# ENERGY ANALYSIS DESIGN REPORT
# APU 3, 4 AND 5 SOLARWALL SOLAR AIR HEATING RETROFIT
## WHITEHORSE GENERAL HOSPITAL
## WHITEHORSE, YT

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# 1.0 Introduction

Reducing energy use for heating in the Canadian north has always been of prime importance due to the very long and severe heating seasons and high-energy costs. While there are many systems that have been used in the past many have failed or performed very poorly. Due to these past problems designers and contractors have often been reticent in installing energy efficiency measures (EEMs), especially on marginal payback applications, due to concerns over their long-term viability. Recently the use of energy efficiency measures has become globally more important due to higher energy costs and concerns over the impact of high-energy consumption on the environment. With this new demand for energy reduction and recovery systems more efficient and reliable equipment has become available making marginal payback systems more attractive.

One system that is now available is the Solarwall passive air solar air heating system. The Solarwall passive solar heating system is used to preheat ventilation air to reduce ventilation heating energy. To preheat the ventilation air the Solarwall utilizes renewable solar energy through an essentially passive system. While there is great potential energy available in solar energy the limitations of utilizing it for ventilation preheat have traditionally made payback on installations in Northern climates difficult. With higher energy costs, however, the potential for this system has vastly improved.

Within the existing Whitehorse General Hospital there are at this time existing mechanical energy reduction and recovery systems. APU 1 and 2, the main treatment area units are fitted with enthalpy wheel energy recovery units capable of operating efficiencies approaching 70%, reducing ventilation preheat requirements for these units. The majority of the AHU and certain hydronic systems are variable flow allowing reduction in standby losses and pumping/fan operating costs.

Other potentially viable systems were not, however, included in the original systems most likely due to poor payback potential based on energy costs at the time of design. With the increase in energy costs certain systems may be now more viable. Most recently a secondary sales electric LPS boiler retrofit has been initiated with construction scheduled for spring 2003. This system results in a reduction in total energy consumption due to an improvement in system efficiency, a reduction in operating costs due to the low rate of secondary sales energy and a reduction in greenhouse gas production due to the use of hydroelectric energy instead of fuel oil heating.

In addition other areas of potential energy reduction were reviewed in a preliminary investigation completed by Northern Climate Engineering in March 2002. Most significantly, for this analysis, was the use of a Solarwall passive solar air heating system to preheat the ventilation air for APU 3, 4 and 5 located in the new building Fan Mezzanine and the retrofit of a RegentEco heat recovery exchanger (HRE) on APU 6.

The preliminary study completed by Northern Climate Engineering showed positive results for both the RegentEco HRE and the Solar wall air heating with paybacks in the 6 year time period based on fuel oil heating. As a result of the positive findings of the Feasibility Investigation, the Energy Solutions Center in conjunction with the Whitehorse General Hospital has advanced the two projects to the design and construction stage. This report is the first deliverable for this project.

While viability was proven in the feasibility investigation, the modeling tools used were relatively crude. Given the high initial capital expenditures for these two projects ($122k-March 2002-NCE) it was determined that prior to initiating the actual capital works more in-depth energy models and costing be completed to verify the feasibility investigation conclusions. This Energy Analysis design report is the deliverable for the more detailed model and attendant evaluation for the Solarwall passive solar air heating system.

## 2.0 Existing Facility Background

The Whitehorse General Hospital is a 49-bed acute care facility completed in approximately 1997. This facility is comprised of about 7150m2 of new building joined to 3865m2 of old renovated hospital. Basements and service spaces are approximately 8063m2. Total building area is 19051m2.

In addition to the hospital loads the Energy Center for the hospital also provides building and service water heating to the adjacent Thompson Center. This long-term care facility is a single storey building of 3658m2 with a full heated crawlspace and basement.

The hospital layout is programmed over two floors with the existing renovated hospital and the new building linked by an enclosed and heated atrium. Administration, outpatients and offices have been located in the old renovated hospital. The new building houses the main patient care functions including the wards, OR and procedures. Housekeeping and Nutrition are also located within the new building with the physical plant located in a separate attached Energy Center to the north of the main buildings.

The Thompson Building is linked to the south end of the hospital with heating services provided through a service utilidor.

The facility HVAC and mechanical systems are similar to those found in acute care hospitals and long term care facilities in other cold climate regions. Three fuel oil fired low-pressure steam (LPS) boilers provide building heating and service heat for humidification, DHW and service hot water heating and LPS for kitchen appliances. For building heating, steam/water and steam/glycol converters located in the boiler room and Thompson Building basement are used to convert the LPS to hydronic heating. The water circuits are used for all building heating. The glycol circuits for the ventilation system air-processing unit (APU) provide heating for ventilation preheat and reheat.

Recently a secondary sales electric LPS boiler retrofit has been initiated with construction scheduled for spring 2003. This system will result in a reduction in total energy consumption due to an improvement in system efficiency, a reduction in operating costs due to the low rate of secondary sales energy and a reduction in greenhouse gas production due to the use of hydroelectric energy instead of fuel oil heating. Detailed discussion of this system is provided in a series of three reports prepared by FSC Architects and Engineers; the Secondary Sales Feasibility Study-Final Submission Jan 15/02, the Energy Analysis Design Report Secondary Sales Electric Boiler-Final Draft Dec 20/02 and the Design Development Report Secondary Sales Electric Boiler-Final Draft Dec 20/02. To summarize two new 1.36MW LPS boilers will be retrofit into the existing generator room. The new boilers will be operating in parallel with the existing FO fired boilers to provide building and service heating. Secondary sales energy is programmed to be provided at approximately 90% availability at a discounted rate of about $0.033/kWh resulting in a reduction in annual energy costs by about 60% and a payback in capital investment of less than 3 years.

Seven APU and two AHU (smaller fan coil units) provide ventilation for the hospital. APU 1 and 2 are the main units for the treatment areas. The units operate in parallel and are provided with energy wheel heat recovery. APU 3 provides ventilation to the lower tech treatment areas and general spaces. Heat recovery is not provided on this unit. APU 4 and 5 are 100% redundant units that provide ventilation to the general spaces and areas of refuge. APU 1 thru 5 all operate on 100% outdoor air and are located in the new fan mezzanine. APU 6 and 7 are located in the renovated hospital mezzanine and are re-circulating units with return fans. APU 6 provides ventilation to the offices while APU7 to the atrium.

The two smaller AHU's are located in the hospital Ambulance Bay (AHU1) and the Energy Center (AHU 2). AHU 1 provides ventilation for control of CO/NOx in the Ambulance Bay. AHU 2 provides cooling and combustion air for boiler operation in the Energy Center.

In the Thompson Building a total of 5 main AHU provide ventilation to the Central, North and South wings of the building. In addition three service units provide ventilation to the two basement mechanical rooms and crawlspace.

LPS for humidification is provided direct from the main LPS system. Steam grid humidifiers located on all the APU provide primary humidity control. In addition local control by duct mounted steam grids provides supplementary humidification for high load critical zones.

Four storage tanks in the Hospital and two in the Thompson Center with tankless heaters provide 82degC service hot water and 60degC domestic hot water in the hospital. An independent high-pressure steam system with two oil-fired boilers provides HPS for sterilization in the Hospital

Medical gas systems, specialty medical mechanical systems, fire protection systems and fuel systems have not been reviewed as a component of this project.

## 3.0 Energy Modeling and Discussions

### Energy Modeling

The purpose of this Energy Analysis was to confirm the findings of the Feasibility Investigation prepared in 2002 by NCE using a RETScreen analysis.

The Solarwall as proposed by NCE in the March 2002 Feasibility Study was recommended for preheat of the outdoor air for APU's 3, 4 and 5. These three fans are all located in the main Hospital fan mezzanine and share a common outdoor air intake located on a southwest exposure wall. The outdoor air intake is located approximately mid wall level with a metal wall finish from the louvers up to the eave and an independent finish for the lower portion of the wall below the louvers. Since the lower wall finish does not lend itself to a solar wall type finish without impacting the architectural finish of the building the initial RETScreen analysis prepared by NCE was completed for the upper portion of the wall area.

The reasoning behind limiting the Solarwall to the upper wall area as elected by NCE is, in review of the building appears to be valid. In addition exposure angles to the lower wall area are poor along with additional obstructions to the South and Southwest of the wall that may affect performance of any lower sections of the Solarwall, these reasonably apparent in Figure 3.1.

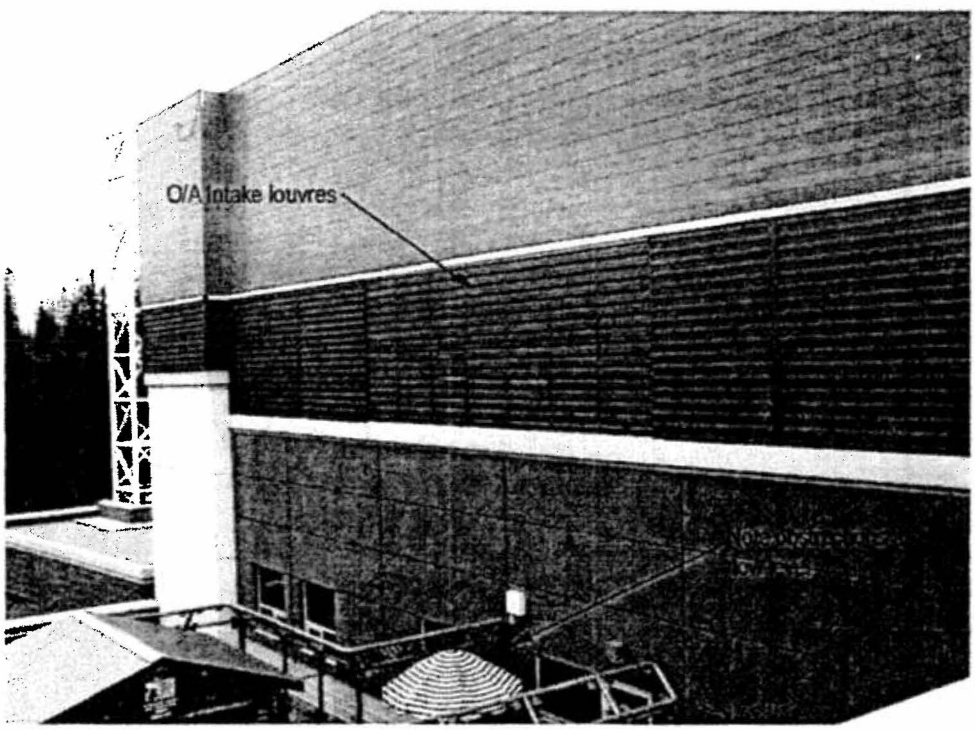



**Fig 3.1** SW Facing Wall of Fan Room viewed to west.

NCE completed two models, the first for a smaller wall area covering a lower band of the wall only, and a second model for the Solarwall covering the complete upper section of the SW wall. The conclusion from the NCE models was that the payback was the same for both systems with greater annual savings for the larger wall area due to the higher amount of recovered energy, but with correspondingly higher initial capital investment.

As noted briefly NCE reported that initial payback was the same for the two different wall areas tested. The lower area was defined as the dark banded metal wall area where the intake louvers are located at a total of 84m2. The larger area was comprised of the lower area along with the upper lighter wall above the intake louvers for a total area of 232m2. For both these estimates the area of wall located along the stairwell on the west end of the wall was not included.

Using these design areas and energy costs of $0.424/L for heating fuel and a marginal rate of $0.131/kWh for electrical energy NCE reported the following values:

| Design Area | Capital Cost w/o REDI grant | w/ REDI grant | Energy Renewable Energy Collected | Bldg Heat Loss Captured | Renewable Energy Delivered | Payback w/o REDI grant | w/ REDI grant |
|---|---|---|---|---|---|---|---|
| 84 m2 | $28 500 | $20 600 | 49.3MWh | 4.6MWh | 53.9MWh | 9 yrs | 6 yrs |
| 232 m2 | $62 000 | $43 400 | 114.7MWh | 12.5MWh | 127.1MWh | 9 yrs | 6 yrs |

**Fig 3.2** NCE March 2002 Data Summary

To verify these results FSC was contracted to complete an updated analysis using a higher accuracy model for energy performance and to update capital cost estimates. To complete this work the DOE2.1e modeling tool was selected as the preferable method. This program is the premier 8760hr-modeling tool currently in use in North America. In essence this program allows designers to accurately model energy consumption in a building on an hourly basis accurately accounting for both internal and external gains and losses and completed detailed analysis of EEM's.

Enersys Analytics who specialize in energy modeling building science, load research, and customized energy information systems provided development of the energy performance model. To complete this task Enersys utilized the calibrated DOE2 model that was completed for the Secondary Sales Energy Analysis project, details for which are described in the Secondary Sales reports noted in Section 2.0. DOE2, however, did not have the capability to analyze a Solarwall EEM directly so data was extracted from the original DOE2 model on an 8760hr basis by creating a 'solarwall' surface with the same characteristics as an actual Solarwall. This data was then used to calculate the energy reclaimed using an excel spreadsheet and calculation procedures from ASHRAE and the Solarwall manufacturers literature.

More detailed explanations of the procedure are provided in Appendix B, along with summaries provided by Enersys Analytics. Included are samples of the data files and analysis files that show the general calculation methods used (note complete output for this report is not possible due to the size of the file to accommodate the 8760hrs of data).

The original intent was that the new model parameters would be selected where possible to coincide with the original NCE values to allow better cross-referencing. This, however, was not deemed to be practical since various differences were immediately noted. First, during discussions with ESC it was determined to evaluate only the larger wall area option since paybacks between the two areas were initially reported as been equal. In addition for the wall area FSC determined that by using the adjacent stairwell area the actual solar wall area could be increased to approximately 248m2 to maximize the potential area.

Also of note is the total air volume that the Solarwall is capable of handling. The NCE models allowed the SAH fan flow rate to exceed 980m3/h/m2 for the 84m2 option and 355m3/h/m2 for the 232m2 option. Both of these values exceed the Solarwall maximum recommended ventilation rate of 127m3/h/m2. Using this value the actual portion of the air that can pass through the Solarwall is greatly reduced from the NCE value of 82300m3/h to about 31740m3/hr. Using these adjusted values the DOE model generated the following energy recovery rates:

| Design Area | Energy Renewable Energy Collected | Bldg Heat Loss Captured | Renewable Energy Delivered |
|---|---|---|---|
| 248 m2 | 70MWh | 2.75MWh | 72.75MWh |

**Fig 3.3** DOE Database Annual Energy Saved

Immediately it is apparent that the DOE database calculated energy delivered is only approximately 60% of the value estimated by NCE for a similar wall area. To reconcile this the NCE RETScreen model was updated using the adjusted air volumes and Solarwall area. This comparison showed a reduction in renewable energy delivered to 116.4MWh that still exceeds the DOE database model by approximately the same value.

| Design Area | Energy Renewable Energy Collected | Bldg Heat Loss Captured | Renewable Energy Delivered |
|---|---|---|---|
| 248 m2 | 103.3MWh | 13.1MWh | 116.4MWh |

**Fig 3.4** Base RETScreen Annual Energy Saved

This very high difference between models raised concern that either the DOE database model or the RETScreen model was in error. To account for the differences FSC and Enersys evaluated the two model parameters with respect to the input and generated data. First the annual Solarwall energy availability was reviewed. From the DOE database model the annual Solarwall Energy Availability was calculated at 181MWh for a Solarwall absorptive of 0.8 and area of 248m2. In comparison the annual availability for RETScreen is calculated at 202MWh or a difference of only about 10%. Further a monthly comparison was completed and is shown in Figure 3.5.

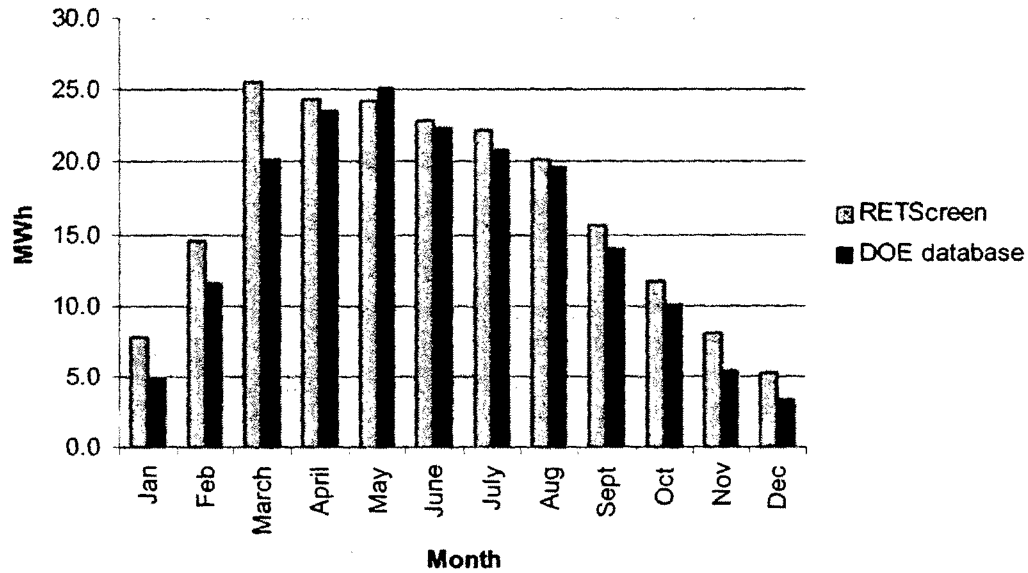



**Fig 3.5** DOE Database vs RETScreen Monthly Solarwall Energy Availability

Again general conformance between the two models is very good with the exception of the month of March. This variation can easily be explained due to the method of calculating the availability or due to the level of reflectance that the programs used. The RETScreen model is based on average monthly data that averages the solar radiation, haze and overcast levels to a single monthly value. In comparison the DOE database is an hourly base that uses specific solar radiation, haze and overcast factors for each hour of a typical year. The use of hourly data has been proven as providing a considerably more accurate representation of actual conditions and is the recommended method for modeling energy consumption by ASHRAE and the Canadian National Energy Code for Buildings. What this tended to indicate is that the difference between the two models is neither the solar values used nor the way that they are calculated.

The second area reviewed was the building heat recaptured. In the case of the DOE database model the recaptured heat was estimated at 2.75WMh vs 13.1MWh for the RETScreen model. This is a significant difference, however, when compared to the total energy delivered the variation can only account for error in between 5-10% of the total, which is not significant enough to account for the 40% difference in the total values.

The final area of consideration was the usefulness of the solar energy captured. To determine this the energy required for preheat without the solar wall must be compared to the amount of energy available from the Solarwall. Where the energy available from the Solarwall exceeds the required value the energy cannot be used and the recovered energy is 'wasted'. In the case of the ventilation systems the leaving air temperature from the units must not exceed the unit discharge air temperature, which determines the required energy. The Solarwall leaving air temperature can, however, exceed the unit leaving air temperature since the full volume of the ventilation units cannot pass through the Solarwall allowing un-preheated air to blend with the Solarwall preheated air to meet the heating requirements. Again the RETScreen model uses a monthly average to calculate this based primarily on what appears to be the maximum delivered air temperature. The DOE database model in comparison calculates the hourly values to determine the amount of captured solar energy that can be used. To address the difficulty in using a monthly average the RETScreen designers have provided a user input control "Fraction of Month Used" to allow fine-tuning of the usefulness. To review this the monthly fraction of energy used by the DOE database model was input into the RETScreen model user input control and the acceptable discharge air temperature adjusted to the maximum acceptable Solarwall air temperature to maintain a blended 13.5degC temperature. Using these values the adjusted RETScreen model Renewable Energy Delivered was calculated at 80.4MWh, or only a 10% difference to the DOE database model at 72.75MWh. This seems to indicate that the major difference in the models is in the usefulness of the energy and the method the model uses to estimate this value. The adjusted RETScreen values are summarized in Figure 3.6.

| Design Area | Energy Renewable Energy Collected | Bldg Heat Loss Captured | Renewable Energy Delivered |
|---|---|---|---|
| 248 m2 | 70.8MWh | 9.5MWh | 80.4MWh |

**Fig 3.6** Adjusted RETScreen Annual Energy Saved

At this stage, models using the SWIFT99 program, which is approved for use on Solarwall analysis by NRCan, where completed in a further attempt to reconcile the RETScreen and DOE database models. Using this program models using parameters similar to those used for the RETScreen and DOE database were completed. The final energy values for a base model with no adjustments generated by this program were as follows in Figure 3.7.

| Design Area | Energy Renewable Energy Collected | Bldg Heat Loss Captured | Renewable Energy Delivered |
|---|---|---|---|
| 248 m2 | 120MWh | 12.2MWh | 132MWh |

**Fig 3.7** SWIFT99 Annual Energy Saved

As can be noted these values significantly exceeded those estimated by the DOE database but more closely matched the unadjusted RETScreen. In comparison, relative to DOE database the SWIFT values are approximately 40% greater. Relative to the RETScreen models the SWIFT values are 13% to the unadjusted RETScreen model and 40% relative to the adjusted model. To reconcile these differences again an analysis comparing the different models was completed. In this instance the Solarwall Energy Availability is not output from the SWIFT so in-lieu the solar radiation incident on the Solarwall surface was used to compare the potential solar energy. Both on an annual and monthly basis large differences between the solar values are evident. Figure 3.8 provides a graphical representation of the differences.

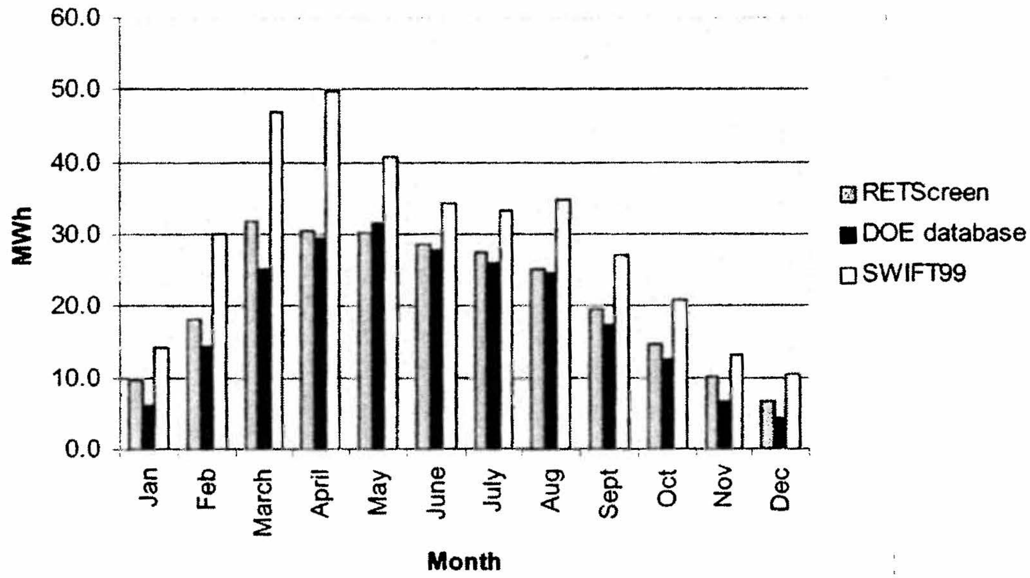



**Fig 3.8** DOE Database / RETScreen / SWIFT Monthly Solar Radiation Incident on Solarwall

Figure 3.8 shows the relatively close correlation between the RETScreen and DOE database models, however the SWIFT values are significantly higher throughout the year varying at up to 60% higher.

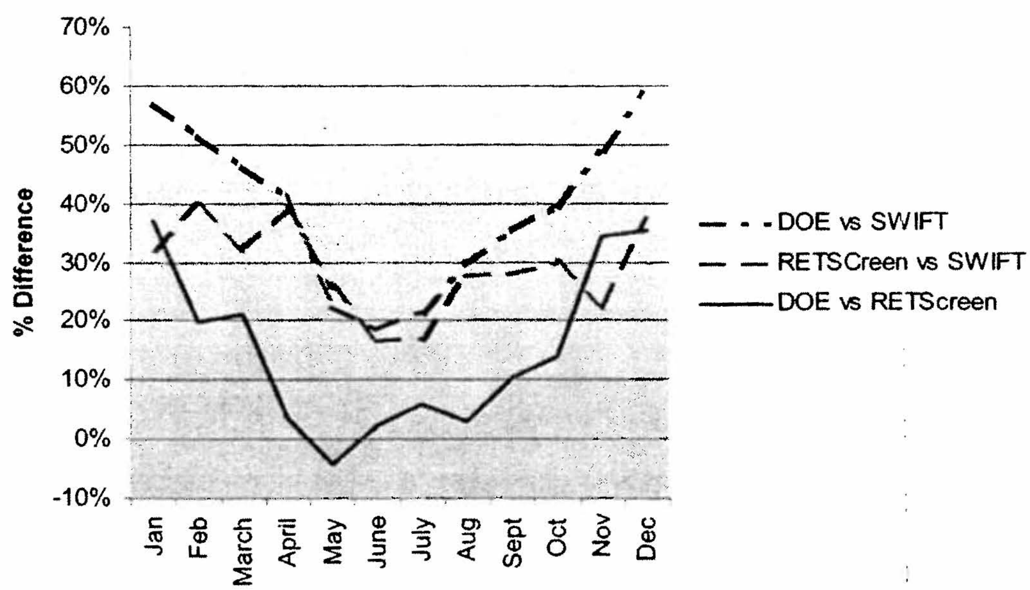
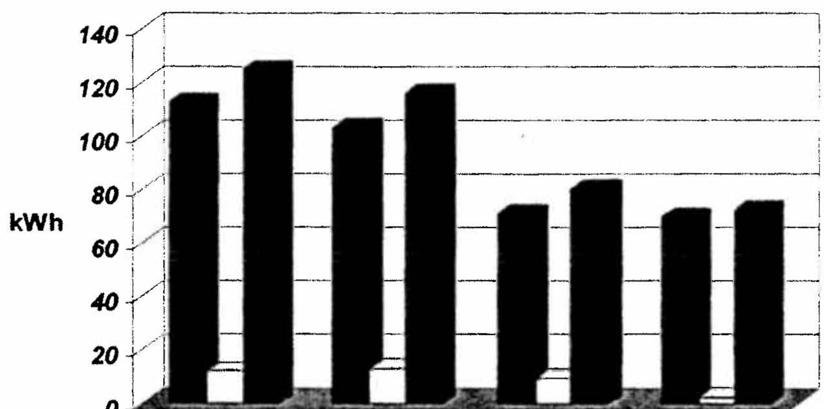



**Fig 3.9** DOE Database / RETScreen / SWIFT % Difference in Monthly Solar Radiation Incident on Solarwall

This is especially noticeable during the winter months with the correlations being considerably higher during the summer months. Figure 3.9 displays the difference in a % basis between the models. On an average basis the difference between DOE and SWIFT is 40%, RETScreen and SWIFT 29% and DOE and RETScreen 15%. On a total annual basis SWIFT estimates a total of 355MWh of solar radiation incident on the Solarwall surface in comparison to 253MWh and 226Mwh for RETScreen and DOE respectively. This seems to indicate that the major difference in the output generated between the RETScreen and DOE vs the SWIFT is the actual solar radiation values and the effect of haze, overcast and reflectance. These values unfortunately are fixed within the database of SWIFT and RETScreen and essentially nothing can be done by a end user to modify these values to reconcile them with other modeling programs.

