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PHOTOVOLTAIC POWER SYSTEMS AT SASKATCHEWAN GAUGING STATIONS

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Water Survey of Canada
Saskatchewan

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INTRODUCTION

Photovoltaic power systems have been used in Saskatchewan since 1978 when the first was installed at the gauging station on Long Creek near Estevan. Although this installation continued to perform with its original battery for over four years, other subsequent installations at some 50 sites have not been as successful. In general, problems arise with the batteries used rather than with the solar panels themselves.

Several different solar panels from two different manufacturers have been used. The panels have been mounted in a number of ways on existing buildings in various parts of the province. In addition many different batteries have been used with the solar panels. In general the batteries power water level servo-manometers or satellite Data Collection Platforms (DCPs). The combinations of site conditions, solar panel battery and instrument are such that each installation could be considered unique.

Despite that, certain trends have emerged and it is possible to make recommendations for the future. This report considers system requirements, describes the existing installations, discusses the problems that have emerged, and makes recommendations for the future. The report is based on information and comments provided by hydrometric staff in Saskatchewan.

SYSTEM REQUIREMENTS

The Water Survey of Canada (WSC) collects water level data at over 300 sites in Saskatchewan. A typical monitoring location includes a small galvanized steel building (1.2 m square by 2 m high) which is used to house a water level recorder. The monitoring sites are found throughout the Province and may be highly exposed in some areas or surrounded by trees in others. The sites were not selected with any regard to possible use of photovoltaic power systems.

The Stevens Type A water level recorder itself does not require electrical power, although, at about 100 sites, water levels are sensed by a battery-driven servo-manometer. The servo-manometer has a nominal 7.5 V voltage requirement but can operate with supply voltages of 6 to 14 V. The instrument normally has no standby power drain and draws about 1.0 W power when water levels change. (The power consumption of the Barber-Coleman motors in some Stacom servo-manometers is more than twice as much.) Because of daily and seasonal fluctuations in water levels, the duty cycle of the servo-manometer could range from almost 0 to nearly 100%.

At some sites data are telemetered by DCP. The power demand of the DCP can be calculated using manufacturer's data; in the standard WSC configuration this demand is equivalent to 0.25 W continuous at 12 V. About 12 DCPs are now installed in Saskatchewan. An increase in the DCP network of at least six sites a year for the next several years is expected. Some sites having DCPs are also equipped with servo-manometers.

The WSC also operates some telephone telemetry systems. These are obsolescent and are powered by 24 V battery packs. There are no plans to use photovoltaic systems to charge these batteries.

With the exception of some DCP installations, the WSC has generally used non-rechargable batteries to supply power to field instrumentation. The advent of inexpensive small solar panels and the obvious availability of many hours of sunshine (Figure 1 and Yorke & Kendall) led to the consideration of photovoltaic power systems. It was felt that, by using such systems, annual replacement battery costs would be significantly reduced as would water level record loss due to dead batteries.

SYSTEM DESCRIPTION AND INSTALLATION

Site Selection

The sites selected for photovoltaic power systems were chosen so that there was a good geographic distribution and a variety of exposures to solar radiation. Emphasis was placed on remote fly-in sites as well, would reduce the long term need to transport batteries. Nearly all of the sites selected were servo-manometer installations although a few DCP sites were also equipped.

Solar Panels

The panels were selected on the basis of manufacturer's literature and discussions with manufacturers' representatives. No attempt was made to carry out a rigorous system design because of variable power demands and exposures. A total of 56 panels were purchased over a three-year period; 5 Arco models and 6 Solarex. The initial buys were one or two at a time and were directed to a specific manufacturer; later buys were larger and based on competitive tenders. The models purchased are shown in Table 1.

Initially some panels were purchased with the idea of charging six-volt batteries for servo-manometers. Very early in the program, however, a switch was made to 12 V systems. Panels were purchased with and without built-in voltage regulation and blocking diodes. Open circuit voltages thus ranged from 6 to 16 V.

