CHAPTER 2. ESTIMATING FUEL AND ENERGY CONSUMPTIONS

2.1. PURPOSE. This Handbook provides information for estimating fuel and energy consumptions in public and Indian housing projects for preparing the Life-Cycle Cost Analyses.

2.2. DEFINITIONS.

a. Consumption and Control Terminology.

(1) Tenant-Metered Service means the cost for the purchase of utilities by each tenant usually at a higher rate.

(2) Master-Metered Service means the management entity for the project purchases the utilities and the cost is included in the tenant's rent. The management for the project must provide, operate, and maintain distribution facilities for the purchase utility services at mastermetered rates.

(3) Checkmetering means continuous measurement of one or more utilities by individual meters installed by the project in the dwelling units. Checkmetering and assessing surcharges to tenants for fuel or energy use in excess of a predetermined reasonable allowance is the only means of controlling the tenant's utilities' consumption when fuel or energy is purchased by the project. If checkmetering is adopted, all of the dwelling units must be checkmetered. Checkmeters should be used to measure consumption for other major utility uses outside of dwelling units.

(4) Meter Loop is a distribution system for electric or gas meters which can be installed at the time of construction. The checkmeters may be installed after the project goes into management.

b. Quantities and measurement terminology.

(1) British thermal units (Btu) means the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit. This is the unit commonly used in heating and cooling calculations.

(2) Kilowatt-hour (kwh) means the common unit of measurement of quantity of electric energy. This amount of energy would be consumed by a 100-watt lamp in ten hours. One kilowatt hour is equivalent to 3413 Btu.

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(3) Kilowatt (kw) means the rate of electric energy use. The term "demand" is used in many electric rate

schedules to mean the maximum rate of energy delivery. Electric demand is expressed in kilowatts, or sometimes in kilovoltamperes (kva) and occasionally in horsepower. One kw equals 1.34 Hp.

(4) Power factor expresses the phase relationship between voltage and current. Master-metered rate schedules sometimes provide discounts for electric systems with a high-power factor and penalties for those with low-power factors. Induction motors, commonly used in electric refrigerators and power machinery, tend to lower the power factor.

(5) Load factor means the ratio of the average load over a designated period of time to the peak load occurring in that period.

(6) Therm is one-hundred thousand (100,000) Btu of energy. Natural gas contains approximately 1,000 Btu per cubic foot. Therefore, a therm of natural gas is usually equivalent to about 100 cubic feet. Any gas heating value can be obtained by asking the utility supplier.

2-3. WATER CONSUMPTIONS.

a. The quantity of water used in dwelling units will vary between localities, depending chiefly on climate, types of dwelling, and the habits of occupants or tenants use. Two hundred to five hundred gallons per dwelling unit per day are usually required. Without a basis for comparison, the average can be 300 gallons per dwelling unit per day. Where "evaporative" coolers are used, additional consumption usually is about 200 gallons per day per cooler.

b. The consumption of water for other project purposes will depend on landscaping and climate. Consumption varies from a negligible quantity in regions of high rainfall to about 120 gallons per dwelling unit per day in the more arid zones. Without specific data for comparison, the average can be 60 gallons per dwelling unit per day.

c. Under normal conditions (where extensive lawn watering is not necessary and "evaporative" coolers are not used), the water consumption may be estimated at 300 gallons (40 cubic feet) per dwelling unit per day or 9,000 gallons (1,230 cubic feet) PUM.

2-4. ELECTRICAL CONSUMPTIONS FOR LIGHTING, REFRIGERATION AND COOKING.

a. Table I shows the estimated national average electrical consumption and demand data PUM for different size dwelling units for lighting and refrigeration and for lighting, refrigeration and cooking. The data are for tenant purchases and master-metered purchases without checkmeters.

