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The IndustriaCredit & Investment Corporation of India Limited

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PACER/ 39846

August 17, 1989

Dr. David Jhirad
Senior Energy Advisor
Office of Energy
U.S. Agency for International
Development
Room 508, SA 18
Washington, D.C. 20523
U.S.A.

Dear Dr. Jhirad:

Third Meeting of Energy Research and Development Advisory Committee (ERDAC) for PACER

The third meeting of ERDAC is scheduled to be held on Tuesday, August 22, 1988 at 3 p.m. at the Department of Non-Conventional Energy Sources (DNES), CGO Complex, Block No. 14, Lodi Road, New Delhi 110 003. We have pleasure in enclosing the notice and agenda papers for the meeting.

We request you to attend the meeting as an observer. Kindly confirm your convenience.

With regards,

Yours sincerely,

P. H. Vaidya
Manager
PACER SECRETARIAT

Enclosures:

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

TO ERDAC MEMBERS

NOTICE is hereby given that the Third Meeting of Energy Research and Development Advisory ommittee (ERDAC) for PACER will be held on Tuesday August 22, 1989 at 3.00 pm in the Department of Non-Conventional Energy Sources, Ministry of Energy, Government of India, Block No. 14. CGO Complex, Lodi Road, New Delhi 110 003 to consider the enclosed agenda.

Dr. J. Gururaja
MEMBER SECRETARY
ERDAC

August 11, 1989

Encl : Agenda

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emphasis on system integration and engineering.

(vii) Upgradation of solar thermal technology for water heating.

(viii) Application of solar thermal technology to drying of coal in cement industry.

(ix) Small wind battery chargers (5W to 50W) .

(x) 6 to 8 W photovoltaic module light/battery.

(xi) Retrofitting of new and efficient illumination systems.

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

Project Ideas for Developing Proposals

(i) Development of cogeneration systems based on existing open cycle DG and thermal power generation facilities.

(ii) Conservation technologies based on process control and heat recovery with emphasis on suitable software development.

(iii) Processing of solid renewable fuels - e.g. Agricoal - it involves shredding of agrowaste, compaction, pyrolysis and briquetting, to get a fuel with about 3000 to 4000 kcal/kg. It will be useful as industrial/urban fuel.

(iv) Gasification systems generating fuel for multiple use with capacities upto about 20 KW.

(v) Production of liquid fuel viz. alcohol at village level.

(vi) Upgradation of technology related to renewable fuel production, machinery for manufacture and utilisation equipment with

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PACER/ 39848

August 17, 1989

Shri S. Padmanabhan
Energy Specialist
U.S. Agency for International
Development
American Embassy
West Building
Chanakyapuri
New Delhi 110 021

Dear Shri Padmanabhan:

ERDAC/PRC Meetings for PACER

We have pleasure in enclosing the notice and agenda papers of the ERDAC and PRC meetings scheduled to be held on August 22, 1989 which may kindly be given to Dr. David Jhirad on his arrival.

With regards,

Yours sincerely,

P. H. Vaidya
Manager
PACER SECRETARIAT

Enclosures:

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ACTIONS TAKEN ON POINTS ARISING FROM MINUTES OF 4TH PRC MEETING HELD ON JUNE 28, 1989 AT ICICI, BOMBAY

Agenda Item 2(a) : PAIC

PACER Secretariat had discussions with proposers (Punjab Agro Industries Corporation) and communicated the PRC's observations. Proposers would be shortly submitting the information requested.

Agenda Item 2(b) : SPIC Ltd.

Dr. P. H. Vaidya had discussions with Dr. S. Parthasarathy, Executive Director, SPIC who has agreed with the suggestions of PRC. The scope of project has now been revised suitably and the cost of non-project specific laboratory equipment worth Rs 10 lacs will be financed by the proposers.

Agenda Item 2(c) : Nagadi Consultants Pvt. Ltd.

A sanction letter specifying terms and conditions has been issued to the proposers.

Agenda Item 3 : Nimbkar Agricultural Research Institute (NARI)

The observations of the PRC were conveyed to the proposers. PACER Secretariat had detailed discussions with the proposers and have decided the precise scope of the project and the revised estimated cost is Rs. 2.90 lacs.

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Agenda Items 4 & 5 :

PACER Secretariat communicated the observations of PRC to various proposes who had sent profiles. Subsequently, detailed applications were received from M/s. Fluidtherm Technology Pvt. Ltd., and Indira Gandhi Institute of Development Research, whereas revised proposals/detailed applications are awaited from Bharat Heavy Electricals Ltd., Bhopal, Total Energy Systems, IIT, Bombay and Lawrence Berkeley Laboratory.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

5th PRC Meeting

August 22, 1989

Confidential

Agenda Item 5

Progress of projects under implementation

1.a) Engineers India Limited (EIL) and HIndustan Zinc Limited (HZL)

At its 2nd meeting held on November 18, 1988, ERDAC sanctioned conditional grant of Rs. 38 lacs to consortium of EIL and HZL for undertaking project on development of optimisation model for energy in milling operation in mineral processing. A sanction letter dated December 30, 1988, covering main terms and conditions of the assistance was issued to them. (EIL) conveyed its acceptance of main terms and conditions on January 24, 1989.

EIL and HZL have drawn up a draft of memorandum of understanding (MOU) for the proposed consortium project. At a joint meeting of ICICI, EIL and HZL held on April 28, 1989 draft agreement for PACER assistance as also draft memorandum understanding between EIL and HZL were discussed. Both the documents are expected to be signed after receiving concurence of HZL which is awaited.

HZL is yet to accept the terms of sanction. PACER Secretariat is actively pursuing with HZL for the comments on the terms of agreement and their acceptance.

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b) **Thermax (Pvt) Ltd (TPL) and Trinity Forge Pvt. Ltd. (TFL).**

Disbursement of Rs. 4.17 lac (more than 50% of the sanction amount) was made and the proposers have made substantial progress. The regenerative burner is being installed at TFL's Ahmednagar works and will start functioning by September 1989.

2. **Research projects undertaken by Tata Energy Research Institute (TERI)**

a) Project to evolve policy directions for smoothening load duration curve in India.

PACER Secretariat disbursed Rs. 6.20 lacs (50% cost of the project) and Rs. 8.50 lacs towards equipment such as data loggers, meters necessary to carry out the research. TERI in consultation with PACER Secretariat has constituted an advisory group (consisting of Sarvashri T.L. Sankar Chairman APSEB, R.S. Verma, Chairman HSEB,

P. Abraham Chairman MSEB, Sethuraman, Chairman MPEB, L.R. Suri Secretary General NCPU, Chikkoba, chief Engineer/Planning TNEB) which would be consulted for considering the on-going efforts of Deptt. of Power, and other agencies. PACER Secretariat had discussions with TERI at various stages. TERI has informed that the study has commenced with field trials at Palawal Haryana. Discussions were held with Haryana State Electricity Board officials and Sonepat has been identified as suitable location for final study in the state of Haryana. Sample selection has already begun at Sonepat

b) Project on assessment of appliance effieciencies in domestic sector.

PACER Secretariat disbursed Rs. 6.90 lacs (50% cost of project) and Rs.4.45 lacs towards equipment essential for the project. PACER Secretariat had discussions with TERI on the progress of the project. TERI has informed that the work on project has commenced. A pilot survey has been initiated for identifying appliances which make significant contribution to the load. The household survey and efficiency measurements will start after analysing pilot survey data for a few selected gadgets. TERI would be submitting the progress report on the project shortly.

c) Project for working out strategies for indigenisation of grid connected wind Electric Generators in India.

PACER Secretariat disbursed Rs. 1.155 lac (50% of cost of project) to TERI towards the project. TERI has contacted

10K

manufacturers of electric generators fibre glass components, gears as also fabricators of steel components to assess which components of wind electric generators can be manufactured indigenously. The main points emerging out of the discussion of representatives of TERI with various manufacturers contacted in connection with the project are as follows :

a) Import duty needs to be imposed on WEG so that indigenous products can compete with foreign machines.

b) Electricity Act needs to be altered to allow for generation of electricity by private sector.

c) Supporting structures (Towers) need be given the same setatus as transmission line towers. This would reduce the cost of land occupied by a windfarm.

d) Optimization of design of rotor is one of the R&D problems which needs to be pursued in order to reduce cost.

As on June 30, 1989 TERI has incurred Rs. 77,750 on project.

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

Confidential

5th PRC Meeting

August 22, 1989

SUMMARY OF EVALUATION OF PROPOSALS (BY PACER SECRETARIAT)

S.NO.	PROPOSAL	PROPOSER(S)	COST (Rs.lacs)	COMMENTS ON SUITABILITY BASED ON SPECIFIED CRITERIA					
				INNO-VATIVE CONTENT	RELEVANCE	BUSINESS ATTRACTIVE-NESS	PROPOSERS' STRENGTH	COST	OVERALL SUPPORT WORTHINESS
	CONSORTIUM PROPOSALS								
1.	Development of continous fluid-ized bed furnaces for heat treatment	Fluidtherm Technology Pvt. Ltd IIT., Madras TI Diamond Chain Ltd.	82.00	Good	Yes	Good	Good	Reasonable	Yes

PRC Agenda 4(a)

NOTE ON "PROGRAMME FOR INTERACTION OF PLANTERS AND ENERGY RESEARCHERS (PIPER)"

The plantation industry, particularly in the north-east and southern parts of the country has been facing severe competition in the international market. Production costs in the plantation industry have been increasing in a manner that has eroded India's competitive position in the world market. A major component of total production costs is the cost of energy use at various stages of the process in producing marketable outputs from commercial plantations. In order to promote efficient use of energy and bring about improvements in the efficiency of plantation operations in the country, a Planters Energy Network (PEN) involving approximately 50 plantation organisations was established in 1986. Technical support for this network has been provided by the Tata Energy Research Institute and the Madurai Kamaraj University.

In the project now proposed, a systematic approach in bringing about technology upgradation related to energy use in plantation industries will be adopted including dissemination of information on improved technology, regular monitoring of energy consumption in plantation units and effective interaction among the planters, researchers and the academic community to ensure attainment of the objectives of higher energy efficiency. The proposed project would be implemented by the Planters Energy Network with technical assistance from the Madurai Kamaraj University and the Tata Energy Research Institute.

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3RD ERDAC MEETING

AUGUST 22, 1989

PROPOSALS LIKELY TO MATERIALISE IN NEXT SIX MONTHS

SR. NO.	PROPOSAL	PROPOSER(s)	LIKELY PROJECT COST (Rs in lacs)	PACER CONTRIBUTION (Rs in lacs)
A.	CONSORTIUM PROJECTS			
1)	DEVELOPMENT OF CONTROL SYSTEM FOR COGENERATION PACKAGE BASED ON PHASED OUT AERO-ENGINES	LOTUS ENERGY SYSTEMS PVT. LIMITED NATIONAL AERONAUTICAL LABORATORY HINDUSTAN AERONAUTICS LTD.	10.00	5.00*
2)	DEVELOPMENT OF DESICANT COOLING SYSTEM	METALLURGICAL AND ENGINEERING CONSULTANTS (I) LTD. BOKARO STEEL PLANT	11.00	5.50
3)	R&D OF INDUSTRIAL AND DOMESTIC GAS FLOW METERS AND DOMESTIC MULTIFUEL GAS STOVE	TOTAL ENERGY SYSTEMS	6.00	3.00 *
4)	DEVELOPMENT OF ENHANCED 3 TON PAYLOAD BATTERY BUS	BHARAT HEAVY ELECTRICALS LIMITED	52.00	26.00
5)	DEMONSTRATION OF A 4 MWE CO-GENERATION PLANT BASED ON CONTROLLED COMBUSTION TECHNOLOGY EMPLOYING PADDY STRAW/HUSK AS FUEL	PUNJAB AGR INDUSTRIES CORPORATION LTD. PRM ENERGY SYSTEM INC. ICB LTD.	1000.00**	450.00

14x

SR. NO.	PROPOSAL	PROPOSER(s)	LIKELY PROJECT COST (Rs in lacs)	PACER CONTRIBUTION (Rs in lacs)
6)	DEVELOPMENT OF PHOTOVOLTAIC SYSTEMS FOR VARIOUS RURAL APPLICATION (LANTERN, STREET LIGHTING & WATER PUMPING)	SURYOVONICS LTD. POWER PACKS PVT. LTD. POLYENE GENERAL INDUSTRIES PVT. LIMITED	260.00	130.00

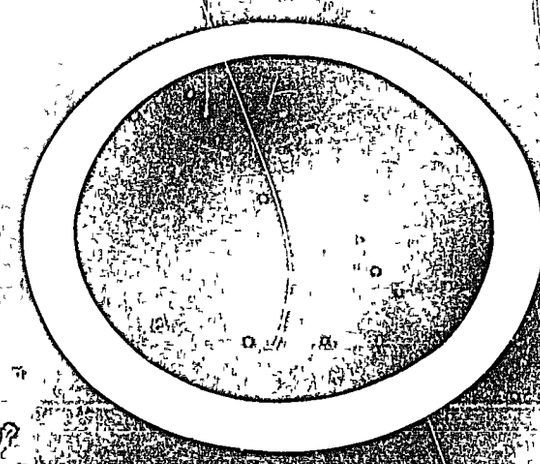
B. RESEARCH PROJECTS

1)	STUDY OF COCOCNUT RESIDUES FOR ENERGY USAGE	I.I.T. BOMBAY	68.00	

* IN THE FORM OF GRANT

** SUBJECT TO DOWNWARD REVISION

HEAT TREATING IN FLUIDISED BED FURNACES



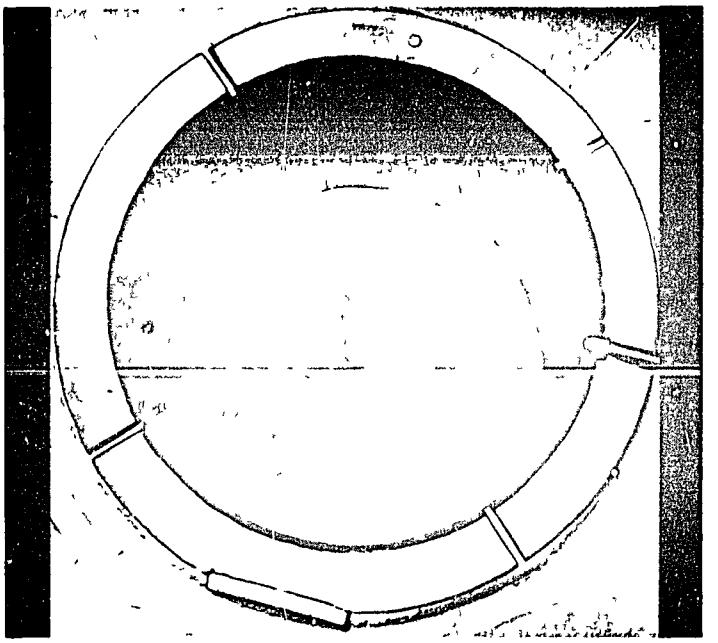
FLUIDTHERM

THE PRINCIPLE

Fluidisation occurs when a stream of air or gas is passed upward through a bed of finely divided particles At a certain velocity, the particles separate and float on a cushion of the fluidising air or gas. When the velocity is increased, bubbles form and as they rise through the bed, they cause rapid mixing of the particles in all areas of the bed

When fluidised, the bed behaves just like a liquid. It is buoyant and light objects float while heavy objects sink. When heated the fluidised bed becomes an excellent media for heat transfer.

In the heating context, alumina is used as the fluidising media. Mixtures of Air, Ammonia, Nitrogen, LPG and many other gases are used as the fluidising gas as well as the heat treating atmosphere. The gas reactions take place in the bed itself without need for a gas generator.
An alloy retort is used as the container and a special alloy distributor system ensures uniform fluidisation.



The bed is heated by gas or electricity externally and in some cases internally. The components are immersed into the bed and lifted out when the treatment cycle is complete, usually with the help of a hoist.

CUSTOMER SUPPORT

FLUIDTHERM maintains a production scale fluidised bed heat treating laboratory where customer trials and process developments are continually performed and made available to clients before and long after a sale is made. The amazing flexibility of the fluidised bed is exploited and experiments in alternate atmospheres, metals and processes are performed and clients are informed of the latest processing techniques.

Clients can run samples or even production lots to optimise their process parameters. Customised processes are developed on request for specific products/applications. It is this commitment to research & development that gives both us and our clients the competitive edge.

ADVANTAGES

OF FLUIDTHERM FLUIDISED BED FURNACES

LOW OPERATING COSTS

The high heat transfer rate (4 to 25 times faster than convection/radiation furnaces) cuts down cycle times. Larger tonnage can be processed in smaller furnaces. When not in use the furnace can be switched off and need not be idled. When off even overnight, the bed retains most of its heat and only needs incremental heating the next day.

The need for effluent treatment and disposal does not arise and pre/post cleaning expenses reduce. All these and other features like low maintenance, no fume handling, lower LPG storage, no gas generator etc., combine to yield an operating cost per kilo that is 50% to 70% of conventional heat treating equipment.

LOW MAINTENANCE

FLUIDTHERM Fluidised Bed Furnaces are rugged workhorses designed to operate in hostile environments. There are no moving parts like fans conveyors etc as in atmosphere furnaces and hence no attendant maintenance problems. Separate gas generators are not required. Periodic furnace burnouts are not needed. Soot formation does not pose problems as the soot deposits on the particles and is burned off at the bed surface The alumina particles are inert and do not require rectification, regeneration or monitoring. The many features built into FLUIDTHERM Fluidised Bed Furnaces make them one of the most maintenance free equipment available.

CLEANING

Precleaning and drying of components required for processing in atmosphere and salt bath furnaces are not required when using Fluidised Bed Furnaces. Oil and moisture on the components and jig simply vaporise without the hazard of explosion. Post treatment cleaning is also greatly reduced. Some alumina adheres to threads, blind holes and the like but these are easily washed or blown off.

QUALITY

The high degree of temperature uniformity (+3°C,Typ.) causes extremely uniform heating of all components, even in very dense loads. Distortion is reduced by the bed buoyancy and uniform heat up from surface to core.

During case treatments, non uniform case depths do not occur. The component surfaces are continually exposed to fresh reactive gas under pressure and are gently scrubbed by the particles which also remove carbon build up on edges and corners. Dense loads can be processed without much care in component positioning and spacing. Once the parameters are set, consistent quality is obtained, batch after batch—for as long as the process is operated.

POLLUTION FREE

Fluidised Bed Furnaces are not poisonous, do not attract the provisions of health and pollution laws and are extremely safe for those operating them. Effluent treatment and disposal equipment are not required.

LOW CAPITAL COST

FLUIDTHERM Fluidised Bed Furnaces cost less than equal capacity, vacuum, sealed quench & pit type furnaces and even salt baths (when effluent treating and safety equipment costs are added). One furnace performs many processes so additional furnaces for specific low volume applications are not required.

EASE OF OPERATON

Fluidised Bed Furnace operation is extremely simple and safe. It involves only setting the desired temperature and gas flow (done automatically in certain models) and immersing the components. At the end of the cycle, the components are lifted out and the furnace is switched off while waiting for the next batch. The lack of any type of hazard makes operator training very simple.

FLEXIBILITY

TEMPERATURE FLEXIBILITY

FLUIDTHERM Fluidised Bed Furnaces can be operated at any temperature from sub zero to 1200°C, and have rapid heat up and cool down ability.

ATMOSPHERE FLEXIBILITY

The fluidising gases which are also the heat treating atmosphere do not reside in the furnace. A fresh gas stream replaces the existing atmosphere completely within seconds. Consequently it is possible to change process atmospheres—batch to batch!

IN WHICH OTHER SINGLE FURNACE CAN YOU . . .

CARBURISE, CARBONITRIDE, NITRIDE, NITROCARBURISE, OXYNITRIDE
AND NEUTRAL HARDEN, TEMPER, STEAM BLUE, BLACK OXIDE
AS WELL AS NORMALISE, ANNEAL, MARQUENCH, PREHEAT, AGE, HOMOGENISE, STRESS RELIEVE, QUENCH
PERFORM TOOL STEEL TREATMENTS, THERMAL SHOCK TESTING, PLASTIC AND PAINT STRIPPING, ETC ETC.?

IN A FLUIDTHERM FLUIDISED BED FURNACE YOU CAN

- ★ TEMPER and NITROCARBURISE in the morning, CARBONITRIDE and NEUTRAL HARDEN in the afternoon, CARBURISE in the evening and NITRIDE overnight.
- ★ Perform partial 'tip only' treatments.
- ★ Process different size components in the same batch.
- ★ Process different case depth jobs in the same batch
- ★ Preheat and harden in the same furnace
- ★ MARQUENCH or AUSTEMPER in a second furnace.
- ★ Do midcycle hardness and case depth checks.

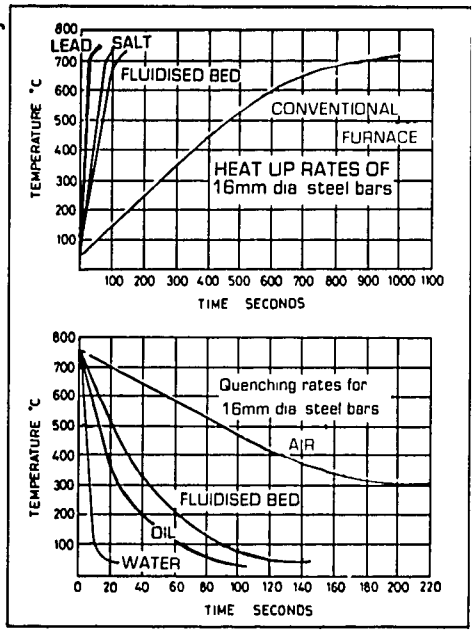
BATCH AND CONTINUOUS FURNACES

APPLICATIONS

SOME COMMON HEAT TREATMENT PROCESSES

NEUTRAL HARDENING

The heat transfer rate from the fluidised bed to the immersed components is very much more rapid than convection/radiation furnaces. Consequently shorter cycle times are required. A small furnace can output as much as larger conventional furnaces. The components are quenched in existing quench systems, whether it be water, oil, polymer or even another fluidised bed. For finished components, clean surfaces are obtained by fluidising with pure nitrogen or commercial nitrogen with hydrocarbon additions. Where nitrogen cannot be used argon and other suitable gases are used. In cases where metal is to be removed after treatment, air is used as the atmosphere. Remember that as the cycle is short, very little decarb/scale occurs as compared to other furnaces. Where production quantities do not justify a second preheating furnace, preheating can be done in the same hardening furnace. Components are immersed when the bed is at a lower temperature and after recovery both the bed and the jobs are taken rapidly to hardening temperatures. It has been seen that when tool and other steels are wrapped in stainless steel foil, surface finish equal to that obtained in vacuum furnaces can be obtained in Fluidised Bed Furnaces also.

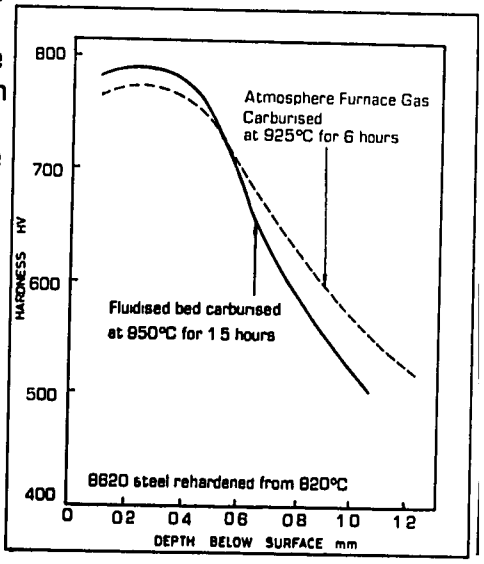


CARBURISING/CARBONITRIDING

The carburising process is much faster in Fluidised Bed Furnaces for a variety of reasons. Firstly the time taken to heat the load is very much lower than in conventional atmosphere furnaces. Secondly Fluidised Bed Furnaces can operate at much higher carbon potentials (1.6%WtC,Typ). At these levels soot formation would damage conventional furnaces but in Fluidised Bed Furnaces the soot merely deposits on the particles and is burned off at the bed surface. Thirdly the use of higher temperatures without grain growth is possible. Distortion is reduced by the buoyancy and temperature uniformity of the bed. Boost/Diffuse carburising can be performed with high potential during boost and inert atmosphere during diffuse.

The consistency of quality is very high. Under or over carburisation does not occur as the component surfaces are continuously exposed to fresh reactive atmosphere and are gently scrubbed by the particles which also contribute to the uniformity of gas composition. Absolutely uniform case depths can be obtained even in dense loads, in any part of the work basket. Equalising grain refinement or lower temperature quenching can be done in the same cycle.

Various atmospheres can be used such as LPG + AIR, N_2 + Methanol + LPG, N_2 + LPG, N_2 + Methanol etc.



NITRIDING/NITROCARBURISING & OXYNITRIDING

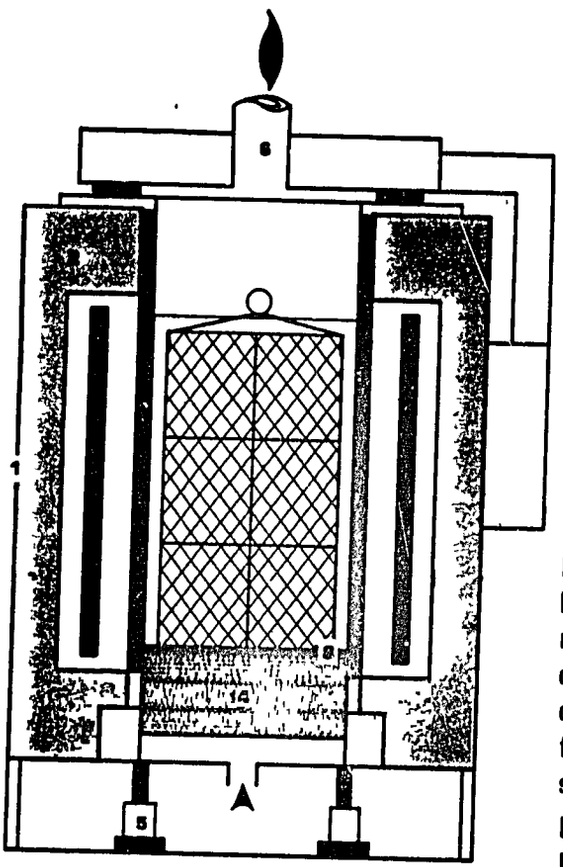
Any mixture of ammonia and other gases such as nitrogen, carbon dioxide, oxygen & hydrocarbons can be used for nitriding type processes in Fluidised Bed Furnaces. The relative concentrations can be adjusted to control the phases formed at the case, the white layer and the compound zone. Properties imparted by various proprietory processes can be easily duplicated and customised treatments for specific components and applications can be developed.

TEMPERING

Temperature uniformity, so critical for quality tempering and solution treatment is what makes the FLUIDTHERM Fluidised Bed Furnace the best available choice for these processes. Precise controllability and a wide temperature range enables the processing of most metals and secondary hardening of tool steels.

FEATURES THAT MAKE THEM SUPERIOR, RELIABLE AND MAINTENANCE FREE

1. **A sturdy shell** and thick deckplate resist damage due to impact and heavy loads. Removable panels allow quick and easy maintenance of heating elements.
2. Low thermal inertia **ceramic fibre insulation** enables the furnace to respond quickly to different temperature settings.
3. **The retort** is made in heavy section superalloy, chosen for maximum high temperature strength and resistance to thermal cycling.
4. The unique FLUIDTHERM multilayer alloy **distributor system** (patent applied for) is designed to produce uniform fluidisation and requires no adjustment.
5. A novel **retort support mechanism,** prevents retort distortion and elongation.
6. **The lift and swing lid** can also open straight up (like a suitcase lid). Lined with ceramic fibre, it incorporates an exhaust duct and a rotating wind screen.
7. **Heaters** are metallic or SiC, designed for safe surface loading. Anchoring, in the case of metallic elements is by a special rigid design that insulates the elements from the shell, both thermally as well as electrically.
8. **The work support** is of rugged construction and is designed for long life under constant maximum loading. A protective barrier is incorporated to trap falling parts.



OPTIONS

- ECONOPULSE— a microprocessor flow adjuster that reduces gas consumption by upto 90%.
- AUTOCARB—a control package for 'hands off' control of carburising and other surface treatments.
- AUTOPACK—an add-on module that converts manual models into automatic models.
- HUMIDIFIER—for steam blueing and colour finishing.

FLUIDTHERM Fluidised Bed Furnaces are modular in design. A basic furnace can be purchased and modules for extra treatment capabilities, controls and automation can be added on at a later date. All furnaces are supplied with free standing control and gas panels.

FLUIDTHERM Fluidised Bed Furnaces undergo a full systems check at the plant before despatch. They are generally fully assembled and need only utility connection to become fully operative. Commissioning can be done in-house or with the help of FLUIDTHERM engineers.

FLUIDTHERM
TECHNOLOGY (P) LTD
132, III Main Road, Industrial Estate,
Ambattur, Madras – 600 058.
Ph: (044) 656789 & 655375
Tlx: 041-22068

AN INTRODUCTION TO FLUIDISED BED HEAT TREATING

BASICS: Fluidisation is a method of making a 'bed' of sand like particles behave like a liquid. This is done by passing a stream of air or gas upward through the particle (eg. alumina) bed. When heated, the fluidised bed becomes an excellent media for heat transfer to products that are immersed into it (Fig.1). The four main beneficial properties of the fluidised bed when used as a heat treatment furnace are:

1) **High Heat Transfer Rate**
2) **High Temperature Uniformity**
3) **High degree of Flexibility**
4) **Its Physical State,** of being dry, clean and non-toxic at all temperatures.

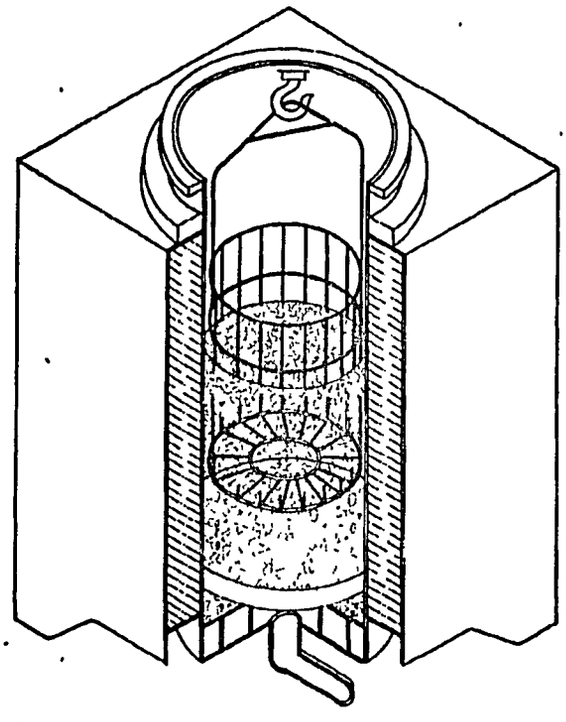


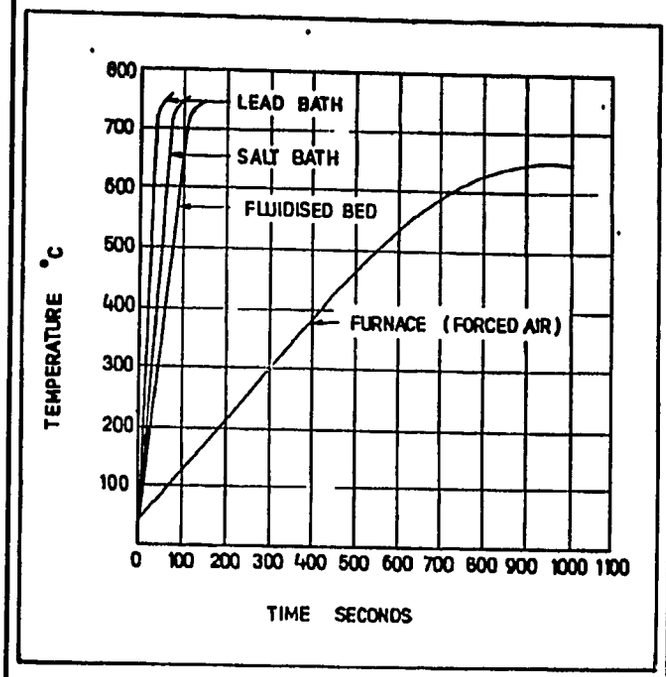
FIG.1- SCHEMATIC OF BASKET BEING IMMERSED INTO A FLUIDISED BED

The heat transfer rate in fluidised bed furnaces (FBF/c) is comparable to that obtained in salt bath furnaces and is very much faster than atmosphere convection furnaces (Fig.2).

This yields high production output from comparatively small FBF/cs. Also as the cycle is shorter the energy consumed is correspondingly lower.

The high degree of **temperature uniformity** is caused by the turbulent motion of the huge number of particles that travel to all corners of the bed. As a matter of fact, thermocouples themselves are calibrated in fluidsed bed furnaces. A

FIG. 2



HEATING RATE FOR 16mm DIA STEEL BAR

temperature uniformity frequently in the order of +/- 2°C yields consistent quality in terms of uniform hardness and case depth in all parts of even heavily loaded work baskets.

Flexibility comes from the ability to operate the same furnace at any temperature between ambient and upto 1200°C. Also any mixture of air or gas (heat treating atmospheres) can be used for fluidising.

Consequently, the same furnace can be used for any and all heat treatment processes.

An added advantage is the fact that a new gas stream completely replaces the existing gas stream within seconds. Hence it is possible to change processes batch after batch, such as carburising the first batch, carbonitriding or hardening the second, tempering or nitriding the third and so on.

Physically, the fluidised media, (alumina in heat treating) is dry at all temperatures. Though it looks and behaves like a boiling salt bath the particles are always separate and dry. Consequently, unlike the salt bath the FBF/c can be operated at any desired temperature without solidification or vapourization. Also when not actually operating, the FBF/c can be simply switched off without fear of solidification or sintering.

Arising out of the above four properties are the following advantages.

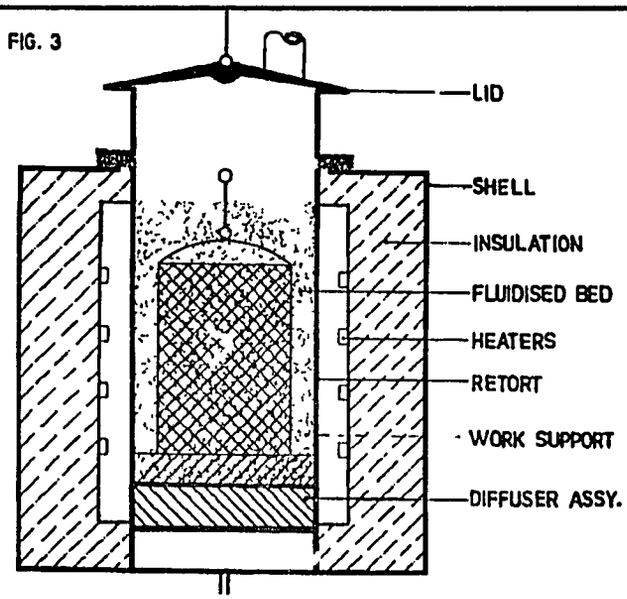
22X

1) **Low operating cost** due to the high heat transfer rate, the ability to switch off when not operating without major loss of temperature, the ability to process large tonnages in a small furnace, a reduction in pre/post cleaning expenses and the complete absence of effluent disposal, separate gas generators etc. Unlike salts, alumina is not 'consumed' and except for minor dragout losses it is used over and over again.

The Government of India has recognised the FBF/c as an energy saving device and has given users the twin incentives of **Zero Sales Tax and 100% Depreciation.**

2) **Low maintenance,** as there are no moving parts in the furnace and no ancillary equipment such as gas generators, etc.

FIG. 3



CROSS SECTION OF AN ELECTRIC FLUIDISED BED FURNACE

3) **Low capital cost** as the FBF/c is constructed similar to the pit type or externally heated electric salt bath furnace (Fig.3).

4) **Ease of operation,** as the FBF/c is loaded and unloaded just like a salt bath.

5) **Non polluting,** as the particles are entirely non-toxic. There is no disposal like for salt and sludge. It is also safer for operating personnel who need not be exposed to cyanide fumes and salt splashes.

6) **Reduction in cleaning** requirements which are quite extensive in the case of components treated in salt baths.

PROCESSES: A single fluidised bed heat treatment furnace has the ability to handle many gas streams. A typical unit uses Air (from a blower), LPG (from domestic cylinders), Nitrogen & Ammonia (from standard cylinders or generators). Typical

	LPG	AIR	NITROGEN	AMMONIA
Carburising	*	*	*	
Carbonitriding	*	*		*
Nitriding			*	*
Nitrocarburising	*		*	*
Neutral hardening			*	
Tempering		*		
Other neutral treatments			*	
Other non neutral treatments		*		

combinations of these gases for various treatments are shown below.

