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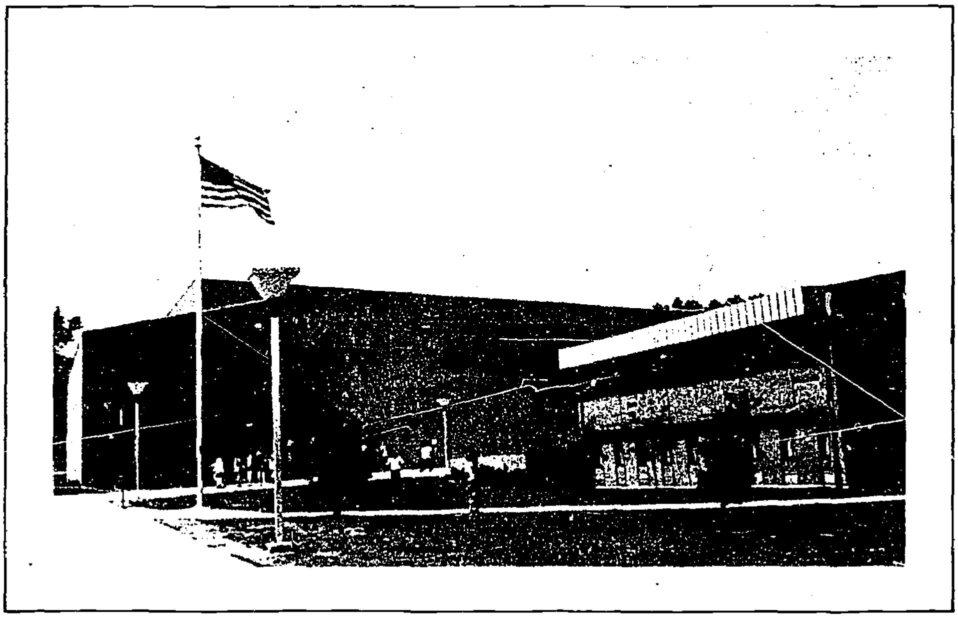
ABSTRACT

This document analyzes the causes of a discrepancy between expected electric costs of $19,460 annually based on full occupancy and usage, compared with a 1972 total billing of $49,819, and the fear of a 1974 $53,000 electric bill. A review was made of detailed proposals for 1967 and 1968 submitted to the building commettee to guide them in reaching a decision about selecting a hydronic system fueled with gas and oil or an all electric system at Mansfield Middle School in Spring Hill, Connecticut. The report explains how, in calculating the expected usage of fuel, certain inaccuracies crept into the equations and points up the value of making an economic comparison of alternate heating systems by estimating both the initial construction costs and the annual operating costs. Had the error in calculations been discovered earlier, the estimated costs between electric and hydronic systems would have reflected a $6,000 greater cost factor for the electic than for the hydronic system. It is hoped that the facts reported about this school will serve as a guide for school boards and building committees in their efforts to evaluate proposals for competing school comfort systems. (Author/MLF)

BUILDING COMMITTEE DECISIONS

Case history:

The All-Electric School



Mansfield Middle School 1968 - 1973

Better Heating-Cooling Council

35 Russo Place, Berkeley Heights
New Jersey 07922

D/173

1973

FINAL NOTICE

PLEASE, BOSS...
DON'T FIRE ME!

To serve you well I've done my best,
I've worked both night and day.
I'm not complaining, this I like —
But I need my monthly pay.

Unless your payment is received by May 22-1970

Your service may be discontinued without further notice.

If you have already paid, thank you—and please ignore this notice. Reddy Kilowatt

MANSFIELD MIDDLE SCHOOL

Spring Hill
Connecticut

"Yes, we often get those notices," reported the Assistant Superintendent of Schools at Mansfield Center, Conn., when asked about the 'Final Notice' threatening to cut off their electricity. "The bills have been staggering, and we're a little behind, but so far the electric company hasn't shut it off."

In reviewing the monthly bills for the electrically heated Mansfield Middle School it becomes apparent why each month's bill comes as a shock to the administration, and why they are considering additional expenditures of several thousand dollars for equipment which promises to reduce the cost of electricity.

Considering that the annual budget for electricity is being increased from $38,000 to $53,000 in the fourth year, after an original estimate for total electric bills of $19,460, school officials feel that something must be done to reverse that trend. In the meanwhile it would be illuminating to other school authorities to learn how to avoid such a trying situation.

A recap of annual electric operating costs is shown in Table 1, together with the Kilowatthour usage, and the Degree Days for that area. Degree Days (DD) are the official measure of the duration and severity of winter weather. Those listed here were officially recorded at the U.S. Meterological Station located at the University of Connecticut, Storrs, Conn., two miles from the Mansfield Middle School.

