2 copies

MAXI AUDIT

FOR THE

CITY OF BLOOMINGTON

BLOOMINGTON, MINNESOTA

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planners

NOVEMBER 1981

RCM JOB NO. 801704

Relates to 1983 Laws, ch 197, sec 5

MAXI AUDIT

OF THE

PUBLIC WORKS ENGINEERING

(NEW PUBLIC HEALTH BUILDING)

FOR

BLOOMINGTON, MINNESOTA

TABLE OF CONTENTS

Introduction

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

Summary

The Public Works Engineering building has just been completely remodeled and enlarged to become the Public Health Service building. The existing building for the most part, was brought up to current energy standards for new building construction. The addition of new equipment should help the efficiency of operating the facility.

The existing five zone heat-cool system and the new six zone heat-cool system gives a very deluxe space control for the intended use. It is suggested that a multi-colored floor plan layout with thermostat and zone identification be utilized by the building and operating managements. A thorough understanding of all eleven zones for winter-summer, and occupied-unoccupied times will add to efficient operation.

If all occupants understand that one single zone setting can upset the master cooling load analyzer during the summer or a single zone improperly set can reset the entire heating system; efficiencies and comfort can be accomplished. A "shakedown" period for heating and cooling should establish the best settings. Interior zones virtually don't know it's winter or summer, only lighting and occupant loads for cooling. Exterior zones should sense and offset all other load demands. There is no reason or economics to have windows open. The new equipment can be set to make use of free cooling for spring and fall if properly adjusted.

With such a thorough remodel of the building, very few energy saving items could be listed; however, these should have future energy cost projections applied.

Energy Saving Items

Item	Cost	Energy Savings	Payback Time
1. Short boiler flue	-	-	-
2. Add relief grille to vestibule	$ 40.00	$ 35.58/yr	1.12 years
3. Add outdoor boiler controller	$ 200.00	$ 149.40.yr	1.34 years
4. Add wall insulation	$ 1,384.80	$ 195.59/yr	7.08 years
5. Solar domestic hot water	$ 2,000.00	$ 42.09/yr	47.5 years
6. Solar space heating	$58,000.00	$ 740.61/yr	78 years

MAXI-AUDIT REPORT

A — CONTACT DATA

BUILDING NAME		NAME OF ORGANIZATION		DATE
Public Works Engineering		City of Bloomington		11-5-81
BUILDING ADDRESS		**ADDRESS**		
10000 Logan 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 W. 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
   - [X] Office (LOCG-OFFC)
   - [ ] Storage (LOCG-STRG)
   - [ ] 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 was reviewed by the city administrator and mini-audit was deemed necessary. Six items completed after energy report.

MINI-AUDIT REPORT:

Twenty-three of the 47 energy opportunities were completed shortly after the mini-audit. Additional items have been completed except for the higher cost items. New recordkeeping system shows reduced energy use and need for maxi-audit.

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 B. Martinsen
Registration no. _____	Registration no. 9597
Firm _____	Firm Rieke Carroll Muller Associates, Inc.
Address _____	Address P.O. Box 130, Hopkins, MN 55343
Phone _____	Phone 612/935-6901
Date _____	Date 11-5-81

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.
1960 office building		21 years	3239
1970 remodel		11 years	3239
1970 new addition		11 years	3600

Remaining Useful Life of the Building	82 Yrs	Gross Floor Area of the Building	6839 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	778.42		1425.77	2204.19
MBTU/sq. ft./Yr.	113.82		208.48	322.3

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.

Above figures based on original building before addition and remodel.