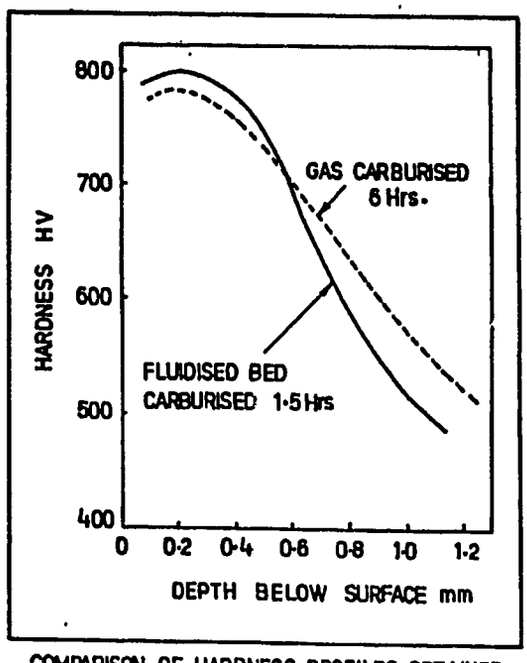
In addition, **two or more processes can be combined in the same cycle.** One example is carburising, cooling and rehardening (grain refining) in a single cycle. Here the products are cooled in a neutral atmosphere after the carburising phase and are then quenched from the relevant hardening temperature. This saves a lot of production time and avoids separate rehardening of components. Another example is the ability to combine tempering and blueing or nitriding and blackening in the same cycle by altering the fludising gas for a portion of the cycle. In times of shortage of certain gases or liquids, other atmospheres can be used without stopping the production. A Methanol/Nitrogen mixture can replace the LPG/Air mixture for carburising. During neutral hardening 100% Nitrogen sometimes with addition of 2% LPG or Hydrogen (to overcome impurities) is used. It is also possible to use LPG/Air mixtures to provide neutral atmospheres of different carbon concentrations.

RAPID CARBURISING: A FBF/c has a carburising rate very much faster than salt baths or atmosphere furnaces (pit, sealed quench etc), (Fig.4). The carburising time depends upon the temperature and the carbon potential of the atmosphere. It is not generally possible to maintain in excess of 1.2% carbon in salt baths or atmosphere furnaces as undesirable cyanide fumes (in the case of salt baths) and heavy sooting (in the case of pit and sealed quench furnaces) would occur. Consequently, the carbon potential has to be kept low and the cycle proceeds for a given time.

In a FBF/c however, it is possible to operate at a very high carbon potential. Soot forms but unlike in atmosphere furnaces, there is no effect on either the process or the furnace. The millions of particles in the fluidised bed prevent soot deposition on the components or the retort and the soot is burnt off at the surface of the bed. Soot ' burnt out' as in sealed quench furnaces is not required.

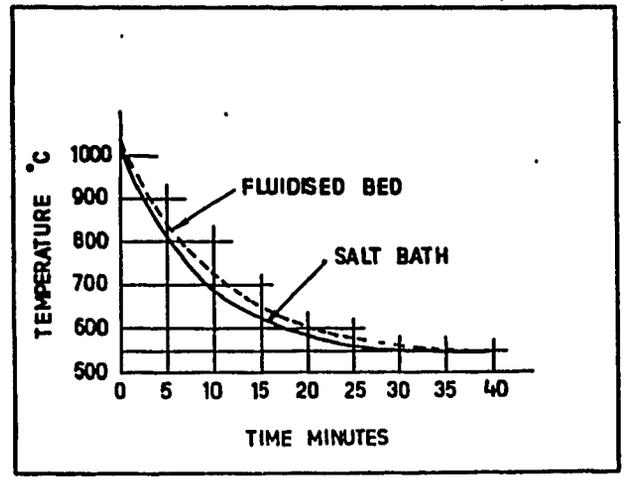
Nitriding and nitrocarburising are performed easily in the FBF/c with Ammonia, Nitrogen and LPG mixtures. With the

FIG.4



COMPARISON OF HARDNESS PROFILES OBTAINED BY FLUIDISED BED CARBURISING AND CONVENTIONAL GAS CARBURISING

FIG. 5



COOLING RATES IN FLUIDISED BED AND SALT BATH
145 mm DIA 200 mm LONG TOOL STEEL

use of certain gases and polymer quenches it is possible to perform ferritic oxynitrocarburising and to duplicate many proprietary salt bath processes such as Tufftride and Sursulf*. This process provides resistance to wear, corrosion, scuffing, galling, cold welding and improves fatigue strength.

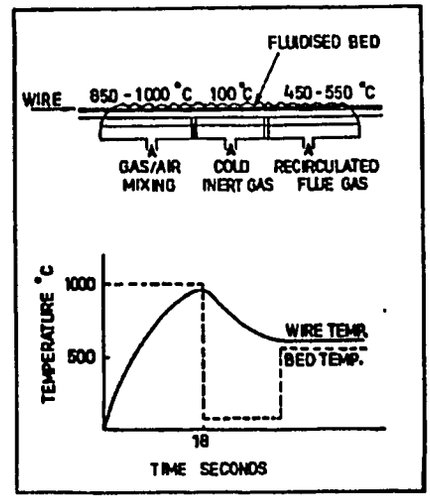
The high degree of **temperature uniformity** enables quality tempering as well as solution treating of aluminium alloys. Tempering can be done at various temperatures, from 160°C to 750°C in the same furnace. Tempering can be combined with blueing and blackening in a single cycle.

Fluidised bed furnaces are also used very effectively for **Marquenching & Austempering** (Fig.5). They have the added advantage that unlike salt baths, the furnace for marquenching can also be used for tempering, nitriding, preheating etc.

Continuous fluidised bed furnaces are also made in various designs. For continuous hardening, carbonitriding, etc. of small parts, a rotary retort (scroll type) furnace is popular. For continuous carburising and hardening of large components, a rectangular FBF/c is used where the components move along the length while suspended from overhead chain conveyors or walking beam mechanisms. Fluidised beds are also very popular choices for continuous **Patenting and Annealing of wires and strips** (Fig.6).

FUTURE PROSPECTS: Research work is currently being carried out influidised bed boronising, CVD coatings as well as in oxidation and reduction of fine particles and ores apart from a number of other applications in steam generation, waste disposal, metal recovery, foundry & chemical engineering.

FIG. 6



PATENTING IN A FLUIDISED BED

For further information on FLUIDTHERM FLUIDISED BED HEAT TREATING TECHNOLOGY & FURNACES, please contact:

Fluidtherm Technology (P) Ltd
No.132, III Main Road
Ambattur Industrial Estate
MADRAS 600 058
INDIA.

Phone: (044) 656789, 655375, 656264
Tlx: 041-22068 IFNW IN

** Trade names of M/s Degussa and H.E.F. respectively.*

ACTION TAKEN ON POINTS ARISING FROM THE MINUTES OF SECOND ERDAC MEETING HELD ON NOVEMBER 18, 1988

1. **Identification of select group of technologies of interest to PACER**

PACER Secretariat had several meetings with officials at DNES and other institutions in the field of energy such as TERI, NPC, IIT and CSIRs etc and has identified some project ideas for developing proposals. PACER Secretariat would survey available literature and identify the areas in which development work would be necessary and prepare detailed proposals for entrusting to suitable entrepreneurs through the mechanism of Request for Proposal.

2. **Publishing of information on Proposals cleared by PRC/ERDAC.**

Press releases on the proposals cleared were issued and are proposed to be issued from time to time after the meetings of ERDAC.

3. **Proposal for solar Pond for low grade heat proposed by Karnataka State Council for Science and Technology and Deejay Hatcheries, Bangalore :**

PACER Secretariat is pursuing the proposal with suitable entrepreneurs. PACER Secretariat has established an active interaction with IREDA. The proposals for consortium R&D and research study sent by IREDA are under consideration.

25x

4. **Proposal from Engineers India Ltd and Hindustan Zinc Ltd. (EIL/HZL)**

PACER Secretariat had several meetings with officials of EIL and HZL to clear various issues relating to the development project. The draft agreement for PACER assistance has been discussed and the proposers are expected to sign the agreement shortly.

5. **Proposal from Thermax (Pvt) Ltd and Trinity Forge Pvt. Ltd. (TPL, TFL).**

Disbursement of Rs. 4.17 lac (more than 50% of the sanction amount) was made and the proposers have made substantial progress. The regenerative burner is being installed at TFL's Ahmednagar works and will start functioning by September 1989.

6. **Research projects undertaken by TERI**

a) Project to evolve policy directions for smoothening load duration curve in India.

PACER Secretariat disbursed Rs. 6.20 lacs (50% cost of the project) and Rs. 8.50 lacs towards equipment such as data loggers, meters necessary to carry out the research. TERI in consultation with PACER Secretariat has constituted an advisory group (consisting of Sarvashri T.L. Sankar Chairman APSEB, R.S. Verma, Chairman HSEB,

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P. Abraham Chairman MSEB, Sethuraman, Chairman MPEB, L.R. Suri Secretary General NCPU, Chikkoba, chief Engineer/Planning TNEB) which would be consulted for considering the on-going efforts of Deptt. of Power, and other agencies. PACER Secretariat had discussions with TERI at various stages. TERI has informed that the study has commenced with field trials at Palawal Haryana. Discussions were held with Haryana State Electricity Board officials and Sonepat has been identified as suitable location for final study in the state of Haryana. Sample selection has already begun at Sonepat

b) Project on assessment of appliance effieciencies in domestic sector.

PACER Secretariat disbursed Rs. 6.90 lacs (50% cost of project) and Rs.4.45 lacs towards equipment essential for the project. PACER Secretariat had discussions with TERI on the progress of the project. TERI has informed that the work on project has commenced. A pilot survey has been initiated for identifying appliances which make significant contribution to the load. The household survey and efficiency measurements will start after analysing pilot survey data for a few selected gadgets. TERI would be submitting the progress report on the project shortly.

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c) Project for working out strategies for indigenisation of grid connected wind Electric Generators in India.

PACER Secretariat disbursed Rs.1,15,500(50% of cost of project) to TERI towards the project. TERI has contacted manufacturers of electric generators fibre glass components. Gears as also fabricators of steel components to assess which components of wind electric generators can be manufactured indigeneously. The main points emerging out of the discussion of representatives of TERI with various manufacturers contacted in connection with the project are as follows :

a) Import duty needs to be imposed on WEG so that indigeneous products can compete with foreign machines

b) Electricity Act needs to be altered to allow for generation of electricity by private sector.

c) Supporting structures (Towers) need be given the same status as transmission line towers. This would reduce the cost of land occupied by a windfarm.

d) Optimization of design of rotor is one of the R&D problems which needs to be pursued in order to reduce cost.

As on June 30, 1989 TERI has incurred Rs. 77,750 on project.

7. **Progress in respect of PACER Conference.**

In view of the comments of ERDAC, suggesting substantial pruning of PACER budget, the Scope of Work of Hagler and Bailey as also Oak Ridge National Laboratory was reviewed in consultation with the Secretary, ERDAC.

PACER Conference is now scheduled to be held on February 2-3, 1990. The details have been given under agenda item 7 of the third meeting of ERDAC.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH

3RD ERDAC MEETING

AUGUST 22, 1989

CO-OPERATION BETWEEN PACER SECRETARIAT AND IREDA

As you may be aware, PACER and IREDA are providing different financial instruments for development of technologies/products related to generation, use and conservation of energy in its various forms and applications. In order that the two entities work with adequate co-operation/co-ordination which enables each of them to serve its aims and objectives better, there has been frequent interaction between the two organisations during the last few months. As a result, the following ideas/actions have emerged:

- PACER Secretariat would participate in seminars and workshops on new and renewable sources of energy organised by IREDA jointly with local institutions. Quite a few of them have been lined up for the next few months.

- IREDA has been directing potential consortium R&D proposals as also research study projects to PACER Secretariat and would continue to do so in future. A list of such proposals received by PACER Secretariat is enclosed. These proposals are at various stages of formulations/suitable modifications.

- Both, PACER Secretariat and IREDA, would continue to have ongoing dialogue for identification and formulation of suitable projects/proposals.

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

PROPOSALS RECEIVED FROM IREDA

Sr. No.	Proposal	Proposer	Likely Project Cost (Rs lacs)
A.	CONSORTIUM PROJECTS		
1.	SOLAR POWERED STEAM GENERATING SYSTEM FOR PROCESS INDUSTRIES	KARNATAKA STATE COUNCIL FOR SCIENCE AND TECHNOLOGY	18.00
2.	DEMONSTRATION OF SOLAR POND FOR LOW GRADE HEAT	DEEJAY HATCHERIES (P) LTD. KARNATAKA STATE COUNCIL FOR SCIENCE AND TECHNOLOGY	3.30
3.	BUILDING OF PROTOTYPE 10 KVA, 440 V AERO-TURBINE	MANAMAR ENGINEERS & CONSULTANTS CEC PVT. LTD.	2.75
4.	UTILISATION OF SOLAR ENERGY FOR HATCHERY	J.G. AND MEHTAB HATCHERIES PVT. LTD.	N.M.
B.	RESEARCH PROJECTS		
1.	TECHNOLOGY OPTIONS FOR SOLAR THERMAL SYSTEMS IN INDIA	DR. RAO ASSOCIATES	25.00
2.	ESTIMATION OF EXPORT DEMAND POTENTIAL FOR RENEWABLE SOURCES OF ENERGY IN THE DEVELOPING COUNTRIES	ANDHRA UNIVERSITY	56.00

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

Third Meeting of Energy Research and Development Advisory Committee (ERDAC) on August 22, 1989 at 3.00 p.m. at Conference Room, DNES, New Delhi

A G E N D A

1. To confirm the minutes of the Second Meeting of ERDAC held on November 18, 1988 at New Delhi.

2. To consider the consortium proposals for financial assistance.

3. To note consortium proposal approved by Peer Review Committee

4. To note Research project proposals approved by Peer Review Committee.

5. To note the status of proposals selected for formulation by Peer Review Committee.

6. To note the proposals not qualifying for assistance under PACER.

7. To review the progress of preparation for the PACER Conference.

8. To review the promotional activities.

9. To consider budget for PACER for 1989-90.

10. Any other item(s) with the permission of the Chair.

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THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22 , 1989

Agenda Item 1

Confidential

Minutes of Second Meeting of Energy Research and Development Advisory Committee held on November 18, 1988 (copy enclosed).

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

Minutes of the Second Meeting of Energy Research & Development Advisory Committee (ERDAC) held on November 18, 1988 in DNES, New Delhi

The second meeting of the ERDAC was held in DNES under the Chairmanship of Dr.Maheshwar Dayal, Secretary, Department of Non-Conventional Energy Sources (DNES), Ministry of Energy at 2.30 p.m. on November 18, 1988. The following attended the meeting:

1.	Dr. Maheshwar Dayal Secretary, DNES	Chairman
2.	Dr. J. Gururaja Adviser, DNES	Member Secretary
3.	Shri S. S. Betrabet Adviser - Technology ICICI, Bombay	Member
4.	Dr. R. K. Pachauri Director, TERI, New Delhi	Member
5.	Shri V. Raghuraman Director (FE) National Productivity Council, New Delhi	Member
6.	Shri L. R. Suri Secretary General National Council of Power Utilities, New Delhi	Member

Also present were:

1.	Dr. P. H. Vaidya Manager, ICICI Bombay	PACER Secretariat
2.	Shri V. M. Deodhar Officer, ICICI Bombay	
3.	Shri S. S. Tamhane Officer, ICICI Bombay	

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4. Shri A. J. Advani Regional Manager	)	ICICI New Delhi
5. Shri B. Grover Officer	)	
6. Shri J. R. Meena Principal Scientific Officer, DNES		
7. Mr. R. W. Beckman Director Office of Technology Development & Enterprise	)	USAID, New Delhi
8. Shri S. Padmanabhan Energy Specialist	)	
9. Shri M. I. Beg Chief Engineer, Planning, CEA		Representing Shri J.K. Bhasin Member, Planning, CEA
10. Shri C. P. Malhotra Chief (Finance & Personnel) IREDA New Delhi		

Shri V. Bakthavatsalam, Managing Director, Non-Conventional Energy Development Corporation of Andhra Pradesh Limited, Shri J.K. Bhasin, Member, Planning, CEA, Shri S. J. Coelho, Managing Director, Ahmedabad Electricity Company Limited, Shri K. C. Lahiri, General Manager, Bharat Heavy Electricals Limited, Shri Dhruv M. Sawhney, Chairman, Energy and Energy Conservation Committee, Confederation of Engineering Industry, Shri Kamlesh Sharma, Joint Secretary, Department of Economic Affairs, and Dr. S. P. Sukhatme, Professor, Mechanical Engineering Department, Indian Institute of Technology, Bombay could not attend the meeting.

Dr. Maheshwar Dayal welcomed the members and the invitees to the second ERDAC Meeting. Before taking up items included in the Agenda, the members reviewed the progress in implementation of PACER since the First ERDAC Meeting held in February 1988 when following observations were made :

1) PACER has generated encouraging response with over 90 enquiries and 20 project profiles in the pipeline. PACER Secretariat has been interacting with the potential applicants. Nearly 50% of the profiles are in the area of renewable energy sources.

2) PACER Secretariat, in consultation with Peer Review Committee (PRC) has established criteria and procedure for evaluation of proposals.

3) Since PACER's thrust is on consortium/contract R&D projects which is new to the Indian entrepreneurs, formulation of such projects requires considerable effort both on the part of entrepreneurs and PACER Secretariat. It would be worthwhile for PRC and PACER Secretariat to identify a select group of techologies of interst to PACER and write proposals on the basis of which bids could be invited for commercial development of the selected technologies from prospective entrepreneurs/institutions. This could be a very innovative method of developing need based technologies in the energy sector as it would build a competitive element in the developmental effort. In this context,

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need for acquiring expertise in the identification of technologies and for drawing up Request for Proposals (RFP) was highlighted.

4) It may be useful to publish information on the proposals cleared by ERDAC/PRC so that potential entrepreneurs would be enthused to take advantage of the scheme.

Agenda Item 1 : To confirm the minutes of the First Meeting of ERDAC held on February 16, 1988 at New Delhi

The Committee confirmed the Minutes of the First Meeting of ERDAC held on February 16, 1988 at New Delhi.

The Committee reviewed action taken by PACER Secretariat on the points arising from the Minutes of the First ERDAC Meeting based on the note placed on the table. The Chairman referred to the project on Solar Pond for low grade heat proposed by Karnataka State Council for Science and Technology and Deejay Hatcheries, Bangalore received through Indian Renewable Energy Development Agency Ltd. (IREDA), which was discussed at the First PRC Meeting held on July 19, 1988 and considered non-supportworthy. He was of the view that the project is quite innovative and deserves support. The Committee considered the scope of the concept for wider application in rural economy and directed PACER Secretariat to get the proposal re-formulated duly incorporating the consortium approach for consideration by PRC in due course.

It was also agreed to scruitinize proposals which IREDA may have from time to time and consider them for assistance under PACER. Some of the IREDA proposals may require appropriate re-moulding to meet PACER's criteria for funding.

Agenda Item 2: To consider the Consortium R&D proposals for financial assistance

2 (a) Development of optimisation model for energy conservation in milling operation in mineral processing

The Committee agreed with the recommendation of the Peer Review Committee to provide to the consortium of Engineers India Limited (EIL) and Hindustan Zinc Limited (HZL) a conditional grant of Rs. 38 lacs. The project was approved on the following main terms and conditions :

1. Before availing of the conditional grant, the proposers shall enter into a Memorandum of Understanding specifying their mutual rights and obligations to the satisfaction of ICICI.

2. The proposers agree to make payments to ICICI of twice the amount of conditional grant disbursed as a negotiated percentage of revenues arising from the project on commercialisation.

3. (a) Machinery or equipment purchased in whole or in part with the conditional grant shall belong to the proposers but shall nonetheless be clearly identified and used only for the proposal purposes, unless ICICI otherwise permits in writing.

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(b) The proposers shall not sell, give on lease, licence to conduct, mortgage, charge or otherwise dispose off the said machinery or equipment except with the prior permission in writing from ICICI.

4. EIL shall bring in Rs. 12 lacs and HZL shall bring in Rs. 46 lacs to meet a part of the cost of the project in a manner and schedule to be finalised in consultation with ICICI.

5. The proposers undertake to bring in additional funds in consultation with and in a form acceptable to ICICI to meet any shortfall that may arise in financing the project and/or other requirements.

6. The proposers shall utilise the conditional grant only in accordance with the Approved Proposal Budget to be finalised in consultation with ICICI.

7. The proposers agree to appoint key persons for implementation of the project in consultation with ICICI.

8. ICICI and its authorised representatives reserve the right to carry out technical, financial and legal inspections during the implementation of the project.

9. The proposers shall keep ICICI informed about the progress of the project by submitting periodic reports in a form and substance to the satisfaction of ICICI.

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2 (b) <u>Development and Demonstation of Regenerative Burner</u>

The Committee agreed with the recommendation of Peer Review Committee to provide to the Consortium of Thermax (P) Ltd. (TPL) and Trinity Forge Pvt. Ltd. (TF) a conditional grant of Rs. 8 lacs. The project was approved on the following main terms and conditions:

1. Before availing of the conditional grant, the proposers shall enter into a Memorandum of Understanding specifying their mutual rights and obligations to the satisfaction of ICICI.

2. The proposers agree to make payments to ICICI of twice the amount of conditional grant disbursed as a negotiated percentage of revenues arising from the project on commercialisation.

3. (a) Land, machinery or equipment purchased in whole or in part with the conditional grant shall belong to the proposers but shall nonetheless be clearly identified and used only for the proposal purposes, unless ICICI otherwise permits in writing.

   (b) The proposers shall not sell, give on lease, licence to conduct, mortgage, charge or otherwise dispose off the said machinery or equipment except with the prior permission in writing from ICICI.

4. TPL shall bring in Rs. 8 lacs to meet a part of the cost of the project in a manner and schedule to be finalised in consultation with ICICI.

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5. The proposers undertake to bring in additional funds in consultation with and in a form acceptable to ICICI to meet any shortfall that may arise in financing the project and/or other requirements.

6. The proposers shall utilise the conditional grant only in accordance with the Approved Proposal Budget to be finalised in consultation with ICICI.

7. The proposers agree to appoint key persons for implementation of the project in consultation with ICICI.

8. ICICI and its authorised representatives reserve the right to carry out technical, financial and legal inspections during the implementation of the project.

9. The proposers shall keep ICICI informed about the progress of the project by submitting periodic reports in a form and substance to the satisfaction of ICICI.

Agenda Item 3: To consider the Research Projects for financial assistance

The Committee considered the revised proposals from Tata Energy Research Institute (TERI) placed on the table.

	Proposal	Proposer	Cost of the Research Project (Rs lacs)
a)	Project to evolve policy directions for smoothening the load duration curve in India	Tata Energy Research Institute New Delhi	21.00

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The Committee discussed the proposal at length and agreed with the need to undertake the same. While discussing the scope and problems associated with the Project, the Committee noted that appropriate meters were not available in India for monitoring peak load and there were several non-technological issues involved in implementation of the policy for mitigating peak load shortages. Dr. Pachauri (in his capacity as Director, TERI) agreed with the Committee's suggestion to conduct a survey of the on-going efforts of the Department of Power and other agencies such as CPRI, CEA etc., and formulate the exact scope of the project including its duration in consultation with an advisory group formed for the purpose by TERI. Similarly, it was agreed to associate a manufacturer and a utility with the pilot project.

The Committee agreed with the recommendation of the Peer Review Committee to entrust the Project to Tata Energy Research Institute on Project to evolve Policy Directions for Smoothening the Load Duration Curve in India subject to the condition that the cost and duration of the Project would be reviewed and finalised by PACER Secretariat in consultation with Secretary, ERDAC, after recasting and compressing the proposal taking into account existing studies and efforts. PACER Secretariat would also draw up comprehensive terms of reference for the proposed Project.

Proposal	Proposer	Cost of the Research Project (Rs lacs)
b) Project for assessing Appliance Efficiencies in the Domestic Sector	Tata Energy Research Institute	20.07

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The Committee agreed with the recommendation of the Peer Review Committee to entrust the Project to TERI. However, the project cost would be worked out in consultation with Secretary, ERDAC after further scrutiny by the PACER Secretariat based on the discussion on the scope of work and the duration of the project.

Proposal	Proposer	Cost of the Research Project (Rs lacs)
c) Project for working out strategies for indigenisation of grid connected wind electric generators in India	Tata Energy Research Institute	2.31

The Committee agreed with the recommendation of the Peer Review Committee to entrust to Tata Energy Research Institute, the Project for working out strategies for indigenisation of grid connected wind electric generators in India at an estimated cost of Rs. 2.31 lacs from PACER funds. The assistance would be in the form of grant and PACER Secretariat would draw up comprehensive terms of reference for the proposed project.

Agenda Item 4: To note the current status of proposals selected for formulation by Peer Review Committee

The Committee noted the current status of 12 proposals (placed on the table) selected for formulation by PRC at its First Meeting held on July 19, 1988.

The Chairman emphasised the need for informing ERDAC, from time to time, a list of rejected proposals so

that if any worthwhile/innovative project is rejected by PRC/PACER Secretariat, the same could be retrieved for development after reformulation as necessary.

Agenda Item 5: To consider delegation of Authority to Peer Review Committee

The Committee agreed to authorise PRC to approve projects involving PACER contribution not exceeding Rs 10 lacs per project in the form of conditional grant/grant. It was further agreed that PACER Secretariat would inform the members of ERDAC about such approvals by PRC.

Agenda Item 6: To discuss the progress in respect of the proposed PACER Conference

The Committee approved the proposal to hold the PACER Conference in March/April 1989 as indicated in the note. The Committee also considered the proposal for engaging the services of Oak Ridge National Laboratory (ORNL) and Hagler, Bailly & Co. Inc. (H&B) to provide US component of the Conference at an outlay of US $ 83,000 and US $ 133,000 out of PACER funds towards the assignment to ORNL and H&B, respectively, and another US $ 123,000 from S&T/EY for certain additional services from ORNL. ERDAC appreciated the interest taken by S&T/EY in the Conference. While it approved the proposal, in principle, ERDAC desired substantial pruning of the PACER budget and towards this objective considered it advisable to increase reliance on published/freely available information of relevance to the

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Conference. The Committee also saw scope for a revision in the cost of the H&B services, if necessary, by reallocating some of the functions to ORNL and suitable Indian institutions. The Committee authorised PACER Secretariat to finalise the arrangements and budget, in consultation with Secretary, ERDAC.

Agenda Item 7: To note reimbursement of costs of PACER Secretariat

The Committee noted ICICI's proposal to charge PACER project a sum of Rs 5 lacs per year towards reimbursement of cost of the PACER Secretariat with effect from September 1, 1987.

Agenda Item 8: Any other items with the permission of the Chair

(a) Meeting with US experts and visits to Institutions in US of relevance to PACER

The Committee approved the proposal of the meeting with US experts for ensuring proper coordination between research papers on the Indian and US sides and visits to institutions in US of relevance to PACER by the Secretary, ERDAC, (Dr. J. Gururaja), the ICICI member on ERDAC (Shri S. S. Betrabet), Manager, PACER Secretariat (Dr. P. H. Vaidya) and representative of Tata Energy Research Institute at an estimated cost of Rs 3.35 lacs. The Committee noted that the proposed visit of the team would help build up expertise into RFP process as also into other aspects relating to implementation of PACER with special reference to consortium and contract research.

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(b) Proposal from Lotus Energy Pvt. Ltd. (Lotus) and National Aeronautical Laboratory (NAL) for development of gas turbine co-generation plant from used aero-engine.

(c) Proposal from Orien Engineers (P) Ltd., Hindustan Aluminium Corporation Ltd. and Institute of Gas Technology for development of fluidised bed technology suitable for low grade Indian coal.

(d) Proposal from Punjab Agro Industries Corporation Ltd. (PAIC) and PRM Energy Systems (PRM) on pilot-cum-demonstration plant for generation of power and steam from agro-residues.

The Committee noted the outline of the above proposals (b, c and d) which were under formulation.

The Meeting concluded with a vote of thanks to the Chair.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

Confidential

Agenda Item 2

Consortium Proposals for Financial Assistance

	Proposal	Proposer(s)	Project cost (Rs. lacs)	PACER contribution (Rs. lacs)
a)	Development of 500 KWe biomass gasifier based power generation system	Ankur Energy and Development Alternative Ankur Scientific Energy Technologies Pvt. Ltd.	29.00	14.50
b)	Development and demonstration of solid polymer eletrolyte fuel cell stacks in the range of 1-5 KW	SPIC Ltd. SPIC Science Foundation	210.00	100:00
c)	Development of continuous type fluidised bed heat treatment furnaces	Fluidtherm Technology (P) Ltd IIT. Madras TI Diamond Chain Ltd.	82.00	41.00*

* subject to review and recommendation by Peer Review Committee at its 5th Meeting scheduled at 11.30 a.m. on August 22, 1989

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

Confidential

Agenda Item 2(a)

MEMORANDUM FROM PACER SECRETARIAT ON THE PROPOSAL OF ANKUR ENERGY & DEVELOPMENT ALTERNATIVE (BARODA) AND ANKUR SCIENTIFIC ENERGY TECHNOLOGIES PVT. LTD. (BARODA)

Project Title	:	Development of a 500 KWe power generation systems based on biomass gasification
Principal Proposer	:	Ankur Energy & Development Alternative
		Rs lac
Project cost	:	29.00
Means of financing	:	Proposers contribution:
		Ankur Energy and Development Alternative (ANKUR) 5.00
		Ankur Scientific Energy Technologies (P) Ltd. (ASCENT) 9.50
		PACER contribution conditional grant 14.50
Project Conept	:	ANKUR and ASCENT propose to undertake Development of a 500 KWe gasifier system based on biomass gasification technology. The proposed system would be coupled with a 50 KW or a 100 kw DG set for the proof of concept testing for future scale up. It would employ microprocessor controls and a turbocharged engine. The air flow passage/tuyers would be developed by ANKUR which would be responsible for design, data collection,

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processing and other support activities whereas ASCENT would undertake fabrication, testing and subsequent manufacturing. The proposed gasifier would be based on wood chips from a supporting energy plantation of fast growing plant species. The biomass gasifiers upto the range of 1 MWe are expected to be viable especially for the remote regions. They can be connected with grid or be used for generation of Power for captive use by medium size process industries. Development of such power generating systems may be taken up in association with an end user as a sequel to the present R&D project.

Project Schedule	:	R&D project	: September 1989 - March 1992 (2 1/2 years)
		Commercial project	: March 1992 - onwards

The above proposal of ANKUR and ASCENT was reviewed at the third PRC meeting. The PRC agreed to recommend the proposal for consideration and approval of ERDAC subject to the condition that GEDA (or any suitable entity/organisation) be included as end user member in the consortium to undertake the project. The committee observed that the scope of proposed project could be limited to development gasifier of 500 KWe capacity and establishment of its successful operation. This aspect of development work may not require a DG set. The committee also indicated that alternative of having (2x250) KWe DG sets vis-a-vis (1x500) KWe DG set may be examined by the proposers for subsequent demonstration and commercialisation.

The PACER Secretariat had conveyed the comments of PRC to the proposer who agreed to incorporate suitable changes in the project. The revised proposal is now placed before ERDAC for its consideration and approval.

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A consortium consisting of Ankur Energy & Development Alternative (ANKUR) and Ankur Scientific Energy Technologies Pvt. Ltd. (ASCENT) Baroda proposes to undertake a project for the Development of a 500 KWe power generation system based on biomass gasification. The estimated cost of the project is Rs 29.00 lacs. To meet a part of this project cost ANKUR has approached ICICI (PACER Secretariat) for a conditional grant of Rs 14.50 lacs out of the funds available under the Program for Acceleration of Commercial Energy Research (PACER).

A. BACKGROUND OF CONSORTIUM MEMBERS

i) Ankur Energy & Development Alternative (ANKUR) is a proprietory engineering and consultancy organisation promoted in July 1986 by Dr. B.C. Jain a well known expert on non-conventional energy sources (see annex A for bio data). It is engaged in design and consultancy in the field of energy with focus on energy efficiency improvement and Renewable sources of energy such as solar, biomass, wind. ANKUR has completed various consultancy assignments for clients from private industries, state nodal agencies, central government and some international organisations. ANKUR has been chosen to execute a countrywide demonstration programme of biomass gasifiers in the 3.5 to 100 kw range. For the period ended June 30, 1987 ANKUR's turnover was Rs 8 lacs on which it earned an operating profit of Rs 1.2 lacs. All the products/studies offered by ANKUR are based on R&D work. ANKUR is engaged presently in carrying out techno-economic feasibility study for setting up a 500 kw biomass gasifier based power plant.

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ii) Ankur Scientific Energy Technologies Pvt. Ltd. (ASCENT) a company incorporated in October 1986 by Dr. B.C. Jain, Managing Director, is engaged in manufacture of various renewable energy devices including biomass gasifiers and solar water heaters. It is jointly financed by Gujarat State Financial Corporation (GSFC) and IREDA. It has a manufacturing plant at village Gothda, taluka savli a backward area of Gujarat. ASCENT has supplied 148 gasifiers of capacities ranging from 3-100 kw. ASCENT developed the 100 kw gasifier in collaboration with ANKUR and is one of the two manufacturers of biomass gasifier based power plants of that capacity in India.

ASCENT has a laboratory, a 48 kw gasifier for carrying out experiments and an energy plantation with 3000 plants of various fast growing species for carrying on R&D work. ASCENT's sales for the 17 months period ended January 31, 1989 amounted to Rs 33 lacs on which it earned a profit of Rs 6 lacs before depreciation.

Both the consortium members have qualified engineers and biodata of key persons who would work on the proposed R&D project is enclosed in Annex A. A Memorandum of Understanding pinpointing the responsibilities and sharing of benefits of the project and other terms would be prepared shortly.

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B. STATEMENT OF THE PROBLEM

Biomass gasification is known to mankind since ages. Coal briquettes cowdung, char etc. have been used conveniently. However, efficient use of such biomass required a great deal of technological innovation. Gasification of biomass must be supported with proper plantation, else it is likely to lead to deforestation. Biomass gasifiers are presently being used mainly for smaller capacity pumps and other electrical equipment. Grid connected or decentralised power supply has not been tried at a major level, In view of this a complete system consisting of biomass gasifier, power generating equipment, transmission and stabilising equipment together with energy plantation to supply biomass is necessary. Biomass gasification power plant is expected to be a viable proposition upto 1 MW capacity. Beyond this capacity the gasifier based power plants have some limitations at present level of technology. These are on account of flow distribution at the large sized throat of the gasifier and the dual fuel engine limitations. However technology is developing fast and gasifiers are expected to be viable upto 3 MW range shortly.

Work done so far: ASCENT has standardised the design of its gasifiers upto a capacity of 40 KW and has supplied 145 gasifiers of various capacities in 3-40 KW range. It has also supplied a 40 KW gasifier based power plant for Grid applications to Maharashtra Energy Development Agency (MEDA) recently. ASCENT has developed a 100 KW gasifier which is a pioneering work, two such gasifiers are in operation in the north eastern states.

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However it is in process of stabilising the design specifications. ANKUR is presntly conducting a techno-economic feasibility study for establishing 0.5 MW power plant based on biomass gasification in Gujarat.

C. **TECHNICAL PROPOSAL**

It is proposed to design and develop a 500 KWe capacity wood gasifier. The proposed gasifier will be integrated with a 125-500 ha energy plantation of fast growing varieties of plants like Acacia Nilotica (Babul), Eucalyptus, Prosopis Juliflora etc. The gasifier will be a down draft type employing, microprocessor based controls for load and wood sensing and controlling production accordingly and for facilitating automatic start/stop operation. At this stage the diesel generator would not be included in the project but would be contributed by the end user such as Gujarat Energy Development Agency/Gujarat Electricity Board. The proposed gasifier which is scaled up five times over the present capacity of 100 kw would involve changes in the design of throat, air passage/tuyers and would include separate ignition port. It will also include a microprocessor based control system which would facilitate i) automatic start and shutdown ii) load and wood sensing for oxidation and reduction monitoring. It is proposed to compress the gas-air mixture prior to entering the engine by means of a turbo-charger. With these changes and innovations the proposed gasifier is expected to achieve a diesel replacement of the order of 70-75%,

an overall efficiency of about 25%, a biomass consumption of 1.2 kg/kwh, gas of calorific value 1000 $KCal/NM^3$ and containing less than 50 mg/NM^3 of tar and particulate matter. The details of technology are enclosed in Annex B.

The proposed work would be carried out according to the following stages.

i) Designing of the gasifier and subsystem from the fundamental considerations.

ii) Fabrication of a prototype and proof-of-concept tests in the laboratory.

iii) Data analysis, prototype modifications and extended laboratory testing of the gasifier.

iv) Development of a micro processor based automatic contol system.

v) Testing of the control system with the gasifier prototype.

The proof-of-concept experiments would enable tests of proper distibution of air flow and ability to produce relatively clean gas. Additional important steps would involve development of appropriate biommass preparation and conveyance systems.

The gasifier after stabilising its performance can be used for other applications as well e.g. thermal operations.

D. IMPLEMENTATION PLAN

The project would be subdivided in two groups of activities a) Design, data collection and analysis and detailed engineering work which will be taken up by ANKUR b) Fabrication, erection and commissioning which require engineering skills would be taken up at ASCENT. The two teams being under same management would work closely and undertake jointly some activities such as trials, testing etc. More specifically ANKUR would undertake the study on techno-economic feasibility of the 500 kw gasifier based power plants. It would also assess the market and potential of energy plantations In India. ASCENT will manufacture the gasifiers on the specifications decided jointly. ASCENT will market the gasifier after successful demonstration.

To facilitate a faster proof-of-concept testing, a prototype without cooling, cleaning subsystem and automatic controls would be first fabricated on which proper air distribution, quality of gas produced, selection of materials would be established.

Based on the activities/stages mentioned earlier, proposers have estimated that the project would be completed in a period of two and a half years time. A bar chart of activities is enclosed in Annex C. In the proposed project the stress would be on designing/testing of the gasifier portion. The gasifier would then be tested with a part load in power mode (say 50 KWe i.e. 10% of gasifier capacity). The field trials of complete power generation system of matching capacity connected to the power

grid would commence after the completion of the present project (i.e. after 2 1/2 years), When, an end user would be inducted into the R&D consortium.

