Volkhard Scholz and Werner Daries, Potsdam-Bornim

Solar-powered drinker supply on pasture

Photovoltaic-powered pump systems can reliably and economically supply drinking water to livestock in fields away from mains connections. This, however, depends on the performance parameters of the pump and the water consumption of the animals being known and matched to one another. In the following report, results from several years of pump tests and water consumption measurements are presented and conclusions made with regard to the planning of photovoltaic-powered pasture drinking facilities. Additionally, practical experiences and costs of applied PV drinking facilities for cattle are reported upon.

Dr.-Ing. Volkhard Scholz is a member of the scientific staff in the Department of Technique in Preparation, Storage and Conservation at the Institute for Agricultural Technology Bornim e.V. (ATB), Max-Eyth-Allee 100, 14469 Potsdam-Bornim (director: Prof. Dr.-Ing. J. Zaske); e-mail: vscholz@atb-potsdam.de
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Photovoltaic systems, as they are increasingly seen on motorways, parking places or on roofs, are in the medium term also sure to come into use in agriculture. In locations away from mains supplies, and where there are reduced power requirements, this type of electricity supply can represent a technically practical and absolutely economic alternative to linking-up to the mains or a diesel generator [1 to 5]. This applies especially to livestock drinkers supplied with water pumped from the ground.

Up until now, only a few practical examples of such photovoltaic drinkers have been available. Also missing are usable engineering performance data and advice as to how such PV drinkers should be planned.

Pump performance

Because manufacturers of PV pumps mostly give only the pumping specifications, which are not, however, sufficient for the dimensioning of PV pump systems, a test station was built at the ATB. This enabled the measurement of three pumps in non-stop work under real sunshine conditions (rated power Pa = 230 Wp, delivery height h from 5 to 10 m).

For determining long-term performance of the pumps, three commercially available rotary pumps (test pumps) matched to the generator with maximum delivery heights between 7 and 25 m and costing between 400 and 2400 DM were investigated on the test station over three years. Additionally, performance data of a rotary pump used in practice (pond pump), and which was used without pause (as long as enough sunlight was available), was evaluated. Every PV pumping system is characterised by an individual procedure of the delivery volume stream Qp depending on the solar energy intensity H. This global solar sum is relatively easy to get from meteorological stations. With regard to the time development, these are mostly absolutely sufficient for the planning of pumping systems. For characterisation of pumping performance the specific delivery performance Pp;spez = Qp(h/Pn in 1(m(WP-1(d-1 is used and this allows the comparison of different pumping systems. Under ideal solar conditions (1000W/m^2; 25 C) is this parameter directly proportional to the efficiency degree of the total system (fig. 1).

Dimensioning basics

In order to optimally lay-out PV pasture drinkers, that means to be able to establish the rated power for the generators, the drin-

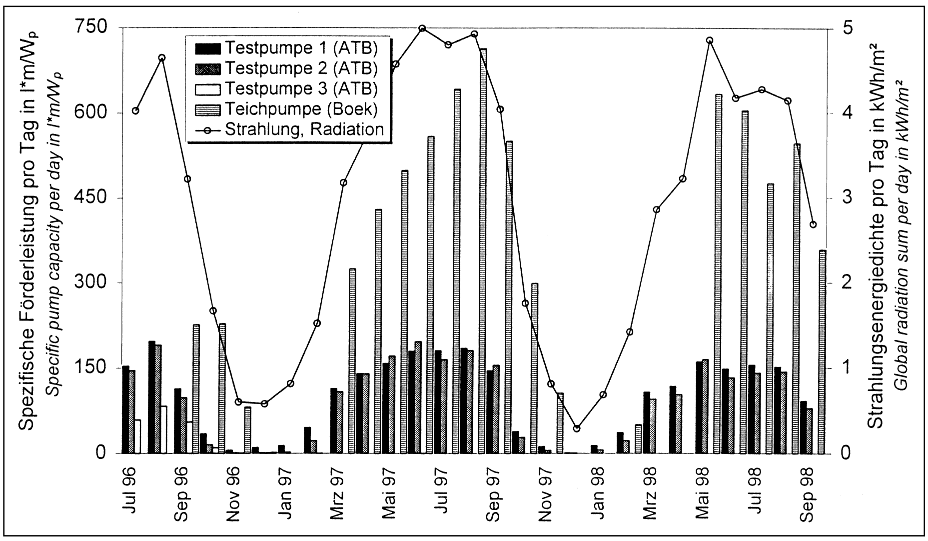

Fig. 1: Yearly courses of the specific pump capacity of different pv-pumps in a monthly average

