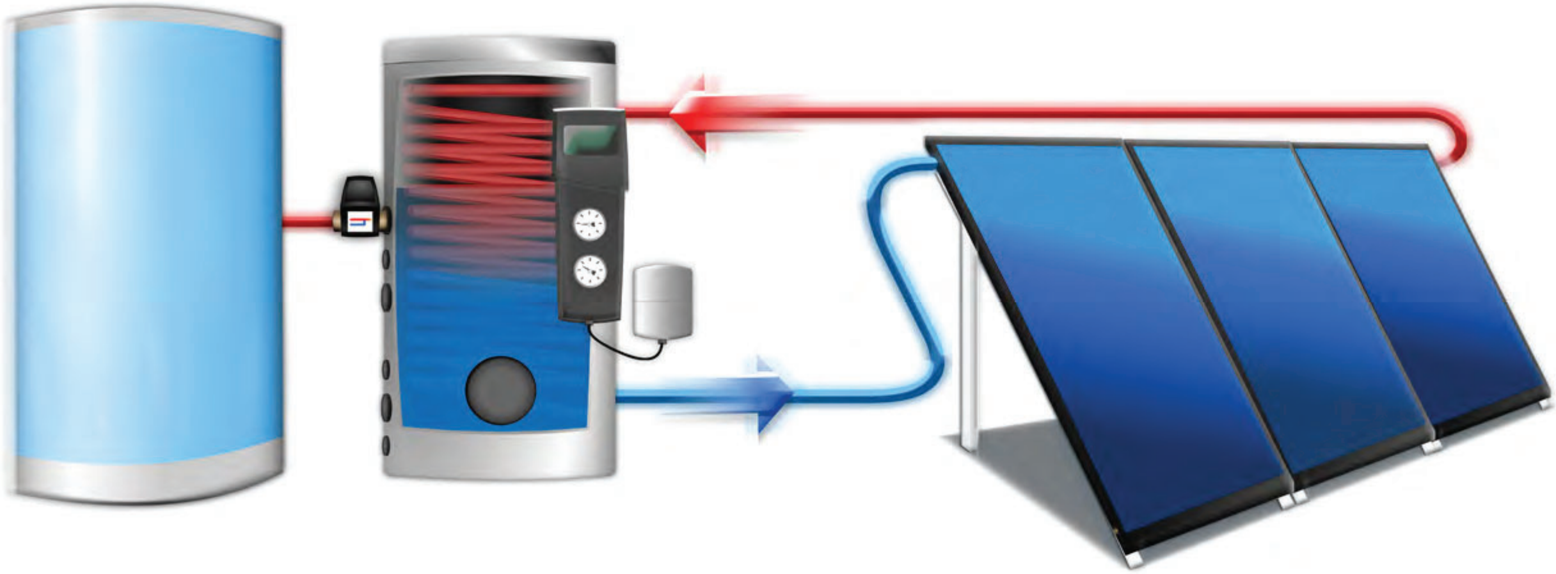

Paul DuQuesnay, CPE
Chapter 49 – Gold Coast
paulduqu@gmail.com

HTETCO Solar Water Heaters

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HTETCO Solar Water Heaters

SECTION 1: INTRODUCTION

Brief Description

A solar thermal system, also known as solar thermal collector, is an assembly used to absorb sunlight as a source of energy to produce heat. This system is not to be mistaken with solar cell or photovoltaic cell technology that converts the energy of light directly into electricity in solar panels. A solar thermal collector or solar water heater efficiently captures solar radiation from infrared and ultraviolet wavelengths and converts it to heat. The solar thermal system employs flat-plate collectors or evacuated tube collectors, sealed panels covered in glass to collect heat. The combination of the hot air trapped in the collector through the greenhouse effect and the fact that the black panels and tubes absorb solar energy can produce temperatures above 200 degrees Fahrenheit.

