Final Report

Survey of Active Solar Thermal Collectors, Industry and Markets in Canada

Report presented to:
Natural Resources Canada
August 2005

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Natural Resources Canada
Canada

Final Report

Survey of Active Solar Thermal Collectors, Industry and Markets in Canada

Science Applications International Corporation
(SAIC Canada)
Renewable Energy and Climate Change Program

Report presented to:
Eugène Omboli
Natural Resources Canada

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EXECUTIVE SUMMARY

A detailed survey of the active solar thermal (ST) industry in Canada was undertaken in the period from January through March, 2005. The primary focus of the survey was to determine the size of the Canadian solar thermal industry and market. This data was then used to derive thermal energy output and avoided greenhouse gas (GHG) emissions from solar thermal systems. As the first survey of this type in over a decade, the questionnaire was distributed widely, to 268 recipients across Canada. The low participation rate by small retail operations was compensated by participation of the majority of larger businesses. This resulted in obtaining reliable data for analysis, and the results provide a solid base of information on which future surveys can build.

The survey reveals annual sales of 24.2, 26.4 and 37.5 MW_{TH} in 2002, 2003 and 2004, respectively. Adding these new installations to the approximately 170 MW_{TH} of operating systems at the end of 2001 yields a total of 258 MW_{TH} of operating solar thermal installations in Canada. This represents over 50% growth in the operating base during the three-year survey period.

As can be seen from Figure 1, sales of all collector types grew substantially during the three-year survey period, with 2004 being an excellent year for the industry, with total sales growth of over 40%, in terms of both area and value. Further to this growth, the survey respondents are expecting 20% growth in both 2005 and 2006. Approximately 10% of all sales were exported during 2002 - 2004.

Figure 1 also indicates that while unglazed liquid collectors (97% of which are used for swimming pool heating) constitute the majority of the collector area sold in Canada, the three major types of solar collectors (combining evacuated with liquid glazed as a single type) all hold roughly one third of the market, when measured on a revenue basis.

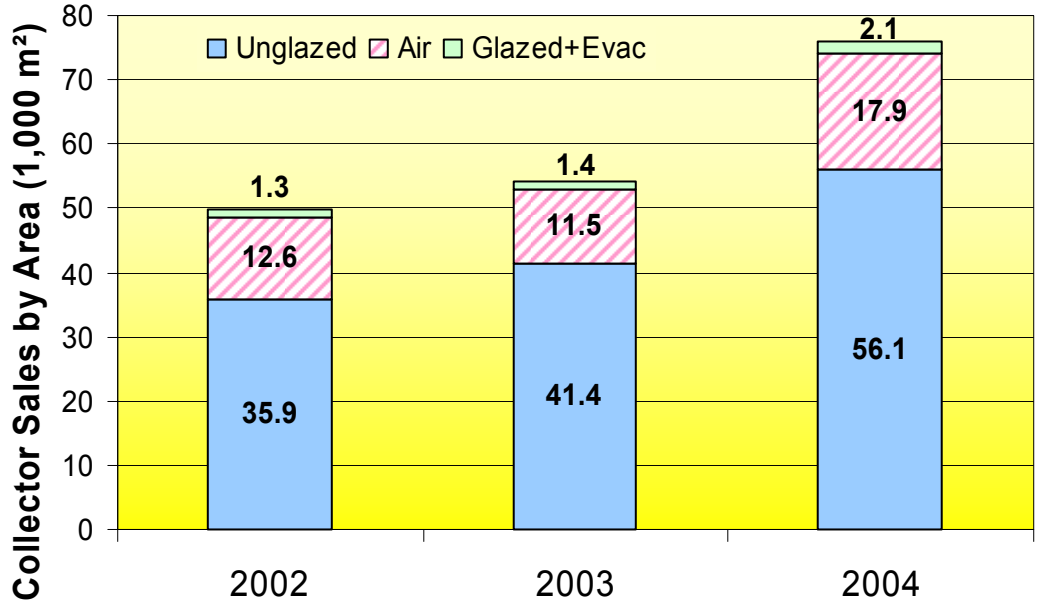
The survey confirmed that the markets and applications for different collector types are distinct:

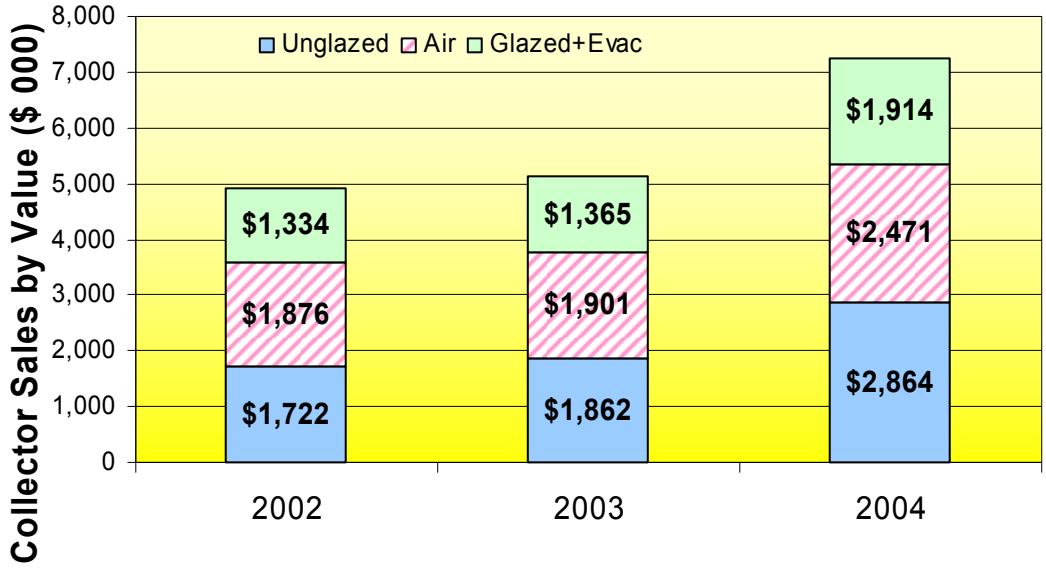
- Almost all liquid unglazed collectors are sold into the residential sector, for swimming pool heating (97%).
- The vast majority of air collectors are sold into the industrial/commercial/institutional (I/C/I) sector (90%), with most of these being used for space heating.
- Sales of liquid glazed and evacuated tube collectors were split between the residential and I/C/I sectors, with approximately 67% in the residential sector. The residential sector sales were primarily for domestic water heating, although in 2004 23% of sales in the residential sector were for combination domestic hot water (DHW) and space heating applications, indicating strong growth in this application. Sales of these collectors into the I/C/I sector were primarily for DHW applications.

The survey also revealed that the solar thermal market in Quebec differed from other regions, with more than double the annual per capita revenue of any other region ($400 per 1,000 residents), due to a much stronger penetration of higher cost solar collectors. This is a

result of the greater market penetration of unglazed air collectors, with a higher cost per square meter than the unglazed liquid collectors.

Figure 1: Total collector sales by area and by value





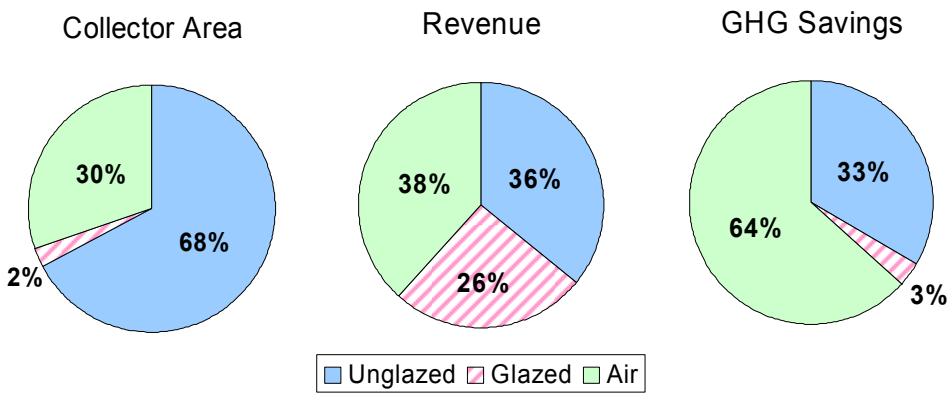
Calculations of the greenhouse gas emissions avoided due to active solar thermal systems currently operating in Canada were made based on historical estimates of solar thermal installations, including when systems were decommissioned. A model was developed to calculate an operating base, by collector type, from 1979 to the present. This model showed that many of the systems installed during the 1980's were decommissioned during the

1990's. It also shows that it is only during recent years that the operating base of solar thermal systems in Canada has begun to increase again (refer to appendix C for details of this model, and to Figure 15, for a summary of the output).

Calculations show that the estimated GHG emissions avoided from all active solar systems operating in Canada during 2004 were 23,200 tonnes of CO_2 equivalent. Similar calculations show that the expected avoidance of CO_2 emissions, from solar collectors sold and installed in Canada during 2004, over their 20 – 30 year life, will total 122,600 tonnes.

The data also show that there are distinct differences in the three types of solar collectors when measured against three major metrics: collector area, earned revenue and GHG emission avoidance. Just as "market share"* by collector type can be measured in either collector area or revenue, it can also be measured against GHG savings. When comparing the collector types against each other, unglazed pool collectors dominate the market in terms of collector area sold, their "market share" is smaller in terms of revenue, and smaller still in terms of GHG savings (largely because swimming pools operate for a shorter season than air or glazed collectors). Conversely, the market share of air collectors rises as we move from collector area to revenue to GHG savings. A major reason for their large contribution to GHG savings is their expected longer life (30 years vs. 20 years for other collectors).

Figure 2: 2004 "market share" by collector type, against three metrics



* Throughout this report, terms such as "market size" and "market share" refer to the actual reported sales of active solar heating systems only. These terms do not refer to potential market sizes, the total HVAC market, or any other values.

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1 INTRODUCTION

This report provides results of a survey of active solar thermal collectors, industry and markets in Canada. The survey was commissioned by Natural Resources Canada (NRCan), in the fall of 2004 and was undertaken by a consortium led by SAIC Canada and including the Canadian Solar Industries Association (CanSIA) and Simhan Research Associates (SRA). The survey period covers three complete calendar years: 2002, 2003 and 2004.

NRCan's Renewable Energy Deployment Initiative (REDI) was launched in April 1998 to stimulate the demand for cost-effective renewable energy heating and cooling systems and help create a sustainable market for those systems. Active solar thermal systems (ASTSs), including air and water heating, represent two of the types of renewable energy technologies (RETs) presently supported by Natural Resources Canada's REDI program. These ASTSs can play a considerable role in the implementation of the climate change plan for Canada.

NRCan conducted an in-house survey of solar thermal collectors installed in Canada from 1995 to 2001 (see Table 9), in support of Canadian contributions to the solar heating market survey of the Solar Heating and Cooling Program of the International Energy Agency (IEA). As a follow-up to the in-house survey, NRCan commissioned the present survey to begin a systematic annual collection process to gather comprehensive, accurate and relevant data on the Canadian active solar thermal industry and market.

Solar thermal collectors are the key component of active solar energy systems. These collectors absorb energy from the sun's rays and convert it into thermal energy that can be used for water and space heating and cooling. Collectors are designed to meet the specific temperature requirements and climate conditions of each use.

The purpose of this study was to survey the Canadian active solar thermal collector industry to obtain data for the 2002, 2003 and 2004 calendar years. The main objectives of the study were:

- To develop a systematic data collection process for tracking solar thermal collector shipments and installations, delivered thermal energy and displaced CO_2 emissions.
- To capture comprehensive and reliable information on market size and industry trends, including Canadian sales and revenues, import and export, and employment figures.
- To analyze and report obtained data for publication and wider dissemination.

The present survey results from a commitment to systematic data collection. Sustaining this commitment in coming years stands to improve industry and program assessment, and will provide information required to optimize communication and decision-making.

The Canadian solar thermal industry is a diverse, growing industry active across Canada, with roots going back to the mid-1970's. Five distinct types of solar collectors were sold in Canada in 2004:

1. Unglazed, liquid plastic collectors;
2. Unglazed, air collectors;

3. Glazed, liquid collectors;

4. Evacuated tube liquid collectors, and;

5. Glazed, air collectors.

Of these, the first two are the lowest cost per unit area, and combined the lion's share of the Canadian market (37% and 36% respectively, by value), with the glazed liquid collectors also achieving a significant market share (15 - 20% by value)*. The final two collector types have only small market share, at present. All five collector types showed growth during the three-year period of the survey: 29% per annum for unglazed liquid; 15% per annum for unglazed air; 22% per annum for glazed liquid; 17% per annum for evacuated tube. Glazed air collector sales showed growth, but remain small. (Preceding growth rates are by revenue; growth rates by collector area differ somewhat.) For all collector types, the 2004/2003 growth rate was higher than the 2003/2002 rate.

As the solar collector designs are diverse, so are the applications. The latter include residential and commercial swimming pool heating, heating of ventilation and makeup air in industrial buildings, commercial buildings and livestock barns, heating of potable hot water in any style of building, from single family homes to large office complexes. Newer applications are coming into use, including residential space heating via radiant floor heating systems.

According to the survey data, Canada is a net importer of solar collectors, although by a very narrow margin. Four collector types are manufactured in Canada, with only the evacuated tube collector available only via import. Even though Canada is a net importer, export sales are very valuable to Canadian manufacturers, accounting for 16% of total industry revenue.

* This value is not reported as a precise value in order to protect the confidentiality of individual survey respondents. Similarly throughout this report, it has been necessary to report some numbers as a range, or simply not report them, to protect the confidentiality of respondents.

2 SURVEY PROCESS

2.1 Survey Development and Distribution

A draft survey questionnaire was developed by the survey team, and then reviewed with seven invited industry members. The questionnaire was then revised, and bilingual copies were distributed by mail to 268 recipients. Shortly thereafter, a letter was sent by the Honourable R. John Efford, Minister of Natural Resources, encouraging the recipients to complete the survey (copy in appendix A). CanSIA also promoted the survey, in their electronic newsletter, and in individual e-mails to some of the key industry personnel. Telephone follow-up was also used extensively, with most recipients receiving two personal phone calls, answering questions about the survey, and encouraging timely responses.

More details of the survey process can be found in Appendix A, along with a copy of the questionnaire.

2.2 Survey Response Rate

The survey team chose to start with a very extensive list of recipients. Although it was recognized that this approach would lead to an overall low response rate, the survey team felt that it was important not to exclude potential respondents simply because they were not previously known to the survey team. This was felt to be particularly important given that:

- The solar thermal industry is dynamic, and undergoing a period of growth, with new members joining regularly.
- The ease with which goods can be transported across the Canada/US border permits localized businesses to exist with little contact to established product distribution networks in Canada.
- Assuming that some wholesalers would not respond, it was hoped that some of their activity could be captured via retailers supplied by them.
- The screened recipient list resulting from the survey process would be invaluable for future surveys.

Given these challenging conditions, the survey team is pleased to report a survey completion rate of 33% (see Table 1), including a 64% completion rate (9 of 14) of major companies that were identified prior to distributing the survey. These fourteen companies included collector manufacturers, major wholesalers, and some large retailers.

Of the companies from whom no response was received, there is a significant number (34) with whom we were unable to make any telephone contact. It is assumed that these companies have ceased operations, or there are errors in the contact information. The remaining 126 recipients who did not respond were contacted by phone during our follow-up campaign, but they neither completed the survey, nor refused to complete the survey. Many gave polite responses, and indicated a general willingness to complete the survey, but avoided any specific commitment.

Table 1: Survey completion rate summary

268	Surveys were mailed out
34	Of these recipients were not located, and assumed defunct
234	Net actual survey recipients
32	Completed survey, reporting ST sales
41	Completed survey, reporting no ST sales
33%	***Completion rate (73 of 234)***
35	Recipients clearly refused to respond
126	Additional recipients did not respond in any clear way

Of the 41 recipients who reported zero solar thermal sales, most were companies that were active in photovoltaics.

Of the 35 recipients who refused to respond, a small number acknowledged substantial ST sales, but were uncooperative. The majority of these companies indicated that they were relatively small retailers, and indicated that it was not important, in their opinion, for them to respond – especially since the survey would have been sent to their supplier, who presumably would complete the survey.

Of the 126 who did not provide any clear response, a few indicated a strong desire to participate, but could not be encouraged to complete it on time. Most simply gave polite, but indefinite, responses to our survey follow-up team.

The 34 recipients that could not be located is the total of those for whom the mailing address was no longer valid, and for which no new address, phone number or other method of contact could be found. In only one case did we receive positive indication that the company was no longer in business.

2.3 Estimated Data Capture Rate

To properly estimate the size of the total solar thermal industry in Canada from the survey results, it is necessary to estimate the data capture rate of the survey. The data capture rate is separate from the survey response rate discussed in the preceding section. The survey response rate is based on the number of forms completed, with all businesses given equal weight, and can be accurately counted. The data capture rate is an estimate – never a count – of the fraction of the available data which was captured by the survey process. In effect, it is a weighted average of the survey response rate, where each business receives a weighting in accordance with its volume of business. The procedure of estimating the data capture rate in this survey is complicated by the fact that there are at least three distinct market segments – and specialized businesses to serve them – within the solar thermal industry. Table 2 lists the three business segments, and the estimated data capture rate for each.