To summarize, initially a DOE database model for the proposed Solarwall installation was completed. This model was completed for comparison to the initial RETScreen energy models developed by NCE in March 2002. Variation between the models was significant prompting FSC to update the NCE RETScreen model to more closely match the new design parameters.

A large difference was still noted between the two models so an analysis of the differences was completed. This analysis indicated that the variation between the models appeared to be due the solar energy captured and its usefulness. The RETScreen model appeared to be utilizing energy that the DOE model indicated was not usable, due to the operating requirements of the system. Using the DOE model, monthly utilization values were generated and then applied to the "Fraction of month use" available on the RETScreen model. When these values were applied correlation between the two models was excellent.




| | SWIFT | RETScreen | Adjusted RRETScreen | DOE database |
|---|---|---|---|---|
| *Solar Energy Collected (kWh)* | 112.9 | 103.3 | 70.8 | 70 |
| *Heat Loss Recaptured (kWh)* | 12.1 | 13.1 | 9.5 | 2.75 |
| *Annual Energy Saved (kWh)* | 125 | 116.4 | 80.4 | 72.7 |

**Fig 3.10** Annual Energy Saved by Model Type

Finally a third system, SWIFT99, was used to model the proposed Solarwall. While correlation between the adjusted RETScreen and DOE was completed the SWIFT model indicated considerably higher energy recovery and utilization than any previous model, including the base RETScreen models. A review of the three models indicated that the differences were associated with the calculated solar radiation incident on the Solarwall which is a fixed weather related variable in the program.

The output from the various program models is summarized in Figure 3.10, which shows the energy recovered and the difference between the models. Figure 3.11 shows an annual distribution of the Calculated Collected Solar Energy by the Solarwall. For the two RETScreen models a monthly breakdown of this data was not available.

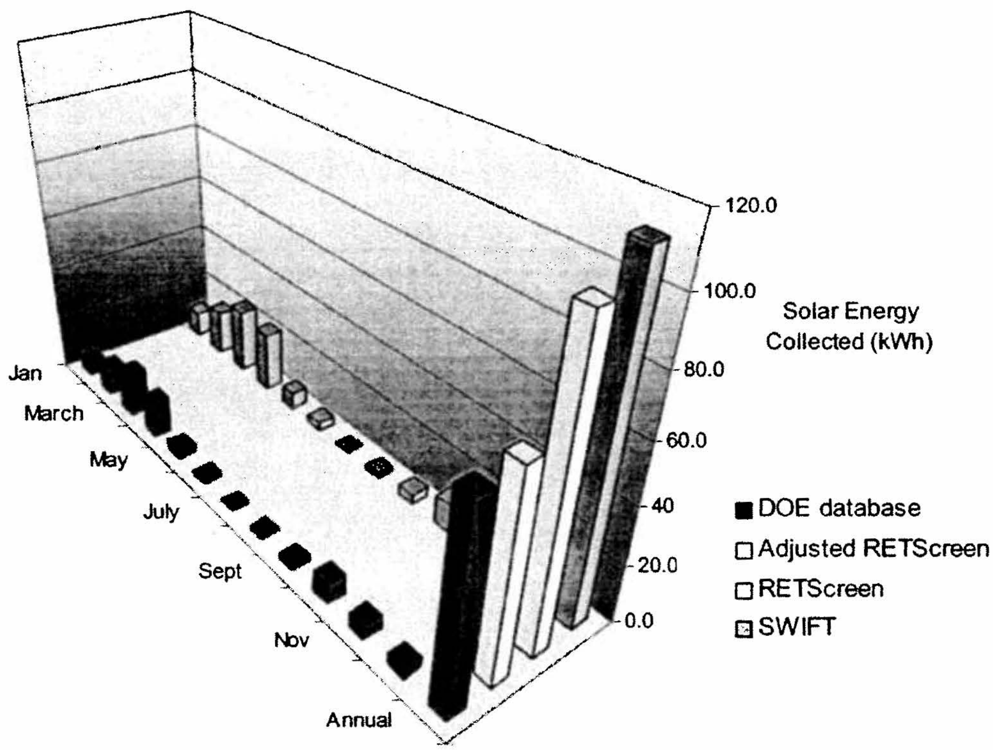



**Fig 3.11** Calculated Solar Energy Collected

In conclusion, a significant difference in output of the three models is apparent for essentially the same data inputs. Where possible the differences were reconciled, however, due to the limitations of user input in the RETScreen and SWIFT programs little could be done to reconcile the variation between all the models. The results then predict a difference of up to 40% in annual energy recovered that will result in a corresponding variation in payback and positive cash flows discussed in subsequent sections.

## Solarwall Installation

The Solarwall as proposed by NCE in the March 2002 Feasibility Study was for APU 3, 4 and 5 located in the main Hospital fan mezzanine. These APU all share a common outdoor air intake located on the southwest exposure wall of the fan room. The outdoor air intake is located approximately mid wall level with a metal wall finish from the louvers up to the eave and an independent finish for the lower portion of the wall below the louvers. Since the lower wall finish does not lend itself to a solar wall type finish without impacting the architectural finish NCE based their analysis on only the upper portion of the wall area.

The reasoning behind limiting the Solarwall to the upper wall area as elected by NCE, in review of the building, appears to be valid. In addition exposure angles to the lower wall area are poor along with additional obstructions to the South and Southwest of the wall that may affect performance of any lower sections of the Solarwall. As noted previously these are reasonably apparent in Figure 3.1.

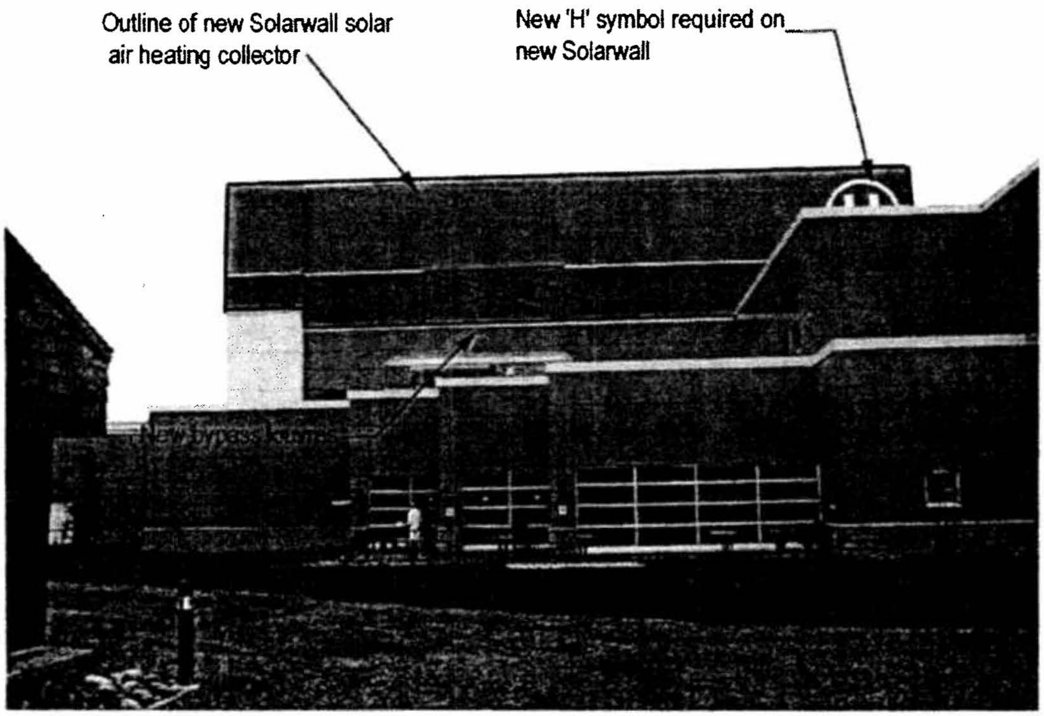



**Fig 3.12** Location of new Solarwall and bypass damper

As discussed in the section on Energy Modeling the Solarwall rated air volume is restricted to a maximum of 31740m3/hr. In comparison the total air volume for AHU 3, 4 and 5 under typical operating conditions is 82300m3/hr enabling only 38% of the typical operating outdoor air to pass through the Solarwall. To enable this a volume of air must bypass the Solarwall at all times with the remainder being drawn through the Solarwall. This would be accomplished by providing a bulkhead approximately 450mm in depth formed by the Solarwall above and around the current location of the existing louvers with a mixing plenum through the bulkhead to the exterior surface of the Solarwall. The mixing plenum will be located in the current location of the existing louvers and will be fitted with a set of new 100% volume bypass louvers and dampers located at the Solarwall surface. Within the void formed by the Solarwall and the building wall, fresh air intake openings from the Solarwall void into mixing plenum will be fitted with control dampers. This system will then enable the nominal 52% fresh air that cannot pass through the Solarwall to go direct to the units while the remaining 48% will be drawn in through the Solarwall and into the mixing plenum through the openings located inside the Solarwall cavity. To optimize the energy recovery the dampers will modulate to maintain a 13.5degC entering air temperature into the existing fresh air intake plenum located inside the fan room. When temperatures exceed the desired set point the dampers will be able to proportionally control to a maximum 100% from the bypass louvers. This arrangement is a relatively simple economizer mixing system that is used throughout the ventilation industry.

During the models the solarwall colour has been selected as a standard Green or Blue. Both colors have a solar absortivity of 0.80. In comparison black has an absorptivity of 0.95, which helps improve the viability of the Solarwall, but will not match the existing colour scheme as effectively. In addition to the base colour a new hospital symbol will be required to be placed on the new Solarwall surface. This white color will reduce the effectiveness of the system due to its very low absorptivity, however, this effect was not included in any of the models generated.

## 4.0 Capital Costs and Financial Analysis

Capital investment costs by NCE for the 2002 Feasibility Investigation were estimated at a base value of $62 000 for a total Solarwall area of 232m2. NRCCan Renewable Energy Deployment Initiative grants were applied at the maximum 40%, based on the classification of Whitehorse as a remote community. This resulted in an adjusted cost of $43 400. Using these construction estimates and based on marginal energy rates of $0.42/L for fuel and $0.131/kWh for electrical energy NCE estimated positive cash flow in 5.2 years and simple payback in 5.8 years. For this cost benefit analysis energy escalation was set at 3%, inflation 2% with a discount rate of 7%.

The NCE costs were based on the fuel oil fired system costs. As noted in the initial introduction, a secondary sales electric LPS boiler retrofit has been initiated in the interim with construction scheduled for spring 2003. This system will provide energy at a rate of $0.033/kWh and a thermal efficiency of about 90% or about $0.0367/ekWh. In comparison the current fuel system, based on a cost of $0.45/L and the annual calculated thermal efficiency of 80% (calculated during the Secondary Sales Energy Analysis) provides energy at a rate of $0.052/ekWh.

For the secondary sales system availability is estimated at a maximum of 92%. To allow an accurate cost analysis the blended equivalent energy rate of $0.0431/ekWh at 100% efficiency was used in the cost analysis spreadsheets.

**The updated capital costs for the proposed Solarwall are approximately $166 000**. These costs were provided as a budget quotation through the Vancouver distributor for Solarwall with installation costs provided by a local Whitehorse contractor. In comparison the 2002 Feasibility Investigation estimated capital costs at approximately $62 000 for a similar area, less than 50% of the current estimated value. Details of the cost estimate can be found in Appendix D. The updated costs include all capital and construction costs plus a 10% construction contingency. The costs do not include design costs, taxes or administration costs.

To allow for an accurate and flexible cost analysis the NRCan RETScreen analysis tool was used as a financial estimating tool for both the RETScreen and DOE database models. To accomplish the financial analysis for the DOE database the Solarwall model was used with the recovered energy values forced to match the values calculated by the DOE database model. This allowed the use of the financial summary and green house gas tools included in the RETScreen spreadsheets. For the SWIFT model the financial analysis was calculated using the SWIFT financial analysis system. For all estimates similar energy cost escalation rates, inflation and discount rates were used. The discount rate was based on a base ASHRAE Handbook rate of 4.5%, which reflects the USDOE recommended rate. Inflation was set to 3% and fuel escalation to 5%. In addition project life was set to 25 years that reflects a typical life cycle for a long-term energy recovery systems. Cost benefit analysis was completed for all four energy models comparing both a fuel fired system and a blended secondary sales/fuel oil fired system.

The NRCCan Renewable Energy Deployment Initiative grant was applied at the maximum 40%, based on the classification of Whitehorse as a remote community for all financial analysis.

| | **Fuel Oil Heating** | | | **Secondary Sales Heating** | | |
|---|---|---|---|---|---|---|
| Model Description | Annual Savings* | Positive Cash Flow | Simple Payback | Annual Savings | Positive Cash Flow | Simple Payback |
| DOE database | $3806 | 16.8y | 27.0y | $3125 | 19.3 | 33.1 |
| RETScreen (Adjusted) | $4209 | 15.6y | 24.5y | $3464 | 18.0 | 30.1 |
| RETScreen | $6099 | 12.2y | 17.1y | $5007 | 14.2 | 21.1 |
| SWIFT | $6516 | n/a** | 15.3 | $5375 | n/a** | 18.5 |

* Net savings adjusted for increased fan kWh requirements, $2002
** Output not provided by SWIFT

**Fig 4.1** Summary of Financial Analysis by Energy Model

Based on the financial parameters payback on all modeled systems is marginal regardless of the modeling tool used. This is primarily due to the relatively high cost of installation due to retrofit of a new bypass/economizer section, the elevated work necessary for the installation and the lack of any credits on finishes that are typical on new installations. Further the payback and positive cash flows are considerably longer than those estimated in the Feasibility Investigation, again primarily associated with the higher estimated capital costs.

## 5.0 Green House Gas Reduction

The RETScreen and SWIFT energy models were also utilized as a simple means to estimate the reduction in green house gas emissions by using solar air heating to offset fuel fired energy. This analysis was completed for all four models and for the fuel fired only and blended fuel fired/secondary sales options. Figure 5.1 outlines the values.

| | GHG Emission Reduction | |
|---|---|---|
| Model Description | Fuel Heating | Blended Fuel / Secondary Sales |
| DOE database | 24.5 tco2 | 2.0 tco2 |
| RETScreen (Adjusted) | 27.0 tco2 | 2.2 tco2 |
| RETScreen | 39.2 tco2 | 3.1 tco2 |
| SWIFT | 41.2 tco2 | 3.3 tco2 |

**Fig 5.1** Summary of GHG Emission Reduction by Energy Model

## 6.0 Conclusions

In general is must be stated that there is very poor correlation between energy models. The closest correlation was between the adjusted RETScreen model and the DOE database model. In general the amount of solar energy available for use was fairly consistent between the DOE and RETScreen models but the usefulness of the energy varied considerably. To reconcile the difference, utilization factors from the DOE database were applied to the RETScreen model resulting in similar collected energy. Unfortunately using the DOE utilization factors may actually affect the true validity of the reconciliation since a DOE based valve is being input into the RETScreen model.

Differences between the SWIFT and the DOE database and RETScreen models were most marked and appeared to be due to a very large difference in the calculated solar energy incident on the Solarwall. This is most likely due to the haze and reflectance factors used between the various energy models.

Since a very large range in the modeled energy recovered was evident, financial analysis was prepared for each model to show the full range of cost-benefit based on all the models. In addition financial analysis was completed for both the fuel oil fired system and a blended fuel oil fired / secondary sales electric system. Overall each model showed very poor system viability with paybacks extending to a maximum of 33 years and a minimum of 15.3 years.

Based on these extended paybacks the cost benefit of the systems is very marginal. The only means to improve the viability is to either decrease the capital expenditure or increase the solar wall capacity to increase the energy recovery with respect to total capital expenditure. Currently the Solarwall supplier is reviewing their system cost in an attempt to reduce capital expenditure, however, review with the costing contractor tends to indicate that the current cost estimates are reasonable and fair.

## APPENDIX A — 2002 NCE FEASIBILITY INVESTIAGTION REPORT AND NCE RETSCREEN OUTPUT

## 1. Introduction

The feasibility of installing several different alternate energy and energy saving technologies at the Whitehorse General Hospital in Whitehorse, Yukon was investigated. The technologies investigated included SOLARWALL® to pre-warm the air to APU-3, APU-4, and APU-5; solar hot water heating to pre-warm the domestic water immediately before the domestic hot water heating system; Regent ECO heat exchanger to capture the heat in the exhaust of the APU-6 ventilation system; and ground water cooling with water-to-water heat pumps to offset the costs for cooling and domestic hot water heating. Throughout this report, it is assumed that the reader is familiar with these technologies. For the feasibility analysis for SOLARWALL® and solar hot water heating, RETScreen™ software was used. Offset fuel costs were based on the provided costs from the maintenance staff at the hospital, namely $0.4238 per litre for fuel oil, and $0.1305 per kilowatt-hour plus $10 per kilowatt demand for electricity. With the exception of the heat pump analysis, electrical demand charges were not considered given that the comparative increase in electrical demand for the other options was nominal.

## 2. SOLARWALL® for APU-3, APU-4, and APU-5 Ventilation Systems

APU-3, APU-4, and APU-5 share a common fresh air intake on the Southwest wall of the main hospital fan room. APU-3 serves the technical services areas, and APU-4 and APU-5 operate in parallel to serve the critical care areas. All 3 units are 100% fresh air units operating 7 days per week, 24 hours a day. Although the units are variable speed, the maintenance staff confirmed that their flow rates and supply temperatures remain relatively constant year round. The units move approximately 22,860 litres per second (l/s) total, and deliver the air at approximately 13.5$^{O}$C.

SOLARWALL® is available in a variety of colours. To match the current colouring scheme for the hospital, green was chosen for the feasibility analysis, which has a slightly reduced performance to the default black collector colour. The wall from which the units draw the fresh air is above the second floor of the hospital where two different textured siding schemes exist. The lower scheme forms a 2.7m band around the base in which the fresh air louver is actually installed. The upper scheme forms the top 7.5m of the wall in which the 'H' symbol is located. Runs were completed for installing the SOLARWALL® only on the bottom band, and on the entire face. In both cases, aside from the SOLARWALL® installation, minimal ducting is expected, consisting only of the summer bypass damper in front of the existing louver. As seen in the summary of the results below, the two different SOLARWALL® areas did not make a difference in the estimated payback, only in the estimated annual savings:



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84 $m^2$ SOLARWALL® area:

Total estimated capital cost without REDI grant: $28,500.00
Total estimated annual savings: $2800.00
Years to positive cash flow: 9

Total estimated capital cost with 40% REDI grant: $20,600.00
Total estimated annual savings: $2800.00
Years to positive cash flow: 6

232 $m^2$ SOLARWALL® area:

Total estimated capital cost without REDI grant: $62,000.00
Total estimated annual savings: $6700.00
Years to positive cash flow: 9

Total estimated capital cost with 40% REDI grant: $43,400.00
Total estimated annual savings: $6700.00
Years to positive cash flow: 6

The RETScreen™ printout for the 84 $m^2$ SOLARWALL® with REDI grant is included in Appendix A.

## 3. Solar Hot Water Heating

The domestic hot water needs for the hospital are provided by four 2653 litre tanks heated by the boiler steam plant. Two tanks are set at 82$^{O}$C for the laundry and kitchen requirements, and the remaining two are set at 60$^{O}$C. Maintenance and support staff advised that although the hospital has a bed capacity of 56, only 40 beds on average are occupied. Due to the fact that the domestic hot water is not metered, hot water use was based on the RETScreen™ calculation for the above occupancy. Further, the feasibility analysis included the provision for an insulated storage tank given the year round analysis and the service nature of the hot water demand. The existing energy plant does not have room for a storage tank, so the cost of building an attached shelter was included. It was assumed that there would be room for the collectors on the roof of the main fan room.

RETScreen™ feasibility was carried out for each of the solar hot water heating collector technologies: unglazed, glazed, and evacuated. For each analysis, the feasibility was optimized for collector slope, number of collectors, and storage capacity. The results are summarized below:



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Evacuated Tube Collector:

Total estimated capital cost with 40% REDI grant: $194,700.00
Total estimated annual savings: $5300.00
Years to positive cash flow: greater than 25

Glazed Collector:

Total estimated capital cost with 40% REDI grant: $121,400.00
Total estimated annual savings: $4500.00
Years to positive cash flow: 24

Unglazed Collector:

Total estimated capital cost with 40% REDI grant: $111,800.00
Total estimated annual savings: $7200.00
Years to positive cash flow: 14

The RETScreen™ printouts for the above are included in Appendix B. Further investigation is ongoing to confirm the relative accuracy of the solar hot water heating feasibility analysis.

## 4. Regent ECO Heat Exchanger

The Regent ECO heat exchanger appears ideal for the Yukon cold weather climate since it is advertised to not suffer from defrost cycles; thus, maintaining heating efficiencies of approximately 90%. This heat exchanger also boasts approximately 80% cooling efficiencies, and minimal loss of building humidity. It's only potential drawbacks are its relatively large mass, and although cross-contamination is negligible, it still exists to some extent. The use of the Regent ECO heat exchanger was considered for the APU-6 ventilation system that serves the Administration Wing. This ventilation system is a mixed air system that does not currently have any heat reclaim provided for it. The APU-6 system includes the air handling unit, APU-6, and three exhaust fans, EF-1, EF-2, and EF-3. The use of EF-3 was not considered for this analysis since this exhaust fan serves chemical exhaust. Although APU-6 is a variable volume unit, the maintenance staff confirmed that airflows and supply temperature for it remain relatively constant year round; namely, 10,616 l/s supply air, 8274 l/s return air, and 2342 l/s fresh air on average, with a supply air temperature setpoint of 12$^{O}$C. This unit does not have any provision for cooling, so any cooling provided by the heat exchanger would be an asset. EF-1 and EF-2 exhaust 3845 l/s and 1248 l/s respectively. The temperature of the exhaust air is around 24$^{O}$C. This ventilation system operates 7 days a week from 5:00 AM to 7:00 PM.



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There appears to be enough room on the roof above the fan room for the heat exchanger. The most economical means of installing the heat exchanger system is ducting outside from the exhaust fan louvers to the heat exchanger. The fresh air for APU-6 is currently served from the roof. In completing the analysis, it was determined that only a portion of the exhaust air from EF-1 would be required to meet the ventilation heating demands for APU-6. It is expected that the Regent ECO EB5000 will be sufficient to meet the current ventilation demands, though this should be verified against the current upper operating limit of APU-6. It is assumed that the present structure is strong enough to accept the mass of the heat exchanger unit. The results of the feasibility analysis are summarized below:

Total estimated capital cost: $60,000.00
Total estimated annual savings: $11,000.00
Estimated simple payback: 5.4 years

## 5. Ground Water Cooling with Water-to-Water Heat Pumps

The hospital's cooling system is a circulated closed-loop water system cooled by an outdoor water-to-air chiller. The cooling system is activated at an outdoor temperature of 15$^{O}$C and provides a cooling capacity of 742 kW. Loop temperatures are maintained at 5.5$^{O}$C supply and 11$^{O}$C return at 30.2 l/s flow rate. According to maintenance staff, the estimated annual operating cost of the chiller is $60,000. In the winter, the water to the outdoor chiller is valved off and dumped.

The area around the hospital has a proven aquifer with average reported groundwater temperatures of 7$^{O}$C. It is assumed from past experience that it is not feasible to construct a well to match the cooling system flow rate, and further, at an average temperature of 7$^{O}$C, the groundwater can only partially meet the heating demands of the school; therefore, the use of water-to-water heat pumps is required. The use of heat pumps has the added benefit of being able to supplement the domestic hot water heating demands of the hospital, stage the cooling in accordance with the demands, and extend the cooling season below 15$^{O}$C (the maintenance staff have advised that cooling is required at outdoor temperatures between 0$^{O}$C and 15$^{O}$C).

With the introduction of heat pumps, the cost of supplying and disposing of groundwater is no longer justified. The heat pumps will for the most part be extracting heat from the cooling system and injecting it into the domestic hot water system. Supplemental heat rejection can be achieved through a fan-coil as required. As such, the expense of burying piping for the heat pump is not required either.

It is estimated that six 30-ton heat pumps will meet 99% of the hospital's cooling demands. These same heat pumps will meet approximately 10% of the facilities domestic hot water heating demands over the cooling season that the chiller traditionally runs. The



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heat pumps can be stacked vertically up the wall where the water piping to the chiller exits the building. Because the chiller is required for some of the cooling season, it is assumed that the heat pumps will contribute to the demand charge (approximately $12,360.00 per year). However, the maintenance staff have also advised that the chiller is not capable of keeping up during the hottest days of the summer; therefore, keeping the chiller will ensure capacity during the hottest days of the year. The results of the feasibility analysis are summarized below:

Total estimated capital cost: $300,000
Total estimated annual savings: $33,100
Estimated simple payback: 9 years

## 6. Conclusions

At this time, preliminary results indicate that the installation of a SOLARWALL® for APU-3, APU-4, and APU-5 ventilation systems may be considered economical with the REDI grant. The installation of the Regent ECO heat exchanger also appears to be a reasonably economical option and worth further exploration. Offsetting cooling costs using heat pumps may be considered if the added comfort levels are factored in. However, the use of solar hot water heating does not appear to be economical.



