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UNITED NATIONS DEVELOPMENT PROGRAMME
Project of the Government of
INDIA

PROJECT DOCUMENT

Number & Title : DP/IND/90/ , Centre for Cryogenic and Gas Separation Technology (CCGST).

Duration : 4 years

Project site : Visakhapatnam

ACC/UNDP Sector & Subsector : (05) Industry, (0510) Industrial Support Services

Government Sector & Subsector : (3530) Heavy Industry, Industrial Services and Institutions

Host Country implementating agency : Bharat Heavy Plate and Vessels Ltd.,on behalf of the Ministry Of Industry

Executing agency : United Nations Industrial Development Organisation (UNIDO)

Estimated Starting date : July 1990

Goverment Inputs (in kind) : Rupees 130,336,400

UNDP and cost-sharing financing		
UNDP/IPF	US $	3,252,500
Others	$	----
Cost Sharing	$	----
UNDP & Cost-Sharing Total	$	3,252,500

Brief description : The project aims to strengthen the present development capacity of BHPV in the field of gas separtion technologies to become a fully integrated "Centre for Cryogenics and Gas Separation Technology",able to carry out development work in air liquifaction and separation by distillation as well as separation by adsorption and membrane technology. Presently air liquifaction/ separation plants are being manufactured by BHPV under licensing, but the capacity to carry out development work, essential for achieving technological self-sufficiency as regards process optimisation, plant design and support services to user industries, is lacking. Adsorption and membrane separation have not yet been introduced in India at all. While the project is of institution building nature,the development work embarked upon will immediately result in industrial applications. Since the technologies are at present almost entirely in the domain of the industrialized countries, TCDC for transferring the technologies to other developing countries, which is the stated intention of the Government, will make a major impact.

Signed on behalf of :	Date	Name/Title(Typed)
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the Government		57
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the Executing Agency		
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UNIDO		

A. CONTEXT

A.1. Description of the subsector

Cryogenics is the science and technology for very low temperatures. Specifically it is concerned with the liquifaction. separation, purification and application of gases boiling below minus 150 C, namely of air, nitrogen, oxygen and all other gaseous elements which are present in air in small quantities (e.g. argon, helium). It is the basis of a large industry manufacturing equipment to liquify air and to separate into its components, primarily nitrogen and/or oxygen in liquid form at various purity grades, depending on the specific application. The sizes of such plants vary from 5 tons of oxygen/nitrogen per day all the way to 1000 tons and even larger in some instances. The smaller units are mainly used to produce oxygen for welding and cutting and for medical purposes and nitrogen for food processing (eg.fast freezing, preservation) and "blanking" in chemical plants. The large size oxygen/nitrogen producing units are used in steel making (oxygen "lancing"), petro-chemical plants (oxidation) and fertilizer production (ammonia). Such plants are usually delivered as "standard" packages (e.g. design, operations) costing from $ 2 million to $ 60 millions in the industrialized countries. Overall worldwide sales of such cryogenic plants, while difficult to define exactly,has a value of at least $ 2 billion per year, practically all manufactured in the industrialized countries. As a matter of fact, the industry is concentrated in a few large corporations and specialized companies and is not a "diffused" sector, which implies that access to the technology in an integrated manner is difficult. Going the licensing or "co-operation" route is costly, as the Indian example demonstrates. And even under such co-operation agreements there are limitations as to what degree the licensor is willing to transfer the technology and internal know-how -- as again the Indian experience shows. While the developing countries are much in need of mastering cryogenic technologies just to cover their own internal requirements, the technology remains to this date almost entirely in the domain of the industrialized countries. The result is a considerable outflow of foreign exchange from the developing countries to buy essential equipment, although in a number of developing countries, among them India, the industrial base exists to absorb and utilize the technology.

Industrial-scale air liquifaction started during the 1920's to supply high purity oxygen for welding and metal cutting and soon after that the process was rapidly scaled-up to produce large quantities of nitrogen needed for ammonia synthesis, the latter required for fertilizer manufacturing. The scaling-up of air liquifaction plants continues to this date. Because of the high energy requirements of the process to produce high purity oxygen solely through air liquifaction /fractional distillation (i.e. 1.42 KW/Kg of liquid oxygen) a new process was put into industrial production during the last 10-15 years namely the selective adsorption of nitrogen, at basically ambient pressures and temperatures, by synthetic inorganic materials (i.e. Zeolites). By using the adsorption process at the front end of liquifaction a preconcentration of oxygen up to about 90% (as compared to 21% in air) became possible, cutting energy consumption by more than 75% (i.e. 0.32 KW/Kg of liquid oxygen). When the main product required is nitrogen, the same process is also applied. Another new development now being utilised on industrial scale is membrane separation technology, also used mainly in combination with other technologies, including cryogenics. Such combibations work synergestically: the final separations are more complete, production costs are lower, and overall efficiencies higher by as much as 10-50 % compared with those of any single method alone. An example is the production of high-purity oxygen or nitrogen from air, whereby membrane separation can be at the front or at the tail end of the process.

Finally, in an integrated cryogenic R&D capability the ability to produce liquid helium is essential in order to reach the cryogenically lowest possible temperatures needed for many purposes, including liquifying other very low boiling gases, namely neon and particularly hydrogen in order to be able to study thermo-physical properties of gas mixtures for developing separation techniques; testing of properties of engineering materials at very low temperatures; instrument calibration, etc.

A.2. Host country strategy

The important role of cryogenic technology was recognised by the Government during the 1960's when air liquifaction/separation units were imported in increasing number to cover the needs of the country's basic industries (steel, fertilizers, welding oxygen etc.). For this reason the Government assigned the responsibility to Bharat Heavy Plate & Vessels Limited (BHPV) to take the lead and become a fully-versed producer of cryogenic plants, systems and components. Since the indigenous expertise or know-how did not exist at that time in India, BHPV concluded in 1971 a co-operation agreement with L'Air Liquide, a world leader in this field, for providing the initial design and fabrication technology for manufacturing air liquifaction/separation plants. Initially, almost 100% of the equipment was supplied by L'Air Liquide, but BHPV succeeded over the years to manufacture a considerable part of the components. The co-operation agreement was subsequently renewed in 1982. The Government has found, however, that the technology transfer did not have the depth and breadth to allow achieving full self-sufficiency in this field. For this reason it has turned to the United Nations System to help attain self-sufficiency as soon as possible in order to reduce the continuing outflow of foreign exchange caused by importation of components and co-operation payments. Furthermore, the Government wishes to establish a capability which will enable BHPV to further develop and improve cryogenic process technology, systems and applications.

A.3. Prior or on-going assistance

No technical assistance, either multilateral or bilateral, has been provided to India as of now in this field.

A.4. Institutional frame work for the cryogenic equipment manufacturing and using sectors.

Research activities are being undertaken in India at various universities and research institutions only related to applications of cryogenic temperatures on various materials and substances, such as behaviour of engineering materials at low temperatures, super conductivity, animal semen preservation, etc. No research has been undertaken on cryogenic process or production technology whatsoever. The only institution where such work has been carried out on a relatively small scale and with limited resources during the last 10 years is the R&D Department of BHPV. Nevertheless due to the dedication of the Company and its staff, successful developments have been achieved. Among them :

- manufacturing technology for trays of copper and alumnium used in medium and large air separation plants;
- cryo-biological containers for storage of bull semen;
- quick freezing units for food processing;
- super insulated piping;
- super insulated containers of 165,1000 and 3000 liters capacity;
- computer programs for design and simulation of air separation units;
- thermophisical, phase-equilibrium and other properties for nitrogen,oxygen,argon gases.

The new Centre for Cryogenics and Gas Separation Technology (CCGST) to be established through the present project will be built on the present core group of highly trained Indian specialists and can thus be considered as institution strengthening. It will draw policy and technical guidence from the Ministry of Industry,Department of Scie[illegible] and Technology, Indian Institute of technology,Madras and Bombay, Anna Technological University, Madras,and the Confederation of Indian Engineering Industries. The requirements of major user groups will be kept in view while formulating detailed work programmes for CCGST.

B. PROJECT JUSTIFICATION

B.1. Problem to be addressed ; the present situation

Cryogenic technology in India is presently restricted to the manufacture of air liquifaction/separation units and related components based on technology acquired through licencing, but a considerable amount of components still have to be imported. There is no capability whatsoever to produce adsorption and membrane separation equipment and systems which, in combination with cryogenic production units, would result in improved technology. In all these three areas (i.e. cryogenics, adsorption, membranes) a basic, supportive technological capability is lacking.

Present manufacturing capabilities are restricted to cryogenic technology only and, as regards equipment manufacturing, the picture is as follows:-

- multi-stage air compressors can be manufactured only in small sizes; large units have to be imported ;

- all heat exchangers have to be imported because vacuum brazing capability is not existing in the country, although the material (i.e. corrougated alluminium clad sheet) could be produced in India. The importation of the heat exchangers is extremely costly, running on the average $ 2 millions for each liquifaction/separation unit;

- all expansion turbines must be imported (this will not change in the near future because of the very advanced technology involved in manufacturing);

- the stainless steel fractionating columns are now produced at BHPV using imported stainless steel and the capability exists to fabricate these in any desired size.

- the fractionation trays are produced entirely at BHPV;

- storage containers, tanks and systems for liquid cryogens are now produced in India, mainly by BHPV;

- all liquid nitrogen vaporisers are produced by BHPV.