Table 2: Estimated data capture rates by business segment/collector type

Business Segment	Description	Collector Types	Estimated Data Capture Rate
Solar air heating	Heating of ventilation air. Primarily for commercial applications, with some residential.	Unglazed & glazed air	100%
Outdoor pool heating	Heating of seasonal use, outdoor pools. Primarily residential, but including some seasonal use commercial facilities.	Unglazed liquid	50%
General water heating	A wide range of applications including residential domestic hot water, indoor pool heating, and commercial water heating applications	Glazed liquid, Evacuated	60%

In estimating the above data capture rates, the survey team reviewed historical data on the Canadian solar thermal industry, as well as current data from other sources, along with the survey completion rate. The full analysis of how these data capture rates were estimated can be found in appendix B.

Important Note

In the body of this report, ***all*** quantified information (e.g. area of collector shipments; value of sales) have had the estimated data capture rates from Table 2 applied, to correct from the raw survey data.

3 SURVEY RESULTS

3.1 Industry Characterization

The survey requested information on which business sectors the respondents were active in, both within the solar thermal industry and outside of it, and about employment levels (Q1 – Q4). Some of the most notable data points are:

1. The number of solar collector manufacturers reported increased from five in 2002 and 2003, to six in 2004.

2. There was a substantial increase (from 0% in 2002 to 37% in 2004) in the number of respondents reporting involvement in activities within the solar thermal envelope, but outside of the manufacturing/distribution/sales/installation path. Perhaps this denotes a growing complexity in the industry (see Figure 3).

3. 28% of respondents reported that solar thermal was their primary business, generating more than 80% of corporate revenue (see Figure 4).

4. 29% of respondents reported that their primary business was in the renewable energy field, but was not solar thermal.

5. Only 7% of respondents reported any involvement in swimming pool sales and installation, even though unglazed pool collectors constitute 37% of reported revenue (74% of sales by collector area), over the three year period.

6. 10% of respondents indicated that their primary business was within the construction trades.

7. Employment levels grew, but only slightly during the three-year period, 2002 – 2004, with well over half of all respondents (59%) reporting no more than one full-time equivalent employee (FTE). However, the percentage of respondents reporting fewer than 0.2 FTE's fell sharply between 2002 and 2004; this may indicate that businesses just entering the solar thermal industry were able to grow their business (see Figure 5) during this period.

Figure 3: Sector involvement within the solar thermal industry

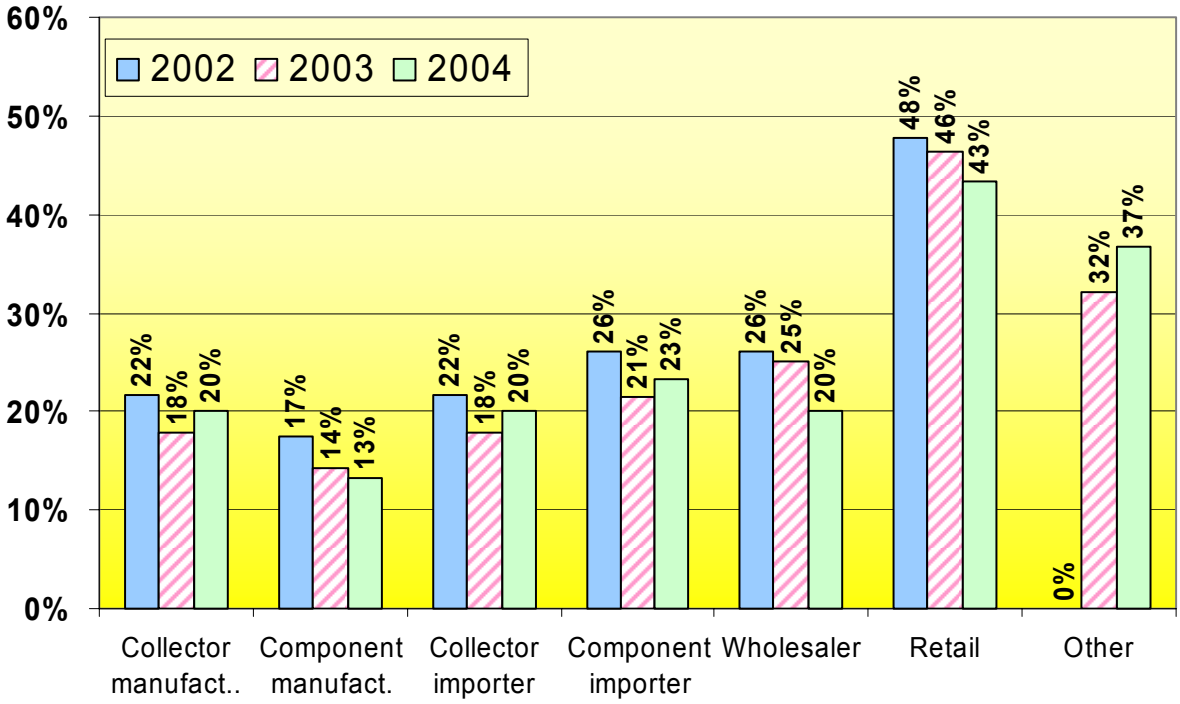


Figure 4: Solar thermal revenue as a percent of total revenue

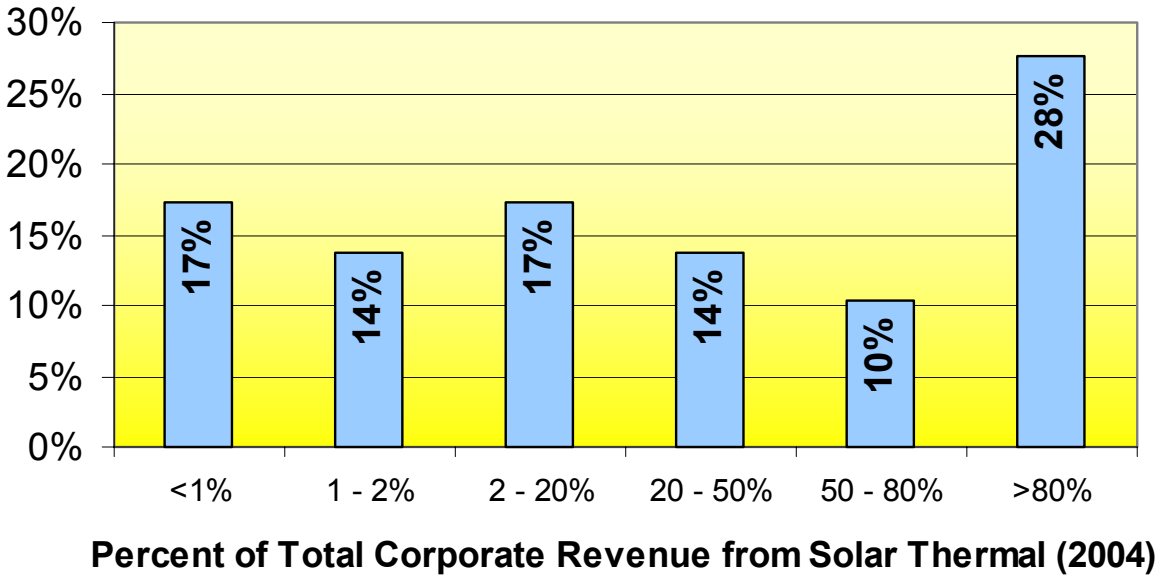
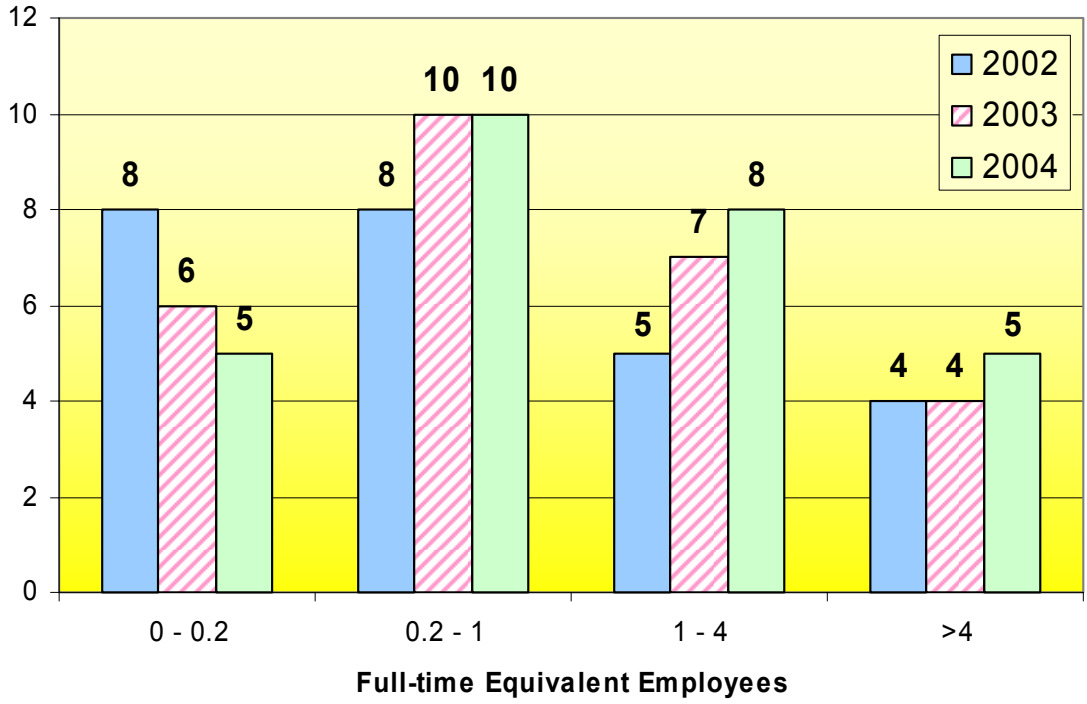


Figure 5: Number of ST employees per company



3.2 Industry Size and Growth

The pace of solar collector sales in Canada – of all types of collectors - continues to grow. Table 3 provides summary of solar collector sales, both for domestic and export sales. Figure 6 shows year-over-year growth rates, by collector area, experienced during the period of the survey. At 4.0% in 2003 and 41.4% in 2004, the revenue growth is very similar to the growth in collector shipments (8.8% and 40.2%, respectively), indicating that prices have remained stable recently.

The growth in the past three years continues, and indeed accelerates, growth trends that have been developing over the past several years. Refer to Figure 7 for a summary of industry growth over the past ten years.

Table 3: Solar collector sales by type, 2002 - 2004

Domestic Sales

	Thermal Capacity (MW)			Collector Area (m²)			Revenue ($1,000's)		
Collector Type	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Air	6.8	7.3	11.3	9,663	10,381	16,196	$1,658	$1,811	$2,354
Liquid Glazed/Evac.	0.8	0.8	0.9	1,079	1,182	1,325	$1,207	$1,252	$1,568
Liquid Unglazed	16.7	18.3	25.2	23,794	26,194	36,050	$1,344	$1,418	$2,199
Total	24.2	26.4	37.5	34,536	37,758	53,571	$4,209	$4,481	$6,121

Export Sales

	Thermal Capacity (MW)			Collector Area (m²)			Revenue ($1,000's)		
Collector Type	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Air	2.1	0.8	1.2	2,931	1,092	1,698	$218	$90	$117
Liquid Glazed/Evac.	0.2	0.2	0.5	252	233	749	$126	$112	$345
Liquid Unglazed	8.5	10.6	14.0	12,118	15,162	20,024	$378	$444	$665
Total	10.7	11.5	15.7	15,301	16,487	22,471	$722	$646	$1,127

Total Sales

	Thermal Capacity (MW)			Collector Area (m²)			Revenue ($1,000's)		
Collector Type	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Air	8.8	8.0	12.5	12,594	11,473	17,894	$1,876	$1,901	$2,471
Liquid Glazed/Evac.	0.9	1.0	1.5	1,331	1,415	2,074	$1,334	$1,365	$1,914
Liquid Unglazed	25.1	28.9	39.3	35,912	41,357	56,074	$1,722	$1,862	$2,864
Total	34.9	38.0	53.2	49,837	54,245	76,042	$4,932	$5,127	$7,249

Figure 6: Annual sales growth by collector type (m²)

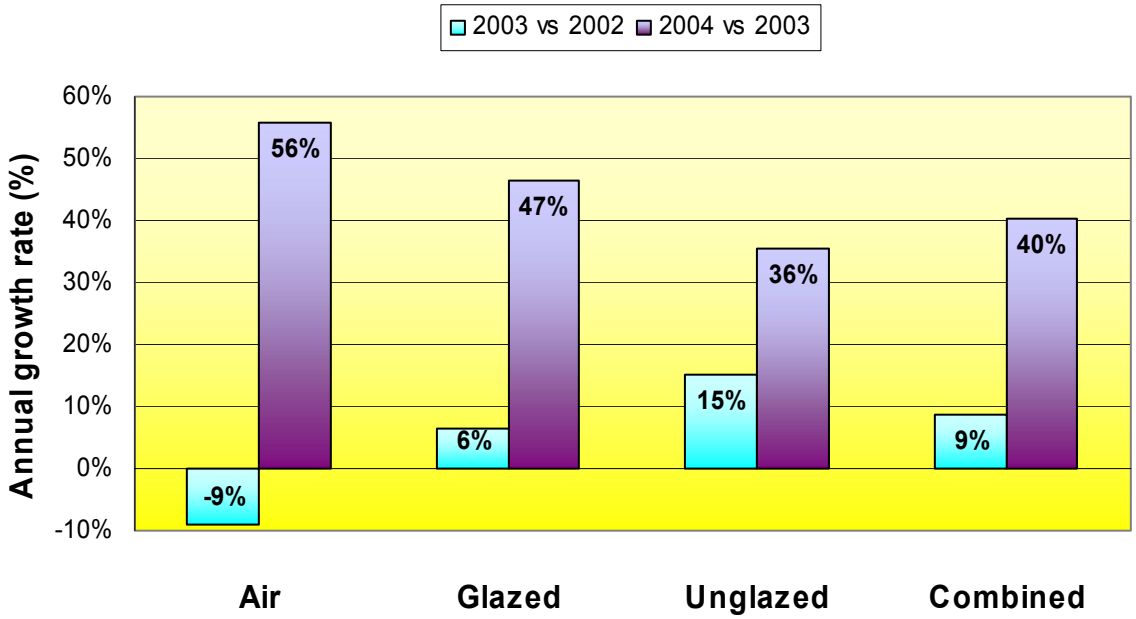
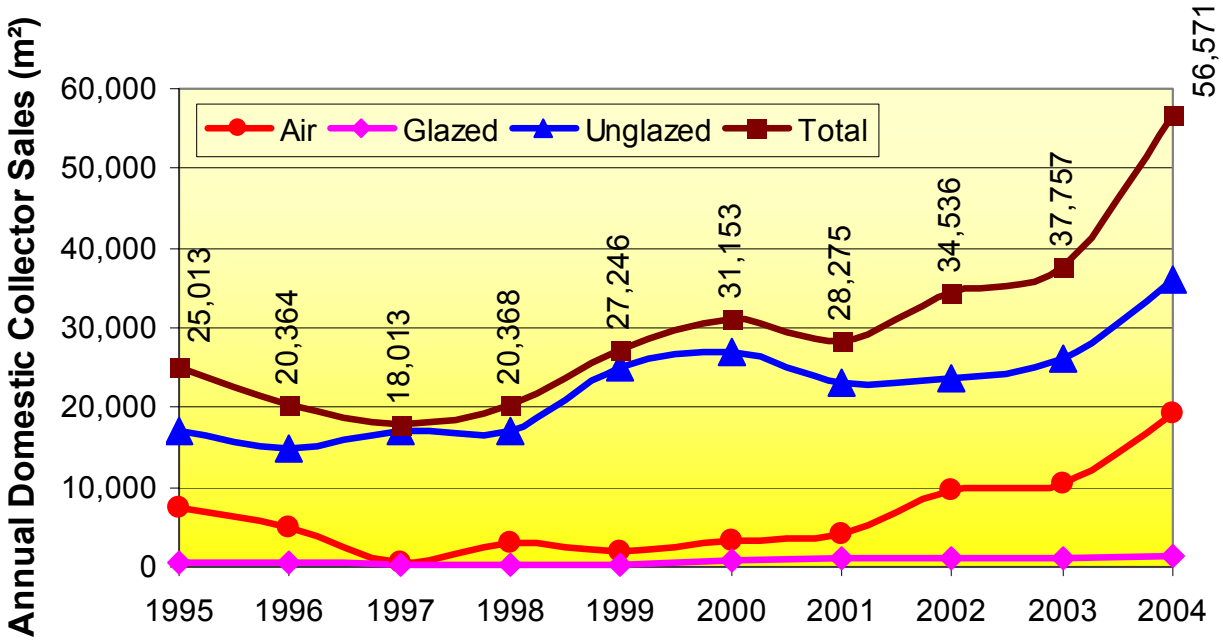


Figure 7: Ten-year history of domestic collector sales



It is instructive to note that the revenue earned per square meter of solar collection surface is much different for the three collector types. Using the sum of the data reported over the three years of the survey, Table 4 provides the revenue earned per unit area of collector, as well as the market share of each collector type. By area, the unglazed pool collectors dominate the Canadian industry, and the combined glazed and evacuated are barely noticed. However, when comparing revenue, the three collector types each have similar market shares. When the revenue differential is combined with the fact that both air collectors (at 58%) and glazed/evacuated collectors (at 38%) have had much higher average annual growth rates over the past five years than unglazed (at 8%), it is entirely possible that the unglazed pool-style collectors will lose their market leading position in the near future.

