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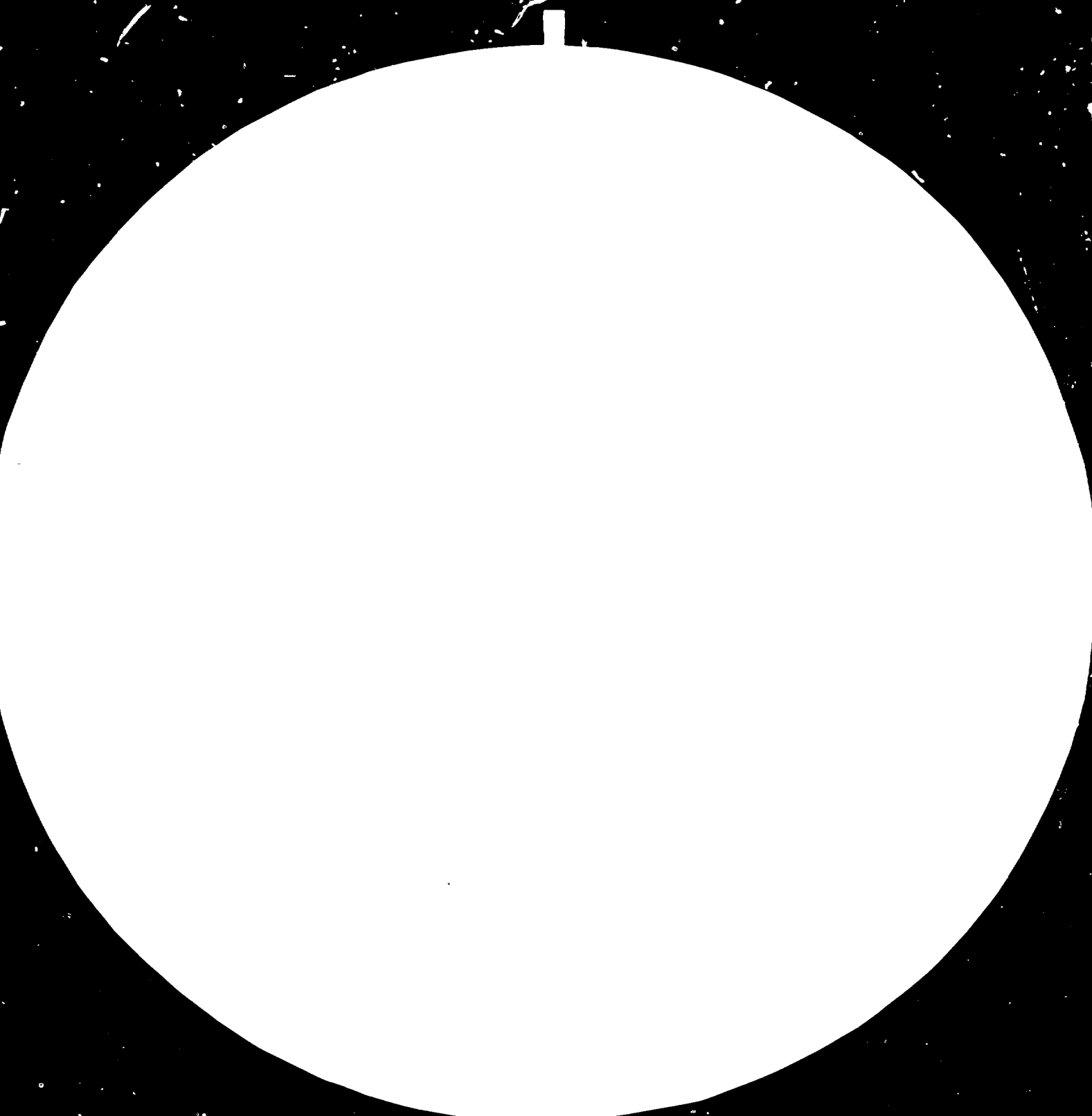