Beyond the manufacturing aspects however, the capabilty to study process parameters needed for optimising plant design is lacking as well as the capability for process control, instrumentation for testing gas composition and purity, trouble shooting capabilty such as leak detection, etc. Furthermore, there is no capabilty to carry out cryogenic research and development work below the normal boiling point temperature of liquid nitrogen, although carrying out experimentation at such extreme low temparatures becomes very important for gearing up to produce Neon, to liquify hydrogen and to determine cryogenic and other thermo-physical properties of gas mixtures for separation purposes. And, as mentioned earlier, no capability exists to carry out development work related to adsorption and membrane technologies. Furthermore, the capability for computerized modelling and simulation, critical for optimising plant and equipment design as well as for process optimisation, is lacking.

The relevance of the entire cryogenic/gas separation technology support need of India can be defined in economic terms :

- it is projected that total sales of cryogenic process equipment of BHPV during the next decade will be in the order of US $ one billion;

- if no further advancements are made in the manufacturing technology of components these will have to be imported to the tune of US $ 300 million during the same time period;

- co-operation/licensing royalities will amount to about US $ 50 million at the same time.

In case of adsorption technology the mechanical elements pose to be less of a difficulty. The problem lies mainly in process control and related instrumentation, in defining optimum design parameters and in the production of the adsorbents themselves. The latter hower, is not a critical issue in case of oxygen/nitrogen plants because the adsorbents have a long process life if sufficient care is taken to remove adsorber "poisons" (e.g. chlorine). The same considerations apply to membrane technology as well, where design and instrumentation parameters, however, can be more complicated. Finally, an integrated cryogenic R&D capability requires the ability to produce liquid helium in order to reach the cryogenically lowest possible temperatures needed for many puposes, including : liquifying other, very low boiling gasses, namely neon and particularly hydrogen in order to be able to study thermo-physical properties of gas mixtures for developing respective seperation techiniques; testing of properties of engineering materials at very low temparatures; instrument calibration etc.

To overcome the above described technological difficulties in order to diminish the negative economic aspects of the present state of manufacturing products by substantially increasing local content, eventually leading to exports and, at the same time providing assistance to other developing countries facing the same problem, is then the justification for the present project.

B.2. Expected end-of-project situation

It is expected that by the end of the project a full institutional capability will have been established in terms of facilities and trained personnel to carry out technology development in the following fields:

(a) air liquifaction/separation technology development for equipment design, process optimisation and control (at pilot plant scale);

(b) adsorption separation technology, process design and control (at pilot plant scale);

(c) membrane separation technology (at the laboratory scale);

(d) extreme low temperature cryogenic R&D capability (at the laboratory scale);

(e) laboratory technical support capability as regards process instrumentation, quality control and compositional analysis, trouble shooting (e.g. leak detection) and others;

(f) Computer-based process and design simulation and optimisation, including a corresponding data bank established.

It is furthermore expected, that practical accomplishments will result in the manufacture of additional process equipment presently being imported, improvements in process control and productivity of cryogenic plants, resulting in higher purity products. Relevant process improvements will have been transferred to companies operating air liquifaction/separation plants and users of cryogens.

B.3. Target Beneficiaries

The target beneficiaries of the project fall under two main categories. In the first group are the enterprises manufacturing cryogenic and other gas-separation-related equipment, primarily BHPV. The second group are enterprises operating cryogenic and other gas separation equipment and production units. In addition, enterprises using pure and/or liquified gases will benefit from the project as well as institutions involved in cryogenic and very low temperature research and development activities. Other developing countries will also derive benefits through TCDC activities (See B.6).

B.4. Project strategy and institutional arrangements

The overall project strategy is to establish an integrated national capability in the field of cryogenic and other gas separation technologies at BHPV, but operating as an autonomous institution under the policy guidance of an Executive Committee composed of representatives from concerned bodies (i.e. ministries) and other national governmental and non-governmental institutions. A Technical Advisory Committee will be involved in establishing and reviewing the work programme of the CCGST. Its membership will include the Chairman of BHPV, the Director of the Centre, a representative of the Confederation of Indian Engineering Industries and a representative of cryogenic user industries among others, to ensure that the work carried out at the Centre will be in line with national priorities.

Needed inputs will be in the form of fellowship training and expert advisory services combined with the provision of essential equipment required for the practical implementation of the new technologies to be introduced. Since some of the specific technologies involved are rather complicated, equipment will be purchased as a package under subcontracting arrangements together with the provision of expertise for installation, start-up and operation of such equipment in order to gain and transfer operational know-how over and above the theoretical knowledge provided by the experts.

An alternate project strategy could be to establish a national centre completely outside BHPV as an independent institution, since being located at and to some degree dependent on BHPV will undoubtly favor development activities of interest to BHPV. But experience shows that a fully independent institution might become overly research-for-the-sake-of-research oriented and become too detached from industry's needs. Economic payback at the national level, however, will very much depend on how much industry can benefit from CCGST's work. Hence the presently forseen institutional arrangements within BHPV's environment, which is by far the largest cryogenic equipment manufacturer in India, will more than compensate economically for any (percieved) priority distortions.

B.5. Reasons for assistance from UNDP and UNIDO

As described in the beginning, it is difficult to get access to all aspects of up-to-date cryogenic and other gas separation technologies in the light of the industry being in the hands of relatively few enterprises in the industrialised countries. Access to elements of the respective technologies will be necessary to ensure that all the requested technology can be made available. This is only possible through multi-lateral assistance. Because the technology is also needed in many other developing countries, the assistance provided through UNDP/UNIDO will ensure access to the technologies through TCDC (see B.6 below).

B.6. Special considerations

Cryogenic and other state-of-the-art gas separation technologies are almost exclusively in the hands of industrialised countries, although these technologies are much needed by many developing countries as well. The Government of India is fully aware of the situation and it was one of the main reasons for requesting assistance through the United Nations System. It is the Government's stated intention to share the results of the project with other developing countries by any viable means, be it through training, demonstrations,advisory services,information or otherwise.

B.7. Co-ordination arrangements

Due to the very specific technological nature of the project, substantive coordination with other on-going project will be minimal. Co-ordination within BHPV will be, however, critical during the construction phase of the new facility as well as during regular development activities, when various manufacturing divisions of BHPV will have to provide essential fabricating support to make prototype equipment and accessories. When development work commences on adsorption and membrane technologies, support from various research institutions and/or university research laboratories will be essential to help develop adsorbents and membranes from indigenous raw materials to achieve self-sufficiency.

B.8. Counterpart of support capacity

As indicated in paragraph A-4, there is a core unit within BHPV's R&D organisation dedicated to development work in the field of cryogenic technology, comprised of 6 professionals and 10 technicians out of a total R&D staff of 17 professionals and 20 technicians. The Government has instructed BHPV to increase dramitically its capabilities in the field of cryogenic and gas separation research and development and thus become the national centre in this field to service not only BHPV's needs but also those of the country as a whole in the field of cryogenic technology. BHPV will receive from the Government an additional massive allocation of resources for the establishment of laboratory facilities as well as for its operating budget and staff resources. Initially the facility newly built for this purpose will cover a total arrea of 4000 Square Meters and have a total personnel consisting of 48 professionals, 60 technicians and 4 office staff. BHPV itself is a large, diversified, well organised, profit-making government enterprise with considerable technological and manufacturing capability, able to provide essential services and support to the new Centre in all respects. Considering that one of its main profit-making business is the production of cryogenic plants and equipment, estimated at $ 160 million and expected to increase considerably in the future, the resulting synergism between BHPV and CCGST will be highly beneficial.

C. DEVELOPMENT OBJECTIVE

C.1. The eighth Five Year Development Plan (1990-94) of the Government gives clear directives to continue expanding the productive sectors of the economy and to improve productivity of installed capacities. This includes all manufacturing industries, in this case those which require large quantities of purified oxygen and/or nitrogen such as steel, petrochemicals, fertilizers and those which produce the equipment for air liquifaction/separation. Just as importantly, the Government stresses the need to broaden the country's industrial technology base and improve, through import substitutions and exports of industrial products, the balance of payment of the country and to generate foreign exchange. This project is designed to contribute to the achievement of these overall objectives.

D. IMMEDIETE OBJECTIVES, OUTPUTS AND ACTIVITIES

D.1. The immediate objective of the project is to establish an integrated technological capability at Bharat Heavy Plate and Vessels Ltd. in the field of cryogenic air liquifaction and separation and other gas separation processes in order to be able to generate the technical information and data base needed for the :

a. optimum design of production units, components and complete plants;

b. establishment of process parameters to achieve optimum operating efficiencies of air separation plants; and

c. to have the means for carrying out cryogenic and other types of gas separation development in its broadest sense, supportive to other institutions in India involved in this field.

This will include the capability for the provision of required technical support, advisory, testing, training and other services to manufacture of cryogenic equipment and components as well as to industrial facilities and institutions using and operating cryogenic facilities and production units.

D.1.1. OUTPUT 1

Technological capability in terms of manpower trained and equipment available to study all aspects of cryogenic gas liquifaction and separation technology and related equipment and instrumentation development with specific emphasis on air liquifaction and oxygen/nitrogen separation. This will include a pilot unit for distillation studies and a laboratory facility for heat transfer investigations. The facility will be completed and fully operational 18 months before the project ends.

	Activities	Responsible parties	Started/end Months
1.1.1	Preparation of subcontract terms of reference, equipment specifications and design for the new laboratory	BHPV/ CCGST/ UNIDO	3 - 6
1.1.2	Construction of the building	BHPV	6 - 18
1.1.3	International bidding & selection of subcontractors/suppliers	UNIDO/ BHPV/ CCGST	6 - 12
1.1.4	10 engineers of BHPV/CCGST undergoing fellowship training of 2 months' duration each in specific aspects of cryogenic technology.	UNIDO	8 - 24
1.1.5	Delivery, installation of and operational training on equipment by subcontractor/supplier.	SUBCONTRACTORS/ SUPPLIERS/ CCGST/UNIDO	18 - 28
1.1.6	On-the-job training, lecturing and demonstration by international experts and carrying out of planned, specific development work	UNIDO/CCGST	30 - 48

D.1.2. <u>OUTPUT 2</u>

Technological capability in terms of manpower trained and equipment available to study all aspects of gas separation by adsorption technology and related equipment and instrumentation development with specific emphasis on process characteristics such as pressure swing adsorption, design of adsorption systems and related equipment, process control and instrumentation, operating cycles, life time of adsorbents, and development of indigenous adsorbents based on locally available raw materials. The facility will be completed and fully operational 18 months before the project ends.