Table 4: Market share by collector type

	Air	Glazed & Evacuated	Unglazed
Average revenue per area ($/m²)	$149	$957	$48
Market share, by area	23%	3%	74%
Market share, by revenue	36%	27%	37%

3.3 Applications of Solar Thermal Technology

For the years 2003 and 2004, respondents were asked to provide details of the types of systems where solar collectors were being employed. Table 5 provides the breakdown by sector and by application. Only major applications are listed; namely, those that were responsible for more than 10% of the reported revenue, for that particular collector type.

The data show, unglazed liquid collectors have a very clear market focus – residential swimming pool heating. A similar statement can be made about air collectors, although there is a little more variation in their application. Of the air collectors sold outside of the dominant ICI space heating application, sales were distributed evenly among residential space heating, ICI DHW heating and ICI process heat.

For the liquid glazed and evacuated tube collectors, there is no clear market focus, and the variations between the two years surveyed were substantial. The primary reason for the large swings is probably simply that sales are small, and one or two large sales in a year can significantly influence the industry-wide statistics. It is also important to note that, for this collector type, just over half of sales reported by respondents were shown as wholesale sales, with the end-use application of the collectors unknown to the survey participant. Thus conclusions drawn from this data must be tentative, at best.

Table 5: Major solar heating applications (by revenue), by sector and collector type

Revenue by Sector	Unglazed		Glazed/Evac.		Air	
	2003	2004	2003	2004	2003	2004
Residential	97%	98%	40%	86%	12%	8%
Industrial/Commercial/Institutional (ICI)	3%	2%	60%	14%	88%	92%

Revenue by Solar Heating Application	Unglazed		Glazed/Evac.		Air	
	2003	2004	2003	2004	2003	2004
Residential pool heating	97%	97%				
Residential domestic water heating			32%	62%		
Residential combined space and water heating			5%	19%		
ICI domestic water heating			57%	13%		
ICI space heating					72%	77%

3.4 Geographic Distribution

Table 6 shows the distribution of solar collector sales within Canada, both by collector area and by revenue. Figure 8 shows the same data, but expressed on a population basis.

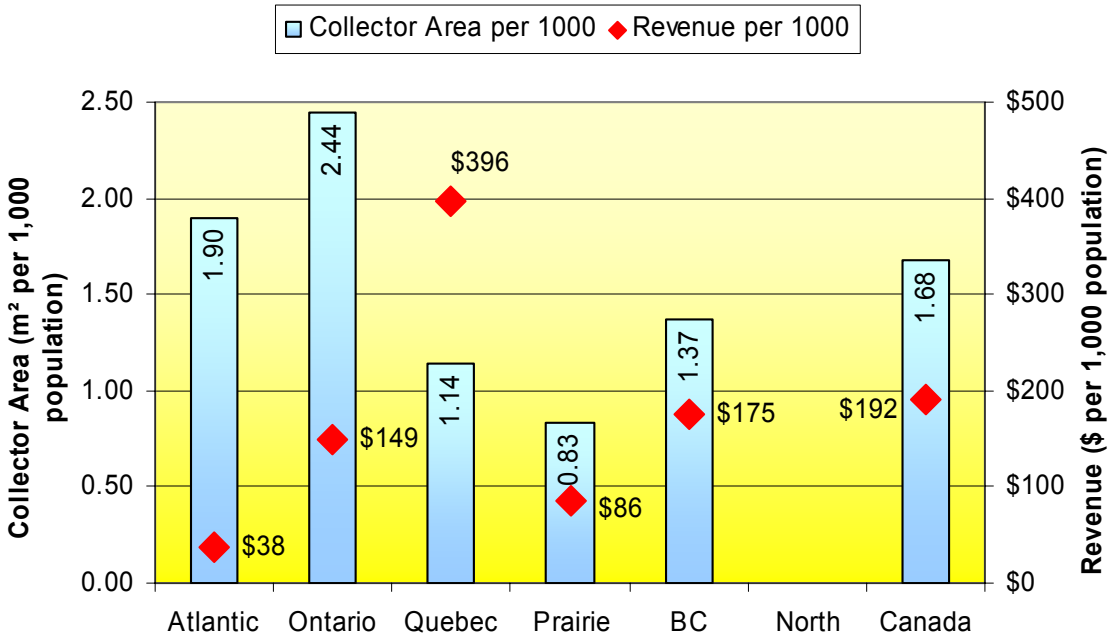
The data shows that, on a population basis, Ontario buys more solar collectors than any other region, followed by the Atlantic provinces and B.C. However, perhaps the most striking fact revealed by this data is that the average Quebecer spent more than twice as much as any other region in 2004, yet installed less collector area. This is not a reflection of high prices in Quebec, but rather an indication that Quebec residents are purchasing a greater proportion of the higher value solar collectors (air and glazed/evacuated tube) than other regions.

This data also shows that, in 2004, the average Canadian spent less than twenty cents acquiring solar thermal collectors and related equipment. This is a clear indication that the solar thermal market in Canada is not yet well developed.

Table 6: Distribution of sales within Canada

	Region	Area (m²)	Area (%)	Sales ($)	Sales (%)
2003	Atlantic	2,327	6.2%	71,313	1.6%
	Ontario	19,804	52.5%	1,165,583	26.0%
	Quebec	8,694	23.0%	2,418,425	54.0%
	Prairies	3,676	9.7%	416,335	9.3%
	BC	3,229	8.6%	368,683	8.2%
	North	27	0.1%	40,904	0.9%
	Total	37,758	100.0%	4,481,243	100%
2004	Atlantic	4,450	8.3%	88,197	1.4%
	Ontario	30,276	56.5%	1,849,038	30.2%
	Quebec	8,626	16.1%	2,987,785	48.8%
	Prairies	4,473	8.3%	463,281	7.6%
	BC	5,747	10.7%	733,379	12.0%
	North	0		0	
	Total	53,571	100.0%	6,121,680	100%

Figure 8: 2004 solar collector sales, by population



3.4.1 Exports and Imports

In addition to satisfying the domestic solar thermal market, the Canadian industry reported that approximately 10% of their revenue was earned from export sales (13%, 9% and 12% of total sales, from 2002 to 2004, respectively). Survey respondents reported exporting solar thermal collectors and equipment to the United States (64% of exports during the survey period) and Europe (36% of exports).

Survey respondents importing solar collectors valued at slightly more than the value of exports (15%, 12% and 14% of total sales, from 2002 to 2004, respectively), making Canada a net importer of solar collectors, although only by a small margin. For each of the three years of the survey, the average value of the imported solar collectors was very close to $1,000/m², which leads to the conclusion that most – if not all – reported imports were of the higher value liquid glazed and evacuated tube collectors.

Table 7: Annual exports - collector area and value

Collector Area Exported (m²)	2002	2003	2004
Air	2,931	1,092	1,698
Liquid Glazed & Evacuated	252	233	749
Liquid Unglazed	12,118	15,162	20,024
Total	15,301	16,487	22,471

Value of Solar Thermal Exports	2002	2003	2004
Air	$218,293	$90,441	$117,244
Liquid Glazed & Evacuated	$126,291	$112,323	$345,383
Liquid Unglazed	$377,667	$443,699	$664,711
Total	$722,252	$646,463	$1,127,338

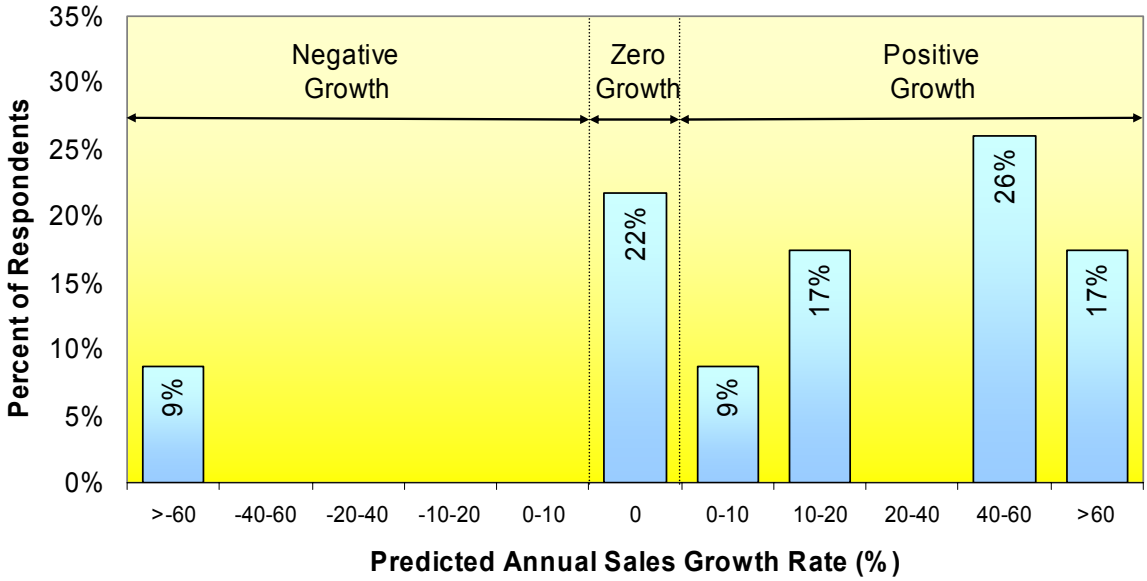
3.5 Trends and Perspectives

The information reported in this section of the report results from questions where respondents provided their opinions, rather than verifiable facts. Thus caution is advised when considering interpretations made from these opinions and encdotal data.

3.5.1 Anticipated Sales Growth

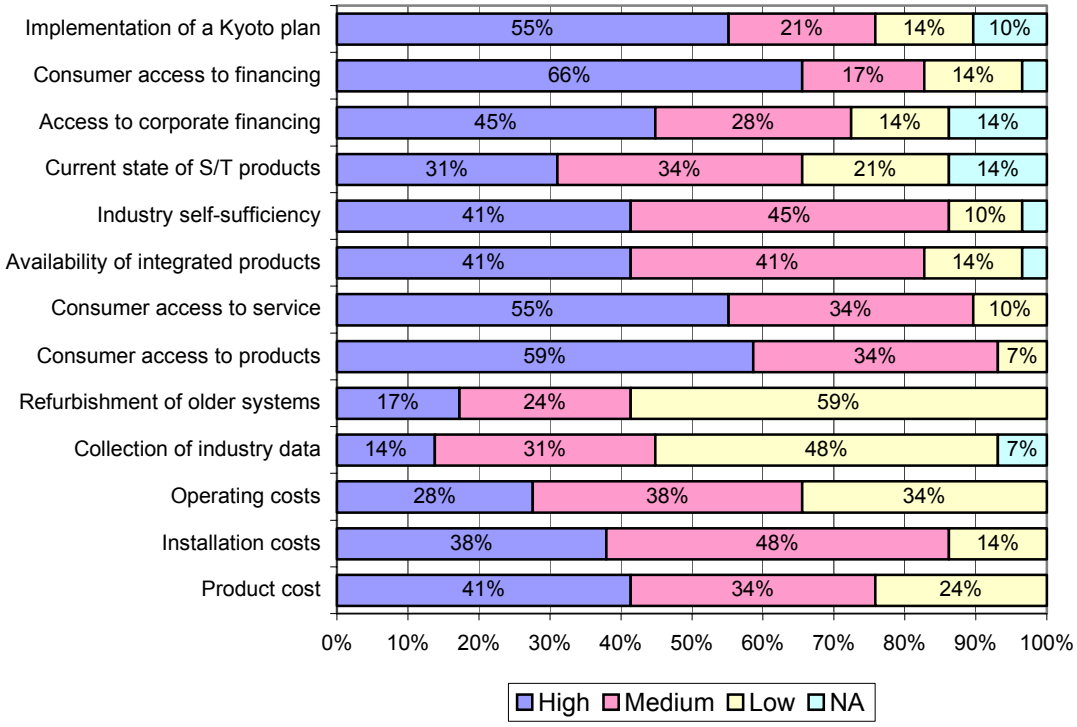
Figure 9 shows the range of survey responses, indicating a strong expectation of growth over the next two years. The weighted average of the responses gives a projected growth rate of 20% annually. This is particularly notable considering that the solar industry had just completed an exceptionally good year in 2004, with 40% annual growth in both collector area and revenue. It is also noteworthy that the only respondents expecting a decline in business are expecting a very large decline, perhaps indicative of plans to retire or otherwise exit the solar thermal business, or of completion of large projects. Thus, it is reasonable to conclude that all collector manufacturers and major distributors are expecting stable or increasing business volumes during 2005 and 2006.

Figure 9: Anticipated sales growth in 2005 and 2006



3.5.2 Issues of Importance to Industry Growth

Figure 10: Issues important to solar thermal industry growth



A separate question (Q12) asked respondents to rate the importance of thirteen issues to future growth of the solar industry. Figure 10 shows the results; the issues that received the greatest response as of “high” importance were:

- Consumer access to financing (66%),
- Consumer access to products (59%),
- Consumer access to after sales service (55%),
- Implementation of a plan to meet the Kyoto targets (55%).

The issues that received the greatest response as of “low” importance were:

- Refurbishment of older systems (59%),
- Collection and trend analysis of ST industry data (48%),
- System operating, maintenance and service costs (34%).

The fact that consumer access to financing, products and after sales service were the three areas of highest importance may imply that industry members believe that they have quality, marketable products to offer, but that the retail network is too weak to interact with enough potential customers, thereby limiting growth.

3.5.3 Threats to the Solar Thermal Industry

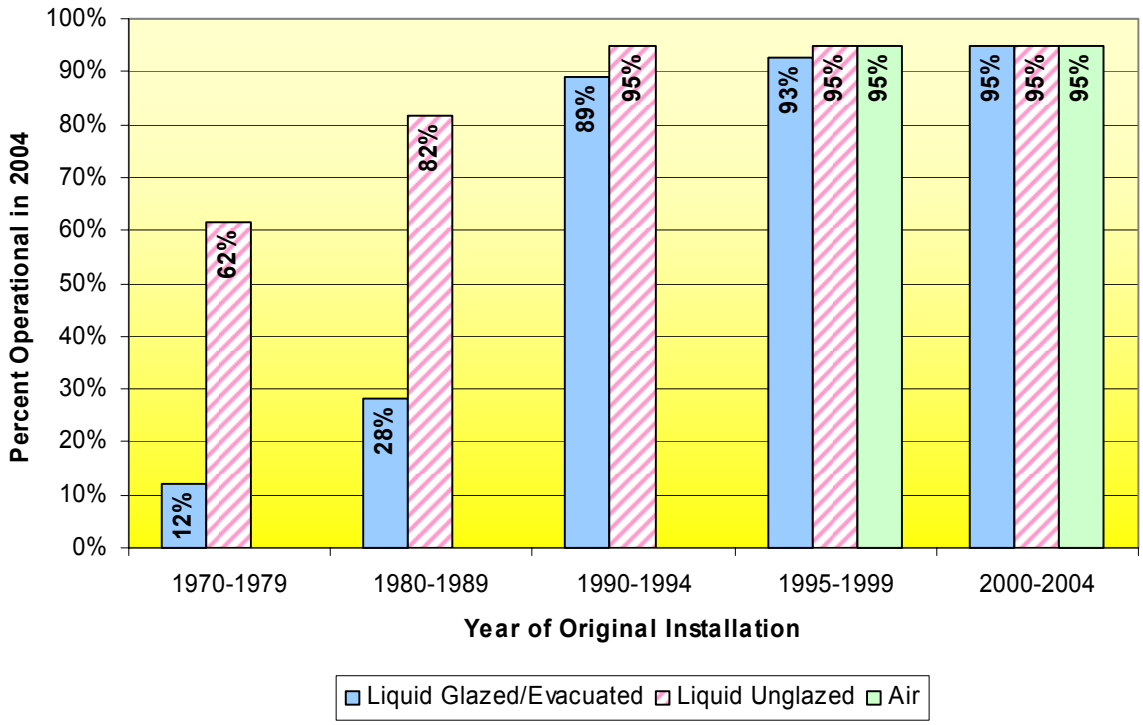
The survey contained a question allowing respondents to describe the single greatest threat to their specific business (Q14). A total of 38 comments were received; some respondents entered multiple comments. The four items listed most often as threats to individual solar thermal businesses were:

- Lack of awareness or education among the buying public – 24%
- High cost of solar thermal – 13%
- Lack of availability of well-trained installers – 11%
- Low costs of competing energy sources – 8%

3.5.4 Expected Life of Older Solar Thermal Systems

The final question on the survey (Q15) asked respondents to report on the current operational status of any older system of which they had direct personal knowledge. It must be emphasized that only a small amount of data was gathered from this question. Only seven respondents provided any opinion on systems more than ten years old; however, these responses did provide data on roughly one fifth of the collectors installed in Canada prior to 1995.

