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MANPOWER REQUIREMENTS IN HYDRO-POWER ENGINEERING

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SYNOPSIS

Sufficient qualified technical personnel are necessary for a sustainable development of the available hydro-power resources of Pakistan. The energy requirements of the country should not be satisfied only on emergency basis. A well-organized and systematic approach is needed, with maximum participation of local experts, especially engineers.

Traditionally, foreign consulting and construction companies have carried out planning, design and implementation of medium and large size projects, such as Nandipur, Shadiwal, Warsak, Mangla, Tarbela and other plants.

The activities of local engineers have concentrated on the implementation of small projects, the majority constructed in the north of the country. Regrettably, due to lack of expertise, many of these projects are not performing satisfactorily. Most of the plants have been constructed with temporary diversion works and without sand traps, leading to a quick deterioration of the rotating parts of the turbines. The situation is aggravated by low quality workmanship, causing poor performance, frequent outages of the plants due to damage of the project components.

A sizeable hydro-power potential has been identified within the Indus Irrigation system and in the north of the country. Feasibility studies are available or in progress for some low head projects at barrages and canal falls in the plains as well as for medium and high-head projects on Indus river and its tributaries in the north of the country. WAPDA at national level and SHYDO at provincial level have carried out the majority of these works with the collaboration of foreign personnel.

Only a limited number of Pakistani professionals have participated in these activities. Due to prevailing institutional policies, rotation of personnel is unavoidable. Therefore, the continuous involvement of local professionals working in governmental institutions is not ensured. It has happened many times that the trained persons (through on the job or formally trained) have been transferred to other quarters to carry out totally unrelated works, wasting completely their gained knowledge and skills.

To ensure the desperately sought self-reliance and autarchy in the energy sector Pakistan needs to institutionalize the development of specialized manpower in all relevant fields. Training activities should continue within the governmental institutions, such as the WAPDA Engineering Academy at Faisalabad. However, specific courses and programmes need also to be introduced at university level. This is especially important to provide the necessary manpower to implement projects in the private sector.

In this connection, CEWRE/UET Lahore and GTZ have been jointly working with the aim to establish a post-graduate programme in "Hydro-power Engineering". Two short courses have already been carried out in the last six months with quite satisfactory results. Efforts are under way to start a new degree programme in Hydro-power at the Centre.

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1. INTRODUCTION

Sufficient qualified technical personnel are necessary for a sustainable development of the available hydro-power resources of Pakistan. In the past, same it has been a practice in Pakistan, as unfortunately in other developing countries, to employ foreign engineering firms to plan, design and construct the projects. This has led to bottlenecks in development and unhealthy dependence on foreign know-how. In practice, it will not be possible that way to develop the potential in a reasonable time and at terms and conditions favorable to the national economy of the country.

The energy requirements of the country should not be satisfied only on emergency basis. A well-organized and systematic approach is needed, with maximum participation of local experts, especially engineers.

2. BACKGROUND

In Pakistan, mostly foreign consulting and construction companies have carried out planning, design and implementation of medium and large size projects, such as Nandipur, Shadiwal, Warsak, Mangla, Tarbela and other plants. The same situation prevails now in case of Chashma HPP and Ghazi-Barotha HPP.

The activities of local engineers have concentrated on the implementation of small projects, the majority constructed in the north of the country. Regrettably, due to lack of expertise, many of these projects are not performing satisfactorily. Most of the plants have been constructed with temporary diversion works and without sand traps, leading to a quick deterioration of the rotating parts of the turbines.

The situation is aggravated by low quality workmanship, causing poor performance, frequent outages of the plant due to damage of the project components. The loss of revenue due to the interruptions in the generation further leads to poor performance of the overall system.

3. AVAILABLE HYDRO-POWER POTENTIAL

Pakistan is gifted with abundant hydro-power resources, with water flowing down the Himalayas and Karakorum heights from some of the world highest glaciers. It is a pity that Pakistan's power shortages should be met from thermal power plants rather than cheaper hydro-power alternative.

Hydro-power is not only environmentally friendly, but its eternally available renewable source of energy is a bounty of nature, in contrast to environmentally hazardous non-renewable (and sometimes imported) sources of energy for thermal plants.