Although the technology of solar water heating dates back hundreds of years, development of the current system occurred in the early 1900s when rooftop collectors and a well-insulated tank to retain heat were implemented. More efficient advancements were made in the 1970s due to an oil crisis, declining production costs, and the use of solar energy in the space program. Modern systems implement the use of parabolic mirrors to concentrate sunlight, heat transfer fluids, and copper heat exchanger pipes for efficiency. This method of producing hot water has increased in use in certain regions given reductions in the payback period due to decreasing initial costs, government incentives, and increasing electricity costs. In the United States, HVAC systems account for approximately 30% of energy costs in commercial buildings and close to 50% in residential buildings. Solar heating technologies should be used to offset a portion of this cost while helping the environment by decreasing the amount of carbon dioxide and air pollution.

MAIN CSI MASTERFORMAT™

DIVISION: 23 00 00, Heating, Ventilating, and Air Conditioning
Sub-Division: 23 56 00, Solar Energy Heating Equipment
Specific Sub-Division: 23 56 13.13 Heating Flate Plate Solar Collectors

Although labor and material are important factors in estimating the cost of solar water heaters, equipment costs are a major factor. The number of collectors needed and the amount of water storage required for the system will have a direct correlation on the price of the overall system. In the planned solar water heater system shown on page 12, (ten) 4'x 8' flat-plate collectors along with (two) 264-gallon hot water storage tanks are to be installed at a laundromat to supply (26) washers with hot water. The quantities and pricing sheet on page 13 represent the means for which the final estimate was done for the proposed solar water heating system shown on page 12.

SECTION 2: TYPES AND METHODS OF MEASUREMENTS

Labor, material, and equipment are typically quantified by units of measure which are specified on the architectural and structural drawings. Using the critical path method of construction, take-off of the number of flat-plate collectors and their square footage should be first. This is followed by the size and number of water storage tanks. Depending on the location of the storage tanks, the quantity of copper tubing, copper fittings, and heat transfer fluid can be calculated.

The four most commonly used units of measure in estimating are square footage, linear footage, weight, and volume. Flat-plate collectors are measured by square footage (length x width) and the amount of collectors used are counted. The amount of water that is to be held in storage tanks is calculated by volume. The cylindrical tank volume is calculated with the equation $V = \varpi r^2 h$. The cubic volume is then divided by 231 in order to find the number of gallons the tank will hold. A gallon of water weighs 8.34 pounds, therefore a 120-gallon tank will weigh approximately 1,000 pounds. Gallons of water to be heated or hot water demand in gallons per day can be used for conceptual estimating when design drawings are in their early stages.

SECTION 3: PROJECT SPECIFIC FACTORS TO CONSIDER IN TAKEOFF AND PRICING

For solar projects, initial costs can be significantly impacted by government incentives. Tax credits, rebates, and other incentives to support energy efficiency and reduce pollution are offered by government agencies, utilities, and other organizations. Specific state incentives differ across the United States, but all of them have some form of financial incentive to encourage the installation of solar energy systems. Cost savings for larger projects applies given increases in labor productivity and discounted costs of materials. Initial costs to install the solar water heating system will be dependent on the complexity of the system. Other factors affecting pricing and take-off include material, site conditions, geographic location of the project, labor rates, and seasonal effects.

The most important factor affecting material pricing is the supply and demand of copper and the type of solar collector used at the project. For example, an evacuated tube collector system can cost around 30% more than a flat-plate collector system. Although this is true, an evacuated tube collector system will perform more efficiently in colder climates. Copper tubing is estimated using linear footage, and pricing will depend on pipe size / wall thickness. Type L copper tubing is most commonly used for solar water heaters and typically costs 25% to 30% more than Type M. Type L copper piping has a slightly larger wall thickness than Type M; consequently, the Type L copper pipe will retain and conduct heat more efficiently than Type M. A nominal 1" diameter Type L tube has a wall thickness of 0.050", while the same size Type M tube has a wall thickness of just 0.0350". Average waste factors for copper tubing material will range from 10% to 15% and fittings must also be accounted for. The amount of copper tubing that is used will correlate with the location of the water storage tanks relative to the solar flat-plates collectors. If the distance from the solar collectors to the storage tanks can be minimized, less copper tubing can be used; and heat retention can be maximized in the system.

