# Solar Powered Borehole Pumps

**Electricity generated by solar panels (photovoltaic power) has been used for powering pumps for many years but in the past these systems have suffered from high capital costs, low power and uncertain reliability. Increasing concern over climate change and the environment; ever rising oil costs with continuing development of solar systems have all combined to make solar power increasingly viable for some situations. The technology is now widely used in remote locations, for example Australia, where it can provide water with minimal supervision.**

**At the current state of development it should be considered as a complementary technology, which fits – in terms of power and number of people it can serve – between hand pumps and diesel powered pumps.**

**This technical brief looks at the currently available products from two of the major manufacturers – Grundfos and Mono Pumps (Australia). It endeavours to highlight the advantages and disadvantages of solar power and identify situations where it could be used and the data that needs to be collected before deciding if it is a suitable power source. The brief is not intended as a design manual because it is felt that at this stage this is best done by passing all the field data to the manufacturers for them to make a system selection.**

## Solar powered borehole pumps

The borehole pumps considered here are all of the type where the motor/pump assembly is fully submerged. Currently available solar pumping systems tend to be much more site specific than conventional pumping systems in terms of the pump required and the size of solar array for optimum performance. It is therefore important to ensure that the site conditions are thoroughly evaluated before choosing the system components. This also means that a number of different kit specifications would be required to cover Oxfam's likely needs in all situations.

Due to the varying flow rates during the day with a solar system, instantaneous flow rates (litres/sec or m3/hour) are not very useful and a daily water production figure is used. Daily water production will also vary through the year with the movement of the sun.

Solar pumping is based on an 8-11 hour 'solar day' and will depend on weather conditions (eg cloudy/rain conditions will decrease output).

The systems described in this brief are designed to run directly from solar panels and batteries are not required.

Solar panel arrays can be either mounted on a ground level support frame or on a vertical pole. For tracking arrays a pole mount is mandatory (see photos on page 4).

Water output can be increased by approximately 25-30% by the use of a tracking solar array which follows the sun's movement and is usually controlled either by an electronic (GPS) or gas system. However, it is fair to say that tracking systems are not trouble free and add an extra layer of complexity to the system and are therefore not recommended at this time.

## Over view of the Grundfos 'SQFlex' system

Ten pumps currently available:

4 helical rotor, positive displacement, 3 inch diameter (high head, 200 metres maximum/ low flow)

6 centrifugal, 4 inch diameter (low head, 70 metres maximum/high flow)

Two motors (900W and 1400W submersible) are currently available. The 900W motor is fitted to the positive displacement pumps and the 1400W is fitted to the centrifugal pumps. In both cases the motor/pump assembly is fully submerged. The motor accepts AC or DC voltage with a built-in electronic control unit. This allows a number of different energy sources:

- Solar panels
- Wind turbine
- Generator
- Batteries

The system also allows certain combinations of the above energy sources to be used (eg solar and generator) by using the appropriate switch box.

Various protection devices are built into the motor including protection against dry running, over/under voltage, over-temperature.

The pump/motor assembly can be installed at any angle between vertical and horizontal.

Grundfos currently use 80W solar panels which can installed either on a ground level frame or on a pole mount. Maximum number of panels per pole is 14 – hence a 28 panel, 2240W array (maximum currently available) would require 2 pole mounts/frames.

**System sizing**

Grundfos has developed a PC-based sizing tool which is integrated within WinCAPS (Grundfos pump selection software) and includes a world-wide database of solar radiation data.

**Warranties**

Grundfos offers a 2 year workmanship warranty and the solar panels are warranted to produce at least 80% of nominal power for 25 years.

More detailed information can be found in the Grundfos Data Booklet (Publication 96 47 78 03 0607) and/or Grundfos WinCAPS/WebCAPS.

*Note: WebCAPS/WinCAPS should be used with caution for choosing solar system components and system sizing as this is a developing technology and the latest products are not always shown.*

## Overview of Mono 'Sun-Sub' system

Three low-head pumps (60 metres maximum) and three high-head (150 metres maximum) are currently available, all helical rotor, positive displacement, 4 inch diameter.

Three motors are currently available, the largest being 2400W. All motors are brushless, oil filled, DC motors.

The system is controlled by a surface installed 'Solar Motor Controller' which provides system monitoring and control.

A useful feature of the Mono system is that the Solar Motor Controller can be used to control the motor speed, which can be useful in low yielding boreholes.

Mono can also supply a surface installed inverter ('AC PowerPak') which enables the system to be powered by a generator.

