placed on assisting those who design the building fabric to design energy effective buildings.

Location of Spaces

The SUNCODE building model does not concern itself with the precise location of rooms (zones) within the building. The SUNCODE building model is concerned with the thermal relationship that each space (zone) has with each other and with the outside wall. However, DOE2.1C requires that the precise spatial location of each space be recorded, in addition to these thermal relationships.

Both programs are able to adequately model every type of building. However, DOE2.1C is more suited to large buildings because:

a)it is more capable of modelling the HVAC services, which have a major impact on the energy performance of large buildings;

b)it is less capable of modelling the thermal storage which dominates the energy performance of small buildings.

Building Description Library

An extensive (though not exhaustive) list of building materials and component descriptions has been compiled for the library database.

The database includes:
a)individual materials (e.g. 100mm thick concrete);
b)system components comprising two or more of the materials (e.g. 100mm thick timber stud wall with insulation);
c)types of glazing (e.g. wooden or aluminium framing);
d)shape descriptions (e.g. 500mm eaves overhang);
e)weather station location data (e.g. height above sea level);
f)defined seasons (e.g. winter, spring, etc);
g)heating and ventilation regimes (e.g. heating to 20^{o}C from 7 a.m. to 6 p.m.).

All these data types are used by each program as part of the building description. The components that make up the library are described in greater detail in Appendix I.

We expect that the database will continue to grow over time, as both ourselves and other users of the programs find a need to use materials and components that have not previously been coded.

We recommend that users be encouraged to provide the supplier of the information with data about new materials they decide to code. Users of the building database should provide the supplier of that information with data about new materials they decide to code. The supplier would then be able to check the figures and to share them with other users. The International Energy Agency is undertaking a project to determine and collate data on new materials and innovative building components (e.g. transparent insulation) which will also be added to the libraries.[v]

Standard Weather Files

Site	Start of weather	End of weather
Alexandra		
Auckland, City	1961	1985
Auckland, Whenuapai	1960	1985
Campbell Island	1970	1979
Chatham Island	1970	1979
Christchurch	1960	1985
Dunedin	1962	1985
Hamilton	1978	1985
Hokitika	1961	1985
Invercargill	1960	1985
Kaikoura	1964	1985
Kaitaia	1962	1985
Nadi, Fiji	1960	1979
Nasouri, Fiji	1973	1979
Nelson	1961	1985
New Plymouth	1961	1985
Ohakea	1960	1985
Paraparaumu	1961	1985
Raoul Island	1970	1979
Rarotonga	1970	1979
Wellington, Airport	1960	1985
Wellington, Kelburn	1961	1985

The aim of this part of the project was to develop standard weather files for New Zealand sites from the raw weather files already held by the School of Architecture.

The 22 raw weather files held by the School of Architecture contain unprocessed weather information from the Meteorological office, with hourly values collected for 21 facets of the weather at the site. Most of these weather files contain data for a period of 26 years.

They contain no solar radiation data as very little was available outside the main centres until recently. The cost of obtaining up-to-date solar data precluded obtaining readings to supplement the files. The original weather files are stored in a binary format with several sites' weather data compressed onto one tape. The processed files exist in several forms, these are:

1.TRY[vi] file, used with associated CONTROL file to create BIN(ary) file for DOE simulation program.

2.BIN file, for use with DOE 2.1C on the IBM.

3.DAT file, in TMY[vii] compressed format, used with TMY2 BIN program to create BIN files for SUNCODE simulation program.

4.SASDATA file, contains all data calculated for the particular year in a SAS dataset. This is the repository of data from which all the other files can be created.

Weather File Conversion

Appendix III describes the weather file conversion process in detail. In summary, the following steps were necessary:

a)convert from binary format to processable format (ASCII) using SAS;

b)interpolate between missing data and remove "spikes";

c)check for missing data values, and put in simulated weather data at these points.

d)use SAS to pick "good" years:

i)sort and print monthly averages, highs and lows for each year;

ii)calculate monthly heating and cooling degree days for each year;

iii)determine long-term mean temperature, wind speed and cloud cover;

iv)calculate normalised temperature, wind speed and cloud cover to help in selection of particular "design weeks": hot windy, hot no wind etc.

e)create a Test Reference Year (TRY) format dataset for entry to the DOE2.1C weather processor for generation of synthetic solar data from available cloud data;

Conversion Assumptions

In order to complete these steps the following assumptions have had to be made:

a)where a particular year fitted all the TMY or TRY selection criteria yet had a large number of missing values, the next closest fit was found;

b)In some cases, ground temperatures were not recorded for some of the sites for which we had hourly data. In this case the closest location that recorded ground temperatures. For some sites, ground temperatures were only collected at 0.3 metres depth, and not the 1 metre depth we sought. In these cases the 0.3 metre values were used. For some sites, records of ground temperatures were started at a later date than some of the years data we were selecting. In these cases, later years' ground temperature data was used for the earlier years' data.

Table I Source of Ground Temperature Data

Location	Solution
Kaikoura	Used Rangiora data for all years
Nandi	Used Nandi 1974 data for 62, 65, 66, 67. 68
Nasouri	Used Nandi, Fiji data for all years
Ohakea	Used Levin data for all years
Paraparaumu	Used Levin data for all years
Raoul Island	Mixed values for 71, 73, 74 to get full monthly data for these three years
Rarotonga	Used Rarotonga 1977 data for all years

c)Some of the weather data spans only a few years. In all cases where there is less than 20 years data there is not enough data to calculate average, hot and cold years. The sites affected by this problem were Campbell Island, Chatham Island, Raoul Island, Rarotonga, Nasouri, Alexandra and Hamilton.

d)The generation of solar radiation data from the cloud cover information in the weather files was the most difficult part of the exercise, and remains the most problematical data in the output files. After consulting the literature[viii] to find a definition of clearness numbers[ix], and analysing the depth of precipitable water in the air, and comparing the results to USA data, we concluded that New Zealand clearness numbers would most likely follow the numbers found along the west coast of the USA. The only exceptions to this would be at Christchurch where the winter smog would give lower clearness numbers in winter, and at sites at high altitudes, like Alexandra or Waiouru. This gave us the following list of monthly clearness numbers for sites in New Zealand:

Table II Clearness Numbers Calculated for New Zealand

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NZ	1.03	1.02	1.00	0.98	0.97	0.95	0.97	0.98	1.00	1.02	1.03	1.05
Chch	1.02	0.98	0.95	0.92	0.88	0.85	0.88	0.92	0.95	0.98	1.02	1.05
High	1.08	1.07	1.05	1.03	1.02	1.00	1.02	1.03	1.05	1.07	1.08	1.10

e)Initial attempts at calculating values for missing data in the weather files, through the generation of sinusoidal patterns that followed the daily variations in temperature, lead us to seek a better method of calculating values for missing data. After consultation with the New Zealand Meteorological Service, [x] we developed an algorithm that calculated missing data in the following fashion. For each month of every year we created a temperature profile for that month which consisted of the hourly average temperatures for that month. This profile was scaled to the first valid value before the missing data and an increment added to each successive hour so the profile would match the first valid data after the stretch of missing data. This technique produced very realistic weather curves for periods with missing data.

The diagram in shows the relationship of all the weather data as it "flowed" through these data manipulation processes.

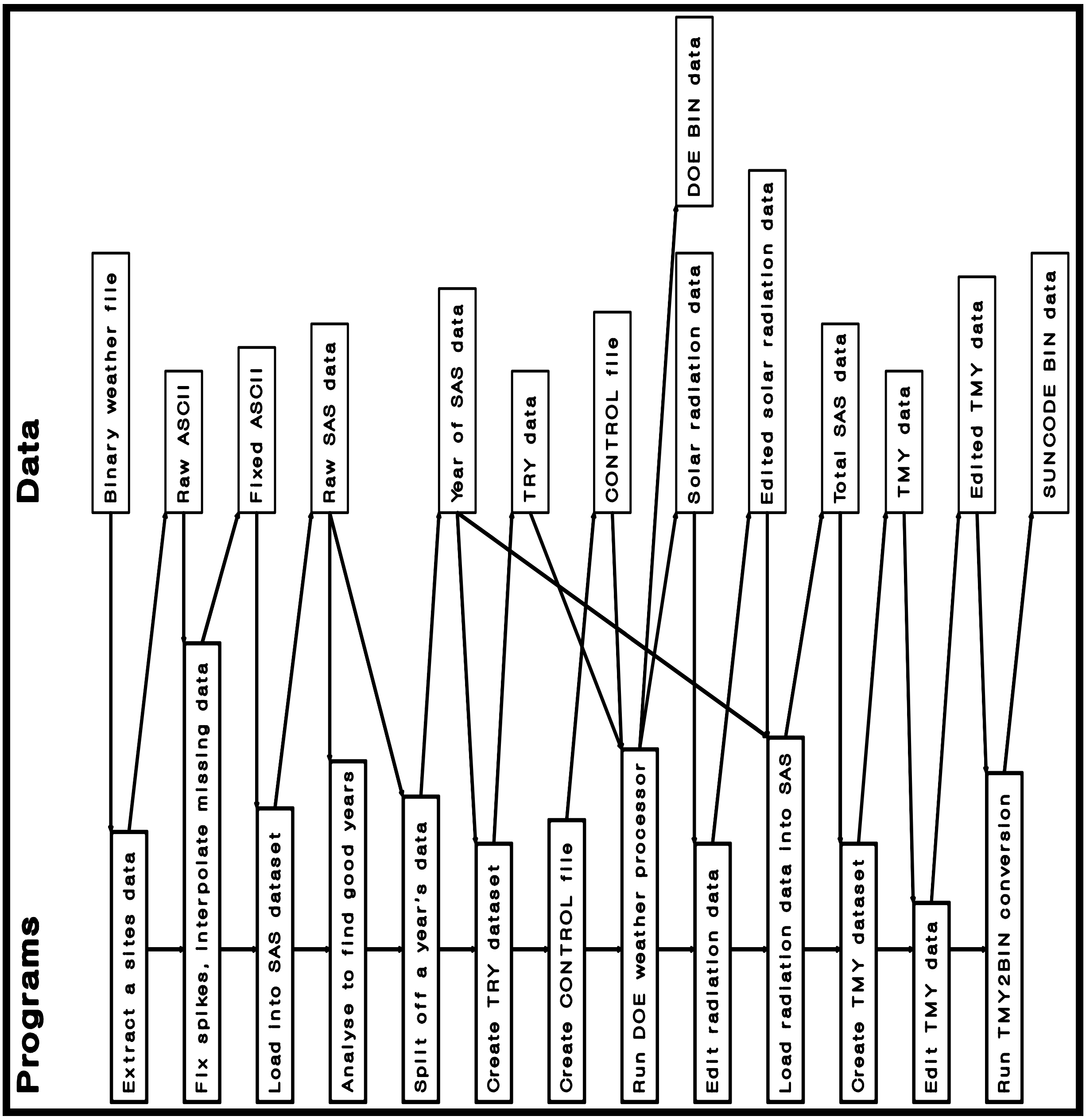

Figure 1 Weather data analysis flow chart.

Weather File Analyses

With the processed weather files, analyses were done to find years of weather data which are average. The average hot and cold years of weather data were also identified. At this stage we analysed the weather data to find weeks of weather data that met certain specific criteria:
(a)hot and windy;
(b)hot and calm;
(c)cool and windy;
(d)cool, calm and sunny;
(e)cool, calm and no sun.

The one percentile week of these types were selected and a year of weather data extracted around each of these weeks. This produced a suite of weather data files for each location which would allow a designer to test a building with average and with extreme periods of weather.