A sizable hydro-power potential has been identified within the Indus River irrigation system and in the north of the country. Feasibility studies are available or in progress for some low head projects at barrages and canal falls in the plains as well as for medium and

high-head projects on Indus river and its tributaries in the north of the country.

4. INSTITUTIONAL SETUP

WAPDA at national level and SHYDO at provincial level have carried out the majority of planning works with the collaboration of foreign experts. Only a limited number of Pakistani professionals have participated in these activities.

GTZ has contributed with contribution of foreign experts, as well through various types of training of Pakistani counterparts. The overall framework of these training activities is shown below:



Topic of general application covered under short courses have included:

Spreadsheets Course
CAD
Text Processing
Computer programming
Novell 3.11 Networking
Introduction to Geographical Information Systems

On the other hand, also specialized short courses have been offered, such as:

Nature of Training	Participants	Approx. Duration
Basis for Dimensioning of Penstocks Considering the Requirements of Stable Turbine Regulation	6	1 Day
Selection and Layout of Water Turbines for High Head Projects	10	3 Days

Long Term Power System Expansion Planning	17	6 Days
Installation and Operation of Hydrological Stations	5	8 Days
Selection and Layout of Water Turbines	10	3 Days
Use of DBANK Package for Entry, Validation and Processing of Hydrological Data	5	6 Days
Use of MHPP - Cost Estimation For Medium-Size Hydro Power Plants	25	3 Days
Introduction to the Operation and Maintenance of Automatic Equipment for Hydrological Stations	10	4 Days
Fortran Language	13	4 Months
Use of SHPP - Cost Estimation For Small-Size Hydro Power Plants	25	3 Days
Use of DBANK Package for Entry, Validation and Processing of Hydrological Data	6	6 Days
Refreshing Course for Field Personnel on the Methods and Equipment Normally Used by SWHP to Take Flow Measurements	9	2 Days
Operation and Maintenance of Automatic Equipment for Hydrological Stations	8	11 Days
Operation of GPS Equipment	8	8 Days
Numerical Modeling in Hydraulics	9	2 Days

Training on the job is a continuos activity, which has taken place during the identification of low-head and high-head hydro-power potential as well as during the preparation of feasibility reports for various projects, such as Chashma, Jinnah, Taunsa, Guddu, Rohri, Golen Gol, etc.

Various study tours abroad have taken place during the past years. The purpose was to give the participants a better understanding of past and present developments in the field. A typical visit would include:

Visit	**Town, Country**	**Details**
Hydraulic Laboratories in Universities	Karlsruhe, Munich, Germany	
Geotechnical/Hydraulic Laboratories, BAW	Karlsruhe, Germany	
Low Head HPP	Rhine, Germany Danube, Germany Lech, Germany	P=(5-100) MW, H=(3-11) m,
Manufacturer of Tunnel Boring Machines	Schwanau, Germany	
Pump Storage HPP	Germany, Austria	P=1000 MW, H=640 m, Q=160 m^3/s
Manufacturer of Hydromechanical Equipment	Sulzer Escher Wyss, Ravensburg, Germany Sulzer Escher Wyss, Zuerich, Switzerland Voith, Heidenheim, Germany Voest Alpine, Linz, Austria Volk, Freiburg, Germany	

Small HPP	Germany, Austria	P=(0.7-50) MW, H=(150-450) m, Q=(0.5-10) m^3/s
Manufacturer of Electrical Equipment	ABB, Mannheim, Germany	
Under Construction High Head HPP	Schruns, Austria	
Hydro Power System Development	Tauern Valley, Austria	
HPP High Head	Sellrain-Silz, Austria	P=500 MW, H=1060 m, Q=48 m^3/s
Under Construction Low Head HPP	Danube, Austria	

Unfortunately, due to prevailing institutional policies, rotation of personnel is unavoidable. Therefore, the continuous involvement of local professionals working in governmental institutions is not ensured. It has happened many times that the trained persons (through on the job and/or formally trained) have been transferred to other quarters to carry out totally unrelated works, wasting completely their gained knowledge and skills.

