MAXI AUDIT

FOR THE

CITY OF BLOOMINGTON

BLOOMINGTON, MINNESOTA

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planners

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DECEMBER 1981

RCM JOB NO. 801704

Relates to 1983, ch 197 sec 5

MAXI AUDIT

OF THE

CREEKSIDE COMMUNITY CENTER

FOR

BLOOMINGTON, MINNESOTA

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Introduction

This Maxi-Audit Report is a detailed engineering analysis of the Creekside Community Center, to identify possible energy conservation measures. These items are shown along with their costs, yearly energy savings and payback times.

Summary

The Creekside Community Center was built in 1960 for use as an elementary school and has recently been adapted for use as a community activity and education center. As a result, the energy requirements have changed to lower ventilation rates, higher temperatures in some areas, less lighting in some areas and more lighting in others. Several areas are occupied for only a few hours a day, yet they are lit for the entire period the building is in use.

Item #1 on the Development Sheets recommends that a 5 HP blower be put on the time clock to meet the reduced energy requirements of the auditorium. This same principle can be applied to other areas, either on thermostats, lights or motors. The City may wish to consider the use of low speed fans (drug store style) in the high ceiling of the auditorium. This may preclude the need for the time clock.

This building has a high energy consumption per square foot of floor space, as noted in Section G on page 13. The City of Bloomington's own Energy Use Tabulations show that the building has a high electrical consumption. Many of the 40 watt fluorescent lamps have not yet been changed to 35 watt lamps.

The boiler is 3-1/3 times too large for the building's needs. It is probable that the boiler was originally installed with thoughts of a future building expansion, but current use of this building indicates that a smaller boiler could be installed and the larger one relocated to another building.

One of the water heaters is also oversized for domestic use. The heater for the dishwasher is the correct size. When replacing the domestic water heater, it is suggested that a much smaller unit be purchased. Smaller recirculator pumps would add to the economical operation of a new water heater. The daily water demand for an activity center is only a fraction of that originally planned for the elementary school.

The energy savings listed on the following page show the cost, yearly savings and simple payback for each item. Additional savings, due to reduced cooling loads, will be realized, depending on the number of hours the building is in use.

Summary (cont)

Energy Saving Items

Item	Cost	Savings	Payback Time
1. Install time clock on gym blower	$ 160.00	$ 758.16/yr	0.21 yrs
2. Insulate upper half of windows	$ 1309.83	$ 994.64/yr	1.32 yrs
3. Reroof with polystyrene insulation	$ 20560.68	$ 618.26/yr	33.26 yrs 11.60 yrs (alt)
4. Solar domestic hot water	$ 6400.00	$ 131.45/yr	48.60 yrs
5. Solar Space Heating	$256000.00	$ 2721.87/yr	94.10 yrs

Additional energy saving items were investigated, however, without a reasonable payback, they were not listed. On page 47, under Section B, "Envelope Characteristics", the "U" value for the wall is 0.41, which is high for this area. However, adding insulation to a tiled wall is too expensive to justify.

With exposed precast ceilings in the classroom area, it is not practical to use the lower-priced batt insulation (as opposed to the rigid roof insulation recommended for the roof of the building).

As a school, this building would have been a good candidate for night setback thermostats. Because it is currently used for an elderly community center, night setback thermostats do not have as good a payback time. It is suggested, however, that this be given consideration at some point in the future.

MAXI-AUDIT REPORT

A — CONTACT DATA

BUILDING NAME		NAME OF ORGANIZATION	DATE
Creekside Community Center		City of Bloomington	12/14/81
BUILDING ADDRESS		**ADDRESS**	
9801 Penn Avenue South		2215 West Old Shakopee Road	
CITY	**ZIP CODE**	**CITY**	**ZIP CODE**
Bloomington, MN	55431	Bloomington, MN	55431
PERSON COMPLETING FORM	**TELEPHONE**	**CONTACT PERSON**	**TELEPHONE**
P.R. Wilcox	(612)935-6901	Arthur Jensen	(612)881-5811

B — BUILDING ELIGIBILITY CODE

Instructions: For blocks 1 and 2 check the box which best fits the building ownership conditions. For block 3 determine which of the four categories describes the building type and then within the category check off the sub category befitting the building function.

1. OWNERSHIP TYPE
   - [X] Public (PUB)
   - [ ] Non-Profit Association (NAP)

2. ULTIMATE OWNER
   - [ ] County (CNTY)
   - [X] City (CITY)
   - [ ] Township (TOWN)
   - [ ] State (STAT)
   - [ ] Public School (PUSC)
   - [ ] Private School (PRSC)
   - [ ] Non-Profit Association (NPAP)
   - [ ] Indian Tribe (INDN)