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	7	3	Short boiler flue may reduce efficiencies under windy conditions.
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 1 Code	Quantity of 1 Saved—Units	Fuel 1 Cost Savings—$	Item No	Classification Major	Classification Sub	Description
22	12,892Ft^3	$ 35.58	2	2	7	Add relief grille to north vestibules so doors will close.
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	12.89	$ 35.58	$10.00	$30.00	-	$40.00	1.12
ELECT. CODE	**Quantity Saved—KWH**	**Elect. Cost Savings—$**	**Increase In O & M Cost—$**	**Salvage Value—$**	**Useful Life—Yrs**	**Total Energy Cost Savings—$**	**Alternate Payback—Yrs.**
10			-	-	50	$35.58	(optional)

Fuel 1 Code	Quantity of 1 Saved—Units	Fuel 1 Cost Savings—$	Item No.	Classification Major	Classification Sub	Description
22	54,129.8Ft^3	$149.40	3	3	1	Add outdoor reset controller to the boiler.
Fuel 2 Code	**Quantity of 2 Saved—Units**	**Fuel 2 Cost Savings—$**	**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	54.2	$ 149.40	$100.00	$100.00	-	$200.00	1.34
ELECT. CODE	**Quantity Saved—KWH**	**Elect. Cost Savings—$**	**Increase In O & M Cost—$**	**Salvage Value—$**	**Useful Life—Yrs.**	**Total Energy Cost Savings—$**	**Alternate Payback—Yrs.**
10			-	-	25	$149.40	(optional)

Fuel 1 Code	Quantity of 1 Saved—Units	Fuel 1 Cost Savings—$	Item No.	Classification Major	Classification Sub	Description:
22	70,772Ft^3	$195.59	4	2	8	Add insulation to southwest walls that are not insulated.
Fuel 2 Code	**Quantity of 2 Saved—Units**	**Fuel 2 Cost Savings—$**	**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	70.8	$195,59	$409.25	$975.55	-	$1384.80	7.08
ELECT. CODE	**Quantity Saved—KWH**	**Elect. Cost Savings—$**	**Increase In O & M Cost—$**	**Salvage Value—$**	**Useful Life—Yrs.**	**Total Energy Cost Savings—$**	**Alternate Payback—Yrs.**
10			-	-	50	$195.59	(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
Public Works Engineering		City of Bloomington		11-5-81
BUILDING ADDRESS		ADDRESS		
10000 Logan 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 W. 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: natural gas	UNIT OF MEASURE: CCF	FUEL TYPE	UNIT OF MEASURE
		FUEL CODE: 22	STORAGE CAPACITY	FUEL CODE	STORAGE CAPACITY
Month	Year	Quantity Used	Cost	Quantity Used	Cost
July	1979	11	$ 5.55		
August	1979	11	5.65		
September	1979	431	116.72		
October	1979	281	77.49		
November	1979	679	181.59		
December	1979	274	75.66		
January	1980	1052	283.53		
February	1980	1082	300.51		
March	1980	994	275.61		
April	1980	385	108.40		
May	1980	168	49.51		
June	1980	30	11.64		
Year Total		5398	$ 1491.86		

Minnesota Energy Agency
EN-00078-01 December 1979

Above figures are for consumption for original building without addition.

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	19 79	25,520			$1144.86
August	19 79	23,480			551.48
September	19 79	11,120			494.43
October	19 79	7,760			321.65
November	19 79	6,800			264.19
December	19 79	8,040			372.03
January	19 80	7,560			367.97
February	19 80	8,760			389.45
March	19 80	6,800			348.66
April	19 80	7,240			365.18
May	19 80	7,560			371.97
June	19 80	9,440			457.71
Year Total		120,080			$5449.58

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 Public Works Engineering 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-50%	Building Heating-49%
Cost	$ 2,000.00	$ 58,000.00
Energy Savings	$ 42.09/yr	$ 740.61/yr
Payback Time	47.5 years	78 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.

