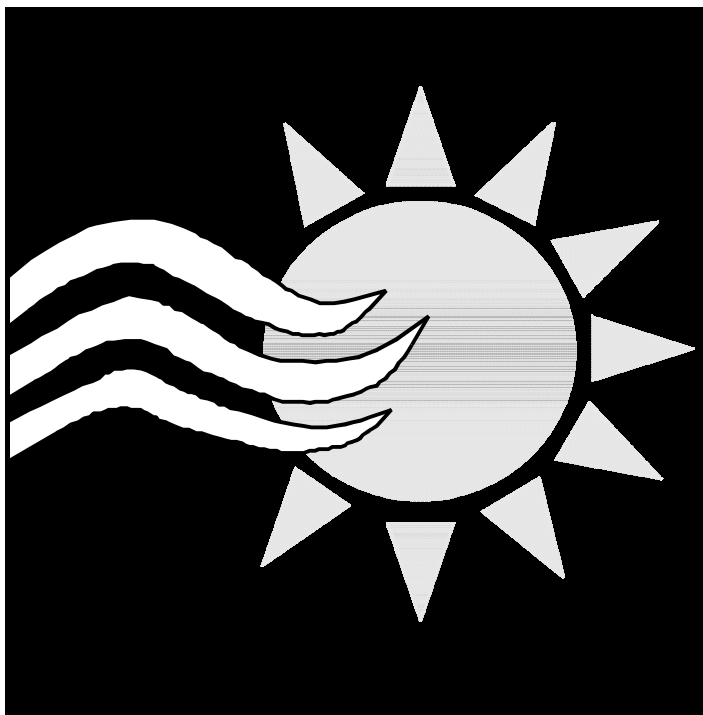


Summary Report 703



Alberta Renewable Energy Test Site

**Summary of Wind and Solar Powered Pumping Units
(1992 Test Season)**

A Co-operative Program Between



PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

SUMMARY OF WIND AND SOLAR PUMPING SYSTEM TESTS (1992)

TABLE OF CONTENTS

Performance results, appearing in alphabetical order, are given for the following wind and solar water pumping systems.

SOLAR SYSTEMS

Canadian Agtechnology Partners:

- 348 MF5
- 448 MRU
- 448 TRU
- ALTA JACK PUMP
- CAP SCREW PUMP

Solar Innovations Inc.:

- SOLAR JACK SDSQ

WIND SYSTEMS

- AERMOTOR
- BREEZE-1
- DELTA 16 (15 metre lift)
- DELTA 16 (30 metre lift)
- KOENDERS
- MAVERICK WINDMOTOR

RENEWABLE ENERGY PUMPING SYSTEMS

Renewable energy pumping systems have become economic alternatives for many agricultural applications. Typically, this type of pumping system is used in locations removed from an electric power source. In these instances, the cost of the pumping system is often less than the cost of extending the power lines from the nearest source. In Canada, the most common agricultural applications of these systems are livestock watering and sub-surface drainage. Livestock watering generally consists of pumping from a dug-out or stream to a watering trough to eliminate contamination of the water source. These systems can also be used to pump to pastures for livestock use as part of a grazing management system. Sub-surface drainage is installed to lower water tables or intercept discharge areas such as sidehill saline seeps or seepage from irrigation canals. The drains gravity feed to a central sump which is then emptied with a pumping system. Both livestock watering and sub-surface drainage are typically low lift applications less than 20 ft. (6 m).

TEST RESULTS

The following results have been extracted from the Lethbridge Wind Research Test Site report for the 1992 test season. The Lethbridge Wind Research Test Site was in operation from 1982 to 1992 and was managed most recently by the Alberta Farm Machinery Research Centre (AFMRC). The test site has since been relocated to Pincher Creek, Alberta and renamed the Alberta Renewable Energy Test Site. The detailed report used for this summary is available upon request from AFMRC.

The purpose of this summary is to condense the available information so that direct comparisons can be made among the various makes and models of the systems tested. This, in turn, will aid in the selection process of the right pumping system for a given application.

SCOPE OF TEST

The wind pumping system tests were performed in accordance with the Canadian Standards Association (CSA) Standard F417-M91 "Wind Energy Conversion Systems (WECS)-Performance". The solar pumping system tests also followed this standard in respect to instrumentation accuracy, sampling speed, averaging intervals and minimum data base requirements. The utilization of the above standard for the solar tests was required as no CSA field test standard has been prepared for solar pumping systems. Use of this standard also ensures uniformity of performance reporting. The Standard requires sampling the input energy (wind speed or incident solar radiation) and the performance variables of the pumping system at one sample per second and calculating ten minute averages. Each ten minute average is then grouped into a range of wind speeds or a range of solar radiation intensities. These ranges are, in turn, averaged, resulting in the final performance curve. The probability of these averages occurring are calculated to determine if they meet the Standard's minimum requirements.

For each system in this summary report, a performance page has been prepared. The performance page consists of a picture of the unit, a physical description of the system, a reporting of its reliability and graph(s) of its performance. In the case of wind systems, a graph of the expected pumping volume as a function of monthly mean wind speed has been produced. The performance graphs of the solar systems present the current draw of the pump and the voltage supplied by the solar panels. They also present the power draw of the pump and the resulting water flow (pumping rate). The Data Summary tables are available upon request.

CAP 348MF5

MANUFACTURER AND DISTRIBUTOR:

Canadian
Agtechnology Partners
P.O. Box 2457
Olds, Alberta, Canada
T0M 1P0
(403) 556-8779

PERFORMANCE:

Testing Period: 112 days
Period Operational: 87 days
Percent Availability: 78%

INSTALLED: June 26, 1992

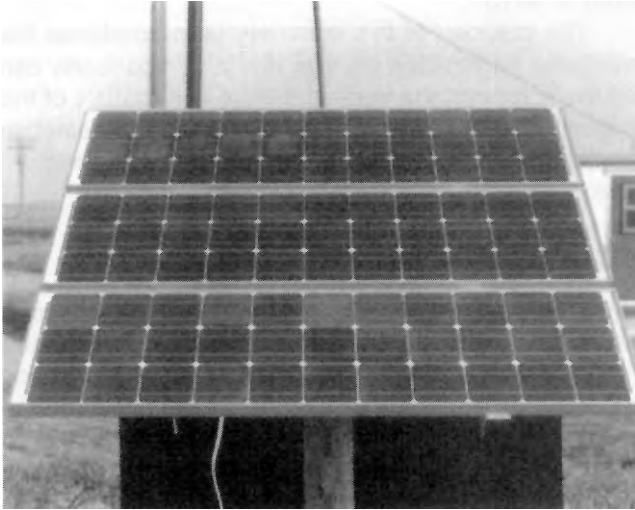


FIGURE 1. CAP 348MF5 Solar System.