E. COST OF PROJECT

The overall cost of the project is estimated at Rs 29.00 lacs as follows :

(Rs lacs)

Item	Year 1	Year 2	Year 3 (6 mths)	Total
1) Equipment	6.50	1.50	-	8.00
2) Salaries, wages and overheads	3.06	3.38	1.85	8.29
3) Materials, stores and consumables	3.20	2.60	1.00	6.80
4) Travel	0.20	0.30	0.20	0.70
5) Data processing & consultants	0.40	0.80	0.40	1.60
6) Other expenses	1.36	0.83	0.35	2.54
7) General and administative	0.38	0.24	0.45	1.07
Total	15.10	9.65	4.25	29.00

Equipment includes microprocessor based control system, biomass preparation and handling system dynamic machinery and miscellaneous measuring instuments like turbine flow meter, gaschromatograph, tar measurement devices/data logger.

Materials and stores include SS-310 and MS sheets, purchased items like drives, diesel oil, charcoal etc.

Salaries are for one project manager, two engineers, two supervisors, and wages are for 2 each of skilled and semi skilled operators.

Consultants' charges would be for microprocessor based system design. The travel does not include any foreign component. Other expenses include contingencies.

F. FINANCIAL PLAN

The cost of project i.e. Rs 29.00 lacs would be shared as under:

	(Rs lac)
ANKUR	5.00
ASCENT	9.50
Conditional grant from PACER	14.50
	29.00

Contribution from ANKUR and ASCENT:

Though both the members of consortium are relatively new, their operations are profitable and financial position is sound. Proposers would bring in their contribution to the project financing in form of equity/quasi equity funds.

Conditional grant from PACER:

The proposers of the consortium R&D project have requested sanction of a conditional grant of Rs 14.50 lacs out of the PACER fund. The Conditional grant will be repayable after successful commercialisation of the product. Payments to PACER will be a negotiated percentqage of revenue arising from the project on commercialisation and limited to a maximum of 200 per cent of the PACER Contribution towards the project cost.

G. PROSPECTS

ANKUR group is one of the two manufacturers of gasifiers of 100 kw capacity at present. It has already established 2 such gasifiers in India whereas the other manufacturer has yet not entered in the market. Thus they are leaders in the technology in India, with the proposed development this unique position is likely to be strengthened. The product is especially useful for areas which are remote and where laying of power grid is difficult. This is particularly so in the north eastern states where ASCENT has installed many gasifiers. Based on the experience gained on 48kw unit set up for captive use ASCENT has proposed several new features in the proposed product which would help making the product more reliable. Moreover the government policy is now to encourage the cultivation of energy plantations and hence the overall prospects for the proposed product are bright. The product (gasifier) could be used for various thermal applications as well. Proposers have estimated that product life cycle of this type of technological device is about seven years. By the end of this period major technological changes or significant product innovation would result.

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H. BUSINESS PLAN

The DG set would contribute to 60% of the cost of the complete power generation system. Hence the profitability is a great deal dependent on this factor. Proposers estimate that the price of 500 kw gasifier would be Rs 35 lacs. The prices of 100 KW gasifier units at present are Rs 6 lacs. Though with rise in capacity the per KW price of the Gasifier system (GS) is expected to come down, the 500 KW GS will employ a microprocessor based control system which is not included in the 100 KW unit. Besides this, the engine is turbo charged as compared to being naturally aspired. Proposers are already in the market as suppliers of gasifiers, hence they expect to get a substantial market share in the 0.5 MW range. The projected sales and profitability is given in Annex-D.

The proposers feel that following factors are likely to contribute significantly to marketing of 500 KW biomass gasifier based power generation systems.

a) prevailing shortages of electricity;
b) shorter gestation periods for the system;
c) low investment per unit installed capacity;
d) competitive power generation costs;
e) savings in petoleum products;
f) ease of start-up and continuous operations.

I. STRATEGIC ANALYSIS

The proposed R&D project was analysed in terms of business attractiveness and consortium strength factors. The details analyses is enclosed in Annex E. As indicated by Business attractiveness score of 40 and consortium fit score of 44 giving a total of 84 the project has a high potential of technology success and commercial viability. The total score is indicated by $ on the identity chart in Annex E (contd.).

RECOMMENDATION

The proposers are technically and financially sound and have in a short period established their names in the business. They have already carried out similar R&D projects and successfully commercialised products. The proposed product involves a quantum jump over present technology. The product is likely to be well received and Government may also extend support for the product. We recommend providing a conditional grant of Rs 14.50 lacs to meet 50% percent cost of the proposed R&D project available under Program for Acceleration of Commercial Energy Research (PACER) on following main terms and conditions.

1. Before availing of the conditional grant, the proposers shall enter into a Memorandum of Understanding specifying their mutual rights and obligations to the satisfaction of ICICI.

2. The proposers agree to make payments to ICICI of twice the amount of conditional grant disbursed as a negotiated percentage of revenues arising from the commercialisation of the project.

3. a) Land, machinery or equipment purchased in whole or in part with the conditional grant shall belong to the proposer but shall nonetheless be clearly identified and used only for the proposal purposes, unless ICICI otherwise permits in writing.

   b) The proposer shall not sell, give on lease, licence to conduct, mortgage, charge or otherwise dispose off the said land, machinery or equipment except with the prior permission in writing from ICICI.

4. The proposers shall bring in Rs 14.50 lacs to meet a part of the cost of the project in a manner and schedule to be finalised in consultation with ICICI.

5. The proposers undertake to bring in additional funds in consultation with and in a form acceptable to ICICI to meet any shortfall that may arise in financing the project and/or other requirements.

6. The proposer shall utilise the conditional grant only in accordance with the Approved Proposal Budget to be finalised in consultation with ICICI.

7. The proposer agrees to appoint key persons for implementation of the project in consultation with ICICI.

8. ICICI and its authorised representatives reserve the right to carry out technical, financial and legal inspections during the implementation of the project.

9. The proposer shall keep ICICI informed about the progress of the project by submitting periodic reports in a form and substance to the satisfaction of ICICI.

Annex A
(Ref. page4)

ANKUR - ASCENT

Name : Dr. B.C. Jain

Qualifications : B.E.(Mech) B.ITs Pilani and M.I.T. U.S.A. M.S. Masters in Mech. Engg. and Management D.Sc. Mech. Engg.

Positions held : 1986 - onwards - President ANKUR and Managing Director ASCENT

1981-1986 General Manager (R&D) with Jyoti Limited, Vadodara

1977-1981 Various positions with Jyoti Ltd. in R&D division.

Founder president of Renewable Energy Equipment Manufacturer's Association (REEMA)

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Name : Abhai Deo Singh Chanhan

Qualifications : B.E Electrical Engg. B.H.V.

Position held : Sr. Consultant - ANKUR - 1988 onwards
1985-88 Chief Executive - CPEC Ltd. Bombay (Associate of Voltas Ltd.)
1982-85 Group General Manager Jyoti Ltd.

1965-82 Plant Manager Jyoti Switchgear Ltd.

1959-65 Senior manufacturing engineer Bharat Heavy Electricals Ltd. Bhopal

1954-59 Asst. Engineer Chambal Hydro Project (M.P.)

Annex B
(Ref. page 7)

ANKUR - ASCENT

Details of Technology

All the material resulting from the biological sources is generally treated as biomass Biomass is basically complex molecular formation of carbon, Hydrogen, Oxygen, Nitrogen, phosphourus, sulphur etc. When the biomass is heated in absence of oxygen first the volatiles evaporate forming gaseous phase compounds, These vapours help in breaking down molecules of complex nature into smaller organic chains. At a still higher temperature called pyrolysis temperature the bigger molecules break and gases such as methane, carbon monoxide and even hydrogen are liberated. Finally all the biomass excepting tar gets gasified. However, to achieve this ideal process external heat would be necessary; to achieve this some of the biomass is allowed to burn liberating heat and oxides of carbon. When these gases pass over further biomass they get reduced to carbon monoxide and methane., This results in low calorific gases. This type of gasification is called Air/oxygen gasification. A similar effect can be obtained with steam.

Air gasifiers are most common as they are very simple type of reactors. Figure 1 describes a typical down draft gasifier system. Similarly up draft or cross draft gasifiers are also available. Gasifier is a fuel specific reactor and different biomass would require separate design. Gasification is very efficient way in tapping energy from biomass 75-80 percent

of biomass stored energy gets converted into gases. The efficiency of gasifier system is therefore controlled by the user system.

For the 500 KWe gasifier based power plants various new features are envisaged. The engine would be turbo-charged instead of being naturally aspired. The microprocessor based control system would be controlling the feed rate depending on load sensing, it would facilitate auto start and shut down etc. The gasifier would have throat of SS 310 welded to M.S. separate ignition ports would also be installed. It is expected to have biomass consumption of 1.2 kg/kwh and 70-75% replacement of diesel. The gas will have a calorific value of 1000 kcal/nm^3 and less than 50 mg/nm tar and particulater.

The gasifiers are quick start equipment which can be started with in 5 minutes. Thus they can readily supply power in case of failure. Turn down ratio (Maximum : minimum gas generation rates at which gasifier can be operated reasonably efficiently without sacrificing gas quality) is expected to be of the order of 3-5. Gasifier based power plants are expected to exhibit higher reliability and all components being indigenous the fabrication/procurement is easier.

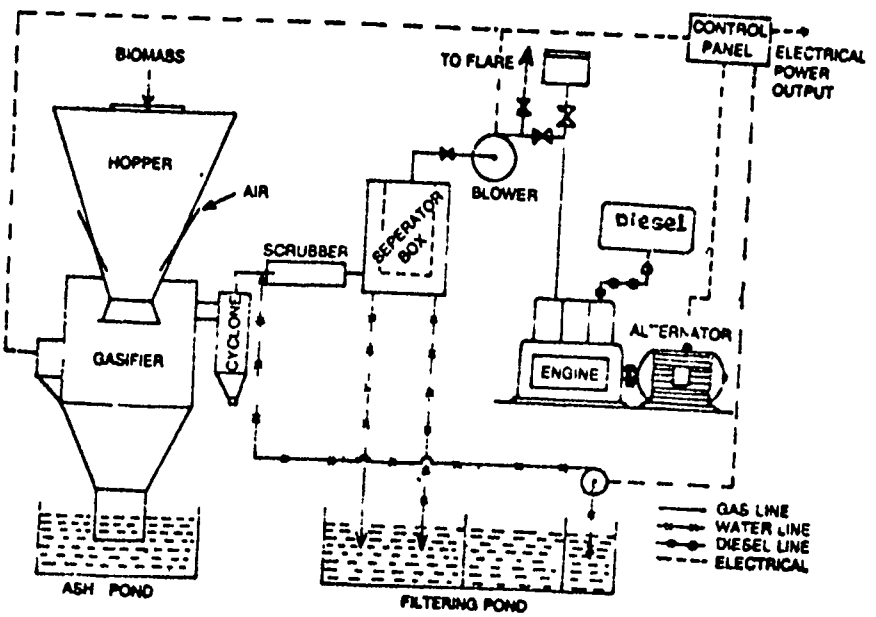
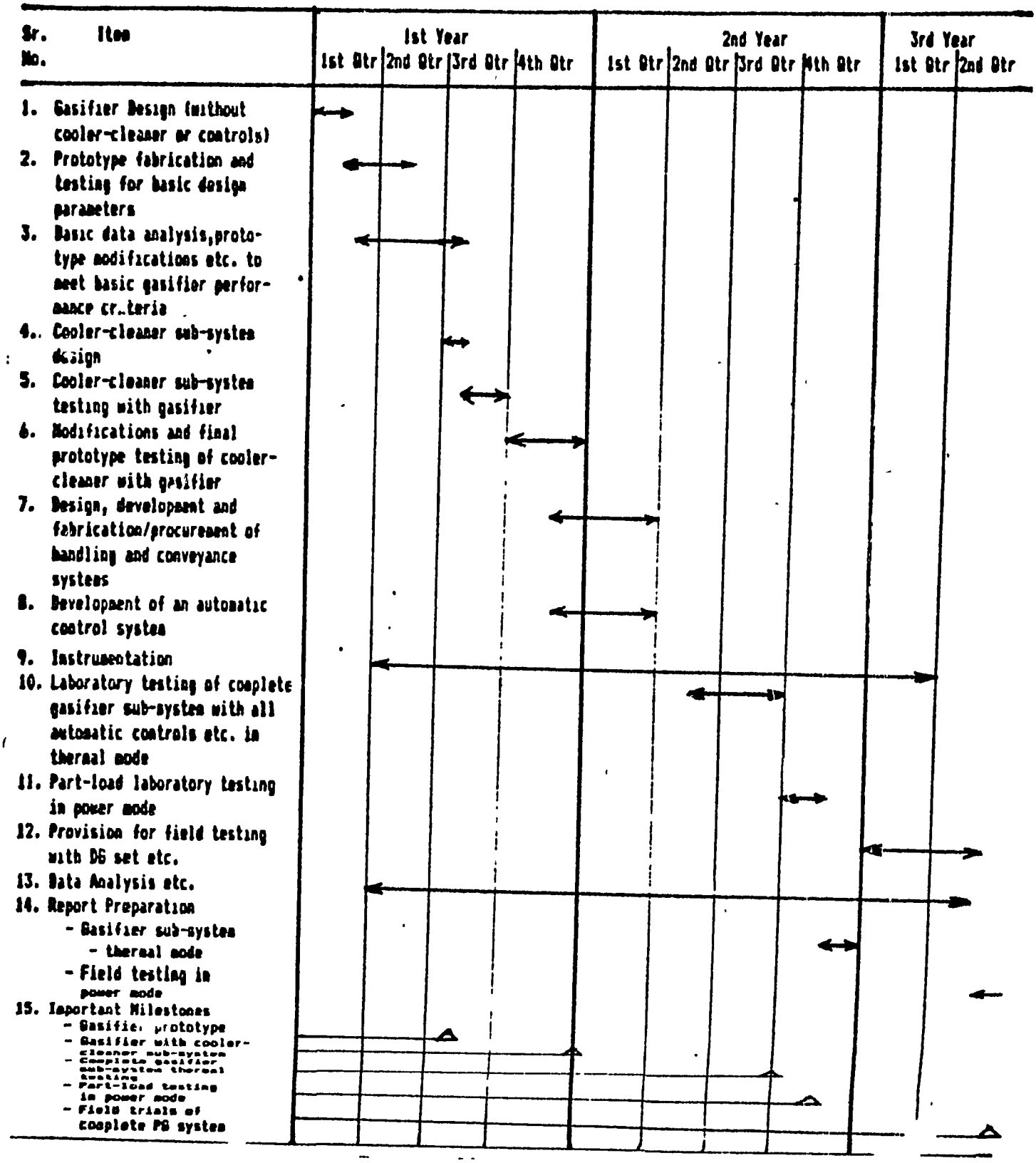


FIGURE 1 : SCHEMATIC DIAGRAM OF BIOMASS GASIFIER BASED POWER PLANT

Annex C
(Ref. Page 8)

ANKUR-ASCENT

Activity Bar Chart



(Annex D)
Ref. Page 12

ANKUR - ASCENT

Profitability Estimates

(Rs.lac)

	Year 1	Year 2	Year 3	Year 4	Year 5
Sales Value	140.0	210.0	280.0	350.0	245.0
Materials, Stores, Components	105.0	157.5	210.0	262.5	183.8
Utilities	1.4	2.1	2.8	3.5	2.5
Salaries & Wages	4.2	6.3	8.4	10.5	7.4
Repairs and maintenance	0.6	0.6	0.6	0.6	0.6
Factory Administration and overheads	5.6	8.4	11.2	14.0	9.9
Royalty	4.2	6.3	8.4	10.5	7.4
Selling expenses	2.8	4.2	5.6	7.0	4.9
Misc. expenses	4.0	4.0	4.0	4.0	4.0
Total Cost	127.8	189.4	251.0	312.6	220.5
Profit before depreciation and Interest	12.2	20.6	29.0	37.4	24.5
Interest	3.5	4.6	5.8	6.9	5.2
Depreciation	2.0	2.0	2.0	2.0	2.0
Operating Profit	6.7	14.0	21.2	28.5	17.3
Taxation	4.0	8.4	12.7	17.1	11.6
Profit after Tax	2.7	5.6	8.5	11.4	5.7
Net cash accruals	8.7	11.6	14.5	17.4	11.7

Annex E
(Ref. Page 13)

ANKUR-ASCENT

Strategic Analysis

The success of any R&D project on commercialisation is a very critical matter for the decision making by the top management. If a reasonable estimate of probability of commercial success of an innovative product is available before commiting large amount of funds on the R&D project, the decision making is greatly faciliated. This is possible to a certain extent by analysing certain factors pertaining to the proposed business iteslf and to the strength/fit of the consortium which would undertake the development. We discuss below 6 factors each from both these class of factors to assess the probability of commercial sucess.

Business Attractiveness factors	Score
a) Sales/profit Potential The product is less capital intensive as compared to other conventional ways. The profit is expected to be 5.10% of the sales which is a realistic estimate.	6/10
b) Growth Rate Due to government policy of promoting non conventional energy sources and development of wastelands and encouragement to growing of energy plantation the market is expected to grow at a very high growth rate.	8/10

c) Competitor Analysis

Apart from ANKUR there is only a single manufacturer capable of producing gasifiers in 100 kw range and no installation has been reported by them. Thus the capability of the competitors if any to successfully develop 500 KWe gasifier power plant seems to be limited. 8/10

d) Opportunity to Resturcture the Industry

If we consider gasifier manufacturing as an Industry the proposed development will lead to a quantum jump in technology development. However in the power generation Industry 500 KW capacity plant will hardly make a sizeable contribution. 5/10

e) Risk Distribution

The gasifier proposed has apart from power generation, several uses such as thermal applications, use in vehicles and use as synthesis gas. 7/10

f) Special Factors

Shortage of power and government's efforts to tap every alternative source in 8th plan, short gestation periods, saving of petro prooducts, significant potential for employment generation etc. are special factos which favour the product. 6/10

Total Business Attractiveness score 40/60

69X

Consortium Fit Factors

a) Capital Requirements

In the power generation context the projects are generally found to be capital intensive. The per kilowatt capital cost of the proposed technological route (for 100 kw capacity) favourably compares with even super thermal (Rs 6,000/kw as against Rs 12,000/kw for superthermal). The member organisations are professionally managed and have sound financial position to meet R&D project cost as well as commercialization project cost. 7/10

b) Marketing Capabilities

ANKUR and ASCENT have successfully marketed similar products of lower capacities. Therefore the marketing of the new product would not pose any difficulty. 7/10

c) Manufacturing Capability

ASCENT has a well equipped workshop where it presently manufacturers gasifiers upto 100 kw range Hence the proposed product would be easily produced with the same production facilities. 8/10

d) Technology Base

The proposed product is completely technology based product and the proposers have a team of professionals with sound technical knowledge and experience in the development of such products. Hence the proposed development work is expected to be successful. 7/10

e) Raw Materials

The product is completely made from indigenous and asily available raw materials. Thus the manufacture even on commercial scale would not pose any problem relating to raw material availability. 8/10

f) Skills Availability

Proposers have personnel with managerial capability supported by a sound team of professionals from various fields. Hence the project coordination, administration and implementation would be effectively carried out. 7/10

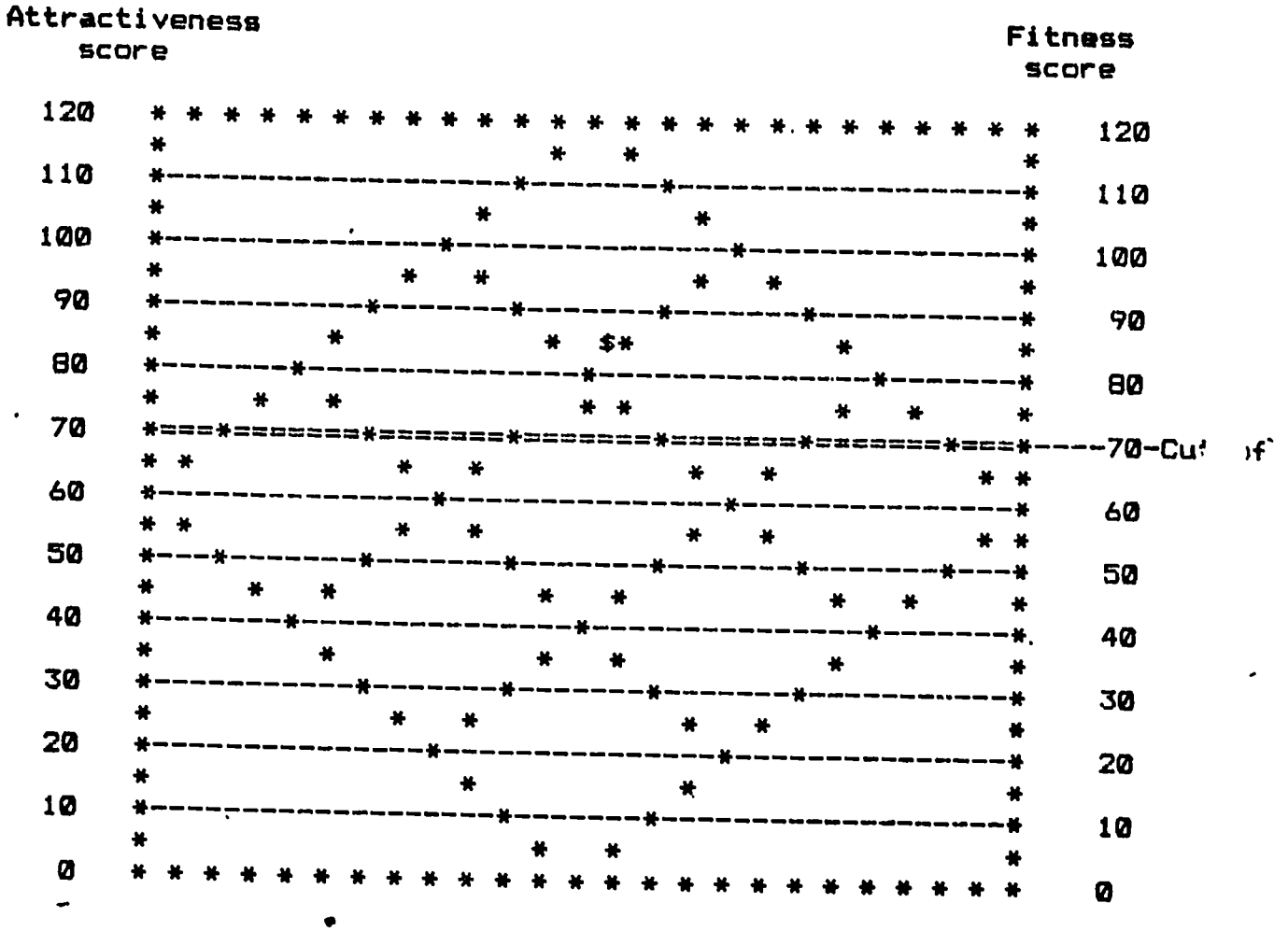
Total consortium fit socre	44/60
Total score	84/120

The total score of 84 is indicated with a $ on the identity chart As it is much above the cut off point iof 70 the proposed development has higher probability of commercial success and it is profitable to invest fund in the R&D project.

ANNEX E (Contd.)
(Ref. Page13)

ANKUR AND ASCENT

IDENTITY CHART



A. Business Attractiveness	Pts	B. Consortium Fit	s
1. Sales/profit potential	6	1. Capital needs	7
2. Growth rate	8	2. Marketing strength	7
3. Competitor analysis	8	3. Manufacturing strength	8
4. Industry restructure	5	4. Technology base	7
5. Risk distribution	7	5. Raw materials availability	8
6. Specialc factors	6	6. Skills availability	7
	* 40		* 44

* Out of a total of 60 possible points.

Total score 84

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

Confidential

Agenda Item 2(b)

MEMORANDUM FROM PACER SECRETARIAT
ON THE PROPOSAL OF
SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LIMITED
(SPIC)
AND
SPIC SCIENCE FOUNDATION (SSF)

PROJECT TITLE	:	Development and demonstration of solid polymer electrolyte fuel cells (SPEFC) stacks in the range of 1 to 5 kw.
PRINCIPAL PROPOSER	:	Southern Petrochemical Industries Corporation Ltd. 97, Mount Road, Madras 600 032
PROJECT COST	:	Rs. 210 lacs
MEANS OF FINANCING	:	(Rs. in lacs)

Proposer's contribution	
- SPIC	110
PACER contribution	
- Conditional Grant	100
	210

13x

PROPOSAL

The consortium of SPIC and SSF propose to develop and demonstrate solid polymers electrolyte fuel cell (SPEFC) stack of 5 kw capacity. The demonstration unit would be set up in the existing chloralkali unit of SPIC at Manali near Madras, where supply of hydrogen as the source of energy would be available on continuous basis. The consortium R&D project envisages establishing use of right type of indigenous electroactive carbon material for electrodes, exploring feasability of using the polymer electrolyte in solid form vis-a-vis in its liquid form suffused in a suitable microporous medium, acheiving optimum electrocatalyst loadng in electrodes as also current density and acheiving cell potential of 0.7 volt.

The R&D consortium would have a suitable consultancy arrangement with Dr. Subramanian Srinivasan of Centre for Electrochemical Systems and Hydrogen Research (CESHR) Texas A & M University (TAMU) of USA.

PROJECT SCHEDULE

R&D Project	:	October 1989 - September 1992
Commercialisation	:	April 1994 onwards

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The above proposal of SPIC and SSF for the development and demonstration of SPEFC stacks in the range of 1 KW to 5 KW was reviewed at the fourth PRC Meeting. The PRC decided to recommend the proposal for approval to ERDAC subject to following observations:

i) The proposal includes establishment of a full fledged electrochemical laboratory. The laboratory equipment which is general and non project-specific may be removed form the scope of the project, with a consequential reduction in the cost of R&D project; and

ii) Scope for materials development in the proposed project may be explored.

The PACER Secretariat had discussion with the proposers on the issues raised by the Peer review Committee. A summary of discussion is contained in the letter dated July 7, 1989 from Dr. S. Parthasarathy (Executive Director: R&D-SSF), a copy of which is enclosed vide Appendix. The proposal incorporating the necessary changes is now placed before ERDAC for its consideration and approval.

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A. PROPOSERS/MEMBERS OF THE CONSORTIUM

SPIC : Principal Proposer

SPIC was incorporated in 1969 and commenced its commercial production in 1975 at Tuticorin, Tamil Nadu. At present its Tuticorin plant has manufacturing facilities for 3,52,000 tonnes/annum of ammonia, 5,12,000 tonnes/annum of urea , 1,43,600 tonnes/annum of P205 equivalent phosphatic fertilisers (diammonium phosphate), 1,50,000 tonnes/annum of sulphuric acid, 52,800 tonnes/annum of phosphoric acid and 2,560 tonnes/annum of Almunium fluoride. Over a period of time, SPIC diversified its activities in technical services (SPIC maintenance organisation), shipping (with acquisition of chemical carriers) and heavy chemicals through take over of chloralkali unit (200 tpd of caustic soda of Kothari Industrial Corporationn at Manali near Madras.

Besides, SPIC has promoted new companies in joint sector with Tamil Nadu Industrial Development Corporation (TIDCO) viz Tuticorin Alkali chemicals Limited (for manufacture of 66,000 tonnes/annum each of soda ash and ammonium chloride) and Tamil Nadu Petro products Limited (for manufacture of 50,000 tonnes/annum of Linear alkyl benzene at Manali). SPIC also promoted SPIC Electronics and Systems Limited to manufacture IC packaging units, computer tapes, diskettes anmd jumbo rolls at Maraimalainagar near Madras, and Manali Petrochemicals Limited to manufacture Propylene oxide, Propylene glycol and Polyol at Manali. SPIC has plans to enter drugs and pharmaceuticals field and to set up aromatics complex at Manali.

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For the year ended on December 31, 1987, SPIC earned operating profit of Rs. 6 crores on turnover of Rs 390 crores. For the period of 15 months ended March 31, 1989 the company's turnover is estimated at Rs 560 crores.

SPIC has an in-house R&D department since 1979 at Tuticorin. It has successfully developed and employed processes for environmental pollution abatement through stripping of ammmonia from cooling tower blowdown and hydrolysis of urea in plant effluent by using biological organisms and electrolytic process for chromates removal from effluents for which SPIC was given R&D award by Feritilisers Association of India. It is also setting up another in-house R&D laboratory recognised by DSIR for research in drugs and pharmaceuticals at Maraimalainagar near Madras. Besides, SPIC lends further support to and has sponsored R&D projects at IIT Madras, Anna University and Central Leather Research Institute at Madras in the fields of agrochemicals and bio technology.

SPIC Science Foundation (SSF) : Co-proposer

SSF was promoted in 1986 by SPIC Ltd and its group companies as an antonomous body registered under Tamil Nadu Societies Registration Act, 1975 with a view to promoting scientific research in the following areas :

(i) Molecular bio-sciences and biotechnology

(ii) Agrochemicals

(iii) Energy technology

(iv) Drugs and Pharmaceuticals

(v) Materials technology

(vi) Electronics and communications

16X

SSF is recognised by Department of Scientific and Industrial Research (DSIR) as a Scientifc and Industrial Research Organisation and hence is entitled to suitable exemptions in respect of import duties. It has rented premises of 6,500 sq ft. for laboratories and 2,500 sq. ft. for officers in Madras. While a part of the laboratory faciliities is already installed and commissioned, the balance equipment and instruments have either arrived or are in various stages of procurement.

During the year ended March 31, 1989, SSF incurred an expenditure of about Rs. 113 lacs mainly on account of infrastructural facilities (Rs 10 lacs), indigenous laboratory equipment (Rs 7.7 lacs), imported laboratory equipment (Rs 64 lacs), revenue and other recurring expenditure (Rs.26 lacs) and contributions towards research projects awarded to other institutions (Rs. 5.3 lacs). This was financed entirely by grants from SPIC Ltd.

SSF has developed energy efficient process for making bricks from gypsum obtained as a by-product in Tuticorin plant. While the results are encouraging, it is yet to be commercialised. In the agrochemical field, SSF has improved production process of fungicides viz. Thiram and Ziram and the same is being tried out on pilot plant scale. As regards bio-technology it is working on micropropagation of roses and regeneration of plantlets embryo tissues of rice and has developed a vermiculite based rhinobial inoculant for legume seed treatment.

Recently, SSF has been sanctioned a conditional grant of US $ 500,000 under PACT program of ICICI for R&D project on genetic improvement of plantation crops,in collaboration with DNA plant technology Corporation of New Jersey, USA.

SSF is governed by a Governing Council comprising 17 members eight of whom are drawn from SPIC Limited, and one each from TIDCO Ltd., Industries Department of the State Government, Central Leather Research Institute (CLRI) and Central Electrochemical Research Institute (CERI). Others include Dr. Anand M. Chakraborty (University of Illinois, College of Medicine, Chicago, USA), Dr. B.D. Tilak (Indian Institute of Education, Pune), Dr. M.S. Valiathan (Director, Sri Chitra Titunal Institute for Medical Sciences & Tech., Trivandrum) Dr. Subramaniam Srinivasan (Dy. Director, (ESHR, TAMU, USA) and Shri B.R. Sreenivasamurthy who is the Member-Secretary of SSF. The Governing Council is chaired by Shri M.A. Chidanbaram.

For the proposed project SSF would have a consultancy arrangement with Dr. Subramaniam Srinivasan of Center for electrochemical Systems and Hydrogen Research (CESHR), Texas A&M University, USA. The university chartered the CESHR in 1986 to develop hydrogen technologies and electrochemical systems (fuel cell and batteries) for enhanced energy conversion efficiences. A number of well known business organisations, institutes and Department of energy in USA have sponsored research at CESHR. In 1983, as part of National Science Foundations Industry - University Co-operative Program, the Hydrogen Research Centre was established and the same has lnow become a part of the CESHR.

Recently Dr. S. Srinivasan and Prof J. Appleby (of CESHR) and their co-workers have achieved high power densities with low catalyst loading in SPEFC. Dr. S. Srinivasan is a member on the Governing council of SSF and is also their consultant. Thus the proposed consultancy arrangements collaboration would enable SSF to be in touch with the latest developments in the field as also avoid duplication of R&D efforts in developing a commercially viable SPEFC stack.

B. STATEMENT OF THE PROBLEM

It is well known that the conventional route of generating electrical energy is through conversion of chemical/nuclear energy of a fossil fuel/processed fuel into thermal energy which in turn is converted into mechaical and electrical energy. The above route of energy coversion is employed in thermal and nuclear power plants as also in all heat engines. The maximum amount of useful power that can be obtained in the above fashion is governed by the efficiencies at each conversion step. Since the above conversion processes occur at substantially different levels of temperatures, the carnot limitation on efficiencies reduces the net available energy in the form of electricity considerably.

In a conventional power plant, the overall efficiency achieved at best is about 30%. Besides, in India, the transmission and distribution losses are about 18-20%. With the dwindling resources of fossil fuels and rising costs of extracting them from earth, technologies for efficient conversion of chemical energy of these fuels into electrical energy are

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being investigated. Besides, in view of substantial transmission and distribution losses involved in extensive grid network to meet localised small loads, suitable cost-effective technology for decentralised power generation facilities are being explored.

A fuel cell produces electricity by an electrochemical reaction between hydrogen (which may be pure or may be supplied by a hydrocarbon fuel) and oxygen (of air). It is an electrochemical device comprising an anode, a cathode and an electrolyte. The chemical energy of the fuel which is fed continuously is directly and efficiently converted into low voltage direct current (D.C.) electrical energy. This low voltage of D.C. power output can be suitably enhanced by connecting number of fuel cells in series or parallel arragement. Unlike other batteries, the fuel cell does not consume its electrode, instead it uses fuel and oxidant fed continuously from outside the cell. Thus the fuel cell neither requires combustion nor any moving parts in the energy conversion process. One of the major advantages of the device is that the electrochemical oxidation can be carried out isothermally and hence the carnot limitation on efficiency does not apply.

The fuel cell technology is being developed to employ a variety of fuel such as hydrogen, methanol, ethanol, natural gas, fuel oil, biogas etc. which can be utilised directly or indirectly after processing. A typical fuel cell power plant would consist of a fuel processor, a fuel cell stack/subsystem, a power conditioner and subsystems for thermal and water

80X

management. The power conditioner converts D.C. into alternating current (A.C.) and thermal management system utilises the heat generated during the electrochemical process so as to increase the efficiency of overall system. A fuel cell generates electricity at 40% efficiency and with proper heat recovery systems the overall efficiency of the fuel cell plant could be 70% to 80% as against 30% to 35% efficiency of the conventional thermal/nuclear power plants. However, the design problems associated with achieving above levels of efficiencies and reliability of its operation on continuous basis over a reasonably longer period of time are being studied and tackled world over.

The fuel cell stack is considered as the heart of the fuel cell power plant. In view of the resources available with the SSF (both financial and technical), it has decided to concentrate on develping reliable, cost effective and efficient fuel cell stack which requires maximum developmental input.

Annexure A provides information on various types of fuel cells and the work being done in the field in India. Among the various fuel cells, the Phosphoric Acid Fuel Cells (PAFC) are in the most advanced stage of development and some studies are being done on alkaline fuel cells. Since alkaline fuel cells are sensitive to presence of traces of oxides of carbon in the processed fuel and air, its scope for commercial applications seems limited. With the development of a new polymer membrane by DuPont, USA the feasibility of developing a Solid Polymer Electrolyte Fuel Cell (SPEFC) appears to have considerably

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enhanced. While SPEFC belongs to low temperature range category of fuel cells as PAFC and Alkaline fuel cells, the SPEFC are expected to generate higher voltage and current density as compared to PAFC. Therefore, SSF has focussed it R&D efforts on developing a prototype SPEFC stack of 5 KW capacity for demonstration.

The need for developing a matching fuel processor is obviated by ensuring a continous supply of pure hydrogen at SPIC's existing chloralkali unit (capacity = 200 tpd of caustic soda) at Manali where the SPEFC would be installed for demonstration.

The caustic soda manufacturing process generates Hydrogen and Chlorine gases as by-products. About 2.5 tonne of Hydrogen and 88 tonnes of Chlorine are generated per 100 tonnes of caustic soda manufactured. It may be noted that a part of the Hydrogen and Chlorine are used for making Hydrochloric acid whereas surplus Hydrogen is used as fuel in caustic soda fusion process and the rest is flared up in most of the units. Even after using hydrogen for making hydrochloric acid and other requirement, about 40% of the hydrogen generated is available. This surplus pure hydrogen can directly be employed as fuel for SPEFC which in turn would generate DC power output. It is proposed that this DC power could be used as such in the electrolytic process of caustic soda manufacture. Thus there is no need for a power conditioner (to conver DC power output into AC power) either. Therefore, the present project proposal limits its scope to the development of only SPEFC stacks.

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On the basis of the state of art, SSF has inferred that it would have to address itself to the following issues and problems in developing commercially viable SPEFC stack :

(i) Achieving high power density by reducing kw/kg ratio, increasing the current density (Amp./sq. cm) and cell potential. It would also involve trying out light weight component materials and reducing the number of auxillary subsystems and their weights.

(ii) Optimum operating conditions in terms of temperature and pressure and tackling thermal and water management.

(iii) Dealing with stability of materials particularly when the fuel cell system is under no-load conditions and elevated temperatures.

(iv) Researching different preparations of the membrane in order to reduce its cost without sacrificing technical performance.

C. TECHNICAL PROPOSAL

SPIC and SSF jointly propose to develop SPEFC in the range of 1-5 KW and demonstrate the same at the existing chlor-alkali unit of SPIC at Manali near Madras. The development of SPEFC would mainly involve (1) performance study of an imported prototype (3KW size) with the help of pure hydrogen available at chlor-alkali plant and simulated reformed gas, 2) components characterisation, (3) design and fabrication of single fuel cell, bipolar plate and electrodes etc. and (4) assembly and testing multicell stack of 500 watts to 5 kw in steps. Critical

problems proposed to be addressed during the development include electrode kinetics, thermal and water management and stability of materials.

