Livestock Watering
FACTSHEET

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POWERING LIVESTOCK WATERING PUMPS

This Factsheet outlines motor and engine options to power pumps typically used in livestock watering systems.

Introduction

The following two pumping energy options were outlined in Table 2 of Factsheet #590.305-1, ***Pumping Livestock Water: It's All About the Energy Choices !:***

- on-site energy (gravity; livestock themselves; solar / wind)
- off-site energy brought to the site (electrical grid; petroleum)

This Factsheet looks at the type of motors or engines typically selected to power livestock watering pumps, mostly using **off-site energy that can be brought to the site**. On-site energy options are covered in other Factsheets in this series.

Electric Motors

Electricity motors can be energized by either direct current (DC) electricity, typically 12 or 24 volt, or by alternating current (AC), typically from the electrical 'grid'.

DC Electric Power. Direct current electricity can be used to power water pumps. As DC power is usually only transmitted short distances, it is generated on-site from solar energy (photovoltaic panels), wind energy, or gravity water flow (hydroelectricity). These are usually low energy systems.

DC Motor Selection. DC motors are unique in that their rotational speed is proportional to the voltage they receive, up to their rated voltage. For instance a 12 volt DC motor will still power a pump when supplied with less than 12 volts; it will just rotate slower (and must be matched to appropriate pumps). This is important in solar systems that directly-power a pump (systems without batteries) as water will be pumped in less than full sunshine.

For livestock watering systems, DC motor selection involves decisions on the following specifications:

- motor voltage – DC systems are typically 12 or 24 volt, but can be any multiple of 12 volt (e.g. Factsheet #590.305-6, ***Using Solar Energy to Pump Livestock Water*** discusses a 180 volt DC system)
- motor size (power); voltage x amperage = wattage (or horsepower)
  - refer to Factsheet #590.304-3 ***Livestock Water System Design #3 - Calculating Pumping Requirements*** for motor sizing information
- consider permanent magnet DC motors for their increased efficiency
- other features will depend on the pumping system

AC Electric Power. Alternating current electricity is a clean, inexpensive (about $0.07 per kilowatt-hour in B.C.) and reliable power source. AC electric motors are very efficient (80-90%+), require minimum maintenance, have a long service life, are easily automated and are available in a wide range of sizes.

The main disadvantage to AC electricity is the cost of the power supply line (if the power is not reasonably close to the pumping site) or of on-site generation. A secondary disadvantage is AC motors run at constant speed. Some pumps may require a speed conversion drive to operate at their best rpm.

Where readily available, AC electricity should be considered the best power source for water pumping. AC electricity is supplied in two "forms": single phase and three phase.

Single Phase AC. The standard electrical distribution system in most areas is single phase power. Generally, motors up to 10 horsepower can be directly hooked to a single phase supply. Motors larger than 10 horsepower will usually require a "soft start" system to operate on a single phase line.

Single phase motors are not self starting requiring an auxiliary starting method. A starting capacitor connected to the start winding of the motor is usually used. The capacitor is used to get the motor started and up to running speed at which point a switch disconnects the capacitor and start winding. Three-wire single phase motors have the starting capacitor and control box located above ground away from the motor – a two wire system has the starting device mounted within the motor housing.

Three Phase AC. Three phase is usually used for motors larger than 10 horsepower. These motors are self starting and do not require starting capacitors or control boxes. Three phase motors use magnetic starters containing three leg overload protection. Many stock watering systems will not require this size of motor.

AC Motor Selection. For livestock watering systems, AC motor selection involves decisions on the following specifications:

- motor size (power) - single phase motors under 10 hp
  - refer to Factsheet #590.304-3 ***Livestock Water System Design #3 Calculating Pumping Requirements*** for motor sizing information
- motor speed - usually 1725 rpm
- motor duty - continuous or intermittent
- motor start type - depending on pump starting load
- motor bearing - sleeve or ball bearings
- motor enclosure - depending on operational environment
- motor mounting base - rigid or adjustable
- motor controls - overload protection or protection from loss of water (an amperage-sensing device which turns off the motor if low amperage draw occurs – i.e., the pump is no longer 'working' and pumping water – with an adjustable re-start timer)

Internal Combustion Engines

Petroleum-fueled internal combustion engines (natural gas, propane, gasoline or diesel) are not as efficient as electric motors and require additional maintenance. The operating costs can be 5 to 10 times higher than electrically operated systems. They would typically be chosen when:

- electricity is not readily available
- the system will only be used temporarily or for emergencies
- the pump system must be portable

Engines can operate over a range of speeds with direct pump drives. However the engine output at the speed it will be operated at must be sufficient to power the pump. For instance a 3 horsepower gasoline engine running at half speed will not produce 3 horsepower. The manufacturers' power curve and specifications should be used to estimate the actual power at the individual systems conditions. Note that the rated power of an engine is usually the maximum output at maximum speed whereas the actual useable power is less.