Voltage Regulation

Since a number of panels were purchased without blocking diodes or voltage regulators, small diode boxes comprising of a blocking diode and a zener diode which reduced the charging voltage to 12 V, or in some cases, 14 V, were constructed. These boxes were connected to the solar panels and the load with colour-coded leads.

Batteries

Batteries selected included lead-acid motorcycle or snowmobile, car, two sizes of Gates sealed lead-acid, Elpower sealed lead acid and Wisco gelled electrolyte batteries. Initially small inexpensive units were selected and, as batteries became the obvious main problem, more expensive and larger batteries were used. Ampere-hour ratings for the batteries ranged from 5 to 100.

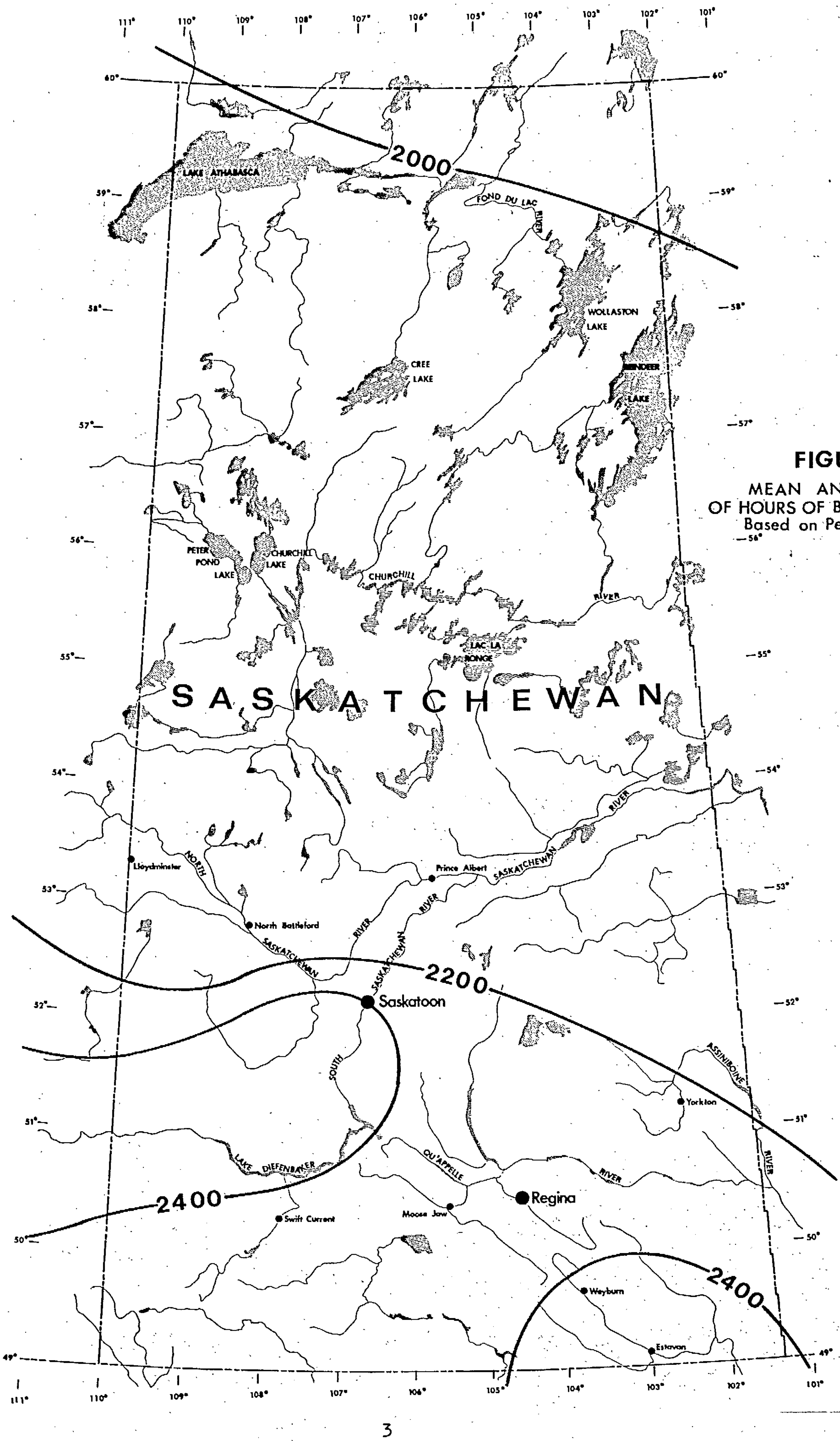

FIGURE 1
MEAN ANNUAL NUMBER OF HOURS OF BRIGHT SUNSHINE
Based on Period 1941-1970

TABLE 1 - Saskatchewan Photovoltaic Systems

PANEL \ BATTERY	6 V motor cycle	12 V motor cycle	12 V ski-doo	12 V auto	12 V Gates (small)	12 V Gates (large)	12 V Elpower	12 V Wisco	TOTAL Panels Purchased
Arco ASI - 8 - 600		X							1
- 9 - 300		X							1
- 16 - 300		X	X						2
- 16 - 500			X		X				9
- 16 - 2000						X			1
Solarex 615	X								2
615 HP	X								1
220		X	X		X		X	X	20
220 HP		X	X		X	X	X	X	9
230		X		X	X				7
230 HP						X			

Mounting

Ideally solar panels should be installed with an elevation angle of latitude plus 10° facing south or slightly west of south. As the panels were retrofitted into existing structures, two installation methods were eventually used. The first and preferred method was to attach the panel vertically to the most southerly wall of the gauge house. This was easy to accomplish and eliminated the problem of bird droppings on the panel and birds pecking off the coating on the panel. The second method, used where vandalism was anticipated was to install the panel flat on the roof on the gauge house. In a few cases a hinged mount was used so that the panel could be swung into a near vertical position for the winter.

Installation

The systems were generally installed by field staff who had little or no training in electrical systems, much less in photovoltaics. In most cases the installations were carried out as part of routine field trips.

PROBLEM AREAS

In the past few years there have been clear cases of record loss attributable to the use of photovoltaic systems. At the same time there have undoubtedly been cases where these systems have reduced record loss due to battery failure and there has been a reduction in batteries consumed. The failure modes can be categorized as follows:

System/Installation Faults.

In the case where diode boxes were constructed for use with unregulated panels, some boxes were incorrectly constructed or labelled, leading to battery failure. Other systems were installed incorrectly, for example, hooked up in reverse polarity causing the blocking diode to burn out or, in one case, installed on the north side of a building (on an overcast day).

Battery Faults

This is unquestionably the major problem area. The batteries used in the majority of installations were low capacity, standard lead-acid motorcycle or Skidoo batteries. In general the solar panel output tended to be too high relative to the size of the battery. The batteries thus tended to boil dry due to overcharging or freeze due to weakened electrolyte, caused by frequent addition of water. Some battery posts became severely corroded over a period of several months.

The two sealed lead acid batteries (Gates and Elpower) have thus far presented fewer problems although some of the Elpower ones suffered broken leads, terminals and loose cells. In a few cases the batteries had defective cells which were replaced under warrenty. These batteries, when used to replace motorcycle batteries seem to have withstood overcharging more successfully. In a few cases the small Gates battery was inadequate to power a servo-manometer at stations with considerable water level changes.

No problems have been encountered in using the large Gates batteries, car batteries, or Wisco gelled electrolyte batteries, although only a few of these types are in use.

Miscellaneous Observations

One concern at the beginning of the solar panel program was the possibility of vandalism. In practise very few panels have been lost: one to a forest fire, two to bears and two to human thieves. One panel was damaged beyond repair by humans and several have been pecked by birds but are still operable. The latter have been covered with double diamond glass to eliminate the problem.

Mounting the solar panels on the wall seems more effective. Some instances of roof-mounted units being covered by snow were noted and, at two stations having open water controls, frost build-up on panels reduced the charging voltage to zero. Painting the frames black may ease the problem.

