SURVEY OF SIMULATION TECHNOLOGY IN AUSTRALIA AND NEW ZEALAND

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In comparison with other Western Industrialised nations of comparable size, the total energy consumed in buildings in both Australia and New Zealand is very little. Energy reserves are adequate to meet domestic needs well into the future. There is however the potential for very worthwhile savings to be made. As with most other countries that have taken advantage of low cost fuels, in the period up to the seventies, many existing building,s--'and their services systems and traditional design practices are not. conducive to saving energy.

Despite the apparent cost incentive to reduce energy cconsumption with today's much higher energy costs, and the now well recognized broader issue of diminishing world fuel reserves, very little has been achieved by way of energy conservation in buildings i Australia and New Zealand since the "energy crisis" in the mid seventies. Quite definite disincentives exist as deterrents to energy efficient design and practice and as consequence to the use of energy simulation technology.

This paper reviews current and predicted building energy consumption in Australia and New Zealand and discusses the use being made of the energy simulation technology available a part of overall strategies for energy conservation as applied by designers, building owners and operators, and Government Departments in these two countries. It also outlines the disincentives and problems that mitigate against the implementation o energy conservation strategies and the use of simulation technology.

AUSTRALIAN ENERGY RESERVES AND DEMANDS

Total known reserves of energy in Australia are considered to be able to meet most domestic requirements and provide substantial exports up to the year 2000 and well into the future (Ref 1). Australia has vast reserves of coal, large reserves of uranium and adequate reserves of natural gas to meet its domestic requirements. The potential for discoveries in each of these sectors is also large. Consumption of oil however to the year 2000 was forecast in 1982 to be nearly twice the amount of recoverable Australian oil remaining in known fields. Forecast consumption between then and the year 2000 is 5 billion barrels but only 2.6 billion barrels of oil, including condensate, remain to be produced from known oil and gas fields.

Remaining reserves of LP gas, coal, uranium and natural gas and the anticipated consumption and exports to the year 2000 are listed in Table 1.

The total Australian annual primary energy consumption (TPE) in 1980/81 was 3102 Peta Joules (2940×10^7 therms). The total annual final energy consumption (TFE) was 2179 Peta Joules. (2065×10^7 therms), (Ref 2).

In June 1981, the Department of Nation Development and Energy published its forecasts energy demand and supply in Australia to 199 (Ref 3). They show energy use and supply patter in Australia over the decade exhibiti considerable departures from the trends experienc during the past two decades as oil use declin relative to other energy sources.

The significant features of these forecasts are:

- A substantial slowing down in the growth demand for Total Primary Energy (TPE) to avera 3.6% pa for the decade, compared with t average 4.7% pa growth in TPE demand experienc over the 20 years to 1979-80.
- Significant switching from oil to gas a coal-based electricity, with forecast minim savings of 16 million barrels of oil per annu or 6% of annual oil demand, by the later yea of the decade.
- A five fold increase in net energy export enhancing our already strong position as a n energy exporter.
- Forecast real increases in all energy pric will have a significant impact on TPE dema over the decade, but the dominant determini factor will be the growth in Gross Domest Product (GDP).

Fuel	Estimated reserves (equiv.billion barrels of oil)	Predicted consumption (equiv. billion barrels of oil)	Exports (equiv.billion barrels of oil)
Oil	2.6	5	--
L.P.Gas	900	400	300
Coal	185	9	12
Nat.Gas	4.8	2.4	0.8
Uranium	27	--	16

Table 1 Reserves, consumption & exports of Australia's energy sources

Historical and forecast trends in usage of the major individual primary energy sources are shown in Figure 1. (Ref 3).

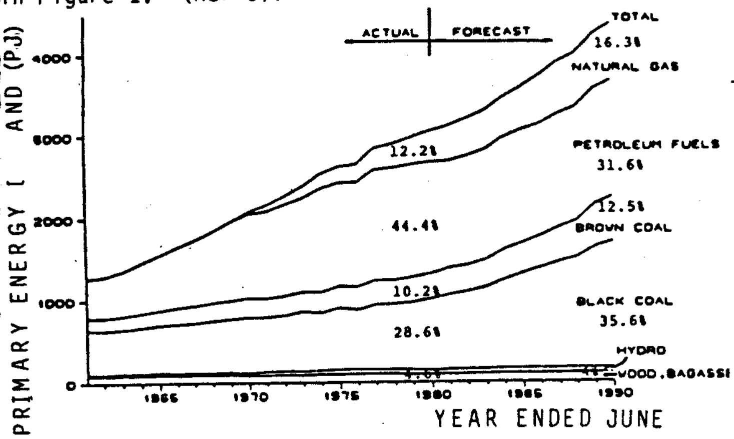

Fig. 1 **Demand for Primary Energy by Fuel Type - Australia**

N.B. Demand for each fuel is represented by the vertical distance between adjacent lines.

