itPower

DFID

WINDPUMP COMMERCIALISATION:
Assistance to existing partners

R7107

Final Report

Subsector: **Energy efficiency**

Theme: **E2 Develop the use of renewable sources of energy**

Project title:

WINDPUMP COMMERCIALISATION: Assistance to existing partners

Research Scheme No. **R7107**
IT Power Project No. 98607
Final Report
September 2000

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1. GOAL, PURPOSE AND OUTPUT OF THE PROJECT

1.1 Background to the work

During the 1980s IT Power developed, with support from DFID (then ODA), a successful range of large water pumping windpumps which are still being successfully manufactured in Zimbabwe, Pakistan and Kenya. These were direct-drive crank machines, with rotors in the size range 5 to 8m in diameter, aimed at providing reliable water supply to rural communities in developing countries. Although they performed this task effectively, their market was restricted mainly to institutional end-users by their large size and hence relatively high cost.

It was concluded from a market study commissioned by DFID (ref Project R5674A) that windpumps could play a more significant role in the mechanisation and improvement of water supply in many more developing countries than at present. However, a small and relatively affordable windpump, suitable for local manufacture, is needed to address the largest sector of the market, small farmers (for livestock water supply) and small isolated communities for human drinking water pumping. The original large windpump is too large for this purpose and is not capable of being simply scaled down since smaller versions of the same design would run too fast for reliable operation (wind turbines tend to rotate at a speed inversely proportional to their rotor size).

Assessment of existing small windpump designs revealed that none were appropriate for manufacture and use in the developing world: Small crank driven machines run too fast and as a result tend to be unreliable; while conventional geared traditional “farm windpumps” as widely used in North America, Australia and Europe in the past are too complex, and costly to manufacture and require high levels of maintenance (gears usually run in an oil-bath which needs regular and reliable replenishment). IT Power has therefore aimed to provide a suitable design for a small windpump which can be effectively manufactured and maintained in developing countries. It needed to be relatively inexpensive to manufacture and to need little maintenance; in short it needed to be “fail safe” under typical conditions in the remote rural areas of developing countries.

IT Power has been working to achieve this goal since 1990. Initial work investigated innovative features for the new design, which then culminated in the detailed design and manufacture of a Stage I prototype. The central feature of the new design was a novel, simple to manufacture, gearing mechanism, necessary to achieve the slow but forceful pump rate which is compatible with reliable and long-term pumping. Testing and development in the UK, supported by DFID, indicated that the machine performed well and the gearing system was efficient and reliable. Contact was then established with potential manufacturers in developing countries who emphasised the demand for the product and helped to formulate the details of the design development needs. The next stage of the work was to carry the windpump development forward from the Stage I UK prototype, effectively a test-bed machine, to a Stage II prototype or pre-production prototype machine produced by SME partners in several developing countries, namely India, China, South Africa and Zimbabwe.

1.2 Project objectives

The aim of this research project (R7107) has been to provide support and to assist developing country SME partners to progress the manufacture of the new IT Power windpump from prototype into a commercially viable unit, through testing and assessment of market development issues.

The overall goal of the work has thus been to develop the use of renewable sources of energy. Its purpose has been to enable developing country partners to commercialise the new IT Power windpump. The outputs from the project are:

- Windpump design package, including additional components (developed in line with partners' identified requirements);
- Results of local market studies/market development activities carried out in three of the four partner countries, namely China, India and South Africa;
- Preparation of preliminary publicity brochure;
- Field-test monitoring systems installed in three partner countries;
- Supporting test results from the UK based prototype.

2. WORK CARRIED OUT IN THIS PERIOD

The objectives of the project have been achieved in four phases designated by the following activities, designed to assist in the development of the outputs in the most efficient manner:

1. Continued manufacturing liaison and support;
2. Development of design enhancements;
3. Windpump testing
    a. In partner countries;
    b. In the UK to provide supporting information;
4. Development/assessment of local markets.

This section describes the work carried out under each of these activities over the duration of the project.

2.1 Continued manufacturing liaison and support

The developing country partners are listed in Table 2.1.

Company	Country	Key contact	Company outline
WindFab	India	Mr S Gurumoorthy	Commercial company involved in windpumping systems.
Stewarts and Lloyds	Zimbabwe	Mr Roy Ndebele	Commercial company involved in water supply systems. Manufacturer of the original IT Windpump & general water supply equipment
Joffe Sheet Metal (Pty) Ltd	South Africa	Mr Richard Ross / Mr Jonathan Yasvoin	Commercial company involved in sheet metal products for agricultural industry
People's Government of Cangxian County, Hebei Province	China	Mr Shen Dechang (CAAMS)	Agricultural machinery manufacturers.

Table 2.1: Developing country partners

At the start of the project contact was made with the existing partners explaining the details of the support being provided for this phase by DFID and asking the partners for comments on this and the other planned activities. Contact was maintained with all of the partners throughout the project through the use of e-mail, faxes, letters, by telephone and through visits. Some problems were encountered with faxed and written communications with

WindFab, the partner in India, and hence additional visits were completed by IT Power India. A schedule of visits is presented in Table 2.2. No extra charges were made to the project for additional visits, costs were covered through savings in other areas.

Visit No.	Partner	Visit: Type	Visit: Date	Visit: IT Power personnel
China 1	People's Government of Cangxian County, Hebei Province	Monitoring system installation	First quarter 1999	Paul Cowley
China 2	People's Government of Cangxian County, Hebei Province	Follow-up	Third quarter 2000	Paul Cowley
India 1	WindFab	Preliminary	Final quarter 1998	IT Power India
India 2	WindFab	Monitoring system installation	Second quarter 1999	Paul Cowley
India 3	WindFab	Follow-up	Third quarter 2000	IT Power India
South Africa 1	Joffe Sheet Metal	Monitoring system installation	Second quarter 1999	Frances Crick
South Africa 2	Joffe Sheet Metal	Follow-up 1	Second quarter 2000	Rolf Oldach
South Africa 3	Joffe Sheet Metal	Follow-up 2	Third quarter 2000	Rolf Oldach
Zimbabwe 1	Stewarts+Lloyds	Preliminary	Second quarter 1999	Frances Crick

Table 2.2: Record of visits made to the project partners

Some queries were raised by the partners relating to technical issues; although many of these were minor, some affected the windpump design. For instance, during a visit to South Africa, discussion was continued regarding the design with both Joffe and with their local suppliers on matters relating to the gearbox manufacture. This has produced a list of technical issues which have had to be addressed.

2.2 Development of design enhancements

Based on discussions previously held and ideas from the IT Power design team, the following four outline ideas for design enhancements were put to the partners.

- The development of a hand winch and linkage for furling (i.e. de-activating or stopping) the windpump from ground level;
- The development of a more effective platform and associated drawings changes to facilitate easier maintenance of the rotor, gearbox and furling mechanism without requiring the tower to be lowered;
- Design for a taller tower for location in areas with tree cover or other obstructions and a shorter tower for Chinese irrigation pumping systems;
- The development and testing of a pump and well-head to enable the machine to be marketed as a complete pumping solution, without requiring components to be bought-in.

It was noted that with limited time not all aspects could be considered. The partners were therefore asked to identify those aspects which they felt to be most important.

The design enhancements judged as most critical to be addressed were:

- The development of a winch and linkage (or similar) for furling the windpump from ground level;
- The development of a more effective platform (associated drawings changes to facilitate easier maintenance of the rotor, gearbox and furling mechanism without requiring the tower to be lowered will be included subject to completion of other design enhancements);

- Completion of the design for the rotor and drive train for the 3m rotor diameter derivative machine, assessment of the changes required for the tower (but not the completion of full engineering drawings for this aspect);
- Investigation into existing and alternative pump suppliers (but not a new pump design).

These items were chosen because they were considered to be important by the majority of the partners.

Additional enhancements (requested by some of the partners) which could not be addressed within this project but which may be progressed in the future are:
- Full design package for a 3m and 4.5m rotor diameter versions of the machine based on the improvements incorporated to date;
- Design for a taller tower for location in areas with tree cover or other obstructions;
- Modification drawings for feet to be added to 8m section of the tower (for Chinese irrigation pumping systems);
- Manufacturing manual (including drawings for jigs, etc.);
- Installation guidelines (for kit systems);
- User's manual.

2.3 Windpump testing

2.3.1 Monitoring system specification

Based on experience gained from monitoring the UK prototype under DFID contract R6242 specification of the field-test monitoring equipment for use by the overseas partners was carried out. The rationale was to supply each of the four partners with an identical monitoring system, to allow cost savings to be made by multi-ordering of identical components and also to help to simplify the trouble-shooting process in the event of problems with the monitoring systems.

There were a number of essential criteria which the field monitoring systems had to adhere to:
1. The systems had to be capable of simultaneously monitoring and recording both windspeed and flow of water delivered, ideally at a sampling rate of 0.5Hz and 10 minute averaging period (standard wind-measurement practice)
2. Robustness of all components (capable of withstanding heat, wind, dust and rain)
3. Autonomous data loggers and methods for data retrieval, as the test sites do not have mains power
4. Reliable and essentially fail-safe data logging and retrieval processes, as the opportunities for troubleshooting by the UK consultants are limited
5. Data storage had to be able to accommodate at least one-month's data, as at least one of the sites (China) was very remote from the in-country test engineers.

Criteria 4 and 5 above posed particular problems for the equipment specification. Portable laptop computers are commonly used for data retrieval in developed countries but most of the overseas partners did not have access to a laptop computer, so either an alternative data retrieval mechanism was required, or suitable computers would have had to be supplied out of the test-equipment budget. The need for a long data storage period was problematic in that the cost of monitoring systems, certainly at the time when the monitoring systems' specifications were being finalised, tended to increase (almost linearly) with increased storage capability.

The possibility of using monitoring devices with GSM capabilities which would permit remote data collection by IT Power staff from the UK was considered, but was discounted on the basis that it was too expensive and the signal availability could not be guaranteed.

An equipment specification brief outlining the monitoring system requirements as described above was prepared and submitted to three manufacturers/suppliers of data logging equipment:

- Manx Wind Energy (suppliers of NRG wind data logging systems)
- Western Windpower (suppliers of Nomad data loggers from Second Wind)
- Skye Instruments (manufacturers of Data Hog loggers used for a variety of environmental applications)

Two alternative approaches for flow measurement (electrical flow-rate meters and proximity sensors for stroke counting) were discussed with the monitoring system specialists. On the basis of compatibility with logger input signal requirements, a decision was made to opt for flow-rate meters.

