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Pacific Northwest National Laboratory
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Alternative Energy Saving Technology Analysis Report for Richland High School Renovation Project

B. Liu

August 2004

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Alternative Energy Saving Technology Analysis Report for Richland High School Renovation Project

Report Issued: August, 2004

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On July 8, 2004, L&S Engineering, Inc. submitted a technical assistance request to Pacific Northwest National Laboratory (PNNL) to help estimate the potential energy savings and cost effectiveness of the solar energy and daylighting design alternatives for Richland High School Renovation Project in Richland, WA. L&S Engineering expected PNNL to evaluate the potential energy savings and energy cost savings, the probable installation costs, incentives or grants to reduce the installed costs and simple payback for the following alternative measures:

1. Daylighting in New Gym
2. Solar Photovoltaics
3. Solar Domestic Hot Water Pre-Heat
4. Solar Outside Air Pre-Heat

Following are the findings of the energy savings and cost-effectiveness analysis of above alternative energy saving technologies.

<u>Daylighting in New Gym</u>

The State of Washington recommends L&S Engineering, Inc to further study the cost effectiveness of implementing daylighting dimming control technology in the new gymnasium. The method chosen for this analysis is a comprehensive computer simulation tool called *eQuest,* a building energy simulation software with DOE-2 engine. A physical model was constructed in the software based on the concept design drawing dated on April 21, 2004. The physical model includes the new gym, weight room, locker room and adjacent existing restroom/laundry room, with a total floor area of 22,111 square feet. See Figure 1 for the 3-D isometric of the model.

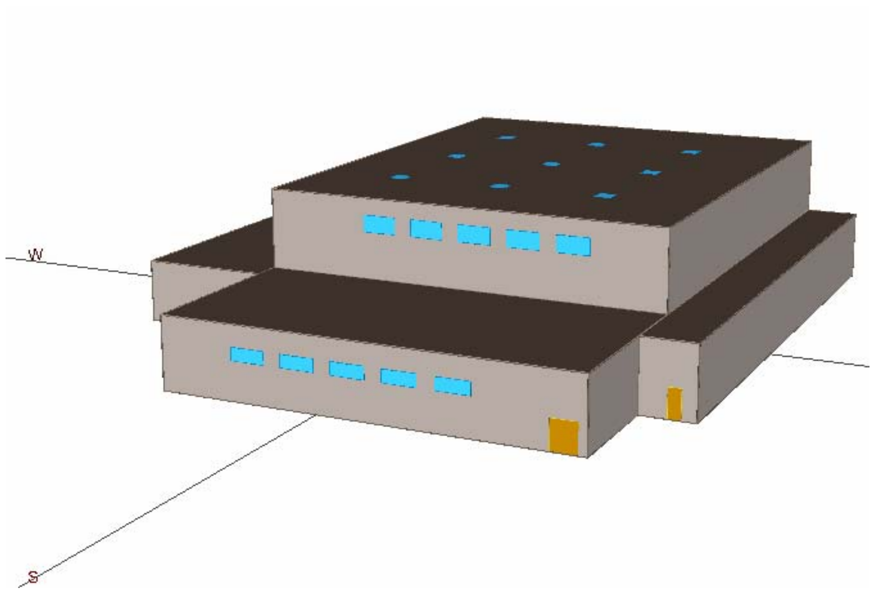

Figure 1. 3-D Isometric View of New Gymnasium in Richland High School

Energy models with three different levels of daylighting design were created. A Base Case is modeled to reflect the current concept design - translucent wall panels on both north and south side of the exterior wall in the new gym, without any daylighting dimming control. Alternative 1 is to use the dimming control to harvest the natural light through the translucent wall panels on the exterior north and south facing walls. Alternative 2 studies the potential energy savings by installing nine 4'x4' prismatic skylights on the roof of the gym with dimming control.