With the years of data selected, the next step required extracting the data from the weather files and formatting it in a manner acceptable to the simulation programs. The problem encountered at this point was that SUNCODE required radiation data in its weather files and none came with the raw weather data. We overcame the problem by using the weather calculation program of DOE which in the process of creating its own binary weather files, calculates radiation data. This calculated radiation data was extracted from the DOE weather files and incorporated into the data files used for the SUNCODE simulation program. The major caveat that must be placed on radiation data generated in this manner is that it relies on correlations between long-term average data and has thus not been `verified' for hour by hour data.[xi]

This has produced 8 years of weather data for each simulation program for each site along with some database files in case further work is required, a total of 16 simulation files for each site, totalling about 8 megabytes of data for each site. All this data is stored on archive tape at the School of Architecture.

Standard Model Building Descriptions

This part of the project devised a simple list of building models which was comprehensive enough to be representative of commercial building `types'.
The standard building model descriptions provide an easy method for designers to start using either simulation program. We anticipate that these standard building models will be used by the designer in the following manner:
a)initially, one of the models forms the basic building file that, when modified, becomes the actual building model to be input to the program;
b)during the performance analyses by the simulation program, the performance of the "standard" building file from the library will provide a benchmark of performance;
c)incremental changes to various model parameters allow the designer to explore the value of each parameter in the energy performance of the proposed building.

The standard descriptions also guide the designer in the best ways to model the various aspects of a building.

In order to define the basic computer models, we determined a range of different building types representative of commercial buildings in New Zealand. The types of occupation as well as the types of construction of a building are important, so they have been incorporated into each basic computer model.

The following range of building and occupation types was defined:

Building Types
a) Small shop (eg diary).
b) Small shop with house attached.
c)Small shop within a row of shops.
d)Two storey office/retail building.
e)A single floor within a multi-storey building.
f)Barn or warehouse building (eg. supermarket)

Occupation Types
a)Retail
b)Office (eg. clerical)
c) Consultancy (eg. legal, medical)
d)Public (eg. art gallery, museum)

Twelve different combinations of building type and occupation type were determined to be representative. Each building and occupation type is described in detail in Appendix II.

The combinations that have been modelled are shown in 3:

Table III Combinations of Building and Occupation Modelled

Building		Occupation		
	Retail	**Office**	**Consultancy**	**Public**
Small Shop	Yes		Yes	Yes
Shop/House	Yes		Yes	
Shop in Row	Yes		Yes	
Two Storey	All combinations combined in one model type			
Multi Storey		Yes	Yes	
Warehouse	Yes			Yes

These twelve combinations are further subdivided according to their "construction type". This was required because the varying construction types each cause a significant change in the model that is used as input for each of the computer programs. This subdivision therefore simplifies the designer's use of the base models.

In the final analysis, 27 base computer models were created for each program. These are described in detail in Appendix II.

Testing of Model Buildings

All stages of the project were tested as each stage was completed.

The data in the building construction and weather libraries was checked for inconsistencies. While we have a comprehensive collection of weather data, we expect that the building construction database will expand over time. The standard building models are less likely to change. They were also tested, and all of them were successfully compiled and run.

Summary

The project described above has shown the feasibility of the library approach to use of programs. However, another major problem with each of these programs is that the user manuals are not very "friendly". A simplified version is required to enable the designer to get his/her "feet wet", thereby gaining confidence in use of the program. They could then make reference to the existing manuals with more confidence as they progress to modelling more complex buildings. In order to fully exploit the data produced by this project, we recommend that simplified users manuals be produced for DOE2.1C and SUNCODE.

ACKNOWLEDGEMENTS

We would like to thank the following people for their help and suggestions in this project.

Dr Steve Reid Meteorological office for the algorithms for replacing missing data, and checking of our raw weather data to the real Met. office tapes.

Mark Bassett (BRANZ), Tony Isles and Brian Weston for help with radiation calculation

Craig Thompson Met. office for help with precipitable water statistics.

Silvia Nichol, Rees Basher and Stuart Burgess for help with radiation calculation.

Harry Trethowen for help with methods of generating accurate data to fill periods of missing data.

This report has been prepared using the Word Perfect Corporation's Word Perfect® software on a Commodore PC-50 "IBM® compatible" personal computer. The graphics were produced in Software Publishing's Harvard™ Graphics programme, and the SAS Institute Inc. SAS® statistical analysis software was used for much of the data processing. Final quality printing has been achieved with a Hewlett Packard Laserjet™ II laser printer in a Times Roman font.

REFERENCES

i.SUNCODE (1981) Ecotope Group, 2812 E. Madison, Seattle, WA 98112

ii .DOE2.1C (1981) Building Energy Simulation Group, Lawrence Berkeley Laboratories, University of California, Berkeley, California 94720

iii. International Energy Agency Solar Heating and Cooling Agreement Annex 8 : a cooperative research project investigating Solar Low Energy Domestic Buildings, through computer modelling and measurement. Publications available from Executive Committee. New Zealand representative: M. R. Donn, School of Architecture, P.O. Box 600, Wellington.

iv.DOE2.1C is designed to allow a very comprehensive modelling of the geometry, all the floors and the HVAC systems in a multi-storey building, while SUNCODE is specifically designed for Residential Energy Simulation, with a capacity to handle fewer zones, less complex geometry and with very little detailed system simulation.

v .Solar Energy Group (Group Q-11), Los Alamos National Laboratory, "DOE-2 "Reference Manuals", reproduced by National Technical Information Service, US Department of Commerce, Springfield, VA 22161, USA, 1981.

vi. **T**est **R**eference **Y**ear

vii. **T**est **M**eteorological **Y**ear

viii.ASHRAE Handbook (1981) Fundamentals, ASHRAE Inc.

DOE 2.1A (1982) Engineers manual, Lawrence Berkeley Laboratory.

Harkness, E. L. and Mehta, M. L. (1978) Solar Radiation Control in Buildings, Applied science publishers.

Kimura, K. and Stephenson, D. G. (1969) Solar Radiation on Cloudy Days, ASHRAE Transactions Part I, pp

227-233.

ven, H. A. (1977) A Computer File of New Zealand Climate, Building Research Association of New Zealand, Report No. 21.

Meteorological Observations for 1960-1985, Stations in New Zealand, Outlying Islands and Antarctica, New Zealand Meteorological Service, Ministry of Transport.

Parmelee, G. V. (1954) Irradiation of vertical and horizontal surfaces by diffuse solar radiation from cloudless skies, ASHRAE Transactions, pp 341-358

Threlkeld, J. L. and Jordan, R. C. (1958) Direct solar radiation available on clear days, ASHRAE Transactions, Vol. 64, pp 45-68.

ix. Clearness Numbers:
Threlkeld, J.L. and Jordan, R.C. (1958) Direct Solar Radiation Available on Clear Days, ASHRAE Transactions, Vol. 64, pp 45-68

x. Dr S. Reid: personal communication

xi.The I.E.A. Solar Heating and Cooling Implementing Agreement Executive Committee has recently initiated an international cooperative research programme, aimed at improving the availability of reliable solar data.

APPENDIX I Building Description

1. General

The building description library comprises two types of components:

a. Data sheets enumerating heat gain from various internal sources, so that the designer using this program can determine the heat gain profile for their own building.
b. Computer library files which can be used directly as input into the two computer programs.

This information will enable the designer to easily amend the standard building models so that they model the building they are designing.

2. Heat Gain from Internal Sources

The following list of sources of heat gains has been compiled so that designers can determine the heat gain profile for almost any building they design.

For examples on how to create an internal heat gain profile, see Appendix II. The chapter on Internal Gains discusses the development of the profile for the standard building models.

NOTE: ALL FIGURES ARE HOURLY
(the data on the next two pages has been extracted from the ASHRAE Handbook 1989 Fundamentals, Published by American Society of Heating Refrigeration and Air Conditioning Engineers, Atlanta, Georgia)

a. **Humans**

Man	Heavy work	0.44 kWh	1584 kJ
	Medium work	0.265 kWh	954 kJ
	Light bench work	0.255 kWh	918 kJ
	Walking slowly	0.235 kWh	846 kJ
	Light work	0.14 kWh	504 kJ
	Seated at rest	0.115 kWh	414 kJ
Woman	Heavy work	0.375 kWh	1350 kJ
	Medium work	0.225 kWh	810 kJ
	Light bench work	0.2 kWh	720 kJ
	Walking slowly	0.135 kWh	486 kJ
	Light work	0.12 kWh	432 kJ
	Seated at rest	0.1 kWh	360 kJ
Child	Running	0.33 kWh	1188 kJ
	Walking	0.22 kWh	792 kJ
	Standing	0.175 kWh	630 kJ
	Sitting	0.085 kWh	306 kJ

b. **Animals**

Mouse	0.0008kWh	2.9 kJ
Rat	0.0049kWh	17.6 kJ
Rabbit	0.011 kWh	39.6 kJ
Cat	0.014 kWh	50.4 kJ
Monkey	0.038 kWh	136.8 kJ
Dog	0.053 kWh	190.8 kJ
Goat	0.083 kWh	298.8 kJ
Sheep	0.11 kWh	396.0 kJ
Pig	0.423 kWh	1522.8 kJ

c. **Mechanical Devices**

Photocopier	Small	1.5 kWh	5400 kJ
	Large	3.5 kWh	12600 kJ
Blueprint machine		1.15-12.5 kWh	4140-45000 kJ
Computer	Microcomputer/ Word processor	0.09-0.53 kWh	324-1908 kJ
	Minicomputer	2.2-6.6 kWh	7920-23760 kJ
	Disk Drive	1.0-6.6 kWh	3600-23760 kJ
	Tape Drive	1.0-4.7 kWh	3600-16920 kJ
	Terminal	0.08-0.18 kWh	288-648 kJ
Printer	Laser	0.3 kWh	1080 kJ
	1000 lpm	1.15 kWh	4140 kJ
	750 lpm	1.15 kWh	4140 kJ
	430 lpm	1.0 kWh	3600 kJ
	300 lpm	0.45 kWh	1620 kJ
Typewriter	Electric	0.05 kWh	180 kJ
	Electronic	0.1 kWh	360 kJ

d. **Electrical Appliances**

Refrigerator/m3	0.031 kWh	112 kJ
Freezer/m3	0.54 kWh	1944 kJ
Refrigerated display case/m3	0.64 kWh	2304 kJ
Frying vat/kg fat	0.1 kWh	360 kJ
Pie warmer (infrared)/bulb	0.25 kWh	720 kJ
Dishwasher/100 dishes/hour	0.17 kWh	612 kJ
Microwave oven	0.4 kWh	1440 kJ
Oven/m3	1.6 kWh	5400 kJ
Stove top/2 burners	0.78 kWh	2808 kJ

e. **Gas Appliances**

Frying vat/kg fat	0.04 kWh	144 kJ
Dishwasher/100 dishes/hour	0.21 kWh	756 kJ
Oven/m3	2.6 kWh	9360 kJ
Stove top/2 burners	1.93 kWh	6948 kJ

f. **Lighting**

Incandescent	300lx	0.05-0.06 kWh/m2	180-216 kJ/m2
Fluorescent	300lx	0.008-0.02 kWh/m2	29-72 kJ/m2
	500lx	0.015-0.035 kWh/m2	54-126 kJ/m2
	750lx	0.02-0.05 kWh/m2	72-180 kJ/m2
Mercury	300lx	0.007-0.014 kWh/m2	25-50 kJ/m2
	500lx	0.013-0.025 kWh/m2	47-90 kJ/m2
	750lx	0.018-0.035 kWh/m2	65-126 kJ/m2
Sodium	300lx	0.004-0.008 kWh/m2	14-29 kJ/m2
	500lx	0.007-0.014 kWh/m2	25-50 kJ/m2

750lx		0.01-0.02 kWh/m2	36-72 kJ/m2
Neon sign per metre	0.03	kWh	108 kJ

3. Computer Library Files

Their are two sets of computer library files, one for each of the programs SUNCODE and DOE2.1C. All descriptions of specific files or data that might be given in this section refer to the SUNCODE library files. The exact format of the DOE2.1C library files has not been finalised, but the information will be similar to that for SUNCODE - the differences will be program specific.