Activities		Responsible parties	Started/end Months
1.2.1	Preparation of subcontract terms of reference, equipment specifications and design for the new laboratory	BHPV/ CCGST/ UNIDO	3 - 6
1.2.2	Construction of the building	BHPV	6 - 18
1.2.3	International bidding & selection of subcontractors/suppliers	UNIDO/ BHPV/ CCGST	6 - 12
1.2.4	4 engineers of BHPV/CCGST undergoing fellowship training of 2 months' duration each in specific aspects of adsorption technology.	UNIDO	8 - 24
1.2.5	Delivery, installation of and operational training on equipment by subcontractor/supplier.	SUBCONTRACTORS/ SUPPLIERS/ CCGST/UNIDO	18 - 28
1.2.6	On-the-job training, lecturing and demonstration by international experts and carrying out of planned, specific development work	UNIDO/CCGST	30 - 48

D.1.3. <u>OUTPUT 3</u>

Technological capability in terms of manpower trained and equipment available to study all aspects of gas separation by membrane technology and related equipment and instrumentation development with specific emphasis on physico-chemical aspects of gas transmission through membranes, process and operating conditions, membrane configurations, development of membranes from indigenous materials. The facility will be completed and fully operational 18 months before the project ends.

Activities	Responsible parties	Started/end Months
1.3.1 Preparation of equipment specifications and design for the new laboratory	BHPV/ CCGST/ UNIDO	3 - 6
1.3.2 Construction of the building	BHPV	6 - 18
1.3.3 International bidding & selection suppliers for equipment	UNIDO/ BHPV/ CCGST	6 - 12
1.3.4 4 engineers of BHPV/CCGST undergoing fellowship training of 2 months' duration each in specific aspects of membrane gas separation technology.	UNIDO	8 - 24
1.3.5 Delivery, installation of the equipment	SUPPLIERS CCGST/UNIDO	18 - 28
1.3.6 On-the-job training, lecturing and demonstration by international experts and carrying out of planned, specific development work	UNIDO/CCGST	30 - 48

D.1.4. <u>OUTPUT 4</u>

Technological capability in terms of manpower trained and equipment available to carry out research and development work at very low cryogenic temperatures (down to helium) and to provide laboratory backup support for all technological areas related to instrumentation, trouble-shooting, gas analysis, quality control and certification. The facility will be completed and fully operational 18 months before the project ends.

	Activities	Responsible parties	Started/end Months
1.4.1	Preparation of subcontract terms of reference, equipment specifications and design for the new laboratory	BHPV/ CCGST/ UNIDO	3 - 6
1.4.2	Construction of the building	BHPV	6 - 18
1.4.3	International bidding & selection suppliers for equipment	UNIDO/ BHPV/ CCGST	6 - 12
1.4.4	2 engineers of BHPV/CCGST undergoing fellowship training of 1 month duration each in the operation and maintenance of the helium liquifying related equipments (at the supplier's facility)	UNIDO	12 - 24
1.4.5	Delivery, installation of the equipment	SUPPLIERS CCGST/UNIDO	18 - 28

D.1.5. <u>OUTPUT 5</u>

A computer capability in terms of man-power trained and equipment available to perform all the specialized computational tasks needed for process modelling, simulation, control, design and optimisation, equipment design, computerised process control and expert system development. The facility will be completed and fully operational 24 months before the project ends.

	Activities	Responsible parties	Started/end Months
1.5.1	Preparation of computer hardware and software specifications.	BHPV/ CCGST/ UNIDO	3 - 6
1.5.2	Construction of the building	BHPV	6 - 18

1.5.3	International bidding & selection suppliers for equipment	UNIDO/ BHPV/ CCGST	6 - 12
1.5.4	4 engineers of BHPV/CCGST undergoing fellowship training of 4 months' duration each in computer based process modelling, simulation and optimisation, expert system development, computer based plant and equipment design and process control	UNIDO	8 - 16
1.5.5	Delivery of computer hardware and software	SUPPLIERS CCGST/UNIDO	14 - 18
1.5.6	On-the-job training, lecturing and demonstration by international experts and carrying out of planned, specific development work	UNIDO/CCGST	24 - 48

D.1.6. OUTPUT 6

At least eight technological development projects completed in co-operation with international experts and respective reports issued in various aspects of cryogenics, adsorption and membrane separation technology.

Activities		Responsible parties	Started/end Months
1.6.1	Carrying out developmental project activities	CCGST staff/ Intl. Experts	30 - 48
1.6.2	Preparation of reports	CCGST staff	36 - 48

D.1.7. OUTPUT 7

At least 30 industry staff trained in various aspects of cryogenic air liquifaction/separation such as process control, process optimisation, trouble shooting, operation and maintenance.

Activities		Responsible parties	Started/end Months
1.7.1	Training and demonstration of industry staff by experts.	CCGST staff/ Intl. Experts	36 - 48

E. INPUTS

1. Government inputs

1.1 Personnel

The following are the national personnel who will be engaged in the implementation of the project. Moreover, BHPV will provide the logistic support services required by international consultants assigned to the project.

- 1	Director	48 man-months
- 2	Deputy Directors	96 man/months
- 5	Departmental Managers	252 man/months
- 40	Professionals	1820 man/months
- 60	Technicians	2380 man/months
- 4	Office Staff	192 man/months
	TOTAL	4768 man/months

1.2 Training

In-plant training /demonstration for industry personnel in cryogenic technology. Rs 150,000

1.3 Equipment, building and consumable materials

The following are the inputs to be procured by BHPV for the specific purposes of this project. News buildings, and laboratories equipment/instruments and pilot plant facilities will be made available.

	Rs in Lakhs	(apprx. US$ equivalent)
- Building construction and other civil engineering works	207.5	(1,200,000)
- Equipment	657.0	(3,870,000)
- Materials for experimentation, other consumables and office equipment	91.2	(550,000)
- Maintenance and miscellaneous expenses	27.8	(160,000)
Total	983.5	(5,780,000)

2. UNDP Inputs

2.1 Personnel

The following consultants will be recruited for assignments to BHPV/CCGST. Specific areas of their experties and qualifications are summarised in Annex V, Job descrptions, of this document.

Post No.	Title	m/m
For all Outputs		
11-01	Chief Technical Advisor - Expert In Cryogenic Technology	12
11-54	Consultant in Techno-Economic Evaluation of Chemical Processes	3
For Output 1 (Cryogenics)		
11-02	Expert in Heat Transfer in Cryogenic Processes	8
11-03	Expert in Mass Transfer in Cryogenic Processes	8
11-04	Expert in Process Control and Optimisation in Cryogenic Processes	8
11-05	Expert in Process Instrumentation in Cryogenic Processes	8
11-06	Expert in Process Design of Air Liquifaction/Separation Equipment and Plants	8
For Output 2 (Adsorption Separation)		
11-07	Expert in Process Design and Control in Adsorption Gas Separation	8
11-51	Consultant in Zeolite Chemistry and Production	3
For Output 3 (Membrane Separation)		
11-08	Expert in Membrane Gas Separation Technology	8
11-52	Consultant in Inorganic Membrane Chemistry and Production	3
11-53	Consultant in Organic Membrane Chemistry and Production	3

For Output 4 (Helium cryogenics/support Laboratory)

Mainly 11-01/11-02/11-03

For Output 5 (Computer Support Capability)

11-09	Expert in Computer-based Modelling of Chemical Processes	6
11-10	Expert in Computer-based Process Control in Chemical Processes	6

For Output 6 (Development Projects/Reports)

All experts/consultants

For Output 7 (Trained Industry Personnel)

All experts/consultants

Total : 92

2.2 Subcontracts

(See Annex VI for details)

2.2.1	Subcontract for Cryogenic Air Liquifaction/Separation Pilot Plant	$ 550,000
2.2.2	Subcontract for Adsorption Pilot Plant	$ 180,000

2.3 Training

2.3.1 Fellowships

(See Annex III for details)

Output 1 (Cryogenics) 10 fellows/2 months each/in 5 specific fields	20 m/m
Output 2 (Adsorption Separation) 4 fellows/2 months each/in 2 specific fields	8 m/m
Output 3 (Membrane Separation) 4 fellows/2 months each/in 2 specific fields	8 m/m
Output 4 (Helium cryogenics/support Laboratory) 2 fellows/1 month each/in the field of helium liquifaction	2 m/m
Output 5 (Computer Support Capability) 4 fellows/4 months each/in 2 specific fields	16 m/m
Total:	54 m/m

2.4 Equipment

2.4.1 Expendable equipment $ 80,000

Standard Gases; adsorbents; membranes; documentation/data acquisition

2.4.2 Non-Expendable equipment $ 990,000

(See Annex IV for details)

F. RISKS

Risk Factors: nature and level of risks and possible impact	Measures envisaged to deal with risks
1. Factors which could affect the immediate project objective	
The most critical issue for suceeding in transferring the desired technologies is to obtain access to these in the industrialised countries, where the technology is "controlled" by relatively few enterprises, which can be expected to be reluctant to divulge internal know-how and proprietory information, be it in the form of making available expertise, accept fellows for training or be willing to bid for subcontracts.	BHPV/CCGST already has considerable in-house expertise and specific elements of the technology can be obtained from sources other than the respective enterprises. This is the reason for utilising the services of individual, specialised expert instead of including expertise and training as integral part of the subcontracts. It is very likely that under the "worst case scenario" atleast 80% of the requested technology will be possible to transfer through the project.

