SOLAR HEATING OF RESIDENTIAL SWIMMING POOLS IN WINNIPEG: AN ANALYSIS OF CONCEPTS

By

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ABSTRACT

The study analyzed a number of concepts associated with solar heating of residential swimming pools in Winnipeg. Projected energy demand by swimming pools in Canada is 3.0 x 10^{15} joules per year through the 1980's. A portion of this demand can be offset by using solar energy.

The analysis was in three areas: (1) a literature review of solar heating for swimming pools--including technology, markets and legislation, (2) a survey of swimming pool owner attitudes toward solar heating and, (3) a financial appraisal of the conversion to solar heating, the role of pool covers and life cycle cost analysis.

The review of the literature revealed that solar heating for swimming pools is the least technically complex of solar equipment and that the market is increasing through demand and government assistance.

Analysis of the survey results revealed that capital cost is still the major deterrent to solar heating of swimming pools. However, rising fuel costs are now affecting pool owners' decisions to move toward solar pool heating. Solar heating was used to maintain higher pool temperatures than conventional heating, but did not extend the pool season. Pool owners expressed a need for pool energy conservation information, but did not desire legislation restricting their choice of pool heating method.

The financial appraisal supported the use of pool covers for all heating methods; while conversion to solar heating is only immediately beneficial to owners of oil heated pools. Owners of gas and electrically heated pools did not benefit from conversion unless the least expensive solar collectors were used. Life cycle costs revealed that solar heating was competitive with conventional heating equipment for first purchasers of heating equipment.

The report concludes that solar heating for swimming pools is an effective method for pool heating and provides recommendation to government, industry and consumer sectors to assist in the use of this energy form.

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CHAPTER I

INTRODUCTION

1.1 Background

In order to reduce conventional energy use, alternate renewable energy sources are gaining in importance. Solar energy is being considered by homeowners as a substitute for non-renewable fuels in the area of space heating and domestic hot water supply in Manitoba. Studies have shown, however, that the use of active solar energy in space heating domestic water heating is not a viable alternative in Manitoba at the present time (Unies, 1981). The major barrier to the use of solar energy in these residential applications has been the high capital cost of the available systems and the extremely long payback periods involved to recover the initial capital cost (Berkowitz, 1977).

While federal funds and programs have been oriented to the promotion of solar energy for heating and cooling of buildings and providing domestic hot water; it is solar heating of the area of swimming pools that has the greatest potential for consumer use at the present time. There is, however, little available information on this application of solar energy in Manitoba.

1.2 Problem Statement

As energy prices rise, and transportation and vacation costs increase relative to other prices, the number of people travelling to recreational areas is growing less rapidly or marginally decreasing. More people are beginning to take advantage of recreational activities closer to home. As a result, the number of private pools is increasing (Canadian Pool and Spa Marketing, 1980).

An estimated 55% of swimming pools on the Prairies (Manitoba, Saskatchewan and Alberta) are heated, as most people desire a water temperature a few degrees above the ambient temperature. The major fuel for pool heating on the Prairies has been natural gas (see Table 1) as most residential housing is served by this fuel in large metropolitan areas. The desired pool temperature was set, by thermostat, at the start of the pool season and left until the close, with no conservation measures made potential for heat losses. However, continued increases in the costs of conventional fuels have caused pool owners to implement conservation measures and consider alternate methods of pool heating.

Choice of a heating system for a swimming pool has implications for the owner, e.g. cost; and for society, e.g. the supply of fuel. The number of pools in Canada, presently growing at 10% per year implies a projected energy demand of 3.0×10^{15} joules per year through the 1980's, with the prairie provinces estimated to consume 5.1×10^{14} joules per year (Bell, 1980). This growth of pools may place demands on energy supplies and on public utilities to supply the fuel for pool

Table 1

Estimated Regional Distribution of Pools, Heaters and Fuels Used

	Atlantic Provinces	Quebec	Ontario	Prairies	British Columbia	Canada
Pools	3%	39%	47%	5%	7%	100%
Percentage of Pools which are heated	10	20	35	55	60	32
<u>Fuel type</u>						
1. Natural gas	0	N	85	95	95	70
2. Propane	40	35	5	N	N	10
3. Oil	50	40	5	N	N	12
4. Electricity	10	20	N	N	N	6
5. Solar	N	3	3	1	2	2

N = Nominal

Source: Bell, 1980.

heating in the future.

Solar energy is capable of meeting a portion of this energy demand, but the receptivity of potential users to solar energy is a problem that may have to be overcome. Choice of a heating system for a swimming pool is linked, in some cases, to the residential heating source. In other cases, the decision may be based on such perspectives as capital cost, attitudes toward energy conservation and perceptions of risk in moving to another energy source.

It is therefore appropriate to determine: (1) the receptivity of pool owners to solar heating; and (2) the associated benefits and costs of solar heating for swimming pools. It is important for owners, manufacturers and government to understand the role of solar energy in swimming pool heating as a question exists whether privately owned swimming pools, which could be considered luxury items, should be heated with non-renewable resources.

1.3 Objectives

The overall objective of the study was to examine a number of concepts regarding solar heating of swimming pools. Specifically this study proposed to:

1. present an overview of existing solar pool heating technology, the swimming pool and solar collector market and current legislation and policy affecting solar heating of swimming pools;

2. identify, compare and evaluate swimming pool owner attitudes toward solar heating;

3. measure the effectiveness of solar heating against conventional methods;

4. compare the costs associated with heating pools using a variety of fuels and equipment with associated payback;

5. survey the extent of the solar pool heating industry in Manitoba;

6. review the extent of government involvement in solar heating of swimming pools;

7. present recommendations to government, manufacturing and retailing and consumer sectors that could increase solar pool heating in the province of Manitoba.

1.4 Data Collection and Evaluation

In providing an analysis of solar pool heating for residential consumers and information that could be beneficial in the formulation of programs to facilitate conversion, it was necessary to:

1. review related literature;

2. interview people possessing expertise on the subject area;

3. prepare and distribute a survey to determine pool owners' attitudes to a number of variables;and,

4. present recommendations to encourage and facilitate solar pool heating.

Standard library resources were used to retrieve the necessary reference material. Emphasis on the gathering of information was placed on direct contact with consumers, retailers and manufacturers of solar equipment; as well as contact with public and private agencies.

The methods are outlined in greater detail in Chapter III.

1.5 Assumptions and Limitations

One assumption underlying the report is based on the findings of Bell (1980). Ignoring passive gain, $3x10^{15}$ joules of energy were required to heat Canadian swimming pools in 1979. A portion of this energy demand may be off-set by the use of solar energy.

A factor influencing the use of solar energy to heat swimming pools is the attitude of the consumer toward newer, unfamiliar energy sources. The study assumed that these attitudes would influence the choice and purchase of a pool heating system.

The study has been limited to the investigation of solar energy conversion in the residential pool sector. Any references to the commercial or municipal pool sector will not be analyzed further than the applicability to residential pool heating systems.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The literature review is presented in four parts and provides:

1. a description of solar heating technology for swimming pools;

2. an overview of the swimming pool market in Canada;

3. a review of solar heating market studies;

4. a review of current legislation affecting use of swimming pools and associated heating methods.

2.2 Solar Heating Technology for Swimming Pools

2.2.1 *Introduction*

Because an understanding of energy supply and demand of swimming pools is necessary to the underlying value of solar heating for swimming pools, this section on solar heating will be prefaced with a description of energy demand and supply profiles of swimming pools.

2.2.2 *Energy Demand and Supply*

All outdoor swimming pools are heated to a certain extent through direct absorption of the incident solar radiation by the water. With no auxiliary heating system or pool cover, the temperature of the pool follows the mean air temperature closely during the summer months.

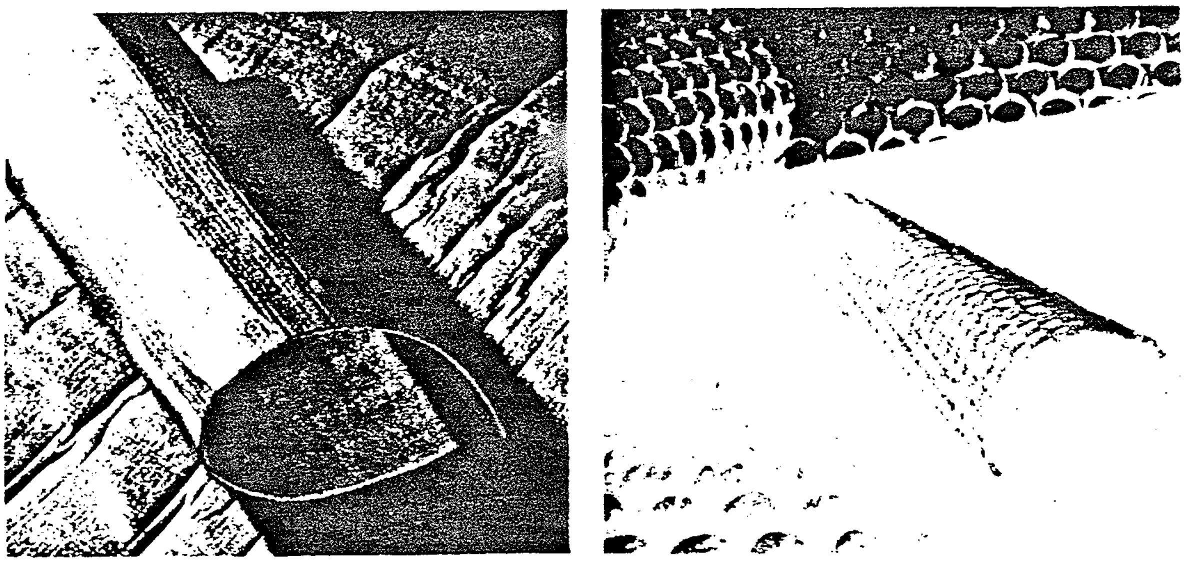
Indoor pools require heating year round to maintain 27°C temperature, as direct solar gain is not available (Bell, 1980). The problem of heating the pool can be separated in two sections:

1. reducing heat losses from the pool
2. providing a source of heat external to the pool (McVeigh, 1978).

Heat losses occur mainly from evaporation, convection, radiation and conduction (Howell and Bereny, 1979). One factor influencing evaporation and convection losses is wind speed over the pool surface (McVeigh, 1978). This can be reduced by providing screening or fencing around the pool.

Evaporation losses can be largely eliminated by use of a cover on the surface. These are retailed as solar blankets or pool blankets and may retard heat loss or, acting as a greenhouse, heat the pool. These covers float on the water surface when the pool is not in use. There are two types: a solid laminate on a thin foam substrate (Figure 1A), and a transparent bubble cover (Figure 1B). In order to retard evaporative heat loss from the pool, the covers:

1. reduce radiative heat loss from the surface; representing about 30% of the total pool energy losses;
2. reduce evaporative losses; which accounts for approximately 50% of total energy losses;



A. Solid Laminate Cover

B. Bubble Plastic Cover

Figure I

Examples of Pool Blankets

Source : B.C. Hydro, 1978

3. reduces convective losses which normally account for 15% of total energy losses (Bell, 1980).

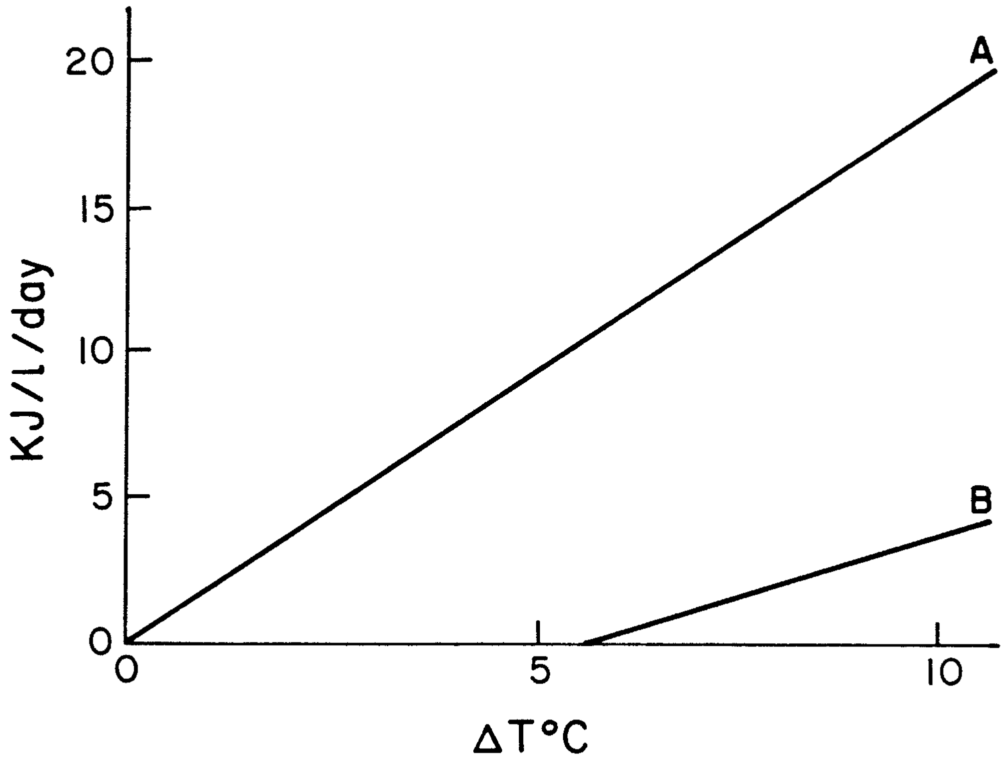
Less than 5% of total energy losses occur through the walls and floor of the pool (Bell, 1980).

An analysis of natural pool temperature for a variety of pools, indicates that uncovered outdoor pools require a seasonal input of 100kJ to 1500kJ per litre of pool water to maintain a 27°C noon-time pool temperature between May 15th and September 15th, compared with between 0 and 200kJ for a covered pool (Bell, 1980). Figure 2 indicates the amount of energy required to maintain temperatures above the natural temperature for both covered and uncovered pools.

Extended periods of cold, cloudy or rainy weather will result in lowered pool temperatures. To offset this, the pool owner must purchase a heater to be guaranteed suitable water temperatures throughout the season. In providing a source of heat external to the pool, pool heating systems fall into three categories:

1. combustion heaters
2. resistance heaters
3. solar heaters

Combustion heaters include natural gas, propane and oil heaters; ranging in size from 75 to 1500 mJ/hr and capable of raising pool temperatures between .75 and 1.5 degrees C per hour. Installed prices range from $1000 to



Curve A — Energy Required for outdoor uncovered pool maintained at the indicated temperature.

Curve B — Energy Required for outdoor covered pool maintained at the indicated temperature.

ΔT°C — Difference between desired temperature and normal temperature of an unheated, uncovered pool.

Figure 2

Energy Requirements for an Average Size Outdoor Pool ($43m^2$ — 60,000 l)

Source : Bell, 1980

$1500 depending upon pool size, type of heater and installation requirements. Life expectancy varies, but an average of seven years is claimed by manufacturers (Bell, 1980).

Resistance heaters are electric heaters and are available with outputs ranging from 5kW to more than 50kW. Sizing recommendations are based on 1 watt per 50 litres of water (Bell, 1980). The installed prices for average pools range from $700 to $1500 with the life of the heaters rated at 7 years. The use of electric heaters is minimal in Winnipeg and is not normally recommended because of the cost of running the equipment.

2.2.3 *Solar Heaters*

2.2.3.1 Panel Types

Solar collectors suitable for swimming pools can be classified into four groups:

1. unglazed and uninsulated flat plate collectors, constructed of plastic;
2. glazed and/or insulated flat plate collectors;
3. open or trickle type collectors, such as a black, corrugated roof surface;
4. collectors made from the pool surroundings (McVeigh, 1978).

Types 1 and 2 are the most common and are available commercially in Manitoba.

The unglazed, uninsulated flat plate collectors are used only in the summer when freeze protection is not required. These are used on outdoor pools operated only in the summer and on indoor pools with other forms of heating during the winter.

The glazed flat plate collectors are normally used with freeze protection in order to be used year-round and require a heat exchanger.

Since pool heating is a low temperature application, with water temperatures ranging up to 115°F (46°C); most commercially available systems are made of plastic (Talwar, 1979). Ordinary available plastics are expected to last two to four years upon exposure to the combinations of heat, pool water chemicals and the ultra-violet rays of the sun; therefore plastic collectors must be ultra-violet stabilized to resist deterioration in the sunlight. When this is done, the life expectancy of the plastic is extended to a minimum of seven years.

2.2.3.2 Technical considerations

Solar heating of swimming pools involves several unique aspects. Talwar (1979) lists these as:

"1. The desire to swim is phased with a warmer trend in the weather.

2. The preferred water temperature usually is only a few degrees above ambient (surrounding) temperature.

3. The amount of water that must be heated and circulated through the solar energy collector panels is relatively large, the recommended flow rate being a circulation of the entire pool water through

the filter about once every 8 to 12 hours. This means a flow rate of 110 l (30 gal) per minute for an average 57000 l (15000 gal) residential pool, compared with an average flow rate of 1.9 l (0.5 gal) per minute for domestic hot water heating.

4. The pool itself, if exposed to the sun, acts as a collector since water absorbs about 75% of the solar energy striking its surface.

5. The volume of water being relatively large, its temperature is affected only slightly by transient changes in atmospheric weather conditions.

6. The need for a storage tank is eliminated since the pool serves as the storage."

Choice of a solar heating system, and size and type of installation depends on 4 factors:

1. site location (including orientation and latitude)

2. desired water temperature

3. use of insulating cover on a pool

4. length of season (Cook, 1978)

These factors must be considered thoroughly before purchase of a system. The proper tilt of collectors for swimming pool heating depends on the site latitude and the season of the year for which the pool heating is desired. In cool climates, when pool use is restricted to the summer, the optimum tilt of the collector is the latitude minus ten degrees (Figure 3) (Howell and Bereny, 1979). The use of racks to achieve the desired tilt can be

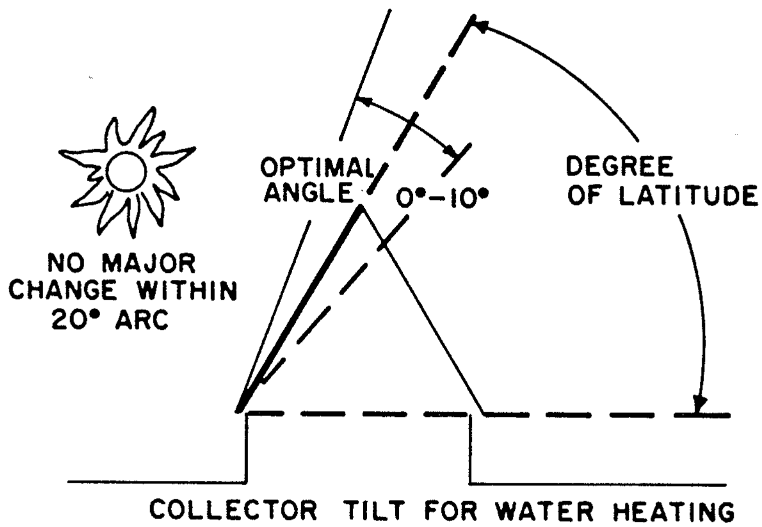


Figure 3
Relationship of Collector Tilt
to Latitude

Source: B.C. Hydro, 1978

expensive, therefore a rule of thumb is to place the collectors on whatever available surface is closest to the optimum (i.e. roofs of houses, garages, etc.).