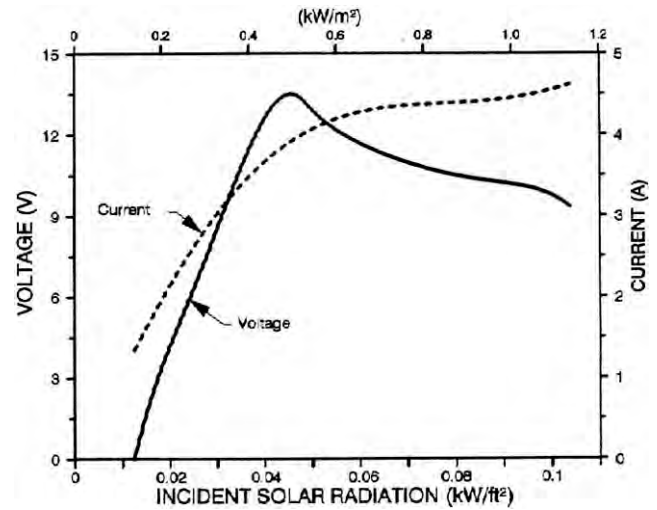


FIGURE 2. Voltage and Current versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 3
Panel Manufacturer: Siemens
Power Rating @ 77°F (25°C) and 93 W/ft²-
(1000 W/m²): 48 W/panel
Configuration: parallel
Mount: fixed
Pump Type: diaphragm submersible pump

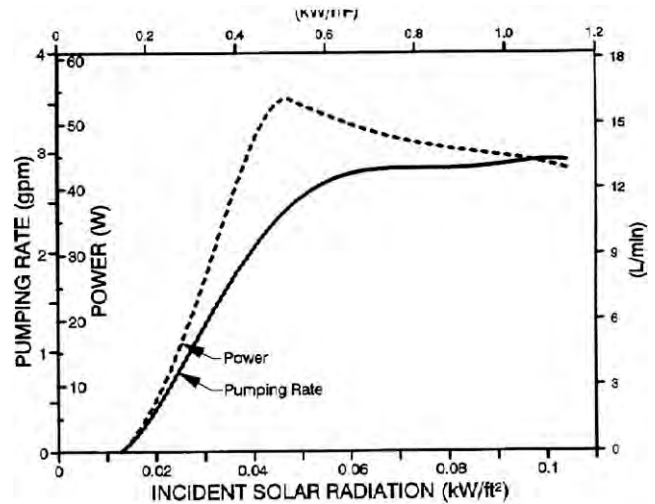


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

CAP 448MRU

MANUFACTURER AND DISTRIBUTOR:

Canadian
Agtechnology Partners
P.O. Box 2457
Olds, Alberta, Canada
T0M 1P0
(403) 556-8779

PERFORMANCE:

Testing Period: 29 days
Period Operational: 29 days
Percent Availability: 100%

INSTALLED: June 26, 1992

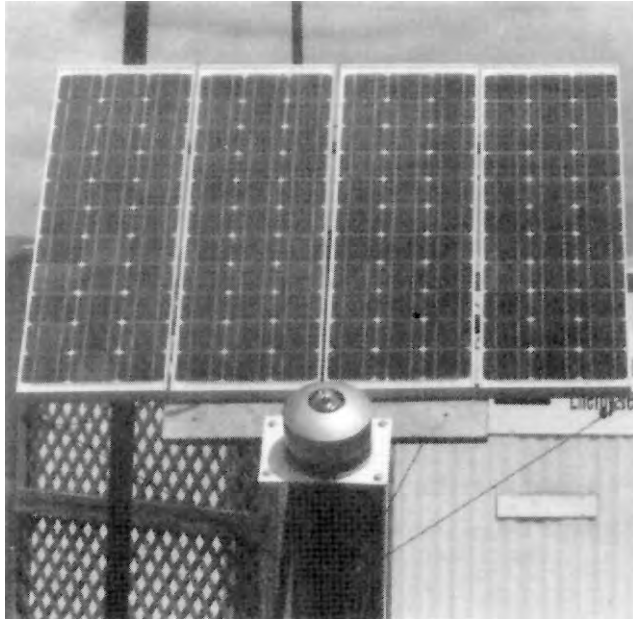


FIGURE 1. CAP 448MRU Solar System.

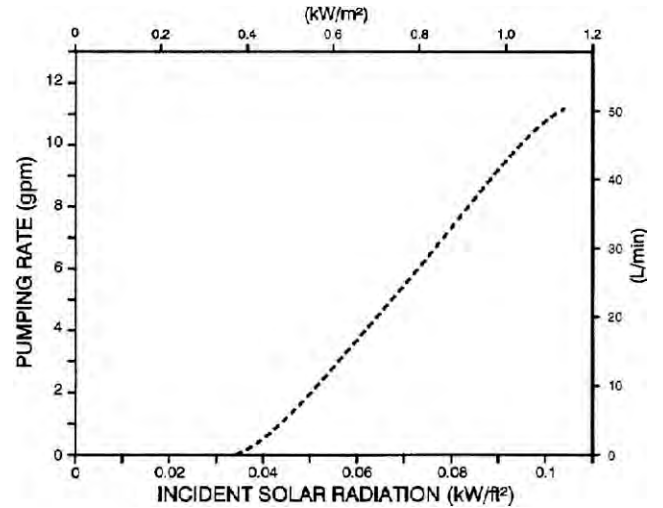


FIGURE 2. Pumping Rate versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 4
Panel Manufacturer: Siemens
Power Rating @ 77°F (25°C) and 93 W/ft²-
(1000 W/m²): 48 W/panel
Configuration: parallel
Mount: fixed
Pump Type: floating centrifugal (RU)

CAP 448TRU

MANUFACTURER AND DISTRIBUTOR:

Canadian
 Agtechnology Partners
 P.O. Box 2457
 Olds, Alberta, Canada
 T0M 1P0
 (403) 556-8779

PERFORMANCE:

