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Wind energy applications in Indian Antarctic station Maitri, Antarctica

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INTRODUCTION

One of the superlatives applied to Antarctica is "the windiest continent" with good reason. In fact, Antarctic weather is rendered unbearable partly because of the chill winds that never seem to let up once started. This is particularly true for coastal areas. Winds have been found to touch 300km/hr under blizzard conditions and dwellings constructed would have to be designed taking such wind loads into account. Wind Energy devices have been used with low to moderate success rates in Antarctica.

The Steering Committee on Antarctic Research set up by the Department of Ocean Development recommended that alternative sources of energy should be used to supplement the station's own and its field camp's energy requirements. To this end Wind Energy Division of National Aerospace Laboratories, Bangalore submitted a comprehensive proposal regarding use of wind energy at Indian station. The proposal was discussed by the expert groups and approved to be implemented during XVI and subsequent expeditions. Accordingly during XVI expedition one senior scientist was deputed form wind Energy Division, National Aerospace Laboratories to Antarctica to get a first hand experience and chart out the future course of action.

Wind Energy In Antarctica- International Experience

Wind Energy has been harnessed in Antarctica by various scientific communities from counties with both temporary and permanent stations. Detailed reports on the precise nature of the experiments conducted are not easily available. From the available resources it has been found that American, Spanish and Russian stations have taken serious interest in using wind energy in their stations. Machine sizes of few watts to 20 kW have been found to be experimented with. These machines were employed essentially for space heating and much of the time only experimented with. Some of the interesting features of these experiments is the different points of view regarding the same machine or experiment. German station at Naumayar had a machine of 20 kW capacity. The designers claimed that the machine was indeed proven in Antarctic environment while Germanischer Lloyds have stated that while the machine would be useful, needs to be strenghtened on several counts. Similar experiences have been reported also from 2 Russian machines. American stations experimented with small systems in the capacity range of 1 to 3 kW. These machines were taken from market and were fully instrumented to study the performance. Some authentic reports form Russia indicate that the machine's life from the quoted twenty plus years gets drastically reduced in Antarctic environment In fact, after two or three years of operation the machines would require major overhauling and replacement of critical components.

Wind Energy Application in Antarctica- Indian experiments

Indian Antarctic Programme has located a permanent station in Schirmacher hills and has summer camp sites. The station can house 25 members during winter and during summer nearly seventy members would live and work in the Indian station. The station is powered by modified diesel engines running on Aviation Turbine Fuel. At any given time two 63 kV 3 phase alternators would be providing electrical power required in the station . Four boilers provide the heating required at the station, turn by turn.

During 1984 , Bharat Heavy Electricals Limited sent a 4 kW wind powered battery charger to be installed at the station for study and experiments. The machine was installed complete with control unit, dump load and batteries. The machine performed for a short while. During a blizzard the machine developed some snags which could not be rectified with the available facilities at the station. Subsequently Research and Dvelopment Establishment, installed a much smaller unit and conducted some experiments. But as such the machine was not contemplated to be used for any specific application. By this time Solar Photo voltaic panels were also used by field camps particularly for charging communication batteries.

These experiments were similar to those conducted elsewhere in the sense that the end use was not very well defined and it was also not feasible to disturb existing life support systems with out fully exploring the feasibility and reliability of the systems used. It was then decided that the matter of using wind power in the Indian Antarctic station should be taken up as a specific task and carry out detailed analysis of available options keeping in view the limitations and safety requirement.

Wind Energy Plan for Indian Antarctic Station

Looking at a sustainable development point of view the following approach was suggested and is being implemented from NAL:

1. Detailed wind resource to be assessed at site of Indian permanent station.
2. Take stock of present energy supply systems at the station and carry out an energy audit
3. Study the site with a view to locate machines in the most suitable location from point of view of energy utilization, maintenance. Also look at the pro-

posed new summer camp site and other field camp sites from Wind Energy Utilization point of view.

4. Take stock of facilities available at Maitri with a view to future machine installation.

5. Work out the best strategy for integrating wind energy systems with existing energy supply systems.

6. Work in tandem with Department of Ocean Development, user departments such as Communication, Indian Institute of Geomagnetism, Geological Survey of India, R & D Engineers Establishment etc.,

Wind Resource Assessment

Getting a good idea of wind resource is very essential before any serious investments are made in wind energy hardware. While the synoptic measurements of wind speeds and directions are available from Meteorological Department, there are some limitations as to the direct applicability of this data for the following reasons.

