Supplemental Heat for Swine– Pork Industry Handbook
Michigan State University Extension Service
Sam L. Harp, Raymond L Huhnke, Oklahoma State University
Issued November 1992
6 pages

pork industry handbook

MICHIGAN STATE UNIVERSITY COOPERATIVE EXTENSION SERVICE • EAST LANSING, MICHIGAN

Supplemental Heat for Swine

Authors
Sam L. Harp, Oklahoma State University
Raymond L. Huhnke, Oklahoma State University

Reviewers
John and Bonnie Korslund, Eagle Grove, Iowa
Gerald L. Riskowski, University of Illinois
Mark E. Smith, Jackson, Tennessee

Supplemental heat is required if the animals do not generate enough heat to keep the room temperature at an acceptable level. The amount of supplemental heat needed depends on many factors such as pig size, building insulation level, desired room temperature and the outside temperature. The ventilation system also affects supplemental heat requirements. In a well-insulated animal facility, as much as 90% of the heat produced in the building is exhausted through the ventilation system. Because of the difficulty in determining the actual supplemental heating needs, estimates are made to size heaters. Table 1 gives the estimated requirements for typical swine facilities in North Central United States.

In some buildings, such as the farrowing house where supplemental heat is regularly used, permanent heating systems should be considered as part of the total environmental control system. Where permanent heating systems are not cost effective, a temporary heater can be moved into the building for several days to get through a cold spell or when the building is partially loaded. Whether you use a permanent or temporary heating system depends on many factors including location in the United States, animal size, and management scheme.

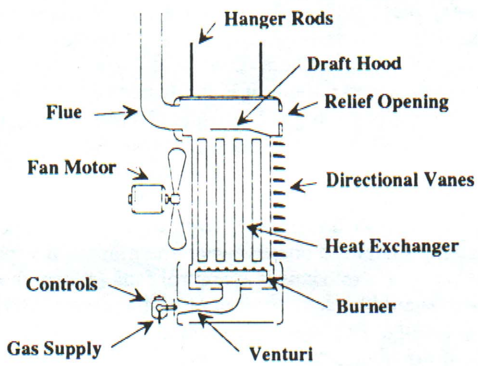

Figure 1. Cross section view of a typical unit heater.

Table 1. Sizing supplemental heaters.*

	Supplemental heat/animal unit		
	Inside temperature	Slotted floor	Bedded/scraped floor
	°F	----- Btuh/unit -----	
Sow and litter	80	4,000	--
	70	3,000	--
	60	--	3,500
Prenursery pig (12-30 lb)	85	350	--
Nursery pig (30-75 lb)	75	350	--
	65	--	450
Growing-finishing pig (75-220 lb)	60	600	--
Gestating sow/boar	60	1,000	--

Source: *MWPS-34, Midwest Plan Service Heating, Cooling and Tempering Air for Livestock Housing.*

*Note: The supplemental heat recommended in Table 1 provides reserve heater capacity to handle heating needs when only a few animals are present. Additional zone heat may be needed for young animals.

Example: A 10-sow farrowing room kept at 70°F requires about 10 x 3,000 = 30,000 Btuh heating capacity.

Unit Heaters

A unit heater has all the components assembled into one container and needs only to be hung in the building and connected to a source of fuel and electricity (see Figure 1). The basic unit heater consists of a fan, either propeller or centrifugal, and a heating element. Some unit heaters are equipped with air intake filters, directional discharge louvers, and automatic temperature controls. Unit heaters are generally installed overhead, eliminating the need for using valuable floor space. Most unit heaters use 100% recirculated air.

There are several types of heating elements used with unit heaters. For swine buildings, however, the direct-and/or indirect-fired gas burners and electric heating elements are the most common. A hot water element is another option, especially in farrowing or nursery buildings where under-floor hot water heat is used.

Dust can be a problem with unit heaters because they use recirculated air. The amount of dust in the air depends on management and the type of feeding system. If the circulated air is filtered, a centrifugal blower works better than a propeller fan against the higher static pressure caused by the filter.