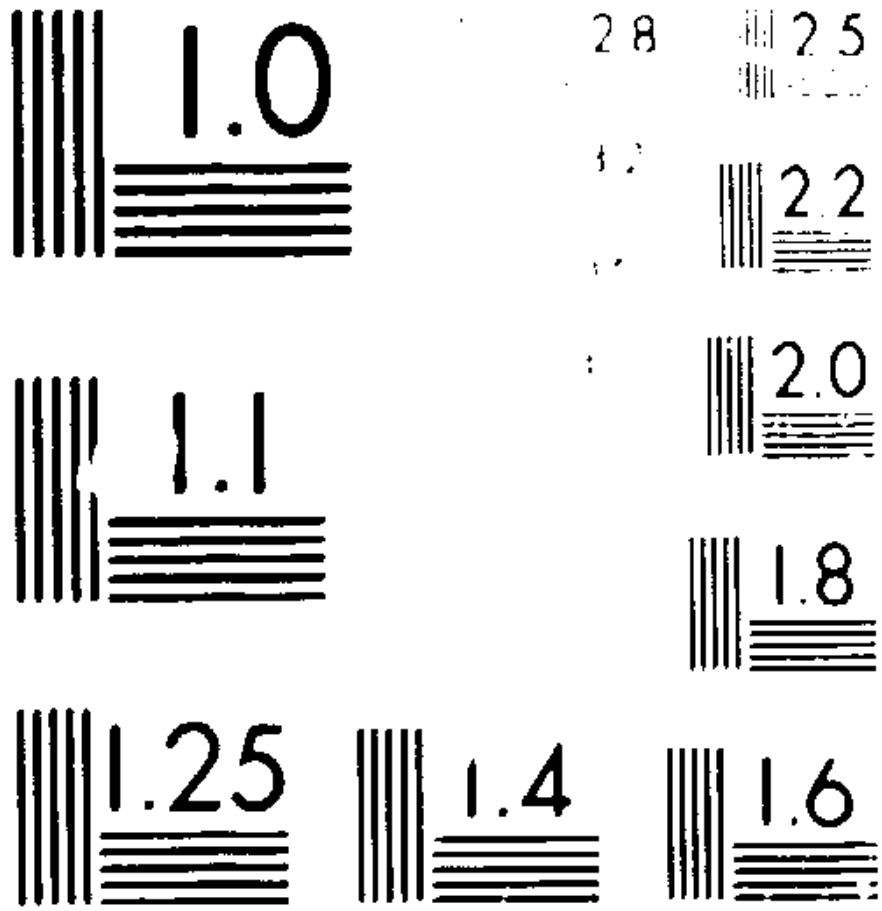
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Distr.
LIMITED

ID/WG.305/33
9 May 1980

ENGLISH

United Nations Industrial Development Organization

Seminar-Workshop on the Exchange of
Experiences and Technology Transfer
on Mini Hydro Electric Generation Units

Kathmandu, Nepal, 10-14 September 1979

DEVELOPMENT OF MINI AND MICRO HYDRO ELECTRIC POWER STATIONS IN PAKISTAN*

by

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INTRODUCTION.

Pakistan's geographical features are characterized by high mountain ranges in the Western, North-Eastern and Northern Regions. The rest of the country is plain with a gradual slope from North-East to South-West. The country is traversed by many rivers, the most important being the Indus, which has its source in the northern mountains. During its flow towards the South, this river is joined by its tributaries and flowing through the plains it falls into the sea.

A vast tract of the plains area is irrigated by canals fed from rivers. The canals offtake from Barrages constructed across the rivers. The canals network system of Pakistan is the largest in the world. The flow of canals is due to the slope of land in the plains from North-East to the South-West direction. The slope is about one foot per mile length.

In Pakistan, Mini and Micro Hydel Power Stations can be built in the mountainous regions on small rivers and streams, and, in the plains on the canals.

2 MINI HYDEL STATIONS IN MOUNTAINOUS REGIONS.

2.1 Socio-Economic advantages.

These regions are sparsely populated and relatively underdeveloped. Most parts of this region are far from the interconnected Electricity Grid System, and it is not economical to electrify them from the Grid due to the sparse loads, inaccessible terrain and distances involved.

To improve the economic conditions of the people of these mountainous regions electricity is very essential. With electricity small industries can be established and numerous direct and indirect benefits accrue from such undertakings. One of these small industries is saw-mills. Some of these areas are covered with valuable timber forests which can be exploited. At present timber logs are transported to down country due to lack of power sawing facilities in the area.