3a. SCHOOLS
   - [ ] Elementary (SCHL-ELM)
   - [ ] Secondary (SCHL-SECD)
   - [ ] Coll. or Univ. (SCHL-POST)
   - [ ] Vocational (SCHL-VOCL)
   - [ ] Education Agency (SCHL-ADMN)
   - [ ] Administration (SCHL-ADMN)
   - [ ] OTHER (SCHL-OTHR)

b. PUBLIC CARE
   - [ ] Nursing Home (PBCR-NURS)
   - [ ] Long Term Care (PBCR-TERM)
   - [ ] Rehab. Facility (PBCR-RHAB)
   - [ ] Public Health Ctr. (PBCR-HCTR)
   - [ ] Res. Child Care Ctr. (PBCR-RCCC)

c. LOCAL GOVERNMENT
   - [ ] Office (LOCG-OFFC)
   - [ ] Storage (LOCG-STRG)
   - [X] Service (LOCG-SERV)
   - [ ] Library (LOCG-LBRY)
   - [ ] Police (LOCG-PLCE)
   - [ ] Fire (LOCG-FIRE)
   - [ ] OTHER (LOCG-OTHR)

d. HOSPITALS
   - [ ] General (HOSP-GENL)
   - [ ] Tuberculosis (HOSP-TUBR)
   - [ ] OTHER (HOSP-OTHR)

C — ENERGY REPORT CHECK-OFF

Check the type of reports which were completed prior to this maxi-audit report form.

- [X] Energy Report
  - [ ] Elementary School Energy Report (form no. ED-00444-02)
  - [ ] Secondary School Energy Report (form no. ED-00445-02)
  - [X] Existing Building Energy Report (form no. EN-00041-01)
- [X] Mini-Audit Report (form no. EN-00065-01)

If no energy report was completed before this maxi-audit report, include one with this report. Elementary school administrators should use form no. ED-00444-02. Secondary and vocational school administrators should use form no. ED-00445-02. All other building owners should use form no. EN-00041-01. All building auditors are to use the mini-audit form EN-00065-01 after completion of one of the first three above.

D — ENERGY REPORT AND MINI-AUDIT REPORT SUMMARY

Instructions: Complete this section with a summary of what was accomplished as a result of the energy report and the mini-audit report.

ENERGY REPORT:

The Energy Report (#EN-00041-01) was completed and application for the Mini-Audit was completed. Energy usage forms were established and reductions were accomplished with more economical operation.

MINI-AUDIT REPORT:

The Mini-Audit (#EN-00065-01) was completed and the Maxi-Audit application approved. Fresh air intakes were reduced, boiler settings were adjusted. Filters are serviced regularly and coils are checked.

E

Instructions: This section is to be completed and signed by a registered architect, a registered mechanical engineer, or a registered electrical engineer. This section should be completed after this maxi-audit report is completed. All blanks must be filled in.

I have reviewed the building energy report and/or the mini-audit report for this building. I found all information contained therein to be correct, to the best of my knowledge, or I have corrected any misinformation on the reports, which will be resubmitted with the maxi-audit report to the Minnesota Energy Agency

I am not directly responsible for the day-to-day operation of this building being audited.

I have fully disclosed my financial interests relating to this maxi-audit and any energy conservation measures considered by this audit.

Referring to section G, I have included an analysis that assumes all energy savings obtained from energy conservation operation and maintenance procedures have been realized.

I have calculated the total energy cost savings, by fuel type, expected to result from the acquisition and installation of all recommended energy conservation measures, taking into account the interaction among the various measures.

The energy prices used in the maxi-audit report are the current prices based on the institution's most recent purchase.

Included in the maxi-audit report is a solar analysis for: (check one or more)

- [X] a domestic hot water heating system
- [X] a space heating system
- [ ] an electrical generation system
- [ ] an attached solar greenhouse
- [ ] other: (specify)_____

I recommend that this building should not undergo a solar installation.
(should, should not)

Included in the maxi-audit report is a list of local zoning ordinances or building codes that will restrict the utilization of solar energy ☐ YES ☒ NO (A no answer indicates that there are no local zoning ordinances or building codes to my knowledge that will restrict the use of solar energy systems.)

I recommend that this building should not undergo a waste, wind, or wood installation.
(should, should not) (circle which one(s))

I hereby certify that this audit was prepared by me or under my direct supervision and all information contained herein is correct to the best of my knowledge. I am a duly registered mechanical engineer, electrical engineer, or architect under the laws of the State of Minnesota. (only one signature is required)

Architect _____	Engineer Paul Martinsen
Signature _____	Signature Paul Martinsen
Registration no. _____	Registration no. 9597
Firm _____	Firm Rieke Carroll Muller Assoc., Inc.
Address _____	Address P.O. Box 130, Hopkins, MN 55343
Phone _____	Phone (612)935-6901
Date _____	Date 12/17/81

MAX-AUDITOR STATEMENTS

F REMAINING USEFUL LIFE OF THE BUILDING

Instructions: For determining the remaining useful life of the building, list each addition of the building and describe the addition, its condition, its age, and its gross square footage. Then for the building as a whole enter the remaining useful life in years. Enter the gross floor area of the building. Some of this information can be found in the energy report.

Building Unit	Condition	Age	Sq. Ft.
Community Center	Good	21	25,241

Remaining Useful Life of the Building		Gross Floor Area of the Building	
82	Yrs	25,241	Sq. Ft.

G ESTIMATED ENERGY INDEX

Instructions: Enter the energy consumption of the building by fuel type in MMBTU's/year when the building is at optimum efficiency. Enter the energy index in MBTU's/square foot/year.

