PEREZ-GUERRERO TRUST FUND FOR ECONOMIC AND TECHNICAL COOPERATION AMONG DEVELOPING COUNTRIES

Final Report on

Research on the Existing SHP Standards for Development of SHP International Standards to Facilitate Orderly and Healthy Development of SHP in Developing Countries: International SHP Standard Framework Design

International Center on Small Hydro Power

June 2020, Hangzhou, China

Content

Ⅰ. Project Overview

1. **Project Title:** Research on the Existing SHP Standards for Development of SHP International Standards to Facilitate Orderly and Healthy Development of SHP in Developing Countries: International SHP Standard Framework Design

2. **Abstract:** At present, more and more developing countries adopt small hydropower projects. However, there are limited standards for the construction and operation of small hydropower plants and these are generally applied to hydropower projects of all sizes. Therefore, in order to promote SHP development in sustainable way, an integrated SHP technical guideline and systematic standard are very necessary. The SHP guidelines and standards should take costs into consideration since SHP has to be affordable to developing countries. The useful and applicable technologies selected should not only comply to product quality and safety, but also abide by reasonable and effective economic principles. Therefore, it is highly necessary and urgent to develop international standards for SHP through the support of an applicable technical guideline that meets the demand of most countries for SHP development and international cooperation. This project is planning to identify the existing SHP standards and guidelines and propose a drafted framework design, serving as the basis for the development of international small hydropower standards.
3. **Background Analysis:** Based on natural resources situation and economic development status, renewable energy such as small hydropower (SHP) have many advantages including small scaled, low investment and controllable environment impacts. Currently, despite the need and availability of small hydropower resources in many countries under development, the SHP resources remain untapped not only due to unfavorable condition but also inadequate knowledge and technology to exploit the potential sites. At present, there are guidelines and manuals available on technical and electromechanical aspects of electricity produced through hydropower. Both the United Nations and the European Union have developed a series of sustainable hydropower standards, as well as multiple other institutions and energy ministries around the world. However, only a few technical guidelines, standards and regulations involved with respect to SHP are available and some are included in relevant documents on energy, hydropower plant and power system. Most of the existing guidelines are used to deal with all sizes of hydropower, which are not suitable to SHP. Therefore, in order to promote SHP development in a consistent way, an integrated SHP technical guideline and systematic standard are necessary. The SHP guidelines and standards should take costs into consideration as SHP has to be affordable to developing countries. The useful and applicable technologies selected should not only conform to the product quality and safety, but also accord with reasonable and effective economic principles. Furthermore, the selection of the standards directly impacts the project cost, benefit and construction period and sometimes it is even the key factor that determines whether a project is feasible.

It is thus important and urgent to design a systematic international SHP standard through the research on existing SHP standards and guidelines, so as to facilitate orderly and healthy development of SHP in developing countries.

The selected developing countries for this project all encountered barriers in the adoption of small hydropower policies. While there is substantial capacity for constructing and operating small hydropower projects, the lack of well-defined legislative framework and standards, as well as the multiple financial obstacles prevented effective development in the SHP sector. Madagascar gives the substantial potential and the opportunities for investment from both the public and private sectors. Therefore, it is essential for small hydropower standards to be developed in the region, ensuring the efficient construction, operation and management of SHP projects. Implementation of small hydropower projects in Sudan will offer a quick and effective solution to a problem the country has confronted with for many years. Development and adoption of standards will ensure better assessments and studies are contacted with regards to feasibility of future projects. In Rwanda, the involvement of Rwanda Standards Boards may ensure the application of SHP standards. In Zambia, only 25% of the urban and 3% of the rural population has access to electricity. The development of SHP standards will ensure the success and cost-efficient construction, management and operation of the planned small hydropower plants.

China's vast experience in the implementation of SHP projects both at a domestic level and at an international one, which makes the country an authority in this field. Besides, China has a completed and systematic small hydropower development standard which provide essential basis for the implementation of this project.

Ⅱ. Implementation

To meet the objective of this project, it was implemented as the following three stages:

- **The first stage** is to collect existing SHP standards and guidelines of international organizations (mainly including IEC, IEEE, etc.) and major small hydropower development countries (including China, India, the United States, etc.). In this stage, a total of 233 domestic and foreign standards related to small water and electricity were collected. ICSHP then invited domestic and international experts as the technical advisors to conduct the research on these standards and organized the symposium to analyze and discuss the demands of developing countries on SHP development. In this stage, a technical committee with 25 experts was established.
- In **the second stage**, the framework of international SHP standards has been drafted based on the research in the first stage. Later, drafts of the international SHP standards/technical guidelines were being developed at the same time. Peer review was organized within the experts of the technical committee and others from the member states of ICSHP. Then, ICSHP organized an international consultation workshop to summarize the research results. During the workshop, the draft

framework of international SHP standards was reviewed and discussed. Meanwhile, experts also review two documents of the international SHP standards/technical guidelines: general technical guideline prat 1-terms and definitions and design part 1- site selection planning.

- **The last stage** is to finalize the framework of international SHP standards, which will serve as the basis for the development of international SHP standards, to facilitate orderly and healthy development of SHP in developing countries, especially those selected countries for this project. The standard framework mainly consists of 5 topics including general technical guide, design, units, construction and management, with a total of 25 parts.
- At the same time, the compilation of international SHP standards/technical guidelines are also being carried out, which will be further reviewed, proofread and improved. In the next step, application and dissemination of the international SHP standards/technical guidelines will be carried globally.

Beneficiaries:

The main beneficiaries of this project will be the regulatory authorities and experts in developing countries which legislations do not include any technical guideline or standard to build and operate SHP. The existence of an internationally recognized standard for SHP will lead to flourishing investment and benefit local businesses in and around rural areas where SHP potential resides. Besides, their manufacturers and investors will be also benefited from the project outcome. It is highly necessary to ensure the standards address small hydropower while keeping in mind the conditions, challenges and needs encountered by developing nations.

Ⅲ. Completed Activities

Activity-1

Time: March-June 2019

Location: Hangzhou, China

Implementation: A total of 233 domestic and foreign standards related to small water and electricity were collected (the list shown in Appendix I), including the existing SHP standards and guidelines of international organizations and major small hydropower development countries. ICSHP then invited domestic and international experts as the technical advisors to conduct the research on these standards and organized the symposium to analyze and discuss the demands of developing countries on SHP development. In this stage, a technical committee with 25 experts was established (the name list shown in Appendix II). The experts, from developed and developing countries, are being with professions of water resources, hydropower engineering, environmental policy and renewable energy policy, mechanical engineering, management, electrical engineering, civil engineering, etc.

Activity-2
Time: May 2019
Location: Hangzhou, China




Implementation: ICSHP organized a symposium to analyze and discuss the demands of developing countries on small hydropower development. Domestic and international experts on standardization and hydropower development gave their suggestions and recommendations on the planning and framework design for the international SHP standards.

Activity-3:
Time: June 2019
Location: Hangzhou, China


Implementation: ICSHP organized an international consultant workshop in Hangzhou to summarize the research results and discuss the compilation of international SHP standards/technical guidelines. Representatives from India, Japan, Nepal, Austria, Mexico, Cuba, Guyana, Ivory Coast, Nigeria, Madagascar, South Africa, Tanzania, Zambia, Papua New Guinea, Micronesia and China and other experts from international/regional organizations including United Nations Industrial Development Organization (UNIDO), International Electrotechnical Commission (IEC), World Food Programme (WFP), Common Market for Eastern and Southern Africa (COMESA), the Pacific Centre for Renewable Energy and Energy Efficiency (PCREEE), Ecowas Center for Renewable Energy and Energy Efficiency (ECREEE), Caribbean Centre for Renewable Energy & Energy Efficiency (CCREEE) and East African centre of Excellence for Renewable Energy and Efficiency (EACREEE) attended the meeting (agenda and participants list shown in Appendix III). During the workshop, the draft framework of international SHP standards was reviewed and discussed. Meanwhile, experts and representatives also review two draft documents of the international SHP standards/technical guidelines: general technical guideline prat 1-terms and definitions and design part 1- site selection planning.