The availability of power will also help to reduce dependence on import of kerosene oil which is being used for lighting, heating and cooking purposes and is sold at very high rates; furthermore, it will save wood which is also being used for these purposes, and resulting in deforestation of these regions; this deforestation is further causing erosion and also increasing floods and siltation of reservoirs and canals.

2.2 Work done upto present and potential.

The power potential of streams and rivers in the mountainous regions of Pakistan has been appreciated since long. Water wheels, utilizing theenergy of flowing water are used for grinding purposes. Many such installations are in operation in the mountainous regions particularly in the North Western Frontier Province, Northern Areas and Azad Kashmir.

Investigations have been carried out by several Government Agencies to assess the power potential of many small rivers and streams from the point of view of construction of Mini and Micro Hydel Power Stations; many suitable sites have been selected, and a number of power stations have been constructed.

2.2.1 Mini Hydel Stations.

The first small Hydel Power Stations tobe built in the Northern Areas of Pakistan were 5 Power Stations initiated in the 1960s by Pakistan Water and Power Development Authority (WAPDA). Four of these were completed in 1967 and one in 1973. Their details are as follows:-

Sr.No.	Name of Power Station.	Location.	Capacity Installed.	Capacity can be increased to	Date completed
1	Naltar	Gilgit-Naltar River.	90 kW	-	Nov. 1967.
2.	Baltit	Hunza-Hassan-abad River.	200 kW	600 kW	Dec. 1967.
3.	Gilgit	Gilgit-Kargah River.	400 kW	800 KW	Feb. 1967.
4	Chalt	Gilgit-Chaport Nallah (Stream)	50 kW	100 kW	Sept. 1967

5.	Skardu	Baltistan-Satpura River.	400 KW	-	March 1973.

Subsequently a sixth Power Station was completed by WAPDA in 1975 at Chitral ; It has a capacity of 450 KW.

During this period the Northern Area Public Works Department (now Northern Area Works Organization-NAWO) also installed 4 Mini Hydel Power Stations at Chilas, Astor, Hunza and Shigar in the Northern Areas. Each of these Power Stations was of 125 KW capacity.

Before the construction of these Power Stations, electricity was being generated at these places by Diesel Generator sets, which was much more expensive. The fuel oil had to be transported by air to these sites.

In 1973, a scheme was initiated by the Government of Pakistan to carry out investigations for more than 100 Mini Hydel Power Stations with capacities from 50 Kw to 300 Kw in the northern mountainous regions of Pakistan. The Pakistan Water and Power Development Authority (WAPDA), was assigned to carry out the investigations.

Subsequently in 1974, 100 standard Turbo-Generator sets, 50 of 50 KW each and 50 of 100 KW each were purchased by the Government of Pakistan for installation in the mountainous regions of North Western Frontier Province, Northern Areas and Azad Kashmir. A separate department Small Hydel Stations Project Directorate, at present under the Ministry of Water and Power, has been incharge of execution of this Project for the construction of the Power Stations where these Turbo-Generator sets are being installed. The work of investigations including site selection, design and construction of the Mini Hydel Power Stations is being carried out by the National Construction Company (NCC) which is a construction company in the public sector.

The basis of selection of the units is that a 50 KW Power Station is installed for a population of upto 500 and 100 KW Power Station for a population between 500 to 1000. For areas with a population of more than 1000, if adequate flows are available, installation of more than one power station of any combination of 50 and 100 KW sets is considered. Salient features of this Project are given below:

Already completed.

1) Chinari (Azad Kashmir) : 2 x 50 KW.

2) Pattika (Azad Kashmir): 1 x 100 KW.

3) Minapin (Gilgit) : 1 x 100 KW.

4) Singal (Gilgit): 2 x 50 KW.

5) Garam Chashma (Chitral): 1 x 100 KW.

Under Construction (Completion 60 to 95%)

1) Sirmik (Skardu): 1 x 100 KW.

2) Kachura (Skardu): 2 x 100 KW.

3). Karora (Swat- NWFP) : 2 x 100 KW.

4) Tamori (Swat-NWFP): 2 x 50 KW.

5) Shishi Gole (Chitral): 3 x 100 KW.

Another Government Agency: The Kohistan Development Board, has also completed feasibility studies for utilization of some of these Turbo-Generator Sets in the Kohistan Area.

