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Standby Electric Generators for Emergency Farm Use

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An emergency source of power is essential for any farm with mechanically ventilated production facilities, bulk milk-handling equipment, automated feeding systems, or facilities requiring constant and consistent heat or refrigeration. A standby power generator is an excellent investment to prevent costly losses during local power failures. This publication provides guidelines to make the selection, sizing, and operation of standby generators easier.

Types of Generators

Standby generators can be either engine- or tractor-driven. Engine-driven generators are often sold together with an engine as a single package or "genset." The engine can be either manual or automatic start. Gasoline-, liquid-propane- (LP-) gas-, and diesel-fueled models are available. Engine-driven standby generators are often large, permanently-mounted, diesel units. The advantages of engine-driven generators include more efficient fuel use, longer periods of continuous operation, lower noise levels, and quicker start-up after power outages. The main disadvantage of engine-driven generators is the high initial cost.

Tractor-driven generators are powered from the tractor's power-take-off (PTO) shaft. The advantages of these generators include lower initial costs and less maintenance because an engine is eliminated. The disadvantages of tractor-driven generators include noisier operation and limited output capacity. These generators also take several minutes to start-up. Tractor-powered generators are often trailer-mounted for portability.

Planning the Generator System

Generators are rated by the amount of electrical power they generate in terms of kilowatts (kW). One kW equals 1,000 watts (W). Two ratings are often listed on the generator nameplate. The smaller number is the "continuous rating," which is the generator's power output during general operation. The larger number is the "peak rate." This is the power produced by the generator for short-term overloads such as when a motor starts.

Generators must provide the same type of power at the same voltage and frequency as that supplied by the power lines. This is usually 120/240 volt, single-phase, 60-cycle alternating current (AC). This type of electrical system can power single-phase motors from 1/4 to 10 horsepower (hp). Motor sizes above this require a three-phase system. This publication only discusses single-phase motors.

Electric motors for agricultural use require about four times more power to start than to run. Thus, the start-up power requirement (load) can be estimated by multiplying the operating load by 4. Heaters and lights are resistance loads, so the start-up and operating loads are the same. Table 1 lists start-up and operating loads for several single-phase motor sizes.

Table 1. Start-up and operating loads for single-phase motors at 240 volts. Start-up loads are assumed to be four times the operating load[1].

Motor Size (hp)	Operating Load (kW)	Start-up Load (kW)
1/2	0.575	2.30
3/4	0.800	3.20
1	1.075	4.30
2	1.85	7.40
3	3.075	12.3
5	4.55	18.2
7 1/2	6.75	27.0
10	9.00	36.0

[1] *Start-up loads can be 2 to 12 times the operating load depending on the motor type and load. For motors designed for non-agricultural use, check with the manufacturer or with an electrical contractor for actual start-up loads.*

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Full Electrical-Load Systems

A full electrical-load (full-load) system provides the electrical load for the entire farmstead. Automatic-start, engine-driven generators are recommended for full-load systems to prevent power disruptions. The main advantage of full-load systems is that all equipment can be started at the same time. Furthermore, the greater generator capacity of full-load systems allows more flexibility to add equipment.

Partial Electrical-Load Systems

A partial electrical-load (part-load) system is used only for critical electrical loads such as milking equipment and ventilation fans. The generator capacity for a part-load system is much smaller than that for a full-load system. Tractor-driven generators are generally used for part-load systems. The main advantage of part-load systems is that lower capacity generators are less expensive and are designated to specific operations.

Sizing a Full-Load Generator System – Example

Determine the size of an automatic-start, engine-driven generator for a full-load electrical system with the equipment listed in Table 2. Assume the start-up load is four times the operating load. Size the generator using the following steps:

1. List the operating and start-up loads of all motors to be connected to the generator. Note that the start-up load is the same as operating load for heaters and lights as previously mentioned.

Table 2. Start-up and operating loads for the equipment in the full-load electrical system example.

Equipment and Motor Size (hp)	Operating Load (kW)	Start-up Load (kW)
Fan #1, 1/2 hp	0.575	2.30
Fan #2, 1/2 hp	0.575	2.30
Water pump, 1/2 hp	0.575	2.30
Milking machine, 1 hp	1.075	4.30
Bulk milk cooler, 2 hp	1.85	7.40
Silo unloader, 5 hp	4.55	18.2
Freezer, 1/2 hp	0.575	2.30
Electric heater	4.80	4.80
Lights	2.00	2.00
Total		**45.9**

2. Total the start-up load.

   Start-up load = **45.9 kW**

3. Add 20% to the total for future expansion, then round up to the nearest 5 kW.

   (45.9 kW × 20%) + 45.9 kW = **55.1 kW (60 kW)**

Sizing a Part-Load Generator System – Example

Determine the size of an automatic-start, engine-driven generator for a part-load electrical system with the equipment listed in Table 2. Assume that Fan #1 and the silo unloader are not essential equipment. Size the generator using the following steps:

1. List the operating and start-up loads of only the critical motors in order of highest start-up load first. Resistance loads (heater and lights) should be added last.