Activity-4:
Time: July 2019
Location: Hangzhou, China


Implementation: Ms. Ni Li, deputy director of the Ministry of Water Resources (MWR),

who is in charge of the standardization management, visited ICSHP, and had a seminar to discuss and deploy the arrangements for the development of international SHP standards. She emphasized the importance of the standardization of SHP development, for the orderly and healthy development of small hydropower globally. She said MWR would give full support to the project. MWR already created well connection with Standardization Administration of the P.R.C. (SAC) to development and dissemination of the international SHP standards.

Ⅳ. Activities Costs

Activities costs of this project were strictly based on the financial budget. ICSHP referred specialized accountants to manage the economic evaluation and review for this project. Project leaders were also responsible for monitoring of cost for each activity regarding to the project and required for submission of periodical report to the Director General of ICSHP for processing and stage of the project. The cost mainly included the international flights for international experts, consultancy fees, venue and equipment rental for the workshop and domestic trips, details shown below:

No.	Items	PGTF Fund	ICSHP Fund	Total
1	International travel	10,000 USD	10,000 USD	20,000 USD
2	International consultants	15,000 USD	0 USD	15,000 USD
3	National experts	5,000 USD	5,000 USD	10,000 USD
4	Workshop organization	0USD	20,000 USD	20,000 USD
5	Domestic travels	0 USD	5,000 USD	5,000 USD
	Total	**30,000USD**	**40,000 USD**	**70,000USD**

Ⅴ. Project Management Arrangements

The project is implemented by the International Center on Small Hydropower (ICSHP). ICSHP has appointed a project coordinator. All project staff is appointed by ICSHP. ICSHP is responsible for producing and submitting a report to the UNDP China Office following allocation of 90% of the budget resources. The ICSHP Director General (DG) bears the ultimate responsibility for overall management of the project.

IC-SHP has executed the project under UNDP National Execution modality (NEX). As executing agent for the project, ICSHP is responsible for the reporting and financial requirement foreseen under the UNDP's national execution procedures and guidelines.

Progress monitoring is mastered by the China International Center for Economic and Technical Exchange, Ministry of Commerce. However, any staff from the UNDP or Perez-Guerrero Trust Fund undertakes monitoring activities in line with managerial roles above. All lessons learned will be written into a report after the project has been implemented.

Ⅵ. Appendixes

Appendix-I The list of collected standards to be analyzed and researched

From China		
1.	Guidelines for investigation and assessment for water power resources	SL562-2011
2.	Standard for new rural hydropower electrification	SL30-2009
3.	Standard substituting small hydropower fuel	SL468-2009
4.	Specification on compiling hydropower development planning of medium and small rivers	SL221-2009
5.	The guideline of development plan of electrical power in the region mainly supplied by rural hydropower	SL22-2011
6.	Hydropower calculation code for small hydropower stations	SL77-2013
7.	Code of safety for small hydropower station construction	SL626-2013
8.	Code for safety detecting and evaluation of small hydropower station	GB/T 50876-2013
9.	The evaluation standard for green small hydropower station	
10.	Guidelines for control techniques of small hydroelectric station downstream flow reduction	
11.	Code of compiling proposal of construction project for small hydropower station	SL356-2006
12.	Code of feasibility study report of rural hydropower station	SL357-2006
13.	Specification on compiling preliminary design report of small hydropower stations	SL179-2011
14.	Technical code for energy-saving refurbishment for small hydropower grids engineering	GB/T50845-2013
15.	Technical specifications of dispatching automation for small hydro power grids	SL53-2013
16.	Hydro power design code for small hydro power projects	SL76-2009
17.	Design code for small hydropower station	GB/T50071-2002
18.	Automation design code for small hydropower station	SL229-2011
19.	Technical renovation code for small hydropower station	GB/T50700-2011
20.	Environmental impact code hydroelectric station project for rural area	SL315-2005
21.	Economic evaluation code for small hydropower projects	SL16-2010
22.	Guide for energy losses calculation of small hydropower grid	GB/T30944-2014
23.	Code for field efficiency test of small hydropower station	SL555-2012
24.	Technical code for construction of small hydropower station	SL172-2012
25.	Application guidelines on control and protection equipment of small hydropower stations	SL692-2014
26.	Containerized mini hydropower plant	
27.	Acceptance code for construction of small hydropower station	SL168-2012

28.	Code for operation and maintenance of small hydropower stations	GB/T50964-2014
29.	Rural hydropower technology management point of order	SL529-2011
30.	Quality evaluation standards of units operation comprehensive performance for small-scale hydropower station	SL524-2011
31.	Technical code of safe operating for small hydropower grid	GB/T50960-2014
32.	Technical management standards for transformer plant of rural hydropower	SL528-2011
33.	Specification for installation and operation of leakage current protector in rural areas	SL445-2009
34.	Specification of engineering geological investigation for medium-small water conservancy and hydropower development	SL55-2005
35.	Design code for rolled earth-rockfill dams in small size water resources and hydroelectric engineering	SL189-2013
36.	Technical specification for hydraulic self-acting flap gates	
37.	Code for start-up test of medium or small size for hydraulic-turbine and generator units	
38.	Electromechanical equipment guide for small hydroelectric installations	GB/T18110-2000
39.	Fundamental technical requirements for small hydraulic turbines	GB/T21718-2008
40.	Code of small and medium governing system for hydraulic turbines	
41.	Fundamental technical requirements of inlet valves for small hydraulic turbines	SL696-2014
42.	Fundamental technical requirements for small hydraulic generators	GB/T27989-2011
43.	Technical requirements for excitation system of small hydraulic generators	
44.	Integral micro hydro turbine generator unit	SL397-2007
45.	Code for field acceptance test of small hydro turbines	GB/T22140-2008
46.	Scrap conditions about electrical and mechanical equipment of small-scale hydropower station	GB/T30951-2014
47.	Guide of protection for small hydraulic turbine against erosion by sand abrasion and cavitation	GB
From India		
48.	General 1.1- Small hydropower definitions and glossary of terms	
49.	General 1.2 and 2.1 - Planning and Layouts	
50.	General 1.3 - Project hydrology and installed capacity	
51.	General 1.4 - Reports preparation: reconnaissance, pre-feasibility, feasibility/ detailed project report and as built report	
52.	General 1.5 - Project cost estimation	

