Assessment of photovoltaic pumping systems in Thailand – one decade experience

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Abstract

By mid 1999 nearly 1000 rural villages in Thailand have been installed with photovoltaic water pumping units. The cumulative wattage is close to 1 MWp. Over 80% are in the Northeast. We conducted a survey between 1995 and 1998 on 489 units, representing over 80% of the units installed then in that region. Interviews were conducted with 360 water users from 18 villages. The results indicate that 45% of the units have been damaged and broken down. Important sources of damages are motor/pump units (35%) and inverters (19%). Inappropriate siting, lack of adequate preparation of villagers and follow-ups by respective agencies are major factors contributing to the untimely damages and breakdown. © 2001 Published by Elsevier Science B.V. All rights reserved.

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1. Introduction [1]

Photovoltaic (PV) water pumping represents one of the three main applications of solar cells in Thailand, the other two being centralized village level battery charging and telecommunication. This particular application arose and rapidly grew in the last part of the 1980s due to persistent drought in northeast Thailand. The Department of Public Works (DPW) under the Ministry of Interior and the Green Northeast (Isan) Project – GIP coordinated by the Ministry of Defence initiated then a nation-wide PV water pumping installation of 50–100 units annually. GIP was terminated in early 1990s while DPW continued the installation well into the late 1990s until the

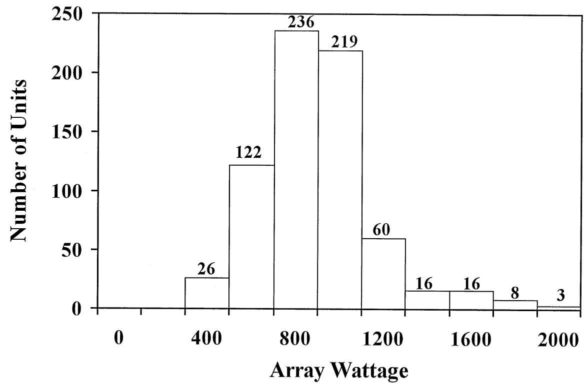

Fig. 1. Distribution of array wattage of PV water pumping units.

economic crisis in mid 1997. AC submersible pumps are used in all sites. Designed pumping capacity of most units are 16–20 m^3/day, requiring 600–1000 Wp array depending on the hydraulic heads (Fig. 1).

Thailand has accumulated about one decade of experience on PV water pumping utilization on a national scale till date. By this time nearly 1000 units (in roughly the same number of villages) have been installed with a cumulative wattage of nearly 1 MWp.

Our group initiated a 3-year survey, starting in 1995, to monitor the status of units installed and to assess the outcomes of PV water pumping applications. The results would be forwarded to the Thai PV Community, promoters and vendors.

2. Survey methodology and monitoring

Site visits would be made during the dry season (January–May) for three consecutive years, 1995–1998, after the time of rice harvest. When the farmers are free from their farm work and access to PV sites is possible. We undertook the following:

(i) Surveying 489 villages in the northeast, representing 83% of villages with PV water pumps in the region, as of the beginning of 1998. These sites were surveyed to determine overall situations regarding functionality and specific technical problems. 1–2 days would be spent at each site.
(ii) Interviewing 360 villagers from 18 selected villages on their access to and use of water, and management of the pumping units. Activities of agencies promoting PV water pumping prior to and after installation of pumps were discussed.
(iii) Monitoring of the technical performance of PV units at the above villages to determine system efficiency.

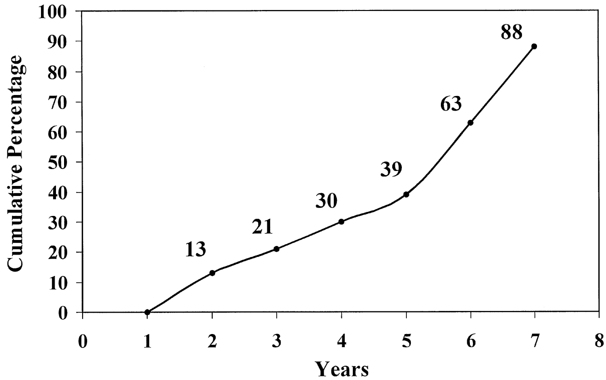

Fig. 2. Cumulative percentage of broken PV water pumping units in relation to number of years after installation.

3. Results and discussion

3.1. Status of installations

Out of the 489 sites surveyed, 220 units (45%) have failed and were not functioning. Seventy eight percent of units installed by the Green Isan Project have failed. The corresponding figure for the Department of Public Works is 36%. We note high failure rates (over 60%) of units installed by both programmes in the early 1990s. Apart from the usage for longer time, this may be due to a "target-driven" approach without due regard to adequate preproject survey, close supervision of installation subcontractors and sufficient follow-up actions.

Results indicate that up to 40% of the units would fail after 4 years of installation. The failure rate increased markedly after this. An average lifetime of a unit would be less than 8 years if there is no intervening and repair mechanism. Fig. 2 illustrates the situation.