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RETScreen® Energy Model - Solar Air Heating Project NCE 232 m²

| Site Conditions | | Estimate | Notes/Range |
|---|---|---|---|
| Project name | | Whitehorse General Hospital | |
| Project location | | Whitehorse | |
| Nearest location for weather data | | Whitehorse A, YT | *Complete SR sheet* |
| Annual solar radiation (tilted surface) | MWh/m² | 1.02 | |
| Annual average temperature | °C | -1.0 | |
| Annual average wind speed | m/s | 3.8 | |

| System Characteristics | | Estimate | Notes/Range |
|---|---|---|---|
| Heating application type | - | Ventilation air | |
| **Base Case Heating System** | | | |
| Heating fuel type | - | **Diesel (#2 oil)** | |
| Heating system seasonal efficiency | % | 75% | 0% to 350% |
| **Building** | | | |
| Building type | - | Commercial | |
| Maximum delivered air temperature | °C | 13.5 | 10.0 to 60.0 |
| RSI-value of building wall | m² - °C/W | 3.5 | 0.1 to 10.0 |
| **Airflow Requirements** | | | |
| Design airflow rate | m³/h | 82,300 | 50 to 1,000,000 |
| Operating days per week | d/w | 7.0 | 1.0 to 7.0 |
| Operating hours per day | h/d | 24.0 | 5.0 to 24.0 |
| **Solar Collector** | | | |
| Design objective | - | Standard operation | |
| Collector colour | - | Green | *See Product Database* |
| Solar absorptivity | - | 0.80 | 0.20 to 0.99 |
| Suggested solar collector area | m² | 762 | |
| Solar collector area | m² | 232 | |
| Percent shading during season of use | % | 0% | 0% to 50% |
| SAH fan flow rate | m³/h/m² | 355 | |
| Average air temperature rise | °C | 1.8 | |
| Incremental fan power | W/m² | 1.0 | 0.0 to 7.0 |

| Annual Energy Production (12.0 months analysed) | | Estimate | Notes/Range |
|---|---|---|---|
| Incremental fan energy | MWh | **2.0** | |
| Specific yield | kWh/m² | 548 | |
| Collector efficiency | % | 48% | |
| Solar availability while operating | % | 100% | |
| Renewable energy collected | MWh | 114.7 | |
| Building heat loss recaptured | MWh | 12.5 | |
| Renewable energy delivered | MWh | **127.1** | |
| - | GJ | 457.7 | |
| | | | *Complete Cost Analysis sheet* |

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## RETScreen® Solar Resource - Solar Air Heating Project

| Site Latitude and Collector Orientation | | Estimate | Notes/Range |
|---|---|---|---|
| Nearest location for weather data | | Whitehorse A, YT | *See Weather Database* |
| Latitude of project location | °N | 60.7 | -90.0 to 90.0 |
| Slope of solar collector | ° | 90.0 | 0.0 to 90.0 |
| Azimuth of solar collector | ° | 45.0 | 0.0 to 180.0 |

**Monthly Inputs**

| Month | Fraction of month used (0 - 1) | Monthly average daily radiation on horizontal surface (kWh/m²/d) | Monthly average temperature (°C) | Monthly average wind speed (m/s) | Monthly average daily radiation in plane of solar collector (kWh/m²/d) |
|---|---|---|---|---|---|
| January | 1.00 | 0.33 | -18.7 | 3.6 | 1.26 |
| February | 1.00 | 1.08 | -13.1 | 4.2 | 2.61 |
| March | 1.00 | 2.53 | -7.2 | 3.9 | 4.15 |
| April | 1.00 | 4.25 | 0.3 | 3.9 | 4.09 |
| May | 1.00 | 5.36 | 6.6 | 3.9 | 3.93 |
| June | 1.00 | 5.89 | 11.6 | 3.6 | 3.84 |
| July | 1.00 | 5.28 | 14.0 | 3.1 | 3.60 |
| August | 1.00 | 4.00 | 12.3 | 3.3 | 3.29 |
| September | 1.00 | 2.44 | 7.3 | 3.9 | 2.63 |
| October | 1.00 | 1.17 | 0.7 | 4.4 | 1.91 |
| November | 1.00 | 0.44 | -10.0 | 4.2 | 1.36 |
| December | 1.00 | 0.19 | -15.9 | 3.9 | 0.86 |

| | | Annual | Season of use |
|---|---|---|---|
| Solar radiation (horizontal) | MWh/m² | 1.01 | 1.01 |
| Solar radiation (tilted surface) | MWh/m² | 1.02 | 1.02 |
| Average temperature | °C | -1.0 | -1.0 |
| Average wind speed | m/s | 3.8 | 3.8 |

*Return to Energy Model sheet*

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## RETScreen® Cost Analysis - Solar Air Heating Project

Type of project: Standard | Currency: $ | Cost references: None

| Initial Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| Feasibility Study | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Development | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Engineering | | | | | | | |
| Other | Cost | 1 | $ 3,500 | $ 3,500 | | - | - |
| Sub-total : | | | | $ 3,500 | 5.7% | | |
| Renewable Energy (RE) Equipment | | | | | | | |
| Solar collector materials | m² | 232 | $ 125 | $ 29,000 | | - | - |
| Equipment installation | m² | 232 | $ 55 | $ 12,760 | | - | - |
| Cladding material credit | m² | -232 | $ - | $ - | | - | - |
| Cladding labour credit | m² | -232 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ 2,000 | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ 41,760 | 67.6% | | |
| Balance of Equipment | | | | | | | |
| Fans and ducting materials | L/s | 22,861 | $ 0.05 | $ 1,143 | | - | - |
| Fans and ducting labour | L/s | 22,861 | $ 0.15 | $ 3,429 | | - | - |
| Fan and duct mat'l credit | L/s | -22,861 | $ - | $ - | | - | - |
| Fan and duct labour credit | L/s | -22,861 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ 4,572 | 7.4% | | |
| Miscellaneous | | | | | | | |
| Overhead | % | 15% | $ 46,332 | $ 6,950 | | - | - |
| Training | p-h | 0 | $ - | $ - | | - | - |
| Contingencies | % | 10% | $ 49,832 | $ 4,983 | | - | - |
| Sub-total : | | | | $ 11,933 | 19.3% | | |
| **Initial Costs - Total** | | | | $ 61,765 | 100.0% | | |

| Annual Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| O&M | | | | | | | |
| Property taxes/Insurance | project | 1 | $ - | $ - | | - | - |
| O&M labour | project | 0 | $ - | $ - | | - | - |
| Travel and accommodation | p-trip | 1 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Contingencies | % | 0% | $ 46,332 | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Fuel/Electricity | kWh | 2,032 | $ 0.1305 | $ 265 | 100.0% | - | - |
| **Annual Costs - Total** | | | | $ 265 | 100.0% | | |

| Periodic Costs (Credits) | | Period | Unit Cost | Amount | Interval Range | Unit Cost Range |
|---|---|---|---|---|---|---|
| Damper Motor | | 5 yr | $ 200 | $ (200) | - | - |
| | | | $ - | $ - | - | - |
| | | | $ - | $ - | - | - |
| End of project life | | - | $ - | $ - | | |

Go to GHG Analysis sheet

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## RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Solar Air Heating Project

Use GHG analysis sheet? | No |

*Complete Financial Summary sheet*

Version 2000



UNEP/DTIE and NRCan/CEDRL

## RETScreen® Financial Summary - Solar Air Heating Project

### Annual Energy Balance

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 2.0 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 127.1 | GHG analysis sheet used? | yes/no | No |
| Heating fuel displaced | - | Diesel (#2 oil) | | | |

### Financial Parameters

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/L | 0.424 | Debt ratio | % | 0.0% |
| | | | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.131 | | | |
| Energy cost escalation rate | % | 3.0% | | | |
| Inflation | % | 2.0% | | | |
| Discount rate | % | 7.0% | | | |
| Project life | yr | 20 | | | |

### Project Costs and Savings

| | | | | | | |
|---|---|---|---|---|---|---|
| **Initial Costs** | | | | **Annual Costs and Debt** | | |
| Feasibility study | 0.0% | $ | - | O&M | $ | - |
| Development | 0.0% | $ | - | Fuel/Electricity | $ | 265 |
| Engineering | 5.7% | $ | 3,500 | | | |
| RE equipment | 67.6% | $ | 41,760 | **Annual Costs - Total** | **$** | **265** |
| Balance of equipment | 7.4% | $ | 4,572 | | | |
| Miscellaneous | 19.3% | $ | 11,933 | **Annual Savings or Income** | | |
| **Initial Costs - Total** | 100.0% | **$** | **61,765** | Heating energy savings/income | $ | 6,690 |
| Incentives/Grants | | $ | 24,700 | | | |
| | | | | **Annual Savings - Total** | **$** | **6,690** |
| **Periodic Costs (Credits)** | | | | | | |
| Damper Motor | | $ | (200) | Schedule yr # 5,10,15,20 | | |
| | | $ | - | | | |
| | | $ | - | | | |
| End of project life - | | $ | - | | | |

### Financial Feasibility

| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 20.1% | | | |
| After-tax IRR and ROI | % | 20.1% | | | |
| Simple Payback | yr | 5.8 | Project equity | $ | 61,765 |
| Year-to-positive cash flow | yr | 5.2 | | | |
| Net Present Value - NPV | $ | 51,609 | | | |
| Annual Life Cycle Savings | $ | 4,871 | | | |
| Profitability Index - PI | - | 0.84 | | | |

### Yearly Cash Flows

| Year # | Pre-tax $ | After-tax $ | Cumulative $ |
|---|---|---|---|
| 0 | (37,065) | (37,065) | (37,065) |
| 1 | 6,617 | 6,617 | (30,448) |
| 2 | 6,816 | 6,816 | (23,632) |
| 3 | 7,020 | 7,020 | (16,612) |
| 4 | 7,231 | 7,231 | (9,381) |
| 5 | 7,669 | 7,669 | (1,713) |
| 6 | 7,671 | 7,671 | 5,958 |
| 7 | 7,901 | 7,901 | 13,860 |
| 8 | 8,138 | 8,138 | 21,998 |
| 9 | 8,382 | 8,382 | 30,380 |
| 10 | 8,878 | 8,878 | 39,258 |
| 11 | 8,893 | 8,893 | 48,151 |
| 12 | 9,160 | 9,160 | 57,311 |
| 13 | 9,435 | 9,435 | 66,745 |
| 14 | 9,718 | 9,718 | 76,463 |
| 15 | 10,278 | 10,278 | 86,741 |
| 16 | 10,309 | 10,309 | 97,051 |
| 17 | 10,619 | 10,619 | 107,669 |
| 18 | 10,937 | 10,937 | 118,606 |
| 19 | 11,265 | 11,265 | 129,872 |
| 20 | 11,900 | 11,900 | 141,772 |

Cumulative Cash Flows Graph


Version 2000



NRCan/CEDRL

## RETScreen® Energy Model - Solar Air Heating Project NCE 84m²

| Site Conditions | | Estimate | Notes/Range |
|---|---|---|---|
| Project name | | Whitehorse General Hospital | |
| Project location | | Whitehorse | |
| Nearest location for weather data | | Whitehorse A, YT | *Complete SR sheet* |
| Annual solar radiation (tilted surface) | MWh/m² | 1.02 | |
| Annual average temperature | °C | -1.0 | |
| Annual average wind speed | m/s | 3.8 | |

| System Characteristics | | Estimate | Notes/Range |
|---|---|---|---|
| Heating application type | - | Ventilation air | |
| **Base Case Heating System** | | | |
| Heating fuel type | - | **Diesel (#2 oil)** | |
| Heating system seasonal efficiency | % | 75% | 0% to 350% |
| **Building** | | | |
| Building type | - | Commercial | |
| Maximum delivered air temperature | °C | 13.5 | 10.0 to 60.0 |
| RSI-value of building wall | m² - °C/W | 3.5 | 0.1 to 10.0 |
| **Airflow Requirements** | | | |
| Design airflow rate | m³/h | 82,300 | 50 to 1,000,000 |
| Operating days per week | d/w | 7.0 | 1.0 to 7.0 |
| Operating hours per day | h/d | 24.0 | 5.0 to 24.0 |
| **Solar Collector** | | | |
| Design objective | - | Standard operation | |
| Collector colour | - | Green | *See Product Database* |
| Solar absorptivity | - | 0.80 | 0.20 to 0.99 |
| Suggested solar collector area | m² | 762 | |
| Solar collector area | m² | 84 | |
| Percent shading during season of use | % | 0% | 0% to 50% |
| SAH fan flow rate | m³/h/m² | 980 | |
| Average air temperature rise | °C | 0.8 | |
| Incremental fan power | W/m² | 1.0 | 0.0 to 7.0 |

| Annual Energy Production (12.0 months analysed) | | Estimate | Notes/Range |
|---|---|---|---|
| Incremental fan energy | MWh | **0.7** | |
| Specific yield | kWh/m² | 642 | |
| Collector efficiency | % | 58% | |
| Solar availability while operating | % | 100% | |
| Renewable energy collected | MWh | 49.3 | |
| Building heat loss recaptured | MWh | 4.6 | |
| Renewable energy delivered | MWh | **53.9** | |
| | GJ | 194 | |
| | | | *Complete Cost Analysis sheet* |

Version 2000  NRCan/CEDRL

## RETScreen® Solar Resource - Solar Air Heating Project

| Site Latitude and Collector Orientation | | Estimate | Notes/Range |
|---|---|---|---|
| Nearest location for weather data | | Whitehorse A, YT | *See Weather Database* |
| Latitude of project location | °N | 60.7 | -90.0 to 90.0 |
| Slope of solar collector | ° | 90.0 | 0.0 to 90.0 |
| Azimuth of solar collector | ° | 45.0 | 0.0 to 180.0 |

**Monthly Inputs**

| Month | Fraction of month used (0 - 1) | Monthly average daily radiation on horizontal surface (kWh/m²/d) | Monthly average temperature (°C) | Monthly average wind speed (m/s) | Monthly average daily radiation in plane of solar collector (kWh/m²/d) |
|---|---|---|---|---|---|
| January | 1.00 | 0.33 | -18.7 | 3.6 | 1.26 |
| February | 1.00 | 1.08 | -13.1 | 4.2 | 2.61 |
| March | 1.00 | 2.53 | -7.2 | 3.9 | 4.15 |
| April | 1.00 | 4.25 | 0.3 | 3.9 | 4.09 |
| May | 1.00 | 5.36 | 6.6 | 3.9 | 3.93 |
| June | 1.00 | 5.89 | 11.6 | 3.6 | 3.84 |
| July | 1.00 | 5.28 | 14.0 | 3.1 | 3.60 |
| August | 1.00 | 4.00 | 12.3 | 3.3 | 3.29 |
| September | 1.00 | 2.44 | 7.3 | 3.9 | 2.63 |
| October | 1.00 | 1.17 | 0.7 | 4.4 | 1.91 |
| November | 1.00 | 0.44 | -10.0 | 4.2 | 1.36 |
| December | 1.00 | 0.19 | -15.9 | 3.9 | 0.86 |

| | | Annual | Season of use |
|---|---|---|---|
| Solar radiation (horizontal) | MWh/m² | 1.01 | 1.01 |
| Solar radiation (tilted surface) | MWh/m² | 1.02 | 1.02 |
| Average temperature | °C | -1.0 | -1.0 |
| Average wind speed | m/s | 3.8 | 3.8 |

*Return to Energy Model sheet*

Version 2000

NRCan/CEDRL

## RETScreen® Cost Analysis - Solar Air Heating Project

Type of project: Standard | Currency: $ | Cost references: None

| Initial Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| Feasibility Study | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Development | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Engineering | | | | | | | |
| Other | Cost | 1 | $ 3,500 | $ 3,500 | | - | - |
| Sub-total : | | | | $ 3,500 | 12.3% | | |
| Renewable Energy (RE) Equipment | | | | | | | |
| Solar collector materials | m² | 84 | $ 125 | $ 10,500 | | - | - |
| Equipment installation | m² | 84 | $ 55 | $ 4,620 | | - | - |
| Cladding material credit | m² | -84 | $ - | $ - | | - | - |
| Cladding labour credit | m² | -84 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ 2,000 | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ 15,120 | 53.1% | | |
| Balance of Equipment | | | | | | | |
| Fans and ducting materials | L/s | 22,861 | $ 0.05 | $ 1,143 | | - | - |
| Fans and ducting labour | L/s | 22,861 | $ 0.15 | $ 3,429 | | - | - |
| Fan and duct mat'l credit | L/s | -22,861 | $ - | $ - | | - | - |
| Fan and duct labour credit | L/s | -22,861 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ 4,572 | 16.1% | | |
| Miscellaneous | | | | | | | |
| Overhead | % | 15% | $ 19,692 | $ 2,954 | | - | - |
| Training | p-h | 0 | $ - | $ - | | - | - |
| Contingencies | % | 10% | $ 23,192 | $ 2,319 | | - | - |
| Sub-total : | | | | $ 5,273 | 18.5% | | |
| **Initial Costs - Total** | | | | $ 28,465 | 100.0% | | |

| Annual Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| O&M | | | | | | | |
| Property taxes/Insurance | project | 1 | $ - | $ - | | - | - |
| O&M labour | project | 0 | $ - | $ - | | - | - |
| Travel and accommodation | p-trip | 1 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Contingencies | % | 0% | $ 19,692 | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Fuel/Electricity | kWh | 736 | $ 0.1305 | $ 96 | 100.0% | - | - |
| **Annual Costs - Total** | | | | $ 96 | 100.0% | | |

| Periodic Costs (Credits) | | Period | Unit Cost | Amount | Interval Range | Unit Cost Range |
|---|---|---|---|---|---|---|
| Damper Motor | | 5 yr | $ 200 | $ (200) | - | - |
| | | | $ - | $ - | - | - |
| | | | $ - | $ - | - | - |
| End of project life | | - | $ - | $ - | | |

Go to GHG Analysis sheet

## RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Solar Air Heating Project

Use GHG analysis sheet? No

*Complete Financial Summary sheet*

Version 2000



UNEP/DTIE and NRCan/CEDRL

## RETScreen® Financial Summary - Solar Air Heating Project

**Annual Energy Balance**

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 0.7 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 53.9 | GHG analysis sheet used? | yes/no | No |
| Heating fuel displaced | - | Diesel (#2 oil) | | | |

**Financial Parameters**

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/L | 0.424 | Debt ratio | % | 0.0% |
| | | | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.131 | | | |
| Energy cost escalation rate | % | 3.0% | | | |
| Inflation | % | 2.0% | | | |
| Discount rate | % | 7.0% | | | |
| Project life | yr | 20 | | | |

**Project Costs and Savings**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Initial Costs** | | | | **Annual Costs and Debt** | | |
| Feasibility study | 0.0% | $ | - | O&M | $ | - |
| Development | 0.0% | $ | - | Fuel/Electricity | $ | 96 |
| Engineering | 12.3% | $ | 3,500 | | | |
| RE equipment | 53.1% | $ | 15,120 | **Annual Costs - Total** | **$** | **96** |
| Balance of equipment | 16.1% | $ | 4,572 | | | |
| Miscellaneous | 18.5% | $ | 5,273 | **Annual Savings or Income** | | |
| **Initial Costs - Total** | 100.0% | **$** | **28,465** | Heating energy savings/income | $ | 2,835 |
| Incentives/Grants | | $ | 11,400 | | | |
| | | | | **Annual Savings - Total** | **$** | **2,835** |
| **Periodic Costs (Credits)** | | | | | | |
| Damper Motor | | $ | (200) | Schedule yr # 5,10,15,20 | | |
| | | $ | - | | | |
| | | $ | - | | | |
| End of project life - | | $ | - | | | |

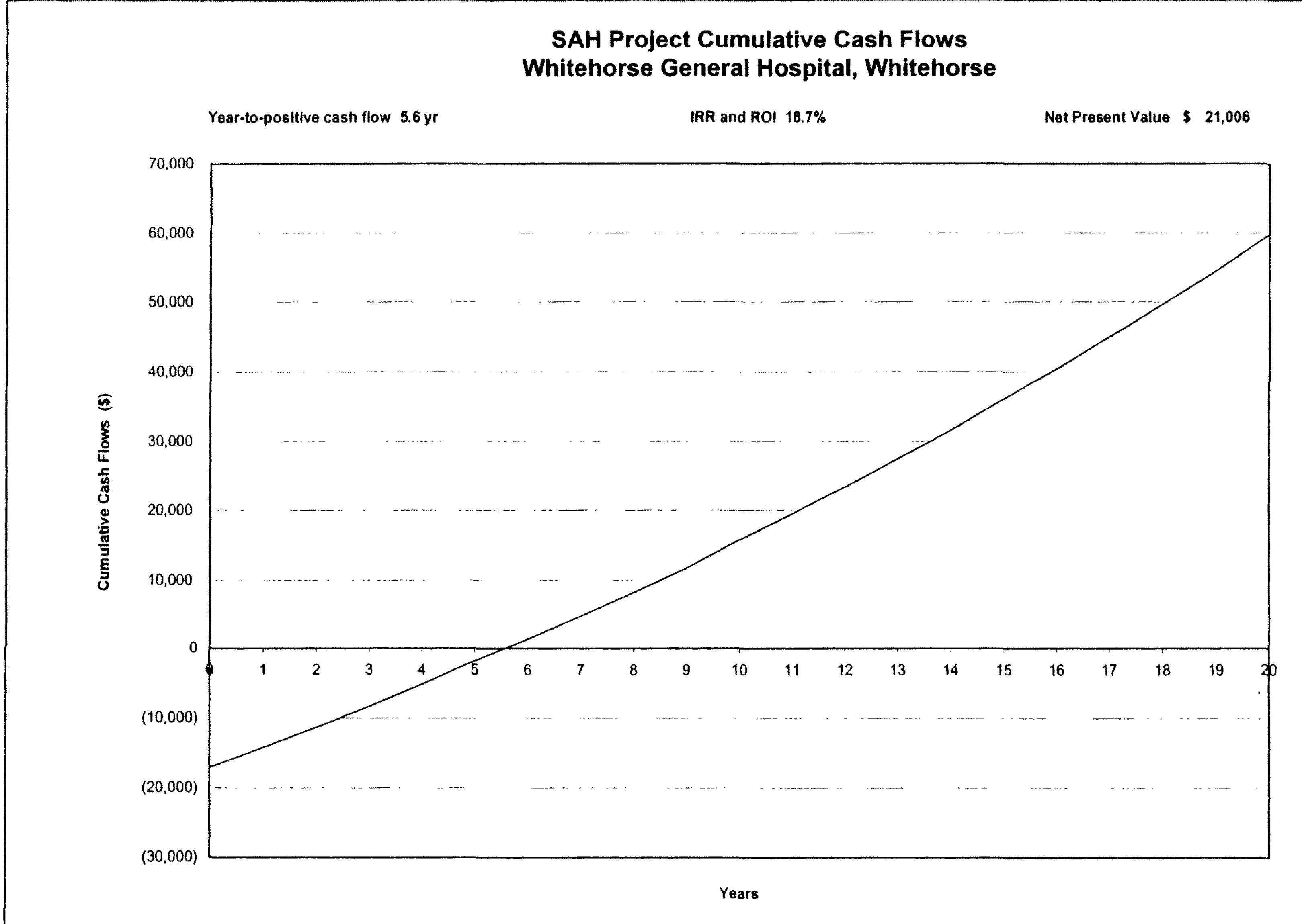
**Financial Feasibility**

| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 18.7% | | | |
| After-tax IRR and ROI | % | 18.7% | | | |
| Simple Payback | yr | 6.2 | Project equity | $ | 28,465 |
| Year-to-positive cash flow | yr | 5.6 | | | |
| Net Present Value - NPV | $ | 21,006 | | | |
| Annual Life Cycle Savings | $ | 1,983 | | | |
| Profitability Index - PI | - | 0.74 | | | |

**Yearly Cash Flows**

| Year # | Pre-tax $ | After-tax $ | Cumulative $ |
|---|---|---|---|
| 0 | (17,065) | (17,065) | (17,065) |
| 1 | 2,822 | 2,822 | (14,244) |
| 2 | 2,906 | 2,906 | (11,338) |
| 3 | 2,993 | 2,993 | (8,344) |
| 4 | 3,083 | 3,083 | (5,261) |
| 5 | 3,396 | 3,396 | (1,865) |
| 6 | 3,271 | 3,271 | 1,406 |
| 7 | 3,369 | 3,369 | 4,775 |
| 8 | 3,470 | 3,470 | 8,245 |
| 9 | 3,574 | 3,574 | 11,820 |
| 10 | 3,925 | 3,925 | 15,745 |
| 11 | 3,792 | 3,792 | 19,537 |
| 12 | 3,906 | 3,906 | 23,442 |
| 13 | 4,023 | 4,023 | 27,465 |
| 14 | 4,143 | 4,143 | 31,609 |
| 15 | 4,537 | 4,537 | 36,146 |
| 16 | 4,396 | 4,396 | 40,542 |
| 17 | 4,528 | 4,528 | 45,069 |
| 18 | 4,664 | 4,664 | 49,733 |
| 19 | 4,803 | 4,803 | 54,536 |
| 20 | 5,245 | 5,245 | 59,781 |

Cumulative Cash Flows Graph




Version 2000



NRCan/CEDRL

## APPENDIX B

## DOE DATABASE MODEL SUMMARY AND OUTPUT

FSC GROUP

# WHITEHORSE GENERAL HOSPITAL
## ENERGY EFFICIENCY STRATEGY ANALYSIS

Curt Hepting, EnerSys Analytics Inc.