1. The Meteorological observations pertain to the synoptic hours rather than the complete hourly data

2. Continuous data is recorded on strip chart recorders and data reading can be cumbersome and carries with it risk of human errors creeping in.

3. Anemometers with considerable distance constants are employed which would even out short term gusts and therefore cannot be properly quantified and used while designing hardware for survival wind speeds for structural integrity.

4. Wind shear closer to ground is not directly available at site. This is a very important input in optimizing future wind turbine design.

Due to these limitations, it was proposed that a tall mast of height about 30 m be used for multi level data acquisition from suitable sensors. It was then suggested by the expert committee that there already exists a 28m mast that has been used for Sodar related experiments by NPL. The mast was to carry three level anemometers and two direction sensors connected to solid state data loggers. The data loggers would sample the wind speeds and directions once every two seconds and average it over pre set intervals. The data would be stored on EEPROMs. The data logger is powered by small alkaline batteries which would have to be replaced once every month. Data stored on EEPROMs is to be down loaded on to a personal computer at regular intervals. The data would then become available for processing and analysis.

Figure 1 shows photographs of the 28 m mast and the mounting arrangements of the anemometers and direction sensors. The mast is on the banks of Priyadarshini lake to the North of Maitri station. Figure 2 shows the digitized contour map of the portion of Shirmacher hills where Maitri is located and the mast location. Basic data for the digitized map is taken from Survey of India[131].

Due to extended periods of operation of the sensors under subzero temperatures, heated anemometers and direction sensors were employed. This was to prevent snow and ice accumulation on the sensors and impairing the functioning of the sensors. Data loggers use 9 V energizers (alkaline). The performance of these batteries falls sharply with low temperatures. Though the data loggers have a provision to take external power supply, maintaining uninterrupted power supply can be difficult particularly through the winter months. Therefore it was decided to run suitably designed wiring systems from the sensors to data loggers housed in the "NPL hut" where other experiments related to Geo-magnetism etc. would be continued through the winter months. The distance from the tower to the hut is about 100 meters. The cables were run through two conduits. In order to minimize the risk of AC induced signal noise, the power required for heaters was routed through an independent conduit. The conduits were embedded into the earth to prevent dislocation and consequent cable damage.

Anemometers were fixed at heights of 28, 22 and 12 m above ground level. Direction sensors were located at 28 and 12 m above ground. North setting of the direction sensors was fixed using a magnetic compass.

Two data loggers were housed in the NPL hut at a place that is located among their electronic equipment and it was ensured that the temperature may not fall below 10°C. Data logging was started on January 16, 1997. Data logging was to continue through the winter months and this was carried out by the Station Engineer at Maitri. Summary results of the data collected is presented in Figure 3 and 4.

Energy Supply System at Maitri

At Maitri, the entire heating and electrical load requirements are met with using Aviation Turbine Fuel oil. Nearly 500,000 liters of fuel would be used in one year. A major portion of this oil gets used by the transport systems that need to be maintained for shifting station's requirements form the ship berthed at the edge of Antarctic coast. Figure 5 shows block diagram of the power supply system used in the station . There are three locations where alternators are installed. Aditya, Bhaskara are two generator houses which are essentially porta-cabins at some distance from the Maitri station. Generators in a block of Maitri are also kept in working condition but are expected only to take care of emergencies. Apart from this, there are two lOOkV generator sets which have been recently added to the stock of equipment available a Maitri . For safety reasons at any point of time two generators one from Aditya and one from Bhaskara power house are kept working. These generatros are connected to independent loads and therefore not synchronized. The machines once started would work continuously for 96 hours. At the end of this period next set of alternators are started and loads are transferred. Generally one generator takes care of boiler room power supply system. Annexure gives details of various connected loads. While there are no energy meters kept to record actual loads, generator output is kept track of by measuring phase voltages and currents on an hourly basis. This record is maintained at each power house. Using these hourly values, it is possible to obtain approximate estimate of energy requirements over the year. Based on this the power requirement at the station has been calculated and figure 6 show a plot of electrical power used in the station. It may be seen that the combined load from two generators is less than 60kW and the average load is in the range of 30 to 40 kW.