The are currently twelve library files for SUNCODE:

GL.LIB = Glazing type definitions
HV.LIB = Heating regime definitions
MT.LIB =Mass types (used by WT.LIB to create wall types)
OV.LIB = Overhang definitions
PCM.LIB =Phase change materials (not used in any of the standard models)
SC1.LIB =Schedule definitions (part 1)
SC2.LIB =Schedule definitions (part 2)
SC3.LIB =Schedule definitions (part 3)
SE.LIB =Season definitions
SI.LIB =Sidefin definitions (not used in any of the standard models)
ST.LIB =Weather station definitions
WT.LIB =Wall type definitions

It is expected that the data in these files will be added to over time. As the size of each file passes its limit, it will be split (as had already occurred with the schedule file).

APPENDIX II Standard Model Buildings

1.Standard Computer Models

The 27 standard computer models produced by this project are identified below. The key represents the file name by which each model is known.

Single Zone Building
SZTIMB-R =single zone, timber floor, retail
SZTIMB-C =single zone, timber floor, consultancy
SZTIMB-P =single zone, timber floor public
SZCONC-R =single zone, concrete floor, retail
SZCONC-C =single zone, conc floor, consultancy
SZCONC-P =single zone, concrete floor, public

Multi Zone Building
MZTIMB-R =multi zone, timber floor, retail
MZTIMB-C =multi zone, timber floor, consultancy
MZCONC-R =multi zone, concrete floor, retail
MZCONC-C =multi zone, concrete floor, consultancy

Space within a Row of Shops
RSTIMB-R =Shop in a Row of Shops, timber walls, retail
RSTIMB-C =Shop in a Row of Shops, timber walls, consultancy
RSCONC-R =Shop in a Row of Shops, concrete walls, retail
RSCONC-C =Shop in a Row of Shops, concrete walls, consultancy

Two Storey Building
TSTIMB =lightweight timber framed exterior walls
TSCONC =concrete block exterior walls
TSGLAZ =glazed curtain exterior walling

Storey within a Multi Storey Building
MSTIMB-C =Lightweight timber walls, consultancy
MSTIMB-O =Lightweight timber walls, office
MSCONC-C =Pre-cast concrete walls, consultancy
MSCONC-O =pre-cast concrete walls, office
MSGLAZ-C =Glazed curtain walls, consultancy
MSGLAZ-O =Glazed curtain walls, office

Barn or Warehouse Building
BNTIMB-R =lightweight timber walls, retail
BNTIMB-P =lightweight timber walls, public
BNCONC-R =concrete block walls, retail
BNCONC-P =concrete block walls, public

The following sections describe the various components of each standard building, from the building and occupancy types through to the insulation, internal gains and heating regime.

2.Building Type Descriptions

We defined the following range of building types as being representative of commercial buildings:

a.Single Zone Building (Small shop)

The single zone building is a simple, small rectangular box. There is only the one zone within this building. It could typically be the corner dairy, a small architectural or legal office, or the local potter's selling outlet/gallery.

b.Multi Zone Building (Small shop with house attached)

The multi zone building is also a simple rectangular box. However, it is larger than the single zone building, as the retail outlet or consultant's office is at one end of the building, but the residence occupies the remainder of the building (about two-thirds). The house is one zone, whilst the business premises forms the other zone.

c.Space within a Row of Shops

The row of shops is seen in a large number of residential zones throughout New Zealand. This base building will enable you to model the thermal characteristics of one of these shops where it is between two other shops.

The shop is a simple rectangular box. It is modelled as one zone. We assume that the shop on either side of the one that is being modelled has the same temperature profile, and therefore do not model the connecting walls (see "Miscellaneous").

If you wish to model the shop at either end of the row, then you will have to add the end wall (and surface definition) onto the base building definition.

The DOE2 base buildings model the complete row of shops. There are 3 shops in the model.

d.Two Storey Building

There are a large number of two or three storey commercial buildings throughout the country.

This building is a simple rectangular box. Each floor is modelled as a separate zone. There is also a third zone (the lobby), which is two storeys high.

The two storey building structure is generally reinforced concrete beams, columns and slabs.

e.Storey within a Multi Storey Building

This base building file models a single floor in a multi storey building (not the top or bottom floor). The floor is a simple rectangular open office, with a central core.

As the open plan office is so large, we break it into five smaller zones: north, east, south, west and central (which surrounds the core). A small air barrier resistance is modelled between these zones. We assume that the floors above and below the one that is being modelled have the same temperature profile, and therefore do not model the connecting floors (see "Miscellaneous").

The core is modelled as a 15m high space. We assume that this will generally be cooler than the other zones, and it is included in an attempt to create a cooler space that will draw some of the heat out of the office floor.

The DOE2 base buildings model every floor of the building (6 floors).

f.Barn or Warehouse Building

This building type is a large rectangular barn (the main zone). Connected to this zone are three other zones: the lobby, the administration area, and the storage area. The administration and storage areas are next to each other.

3.Occupancy Categories

We defined the following range of occupation types as being representative of commercial buildings:

a.Retail

This use category is fairly self-explanatory, covering dairies, clothing shops and the like.

b.Office

The office use category is defined as a setting where the employees are involved in clerical type work, ie 90% of their day involves sitting at a desk.

c.Consultancy

The consultancy category is a situation where the employees are not primarily sitting around desks, but are often involved in meetings with clients, visits to sites (or for other reasons).

The types of occupations that we have in mind for this category are: architects, lawyers, doctors, real estate agents, etc.

d.Public

The public use category is a situation with a high volume of visitors, such as an art gallery or museum.

4.Construction

There are twelve combinations of building versus occupation types which are further subdivided according to their "construction type". This is required because the varying construction types each cause a significant change in the model that is used as input for each of the computer programs.

a.Floor

Every base building type models a 100mm concrete slab on ground (uninsulated). The exception is the multistorey building, which does not model a floor at all (see the section "Building Type Descriptions").

The single and multi zone building types also model a suspended timber floor (insulated with aluminium foil).

b.Walls

There are a number of different types of wall modelled as options by the base building types. In addition to these, there are a few other types which remain constant within each building type.

1) **Light Weight Timber Frame**

Every building type models this type of wall. It is the only wall modelled in the single and multi zone building types, and is one of the options for the other four building types.

It consists of 100mm studs, with a 10mm gibboard interior lining and a 20mm plaster board exterior lining.

Within all of the buildings, all interior walls between zones are also timber framed (exceptions: wall between central and core zones of multi storey building; some glazing in barn building).

2) **Concrete Block**

This wall type is modelled as an option by the row of shops, two storey and barn building types.

It consists of 200mm concrete blocks, reinforced and grouted. The wall surfaces are painted. Where there is a large window in the wall, a timber framed wall is used for the the lintel and above.

3) **Precast Concrete Panel**

This wall type is modelled as an option by the multi storey building type.

The precast panels are 100mm thick, and extended above and below the floor slabs, forming both sill and head to all the windows.

4) **Glazed Curtain Walling**

This wall type is modelled as an option by the two storey and multi storey building types.

It consists of aluminium framed glazing outside the structure. It is modelled as a window, not a wall.

5) **Suspended Floor Slab**

This `wall type' is modelled within the two storey building, to separate the two floors.

It consists of a 200mm concrete slab, with a ceiling suspended below it - resulting in an air layer between these two surfaces. The models assume a zero thickness for this wall.

6) **Air and Partition Layer**

This `wall type' is modelled within the multi storey building type, to break the large, open floor into smaller pockets (related to orientation).

The partitions are not full height, but we use them, and an unspecified thickness of air to try and model the effect of different parts of the floor having different hvac requirements.

We assume that the air and partition barrier resistance is R=0.3 Km^2/W. This wall is modelled as INTERZONE, not WALLS, so divide the area of the `wall' by this resistance to determine the conductance.

7) **Concrete Wall**

This wall type is modelled between the central and core zones of the multi storey building type.

It is a 200mm thick reinforced concrete wall.

8) **Glazing**

This wall type is modelled as some of the internal walls in the barn building type.

It is 3mm clear float glass, framed in aluminium.

c.<u>Windows</u>

The windows in the single zone, multi zone and row of shops building types are all wooden frame with 3mm single clear float glass.

The windows in the timber and concrete block wall options of the two storey building type are also all wooden frame with 3mm single clear float glass.

The windows in the two-storey glazed curtain wall options and in the multi-storey and barn buildings are all aluminium frame with 6mm single clear float glass.

d.Roof

All roofs are light timber framed, with corrugated or long-run steel cladding.

The roofs for the single and multi zone building types have an angle of 15 degrees. The other building types all have flat roofs (<2 degrees).

The single and multi zone and two storey building types all have a ceiling and trapped air layer. The row of shops and barn do not.

NOTE:The multi storey building does not have a `roof', as there is assumed to be zero net heat transfer with the floor above.

5.Insulation

Only the single zone and multi zone buildings are insulated. These are the domestic scale buildings. All the larger buildings (and the row of shops) have no insulation at all.

The two domestic scale buildings have 100mm fibreglass insulation in both the walls and the roof. When the floor is timber, they have draped aluminium foil insulation. When the floor is concrete, they have no insulation.

6.Infiltration

The infiltration rates were initially calculated using Mark Bassett's[1] graphical method. This method has been developed from measurements of air infiltration rates within residential buildings. All calculations assumed that the building was in infiltration zone A (eg Wellington) and in a medium sheltered area.

This method works well with single and multi zoned buildings. As expected for the larger buildings, the calculated infiltration rate was not realistic. In these instances, an infiltration rate of 0.1 was assumed.

Determination of Infiltration Rate

Bassett's method requires the user to calculate both the volume of the building and the 'joint length' of the building. These two figures are used as input to a graph (along with the infiltration zone and wind exposure), the output being the infiltration rate.

The joint length of the building is the sum of the length of all floor-wall, wall-wall & wall-ceiling joints.

The infiltration rate calculations are shown below:

Single Zone Building
joint length = 69.6m, volume = 134.4 m3

==> infil = 0.5 ACh

Multi Zone Building
joint length = 83.6m, volume = 211.2 m3

[1] Bassett, M. "Air Infiltration and The Shape of Houses", Proceedings of the 19th Conference of the Australia and New Zealand Architectural Science Association, University of Auckland, School of Architecture, 1986.

==> infil = 0.4 ACh

Space within a Row of Shops
joint length = 44.0m, volume = 162.0 m3

==> infil = 0.3 ACh

The joint length here is smaller than might be expected, as we have not the floor-wall joints of the side walls. These joints connect to the neighbouring shops, hence there will be no infiltration, as we assume that these are the same temperature.

Two Storey Building
joint length = 220.4m, volume = 3060 m3

infiltration estimated at 0.1 ACh

Lobby:As the external doors to the lobby are likely to kept kept open for a substantial part of the day, its infiltration rate will be modelled as 1.0 ACh during opening hours.

Storey in a Multi Storey Building
Estimate an infiltration rate of 0.1 ACh for all the zones - the central zone receives this from the core. Alternative methods exist for commercial buildings and are documented in the ASHRAE[2] and CIBS[3] handbook.

Barn or Warehouse Building
Estimate an infiltration rate of 0.1 ACh for all the zones.

7. Miscellaneous

This section describes various assumptions made when producing the standard model buildings.

a.Single Zone Building & Multi Zone Building

The buildings have 500mm wide eaves on every side.

All solar gain through the windows is assumed to be absorbed by the air node, not by any material masses.

b.Space within a Row of Shops

The east and west walls each have a neighbouring shop on the other side of them. We assume that these shops have a similar internal temperature profile as the one that is being modelled. Because of this, we do not model either of the two side walls, assuming that there is a net heat flow through these walls.

