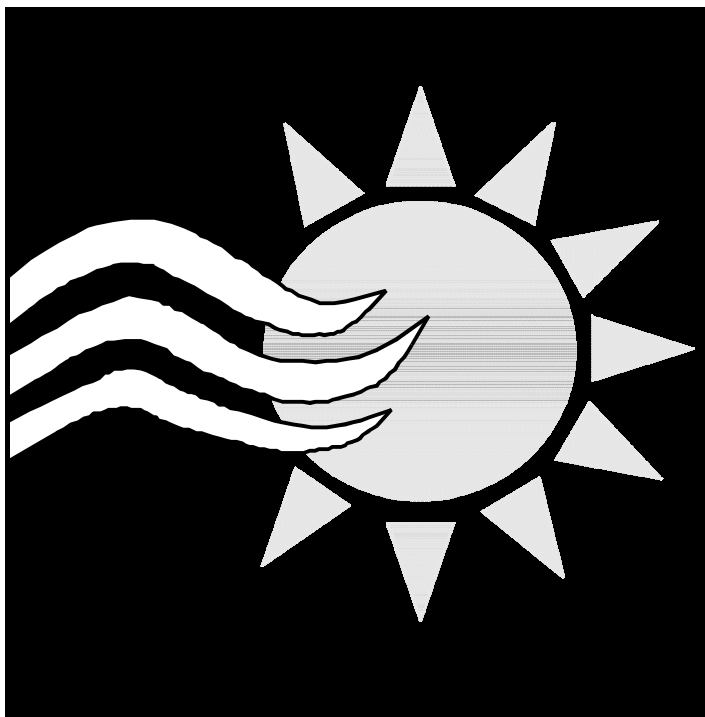


Summary Report 683



Alberta Renewable Energy Test Site

**Summary of Wind and Solar Powered Pumping Units
(1990 Test Season)**

A Co-operative Program Between



PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

SUMMARY OF WIND AND SOLAR PUMPING SYSTEM TESTS (1990)

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:
 - 2 Panel
 - 3 Panel
 - 4A Panel
 - 4B Panel
 - 8 Panel
 - WARDUN
- Nor'Western Energy Systems Ltd.
 - Solar Econo-Sub

WIND SYSTEMS

- Dutch Industries Ltd.
 - Delta 16
- Maverick Wind Energy Ltd.
 - Windmotor
- Prairie Ditching Ltd.
 - PD8-6
- Wind Baron Corp.
 - Softwind 21

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 reports for 1990 test season. The Lethbridge Wind Research Test Site was in operation from 1982 to 1991 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. Detailed reports used for this summary are 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 as a range of wind speeds or a range of solar radiation intensities. These ranges are, in turn, averaged, resulting in the final performance curves. 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 for a range of monthly wind speeds 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). Data summary tables to CSA standards are available upon request.

CAP 2 SOLAR PANEL

MANUFACTURER AND DISTRIBUTOR:

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

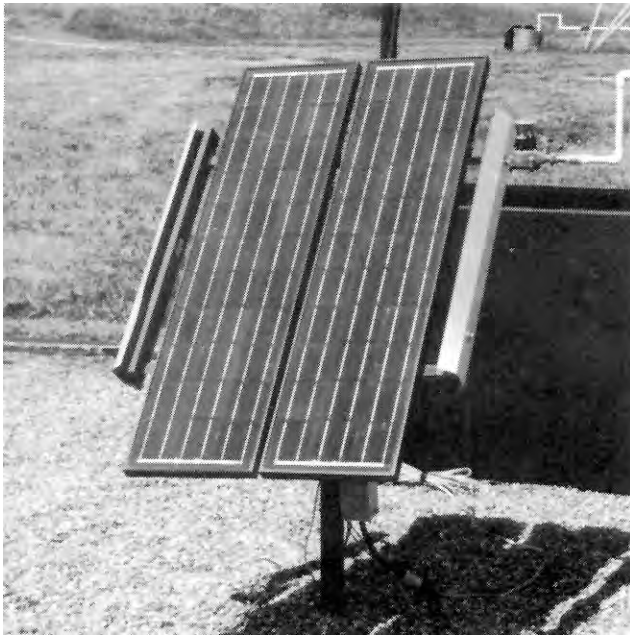


FIGURE 1. Cap 2 Solar Panel

PHYSICAL DESCRIPTION:

Number of Panels: 2
 Panel Manufacturer: ARCO
 Power Rating @ 77°F (25°C) and
 93 W/ft² (1000 W/m²): 47 W/panel
 Configuration: series
 Mount: tracking
 Pump Type: 2 valve diaphragm

SUMMARY OF RESULTS:

Testing Period: 206 days
 Period Operational: 206 days
 Percent Availability: 100%

INSTALLED: May 30, 1989

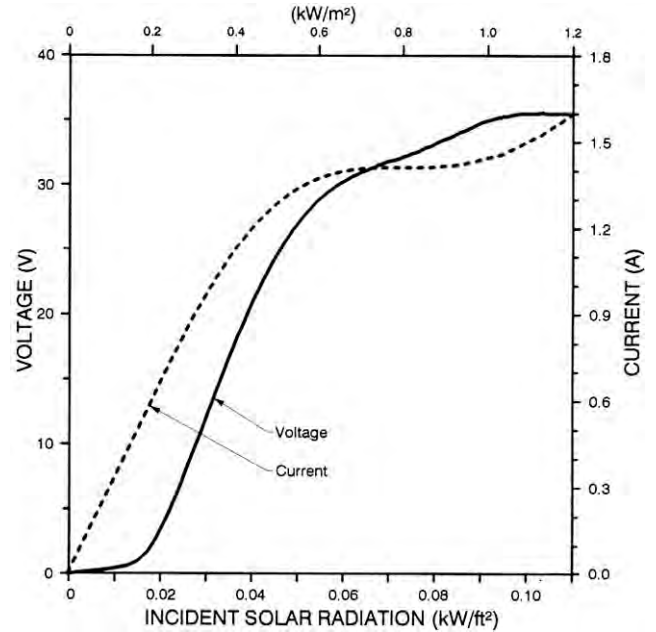


FIGURE 2. Voltage and Current versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