TABLE I
ELECTRICAL CONSUMPTION AND DEMAND
PER DWELLING PER MONTH

Size of Dwelling Unit and Function (Column Number)	Tenant Metering KWH (1)	Master - Metering KWH (2)	Master - Metering KW (3)
0-Bedroom			
Lighting and Refrigeration	85	117	.29
Ltg., Refrig. & Cooking	130	175	.53
1-Bedroom			
Lighting and Refrigeration	120	160	.40
Ltg., Refrig. & Cooking	175	235	.71
2-Bedroom			
Lighting and Refrigeration	170	230	.58
Ltg., Refrig. & Cooking	245	330	.99
3-Bedroom			
Lighting and Refrigeration	210	280	.70
Ltg., Refrig. & Cooking	200	405	1.22
4-Bedroom			
Lighting and Refrigeration	235	315	.79
Ltg., Refrig. & Cooking	350	465	1.40
5-Bedroom			
Lighting and Refrigeration	260	350	.88
Ltg., Refrig. & Cooking	395	525	1.58

b. Lighting and refrigeration includes consumption for lighting, refrigeration and miscellaneous electrical appliances for tenants in public and Indian housing projects. The consumption data are based on an average of two persons per bedroom unit except efficiency units (0-Bedroom Units) for occupancy by a single elderly person. If two or more persons per bedroom

(exclusive of infants) occupy the dwelling unit, these estimated data should be increased.

c. Refrigeration data are for manual-defrost refrigerators with a capacity of approximately 12-cubic feet. If frost-free refrigerators are used, data shown on Table I should be increased as follows:

(1) Add 35 kwh for automatic defrost in general compartment only.

(2) Add 70 kwh for automatic defrost in both freezer and general compartments.

d. Column (1), Tenant Metering, applies where tenants purchase electricity directly from the utility company. Columns (2) and (3), Master Metering, applies where the project purchases electricity on a large volume and distributes it for the project use.

e. Demand. Column (3), Table I, may be used to estimate monthly electrical demand. The data are developed based on no check-meters and are average integrated demands for projects of 30 or more dwelling units. Demand per unit increases considerably below 30 units per meter.

f. If checkmeters are specified and a system of surcharging is to be instituted, quantities should be reduced by multiplying Column (2) by 0.82 and Column (3) by 0.97.

g. Normal electrical appliances. The electric demands and consumptions in Table I are for electrical appliances normally in public and Indian housing projects. If electric clothes dryers, food freezers and other high demand electrical appliances are used by tenants, the consumptions should be increased.

h. Higher demand electrical appliances. Table II, lists estimated monthly consumptions of some high demand electrical appliances, and may be used to adjust the Table I consumptions. When electricity is purchased through master meters, the monthly electrical demand must be estimated. The monthly electrical demand for lighting and refrigeration may be estimated at 2.50 watts per kwh. If electricity is used for lighting, refrigeration and cooking, monthly demand may be estimated at 3.00 watts per kwh.

TABLE II
ESTIMATED MONTHLY CONSUMPTION 1/
FOR ELECTRICAL APPLIANCES

Appliance	Monthly Consumption (KWH)
Cooking	
Broiler	8
Coffee Maker	9
Deep Fat Fryer	8
Dishwasher	30

Fry Pan	16
Hot Plate	8
Roaster	22
Food Preservation	
Food Freezer	
15 cu. ft. Manual Defrost	100
15 cu. ft. Frostless	150
Refrigerator	
12 cu. ft. Manual Defrost	60
12 cu. ft. Frostless	100
Refrigerator-Freezer	
14 cu. ft. Manual Defrost	95
14 cu. ft. Frostless	150
Laundry	
Clothes Dryer	85
Iron	12
Automatic Washing Machine	9
Home Entertainment	
Television (B & W)	30
Television (Color)	40
Comfort and Health	
Bed Covering	10
Dehumidifier	35
Fan (Attic)	30
Heater (Radiant)	15
Humidifier	13

31 From information furnished by Edison Electric Institute.

1.Electricity for domestic hot water.