The following utility tariffs were used for the model:

Electric Utility Rate: Schedule 24 by City of Richland
Monthly Customer Charge: $50.00/mo.
Monthly Energy Charge:

Winter (billed September 1 through March 31, inclusive)	
First 20,000 kWh/mo.	$ 0.0431/kWh
Over 20,000 kWh/mo.	$ 0.0324/kWh
Summer (billed April 1 through August 31, inclusive)	
First 20,000 kWh/mo.	$ 0.0374/kWh
Over 20,000 kWh/mo.	$ 0.0235/kWh

Monthly Demand Charge:

First 50 kW/mo.	@	No Charge
Excess above 50 kW/mo.	@	$ 5.70/kW

Natural Gas Rate:	Schedule No. 504 by Cascade Natural Gas	
Monthly Charge:	$7.0	
Energy Charge:	First 50 therms per month	$0.85082 per therm
	Next 450 therms per month	$0.84482 per therm
	Next 3500 therms per month	$0.79672 per therm
	Over 3500 therms per month	$0.75681 per therm

The potential energy consumption and energy cost savings for all three models are listed in Table 1. The results of the simulation indicate that it will save 6% in electric energy and 2% energy costs if the daylighting dimming control system is installed in the new gym. Adding the prismatic dome skylights, it will save 14% in electric energy and 4% total energy costs. A special attention should be paid that the energy savings and energy costs savings are estimated based on the assumption that the new gym will be air-conditioned by a HVAC system with a hot water boiler and DX cooling units. Dimming control will turn off the electrical lights outputs when daylight available, which will reduce the energy consumption of light fixtures. In the cooling season, the reduction of light fixtures will further reduce the cooling load and save the energy usage from the cooling equipment. However, in the heating season, additional heating will be provided to maintain the space temperature, resulting in more natural gas consumption. The relatively high cost of natural gas and low cost of electricity in Richland High School reduce the economic benefits of the daylighting dimming control measure in the new gym. Detail energy modeling results of the new gym are included in Appendix A.

Table 1. Energy Savings and Simple Payback Using Daylighting Dimming Control

Richland High School Renovation - New Gym

Total Modeled Floor, sf:	22,111									
Gym Floor, sf:	11,623									
	Annual Energy Use				Annual Energy Cost			First	Energy	Simple
Case	Electric (kWh)	Gas (therm)	Total (MBtu)	EUI (kBtu/sf)	Electric ($)	Gas ($)	Total ($)	Cost[1] ($)	Savings ($)	Payback (Yrs)
Base Case	101,458	15,812	1,927	87.2	7,850	12,911	20,761	NA	NA	NA
Alt 1 - Daylite	95,283	15,846	1,910	86.4	7,438	12,938	20,376	2,400	385.0	6.2
Alt 2- Skylite	87,072	15,925	1,890	85.5	6,948	13,001	19,949	7,935	812.0	9.8

Note:

1. First cost for Alternative Case 1 includes the installation of the dimmable ballast and associated controls and wiring; First cost for Alternative Case 2 includes the first cost for Alternative 1 plus the installation cost of prismatic skylights.

Solar Photovoltaics

The design team proposed to install solar photovoltaic (PV) panels on the roof of the Science Classroom in MacIntosh Hall. The 2,360 square feet Science Classroom is located at the south end of the 2nd floor in MacIntosh Hall. The demonstration PV system will provide the electrical power to the interior lighting fixtures in this classroom. The designed total installed lighting power of the classroom is 2.8 kW with the lighting power density of 1.2 watts/sf. Therefore the proposed PV array will be selected to generate 2.8 kW AC power.

1. PV Systems Energy and Cost Savings:

Using *PVWATTS*, a 2.8 kW Photovoltaic system would supply 4,326 kWh to the Science Classroom and save approximately $337 per year in utility costs. *PVWATTS* is an Internet-accessible simulation tool, developed by the National Renewable National Laboratory. This tool can provide a quick estimate of the electrical energy produced by crystalline silicon photovoltaic system. Table 2 shows the detail estimation results generated by *PVWATTS.* A blending electricity cost of 7.8 cents/kWh is used to calculate both energy kWh and demand kW reduction from the utility by PV system. Approximately 300 square feet roof area will be needed to install the 20 PV modules if using 12%-efficient PV system. [1]

2. PV System Costs and Simple Payback:

The PV system would cost around $29,000[2], including twenty 140-watt PV Modules, DC/AC Inverter, Battery Bank, Charge Controller, Digital Readout Panel and associated mounting and wiring system. Without any grant money or incentives, the simple payback period would be 86 years. Without the battery backing back components, the PV system cost may be reduced down to around $23,000.