Table 1. ANNUAL TOTALS

Calendar Year	DD	% Change	KWH	% Change	$ Billed	% Change
1970	6752		1,846,080		30,889.	
		-3.4		+ 3.0		+17.9
1971	6523		1,902,240		36,416.	
		+3.7		+19.5		+36.8
1972	6762		2,272,320		49,819.	
1970 vs1972		+0.1		+23.1		+61.3

Degree Day totals, compiled and published by the U.S. Weather Bureau, serve as a realistic base for estimating energy usage for heating, using the normal Degree Days for that locality, which in the case of Storrs, Conn. is listed as 6578 for a typical heating season. (This can be compared with cities such as: Hartford - 6235; Pittsfield - 7578; Detroit - 6232; Albany - 6875; Toledo - 6500.)

The increase or decrease of actual DD, when compared with the normal, may be used as a reliable explanation for the consumption of more or less energy during the heating season. Thus, in Table 1 the total actual DD for 1970 was 2.6% greater than normal for the calendar year. For 1971 there was a decrease of 3.4% from the previous year, and for 1972 an increase of 3.7%.

Comparing these actual weather changes for the three calendar years for which full data is available, the usage of electricity increased 23.1% during that period, and the cost of electricity billed by the utility company increased 61.3%.

Table 2. SIX-MONTH TOTALS
(October to March = 83% of Annual Heating Requirements)

6 Months	DD	% Change	KWH	% Change	$ Billed	% Change
1969-70	5758		1,219,680		20,328.	
		-2.4		+22.6		+28.9
1970-71	5617		1,494,720		26,213.	
		-6.1		+ 6.8		+24.9
1971-72	5272		1,596,960		32,731.	
		+4.5		- 9.4		+ 9.1
1972-73	5511		1,445,760		35,713.	
69-70 vs72-73		-4.3		+18.5		+75.7

In October 1972 the special rate for electrically-heated schools was rescinded by the Connecticut Light & Power Co. As data now available ends with March 1973, a comparison was made in Table 2 on the basis of the last 6-month heating period to determine the specific effects of the higher rate now in effect. For this period which reflects approximately 83% of the year's normal heating requirements, it was found that the DD during this 72-73 period had increased 4.5% over the similar period of the previous year, while the Kilowatt hours had decreased 9.4%, and the total billing for the six months had increased 9.1%. A month-by-month analysis of actual bills (Table 3) will lead to the explanation for this unexpected variation. (See Page 4.)

The question arises as to the discrepancy between the expected electric costs of $19,460 annually based on full occupancy and usage, compared with the 1972 total billing of $49,819, and the fear of a $53,000 electric bill this coming year. Analysis of the causes for such remarkable discrepancies may be helpful to other school officials in their efforts to evaluate proposals for competing school comfort systems. The fact that electric rates "increased" is not sufficient justification.

Origins of Operating-Cost Estimate

To determine the origin of the discrepancy for this 100,300 square foot school designed for 900 students, it will be necessary to review the detailed proposals of 1967 and early 1968 submitted to the building committee to guide them in reaching a decision. Table 4 is the final tabulation of estimated annual costs submitted on January 8, 1968 as the basis for selecting the appropriate heating system for this school, comparing a Hydronic system fueled with gas and oil, with "all-electric".

Table 4. Owning and Operating Costs (estimated in 1968)

	Hydronic	All-Electric
Fuel Cost for Heating and Hot Water	$ 5,628	
Electric for Burners & Heating Pumps	1,600	
Light & Power General Use	8,400	4,460
Electricity for Heat & Hot Water		15,000
Fixed Charges($44,500 @3% @20 Years)Annual	4,040	
Depreciation - Net Increment Differential	900	
Operating Labor & Matl., Increment Addn.	1,056	
Annual Maint. & Repair, Increment Addn.	800	
Boiler Insurance, Increment Addition	250	
Total Annual Owning & Operating Cost	$ 22,674	$ 19,416 (sic)
Net Difference	($ 3,258)	

Table 3

	DEGREE-DAYS AT STORRS, CONN.					
		ACTUAL				
	Norm.	1969	1970	1971	1972	1973
January	1203		1441	1380	1147	1100
February	1070		1063	1061	1112	1070
March	955		977	955	987	E. 955
April	588		571	625	693	
May	273		258	304	226	
June	63		78	59	89	
July	0		5	4	6	
August	34		2	26	-	
September	141	126	136	83	116	
October	415	401	378	269	540	
November	723	708	657	780	804	
December	1113	1168	1186	977	1042	
TOTAL	6578		6752	6523	6762	

