An Investigation into the Profitability of Energy Management in Office Buildings

By

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ABSTRACT

This thesis examines the costs and benefits of energy management in office buildings and investigates the relationships between operating costs, space lease contracts, and building value.

Energy Management by building owners and managers begins with monitoring and analysing building energy use and continues by reducing energy consumption through operating procedure changes, equipment replacement and control, personnel training, and continued monitoring. The cost to complete energy management projects in 12 office buildings is analysed. The average, before tax, internal rate of return for the the 12 energy management programs was 22.1%, on total expenditures of roughly $1,200,000.

Nine of the office buildings are publicly owned and occupied by the provincial government of B.C. The return on the investments in these buildings directly benefits the citizens of B.C. However, in the three privately owned and tenant occupied buildings, the owners have a less direct method of receiving the benefits due to net lease contracts with tenants, under which the tenants pay the energy costs and would normally receive the energy cost savings. If only the energy cost savings in vacant areas acrue to the owner, the after tax returns to the owner from the investments in energy management for the three privately owned buildings are all negative.

However, because building value is determined by the net income of a property, and net income is dependent on revenues and operating costs, a statistical analysis of revenues and costs was completed on a 140 building sample of office buildings in the Vancouver, B.C. metropolitan area. The results of that analysis provided support for the hypothesis that energy cost reductions could result in increased lease revenues at the time of lease expiries because tenants are concerned primarily about the total space cost, not the lease payment to the owner. In that case, the returns to the building owners were significantly improved, were all positive, and were as great as 80%.

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Most of all, I extend a very special thank you to my wife, Astrid, who is always an inspiration. This thesis is dedicated to her.

"The very best investment opportunity today is in energy conservation where returns of 35% to 50% are possible" - *Forbes Magazine, March 1980,* evaluating investment opportunities in diamonds, gold, money markets, stocks, & real estate.

1.0 Introduction

The efficient markets hypothesis of the finance world states that, if capital markets are efficient, then the purchase or sale of any security, at the prevailing market price, is a zero net present value transaction. This means that there is a long run inability to make abnormal profits - the return will be fair compensation for the risk undertaken. Tests of the hypothesis in financial markets and real estate markets have shown that all available information will be impounded in the price of the investment and superior risk adjusted returns cannot be expected.[1] The primary hypothesis of this research is that <u>the risk adjusted returns to investments in office building energy management are sufficient to encourage investment and may even be superior to other common investments, such as stocks, bonds, or real estate</u>. This will be shown to be true even in cases where a tenant receives most of the annual energy cost savings under net lease contracts (triple net rents). A superior, or abnormal, risk adjusted return would indicate that barriers to investment exist, or information is not being passed on to the marketplace.

An expenditure to reduce energy use should be viewed as an investment, not a necessity. Consequently, *energy efficiency* or *energy management* are more appropriate investment objectives than *energy conservation*.[2] Energy management is any management action which serves to monitor, control, or reduce energy use and, especially, energy cost. A goal in the energy management process is to increase the efficiency of energy use. An energy *efficient* office building provides a comfortable and safe environment with the *least* amount of input energy.

This thesis will analyse the returns to investments in energy efficiency in office buildings by way of cash flow impacts and by a percentage rate of return to the money invested, on a present value basis. A principle objective of this study is to allow comparison of the returns to investments in energy management with any other investment.

The information in this thesis will expand the existing base of simple cost benefit studies on energy management, and will investigate the effects of triple net lease contracts on the implementation of energy management projects in office buildings. Triple net leases are those which require the tenants to pay property taxes, operating costs, and utility expenses.

While the ongoing energy cost savings from energy use reductions accrue to the tenants, future benefits to the owner from a reduction in tenant paid costs may include increased lease revenues and enhanced building value. A second hypothesis in this thesis is that **the value tenants perceive in office space is reflected by gross space costs, not by triple net rents.** If this hypothesis is proven true, then a reduction in operating expense could result in higher triple net rents, and increased value of the real estate asset.

Members of the technical community will note that no engineering analysis of the energy management projects is completed. The objective of this thesis is to examine twelve case studies and to explore the issues affecting the financial returns to energy management. This thesis is worthwhile reading to gain a better appreciation of how energy management can increase building value. Real estate professionals will find the discussion on valuation a review, but will gain insights from an empirical analysis of the effects of operating costs on lease revenues. Methods of overcoming the barriers of net lease contracts will also be of interest.

Data will be provided on energy use and cost in office buildings and types of energy management projects which have been completed in office buildings will be summarized. The rents and operating costs in metropolitan Vancouver office buildings will be reviewed and relationships between the two will be investigated. The findings of studies on the energy savings from energy management investments will be presented and an analysis of the rate of return from energy management projects is detailed for 12 office buildings. The barriers to investment and various methods of financing energy management projects are also presented.

Footnotes appear at the end of each chapter

1 A good review on stock market efficiency is E. F. Fama, "Efficient Capital Markets: A Review of Theory and Empirical Work," Journal of Finance 25 (May 1970): 383-417. As applied to real estate investments, see G.W. Gau, "Public Information and Abnormal Returns in Real Estate Investments," AREUEA Journal 13-1 (1985): 15-31 .

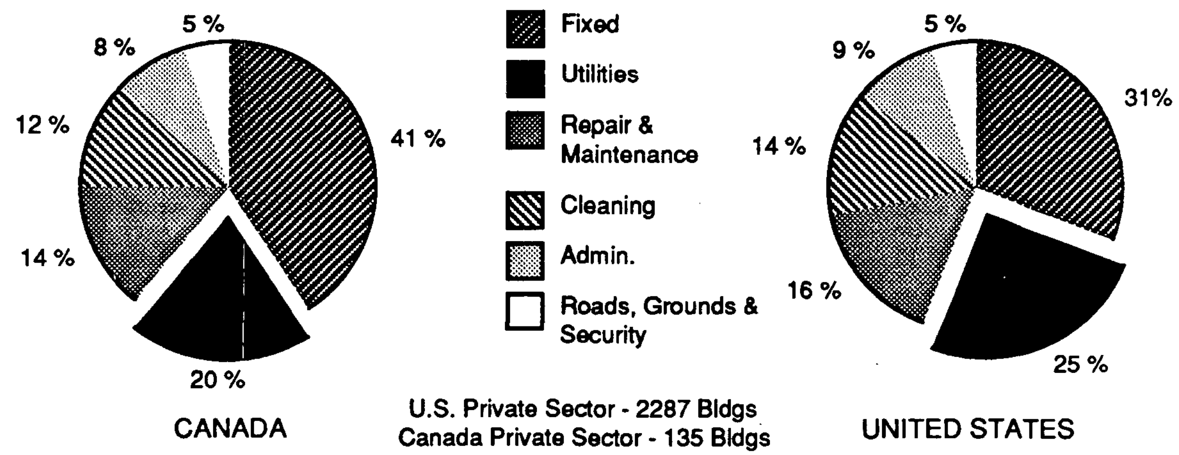
2 Conservation is defined as preservation. The Merriam-Webster Dictionary, 1974 ed., s.v. "Conservation"

2.0 Energy Costs, Consumption, and Management in Office Buildings

2.1 Energy Costs in Office Buildings

The Building Owners and Managers Association (BOMA) reported that, on average, energy costs were the second largest expense in office buildings in 1985, in both Canada and the United States[3]. Figure 1 illustrates the expense categories in office buildings.

Figure 1. Relative Operating Expenses in Office Buildings



Source: (BOMA, 1986)

The utility costs reported in the BOMA report include water and sewer, which tend to be relatively small. Therefore, for general use purposes, the utilities category may be considered to be energy. The actual revenues and expenses for a sub-sample of the above noted BOMA survey were reported to be :

	CANADA		U.S.A.	
1985 $/square foot	**Median**	**Average**	**Median**	**Average**
Revenues	$12.44	$15.26	$11.68	$14.17
Utilities	**$1.44**	**$1.38**	**$1.64**	**$1.85**
Total Operating Expenses	$4.35	$4.18	$4.35	$5.21
Total Operating + Fixed Exp.	$6.58	$6.94	$5.74	$7.38

NOTE : Canadian figures in Canadian dollars, U.S. figures in U.S. dollars

Canada private sector : 108 office buildings - 27.9 million square feet
Source: (BOMA, 1986), pg 277 - Data for 1985
U.S. private sector : 2287 office buildings - 437.4 million square feet
Source: (BOMA, 1986), pg 165 - Data for 1985

In 1985, as a percentage of the average total *operating* expense in office buildings (excluding fixed costs and leasing costs), the average utility cost was 33% in Canada and 36% in the United States. In Canada, the relative size of energy costs has increased from 27% in 1981.

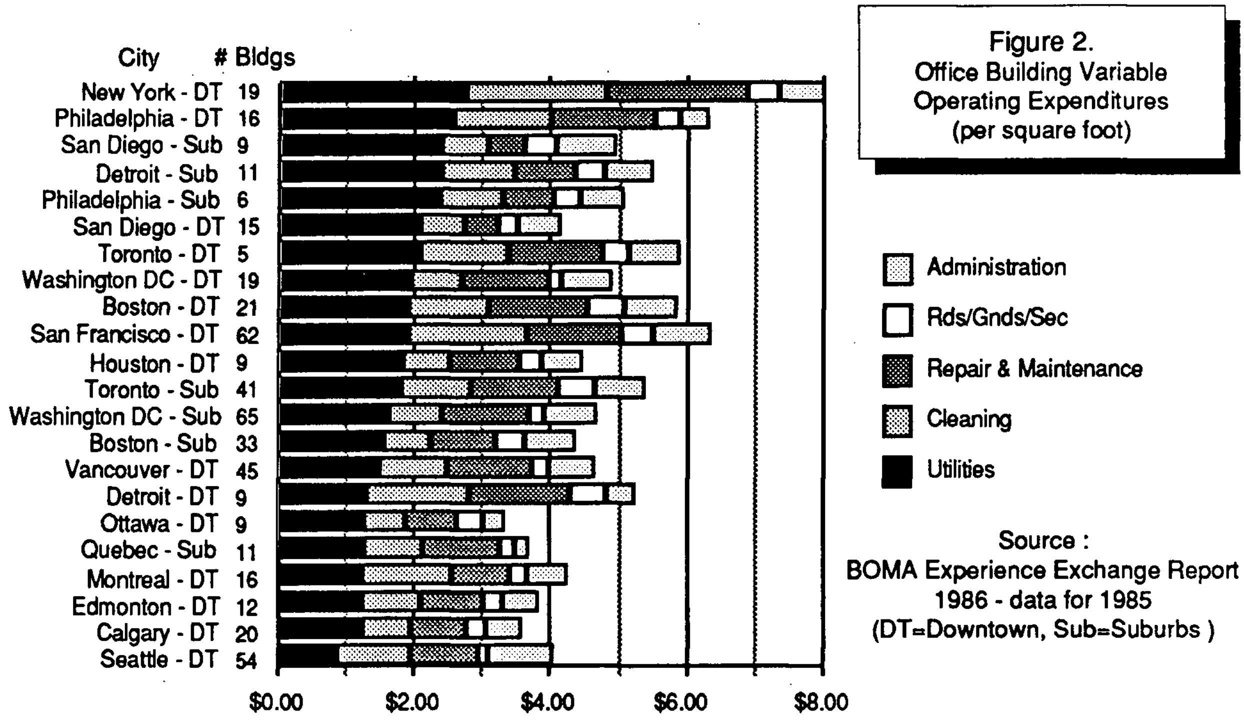


Figure 2.
Office Building Variable
Operating Expenditures
(per square foot)

(Costs for American cities in U.S. dollars, costs for Canadian cities in Canadian dollars.)

Figure 2 illustrates average operating expenditures for office buildings in specific cities across North America. Note that the chart is not equally area-weighted for each city (i.e. average costs for some cities are calculated with data from more buildings and greater floor areas.)

Figure 3 presents this same data as percentages of each $100 of operating cost expenditure. The motivation for

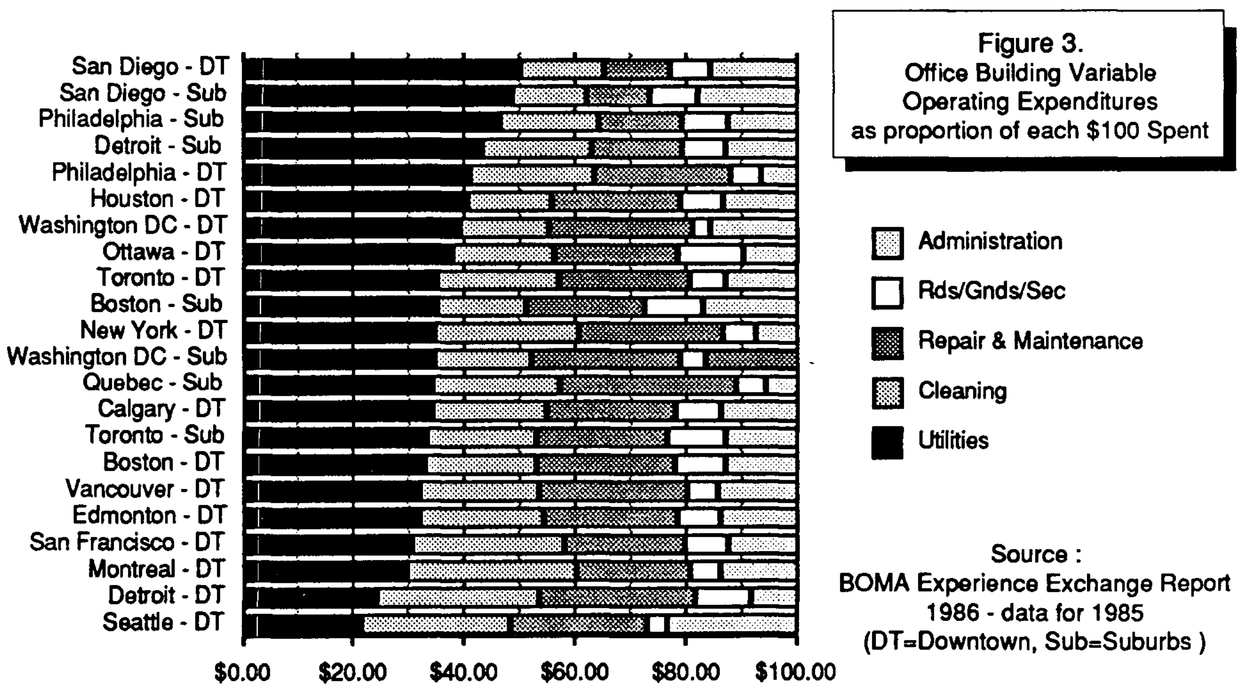


Figure 3.
Office Building Variable
Operating Expenditures
as proportion of each $100 Spent

(Costs for American cities in U.S. dollars, costs for Canadian cities in Canadian dollars.)

implementing energy management projects will be dependent on both the absolute cost and the relative magnitude of the energy costs. For instance, in San Diego, for the buildings reported, energy costs represented 50% of the total operating cost. There is a greater incentive to control energy costs than, say, cleaning expenses. Conversely, the properties in Montreal, Edmonton, Vancouver and Seattle have lower incentives to save energy due to lower utility unit costs, even though the energy use per unit area (kWh/ft^2) may be high. (In 1985, San Diego had the highest cost per unit energy in the U.S.[4])

The relative size of energy expenses and revenues also differs between suburban and downtown office buildings. The data in the BOMA report showed the downtown office buildings generated *more* revenue than the suburban offices and, in Canada, the downtown office buildings had *lower* relative energy costs than the suburban office buildings.

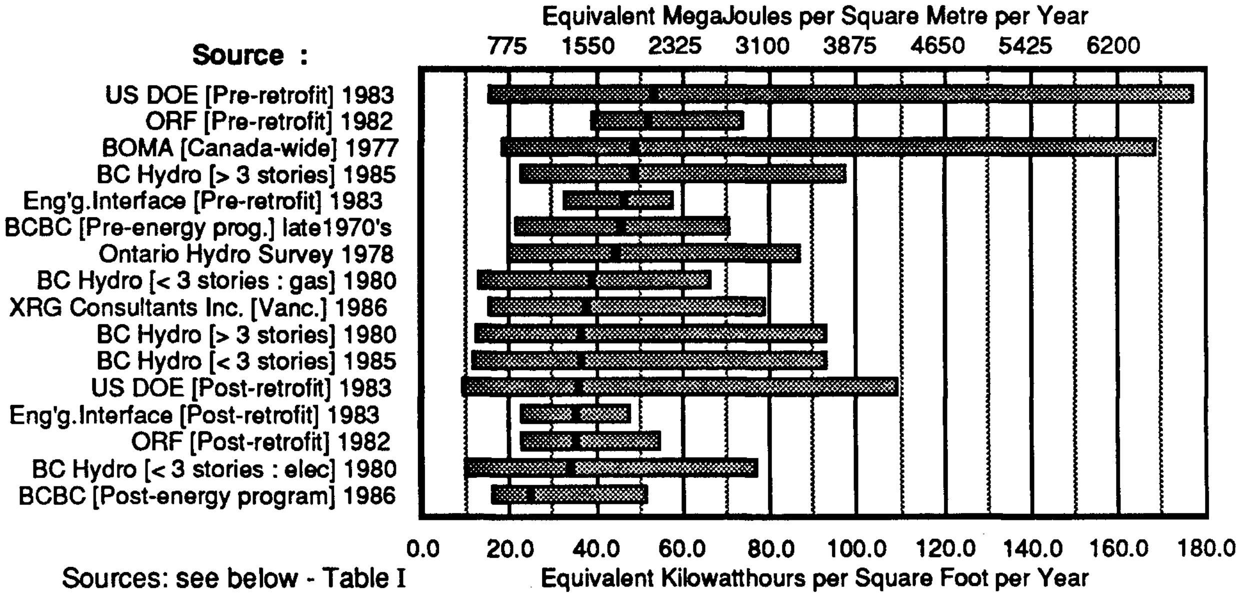
	Canada (Can. $)		United States (U.S. $)	
1985 Revenue :	# Bldgs		# Bldgs	
Downtown	90	$15.65	1022	$14.96
Suburban	18	$11.77	1264	$12.49
1985 Utility Expense :				
Downtown		$1.35		$1.95
Suburban		$1.58		$1.62

Source: (BOMA, 1986) pp. 165 and 277

2.2 Energy Consumption in Office Buildings

Energy use per unit area[5] varies dramatically between office buildings. Studies have found energy use in office buildings ranged from a low of 9.8 EkWh/ft^2 (380 MJ/m^2) to a high of 169.0 EkWh/ft^2 (6549 MJ/m^2)[6]. These findings are summarized in Figure 4. The number of buildings and average size in each study is noted in table I.

Figure 4. Office Building Energy Consumption per Unit Area
EkWh / sf : (Minimum, Average, Maximum)



Sources: see below - Table I

Table I. Data for Figure 4 - Energy Consumption per Unit Area

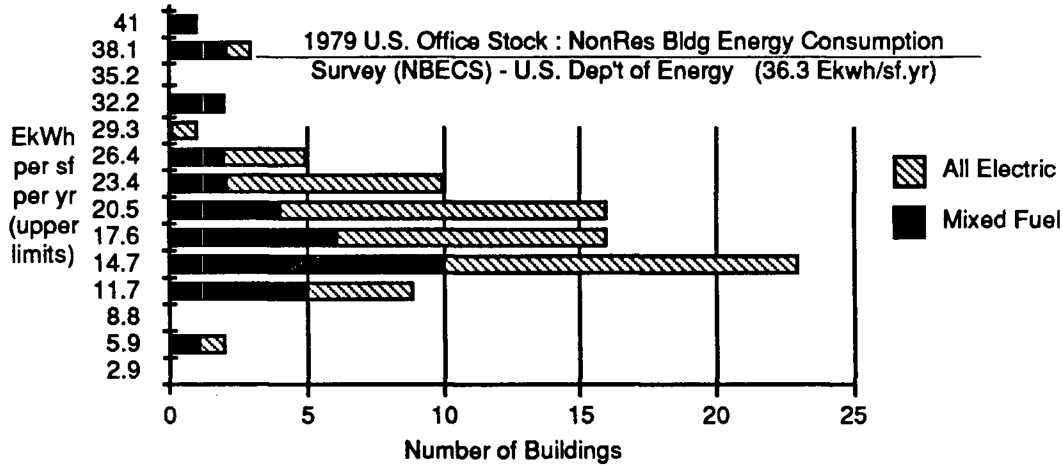
# Bldgs	Avg ft²	Study	Year	Low	Average	High
				<—EkWh/ ft²—>		
35	50,725	BCBC [Post-energy program]	1986	15.1	24.6	51.7
35		BC Hydro [< 3 stories : elec]	1980	9.0	33.8	77.4
9	266,221	ORF [Post-retrofit]	1982	22.0	35.0	55.0
3	679,333	Eng'g.Interface [Post-retrofit]	1983	21.8	35.3	48.2
26	625,846	US DOE [Post-retrofit]	1983	8.4	35.9	109.1
28	14,400	BC Hydro [< 3 stories]	1985	11.1	36.1	93.0
27	107,250	BC Hydro [> 3 stories]	1980	11.6	36.5	93.2
47	175,069	XRG Consultants Inc. [Vanc.]	1986	14.9	37.3	78.7
25		BC Hydro [< 3 stories : gas]	1980	12.4	38.8	66.9
80		Ontario Hydro Survey	1978	19.0	44.4	87.0
35	50,725	BCBC [Pre-energy program]	1970's	20.8	45.6	71.2
3	679,333	Engineering Interface [Pre-retrofit]	1983	31.8	46.2	57.7
19	88,025	BC Hydro [> 3 stories]	1985	22.3	48.6	97.8
		BOMA [Canada-wide]	1977	18.0	48.6	169.0
9	266,221	ORF [Pre-retrofit]	1982	38.0	52.0	74.0
26	625,846	US DOE [Pre-retrofit]	1983	14.7	52.7	177.2

TOTAL Number of Buildings = 407 +

Sources: B.C. Buildings Corp. internal summaries (1986), BC Hydro (1983), BC Hydro internal updates (1987), ORF (1980), Engineering Interface (1983), Ross and Whalen (1983), XRG Consultants Inc. (1986)

Figure 5 illustrates the energy use for 88 selected *new* office buildings in the United States (1982 to 1984) compared with 1979 *average* U.S. office stock energy use levels. The new office buildings show major reductions in energy consumption levels. Higher thermal resistance in walls, higher efficiency heating and cooling systems, computerized control, and daylighting have contributed to these improvements.

Figure 5. U.S. New Office Building Energy Consumption
BECA - CN data base : 1982 - 1984
Total Number of Buildings : 88



(36.3 $EkWh/ft^2$ = 1406 MJ/m^2, 14.7 $EkWh/m^2$= 570 MJ/m^2)

Source: Ross and Whalen (1983)

Correale (1973) found, in a survey of 76 office buildings in New York City, that energy consumption increased with the number of stories in a building. He also found that older buildings used less energy. This fact reversed after 1970, when the newer buildings used less energy. Anderson (1983) found, in a survey of 73 office buildings in Vancouver, B.C., that energy consumption was highly correlated[7] with the existence of underground parking (0.44), the number of stories (0.47), the presence of air conditioning (0.41), and the presence of elevators (0.48). Anderson also found that the age of the building was negatively correlated (-0.32) with energy consumption for buildings constructed prior to 1971, indicating that older buildings used less energy than newer buildings. Anderson also found that this correlation reversed (+0.26) for buildings with major alterations after 1971 or constructed after 1971 - newer buildings used less energy.

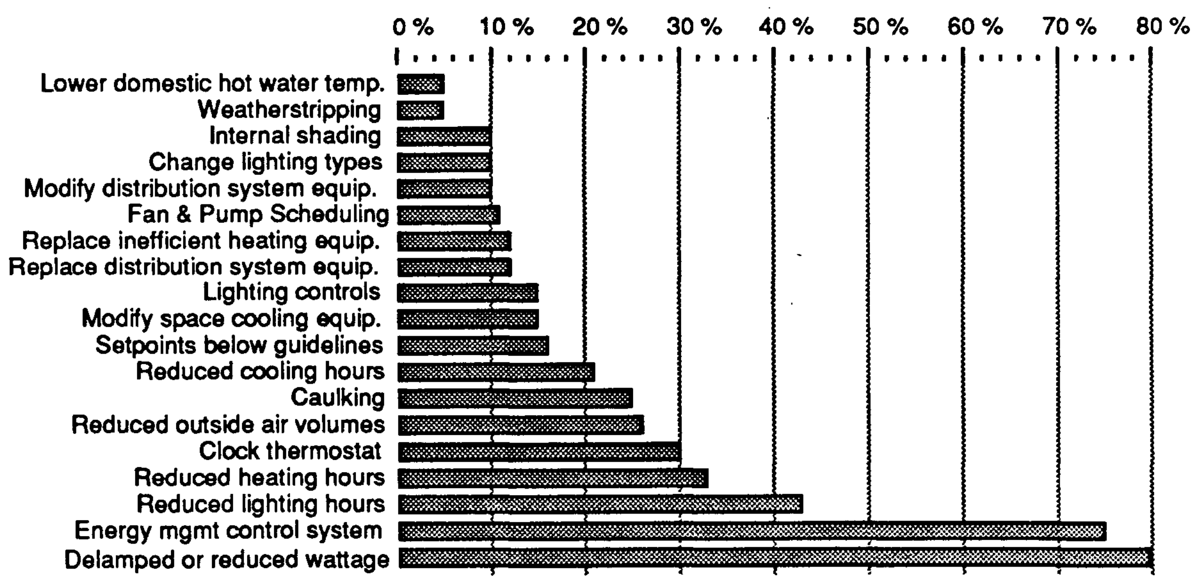
A study commissioned by the National Research Council of Canada found that the hours of work and the work days per year were the most important factors contributing to high energy use in a study of four office buildings.[8] The highest energy user was in Vancouver, at 100 $EkWh/ft^2$, while properties in Edmonton and Saskatoon, cities with much more severe climates, consumed approximately 60 $EkWh/ft^2$. Weather influences are important, but are not necessarily a predominant cause of high energy use.

2.3 Energy Management Projects

Energy management activities may be simple operations and maintenance changes, or sophisticated alterations to building systems. Energy audits of a building will show the potential for savings and the costs to complete each project. Analyzing the costs and benefits of each project will then allow prioritizing. Simple projects, such as reducing operating hours, changing temperature setpoints, and delamping (removing unnecessary lighting), are generally low cost or no cost measures. Ross and Whalen (1983) reported that investments of less than \$0.10/ft^2 (1980 \$U.S.) achieved energy savings of 8% to 14%. Mechanical and electrical equipment modifications vary from low cost measures, such as installing timeclocks to shut down fans and turn off lights, to higher cost boiler or air conditioning equipment replacement, heat recovery and computerized control systems. Structural and architectural changes to a building can be of moderate cost, such as weatherstripping, or higher cost investments, such as window replacement or the addition of insulation. Ross and Whalen (1983) noted that major architectural changes can rarely be economically justified on energy savings alone.[9] Greater costs are incurred if changes are made after initial construction. When retrofitting, (improvements made after initial installation), work must conform to tenant needs, access to the building infrastructure is restricted, and old equipment must be removed.