Manx (NRG) was eventually selected to supply the monitoring packages on the basis that it was the only supplier able to satisfy the various technical considerations outlined above within the available monitoring equipment budget (not including flow-sensors which were purchased separately). The choice of flow-sensor was limited to models supplied by one manufacturer on the basis of compatibility with logger input signal requirements and budgetary constraints.

The monitoring equipment finally specified was considered sufficient for purpose within the budget allocated, although this did place severe restrictions on the equipment options. Discussion was held with DFID to extend the budget in order to allow for more sophisticated equipment but no further funds were available. It should be noted that due to budgetry constraints at the time this project was approved, DFID asked that it be carried through on a significantly lower budget than had originally been estimated. IT Power made considerable efforts to economise and broadly speaking succeeded in so doing, but with hindsight some of the problems experienced and described later stem from cost-cutting.

2.3.2 Monitoring system installation

Prior to installation of the monitoring systems overseas, IT Power engineers undertook a proof-test installation of one of the field-test monitoring kits at the company's UK wind pump test-site on the Silsoe College Campus of Cranfield University. The test installation was successful and no major problems with the monitoring package were identified. On that basis three further identical systems were ordered. All four systems were made ready for delivery to the partners, although one was later re-installed at the Silsoe test site to provide supporting test results[1].

The first overseas field-test monitoring kit was installed on the Chinese prototype machine during March 1999. Some problems were encountered with the flow sensor during the commissioning of the monitoring system (as described in Section 3.3). Work was undertaken

[1] Due to the problems encountered in Zimbabwe, as described more fully under section 3.1.4, the monitoring system destined for Zimbabwe was never installed in-country. Therefore that monitoring system was installed on the UK prototype to supplement the field-test results.

during April/May 1999 at IT Power's headquarters in the UK to establish an approach for resolving the problem (the problem being a combination of clogging caused by debris and, more significantly, a higher than anticipated back-pressure which would have resulted in inaccurate data records). The results of this investigative work, and the actions taken to resolve the monitoring difficulties (particularly with respect to the Chinese partners) are described more fully later in this report.

Monitoring systems were installed in India and in South Africa during the second quarter of 1999. The installation in South Africa ran smoothly but some problems have been encountered since then. In India problems were encountered upon re-activation of the machine, subsequent to the installation of the monitoring system, although further investigation led to the conclusion that these problems were predominately related to modifications to the windpump design not being correctly incorporated by the local partner into the operating unit.

Details of the monitoring system installation and set-up are reported on in Section 3.3.

2.4 Development/assessment of local markets

This activity has aimed to address the best approach to take to develop the market for the IT Power windpump in the different partners countries. This has been carried out by reviewing the current market and considering how best to position the IT Power windpump within that market and also the scope for developing new markets. The specific issues were addressed by:

- Examining the nature of potential customers
- Understanding the nature of the competition
- Identifying the best market opportunities for the new machine
- Estimating potential sales, based on cost estimates
- Examining barriers/support mechanisms – technical and non-technical
- Identifying the best way forward

At an early stage of the project the partners expressed an interest in the development of a brochure which could be later used as a marketing tool. Work has therefore been carried out to produce a generic brochure which, with minor variations, can be used in the different countries.

In China, promotion of the machine to relevant government ministries at State, Province and County levels has also been assisted through the China Windpump Network (CWN). CWN is administered by CAAMS, the facilitator for the Chinese partners in this project. In March/April 1999, an IT Power engineer gave a presentation about the New Small Windpump at the biennial CWN Forum in Beijing. The meeting was attended by representatives of the State Development and Planning Commission and Ministry of Science and Technology, as well as representatives from research institutes and other wind energy organisations. Progress with the windpump has been reported in the CWN Newsletter which is widely distributed to government ministries at all levels.

3. OVERALL RESULTS/FINDINGS OBTAINED BY THE PROJECT

3.1 Continued manufacturing liaison and support

The developing country partners considered that this activity was a very important part of the programme of work and should be an on-going process to allow problems which arose to be modified. A number of minor technical issues were raised by the partners during the project (either through correspondence or during visits – visit reports are included as Annex II) with regard to modifications to existing drawings to either rectify errors or make the drawings clearer. No major concerns that can be attributed to design problems have been reported. A full listing of technical issues raised is included in Annex III. Where appropriate, drawings have been modified to take account of these items.

In general communication and liaison with most of the project partners was good, one exception to this was WindFab in India. Delays in responses from all partners were one of the biggest problems faced during the project. Partners continually re-iterated their interest but for a variety of reasons, mainly pressure of current business over new product development, i.e. the windpump, were often slow to respond to issues raised. The position of the partners is described in the following sections.

3.1.1 China

Communication with the Chinese manufacturing partner, the Cangxian County Agricultural Machinery Repairing and Manufacturing Factory, (via the local facilitator partner, CAAMS, the Chinese Academy for Agricultural and Mechanisation Sciences, which is a bureau of the Ministry of Agriculture) has generally been effective, apart from a six-week period during the first half of 2000 when there was an interruption to CAAMS e-mail service. The result of this interruption was that several important messages from IT Power were undelivered without generation of delivery failure notices.

An excellent relationship has been established with CAAMS who remain strongly committed to further development of the ITP Small Windpump within China. Unfortunately, the manufacturing partner itself has been experiencing some general economic difficulties. The state-owned factory is unable to compete with the new private sector enterprises that do not have the same level of overheads to address (workers' accommodation, pensions etc.). The factory staff have been laid-off and activity at the plant has now effectively ceased. CAAMS is exploring alternative possibilities for manufacturing the windpump in China and ITP where it would be applied for water supply duties in more arid regions of the country.

A number of technical difficulties have been encountered during the course of the project, which have affected the collection of data on the machine's performance. The technical problems with the monitoring system are described more fully under Section 3.3. Other contributory factors are detailed below.

The windpump foundations were slightly damaged during severe floods in July / August 1998. In order to make repairs to the foundations, and also to avoid potential problems with freezing during the very cold winter months, the machine was dismantled for a number of months. It was re-erected early in 1999 and at this time a visit was made to fit the monitoring equipment. However, it was not possible to commence the monitoring programme at that time.

CAMMS reported a delay on the Chinese side as the system user, Mr. Wang, could not be on site until June 1999 (a fire at the user's main residence had resulted in serious injury to close family members).

Additional delays were encountered on the UK side as a result of re-specification and delivery of components and essential modifications of the monitoring system (specifically the flow-meter units).

The local machinery workshop which manufactured the windpump removed the monitoring system over the winter period (from November 1999 to March 2000) to prevent possible damage to, or theft of the components. The user returns to his main residence over the winter period, so was not on site during this time to guard against this. The windpump was also dismantled during this period to assess for wear and to determine whether any repairs were required (a slight knocking noise had been discernible from the rotor end of the drive-train). It is believed that the noise was caused by a slight loosening of the bolts which fasten the connecting bar to the bottom of the gearbox, but no damage was reported. Wear to the key components was reportedly minimal and no repairs were required, though findings from a subsequent visit by IT Power's engineer call this assessment into question (see Section 3.3.2).

The machine was re-installed in March/April 2000. However, this installation was completed incorrectly, with the user introducing some unauthorised changes to the design in an effort to increase water output. In addition, the monitoring system was not returned to site when the machine was reinstalled. CAAMS advised IT Power of the position shortly after the re-installation had been undertaken. IT Power requested clarification of the extent of the modifications, which was duly provided, but several subsequent messages insisting that the machine be restored to the design condition and proposing that an engineer from the UK visit the machine to check the condition and undertake some testing were not received by CAAMS due to e-mail system failure. The communications problem was only identified after some delay when IT Power re-established contact by phone.

An IT Power engineer re-visited the installation during third quarter 2000 to re-assess the condition of the machine, undertake some final testing and to gauge the user's opinion of the machine's performance. Additional discussions as to possible approaches for future deployment of the machine within China were also held with CAAMS during this time. Notes from this visit are included under Annex II, but the key conclusions of the visit are:

- CAAMS are keen to continue development of the ITP Small Windpump
- It is unlikely that the current manufacturing partner will resolve its financial difficulties, so a new partner would be required to undertake manufacture and maintenance of future systems
- The 2m rotor diameter machine is not appropriate for small farm-holding irrigation purposes (in hindsight it was a mistake to submit to County-level politics which insisted on assessing the machine for irrigation applications).
- Government support is critical for assisting more widespread dissemination of the technology. Provincial level government appears to be the most important for near-term market development.
- Initial cost of the machine still presents a problem. Even with volume production, it is likely to be more expensive than comparable Chinese alternatives, which are of lower quality and usually lower output (they start at higher windspeeds), so this will need to be made clear to potential customers with effective marketing. In addition windpumps in

general have a greater first cost than diesel driven systems. Alternative approaches for financing purchases of windpumps are needed to assist private market development.

The installed machine is shown in Figure 3.1.

Figure 3.1: Machine installed on Chinese smallholding

Figure 3.2: IT Power windpump in India

3.1.2 India

In the early stages of the project failed communications systems (faxes and letters) meant that many communications from IT Power to WindFab had not been received. This matter was resolved when IT Power's India office met with WindFab in December 1998, on behalf of IT Power UK. A full report of this visit is included in Annex II. It was concluded that WindFab, as project partners, were clearly technically viable with the required infrastructure to take the project forward. Concerns were noted at that time about the commitment of WindFab to wind pumping as their priorities in grid connected wind electricity generation were increasing. However since WindFab strongly re-iterated their interest and commitment to pursuing the project their participation was continued.

A second visit was arranged for May 1999 when the monitoring system was installed. Figure 3.2 shows the installed machine with the monitoring equipment clearly visible. Although a number of technical problems with the machine and the monitoring system (see Annex II and Section 3.3.2) were encountered during this visit it was clear that WindFab had, in the period between the two visits, worked on the machine addressing some issues raised previously and in correspondence. This activity therefore supported their earlier commitment to the project.