	KILOWATT HOURS BILLED TO MANSFIELD MIDDLE SCHOOL				
	1969	1970	1971	1972	1973
January		256,320	331,200	357,120	240,480
February		283,680	264,960[1]	319,680	264,960[3]
March		252,000	211,680	239,040	182,880[4]
April		100,800	144,000	190,080	
May		69,120	77,760	131,040	
June		40,320[1]	31,680	56,160	
July		24,480	34,560	40,320[1]	
August		E. 40,320	40,320[1]	57,600	
September	1,440	92,160	84,960	123,840	
October	73,440	152,640	126,720[6]	182,880[2]	
November	126,720[6]	204,480	280,800	273,600[7]	
December	227,520	329,760	273,600[2]	300,960	
TOTAL		1,846,080	1,902,240	2,272,320	

	$ MONTHLY BILLING TO MANSFIELD MIDDLE SCHOOL				
	1969	1970	1971	1972	1973
January		4,272.	5,942.	7,231.	5,966.
February		4,728.	4,906.	6,563.	6,694.
March		4,200.	3,917.	5,029.	4,685.
April		1,680.	2,636.	3,967.	
May		1,152.	1,401.	2,766.	
June		672.	571.	1,179.	
July		408.	652.	856.	
August		E. 793.	793.	1,223.	
September	24.	1,536.	1,690.	2,637.	
October	1,224.	2,544.	2,525.	4,322.	
November	2,112.	3,408.	5,851.	6,633.	
December	3,792.	5,496.	5,532.	7,413.	
TOTAL		$30,889.	$36,416.	$49,819.	

E = ESTIMATED

Although there are many items in the first column which do not appear in the second column, such as incremental costs for both "Operating Labor & Material" and "Annual Maintenance and Repair", the item of "Fixed Charges" stands out. This $4,040 additional cost in the first column increases the estimate just enough to swing the advantage to "All Electric", so it would be well to find its origin. This is based on the annual interest for a presumed $44,500, estimated as the higher cost of the hydronic system. (See Table 9.)

However, at 43 schools in all parts of the country, where actual bids were requested simultaneously for each school, with alternate bids for two heating systems, hydronic vs. electric, there was no significant difference found in first cost. (See School Heating Facts 167-8) In the case of the Mansfield School, unfortunately, no alternate bids were requested, so the $44,500 difference is merely an estimate upon which the $4,040 annual advantage is built.

It should be noted that all energy in the first column (first 3 items) totals $15,628, compared with the "all Electric" total of $19,460. It will be necessary, considering the excessive actual expense being encountered, to examine these dollars in detail. When all calculations are corrected it will be found that the estimated energy for the oil-fired hydronic system should total $15,485 and the electricity for the "all electric " system totals $28,880.

In calculating the expected usage of fuel, certain inaccuracies crept into the equations. One standard method makes use of the Normal Degree Days for the area, but in this case a figure of 6100 was used, the former norm for Hartford, Conn., rather than 6578, normal for Mansfield, thereby underestimating by 7%. Although this incorrect figure was applied to both the hydronic and the electric equations, and percentage-wise would have the same effect on both, the under-estimate would be more favorable to the more expensive type of energy, because the dollar difference between the two would be minimized.

The Feasibility Study

In making an economic comparison of alternate heating systems it is necessary to estimate both the initial construction costs and the annual operating costs. An important component of the latter is the estimate of energy to be used -- for heating, for domestic hot water, and for general light and power. For comfort heating in this case the heat loss was calculated both with normal insulation and with the "special" insulation recommended by utility companies in order to keep electric bills low. Because of the mistakes made in the calculations (Table 5) it is necessary to review some of the figures and make appropriate corrections.

There are two quantities comprising the heat loss: the outward transmission of heat through the walls, windows and ceiling, and the heating of ventilation air as it comes into the building. Unlike a home, a school is generally unoccupied for many hours during the night, and with the thermostats automatically "set back" to about 60° at night, there is less heat lost through transmission outward.

Table 5. Heating Load Summary (Original)

	Normal Insulation	Special Insulation
Transmission, Btu/hr @70° T.D.	2,160,000	1,212,000
Ventilation Air Btu/hr	1,758,600	1,758,600
Net Heat Load, Occupied	3,918,600	2,970,600
Transmission, Btu/hr @60° T.D.	1,850,000	945,000(?)
Infiltration Air, Btu/hr	545,000	245,000(?)
Net Heat Load, Unoccupied	2,395,000	1,290,000(?)

For normal insulation the hourly transmission figure of 1,850,000 in the original summary is correct for the "unoccupied" heat loss (60°/70° of 2,160,000), but for that item under Special Insulation there is an error; based on the 6/7 ratio the transmission should be 1,040,000 Btu per hour, rather than 945,000, a difference of about 10%.

The figures for air heating while the ventialtion fans are operating is correct. However, the Btu's for the air infiltrating at night is shown as 545,000 for a normal building, and 245,000 for one with electric insulation. As there would be no difference in such figures this is evidently a typographical error, and the total for the unoccupied period, with both those mistakes corrected, should be 1,585,000 Btu/hr instead of 1,190,000 (listed incorrectly in the total as 1,290,000). Table 6 shows the corrected tabulation of the heating totals.