Mono currently use 150W panels which can installed either on a ground level frame or on a pole mount. Maximum number of panels per pole is 4 – hence a 2400W array (maximum currently available) would require 4 pole mounts/frames.

**System sizing**

Mono have developed a PC-based sizing tool, CASS (Computer Aided Solar Selection), with a world-wide database of solar radiation data.

**Warranties**

Mono offer a two year workmanship warranty and the solar panels are warranted to produce at least 80% of nominal power for 25 years.

*Note: Information in Mono literature and on the website should be used with caution as it is not fully up-to-date at the time of writing.*

## Advantages and disadvantages of solar power

**Advantages**

- Simple – only moving parts are pump/motor. Plug-and-play electrical connections.
- No fuel costs.
- No routine maintenance.
- Minimal supervision.
- Capital costs increasingly competitive with diesel power.
- Environmentally friendly.

**Disadvantages**

- Limited power (at current stage of development).
- Reliability and system life under Oxfam conditions of use unproven.
- Technology may not be well understood by beneficiaries (compared with diesel) – risk of damage to sensitive electronic components.
- Water output adversely affected by abnormal weather conditions.
- Solar arrays may be attractive to thieves and vandals.
- Technical expertise/support limited outside main countries of use (Australia, South Africa, USA).

## Situations Favouring Solar Power

The relatively low power output of currently available systems mean that solar power is only suitable to serve fairly small populations. Because the power required to pump water is a product of flow and head, the greater the head the smaller the population that can be served. The examples in Appendix 1 show that for a borehole with a dynamic (pumping) water level of 50 metres and a surface pipe delivering into a tank 5 metres above ground level, a solar system can only serve around 2,000 people if Sphere standards are adhered to. Appendix 2 shows how dramatically the flow is increased if the head is reduced. Here, the dynamic (pumping) head is reduced to 10 metres, other installation parameters and number of solar panels remain the same, but output has increased threefold thus enabling a population of around 6,300 people to be served.

The criteria for deciding if solar is likely to be viable can be summarised as:

- Reliable solar conditions – to ensure system meets expectations from calculations (micro-climatic conditions could be critical).
- High pumping (dynamic) water level – to reduce pumping head
- Relatively flat terrain – to reduce static head above ground
- Short surface pipe lengths – to reduce losses due to pipe friction.
- Pipe sizes should be as large as possible – to reduce losses due to pipe friction.

It is also considered essential that solar systems *always* include an adequately sized storage tank, including a reserve (eg two level draw-off arrangement) in case of abnormal weather conditions.

## Data needed for system sizing

Collection of the necessary field data is vitally important. For example, relying on driller's initial yield estimates (often wildly optimistic) or guessing at the static head is much more likely to result in an unsatisfactory installation than with conventional systems because the power available is more limited.

Data that is needed for entering into the sizing programs is:

- Pump installation depth
- Static (standing) water level
- Pumping (dynamic) water level
- Pump tested borehole yield*
- Drop cable length
- Drop cable diameter
- Rising main length
- Rising main diameter
- Surface pipe length
- Surface pipe diameter
- Static lift from ground level

* Accurate yield data is always vitally important when sizing borehole pumps and particularly so with solar systems. Examination of the daily flow rate charts in Appendices 1 and 2 shows that pumping rates are at their highest at mid-day – if the borehole cannot sustain these rates then the daily water production will be reduced, possibly seriously because solar pumping rates cannot be increased at other times to compensate.

## Costs

Quotations from Grundfos and Mono Pumps for a 'high head' system (pump, all essential borehole fittings and solar array) are given in Appendix 1, summarised they are:

| | |
|---|---|
| Grundfos | GBP 12,490 |
| Mono Pumps | GBP 11,584 |

The 'low head' examples in Appendix 2 would have similar capital costs as the number of solar panels is the same. There would be some differences due to different rising main and cable lengths etc.

Although there is no routine maintenance, it remains to be seen what running costs would be incurred under Oxfam conditions.

For comparison, Appendix 3 shows the capital and running costs for a small diesel genset over a five year period.

## Further information

Grundfos SQFlex Data Booklet. Publication 96477803 0706. Hard copy or downloadable document from Grundfos WebCAPS.

SQFlex sizing in WinCAPS. Downloadable document from WinCAPS.

Grundfos GF Solar Modules. Publication 96620857 0306. Downloadable document from Grundfos WebCAPS.

Grundfos WinCAPS Solar Version 7.84.05 SQFlex

Grundfos Win CAPS CD, including sizing program. Awaiting confirmation of correct version to be used.

Mono Pumps Computer Aided Solar Selection (CASS) CD, V. 3.3

Photo: Grundfos A/S