3. PV Systems Incentives

Washington State has two kinds of incentives available to promote solar PV technology at schools. One is called Solar 4R Schools managed by the Renewable Energy Programs of Bonneville Environmental Foundation (BEF). Rob Harmon (206-463-4986), Vice President of Renewable Energy Programs at BEF, indicated that BEF is still open to accept the Solar 4R Schools grants application and normally the maximum grants awards to school is 50 percent of the solar project budgets and maximum to $10,000 grant. There are two steps to the funding process. The first is the submission of a Letter of Enquiry. The second is a full proposal upon request by BEF after the Letter of Enquiry is reviewed. More detailed guide to the application process and the application forms are available at http://www.b-e-f.org/grants/guide.shtm.

Another inventive is Green Tags (http://www.cascadesolar.com/greentags.htm). BEF and the Northwest Renewable Energy Cooperative (NWREC) joined together to help reduce the costs of small residential and commercial photovoltaic systems in Oregon and

[1] *A Consumer's Guide – Get Your Power From The Sun,* by U.S. Department of Energy

[2] Cost Data Source: *RS Means Green Building Project Planning & Cost Estimating* and personal contacts with NREL.

Washington. NWREC will sign 5-year agreements with the owners of new photovoltaic systems and will pay them an annual amount equivalent to 10 cents/kWh – Green Tags – produced by the solar systems. System owners will be paid annually. BEF will then purchase the Green Tags from NWREC and sell them to its wholesale customers. The point of contact of this program is Doug Boleyn (503-655-1617) at NREC. Detail information and procedure to sell the Green Tags can be found at the web site of http://www.cascadesolar.com/greentags.htm.

Assuming that a $10,000 grant is awarded by BEF and $433 per year worth of the PV generated electricity is sold as Green Tags, the simple payback period will be 25 years for the system including battery bank and 17 years without battery backing system.

Table 2. Photovoltaic System Energy and Cost Savings Results

PVWATTS v.2: AC Energy and Cost Savings

AC Energy and Cost Savings

Station Identification	
Cell ID:	0193334
State:	Washington
Latitude:	46.3 ° N
Longitude:	119.3 ° W
PV System Specifications	
AC Rating:	2.8 kW
Array Type:	Fixed Tilt
Array Tilt:	46.3 °
Array Azimuth:	180.0 °
Energy Specifications	
Cost of Electricity:	7.800 ¢/kWh

Energy Production		
Month	Energy (kWh)	Energy Value ($)
1	207	16.15
2	289	22.54
3	374	29.17
4	427	33.31
5	437	34.09
6	440	34.32
7	479	37.36
8	471	36.74
9	461	35.96
10	380	29.64
11	207	16.15
12	155	12.09
Year	4326	337.43

4. PV Systems Grid Connection and Net Metering

State of Washington also suggests the design team to investigate the possibility of net metering and selling the electricity power produced by the PV systems back to the utility company. Clint Whitney (509-942-7419), a City of Richland engineer, was contacted regarding the possibility of selling electricity generated by photovoltaic system back to the grid. According to him, City of Richland already has the infrastructure to reverse the electric meter for buying back the electricity generated by clients. However there are some barriers to sell back to the grid. One is that City of Richland is still working to create a rate structure to support the purchase back the electricity from customers. Another is the capacity of the PV system has to be large enough to overcome the minimum demand at Richland High School in order to get back to the grid. Currently the minimum demand at Richland High School is estimated around 100 kW. If RHS installs a 2.8 kW PV system, it will not be large enough to get back to the grid.

Solar Water Heating System

A drain-back solar water heating system was evaluated to potentially provide domestic hot water to the 3,840-sf kitchen, which is located at the south end of the Administration-Classroom Complex. Figure 2 shows the schematic drawing of a typical drain-back system. Solar water heating system is designed to provide about 70% of the kitchen's hot water needs. The rest of domestic hot water load will be met by the backup gas-fired water heater. Solar water heating is most effective when it serves a steady water heating load that is constant throughout the week and year. Preliminary analysis of the Energy savings and cost savings from the solar hot water system were performed using a computer program FRESA[3]. FRESA (Federal Renewable Energy Screening Assistant) is a screening tool to identify potentially cost-effective applications of renewable energy technology on a building and facility level.