Figure 11: Expected life of older systems



The responses (Figure 11) show that the average life expectancy of early systems employing liquid glazed collectors does not exceed 20 years, as the percent of operating systems has fallen well below 50% for systems that are 15 – 25 years old. There were no reports of older systems using air type collectors.

Surprisingly, a large percentage of the older systems with unglazed liquid collectors are reported as operational, including 62% of those installed more than 25 years ago. As the life expectancy of swimming pool style collectors installed in the 1970's and early 1980's was below 20 years, this report of a high percentage still in operation may indicate that, when parts and service are available, system owners will replace failed collectors, and keep the system operating. It should also be noted that while survey respondents report that 82% of the 1980's era systems with unglazed collectors are still operational, the survey reported on only 10% of the half a million square meters of this collector type installed during the 1980's. If we take a pessimistic view, we could postulate that all of the remaining 90% of installations are now non-functional, and thus only 8% of the 1980's era systems are still in operation. While this wholly pessimistic view is probably too harsh, it is possible – and perhaps even likely – that the 10% of systems reported in the survey are more heavily weighted to systems that received regular, professional service, and thus are not necessarily representative of the 90% of unreported systems.

4 ESTIMATE OF AVOIDED GREENHOUSE GAS EMISSIONS

4.1 Background

Estimating GHG emissions avoided due to solar thermal installations in Canada requires a substantial amount of data that was not (and could not be) requested in the survey, primarily because present performance of GHG emissions depend heavily on past sales of solar thermal technology. As this is the first year of this independent survey, a number of assumptions had to be made to generate a comprehensive GHG analysis. The limited data on past sales volumes, past application types and types of fuel displaced by solar heating systems complicate the generation of accurate data on avoided GHG emissions. It is within this context of data and methodological uncertainty that this evaluation of avoided GHG emissions was completed. Despite these uncertainties, this estimate can assist priority setting and policy decision-making, as well as to further inform stakeholders and educate the public. Where applicable, conservative assumptions were made in quantifying the potential solar thermal technologies to avoid GHG emission avoidance potential

4.2 Methodology

The methodology for estimating GHG emission avoidance in a current year involved the following major steps.

- Researching historical sales data, and interpolating as necessary to provide estimates for missing data.
- Estimating the useful operational life of various solar thermal collectors or systems, to estimate the total solar collector area operational in a specific year.
- Developing typical or reference systems and applications, from which to estimate annual energy production per square meter of collector surface.
- Analyzing the fuel being displaced by solar, for each of the reference systems.
- Calculating the quantity of displaced fuel, and thus the GHG emissions avoided.

Details of the process of reviewing historical sales data, and the resulting estimates of the capacity of solar collectors currently in operation, can be found in Appendix C.

Where reasonable, the methodology used in this report follows that developed by Weiss[*] *et al* for estimating GHG emissions avoided due to solar thermal systems. However, some modifications were made, so that the methodology would better apply in the Canadian context.

[*] Weiss, Werner; Bergmann, Irene and Faninger, Gerhard, February 2004. Solar Heating Worldwide: Markets and Contribution to the Energy Supply 2001. IEA Solar Heating & Cooling Program.

1. We added a reference system using air as a heat transfer medium, as this is a particularly strong segment of the market in Canada, and we had adequate data available to characterize these systems.

2. We expanded the analysis of displaced fuels. Weiss assumed that all solar heating systems displaced oil heating. Since very few solar heating systems displace oil in Canada (<5% by collector area), we performed an analysis to generate a different blend of displaced fuel for each reference system. Although still based on incomplete data, this does offer a closer approximation to the actual.

3. Weiss did not determine a useful life expectancy for various products and applications, as the vast majority of solar heating systems in the world were less than 20 years old in 2001, and most solar collectors are assumed to have a lifetime of 20 years or longer. Assuming that all systems reported as installed were still operating was a reasonable first approximation. However, in Canada, there have been significant numbers of solar thermal installations going back more than 25 years, and there are reasons to believe that a substantial number of older systems are no longer in operation, reasons separate from the life expectancy of the products. Thus, we defined an average life expectancy for each reference system type, applicable in Canada, which was used in calculating an operational base.

In addition, Weiss selected Montreal as a reference climate for all systems in Canada. Whereas there is some merit in choosing a location in south-central Canada, as this area contains the heaviest population concentration, the vast geography of Canada contains diverse climate regions, with a range of displaced fuels, and this should be given some consideration. However, this survey process did not yield sufficient data on the regional distribution of various types of applications, to conduct this type of analysis, so no changes were made.

4.2.1 Reference System Definitions

Weiss developed four reference systems in his work on estimating avoided GHG emissions, but only three of these four were applicable within Canada. We have chosen to use the same three systems, albeit with some adjustments to reflect the Canadian market, plus a fourth – commercial air.

Residential DHW – This system is identical to Weiss' solar domestic hot water systems for single family houses in Canada. It represents a typical solar DHW preheat system consisting of two 4' x 8' (6 m²) glazed solar collectors, 150 L/d hot water usage[*], with a 300 L hot water storage tank. Commercial marketing material indicates that each system will produce about 50% of the energy required for hot water in a home, on an annual basis.

Commercial Water – This system is essentially a new name for Weiss' solar domestic hot water systems for multi-family houses and district heating, retaining many of its features. This incorporates all larger scale systems with glazed, liquid collectors, covering applications

[*] The 150 L/d hot water usage used by Weiss is probably low for Canadian practice, but we chose to keep this value for consistency with international reports. Using a larger hot water draw (~225 L/d is more typical of actual hot water usage in Canada) would have increased the estimate of GHG avoided, but since DHW heating systems are a small segment of the Canadian market, the overall effect would be negligible.

from institutional or multi-residential DHW, to municipal indoor pool heating, to process water at car washes, laundries or other facilities. As with Weiss, the reference system consists of 50 m² of collectors, 2,000 L/d hot water draw and a 2,500 L storage tank.

Residential Pool – This system is identical to Weiss, except that the collector area has been reduced from 200 m² to 25 m², to more closely reflect the Canadian market (5-6 nominal 4' x 12' collectors per system). This reduction in size has little impact on the GHG analysis, but it does affect the calculation of the number of systems. Note that this reference system covers all unglazed, liquid-type collectors, and thus does include seasonal municipal or resort pools, which may have collector areas of 50 – 300 m². However, these commercial pools constitute well below 5% of the Canadian market, and they do perform similarly to the more common residential pools.

Commercial Air – This is a new reference system, based on the successful use of unglazed air collectors for preheating ventilation and makeup air in industrial, commercial and agricultural (livestock barns) applications. Within Canada, this is a strong market sector, and cannot be ignored. System sizes vary widely from below 50 m² to 10,000 m². For a reference system we have selected 200 m², because it is within the size range for both agricultural and industrial/commercial/institutional sectors, and should provide a reasonable estimate of the mean size of all systems.

4.3 GHG Emission Avoidance Calculations

Table 8 shows the calculations used to estimate the GHG emissions avoided due to all solar thermal systems operating in Canada at the end of 2004.

Table 8: Analysis of avoided GHG emissions, using four reference systems, 2004

Parameter	Residential DHW	Commercial Water	Residential Pool	Commercial Air
Collector type	glazed	glazed	unglazed	unglazed air
Collector area (m²)	6	50	25	200
Annual yield per system (GJ/a)	9.9	82.1	19.4	422
Specific annual yield (GJ/a-m²)	1.64	1.64	0.78	2.11
Displaced fuel mix (%)				
• Oil (73 kg of CO_2/GJ)	4%	15%	1%	5%
• Natural gas (50 kg of CO_2/GJ)	50%	75%	63%	50%
• Propane (60 kg of CO_2/GJ)	--	5%	--	40%
• Electricity (151 kg of CO_2/GJ)	46%	5%	12%	5%
• Heat pump (38 kg of CO_2/GJ)	--	--	24%	--
• No fuel	--	--	--	--
Blended CO_2 avoided (kg of CO_2/GJ)	97	59	59	60
Annual CO_2 avoided (t/a-system)	0.96	4.84	1.14	25.3
Annual specific CO_2 avoided (kg/a-m²)	160	97	46	127
Estimated system life (years)	15/20	15/20	15/20	30
Total operating collector area (m²)	7,817	1,700	291,482	67,219
Calculated number of systems	1,303	34	11,659	336
Total annual CO_2 avoided (t/a)	1,251	165	13,291	8,501
Total annual CO_2 avoided, all types (t/a)	23,208			

Notes on Table 8:

- "/a" designates yearly values (*per annum*).
- The annual yield per system (GJ/a) values were taken from Weiss, except for the commercial air systems. The value for commercial air systems was derived by averaging estimates from more than 100 recent Canadian installations, after discarding the ten highest and ten lowest specific yield values. This data was provided by Bruce Sibbitt, on behalf of the REDI program.

- The mix of displaced fuels for commercial water and commercial fuel systems were taken from data from the Renewable Energy Deployment Initiative (REDI). The fuel mix for residential DHW systems is from figure 6.1.1 of the "1997 Survey of Household Energy Use – Summary Report", Office of Energy Efficiency, NRCan. The data for residential pool systems is from table 3.3 of the NRCan report "Potential for Solar Heating of Outdoor Residential Pools to 2020", by Enermodal Engineering, February 1999. Note that the estimates of displaced fuels are national averages, and can vary by region.

- The CO_2 emissions value for heat pumps was set at 25% of that for electricity, assuming a COP of 4. Further data is required to develop a more accurate estimate.

- The "total operating collector area" was calculated assuming that the estimated life of systems installed in the 1970's and 1980's was 15 years. All systems installed in 1990 or later are assumed to have life expectancies of at least 20 years. Refer to appendix D for details of how these values were derived.

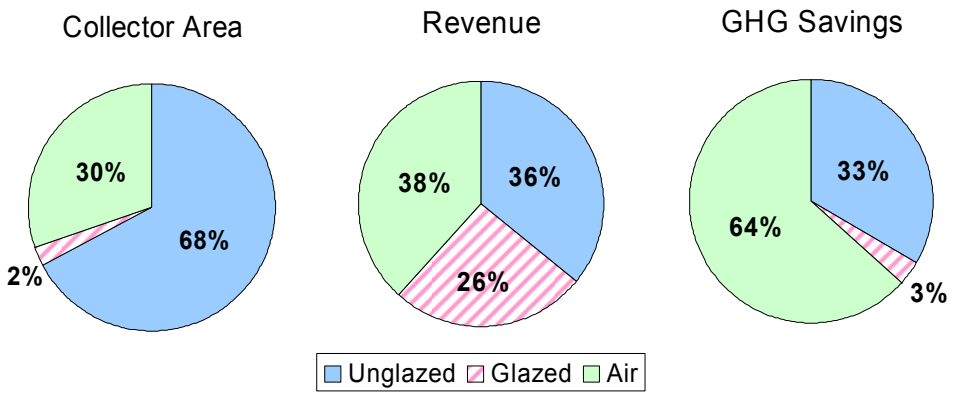
- The estimate of 11,659 reference pool heating systems is lower than the estimate of 20,000 actual solar pool heaters given in the 1999 study by Enermodal Engineering, but the estimate of 13,291 t/a of CO_2 emissions avoided is similar to Enermodal's 1999 estimate of 13,000 t/a. Perhaps the reference system size of 25 m², used in this report, is larger than the average installation, as estimated in the earlier Enermodal report.

4.4 Forecast GHG Emission Avoidance from Collectors sold in 2004

An alternative view of GHG emission avoidance - and one that is more representative of the current sales rate of solar thermal systems, rather than past sales - is to estimate the total GHG's that will be avoided over the operating life of systems installed in the current year. Applying the same calculations in the previous section to the 53,571 m² of collectors installed in Canada during 2004, leads to the conclusion that 122,600 tonnes of CO_2 equivalent will be saved over the lifetime of these systems (using a 20 year expected life for all water systems and a 30 year life for commercial air systems). Since the solar industry earned slightly over six million dollars in revenue from domestic sales in 2004, this means that one tonne of CO_2 is saved for every $50 of revenue (neglecting any service and repair revenue that may be earned over the life of the systems). Depending upon climatic conditions and displaced fuels data in the country of use, it is likely that the solar collectors exported from Canada during 2004 will be responsible for avoiding another 50,000 tonnes of CO_2 equivalent, during their operating life.

Just as "market share" by collector type can be measured in either collector area or revenue, it can also be measured against GHG savings. While unglazed pool collectors dominate the market in terms of collector area sold, their market share is smaller in terms of revenue, and smaller still in terms of GHG savings (largely because swimming pools operate for a shorter season than air or glazed collectors). Conversely, the market share of air collectors rises as we move from collector area to revenue to GHG savings. A major reason for their large contribution to GHG savings is their expected longer life (30 years vs. 20 years for other collectors).

Figure 12: 2004 "market share" by collector type, against three metrics



4.5 Conclusions

The estimated total annual CO_2 emissions avoided, for all solar thermal systems, are shown in Table 8 as 23,208 tonnes per annum. This is fully 64% lower than the 64,563 t/a calculated by Weiss *et al* in their earlier report. There are three identifiable reasons for this discrepancy.

The most significant reason for the discrepancy is that Weiss used a value of 589,682 m² of installed, operating collector area for Canada in 2001. From Table 8, the estimated total operating area of solar collectors in Canada in 2004 is 368,218 m². This 38% “decline” in estimated operating collector area is due to the removal of all systems installed in 1989 and earlier, because of their assumed shortened life (due to a lack of parts and service).

A second, less significant, reason for the drop in estimated GHG emissions avoided is that Weiss assumed that all solar thermal systems displaced oil, and thus employed a value of 74.4 kg of CO_2/GJ of energy, whereas we have used values ranging from 38 – 151 kg of CO_2/GJ, with a weighted average of 60 CO_2/GJ, 20% lower than the value that Weiss used.

A third reason for a discrepancy between estimates of avoided GHG emissions is that this report deals directly with air-based solar collectors as a distinct technology – and they account for fully 37% of GHG savings. The Weiss team had insufficient data on air-based systems, and it is unclear how they were included in their calculations.

5 RECOMMENDATIONS FOR FUTURE SURVEYS

The survey team makes the following recommendations for future surveys, divided into three general categories, relating to data quality, data depth and data analysis.

5.1 Recommendations concerning data quality

The recommendations in this section are concerned primarily with improving the completeness and accuracy of the data set available for analysis. Any action that enhances the response rate to the survey is considered to improve data quality.

1. Maintain strict data confidentiality, such as employed during this survey. Although the confidentiality requirements restricted the analysts' ability to analyze certain issues in depth, the survey respondents were generally very concerned about confidentiality, and survey participation is likely to drop off if confidentiality is endangered.

2. Continue to survey all industry participants, in an effort to obtain more complete data, but consider developing a "short form" survey targeted at retailers/installers. Any short form survey should contain identical questions, but fewer of them. (The question of how many industry members to survey should be reviewed frequently, but for now we recommend surveying the entire industry.)

3. Review the time of year at which the survey is to be issued, and the length of time given for response. This first survey was completed during February and March, 2005. For many companies, this period is busy either with year end bookkeeping chores, or with important marketing activities (e.g. trade show participation) – or both. This contributed to the non-participation of some companies. Possible alternatives include issuing the survey document in early December, with a completion date as late as April, allowing companies to complete the survey in parallel with year-end activities, at a time of their choosing, or delaying the survey to occur in the late summer and early autumn, when industry activity levels are generally lower.

4. To align with recently adopted IEA practice, future surveys should request collector data in terms of thermal capacity (energy) rather than physical size (m^2). This will encourage industry members to maintain internal data in this format.

5. Publicize the data from this survey widely. Making the data from this survey widely available to the industry and other interested personnel will encourage future participation. Specifically, we recommend that future survey mailings include at least a summary of the report from the previous survey, preferably with a web link or other means of accessing the full report.

6. Consider developing a publicly accessible database of large (e.g. with collector area >50 m^2) solar thermal systems in Canada, with specified data on each system. Systems which have received support from the REDI program could form the initial core of this database.

5.2 Recommendations concerning data depth

There were some areas where additional data would have further enriched the analysis. While recognizing the risks of a more detailed survey, it may be beneficial to request some additional data in future surveys – particularly since these surveys will cover only a single year.

7. Where practical, expand questions to ask for response by collector type. Specifically, this level of detail should be added to all questions about import and export of solar collectors, and possibly on Q9, regarding geographic distribution within Canada.

8. Although no specific recommendation is provided, it may be helpful to add more detail to Q8, requesting additional detail of applications, or perhaps providing more clarity to the definition of each application and sector.

9. Conduct further analysis of the regional distribution of the installed base of solar collectors in Canada, to develop a more precise calculation of avoided GHG emissions attributable to active solar thermal systems. The three primary tasks that would contribute to this include:

    - Simulating the performance of the reference systems under climatic conditions typical of each region;

    - Analyzing the fuel types displaced in each region (by each solar thermal system type), and then employing local data for GHG emissions associated with that fuel type;

    - Developing a more in-depth understanding of the regional distribution of solar thermal systems, by type, within Canada.