2. Factors which could affect the achievement of the development objective

No risk factor exists in this regard in the light of the already developed state of the technology at BHPV.

G. PRIOR OBLIGATIONS AND PREREQUISITES

It is critical to the successful implementation of the Project that the Government (BHPV - CCGST) próvide the forseen inputs intime, namely construction and completion of the new buildings/facilities, provision of the equipment, hiring the personnel for CCGST and providing the necessary operating budget (See Anneces VII,a,b,c and d).

H. PROJECT REVIEW, REPORTING AND EVALUATION

(a) The project will be subject to tripartite review (joint review by representatives of the Government, UNIDO and UNDP) at least once every 12 months, the first such meeting to be held within the first 24 months of the start of full implementation. The National Project Director shall prepare and submit to each tripartite review meeting a Project Performance Evaluation Report (PPER). Additional PPERs may be required, if necessary, during the project.

(b) A project terminal report will be prepared for consideration at the terminal tripartite review meeting. It shall be prepared in draft sufficiently in advance to allow review and technical clearance by the Government executing agency and the UN associating agency (UNIDO) at least four months prior to the terminal tripartite review.

(c) The project shall be subject to midterm technical and monitoring evaluation 18 months after the start of full implementation and to end evaluation 3 months before termination. The organization, terms of reference and final timing will be decided after consultation between the parties to the project document.

I. LEGAL CONTEXT

This project document shall be the instrument referred to as such in Article 1 of the Standard Basic Assistance Agreement between the Government of India, and the United Nations Development Programme , signed by the parties on 20th October 1959. The host country implementing agency shall, for the purpose of the Standard Basic Assistance Agreement, refer to the Government cooperating agency described in that Agreement.

The following types of revisions may be made to this project document with the signature of the UNDP resident representative only, provided he or she is assured that the other signatories of the project document have no objections to the proposed changes:

(a) Revisions in, or addition of, any of the annexes of the project document.

(b) Revisions which do not involve significant changes in the immediate objectives, outputs or activities of the project, but are caused by the rearrangement of inputs already agreed to or by cost increases due to inflation; and

(c) Mandatory annual revisions which rephase the delivery of agreed project inputs or increased expert or other costs due to inflation or take into account agency expenditure flexibility.

PROJECT BUDGET COVERING UNDP CONTRIBUTION

		TOTAL		1990		1991		1992		1993		1994	
		m/m	$	m/m	$	m/m	$	m/m	$	m/m	$	m/m	$
10	PERSONNEL												
11-01	CTA- Cryogenic Technology	12	138,000	2	20,000	2	22,000	3	36,000	3	36,000	2	24,000
11-02	Heat Transfer - Cryogenic Processes	8	96,000					3	36,000	3	36,000	2	24,000
11-03	Mass Transfer - Cryogenic Processes	8	96,000					3	36,000	3	36,000	2	24,000
11-04	Process Control/Optimization - Cryogenic Pros.	8	96,000					3	36,000	3	36,000	2	24,000
11-05	Process Instrumentation - Cryogenic Pros.	8	96,000					3	36,000	3	36,000	2	24,000
11-06	Process Design - Air liquifaction/separation	8	96,000					3	36,000	3	36,000	2	24,000
11-07	Process Design/Control - Adsorption	8	96,000					3	36,000	3	36,000	2	24,000
11-08	Membrane Separation Technology	8	96,000					3	36,000	3	36,000	2	24,000
11-09	Computer-based Modelling - Chemical Pros.	6	72,000					2	24,000	2	24,000	2	24,000
11-10	Computer-based Process Control - Chemical Pros.	6	72,000					2	24,000	2	24,000	2	24,000
11-49	Sub-Total Experts	80	954,000	2	20,000	2	22,000	28	336,000	28	336,000	20	240,000
11-51	Zeolite Chemistry and Production	3	33,000			3	33,000						
11-52	Inorganic Membrane Chemistry/Production	3	33,000			3	33,000						
11-53	Organic Membrane Chemistry/Production	3	33,000			3	33,000						
11-54	Techno-Economic Evaluation/Chemical Pros.	3	36,000							3	36,000		
11-98	Sub-Total Consultants	12	135,000			9	99,000			3	36,000		
11-99	Sub-Total Experts/Consultants	92	1,089,000	2	20,000	11	121,000	28	336,000	31	372,000	20	240,000
11-16	Mission Costs		20,000						4,000		12,000		4,000
19	Component Total	92	1,109,000	2	20,000	11	121,000	28	340,000	31	384,000	20	244,000
20	SUBCONTRACTS												
21	Cryogenic Distillation Pilot Plant		550,000				150,000		400,000				
22	Adsorption Pilot Plant		180,000				60,000		120,000				
29	Component Total		730,000				210,000		520,000				

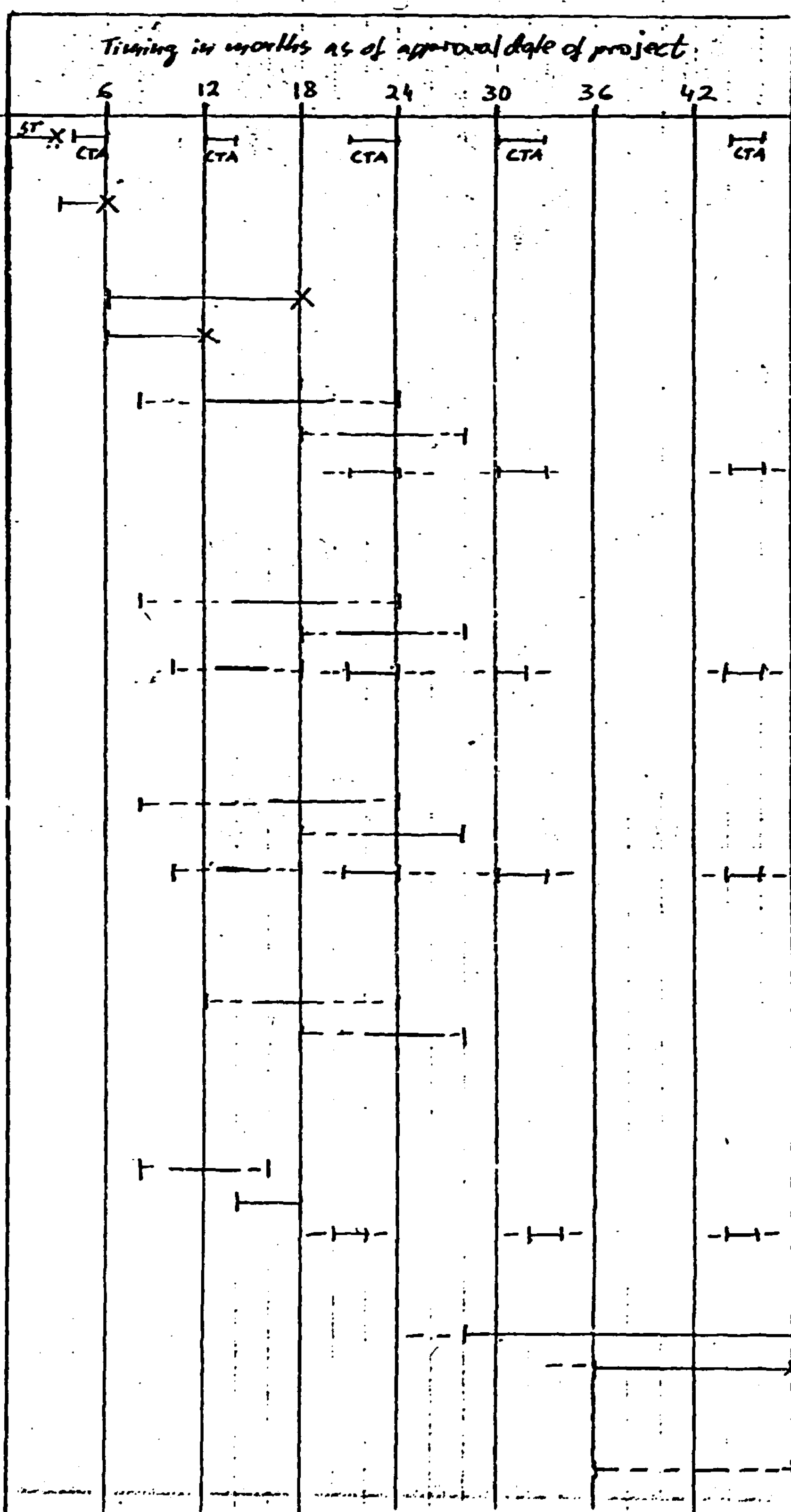
PROJECT BUDGET COVERING UNDP CONTRIBUTION

		TOTAL		1990		1991		1992		1993		1994	
		m/m	$	m/m	$	m/m	$	m/m	$	m/m	$	m/m	$
30	TRAINING												
31	Fellowships (2.4 fellows)	54	324,000			28	168,000	26	156,000				
39	Component Total	54	324,000			28	168,000	26	156,000				
40	EQUIPMENT												
41	Expendable equipment		80,000						30,000		30,000		20,000
42	Non-expendable equipment		990,000				800,000		190,000				
49	Component Total		1,070,000				800,000		220,000		30,000		20,000
50	MISCELLANEOUS												
51	Operation and maintenance of Equipment		15,000						5,000		5,000		5,000
52	Reporting costs		1,500										1,500
53	Sundries		3,000						1,000		1,000		1,000
59	Component Total		19,500						6,000		6,000		7,500
99	GRAND TOTAL		3,252,500		20,000		1,299,000		1,242,000		420,000		271,500

ANNEX I.