Testing Period: 44 days
 Period Operational: 44 days
 Percent Availability: 100%

INSTALLED: August 31, 1992

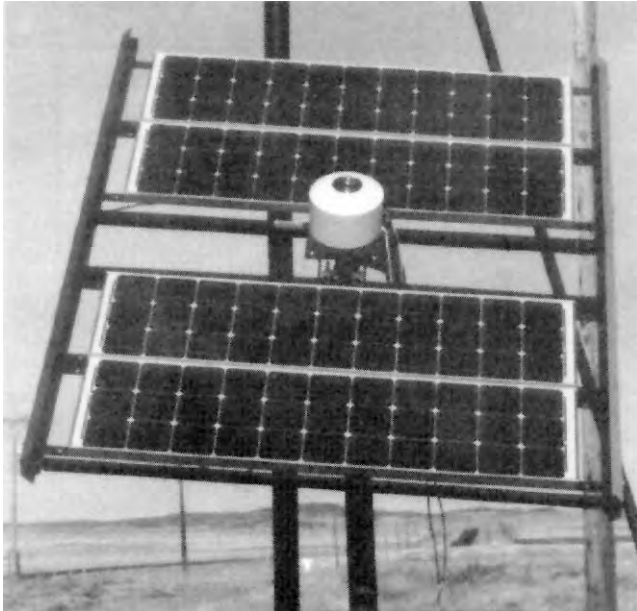


FIGURE 1. CAP 448TRU Solar System.

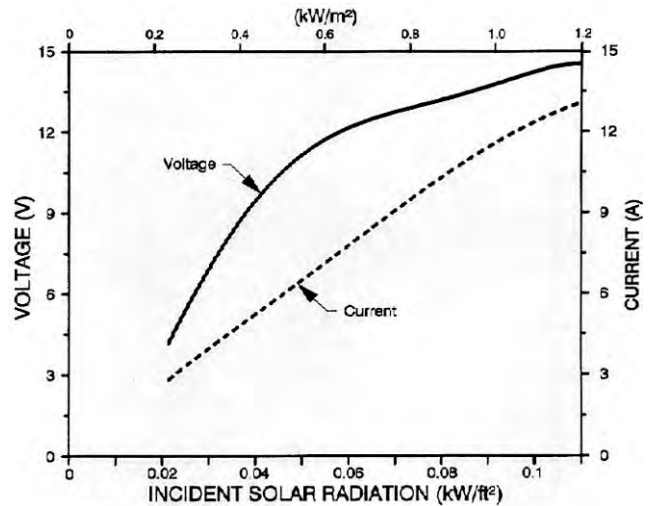


FIGURE 2. Voltage and Current versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 4
 Panel Manufacturer: Siemens
 Power Rating @ 77°F (25°C) and 93 W/ft²-
 (1000 W/m²): 48 W/panel
 Configuration: parallel
 Mount: tracker
 Pump Type: floating centrifugal (RU)

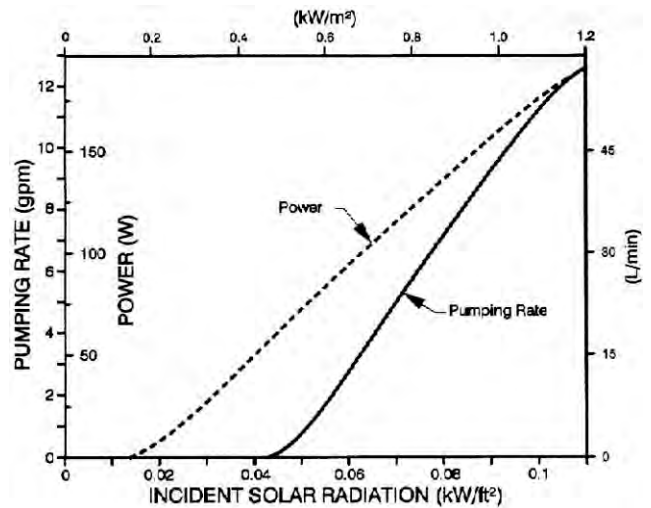


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

ALTA JACK PUMP

MANUFACTURER AND DISTRIBUTOR:

Canadian
 Agtechnology Partners
 P.O. Box 2457
 Olds, Alberta, Canada
 T0M 1P0
 (403) 556-8779

PERFORMANCE:

Testing Period: 29 days
 Period Operational: 6 days
 Percent Availability: 21%

INSTALLED: October 16, 1992

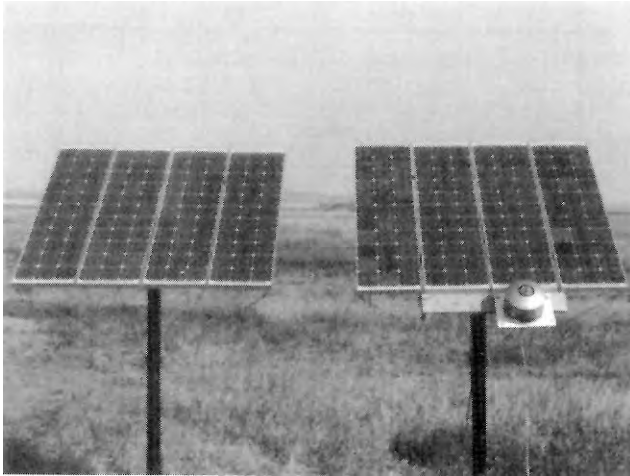


FIGURE 1. ALTA JACK PUMP Solar System.

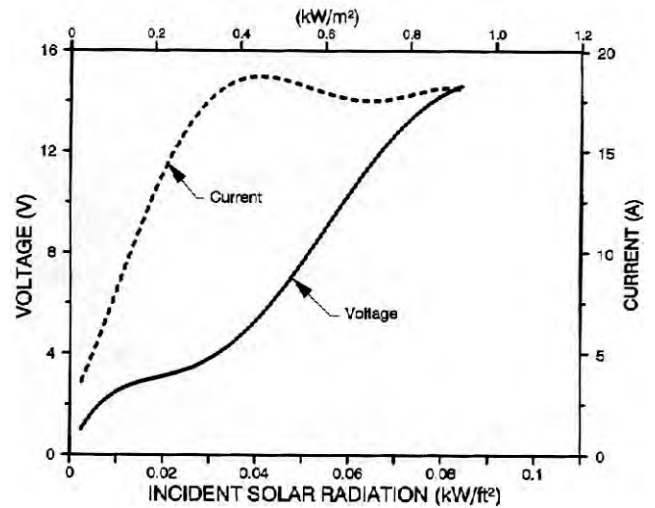


FIGURE 2. Voltage and Current versus Incident Solar Radiation for a 105 foot (32 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 8
 Panel Manufacturer: Siemens
 Power Rating @ 77°F (25°C) and 93 W/ft²-
 (1000 W/m²): 48 W/panel
 Configuration: parallel
 Mount: fixed
 Pump Type: positive displacement piston pump