5.3 Recommendations concerning data analysis

Strictly speaking, much of the data analysis can be separate from the actual data collection. The following recommendations deal with how to better use the data to draw accurate conclusions.

10. Develop a means for coordinating activities and sharing survey information with the US Energy Information Administration, allowing better analysis of Canada/US cross border shipments of solar collectors.

11. Refine the “commercial air” reference system, and simulate its performance in a manner similar to the work already done by Weiss on the liquid-based reference systems, so as to normalize comparisons among the different reference systems.

12. Continue to work towards standardized, consistent methodologies for calculating avoided GHG emissions due to active solar thermal systems; specifically, develop guidelines for determining the type of fuel displaced by solar.

6 REFERENCES

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APPENDIX A – Survey Process and Questionnaire

A1 Survey Promotion

Promotion of the survey began in November 2004, at the CanSIA Solar Forum 2004, held in Ottawa from November 3 – 6, 2004. With the cooperation of CanSIA, SAIC Canada staff manned a table promoting the upcoming survey during the conference, informing attendees of the pending survey, and answering questions that they might have. At the same conference, Mr. Bill Wong of SAIC Canada gave a short presentation at a plenary session, explaining the purpose of the survey. When the survey was distributed, CanSIA continued efforts to promote the survey, and encourage cooperation by CanSIA members, through their electronic newsletters and direct e-mails to their members.

A2 Questionnaire Development

A questionnaire was drafted with questions primarily designed to collect salient facts, in a manner compatible with industry practices and terminology. This draft questionnaire was then reviewed with technical experts from NRCan, and by a group of seven selected individuals from the Canadian solar thermal industry, who formed the industry review panel. The panel, which was convened by CanSIA to assist in the review and improvement of the questionnaire, consisted of senior executives of seven companies from Canada's solar thermal industry. The members of this panel were:

- Dan Takahashi, Enersol Solar Products Inc., Campbellville ON
- Jean-Pierre Pawliw, Generation Solar, Peterborough ON
- John Hollick, Conserval Engineering, Toronto, ON
- Joe Thwaites, Taylor-Munro, Delta BC
- Michael Noble, EnerWorks Inc., Dorchester ON
- Robert Waters, Viessmann Manufacturing Company Inc., Waterloo ON
- Zeb Fisher, Thermomax Industries Ltd., Victoria BC

The industry review panel was invaluable in assisting us to generate an effective survey document. It significantly contributed to the implementation of the formal protocol that ensured protection of the confidentiality of individual survey responses, and prevented the release of sensitive data to CanSIA, NRCan, or any SAIC staff members involved in the solar industry. This protocol, developed in consultation with the panel, was included with every copy of the survey document. A copy may be found in appendix B. Feedback from the staff conducting the telephone follow-up has confirmed the wisdom of instituting this tight confidentiality protocol.

A3 Preparation of List of Survey Recipients

In parallel with the questionnaire development, a survey distribution list was prepared. The contact information for industry participants was gathered from a number of public sources, and then augmented by the personal knowledge of the project team. A complete list of 268 possible survey recipients was compiled, of which 152 were "confirmed" as having some

involvement with solar thermal technology. Of the remaining 116 companies, it was assumed by the project team that a large percentage was involved only in photovoltaics, and not solar thermal. However, there was insufficient time to conduct a thorough pre-screening, and since there is a significant overlap – at the retail level - of companies active in both solar thermal and photovoltaics, it was decided to issue the survey questionnaire to all 268 companies on the list, using the questionnaire itself as a screening tool.

A4 Distribution and Follow-up

A bilingual hardcopy of the survey was mailed on January 14, 2005, with a requested response date of February 8, 2005. In addition to the actual survey document, the package included (also bilingual):

- A covering letter from CanSIA.
- An instruction sheet for completing the survey.
- A confidentiality protocol, ensuring survey respondents that their information would be kept confidential.
- A stamped return envelope.

As a follow-up to encourage greater participation, the Minister of Natural Resources, the Honourable R. John Efford, issued a follow-up letter to all 268 survey recipients, on February 11, 2005 urging the recipients to respond (see appendix). CanSIA mentioned the survey in newsletters and messages to members (see appendix). In addition SAIC staff:

- Attempted to speak to each survey recipient at least twice. A small number (23) did not receive a second phone call, primarily because it was difficult to get a call through (no answer, answering machine only). A number of recipients received more than two calls, especially those whose initial response was that they would complete the survey, but who were then tardy in doing so.

- Searched various sources (e.g. Yellow pages, Canada411.com, internet searches) for valid phone numbers or updated addresses, in order to contact those whose initial contact information was either incomplete or outdated.

- Forwarded the blank survey form by e-mail to those who could not locate their mailed hard copy.

- Responded to e-mail or telephone inquiries promptly.

Despite the announced deadline in February, survey responses were accepted through the end of March. Half of the completed surveys were received later than the published date.

A5 Sample Questionnaire, with Enclosures

The following pages provide a copy of the questionnaire and attachments that were mailed to all survey recipients. Each recipient received a fully bilingual copy of this package.

Canadian Solar Industries Association
L'Association des Industries Solaires du Canada

Suite 208 – 2378 Holly Lane
Ottawa, Ontario CANADA K1V 7P2

tel: 1-613-736-9077
1-866-522-6742
fax: 1-613-736-8938
email: info@cansia.ca

www.cansia.ca

RE: SURVEY OF THE COMMERCIAL ACTIVITIES IN THE ACTIVE SOLAR THERMAL INDUSTRY IN CANADA

Dear solar industry colleague,

Canada is one of only a few International Energy Agency (IEA) participating nations that has not routinely carried out comprehensive annual surveys of its national solar thermal industry. The most recent comprehensive survey was carried out in 1986 by KPMG, on behalf of CanSIA. In the summer of 2002, the government of Canada undertook a survey of solar collector areas that covered the years from 1995 to 2001. These results helped update Canada's records in the IEA annual solar collector market reports for 2000 and 2001, but the survey was not comprehensive enough to track all aspects of the solar thermal industry in Canada. Tracking is an invaluable tool for identifying marketing opportunities and for measuring the health of the industry.

CanSIA has long been an advocate for the increased monitoring of the solar industry's commercial activities, and is pleased that Natural Resources Canada has initiated this comprehensive annual survey. We are also pleased to collaborate in this process, to ensure that it meets industry needs, as well as continuing to fulfill ongoing IEA reporting requirements.

This year's survey has three main objectives:

- Developing baseline data of three years (2002, 2003, 2004) that will allow comparison to international growth trends in the solar thermal industries;
- Identify the size of the solar industry in Canada and identify the market areas and their relative sizes;
- Identify key policy issues that the industry feels are critical to its future success.

While I understand that attempting to collect data for three years at once may be a challenge I encourage all industry members to be involved. Your involvement in developing a sound information base is invaluable in understanding the size of the industry, its creation of wealth and jobs for Canadians, its growth potential and its impact on the environment. As a participant in the survey you will receive a copy of the final report.

To ensure a high participation rate in the survey we are offering two methods of survey completion:

- A hard copy of the survey is attached to this letter and can be filled out and sent back by fax or mail.
- A telephone survey if you prefer, which would reduce the time involved in filling out the questionnaire. If you prefer this, please contact SAIC at the number listed on the cover, to arrange for a telephone interview. You will need to collect your sales data (square metres and dollars) by collector type and application area for the calendar years 2002, 2003 and 2004.

CanSIA has carefully reviewed the process of data collection to insure that strict confidentiality is maintained. NRCan, CanSIA and the survey analysis will only receive aggregated total results and your individual firm's data will not be released to anyone. SAIC has developed a confidentiality protocol (enclosed) which I feel will insure the confidentially of your information.

I thank you for your participation in this important initiative and I believe it will be an invaluable tool for the industry in developing long term plans for its growth in the future.

Yours truly,

Rob McMonagle
Executive Director

ID No. _____

To be assigned during processing

Questionnaire

Solar Thermal Collector Survey

Calendar Years: 2002, 2003, and 2004

Please note that, for the purpose of this survey, Solar Thermal (ST) includes activity pertaining to solar collector-based systems only. Some questions only ask for data on the more recent years namely 2003, 2004 to reduce response burden.

Please enter company contact information:

COMPANY _____

ADDRESS _____

_____

_____

NAME _____

TITLE _____

TELEPHONE _____

FAX _____

E-MAIL _____

DEADLINE FOR COMPLETION IS FEBRUARY 8, 2005

Completed surveys should be returned to:

Anna Mastilovic
SAIC Canada
Suite 1516, 60 Queen Street
Ottawa, Ontario
K1P 5Y7

Tel: (613) 563-7242
Fax:(613) 563-3399
toll-free number: 1-888-SAIC-CAN

e-mail: mastilovica@saiccanada.com

CONFIDENTIAL WHEN COMPLETED

ID No. [ ]
To be assigned during processing

1. Business Profile

1. Please provide some profile information pertaining to your Solar Thermal business. Which of the following business segments were/are applicable to your organization for the calendar years 2002, 2003 and 2004?

Business Segments	2002	2003	2004
a. ST Collector Manufacturer	☐	☐	☐
b. ST System Component Manufacturer	☐	☐	☐
c. ST Collector Importer	☐	☐	☐
d. ST System Components Importer	☐	☐	☐
e. Wholesale Distributor	☐	☐	☐
f. Retailer/installer	☐	☐	☐
g. Other: Design/consulting services: Please describe:	☐	☐	☐

2. Please estimate the time spent on ST activities of all employees (full and part-time), and contractors, to provide the number of full-time employee equivalents for the three calendar years.

_____ Person-years in 2002

_____ Person-years in 2003

_____ Person-years in 2004

Including full-time, part-time and seasonal staff, but excluding contractors, what was the peak number of persons employed at any single time during 2004? _____

3. In 2004, what proportion of your organization's total revenue was from active solar thermal business? _____%

ID No. ☐

To be assigned during processing

4. In addition to solar thermal, please indicate if your business was involved in any of the following business segments in 2004. Check all that apply in the left column; in the right column, check only one, and only if you would describe one of these as your primary area of business.

Business Segments	Some Involvement	Primary Business
Other renewable energy (e.g. PV, wind, wood stoves, etc.)	☐	☐
Swimming pool sales and installation	☐	☐
Plumbing contractor	☐	☐
HVAC contractor	☐	☐
HVAC equipment manufacturer or distributor	☐	☐
Building contractor	☐	☐
Other building trades	☐	☐
Other	☐	☐

5. For purposes of industry profile generation, please check the appropriate month denoting your fiscal year-end.

☐ January ☐ February ☐ March ☐ April ☐ May ☐ June

☐ July ☐ August ☐ September ☐ October ☐ November ☐ December

2. Sales

6. In the following table, please report your total revenue earned from solar thermal activities and then provide the percentage of this revenue that was earned from export sales, and the percentage earned from sales to re-sellers located within Canada. For this table please include all types of revenue related to ST activities (e.g. product sales, service contracts, installation fees, consulting revenues).

Year	Total Sales Revenue from Solar Thermal Activities	Export Sales Revenue (%)	Sold to Domestic Re-sellers (%)
2002	$	%	%
2003	$	%	%
2004	$	%	%

ID No. [ ]
To be assigned during processing

7. Please report collector sales in two units, square metres and dollars, for the three years. If your business involved the sale of complete systems, or related services or components along with solar collectors, please report the total revenue earned for the sale, in the most appropriate column.

Year	Sales	Collector Type				
		Air		*Liquid*		
		Glazed	**Unglazed**	**Evacuated**	**Glazed**	**Unglazed**
2002	Collector area (m^2)					
	Revenue ($)					
2003	Collector area (m^2)					
	Revenue ($)					
2004	Collector area (m^2)					
	Revenue ($)					

8. For the calendar years 2003 and 2004, please provide a percentage distribution, by collector type, of dollar sales by application. If you where wholesaling the product to re-sellers, and are unaware of the final application, please report these shipments in the "unknown" category.

2003						
Sector	**Application**	**Collector Type**				
		Air		*Liquid*		
		Glazed	**Unglazed**	**Evacuated**	**Glazed**	**Unglazed**
Residential	Pool	%	%	%	%	%
	DHW	%	%	%	%	%
	Space	%	%	%	%	%
	Combined/other (includes hot tubs)	%	%	%	%	%
Industrial/ Commercial/ Institutional	Pool	%	%	%	%	%
	DHW	%	%	%	%	%
	Process heat	%	%	%	%	%
	Space heat	%	%	%	%	%
	Combined/other	%	%	%	%	%
Unknown/Wholesale		%	%	%	%	%
Total		**100%**	**100%**	**100%**	**100%**	**100%**

ID No. [ ]
To be assigned during processing

2004						
Sector	**Application**	**Collector Type**				
		Air		*Liquid*		
		Glazed	**Unglazed**	**Evacuated**	**Glazed**	**Unglazed**
Residential	Pool	%	%	%	%	%
	DHW	%	%	%	%	%
	Space	%	%	%	%	%
	Combined/other (includes hot tubs)	%	%	%	%	%
Industrial/ Commercial/ Institutional	Pool	%	%	%	%	%
	DHW	%	%	%	%	%
	Process heat	%	%	%	%	%
	Space heat	%	%	%	%	%
	Combined/other	%	%	%	%	%
Unknown/Wholesale		%	%	%	%	%
Total		**100%**	**100%**	**100%**	**100%**	**100%**

ID No. [ ]
To be assigned during processing

9. For the calendar years 2003 and 2004, please provide details on the geographic area to which the ST Collectors were shipped/sold. Please divide your sales by region within Canada. For sales outside Canada, please allocate export sales by global region of export.

Year	Domestic Sales			Export Sales		
	Region	ST Collector sales inside Canada		Global region of Export	ST Collector sales outside Canada	
		m^2	$		m^2	$
2003	Atlantic Provinces			United States		
	Ontario			Central-South America, Mexico, Caribbean		
	Quebec			Europe		
	Prairie Provinces			Asia, including Middle East		
	B. C			Africa		
	Northern			Australia, New Zealand, Oceania		
2004	Atlantic Provinces			United States		
	Ontario			Central-South America, Mexico, Caribbean		
	Quebec			Europe		
	Prairie Provinces			Asia, including Middle East		
	B. C			Africa		
	Northern			Australia, New Zealand, Oceania		

ID No. [ ]
To be assigned during processing

3. Source of Collectors

10. Please list your sources of ST collectors, including in-house manufacturing. For calculation purposes, use dollar value of ST collectors from all sources for the year as 100%. Use an additional sheet, if needed.

Year	Collector Source	Supplier Name	Supplier Location	% of total supply
2002	Manufactured In-house	n/a		
	Purchased Within Canada			
	Purchased Outside Canada			
			Total	100%
2003	Manufactured In-house	n/a		
	Purchased Within Canada			
	Purchased Outside Canada			
			Total	100%
2004	Manufactured In-house	n/a		
	Purchased Within Canada			
	Purchased Outside Canada			
			Total	100%

4. Trends & Perspectives

11. Compared to this year, does your organization expect more, less or about the same revenues in the ST collector and components sales and services area over the next 2 years?

    ☐ Remain the same

    ☐ Increase by _____% average per year

    ☐ Decrease by _____% average per year

12. The following table provides a list of issues pertaining to the solar thermal industry. Using the check boxes in the left hand columns, please rate your opinion on how effectively these issues are being addressed by governments. Similarly, using the check boxes in the right hand columns indicate the level of priority that should be accorded to these issues over the next three years.

Current Effectiveness				**Issue**	**Recommended Priority**			
Low	**Moderate**	**High**	**No Opinion**		**Low**	**Moderate**	**High**	**No opinion**
☐	☐	☐	☐	Product standards and certification	☐	☐	☐	☐
☐	☐	☐	☐	Codes and regulatory issues	☐	☐	☐	☐
☐	☐	☐	☐	Product research and development	☐	☐	☐	☐
☐	☐	☐	☐	Technology demonstration	☐	☐	☐	☐
☐	☐	☐	☐	Public education on solar thermal technology	☐	☐	☐	☐
☐	☐	☐	☐	Marketing & promotion	☐	☐	☐	☐
☐	☐	☐	☐	Tax policies for business users of solar	☐	☐	☐	☐
☐	☐	☐	☐	Tax policies for non-business users of solar	☐	☐	☐	☐
☐	☐	☐	☐	Work force training	☐	☐	☐	☐
☐	☐	☐	☐	Solar thermal purchase incentives	☐	☐	☐	☐
☐	☐	☐	☐	Government procurement of solar thermal	☐	☐	☐	☐

13. In the following table, please rate the extent to which each issue is important for the growth of the solar thermal industry.