The two basic types of collectors, unglazed plastic and glazed flatplate, which have been mentioned previously, are discussed in greater detail in the following section.

2.2.3.3 Unglazed plastic collectors

This category can be broken into three types of collectors:

1. rigid plastic sheet collectors
2. flexible plastic tube collectors
3. plastic tubing heat collectors

Rigid plastic sheet collectors are the most commonly retailed solar pool heaters in Manitoba. The collectors are relatively inexpensive averaging $\$45/m^2$ installed.

These collectors are simple in construction, usually built in 4' by 8' (1.5 m by 2.5 m) and 4' by 10' (1.5 x 3.0 m) modules, that can be attached in varying numbers depending on the need. The extruded sections are bonded to large diameter plastic feeder tubes at the top and bottom. The panels are often installed without insulation behind them and without transparent covers over their exposed surfaces. They are mounted in such a way to drain when not in use (i.e. a drain-down system). The water is pumped bottom to top; therefore there is contact between all of the solar heated surface and the circulating water (Root *et al.*, 1980). Figure 4 shows an example of this type of system.

Flexible plastic tube collectors consist of flexible, rubber tubes connected to each other laterally to form a six inch ribbon to be cut into convenient lengths. The tubes are glued to the support structure. The individual tubes in the array may be separated at the ends with a knife and inserted into pre-drilled manifolds. Because the array of rubber tubes is not damaged by freezing, only the manifolds require draining (Root *et al.*, 1980). Figure 5 shows an example of a flexible plastic tube collector.

Plastic tubing heat collectors are used primarily by do-it-yourselfers, interested in heating their pool with the least expense. The construction is simple, utilizing various plastic pipes containing UV inhibitors. The plastic tubing is either coiled (Figure 6) or laid in straight lines upon a large surface such as a roof. Adequate drainage and freezing protection must be considered in order for the system to be used season to season (Root *et al.*, 1980).

2.2.3.4 Glazed flat plate collectors

These are normally used for domestic hot water or water for heating buildings. These are designed to operate in a higher temperature range (60 to 70 degrees C) but are applicable to low temperature applications due to their

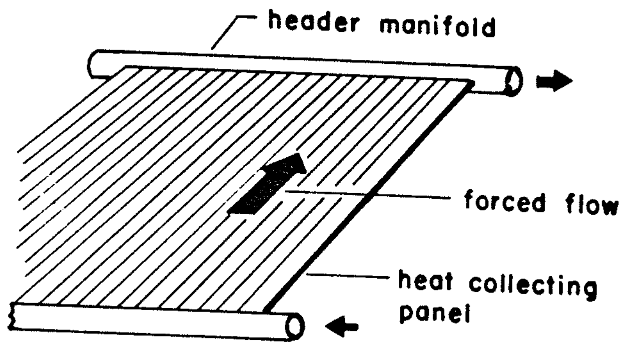


Figure 4

A Rigid Plastic Solar Collector

Source : Root *et al*, 1980

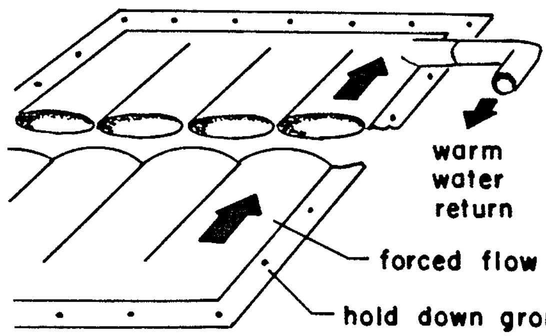


Figure 5

Flexible Plastic Tube Collector

Source : Root *et al*, 1980

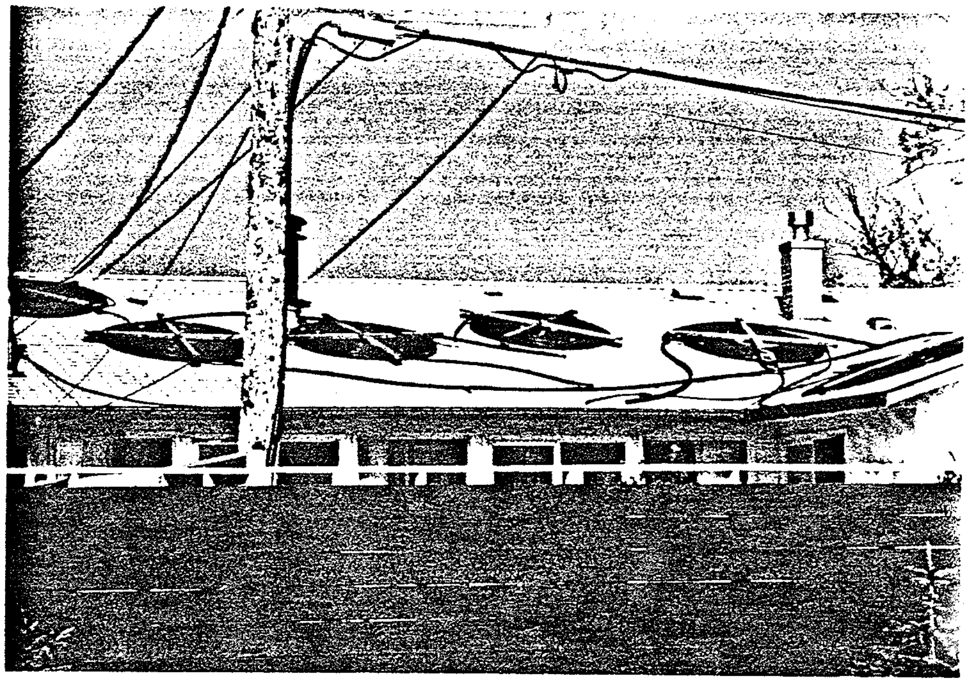


Figure 6

Home Built Plastic Tubing Collectors

Photo : Lamb, 1981

higher efficiency. While more expensive per square meter than plastic collectors, efficiency is higher in cooler weather; and when properly built, will last for approximately 20 years (Root et al., 1980).

The collector consists of a box containing the tubing backed by absorbing material. The collector is insulated behind the absorbant material and the collector is covered by a transparent sheet of glass or plastic (see Figure 7). This system may be used year round, in conjunction with an anti-freeze fluid and a heat exchanger.

2.2.3.5 Sizing and installation

Active solar pool heating systems are generally sized on the basis of 1 m^2 of collector per 2 m^2 of pool surface area. This is a rule of thumb applied by most pool retailers, provided that the solar collectors are oriented directly south.

Canadian Pool and Spa Marketing (1981) suggests a rule of thumb as follows:

> The optimum facing direction for your solar collector (panels) is due south or 180 degrees on the compass rose. For a 16 x 32 foot pool, the rule is that the solar panel's areas should equal 50 percent of the pool surface. In square feet, this would mean that the 16 x 32 foot pool (approximately 500 square feet) should have a collector surface of approximately 250 square feet. Since average panels measure 4' x 10' (40 square feet), the required number of collectors would be six (total 240 square feet). This rule of thumb applies to a situation where the surfaces of the collectors are facing a southerly exposure (ie. within 160 and 200 degrees on the compass) which provides the optimum

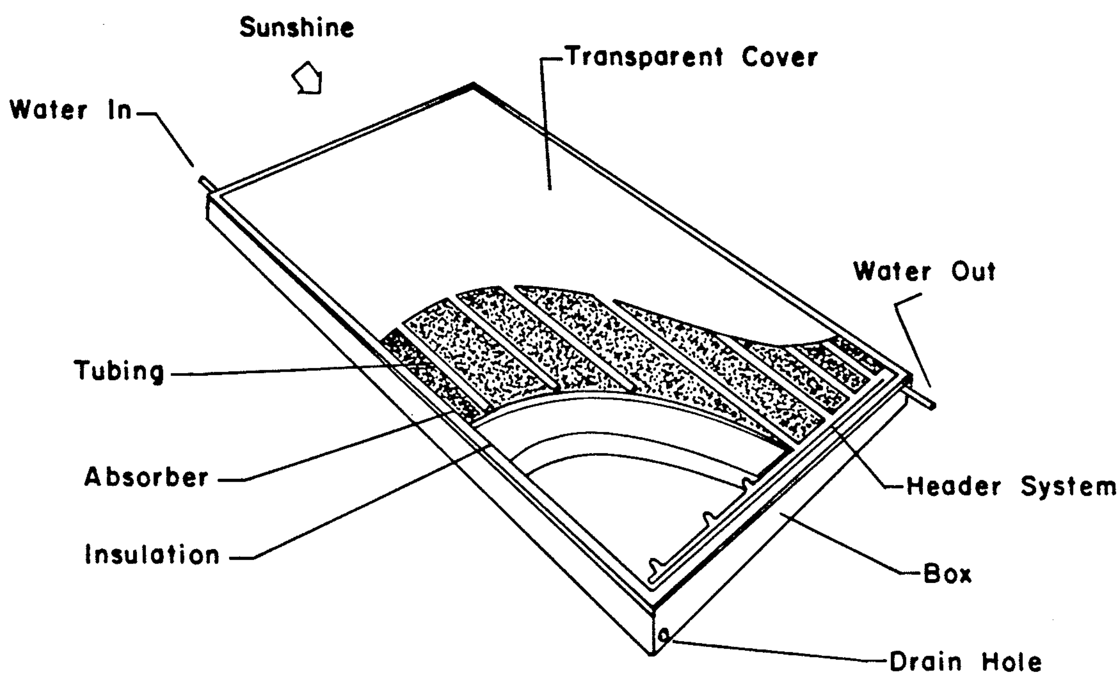


Figure 7
Example of a Flat Plate Collector

Source : Talwar, 1979

> radiation. As the collector surfaces face beyond these directions, additional panels are required to provide the same amount of heat. A solar collector setup that would face between 270 and 135 degrees, which represents the northern quandrant of the compass, is considered unsuitable for a solar application.

Figure 8 shows the suggested ratios of area of collector to pool surface area at the various compass points. Table 2 indicates the number of panels required, based on 40 square foot (3.7 m^2) panels, for specific size pools and compass readings. Retailers tend to oversize rather than undersize systems in order to prevent ineffective heat collection.

Installation of the system must concern itself with other physical factors including slope of roof, tree shade and wind. Slopes of 25 to 40 degrees are acceptable to collect the optimum sun rays in southern Manitoba (see Figure 3). If the roof is flat or if the panels are placed on the ground, a rack with the appropriate slope would be required.

Potential shading problems from trees and nearby buildings must be examined. If shade covers 50% of the collectors, a 70% loss of efficiency will result. Highest radiation is between 10:30 a.m. and 4:00 p.m., therefore shade should not occur, between these times, on the collectors.

Wind can work as a positive factor in June, July and August and as a negative factor in May and September on potential heat gain by collectors. Only where there is a

Table 2
Solar Collector Panel Requirements by
Pool Size and Orientation

Pool Size (ft.)	Area ($ft.^2$)	Number 40 $ft.^2$ panels at Compass Exposure Degrees 160°-200°	200°-225°	225°-279°	153°-160°
12' x 24'	288	5	5	5	5
14' x 28'	392	6	7	8	8
16' x 32'	512	6	8	9	9
18' x 36'	648	8	10	12	12
20' x 40'	800	10	13	15	15

(From Canadian Pool and Spa Marketing, 1981)

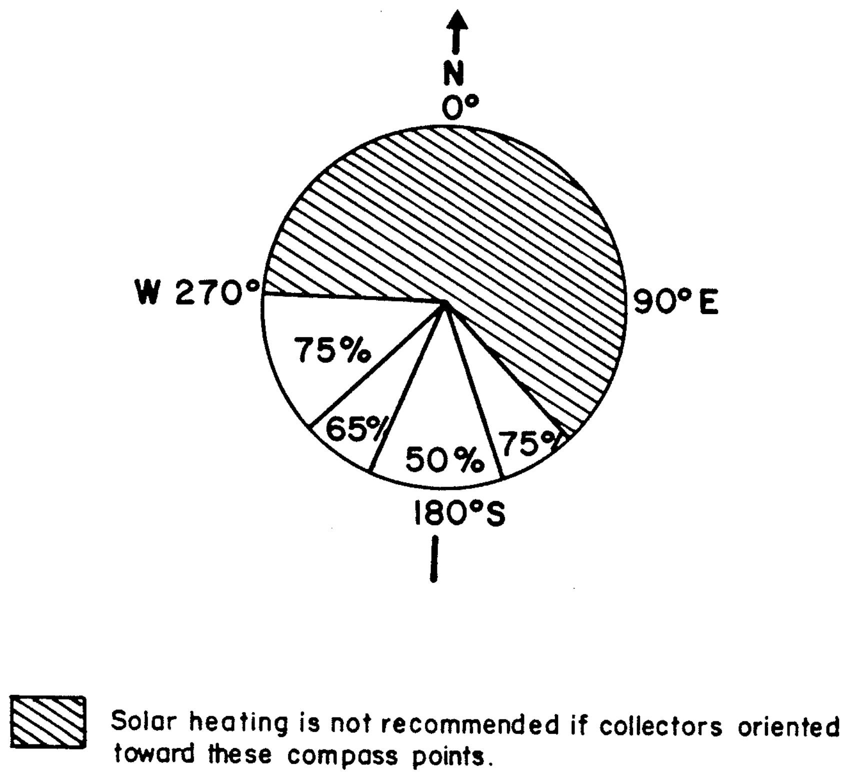


Figure 8

Ratio of Collector Area to Pool Surface Area at Various Compass Points

20 degree differential between wind and panel temperature, will serious efficiency losses occur.

Collector panels may be arranged as shown in Figure 9. Layouts depend upon roof type, ie. slant, architecture and orientation of the building. Water is pumped from the pool through the pool filtering system, onto the roof and through the collectors. The heated water is then returned to the pool. The existing pumps on the pool filtering system are adequate to move the water the extra distance unless undersized initially, or if the water must be pumped to collectors on the roof of a two storey building. If this is the case, booster pumps are added to the system (Walters, 1981).

In addition, some pool owners may combine a solar system and a conventional heater (Figure 10). The conventional heater may have been purchased initially as an integral part of the pool package. The solar collector would have been purchased later to assist in heating the pool, with resultant lowered operating costs.

In other cases, the solar system may have been purchased initially, with a conventional heater purchased later to shorten the warm-up period and to assist on cloudy days. In either situation, the conventional heater in these hybrid systems is not used except at the start or the end of the pool season.

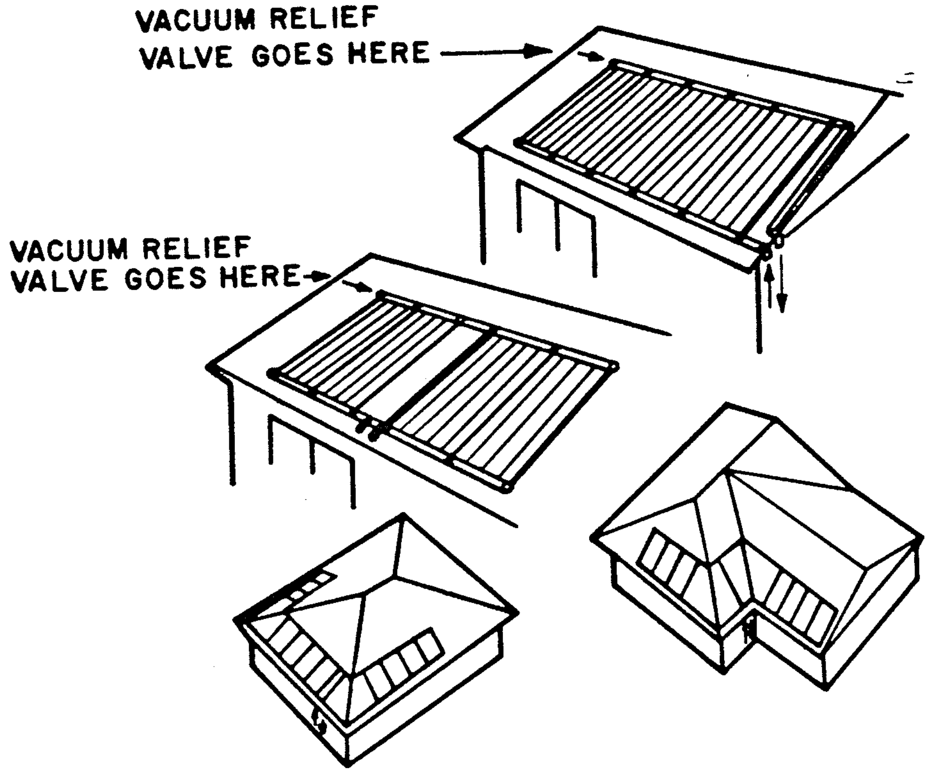


Figure 9

Collector Panel Arrangement on Roof

Source: Lucas, 1979

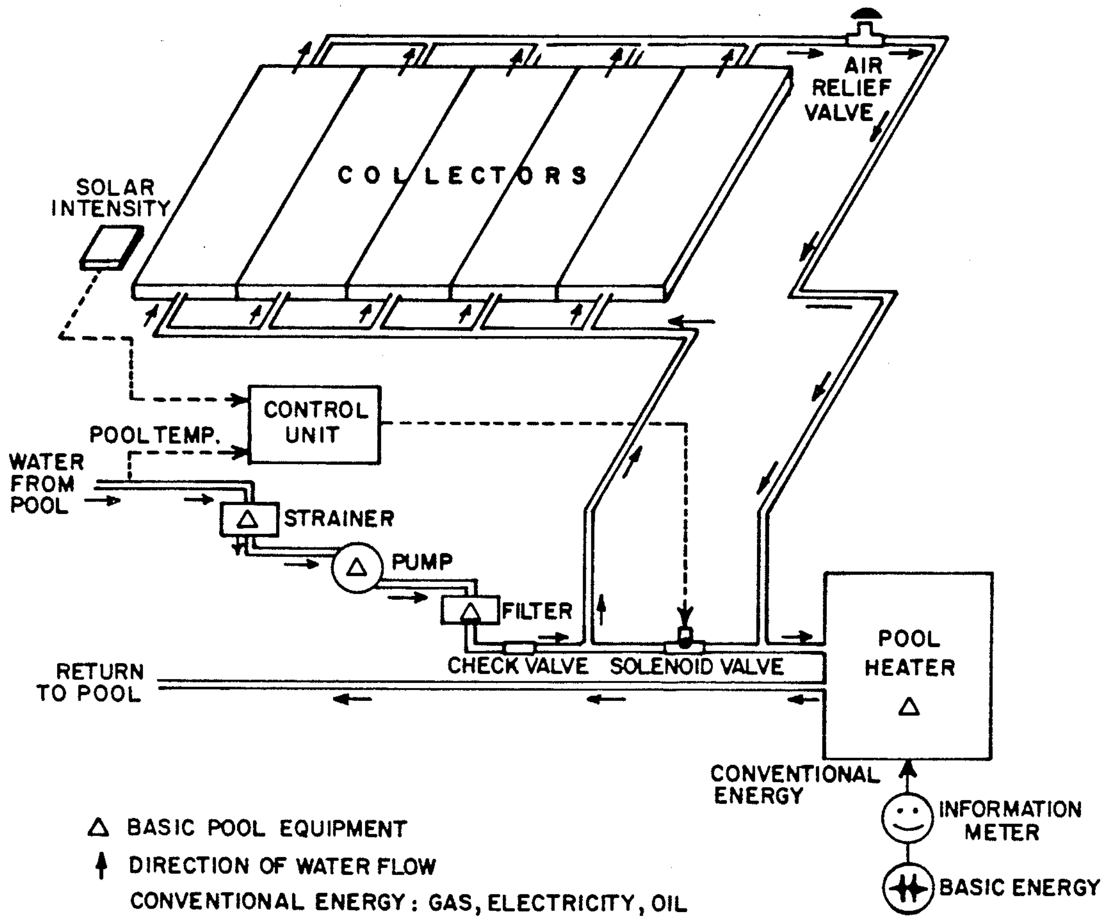


Figure 10

Basic Solar Pool Heating Equipment and Layout with Conventional Heating Unit.