	Fuel 1	Fuel 2	Electricity	Total
MMBTU/Year	1600.21	92.48	2945.47	4638.16
MBTU/sq. ft./Yr.	63.40	3.66	116.69	183.75

NOTE: For the conversion of fuel quantity to BTU's, use the following conversion factors *for this section only.*

Electricity—11,600 BTU per kilowatt-hour
Natural gas—1,030 BTU per cubic foot
Distillate fuel oil—138,690 BTU per gallon
Residual fuel oil—149,690 BTU per gallon
Coal—24.5 million BTU per standard short ton
Liquefied petroleum gases including propane and butane—95,475 BTU per gallon
Steam—1,390 BTU per pound

The above conversion factors are stipulated in the federal requirements for the Institutional Buildings Grants Program. These source conversion factors are to be used in this section only. Conversion factors may be taken from engineering reference manuals for fuels not listed.

H

ECO REPORT SUMMARY

Instructions: Read through the list of energy conservation opportunities provided in the Maxi-Audit Manual. Upon completion of a thorough engineering and economic analysis enter all the energy conservation opportunities in this section. Enter the results of the engineering and economic analysis for each energy conservation opportunity as indicated on the "Energy Conservation Measure Development Sheet" and/or "Energy Conservation Operations and Mainenance Procedure Development Sheet" or other format in the appropriate boxes. The classification numbers, major and subclass, should be taken from the classification scheme for energy conservation opportunities. Use the fuel codes as listed. The fuel codes indicate the type and the unit of measure. If the fuel comes under OTHER convert the units of measure to MBTU and describe the fuel saved in the description. Enter yes or no in the box entitled "Funding Requested" to indicate whether funding is being applied for through the Institutional Buildings Grants Program. The "Funding Requested" and "Implementation Date" boxes are the only boxes that are not required to be filled upon completion of the maxi-audit report. See page 14 for important detailed instructions.

Electricity, kwh	10	No. 2 fuel oil, gallons	31	Street steam, Mlbs	51
Natural gas, therms	21	No. 4 fuel oil, gallons	32	Solar, hours	52
Natural gas, CCF	22	No. 5 fuel oil, gallons	33	Wind, kwh	53
Natural gas, MCF	23	No. 6 fuel oil, gallons	34	Wood, tons	54
Natural gas, CF	24	Hard coal, tons	41	Other (specify), MBTU	55
LPG, gallons	25	Soft coal, tons	42		

Fuel 1 Code	Quantity of 1 Saved Units	Fuel 1 Cost Savings $	Item No	Classification Major	Classification Sub	Description
			1	3	1	Install time clock on gym/auditorium air handler. Run only at noon meal time for one hour.
Fuel 2 Code	**Quantity of 2 Saved Units**	**Fuel 2 Cost Savings $**	**Funding Requested**	**Implem Date**		

	Total Fuel Savings MMBTU	Total Fuel Cost Savings $	Acquisition Cost $	Installation Cost $	Design Cost $	Total Modification Cost $	Simple Payback Period Yrs
TOTAL FUEL			$ 50.00	$ 110.00	-	$ 160.00	0.21
ELECT CODE	**Quantity Saved KWH**	**Elect Cost Savings $**	**Increase In O & M Cost $**	**Salvage Value $**	**Useful Life Yrs**	**Total Energy Cost Savings $**	**Alternate Payback Yrs**
10	14,040	$ 758.16			20		(optional)

Fuel 1 Code	Quantity of 1 Saved - Units	Fuel 1 Cost Savings - $	Item No	Classification Major	Classification Sub	Description
22	307,937Ft^3	$ 994.64	2	2	10	Insulate upper half of all windows with rigid urethane and reduce heat loss.
Fuel 2 Code	**Quantity of 2 Saved - Units**	**Fuel 2 Cost Savings - $**	**Funding Requested**	**Implem Date**		

	Total Fuel Savings - MMBTU	Total Fuel Cost Savings $	Acquisition Cost $	Installation Cost - $	Design Cost - $	Total Modification Cost $	Simple Payback Period - Yrs
TOTAL FUEL	307.9	$ 994.64	$ 745.23	$ 564.60	0	$ 1309.83	1.32
ELECT CODE	**Quantity Saved - KWH**	**Elect. Cost Savings - $**	**Increase In O & M Cost - $**	**Salvage Value - $**	**Useful Life - Yrs**	**Total Energy Cost Savings - $**	**Alternate Payback - Yrs**
10			0	0	50	$ 994.64	0 (optional)

Fuel 1 Code	Quantity of 1 Saved - Units	Fuel 1 Cost Savings - $	Item No	Classification Major	Classification Sub	Description
22	191,413Ft^3	$ 618.26	3	2	6	Reroof with 2" polystyrene insulation. insulation.
Fuel 2 Code	**Quantity of 2 Saved—Units**	**Fuel 2 Cost Savings—$**	**Funding Requested**	**Implem. Date**		

	Total Fuel Savings—MMBTU	Total Fuel Cost Savings $	Acquisition Cost - $	Installation Cost—$	Design Cost—$	Total Modification Cost—$	Simple Payback Period—Yrs.
TOTAL FUEL	191.4	$ 618.26	$14,441.43	$ 6119.25	0	$ 20,560.68	33.26
ELECT CODE	**Quantity Saved—KWH**	**Elect. Cost Savings—$**	**Increase In O & M Cost—$**	**Salvage Value—$**	**Useful Life—Yrs**	**Total Energy Cost Savings—$**	**Alternate Payback—Yrs.**
10			$18,112.98	0	20	$ 618.26	11.6 (optional)