(1)Electrical consumption in kwh PUM should be calculated as follows:

		NORTHERN LOCALITIES	NORTH CENTRAL LOCALITIES	CENTRAL LOCALITIES	SOUTHERN LOCALITIES
Cold Water Temperature:		40	50	60	70
Size of Unit	Hot Water Requirements				
O-BR	30Gal/Day	210	185	165	140
l-BR	40Gal/Day	280	250	220	185
2-BR	50Gal/Day	350	310	270	235
3-BR	60Gal/Day	420	375	325	280
4-BR	70Gal/Day	490	435	380	325
5-BR	80Gal/Day	560	500	435	375

(2) Demand. The monthly demand for lighting, refrigeration, appliances, cooking, and individual domestic hot water heaters, should be estimated at 2.65 watts per kwh.

j. Central, Group or Building Systems.

(1) Consumption. For project-operated domestic hot water systems, the above-listed kwh per dwelling per month for individual dwelling equipment should be multiplied by the following factors to allow for circulation and standby heat losses for:

Recirculating hot water systems with insulated piping in a single building
1.33 x kwh (Individual)

Systems with low draw off, uninsulated piping or extensive piping between buildings
1.67 x hwh (Individual)

(2) Demand. The monthly demand for electricity used for lighting, refrigeration, appliances, cooking and central domestic hot water, should be estimated at 2.55 watts per kwh. The application of demand limiting devices, which can reduce or eliminate water heating electrical demand should be evaluated.

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k. Electricity for auxiliary equipment of individual dwelling space heating systems.

(1) Average consumptions in kwh PUM should be calculated as follow:

Degree Days:	3000	4000	5000	6500	8000
EQUIPMENT					
Blower	22	26	28	30	32
Blower & Burner or Blower & Pump	32	38	40	42	44

(2) Demand. The blower equipment demand may be estimated at 0.17 kw and for the blower-burner or blower-pump combination at 0.25 kw.

l. Electricity for auxiliary equipment of central, group or building heating plants should be calculated as follows: 1/

(1) Average consumptions in kwh PUM.

Degree Days:	3000	4000	5000	6500	8000

Design Temp. (F)	15	10	0	-10	-20
(a) Steam System					
Oil 2/	13	14	16	19	23
Gas	9	10	11	13	15
(b) Forced Hot Water System					
Oil	31	33	36	40	45
Gas	27	29	31	34	37

(2) Demand. The electrical demand and oil burning equipment may be estimated at .05 kw per dwelling unit, for gas burning equipment at .035 kw per dwelling unit, and for electric oil heating at .064 kw per dwelling unit.

1/ For small building plants in buildings not exceeding three stories in height, use one half the values shown.
2/ If electricity is used to maintain No. 6 oil at pumping temperature, and to heat it to firing temperature, add a 25 kwh PUM.

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m. Electricity for specific project light and power uses should be calculated as follows:

(1) These additional consumption applications should be selected:

	Kwh/PUM
Parking and Area Lighting	10
Special Security Lighting	5
Street Lighting	5
Elevators	25
Water Pumping	10
Central Ventilation and Exhaust	20

(2) Community laundry.

	kwh/PUM	
	Elderly	Family
Clothes washer and gas dryer motor	2	5
Clothes washer and electric dryer	12	35

n. Electricity for other general light and power use should be calculated as follows:

(1) Consumption. Electrical consumption in nondwelling space including community and commercial spaces varies considerably by project type. Two optional methods are provided to accurately estimate consumption.

(a) Option I- For use when specific nondwelling area dwelling area definition is known.

-Row House or Garden Buildings

$$\frac{\text{Gross Area of Buildings}}{\text{Total Dwelling Units}} \times .025 = \text{kwh/PUM}$$

-Low Rise or High Rise Buildings

$$\frac{\text{Gross Area of Buildings}}{\text{Total Dwelling Units}} \times .10 = \text{kwh/PUM}$$

(b) Option II - For use when detailed plans are available.