Source : B.C. Hydro, 1978

2.3 Swimming Pool Market

2.3.1 *Introduction*

A description of the swimming pool market is in order to demonstrate the extent of the potential market for solar pool heating.

2.3.2 *Pool Types*

Swimming pools come in a myriad of sizes, shapes and construction types and are purchased by private residences, commercial institutions, municipalities and institutions.

According to Bell (1980) these pools can be broken into five categories:

1. Residential on-ground -- outdoor
2. Residential in-ground -- outdoor
3. Residential indoor
4. Institutional outdoor
5. Institutional indoor

Category 1 (Residential on-ground - outdoor) pools are fabricated of rigid, free-standing walls of metal, plastic or wood and a vinyl liner, ranging in size from 4m in diameter (5,000 litres) to 6 x 12m (130,000 litres) and cost from $2,000 to $10,000 installed. These are the cheapest on a unit volume basis and the least likely to be heated (Bell, 1980). Canadian sales in this category reached 1,250 (on-ground pool sales) and 11,295 (large above ground pool sales) in 1979 (Canadian Pool and Spa

Marketing, 1980) (see Table 3). Total installations in Canada are listed between 50,000 and 70,000 pools (Bell, 1980).

Category 2 includes the concrete pool manufactured onsite, as well as the pool type in Category 1 installed below grade. The concrete pool is being rapidly displaced by the vinyl-liner type. Vinyl lined pools are the dominant type in the Canadian market, representing 80% of the in-ground installations and showing almost 90% of the total pool sales for the country. Table 4 shows the dominance of vinyl lined pools for in-ground installations in Canada, compared with the United States, based on 1978 figures (Canadian Pool and Spa Marketing, 1980).

The dominance of vinyl-lined pools is attributed to the climatic conditions of the country. With an outdoor pool season of approximately 4 months, the majority of the consumers would prefer to limit the amount of their expenditures and choose the less expensive vinyl lined pool (Canadian Pool and Spa Marketing, 1980).

Sizes in this category of pool range from 3.5 x 5.5 m (25,000 l) to 7.5 x 15 m (200,000 l); with installed prices from $5000 to $15,000. Sales in 1979 of both concrete and vinyl in-ground pools totalled 13,195 - approximately one-half of the total pool sales in 1979.

Installations to date in Canada of in-ground pools, total 175,000 (Canadian Pool and Spa Marketing, 1980). Trends in this area are to smaller pools and less expensive total packages as the size of backyards decrease.

Table 3
Regional Breakdown of Pool Sales in Canada in 1979

Pool Type	Region						
	Atlantic	Quebec	Ontario	Prairies	Alberta	B.C.	Total
Vinyl	175	2310	6720	190	435	690	10,520
Concrete	60	490	1010	100	125	480	2,265
Other	40	160	135	10	20	45	410
Onground	25	300	820	25	15	65	1,250
Above ground	400	6500	3350	175	300	570	11,295
Above ground			N/A				
Splasher type			N/A				
Totals	700	9760	12035	500	895	1850	25,740

Total Inground Pool Sales	13,195
Total Onground Pool Sales	1,250
Total Large Above Ground Pool Sales	11,295

(From Canadian Pool and Spa Marketing, 1980)

Table 4

Proportion of Vinyl-lined Pools

	Total Pools		
Concrete Pools	Installed	Concrete	Percent
United States	104,000	60,482	58.1
N.E. United States	12,400	1,550	12.5
Canada	11,920	2,500	20.8
Vinyl-lined Pools	Installed	Vinyl	Percent
United States	104,100	32,583	31.3
N.E. United States	12,400	9.535	76.9
Canada	11,920	9,120	76.5

(From Canadian Pool and Spa Marketing, 1980).

The pools in category 3 are residential indoor pools. These are generally made of concrete and integrated into the basic design of the house. Annual sales are 400 - 500 units and approximately 3000 to 5000 units are currently in use in the country (Bell, 1980).

Categories 4 and 5 include such users as municipalities, recreation centres, hotels, motels, apartment buildings and commercial recreation facilities. Sizes vary and pools are predominantly made of concrete. Unit sales in Category 4 average 300 per year with approximately 3000 to 4000 units in service (Bell, 1980).

Sales in Category 5 average 100 per year with approximately 1000 to 1500 pools in service (Bell, 1980).

2.3.3 *Market Trends*

Sales of inground swimming pools in Canada increased approximately 10.5% in 1979 over 1978 (Canadian Pool and Spa Marketing, 1980). This is reflected in the figures obtained from building permits registered with the City of Winnipeg. The number of pools indicated on building permits in 1978, were 285, 349 in 1979 and 374 in 1980. This indicates an increase of 22% per year between 1978 and 1979, and 7% between 1979 and 1980.

Recent economic conditions have not been conducive to large purchases, therefore these increase appear unusual. It is only when such factors as uncertain fuel supply and costs, increased mortgage rates -- causing people to retain their home and spend on home improvements, plus the decline of the Canadian dollar affecting travel abroad, are examined, that the increase in pool sales is explained. A drop in sales in 1975 and 1976, (see Table 5), reflected the changing world economic conditions. The yearly sales of inground pools has not again reached the high of 14,200 pools reached in 1975; although 1980 was estimated to be a successful year (Canadian Pool and Spa Marketing, 1980).

Projected sales in Canada in 1980, were 14,515 pools. Since the prairies (Manitoba and Saskatchewan) have 3% of the sales, it can be estimated that 435 pools were constructed in Manitoba and Saskatchewan. Building permits show, however, that 375 pools were built in Winnipeg, in 1980, alone. Therefore, these projected figures appear to be conservative and may not accurately represent the market.

The cost of pools has remained low, relative to other major recreational purchases such as cottages, and recreational vehicles. Basic average pool prices (pool, circulation kit, pump, one ladder) are approximately $4,000 to $10,000. The prices do not include the cost of a heating unit which would add a minimum of $1000 to the capital cost price of the pool.

As there are approximately 175,000 in-ground pools in Canada (Canadian Pool and Spa Marketing, 1980), out of 250,000 pools in total; this gives an estimated 6,600 pools installed in the prairie region. Manitoba alone has approximately 6000 pools (T. Hood, pers.comm.)

Table 5

Sales of Inground Pools in Canada per Year

Year	Units	% Change Year to Year
1958	3000	
1959	3200	7
1960	3400	6
1961	3700	9
1962	4000	8
1963	4300	8
1964	4500	5
1965	4800	6
1966	5200	8
1967	5900	14
1968	6600	12
1969	8300	8
1970	8700	5
1971	9300	7
1972	10800	16
1973	11800	9
1974	14200	20
1975	9800	−31
1976	9900	1
1977	10525	6
1978	11920	13
1979	13195	17

(From Canadian Pool and Spa Marketing, 1980)

There is a trend toward smaller, better equipped pools. This is linked to diminishing size of backyard lots in Canada (Canadian Pool and Spa Marketing, 1980). The percentage sales to pool size is shown in Table 6. To off-set the decline of larger, more expensive pools, retailers are selling more equipment, including such options as solar heating equipment.

2.4 Solar Heating Market Studies

2.4.1 *Introduction*

A number of studies have been performed on the market feasibility of solar heating. Most of the studies have dealt with solar heating of houses and domestic hot water, but some underlying concepts and problems are similar to solar heating of swimming pools.

2.4.2 *Decision Making Process*

The fact that approximately 55% of the pools in Manitoba and Saskatchewan are heated (Bell, 1980), suggests that a sizeable market for solar heating exists.

In sample studies on solar heating of homes, interest in solar energy tended to be associated positively with energy conservation, but not cost-benefit (George Washington University, 1978). This results in the interest being moved from the present and placed it some time in the future; where an ultimate energy crisis is perceived as real, but a present energy crisis is greeted with skepticism.

Table 6

Percent Sales of Swimming Pools
per Pool Size in Canada

Pool Size feet [meters]	Percent Sales
Under 16 x 32 [5 x 10]	10
16 x 32 [5 x 10]	55
18 x 36 [6 x 11]	25
20 x 40 [6 x 12]	7
Over 20 x 40 [6 x 12]	3

(From Canadian Pool and Spa Marketing, 1980)

Note: Metric equivalents are rounded to nearest meter

In consequence, the private consumer's time preference tends to be short term. This appears to be related directly to housing, and hence to solar systems or other home improvements. Prospective first home owners (age group in their 20's and 30's) do not anticipate buying one home for life. Therefore consumers are more worried about the initial cost of the solar system, than the long-term payback and its present value. They tend not to think about rising energy costs over the next 10 to 20 years.

There is also an investment perspective associated with the solar collector system as it may or may not add to the re-sale value of the home. There is no method of directly measuring this, as it is masked by the re-sale value associated with the pool.

The consumer's decision making is influenced by what he sees for himself, by opinions and experience of people he trusts, and by the actions of large organizations. Key decision makers include:

1. other consumers who are perceived to be like himself
2. reputable solar heating equipment suppliers
3. the media
4. the government

There are also critical factors in the homeowner's decision making. These include:

1. cost
2. cost facilitators
3. reliability
4. aesthetics
5. simplicity of the system

The George Washington University study (1978) found that, as a consumer, the private homeowner is not ready to spend now to conserve energy; not prepared to take the initiative and seek a conserving technology; and not willing to tolerate a payback period as long as five years.

The study on solar energy incentives performed at George Washington University (1978) mentioned a state of mind called 'psychic income', and suggests that it be included in the cost-benefit ratio. This is derived from several sources which are usually consistent with the individual's value system and lifestyle. These sources may include:

1. the conservation ethic
2. strong environmental feelings
3. being 'first on the block', ie. leadership satisfaction
4. an intense futuristic interest in science
5. strong mechanical inclination and the desire to produce or own something constructive.

These incentive studies have shown that cost effectiveness or financial return is the major reason for consumers in making their choice, followed by personal gratification and socio-environmental impact.

A study of swimming pool owners in California (Unseld and Crews, 1979) found that users of solar heaters for swimming pools were characterized as more technically oriented than the typical solar consumer. The owners were less emotionally involved with their systems than were (solar) hot water users and more likely to have their systems installed commercially. The users viewed their systems simply as products to meet a particular need. Motivation consisted primarily of concern with present and future energy costs.

The selection of a contractor appeared casual; few owners talked to more than one contractor or requested references. They obtained information about contractors through mailings, solar energy fairs and word of mouth. Most considered aesthetics of the pool heater to be neutral.

2.4.3 *Solar Heating Sales*

A study undertaken by the Ministry of Industry and Tourism in Ontario (Canadian Pool and Spa Marketing, 1980) indicated that solar collector markets are expanding. The researchers contacted present and potential Canadian manufacturers and distributors of solar collectors. For the purpose of the study, the country was broken down into three regions: Atlantic (Maritimes and Newfoundland), Central (Ontario and Quebec) and Western (all provinces west of Ontario). The results are shown in Tables 7 and 8.

It can be seen that estimated solar pool collector sales for 1980 and onward are high. This may be compared to 183,500 ft^2 (17047 m^2) of solar collector manufactured in Canada up to May 15, 1980 (Lavigne et al., 1980) for domestic hot water. The proportion of pool collectors to domestic hot water collectors is high; indicating a larger market demand exists for solar pool heating.

2.4.4 *Perceived Risks and Benefits*

The Solar Energy Research Institute (SERI) conducted a poll in 1980, of the residential solar consumer in the United States (Pilgrim and Unseld, 1981). The poll addressed a number of concerns that homeowners had regarding solar heating. Table 9 lists the perceived barriers to solar energy that were indicated by the respondents.

Homeowners were very concerned about risk, with major emphasis on initial solar collector system purchases. Lifestyle and aesthetic issues, considered significant barriers to commercialization of solar heating by professionals, the industry and government were revealed to be less important by many homeowners.

Homeowners perceived benefits as relief from economic pressures--price of fuel and inflation. Items such as environmental protection, security and comfort are also

Table 7

Solar Collector Installations for Swimming Pools per Year

Region	(Estimated installations)							Projected	
	1974	1975	1976	1977	1978	1979	1980	1981	1982
Central	4	228	278	400	817	1240	1835	2532	3572
Western	-	-	3	24	23	72	210	316	1900
Atlantic	-	-	-	-	-	-	-	-	-
Totals	4	228	281	424	835	1312	2045	2848	5472

Note: Installation figures are based on an average collector size of 40 $ft.^2$ [4 m^2] average collectors in an installation -- eight.

(From Canadian Pool and Spa Marketing, 81).

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Table 8
Solar Heating Sales for Swimming Pools

(total square feet of collectors)

	Historical							Projected	
Region	1974	1975	1976	1977	1978	1979	1980	1981	1982
Central	1152	73000	89150	128530	260145	396709	587611	810491	1143161
Western			1000	7740	7500	23000	67500	101250	607500
Atlantic	-	-	-	-	-	-	-	-	-
Totals	1152	73000	90150	138270	267645	419784	655111	911741	1750661

(From Canadian Pool and Spa Marketing, 1980)

Table 9

PERCEIVED BARRIERS TO SOLAR ENERGY

I am going to read you a list of some things you might see as problems with solar energy. For each item on the list, please tell me how important a concern it would be for you, if you were thinking about using solar energy in your home. (Response codes: Not at all important, Slightly important, Somewhat important, Important, Very important)

Responses	% Important	% Very Important	Total
Warranty coverage for solar energy systems	28	58	86
Initial cost of a solar home or solar energy systems	25	60	85
Operating reliability of solar energy systems (need for frequent repair and maintenance)	29	56	85
Dependability and reputability of solar firms	25	58	83
Possible damage to solar energy systems by dirt, vandalism, storms, corrosion, etc.	33	46	79
Safety of solar energy systems	25	53	78
Cost and difficulty of getting solar energy systems covered by homeowner's insurance	32	44	76
Expense of maintaining solar energy systems	32	41	73
Possibility that solar energy systems now on the market will soon be obsolete and better systems will be available later	32	34	66
Problems of obtaining a loan to finance the solar energy system	30	34	64
Climate too cold or cloudy or not enough wind	26	34	60
Codes or covenants might prohibit it	30	28	58
Possibility of lowering resale value of house	23	29	52
Worry over whether getting a solar energy system would be time-consuming and difficult	29	14	43
Effects of solar energy systems on attractiveness of house	28	14	42
Possible problems with the utility company	20	14	34
Might interfere with lifestyle	13	7	20
What friends and neighbors would say	5	2	7

Reprinted from Pilgrim and Unseld, 1981.

rated highly (see Table 10).

Solar energy has a number of attractive benefits such as the potential and economic benefits of conserving fossil fuels. In addition, there are the environmental benefits -- solar energy being a relatively benign energy source. More importantly, in the swimming pool heating industry, most solar systems perform well in small scale installations; therefore, the time lag between the decision to build (or buy) and actual operation can be short. This may be considered as a factor in influencing a pool owner to purchase such a system.

In research performed in Canada by Foster & Sewell (1977) it was revealed that similar benefits and costs to those found in the Pilgrim and Unseld study (1981) are perceived by Canadian consumers with respect to solar heating.

The question underlying most long term planning of renewable energy strategies is, who is willing to pay for the fuel conservation benefits of solar technologies over the next few decades. At present, the relatively high capital costs of even the most economical solar technologies form a barrier to wider use (National Research Council, 1979). The initial system investments are high in comparison with those of conventional systems, which spread their main costs for fuel over many years.

Table 10

PERCEIVED BENEFITS TO SOLAR ENERGY

I am going to read a list of possible advantages of using solar energy that could enter into your decision about using solar energy in your home. For each item on the list, please tell me how important it would be for you in making such a decision. (Response categories: Not at all important, Slightly important, Somewhat important, Important, Very important)

Item	**% Important**	**% Very Important**	**Total**
Saving money over the long term	31	53	84
Reducing utility bills now	28	54	82
Protecting against rising costs	36	46	82
Having a more reliable supply of energy	36	43	79
Conserving natural resources; protecting the environment	35	42	77
Increasing comfort of home	41	30	71
Easing energy shortage	37	33	70
Increasing overall self-reliance	36	32	68
Increasing independence from utility company	28	37	65
Availability of income tax credits	36	29	65
Reducing need for more large power plants	35	29	64
Increasing independence from federal government policies	28	35	63
Increasing resale value of home	33	28	61
Getting to innovate or experiment	20	7	27
Increasing status, prestige, self-esteem	9	5	14

Reprinted from Pilgrim and Unseld, 1981.

2.5 Legislation and Policy

2.5.1 *Introduction*

This section will discuss methods presently in use to promote solar energy use by various government sectors and agencies and what effects these have had or may have on the use of solar heating for swimming pools. The advantages outlined in this section are not reflections in today's market. Conventional energy sources, with lower first costs, average fuel costs and established industries will be favoured unless the barrier to high initial investments of solar, can be surmounted.