All solar gain through the windows is assumed to be absorbed by the air node, not by any material masses.

c.Two Storey Building

For the purposes of modelling the external surfaces, we assume that both the intermediate slab-ceiling and

[2] ASHRAE HANDBOOK OF FUNDAMENTALS (1989)
American Society of Heating Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

[3] CIBSE Guide (1986)
Chartered Institution of Building Services Engineers, London.

roof-ceiling have a thickness of zero. This means that the height of the external surfaces is 5.1, the sum of the two floor-ceiling heights.

We have not modelled either of the two voids mentioned above as a separate zone. It would be more accurate to model the trapped air layer as a separate zone, but this would generate more information for the user to try and interpret, and would also increase the number of parameters that have to be used within the building input file - possibly over the allowable limit. It is also much simpler to model the building as we have done, making it easier for users to massage our base building to their own requirements.

All solar gain through the windows is assumed to be absorbed by the air node, not by any material masses.

d. Storey within a Multi Storey Building

The floor and ceiling each have a neighbouring storey on the other side of them. We assume that these storeys have a similar internal temperature profile as the one that is being modelled. Because of this, we do not model either the floor or ceiling, assuming that there is a net heat flow through these surfaces.

All solar gain through the windows is assumed to be absorbed by the air node, not by any material masses.

e. Barn or Warehouse Building

All solar gain through the windows is assumed to be absorbed by the air node, not by any material masses.

8. Internal Gains

Buildings are generally heated by three different source types. These are: the sun; heating appliances or systems; and internal gains from people and equipment within the building.

We have assumed that all buildings receive heat from internal gains, and detail those sources of heat in the following sub-sections.

Note that the programs allow us to vary the amount of heat gain at various times of the day. This is known as "scheduling" when the heat is input into the building.

a. Retail

1) **Single Zone Building** (eg. dairy)

Operates for 13 hours a day, from 7am to 8pm.

Assume 1 man serving whole day (doing light work) = 0.14 kWh. Customers:
- -peak hours (7am-8am & 5pm-7pm) assume an average of 1 man (walking slowly) = 0.24 kWh
- -off-peak hours assume an average of 0.1 men (walking slowly) = 0.03 kWh.

The lighting will be on all during opening hours, fluorescent @ 300 lux (0.01 kWh per m2) x 56m2 = 0.56 kWh.

A pie warmer on all day = 0.25 kWh. A refrigerated display case (0.64 kWh per m3) @ 3m3 on for 24 hours = 1.92 kWh. A freezer on for 24 hours = 0.54 kWh.

Therefore, the internal gain schedule for the year is:

1	2.46	<==>	1	2.46
8	3.65	?	8	3.55
9	3.44		21	2.46
18	3.65			
20	3.44			

21	2.46			

2) **Multi Zone Building** (eg. dairy)

Operates for 13 hours a day, from 7am to 8pm.

Assume 1 man serving whole day (doing light work) = 0.14 kWh. Customers:
-peak hours (7am-8am & 5pm-7pm) assume an average of 1 man (walking slowly) = 0.24 kWh
-off-peak hours assume an average of 0.1 men (walking slowly) = 0.03 kWh.

The lighting will be on all during opening hours, fluorescent @ 300 lux (0.01 kWh per m2) x 40m2 = 0.40 kWh.

A pie warmer on all day = 0.25 kWh. A refrigerated display case (0.64 kWh per m3) @ 3m3 on for 24 hours = 1.92 kWh. A freezer on for 24 hours = 0.54 kWh.

Therefore, the internal gain schedule for the year is:

1	2.46	<==>	1	2.46
8	3.49	?	8	3.39
9	3.28		21	2.46
18	3.49			
20	3.28			
21	2.46			

3) **Space within a Row of Shops** (eg clothing shop)

Operates for 8 hours a day, from 9am to 5pm.

Assume 2 employees, each with a half-hour's break before 12 or after 2. Therefore:

9-11	=	0.26 KWh
11-12	=	0.20
12-2	=	0.26
2-3	=	0.20
3-5	=	0.26

Customers:-peak hours (12-2pm) assume an average of 2 people (walking slowly) = 0.37 KWh.
-off-peak hours assume an average of 0.2 men (walking slowly) = 0.05.

The lighting will be on all during opening hours, fluorescent @ 500 lux (0.02 kWh per m2) x 60m2 = 1.2 kWh.

Therefore, the internal gain schedule for the year is:

1	0	<==>	10	1.48
10	1.51	?	13	1.83
12	1.45		15	1.48
13	1.83		18	0
15	1.45			
16	1.51			
18	0			

4) **Two Storey Building** (eg. furniture showroom)

Operates for 8 hours a day, from 9am to 5pm.

Assume 4 employees, each with half-hour breaks between 12 and 2. The activity will be a mixture of walking slowly and seated at rest - 2 male, 2 female. Therefore:

9-12 = 0.59 KWh
12-2 = 0.44
2-5 = 0.59

Customers:-peak hours (12-2pm) assume an average of 3 people (walking slowly) = 0.56 KWh.
-off-peak hours assume an average of 0.5 men (walking slowly) = 0.12.

The lighting will be on all during opening hours, fluorescent @ 500 lux (0.02 kWh per m2) x 576m2 = 11.52 kWh.

Therefore, the internal gain schedule for the year is:

1	0		<==>	1	0
10	12.21	?		10	12.21
13	12.08			18	0
15	12.21				
18	0				

5)**Barn or Warehouse Building** (eg. supermarket) - Main Zone:

Operates for 11 hours a day, from 9am to 8pm.

Assume 28 employees at peak times and half this number at off-peak times:
12 on checkout (6 lightwork, 6 mediumwork)
10 stocking shelves (medium work)
6 on duty-security, managers, etc (walking)
As there is a lot of casual labour, we will ignore reduced numbers for morning teas, etc. Assume equal number male-female. Therefore:
9-12 = 2.90 KWh
12-2 = 5.81
2-5 = 2.90
5-8 = 5.81
8-9 = 2.90

Customers: The peak hours are 12-2 & 5-8. Assume 120 people (32.6 KWh) at peak hours (male-female-child) and 60 people (16.3) at other times, all walking slowly.

The lighting will be on from 9am to 9pm (0.03 KWh-m2 x 12975 m2 = 389 KWh).

6 cash registers will be operating 9am to 8pm (@ 0.2 KWh) = 1.2 KWh. There will be various refrigeration units operating 24 hours a day - say 20m3 open fridge cases at 0.64 KWh-m3 = 12.8 KWh

Therefore, the internal gain schedule for the Main zone is:

1	12.8	<==>	1	12.8
10	432.2		10	436.8
13	441.4		21	405.9
15	432.3		22	12.8
18	441.4			
21	405.9			
22	12.8			

b. <u>Office</u>

1) **Two Storey Building** (eg. data entry firm)

Operates 9 hours a day, from 8am to 5pm. Assume 20 employees, each with an hour's break between 12 and 2. 10 male and 10 female, doing light work. Therefore:

8-12 = 2.60 KWh
12-2 = 1.30
2-5 = 2.60

This is a no customer situation. The occasional client may come in, but the effects and frequency of this would be negligible.

The lighting will be on during operating hours - fluorescent @ 300 lux (0.01 KWh per m2 x 576m2) = 5.76 KWh. Each work station will have its own task lighting (100W bulb) = 2 KWh.

There will be 20 wordprocessors being used (@ 0.3KWh) = 6KWh. We will assume that there are two laser printer (@ 0.3KWh = 0.6KWh).

Therefore, the internal gain schedule for the year is:

1	0	<==>	9	16.96
9	16.96		13	15.66
13	15.66		15	16.96
15	16.96		18	0
18	0			

2)**Storey in a Multi Storey Building** (eg government department)

Operates 9 hours a day, from 8am to 5pm. Assume 150 employees, each with an hour's break between 12 and 2. Equal mix of male-female, doing light work. Therefore:

8-12 = 19.5 KWh
12-2 = 9.8 KWh
2-5 = 19.5 KWh

Assume that there is an average of 1 visitor every hour, doing light work = 0.13 KWh.

The lighting will be on all during operating hours - fluorescent @ 500lux (0.025 KWh-m2 x 2464m2 = 61.6 KWh.

There will be 20 wordprocessors-computers (@ 0.3KWh) = 6KWh. We will assume that there are two laser printers (@ 0.3 KWh) = 0.6KWh. There is one photocopier = 2.0 KWh

Therefore the internal gain schedule for the whole floor for the year is:

1	0
9	89.8
13	80.1
15	89.8
18	0

The internal gain schedule for each of the outer zones is (area proportion):

1	0
9	19.1
13	17.1
15	19.1
18	0

The internal gain schedule for the central zone is (area proportion):

1	0
9	13.3
13	11.9
15	13.3

18	0

c. Consultancy

1) **Single Zone Building** (eg. architect)

Operates for 9 hours a day, from 9am to 6pm.

The office will have 3 people working there - 2 professionals and 1 administration. On average, there will be 2.5 of them in the office between 9am-12pm and 2pm-5pm. There will be 1.5 of them in the office between 12pm-2pm. There will be 1.0 of them in the office from 5pm-6pm. Therefore: 9-12 = 0.3 kWh
12-2 = 0.18 kWh
2-5 = 0.3 kWh
5-6 = 0.13 kWh.

Visitors would be irregular - say 0.1 man per hour from 9-12 and 2-5 = 0.01 kWh.

The lighting will be on all during opening hours - fluorescent @ 500 lux (0.02 kWh per m2) x 56m2 = 1.12 kWh.

Equipment operating during opening hours would include: small photocopier (1.5), 2 micro computers (0.3), laser printer (0.3) = 2.4 kWh.

Therefore, the internal gain schedule for the year is:

1	0		<==>	1	0
10	3.83	?		10	3.75
13	3.70			18	3.65
15	3.83			19	0
18	3.65				
19	0				

2) **Multi Zone Building** (eg. architect)

Operates for 9 hours a day, from 9am to 6pm.

The office will have 2 people working there - 1 professional and 1 administration. On average, there will be 1.7 of them in the office between 9am-12pm and 2pm-5pm. There will be 1.0 of them in the office between 12pm-2pm. There will be 1.0 of them in the office from 5pm-6pm. Therefore:
9-12 = 0.2 kWh
12-2 = 0.13 kWh
2-5 = 0.2 kWh
5-6 = 0.13 kWh.

Visitors would be irregular - say 0.1 man per hour from 9-12 and 2-5 = 0.01 kWh.

The lighting will be on all during opening hours - fluorescent @ 500 lux (0.02 kWh per m2) x 40m2 = 0.80 kWh.

Equipment operating during opening hours would include: small photocopier (1.5), 2 micro computers (0.3), laser printer (0.3) = 2.4 kWh.

Therefore, the internal gain schedule for the year is:

1	0		<==>	1	0
10	3.41	?		10	3.38

13	3.34		19	0
15	3.41			
18	3.34			
19	0			

3) **Space within a Row of Shops** (eg real estate agent)

Operates for 10 hours a day, from 8am to 6pm.

Assume 4 employees. 1 is a receptionist, 3 are agents. The receptionist has an hour off from 1-2pm. The 3 agents are all there half of the time (on the road the other half). All counts as light work. Therefore:

8-1	=	0.32 KWh
1-2	=	0.20
2-6	=	0.32

Customers: There will be a reasonable flow of people through the building, but not many will hang about for a long time - out on the road with the agents. Say 0.5 people there each hour (seated at rest) = 0.05 KWh.

The lighting will be on all during opening hours - fluorescent @ 500 lux (0.02 kWh per m2) x 60m2 = 1.2 kWh.

Equipment operating during open hours would include: small photocopier (1.5), 6 microcomputers (@ 0.2 ea.), printer (0.45).