Heating energy is provided by boilers and burners with a re-circulating hot water system. Boilers and burners are manually controlled by noting the ambient temperature observed in suitably placed thermometers. There are a few electrical heaters proivded in the hot water tanks. Boiler room also serves as the inlet point for water pumped from Priyadarshini lake for the station's use. During XVI expedition a trace heating system was introudced in the piping system from the lake to boiler room. This works on electrical power and is expected to keep water from freezing during winter. This would increase the electrical load by additional 8 to 10 kW when switched on. Average fuel consumption in the boiler room is given in table 1 & figure 7 on a monthly basis. Fuel oil used is calculated by using specific fuel consumption (oil burnt per hour per burner). As can be seen , the fuel consumption would be highest during June-July-August period and gradually fall on either sides.

Based on the generated electricity and assuming an average efficiency of conversion at 10% (Thermal to electrical energy), the fuel used for generators the estimated fuel consumption would work out to 1,60,000 liters per year.

The automotive workshop has its own 30kW generator and is used intermittently and on none of these systems the fuel consumption is monitored. But the consumption of fuel in this connection is really quite small and therefore neglected.

Based on these factors, the average fuel oil requirements of the station is estimated to be about 2,40,000 liters per year.

Land availability for Wind Energy Generation

Maitri is located in Shirmacher hills . The station has, to its back, continental ice rising about 50 m and in front the Priyadarshini Lake. Between the lake and the station are summer huts and other utilities. A local grid formed using buried cabling caters electrical power to the summer huts. SOI map gives locations of these utilities to scale . The approach to lake is gently sloping form Maitri. The rocky terrain with permafrost below the gravel covering in the area with the huts make up for land in the station. The station is surrounded by many peaks and generally working on these peaks can pose many difficulties. The Easterly and South Easterly directions have elevations that are marginally higher than those at Maitri. Proposed new station is to be located in this area. Several locations were looked at with a view to setting up wind machines in future.

Based on present and future land use around Maitri, the areas to the east of Maitri can be considered . This would be close to future summer camp site and therefore the location can also be used for generating Wind Power for both camps.

Facilities

It has been found that the station has all the facilities required to set up a Wind Turbine of 10 to 20 KW capacity. Apart from quite a few lifting and pulling machines, there are crab winches of 5 to 10 ton capacity. There is also track mounted 20 ton crane with boom lengths upto 20m agl The details of the crane are given in table 1.

At Maitri during summer the average man power available is about 50 to 60 persons. On crucial days and hour help from a major portion of this can be available. With prior arrangement help in term of technical work can become available. At the station a qualified station engineer is a available over the winter as well as summer. Most of the Civil work is undertaken during summer. During discussions with the leader and station engineer it emerged that casting normal foundation can be a problem due to permafrost. It was therefore decided that alternative methods of supporting Wind Turbines structure were to be experimented with.

Conclusions

1. **It** was found that the station can use Wind Energy to supplement energy requirement in the station and field camps.
2. There is enough land available around the station for installation of Wind Energy Hard Ware.
3. There is enough infrastructure available at the station required to set up a machine in the capacity range of 10 to 20 KW.
4. A proper work plan has to be prepared to implement inclusion of Wind as a source of Energy at Indian Antarctic station.

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Prof. U.R. Rao, Chairman of the Steering Committee on Antarctic Research, suggested this project and gave a starting push to the idea of utilization of Wind as an energy resource in Antarctica. Department of Ocean Development has provided an opportunity for testing and implementing renewable energy schemes in Antarctica. Chairman, CSIR-SCAR committee has provided funds required for the program. The leaders of XV and XVI IASE have provided an excellent work environment. The Army contingent was most helpful in extending fullest cooperation both at intellectual and logistic level. Colleagues from other

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The cooperation and participation of various agencies and persons is gratefully acknowledged.