Table 6. Heating Load Summary (Corrected)

	Normal Insulation	Special Insulation
Net Heat Load, Occupied, Btu/hr	3,918,600	2,970,600
Net Heat Load, Unoccupied "	2,395,000	1,585,000

During time of occupancy there is also a heat gain -- from lights and body heat of the occupants. For accuracy in determining the expected energy usage, this heat gain is subtracted, in this case 237,400 Btu subtracted from the occupied figure in both columns, giving a net of 3,681,200 and 2,733,200 Btu/hr respectively.

(It is regrettable that this analysis must itemize so many details, but the explanations may serve as a guide to the reader when faced with similar problems and decisions. As pointed out in the original study, " . . . projecting fuel costs is at best risky and can easily be wrong.")

Light and Power, General Use

In the list of operating costs (Table 4) electricity for oil burners and heating pumps is shown as $1,600, and for Light & Power as $8,400, for a total of $10,000. This is based on an estimate of 10¢ per sq.ft. of building, arrived at from the figures of 19 other schools hydronically heated.

Although actual light & power bills of a full high school in Hampshire, Mass., with vocational shops etc., is running 8.1¢ per square foot per year, there is no way to fault the figure provided in the above estimate, as the Mansfield School actually has only one meter for all electricity and there is no way to separate the heating cost from the other uses.

However, it will be noted above that the Light & Power estimate under "All Electric" is about half that for the Hydronic school. This is based on the promise that miscellaneous uses of electricity will be billed at the special electric heat rate; otherwise, if the school uses other fuels the utility company will charge the full rate for electricity, in this case estimated as double the electric heat rate. It can readily be seen that the higher the estimate for "other uses of electric" the greater will be the difference between the two columns. (See "Grinding a Fine Edge", School Heating Facts #167-11.)

Calculating Heating Costs

Using the corrected heat loss figures and the corrected Degree Days, a reliable comparison of operating costs should be obtainable. There is one caution: Different equations and different factors are used in estimating natural fuel vs. electricity.

The Degree Day method suggested by the ASHRAE Guide (American Society of Heating, Refrigeration and Air Conditioning Engineers) for residential estimating, and used in calculating oil and gas usage for this school, comes out with different answers than the NEMA Residential Method (National Electrical Manufacturers Association) used by the electric utility companies in estimating electric heat usage. In a study reported by Prof. W. S. Harris and his staff at the University of Illinois in July 1965, it was found that the Degree Day method consistently overestimated fuel consumption by 13%, while the NEMA method underestimated electric heat energy by 12.6%. This was based on detailed analysis of actual fuel consumption of 170 homes in 6 widely-scattered cities. (See HVAC data file #1.)

A uniformly accurate but highly complicated equation was recommended by Prof. Harris for estimating home energy usage, but has not been tested for reliability in other types of buildings.

Another complicated equation, this one suitable for small commercial buildings with night set-back, was recommended to the Electric Council of New England at their electric heat seminar in September 1964. It is currently being used internally by some utility companies, and is claimed to be highly accurate, but as it is based on electric heat efficiencies of less than 100%, as shown in the following table, it is not generally publicized.

Type of Electric Heating System (Residential & Small Commercial)	Utilization Efficiency
Electric Furnace	74% - 84%
Electric Fan Units	90% - 100%
Ceiling Heating Wires	79% - 90%
Electric Glass Panels	68% - 79%
Electric Resistance Baseboard	90% - 100%
Electric Storage Heat	58% - 68%

We will presently get into the corrected calculation of energy usage for the Mansfield Middle School, but one more word of caution -- the NEMA equation for electric heat contains a questionable constant:

$$\textit{Kilowatthours} = \frac{\textit{Heat Loss} \times \textit{Degree Days} \times \textit{Constant (NEMA C)}}{\textit{Temperature Difference}}$$

The NEMA "C" constant was arrived at by reducing the usual 24-hour operating period to 18.5, based on the fact that the normal heat gains in a home from lights, cooking, people, etc., would reduce the amount of heat required from the electric heat system.

Although this is somewhat correct, deduction has already been made in the calculations for the Mansfield School for the heat gain of 237,400 Btu/hr. So letting that allowance for heat gain stand where shown in the calculations, as being accurately and equally applicable to both types of systems, the NEMA equation must be restated with the 24-hour figure to prevent duplication of the heat gain figure.

The following equations for energy consumption essentially follow those used in the 1968 feasibility study, with the further correction of an arithmetic error in the percentages of occupied and unoccupied period, incorrectly calculated as 30% and 70% instead of 26% and 74%. The factors of .00347 for oil and .00429 for gas are those used in the study, as listed in the ASHRAE Guide.