Fuel 1 Code	Quantity of 1 Saved—Units	Fuel 1 Cost Savings—$	Item No.	Classification Major	Classification Sub	Description.
Fuel 2 Code	**Quantity of 2 Saved—Units**	**Fuel 2 Cost Savings—$**	**Funding Requested**	**Implem. Date**		

	Total Fuel Savings—MMBTU	Total Fuel Cost Savings $	Acquisition Cost - $	Installation Cost—$	Design Cost—$	Total Modification Cost—$	Simple Payback Period—Yrs.
TOTAL FUEL							
ELECT. CODE	**Quantity Saved—KWH**	**Elect. Cost Savings—$**	**Increase In O & M Cost—$**	**Salvage Value—$**	**Useful Life—Yrs**	**Total Energy Cost Savings—$**	**Alternate Payback—Yrs.**
10							(optional)

FUEL AND ELECTRIC CONSUMPTION REPORT

A Instructions: Enter the organization name, date, building name, building address, city, and zip code as used on the prior report, mini-audit report, and/or maxi-audit report.

CONTACT DATA

BUILDING NAME		NAME OF ORGANIZATION	DATE
Creekside Community Center		City of Bloomington	12-14/81
BUILDING ADDRESS		**ADDRESS**	
9801 Penn Avenue South		2215 West Old Shakopee Road	
CITY	**ZIP CODE**	**CITY**	**ZIP CODE**
Bloomington, MN	55431	Bloomington, MN	55431
PERSON COMPLETING FORM	**TELEPHONE**	**CONTACT PERSON**	**TELEPHONE**
P.R. Wilcox	(612)935-6901	Arthur Jensen	(612)881-5811

B Instructions: Complete this section of fuel consumption as accurately as possible. Indicate the fuel types used by the fuel code as listed. The fuel code number describes the fuel type and the units of measure.

Electricity, kwh	10	No. 6 fuel oil, gallons	34
Natural gas, therms	21	Hard coal, tons	41
Natural gas, CCF	22	Soft coal, tons	42
Natural gas, MCF	23	Street steam, Mlbs	51
Natural gas, CF	24	Solar, hours	52
LPG, gallons	25	Wind, kwh	53
No. 2 fuel oil, gallons	31	Wood, tons	54
No. 4 fuel oil, gallons	32	Other (specify), MBTU	55
No. 5 fuel oil, gallons	33		

If the fuel used comes under the heading of OTHER, enter the code number 55 and specify the fuel type. For the units of measure convert the units as stipulated from the supplier to MBTU using the conversion factors as listed in the Maxi-Audit Manual or other engineering reference text. Enter the storage capacities of each fuel type for the building. Enter the year the data is being completed for. Enter the monthly quantities used, if it is measured, and the cost corresponding with the quality used. Otherwise enter the purchased quantities and costs. If more than two fuels are used make additional copies of this form.

FUEL CONSUMPTION

		FUEL TYPE: Nat. gas.	UNIT OF MEASURE: CCF	FUEL TYPE: #2 Fuel Oil	UNIT OF MEASURE: Gal
		FUEL CODE: 22	STORAGE CAPACITY	FUEL CODE: 31	STORAGE CAPACITY
Month	Year	Quantity Used	Cost	Quantity Used	Cost
July	19 80	270	$ 91.93	666.8	$ 464.89
August	19 80	300	99.11		
September	19 80	510	149.35		
October	19 80	1,070	302.78		
November	19 80	2,200	624.57		
December	19 80	3,670	1,045.20		
January	19 81	3,110	929.60		
February	19 81	2,270	747.48		
March	19 81	1,390	474.58		
April	19 81	66	249.91		
May	19 81	370	161.69		
June	19 81	310	139.92		
Year Total		15,536	$ 5,016.12	666.8	$ 464.89

Minnesota Energy Agency
EN-00078-01 December 1979

C ELECTRICAL CONSUMPTION

Instructions: Complete this section on electrical consumption as accurately as possible. Enter the electrical utility name supplying electrical power to the building and the rate classification utilized. Enter the year that the data is being completed for. Use the same months and year for this section as were used in the fuel consumption section. Enter the electrical energy consumed in kilowatt-hours. Enter the total electric bill for each month. If the building has a demand meter, enter the maximum kilowatt demand for each month. Enter the power factor also, if it is included in the utility metering.

Utility Name: Northern States Power

Rate Classification: Commercial

Month	Year	Energy Kilowatt-Hours	Maximum Demand Kilowatts	Power Factor	Cost ($)
July	1980	31,920	150.0	91.24	$ 1505.81
August	1980	27,200	137.0	90.99	1468.20
September	1980	16,960	120.0	90.09	970.46
October	1980	17,120	120.0	95.43	901.26
November	1980	18,240	120.0	93.29	985.14
December	1980	18,320	120.0	90.90	989.10
January	1981	17,600	120.0	92.41	960.35
February	1981	16,480	120.0	92.60	923.58
March	1981	18,160	120.0	94.32	975.78
April	1981	17,280	120.0	96.00	963.31
May	1981	23,840	120.0	94.42	1278.51
June	1981	30,800	153.0	93.01	1581.25
Year Total		203,920	126.67	93.31	13057.88

Upon completion of the Fuel and Electrical Consumption Report Form mail it to:

Minnesota Energy Agency
Conservation Research and Development
Conservation Division
980 American Center Building
150 East Kellogg Boulevard
St. Paul, Minnesota 55101

Minnesota Energy Agency
EN-00078-01 December 1979

Renewable Resources Report

The most practical renewable resource area for the Creekside Community Building is solar. The building was analyzed for application of a solar collector system for both the domestic hot water system and the building heating system. The results are tabulated below.