Site conditions will affect two important cost factors, installation and equipment time. Depending on the size, weight, and how high the solar collectors / water storage tanks are installed, a crane will need to be employed for lifting. In general, the higher the product is installed, the greater the cost will be to move it into position. Factors that affect hoisting equipment rates vary by crane size, location, number of mobilizations, and time of use. Ease of project access and the ability to acquire or rent suitable hoisting equipment is crucial.

The geographic location of the project and local government regulations will affect the overall costs of the project. Solar thermal collectors pricing may be more strongly impacted by transportation costs than other assemblies. Solar water heaters are commonly used in locations that may be off the electrical grid. In this case, generators or other sources of electrical power may need to be used during the installation process. Generally, the farther the project is from a populated area, the more expensive overall costs will be. A project located in a rural area may be more costly than the same project located in a populated due to these factors.

Labor rates may have a greater effect on project costs and are commonly more affected by project location and government regulations than materials used. Solar water heating systems may be less labor intensive than other assemblies, but there is still a need for skilled labor to complete the project as it is a specialized industry. Labor factors affecting pricing include the following: union versus open shop, experience factors such as the learning curve, turnover, crew size, site access, governmental or regulatory requirements such as the Davis Bacon Act, and proximity to transportation and logistics.

Seasonal effects such as weather conditions may also affect estimating. Lost days for bad weather are hard to predict and may be accounted for with a contingency. Heavy rain, snow, or wind can cause significant safety issues, delays, and the need for additional equipment. A project may have to be interrupted or postponed due to snow in colder climates. These conditions should be accounted for or excluded from the estimate.

SECTION 4: OVERVIEW OF LABOR, MATERIAL, EQUIPMENT, INDIRECT COSTS AND APPROACH TO MARKUPS

Labor rates can be difficult to predict as they are affected by many project specific factors and market conditions that are hard to forecast. Three main elements drive labor rates: supply, demand, and the construction schedule. In the short term, supply and demand of labor can be accurately predicted by studying market conditions. In a longer time horizon, including escalation in the estimate may be necessary. The construction schedule can have a significant impact on labor rates due to overtime. The scenario of a shortage of labor with an accelerated construction schedule will increase labor costs considerably.

An accurate labor rate should include an acceptable and calculated labor burden. The labor burden includes costs paid aside from salary: which are taxes, pensions, vacation, health insurance, social security, workers compensation, liability insurance, and any other benefit provided by the company to its employees. Labor burden rates should be applied in the amount of 1.30% to 1.45% times the hourly rate.

Although labor rates may be hard to determine, accurate man-hours may be easier to forecast using historical cost data. Historical labor costs on similar projects can be adjusted to account for specific project conditions, location, and size. For example, if a car wash was built in Charlotte, NC one year ago with total hot water demand of 1,000 gallons per day, 10 each 7.5' x 6.5' evacuated tube collectors, and 2 each 264-gallon solar water heater storage tanks with a cost of $20,000 after rebates and tax incentives, the project can be used as historical data and pricing / estimating of future projects. Given this cost data, the car wash solar water heater project cost $20.00 per GPD, $41.03 per SF of evacuated tube collector, and $37.88 per gallon of water storage. Given this historical cost data, it can be derived that a similar project in Raleigh, NC with a total hot water demand of 1,500 gallons per day, employing 15 each collectors, and 3 each SWHs, it can be calculated that the project will be close to $30,000. This assumes comparable rebates and incentives being that the project is in the same state. Adjusting this number by 2.5% for escalation and 3.5% for market conditions it can be concluded that the project in Raleigh, NC will cost $30,000 x 1.06% = $31,800.00

Material prices for a project can be accurately determined given a complete set of plans, specifications, and the correct quantities. Material prices should include all applicable delivery charges, surcharges, and sales tax. Economies of scale, demand, and supply will affect the price of materials. In the case of solar water heaters, material prices are affected by the amount of rebates and tax incentives that are available. According to solarpowerrocks.com, the states with the best solar energy incentives are Massachusetts, Rhode Island, and New Jersey. Copper is a commodity that trades on the London Metals Exchange. Although the option exists, most construction materials are not hedged in the financial markets during a typical project. Fortunately, most suppliers are willing to guarantee pricing for 6 months or for the project duration. If this is not negotiated, a certain percentage of escalation should be used in estimating materials. While a risk to price fluctuations in copper and other materials may exist, the majority of total project costs for SWH systems will be spent on labor and equipment to put the solar collectors and water storage tanks in place.