TENTATIVE WORKPLAN – ACTIVITIES SCHEDULE

Output/Activity Number	Description
	Study tour / CTA
1.1	Cryogenics
1.1.1	Designing of new facilities, preparing subcontract TOR " equipment specs.
1.1.2	Construction of facilities
1.1.3	Intnl. bidding/selection of subcontractors/suppliers
1.1.4	fellowship training
1.1.5	delivery/installation/start-up equipt.
1.1.6	experts/consultants
1.2	Adsorption Separation
(1.2.1/2/3	same as under 1.1.1/2/3.)
1.2.4	fellowship training
1.2.5	Delivery/installation/start-up equipt.
1.2.6	experts/consultants
1.3	Membrane Separation
(1.3.1/2/3	same as under 1.1.1/2/3)
1.3.4	fellowship training
1.3.5	Delivery/installation/start-up equ.
1.3.6	experts/consultants
1.4	Helium Cryogenics/Support Laboratory
(1.3.1/2/3	same as under 1.1.1/2/3)
1.4.4	fellowship training
1.4.5	delivery/installation/start-up equipt
1.5	Computer Support Capability
(1.5.1/2/3	same as under 1.1.1/2/3)
1.5.4	fellowship training
1.5.5	delivery/installation computer
1.5.6	experts/consultants
1.6	Development Projects/reports
1.6.1	development work
1.6.2	preparation of reports
1.7	Trained Industry Personnel
1.7.1	training seminars/demonstrations



x indicates target dates
——— core time for activities
- - - - allowable deviation time for activities

ANNEX II

Schedule of project reviews, reporting and evaluation

The project will be subject to periodic tripartite reviews, evaluation and performance reporting in accordance with the policies and procedures established by UNDP for monitoring and evaluation of project and programme implementation.

The following is the tentative schedule for tripartite and terminal tripartite reviews, project performance reporting and evaluation:

Type of reviews	Dates of reviews
1st Project Performance evaluation report	May 1992
1st Tripartite review meeting	June 1992
2nd Project Performance evaluation report	January 1993
Mid-term technical and monitoring evaluation	February 1993
2nd Tripartite review meeting	October 1993
Draft project terminal report	November 1993
Terminal tripartite review meeting/evaluation	March 1994
Project terminal report	June 1994

ANNEX III

Training programme

Post title/duration Number of fellows	Areas of training

A. Individual fellowships for BHPV staff in the following fields

1.1.4 Heat transfer/Cryogenics
- 2 fellows, 2 months each

Mass transfer/Cryogenics
- 2 fellows, 2 months each

Process control/cryogenics
- 2 fellows, 2 months each

Process instrumentstion/Cryogenics
- 2 fellows, 2 months each

Process design/cryogenics
2 fellows, 2 months each

1.2.4 Mass treansfer/adsorption
- 2 fellows ,2 months each

Process design, control and instrumentation/adsorption
- 2 fellows ,2 months each

1.3.4 Physico chemistry of membrane gas transimission.
- 2 fellows ,2 months each

Process design,control and instrumentation/membrane gas transimission.
- 2 fellows, 2 months each

1.4.4 Helium liquifaction operation
- 2 fellows ,1 month each

1.5.4 Computer based process modelling, simulation and optimization and expert system development
- 2 fellows, 4 months each

Computer based plant and equipment design and process control
- 2 fellows, 4 months each

Each fellow will acquaint him or herself of the various topics/aspects related to the specific technology of his/her field of specialization as reflected in their respective fellowship titles. The following are examples of topics of training, as applicable to the respective fields of specialization:
- theoretical aspects of the technology or techniques involved
- practical/experimental aspects of laboratory and pilot plant work
- practical aspects of the technology at the production level
- theory and practical aspects of applications technology testing and quality control
- overview of world-wide development trends

ANNEX IV

Equipment requirements

Equipment will be purchased individually in addition to that provided through the subcontracts (see Annex VI), needed for establishing a full developmental capability at CCGST in the fields of cryogenics, air separation by liquifaction/distillation, adsorption and membrane separation, including an ability to carry out investigations at the lowest possible cryogenic temperatures and to carryout computer based modelling for plant and process design and scale-up.

		Estimated cost (US$)
a)	Membrane technology:	
	1. Hydrogen compressor	40,000
	2. Flow regulators	15,000
b)	Heat transfer laboratory	
	3. Pressure and differential tranducers	20,000
	4. 12 Channel dip measuring system with chart recorder	15,000
	5. Data acquisition system with software	25,000
c)	Very low temperature cryogenic laboratory	
	6. Helium liquifier	300,000
	7. Helium gas bag purification system	30,000
	8. Helium leak detector	50,000
	9. Residual gas analyser	70,000
	10. Storage/transportation vessel for liquid helium.	50,000
	11. Gas chromatograph-microprocessor coupled	25,000
d)	Computer Hardware/software Minicomputer-multi station; graphic terminal, A0 size plotter, data logger system, computer-instrumentation interface, system software, etc. (VAX 6210 or equivalent)	350,000
	Total:	990,000

ANNEX V

Job descriptions

A non-resident CTA will be assigned to the project, whose duties will be broader then that of the experts/consultants, and is described in some detail. The duties of the consultants/experts will be essentially identical within the parameters of their respective fields of specialisations. The differences will be only in their qualifications and duration of assignments. These are separately described below. As regards their duties, these can be formulated as follows:

"The consultant will be assigned to BHPV/CCGST where under the guidance of the National Project Director, will be expected to perform the following task in his/her field of specialisation:

1. Advise CCGST staff in all theoretical and practical aspects of the technology, methodologies and practises involved;

2. Conduct information/training seminars on the subject of a specific aspect thereof, as appropriate and requested;

3. Provide essential documentation (such as reports, publications, data, etc.) relevent to the field which are in his/her possession (and involve no added costs for the consultant);

4. Assist in experimental work and demonstrate relevant techniques, thus providing on-the-job training for the national staff.

The consultant will also be expected to prepare a technical report setting out his/her findings and recommendations on further actions which might be taken."

The specialist consultants required by the project including their respective qualifications and forseen duration of their assignments is described in the following. For all experts/consultants good command of English is mandatory.

		Duration m/m	Number of Split missions
		-----	-----
11-01	Chief Technical Advisor-Expert in Cryogenic Technology	12	5
	Duties --Advise on: Preparation of subcontracts TORs ; equipment specifications; design/layout of the new facilities; selection of experts; development of programmes to be carried out; co-ordination of experts' activities-- in addition perform the duties above as expert in his field of specialisation.		
	Qualifications: University degree in chemical or mechanical engineering, with extensive experience in industrial air separation plants and other cryogenic fields. R&D experience in cryogenic technology development, particularly at pilot plant level highly desirable.		
11-02	Expert in Heat Transfer in Cryogenic processes		
	Qualifications: University degree in chemistry or chemical engineering; extensive research/development experience in cryogenic heat transfer phenomena.	8	3
11-03	Expert in Mass Transfer in Cryogenic processes		
	Qualifications: University degree in chemistry or chemical engineering; extensive research/development experience in cryogenic mass transfer phenomena.	8	3

11-04	Expert in Process Control and Optinization in Cryogenic processes Qualifications: University degree in chemical or mechanical engineering, with extensive experience in process control in air liquifaction plants; R&D experience highly desirable.	8	3
11-05	Expert in Process Instrumentation in Cryogenic processes Qualifications: University degree in chemical or mechanical or electrical/electronici engineering; extensive experience in process control instrumentation in air liquifaction plants; R&D experience highly desirable.	8	3
11-06	Expert in Process Design of Air Liquification/Sparation Equipments and plants. Qualifications: University degree in chemical and mechnical engineering; extensive experience in the design of air liquification and separation equipment and plants; R&D experience highly desirable.	8	3
11-07	Expert in Process Design and Control in Adsorption Gas Separation. Qualification: Unversity degree in chemical engineering; extensive experience in adsorption gas separation technology at the R&D and/or production level.	8	3
11-08	Expert in Membrane Gas Separation Technology. Qualification: Unversity degree in chemistry or chemical engineering; extensive experience in membrane gas separation technology at the R&D level.	8	3

11-09	Expert in Computer-based modelling of Chemical Processes Qualification: Unversity degree in mathematics or physics or physical chemistry or chemical engineering; extensive experience in mathematical modelling of chemical processes; experience in modelling of cryogenic processes highly desirable.	6	3
11-10	Expert in Computer-based Process Control in Chenical Processes Qualification: Unversity degree in physics or physical chemistry or chemical engineering; extensive experience in process control instrumentation in chemical processes including instrument-computer interfacing; experience in air liquifaction/separation processes highly desirable.	6	3
11-51	Consultant in Zeolite Chemistry and Production	3	---
11-52	Consultatnt in Inorganic Membranes Chemistry and Production	3	---
11-53	Consultatnt in Organic Membranes Chemistry and Production	3	---
11-54	Consultatnt in Techno-Economic Evaluation of Chemical Processes	3	---

ANNEX VI

Terms of Reference (TOR) for subcontracts

There are two separate subcontracts forseen under the project document. The complete Terms of Reference (TOR) for each will be drawn up by the Government Executing Agency (BHPV/CCGST) in consultation with the Chief Technical Advisor and the Executing Agency (UNIDO). The format and content of the TORs will be in compliance with UNDP policies and procedures to enable equitable international bidding. The TORs should spell out: adequate specifications of the equipment/instruments to be supplied and installed by the subcontractor; the performance standards to be met by the equipment; the conditions of guarantee of performance and workmanship; the training support to be provided by the subcontractor; and other relevant legal clauses to ensure as far as possible the delivery of expected performance by the subcontractor. Each subcontract will be one single contract with a well recognised foreign firm with proven experience and capacity to provide the required equipment and services for installation, start-up, demonstration and training in operations. The following highlight only the main items of services and goods to be provided by the subcontractor. The cost estimates are given for perusal to the parties of this project document exclusively and not to be communicated to the bidders.