	Domestic Hot Water	Building Heating
Cost	$ 6400.00	$ 256,000.00
Energy Savings	$ 131.45/yr	$ 2,721.87/yr
Payback Time	48.6 years	94.1 years

Based on the above data, the systems would not be practical to install, because the payback time is excessive or will probably exceed the life of the building. Also, the building has a hot water heating system which would require costly modifications to be compatible with a solar collector heating system.

SOLAR ASSISTANCE TO DOMESTIC WATER HEATING
(GIVEN DATA)

Month	D_o Work days/mo.	N_d (Days per month)	T_a (^0F)	H_t (Btu/day ft^2)
January	23	31	12.2	1124
February	21	28	15.8	1363
March	21	31	28.4	1433
April	22	30	44.6	1442
May	22	31	57.2	1475
June	21	30	66.2	1522
July	23	31	71.6	1588
August	21	31	69.8	1581
September	22	30	60.8	1519
October	23	31	50.0	1484
November	20	30	32.0	1004
December	23	31	19.4	897

T_a = monthly average ambient temperature (^oF)

H_T = daily average radiation incident on the collector surface (Btu/day ft^2)

SOLAR ASSISTANCE TO DOMESTIC WATER HEATING
(CALCULATED DATA)

Month	L_w (Btu/Month)	N_f (BTU/Ft3)	X/A ($1/ft^2$)	Y/A ($1/ft^2$)	X	Y	f	f x L_w (Btu/Month)
January	5,200,507	7212	0.03	0.004	4.8	0.64	0.30	1,560,062
February	4,748,289	6585	0.02	0.005	3.2	0.80	0.50	2,374,144
March	4,748,289	6585	0.02	0.006	3.2	0.96	0.60	2,848,973
April	4,974,398	6899	0.02	0.005	3.2	0.80	0.50	2,487,199
May	4,974,398	6899	0.02	0.005	3.2	0.80	0.50	2,487,199
June	4,748,289	6585	0.01	0.006	1.6	0.96	0.67	3,181,353
July	5,200,507	7212	0.01	0.006	1.6	0.96	0.67	3,484,339
August	4,748,289	6585	0.01	0.006	1.6	0.96	0.67	3,181,353
September	4,974,398	6899	0.02	0.005	3.2	0.80	0.50	2,487,199
October	5,200,507	7212	0.02	0.005	3.2	0.80	0.50	2,600,253
November	4,522,180	6272	0.02	0.004	3.2	0.64	0.37	1,673,206
December	5,200,507	7212	0.02	0.003	3.2	0.48	0.25	1,300,126
	59,240,558	82157						29,665,406

$$L_w = 8.33 \times N \times Z \times D_o \times (T_w - 52)$$

$$N_f = \frac{L_w}{H_f \times E_f}$$

$$X/A = 16.8 \times N_d \times (212 - T_a) \times \frac{1 + 0.006(60 - T_a)}{L_w}$$

$$Y/A = 0.59 \times H_T \times \frac{N_d}{L_w}$$

$$X = X/A \times A$$

$$Y = Y/A \times A$$

$$f = 1.029Y - 0.065X - 0.245Y^2 + 0.0018X^2 + 0.0215Y^3$$

N = No. of bldg. occupants = 156

Z = Daily water consump/occupant = 3 gal

D_o = No. of days per mo. bldg. is occupied

T_w = Water temperature (^oF) = 110°

H_f = Fuel heating value = 1030 BTU/Ft3

E_f = Avg. heating efficiency = 70%

A = Solar collector plate area = 160 Ft^2

SOLAR ASSISTANCE TO DOMESTIC WATER HEATING
COLLECTOR SYSTEM CALCULATIONS

1. System Contribution (F)

$$F = \frac{\sum f \times L_w}{\sum L_w}$$

$$= \frac{29,665,406}{59,240,558}$$

$$= .50 \text{ or } 50\%$$

2. System Cost (Cs)

$$C_s = \$40.00/Ft^2 \times \text{Area}$$

$$= \$40.00/Ft^2 \times 160\ Ft^2$$

$$= \$6,400.00$$

3. System Energy Savings (S_s)

$$S_s = F \times \sum N_f \times C_f$$

C_f = fuel cost per unit

$$= 0.50 \times 82,157\ Ft^3/yr \times \$\ 0.0032/Ft^3$$

$$= \$131.45/year$$

4. System Payback Time (t)

$$t = \frac{C_s}{S_s}$$

$$= \frac{\$6,400.00}{\$131.45/yr}$$

$$= 48.6 \text{ years}$$

SOLAR ASSISTANCE TO BUILDING HEATING
(GIVEN DATA)

Month	N_d (Days per month)	T_a (^0F)	H_t (Btu/day ft^2)	N_f (ft^3/month)
January	31	12.2	1124	329,685
February	28	15.8	1363	242,805
March	31	28.4	1433	152,356
April	30	44.6	1442	13,715
May	31	57.2	1475	40,303
June	30	66.2	1522	31,931
July	31	71.6	1588	27,250
August	31	69.8	1581	30,355
September	30	60.8	1519	53,160
October	31	50.0	1484	112,780
November	30	32.0	1004	231,618
December	31	19.4	897	383,659
				1,649,617