Although quite significant reductions are likely in specific instances, changes in energy consumption in the buildings sector are likely to be relatively small overall (predicted at 4%) (Ref 3) both in relative and absolute terms because the total energy consumption is, for various reasons, already quite low.

ENERGY CONSUMPTION IN BUILDINGS IN AUSTRALIA

Of the total annual primary energy consumption of ~102 Peta Joules (2940×10^7 therms) in 1980-81 in Australia, the buildings sector used 25.9% as indicated in Table 2 (Ref 2). In terms of final energy cconsumption the corresponding figure is 16.9% i.e. 368 PJ (349×10^7 therms). The break up of this figure according to fuel type in 1980/81 was:

- Electricity 45.8%
- Natural & towns gas 17.9%
- Petroleum 12.6%
- Solid fuels 21.2%

A dissection of the energy consumption in a typical building in Sydney is indicated in Table 3. (Ref 4).

Element	Annual Energy Consumption		% of Total
	MJ/a.m^2	Therms/a.ft^2	
Airconditioning -			
Refrigeration	60	52.83×10^3	9.1
Heating	160	140.88×10^3	24.2
Fans etc.	80	70.44×10^3	12.1
	300	264.15×10^3	45.5
Hot water service	10	8.80×10^3	1.5
Lifts	50	44.03×10^3	7.6
Public Light & Power	50	44.03×10^3	7.6
Tenant Light & Power	200	176.10×10^3	30.3
Car Park Light	50	44.03×10^3	7.6
TOTAL	660	581.13×10^3	100.0

Table 3 Energy Consumption in a Typical Office Building in Sydney

Residential buildings accounted for approximately 73% of the above final energy consumption and the non-residential sector for the remaining 27% i.e. 99.4 PJ (93.7×10^7 therms).

ENERGY CONSUMPTION OF BUILDINGS IN NEW ZEALAND

The situation in New Zealand is somewhat similar to that in Australia. The amount of energy consumed in buildings and the potential for energy consumption is small compared to the Nation's total energy consumption. Worthwhile savings could be made in the building sector but little has been achieved over the last decade. During the period from 1972 to 1980 the energy consumed in commercial buildings remained at 11% of the total annual final energy consumption. In absolute terms the amount increased by 15% from 26.1 PJ (24.7×10^7 therms) to 30.1 PJ (28.5×10^7 therms) per annum (Ref 5). The energy consumption and break up of these figures for three typical commercial buildings constructed in 1970 (heavy reinforced concrete construction with approximately 25% glazing) is indicated in Table 4.

THE ERA OF CHEAP ENERGY

The climate of the cities of population in Australia and New Zealand are relatively mild so many buildings were designed in the early modern era for ventilation only. Heating was either not

Year	Primary Energy %			Total	Final Energy %			Total
	Transport	Indust.	Bldgs.	PJ (Therms)	Transport	Indust.	Bldgs	PJ (Therms)
76/77	29.5	45.9	24.6	2859(2710×10^7)	36.7	46.5	16.8	2064(1956×10^7)
78/79	29.9	45.0	25.1	2991(2835×10^7)	37.7	45.4	16.9	2156(2044×10^7)
80/81	29.5	44.6	25.9	3102(2940×10^7)	37.9	45.2	16.9	2179(2065×10^7)

Table 2 Primary and Final Energy Consumed in Australia by Industry (Ref 1)

Element	Building 1 MJ/a.m²	Building 1 Therms/a.ft²	Building 1 % of total	Building 2 MJ/a.m²	Building 2 Therms/a.ft²	Building 2 % of total	Building 3 MJ/a.m²	Building 3 Therms/a.ft²	Building 3 % of total
Heating	9	7,925	2.6	109	95,975	20.8	320	281,762	48.1
Cooling	4	3,522	1.1	13	11,447	2.5	42	36,981	6.3
Public Lighting	50	44,025	14.3	13	11,447	2.5	19	16,730	2.9
Lifts,fans pumps	39	34,340	11.1	91	80,126	17.3	105	92,453	15.8
Tenant Lighting	78	68,680	22.3	255	224,530	48.6	154	135,600	23.1
Tenant power	167	147,045	47.7	45	39,623	8.6	27	23,774	4.1
TOTAL	350	308,177	100.0	525	462,266	100.0	666	586,417	100.0

Table 4 Measured Energy Consumption for Three Buildings in Wellington N.Z.

provided or quite localised and intermittent. Extensive use was made of shading particularly in residential buildings. A few buildings afforded the luxury of evaporative cooling.