Under contract to Ferguson Simek Clark (FSC), we were retained to evaluate the energy cost savings impacts for implementing the following energy efficiency measures (EEMs):

1) RegentEco exhaust heat recovery on APU-6.
2) Solarwall to preheat the outside air provided to APU-3, APU-4 and APU-5 and

## APPROACH BACKGROUND

The analysis of these EEMs was based on using an hourly DOE2.1e energy performance model of the facility I developed for a previous study on behalf of FSC. This involved representing the building geometry and general systems in an hourly DOE2 model *for the purposes of estimating the building's hourly heating requirements for a typical year.* Hence, the level of detail in the model was appropriate for this original task and is not intended as an exact representation of each specific building component and/or system. However, the model is more than appropriate given not only the purpose of this effort, but also given the level of accuracy of the provided information (for instance, schedules alone embody a set of assumptions which likely exceed the error margins of most other building characteristics).

The development the energy performance simulation first required translating the information provided by FSC into a baseline DOE2 model. This includes describing the building geometry and shell components, the interior space conditions for lighting, equipment, people, process loads, etc., and the mechanical HVAC and DHW systems which serve the building. Since not all inputs can be perfectly known, several assumptions have to be made. The most significant of these assumptions typically resides in the schedules. But other characteristics such as the true amount of outdoor air, the DHW load, the boiler part-load operation, minimum fan configuration settings, and cooking and process loads can all have a significant impact on the heating load and overall fuel oil consumption.

To help provide a relatively high level of confidence to the model's accuracy, we calibrate the model to correspond with the electrical and fuel oil billing history. In this case, I calibrated to the average calendar-normalized fuel oil consumption for summer-1998 through summer-2000, and the average calendar-normalized electrical energy use (demand was not provided) for summer-1997 through summer-2001. These time periods were chosen based on the data provided to me by FSC. The results from this exercise confirmed that the model description and inputs provided by FSC were quite reasonable since I did not need to significantly change the building inputs, outside of a reasonable expected margin of error, to produce a very good calibration.

Using this baseline energy model, I reflected the necessary changes to estimate the energy savings for the EEMs.

## ENERGY EFFICIENCY MEASURE ANALYSIS

I modified to the baseline energy model to appropriately represent each of the EEMs. Because of the differences between the baseline model and specifics with each measure, along with limitations in DOE2, certain assumptions and adjustments are often required. These are described below.

### *RegentEco Exhaust Heat Recovery*

Annual Energy Impacts: 44,960 liters of oil saved (3.6%), 12,490 kWh *added* in electrical energy (-0.3%) for a total net energy savings of 1,710 GJ (2.7%)
Annual Utility Bill Impacts: $16,800 at marginal rates of $0.40/liter, $0.121/kWh and $11.53/kW
Note: If fans are actually on only 14 hours/day instead of 17 hours/day (see below), savings would decrease accordingly by approximately 18% to $13,800/year).

The RegentEco system has an impressive heat recovery effectiveness of 90%. In applying this option in the model using the RECOV-EFF keyword, however, *DOE2 did not produce any savings using its heat recovery capability for an unknown reason.* In checking the hourly mixed air and supply air temperatures, there exists many hours where the mixed air temperature is below the minimum supply air temperature of 59°F (less the fan heat dT of up to 2.5°F). In fact, at 25% outside air estimated for the baseline model, heat recovery should become effective at outside air temperatures below about 11°F.

As a secondary approach to estimating the effectiveness of the heat recovery, I performed simulations with the minimum outside air level decreased by 90%. This is a representative approach for an enthalpy wheel in which the latent heat is also recovered, but will significantly overstate the savings for latent heat recovery. Hence, to estimate only the sensible component, I performed two runs that effectively removed the latent component:

1) the baseline without humidification (WGH_B2-NoHumid.std) and
2) the baseline without humidification, OA for APU-6 reduced by 90% and the effective static pressure on supply and return increased by 0.5" each (WGH_B2-NoHumid+HRV.std).

The results from this analysis are archived in EEM Analysis, and contained in the DOE2 output files indicated above.

On a final note, I observed the following discrepancies between NCE's assumptions and those embodied in the above modelling analysis:

- Minimum outside air is represented in the models at 4605 l/s (25%), while NCE's is indicated at "2342 l/s fresh air on average" (22%) but exhaust is indicated to be at 5,093 l/s.
- Hours of operation for the fans are 17 hours/day for the models and only 14 hours for NCE. In the model, the fans are allowed to cycle on to meet heating load during setback periods; it is unknown how NCE's analysis accounts for this.
- In the models, the setback by 5°F from about 7pm – 6am; it is unknown how NCE accounts for setback.

### *Solarwall Preheat on APU-3, 4 and 5*

Annual Energy Impacts:

- Lower estimate for 84 m² Solarwall:
  - Annual Energy: 2211 liters of oil saved, 737 kWh *added* in electrical energy.
  - Annual Utility Bill Impacts: **$814** at marginal rates of $0.40/liter and $0.0955/kWh (blended)
- Upper estimate for 262.5 m² Solarwall:
  - Annual Energy: 6909 liters of oil saved, 2302 kWh *added* in electrical energy.
  - Annual Utility Bill Impacts: **$2544** at marginal rates of $0.40/liter and $0.0955/kWh (blended)

Note: SolarWall.xls spreadsheet contains formulas and inputs for figuring calculated impacts.

The Solarwall system acts as a preheat on the outside air when conditions are favourable (i.e., the sun heats up a cavity behind an exterior perforated screen through which the outside air is drawn through *and* the need for preheating exists). DOE2 does not have the capability to analyze this option. However, data extracted from appropriate DOE2 runs can be used to estimate the impact by creating a "solarwall" surface with the same characteristics as exists with the actual solarwall. In summary, I performed the following steps:

1) Created a cavity with a 100 m² southwest exposure. The actual wall area for the Solarwall is not required since hourly results from the DOE2 analysis will be imported into a spreadsheet, in which the desired Solarwall area can be input and the impacts recalculated. Note that I estimate the maximum potential coverage at 35 m x 7.5 m → 262.5 m².

2) Attach an exterior metal wall with an 80% absorptance, although the absorptance is inherent in the air temperature rise curves provided by Solarwall.
3) Provide for an exhaust fan power of 0.093 W/ft² per NCE's Retscreen analysis. Note that added fan power is accounted for in the Solarwall analysis spreadsheet.
4) Pull the following hourly data for importing into the Solarwall.xls spreadsheet:
    a. Energy required for preheating OA, determined from pulling the heating energy for all *apparent* 53,976 cfm[1] of outside air serving the "SYSTEM-NEW" (QH-5 + QHP-10 for System-New), adjusted by the estimated affected amount of OA for APU-3 and APU-4/5 of 22,860 l/s[2]; this will be used to figure the maximum hourly OA heating requirement
    b. Incident solar on an hourly basis (SOLI-1 of SolarWall wall). Using published Solarwall information on the air temperature rise vs. W/m² of incident solar radiation by air-flow rate.
    c. Calculate the maximum air flow that passes through the Solarwall cavity and will be preheated. At the maximum OA air flow, up to 17.1 (22,860 cfm/sf / 262.5 m²) cfm/sf of air would be required to pass through the Solarwall cavity. However, Solarwall indicates that 7.0 cfm/sf is the maximum allowed flow and hence, this limits the direct maximum effect on 7.0/17.1 = 41% of the outside air flow. At less than 100% Solarwall coverage, this percentage would decrease proportionally; for instance, at the minimum 84 m² of coverage, only (7.0/53.6 = 7.7% of the outside air requirements can be directed through the Solarwall.
    d. Energy available from solarwall determined by applying the linear formulas from the Solarwall product literature for how much the outside air temperature rises on an hourly basis (dT): 1.08 x CFM x dT x 1.070 altitude factor.
5) Calculate the hourly OA energy requirements and contributions from the Solarwall . Add in the electrical energy from the additional fan power, assuming no by-pass for when no preheating is applicable (otherwise, Solarwall shouldn't claim wall loss recapture during all heating hours).
6) Increase the southwest R-value by R-50 (per Solarwall literature) for the mechanical room area cladded with Solarwall. Note that the present assumption is that this space is only marginally conditioned to stay about 50°F. The annual savings obtained from increasing the 2886 ft² SW wall

---

[1] OA appears lower than actual since it was reduced in model to reflect enthalpy wheel heat recovery on APU1/2, which is combined with APU-3 and APU-4/5. Hence, indicated level effectively represents the net volume flow of outside air that requires full preheating. Actual minimum OA pulled from hourly data.

[2] From NCE report, although preliminary analysis by FSC in "Secondary Sales Feasibility Study" (Jan 15, 2001) indicated higher estimated amounts. Note that calibration to billed energy use dictated that outdoor air levels had to be on the low side in order to account for the billing data.

by R-50 amounts to about 0.00104 mmBtu/ft², assuming application during all heating hours.

7) Apply marginal costs (blended electricity rates since demand coincidence is problematic) to yield annual cost savings.

Note that Retscreen is an accepted and tested (I assume) application that is provided by Natural Resources Canada (NRCan) for performing solar thermal analyses. While I believe my approach with making use of the calibrated hourly baseline model and associated weather data is valid (instead of monthly data, as with Retscreen), it has not been validated against an actual operating system. Furthermore, there appears to be a significant difference between the Retscreen analysis results from NCE, with their lower estimate 3.4 times higher than my calculations. Consequently, FSC should carefully review both approaches to evaluate the merits and validity for the analysis.

240 m²

## Solarwall Hourly Analysis

**Whitehorse General Hospital**

3-Jan-03
C. Hepting, EnerSys Analytics
Modifed RDA, FSCC Jan 22/03

**Inputs**

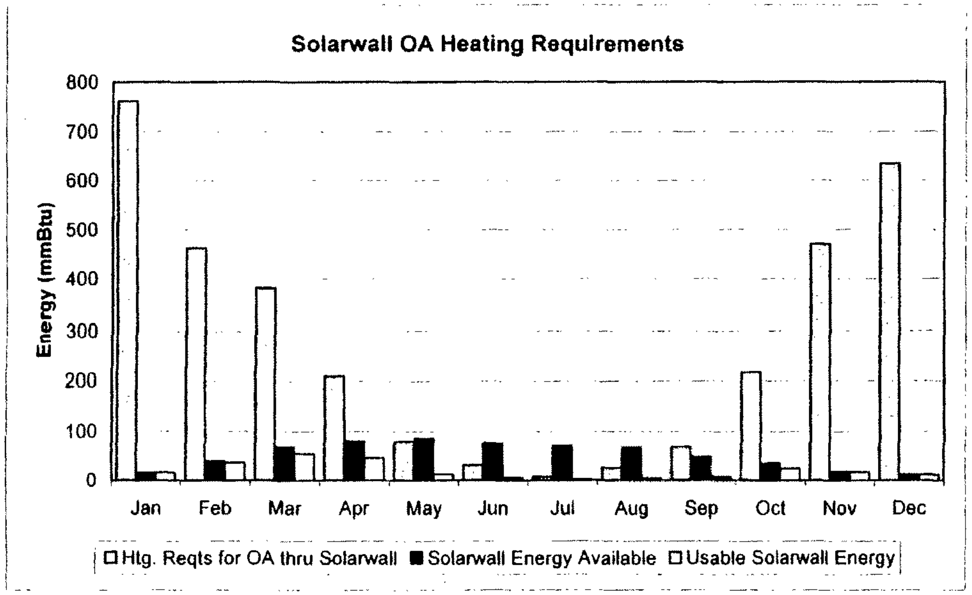
| | | | | |
|---|---|---|---|---|
| **Air Flow Across Solarwall:** | **7 cfm/ft²** | **Seasonal Heating Plant Efficiency:** | **80.6%** | (from DOE2) |
| Corresponding dT vs. solar radiation: | 0.01667 °C/(W/m²) | **Fan Power Increase for Solarwall:** | **0.0930** | W/ft² |
| **Surface Area of Solarwall:** | **2,669 ft²** | **Heating Content for Heating Fuel:** | **37,003** | Btu/liter |
| Maximum solarwall air flow: | 18,683 | **Marginal Rate for Heating Fuel:** | **$0.450** | per liter |
| | | | $12.161 | per mmBtu |
| **Applicable OA for Preheating:** | **48,440 cfm** | **Marginal Rate for Electricity:** | **$0.1300** | per kWh |
| Proportion of OA preheated by Solarwall: | 38.6% | | | |
| Amount of OA preheated by Solarwall: | **18,683** cfm | | | |

For WGH Application:
Minimum application = 84 m²
Maximum application = 262.5 m²

**Annual Results**

| | | | |
|---|---|---|---|
| Preheat Provided by Solarwall: | 238.73 mmBtu (in) | 251.9 GJ | |
| Fuel Avoided from Solarwall Preheat: | 6,452 liters | | |
| Reclaimed Wall Losses by System: | 255 liters | 9.9 GJ | |
| **Total Fuel Savings for Solarwall:** | **6,706 liters** | **Added Fan Energy (3611 hrs/yr):** ☑ By-Pass | **896 kWh** |
| **Fuel Cost Savings for Solarwall:** | **$3,018 /year** | **Added Electrical Costs from Solarwall:** | **$117 /year** |
| **Net Utility Cost Savings for Solarwall:** | **$2,901 /year** | | |

| Day of Year | Month | Day | Hour | OA for Solarwall (cfm) | Solarwall OA Htg Req'ts (Btuh) | Solarwall Air Temp. Rise (°F) | Solarwall Preheat Available (Btuh) | Solarwall Energy Used (Btuh) |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 18,683 | 971,144 | 0.0 | 0 | 0 |
| 2 | 1 | 1 | 2 | 18,683 | 773,908 | 0.0 | 0 | 0 |
| 3 | 1 | 1 | 3 | 18,683 | 635,644 | 0.0 | 0 | 0 |
| 4 | 1 | 1 | 4 | 18,683 | 558,647 | 0.0 | 0 | 0 |
| 5 | 1 | 1 | 5 | 18,683 | 539,010 | 0.0 | 0 | 0 |
| 6 | 1 | 1 | 6 | 18,683 | 518,600 | 0.0 | 0 | 0 |
| 7 | 1 | 1 | 7 | 18,683 | 576,364 | 0.0 | 0 | 0 |
| 8 | 1 | 1 | 8 | 18,683 | 556,347 | 0.0 | 0 | 0 |
| 9 | 1 | 1 | 9 | 18,683 | 520,268 | 0.0 | 0 | 0 |
| 10 | 1 | 1 | 10 | 18,683 | 518,459 | 0.0 | 0 | 0 |
| 11 | 1 | 1 | 11 | 18,683 | 478,511 | 0.1 | 2,008 | 2,008 |
| 12 | 1 | 1 | 12 | 18,683 | 477,119 | 0.4 | 9,329 | 9,329 |
| 13 | 1 | 1 | 13 | 18,683 | 481,496 | 8.9 | 192,665 | 192,665 |
| 14 | 1 | 1 | 14 | 18,683 | 496,194 | 6.5 | 140,061 | 140,061 |




**Monthly Energy (mmBtu)**

| | Month | Htg. Reqts for OA thru Solarwall | Solarwall Energy Available | Usable Solarwall Energy | "Wasted" Solarwall Energy | |
|---|---|---|---|---|---|---|
| 1 | Jan | 760.90 | 16.66 | 16.66 | 0.00 | 0.999782 |
| 2 | Feb | 462.87 | 39.59 | 36.48 | 3.11 | 0.921521 |
| 3 | Mar | 381.77 | 68.83 | 54.50 | 14.33 | 0.791795 |
| 4 | Apr | 208.37 | 80.13 | 45.72 | 34.41 | 0.570569 |
| 5 | May | 79.72 | 85.99 | 12.89 | 73.11 | 0.149857 |
| 6 | Jun | 31.80 | 76.08 | 6.21 | 69.87 | 0.081615 |
| 7 | Jul | 8.30 | 71.15 | 2.03 | 69.12 | 0.028521 |
| 8 | Aug | 26.79 | 67.10 | 3.51 | 63.59 | 0.052294 |
| 9 | Sep | 68.15 | 47.78 | 7.19 | 40.59 | 0.15053 |
| 10 | Oct | 215.87 | 34.49 | 24.62 | 9.87 | 0.713782 |
| 11 | Nov | 470.92 | 18.16 | 17.23 | 0.92 | 0.949069 |
| 12 | Dec | 634.48 | 11.69 | 11.69 | 0.00 | 1 |
| | Annual | 3,349.94 | 617.65 | 238.73 | 378.92 | |
| | | | 651.62 GJ | | | |

**Solarwall Hourly Analysis**
**Whitehorse General Hospital**

3-Jan-03
C. Hepting, EnerSys Analytics
Modifed RDA, FSCC Jan 22/03

**Inputs**

| | | | | |
|---|---|---|---|---|
| **Air Flow Across Solarwall:** | 7 cfm/ft² | **Seasonal Heating Plant Efficiency:** | 80.6% | (from DOE2) |
| Corresponding dT vs. solar radiation: | 0.01667 °C/(W/m²) | **Fan Power Increase for Solarwall:** | 0.0930 | W/ft² |
| **Surface Area of Solarwall:** | 2,669 ft² | **Heating Content for Heating Fuel:** | 37,003 | Btu/liter |
| Maximum solarwall air flow: | 18,683 | **Marginal Rate for Heating Fuel:** | $0.450 | per liter |
| | | | $12.161 | per mmBtu |
| **Applicable OA for Preheating:** | 48,440 cfm | **Marginal Rate for Electricity:** | $0.1300 | per kWh |
| Proportion of OA preheated by Solarwall: | 38.6% | | | |
| Amount of OA preheated by Solarwall: | 18,683 cfm | | | |

For WGH Application:
Minimum application = 84 m²
Maximum application = 262.5 m²

**Annual Results**

| | | | | |
|---|---|---|---|---|
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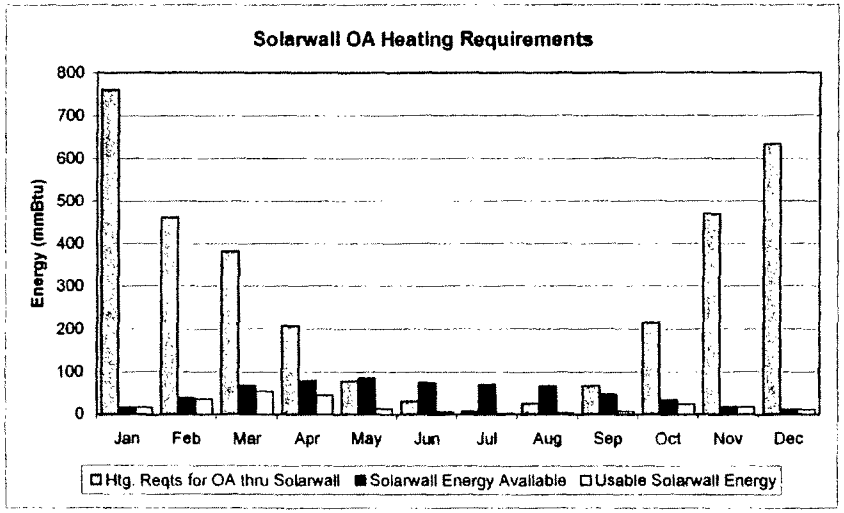
| Reclaimed Wall Losses by System: | 255 liters | 9.9 GJ | | |
| **Total Fuel Savings for Solarwall:** | **6,706 liters** | **Added Fan Energy (3611 hrs/yr):** | ☑ By-Pass | **896 kWh** |
| **Fuel Cost Savings for Solarwall:** | **$3,018 /year** | **Added Electrical Costs from Solarwall:** | | **$117 /year** |
| **Net Utility Cost Savings for Solarwall:** | **$2,901 /year** | | | |

| Day of Year | Month | Day | Hour | OA for Solarwall (cfm) | Solarwall OA Htg Req'ts (Btuh) | Solarwall Air Temp. Rise (°F) | Solarwall Preheat Available (Btuh) | Solarwall Energy Used (Btuh) | Solarwall Air Temp. Rise (°F) | Solarwall Leaving Air Temp (degF) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 18,683 | 971,144 | 0.0 | 0 | 0 | N/A | N/A |
| 2 | 1 | 1 | 2 | 18,683 | 773,908 | 0.0 | 0 | 0 | N/A | N/A |
| 3 | 1 | 1 | 3 | 18,683 | 635,644 | 0.0 | 0 | 0 | N/A | N/A |
| 4 | 1 | 1 | 4 | 18,683 | 558,647 | 0.0 | 0 | 0 | N/A | N/A |
| 5 | 1 | 1 | 5 | 18,683 | 539,010 | 0.0 | 0 | 0 | N/A | N/A |
| 6 | 1 | 1 | 6 | 18,683 | 518,600 | 0.0 | 0 | 0 | N/A | N/A |
| 7 | 1 | 1 | 7 | 18,683 | 576,364 | 0.0 | 0 | 0 | N/A | N/A |
| 8 | 1 | 1 | 8 | 18,683 | 556,347 | 0.0 | 0 | 0 | N/A | N/A |
| 9 | 1 | 1 | 9 | 18,683 | 520,268 | 0.0 | 0 | 0 | N/A | N/A |
| 10 | 1 | 1 | 10 | 18,683 | 518,459 | 0.0 | 0 | 0 | N/A | N/A |
| 11 | 1 | 1 | 11 | 18,683 | 478,511 | 0.1 | 2,008 | 2,008 | 0.0930186 | 22.0930186 |
| 12 | 1 | 1 | 12 | 18,683 | 477,119 | 0.4 | 9,329 | 9,329 | 0.4320864 | 22.4320864 |
| 13 | 1 | 1 | 13 | 18,683 | 481,496 | 8.9 | 192,665 | 192,665 | 8.9237844 | 30.9237844 |
| 14 | 1 | 1 | 14 | 18,683 | 496,194 | 6.5 | 140,061 | 140,061 | 6.4872972 | 27.4872972 |

[illegible] <<Avg air temp rise
[illegible] <<Avg Solarwall LAT




**Monthly Energy (mmBtu)**

| | Month | Htg. Reqts for OA thru Solarwall | Solarwall Energy Available | Usable Solarwall Energy | "Wasted" Solarwall Energy | |
|---|---|---|---|---|---|---|
| 1 | Jan | 760.90 | 16.66 | 16.66 | 0.00 | 0.999782 |
| 2 | Feb | 462.87 | 39.59 | 36.48 | 3.11 | 0.921521 |
| 3 | Mar | 381.77 | 68.83 | 54.50 | 14.33 | 0.791795 |
| 4 | Apr | 208.37 | 80.13 | 45.72 | 34.41 | 0.570569 |
| 5 | May | 79.72 | 85.99 | 12.89 | 73.11 | 0.149857 |
| 6 | Jun | 31.80 | 76.08 | 6.21 | 69.87 | 0.081615 |
| 7 | Jul | 8.30 | 71.15 | 2.03 | 69.12 | 0.028521 |
| 8 | Aug | 26.79 | 67.10 | 3.51 | 63.59 | 0.052294 |
| 9 | Sep | 68.15 | 47.78 | 7.19 | 40.59 | 0.15053 |
| 10 | Oct | 215.87 | 34.49 | 24.62 | 9.87 | 0.713782 |
| 11 | Nov | 470.92 | 18.16 | 17.23 | 0.92 | 0.949069 |
| 12 | Dec | 634.48 | 11.69 | 11.69 | 0.00 | 1 |
| | Annual | 3,349.94 | 617.65 | 238.73 | 378.92 | |
| | | | 651.62 GJ | | | |

# RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Solar Air Heating Project

Use GHG analysis sheet? Yes    Type of analysis Standard

## Background Information

**Project Information**

| | |
|---|---|
| Project name | Whitehorse General Hospital |
| Project location | Whitehorse |

**Global Warming Potential of GHG**

1 ton $CH_4$ = 21 tons $CO_2$ (IPCC 1996)
1 ton $N_2O$ = 310 tons $CO_2$ (IPCC 1996)

## Base Case Electricity System (Reference)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | T & D losses (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|---|
| Small hydro | 100.0% | 0.0 | 0.0000 | 0.0000 | 100.0% | 8.0% | 0.000 |
| Electricity mix | 100% | 0.0 | 0.0000 | 0.0000 | | 8.0% | 0.000 |

## Base Case Heating System (Reference)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|
| **Heating system** | | | | | | |
| Diesel (#2 oil) | 100.0% | 74.1 | 0.0020 | 0.0020 | 80.0% | 0.336 |

## Proposed Case Heating System (Mitigation)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|
| **Heating system** | | | | | | |
| Electricity | 2.9% | 0.0 | 0.0000 | 0.0000 | 100.0% | 0.000 |
| Solar | 97.1% | 0.0 | 0.0000 | 0.0000 | 100.0% | 0.000 |
| Heating energy mix | 100.0% | 0.0 | 0.0000 | 0.0000 | | 0.000 |

## GHG Emission Reduction Summary

| | Base case GHG emission factor ($t_{CO2}$/MWh) | Proposed case GHG emission factor ($t_{CO2}$/MWh) | End-use annual energy delivered (MWh) | Annual GHG emission reduction ($t_{CO2}$) |
|---|---|---|---|---|
| **Heating system** | 0.336 | 0.000 | 72.7 | 24.45 |
| | | | Net GHG emission reduction $t_{CO2}$/yr | **24.45** |