-Commercial and Community Space (including offices, lobbies, community rooms and other public occupied space).

$$\frac{\text{Sq. Ft. community space}}{\text{total dwelling units}} \times 0.8 \text{ kwh/sq.ft.} = \text{kwh/PUM}$$

-Other nondwelling space (corridors, stairwells, mechanical rooms and other nondwelling space, normally unoccupied).

$$\frac{\text{Sq. Ft. nondwelling space}}{\text{total dwelling units}} \times 0.33 \text{ kwh/sq.ft.} = \text{kwh/PUM}$$

(2) Demands (for paragraphs m and n).

Row House or Garden buildings	2.5 watts/kwh
Low Rise or High Rise buildings	2.0 watts/kwh

o. Electric Space Heating should be calculated as follows: 1/

(1) Consumption. Master-metered electrical space heating may be calculated from the following formula.

$$\text{Annual electric heating (kwh)} = \frac{\text{Annual DD} \times \text{Experience Factor} \times \text{Total Sq.Ft.}}{1000}$$

Experience factor - The Annual 1000 x kwh/DD x Sq. Ft. for heating is derived from actual metered data from electrically heated projects. Inside temperatures were 75 F.

Experience Factors

Type of Building	Typical Heat Loss (Btuh/Sq. Ft.)	Experience Factor 1/
High Rise	27.0	1.5991
Non-High Rise	32.0	1.8952

1/ Experience factors are based on Gross Floor Area of the project and includes dwelling and nondwelling area. If only area within the dwelling unit is known, multiply listed Experience Factors by 1.37.

(a) Adjustment factors for the above formula

1 If detailed working drawings are available, the calculated heat loss based on one air change per hour and expressed in Btuh/Sq. Ft. may be used to adjust the annual kwh from the following formula:

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Adjusted
Annual kwh =  Calculated Heat Loss per Sq. Ft.         Annual kwh
for heating   -----------------------------------  X   from
         Heat Loss per Sq. Ft. from Table #1      Formula #1
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2 In areas where the degree days are less than 3,000, add 15% to the kwh calculated from Formula #1. Additional adjustments may be required in certain low degree-day areas where degree days are not an accurate measure of heating requirements.

3 If electrical space heating is supplied through individual meters, multiply kwhs from Formula #1 by .85.

(b) Average monthly demand. The average monthly demand using master-metered electricity for all applications (lighting, refrigeration, appliances, cooking, water heating, space heating and general use) may be estimated at 2.75 watts per average monthly kwh. Usually average monthly consumptions and demands will accurately estimate utility costs.

p. Power factor. The following consumptions and percentages may be used if the applicable electrical rate schedule provides for kilovolt-ampere (kva) billing, or contains an applicable power factor clause on incentives for maintaining a higher power factor or a penalty for not maintaining a specified minimum power factor.

- Tenant, and project lighting and refrigeration 87%

- Tenant, and project lighting, refrigeration and forced warm air furnaces 76%

- Tenant, and project lighting, refrigeration 91% and cooking

- Tenant and project lighting, refrigeration, cooking and forced warm air furnaces 81%

- Tenant, and project lighting, appliances and power electric cooking and electric space heating 97%

Where the project will benefit from a high power factor, installation of power factor corrective equipment (capacitors) should be considered.

q. Distribution loss adjustment. The previous consumption and demand tables have not included energy and power losses in electrical distribution systems. Consumption and demand should be increased for master-metered electricity to cover losses on the project's distribution system as follows:

2% for single step transformation
4% for two-step transformation

2-5. GAS CONSUMPTIONS.

a. Gas consumption for cooking.

(1) Table III shows the estimated national average gas consumptions in therms PUM for the different size dwelling units. The data are for tenant-metered purchases and master-metered purchases without checkmeters.

(2) The consumptions are for an average of two persons per bedroom except in "0-bedroom units" of the bed-alcove type and for occupancy by single elderly. If two or more persons per bedroom (exclusive of infants) occupy the dwelling units, the suggested consumptions should be increased as the number of persons within the dwelling unit increases.