The advent of air conditioning was assocciated with an era of cheap energy and high energy consuming buildings were acceptable.

Many of today's buildings show excessive use of this design freedom with the result that they are often not comfortable shelters and their cost of operation is now quite uneconomical.

Surveys of energy use in buildings have revealed a very wide range of specific consumption. For example BOMA's 1982 Sydney Survey of Offices reported a range of 200 to 700 MJ/a.m² (17600 to 616,000 therms /a.sq.ft) after some correctionss were made for operating time (Ref 4). Some typical buildings measured in Melbourne ranged from 700 to 1200 MJ/a.m² (616,000 to 1,056,000 therms/a.sq.ft). Surveys by Poole and Baird in New Zealand reported a range of 390 to 2580 MJ/a.m² (343,000 to 2,272,000 therms/a.sq.ft.) (Ref 5). In New South Wales, HOSPLAN reported survey results of 94 GJ/a.bed (89 therms/a.bed) with a standard deviation of 70 GJ/a.bed (66 therms/a.bed) (Ref 6).

Until the late seventies/early eighties energy prices fell in real terms and there was little incentive to conserve energy. In South Australia for example, Noble (Ref 7) reports that during the period 1960-1977, real average domestic gas and electricity prices fell by about 50% and 65% respectively. Over the same period, real disposable income per capita in the State rose by 75%. Partly in response to this trend, electricity consumption per domestic customer rose by 95% over the same period, while gas consumption rose by 80%.

The use of energy in buildings continues to expand due to increasing trends for provision of space and greater comfort by heating and airconditioning, and the installation of other equipment.

In the residential area, until recently, cooling of houses was not widely practiced, but this is now changing with increasing use of heat pump and reverse cycle units using relatively cheap electricity and providing heating and cooling with the same piece of equipment. The energy cost savings of replacing oil fired heaters is often fully negated by installing such devices to provide cooling in summer as well as heating in winter.

POPULATION & CLIMATE

The two main reasons for the relative low total energy cconsumption in the building sector in Australia & New Zealand are the small population in both countries and the climate at the centres of population. Australia is one of the most sparsely populated countries in the World. Although the Australian continent is approximately the same size as the U.S.A. the population is a little over 7.5% of that of the U.S.A. 60% of the Australian population resides and works in the eight capital cities all of which except Canberra are on the coast and all, except Darwin & Brisbane are in the temperate zone.

The climate in Australia does vary quite appreciably with tropical conditions in the North, hot dry desert conditions in the centre and temperate conditions in the south where quite warm summers but very mild winters prevail. Because however the main population centres are in the green belt near the coast, the climate to be considered in the design and operation of most buildings (particularly non-residential buildings) is such that although there are appreciable differences and in some locations relatively high temperatures do occur, from an energy consumption viewpoint,the climates are quite mild. This is particularly so during the heating seasons. A significant factor however is that the building stock varies very little in construction between locations.

In New Zealand with all major cities close to the sea, the climate is even milder than most of the Australian capital cities and summer temperatures are noticeably lower.

Location	Total (million) 1984	per km^2 land mass
Australia	15.28	1.989
Adelaide SA	0.96	
Brisbane QLD	1.10	
Canberra ACT	0.23	
Darwin NT	0.05	
Hobart TAS	0.13	
Melbourne VIC	2.58	
Sydney NSW	3.20	
Perth WA	0.92	
New Zealand	3.23	12.01
Wellington	0.34	
USA	226.55	24.196
New York	7.89	
Los Angeles	2.81	
Chicago	3.37	
Detroit	1.51	

Table 5 Population and population density of Australia and New Zealand and Capital Cities with some USA cities for comparison