53.	General 1.6 - Economic and financial analysis and tariff determination
54.	General 1.7 - Model contracts for execution and supplies of civil and E&M works
55.	General 1.8 - Project Management of Small Hydroelectric Projects
56.	General 1.9 - Environment Impact Assessment
57.	General 1.10 - Performance evaluation of small hydro power plants
58.	General 1.11 – Renovation, Modernization and Uprating
59.	General 1.12 - Site Investigations
60.	Civil Works 2.2 & 2.3 - Hydraulic and Structure design
61.	Civil Works 2.4 - Maintenance of civil works (including hydro-mechanical)
62.	Civil Works 2.5 - Technical specifications for Hydro Mechanical Works
63.	Electro Mechanical works 3.1 - Selection of Turbine and Governing System
64.	Electro Mechanical works 3.2 - Selection of Generator and Excitation systems
65.	Electro Mechanical works 3.3 – Design of switchyard and selection of equipment, main SLD and layout
66.	Electro Mechanical works 3.4 – Selection of Control, Automation, Protection and Monitoring system
67.	Electro Mechanical works 3.5 – Design of Auxiliary systems and selection of equipment
68.	Electro Mechanical works 3.6 - Technical Specifications for procurement of generating equipment
69.	Electro Mechanical works 3.7 - Technical Specifications for procurement of auxiliaries
70.	Electro Mechanical works 3.8 - Technical Specifications for procurement and installation of switchyard equipment
71.	Electro Mechanical works 3.9 - Technical Specifications for procurement of control, automation, protection and monitoring systems
72.	Electro Mechanical works 3.10 - Power Evacuation and Interconnections with Grid
73.	Electro Mechanical works 3.11 - Operation and maintenance
74.	Electro Mechanical works 3.12 - Erection, Testing and Commissioning
From International Electromechanical Commission (IEC)	
75.	IEC 60308: 1970 International code for commissioning, operation and maintenance of hydraulic turbines.
76.	IEC 60609: 1978 Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines.
77.	IEC 60994: 1991 Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump turbines)
78.	IEC 61362: 2012 Guide to specification of hydro-turbine control system
79.	IEC 61366 Hydraulic turbine of giving outputs higher than rated outputs to match 10% overload capability of the generators.
80.	IEC-60034-1: 1983 Rotating Electrical Machines Rating and Performance
81.	IEC-60034-2A-1972 Rotating Electrical Machines Methods for determining losses and efficiency of electrical machinery from tests (excluding machines for traction vehicles
82.	IEC-60034-5-1991 Classification of degrees of protection provided by enclosures for

	rotating electrical machines (IP Code)
83.	IEC-60085-1987 Classification of materials for the insulation of electrical machines
84.	IEC- 60041 (1991-11) Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
85.	IEC-60041 (1996-03)Corr. 1 Corrigendum 1 – Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
86.	IEC 60193 (1999-11) Hydraulic turbines, storage pumps and pump-turbines – Model acceptance tests
87.	IEC 60308 (2005-01) Hydraulic turbines – Testing of control systems
88.	IEC 60545 (1976-01) Guide for commissioning, operation and maintenance of hydraulic Turbines
89.	IEC 60609-1 (2004-11) Hydraulic turbines, storage pumps and pump-turbines – Cavitation pitting evaluation – Part 1: Evaluation in reaction turbines, storage pumps and pump-turbines
90.	IEC 60609-1 (1997-11) Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump-turbines – Part 2: Evaluation in Pelton turbines
91.	IEC 60805 (1985-09) Guide for commissioning, operation and maintenance of storage pumps and of pump-turbines operating as pumps
92.	IEC 60994 (1991-02) Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines)
93.	IEC 60994 Corr. 1 (1997-04) Corrigendum 1 – Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines)
94.	IEC 61116 (1992-10) Electromechanical equipment guide for small hydroelectric installations
95.	IEC 61362 (1998-03) Guide to specification of hydraulic turbine control systems
96.	IEC 61362 Corr.1 (2000-03) Corrigendum 1 – Guide to specification of hydraulic turbine control systems
97.	IEC/TR 61364 (1999-07) Nomenclature for hydroelectric power plant machinery
98.	IEC 61364 Corr.1(2000-08) Corrigendum 1 – Nomenclature for hydroelectric power plant machinery
99.	IEC/TR 61366-1 (1998-03) Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents – Part 1: General and annexes
100.	IEC/TR 61366-2 (1998-03) Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents – Part 2: Guidelines for technical specifications for Francis turbines
101.	IEC/TR 61366-3 (1998-03) Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents – Part 3: Guidelines for technical specifications for Pelton turbines
102.	IEC/TR 61366-4 (1998-03) Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents – Part 4: Guidelines for technical specifications for Kaplan and propeller turbines
103.	IEC/TR 61366-5 (1998-03) Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents – Part 5: Guidelines for technical specifications for Tubular

	turbines
104.	IEC/TR 61366-6 (1998-03) Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents – Part 6: Guidelines for technical specifications for Pump turbines
105.	IEC/TR 61366-7 (1998-03) Hydraulic turbines, storage pumps and pump-turbines – Tendering Documents – Part 7: Guidelines for technical specifications for Storage turbines
106.	IEC 62256 (2008-01) Hydraulic turbines, storage pumps and pump-turbines – Rehabilitation and performance improvement
107.	IEC-62006-2010 Hydraulic Machines - Acceptance Tests of Small Hydroelectric Installations
108.	IEC-60034-1: 2004 Rotating Electrical Machines, Rating and Performance
109.	IEC-60034-9-2003 Rotating Electrical Machines - Part 9: Noise Limits
110.	IEC-60034-2A-1987 Rotating Electrical Machines Methods for determining losses and efficiency of electrical machinery from tests (excluding machines for traction vehicles)
111.	IEC 60085-2007 Electrical insulation – Thermal evaluation and designation
112.	IEC-60354 (1993) Guide for loading of oil immersed transformers
113.	IEC: 60076 (Part1to5) (2011) Specifications for Power Transformer
114.	IEC: 60076 (Part 1 to 5) (2000-05) Specifications for Power Transformer
115.	IEC: 62271 (2002) High voltage alternating current circuit breakers
116.	IEC: 60502-2005 Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV
117.	IEC 60502-2009 Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV
118.	IEC: 60331-2009 Fire resisting characteristics of electric cables
119.	IEC 60332-3-24:2008 Tests on electric cables under fire conditions. Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables
120.	IEC: 60332-2009 Part3 Tests on electrical and optical fibre cables under fire conditions
121.	IEC: 60947 4-1-2002 and (Part 4-1) Contactors and motor-starters – electromechanical contactors motor-starters
122.	IEC: IEC-60947-1-011 Degrees of Protection of Enclosures of LV Switchgears and Controllers
123.	IEC: 60076-11:2004 Dry type transformers
124.	IEC:61125-1996 Recommended practice for preparation of equipment specifications for speed governing of hydraulic turbines intended to drive electric generators
125.	IEC 60034-18-32-2010 Functional evaluation of insulation system test procedures for form –would windings – evaluation by electrical endurance
126.	IEC 60034-2010 Direct action indicating electrical measuring instruments
127.	IEC 60055-2005-Part 2 Paper-insulated metal-sheathed cables for rated voltages up to 18/30 kV
128.	IEC 62271.100-2008- Part 100 High voltage switch gear and controls -Alternating current circuit Breakers
129.	IEC 60068-2008-Part 2-27 Environmental testing Tests – Test Eq. and guidance shock