A. Subcontract for cryogenic air liquifaction/separation pilot plant

1. Object of subcontract

To establish a complete self-contained pilot plant facility for studying air separation technology, including all the required instrumentation and peripheral hardware , according to the following specifications:

a) suitable for the production of either high purity oxygen and/or nitrogen in any combination of liquid/gaseous products (O_2/N_2 = G/G, G/L,L/G,L/L);

b) a minimum capacity of 200 Kg/hour of 99 % purity oxygen (liquid or gaseous) under continuous operating conditions;

c) the desired internal diameter (tray diameter) is 1 metre and a column height to hold upto 50 trays;

d) the column should have visual observation ports on at least 3 locations (bottom, middle, top) and be equipped to fix temperature/pressure gauges on sufficient locations needed for development of work. Sampling should be possible at every fifth tray;

e) provision should be made to insert or remove trays at any location of the column.

2. Provisions by the Government of India

The Government will provide the air compressor required for the liquifaction of air and will fabricate the column according to the subcontractor's drawings, specifications, and manufacturing instructions.

3. Goods to be supplied by the subcontractor

The subcontractor will supply all equipment such as heat exchangers, top condenser, expansion turbines, CO_2 analyzer fittings and control mechanisms not available in India, required for the successful operation of the facility, as specified in the subcontractor's engineering and installation design and specifications. This should include essential spare parts for 2 years of operation and specialized tools needed for maintenance.

4. Know-how and documentation

The contractor shall provide technical documentation as follows:

a) material, dimensional, fabrication and all other required specifications and documentations for the fabrication and assembly of the distillation column;

b) detailed layout and construction specifications for the installation and equipment/instruments;

c) detailed specifications and layout for all service facilities required in the operation of the equipment/instruments (e.g. electrical supply and cable routing, lighting and earthing, starting from the main switch point;etc.);

d) operational and maintenance manuals for all equipment/instruments supplied, including for start-up, continuous operations, preventive maintenance and calibration.

5. Services to be provided by the subcontractor

The subcontractor will be responsible for the packaging and shipping all the equipment supplied to ensure damage free transportation and delivery. Furthermore, the subcontractor will provide the services of experienced specialist to perform the following:

a) assistance during the fabrication of the distillation column;

b) installation of the equipment;

c) start-up operations;

d) demonstration runs and training of national staff in operations,maintenance and related calibrating procedures;

e) training in any techniques required for trouble-free operation and use of equipment/instruments.

6. Cost estimates (for internal use only)

	Estimated Cost (US $)
- Equipment and spare parts for 2 years	450,000
- Shipping and handling	10,000
- Documentation and engineering services (1 person for 2 months)	50,000
- Assistance during the fabrication of the column	20,000
- Installation and training of personnel (2 persons for one month)	20,000
TOTAL:	550,000

B. Subcontract for the Adsorption Pilot Plant

1. Object of subcontract

To establish a complete, self-contained pilot plant facility including all the required instrumentation and peripheral hardware, for studying air separation technology by adsorption process, according to the following specifications:

a) 4 adsorption vessels interlinked in such manner that air or other gases can be put through in any desired sequence.

b) vessel dimensions should be:

- height 3 meters
- diameter 1 meter.

c) visual observation port should be located at 3 places on each vessel (bottom, middle and top)

d) instrumentation ports for temperature and pressure measurement and for sampling of gas should be provided as specified by the subcoontractor.

2. Provision by the Government of India

The Government will provide the air compressor and will fabricate the adsorption vessels according to the subcontractor's drawings, specifications and manufacturing instructions.

3. Goods to be supplied by the subcontractor

The subcontractor will supply all equipment and control mechanisms not available in India, required for the successful operation of the facililty, as specified in the engineering and installation design and specifications. This should include all the required permanently installed as well as portable control, measuring instruments and hardware, such as control valves, mass flow meters, oxygen, CO and CO2 analysers, oil content meters, leak detectors etc. This should also include essential spare parts for 2 years of opertation and specialised tools needed for maintenance.

4. Know-how and documentation

The contractor shall provide technical and scientific documentation as follows:

a) material, dimensional, fabrication and all other required specifications and documentations for the fabrication and assembly of the adsorption pilot plant;

b) detailed lay out and construction specifications for the installation of the equipment/instruments;

c) detailed specifications and layout for all service facilities required in the operation of the equipment/instruments (e.g. electrical supply and cable routing, lighting and earthing, starting from the main switch point; compressed air supplies; running or chilled water supply; etc.)

d) operational and maintenance manuals for all equipments/instruments supplied, including for start-up, continuous operations, preventive maintenance and calibration.

5. <u>Services to be provided by the subcontractor</u>

The subcontractor will be responsible for the packaging and shipping all the equipment supplied to ensurre damage free transportation and delivery. Furthermore, the subcontractor will provide the services of experienced specialist to perform the following:

a) installation of the equipment;

b) start-up operations;

c) demonstration runs and training of national staff in operations, maintenance and related calibrating procedures;

d) training in any techniques required for trouble-free operation and use of equipment/instruments

6. <u>Cost estimates (for internal use only)</u>

	Estimated cost (US$)
-Equipment and spare parts for 2 years	120,000
-Shipping and handling	5,000
-Documentation and engineering services	35,000
-Installation and training of personnel (2 persons forr 1 month)	20,000
	180,000

ANNEX VII a

COST ESTIMATE FOR CENTRE FOR CRYOGENICS AND GAS SEPARATION TECHNOLOGY IN PREMISES OF BHPV

S.NO.	Particulars	Area (sq.m)	Unit Rate (Rs/sq.m)	Total (Rs.in Lakhs)
1.	Administrative Building (Ground floor,First Floor)	1568	3750.00	58.80
2.	Dehumidified Building. A/c	360	2000.00	7.20
3.	Instrumentation Room. A/c	288	2000.00	5.76
4.	Cryo lab (without EOT crane) A/c shed	432	1500.00	6.48
5.	Pilot Plant (with 3T EOT crane)	744	3600.00	26.80
6.	Work Shop	744	3600.00	26.80
7.	Distillation Pilot Plant (civil works only)	LS		0.50
8.	Ancillary buildings like security office, parking sheds etc.	LS		4.00
9.	Roads - 750 m	LS		3.00
10.	Boundary wall - 450 m	LS		2.70
11.	External water supply and sewage	LS		2.00
12.	External electrical services & internal power distribution	LS		1.50
13.	Site leveling,area development & Horticulture	LS		4.50
14.	Air conditioning Plants 3500 m3	LS		30.00
15.	Dehumidification & Ac Plants	LS		8.00
16.	Interior decoration of computer ,conference room	LS		5.00
17.	Street Lighting,telephones and Public address system	LS		2.00
	Sub Total			207.50

ANNEX VII b

LIST OF MACHINERY AND EQUIPMENT TO BE PROCURED UNDER GOVERNMENT INPUT FOR CENTRE FOR CRYOGENICS AND GAS SEPARATION TECHNOLOGY

S.NO	Specification of equipment	Qty	Approx. cost in Rs in Lakhs
1.	Adsorption pilot plant :		
1.1	Fabricated equipment such as adsorption column, storage vessels etc.	LS	10.00
1.2	Air Compressor	1	5.00
1.3	Vaccum Pumps	1	2.00
1.4	Electrical equipment	LS	1.00
1.5	Civil works	LS	2.50
1.6	Controllers (Microprocessor based)	LS	2.00
1.7	Activated Alumina others	LS	2.00
1.8	Manual valves, fittings	LS	1.00
1.9	Pressure switches, pressure gauges	LS	0.50
1.10	Flowmeters	LS	0.25
1.11	Blowers	2	2.00
1.12	Refrigeration Unit	1	2.50
1.13	Molecular Sieves	LS	4.50
1.14	Mercury Porosity mater	1	6.00
1.15	Personal Computer	1	1.50
1.16	Miscellaneous	LS	2.75
	Sub Total		45.50
2.0	Membrane separation process		
2.1	Fabrication equipment such as columns, piping etc.	LS	8.00
2.2	Membranes	LS	4.50
2.3	Zirconium Oxygen Analyser	1	1.50
2.4	Hydrogen Analyser	1	3.00
2.5	Blowers	LS	3.00
2.6	Microprocessor controllers	LS	3.00
2.7	Control Valves	LS	2.00
2.8	Pressure gauges, thermocouples etc.	LS	2.00
2.9	Manual Valves, sample valves etc.	LS	1.50

2.10	Flow meters	LS	0.20
2.11	Electrical equipments	LS	1.50
2.12	Civil Works	LS	2.50
2.13	Personal Computer	1	1.50
	Sub Total		34.20
3.0	Heat Transfer		
3.1	Brazed Aluminium Exchanger	3	9.00
3.2	Fabricated equipments, Strucrures etc.	LS	5.00
3.3	Rotary equipment	1	2.00
3.4	Instrumentation & controls (Programmble)	LS	12.00
3.5	Flow meters & others	LS	3.00
3.6	Flow characterisation rig	LS	2.00
3.7	Civil works	LS	0.50
	Sub Total		33.50
4.0	Distillation Pilot Plant		
4.1	Oxygen Analyser	1	7.50
4.2	Control Valves	LS	36.00
4.3	Fabricated equipment such as columns,piping etc.	LS	65.00
4.4	Electrical equipment	LS	25.00
4.5	Civil Works	LS	25.00
4.6	Pressure gauges	LS	6.00
4.7	Erection hardware	LS	7.00
4.8	Pressure switches	LS	1.00
4.9	Temparature switches	LS	1.00
4.10	Temparature Thermometers	LS	14.00
4.11	Pressure Thermometers	LS	21.00
4.12	Level Indicators/controllers	LS	13.00
4.13	Flow meters	LS	7.00
4.14	Field instruments	LS	27.50
4.15	Air Compressor	1	50.00
4.16	Miscellaneous items	LS	35.00
	Sub Total		341.00