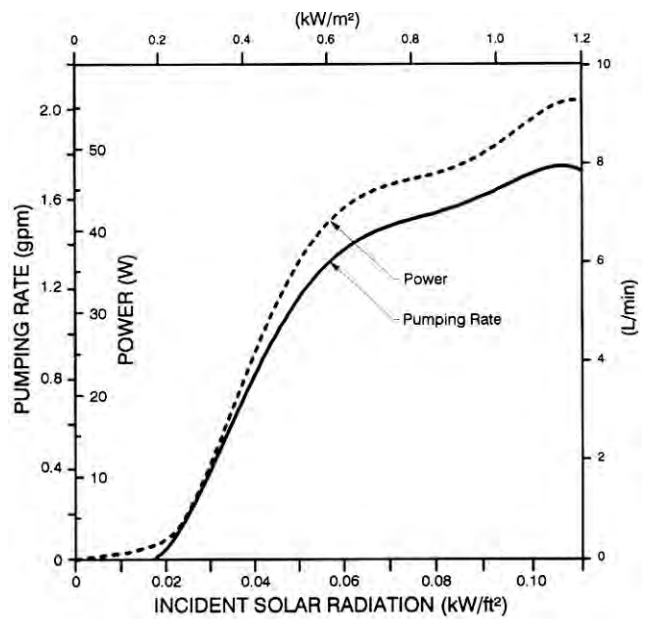


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

CAP 3 SOLAR PANEL

MANUFACTURER AND DISTRIBUTOR:

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



FIGURE 1. Cap 3 Solar Panel

PHYSICAL DESCRIPTION:

Number of Panels: 3
 Panel Manufacturer: ARCO
 Power Rating @ 77°F (25°C) and
 93 W/ft² (1000 W/m²): 43 W/panel
 Configuration: parallel
 Mount: fixed
 Pump Type: CAP F4 (4 valve diaphragm)

SUMMARY OF RESULTS:

Testing Period: 50 days
 Period Operational: 18 days
 Percent Availability: 36%
 (Under development)

INSTALLED: July 6, 1990

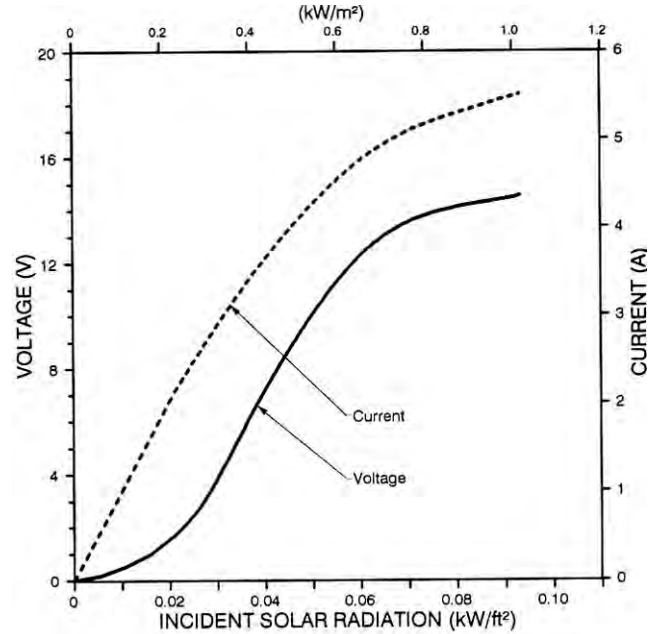


FIGURE 2. Voltage and Current versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

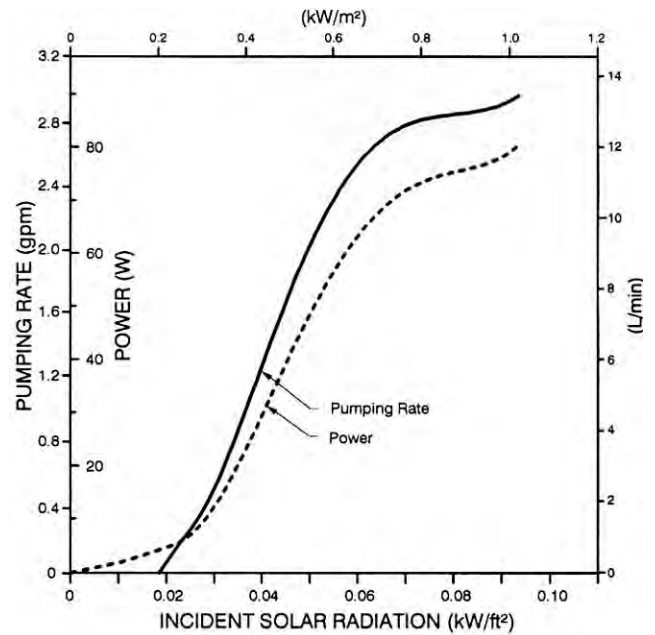


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

CAP 4A SOLAR PANEL

MANUFACTURER AND DISTRIBUTOR:

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

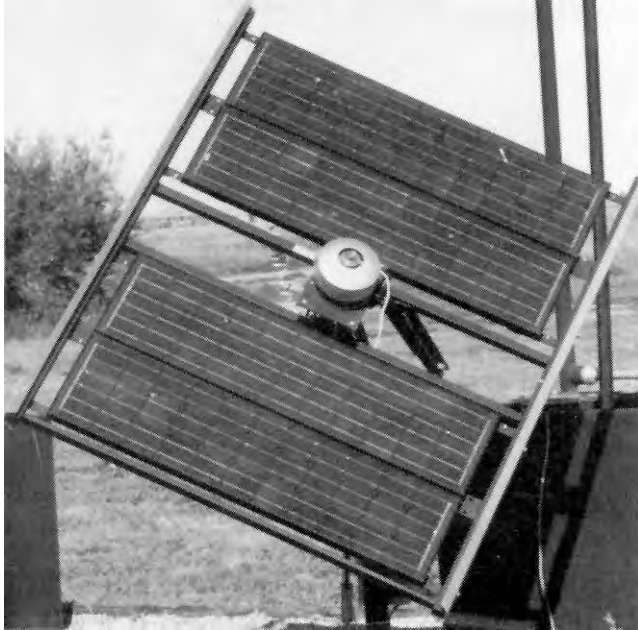


FIGURE 1. Cap 4A Solar Panel

PHYSICAL DESCRIPTION:

Number of Panels: 4
 Panel Manufacturer: ARCO
 Power Rating @ 77°F (25°C) and
 93 W/ft² (1000 W/m²): 47 W/panel
 Configuration: parallel
 Mount: tracking
 Pump Type: centrifugal

SUMMARY OF RESULTS:

Testing Period: 257 days
 Period Operational: 257 days
 Percent Availability: 100%

INSTALLED: May 30, 1989

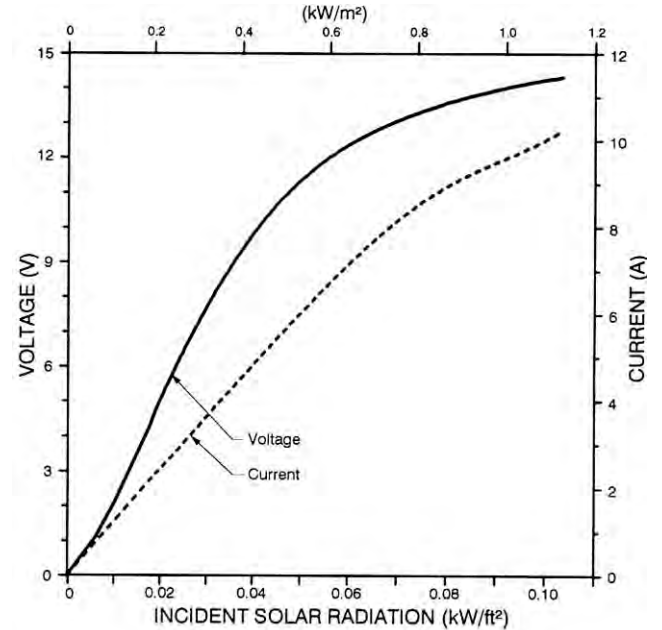


FIGURE 2. Voltage and Current versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

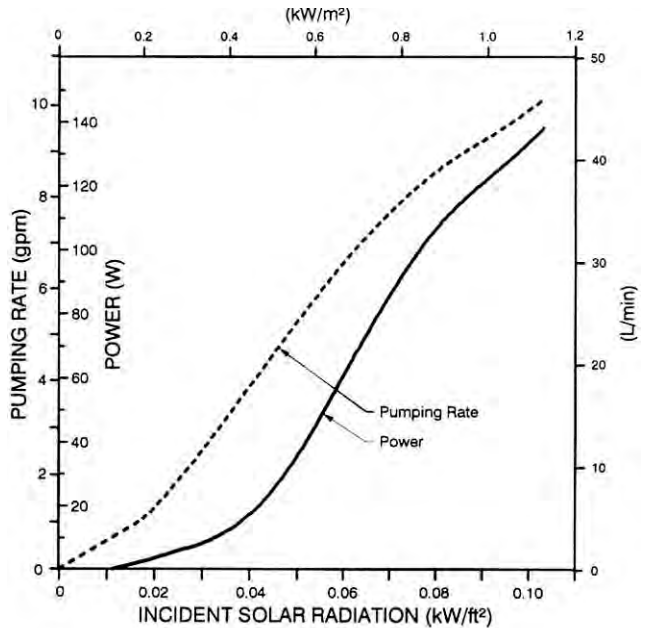


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

CAP 4B SOLAR PANEL

MANUFACTURER AND DISTRIBUTOR:

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



FIGURE 1. Cap 4B Solar Panel

PHYSICAL DESCRIPTION:

Number of Panels: 4
 Panel Manufacturer: ARCO
 Power Rating @ 77°F (25°C) and
 93 W/ft² (1000 W/m²): 55 W/panel
 Configuration: parallel
 Mount: fixed
 Pump Type: centrifugal

SUMMARY OF RESULTS:

Testing Period: 11 days
 Period Operational: 11 days
 Percent Availability: 100%

INSTALLED: May 24, 1990

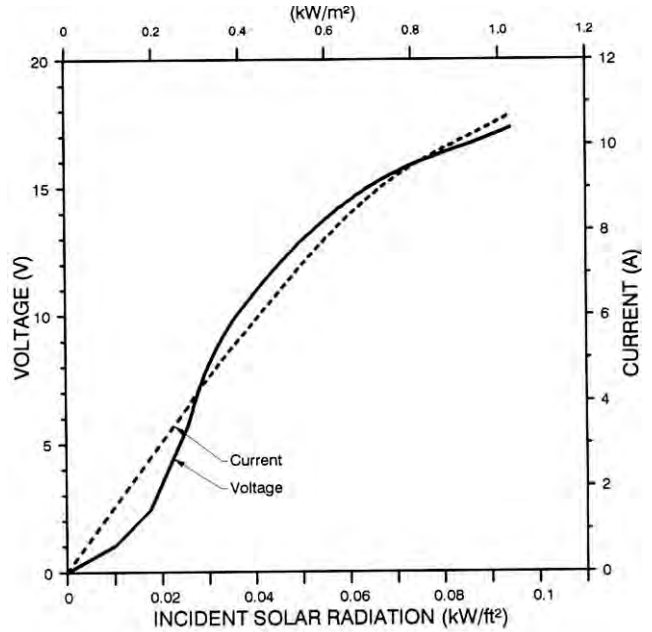


FIGURE 2. Voltage and Current versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