The participation in various energy saving projects for a study group of 214 office buildings across the United States in the period 1973 to 1980 is charted in Figure 6. Delamping or reduced lighting wattage and Energy Management

Figure 6. Per Cent Participation : Energy Conservaton Projects
214 Office Buildings - 1973 to 1980 (most after 1978)
(Penn, Md, Calif, Ill, Mich, Wisc. - USA)



Source: Hittman (1982)

Control Systems had been implemented in 75% to 80% of the buildings studied. Energy management control systems (EMCS or EMS) have had tremendous growth and acceptance in the office building industry. Whereas in 1974 there were fewer than 10 suppliers of these computer based systems, the U.S. industry now has more than 200, according to the Electric Power Research Institute of Palo Alto, California. Booz, Allen & Hamilton, consulting engineers in New York, estimate that the 1987 EMCS market was worth $2.5 billion per year, and is growing at approximately 10% per year.[10]

Investments in energy efficiency should be viewed primarily as investments to reduce operating costs, but should also be viewed as investments in revenue generation. Because reduced energy cost and improved control will be viewed as a benefit by the tenant, an energy management project will increase the probability of acquiring or retaining tenants. During the research for this thesis, it was clear that building owners and managers are concerned about, or at least aware of, energy costs. The reason for completing energy efficiency investments was often related to the need to maintain tenant satisfaction, not because of direct investment returns. But maintaining tenant satisfaction *is* an investment if it prevents having vacant space because operating costs are too high.

While most energy management projects do offer many benefits, not all projects are successful. Ross and Whalen suggested that on-site operator disinterest and a lack of knowledge about building systems were the primary causes for failed energy management projects. This concern was also mentioned in a working paper by the Ontario Research Foundation[11], which reported the views and concerns of 16 individuals (property managers and owners, equipment suppliers and manufacturers, architects, energy consultants, and government officials) from a discussion group on energy conservation in the high-rise office sector. The subject of operator skills and training requirements led to more comment than any other topic. An operator's lack of incentive to save energy was considered to be a problem by the building owners. Progress is not necessarily progress if operators are not educated, kept informed, and trained to new schedules. They, more than anyone, may determine success or failure.[12]

A lack of operator knowledge and skill must be blamed on poor management, not solely on the operators. Information transfer is the key factor in establishing an efficient energy management marketplace. Feedback on system operation is essential for a successful retrofit project.

3 Building Owners and Managers Association International, 1986 Experience Exchange Report : Income/Expense Analysis for Office Buildings, 1250 Eye Street, N.W., Washington, D.C. - p. 7.

4 Energy User News, June 23, 1986 - Vol. 11, No. 25 - See Appendix A for Canadian utility rates.

5 The unit of energy use in this report will be Equivalent kiloWatthour (EkWh) and Equivalent kiloWatthour per square foot (EkWh/sf). The predominant area measurement in the real estate industry is square feet. EkWh is the energy equivalent in kiloWatthours of other energy units, which may be reported in litres (oil), GigaJoules (natural gas), Hundreds of cubic feet (ccf - gas), cubic metres (gas), and pounds of steam.

6 To get MJ/m2 from EkWh/ft2 multiply EkWh/ft2 by 38.75 :
1 kWh/ft2 = 1 kJhr/ft2s • 3600 s/hr • (3.2808 ft/m)2 • 1 MJ/1000 kJ = 38.75 MJ/m2

7 The correlation is given in brackets and ranges between -1 and +1. The closer it is to +1, the greater is said to be the degree of linear association. A positive correlation indicates that, as one variable increases, the other tends to increase as well. A negative correlation implies an increase in one would generally be associated with a decrease in the other.

8 Vinto Engineering Ltd., Study of Energy Consumption of Office Buildings, National Research Council of Canada, 1978, (Unpublished)

9 For more information on energy management projects and opportunities contact the local Hydro office (i.e. BC Hydro and Ontario Hydro) or contact the Canadian Electrical Association, The National Research Council, National Electrical Contractors Association (U.S.), National Electrical Manufacturers Association (U.S.), Energy, Mines & Resources Canada, the U.S. Department of Energy, any University engineering department, or a local energy engineering consulting firm.

10 Richard J. Myers, "Energy Management Market Continues to Heat Up", High Technology, February 1987, p. 40.

11 Ontario Research Foundation, Energy Conservation Implementation in the High-Rise Office Sector : State-of-the-Art and Future Technology Transfer Needs, Energy Mines and Resources Canada - The Buildings Energy Technology Transfer Program (BETT), January, 1984 OR-83-02

12 Jake Klassen, "LifeCycle Cost Effectiveness", Heating, Piping & Air Conditioning, September, 1986, pp. 75-84. At date of printing, Mr. Klassen was the Senior Engineer, Training, Energy Mines and Resources Canada in Ottawa, Ontario.

3.0 Energy Management Investment Decisions

3.1 The Lack of Incentive Problem

The previous chapter showed that utility costs are a major operating expense in office buildings. If the cost of providing energy is so significant, reasons must exist for a lack of involvement in energy management, evidenced by the large variance in the amount of energy consumed in office buildings (see figure 4.) Varying occupancy levels and weather conditions explain only a small portion of this variance. One of the most important reasons for reduced interest in energy management investments in office buildings, and consequent high variance in energy use, is the lack of incentive for office building owners to carry out projects to reduce energy costs.

In office buildings which are tenant occupied, leases are most often triple net contracts, or base year contracts. In a triple-net lease contract, the tenant is responsible for paying:

i) taxes,
ii) operating, maintenance, repair, and service costs, and
iii) utility costs

Base year contracts require the tenant to pay any costs above the base (usually first) year costs. With either of these leases, the owner has no direct financial incentive to invest in energy management because any energy cost savings will immediately benefit only the tenant, not the owner. The owner must keep the building in good physical and operating condition, but the costs to do this are most often not recoverable from the tenants.

The majority of privately owned office buildings have this lack of incentive. In 1985 the IEA Consulting Group[13] estimated the Canadian office stock to be comprised of:

Private rental	78%
Government	20%
Owner occupied	2%

In the study, IEA noted that one of the major obstacles to energy management was, in fact, the standard commercial lease. Participants in a Building Energy Technology Transfer Program (BETT)[11] workshop also echoed this concern. In contrast, the governments of Canada do have a large incentive to reduce energy use in buildings which they own and occupy. According to the Honourable Stewart McInnes, Minister of Public Works -Canada[14] : " Public Works Canada is the largest realty management business in Canada. ...Through our Realty Management Services, we operate and maintain assets worth \$6 billion, including 7700 buildings and leases, totalling 8.9 million m² (96 million ft²)." At a cost approaching \$2/ft² for energy expenses, a small savings is significant.

Two of the owners of the 3 privately owned office buildings analysed in this thesis *were* able to pass the capital costs of the improvements on to the tenants. This was accomplished in two different ways. In one building, most of the improvements were purchased through a lease contract from a finance firm, thereby becoming an operating expense. In the second building, the owner's representatives were able to negotiate an agreement with tenants, whereby all savings would revert to the owner for a period of 3.5 years. Should no savings result, the capital cost would be absorbed by the owner. The solar film installation completed in the third building was expensed over a two year period.

A report by Energy, Mines, and Resources[15] noted that there are advantages to implementing energy management programs in tenant occupied buildings :

i) to make leases more competitive in the marketplace, and
ii) to enhance the building resale value.

This second advantage warrants detailed examination.

3.2 Real Estate Valuation

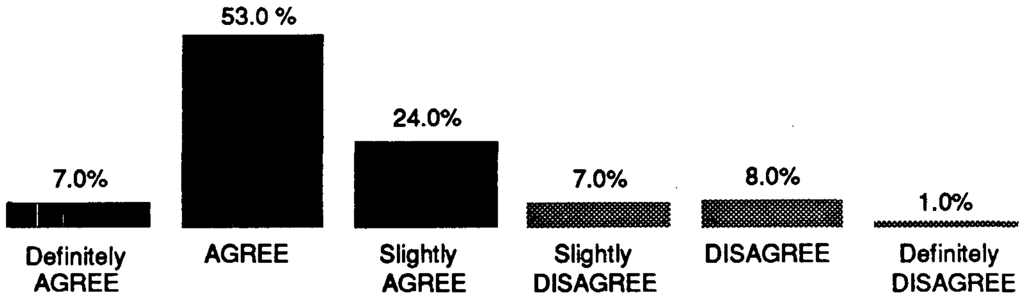
Energy efficiency improvements provide the owner with three forms of economic return: cash flow, tax benefits, and appreciation. (Neglecting the incentive problems for now.) Reduced energy expense increases cash flow, capital improvements shelter taxable income through depreciation, and increased net incomes will increase the resale value of a property.

In his study on energy use in office buildings in Vancouver, B.C., Anderson rejected his central hypothesis that: An increase in the expense of energy consumed by a commercial office building has *the effect of reducing the market value of an office building*. The implication of Anderson's conclusion is that reducing the energy expenses in office buildings does not increase the market value. However, Anderson found that high energy expense was highly correlated with the presence of air conditioning, the number of stories, elevators, and underground parking. Since building value would increase with each of these values (increases in comfort, view, service or amenities, and income), it is expected that higher energy expenses would be statistically associated with higher building value in that sample.

The important question for energy efficiency improvements is whether a reduction in a *specific* building's energy expense has the effect of increasing that buildings value. Figure 7 shows that lenders believe that increased energy efficiency *does* increase property value, however, the survey was taken in the 1970's when rising energy costs were a greater concern.

Office properties, and other income properties, will be valued using the income approach. This approach may include direct capitalization of net incomes or discounting of cash flows. Discounted cash flow techniques are useful

Figure 7. Extent of Lender Agreement that Energy Efficient Non-Residential Income Properties Command Higher Market Values than Comparable Buildings - A survey of 1,721 Lenders



Source: Isakson (1977)

when a direct capitalization rate cannot be obtained from recent market sales activity or when operating revenues are not stabilized and may vary during the holding period.[16]

The direct capitalization of net operating incomes is the paradigm of income valuation techniques. This simple valuation model is :

$$\text{Value} = \frac{\text{Net Operating Income}}{\text{Capitalization Rate}} = \frac{\text{NOI}}{\text{R}}$$

Where NOI = Gross Potential Income plus other revenues
minus vacancy & collection losses
minus operating expenses

This formula is the model of a perpetuity: the present value of a perpetual flow of net incomes, discounted at a constant rate R, the capitalization rate, or CAP rate. The CAP rate, R, is determined from recent sales of comparable market properties.

In owner occupied office buildings, or in those using gross leases, the financial return to an energy management investment would be increased if the property NOI increased by the reduction in energy cost. Consider the following simple illustration. The cost of an energy management project is $100,000 and the simple payback is 2 years. No other costs or benefits resulted. The property is sold at the end of three years with an income capitalization rate, R, of 10%, and the discount rate is 15%.

——— Energy savings ——— Value increase

$$\text{Project NPV} = (-\$100{,}000) + \frac{\$50{,}000}{1.15} + \frac{\$50{,}000}{1.15^2} + \frac{\$50{,}000}{1.15^3} + \frac{(\$50{,}000/10\%)}{1.15^3}$$

$$= \$342{,}919$$

Internal Rate of Return (IRR) = 105 % (with increase in value)
Internal Rate of Return = 24 % (NO increase in value)

The inclusion of the increase in value of the property in the investment analysis boosts the internal rate of return on the energy project from 24% to 105%.

The analysis shown in table II reviewed several incentive alternatives for a specific office building in the northwestern United States. Increases in income were estimated and, based on the owners equity in the office property, the overall rate of return on the ENTIRE real estate investment increased from 24.5% to 35.6% for the single investment in heating efficiency (convertors). The return was based on full capitalization of the energy cost savings into building value.

3.3 The Importance of Operating Costs

Energy cost reductions will not immediately increase the owner's net operating incomes when triple-net leases are used. However, if an office leasing market is efficient, net operating incomes will increase at the time of lease renewal. The following example will illustrate: (Each cost is tenant paid dollars per square foot)

Option	Triple-Net Rent	Operating expense	Total
A	$\$15^{00}$	$\$9^{00}$	$\$24^{00}$
B	$\$15^{00}$	$\$8^{00}$	$\$23^{00}$
C	$\$16^{00}$	$\$8^{00}$	$\$24^{00}$

All other considerations being equal, a firm requiring office space would prefer option B, at $\$23^{00}$/sf total space cost. A tenant renewing a lease should be indifferent between option A and option C at $\$24^{00}$/sf. If the energy costs were reduced by $\$1^{00}$/sf, and this reduction is stable, then the lease income of the property should increase when leases are renewed. But, is this realistic?

The second hypothesis of this thesis, that tenants are concerned about the total cost of their space, not just the lease rental payments, is tested using data from office buildings in the metropolitan Vancouver area. In order to assess the liklihood of translating energy cost savings into increased lease revenues, data were obtained for 140 office buildings as follows:

	# in CLASS				AREA ft²		
MARKET AREA	A	B	C		LOW	AVG	HIGH
Vancouver Downtown	24	33	22	: 79	20,000	149,435	578,844
Vancouver Broadway	10	11	5	: 26	18,000	56,615	132,000
Burnaby	4	9	14	: 27	11,120	50,538	110,000
North Shore	4	3	1	: 8	14,000	35,779	68,000
			Total	140			

Source: Royal LePage, Commercial Real Estate Services, Vancouver, B.C.

Table II. Northeastern U.S. High Rise Office Building
Five years after retrofit

Retrofit Option	1975 cost	% Energy Saved	Building Investment Profit - (non discounted): Policy Alternatives for Energy Management Projects			
			Existing Law	15% tax credit	3 year writeoff	7.5 % debt on 90%
NO RETROFIT			**$7,735,000**	–	–	–
Water heating	$3,500	2.9%	$7,934,000	$7,934,000	$7,934,000	$7,933,000
Fan Pulleys	$1,500	0.1%	$7,743,000	$7,743,000	$7,743,000	$7,743,000
Convertor	$24,000	17.1%	$8,902,000	$8,906,000	$8,904,000	$8,899,000
Thermopane	$614,000	11.5%	$8,165,000	$8,257,000	$8,223,000	$8,081,000
All Measures	$643,000	31.6%	$9,536,000	$9,632,000	$9,596,000	$9,448,000

Retrofit Option	Discounted After Tax Rate of Return (entire Building)			
	Existing Law	15% tax credit	3 year writeoff	7.5 % debt on 90% cost
NO RETROFIT	24.5%			
Water heating	24.7%	24.7%	24.7%	24.7%
Fan Pulleys	24.5%	24.5%	24.5%	24.5%
Convertor	25.6%	25.6%	25.6%	35.6%
Thermopane	24.2%	24.4%	24.4%	24.8%
All Measures	25.5%	25.7%	25.7%	26.1%

Building statistics :

Built in 1970 for $27,000,000
770,000 gross sq.ft.
No. of stories = 40
Pre-retrofit Electricity costs = $341,000
Pre-retrofit Steam costs = $374,000
Pre-retrofit Water & Sewage = $15,000
Energy Cost = $ 0.95 / gross sq.ft.

Investment Profits INCLUDE value increases in building due to increased NOI (Assumed CAPitalization rate = 10 %)
Entire retrofit cost borne by owner
Savings shared between tenant and owner
Equipment written off over 8 years
50 % tax rate assumed

Source : U.S. Deparment of Commerce
Commercial Space : Policy Analysis of Profitability of Retrofit for Energy Conservation
Metrostudy Corp., Washington, D.C., June, 1976
Prepared for : Federal Energy Administration, Washington, D.C., Office of Energy Conservation and Environment.
National Technical Information Service : PB-269 189

The available data relating to each of these properties was limited to the following variables :

Class (A, B, or C)	Year built
Taxes + operating expenses ($/ft²/yr)	Number of floors
Triple Net rent (asked) ($/ft²/yr)	Total building area (ft²)
Location	Total vacant area (ft²)
Retrofit occurance (usually architectural) (1-0)	Number of parking stalls

Other variables which were not available but would influence the level of the rent are:

Number of elevators	Existence of air conditioning
View characteristics	More specific location variables
Actual effective rents	

A statistical regression analysis was completed to estimate an equation for the rents tenants pay for their office space. The value a tenant places on office space can be proxied by either the triple net rent paid or by the gross cost of the space (triple net rent plus operating expenses). Each amenity provided to the tenant will contribute to the value placed on the space. An equation can be modelled whereby each amenity is given some weight, or portion of the price paid. The model equations tested were :

A: Triple Net Rent (TNR) $= \text{constant} + \beta_1*(\text{amenity}_1) + \beta_2*(\text{amenity}_2) + ... + \beta_n*(\text{amenity}_n)$

B: TNR + Operating Costs $= \text{constant} + \beta_1*(\text{amenity}_1) + \beta_2*(\text{amenity}_2) + ... + \beta_n*(\text{amenity}_n)$

The strength of each model is compared to determine which rent is better estimated by the amenities provided with the office space. If the gross rents prove to be more important to a tenant, then it follows that a reduction of operating costs could be coupled with an increase in triple net rents. Thus a reduction in energy expense could follow with an increase in lease revenues which, when capitalized, would generate much greater returns to an owner of an office building with triple net rents. (Where a lack of incentive to invest exists.) The objective of the first test is to determine the best proxy for the value that tenants place on the amenities provided in office space - TNR or Gross rents. The models were tested using regression techniques, which provide least squares estimates of the β parameters. The statistics which give an indication of fit of a model are the R-Square and the F-Value:

R-Square : Measures the proportionate reduction of total variation in the dependent variable (TNR or Gross rent) associated with the use of the set of independent variables (amenity_1 - amenity_n.) Because the R-Square cannot decrease as more variables are added to a model (the better one can fit the data and the smaller are the deviations around the fitted regression line), an adjusted R-square is used to take into account the number of parameters in the model.

F-Value : A test statistic used to evaluate the hypothesis that all parameter estimates are zero. The larger the value, the greater the goodness of fit of the model.

In this first test, the strength of each model is the key concern, not the accuracy, level, or sign of the coefficients. However, the credibility and fit of the models is also indicated by the t-statistic (t*) for each parameter estimate. The t* is the ratio:

$$t^* = \frac{\text{parameter estimate}}{\text{standard error of the estimate}}$$

This ratio gives an indication of the accuracy of the parameter estimate. A t* value of about 2 (significance of the t-valuevaries with number of observations) allows a 95% confidence that the estimate is not zero. The larger the t*, the greater the confidence.

A second test was completed to determine the effect of operating costs on triple net rents. Model A was used and taxes+operating costs were included as an amenity. The expected sign of the parameter estimate for taxes+operating cost is negative - higher operating costs would reduce TNR a tenant would be willing to pay.

3.4 Results of Regression Modelling

Table III shows the results of the regression modelling.

Table III. Results of Regression Modelling

Dependent Variable :		GROSS RENTS		<----- TRIPLE NET RENTS		----->	
	Variable Type	Parameter Estimate	t*	Parameter Estimate	t*	Parameter Estimate	t*
Intercept		11.81	**8.82** °	7.24	**6.03** °	5.63	**3.53** °
Class A	1 - 0	5.88	**7.04** °	4.69	**6.26** °	4.26	**5.37** °
Class B	1 - 0	2.48	**3.91** °	1.82	**3.20** °	1.58	**2.70** °
Area + 600,000	sf/600,000	11.86	**3.47** °	10.80	**3.53** °	10.43	**3.41** °
Vancouver	1 - 0	3.20	**2.78** °	0.95	0.92	0.15	0.14
Burnaby	1 - 0	-0.95	-0.85	-1.47	-1.47	-1.65	**-1.65**
Broadway	1 - 0	0.79	0.73	-0.28	-0.28	-0.65	-0.65
# of Floors	#	-0.04	-0.49	-0.07	-0.89	-0.07	-1.02
Age	yrs	-0.05	**-2.68** °	-0.05	**-2.75** °	-0.04	**-2.67** °
Parking	1 - 0	1.96	**2.41** °	1.44	**1.98**	1.26	**1.71**
Retrofit**	1 - 0	2.18	**2.07**	3.20	**3.39** °	3.56	**3.68** °
% Vacancy	%	1.94	1.48	1.97	**1.67**	1.98	**1.69**
Taxes+Operating Costs	$/sf					0.35	1.52
R Square		**0.79**		**0.74**		**0.74**	
Adjusted R Square		**0.77**		**0.72**		**0.72**	
F Value		**44.29**		**32.91**		**30.67**	

** The retrofit variable (1-0) was not detailed, and may be architectural only.
Bolded t* indicates significance at 5% level, **Bolded** ° indicates significance at 1% level. The R-Square and F Value are improved when GROSS rents replace TRIPLE NET rents as the dependent variable. The results in the right two columns show the effect of taxes & operating costs. The variable is not significant at the 5% level.

The t-statistics for most parameter estimates, the R-Square, and the F-Value improved greatly when Gross rents were substituted in place of Triple Net rents.

Tenant inducements, free rent periods, rental credits and abatements, and other hidden perquisites were prevalent in 1987 for the office leasing market, but were not available for this study. Each of these would affect the accuracy of using contract rent levels as an indicator of the cost of office space to a tenant. Also, the only lease rate information available were asking prices for vacant space in office buildings, not actual tenant rents. However, these rents will be the comparison rents when existing office tenants search for new space.

Unfortunately, a conclusion about which rent, TNR or Gross, reflects the VALUE of the office space is not possible with these data. There is no available variable which accurately reflects the true value of the office space, and, hence no possibility of comparison. The improved R-Square and F-Value show only that the reduction in the variation of *gross rents* across 140 office buildings is greater than that of *triple net rents* with the amenities included in the model. In other words, for this analysis, the variables and regresson coefficients combine to estimate the gross rents more accurately than they estimate the triple net rents. It is not the case that the gross rents estimate the value of the space - it is not known what the true value of the office space is. As a result, no firm conclusion can be drawn about the validity of the second hypothesis - a tenant is more concerned about total costs than triple net rental costs. The statement is intuitively appealing, but is herein strictly unproven, though supported by the improvements in model accuracies when gross rents were used.

The second test was completed to determine the effect of operating costs (including taxes) on triple net rent levels. Figures 8a and 8b show the triple net rents and operating costs for the 140 buildings in the analysis.

One statistic which will be important for this second test is the correlation between variables. The correlation is a measure of the relationship between variables. For example, area will be positively correlated with the number of floors in a building - with more floors there will generally be greater area. The correlation will range from -1.0 to +1.0, where +1.0 is perfect positive correlation. When independent variables are correlated, the regression coefficient of any independent variable depends on which other independent variables are included in the model and which ones are left out. Thus, a regression coefficient (parameter estimate) reflects only a marginal or partial effect on the dependent variable (rent), given whatever other correlated independent variables are included in the model.[17]

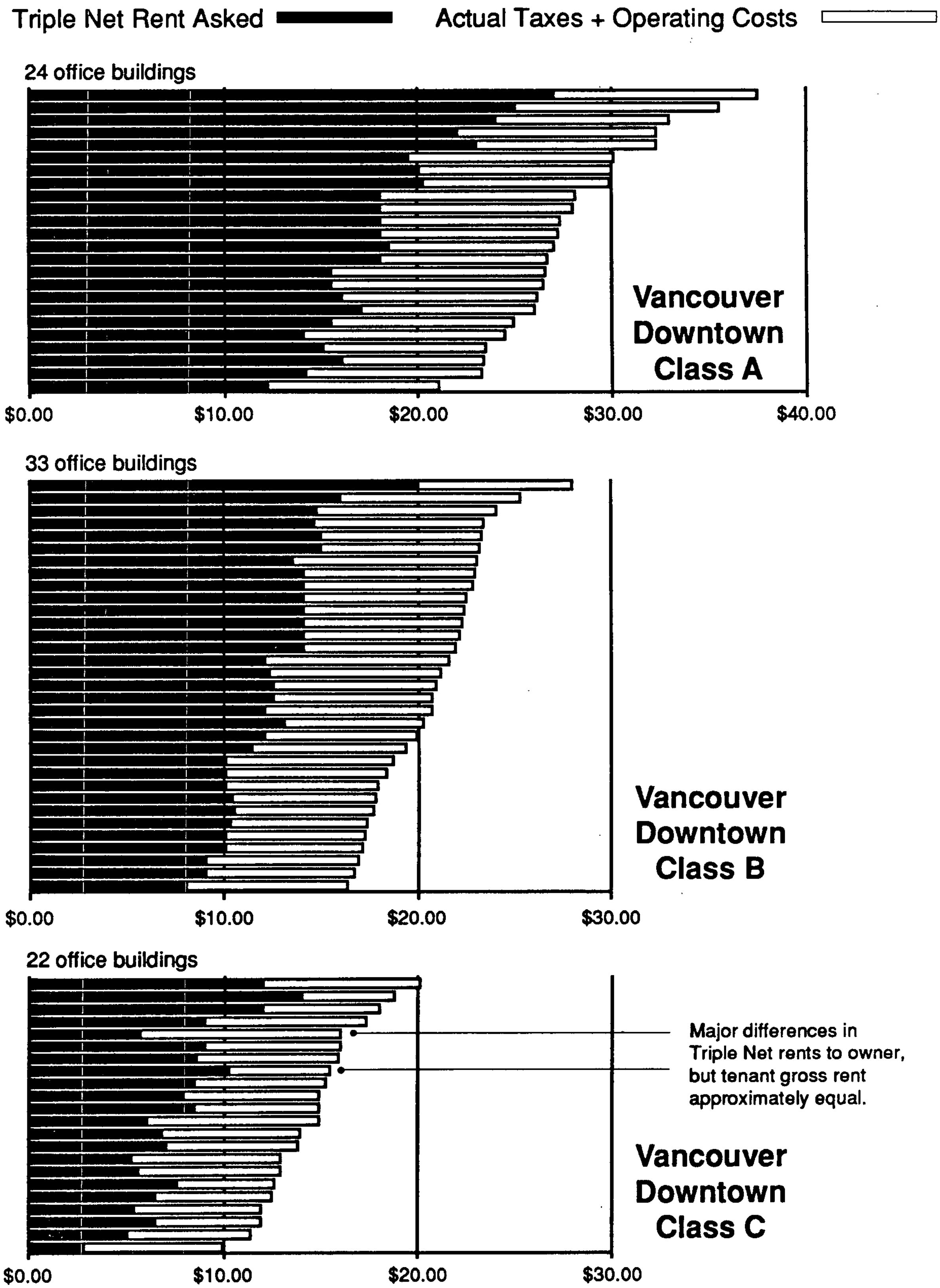
Table IV lists the correlations between each of the variables. In each case of strong correlation, the sign of the correlation (+/-) is as expected. TNR had strong positive correlations with taxes+operating expenses, # floors, existence of parking, area, and Vancouver class A. TNR also had a strong negative correlation with Vancouver class C. The