Therefore, the internal gain schedule for the year is:

1	0		<==>	1	0
9	4.72	?		9	4.66
14	4.60			19	0
15	4.72				
19	0				

4) **Two Storey Building** (eg medical centre)

Operates for 10 hours a day, from 8am to 6pm.

Assume 1 receptionist, four doctors, three nurses. The doctors main activity will be light work, while the nurses and receptionist's activities will be walking slowly\light bench work. Assume 2 male, 2 female doctors & 3 female, 1 male for the others. Each will get half an hour's lunch between 12-2. Therefore:

8-12	=	1.28 KWh
12-2	=	0.96
2-6	=	1.28

Customers: Assume an average of 8 people (seated at rest) = 0.86 KWh, and 2 children (sitting at play) = 0.2 KWh

The lighting will be on all during opening hours - fluorescent @ 500 lux (0.02 kWh per m2) x 576m2 = 11.52 kWh.

Various equipment will be operating during opening hours - assume a value of 1.0 KWh.

Therefore, the internal gain schedule for the year is:

1	0		<==>	1	0
9	14.86	?		9	14.70

13	14.54	19	0
15	14.86		
19	0		

5) **Storey in a Multi Storey Building** (eg. legal firm)

Operates 10 hours a day, from 8am to 6pm.

Assume 100 employees, each with an hour's break between 12 and 2. Equal mix of male-female, doing light work. Therefore:

8-12 = 13.0 KWh
12-2 = 6.5 KWh
2-5 = 13.0 KWh

Assume that there is an average of 5 visitors every hour, doing light work = 0.65 KWh.

The lighting will be on all during operating hours - fluorescent @ 500lux (0.025 KWh-m2 x 2464m2 = 61.6 KWh.

There will be 40 wordprocessors-computers (@ 0.3KWh) = 12KWh. We will assume that there are three laser printers (@ 0.3 KWh) = 0.9KWh. There are three photocopiers = 6.0 KWh

Therefore the internal gain schedule for the whole floor for the year is:

1	0
9	94.2
13	87.7
15	94.2
19	0

The internal gain schedule for each of the outer zones is (area proportion):

1	0
9	20.1
13	18.7
15	20.1
19	0

The internal gain schedule for the central zone is (area proportion):

1	0
9	13.9
13	12.9
15	13.9
19	0

d. Public

1) **Single Zone Building** (eg. small gallery)

Operates for 8 hours a day, from 9am to 5pm.

Assume 1 man serving whole day (doing light work) = 0.14 kWh.

Customers:-peak hours (12pm-3pm) assume an average of 3 visitors (walking slowly) - 1 man, woman and child = 0.59 kWh.
-Off-peak hours assume an average of 0.2 men (walking slowly) = 0.05 kWh.

The lighting will be on all during opening hours, fluorescent @ 500 lux (0.02 kWh per m2) x 56m2 = 1.12 kWh.

Therefore, the internal gain schedule for the year is:

1	0
10	1.31
13	1.85
16	1.31
18	0

2) **Two Storey Building** (eg. larger art gallery)

Operates for 9 hours a day, from 9am to 6pm.

Assume 2 employees, each with half-hour breaks between 1 and 2. The activity will be a mixture of walking slowly and seated at rest - 1 male, 1 female. Therefore:

9-1	=	0.29 KWh
1-2	=	0.15
2-6	=	0.29

Customers:-peak hours (12-2pm and 4-6pm) assume an average of 8 people (walking slowly) = 1.48 KWh.
-off-peak hours assume an average of 1 men (walking slowly) = 0.24.

The lighting will be on all during opening hours, fluorescent @ 500 lux (0.02 kWh per m2) x 576m2 = 11.52 kWh.

Therefore, the internal gain schedule for the year is:

1	0		<==>	1	0
10	12.05	?		10	12.05
13	13.29			13	13.22
14	13.15			15	12.05
15	12.05			17	13.29
17	13.29			19	0
19	0				

3)**Barn or Warehouse Building** (eg. large gallery or museum) -Main Zone

Operates for 9 hours a day, from 9am to 6pm.

Assume 8 employees, walking slowly or doing light work. Assume equal number male-female. Therefore:

9-6	=	1.26 KWh

Customers: The peak hours are from 12-2 & 4-6. Assume 30 people (8.75) at peak hours (male-female-child) and 10 people (2.92) at other times, all walking slowly.

The lighting will be on from 9am to 6pm (0.02 KWh-m2 x 12975 m2 = 260 KWh).

Therefore, the internal gain schedule for the Main zone is:

1	0	<==>	1	0
10	264.2		10	267
13	270.0		19	0
15	264.2			
17	270.0			
19	0			

e. <u>House Zone</u> - **Multi Zone Building**

Assume that the household consists of two adults and two children. For this zone, we use the same internal gain profile as that used by Leslie in his SUSTEP CLIMDATA runs:

1	0.4 KWh
8	2.0
9	0.15
17	4.0
19	1.0
24	0.4

f. Lobby Zone

1) **Two Storey Building & Barn or Warehouse Building**

The only internal gains will be from the lighting (@ 0.025 KWh-m2 x 24 m2 = 0.6 KWh). This value is negligible, therefore, the internal gain schedule for the lobby is:

1	0

g. Admin Zone - **Barn or Warehouse Building**

(Supermarket)

Assume 5 employees working from 9am to 5pm, light work = 0.65 KWh.

Lighting will be on from 9am to 8pm (@ 0.025 KWh-m2 x 300 m2 = 7.5 KWh).

There will be four computers or electronic typewriters @ 0.1 KWh = 0.4 KWh.

Therefore, the internal gain schedule for the Admin zone is:

1	0
10	8.55
18	7.5
21	0

(Gallery or Museum)

Assume 2 employees working from 9am to 6pm, light work = 0.26 KWh.

Lighting will be on from 9am to 6pm (@ 0.025 KWh-m2 x 300 m2 = 7.5 KWh).

There will be two computers or electronic typewriters @ 0.1 KWh = 0.2 KWh.

Therefore, the internal gain schedule for the Admin zone is:

1	0
10	7.96
19	0

h. Store Zone - **Barn or Warehouse Building**

(Supermarket)

Lighting will be one from 9am to 9pm, (@ 0.014 KWh-m2 x 1050 m2 = 14.7 KWh).

There will probably be some refrigerated storage, say 10m3 in fridge @ 0.03 = 0.3 KWh and say 10m3 in freezer @ 0.54 = 5.4 KWh.

Therefore, the internal gain schedule for the Store zone is:

1	5.7
10	20.4
22	5.7

(Gallery or Museum)

Lighting will be on only irregularly, only as required, so assume none.

Therefore, the internal gain schedule for the Store zone is:

1	0

9.<u>HVAC Regime</u>

Every building has been modelled with a heating regime. This regime is detailed below in each sub-section.

All of these models assume that the door is kept closed when it is cold outside, and is only opened when ventilation (for cooling) is required.

If a person doing their own modelling wants to model a door that is open all during opening hours, then the infiltration rate will have to be scheduled. The night value will be as indicated in the infiltration section above, and the day value will be between 2.0 and 5.0, depending upon the microclimate around the building. SUNCODE is not able to model the door being closed in only the worst weather. In this situation, it would be advisable to model an adequate amount of heating being available, in order to determine what level of heating would be required.

a. <u>Retail</u>

1) **Single Zone Building** & **Multi Zone Building** (eg. dairy)

The door will often be left open within this building, so the proprietor will accept a lower temperature than is normal in a domestic situation.

The heating level is set at 16C, with a capacity of 2KW (1 heater). The ventilation level is set at 22C, with an adequate capacity. There is no cooling. The hvac 'system' operates between the hours of 7am - 8pm.

2) **Space within a Row of Shops** (eg clothing shop)

The heating level is set at 22C, with a capacity of 5KW. The ventilation level is set at 28C, with an adequate capacity. There is no cooling. The hvac 'system' operates between the hours of 9am - 5pm.

3) **Two Storey Building** (eg. furniture showroom)

The heating level is set at 20C, with a capacity of 10KW. The ventilation level is set at 24C, with an adequate capacity. A mechanical heating & ventilation system will probably be required, although this does not effect the SUNCODE model. There is no cooling. The hvac system operates between the hours of 9am - 5pm.

4) **Barn or Warehouse Building** (eg. supermarket)

There is no heating. The ventilation level is set at 24C, with an adequate capacity. A mechanical ventilation system will probably be required, although this does not effect the SUNCODE model. There is no cooling. The hvac system operates between the hours of 9am - 8pm.

b. <u>Office</u>

1) **Two Storey Building** (eg. data entry firm)

The heating level is set at 22C, with a capacity of 20KW. The ventilation level is set at 26C, with an adequate capacity. A mechanical heating & ventilation system will probably be required, although this does not effect the SUNCODE model. There is no cooling. The hvac system operates between the hours of 8am - 5pm.

Some of the workstations might have their own fans, to aid in air movement. This can be ignored by the SUNCODE model.

2)**Storey in a Multi Storey Building** (eg government department)

The heating level is set at 20C, with an adequate capacity. The ventilation level is set at 24C, with an adequate capacity. A ducted mechanical heating & ventilation system will be required, although this does not effect the SUNCODE model. There is no requirement to model cooling, as the adequate ventilation specification will handle all required cooling. The hvac system operates between the hours of 8am -5pm.

c. Consultancy

1)**Single Zone Building** & **Multi Zone Building** (eg. architect)

The heating and venting levels for these occupations will be similar to the living zone of a house.

The heating level is set at 20C, with a capacity of 6KW (3 heaters). The ventilation level is set at 26C, with an adequate capacity (windows). There is no cooling. The hvac 'system' operates between the hours of 9am - 6pm.

2) **Space within a Row of Shops** (eg real estate agent)

The heating level is set at 20C, with a capacity of 5KW. The ventilation level is set at 26C, with an adequate capacity. There is no cooling. The hvac 'system' operates between the hours of 8am - 6pm.

3) **Two Storey Building**

The heating level is set at 22C, with a capacity of 20KW. The ventilation level is set at 26C, with an adequate capacity. A mechanical heating & ventilation system will probably be required, although this does not effect the SUNCODE model. There is no cooling. The hvac system operates between the hours of 8am - 6pm.

Some of the rooms might have their own fans, to aid in air movement. This can be ignored by the SUNCODE model.

4) **Storey in a Multi Storey Building**

The heating level is set at 20C, with an adequate capacity. The ventilation level is set at 24C, with an adequate capacity. A ducted mechanical heating & ventilation system will be required, although this does not effect the SUNCODE model. There is no requirement to model cooling, as the adequate ventilation specification will handle all required cooling. The hvac system operates between the hours of 8am -6pm.

d. Public

Assume that the hvac is for the benefit of the human occupants, not the exhibits.

1) **Single Zone Building** (eg. small gallery)

The heating level is set at 20C, with a capacity of 6KW. The ventilation level is set at 26C, with an adequate capacity. There is no cooling. The hvac 'system' operates between the hours of 9am - 5pm.

2) **Two Storey Building** (eg. larger art gallery)

The heating level is set at 20C, with a capacity of 10KW. The ventilation level is set at 24C, with an adequate capacity. A mechanical heating & ventilation system will probably be required, although this does not effect the SUNCODE model. There is no cooling. The hvac system operates between the hours of 8am - 6pm.

3)**Barn or Warehouse Building** (eg. large gallery or museum)

The heating level is set at 18C, with an adequate capacity. The ventilation level is set at 24C, with an adequate capacity. A mechanical heating & ventilation system will probably be required, although this does not effect the SUNCODE model. There is no cooling. The hvac system operates between the hours of 9am - 6pm.

e. House Zone - **Multi Zone Building**

The heating level is set at 18C, with an adequate capacity. The ventilation level is set at 26C, with an adequate capacity. There is no cooling. The hvac 'system' operates between the hours of 7am - 11pm.

f. Lobby Zone

1) **Two Storey Building** & **Barn or Warehouse Building**

There is no hvac within the lobby.

g. Admin Zone - **Barn or Warehouse Building**

The heating level is set at 20C, with an adequate capacity. The ventilation level is set at 26C, with an adequate capacity. There is no cooling. The hvac 'system' operates between the hours of 9am - 5pm.

h. Store Zone - **Barn or Warehouse Building**

There is no heating or venting within the store.