Depending on the annual operation time, life expectancy of engines is less than electric motors: gasoline engines can be as low as a year or two; diesel engines a few years and electric motors up to 20 years. The periodic engine rebuilding costs must be included in the annual operating costs.

The main reason for considering internal combustion engines is their quick set up time and portability. For the water volumes usually pumped in livestock watering systems, small gasoline engine/pump units are commercially available. These are typically medium to high volume pumps with low lift. For a particular site condition, the engine and pump must be selected for the system requirements.

Gasoline vs Diesel Engines. Diesel engines are usually selected over gasoline engines in larger horsepower systems or systems operating many hours annually. The initial cost of a diesel engine is approximately 3 to 4 times that of a gasoline engine but has a life expectancy equally longer. For small systems, gasoline may offer a greater selection of engines than diesel. In most cases, as system size increases, diesel will typically be preferred.

Selecting a Power System for a Pump

Use Table 1, next page, which outlines the above points and consider the following points when selecting a power system for a pump:

- does the watering system need to be automatically started and stopped?
  - electrical motors can be easily automated
  - fuel engines are much more difficult to automate
- is the water volume small (less than 10 USgpm or 5,000 US gal per day)?
  - small volume systems may not be a good match with fuel engines
- is the system operated for only a few hours daily?
  - similar to above, small systems may not be a good match with fuel engines
- what 'duty cycle' or operation cycle is needed?
  - whether the pump will be operated intermittently or continuous
- what is the comparison costs of options?
  - compare the cost of supplying electrical power plus operational cost to the engine cost and operating fuel cost as shown in the Example, next page

Motor Drives

If motor and pump speed match, a direct drive can be used. The motor can be coupled directly to the pump with a flexible device that will allow for misalignment.

If motor speed doesn't match the required pump speed, a speed conversion drive will be required. Pulley-and-belt drives, gear drives and chain-and-sprocket drives are three common drives for speed conversion.

Table 1 Characteristics of Pump Motors and Engines Typically Used in Livestock Watering Systems [1]

Power Type	Relative Cost [2]	Energy Cost	Efficiency [2]	Life [3]	Abilities	Limitations
DC Motor (fractional horsepower) [4]						
field wound	mid	generated on-site [5]	low/mid	medium	-variable-speed with voltage	- on-site generation costs
permanent magnet	mid		mid		-variable-speed with voltage -efficiency makes good match for solar systems	
AC Motor						
single phase	low	$0.07 per kWhr [6]	mid	long	-inexpensive; long life -easy to automate	-under 10hp or soft start -electrical supply costs
three phase	low		high		-over 10 hp possible	-limited grid available
Gasoline Engine						
single or multi cylinder	low/mid	$0.80 per litre [6]	low/mid	short/ medium [7]	-matched to small/mid systems (volume, lift, hours of use)	-difficult to automate -fuel delivery issues
Diesel Engine						
single or multi cylinder	high	$0.80 per litre [6]	mid	medium/ long [7]	-matched to mid/large systems (volume, lift, hours of use)	-difficult to automate -fuel delivery issues

[1] refer to the text for engine and motor details

[2] as the power unit is typically used for a livestock watering pump: cost and efficiency relative to other choices of equal power lowest cost usually for a manufacturers power unit and pump combination rather than separate components assembled

[3] as the power unit is typically used for a livestock watering pump: short = under 4 years; medium = 4-8 years; high = over 8 years

[4] DC motors used in livestock watering systems are usually low power motors

[5] energy cost varies with cost of typical on-site solar, wind, or hydroelectric generation system

[6] electricity and marked fuel costs as of February 2006

[7] depending greatly on maintenance done; longer life with regular maintenance, such as oil changes on engines w/o oil filter

Other Information

A web site on how DC motors work:
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/motdc.html

A web site on how AC motors work:
http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/motorac.html#c1

A web site with detailed information on electric motors:
http://www.electricmotors.machinedesign.com/

A web site on how internal combustion engines work:

- gasoline engines http://auto.howstuffworks.com/engine1.htm
- diesel engines http://auto.howstuffworks.com/diesel1.htm

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