Table IV : Pearson Correlation Coefficients

	#	TaxOp	TNR	# Flrs	Refit	Prkg	Area	%Vac	Age	AVan	BVan	CVan	ABdwy	BBdwy	CBdwy	ABurn	BBurn	CBurn	ANShr	BNShr
Taxes + Op Costs	140	**1.00**																		
		0.00																		
Triple Net Rent	140	**0.60**	**1.00**																	
		0.00	*0.00*																	
# Floors	140	**0.72**	**0.61**	**1.00**																
		0.00	*0.00*	*0.00*																
Retrofit (1-0)	140	-0.20	0.07	-0.09	**1.00**															
		0.02	*0.40*	*0.27*	*0.00*															
Parking (1-0)	140	0.15	**0.40**	0.09	0.01	**1.00**														
		0.08	*0.00*	*0.30*	*0.92*	*0.00*														
Area sf	140	**0.67**	**0.67**	**0.92**	-0.10	0.19	**1.00**													
		0.00	*0.00*	*0.00*	*0.24*	*0.03*	*0.00*													
% Vacancy	140	-0.14	0.04	-0.24	0.11	0.18	-0.23	**1.00**												
		0.09	*0.67*	*0.00*	*0.20*	*0.03*	*0.01*	*0.00*												
Age of Building	140	-0.16	-0.40	-0.11	0.19	**-0.52**	-0.16	-0.18	**1.00**											
		0.05	*0.00*	*0.19*	*0.02*	*0.00*	*0.05*	*0.03*	*0.00*											
Class A Vancouver	24	**0.62**	**0.68**	**0.74**	-0.02	0.20	**0.78**	-0.20	-0.17	**1.00**										
		0.00	*0.00*	*0.00*	*0.84*	*0.02*	*0.00*	*0.02*	*0.05*	*0.00*										
Class B Vancouver	33	0.28	0.07	0.13	-0.05	0.01	0.01	0.12	-0.05	-0.25	**1.00**									
		0.00	*0.42*	*0.12*	*0.56*	*0.92*	*0.92*	*0.15*	*0.56*	*0.00*	*0.00*									
Class C Vancouver	22	-0.17	**-0.42**	-0.11	0.17	**-0.62**	-0.21	-0.04	**0.58**	-0.20	-0.24	**1.00**								
		0.05	*0.00*	*0.20*	*0.04*	*0.00*	*0.01*	*0.63*	*0.00*	*0.02*	*0.00*	*0.00*								
Class A Broadway	10	0.01	0.13	-0.13	-0.06	0.12	-0.07	0.03	-0.13	-0.13	-0.15	-0.12	**1.00**							
		0.90	*0.13*	*0.11*	*0.46*	*0.16*	*0.41*	*0.74*	*0.12*	*0.14*	*0.07*	*0.16*	*0.00*							
Class B Broadway	11	-0.11	-0.10	-0.16	-0.07	0.13	-0.16	-0.10	-0.06	-0.13	-0.16	-0.13	-0.08	**1.00**						
		0.20	*0.26*	*0.07*	*0.43*	*0.14*	*0.05*	*0.25*	*0.52*	*0.12*	*0.06*	*0.14*	*0.34*	*0.00*						
Class C Broadway	5	-0.17	-0.18	-0.17	-0.04	-0.13	-0.15	-0.05	0.01	-0.09	-0.11	-0.08	-0.05	-0.06	**1.00**					
		0.05	*0.04*	*0.04*	*0.60*	*0.13*	*0.08*	*0.54*	*0.86*	*0.30*	*0.21*	*0.33*	*0.53*	*0.51*	*0.00*					
Class A Burnaby	4	-0.12	-0.02	-0.02	-0.04	0.07	-0.01	-0.05	-0.12	-0.08	-0.10	-0.07	-0.05	-0.05	-0.03	**1.00**				
		0.15	*0.84*	*0.84*	*0.64*	*0.38*	*0.88*	*0.59*	*0.17*	*0.36*	*0.26*	*0.38*	*0.58*	*0.56*	*0.70*	*0.00*				
Class B Burnaby	9	-0.14	-0.17	-0.21	-0.06	0.11	-0.10	-0.08	-0.07	-0.12	-0.15	-0.11	-0.07	-0.08	-0.05	-0.04	**1.00**			
		0.10	*0.05*	*0.01*	*0.48*	*0.18*	*0.24*	*0.35*	*0.43*	*0.16*	*0.09*	*0.18*	*0.39*	*0.37*	*0.55*	*0.60*	*0.00*			
Class C Burnaby	14	-0.39	-0.25	-0.28	0.03	0.14	-0.22	0.14	-0.02	-0.15	-0.19	-0.14	-0.09	-0.10	-0.06	-0.06	-0.09	**1.00**		
		0.00	*0.00*	*0.00*	*0.70*	*0.09*	*0.01*	*0.11*	*0.77*	*0.07*	*0.03*	*0.09*	*0.28*	*0.25*	*0.45*	*0.50*	*0.30*	*0.00*		
Class A North Shore	4	-0.09	0.11	-0.13	-0.04	0.07	-0.10	0.25	-0.14	-0.08	-0.10	-0.07	-0.05	-0.05	-0.03	-0.03	-0.04	-0.06	**1.00**	
		0.27	*0.20*	*0.11*	*0.64*	*0.38*	*0.23*	*0.00*	*0.10*	*0.36*	*0.26*	*0.38*	*0.58*	*0.56*	*0.70*	*0.73*	*0.60*	*0.50*	*0.00*	
Class B North Shore	3	-0.22	0.01	-0.14	0.19	0.06	-0.11	0.03	-0.08	-0.07	-0.08	-0.06	-0.04	-0.04	-0.03	-0.03	-0.04	-0.05	-0.03	**1.00**
		0.01	*0.93*	*0.10*	*0.02*	*0.45*	*0.18*	*0.72*	*0.36*	*0.43*	*0.33*	*0.45*	*0.63*	*0.61*	*0.74*	*0.77*	*0.65*	*0.56*	*0.77*	*0.00*
Class C North Shore	1																			

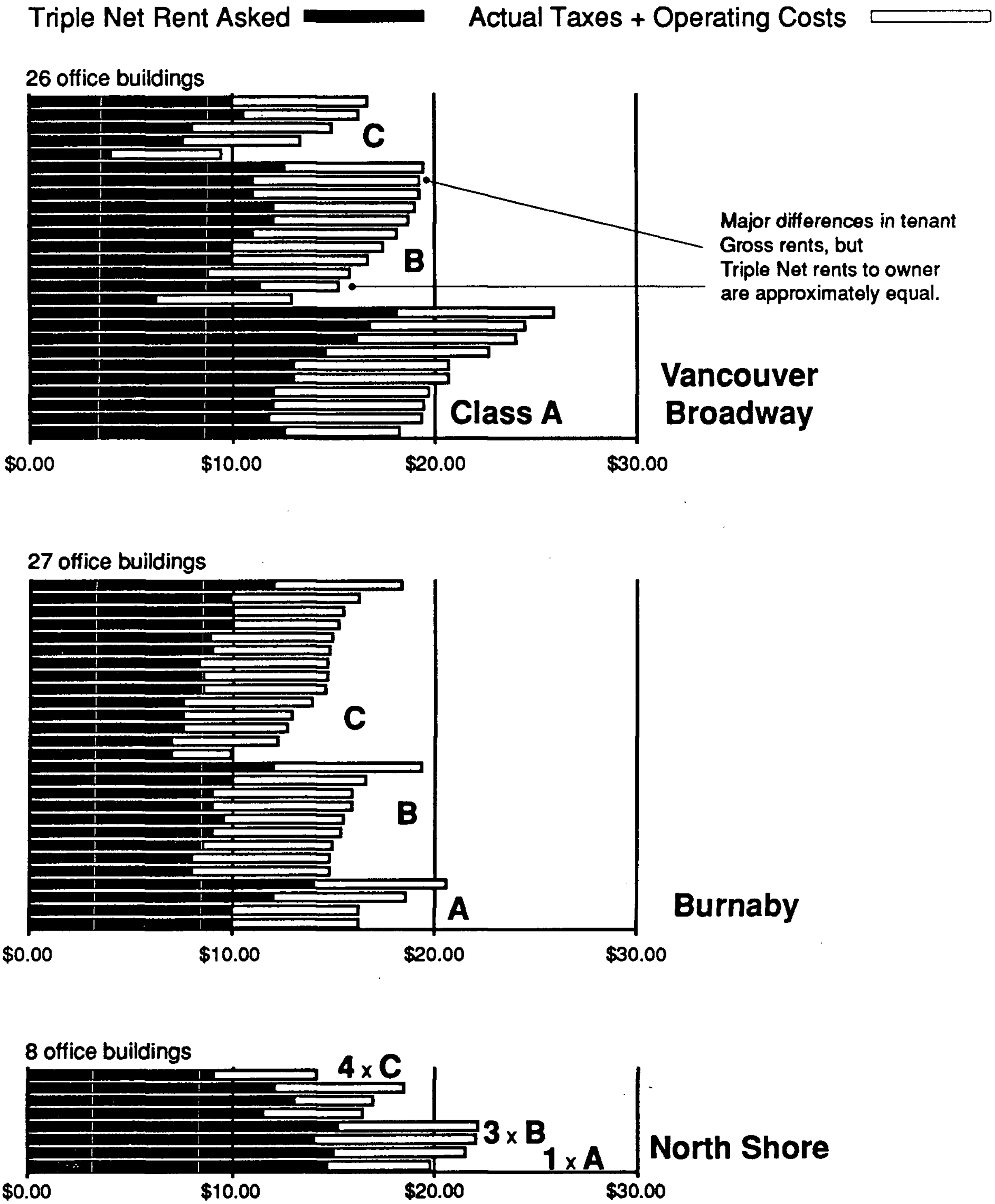
Bold : Correlation > 0.40
Italic : Probability that correlation = 0.0
Total number of Office Buildings = 140

Figure 8a. Metropolitan Vancouver, B.C.
Office Rents and Operating Costs - 1987



Source: Royal LePage, Commercial Real Estate Services, Vancouver, B.C.

Figure 8b. Metropolitan Vancouver, B.C.
Office Rents and Operating Costs - 1987



Source: Royal LePage, Commercial Real Estate Services, Vancouver, B.C.

variable 'taxes+operating expenses' was strongly correlated with # floors, area, and Vancouver class A, again as Anderson shared earlier. There is thus some a priori expectation of a *positive* parameter estimate for taxes+operating costs due to the effect of the positive correlation with value adding variables. One would expect lower acceptable rent levels -a *negative* sign on the coefficient - if operating costs were abnormally high, relative to other properties with similar amenities.

Using all 140 observations, the taxes+operating costs variable had a positive coefficient in the model. This was expected due to the correlations cited above. The location, class, size of building, age, parking and retrofit variables emerged as significant. The existence of a retrofit (unspecified as to type of retrofit - architectural and/or mechanical) was significant and had a coefficient of +3.56 $/sf (t*=3.68). Retrofit was also negatively correlated with taxes+operating costs (-0.20). Although the correlation is not strong, the probability of it being zero was only 2%. Also, triple net rents were higher by $3.56/sf but gross rents were higher by only $2.18/sf. This shows that retrofitted buildings had lower operating costs and higher triple net rents than comparable properties.

Figures 8a and 8b showed that few properties had taxes+operating costs out of line, relative to rents, with market averages. This fact is important because an expected negative coefficient would only occur if a significant variance in relative operating costs existed. Several office buildings in Vancouver C class and Broadway did have low triple net rents and high taxes+operating costs. These two market areas were tested alone in a regression, but the result were poor. The adjusted R-Squares were less than 0.10, indicating almost no explanation of the variation in the rents. The taxes+operating costs variable did have a negative coefficient, but had a low significance level with a t* of only -0.81. The available variables and number of observations were not sufficient to accurately model the rent levels. Some offices in the Broadway office district have spectacular views of the city and mountains and this information would be important in estimating rent levels.

The hypothesis that the perceived value of office space is proxied better by gross rents than by triple net rents can not be accepted or refuted. Problems with multicollinearity did not allow firm answers to be provided. The gross rents are better modelled using the amenities, but this leads to no firm conclusions about tenant cost concerns. Also, taxes+operating costs were not significant in estimating triple net rents. The results suggest taxes+operating costs have some influence on rents, but poor results preclude any firm conclusions. Figures 8a and 8b did show that operating costs were fairly consistent across the office properties. This is evidence of an efficient office space market. The variable taxes+operating costs was not significant due to collinearity problems, but also because there were few deviations from the costs which would be expected.

3.5 Translating Energy Cost Savings into Increased Lease Revenues

Given the results of the analysis, it would be unreasonable to proclaim that a savings in energy costs, especially a small savings, would translate into an increase in lease revenues for several reasons:

i) Lease contracts may include perquisites valued at up to $30 to $50 /sf - 3 years rent on a long term contract. Inclusion of a $0.10/sf increase would be insignificant.

ii) A small savings per square foot may be difficult to detect in the presence of changing use and operating conditions.

iii) Tenants would be dubious about a small sustained decrease in energy costs. It could be dismissed as an anomoly.

iv) Changing weather patterns could mask savings so that tenants might be skeptical of owner claims.

V) Leasing representatives concentrate on Triple Net rates with less emphasis on operating costs.

vi) If capital costs *were* passed on to tenants, then tenants would have legitimate complaints concerning an increase in rent levels.

The data analysed in the regression studies are more applicable to businesses searching for space than for existing tenants. Location and visible amenities will be most important when businesses evaluate office space alternatives. However, when a business has been in place, and is satisfied with the space, attention will be focused more on the costs of occupying that space. At that time, the costs of energy and other operating costs paid by a tenant will take on greater importance. A an increase in rent levels with lowered operating costs would then be more likely than in the case of a space search.

An office building owner, or their representative, would negotiate rent levels with a tenant when leases expire. In the negotiations, the fact that operating costs have decreased can be highlighted to show the concern of the owner for the tenants space costs. A positive atmosphere in any negotiation process will lead to greater satisfaction for all parties.

To translate energy cost savings into increased lease revenues, the cost savings would have to be significant and the savings would have to be sustained - a tenant must be confident that costs have lowered before submitting to higher rent levels. If these conditions were met, then the returns to energy efficiency investments would be significantly improved by the increase in value on the property.

A review of empirical savings for energy management projects follows in the next chapter.

13 IEA Consulting Group Ltd., Development and Implementation of a Strategic Plan to Support Savings Financing of Energy Management, Prepared for Energy, Mines, and Resources Canada, May 1985

14 BOMA BC News, June, 1987 - Volume 10, #6.

15 Engineering Interface Limited, Identification of the Energy Conservaton Potential in the Medium to High-Rise Residential and Office Sectors, Task 2.1 Buildings Technology Transfer Program (BETT). A project of the conservaton and Renewable Energy Branch, Energy, Mines, and Resources Canada, Oct. 1982

16 The holding period is the length of time which the real estate investment will be owned by the investor.

17 Neter, J., Wasserman, W., and Kutner, M.H., Applied Linear Statistical Models, Richard D. Irwin, Inc., Homewood, Illinois, 1985 - pg. 277

4.0 Empirical Studies on Energy Management Investments

A survey of existing literature provided only a limited sampling of case studies with sufficient details of energy management project costs and savings. Thirty eight (38) case studies for office buildings located in the U.S.A., Canada, Sweden, and France were identified. The case studies are all for projects completed prior to 1981. Data from an additional nine (9) buildings in Ottawa, Ontario, with actual energy conservation project costs but *estimated* dollar savings, were received from the Manager, Building Resources, Public Works Canada. These sample Public Works projects were completed between 1981 and 1986. Table V summarizes the 47 projects. Appendix B contains summaries of the 47 case studies.

For 38 projects, excluding the Public Works projects, an average energy savings of 27.0% was achieved (23.4% area weighted - in the sample, larger buildings saved more.) Financial rates of return on the projects were not calculated in any of the studies because only one year of savings was reported in most cases. The reported simple paybacks for the projects were less than two (2) years in each of the 22 buildings which reported project costs and dollar savings.

The most extensive study by Ross and Whalen (1983) reported that the reductions in energy use were maintained for the years following the retrofits and were actually reduced further in many cases.

The Public Works projects (9 buildings) had an *estimated* average simple payback of 4.6 years, although it was further *estimated* that the savings were conservatively calculated. Actual savings in energy use were not available for these office buildings.

Before introducing the study buildings and the projects undertaken, a discussion of energy accounting and the effects of weather follows. Correcting energy use to a standard for comparison is necessary to determine energy and cost savings.

Table V. A Survey Of Office Building Energy Management Projects

Study / Source	# Bldgs	Location	Year of Projects	Gross Flr Area (sq.m.)	Gross Flr Area (sq.ft.)	Energy Use (MJ/sq.m.) Initial	Energy Use (MJ/sq.m.) Final	Energy Use (ekWh/sf.) Initial	Energy Use (ekWh/sf.) Final
Ontario Research Foundation (1982)	9	Ontario	< 1979	222,600	2,395,988	1997	1341	51.5	34.6
Engineering Interface (1983)	3	Ontario	1980/81	189,341	2,038,000	1790	1368	46.2	35.3
US Dep't of Energy (1983)	14	USA/Swe	< 1980	592,531	6,377,800	2107	1650	54.4	42.6
US Dep't of Energy (1983)	12	USA/Fr	< 1980	919,205	9,894,000	1686	1225	43.5	31.6
Public Works Canada (1986)	9	Ottawa	1981-86	306,597	3,300,102	n/a	n/a	n/a	n/a
Totals / Averages	47			2,230,274	24,005,891	1862	1383	48.0	35.7
						Excluding public works projects			

Study / Source	Avg % Energy Savings Area Weighted	Avg % Energy Savings Not Weighted	Total Project Cost ($)	Avg Cost $ / sf	Total Savings ($ /yr)	Simple Payback (years)	Note
Ontario Research Foundation (1982)	32.8%	32.0%	$413,000	$0.17	$700,200	0.6	¥
Engineering Interface (1983)	24.9%	24.1%	$1,137,000	$0.56	$810,600	see note	Δ
US Dep't of Energy (1983)	19.1%	24.7%	$2,406,559	$0.38	n/a	≈ 1	Σ
US Dep't of Energy (1983)	23.5%	26.6%	n/a	n/a	n/a	n/a	◊
Public Works Canada (1986)	n/a	n/a	$2,418,935	$0.73	$526,080	4.6	••
Averages	23.4%	27.0%					
	Excluding public works						

NOTES :

¥ Savings and energy use are floor area weighted averages. Projects implemented prior to 1979

Δ The indicated savings were achieved, on average, 4 years after project implementation. Savings in the first years were not provided.

Σ Three (3) of the 14 bldgs were located in Sweden. Dollar savings were not provided. Cost figures were provided on a per square foot basis.

◊ One (1) of the 12 buildings is located in Paris, France. Cost data and dollar savings were not available for these buildings.

•• Savings are estimates of the energy cost savings. Project costs are actual outlays.

For all of the US Dep't of Energy (DOE) case studies, costs were provided in 1980 $.

5.0 Energy Use Accounting

5.1 Monitoring Actual Energy Use

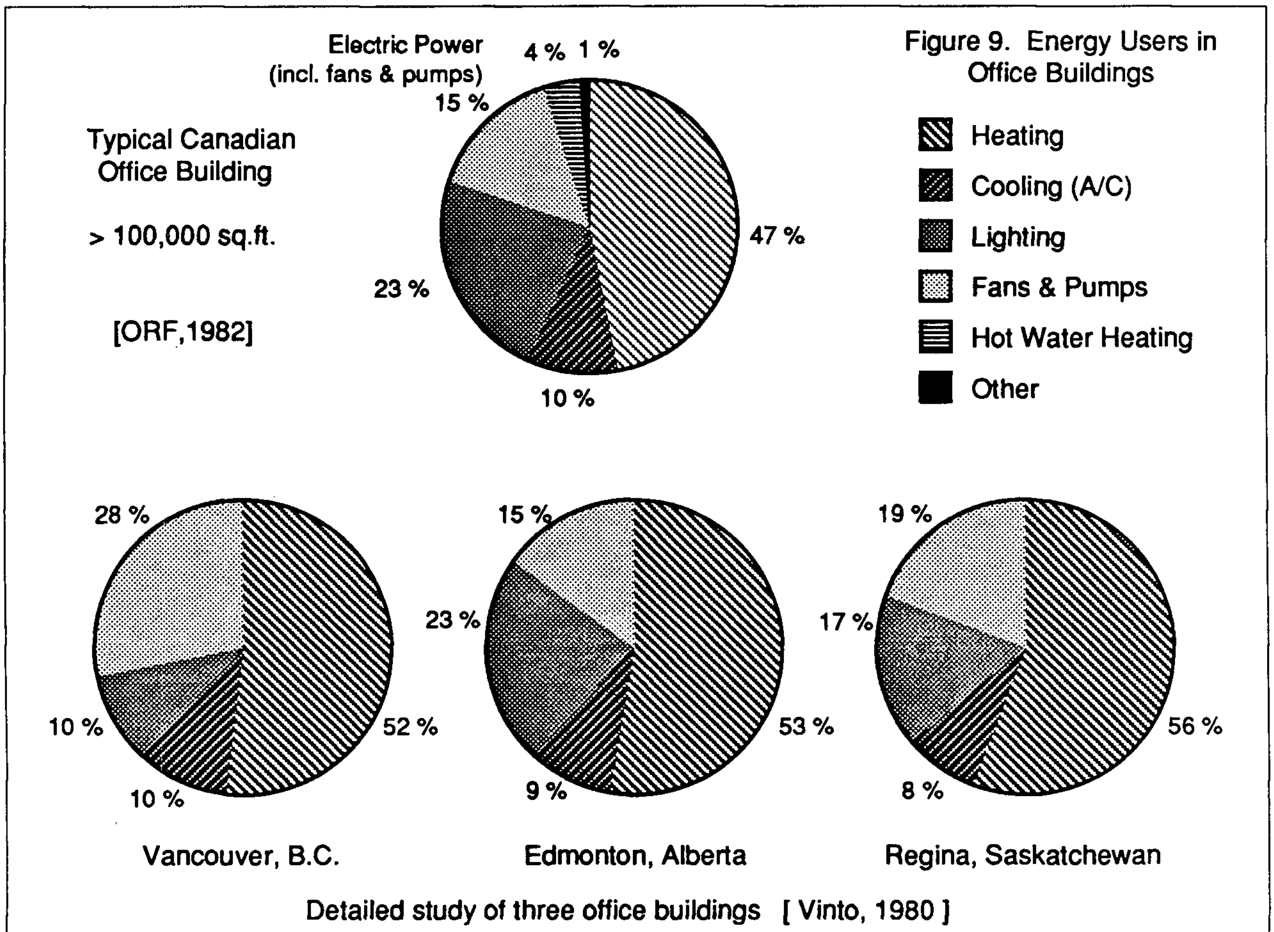
Before and especially after an energy management project has been implemented, monitoring the building energy performance is essential. Monitoring serves three functions: to evaluate progress, to show which measures are cost effective, and to show which measures do not work. The results of completed projects will aid in the prioritization of new investments. Calculating the savings will also be an integral part of energy service contracts and shared savings investments.

Heating, ventilating, and air conditioning accounts for approximately 50% to 60% of the total energy use in a typical office building[18], so weather will have a large effect on energy use in any specific building. But, calculating the savings in energy use is complicated by more than changes in weather. Major influences on energy use in office buildings include: the quality of operations personnel, management's commitment to energy issues, tenant mix and occupancy, hours of operation, weather, lighting load, air conditioning, presence of computers, elevators, orientation to sun and wind, type of heating system (heat transfer by air, water, or water and air), efficiency of systems, age of structure, and levels of insulation.

Vacancy, does not have as clear an effect on energy use as does, say, hours of operation. Depending on the heating and cooling systems, the weather, and on the thermal resistance of exterior walls, an increase in vacancy may actually cause *heating* energy use to increase. Electrical energy used by appliances, equipment, lighting, and computers is converted into heat. People also provide heat to the space. When space is vacant, these heat sources are lost. *Electrical* energy should be reduced with increased vacancy, however, not linearly with the square footage. The operation of fans, pumps and central equipment will continue, with minimal reductions due to vacant space.

The operation of a fully occupied office building may use energy as shown in Figure 9. Some of the energy loads will be sensitive to weather conditions. For office buildings, the components of Figure 10 may derive from one or more of the following energy users[19]:

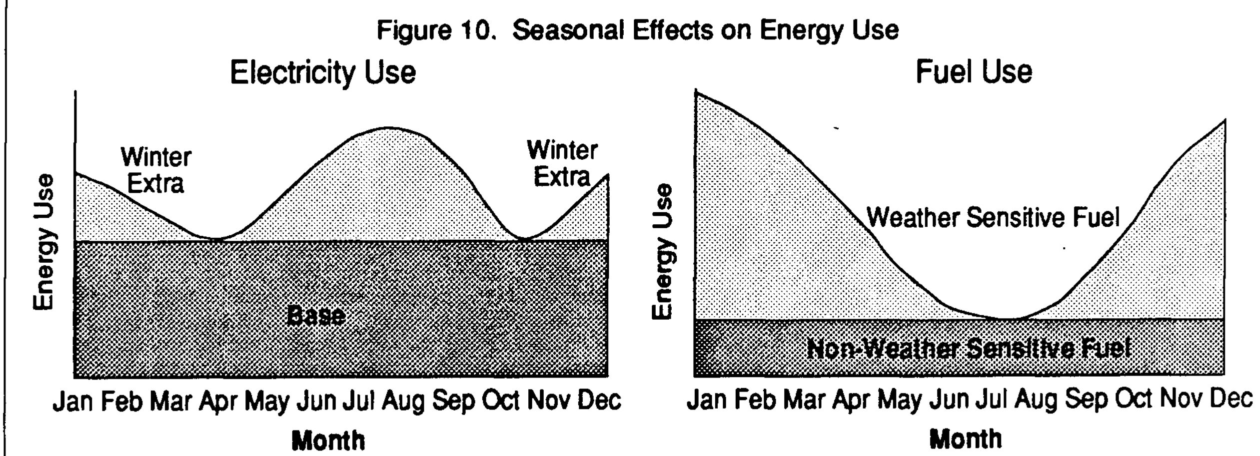
Energy Type :		Energy User :
Non-weather-sensitive fuel	:	Domestic hot water, reheat, absorption cooling.
Weather sensitive fuel	:	Heating, makeup air.
Base electricity	:	Lighing, fans, pumps, office equipment, elevator, domestic hot water, heat pumps, chillers.
Winter extra electricity	:	Electric heat, longer lighting hours, heat pumps, ramp heating, block heaters, pipe tracing.
Summer extra electricity	:	Cooling: compressors, cooling tower, fans, pumps, lower occupancy.