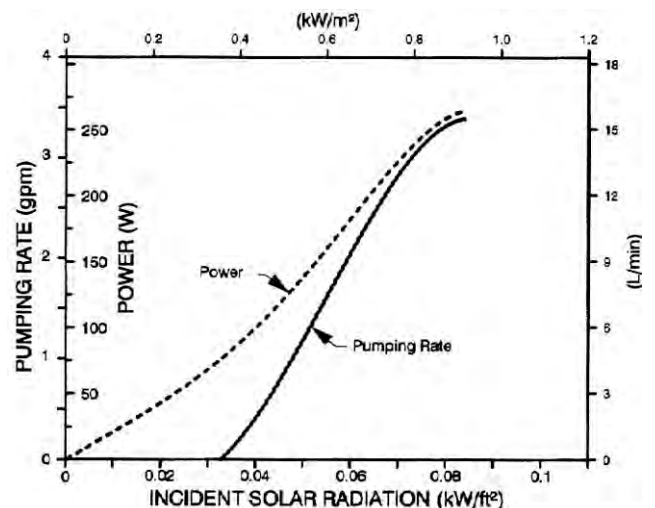


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for a 105 foot (32 m) Lift.

CAP SCREW PUMP

MANUFACTURER AND DISTRIBUTOR:

Canadian
 Agtechnology Partners
 P.O. Box 2457
 Olds, Alberta, Canada
 T0M 1P0
 (403) 556-8779

PERFORMANCE:

Testing Period: 32 days
 Period Operational: 30 days
 Percent Availability: 94%

INSTALLED: October 16, 1992

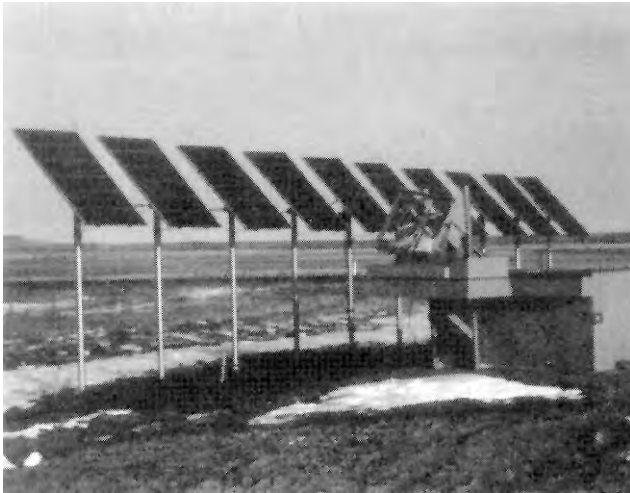


FIGURE 1. CAP SCREW PUMP Solar System.

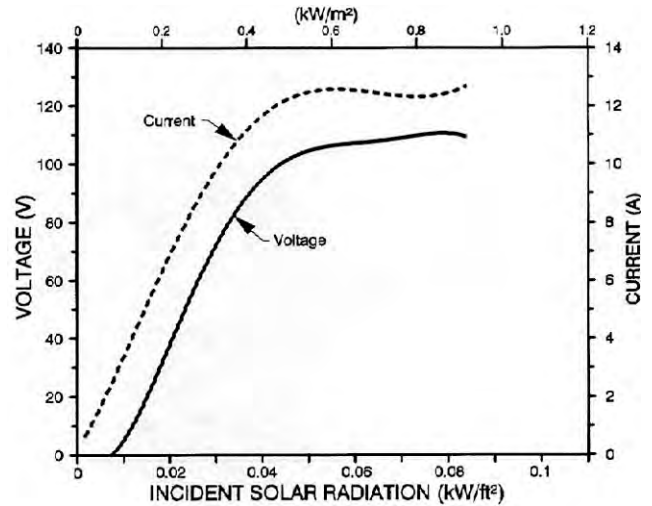


FIGURE 2. Voltage and Current versus Incident Solar Radiation for a 4.6 foot (1.4 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 60
 Panel Manufacturer: Siemens
 Power Rating @ 77°F (25°C) and 93 W/ft²-
 (1000 W/m²): 48 W/panel
 Configuration: 6 series, 10 sets parallel
 Mount: fixed
 Pump Type: archimedes screw pump

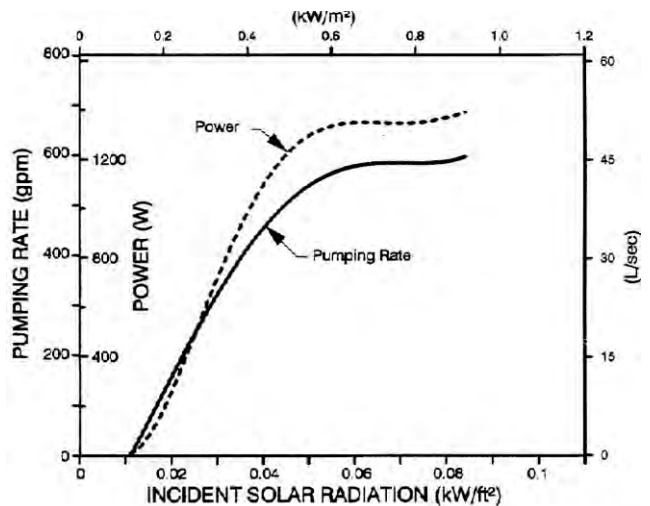


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for a 4.6 foot (1.4 m) Lift.

SOLAR JACK SDSQ

MANUFACTURER AND DISTRIBUTOR:

Solar Innovations Inc.
 7126 Barlow Trail S.E.
 Calgary, Alberta, Canada
 T2C 2E1
 (403) 279-6222
 FAX: (403) 279-6765

PERFORMANCE:

Testing Period: 103 days
 Period Operational: 103 days
 Percent Availability: 100%

INSTALLED: July 3, 1992

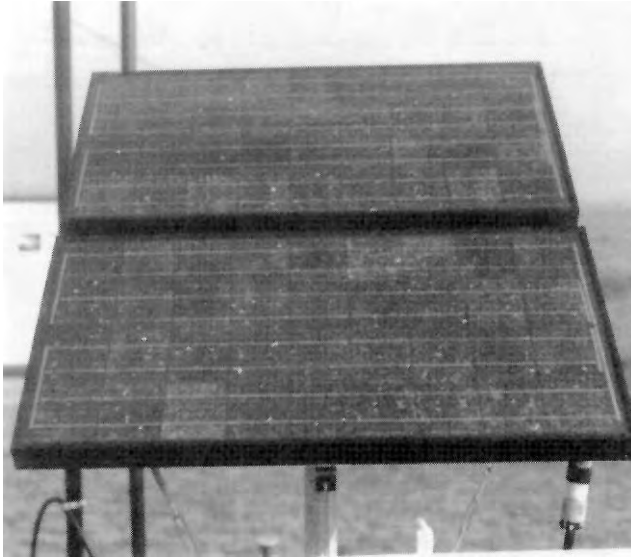


FIGURE 1. SOLAR JACK SDSQ Solar System.