The size and number of unit heaters needed depend on the heat requirement and floor area of the particular swine building. As an example, a 24-sow farrowing room kept at 70°F located in central Illinois would need about 72,000 Btuh (Btu per hour) of supplemental heat (24 times 3,000 from Table 1). Assuming a heater efficiency of 80%, heater size would be approximately 90,000 Btuh (72,000 divided by 0.80). This heat could be provided using one large unit or two smaller heaters at about 45,000 Btuh each. Two heaters probably would give better heat distribution than if just one single unit was installed.

Table 2. Typical efficiencies for some common heating systems.

Solid Fuel (coal and wood) Furnace	40-60%
Gas or Oil Furnace	50-95%
Electric Resistance	100%
Air-source Heat Pump	150-250% (COP = 1.5 to 2.5)
Ground-source Heat Pump	250-300% (COP 2.5 to 3.0)

The thermal efficiency (Table 2) of fuel burning heaters is defined as the amount of useful heat produced divided by the heating value of the fuel consumed. Thermal efficiency is usually less than 100% due to incomplete combustion of the fuel and, for vented heaters, heat lost due to venting. Venting of fuel burning equipment is necessary to remove the products of combustion from the space. If unvented heaters are used, increase the ventilating rate by 2.5 cfm for each 1,000 Btuh of heater capacity to prevent buildup of moisture and poisonous combustion gases. When vented heaters are used with negative pressure ventilation systems, use fan powered vents with a vent damper.

Thermal efficiency of electric heat pumps is called coefficient of performance (COP) and is defined as useful heat output divided by heat equivalent of the electrical energy required to operate the system. Another term commonly used for heat pumps is heating season performance factor (HSPF) and is merely the COP multiplied by a constant of 3.413. Heat pumps can have efficiencies greater than 100% because they do not convert electrical energy to heat. Instead, they use this energy to "pump" heat from the source (typically air or ground) to the space being heated. Efficiency is highly dependent upon source temperature. Low source temperature results in correspondingly low efficiency.

The term "throw" relates to the horizontal distance that the warm air is projected from the heater. If the 90,000 Btuh and 45,000 Btuh heaters in the previous example have about the same throw, the two smaller units would probably produce a more uniform temperature throughout the house compared to the larger heater. Another option would be for the unit heater, used in combination with some type of simple duct air tube system, to distribute the heated air along the length of the house. Another approach would be to divide the farrowing house into two smaller rooms with one 45,000 Btuh heater per room.

If the room does not have an air distribution system, a more uniform temperature distribution is obtained when the unit heater is installed to blow along the coldest wall. The warm air will intercept the cold drafts from that wall. Likewise, a heater should discharge heated air across a cold air baffle inlet or series of ceiling inlets to provide for better air mixing. Where several heaters are used, they should be arranged so that the discharge from each heater helps create a general circulatory motion of air within the room. Ceiling-mounted units with the outlet louvers properly set should deliver the heated air to the occupied zone (pig level) at acceptable temperatures and velocities.

Because dust and high humidity are often a problem in swine units, a regular maintenance schedule must be established. Inspect heaters weekly for dust build-up. The amount and frequency of cleaning will depend on your particular heater and room conditions. The heating elements, fan blades and output louvers are often cleaned by brushing or blowing with high-pressure air. Whenever the building is cleaned with a high-pressure water or steam cleaner, the heater also should be cleaned. Check the heater service manual for recommended cleaning methods. **CAUTION: Totally disconnect the electric power before cleaning, and be sure no moisture remains in the electrical boxes before restoring the power. The fan motor should be totally enclosed. All electrical wiring and fuel line connections should be inspected annually.**

Make-up Air Heaters

Most unit heaters use 100% recirculated air; whereas, most make-up (ventilation) air heaters use 100% outside air. Since the make-up air heater heats air entering the building, some air must also be exhausted or removed from the building. Make-up air heaters are generally located outside of the space or building they are heating.