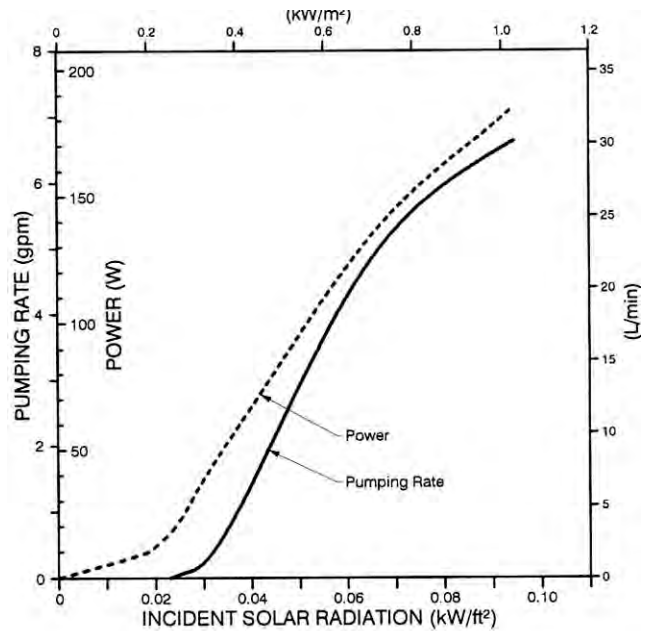


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

CAP 8 SOLAR PANEL

MANUFACTURER AND DISTRIBUTOR:

Canadian Agtechnology Partners
P.O. Box 2457
Olds, Alberta, Canada
T0M 1P0

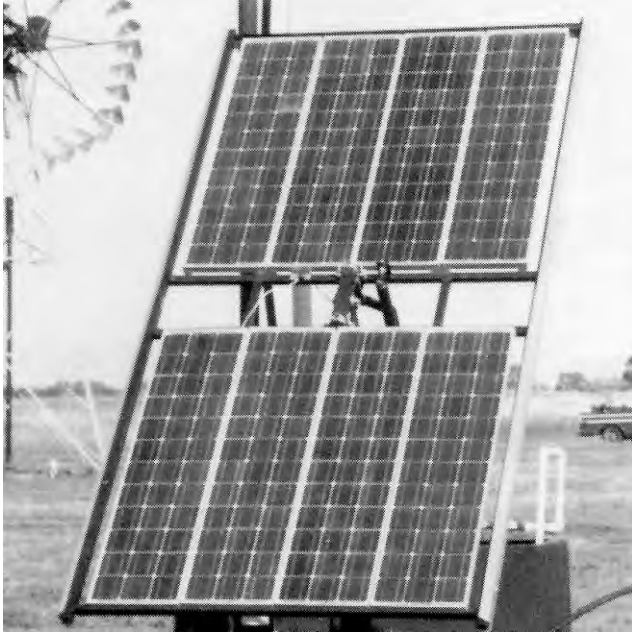


FIGURE 1. Cap 8 Solar Panel

PHYSICAL DESCRIPTION:

Number of Panels: 8
Panel Manufacturer: ARCO
Power Rating @ 77°F (25°C) and
93 W/ft² (1000 W/m²): 55 W/panel
Configuration: parallel
Mount: fixed
Pump Type: centrifugal

SUMMARY OF RESULTS:

Testing Period: 6 days
Period Operational: 6 days
Percent Availability: 100%

INSTALLED: May 19, 1990

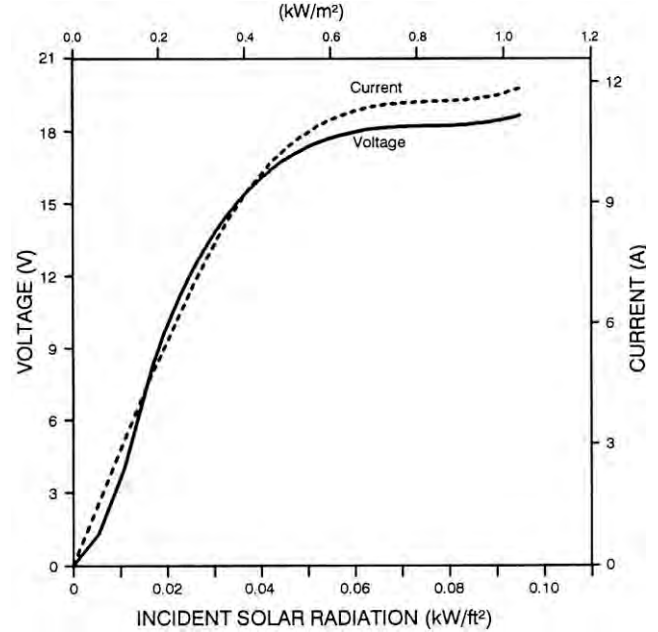


FIGURE 2. Voltage and Current versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

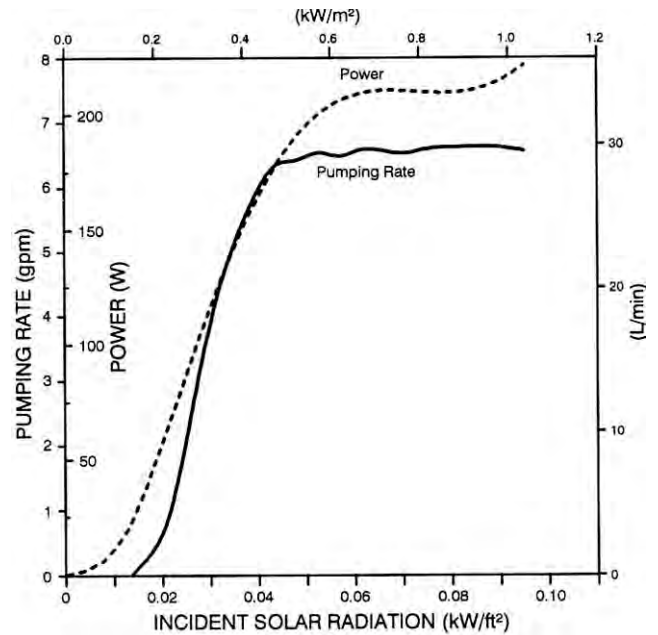


FIGURE 3. Pumping Rate and Power versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