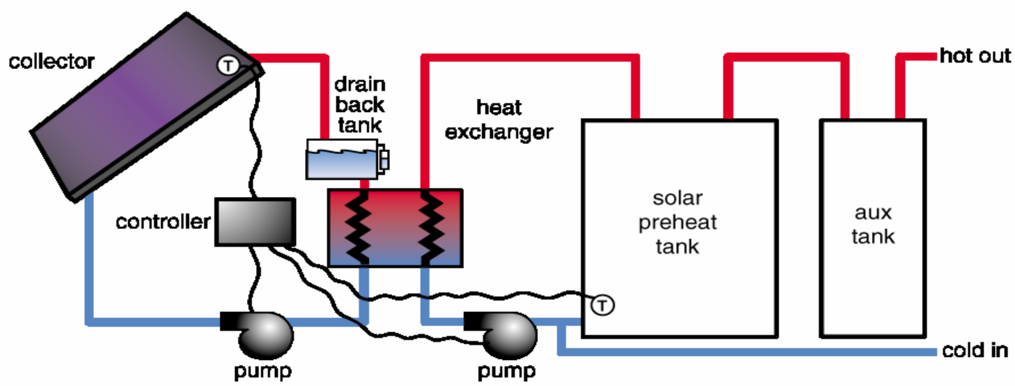

Figure 2. Drain-Back Solar Water Heating System

The daily use of domestic hot water in the kitchen was calculated base on the assumption of 1200 meals per day and 2.4 gallons/meal[4]. So the total hot water load is 2880 gallons/daily and the solar water system load is around 2000 gallons/daily. Yakima solar radiation data were used for the FRESA analysis. The computer simulation results show that it will save 5780 therm natural gas consumption and $4,739 in natural gas costs if the solar water heating system is installed. It requires 1,380 square feet area for solar collectors to meet the design load. The total installation cost of the solar water heating system is $43,400. It is estimated based on $30/sf[5] for parabolic trough system. In addition to the unit collector cost, a base cost of $2,000 was added to cover the storage tank, piping, controller and sensors, insulation and other plumbing specialties. It was determined that the simple payback period of the solar water heating system would be 9.2 years. The FRESA inputs and results are listed in Appendix B.

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[3] Free download FRESA software from http://www.eere.energy.gov/femp/information/download_fresa.cfm
[4] ASHRAE Handbook 2003 HVAC Application
[5] Cost Data Source: *RS Means Green Building Project Planning & Cost Estimating*.

Contact was made to City of Richland for the incentives of solar domestic water heater. Currently City of Richland does not have a program to provide any incentives for the application of solar water heater. However, City of Richland does have a conservation loan available for the solar energy application. The conservation loan program is managed by the Power and Resource Management Division (509-942-7436).

Solar Ventilation Preheat

Solar ventilation air preheating is a cost-effective application of solar energy due to the low cost and high performance of transpired collectors (Figure 3). The transpired collector is mounted about six inches away from the south wall of a building, forming a plenum between the wall and the collector. A fan is installed in the wall to draw air form the plenum into the supply ductwork. The solar preheated air can be delivered to the air handler for the heater. A by-pass damper is provided to bring outside air directly in, bypassing the solar wall in summertime.

The design team proposed to install the transpired collectors at the south ends of McINTOCH Hall to preheat the outside air serving the Science and Math Classrooms. Currently the south end walls have no glass and were constructed with 6 inches metal studs, R-19 batt insulation and 1.5 inches EIFS. Outside air is estimated at 1200 cfm total. With a heating capacity of 6 cfm outside air per square foot, a 200 square feet transpired collector can meet the demand for ventilation air preheating, and save 460 therms per year of natural gas. The solar ventilation preheating system would cost $2,800 and save $404 per year, making a 6.9 years of simple payback period. The detail inputs and analysis results from FRESA are listed in Appendix C.