The key technical problem was the gearbox failure that occurred during the visit in May 1999. With an IT Power engineer on site the problems were discussed and solutions raised. WindFab stated that the activities noted to solve the problem would be implemented. Over the ensuing months it became clear that delays had occurred and the solution had not been implemented. WindFab, however, informed IT Power that because their busiest time for core business (wind generator work) was from April to October pressures of other work prevented them from resolving these problems but that the work would be carried out after this period. Later (after some delay in eliciting any response) WindFab informed IT Power that some work had been completed but due to other business pressures faced by WindFab not all matters had been resolved. WindFab stated that they were progressing matters when time was available. It was planned to visit the installation early in 2000 but WindFab's other business commitments meant that they only offered suitable dates for a visit late in the third quarter of the year. It was only during the final visit (September 2000) that the real situation was revealed, which was that the machine had not been repaired until just before the visit.

Therefore, it has become clear that WindFab are not committed as a project partner and collaborator on the IT Power windpump, although this has only been revealed late in the project due to WindFab's insistence to the contrary. Correspondence has always indicated that activities are on-going, if sometimes delayed. The conclusion must be that WindFab started this work with the intention of introducing the IT Windpump to the market but, in the meantime, WindFab, as a business, has shifted its operations into the more lucrative grid-connected wind farming. It is difficult to see them renewing or carrying out windpumping activities. It seems that they are interested in the work (hence they wanted to remain involved) but that they do not consider the work of sufficient priority to redirect resources.

3.1.3 South Africa

The South African partner, Joffe, had a very busy period (with their main manufacturing business) during 1998 and into the New Year and therefore only installed the windpump at the chosen test site well into 1999. A visit was made to the machine in May 1999 when the monitoring system was installed, Figure 3.3, and productive discussion ensued with regard to progressing the marketing of the windpump

Initially the machine ran well, although some minor problems were encountered with the monitoring equipment (see Section 3.3) which were assessed by IT Power and a solution provided, but no action was taken by Joffe although the information received by IT Power was to the contrary. Towards the end of the year (1999) the machine suffered from pump rod failure. Although support was provided by IT Power on the causes of the failure the investigation and correction of the problem by Joffe did not occur until after IT Power's follow-up visit mid way through the year (2000) although indications from Joffe were, again, to the contrary. Joffe blame these misunderstandings on a change of personnel and a busy period at their factory. The failure was found to be caused by a sticking pump problem, exacerbated by alignment problems of the pump rod guides. Of importance for the future is the careful alignment of the pump and guides. This has been noted for future installations.

In the middle of 2000 a key member of Joffe's staff, who was Marketing Director and who instigated the windpump work left the company. Joffe then became concerned about their role. They do not consider themselves to be strong on marketing – the loss of personnel badly affected this area. Joffe concluded that they could not now commit themselves to the marketing yet they remain keen to be involved in manufacturing the machine. They stated that they would be interested in a joint venture (20-25% stake) or similar with another or new company. Some work was carried out to identify a potential partner. Contacts made to investigate alternative pump suppliers (see Section 3.2.4) identified that the major South African pump supplier, Jooste Cylinder & Pump Co., had an interest in selling the machine. A visit was made by the pump supplier to see the Stage II prototype in South Africa when they re-iterated their interest. Discussions are now on-going into how the two companies might work together to market the windpump.

Figure 3.3: The IT Power windpump in South Africa with the anemometer and windvane

3.1.4 Zimbabwe

During the early stages of the project the Zimbabwean partner, Stewart & Lloyds, went though major restructuring following a change of ownership of the company. During this time of flux it was not clear if work on the windpump project would be able to continue, and certainly during that period the system remained dormant. However in the early part of 1999, and under new ownership, Stewart & Lloyds confirmed their continued wish to participate in the project. Therefore, to discuss activities and progress the installation of the machine, a visit was made to Stewart & Lloyds at the end of May 1999. At this time Stewart & Lloyds re-commenced discussions with the University in Bulawayo to set-up the machine at a test site on their premises. A meeting was held with the University during IT Power's visit.

However, Zimbabwe generally continued to experience economic and political difficulties, and this continued to cause problems for Stewart & Lloyds, and other industrial companies. Funds were denied from the company's Head Office and this led to, what appeared to be, simply a continued delay in setting-up the machine at a suitable test location.

In September 1999 Stewart & Lloyds underwent further management restructuring, though the core-staff involved with the windpump project remained the same, and the support for the project was re-iterated. The lead engineer was very positive about the new company infrastructure, believing that it was much more receptive to development projects such as the small windpump. It was only in June 2000 that the lead engineer was able to ascertain (after numerous instances of delays whilst re-iterating interest from his head office) that the windpump work was being shelved. Recent communications with the company suggest that it is in serious financial difficulties and likely to cease trading.

A new company in Zimbabwe, Jooste Water Works, however has expressed an interest in developing the IT Power windpump. This company supplies equipment for water supply and irrigation and is an agent for the reciprocating pump supplier in South Africa who are interested in marketing the windpump (see Section 3.1.3). This new link is of potential benefit to the commercialisation of the IT Power windpump and is being developed.

3.2 Development of design enhancements

Design briefs were developed for the key design enhancements. The briefs, including the design outputs/results are presented here. Drawings/calculations for the design enhancements, were appropriate are included in Annex IV.

3.2.1 Ground level furling mechanism

Introduction

The ground-level furling mechanism is illustrated in schematic layout in Figure 3.4and Figure 3.5.

With the current design for the IT Power windpump it is necessary to climb the tower and pull a loose chain that hangs alongside the windpump head mechanism in order to furl the machine. This is not a convenient operation especially in stormy weather. The development of a "ground level" furling mechanism, winch and linkage (or similar) for furling (turning out of the wind) the windpump from the ground was recognised by the partners as an important option for the windpump when used in windier climates, or in more sophisticated market environments.

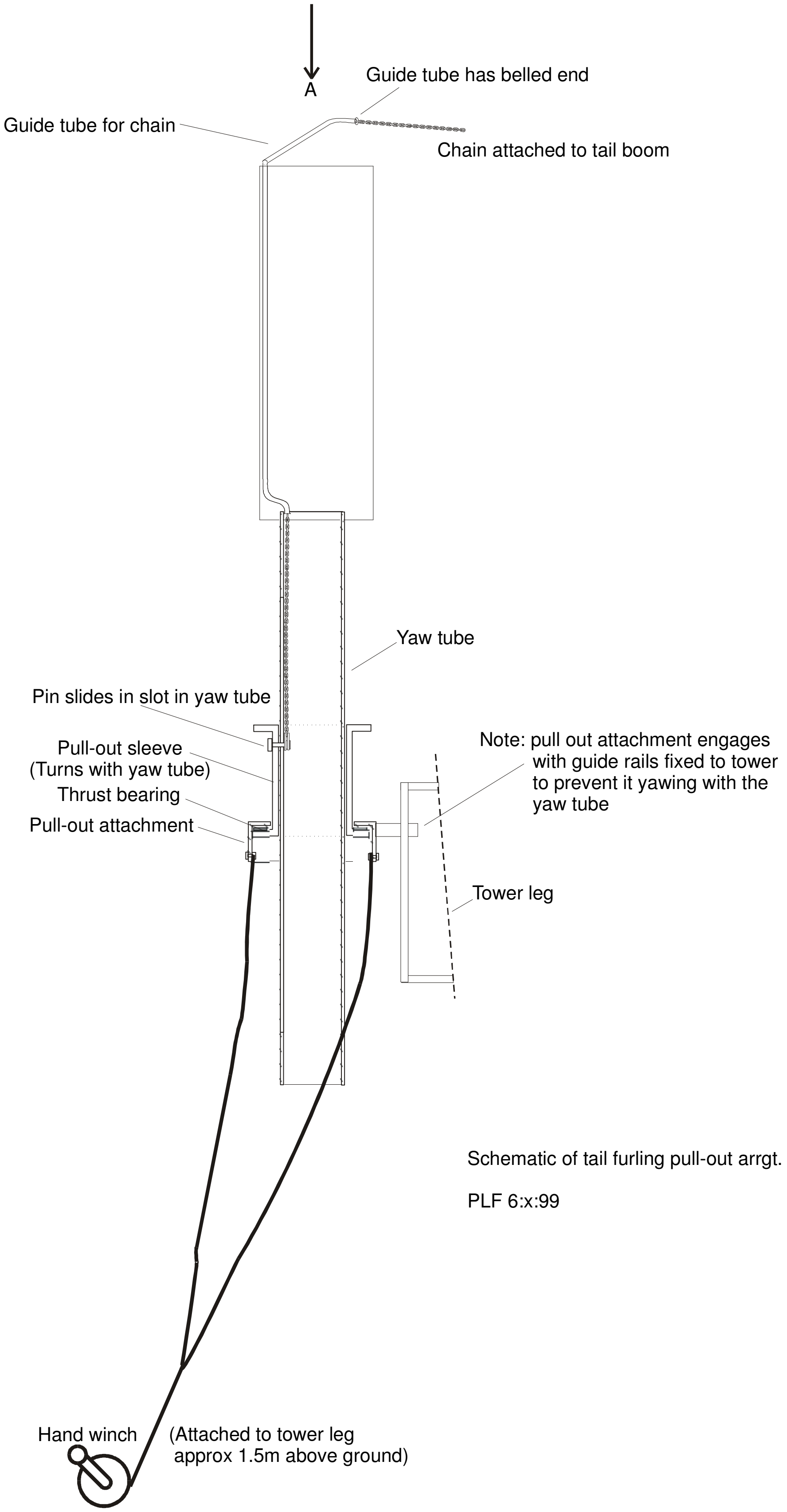

Figure 3.4: Tail furling arrangement

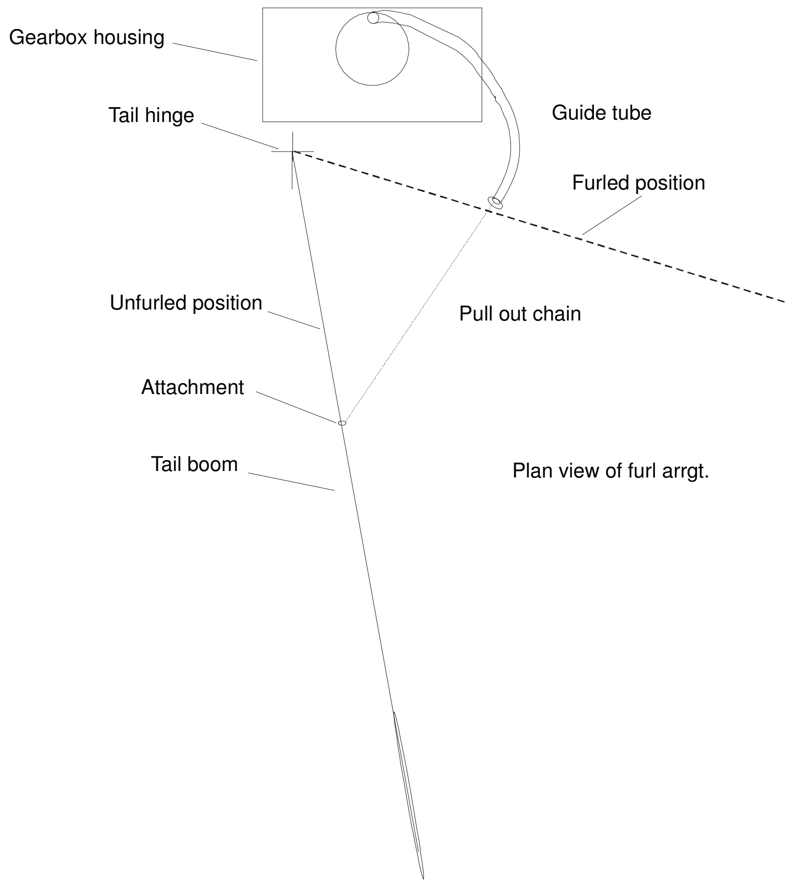

Figure 3.5: Tail furling arrangement – plan view

Design rationale/target requirements

Requirements of the "ground level" furling mechanism were identified as:

- development that can be added to the basic design by the overseas manufacturing partners;
- operable by a person standing at ground level;
- must add minimal cost;
- must not foul or lock especially when furling (unfurling is marginally less critical since this implies lower windspeeds when intervention is possible).

Design output/results

The ground furling consists of a chain attached to the tail about 25% of its length from the pivot point, such that the travel distance for the chain is about 1000mm if it pulls the tail from the operating position (straight back) to the furled position (near parallel with the rotor). The "pull out" chain is threaded through a length of steel pipe shaped to align with the chain as it enters from the direction of the tail (via a bell mouth so it will not catch) and lead the chain down through the from part of the gearbox casing (clearing the gearbox) and into the front of the yaw tube.

The chain hangs down the front interior surface of the yaw tube. The front surface of the yaw tube is slotted with a 1.1m long slot and has an outer sleeve (pull-out sleeve) with a pin which passes through the slot in the yaw tube and is connected by a suitable fitting to the chain. Therefore if the pull-out sleeve around the yaw tube is pulled down, it pulls the chain through the shaped steel pipe and this in turn pulls the tail into the furled position.

The pull-out sleeve will yaw with the yaw tube but it has a flange at its lower side which carries another flanged sleeve supported on a ring of low friction material (i.e. nylon) and this ring is constrained by a peg which engages in two rails mounted inside the tower so that it cannot yaw, i.e. the yaw tube sleeve turns within this ring when the windmill yaws to face the wind. A yoke consisting of two stainless steel cables is attached to this sleeve, and the two cables are joined to a single cable lower down which can be pulled by a small hand winch. Marine rigging components can be used for this purpose. The hand winch will have a ratchet mechanism to lock it and prevent it unwinding when the handle is released. Then by winding the hand winch the tail is pulled into the furled position. The process can be reversed by releasing the ratchet mechanism on the hand winch and winding it back.

3.2.2 Platform development

Introduction

The development of a more effective platform (this is to facilitate easier maintenance of the rotor, gearbox and furling mechanism without requiring the tower to be lowered).

Design rationale/target requirements

Changes identified to improve the current platform include:

- weight reduction
- access improvement (relative to the revised tower ladder)
- simple fitment
- improved location for easier maintenance of the machine head rotor, whilst still maintaining its primary functions - support of the tower during construction and use as an access platform.

Design output/results

The new platform design, see Annex IV, serves two purposes, to provide a safe working platform for servicing the mechanism of the machine when it is upright and operational and also of providing support for the hinged tower of the machine once lowered (for initial construction and for maintenance) so as to keep the rotor and mechanism just clear of the ground. It is located two meters below the tower top. To improve access to the rotor- head steps are provided to climb from the platform to the top of the tower. To raise the platform further would have potentially interfered with the blades on the larger rotor diameter machines in the series (it is intended for simplicity of manufacture that the tower design throughout the range of machine sizes should essentially remain the same, only allowing for the use of larger size structural steel sections for improved strength as the machine size increases).

3.2.3 Rotor and drive train consideration for the 3m rotor derivative

Introduction

Completion of the design layout for the rotor and drive train for the 3m rotor diameter derivative machine, assessment of the changes required for the tower (but not the completion of full engineering drawings for this aspect);

Design rationale/target requirements

Changes identified to define the design layout include:

- stress analysis assessment for main rotor and drive train components and for tower

- key features (including outline sizing) and layout

Design output/results

Design analysis reveals that the following key element sizes will be required for the design of the 3m rotor within the allowable stress limitations, see Annex IV.

Item	Key description/ dimension	On 2m machine	On 3m machine
Blade	Blade chord	250mm	297mm
Blade spar	Hollow circular section	21.3mm dia x 3.2mm wall	26.9mm dia x 3.2mm wall
Drive shaft	Solid round	30mm dia	30mm dia
Rotor support tube	Hollow circular section	60.3mm dia x 5mm wall	76.1mm dia x 5mm wall
Transmission support column	Hot rolled seamed pipe	80mm nominal bore x 4.05mm wall	100mm nominal bore x 4.5mm wall

Investigations into the design layout have revealed a key finding: the layout utilised for the 2m rotor diameter machine can be used for the 3m rotor diameter simply by replacing the key components noted above. Detail drawings will be required to define items such as the drive shaft bearing spacer, new bearings, and other components which although not critical in terms of strength/life are defined by sizes of those components which are critical.

An outline review of the gearbox requirements (based on the newer design used for the 2m rotor diameter machine) for the larger machine indicates that the gearbox design currently utilised could be adapted by replacing the plastic gear teeth with cast iron (a high grade cast iron such as ASTM A48 class 40, requires approximately half the gear facewidth for the same load). Detailed analysis is required before the design layout is finalised. This would also consider the effect on output of using the same gear reduction ratio for the two different sized machines.

3.2.4 Alternative pump suppliers

It was agreed with the partners to the project that one of the design enhancements should include an investigation into existing and alternative pump suppliers (but not a new pump design). A number of problems encountered with pumps/pumping systems prompted this decision:

- Testing on the UK Stage I prototype with a conventional reciprocating pump (brass bore, leather cups) caused a pump rod failure due to a high degree of “stiction” in this rather old design of pump, hence a new design of pump (GRP impregnated with PTFE bore, neoprene piston seal and all other components plastic or stainless steel) used in the UK after the problems reported above was much more efficient (of considerable interest to the partners);
- Pump and system corrosion was reported by the partners to be a common problem with many windpumping/water lifting systems and this was also a perceived problem with potential customers;
- The pump was felt to be a key area which could adversely affect the efficiency and the reliability of the machine; since the new gearbox aimed to improve output, ignoring the effect of a poor pump on the performance was seen to be counter productive.

Working with the overseas partners IT Power has investigated existing and alternative pump suppliers. One key criteria was that any pump should be produced ideally in the country and if not then certainly in the local region.

Investigated at an early stage was the UK supplier who provided the more modern GRP/PTFE pump for the machine testing in the UK because the pump had performed so well and was of considerable interest to the partners. However, it was concluded that transfer of this technology was not viable, the materials were quite specialised and would be difficult to obtain and therefore the quality of the pump could not be guaranteed if it were produced elsewhere. Obviously purchase of the pump in UK was ruled out for both reasons of cost and complexity to supply. Contact was then made with pump suppliers in the regions where the IT Power windpump partners are located. Most pump manufacturers where found to produce conventional pumps, however, one in South Africa which produces a non-conventional modern type of pump was identified.

In May 1999, a visit was made to the South African pump manufacturers, Jooste Cylinder & Pump Co. Jooste manufacture stainless steel based borehole pumps and although more expensive they do claim to have a much greater life and reduced frictional forces. Both of these aspects are very important for effective and efficient pumping systems and also frequent replacement of borehole pump components is extremely costly. One clear benefit would be to reduce the problems associated with corrosion since internal surface degradation of pump cylinders leads to rapid wear of the seals. Many development agencies will consider the use of a retractable pump, (i.e. one which can be raised through the rising main) which although much more expensive can be more easily serviced. Jooste pumps avoid the need for frequent servicing. The cost implications of using this type of pump were investigated. It was concluded that Jooste pumps should add no more that 5% additional cost to the initial price of the wind pump – assuming a non-retractable pump (3-4% to overall cost of machine) and would almost certainly have significant advantages in reliability, performance and keeping running costs down.

The South Africa partners in the project, Joffe, purchased one of Jooste's pumps and it forms part of the test system on the windpump currently being monitored. Discussions have commenced with Jooste to consider what size pumps would be suitable for the range of sizes of IT Power windpump.

In addition other pump designs were investigated. A new design of water driven deep well pump, produced by a Danish manufacturer (Thanner & Co.) was of interest to Stewart & Lloyds in Zimbabwe and it was intended that part of the test programme would have been to investigate the use of this pump. However, with the withdrawal of Stewart & Lloyds involvement this activity was not possible.

3.3 Windpump testing

IT Power considers field testing of the small windpump - both in terms of qualitative and quantitative performance assessments - to be an important element of marketing the machine. Users and choosers of such technology want to know the capabilities of the machine in terms of water delivery, reliability and ease of use in environments similar to their own. The campaign to monitor several machines under several different conditions of demand / head / climate was envisaged as an important measure to demonstrate satisfactory capabilities.

Unfortunately, within the time frame of this project, the monitoring programme has not provided test results from the developing country machines for a variety of reasons as described in section 3.3.2. This has been, at least, partially caused by the need to compromise in the specification of the equipment as a result of budget reductions (an error only really clarified with the benefit of hindsight), the windpumps themselves generally performed as expected although useful lessons were learnt in that a few technical problems were identified and resolved.

3.3.1 Monitoring system specification

Specification and procurement of the field-test monitoring equipment for use by the overseas partners was completed according to the requirement and constraints noted in Section 2.3.1.