5. REQUIREMENTS

To ensure the desperately sought self-reliance and autarchy in the energy sector Pakistan needs to institutionalize the development of specialized manpower in all relevant fields. Training activities should continue within the governmental institutions, such as the WAPDA Engineering Academy at Faisalabad. However, specific courses and programs need also to be introduced at university level. This is especially important to provide the necessary manpower to implement the project in the private sector.

6. CEWRE/GTZ INITIATIVE

In this connection, CEWRE/UET Lahore and GTZ have been jointly working with the aim to establish a post-graduate program in "Hydro-power Engineering". Two short courses have already been carried out in the last six months with quite satisfactory results. Efforts are under way to start a new degree program in Hydro-power at the Center.

The Centre of Excellence in Water Resources Engineering was established in 1976 at the campus of the University of Engineering and technology, Lahore. The charter of the Center is to advance and disseminate knowledge and to promote high level goal oriented research in various disciplines of water resources. At present, the following programs are offered at the Center leading to M. Sc., M. Phil. and Ph.D. degrees:

Water Resources Engineering
Water Resources Management
Engineering Hydrology

So far, more than 150 persons have graduated from the Centre. Different government departments, research organizations, universities and consultants are employing the graduates of the Centre. These include Irrigation and Power Departments, Department

of Agriculture, Planning Division and WAPDA in the public sector.

The proposed program in hydro-power engineering will be an extension of the already ongoing activities. As a matter of fact, the curriculum will include courses already being offered as well as induction of some new courses.

For example, a program for a Master's degree could be structured as follows:

First Semester	
Essential Courses	
Applied Hydrology	Existing
Advanced Open Channel Hydraulics	Existing
Hydro-power Engineering-Low Head	New
Optional Courses	
Remote Sensing and Applications	Existing
Sediment Transport	Existing
Numerical Analysis	Existing
Computer Applications	Existing
Design of Hydraulic Structures	Existing
Second Semester	
Essential Courses	
Dam Engineering	Existing
Hydro-power Engineering-High Head	New
Construction Methods and Techniques	New
Optional Courses	
Engineering Economics	New
Physical and Numerical Modeling	New
Geo-technical Engineering for Hydro-power Development	New
Environmental Impact Assessment	Existing
River Engineering	Existing

The structure of the available training material on low-head and high-head is presented in Annex 1. As an example, the topics to be covered for the course on high-head hydro-power are given in the Annex 2.

CONCLUSIONS AND RECOMMENDATIONS

To cope with the ongoing energy crisis in the country, there is an urgent need to institutionalize the training of Pakistani engineers to harness the available hydropower potential of the country.

During recent months, two short courses have already been carried out by CEWRE-GTZ, with satisfactory results.

Comprehensive course material is available, which has already been used to carry out the short

courses.

CEWRE, with the collaboration of GTZ, can be in a position to implement a post-graduate program within a relatively short time.

Annex 1 – Structure of Training Material on Hydropower

HYDRO-POWER DEVELOPMENT

Structure of Training Material

LOW HEAD HYDRO-POWER	HYDRO-POWER	HIGH HEAD HYDRO-POWER
	Hydro-power in General	
Components		Components
Data Collection And Data Processing		Data Collection and Data Processing
Layout and Sizing		Layout and Sizing
Engineering Design		Engineering Design
Economic and Financial Analysis		Economic and Financial Analysis
	Project Implementation	

Annex 2 – Contents of Course Material on High-Head Hydro-power

Components

1. High Head Hydro-power Developments
2. Civil Components
2.1 Headwork And Appurtenant Structures
2.2 Waterways
2.3 Powerhouse
3. Hydro-Mechanical Components
3.1 Turbines
3.2 Regulation of High Head Turbines
3.3 Gates
3.4 Valves and Valve Chambers
4. Electro-Mechanical Components
4.1 Generators
4.2 Transformers
4.3 Switchgear
4.4 Transmission Line Components
5. Auxiliary Equipment
5.1 Mechanical Auxiliary Systems
5.2 Electrical Auxiliary System