5.0 Cryogenic Laboratory

5.1	Diffusion vaccum pumping system	1	10.50
5.2	Prcision weighing machines & Heating ovens	LS	3.00
5.3	LPG Supply system	1	4.00
5.4	Polorograph	2	3.00
5.5	Polorometer	1	1.00
5.6	Moisture Analysers	LS	1.00
5.7	Metler balances	2	0.80
5.8	Programmble temparature controllers	LS	6.00
5.9	Selector switches	LS	0.15
5.10	Thermostats	LS	0.30
5.11	Personal Computer	1	1.50
5.12	Vacuum fittings,gauges, gauge leads filters etc.	LS	4.50
5.13	Cryostats	LS	15.00
5.14	Infrared Gas Analyser	1	4.50
5.15	Test rig for cryogenic adsorption and purification Columns	LS	9.00
5.16	Laboratory Distillation unit with accesories	LS	12.00
5.17	Nitrogen Liquifier	1	25.30
5.18	Miscelaneous	--	2.00
	Sub Total		103.55

6.0 Computer Facility :

6.1	Terminals	3	0.60
6.2	PC's XTs	3	4.50
6.3	Furniture	LS	0.50
6.4	Vacuum cleaner	1	0.10
6.5	Computer stationery	LS	2.50
	Sub Total		8.20

7.0 Data Centre :

Data centre will have one file server and a special purpose PC AT of desk top publishing which will be housed in the Library.

7.1	File server Pc At with 8MB memory with 200 MB (formatted) fixed disk for files,color monitor with EGA, printer and facility for 16 users.	1	3.00
7.2	PC AT for desk top publishing 300 dpi 8 ppm laser printer, microsoft mouse and EGA.	1	4.00
7.3	PC AT for mathmatical modelling and computational analysis with 300 dpi 8 ppm laser printer, microsoft mouse and EGA.	1	3.00
7.4	Slide making attachment to PC.	1	1.50
7.5	Overhead projector attachment for PC.	1	1.50
7.6	Personal computers for Director adminisration, data centre and planning & training.	4	6.00
7.7	Voltage stabilisers,isolation transformers,floppies,ribbons, etc.	LS	3.00
	Sub Total		22.00

8.0 Library and Technical Services :

8.1	Photo Studio equipment	1 set	0.50
8.2	Ammonia printing machine	1	0.20
8.3	Slide preparation Unit	1	0.50
8.4	Books & technical journals etc.	LS	4.00
8.5	Furniture	LS	2.00
8.6	Plain Paper Reader Printer, and micro fiche reader	LS	10.00
	Sub Total		17.20

9.0 CAPITAL EQUIPMENT FOR WORKSHOP

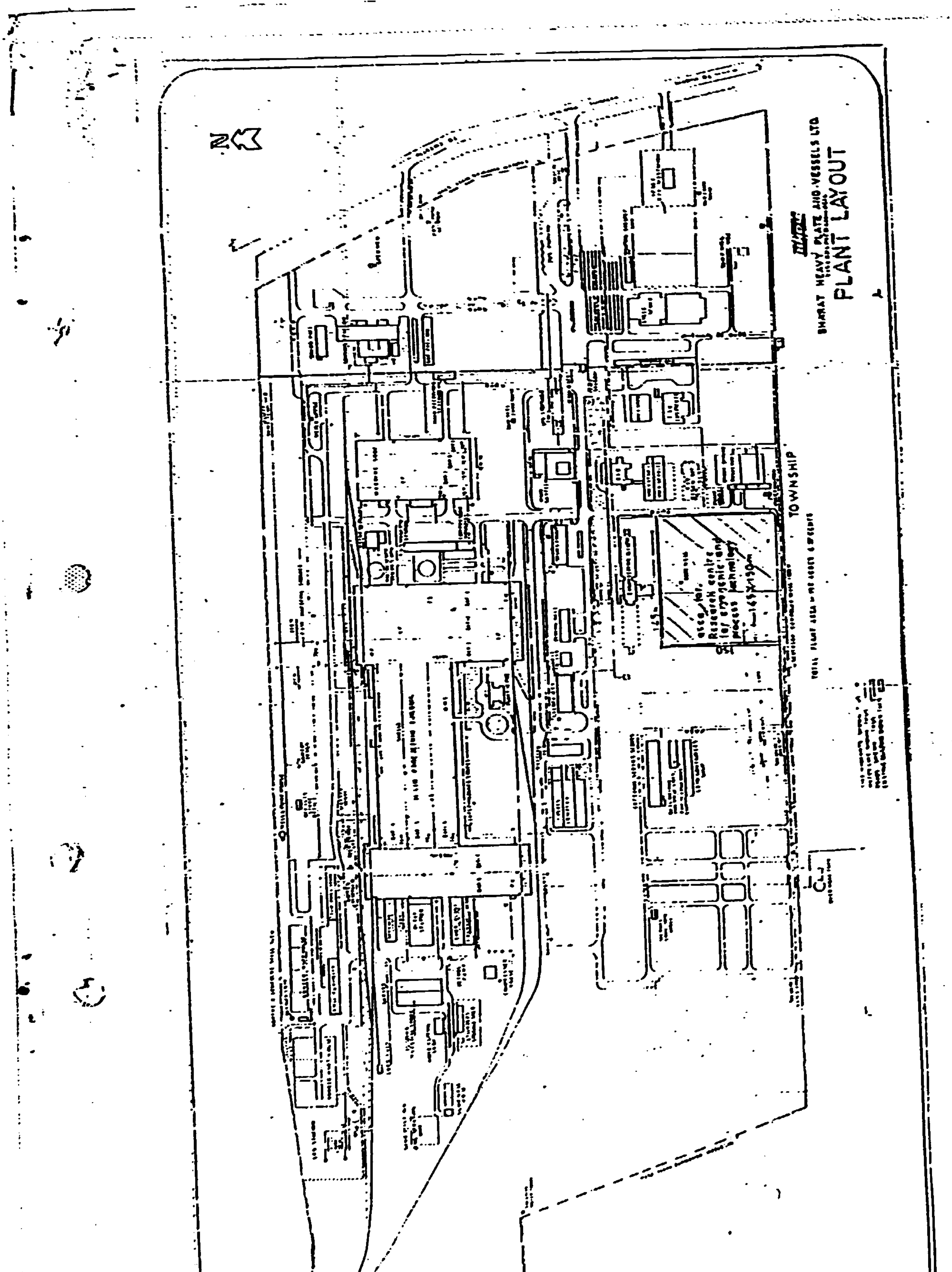
9.1	EOT Cranes	1	8.00
9.2	High Precision lathe	1	5.00
9.3	Milling Machine	1	4.00
9.4	Radial drilling Machine	1	2.50
9.5	Power saw	1	1.00
9.6	Shearing Machine	1	3.00