However (for the supermarket only), it is continuously cooled to keep the temperatures below 15C, with an adequate capacity.

10.Building Dimensions

a.Single Zone Building

Zone - Shop
Dimensions: 8m x 7m x 2.4m
Window Area
North: 5.1 x 1.5 = 7.65
East: 2.5 x 1.0 = 2.5

South: 1.0 x 1.0 = 1.0
West: 2.5 x 1.0 = 2.5

Wall Area

North: (8m) = 11.55
East: (7m) = 14.3
South: (8m) = 18.2
West: (7m) = 14.3
Roof: = 56.0
Floor: = 56.0

b.Multi Zone Building

Zone 1 - shop

Dimensions: 8m x 5m x 2.4m

Window Area

North: 5.1 x 1.5 = 7.65
East: 1.8 x 1.0 = 1.8
South: no window - interior wall to zone 2
West: 1.8 x 1.0 = 1.8

Wall Area

North: (8m) = 11.55
East: (5m) = 10.2
South: = 19.2 (interior wall to zone 2)
West: (5m) = 10.2
Roof: = 40.0
Floor: = 40.0

Zone 2 - house

Dimensions: 8m x 11m x 2.4m

Window Area

North: no window - interior wall to zone 1
East: 6.1 x 1.3 = 7.93
South: 3.8 x 1.0 = 3.8
West: 6.1 x 1.3 = 7.93

Wall Area

North: = 19.2 (interior wall to zone 1)
East: (11m) = 18.47
South: (8m) = 15.4
West: (11m) = 18.47
Roof: = 88.0
Floor: = 88.0

c.Space within a Row of Shops

Zone - Shop

Dimensions: 10m x 6m x 2.7m

Window Area:

North: 5.3 x 2.0 = 10.6
East: no window
South: 1.0 x 0.8 = 0.8
West: no window

Wall Area:

North: (6m) = 5.6

East: common wall with neighbouring shop
South: (6m) = 15.4
West: common wall with neighbouring shop
Roof: = 60.0
Floor: = 60.0

d. Two Storey Building

Building in General
Area: 30m x 20m
Ground floor height: 2.7m floor-ceiling
First floor height: 2.4m floor-ceiling

The building has three zones: ground, first and lobby. The lobby is two levels in height, and its floor area is 6m x 4m.

Zone 1 - Ground floor
Dimensions: 30m x 20m (less 6m x 4m lobby) x 2.7m
Window Area
Lightweight timber framing option
North: 19.2 x 1.5 = 28.8
East: 16.0 x 1.5 = 24.0
South: 24.0 x 1.5 = 36.0
West: 16.0 x 1.5 = 24.0
Concrete block exterior walls option
North: 19.2 x 1.0 = 19.2
East: 16.0 x 1.0 = 16.0
South: 24.0 x 1.0 = 24.0
West: 16.0 x 1.0 = 16.0
Glazed curtain walling option
North: 24.0 x 2.7 = 64.8
East: 20.0 x 2.7 = 54.0
South: 30.0 x 2.7 = 81.0
West: 20.0 x 2.7 = 54.0
Wall Area
Lightweight timber framing option
North: (24m) = 36.0
East: (20m) = 30.0
South: (30m) = 45.0
West: (20m) = 30.0
To Lobby (14m) = 37.8
Roof: = 576.0 - connects to zone 2
Floor: = 576.0
Concrete block exterior walls option
North: (24m) = 45.6 (13.4 is timber - above window)
East: (20m) = 38.0 (11.2 is timber)
South: (30m) = 57.0 (16.8 is timber)
West: (20m) = 38.0 (11.2 is timber)
To Lobby (14m) = 37.8
Roof: = 576.0 - connects to zone 2
Floor: = 576.0
Glazed curtain walling option
North: (24m) = 0.0
East: (20m) = 0.0
South: (30m) = 0.0
West: (20m) = 0.0

To Lobby (14m) = 37.8
Roof: = 576.0 - connects to zone 2
Floor: = 576.0

Zone 2 - First floor
Dimensions: 30m x 20m (less 6m x 4m lobby) x 2.4m
Window Area

Lightweight timber walls option
North: 19.2 x 1.0 = 19.2
East: 16.0 x 1.0 = 16.0
South: 24.0 x 1.0 = 24.0
West: 16.0 x 1.0 = 16.0

Concrete block exterior walls option
North: 19.2 x 1.0 = 19.2
East: 16.0 x 1.0 = 16.0
South: 24.0 x 1.0 = 24.0
West: 16.0 x 1.0 = 16.0

Glazed curtain walling option
North: 24.0 x 2.4 = 57.6
East: 20.0 x 2.4 = 48.0
South: 30.0 x 2.4 = 72.0
West: 20.0 x 2.4 = 48.0

Wall Area

Lightweight timber walls option
North: (24m) = 38.4
East: (20m) = 32.0
South: (30m) = 48.0
West: (20m) = 32.0
To Lobby (14m) = 33.6
Roof: = 576.0
Floor: = 576.0 - connects to zone 1

Concrete block exterior walls option
North: (24m) = 38.4 (7.7 is timber - above window)
East: (20m) = 32.0 (6.4 is timber)
South: (30m) = 48.0 (9.6 is timber)
West: (20m) = 32.0 (6.4 is timber)
To Lobby (14m) = 33.6
Roof: = 576.0
Floor: = 576.0 - connects to zone 1

Glazed curtain walling option
North: (24m) = 0.0
East: (20m) = 0.0
South: (30m) = 0.0
West: (20m) = 0.0
To Lobby (14m) = 33.6
Roof: = 576.0
Floor: = 576.0 - connects to zone 1

Zone 3 - Lobby
Dimensions: 6m x 4m x 5.1m
Window Area

Lightweight timber frame & concrete block options
North: 4.0 x 4.7 = 18.8

Glazing curtain walling option
North: 6.0 x 5.1 = 30.6

Wall Area

Lightweight timber frame option

North: (6m) = 11.8
To Zone 1 (14m) = 37.8
To Zone 2 (14m) = 33.6
Roof: = 24.0
Floor: = 24.0

Concrete block exterior walls option
North: (6m) = 11.8 (1.6 is timber - above window)
To Zone 1 (14m) = 37.8
To Zone 2 (14m) = 33.6
Roof: = 24.0
Floor: = 24.0
Glazing curtain walling option
North: (6m) = 0.0
To Zone 1 (14m) = 37.8
To Zone 2 (14m) = 33.6
Roof: = 24.0
Floor: = 24.0

e. Storey within a Multi Storey Building

Building in General
Area: 50m x 50m (less the core of 6m x 6m) = 2464 m2.
Ceiling height: 2.7m - to underside of suspended ceiling

The building has five zones: north, east, south, west and central. We have also modelled a sixth zone (core), which will act as a heat sink to the central zone.

The central zone is 20m x 20m (less the 6x6 core). Each of the other 4 zones is an isosceles trapezium, 15m across.

These zones are not separated by full height partitions. Instead, we are merely modelling them as being separated by an air mass and low partitions. Therefore, the central zone is not merely the circulation area around the core - it also includes the inner desks not near the windows.

The air (and partition) barrier resistances have been modelled assuming a resistance of R=0.3 K.m2/W. This is divided into the area of the barrier between each zone to find the conductance coefficient (W-C) between each zone.

Zone 1 (, 2, 3 & 4) - North (, East, South & West)
Dimensions: 35m (av) x 15m x 2.7m
Window Area
Lightweight timber framing and precast concrete options
North: 45.0 x 1.2 = 54.0
Glazed curtain walling option
North: 50.0 x 2.7 = 121.5

Wall Area
Lightweight timber framing and precast concrete options
North: (50m) = 81.0
To East : (21.2m) = 57.3 (air & part.)
To Central: (30m) = 81.0 (air & part.)
To West : (21.2m) = 57.3 (air & part.)
To Floor Above - 0 net heat flow, therefore don't model
To Floor Below - 0 net heat flow, therefore don't model
Glazed curtain walling option
North: (50m) = 00.0

To East : (21.2m) = 57.3 (air & part.)
To Central: (30m) = 81.0 (air & part.)
To West : (21.2m) = 57.3 (air & part.)
To Floor Above - 0 net heat flow, therefore don't model
To Floor Below - 0 net heat flow, therefore don't model

Zone 5 - Central
Dimensions: 20m x 20m (less 6x6) x 2.7m
Window Area: none
Wall Area
To North: (20m) = 81.0 (air & part.)
To East : (20m) = 57.3 (air & part.)
To South: (20m) = 81.0 (air & part.)
To West : (20m) = 57.3 (air & part.)
To Core : (24m) = 64.8 (conc wall)
To Floor Above - 0 net heat flow, therefore don't model
To Floor Below - 0 net heat flow, therefore don't model

Zone 6 - Core
Dimensions: 6m x 6m x 15m high
Window Area: none
Wall Area
To Central: (24m) = 64.8
To Roof: = 36.0
To Ground: = 36.0

f. Barn or Warehouse Building

Building in General
Area : 100m x 80m
Height : 4.0m (floor - ceiling)

This building has 4 zones:
shopping-public zone;
administration zone;
storage zone;
lobby zone.

The lobby is attached to the main area. The administration area is attached to the store and main area. The store is attached to the main area.

The lobby is in the north west corner, and is 5mx5m. The administration area and store are at the south of the building - administration on the west. Administration is 15m x 10m, Store is 15m x 70m.

Zone 1 - Main area
Dimensions: 85m x 80m (less 5m x 5m lobby) x 4.0m
Window Area - (the 0.5 high windows are at ceiling level)
North: 75.0 x (2.0 + 0.5) = 187.5
East: 85.0 x 0.5 = 42.5
South: no windows
West: 80.0 x 0.5 = 40.0
Wall Area
North: (75m) = 112.5 (always timber)
East: (85m) = 297.5 (depends on option)
South: - no exterior wall
West: (80m) = 280.0 (depends on option)
To Lobby (10m) = 40.0 (glazing)

To Admin (10m) = 40.0 (timber, 6.0 glazed)
To Store (70m) = 280.0 (timber)
Roof: = 6775.0
Floor: = 6775.0

Zone 2 - Lobby area
Dimensions: 5m x 5m x 4.0m
Window Area - (0.5 windows are high level)
North: 5.0 x (2.0 + 0.5) = 12.5
East: no windows
South: no windows
West: 5.0 x (2.0 + 0.5) = 12.5
Wall Area
North: (5m) = 7.5 (timber)
East: - no exterior wall
South: - no exterior wall
West: (5m) = 7.5 (timber)
To Main (10m) = 40.0 (glazing)
Roof: = 25.0
Floor: = 25.0

Zone 3 - Admin area
Dimensions: 10m x 15m x 4.0m
Window Area - (0.5 windows are high level)
North: no windows
East: no windows
South: 6.0 x 1.0 = 6.0
West: 9.0 x 1.0 = 9.0

Wall Area
North: - no exterior wall
East: - no exterior wall
South: (10m) = 34.0 (varies)
West: (15m) = 51.0 (varies)
To Main (10m) = 40.0 (timber, 6.0 glazed)
To Store (15m) = 60.0 (timber)
Roof: = 150.0
Floor: = 150.0

Zone 4 - Store area
Dimensions: 70m x 10m x 4.0m
Window Area
North: no windows
East: no windows
South: no windows
West: no windows
Wall Area
North: - no exterior wall
East: (15m) = 60.0 (varies)
South: (70m) = 280.0 (varies)
West: - no exterior wall
To Admin (15m) = 60.0 (timber)
To Main (70m) = 280.0 (timber)
Roof: = 1050.0
Floor: = 1050.0

APPENDIX III WEATHER PROCESSING

1.Weather files and sites

a.The original weather files are stored in a binary format with three or more sites weather compressed into one file

b.Each record in the binary weather file is an array of 13 binary halfwords. Where the items in the array are :-

1)Station number

2)Year * 100 + month

3)Day * 100 + hour

4)Cloud cover * 100 + horizontal visibility

a)Cloud cover has a value between 0 and 9, where the value 0 to 8 indicates n eighths of the sky covered with cloud, 9 indicates that the sky is obscured or the value can not be determined. A value of 100 indicates missing data.

b)Horizontal visibility takes a value between 0 and 99, with the following coding

Code	Visibility distance
00	Less than 100 meters
01-50	(Code * 100) meters ie 100 meters to 5 km
51-55	Not used
56-80	(Code - 50) km ie 6km to 30 km
81-88	(Code * 5 - 370) km ie 35 km to 70 km
89	Greater than 70 km
99	Missing data

5)Wind speed * 100 + wind direction

a)Wind speed is the mean speed of the wind over the preceding 10 minutes in knots, a value of 200 indicates missing data

b)Wind direction is given as the true direction from which the wind is blowing, given in 10's of degrees. A value of 36 indicates due north, a value of 0 indicates calm, a value of 99 indicates variable direction, a value of 89 indicates missing data.