TABLE III
ESTIMATED GAS CONSUMPTIONS FOR COOKING IN THERMS PUM 1/

Size of Dwelling Unit	Tenant Metering	Master-Metering
0-Bedroom	4.8	6.0
1-Bedroom	5.4	6.8
2-Bedroom	6.5	8.3

3-Bedroom	7.4	9.6
4-Bedroom	8.1	10.7
5-Bedroom	8.8	11.7

1/ The number of therms in a given volume of gas is determined by multiplying the number of cubic feet of gas by the average Btu per cubic foot and dividing the product by 100,000. For example, 1000 cubic feet of gas having a heating value of 1,000 Btu per cubic foot is equivalent to 10 therms.

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b. Gas consumption for individual dwelling domestic hot-water equipment should be calculated as follow:

GAS CONSUMPTIONS FOR DOMESTIC HOT WATER IN THERMS PUM

Size of Unit	Hot Water Requirements	NORTHERN LOCALITIES	NORTH CENTRAL LOCALITIES	SOUTH CENTRAL LOCALITIES	SOUTHERN LOCALITIES
Cold Water Temperature:		40	50	60	70
O-BR	30 Gal/Day	11.9	10.4	9.3	7.9
l-BR	40 Gal/Day	15.3	13.7	12.0	10.l
2-BR	50 Gal/Day	18.3	16.3	14.1	12.3
3-BR	60 Gal/Day	21.3	19.1	16.5	14.2
4-BR	70 Gal/Day	24.7	21.9	19.2	16.4
5-BR	80 Gal/Day	28.1	25.1	21.9	18.8

c. Gas consumption may be estimated at 3.5 therms PUM for mechanical dryers in community laundries.

d. The gas consumption will be approximately 4.0 therms PUM for gas-fired incinerators installed/operated by the development.

e. The foregoing consumption tables exclude leakage losses in project's distribution systems. The consumption estimates should be increased by 3 percent for master-metered purchased gas to cover losses in the project's distribution system.

2-6.FUEL AND HEATING SUPPLIES.

a. Space heating.

(1) The space heating fuel supplied by either project or tenant-operated plants may be estimated from the following formula if the Degree Days are more than 3,000:

FUEL UNITS CON- Heat Loss x Annual Degree Days x Use Factor
SUMED ANNUALLY = --

Btu per Fuel Unit x Design Range

If the Degree Days are less than 3,000, add 15% to the amount of fuel calculated using the formula.

(2) The factors in the formula are as follows:

(a) Heat Loss is the hourly project heat loss at design and is usually estimated in early planning stage before detailed design of the project is completed.

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heat loss should be calculated by the current ASHRAE "Handbook" recommended procedure. The heat loss may be estimated without detailed project plans using the following:

Height of Buildings	Maximum Heat Loss Btu/Hr/Sq. Ft. of Dwell. Unit Floor Area
More than three stories	21
Two and three stories	25
One story	35

(b) Annual Degree Days (65 F. Base) data for a given locality may be obtained from Weather Bureau records, from the current ASHRAE "Handbook" or local utility companies and should cover the most recent period. The degree-days per day is the difference between 65 F. and the daily mean temperature when the latter is less than 65 F. The degree-days for a given day is equal to (65 - mean temperature for that day) x (1 day), and the degree-days for any longer period is the sum of all such products for as many days as the period covers.

(c) Use Factor includes heat losses in project distribution lines, seasonal efficiency of heating plants, and fuel purchase method. Seasonal efficiencies and Use Factors will vary due to conditions in various areas and from plant-to-plant.

Project Plants Use Factors are based upon experience in public housing projects. Individual Dwelling Plants Use Factors reflect the best information for new equipment properly installed and maintained. If oil burner equipment for individual dwellings does not include the latest burner devices to improve combustion efficiency, then the Use Factors should be increased appropriately. In the absence of local experience, the Use Factors should be used for estimating fuel consumption for new public and Indian housing projects.

(d) Design range is the difference between the inside temperature, generally 70 F., and the outside temperature generally used in the area for calculating the Heat Loss. The design outside temperature may be obtained from local heating contractors, utilities or from the current ASHRAE "Handbook".