Issue	Importance			
	Low	Moderate	High	No opinion
Product capital costs	☐	☐	☐	☐
System installation costs	☐	☐	☐	☐
System operating, maintenance and service costs	☐	☐	☐	☐
Collection and trend analysis of ST industry data	☐	☐	☐	☐
Refurbishment of older systems	☐	☐	☐	☐
Consumer access to products	☐	☐	☐	☐
Consumer access to after sales service	☐	☐	☐	☐
Availability of integrated products	☐	☐	☐	☐
Industry self-sufficiency	☐	☐	☐	☐
Current state of S/T product maturity	☐	☐	☐	☐
Access to venture capital and financing	☐	☐	☐	☐
Consumer access to financing	☐	☐	☐	☐
Implementation of a plan to meet the Kyoto targets	☐	☐	☐	☐

14. What do you feel is the single greatest threat to the future success of your solar thermal business?

15. In this question we are asking for your opinion, not verifiable statistics. For this question, please report on all active solar heating systems, by technology (liquid glazed, liquid un-glazed and air), that your firm has direct knowledge of (e.g. you installed it, serviced it, decommissioned it, etc.). For each period in the table, estimate the total number of square meters of collector surface in all systems that your firm has direct knowledge of, and then indicate the percentage (by square metres of collector surface) that you believe to be still operating at the end of 2004.

Systems with Liquid Collectors, Glazed						
Year of Original Installation	**Total Estimated Area (m²)**	**Still Operating at end of 2004**				
		0 – 24%	25 – 49%	50 – 74%	75 – 89%	90 – 100%
2000 to 2004		☐	☐	☐	☐	☐
1995 to 1999		☐	☐	☐	☐	☐
1990 to 1994		☐	☐	☐	☐	☐
1980 to 1989		☐	☐	☐	☐	☐
1970 to 1979		☐	☐	☐	☐	☐

Systems with Liquid Collectors, Un-glazed						
Year of Original Installation	**Total Estimated Area (m²)**	**Still Operating at end of 2004**				
		0 – 24%	25 – 49%	50 – 74%	75 – 89%	90 – 100%
2000 to 2004		☐	☐	☐	☐	☐
1995 to 1999		☐	☐	☐	☐	☐
1990 to 1994		☐	☐	☐	☐	☐
1980 to 1989		☐	☐	☐	☐	☐
1970 to 1979		☐	☐	☐	☐	☐

Systems with Air Collectors, Glazed and Un-glazed						
Year of Original Installation	**Total Estimated Area (m²)**	**Still Operating at end of 2004**				
		0 – 24%	25 – 49%	50 – 74%	75 – 89%	90 – 100%
2000 to 2004		☐	☐	☐	☐	☐
1995 to 1999		☐	☐	☐	☐	☐
1990 to 1994		☐	☐	☐	☐	☐
1980 to 1989		☐	☐	☐	☐	☐
1970 to 1979		☐	☐	☐	☐	☐

Instructions

Solar Thermal Collector Survey
Calendar Years: 2002, 2003 and 2004

General Instructions and Explanations

1. If your firm earns no revenue from solar thermal activities, please complete the company details section on page 1, write "no ST business" on it, and fax page 1 to SAIC Canada. Your company name will be removed from the survey distribution list for future years.
2. All responses should be by calendar year, not fiscal year.
3. All dollar values should exclude sales taxes.
4. All dollar values may be rounded off to the nearest thousand.
5. To determine the date a sale occurred, please use the date that you booked the revenue for the sale (e.g., the invoice date).
6. Although this survey covers three years (2002, 2003 & 2004), some questions do not cover all three years. This has been done to reduce the level of effort required to complete the survey.
7. This is intended as the first in a series of regular, annual surveys. Future surveys will request data for only a single year.

Instructions and Explanations Relating to Individual Questions

Q4 If you check the "other" category for either "some involvement" or "primary business", it is not necessary to indicate the nature of this business.

Q6 This is the only question that requests revenue data for purely service or other non-collector related sales.

Q7-10 If your business does not sell solar collectors, you may skip questions 7 through 10.

Q7 The revenue figures in this table should exclude any revenue that is not associated with a particular collector type (e.g. a study of various solar heating projects). Thus the total of all revenue values in this table may be lower than the total revenue reported in Q6.

Q8 Note that the values in each column must add to 100%, which should equate to the revenue reported by collector type in Q7.
If you sold collectors to a re-seller, please report by the location of the re-seller, not the ultimate destination of the products.

Q9
- Atlantic – Newfoundland, Nova Scotia, Prince Edward Island & New Brunswick
- Prairie – Manitoba, Saskatchewan & Alberta
- Northern – Yukon, North West Territories & Nunavut

Q10 Please note that this question is asking for the source of purchased, completed solar collectors, whether imported or purchased domestically. If you manufacture solar collectors, it is not necessary to report the source of the various materials.

Q15 This question concerns the current health of systems previously installed within Canada. If you have little knowledge of older systems, you may skip this question, or complete only the first line (for period 2000 to 2004) of the tables, as appropriate.

Inquiries

If you have questions about any facet of this survey, please direct them to the SAIC Canada employee identified on page 1 of the survey document.

Confidentiality Protocol:

Project Name: Solar Thermal Industry Survey

Version #: 2

Plan Date: January 7, 2005

SAIC Project Number: 10806.B.01

CM Number: 001712

Plan Sign-Off

Protocol Review by:	_____ Larry McClung	**Date:** _____
Protocol Audit by:	_____ Ken Donovan	**Date:** _____
Project Manager:	_____ Bill Wong	**Date:**_____

A. Protocol management plan

A-1 Project scope and requirements

This document defines the procedure for handling completed surveys and the data that they contain, after they are received by SAIC Canada (in paper form), and of any electronic or hardcopy documents derived from the survey documents. The primary purpose of this protocol is to ensure confidentiality of the data supplied by individual respondents.

A-2 Approach

Natural Resources Canada (as the commissioning agent), SAIC Canada (as the prime contractor), and Simhan Research Associates and CanSIA (as subcontractors) all recognize the absolute necessity of maintaining the confidentiality of data submitted by respondents to the solar thermal collector survey. This protocol, detailing how the data will be handled, has been developed to ensure that the strictest confidentiality is maintained throughout the data gathering and reporting process.

An essential element for ensuring confidentiality is the physical arrangement of the Ottawa area offices of SAIC Canada. SAIC Canada maintains two widely separated offices in the Ottawa area, at 335 River Road South and at 60 Queen Street. The River Road facility houses the staff of the Renewable Energy and Climate Change Program, who oversaw the development of the survey, and who will be involved in analysis and reporting of aggregate data, but who will have no access to sensitive data such as individual survey responses. The survey responses are to be sent directly to our Queen Street facility, where a small number of the staff have been specifically trained to handle the sensitive survey data, and deliver it to authorized staff of Simhan Research, an independent subcontractor who will analyze and aggregate the data into reports that contain no sensitive information. These reports will be the only survey data available to the staff of SAIC's Renewable Energy and Climate Change Program, to CanSIA staff, and to NRCan.

A-3 Definitions

A "completed survey" shall be considered any survey document (paper) received from a respondent that contains one or more answers, complete or partial, to any of the survey questions.

The "survey log" is a password-protected, electronic file that cross-references the survey respondent's administrative information with their assigned ID number. It resides on a computer at SAIC Canada's 60 Queen Street facility, and is backed up following standard procedures.

The "survey database" is a password-protected, electronic file containing all survey data. It resides on a computer at the offices of Simhan Research Associates, and is backed up following standard procedures.

The "secure file area" refers to a locked, restricted access filing facility located at SAIC Canada's 60 Queen Street facility.

A-4 Project team structure.

Completed surveys are to be handled only by persons specifically authorized in the following table ("authorized personnel"), and only for the purposes outlined within this document. No other person shall be permitted to handle or view any portion of the completed surveys.

Role	Personnel
Survey administrator	• Sandi Mish, SAIC Canada • Gerry Clermont, SAIC Canada
Survey assistant analyst	• Anna Mastilovic, SAIC Canada • Monica Hornof, SAIC Canada
Survey chief analyst	• Vasantha Narasimhan, Simhan Research Associates • Perfecto Vélez Macho, Simhan Research Associates
Protocol Auditor	• Ken Donovan, SAIC Canada

B. Permissions and Restrictions

1. Only the listed administrators and assistant analysts have permission to access or view the originals of the completed surveys.
2. Only the listed administrators and assistant analysts have permission to produce a photocopy of a completed survey, and only one photocopy of a completed survey shall exist at any time.
3. Only the listed administrators and assistant analysts have permission to access or view the survey log.
4. No hardcopy of the survey log shall be permitted, unless it is either filed in the secure area, or destroyed by the individual who created it, prior to the close of business on the day it was created.
5. Only listed administrators, assistant analysts and chief analysts are permitted to access or view any data from a single respondent, or any aggregate data that is from a sufficiently small sample that identification of data from individual respondents becomes a risk.
6. Only the listed chief analysts shall access the survey database.
7. All SAIC Canada employees who are members of the Renewable Energy and Climate Change Program are specifically prohibited from any access to sensitive survey data.
8. Similarly, all NRCan staff and all CanSIA staff are specifically prohibited from any access to sensitive survey data.
9. Notwithstanding any of the above, the auditor is permitted to access any and all documents judged necessary to verify compliance with this protocol.

C. Project operations plan.

C-1 Procedures during the survey process.

Step	Task Description	Responsibility
1	Receive and open completed surveys. Assign respondent ID number, and enter on every page of the survey original. Enter respondent's data into the survey log.	Administrator
2	Ensure that respondent's name and contact info appear only on page 1 of the original. Produce a single photocopy, omitting page 1. File the original document in the secure file area.	Administrator
3	Review the photocopy for completeness and readability.	Assistant Analyst
4	Issue acknowledgement of receipt to the respondent, requesting clarifications or additions, if necessary.	Assistant Analyst
5	Enter data into the database; produce and analyze preliminary reports.	Chief Analyst
6	Review data for consistency. Request assistant analysts to perform additional follow up with respondents, as necessary.	Chief Analyst
7	Request clarifications and/or additional data from respondents, as necessary.	Assistant Analyst
8	Once sufficient data is entered to ensure the confidentiality of individual respondents, produce consolidated reports to share with the full survey team.	Chief Analyst
9	Verify compliance with this protocol.	Auditor

C-2 Survey Wrap-up Procedures.

Step	Task Description	Responsibility
1	Make two electronic copies of the survey database (on CD or other suitable media) and delete all electronic versions of the survey database.	Chief Analyst
2	Return both copies of the survey database, along with all copies of completed surveys, to SAIC Canada's facility at 60 Queen Street.	Chief Analyst
3	Destroy the photocopies of all completed surveys. Record destruction in the survey log.	Assistant Analyst
4	Make two electronic copies (on CD or other suitable media), plus one hardcopy, of the survey log.	Administrator
5	File the copies of the survey database and the survey log in the secure filing area	Administrator
6	The survey auditor is to issue a report evaluating compliance with this protocol. This report will be included with the final project report.	Auditor
7	The original copies of the completed surveys, and the copies of the survey log and the survey database, are to be kept for two years after project completion, after which they will be destroyed. Originators to be informed of destruction of material.	Administrator

A6 Copy of the letter from the Honourable R. John Efford

The following page provides a copy of the letter mailed to all survey recipients, from the Minister of Natural Resources Canada. The actual letter was mailed in bilingual format.

Minister
of Natural Resources Canada

Ministre
des Ressources naturelles Canada

Ottawa, Canada K1A 0E4

FEB 1 1 2005

Dear prospective survey respondent:

I am writing to request your support for a comprehensive survey of solar collectors, industries and markets in Canada.

My department is partnering with the Canadian Solar Industries Association (CanSIA) to document data on installed collector areas and to ascertain solar thermal energy supply trends.

As you may recall, Natural Resources Canada (NRCan) conducted a survey of installed solar collector areas in the summer of 2002. Its results were published in the annual market development reports of the International Energy Agency for 2000 and 2001. Officials of NRCan's Renewable Energy Deployment Initiative (REDI) in conjunction with CanSIA have determined that there is a need to update and expand this database to facilitate informed decision-making.

The proposed survey represents one of the Government of Canada's investments in solar infrastructure and capacity building. The consultant team in charge of this survey will ensure the required confidentiality. NRCan and CanSIA will access only aggregated data. I encourage you to collaborate with REDI's officials and members of CanSIA's project advisory panel.

Again, thank you in advance for your cooperation in this joint undertaking.

Yours sincerely,

R. John Efford

The Honourable R. John Efford, P.C., M.P.

Canada

APPENDIX B – Summary of Statistical Information from Alternate Sources and Estimating the Data Capture Rate

B1 Historical Canadian Data

From 1979 and 1985, there was an annual survey of the solar thermal industry in Canada, providing sound statistical data. More recently, NRCan staff conducted an in-house survey of the solar thermal market in Canada, covering the period from 1995 through 2001. NRCan's analysis was based on:

- An electronic survey of screened industry members;
- Estimates based on market statistics available from the pool and spa industry;
- REDI and other records of major installations within Canada, and;
- Data from key international sources.

A summary of NRCan's results is shown in Table 9. Unfortunately, for the years between these two surveys (1986 through 1994) there is very little data available, and certainly no consistent source of data.

Table 9: Solar thermal collector area installed in Canada, 1995 - 2001 (m²)

	Liquid Based			Air Based		Total
	Unglazed	Glazed	Evacuated	Unglazed	Glazed	
1995	17,000	471	51	7,491	0	**25,013**
1996	15,000	486	20	4,858	0	**20,364**
1997	17,000	303	52	658	0	**18,013**
1998	17,000	327	29	3,012	0	**20,368**
1999	25,000	234	30	1,982	0	**27,246**
2000	27,000	626	161	3,366	0	**31,153**
2001	23,000	997	166	4,112	0	**28,275**
Total	**141,000**	**3,444**	**509**	**25,479**	**0**	**170,432**
Avg./year	20,143	492	73	3,640	0	24,348
Percent	*83%*	*2%*	*0.3%*	*15%*	*0%*	*100%*

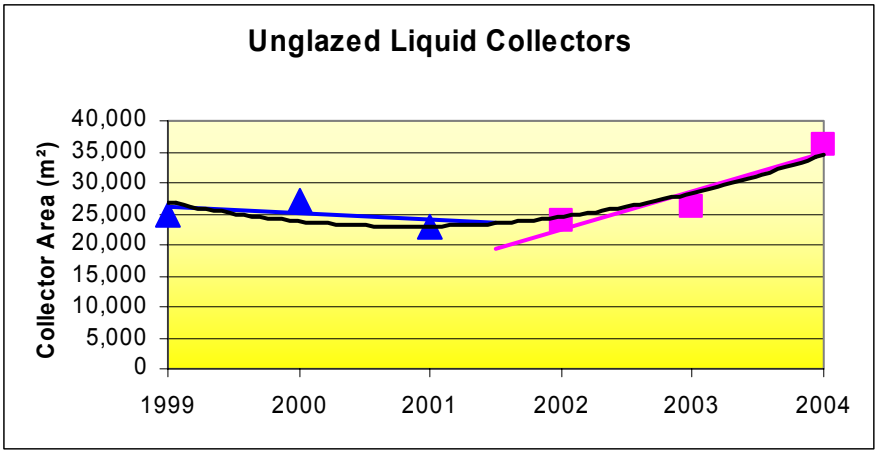
Source: Omboli, E., McClenahan, D., 2002. NRCan in-house survey of solar collectors for 1995-2001

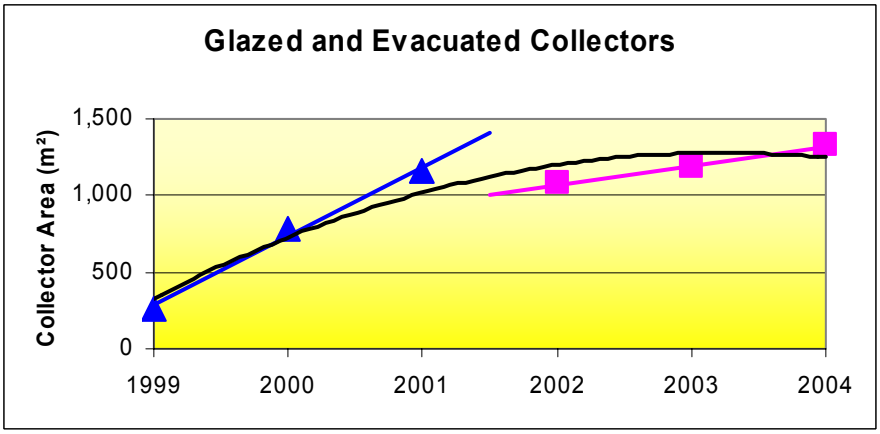
There is no overlap in years between the NRCan survey in Table 9, and the current survey data. However, if both the NRCan data and the survey data are accurate, one would expect to see continuity between the two sets of data. If either, or both, data sets are in error or incomplete, one would expect to see discontinuities at the 2001/2002 interface between them. Figure 13 shows plots of the most recent three years of the NRCan analysis (1999 – 2001), along with the three years covered by this survey (2002 – 2004). There are three individual charts, one for each major collector type (with glazed and evacuated tube combined, for reasons of confidentiality). Actual data points are marked, along with linear trend lines.