Sources: ORF (1982), and Vinto (1980)

In addition to energy consumption, an office building will be charged for peak power use. Power is the rate of energy use and is metered in kilowatts (kW) or kiloVoltAmperes[20] (kVA). Seasonal variations also occur for power demand due to :

Winter extra	:	Electric heat, ramp heating, block heaters, pipe tracing.
Summer extra	:	Cooling: compressors, cooling tower



Source: Engineering Interface (1982)

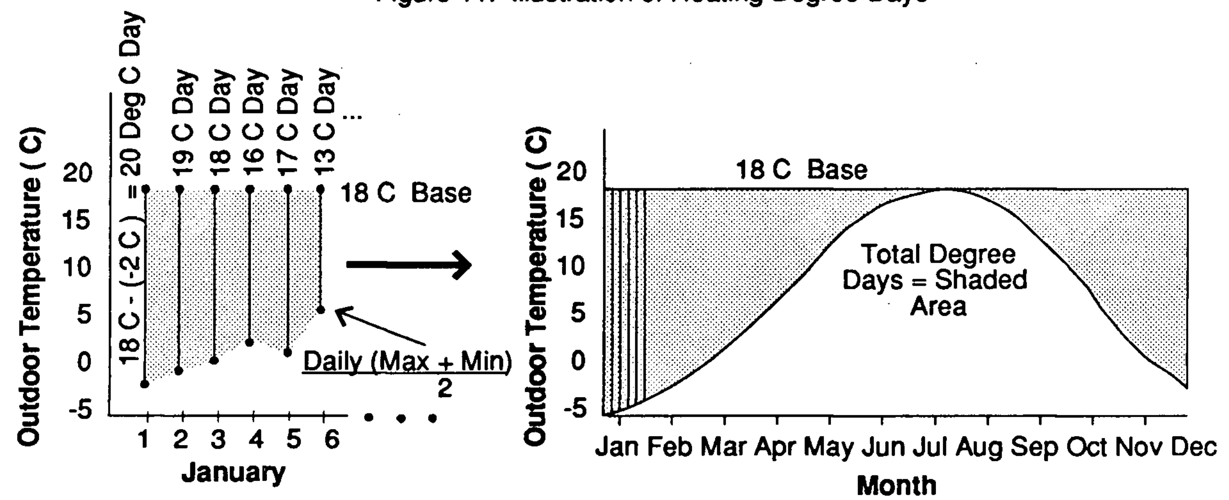
5.2 Effects of Weather on Energy Use

Heat losses from a building are linearly and inversely related to outdoor temperatures.[21] This linear relationship may not translate into a linear relationship between fuel use and temperature. In a study of energy use in two commercial buildings, Palmiter[22] found that a nonlinear relationship between temperature and energy use was introduced by equipment capacities, manual control of the equipment, multiple modes of equipment operation, multiple types of equipment, and nonlinear equipment performance curves.

Some energy use will have a misleading relationship with ambient temperatures. Colder weather (winter) would be associated with fewer hours of daylight, and consequent greater lighting requirements. A statistical analysis may therefore spuriously indicate a stronger relationship between temperature and electrical energy use than actually exists.

Some correction for weather must be completed to determine actual energy savings. A widely used measure of temperature patterns is the **degree day**. Figure 11 illustrates what a degree day is.

Figure 11. Illustration of Heating Degree Days

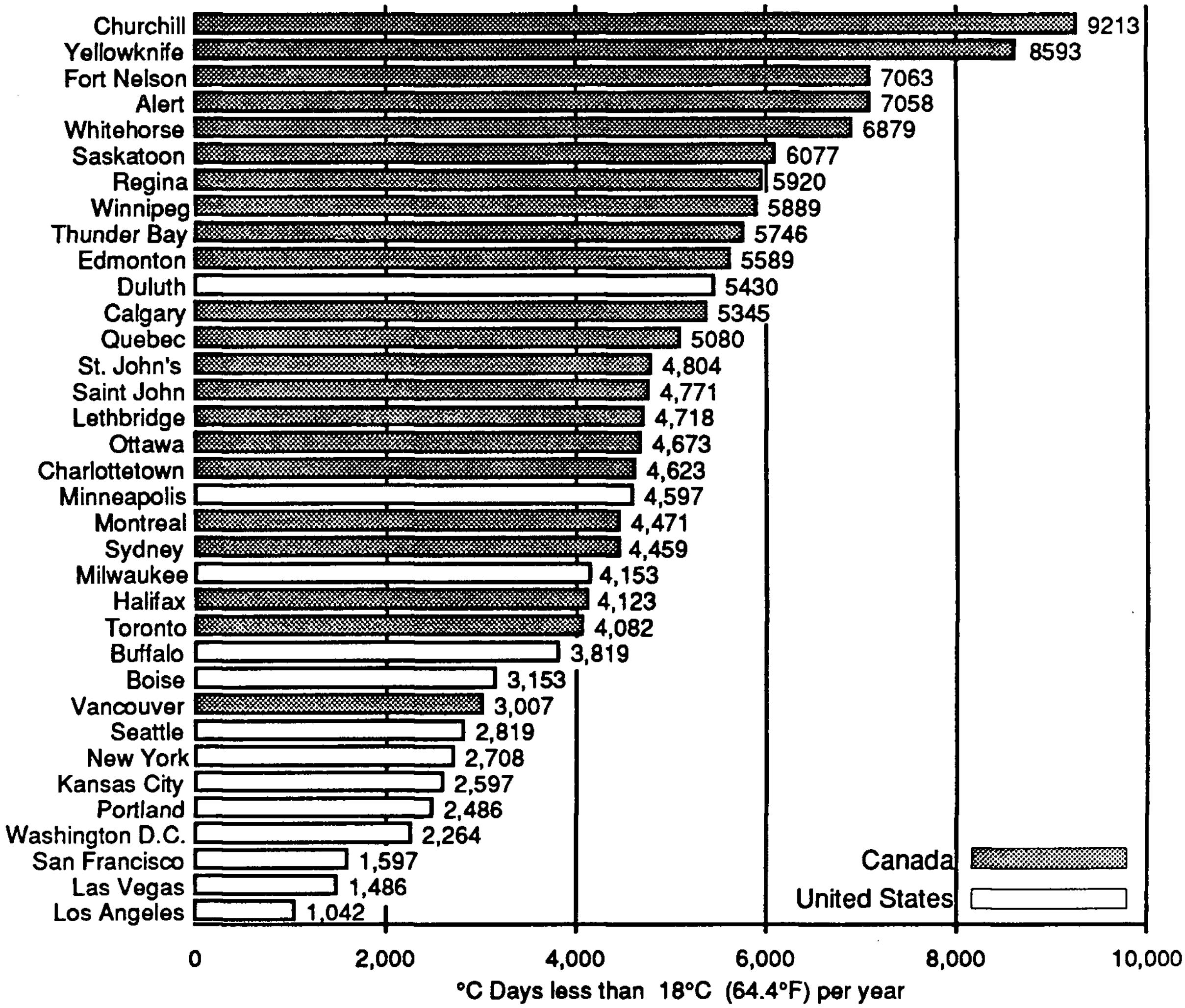


Source: Authors illustration

As outdoor temperatures fall, degree days increase, so, the higher the degree days, the more the heating energy use. Heating degree days are commonly tabulated with an 18° C or 65° F base.[23] Figure # 13 is a chart of heating degree days for North American cities, calculated to an 18° C base temperature.

Heating energy input may not be required until low outdoor temperatures occur. The temperature at which a building requires no additional heat input or heat removal is known as the balance point. This balance point will vary with internal heat generation and heat loss. Large office buildings may require year-round cooling in the core areas and have balance points below 10° C (50° F). Office buildings with low internal heat generation and greater roof heat losses may have balance points in the 18° C - 20° C (65° F - 69° F) range.

Figure 12. Annual Degree C Days Less Than 18°C for Selected North American Cities



Sources : National Building Code of Canada (Supplement), and the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

18 Cleary (1986), Gardiner (1985) - see bibliography

19 The basic format for figure 11 was derived from Engineering Interface (1982)

20 kVA is the total power generated and includes kW and kVAR. The R in kVAR is 'Reactive' power which is the power used to maintain magnetic fields, such as in motors and fluorescent lighting. The power used to generate the magnetic field is necessary, but not useful power. The ratio kW/kVAR is termed power factor. Electrical utility companies may charge for kVAR or for kW with a penalty for low power factor.

21 Radiation heat transfer is proportional to temperatures raised to the fourth power [T^4] but, at temperatures below 100°C, it's effect is small, relative to conduction and convection heat transfers, which are linear with temperature.

22 Palmiter, L.S., and Hanford, J.W., "Relationship Between Electrical Loads and Ambient Temperature in Two Monitored Commercial Buildings", ASHRAE PO-86-07, No. 2

23 Environment Canada offices record daily mean temperatures [(max + min)/2] and summarize heating and cooling degree days from an 18° C base.

6.0 Introduction to Buildings in the Study Sample

Data for energy use and energy management projects were obtained for twelve office buildings in British Columbia, Canada. Table VI summarizes the buildings. The available energy data is shown in table VII, and the retrofit options completed for the properties are detailed in table VIII. Detailed project descriptions are found in Appendix C.

Table VI. Buildings in the Study Sample

Building Code	Location	Prov	Owner	Occupant	Area sq.m.	Area sq.ft.	Pre-Retrofit Energy Use EkWh	MJ/sm	EkWh/sf
A	Vancouver	B.C.	Gov't	Owner	20,978	225,800	5,649,251	969	25.0
B	Victoria	B.C.	Gov't	Owner	5,130	55,218	943,262	662	17.1
C	New Westminster	B.C.	Gov't	Owner	18,362	197,642	3,329,658	653	16.8
D	Victoria	B.C.	Gov't	Owner	12,363	133,071	2,972,492	866	22.3
E	Victoria	B.C.	Gov't	Owner	2,535	27,286	738,271	1048	27.1
F	Victoria	B.C.	Gov't	Owner	19,679	211,818	6,189,833	1132	29.2
G	Victoria	B.C.	Gov't	Owner	2,378	25,596	1,007,724	1526	39.4
H	Victoria	B.C.	Gov't	Owner	22,838	245,820	7,156,243	1128	29.1
I	William's Lake	B.C.	Gov't	Owner	5,250	56,509	1,514,651	1039	26.8
J	Victoria	B.C.	Private	Tenant	6,327	68,100	2,468,526	1405	36.2
K	Burnaby	B.C.	Private	Tenant	7,129	76,736	4,068,071	2054	53.0
L	Vancouver	B.C.	Private	Tenant	43,720	470,586	23,606,929	1944	50.2

Internal and confidential sources from 4 B.C. property companies, and B.C. Hydro

Buildings A through I are government owned and occupied office buildings. Properties C and D are court houses which have office space within. Buildings J, K, and L are privately owned and tenant occupied office buildings.

Table VII. Energy Data Available and Project Dates for Buildings in the Study Sample

Building	**Years of data**							**Project Dates**
A	X	X	’83	’84	[‘85]	’86	X	1985
B	*‘81*	’82	’83	’84	[‘85]	’86	X	1985
C	*‘81*	’82	’83	’84	[’85]	[‘86]	X	1985 & 1986
D	*‘81*	[‘82]	’83	’84	[‘85]	’86	X	1982 & 1985
E	*‘81*	’82	’83	’84	[‘85]	’86	X	Jan - Mar 1985
F	*‘81*	[’82]	[‘83]	’84	[‘85]	’86	X	1983 & 1985
G	*‘81*	’82	’83	[‘84]	’85	’86	X	Aug 1984
H	X	*‘82*	[’83]	[’84]	’85	[‘86]	X	Mar-Jul 1983, 1984, 1986
I	X	[*‘82*]	’83	’84	’85	’86	X	1982
J	X	X	X	*‘84*	’85	[‘86]	*‘87*	Feb-Apr 1986
K	X	X	X	*‘84*	[‘85]	’86	*‘87*	Jun - Sep 1985
L	X	X	X	*‘84*	[‘85]	’86	*‘87*	Mar-Oct 1985

Italic indicates incomplete energy data for year

[yr] indicates changes made during year

Internal and confidential sources

Table VIII. Energy Management Projects Completed in the Study Sample

Retrofit Option	BUILDING											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Operations & Maintenance	•	•	•	•	•	•	•	•	•	•	•	
Change schedules	•	•	•	•	•	•	•		•	•	•	
Energy Mgmt Control System	•	•	•	•	•	•	•			•	•	
Heating, Ventilating, & A/C	•		•		•	•		•	•	•	•	
Lighting changes	•		•			•		•	•	•	•	
Electrical (incl. demand)			•			•					•	
Reduce air volumes	•					•						
Replace equipment	•					•						
Domestic Hot Water	•											
Window film												•

Internal and confidential sources

The government buildings are monitored closely for energy use and energy cost reduction has been a priority since the 1970's with the energy management division of the provincial government property company. The department oversees the energy use and reduction program for over 250 properties, approximately 50 of which are office buildings. The Energy Management Division is concerned primarily with the energy performance of the properties, but also has input into new construction, maintenance, and repair procedures for each property. Consultants are hired for specific projects as required.

The three privately owned office buildings do not have energy management departments. Energy consultants are relied upon to provide advice. The property managers are conscious of energy use and cost, but are not active in energy management.

7.0 Analysis of Energy Management Projects in the Study Buildings

7.1 Weather Influences

In order to analyse weather influences, the balance point for each of the 12 buildings was determined. Daily mean temperatures were used to calculate the heating degree days (HDD) for base temperatures from 9° C to 20° C in single degree celcius increments. All energy used was converted to equivalent energy units in kilowatthours. The base temperature was determined using a stepwise regression procedure which iterates to find the best fitting model for the data. The equation used was a linear model :

$$\text{Heating Energy} = \text{constant} + \beta_1 * (\text{Heating Degree Day}) \qquad (1)$$

The results are shown in Table IX. The heating base temperature for each year and, in brackets below, the number of observations and the R-Square are shown in the table. Appendix C contains charts of heating energy plotted against balance point degree days for each property, as well as detailed project descriptions. The results of the regressions are very good, which confirms that the linear temperature influence in equation (1) is reasonable for the analysis. The R-Square is the correlation between the predicted values from the equation estimate and the observed values. It indicates the reduction in the variation of the energy use when a degree day correction is applied. Only 1 of the 12 office buildings failed to achieve an R-square greater than 0.90 in at least one year.

The calculated base temperatures vary greatly from year to year which suggests that either the heating base temperature in each office building varied a great deal from year to year, or that the regression analysis does not account for variables with a major contribution to energy use. One major problem with the data is that for eight (8) of the buildings, the heating energy is provided by oil. The deliveries are made by truck and do not necessarily correspond with the actual energy used in the period since the last delivery. The delivery may leave the tank much less than full.

The same procedure was used to establish a cooling base temperature. The results in Table X are not nearly as good. The highest R-square was 0.85, but most R-Squares were much lower. Electrical energy consumption would be dependent more on the tenant usage than on ambient temperature, unless heating is electric. Palmiter found that interior lighting and general electrical energy use showed no relationship with temperature. Lighting in an office building may represent 30% to 40% of the electrical load. In summer, however, air conditioning loads (electric) would vary with cooling degree days.

Table IX. Base Heating Temperatures for Buildings in Study Sample

Calculated using stepwise regression techniques, which determines best fit for the model :

ENERGY = Alpha + ß x Heating Degree C Day

Building	YEAR 1981	1982	1983	1984	1985	1986
A	•	•	•	**20° C**	**15° C**	**14° C**
B	**16° C**	**17° C**	**14° C**	**14° C**	**18° C**	**13° C**
C	**18° C**	**15° C**	**16° C**	**18° C**	**16° C**	**12° C**
D	**20° C**	**17° C**	**19° C**	**19° C**	**15° C**	**17° C**
E	**13° C**	**9° C**	**13° C**	**12° C**	**20° C**	**14° C**
F	**11° C**	**13° C**	**16° C**	**17° C**	**9° C**	**16° C**
G	**16° C**	**18° C**	**14° C**	**20° C**	**15° C**	**15° C**
H	•	**15° C Δ**	**12° C**	**13° C**	**14° C**	20° C
J	•	•	•	•	**20° C**	**14° C**
K	•	•	•	•	**20° C**	**18° C**
L	•	•	•	**17° C ¥**	**15° C**	**15° C**

Bolded temperatures indicated significance at 5% level.
• indicates data not available or too few observations.
¥ indicates only 9 observations.
Δ indicates only 11 observations. (Only 11 observations for ALL 1981)

Source: Authors data

Table X. Base Cooling Temperatures for Buildings in Study Sample

Calculated using stepwise regression techniques, which determines best fit for the model :

ENERGY = Alpha + ß x Cooling Degree C Day

Building	YEAR 1981	1982	1983	1984	1985	1986
A	•	•	•	**18° C**	**11° C**	**10° C**
B	**10° C**	**10° C**	10° C	10° C	**10° C**	**10° C**
C	**10° C**	**13° C**	**10° C**	**18° C**	**10° C**	15° C
D	**15° C**	**10° C**	**10° C**	10° C	18° C	18° C
E	**10° C**	18° C	**10° C**	10° C	**10° C**	**10° C**
F	10° C	**10° C**	**10° C**	16° C	**18° C**	10° C
G	**10° C**	**10° C**	**16° C**	10° C	**18° C**	16° C
H	•	**10° C Δ**	**14° C**	**15° C**	**11° C**	13° C
J	•	•	•	**10° C**	**10° C**	**11° C**
K	•	•	•	**16° C ¥**	**10° C**	**11° C**
L	•	•	•	**12° C ¥**	**13° C**	**13° C**

Bolded temperatures indicated significance at 5% level.
• indicates data not available or too few observations.
¥ indicates only 9 observations.
Δ indicates only 11 observations. (Only 11 observations for ALL 1981)

Source: Authors data

7.2 Calculation of Energy Savings

Three general methods of calculating energy savings are:

i) no correction - base year consumption less current year consumption,
ii) correct heating energy use for degree days, or
iii) use regression techniques to determine the relationships between relevant variables and energy use.

Table XI shows the savings in each of the buildings using the first method. The first year of available data was used as the Base Year. Method ii was utilized to calculate energy savings for further analysis of project returns. Forecast energy use, beyond the years of data, is calculated using 30 year average degree day measures to the appropriate base temperatures. The correction is done by initially determining the constant and slope in equation 1 for the base year. In the following years, the actual heating degree days, calculated using the same base temperature, are substituted into the equation to get the expected energy use which would occur with no changes in operation. Subtracting the actual energy use from the calculated value yields the savings. Table XII details the energy savings after correction for heating degree days to the calculated heating balance point.

7.3 Financial Returns to Energy Management Projects in Study Buildings

7.3.1 Return Measures

The energy management industry has historically used very simple return measures to estimate the return on energy management projects. Clinton[24] surveyed 45 firms and found the following results:

Q ? For the top decision makers in your organization who review your energy management recommendations, what are the critical criteria they consider ? (more than one response was permitted)

Response :	Percent :
Payback	53 %
Cost or Outlay	27 %
Return on Investment	20 %
Acceptance to occupants	16 %
Product reliability or risk	11 %
Image or external comparison	9 %
Savings	9 %
Other	16 %

Because it is often difficult to get sufficient energy use data from energy management retrofits to properly evaluate the financial return, the simple payback is used and widely accepted. Any measure of financial return should include, however, some consideration of the time value of money. The idea that a dollar today is worth more than a dollar tomorrow is not new, but is often not accounted for. The financial return to the energy management projects for each

Table XI. Energy Savings in Study Buildings - Consumption minus Base Year (No correction)

BLDG Code	1982 Savings EkWh	1982 Savings Dollars	1983 Savings EkWh	1983 Savings Dollars	1984 Savings EkWh	1984 Savings Dollars	1985 Savings EkWh	1985 Savings Dollars	1986 Savings EkWh	1986 Savings Dollars
A					90,431	$1,470	1,589,838	$31,378	2,054,952	$37,871
B	-189,551	($5,420)	-227	$20	-162,049	($3,998)	-167,222	($4,438)	144,304	$3,960
C	-64,426	($2,135)	250,146	$2,817	385,058	$7,145	709,529	$16,062	1,540,381	$33,036
D	23,597	$239	414,865	$11,015	329,081	$10,637	378,197	$12,321	787,213	$20,977
E	77,137	$2,204	159,931	$5,575	107,637	$3,428	-85,887	($5,443)	67,881	($1,088)
F	825,677	$19,000	1,395,833	$35,138	1,745,392	$44,812	1,446,828	$30,923	1,753,554	$36,315
G	-52,420	($1,328)	425,059	$12,607	429,950	$14,398	405,681	$13,648	355,767	$11,276
H			519,537	$14,177	378,551	$17,822	-162,385	$969	365,733	$14,223
I			437,052	$13,404	536,385	$17,495	460,679	$16,005	432,753	$15,444
J									838,140	$19,473
K							267,929	$8,143	865,805	$27,598
L							1,518,122	$56,843	4,469,894	$136,406
	620,014	$12,560	3,602,196	$94,754	3,840,436	$113,209	6,361,309	$176,411	13,676,377	$355,492

Table XII. Energy Savings in Study Buildings - Consumption minus Base Year (Degree C Day Corrected)

BLDG	1982 EkWh	1982 Dollars	1983 EkWh	1983 Dollars	1984 EkWh	1984 Dollars	1985 EkWh	1985 Dollars	1986 EkWh	1986 Dollars	Future EkWh	Future Dollars
A	•	•	•	•	89,186	$1,450	1,704,196	$33,250	1,988,103	$33,973	1,990,670	$31,217
B	•	•	141,951	$2,616	-680	$533	98,473	$3,244	269,655	$7,734	207,160	$6,615
C	-7,565	($1,307)	373,833	$2,731	454,416	$8,412	813,292	$18,796	1,541,037	$34,210	1,558,026	$32,616
D	56,573	$1,091	277,679	$7,023	390,013	$12,122	586,267	$17,812	699,288	$19,265	715,545	$17,611
E	84,152	$2,487	117,901	$3,498	124,374	$3,449	-27,576	($2,536)	40,766	($851)	47,052	($1,442)
F	881,976	$20,482	1,267,744	$32,022	1,824,608	$47,413	1,743,250	$39,354	2,114,837	$44,010	2,159,953	$37,121
G	-30,566	($810)	384,482	$11,059	451,147	$13,726	476,796	$14,717	378,944	$10,597	427,779	$10,595
H	•	$0	477,823	$12,490	624,288	$23,946	384,533	$15,570	790,608	$15,281	653,017	$13,876
I	•	$0	408,630	$13,404	529,421	$17,495	466,667	$16,005	397,453	$15,444	389,549	$15,300
J	•	$0	•	•	37,525	$1,025	129,408	$4,825	924,714	$22,302	1,233,707	$27,565
K	•	$0	•	•	•	•	203,554	$6,042	640,014	$22,749	660,677	$23,386
L	•	$0	•	•	•	•	1,631,360	$57,253	3,340,157	$105,230	3,609,453	$105,512
	984,571	$21,943	3,450,043	$84,843	4,524,297	$129,569	8,210,222	$224,332	13,125,576	$329,943	13,652,589	$319,971

office building in this thesis is evaluated using present value techniques. (Appendix D reviews several alternative return measures.) The rates of return are calculated for the entire energy management program including simple maintenance changes which occur prior to major changes in operating hours or equipment. The rates of return calculated will be net present value (NPV), internal rate of return (IRR), and adjusted internal rate of return (AIRR). Energy savings were forecasted for 5 years following the last year of data (1986).

The present value (PV) of a project is the value of future cash flows in todays dollars - discounted to the present using a discount rate. The discount rate, or hurdle rate, is the minimum return required for the project. The NPV of a project is a dollar amount, found by subtracting the present value cost of the project from the present value of the future cash flows.

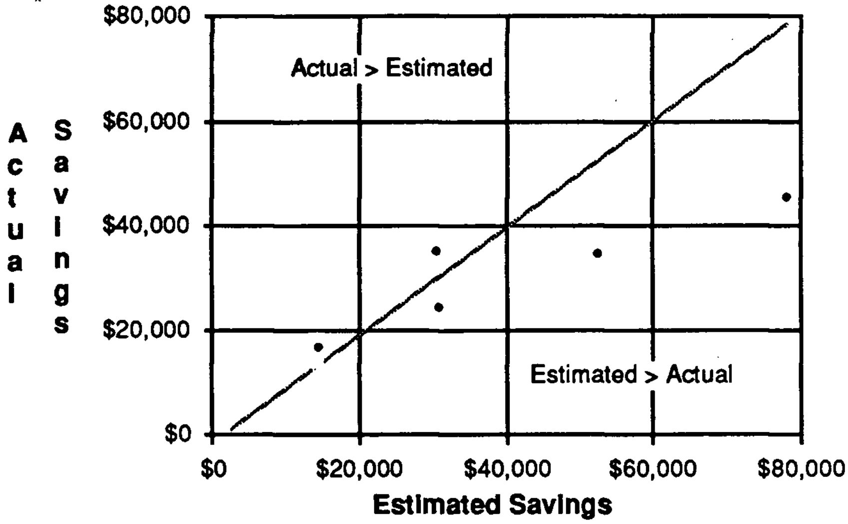
The IRR is a percentage rate of return which makes the NPV equal to zero (0). The IRR assumes that all positive cash flows will generate this return until the end of a project. For instance, if a project saved $1,000 in the first year of a five year life, and an IRR of 30% is calculated, then that $1,000 is assumed to generate 30% return for the remaining 4 years. To account for a different rate of return on cash flows, an adjustment is necessary. The adjustment in AIRR is a rate of return which cash flows will generate - i.e. a short term savings rate for positive cash flows.

7.3.2 Risk Assessment

The two key determinants of future energy savings are the success of a retrofit project and the cost of energy. Figure 13 illustrates the success of the energy management projects in 5 of the 12 study buildings, as measured by the difference between estimated and actual energy cost savings. Differences between estimated and actual energy savings and costs result from a number of factors including: imaccurate estimation of potential savings by technical staff or consultants, changes in marginal energy rates, operators not accepting or even understanding new equipment and procedures, poor installation or initial operating setup of new equipment, and errors in calculating the actual energy savings due to changing building uses, weather patterns, or occupancies. In the study by Ross and Whalen (1983), pre-retrofit savings estimates were available for 60 buildings, unfortunately, none of which were office buildings. However, for those energy management projects in schools and community centres which had corresponding savings estimates, 60% achieved greater energy savings than predicted, and 40% achieved less.