The purchase of standard sets has posed the problem of finding sites to suit the sets. It would have been better if sites were selected first and then each set ordered according to the particular site conditions.

2.2.2 Micro Hydel Power Stations.

The development of Micro Hydel Power Stations i.e. of a capacity of upto 10 KW is being carried out by the Appropriate Technology Development Organization of the Government of Pakistan (ATDO). The endeavour of ATDO is, as far as possible, to utilize local resources. An outstanding feature of the program is the participation of the local community who undertake the entire civil works: intake system, power channel, forebay, penstock and power house building. Only guidance and occasional supervision is provided by the ATDO. The turbine-generator plant is supplied by the

ATDO; the turbine is designed and fabricated locally and the electric generator is, at present, purchased from the market. The plant is installed by ATDO with the assistance of the local people. The site of the power house is selected in such a way that it is not far from the village.

The distribution system is laid out by the local people on the technical advice of the ATDO. The maintenance and the management of the plant are taken care of by the community. Table A lists the plants already in operation, while some proposed sites for installation of more Micro Power Stations are listed in Table B.

The main technical features of the plant are summarized below:-

1. Intake system: A 2' - 3' high "bond"of stones.

2. Power Channel: Unlined, natural soil, various sizes and lengths.

3. Forebay: 5' x 5' x 4' cemented tank with three openings (intake, outlet, overflow) having slide-gates.

4. Penstock: Usually wooden, rectangular section.

5. Power House: dry rubble-masonary & timber roof, 10' x 10' size.

6. Turbine: Cross-flow Banki turbine, made from sheet steel.

7. Generator: Chinese-made, 1 ph/3 ph, 230/400 V, 50 c/s.

8. Coupling: Mostly V-Pulleys.

9. Control: Manual.

10. Distribution System: Low-voltage, 8/10 SWG bare copper wire, wooden poles.

By utilizing the concepts of appropriate technology, it has been possible to build these power houses at an amazingly low cost. With labour free of cost and using the locally available materials, the civil work is almost at no cost. The cost of the distribution material is shared by the local people. It is only the cost of turbine-generator plant which is incurred by the Government. This approach has enabled installation of the plants at a cost of about Rs. 2000 per KW.

Innumerable sites are available in Swat, Dir, Chitral, Hazara, Kohistan, Northern Areas and Azad Kashmir where streams of 5-10 cusecs of water flow perennially and head of 20'-30' can be created easily. During work carried out with rural people in a number of villages, a great sense of achievement has been observed among them. People have become so motivated in this program that they mobilize their efforts quickly and complete the job within a couple of weeks.

Another feature of this program is the industrial application of the power plant. At a couple of places cottage industries have been establish· Commonly, rice-husking, cotton ginning, saw machine, wooden la flour milling and grinding units are installed in the power house building. When electricity is not needed during the day time, these machines are run by the turbine, through various sets of pullies. At one installation, a small welding transformer has been used; while at another site, an electric motor-driven wheat thresher has been used. These additional activities around the Micro Hydro-electric plant have generated employment for a number of people.

Table A : List of Installations in Operation

No.	Site/Village	Discharge, Cusecs	Head, ft.	Installed Capacity KW	No. of Houses Electrified
1.	Lilloni No. 1	10	16	5	72
2.	Lilloni No. 2	10	26	5	9
3.	Lilloni No. 3	10	16	5	33
4.	Gulabad	10	16	5	7
5.	Banda Chini	10	18	3.5	17
6.	Qadar Nagar	1	60	3	4
7.	Barkana	10	24	10	50
8.	Bishbard	2	50	5	20
9.	Sultanabad	10	35	10	65
10.	Bunji	5	55	10	20

N. B. At some of these sites, work is in progress to electrify additional houses.

Table B : List of Installations under Progress

No.	Site/Village	Discharge, Cusecs.	Head, Ft.	Installed Capacity KW	No. of houses proposed to be electrified.
1.	Jogani	6	6	3	10
2.	Naikot	2	35	3	15
3.	Gamser	10	20	5	50
4.	Biakand	3	40	3	40
5.	Barkalay	3	70	5	20
6.	Mehregai	5	75	10	60
7.	Malka	2	131	7.5	50
8.	Ghanorai	5	50	7.5	50
9.	Hareho-I	8	80	12.5	120
10.	Hareho-II	6	60	10	56

3. MINI AND MICRO HYDEL POWER STATIONS ON CANALS.

As already mentioned in the beginning, the canals in Pakistan flow due to the slope of land from North-East to the South West, @ 1 foot per mile. In order to economize the section of the canals, falls are created in them along their length at regular distance intervals; these falls, with a head varying between 2 to 10 feet (or sometimes upto 50 feet), are provided with stilling basins to dissipate the energy of water. These falls can be used to generate electricity.