SOLAR ASSISTANCE TO BUILDING HEATING
(GIVEN DATA)

Month	N_d (Days per month)	T_a (^{0}F)	H_t (Btu/day ft^2)	N_f (ft^3/month)
January	31	12.2	1124	105,200
February	28	15.8	1363	108,200
March	31	28.4	1433	99,400
April	30	44.6	1442	38,500
May	31	57.2	1475	16,800
June	30	66.2	1522	3,000
July	31	71.6	1588	1,100
August	31	69.8	1581	1,100
September	30	60.8	1519	43,100
October	31	50.0	1484	28,100
November	30	32.0	1004	67,900
December	31	19.4	897	27,400

T_a = monthly average ambient temperature (^{0}F)

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	65,013,600	1.60×10^{-3}	0.32×10^{-3}	2.32	0.46	0.30	19,504,080
February	66,867,600	1.38×10^{-3}	0.34×10^{-3}	2.00	0.49	0.32	21,397,632
March	61,429,200	1.56×10^{-3}	0.43×10^{-3}	2.26	0.62	0.41	25,185,972
April	23,793,000	3.55×10^{-3}	1.11×10^{-3}	5.15	1.61	0.83	19,748,190
May	10,382,400	7.77×10^{-3}	2.60×10^{-3}	11.27	3.77	1.00	10,382,400
June	1,854,000	39.63×10^{-3}	14.53×10^{-3}	57.46	21.07	1.00	1,854,000
July	679,800	107.56×10^{-3}	42.73×10^{-3}	155.96	61.96	1.00	679,800
August	679,800	108.94×10^{-3}	42.54×10^{-3}	157.96	61.68	1.00	679,800
September	26,635,800	2.86×10^{-3}	1.01×10^{-3}	4.15	1.46	0.81	21,574,998
October	17,365,800	4.85×10^{-3}	1.56×10^{-3}	7.03	2.26	0.93	16,150,194
November	41,962,200	2.16×10^{-3}	0.42×10^{-3}	3.13	0.61	0.37	15,526,014
December	16,933,200	5.92×10^{-3}	0.97×10^{-3}	8.58	1.41	0.61	10,329,252
	333,596,400						163,011,930

$L_T = N_f \times H_f \times E_f$

H_f = fuel heating value = 1030 BTU/ft^3

E_f = average furnace efficiency = 70%

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

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

A = solar collector plate area = 1,450 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)

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

$$= \frac{163,011,930}{333,596,400}$$

$$= 0.49 \text{ or } 49\%$$

2. System Cost (Cs)

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

$$= \$40.00ft^2 \times 1,450ft^2$$

$$= \$58,000.00$$

3. System Energy Savings (S_s)

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

C_f = fuel cost per unit

$$= .49 \times 5,398,000\ ft^3/yr \times \$.0028/ft.^3$$

$$= \$740.61/year$$

4. System Payback Time (t)

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

$$= \frac{\$580.000.00}{\$740.61/yr}$$

$$= 78.31 \text{ years}$$

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 (Ft^3/mo)	X/A ($1/ft^2$)	Y/A ($1/ft^2$)	X	Y	f	f x L_w (Btu/Month)
January	1,624,683.2	2,628.94	0.082	0.0127	4.10	0.64	0.35	568,639.12
February	1,483,406.4	2,400.33	0.079	0.0152	3.95	0.76	0.42	623,030.69
March	1,483,406.4	2,400.33	0.077	0.0177	3.85	0.89	0.52	771,371.33
April	1,554,044.8	2,514.64	0.059	0.0170	2.95	0.85	0.55	854,724.64
May	1,554,044.8	2,514.64	0.053	0.0173	2.65	0.87	0.58	901,345.98
June	1,483,406.4	2,400.64	0.048	0.0182	2.40	0.91	0.60	890,043.84
July	1,624,683.2	2,628.94	0.042	0.0179	2.10	0.90	0.61	991,056.75
August	1,483,406.4	2,400.33	0.047	0.0195	2.35	0.98	0.66	979,048.22
September	1,554,044.8	2,514.64	0.049	0.0173	2.45	0.87	0.57	885,805.54
October	1,624,683.2	2,628.94	0.055	0.0167	2.75	0.84	0.53	861,082.10
November	1,412,768.0	2,400.33	0.075	0.0126	3.75	0.63	0.34	480,341.12
December	1,624,683.2	2,628.94	0.077	0.0101	3.85	0.51	0.25	406,170.80
	18,507,261	30,061.33						9,212,660.10