ASHRAE Equation for oil:

$$Gals/yr = \frac{Heat\ Loss}{1000} \times .00347 \times Degree\ Days$$

ASHRAE Equation for gas:

$$Therms/yr = \frac{Heat\ Loss}{1000} \times .00429 \times Degree\ Days$$

NEMA Equation for electric:("Heat gain" factor corrected to 24)

$$Kwh/yr = \frac{Heat\ Loss \times Degree\ Days \times 24}{Temperature\ Difference(Outside-Inside)}$$

In the January 1968 feasibility study for Mansfield Middle School the estimate for each fuel was totalled for both "Normal Insulation" and for "Special Insulation." This was redundant, as normal insulation would not be used for an electrically-heated building, and conversely, "special insulation" would not be required for hydronic systems using oil or gas. For simplicity then, the impractical combinations are not listed in the comparisons on Page 10.

Table 7. RECAP FOR HEATING & HOT WATER (300 Million Btu's added throughout for domestic hot water)

	1968 Study	Corrected
Oil Heat	59,500	62,300
Hot Water	3,000	3,000
Total Oil, Gals	62,500	65,300
Gas Heat	72,770	77,000
Hot Water	3,750	3,750
Total Gas, Therms	76,520	80,750
Elec. Heat	810,000	1,373,800
Hot Water	88,500	88,500
Total Elec., Kwh	898,500	1,462,300

1968 FEASIBILITY STUDY (simplified for clarity)
(?) indicates incorrect factors

Gallons of Oil (141,000 Btu/gal) per year (normal insulation)

Occupied: $\frac{3,681,200}{1000} \times .00347 \times 6100$ (?) DD $\times$ 30% (?) = 24,000

Unoccupied: $\frac{2,395,000}{1000} \times .00347 \times 6100$ (?) $\times$ 70% (?) = 35,500

Oil Heating 59,500 gals/yr

Therms of Gas (100,000 Btu/Therm) per year (normal insulation)
(Not shown separately in 1968 Study but using equivalent factors)

Occupied: $\frac{3,681,200}{1000} \times .00429 \times 6100$ (?) $\times$ .30 (?) = 28,900

Unoccupied: $\frac{2,395,000}{1000} \times .00429 \times 6100$ (?) $\times$ .70 (?) = 43,870

Gas Heating 72,770 therms/yr

Interruptible Gas-Oil Combination
(Shown on study as 90% gas — 10% oil)
Total (incl. Dom. Hot Water) = 71,300 therms gas + 6,250 gals oil

Kilowatthours of Electric (3413 Btu/Kw) per year (special insulation)

Occupied: $\frac{2,733,200}{3413} \times \frac{6100}{70°}$ (?) $\times$ 18.5 (?) $\times$ .30 (?) = 387,000

Unoccupied: $\frac{1,290,000}{3413}$ (?) $\times \frac{6100}{70°\ (?)}$ (?) $\times$ 18.5 (?) $\times$ .70 (?) = 423,000

Electric Heating 810,000 Kwh/yr

CORRECTION OF FEASIBILITY STUDY

Gallons of Oil per year (normal insulation)

Occupied: $\frac{3,681,200}{1000} \times .00347 \times 6578$ DD $\times$ 26% = 21,850

Unoccupied: $\frac{2,395,000}{1000} \times .00347 \times 6578 \times$ 74% = 40,450

Oil Heating 62,300 gals/yr

Therms of Gas per year (normal insulation)

Occupied: $\frac{3,681,200}{1000} \times .00429 \times 6578 \times .26$ = 27,000

Unoccupied: $\frac{2,395,000}{1000} \times .00429 \times 6578 \times .74$ = 50,000

Gas Heating 77,000 therms/yr

Kilowatthours of Electric per year (special insulation)

Occupied: $\frac{2,733,200}{3413} \times \frac{6578}{70°} \times$ 24 hrs $\times$ .26 = 469,575

Unoccupied: $\frac{1,585,000}{3413} \times \frac{6578}{60°} \times 24 \times .74$ = 904,225

Electric Heating 1,373,800 Kwh/yr

It is regrettable that the original totals were incorrect, as the final decision was substantially based on these energy figures. Using the corrected figures, and using the fuel costs applicable at the time of the original study, we find the following:

Estimated fuel cost for heating and hot water per year

#4 Oil:	65,300 gals at	8.4¢	=	$ 5,485.
Gas:	80,750 therms at	7.5¢	=	6,056.
Elec:	1,462,300 Kwh at	1.67¢	=	24,420.

Fuel prices have increased since the study was made, so the above totals do not reflect today's costs. But they would have given a more realistic picture at the time decisions were being made. The fuel cost shown then (Table 4) for "interruptible" gas-oil combination was listed as $5,628, taking advantage of a lower "step" in the rates, which would have complicated the analysis here. The electricity cost for heat and hot water was shown as $15,000, to which was added $4,460 for Light & Power, bringing that estimate to $19,460. Adding the corrected electric heat figure of $24,420 to $4,460 would give a total of $28,880, some $6,000 higher for electric than all the items added in to make the hydronic total of $22,674 in Table 4.