6)Past weather * 100 + present weather

a)If both past weather and present weather have a value of zero it indicates a missing value for both items.

b)Past weather over the last hour has the following values

Code	Meaning
0	Cloud covering half or less of the sky
1	Cloud covering more than half of the sky for part of the period and half or less during part of the period.
2	Cloud covering more than half of the sky
3	Duststorm, sandstorm or blowing snow
4	Fog, ice fog or thick haze
5	Drizzle
6	Rain
7	Snow, or rain and snow mixed
8	Shower(s)
9	Thunderstorm with or without precipitation

c)Present weather takes values in the range 0 to 99 as follows

Code	Meaning
0-19	No precipitation, Fog, Ice fog or thunderstorm
20-29	Precipitation, Fog, Ice fog or thunderstorm
30-39	Duststorm, Sandstorm, Drifting or blowing snow
40-49	Fog or ice fog at time of observation
50-59	Drizzle
60-69	Rain
70-79	Solid precipitation not in showers
80-90	Showery precipitations
91-99	Current or recent thunderstorm with precipitation at time of observation

7)Cloud group 1, Amount of individual cloud * 1000 + type of cloud * 100 + height of cloud.

a)Amount of individual cloud is coded in the same manner as cloud cover.

b)If type of cloud has a value of 9 and height of cloud has a value of 99 then they are both missing.

c)type of cloud has the following coding

Code	Meaning
0	Cirrus
1	Cirrocumulus
2	Cirrostratus
3	Altocumulus
4	Altostratus
5	Nimbostratus
6	Stratocumulus
7	Stratus
8	Cumulus
9	Cumulonimbus

Height of cloud takes the following codes

CodeFeet
0Less than 100
1-50Code * 100
56-80Code - 50 * 1000
81-88Code - 80 * 5000 + 30,000
89Over 70,000
99Missing

8)Cloud group 2, same as cloud group 1

a)Cloud group 3, same as cloud group 1

b)Dry bulb temperature * 100 + wet bulb temperature

c)Dry bulb temperature in degrees Celsius, a value of 99 indicates missing data, a negative value is indicated by adding 50 to the absolute value.

d)Wet bulb temperature is recorded in the same manner as dry bulb temperature

e)Relative humidity * 100 + dewpoint temperature

f)Relative humidity as a percentage in the range 2 to 100, a value of 0 indicates missing data.

g)Dewpoint temperature is recorded in the same manner as dry bulb temperature

9)MSL pressure

a)MSL pressure is measured in millibars and tenths and takes values from 09300 to 10500, a value of 0 indicates missing data.

10)Rainfall

a)Hourly rainfall is recorded in tenths of a millimetre, a value of -1 indicates missing data.

c.The stations grouped together in this binary format are:-

TapeStationStat. #StartEndUsed
30Hamilton1727885Y
Alexandra8307885Y
31Nasouri6837379Y
Christchurch airport 7806085Y
Rarotonga8437079Y
Invercargill 8446085Y
32Hokitika6146185Y
Kaikoura6776485Y
Nadi6806079Y
33Kelburn4346185Y
Wellington4366085Y
Nelson5456185Y
34Taiere8826162Y
Dunedin8906285Y
Campbell Islands9447079Y
Chatham Islands9867079Y

Raoul Islands9977079Y
35New Plymouth3086185Y
Ohakea4016085Y
Paraparaumu4176185Y
36Kaitaia Aerodrome0116285Y
Kaitaia Observatory0128585
Whenuapai1126085Y
Auckland1156185Y

2.Processing weather data files

a.Binary format -> ASCII for processing

This step involves breaking off one stations weather data from the binary file, all the Attributes or each record are split into individual attributes by the appropriate division, and the data is rewritten in a fixed length ASCII format file for some preliminary processing before analysis (WERDUMP1 SAS)

b.Interpolating some missing data and fixing spikes

c.Load fixed file to SAS dataset

This step involves loading the processed ASCII file into a SAS dataset for further processing and analysis. Attributes that are to be analysed have their missing value codes changed to the SAS missing value code ie to a '.' (WELOAD1 SAS)

d.Analyse a site's dataset to pick good years. This involves running four programs on the dataset.

1)Find the monthly averages for each year, as well as monthly highs and lows for each year, sort them and print (WEMOD6 SAS).

2)Calculate heating and cooling degree day values for each month of the year. The heating degree day base is set at 20 degrees celsius, and the cooling base at 24 degrees celsius. Sort values and print (WEMOD8 SAS).

3)Find the mean dry bulb temp, wind speed and cloud cover over all data for a site, this is for the normalising step to follow (WEMOD14 SAS).

4)Calculate normalised temperature, wind speed and cloud cover to help select weeks of selected data, namely to find hot windy, hot no wind, cold windy, cold no wind sunny and cold no wind no sun weeks (WEMOD15 SAS).

e.Split off a selected years weather data into a separate SAS dataset. This program changes all the missing values to SAS type missing value code ie '.' (WEMOD3 SAS)

f.Create a TRY dataset to run through DOE for radiation information. This requires extensive modification of the values of data in the dataset, and writing of a file in a very specific FORTRAN style (WEMOD4A SAS).

For leap years the program will not output the data for the 29th of February, as none of the simulation programs are set up to work over leap years so expect all files to have only 365 days data in them.

1)TRY file checking, check the number of records in the TRY file that is produced, if there are more than 8760 records then the WEMOD4A program found errors in the raw data which are flagged in the TRY file, search for the keyword 'ERROR' to find the description and position of the error in the input file. Modify the data in the SAS dataset, and re-run the WEMOD4A SAS program.

2)Attribute translations for TRY file

The following attributes have been modified from their values in the NZ Met. service code to a code recognisable in the TRY format

Present Weather is translated as follows

FromTo
1-30
43
5-62
7-99
10-121
130
15-160
175
180
196
20-227
238
24-257
26-278
281
295
30-359
36-398
40-491
50-697
70-798
80-847
85-908
91-995

Cloud type is translated as follows

FromTo
08
1-29
37
4-56
63
72
84
95

3)TRY file format

Posit. Attribute

1-5Station number, a unique number to represent each station. Usually a WBAN number, but occasionally a WMC or other number system. Must be a number between 1001 and 98999.

6-8Dry bulb temperature. In whole degrees Fahrenheit. ranges from -80 to 140 degrees Fahrenheit, or 999 if missing

9-11Wet bulb temperature, like dry bulb temperature.

12-14Dew point temperature, like dry bulb temperature.

15-17Wind direction, direction from which wind is blowing in whole degrees. Ranges from 1 to 360, a value of 0 indicates calm, and 999 indicates missing data.

18-20Wind speed, in whole knots, ranges from 1 to 230, a value of 0 indicates calm and 999 indicates missing data.

21-24Station pressure, in inches and hundredths of Hg. Ranges from 1900 to 3999 (ie 19.00 to 39.99 in Hg), and 9999 indicates missing data.

25-25 Weather, type of weather at time of observation

Code Weather
0 No weather or obstructions to vision
1 Fog
2 Haze
3 Smoke
4 Haze and smoke
5 Thunderstorm
6 Tornado
7 Liquid precipitation (rain, rain showers, freezing rain, drizzle, freezing drizzle).
8 Frozen precipitation (snow, snow showers, snow pellets, snow grains, sleet, ice pellets, hail).
9 Blowing dust, blowing sand, blowing spray, dust.

Where a combination of these types of weather may occur in a single hour, the following priorities were assigned: code 7 then code 8 then codes 1, 2, 3, 4, 9 then code 5 then code 6.

26-27 Total sky cover, in tenths. Ranges from 0 to 10, and 99 indicates missing data.
28-29 Amount of lowest cloud cover, as for total sky cover.
30-30 Type of lowest cloud or obscuring phenomena, with codes:

Code Cloud type
0 Clear
1 Fog or other obstructing phenomena
2 Stratus or Fractus Stratus
3 Stratocumulus
4 Cumulus or Cumulus Fractus
5 Cumulonimbus or Mammatus
6 Altostratus or Nimbostratus
7 Altocumulus
8 Cirrus
9 Cirrostratus or Cirrocumulus
9 Unknown if the amount of cloud is 99

31-33 Height of base of lowest cloud, in hundreds of feet, ranges from 0 to 760, a value of 777 indicates unlimited - clear, a value of 888 indicates Cirroform clouds of unknown height, and a value of 999 indicates missing data.
34-35 Amount of second cloud layer, like amount of lowest cloud layer
36-36 Type of cloud, second layer, like type of lowest cloud or obscuring phenomena
37-39 Height of base of second layer, like height of base of lowest layer.
40-41 Summation of first two layers of cloud amount.
42-43 Amount of third cloud layer, like amount of lowest cloud layer.
44-44 Type of cloud, third layer, like type of lowest cloud or obscuring phenomena.
45-47 Height of base of third layer, like height of base of lowest layer.
48-49 Summation of first three layers of cloud amount.
50-51 Amount of fourth cloud layer, like amount of lowest cloud layer.
52-52 Type of cloud, fourth layer, like type of lowest cloud or obscuring phenomena.
53-55 Height of base of fourth layer, like height of base of lowest layer.
56-59 Solar radiation, total solar radiation in Langleys to tenths. Values are for the hour ending at the time of the hour field. Ranges from 0 to 1999 (ie 0 to 199.9 Langleys), and a value of 9999 indicates missing data.
60-69 Blank fields reserved for future use.
70-73 Year of the data, ranges from 1948 to 1980 (but have used up to 1985 with no errors indicated).
74-75 Month of the year, 1=Jan, 2=Feb etc.
76-77 Day of the month, ranges from 1 to 31.
78-79 Hour of the day in local standard time, ranges from 0 to 23.
80-80 Blank field reserved for future use.

g. Run DOE weather processor on TRY data file.