The solar water heater storage tanks, solar collectors, and the equipment necessary to install the product will account for approximately half the total cost of the project, but will be dependent upon the amount of rebates and various tax incentives that are received. A 264-gallon solar heater tank costs approx. $5,000 while an evacuated tube collector cost approx. $1,250 before any rebates or tax incentives are accounted for. Hoisting equipment costs should also include an hourly or daily rate for an operator with the appropriate labor burden. If the product is installed on the roof of a structure, safety measures and site constraints such as overhead power lines will need to be assessed. If the project site conditions are unobstructed adding these additional costs to the estimate is not necessary.

Major indirect project costs include shop drawings, mobilization, parking, office facilities, accounting and office staff, administrative, supervision, bonding if required, and insurance. These costs are usually estimated as a percentage of total costs. Markup or overhead and profit is typically a percentage of total project cost which is adjusted based on the total cost of the contract and the desire to win the contract.

SECTION 5: SPECIAL RISK CONSIDERATIONS

A potential risk to consider in evaluating the cost of a solar water heater system is efficiency and price after tax incentives and rebates. Depending on the project location, the efficiency of the product and the price can greatly affect the return on investment / payback period. Rebates, tax credits, performance payments, sales tax exemptions, and property tax exemption vary state to state. For example, Oklahoma offers very poor incentives to use solar energy while neighboring state Colorado encourages it with some of the best incentives in the country. In a situation of little incentives and low electricity prices, solar simply may not be a good choice due to the high initial cost of the system. In order to qualify for these various incentives, the product must be Buy American Compliant and SRCC Certified.

The type of solar collector used and the amount of sunlight the system can absorb will affect the efficiency and payback period of the assembly. A flat-plate collector will lose efficiency more rapidly than an evacuated tube collector on a partially cloudy day. In cooler climates, the evacuated tube collector also performs better because the vacuum that surrounds the tube reduces heat loss. Evacuated tube collectors do cost more than flat-plate collectors and the technology may actually be less productive in warm climates. It is important to have a solar engineer design and implement a plan for a solar water heater system to maximize efficiency and reduce the payback period. Optimum collector tilt position is also crucial for solar panels. They should always face true south if you are in the northern hemisphere, and the amount of tilt is dependent upon the site latitude.

Qualifications, allowances, and contingencies are typical ways to mitigate risk. Qualifications should be addressed for items that are not completely defined or are contradicting in the plans and specifications. A solar water heater system estimate may include flat-plate collectors as a qualification if the type of solar collector is not defined. An allowance can be included in an estimate to protect against known but undefined cost. Given an incomplete set of drawings, an allowance for roof clamps or copper tubing could be used that are standard for the system and location of the project. A contingency is another way to sage

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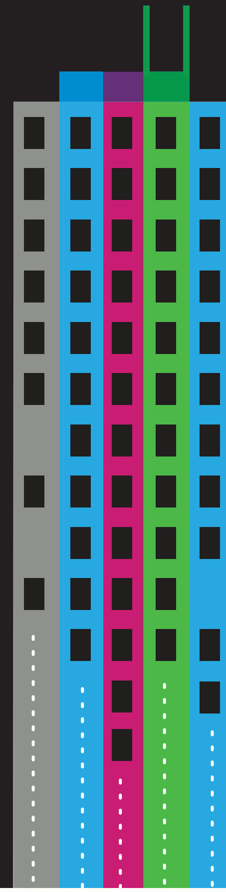

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mitigate risk by simply adding the item to the estimate for conditions or circumstances that most likely will result in additional project costs. The amount of the contingency is typically based on past experience and project uncertainties.