Location	Av. Daily total solar radiation KJ/m^2 (BTU/ft^2) Jan	July	Heating degree days °C (°F)	Monthly av. temp. Jan °C (°F)	July °C (°F)	Mean daily Max Temp (Jan) °C (°F)	Min Temp (July) °C (°F)
Australia							
Canberra ACT	25100	9000	1422	20.2	5.3	27.4	-0.4
	(2210)	(793)	(2560)	(68.4)	(41.5)	(81.3)	(31.3)
Darwin NT	23200	20300	0	28.8	24.3	31.7	19.0
	(2043)	(1787)	(0)	(83.8)	(75.7)	(89.6)	(66.2)
Hobart TAS	22500	6900	1166	16.4	8.0	21.8	4.6
	(1982)	(680)	(2098)	(61.5)	(46.4)	(71.2)	(40.3)
Melbourne VIC	25000	7300	692	20.1	10.2	26.2	6.6
	(2201)	(643)	(1246)	(68.2)	(50.4)	(79.2)	(43.9)
Sydney NSW	22300	11300	217	22.3	12.1	25.9	8.3
	(1964)	(995)	(391)	(72.1)	(53.8)	(78.6)	(46.9)
New Zealand							
Auckland	23040	7560	--	19.3	10.8	22.9	7.8
	(2029)	(666)	--	(66.7)	(51.4)	(73.2)	(46.0)
Wellington	23040	5400	--	16.3	8.1	19.9	5.4
	(2029)	(476)	--	(61.3)	(46.6)	(67.8)	(41.7)

Table 6 Climate Conditions for some Cities in Australia & New Zealand

Table 6 summarises the climatic conditions in Australia & New Zealand. The nett result of these mild climates is that the energy consumptions of buildings in Australia & New Zealand even if not designed with low energy consumption in mind, are very likely to be lower energy consumers than the equivalent building in North America, Canada & Europe.

ENERGY SIMULATION IN PERSPECTIVE

Despite the relatively small amount of energy used in buildings in Australia & New Zealand, there are still very worthwhile savings to be made. Many individual examples have been reported in all segments of the buildings sector where succcessful energy conservation programs which have brought savings in excess of 30% with 50% not being uncommon.

The steps have been simple and principally required a resolve on the part of the person/organisation paying the bills to address the way in which energy is being consumed.

A co-ordinated effort to establish consumption figures in Australia & New Zealand has only been made in commercial office buildings, however some surveys have also been carried out in hospitals, schools and supermarkets. All surveys have shown a wide variation in specific energy consumption, even between buildings of similar design in similar climatic locations. This suggests that while design and siting are important determinants of energy consumption, operational practices are far more significant.

Existing buildings are more significant in terms of potential for energy savings (because there are many more existing buildings than new buildings). Energy simulation techniques on the other hand, are generally more applicable and beneficial in the design of new buildings.

New Buildings

A number of authorities in Australia have considered the use of precriptive standards for the design of buildings. Because the Australian & New Zealand climate is not severe it is considered however that prescriptive standards would not be very effective. They can lead to increased expenditure and inefficiency and are generally applicable to the particular components rather than the total system. Often the components providing significant contribution to energy cconservation are offset by wasteful components, resulting in a mediocre result overall.

In new buildings energy simulation can play a very important role in energy conservation allowing the designer to quickly review numerous alternative building and services systems designs. Computerised analysis allows designers to evaluate these alternative proposals in detail with respect to not only energy consumption but also the thermal performance and function (e.g. comfort) of the building. From the results of such studies the total capital and owning and operating costs of the building can be evaluated.

In the long term the key to appropriate design of the building envelope and associated energy-consuming systems is the availability of simple, but accurate, design aids (including computer programs) and guidelines for use by designers. Much work has been undertaken on making such aids, but their further simplification and transfer to the user must still be undertaken.

Existing Buildings

A necessary first step in an energy conservation program in existing buildings, is to identify the current nature and level of energy use by undertaking an "energy audit" or survey. This can lead to a plan of action involving a retrofit to the building and its services, and revised maintenance and operational procedures. Although energy simulation can be a useful aid to predicting the affects of implementing this plan of action, significant reductions in energy consumption can usually more readily be achieved by adoption of appropriate management practices, many of which do not involve high capital investment or extensive calculations to validate.

The concept of energy audits has become more accepted in the last five years in Australia & New Zealand and although the practice is not widespread a number of specialist firms and State Government centres exist to provide this and associated consulting services. Very few at this stage use energy simulation techniques, relying mainly on the implementation of revised maintenancce, operational and maintenance procedures and correction of obvious design or installation faults to reduce the consumption of the more obvious high energy consuming equipment.

An important item of information required by building owners and occupants is the expected level of energy consumption of their particular building whether it be existing or new. Such information would enable a rapid assessment of the building and its associated energy consuming systems and an energy simulation program can be a useful aid to the designer in making an estimate of this.