The central component of the system was the NRG WindExplorer data-logger which utilises a robust 132kB dataplug for storage purposes. The dataplug, which is a “solid-state” electronic memory device, is capable of storing more than two months worth of monitored wind speed/direction and water-flow data (10 minute averages), and has a simple pull-out / plug-in replacement procedure. A designated local technician was to undertake periodic replacement of the dataplugs, which were to be returned to IT Power to enable retrieval of the stored data.

The turnkey monitoring systems, supplied by Manx Wind Energy Services, consist of NRG WindExplorer data-logger plus compatible anemometer and wind-vane, and Gems Sensors’ Rotorflow flow-meter (paddle-wheel type turbine flow sensor, max 75l/min). The logger, together with the interface (needed to convert the power supply to, and data signal from, the flowmeter) are housed in a toughened plastic enclosure box to protect against the elements, Figure 3.6.

As a number of the local test sites do not have access to a suitable on-site power supply, the monitoring systems have a self-contained power unit. This is provided by two small photovoltaic modules, which are integrated into the enclosure box, recharging 4 x 4.5Ah Sealed Ni-Cad batteries. An overview of the field-test monitoring system is included as Annex V.

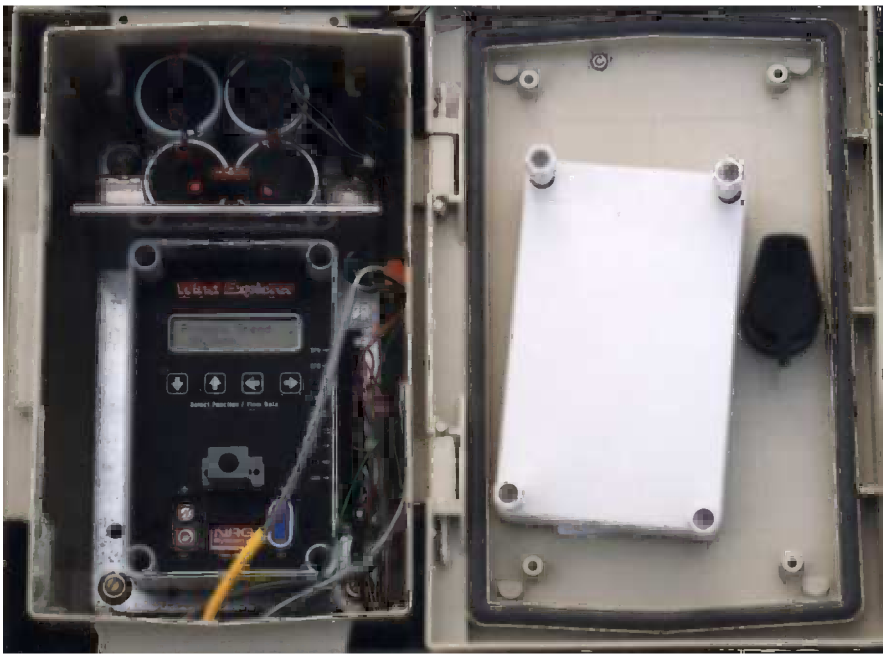

Figure 3.6 NRG Data logger and batteries in housing

3.3.2 Monitoring system set-up/results

Prior to installation of the monitoring systems overseas, IT Power engineers undertook a proof-test installation of one of the field-test monitoring kits at the company's UK wind pump test-site.

China

Following the successful test installation of the monitoring kit in the UK the first overseas field-test monitoring kit was installed on the Chinese prototype machine during March 1999. The monitoring package was installed without difficulty. Unfortunately, however, a problem was encountered with the flow sensor, which became clogged with debris (dirt and rust from the bore-hole and pipe-work). In addition the flow sensor exerted a back-pressure on the outflow which caused water leakage; this was because the Chinese pump installation does not have a conventional well-head, in that there is no stuffing box. As a result, the resistance created by the flow-sensor caused some of the pumped water to be diverted out of the well-head riser around the pump-rod, rather than allowing the entire volume to pass through the outflow pipe, Figure 3.7.

Figure 3.7: Problem of leakage out of the well head riser

Work was undertaken during April/May 1999 at IT Power's headquarters in the UK to establish an approach for resolving the problem.

Because the logger interface of the monitoring system has been specially designed for this application, it was not possible to modify the system to monitor an alternative indicator of performance (e.g. pump-rod stroke-rate) without serious implications for the overall project budget, (the hardware budget had been exhausted in purchasing the four monitoring kits.)

IT Power engineers considered three alternative approaches for overcoming the flow-monitoring problems:

1. Incorporation of a settling tank with low cost filter between the windpump delivery pipe and the existing flow-sensor;

2. Incorporation of a suitable in-line filter (higher cost and likely to add to the back-pressure problem);
3. Re-specification of the flow-sensor.

The settling tank was conceived as a relatively inexpensive solution, enabling the bulk of the water-borne debris to be easily removed, and with the added advantage that the surge associated with the piston pump action was smoothed.

Analysis and testing were undertaken to determine the precise relationship between delivery flow and sensor back-pressure, and to identify suitable dimensions of the settling tank to accommodate the dynamic flow regime. While the arrangement proved mechanically suitable (provided a sufficiently high-sided tank was used), it was concluded that it was not an ideal solution in that the size of settling tank required imposed a time-lag between the measured windspeed and the measured water delivery. The lag was also variable, dependent upon the precise flow-dynamics (given that the sensor back-pressure varied with flow - or in this case, the head of water in the tank).

Efforts to resolve the problem thereafter focused on specification of an alternative flow-sensor and a suitable in-line filter. This option required careful consideration such that re-specification of the flow-sensor would not require some re-design of the logger interface (with associated high cost). A higher-capacity flow-sensor using the same input and output signals was found to be available from a supplier in the USA. This unit did not have the same accuracy of the previous model at low-flow rates, but it did exert a much lower back-pressure on the flow. However, a considerable delay was encountered when ordering the units which had to be specially shipped from the USA.

The problems described above meant that no results were obtained from the Chinese machine until the autumn of 1999. In addition, the local partners did not wish to leave the monitoring system installed on the test-site between November 1999 to March 2000; the user who is responsible for the windpump returns to his village over the winter period, and the Chinese partners were concerned that the monitoring system might be subjected to vandalism or theft if left unattended.

The machine was reinstalled in early 2000, but incorrectly. IT Power urged that the machine be rectified to the proper design condition and scheduled another visit to assist with short-term testing in an attempt to gain a set of performance results.

On arrival, the machine had apparently been restored to the IT Power design condition. However, it transpired that the gearbox had not been fully reconnected and the local technician (who was responsible for some unauthorised modifications) was not available to complete the reconnection.

In addition the monitoring system had not been reinstalled. The logger enclosure box had been in storage for some time, hence the battery was not being charged by the solar modules during this period. The rechargeable battery was therefore discharged, but this did not present a major problem as it is possible to utilise a standard 9V dry cell as an alternative power supply for short periods (i.e. a few days). The system was checked to ensure that the logger was functioning correctly (logger indicated initial battery voltage to be 9.7V, all input channels responded correctly).

Further problems were encountered when the local technician attempted to complete the gearbox reconnection. Inspection of the gearbox casing stop plate, showed substantial wearing of the bearing retaining flange, to the extent that the flange was virtually eroded towards the flared end (bottom of rack). There was additional damage to the flange, possibly caused during removal or reinstallation of the gearbox. Note: when IT Power enquired earlier in the year as to condition of components (following winter removal / assessment by Cangxian County partners) no problems were reported - the machine had been functioning satisfactorily until the winter disassembly. It is thought that the wear / damage to the flange may have resulted from failure to heat treat the component (No. 3-00-029), which is subjected to constant contact from the cam roller bearing.

India

The monitoring system was installed in India during the second quarter of 1999. A serious gearbox failure (see Annex II) was encountered upon re-activation of the machine, subsequent to the installation of the monitoring system, although further investigation led to the conclusion that these problems were predominately related to modifications to the windpump design (issued when the overseas machines were being manufactured) not being correctly incorporated into the operating unit.

Prior to IT Power's visit, WindFab had reported that the machine had not been furling as expected. On inspection, IT Power's engineer advised that this was largely due to the failure to implement the advised changes to the transmission support column (TSC) pipe and TSC grease-ring bearing assembly, coupled with an incorrect setting of the tail adjuster. This served to keep the rotor open to the wind even at high winds and therefore resulted in overloading the system.

The unfortunate result was that while the system was being tested following installation of the monitoring equipment, the machine failed to show signs of furling even in a gust exceeding 16m/s (a peak gust of 16.3m/s was recorded from the monitoring system). The excessive stroke rate (of the order of 40Hz), coupled to a number of other contributory factors including the removal of some pump-rod guides and apparent incorrect tolerancing on the casing stop plate (which is designed to prevent the rotor pinion riding up off the gearbox rack) led to a meshing failure between rack and pinion. This resulted in the nylon rack gear-teeth being eroded by the steel pinion and hence the failure of the gearbox.

The gearbox failure, requiring the re-manufacture of several components, together with the manufacture and assembly of the new components needed to bring the machine in line with the design specification seriously delayed system monitoring.

IT Power were led to believe that the modifications and necessary repairs to the system (as identified during the June 1999 visit) had been addressed and that the monitoring campaign had recommenced by final quarter 1999. Indeed WindFab informed IT Power that two dataplugs containing system performance data had been despatched to the UK for processing. However, the plugs were never delivered. WindFab were apparently unable to ascertain from the postal authorities why delivery was not completed. In fact, as reported in Section 3.1.2, the machine was not repaired until immediately prior to the final visit so it can only be assumed that no dataplugs had been despatched.

As a result of the experiences encountered in India, a number of additional modifications to the design have been proposed, notably:

1. The rim on the gearbox casing stop plate (Part No. 3-00-029) should be extended to 10mm to reduce the possibility of the pinion riding-up off the rack
2. It is advisable to include a "soft-link" (e.g. cable or chain section) in the pump-rod train. This would avoid possible pump-rod compression should a similar rotor / pump-rod overspeed situation be encountered in future. Also, it would tend to transfer the likely failure point away from the (expensive) gearbox and onto a simple, inexpensive and easily replaceable component.

South Africa

The monitoring system, using the small flow-sensor, was installed in South Africa in May 1999 during IT Power's visit, Figure 3.8. Initial tests indicated that the system was functioning correctly although it was not possible to test the machine fully because during this period wind speeds were very low. Low wind speeds dominated the period through May, June and into the early part of July so the machine was only running for short periods of time.