SECTION 6: RATIOS AND ANALYSIS - TESTING THE BID

Checking and testing the figures in an estimate using ratio analysis can confirm the quantities and pricing used to develop the final estimate. Unit costs and total system costs on past projects should correlate with future projects. Although pricing and the location of the project may differ, historical estimates can be adjusted to reflect the current market environment assuming that the same type of SWH system is used. Ratios are very effectively used for conceptual and schematic drawings when plans are incomplete and the product is still in the early design stages. Utilizing available historical cost data along with these ratios can be very beneficial during preconstruction and planning stages of the project to produce budget numbers. For a typical SWH system the following ratios would be used.

Collector Gross Surface Area: The total size of the surface of the collectors.

Collector Net Aperture Area: Includes only the glazed or glass covered area for flat-plate collectors. Includes the cross-sectional surface area of the outer glass tube measured using the internal diameter for evacuated tubes.

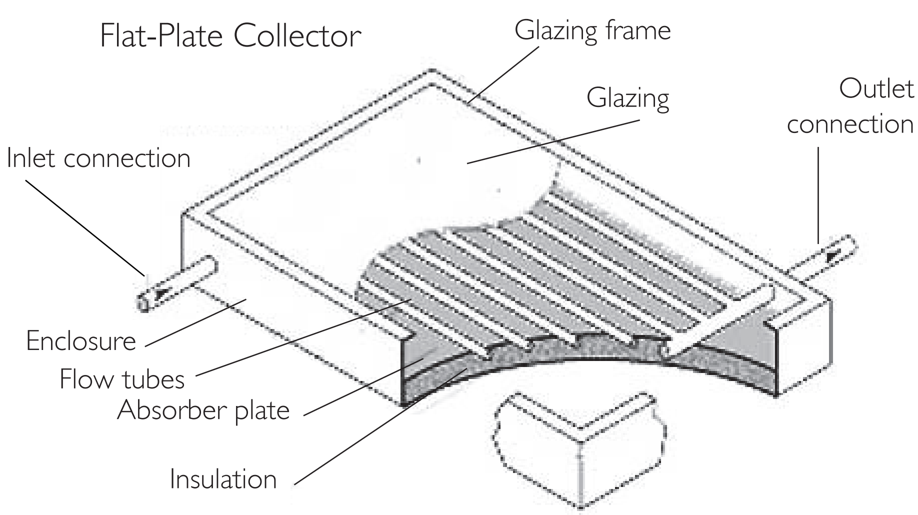
Collector Absorber Area: Includes only the size of the black absorber surface inside the glass cover for flat-plate collectors. Includes the cross-sectional area of the inner tube using the outside diameter for evacuated tube collectors.

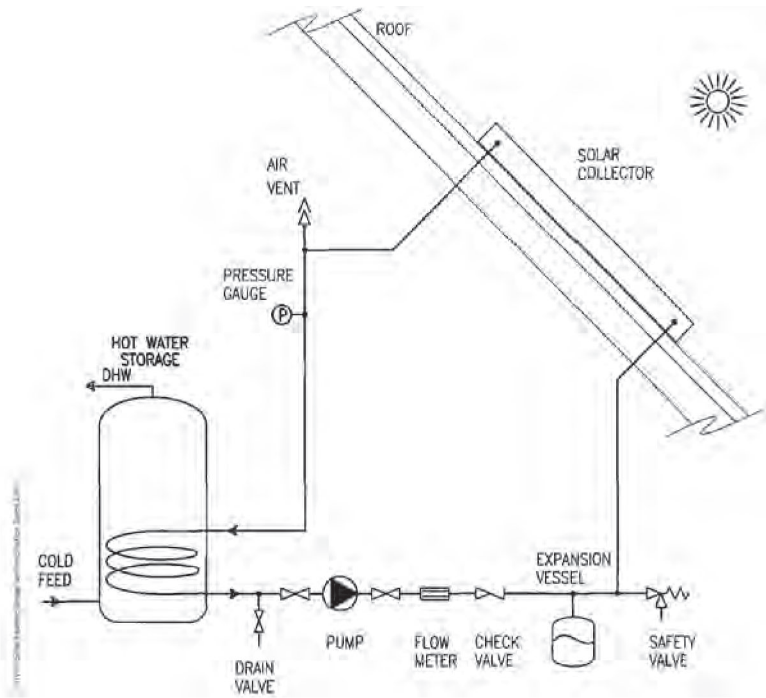
Storage Tank Volume in Gallons: ($\varpi r^2 h$) / 231