Data Collection and Data Processing

1. Load Demand Analysis And Forecast
1.1 General
1.2 Data Collection
1.3 Data Processing
1.4 Application
2. Topography
2.1 Site Identification
2.2 Data Collection
2.3 Data Processing
2.4 Application
3. Hydrology
3.1 General
3.2 Data Collection
3.3 Data Processing
3.4 Application
3.5 Methods for Estimation of Design Parameters
4. Sediment
4.1 General
4.2 Data Collection
4.3 Data Processing
4.4 Application
5. Engineering Geology
5.1 Geotechnical Principles And Investigation Methodology
5.2 Data Collection

5.3 Data Processing
5.4 Site Reconnaissance
6. Seismicity
6.1 General
6.2 Region North Pakistan
6.3 Data Collection
6.4 Data Processing
6.5 Seismic Hazard Evaluation - Design Earthquake At Several Hazard Levels
6.6 Conclusions And Recommendations
7. Environmental And Socio-Economic Aspects
7.1 General
7.2 Data Collection
7.3 Data Processing At Golen Gol, Chitral
7.4 Application In Form Of Impact Assessment
7.5 Environmental Measures

Layout and Sizing
1. Interdependence of Layout, Sizing, Economics, and Modelling
2. Alternative Project Layout
2.1 Site Location
2.2 Headwork Layout
2.3 Sand Traps
2.4 Waterways
2.5 Layout Of Turbines
2.6 Powerhouse Layout
2.7 Layout Recommendations
3. Sizing Of Structures
4. Preliminary Cost Estimation And Plant Size Optimisation
4.1 Preliminary Cost Estimation
4.2 Quantities And Costs In Different Stages Of Work
4.3 Optimization And Selection Of The Plant Size
4.4 Golen Gol Hydropower Project
4.5 Khan Khwar Hydropower Project
5. Hydraulic Modeling In Hydropower Development
5.1 General
5.2 Numerical Modeling
5.3 Physical Modeling
5.4 Calibration Of Models
5.5 Numerical Model Studies Allai Khwar
5.6 Physical Model Studies Golen Gol

Engineering Design
1. Headworks And Appurtenant Structures
1.1 Dams
1.2 Reservoirs
2. Waterways

2.1 Intakes
2.2 Open Channels
2.3 Sandtrap
2.4 Penstock
2.5 Pressure Tunnels And Pressure Shafts
2.6 Pipe Branches
2.7 Surge Tanks
3. Powerhouse
4. Hydro-Mechanical Components
4.1 Turbines
4.2 Pumps
4.3 Gates and Valves
5. Electro-Mechanical Components
5.1 Generator
5.2 Transformer
5.3 Switchgear
5.4 Medium And Low Voltage Installations
5.5 Control And Protection
5.6 Earthing System
5.7 Control And Alarm System

Economic and Financial Analysis
1. Quantity Survey and Cost Estimation
1.1 Methodology
1.2 Cost Estimation
1.3 Alternate Cost Estimation
2. Project Phasing And Construction Schedule
2.1 General
2.2 Project Phasing
2.3 Construction Time Schedule
2.4 Cashflow Schedule Of Investment
3. Economic And Financial Analysis
3.1 General
3.2 Power Market Analysis
3.3 Economic Analysis
3.4 Financial Analysis
3.5 Case Study Golen Gol Hydropower Project, Chitral, Pakistan

Project Implementation
1. General
2. Tendering And Contracting
2.1 Premises
2.2 Tendering Procedures
2.3 Tender Documents
2.4 Types Of Contracts
2.5 Contract Arrangements

3. Construction Management And Scheduling
3.1 Project Network Analysis CPM
3.2 Program Evaluation And Review Technique-PERT
3.3 The Time-Grid Diagram Method
3.4 Computerized Scheduling
3.5 Resource Scheduling
3.6 Construction Project Cash Flow
3.7 Job Layout
4. Quality Assurance And Quality Control
4.1 General
4.2 Quality Assurance
4.3 Quality Plan
4.4 Quality Control
5. Project Commissioning And Taking-Over
5.1 Tests On Completion
5.2 Taking-over
6. Risk Management And Dispute Solution
6.1 Risk Protection
6.2 Bonds and Insurances
6.3 Contract Arrangements For Underground Works As An Example Of Dispute Resolution
6.4 Conflict Avoidance