An added risk in the investment decision is that rapid changes in a technology may result in money being better spent at some point in the future. Funds could be invested reversibly in alternative investments until the timing is deemed more suitable.

Figure 13. Estimated versus Actual Energy Cost Savings
for Office Buildings in the Study Sample



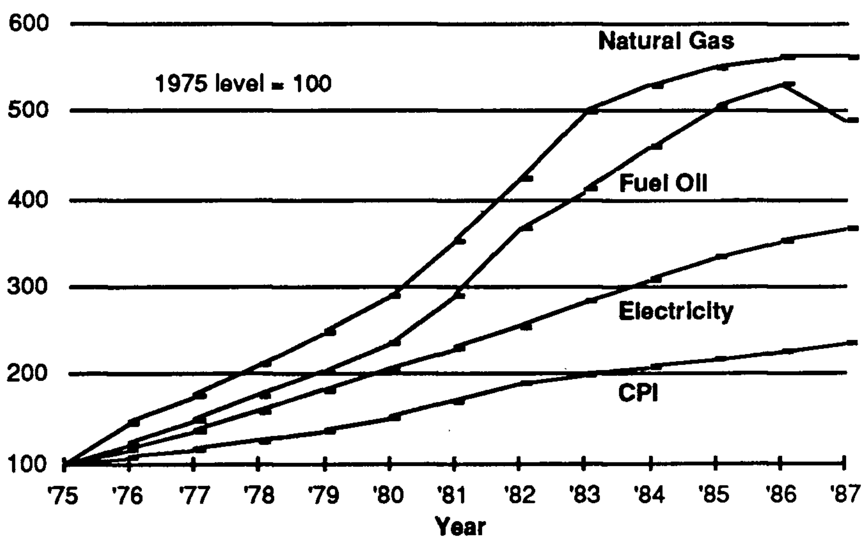
Source: Authors data

A building owner faces another risk that energy prices might rise at a slower rate than inflation, or even fall. Conversely, large increases in energy prices would yield greater savings. Each component of the total risk of the investment may be difficult to assess and this introduces a complication into the investment decision. To account for risk, the discount rate, or hurdle rate, often has an added risk premium.

The unpredictability of future energy prices could, however, actually lead to a *reduction in the risk premium*, rather than an increase, when considered in a portfolio framework. Cost savings generated by energy management are negatively correlated with the return on the market portfolio[25]. In the case of triple net lease contracts, when vacancies

Figure 14.

Relative Price Increases (Canada) Natural Gas, Fuel Oil, Electricity, and Consumer Price Index



Source: National Utility Service (Canada) Ltd.

are low owner paid energy costs are low, but, when vacancies rise, and income falls, owner paid energy costs will increase. In this sense, reducing energy costs acts as a hedge against poor markets. As will be seen, vacancies are a significant factor in the returns to office building owners.

Since the price of energy stands to affect the success of an energy management program more than any other variable, it is worthwhile to illustrate historic and projected prices. Figure 14 shows the price of electricity, natural gas and oil from 1975 to 1987. The consumer price index is also plotted to show historic inflation rates. Note that the price of electricity has not risen as much as the price of oil related products. This will continue if the 1986 projections of the US Deparment of Energy prove true. Figure 15 illustrates the projections to the year 2000 (top bar) in 1986 dollars for electricity, natural gas, and distillate oil. While the price of oil related products is projected to increase, the price of electricity is actually projected to fall in real terms (1986 dollars). A project should not rely on increased electrical energy costs to ensure a reasonable return. However, these are only projections and, as learned by the 1986 fall in world oil prices, should be considered only a best guess estimate.

The discount rates used in the analysis herein are 15% and 20%.

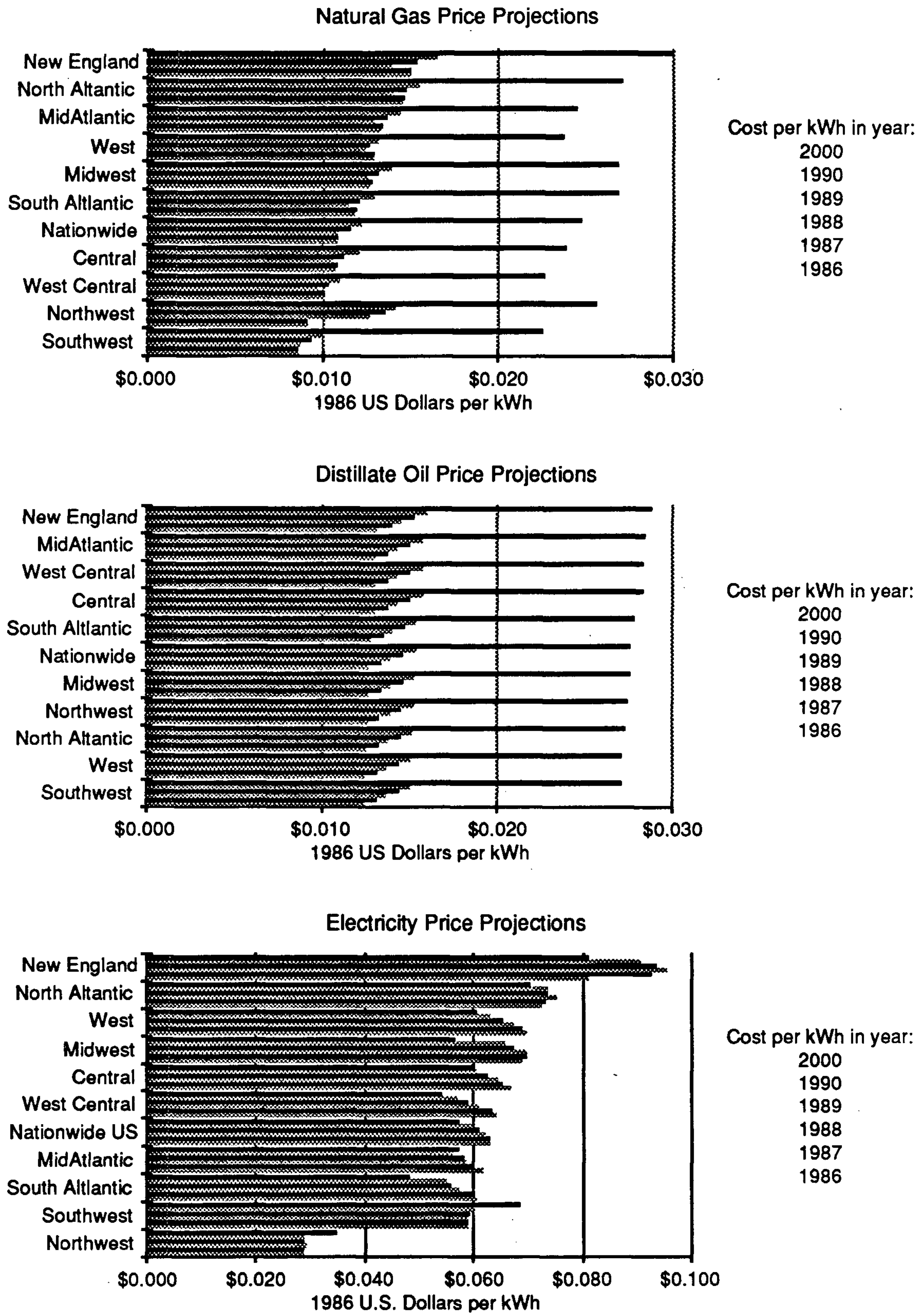
7.3.3 Results

The financial analysis for each of the office building energy management investments is detailed in Appendix E. The assumptions used in the analysis are included at the beginning of Appendix E. Tax considerations were not included for the 9 government properties. For the 3 privately owned office buildings, taxes were estimated for each of the projects. Additionally, the financial returns are calculated using three different assumptions. The first returns are for the project itself, accounting for all cash flows. The second returns are returns to the building owners with no increases in lease revenues, and the third calculation is returns to the building owner with space lease revenues (triple net rents) increased by 60% of the energy cost savings at the time of lease expiries. The 60 % figure was chosen because head leases and long term leases (10 to 30 years) represented roughly 40% of the total space in one of the study buildings.

The returns to the building owners were calculated under the assumption that the owner pays all vacant area operating costs. Vacancies are an important part of the return to the 3 privately owned properties. Each had vacancies in the 20% to 33% range during the years of available data. In the forecast period, these rates were estimated to fall to the 11% to 15% range, based on 1988 market projections.

In Appendix E, the net present value, at a discount rate of 15% and 20%, is shown for each project, as is the internal rate of return. Adjusted internal rates of return were calculated only for the 3 privately owned office properties.

Figure 15. United States Energy Price Projections to the Year 2000



Source : "Annual Energy Outlook", item 061-003-00517-9
Available from the U.S. Government Printing Office, Washington D.C. 20402

The before tax cash flows (BTCF) for each property are summarized in table XIII. Table XIV summarizes the after tax cash flows (ATCF) for the 3 privately owned, tenant occupied, office building energy management projects under the three assumptions.

The before tax cash flows for the energy management projects in all buildings combined yielded an internal rate of return of 22.1%. This measure includes *only* 5 years of forecasted savings (to 1991 inclusive). The internal rate of return for all the projects in the government buildings was 16%.

With no increase in space lease revenues, the after tax returns to the property owners were all negative. Support was found, however, for the hypothesis that triple net lease revenues increase by at least some of the energy cost savings. If lease revenues increase by at least some of the energy cost savings, then the returns to a project will compensate the owner for the investment. The after tax adjusted internal rates of return to the property owners in the privately owned, tenant occupied, triple net lease case buildings, were 13%, 31%, and 68%. These returns were achieved by lower vacant area costs, increased lease revenues when leases expire, and increased value of the building at the time space lease revenues increase.

The primary hypothesis, that the returns to investments in office building energy management are sufficient to encourage investment, is concluded, given the resulting average discounted before tax rates of return of 22.1% in the study sample, and significant energy savings in the empirical case studies. This is especially salient in the case of these British Columbia office buildings, since the energy rates in B.C. are among the lowest in North America.

The building with the lowest rate of return (-17%) had a pre-retrofit energy use of only 17 EkWh/sf, which is low to begin with. Two of the other three properties with low rates of return had pre-retrofit energy use under 30 EkWh/sf. Also, the price of heating oil dropped by 25% or more in the last year of the analysis which would explain lower returns than anticipated. The building managers for the fourth property with a poor return indicated that other benefits, such as the ability to account for charge backs in energy use and the expression of good faith to the tenants, were the motivating factors in the investment decision. This fourth office building had a high pre-retrofit energy use of 53 EkWh/sf, which does not help to explain the poor results. Discussions with property managers for the study properties indicated that energy savings have increasesd in several buildings with fine tuning of the energy management control systems, but this data was not available at the time of writing.

The wide variance in the returns to the twelve projects indicates that energy management can be a risky investment. Prioritizing the projects and completing the most cost effective first would reduce the risk of total project failure. Reducing the risks in energy management is discussed further in the following chapter.

The existence of triple net lease contracts does have a negative impact on the decision by private owners to invest in energy management. Most of the annual energy costs savings are foregone, but this study has shown that future building valuation effects are significant and may be sufficient to warrant an energy management investment. If an owner of an office building does not have the power to distribute, or pass through, the costs of the investment, and does not receive the greatest portion of yearly cost savings, the results show that energy management investments can still provide significant after tax returns to that owner. The chief component of this return is the increase in the value of the building when lease revenues increase.

Combined with valuation effects, the potential for returns being superior to other common investments, such as stocks, bonds, or real estate, is real and probable. But, because no conclusive evidence was found for the magnitude of these effects, this extension of the primary hypothesis cannot be concluded.

A discussion of methods to reduce the barriers and risks of energy management follows.

Table XIII. Before Tax Cash Flows to Projects
(No consideration to who receives the benefits)

							Forecast Δ	As at 1st year	
Bldg.	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	*1987 to 1991*	**PV@15%**	**IRR**
A	•	•	($9,000)	($3,066)	($87,406)	$29,457	*$26,701*	$402	15.2%
B	($13,404)	($1,104)	$412	($2,071)	$2,140	($46,420)	*$5,511*	($24,424)	-17.7%
C	•	•	($5,422)	$4,459	($103,156)	$30,257	*$28,664*	$3,066	16.6%
D	($14,961)	($3,070)	$4,362	$7,961	$15,151	($36,446)	*$14,950*	$5,529	20.8%
E	($546)	$1,941	($648)	$1,203	($21,282)	($2,897)	*($1,988)*	($13,458)	NA
F	•	($22,954)	($173,914)	$39,577	$21,543	$27,774	*$32,884*	($44,511)	5.7%
G	•	•	$10,547	($16,086)	$14,205	$10,085	*$10,083*	$31,439	
H	•	•	($10,226)	$16,530	$7,354	$5,765	*$8,960*	$28,909	120.5%
I	($11,030)	($11,825)	$12,274	$16,364	$14,875	$14,314	*$14,170*	$33,013	48.7%
J	•	•	•	•	($775)	$4,886	*$17,940*	$49,541	814.6%
K	•	•	•	•	($123,710)	$20,949	*$21,586*	($37,020)	1.2%
L	•	•	•	•	($195,549)	$97,646	*$97,928*	$166,248	46.4%
ALL :	($39,942)	($37,013)	($171,617)	$64,870	($456,612)	$155,369	*$277,388*		
GOV'T :	($39,942)	($37,013)	($171,617)	$64,870	($136,578)	$31,888	*$139,934*		

ALL BUILDINGS		**GOVERNMENT BUILDINGS**	
Net Present Value (1981) @ 15 % =	$112,420	Net Present Value (1981) @ 15 % =	$10,209
Net Present Value (1981) @ 20 % =	$25,183	Net Present Value (1981) @ 20 % =	($31,077)
Internal Rate of Return	22.1%	Internal Rate of Return	16.0%

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28 Clinton, J.M., Achieving Commercial/Industrial Energy Efficiency in a Market Environment, in ACEEE 1986 Summer Study on Energy Efficiency in Buildings - Vol. 5 : Proceedings from the Panel on Marketing, American Council for an Energy-Efficient Economy, Wash. D.C., 1986, pp 5.20-5.36

29 Sametz, A.W., "Financial Barriers to Investment in Conservation", in Financing Energy Conservation, American Council for an Energy-Efficient Economy, Wash. D.C., 1986, p 133

Table XIV. Benefit Flows to Private Office Buildings

1. After Tax Cash Flows to Project. Assuming owner receives benefit flows (NO increases in lease revenues)

Bldg	1985	1986	*Forecast Δ* *1987 Δ*	*1988 Δ*	*1989 Δ*	*1990 Δ*	*1991 Δ*	As at 1985 PV@15%	IRR	AIRR
J	($3,118)	($2,783)	*$9,368*	*$10,207*	*$10,190*	*$10,174*	*$11,690*	$21,040	104.2%	45.3%
K	($124,890)	$13,626	*$13,787*	*$14,432*	*$14,304*	*$14,183*	*$14,067*	($62,448)	-10.1%	-3.3%
L	($160,975)	$112,023	*$48,964*	*$58,032*	*$58,032*	*$58,032*	*$58,032*	$85,859	39.5%	20.5%
ALL :	($288,982)	$122,867	*$72,119*	*$82,671*	*$82,526*	*$82,388*	*$83,789*	$44,451	21.8%	

Net Present Value at 1985 @ 20 % = $10,250

2. After Tax Cash Flows to Office Building Owners. Assuming owner receives vacant area energy cost reductions only (NO increases in lease revenues)

Bldg.	1985	1986	*Forecast Δ* *1987 Δ*	*1988 Δ*	*1989 Δ*	*1990 Δ*	*1991 Δ*	As at 1985 PV@15%	IRR	AIRR
J	($4,190)	($8,278)	*$2,909*	*$2,807*	*$2,297*	*$1,787*	*$2,001*	($3,718)	-1.8%	2.3%
K	($124,665)	$14,526	*$14,687*	*$15,422*	*$7,577*	*$4,240*	*$4,124*	($71,795)	-21.2%	-7.5%
L	($183,876)	$72,965	*$9,793*	*$9,865*	*$8,124*	*$6,384*	*$6,384*	($83,442)	-19.1%	-2.7%
ALL :	($312,731)	$79,213	*$27,389*	*$28,094*	*$17,998*	*$12,410*	*$12,509*	($158,955)	-18.9%	

Net Present Value at 1985 @ 20 % = ($161,321)

3. After Tax Benefit Flows to Office Building Owners. Assuming owner receives vacant area energy cost reductions only. (INCLUDING increases in lease revenues and building value)

Bldg.	1985	1986	*Forecast Δ* *1987 Δ*	*1988 Δ*	*1989 Δ*	*1990 Δ*	*1991 Δ*	As at 1985 PV@15%	IRR	AIRR
J	($4,190)	($8,278)	*$2,909*	*$2,807*	*$2,297*	*$62,430*	*$128,800*	$70,168	79.5%	68.2%
K	($124,665)	$14,526	*$14,687*	*$15,422*	*$59,026*	*$60,366*	*$64,927*	$907	15.2%	13.0%
L	($183,876)	$72,965	*$9,793*	*$9,865*	*$8,124*	*$470,636*	*$280,715*	$220,399	40.7%	31.1%
ALL :	($312,731)	$79,213	*$27,389*	*$28,094*	*$69,447*	*$593,432*	*$474,443*	$291,474	35.4%	

Net Present Value at 1985 @ 20 % = $182,856

8.0 Overcoming the Barriers to Energy Management in Office Buildings

8.1 Investment Barriers

Two major barriers to investment in energy management common to all building sectors are informational and financial.

Informational barriers are especially significant for smaller firms, where owners and managers may have little experience in energy management and have no in-house technical support. Information transfer to all owners is essential to increase the acceptance and implementation of energy use reduction investments. The transfer methods which were judged most cost effective by the BETT program (ORF(1983)) are: word of mouth, magazine articles, case studies, student training, workshops, and trade organizations. The case studies detailed herein do support the hypothesis that energy management investments can provide significant financial returns.

Even with an appreciation of the potential for energy savings, building managers may not have the experience to assess the need for reductions in energy use. This may be a cause of no action, but should not represent a significant barrier to investment. A simple, low cost, ananlysis of energy use can be completed by consultants. But increased awareness must extend beyond the building owner and manager. Tenants may perceive an investment in energy management to be highly risky, but there are methods of substantially reducing the risk. Tenants may also equate energy management with a sacrifice in comfort or health safety. Office environments can, however, become healthier with more efficient equipment and operating procedures.

Financial barriers are also more prevalent for smaller firms. Access to funding is often restricted and cost reduction programs, such as energy management, usually have lower priority than investments which increase revenue. Consequently, capital budgeting would often exclude energy use reduction investments. Larger firms may have in-house technical staff, which would reduce the information barrier and increase the liklihood of researching financing options.

Other barriers specific to the commercial building sector include the existence of triple net leases and short term leases. As has been shown, triple net lease contracts reduce the incentive for office building owners to invest in energy management. Although an owner or manager can negotiate with tenants to have the capital costs of an investment passed on, in a building with short term leases or a great many tenants, this may not be practical due to limited manpower.

8.2 Overcoming The Barriers

A number of innovative financing methodologies are available to have energy management costs become an operating expense, which can then be passed on to the tenants, who will benefit from energy savings. The financing can be structured so that energy cost savings exceed ongoing finance charges. Innovative financing also solves problems for building owners who have capital constraints. In an efficient office market, these options will be utilized to reduce energy consumption when alternative methods are not practical. In a competitive market, high operating costs will *eventually* affect the financial retursn to an office building investment due to vacancies and less than optimum rent levels.

The following alternatives overcome the main barriers to investing in energy management:

i) Leasing of equipment and services

All the capital costs of an investment can be covered with a lease. Whereas interest on debt may not be considered a legitimate operating expense for an owner, lease payments would fall into this category because the lessor retains ownership of the equipment. Capital depreciation and any tax credits will accrue to the lessor and, consequently, the financing charges may be lower than typical loans available to the lessee (property owner). Consulting fees to analyse and design an energy saving investment can be included in the lease package.

ii) Energy Service Companies (ESCO's)

Again, in a contract with an ESCO, no capital investment is necessary. In addition, the risk of the project may be reduced significantly by guarantees, and the technical expertise is included and readily available from a single source. It should be noted, though, that with reduced risk, an owner must expect a reduced return to the investment. The ESCO also has an incentive to achieve energy savings to increase its' financial return. Problems may arise due to redueced flexibility for the owner regarding operating conditions and hours, and the contract may extend over a period of 7 years for larger projects. Energy savings are usually calculated using some form of ambient temperature correction (usually degree day) and operating conditions correction. Several contract types are available with energy service companies:

a) Shared savings

The savings from the energy management project would be shared between the ESCO and the energy user on a set schedule.

b) Chauffage

The ESCO pays the utility charges and is reimbursed by the building owner at a prescribed percentage of pre-retrofit energy costs. For example, a user may pay 90% of previous energy costs to the ESCO. Any savings greater than 10% would be realized by the ESCO.

c) First out

In this arrangement, the ESCO receives 100% of the savings for a period sufficient to cover the cost of the project, including consulting fees, equipment costs, financing charges, and markup. A maximum duration is usually specified.

An ESCO will only be interested in pursuing a project if the potential savings exceed a minimum amount, usually $50,000 to $100,000. If this represents a 20% savings, then the building would have to be spending a minimum of $250,000 per year to be worthy of consideration by an ESCO.

With any of these options, the cost of the project is paid by the tenant through regular monthly charges, most often <u>less</u> than previous costs. There are advantages to each and which one is best depends on the expertise and desires of the building owner. Table XV summarizes the features of each.

Table XV. Features of Leasing and Energy Service Company Contracts

	Lease	Shared/First out	Chauffage
Services & Financing			
Audit		•	•
Design		•	•
Financing	•	•	•
Equip purchase & install	•	•	•
Maintenance		•	•
Project Management		•	•
Fuel & energy supply			•
Technical Risk Avoided			
Equip does not perform		•	•
Equip not appropriate or improperly installed		•	•
Not properly maintained		•	•
Equipment obsolete	•	•	•
Financial Risk Avoided			
Energy prices fall		•	•
Capital costs increase	•	•	•
Project cost overruns		•	•
Operating Risk Avoided			
Occupancy, or other, declines and also energy use		•	•

** Note that with triple net rents, the risks with an equipment lease are passed on to the tenant because they pay the utility charges.

Source: Rosenberg (1984)

9.0 Summary, Implications, and Future Work

The results of this research show that benefits of energy management investments extend beyond yearly cost savings and improvements in equipment control. While the extent of building value increases was not quantifiable, the fact that cost reductions should have this impact is important.

The variance in the rates of return to the energy management projects illustrates the fact that energy management projects can be risky. However, when combined in a portfolio framework, as is done with public sector programs, the risk is largely reduced. In addition, the returns from energy management to building owners of net lease contract buildings will be negatively correlated with the profitability of the building, (decreased revenue and increased energy savings when vacancies rise), which reduces the negative aspects of the risk.

The implications of this work is that energy management investments are worthwhile and often very profitable, but must be considered carefully on a building by building basis due to the potential for failure. It is hoped that this work expands the understanding of the effects of energy management on office building value, and illustrates the problems of triple net lease contacts. Building value effects were addressed in very few energy management case studies and reports researched for this work. A conclusion of this author is that information transfer to building owners and managers, and especially the technical community, should include both the technical aspects of energy management and *real estate considerations*. Professionals selling or acquiring an energy management product or service should be aware of these valuation effects to increase the acceptance of energy management in office buildings.

The weaknesses of this work include the inability to directly quantify valuation effects and the poor relationships found between operating costs and rent levels. Also, the risk elements within the paper were addressed in a cursory fashion.

Future work which would determine the appropriate discount rates for assessing the merits of an energy management project would be beneficial to both the technical community and to building managers. To complete an ideal analysis, examination of many energy management programs would be necessary. Energy cost savings, project costs, consulting fees, manpower costs, insurance, maintenance savings, repair cost savings, weather and vacancy effects, and building net income increases should all be considered in the analysis. Examination of actual net incomes and disposition prices of efficient office buildings would provide valuable insights into the true valuation effects of reducing operating costs - a difficult task considering the paucity of conventional energy management case studies and the proprietary nature of office building cash flows.