WARDUN

MANUFACTURER AND DISTRIBUTOR:

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

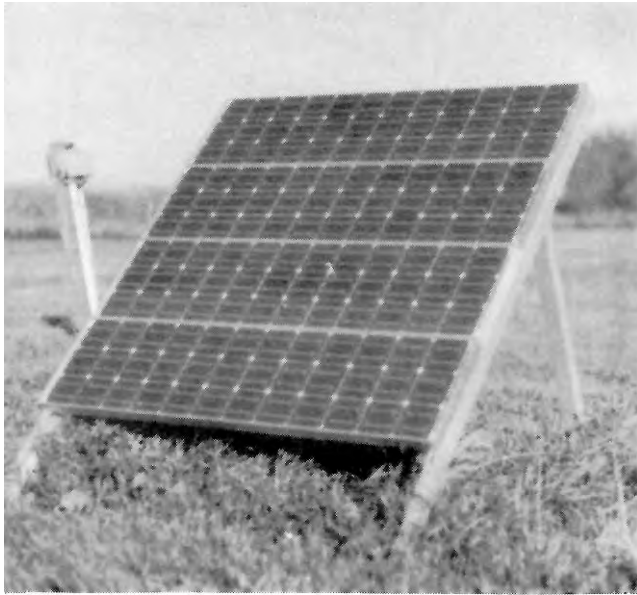


FIGURE 1. Wardun Solar Panel

PHYSICAL DESCRIPTION:

Number of Panels: 4
Panel Manufacturer: ARCO
Power Rating @ 77°F (25°C) and
93 W/ft² (1000 W/m²): 43 W/panel
Configuration: parallel
Mount: fixed
Pump Type: helical progressing cavity

SUMMARY OF RESULTS:

Testing Period: 50 days
Period Operational: 50 days
Percent Availability: 100%

INSTALLED: August 9, 1990

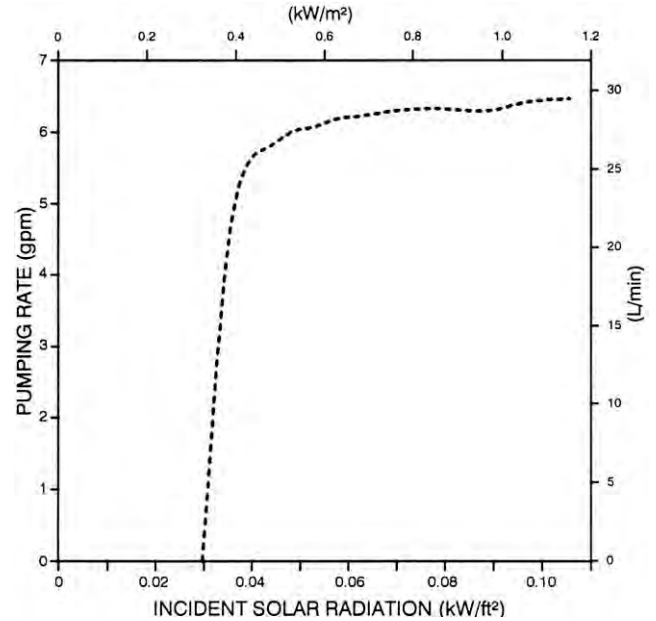


FIGURE 2. Pumping Rate and Power versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

SOLAR ECONO-SUB

MANUFACTURER AND DISTRIBUTOR:

Nor'wester Energy Systems Ltd.
Box 7, Site 32, R.R.12
Calgary, Alberta, Canada
T3E 6W3
(403) 249-3337

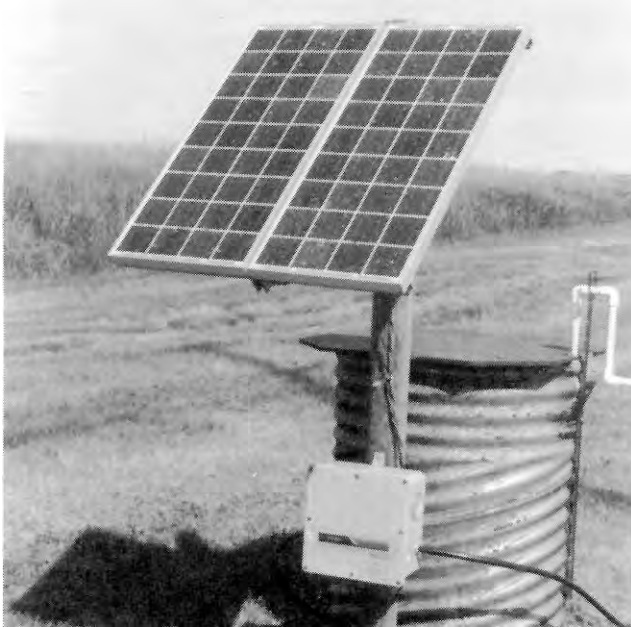


FIGURE 1. Solar Econo-Sub.

PHYSICAL DESCRIPTION:

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

SUMMARY OF RESULTS:

Testing Period: 42 days
Period Operational: 42 days
Percent Availability: 100%

INSTALLED: August 15, 1990

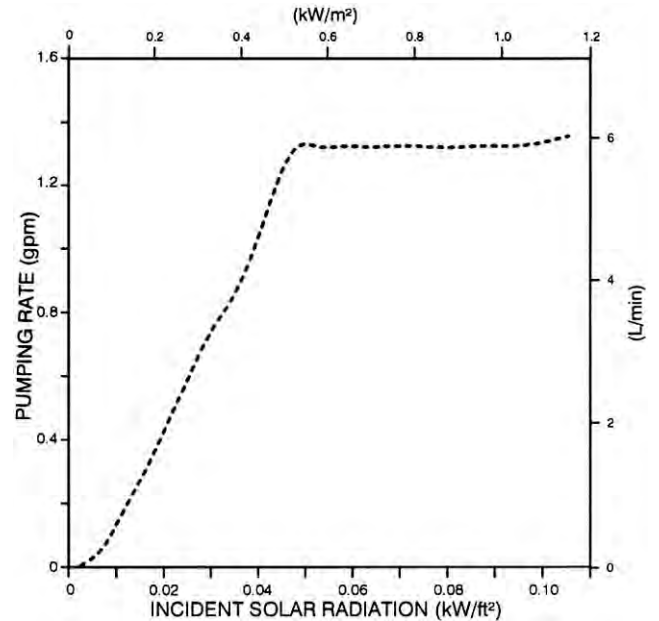


FIGURE 2. Pumping Rate and Power versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