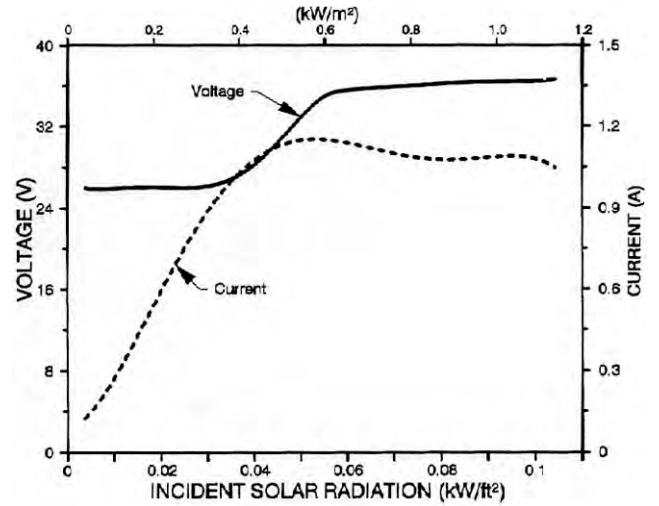


FIGURE 2. Voltage and Current versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Number of Panels: 2
 Panel Manufacturer: Solarex
 Power Rating @ 77°F (25°C) and 93 W/ft²-
 (1000 W/m²): 50 W/panel
 Configuration: series
 Mount: fixed
 Pump Type: submersible diaphragm

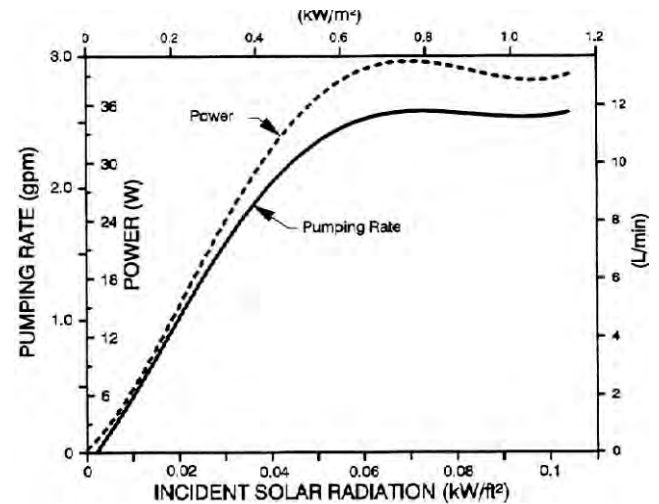


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for an 18 foot (5.5 m) Lift.

AERMOTOR

MANUFACTURER AND DISTRIBUTOR:

Tensigrity Systems Limited
 RR1
 Metcalfe, Ontario, Canada
 K0A 2P0
 (613) 821-4420

PERFORMANCE:

Testing Period: 139 days
 Period Operational: 139 days
 Percent Availability: 100%

INSTALLED: June 18, 1992

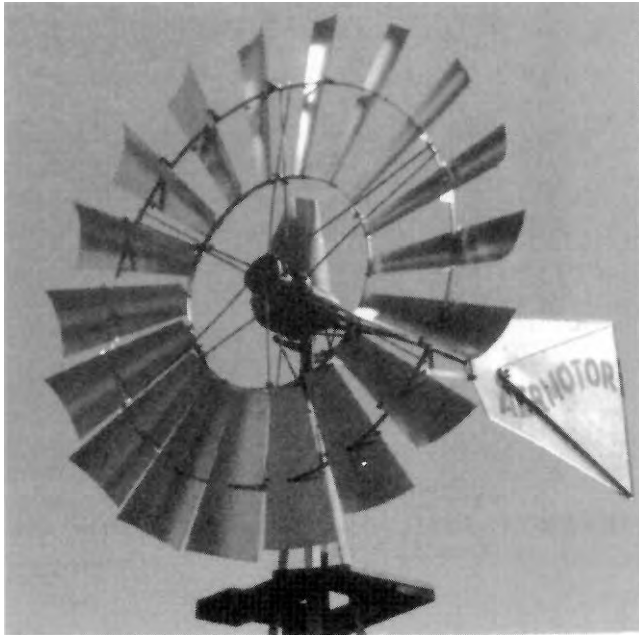


FIGURE 1. Aermotor Wind Turbine.

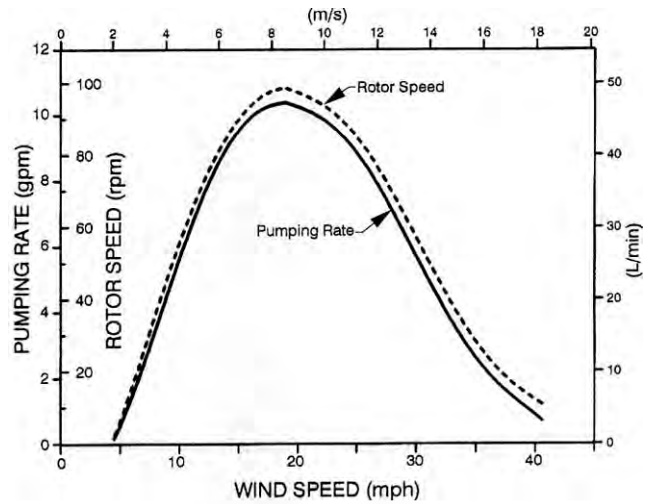


FIGURE 2. Pumping Rate and Rotor Speed versus Wind Speed for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
 Axis: horizontal
 Rotor Diameter: 8 ft (2.44 m)
 Swept Area: 50.38 ft² (4.68 m²)
 Number of Blades: 18
 Blade Design: torque aerofoil
 Blade Material: galvanized steel
 Hub Height: 25 ft (7.63 m)
 Transmission: mechanical gearing
 Gear Ratio: 3.29:1
 Pump Type: reciprocating piston
 Pump Size: 4 in dia. (102 mm)
 Stroke: 7.3 in (18.5 cm)
 Pumping System Description:
 reciprocating rod connected to positive displacement pump

