This is separate from the project technical report ANNEX 4.2

FINAL REPORT GUIDELINES

The report is to be a maximum of 4 sides of A4 size paper. Excluding the Output to Purpose Report

D A T E

8 February 2001

TITLE OF PROJECT & PROJECT NUMBER	**Low Cost, Low Maintenance Propeller Turbines R- 6482A**
ORGANISATION	**ITC Ltd**
REPORTING PERIOD	From **Oct 1996** To **Sep 2000**

ANTICIPATED COMPLETION DATE **September 2000**

1. Goal, Purpose and Outputs of the Project

The purpose of this project is to design and manufacture a propeller turbine, which is capable of being built in local workshops in developing countries. Market research identified the demand for propeller turbines to produce some tens of kW kilowatts of power from heads of water of between to 2 to 8 metres. The outputs of the project will be: a design of propeller turbine to cope with that head range and with particular characteristics concerning low cost and low maintenance, manufacturing of the turbine in a small workshop in a developing country (Peru), installation of a prototype, testing the performance of the prototype, issuing designing pack consisting in a set of drawings plus a guide of how to use it to manufacture and installation purposes.
The goal of the project is to develop the use of renewable sources of energy. When successfully completed, this project will lead to improving the access of rural and isolated communities to energy.

2. Summary of work carried out in this period:

2.1. Procurement
This activity includes the purchase of all equipment and accessories necessary for the manufacturing and installation of a pilot machine in the village “Las Juntas”. The main equipment referred are: electrical generator, electronic load controller, an electrical load for testing purposes (designed and specified to coupe with the full load of the scheme), penstock, step-up and step-down transformers used for the transmission line. A pack of small accessories.

2.2. Turbine design & development
This activity was agreed to be divided into two main components: hydraulic design and Mechanical design. Also at the early stages of the project it was agreed that the hydraulic design would be done in the UK under the responsibility of ITC, while the mechanical design was to be done in Peru under the

responsibility of the Energy Programme of ITDG-Peru. The hydraulic design was finished by the end of May 1998 and the mechanical by the end of August of 1998.
The main hydraulic characteristics of this machine are:

a) Runner type: Four bladed propeller turbine, although the propeller turbines are considered of high specific speed in general, this particular rotor is located within the lower range of the specific speeds corresponding to this sort of machines. The blades are fixed to the hub by welding
b) Specific speed, low specific speed within the range of propellers
c) Case.- Spiral case, made from steel plate by welding
d) Suction tube. Manufactured from steel plate.
e) Guide veins. - Adjustable with bolts,
f) Gate valve. - The gate valve has been designed in Peru with the idea of reducing costs, since commercial ones are about three times the cost of the one used.

Among the most important decisions taken for the design of this machine was the initial layout of a spiral case with a vertical shaft. Although for some designers this appears to be more difficult for manufacturing and maybe a bit more expensive than other possible lay-outs, for the Peruvian team this feature was one of most important requirements because it ensures the use of simple and commercial bearing (from experience the bearings are a critical component).
The pilot machine. - Although this machine is applicable in a range of head and flows, The machine was designed taken into consideration a particular set of data, as follows.

Gross head	7m.
Flow	525 l/s
Speed	900 rpm
Runner diameter	0.4 m

Its manufacturing was done in a small workshop in Lima Peru, under the supervision of the owner of the workshop and the energy team of ITDG-Peru.

2.3. Turbine Manufacture

The manufacturing of this machine required few steps:

a) Search for an appropriate workshops for the construction of the model turbine, the gig and the turbine, long discussion sessions with the technical people of the workshops chosen
b) Construction of the model and the gig, both were made by a local enterprise experienced in this sort of work called VSQ.
c) Casting of the blades, done in a local foundry
d) Construction of the turbine, which took quite a long time due to the fact that it was the first machine manufactured, hence it implied a process of learning.
e) Selection and adaptation of some accessories like bearing, belts, pulleys and others.
f) Assembly of the machine with the other electromechanical components, in order to make sure that all fit together (done in the workshop of TEPERSAC)

.