Among the more prominent incentives suggested by Bezdek and Maycock (1976) have been:

1. economic incentive programs
2. property and sales relief
3. investment tax credits
4. accelerated depreciation

2.5.2 *Economic Incentives*

Economic incentive programs such as subsidies to purchase solar heating equipment are not unknown. The best known of these exists in California where the state has adopted a 55% tax credit on the capital cost of a solar heating system. This is intended to promote a significant market acceptance at the current prices of competing fossil fuels.

Consumer incentive programs would be premature and inadequate unless product quality has been improved. To this end, the Canadian government in 1977, created a solar energy program for: (1) research and development, and (2) to develop an unsubsidized solar industry. Three programs were created to assist in the creation of an unsubsidized solar industry. The programs were:

1. PUSH - Purchase and Use of Solar Heating
2. PASEM - Program of Assistance to Solar Equipment Manufacturers
3. LEBDA - Low Energy Building Design Awards

Only the PUSH and PASEM programs will be examined in detail as the LEBDA program is not concerned with solar heating of swimming pools.

2.5.2.1 PUSH

The PUSH Program is designed for federal government purchases of solar equipment (Department of Public Works, (1979). This program includes $125 million of solar purchases by the federal government over a period of five years (beginning in 1977), in order to create a market for Canadian companies. By 1984, planned capital expenses would be $50 million annually. Approximately 15,000 man years of employment will be created, and all but $12.8 million will be returned to the treasury in fuel savings over the planned five year period (Berkowitz, 1979).

At present almost 500 projects are underway, with four projects involving solar heating of swimming pools (Table 11). The systems installed are for public or municipal pools (Public Works Canada, 1981). There are no PUSH sponsored swimming

Table 11

PUSH Projects for Solar Heating of Swimming Pools

Project Title Manufacturer	Urban Area Province	Design Consultant Contractor	Application Collector Area [m^2]	Stage
1. CFB Swimming Pool Petrosun	Naden B.C.	Ascent Structures Van Isle	Sw. Pool 170	Under Con- struction
2. Swimming Pool & Bldg. Petrosun	Jasper National Park Alberta	JoTech Dirk and Price	Sw.Pool DHW & SH 173	Completed
3. Swimming Pool & Bldg Petrosun	Waterton National Park Alberta	Solar Systems Dirk and Price	Sw.Pool DHW & SH 460	Completed
4. Clark Municipal Swim Pool, Ottawa Solartronics	Ottawa Ontario	Solartronics	Sw.Pool 214	Completed-

Source: Public Works Canada (1982)

Note: Sw. Pool - Swimming Pool
DHW - Domestic Hot Water
SH - Space Heating

pool projects underway at present in Manitoba.

By purchasing solar heating systems for its own use, the federal government is assuming the risk inherent in the solar energy industry's development and acting as a proving ground for new technology. The guaranteed market provided by the PUSH program is intended to increase the scale of solar manufacturing in Canada and to help establish competitively priced, high quality products for private sector use (Public Works Canada, 1981).

However, the focus of PUSH on solar systems for government buildings is unrepresentative of what the long term solar market will be like. The eventual residential market will require a whole different range of systems and marketing strategies.

2.5.2.2 PASEM

The PASEM program, completed in February 1981 (Public Works Canada, 1981) issued solar equipment development contracts to solar equipment manufacturers to reduce these companies' costs for development, production and marketing work (Department of Public Works, 1979). These contracts, initially, consisted of up to 25 grants of $10,000 each to firms to prepare solar equipment design proposals. After the proposals were assessed, ten awards of $20,000 to $30,000 each were handed out to assist Canadian firms to design and develop solar heating equipment that was purchased by the federal government (Berkowitz, 1979).

One firm, Ottawa Solartronics Ltd., was financed under this program and presently has a well-defined market for its plastic glazed swimming pool solar panels (Public Works Canada, 1981).

The PASEM program was viewed, upon completion, as a very successful program in producing a wide industrial base in solar heating (Public Works Canada, 1981).

2.5.2.3 Consumer incentives

The most widely used of these incentives are the property and sales tax waivers. Manitoba amended its property tax assessment to remove the additional assessment on property, utilizing a solar collector (Shillington, 1979) (See Appendix B). The homeowner pays the property tax assessed on his house without the collector. The province reimburses the city on the difference between the assessed value of the house with the collector, and without it.

The federal government removed the sales tax on solar heating equipment in 1976 . The individual provincial governments, may or may not have removed the sales tax on solar heating equipment. Some provinces have implemented either a sales tax exemption or a tax rebate. The tax exemption is applied to commercially manufactured solar collector systems. The tax rebate, in some provinces, may be applied to the components of homebuilt systems and to commercially manufactured systems (C. Toussaint, 1982, pers. comm.). The Retail Sales Tax Branch of Manitoba in May 1980, removed the sales tax from energy saving devices, including active solar energy collection equipment (see Appendix C).

Other provinces have also implemented property tax incentives and demonstration projects (see Table 12). Each province is pursuing research and development in the renewable resources area with provincially allocated funds and federal support, or some combination thereof. Included in this, is the Manitoba-Canada Agreement on the Development and Demonstration of Renewable Energy and Energy Conservation Technologies to run from May 9, 1980 to March 31, 1984 (see Appendix D), which has sponsored the installation of solar heating equipment at public swimming pools in Winkler and Deloraine, Manitoba.

The sales tax rebates or exemptions and property tax relief are ideally suited to the individual residential pool owner. The effect of these sales tax waivers have resulted in lowered capital costs to the consumer, and hence provide an incentive to purchase solar heating systems.

The research and demonstration projects, while providing technical information, also provide to the public, information on the practical applications of solar heating.

2.5.3 *Canadian Oil Substitution Program*

The Canadian Government established the Canadian Oil Substitution Program in May of 1981. This program, although applied primarily for the substitution of natural gas, electricity, or alternate fuels for oil for home heating, has

Table 12

Provincial Solar Energy Incentives

Province	Tax Incentives	Demonstration Projects
Nova Scotia	sales tax rebate property tax relief	none at present
New Brunswick	none	none at present
Newfoundland	none	none at present
Prince Edward Island	sales tax rebate	yes
Quebec	none	yes
Ontario	sales tax rebate & exemption	yes
Manitoba	sales tax exemption property tax relief	yes
Saskatchewan	none	yes
Alberta	none	yes
British Columbia	sales tax exemption	none at present

Source: Berkowitz (1979) and C. Toussaint (1982) also provided grants for the switching to solar heating from oil for swimming pools.

The grant will supply up to a maximum of $800 towards the conversion of oil-heated swimming pools to solar heating. Bell (1980) indicates that only a nominal percentage of oil heated pools exist in Canada at present, while there are in excess of 95% natural gas and other types of heated pools, which would not be able to receive this incentive to switch to solar heating (Energy, Mines and Resources Canada, 1981).

2.5.4 *Legislative Efforts*

At present, there are no legislative acts prohibiting the use of conventional heating equipment in Manitoba. San Diego County, California, (Pulliam and Hedgecock, 1980) has adopted an ordinance requiring solar swimming pool heaters, with collectors at least half the size of the surface area of the pool, be installed whenever a new swimming pool is to be heated or an existing heater is to be replaced. This was adopted in November, 1979 and the ordinance took effect on March 1, 1980, in unincorporated areas not served by natural gas and to take effect in other unincorporated areas by October 1, 1980.

An act such as this, in Manitoba may not occur as a result of actions by the major gas distributors and other energy utilities. Such utilities, who obtain most of their income from the winter heating season, would try to maintain revenues over the summer season and may lobby against such a proposed act.

CHAPTER III

RESEARCH METHOD

3.1 Introduction

Primary and secondary data were used to generate information for this study. The former was obtained through a survey of Winnipeg swimming pool owners and provided the basis for the attitudinal analysis. The secondary data consisted of published literature and personal communication which were used in the literature review, in designing the survey and in performing the subsequent survey and financial analyses. Due to time and budget constraints, Winnipeg was selected as the survey study area and a mail-out questionnaire was chosen as the data collection method.

3.2 Survey Design

The survey method and sample questionnaire design are outlined in the following sections.

3.2.1 *Sample Design*

Selection of a population for the purpose of a survey affects the results of the survey; therefore, these results are no more trustworthy than the quality of the population or the representativeness of the sample (Leedy, 1974). A finite population sample is often used as a measure of social and economic characteristics of human populations. The sample results in a saving of time, labour and cost as opposed to a complete enumeration (Baydack, 1977). Leedy

(1974) states that:

> The sample should be carefully chosen that through it the researcher is able to see all the characteristics of the total population in the same relationship that he would see them if he were actually to inspect the totality ... of (the) data.

The appropriate sample size for a survey is determined by three factors:

1. "The degree of precision required between the sample population and the general population,
2. the variability factor of the population,
3. the method of sampling employed (Leedy, 1974)."

Assuming the population is normally distributed,

$$N = \frac{(Z)^2}{(e)^2} p(1-p)$$

where:

N = size of sample

Z = standard score corresponding to a given confidence level

e = proportion of sampling error in a given set

p = estimated proportion or incidence of use in the population

1-p = estimated proportion or incidence of use in other segment of the population

Assuming a maximum value of 200 solar installations in Winnipeg (T. Hood, pers. comm.) in a total population of

4000 estimated swimming pools in Winnipeg; the proportion of pools heated by solar installation is p = 0.05. Assuming a practical estimation error of 0.10 (Costis, 1972) at the 95% confidence level where Z = 1.96; N is calculated to be:

$$N = \frac{(1.96)^2}{(0.10)^2} (0.05)\ (0.95)$$

N = 18 responses

This means 18 responses would be significant at the 95% confidence level using a maximum value for p(1-p) and and estimation level of 0.10.

Using building permits filed with the City of Winnipeg for the years 1978 and 1979, a total of 65 names and addresses were obtained. Since the population was divided into solar and non-solar, both sub-groups were included in the sample. As these two groups could not be identified through the permits, it was necessary to obtain the names and addresses of solar users from pool retailers. This was done to aid in the comparison of the two groups.

The sampling procedure utilized as a non-proportional, stratified random sampling (O'Leary and Dottavio, 1979). This necessitated a different sampling fraction for each strata (solar and non-solar heated pools) and weighing the data for the population as a whole (Figure 11). This method allowed for a smaller sample size; reducing data collection costs and time.

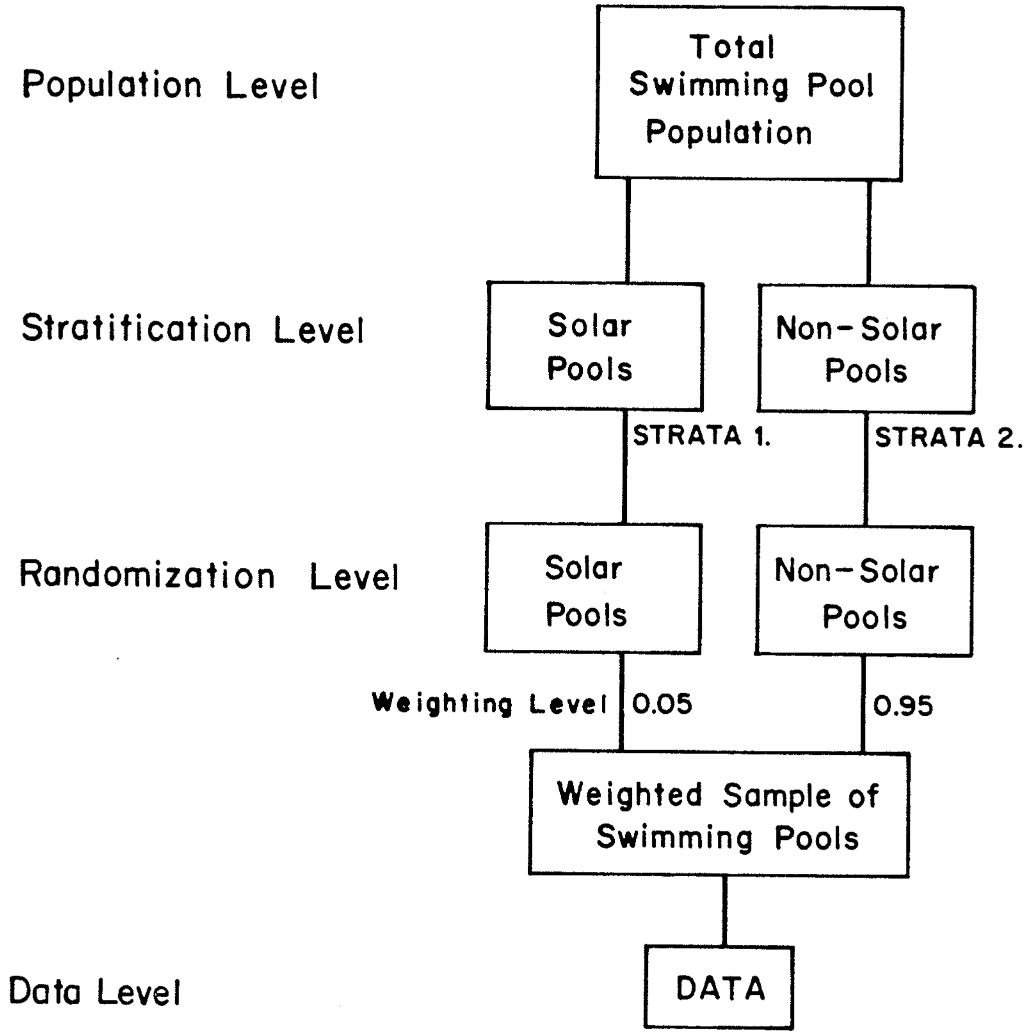

Figure II

Sampling Technique

3.2.2 *Questionnaire Design*

The questionnaire was designed to answer questions posed by the objectives. A sample copy of the questionnaire and covering letter is included in Appendix A.

Question 1 - was included to determine the energy source used to heat the respondent's pool. All possible heating methods were included. This was used as a base to compare respondents' answers to further questions, with others using the same heat source and to contrast it with those who do not. Question 1, was also designed with ease of answering in mind, to give the respondent confidence to continue (Selltiz, et al., 1959).

Question 2 - was designed for the solar energy consumers. The question allowed them to check a number of decision factors which led them to choose solar energy to heat their pool.

Question 3 - was directed to the owners of non-solar heated swimming pools. Decision factors were listed in order for the respondent to indicate why he or she may have rejected solar energy as a pool heating method.

The decision factors in questions 2 and 3 were determined through readings on consumer behaviour to solar heating (Pilgrim and Unseld, 1981) and conversations with swimming pool owners and retailers.

Question 4 - was used as a measure of pool owner attitudes toward a number of factors common in the decision making process of choosing an energy source to heat swimming pools. It was used to rate each fuel on a scale of 1 to 5 (1 being very favourable and 5 very unfavourable). This measures the perception of each consumer to each of the major pool heating fuels for various characteristics.

Question 5 - was used to measure consumer reaction to a number of legislative articles affecting use of swimming pools and solar heating.

Question 6 to 8 - were designed to determine certain physical characteristics of swimming pools in Winnipeg. Question 8 was included to determine whether pool owners are utilizing any simple conservation measures to reduce energy consumption.

Question 9 - was designed to measure the effectiveness of solar heating versus non-solar by comparing the length of the pool season. In addition, *Question 10* was used in the same manner. A higher pool temperature for the solar users may indicate that gas consumers are implementing conservation measures to reduce their energy cost.

Question 11 - was designed to measure the amount of pool use by pool owners. The number of people using the pool may affect the overall temperature as heat loss results. As well, it can be used as a measure of recreational value.

Question 12 - was designed for the non-solar swimming pool owner. This was used to measure actual average fuel consumption for each pool size indicated in Question 6. It would also measure perceptions pool owners may have of estimated and actual fuel consumption.

The following principles were considered in the preparation of the questionnaire; shorter questions and questionnaires gain a higher return rate (Selltiz in Baydack, 1977). The questionnaire must be of interest to the subject group, to elicit valid opinions and garner a higher return. All possible answers must be considered in designing pre-coded questions to promote ease of answering, standardize responses, facilitate data processing and to simplify the questionnaire.

The questionnaire included a covering letter outlining the purpose of the study, the importance of the study to the subject group and the researcher. It assured confidentiality of all responses and invited respondents to reply by a given date.

The questionnaire was printed on 8.5 x 11 inch white bond paper with the covering letter printed on white bond paper bearing the letterhead of the Natural Resources Institute, University of Manitoba. It was signed by the researcher and an incentive was included (A summary of the findings of the study).

3.2.3 *Data Processing and Analysis*

Returned questionnaires were coded onto IBM coding forms, using a predetermined coding scheme. The information was then transferred onto a computer file for analysis.

The data were analyzed, using the Statistical Package for the Social Sciences (SPSS) on the University of Manitoba computer. Data were analyzed, using univariate and bivariate statistical procedures (Nie et al., 1975 and Huntsberger and Billingsley, 1973).

3.3 Solar Equipment Costs and Technical Considerations

3.3.1 *Introduction*

This section will present the method for the financial analysis of solar heating for swimming pools. Costs for a range of collectors sold in Manitoba were compared. This data was then used to perform a simple payback and sensitivity analysis. Belding (in Graham, 1981) indicated that most consumers have been found to base decisions to convert to alternate fuel sources on initial rather than life cycle or total costs. However, consumers are becoming more aware of the impact of payback and life cycle costs on the purchase value of a swimming pool and associated heating methods. It is important to communicate to pool owners the financial benefits which can be derived from use of solar energy for swimming pool heating.

3.3.2 *Survey of Collectors*

Swimming pool retailers in Winnipeg were contacted to determine which companies were selling solar heating equipment. Approximately 7 swimming pool installers in Winnipeg sold 4 different solar heating equipment systems.

Using information gathered on the area of the collector, together with its cost for a typical family swimming pool with surface area of 512 ft.^{2} (47.6 m^2) (16 x 32 ft.); solar collector costs for this pool were determined (Table 13).

The cost of the collectors varies from approximately \$5 per square foot (\$46/m^2) to \$14 per square foot (\$155/m^2). Most of the collectors shown were uninsulated and unglazed. Insulated collectors are not necessary for pools to be used only in the summer, and are more expensive. Glazing is an option which can reduce convective and radiative heat loss, but may reflect 10% to 20% of the incident radiation (Brunt and McNelis, 1976). The gains in utilizing this type of collector may not be sufficient to offset the higher cost and lowered efficiency.

3.3.3 *Financial Analysis of Solar Heating*

3.3.3.1 Evaluation of method

Benefits to be derived from the conversion of conventional heating to solar heating are directly proportional to the difference between the cost of the conventional fuel and solar energy, and the cost of conversion.