Table 3. Start-up and operating loads for the equipment in the part-load electrical system example.

Equipment and Motor Size (hp)	Operating Load (kW)	Start-up Load (kW)
Bulk milk cooler, 2 hp	1.85	7.40
Milking machine, 1 hp	1.075	4.30
Fan #2, 1/2 hp	0.575	2.30
Water pump, 1/2 hp	0.575	2.30
Freezer, 1/2 hp	0.575	2.30
Electric heater	4.80	4.80
Lights	2.00	2.00

2. Determine the peak load as each of the loads is added as shown in Table 4. Add the start-up load of the next piece of equipment to the operating load of the running equipment. In this case, the peak load occurs at Step 7 when the lights are added. **The peak load is 11.5 kW**.

3. Add 20% to the total for future expansion, then round up to the nearest 5 kW.

   (11.5 kW × 20%) + 11.5 kW = **13.8 kW (15 kW)**

Table 4. Peak electrical loads using sequence of motors shown in Table 2. Shaded boxes indicate start-up loads.

Equipment and Motor Size (hp)	Step 1 (kW)	Step 2 (kW)	Step 3 (kW)	Step 4 (kW)	Step 5 (kW)	Step 6 (kW)	Step 7 (kW)
Bulk milk cooler, 2 hp	7.40	1.85	1.85	1.85	1.85	1.85	1.85
Milking machine, 1 hp		4.30	1.075	1.075	1.075	1.075	1.075
Fan #2, 1/2 hp			2.30	0.575	0.575	0.575	0.575
Water pump, 1/2 hp				2.30	0.575	0.575	0.575
Freezer, 1/2 hp					2.30	0.575	0.575
Electric heater						4.80	4.80
Lights							2.00
Peak Load (W)	**7.40**	**6.15**	**5.225**	**5.80**	**6.375**	**9.45**	**11.5**

Sizing a Tractor for a Tractor-Driven Generator

The tractor for a tractor-driven generator must have at least twice the horsepower as electrical output of the generator (2 hp per 1 kW). For example, determine the tractor size for a 60 kW generator:

2 hp/kW × 60 kW = 120 hp tractor size

Connecting the Generator System

Improperly connected generators can pose serious safety hazards to people and livestock. Generators must be connected to a wiring system through a transfer device that prevents power from feeding back in the supply line. Install a double-pole transfer switch to prevent feedback. Contact your local power supplier before installing a generator and have a licensed electrician make all electrical connections. Wiring should be installed in accordance to local codes and the requirements of the local power supplier.

Generators should be anchored to a 6-inch concrete pad and sheltered from the weather. For generators housed inside, provide a half of a square foot of inlet and outlet air opening for each 1 kW of generator rating to allow excess heat to escape. Combustion fumes must be carried outdoors safely and away from building inlets. Exhaust pipes should be at least 6 inches from combustible material.

Operation

Automatic-start generators should start automatically when power fails and stop when power is restored. The procedure for using manual-start engine-driven or tractor-driven generators follows:

- Call power supplier and advise of power outage
- Turn off or disconnect all electrical equipment before starting
- Position the tractor or engine for belt of PTO drive
- Start the unit and bring the generator up to proper speed (540 or 1000 rpms)
- Check voltage to indicate when the generator is ready to carry the load
- Put the transfer switch in the generator position
- Turn on the motors one at a time, starting with the largest motor first
- Monitor voltage and keep 240 V (±10%) at generator
- Put the transfer switch in normal power position when commercial power is restored
- Stop the standby unit

The length of time a generator can run depends on the size of the fuel tank and the size of the load on the generator. Higher loads require more fuel. Gasoline- and diesel-fueled models use slightly less fuel than those fueled by LP-gas. Check with the manufacturer for specific information.

Maintenance

Generators should be kept clean and in good running condition, so they will be ready for immediate use. Dust and dirt accumulations on the motor can cause it to overheat when running. To keep engines in good operating condition, generators should be operated under at least 50 percent load for short durations throughout the year. Fuel should be replaced or used every two months to prevent moisture condensation in the tank.

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For Additional Information:

On Farm-Building Wiring:

MWPS-28 "Farm Buildings Wiring Handbook" ($10.00)

On Stray Voltage:

NRAES-149 "Stray Voltage and Dairy Farms" ($45.00)

To order MWPS or NRAES publications, contact your local Virginia Cooperative Extension office.

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