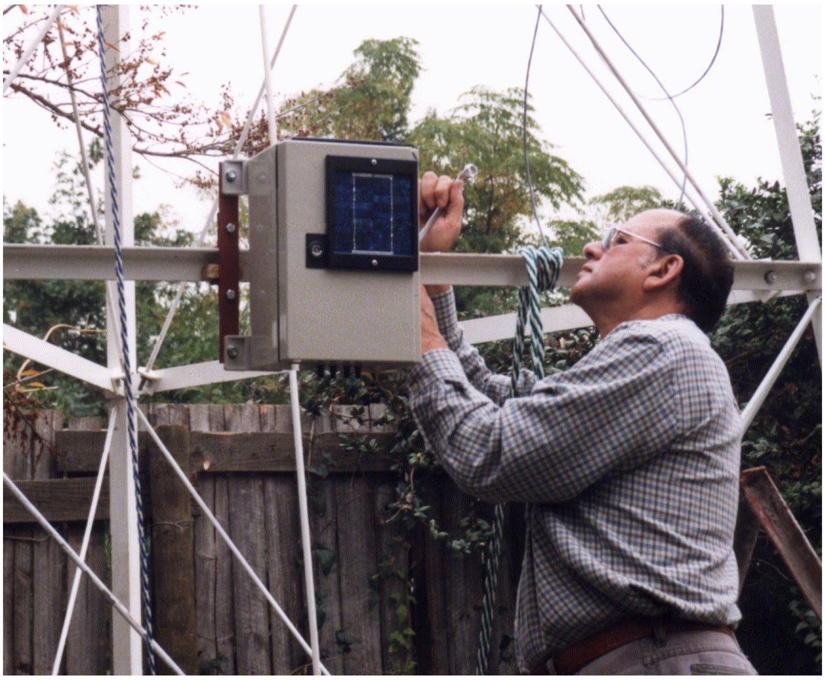

Figure 3.8: Installing the monitoring system in South Africa

During July it was discovered that the battery powering the logger was not being charged correctly. Consequently flow data (which required sustained battery voltage levels for an output signal to direct the flow meter to take a reading) was lost due to low battery levels. The pattern of recorded wind data indicated that the logger was only operating correctly for a few hours around the middle of the day. The obvious conclusion was that bushes and other obstacles around the machine were not allowing enough sun to reach the PV panels on the monitoring equipment. The Logger enclosure was therefore relocated to improve this situation and the batteries re-charged.

However, after this a problem was encountered with the pump rods which necessitated their removal for alignment verification. Corrective action to resolve the misalignment was only implemented shortly before IT Power's engineer revisited the installation in 2nd quarter 2000.

Subsequently, it transpired that there was still a problem with the recharging of the logger battery, which was identified during the final visit. IT Power's engineer determined that the PV module (nominally 12V) was delivering insufficient voltage to allow the battery to recharge. The likely cause is a faulty module. This problem was only discovered late in the project because of the other delays mentioned previously.

The consequence of these combined problems means that only a limited amount of data for the machine operating is available to date and this data cannot be used because its accuracy is questionable due to the fluctuating battery levels.

Zimbabwe

The problems experienced by the Zimbabwean partners as described in section 3.1.4 meant that the monitoring system destined for Zimbabwe was never installed. No results, either quantitative or qualitative, are therefore available for Zimbabwe.

Supplementary test results from the UK prototype

The test monitoring system installed on the UK prototype worked well and revealed no problems when installed, as discussed in Section 2.3.2. It was then removed with the intention that it be used by one of the overseas partners but was later re-installed to attempt to replicate some of the problems encountered elsewhere with a view to resolving them. It remained in place for the collection of supporting data where it performed with no problems. The results are presented in Figure 3.9.

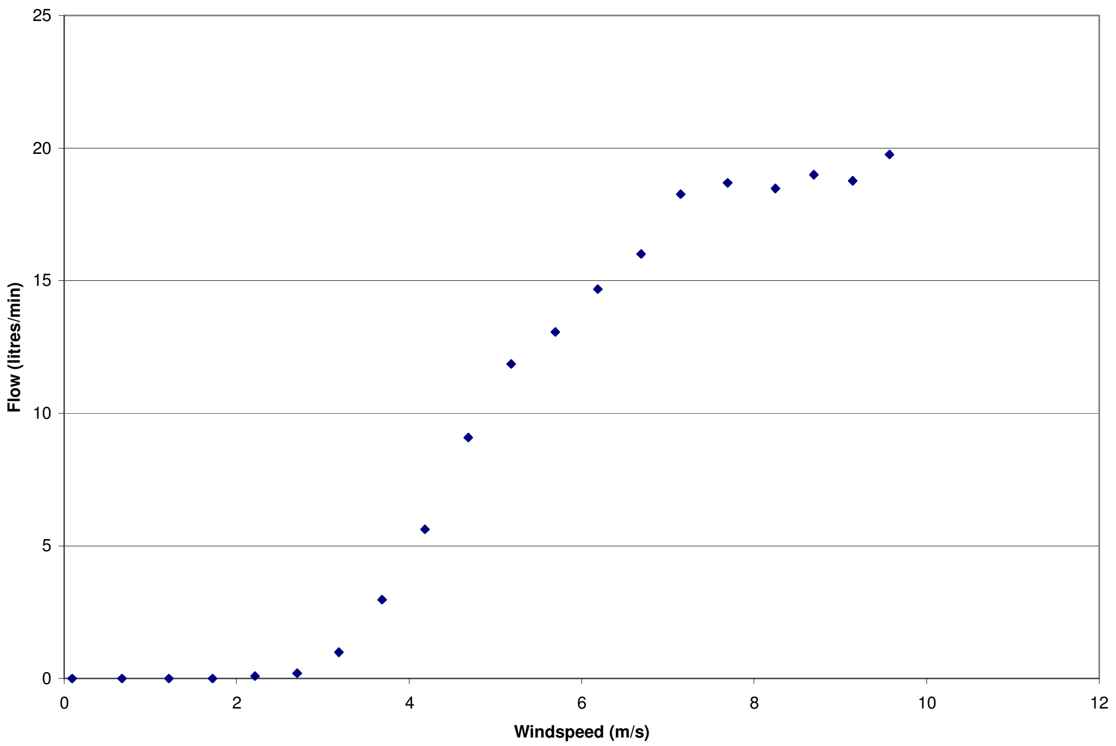

Figure 3.9: Supporting results from UK tests

The results obtained from this monitoring system confirm its operational performance and usability. They can be seen to mirror the results from testing during the previous project

(DFID Ref. R6242) indicating that, within the bounds of experimental error the monitoring system although substantially simplified to fall within the reduced project budget was fit for purpose. The problems encountered on the developing country systems could have been avoided had the budget been available to specify more effective components, i.e. flow sensor and spend more time on trouble-shooting.

3.4 Development/assessment of local markets

As noted in Section 2.4 the partners expressed an interest in the development of a brochure which could be later used as a marketing tool. Work has therefore been carried out to produce a generic brochure which, with minor variations, can be used in the different countries. The brochure presented in Annex VI uses data from the supporting test work carried out in the UK, obviously this would be replaced by real results from the different countries in each case.

3.4.1 China

Working with IT Power the Chinese partners reviewed the market situation in China, the details are summarised below. It was concluded that the market situation for windpumps in China is somewhat different to that of the other participating countries in that, while the country is certainly progressing towards a market economy, the government (at all levels from country to province to state) still exerts a strong influence on economic and social development initiatives. While small private markets for windpump technology do exist in certain areas of the country (e.g. Inner Mongolia and Shandong), governmental support for the technology is perceived to be the most important driver for more widespread deployment. To this end, "marketing" efforts for the ITP small windpump in China have focused on improving governmental awareness and acceptance of the technology.

As part of the Chinese partners' efforts in market assessment/development, the IT Power windpump was introduced to the China Windpump Network at a three-day forum held at CAAMS in Beijing during spring 1999. The forum was attended by 26 delegates including many representatives of the Chinese wind industry and wind research institutes, as well as representatives from the Chinese Ministry of Science and Technology and a number of national and regional energy and agricultural bodies.

Immediate plans for the future market development of the ITP small windpump in China are also progressing along the lines of improving awareness amongst government and implementing agency officials of the potential role for windpumps in China. While the role of large grid-connected wind turbines in contributing to Chinese energy sector development is well known and well supported, the potential for windpumps and small wind turbine generators to contribute to development, particularly in some of the poorest rural regions of China is less well known and not so well accepted.

Future activities that have been discussed with CAAMS, the facilitator partner in China, include:

- organising a seminar on small wind energy systems (to include windpumps and small wind generating systems) aimed at national / prefecture government and implementing agencies (NGOs, etc.).
- targeting of a provincial level rural energy office to pilot a demonstration programme of the small windpump (4-5 units)

Potential customers

Windpump applications in China can effectively be separated into two groups:

- relatively high head, low volume applications for drinking water provision and livestock watering, mainly in the North and west of the country (Provinces of Inner Mongolia, Gansu, Qinghai, Xinjiang)
- low head, high volume applications for irrigation and drainage, mainly in the southern and eastern provinces (e.g. Jiangsu and Fujian)

The ITP small windpump is clearly more suited to the first of these applications.

Prior to the 1980s, large diameter Windpumps were quite common on the communes, but over the past two decades, the communes have given way to individual land holdings, and relatively expensive windpumps have tended to give way to cheaper (first cost) diesel driven pumping systems. Recently, though, diesel prices have been on the increase, presenting a potential opportunity for windpump technology.

Small, but promising private markets for windpumps already exist in Inner Mongolia autonomous region, where herdsmen have the means to make outright cash purchases, and in Shangdong, where a low cost wind-driven air-pressure pumping system is proving popular. In the main, however, government is still critical player in windpump deployment.

Competition

There are about a dozen different windpumping systems and some 1600 windpump units in use in China. According to Agriculture Ministry Survey maybe only 500 of these units are actually in good operation. Main causes of failure are transmission shaft and gearbox problems.

This total includes some traditional Chinese Sail with screw or chain pumps, mainly in Fujian province. Here some people are using WPs even though they have access to the mains electricity supply.

The other main regions of note are:

- Shangdu approximately 100 units in operation (Air pressure delivery system is selling well, with approximately 40 units sold in 2000)
- Tianjin approximately 100 systems (this is the only place where there is a government subsidy available for windpump purchases: 5m diameter units costing 44kRMB are being bought by the government for farmers – contrast this to Daqing where similar size units costing only 10k RMB are not selling)
- Jiangsu approximately 100 systems. WP used to be very popular here, but popularity has diminished over the last two decades.
- Inner Mongolia 100-150 systems. Local manufacture already exists.