From the net cash flow (benefits minus costs), the payback period can be determined. This is the time needed to

Table 13

Summary of Swimming Pool Collectors

Collector Type of Pool	Ratio of Panel Area Pool Area	Installed Cost ($/ft^2) [$m^2]	Panel Area (ft^2) [m^2]	Number of Panels	Cost ($)	Installed Cost ($)
A Glazed, plastic, uninsulated	.35	14 [155.8]	192 [18]	24 (2'x4')	2379	2774
B Plastic, uninsulated	.50	4.5 [46.2]	280 [26]	7 (4'x10')	840	1200
C Glazed, insulated	.50	14 [150.00]	336 [31]	14 (3'x8')	4704	--
D Plastic, uninsulated	.50	8.6 [92.9]	280 [26]	7 (4'x10')	2401	2416

Note: Metric equivalents are to the nearest meter.

recover the initial cash outlay. This method does not take into account the time value of the money spent and ignores the economic life of the system.

A discounted cash flow (DCF) method utilizing the costs and benefits which occur at different points in time, may be converted to an equivalent time base (present value). This reduces the stream of benefits and initial capital cost to a single value which may be positive or negative.

This DCF method is sensitive to the rate at which the costs and benefits are discounted to present value terms. For private sector expenditure decisions, the appropriate rate of discount is usually equivalent to the prime rate of interest which reflects the cost of obtaining the capital necessary to purchase the conversion equipment (Graham, 1981). A positive present value reflects the benefit the investor may obtain by converting to solar energy.

For the purposes of this analysis, discount rates of 9%, 13%, 17% were chosen as representative interest rates to borrow capital over a time frame of seven years. If discounted costs exceed discounted benefits at the end of seven years, thereby giving a negative value, the consumer would be unwilling to undertake the project.

The private consumer's decision to proceed with conversion depends on an objective of profit maximization. Theoretically, if the payback period is short and if the net present value is positive the consumer could benefit by undertaking the conversion to solar energy.

The consumer, although deciding primarily on financial grounds, may be influenced to convert to solar energy even if the investment does not appear profitable.

3.3.3.2 Sensitivity and payback analysis

For the purposes of the financial analysis, the pool size was the average of 512 ft.^{2} (47.6 m^2). An uncovered pool this size has an energy demand of 98 x 10^6 Btu (1.03 x 10^{11} joules). This produces fixed seasonal pool heating costs as shown in Table 14. From this information, the payback periods were calculated for a sensitivity analysis performed for fixed energy costs over the 7 year time frame of the analysis. As fixed costs are unrealistic in the long run, an additional financial analysis was performed with rising costs, building in planned gas and oil price increases from the National Energy Program (Energy, Mines and Resources, Canada, 1980) plus theoretical operating costs of 12% (Greater Winnipeg Gas, 1982) over a seven year time period. Manitoba Hydro has fixed its residential rate at $0.0253 per kWh until 1984. Although this freeze may be removed by the end of 1982, present value was calculated with the rate freeze until 1984 and using rising costs thereafter.

An additional payback series and sensitivity analysis was performed to determine the present value of using a pool cover alone, without the solar collector conversion.

The summaries of these analyses and subsequent discussion are presented in Chapter IV.

Table 14

Seasonal Cost of Pool Heating
Summary

SOURCE	COST/UNIT	BTU/UNIT	EFFICIENCY	COST/SEASON	
				No Blanket	Blanket[4]
Manitoba Hydro[1]	\$0.0253/kWh	3413 Btu/kWh	1.00	\$726.00	\$363.00
Greater Winnipeg Gas[2]	\$3.61/mcf	1000 Btu/ft^3	0.65	\$545.00	\$272.50
Shell Oil[3]	\$1.31/gal.	1.0×10^5 Btu/gal	0.60	\$2140.00	\$1070.00

[1]A five year rate freeze was implemented in 1978.

[2]As of January 1, 1982.

[3]As of February 18, 1982.

[4]Assume blanket cuts 50% of heating costs.

3.4 Limitations

3.4.1 *Questionnaire*

The questionnaire portion of the study was limited by the nature of surveys. Many factors affect the validity of a survey questionnaire including response rate and the type of questions asked.

For a subject to decide whether to respond to a survey, factors such as contact (type of approach), organization of the survey, and personal characteristics affect response. Lack of interest or motivation is sufficient to overcome the effort, inconvenience and possible risks involved in survey participation. There is more public trust in and responsiveness to, government agencies and universities, than to private companies (National Research Council, 1979).

Another factor is whether to include income in a survey. Although it is an important item in many surveys, in many cases it has a negative effect on the response.

Questions regarding education or income were not asked in this survey, as research by Berliner et al., (1978) determined that this does not have a major effect on decisions made on solar heating for pools. In addition, this survey closely followed the 1981 census and the response rate would have been lower if these questions had been included.

3.4.2 *Payback and Sensitivity Analysis*

A payback series and sensitivity analysis are limited when forecasting of fuel price increases or decrease, and discount rates must be made. The best option is to select worse case and best case conditions and provide a range of possibilities, that may fit future conditions.

CHAPTER IV

ANALYSIS

4.1 Questionnaire Analysis

4.1.1 *Survey Response*

By the pre-determined deadline of September 2, 1981, 51 questionnaires, from an initial sample of 75, were returned: giving a response rate of 68 percent. This high percentage of returned questionnaires is due to the combined sampling methods of dropoff-pickup and a mailout reply.

The breakdown of responses is shown in Table 15. The relative percentages are not indicative of the proportion of these heating types in the total swimming pool population. In order to obtain a significant number of responses from the solar heating population, this portion of the sample population was surveyed more intensively than the rest of the population. Twenty-six questionnaires were distributed to those pool owners who were identified as solar consumers. The rest of the questionnaires (49) were distributed to pool owners randomly selected from building permits filed with the City of Winnipeg.

Of the 49 questionnaires distributed to owners of non-solar heated pools, 49 percent were returned. The proportion of returns by owners of solar heated pools was greater than 100 % due to occurrence of hybrid systems (gas or electric and solar) in the sample.

Table 15

Proportion of Questionnaire
Returns by Heating Unit

Heating Unit	Absolute Frequency of Returns	Relative % of Returns	Weighted proportion in Total Population %
Gas	21	41	94.2
Solar	18	35	4.5
Solar and Gas	9	18	0.5
Solar and Electric	1	2	0.1
Electric	1	2	0.1
Unheated	1	2	0.1
Totals	51	100	100.0

From consumer comments, the use of hybrid systems stems from two areas. Initially, the swimming pool may have been heated by a conventional pool heater; the owner, upon observing fuel cost increases reflected in his energy bill, purchased a solar collector. Or, the pool owner, upon purchasing a swimming pool, installed both a conventional heater and a solar collector. The customer may have been recommended to purchase both, on the reasoning that the conventional heater would assist on extended cold or cloudy days, or to speed up the start-up period.

4.1.2 *Physical Factors of Swimming Pools*

Questions 6, 7 and 11, were designed to gather information of pool construction and usage patterns.

The volume and area of pools covered in this survey are shown in Tables 16 and 17. It is apparent from these figures that the most common pool area, is in the 500 to 550 $ft.^2$ (47 m^2 to 51 m^2) range (28%). The most common volume is 15,000 to 20,000 gallons (68,000 l to 91,000 l) at 25%. This percentage is not in agreement with the national average of 55% for pools of 512 $ft.^2$ (48 m^2) in area (Canadian Pool and Spa Marketing, 1980), but it does contain the majority of the pools surveyed. The grouping of pools at the lower size range may be linked to 1) cost of the pool and 2) the size of the yard available to install a swimming pool.

Table 16

Proportion of Questionnaire
Returns by Pool Volume

Volume - gallons [litres]	Absolute Frequency	Weighted Proportion % in Total Population -
7,200 - 10,000 [33,000 - 46,000]	21	47
10,001 - 15,000 [46,001 - 68,000]	3	5
15,001 - 20,000 [68,001 - 90,000]	12	28
20,001 - 25,000 [90,001 -114,000]	9	10
25,001 - 30,000[114,001 -137,000]	5	10
30,001 - 32,675[137,001 -149,000]	1	0
Totals	51	100

Note: metric equivalents are to the nearest litre

Table 17

Proportion of Questionnaire
Returns by Pool Area

Area - ft^2 [m^2]	Absolute Frequency	Weighted Proportion % in Total Population
288 - 500 [27.0 - 47.0]	13	24
501 - 550 [47.1 - 51.0]	17	24
551 - 600 [51.1 - 56.0]	5	10
601 - 650 [56.1 - 60.0]	8	19
651 - 700 [60.1 - 65.0]	1	0
701 - 750 [65.1 - 70.0]	1	0
751 - 800 [70.1 - 74.0]	3	9
801 - 850 [74.1 - 79.0]	-	-
851 - 960 [79.1 - 89.0]	3	14
Totals	51	100

Note: metric equivalents to nearest meter

The sample of swimming pools showed that:

1. 100% of the pools were inground
2. 95% were vinyl lined (5% concrete lined)
3. 6% were indoor pools (94% were outdoor pools)

This sample of pools indicates that the owners have made a decision to install a permanent inground pool, but have proceeded with the least expensive options; hence the high proportion of vinyl lined and outdoor pools. The high proportion of outdoor pools indicates that most pool owners are concerned with a pool season running from spring, through summer and early fall.

Question 11 was designed to determine the number of people utilizing the pool. The median frequency was for groups of 3 to 5 people (see Table 18).

Comments by owners indicated that pool usage is restricted primarily to the immediate family. Pool owners commented that the pool was purchased in order to enjoy more of their leisure time without the associated travel costs in time and money to distant recreational areas.

4.1.3 *Pool Blanket*

The use of a pool blanket is the primary conservation measure performed by a swimming pool owner. Of the 51 owners surveyed, 85% indicated they use a pool blanket. This usage is higher than the average of 55% mentioned by Bell (1980).

TABLE 18

Frequency of Pool Use

People	Absolute Frequency of Returns	Weighted Proportion (%) in Total Population
1 to 2	4	14
3 to 5	33	61
6 to 10	9	20
over 10	2	5
Total	48	100

Use of blankets or other pool coverings, such as canopies, are recommended for outdoor pools to reduce evaporative heat losses. Pool cover costs are in the order of $250 to $300 for a standard sized 16 ft. by 32 ft. (4.8 m by 9.8 m) pool (B.C. Hydro, 1979). They are suitable for indoor pools, helping to reduce costs and conserve energy year-round; and to reduce moisture and condensation problems in the pool building. However, this survey indicated that none of the owners of indoor pools utilized pool blankets.

4.1.4 *Energy Cost and Fuel Consumption*

4.1.4.1 Energy Costs

Pool owners utilizing conventional heating methods were asked to estimate their fuel costs for the 1980 pool season. Permission was obtained to review consumption records with their utility to determine actual costs and fuel consumption.

Estimated fuel costs ranged from $10. per pool season to $500. Assuming pool size is constant, the estimated fuel cost mean, from the returned questionnaires, was found to be $248. per season with a median of $207. When actual costs were examined from Greater Winnipeg Gas records, it was found that the mean cost was $157. and a median cost of $132.

The pool owners' estimated heating costs to actual heating costs was tested to determine if perception of cost was within the range of actual cost. When tested for significant difference of means, it was found that the owners' estimation of costs to actual cost was significant at the .01 confidence level; the owners' perception of estimated versus actual costs differ. The owners' estimates of fuel costs for pool heating are higher than the actual charges. This may be associated with the fact that a budget plan for energy use is in effect for most householders in the city, and the billing does not reflect actual consumption of fuel. Householders are billed by Greater Winnipeg Gas, at $15.00 per month minimum for consumption of 35 ccf of natural gas on the budget plan (Greater Winnipeg Gas, 1981).

4.1.4.2 Fuel Consumption

An easier examination is the determination of energy consumption. This analysis is restricted to gas consumers, as these were the only respondents who gave permission to examine consumption records.

Consumption ranged from 171 ccf to 1650 ccf depending upon use of a pool cover. A test of chi-square indicated that a relationship between pool cover and fuel consumption does exist. Non-use of a pool cover is reflected in a higher consumption and is statistically significant at the 0.01 level.

4.1.5 *Pool Season and Temperature*

4.1.5.1 Pool Season

In order to measure the effectiveness of solar heating, as compared to conventional heating methods; the first day and last day means of each heating type were compared. Table 19 and 20 show the relative frequencies of first day and last day of pool use for the entire swimming pool sample population; with the average breakdown of season to heating method presented in Table 21. Value labels presented are defined in Tables 18 and 20 in reference to start and stop dates. Prior to the testing for significant difference of means between heating types, a basic hypothesis was posed: "Is the mean start (or closing) date for solar heated pools earlier (or later) than conventionally heated pools."

Tests of this hypothesis revealed that there was no significant difference between the start dates for gas and solar heated pools (Table 21). The hybrid system pools started significantly later; with the solar heated pools opening approximately May 1, and the gas and solar hybrid heated pools opening about May 15.

The closing date of the pool seasons revealed that both the gas, and gas and solar heated pools closed significantly later than the solar heated pools. The solar heated pools were closed down around September 1st, while the gas pools closed around September 15th. The hybrid pools stayed open until October 1st.

Table 19

Proportion of First Day Use
by Sample Population

Value Labels	First Day	Absolute Frequency	Weighted Proportion (%) in Total Population
1	Apr 1 - Apr 14	2	6
2	Apr 15 - Apr 30	19	55
3	May 1 - May 14	7	6
4	May 15 - May 31	10	22
5	Jun 1 - Jun 14	2	6
6	Jun 15 - Jun 30	2	1
7	Other	2	7
Total		44	100

Note: For breakdown by heating method, see Table 21.

Table 20

Proportion of Last Day Use
by Sample Population

Value Labels	Last Day	Absolute Frequency	Weighted Proportion (%) in Total Population
1	Aug 15 - Aug 31	2	1
2	Sept 1 -Sept 14	9	17
3	Sept 15 -Sept 30	23	50
4	Oct 1 - Oct 14	7	27
5	Oct 15 - Oct 31	4	5
6	Other	1	0
Total		46	100

Note: For breakdown by heating method, see Table 21.

Table 21

Significance of Means for
Pool Season and Temperature

Variable	Total Population (Value Labels)[1]	Weighted Means of Value Labels					
		Gas	Gas and Solar	Electric	Electric & Solar	Unheated	Solar
First Day	2.952	2.944 NS	4.000 **	0	0	0	3.000
Last Day	4.199	4.222 **	4.750 *	0	0	0	3.705
Temperature	2.887	2.857 **	3.000 **	0	0	0	3.500

NS - not significant

* - significant at t >.01

** - significant at t >.05

0 - sample size not large enough to test

1 - value labels from Tables 19, 20, 22 (averaged by heat type)

The length of the pool season was dependent upon a number of factors including frequency of use, ambient temperature and type of heating system involved. The solar heated pools may have closed earlier due to a cool, cloudy fall. The extended season for the gas and hybrid systems may be due to the conventional heater capable of heating pools even when it was cloudy. The length of season appears to be equal for each heating system, although start and close dates may differ.

The most effective system in providing a longer pool season, from comments by pool owners and retailers, is a hybrid system of a conventional fuel and solar energy. The start-up periods are shorter, and the season is longer in the fall.

4.1.5.2 Temperature

In order to measure the effectiveness of solar heating, the temperatures of the pool with each type of heating system were compared and presented in Table 21. The average temperatures for the entire sample population is shown in Table 22. The hypothesis posed for pool temperatures was: "Do solar heated pools maintain a higher average temperature than conventional or hybrid heating systems?"

Tests showed (Table 21) that solar heated pools were maintained at a higher average temperature, (value label 3.5) than gas or gas and solar heated pools. There was a signi-

Table 22

Frequency of Temperature Range
for Sample Population

Value Labels	Temperature °F [°C]	Absolute Frequency	Weighted Poportion (%) in Total Population
1	70-74° [21-23°]	4	5
2	75-78° [24-25°]	4	14
3	79-82° [26-28°]	27	70
4	83-86° [29-30°]	14	10
5	87-highest [31°-]	2	1
Total		51	100.0

Note: Metric equivalent rounded to nearest degree

Note: for breakdown by heating method (mean value labels), see Table 21.

ficant difference in temperatures between heating systems and this may be related to the removal of utility bills in heating the pool with conventional equipment. Pool owners are reluctant to heat their pools to a higher, possibly more comfortable temperature if it results in higher fuel bills.

The electric, electric and solar, and unheated pools were unable to be tested, due to the small sample sizes.

4.1.6 *Solar Decision Factors*

In order to determine what factors may have influenced swimming pool owners to choose solar heating for their pools, question 2 listed potential influencing factors and asked the respondent to indicate which factors caused them to choose solar heating. Table 23 lists the influencing factors and the proportion of responses by owners of solar heated pools.

The respondents indicated four major factors (over 50% of the responses), which affected their decision to choose solar heating. Anticipation of fuel cost increases (93%), no annual fuel costs and correct orientation of pool or house (75%) and little or no maintenance costs (68%).

Relief from economic pressure is the primary perceived benefit in choosing solar pool heating. This conclusion is similar to research performed by Pilgrim and Unseld (1981). The pool owners recognized a risk in continuing to heat their pools with energy supplied by a utility. The dependence upon a utility results in paying for energy costs when heaters

Table 23

Solar Heating Decision Factors

Question: Which of the following criteria led you to select solar energy to heat your pool?

Decision factor	Absolute Frequency	%(N = 28*)
Anticipation of fuel cost increases	26	93
No annual fuel costs	21	75
Pool or house oriented correctly	21	75
No maintenance costs	19	68
Energy conservation	13	46
Environmental considerations	8	29
Lengthens pool season	8	29
Interested in technological aspects	6	21
Pool retailer sells and maintains product	6	21
Pool retailer sells solar heating	5	18
No provincial sales tax	4	14
Pool retailer recommends solar	3	11
Other[1]	7	25

*includes responses by solar, gas and solar, electric and solar

N = total Responses of solar heated pool owners (unweighted).

1 = includes comments such as allowance for more yard space, long term choice, reduced fuel costs, maintain higher pool temperatures.

are used. In most cases, movement toward solar was prompted when the pool owners received their energy consumption bills for the summer pool season.

Orientation of the house or pool must also be considered as a number of respondents commented that, due to the orientation of their house, they were able to utilize solar heating. All respondents had a southern or western exposure, with adequate roof area to install solar collectors.

Pilgrim and Unseld (1981) found that environmental protection, security and comfort rated highly (see Table 10, page 46); but not as high as the role of costs. This is reflected in Table 23, from the sample of Winnipeg swimming pool owners; where energy conservation and environmental consideration were not a highly rated factor in switching to solar heating.

One factor noted in this study, is the role of the swimming pool retailer. Many of the pool retailers interviewed were either very positive or very negative with regard to recommending solar heating for their customers. A number of pool retailers and installers sell and install solar heating equipment. These retailers do not hesitate to recommend solar heating, if the situation warrants it. Some pool owners were unaware that solar heating for pools was available until the retailers were able to demonstrate systems and show warranty and service protection.