2.3. Civil works

The civil works have been a very important activity, which was funded by Thrasher Foundation from USA. This activity was fully under the responsibility of the Energy Programme of ITDG-Peru
Although there have been certain climatic complications due to El Niño Phenomenon and others which delayed the civil work activities, generally they were done successfully.

The particularities of the civil works in low head turbines installations are the extent of them, because in this case the rivers are generally larger than when the installations are in high head conditions, low head hydro demand larger channels, larger intakes, etc.

2.4. Installation

The activities related to the installation were also co-funded by Thrasher foundation; these can be grouped into three main components:

a) The installation of the electromechanical equipment and accessories: turbine, generator, load controller control valves, load for testing, and other smaller ones.
b) Installation of transmission lines. - Funded by Thrasher Foudation. - Although the power house is not far away from the village itself, it was necessary to install a small transmission line of about 600m plus a distribution micro-grid, with a step-up and step-down transformer, the transmission lines are at 11kV according the national standards required.
c) The wiring of the village which was funded by FONCODES (a government organisation for social compensation projects).

A and B activities were fully the responsibility of the Energy Programme of ITDG-Peru, while activity C required only technical supervision from the programme because the execution was the responsibility of FONCODES.

2.5. Testing and optimisation

Part of the research activities were to carry out performance tests of the prototype machine, therefore a careful plant and test were done in order to measure power and efficiency.
Two sets of tests were taken, in March and May respectively; the main parameters evaluated were:

Head, Flow, Power, Efficiency

The results of the tests are:

Power, Plant efficiency, Turbine efficiency

Among other parameters considered in the performance of the scheme are vibration and leakage. The tests confirmed that it is a smooth machine and no vibration has been perceived during and after the tests.
Up to now the scheme has been working for more than 10,000 hours of continuous work, apart from one short interruption for inspection.

Generally the conclusion from the tests are:

- It is a relatively simple machine for manufacturing but with a very good performance and reliability
- The efficiency of the whole machine is within the acceptable for its size and it is in the range of 0.50, which is reasonable for schemes of this size.
- It is machine which can be easily installed
- The particular design is ready to be transferred to small workshops

2.5. Manufacturing pack

The production of the manufacturing pack is not something which has been done during the whole process of research, however there was an important concentration of the team in producing (or perhaps Systemising the design products) during June, July, Augusts and September 2000.

The manufacturing pack is composed by: a set of drawings which includes all the necessary information about materials, and process of manufacturing and two small manuals: one for specifically for the manufacturing process and another one for the installation of the equipment

This information is ready to be used in other workshops if needed.

It is also important to mention at present there is the internal capacity to manufacture similar cases. In fact TEPERSA the small company which manufactured the turbine for Las Juntas is now completing the manufacturing of a 4.5kW machine which has been contracted privately.

3. Overall Results of findings obtained by the project

- Knowledge about the construction of propeller turbines in Peru, ready to be transferred to other workshops (apart from that one who manufactured the prototype)
- A manufacturing pack ready to be transferred to small workshops in other developing countries
- A 25kW prototype working properly and providing electricity to a small village of about 60 families
- Technical people in Peru with experience and confidence to transfer the technology to other parts in developing countries.
- A 4.5 kW of similar hydraulic characteristics constructed and ready to be installed (privately contracted)

4. Implications of the results or findings for achieving the outputs and purpose of the project:

The results are according those considered in the Log-frame, the outputs and purpose of the project have been attained

5. Priority Activities tasks for follow-up in order to pursue the Goal:

ITDG-Peru has had requests for either technology or information about this project, therefore it is convenient to think about an appropriate strategy to transfer the technology, because it is clear that it is required in several countries.

If possible it is convenient to look for extra funds in order to do an International or at least Latin American workshop in two levels one for dissemination purposes and another one to transfer technology

Prepare technology packs to sell or distribute to those potential manufactures under request, although it is not the best way of transferring technology due to the fact that a lot of dependence will be generated and hence time consuming for the ITDG-Peru energy Team to reply possible requests for more and more explanations and information. Therefore the recommendation is to go for a strategy of large dissemination via workshops as mentioned above.