The question as to which estimate is more accurate can be easily resolved by comparing the original total kilowatt-hours estimated at 898,500 and the corrected estimate of 1,462,300, with the actual Kwh used in the three full years the school has been in operation: 1970 - 1,846,000; 1971 - 1,902,000; 1972 - 2,272,000.

There is good reason why the actual electric usage is even higher than the corrected estimate. The occupied time is substantially greater than 26% or the 30% originally estimated, so the calculated advantage of automatic "set-back" of the thermostat by 10° during the unoccupied hours is seldom realized. Instead of being occupied from 7 a.m. to 4 p.m., on schooldays only, the school has a typical program of evening and weekend activities, negating much of the estimated savings.

Interviews with school officials brought out another major reason for the growing increase in electric energy usage. During the earlier period the building was not fully completed. In September 1969 only the gym and one wing of classrooms were completed. As additional classrooms, auditorium, cafeteria, homemaking, etc., were completed, they were put to use, until, in September 1971, the building was fully completed and occupied by 800 students. It can thus be expected that the energy usage will continue at approximately the same high level shown in Table 1 for the year 1972. However, a substantial rate increase was instituted on October 20, 1972 so it is expected that the dollar costs will rise above present levels.

Actual Kilowatthour Usage

In trying to determine a pattern for future budgetary estimates, an itemized listing of Kwh was made on a fiscal year basis, and compared with the Degree Day pattern. Finding this provided totals for only two full years, a similar table was drawn up on a calendar year basis which gives a 3-year pattern. (Table 3). As the monthly Kwh figures were examined it was found there was poor correlation with DD in recent months. DD in January 1973 were 4% less than in January 1972, yet the Kwh decreased 33%. Again, in February 1973 the DD decreased 4% from the previous year, yet the Kwh decreased 17%.

Examining the monthly Kwh figures, it was found that some were duplicated in various places. For example, 40,320 Kwh appears for June 1970, August 1971, and July 1972. A possible explanation for this is the common practice of some utility companies, when the meter reader can not get access into the house, of putting down an arbitrary figure, and making an adjustment the following month when the meter is accessible. Although this might be plausible for a school during the summer months, it does not seem likely during the active school year in a small town.

We find, for example, that November 1972 usage (after a price increase in October 1972) seems to be copied from December 1971 even though the DD are different. The Kwh for February 1973 are the same as February 1971, even though there was substantially more usage and occupancy in early 1973. The Kwh for March 1973 is the same as October 1972 although the DD is 77% higher.

To belabor the point a bit we can look at the dollar comparisons in Table 8 for the last three months of 1972, compared with the first three months of 1973. It was 31% colder in Jan,Feb,March 1973 than it was in Oct,Nov,Dec. 1972; however, the bill was 5% less. Perhaps the utility company executives were just as much shocked by the rising bills as were the school officials.

Table 8. Three-Month Comparison (Oct,Nov,Dec. 1972-vs-Jan,Feb,March 1973)

3 Mos. 1972	2386 DD	757,440 Kwh	$18,368.
	+31%	- 9%	-5%
3 Mos. 1973	3125 DD	688,320 Kwh	$17,345.

Dwindling Costs

This pattern is certainly more beneficial to the school than the $5,000 rebate given to them initially by the utility company "for publicity purposes -- to take pictures." There was no way that the gift could be incorporated into school building funds, so the check was generously turned over to the town, as has been done in other similar cases. Unfortunately, the $5,000 rebate was shown in the feasibility study as a deduction from the initial cost of building the "all-electric school."

This pattern of dwindling costs, in the face of rate increases, might be equated with the utility company's statement on trends in operating costs. In their 20-page presentation to the school authorities dated February 1967 they emphasized ". . . the steadily declining rate of electricity. Connecticut Light & Power's school electric heating rate has dropped a substantial 100 percent in ten years." Can this downward trend continue?

Rate Increases

Electric Rate No. 44 for school space heating went into effect in April 1960. When the choice of energy was being debated for the Mansfield Middle School in 1967, that rate was 1.67¢ per kilowatthour for all electricity used in the building. In January 1971, after the building was occupied for more than a year, a "fuel adjustment" factor was added to the basic energy cost. The fuel adjustment factor is a varying amount each month and is added to the bill to reflect the variation in the utility company's fuel costs. Although this factor appeared in other C.L.&P. rate schedules, they had not asked for it in their school heating rate until 1971.

The fuel adjustment factor is expressed in very small units per kilowatthour, ranging in this case from a low of $0.00058 (1/2 mill) to a high of $0.00254 (1/4 cent). When multiplied by the monthly Kwh usage they do add up to an appreciable sum. In calendar year 1971 it added $2,300 to the school's electric bill, and $3,590 in 1972.