Only four respondents indicated that the absence of a provincial sales tax on solar heating equipment affected their decision to purchase a collector. A number of respondents commented that they were unaware such an incentive existed. These people may have purchased their systems previous to May, 1980 when this legislation came into effect (Retail Sales Tax Branch, 1980), as the lack of sales tax is a major selling point for the solar heating equipment retailers (T. Hood, pers.comm.) and is presented immediately to the potential purchaser.

4.1.7 *Non-Solar Decision Factors*

Pool owners who are not using solar heating have some major concerns about risk which may have prevented their purchase of a solar heating system (Foster & Sewell, 1977, and Pilgrim and Unseld, 1981). The risks can be categorized into three groups:

1. initial system purchases
2. concerns with living with a solar system, and
3. lifestyle and aesthetic issues (Pilgrim and Unseld, (1981) (see Table 9).

The results of Question 3 are shown in Table 24. Initial cost of purchase and installation were a major barrier to some consumers; as the initial capital cost of a solar heating system ranges from 1.5 to 2 times the capital cost of a conventional heating system.

Table 24

Non-Solar Decision Factors

Question 3: Please check as many of the considerations below which led you to reject solar energy as a method of heating your pool?

Decision Factor	Frequency	%(N=23*)
Initial cost of purchase and installation	10	44
Credibility of advocates of solar energy	8	35
Pool heating fuel initially heating home	8	35
Inconvenient or difficult to install	5	22
Pool retailer does not sell solar heating equipment	4	17
Aesthetic considerations	3	13
Pool or house not oriented correctly	3	13
Difficulty involved indiscontinuing solar if system becomes ineffective	2	9
Possibility of increased property taxes	2	9
Pool retailer sells but does not recommend for your pool	2	9
Cost of maintaining collectors	1	4
Wished to stay with more conventional equipment	1	4
Pool not large enough to heat	-	-
No Service or maintenance	-	-
Other[1]	10	44

*include gas, electric, unheated pools

1 - includes comments regarding need for supplementary heat, pool packages sold with conventional heaters, lack of guarantees.

Many respondents indicated that they doubted the credibility of advocates of solar energy; including the reliability of solar firms. This opinion has basis in fact, due to the quality of some equipment that has been placed on the market in the past, by companies who have not had extensive experience in handling solar heating equipment. Canadian Pool and Spa Marketing (1980) reported panel failures, control problems, leaks due to poor design, improper manufacturing techniques coupled with incorrect installation which have caused a number of pool retailers and pool owners to reject solar heating for swimming pools. Many of the design and manufacturing problems have been corrected, with the equipment now having to meet national safety and warranty standards. These standards do not, however, include the ability of retailers to install or back-up installations with service. Presently, a program is being developed to present seminars and courses on installation, and maintenance of solar systems to retailers (Canadian Pool and Spa Marketing, 1981).

A number of respondents (35%) indicated that they preferred to remain with the fuel that was initially heating their house. They were satisfied with the conventional heating system and installation (including piping to the pool) was inexpensive.

Two respondents indicated that the possibility of increased property taxes, because of solar heating equipment, affected their choice of heating equipment. This is unlikely as to Manitoba Bill 87 (1977), regarding property tax reductions for solar heating (see Appendix B) does not apply to solar heating of swimming pools.

A number of respondents indicated that they did not reject solar heating, but would reconsider if they could afford it or if their house was oriented correctly. Other respondents indicated that they were not satisfied with the dependability of present solar systems. Warranty considerations were a factor in not purchasing a solar collector.

Other pool owners indicated that solar heating was not stressed at time of pool purchase and that the lower price of gas at that time, was a factor in remaining with gas heat. A number of respondents also indicated that they were not familiar with solar heating and this mitigated against the purchase of a system.

4.1.8 *Perceptions about Heating Systems*

Question 4 dealt with pool owners' perceptions about heating units, i.e. gas, electric and solar, for a number of factors which have proven significant in their choice of a good heating system (Berliner et al., 1979).

After the respondents indicated their opinion, on a scale of 1 to 5 (very favourable to very unfavourable) for each factor; the means were determined. The differences in the means between the conventional heating unit and the solar unit (see Table 25) were then tested.

Table 25

Mean Scores of Heating System
Perceptions for each Characteristic

Characteristic	Heating System		
	Gas	Electric	Solar
Cost to purchase and install	2.8698*	4.748*	4.056
Cost to run per season	3.659*	4.796*	2.289
Aesthetic considerations	2.611*	2.754*	3.209
Environmental impact	3.679*	2.976**	1.938
Energy conservation	4.538*	3.087*	1.337

NS Not significant

* significant at 99% confidence level

** significant at 95% confidence level

The difference in means between solar and gas, and solar and electricity were found to be significant in all cases for each characteristic (Table 25); however, each heating system was viewed differently.

In the cost to purchase and install, gas units were viewed more favourably, at 2.8698 than solar; but solar was viewed more favourably than electric units. This was surprising as the cost of an electric unit was equivalent to a gas heater.

Gas and electric units were viewed unfavourably in terms of cost to run each season. This is linked to the fact that gas and electricity must be supplied by a utility and therefore, bills are submitted to consumers. Solar collectors were viewed favourably, but not extremely so. The electric units were considered more unfavourable to run than a gas unit; as gas was perceived as the least expensive fuel.

When tested for difference of means due to aesthetic considerations, it was found that there were significant differences between gas and solar, and gas and electricity. This may be traced to either of two aspects: 1) it is a major consideration in the purchase of a heating unit, or, 2) the units are in an 'out of sight, out of mind' relationship. Even though gas and electric units are tucked into a corner of the yard, and the solar collectors are placed on a roof; appearance may cause the purchase of a conventional unit over a solar unit. In either case, the appearance of a solar collector is viewed as more unfavourable than gas or electric.

Gas and electricity were found to be significantly different to solar when pool owners were questioned on their perceptions of environmental impact. Both gas and electricity were perceived unfavourably, while solar energy was considered favourable in environmental impact. Electric units were viewed more favourably than gas units as electricity is considered a renewable energy with a lowered environmental impact than gas.

When means were tested for similarity in regard to energy conservation characteristics; it was found that gas and electricity were significantly different from solar energy. Solar heating was perceived as an energy conserving method to heat pools. Overall, factors negating the purchase and use of a solar energy system for pools lies in the area of capital cost and aesthetics. Once the capital costs become more competitive with conventional heating equipment, this factor will be eliminated.

4.1.9 *Legislation*

Question 5 related to potential and actual legislative and policy actions which may be applied to persons owning a swimming pool and wishing to heat it. The breakdown of responses is shown in Table 26.

Table 26

Legislative and Policy Actions

Question: *In view of rising energy costs and shortages, if the heating of swimming pools becomes a factor, what would your reaction be to the following?*

Statement	In favour %	Very In favour %	Total %
Require by law or ordinance solar water heating of new pools	26	26	52
Restricting use of fossil fueled pool heaters	28	18	46
Legislation to subsidize purchase of solar pool heaters	8	49	57
Surcharges on conventional energy consumed by outdoor pool heaters	8	14	22
Voluntary conservation of energy to heat outdoor pools	33	43	76
Information made available on conserving energy in heating swimming pools	28	62	90
Legislation permitting the heating of swimming pools by solar energy only	12	10	22

The pool owners indicated that 52% were in favour of a law or ordinance requiring the solar water heating of new pools. This positive reaction must be viewed in the light that these owners believe that this would not apply to them. When the last question was presented, only 21.6% were in favour of heating pools by solar energy only. These two questions, although similar in wording, apply to two different concepts of solar heating for swimming pools. The latter question would apply to anyone heating a pool, while question 1 would apply to new pool purchasers.

Forty-six percent of the respondents were in favour of restricting use of fossil fueled pool heaters. This would have a major impact on utilities if implemented and would restrict the number of people who could heat their pool. It may be applied with provision to people who do not have the proper orientation to utilize a solar collector. In view of the responses to these ordinances, which are similar to those in effect in California; it would appear that any restrictive legislation on the heating of swimming pools would be ineffective in Winnipeg.

Legislation to subsidize the purchase of solar pool heaters received a relatively low 57% of the favourable comments. This subsidy would provide an incentive to that proportion of the population who have no desire to switch due to the cost of the solar heating equipment. At present the federal government has provided, under the auspices of the Canadian Oil Substitution program (COSP), grants for the substitution of solar heating for oil heated swimming pools. Appendix E contains the details of the program. The grant will supply $800 toward half the costs directly related to the conversion; including equipment, materials, labour costs and related provincial or municipal authorizations (Energy, Mines and Resources, Canada, 1981. There is no provision at present to supply grants for the movement to solar heating from natural gas or electricity.

The majority of pool owners (76%) would prefer to remain with voluntary conservation of energy in heating their pools. This is in addition to the 90% of the respondents who would like to have information made available on conserving energy for swimming pools.

4.2 Financial Analysis

4.2.1 *Introduction*

This section will discuss the results of the financial analysis of:

1) using a pool cover alone with conventional heating;

2) the conversion to solar heating from conventional heating; and

3) the comparison of life cycle costs of conventional and solar heating.

Sample calculations are shown in Appendix F.

4.2.2 *Pool Cover (with Conventional Heating)*

A pool cover is the initial conservation measure selected by most pool owners. A cover reduces the energy demand of the pool by at least 50%. If the pool is heated by conventional energy, the energy reduction is reflected in a decrease in seasonal fuel bills.

When the costs of two pool covers, (each lasting three and one half years), are deducted from the accrued fuel cost savings during the seven-year life of the conventional equipment; the benefits far outweigh the costs (see Table 27). Appendix F contains the sample calculations.

The present values of savings are positive for all three conventional fuels. Changes to the discount rate do not unduly affect the final, positive present values. The payback period of the pool covers for all three conventional fuels is within one year.

Any pool owner of a conventionally heated pool will receive immediate benefit in fuel savings, if a pool cover is used and recover the cost of the cover within one year of purchase. Owners of solar heated pools may also use pool covers, in order to maintain the pool at a constant temperature during the night and cloudy periods. However, there will be no fuel cost savings as there are no fuel costs associated with solar heating only.

Table 27

Present Value of Rising Conventional Fuel Cost Savings from Using Pool Cover Only

Discount Rate	Present Valued Pool Cover Cost[1]	Present Value of Benefits[2]					
		Natural Gas		Electricity		Oil	
		P V	Payback Years	PV	Payback Years	PV	Payback Years
9%	528.68	$1822.44	(1)	$1768.37	(1)	$7832.88	(1)
13%	491.27	1541.60	(1)	1458.37	(1)	6738.22	(1)
17%	459.92	1315.29	(1)	1260.79	(1)	5853.51	(1)

1. Cost of Pool cover (year 0) plus discounted, inflated (12%), cost of pool cover (year 4)

2. Present value of discounted savings less present value of cost of pool cover(s).

4.2.3 *Conversion to Solar Heating*

The present values of conversion to solar heating from conventional heating methods, were calculated and presented in Tables 28 and 29. The sample calculations are presented in Appendix F.

The analysis examined such variables as:

1) fixed and rising fuel costs
2) changes in the discount rate
3) use or non-use of a pool cover, and
4) changes in the capital cost of the available Winnipeg solar collector systems.

Some variables had a larger effect than others on the final present values of benefits to be derived from the conversion to solar heating.

Variation in the discount rate, whether with fixed or rising fuel costs, did not have a great effect on the final present value results. Only in one case (Table 28) did the change in the discount rate result in a move from a positive to a negative present value.

When fixed and rising fuel costs were compared as to the effect on the present value of benefits of conversion, it was found that fixed fuel costs did not result in benefits outweighing costs for natural gas and electricity for most conversion to solar heating. Only oil heated pools resulted in immediate positive present values to the consumer.

Rising fuel costs over the seven-year analysis period, (Table 29) increased the stream of benefits to the consumer;

Table 28

Summary of Financial Analysis of the Conversion to Solar Heating from Conventional Heating (with fixed conventional fuel costs and sunk capital cost over 7 years)

Solar Collector Cost[1]	Blanket	Natural Gas $3.61 MCF Present Value ($) [Payback (years)]			Electricity $0.0253 KWH Present value ($) [Payback(years)]			Oil $1.31 / gal. Present Value ($) [Payback(years)]		
		9%	13%	17%	9%	13%	17%	9%	13%	17%
A	B	-1829.61 [>7]	-1972.15[>7]	-2088.62[>7]	-1374.14[>7]	-1571.92[>7]	-1733.59[>7]	2184.15[4]	1554.87[4]	1039.58[5]
$2774	N	- 31.04 [>7]	- 363.68[>7]	- 636.38[>7]	879.92[5]	436.82[6]	73.65[7]	7996.52[2]	6690.39[2]	5619.98[2]
B	B	- 255.62 [>7]	- 399.16[>7]	- 514.56[>7]	199.86[6]	2.08[6]	- 159.59[>7]	3758.15[2]	3128.87[3]	2613.58[2]
$1200	N	1542.96 [3]	1210.32[3]	937.70[3]	2453.92[2]	2010.82[2]	1647.65[3]	9570.52[1]	8264.39[1]	7193.89[1]
C	B	-3759.62 [>7]	-3902.16[>7]	-4018.56[>7]	-3304.14[>7]	-3501.92[>7]	-3663.58[>7]	254.15[7]	- 375.13[>7]	- 890.42[>7]
$4704	N	-1961.04 [>7]	-2293.68[>7]	-2566.30[>7]	-1050.08[>7]	-1493.20[>7]	-1856.36[>7]	6066.52[3]	4760.39[4]	3689.89[4]
D	B	-1471.62 [>7]	-1614.16[>7]	-1730.56[>7]	-1016.14[>7]	-1213.92[>7]	-1375.59[>7]	2542.15[4]	1912.87[4]	1397.58[4]
$2416	N	326.96 [5]	- 5.68[>7]	- 278.30[>7]	1237.92[5]	794.82[6]	431.65[6]	8354.52[2]	7048.39[2]	5977.89[2]

[1] see Table 13

[N] No pool blanket - present value of fuel savings less cost of solar collector.

[B] with pool blanket - present value of fuel savings less cost of solar collector & pool cover(s)

Table 29

Summary of Financial Analyses of Conversion
to Solar Heating from Conventional Heating Methods
(with rising conventional fuel costs and sunk capital cost over 7-years)

Solar Collector Cost[1]		NATURAL GAS Present Value ($) [Payback(years)]			ELECTRICITY Present Value ($) [Payback(years)]			OIL Present Value ($) [Payback(years)]		
		9%	13%	17%	9%	13%	17%	9%	13%	17%
A	B	- 951.56 [>7]	-1232.46[>7]	-1458.71[>7]	-1005.63[>7]	-1275.63[>7]	-1493.21[>7]	5058.88[3]	3964.18[4]	3079.51[4]
$2774	N	1928.27 [5]	1291.62[5]	776.42[6]	1820.12[4]	1205.28[5]	707.42[6]	13949.12[1]	11684.98[2]	9852.86[2]
B	B	622.44 [5]	341.54[5]	115.28[7]	648.69[6]	367.91[7]	141.29[7]	6632.88[2]	5538.22[2]	4653.51[2]
$1200	N	3502.27 [2]	2865.62[3]	2350.46[3]	3394.12[2]	2779.28[2]	2281.43[3]	15523.12[1]	13258.98[1]	11426.86[1]
C	B	-2881.56 [>7]	-3162.46[>7]	-3388.71[>7]	-2935.63[>7]	-3205.61[>7]	-3432.21[>7]	3128.88[5]	2034.22[5]	1149.51[6]
$4704	N	- 1.73 [>7]	- 638.38[>7]	-1153.54[>7]	- 109.88[>7]	- 724.72[>7]	-1222.58[>7]	12019.12[3]	9754.98[3]	7922.86[3]
D	B	- 593.56 [>7]	- 874.46[>7]	-1100,71[>7]	647.63[>7]	- 917.63[>7]	-1135.21[>7]	54167.88[3]	4322.18[3]	3437.51[3]
$2416	N	2286.27 [4]	1649.62[5]	1134.46[5]	2178.12[4]	1563.28[5]	1065.42[6]	14307.12[1]	12042.98[2]	10210.86[2]

[1]See Table 13.

[N]No pool blanket - present value of fuel savings (increasing prices) less cost of solar collector

[B]with pool blanket - present value of fuel savings " " less cost of solar collector & pool cover(s) if conversion to solar heating took place. However, with the exception of oil heated pools, conversion to solar heating from natural gas or electricity was not cost-effective unless the least expensive solar collector system was used.

Use of a pool cover on conventionally heated pools reduces the stream of benefits of the solar conversion to the pool owner; as fuel costs (potential savings) are immediately reduced. When fuel rates remain fixed (Table 28) and a pool cover is used; it is not cost-effective for any conventional fuel with the exception of oil, to be converted to solar heating. As conventional fuel charges are increased (Table 29), only the least expensive solar collector conversion becomes cost-effective for natural gas and electricity. The benefits to the owners of oil heated pools remain positive and increase over time for all solar conversions.

Variation in the capital cost of the solar collector systems has an effect on the size of the present value for all conventional systems. The lower the capital cost of the systems (Tables 28 and 29), the larger the stream of benefits to the pool owner if conversion takes place.

4.2.4 *Comparison of Life Cycle Costs*

The present value of life cycle costs of two solar collector systems, and the three conventional heating systems were computed and presented in Table 30. The capital cost

Table 30

Comparison of Present Value[1] of Life Cycle Costs of Solar and Conventional Heating[2] when Pool Cover is Used

Heating Method	Solar A	Solar B	Natural Gas	Electricity	Oil
Capital Cost of Equipment (Year 0)	2774.00	1200.00	1000.00	700.00	1000.00
Cost of Pool Cover (Year 0)	250.00	250.00	250.00	250.00	250.00
(Year 4)	209.92	209.92	209.92	209.92	209.92
Operating Costs (Present Value) 1	0	0	288.00	310.26	1024.27
2	0	0	275.70	265.18	980.50
3	0	0	263.92	253.84	938.59
4	0	0	252.63	242.99	898.49
5	0	0	241.84	232.61	860.09
6	0	0	231.51	222.67	823.34
7	0	0	221.61	213.16	788.15
Present Value Cost	3233.92	1659.92	3235.13	2900.63	7773.35

[1]Discount rate of 17%; inflation rate of 12%

[2]Rising fuel costs.

of each system in year zero (0), plus the cost of two pool covers (average life 3.5 years) over the seven-year life of the systems and the operating costs each year were totalled and compared after seven years.

The present value of costs over the seven-year period (Table 30) indicates that the least expensive solar collector system is the best option for any pool owner deciding on an initial heating system (no conversion) for their pool. The pool owner would not choose an oil heating system as the cash flow of costs is extremely high. An oil heating system is not recommended by retailers at all.

An electrical heating system may appear inexpensive over the long term; however electricity rates have been frozen until 1984 and the increase projected in the analysis for 1985 onward may be conservative.

The projected fuel rate increases for natural gas are also conservative, therefore the total cost of a natural gas heated pool may be higher in the long run.