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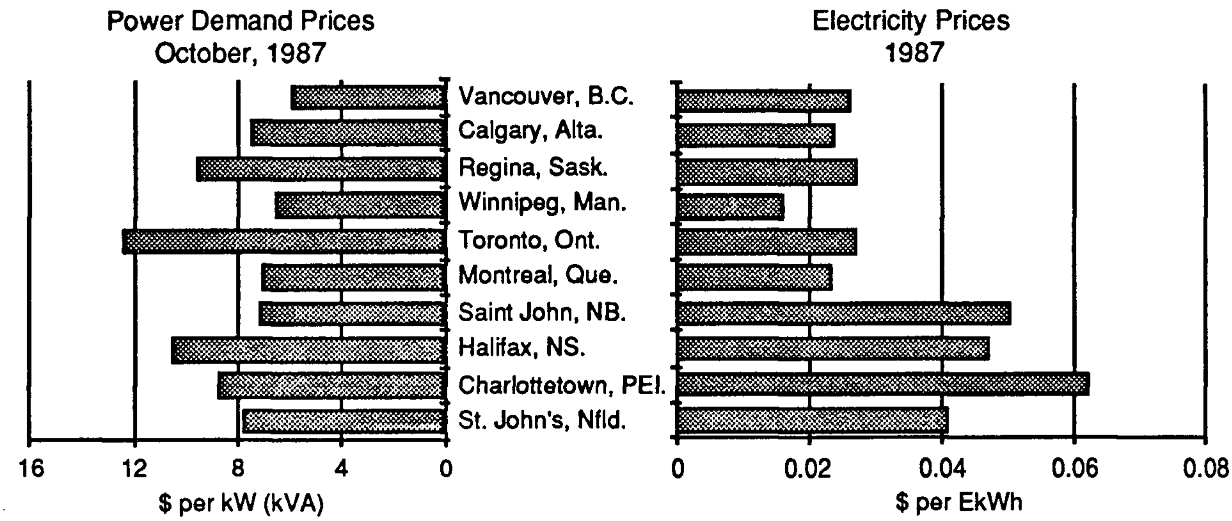
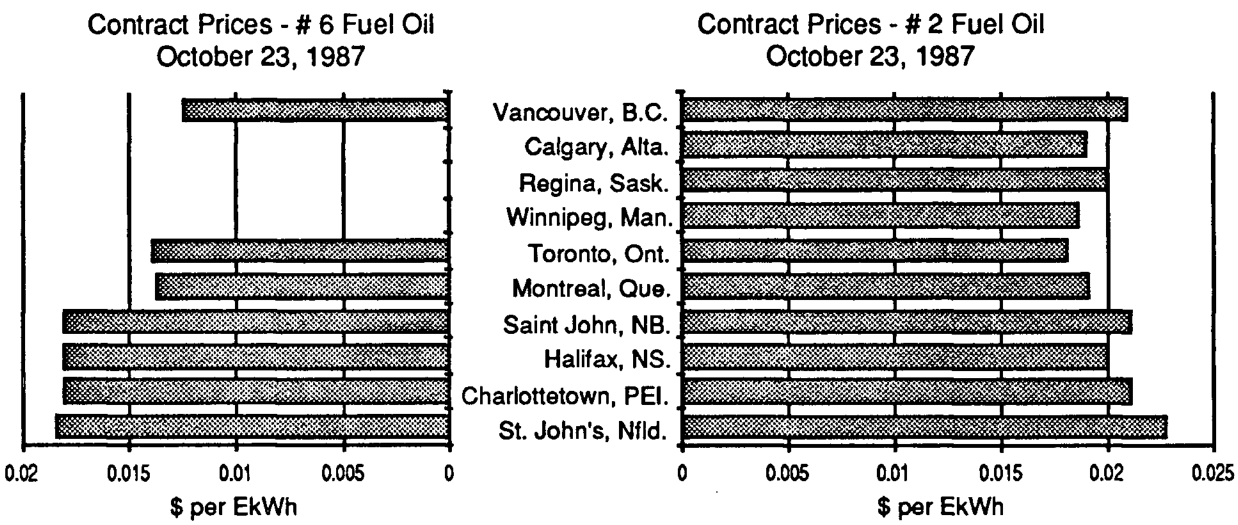
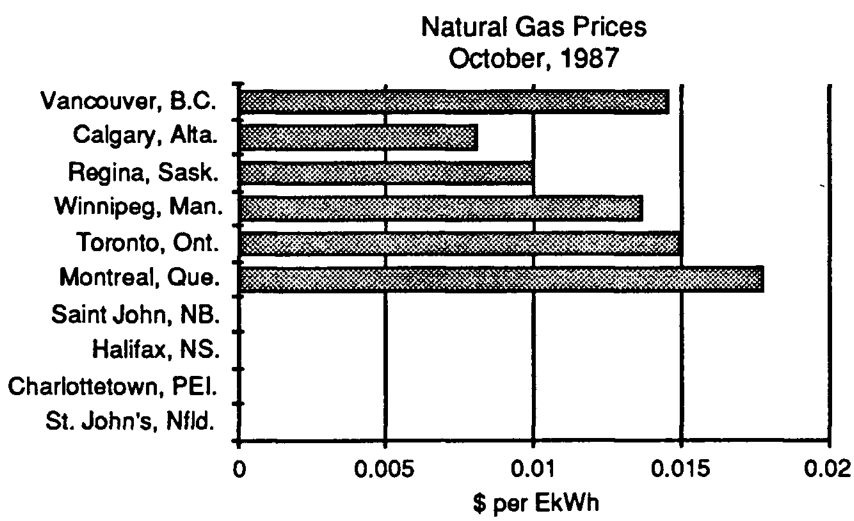
Appendix A. Canadian Energy and Power Pricing







Source:
Local utility pamphlets
and refined fuel reports
provided by :

National Utility Service
(Canada) Ltd.

Appendix B. Energy Management Case Studies

Office Building Energy Conservation Projects completed by PUBLIC WORKS CANADA Ottawa, Ontario

Bldg	Area sq.m.	Project Complete	Type of Project	Project Cost	ESTIMATED Yearly Savings: Natural Gas (cu.m.)-->	Natural Gas (EkWh)	Electricity (kWh)	Electricity (kW)	TOTAL (EkWh)	Dollars (Can. $)	Based on Rates of :	Simple Payback
1	40,064	1981	HO	$63,867	195,579	2,024,047	369,000	•	2,393,047	$34,458	1981	1.85
		1986	A	$422,000	545,582	5,646,228	(44,477)	(1,538)	5,601,751	$78,166	1986	5.40
2	38,322	1983	HOC	$347,000	328,722	3,401,944	330,653	1,740	3,732,597	$71,536	1983	4.85
		1984	HOC	$202,700	378,433	3,916,403	77,459	•	3,993,862	$60,583	1984	3.35
		1984	HE	$201,000	131,507	1,360,966	191,611	•	1,552,577	$24,264	1985	8.28
3	100,191	1984	RO	$23,800	•	•	1,300,000	1,560	1,300,000	$46,514	1984	0.51
4	9,524	1985	OT E	$604,500	240,227	2,486,109	922,644	•	3,408,753	$68,980	1985	8.76
5	17,830	1986	HOE	$100,000	51,811	536,192	80,970	•	617,162	$10,868	1986	9.20
6	35,747	1983	HC	$212,348	245,743	2,543,194	323,948	•	2,867,142	$48,823	1983	4.35
7	2,564	1984	T	$63,000	58,431	604,702	•	•	604,702	$9,290	1984	6.78
8	19,503	1983	OH	$113,651	147,989	1,531,538	282,875	•	1,814,413	$32,044	1983	3.55
9	42,852	1982	HC	$65,069	261,471	2,705,963	•	•	2,705,963	$40,554	1982	1.60
9	306,597			$2,418,935	2,585,495	26,757,288	3,834,683	1,762	30,591,971	$526,080		4.60

TYPES OF PROJECTS :

- **O** Reduction in equipment operating hours
- **R** Reduction in air quantities
- **A** Air conditioning or chiller modifications
- **H** Heating and ventilating equipment modifications
- **E** Energy management control systems
- **C** Controls other than computer based
- **T** Heat recovery

NOTES :

- All dollar savings shown are calculated using energy rates from the year noted to the left of the $ figure.
- Actual energy savings were not available. Estimated savings are shown.
- The "simple payback" shown for the total of all projects is not an accurate measure due to different years and rate structures. It is shown to provide a ROUGH performance estimate of the total investment.
- Totals and simple paybacks are shown for comparative purposes only.

SOURCE : Mr. Ludwig Cyfracki
Manager, Building Resources
Plant Engineering
Public Works Canada
National Capital Region

"...we are unable to provide you with meaningful energy usage data before and after retrofit due to the fact that full implementatin of each change took considerable time, during which, there were numerous changes in loads, occupancy patterns, working hours, operational requirements and procedures, etc. We are confident, however, that the given estimated energy savings are not exaggerated. They have been computed very conservatively and we expect the actual savings to be higher than estimated. "

Energy Management Study - Ross and Whalen (1983) - U.S. Dep't of Energy

Bldg #	Location	State	Area 1000's sq.ft.	Annual EkWh per Square Foot: BEFORE Elect.	BEFORE Fuel	BEFORE TOTAL	AFTER Elect.	AFTER Fuel	AFTER TOTAL	Saved	%	Simple Paybk (yrs)	Cost of Retrofit $/sq.ft.	Cost of Retrofit (1980 $)	Cooling ° Day (>50 F°)	Heating ° Day (< 60 F°)
68	New York	NY	1500	16.6	35.2	51.8	16.1	31.4	47.5	4.3	8.3%	<1	0.02	$30,000	3653	3739
70	New York	NY	449	16.5	28.7	45.2	16.0	25.2	41.2	4.0	8.9%	<1	0.05	$22,450	3653	3739
69	New York	NY	589	17.1	32.8	49.9	15.8	27.8	43.6	6.3	12.6%	<1	0.06	$35,340	3653	3739
71	New York	NY	448	10.4	24.9	35.3	7.9	22.9	30.8	4.6	12.9%	<1	0.06	$26,880	3653	3739
72	New York	NY	412	13.9	31.7	45.6	13.8	25.2	39.0	6.5	14.4%	<1	0.06	$24,720	3653	3739
85	Rock Springs	MD	136	23.9	•	23.9	19.6	•	19.6	4.3	18.0%	1-2	0.38	$51,680	4237	3182
74	New York	NY	141	51.5	47.5	99.0	49.1	39.3	88.4	10.6	10.7%	<1	0.56	$78,960	3653	3739
83	New York	NY	1482	13.9	36.6	50.5	13.0	24.9	37.9	12.6	25.0%	1-2	0.56	$829,920	3653	3739
73	Hartsdale	NY	48	19.7	19.3	39.0	14.6	11.4	26.0	13.0	33.3%	<1	0.56	$26,880	3653	3739
64	Stockholm	SWE	452	5.6	14.7	20.3	5.4	9.4	14.8	5.5	27.0%	•	0.75	$339,075	159	7832
88	Columbus	OH	222	49.0	122.5	171.5	27.0	82.1	109.1	62.4	36.4%	<1	0.79	$175,222	3183	4513
65	Stockholm	SWE	183	6.6	12.0	18.6	6.6	3.2	9.8	8.8	47.2%	•	1.02	$186,660	159	7832
206	Austin	TX	219	30.7	146.5	177.2	19.9	72.4	92.3	85.0	47.9%	•	1.28	$280,320	•	1737
63	Stockholm	SWE	97	2.1	12.6	14.7	•	•	8.4	6.3	43.0%	•	3.08	$298,452	159	7832
109	Newark	NJ	650	3.8	32.2	36.0	4.1	30.8	34.9	1.2	3.2%	•	•	•	3533	3911
108	Newark	NJ	2077	4.7	20.8	25.5	4.8	19.1	23.9	1.7	6.5%	•	•	•	3533	3911
117	Charleston	WV	227	30.2	•	30.2	28.1	•	28.1	2.1	7.0%	•	•	•	3750	3500
110	Newark	NJ	1268	9.1	31.4	40.5	8.3	29.3	37.6	2.9	7.0%	•	•	•	3533	3911
61	Paris	FR	988	9.1	13.5	22.6	7.6	8.5	16.1	6.5	28.7%	•	•	•	193	4986
37	Houston	TX	578	65.2	•	65.2	45.3	•	45.3	19.9	30.5%	•	•	•	7150	684
118	Charleston	WV	88	20.3	19.3	39.6	18.8	8.5	27.3	12.3	31.1%	•	•	•	3750	3500
107	Newark	NJ	1527	23.7	41.0	64.7	20.3	23.4	43.7	21.0	32.4%	•	•	•	3533	3911
85A	Tucker	GA	251	35.1	•	35.1	21.5	•	21.5	13.6	38.7%	•	•	•	4880	2189
119	Charleston	WV	1079	25.0	34.3	59.3	22.6	11.4	34.0	25.3	42.6%	•	•	•	3750	3500
35	St. Paul	MN	840	18.3	32.2	50.5	11.5	16.1	27.6	22.9	45.4%	•	•	•	2575	6842
36	Atlanta	GA	320	40.5	16.7	57.2	26.6	4.4	31.0	26.2	45.8%	•	•	•	4880	2189
25	<-- # buildings		16,272			47.8	Area-wtd avg		35.9	11.9	21.8%					

SOURCE : Building Energy Use Compilation and Analysis (BECA)
Part C: Conservation Progress in Retrofitted Commercial Buildings
Howard Ross and Sue Whalen
Buildings Division, Department of Energy, Washington D.C. 20585, U.S.A.

FROM : Energy and Buildings, 5 (1983) 171-196

Energy Conservation Performance : Office Buildings in Southern Ontario
Case Studies by Ontario Research Foundation

Case Study	Owner	Occupant	Building Area (sq.m.)	Building Area (sq.ft.)	Energy Use (ekWh/sq.m.) Initial	Energy Use (ekWh/sq.m.) Final	Energy Use (ekWh/sf.) Initial	Energy Use (ekWh/sf.) Final	% Saved	Project Cost ($)	Time Frame Years	Notes	Yearly Savings ($)	Simple Payback (years)	Retrofit Measures (see notes)
1	Public	Owner	13,500	145,309	563	346	52	32	39 %	$27,000	2		$26,000	1.0	RSTE
2	Public	Owner	17,100	184,058	410	348	38	32	15 %	$27,500	1		$17,900	1.5	STELM
3	Public	Owner	7,300	78,575	665	595	62	55	11 %	$1,900	2		$6,300	0.3	RSTELM
4	Public	Owner	14,700	158,226	595	512	55	48	14 %	Minimal	2	Ω	$10,000	•	RSTLM
5	Public	Owner	35,800	385,339	480	239	45	22	50 %	$44,600	2		$100,000	0.4	RSELM
6	Public	Owner	14,000	150,691	522	315	48	29	40 %	$132,000	2	Δ	$70,000	1.9	E L
7	Private	Tenant	67,700	728,699	587	414	55	38	29 %	$60,000	2	¥	$125,000	< 0.5	TEL
8	Private	Tenant	7,900	85,033	798	358	74	33	55 %	$60,000	3	¥	$45,000	< 1.3	TEL
9	Private	Owner	44,600	480,059	•	•	•	•	35 %	$120,000	4	§	$300,000	0.4	RSTELA
TOTALS			222,600	2,395,988	555	373	52	35	32.8%	$413,000			$700,200	**0.6**	
Average			24,733	266,221	Area weighted averages										

NOTES

- Ω Does not include outside consulting fees.
- Δ Estimated costs and savings. One (1) year into program a 25% reduction had been attained, due mainly to reduced lighting levels.
- ¥ A combined expenditure of $60,000 is cited for these two buildings.
- § Energy use not available.

Retrofit Measures :

HVAC :	R	Reduction in air volumes
	S	Shut-down after hours
	T	Temperature setback
	E	Equipment Modifications
Lighting :	L	Lighting levels reduction
	A	After-hours shutoff
Operations :	M	Maintenance rescheduled

SOURCE : ORF (1982)

Energy Conservation in Office Buildings : A Case Study Analysis of Conservation Practices in Office Buildings
A Project of the Conservation and Renewable Energy Branch, Energy, Mines and Resources Canada
By : Energy and Combustion Systems Division
Department of Engineering and Metallurgy
Ontario Research Foundation
March, 1982
Projects all completed prior to 1979

Case Studies of Energy Management Programs
by Engineering Interface - A Consulting Firm in Metropolitan Toronto, Canada.

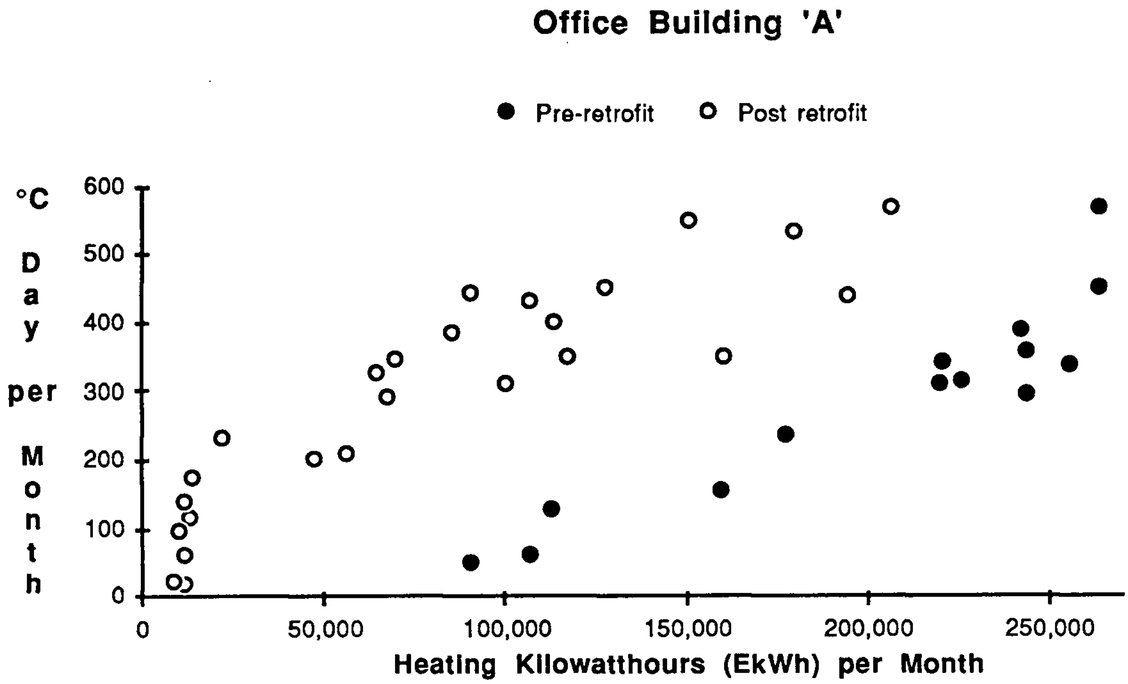
	Area		Energy Use				Project	Savings	
Building	Sq. m.	Sq. Ft.	Date	Initial	Final	Date	Cost	% Energy	$ / year
Toronto City Hall	66,892	720,000	1981	52.7	39.9	1986	$732,000	24.3%	$410,000
Bell Canada Centre	71,537	770,000	1978	31.8	21.8	1982	$300,000	31.4%	$166,600
Toronto Star Building	50,912	548,000	1980	57.7	48.2	1983	$105,000	16.5%	$234,000
Totals		2,038,000		46.1	35.3		$1,137,000	24.9%	$810,600

Sources : Engineering Interface Ltd. Newsletter, November, 1983 and March, 1983
Engineering Interface Ltd. Case Study - "Energy Management at Work" - Toronto City Hall

Contact : Engineering Interface Ltd.
2 Sheppard Avenue East,
Willowdale, Ontario
M2N 5Y7

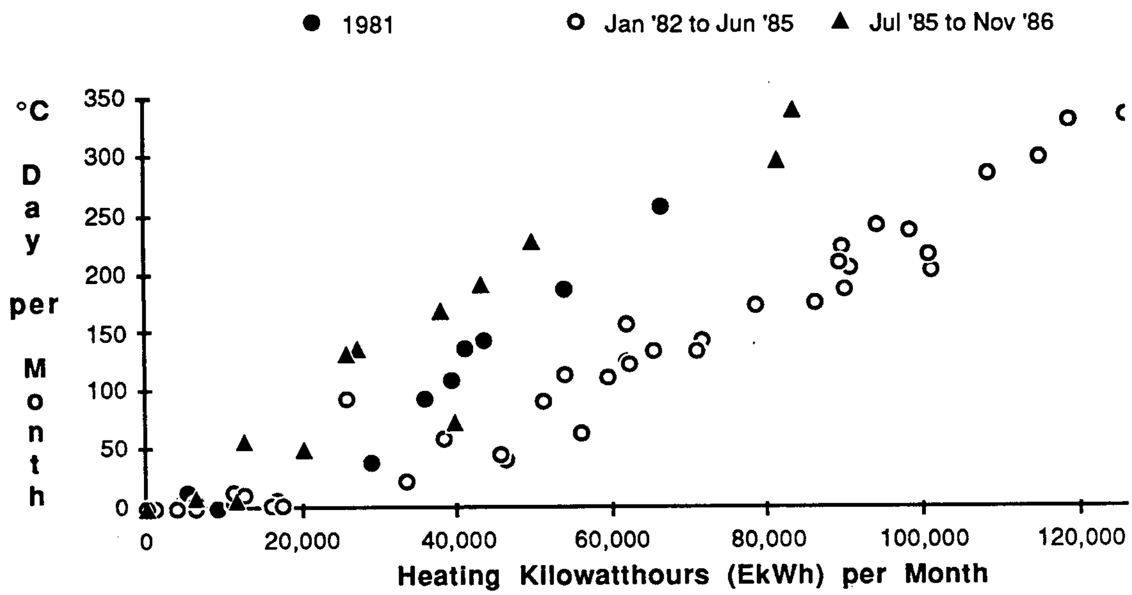
Appendix C.

Detailed Project Descriptions
for
Energy Management Projects in Study Buildings
and
Charts of Heating Energy Versus Balance Point Degree Days



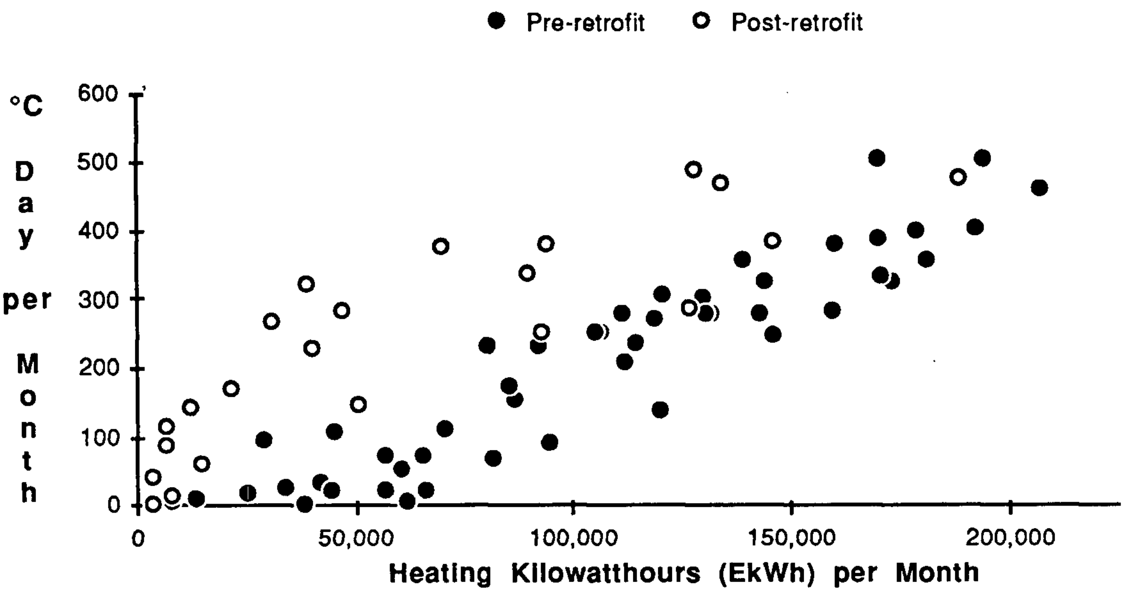
PROJECT / activity	Installed Date	Installed Cost	Estimated Savings
Consulting - Walk-thru	Oct-83	$1,000	
- Audit	Oct-83	$8,000	
Mechanical room vent unit control	1985	$150	$100
Parkade exhaust control	1985	$3,000	$900
DHW recirc pump control	1985	$1,000	$530
Parkade lights	1985	$1,290	$420
Stairwell lights	1985	$450	$270
lobby and hallway lights	1985	$2,250	$1,125
Lobby and exterior lights	1985	$1,000	$285
Evaporative cooling	1985	$5,000	$7,500
	1985		$6,000
EMCS	1985	$80,000	$27,500
Reduce fan capacity	1985	$22,000	$8,000
TOTALS		$116,140	$52,630

Office Building 'B'



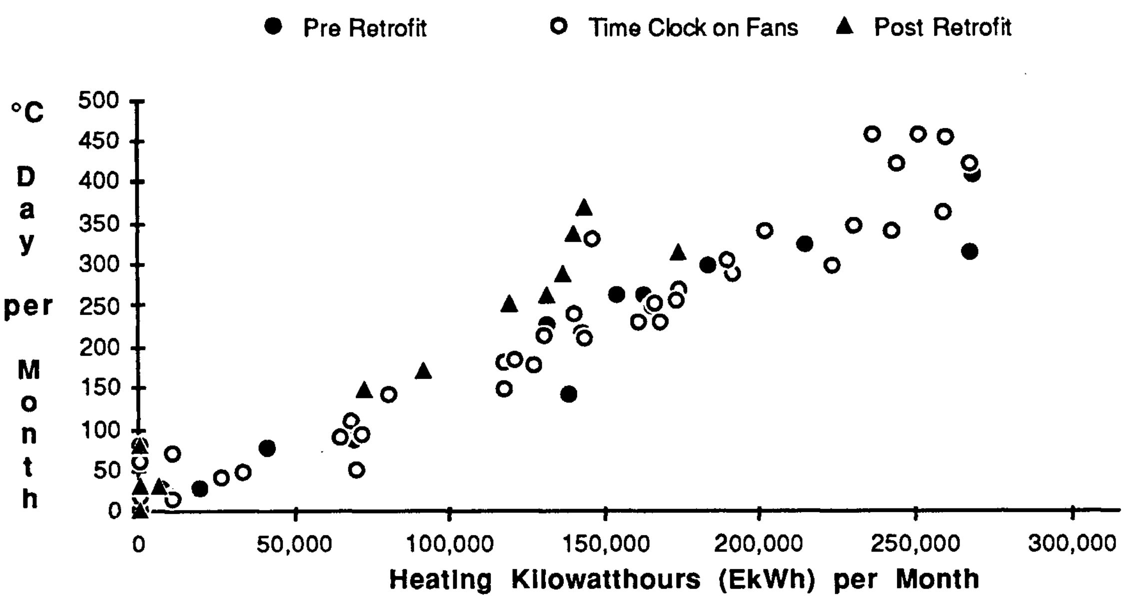
PROJECT / activity	Installed Date	Installed Cost
Consulting	Jul-83	$1,100
Consulting	Feb-81	$12,300
Consulting	Nov-84	$1,500
EMCS	Sep-86	$53,050
TOTALS		$67,950

Office Building 'C'

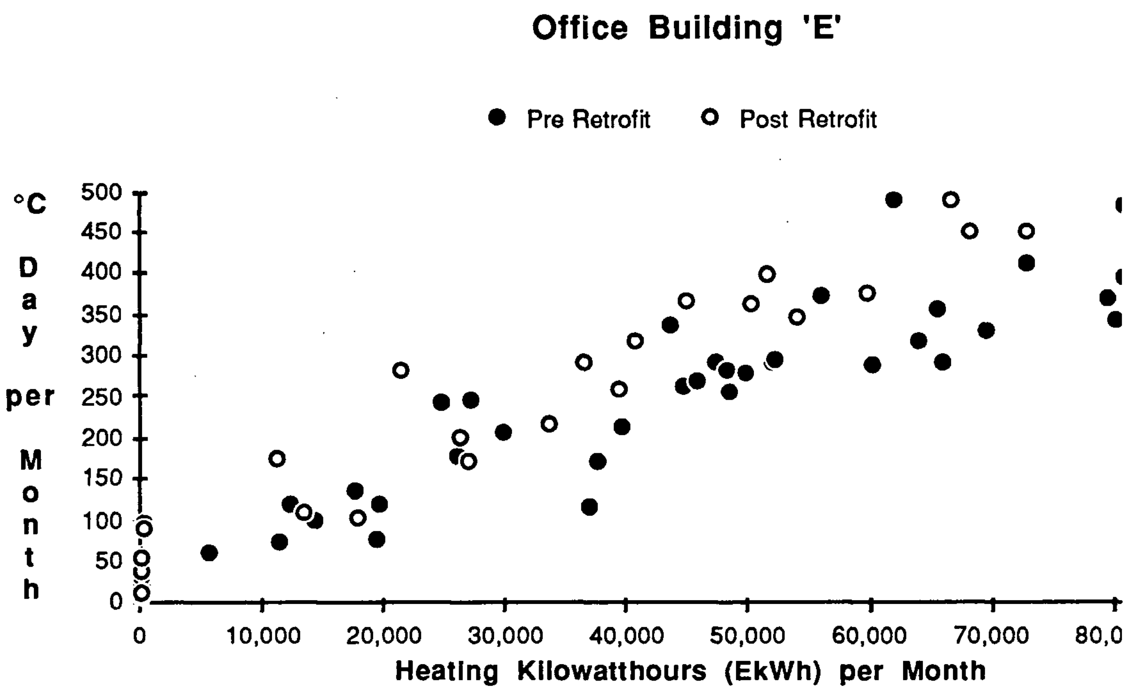


PROJECT / activity	Installed Date	Installed Cost	Estimated Savings	
Consulting	Oct-83	$4,200		
Consulting	Feb-85	$2,000		
Consulting	29645	$3,000		Proposal document
Consulting	29737	$2,000		Evaporative cooling
Consulting	29737	$2,000		pressurization - Problems
EMCS c/w DDC	1985	$85,000	$12,400	+ Maint. savings of $8,000 p.a.
Evaporative cooling - direct	1985	$5,500	$4,000	
Shut down 1 transformer	1985	$500	$5,700	
Lighting	1985	$15,000	$5,000	
Modify AHU 15	1986	$3,000	$2,000	
TOTALS		$122,200	$29,100	+$8,000 Maintenance