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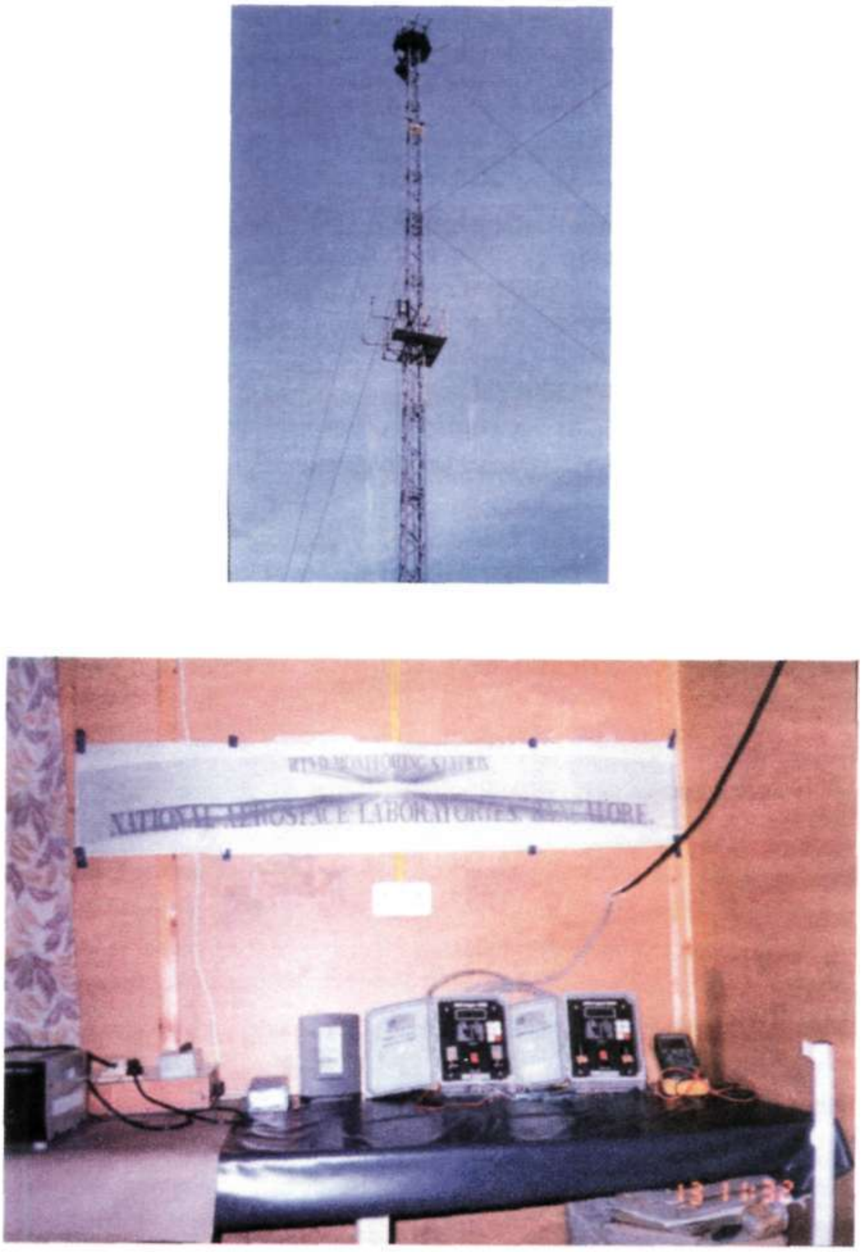
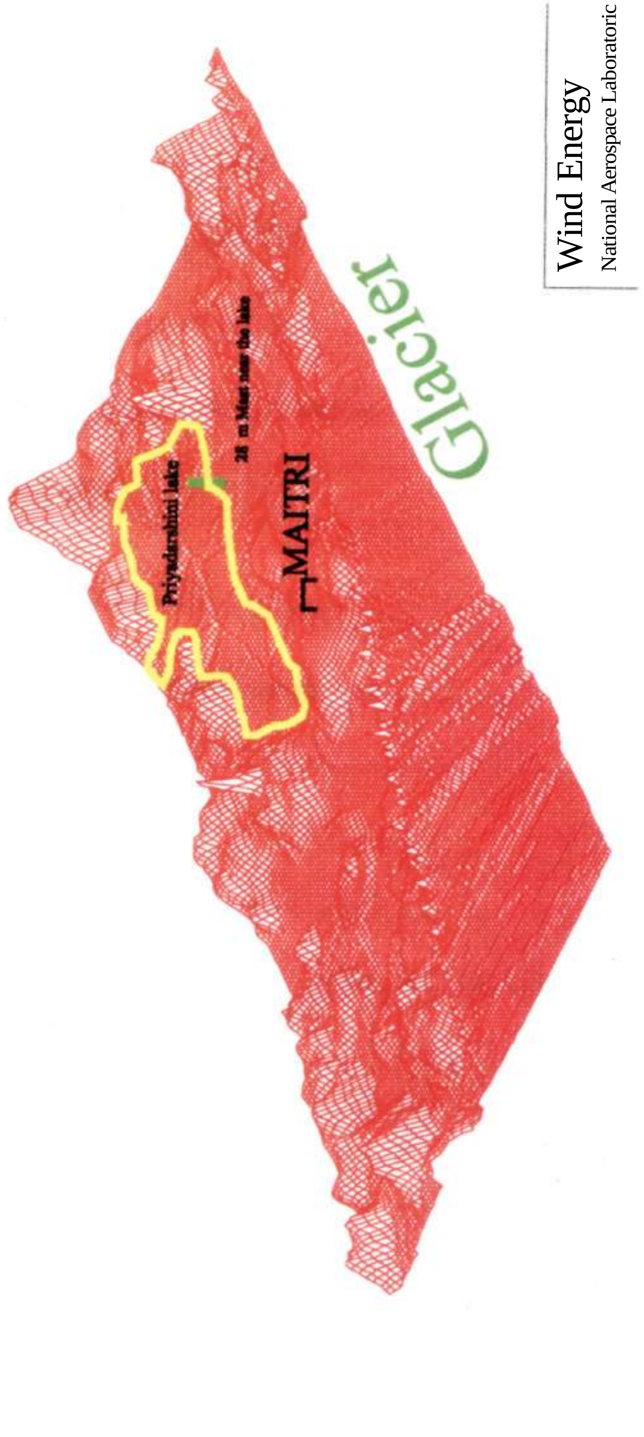