ENERGY CONSERVATION POLICIES AND INITIATIVES

Over the last decade a considerable number of energy conservation policies and initiatives have been implemented in Australia by the Federal Government. These include -

(i) Pricing & incentives
- Import parity pricing for crude oil
- Removal of sales tax on non-oil domestic space heating equipment and solar equipment
- Full tax deductability of home insulation costs for a persons first home.

(ii) Publicity/information & education
- National Energy Conservation Program (NECP) - Information bulletin, What is Happening to Oil?
- National Industrial Energy Management Scheme - Conferences, Seminars, Workshops, $300 subsidy for energy audits, energy awards.
- CSIRO - Design guidelines and technical information service
- Dept. of Housing & Construction - guidebook on energy conservation and thermal comfort.

(iii) Support for Research Development & Demonstration
- demonstration of economy of existing low energy multistorey office building
- energy audits and study of load management in existing commercial buildings.
- development of energy simulation program BUNYIP.

(iv) Government Example & demonstration
- Low energy design & fuel conversions in Commonwealth housing & buildings.

(v) Standards, regulations and quantitative controls.

The State Governments have also adopted energy conservation policies. For example, the Public Buildings Dept. of SA have adopted ASHRAE 90-75 and the Public Works Dept. of Victoria have developed a similar prescriptive standard. (Ref 8).

In the private sector BOMA (The Building Owners and Managers Association) have recently published an Energy Guideline for office buildings. (Ref 9). As one of the most aware and active user organisations they have subtly established peer group pressures with some noticeable results.

A similar concern exists in New Zealand where considerable work has been carried out in surveying energy consumption in existing buildings. In 1982 the Standards Association of N.Z. published their Code of Practice for Energy Conservation in Non Residential Buildings. This Standard is performance oriented and defines both design targets (for designers) and consumption targets (for building managers).

A recent important initiative taken by the Department of Housing & Construction, the Australian Government's building & construction authority, was the introduction of energy targets for the various buildings that it has responsibility for (Ref 10 & 11). This in many instances will mean that computer simulation will need to be undertaken to verify designs and will provide a flexible means of tightening the belt on energy consumption through the review of established targets as a result of achievements through the implementation of this policy. The policy provides for measurement of achieved targets and comparisons with the design target and values calculated by simulation techniques.

The targets have been established from a data base of efficient designs of various buildings and system types in different locations throughout Australia. They are for the design of economic buildings based on life cycle costing including energy costs. In establishing the target for a particular building, account is taken of the building occupancy and function and the location of the building. Provision is also made for the comparison of the measured energy consumption and cost of this energy consumption for the new or retrofitted building, compared to the target in terms of a consumption ratio and cost performance ratio.

The base energy indices and the locality adjustment factors are listed in Tables 7 and 8.
This concept of energy targets has also been introduced to organisations in New Zealand through a series of seminars and is currently being widely promoted by the Federal Government throughout Australia.

Building Type	Cooling		Heating		Hot Water Service	
	MJ/ a.m^2	Therms/ a.ft^2	MJ/ a.m^2	Therms/ a.ft^2	MJ/ a.m^2	Therms/ a.ft^2
Offices	120	105,660	200	176,100	5	4,400
Schools	90	79,250	170	150,000	20	17,610
''ospitals	450	396,250	500	440,250	180	158,500
rmitories	80	70,440	300	264,150	100	88,050
Warehouses			150	132,080	10	8,800
Workshops			150	132,080	20	17,610
Laboratories	180	158,500	250	220,120	40	35,220

Table 7 Base Energy Indices for Department of Housing & Construction Energy Targets

Location	Cooling Fc	Heating Fh
Melbourne	1.00	1.00
Geelong	0.9	1.21
Ballarat	0.9	1.51
Sydney	2.2	0.54
Albury	1.2	1.17
Canberra	0.7	1.47
Adelaide	1.2	0.77
Mt.Gambier	1.0	1.30
Hobart	0.6	1.44
Launceston	0.6	1.59
Perth	1.8	0.54
Brisbane	4.4	0.24
Townsville	13.0	0.0

Table 8 Cooling and Heating Factors

THE EFFECTS OF THESE POLICIES AND INITIATIVES

To date, these energy conservation policies and initiatives although producing some significant reductions in some specific instances have resulted in actions primarily confined to fuel substitution away from petroleum sources to natural gas and electricity as illustrated in Table 9.