SSF proposes to import two SPEFC stacks from USA for performance study and component characterisation. Performance study would be conducted at the laboratory of SSF using hydrogen from Manali plant stored in hydrogen storage units (based on hydrides). The performance tests would include following steps : study of 1) output as a function of current density and evaluate the efficiency, (2) open and closed circuit voltage as a function of temperature (3) response to fluctuating loads, (4) performance variation over period of time (3 years) and (5) compare cost of power with other options.

SSF would commence fabrication of test electrodes and single cell after gathering data on physico-chemical characteristics of various components including membranes. Single cell would be evaluated for various performance characteristics such as voltage, current density and stability of cell over long duration using hydrogen and air as reactants. The cell performance would be studied with varying catalyst (platinum) loading and optimum platinum loading would be arrived at.

After optimising the performance of single cell, fabrication of bipolar plates and electrodes with larger areas as also fabrication of multicell stack would commence.

Design and fabrication of multicell stack would involve incorporation of locally available materials to the extent possible for electrodes and bipolar plates with a view to reducing cost. Performance evaluation would be conducted at chlor-alkali plant as also life time studies would be carried out.

D. IMPLEMENTATION PLAN :

The proposed development project would be jointly undertaken by SPIC and SSF. As detailed above, fuel cells development work would be carried out by SSF while personnel at chlor-alkali plant would provide need based support for trials and demonstration.

SSF proposes to acquire various equipment and laboratory instruments for the development work which mainly include automated rolling mill (laboratory type), sintering over, hot press, CNC machines (milling), grooving machine, calendering machine, induction furnace, electrochemical impedance measurment system, test rig for fuel cells testing, reference electrodes and other electrochemical apparatus.

The development activities at SSF would be carried out by 3 scientists (Ph.Ds), 8 engineers (chemical - 3, mechanical - 2, electrical - 1, electronics - 1, and electrochemical - 1), 4 research associates 4 Technicians and 3 other supporting staff and would be co-ordinated by Dr. S. Parthasarathy. Dr. Supramaniam Srinivasan, Deputy Director, Centre for Electrochemical Systems and Hydrogen Research, Texas, USA would

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associate with the project as a consultant and visit SSF for providing guidance in specific problem areas. Scientists and engineers from SSF would also be trained at CESHR. Resume of key personnel involved in the project are provided in Annexure - B .

Implementation of the R&D project is expected to commence from October 1989 and last for about 3 years, till September 1992.

E. COST OF PROJECT

The cost of development project is estimated at Rs.210 lacs spread over the implementation period of 3 years as follows:

(Rs. in lacs)

	Item	Year I	Year II	Year III	Total
1.	Equipment-imported	88.0	-	-	88.0
	-indigenous	2.0	9.0	3.0	14.0
2.	Salaries, wages & overheads	17.5	18.1	18.6	54.4
3.	Materials, stores & consumables	5.0	6.0	5.5	16.5
4.	Travel - Foreign	2.0	1.0	-	3.0
	- Domestic	1.0	1.0	-	2.0
5.	Data processing, Books/Journals/Patent/ literature	5.0	3.0	2.0	10.0
6.	Subcontracts	2.0	2.0	2.0	6.0
7.	Consultancy				
	- Foreign	2.0	2.0	2.0	6.0
	- Indian	0.6	0.6	0.6	1.8
8.	Others (training expenses)	3.0	0.5	-	3.5
9.	General and Administration expenses	3.0	1.0	1.0	5.0
		131.1	44.2	34.7	210.0

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Imported equipment provide for cif cost of laboratory instruments and devoices for testing such as custom built test rig, differential scanning calorimetry system, reverse osmosis unit, high vaccum unit, polorographs etc., and 2 nos. prototypes of SPEFC fuel cells of 3 kw each. While the R&D project would also need an electrochemical impedence measurement system, it would have a longer life and would find multiple uses outside the scope of this project. Therefore, it would be financed exclusively by the proposers. The imports will not attract customs duty. The indigineous equipment provide for clean room facility, storage devices, heat exchangers and processing equipment like rolling mill, calendering machine, CNC machine, microcatalytic reactors, furnaces, salaries and wages are based on requisite manpower to be engaged in different categories during the implementation period.

There would be a team of 4 senior engineers, 4 junior engineers, 3 scientists, 4 Research Associates, 4 technicians and other supporting staff. Materials, stores and consultants provide for chemicals, catalysts, electrodematerials, bipolar plate etc. Travel expenses include foreign and domestic travels of scientists/technologists and consultants. Suitable provisions are made for data processing, books, journals etc.

Subcontracts would take into account testing services at IIT, CLRI and other institutes/laboratories. Consultancy charges provide mainly for services to be rendered by S. Srinivasan and towards exploring possibilities/prospects for the technology in likely market segments of India. Suitable procession is made towards training needs of technical personnel.

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F. MEANS OF FINANCING

The estimated project cost of Rs.210 lacs is proposed to be financed as follows :

	(Rs. in lacs)
Proposers contribution - SPIC	110.0
PACER Contribution - Conditional Grant	100.0
	210.0

Proposers contribution:

SPIC has been providing funds to SSF in form of grant so far. For the proposed project SPIC would contribute grant of Rs.110 lacs over the implementation period of 3 years to meet a part of the cost of the project.

Conditional grant under PACER:

The proposers of the consortium R&D project have requested ICICI to provide conditional grant of Rs. 100 lacs out of the funds available under PACER to meet a part of the cost of the project. The conditional grant will be repayable on successful commercialisation of the product. Payment to PACER will be by way of a negotiated percentage of revenue arising from the project on commercialisation and limited to a maximum of 200% of the PACER contribution towards the project cost.

G. PROSPECTS

Hydrogen is a clean, renewable, non-polluting, energy - efficient fuel. Hydrogen can be used in the near-term as an energy supplement and in the long term as a medium of energy

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energy supplement and in the long term as a medium of energy storage and transportation. Hydrogen, as a fuel produced from water, doesn't increase the " greenhouse effect."

Hydrogen can be burnt like fossil fuels in heat engines, but is almost as inefficient in this mode of utilization. Hydrogen is the only fuel that can be readily used in fuel cells. Fuel cells, which are electrochemical energy converters, are twice as efficient as combustion engines in converting hydrogen to electrical energy.

Hydrogen produced from renewables (solar energy and water) is costly compared to today's fossil fuels. But extensive and continued R&D can provide technical progress to lower costs, especially when adding the environmental benefits associated with non-polluting hydrogen fuel.

The proposed R&D project aims at developing use of pure hydrogen so as to convert it efficiently into electrical energy in a commercially viable manner. As mentioned earlier, chlor-alkali industry provides substantial quantities of spare pure hydrogen as the right fuel which needs no processing. It alone holds promise of generating 25 MW power through the use of spare hydrogen and same energy worth about Rs.18 crores/annum after taking into account the fuel value of hydrogen. In this context it is evident that chloralkali industry offers adequate market for sizeable commercial exploitation of fuel cell stack technology without fuel processing and power conditioning

systems. It may be noted that SPEFC stack life is expected to be about 40,000 hours and hence it is required to replace about every 5 years.

It is estimated that with successful commercialisation and larger scale production of SPEFC stacks, the capital cost of the stack would be around Rs.10,000/kw. Assuming that its life would be 40,000 hours of operation and that it would generate 18.6 kwhr/kg of hydrogen, for a chloralkali unit the cost of power would be around Rs.0.45/kwhr, without assigning any price to surplus hydrogen otherwise being flared away.

After successful commercialisation of SPEFC stacks as above and reasonably long and satisfactory commercial experience of the fuel cell stacks technology, SSF might undertake development of the other auxiliary systems fuel processor, power conditioner and heat recovery systems - for an independent decentralised power generating plant in future.

It is estimated that even with a fuel cell power plant working on natural gas as fuel, the cost of power would be comparable with that of the Diesel Generating Set power and certainly far cheaper than the solar photovoltaic power.

Thus fuel cell technology has bright prospects and the approach of SSF in particular, in developing first SPEFC stack alone, holds good promise.

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H. BUSINESS PLAN

The commercial project for manufacture of SPEFC stacks would be undertaken by SPIC Ltd. - either by a new division under the management of the same company or by a seperate company to be promoted by SPIC. The manufacturing capacity proposed for the commercial project would be SPEFC stacks equivalent to aggregate power generation capacity upto 5 mw/annum. Its capital cost is likely to be of the order of about Rs. 5 crores. It is expected to operate at 40% (2 mw), 60% (3 mw) and 80% (4 mw) of the SPEFC stacks manufacturing capacity during the first, second and third year of commercial operations, respectively. Assuming selling price of SPEFC stacks @ Rs.10,000/kw capacity, SPIC would effect sales of Rs. 2 crores, Rs. 3 crores and Rs. 4 crores in corresponding years. The commercial operations would incur losses in the first year but is exected to earn marginal operating profit in the second year (Refer Annexure - C). Assuming payments to PACER @ 6% in sales, the obligations in respect of the conditional grant are expected to be discharged during the first ten years of commercial operations.

I. STRATEGIC ANALYSIS

The proposed project has been analysed in terms of business attractiveness and consortium strength factors. The details of analysis are provided in Annexure - D. It may be observed that the business attractiveness score is 39 while the cortinum fitness score is 43 each out of the possible 60 points score. The aggregate score works out to 82 points out of 120 points which is above cut off point at 70. The aggregate score indicates good success potential for the proposed development project.

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the cost of the proposed development project out of the funds available under the Program for Acceleration of Commercial Energy Research (PACER) on the following main terms and conditions :

1. Before availing of the conditional grant, the proposers shall (a) enter into a Memorandum of Understanding specifying their mutual rights and obligations to the satisfaction of ICICI, and (b) enter into a suitable consultancy arrangement with s. Srinivasan of Center for Electrochemical systems and Hydrogen Research, Texas A&M University to the satisfaction of ICICI.

2. The proposers agree to make payments to ICICI of twice the amount of conditional grant disbursed as a negotiated percentage of revenues arising from the project on commercialisation.

3. (a) Machinery or equipment purchased in whole or in part with the conditional grant shall belong to the proposers but shall nonetheless be clearly identified and used only for the proposal purposes, unless ICICI otherwise permits in writing.

   (b) The proposers shall not sell, give or lease, licence to conduct, mortgage, charge or otherwise dispose of the said machinery or equipment except with the prior permission in writing from ICICI.

4. The proposers undertake to bring in additional funds in consultation with an in a form acceptable to ICICI to meet any shortfall that may arise in financing the project and/or other requirements.

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5. SPIC shall bring in Rs. 110 lacs to meet a part of the cost of the project in a manner and schedule to be finalised in consultation with ICICI.

6. The proposers shall utilise the conditional grant only in accordance with the Approved Proposal Budget to be finalised in consultation with ICICI.

7. The proposers agree to appoint key persons for implementation of the project in consultation with ICICI.

8. ICICI and its authorised representatives reserve the right to carry out technical, financial and legal inspections during the implementation of the project.

9. The proposers shall keep ICICI informed about the progress of the project by submitting periodic reports in a form and substance to the satisfaction of ICICI.

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RECOMMENDATION

We recommend providing to the consortium of Southern Petrochemical Industries Corporation Ltd. and SPIC Science Foundation a conditional grant of Rs.100 lacs to meet a part of

Appendix

APPENDIX

Tel Off 447573/445113
Telex. 041-7121 & 8735 SPIC IN
Telegrams: 'SOUTHPETRO'

SPIC SCIENCE FOUNDATION

Dr S PARTHASARATHY
EXECUTIVE DIRECTOR (R&D)

'East Coast Chambers', IIIrd Floor,
92, G.N. Chetty Road,
T. Nagar, Madras – 600 017.

July 7, 1989

Dear Dr Vaidya:

From our discussions yesterday, we are happy to note that there is a positive response from the peer Review Committee and they have raised two points regarding our project, namely overall cost of the project and materials development, as a part of the project. With reference to these, our observations are as follows:

Overall cost of the project with special reference to possible reduction in cost:

As you would recall, the project proposal submitted by us on 18-5-89 envisaged a total cost of Rs 219.53 lakhs. After discussions with your technical group in PACER Secretariat, a reduction of Rs 9 lakhs was made, by pruning down to the maximum extent the revenue items for the project.

We once again make it clear that every item of expenditure listed under project cost E(a) Annexure A, pages 26, 27 and 28 are specific to the project and absolutely essential for successful completion of the project. We have ensured that no infrastructural facilities or the instruments not related to the project are included in the Fuel Cell Project Budget. We are making substantial investments in laboratory infrastructure and general purpose instruments, apart from our matching contribution to Fuel Cell (R&D) Project.

The only item of laboratory instrument which is of general nature,which will have long life and will be of use in other projects, is EG&G Princeton Applied Research, Model - Electro Chemical Impedance System described in pages 37, 38, 39, 40 and 41 of our PACER Grant Application. The cost is US $ 62,360 which is about Rs 10 lakh as of today. We propose to have this instrument purchased from our own resources and make available for this project. Thus, the PACER support required will be only Rs 100 lakhs. This is in deference to your desire to reduce project cost.

Materials Development:

The goals envisaged in the proposal for 'Research and Development and Demonstration of SPE Fuel Cell and Knowhow for Production of 5 KW Fuel Cell Power Sources', make it clear that we will be developing a device namely the SPEFC Electrochemical Stack for utilising bye-product hydrogen and making DC power, with substantial lowering of amount of platinum necessary as electro catalyst and thus reducing the cost of the final product. The SPEFC uses a

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Solid Polymer Electrolyte which is a proton conducting membrane, which is presently available from companies like Du Pont of USA. Side by side with our R&D Project, we propose to develop competitive substitutes for this item. We are definitely hopeful of developing relevant polymer materials for the purpose, which will be useful not only for SPEFC application but for a variety of other applications.

Electron conducting and corrosion resistant light weight bi-polar plate material development will also be undertaken as a part of our R&D endeavour.

The varieties of carbon available in our country offer a challenge to our R&D Scientists to prepare an efficient and cost effective electrode for use in the SPEFC.

I hope from the foregoing, it will be clear that the project provides for substantial efforts in material development which will have a very wide application in our country. As far as the cost is concerned, any further reduction from the proposed shifting of Rs 10 lakhs to the Co-Sponsor will not be feasible without affecting the objectives of the project or compromising the thoroughness of investigation.

Thanking you,

Yours sincerely,

Dr S Parthasarathy

To
Dr P H Vaidya
PACER Manager
ICICI,
163 Backbay Reclamation
Bombay 400020

SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LIMITED AND SPIC SCIENCE FOUNDATION

(Information on various types of fuel cells and work being done in the field in India)

Fuel cells can be classified on the bases of combination of type of fuel and oxidant, method of fueling - direct or indirect, type of electrolyte and the temperature of operation. In a direct fuel cell, the fuel used is readily oxidised electrochemically and fed directly to the fuel cell. In the indirect system, a hydrocarbon fuel or mixture of such fuels is first processed in a subsystem (viz. fuel processor) to an easily oxidisable hydrogen rich gas which in turn is fed into the cell.

Fuel cells can be classified by combining the electrolyte system with operating temperature based upon the thermal capability of the electrolyte as follows :

Operating temperature	Electrolyte
Low Temperature range	- Alkaline fuel cell (65 deg c - 160 deg c) - Solid Polymer electrolyte fuel cell (upto 120 deg c) - Phosphoric acid fuel cell (175 deg c - 200 deg c)
High temperature range	Molten Carbobnate fuel cell (600 deg c - 700 deg c)
Very high temperature range	Solid oxide fuel cell (over 750 deg c)

The cells that are being most extensively developed are those that use hydrogen as the fuel and oxygen (pure) or oxygen in air as the oxidant.

Development work done/being done in India

A few groups of scientists/technologists have been working on different aspects of fuel cell technology using different configurations of electrodes, catalysts, fuels, electrolytes at various research institutes/universities/R&D divisions of industrial organisations since mid seventies. These include Central Fuel Research Institute (CFRI) at Dhanbad, Indian Institute of Technology at Kharagpur, Indian Institute of Science at Bangalore, Central Electrochemical Research Institute at Karaikudi, Tata Institute of Fundamental Research at Bombay, University of Delhi, Indian Institute of Technology at Delhi and Tata Energy Research Institute at Delhi. While most of the above groups limited their scope of activity to studying and researcing electrochemistry and certain components of the system, none of them has taken up a comprehensive development project to make a commercially viable fuel cell stack.

A group of engineers/technologists has been working on developing a phosphoric acid fuel cell (PAFC) stack for over a period of three years at Corporate R&D Centre of Bharat Heavy Electricals Limited at Hyderabad. It is understood that they have achieved capability for manufacturing PAFC stack upto 100 watts and are in the advanced stage of developing PAFC stack for about 500 watts.

However, no substantive work is reported to have been undertaken to develop SPEFC stacks.

Annexure - B

SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LIMITED
AND
SPIC SCIENCE FOUNDATION

Resume of Dr. S. Parthasarathy

Designation : Executive Director (R&D)

Educational Background : M.A., M.Sc., I.R.A.S.
Ph.D. (Chemistry)
F.R.C.S. (London)

Experience :

1) Studies undertaken on proton ionisation of dicarboxylic acids, Ionic interactions in electrolyte solutions.

2) Thermodynamic investigations of ionic solutions with reference to alkaline earth cations.

3) Developed magnesium cuprous chloride batteries.

4) Developed magnesium - silver - chloride sea-water activated batteries.

5) Development of process for chloromethylation of styrene-divinyl benzene co-polymer beads.

6) Development of process know-how and project engineering for production of power sources for under-water applications.

7) Manufacture of computer magnetic tapes.

8) Has vast experience in the field of finance and management also.

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Resume of Dr. Supramanium Srinivasan

Designation : Deputy Director
Centre for Electrochemical Systems
and Hydrogen Research
Texas A&M University
Texas, U.S.A.

Educa' ional Qualifications : Ph.D. (Physical Chemistry)

Research Experience : Research Areas
- Electrod Kinetics
- Electrocatalysis
- Bioelectrochemistry
- Fuel cells
- Batteries

1980-88 : Staff member at Los Alamos National Laboratory Group leader, Electrochemical Technology Group, Brookhaven National Laboratory

1974-80 : Associate Professor of Electrochemistry in Surgical Research

1966-73 : Downstate Medical Centre, SUNY

1963-66 : Post Doctoral Research Associate University of Pennsylvania

Resume of Gopalkrishnamurthy

Designation : Senior Manager
Energy Division
SPIC Science Foundation

Educational Qualifications : B.Tech (Chem.), IIT, Madras
M.E. (Chem.) Jadavpur University

Experience : 1968-74 : Scientist, Propulsion Division National Aeronautical Laboratory, Bangalore

: 1974-79 : Engineer, Propellent Engg. Division, ISRO, Trivandrum

: 1979-84 : Senior Scientist, R&D SPIC Ltd.

Worked on following projects :

- Development of gypsum bricks from byproduct Phosphogypsum.
- Development of high energy fuelfor 4th stage of SLV-3
- Development of Hypergolic fuel for use in after burner in GNAT engines.

Resume of V. Venkitakrishnan

Designation	:	Senior Manager (R&D) SPIC Science Foundation
Educational Qualifications	:	B. Tech. (Chem.), IIT, Madras
Experience	:	Joined SPIC Ltd. as Engineering Management Service Trainee. Has varied experience including process design of chemical plants and equipment, commissioning of chemical plants, pilot plant experiments etc.

Resume of Dr. K. S. Dhathathreyan

Designation	:	Senior Scientist, Energy Division SPIC Science Foundation
Educational Qualifications	:	M.Sc. (Chemistry) Ph.D. (Chemistry)
Post Doctoral Research Experience	:	1982-84 : University of Goettinger, W. Germany 1984-85 : University of Groningen, Holland 1985-87 : University of Calgary, Canada 1987-89 : Max Planck Institute, Goettingen, W. Germany

SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LIMITED
AND
SPIC SCIENCE FOUNDATION

ANNEXURE 'C'

ANNEXURE C - (Rs. IN Lakhs)
PROJECTION OF OPERATING RESULTS AFTER COMMERCIALISATION

YEAR ENDING	1	2	3	4	5	6	7	8	9	10	TOTAL
1. SALES QUANTITY MT	2.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	37.00
VALUE IN RS.	200.00	300.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	3700.00
2.MATERIALS STORES/COMPONEN	60.00	90.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	0.00 1110.00
3. UTITILITIES 05% OF SALES	10.00	15.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	0.00 185.00
4. SALARIES & WAGES (150 * 18000P.A)	27.50	30.00	32.50	35.00	40.00	40.00	42.50	45.00	45.00	50.00	0.00 387.50
5. REPAIRS & MAINTENANCE	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	0.00 300.00
6. FACTORY SUPERVISION/ADMIN	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	0.00 70.00
7. ROYALTY 06% SALES (GRANT OF 210LACS WILL BE REPAID)	-	18.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	0.00 210.00
8. SELLING EXPENSES	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.00 100.00
9. INTEREST a. Termloan15%	52.00	52.00	49.00	41.00	32.30	23.10	17.30	9.50	1.30	-	0.00 277.50
b. WC loan 10%	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	-	81.00
10 DEPRECIATION	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	0.00 365.00
11. TOTAL PRODUCTION COST	242.00	297.50	338.00	332.50	326.30	319.60	316.30	311.00	305.30	297.50	3086.00
12. OPERATING PROFITS/LOSS	-42.00	2.50	62.00	67.50	73.70	80.40	83.70	89.00	94.70	102.50	614.00
13. R&D SSF EXPENSES	-	14.00	24.00	24.00	24.00	24.00	-	-	-		110.00
14. PROFIT (PBT)	-42.00	-11.50	38.00	43.50	49.70	56.40	83.70	89.00	94.70	102.50	504.00
15. PROVISION FOR TAXATION	-	-	19.00	21.80	24.80	28.20	41.85	44.50	47.40	51.30	252.00
16. PROFIT (PAT)	-42.[illegible]	-11.50	19.00	21.70	24.85	28.20	41.85	44.50	47.30	51.20	252.00
17. NET CASH ACCURUAL (PAT + DEPRECIATION)	-5.50	25.00	55.50	58.20	61.35	64.70	78.35	81.00	83.50	87.70	617.00

SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LIMITED AND SPIC SCIENCE FOUNDATION

STRATEGIC ANALYSIS

A. Business Attractiveness

1. Sales/Profit Potential

Projected sales and profitability estimates are based on potential of hydrogen available at Chlor-alkali plants only. These estimates indicate adequate returns. However,there is good potential for fuel cells based on natural gas. 5/10

2. Growth Rate

The growth rate would depend upon adaptbility of technologyto employing other sources of fuel, asalso various applicatiuons of SPEFC. The growth rate foreseable is conservatively estimated at 6% per annum. 6/10

3. Competitor Analysis

At present, no company in the country is manufacturing SPEFC or no institution has reached advanced stage of development of the same. The other companies would enter into the field of manufacture of fuel cells depending upon the success of the technology. 6/10

4. Opportunity to Restructure the Industry

If SPEFC technology or fuel cell technoology becomes viable nd successful then there is possibility of wider spplications of fuel cells. 7/10

5. Risk Distribution

SPEFC would find applications in railway signalling, telecommunications, navigational aids, electric vehicles, tractors, rural electrification. SPIC enisages development of phosporic acid fuel cells at a later stage. 7/10

6. Special Factors

Commercial manufacture of fuel cell would not require special infrastructure. Manufacture of fuel cell is not an energy intensive process. 8/10

39/60

B. CONSORTIUM STRENGTH (OR FIT) FACTORS

1. Capital Requirements

Manufacture of SPEFC on commercial scale would require capital of the order of Rs 6 crores which SPIC can raise comfortably. 8/10

2. Marketing Capablity

SPIC has existing marketing network for its groupcompanies including SPIC Electronics, which would play a key role in marketing fuel cells. 7/10

3. Manufacturing Capability

SPIC has existing workshops formaintenance of its plants. SPIC would set up separate facilities for manufacture of fuel cells. 6/10

4. Technolgy Base

SPIC has strong technological base. 8/10

5. Raw Material

Most of the components of fuel cell would be manfactured indigenously except membrane (electrolyte). 6/10

6. Skills Availability

SPIC and SSF have necessary technical and managerial skills. Association of Dr. Srinivasan would be helpful. 8/10

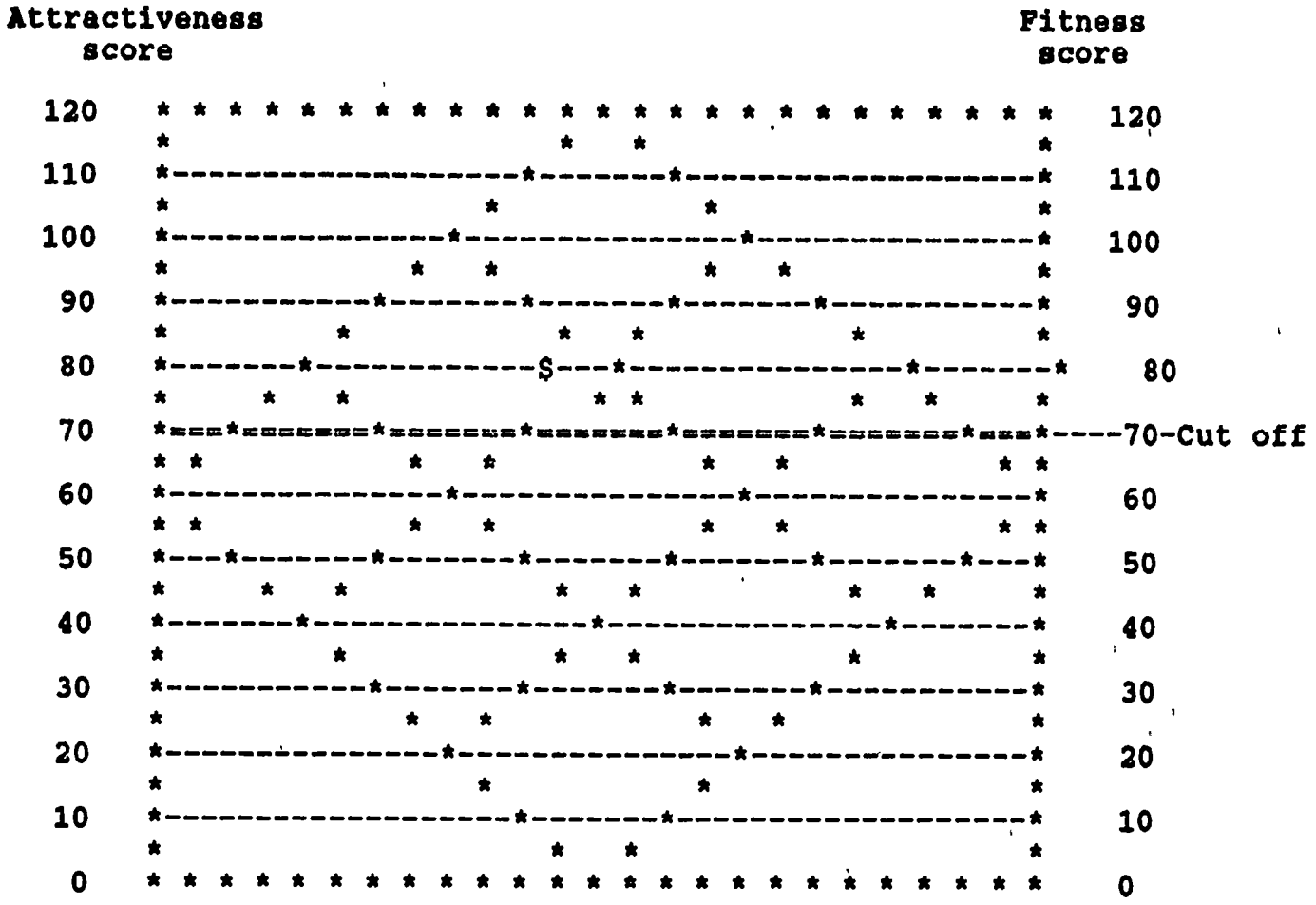
43/60

Total Score 82/120

ANNEX D (Contd.)
(Ref. Page 20)

SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LIMITED
AND
SPIC SCIENCE FOUNDATION

IDENTITY CHART



A.Business Attractiveness	Pts	B.Consortium Fit	Pts
1.Sales/profit potential	5	1.Capital needs	8
2.Growth rate	6	2.Marketing strength	7
3.Competitor analysis	6	3.Manufacturing strength	6
4.Industry restructure	7	4.Technology base	8
5.Risk distribution	7	5.Raw materials availability	6
6.Specific factors	8	6.Skills availability	8
	39*		43*
		Total score	82

* Out of a total of 60 possible points.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

Confidential

Agenda Item 2 (c)

MEMORANDUM FROM PACER SECRETARIAT ON THE PROPOSAL OF FLUIDTHERM TECHNOLOGY PRIVATE LIMITED, INDIAN INSTITUTE OF TECHNOLOGY, MADRAS AND TI DIAMOND CHAIN LIMITED

PROJECT TITLE : Development of energy efficient continuous type fluidised bed heat treatment furnaces.

PRINCIPAL PROPOSER : Fluidtherm Technology Private Limited
132, III Main Road
Ambattur Industrial Estate
Ambattur
Madras 600 058

PROJECT COST : Rs. 82 lacs

MEANS OF FINANCING :

	(Rs. in lacs)
Proposer's Contribution	
- Fluidtherm Technology Pvt. Ltd.	41
PACER contribution	
- Conditional Grant	41
	82

108+

PROPOSAL - SUMMARY

The Consortium of Fluidtherm Technology Pvt. Ltd. (FTPL), Madras, Indian Institute of Technology, Madras (IITM) and TI Diamond Chain Limited, (TIDC), Madras proposes to undertake project to develop energy efficient continuous type Fluidised Bed (FB) furnaces for various heat treatment applications. The proposal envisages mainly development of 3 different types of continuous FB furnaces viz a) continuous Sealed quench furnace, b) Rotary retort furnace and c) End heating furnace. These furnaces are not manufactured in the country and have following features: 1) higher thermal efficiency, 2) Smaller in size 3) Shorter start-up time and 4) Lower initial capital cost as also maintenance cost. The design, development and fabrication would be co-ordinated by FTPL while IITM would help in defining process parameters for various heat treatment processes. Rotary retort furnace would be set up and demonstrated at the premises of TIDC (user) while the other two furnaces will be installed at the premises of FTPL.

PROJECT SCHEDULE

Development of Furnaces	:	October 1989 - November 1991
Commercialisation	:	December 1991 onwards

A. MEMBERS OF THE CONSORTIUM

Fluidtherm Technology Private Limited (Principal Sponsor) :

FTPL, a private limited company promoted by N. Gopinath in 1985, is engaged in the manufacture and marketing of batch type fluidised bed (FB) furnaces of various sizes ranging from 5 kg/batch to 1500 kg/batch at Madras, for applications such as heat treatment of gears and automobile components and tools and moulds as well as oxidation of superconducting materials. FTPL has so far supplied more than 20 FB furnaces to various organisations including Mahindra and Mahindra Ltd., Hindustan Motors Ltd., Premier Automobiles Ltd. etc.

As at June 30 1989 the equity capital of FTPL was Rs 4 lacs and reserves and surplus stood at about Rs 21 lacs. The total income of FTPL during 19 months period ended January 31, 1989 amounted to Rs. 86 lacs (Rs 54 lacs on annualised basis) on which it earned operating profit of Rs.11 lacs (Rs 7 lacs on annualised basis). During the five months ended June 30, 1989 FTPL's turnover was Rs 53 lacs on which it earned operating profit of Rs 8 lacs indicating substantial improvement in its operations. For the period of 14 months ending March 31, 1990 the company's turnover is estimated at Rs. 175 lacs with operating profit of Rs. 39 lacs.

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In July 1985 FTPL developed and fabricated a laboratory scale furnace unit and adapted FB for heat treatments such as carburising, nitriding etc. The first full-scale commercial FB furnace was launched in May 1987. Thereafter FTPL has developed and commercialised FB furnaces for plastic and paint stripping and thermal shock testing as also equipment such as quench cooling curve test facilities, silicon carbide heaters and methanol/acetone vapourisers. Details of products and processes developed and commercialised by FTPL are provided in Annexure - A.

Manufacture of important subassemblies and final assembly of the furnaces as also testing is carried out at the establishment of FTPL. FTPL has two work sheds with total area of more than 800 sq. mts at Ambattur Industrial Estate, Madras where facilities for welding, metal working, material handling (automated pulleys) etc have been provided. The other subassemblies and parts are procured from local fabricators.

FTPL is managed by a Board of Directors comprising 5 members with N. Gopinath as Chairman. Gopinath (37) a graduate in commerce, has over 13 years of experience in the heat treatment industry in the field of manufacturing, marketing, errection and commissioning. The day to day activities of FTPL are carried out by 5 Managers, 12 Engineers, 10 technicians and 10 other supporting staff under the overall guidance of N. Gopinath.

Indian Institute of Technology, Madras :
(Co-sponsor)

The Indian Institute of Technology, Madras (IITM), established in 1959 has a number of well equipped laboratories in the fields of Science and Technology and activities of the Institute encompass chiefly 13 departments and a few advanced research centres. The Institute has a Centre for liaision with outside agencies for Industrial Consultancy and sponsored research activities, which provides specialised assistance to industry. Each assignment is routed through the concerned department.

Dept. of Production Engg. and machine tools section of IITM headed by Dr. R. Krishnamurthy, will be associated in the development work. Dr. Krishnamurthy (48) has doctorate in the field of surface engineering and has over 28 years of experience in industry as also in teaching and consultancy. He has published number of papers in the field.

Dept. of Production Engg. is currently engaged in over 12 assignments from companies such as Widia, Fluidtherm, etc. FTPL at present is developing 'boronising process in FB furnaces' with IITM. This process imparts very high surface wear resistance and hardness and is employed for tools and dies. IITM has identified process parameters of the process and trials are conducted at FTPL on laboratory scale continuous sealed quench furnace. The

112+

metallographic inspection and other tests such as friction and wear characteristic of boride layer testing are conducted at IITM and changes in process parameters are suggested to improve and refine the process.

TI Diamond Chain Limited (TIDC) :
(Co-sponsor)

TIDC, a subsidiary of Tube Investments of India Limited, has facilities at Ambattur, Madras for manufacture of industrial roller chains. TIDC has collaboration with Diamond Chain Company, USA. As on December 31, 1987 the equity share capital of TIDC was Rs. 68 lacs and reserves and surplus stood at Rs. 318.70 lacs. The sales turnover of the company for the year ended December 31, 1987 was Rs. 1128.5 lacs on which it earned an operating profit of Rs. 45 lacs. TIDC is managed by a Board of Directors consisting of 7 members including M.V. Arunachalam as Chairman. The company has ongoing relations with FTPL and is interested in development of continuous rotary retort FB furnace which would be useful for heat treatment of various components of chains such as roller pins, bushes, connecting links etc.

B. STATEMENT OF THE PROBLEM

Heat treatment of metallic components is an essential step in metallurgical and mechanical industries to get required structures and properties. Success of heat treatment operations

depends upon stringent control over atmosphere as well as temperature. Fluidised bed offers a better solution to this problem as it fulfills most of the requirements. Fluidised beds have excellent heat transfer characteristics and offer precise temperature control and temperature uniformity. These advantages led to development of fluidised bed (FB) furnaces in early 70's mainly in Russia and East Europe. The development of FB furnaces further picked up after oil crisis.

The FB furnaces can be used for various heat treatments processes such as hardening, tempering, marquenching, wire patenting, tool steel processing, carburising, nitriding etc. The details of the principle of operation of FB furnace and its advantages are explained in Annexure - B. Comparison of power consumption in FB furnace with that in conventional furnace is provided in Annexure - C

The FB furnaces can be categorised on various bases such as a) continuous and batch type, b) externally heated, submerged combustion type, internal combustion type c) electrically heated, oil/gas fired, biomass fired, wood waste fired etc. Batch type furnaces in general are used for smaller production scales ie upto 100 kg/hr whereas continuous type of furnaces are used for high production volumes.

FB furnaces have been developed and commercialised in a few advanced countries. At present FTPL is the only company in India to develop, design and manufacture 'batch type' FB furnaces. The indigeneously manufactured continuous FB furnaces are not available in the country at present. The continuous FB furnaces are preferred over conventional furnaces mainly for their following advantages over conventional ones :

a) Its thermal efficiency is higher than that of conventional furnace.

b) The size of continuous FB furnace is almost 1/3rd of that of conventional continuous furnace

c) It takes a shorter start-up time and attains steady state faster.

d) The initial capital cost is lower

e) It is more versaltile and flexible as it can be used for variety of applications.

On the basis of its experience in development and commercial production of batch type FB furnaces, FTPL proposes now to undertake development of continuous type of FB furnaces for heat treatment.

The main problems to be tackled in succfessful development of continuous FB furnace include, stability of fluidised bed, design of transportation system process control

instrumentation, prepared atmosphere systems and heating systems. These problems also exist in case of development of FB furnaces such as sealed quench furnaces, oil fired furnaces, coil wire furnaces, rotary and oscillating hearth furnaces. It may be noted that transfer of technology or know-how for manufacture of these furnaces would require payment of large sums to the collaborator as fees and royalty of about Rs. 50 lacs for each type of furnace. Thus indigenous development of these furnaces would be a significant achievement.

Work done so far : As a part of experimental set up for study on fluidised bed boronising, FTPL has developed laboratory scale continuous FB furnace with 'transportation hood'. The hood is used for transfer of components heated in laboratory scale FB furnace to quench tank under inert atmosphere. The hood moves on rollers over a guide plate. The FB furnace, quench tank and transportation hood together constitute continuous FB furnace. FTPL has initiated conceptual design work of proposed furnaces to be developed.

C. TECHNICAL PROPOSAL

FTPL and IITM jointly propose to develop continuous FB furnaces for heat treatment. FTPL would design, fabricate, test and commission the furnaces whereas IITM would provide necessary support for development of heat treatment processes on continuous FB furnaces. TIDC would provide necessary facilities and support for demonstration of one of the furnace prototypes (i.e. rotary retort type).