Office Building 'D'

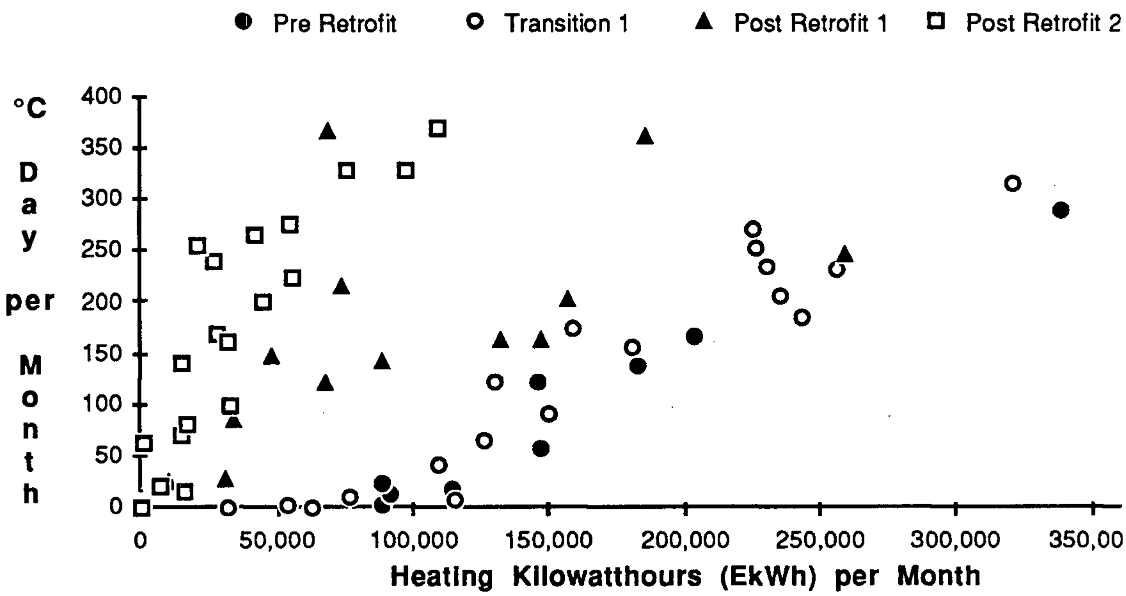


PROJECT / activity	Installed Date	Installed Cost
Time Clock on fans	1982	$1,500
Consulting	Feb-81	$12,300
Consulting	Nov-84	$1,500
EMCS	Sep-86	$53,050
TOTALS		$68,350

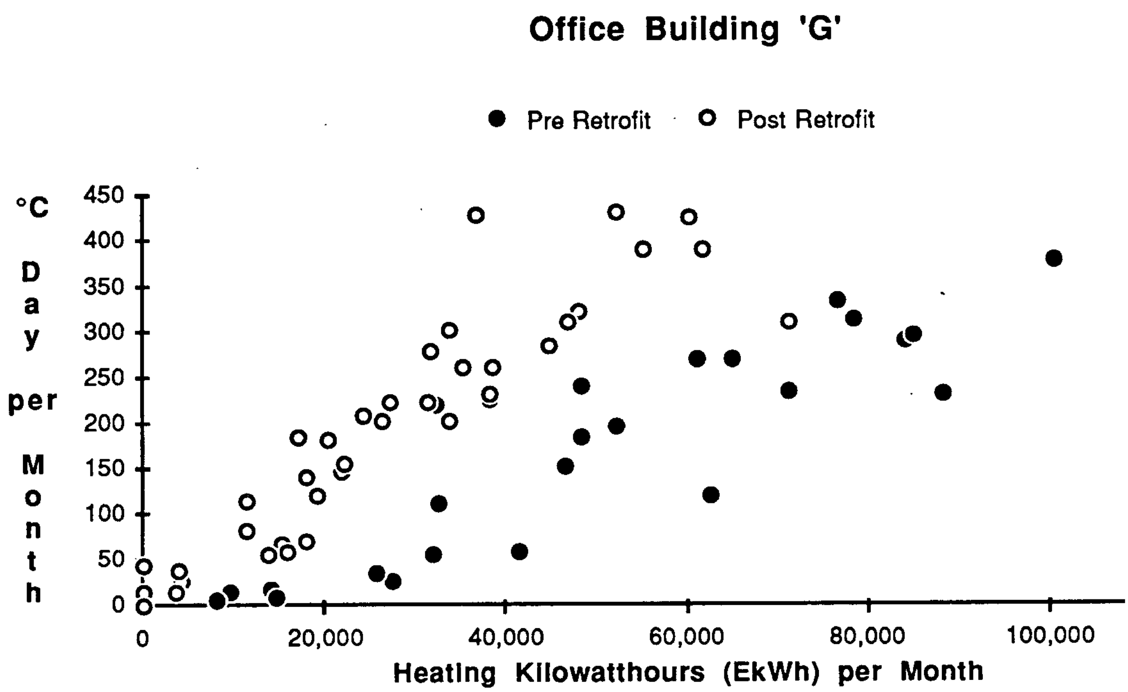


PROJECT / activity	Installed Date	Installed Cost
Consulting : Dvlpm't of control strategies	Jul-83	$1,100
Consulting	May-86	$1,500
Consulting : Justification of EMCS	Aug-83	$2,500
Consulting : Complete EMCS Concepting	Aug-84	$1,700
50% RH &Temp Control	Mar-85	$900
EMCS	Jan-85	$15,600
TOTALS	-	**$23,300**

Office Building 'F'

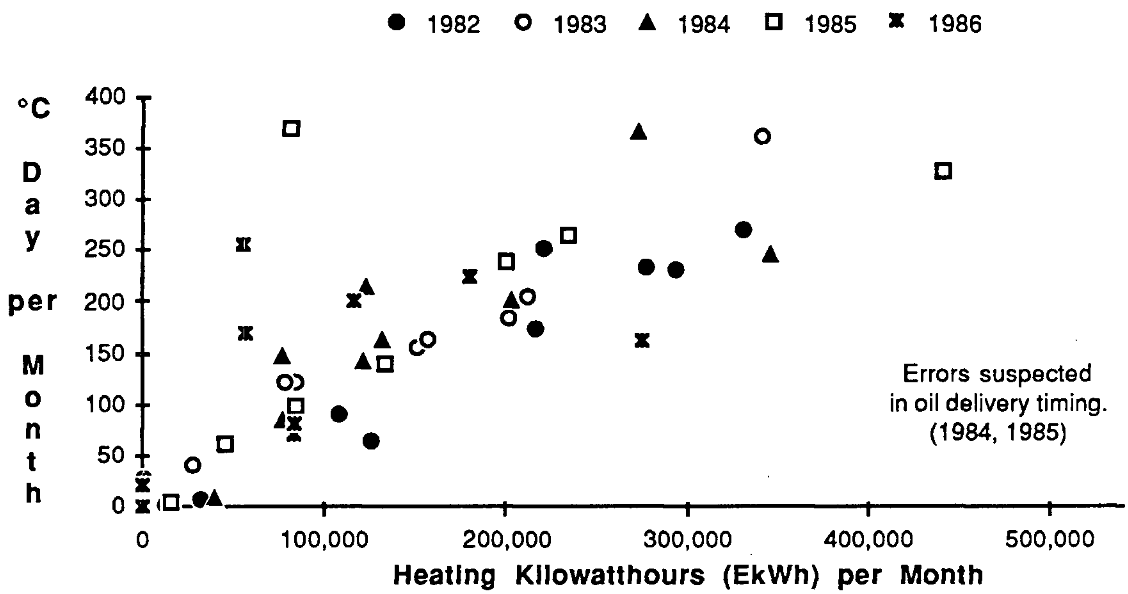


PROJECT / activity	Installed Date	Installed Cost	Estimated Savings	Notes
Consulting	Jun-82	$3,000		
Consulting	Aug-82	$8,900		
Consulting	Mar-82	$1,200		
Consulting	Aug-82	$4,000		EMCS Proposal
Consulting	Jan-Dec 83	$1,650		SUMAC Reports
Consulting	Jun-84	$500		
Consulting	Jul-84	$1,500		
Consulting	Jul-84	$1,600		EMCS
Consulting	Jan-86	$5,000		Energy review/ Comfort study
Consulting	Jun-86	$2,000		Electrical & Lighting
Consulting	May-85	$2,175		Upgrade Software
Consulting	Aug-85	$1,500		
Consulting	Mar-86	$5,000		
Radiant panel control valves	1983	$42,000	$21,000	
Control valves - Pandora wing	1983	$19,800	$6,600	
Delamping	1981-1983			
Econowatt lighting	1982	$21,500	$8,000	
Pot lighting reflectors	1982	$600	$230	
Return air fan shutdown	1983	$7,000	$3,400	
Off peak power	1983	$39,000	$9,370	
Electric demand control	1983	$20,000	6140	
Combine entrance htr & VAV-Pandora	1983	$1,000	0-750	
Repipe controls to sequence mixed air	1983	$1,200	0-1900	
cooling economizer control changes	1983	$50	$350	
General optimization	1983	$10,000	$4,500	
EMCS	1983	$60,000	$20,350	
Rewrite control strategies	1985	$3,000		
Add 10 sensors	1985	$2,400		
Add points to improve chiller pumping	1985	$4,500		
TOTALS		$270,075	$79,940	

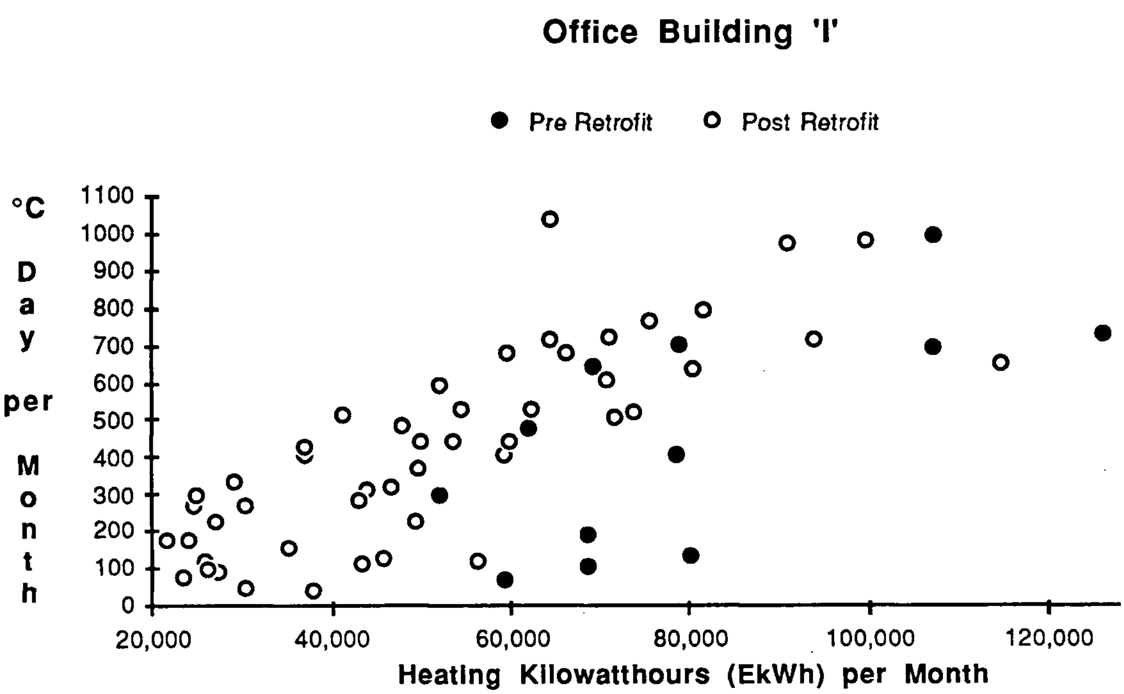


PROJECT / activity	Installed Date	Installed Cost
Consulting	Apr-84	$1,500
EMCS	Aug-84	$26,000
Software	Aug-84	$1,800
TOTALS		$29,300

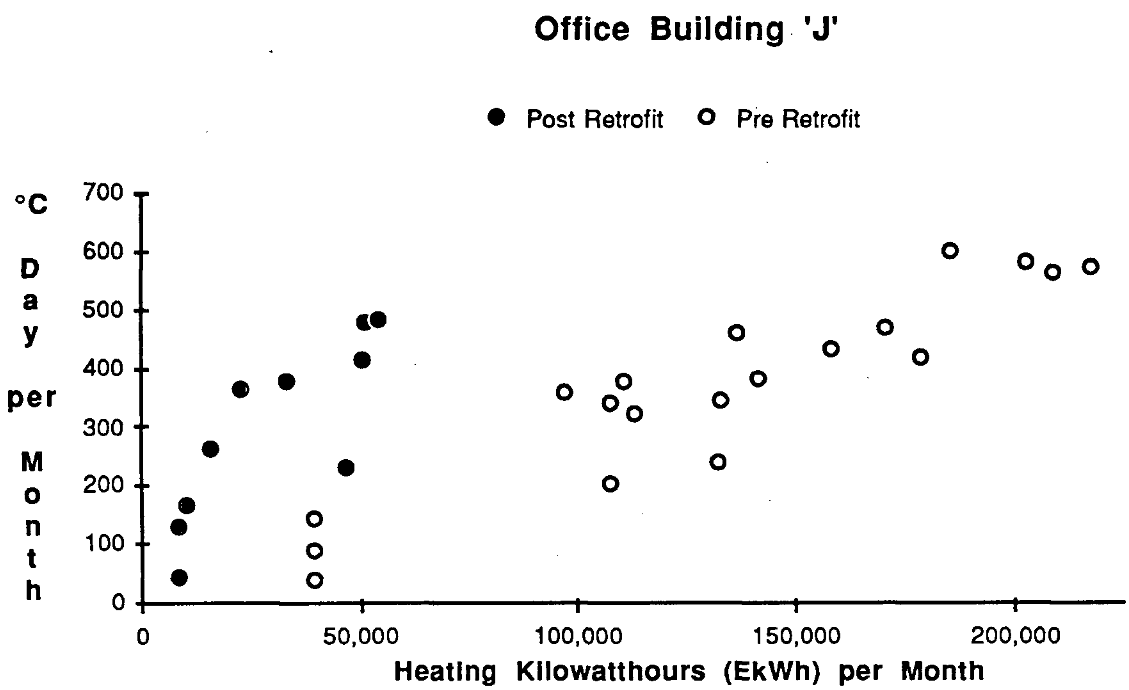
Office Building 'H'



PROJECT / activity	Installed Date	Installed Cost	Estimated Savings
Consulting	•	$6,000	
Parking lighting cost-benefit study	Mar-83	$1,500	
Audit	Jun-83	$10,000	
Bldg Energy Payback Evaluation Rpt	Jun-83	$1,200	
Lighting I	Jul-83	$1,300	
HID lighting design	Dec-83	$800	
Light fixture test	Apr-84	$500	
Interconnect air systems	Dec-84	$2,000	
Exhaust/infiltration study	Feb-85	$1,800	
Automatic Chiller By-Pass	Oct-85	$1,500	Air Quality - related to energy mgmt
Relief air dampers	Jan-86	$400	Air Quality - related to energy mgmt
aupply air systems	Jan-86	$350	Air Quality - related to energy mgmt
Energy Performance and Occ. Comfort	Jan-86	$5,000	
Parking lighting	Apr-86	$1,700	
TOTALS		**$34,050**	

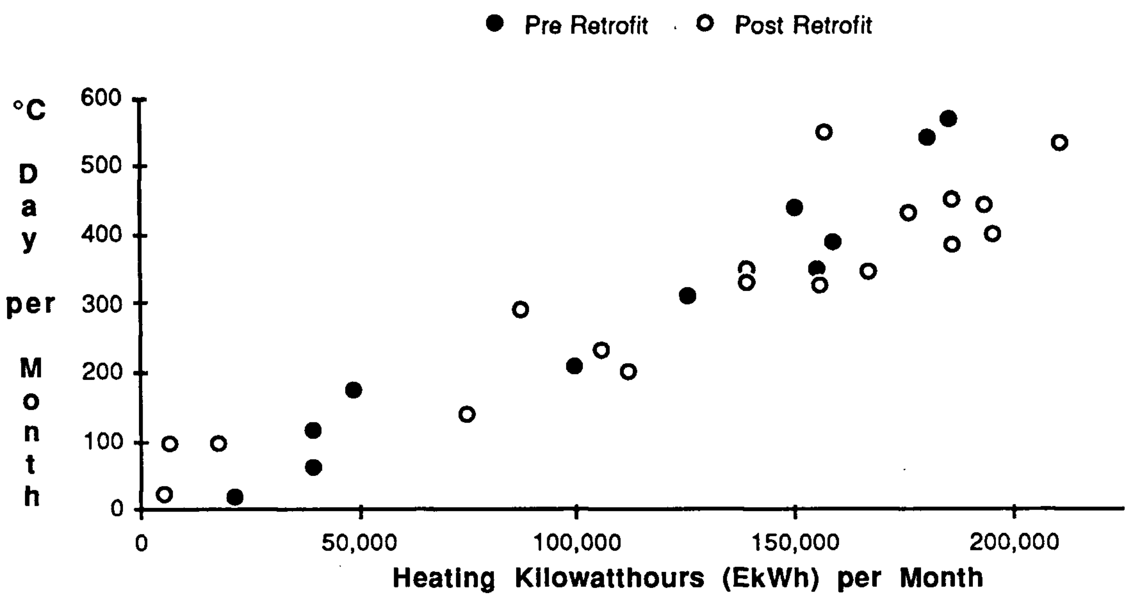


PROJECT / activity	Installed Date	Installed Cost	Estimated Savings
Consulting	1981	$9,900	
Delamping corridors	1982	$1,800	$720
Selective delamping	1982	$4,320	$2,720
Reduce HVAC operating hours	1982	-	$2,674
Maintenance	1982	-	$1,976
Preheat / reheat	1982	-	$650
Chiller controls	1982	$600	$780
Exhaust heat recovery	1982	$3,000	$1,445
Parkade block heaters	1982	$975	$1,200
TOTALS		$20,595	$12,165

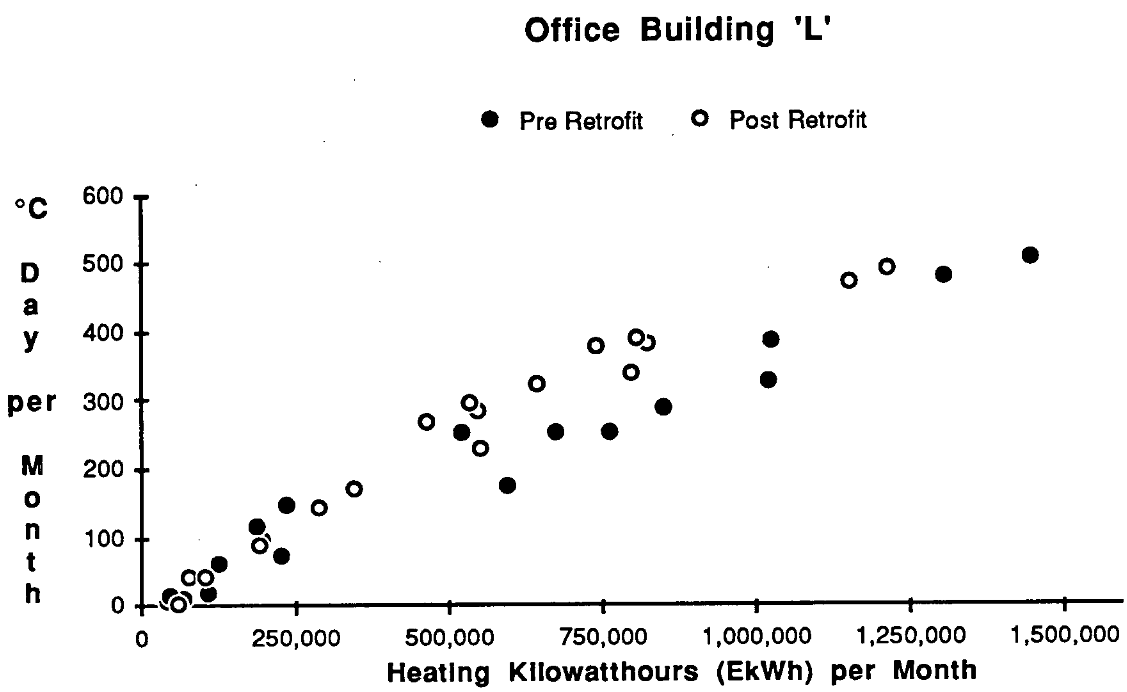


PROJECT / activity	Installed Date	Installed Cost
Consulting	< Feb 1986	$5,600
EMCS	Feb-Apr 1986	$37,000
Valve installation	Feb-Apr 1986	$3,000
Start-up	Feb-Apr 1986	$2,600
Ductwork changes	Feb-Apr 1986	$2,100
Air rebalancing	Feb-Apr 1986	$3,300
TOTALS		$53,600

Office Building 'K'



PROJECT / activity	Installed Date	Installed Cost	Estimated Savings
Consulting	< Jun 1985	$10,000	
Electrical Work	Jun-Sep 1985	$14,043	
EMCS	Jun-Sep 1985	$24,930	
Mechanical Work	Jun-Sep 1985	$33,896	
Relamping	Jun-Sep 1985	$10,000	
Balancing	Jun-Sep 1985	$7,800	
Start up & commissioning	Jun-Sep 1985	$2,500	
Construction changes	Jun-Sep 1985	$7,485	
Documentation & orientation	Jun-Sep 1985	$2,000	
Energy service company mark-up	Jun-Sep 1985	$16,648	
TOTALS		$129,302	$30,000



PROJECT / activity	Installed Date	Installed Cost
Solar Film installation	Mar-Oct 1985	$252,802

Appendix D. Alternative Measures of Financial Return

1) *The Simple Payback*

Simple paybacks determine the number of years required for the invested capital to be returned from before tax cash flows:

$$\textbf{Simple Payback} = \frac{\textbf{Net Investment (\$)}}{\textbf{Net Annual Before Tax Cash Flow (\$)}}$$

$$\text{i.e.} \quad \frac{\$\,100{,}000}{\$50{,}000 \text{ per year}} = 2 \text{ years}$$

Simple paybacks do have some advantages over more complicated measures. A fast cursory risk assessment is possible by altering either the estimated initial costs, or the estimated future costs. Simple payback is well understood and easy to quantify, but the financial return is hidden. The time value of money is not considered and cash flows following the payback period are disregarded.

2) *Investor's Rate of Return*

This return measure is simply the reciprocal of the simple payback:

$$\textbf{Investor's Rate of Return} = \frac{\textbf{Net Annual BT Cash Flow (\$)}}{\textbf{Investment (\$)}} \times 100\ \%$$

$$\text{i.e.} \quad \frac{\$50{,}000 \text{ per year}}{\$\,100{,}000} \times 100\ \% = 50\ \% \text{ per year}$$

3) *Net Present Value and Profitability Index*

The Net Present Value (NPV) of any investment is equal to the sum of all cost and benefit flows from the investment, discounted to present day value at the required rate of return. The required rate of return is also known as the discount rate or hurdle rate.

$$\textbf{Present Value} = \frac{CF(1)}{(1+r)} + \frac{CF(2)}{(1+r)^2} + \frac{CF(3)}{(1+r)^3} + \cdots + \frac{CF(n)}{(1+r)^n}$$

Net Present Value = Present Value – Implementation Cost ($)

Where : CF = $ Cash Flow (including taxes, monitoring, maintenance, and savings)
r = Risk adjusted discount rate, hurdle rate, opportunity cost of capital, or minimum acceptable % return.

$$\text{i.e. NPV} = -\$100{,}000 + \frac{\$50{,}000}{(1+0.15)^1} + \frac{\$50{,}000}{(1+0.15)^2} + \frac{\$50{,}000}{(1+0.15)^3} + \frac{\$50{,}000}{(1+0.15)^4}$$

$$= \$142{,}749$$

(Investing $142,749 at 15% return would yield the same returns as this $100,000 project)

Investments should be made if the NPV is nonnegative - the project will increase the value of the firm. Net present value techniques work with any cash flow pattern (i.e. positive or negative), account for the time value of money, and are easy to calculate. The disadvantages of this method are that it may be difficult to determine the risk adjusted discount rate, and the cash flows are implicitly assumed to be reinvested (or borrowed for negative cash flows) at the discount rate.

Also, a nonzero NPV also does not give a clear idea of the relative merit of one proposal when several alternatives are available. The Profitability Index, or Benefit-Cost Ratio, can be used with NPV to overcome this problem. The index is the present value of forecasted future cash flows divided by the initial cost. For example:

Project	C_0	C_1	PV @ 10%	NPV @ 10%	Profitability Index
A	-20,000	+26,000	+23,636	+3,636	1.18
B	-10,000	+15,000	+13,636	+3,636	1.36

Each project has an equal net present value, but project A has a lower profitability index. Project B would be chosen in this simple example.