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

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

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

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

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

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

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

N = No. of bldg. occupants = 80

Z = Daily water consump/occupant = 2 gal

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

T_w = Water temperature (^oF) = 105^o

H_f = Fuel heating value = 1030 BTU/Ft^3

E_f = Avg. heating efficiency = 60%

A = Solar collector plate area = 50 Ft2

SOLAR ASSISTANCE TO DOMESTIC WATER HEATING
COLLECTOR SYSTEM CALCULATIONS

1. System Contribution (F)

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

$$= \frac{9,212,660.1}{18,507,261}$$

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

2. System Cost (Cs)

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

$$= \$40.00/Ft^2 \times 50\ Ft^2$$

$$= \$2,000.00$$

3. System Energy Savings (S_s)

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

C_f = fuel cost per unit

$$= .50 \times 30,061.33\ Ft^3/yr \times \$\ 0.0028/Ft^3$$

$$= \$42.09/\text{year}$$

4. System Payback Time (t)

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

$$= \frac{\$2,000.00}{\$42.09/yr}$$

$$= 47.52 \text{ years}$$

ENERGY CONSERVATION OPERATIONS AND MAINTENANCE
PROCEDURE DEVELOPMENT SHEET

Building: Public Works Engineering
10000 Logan Avenue South
Bloomington, MN 55431

Date 11-5-81
Item No. 1
Major Class 7
Sub. Class. 3

Energy Conservation Operation and Maintenance Procedure

Description of existing condition:

Boiler and water heater flue extends only 3 ft above the flat roof. It appears marginal for minimum draft conditions when only the water heater is running on windy days. Inlet fresh air is also ceiling mounted which may cause a back draft condition.

Description of O & M procedure:

Flue gas back drafts may occur on windy days and reduce boiler and water heater efficiencies. Flue pipe extension may be needed. Boiler has two stage gas valve and should be tested on both stages. Burner is atmospheric combustion.

Estimated energy savings:

Depends on boiler efficiency tests under windy conditions.

Estimated energy cost savings:

It's not so much cost savings as occupant health.

Estimated change of maintenance and operation costs:

none

Date of implementation:

ENERGY CONSERVATION MEASURE
DEVELOPMENT SHEET

Building: Public Works Engineering
10000 Logan Avenue South
Bloomington, MN 55431

Date 11-5-81
Item No. 2
Major Class 2
Sub. Class 7

Energy Conservation Measure

Description of existing equipment:

The north vestibule (room 119) has weatherstripped inner and outer doors with an air tight space. Opening one door forces the other open.

Description of energy conservation measure:

Install a relief grille above the inner door to the inside and reduce the infiltration of the outer door from 3.2 CFM/ft of crack to 1 CFM/ ft of crack.

Useful life 50 years

Engineering Analysis:

(Per 1976 ASHRAE Systems Handbook)

H_L = Design Heat Loss (Btu/hr)
U = Heat Transfer Coeff. (Btu/hrxFt^2x^oF)
A = Area (Ft^2)
Δt = Inside-outside temp (^oF)
D = Degree Days
η = Equipment Efficiency
V = Fuel Heating Value (Btu/Ft^3)
C_D = Correction Factor
C_F = Load Correction Factor

Annual heating degree days 8159
Annual cooling degree days _____
Fuel 1 natural gas units of Measure CCF
Fuel 2 _____ units of Measure _____

Heat Loss = $H_L = 1.09 \times CFM/ft \times ft \times \Delta t$

$$\text{Energy savings} = E = \left(\frac{H_L \times D \times 24}{\Delta t \times \eta \times V}\right) C_D \times C_F$$

$$\Delta E = \left(\frac{(1.09 \times 2.2 \times 22 \times (70-(-15)) \times 8159 \times 24}{70-(-15) \times 0.80 \times 1000}\right) 0.64 \times 1.56$$

ΔE = 12,892 Ft^3/yr

electrical savings 0 kwh/year
fuel 1 savings 12,892 Ft^3 /year
fuel 2 savings 0 /year
Total Fuel Savings 12.89 MMBTU/Year