Fig. *1:Anemometer, Direction Sensors & Data Loggers at Maitri.*

Fig 2. Digitized Perspective view of Maitri & environs



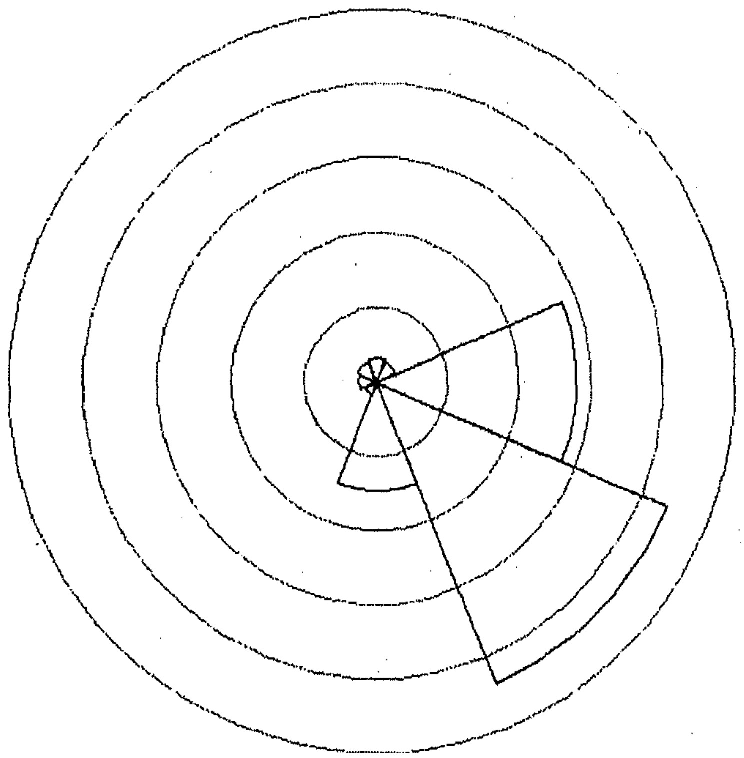
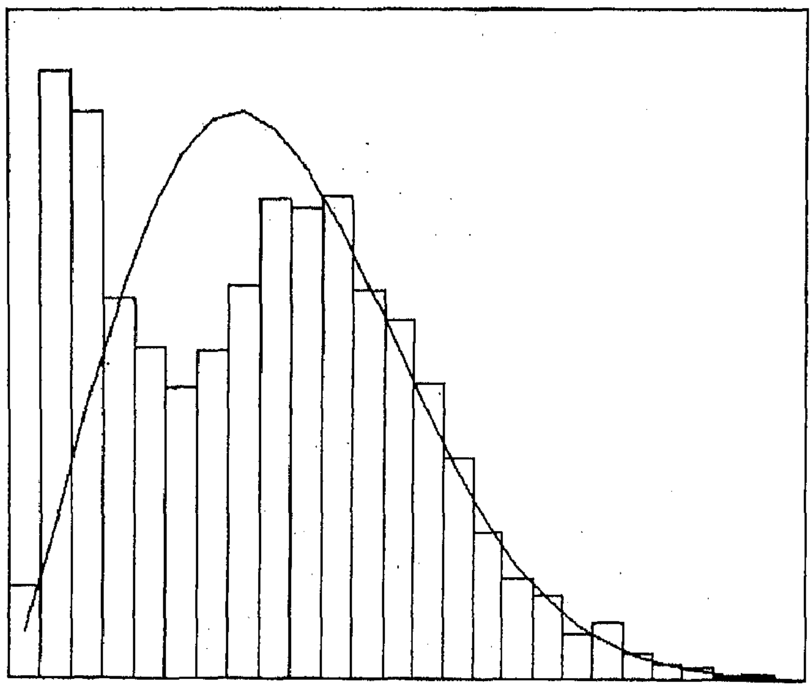