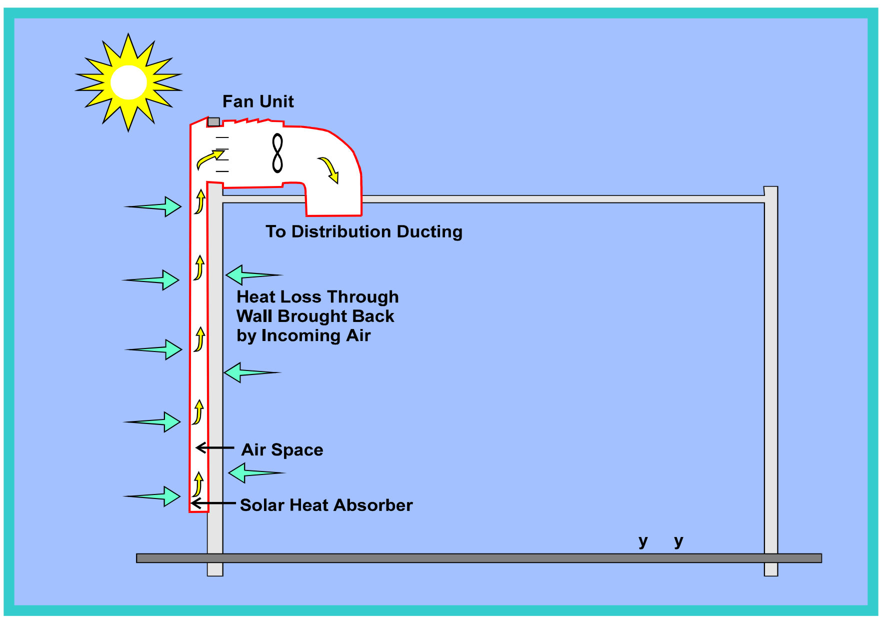

Figure 3 Solar Ventilation Air Heating

Appendix A: Energy Modeling Results for Richland High School New Gymnasium

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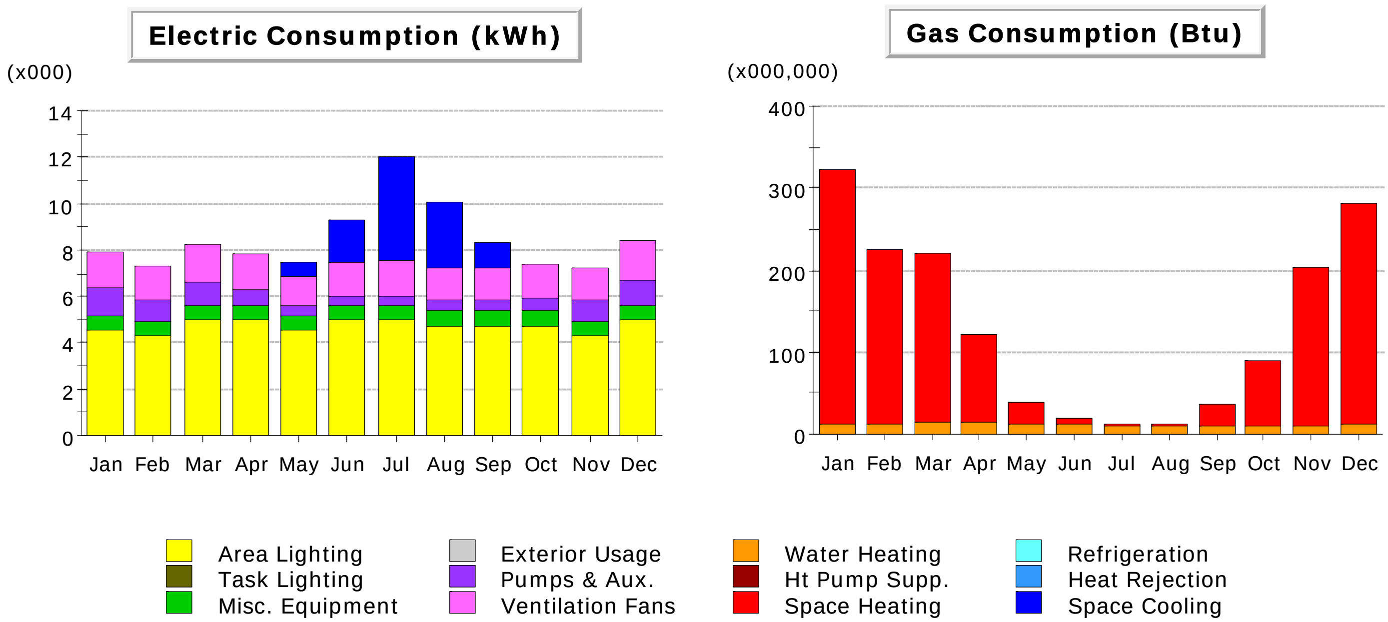
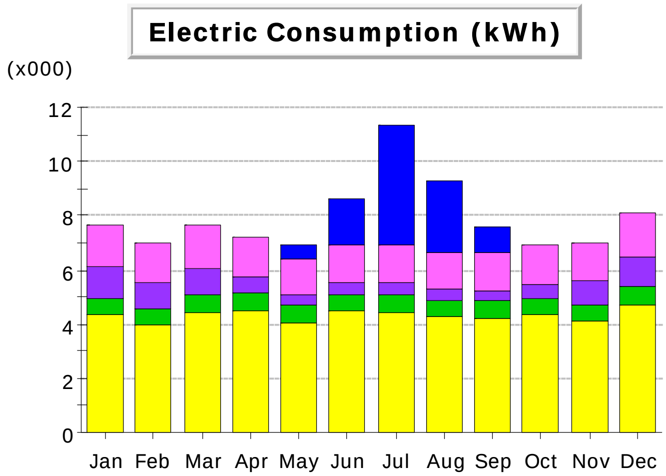