Economic Analysis

(1) Design cost: $ 0

(2) Acquisition cost: $ 10.00

1 - Relief grille

(3) Installation cost: $ 30.00

1 man - 2hrs

Total Modification Cost = (1) + (2) + (3): $ 40.00

Increased operation and maintenance costs: $ 0

Salvage or disposal costs: $ 0

Energy Cost Savings

Electrical and/or fuel cost savings:

$$12{,}892\ Ft^3 \times \frac{\$2.76}{1000Ft^3} = \$35.58/year$$

Electrical $ 0 /year
fuel 1 $ 35.58 /year
fuel 2 $ 0 /year
Total Fuel (1 + 2) $ 35.58 /year

Payback Period

Simple and alternate payback period:

$$\frac{\$\ 40.00}{\$\ 35.58/year} = 1.12\ years$$

Simple 1.12 years
Alternate _____ years

Economic Analysis

(1) Design cost: $ 0

(2) Acquisition cost: $ 100.00

1-outdoor controller (T-475A)
Honeywell

(3) Installation cost: $ 100.00

1 electrician - 4 hrs

Total Modification Cost = (1) + (2) + (3): $ 200.00

Increased operation and maintenance costs: $ 0

Salvage or disposal costs: $ 0

Energy Cost Savings

Electrical and/or fuel cost savings:

$$54{,}129.8\ Ft^3 \times \frac{\$2.76}{1000\ Ft^3} = \$149.40/year$$

Electrical $ 0 /year
fuel 1 $ 149.40 /year
fuel 2 $ 0 /year
Total Fuel (1 + 2) $ 140.40 /year

Payback Period

Simple and alternate payback period:

$$\frac{\$\ 200.00}{\$\ 149.40/year} = 1.34\ years$$

Simple 1.34 years
Alternate _____ years

ENERGY CONSERVATION MEASURE
DEVELOPMENT SHEET

Building: Public Works Engineering
10000 Logan Avenue South
Bloomington, MN 55431

Date 11-5-81
Item No. 4
Major Class 2
Sub. Class 8

Energy Conservation Measure

Description of existing equipment:

Brick-concrete block walls have no insulation and have an overall "R" value of 2.40 or a "U" value of 0.42.

Description of energy conservation measure:

Add 1½" of styrofoam insulation to the interior surfaces of the wall to decrease the overall "U" value from 0.42 to 0.10. This includes furring the walls, attaching the insulation and covering with ½" sheetrock. This will reduce the heat loss through the wall.

Useful life 50 years

Engineering Analysis:

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

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

Since energy savings = $\Delta E \& H_L = UA\Delta t$

Then energy savings = $\Delta E = \left(\frac{\Delta U \times A \times \Delta t \times D \times 24}{\Delta t \times \eta \times V}\right) \times C_D \times C_F$

$\Delta E = \left(\frac{0.32 \times 905 \times 68-(-14) \times 8159 \times 24}{68-(-14) \times 0.80 \times 1000}\right) \times 0.64 \times 1.56$

$\Delta E = 79{,}772\ Ft^3/year$

*see page 35 for symbol clarification.

electrical savings 0 kwh/year
fuel 1 savings 70,772 Ft^3 /year
fuel 2 savings 0 /year
Total Fuel Savings 70.8 MMBTU/Year

Economic Analysis

(1) Design cost: $ 0

(2) Acquisition cost: $ 409.25

*Furring	930 Ft_2 x $0.08/$Ft_2$	= $ 74.40
Insulation	905 Ft^2 x $0.20/$Ft^2$	= $ 181.00
Sheetrock	905 Ft^2 x $0.17/$Ft^2$	= $ 153.85

(3) Installation cost: $ 975.55

*Furring	930 Ft_2 x $0.65/$Ft_2$	= $604.50
Insulation	905 Ft^2 x $0.23/$Ft^2$	= $ 208.15
Sheetrock	905 Ft^2 x $0.18/$Ft^2$	= $ 162.90