Solar collector A (Table 30) is not the most expensive system considered in this study; however, the life cycle cost of this system is within the range of the conventional heating systems.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Solar energy is a viable method for heating residential swimming pools in Winnipeg. The study revealed that several levels of solar pool heating technology currently exists in the Winnipeg market, including:

i) commercially manufactured systems -- primarily flat, plastic roof panels;

ii) homebuilt systems consisting of coils or rows of PVC piping;

iii) hybrid systems--a combination of conventional heating equipment and solar collectors;

iv) pool covers--used in combination with conventional or solar heating equipment, or alone.

Each level (i - iii) is a satisfactory method of heating a swimming pool and level iv is a conservation measure. Ultraviolet degradation affects most homebuilt systems and owners of hybrid systems are still affected by fuel utility rates. The review of the literature indicated that the number of privately owned, residential swimming pools is increasing across Canada, and Winnipeg is no exception. The necessity to heat swimming pools, together with increasing fuel costs; has resulted in a larger market for solar collectors for swimming pools. Improved manufacturing and installation techniques, warranties, and the assistance of the federal government have aided in the creation of a solar market in Canada.

Direct government involvement in solar heating of swimming pools has been minimal, but effective. The Program of Assistance to Solar Equipment Manufacturers (P.A.S.E.M.) has succeeded in supporting a manufacturing sector for solar pool heating. This has allowed the quality of the product to improve while market demand increased. The Purchase and Use of Solar Heating (P.U.S.H.) program, although purchasing solar collectors for swimming pools, is only directed to government and public buildings. Therefore this program does not directly affect the private pool owner.

The federal government, and some provincial government, have assisted in stimulating the solar market by eliminating or rebating sales taxes on solar heating equipment. With the exception of the Canadian Oil Substitution Program (C.O.S.P.) there have been no direct subsidies to assist the pool owner to convert to solar heating. Two research and demonstration projects on solar pool heating, under the auspices of the Manitoba-Canada Agreement on Development and Demonstration of Renewable Energy and Energy Conservation Technologies (M.C.A.D.D.R.E.E.C.T.), are now underway. These projects, however, were developed to municipal pools; while market demand is in the private sector.

Commercial solar collector systems are not manufactured in Manitoba. Most solar systems in use in Winnipeg have been manufactured in Ontario. The solar pool heater retailing sector is not extensive in Winnipeg. At the time of the study only seven pool companies in Winnipeg sold solar equipment. The small number of companies involved was due to: 1) little information reaching pool retailers on solar heating, and 2) the poor quality of equipment that was placed on the market a few years ago.

The pool owner population, from the survey, viewed solar heating favourably with respect to environmental impact, energy conservation and cost to run each season. Pool owners, as a group, viewed the capital cost of available solar systems negatively, as compared with conventional heating equipment. This perception prevented many pool owners from choosing solar heating for their pools. Some pool owners, while cognizant of the high capital cost of the system, recognized the risk of increasing fuel charges for conventional heating and chose solar energy. Factors such as energy conservation while minor, also influenced the move to solar heating. Credibility of solar energy advocates, ie. reputability and reliability of solar firms prevented many pool owners from choosing solar heating.

Potential restrictive legislation on: 1) the use of conventional heating equipment or fuels and, 2) the use of solar heating only for swimming pools, should not be implemented. Some pool owners, due to site and pool orientation, would be unable to utilize solar heating and must rely on conventional heating methods. Aside from enforcement difficulties by the government, the survey results showed that the pool owner reaction to these measures would not be favourable. Pool owners are more interested in conservation measures that can be applied by themselves directly and therefore a large percentage (85%) used a pool cover.

Initial date of pool use was approximately the same for solar and conventionally heated pools. Gas heated pools, while remaining open longer in the fall than solar heated pools, did not remain in use as long as hybrid system heated pools. These results would support some pool retailers' contention, that a hybrid system would be most effective for extending the season. Solar heated pools were maintained at a higher average temperature than conventional or hybrid systems. This is conclusively linked to the elimination of fuel charges associated with conventional equipment.

The financial analysis indicated that use of a pool cover resulted in immediate benefits to the owners of conventionally heated pools. The payback period is less than one year for all conventional heating methods.

The more expensive the seasonal pool heating fuel bill, the larger the benefits resulting from the conversion to solar heating. Owners of oil heated pools would benefit immediately from the conversion to solar heating, even with the most expensive solar collector. The Canadian Oil Substitution Program (C.O.S.P.) grant would assist these pool owners to offset the capital cost of conversion, but appears to be unnecessary when one considers the positive benefits occuring within one year of use.

For initial purchases of a pool heater, life-cycle costs revealed that solar heating, using the least expensive collector system available in Winnipeg, is cost-effective with all conventional heating methods.

5.2 Recommendations

5.2.1 *Introduction*

Recommendations arising from this study may be directed to three sectors: (1) government, (2) industry, and (3) consumers.

5.2.2 *Government*

I recommend that:

1) A demonstration program involving solar heating of residential swimming pools be established under the Manitoba-Canada Agreement on Development and Demonstration of Renewable Energy and Energy Conservation Technologies, since recent research and demonstration projects have been exclusively for government and municipal installations.

2) An information package be prepared to educate consumers to the advantages of pool energy conservation and the relative merits of the various pool heater types in response to pool owners' expressed needs for this information.

5.2.3 *Industry*

I recommend that:

1) The manufacturing sector concentrate on the production and sale of less expensive, more efficient and effective solar pool heaters because of the necessity of reaching a consumer concerned with the high capital cost and technical quality of solar heating equipment.

2) The solar manufacturing industry take advantage of available government services and programs such as P.U.S.H. to assist in the production, testing and sale of solar collectors; in order to improve their product.

3) Due to an information gap between solar equipment manufacturers and some pool heating equipment retailers, manufacturers of solar heating equipment develop a more extensive product promotion and include information on warranties, efficiencies and cost-effectiveness, in addition to providing seminars on installation and repairs.

4) The pool retailing sector recommends to consumers the use of a pool cover for any swimming pool as a necessary energy conservation measure, because it has been demonstrated that the cover is cost-effective with a payback period of less than one year.

5.2.4 *Consumer*

I recommend that:

1) For any heating method, a pool cover is to be used to maintain pool temperature and conserve energy.

2) Pool owners should familiarize themselves with all heating methods, associated costs and technical quality prior to pool or heater purchase in order to make an informed choice of heating method.

3) In order for owners of gas and electrically heated pools to receive benefits from conversion to solar heating at present and projected energy costs; the least expensive and technically efficient solar collectors should be purchased.

4) Due to high seasonal heating costs and the availability of the COSP grant; owners of oil heated pools should convert to solar heating.

5) As fuel costs increase or solar equipment decreases in real cost, pool owners should seriously consider conversion to solar heating.

6) As solar heating for swimming pools is cost-effective with conventional equipment in new installations, this method should be considered by all new pool owners providing the orientation of the pool or house is correct.

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APPENDIX A

QUESTIONNAIRE AND COVER LETTER

THE UNIVERSITY OF MANITOBA

NATURAL RESOURCES INSTITUTE

Winnipeg, Manitoba
Canada R3T 2N2

(204) 474-8373

July 13, 1981

Dear Swimming Pool Owner:

You have been selected to assist in a research study on energy use by swimming pool owners in Manitoba. The purpose of this study is to obtain swimming pool owners' attitudes toward solar energy, as a method of pool heating. As well, the study intends to determine the amount of energy consumed by conventional pool heating methods in a randomly selected sample of gas, electric and propane heated pools. The information obtained will be used as a guideline for efficient energy use in swimming pools in Manitoba.

I have attached a questionnaire which I am asking you to complete. It is essential to the study that both solar and non-solar swimming pool owners complete the questionnaire. The questionnaire has been designed so that it requires no more than fifteen minutes of your time to complete. In most cases, you can answer with a simple check mark __/__.

This questionnaire was dropped off at your residence on the date indicated above. I will return and pick up the completed questionnaire in the envelope provided in one week's time. If you wish to have the questionnaire picked up before this date, or you wish to arrange a specific time, please telephone (204) These arrangements are due to the recent postal strike, which have prevented this questionnaire from being delivered in the mail.

Please be assured that all responses will be held in the strictest confidence. If you have any questions, please do not hesitate to call me at the above telephone numbers. You will receive an advance copy of the findings of this study at the completion of the research in late August.

Thank you for the courtesy of your assistance.

Yours sincerely,

Meredith L. Lamb

1981 SWIMMING POOL ENERGY SURVEY

Please check ✓ the most appropriate answer.

1. What do you use to heat your swimming pool?

___ gas	___ electricity	___ unheated
___ solar energy	___ oil	___ other ___________

If you have or are presently using solar energy, please answer question 2. Others, please skip to question 3.

2. Please check as many of the following criteria which led you to select solar energy to heat your pool?

___ no annual fuel costs

___ little or no annual maintenance costs

___ pool or house was oriented correctly to take advantage of the sun

___ no provincial sales tax on solar heating equipment

___ environmental considerations

___ wish to practice energy conservation

___ anticipation of fuel cost increases

___ interested in the technological aspects of it

___ pool retailer sells product

___ pool retailer sells and maintains product

___ pool retailer recommends product

___ lengthens pool season

___ other (Please Specify) ______________________________

Now would you please skip to question 4.

3. Please check as many of the considerations below which led you to reject solar energy as a method of heating your pool?

___ initial cost of purchase and installation

___ cost of maintaining solar collectors

___ amount of difficulty involved in discontinuing dependence on solar and changing to another energy source if the solar energy system is adopted and becomes ineffective

___ credibility of advocates of solar energy; dependibility and reliability of solar firms

___ inconvenient or difficult to install as compared to conventional heating systems

___ possibility of increased property taxes following incorporation of solar heating system

___ aesthetic considerations eg. attractiveness and appearance of collectors

___ your pool is not situated (oriented) correctly and/or shaded by trees to take advantage of the sun

___ your pool heating fuel was initially heating your house

___ pool is not large enough to warrant heating

___ your pool retailer/installer does not sell solar collecting equipment

___ your pool retailer sells solar collecting equipment but does not recommend it for your pool

___ your pool retailer sells solar collecting equipment, but does not provide service or maintenance of the installation

___ your pool retailer sells solar collecting equipment recommends it for your pool, but you wished to stay with more conventional equipment

___ other (please specify) ____

____

4. Concerning each of the characteristics listed below, please try to estimate your feelings (on a scale of 1 to 5) about each of the fuels.

	Very Favorable				Very Unfavorable	Don't Know
___ cost to purchase & install heating unit:						
gas	1	2	3	4	5	0
electricity	1	2	3	4	5	0
solar energy	1	2	3	4	5	0
___ cost to run heating unit each season						
gas	1	2	3	4	5	0
electricity	1	2	3	4	5	0
solar energy	1	2	3	4	5	0
___ aesthetic consideration of heating unit						
gas	1	2	3	4	5	0
electricity	1	2	3	4	5	0
solar energy	1	2	3	4	5	0
___ environmental impact						
gas	1	2	3	4	5	0
electricity	1	2	3	4	5	0
solar energy	1	2	3	4	5	0
___ energy conservation characteristics						
gas	1	2	3	4	5	0
electricity	1	2	3	4	5	0
solar energy	1	2	3	4	5	0

5. In view of rising energy costs and shortages, if the heating of swimming pools becomes a significant factor, what would be your reaction to the following. Please circle your opinion:
1 = strongly in favor 2 = in favor 3 = no opinion 4 = against
5 = strongly against

___	require by law or ordinance, solar water heating of new pools	1	2	3	4	5
___	restricting use of fossil fueled pool heaters	1	2	3	4	5
___	legislation to subsidize the purchase of solar pool heaters	1	2	3	4	5
___	surcharges on conventional energy consumed by outdoor pool heaters	1	2	3	4	5
___	voluntary conservation of energy to heat outdoor pools	1	2	3	4	5
___	information made available on conserving energy in heating swimming pools	1	2	3	4	5
___	legislation permitting the heating of swimming pools by solar energy only	1	2	3	4	5

All respondents please answer these questions.

6. What is the size of your pool?

Volume: ________________ Surface Area: ________________

OR

Dimensions: ________________________

7. Is your pool: (a) in ground ___ above ground ___

(b) vinyl lined ___ concrete lined ___

(c) indoor ____ outdoor ____

8. Do you use a solar blanket? ___ Yes ___ No

9. What was the length of your 1980 pool season?

First Day ________________ Last Day ________________

10. At what temperature do you maintain your pool? ________________

11. How many people use the pool on a regular basis:

___ 1 to 2 ___ 6 to 10

___ 3 to 5 ___ over 10

Solar energy consumers please skip question 12

12. What was the estimated cost to heat your pool for your 1980 pool season? _____

What was the energy consumption to heat your pool for your 1980 pool season?

________ Kwh of electricity

________ mcf of gas

________ gallons oil

Can you provide your energy consumption records for your 1980 pool season? YES NO

If no, may I have your permission to approach your utility for this information? YES NO

Address ____

Signature ____

Utility ____

* * * * * * *

APPENDIX B

PROPERTY TAX EXEMPTIONS

Manitoba Bill 87, 1977: Property Tax Exemptions for Solar Heating Equipment

PART II

TAX REDUCTIONS FOR SOLAR HEATING

Special assessment.

9 Where the principal residence of a taxpayer is equipped with solar heating equipment used for heating the principal residence, the assessor of the municipality in which the principal residence is situated shall, in addition to making the normal assessment in respect of the principal residence, make a special assessment of the principal residence which shall be the amount that, in the opinion of the assessor, the assessment of the residence would be if the house was not equipped with solar heating equipment but was heated solely with the type of heating equipment that is most usual in the neighborhood of the municipality in which the principal residence is situated.

Note of special assessment on assessment roll.

10 The assessor of the municipality shall make a note on the assessment roll of each principal residence in respect of which he has made a special assessment under section 9 indicating the amount of the special assessment.

Levying of tax against special assessment.

11 Where the special assessment of the principal residence of a taxpayer is less than the normal assessment for the principal residence, the municipality in which the principal residence is situated shall assess and levy taxes on the principal residence on the basis of the special assessment and shall, on or before November 30 in each year, notify the minister of the difference between the taxes assessed and levied in that year against principal residences in the municipality on the basis of special assessments and the amount of taxes that would have been assessed and levied in that year against those principal residences if taxes had been assessed and levied against them on the basis of the normal assessment.

Compensation by government.

12 Where the minister receives notice under section 11 of the difference between taxes assessed and levied by a municipality in a year against the principal residences on the basis of special assessments and the amount of taxes that would have been assessed and levied by the municipality in that year against the principal residences if the taxes had been assessed and levied against them on the basis of normal assessment, he shall request the Minister of Finance, to pay, and the Minister of Finance shall pay, the amount of that difference to the municipality.

From Shillington (1979)

APPENDIX C

MANITOBA - CANADA AGREEMENT ON THE DEVELOPMENT AND DEMONSTRATION OF RENEWABLE ENERGY AND ENERGY CONSERVATION TECHNOLOGIES

MANITOBA-CANADA AGREEMENT ON THE DEVELOPMENT AND DEMONSTRATION OF RENEWABLE ENERGY AND ENERGY CONSERVATION TECHNOLOGIES

Introduction:

The availability of secure and affordable sources of energy is a subject of national concern.

To this end the Government of Manitoba and the Government of Canada have entered into a demonstration project agreement which was signed 9 May 1980, and will run until 31 March 1984.

Objectives:

The objectives of this program are three-fold.

- To develop and demonstrate promising new technologies which, when widely adopted, will exploit renewable resources, conserve energy or make its use more efficient.
- To encourage employment in new or existing energy-related industries.
- To develop broad public awareness of the potential of renewable energy and conservation technology.

Funding:

The program is co-funded by the Government of Canada and the Government of Manitoba, and has a total budget of $18 million.

Projects approved under the agreement will be cost-shared by the applicant, Government of Canada and the Government of Manitoba.

Who Can Apply?

Proposals for demonstrations are welcome from:

- industry
- consultants
- Government Departments and agencies
- Municipalities
- voluntary and non-profit organizations
- individuals
- associations
- colleges and universities

Types of Suitable Projects:

Energy conservation projects suitable for funding under the program, must demonstrate technologies which will result in significant energy savings. These demonstrations may involve reductions in energy requirements for space heating, software for energy management, the efficient use of waste and low grade heat, or reductions in fuel requirements in transportation.

Acceptable projects in the area of renewable energy resources include technologies which demonstrate and develop low-head hydro electric potential, active and passive solar energy, wind, fuel alcohol, peat, wood and other biomass resources.

Two types of technologies may be used in the projects:

a) economic, technically proven, commercially available technologies which are new to the Manitoba circumstance and require demonstrations to gain widespread adoption and;

b) feasible technologies which are in the final stages of development and require demonstrations to establish their potential for energy savings and commercial success in the Province.

How to Apply:

Applications can be initiated by submitting a detailed proposal to the Manitoba Department of Energy and Mines. Proposals should be concise and organized as follows:

a) Technical plan:
- project objectives in relation to program criteria;
- detailed work program including costs and requested funding;
- resumes of project personnel

b) Cost estimate:
- a detailed cost breakdown for the entire project;
- a cost-benefit or pay back analysis;
- sources of funds

c) Information transfer plan:
- identification of target audiences;
- schedules for production, numbers, distribution;
- cost estimate

All proposals and requests for further information should be directed to:

Director
Conservation & Renewable Energy Branch
Department of Energy & Mines
200 - 500 Portage Avenue
Winnipeg, Manitoba R3C 0V8

MANITOBA
DEPARTMENT OF ENERGY AND MINES

MANITOBA - CANADA

ENERGY DEMONSTRATION

PROJECT # 1

Solar Heating for Winkler Swimming Pool

A simple, easy-to-maintain and inexpensive solar hot water heater in the Town of Winkler has become the first energy conservation demonstration project outside the City of Winnipeg to be funded under the Manitoba-Canada Energy Agreement.

The low-cost solar heater consists of 5,000 feet of 1-inch black plastic PVS pipe coiled flat on top of the south-facing roof of the changing area building. Cool water is drawn from the deep end of the 175,000-gallon outdoor swimming pool and circulated slowly through the pipe before being returned through the pool's normal filtering system. Town officials report water temperatures are raised from about 22° C (75° F) to about 40° C (105° F) under normal operating conditions.

Because the pool is drained in winter, no expensive systems are required to protect the unit against freezing. Only minor alterations in the pool's normal filtering system were necessary to incorporate the solar heater. The simplicity of the system makes it extremely economic to operate.

Because of its efficiency, Winkler Town officials suggest that total annual water heating costs could be reduced by 30 to 35 per cent. Construction costs totalled $2,250, and annual energy savings indicate a payback period of about three years.