While fuel substitution cannot of itself be called the opportunity is often taken to audit the energy conservation, energy consumption and to reassess energy consuming plant.

Despite the policies and initiatives implemented to date considerable disincentives to the application of energy conservation strategies exist in both Australia & New Zealand.

It is forecast that the energy consumption in the building sector will not decrease overall in the eseeable future and will in fact continue to rease. (Ref 2).

The forecast energy consumption in the building sector by fuel type is shown in Fig. 2 and this indicates an anticipated further substitution away from petroleum but little change in the overall rate of increase in total energy consumption.

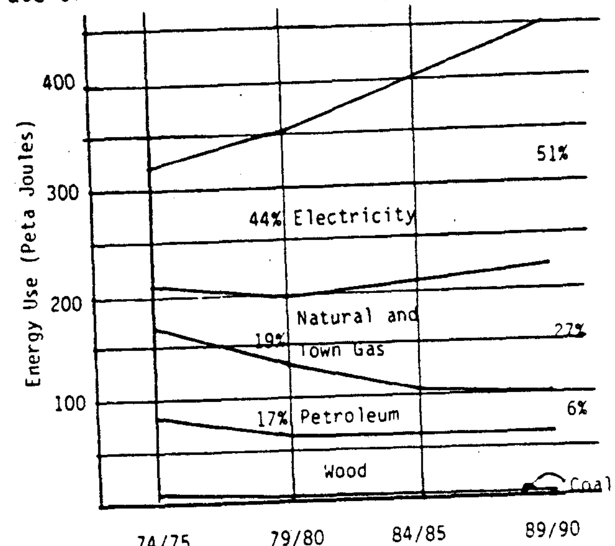

Fig 2 Forecast energy use in Buildings sector by fuel type in Australia

Energy Type	%Change 1976/77 to 1980/81
Electricity	+25.7
Natural and Town gas	+35.8
Petroleum	-38.7
Solid Fuels	-8.0
TOTAL nett change	+5.18

Table 9 Percent Change in Total Final Energy Used in Buildings Sector in Australia by Energy Type.

SIMULATION PROGRAMS AVAILABLE IN AUSTRALIA AND NEW ZEALAND

Throughout the nineteen seventies, a variety of energy simulation programs for analysing commercial buildings have appeared on the scene in Australia and New Zealand including ECUBE, DOE-2, ESPI, TEMPMASTER, ESAS, TRACE and others. All of these were developed overseas and were not readily usable in Australia or New Zealand. They were generally in imperial units and did not match Australian design and construction practice. Material properties were based on overseas building practice and other subtle differences often existed and at times these differences were not readily perceptable, e.g. many assumed [illegible] setback heating (a practice that is only [illegible] employed in Australia and New Zealand) unless specific action is taken by the user to suppress this. More importantly the majority of these programs did not have reliable technical support readily available and local knowledge on their use and application was very limited. Many are proprietory with no access provided to the source code and hence the methodology employed was unavailable for detailed review. Often it took two to three weeks or more before problems with the use and application of the program could be resolved, if at all.

Approximately two years ago, ACADS negotiated an agreement with APEC (Automated Procedures for Engineering Consultants Ltd.) for the ESPII simulation program to be made available in Australia and New Zealand with ACADS metricating the program and making it suitable for use in these two countries. The agreement also provided for ACADS to become agents for the release of the program in Australia and New Zealand and to provide local technical support. This work has been completed and the program has now been available for use for the last 12 months.

At the same time, CSIRO (The Commonwealth Scientific and Industrial Research Organisation) under a NERDDC (National Energy Research Development and Demonstration Council) grant commenced the development of an Australian energy simulation program called BUNYIP (Refer Appendix A). This program uses binned weather data and can model a wide range of building services systems. The program has now been validated against measured data and commercialised and is to be made available for use through ACADS within the next few months.

Two additional simulation programs from overseas have within this same time period also appeared on the scene in Australia, with this time, some local technical support offered. They are the program BLAST on the CDC network and the Carrier E-20 programs. Both of these programs are in metric units and are claimed to be specifically suitable for use in Australia. However they are proprietory programs, with no access provided to the source code and it is yet to be proven whether reliable technical support is available locally, although a number of organisations are trying them out. There is certainly some doubt about the support that is available for BLAST.

In New Zealand these same four programs are available but no use is as yet being made of them. The New Zealand Ministry of Works also have their own building simulation and analysis package called HEAVEN.