(e) Btu per Fuel Unit is the heating value of one unit of whatever fuel is to be used. This unit may be cubic feet, gallons, pounds, tons, etc. The resulting annual fuel consumption will be expressed in the same units.

(3) Electrical requirements for space heating should be calculated using the formulas and factors in paragraph 2-4.

TABLE IV
USE FACTORS - SPACE HEATING

Project Plants	Gas	Oil	Purchased Steam
Central			
High Pressure Steam	44.57	44.57	36.71
Low Pressure Steam and Low Temperature Water	38.40	38.40	-
Group			
Low Pressure Steam and Low Temperature Water	37.71	37.71	-
Building			
Low Pressure Steam and Low Temperature Water	36.00	36.00	-

Individual Dwelling Plants (All Systems)

	FUEL PURCHASER	
FUEL	TENANT	PROJECT 1/
Gas-Room Heater or Wall Furnace	27.5	38.0
Gas-Integral Unit - Other than Room Heater or Wall Furnace	24.0	32.0
Oil-Integral Unit with Latest Burner Devices to Improve Combustion Efficiency	24.0	32.0

b. Project-operated domestic hot water.

(1) The project may provide domestic hot water from central, group, or building plants with either direct fired boilers, steam-coil or water-coil generators. The average monthly

1/ Use Factors based on no checkmetering. If check meters are to be required and tenants surcharged for excessive use, Factors should be multiplying by 0.85.

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fuel consumption may be determined for these methods by the following formula:

$$\text{FUEL CONSUMED PUM} = \frac{\text{Temperature Rise} \times \text{Utilization Factor} \times \text{Gallon}}{\text{Btu per Fuel Unit}}$$

(a) Temperature Rise is the average water temperature rise, or the difference between the mean cold water temperature, averaged over the longest record available, and 140 degrees.

(b) Gallon is the estimated consumption per month of hot water required per dwelling unit. See paragraph 2-5.

(c) Btu per Fuel Unit is the heating Btu value of a fuel unit.

(d) Utilization Factor is the combined effect of the heat losses in the distribution pipe lines and the heating plant efficiency. Utilization Factors for some plants and fuels are as follows:

UTILIZATION FACTORS - PROJECT SUPPLIED DHW

	Gas or Oil
Recirculating hot water systems with insulated piping in a single building	485
Systems with low draw off, uninsulated piping or extensive piping between buildings	605

c. The annual cost of miscellaneous supplies should be estimated based on local experiences.

2-7. SELECTING AN AIR-CONDITIONING SYSTEM. An air-conditioning system should be selected which is adequate for design conditions and maintains the desired indoor conditions at the lowest costs, consistent with local codes and standards.

Selection should be based on desired comfort, control, reliability, simplicity, maintenance, initial cost, life of equipment and annual operating costs.

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a. Types of air-conditioning systems.

- Window units - electric motor compressor.

- Through-the-wall-room systems - electric motor compresser.

- Individual dwelling unit central systems - gas absorption, electric motor compressor.

- Central systems for one or more buildings - chillers employing high-temperature hot water, steam, or gas fired absorption; electric motor compressor(s); or electric motor, gas or steam turbine driven compressor(s).

b. Definition of air-conditioning terms.

(1) Design heat gain means the calculated addition of heat, expressed in Btu/hr., to a structure from both external and internal sources. Heat is added externally in warm weather through windows, ceilings, walls and floors and internally by people and appliances. During early project development, when heat gain calculations can not be made, heat gain for residential construction can be estimated at 25 Btu per square foot per hour of floor area.

(2) Design ton means the design heat gain divided by 12,000 Btu/hr.

(3) Equivalent Full Load Hours (EFLH) means the number of hours, usually expressed for a cooling season, that the compressor or absorption unit must operate at full load under design conditions to satisfy the annual cooling reauirements. EFLH is based on an indoor design temperature of 8O F., and may be obtained from local utility experience. See Table V.