The canals flow even in very remote areas which are far from the interconnected Power Grid System of Pakistan. In most of these areas the electric load demand is not so much as to justify the high cost of extension of the Grid System to these areas. As such, the solution is to install small hydel Power Stations on these canals near villages so that cheap electricity can be provided to the villages which would bring in several advantages as already mentioned above.

3.1 Work done upto present and potential.

The power potential of the canals has been appreciated since long. In 1925, a private individual built a Power Station on a canal near Renala Khurd, in the province of Punjab, for use of electricity on his big farm. The total capacity of the power station which is in operation uptopresent is 1100 KW, made up of 5 units each of 220 KW. The Grid System of Pakistan is now also supplying power to the areas around this Mini Power Station.

The first survey on the potentials of power generation on the canal system of the Punjab Province of Pakistan, by utilizing the falls of the canals, was carried out in 1947 by the Punjab Irrigation Department. On the basis of this report the following four power stations were subsequently constructed:

i) Rasul Hydel Power Station: 2 x 11 MW

ii) Nandipur Hydel Power Station: 3 x 4.6 MW

iii) Chichoki Hydel Power Station: 3x4.4 MW

iv) Shadiwal Hydel Power Station: 2 x 6.75 MW.

A disadvantage in canal Hydel Power Stations is that every year canals are closed for 1½ months for repairs. Also, during floods the canals have to be closed, and during periods of short supplies there are wide fluctuations both in the discharge and head.

A study conducted by WAPDA has indicated that upto 60 MW can be generated on one of the major canals viz Chashma-Jhelum Link Canal at the point where it falls into the Jhelum river; a head of 50 to 60 feet can be made available at this point. This canal interlinks the Indus and Jhelum rivers.

As regards Mini and Micro Hydel Power Stations of smaller capacities, a lot of potential exists on the canals and more detailed investigations need to be carried out to fix the sites, determine the types of turbines best suited etc.

Investigations in this regard need to be carried out for two methods of generating power viz the utilization of falls of the canals, and the possibility to utilize the energy of water flowing steadily in a canal.

4. PROBLEMS AND CONSTRAINTS IN DEVELOPMENT OF MINI AND MICRO HYDRO ELECTRIC POWER STATIONS.

Pakistan has adequate trained manpower and a sufficient strong technological base to manufacture most equipment locally, and carry out the construction of Micro (10 KW and below) and Mini (above 10 KW and upto about 10 MW) Hydel Power Stations through local personnel. However, at present except for generators of upto 250 KVA,

distribution transformers upto 10,000 KVA with primary voltage upto 33 KV, potential transformers, current transformers, gear boxes, draft tubes, elastic couplings, fly-wheels and some other items, all other major items like turbines, governors, voltage regulators, protection relays, circuit breakers, instruments like tachometers, pressure gauges, vacuummeters, voltmeters, ammeters etc are imported. However, sheet steel panels are manufactured locally and the mounting of circuit breakers, measurement and protective instruments etc is carried out locally.

Due to the fact that a large amount of equipment has to be imported, the cost of Mini Power Stations is quite high, and thus finances are the main constraint in the development of such Power Stations.

5. SUGGESTED SOLUTIONS TO THE PROBLEMS.

It is suggested that in addition to external financial help, technical help be also provided; this technical help may be provided for mobilizing the present facilities existing in the country and organizing them to produce locally the maximum possible amount of standard equipment required for the construction of Mini Hydel Power Stations. If most of the components could be produced locally at costs lower than those of imported equipment, the cost per KW of installed capacity of the Power Stations would go down, and a greater number of such Power Stations could be constructed within the available finances. Furthermore, the increase in local fabrication facilities would add to the technical know-how within the country and thus maintenance and repair would become better and cheaper.

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