4) *Internal Rate of Return*

The internal rate of return (IRR) is equal to that discount rate which equates the NPV to zero (i.e. setting the NPV equation equal to zero and solve for R.) Managers are familiar with this measure and it gives an clearer indication of the relative strength of the investment than net present value alone.

$$0 = -\$\,\text{Cost} + \frac{CF(1)}{(1+r)} + \frac{CF(2)}{(1+r)^2} + \frac{CF(3)}{(1+r)^3} + \cdots + \frac{CF(n)}{(1+r)^n}$$

Where : CF(n) = $ Cash Flow in period n.

r = Internal Rate of Return (IRR).

$$\text{i.e. } 0 = -\$100{,}000 + \frac{\$50{,}000}{(1+IRR)^1} + \frac{\$50{,}000}{(1+IRR)^2} + \frac{\$50{,}000}{(1+IRR)^3} + \frac{\$50{,}000}{(1+IRR)^4}$$

IRR = 34.9 %

(This measure assumes each of the $50,000 yearly savings (net of all costs) is reinvested at the IRR of 34.9% until the end of period 4)

There are few analytical methods without problems and internal rate of return is no exception. The formula implicitly assumes that cash flows are reinvested at the calculated IRR - for example : an internal rate of return of 22% implies that all positive cash flows earn 22% and all negative borrowings are made at 22% until the final period in the analysis. Also, where positive and negative cash flows exist, there may be multiple solutions to the equation.

5) *Adjusted Internal Rate of Return*

To account for reinvestment rates and negative cash flows from an investment, the IRR calculation can be modified so that all cash flows are compounded forward at the reinvestment rate.

$$0 = -\$Cost + \frac{CF(1)\ (1+I)^{n-1}}{(1+r)^{n}} + \frac{CF(2)\ (1+I)^{n-2}}{(1+r)^{n}} + \frac{CF(3)\ (1+I)^{n-3}}{(1+r)^{n}} + \cdots + \frac{CF(n)}{(1+r)^{n}}$$

Where : CF(n) = \$ Cash Flow in period n.
i = reinvestment rate for positive cash flows
r =**Adjusted Internal Rate of Return (AIRR)**

$$\text{i.e. } 0 = -\$100{,}000 + \frac{\$50{,}000(1+0.12)^3}{(1+AIRR)^4} + \frac{\$50{,}000(1+0.12)^2}{(1+AIRR)^4} + \frac{\$50{,}000(1+0.12)}{(1+AIRR)^4} + \frac{\$50{,}000}{(1+AIRR)^4}$$

Rearranging :

$$AIRR = \sqrt[4]{\frac{\$50{,}000}{\$100{,}000} \times \{1.12^3 + 1.12^2 + 1.12 + 1\}} - 1$$

$$= 24.3\ \%$$

Positive cash flows are reinvested at 12 %. (for example, pay off existing mortgage.) The Adjusted IRR for this cash flow stream is 24.3 %. In this example, yearly savings are identical, which allows rearranging the equation, as shown.

Two reinvestment rates can also be used. The first rate would provide a return to initial cash surplus (such as short term savings rates), and the second rate can be used when cash surplus reaches a certain level and can be reinvested at a higher rate. The formula then becomes (with only one reinvestment rate):

Appendix E.

Financial Analyses
of
Energy Management Programs in Study Buildings

The following notes on the analysis should be considered when observing the results :

i) 7 of the buildings use oil for heating fuel. Forecast savings use 1986 energy rates.

ii) No attempt was made to provide for energy rate increases or decreases in the forecast years.

iii) No reduction in savings was allowed for, which is possible as equipment may deteriorate.

iv) For the government buildings, a cost of $0.02/sf per year is included as a management expense. This figure is based on the total square footage of all property types monitored by the Energy Management Division and an estimated $400,000 per year for department costs.

v) Heating energy is corrected for degree days based on the first year of data and the calculated heating balance point. Energy used for cooling is not corrected for weather. For detailed analysis, cooling energy should be temperature corrected.

vi) Electrical energy savings and kW demand savings are straight line over the base year. kW savings are cumulative for 12 months.

vii) All cost savings are calculated using actual marginal energy rates at the time of energy savings and include all sales taxes.

viii) Maintenance expenses may change with new equipment, but are not included except where service contracts were noted. In the case of window film installation, a 3% cost replacement allowance was included for 2 years.

ix) A capitalization rate (CAP rate) of 10% was used to estimate building values.

x) Savings are forecasted for a 5 year period beyond the last year of data. Savings beyond this point are less certain but could increase returns to the project. (At a 15% discount rate, a 1$ savings achieved 10 years hence is worth $0.247 in present value terms.)

xi) The adjustment savings rate for positive cash flows for the Adjusted Internal Rate of Return (AIRR) calculations is 8%.

xii) Taxes on capital gains resulting from increased value on sale of a property are not included.

xiii) Insurance costs are not included.

xiv) No salvage value is included in the analysis. The project equipment becomes an integral part of the office building and the value of the equipment on the sale of the building is primarily determined by property cash flows.

OFFICE BUILDING 'A' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings		$1,450	$33,250	$33,973	$31,217	$31,217	$31,217	$31,217	$31,217
Less management @ $0.02/sf		$4,516	$4,516	$4,516	$4,516	$4,516	$4,516	$4,516	$4,516
Net Operating Savings	$0	($3,066)	$28,734	$29,457	$26,701	$26,701	$26,701	$26,701	$26,701
Project Expenditures									
Consulting	$9,000	$0	$0						
Equipment	$0	$0	$116,140						
Total Project Costs	$9,000	$0	$116,140						
Cash Flow	($9,000)	($3,066)	($87,406)	$29,457	$26,701	$26,701	$26,701	$26,701	$26,701
Cumulative				$29,457	$58,515	$89,897	$123,789	$160,394	$199,926
Savings @		8.0%		$0	$2,357	$4,681	$7,192	$9,903	$12,831

NPV @	15.0%	$402
NPV @	20.0%	($7,497)
	Internal Rate of Return	15.2%
	Adjusted Internal Rate of Return	11.9%

OFFICE BUILDING 'B' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1981	1982	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings			$2,616	$533	$3,244	$7,734	$6,615	$6,615	$6,615	$6,615	$6,615
Less management @ $0.02/sf	$1,104	$1,104	$1,104	$1,104	$1,104	$1,104	$1,104	$1,104	$1,104	$1,104	$1,104
Net Operating Savings	($1,104)	($1,104)	$1,512	($571)	$2,140	$6,630	$5,511	$5,511	$5,511	$5,511	$5,511
Project Expenditures											
Consulting	$12,300	$0	$1,100	$1,500	$0	$0					
Equipment	$0	$0	$0	$0	$0	$53,050					
Total Project Costs	$12,300	$0	$1,100	$1,500	$0	$53,050					
Cash Flow	($13,404)	($1,104)	$412	($2,071)	$2,140	($46,420)	$5,511	$5,511	$5,511	$5,511	$5,511
Cumulative			$412	($1,627)	$383	($46,007)	($44,177)	($42,200)	($40,066)	($37,761)	($35,271)
Savings @	8.0%			$33	($130)	$31	($3,681)	($3,534)	($3,376)	($3,205)	($3,021)

NPV @	15.0%	($24,424)
NPV @	20.0%	($21,865)
IRR		-17.7%

*** NOTE ***

The major energy management project was completed in late 1986 .
The energy savings noted beyond 1986 may not reflect the eventual total savings.
The indicated low return will add conservatism to the total return of the combined projects (Table XIV)

OFFICE BUILDING 'C' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings	$2,731	$8,412	$18,796	$34,210	$32,616	$32,616	$32,616	$32,616	$32,616
Less management @ $0.02/sf	$3,953	$3,953	$3,953	$3,953	$3,953	$3,953	$3,953	$3,953	$3,953
Net Operating Savings	($1,222)	$4,459	$14,844	$30,257	$28,664	$28,664	$28,664	$28,664	$28,664
Project Expenditures									
Consulting	$4,200	$0	$9,000	$0	$0				
Equipment	$0	$0	$109,000	$0	$0				
Total Project Costs	$4,200	$0	$118,000	$0	$0				
Cash Flow	($5,422)	$4,459	($103,156)	$30,257	$28,664	$28,664	$28,664	$28,664	$28,664
Cumulative				$30,257	$61,342	$94,913	$131,169	$170,326	$212,616
Savings @	8.0%			$0	$2,421	$4,907	$7,593	$10,494	$13,626

NPV @	12.0%	$10,183
NPV @	15.0%	$3,066
	Internal Rate of Return	16.6%
	Adjusted Internal Rate of Return	12.6%

OFFICE BUILDING 'D' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1981	1982	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings		$1,091	$7,023	$12,122	$17,812	$19,265	$17,611	$17,611	$17,611	$17,611	$17,611
Less management @ $0.02/sf	$2,661	$2,661	$2,661	$2,661	$2,661	$2,661	$2,661	$2,661	$2,661	$2,661	$2,661
Net Operating Savings	($2,661)	($1,570)	$4,362	$9,461	$15,151	$16,604	$14,950	$14,950	$14,950	$14,950	$14,950
Project Expenditures											
Consulting	$12,300	$0	$0	$1,500	$0	$0					
Equipment	$0	$1,500	$0	$0	$0	$53,050					
Total Project Costs	$12,300	$1,500	$0	$1,500	$0	$53,050					
Cash Flow	($14,961)	($3,070)	$4,362	$7,961	$15,151	($36,446)	$14,950	$14,950	$14,950	$14,950	$14,950
Cumulative			$4,362	$12,671	$28,835	($5,304)	$9,221	$24,908	$41,850	$60,148	$79,910
Savings @	8.0%			$349	$1,014	$2,307	($424)	$738	$1,993	$3,348	$4,812

NPV @	12.0%	$9,792
NPV @	15.0%	$5,529
Internal Rate of Return		20.8%
Adjusted Internal Rate of Return		16.3%

OFFICE BUILDING 'E' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1981	1982	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings		$2,487	$3,498	$3,449	($2,536)	($851)	($1,442)	($1,442)	($1,442)	($1,442)	($1,442)
Less management @ $0.02/sf	$546	$546	$546	$546	$546	$546	$546	$546	$546	$546	$546
Net Operating Savings	($546)	$1,941	$2,952	$2,903	($3,082)	($1,397)	($1,988)	($1,988)	($1,988)	($1,988)	($1,988)
Project Expenditures											
Consulting	$0	$0	$3,600	$1,700	$1,700	$1,500	$0				
Equipment	$0	$0	$0	$0	$16,500	$0	$0				
Total Project Costs	$0	$0	$3,600	$1,700	$18,200	$1,500	$0				
Cash Flow	($546)	$1,941	($648)	$1,203	($21,282)	($2,897)	($1,988)	($1,988)	($1,988)	($1,988)	($1,988)
Cumulative				$1,203	($19,982)	($24,477)	($28,423)	($32,685)	($37,287)	($42,258)	($47,626)
Savings @		8.0%		$0	$96	($1,599)	($1,958)	($2,274)	($2,615)	($2,983)	($3,381)

NPV @	12.0%	($14,598)
NPV @	15.0%	($12,540)

OFFICE BUILDING 'F' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

		1982	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings		$20,482	$32,022	$47,413	$39,354	$44,010	$37,121	$37,121	$37,121	$37,121	$37,121
Less management @ $0.02/sf		$4,236	$4,236	$4,236	$4,236	$4,236	$4,236	$4,236	$4,236	$4,236	$4,236
Net Operating Savings		$16,246	$27,786	$43,177	$35,118	$39,774	$32,884	$32,884	$32,884	$32,884	$32,884
Project Expenditures											
Consulting		$17,100	$1,650	$3,600	$3,675	$12,000	$0				
Equipment		$22,100	$200,050	$0	$9,900	$0	$0				
Total Project Costs		$39,200	$201,700	$3,600	$13,575	$12,000	$0				
Cash Flow		($22,954)	($173,914)	$39,577	$21,543	$27,774	$32,884	$32,884	$32,884	$32,884	$32,884
Cumulative				$39,577	$64,285	$97,202	$137,863	$181,776	$229,203	$280,423	$335,742
Savings @		8.0%		$0	$3,166	$5,143	$7,776	$11,029	$14,542	$18,336	$22,434

NPV @	12.0%	($34,255)
NPV @	15.0%	($44,511)
	Internal Rate of Return	5.7%
	Adjusted Internal Rate of Return	6.8%

OFFICE BUILDING 'G' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings	$11,059	$13,726	$14,717	$10,597	$10,595	$10,595	$10,595	$10,595	$10,595
Less management @ $0.02/sf	$512	$512	$512	$512	$512	$512	$512	$512	$512
Net Operating Savings	$10,547	$13,214	$14,205	$10,085	$10,083	$10,083	$10,083	$10,083	$10,083
Project Expenditures									
Consulting	$0	$1,500	$0	$0	$0				
Equipment	$0	$27,800	$0	$0	$0				
Total Project Costs	$0	$29,300	$0	$0	$0				
Cash Flow	$10,547	($16,086)	$14,205	$10,085	$10,083	$10,083	$10,083	$10,083	$10,083
Cumulative			$14,205	$25,427	$37,543	$50,629	$64,763	$80,026	$96,511
Savings @	8.0%		$0	$1,136	$2,034	$3,003	$4,050	$5,181	$6,402

NPV @	15.0%	$31,439
NPV @	20.0%	$25,244
Internal Rate of Return		72.0%
Adjusted Internal Rate of Return		50.4%
(combining year 1 and 2 into 1)		

Savings achieved initially due to operating changes. The rates of return include these low cost measures.
The equipment installation (EMCS) may provide future savings in manpower which have not been accounted for.

OFFICE BUILDING 'H' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings	$12,490	$23,946	$15,570	$15,281	$13,876	$13,876	$13,876	$13,876	$13,876
Less management @ $0.02/sf	$4,916	$4,916	$4,916	$4,916	$4,916	$4,916	$4,916	$4,916	$4,916
Net Operating Savings	$7,574	$19,030	$10,654	$10,365	$8,960	$8,960	$8,960	$8,960	$8,960
Project Expenditures									
Consulting	$15,700	$0	$1,800	$2,500					
Equipment	$2,100	$2,500	$1,500	$2,100					
Total Project Costs	$17,800	$2,500	$3,300	$4,600					
Cash Flow	($10,226)	$16,530	$7,354	$5,765	$8,960	$8,960	$8,960	$8,960	$8,960
Cumulative		$16,530	$25,206	$32,987	$44,585	$57,112	$70,640	$85,251	$101,031
Savings @	8.0%	$0	$1,322	$2,016	$2,639	$3,567	$4,569	$5,651	$6,820

NPV @	15.0%	$28,909
NPV @	20.0%	$22,914
Internal Rate of Return		120.5%
Adjusted Internal Rate of Return		33.2%

OFFICE BUILDING 'I' - Provincial Government
Energy Management Program Financial Analysis

Δ Forecast = 1986 savings

	1981	1982	1983	1984	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings			$13,404	$17,495	$16,005	$15,444	$15,300	$15,300	$15,300	$15,300	$15,300
Less management @ $0.02/sf	$1,130	$1,130	$1,130	$1,130	$1,130	$1,130	$1,130	$1,130	$1,130	$1,130	$1,130
Net Operating Savings	($1,130)	($1,130)	$12,274	$16,364	$14,875	$14,314	$14,170	$14,170	$14,170	$14,170	$14,170
Project Expenditures											
Consulting	$9,900	$0									
Equipment	$0	$10,695									
Total Project Costs	$9,900	$10,695									
Cash Flow	($11,030)	($11,825)	$12,274	$16,364	$14,875	$14,314	$14,170	$14,170	$14,170	$14,170	$14,170
Cumulative			$12,274	$29,620	$46,865	$64,927	$84,291	$105,205	$127,791	$152,184	$178,528
Savings @ 8.0%				$982	$2,370	$3,749	$5,194	$6,743	$8,416	$10,223	$12,175

NPV Cash Flow @	12.0%	$41,431
NPV Cash Flow @	15.0%	$33,013
Internal Rate of Return		48.7%
Adjusted Internal Rate of Return		24.1%

Energy Management Project Financial Summary - Office Building 'J'							
			Δ Forecast				
A. PROJECT *returns*	**1985**	**1986**	*1987 Δ*	*1988 Δ*	*1989 Δ*	*1990 Δ*	*1991 Δ*
Operating Savings	$4,825	$22,302	$27,565	$27,565	$27,565	$27,565	$27,565
Less : Lease Payments	$0	$6,416	$9,625	$9,625	$9,625	$9,625	$6,840
Net Operating Savings	$4,825	$15,886	$17,940	$17,940	$17,940	$17,940	$20,725
Project Expenditures							
Consulting	$5,600	$0	Remaining project equipment leased				
Equipment	$0	$11,000					
Total Project Costs	$5,600	$11,000					
Before Tax Cash Flow	($775)	$4,886	$17,940	$17,940	$17,940	$17,940	$20,725
Tax Considerations							
Capital Cost Allowance @ 5%	$140	$548	$796	$756	$718	$682	$648
Taxable benefit	$4,685	$15,338	$17,145	$17,184	$17,222	$17,258	$20,077
Assumed tax rate	50.0%	50.0%	50.0%	45.0%	45.0%	45.0%	45.0%
Tax Payable	$2,343	$7,669	$8,572	$7,733	$7,750	$7,766	$9,035
After Tax Cash Flow	($3,118)	($2,783)	$9,368	$10,207	$10,190	$10,174	$11,690

NPV @ 15 % =	$21,040	Internal Rate of Return =	104.2%
NPV @ 20 % =	$16,578	Adjusted Internal Rate of Return =	45.3%
		(@ 8% savings rate on positive cash flows)	

Energy Management Project Financial Summary - Office Building 'J'

B. Building OWNER Returns	1985	1986	Forecast 1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Total Operating Savings	$4,825	$22,302	$27,565	$27,565	$27,565	$27,565	$27,565
x Vacancy	31.0%	31.0%	28.0%	25.0%	20.0%	15.0%	15.0%
Operating savings to owner	$1,496	$6,914	$7,718	$6,891	$5,513	$4,135	$4,135
less Owner paid lease payments	$0	$1,989	$2,695	$2,406	$1,925	$1,444	$1,026
Lease expiries						20.0%	40.0%
Increase in lease revenues						$5,513	$16,539
Capitalized value @ 10 %						$55,130	$110,260
NET Owner Benefits	$1,496	$4,925	$5,023	$4,485	$3,588	$63,334	$129,908
Project Expenditures	$5,000	$11,000					
Before Tax Cash Flow (with no increase in Lease revenues)	($3,504)	($6,075)	$5,023	$4,485	$3,588	$2,691	$3,109
Tax Considerations							
Capital Cost Allowance @ 5%	$125	$519	$796	$756	$718	$682	$648
Taxable benefit	$1,371	$4,406	$4,228	$3,729	$2,870	$2,009	$2,461
Assumed tax rate	50.0%	50.0%	50.0%	45.0%	45.0%	45.0%	45.0%
Tax Payable	$685	$2,203	$2,114	$1,678	$1,292	$904	$1,107
After Tax Cash Flow	($4,190)	($8,278)	$2,909	$2,807	$2,297	$1,787	$2,001
ATCF + Value & lease Increase	($4,190)	($8,278)	$2,909	$2,807	$2,297	$62,430	$128,800

Rates of return NOT Including Value and Lease Increase

NPV ATCF @ 15 % =	($3,718)	IRR - no value increase =	-1.8%	
NPV ATCF @ 20 % =	($4,123)	Adjusted Internal Rate of Return =	2.3%	(8% savings)

Rates of return INCLUDING Value and Lease Increase

NPV ATCF @ 15 % =	$70,168	IRR with Value Increase =	79.5%	
NPV ATCF @ 20 % =	$51,574	Adjusted Internal Rate of Return =	68.2%	(8% savings)

Energy Management Project Financial Summary - Office Building 'K'

A. PROJECT returns	1985	1986	*Forecast Δ* 1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Operating Savings	$6,042	$22,749	$23,386	$23,386	$23,386	$23,386	$23,386
Less : maintenance contract	$450	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800
Net Operating Savings	$5,592	$20,949	$21,586	$21,586	$21,586	$21,586	$21,586
Project Expenditures							
Consulting	$10,000						
Equipment	$119,302						
Total Project Costs	$129,302						
Before Tax Cash Flow	($123,710)	$20,949	$21,586	$21,586	$21,586	$21,586	$21,586
Tax Considerations							
Capital Cost Allowance @ 5%	$3,233	$6,303	$5,988	$5,689	$5,404	$5,134	$4,878
Taxable benefit	$2,359	$14,646	$15,598	$15,897	$16,181	$16,452	$16,708
Assumed tax rate	50.0%	50.0%	50.0%	45.0%	45.0%	45.0%	45.0%
Tax Payable	$1,180	$7,323	$7,799	$7,154	$7,282	$7,403	$7,519
After Tax Cash Flow	($124,890)	$13,626	$13,787	$14,432	$14,304	$14,183	$14,067

NPV @ 15 % =	($62,448)	Internal Rate of Return =	-10.1%
NPV @ 20% =	($65,250)	Adjusted Internal Rate of Return =	-3.3%
		(@ 8% savings rate on positive cash flows)	

Energy Management Project Financial Summary - Office Building 'K'

B. Building OWNER Returns

B. Building OWNER Returns	1985	1986	*Forecast Δ* *1987 Δ*	*1988 Δ*	*1989 Δ*	*1990 Δ*	*1991 Δ*
Total Operating Savings	$6,042	$22,749	$23,386	$23,386	$23,386	$23,386	$23,386
x Vacancy	19.4%	24.0%	30.0%	25.0%	20.0%	15.0%	15.0%
	$1,172	$5,460	$7,016	$5,846	$4,677	$3,508	$3,508
Tenant recoveries	$4,870	$17,289	$16,370	$17,539	$4,677	$0	$0
Lease expiries					$0	20.0%	20.0%
Increase in lease revenues					4677.16174	$9,354	$14,031
Capitalized value @ 10 %					$46,772	$46,772	$46,772
NET Owner Benefits	$6,042	$22,749	$23,386	$23,386	$60,803	$59,634	$64,311
Project Expenditure	$129,302						
BEFORE TAX CASH (with no increase in Lease revenues)	($123,260)	$22,749	$23,386	$23,386	$9,354	$3,508	$3,508
Tax Considerations							
Capital Cost Allowance @ 5%	$3,233	$6,303	$5,988	$5,689	$5,404	$5,134	$4,878
Taxable benefit	$2,809	$16,446	$17,398	$17,697	$3,950	($1,626)	($1,370)
Assumed tax rate	50.0%	50.0%	50.0%	45.0%	45.0%	45.0%	45.0%
Tax Payable	$1,405	$8,223	$8,699	$7,964	$1,777	($732)	($616)
After Tax Cash Flow	($124,665)	$14,526	$14,687	$15,422	$7,577	$4,240	$4,124
ATCF + Value & lease Increase	($124,665)	$14,526	$14,687	$15,422	$59,026	$60,366	$64,927

Rates of return NOT including Value and Lease increase

NPV ATCF @ 15 % =	($71,795)	IRR - no value increase =	-21.2%	
NPV ATCF @ 20 % =	($64,089)	Adjusted Internal Rate of Return =	-7.5%	(8% savings)

Rates of return INCLUDING Value and Lease increase

NPV ATCF @ 15 % =	$907	IRR with Value Increase =	15.2%	
NPV ATCF @ 20 % =	($15,805)	Adjusted Internal Rate of Return =	13.0%	(8% savings)

Energy Management Project Financial Summary - Office Building 'L'

Δ Forecast

A. PROJECT returns	1985	1986	*1987 Δ*	*1988 Δ*	*1989 Δ*	*1990 Δ*	*1991 Δ*
OPERATING SAVINGS	$57,253	$105,230	$105,512	$105,512	$105,512	$105,512	$105,512
Replacement & repair @ 3 %		$7,584	$7,584				
NET OPERATING SAVINGS	$57,253	$97,646	$97,928	$105,512	$105,512	$105,512	$105,512
Project Expenditures							
Solar Film	$252,802						
Total Project Costs	$252,802						
Before Tax Cash Flow	($195,549)	$97,646	$97,928	$105,512	$105,512	$105,512	$105,512
Less : Operating expenses	$126,401	$126,401					
Taxable Benefit	($69,148)	($28,755)	$97,928	$105,512	$105,512	$105,512	$105,512
Assumed tax rate	50.0%	50.0%	50.0%	45.0%	45.0%	45.0%	45.0%
Taxes Payable	($34,574)	($14,378)	$48,964	$47,480	$47,480	$47,480	$47,480
After Tax Cash Flow	($160,975)	$112,023	$48,964	$58,032	$58,032	$58,032	$58,032

NPV @ 15 % =	$85,859	Internal Rate of Return =	39.5%
NPV @ 20 % =	$58,922	Adjusted Internal Rate of Return =	20.5%
		(@ 8% savings rate on positive cash flows)	

Energy Management Project Financial Summary - Office Building 'L'

B. Building OWNER Returns

	1985	1986	1987 Δ	1988 Δ	1989 Δ	1990 Δ	1991 Δ
Total Operating Savings	$57,253	$105,230	$105,512	$105,512	$105,512	$105,512	$105,512
Replacement & repair @ 3 %		$7,584	$7,584				
Vacancy	20.0%	20.0%	20.0%	17.0%	14.0%	11.0%	11.0%
Operating savings to owner	$11,451	$21,046	$21,102	$17,937	$14,772	$11,606	$11,606
Owner paid replacement		($1,517)	($1,517)				
Lease expiries						40%	20%
Increase in lease revenues						$42,205	$63,307
Capitalized value @ 10 %						$422,048	$211,024
NET Owner Benefits	$11,451	$19,529	$19,586	$17,937	$14,772	$475,860	$285,938
Project Expenditures	$252,802						
BT Cash Flow (with no increase in Lease revenues)	($241,351)	$19,529	$19,586	$17,937	$14,772	$11,607	$11,607
Operating Expenses	$126,401	$126,401					
Taxable Benefit	($114,950)	($106,872)	$19,586	$17,937	$14,772	$11,607	$11,607
Assumed tax rate	50.0%	50.0%	50.0%	45.0%	45.0%	45.0%	45.0%
Taxes Payable	($57,475)	($53,436)	$9,793	$8,072	$6,647	$5,223	$5,223
After Tax Cash Flow	($183,876)	$72,965	$9,793	$9,865	$8,124	$6,384	$6,384
ATCF + Value & lease Increase	($183,876)	$72,965	$9,793	$9,865	$8,124	$470,636	$280,715

Rates of return NOT Including Value and Lease Increase

NPV ATCF @ 15 % =	($83,442)	IRR - no value increase =	-19.1%	
NPV ATCF @ 20 % =	($84,951)	Adjusted Internal Rate of Return =	-2.7%	(8% savings)

Rates of return INCLUDING Value and Lease Increase

NPV ATCF @ 15 % =	$220,399	IRR - no value increase =	40.7%	
NPV ATCF @ 20 % =	$147,087	Adjusted Internal Rate of Return =	31.1%	(8% savings)

Capital gains tax on sale not included for value increase