*Complete Financial Summary sheet*

## APPENDIX C

## RETSCREEN AND SWIFT ANALYSIS OUTPUT AND MISC CALCULATIONS

## RETScreen® Energy Model - Solar Air Heating Project

| Site Conditions | | Estimate | Notes/Range |
|---|---|---|---|
| Project name | | **Whitehorse General Hospital** | |
| Project location | | **Whitehorse** | |
| Nearest location for weather data | | Whitehorse A, YT | *Complete SR sheet* |
| Annual solar radiation (tilted surface) | MWh/m² | 1.02 | |
| Annual average temperature | °C | -1.0 | |
| Annual average wind speed | m/s | 3.8 | |

| System Characteristics | | Estimate | Notes/Range |
|---|---|---|---|
| Heating application type | - | Ventilation air | |
| **Base Case Heating System** | | | |
| Heating fuel type | - | **Diesel (#2 oil)** | |
| Heating system seasonal efficiency | % | 75% | 0% to 350% |
| **Building** | | | |
| Building type | - | Commercial | |
| Maximum delivered air temperature | °C | 13.5 | 10.0 to 60.0 |
| RSI-value of building wall | m² - °C/W | 3.5 | 0.1 to 10.0 |
| **Airflow Requirements** | | | |
| Design airflow rate | m³/h | 31,740 | 50 to 1,000,000 |
| Operating days per week | d/w | 7.0 | 1.0 to 7.0 |
| Operating hours per day | h/d | 24.0 | 5.0 to 24.0 |
| **Solar Collector** | | | |
| Design objective | - | Standard operation | |
| Collector colour | - | Green | *See Product Database* |
| Solar absorptivity | - | 0.80 | 0.20 to 0.99 |
| Suggested solar collector area | m² | 294 | |
| Solar collector area | m² | 248 | |
| Percent shading during season of use | % | 0% | 0% to 50% |
| SAH fan flow rate | m³/h/m² | 128 | |
| Average air temperature rise | °C | 4.3 | |
| Incremental fan power | W/m² | 1.0 | 0.0 to 7.0 |

| Annual Energy Production (12.0 months analysed) | | Estimate | Notes/Range |
|---|---|---|---|
| Incremental fan energy | MWh | **2.2** | |
| Specific yield | kWh/m² | 470 | |
| Collector efficiency | % | 41% | |
| Solar availability while operating | % | 100% | |
| Renewable energy collected | MWh | 103.3 | |
| Building heat loss recaptured | MWh | 13.1 | |
| Renewable energy delivered | MWh | **116.4** | |
| | GJ | 419.1 | |
| | | | *Complete Cost Analysis sheet* |

Version 2000  NRCan/CEDRL

## RETScreen® Solar Resource - Solar Air

**Site Latitude and Collector Orientation**

Nearest location for weather data
Latitude of project location
Slope of solar collector
Azimuth of solar collector

**Monthly Inputs**

| Month | Fraction of month used (0 - 1) |
|---|---|
| January | 1.00 |
| February | 1.00 |
| March | 1.00 |
| April | 1.00 |
| May | 1.00 |
| June | 1.00 |
| July | 1.00 |
| August | 1.00 |
| September | 1.00 |
| October | 1.00 |
| November | 1.00 |
| December | 1.00 |

Solar radiation (horizontal)
Solar radiation (tilted surface)
Average temperature
Average wind speed

## RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Solar Air Heating Project (FO Heating)

Use GHG analysis sheet? Yes

Type of analysis Standard

### Background Information

**Project Information**

| | |
|---|---|
| Project name | Whitehorse General Hospital |
| Project location | Whitehorse |

**Global Warming Potential of GHG**

| | | |
|---|---|---|
| 1 ton $CH_4$ = | 21 tons $CO_2$ | (IPCC 1996) |
| 1 ton $N_2O$ = | 310 tons $CO_2$ | (IPCC 1996) |

### Base Case Electricity System (Reference)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | T & D losses (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|---|
| Small hydro | 100.0% | 0.0 | 0.0000 | 0.0000 | 100.0% | 8.0% | 0.000 |
| Electricity mix | 100% | 0.0 | 0.0000 | 0.0000 | | 8.0% | 0.000 |

### Base Case Heating System (Reference)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|
| **Heating system** | | | | | | |
| Diesel (#2 oil) | 100.0% | 74.1 | 0.0020 | 0.0020 | 80.0% | 0.336 |

### Proposed Case Heating System (Mitigation)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|
| **Heating system** | | | | | | |
| Electricity | 1.8% | 0.0 | 0.0000 | 0.0000 | 100.0% | 0.000 |
| Solar | 98.2% | 0.0 | 0.0000 | 0.0000 | 100.0% | 0.000 |
| Heating energy mix | 100.0% | 0.0 | 0.0000 | 0.0000 | | 0.000 |

### GHG Emission Reduction Summary

| | Base case GHG emission factor ($t_{CO2}$/MWh) | Proposed case GHG emission factor ($t_{CO2}$/MWh) | End-use annual energy delivered (MWh) | | Annual GHG emission reduction ($t_{CO2}$) |
|---|---|---|---|---|---|
| **Heating system** | 0.336 | 0.000 | 116.4 | | 39.17 |
| | | | Net GHG emission reduction | $t_{CO2}$/yr | **39.17** |

*Complete Financial Summary sheet*

## RETScreen® Energy Model - Solar Air Heating Project

Adjusted

| Site Conditions | | Estimate | Notes/Range |
|---|---|---|---|
| Project name | | **Whitehorse General Hospital** | |
| Project location | | **Whitehorse** | |
| Nearest location for weather data | | Whitehorse A, YT | *Complete SR sheet* |
| Annual solar radiation (tilted surface) | MWh/m² | 1.02 | |
| Annual average temperature | °C | -1.0 | |
| Annual average wind speed | m/s | 3.8 | |

| System Characteristics | | Estimate | Notes/Range |
|---|---|---|---|
| Heating application type | - | Ventilation air | |
| **Base Case Heating System** | | | |
| Heating fuel type | - | **Diesel (#2 oil)** | |
| Heating system seasonal efficiency | % | 75% | 0% to 350% |
| **Building** | | | |
| Building type | - | Commercial | |
| Maximum delivered air temperature | °C | 60.0 | 10.0 to 60.0 |
| RSI-value of building wall | m² - °C/W | 3.5 | 0.1 to 10.0 |
| **Airflow Requirements** | | | |
| Design airflow rate | m³/h | 31,740 | 50 to 1,000,000 |
| Operating days per week | d/w | 7.0 | 1.0 to 7.0 |
| Operating hours per day | h/d | 24.0 | 5.0 to 24.0 |
| **Solar Collector** | | | |
| Design objective | - | Standard operation | |
| Collector colour | - | Green | *See Product Database* |
| Solar absorptivity | - | 0.80 | 0.20 to 0.99 |
| Suggested solar collector area | m² | 294 | |
| Solar collector area | m² | 248 | |
| Percent shading during season of use | % | 0% | 0% to 50% |
| SAH fan flow rate | m³/h/m² | 128 | |
| Average air temperature rise | °C | 4.7 | |
| Incremental fan power | W/m² | 1.0 | 0.0 to 7.0 |

| Annual Energy Production (6.4 months analysed) | | Estimate | Notes/Range |
|---|---|---|---|
| Incremental fan energy | MWh | **1.2** | |
| Specific yield | kWh/m² | 324 | |
| Collector efficiency | % | 66% | |
| Solar availability while operating | % | 43% | |
| Renewable energy collected | MWh | 70.8 | |
| Building heat loss recaptured | MWh | 9.5 | |
| Renewable energy delivered | MWh | **80.4** | |
| | GJ | 289.3 | |
| | | | *Complete Cost Analysis sheet* |

Version 2000  NRCan/CEDRL

## RETScreen® Solar Resource - Solar Air Heating Project

| Site Latitude and Collector Orientation | | Estimate | Notes/Range |
|---|---|---|---|
| Nearest location for weather data | | Whitehorse A, YT | *See Weather Database* |
| Latitude of project location | °N | 60.7 | -90.0 to 90.0 |
| Slope of solar collector | ° | 90.0 | 0.0 to 90.0 |
| Azimuth of solar collector | ° | 45.0 | 0.0 to 180.0 |

**Monthly Inputs**

| Month | Fraction of month used (0 - 1) | Monthly average daily radiation on horizontal surface (kWh/m²/d) | Monthly average temperature (°C) | Monthly average wind speed (m/s) | Monthly average daily radiation in plane of solar collector (kWh/m²/d) |
|---|---|---|---|---|---|
| January | 1.00 | 0.33 | -18.7 | 3.6 | 1.26 |
| February | 0.92 | 1.08 | -13.1 | 4.2 | 2.61 |
| March | 0.80 | 2.53 | -7.2 | 3.9 | 4.15 |
| April | 0.57 | 4.25 | 0.3 | 3.9 | 4.09 |
| May | 0.15 | 5.36 | 6.6 | 3.9 | 3.93 |
| June | 0.08 | 5.89 | 11.6 | 3.6 | 3.84 |
| July | 0.03 | 5.28 | 14.0 | 3.1 | 3.60 |
| August | 0.05 | 4.00 | 12.3 | 3.3 | 3.29 |
| September | 0.15 | 2.44 | 7.3 | 3.9 | 2.63 |
| October | 0.71 | 1.17 | 0.7 | 4.4 | 1.91 |
| November | 0.95 | 0.44 | -10.0 | 4.2 | 1.36 |
| December | 1.00 | 0.19 | -15.9 | 3.9 | 0.86 |

| | | Annual | Season of use |
|---|---|---|---|
| Solar radiation (horizontal) | MWh/m² | 1.01 | 0.28 |
| Solar radiation (tilted surface) | MWh/m² | 1.02 | 0.43 |
| Average temperature | °C | -1.0 | -8.9 |
| Average wind speed | m/s | 3.8 | 4.0 |

*Return to Energy Model sheet*

Version 2000



NRCan/CEDRL

RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Solar Air Heating Project (Adjusted) FO Heating

Use GHG analysis sheet? Yes | Type of analysis Standard

## Background Information

**Project Information**

Project name: Whitehorse General Hospital
Project location: Whitehorse

**Global Warming Potential of GHG**

1 ton $CH_4$ = 21 tons $CO_2$ (IPCC 1996)
1 ton $N_2O$ = 310 tons $CO_2$ (IPCC 1996)

## Base Case Electricity System (Reference)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | T & D losses (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|---|
| Small hydro | 100.0% | 0.0 | 0.0000 | 0.0000 | 100.0% | 8.0% | 0.000 |
| Electricity mix | 100% | 0.0 | 0.0000 | 0.0000 | | 8.0% | 0.000 |

## Base Case Heating System (Reference)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|
| **Heating system** | | | | | | |
| Diesel (#2 oil) | 100.0% | 74.1 | 0.0020 | 0.0020 | 80.0% | 0.336 |

## Proposed Case Heating System (Mitigation)

| Fuel type | Fuel mix (%) | $CO_2$ emission factor (kg/GJ) | $CH_4$ emission factor (kg/GJ) | $N_2O$ emission factor (kg/GJ) | Fuel conversion efficiency (%) | GHG emission factor ($t_{CO2}$/MWh) |
|---|---|---|---|---|---|---|
| **Heating system** | | | | | | |
| Electricity | 1.4% | 0.0 | 0.0000 | 0.0000 | 100.0% | 0.000 |
| Solar | 98.6% | 0.0 | 0.0000 | 0.0000 | 100.0% | 0.000 |
| Heating energy mix | 100.0% | 0.0 | 0.0000 | 0.0000 | | 0.000 |

## GHG Emission Reduction Summary

| | Base case GHG emission factor ($t_{CO2}$/MWh) | Proposed case GHG emission factor ($t_{CO2}$/MWh) | End-use annual energy delivered (MWh) | Annual GHG emission reduction ($t_{CO2}$) |
|---|---|---|---|---|
| **Heating system** | 0.336 | 0.000 | 80.4 | 27.04 |
| | | | Net GHG emission reduction $t_{CO2}$/yr | **27.04** |

*Complete Financial Summary sheet*

# SOLAR HEATING SYSTEM SPECIFICATIONS

## ENERGY INPUTS

| System | Flow (l/s) | Schedule | Heating Fuel | Heating Efficiency | Cost of Fuel |
|---|---|---|---|---|---|
| Wall 1 | 8816 | * 7 days/week 24 hrs/day | Oil ( l ) | 80.0 % | $ 0.45 |

## BUILDING INPUTS

| System | Min. Supply Air Temp. (°C) | Max. Useful Supply Temp. (°C) | Ceiling R-Value (°C-m²/W) | Wall R-Value (°C-m²/W) | Building Temperature (°C) | Ceiling Temperature (°C) | Exhaust Fan Location |
|---|---|---|---|---|---|---|---|
| Wall 1 | 13.5 | 12.5 | 2.11 | 3.50 | 20.0 | 25.0 | Ceiling |

## COLLECTOR

| System | Total Area (m²) | Porosity | Depth (m) | Collector Height (m) | Canopy Height (m) | Collector Width (m) | Canopy Width (m) |
|---|---|---|---|---|---|---|---|
| Wall 1 | 248.20 | High | 0.50 | 7.30 | 2.50 | 34.00 | 34.00 |

## BYPASS DAMPERS

| System | Number of Bypass Dampers | Type of Bypass Damper | Damper Area (m²) | Bypass Temperature (°C) | Damper Width (m) | Damper Height (m) |
|---|---|---|---|---|---|---|
| Wall 1 | 1 | Wall | 3.33 | 13.5 | 3.65 | 0.91 |

## SOLARWALL FAN

| System | Number of Fans | Fan Efficiency | Motor Efficiency | Flow (l/s) | Power (kW) | Pressure (Pa) |
|---|---|---|---|---|---|---|
| Wall 1 | 1 | High | High | 8816 | 12.5 | 873.1 |

## DUCTING

| System | Number | Length (m) | Duct Area (m²) | Accessories |
|---|---|---|---|---|
| Wall 1 | 1 | 100.00 | 0.50 | Tapered Inlet |

# Monthly Results for Wall: 1

| Month | Degree-Days Base (18°C) | Solar Radiation Incident (GJ) | Solar Radiation Incident Operational | Average Daytime Temp. Rise | Solar Energy Collected (GJ) | Insulation Savings (GJ) | Destrat. Savings (GJ) | Total Savings (GJ) |
|---|---|---|---|---|---|---|---|---|
| January | 1193 | 51.3 | 48.7 | 4.3 | 33.5 | 7.5 | N/A | 41.0 |
| February | 821 | 108.0 | 90.3 | 6.2 | 59.7 | 5.0 | N/A | 64.8 |
| March | 752 | 168.9 | 135.8 | 6.4 | 87.1 | 4.5 | N/A | 91.6 |
| April | 536 | 179.4 | 132.1 | 5.0 | 80.5 | 3.1 | N/A | 83.6 |
| May | 350 | 146.2 | 44.6 | 1.2 | 23.0 | 2.1 | N/A | 25.1 |
| June | 196 | 123.0 | 20.8 | 0.6 | 10.5 | 1.3 | N/A | 11.9 |
| July | 125 | 119.6 | 5.3 | 0.2 | 2.7 | 0.9 | N/A | 3.6 |
| August | 198 | 125.7 | 8.9 | 0.3 | 4.8 | 1.3 | N/A | 6.1 |
| September | 328 | 97.6 | 24.6 | 1.0 | 13.1 | 2.1 | N/A | 15.2 |
| October | 552 | 75.3 | 59.1 | 3.2 | 36.6 | 3.5 | N/A | 40.1 |
| November | 848 | 47.0 | 44.7 | 3.6 | 29.6 | 5.4 | N/A | 35.0 |
| December | 1047 | 37.9 | 37.5 | 3.6 | 25.4 | 6.7 | N/A | 32.0 |
| **TOTAL** | **6946** | **1279.8** | **652.4** | **2.5** | **406.5** | **43.5** | **N/A** | **450.0** |

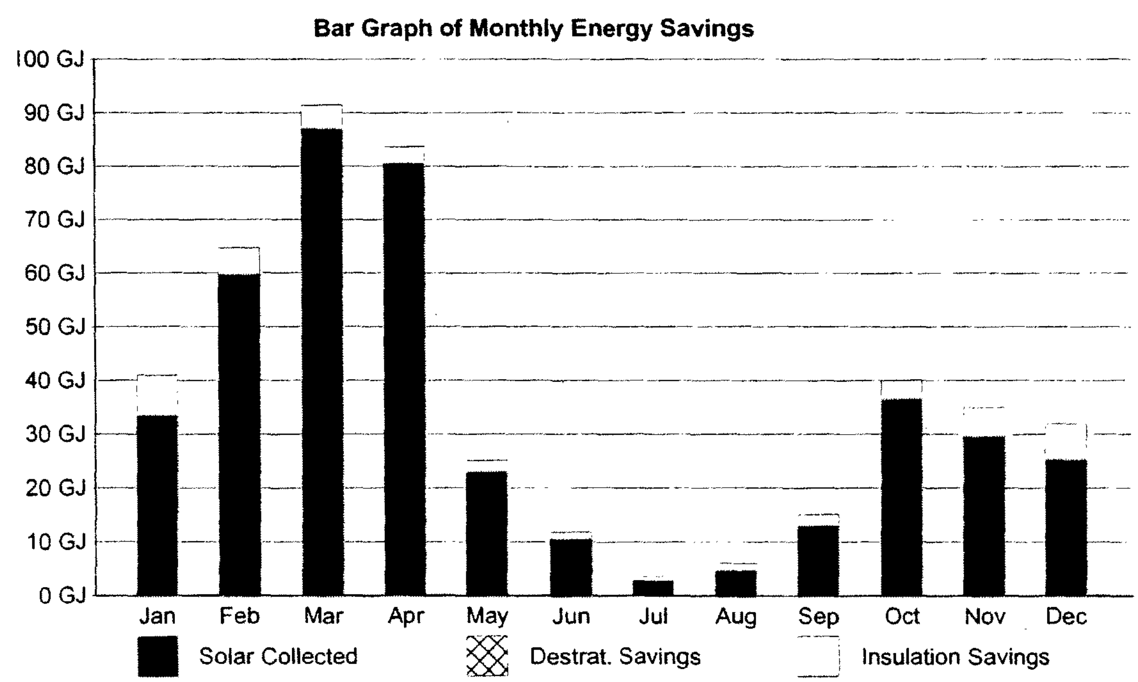
## ANNUAL SYSTEM PERFORMANCE

**PERFORMANCE**

| | Solar | Total |
|---|---|---|
| **Annual Savings ($GJ/m^2$)** | 1.64 | 1.81 |
| **Collector Efficiency (%)** | 62 | — |

**LOAD**

| | Daytime | Total |
|---|---|---|
| **Annual Ventilation Load (GJ)** | 1783.70 | 5181.07 |
| **Ventilation Load by Collector (%)** | 24 | 9 |



# SOLAR HEATING SYSTEM SPECIFICATIONS

## ENERGY INPUTS

| System | Flow (l/s) | Schedule | Heating Fuel | Heating Efficiency | Cost of Fuel |
|---|---|---|---|---|---|
| Wall 1 | 8816 | * 7 days/week 24 hrs/day | Elec. ( kWh ) | 100.0 % | $ 0.04 |

## BUILDING INPUTS

| System | Min. Supply Air Temp. (°C) | Max. Useful Supply Temp. (°C) | Ceiling R-Value (°C-m²/W) | Wall R-Value (°C-m²/W) | Building Temperature (°C) | Ceiling Temperature (°C) | Exhaust Fan Location |
|---|---|---|---|---|---|---|---|
| Wall 1 | 13.5 | 12.5 | 2.11 | 3.50 | 20.0 | 25.0 | Ceiling |

## COLLECTOR

| System | Total Area (m²) | Porosity | Depth (m) | Collector Height (m) | Canopy Height (m) | Collector Width (m) | Canopy Width (m) |
|---|---|---|---|---|---|---|---|
| Wall 1 | 248.20 | High | 0.50 | 7.30 | 2.50 | 34.00 | 34.00 |

## BYPASS DAMPERS

| System | Number of Bypass Dampers | Type of Bypass Damper | Damper Area (m²) | Bypass Temperature (°C) | Damper Width (m) | Damper Height (m) |
|---|---|---|---|---|---|---|
| Wall 1 | 1 | Wall | 3.33 | 13.5 | 3.65 | 0.91 |

## SOLARWALL FAN

| System | Number of Fans | Fan Efficiency | Motor Efficiency | Flow (l/s) | Power (kW) | Pressure (Pa) |
|---|---|---|---|---|---|---|
| Wall 1 | 1 | High | High | 8816 | 12.5 | 873.1 |

## DUCTING

| System | Number | Length (m) | Duct Area (m²) | Accessories |
|---|---|---|---|---|
| Wall 1 | 1 | 100.00 | 0.50 | Tapered Inlet |

SWift was produced by:

Natural Resources Canada
Ressources Naturelles Canada

# Monthly Results for Wall: 1

| Month | Degree-Days Base (18°C) | Solar Radiation Incident (GJ) | Solar Radiation Incident Operational | Average Daytime Temp. Rise | Solar Energy Collected (GJ) | Insulation Savings (GJ) | Destrat. Savings (GJ) | Total Savings (GJ) |
|---|---|---|---|---|---|---|---|---|
| January | 1193 | 51.3 | 48.7 | 4.3 | 33.5 | 7.5 | N/A | 41.0 |
| February | 821 | 108.0 | 90.3 | 6.2 | 59.7 | 5.0 | N/A | 64.8 |
| March | 752 | 168.9 | 135.8 | 6.4 | 87.1 | 4.5 | N/A | 91.6 |
| April | 536 | 179.4 | 132.1 | 5.0 | 80.5 | 3.1 | N/A | 83.6 |
| May | 350 | 146.2 | 44.6 | 1.2 | 23.0 | 2.1 | N/A | 25.1 |
| June | 196 | 123.0 | 20.8 | 0.6 | 10.5 | 1.3 | N/A | 11.9 |
| July | 125 | 119.6 | 5.3 | 0.2 | 2.7 | 0.9 | N/A | 3.6 |
| August | 198 | 125.7 | 8.9 | 0.3 | 4.8 | 1.3 | N/A | 6.1 |
| September | 328 | 97.6 | 24.6 | 1.0 | 13.1 | 2.1 | N/A | 15.2 |
| October | 552 | 75.3 | 59.1 | 3.2 | 36.6 | 3.5 | N/A | 40.1 |
| November | 848 | 47.0 | 44.7 | 3.6 | 29.6 | 5.4 | N/A | 35.0 |
| December | 1047 | 37.9 | 37.5 | 3.6 | 25.4 | 6.7 | N/A | 32.0 |
| **TOTAL** | **6946** | **1279.8** | **652.4** | **2.5** | **406.5** | **43.5** | **N/A** | **450.0** |

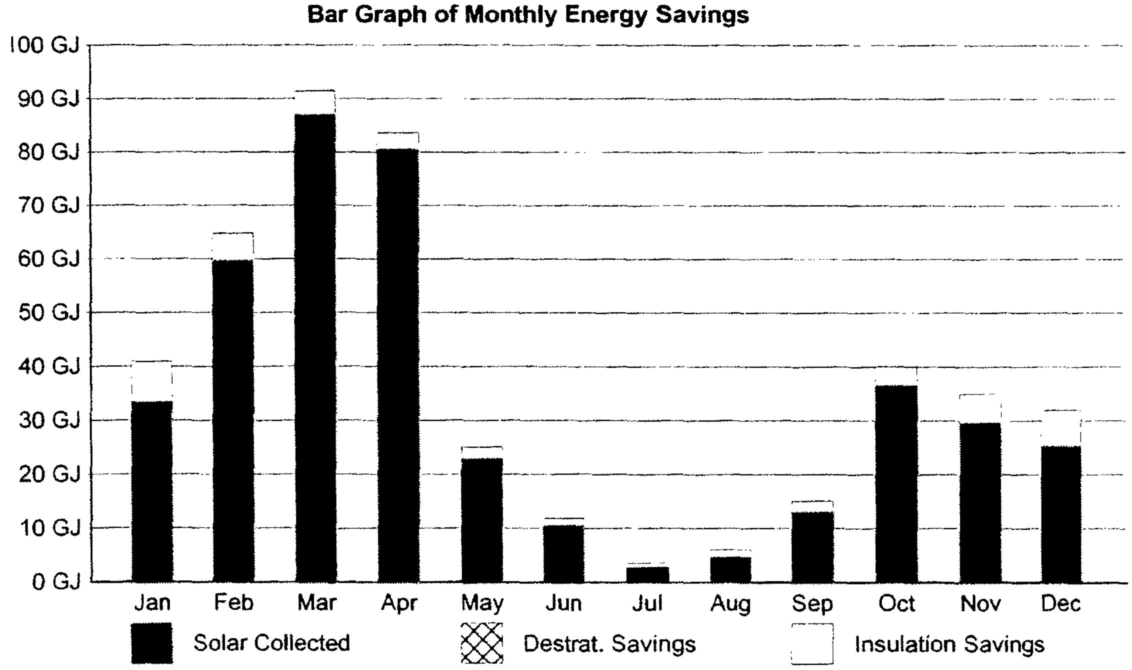
## ANNUAL SYSTEM PERFORMANCE

### PERFORMANCE

| | Solar | Total |
|---|---|---|
| **Annual Savings (GJ/m²)** | 1.64 | 1.81 |
| **Collector Efficiency (%)** | 62 | — |

### LOAD

| | Daytime | Total |
|---|---|---|
| **Annual Ventilation Load (GJ)** | 1783.70 | 5181.07 |
| **Ventilation Load by Collector (%)** | 24 | 9 |




**SWift was produced by:**

Natural Resources Canada
Ressources Naturelles Canada

# ANALYSIS OF AVAILABLE SOLAR ENERGY THRU SOLARWALL ON MONTHLY BASIS

RETScreen values

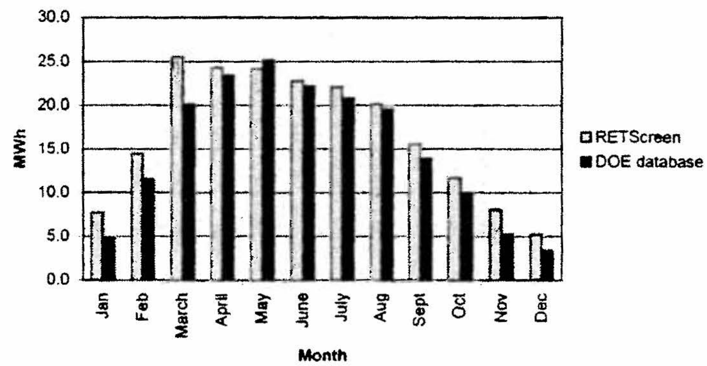
| | kWh/m2/d | d | MWh | Avail MWh |
|---|---|---|---|---|
| Jan | 1.28 | 31 | 9.7 | 7.8 |
| Feb | 2.81 | 28 | 18.1 | 14.5 |
| March | 4.15 | 31 | 31.9 | 25.5 |
| April | 4.09 | 30 | 30.5 | 24.4 |
| May | 3.93 | 31 | 30.2 | 24.2 |
| June | 3.84 | 30 | 28.5 | 22.8 |
| July | 3.60 | 31 | 27.7 | 22.1 |
| Aug | 3.29 | 31 | 25.3 | 20.2 |
| Sept | 2.63 | 30 | 19.5 | 15.6 |
| Oct | 1.91 | 31 | 14.7 | 11.7 |
| Nov | 1.36 | 30 | 10.1 | 8.1 |
| Dec | 0.86 | 31 | 6.6 | 5.3 |
| | | | 252.9 | 202.3 |
| | Area= | 248 | | |
| | absorptive | 0.8 | | |