Fig. 3&4 : Wind rose and frequency distribution at Maitri, Antarctica



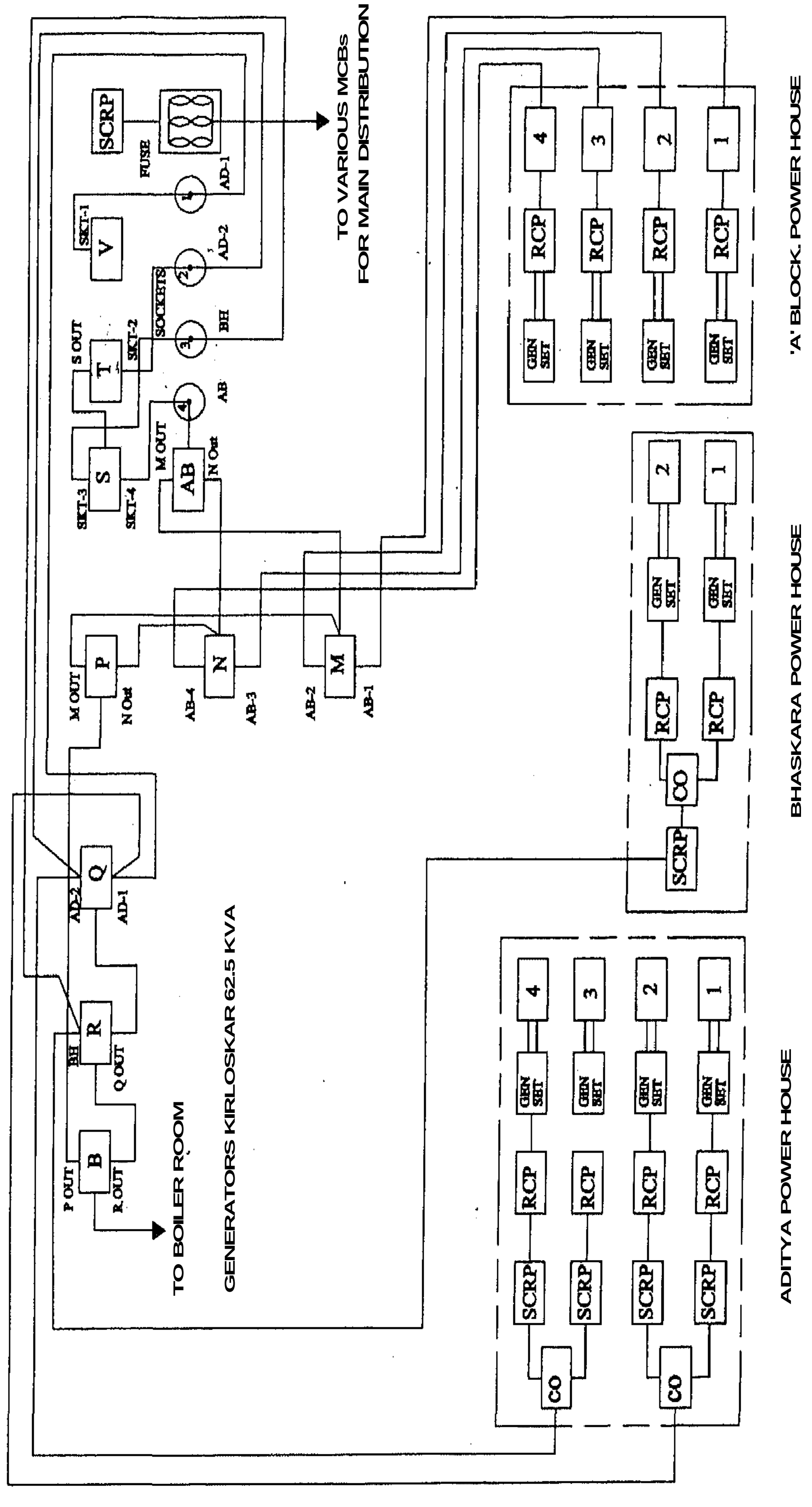