Make-up air heaters are sized either by: 1) rate of air flow through the unit, 2) maximum energy input to the heating element, or 3) both methods. Typical farm application sizes range from about 600 to 2,000 cfm with gas as the usual fuel choice. Most heaters have a potential of over 120°F temperature rise for the air passing through the heater at maximum fuel input.

Some gas make-up heaters burn the gas directly in the air stream entering the building resulting in all the products of combustion entering the building along with the heated air. If direct-fired units are used, add at least 2.5 cfm to the cold weather ventilation rate for each 1,000 Btuh of heater capacity.

Air distribution must be considered when using make-up air heaters. When the make-up air heater is operating, most of the air will enter at one point instead of being uniformly distributed around the building. This can cause uneven air temperatures within the building. Therefore, an air distribution system such as a fan-tube or duct often is used to ensure good air mixing and more uniform air temperatures. Ducts near heaters need to be fireproof.

Controls

Careful consideration must be given to the safety controls of heating equipment. For gas heaters, some type of gas and fan shut-off is needed if ignition by the electrical igniter does not occur within approximately one minute. Also, some type of manual reset flame sensor is needed that will shut down the unit in case the gas supply is exhausted. A sail switch, sensitive to the flow of air, will make sure that the blower is operating or that air is passing through the unit before the ignition circuit is activated. If the air flow stops after activation, the main gas valve should close. There also should be a high-temperature switch to shut down the unit if the temperature at the discharge and/or burner is too high. The usual electrical safety equipment, such as circuit breakers, should be available to protect the blower motor from possible overload damage.

A minimum level of ventilation should be maintained in a swine building at all times. Therefore, it is not uncommon for the heating system to operate when the minimum ventilation fan is operating. Thermostats that control fans (except the minimum fan rate) should be set a minimum of 4°F above the heater thermostat setting. The preferred method is to have the heater and fan controls interlocked or operated by the same controller. If the thermostats are not properly set, ventilation fans that control temperature may run when the heater is operating, thus wasting energy. When several persons are involved in a swine operation,

Table 3. Suggested use, location and control of radiant heaters for swine.

Type and size	Use	Location and number	Radiant output	Control
Gas, Catalytic or Ceramic Core 4-6 MBH*	Farrowing house	Hung over two adjacent pig creep areas	30-35%**	Uncontrolled: intentionally on or off.
10-12 MBH	Nursery and growing/finishing	5 to 6 ft. above the sleeping area; one heater per 100 sq ft of sleeping area	40-45%	Mounted air set at 35-40°F in open front building, 50°F in closed building. (Should have automatic gas shut-off in case of pilot light failure.)
Electric 250 W bulb	Farrowing house	One per pig creep	70-75%	Uncontrolled: intentionally on or off.
1-2.5 kW	Nursery and growing/finishing	5-6 ft. above the sleeping area	75-80%	Radiant receptive thermostat advisable because of small amount of air heating. Settings similar to gas.
Gas or electric	Emergency situations and partially loaded buildings.	Near ceiling; as many as deemed necessary		Air thermostat set at 45-55°F or manual adjustment as necessary.

* Thousand Btuh input rating.

** 30-45% of the input energy to gas heaters is given off as radiant heat. The remaining 50-65% of the energy heats the air. For electrically powered heaters the percentage of radiant heat output is typically in the range of 70-75% with 25-30% heating the surrounding air.

only one should have the responsibility of adjusting the heater control.

Radiant Heaters

Radiant heaters have a special advantage because the heat produced is transmitted by radiation, like light rays, rather than heating the air. Therefore, they can be fairly effective in open front buildings. Radiant heater types range from heat lamps for zone heating to fan-driven pipe units for providing heat in an entire building.

Radiant heat is transferred to an object when it strikes the object in its path. Thus, radiant heat shining on a pig transfers the heat directly to the animal without heating the air. This allows the animal to be comfortable even though the surrounding air, by itself, is too cool for comfort. Comfort can be provided without heating all the building air. Therefore, this allows a dual environment in a farrowing house where the thermostat can be set to maintain a 60°F temperature for the sows, and radiant heat can be added to the pig creeps to provide an 80 to 85°F equivalent environment for the small pigs (Table 3).