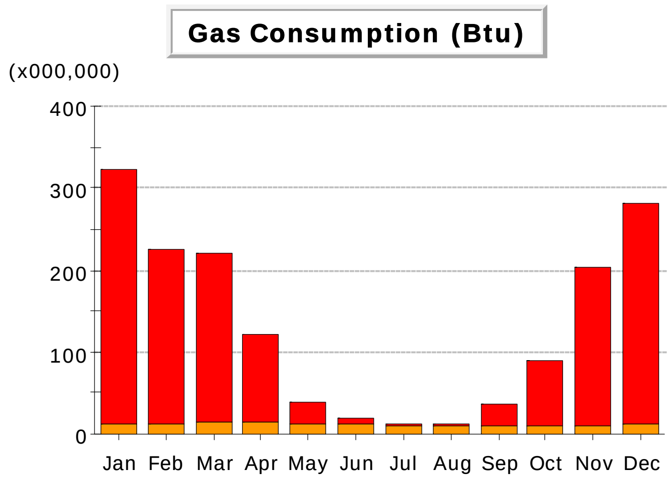
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.58	1.79	4.54	2.80	1.08	0.02	0.00	-	10.81
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	1.58	1.45	1.64	1.53	1.34	1.47	1.47	1.41	1.41	1.43	1.43	1.67	17.84
Pumps & Aux.	1.19	0.98	1.00	0.64	0.41	0.43	0.42	0.41	0.43	0.54	0.91	1.11	8.46
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.61	0.57	0.65	0.64	0.61	0.64	0.65	0.63	0.62	0.63	0.58	0.65	7.47
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	4.55	4.31	4.98	4.97	4.55	4.97	4.98	4.76	4.75	4.76	4.32	4.98	56.88
Total	7.93	7.31	8.26	7.78	7.49	9.29	12.06	10.01	8.30	7.39	7.25	8.41	101.46

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	310.8	213.0	206.1	107.3	27.0	6.9	0.5	3.1	27.1	79.2	193.5	269.2	1,443.6
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	12.1	11.8	13.7	13.4	11.4	11.6	10.8	9.9	9.9	10.4	10.1	12.4	137.6
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	322.9	224.8	219.8	120.6	38.4	18.5	11.4	13.0	37.0	89.5	203.6	281.7	1,581.2