130.	IEC 60071-2011-Part1 Insulation co-ordination
131.	IEC 60072-1994 Dimensions and output ratings for rotating electrical machines
132.	IEC 60073-2002 Basic and safety principals for man machine interface marking and identification coding principles for indicators and actuators
133.	IEC 60076-2008 Part12 Power Transformers
134.	IEC 60086-2011 Primary Batteries
135.	IEC 60095-2009-Part 2 Lead Acid Starter Batteries
136.	IEC 60099-2009-Part4 Surge arresters
137.	IEC 62271-2012-Part 102 High voltage switch gear and controls
138.	IEC 60 137-2008 Insulated bushings for alternating voltages above 1000 V
139.	IEC 60947.1-2011 Low voltage switch gear and control gear- part1
140.	IEC 60947 -2009Part 2 Low voltage switchgear and control gear -2
141.	IEC 60168-2000 Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V
142.	IEC 60044-1-2000 Current transformers
143.	IEC 60044-2-2003 Inductive voltage transformers
144.	IEC 60189-2007-Part 3 Low frequency cables and wires with P.V.C. insulation and PVC Sheath
145.	IEC 60214-2003-Part 1 Performance requirements and test methods
146.	IEC 60227-2012- Part7 Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
147.	IEC 60228-2004 Conductors for insulated cables
148.	IEC 60230-1966 Impulse tests on cables and their accessories
149.	IEC 60255-2010Part27 Measuring relays and protection equipment
150.	IEC 60287-2006 Part 2 Electrical cables calculation of current rating
151.	IEC 60947.4.3-2012 Low voltage switch gear and control gear
152.	IEC 60296-2012 Fluids for electro-technical applications
153.	IEC 62271.200-2011 High voltage control gear and switch gear
154.	IEC 60304-1982 Standard colours for insulation for low frequency cables and wires
155.	IEC 60344-2007 Guide to the calculation of resistance of plain and coated copper conductors of low-frequency cables and wires
156.	IEC 60076.7-2005 Loading Guide for oil immersed transformers
157.	IEC602271.101-2010 Report on synthetic testing of high voltage alternating current breakers
158.	IEC 60439-2006-Part 5 Low voltage switchgear and control gear assemblies
159.	IEC 60446-2007 Identification of insulated and bare conductors by colours
160.	IEC 60447-2004 Basic and safety principles for man machine interface, making and identification
161.	IEC 60489-2000 Methods of measurement of radio equipment used in the mobiles services
162.	IEC 62052.21-2004 Electricity metering equipment (a.c.)
163.	IEC 60811.1-1 -2001 Test methods for insulations and sheaths of electric cables and cords

164.	IEC: 60947 4-1-2002 Contactors and motor-starters electromechanical contactors motor starters
165.	IEC 60754-1:2011 Test on gases evolved during combustion of materials from cables. Part 1: Determination of the amount of halogen gas
166.	IEC:60761-2002 Specific requirement for tritium monitors
167.	IEC:60376-2005 SF6 Circuit Breaker
168.	IEC:60044.2-2006 Inductive Voltage Transformer
169.	IEC 62053-2003 Electrical metering equipment
170.	IEC 61810-2008 Electro mechanical relays
171.	IEC 60255-21-1 -1988 Vibration
172.	IEC 60255-21-2-1988 National Electrical Code
173.	IEC 61000-4-2-2008 Static discharge test
174.	IEC 61000-4-3-2007 Dielectric test
175.	IEC 61000-4-4-2004 Transient fast burst test
176.	IEC 61000-4-5-2005 Surge protection
177.	IEC 61000-4-6-2007 Electromagnetic fields
178.	IEC 61000-4-11-2004 Voltage dips
179.	IEC 60255-22-1-2007 1MHz burst disturbance
180.	IEC 68-2-1 & 68-2-2 1976 Temperature
181.	IEC 68-2-30-2005 Humidity
182.	IEC 68-2-6 -2007 Vibration of Unpackaged Products
183.	IEC 68-2-27 -2008 Shock of Unpackaged Products
184.	IEC 61000-4-3 -2006 Radiated Electromagnetic Immunity
185.	IEC 61000-4-6 -2008 Conducted Electromagnetic Immunity
186.	IEC:CISPR11-2009 Industrial, Scientific and Medical Equipment–Radio-Frequency Disturbance Characteristics Limits and Methods of Measurement
From International Electrical and Electronics Engineers (IEEE)	
187.	IEEE: 1010-2006 Guide for Control of Hydro Power Plants
188.	IEEE: C50.12-2005 Salient –pole50 HZ and 60HZ Synchronous Generator/ Motors for Hydraulic Turbine Applications rated 5 MVA and above
189.	IEEE: 1010– 1987 IEEE Guide for Control of Hydroelectric power plants
190.	IEEE: 1249 – 1996 IEEE std. for computer-based control for Hydroelectric power plant Automation
191.	IEEE: C37.102 (2006) IEEE Guide for AC Generator Protection
192.	IEEE: 421.4-2004 IEEE Guide for the preparation of excitation system specifications
193.	IEEE:421A-1978IEEE Guide for Identification, Testing and Evaluation of the Dynamic Performance of Excitation System
194.	IEEE: 421.3-1997 High potential test requirements for excitation systems for synchronous Machines
195.	IEEE: C57.12.91-2001 Test code for dry type distribution and power transformers
196.	IEEE: C37.010 (1999) IEEE Application Guide for AC high voltage circuit breakers
197.	IEEE: C37.013 (1997) AC high voltage generator circuit breaker rated on symmetrical

	current basis
198.	IEEE: 1020:1988 IEEE guide for control of small hydro electric power plants
199.	IEEE: 1046:1991 IEEE application guide for distributed digital control and monitoring for power plants
200.	IEEE: C37.101:2006 IEEE guide for generator ground protection
201.	IEEE: C37.1:2007 IEEE Standard for SCADA and Automation systems
202.	IEEE: 242:1996 IEEE recommended practice for protection and coordination of industrial and commercial power systems
203.	IEEE: C 3721987 IEEE standard electrical power systems device function numbers
204.	IEEE: 485 –2010 IEEE recommend practice for sizing lead acid batteries
205.	IEEE: 944-1986 Recommended practice for application and testing of uninterruptible power supplies for power generating stations
206.	IEEE: 142-2007 Recommended practice for grounding of industrial and commercial power systems
207.	IEEE: 80-2000 Guide for safety in AC substation grounding
208.	IEEE: 665-1995 Guide for generating station grounding
209.	IEEE: 115-2009 Test Procedure for Synchronous Machine
210.	IEEE: 2519 -1999 Power Quality
211.	IEEE: C37.95: 1974 IEEE guide for protective relaying of utility
212.	IEEE: 1248-1998 IEEE Guide for commissioning of Electrical systems in Hydroelectrical Power Plants
213.	IEEE: 492-1999 IEEE Guide for operation and maintenance of hydro generators
214.	IEEE:1147-2005 Guide for rehabilitation of Hydro Electric Power Plants
215.	IEEE: 433-2009 Recommended Practice for Insulation Testing of AC Electric Machinery with High Voltage at Very Low Frequency
216.	IEEE:95-2002 Recommended Practice for Insulation Testing of AC Electric Machinery (2.3kV and Above) With High Direct Voltage
217.	IEEE:286-2000 Recommended Practice for measurement of power factor tip-up of Electric Machinery Stator Coil Insulation
218.	IEEE:1434-2000 Trial-Use Guide to the Measurement of Partial Discharges in Rotating Machinery
219.	IEEE: 1207-2004 Guide for the application of turbine governing system for hydroelectric generating units
220.	IEEE: 125-1996 Recommended practice for preparation of equipment specifications for speed governing of hydraulic turbines intended to drive electric generators
From National Electrical Manufacturers Association of the United States (NEMA)	
221.	NEMA: Std. TR 1 Transformers, regulators and reactors
222.	NEMA: Guide 5.2-1989Installation of Vertical Hydraulic Turbine – Driven Generator &Reversible G/M for Pumped Storage Installation
From American Society of Mechanical Engineers (ASME)	
223.	ASME: Power Test Codes-1949 Test code for Hydraulic Prime Movers