Fig. 5 : Electric power supply system at Maitri

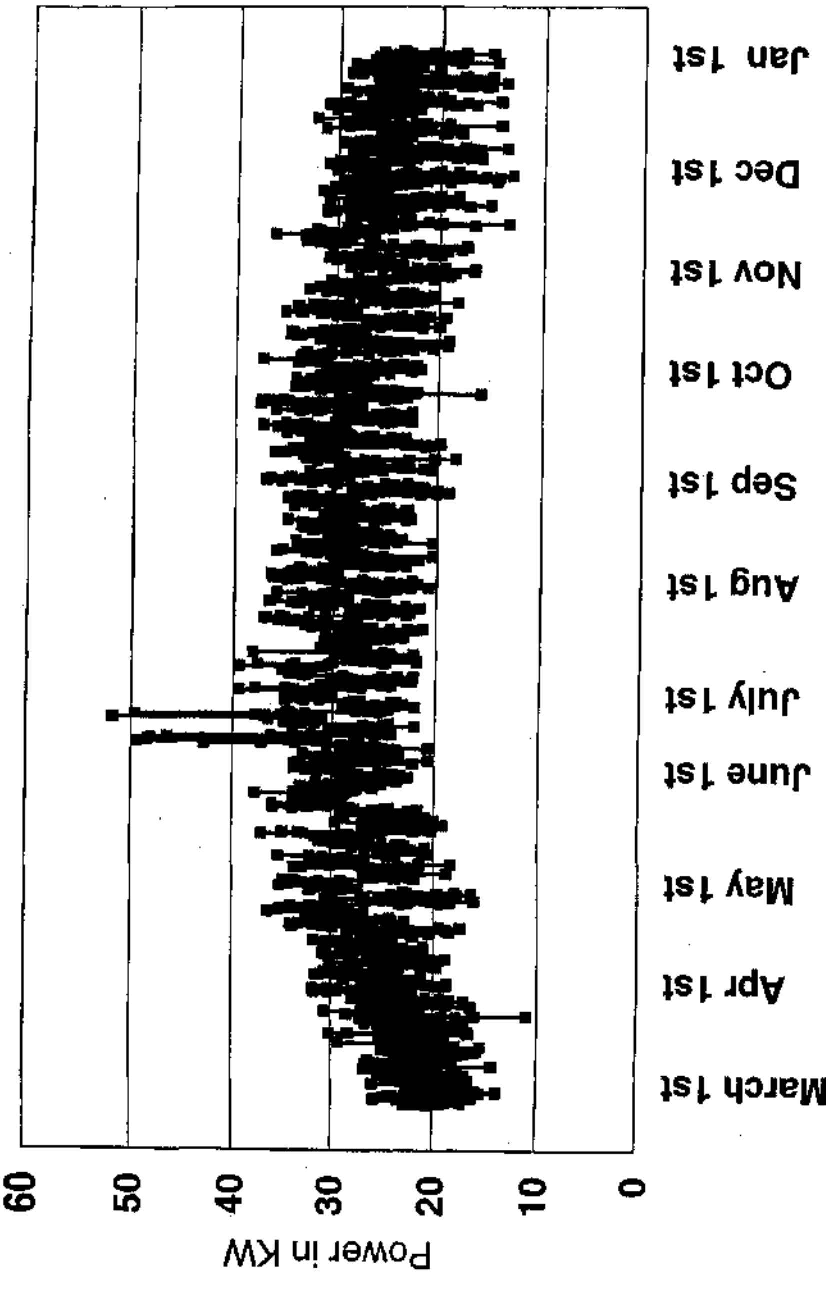


Fig. 6: Electrical power consumption at Maitri.