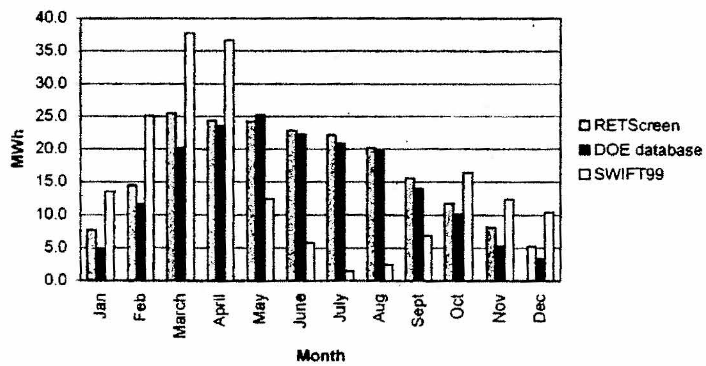
DOE values

| mmBtu | Avail MWh |
|---|---|
| 16.68 | 4.9 |
| 39.59 | 11.6 |
| 68.83 | 20.2 |
| 80.13 | 23.5 |
| 85.99 | 25.2 |
| 76.08 | 22.3 |
| 71.15 | 20.9 |
| 67.1 | 19.7 |
| 47.78 | 14.0 |
| 34.49 | 10.1 |
| 18.16 | 5.3 |
| 11.69 | 3.4 |
| 617.65 | 181.0 |

SWIFT99 values

| GJ | MWh | | |
|---|---|---|---|
| 48.7 | 13.5 | 33.5 | 0.69 |
| 90.3 | 25.1 | 59.7 | 0.66 |
| 135.8 | 37.7 | 87.1 | 0.64 |
| 132.1 | 36.7 | 80.5 | 0.61 |
| 44.6 | 12.4 | 23 | 0.52 |
| 20.8 | 5.8 | 10.5 | 0.50 |
| 5.3 | 1.5 | 2.7 | 0.51 |
| 8.9 | 2.5 | 4.8 | 0.54 |
| 24.6 | 6.8 | 13.1 | 0.53 |
| 59.1 | 16.4 | 36.6 | 0.62 |
| 44.7 | 12.4 | 29.6 | 0.66 |
| 37.5 | 10.4 | 25.4 | 0.68 |
| 652.4 | 181.2 | | |




^^^^^^TABLE NOT VALID INPUT IS NOT SAME PARAMETERS

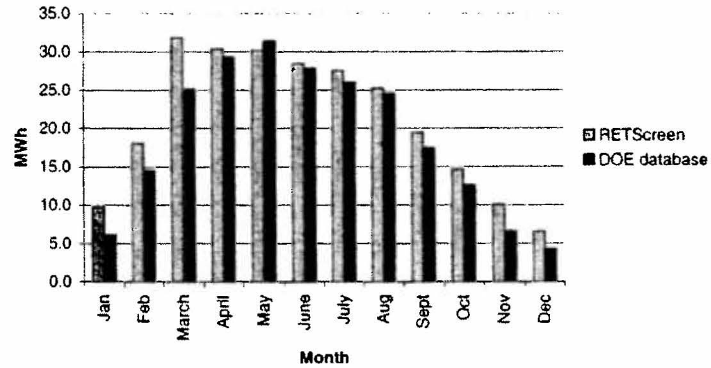
# ANALYSIS OF TOTAL SOLAR RADIATION INCIDENT ON SURFACE AREA ON MONTHLY BASIS

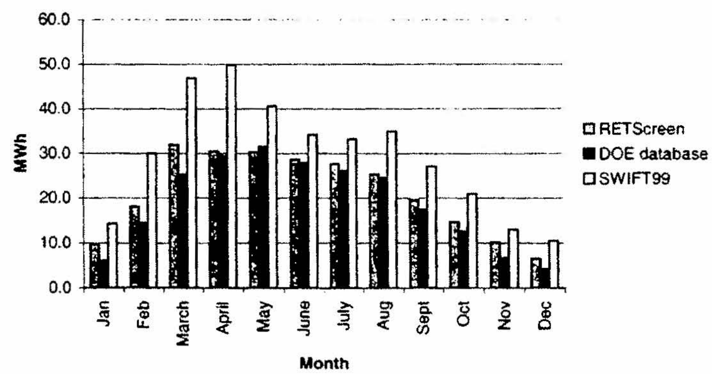
[illegible]

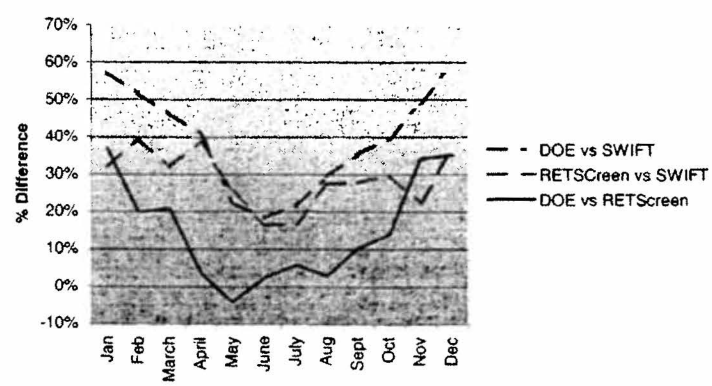
| DOE values | mmBtu | Avail MWh |
|---|---|---|
| | 16.66 | 6.1 |
| | 39.59 | 14.5 |
| | 68.83 | 25.2 |
| | 80.13 | 29.4 |
| | 85.99 | 31.5 |
| | 76.06 | 27.9 |
| | 71.15 | 26.1 |
| | 67.1 | 24.6 |
| | 47.78 | 17.5 |
| | 34.49 | 12.6 |
| | 18.16 | 6.7 |
| | 11.69 | 4.3 |
| | 617.65 | 226.3 |

| SWIFT99 values | GJ | MWh |
|---|---|---|
| | 51.3 | 14.3 |
| | 108 | 30.0 |
| | 168.9 | 46.9 |
| | 179.4 | 49.8 |
| | 146.2 | 40.6 |
| | 123 | 34.2 |
| | 119.6 | 33.2 |
| | 125.7 | 34.9 |
| | 97.6 | 27.1 |
| | 75.3 | 20.9 |
| | 47 | 13.1 |
| | 37.9 | 10.5 |
| | 1279.9 | 355.5 |

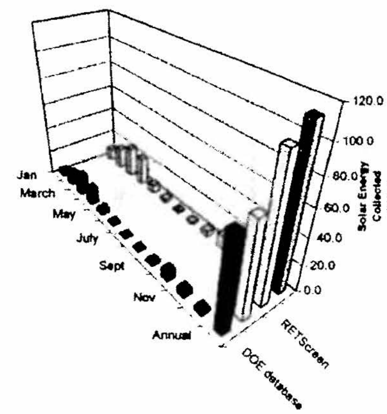
| % diff | DOE/S | RET/S | DOE/RET |
|---|---|---|---|
| Jan | 57.17% | 31.99% | 37.03% |
| | 51.66% | 39.64% | 19.91% |
| | 46.26% | 32.02% | 20.94% |
| | 41.10% | 38.89% | 3.61% |
| | 22.44% | 25.52% | -4.13% |
| | 18.43% | 16.47% | 2.35% |
| | 21.55% | 16.73% | 5.79% |
| | 29.60% | 27.53% | 2.86% |
| | 35.44% | 27.95% | 10.40% |
| | 39.60% | 29.80% | 13.95% |
| | 49.05% | 22.48% | 34.27% |
| Dec | 59.32% | 37.15% | 35.28% |
| **Avg** | **39.30%** | **28.85%** | **15.19%** |



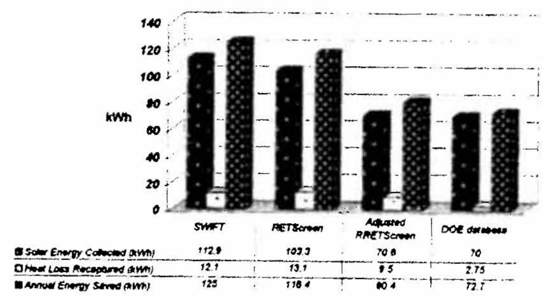



| | Solar Energy Collected | | Insulation Savings | | Total Energy | |
|---|---|---|---|---|---|---|
| | SWIFT | | | | | |
| Jan | 33.5 | 9.3 | 7.5 | 2.1 | 41 | 11.4 |
| Feb | 58.7 | 16.6 | 5 | 1.4 | 64.7 | 18.0 |
| March | 87.1 | 24.2 | 4.5 | 1.3 | 91.6 | 25.4 |
| April | 80.5 | 22.4 | 3.1 | 0.9 | 83.6 | 23.2 |
| May | 23 | 6.4 | 2.1 | 0.6 | 25.1 | 7.0 |
| June | 10.5 | 2.9 | 1.3 | 0.4 | 11.8 | 3.3 |
| July | 2.7 | 0.8 | 0.9 | 0.3 | 3.6 | 1.0 |
| Aug | 4.8 | 1.3 | 1.3 | 0.4 | 6.1 | 1.7 |
| Sept | 13.1 | 3.6 | 2.1 | 0.6 | 15.2 | 4.2 |
| Oct | 36.6 | 10.2 | 3.5 | 1.0 | 40.1 | 11.1 |
| Nov | 29.6 | 8.2 | 5.4 | 1.5 | 35 | 9.7 |
| Dec | 25.4 | 7.1 | 6.7 | 1.9 | 32.1 | 8.9 |
| **Annual** | **406.5 GJ** | **112.9 kWh** | **43.4 GJ** | **12.1 kWh** | **449.9 GJ** | **125.0 kWh** |
| | RETSCreen | | | | | |
| Jan | | | | | | |
| Feb | | | | | | |
| March | | | | | | |
| April | | | | | | |
| May | | | | | | |
| June | | | | | | |
| July | | | | | | |
| Aug | | | | | | |
| Sept | | | | | | |
| Oct | | | | | | |
| Nov | | | | | | |
| Dec | | | | | | |
| **Annual** | | **103.3 kWh** | | **13.1 kWh** | | **116.4 kWh** |
| | Adjusted RETSCreen | | | | | |
| Jan | | | | | | |
| Feb | | | | | | |
| March | | | | | | |
| April | | | | | | |
| May | | | | | | |
| June | | | | | | |
| July | | | | | | |
| Aug | | | | | | |
| Sept | | | | | | |
| Oct | | | | | | |
| Nov | | | | | | |
| Dec | | | | | | |
| **Annual** | | **70.8 kWh** | | **9.5 kWh** | | **80.4 kWh** |
| | DOE Database | | | | | |
| Jan | 16.66 | 4.9 | | | | |
| Feb | 36.48 | 10.7 | | | | |
| March | 54.5 | 16.0 | | | | |
| April | 45.72 | 13.4 | | | | |
| May | 12.89 | 3.8 | | | | |
| June | 6.21 | 1.8 | | | | |
| July | 2.03 | 0.6 | | | | |
| Aug | 3.51 | 1.0 | | | | |
| Sept | 7.19 | 2.1 | | | | |
| Oct | 24.62 | 7.2 | | | | |
| Nov | 17.23 | 5.0 | | | | |
| Dec | 11.69 | 3.4 | | | | |
| **Annual** | mmBtu | **70.0 kWh** | | **2.75 kWh** | | **72.7 kWh** |




| SWIFT | RETScree | Adjusted F | DOE database | |
|---|---|---|---|---|
| 112.9 | 103.3 | 70.8 | 70 | Solar Energy Collected (kWh) |
| 12.1 | 13.1 | 9.5 | 2.75 | Building Heat Loss Recaptured |
| 125 | 116.4 | 80.4 | 72.7 | Annual Energy Saved |



# APPENDIX D FINANCIAL ANALYSIS

JOB NAME: WGH Solarwall
JOB NUMBER: 2002-4110.22
LOCATION: Whitehorse, YT
COMMUNITY FACTOR 1.30
ESTIMATED BY: RDA
DATE ESTIMATED: Jan 24/03
MAN HOUR RATE $70.00

| Description | Qty | | @ | Material | Hrs | Labour | TOTAL | Subtotals | % sub | Adj Subtotals |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ - | $ - | | $ - | $ - | | | |
| **Item** | | | | | | | | | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| | | | $ - | $ - | | $ - | $ - | $ - | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| **Solarwall** | | | $ - | $ - | | $ - | $ - | | | |
| Painting "H" symbol | 1 | uc | $ 500.00 | $ 650 | 40.00 | $ 2,800.00 | $ 3,450 | | | |
| | | | $ - | $ - | | $ - | $ - | $ 3,450 | 12.57% | $4,264 |
| | | | | | | | | | | |
| **Item** | | | | | | | | | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| | | | $ - | $ - | | $ - | $ - | $ - | | |
| | | | $ - | $ - | | $ - | $ - | | | |
| **Controls** | | | $ - | $ - | | $ - | $ - | | | |
| Reprogramming | 1 | uc | $ 500.00 | $ 650 | 20.00 | $ 1,400.00 | $ 2,050 | | | |
| Total new points | 5 | uc | $ 500.00 | $ 3,250 | | $ - | $ 3,250 | | | |
| Site and startup | 1 | uc | $ 500.00 | $ 650 | 20.00 | $ 1,400.00 | $ 2,050 | | | |
| | | | $ - | $ - | | $ - | $ - | $ 7,350 | 26.77% | $9,085 |
| | | | | | | | | | | |
| **Startup and Commissioning** | | | $ - | $ - | | $ - | $ - | | | |
| Mech | 1 | uc | $ 2,500.00 | $ 3,250 | 20.00 | $ 1,400.00 | $ 4,650 | | | |
| Controls | 1 | hr | $ - | $ - | 16.00 | $ 1,120.00 | $ 1,120 | | | |
| Commisioning | 1 | uc | $ 150.00 | $ 195 | 16.00 | $ 1,120.00 | $ 1,315 | | | |
| | | | $ - | $ - | | $ - | $ - | $ 7,085 | 25.81% | $8,757 |
| | | | $ - | $ - | | $ - | $ - | | | |
| **Misc** | | | $ - | $ - | | $ - | $ - | | | |
| Permints | 1 | uc | $ 1,000.00 | $ 1,300 | | $ - | $ 1,300 | | | |
| TAB | 1 | uc | $ 500.00 | $ 650 | 16.00 | $ 1,120.00 | $ 1,770 | | | |
| Admin | | | | $ - | | $ - | $ - | | | |
| Travel( Controls 1 trips/startup 1 trip) | 2 | uc | $ 2,500.00 | $ 6,500 | | $ - | $ 6,500 | $ 9,570 | 34.86% | $11,829 |
| | | | | | | | | | | |
| | | | | $ - | | $ - | $ - | | | |
| | | | | $ - | | $ - | $ - | | | |
| | | | | $ - | | $ - | $ - | | | |
| | | | | $ - | | $ - | $ - | | | |
| | | | | $ - | | $ - | $ - | | | |
| ***SUB-TOTAL 1*** | | | | $ 17,095 | 148 | $ 10,360 | $ 27,455 | | 100% | $33,934 |
| ***Plus 3% Inflation*** | | | | $ 513 | | $ 311 | $ 824 | | | |
| ***SUB-TOTAL 1*** | | | | $ 17,608 | 296 | $ 10,671 | $ 28,279 | | | |
| ***Plus 10% O/H & 10% Profit*** | | | | $ 3,522 | | $ 2,134 | $ 5,656 | | | |
| ***SUB-TOTAL 2*** | | | | $ 21,129 | | $ 12,805 | $ 33,934 | | | |
| ***Plus Solarwall Quotation*** | | | | - | | - | 116,950 | | | |
| ***SUB-TOTAL 2*** | | | | $ 21,129 | | $ 12,805 | $ 150,884 | | | |
| ***Plus 10% Contingency*** | | | | 2,113 | | 1,280 | 15,088 | | | |
| ***TOTAL*** | | | | $ 23,242 | | $ 14,085 | $ 165,973 | | | |

**Notes:** 1. Class D estimate accurate within +/- 20% with more than 3 bids in public tender.

**From:** "dml" <2dl@telus.net>
**To:** altodom.altapo(Ross)
**Date:** Fri, Jan 24, 2003 12:33 PM
**Subject:** Solarwall

Hi Ross
Thank you for your patience. Have just heard from Steve.
Preliminary cost estimate based on information given to date:

$116,000 plus GST including freight and also including modulating dampers for both main air intakes to create suction for Solarwall cavity, also dampers connected to Solarwall cavity plus all controls.

Pat has asked Steve to e-mail you a copy of his quote so you will know the details included.
Thanks again for your patience.
Sincerely,
Donna Lewis, MBA
Astravan Distributors
Your Environmental Partner
1-800-663-8405

**From:** "Steve Duncan" <steve@duncansltd.com>
**To:** fscykdm3.gwiafscyk3("info@astravan.com")
**Date:** Fri, Jan 24, 2003 1:11 PM
**Subject:** Whitehorse General Hospital

Hi Pat:

I have the following budget only price for the supply and installation of all materials necessary to provide a complete solar wall installation for the Whitehorse General Hospital as per the information provided. Included are the following items.

1. All necessary 18 Ga. Z bars for a 6" cavity behind all of the panels except where the ducts will be installed, based on a 2' grid system.
2. Supply and installation of all solar wall panels as supplied by Astravan, for wall area of about 118' x 25'.
3. Removal of the existing outside air intake louvre and the extension of the 25' x 9' duct by about 30"
4. To supply and install a motorized damper assembly for the 25' x 9' duct, and to install the louvre on the outside of the extended duct.
5. To install one smaller and one larger duct into the 25' x 9' duct extension. Each duct will have its own damper and actuator. These ducts will be extended approximately 12' up to the inlet location near the top of the solar wall.
6. The perimeter of the wall will have insulation installed and flashings provided for watertight finishing of the installation. Flashings will be provided for the jog on the left side of the wall and for the duct shaft enclosure area.
7. All necessary craning, lifts, scaffolds etc. necessary for the installation are included.
8. All necessary control and electrical wiring is included.

The above is for budget purposes only and is based on a wall spaced 6" except for the enclosure around the vertical ducts where the enclosure will be approximately 30" from the existing wall surface.
Our budget only price: $116,959.00 GST extra

Please call if you have any questions or require additional information.

Steve Duncan
President
Duncan's Limited
867-667-6613

**CC:** altodom.altapo(Ross)

## RETScreen® Cost Analysis - Solar Air Heating Project FO Heating

Type of project: Standard | Currency: $ | Cost references: None

| Initial Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| Feasibility Study | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Development | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Engineering | | | | | | | |
| Other | Cost | 1 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Renewable Energy (RE) Equipment | | | | | | | |
| Solar collector materials | m² | 248 | $ 608 | $ 150,883 | | - | - |
| Equipment installation | m² | 248 | $ - | $ - | | - | - |
| Cladding material credit | m² | -248 | $ - | $ - | | - | - |
| Cladding labour credit | m² | -248 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ 150,883 | 90.9% | | |
| Balance of Equipment | | | | | | | |
| Fans and ducting materials | L/s | 8,817 | $ - | $ - | | - | - |
| Fans and ducting labour | L/s | 8,817 | $ - | $ - | | - | - |
| Fan and duct mat'l credit | L/s | -8,817 | $ - | $ - | | - | - |
| Fan and duct labour credit | L/s | -8,817 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Miscellaneous | | | | | | | |
| Overhead | % | 0% | $ 150,883 | $ - | | - | - |
| Training | p-h | 0 | $ - | $ - | | - | - |
| Contingencies | % | 10% | $ 150,883 | $ 15,088 | | - | - |
| Sub-total : | | | | $ 15,088 | 9.1% | | |
| **Initial Costs - Total** | | | | $ 165,972 | 100.0% | | |

| Annual Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| O&M | | | | | | | |
| Property taxes/Insurance | project | 1 | $ - | $ - | | - | - |
| O&M labour | project | 0 | $ - | $ - | | - | - |
| Travel and accommodation | p-trip | 1 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Contingencies | % | 0% | $ 150,883 | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Fuel/Electricity | kWh | 2,172 | $ 0.1305 | $ 284 | 100.0% | - | - |
| **Annual Costs - Total** | | | | $ 284 | 100.0% | | |

| Periodic Costs (Credits) | | Period | Unit Cost | Amount | Interval Range | Unit Cost Range |
|---|---|---|---|---|---|---|
| Damper Motor | | 5 yr | $ 200 | $ (200) | - | - |
| | | | $ - | $ - | - | - |
| | | | $ - | $ - | - | - |
| End of project life | | - | $ - | $ - | | |

Go to GHG Analysis sheet

RETScreen® Financial Summary - Solar Air Heating Project FO Heating

## Annual Energy Balance

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 2.2 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 116.4 | GHG analysis sheet used? | yes/no | Yes |
| | | | Net GHG emission reduction | $t_{CO2}$/yr | 39 |
| | | | Net GHG emission reduction - 25 yrs | $t_{CO2}$ | 979 |
| Heating fuel displaced | - | Diesel (#2 oil) | | | |

## Financial Parameters

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/L | 0.450 | Debt ratio | % | 0.0% |
| GHG emission reduction credit | $/$t_{CO2}$ | - | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.131 | | | |
| Energy cost escalation rate | % | 5.0% | | | |
| Inflation | % | 3.0% | | | |
| Discount rate | % | 4.5% | | | |
| Project life | yr | 25 | | | |

## Project Costs and Savings

| | | | | | | |
|---|---|---|---|---|---|---|
| **Initial Costs** | | | | **Annual Costs and Debt** | | |
| Feasibility study | 0.0% | $ | - | O&M | $ | - |
| Development | 0.0% | $ | - | Fuel/Electricity | $ | 284 |
| Engineering | 0.0% | $ | - | | | |
| RE equipment | 90.9% | $ | 150,883 | **Annual Costs - Total** | **$** | **284** |
| Balance of equipment | 0.0% | $ | - | | | |
| Miscellaneous | 9.1% | $ | 15,088 | **Annual Savings or Income** | | |
| **Initial Costs - Total** | 100.0% | **$** | **165,972** | Heating energy savings/income | $ | 6,099 |
| Incentives/Grants | | $ | 66,388 | | | |
| | | | | **Annual Savings - Total** | **$** | **6,099** |
| **Periodic Costs (Credits)** | | | | | | |
| Damper Motor | | $ | (200) | Schedule yr # 5,10,15,20,25 | | |
| | | $ | - | | | |
| | | $ | - | | | |
| End of project life - | | $ | - | | | |

## Financial Feasibility

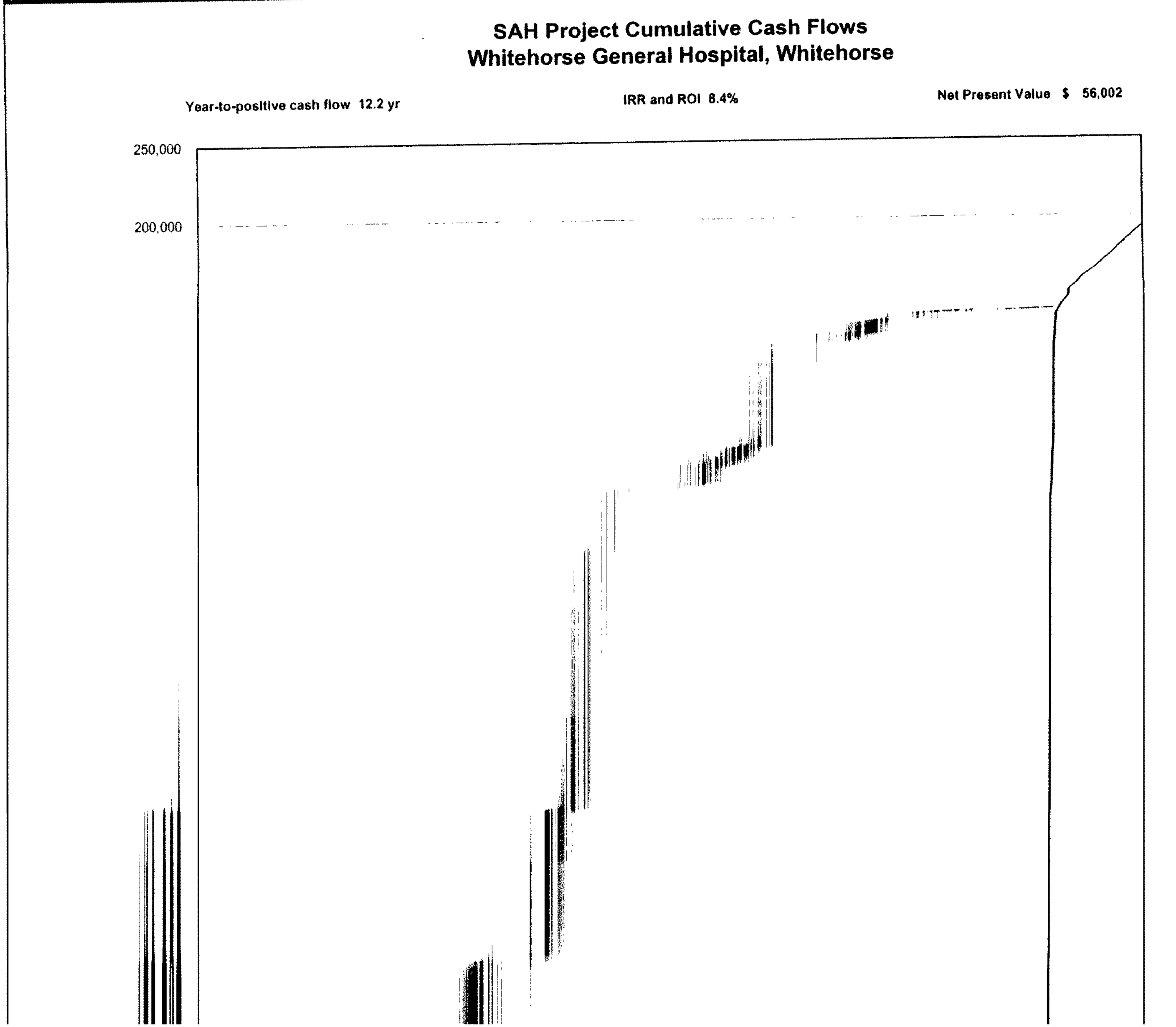
| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 8.4% | Calculate GHG reduction cost? | yes/no | No |
| After-tax IRR and ROI | % | 8.4% | | | |
| Simple Payback | yr | 17.1 | Project equity | $ | 165,972 |
| Year-to-positive cash flow | yr | 12.2 | | | |
| Net Present Value - NPV | $ | 56,002 | | | |
| Annual Life Cycle Savings | $ | 3,777 | | | |
| Profitability Index - PI | - | 0.34 | | | |