The Manitoba-Canada Energy Agreement is aimed at developing and demonstrating promising new technologies which, when widely adopted, will exploit renewable resources, conserve energy, or make its use more efficient, and to develop public awareness of the potential of renewable energy and conservation technologies.

Under the Agreement in this case, Manitoba and Canada each contributed one-third of the total capital expenditure, with Winkler contributing the balance.

For further information on the Winkler solar hot water heater, contact:

Arnold Kuhl, Town Clerk
Town of Winkler
Winkler, Manitoba
204—325-9524

Energy Information Centre
Department of Energy and Mines
500 Portage Avenue
Winnipeg, Manitoba
R3C 0E9
944-4154 or
Toll-Free: 1—800—282-8069

MANITOBA
DEPARTMENT OF ENERGY AND MINES
Honourable D.W. Craik, Minister

Energy, Mines and Resources Canada | Energie, Mines et Ressources Canada
Honourable M. Lalonde, Minister

Solar Heated Swimming Pool

Deloraine, Manitoba

Deloraine Community Swimming Pool Inc. has installed an active solar system to heat the community owned outdoor swimming pool. The Manitoba Department of Energy and Mines, and Energy, Mines and Resources Canada have contributed a $35,000 grant for the construction and demonstration of the active solar unit under the terms of the Manitoba-Canada Energy Agreement.

Designed to serve a community of between 1,000 to 5,000 residents, the Deloraine community pool and facility showers are heated by the active solar system. The outdoor mini-olympic sized pool operates from May through September, but has been designed to accommodate total enclosure for year-round use.

A total of 48 solar collectors have been linked in four rows of twelve, spanning an area of 24 feet by 100 feet, tilted on a 35 degree angle. The system is elevated from four feet to 20 feet off the ground. Located on north side of the pool, the collectors face south to gain the maximum solar benefit.

Pool operation depends on a system of temperature control and solar storage. When the pool water reaches its designated temperature after sufficient solar heat collection, water flowing through the collectors is reduced and diverted through a water-to-water heat exchanger for heating the shower water. Any excess hot water is stored in a 405-gallon, stone-lined tank until required by the showers, which are equipped with time delay faucets and temperature controls.

The total cost of installing the active solar unit was $60,000. A similar sized pool to Deloraine's would cost about $6,800 a year to heat using fuel-fired equipment for normal operation. As the Deloraine Pool has no boiler, there are no additional fuel costs.

The efficiency of the system will be monitored by engineering consultants who will evaluate the performance of the solar system.

Print-out temperature monitoring controls have been installed in the system, providing four daily readings. Weekly and monthly temperature profiles will be constructed during the first year of operation. It is expected that pool temperature will fluctuate slightly.

The corresponding ambient air temperature will be recorded, to evaluate the system performance against varying climatological conditions. Also being evaluated is the cost-effectiveness of integrating the domestic hot water (showers) with the solar heated pool system, and the effectiveness of pool covers.

For further information on the Deloraine Solar Heated Swimming Pool, please contact:

Energy Information Centre
500 Portage Avenue
Winnipeg, Manitoba.
R3C 0V8

944-4154

or

Toll-Free: 1-800-282-8069

Mr. Charles McMachen, Chairman
Deloraine Community Swimming Pool Inc.
Deloraine, Manitoba.
R0M 0M0

1-747-2733

APPENDIX D

RETAIL SALES TAX EXEMPTIONS

Manitoba Government Department of Finance

INFORMATION SERVICE

RETAIL SALES TAX BRANCH, NORQUAY BLDG., WINNIPEG, MANITOBA

Circular No. 80-37

Manitoba Retail Sales Tax Changes

This circular summarizes the retail sales tax changes proposed by the Minister of Finance in his Budget Address of May 13th.

NEW EXEMPTIONS FOR THE FOLLOWING ITEMS EFFECTIVE MIDNIGHT MAY 13TH, 1980.

- energy-saving devices as specified
- patterns for sewing clothing at home
- children's safety seats approved for use in motor vehicles
- first aid kits, sterilized bandages and dressings, and medical thermometers of the household type
- smoke alarms of the self-contained type designed for household use
- safety items of special design worn by workers
- ambulances and related equipment carried in the ambulance
- exemption to farmers for water systems, field drainage tile and ventilation fans for agricultural use
- exemption to licensed fur trappers for traps and related items

OTHER CHANGES

- vendor commission for collecting the tax increases from 5% to 10% on the first $200.00 tax, commencing with the tax returns to be filed in July, 1980.
- refunding period between purchase and sale of aircraft extended from 30 days to six months, applicable to aircraft purchases made on or after May 14th, 1980.
- registration number to be used for exemption to officials of the Foreign Diplomatic Corps.

PLEASE RETAIN FOR FUTURE REFERENCE

The following information is intended to serve as a general guideline for vendors to implement these changes. Further details, as they become available, may be obtained by inquiring directly at the Retail Sales Tax Branch, 115 Norquay Building, Winnipeg R3C 0V8, telephone Winnipeg 943-3561, Manitoba Toll Free 1-800-542-8925.

ENERGY-SAVING DEVICES - The exemption includes: storm windows and storm doors; heat pumps for heating buildings; units for recovering heat from exhaust water, air or gases; solar cells used for charging batteries; solar furnaces, panels and tubes specially designed to collect and convert solar energy into heat for use in a solar heating system; windmills and wind-powered generators for producing mechanical or electrical energy, including related equipment such as pumps and generators specially designed for that purpose; timer-controlled thermostats; timer controls for electrical lighting systems, including timer controls bought for use with vehicle plug-in heaters; wood-burning stoves and wood-burning furnaces, but not including fireplaces; wind deflectors for trucks.

PATTERNS - Exemption is for the type of patterns ordinarily bought for sewing clothing at home. There is no size restriction on the exemption.

CHILDREN'S SAFETY SEATS - This exemption is intended for children's safety seats that are specially designed for use in motor vehicles and meet, or exceed, the safety standards set by government regulation.

FIRST-AID KITS, ETC. - This exemption includes medical thermometers of the household type, prepared sterilized dressings, pads and bandages (e.g. band-aids) and first aid kits containing these items. Medical tape and cotton packaged and sold specially for use in the treatment of wounds are included in this exemption.

SMOKE ALARMS - Exemption is for self-contained smoke detectors of the type ordinarily bought for the home. The exemption does not extend to devices purchased for the purpose of installation as part of an alarm or warning system.

SAFETY ITEMS FOR WORKERS - This exemption is for items that are worn by workers in industry and are specially designed to prevent serious bodily injury. Some examples of tax exempt items are safety glasses and steel-mesh gloves worn by production workers, helmets for policemen, ear protectors worn by airport workers. The exemption does not apply to such items as: clothing in general, coveralls, uniforms, equipment for recreational or sports use.

APPENDIX E

CANADA OIL SUBSTITUTION PROGRAM

May 25/81

CANADA OIL SUBSTITUTION PROGRAM
(COSP)

Eligibility of Solar-Heating Systems

The following criteria define the conditions under which solar-heating systems and materials are eligible under COSP. They are subject to revision from time to time. It should be noted that installation of solar-heating equipment is subject to local regulation in many parts of the country.

Types of Eligible Systems

Active solar-heating systems designed to provide domestic hot water (DHW), and/or space heat, to provide service hot water or to heat swimming pools are eligible provided they satisfy the following conditions. Thermosyphoning DHW systems are also eligible. Passive solar-heating systems are not eligible.

Qualification of System

Solar-heating systems must either:

- be certified to a relevant Canadian Standard[1], or
- be a packaged DHW system or swimming-pool heater accepted by Energy, Mines and Resources (EMR), or
- be designed by an individual or organization accepted by EMR, using solar collectors certified to a relevant Canadian Standard[1] or accepted by EMR.

1 CSA Standards for solar-heating panels and for solar DHW systems are in preparation.

Qualification of Installation

At least one member of the installation team shall have successfully completed the Canadian Solar Industries Association (CSIA) course on installation of solar-heating systems, or an equivalent accepted by EMR, and be so registered with EMR. Following installation, systems may be inspected by, or on behalf of, EMR.

Displacement of Oil

Solar-heating systems are required to displace at least one-third of the oil used for the functions they discharge. The guidelines given below shall be used to prove that this criterion is satisfied.

Guidelines

a) Space Heating Systems

(i) The collector area must be equal to at least 20 per cent of heated floor area.

(ii) The storage system must contain a minimum of:

EITHER 0.3 cubic metre of water per square metre of collector area

OR 1 cubic metre of stone aggregate per square metre of collector area

OR 3 Megajoules of heat per square metre of collector area for other forms of storage.

(iii) The building into which the system is to be installed must have insulation of at least RSI 2 in the walls and RSI 3.5 in the ceiling.

b) Domestic Hot Water Heating Systems

(i) The collector area must be at least 0.85 square metre for each full-time occupant.

(ii) Solar storage volume must be at least 60 litres per full time occupant.

c) Commercial Service Water Heating

(i) The collector area must be at least 0.85 square metre for each 100 litres of heated water consumed each day.

(ii) The storage volume must be at least one day's average hot water usage.

d) Outdoor Pool Heating

(i) The collector area must be at least one-third of the surface area of the pool for glazed collectors and one-half of the surface area for unglazed collectors if a solar blanket is used.

(ii) The collector area must be at least one-half of the surface area of the pool for glazed collectors and three-quarters of the surface area for unglazed collectors if a solar blanket is not used.

(iii) The oil heater must be permanently disabled.

e) Indoor Pool Heating

(i) The collector area must be at least 25 per cent of the surface area of the pool and of a type such that efficiency does not drop to zero until the difference between pool temperature and ambient air temperature exceeds 40°C at insolation rates of 600 watts per square metre.

f) In all systems collectors must be mounted as follows:

(i) Within 45° of due south;

(ii) At tilt angles of:

- between 35° and 80° for space heating;
- between 20° and 65° for service hot water and indoor pool heating;
- between 5° and 50° for outdoor pool heating.

(iii) So as to be totally unshaded for the period of 2 hours before solar noon to two hours after solar noon and for at least 75 per cent of the remaining hours of sunlight.

APPENDIX F

SAMPLE CALCULATIONS FINANCIAL ANALYSIS

ENERGY PRICES FOR FINANCIAL ANALYSES

Year	Natural Gas Fixed	Natural Gas Rising[1]	Electricity Fixed	Electricity Rising[2]	Oil Fixed	Oil Rising[3]
	$/mcf		$/kWh		$/gal	
0	3.61	3.61	0.0253	0.0253	1.31	1.31
1	3.61	4.47	0.0253	0.0253	1.31	1.47
2	3.61	5.01	0.0253	0.0253	1.31	1.64
3	3.61	5.61	0.0253	0.0253	1.31	1.84
4	3.61	6.28	0.0253	0.3170	1.31	2.06
5	3.61	7.03	0.0253	0.0355	1.31	2.31
6	3.61	7.87	0.0253	0.0398	1.31	2.59
7	3.61	8.82	0.0253	0.0445	1.31	2.90

[1] Includes $.15 mcf Federal tax es. (N.E.P.) plus 12% operating cost.

[2] Frozen until 1984, then rising at 12%/year.

[3] Increasing at 12%/year.

POOL COVER COSTS DISCOUNTED

Discounted Rate	Fixed Prices	Rising Prices
9%	$250 + 250(1 + .09)^{-4} = 427.10$	$250+[250(1+.12)^4/(1+.09)^4] = 528.68$
13%	$250 + 250(1 +.13)^{-4} = 403.32$	$250+[250(1+.12)^4/(1.+.13)^4] = 491.26$
17%	$250 + 250(1 +.17)^{-4} = 383.41$	$250+[250(1+.12)^4/(1+.17)^4] = 459.92$

SAMPLE CALCULATIONS
OF COST OF CONVERSION TO SOLAR HEATING
FROM NATURAL GAS (RISING COSTS WITH POOL COVER)

Year	Cash Out	Total Cost with Gas	Total Cost with Solar	NCF	NCF Discounted 9%	CDCF
0	-(2774 + 250)	-	-	-	-	-
1		336.97	0	336.97	309.15	-2714.85
2		377.41	0	377.41	317.66	-2397.19
3		422.69	0	422.69	326.39	-2070.80
4	-(278.68)	473.41	0	473.41	335.38	-2014.10
5		530.23	0	530.23	344.61	-1669.49
6		593.86	0	593.86	354.09	-1315.48
7		665.12	0	665.12	363.84	- 951.56
					2351.12	

Sample Calculations of Cost of Conversion to Solar Heating from Natural Gas (Rising Costs with Pool Cover) (Continued)

Cash Out	Year	NCF @ 13%	CDCF	Cash Out	NCF @ 17%	CDCF
-(2774 & 250)	0	-	-	-(2774 & 250)	-	-
	1	298.20	-2725.80		288.00	-2736.00
	2	295.56	-2430.24		275.70	-2460.30
	3	292.95	-2137.29		263.92	-2196.38
- (241.27)	4	290.35	-2088.21	-(209.92)	252.63	-2153.67
	5	287.79	-1800.42		241.84	-1911.83
	6	285.24	-1515.18		231.51	-1680.32
	7	282.72	-1232.46		221.61	-1458.71
		2032.81			1775.21	

SAMPLE CALCULATIONS
OF COST OF CONVERSION TO SOLAR HEATING
FROM NATURAL GAS (RISING COSTS WITHOUT POOL COVER)

Year	Cash Out	Total Cost with Gas	Total Cost with Solar	NCF	NCF Discounted 9%	CDCF
0	2774	-	-	-	-	-
1		673.94	0	673.94	618.15	-2155.85
2		754.82	0	754.82	635.32	-1520.53
3		854.38	0	845.38	652.78	- 867.75
4		473.41	0	473.41	670.76	- 196.99
5		1060.46	0	1060.46	689.22	492.23
6		1187.72	0	1187.72	708.18	1200.41
7		1330.24	0	1330.24	727.68	1928.09
					4702.24	

Sample Calculations of Cost of Conversion to Solar Heating from Natural Gas (Rising Costs without pool cover) (continued)

Cash Out	Year	NCF @ 13%	CDCF	Cash Out	NCF @ 17%	CDCF
-(2774)	0	-	-	-(2774)	-	-
	1	596.40	-2177.60		576.00	-2198.00
	2	591.12	-1586.48		551.40	-1646.60
	3	585.90	-1000.58		527.84	-1118.76
	4	580.70	- 419.88		505.26	- 613.50
	5	575.58	155.70		483.68	- 129.82
	6	570.48	726.18		463.02	333.20
	7	565.44	1291.62		443.22	776.42
		4065.62			3550.42	

SAMPLE CALCULATIONS
OF COST OF CONVERSION TO SOLAR HEATING
FROM NATURAL GAS (FIXED COSTS WITHOUT POOL COVER)

Year	Cash Out	Total Cost with Gas	Total Cost with Solar	NCF	NCF Discounted 9%	CDCF
0	(2774)	-	-	-	-	-
1		545.00		545.00	500.00	-2774.00
2		545.00		545.00	458.72	-1815.28
3		545.00		545.00	420.84	-1394.44
4		545.00		545.00	386.09	-1008.35
5		545.00		545.00	354.21	- 654.14
6		545.00		545.00	324.96	- 329.18
7		545.00		545.00	298.13	- 31.05
					2742.95	

Sample Calculations of Cost of Conversion to Solar Heating from Natural Gas (Fixed costs without pool cover) (continued)

Cash Out	Year	NCF @ 13%	CDCF	Cash Out	NCF @ 17%	CDCF
-(2774)	0	-	-	-(2774)	-	-
	1	482.30	-2291.70		465.81	-2308.19
	2	426.81	-1864.89		398.13	-1910.06
	3	377.71	-1487.18		340.28	-1569.78
	4	334.26	-1152.92		290.84	-1278.94
	5	295.80	- 857.12		248.58	-1030.36
	6	261.77	- 595.35		212.46	- 817.90
	7	231.66	- 363.69		181.59	- 636.31
		2410.31			2137.69	

SAMPLE CALCULATIONS
OF COST OF CONVERSION TO SOLAR HEATING
FROM NATURAL GAS FIXED COSTS WITH POOL COVER

Year	Cash Out	Total Cost with Gas	Total Cost with Solar	NCF	NCF Discounted 9%	CDCF
0	(2774 + 250)	-	-	-	-	-
1		272.50	0	272.50	250.00	-2774.00
2		272.50	0	272.50	229.36	-2544.64
3		272.50	0	272.50	210.42	-2334.22
4	(177.10)	272.50	0	272.50	193.05	-2318.27
5		272.50	0	272.50	177.11	-2141.16
6		272.50	0	272.50	162.48	-1978.68
7		272.50	0	272.50	149.07	-1829.61
					1371.48	

Sample Calculations of Cost of Conversion to Solar Heating from Natural Gas (Fixed costs with Pool Cover) (Continued)

Cash Out	Year	NCF @ 13%	CDCF	Cash Out	NCF @ 17%	CDCF
-(2774 & 250)	0	-	-	-(2774 & 250)	-	-
	1	241.15	-2782.85		232.91	-2791.09
	2	213.41	-2569.44		199.07	-2592.02
	3	188.86	-2380.58		170.28	-2421.74
-(153.32)	4	167.13	-2366.77	-(133.41)	145.42	-2409.73
	5	147.90	-2218.87		124.29	-2285.44
	6	130.89	-2087.98		106.23	-2179.21
	7	115.83	-1972.15		90.59	-2088.62
		1205.16			1068.85	

SAMPLE CALCULATIONS
ANALYSIS OF THE COST OF USING A POOL COVER ONLY WITH CONVENTIONAL HEATING

Year	Cash Out	Total Fuel Cost without Pool Cover	Total Fuel Cost with Pool Cover	Net Cash Flow	NCF Discounted @ 9%	Cumulative Discounted Cash Flow
0	$(250.00)	-	-	$(250.00)	$(250.00)	$(250.00)
1		673.94	336.97	336.97	309.15	59.15
2		754.82	377.41	377.41	317.66	376.81
3		845.38	422.69	422.69	326.39	703.20
4	(278.68)	473.41	473.41	473.41	335.38	759.90
5		1060.46	530.23	530.23	344.61	1104.51
6		1187.72	593.86	593.86	354.09	1458.63
7		1330.24	665.12	665.12	363.84	1822.44
					2351.12	

Sample Calculations Analysis of the Cost of Using a Pool Cover Only with Conventional Heating (Continued)

Cash Out	Year	NCF @ 13%	CDCF	Cash Out	NCF @ 17%	CDCF
$(250.00)	0	-	-	$(250.00)	-	-
	1	298.20	48.20		288.00	38.00
	2	295.56	343.76		275.70	313.70
	3	292.95	636.71		263.92	577.62
(241.26)	4	290.35	685.85	(209.92)	252.63	620.33
	5	287.79	973.64		241.84	862.17
	6	285.24	1258.88		231.51	1093.68
	7	282.72	1541.60		221.61	1315.29
		2032.81			1775.21	