Creep area heating requires a localized high temperature source which is generally supplied by electrical heat lamps or gas-fired radiant heaters. If the floor is heated in a farrowing creep area, provide a 250 watt (852 Btuh) overhead heat lamp for the first few days after farrowing. If no floor heat is used, provide 2,200 Btuh of overhead radiant heat per litter. This is especially important in cold climates where heat lamps may not be enough. Make sure the radiant heat is heating only the creep area and not the sow.

Heat lamps are a potential fire hazard if not handled properly. Suspend lamps on chains and make the lamp cord at least 12 in. shorter than the floor-to-ceiling height, so it unplugs if the lamp drops to the floor. For pigs, mount lamps at least 30 in. above pen floors and 18 in. above creep floors. Place no more than seven 250 watt heat lamps on one 20 amp circuit. Consider manual or automatic voltage controllers to regulate heat lamps when full wattage is not required.

Gas catalytic radiant heaters are flameless and have relatively low surface temperatures. Catalytic heaters are usually not thermostatically controlled, which makes them less efficient. They do not require gas flues if the room is properly ventilated. Radiating surfaces of catalytic heaters must be kept clean to maintain heating efficiency.

Floor Heat

Floor heat is used primarily for localized heating. Common floor heaters are electric resistance cables or hot water pipes buried in the concrete floor. For more detailed information on floor heating systems see MWPS-34, *Heating, Cooling and Tempering Air for Livestock Housing*, Midwest Plan Service.

Move-in Heaters

The greatest need for temporary heating generally occurs when a building is under stocked, perhaps at the start or end of a farrowing or nursery cycle, or when there are only a few animals in a large pen. A sudden cold spell also could require some type of quick, temporary heat.

Most heaters moved into a building for temporary heating are direct-fired gas or oil. These heaters have their own fuel supply in an accompanying tank and only 115 volt power is needed for fan and control operation. No flue is necessary if the room is properly ventilated. Sizes are available from about 30,000 Btuh to 100,000 Btuh.

The operating thermostat is usually located on the unit which will cause greater temperature fluctuations within the building. It is difficult to coordinate such a unit with the normal ventilation controls to keep the two from acting against each other. Any unit employed in an animal shelter should have some type of *flame-out* control that will automatically shut off the fuel supply if the flame goes out for any reason. Loss of electrical power should cause a full shut-down of the burner. Continual use of move-in heaters in poorly ventilated farrowing rooms can cause an increase in the incidence of stillbirths.

Air Tempering

Several methods, such as heat exchangers, solar walls, and earth tubes, are being used to temper the air before it enters a building. Warmed-air tempering systems help most in small animal housing because they reduce drafts by improving air distribution, providing higher temperature ventilating air, and enhancing warm and cold air blending.

Warmed air tempering also simplifies air inlet management. Tempered air is warmer and less dense, it is thrown farther into a room, mixes better with room air before entering the animal zone, and reduces drafts. Although some tempered air systems reduce heating and sometimes cooling requirements, it is difficult to justify their purchase on energy savings alone.

Warmed tempered air systems usually provide cold weather ventilation. Use a conventional ventilating system for mild and hot weather ventilation. Switch from tempered to outside air when the outside air temperature is high enough so animals are not chilled. For more detailed information on floor heating systems see MWPS-34, *Heating, Cooling and Tempering Air for Livestock Housing* Midwest Plan Service.

Heat Exchangers

Heat exchangers are designed to move heat from the exhaust air to the intake air. One type of heat exchanger is a parallel plate unit in which exhaust and intake air are separated by thin plates. These units can reclaim from 40 to 60% of the heat normally lost in the exhaust air. However, they can have problems with the accumulation of dust, moisture and freezing. Heat exchangers should include methods for easy cleaning and defrosting. For more detailed information, see PIH-124, *Heat Exchangers in Swine Facilities.*

Solar Energy

Because the sun is free and provides a readily available and endless source of energy, it seems to be a very attractive energy source for swine facilities. Some swine facilities already make use of some solar collection by allowing ventilation air in the winter to enter through the attic of the building.