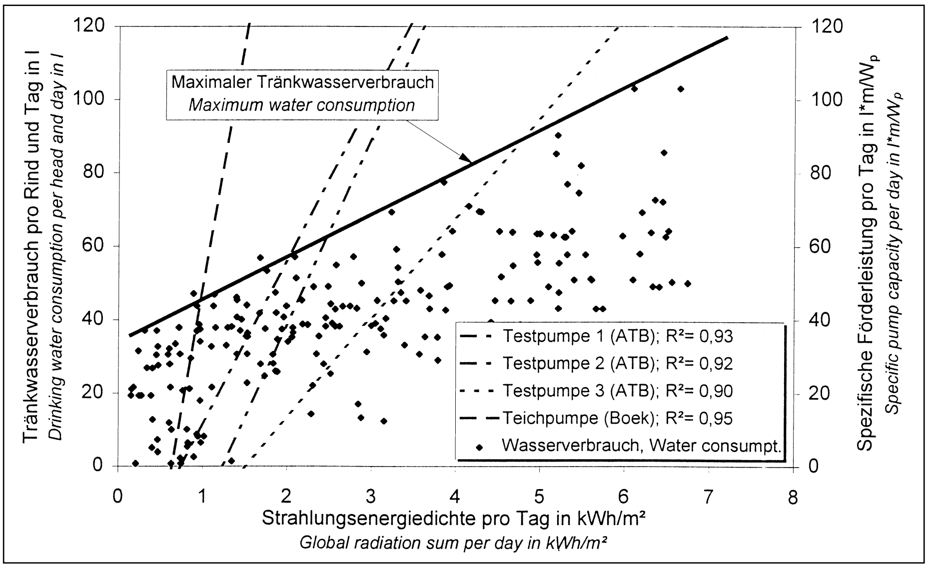

Fig. 2: Drinking water consumption of non-lactating cows and specific capacity of pv-pumps versus global solar radiation intensity

king water requirements of the animals must be known. Alongside breed, age, animal performance and feed this is also dependant on management conditions, the type of drinker and the weather and can lie up to 200% over the guide values [6]. A statistically-secured asssociation to individual meteorological parameters is hardly possible to produce. However, there is an association between the global solar intensity and the respective maximum measured water consumption of cattle In that the delivery performance of pumps also correlate with the global solar intensity, the maximum water requirements can be catered-for through choice of suitable pumping systems for delivery performance (fig. 2).

From the PV pump systems that were investigated, the performance-capability of the pond pump with an installed rated power of 1 Wp per delivered height meter could securely cover the water requirements of a non-lactating cow on days with a solar energy intensity H(1.0 kWh/m^2 (drawn from the local long-year monthly average from February to October). While the poor-performance test pump 3 could only deliver enough drinkwater under similar conditions from May to July without a higher rated performance.

Working experiences

As part of a demonstration supported by the BMBF, five PV-powered pasture drinkers were installed in different farms in eastern Germany and investigated *(table 1)*.

A few PV systems supply – outwith the water pumps – additional electrical-power for lamps, electric fences and alarm systems. Three of the PV drinkers are mobile and fitted on a water-wagon. The PV year-round drinker on the Florahof is fitted with an electronic frost-protection security system which activates the pump when a sensor in the drinking bowl registers a temperature of under +1 C.

In the trial periods up until now – of from four to seven years – generally good experiences have been made with the five installed PV pasture drinkers. The livestock water requirements could be continuously supplied. Only on two systems did the floating switch and the pump have to be replaced.

Economy

According to the performance capability and equipment, the investments for the investigated PV pasture drinkers lay between 7000 and 52,000 DM. This represents a specific investment of from 23 to 156 DM per adult livestock unit and delivery height metre. From these investments just under half was required for the PV generator (module and transformer).

For the PV water drinker supply, costs per m3 of used water are decisive. Depending on pump equipment and its amount of use, these amount to around 4 to 18 DM. Winter operation (Florahof) and extreme delivery heights (Gut Templin) led, however, to a considerable rise in costs *(table 1)*. For drinking water supply by tractor and water wagon, the specific costs on average were about 15 DM/m3. When cost of water at the mains outlet was added, one has costs that are higher by a factor of 4 than those of the most economical PV drinker supply (Hennig farm).

Conclusions

PV driven pumping systems are well-suited for application in agriculture and, with the exception of a very few components, are reliable and require little servicing. Under middle European climatic conditions in the summer months capable pumping systems achieve average specific daily delivery performances of over 150 litres(height metre per 1 watt installed power.

Optimised PV pasture drinkers can deliver the drinking water at less than a quarter of the cost of conventional drinking water supply technologies. Where the application remains limited to the summer grazing season, around 1 to 2 watt installed power per cow and delivery height metre is required for a non-lactating cow.

Table 1: Specifications and costs of examined pv pasture drinkers

	Farm Hennig 1)	City farm-Berlin 1) 2)	AG Buckau	Florahof Schüler 3)	Farmt Templin
Generator performance W_p	200	672	288	275	1113
Rated voltage V	24	12	24	12	134
Battery capacity Ah	0	350	140	75	0
Water storage volumes l	3000	0	4000	0	50000
Delivery height m	3	4	3	5	45
Number of cattle	45	110	100	20 GV	50
Investments, total DM	6789	22529	21313	15604	51554
of which, PV-generator DM	1660	12143	5203	3251	18154
Battery DM	-	2257	486	448	-
Pumping system DM	1249	388	2458	1200	5400
Others DM	3889	7741	13166	10705	28000
Running costs DM	68	225	213	156	515
Total annuity4)DM/annum	1114	2516	3028	2196	6778
Water consumption m^3/a	306	185	172	48	110
Seasonal water supply-costs DM/m^3	**3,65**	**13,60**	**17,60**	**45,75**	**61,60**

1)In cooperation, with the drinkers looked after by Agricultural Engineering, Weihenstephan
2) Currently out of order because of organisational measures
3) Year-round drinkers for – 10 cattle, 5 horses and 50 sheep
4) Calculated working life: 25 yrs for PV generator, 15 yrs for others and 5 yrs for pumps and batteries; calculation interest 7%; yearly cost increases 4%; observation period 10 yrs

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