(4) Operating Hours (OH) means the hours that the electrical auxiliaries of an air conditioning system operates during a normal cooling season. Operating hours may be obtained from local utility experience and is about twice the EFLH.

d. Checklist for operating cost analysis.

(1) Applicable electric, gas and water rate schedule.

(2) Applicable terms and conditions of service of local electric, gas and water utilities.

(3) Heating value of gas (Btu per cubic foot).

TABLE V
EQUIVALENT FULL LOAD HOURS (EFLH) OF
OPERATION FOR RESIDENTIAL AIR CONDITIONING

CITY	EFLH PER COOLING SEASON
Albany, New York	200
Albuquerque, New Mexico	625
Atlanta, Georgia	750
Baltimore, Maryland	700
Boise, Idaho	550
Boston, Massachusetts	200
Buffalo, New York	150
Chicago, Illinois	400
Cincinnati, Ohio	850
Cleveland, Ohio	450
Columbus, Ohio	650
Dallas, Texas	1,425
Denver, Colorado	350
Detroit, Michigan	450
Duluth, Minnesota	200
El Paso, Texas	955
Ft. Wayne, Indiana	650
Fresno, California	920
Grand Rapids, Michigan	500
Houston, Texas	1,450
Indianapolis, Indiana	800
Jackson, Mississippi	1,150
Jacksonville, Florida	1,615
Kansas City, Misouri	900
Little Rock, Arkansas	1,200
Memphis, Tennessee	1,050
Miami, Florida	1,730
Milwaukee, Wisconsin	350
Mobile, Alabama	1,310
New Orleans, Louisiana	1,500
New York, New York	350
Omaha, Nebraska	800
Phoenix, Arizona	1,300
Pittsburgh, Pennsylvania	400
Raleigh, North Carolina	1,050
Reno, Nevada	500
Salt Lake City, Utah	600
San Antonio, Texas	1,300
Shreveport, Louisiana	1,460
St. Louis, Missouri	1,000
St. Paul, Minnesota	350
Tulsa, Oklahoma	1,050

Washington, D.C.	1,000
Wichita, Kansas	1,350

(4) Gas consumption of gas equipment (Btu per ton hour).

(5) Electric requirements (kW demand) of auxiliaries.

(6) Electric requirements (kW demand) of electric motor driven compressors.

(7) EFLH for the project's location should be distributed monthly to the cooling system. Table VI is a recommended EFLH distribution for selected large cities.

(8) Make-up water requirements for air-conditioning systems with cooling towers or evaporative condensers.

(9) Maintenance and attendance labor requirements for each air conditioning system.

(10) Probable useful life of the air-conditioning systems and components being compared.

f. Electrical air-conditioning systems.

(1) Requirements of electrical equipment

	Compressor Auxiliaries	
System	KW/Design Ton	KW/Design Ton
Window Units	1.46	0.32
Through-wall Units	1.64	0.30
Individual Dwelling-Central System	1.49	0.14
Central Bldg. or Project System		
3 to 25 tons air cooled plant	1.20	0.20
25 to 100 tons air cooled plant	1.18	0.21
Over 100 tons water cooled plant	0.79 to 0.85	0.20

(2) Energy Use (kWh)

(a) Compressor. Calculate compressor monthly kWh by multiplying compressor kW/Design Ton times Design Tons times monthly EFLH. See Table V and VI.

(b) Auxiliaries. Calculate auxiliaries monthly kWh by multiplying auxiliaries kW/Design Ton times Design Tons times monthly Operating Hours (OH). Monthly OH are generally about two times monthly EFLH of the compressor.

(c) Total compressor and auxiliaries. Add monthly compressor kWh and monthly auxiliary kWh to obtain

total monthly kWh of air conditioning equipment. NOTE: Energy for indoor air handlers (evaporator fans) is included in the above calculations and must be considered as part of the base electrical load.

(3) Electric demand (kW).