The project envisages design, development and fabrication of following 3 different types of continuous FB furnaces :

a) sealed quench furnace;

b) rotary retort furnace; and

c) end heating furnace (for forging application)

Additionally FTPL proposes to develop and fabricate few other subsystems such as travelling hood, oscillating hearth/fixture, endogas generator, quench vestibule, quench tanks and indirect oil heating subsystems. With these subsystems, FTPL can demonstrate 3 more types of furnaces as follows :

a) batch mode of operation of sealed quench furnace

b) oil fired furnace

c) oscillating hearth furnace

The specifications of each of the furnace prototype to developed are given in Annexure - D.

The development of continuous type FB furnaces would involve development of various furnace support systems which include :

i) Computerised process control systems

ii) Prepared atmosphere systems

iii) Transportation systems

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a) Travelling hood

b) Quench vestibule

c) Walking beam and

d) Scroll

iv) Alumina recovery/cleaning systems and

v) Heating systems

The main features and other details of development of each support system are provided in Annexure - E

FTPL alongwith IITM would refine various heat treatment processes for application in continuous FB furnaces. IITM would provide support for defining process parameters as also it would help standardising process by metallurgical analysis of heat treated componments(test samples). IITM would provide its report on micro hardness profile, metallographic examination, consistency of results over number of trials as also with respect to location of charge in the fluidised bed.

In order to further enhance the usefulness of continuous FB furnaces, FTPL also standardise processes for Ferro Oxy nitrocarbonising which imparts corrosion resistance to the heat treated components. FTPL proposes to undertake the above powers development is association with College of Engineering, Pune. As regards quenching in continuous FB furnaces, FTPL would seek consultancy services from R.W. Reynoldson, an Australian citizen experienced in Kinetics of heat transfer in FB furnaces.

The main stages in development of these furnaces include :

a) **Design of each subsystem, component and furnace as a whole:** This would mainly involve identifying various process parameters to be achieved in each furnace and deciding specifications of standard components and subsystems. Detailed drawings would be prepared for various subsystems.

b) **Planning of procurement and production of materials:** A detailed plan for procurement of standard components and subcontracted items would be prepared. The schedule for inhouse fabrication of important components and final assembly and testing would be finalised.

c) **Subassembly contracting:** The procurement plan would be executed by giving contracts to various suppliers, fabricators to get materials.

d) **Assembly:** Assembly of each furnace would be carried out by FTPL at its factory. It would involve welding of various components and subassemblies and other related work.

e) **Testing and commissioning:** This is the most important step wherein each furnace would be tested and commissioned after its assembly. IITM would play major role by specifying process parameters and assessing

success of process. Components will be tested after heat treating them in trial runs. Necessary modifications in furnace hardware would be carried out before final commissioning.

FTPL would instal and commission rotary retort furnace at the premises of TI Diamond Chain Limited and it would be available for demonstration to prospective buyers. The other types of furnaces would be demonstrated at the premises of FTPL.

D. IMPLEMENTATION PLAN

The proposed project would be carried out jointly by FTPL and IITM. As detailed above FTPL would mainly carry out design and fabrication of furnaces whereas IITM would provide necessary support in testing heat treated components and advising on process parameters. A bar chart representing plan of implementation is provided in Annexure - F. The development project would be completed in 26 months after its commencement.

The fabrication of important components such as diffuser and final assembly would be carried out at the establishment of FTPL where necessary facilities have been provided. IITM has well equipped laboratory with most modern testing equipment for X-Ray diffraction and metallography.

The project would be carried out by 2 design engineers, 1 process metallurgist, 5 technicians and 1 materials officer under the overall guidance of N. Gopinath and S. Dilip, Director.

Dillip is a metallurgical engineer and has 13 years of experience in production activity of which 7 years in production of heat treatment equipment. The activities at IITM would be coordinated by Dr. R. Krishnamurthy who would be assisted by 1 M. Tech. student.

E. COST OF THE PROJECT

The cost of the proposed scheme is estimated at Rs 82 lacs as follows which would be incurred over a period of 26 months.

(Rs in lacs)

	Years			
	1	2	3 (2 months)	Total
Equipment				
- Furnace prototypes	20.90	8.00	-	28.90
- Attachments - (subassemblies)	17.30	2.00	-	19.30
- Laboratory equipment	9.30	-		9.30
Salaries and wages	2.60	2.60	0.50	5.70
Materials, stores and other consumables	4.35	2.15	0.30	6.80
Utilities	0.50	0.50	0.50	1.50
Travel	0.20	1.80	0.50	2.50
Data processing	0.50	0.50	-	1.00
Consultancy	3.00	-	-	3.00
Others	1.80	1.80	0.40	4.00
	60.45	19.35	2.20	82.00

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Equipment include 3 FB furnace prototypes (namely continuous sealed quench furnace, end heating furnace and rotary retort), subassemblies/attachments (in order to demonstrate heat treatment processes and other types of furnaces e.g.oscillating hearth furnace would be demonstrated by developing oscillating fixture) and laboratory equipment. Laboratory equipment mainly includes micro hardness tester, oscilloscope, orsat apparatus, a laboratory model high temperature furnace etc.

Salaries and wages are provided for 2 senior engineers, 1 metallurgist, 1 materials officer and 5 technicians. Materials, stores and consummables include alumina, gases, methanol, quench oil, salts, electrodes for welding and jigs and tools. Utilities have been considered for manufacture, commissioning, demonstration and trials. Travel accounts for foreign and domestic travel. Foreign travel expense of Rs. 2 lacs account for 2 trips to USA for meeting with consultants and 1 trip each to Far east and USA for promotion of products totaling to 35 mandays.

Consultancy is sought in areas of (a) Heat transfer while quenching in fluidised beds and (b) Ferritic oxy nitrocarburising an application area in these furnaces. A few consultants have been identified all over the world and the estimate herein is based on the general figure for metallurgical consultancy of US$ 25 per working hour. The terms of reference

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considering Fluidtherm's design strength will be restricted to basic concept and after treatment analysis of results (trouble shooting). The estimate is for 100 full time consultant days.

F. MEANS OF FINANCING

The cost of the proposed development project estimated at Rs. 82 lacs is proposed to be financed as follows :

	(Rs. in lacs)
Proposer's contribution	
- Fluidtherm Technology Pvt. Ltd.	41.0
Conditional Grant under PACER	41.0
	82.0

Contribution from FTPL : During the 5 months period ended June 30, 1989 FTPL's cash accruals amounted to Rs. 8.40 lacs. The cash accruals of FTPL during the next two years of operations are expected to be about Rs. 40 lacs and Rs. 60 lacs. Based on these projections the company is expected to meet its contribution through cash accruals. We propose to stipulate a condition that FTPL would contribute to the proposed project in the form of interest free unsecured loan, in the event of shortfall in cash accruals.

Conditional Grant under PACER : It is proposed to provide conditional grant of Rs. 41 lacs out of funds available under PACER. The conditional grant will be repayable after successful commercialisation of the continuous FB Furnaces. Payments to PACER will be a negotiated percentage of revenue arising from the project on commercialisation including job work and limited to a maximum of 200 per cent of the PACER contribution towards the project cost. The proposers would also pay 50% of the revenue earned by selling prototypes developed under the project toward repayment of conditional grant. We are stipulating suitable conditions in this regard.

G. PROSPECTS

At present there are only 6 major manufacturers of FB furnaces in the world including FTPL. Others include Schwing, W. Germany; Procedyne Corpn., USA; Fluidfire, U.K.; CanEng, Canada and Komastu, Japan. Thus FTPL is the only manufacturer of FB furnaces in India. The cost of an imported FB furnace is almost 2 to 3 times that of FTPL's equivalent furnace. (eg for a particular type of batch type FB furnace Procedyne Furnace Rs. 14.50 lacs - 1985 prices, Schwing Furnace Rs. 23.61 lacs - 1986 prices and Fluidtherm Rs. 7.87 lacs - 1989 prices). The FTPL would have price advantage over imported FB furnaces. It may be noted again that products of FTPL are exempted from sales tax as also 100% depreciation can be claimed in the year of installation as they are classified as energy saving devices.

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Heat treatment process is an important step in manufacture of automobile components or parts of machine tools to get certain properties in metal. Heat treatment furnaces are essential equipment in automobile industry (and automobile ancilliaries), machine tool industry, plastic industry, tool and die industry and engineering industry in general. The typical components which can be heat treated in continuous FB furnaces include gears, crank shafts, valves, engine components, fasteners, turbine components, press tools, extruders, die casting moulds and cutting tools.

In the recent years automobile industry has grown rapidly. The average growth rate of automobile industry is expected to be about 10% during the eight plan period. With the implementation of phased indigenisation programme to be undertaken by various automobile manufacturing units and its ancilliaries there would be increasing demand for energy efficient continuous fluidised bed furnaces. In addition it would be economical for such units to go for continuous type of heat treatment furnaces as the rate of production in these units would be higher.

It is expected that the energy consumption in case of the proposed furnaces to be developed under the project would be significantly lower as compared to conventional furnaces for similar heat treatments (please refer to Annex-C).

Based on growth in automobile industry and other industries mentioned above there would be good demand for heat treatment equipment. FTPL proposes to manufacture and market rotary retort, oscillating hearth, sealed quench, end heating, gas fired continuous FB furnaces in that order after development.

H. BUSINESS PLAN

FTPL proposes to manufacture various types of continuous FB furnaces after their development using existing manufacturing facilities, at Madras. FTPL proposes to manufacture 10, 13, 18 and 22 continuous FB furnaces in the 1st, 2nd, 3rd and 4th year of commercial operations respectively, FTPL would require additional investment of Rs. 65 lacs for commercialisation, of which Rs. 35 lacs would be required to build an additional workshed together with necessary equipment on existing plot and Rs. 30 lacs would be required for increase in working capital. The company proposes to raise suitable term loan from Bank to meet a part of the cost of the commercial project.

The operating results and profitability in respect of commercialisation of continuous FB furnaces by FTPL are provided in Annexure - G. The turnover of continous FB furnaces is expected to increase from RS. 100 lacs in the 1st year to Rs. 350 lacs in the 4th year of commercialisation. The project is expected to earn operaing profit of Rs. 8 lacs in the 1st year of operation which would increase to Rs. 43 lacs in the 4th year of operation.

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In addition to the above FTPL expects to sell some of the prototypes of continuous FB furnaces after their development and successful demonstration to interested users under the project. The company is expected to pay 50% of the income derived from above sale towards repayment of the conditional grant. The company also proposes to undertake job orders for heat treatment of various components during the course of demonstration of these furnaces. These two aspects have not been taken into account for projecting operating results of the commercial project.

I. STRATEGIC ANALYSIS

The proposed project has been analysed in terms of business attractiveness and consortium strength factors. The details of analysis are provided in Annexure- H . It may be observed that the business attractiveness score is 42 while the consortium fit score is 45 each out of the possible 60 points score. The aggregarte score works out to 87 points which is above cut-off points of 70 points. The aggregate score indicates good success potential for the proposed development project.

RECOMMENDATION

FTPL is the first company to develop and manufacture batch type continous fluidised bed furnaces for heat treatment and various other applications in the country. The company has

good track record of development. It has ongoing projects for development of processes with IIT, Madras. The proposed development project of FTPL would result into development and commercialisation of more versatile energy efficient heat treatment furnaces at economically attractive cost.

We recommend providing to consortium of FTPL, IITM and TIDC a conditional grant of Rs. 41 lacs to meet a part of the cost of proposed development scheme out of funds available under the Program for Acceleration of Commercial Energy Research (PACER) on the following main terms and conditions :

1. Before availing of the conditional grant, the proposers shall enter into a Memorandum of Understanding specifying their mutual rights and obligations to the satisfaction of ICICI.

2. The proposers agree to make payments to ICICI of twice the amount of conditional grant disbursed

   (a) as a negotiated percentage of revenues arising from the project including job work on commercialisation and/or

   (b) by way of paying 50% of the revenue earned by selling prototype furnaces developed under the project.

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3. (a) Machinery or equipment purchased in whole or in part with the conditional grant shall belong to the proposers but shall nonetheless be clearly identified and used only for the proposal purposes, unless ICICI otherwise permits in writing.

(b) The proposers shall not sell, give on lease, licence to conduct, mortgage, charge or otherwise dispose off the said machinery or equipment except with the prior permission in writing from ICICI.

4. The proposer shall bring in Rs 41 lacs by way of cash accruals/interest free unsecured loans to meet a part of the cost of the project in a manner and as per a schedule to be finalised in consultation with ICICI.

5. The proposers undertake to bring in additional funds in consultation with and in a form accepable to ICICI to meet any shortfall that may arise in financing the project and/or other requirements.

6. The proposers shall utilise the conditional grant only in accordance with the Approved Proposal Budget to be finalised in consultation with ICICI.

7. The proposers agree to secure participation of TI Diamond Chain Limited in the form of specific facilities and

support required for carrying out the demonstration of rotary retort FB furnace at their premises as indicated in the proposal.

8. The proposers agree to appoint key persons for implementation of the project in consultation with ICICI.

9. ICICI and its authorised representatives reserve the right to carry out technical, financial and legal inspections during the implementation of the project.

10. The proposers shall keep ICICI informed about the progress of the project by submitting periodic reports in a form and substance to the satisfaction of ICICI.

Annexure - A

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

AND

TI DIAMOND CHAIN LIMITED

(List of products/processes developed and commercialised by FTPL)

(Ref. Page 4)

Sr. No	Product/ Process	When commercialised	No. of units sold	Aggregate Sale (Rs. in lacs)
1.	Fluidised Bed Batch Type furnaces	May 1987	22	80
2.	In line/batch vapour Degreasers	Early 1986	6	12
3.	Methanol/Acetone Vaporiser	Mid 1987	6	3
4.	Quench cooling curve test equipment	Mid 1987	1	2.5

Annexure - B

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

AND

TI DIAMOND CHAIN LIMITED

(Details of principles of operation of FB furnaces and advantages of using FB furnaces)

(Ref. Page 8)

The Principles of operation of FB furnaces :

Fluidisation occurs when a stream of air or gas is passed upward through a bed of finely divided particles. At a certain velocity, the particles separate and float on a cushion of the fluidising air or gas. When the velocity is increased, bubbles form and as they rise through the bed, they cause rapid mixing of the particles in all areas of the bed.

When fluidised, the bed behaves just like a liquid. It is buoyant and light objects float while heavy objects sink. When heated the fluidised bed becomes an excellent media for heat transfer.

Aluminia is used as the fluidising media. Mixtures of Air, Ammonia, Nitrogen, LPG and many other gases are used as the fluidising gas as well as the heat treating atmosphere. The gas reactions take place in the bed itself without need for a gas generator.

An alloy retort is used as the container and a special alloy distributor system ensures uniform fluidisation. The bed is heated by gas or electricity externally and in some cases internally. The components are immersed into the bed and lifted out when the treatment cycle is complete, usually with the help of a hoist.

ADVANTAGES

LOW OPERATING COSTS

The heat transfer rate (4 to 25 times faster than convection/radiation furnaces) cuts down cycle times. Larger tonnage can be processed in smaller furnaces. When a FB furnace is not in use it can be switched off even overnight, the bed retains most of its heat and only needs incremental heating the next day. Therefore its idling is unnecessary which in turn results in saving of energy.

The need for effluent treatment and disposal does not arise and precleaning expenses reduce. All these and other features like low maintenance, no fume handling, lower LPG storage, no gas generator etc., combine to yield an operating cost per kilo that is 50% to 70% of conventional heat treatment equipment (See enclosed cost sheet).

which also remove carbon build up on edges and corners. Once the parameters are set, consistent quality is obtained, as long as the process is operated.

POLLUTION FREE

Fluidised Bed Furnaces are not poisonous, do not attract the provisions of health and pollution laws and are safe for those operating them. Effluent treatment and disposal equipment are not required.

LOW CAPITAL COST

Fluidised Bed Furnaces cost less than equal capacity, vacuum, sealed quench and pit type furnaces and even salt baths (when effluent treating and safety equipment costs are added). One furnace performs many processes hence additional furnaces for specific low volume applications are not required.

EASE OF OPERATION

Fluidised Bed Furnace operation is simple and safe. It involves only setting the desired temperature and gas flow (done automatically in certain models) and immersing the components. At the end of the cycle, the components are lifted out and the furnace is switched off while waiting for the next batch.

The advantages of fluidised bed furnaces over conventional furnaces can be summarised as follows :

1. High heat transfer rate - hence shorter cycle time and faster attainment of steady state.

135K

LOW MAINTENANCE

There are no moving parts like fans,conveyors, etc. as in conventional furnaces and hence no attendant maintenance problems. Soot formation does not pose problems as the soot deposits on the particles are burnt off at the bed surface. The alumina particles are inert and do not require rectification, regeneration or monitoring. Such features built into Fluidised Bed Furnaces make them maintenance free equipment.

CLEANING

Precleaning and drying of components required for processing in atmosphere and salt bath furnaces are not required when using Fluidised Bed Furnaces. Oil and moisture on the components and jig simply vaporise without the hazard of explosion. Some alumina which adheres to threads, blind holes and the like can be easily washed or blown off.

QUALITY

The high degree of temperature uniformity (+3 C.) causes extremely uniform heating of all components, even in very dense loads. Distortion is reduced by the bed buoyancy and uniform heating of components.

During case treatments non uniform case depths do not occur. The component surfaces are continually exposed to fresh reactive gases under pressure and are scrubbed by the particles

2. Flexibility to switch on/off - hence no 'idling' energy consumption, as there is high heat retention;

3. The same furnace can be used for variety of heat treatments;

4. High degree of temperature uniformity;

5. Minimum downtime, as no precleaning and minimum post cleaning;

6. There is no loss of material due to scaling;

7. Lower running and maintenance cost; and

8. There are no furnace burnouts as also there are no explosion hazards;

Enclosure to Annexure-B

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED
HEAT TREATMENT COST SHEET

TREATMENT : CARBURISING

FURNACE : MODEL 1000.60/90 (CN) Max Temp 1050 Deg C

COMPONENT WEIGHT : 225 KGS / LOADS . COMPONENTS : GEARS

FIXTURES WEIGHT : 75 kGS TEMPERATURE : 950 Deg C
GAS FLOW RATE : 11M3/Hr

START UP TIME : 1.5 Hours (after night shut down)

RECOVERY TIME : 0.75 Hours

TREATMENT TIME : BOOST - 1.50 Hours
DIFFUSE - 1.0 Hour

FLUIDISING GAS
TOTAL CYCLES/DAY = 4
TOTAL LOAD/DAY = 900 KGS

DURING RECOVERY : N2 - 100%
DURING BOOST : AIR - 86.0%
LPG - 14.0%
DURING DIFFUSE : N2 - 100%

COST CLASSIFICATON
Costs are divided into variable costs and fixed costs

			(In Rs.)
A.	VARIABLE COST	-	
a.	Furnace Start up (Cost of heating up the furnace to operating temp - Once a day)	-	48.40
b.	Processing Cost During Recovery and Treatment		
	Electricity	-	300.00
	Gas	-	906.60
B.	FIXED COSTS (3 shifts basis)		
c.	Oxide Consumption	-	51.00
d.	Jigs and Fixtures	-	44.00
e.	Maintenance	-	197.08
f.	Wages	-	24.00
g.	Depreciation	-	350.00
			1921.08
	TOTAL ROAD / DAY		900 KGS.
	TOTAL COST / KG		Rs.2.13

NOTE : Above figures are on the basis of actual trials conducted at the Fluidtherm Plant working for 2 shifts only. If operated for 3 shifts the variable costs and the tonnage will rise and the revised cost per kilo processed will be Rs.1.86/Kg

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FLUIDTHERM TECHNOLOGY PRIVATE LIMITED

INPUT FORMULAE AND ASSUMPTIONS

a. FURNACE START UP = $\frac{\text{Start up time x Max KW x Electricity cost}}{2}$

b. START UP GAS = Since fluidisation by air Blower Motor KW x Start up time

c. HEAT TREATMENT ELECTRICITY = ((Recovery time x Max KW) + (Soak time x Power loss in KW)) x Unit cost of electricity.

d. HEAT TREATMENT GAS = Flow per hour x Rate per CF x Hrs/Cycle

e. OXIDE CONSUMPTION = 3 Kgs x Rate/Kg

f. JIGS AND FIXTURES = Rs.44/- per day

g. MAINTENANCE (Parts & Labour) = $\frac{\text{7\% of Furnace Price}}{\text{250 days / year}}$

h. Wages = Hours per day x cost per hour

i. Depreciation = $\frac{\text{Furnace Price}}{\text{8 years x 250 days/year}}$

1. Cost of Electricity = Re.1.00/KW hr
2. Oxide Consumption = 0.5%/day
3. Cost of Jigs and Fixtures = Rs.11000/year
4. Oxide Rate/Kg = Rs.17.00
5. Work days/year = 250 days
6. Depreciation Period = 8 years
7. Nitrogen cost/M3 = Rs.9.00
8. Ammonia Cost/M3 = Rs.12.86
9. LPG Cost/M3 = Rs.20.00

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Annexure - C

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

AND

TI DIAMOND CHAIN LIMITED

(Comparison of power consumption between Fluidised Bed Furnaces and Conventional Furnaces)

(Ref. Page 8)

COMPARISON OF POWER CONSUMPTION

Process under consideration : Carburising

Case depth : 1 MM.

(in KW/Kg.)

		Fluidised Bed	Conventional
1.	Sealed quench	0.65	1.60
2.	Rotary scroll	0.84	1.57
3.	End heating	0.80	2.60
4.	Continuous gas carburising	0.30	2.20

Annexure - D

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

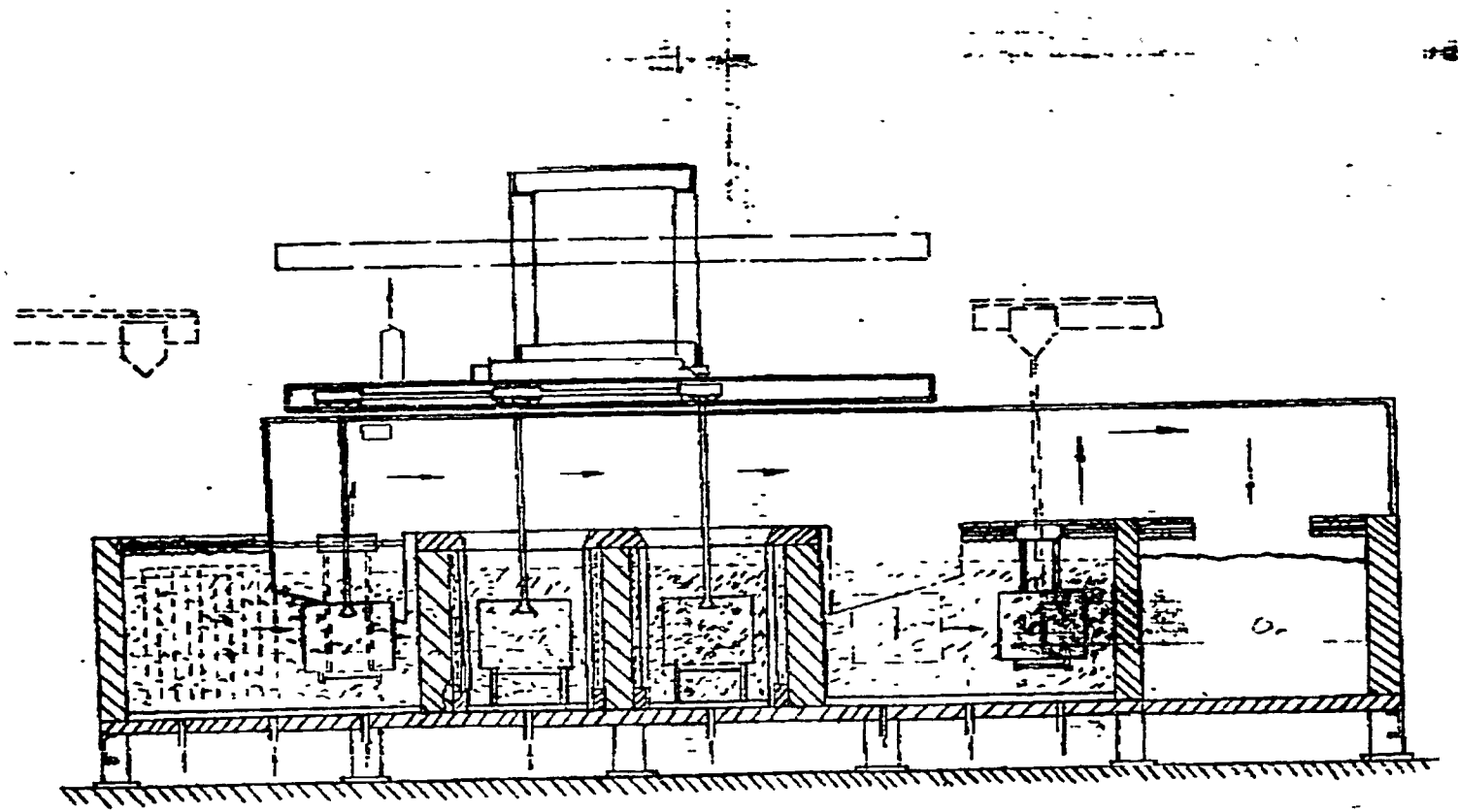
AND

TI DIAMOND CHAINS LIMITED

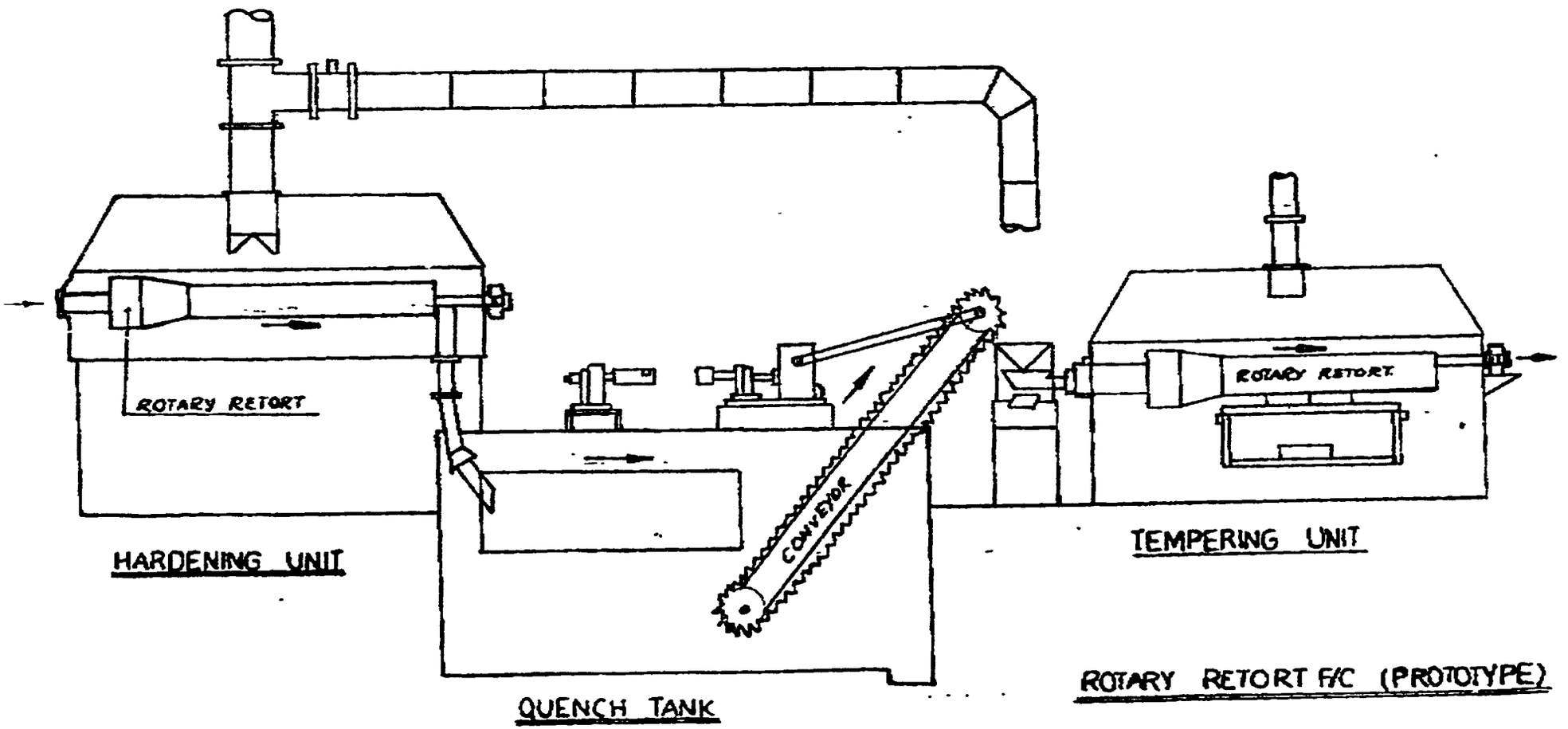
(Specifications of the Furnace Prototypes proposed to be developed)

(Ref. Page 11)

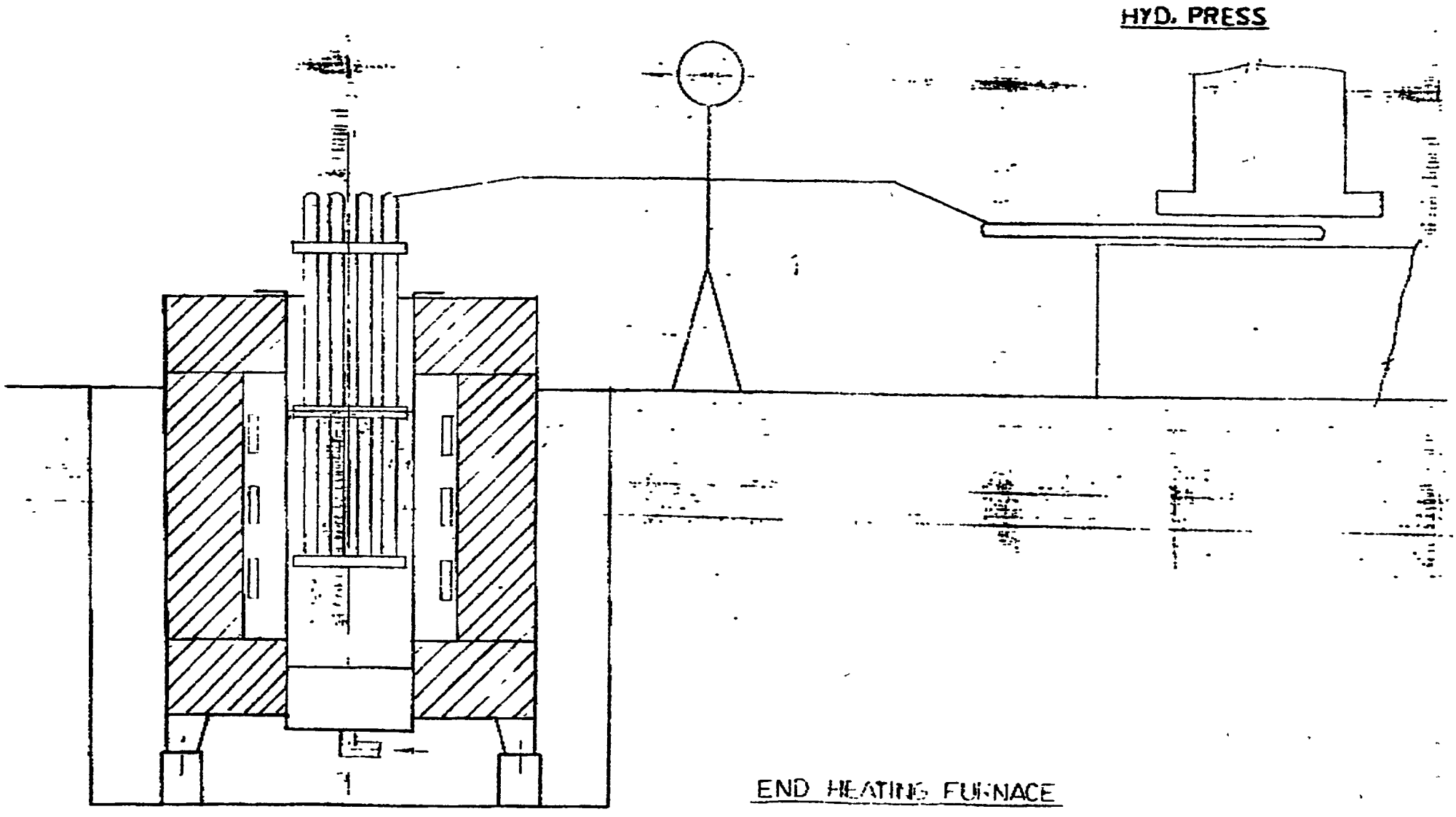
Types	Hot Zone Size	Batch/Hourly Capacity	Temperature
CONTINUOUS FURNACE			
IN CONTINUOUS MODE	300 mm dia x 600 mm deep 4 chambers	100 kg/hr. carburising 0.6 mm	1050 deg C
(IN BATCH MODE)	300 MM X 600 x 1 chamber	100 kg/batch	1050 deg C
ROTARY RETORT	450 mm dia x 900 mmL Retort x 2 (Hardening and tempering)	100 kg/hr Hardening 2 mm thick chain link plates	950 deg C
(OSCILLATING FIXTURE)	Suits any one chamber of the continuous furnace	25 Kg/hr. of 2mm thick chain link plates	950 deg C
END HEATING FURNACE	450 mm diax300 deep	48 bars of 25 mm dia/ per batch. Output 1 bar every minute	1200 deg C
(OIL FIRING MODULE)	Will be used on Rotary retort furnace with retort removed	can heat upto 500 kg/ hr of 16 dia bars	1200 deg C



CONTINUOUS SEAL QUENCH FURNACE



ROTARY RETORT F/C (PROTOTYPE)


HYD. PRESS
END HEATING FURNACE

Annexure - E

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

AND

TI DIAMOND CHAIN LIMITED

(Main Features of Development of Support Systems)

(Ref. Page 11)

1. **Computerised process control systems:**

The process control can be basically done with the help of Programmable Logic Controller (PLC) which consists of CPU and input/output modules. The PLC controls the process on the basis of pre-programmed path of control which is effected by sequential switching of various outputs. The extension of this system is to use a Personal Computer (PC-AT type) loaded with actual process software. The programme for computer can be much more detailed and flexible than PLC software, thus the scope of control is vastly extended. The main area where the work is needed is development interface between PC and PLC. The PC based control system would be able to control operations including loading/unloading of furnaces, switching furnace temperatures with respect to process time, auto correction/compensation for time lost due to interruptions, power failures etc. and data logging.

2. **Prepared Atmosphere Systems:**

The cost of Nitrogen, especially in low temperature treatments is somewhat high and low cost systems currently

available for conventional furnaces are sought to be adapted for use for FB furnaces. In these cases, different gas mixtures are used directly (such as Nitrogen/Methanol systems) or are used after they have reacted in a separate gas generator (like Endogas and Exogas - both mixtures of LPG and Air).

The development aspects for adapting this system for use in FB furnaces includes vaporisation and super-heating of directly used liquid/gas mixtures in equipment that do not cause sooting and which have an accurate flow and outlet pressure control.

Modification of standard endogas generator would be carried out for following purposes :

(a) Trapping water vapour;

(b) Boosting pressure from 5 Kpa to 30 Kpa;

(c) Installing cold gas atmosphere sensors and

(d) Developing soot traps.

3. **Transportation Systems**:

The project envisages development of following transportation systems for continuous type FB furnaces :

(a) Travelling hood

(b) Quench vestibule

(c) Walking beam and

(d) Scroll

a) <u>Travelling Hood</u>: An inverted hood that travels on rails is used for carrying components to furnace chambers and tanks. Though similar system exists in case of plating plants, certain modifications would be carried out for adopting it for FB furnaces.

b) <u>Quench Vestibule</u>: In cases where complete heat treatment cycle is carried out with one FB furnace and one quench tank, then the travelling hood is not needed. FTPL proposes to attach FB furnace and quench tank together and entire top portion to cover with steel box (vestibule) with three doors. A pusher would be synchronised with the furnace door which would be used to transfer the components. The components would be transported in vertically stored position (vertical repose) instead of horizontal repose.

c) <u>Walking beam</u>: This system is used in long rectangular furnace wherein fixture which holds component is transported with the help of walking beam mechanism. This system is widely used in conventional furnaces which would be modified to achieve lift of about 800 mm instead of 200 mm.

d) <u>Scroll</u>: This is a part of rotary retort furnace which is partially submerged in FB. The components are conveyed from one end to another with the help of hellical baffles. The main developmental work involved is immersion of retort in fluidised bed for faster heat transfer.

4. Alumina Recovery/Cleaning Systems:

Components which have been processed in FB furnaces tend to have alumina particles adhering to them. It is necessary for downstream processes to remove this alumina and also to recover the removed alumina for re-use in the bed.

The first stage is the recovery of 'drag out' alumina from the quench oil or salt. This is sought to be achieved by traditional filtration. The development aspect lies in that the alumina particles are extremely tiny (o.1mm diameter) and on line filtration will slow down the velocity of the oil flow (velocity being critical for the process). This system has to be modified for localised collection of alumina away from the main flow and a batch wise independent filtration system. Prior to this, to reduce the drag out itself, a simple cam operated jig shaker mechanism would be developed to shake to jig wile lifting the charge so as to drop the drag out alumina into the bed.

5. Heating Systems:

Current FB furnaces employ indirect electric resistance heating where the container is heated externally by electric elements. The rationale for developing alternate systems are :

a) Reduction of input energy;

b) Alternate heating sources (gas/oil) when electricity is scarce.