T_a = monthly average ambient temperature (^0F)

H_T = daily average radiation incident on the collector surface (Btu/day ft^2)

N_f = number of fuel units consumed per month (ft^3/month)

SOLAR ASSISTANCE TO BUILDING HEATING
(CALCULATED DATA)

Month	L_T (Btu/Month)	X/A $1/ft^2$	Y/A $1/ft^2$	X	Y	f	f x L_T (Btu/Month)
January	237,700,000	0.44×10^{-3}	0.09×10^{-3}	2.8	0.58	0.35	83,195,000
February	175,060,000	0.53×10^{-3}	0.12×10^{-3}	3.4	0.77	0.45	78,777,700
March	109,850,000	0.87×10^{-3}	0.24×10^{-3}	5.6	1.50	0.76	83,486,000
April	9,888,500	8.50×10^{-3}	2.60×10^{-3}	54.4	16.60	1.00	9,888,500
May	29,058,500	2.70×10^{-3}	0.93×10^{-3}	17.3	5.90	1.00	29,058,500
June	23,022,300	3.20×10^{-3}	1.20×10^{-3}	20.5	7.70	1.00	23,022,300
July	19,647,300	3.70×10^{-3}	1.50×10^{-3}	23.6	9.60	1.00	19,647,300
August	21,886,000	3.40×10^{-3}	1.30×10^{-3}	21.8	8.30	1.00	21,886,000
September	38,328,400	2.00×10^{-3}	0.70×10^{-3}	12.8	4.50	1.00	38,328,400
October	81,314,400	1.00×10^{-3}	0.33×10^{-3}	6.4	2.10	1.00	167,000,000
November	167,000,000	0.54×10^{-3}	0.11×10^{-3}	3.0	0.70	0.40	66,800,000
December	276,620,000	0.36×10^{-3}	0.06×10^{-3}	2.3	0.38	0.23	63,622,600
	1,189,375,400						599,026,700

$$L_T = N_f \times H_f \times E_f$$

H_f = fuel heating value = 3413 BTU/kWH

E_f = average furnace efficiency =

$$X/A = \frac{16.8 \times N_d \times (212 - T_a)}{L_T}$$

$$Y/A = \frac{0.59 \times H_T \times N_d}{L_T}$$

A = solar collector plate area = 6400 Ft^2

$$X = X/A \times A$$

$$Y = Y/A \times A$$

$$f = 1.029Y - 0.065X - 0.245Y^2 + 0.0018X^2 + 0.0215Y^3$$

SOLAR ASSISTANCE TO BUILDING HEATING
COLLECTOR SYSTEM CALCULATIONS

1. System Contribution (F)

$$F = \frac{\Sigma f \times L_T}{\Sigma L_T}$$

$$= \frac{599,026,700}{1,189,375,400}$$

$$= 0.50 \text{ or } 50\%$$

2. System Cost (Cs)

$$C_s = \$40.00/ft^2 \times \text{Area}$$

$$= \$40.00 ft^2 \times 6,400\ ft^2$$

$$= \$256,000.00/\text{year}$$

3. System Energy Savings (S_s)

$$S_s = F \times \Sigma N_f \times C_f$$

C_f = fuel cost per unit

$$= 0.50 \times 1,649,617\ Ft^3/yr \times \$0.60/Ft^3$$

$$= \$2,721.87/\text{year}$$

4. System Payback Time (t)

$$t = \frac{C_s}{S_s}$$

$$= \frac{\$256,000.00}{\$2,721,87/yr}$$

$$= 94.1 \text{ years}$$

ENERGY CONSERVATION MEASURE
DEVELOPMENT SHEET

Building: Creekside Community Center
9801 Penn Avenue South
Bloomington, MN 55431

Date 12/14/81
Item No. 1
Major Class 3
Sub. Class 1

Energy Conservation Measure

Description of existing equipment:

The gymnasium/auditorium was originally designed for a different purpose and is presently circulating 7830 CFM for 10 hours a day. 5 HP blower operates this area.

Description of energy conservation measure:

Install a time clock to turn on for 1 hour only at noon meal. Leave it off the rest of the time. Use during occupied time only. Ventilation system is grossly oversized for the present occupancy.

Useful life 20 years

Engineering Analysis:

Annual heating degree days 8159
Annual cooling degree days 523
Fuel 1 Elec units of Measure kWH
Fuel 2 _____ units of Measure _____

260 days x 9 hours x 5 HP x 1.2 = 14,040 kWH/year

electrical savings 14,040 kwh/year
fuel 1 savings _____ /year
fuel 2 savings _____ /year
Total Fuel Savings _____ MMBTU/Year

Economic Analysis

(1) Design cost: $ _____

(2) Acquisition cost: $ 50.00

1 - time clock

(3) Installation cost: $ 110.00

1 - electrician @ $22.00 for 5 hours

Total Modification Cost = (1) + (2) + (3): $ 160.00

Increased operation and maintenance costs: $ _____

Salvage or disposal costs: $ _____

Energy Cost Savings

Electrical and/or fuel cost savings:

14,040 kW x $0.054/kW = $758.16/year

Electrical $ 758.16 /year
fuel 1 $ _____ /year
fuel 2 $ _____ /year
Total Fuel (1 + 2) $ _____ /year

Payback Period

Simple and alternate payback period:

$$\frac{\$160.00}{\$758.16/\text{year}} = 0.21 \text{ years}$$

Simple 0.21 years
Alternate _____ years

ENERGY CONSERVATION MEASURE
DEVELOPMENT SHEET

Building: Creekside Community Center
9801 Penn Avenue South
Bloomington, MN 55431

Date 12/14/81
Item No. 2
Major Class 2
Sub. Class 10

Energy Conservation Measure

Description of existing equipment:

The largest single heat loss (and heat gain) is the windows. (See Item C, Heat Loss, 192,166 BTUH plus infiltration, 77,827 BTUH for a total of 269,993 BTUH or 46% of the total building heat loss.) The U value is 0.58 and the infiltration rate is 0.55.

Description of energy conservation measure:

The upper half of all windows can be insulated with aluminum faced 1" urethane board (R-8) which will reduce the U value to 0.12 and the infiltration rate to 0.10. The total glass area is 3765 sq. ft. of which the upper half is 1882 sq. ft. The total crackage is 1608 ft, of which the upper half is 804 ft.

Useful life 50 years

Engineering Analysis:

Annual heating degree days 8159
Annual cooling degree days 523
Fuel 1 Nat gas units of Measure CF
Fuel 2 _____ units of Measure _____

*Energy Consumption $E = \frac{H_L \times D \times 24}{\Delta t \times n \times V} \times C_D \times C_F$

H_L = Design Heat Loss (BTU/hr)
U = Heat Transfer Coefficient (BTU/hr x Ft^2 x °F)
A = Area (Ft2)
Δt = Inside/outside temp (°F)
D = Degree Days
n = Equipment Efficiency
V = Fuel Heating Value (BTU/Ft^3)
C_D = Correction Factor
C_F = Load Correction Factor

Since Energy Savings = E and $H_L = (U \times A \times \Delta t) + (1.09 \times CFM \times \Delta t)$ ie., Transmission Loss + Infiltration Loss

Then Energy Savings = $E = \left(\frac{(U \times A \times \Delta t) + (1.09 \times CFM \times \Delta t) \times D \times 24}{t \times n \times V} \right) \times C_D \times C_F$

$$E = \left(\frac{[(0.46 \times 1882 \times 68-(-20)) + (1.09 \times 0.45 \times 804 \times 68-(-20)] \times 8159 \times 24}{68-(-20) \times 0.80 \times 1000} \right) \times 0.64 \times 1.56$$

E = 307,937 Ft^3/year (gas reduction)

*Per 1976 ASHRAE Systems Handbook

electrical savings _____ kwh/year
fuel 1 savings 307,937 Ft3 /year
fuel 2 savings _____ /year
Total Fuel Savings 307.9 MMBTU/Year

Economic Analysis

(1) Design cost: $ _____

(2) Acquisition cost: $ 745.23

1882 Ft^2 + 100 Ft^2 (waste) x \$0.376 Ft^2
"Thermax" mfg. by Celotex - alum. faced both sides
Local quote

(3) Installation cost: $ 564.60

1882 Ft2 x \$0.30/Ft^2
Clips furnished by installer

Total Modification Cost = (1) + (2) + (3): $ 1309.83

Increased operation and maintenance costs: $ _____

Salvage or disposal costs: $ _____

Energy Cost Savings

Electrical and/or fuel cost savings:

$$307{,}937\ Ft^3 \times \frac{\$3.23}{1000\ Ft^3} = \$\ 994.64/year$$

Electrical $ _____ /year
fuel 1 $ 994.64 /year
fuel 2 $ _____ /year
Total Fuel (1 + 2) $ 994.64 /year

Payback Period

Simple and alternate payback period:

$$\frac{\$1309.83}{\$\ 994.64/yr} = 1.32 \text{ years}$$

Cooling load is reduced but not included in the payback.

Simple 1.32 years
Alternate _____ years

ENERGY CONSERVATION MEASURE
DEVELOPMENT SHEET

Building: Creekside Community Center
9801 Penn Avenue South
Bloomington, MN 55431

Date 12/14/81
Item No. 3
Major Class 2
Sub. Class 6

Energy Conservation Measure

Description of existing equipment:

The second largest single heat loss component of the building is the roof. 172,318 BTUH. Present roof has an "R" value of 12.81 and "U" value of 0.08. Roof is leaking moisture into the insulation.