SECTION 7: OTHER PERTINENT INFORMATION

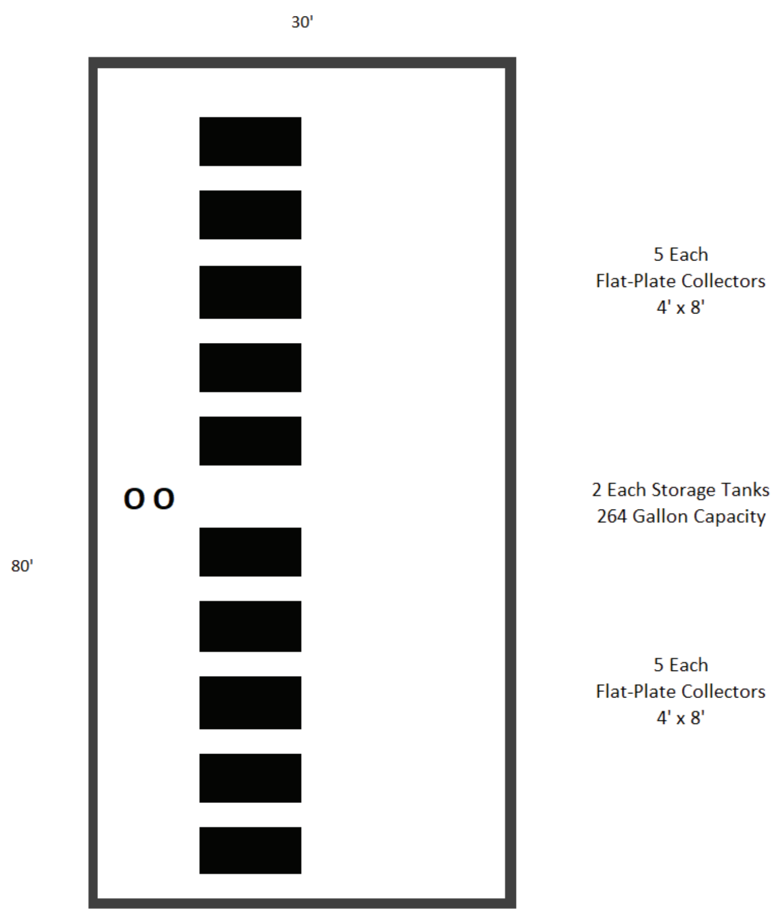
Any other information that may affect the scope of work is relevant to the estimate. This may include responses to RFIs, clarifications, assumptions, and addendums. The project schedule is also of considerable importance as a change in the schedule could significantly affect labor rates. An accelerated schedule typically results in more overtime for labor and additional supervision. Federal and state tax credits, rebates, and exemptions for solar water heaters vary from state to state and may change over time.