In the first system, the electric elements would be immersed into the bed without increasing the diameter of the chamber which will increase the gas flow considerably (thereby offsetting the energy saving).

The second system is indirect oil heating. The main problem in this system lies in that the sulphur in oil reacts with the nickel in the container and melts it at very low temperatures. Two alternate systems to overcome this would be developed by way of special coatings and another by way of disposable radiant tubes. The third system is of immersed oil heating where an oil/gas burner fires directly into the bed. This system is well known in heating of large chemical vats and swimming pools and would be modified for use in FB furnaces. The fourth and the most significant system is the use of LPG/air mixtues for fluidisation which themselves combust i the bed for heating up. Thus the total electrical energy is expected to reduce by 66% as it is needed only to maintain the bed temperature.

Annexure F

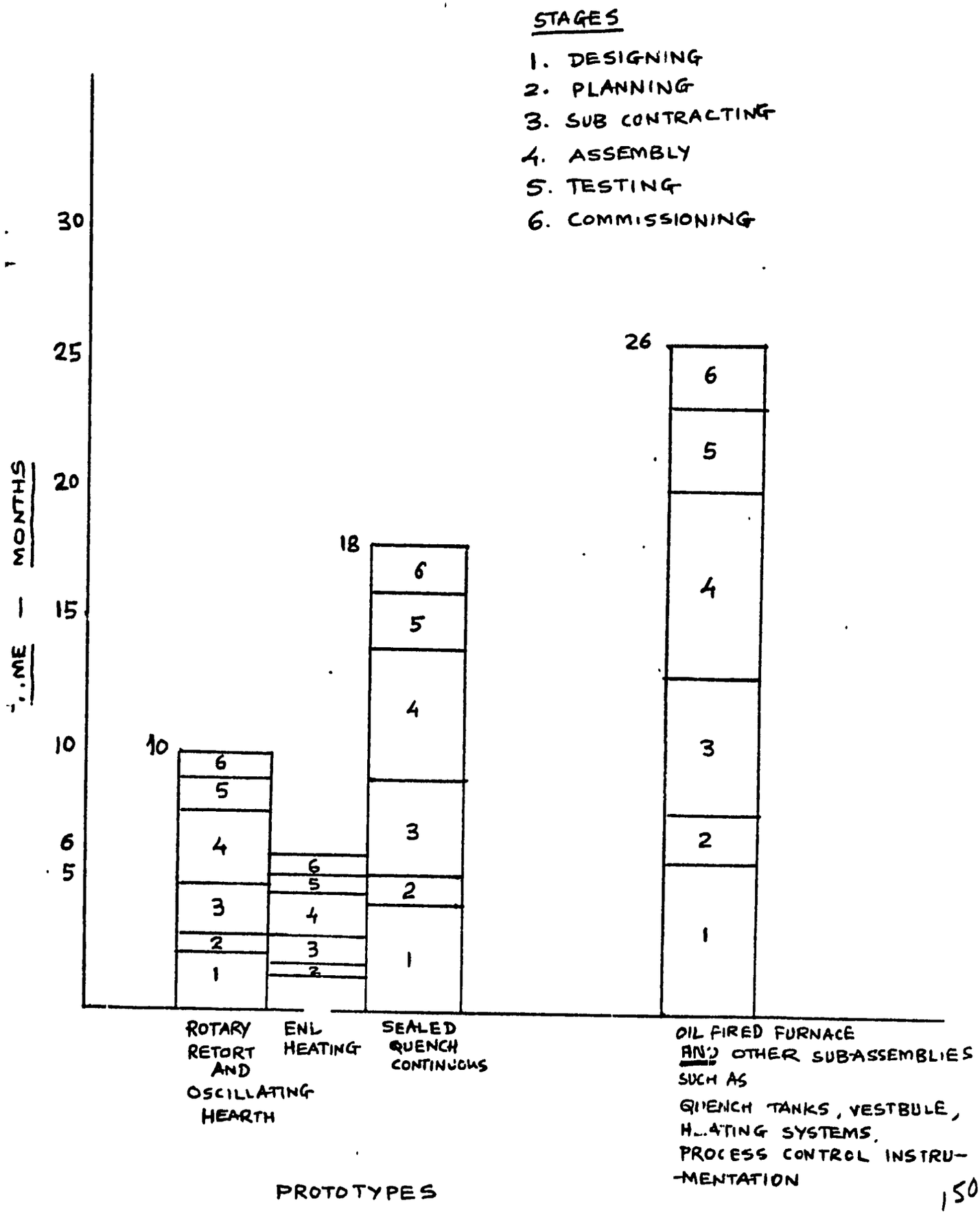
FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

AND

TI DIAMOND CHAIN LIMITED

(Schedule of Implementation)



Annexure-G

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

AND

TI DIAMOND CHAIN LIMITED

(PROJECTIONS OF OPERATING RESULTS)

(Ref. Page 20)

(Rs. in lacs)

		Years after commercialisation			
		(1)	(2)	(3)	(4)
1.	Sales (Quantity) (Nos.)	10	13	18	22
	(Value)	100	150	200	350
2.	Materials, Stores, components	58	87	116	221
3.	Utilities	3	5	6	11
4.	Salaries & wages	3	4	5	6
5.	Repairs & maintenance	1	2	2	4
6.	Factory supervision and Admn. overheads	2	3	6	11
7.	Selling expenses	7	11	14	25
8.	Royalty @ 3% on sales payable to PACER	3	4	6	11
9.	Interest	11	17	16	19
10.	Depreciation	7	10	10	10
11.	Total production cost	95	143	181	328
12.	Operating profit/loss	5	7	19	32
13.	Provision for taxation	1	2	10	17
14.	Profit after taxation	4	5	9	15
15.	Cash accruals (10 + 14)	11	15	19	25

Annexure-H

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,

INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

AND

TI DIAMOND CHAIN LIMITED

STRATEGIC ANALYSIS

(Ref. page No.20)

The success of commercialisation of the technology depends on proper demonstration in the proposed project. It is, therefore, essential to assess the probability of successful commercialisation through analysis of various factors. We provide analysis of 6 such factors each from two catagories relating to (a) the type of business (b) fitness of consortium to take up the project.

A. BUSINESS ATTRACTIVENESS

1. Sales/profit Potential

The internal rate of return works out to about 21% and the proposed project would contribute significantly to the profit of the company. 8/10

2. Growth Rate

Considering growth in automobile industry and ancillary industries as also indigenisation program of various automobile manufacturers growth rate of 12-15% is expected for heat treatment furnces. 7/10

3. Competitor Analysis

FTPL would be pioneer in commercialising the continuous FB furnaces in the country. At present FTPL is the only manufacturer of FB furnaces. It will, however face competition from conventional furnace manufacturers as also new FB furnace manufacturers, and hence FTPL will have to make extra efforts for marketing. 6/10

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4. Opportunity to Restructure the Industry

FTPL has already made significant progress in marketing FB furnaces (Batch type) and will have dominant position in the market for FB furnaces. FTPL will have good opportunity to price other entrants in FB furnace market. 6/10

5. Risk Distribution

Development of continuous FB furnaces would lead to possibility of developing a set of new applications of these furnaces as also other types of appliances (eg. wire annealing furnaces). 7/10

6. Special Factors

At present FB furnaces are categorised as energy saving devices and are exempt from sales tax and are eligible for 100% depreciation. 8/10

42/60

B. CONSORTIUM STRENGTH (OR FIT) FACTORS

1. Capital Requirements

FB furnaces are mainly fabricated and then assembled. Fabrication work is generally carried out through vendors. Manufacture of continuous FB furnaces would not require large investment and can be financed out of FTPL's cash accruals. 7/10

2. Marketing Capability

FTPL has existing set up of marketing with 1 Marketing Manager and 3 Sales Engineers and has representatives in major cities in the country. The existing set would be strengthen to market continuous FB furnaces. 8/10

3. Manufacturing Capability

FTPL has necessary facilities, and skills to manufacture important (key) components of FB furnaces. Other standard parts are made as per requirement through local fabricators. 7/10

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4. Technology Base

FTPL constantly upgrade its skills in heat treatment procers technology in association with IITM and college of Engineering, Pune and other consultants. 8/10

5. Raw Materials Availability

Raw materials required to manufacture FB furnaces include mild steels, alloy steel structural sections (all fabrication items), standard electrical and mechanical components such as solenoid valves, motors, PLCs, etc. which are easily available. 8/10

6. Skills Availability

FTPL and IITM both have necessary managerial and technical skills. 7/10

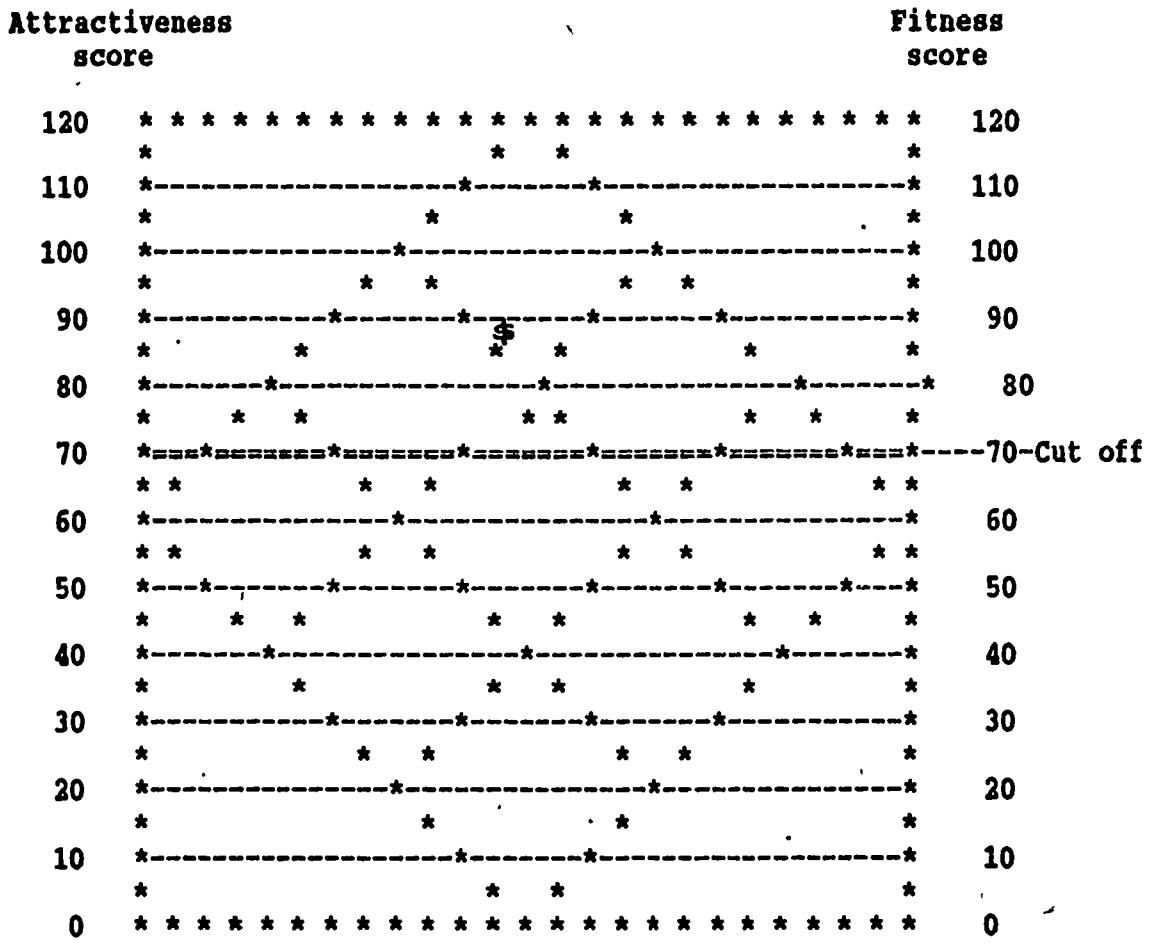
45/60

Total score 87/120

ANNEX H (Contd.)
(Ref. Page 20)

FLUIDTHERM TECHNOLOGY PRIVATE LIMITED,
INDIAN INSTITUTE OF TECHNOLOGY, MADRAS
AND
TI DIMOND CHAIN LIMITED

IDENTITY CHART



A.Business Attractiveness	Pts	B.Consortium Fit	Pts
1.Sales/profit potential	8	1.Capital needs	7
2.Growth rate	7	2.Marketing strength	8
3.Competitor analysis	6	3.Manufacturing strength	7
4.Industry restructure	6	4.Technology base	8
5.Risk distribution	7	5.Raw materials availability	8
6.Specific factors	8	6.Skills availability	7
	*		*
	42		45
		Total score	87

* Out of a total of 60 possible points.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESSEARCH (PACER)

3rd ERDAC Meeting

August 22 , 1989

Confidential

Agenda Item 3

Consortium proposals approved by PRC

	Proposal	Proposer(s)	Project cost (Rs. lacs)	PACER contribution (Rs. lacs)
a)	Development of Combustion Control System for Optimal utilisation of fuel in industrial furnaces/boilers by continuous Oxygen monitoring	Nagadi Consultants (P) Ltd. Micro Controls T.I. Cycles of India Ltd.	8.00	4.00

A brief summary of the project is enclosed

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THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

4th PRC Meeting

June 28, 1989

Confidential

Agenda Item 2(c)

MEMORANDUM FROM PACER SECRETARIAT ON THE PROPOSAL OF NAGADI CONSULTANTS PRIVATE LIMITED, MICRO CONTROLS AND TI CYCLES

PROJECT TITLE : Development and demonstration of low cost combustion control system based on oxygen sensing.

PRINCIPAL PROPOSER : Nagadi Consultants Private Limited

PROJECT COST : Rs. 8.0 lacs

MEANS OF FINANCING :

(Rs. in lacs)

Proposer's contribution		
- Nagadi consultants	3.5	
- Micro Controls	0.5	

		4.0
PACER contribution		
- Conditional Grant		4.0

		8.0

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PROPOSAL

The consortium of Nagadi Consultants Pvt. Ltd. (NC), Madras, Micro Controls (Micro), Madras and TI Cycles (TIC) Madras proposes to develop and demonstrate low cost combustion control system (CCS) based on continous oxygen sensing with the help of zirconia sensor system. The CCS proposed to be developed would continously monitor level of oxygen in the flue gases and would regulate air-fuel mixture of the burners, thereby ensuring efficient combustion and fuel saving (more than 5%). The proposed CCS can be retrofitted onto existing burners in boilers or furnaces, as also in new burners. Combustion Control Systems available at present in the market are in the nature of complete automation systems of boilers or furnaces based on programmable logic controllers (PLC's), costs of which range from Rs. 5 lacs to Rs. 12 lacs, whereas the proposed CCS is expected to cost between Rs. 0.8 to Rs 0.9 lac. The proposed CCS would have electronic circuit based on 8085 microprocessor instead of PLC based design. Its circuit will be developed by Micro Controls and the system will be demonstrated on the boiler at TI Cycles.

PROJECT SCHEDULE

R&D Project	- August 1989	- February 1990
Commercialisation	- March 1990	- onwards

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THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22 , 1989

Confidential

Agenda Item 4

Research project Proposals approved by PRC

	Proposal	Proposer(s)	Project cost (Rs. lacs)
a)	Technoeconomic Feasibility project for setting up a 10 MWe biomass based electric Power Station in a taluka in Maharashtra	Nimbkar Agricultural Research Institute	2.90
b)	Optimal utilisation of natural gas in India	I.J. Raju & Associates	4.32
c)	Research Project on Fuel substitution by natural gas in transport sector	Indira Gandhi Institute of Development Research	4.00

A brief summary of each of the project is enclosed.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

4th PRC Meeting

June 28, 1989

Confidential

Agenda Item 3

MEMORANDUM FROM PACER SECRETARIAT

ON THE PROPOSAL OF

NIMBKAR AGRICULTURAL RESEARCH INSTITUTE

(Research Project)

The Nimbkar Agricultural Research Institute (NARI), Phaltan, Dist. Satara, Maharashtra, a registered society, is engaged in research in the fields of energy, agriculture and forestry. NARI proposes to undertake a research project to study techno-economics of setting up a 10 MWe biomass based electric power station on co-operative basis in a Taluka in Maharashtra. The total cost of the research project is estimated at Rs. 2.90 lacs and NARI has requested for a grant of equal amount under the Program for Acceleration of Commercial Energy Research (PACER). We propose to provide NARI a grant of Rs. 2.90 lacs out of PACER funds.

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BACKGROUND

NARI was set up in 1968 to undertake reserch in the fields of agriculture, forestry and solar, wind and biological energy. NARI, an independent public foundation, is registered under Societies Registration Act Till 1981, the work conducted at the institute was in the area of agricultural research, and thereafter, research in other areas was commenced. The basic philosophy of the institute is to solve the problems of rural areas with the use of modern science and technology.

The institute is housed in buildings with total area of 1000 sq. metres and has about 50 hectares of farm attached to it for research purposes. NARI has laboratories in the areas of alternative energy research, botany, chemistry, entomology, and tissue culture. The Institute has a workshop, weather station and computer installations. NARI has a library with over 5,000 books and 70 periodicals.

The Institute is governed by a Governing Council and is advised by a panel of distingulished scientists. Annexure-A provides list of members of Governing Council and Research Advisory Committee. The activities of the Institute are carried out by 25 scientists (5 PhD, 9 M.Sc and 11 BSc) and about 25 other supporting staff under the guidance of Dr. Anil K. Rajvanshi, Director. He is a post graduate mechanical engineer from IIT, Kanpur and also has doctorate in mechanical enginering from University of Florida, USA to his credit. Prior to joining NARI, he was Instructor at the Centre for Training in Alternative Energy Technologies at University of Florida.

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Research efforts of NARI in the field of alternate energy are directed towards solving the rural energy crisis. The institute has developed a) wood stove cum cooker based on heat pipe principle, b) 3-5 KWe wood gasifier for pumpset and power generation c) 50 litres/day solar powered alcohol distillation plant d) improved kerosene lantern etc. The institute has collected weather data including solar radiation, wind velocities, rainfall, relative humidity for its location since 1982. The institute has also developed high yielding varieties of cotton, maize, sunflower, safflower and Sorghum. NARI has made considerable efforts in the areas of tissue culture, agrochemicals testing and pasture and sheep development.

NEED FOR THE RESEARCH PROJECT

Rural areas of India suffer from shortage of electric power. In Maharashtra which has surplus electric power, its availability in rural areas is inadequate. Only 16-20% of total rural households have electric connections, Besides the shortage of power in rural areas, problem of high unemployment also persists. Hence there is a need for a scheme which could provide electric power as well as employment. One of the ways to overcome the power crisis in rural areas is to generate the power in these areas itself. This can be achieved by using biomass (combustion or gasification), solar, wind or such other sources of energy.

In Europe, USA and other developed countries wood fired power plants of 1-50 MW capacities have been established for which the technology has already been developed. There are more than 100 power stations running on wood in USA. Most of the wood

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fired plants are based on steam Rankine cycle. There are few experimental plants which are running on gasification process but the technology for gasification plants of power ratings of 500 KW and above is still not proven one. Hence, it is envisaged that the 10 MW power plant could be based on steam Rankine cycle using wood combustion route.

There was an attempt for producing power from wood and wood-waste, however, the programme failed because of unavailability of sufficient biomass. This was primarily because of poor survival rate of seedlings. Thus there is a need to study soil conditions for plantations of species of biomass for production of biomass.

All the recent efforts in the development of energy technologies for rural areas have been focussed towards an individual village as a single unit. However, power generation at village level, is not economically viable. It is, therefore, envisaged to study economics for power generation from wood biomass, considering taluka as a base unit for considering power needs of total taluka. In the past also co-operative sugar factories in taluka have provided successful examples apart from providing employment opportunities for sugarcane growers.

Data on electric energy consumption for taluka in Maharashtra show that 5-10 MW power station can supply all its needs of electrical energy of a taluka. NARI has caried out techno-economic analysis for 5 MW wood fired plant which is based on available published data and literature. The salient features and conclusions of the analysis are provided in Annexure - B.

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The analysis has 3 major components which include biomass, production, power plant and environmental considerations.

The techno-economic analysis for the 5 MW wood fired plant, however, was not based on (a) survey of any particular area/location specifically identified for setting up such a plant, (b) discussion with local farmers and (c) study of soil conditions and water availability in specific location. NARI, recently, held discussions with Maharashtra State Electricity Board (MSEB) and officials of a co-operative society for setting up a 10 MW wood fired plant in taluka in Maharashtra and there has been a general agreement among these officials that such a project could be undertaken. At present there is no power plant based on biomass combustion in the order of 10 MW in the country. Considering the size of such plant there is a need for carrying out a techno-economic analysis before setting up the plant.

RESEARCH PROJECT PROPOSAL

NARI proposes to undertake research project to study techno-economics of setting up a 10 MWe biomass based electric power station on co-operative basis in a taluka in Maharashtra. The project mainly involves identification of suitable location based on soil conditions, availability of water and willingness of local farmers for growing biomass, identification of USA based supplier of power plant, identification of local fabricators for manufacture of certain equipment under the guidance of power plant supplier company and working economic feasibility for the project.

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Major steps involved in the project are as follows :

a) Discussions with manufacturers of wood fired plants from USA regarding setting up 10 MW power plant in India on turnkey basis and later on transfer of technology. A two member team from NARI would visit USA for the purpose and would finalise the supplier of the power plant.

b) Finalisation of Indian/local fabricators for manufacture of peripheral equipment as per the specification to be provided by the supplier of the power plant.

c) Discussions with officials of MSEB to decide modalities of purchase of electricityfrom power station.

d) Deciding species of biomass to be planted and discussions with local farmers for planting fast growing biomass species.

e) Analysis of availability of water from irrigation canal as also exploiting various mechanisms of water conservation methods for growing large plantations.

f) Working out the cost of setting up the power plant, operating results cash flows and viability indicators based on data collected during visits and discussions. Preparation of techno-economic feasibility report to set up 10 MW power plant based on biomass combustion in the form of co-operative society.

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NARI envisages publishing papers based on the research project. It is expected to generate discussion on kpolicy issues related to thermal power stations based on wood biomas produced under definite plantation programme. It is also expected that the report prepared by NARI may be useful to DNES, Planning Commission, MSEB, Ministryof Energy, Government of Maharashtra, World Bank etc. Power plant based on wood biomass (10 MWe) may be set up in taluka in western Maharashtra provided the techno-economic feasibility report shows strong viabiity.

The project would be carried out under the overall guidance of Dr. Rajvanshi by 2 Scientists (1 Engineer and 1 Research Assistant) and other supporting staff. The proposed project would be completed with 12 months after commencement. The terms of reference indicating scope of the research project, schedule of assignment, compensation etc. for undertaking the project are provided in Annexure - C.

The total cost of the project is estimated at Rs 2.90 lacs comprising salaries and wages of Rs 0.85 lac, expenses on travel of Rs 1.45 lacs, data processing Rs 0.15 lacs, miscellaneous expenses Rs 0.20 lac and expenses of organising workshop Rs. 0.25 lac.

NARI has requested for grant of Rs 2.90 lacs under PACER.

RECOMMENDATION

NARI is a reputed research institute carrying out its activities in the fields of renewable energy, agriculture, and forestry. The proposed research project would help arriving at

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a decision for setting up 10 MW based on biomass combustion power plant on cooperative basis. The above plant, if set up, would be the first of its kind in India.

We recommend to provide NARI a grant of Rs 2.90 lacs out of PACER. Funds to undertake the research project to study techno-economics of setting up a 10 MWe biomass based electric power station in a taluka in Maharashtra. The research project would be carried out as per the Terms of Reference mentioned in the Annexure - C.

NIMBKAR AGRICULTURAL RESEARCH INSTITUTE

(List of Members of Governing Council and Research Advisory Committee)

Governing Council

1. B. V. Nimbkar, President
2. Dr. A. K. Rajvanshi, Director
3. Dr. (Smt.) N. Nimbkar, Director
4. Dr. A. D. Karve
5. Y. A. Nimbalkar
6. Kum. C. Nimbkar
7. A. B. Patel

Research Advisory Committee

1. Dr. C. R. Bhatia, Head
   Nuclear Agriculture Division
   Bhabha Atomic Research Centre
   Bombay

2. Dr. A. B. Joshi
   Ex-Deputy Director General
   Indian Council of Agricultural Research
   New Delhi

3. Dr. A. D. Karve, Head
   Agricultural Research Sectior
   Hindustan Lever Limited
   Bombay

4. Dr. Avinash Kulkarni
   Managing DirectorLitex Ltd.
   Pune

5. Dr. K. S. Rao
   Director
   Gujarat Energy Development Agency
   Vadodara

6. Dr. G. R. Shah
   Former Project Coordinator
   Central Food Technological Research Institute
   Bombay

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7. Annasaheb Shinde
Ex-Minister of State for Agriculture
Government of India and
a progressive agriculturist, Ahmednagar

8. Dr. A.P.B. Sinha
Scientist in Director's Grade
National Chemical Laboratory
Pune

9. Dr. S. P. Sukhatme
Professor
Department of Mechanical Engineering
Indian Institute of Technology
Bombay

10. Dr. B. D. Tilak
Chief Coordinator
CASTFORD
Pune and
Honorary Advisor in Science & Technology
to the Government of Maharashtra

11. Dr. N. G. Perur
Vice Chancellor
Mahatma Phule Agricultural University
Rahuri
Dist. Ahmednagar

12. Vice Chancellor or his nominee
Shivaji University
Kolhapur

NIMBKAR AGRICULTURAL RESEARCH INSTITUTE

Salient features of conclusions of techno-economic analysis of 5 MW wood fired power station

Energy self sufficient talukas or tehsils provide a mechanism by which rural energy demand can be met and the standard of living of rural population can be raised. Producing electric power from a power plant in the range of 5-10 MW using wood as a source is a possible solution to creating energy self sufficiency on taluka basis.

To produce 5 MW electric power it would require 2,350 ha of land under fast growing species of trees. An average wood yields of 50 tons (dry weight)/ha/3 year cycle has been assumed from the plantations. The power plant will require about 39,000 tons of dry wood/year and would cost Rs 12.5 crores.

The estimates of costing of electric power for this plant reveal that it is possible to produce electricity at Rs 0.92/kwhr with wood price at Rs 0.5/kg. This is based on assumption of availability of soft loans at 7% interest for financing the scheme.

It is envisaged that the charter of this power station will be similar to that of existing sugarcane cooperatives in Maharashtra. Thus, the mechanism of harvesting wood, transportation and payment to the farmers will be on similar lines.

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Conclusions of the Study

1. It is technologically feasible and economically viable to produce power from wood for rural areas. The steam Rankine cycle technology is well established and can be taken up easily for rural India.

2. The power plant may be a cooperative one and may have similar charter as that of existing sugar cooperatives in state of Maharashtra.

3. The cost of power produced works out in the range of Rs 0.8 to Rs 0.92/kwhr for wood price of Rs 0.4 to Rs 0.5/kg. This pricing is based on loan availability at 7%.

4. The social, economic and environmentl benefits of the power production from this scheme are numerous and warrants setting up one such plant on a priority basis.

Annexure - C

NIMBKAR AGRICULTURAL RESEARCH INSTITUTE

Terms of reference for undertaking research project to study techno-economics of setting up a 10 MWe Biomass based electric power station in taluka in Maharashtra

1. Scope of the Project

Nimbkar Agricultural Research Institute (NARI) would carry out the project onthe following broad guidelines:

1. Discuss with manufacturers of power plants based on wood and wood-waste (about 10 MW size) from USA for setting up similar power station in rural area. Discussions will also cover pollution control problems, possibility of manufacturing peripheral equipment in India;

2. Discuss with local Indian vendors possibility of fabrication of peripheral equipment as per specifications of collaborator;

3. Discuss with MSEB possibility of purchase of power from co-operative.

4. Discuss with local farmers and decide on species of fast growing biomass for plantation,

5. Analyse water availability both from irrigation canal and evolve various mechanisms for conservation of water for growing large plantations;

6. Organise a workshop whereat the draft report on the research project would be presented and discussed before preparation of final report.

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Final recommendations would be in the nature of techno-economic feasibility report for setting up of 10 MW power station on co-operative basis.

2. Schedule of Assignment

NARI would submit draft report one year after commencement of project. After incorporating suggestions made by ICICI, NARI would provide final report within 3 months after receipt of comments from ICICI.

3. Copies of Report

NARI would submit 10 copies of draft report and 10 copies of the final report.

4. Assistance

ICICI would provide a grant of Rs 2.90 lacs to NARI for undertaking the project and prepare the reports. NARI would bear any increase in cost of the project.

5. Schedule of Payment

- upto 50% of the total grant would be payable at the time of commencement of project.
- upto 80% of the total grant would be payable on submission of draft report to the satisfaction of ICICI (Interim disbursement may be considered based on the progress made by NARI) and
- balance grant would be payable on submission of final report to the satisfaction of ICICI.

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5. Reporting Requirement

NARI would provide quarterly progress reports to ICICI on the lines of the format to be given by ICICI.

6. In the event of NARI not being able to complete the project or abandoning it for any reason whatsoever, all the data collected by NARI shall be handed over to ICICI.

7. (a) Any publication of data or other information derived from the work hereunder, or any publication related to the work, shall contain the following legend or its approved equivalent :

"the work on which this (Article/Publication) is based was supported by a grant from ICICI pursuant to the Agreement between ICICI and United States of America for Program for Acceleration of Commercial Energy Rresearch. The views and information contained herein are those of the authors and not necessarily those of ICICI. ICICI assume no liability for the contents of this document by virtue of the support given."

(b) Should ICICI agree to NARI making available copies of the Report to third parties at a price, the sale proceeds thereof would be shared between NARI and ICICI on mutually agreed terms.

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THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCLERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

5th PRC Meeting

August 22, 1989

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Agenda Item 3 (a)

MEMORANDUM FROM PACER SECRETARIAT

ON THE PROPOSAL OF

I.J.RAJU & ASSOCIATES

(Revised Proposal for Research Project)

A research project proposal of I.J. Raju and Associates (IJR), New Delhi on 'optimal utilisation of natural gas in India' was discussed at the second meeting of Peer Review Committee (PRC) held on October 27, 1988. PRC indicated that IJR may submit the revised proposal for the research project explaining the precise scope of the research project in view of the various studies being carried out by Planning Commissioin, ONGC and other government institutions/agencies. Similarly the project should address itself to specific areas keeping in mind the need for identifying appropriate technologies and end users of gas. PRC also indicated that it may be necessary to identify end users of such a research project.

At its 3rd meeting held on March 27, 1989 PRC considered revised proposal of IJR and its comments were as follows :

PRC agreed with recommendation of PACER Secretariat to place the proposal of I.J. Raju and Associates before ERDAC for

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consideration and approval for a suitable amount of grant for the research project on optimal utilisation of natural gas in India, subject to examination of cost of project and scope of the study taking into consideration the time frame of 20 years for projections.

PACER Secretariat subsequently conveyed decision of PRC to IJR as also it held discussions with the consultant. The research project proposal of IJR after incorporating changes keeping in mind observations made by the PRC is now again placed before PRC for its consideration and approval.

IJR, now, proposes to undertake a research project on optimal utilisation of natural gas in India which includes study of factors affecting development of market for use of gas in various sectors and status of technology and capabilities of equipment manufacture for utilisation of natural gas. The projection of availability of natural gas would be worked out with respect co time frame of 20 years. The total cost of the research project is estimated at Rs 4.32 lacs and IJR has requested for grant of an equal amount under the Programme for Acceleration of Commercial Research. We propose to provide IJR a grant of Rs 4.32 lacs out of PACER funds.

BACKGROUND

IJR was promoted in 1987 by I.J.Raju (Raju), a chemical engineer and other professionals for undertaking consultancy assignments and providing advisory services in the fields of management and technology. IJR provides a range of consultancy services including identification of business opportunities,

techno-economic viability studies, financial management, organisational structure, marketing and distribution, industrial engineering etc.

Raju is a post graduate chemical engineer and fellow of management (IIM, Calcutta) and has professional consultancy experience of over 14 years. Prior to promoting IJR he was General Manager of management consultancy division of S.B. Billimoria & Co. The activities of IJR are carried out by a team of 7 experienced professionals including Raju. IJR also avails services of outside technical experts on project to project basis.

IJR has carried out about 20 consultancy assignments for various organisations in India and abroad. Some of the clients of IJR include Ballarpur Industries Limited, Triveni Engineering Works Ltd., Luz International Inc. USA and World Bank. The assignments carried out by IJR in the area of energy include cost benefit analyses of solar thermal power projects in Punjab and Gujarat, potential and economics of gas turbine in India, market survey for industrial steam turbine, etc. We have gone through some of these studies and are satisfied about IJR's capabilities.

NEED FOR RESEARCH PROJECT

Reserves of natural gas in the country increased rapidly after the discovery of oil and gas in Bombay high. The gas reserves increased almost 16 times from 68 billion cubic metres (bcm) in 1974 to 1,100 bcm in 1988 whereas production of natural gas increased only 7 times from 2,040 million cubic metres (mcm) to 14,400 mcm in the corresponding years.

In the recent years, considerable analysis has been carried out on economics of utilisation of natural gas only in the utility and fertiliser sectors. As a result, government policies for utilisation of natural gas have undergone a gradual transformation. While the priority for use of heavier fractions of natural gas as feed stock for petrochemicals and LPG remains unchanged, the priorities for the use of lean gas (i.e. methane rich gas) which constitutes about 75% by volume of natural gas, have been changed. It is well accepted by now that utility power generation using natural gas as fuel in combined cycle plants is economical option and has high priority. The above change was a result of various studies conducted by Government as well as private agencies. Such studies provide a background for carrying out analyses in other sectors such as transportation, domestic, non utility power generation, co-genration, etc. The need for conducting study by an independent consultant on optimal utilisation of natural gas in India has also been indicated in various seminars.

In view of the above there is a need to carry-out a study on optimal utilisation of natural gas with respect to various parameters which include a) possibility of utilisation of natural gas in different sectors apart from utility and fertilizers, b) availability of new reserves of gas and depletion of gas after use in the next few years, c) evaluation of alternatives for local utilisation against transmission of gas, d) economic cost-benefit analysis and e) identification of technologies required for use of natural gas. The need for such study has primarily been felt because of certain drawbacks in the methodologies of earlier gas utilisation studies and improper assessment of economic value of gas.

PROPOSAL

IJR earlier, in September 1988, submitted proposal to conduct a research project on optimal utilisation of natural gas in India. The scope of the research project envisaged in the original proposal included review of availability of gas over the next 10-15 years, identification of extent of potential use of gas in various sectors, developing methodology for economic cost-benefit analysis, analysis of economics of utilisation and conducting sensitivity analysis of optimal utilisation pattern. The proposal was discussed at the second meeting of the PRC held on October 27, 1988. The comments of PRC on the proposed IJR were as follows :

(1) It would be necessary to collect more information about similar studiies being conducted in other organisations such as ONGC, Planning Commission etc.

(2) The study should address itself to specific areas keeping in mind the need for identifying appropriate technologies and end users of gas.

(3) Though such a study by a private consultant could be useful, it would be necessary to reformulate its scope and ascertain properly the methodology to be adopted and also possible users of the study.

PRC directed PACER Secretariat to discuss the proposal with the proposer and place before the next PRC, the revised version in the light of the above observations.

Accordingly, IJR submitted a revised proposal to undertake research project on optimal utilisation of natural gas

in India. The scope of the revised research project also includes, in addition to the scope envisaged in original proposal, analyses of impediments to development of commercial markets for use of gas in non-utility power generation, co-generation, industrial, transport and domestic sectors, analyses of capabilities of indigenous technology and equipment manufacture for use of natural gas in above sectors based on detailed field survey including study of managements' attitude for such use, analyses of investment required to develop gas markets in the above decentralised sectors.

As indicated at 3rd PRC meeting the projections of availability of natural gas as also other estimates would be worked out with respect to time frame of 20 years.

The research project would be carried out in one phase as against in two phases as envisaged earlier. The project involves substantial increase in field work from 22 man days to 90 man days and would cover about 100 different organisations instead of 26. The research project is expected to require 145 man days of the project leader and 230 man days of a consultant. The project would be conducted within 6 months after its commencement and draft report would be presented at a workshop to be organised as part of the project. IJR would submit final report 1 month after receipt of comments on draft report. A steering committee may be set up to finalise the exact scope of the project, detailed methodology and planning of the study, to review the progress of the project and to discuss and finalise the draft report. Annexure A provides data on the revised research project proposal.

The total cost of undertaking the research project is estimated at Rs 4.32 lacs which includes professional fee of Rs 3.17 lacs and out of pocket expenses of Rs 1.15 lacs. The details of the estimates of costs are provided in Annexure - B.

The terms of reference indicating scope of the project, schedule of assignment, compensaton etc. for undertaking the project are given in Annexure C.

The outcome of the research project is expected to be used as an input for discussions and formulation of policies on utilisation of natural gas in future. The report on the project may be useful to various government agencies, ONGC, GAIL, and various industry associations such as FICCI, ASSOCHAM, CEI etc. The report based on the research project is expected to provide basis for debate and analysis on the subject.

RECOMMENDATION

We recommend to provide IJR a grant of Rs 4.32 lacs out of PACER Funds to undertake the research project on optimal utilisation of natural gas in India.. The project would be carried out as per the Terms of Reference mentioned in Annexure C.