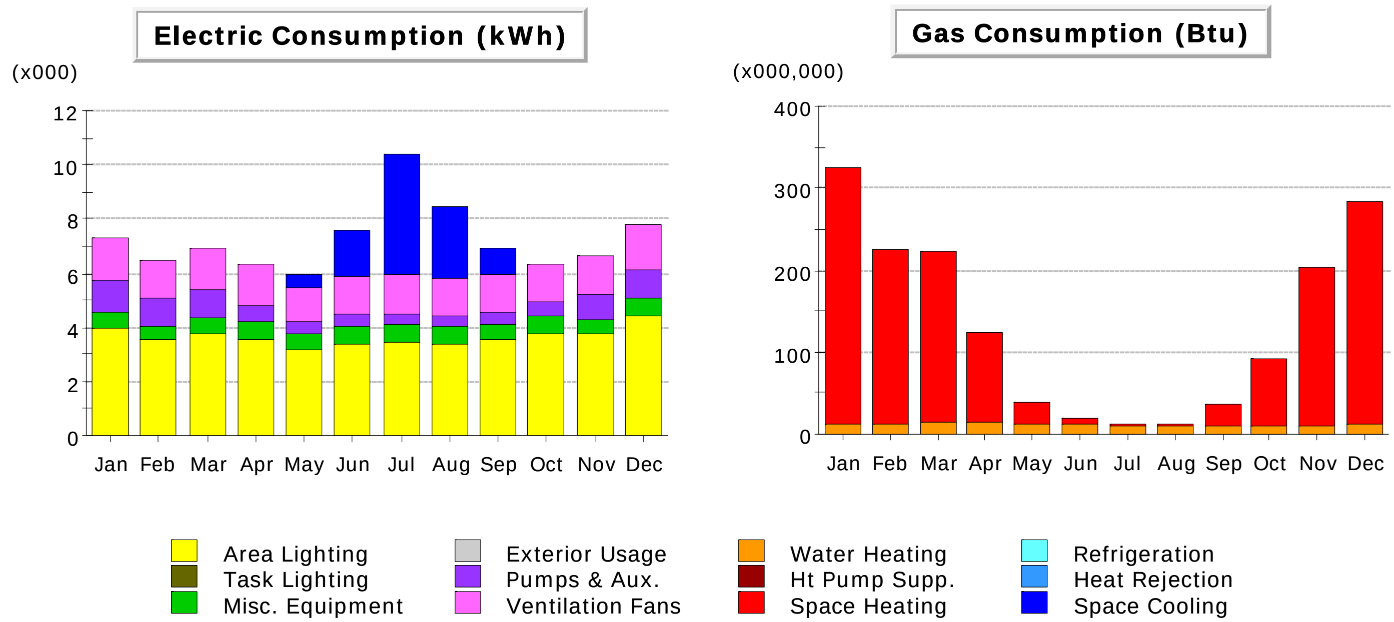


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	0.50	1.66	4.37	2.66	0.98	0.01	0.00	-	10.17
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	1.55	1.42	1.61	1.50	1.31	1.44	1.44	1.38	1.38	1.40	1.40	1.64	17.47
Pumps & Aux.	1.17	0.97	0.98	0.63	0.40	0.42	0.41	0.40	0.43	0.54	0.89	1.09	8.34
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.61	0.57	0.65	0.64	0.61	0.64	0.65	0.63	0.62	0.63	0.58	0.65	7.47
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	4.33	4.01	4.43	4.48	4.07	4.46	4.43	4.24	4.21	4.32	4.13	4.73	51.84
Total	7.66	6.97	7.67	7.25	6.90	8.61	11.31	9.30	7.61	6.90	7.01	8.11	95.28

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	310.2	213.5	207.2	108.5	27.2	6.9	0.5	3.1	27.6	80.2	193.1	269.0	1,447.1
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	12.1	11.8	13.7	13.4	11.4	11.6	10.8	9.9	9.9	10.4	10.1	12.4	137.6
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	322.3	225.3	220.8	121.9	38.6	18.5	11.3	13.0	37.6	90.6	203.3	281.4	1,584.6



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	0.49	1.66	4.43	2.68	1.00	0.01	0.00	-	10.27
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	1.55	1.42	1.60	1.49	1.31	1.44	1.44	1.37	1.37	1.40	1.40	1.64	17.42
Pumps & Aux.	1.17	0.96	0.98	0.63	0.40	0.42	0.41	0.40	0.42	0.53	0.89	1.09	8.32
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.61	0.57	0.65	0.64	0.61	0.64	0.65	0.63	0.62	0.63	0.58	0.65	7.47
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	3.96	3.51	3.72	3.54	3.15	3.41	3.46	3.40	3.53	3.77	3.72	4.40	43.59
Total	7.28	6.47	6.95	6.30	5.96	7.57	10.39	8.49	6.95	6.35	6.60	7.77	87.07

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	311.7	214.8	208.2	109.4	27.1	6.8	0.5	3.1	27.5	80.7	194.5	270.5	1,454.9
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	12.1	11.8	13.7	13.4	11.4	11.6	10.8	9.9	9.9	10.4	10.1	12.4	137.6
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	323.8	226.6	221.9	122.8	38.5	18.4	11.3	13.0	37.4	91.1	204.7	282.9	1,592.5