Solar systems for swine facilities can be either a passive or active type. Passive systems are a combination of south-facing windows and a proper roof overhang which allows the building to collect the solar energy. Active systems require methods for collecting and transferring solar energy. Active systems may allow for heat to be stored in one location and used elsewhere.

Without a method of storage, an active system may provide more solar energy than necessary during clear days and not enough heat energy at night. See PIH-90, *Solar Heating in Swine Buildings* for more detailed information.

Earth-Tube Systems

Earth-tube heat exchangers use soil as a heat sink or source for tempering the ventilating air. Depending on the season, air is heated or cooled as it is drawn through a buried tube. The temperature 7 to 10 feet underground is nearly constant throughout the year.

Both soil characteristics and air-tube parameters affect the performance of the system. Soil characteristics include soil type, moisture content, and water table elevation. Air-tube parameters include diameter, length, depth of placement, spacing, flow rate, and the shape of the tube. Typically, an 8 in. to 12 in. diameter non perforated corrugated plastic drainage tile is used because it is readily available and inexpensive. The corrugations increase the heat-transfer rate. For more detailed information, see PIH-102, *Earth Tempering of Ventilation Air.*

Fuel Selection

The choice of fuel used in swine buildings depends on availability, price and special requirements. The main sources of energy in most regions of the United States are propane, natural gas and electricity. The relative availability of different fuels may change in coming years, especially in local situations. Therefore, consider long-term fuel supplies before making final decisions about equipment.

The nomograph in Figure 2 can be used to estimate cost per million Btu's of the heat supplied. To use the nomograph you first need to know the type of heating system and its efficiency. To estimate the cost of heat you must draw a straight line from the cost per unit of the energy source through the heating system efficiency scale to where it crosses the heat cost scale. For example, an L.P. gas furnace with an efficiency of 80% and a fuel cost of $0.80 per gallon would result in a heat cost of about $11.00 per million Btu's. This nomograph also can be used to compare heating costs for different types of heating systems and fuels. To estimate the cost of heating with L.P. gas use scales 1, 3 and 5; for natural gas use scales 2, 3 and 5; for fuel oil use scales 1, 4 and 5; for electric resistance and heat pumps use scales 7, 6 and 5.

The cost of operating electric heat lamps or noncontrolled gas-fired radiant heaters in a farrowing house is easily determined on an hourly use basis because the rate of energy consumption is constant. A 250-watt heat lamp uses 1/4 kWh during each hour of use. If electricity costs $0.08 per kWh, then the cost of operation is $0.02 per hour or $0.48 per day. A 4,000 Btuh gas-fired radiant heater uses slightly over 1 gal. of propane per day and operating cost at $0.80 per gal. is about $0.03 per hour or $0.80 per day.

Application Suggestions

Proper control of any heating system is necessary both from an economic standpoint and for safety. Thermostats for unit heaters and make-up air heaters should be hung low but still within easy visual range. They should be located so as not to be biased by the sun, animal mass, or by the output from nearby heaters. When using small radiant heaters or some solid fuel heaters, the operator usually must assume the task of turning them on and off as needed.

All gas lines and/or gas heaters should have safety shut-off valves. If the gas supply is interrupted, all valves should close and require manual resetting unless automatic electric ignition is provided for the heater. Small gas radiant heaters usually do not have pilot lights and safety shut-off valves and thus need to be closely monitored by a reliable operator.