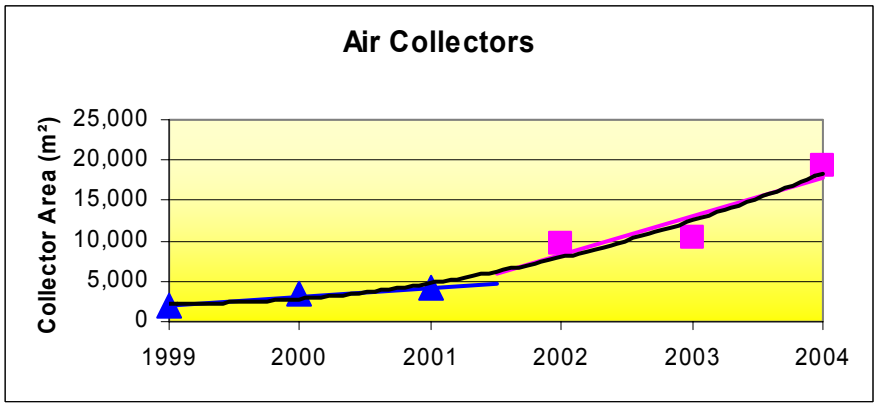
As can be seen from the plots, there are only small discontinuities between the current survey data and the previously reported data. The most troubling discontinuity is that in the glazed plus evacuated graph, which shows a slight drop from 2001 to 2002, combined with a change from a period of rapid growth to a period of slower growth (although still robust, at roughly 10% per year).

Despite this anomaly, the generally smooth transition between the two surveys gives confidence that both surveys have yielded reliable data.

Figure 13: Continuity between NRCan survey and current survey







B2 Energy Information Administration (US)

The Energy Information Administration (EIA) is a statistical agency of the U.S. Department of Energy. They provide policy-independent data, forecasts, and analyses to promote sound policy making, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment. The EIA conducts an annual survey of solar thermal collector manufacturers and importers. This survey is mandatory for "companies (1) that manufactured and shipped (including exporting) solar thermal collectors and/or (2) that imported solar thermal collectors"* into the U.S. The survey period is always one calendar year. As a result, consistent statistics are available on the U.S. solar collector industry – including U.S. exports to Canada - for every year since 1994.

* Form EIA-63A (12/02), "Instructions for form EIA-63A, Annual Solar Thermal Collector Manufacturers Survey", Energy Information Administration, U.S. DOE., 2004

Figure 14 shows American exports of solar collectors into Canada, as reported by the EIA in their annual reports. Although the year-by-year variances are large, it does show a growth trend at an annual average rate of 9%. However, it is also clear that, for the most recent five-year period (1999 – 2003), the average annual Canadian imports have "stabilised" at approximately 21,250 m² (although significant year-to-year variations remain). During this same five-year period, Canada has accounted for 38% of all solar collector exports from the U.S.

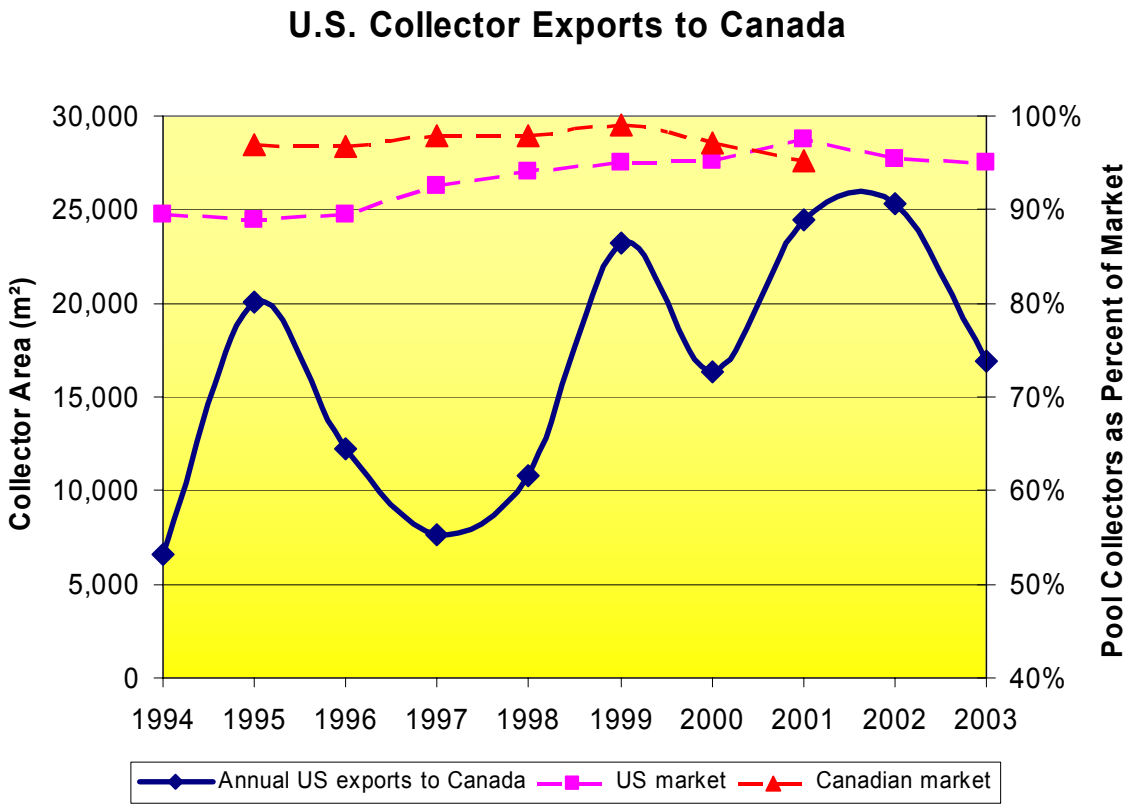


Figure 14: US exports to Canada (10 year history)

The chart also shows that low temperature, unglazed pool collectors constitute well over 90% of the total market for liquid-type solar collectors. (This excludes Canada's healthy market in domestically manufactured air collectors). Thus, although the EIA does not provide a breakdown of exports by collector type, it is reasonable to assume that virtually all of the solar collectors that Canada has imported from the US over the past ten years have been unglazed pool collectors.

In comparing U.S. export data with Canadian shipment data, it should be noted that collectors may be reported in different years, since collectors may be shipped across the border in one year (U.S. report), but not shipped to the end customer until the following year (Canadian report). Given that year-by-year discrepancies may exist, there should be a strong correlation between reported U.S. exports into Canada, and reported Canadian sales (of unglazed pool collectors). As noted above, from 1999 to 2003 the U.S. has exported 21,250 m² per year of solar collectors to Canada. Over this same period, Canada has reported average sales of unglazed liquid collectors of 21,900 m². These values are close to

each other – so close that they imply that Canada's domestic manufacturers of unglazed collectors produce only 650 m² of product annually (or that Canada is importing other types of solar collectors from the U.S.). A more palatable – and more likely – explanation is that Canada has been consistently under-reporting sales of unglazed solar pool collectors for several years. This could be an artefact of the methodology followed in the years 1995 – 2001. During those years, an estimate of pool collector area was generated by experts within the Canadian pool and spa sales and installation industries, and then reviewed by solar energy experts. This methodology would have a high probability of capturing most of the solar pool heaters that were sold coincident with a new pool, or those aftermarket solar heaters sold by pool and spa distributors. However, this methodology could easily miss aftermarket sales by companies whose primary business is solar heating (or anything else outside the pool and spa industry). This would be particularly true if these companies purchased imported solar collectors, or if they followed a supply chain separate from most pool equipment. Some justification for this explanation is found in anecdotal comments that it can be difficult to locate a retail supplier/installer of aftermarket solar pool heaters from among local pool equipment suppliers.

An alternative (or additional) possible explanation for consistent under-reporting of solar pool collectors in recent years is that, in the absence of direct quantities, the analysis followed too conservative a path. The pool and spa experts may have under-estimated revenue, as solar heaters are not a key component of their industry. Solar industry experts could then have used a conservative method to convert these revenue estimates into total m² of collectors.

B3 Major Canadian Solar Projects

Information on many major solar heating installations in Canada are publicly available from a variety of sources, including suppliers' and purchasers' websites, press releases, industry publications, and funding agency data, where outside funding has been used. Since 1998 the Renewable Energy Deployment Initiative (REDI), a program of Natural Resources Canada, has provided funding to dozens of solar thermal projects in Canada, including many of the larger installations of various collector types. REDI has graciously allowed us to review summary data on over 150 installations that they have supported between 1998 and 2003. Table 10 is a summary of collector area, by type, in many larger installations; most of these systems received support from REDI, although the list data has been augmented by other known installations that did not receive support from REDI.

Table 10: Collector area in large Canadian installations*

	Liquid Based			Air Based		Total
	Unglazed	Glazed	Evacuated	Unglazed	Glazed	
1998	--	71	--	2,044	--	**2,115**
1999	89	120	--	516	--	**725**
2000	334	87	30	2,987	--	**3,438**
2001	308	145	48	2,938	--	**3,439**
2002	431	303	25	7,054	--	**7,813**
2003	750	1,198	4	11,335	--	**13,287**
Total	**1,912**	**1,924**	**107**	**26,874**	**--**	**30,817**
Avg./year	319	321	18	4,479	--	5,136
Percent	*6%*	*6%*	*0.3%*	*87%*	*--*	*100%*

The same caution applies to this data, in that the year in this table may not correspond exactly to the year that shipments are reported in the survey, although care was taken to ensure the best correlation possible. With this caution, Table 10 should provide minimum data points for the Canadian solar thermal installations. It should be noted that value of the data varies substantially with collector type. By their nature, most unglazed air collector installations are fairly large, so are likely to become public knowledge, and are likely to qualify for support from REDI. Thus, the table should capture a fairly high percentage of all installations. Conversely, most unglazed liquid collectors are used in small systems, for heating pools at private homes. These types of systems do not qualify for REDI support, and there are few other mechanisms for these systems to become public knowledge. Thus, this table can be assumed to capture only a small percentage of installations of liquid, unglazed collectors.

B4 Estimated Data Capture Rate

Data Capture Rate: Air Collectors

The solar air heating industry, specifically those collectors using unglazed air collectors, is known to be dominated by one large Canadian manufacturer of collectors. There are some smaller businesses involved, including some Canadian distributors/dealers for the manufacturer. Most installations of unglazed air collectors are larger systems in the I/C/I sector, and thus a high percentage of installations have received REDI funding, or are otherwise known publicly, and thus are included in our database of large Canadian

* Most of the data in this table was provided by Bruce Sibbitt of NRCan, from installations receiving financial support from the Renewable Energy Deployment Initiative (REDI).

installations (see Table 10). By comparing survey results for 2002 and 2003 (9,663 and 10,381 m²) with known installations in the same years (7,054 and 11,335 m²), we conclude either that the dominant manufacturer has completed the survey, or that a fairly complete group of dealers of this product have completed this survey. In either case, we must assume that we have effectively captured 100% of the data from this sector of the solar thermal industry.

Data Capture Rate: Unglazed Liquid Collectors

The bulk of unglazed liquid collectors are installed in residential pool heating systems, and thus only a very small fraction of these collectors are included in our database of large systems. Fortunately, there are two other sources of data that we can use for comparison.

Pool & Spa Marketing (PSM) magazine publishes an annual report summarizing key statistics from the Canadian pool industry, including data on solar pool heaters. The data is provided only as an estimate of retail dollar value of sales, with no equipment or geographic breakdown. The data is gathered primarily via telephone interviews with key industry members. Neither the completeness of the data nor the method of converting raw data into retail sales estimates is known. Nor were we able to obtain a complete set of recent reports, but only 2001 ($2.5 million) and 2003 ($4.0 million). However, this data does have the benefit of having been collected and analysed by the same individual, presumably in a consistent manner, over a number of years.

To convert the PSM data to square meters of collectors, it was necessary to derive a method for converting cost to collector area. To accomplish this conversion, we used a factor of $137.40/m². This factor was derived by assuming that typical installation with the following characteristics:

25 m²	collector area per system
$2,125	collector cost, including fasteners & couplings ($85/m²)
$ 650	cost of automatic controller and other system components
$ 100	for plastic pipe and fittings
$ 560	installation labour (16 hours @ $35/hour)
$3,435	total system cost, installed

The retail prices of collectors, controllers and other solar equipment came from price lists current during 2004. The additional fittings and labour estimates were derived by interviewing installers.

Applying the $137.40/m² factor to the $4.0 million sales estimate leads to an installed collector area of 29,112 m². Comparing this value to the 2003 survey result of 20,678 m² leads to an estimated data capture rate of 71%.

The second data set used as input to estimating the data capture rate in this sector is the annual survey data from the U.S. Energy Information Administration. For 2002 and 2003, the EIA survey reported shipping 25,284 and 16,886 m² of collectors into Canada, which we

can assume consist almost entirely of unglazed liquid collectors. In the survey results, no respondents admitted importing unglazed liquid collectors. Therefore, as a minimum, we can assume that total shipments for these two years are the sum of the survey results and the reported US exports to Canada.

Table 11: Unglazed collector imports from US

	Survey	EIA Report	Sum	Derived Data Capture Rate
2002	17,956	25,284	43,240	42%
2003	20,678	16,886	37,564	55%

In addition to the issues discussed in section B2, there is a significant complicating factor in the above analysis. At least one Canadian-based company selling unglazed liquid collectors (Techno-Solis), has their manufacturing plant located in the U.S., Thus the U.S. office would be expected to respond to the EIA survey as exporting these to Canada, but the Canadian office may have reported these same collectors as "manufactured in-house". Since confidentiality concerns preclude the analysts from knowing who has responded to the survey, this possibility can be neither confirmed nor ruled out.

In summary, knowing that:

- this survey did not capture all of the "known" major solar businesses in Canada;
- having general confidence in the EIA data (with the proviso that the "year" in the EIA survey and this survey may differ);
- being aware of persistent, anecdotal concerns that the PSM data has historically underestimated the Canadian solar pool heating market, and;
- wishing to be conservative in estimating the industry sales;

we have estimated our data capture rate for this industry segment at 50%.

Data Capture Rate: Glazed liquid and Evacuated Collectors

Estimating the data capture rate for this segment of the industry is the most problematical. This segment has the highest number of domestic manufacturers and is used in widely varying applications. It is also likely that there are both significant imports and exports of these collectors. The only useful external data source is the database of large Canadian installations (Table 10), and this is primarily useful only in establishing minimal levels, as it is known that a very significant number of these solar collectors are installed in residential domestic water heating systems, and thus would not be found in this database. Even then, the mismatch between the survey year and the year reported in this database is probably higher than for any of the other external sources we have used.

Combining 2002 and 2003, the database of large installations yields 1,530 m² of liquid glazed and evacuated collectors. The corresponding figure from the survey is 1,648 m². The closeness of these two values does provide us with confidence that the survey has captured a substantial portion – likely even a majority – of the data available, but it does not lead us to conclude that the survey has a data capture rate near 100%.

In the final analysis, there is no procedure for establishing an accurate estimate of the data capture rate. Our estimate of the data capture rate is 60%, based on:

- We received valid, completed surveys from nine businesses on our list of fourteen major solar businesses (64%) – ten of whom are believed to be active in this sector.
- The probability that we have captured a majority of the collector shipments, based on a comparison with known large installations.
- Our desire to be conservative in estimating data that was not directly captured by the survey.

APPENDIX C – Estimating the Operating Base of Solar Thermal Systems in Canada

C1 Background

To properly calculate avoided GHG emissions due to solar thermal systems, it is necessary to estimate the number, size and performance of all operating solar heating system within Canada. Obviously, understanding the precise size and performance of every system in Canada is not achievable, so the immediate goal is to estimate the total collector area, by type, in all operating systems in Canada. Based on the collector type, generalized estimates can be made of system performance.

In principle the task of estimating the quantity of solar collectors operating in a given year is straightforward: simply add new collectors that went into service, subtract any collectors that went out of service during the year, and make a net change to the value from the previous year. Although this survey process has generated estimates for new collectors going into service in 2002, 2003 and 2004, there exists no good estimate of how many collectors were in service when this period began, nor is there a generally accepted methodology for estimating how many solar collectors are removed from service in a given year. The methodology described in the following section was developed to provide reasonable estimates of the operational base in any given (recent) year. As such, it was necessary to complete two tasks:

1. Create a history of all new collector sales and installations in Canada going back at least 20 years, and;

2. Estimate a useful life for all collector types and/or applications.

C2 History of solar collector sales in Canada

Between 1979 and 1985 the Canadian Solar Industries Association (CSIA) was contracted by Energy Mines and Resources (the predecessor to Natural Resources Canada) to carry out annual surveys of the solar thermal industry. This data is reported both in the survey reports[*], and in the *Energy in Canada Handbooks*[†] from this period. Although no survey was conducted covering 1986, data for this year is reported in the 1987 Handbook, with a note that it was provided as an estimate from CSIA.

During the 1986 – 1987 period, the federal government terminated the various programs and subsidies that promoted the adoption of solar energy in Canada. The last program, for solar DHW systems, ended in March 1987. As a result, the industry suffered a sales collapse, and there was little official interest in the sector. Annual surveys ceased, and no other form of reliable data on industry sales replaced them.

Throughout the 1990's, the industry slowly rebuilt itself. In 2001 NRCan carried out an in-house survey of the industry, and provided estimates of collector annual sales for the period

[*] CSIA survey report, 1985
[†] Energy in Canada Handbooks for 1985, 1986, 1987 & 1988.

of 1995 – 2001; thus, reliable data is available for this period. However, there is a gap of eight years, from 1987 through 1994, during which no reliable data is available.