The silicone coating on some of the Solarex panels seems to fog with time. This fogging does not seem to affect system performance. The cause could be a sand blasting effect from wind blown sand and dirt in highly exposed areas.

As stated earlier some batteries have been over-charged. Where significant overcharging occurs, some metal parts of recorder shelters have corroded when standard lead-acid batteries are used. This is most apparent in buildings where photovoltaic systems have been in operation for a number of years.

The solar panels will withstand considerable abuse. Some panels have been covered partially with cardboard to reduce power output with no serious problems.

Field staff installed and operated the panels with little or no training. Although the panels themselves presented no problems, the separate voltage regulation system used at many sites was a concern. Personnel found that it was difficult to work on and trouble-shoot the separate control box and much preferred the panels with built-in blocking diodes and voltage regulation.

THE IDEAL WSC PHOTOVOLTAIC SYSTEM

There are three clear uses of photovoltaic systems in the WSC: servo-manometer, DCP, and servo-manometer plus DCP. Because the servo-manometer is a variable load and because site conditions vary so widely, it is possible to define only ranges of panel size that are suitable for Saskatchewan then use the experience and judgement of field staff to determine which panel should be installed. Suggested ranges are:

Servo-manometer	– 2 to 3 W
DCP	– 4 to 5 W
Both	– 6 to 8 W

The uncertainty in power demand and the possibility of overcharging plus other factors mean that a robust, maintenance-free battery is required. A sealed unit is preferred for safety reasons. The large 12 V Gates, Delco 2000, Globe Union Gell Cell, or Wisco batteries, all with a 80 to 100 Ah rating, seem suitable. The battery should be able to withstand transportation shock, special containers may be required.

The photovoltaic system should include a blocking diode and be regulated to 14 V rather than 12 V so that all types of batteries can be fully charged. Because of the uncertain nature of the load, some sort of taper charging circuitry is highly desirable to prevent overcharging. Based on manufacturer's literature the "Arco Battery Protector" seems to be able to meet all of these requirements. However, one unit that was tested recently in Saskatchewan did not prevent overcharging. It may be preferable to buy the solar panels with blocking diode and regulation to 14 V as part of the package and continue to seek some other commercially available means of preventing overcharging.

CONCLUSIONS AND RECOMMENDATIONS

Despite a number of problems it is clear that adoption of photovoltaic systems as a standard power source for Saskatchewan gauging stations will have long term benefits in increased record recovery and reduced operating costs. The Saskatchewan program would have benefited from testing fewer systems simultaneously and a quicker move to better batteries. Some specific recommendations are:

1. Adopt 12 V as the standard supply voltage for all installations. This would mean replacing three solar panels and batteries eventually.

2. Instead of using relatively small batteries with large panels, use large batteries with small panels.

3. Stop purchasing unsealed batteries and replace existing units as they fail with sealed, large batteries in the 80 to 100 Ah range.

4. Re-deploy existing panels as required, to more closely match load requirements. This would mean moving some Arco ASI-16-500 and Solarex 230 series units to gauging stations having DCPs or very active servo-manometers.

5. Continue evaluation of "Battery Protector". If this or similar product proves suitable, it could be added to installations having chronic overcharging problems.

6. New panels purchased should contain the blocking diode and be regulated to 14 V as an integral part of the system. Tempered glass, rather than silicone, facing is preferred if the panel is not attached to a wall.

7. Install all panels vertically on the south wall of gauge houses, except for those sites where vandalism is anticipated. Wires leading into the buildings should be equipped with drip loops to prevent water from entering the building.

8. All field staff should be instructed in the installation and operation of photovoltaic systems. This should include the thorough documentation of installations so that a clear "paper trail" exists for future evaluation. This could be one component of a broader course on trouble-shooting electronic instrumentation.

REFERENCE

Yorke, B.J. and G.R. Kendall, 1972, Daily Bright Sunshine 1941-1970, Report CCI-6-72, Atmospheric Environment Service, Department of the Environment, Downsview.