For domesticc buildings, two simulation programs that have been developed in Australia are available and have been used for a number of years. These are TEMPAL a program developed and made available by Melbourne University and ZSTEP2, a program developed by the CSIRO, Division of Building Reserach.

DETERRENTS TO THE USE OF SIMULATION PROGRAMS

The number of commercial buildings that have been analysed with energy simulation programs in Australia would number little more than twenty. In New Zealand the number is even less. The reasons for this are partly because of Australia's and New Zealand's mild climates and low use of energy in buildings as discussed earlier, but also because there are quite a number of deterrents that mitigate against energy conservation strategies in general and because there are difficulties associated with the actual use of the programs that are available.

(i) Deterrents to energy conservation strategies

Although much work has been done by both Federal and State Governments in promoting energy conservation other existing conditions act as deterrents. These include:-

(a) "The practice of spending money (capital) to save money (expenses) is not widespread in Australia or New Zealand and it is not likely to be until the increase in the prices of <u>all</u> energy types exceeds normal inflation <u>and</u> until the use of life cycle costing in the building sector has become much more common practice" (Ref 2)

There are difficulties in securing finance for energy saving investments, due to an historical bias among lenders and borrowers alike towards a low initial cost, even when more energy-efficient alternatives result in lower life-time costs.

(b) In the public sector the organisation of government funding whereby capital and operating costs are budgeted separately together with general budgetary constraints often lead to difficulties in obtaining extra capital to pay for more energy efficient buildings.

(c) Even when life cycle costing techniques are employed tax deductions on energy costs in the private sector as part of building operating costs mitigate directly against spending additional capital to reduce energy consumption.

(d) Most commercial energy tariffs are structured such that the more energy a consumer uses the cheaper the unit rate is. For example one of the State electricity authorities commercial all purpose tariff charges are:

First 500	kWhrs/month		20.8 c/kWhr
Next 4500	"	"	15.72 "
Next 20000	"	"	8.34 "
Balance	"	"	7.84 "

(e) Market prices of fuels do not fully reflect the non-renewability of energy resources and the environmental and social costs associated with energy production, distribution and use.

(f) Despite the commendable efforts of the Government there is still a widespread lack of awareness about the benefits and methods of reducing energy consumption.

(g) There exists a management bias towards investments and projects which raise output, even when the energy-saving alternatives have higher rates of return and add directly and predictably to profits.

(h) There is a commitment to the existing infrastructure,capital stock, and other assets and a consequent inertia with respect to making energy-saving changes even where price movements have made them more effective.

(ii) Difficulties with the use of the available programs.

Even if the above deterrents were negated and worthwhile incentives provided to undertake simulation studies, problems exist with the use and application of the current stock of programs available in Australia and New Zealand.

(a) Most mechanical building services designers in Australia and New Zealand are novices in the use and application of computers, use to date being mostly confined to the simpler computerised tasks such as air conditioning load estimation. Energy simulations also require considerable engineering expertise and existing energy analysis programs require a degree of computing skills.

Because of the relatively mild climate, small population and consequent small amount of energy consumed in buildings there are very few, if any, consultants in Australia and New Zealand that undertake energy simulations as their bread and butter trade. As a consequence the scope for development of skills in energy simulation is very limited. The majority of building services consultants don't really want to get involved in computerised energy simulation studies because it is all too difficult.

(b) The current fee structure for consultants does not have any spefific provisions for extra payment for energy simulation studies. If energy studies are seen to be needed by the consultant these are normally expected to be included within the normal fees. Consultants normally have to negotiate a separate fee for (and work hard to convince the building owner of the benefits of) any sizeable energy simulation.

(c) The energy analysis programs currently available are based on fixed format (card image) format input which presents difficulties with entering data. There is a critical need for "front end" prompter programs.

(d) Reporting of results is also not very conveniently provided for except to a limited degree in the program BUNYIP. Most of the currently available programs have fixed output with very limited options for obtaining reduced (summary) or more detailed output. These options are part of the input data and hence have to be exercised before a run is made. There is a need to provide for more sophisticated capabilities in terms of reviewing the results in part and/or in full in what ever way the user desires, i.e. the complete detailed results directed to a file and then a separate interactive reviewing progrqm that provides the user with the capability of "homing in" on the specific summary or more detailed information for any portion of the results that he desires.