Electrical wiring in and to the swine buildings must be of adequate size if electrical supplemental heaters are used. Circuit load capacity is determined by the wire size used and not by the size of the fuse that could be placed in the fuse box. Any changes made in the electrical system should be done by someone capable of determining safe circuit loads. For more detailed information, see PIH-110, *Electrical Wiring for Swine Buildings.*

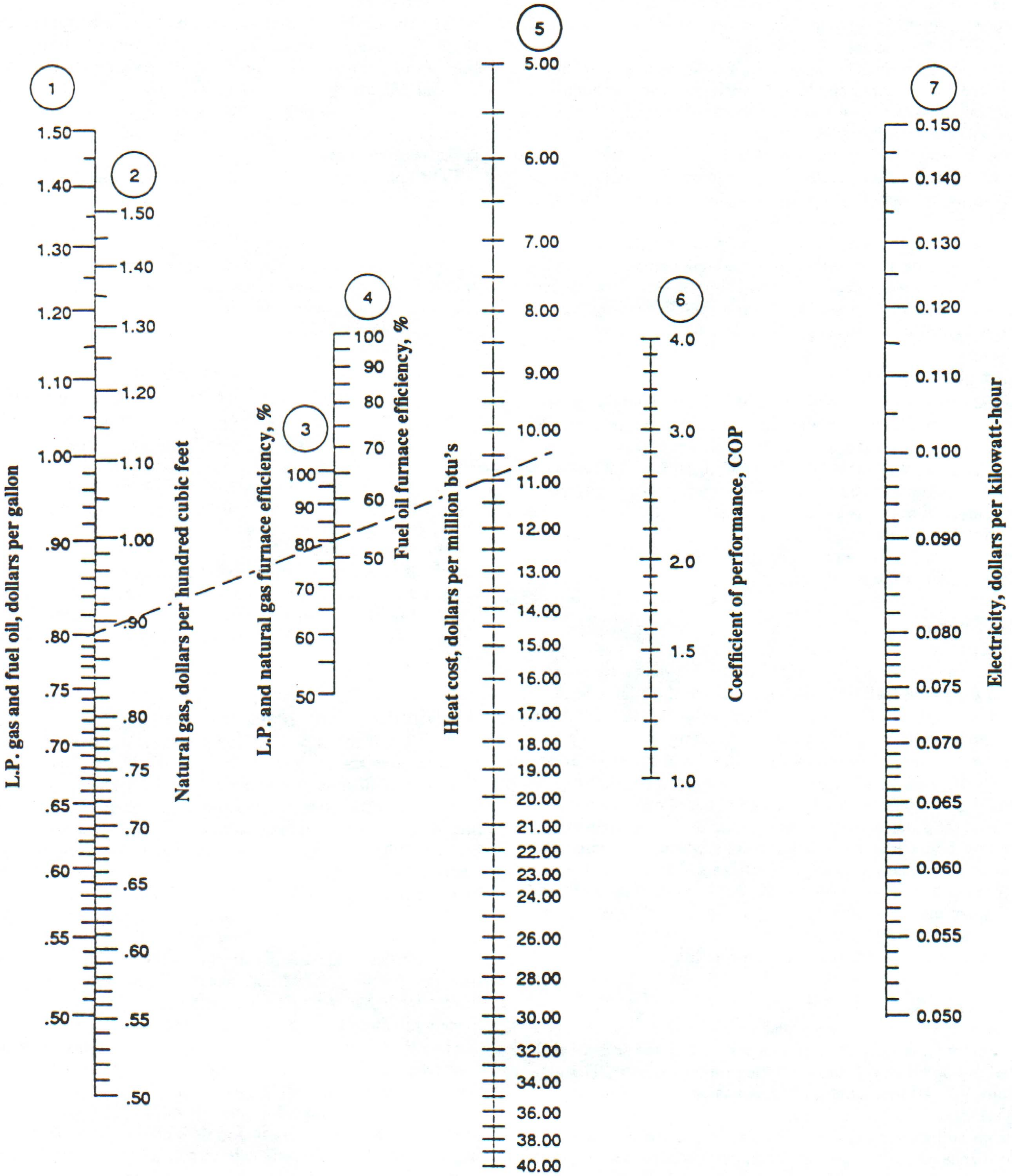

Figure 2. Nomograph for estimating heat cost.

Produced by Outreach Communications and printed on recycled paper using vegetable-based inks.

MAJOR REV (destroy old)-11/92-2M-ES-SP-35¢