I. J. RAJU & ASSOCIATES

Data on the Revised proposal to conduct research project on optimal utilisation of natural gas

	Revised
Man-days efforts	
- Project leader	145
- Consultants	230
Total time required (weeks)	24
No of organisations to be contacted	100
Manpower requirement	
- Project leader	1
- Consultants	2
Total cost of research project : (Rs)	
- Professional fee	3,17,000
- workshop and out of pocket expenses	1,15,000
Total	4,32,000

Annexure - B

I. J. RAJU & ASSOCIATES

(Details of Cost Estimates)

A. **Man-Day Costs**

	Estimated Man-Days	
	Project Leader	Consultant
° Detailed planning of the study (Delhi)	3	6
° Initial discussion with PACER Secretariat (Bombay)	2	2
° Secondary Research		
- Delhi	8	15
- Outside Delhi (Dehradun, Bombay)	2	5
° Development of Methodology & Framework for Economic Analysis (Delhi)	10	10
° Collection of Technical & Cost Data and Discussions with the various Organisations & Field Survey		
- Delhi	10	20
- Outside Delhi	20	40
(Bombay, Ahmedabad, Baroda, Madras, Rajahmundry, Hyderabad, Kanpur, Dehradun, etc.) (60 interviews by a team of 2 persons)		
° Data Analysis (Delhi)	20	40
° Draft Report Preparation (Delhi)	10	20
° Discussion & Presentation of Draft Report (Delhi/Bombay)	5	10
° Additional Analysis (Delhi)	10	15
° Report Finalisation (Delhi)	5	12
° Contingencies (Delhi/Others)	15	30
° Project Coordination (Delhi)	10	-

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Proposal Preparation & Pre-study effort	(Delhi)	15	5
Total	(Delhi)	115	180
	(Outside Delhi)	30	50
	(Total)	145	230

Man-Day Costs

	Man-days	Man-day rate Rs.	Cost Rs.
Project Leader	145	1000	145000
Consultant	230	750	172500
		Total Rs.	317500
		Say	**Rs. 317000/-**

(Though our man-day rates were revised upwards from April 89, we are using the same rates as indicated by us in our original proposal of September 1988 and thus this study will be carried out by us on cost basis without any profit margins because of our interest in this subject).

B. **Out-of-Pocket Expenses**

i) Travel Cost

	No. of man visits	Cost Rs.
Visits to Bombay for discussions with ICICI during the study & secondary Data Collection	4	10,000
Travel for Data Collection & Discussions during field survey		
- Dehradun	2	1,000
- Bombay/Ahmedabad/Baroda	2	7,000
- Madras/Rajahmundry/Hyderabad	2	8,000
- Kanpur/Lucknow	2	2,000
- Others	2	3,000
		31,000
	Say	Rs. 30,000

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ii) Out Station Stay Cost

	No. of man days of oustation stay	Cost Rs.
° Visits for Bombay for meeting with ICICI	4	
° Field Survey outside Delhi (60 interviews @ 2 interviews per day by a team of 2 consultants)	60	
° Secondary Data Collection outside Delhi	7	
° Discussion of Draft Report at Bombay	5	
° Others & Contingency	4	
Total	80	
Average cost of stay per man day stayed outside Delhi (Lodging, Boarding, Conveyance etc.)	Rs. 600 per man day	
Total cost of outstation stay		48,000

iii) Local conveyance in Delhi including visits to Ghaziabad, Faridabad etc.
Rs. 800 per man month x 12-1/2 man months 10,000

iv) Report Preparation (5 copies of Draft Report & 10 copies of Final Report)

° Typing	Rs. 4,000/-	
° Photostat & Binding	Rs. 3,000/-	
° Presentation Material	Rs. 3,000/-	10,000

v) Computer Time 10,000

vi) Miscellaneous (Telex, STD Telephone, Books etc.). 7,000

Total Rs. 1,15,000

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C. **TOTAL COST (Man-day Costs & Out-of-Pocket Expenses)**

			Rs.	Rs.
A.	Man-day Costs			3,17,000
B.	Out of Pocket Expenses			
	i)	Outstation Travel costs	30,000/-	
	ii)	Outstation stay cost	48,000/-	
	iii)	Local Conveyance	10,000/-	
	iv)	Report Preparation	10,000/-	
	v)	Computer Time	10,000/-	
	vi)	Miscellaneous	7,000/-	
				1,15,000
			Total (A & B)	**Rs. 4,32,000**

(Rupees Four lakh thirty two thousand only)

J. T. Rai

I. J. RAJU & ASSOCIATES

Terms of Reference for undertaking the research project on optimal utilisation of natural gas in India

1. Scope of the research project:

The consultants (IJR) would carry out the project and prepare a report incorporating following aspects:

i) Review of availability of natural gas in the next 20 years and indicate locations of gas reserves. This review would include aspects such as present and future availability of gas in the country, present commitments of gas, present and proposed netwrok for transmission and distribution of gas, compositions and calorific values of gas from various parts of the country, availability of lean gas after extracting LPG and petrochemical feed stocks and transportation costs of gas.

ii) Identify the extent of potential use of gas in various sectors. This would call for review of likely demand for gas for installed capacities of various possible user sectors, production technologies available with user sectors to use gas, availability of alternative feedstock, feasibility and hence potential for use of gas in user sectors.

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iii) Economic analysis including evaluation of extent to which the output of the user sectors are tradeable or non-tradeable, devising methodology to arrive at economic values of gas use in various sectors, working out economic cost from the nation's point of view, study of trends in international prices of gas and other fuels, study of life-cycle economic costs of alternative methods of production in various user sectors working out imputed economic values of gas in user sectors, cost of transmission and distribution, arriving at economic policy for utilisation of gas and sensitivity analysis and study of cost associated with development of a national gas grid. The economic analysis would also focus on likely scenario of gas fields and transmission net-works.

2. **Schedule of assignment:**

The consultants would submit the draft report within 6 months after receipt of sanction letter. The draft report would be presented at a workshop to be organised as part of the project. Final report would be submitted 1 month after receipt of comments on draft report from PACER Secretariat.

3. **Copies of the report:**

The consultants would submit 10 copies of the draft report and 10 copies of the final report.

4. **Compensation:**

The consultants would charge a sum of Rs 1,72,500 towards compensation for undertaking the study.

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Schedule of Payment

-Upto 50% of the total compensation would be payable at the time of commencement of the project.

-Upto 80% of the total compensation would be payable on submission of draft report to the satisfaction of ICICI (Interim disbursements may be considered based on the progress reports submitted by the consultants)

- balance 20% of the total compensation would be payable on submission of final report to the satisfation of ICICI.

5. In the event of IJR not being able to complete the project or abandoning it for any reason whatsoever, all the data collected by IJR shall be handed over to ICICI.

6.(a) Any publication of data or other information derived from the work hereunder, or any publication related to the work, whall contain the following legend or its approved equivalent :

"the work on which this (Article/Publication) is based was supported by a grant from ICICI pursuant to the Agreement between ICICI and United States of America for Program for Acceleration of Commercial Energy Research. The views and information contained herein are those of the authors land not necessarily those of ICICI. ICICI

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assume no liability for the contents of this document by virtue of the support given."

(b) Should ICICI agree to IJR making available copies of the Report to third parties at a price, the sale proceeds thereof would be shared between IJR and ICICI on mutually agreed terms.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

5th PRC Meeting

August 22, 1989

Confidential

Agenda Item 3(b)

MEMORANDUM FROM PACER SECRETARIAT ON THE PROPOSAL OF INDIRA GANDHI INSTITUTE OF DEVELOPMENT RESEARCH

(Proposal for Research Project)

Indira Gandhi Institute of Development Research (IGIDR), Goregaon, Bombay, set up by the Reserve Bank of India (RBI) conducts studies on various issues of significance to economic development. IGIDR proposes to undertake a research project on fuel substitution by natural gas in the transport sector. The total cost of the research project is estimated at Rs.4 lacs and IGIDR has requested for a grant of equal amount under the Program for Acceleration of Commercial Energy Research (PACER). We propose to provide IGIDR a grant of Rs. 4 lacs out of funds available under PACER.

BACKGROUND

IGIDR, a registered society set up by RBI in 1987, as part of the commemoration of RBI's golden jubilee, for the study of issues relating to economic development aims at promoting the

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study of and conducting research on development (its economic, technological, social, political and ecological aspects) with a broad perspective, to gain insight into the process of development and alternative policy options.

IGIDR is located at Goregaon, a western suburb of Bombay, on a 14 acre site. The institute`s campus is spacious and impressive. It consists of office buildings for research and administrative staff, seminar rooms of different seating capacities, an auditorium with 500 seats, a library, a computer centre, a cafetaria and housing for staff. The campus also has a guest house cum hostel for visiting scholars and students. IGIDR`s library has a collection of over 4,500 books and it subscribes to about 200 periodicals/journals. The institute has 11 personal computers and a mini computer at its computer centre.

IGIDR`s Governing Council comprises eminent experts with Shri R.N. Malhotra, Governor, RBI as chairman. Annexure - A provides a list of members of the Governing Council of the institute. The activities of the IGIDR are carried out by about 20 faculty members, 7 Research assistants and about 15 supporting staff under the guidance of its Director, Dr. Kirit Parikh. Dr. Kirit Parikh is a post graduate in civil engineering from IIT Kharagpur and has a doctorate in the subject from Massachusetts Institute of Technology, USA. He has a wide research and academic experience in the fields of Energy, water, agriculture studies, development policy, food, planning models and technology policies.

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Annexure - C

INDIRA GANDHI INSTITUTE FOR DEVELOPMENT RESEARCH

Terms of reference for undertaking research project on fuel substitution by natural gas in transport sector

1. Scope of the Project

Indira Gandhi Institute for Development Research (IGIDR) would carry out the research project on the following broad guidelines:

a. Examine economic feasibility and extent of substitution of petroleum based fuels in transport sector by natural gas, under different sets of domestic and international environments on account of variations in oil prices, refinery margins, user habits, etc. ;

b. Identify and analyse policy options to achieve desired level of substitution of petroleum fuels by natural gas;

c. Identify various details of infrastructural requirements like feeder pipe lines, fuelling stations and investment needed;

d. Conduct study of environmental effects after introduction of vechicles using Compressed Natural Gas (CNG); and

e. Organise a workshop whereat the draft report would be presented and discussed before preparation of final report.

Final recommendations would be in the nature of report which would include detailed plan of action to achieve the desired results indicated by findings from above. IGIDR would also identify a consortium R&D project alongwith proposed members of consortium.

2. Schedule of Assignment

IGIDR would submit draft report one year after commencement of the project. After incorporating suggestions made by ICICI, IGIDR would provide final report within 3 months after receipt of comments from ICICI.

3. Copies of Report

IGIDR would submit 10 copies each of draft report and the final report.

4. Assistance

ICICI would provide a grant of Rs 4 lacs to IGIDR for undertaking the project and prepare the reports. IGIDR would bear any increase in cost of the project.

5. Schedule of Payment

- upto 50% of the total grant would be payable at the time of commencement of project.

- upto 80% of the total grant would be payable on submission of draft report to the satisfaction of ICICI (interim disbursement may be considered based on the progress made by IGIDR) and

- balance grant would be payable on submission of final report to the satisfaction of ICICI.

5. Reporting Requirement

IGIDR would provide quarterly progress reports to ICICI on the lines of the format to be given by ICICI.

6. In the event of IGIDR not being able to complete the project or abandoning it for any reason whatsoever, all the data collected by IGIDR shall be handed over to ICICI.

7. (a) Any publication of data or other information derived from the work hereunder, or any publication related to the work, shall contain the following legend or its approved equivalent :

"The work on which this (Article/Publication) is based was supported by a grant from ICICI pursuant to the Agreement between ICICI and United States of America for Program for Acceleration of Commercial Energy Research. The views and information contained herein are those of the authors and not necessarily those of ICICI. ICICI assume no liability for the contents of this document by virtue of the support given."

(b) Should ICICI agree to IGIDR making available copies of the Report to third parties at a price, the sale proceeds thereof would be shared between IGIDR and ICICI on mutually agreed terms.

IGIDR has carried out research mainly in the areas of methods of planning, alternative strategies of development, food policy, energy systems studies, and technology assessment. The Institute conducted a seminar on applications of high temperature superconductors in power sector in July 1988. Under energy systems studies IGIDR is pursuing research in following fields:

a) Energy conservation

b) Oil and natural gas model for India

c) Technology assessment of application of superconductivity in power sector

d) Rural energy, national grid and power system

NEED FOR THE RESEARCH PROJECT

India, like many other oil importing developing countries, is facing the problem of maintaining a delicate balance between pressing needs of meeting the necessary energy requirements of different sectors of economy and maintaining a healthy desirable balance of payment position of the country. The single largest factor disturbing the balancing act has been the increasing imports of crude oil and middle distillates. The experience of the last decade suggests that a well conceived sectoral approach which may logically fit into the matrix of overall strategy to mitigating the problem could prove to be effective in terms of both time and cost.

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Share of middle distillates particularly diesel in the total consumption of petroleum products is about 40%. A study indicates that consumption of middle distillates would grow to about 70% by the turn of the millennium. With 10% growth in heavy traffic, the transport sector alone is expected to constitute about 80% of diesel consumption.

The recent trends in discoveries of oil/gas indicate that increasing quantitites of natural gas resources are struck. Natural gas has emerged as a viable substitute for different petroleum products in various sectors. It is contemplated that compressed natural gas (CNG) can probably be a feasible substitute fuel for diesel in transport sector which forms a major bulk of middle distillates now being consumed in India.

Systematic studies, which could indicate potential for and mechanics of substitution of fuel by natural gas in transport sector along with plan of action and related resource requirements, have not been carried out in the country. Thus there is need for such a study which would provide Government with the policy guidelines and information on the role of various agencies on the one hand and identify infrastructural requirements.

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RESEARCH PROJECT PROPOSAL :

IGIDR proposes to undertake research project on fuel substitution by natural gas in transport sector. The main objectives of the project are

a) to examine economic feasibility and extent of substitution of petroleum based fuels in transport sector by natural gas;

b) to analyse various policy options to achieve desired level of substitution of petroleum fuels; and

c) to prepare detailed plan of action to achieve the desired results indicated by the research project.

The research project would identify potential for substitution of fuel in transport sector under different sets of domestic and international environments on account of variations in oil prices, refinery margins, user habits etc. The project would also identify policies which would lead to a desired level of substitution. The research project would bring out various infrastructural requirements such as feeder pipe lines, fuelling stations and investment needed as also environmental effects after introduction of vehicles using Compressed Natural Gas (CNG) as fuel.

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The major steps involved in the project are as follows :

a) Development of theoretical framework for the study;

b) Data collection and processing;

c) Surveys and lab tests, if necessary;

d) Analysis and report preparation; and

e) Preparatory work for consortium projects.

All the activities except laboratory tests and surveys would be carried out at IGIDR. The laboratory tests and surveys may be needed to measure pollutants from natural gas vis-a-vis conventional fuels, vehicle movements, user habits etc. and the same would be carried out at other established laboratories.

The research project wouldalso involve interactions with various agencies like Planning Commission, ONGC, GAIL, etc. dealing in natural gas, government departments and experts in this area for technical consultations.

The research project would be carried out by 1 research fellow and 3 other research associates under the overall guidance of Dr. Jyoti Parikh, Senior Professor and co-ordinator of Energy Systems Studies and Technology Assessment. Dr. Jyoti Parikh is a post graduate in physics and has Ph.D. in the field from University of Maryland , College Park, USA. She has vast research experience in energy modelling, technology and

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environment. She has worked at the International Institute of Applied Systems Analysis for about 8 years on energy problems of the developing countries. She has also developed Energy demand model for India for the Planning Commission. She has also served as a consultant to various international agencies such as the US Dept. of Energy, EEC, UNIDO, UNESCO etc.

The research project is expected to lead to development of a suitable consortium R&D project related to CNG based automotive system. IGIDR would identify suitable members of consortium for the R&D project. The proposers would present its draft report on the research project at a workshop to be organised within the scope of this proposal. The probable participants at the workshop would comprise representatives from Planning Commission, Ministries of Petroleum and Industry, ONGC, GAIL, DNES, PCRA, vehicle manufacturers, etc.

The proposed research project would be completed within 12 months after its commencement. A bar chart indicating major steps involved and time required for each step is provided in Annexure - B. The terms of reference indicating scope of the research project, schedule of assignment, compensation etc. for undertaking the project are provided in Annexure - C.

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The total cost of the research project is estimated at Rs. 4 lacs as follows :

	(Rs in 000's)
Salaries and wages	100
Travel and communication	80
Data processing	20
External consultants and Laboratory tests	80
Literature, Journals etc	30
Workshop expenses	25
Administrative overheads	65
	400

IGIDR has requested for grant of Rs. 4 lacs under PACER.

RECOMMENDATION

IGIDR is a reputed development research institute promoted by RBI, conducting research in the areas of policy analysis, strategies of development, energy systems, technology assessment, etc. The proposed research project is expected to lead to formulation of consortium R&D project for utilisation of natural gas as fuel in transport and industry sectors, which in turn can revolutionalise these sectors.

We recommend to provide IGIDR a grant of Rs. 4 lacs out of funds available under PACER to undertake research project on fuel substitution by natural gas in transport sector as per the terms of reference mentioned in the Annexure - C.

Annexure - A

INDIRA GANDHI INSTITUTE OF DEVELOPMENT RESEARCH

(Members of the Governing Council)

Chairman

Shri R.N. Malhotra
Governor
Reserve Bank of India

Members

Dr. Sukhamoy Chakravarty
Chairman, Economic Council
Government of India
Professor
Delhi School Economics

Dr. M.S. Gore
Professor
Tata Institute of Social Sciences

Dr. P.K. Iyengar
Director
Bhabha Atomic Research Centre

Dr. D. T. Lakdawala
Director, Sardar Patel Institute for Economic Research
Director
Center for Maintaining Indian Economy

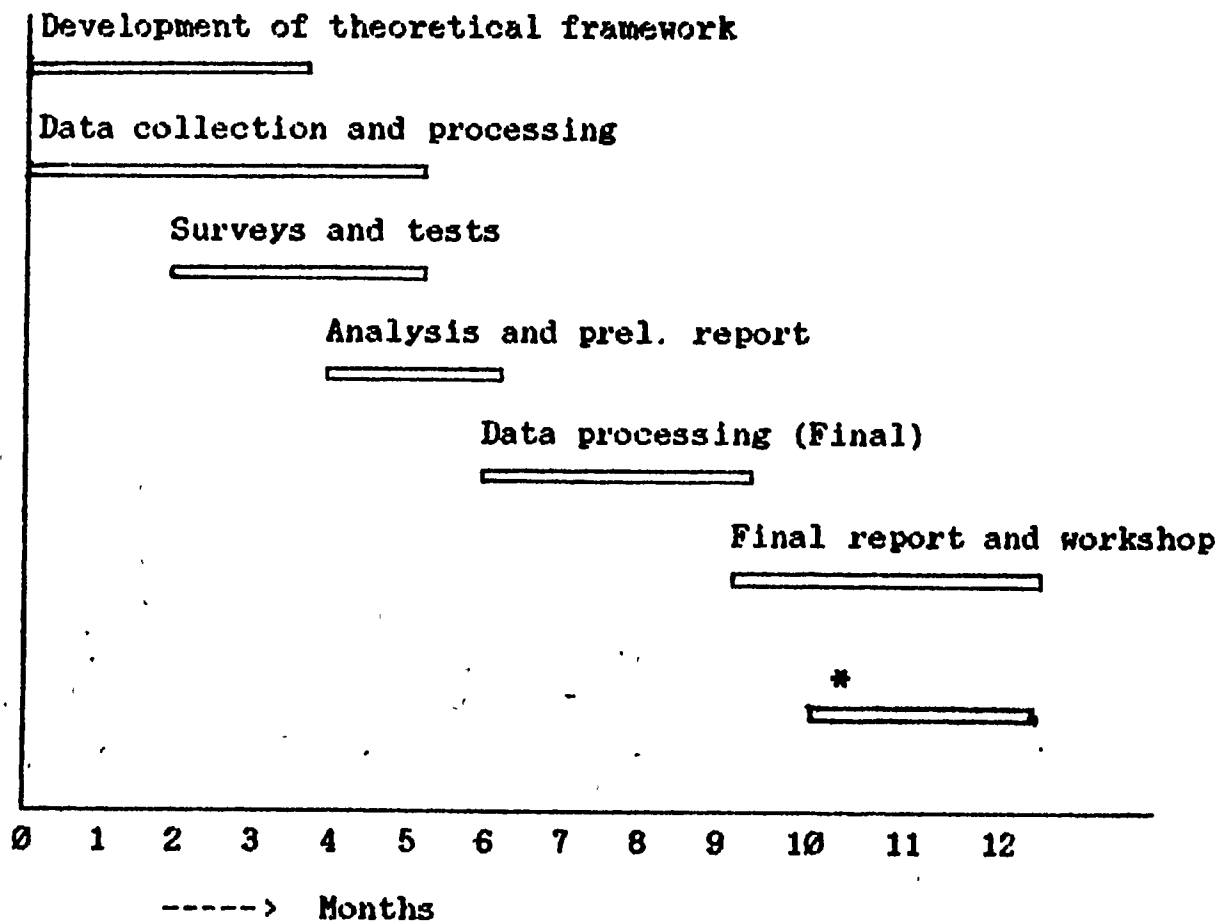
Dr. Kiirit Parikh
Director
Indira Gandhi Institute of Development Research

Dr C. Rangarajan
Deputy Governor
Reserve Bank of India

Annexure - B

INDIRA GANDHI INSTITUTE OF DEVELOPMENT RESEARCH

(Bar chart indicating steps involved and time required)



Bar Chart for the Research Study Project

*Identifying R & D Consortium/prep. work for Consortium project.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

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Agenda Item 5

STATUS OF PROPOSALS UNDER FORMULATION

I. Consortium Projects

	Proposal	Proposer(s)	Project cost (Rs lacs)
a)	Development of coal gasification process for high ash coal	Orien Engineers (P) Ltd. Hindustan Aluminium Corporation Institute of Gas Technology	860.00
b)	Building of prototype 10 KVA, 440V Aeroturbine	Manamar Engineers & Consultants CES Pvt. Ltd.	2.75
c)	Development and demonstration of 30 MWe AFBC boiler	Bharat Heavy Electricals Limited, Tiruchirapally and Ahmedabad Electricity Company Limited	1950.00
d)	Solar thermal power plant with stretched membrane concentrator and stirling power pack	Bharat Heavy Electricals Limited Rudrapur	78.00
e)	Solar powered steam generating system for process industry	Karnataka State Council for Science and Technology	18.00
f)	Demonstration of solar pond for low grade heat	Karnataka Stae Council for Science and Technology	**

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	Proposal	Proposer(s)	Project cost (Rs lacs)
g)	Development of parabolic dish collector decentralised solar thermal power station	Punjab Agro Industries Corporaion Ltd. Lajet Energy Co.	575.00
h)	Development of electrode and membrane cell process for production of caustic soda and chlorine	Central electro-chemical Research Institute	524.09
i)	Development of complete co-generation package with control system based on phased out aero engines	Lotus Energy Systems Pvt. Ltd. National Aeronautical Laboratory Hindustan Aeronautics Ltd.	**
j)	Development of a desiccant cooling system	Metallurgical and Engineering Consul-tants (I) Ltd.	11.00
k)	R&D of industrial and domestic gas flow meters and domestic multifuel gas stove	Total Energy Systems	6.00
l)	Development of enhanced 3 Ton pay load battery bus	Bharat Heavy Elec-tricals Ltd. Bhopal	2.00

	Proposal	Proposer(s)	Project cost (Rs lacs)
m)	Demonstration of a 4 MWe co-generation plant based on controlled combustion technology employing paddy straw/husk as fuel	Punjab Agro Industries Corporation Ltd. PRM Energy System ICB Ltd.	1000.00
n)	Development of Photovoltaic systems for various rural applications (lantern street lights, water pumping)	Suryovonics Ltd. Powerpacks Pvt. Ltd. Polyene General Industries Pvt. Ltd.	222.00
II.	Research Projects		
o)	An extended field experiment on diffusion of fluorescent lamps in doemestic and commercial sector and to assess its impact on utility system	Lawrence Berkeley Laboratory Phillips India Indira Gandhi Institute of Development Research BEST	65.30
p)	Study of coconut residues for energy usage	I.I.T., Bombay	68.00

** Not indicated

Confidential **Agenda Item 5 (a)**

Proposal		Development of a coal-gasifier for Indian coal
Proposer		Orien Engineers Pvt. Ltd. (Lead) (ORIEN) and Hindustan Alumiinium Corporation Ltd. (HINDALCO) and Institute of Gas Technology (IGT)
Brief Description of the Project	:	The proposed project envisages developing the U-gas technology so as to suit Indian coals. The additional features would be ash agglomeration, hot gas clean-up, hot gas burners. Proposed to be iinstalled at Renukoot Works of HINDALCO.
Cost of the project	:	Rs 860 lacs
Duration	:	3 years
Status	:	The profile was placed before the Second ERDAC Meeting held on November 18, 1988. PACER Secretariat held several meetings with proposers representatives. It was felt that before taking up the main project, proposers would test Indian coal atleast for 10 days on either the existing pilot plant of IGT at Chicago, or a gasifier of small capacity (30 TPD) at any Indian research institute like CFRI, RRL or on a small plant set up specially, as a first stage of the project. The cost of such testing/prototype would be a part of the project cost. The proposers are also looking into the possibility of including Coal India Ltd. in the consortium. The proposers were expected to work out the cost economics of each of the alternatives and to send us proposal alongwith detailed application for consideration of the PACER Secretariat. However more than six months have passed and they have not

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yet submitted detailed application to PACER Secretariat.

Meanwhile PACER Secretariat refered the proposal to Dr. Ram Iyengar, Addl. Director General, CSIR who is chairing a working group of Integrated Gasification Combined Cycle Plants for power generation and also had discussion with him on July 13, 1989. He has indicated that Govt. of India has been adressing the problem of using coal gasification for combined cycle power generation in which larger number of national agencies, including CSIR, NTPC, CMPDIL, PDIL etc. are participating. A joint INDO-US programme has been undertaken to study feasibility of using the advanced entrained bed gasification system using high ash Indian coal. Even in the USA, the fluidized bed process, such as U-gas, KRW has not reached the same stage of development as the entrained bed process has. It would therefore be prudent for the private sector in India not to rush into developing a process which has not been fully accepted by the countries of their origin.

Confidential **Agenda Item 5 (b)**

Proposal	:	Building of prototype 10 KVA, 440 V aeroturbine
Proposer	:	Manamar Engineers and Consultants Chandigarh and CES Pvt. Ltd., New Delhi
Brief description of the project	:	Proposers would build an aeroturbine with standard design and materials of constructin. Proposers would carry out tests, generate data and demonstrate use of the equipment for water pumping and agricultural processing operations.
Cost of the project	:	Rs 2.75 lacs
Duration	:	6 months
Status	:	PRC, at its third meeting reviewed the proposal and asked the PACER Secretariat to assess the scpe of the R&D project and examine its innovative content aft er discussion with proposers. Accordingly, the representatives of PACER Secretariat had discussions with the proposers at Chandigarh. PACER Secretariat representatives clarified the procedural aspects of the scheme and the need for further information on the proposal. They also enquired about the innovative content as also into the possibility of expanding the scope of the proposal in order to develop aeroturbines having lower cut in speeds and higher availability in various geographic regions of India. Subsequently, form of applicatin for PACER Secretariat was sent to the proposers. Propsers feel that they would first build the prototype and then, based on trials on it, they would provide data and information necessary to process the proposal.

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Confidential **Agenda Item 5(c)**

Proposal	:	Development and demonstration of 30 MWe AFBC boiler
Proposer	:	Bharat Heavy Electricals Ltd., (Trichy) BHEL Ahmedabad Electricity Co. Ltd.
Brief description of the project	:	BHEL has developed the Atmospheric Fluidised Bed combustion Boilers of steam generation capacities 10-15 t/hr for the process steam generation. Based on this experience, they have designed 165 t/hr., 65 atmosphere pressure system equivalent to 30 MW for power generation. The design has been studied by Tenesse Valley Authority (TVA), USA. The technology is suitable for the high ash Indian coals. Proposed project would demonstrate the working of this 50 MWe Power generating system.
Cost of project	:	Rs. 1,950 lacs
Duration	:	4 years
Status	:	PRC, at its first meeting had cleared the proposal for further development. PACER Secretariat sent the detailed application form to BHEL. BHEL recently sought clarifications regarding the terms and conditions of the assistance under PACER, whcih were provided. AEC has informally conveyed its inability to associate with the project. BHEL has agreed to identify any other suitable consortium member such as Indian Aluminium, Calcutta Electricity Supply Co. etc. who may be interested in the development of the technology. BHEL has simultaneously initiated steps to instal a 30 MWe AFBC boiler in place of the stoker fired boiler in an existing power plant with minor changes in the balancing equipment. The estimated cost of this repowering project is about Rs 4-5 crores. This development would be undertaken by BHEL with its own source of finance.

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Confidential **Agenda Item 5(d)**

Proposal	:	Solar thermal power plant with stretched membrane concentrator, and stirling power pack.
Proposer	:	Bharat Heavy Electricals Ltd. (Rudrapur) BHEL
Brief description of the project	:	The proposer intends to import the stretched membrane concentrator, controls, tracking system and stirling power pack from U.S.A. and install a 15-20 KWe demonstration unit at Rudrapur. Based on the trials and tests on this a 50 KWe stirling power pack system would be designed and commercialised.
Cost of the project	:	Rs 90 lacs
Duration	:	2 years
Status	:	PRC had cleared the proposal at its first meeting for further development. It was clarified to BHEL that as the project would result in a commercial product, the proposal would be considered in consortium R&D category wherein the sponsor would bring in 50% of the finance required. BHEL would be submitting the proposal after clearence from its management and identify a member of consortium (a US company).

Confidential **Agenda Item 5 (e)**

Proposal	:	Solar powered steam generating system for process industry
Proposer	:	Karnataka State Council for Science and Technology (KSCST), Bangalore IISc, Bangalore
Brief description of the project	:	The project envisages development of solar powered steam generating system of 500 kg/hr size for process industry. Project involves development of various components of the system indigenously which include metal absorber, absorber coating collectors, tracking mechanism, etc.
Cost of the project	:	Rs 18 lacs (likely to be increased)
Duration	:	Not indicated
Status	:	At the first PRC meeting, it was indicated that the project may be considered provided a suitable entrepreneur is ready to join as consortium member who later could commercialise the system. KSCST is still in the process of identifying a suitable entrepreneur/manufacturer and user industry in order to form a consortium. Officers from PACER Secretariat called on Shri M. S. Rama Prasad, Director, CREDA, KSCST at Bangalore and had discussion on the project.

Proposal	:	Demonstration of solar pond for low grade heat.
Proposer	:	Karnataka State Council for Science and Technology (KSCST), Bangalore and Deejay Hatcheries Pvt. Ltd., (Deejay), Bangalore.
Brief description of the project	:	Project envisages construction of a solar pond of 20m x 20m (400 sq. m) size adjacent to the incubators. Project would involve setting the pond into operation after developing 3 zones namely storage, gradient and surface zones. The project involves study of variation temperature of pond during the year and study effect of rain, wind etc. on the performance of solar pond.
Cost of the project	:	Rs 3.5 lacs
Duration	:	2 years
Status	:	At the second ERDAC meeting it was indicated that the above proposal may be developed considering the scope of the concept for wider application in rural economy. KSCST was accordingly requested to provide detailed proposal. KSCST later informed that there was a change in Management at Deejay and hence it may take some time to formulate the proposal. Officers from PACER Secretariat called on Shri M. S. Rama Prasad to discuss the status of formulation of the proposal. It was informed that Deejay has some reservations about the solar pond technology and would like to study effect of salt content in the pond on the neighbouring soil before taking up the proposal. In order to expedite formulation of proposal on solar pond, PACER Secretariat had written to M/s. Tata Chemicals Ltd. to form a consortium with R&D institutes like I.I.Sc. or TERI. PACER Secretariat has planned a visit to solar pond being set up by GEDA and TERI at Bhuj. Efforts would be made thereafter to formulate a suitable consortium R&D proposal by associating an end user.

Confidential **Agenda Item 5 (g)**

Proposal	:	Development of parabolic dish collector decentralised solar thermal power station.
Proposer	:	Punjab Agro Industries Corporation Ltd. (PAIC), Lajet Energy Co. (USA)
Brief description of the project	:	Project envisages development of parabolic dish collector, tracking system and stirling power pack for decentralised power generation plant of 1-5 MW capacity.
Cost	:	Rs 575 lacs
Duration	:	2 years
Status	:	PRC at its first meeting reviewed the profile and its comments were as follows : Proposer does not have R&D background and engineering base. The data on life of the plant is not available. Some development work has already been carried out by Lajet but such systems have not been proved to be commercially viable. Suitable stirling powerpacks need to be developed for this capacity and clear perception of market in India is necessary. PACER Secretariat conveyed these to the proposers. PAIC was to get in touch with PACER Secretariat in the matter. Meanwhile it has submitted a proposal for demonstration of 4 MWe cogeneration plant using paddy straw which is under active consideration.

Confidential **Agenda Item 5 (h)**

Proposal	:	Development of Electrodes and membrane cell process for production of caustic soda and chlorine.
Proposer	:	Central Electro-chemical Research Institute (CECRI), Karaikudi
Brief Description of the project	:	It is proposed to develop composite cationic exchange membranes indiigenously and modify the electrodes suitably. The project envisages 10 KA capacity, monopolar and bilpolar membranes and 72 KA monopolar membranes.
Cost of the project	:	Rs 524.09 lacs
Duration	:	3 years
Status	:	After the first PRC Meeting, PACER Secretariat asked for clarifications on the details of consortium members especially the manufacturer, who would commercialise the technology later. Details of actual work envisaged were also requested. The proposers have not yet sent the clarifications or reply to subsequent reminders.

Confidential **Agenda Item 5 (i)**

Proposal	:	Development of complete co-generation package with control system based on phased out aero-engine.
Proposers	:	Lotus Energy Systems Pvt. Ltd. (Lotus) National Aeronautical Laboratory (NAL) Hindustan Aeronautics Ltd (HAL)
Cost of the Project	:	Being finalised
Duration	:	One year
Status	:	At the Second Meeting of ERDAC held on November 18, 1988 an outline of the Proposal was placed, ERDAC had cleared the profile for formulation of a detailed proposal for consideration of PRC. Lotus, accordingly, has taken steps to develop the proposal which is now proposed to be undertaken in two phases jointly with NAL and HAL, PACER Secretariat has indicated that research award upto 50% of the cost of phase I in the form of grant could be considered.

Confidential **Agenda Item 5(j)**

Proposal	:	Development of a desiccant cooling system
Proposer(s)	:	Metallurgical and Engineering Consultants (India) Ltd.
Brief description: of the project		The proposal envisages development of 2 desicant cooling systems of 1.5 kw and 1.5 kw sizes. These would be based on utilisation of waste heat from industries or solar energy. Prototypes would be designed, fabricated and tested in laboratory as well as at an actual users site.
Cost of project	:	Rs. 11 lacs
Duration	:	3 years
Status	:	The profile of the project was reviewed by PRC at third meeting held on March 27, 1989. Thereafter PACER Secretariat sent the format of detailed application form to MECON. Proposers submitted the detailed proposal in July 1989 on which PACER Secretariat has raised a few queries and reply from MECON is awaited.

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Confidential **Agenda Item 5 (k)**

Proposal	:	R&D of industrial and domestic gas flow meters and domestic multifuel gas stove.
Proposer(s)	:	Total Energy Systems (TES)
Brief description: of the project		Development of turbine type domestic gas flow meter and domestic multifuel stove with variable annular orifice.
Cost of project	:	Rs. 6 lacs
Duration	:	12 months
Status	:	Profile was reviewed at the fourth PRC meeting when the scope of the project was curtailed to the above two items. The proposer has been advised to formulate the project accordingly which is awaited. PACER Secretariat has indicated that research award up to 50% of the cost of project in the form of grant could be considered.

Confidential **Agenda Item 5(1)**

Proposal	:	Development of enhanced capacity 3 ton payload battery bus
Proposer	:	Bharat Heavy Electricals Ltd. Bhopal
Brief description of the project	:	The project envisages development of components such as chasis, chopper controller etc required for the battery driven bus. BHEL proposes to develop the components using the designs of existing components of1.2 T pay load buses with improvement in their efficiency and performance.
Cost of project	:	Rs. 52 lacs
Duration	:	One year
Status	:	The PRC at its fourth meeting on June 28, 1989 cleared the profile of the project. PACER Secretariat has sent a format of application to BHEL and reply is awaited.

Confidential **Agenda Item 5(m)**

Proposal	:	Demonstration of a 4 MWe co-generation plant based on controlled combustion technology employing paddy straw/husk as fuel.
Proposer(s)	:	Punjab Agro Industries Corporation Ltd., ICB Ltd. and PRM Energy Systems, USA.
Brief description:		It is proposed to demonstrate a plant for generating 2.5 MW power and 8T/hr of process steam using paddy straw/husk as fuel. The plant would employ controlled combustion technology wherein the gasification of biomass is achieved by feeding at controlled rate and mechanical agitation by screw conveyor. The gas would be fired in a combustion tube of the boiler and the heat would be used to generate superheated steam. Power generation would be done by a condensing/extractive type of turbine generator set.
Cost of project		Rs 1000 lacs
Duration	:	2 1/2 years
Status	:	The proposal was reviewed at the 4th meeting of PRC on June 28, 1989. PRC's observations were as follows :

i) Prior to importing the required Turbo Generator (TG) set having condensing turbine with intermediate steam extraction facility, indigenous availability of such equipment with respect to its cost, delivery schedule and performance levels/parameters may be thoroughly explored and compared to the proposed imported equipment.

ii) Arrangement and mechanism for procurement, collection, storage and assured supply of fuel (i.e. rice straw) may be scrutinised;

iii) To ensure proper acquisition/absorption, assimilation and further development of technology, a suitable memorandum

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Agenda Item 5 (n)

Proposal	:	Development of photovoltaic systems for various rural applications consisting of lantern, street, lighting and water pumping.
Proposer(s)	:	Suryovonics Ltd., Powerpacks Pvt. Ltd. and Polyene General Industries Pvt. Ltd.
Brief description:		The proposed project envisages development of electronic ballast, energy efficient storage battery and balancing system for rural applications in lighting and water pumping based on photovoltaic (PV) power supply. Suryovonics Ltd. (SL) would provide Amorphous Silicon PV modules from the production of the same in an export oriented Unit (EOU) which it is setting up in collaboration with Energy Conversion Devices Inc, USA. The project envisages developing Nickel Hydride storage batteries for terestrial applications based on technology of M/s Ovonics Inc., USA. The electronic ballast would be developed for controlling and inverting of power generated from PV supply. The project would lead to solar lantern, street lighting system, irrigation pumps and drinking water packages for villages.
Cost of project	:	Rs 222 lacs
Duratioon	:	2 years
Status	:	PRC reviewed the proposal at third meeting held on March 27, 1989 and its observations were as follows :

- The terms and conditions of the license issued to SL needs to be studied carefully in order to verify the availability of 25% of the ASi PV modules for local use for the proposed R&D project.