(a) Compressor. Determine compressor monthly kW demand by multiplying compressor kW/Design Ton time Design Tons times the utilization factor (UF). The UF is the percentage that the compressor kW adds to monthly demand. UF percentages are: April 40%, May 60%, June 70%, July 100%, August 100%, September 80% and October 40%.

(b) Auxiliaries. Determine monthly kW demand of auxiliary equipment by multiplying auxiliary kW/Design Ton times Design Tons.

(c) Total compressor and auxiliaries. Add monthly compressor kW demand and monthly auxiliary kW demand to obtain total monthly kW demand of air conditioning equipment. NOTE: kW demand for indoor handlers (evaporator fans) is not included in the above calculation and must be considered as part of the base electrical load.

(4) Electrical operating costs. Apply applicable electric utility rate schedules monthly to electrical usage to operating costs. Anything that affects billing should be considered including energy, demand, power factor, fuel adjustment clause, taxes, and any special credits or charges.

g. Gas Air Conditioning Systems.

(1) Energy consumption for gas air-conditioning units.

Type of Unit	Btu/Ton Hour (thousands)
Air Cooled Absorption	26
Water Cooled Absorption	16 - 23
Steam Turbine Centrifugal	17.5
Gas Engine Driven Centrifugal	8 - 13

(2) Auxiliary electrical consumption for gas absorption units.

Auxiliaries

System	kW/Design Ton
Individual Dwelling - Central System	0.36
Central Bldg or Project System	
3 to 25 tons air cooled	0.32
25 to 100 tons water cooled	0.21
Over 100 Tons water cooled	0.25 to 0.29

(3) Electric and gas operating cost. Apply applicable electrical and gas utilities rate schedules monthly to total gas and electric usages to determine operating costs. Anything that may affect billings should be considered including energy, demand, power factor, fuel adjustment clauses, taxes and any special credits or charges. Many gas utilities have special rate schedules that apply for gas and air conditioning.

h. Make-up water requirements for water-cooled air conditioning equipment.

(1) Electrical motor driven chillers calculate make-up water requirements in gallons by multiplying the design tons times EFLH times 3.2.

(2) Absorption chillers calculate make-up water requirements in gallons by multiplying the Design Tons times EFLH times 6.2.

(3) Cost of make-up water-apply local water utility rate.

2-8. HEAT PUMP. Energy consumption for heat pumps should be calculated in accordance with recognized industry procedures such as the ASHRAE's Modified Degree-Day Method.

2-9.SOLAR ENERGY SYSTEM.

a. Energy savings for active or passive solar systems should be calculated in accordance with recognized industry procedures e.g., the f-chart method, the solar load ratio (SLR) method or its equivalent. HUD's Residential Solar Viability Program (RSVP) can be obtained from the Department's central computer, to estimate energy savings from active solar systems.

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b. Form HUD-5l994 should be used to identify the lowest cost utility combination for the project. The solar energy system is cost effective if the total savings in 15 years exceed or equal the cost of the system i.e., when line 17 on the Form HUD-5l994 Part A is zero or less than zero).

2-10. OPERATING LABOR.

a. The labor costs for project operated heating and/or air conditioning plants should be carefully estimated since these costs are the most important expenses in plant operation. To avoid duplication of cost estimates, operating labor costs should only be included, especially supervision and labor for adjusting, oiling, inspecting when performed as part of normal operations. Chapter 3 provides procedures for estimating maintenance and repair costs for facilities and equipment. Estimated labor costs should include basic salary or wage, annual and sick leave, compensation insurance, retirement plans, hospitalization and medical insurance plans, life insurance, unemployment insurance and all other "fringe" benefits.

b. Tentative operating schedules should be formulated in accordance with local regulations, prevailing labor union contracts, and labor customs when estimating labor costs. Labor costs should not be included for individual dwelling heating and/or air-conditioning installations.

2-11. GAS PIPELINE SAFETY REGULATIONS. State requirements for the Natural Gas Pipeline Safety Act of 1968 may add to maintenance/operation costs for gas distribution systems. The compliance cost of these regulations should be included in a gas distribution system's maintenance cost.