Discussions are underway in Gansu regarding possible establishment of a joint venture agreement to introduce the European designed Poldaw system to this region.

There is no easy access to loans or credit arrangements for potential customers to spread the cost of purchasing a windpump.

Solar pumps do not currently pose a serious competitive threat to windpumps in China. PV pumping systems are typically five times more expensive than windpumps.

Potential market

The provinces of Inner Mongolia and Gansu offer some of the best wind resources in China. These regions, together with Qinghai and Xinjiang also have the greatest need for drinking water delivery services. A 1987 study undertaken as part of the World Bank / UNDP Global Windpump Evaluation Programme suggested that some 5000 deepwell (10-100m) windpumps of between 2.5m to 7m diameter were required on the prairies of Inner Mongolia. Nevertheless, attempting to establish a market for the IT Power windpump in Inner Mongolia would be more difficult in this area as it is one of the few regions which already has indigenous windpump manufacturing. Similarly, the Poldaw system is being promoted in Gansu, so competition at this time from another manufacturer may be inappropriate.

Although Qinghai and Xinjiang have real need of water delivery services, it is felt that these two large provinces are not ideal markets for early-stage development of the ITP small windpump; establishment of suitable manufacture, installation and particularly service facilities could be problematic and large areas, particularly of Xinjiang, have questionable wind resources, which would not assist deployment of the technology.

It is believed that Hebei province surrounding Beijing offers the best near-term market potential for the ITP small windpump, particularly in its 3m diameter form. There is a significant requirement for household drinking water and small courtyard irrigation systems. It is also felt that the provincial rural energy office might be amenable to a demonstration project involving the ITP small windpump, as a precursor to more widespread deployment.

The initial cost of the ITP windpump does present a problem even at 50 to 100 units a year the unit cost is estimated to be 4-5k RMB. Other small Chinese windpumps are available for approximately 60% of this price. Nevertheless, as experience of a government driven initiative in Hubei demonstrates, low cost can mean low quality. There may be a willingness to pay for better quality systems, if financial mechanisms to assist purchase are available.

External influences

The government is viewed as a key player in windpump market development. At the state level, while large grid-connected wind turbines are very much in vogue, there is very little support or acknowledgement of the potential role for windpumps in helping to meet water delivery service requirements.

Tianjin is one of the few regions where windpumps are being deployed. The market here is artificial in that a government subsidy is available to enable farmers to purchase large machines for irrigation purposes.

There is no subsidy on diesel fuel, but the price is rising rapidly (currently around 3.3 RMB/l), which creates a potential opportunity renewable energy technologies.

Windpumps may have a poor image problem to overcome. Given that only 500 or so machines from 1600 units are currently in good working order throughout the whole of China, system reliability, maintenance and repair issues need to be addressed if the technology is to gain favour from public and government alike.

Conclusions

The key conclusions from the market assessment are:

- the government can play a significant role in assisting promotion of windpump technology
- up-front cost is one of the key criteria upon which pumping technology purchases are based. To be attractive, the product either needs to be cheap and reliable, or a government subsidy needs to be available, or some finance arrangement to spread the cost of purchase needs to be introduced.

The way forward

Immediate plans for the future market development of the IT Power small windpump in China are progressing along the lines of improving awareness amongst government and implementing agency officials of the potential role for windpumps in China, and demonstrating the IT Power small windpump to be a reliable and appropriate water delivery option. Initiatives to achieve this include:

- organising a seminar on small wind energy systems (to include windpumps and small wind generating systems) aimed at national / prefecture government and implementing agencies (NGOs, etc.).
- targeting of a provincial level rural energy office to pilot a demonstration programme of the small windpump (4-5 units)

Subsequent actions should aim to address the high up-front cost of the system. Innovative financing mechanisms, for example a revolving fund to facilitate windpump purchases on credit, would greatly improve the prospects for future windpump deployment in China.

Figure 3.10: The old windpump which was replaced by the IT Power windpump

Figure 3.11: The user and his son in front of IT Power windpump which now provides their water

3.4.2 India

A market study prepared for the Indian market is included as Annex VII. The study was carried out through discussions with existing manufacturers who are active in the Indian market, with the Ministry of Non-Conventional Energy Sources (MNES), the national programme managers for the Government Programme to install windpumps and through assessment of other water pumping markets. The most significant points can be summarised:

Potential customers

The current market for windpumps is stimulated by the national programme on deployment of wind pumps by MNES. This is a revision of the earlier programme launched earlier in 1993. The programme is the mainstay of windpumping activity in India and has so far achieved cumulative installations of 650 windpumps by August 2000. There are windpump installations outside the programme but the industry in general considers these markets to be insignificant.

The national programme has a provision to subsidise 200 windpumps every year. However the actual number of installations have been significantly below the targets. The western Indian states of Gujarat and Rajasthan are the key markets for windpumping. Both the states together account for 70% of the total market. The rest of the markets lie in Kerala, Bihar, Tamil Nadu followed by Karnataka and Maharashtra.

The major applications are agriculture and drinking water supply. The agricultural applications for irrigation and livestock watering are in the remote/decentralised areas not powered by the grid. Drinking water applications are generally for remote communities and establishments such as hostels, clinics, schools etc.

Competition

There are only six companies currently active in the field All offer a conventional geared wind pump suitable for deep well installations. These are basically indigenous adaptations of the "Yellow Tail" windpumps that were marketed in India by WD Moore of Australia.

Typically the geared windpumps costs Rs 75,000 (1,600 US$) for a 3 m rotor diameter with 18 blades and 9 m high tower. The direct drive AV-55 costs Rs 120,000 (2,600 US$) for a 5.7 m rotor diameter with 24 blades and towers in the 13-23 m height range.

The competition, in general, is with the diesel pumps for these markets. Diesel pumps are available 'off the shelf' and the capital investment costs are only about Rs 15,000 (325 US$). There are also diesel engine and pump technicians available widely which makes maintenance easy.

Interestingly, in one of the markets - Auroville, where there are communities and residences not served by the grid, PV pumping systems are directly competing with windpumps and have captured a much larger market share. The possibility of multiple use (battery charging for lighting and entertainment when water requirements are met) is considered to be the main driver for purchase decisions in favour of PV.

Potential market

The potential market is the almost two-thirds of resources which are not utilised by MNES on-account of lack of demand. In terms of applications, it will continue to be agriculture and drinking water. Although the number of windpumps being sold to these markets is insignificant (in comparison to diesel pumps), this is a huge market and significant gains could be made by windpump manufacturers tapping into these markets aggressively.

There is also a possibility of a niche market involving weekend and holiday cottages/resorts as well as organised farming involving high value crops (floriculture, vegetables, cash crops etc.). Following the PV pumping experience in India it is felt that this niche is large enough to drive the windpumping market. However, its development could be difficult.

External influences

The MNES provides capital subsidies for Windpumps depending upon the technology and the estimated production cost. The subsidy is considered to cover 50% of the manufacturing costs of the windpump by MNES. One of the major drivers in the market are the state level nodal agencies who are the implementers of the windpump programmes. Two of the nodal agencies - Gujarat Energy Development Agency (GEDA) and the Rajasthan Energy Development Agency (REDA) have distinguished themselves amongst the nodal agencies in this regard.

The major barrier to windpumping is the bad reputation for reliability of the technology. Lack of a maintenance network is another barrier that makes the after-sales service costly. This is a 'Chicken and Egg' problem in so much that the manufacturers will need larger volumes to put in place a network, and the absence of network hampers sales. The free electricity available to farmers as a result of political decisions is stated as yet another barrier to windpumps not making a presence in the grid connected remote markets[2].

Conclusions

The windpump market in India is very small and is being operated through a procedural governmental channel that is limiting the market. This has resulted in only some state-level nodal agencies being active and the markets being driven by them. The current market is small vis-à-vis the resources allocated by MNES and a disappointment considering the market potential in the country. Current manufacturers are only active in the protected space of the MNES subsidy and there are no visible efforts to exploit the market which is currently being successfully covered by the PV industry which has sold over 4,000 PV pumps.

It is felt that the windpump industry can find more buyers in the traditional areas of agriculture and drinking water supply. However, this will need aggressive marketing efforts. Because of the low volumes, most of the active players have not been able to create a good network for after-sales service and/or marketing. Promotional efforts are also not common and whenever they do occur, they are low key. A major barrier is the bad reputation of the technology, created by earlier failures and this need to be overcome by awareness campaigns and trade shows.

The IT Power windpump is widely perceived to offer several benefits and considered by the active manufacturers to be suitable for the Indian market. It should be noted that the 3m rotor diameter IT Power windpump as tested in the early part of the wind development work had an output of 12 l/min [20m head, average 4m/s windspeed] which is approximately 30% more than a 3.5m machine on the MNES approved list.

[2] These markets for diesel pumps are driven by availability and quality of the electricity service.

The way forward

In view of the situation with the current partner, WindFab, as reported in Section 3.1.2, there is a need to find a new partner who will progress the machine. Three manufacturers expressed interest in taking on the future development and marketing of the machine. Once a partner has been identified a number of prototypes will need to be produced to demonstrate performance. This will involve the partner and a technical institute so that the results can be used to support listing of the machine by MNES. The selection of a good local manufacturing partner who is technically competent and with entrepreneurial skills will be critical for the future plans

There needs to be an effort to identify, characterise and quantify the new and self-sustaining markets for windpumps that are outside the conventional subsidy driven market. This is essential for the industry to survive in the long run.

In general the windpump industry in India needs assistance in overcoming the barrier of bad reputation and to build confidence in the current technology. A series of efforts such as awareness workshops, targeted technology seminars and trade shows are needed to facilitate this. However, above all it would help to have some successful installations visibly operating to give credibility to the idea that good quality windpumps can be built and do perform.