- Scope of project should be limited to development of ballast/inverter, storage battery and components for lighting and pumping applications.

- necessity of approvals from government for manufacture of Nickel Hydride batteries should be explored

- sources and means of financing for EOU project for manufacture of ASi PV modules as also for R&D project need to be examined carefully.

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In view of the above observations, proposers, in consultation with PACER Secretariat, revised the scope of project and limited it only to lighting and pumping applications. This resulted in a reduction of Rs. 40 lacs in the project cost. As explained earlier, there is further reduction of Rs 38 lacs from the original cost estimate of the R&D project cost, resulting in a total reduction of Rs. 78 lacs . Thus, the estimated cost is revised (from Rs 300 lacs) to Rs 222 lacs.

PACER Secretariat now proposes to ascertain the adequacy of technical arrangements in respect of Ni-hydride batteries, submersible/floating pumps, DC motors, fluorescent lamps and such other components which may be crucial to the systems' development and also progress of setting up EOU project.

Confidential **Agenda Item 5(o)**

Proposal	:	An extended field experiment on diffussion of fluorescent lamps in the domestic and commercial sector and to assess its impact on the utility system.
Proposer	:	Lawrence Berkeley Laboratory (USA) Peico Electronics and Electricals Ltd. Indira Gandhi Institute of Development Research BEST
Brief Description of the project	:	The proposed Research project envisages study of existing lighting load in a district in south Bombay. Thereafter suitable imported fluorescent lamps and fittings would be installed and load characteristics would be compared with the existing systems to ascertain the impact of change.
Cost of project	:	Rs. 65.30 lacs (US $ 4,00,000)
Duration	:	2 years
Status	:	PRC reviewed the profile of the project at its fourth meting on June 28, 1989 and suggested that such a study could be supported jointly by a few agencies such as Energy conservation fund, DNES, DESU, DEDA. PACER and the proposers themselves. PACER Secretariat has conveyed these observations to the proposers and reply is awaited.

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Agenda Item 5(p)

Proposal	:	Study of coconut residues for energy usage
Proposer	:	Indian Institute of Technology, Bombay
Brief description of the project	:	The proposal envisages study of gasification/ combustion related properties of coconut residues and would lead to design and development of utilisation equipment for in site installation
Cost of project	:	Rs. 68 lacs
Duration	:	3 years
Status	:	PRC reviewed the profile of the project at its fourth meeting in June 28, 1989. It was indicated that the scope and cost of the project should be reduced. PACER Secretariat has conveyed PRC's observations to the proposer and reply/revised proposal is awaited.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

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Agenda Item 6

Proposals not qualifying for assistance under PACER

Proposal	Proposer(s)	Remarks
Development and Commercialisation of 1) High Velocity recirculation furnaces 2) Flameless furnaces 3) Low excess air burners 4) Self recuperative burners 5) Flat flame burners	ENCON furnaces (P) Ltd.	The proposals are in the nature of technology transfer from U.K.
6) Analysis of Dynamic Behaviour of bladed discs	Bharat Heavy Electricals Limited Hyderabad	Sponsoring candidate for Phd. at Carnegi Melon Univ. USA not considered supportworthy under PACER
7) Development of 10 Kw molten carbonate fuel cell system based on internal	Bharat Heavy Electricals Limited Hyderabad	BHEL has been developing a Phosphoric Acid Fuel Cell (PAFC) system for over 3 yrs and made certain progress on it. Once BHEL makes a commercially demonstrable PAFC system of 5 to 10 KW range, the proposal on developing next generation of fuel cell (i.e. Molten Carbonate variety) can be looked into

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Proposal	Proposer(s)	Remarks
8) Retrofitting of a coal gas based combined cycle plant to a 60 MWe thermal power station	Bharat Heavy Electricals Limited Hyderabad	Besides substantial investment (Rs 30 crores) involved in the project, there are three other proposals from BHEL in the pipeline for consideration
9) Proposal to manufacture solar refrigerators in India	ERGON Enterprises	This is a case of technology transfer
10) Generation of Commercial Energy Resource through bio-technology	Burn Standard Co. Ltd	Proposal is considered non-viable for power generation
11) Development of structured packings	Engineers India Ltd.	Proposal is not relevant to the energy field
12) Rice Husk for power generation	Madhuri Enterprises	This is a case of Technology transfer
13) Development of small capacity (5t/hr.) AFBC Boilers	Industrial Boilers Pvt. Ltd	Proposal is for technology transfer. Product commercially devloped by other manufacturers for the same capacity
14) Development of high preheated air burners suitable for high back pressure	Industrial Boilers Pvt. Ltd.	Project is in the nature of Technology Transfer from U.K.

Proposal	Proposer(s)	Remarks
15) Individual spindle drives for spinning frames	Ahmedabad Textile Industries Research Association	Projects are not of much significance to the energy sector.
16) Use of Non-conventional Energy sources for textile processing	- do -	
17) Energy efficient coating process with Electron Beam Technology	Transworld Associates and consultants	Technology is already developed. Proposal involves import of major equipment
18) Generation of methane from mini paper mill effluents	Rohit Pulp and Paper Mills Ltd	Proposal is mainly for effluent treatment and not commercially viable
19) Establishing a cell for Renewable Energy Prototype Development, adaptation Certification, Testing and standardization	Tata Energy Research Institute	Establishment of testing facilities not included in PACER scheme
20) Development of leak sealing Compounds based on various polymer and blends	The National Insulated Cable Co. of India Ltd	Proposal not directly related to energy field
21) Development of Biomass and biogas liquefaction and bottling process.	Collective Rural Development in India	Process has been already commercialised
22) Development of 200 Kw horizontal Axis Wind Electric Generator	Bharat Heavy Electricals Ltd. Hyderabad	The product is commercially available abroad, extent of technology development is not clear

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Proposal	Proposer(s)	Remarks
23) Development of software for advanced control systems for process industry	Engineers India Ltd.	Proposal not directly related to energy field
24) Silicon Carbide Ceramic tubes	Thermax Pvt. Ltd	The proposal is not of direct relevance to PACER concept. The developmental effort involved in the project is negligible
25) LiBr-Water Absorption Chiller	Thermax Pvt. Ltd	The company has collaboration with Sanyo of Japan for LiBr water system. The devlopmental and innovative content is negligible. Whether modification equipment is out of purview of PACER
26) Development of air to water heat pump water heaters	Solaren Technology Pvt. Ltd Melk engineers	In view of doubtful capabilities of proposers and lack of scientific approach to the problem, the proposal was not considered supportworthy.
27) Development of pilot scale biomass pyro-gasifier	Unique Fuelex (I) Pvt. Ltd Dhawalgiri Health Foods Pvt. Ltd.	As the main proposer does not have capability and resources to undertake the development project, PRC considered the proposal not supportworthy.

Proposal	Proposer(s)	Remarks
28) Development of Process for manufacture of building material from flyash	Ahmedabad Electricity Co. Ltd.	The committee observed that the proposal has no direct relevance to the energy sector and hence not considered supportworthy.
29) Development of energy efficient high temperature ladle driers for steel plants and metallurgical industries	Wellman Incadescant India Ltd. Tata Iron and Steel Co. Ltd	As the collaborators of the main sponsor has already developed the proposed product, the proposal was found to be in the nature of technology transfer, and hence, considered not supportworthy.
30) Development of 40-275 KW power generation system based on briquetting and gasification of biomass residues	Tata Energy Research Institute Solar Sciences Consultancy (P) Ltd.	The PRC felt that until the results of the proposal from Ankur Energy and Development Alternative are known, support to such proposals may be deferred.
31) Developemnt of heat pump assisted air-to-air dehumidifier and air to water geyser	Balmer Lawrie and Co. Ltd and National Chemical Laboratory	As Balmer Lawrie & Co. is not in the field of manufacture of compressors, the PRC felt that the proposed consortium does not have suitable background to take up such R&D project. Hence, the project was not considered supportworthy.

Proposal	Proposer(s)	Remarks
32) Conversion of bullock and human energy to electrical energy through generation of compreessed air	Fluidomat Ltd	In view of uncertain prospects for commercialisation as also the work accomplished at other organisations such as NITIE, Bombay and Murugappa Polytechnic. PRC considered the proposal not supportworthy.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

Confidential

Agenda Item 7

NOTE FROM PACER SECRETARIAT

PACER CONFERENCE

At the second ERDAC meeting held in November 1988, the proposal to hold PACER Conference with participation of experts from U.S. and India was considered. It was indicated that the Conference would be arranged during March-April 1989. While ERDAC approved the proposal in principle, the committee had desired a reduction in the overall budget for the Conference and had authorised PACER Secretariat to finalise the arrangements and the budget in consultation with the Secretary, ERDAC.

PACER Secretariat had a series of discussions with Dr. J. Gururaja, Secretary, ERDAC, Dr. R. K. Pachauri, Dr. David Jhirad and S. Padmanabhan on the subject and a revised statement of work by U.S. consultants was drawn and the budget for their services was finalised in consultation with the Secretary, ERDAC which is provided in Annexure A.

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As ERDAC is aware, Tata Energy Research Institute (TERI), New Delhi has been entrusted with the responsibility of broadly structuring the Conference, identifying topics for preparing research papers as also with arrangements for organising the Conference. While TERI will be contributing eight papers based on rsearch projects, National Productivity Council and Bharat Heavy Electricals Limited would be contributing one paper each based on their work. The Steering Committee for PACER Conference has also decided to invite representatives of Korea Electric Power Company (KEPCO) and Electricity Generation Authority of Thailand (EGAT) who would present a paper each at the Conference. Their participation is considered useful for sharing of experience in the light of significant advances made by them.

At the third meeting of the Steering Committee held on July 12, 1989 the progress of preparation for the Conference was reviewed. Annexure B provides a summary of discussion at the meeting as also the revised agenda.

PACER Conference is now scheduled to be held on February 2 and 3, 1990 at New Delhi. While the preparation for the Conference on the Indian side is quite satisfactory, it is necessary to review the work initiated by the U.S. consultants. Dr. David Jhirad is expected to attend the ERDAC meeting and inform the committee about the status of contract to be awarded to U.S. consultants for procuring their services and the consequent preparation of research papers for the Conference.

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Annexure H

STATEMENT OF WORK

PACER Conference Preparation and Participation

OAK RIDGE NATIONAL LABORATORY

Through the Energy Policy Development and Conservation (EPDAC) Project of the A.I.D. Office of Energy, Science and Technology Bureau (S&T/EY), the Oak Ridge National Laboratory (ORNL) will provide technical support to the Project to Accelerate the Commercialization of Energy Research (PACER).

This assistance will be accomplished through a collaborative effort with S&T/EY. The period of performance will be January 1 through December 31, 1989.

Specifically, ORNL will provide technical assistance to PACER in the following areas:

1. Preparation of topical papers for presentation at the PACER Conference, by ORNL staff and consultants,

2. Participation in PACER Conference Editorial Review Board to review conference papers and presentations by U.S. conference participants, and

3. Assistance to S&T/EY in organization and preparation of the PACER conference

1. Topical Papers

In support of the preparation of expert topical papers, ORNL shall be responsible for:

a. Development of preliminary/indicative outlines of the topical papers to be contributed by U.S. participants,

b. Major contributions to topical paper on the role of the National Laboratories in fostering power systems innovation,

c. Major contributions to topical paper on Transmission and Distribution Technology Innovations,

d. Major contributions to topical paper on the U.S. Experience with the Commercialization of Wind Electric and Photovoltaic Power Technologies,

e. Participation in critical editorial review of the topical papers by U.S. conference participants, and

f. Development of background information on successful commercialization of advanced power technology and on peak load pricing experience in the U.S.

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2. Editorial and Word Processing Support

An Editorial Review Committee has been established to review Indian and U.S. contributions to the PACER Conference. The projected makeup of the PACER Conference editorial review committee is:

Dr. David Jhirad, U.S.A.I.D. (Co-Chairman)
Dr. R. K. Pachauri, TERI (Co-Chairman)

Mr. S. S. Betrabet (I.C.I.C.I.)
Dr. J. Gururaja, DNES
Mr. S. Padmanabhan, U.S.A.I.D./New Delhi
Mr. Alain Streicher, Hagler Bailly
Dr. P. H. Vaidya (I.C.I.C.I)
Dr. Jerome Weingart, L.B.L.
Dr. Thomas Wilbanks, ORNL

Dr. Thomas Wilbanks shall serve as a member of the Editorial Review Board, and participate in editorial review committee meetings in the U.S.

ORNL shall provide high-quality camera-ready versions of the topical papers, including all text, graphics, and photographs, and shall prepare similarly high-quality presentation materials for each of these papers. One master set of presentation materials (e.g. overhead transparencies, slides, videotapes if any) shall be provided to I.C.I.C.I.

3. Conference Organization

ORNL will support S&T/EY in planning and organization the conference.

4. Budget and Funding

It is understood that these activities will be supported by a cost-sharing arrangement between A.I.D./New Delhi and S&T/EY. The total budget for calendar year 1989 for the activities indicated in Tasks 1, 2, and 3 above is $ 86,063.00

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PACER CONFERENCE BUDGET - Oak Ridge National Laboratory -
(Funding for CY 1989 Only)

TASKS	ORNL LABOR COSTS: Sr. Mgr. (500/d)	Staff (372/d)	Assoc. (372/d)	Conslt (421/d)	ORNL Labor	OTHER DIRECT COSTS: Partic. Hnraria	Int'l Tvl, PD	Dmstc Tvl, PD	Mtls & Srvcs	Communi-cation	ORNL OH on ODC	Total ODC	TOTAL
1 - Pricing TP	0	1,116	0	0	1,116	5,000	0	0		0	400	5,400	$6,516
2 - T&D TP	0	0	13,020	0	13,020		4,550		1,500		2,329	8,379	$21,399
3 - Wind TP	0	0	0	4,633	4,633		4,550	0			1,752	6,302	$10,935
4 - Commerc. TP	0	0	0	0	0						0	0	$0
5 - Edit Support	1,500	1,340	0	1,264	4,104			0			0	0	$4,104
6 - Conf. Plng.	3,000	5,208	0	1,685	9,893			3,000			1,155	4,155	$14,048
7 - ORNL Paper	10,000	5,000	0	0	15,000		4,550				1,752	6,302	$21,302
8 - Conf. Partic	3,000	0	2,232	2,527	7,759		0	0			0	0	$7,759
SUBTOTAL	17,500	12,664	15,252	10,109	55,525	5,000	13,650	3,000	1,500	0	7,388	30,538	$86,063
DAYS	35	34	41	24	134								

$86,063 = Total ORNL Budget for CY 89, including $35K S&T/EY contribution

Note: Labor rate = $240/day * (1.20 + 1.35) = $372/day
Note: Overhead on ODC = 38.5%
Note: Consultant daily rate ($390) multiplied by 1.08

STATEMENT OF WORK

PACER Conference Preparation and Participation

RCG/HAGLER BAILLY

The Contractor shall support S&T/EY in the preparations for the PACER Conference on Power Sector Innovation, to be held in New Delhi, India in the Fall, 1989. In addition, the Contractor shall participate in the conference through preparation and presentation of an expert paper as described below.

SUMMARY

Support to S&T/EY in preparation of the conference shall include the following tasks:

1. Support of all travel and associated logistical arrangements for six to ten U.S. participants, including two Contractor senior staff members.

2. Editorial and word processing support for papers prepared by U.S. participants, in collaboration with S&T/EY and Oak Ridge National Laboratory (ORNL)

3. Graphics support for papers prepared by some of the U.S. participants

4. Procurement of suitable equipment and supplies for producing and displaying high quality graphics at the conference (see Attachment A)

5. Editorial review of papers and presentation graphics of U.S. participants, in collaboration with S&T/EY and ORNL.

6. Preparation of an expert paper mainly on the U.S. experience, but possibly including some selected examples of LDC experience, with end-use electric energy efficiency and load management.

7. Presentation of the expert paper at the conference

The projected makeup of the PACER editorial review committee is:

Dr. David Jhirad, U.S.A.I.D. (Co-Chairman)
Dr. R. K. Pachauri, TERI (Co-Chairman)

Mr. S. S. Betrabet (I.C.I.C.I.)
Dr. J. Gururaja, DNES
Mr. S. Padmanabhan, U.S.A.I.D./New Delhi
Mr. Alain Streicher, Hagler Bailly
Dr. P. H. Vaidya (I.C.I.C.I)
Dr. Jerome Weingart, L.B.L
Dr. Thomas Wilbanks, ORNL

As discussed under Task 6 below, the Contractor and S&T/EY shall jointly arrange a two-day meeting of the editorial review committee in Washington, DC in 1989. The exact dates will be determined in concert with S&T/EY. No travel-related expenses to HBI are anticipated in connection with the participation of editorial review committee members.

3. Graphics Support

Many conferences have presentations in which the graphics (slides, overhead transparencies) are of poor quality. For the PACER conference, the Contractor shall provide high quality graphics for the presenters, both as black and white hard copy for inclusion in the conference proceedings, and professional quality 35mm color slides using appropriate PC-based graphics software.

Color slides shall be produced using professional graphics service bureau support. Development of high quality graphics for both presentation and report purposes will require that the graphics expert work closely with the authors

In some cases, notably for participants from EPRI and from some of the electric utility companies and industries, authors will be able to have professional quality graphics produced in-house. In this case, the Contractor, in consultation with S&T/EY, shall distribute a set of guidelines and examples for both the color and black and white graphics for the presentations and papers. The Contractor and the Editorial Review Committee will review the graphics and suggest any necessary modifications.

4. Procurement and Shipment of Equipment and Supplies

The Contractor shall procur equipment and associated supplies for use by A I.D./New Delhi for preparation of high quality graphics materials for use by the U.S. and Indian participants in India. The Contractor is also responsible for packing and shipping the equipment to the U.S.A.I.D. Mission in New Delhi. This equipment will be used for the PACER conference and for subsequent preparation of graphics materials for the PACER project. A list of the required equipment, by type, with suggested manufacturers and models, is presented in Attachment A.

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5. Meeting of PACER Editorial Review Committee, Washington, DC (1989)

The Contractor shall participate in a two-day meeting of the PACER Editorial Review Committee, to be held in Washington, DC at an appropriate time in 1989. The purpose is to review the draft papers and presentation materials, and propose specific modifications, if required. The Contractor, in consultation with S&T/EY, shall arrange a suitable location for the meeting and provide advance copies of the papers and presentation materials to the members of the editorial review committee.

The Contractor will not be responsible for any travel-related costs.

6. Preparation of an expert paper on U.S. (and possibly selected LDC) experience with diffusion of end-use electric energy efficiency and load management techniques

The Contractor shall prepare and present at the PACER conference an expert paper on the experience mainly within the U.S., though possibly with selected developing country examples, with the introduction and diffusion of electricity end-use efficiency and load management technologies and strategies.

7. Conference Participation

Two of the Contractor's senior staff members shall participate in the PACER conference, and present the paper referred to in Task 7.

BUDGET

A total budget of $ 117,752.00 is allocated.

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ATTACHMENT A

GRAPHICS EQUIPMENT FOR USE BY A.I.D./NEW DELHI

1. Xerox Model 4020 color inkjet printer or equivalent
2. Polaroid PalettePlus (EGA-compatible) color slide maker
3. Polaroid instant color slide film developer
4. Kodak, Dukane, or equivalent transparent liquid crystal display unit (designed for use with a conventional overhead projector)
5. Serial "smart" cable to connect IBM-compatible PC and the overhead display unit
6. Supplies, including
   a. 200 sheets of overhead transparencies (for use with color inkjet printer)
   b. Color and black inkjet cartridges
   c. 4 boxes of inkjet printer paper (continuous fan-fold)
   d. 20 rolls Polaroid instant 35mm color slide film

Item	Estimated Cost
1. Xerox 4020 color inkjet printer	1,200.00
2. Polaroid PalettePlus	2,700.00
3. Polaroid instant color slide film developer	200.00
4. Overhead LDC display unit	1,200.00
5. "Smart" serial cable	100.00
6. Supplies	
o 200 sheets inkjet overhead transparencies	250.00
o Color and black inkjet printer cartridges	500.00
o 4 boxes fanfold inkjet printer paper	120.00
o 20 rolls Polaroid 35mm instant color slide film	200.00
7. Shipping to India	1,000.00
TOTAL	**$7,470.00**

PACER CONFERENCE BUDGET - RCG/HAGLER BAILLY

TASKS	RCG/HB LABOR					OTHER DIRECT COSTS									TOTAL
	S.V.P. (800/d)	Coord. (600/d)	Assoc. (450/d)	Admin. (297/d)	HBI Labor	Partic. Hnraria	Partic. Tvl, PD	HBI Tvl, PD	Equip., Shipping	Graphics	Xerox	Communi-cation	HBI Fee & G&A on ODC	Total ODC	
1&2 - Logistics	800	1,200	900	1,500	4,400	7,000	27,300					1,000	3,036	38,336	$42,736
3 - Edit, WP	1,600	5,400	4,500	1,500	13,000						500	500	86	1,086	$14,086
4 - Graphics		1,200	0	0	1,200					10,500			903	11,403	$12,603
5 - Equipment			900	150	1,050				7,500				645	8,145	$9,195
6 - Edit. Rev.	1,600	3,600	1,800	600	7,600		0				0		0	0	$7,600
7 - HBI Paper	8,000	1,800	1,800	300	11,900								0	0	$11,900
8 - Conf. Partic	9,600			150	9,750			9,100					783	9,883	$19,633
SUBTOTAL	21,600	13,200	9,900	4,200	48,900	7,000	27,300	9,100	7,500	10,500	500	1,500	5,452	68,852	$117,752
DAYS	27	22	22	14	85										

$117,752 = Total RCG/Hagler Bailly Budget

SVP = Senior Vice President
Coord. = Coordination Specialist
Assoc. = Technical Associate
Admin. = Administrative Support

Note 1: 6 days @ $125/day, R/T air fare = $3,800 for all travel
Note 2: 4-6 non-HBI participants plus 2 partic. orig. under ORNL budget
Note 3: Pan Am C Class Oct 89 SFO/DEL $4,190 IAD/DEL $3,426 Average = $3,800

Annexure B

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

PACER CONFERENCE

Third Meeting of Steering Committee
(Summary of Discussion)

The third meeting of the Steering Committee was held on July 12, 1989 at 12.00 noon at Tata Energy Research Institute (TERI), 7 Jor Bagh, New Delhi. Following persons attended the meeting :

Dr. J. Gururaja	-	Chairman	
Shri S. S. Betrabet	-	Member	
Shri S. Padmanabhan	-	Member	
Dr. P. H. Vaidya	-	Secretary	
Dr. R. K. Pachauri	-	TERI	Invitees
Dr. V. V. N. Kishore			
Ms. Leena Srivastava			
Shri J. R. Meena	-	DNES	
Shri B. A. Bhatt	-	ICICI	

Leave of absence was granted to Dr. David Jhirad. The following is a summary of discussion at the meeting.

Dr. Pachauri informed the Committee that he had a meeting with Dr. David Jhirad in Washington when preparation for the Conference was reviewed. Dr. David Jhirad indicated to him that there was delay in awarding contracts to Oak Ridge National Laboratory (ORNL) and Hagler, Bailly Inc. (HB) for preparation of research papers for the Conference. Shri Padmanabhan informed

that the contracts would be finalised by mid-July 1989. Based on this, the schedule for the PACER Conference to be held in New Delhi has been tentatively revised to February 2 and 3, 1990.

Highlighting the importance of PACER Conference, Dr. Gururaja observed that the Steering Committee should be enlarged with representatives from concerned departments of the Government such as Power, Coal, DNES, Energy Conservation, etc. Their association and involvement would go a long way in achieving the overall objectives of the Conference. Dr. Pachuari was requested to contact the concerned departments, brief them on the PACER Conference and also get their nominees on the Steering Committee.

The Committee agreed that the focus of all the papers to be presented at the Conference would have to be on identification of project ideas for promoting consortia R&D projects under PACER as also on various policy matters concerning energy. It was felt that this matter should be borne in mind while finalising the research papers.

Dr. Pachauri informed the Committee that TERI's work on preparation of research papers was in advanced stage of completion and TERI has been in touch with NPC and BHEL with regard to their papers on Energy Conservation and Coal Technologies respectively.

The Committee discussed at length enclosed agenda for PACER Conference and suggested some changes in titles. Dr. Pachauri agreed to incorporate them and circulate a revised

programme shortly. Similarly it was agreed to finalise the detailed programme of the Conference (especially names of guests to be invited for inaugural and Chairmen for various technical sessions) at a later date. Dr. Pachauri agreed to prepare a brief report reviewing the progress of preparation for PACER Conference which would be placed before the ensuing meeting of Energy Research and Development Advisory Committee (ERDAC).

PACER CONFERENCE AGENDA (REVISED)
New Delhi

FIRST DAY

09.00-10.00 Inaugural Session / Welcome and Introduction to the Programme for the Commercialization of Energy Research (PACER)

10.00-10.30 Tea Break

10.30-11.30 PLENARY SESSION: **Innovation in the Electric Sector - New Strategic Opportunities**

- High Capital Productivity in the Power Sector: Issues and Challenges for India (Dr. R.K. Pachauri, Tata Energy Research Institute)
- Innovative Solutions to Power Sector Problems - A Mandate for Decision Makers? (Dr. David Jhirad, U.S. Agency for International Development)

11.30-13.00 PANEL DISCUSSION - **Innovation - Its success and role in financing power development**

- Chairman, ICICI
- Electric Power Research Institute (USA)
- Dr. Eugene McCarthy (World Bank)
- Ministry of Energy (India)
- Dr. Makarand Dehejia (IFC)

13.00-14.00 LUNCH

14.00-15.30 Parallel Sessions

Session 1A - **ADDRESSING THE PEAK LOAD PROBLEM**

- U.S. Experience with Innovative Peak Load Management and Pricing Strategies (EPRI, Florida Power and Light, PG&E,...)
- Innovative Pricing Possibilities in India (Dr. Bhaskar Natarajan)
- Optimal Investment Planning Under Capital Constraints (Dr. Peter Meier)

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Session 1B - RENEWABLE ENERGY STRATEGIES

- Commercializing Solar Water Heating Technology in India and its Impact on Peak Load (Dr. K. Thukral)

- Case Studies on Decentralized Power Production in India

  - Biomass (Dr. V.V.N. Kishore)
  - Photovoltaics (Dr. T.K. Bhattacharya and Ms. Akanksha Dubey)

- Commercialization of Wind Electric and Photovoltaic power Generation Technologies in the U.S. (Dr. Jerome Weingart)

- Experience with and Potential for Wind Farms in India (Dr. V.V.N. Kishore and Mr. Jami Hossain)/DNES

15.30-16.00 Tea/Coffee Break

16.00-17.30 Parallel Sessions

Session 2A - ADVANCED COAL BASED TECHNOLOGIES

- Commercialization in the United States

  - AFBC (EPRI or U.S. electric utility representative)
  - IGCC (Mr. Neville Holt, EPRI)
  - Coal Beneficiation in the United States

- Commercialization in India

- Discussion from the floor (speakers as panelists)

Session 2B - T&D and Power Electronics

- Innovative Transmission and Distribution Technologies (U.S. author)

- Improvement in Transmission and Distribution Systems in Korea (KEPCO representative)

- Improvement in Transmission and Distribution Systems in Thailand (EGAT Representative)

- Improvement in Quality of Power Supply

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SECOND DAY

09.00-10.30 **PLENARY SESSION (Chair: India)***

- U.S. Experience and Prospects: Research, Development, and Renewables (Dr. Richard Balzhiser, Electric Power Research Institute)

- The U.S. Department of Energy Experience in Energy Technology Innovation and Commercialization (Senior USDOE Representative)

- The Role of the U.S. National Laboratories in Development and Commercialization of Advanced Energy Technologies (Dr. Thomas Wilbanks, Oak Ridge National Laboratory) Suggested Topic

10.30-11.00 Tea/Coffee Break

11.00-13.00 Parallel Sessions

Session 3A - **"ENERGY EFFICIENCY STRATEGIES - SUPPLY**

- Review of Technologies for Energy Efficiencies in India (Mr. G. Sambasivam)

- Experience in Implementing Innovative Energy Conservation Technologies - case studies (National Productivity Council)

- Developing and Commercializing Cogeneration Technology in the U.S. (U.S.author)

- Industrial Cogeneration in India - An Agenda for Action (Mr. S. Anand)

Session 3B - **ENERGY EFFICIENCY STRATEGIES - End-Uses**

- Technology for Increasing Electricity End-Use Efficiency (U.S.author)

- Development and Commercialization of High-Efficiency Lighting Systems in the U.S. (Sam Berman or other)

- An approach for Lighting Efficiency Improvements in India.

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* The Scope & Coverage of this session may be redefined following discussions with Dr. David Jhirad.

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13.00-14.00 LUNCH

14.00-16.30 **SPECIAL TECHNICAL SESSION ON INNOVATIVE APPROACHES TO POWER PLANNING**

Demonstration of Software for Optimizing Capital Investment in the Power Sector Under Capital Constraints (Dr. Peter Meier and TERI Representative)

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THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

Confidential

Agenda Item 8

Review of Promotional Activities

At the first meeting of ERDAC held on February 16, 1988, it was indicated that PACER Secretariat would organise promotional activities which would disseminate information relating to the PACER project leading to identification of suitable project ideas and prospective entrepreneurs. In pursuance of the above, PACER Secretariat has been participating in suitable seminars/conferences for making presentations on PACER project, often to a target audience working in the energy related fields. PACER Secretariat has also been invited to make exclusive presentation to such gatherings as assembled under the auspices of a State Electricity Board or a trade organisation/association, providing a responsive audience. Such participation/presentation has resulted in stimulating discussions on the effectiveness and workability of the scheme as envisaged. Since May 1988, the following promotional activities were undertaken by the PACER Secretariat :

i) A preproposal meeting to discuss projects in the area of Development of Energy Efficient Systems was arranged in Bombay on May 4, 1988. Consequent to this meeting, PACER Secretariat received about 15 enquiries/proposals. While

7 of them did not qualify for PACER assistance, 2 of them are sanctioned and the remaining ones are still in formulation stage.

ii) A PACER presentation was made in New Delhi on June 1, 1988 under the auspices of Indo-Amrican Chamber of Commerce (North India Council).

iii) A meeting of 20 experts in power sector was arranged in Delhi on June 29, 1988 to identify candidate projects.

iv) Presentations on PACER were made at various seminars organised by different regional wings of Confederation of Engineering Inustry (CEI) over the last one year as follows :

- Bangalore, June 5, 1988.
- Madras, July 30, 1988.
- Calcutta, August 29, 1988
- New Delhi, August 30, 1988 at the meeting of Energy and Energy Conservation Committee
- Bombay, August 2, 1989

A workshop on PACER with focus on cogeneration technologies was organised at Calcutta on January 31, 1989 in cooperation with CEI, Eastern Region. As a sequel to this workshop, another PACER workshop/meet with organisations/consultants working particularly in the energy sector was organised under the auspices of West Bengal State Electricity Board at Calcutta on

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March 7, 1989. The meet generated stimulating discussions which resulted in identification of a few probable project ideas.

v) At the seminar on "Energy Conservation in Industry" organised by Chemtech Foundation at New Delhi during November 24-26, 1988, the PACER Secretariat participated and distributed PACER brochure amongst the participants.

vi) A PACER presentation was made on December 3, 1988 at the "National Solar Energy Convention" organised by Solar Energy Society of India at Hyderabad.

vii) At the seminar on "Availability and Utilisation of Natural Gas" organised by FICCI at New Delhi on December 20, 1988 representatives of PACER Secretariat discussed salient features of PACER Project with participating delegates.

viii) PACER Secretariat participated in the seminar on Energy Conservation and Generation through Renewable Resources organised by Indian Institute of Metals at Ranchi on January 19-20, 1989 and explained to other participants as to how the scheme provided an attractive financing instrument for developing energy related technologies.

ix) During the Energy Conservation Week at New Delhi from February 2-9, 1989, a presentation on PACER was made.

x) Highlights of PACER Project were presented at the seminar on Energy Conservation organised by Ahmedabad Management Association at Ahmedabad on April 11, 1989.

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xi) At a meeting of ICICI-led Technical Consultancy Organisations (TCOs) of Gujarat, Maharashtra and Tamilnadu on April 26, 1989, a presentation on PACER was given. The representatives of TCOs agreed to assist PACER in identifying project ideas and to help entrepreneurs in their regions in formulating proposals for PACER assistance. As decided at the above meeting, the first of the PACER presentations was arranged at TCO of Tamilnadu at Madras on May 10, 1989.

xii) PACER Secretariat had a meeting with Shri V. Bakthavatsalam, Managing Director, Indian Renewable Energy Development Agency Limited (IREDA) on July 13, 1989 to discuss the mechanics of co-operation between IREDA and PACER.

xiii) Various Operations Departments including regional offices of ICICI have been introduced to the PACER Project - its concept, objectives and its scope. This has helped to establish linkage with ICICI clientele of over 2500 companies.

In addition to using the various fora for promoting the concept of PACER project as indicated above, representatives of PACER Secretariat contacted potential project proposers to explore the possibilities of their taking up suitable proposals. In order to further acquaint themselves with different R&D activities being pursued in the Indian energy sector, the PACER Secretariat representatives have been meeting senior and operational level officials of various government

departments/agencies and organisations such as DNES, CSIR, NPC, TERI, BHEL, NAL, IISc., IITs, SEBs, State level councils for science and technology etc. During the course of such interactions, a host of project ideas/concepts are identified or evolved. On this basis, PACER Secretariat may solicit in future, suitable R&D consortium project proposals under RFP (Request for Proposal) mechanism.

PACER Secretariat proposes to establish an on-going rapport with various organisations/agencies working in the energy field. Besides, PACER Secretariat might avail of suitable technology information services available from within as also from outside the country, to keep themselves abreast with state of art and developmental work on the frontiers of energy technologies.

PACER Secretariat is also co-ordinating the organisation of PACER Conference. TERI has been entrusted the responsibility of arranging the Conference. The agenda and subject topics of the papers to be presented at the Conference by various participants had been discussed and approved in principle, at the third meeting of the Steering Committee of PACER Conference held on July 13, 1989 at Delhi. It was indicated that the Conference might be scheduled for early 1990. USAID, Washington is expected to subcontract the Conference papers to be prepared in USA shortly.

Thus, PACER Secretariat has geared up to play its proactive role in implementing the PACER project and achieving its objectives.

THE INDUSTRIAL CREDIT AND INVESTMENT CORPORATION OF INDIA LIMITED

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

3rd ERDAC Meeting

August 22, 1989

Confidential

Agenda Item 9

BUDGET FOR PACER - 1989-90

(Note from PACER Secretariat)

During the first year of operation of PACER ended March 31, 1989 sanctions of Rs 112.40 lacs (US $ 749,000) and disbursements of Rs 47.31 lacs (US $ 345,000) were made out of funds available under PACER. Annexure A provides break-up of sanctions and disbursements during the year 1988-89. The sanctions and disbursements were relatively slow during the year 1988-89 as the PACER scheme as also the financing instrument (Conditional Grant) envisaged were new and required considerable amount of promotional work to create awareness of the scheme. In response to the promotional work carried out during the year as spelt out under Agenda Item 8, PACER Secretariat has received over 140 enquiries for assistance. Based on the pipeline of proposals under formulation, it is expected that the sanctions and disbursements would gain momentum during the year 1989-90.

Our estimates of sanctions and disbursements during the year 1989-90 are indicated below. In addition to formulating projects from the list of unsolicited category of

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enquiries/proposals, PACER Secretariat proposes to play a pro-active role by initiating action to identify a select group of project ideas to be undertaken for development through the mechanism of Request for Proposal. Action has already been initiated in this direction.

(Rs in lacs)

Particulars	Sanctions	Disbursements
Component - I		
1. Consortium R&D projects		
- Unsolicited proposals (8 proposals)	400	246
- Solicited proposals (under RFP process - 2 proposals)	200	100
Component - II		
Research Awards (4 proposals)	50	25
Component III		
Research Projects (Studies) (10 proposals)	70	50
PACER Conference		
US Consultants Preparation of research papers, logistics, graphics and Conference participation (US $)		
ORNL 51,063 H&B 117,752 --- 168,815	27	32
Promotional, Training and Project Administration expenses	20	20
	767	473
US $ in thousands	(4794)	(2956)

(Assumed 1 US $ = Rs 16)

ANNEXURE - A

PROGRAM FOR ACCELERATION OF COMMERCIAL ENERGY RESEARCH (PACER)

(Break up of sanctions and disbursements during the year 1988-89)

(Rs in lacs)

Particulars	Sanctions	Disbursements
Component - I		
Consortium R&D projects	46.00	Nil
Component - II		
Research Awards	-	-
Consortium - III		
Research projects	41.46	27.21
PACER Conference (Indian consultants)	14.15	9.31
Promotional, Training and Project Administration expenses	10.79	10.79
	112.40	47.31
US $ in thousands	(749)	(345)

(Assumed 1 US $ = Rs 16)

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