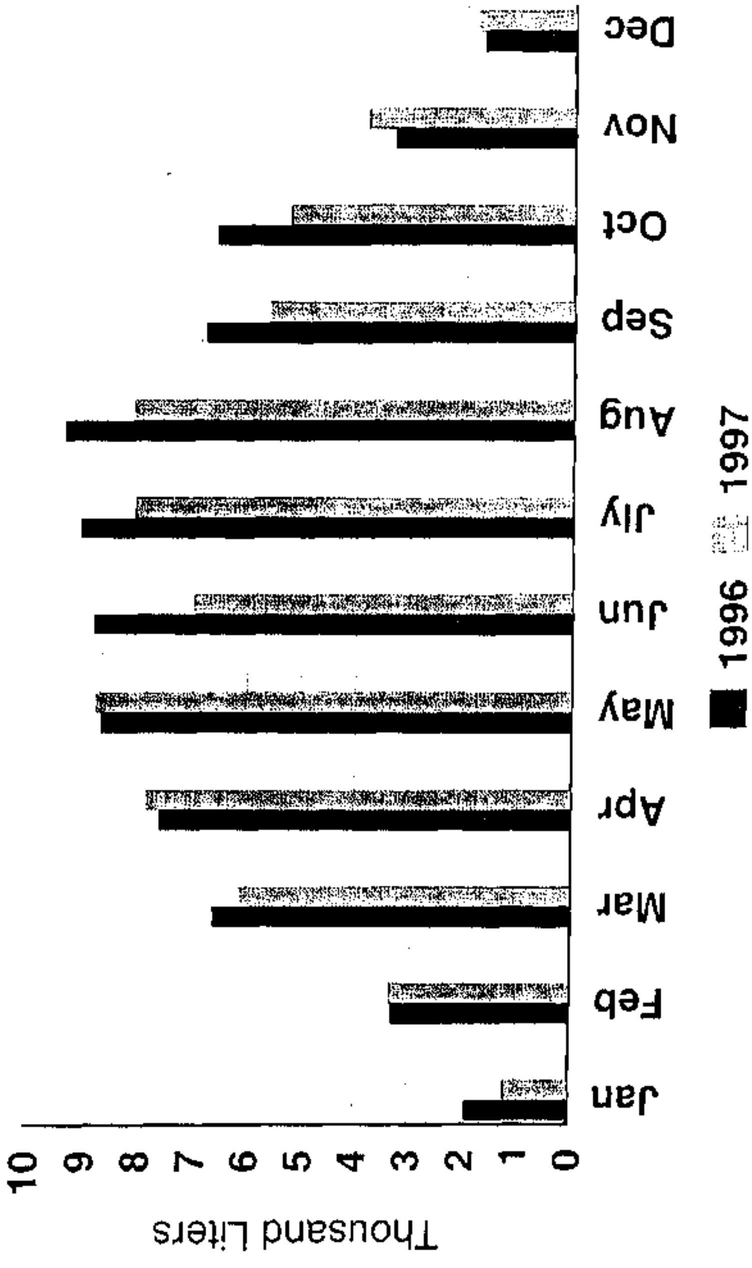


Fig. 7 : Fuel consumption pattern at Maitri

Table 1 : 18 ton hydraulic crawler crane Mantis model 3612 (PCSA class 1251)

Crane Without the Jib

Boom Rad (feet)	Boom Ht (feet)	Max load (lbs)
15	58	26885
20	57	18033
25	55	14208
30	52	11585
40	45	7432
50	33	4153
60	0	2295

15' A frame Jib Cappacity with 0° offset

Boom angale Deg	Rated Cappacity Pounds	Tip hight Feet	Tip Radius Feet
75	5000	88	21
70	4500	86	28
65	4000	83	35
60	3500	80	42
55	3000	76	48
50	2500	71	54

15' A frame Jib Cappacity with 30° offset

Boom angale Deg	Rated Cappacity Pounds	Tip hight Feet	Tip Radius Feet
75	2500	85	28
70	2250	82	34.5
65	2000	78	41
60	1750	74	47.5
55	1500	70	53
50	1250	65	58.5

Jib is utilized for added lifting height NOT RADIUS