RSD:CS
III-4

Department of Commerce
NATIONAL BUREAU OF STANDARDS
Washington

Letter
Circular
LC-694

THERMOSTAT SETTING AND ECONOMY IN HOUSE HEATING

June 9, 1942

The heat loss from a house, according to experience is proportional to the average differences in temperature maintained between the inside and the outside. When, therefore, the thermostat is "set down" for a time, enough to affect the temperature sensibly, the average inside-to-outside temperature difference is decreased and the heat loss of the house is thereby lessened. The effect, however, is small in some cases, as will be demonstrated below. Since the heat capacity of houses and the general relation between heat losses and capacity of heating systems is not known, some assumptions will have to be made on which to base computations.

Assume a house in which the thermostat is set at 70°F when comfort heat is desired and at 55°F at other times and assume that the house is in a region with an average winter outdoor temperature of 30°F, which represents a rather cold climate such as that of parts of Michigan, Wisconsin or New England.

The heat loss when the thermostat is "set up" would be proportional to 70° - 30° = 40 degrees F., and the heat loss when the thermostat is "set down" would be proportioned to 55 - 30 = 25 degrees F.

It is assumed, of course, that thermostat setting accurately represents house temperature.

Now, if the thermostat were set down all the time, the saving would be

$$\frac{40 - 25}{40} = 37.5 \text{ per cent}$$

This would indeed be a worthwhile saving, but consider further.

Many families require heating comfort from about 7 A.M. to about 11 P.M. or 16 hours and might be content to have the heat off the remainder of the 24 hours, or 8 hours, per day. This means that the above saving would be in effect only one-third of the time. As a theoretical maximum, the saving could not exceed

$$1/3 \times 37.5 = 12.5 \text{ per cent}$$

This represents the saving that could be attained if the temperature in the house followed immediately the thermostat setting. But, as is common knowledge, any house requires from one to several hours to "cool down" and also from one to several hours to "heat up". If we assume that the house requires 3 hours to cool down and one hour to heat up and, further, that the average temperature is half way between the maximum and minimum, or 62.5°F., during the heating-up and during the cooling-down periods, the per cent saving would be

$$S = \frac{3x\ (70 - 62.5) + 4\ x\ (70 - 55) + 1\ x\ (70 - 62.5)}{24\ x\ (70 - 30)} = 9.4 \text{ percent}$$

Some people are absent from their houses during the day and see no reason for keeping the thermostat "up" while they are away. The following heating schedule might be assumed for such houses for estimating purposes. It is assumed, as before, that the house will require 1 hour to "warm up" and 3 hours to "cool down".

6:00 A.M. - Thermostat Set Up	
6 to 7 A.M. - Warming Up Period	1 Hr.
7 to 8 A.M. - Warm Period	1 Hr.
8:00 A.M. Thermostat Set Down	
8 to 11 A.M. - Cooling Period	3 Hrs.
11 to 5 P.M. - Cool Period	6 Hrs.
5:00 P.M. Thermostat Set Up	
5 to 6 P.M. Warming Up Period	1 Hr.
6 to 11 P.M. Warm Period	5 Hrs.
11:00 P.M. Thermostat Set Down	
11 P.M. to 2 A.M. - Cooling Period	3 Hrs.
2 to 6 A.M. - Cool Period	4 Hrs.

This can be summarized as follows

Total Time Warm	6 Hours
" " Cool	10 "
" " Changing	8 "

Using the temperature conditions chosen previously, the saving in heat loss indicated is as follows:

$$S = \frac{10 \times (70 - 55) + 8 \times (70 - 62.5)}{24 \times 40} = 21.9 \text{ per cent.}$$

It should be remembered that the figures apply only to a house operating according to the assumptions. If the house heats up and cools down at other rates the estimated saving would change accordingly. Nothing is gained of course by setting the thermostat lower than that temperature to which the house will fall during the off period. It is, in fact, the inability of houses to cool quickly in mild weather which prevents the savings estimated by the above method from being fully attained. From this it appears immediately that the possible per cent saving is smaller for more heavily constructed houses with greater capacities for absorbing heat. In such houses, the fall of temperature during any part of the day when the heat is off is relatively small. This means that the house is heated by heat from the walls and other parts of the house during such a period and this heat must be restored by relatively long operation of the heater during its next operation. This, however, is not to be construed as a condemnation of houses with some considerable heat capacity. Uniformity of temperature has been and is regarded as desirable and heat capacity in a house tends to promote it. It is doubtful that a sacrifice in this respect is justified in an effort to save a fraction of the fuel consumed by setting back the thermostat at night. In a word, construction of dwelling houses specifically designed for large percent-savings of heat by means of special daily heating schedules, such as those described herein, is not advocated.

Another, perhaps minor complication, is the fact that, for equal effective temperature, the air in a house must be warmer when the walls are cooler. For this reason, the air in a house must be heated somewhat more than usual, if the house is to be equally comfortable, after a period when the heat has been shut off or reduced.

It will be noted in the above that savings have been discussed in terms of heat loss. The saving in fuel, and consequently in cost of heating, may or may not be approximately proportional to saving in heat loss, depending on the kind of fuel burned and the equipment used to burn it. It is probably safe to assume that the efficiency of most oil- and gas-burning equipment is approximately constant, regardless of the schedule of operation, so that the above estimates might apply at least approximately for such equipment. On the other hand, the inability of a hand-fired boiler or heater to change loads quickly and the use of fuel during banking periods are likely to nullify some of the saving which might be expected from some particular heating schedule. Stoker fired equipment would be better in this respect than hand fired equipment. The per cent saving with it due to special setting of thermostat would be less than that expected with oil and gas burning equipment.

This does not mean that fuel can not be saved by careful firing of hand fired equipment. A skillful and careful fireman can save considerable fuel, especially if the fuel is bituminous coal. Most users of hand-fired equipment do bank the fire at night as a matter of convenience and thus simulate setting the thermostat down.

Many persons keep the windows open at night in sleeping rooms. The heat lost through open windows is considerable, but this loss can be very materially decreased by turning off the heat supply to such rooms while the windows are open.

Some houses equipped with warm air heating systems have return- as well as supply-registers in the bed rooms. In the interest of economy, both the return- and the supply-register should be closed when the windows are open. The return, if left open, will receive cold air from the room. The supply register should be closed to keep it from, in effect, delivering heat to the out-of-doors.

It is somewhat short-sighted to say, as some do, that no economy is effected by setting the thermostat down because the burner "runs longer" in the morning. Heat is stored in the walls and other parts of a warm house and when the burner is stopped, some of this heat is withdrawn from the walls and warms the house for a while. When the burner "runs longer" in the morning, it is simply replacing the heat lost from the heat-absorbing parts of the house. The governing factors, as stated above, are (1) the average inside-outside temperature difference, (2) the effect of special firing schedules on the efficiency of the heating plant and (3) the heat capacity and insulation of the walls which determine the rate of cooling.