(e) There is only a sparsity of information on the reliability of programs. It is recognised that it is nigh on impossible to completely validate programs particularly with such complicated programs as those that perform energy analysis. However, currently, one of the major deterrents to the use of energy simulation programs in Australia and New Zealand is the lack of validation data. Even after a user has had a few trial runs it is still extremely difficult to gain confidence in the results produced. This is further aggravated by the fact that with energy simulation programs there is little the user can do to manually check even small parts of the calculations without devoting an inordinte amount of time to this task.

(f) There are many areas where the currently available programs do not specifically model particular practical applications and this means that the user must be very proficient at modelling and have an indepth knowledge of the program or have ready and convenient access to a person with an intimate knowledge of the program and the methodologies used. The minimal usage of programs to date in Australia & New Zealand to date is making this difficult to achieve.

(g) Although with the ESPII and BUNYIP program the code has been written with flexibility in terms of modelling in mind, there is an essential requirement for continuing on-going enhancements to cater for new systems and system variations. Energy conservation studies promote innovation and of the limited number of simulation studies undertaken to date in Australia with computer programs, more than half would have found the system configuration provided for inadequate. The following are typical examples of problems encountered:

- a dual conduit system in which the perimeter zone handles the building skin load only.
- pre-occupancy warm up with no fresh air supply during this warm up period.
- fan assisted terminal VAV units - ACI House Melbourne (ASHRAE Energy Award).
- systems with multiple cooling coils - this has been a problem on a number of occasions.
- ice storage systems.
- condenser water precooling coils.
- buildings with atriums
- difficulties in modelling unconditioned spaces.

CONCLUSION

Although energy simulation computer programs have been available to designers and building owners in Australia & New Zealand for a number of years now, very little use is being made of this technology. Actions are needed to alleviate this problem as discussed in detail in this paper. Considerable resources and expenditure would need to be devoted to this, far more than Australia and New Zealand as small users, and possibly any other single Nation, can afford. The solution lies in the collaborative efforts of all involved with greater interchange of ideas and experiences and co-operative prograr development, on going enhancement and program validation.

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APPENDIX A Brief Description of Energy Analysis Program BUNYIP (Ref 12)

The program BUNYIP consists of a heat transfer model of a building, or part thereof, and its associated building services systems. In particular, the program is set up to calculate the energy consumed by the plant in providing the building occupants with heating and cooling and with humdification or dehumidification. The program accepts information on the building occupancy and operation, and estimates the actual energy consumed in fuelling the specified plant and the associated water and air distribution systems.

It is expected that the plant capacity for a particular building will have been chosen through a design day calculation using other load estimation programs, so that the plant can be specified well enough for its leading characteristics to be available to run BUNYIP. The program is intended for use at any stage of a building project, consistent with the type of data available. Thus it can be used for the analysis of alternative designs of new buildings and their systems or in the assessment of retrofit options and changes being considered for existing buildings. Its principal output will provide the user with an estimate of annual and seasonal energy consumption across these alternatives and options.

The program uses the type of finite difference model contained in the program TEMPER (Ref 13) for the building envelope, but has entirely new modules for system and plant performance. In addition a suitable climatic data bank has been established om Bureau of meteorology data.

A summary of the main features of the program are:

. hour by hour computation of building thermal loads, simulation of the air handling system meeting these loads, and simulation of the heating and cooling plant providing appropriate thermal transfer to the air handling system. Thus, the energy consumed by the plant is estimated, as well as that used by fans and other equipment in the air distribution network.

. the hour-by-hour computation is executed for a pre-selected number of "characteristic days", chosen from the whole range of days in 6 two-month periods of the year on the basis of daily maximum temperature.

. the building thermal performance is computed using finite difference techniques, similar to those used in program TEMPER.

. the system simulation enables the user to specify the air handling systems by detailing the components that link the conditioned zones with heating and/or cooling coils and the outdoor air. This enables the user to model a wide range of variations on the standard systems provided for, such as: variable air volume, dual duct, terminal reheat, or induction systems. The components modelled in the systems package include fresh air controls (economiser), coils, ducts, fans, heat recovery equipment, and control devices such as VAV boxes, reheaters, mixing boxes and induction units.

. the plantroom model contains routines to cover several different types of chiller and boiler as well as cooling towers. Sequencing data and custom part-load information can be input by the user.

. flexibility - the limits on the major vaiables, which determine the size of problem that BUNYIP can handle and the memory required to run the program, can be easily altered before compilation. This enables BUNYIP to be used on a wide range of computers from a micro computer to a large mainframe machine. These variables include the maximum number of zones, systems and plantrooms allowed.

. BUNYIP is written in ANSI Standard Fortran IV