In July 1971 there was an increase in the regular price on Rate No. 44, from 1.67¢ to 1.85¢/Kwh, about 11%. In May 1972 another increase was granted in this rate, now going to 1.952¢, pending a decision on the request from C.L.&P. that Rate No. 44 be rescinded entirely.

Rate No. 44, for "all-electric " schools and churches, was rescinded effective October 20, 1972, and the school was put on an ordinary commercial schedule, Rate No. 40. Rate No. 40 is a "step" rate, with the initial usage each month priced as follows:

First 12 Kwh	for $1.90 minimum	=	$ 1.90
Next 188 "	at 5.513¢ each		10.35
Next 1300 "	at 2.513¢		32.67
	First 1500 Kwh/month		$ 44.92
Excess Kwh above 1500 at 2.363¢ each.			

Thus, the first 1500 Kwh per month are billed at 3¢ each and all the remainder at 2.363¢, to which must be added the "fuel adjustment" each month. Although a "demand" factor has been appearing on Mansfield's bills since July 1972, there has been no additional charge for demand, as it is not yet included in Rate No. 40. The demand charge in C.L.&P.'s other commercial rates is based on the highest average 15-minute draw of kilowatts each month, and is added to the energy charge.

Broken Promises

Although it may be claimed that "everything is going up," it must be realized that the decision to go "all-electric" was partly based on the electric company's assurances that prices will continue to decline. In an attractive 12-page booklet published in March 1967 by The Electric Coordinating Council of New England, and presented in multiple copies to help the building committee at Mansfield make their decision, there was great acclaim for the growth and reliability of their "Big-11 Powerloop" and the expectation of decreasing costs:

"In our previous reports we expressed the belief that the overall <u>cost</u> of generating electricity in New England would be reduced 22% in 1973 as compared to 1965 -- from 9.7 mills to <u>7.6 mills</u> per kilowatthour." ". . . we believe that the average price per kilowatthour of electricity sold should continue downward . . ." This might be construed as "good intentions gone awry", until we consider the pattern of electric bill increases granted in recent years.

In the 1950's the increases in electric bills nationwide were averaging $46 million per year. From 1960 through 1968, during the period that electric heat was being strongly promoted, the increase was averaging only $22 million annually. The pattern of increases since then is quite revealing: 1969 -- $100 million increase granted; 1970 -- $430 million increase granted; 1971 -- $802 million increase granted; 1972 (first 9 months) $600 million increase granted. At the end of 1972 the pending requests for electric rate increases totalled *$1.3 billion!*

In the March 1967 booklet mentioned above, the New England utility companies devoted a page to "The Price of Electricity," opening with the following paragraph:

"In the year 1964 the Federal Power Commission issued its National Power Survey. In that report FPC predicted a drop of 27% in the national average price of electricity for the period 1962 to 1980. It also predicted a 30% drop for the Northeastern United States during the 1962-1980 period." (emphasis added)

As the Federal Power Commission does not set utility prices, it would be enlightening to check the New York Times of December 13, 1964 whose front-page article opened as follows:

"The Federal Government believes that the nation's electric power industry can, if it tries hard enough, cut the price of electricity 27 per cent by 1980, barring sharp inflation. This is the gist of the voluminous National Power Survey released yesterday by the Federal Power Commission." (emphasis added) Evidently, the word "believes" became a prediction.

Nuclear Energy Costs

Other than the fact that the most modern fuel-consuming power plants are now operating at 33% efficiency instead of the more typical 25%, the hope being promoted to the American public for reduced electric rates is based on "cheap nuclear energy" (See HVAC data file #2). Without going into a full-scale financial analysis, the essential facts can be illuminated by a few choice quotations from recognized experts in the field.

In a June 1970 article Mr. Philip Sporn, former President of the American Electric Power Co. reported that nuclear power was costing 8 mills at the power plant, not the 4, 5, or 6 mills hoped for, and he stated, "7-mill nuclear power at the (utility) switchboard . . . is simply not good enough to heat water, to heat houses," etc.

In early 1971 Mr. L. H. Roddis, Jr., president of Consolidated Edison Co., and past president of the American Nuclear Society, reported that construction costs for nuclear plants had doubled in three years (in terms of current dollars) and foresaw a further doubling during the next several years. In November 1972 Mr. Roddis expressed his disappointment by stating, "Many glorious promises have been made. . ." but "there has been little or moderate realization," in the actual performance of nuclear power plants.

Typical of nuclear plants in other parts of the country, the experience at Con Ed's nuclear facility at Indian Point, N.Y. can give an indication of the direction of electricity prices in the future. Instead of delivering the expected 80% of rated capacity, that plant is operating at 47%, somewhat below the general average of 60%. Part of the problem is excessive breakdowns. At Indian Point it took seven months and 700 men to analyze and correct a failure, where a conventional plant would have taken 25 men working a total of two weeks.