224.	ASME PTC-29-2005 Performance Test Code for Speed-Governing Systems for Hydraulic Turbine generator unit
225.	ASME-1996 Guide to Hydropower Mechanical Design (Book)
From American Society of Civil Engineers (ASCE)	
226.	ASCE-2007 Civil works for Hydroelectric Facility – Guidelines for life extension and upgrade
227.	ASCE-1995 Guidelines for evaluating ageing penstocks
From American Society for Testing and Materials (ASTM)	
228.	ASTM: D2863-2000 Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics
229.	ASTM: D 2843-1999 Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics
230.	ASTM: D999-1975 Vibration of Packaged products
231.	ASTM: D775-1980 Shock of Packaged products
From Verein Deutscher Ingenieure (VDI)-Association of German Engineers	
232.	VDI:2056-1964 and VDI:2059-1985 Vibration level in rotating machines
From European Small Hydropower Association (ESHA)	
233.	Guide on how to develop a small hydropower plant (2004)

Appendix-II Name list of the international technical committee

No.	/Name	Nations	Positions	Profession
1.	Mr. Liu Heng	UNIDO	Chief Technical Advisor, Department of Energy, UNIDO	Water resources and hydropower engineering
2.	Mr. Mohamedain E. Seif Elnasr	COMESA	Chief Executive Officer a.i. Regional Association of Energy Regulators, COMESA	Energy policy
3.	Ms. Birgit Vogel	Austria	IWRM and policy expert, RBM solutions-River Basin Management	Applied Hydrobiology and Water Resources Management
4.	Prof. Arun Kumar	India	Professor, Alternate Hydro Energy Center	Water resources and hydropower engineering
5.	Ms. Shannon Ames	United States	Executive Director, Low Impact Institute	Environmental policy and renewable energy policy
6.	Mr. Geraldo Lúcio Tiago Filho	Brazil	Full Professor/Director, Federal University of Itajub á -UNIFEI-Brazil	Mechanical Engineering/Civil Engineering/Hydraulics
7.	Mr. Tokihiko FUJIMOTO	Japan	Associate Professor, Shizuoka University (National University Corporation in Japan)	Agriculture
8.	Mr. Tobias Dertmann	Germany	Hydropower Consultant, Guyana Energy Agency, German Development Agency	Mechanical Engineering
9.	Mr. K.M.Dharesan Unnithan	India	Director, Energy Management Center, Kerala India	Management
10.	Dr. Egidijus Kasiulis	Lithuania	Dr. Aleksandras Stulginskis University Aleksandras Stulginskis	Water Resources Engineering
11.	Mr. Gift Chiwayula	Malawi	Energy Officer, Department of Energy Affaris	Renewable Energy Technology
12.	Dr. Engku Ahmad Azrulhisham	Malaysia	Dr. Center for Water Engineering Technology, University of Kuala Lumpur	Science of water and hydropower Engineering
13.	Mr. Robert Nyamvumba	Rwanda	Energy Division Manager, Ministry of Infrastructure (MININFRA)	Electrical Engineer
14.	Mr. Theoneste HIGANIRO	Rwanda	Head Generation Projects/Implementation Rwanda Energy Group/REG-EDCL	Energy Engineering

15.	Ms. Nimashi Fernando	Sri Lanka	Executive, Sri Lanka Sustainable Energy Authority	Energy Engineering
16.	Mr. Nuwan Premadasa	Sri Lanka	Engineer Sri Lanka Sustainable Energy Authority	Engineering
17.	Mr. Ashurboy Mirzoev	Tajikstan	Project Manager, Golovnaya 240MW Hydro Power Plant Rehabilitation Project State Establishment Project Management Unit for Electro-energy Sector	Project Management
18.	Dr. Anastasia Moroz	Ukraine	Senior science employee, Department of Hydropower, Institute of the Renewable Energy, National Academy of Science of Ukraine	Hydropower Engineering
19.	Mr. Bryan Karney	Canada	Professor, University of Toronto	Civil Engineering
20.	Mr. Sergio Armando TRELLES JASSO	Mexico	Investigator, Instituto Mexicano de Tecnología del Agua (IMTA)	Water Resources and Renewable Energy
21.	Mr. Miguel Ángel GUZMÁN BARRIGA	Mexico	Investigator, Instituto de Electricidad y Energías Limpias (INEEL)	Civil engineering applied research and development
22.	Mr. Tumenjargal Makhbal	Mongolia	Director, Energy Economics Institute, Mongolia	Electrical engineering
23.	Mr. Ejaz Hussain Butt	Pakistan	General Manager (Hydropower & Dams), Engineering General Consutants EGC(Pvt.) Ltd.	Hydropower/Civil engineering
24.	Mr. Mundia Simainga	Zambia	Senior Manager, ZESCO	Hydropower/Civil engineering
25.	Mr. Rloyd Chijikwa	Zambia	Power Manager ZESCO	Mechanical Engineering

Appendix-III Schedule and participants of the international consultant workshop

Schedule				
Date	**Time**	**Activities**	**Venue**	**Moderator**
6.24		Registration	Jade Emperor Hotel	/
6.25	10:00-13:00	1. Introduction of participants 2. Project brief 3. Report on the preliminary work and research outcomes 4. Question & discussion	Jade Emperor Hotel	Cheng Xialei
	15:00-18:00	5. Review and revise the draft framework of international SHP standards 6. Discussion on two draft documents of international SHP standards/technical guidelines 7. Reports from the representatives 8. Question & discussion		

Name list of participants				
No.	**Name**	**Country**	**Organization**	**Title**
1.	Mr. Liu Heng	Austria	United Nations Industrial Development Organization (UNIDO)	Senior Technical Advisor
2.	Ms. Yi Bingxing	China	The Administrative Centre for China's Agenda 21 (ACCA21)	Project Manager
3.	Mr. Xu Wei	China	IEC TC4/HRC	Director of R&D Center
4.	Ms. Xu Jie	China	IEC TC4	Co-project leader of Smart Hydro WG
5.	Mr. Rui Jun	China	IEC TC4/NARI	Deputy Director
6.	Mr. Zhou Yuguang	China	China Agricultural University	Associate Professor
7.	Mr. Wang Xinliang	China	Zhejiang Provincial Market Supervisory Authority	Division Chief
8.	Mr. Zhou Shuhua	China	Zhejiang Institute of Standardization (ZIS)	Senior Standardization Engineer
9.	Mr. Guei Guillaume	Cote d'Ivoire	ECOWAS Centre for Renewable	Program Officer-Renewable Energy