Description of energy conservation measure:

Reroof with 2" of polystyrene insulation and reduce "U" value to 0.048. 24,477 Ft^2 of roof area. Useful life 20 years

Engineering Analysis:

Annual heating degree days 8159
Annual cooling degree days 523
Fuel 1 _____ units of Measure _____
Fuel 2 _____ units of Measure _____

* Energy Consumption = $E = \left(\frac{H_L \times D \times 24}{\Delta t \times n \times V}\right) \times C_D \times C_F$

Since Energy Savings = E and $H_L = UA\Delta t$

Then Energy Savings = $E = \left(\frac{U \times A \times \Delta t \times D \times 24}{\Delta t \times n \times V}\right) \times C_D \times C_F$

$E = \left(\frac{0.032 \times 24477 \times 68-(-20) \times 8159 \times 24}{68-(-20) \times 0.80 \times 1000}\right) \times 0.64 \times 1.56$

E = 191,413 Ft^3/year (gas reduction)

*See page 39 for symbol clarification.

electrical savings _____ kwh/year
fuel 1 savings 191,413 Ft^3 /year
fuel 2 savings _____ /year
Total Fuel Savings _____ MMBTU/Year

Economic Analysis

(1) Design cost: $ _____

(2) Acquisition cost: $ 14,441.93

$24,477\ Ft^2 \times \$0.59/Ft^2$

2" Polystyrene extruded

(3) Installation cost: $ 6,119.25

$24,477\ Ft^2 \times \$0.25/Ft^2$

Total Modification Cost = (1) + (2) + (3): $ 20,560.68

Increased operation and maintenance costs: $ 18,112.98

New asphalt roofing has to be added due to leakage. 3-ply roof (built-up)
24,477 Ft2 x $0.74 material and labor

Salvage or disposal costs: $ _____

Energy Cost Savings

Electrical and/or fuel cost savings:

$191,413\ Ft^3 \times \$3.23/1000\ Ft = \$618.26/year$

Electrical $	_____	/year
fuel 1 $	618.26	/year
fuel 2 $	_____	/year
Total Fuel (1 + 2) $	618.26	/year

Payback Period

Simple and alternate payback period:

$$\frac{\$20,560.68}{\$\ 618.26/yr} = 33.26 \text{ year (insulation only)}$$

Alternate payback based on 25% increase cost of fuel for 5 years and 10% inflation for additional years.

Simple	33.26	years
Alternate	11.60	years

Building Characteristics

A. Description

The Creekside Community Center is a twenty-year-old structure in good condition, built of concrete block and face brick. The flat roof, one-story structure, is pitch and gravel roofing on insulation over a concrete decking. The auditorium is a raised section with a 20' roof. All of the structure is built on a concrete slab on grade, except the mechanical room, which is recessed to a full basement level.

B. Envelope Characteristics

1. Wall

	"R"
Outside Air Film	0.17
4" Face Brick	0.44
8" Concrete Block	1.11
½" Glazed Tile	0.04
Inside Air Film	0.68
	2.44

"U" = 1/R = 1/2.44 = 0.41

2. Roof

Outside Air Film	0.17
Built-Up Roofing	0.33
2" Insulation	7.40
4" Concrete	0.80
Air Space	0.85
3/4" Ceiling Tile	2.70
Inside Air Film	0.61
	12.81

"U" = 1/R = 1/12.81 = 0.08

C. Building Heat Loss

Walls	0.41 x 3621 Ft^2 x 88° t =	130,646 BTUH
Roof	0.08 x24477 Ft^2 x 88° t =	172,318 BTUH
Windows	0.58 x 3765 Ft^2 x 88° t =	192,166 BTUH
Doors	1.00 x 175 Ft x 88° t =	15,400 BTUH
Infil. - Windows	0.55 x 1608 Ft x 88° t =	77,827 BTUH
Infil. - Doors	0.69 x 72 Ft x 88° t =	4,372 BTUH
		592,729 BTUH

D. Building Energy Using Systems

1. Heating

A hot water heating system supplies cabinet unit heaters in each space. The cabinet unit heaters are thermostatically controlled,

D. Building Energy Using Systems (cont.)

and through-the-wall fresh air intakes (presently closed off and insulated). The auditorium is heated and cooled with an air handler equipped with a hot water coil and chilled water coil.

2. Air Conditioning System

A compressor-condensor unit outdoors on grade cools a heat exchanger in the mechanical room, which supplies chilled water to blower/coil units in each space. Office spaces have separate window air conditioners.

3. Lighting System

Fluorescent lighting is used throughout the building with a few exceptions. The auditorium, lavatories, storage and service areas have incandescent lighting.

E. Building Energy Using Equipment

1. Boiler

Kewanee - with gas/oil combination burner
Model LW882
2460 MBH - firing rate
1969 MBG - output

2. Air Conditioning Condenser

Trane - Model RAVA-600M
60 ton unit, 440 volts

3. Air Handler

American Standard, Model 2V-15
5 HP Blower
Hot water coil and chilled water coil

4. Circulating Pumps

a. Armstrong Model 26E (chilled water)
$7\frac{1}{2}$ HP - 227 GPM

b. Bell and Gossett - Model PB-12 (H.W. Recirc)
$\frac{1}{4}$ HP

c. (2) Bell & Gossett - Model FV
$\frac{1}{4}$ HP Recirculators

d. (3) Bell & Gossett - Model 60
$\frac{1}{2}$ HP Recirculators

E. Building Energy Using Equipment (cont.)

5. Air Compressor

Honeywell Co., Model unknown
¼ HP - (for air controls only)

6. Lights

a. 2 tube, 4' fixtures, exposed tubes

b. 700W incandescent fixtures, auditorium

c. Miscellaneous incandescent, indoor and outdoor

7. Water Heaters

A.O. Smith - Model 716 - Natural gas H.R.
420,000 BTUH input
336,000 BTUH output

A.O. Smith - Model B7-365-736 - Natural Gas
365,000 BTUH input
292,000 BTUH output