## Yearly Cash Flows

| Year | Pre-tax | After-tax | Cumulative |
|---|---|---|---|
| # | $ | $ | $ |
| 0 | (99,584) | (99,584) | (99,584) |
| 1 | 6,106 | 6,106 | (93,478) |
| 2 | 6,411 | 6,411 | (87,066) |
| 3 | 6,732 | 6,732 | (80,335) |
| 4 | 7,068 | 7,068 | (73,266) |
| 5 | 7,654 | 7,654 | (65,613) |
| 6 | 7,793 | 7,793 | (57,820) |
| 7 | 8,182 | 8,182 | (49,638) |
| 8 | 8,592 | 8,592 | (41,046) |
| 9 | 9,021 | 9,021 | (32,025) |
| 10 | 9,741 | 9,741 | (22,284) |
| 11 | 9,946 | 9,946 | (12,338) |
| 12 | 10,443 | 10,443 | (1,895) |
| 13 | 10,965 | 10,965 | 9,070 |
| 14 | 11,514 | 11,514 | 20,584 |
| 15 | 12,401 | 12,401 | 32,985 |
| 16 | 12,694 | 12,694 | 45,679 |
| 17 | 13,328 | 13,328 | 59,007 |
| 18 | 13,995 | 13,995 | 73,002 |
| 19 | 14,695 | 14,695 | 87,696 |
| 20 | 15,790 | 15,790 | 103,487 |
| 21 | 16,201 | 16,201 | 119,687 |
| 22 | 17,011 | 17,011 | 136,698 |
| 23 | 17,861 | 17,861 | 154,559 |
| 24 | 18,754 | 18,754 | 173,314 |
| 25 | 20,111 | 20,111 | 193,425 |

RETScreen® Financial Summary - Solar Air Heating Project FO Heating

Cumulative Cash Flows Graph



## RETScreen® Cost Analysis - Solar Air Heating Project

Secondary Sales

Type of project: Standard    Currency: $    Cost references: None

| Initial Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| Feasibility Study | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Development | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Engineering | | | | | | | |
| Other | Cost | 1 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Renewable Energy (RE) Equipment | | | | | | | |
| Solar collector materials | m² | 248 | $ 608 | $ 150,883 | | - | - |
| Equipment installation | m² | 248 | $ - | $ - | | - | - |
| Cladding material credit | m² | -248 | $ - | $ - | | - | - |
| Cladding labour credit | m² | -248 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ 150,883 | 90.9% | | |
| Balance of Equipment | | | | | | | |
| Fans and ducting materials | L/s | 8,817 | $ - | $ - | | - | - |
| Fans and ducting labour | L/s | 8,817 | $ - | $ - | | - | - |
| Fan and duct mat'l credit | L/s | -8,817 | $ - | $ - | | - | - |
| Fan and duct labour credit | L/s | -8,817 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Miscellaneous | | | | | | | |
| Overhead | % | 0% | $ 150,883 | $ - | | - | - |
| Training | p-h | 0 | $ - | $ - | | - | - |
| Contingencies | % | 10% | $ 150,883 | $ 15,088 | | - | - |
| Sub-total : | | | | $ 15,088 | 9.1% | | |
| **Initial Costs - Total** | | | | $ 165,972 | 100.0% | | |

| Annual Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| O&M | | | | | | | |
| Property taxes/Insurance | project | 1 | $ - | $ - | | - | - |
| O&M labour | project | 0 | $ - | $ - | | - | - |
| Travel and accommodation | p-trip | 1 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Contingencies | % | 0% | $ 150,883 | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Fuel/Electricity | kWh | 2,172 | $ 0.1305 | $ 284 | 100.0% | - | - |
| **Annual Costs - Total** | | | | $ 284 | 100.0% | | |

| Periodic Costs (Credits) | | Period | Unit Cost | Amount | Interval Range | Unit Cost Range |
|---|---|---|---|---|---|---|
| Damper Motor | | 5 yr | $ 200 | $ (200) | - | - |
| | | | $ - | $ - | - | - |
| | | | $ - | $ - | - | - |
| End of project life | | - | $ - | $ - | | |

Go to GHG Analysis sheet

Version 2000



NRCan/CEDRL

RETScreen® Financial Summary - Solar Air Heating Project *Secondary Sales*

**Annual Energy Balance**

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 2.2 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 116.4 | GHG analysis sheet used? | yes/no | Yes |
| | | | Net GHG emission reduction | $t_{CO2}$/yr | 0 |
| | | | Net GHG emission reduction - 25 yrs | $t_{CO2}$ | 0 |
| Heating fuel displaced | - | Electricity | | | |

**Financial Parameters**

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/kWh | 0.043 | Debt ratio | % | 0.0% |
| GHG emission reduction credit | $/$t_{CO2}$ | - | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.131 | | | |
| Energy cost escalation rate | % | 5.0% | | | |
| Inflation | % | 3.0% | | | |
| Discount rate | % | 4.5% | | | |
| Project life | yr | 25 | | | |

**Project Costs and Savings**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Initial Costs** | | | | **Annual Costs and Debt** | | |
| Feasibility study | 0.0% | $ | - | O&M | $ | - |
| Development | 0.0% | $ | - | Fuel/Electricity | $ | 284 |
| Engineering | 0.0% | $ | - | | | |
| RE equipment | 90.9% | $ | 150,883 | **Annual Costs - Total** | **$** | **284** |
| Balance of equipment | 0.0% | $ | - | | | |
| Miscellaneous | 9.1% | $ | 15,088 | **Annual Savings or Income** | | |
| **Initial Costs - Total** | 100.0% | **$** | **165,972** | Heating energy savings/income | $ | 5,007 |
| Incentives/Grants | | $ | 66,388 | | | |
| | | | | **Annual Savings - Total** | **$** | **5,007** |
| **Periodic Costs (Credits)** | | | | | | |
| Damper Motor | | $ | (200) | Schedule yr # 5,10,15,20,25 | | |
| | | $ | - | | | |
| | | $ | - | | | |
| End of project life - | | $ | - | | | |

**Financial Feasibility**

| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 6.5% | Calculate GHG reduction cost? | yes/no | No |
| After-tax IRR and ROI | % | 6.5% | | | |
| Simple Payback | yr | 21.1 | Project equity | $ | 165,972 |
| Year-to-positive cash flow | yr | 14.2 | | | |
| Net Present Value - NPV | $ | 26,949 | | | |
| Annual Life Cycle Savings | $ | 1,817 | | | |
| Profitability Index - PI | - | 0.16 | | | |

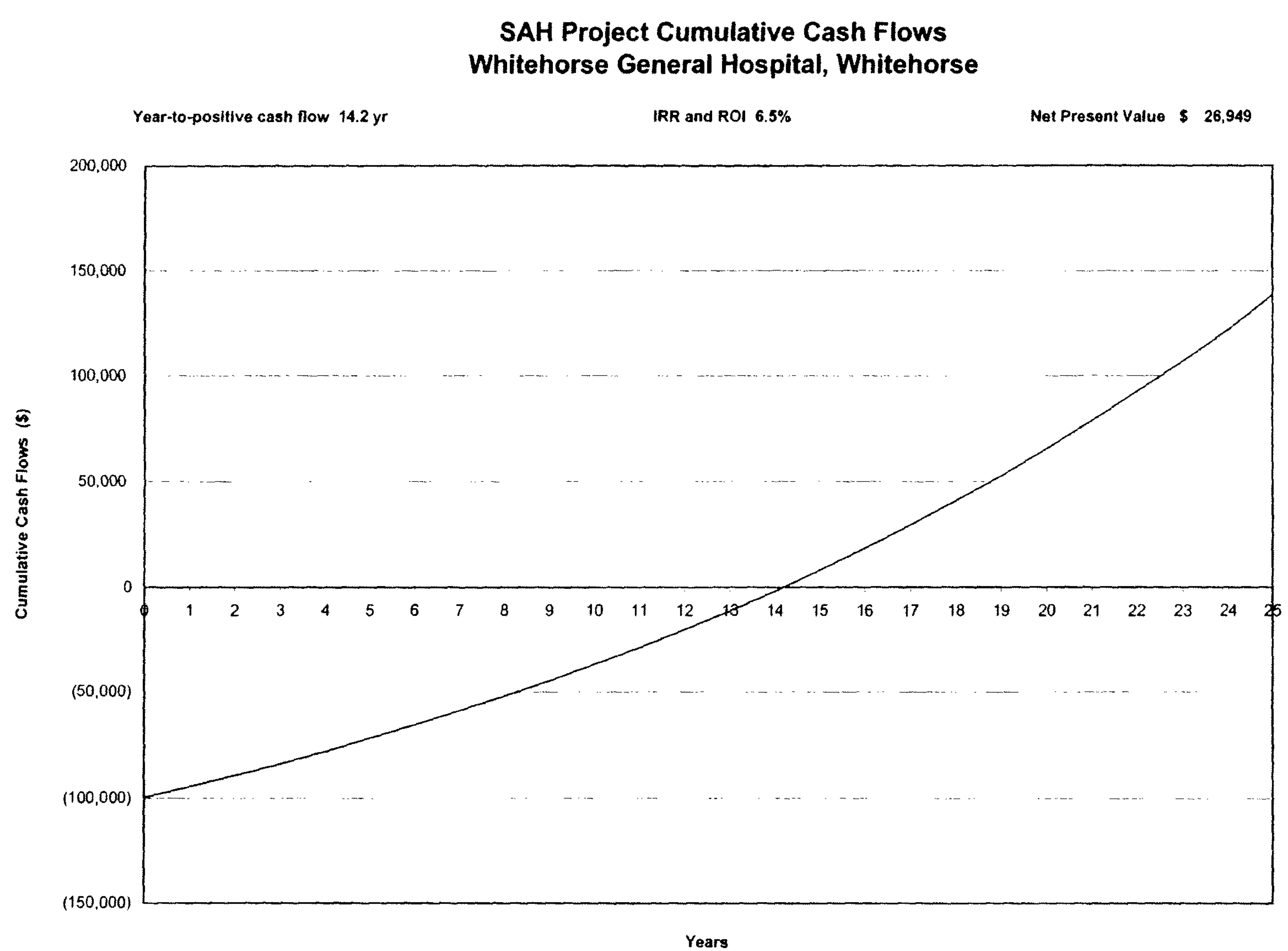
**Yearly Cash Flows**

| Year # | Pre-tax $ | After-tax $ | Cumulative $ |
|---|---|---|---|
| 0 | (99,584) | (99,584) | (99,584) |
| 1 | 4,960 | 4,960 | (94,624) |
| 2 | 5,208 | 5,208 | (89,416) |
| 3 | 5,468 | 5,468 | (83,948) |
| 4 | 5,742 | 5,742 | (78,206) |
| 5 | 6,260 | 6,260 | (71,946) |
| 6 | 6,330 | 6,330 | (65,616) |
| 7 | 6,647 | 6,647 | (58,970) |
| 8 | 6,979 | 6,979 | (51,991) |
| 9 | 7,328 | 7,328 | (44,663) |
| 10 | 7,963 | 7,963 | (36,700) |
| 11 | 8,079 | 8,079 | (28,621) |
| 12 | 8,483 | 8,483 | (20,138) |
| 13 | 8,907 | 8,907 | (11,231) |
| 14 | 9,352 | 9,352 | (1,879) |
| 15 | 10,132 | 10,132 | 8,253 |
| 16 | 10,311 | 10,311 | 18,563 |
| 17 | 10,826 | 10,826 | 29,390 |
| 18 | 11,368 | 11,368 | 40,758 |
| 19 | 11,936 | 11,936 | 52,694 |
| 20 | 12,894 | 12,894 | 65,588 |
| 21 | 13,160 | 13,160 | 78,748 |
| 22 | 13,818 | 13,818 | 92,565 |
| 23 | 14,508 | 14,508 | 107,074 |
| 24 | 15,234 | 15,234 | 122,308 |
| 25 | 16,414 | 16,414 | 138,722 |

Version 2000  NRCan/CEDRL

RETScreen® Financial Summary - Solar Air Heating Project Secondary Sales

Cumulative Cash Flows Graph



## RETScreen® Cost Analysis - Solar Air Heating P

Type of project: Standard

| Initial Costs (Credits) | Unit |
|---|---|
| **Feasibility Study** | |
| Other | Cost |
| Sub-total : | |
| **Development** | |
| Other | Cost |
| Sub-total : | |
| **Engineering** | |
| Other | Cost |
| Sub-total : | |
| **Renewable Energy (RE) Equipment** | |
| Solar collector materials | m² |
| Equipment installation | m² |
| Cladding material credit | m² |
| Cladding labour credit | m² |
| Incremental transportation | project |
| Other | Cost |
| Sub-total : | |
| **Balance of Equipment** | |
| Fans and ducting materials | L/s |
| Fans and ducting labour | L/s |
| Fan and duct mat'l credit | L/s |
| Fan and duct labour credit | L/s |
| Incremental transportation | project |
| Other | Cost |
| Sub-total : | |
| **Miscellaneous** | |
| Overhead | % |
| Training | p-h |
| Contingencies | % |
| Sub-total : | |
| **Initial Costs - Total** | |

| Annual Costs (Credits) | Unit |
|---|---|
| **O&M** | |
| Property taxes/Insurance | project |
| O&M labour | project |
| Travel and accommodation | p-trip |
| Other | Cost |
| Contingencies | % |
| Sub-total : | |
| Fuel/Electricity | kWh |
| **Annual Costs - Total** | |

| Periodic Costs (Credits) | |
|---|---|
| Damper Motor | |
| | |
| | |
| End of project life | |

Version 2000

RETScreen® Financial Summary - Solar Air Heating Project (Adjusted) FO Heating

## Annual Energy Balance

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 1.2 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 80.4 | GHG analysis sheet used? | yes/no | Yes |
| | | | Net GHG emission reduction | $t_{CO2}$/yr | 27 |
| | | | Net GHG emission reduction - 25 yrs | $t_{CO2}$ | 676 |
| Heating fuel displaced | - | Diesel (#2 oil) | | | |

## Financial Parameters

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/L | 0.450 | Debt ratio | % | 0.0% |
| GHG emission reduction credit | $/$t_{CO2}$ | - | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.131 | | | |
| Energy cost escalation rate | % | 5.0% | | | |
| Inflation | % | 3.0% | | | |
| Discount rate | % | 4.5% | | | |
| Project life | yr | 25 | | | |

## Project Costs and Savings

| | | | | | | |
|---|---|---|---|---|---|---|
| **Initial Costs** | | | | **Annual Costs and Debt** | | |
| Feasibility study | 0.0% | $ | - | O&M | $ | - |
| Development | 0.0% | $ | - | Fuel/Electricity | $ | 151 |
| Engineering | 0.0% | $ | - | | | |
| RE equipment | 90.9% | $ | 150,883 | **Annual Costs - Total** | **$** | **151** |
| Balance of equipment | 0.0% | $ | - | | | |
| Miscellaneous | 9.1% | $ | 15,088 | **Annual Savings or Income** | | |
| **Initial Costs - Total** | 100.0% | **$** | **165,972** | Heating energy savings/income | $ | 4,209 |
| Incentives/Grants | | $ | 66,388 | | | |
| | | | | **Annual Savings - Total** | **$** | **4,209** |
| **Periodic Costs (Credits)** | | | | | | |
| Damper Motor | | $ | (500) | Schedule yr # 5,10,15,20,25 | | |
| | | $ | - | | | |
| | | $ | - | | | |
| End of project life - | | $ | - | | | |

## Financial Feasibility

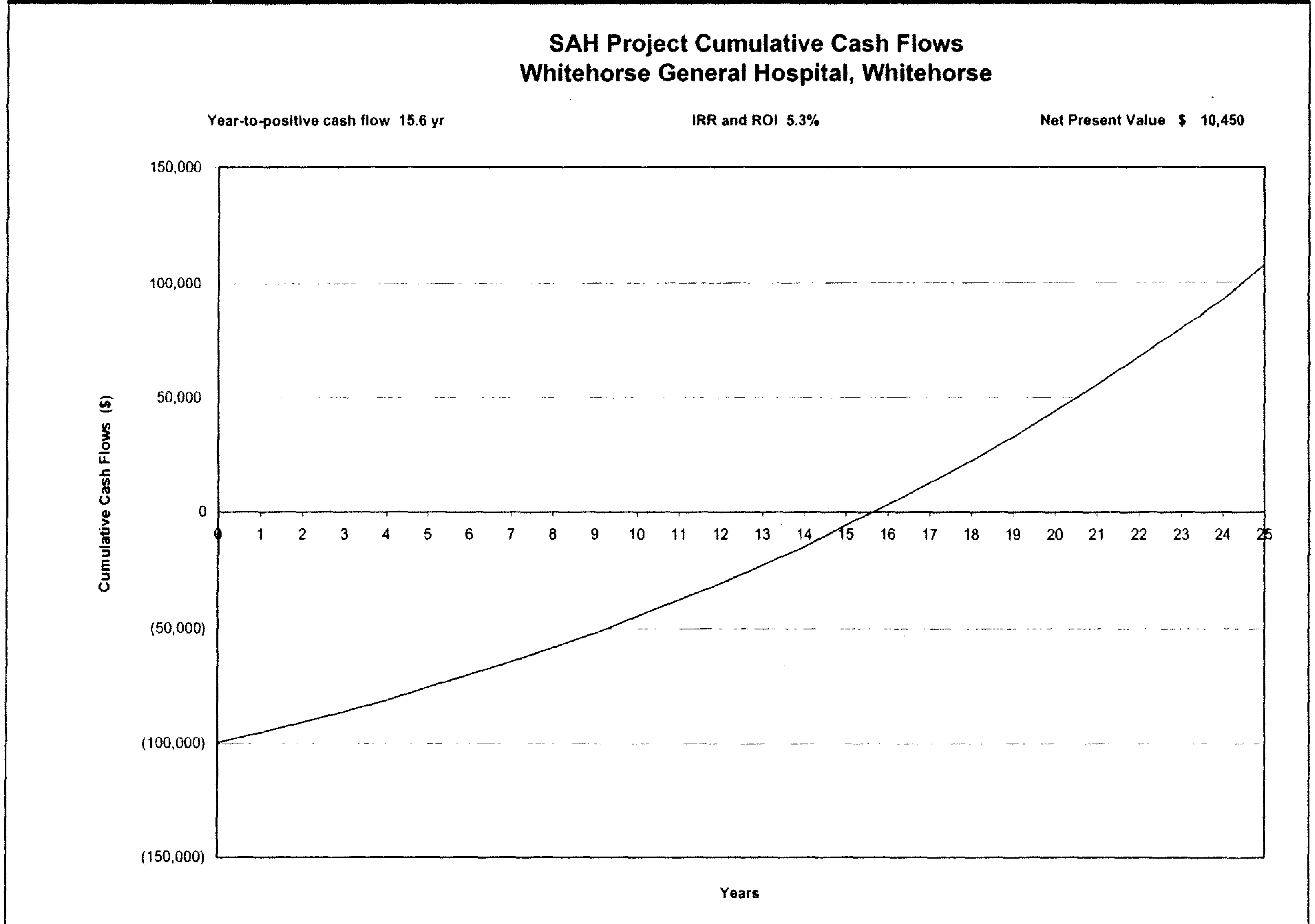
| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 5.3% | Calculate GHG reduction cost? | yes/no | No |
| After-tax IRR and ROI | % | 5.3% | | | |
| Simple Payback | yr | 24.5 | Project equity | $ | 165,972 |
| Year-to-positive cash flow | yr | 15.6 | | | |
| Net Present Value - NPV | $ | 10,450 | | | |
| Annual Life Cycle Savings | $ | 705 | | | |
| Profitability Index - PI | - | 0.06 | | | |

## Yearly Cash Flows

| Year # | Pre-tax $ | After-tax $ | Cumulative $ |
|---|---|---|---|
| 0 | (99,584) | (99,584) | (99,584) |
| 1 | 4,261 | 4,261 | (95,323) |
| 2 | 4,474 | 4,474 | (90,849) |
| 3 | 4,698 | 4,698 | (86,151) |
| 4 | 4,933 | 4,933 | (81,218) |
| 5 | 5,759 | 5,759 | (75,459) |
| 6 | 5,438 | 5,438 | (70,021) |
| 7 | 5,710 | 5,710 | (64,311) |
| 8 | 5,996 | 5,996 | (58,316) |
| 9 | 6,295 | 6,295 | (52,020) |
| 10 | 7,282 | 7,282 | (44,738) |
| 11 | 6,941 | 6,941 | (37,797) |
| 12 | 7,288 | 7,288 | (30,510) |
| 13 | 7,652 | 7,652 | (22,858) |
| 14 | 8,035 | 8,035 | (14,823) |
| 15 | 9,215 | 9,215 | (5,608) |
| 16 | 8,858 | 8,858 | 3,251 |
| 17 | 9,301 | 9,301 | 12,552 |
| 18 | 9,766 | 9,766 | 22,318 |
| 19 | 10,254 | 10,254 | 32,572 |
| 20 | 11,670 | 11,670 | 44,243 |
| 21 | 11,306 | 11,306 | 55,548 |
| 22 | 11,871 | 11,871 | 67,419 |
| 23 | 12,464 | 12,464 | 79,883 |
| 24 | 13,088 | 13,088 | 92,971 |
| 25 | 14,789 | 14,789 | 107,760 |

Version 2000  NRCan/CEDRL

Cumulative Cash Flows Graph



**RETScreen® Cost Analysis - Solar Air Heating Project** (Adjusted) Secondary Sales

Type of project: Standard | Currency: $ | Cost references: None

| Initial Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| Feasibility Study | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Development | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Engineering | | | | | | | |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Renewable Energy (RE) Equipment | | | | | | | |
| Solar collector materials | m² | 248 | $ 608 | $ 150,883 | | - | - |
| Equipment installation | m² | 248 | $ - | $ - | | - | - |
| Cladding material credit | m² | -248 | $ - | $ - | | - | - |
| Cladding labour credit | m² | -248 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ 150,883 | 90.9% | | |
| Balance of Equipment | | | | | | | |
| Fans and ducting materials | L/s | 8,817 | $ - | $ - | | - | - |
| Fans and ducting labour | L/s | 8,817 | $ - | $ - | | - | - |
| Fan and duct mat'l credit | L/s | -8,817 | $ - | $ - | | - | - |
| Fan and duct labour credit | L/s | -8,817 | $ - | $ - | | - | - |
| Incremental transportation | project | 0 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Miscellaneous | | | | | | | |
| Overhead | % | 0% | $ 150,883 | $ - | | - | - |
| Training | p-h | 0 | $ - | $ - | | - | - |
| Contingencies | % | 10% | $ 150,883 | $ 15,088 | | - | - |
| Sub-total : | | | | $ 15,088 | 9.1% | | |
| **Initial Costs - Total** | | | | $ 165,972 | 100.0% | | |

| Annual Costs (Credits) | Unit | Quantity | Unit Cost | Amount | Relative Costs | Quantity Range | Unit Cost Range |
|---|---|---|---|---|---|---|---|
| O&M | | | | | | | |
| Property taxes/Insurance | project | 1 | $ - | $ - | | - | - |
| O&M labour | project | 0 | $ - | $ - | | - | - |
| Travel and accommodation | p-trip | 1 | $ - | $ - | | - | - |
| Other | Cost | 0 | $ - | $ - | | - | - |
| Contingencies | % | 0% | $ 150,883 | $ - | | - | - |
| Sub-total : | | | | $ - | 0.0% | | |
| Fuel/Electricity | kWh | 1,156 | $ 0.1305 | $ 151 | 100.0% | - | - |
| **Annual Costs - Total** | | | | $ 151 | 100.0% | | |

| Periodic Costs (Credits) | | Period | Unit Cost | Amount | Interval Range | Unit Cost Range |
|---|---|---|---|---|---|---|
| Damper motor | | 5 yr | $ 500 | $ (500) | - | - |
| | | | $ - | $ - | - | - |
| | | | $ - | $ - | - | - |
| End of project life | | - | $ - | $ - | | |

Go to GHG Analysis sheet

Version 2000



NRCan/CEDRL

## RETScreen® Financial Summary - Solar Air Heating Project (Adjusted) Secondary Sales

### Annual Energy Balance

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 1.2 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 80.4 | GHG analysis sheet used? | yes/no | Yes |
| | | | Net GHG emission reduction | $t_{CO2}$/yr | 0 |
| | | | Net GHG emission reduction - 25 yrs | $t_{CO2}$ | 0 |
| Heating fuel displaced | - | Electricity | | | |

### Financial Parameters

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/kWh | 0.043 | Debt ratio | % | 0.0% |
| GHG emission reduction credit | $/$t_{CO2}$ | - | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.131 | | | |
| Energy cost escalation rate | % | 5.0% | | | |
| Inflation | % | 3.0% | | | |
| Discount rate | % | 4.5% | | | |
| Project life | yr | 25 | | | |