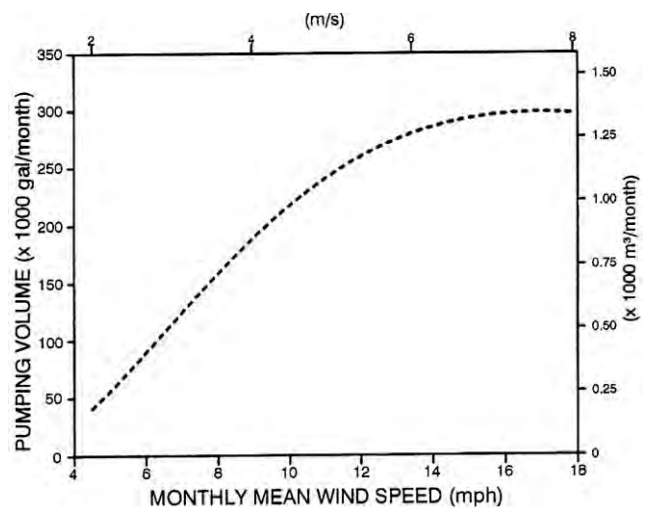


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

BREEZE- 1

MANUFACTURER AND DISTRIBUTOR:

Wind Powered Equipment
Box 416
Manning, Alberta, Canada
T0H 2M0
(403) 836-3907
FAX: (403) 836-3022

PERFORMANCE:

Testing Period: 90 days
Period Operational: 70 days
Percent Availability: 78%

INSTALLED: July 15, 1992



FIGURE 1. BREEZE-1 Wind Turbine.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
Axis: horizontal
Rotor Diameter: 7 ft (2.13m)
Swept Area: 38.43 ft² (3.57 m²)
Number of Blades: 3
Blade Design: airfoil
Blade Material: wood
Hub Height: 10.8 ft (3.3 m)
Transmission: direct drive
Gear Ratio: 1:1
Pump Type: diaphragm
Pump Size: diaphragm size = 5.9 in dia. (150 mm)
Stroke: 0.7, 0.86 or 0.98 in (18, 22 or 25 mm)

DELTA 16A (15 Metre Lift)

MANUFACTURER AND DISTRIBUTOR:

Dutch Industries Ltd.
 705 - 1st Avenue
 Regina, Sask., Canada
 S4N 4M4
 (306) 949-9522

PERFORMANCE:

Testing Period: 153 days
 Period Operational: 149 days
 Percent Availability: 97%

INSTALLED: May 1, 1992



FIGURE 1. DELTA 16A Wind Turbine.

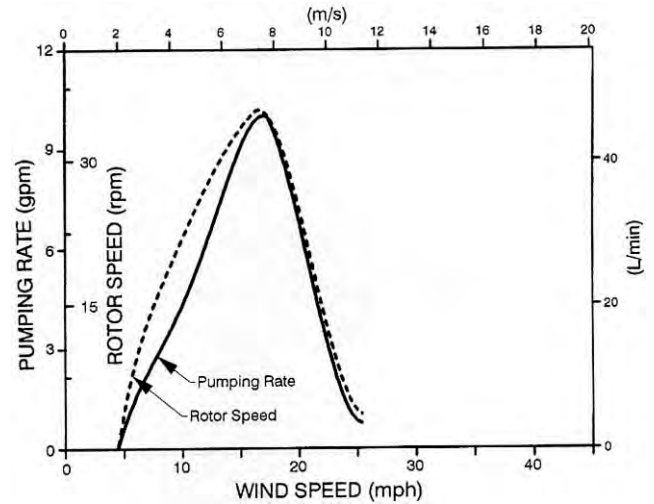


FIGURE 2. Pumping Rate and Rotor Speed versus Wind Speed for a 49 foot (15 m) Lift.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
 Axis: horizontal
 Rotor Diameter: 15.8 ft. (4.82 m)
 Swept Area: 80.5 ft² (7.48 m²)
 Number of Blades: 32
 Blade Design: Delta Wing
 Blade Material: mild steel (20 GA)
 Hub Height: 27 ft (8.25 m)
 Transmission: direct drive
 Gear Ratio: 1:1
 Pump Type: reciprocating piston
 Pump Size: 4 in dia. (101.6 mm)
 Stroke: 6.5 in (165 mm)
 Pumping System Description:
 reciprocating rod connected to positive displacement pump

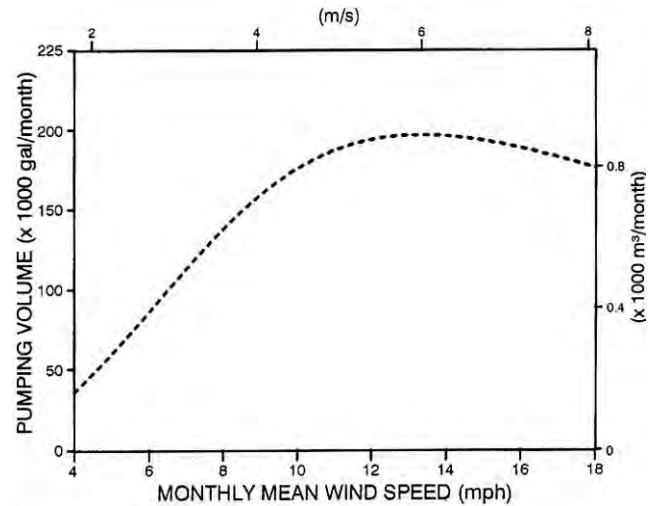


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

DELTA 16A (30 Metre Lift)

MANUFACTURER AND DISTRIBUTOR:

Dutch Industries Ltd.
 705 - 1st Avenue
 Regina, Sask., Canada
 S4N 4M4
 (306) 949-9522

PERFORMANCE:

Testing Period: 13 days
 Period Operational: 13 days
 Percent Availability: 100%

INSTALLED: October 1, 1992

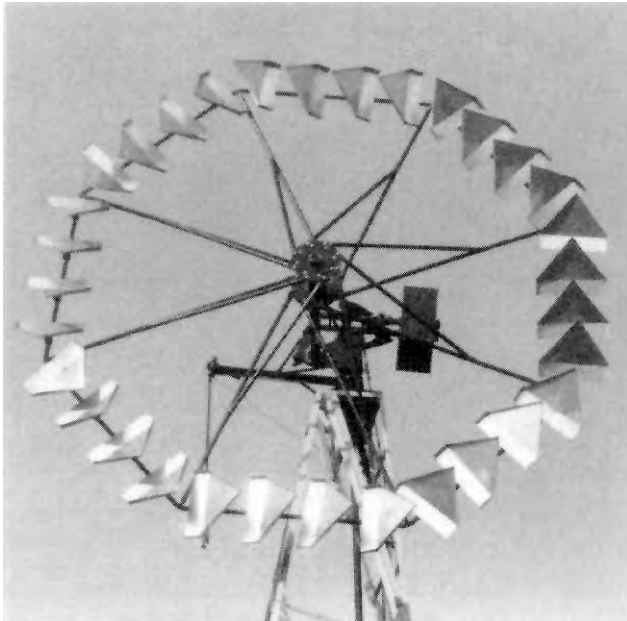


FIGURE 1. DELTA 16A Wind Turbine.

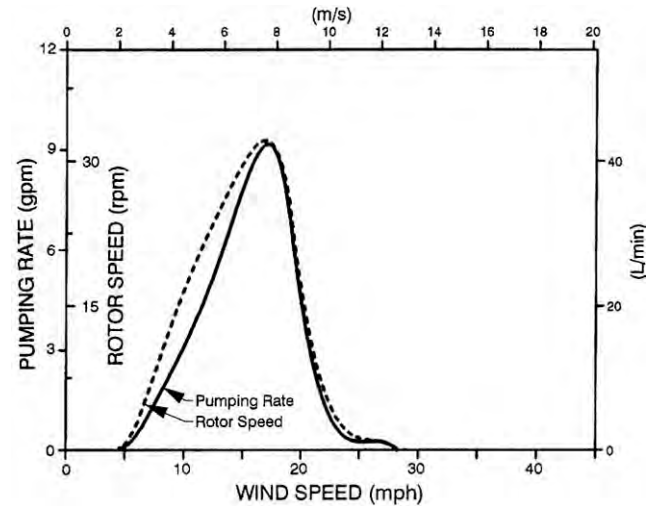


FIGURE 2. Pumping Rate and Rotor Speed versus Wind Speed for a 98 foot (30 m) Lift.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
 Axis: horizontal
 Rotor Diameter: 15.8 ft. (4.82 m)
 Swept Area: 80.5 ft² (7.48 m²)
 Number of Blades: 32
 Blade Design: Delta Wing
 Blade Material: mild steel (20 GA)
 Hub Height: 27 ft (8.25 m)
 Transmission: direct drive
 Gear Ratio: 1:1
 Pump Type: reciprocating piston
 Pump Size: 4 in dia. (101.6 mm)
 Stroke: 6.5 in (165 mm)
 Pumping System Description:
 reciprocating rod connected to positive displacement pump

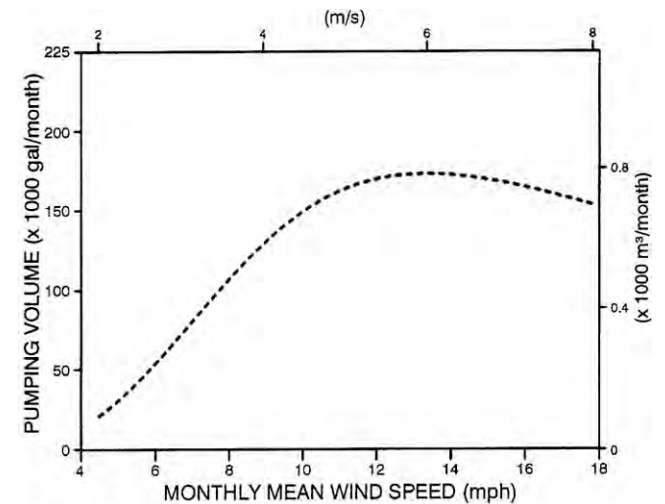


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

KOENDERS

MANUFACTURER AND DISTRIBUTOR:

Koenders Mfg. Co. Ltd.
 P.O. Box 171
 Englefield, Saskatchewan, Canada
 S0K 1N0
 (306) 287-3139

PERFORMANCE:

Testing Period: 114 days
 Period Operational: 105 days
 Percent Availability: 92%

INSTALLED: June 24, 1992



FIGURE 1. Koenders Wind Turbine.

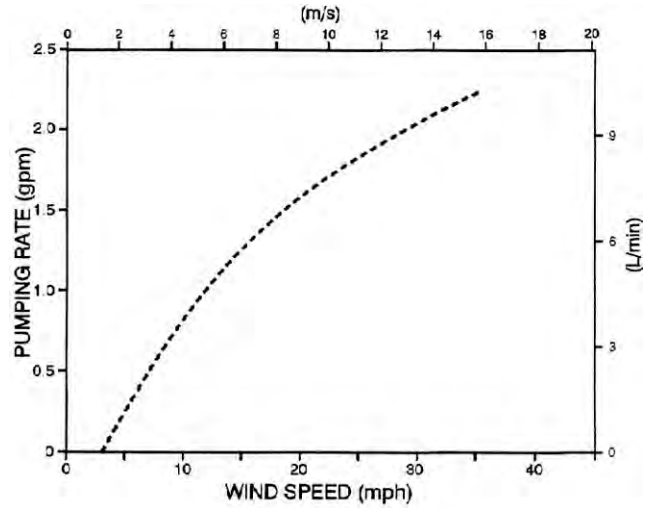


FIGURE 2. Pumping Rate versus Wind Speed for an 18 foot (5.5 m) Lift.