DELTA 16

MANUFACTURER AND DISTRIBUTOR:

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



FIGURE 1. Delta 16

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: 10.4 in (264 mm) Diameter
 Stroke: 6.5 in (165 mm)
 Pumping System Description: reciprocating rod connected to positive displacement pump

SUMMARY OF RESULTS:

Testing Period: 286 days
 Period Operational: 265 days
 Percent Availability: 96.2%

INSTALLED: May 18, 1989

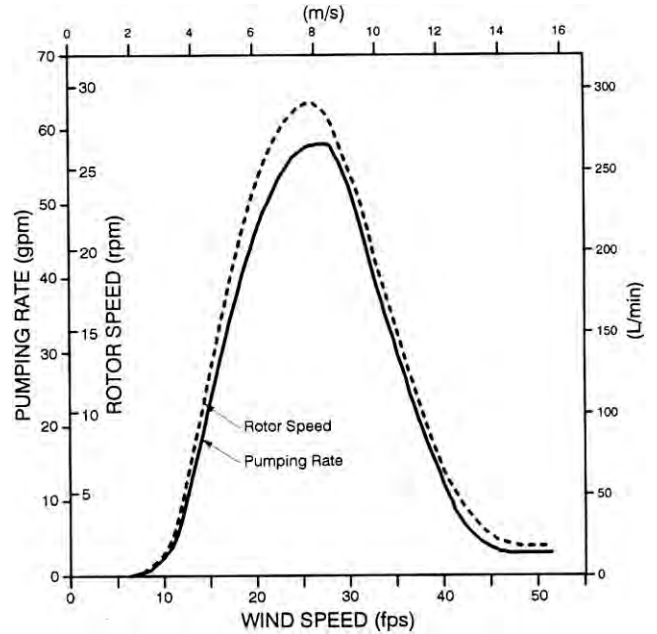


FIGURE 2. Pumping Rate and Rotor Speed versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

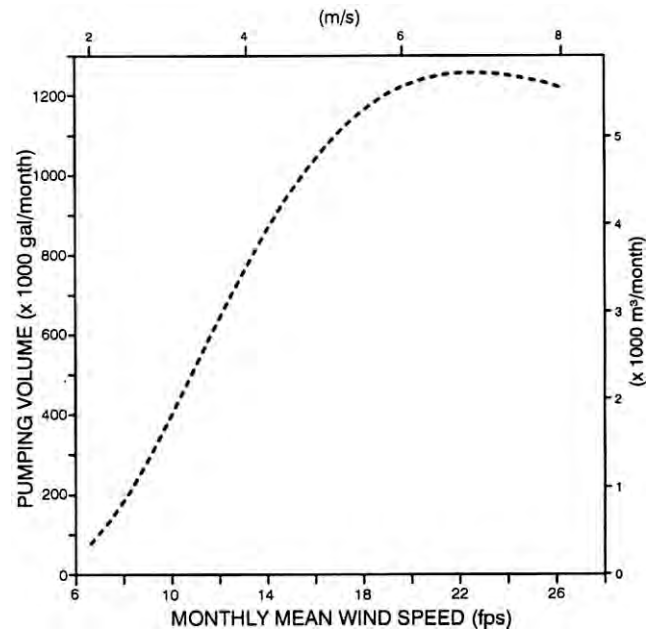


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

MAVERICK WINDMOTOR

MANUFACTURER AND DISTRIBUTOR:

Maverick Wind Energy Ltd.
 P.O. Box 2707
 Pincher Creek, Alberta, Canada
 T0K 1W0
 (403) 627-3630
 (403) 627-3091

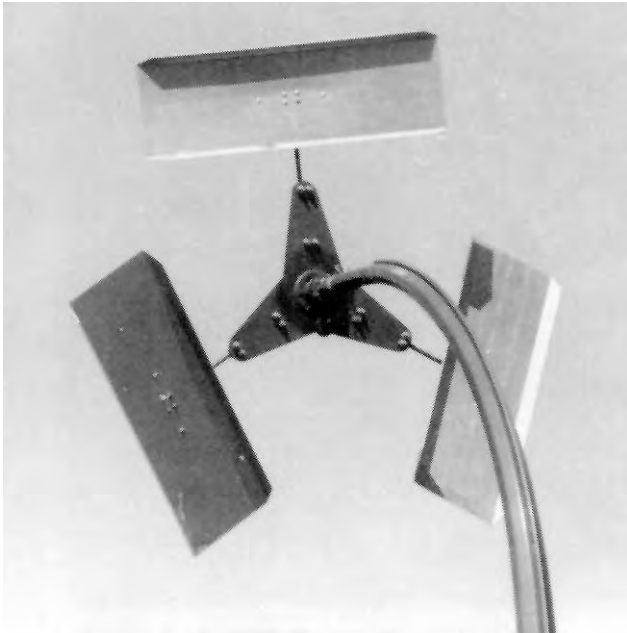


FIGURE 1. Maverick Windmotor

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: 3
 Blade Design: proprietary
 Blade Material: extruded aluminum
 Hub Height: 25 ft (7.62 m)
 Transmission: direct drive
 Gear Ratio: 1:1
 Pump Type: helical progressing cavity
 Pump Size: 2 in (51 mm) diameter
 Pumping System Description: direct cable drive from rotor to pump

SUMMARY OF RESULTS:

Testing Period: 97 days
 Period Operational: 97 days
 Percent Availability: 100%

INSTALLED: June 22, 1990

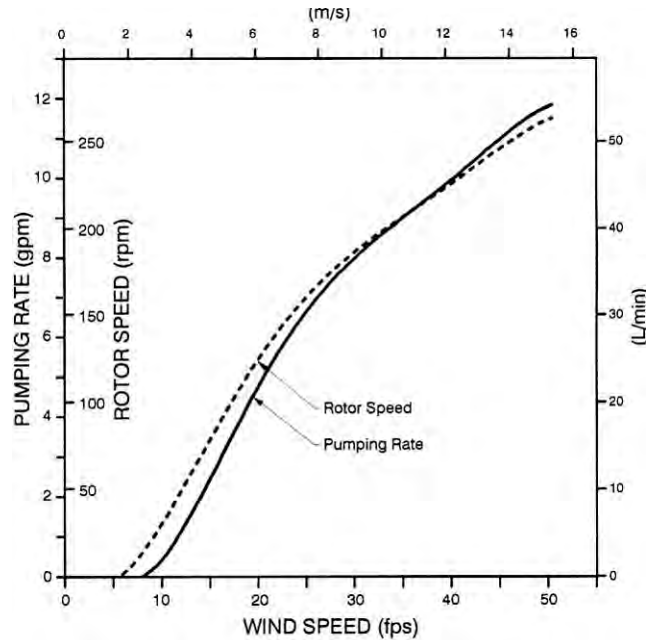


FIGURE 2. Pumping Rate and Rotor Speed versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

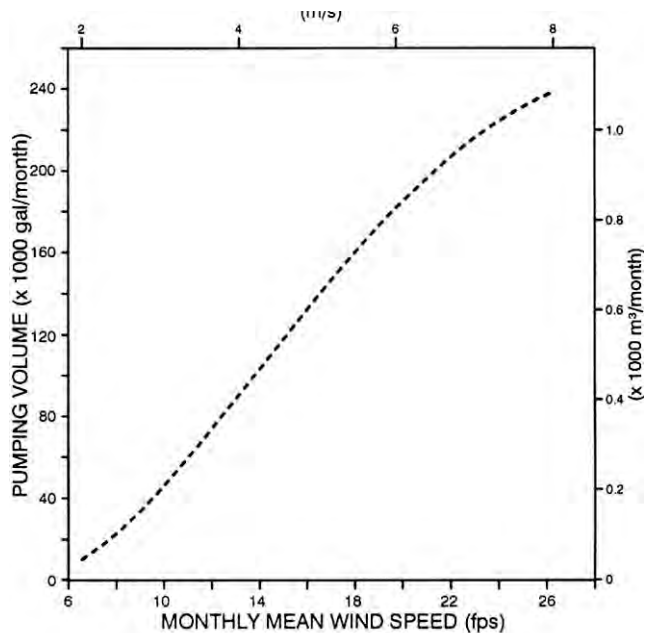


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

PRAIRIE #PD8-6

MANUFACTURER AND DISTRIBUTOR:

Prairie Ditching Ltd.
418 - 26 Street South
Lethbridge, Alberta, Canada
T1J 3R2
(403) 327-8280

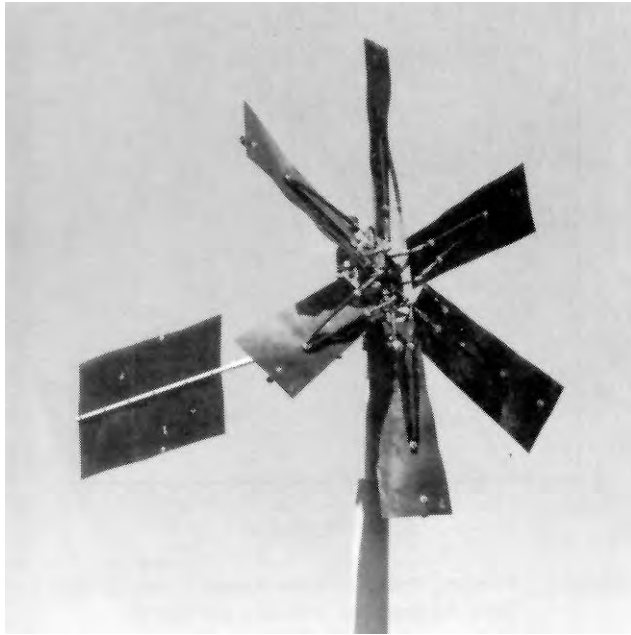


FIGURE 1. Prairie #PD8-6

PHYSICAL DESCRIPTION:

Turbine Type: upwind
Axis: horizontal
Rotor Diameter: 7.3 ft (2.24 m)
Swept Area: 42.2 ft² (3.92 m²)
Number of Blades: 6
Blade Design: proprietary
Blade Material: polyethelene
Hub Height: 25.4 ft (7.74 m)
Transmission: direct drive
Pump Type: air lift
Pumping System Description: windmill driven air compressor

SUMMARY OF RESULTS:

Testing Period: 227 days
Period Operational: 219 days
Percent Availability: 96.5%

INSTALLED: July 17, 1989

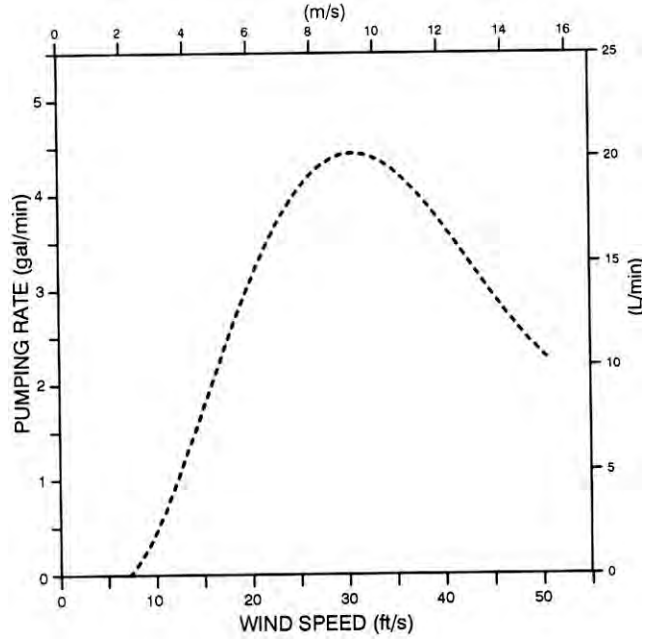


FIGURE 2. Pumping Rate and Rotor Speed versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