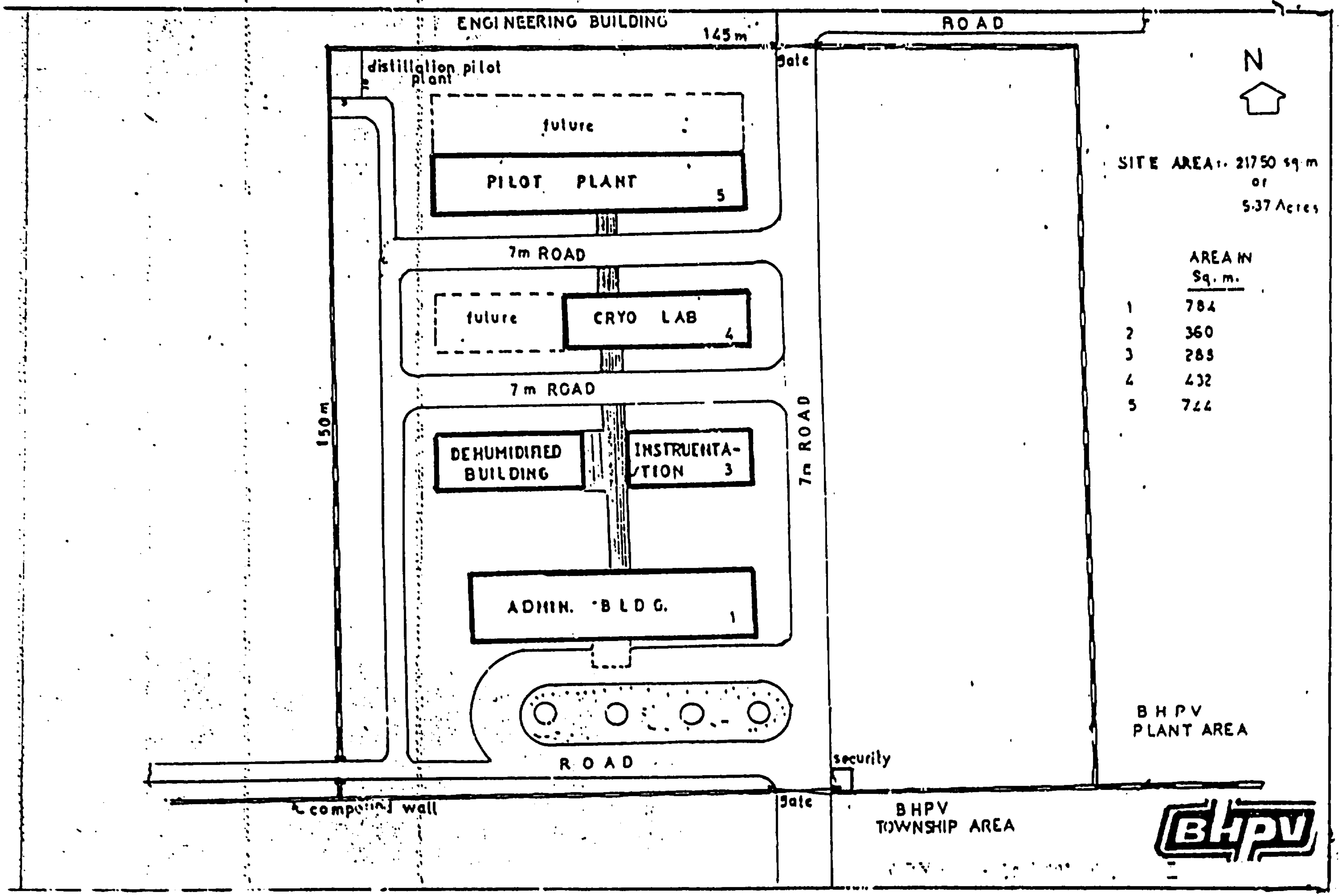
9.7	Sheet rolling Machine	1	1.00
9.8	TIG welding Machines	1	3.00
9.9	Rectifiers & Generators	1	2.00
9.10	Surface grinding machine	1	2.00
9.11	Cylindrical grinding machine	1	2.00
9.12	Pedestal grinders	1	1.00
9.13	Battery truck	1	1.00
9.14	Welding positioners, rotators, surface plate, measuring instruments, portable grinding machines, bench vices, hand shearing machine, portable drilling machine, tools such as hand taps, machine taps, drills, try squares etc.	LS	4.00
9.15	Weighing machine	1	0.50
9.16	Hydraulic testing machine	1	2.00
9.17	Electric furnace	1	2.00
9.18	Hydraulic press	1	2.00
9.19	Pipe bending, sheet bending machines	LS	1.00
	Sub Total		47.00

10.0 UTILITIES

10.1	Project vehicle diesel pick up van	1	1.00
10.2	Water coolers	4	0.20
10.3	Pedastal fans	10	0.80
10.4	Telephone 30 line exchange with board	1	0.70
10.5	Refrigerator	2	0.25
10.6	Intercom 24 lines	1	0.25
10.7	Time clocks punching	1	0.15
10.8	Generator (30 KW)	1	1.50
	Sub Total		4.85
	Grand Total		657.00

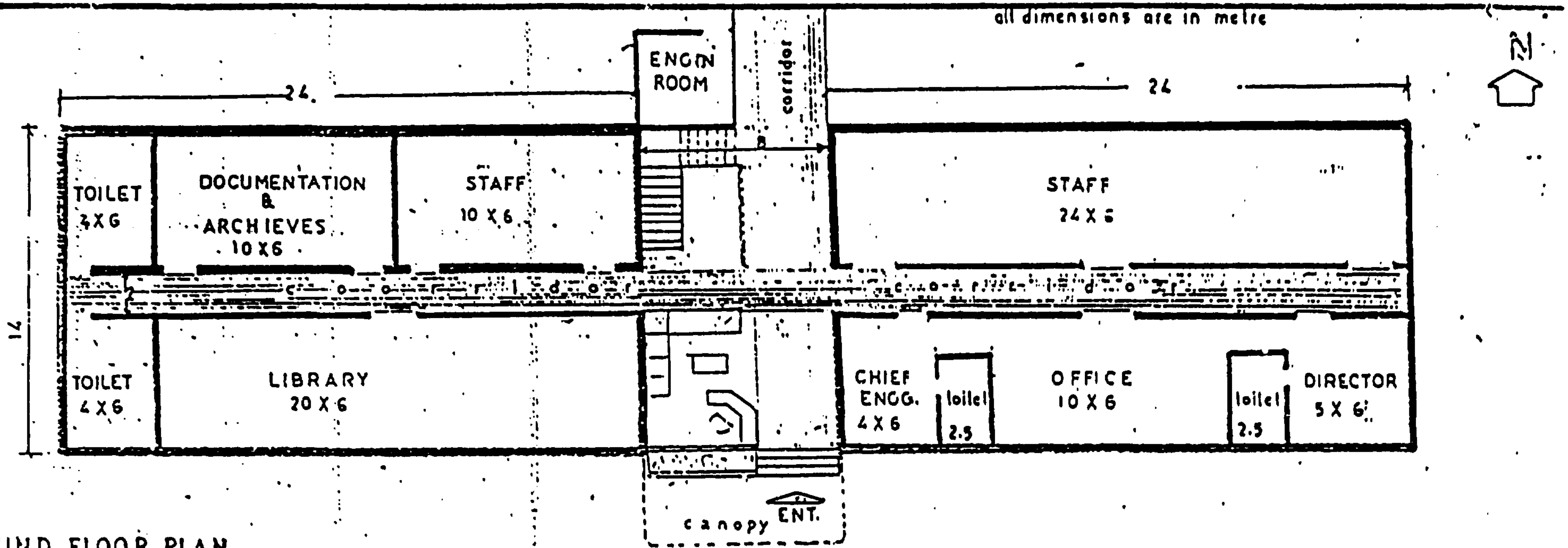
ANNEX VIIC/1



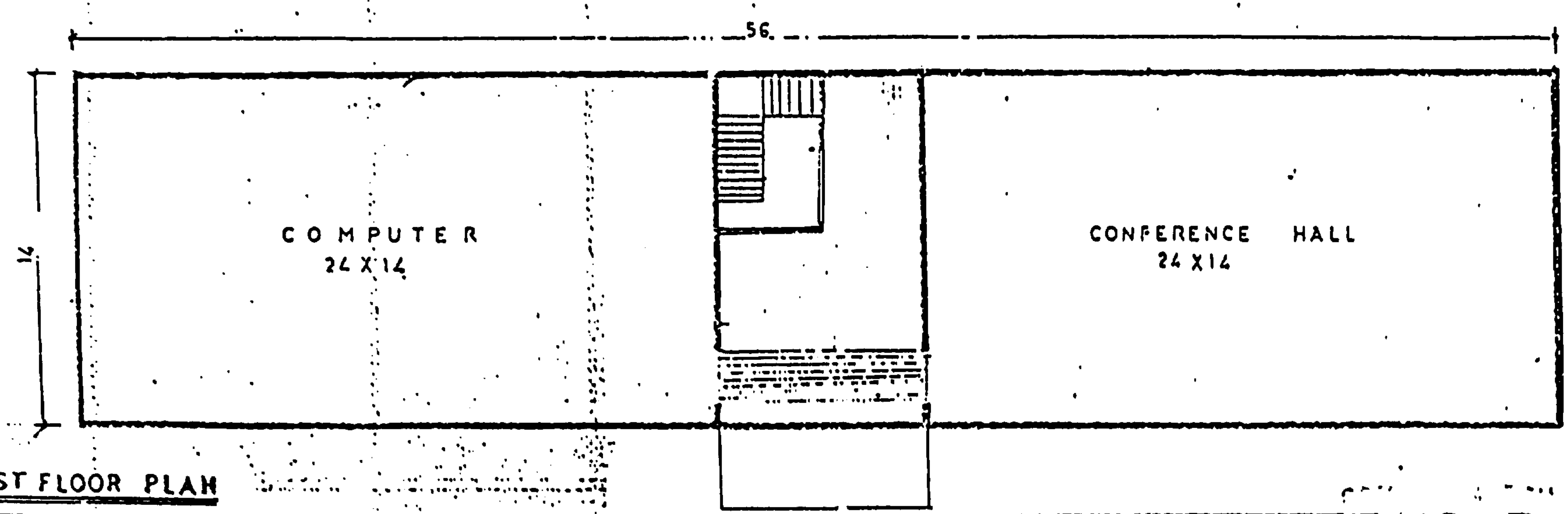

ENGINEERING BUILDING
145 m
ROAD
Gate
distillation pilot plant
future
PILOT PLANT 5
7m ROAD
future
CRYO LAB 4
7m ROAD
DEHUMIDIFIED BUILDING
INSTRUMENTATION 3
7m ROAD
150 m
ADMIN. BLDG. 1
ROAD
security
compound wall
Gate
BHPV TOWNSHIP AREA
BHPV PLANT AREA
N
SITE AREA:- 21750 sq m or 5.37 Acres
AREA IN Sq. m.
1 784
2 360
3 285
4 432
5 744
BHPV

ANNEX VIIC/2

ANNEX VIIC/3



GROUND FLOOR PLAN



FIRST FLOOR PLAN

ANNEX VIII

PROJECTED BUISINESS OF CRYOGENIC PLANTS (1990-2000AD)

	Rs in crores
Steel Modernisation (Tonnage Oxygen Plants)	500
Steel Revamping (Tonnage Oxygen Plants)	200
Petrochemical (Nitrogen,Oxygen HPN Plants)	60
Small Oxygen Plants	10
Fertiliser Plants (Purge Gas, N2, Argon Recovery)	80
Space Oriented (Space Chambers)	200
Gas Sales	50
Others Like Transportation Storage Vessels and CBC etc.	120
Refineries (HPN)	10
Oil Exploration	20
PSA & Membrane Plants	200
	1450