Total Modification Cost = (1) + (2) + (3): $ 1384.80

Increased operation and maintenance costs: $ 0

Salvage or disposal costs: $ 0

Energy Cost Savings

Electrical and/or fuel cost savings:

Gas: $\frac{70{,}772\ Ft^3}{year} \times \frac{\$2.76}{1000Ft^3} = \$195.59/year$

Electrical $ 0 /year
fuel 1 $ 195.59 /year
fuel 2 $ 0 /year
Total Fuel (1 + 2) $ 195.59 /year

Payback Period

Simple and alternate payback period:

$\frac{\$1384.80}{\$\ 195.59/year} = 7.08$ years

*Costs from 1981 Means Building Construction Cost Data - including overhead and profit.

Simple 7.08 years
Alternate _____ years

Building Characteristics

A. Description

The Public Works Engineering building was built in 1960 with additional building space in 1970. Primary use is office space with small amount of storage space.

B. Envelope Characteristics

1. Walls(insulated)

	"R"
Outside Air Film	0.17
4" Face Brick	0.44
1¼" Rigid Insulation	4.63
8" Concrete Block	0.64
Inside Air Film	0.68
	6.56

U = 1/6.56 = 0.15

2. Walls(uninsulated)

Outside Air Film	0.17
4" Face Brick	0.44
¼" Air Space	0.00
8" Concrete Block	1.11
Inside Air Film	0.68
	2.40

U = 1/2.40 = 0.42

3. Roof

Outside Air Film	0.17
Built-up Roofing	0.33
3" Rigid Insulation(urethane)	12.51
10" Concrete Pre-stressed	0.60
Air Space	0.85
5/8" Acoustic Ceiling	1.40
Inside Air Film	0.61
	16.47

U = 1/16.47 = 0.06

C. Building Heat Loss

Walls - insulated	0.15 x 2160 Ft^2 x $82^{o}\Delta t$	=	26,568 BTUH
Walls - uninsulated	0.42 x 905 Ft^2 x $82^{o}\Delta t$	=	31,168 BTUH
Glass & Doors	0.55 x 432 Ft^2 x $82^{o}\Delta t$	=	19,482 BTUH
Roof	0.06 x 9323 Ft^2 x $82^{o}\Delta t$	=	45,869 BTUH
Edge Loss	95 x 412 Ft	=	18,540 BTUH
Infil.-windows	0.89 x 427 Ft x $82^{o}\Delta t$	=	31,162 BTUH
Infil.-doors	0.98 x 110 Ft x $82^{o}\Delta t$	=	8,840 BTUH
			181,630 BTUH

D. Energy Using Systems

1. Heating

There is a combination heat-cool warm air gas fired furnace with baseboard heat-cool supplies. Fresh air intakes are on each unit.

2. Ventilation

Exhaust units for continuous use while occupied mounted on the roof.

3. Lighting System

Fluorescent lighting with high efficiency ballasts for most of the lighting. Outside lighting on light sensors.

E. Building Equipment

1. Furance - horizontal
Tjernlund - 5 zone heat-cool decks
400,000 BTUH input gas max
120,000 BTUH input minimum

2. Air Handler
Trane Climate Changer - Blow Three
Model CC88128D-180
6 zone heat-cool
5HP blower - 208 volts/3 phase/60 HZ

3. Condensing Units
Trane condensing unit
Model RAS-103A
(2) compressors - F.L.A. 24.3
(2) cond. fans - F.L.A. 2.3 - 1/3HP each

E. Building Equipment (continued)

4. Condensing Units
   Trane condensing unit
   Model RAUC-C156A
   (2) compressors - F.L.A. - 27.1
   (2) cond. fans - 3/4 H.P. each

5. Boiler
   Ajax - hot water/natural gas
   Model WG
   250,000 BTUH input
   200,000 BTUH output

6. Water Heater
   Lockinvar - natural gas
   Model ETN
   40 gallon capacity
   35,000 BTUH input

7. Electric Wall Heaters
   Berko (North entry)
   Model FFR-024A
   3kW

   Berke (East hallway)
   Model FFR-2024A
   2kW