### Project Costs and Savings

| | | | |
|---|---|---|---|
| **Initial Costs** | | | |
| Feasibility study | 0.0% | $ | - |
| Development | 0.0% | $ | - |
| Engineering | 0.0% | $ | - |
| RE equipment | 90.9% | $ | 150,883 |
| Balance of equipment | 0.0% | $ | - |
| Miscellaneous | 9.1% | $ | 15,088 |
| **Initial Costs - Total** | 100.0% | **$** | **165,972** |
| Incentives/Grants | | $ | 66,388 |
| **Periodic Costs (Credits)** | | | |
| Damper motor | | $ | (500) |
| | | $ | - |
| | | $ | - |
| End of project life - | | $ | - |

| | | |
|---|---|---|
| **Annual Costs and Debt** | | |
| O&M | $ | - |
| Fuel/Electricity | $ | 151 |
| **Annual Costs - Total** | **$** | **151** |
| **Annual Savings or Income** | | |
| Heating energy savings/income | $ | 3,464 |
| **Annual Savings - Total** | **$** | **3,464** |

Damper motor: Schedule yr # 5,10,15,20,25

### Financial Feasibility

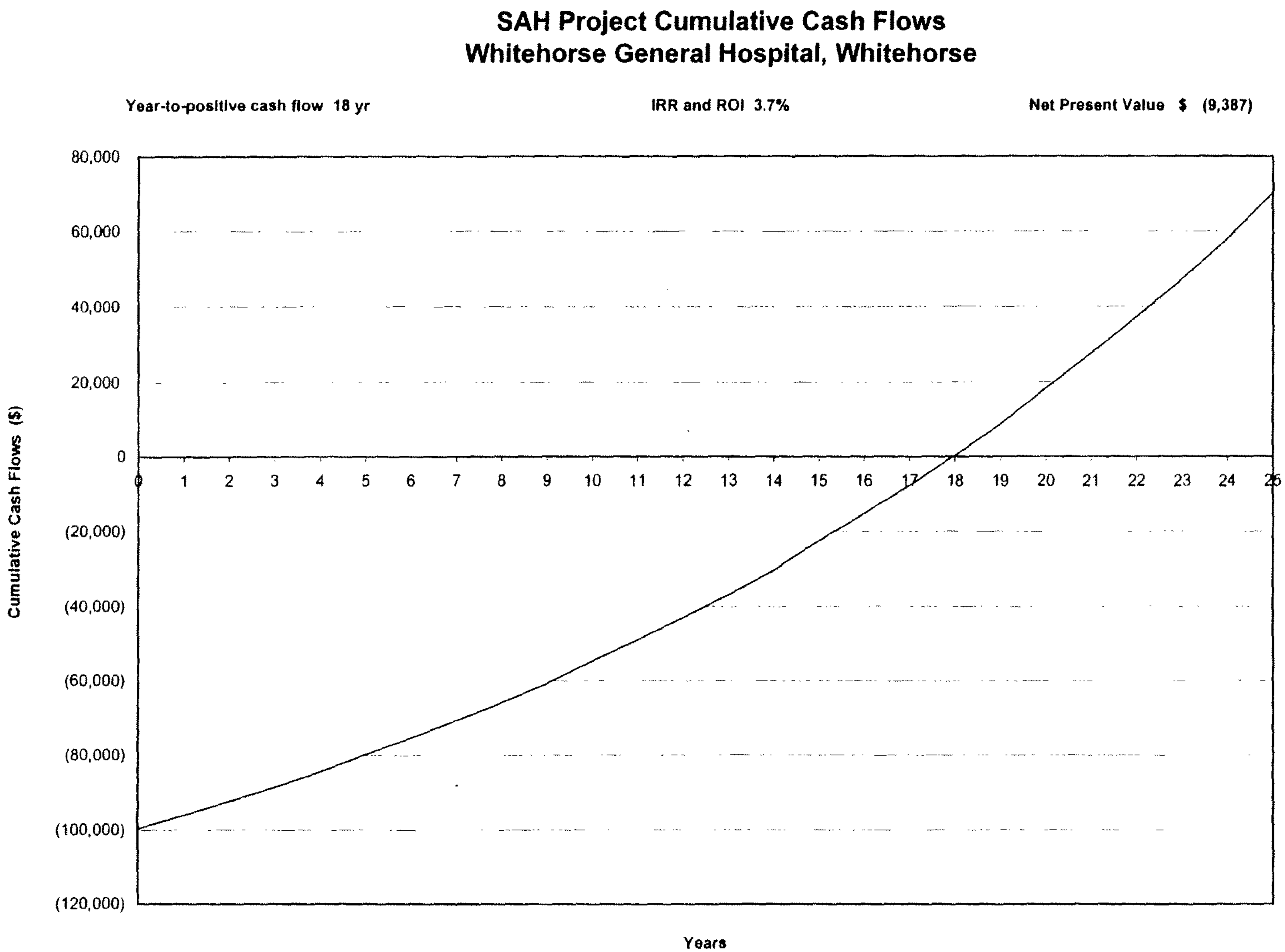
| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 3.7% | Calculate GHG reduction cost? | yes/no | No |
| After-tax IRR and ROI | % | 3.7% | | | |
| Simple Payback | yr | 30.1 | Project equity | $ | 165,972 |
| Year-to-positive cash flow | yr | 18.0 | | | |
| Net Present Value - NPV | $ | (9,387) | | | |
| Annual Life Cycle Savings | $ | (633) | | | |
| Profitability Index - PI | - | (0.06) | | | |

### Yearly Cash Flows

| Year # | Pre-tax $ | After-tax $ | Cumulative $ |
|---|---|---|---|
| 0 | (99,584) | (99,584) | (99,584) |
| 1 | 3,478 | 3,478 | (96,105) |
| 2 | 3,652 | 3,652 | (92,453) |
| 3 | 3,835 | 3,835 | (88,618) |
| 4 | 4,027 | 4,027 | (84,591) |
| 5 | 4,808 | 4,808 | (79,784) |
| 6 | 4,439 | 4,439 | (75,344) |
| 7 | 4,661 | 4,661 | (70,683) |
| 8 | 4,894 | 4,894 | (65,788) |
| 9 | 5,139 | 5,139 | (60,649) |
| 10 | 6,068 | 6,068 | (54,581) |
| 11 | 5,666 | 5,666 | (48,915) |
| 12 | 5,949 | 5,949 | (42,966) |
| 13 | 6,247 | 6,247 | (36,719) |
| 14 | 6,559 | 6,559 | (30,160) |
| 15 | 7,666 | 7,666 | (22,494) |
| 16 | 7,231 | 7,231 | (15,263) |
| 17 | 7,593 | 7,593 | (7,670) |
| 18 | 7,973 | 7,973 | 302 |
| 19 | 8,371 | 8,371 | 8,674 |
| 20 | 9,693 | 9,693 | 18,366 |
| 21 | 9,229 | 9,229 | 27,596 |
| 22 | 9,691 | 9,691 | 37,286 |
| 23 | 10,175 | 10,175 | 47,461 |
| 24 | 10,684 | 10,684 | 58,145 |
| 25 | 12,265 | 12,265 | 70,410 |

 (Adjusted) Secondary Sales

Cumulative Cash Flows Graph



RETScreen® Financial Summary - Solar Air Heating Project (DOE Database) Fuel Oil

## Annual Energy Balance

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 2.2 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 72.7 | GHG analysis sheet used? | yes/no | Yes |
| | | | Net GHG emission reduction | $t_{CO2}$/yr | 24 |
| | | | Net GHG emission reduction - 25 yrs | $t_{CO2}$ | 611 |
| Heating fuel displaced | - | Diesel (#2 oil) | | | |

## Financial Parameters

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/L | 0.450 | Debt ratio | % | 0.0% |
| GHG emission reduction credit | $/$t_{CO2}$ | - | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.054 | | | |
| Energy cost escalation rate | % | 5.0% | | | |
| Inflation | % | 3.0% | | | |
| Discount rate | % | 4.5% | | | |
| Project life | yr | 25 | | | |

## Project Costs and Savings

| | | | | | | |
|---|---|---|---|---|---|---|
| **Initial Costs** | | | | **Annual Costs and Debt** | | |
| Feasibility study | 0.0% | $ | - | O&M | $ | - |
| Development | 0.0% | $ | - | Fuel/Electricity | $ | 117 |
| Engineering | 0.0% | $ | - | | | |
| RE equipment | 90.9% | $ | 150,883 | **Annual Costs - Total** | **$** | **117** |
| Balance of equipment | 0.0% | $ | - | | | |
| Miscellaneous | 9.1% | $ | 15,088 | **Annual Savings or Income** | | |
| **Initial Costs - Total** | 100.0% | **$** | **165,972** | Heating energy savings/income | $ | 3,806 |
| Incentives/Grants | | $ | 66,388 | | | |
| | | | | **Annual Savings - Total** | **$** | **3,806** |
| **Periodic Costs (Credits)** | | | | | | |
| Damper Motor | | $ | (200) | Schedule yr # 5,10,15,20,25 | | |
| | | $ | - | | | |
| | | $ | - | | | |
| End of project life - | | $ | - | | | |

## Financial Feasibility

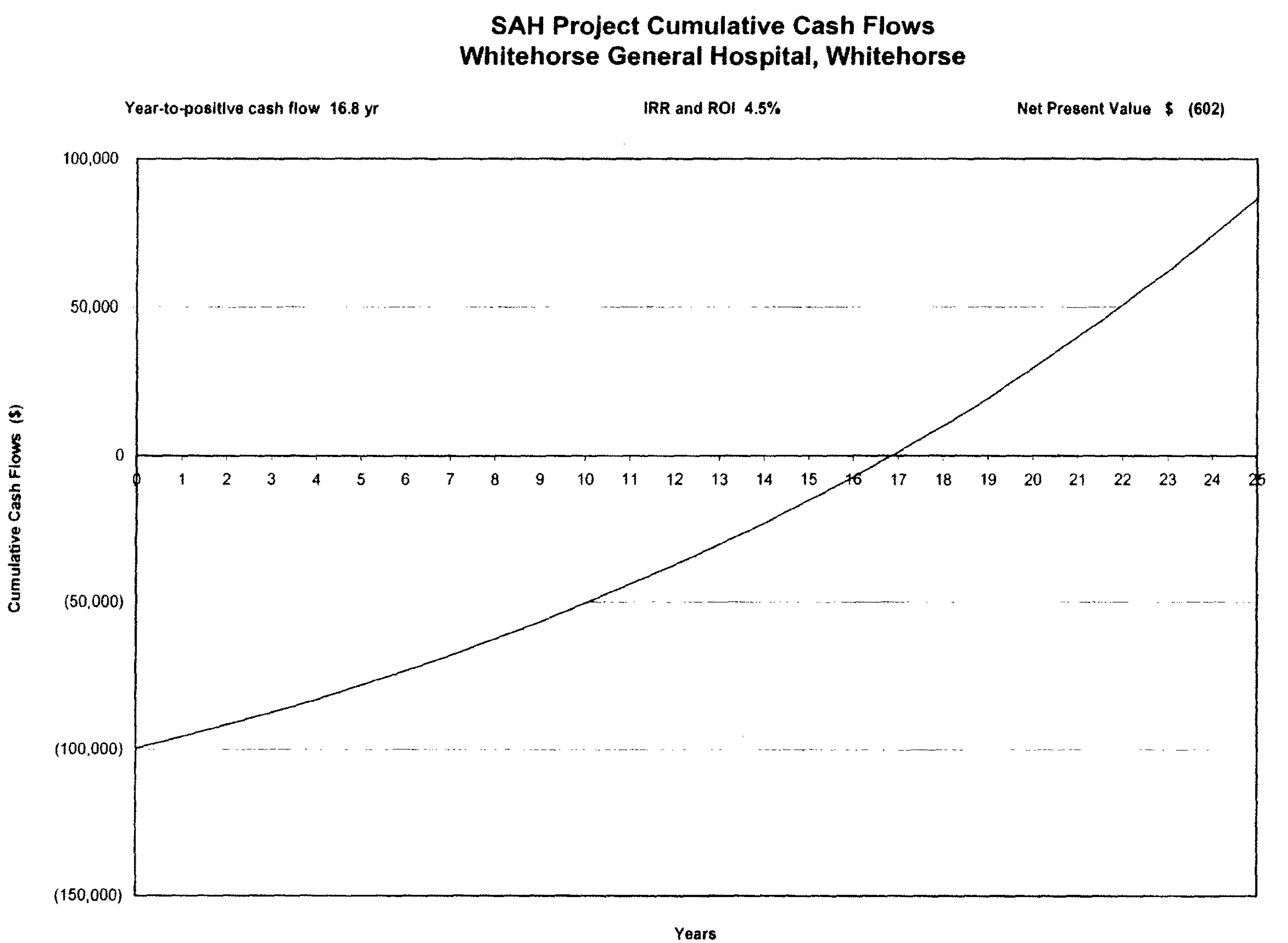
| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 4.5% | Calculate GHG reduction cost? | yes/no | No |
| After-tax IRR and ROI | % | 4.5% | | | |
| Simple Payback | yr | 27.0 | Project equity | $ | 165,972 |
| Year-to-positive cash flow | yr | 16.8 | | | |
| Net Present Value - NPV | $ | (602) | | | |
| Annual Life Cycle Savings | $ | (41) | | | |
| Profitability Index - PI | - | (0.00) | | | |

## Yearly Cash Flows

| Year # | Pre-tax $ | After-tax $ | Cumulative $ |
|---|---|---|---|
| 0 | (99,584) | (99,584) | (99,584) |
| 1 | 3,873 | 3,873 | (95,711) |
| 2 | 4,067 | 4,067 | (91,644) |
| 3 | 4,270 | 4,270 | (87,374) |
| 4 | 4,483 | 4,483 | (82,891) |
| 5 | 4,939 | 4,939 | (77,952) |
| 6 | 4,943 | 4,943 | (73,009) |
| 7 | 5,190 | 5,190 | (67,819) |
| 8 | 5,450 | 5,450 | (62,369) |
| 9 | 5,722 | 5,722 | (56,647) |
| 10 | 6,277 | 6,277 | (50,370) |
| 11 | 6,308 | 6,308 | (44,062) |
| 12 | 6,624 | 6,624 | (37,438) |
| 13 | 6,955 | 6,955 | (30,483) |
| 14 | 7,303 | 7,303 | (23,180) |
| 15 | 7,980 | 7,980 | (15,200) |
| 16 | 8,051 | 8,051 | (7,149) |
| 17 | 8,454 | 8,454 | 1,305 |
| 18 | 8,877 | 8,877 | 10,182 |
| 19 | 9,321 | 9,321 | 19,502 |
| 20 | 10,148 | 10,148 | 29,650 |
| 21 | 10,276 | 10,276 | 39,926 |
| 22 | 10,790 | 10,790 | 50,715 |
| 23 | 11,329 | 11,329 | 62,045 |
| 24 | 11,896 | 11,896 | 73,940 |
| 25 | 12,909 | 12,909 | 86,849 |

RETScreen® Financial Summary - Solar Air Heating Project

Cumulative Cash Flows Graph

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**RETScreen® Financial Summary - Solar Air Heating Project** (DOE Database) Secondary Sales

## Annual Energy Balance

| | | | | | |
|---|---|---|---|---|---|
| Project name | | Whitehorse General Hospital | Electricity required | MWh | 2.2 |
| Project location | | Whitehorse | | | |
| Renewable energy delivered | MWh | 72.7 | GHG analysis sheet used? | yes/no | Yes |
| | | | Net GHG emission reduction | $t_{CO2}$/yr | 0 |
| | | | Net GHG emission reduction - 25 yrs | $t_{CO2}$ | 0 |
| Heating fuel displaced | - | Electricity | | | |

## Financial Parameters

| | | | | | |
|---|---|---|---|---|---|
| Avoided cost of heating energy | $/kWh | 0.043 | Debt ratio | % | 0.0% |
| GHG emission reduction credit | $/$t_{CO2}$ | - | Income tax analysis? | yes/no | No |
| Retail price of electricity | $/kWh | 0.054 | (note elect costs adjusted to reflect DOE total cost of elect) | | |
| Energy cost escalation rate | % | 5.0% | | | |
| Inflation | % | 3.0% | | | |
| Discount rate | % | 4.5% | | | |
| Project life | yr | 25 | | | |

## Project Costs and Savings

| | | | | | | |
|---|---|---|---|---|---|---|
| **Initial Costs** | | | | **Annual Costs and Debt** | | |
| Feasibility study | 0.0% | $ | - | O&M | $ | - |
| Development | 0.0% | $ | - | Fuel/Electricity | $ | 117 |
| Engineering | 0.0% | $ | - | | | |
| RE equipment | 90.9% | $ | 150,883 | **Annual Costs - Total** | **$** | **117** |
| Balance of equipment | 0.0% | $ | - | | | |
| Miscellaneous | 9.1% | $ | 15,088 | **Annual Savings or Income** | | |
| **Initial Costs - Total** | 100.0% | **$** | **165,972** | Heating energy savings/income | $ | 3,125 |
| Incentives/Grants | | $ | 66,388 | | | |
| | | | | **Annual Savings - Total** | **$** | **3,125** |
| **Periodic Costs (Credits)** | | | | | | |
| Damper Motor | | $ | (200) | Schedule yr # 5,10,15,20,25 | | |
| | | $ | - | | | |
| | | $ | - | | | |
| End of project life - | | $ | - | | | |

## Financial Feasibility

| | | | | | |
|---|---|---|---|---|---|
| Pre-tax IRR and ROI | % | 2.9% | Calculate GHG reduction cost? | yes/no | No |
| After-tax IRR and ROI | % | 2.9% | | | |
| Simple Payback | yr | 33.1 | Project equity | $ | 165,972 |
| Year-to-positive cash flow | yr | 19.3 | | | |
| Net Present Value - NPV | $ | (18,732) | | | |
| Annual Life Cycle Savings | $ | (1,263) | | | |
| Profitability Index - PI | - | (0.11) | | | |

## Yearly Cash Flows

| Year # | Pre-tax $ | After-tax $ | Cumulative $ |
|---|---|---|---|
| 0 | (99,584) | (99,584) | (99,584) |
| 1 | 3,158 | 3,158 | (96,426) |
| 2 | 3,316 | 3,316 | (93,110) |
| 3 | 3,481 | 3,481 | (89,629) |
| 4 | 3,655 | 3,655 | (85,974) |
| 5 | 4,070 | 4,070 | (81,904) |
| 6 | 4,030 | 4,030 | (77,874) |
| 7 | 4,232 | 4,232 | (73,642) |
| 8 | 4,443 | 4,443 | (69,199) |
| 9 | 4,665 | 4,665 | (64,534) |
| 10 | 5,167 | 5,167 | (59,367) |
| 11 | 5,143 | 5,143 | (54,223) |
| 12 | 5,401 | 5,401 | (48,823) |
| 13 | 5,671 | 5,671 | (43,152) |
| 14 | 5,954 | 5,954 | (37,198) |
| 15 | 6,563 | 6,563 | (30,634) |
| 16 | 6,564 | 6,564 | (24,070) |
| 17 | 6,893 | 6,893 | (17,177) |
| 18 | 7,237 | 7,237 | (9,940) |
| 19 | 7,599 | 7,599 | (2,341) |
| 20 | 8,340 | 8,340 | 6,000 |
| 21 | 8,378 | 8,378 | 14,378 |
| 22 | 8,797 | 8,797 | 23,175 |
| 23 | 9,237 | 9,237 | 32,412 |
| 24 | 9,699 | 9,699 | 42,111 |
| 25 | 10,602 | 10,602 | 52,713 |

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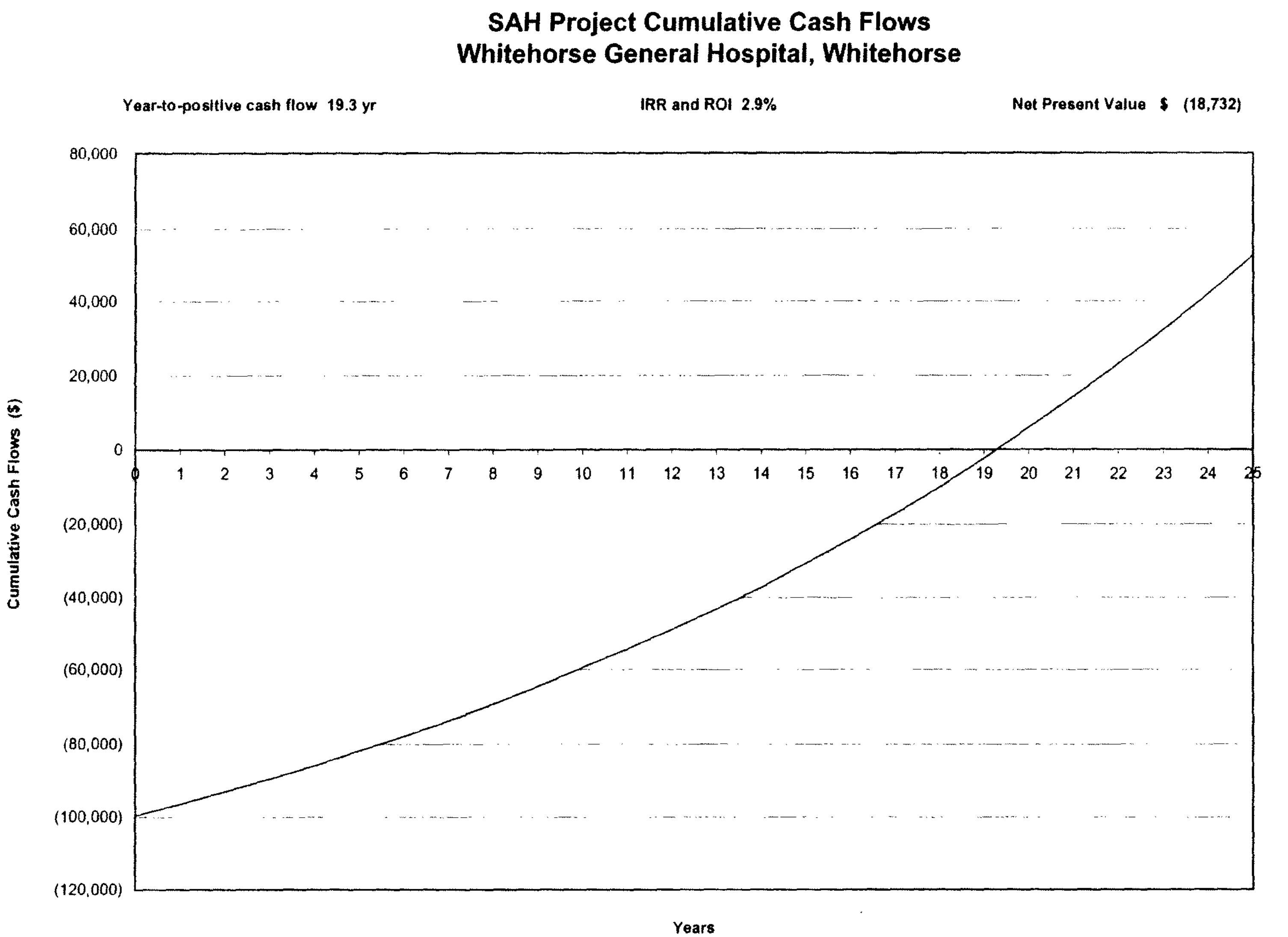
RETScreen® Financial Summary - Solar Air Heating Project (DOE Database)

Cumulative Cash Flows Graph

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# SWIFT ENERGY SAVINGS ANALYSIS

## PROJECT INFORMATION

| CLIENT | | DEALER / SIMULATOR | |
|---|---|---|---|
| **Name:** | ESC-Whitehorse General Hospital | **Name:** | |
| **Job:** | 2002-4110.22 | | |
| **Address:** | Whitehorse, YT<br>Canada, | **Address:** | ,<br>, |
| **Telephone:** | | **Telephone:** | |
| **Fax:** | | **Fax:** | |
| **E-mail:** | | **E-mail:** | |
| **Contact:** | | **Website:** | |

## ANNUAL RESULTS

| System | Size ($m^2$) | Energy Savings (GJ) | Fuel Savings | Cost Savings ($) |
|---|---|---|---|---|
| Wall 1 | 248.20 | 450.0 | 14478.8 Oil ( l ) | 6515.48 |
| **Total** | **248.20** | **450.0** | | **6515.48** |

## FINANCIAL RESULTS

| COSTS | | | BENEFITS/PAYBACK | |
|---|---|---|---|---|
| **Capital Costs** | $ | 165971 | **Simple Payback (yrs)** | 15.3 |
| **Grant / Subsidy** | $ | 66389 | **Internal Rate of Return (%/yr)** | 7.3 |
| **Capital Cost Credits** | $ | 0 | **Life Cycle Savings ($)** | 36128 |
| **Net Cost** | $ | 99583 | **Reduced CO2 Emissions (tonnes/yr)** | 41.2 |

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# SWIFT ENERGY SAVINGS ANALYSIS

## PROJECT INFORMATION

| CLIENT | | DEALER / SIMULATOR | |
|---|---|---|---|
| **Name:** | ESC-Whitehorse General Hospital | **Name:** | |
| **Job:** | 2002-4110.22 | | |
| **Address:** | Whitehorse, YT<br>Canada, | **Address:** | ,<br>, |
| **Telephone:** | | **Telephone:** | |
| **Fax:** | | **Fax:** | |
| **E-mail:** | | **E-mail:** | |
| **Contact:** | | **Website:** | |

## ANNUAL RESULTS

| System | Size ($m^2$) | Energy Savings (GJ) | Fuel Savings | Cost Savings ($) |
|---|---|---|---|---|
| Wall 1 | 248.20 | 450.0 | 125000.8 Elec. ( kWh ) | 5375.04 |
| **Total** | **248.20** | **450.0** | | **5375.04** |

## FINANCIAL RESULTS

| COSTS | | | BENEFITS/PAYBACK | |
|---|---|---|---|---|
| **Capital Costs** | $ | 165971 | **Simple Payback (yrs)** | 18.5 |
| **Grant / Subsidy** | $ | 66389 | **Internal Rate of Return (%/yr)** | 5.5 |
| **Capital Cost Credits** | $ | 0 | **Life Cycle Savings ($)** | 12374 |
| **Net Cost** | $ | 99583 | **Reduced CO2 Emissions (tonnes/yr)** | 0.0 |

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