3.2. Damages and failures [2]

In 1996, we reported results of an initial survey, indicating that most failures were due to inverter breakdown (10%) and motor-pump breakdown (23%). The remaining were structural problems, leakages and drying of water sources. Motor-pump failures are closely related to poor water quality and lack of simple maintenances to prevent algae, water plants and sediments from blocking pipes and pumps. Inverter failures occur from surge during lightnings, inadequate protection from moisture and temperature build up. Insect nesting in inverters can also cause short-circuiting.

After completing the 3-year survey a worsening situation emerged. Now over half of the failures are caused by inverter failures (19%) and motor-pump failures (32%) (Fig. 3). While the former could not have been rectified by villagers, the latter could have been reduced by training and proper management by villagers.

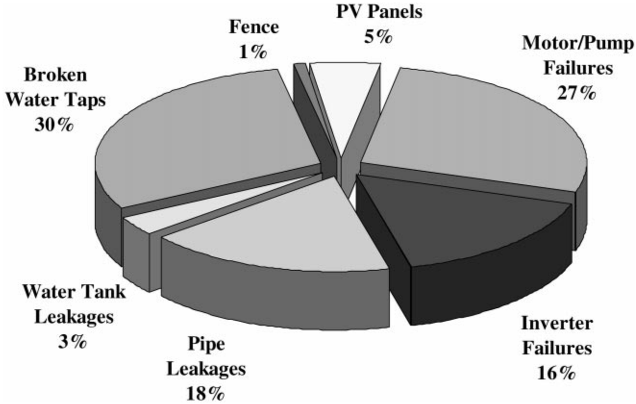

Fig. 3. Sources of failures and damages of PV water pumping units from 1996 to 1998 survey (489 sites).

Table 1
Sources of water for PV pumping from 1996 to 1998 survey (489 sites)

Sources	Reported sites	Percentage
Surface water with embankment		
Reservoirs	51	10.0
Man-made ponds	142	29.0
Surface water without embankment		
Flooded wetland	134	27.4
Shallow ponds	53	10.8
Rivers	84	17.2
Canals/stream	15	3.1
Artesian wells	10	2.0

Proper selection of water sources could have reduced failures due to blockages. Nearly all the pumping units draw water from the surface water, only 2% use water from artesian wells.

It is found that failures of motor-pump units due to blockages by sediments are mostly associated with the surface water sources without embankment (i.e. flooded wetland, shallow ponds, rivers) to protect run-off water from the ground into the water sources. This occurs mainly during the rainy season whereby substantial sediments are washed from the soil surface due to erosion. Surface mount pumps may be more appropriate than submersible ones. Sources of water for PV pumping are shown in Table 1.

3.3. *Access to water*

Table 2 indicates the level of villagers making use of PV water pumps. It reflects that when units are operational most of the villagers would make use of them.

Table 2
Access to water from PV water pumps from 1996 to 1998 survey (489 sites)

Proportion of Families in villages making use of PV water pumps	Number of villages
Less than 1/5	52
1/5–2/5	56
2/5–3/5	76
3/5–4/5	72
Over 4/5	233

Table 3
Village management mechanism from 1996 to 1998 survey (489 sites)

	Number of villages	
	With management mechanism	Without management mechanism
Water fee collection	7	467
Pumping management group	47	442

According to the survey, results not reported here, underutilization occurs when water distribution points are not "neutrally placed", e.g. within the compound of a village headman and the villagers deem that the pumps are not for the benefit of them, and stay away.

3.4. Participation of villagers

In most cases, villagers have not been equipped, prior to or after installation, to manage and maintain PV pumping units. Only 10% of the villages surveyed have village water pumping groups to oversee pumping operation. Water usage charges are exacted in seven villages to be used for maintenance and repairs, and pump keeper fees. The situation is shown in Table 3. The existence of a mechanism for water management, including fee collection, within each village is a condition for a PV pumping installation. However, this has not been actively pursued by promoting agencies. This results in the lack of responsibility, village commitment and untimely failure of pumping units.

3.5. Technical performances [3]

Monitoring was made on energy efficiency of 13 units on a continuous basis. The range of PV wattage of the units is between 750 and 1400 Wp, that of static head being 12–26 m (from engineering data design, not actual measurement during the survey).

Based on the measured daily radiation and delivered volume of water, results from eight sites yield daily average, on a yearly basis, energy efficiencies of 0.7%, 2.85%, 2.9%, 3.1%, 3.2%, 3.7% and 3.9%. The lowest value is associated with a unit installed in 1994 and may indicate substantial blockages due to sediments and water plants. The highest value is that of a unit installed in 1996.

The energy efficiency range of 2.5–3.5% is typical of that of PV water pump units previously installed and reported.

4. Conclusions

We report here results of surveying 489 photovoltaic water pumping systems in the northeast Thailand. It is found that 220 units (45%) have failed. Lack of adequate supervision during installation caused systems to fail soon after installation in the early part of 1990s. Most failures are due to blockage of pumps and pipes because of water plants, sediments, and inverter breakdown. In most cases, villagers have not been equipped, prior to or after installation, to manage and maintain the pumping units. When units are functioning, most villagers have access to and make use of water drawn by PV pumps.

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