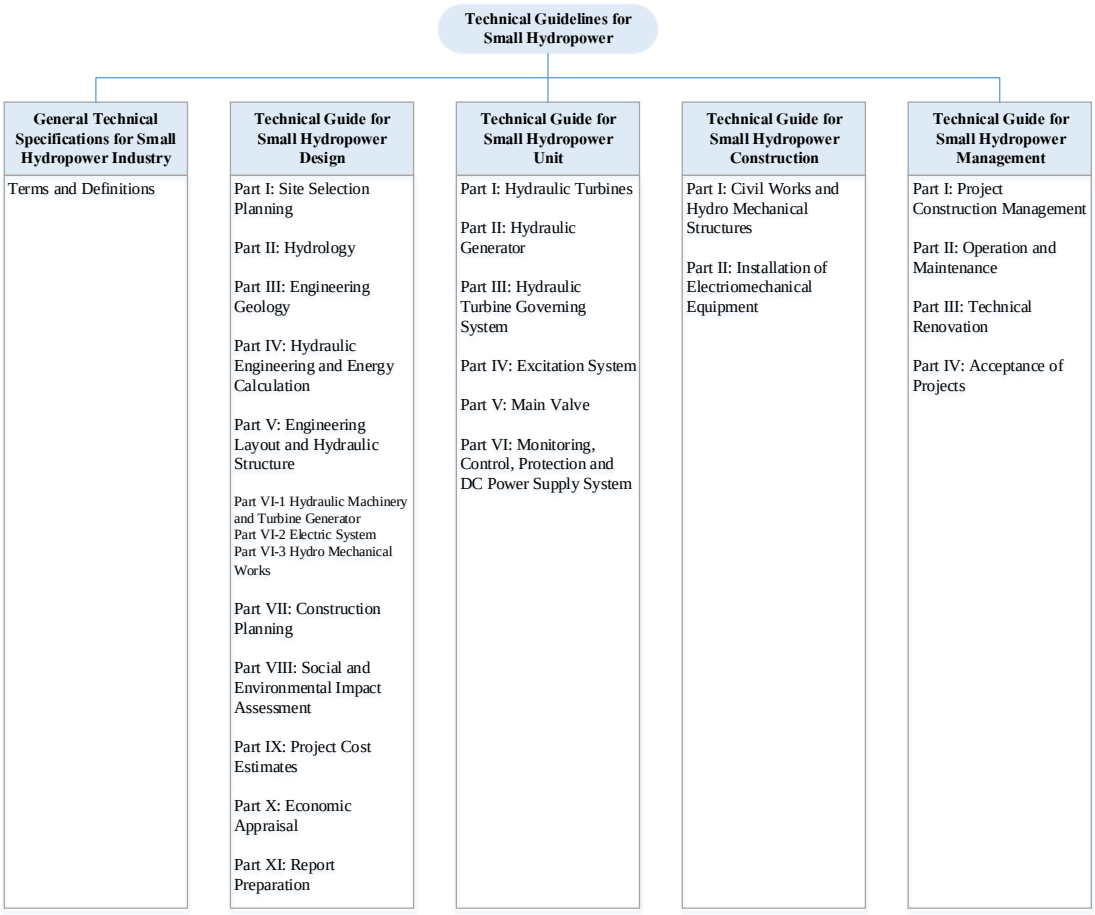
	Fulbert KOUHIE		Energy and Energy Efficiency (ECREEE)	
10.	Mr. Lamyser Castellanos Rigoberto	Cuba	Hydropower Enterprise	PhD. /Hydropower Engineer
11.	Mr. Dolwin Khan	Guyana	Representative of CCREEE/Guyana Energy Agency	Hydropower Support Engineer
12.	Mr. Arun Kumar	India	Alternate Hydro Energy Center	Professor
13.	Mr. Sandeep Kher	India	GE Power India Ltd.	Senior Engineer
14.	Mr. Atul Sarthak	India	Nakayama Iron Works Ltd.	Engineer
15.	Mr. Tokihiko Fujimoto	Japan	Shizuoka University	Associate Professor
16.	Mrs. Sitraka Zarasoa RAKOTOMAHEFA	Madagascar	Bureau des Normes de Madagascar	Head of Standardization Service
17.	Mr. Tovoniaina RAMANANTSOA ANDRIAMPANIRY	Madagascar	Ministry of Energy, Water and Hydrocarbons	Technical Advisor of the Director General of Energy
18.	Mr. Sergio Armando TRELLES JASSO	Mexico	Instituto Mexicano de Tecnología del Agua (IMTA)	Researcher in Water Resources and Energy
19.	Mr. Sidney Kilmete	Micronesia	Pohnpei Utilities Corporation	Renewable Energy Manager
20.	Ms. Januka Gyawali	Nepal	World Food Programme	Programme Associate/Hydrologist
21.	Mr. Adoyi John Ochigbo	Nigeria	Federal Ministry of Water Resources, Nigeria	Director
22.	Mr. Bassey Edet Nkposong	Nigeria	Federal Ministry of Water Resources, Nigeria	Managing Director
23.	Mr. Olumide Taiwo ALADE	Nigeria	Standards Organization of Nigeria (SON)	Chief Standards Engineer
24.	Mr. Garaio Donald Gafiye	Papua New Guinea	Representative of PCREEE/Clean Energy Solutions	Manager
25.	Mr. Harold John Annegam	South Africa	China Agricultural University	Professor
26.	Ms. Chileshe Kapaya Matantilo	Zambia	Zambia Bureau of Standards (ZABS)	Standards Officer
27.	Mr. Mundia Simainga	Zambia	ZESCO	Senior Manager
28.	Mr. Yohane Mukabe	Zambia	Common Market for Eastern and Southern Africa	Project Manager

			(COMESA)	
29.	Mr. Liu Deyou	China	International Center on Small Hydro Power (ICSHP)	Director General
30.	Ms. Huang Yan	China	International Center on Small Hydro Power (ICSHP)	Managing Director
31.	Mr. Fu Zilong	China	International Center on Small Hydro Power (ICSHP)	Managing Director
32.	Ms. Cheng Xialei	China	International Center on Small Hydro Power (ICSHP)	Professor
33.	Ms. Hu Xiaobo	China	International Center on Small Hydro Power (ICSHP)	Division Chief
34.	Ms. Zhang Yingnan	China	International Center on Small Hydro Power (ICSHP)P	Program Officer
35.	Mr. Tan Xiangqing	China	International Center on Small Hydro Power (ICSHP)	Chief Engineer
36.	Ms. Xie Lihua	China	Zhejiang Design Institute of Water Conservancy & Hydro-Electric Power	Professor
37.	Mr. Zeng Jinnian	China	Zhejiang Design Institute of Water Conservancy & Hydro-Electric Power	Professor
38.	Ms. Chen Yueqing	China	Zhejiang Design Institute of Water Conservancy & Hydro-Electric Power	Senior Engineer
39.	Mr. Dong Guofeng	China	International Center on Small Hydro Power (ICSHP)	Deputy Chief
40.	Mr. Zheng Liang	China	International Center on Small Hydro Power (ICSHP)	Engineer
41.	Ms. Chang Fangyuan	China	International Center on Small Hydro Power (ICSHP)	Engineer

Appendix-IV Framework of International SHP Standards

Through global expert cooperation based on successful experiences, ICSHP decided to design a framework of international SHP standards, serving to develop international SHP standards/technical guidelines to meet the demand existing in developing countries. The standards/guidelines are intended to provide countries with guidance on improving their current SHP-related policies, technologies and environmental conditions. Countries that have limited institutional and technical capacities will be able to enhance their knowledge in developing SHP plants, thereby attracting more investments, while at the same time encouraging favorable policies and therefore subsequently assisting in accelerating economic development at a national level.

The standard framework mainly consists of 5 topics including general technical guide, design, units, construction and management, with a total of 25 parts, shown as below.



The international SHP standards/technical guidelines can be taken as a principle and basis for planning, designing, constructing and managing SHP plants up to 30 MW. The TGs are divided into the following five key topics that address the multi-faceted nature of SHP development:

The General Technical Specifications will specify the professional technical terms and definitions commonly used for SHP plants; the Design Guidelines provide guidelines for basic requirements, methodology and procedure in terms of site selection, hydrology, geology, project layout, configurations, energy calculations, hydraulics,

electromechanical equipment selection, construction, project cost estimates, economic appraisal, financing, social and environmental assessments—with the ultimate goal of achieving the best design solutions; The Units Guidelines specify the technical requirements for SHP turbines, generators, hydropower turbine governing systems, excitation systems, main valves as well as monitoring, control, protection and DC power supply systems; The Construction Guidelines can be used as the technical guidance document for the construction of SHP projects; and the Management Guidelines provide technical guidance for the management, operation, maintenance, technical renovation and project acceptance of SHP projects.