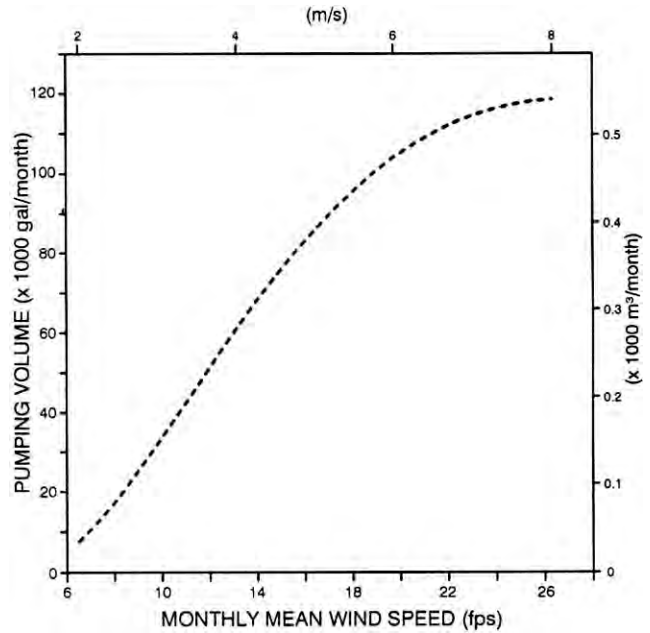


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.

SOFTWIND 21

MANUFACTURER AND DISTRIBUTOR:

Wind Baron Corp.
 3920 East Huntington Drive
 Flagstaff, Arizona, U.S.A
 86004
 (602) 526-6400



FIGURE 1. Softwind 21

PHYSICAL DESCRIPTION:

Turbine Type: upwind
 Axis: horizontal
 Rotor Diameter: 21 ft (6.4 m)
 Swept Area: 346.3 ft² (32.17 m²)
 Number of Blades: 18
 Blade Design: high torque sails
 Blade Material: galvanized steel
 Hub Height: 40 ft (2.2 m)
 Transmission: mechanical gearing
 Gear Ratio: 3.25:1
 Pump Type: reciprocating piston
 Pump Size: 12 in (305 mm) diameter
 Stroke: 20.4 in (518 mm)
 Pumping System Description: reciprocating rod connected to positive displacement pump

SUMMARY OF RESULTS:

Testing Period: 108 days
 Period Operational: 29 days
 Percent Availability: 26.9%

INSTALLED: May 30, 1990

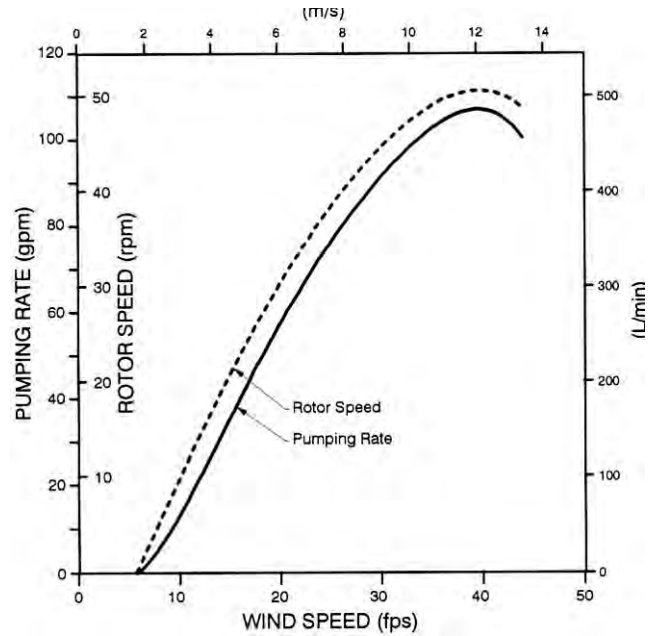


FIGURE 2. Pumping Rate and Rotor Speed versus Incident Solar Radiation for a 18 foot (5.5 m) Lift.

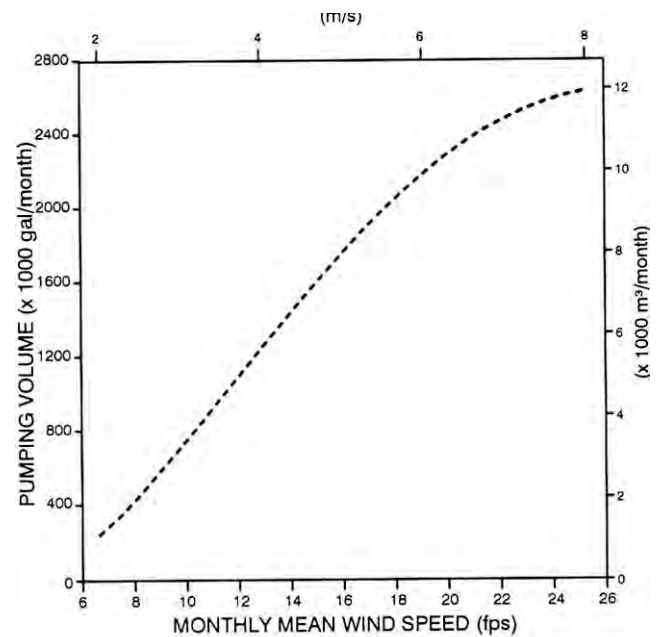


FIGURE 3. Pumping Volume versus Monthly Mean Wind Speed Based on 100% Availability, Rayleigh Distribution of Wind Speeds and a 30 Day Month.



**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