6. Summary of Financial Expenditure

Financial year	**1996/97**	**1997/98**	**1998/99**	**1999/00**	**2000/01**
Personal emoluments	36506.17	41050.33	27071.88	21751.00	5894.00
Capital cost	4671.04	32790.00	2600.00	3942.00	
Other charges	5597.79	6434.67	5566.12	4288.00	1606.00
Sub Total			***35238.00***	***29981.00***	***7500.00***
VAT			6166.65	5246.68	1312.50
Total costs	**46775.00**	**80275.00**	**41404.65**	**35227.68**	**8812.50**

7. Name and signature of author of this final report:

Oliver Wakelin

OUTPUT TO PURPOSE SUMMARY REPORT			
Title: Low Cost, Low Maintenance Propeller Turbines	**Country:** Peru	**MISCODE:**	
Report No. 6	**Date:** 8 Feb 01	**Project start date:** 1 Oct 1996 **Project end date:** 30 Sep 2000	**Stage of project:** Completed

Project Framework

Goal statement: Develop the use of renewable sources of energy

Purpose statement: Produce propeller turbine design which can be built in local workshops.

Outputs:	**OVIs;**	**Progress:**	**Recommendation / actions:**	**Rating:**
1. Initial product design specification based on customer requirements	1. Design specification, risk analysis and design improvement targets are documented and reviewed	Complete		
2. Detailed product and manufacturing process specification	2. Specification acceptable to manufacturer	Complete	One manufacturer has adapted design to a power, and simplier construction	
3. 25kW turbine installed on community hydro scheme and operating for 1 year	3. Performance acceptable (bearing life, vibration, cavitation) 70% efficiency Turbine generator performance to spec. Ex-factory price less than $500 per kW.	Acceptable		
4. Design pack containing drawings and manufacturing instructions	4. Design packs published	Published and available on CD through ITDG Latin America, or ITC.		
5. Transfer of turbine design pack to workshops in Sri Lanka and Nepal	5. 20 design packs supplied Turbine construction outside of Peru completed by end 2001	Sri Lanka, Nepal and the UK all hold possibilities for further turbine builds.		

Purpose:	**OVIs**	**Progress:**	**Recommendations / action**
As given above	3 workshops in 3 countries to have built a propeller turbine by end 2001	Dissemination outside Peru can be started now that CD has been created.	Requests are being made about this technology to ITDG Latin America. Therefore the recommendation is to go for a strategy of large dissemination via international or regional workshops.

PHOTOGRAPHS

Photo 1: Turbine manufacturing

Photo 2: Turbine manufacturing

Photo3: Intake

Photo 4: Powerhouse

Photo 5: Evaluation and performance test

Photo 6: Evaluation and performance test

Photo 7: Evaluation and performance test

Photo 8: Evaluation and performance test

Photo 9: Training in management

Photo 10: Training in operation & maintenance

Photo 11 and 12: Training on installation of power meter and reading meter

Photo 13: Electricity for health service

Photo 14: Electricity for small business

Photo 15: Domestic use of electricity

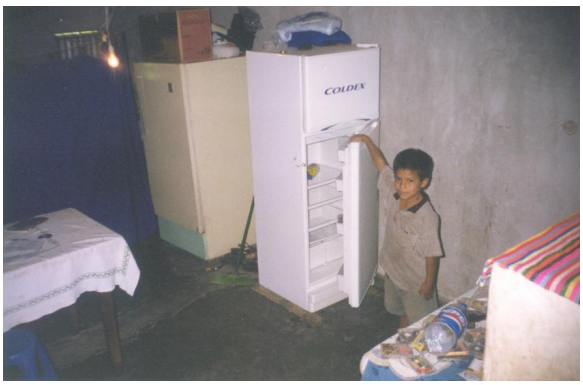

Photo 16: Domestic use of electricity