Content

Section 1: Terms and Definition

This document defines the professional technical terms and definitions commonly used for SHP plants.

ADDRESSED SUBJECTS	
Hydrology	Hydraulic machinery
Engineering geology	Hydro mechanical structure
Hydraulic engineering and energy	Electrical system
Hydraulic structure	Social and environmental impact assessment
Engineering construction	Economic evaluation and project investment

Section 2: Design

The Design Guidelines will provide strategies for basic requirements, methodology and procedure, in terms of site selection, hydrology, geology, project layout, energy calculations, hydraulics, electromechanical equipment selection, construction, project cost estimates, economic appraisal, financing, social and environmental assessments—with the ultimate goal of achieving the best design solutions.

Design Part I: Site Selection Planning

This Part of the Design Guidelines specifies the general principles of site selection planning for SHP projects, and the methodologies, procedures and outcome requirements of SHP plant site selection.

ADDRESSED SUBJECTS	
Planning principles	Preparation of site construction plan
Planning scope	Preliminary assessment of social and environmental impacts
Planning methods and steps	Assessment of power demand

Basic data collection and analysis	Cost estimation ad benefits assessment
Computation of river basin or sub-basin hydropower potential	Evaluation of planning site and development sequence
Site surveys and investigations	Preparation of site selection planning report

Design Part II: Hydrology

This Part of the Design Guidelines covers the basic hydrological data as well as the computation methods for the required rational analysis of the main hydrological parameters such as rainfall, runoff, flood and sediment applicable during the planning, design, construction and operation of an SHP plant.

ADDRESSED SUBJECTS	
Basic data	Design flood
Design runoff	Stage-discharge relation curve
Flow duration curve	Sediment, evaporation, ice regime and others
Low water analysis	Rationality check of outcomes

Design Part III: Engineering Geology

This Part of the Design Guidelines clarifies the basic provisions on engineering geological investigation of an SHP station, specifies the technical requirements for investigation in terms of aspects of areal geology and reservoir engineering geology and defines specific requirements for investigation technologies and methods to be applied in various stages in relation to aspects of engineering geology of the dam area, water delivery way, power plant area and natural construction materials.

ADDRESSED SUBJECTS	
Basic provisions	Engineering geological investigation of water delivery route
Areal geology	Engineering geological investigation of power plant area
Engineering geological investigation of reservoir area	Geological investigation of natural construction materials
Engineering geological investigation of dam area	

Design Part IV: Hydraulic Engineering and Energy Calculation

This Part of the Design Guidelines specifies the methods and steps of hydraulic engineering and energy calculations for SHP development, and covers the aspects that might be involved in hydropower station design, such as the load assessment and the electric power load balance.

ADDRESSED SUBJECTS	
General principles	Selection of the installed capacity and unit size

Runoff calculation	Selection of the head race dimension and the daily regulating pond volume
Hydraulic energy calculation	Analysis of the reservoir sediment accumulation and calculation of the backwater
Load prediction and electric power load balance	Reservoir operating modes and operational characteristics over the years
Selection of the characteristic water level for flood regulation and flood control	Figures
Selection of the normal and dead reservoir levels	

Design Part V: Engineering Layout and Hydraulic Structure

This part of the Design Guidelines clarifies the flood control design standards for the hydraulic structures of an SHP station, defines specific requirements for the general engineering layout as well as the type selection and the design of the water retaining structure, water releasing structure, diversion structure, powerhouse and switchyard, and specifies the technical requirements for engineering safety monitoring, and concrete and steel performance. The applicable height of a reservoir dam in this document is: 30 m for a rolled earth-rock dam, 50 m for a concrete faced rockfill dam and 70 m for a concrete (masonry) gravity dam. When the above-mentioned height is exceeded, the building design standard and safety margin shall be determined by referring to other technical standards.

ADDRESSED SUBJECTS	
Flood control standard	Diversion structure
General engineering layout	Powerhouse
Water retaining structure	Engineering safety monitoring
Release structure	Concrete strength, durability and steel performance

Design Part VI-1: Hydraulic Machinery and Turbine Generator

This Part of the Design Guidelines specifies the type selection design and arrangement of the main and auxiliary hydraulic machinery, the type selection design and arrangement of the turbine as well as the design of the heating, ventilation and fire control systems of a SHP station. It includes the basic principles of type selection for different machines, the selection and calculation of the basic parameters, scheme comparison as well as the examples of typical diagrams of different powerhouse layouts.

ADDRESSED SUBJECTS	
Turbine	Auxiliary system
Generator	Fire extinguishing system
Turbine governing system	Layout of the powerhouse
Main value of the turbine	

Design Part VI-2: Electric System

This Part of the Design Guidelines sets forth the general requirements for the design of the electrical system of an SHP station, and defines specific technical requirements for the selection and arrangement of connections to the power system, main electrical connection, grounding, lighting, relay protection, control system and other electrical equipment.

ADDRESSED SUBJECTS	
Connection of the hydropower station to the power system	Excitation system
Main electrical connection wiring	Automatic monitoring system
Selection of the main transformer	Plant service power supply and dam region power supply
Selection of high-voltage electrical equipment	DC operational power source
Lighting overvoltage protection and grounding system	Video monitoring system
Lighting system	Communication
Arrangement of the main electrical equipment inside and outside the power station	Electrical repair and electrical testing
Automatic devices for relay protection and system safety	

Design Part VI-3: Hydro Mechanical Works

This part of the Design Guidelines sets out the contents and requirements for design of hydro mechanical works in an SHP station and provides specific requirements for the selection and arrangement of hydro mechanical equipment, hydraulic design calculations and anti-corrosion measures.

ADDRESSED SUBJECTS	
Contents and requirements of design	Anticorrosion of hydro mechanical structures
Selection and layout of equipment	Workload of hydro mechanical structures
Hydraulic design and calculation	

Design Part VII: Construction Planning

This Part of the Design Guidelines sets out the principles for construction planning for an SHP station and the specific requirements for river diversion, construction of the main engineering works, construction and planning of roads and transportation, construction of the plant facilities, the general construction layout, the overall construction progress and safety measures. Most of the given guidance will need to be simplified accordingly when dealing with smaller capacity stations (below 10 MW).

ADDRESSED SUBJECTS	
Construction of a river diversion	General construction layout

Construction of the main works	Overall construction programme
Construction planning of roads and transportation	Construction safety
Construction of plant facilities	

Design Part VIII: Social and Environmental Impact Assessment

This part of the Design Guidelines sets out the general principles, contents and requirements for an environmental impact assessment of an SHP construction project. As countries typically have robust policies in place for social impact assessment, resettlement and soil and water conservation impact assessment, special studies are usually carried out by the departments designated by the country; this document only provides general technical guidance.

ADDRESSED SUBJECTS	
Environmental impact assessment	Social impact assessment
Resettlement	Conclusion of assessment and advice
Soil and water conservation	

Design Part IX: Project Cost Estimates

This part of the Design Guidelines specifies how to formulate cost estimations for SHP projects and details how to prepare cost estimation documents.

ADDRESSED SUBJECTS	
Project division	Composition of cost estimation documents
Composition of expenses and unit costs	Preparation of investment estimation for the construction part
Formulation of cost estimation in construction	

Design Part X: Economic Appraisal

This part of the Design Guidelines sets forth the principles, contents, methods and parameters of the economic appraisal of SHP projects. This document is applicable to the economic appraisal at the pre-feasibility study and feasibility study stages of SHP projects.