Date: 7/30/2004

APPENDIX B - FRESA 2.5 CLIMATE DATA FOR Richland

Site Data

Zip Code	98900
Representative City	Yakima,WA
Latitude	46.57
Census Region	4

Heating Season Data

Winter Design Temp.	8.96 F
Average Winter Temp.	43.24 F
Heating Degree Days	6,221.76 F-days
Winter Length	30.24 weeks
EIH	52.14 MBtu/1000 cfm

Cooling Season Data

Summer Design Temp.	91.04 F
Average Summer Temp.	79.33 F
Cooling Degree Hours	4,474.28 F-hr
Summer Length	12.77 weeks
EIC	17.86 MBtu/1000 cfm
Design Dew Point Temp.	57.02 F
Average Dew Point Temp	44.04 F

Solar and Wind Resource Data

Min Ave Solar	1.10 kWh/sqm-day
Max Ave Solar	7.20 kWh/sqm-day
Min Ave 1X Beam	1.40 kWh/sqm-day
Max Ave 1X Beam	7.60 kWh/sqm-day
Min 2x Beam	1.50 kWh/sqm-day
Max 2x Beam	8.10 kWh/sqm-day
Solar Offset	0.60 months
Wind Power Class	4.00

Date: 7/30/2004

APPENDIX B: SOLAR HOT WATER ANALYSIS for Richland High School Kitchen

Building Information

Building Type	Dining
Number of Similar Bldgs	1
Building Foot Print	3,840 SF
Aspect Ratio	1.33
Number of Floors	1
Total Area	46,000 SF
Weekly Operating Hours	30
Cooling Plant EER	8.0
Electricity Consumption	57,619 kWh/yr
Heating Fuel	Natural Gas
Heating Plant Efficiency	0.80
Fuel Consumption	224 MBtu/yr

FRESA 2.5 Richland High School Kitchen

Energy Conservation Measure: Solar Hot Water

User Input	Value
Water Heater Fuel Type	Natural Gas
Daily Hot Water Demand	2 gal/day-occupant
Hot Water Supply Temperature	130 F
Available Area for Panels	4000 SF
Average Building Occupancy	1000
Collector Panel Tilt	60 deg
Cost of Solar Collectors	30

Output Name	Value
Prescreen	Yes
SIR	1.410
Simple Payback	9.2
Electricity Savings	0 kWh/yr
Fuel Savings	578 MBtu/yr
Fuel Cost Savings	$4,739
Electricity Cost Savings	$0
Life Cycle Savings	$61,406
Life Cycle Cost	$43,400
Capital Cost	$43,400
Net Savings	$18,006
Max Allowable Solar Panel Area	1,380 SF
Collector Area	1,380 SF
Winter Solar Heating Capacity	433,486 kBtu/mo
Summer Solar Heating Capacity	433,486 kBtu/mo
O & M Cost	$1,302

Date: 7/30/2004

APPENDIX C: SOLAR VENTILATION PREHEAT ANALYSIS For Richland High School

Building Information

Building Type	School
Number of Similar Bldgs	1
Building Foot Print	2,400 SF
Aspect Ratio	0.74
Number of Floors	2
Total Area	4,800 SF
Weekly Operating Hours	50
Cooling Plant EER	8.0
Electricity Consumption	60,785 kWh/yr
Heating Fuel	Natural Gas
Heating Plant Efficiency	0.80
Fuel Consumption	240 MBtu/yr

FRESA 2.5 RHS McINTOCH Hall Science & Math Classrooms

Energy Conservation Measure: Solar Ventilation PreHeat

User Input	Value
Building Construction	Light
Glazing Type	Double Pane
U-Value of Wall Insulation	0.07 Btu/SF-deg-hr
Window Ratio	0.05
Ventilation Requirement	1200 cfm
Solar Collector Cost	$7 /SF

Output Name	Value
Prescreen	Yes
SIR	2.380
Simple Payback	6.9
Electricity Savings	0 kWh/yr
Fuel Savings	46 MBtu/yr
Fuel Cost Savings	$404
Electricity Cost Savings	$0
Life Cycle Savings	$6,664
Life Cycle Cost	$2,800
Capital Cost	$2,800
Net Savings	$3,864
Annual Energy Savings	584 kWh/sqm-yr
Annual Ventilation Heat Load	75.2 MBtu
Vent Load Solar Fraction	0.49
Total Annual Building Heat Load	160 MBtu/yr
Area of collector	200 SF
Annual Building Heat Load Supplied	.0 MBtu
O & M cost	$14