SECTION 8: SAMPLE SKETCHES





Drawing of Proposed Laundromat



SECTION 9: SAMPLE TAKEOFF AND PRICING

Description	Takeoff Quantity	Units	Labor Cost / Unit	Labor Total	Material Price	Material Total	Equip. Price	Equip. Total	Total Amount	Total Cost / Unit	% of Total
Collectors											
Solar Flat-Plate 4' x 8'	10.00	each	$298.00	$2,980.00	$1,087.00	$10,870.00	$125.00	$1,250.00	$15,100.00	$1,510.00	27.6%
Roof Clamps	10.00	each	$74.00	$740.00	$18.00	$180.00			$920.00	$92.00	1.7%
Misc. Hardware	1.00	ls	$225.00	$225.00	$334.00	$334.00			$559.00	$559.00	1.0%
Storage Tanks											
Water Storage 264-Gallon	2.00	each	$945.00	$1,890.00	$4,917.00	$9,834.00	$280.00	$560.00	$12,284.00	$6,142.00	22.5%
Controls, Sensors & Valves											
Thermostat	2.00	each	$154.00	$308.00	$92.00	$184.00			$492.00	$246.00	0.9%
Valves	9.00	each	$46.00	$414.00	$139.00	$1,251.00			$1,665.00	$185.00	3.0%
Sensors	4.00	each	$135.00	$540.00	$138.00	$552.00			$1,092.00	$273.00	2.0%
Copper Tubing, Fittings											
Type L 1"	45.00	lf	$10.28	$462.60	$12.00	$540.00	$2.00	$90.00	$1,093.00	$24.28	2.0%
Type M 1"	160.00	lf	$7.53	$1,204.80	$9.00	$1,440.00	$1.50	$240.00	$2,885.00	$18.03	5.3%
General Conditions											
Misc. Equipment	320	sf					$4.00	$1,280.00	$1,280.00	$4.00	2.3%
SUBTOTAL				**$8,764.40**		**$25,185.00**		**$3,420.00**	**$37,369.00**		
Contingency	320	sf					$2.00	$640.00	$640.00	$2.00	1.2%
Allowances	320	sf					$0.75	$240.00	$240.00	$0.75	0.4%
SUBTOTAL	320	sf							**$38,249.00**	**$119.53**	
Escalation	2	%							$765.00	$2.39	1.4%
Subtotal with Escalation									**$39,014.00**	**$121.92**	
Supervision	1	ls							**$6,500.00**	$20.31	11.9%
SUBTOTAL									**$45,514.00**	**$142.23**	
Markup (20%)									**$9,103.00**	**$28.45**	**16.7%**
TOTAL CONTRACT:									**$54,617.00**	**$170.68**	**100.0%**

*** Potential Savings from Rebates and Incentives are not included**

SECTION 10: GLOSSARY AND TERMINOLOGY

Absorber: The part of the collector that actively absorbs sunlight / solar radiation. Measured as the cross-sectional area of the inner tube using the outside diameter for evacuated tube collectors.
Addendum: Written or graphic instruments issued prior to the date for opening of bids which may interpret or modify the bidding documents by additions, deletions, clarification, or corrections.
Allowances: Resources included in estimates to cover the cost of known but undefined requirements.
Aperture: The part of the collector through which light enters. Measured as the cross-sectional surface area of the outer glass tube using the internal diameter for evacuated tube collectors.
Bid Bond: A bond that guarantees the bidder will enter into a contract on the basis of the bid.
BTU: British Thermal Units, the unit of measurement for heat.
Buy American Compliant: Conforms to the Buy American Act and American Recovery & Reinvestment Act.
Performance Bond: A bond which secures the performance and fulfillment of all the undertakings, covenants, terms, conditions, and agreements contained in the contract.
Conceptual Estimate: An estimate made without the benefit of detailed engineering data.
Contingency: An amount added to an estimate to allow for items, conditions, or events for which the occurrence is uncertain and experience shows will likely result in additional costs.
Cost Estimate: A prediction of quantities, cost, and price of resources required by the scope of work, activity, or project. As a prediction, an estimate must address risks and uncertainties.
Efficiency: Measured as a percentage of gross area, aperture area, and absorber area.
Escalation: The provision for an increase in the cost of equipment, material, labor, etc., over that specified in the contract due to continuing price level changes over time.
Indirect Cost: Costs which do not become a final part of the installation, but which are required for the completion of the installation including field administration, direct supervision, capital tools, startup costs, contractor's fees, and insurance.
Insolation: The amount of solar radiation that reaches the earth's surface.
Labor Burden: Benefits plus taxes & insurances the employer is required to pay by law based on labor payroll.
Markup: Includes such percentage applications as general overhead, profit, and other indirect costs.
Open Shop: A project condition where either union or non-union contractors or individuals may be working.
Qualification and Assumptions: Items that are not completely defined in the project documents for which the estimator was required to use judgment in developing the estimate.
Quantification: To translate project scope information into resource quantities suitable for costing.
Scope: All that is contractually committed to be performed or delivered.
SRCC Certified: Certified according to guidelines of the Solar Rating & Certification Corporation

SECTION 11: REFERENCES

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