ADDRESSED SUBJECTS	
Cost calculation	Financial appraisal
Benefits calculation	Uncertainty analysis
Economic analysis	Proposal comparative method

Design Part XI: Report Preparation

This part of the Design Guidelines stipulates the principles, contents, requirements and outlines of different reports required for an SHP project at the pre-feasibility study and feasibility study stages.

ADDRESSED SUBJECTS
Report compilation principles
Guidelines for the pre-feasibility study report
Guidelines for the feasibility study report

Section 3: Units

The Units Guidelines will specify the technical requirements for SHP turbines, generators, hydropower turbine governing systems, excitation systems, main valves as well as monitoring, control, protection and DC power supply systems.

Units Part I: Hydraulic Turbines

This Part of the Units Guidelines specifies the technical requirements, main component structure and material requirements, the supply scope, spare parts, technical documents as well as the basic requirements for inspection and acceptance, packing, transportation, storage, installation, testing, commissioning, contractual performance testing, operation and maintenance for SHP hydraulic turbines. This document is applicable to SHP hydraulic turbines with unit capacity less than 10 MW; for Francis and Pelton turbines, the nominal runner diameter is less than 1.0 m; for axial-flow, diagonal and tubular turbines, the nominal runner diameter is less than 3.3 m.

ADDRESSED SUBJECTS	
Service environment conditions	Inspection and acceptance
Technical requirements	Nameplate, packing, transportation and storage
Supply scope and spare parts	Installation, operation and maintenance
Technical documents	Quality guarantee period

Units Part II: Turbine Generator

This Part of the Units Guidelines specifies the technical requirements as well as the basic requirements for the supply scope, spare parts, technical documents, inspection and acceptance, packing, transportation, storage, installation, operation and maintenance for the three-phase 50 Hz or 60 Hz salient pole synchronous turbine generator with rated capacity up to 12.5 MWA connected to a turbine.

ADDRESSED SUBJECTS	
Service conditions	Inspection and acceptance

Technical requirements	Nameplate, packing, transportation and storage
Supply scope and spare parts	Installation, use and maintenance
Technical documents	Quality guarantee period

Units Part III: Turbine Governing System

This Part of the Units Guidelines specifies the technical requirements as well as the basic requirements for the supply scope, spare parts, technical documents, inspection and acceptance, packing, transportation, storage, installation, operation and maintenance for the SHP turbine governing system. This document applies to the electro-hydraulic governor (hereinafter referred to as the governor) with a working capacity of 350 N•m or above as well as an oil pressure device. It is recommended to use the electric governor or operator for the governor with a working capacity less than 350 N•m.

ADDRESSED SUBJECTS	
Service conditions	Inspection and acceptance
Technical requirements	Nameplate, packing, transportation and storage
Supply scope and spare parts	Installation, operation and maintenance
Technical documents	Quality guarantee period

Units Part IV: Excitation System

This Part of the Units Guidelines specifies the technical requirements as well as the basic requirements for the supply scope, spare parts, technical documents, inspection & acceptance, packing, transportation, storage, installation, operation and maintenance for the SHP excitation system. This Document applies to the synchronous machine excitation system.

ADDRESSED SUBJECTS	
Service conditions	Test
Technical requirements	Nameplate, packing, transportation and storage
Supply scope and spare parts	Installation, operation and maintenance
Technical documents	Quality guarantee period

Units Part V: Main Valves

This Part of the Units Guidelines specifies the technical requirements as well as the basic requirements for the supply scope, spare parts, technical documents, inspection, testing, packing, transportation, storage, installation, commissioning and operation & maintenance for the SHP turbine main valves. This document is applicable to butterfly, spherical and gate types of SHP turbine main valves.

ADDRESSED SUBJECTS	
Technical requirements	Acceptance and guarantee
Supply scope and spare parts	Nameplate, packing, transportation and storage
Technical documents	Installation and welding
Test	Operation and maintenance

Units Part VI: Monitoring, Control, Protection and DC Power Supply System

This Part of Units Guidelines specifies the technical requirements as well as the basic requirements for the supply scope, spare parts, technical documents, testing, inspection and acceptance, packing, transportation, storage, installation, training, operation and maintenance for SHP station monitoring, control and protection and the DC power supply system.

ADDRESSED SUBJECTS	
Service conditions	Site acceptance
Technical requirements	Nameplate, packing, transportation and storage
Supply scope and spare parts	Installation and training
Technical documents	Quality guarantee period
Factory inspection	

Section 4: Construction

The Construction Guidelines will be used as the guidance technical document for the construction of SHP projects.

Construction Part I: Civil Works and Hydro Mechanical Structures

This Part of the Construction Guidelines stipulates the general principles, construction conditions, operating methods, working procedures, technological requirements, and quality standards for civil works and hydro mechanical structures according to construction characteristics of SHP stations. This document includes only technical guidance on engineering construction and excludes construction organization management.

ADDRESSED SUBJECTS	
Construction survey	Construction of hydraulic structures
Construction diversion	Installation of hydro mechanical structures
Basic regulations for civil works construction	Environmental protection

Construction Part II: Installation of Electromechanical Equipment

According to the construction characteristics of SHP projects, this part of the Construction Guidelines stipulates the basic regulations and technical requirements for the installation of electromechanical equipment. This document includes only technical guidance on engineering construction and excludes construction organization management.

ADDRESSED SUBJECTS	
Installation of turbine generator units and hydraulic machinery auxiliary equipment	Installation of the automatic hydrological forecasting and reporting system
Electrical equipment installation	Installation of safety monitoring Equipment

Section 5: Management

The Management Guidelines will provide technical guidance for the management, operation, maintenance, technical renovation and project acceptance of SHP projects.

Management Part I: Project Construction Management

This Part of Management Guidelines will set forth the basic contents, management method and general requirements for construction management for SHP projects.

ADDRESSED SUBJECTS	
Project management organization	Procurement management for the project
Project integration management	Project contract management
Early stage planning of the project	Project environmental protection and water and soil conservation management
Project scope management	Engineer management
Project technical management	Project communication management
Project quality management	Project information management
Project progress management	Occupational health and safety management for the project
Project cost management	Project risk management

Management Part II: Operation and Maintenance

This Part of the Management Guidelines will specify the basic management requirements for the operation and maintenance of an SHP station as well as the specific requirements for the operation and maintenance of a hydraulic structure, hydro mechanical works.

ADDRESSED SUBJECTS	
Basic requirements	Electro-mechanical equipment

Hydraulic structures	Optimized operation
Hydro mechanical works	

Management Part III: Technical Renovation

This Part of the Management Guidelines will specify the basic principles, contents, methods and requirements for the technical renovation of an SHP station.

ADDRESSED SUBJECTS	
General provisions	Renovation contents and requirements
Status analysis and evaluation	Technical performance index
Detection and evaluation	

Management Part III: Acceptance of Projects

This part of the Management Guidelines stipulates acceptance conditions and the main content of SHP key acceptance work, including acceptance before river diversion (closure) of the project, acceptance of reservoir (barrage) impoundment, acceptance of unit start-up and acceptance of project completion. The acceptance organization, specifications, procedures and methods, as well as project handover and resolution of outstanding issues, shall be handled according to the provisions of project contract documents.

ADDRESSED SUBJECTS	
Acceptance before river diversion (closure) of project	Acceptance of unit start-up
Acceptance of reservoir (barrage) impoundment	Completion acceptance