PHYSICAL DESCRIPTION:

Turbine Type: upwind
 Axis: horizontal
 Rotor Diameter: 5.1 ft (1.57 m)
 Swept Area: 21 ft² (1.95 m²)
 Number of Blades: 12
 Blade Design: proprietary
 Blade Material: galvanized steel
 Hub Height: 12 ft (3.66 m)
 Transmission: direct drive
 Pump Type: air operated proprietary system
 Pumping System Description:
 windmill driven diaphragm injects air into pump

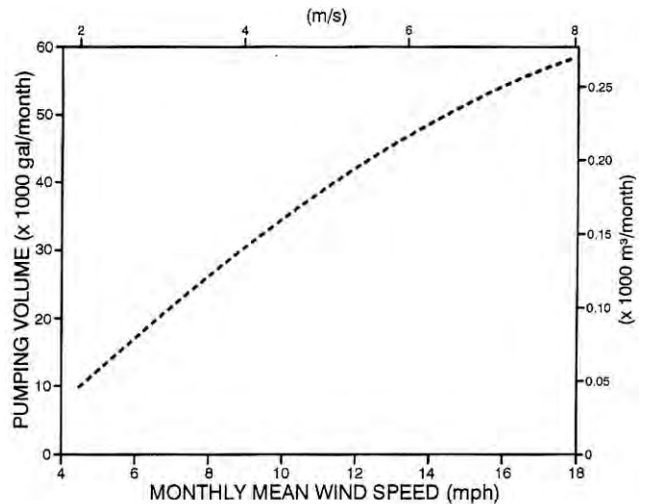


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

MAVERICK WINDMOTOR

MANUFACTURER AND DISTRIBUTOR:

Maverick Wind Energy Ltd.
 P.O. Box 2707
 Pincher Creek, Alberta, Canada
 TOK 1W0
 (403) 627-3630
 (403) 627-3091

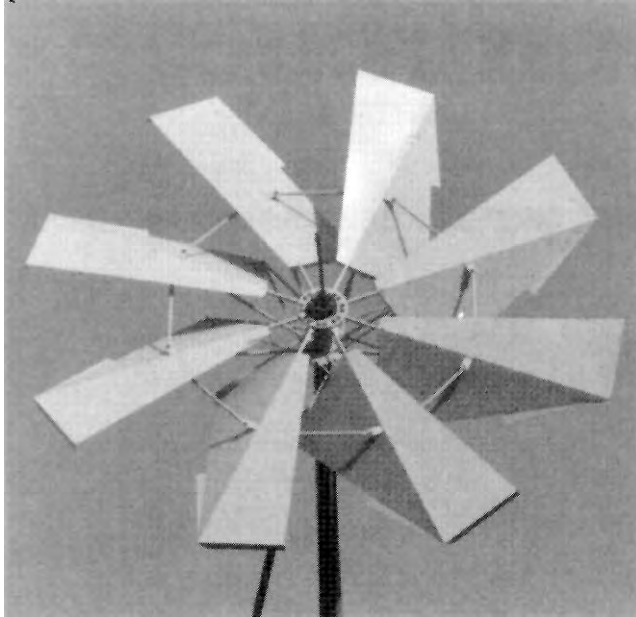


FIGURE 1. Maverick Windmotor Wind Turbine.

PHYSICAL DESCRIPTION:

Turbine Type: downwind
 Axis: horizontal
 Rotor Diameter: 8 ft (2.44 m)
 Swept Area: 50.4 ft² (4.68 m²)
 Number of Blades: 8
 Blade Design: high speed delta
 Blade Material: sheet metal
 Hub Height: 25 ft (7.62 m)
 Transmission: direct drive
 Gear Ratio: 1:1
 Pump Type: helical progressing cavity
 Pump Size: 4.5 in (114.3 mm) diameter
 Pumping System Description:
 direct cable drive from rotor to pump

PERFORMANCE:

Testing Period: 96 days
 Period Operational: 96 days
 Percent Availability: 100%

INSTALLED: July 9, 1992

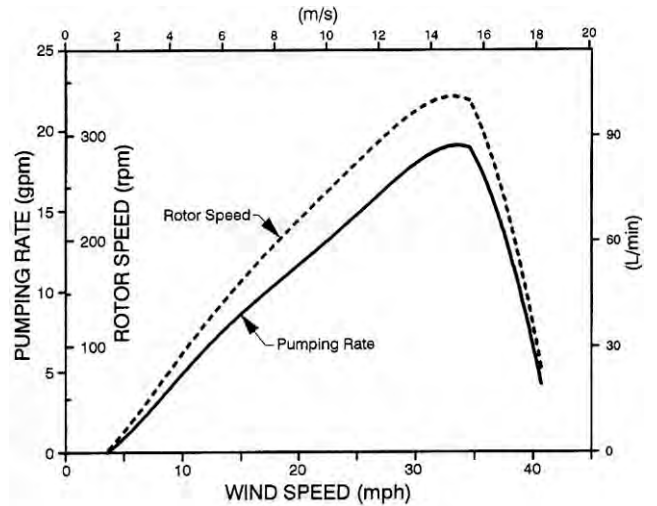


FIGURE 2. Pumping Rate and Rotor Speed versus Wind Speed for an 18 foot (5.5 m) Lift.

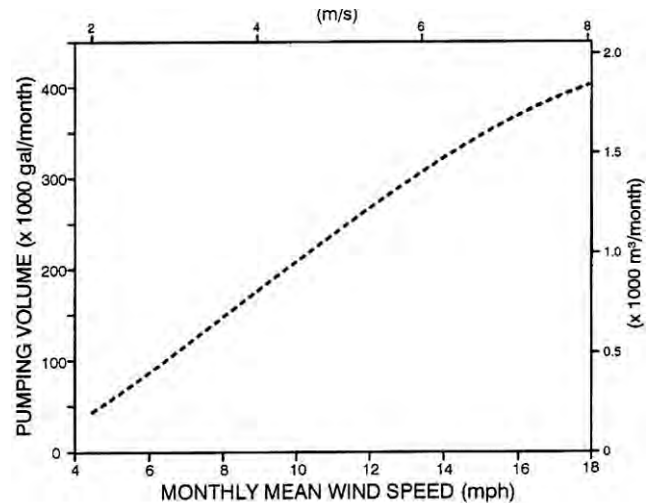


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.



**ALBERTA
 FARM
 MACHINERY
 RESEARCH
 CENTRE**

3000 College Drive South
 Lethbridge, Alberta, Canada T1K 1L6
 Telephone: (403) 329-1212
 FAX: (403) 329-5562
<http://www.agric.gov.ab.ca/navigation/engineering/afmrc/index.html>

Prairie Agricultural Machinery Institute

Head Office: P.O. Box 1900, Humboldt, Saskatchewan, Canada S0K 2A0
 Telephone: (306) 682-2555

Test Stations:
 P.O. Box 1060
 Portage la Prairie, Manitoba, Canada R1N 3C5
 Telephone: (204) 239-5445
 Fax: (204) 239-7124

P.O. Box 1150
 Humboldt, Saskatchewan, Canada S0K 2A0
 Telephone: (306) 682-5033
 Fax: (306) 682-5080