or another, charges both for demand and energy. Demand may be indicated directly by a demand meter or be derived from manufacturers' rating data shown on nameplates of the heating equipment. In block-type rates, where demand is not specifically mentioned, it is in part reflected by higher charges per kilowatt-hour in the earlier blocks.

Control of Electric Demand

To obtain electricity for space heating at minimum cost, it is necessary to keep the user's kilowatt demand as low as possible, by provisions in original design of the installation and by judicious methods of operation. Excess heating capacity should be avoided, but without jeopardizing satisfactory performance in cold weather. A variety of control methods can be applied to minimize both demand and consumption. Decentralized control with a thermostat in each room or on each heating unit, together with manual switch to cut off any unoccupied room, is one method. Sequence switching whereby electric service to individual rooms or circuits is shifted in rotation by an automatic timing device and sequence is modified by outdoor thermostat or by total electric load, is another.

Load-limiting controls of several types have come into use. These are generally arranged to measure the customer's total power demand, which for a residence may be grouped as lighting and miscellaneous appliances, refrigerator and water heater, cooking range, and the space heating system. When the demand exceeds a preset value, one or more heating circuits are cut off progressively in rooms least affected by the interruption. Experience shows that with electric floor or ceiling panel heating, temperature drop occurs slowly, at the rate of about 1 deg per hour for concrete slabs and 2 deg for plaster construction or rigid panels properly backed with thermal insulation. Moreover, electricity consumed by lighting, appliances and cooking ranges is contributing some useful heat at such times.

Another form of limiting control for 120/240-volt 3-wire circuits provides complete or sequence transfer of space heating units from 240 volts to 120 volts, thereby reducing the electric input to one quarter whenever the total load or general-service component exceeds a preset limit. This method lends itself to use of an outdoor thermostat actuating a relay, whereby in mild weather the entire heating system operates at 120 volts and with lengthened cycles obtains more uniform room temperature. For reducing temperature at night, if desired, a clock-operated master thermostat can be provided to lower the heating-system voltage. On some electric utility systems, centralized control by means of a pilot-wire or carrier-current actuating a relay is applied to house-heating installations.

With any type of control, time-delay relays should be used in order that upon restoration after an emergency service interruption or whenever a master thermostat calls for heat, the individual circuit or units will come on non-simultaneously over a period of a few minutes. This is advisable especially for types of resistor units that have a power input, when cold, as much as 50 percent above the rated value at normal operating temperature.

Operating Costs

The range of electric costs for house heating, on residential rate schedules typical of country-wide conditions, is from something over two cents per kilowatt-hour where house-heating consumption comes mainly on the

bottom step of a block-type residential rate, to as little as half that figure in areas served by large hydroelectric systems. Since the range of heat factors for houses of differing construction types with various methods of resistance electric heating and with a variety of occupancy is likewise more than 2-to-1, costs of house heating for dwellings of the same size in similar winter climates may vary through a range of nearly 5-to-1. However, an

Table 3. Relation of Resistor Voltage to Heat Delivery

Condition	Volts	Heat Delivered %
Electric system, nominal value	120/240	103.3
For design of equipment, at terminals	118/236	100
Range, as basis for design		
Minimum	110/220	86.8
Maximum	124/248	110.5
On secondary distribution system		
Favorable zone, as to voltage conditions		
Minimum	110/220	86.8
Maximum	125/250	112.0
Tolerable zone		
Minimum	107/214	82.2
Maximum	127/254	116.8
Emergency conditions	90/180	58.3

8000-cu ft house can be heated with 8000 kilowatt-hours of electrical energy annually in 5000 degree-day climate, if a heat factor of 0.2 is attained by means of good construction and adequate insulation.

Voltage Requirements

The preferred nominal system voltage at point of electric utilization by equipment, for single-phase 3-wire systems necessary with space heating, is 120/240 volts, as stipulated by standards of the electrical industry (*EEI* publication R-6 and *NEMA* publication No. 117 issued May 1949). For household heating appliances mentioned in the standards, such as air heaters, water heaters, and cooking ranges, the *equipment voltage rating for design* is specified as 118/236 volts, and the range of *voltages to be used as a basis of design* extends from 110/220 minimum to 124/248 maximum. However, naturally variations exist from time to time in the conditions at different points in any secondary distribution system and will affect both voltage level and range of fluctuations. Under emergency conditions on electricity supply systems, voltages of the order of 90/180 may be encountered. Heat delivery by resistors with these voltage values, expressed in percent of rated delivery with the normal 118/236 volts (at terminals) is given in Table 3.

Voltages stipulated for secondary distribution systems are at point of service entrance to the building; the drop of voltage in the house supply wiring to terminals of the heating equipment may be 2 to 3 percent, thus reducing heat delivery by some 5 to 8 percentage points below the *favorable zone* and *tolerable zone* values included in the last column of Table 3. Ac-