The $217 million Vermont Yankee nuclear power plant had to shut down within three months after it was granted its license to operate in 1972, after experiencing two "incidents". It is operating at half its capacity "because of high radiation levels" reported the New York Times on December 17, 1972, and one day "the workers were kept away from the plant because of higher radiation levels." The plant went back into operation shortly after, but had been scheduled for shut-down again in January 1973 for further repairs.

On May 5, 1973 The Wall Street Journal front-paged a lengthy article entitled,

"Atomic Lemons;
Breakdowns and Errors in Operation
Plague Nuclear Power Plants,"

citing other examples of deficiency and failure. Evidently, nuclear electricity will not be as cheap nor as reliable as was predicted. In the meantime, 134 more such power plants are in various stages of planning or construction, to be paid for in the future.

Construction Costs at Mansfield

While operating cost and reliability are prime considerations to the parents, taxpayers and school officials, we should consider whether the savings in initial construction cost justified the increased operating expense.

Although a total of $2,865,672 was appropriated in early 1968, only $2,513,333 was earmarked for all construction, the remainder being allocated to fees, furnishings, etc. The low bid in August 1968 was $2,710,743, about $200,000 over the estimate. Through negotiation with the low bidder some 57 items were either eliminated or modified to bring costs down, including such items as cheaper floor tiles, no baseboard splash molding, no air conditioning for the administrative offices, elimination of one playing field, etc. (See cover photo) Fortunately, the committee rejected the recommendation to eliminate the expensive thermal-insulating windows or to reduce the building insulation.

The decision to use all-electric heating instead of the more typical hydronic system was directly based on the estimate of comparative initial costs, as itemized in the Janaury

1968 feasibility study, Table 9 below:

Table 9. Construction Costs (estimated in 1968)

	Hydronic	All-Electric
Radiation - All Types	$ 25,000	$ 37,500
Piping and Insulation	55,000	
Wiring and Panels	4,000	30,000
Boilers, Burners, Pumps, Piping, Etc.	50,000	
Switchgear	1,000	10,000
Temperature Controls and Exhaust Systems	100,000	100,000
Electric Service Rebate, Estimated Value		(5000)
Additional Insulation for Electric Heat		18,000
Totals	$235,000	$190,500
Net Difference	($44,500)	

Unfortunately, the $190,500 net figure for the electric heating installation was substantially inaccurate. The electric work for this job was bid at $587,770 (not including the six large electric water heaters furnished under the plumbing contract).

The electrical contractor estimates that $250,000 to $270,000 is directly attributable to the heating and ventilating, including heating units, control system, sheet-metal subcontract, labor, etc. Another $35,000 to $40,000 could have been saved if not for the heavier electric service, wiring, panels, switchgear, etc., needed for an electric heat system. Thus we find that the electric heat cost some $285,000 to $310,000, instead of the $190,500 shown. In the total then, instead of a purported saving of $44,500, the electric heating ran some $50,000 higher than hydronics.

These corrected figures would have swung the balance entirely in the other direction (see Table 4), and the school would not now be suffering from electric bills 2½ times the original estimate.

It is obvious now, as it has been to other school building committees, that initial questions concerning competing heating systems must be resolved factually. Where such estimates have been bandied about it has proved judicious to obtain alternate bids for both complete heating systems. Then the choice can be based on firm, actual bids, rather than projections and estimates.

Comfort

A comparison with the reports at a hydronically-heated school in Western Massachusetts (Hampshire Regional School completed in 1971) can serve as a base for evaluating the comfort level at Mansfield Middle School. A personal tour of Hampshire School during school hours elicited compliments and full satisfaction with the comfort conditions at the school, from individual teachers as well as officials. This can be attributed to the more even level of heat provided by hydronic systems, but is also due to the fact that each teacher has access to the thermostat in the room and can control the temperature to suit varying conditions of occupancy.

In the electrically-heated Southwick school, twenty miles south of Hampshire and completed at the same time, there are thermostats in each room but they are locked inside the cabinet of the unit ventilator, and are accessible only to the custodian. This is considered essential in "all-electric" schools in order to minimize operating costs.

Although each room in Mansfield has a wall thermostat, it is locked to prevent "tampering" by the teacher. A chat with a teacher while her class was in session elicited the comment, "It's either too hot or too cold," and the students chimed in, "Too cold! Too cold!" Although it is debatable whether the unmodulated 'on-off' operation of electric coils may be at fault, the essential problem is the need to keep the lid on rising electric bills.

Conclusion

Although there is not much that can be done to overcome the problem at Mansfield, other than seek higher operating budgets in the future or rely on the charitable attitude of the electric company, the facts reported about this school, and applicable as well to untold other schools, should serve as a guide for school boards and building committees in their efforts to unearth reliable information.