This step creates the BIN files of weather data to be used with the DOE simulation program. To run the processor requires

1)WESOLAR CONTROL file must be edited to contain the correct information for the particular site and year. Format of this file is as follows:

Line 1
The word PACK in columns 1-4
Line 2
The station name in columns 1-20
Line 3
ColumnUse
1-6The word TRYKS
7-12The weather station number
13-18The year of the weather data (use -999)
19-24The time zone (-12)
25-30Latitude (eg -39.0)
31-36Longitude (eg -174.1)
37-42The word 30-BIT
43-48The word SOLAR
49-54Interpolation interval (eg 24 hours)
55-60Maximum dry bulb change in 1 hour (eg 10 degrees).
Line 4
Clearness numbers for all 12 months 1-6, 7-12, etc
Line 5
12 ground temperatures in deg F, 1-6, 7-12, etc
Line 6
The word LIST
Line 7
ColumnUse
1-6The word PACKED
7-12The year of weather data (use -999).
13-18The station number (use -999).
19-24Start month (usually 1).
25-30End month (usually 12).
Line 8
The word STAT
Line 9
The word END

2)WEATHER EXEC must be run with the right TRY file name as the first argument to create the output datasets.

h.Edit file containing radiation data from DOE processor, in XEDIT use the REMTITLE macro to remove extraneous title lines from the file, also must remove all lines with just 0's in them between some of the months, use the REMBLANK macro to achieve this.

i.Load radiation data into yearly SAS datasets and calculate other radiation data from that supplied, also must change radiation data units into W/m^2. The calculated radiation values are diffuse horizontal and direct horizontal.

(WEMOD5 SAS).

j.Calculate dewpoint temperatures for SUNCODE data file if they are missing, from equations in ASHRAE fundamentals manual (F5.2 equations 3 and 4; F5.4 equations 40a and 41a). This step creates a TMY data file to be used in the SUNCODE program after transformation (WEMOD7 SAS).

1)In the transformation to a TMY file all radiation data is converted from units of W/m^2 to units of KJ/m^2.

2)The TMY file must be checked for missing values in the dewpoint column, they are caused by relative humidities of 0 (This used to cause errors in the FORTRAN program, 10 errors and the program would stop !) The missing values must be removed. We have replaced them with values calculated by adding the previous value to the next good value and dividing by 2. This figure replaces all missing values in the range.

3)TMY file format

Posit. Attribute
1-4Direct normal radiation in whole KJ/m^2.
5-8Total horizontal radiation in whole KJ/m^2.
9-13Drybulb temperature in tenths of degrees Celsius (ie 210 = 21.0 degrees Celsius).
14-18Dewpoint temperature in tenths of degrees Celsius.
19-22Wind speed in metres/second.

k.Transform TMY format weather file to SUNCODE BIN format weather file. The TMY data file is in the SUNCODE compressed form (ie option 4 in the program menu) (TMY2BIN.EXE).

3.Method behind the interpolation of missing weather data

a.Our initial attempts at calculating missing data in the weather files was through the generation of sinusoidal patterns that followed the daily variations in temperature fairly closely. These patterns were scaled to match the start and end of the missing data, and worked well. The problem with this sort of fit, was that it was very smooth, and the sinusoidal curve did not approximate the temperature swings through the day that closely.

b.After consultation with Dr Steve Reid from the Meteorological office, we developed an algorithm that calculated missing data in the following fashion. For each month of every year we had data we would create a temperature profile for that month which consisted of the hourly average temperatures for that month. This profile was scaled to the first valid value before the missing data and an increment added to each successive hour so the profile would match the first valid data after the stretch of missing data. This technique produced much more believable data.

4.Method of removing spikes in the weather data

a.From analysis of plots of the weather data, it was apparent that there was some erroneous data in the raw weather data files, namely spikes. We defined a spike to be a period of three hours where the temperature would rise and then fall three or more degrees, or vice versa. The spike value would then be changed to the average of the two points before and after the spike. This removed most of the major spikes, although there are likely to be some small spikes (ie rises and falls of two degrees in three hours), these can not be readily distinguished from the occasions where it happens naturally.

5.Methods behind the selection of a years weather data

a.Normalised weather data

Normalising weather data is a method to scale the value of an attribute so it can be added to another normalised attribute so they both make an even contribution to the sum. This allows us for example to add temperature and wind speed together to get a number which reflects how hot and windy the week was. To normalise an attribute we calculate its mean value over all the data we hold. We then divide the attribute by its mean value to generate a normalised number which if above one is above average and below one is below average.

b.TRY data

1)The principle of selection of a TRY years data is to eliminate years in the period of record containing months with extremely high or low mean temperatures until only one year remains

2)Extreme months are arranged in order of importance for energy comparisons. Hot Februaries and cold July's are assumed to be the most important. All months are ranked by alternating between the warm half and the cold half of the year, with the months closest to late February or late July given priority. The resulting order is given below. If, in addition, it is assumed that hot summer months or cold winter months are more important than cool summer or mild winter months, then the order of extreme months will be down the first column below from "Hottest February" to "Coolest October" and then down the last column from "Coolest February" to "Warmest October".

Month	Primary	Secondary
February	Hottest	Coolest
July	Coldest	Mildest
March	Hottest	Coolest
August	Coldest	Mildest
January	Hottest	Coolest

June ColdestMildest
April HottestCoolest
September ColdestMildest
December WarmestCoolest
May CoolestWarmest
November WarmestCoolest
October CoolestWarmest

3)The first step in the selection process is to mark all 24 extreme months.

4)Continue marking months starting with the next-to-hottest February, then the next-to-coldest July and so on down the first column and then down the second column until only one year remains without any marked months, the process is repeated with the third, fourth , etc hottest or coldest extremes until only one year remains without any marked month. The remaining year is the TRY year.

c.Hot years data

A hot years weather data is selected in the following fashion. From the printout of monthly highs for all years. Use the maximum monthly temperatures for January and February. List the ranked two months side by side and match up years between both sides. Omit years which match to the extreme maximum. Use the most extreme of the matched years as our selected year. As a final check the selected year must lie in the top 5 cooling degree day years of either January or February.

d.Cool years data

A cool years weather data is selected in the following fashion. From the printout of monthly lows for all years. Use the minimum monthly temperatures for July and August. List the ranked two months side by side and match up years between both sides. Omit years which match to the extreme minimum. Use the most extreme of the matched years as our selected year. As a final check the selected year must lie in the top 5 heating degree day years of either July or August.

e.Hot windy week

From the lists of normalised weather data a hot windy week is selected as the 1 percentile highest week of ranked normalised average temperature and average wind speed.

f.Hot calm week

A hot calm week is selected as the 1 percentile highest week of ranked normalised temperature and (1 - normalised wind speed).

g.Cool windy week

A cool windy week is selected as the 1 percentile lowest week of ranked normalised temperature and (1 - normalised wind speed).

h.Cool calm and sunny

A cool calm and sunny week is selected as the 1 percentile lowest week of ranked normalised temperature, wind speed and (1 - normalised cloud cover).

i.Cool calm and no sun

A cool calm and no sun week is selected as the 1 percentile lowest week of ranked normalised temperature, wind speed and cloud cover.

6. Years data selected for each site

Site	Avg	Hi	Lo	Cold windy	Hot calm	Hot windy sunny	Cold calm no sun	Cold calm
Alexandra	-	-	-	8/7/79	27/1/80	10/1/82	4/7/82	27/7/80
Auckland	73	71	65	7/11/76	26/1/75	9/3/75	6/6/82	27/6/76
Campbell Island	-	-	-	28/5/72	23/1/77	14/2/71	9/7/72	24/7/77
Chatham Island	-	-	-	22/6/75	29/12/74	19/12/71	12/6/77	17/7/77
Christchurch	64	81	82	1/5/77	18/2/62	21/11/82	7/6/70	15/7/73
Dunedin	64	75	71	25/4/65	3/3/68	4/1/81	22/8/65	31/7/77
Hamilton	-	-	-	3/8/80	30/12/84	29/11/81	17/7/83	10/6/79
Hokitika	73	71	63	6/6/65	27/12/64	22/12/85	18/8/63	16/7/67
Invercargill	73	71	63	7/6/64	14/4/85	27/11/66	18/8/63	5/8/79
Kaikoura	73	70	65	18/8/74	15/1/78	12/3/72	20/6/71	24/7/77
Kaitaia	64	82	69	8/7/73	10/1/82	3/3/68	6/6/82	11/5/80
Kelburn	73	71	66	15/8/71	21/2/82	25/1/76	16/8/64	14/6/64
Nadi	62	77	66	1/8/65	12/2/67	5/12/76	26/5/68	1/6/75
Nasouri	-	-	-	22/7/79	4/3/79	20/11/77	24/7/77	6/3/77
Nelson	79	71	72	10/8/80	9/2/64	12/11/67	24/5/81	17/8/75
New Plymouth	80	74	69	8/9/68	3/3/68	23/2/75	1/7/73	29/9/63
Ohakea	79	78	66	15/6/69	14/12/69	5/3/72	4/8/85	20/7/69
Paraparaumu	64	81	72	27/7/75	19/2/67	29/11/70	24/5/81	17/7/77
Raoul Island	-	-	-	7/11/71	17/12/78	31/3/74	10/7/77	20/5/73
Rarotonga	-	-	-	10/7/77	10/1/71	10/4/77	9/6/74	8/5/77
Wellington	80	81	76	30/8/64	17/12/67	19/1/64	6/7/75	25/7/65
Whenuapai	63	74	69	4/9/66	28/1/62	13/1/80	9/6/63	8/6/69

7. Practical problems with weather data

a. TRY station numbers

As we needed unique station numbers for the TRY format, and the station numbers for New Zealand weather station range between 0 and 1000, we simply added 10,000 to all New Zealand station numbers to obtain a number for use in the TRY format.

b. Selected years or months.

Sometimes the years or months of data selected by the methods above would give us a years data for a year which had large amounts of missing data for the year, in this case the next most likely candidate year was selected (ie. much of the data in years 60-62 where a lot of the weather data at that time was only recorded every three hours).

c.Normalised data at the 1 percentile mark

In some cases the week at the 1 percentile position in the lists of normalised data would have a very extreme value for one of the attributes, therefore skewing the sum of normalised values, often this would mean some of the other attributes were very close to, or over the mean value for all the data. In this case the next best weeks data in the list of ranked normalised data was selected.

d.Ground temperatures

In some cases ground temperatures were not recorded for some of the sites we had hourly data for, in this case the closest location that recorded ground temperatures was selected. For some sites ground temperatures were only collected at 0.3 metres depth, and not the 1 metre depth we were using, in these cases the 0.3 metre values were used. For some sites ground temperatures were started to be recorded at a later date than some of the years data we were selecting, in these cases, later years data was used for the earlier years data.

LocationSolution
KaikouraUsed Rangiora data for all years
NadiUsed Nandi 1974 data for 62, 65, 66, 67, 68
NasouriUsed Nandi, Fiji data for all years
OhakeaUsed Levin data for all years
ParaparaumuUsed Levin data for all years
Raoul IslandMixed values for 71, 73, 74 to get full monthly data for these three years
RarotongaUsed Rarotonga 1977 data for all years

e.Few years to analyse

Some of the weather data we have spans only a few years, in all cases where there is less than 20 years data there is not enough data to calculate average, hot and cold years. The sites affected by this problem were Campbell Island, Chatham Island, Raoul Island, Rarotonga, Nasouri, Alexandra and Hamilton.

f.Clearness Numbers

After consulting the literature to find a definition of clearness numbers, and analysing the depth of precipitable water in the air and comparing the results to USA data we concluded that New Zealand clearness numbers would most likely follow the numbers found along the west coast of the USA. The only exceptions to this would be in Christchurch where the winter smog would give lower clearness numbers in winter, and sites at high altitudes, like Alexandra or Waiouru. This gave us the following list of monthly clearness numbers for sites in New Zealand:

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NZ	1.03	1.02	1.00	0.98	0.97	0.95	0.97	0.98	1.00	1.02	1.03	1.05
Chch	1.02	0.98	0.95	0.92	0.88	0.85	0.88	0.92	0.95	0.98	1.02	1.05
High	1.08	1.07	1.05	1.03	1.02	1.00	1.02	1.03	1.05	1.07	1.08	1.10