3.4.3 South Africa

A brief marketing overview prepared by Joffe when they first became involved in the project was further developed in the light of Joffe increased knowledge regarding the manufacture and capabilities of the new machine. The key findings can be documented as:

- Potential customers – the target markets were recognised to be the farming community and rural community water supply projects through Government and NGOs. It should be noted that animal farmers have faced severe financial difficulties in recent years and would be very price conscious. Black farmers, usually on small holdings, would typically need funding to be able to afford a windpump. Normally farmers purchase all equipment through co-operatives. Farmers pay as they are able to do so. In some cases banks or farmers co-operatives have to authorise farmers' purchases. Would need to consider financing aspects for these different scenarios.
- Competition – key competitors are Stewart & Lloyds (South Africa) – Climax windmills, Southern Cross Industries (Pty) Ltd, Dreyer's Engineering, and few smaller companies and solar pumps (other technologies must not be overlooked). Competitors' products cost around R11,000 (£1,100). Erection/installation adds R3,000-4,000 to the cost which presses the case for kit form installed by farmers.
- Although as many as 250,000 windpumps are said to be in use in South Africa the current market size varies according to different estimates and Joffe do not feel that they have been able to ascertain reliable figures.
- Barriers/support mechanisms – potential support through aid programmes needs to be fully investigated to allow the machines to prove themselves before a wider marketing programme can be developed. Joffe would require help and support from IT Power to do this since it is outside their normal channels of work.
- Joffe concluded that they could not now commit themselves to the marketing/implementation of the machine. However they remained keen to be involved primarily in manufacturing the machine. They stated that they would be interested in a joint venture (20-25% stake) or similar with another/new company. Some work was carried out to identify a potential partner. Contacts made to investigate alternative pump

suppliers (see Section 3.2?) identified that the pump supplier, Jooste, had an interest in selling the machine. A visit was made by the pump supplier to see the Stage II prototype in South Africa. Discussions are now on-going into how the two companies might work together to market the windpump.

3.4.4 Zimbabwe

Discussion ensued between Stewarts & Lloyds and IT Power on this matter. It was concluded that a market study should be carried out and following that a forum to address the issue of water lifting generally, not just windpumps, (to encompass Stewart's and Lloyds overall business) with NGOs and key Government officials invited to participate and to consider the arguments. Personnel from Stewart & Lloyd were allocated to be involved in this work. Areas that the market study should address and a table of contents were developed, in addition to an outline for the forum. However, due to the situation at Stewarts & Lloyds (see Section 3.1.4) no work was carried out on this activity by the Zimbabwean partner.

4. IMPLICATIONS OF THE RESULTS OR FINDINGS FOR ACHIEVING THE OUTPUTS AND PURPOSE OF THE PROJECT

4.1 Outputs realised

The outputs realised from the project are:

- Complete windpump design package, including ground furling mechanism, improved platform, outline design for the larger rotor diameter machine (including stress analysis of key components) investigation into new pump designs with contact made with new pump suppliers.
- Preliminary publicity brochure;
- Local market study/assessment carried out in three partner countries; China; India and South Africa including plans for the way forward to develop the market for the IT Power windpump.

Windpumps have been installed and tested in three of the four countries, but unfortunately despite the extension of the project, the partners failed to deliver the test results that were expected within even the extended time frame. Although there were problems with the test programme, partially caused by the need to compromise in the specification of the equipment as a result of budget reductions (an error only really clarified with the benefit of hindsight), the windpumps themselves generally performed as expected although a few technical problems were identified and resolved. In Zimbabwe the partner has not progressed work on the machine due to economic difficulties within the country, however, a potential new partner has been identified. It is thought that with limited further funds and some modification of the test equipment combined with training of local technicians to interpret results, it would still be possible to obtain performance results, certainly in China and South Africa.

4.2 Purpose realisation

The lack of measured results from the partners may at first seem disappointing since none of the partners have so far initiated commercial development of the technology. However, other activities have been successfully completed, including market studies/assessments and there are prospects for future development, which offer encouragement.

To put this in perspective, the earlier project to develop the large IT windpump which was also supported by ODA (as DFID was called at the time) resulted in commercial development in only two (Kenya and Pakistan) out of six partner countries (a third country, Zimbabwe, came along later). On this evidence, achieving about one in three partner companies going through the R&D process to commercial development is probably a reasonable result. In this case we started with only four partners in four different countries but there are prospects that in both South Africa and China development will be taken further, subject to various requirements mentioned earlier and there are also possibilities in India and Zimbabwe in the longer term.

The Zimbabwean partner has gone through a series of financial crises and changes of ownership which have been exacerbated by the local economic situation and they seem unlikely to proceed any further with it, if indeed they survive at all as a business (however a potential new Zimbabwean partner has been identified). The Indian partner has in reality lost interest through getting involved in large-scale wind farm development. However, there are prospects that IT Power's Indian partner company – IT Power India Pvt Ltd – could find an alternative Indian company to take over the windpump development. This is under active investigation since there has also been interest in the project from the Indian government's Ministry for Non-conventional Energy Sources. However any new partner will need technical support initially from IT Power and the provision of such support would require financing perhaps under a small follow-on project.

5. PRIORITY ACTIVITIES/TASKS FOR FOLLOW-UP IN ORDER TO PERSUE THE GOAL

5.1 General issues which will promote the development of the windpump as a whole

It would greatly enhance the prospects for the successful application of this technology if the partners still committed to commercialising the machine (and if possible some new partners in other regions or countries) could be encouraged to gain practical experience and to demonstrate the technology by being given the resources to build and install two or three machines in villages or on farms. This would serve to confirm the value of the technology in real applications to give it the credibility needed to attract the investment in resources needed to take it to commercial production, it could allow any teething troubles to be dealt with under controlled conditions, and most important, provide an opportunity to demonstrate the windpumps to potential future clients.

To this end IT Power would like to explore whether DFID country desks might support some small windpump projects serving recognised development needs in order to facilitate the initial dissemination as well as the further development of the technology. Indeed we would strongly recommend that there is a need to assist the technology in its initial deployment for "real life" applications for either human or livestock water supply through small test projects in selected areas with correct market conditions.

There is also a need to keep a minimum level of dialogue active between IT Power as originator of the design and the manufacturers in order to resolve any teething problems with commercial development of the technology. IT Power is an SME with limited resources and therefore needs to find a method to finance any such activity over the next two/three years if it is to be more than a minimal level of contact (e.g. including occasional visits to partners to resolve any difficulties).

Therefore IT Power and the partners hope that it may be possible to gain some further level of support to ensure that contact can be maintained.

5.2 Country specific requirements

5.2.1 China

As discussed in section 3.4.1, immediate plans for the future market development of the ITP small windpump in China are progressing along the lines of improving awareness amongst government and implementing agency officials of the potential role for windpumps in China, and demonstrating the ITP small windpump to be a reliable and appropriate water delivery option. Several initiatives to achieve this are proposed:

- organising a seminar on small wind energy systems (to include windpumps and small wind generating systems) aimed at national / prefecture government and implementing agencies (NGOs, etc.).
- targeting of a provincial level rural energy office to pilot a demonstration programme of the small windpump (4-5 units)

A good relationship exists between IT Power and the Chinese facilitator partner, CAAMS, which will be maintained with a view to future development both of the market for the ITP small windpump, and of the product itself. Unfortunately, it seems that the current manufacturing partner is unlikely to survive as a business venture, indeed staff have been laid-off and work at the factory has ceased. Therefore a new manufacturing partner must be identified to take the product and market development forward.

In the short to medium term, an initiative to offer easier payment terms to customers wishing to purchase windpump technology would greatly assist market development within China.

5.2.2 India

The Ministry of Non-Conventional Energy Sources (MNES) of the Government of India has a national programme on deployment of waterpumping windmills and small aero-generator systems, which has been revived recently.

After problems with their previous windpump (listed in the MNES programme) it is clear that WindFab started this work with the intention of introducing the IT Power Windpump to the market but, in the meantime, WindFab, as a business, has shifted the thrust of its operations into the development of more lucrative grid-connected wind farms.

MNES seem generally favourable to new windpump technologies getting introduced in the country and windpump activity reviving itself. There is therefore scope for finding an alternative Indian company to work with IT Power on the windpump development.

An immediate action to take market development of the IT Power windpump forward within India, is the identification of a new manufacturing partner which is willing and capable of devoting time to development of the machine as a product and to marketing the technology.

Once this has been achieved, a pilot demonstration scheme to prove reliability of 4 or 5 machines should be undertaken to assist with gaining inclusion of the IT Power windpump on MNES's approved shortlist.

5.2.3 South Africa

The marketing of the machine in South Africa will progress once negotiations between IT Power, Joffe and Jooste can be successfully concluded. There are two main approaches:

1. Via ministries to gain support to purchase/install a number of machines in water provision programmes
2. Via private sales to farmers through co-operatives but with some form of marketing (not to be carried out by Joffe but possibly through Government supported black empowerment programme)

The first approach was the preferred one for the initial stage although preliminary enquiries for the latter approach are also being made. A pilot project subsidised by development assistance could be timely and important in allowing successful demonstration of the technology in the field; IT Power would like to see whether the DFID Country Desk at the UK Mission in Pretoria might consider a small project of this kind to evaluate the performance of the systems under field conditions when used by rural communities.

5.2.4 Zimbabwe

A new company in Zimbabwe, Jooste Water Works, has expressed an interest in developing the IT Power windpump. This company supplies equipment for water supply and irrigation and is an agent for the reciprocating pump supplier in South Africa who are interested in marketing the windpump. This new link is of potential benefit to the commercialisation of the IT Power windpump and is being developed.

Based on experience from the other participating countries, it would seem more appropriate to concentrate on demonstrating suitability of the 3m diameter machine for applications in Zimbabwe, where pumping tends to be from deepwell boreholes, typically 50m or above.

Given the current economic and political situation within Zimbabwe, it seems unlikely that a private market for purchases of windpump systems can be sustained, at least in the short to medium term. Therefore, market development efforts will concentrate on raising awareness and demonstrating the technology to relevant government departments and development agencies with a remit for providing water delivery services in the hope that if and when the economy returns to normal there may be good opportunities to market the technology.

6. SUMMARY OF FINANCIAL EXPENDITURE

The project has remained within the overall budget for the period of the project. The procurement budget for field-test monitoring equipment proved to be insufficient. In addition, considerable unplanned costs were incurred during trouble-shooting of the monitoring system and re-specification of components for the monitoring system. These were paid for out of savings made in other budgets.

7. NAME AND SIGNATURE OF AUTHOR OF THIS FINAL REPORT

This report has been prepared by Peter Fraenkel, Director/Senior Engineer; Frances Crick, Senior Project Engineer and Paul Cowley, Energy Engineer.

Name	Signature

Peter Fraenkel	
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