The following sections of this report summarize data from the early period (1979 – 1986), and from the recent period (1995 – 2001), and then provide a methodology for estimating sales during the intervening period (1987 – 1994), to build a complete record of sales estimates for the full twenty-three year period.

Estimated sales from 1979 - 1986

Data for the 1979 - 1986 period is derived from two sources – from the 1985 Survey Report (which had a recap of annual sales back to 1979) and the Energy in Canada 1987 Handbook (published by EMR). The surveying data fields in the period of 1979-85 do not correspond to the current methodology of collector type as shown in the below table.

1979-1985 CSIA Surveys	**Current Methodology**
• Pool Collectors	• Glazed water, unglazed water
• Liquid Flat Plate	• Glazed water
• Air and Evacuated Tube	• Glazed air, unglazed air, evacuated tube water
• Domestic Hot Water	• Glazed water

To obtain data points using the current methodology from the previous data we have made the following assumptions

1979-1985 CSIA Surveys	**Current Reporting Method**
• Pool Collectors	• Unglazed water
• Air and Evacuated Tube	• 50% evacuated tube water, and 50% glazed air (note that the first unglazed air was not installed until 1989, after the close of this period)
• Liquid Flat Plate + Domestic Hot Water	• Glazed water

The CSIA Survey Reports had a number of significant gaps in annual collector sales due to reasons of confidentiality (low number of respondents). The years in which data was not reported are:

Pool collectors – 1982, 1984, 1985

Air and evacuated tube – 1982, 1983, 1984, 1985

The Energy in Canada 1987 Handbook presents complete data for those years – it is uncertain how these numbers were obtained. Also the Handbook data is shown in a different

format than the survey data - by application (pools, commercial/industrial, and SDHW) rather than by collector type. It was possible to derive data from the missing air and evacuated tube sector, as the CSIA surveys had complete annual data for liquid flat plate, therefore for the missing years we can use the equation: *Air and Evacuated Tube = commercial/industrial sales – Liquid flat plate*. When this calculation is used the date table looks like below.

Table 12: Comparison of early sales of solar collectors

Year	Liquid Flat Plate (CSIA)	Commercial/ Industrial (Handbook)	Air and Evacuated	
			Derived	CSIA Report
1979	5,064	6,043	979	979
1980	6,215	8,444	2,229	2,229
1981	15,600	20,272	4,672	4,672
1982	20,167	23,980	3,813	0
1983	14,538	14,538	0	0
1984	10,882	10,882	0	0
1985	9,543	9,543	0	0

It appears that the Handbook had the missing data for the pool sector, but not the data for the air and evacuated tube data fields (except for 1982). The Handbook did not report this shortfall and thus may have provided misleading sales figures for years of 1983, 1984, and 1985.

The result of this analysis, restated in the same collector-type categories used in current reporting, is shown in Table 13.

It is instructive to note that there is no mention of solar sales in the 1988 Handbook; however the 1989-90 Handbook estimated that there were 600,000 m² of solar collectors installed in Canada by the end of 1988. Since the total of all collector sales from 1979 – 1986 is 598,115 m², it can be assumed that collector sales in both 1987 and 1988 were extremely low, compared to previous years (although the Handbook makes no mention of a sales collapse).

Table 13: Solar collector sales in m², 1979 - 1986 (restated in current categories)

	Liquid Based			Air Based		Total
	Unglazed	Glazed	Evacuated	Unglazed	Glazed	
1979	14,462	5,685	490	0	490	**21,127**
1980	37,881	6,997	1,115	0	1,115	**47,108**
1981	71,743	21,859	2,336	0	2,336	**98,274**
1982	36,500	23,012	1,907	0	1,907	**63,326**
1983	48,455	27,012	0	0	0	**75,467**
1984	71,761	23,839	0	0	0	**95,600**
1985	70,357	27,856	0	0	0	**98,213**
1986	70,000	29,000	0	0	0	**99,000**
Total	**421,159**	**165,260**	**5,848**	**0**	**5,848**	**598,115**

Estimated sales from 1995 – 2001

Estimated solar collector sales for this period were previously provided as Table 9, from NRCan's in-house survey. For ease of reference, this table is repeated here, as Table 14. As previously stated, NRCan staff collected sales values for all collector types - except unglazed liquid - via an in-house telephone survey of key industry members. Data for the unglazed liquid (pool type) collectors were derived from total solar pool heater revenue data provided by "Pool & Spa Marketing" magazine in their annual market summary reports*. NRCan obtained these revenue figures, and then consulted with CanSIA to determine an appropriate factor for converting to collector area.

* Pool & Spa Marketing annual market reports, 1995 - 2001

Table 14: Solar collector sales in m², 1995 – 2001

	Liquid Based			Air Based		Total
	Unglazed	Glazed	Evacuated	Unglazed	Glazed	
1995	17,000	471	51	7,491	0	**25,013**
1996	15,000	486	20	4,858	0	**20,364**
1997	17,000	303	52	658	0	**18,013**
1998	17,000	327	29	3,012	0	**20,368**
1999	25,000	234	30	1,982	0	**27,246**
2000	27,000	626	161	3,366	0	**31,153**
2001	23,000	997	166	4,112	0	**28,275**
Total	**141,000**	**3,444**	**509**	**25,479**	**0**	**170,432**

It is important to note that the various government deployment programs for solar thermal systems ended in the period of 1986-1987 (the last program was for solar DHW systems which ended in March 1987). Between 1986 and 1988 the solar industry experienced a collapse of sales.

Estimated Sales for 1987-1994

With no reliable records of collector sales for this eight-year period, it has been necessary to derive sales estimates. A number of individuals* who had been in the solar industry during this period were contacted and personally interviewed to obtain their opinions on the sales profile during this period. Based on their comments, annual sales estimates for all four collector types (excluding glazed air, for which there were no known sales during this period) were calculated. Each of the four collector types was evaluated separately; the calculation methods, and the reasoning behind them, are given in the following sections. The results of these calculations are provided in Table 15.

Unglazed Water

Residential solar pool heating did not experience as significant a drop in sales as the other solar thermal technologies, as there had been no government deployment programs for residential systems in the 1980's. Sales did drop over a period of years, and appear to have bottomed out in 1990. Sales thereafter increased slowly but steadily (at around 10% a year). There was a small surge of sales in the mid 1990's due to hot summers that were experienced. Some industry members did comment that the annual sales previously reported to the IEA for the period 1995-2001 (see Table 14) are low compared to their own

* Individuals contacted were Andy McKegney (SolarOntario.com), Dan Takahashi (Enersol), John Hollick (Conserval), Bob Swartman (Solcan), Peter Allen (Thermodynamics) and Doug McClenahan (NRCan)

estimates. However, no adjustments have been made to our estimates in response to this comment.

To estimate the missing years, sales were calculated backwards from the 1995-reported number, at an annual growth of 10% through to 1990. Sales were calculated forwards from the 1987 data, using an average annual decrease to meet the calculated 1990 number.

Glazed Water

Sales of glazed solar water systems plummeted after the deployment programs ended; within two years the estimated sales were under 200 m² per year. Sales have been growing steadily since the early 1990's.

To estimate the missing years, sales were calculated backwards from the 1995-reported number at an annual growth of 10% through to 1990. Sales were calculated forwards from the 1987 data, using an average annual decrease to meet the 1990 number.

Evacuated Tube

Sales of evacuated tube systems were not reported during the period of 1983 - 1987 and the numbers reported from 1995 on have been very low.

To estimate the missing years, sales were calculated backwards from the 1995-reported number, at an annual growth of 10% through to 1990.

Unglazed Air

Unglazed air systems were introduced into the Canadian market in 1989 and a number of sales were made to replace older, glazed systems. However, a recession in the early 1990's (and the resulting drop in the construction of commercial buildings) contributed to low sales for this technology through 1994. High sales in 1995 and 1996 were the result of a single large installation.

To estimate the missing years, rough estimates were provided by John Hollick of Conserval Engineering, the one company responsible for the vast majority of sales of this technology during this period.

Table 15: Solar collector sales in m², 1987 – 1994

	Liquid Based			Air Based		Total
	Unglazed	Glazed	Evacuated	Unglazed	Glazed	
1987	55,000	1,000	0	0	0	**56,000**
1988	40,000	500	0	0	0	**40,500**
1989	25,000	266	29	2,000	0	**27,295**
1990	10,556	292	32	1,000	0	**11,880**
1991	11,611	322	35	500	0	**12,468**
1992	12,772	354	38	500	0	**13,664**
1993	14,050	389	42	500	0	**14,981**
1994	15,455	428	46	1,000	0	**16,929**
Total	**184,444**	**3,551**	**222**	**5,500**	**0**	**193,717**

C3 System Life Expectancy

The issue of system life expectancy must be addressed before reasonable estimates of annual energy production or avoided GHG emissions can be made, as these require knowledge of the total number of systems in operation in a given year. The IEA currently does not take into account system life expectancy when reporting capacity or avoided GHG values. However, there is a proposal that the IEA begin using a life expectancy of 25 years for all solar thermal systems.

In Canada, due to the sudden collapse of the industry in the mid-1980's, the issue of accounting for life expectancy is a critical one for estimating the current installed capacity. The collapse resulted in a lack of qualified maintenance personnel and replacement parts, as well as a loss of interest in doing the required maintenance, which resulted in premature failures. This problem was particularly acute in the glazed water systems that had been part of the government deployment programs. As well, some products in the 1980's were rushed to market prematurely, resulting in a higher incidence of premature failures.

In the individual interviews with long-time industry members, there was a fairly consistent consensus that systems installed during the 1980's should not be included in installed capacity numbers, as few from this period were still operating after fifteen years.

A brief internet search was conducted to provide an estimate of the expected life for systems installed currently; these results are also presented in table 16.

For the glazed, unglazed and evacuated water collectors, which were particularly hard hit in terms of lack of availability of skilled maintenance and replacement parts after the industry collapse of the late 1980's, it was decided to use a life expectancy of 15 years for all

systems installed in 1989 and earlier, and 20 years for all systems installed in 1990 or later. More study is required to validate these life expectancy estimates, work which is beyond the scope of this study. These values have been used in the operating capacity calculations

Table 16: System life expectancy, by collector type

Technology	Range of Life of Systems in Current Operation	Value Used for Calculating Capacity	Range of Current Life Expectancies
Unglazed Water	10-20 years	15/20 years	20-30 years
Glazed Water	20-25 years	15/20 years	20-35 years
Evacuated Tube	15-20 years	15/20 years	15-25 years
Unglazed Air	30-40 years	30 years	30-40 years
Glazed Air	10 years	10 years	Not found

C4 Operating Capacity of Solar Collectors in Canada

By summing the annual sales figures found in Table 13, Table 14 and Table 15, along with the data for years 2002 – 2004 from this survey (Table 3), and then by applying system life expectancies, we are able to calculate the operational capacity of solar collectors in any given year. Figure 15, shows charts of how Canada's installed capacity of solar collectors has varied over time, using different assumptions for collector life expectancy. Using the middle chart (15-year life expectancy of early systems; 20-year for systems installed since 1990), we can see that the operating capacity declined steeply from 1993 (769,000 m²) to 2003 (340,000 m²), and began climbing again only in 2004 (368,000 m²). While the precise timing and depth of the minimum operating capacity are subject to debate, the settling of which is beyond the scope of this report, it is likely that this valley is in the past, and that Canada has now entered a phase where the operating capacity is increasing fairly rapidly. Given current economic and environmental considerations in the energy sector, it is likely that this growth phase will be long and sustained.

Figure 15: Effect of average life on installed capacity

The three charts at right show the affect of assuming different average life expectancies for the solar collectors.

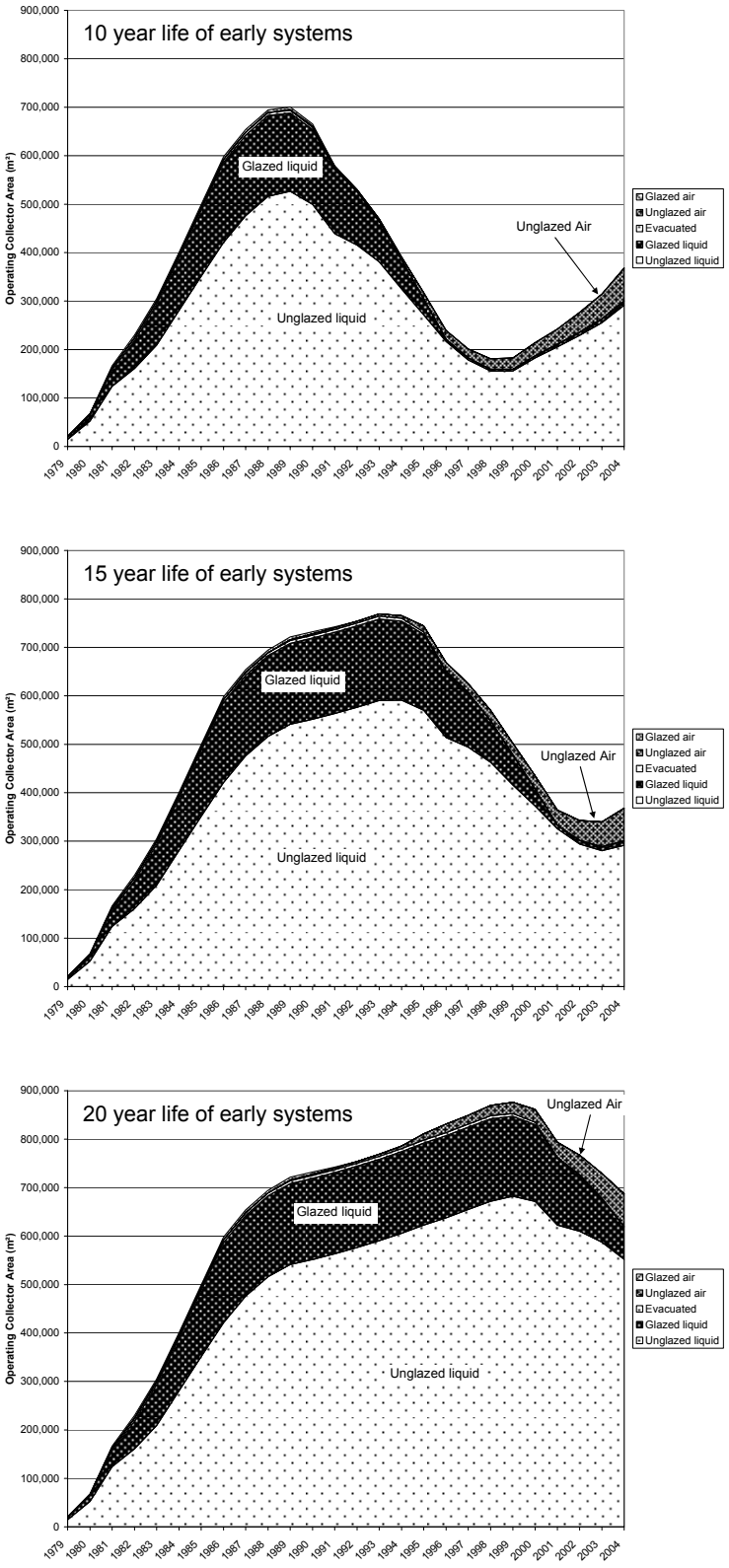
In the upper chart, solar collectors sold prior to 1990 are assumed to have a 10-year average life, with those sold in 1990 and later having a 20 year life.

In the middle chart, the early solar collectors are assumed to have an average 15-year life expectancy, with those sold in 1990 and later having a 20 year life

In the lower chart, all solar collectors are assumed to have a 20-year life expectancy.

With either of the 10 or 15-year assumptions, the current (2004) operating systems include 368,000 m² of solar collectors, and the installed capacity is rising. If a 20-year life expectancy is assumed for the earliest collectors, the current installed base is much greater, at 687,000 m², but it is still declining.

For the purposes of calculating avoided GHG emissions due to solar thermal systems, the assumption that early systems had a 15-year life expectancy was used. Further study is required to verify the validity of this assumption.



C5 Conclusions

Correctly estimating the operational life of older solar heating systems, particularly those installed in the 1980's, is essential to properly estimating the total operating capacity of solar collectors in Canada, and thus reporting accurate capacity and avoided GHG emission values. Using different assumptions from the ones used in this report can lead to radically different vales. Unfortunately, a detailed analysis of the life expectancy of older systems was beyond the scope of this survey; more study is required to validate the 15 year average life expectancy used in this analysis.

Evacuated and glazed air collectors have never been any more than a very small slice of the Canadian solar collector market, in terms of collector area. However, their high value per unit area ensures that they make a significant contribution to the solar thermal business in Canada.

To allow easier comparison with other types of generators, the IEA has recently recommended switching all reporting of solar thermal system capacity from collector area (m^2) to energy capacity (MW), using a conversion factor of 0.7 kW per square meter of collector area (for all collector types). Using this factor, the combined capacity of operating solar thermal system in Canada during 2004 was 258 MW. This is the same capacity that Canada had twenty years ago.

Since the IEA has only limited data on unglazed solar air heaters, and since they are such a substantial component of the Canadian market, it would be appropriate to evaluate the applicability of the recommended 0.7 kW/m^2 conversion factor. However, in this report this factor has been used, without further evaluation.