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Technical guidelines for the development of small hydropower plants —

Part 2: Site selection planning

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

International Workshop Agreement IWA 33 was approved at a workshop hosted by the Standardization Administration of China (SAC) and Austrian Standards International (ASI), in association with the International Center on Small Hydro Power (ICSHP), held in Hangzhou, China, in June, 2019.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

A list of all parts in the IWA 33 series can be found on the ISO website.

Introduction

Small hydropower (SHP) is increasingly recognized as an important renewable energy solution to the challenge of electrifying remote rural areas. However, while most countries in Europe, in North and South America and in China have high degrees of installed capacity, the potential of SHP in many developing countries remains untapped and is hindered by a number of factors including the lack of globally agreed good practices or standards for SHP development.

The technical guidelines for the development of small hydropower plants contained in this document address the current limitations of the regulations applied to technical guidelines for SHP plants by applying the expertise and best practices that exist across the globe. It is intended for countries to utilize this document to support their current policy, technology and ecosystems. Countries that have limited institutional and technical capacities will be able to enhance their knowledge base in developing SHP plants, thereby attracting more investment in SHP projects, encouraging favourable policies and subsequently assisting in economic development at a national level. This document will be valuable for all countries, but especially allow for the sharing of experience and best practices between countries that have limited technical know-how.

This document is the result of a collaborative effort between the United Nations Industrial Development Organization (UNIDO) and the International Network on Small Hydro Power (INSHP). About 80 international experts and 40 international agencies were involved in this document's preparation and peer review. This document can be used as the principles and basis for the planning, design, construction and management of SHP plants up to 30 MW.

Technical guidelines for the development of small hydropower plants —

Part 2: Site selection planning

1 Scope

This document specifies the general principles of site selection planning for small hydropower (SHP) projects, and the methodologies, procedures and outcome requirements of SHP plant site selection.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IWA 33-1, *Technical guidelines for the development of small hydropower plants — Part 1: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IWA 33-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Planning principles

4.1 Site selection shall be carried out in accordance with the laws and regulations of the relevant state/provinces/country.

4.2 Site selection shall follow the principles of localized planning, subject to overall national integrated water resources planning and to comprehensive river basin planning with the systematic prospection of potential sites.

4.3 Site selection shall meet the requirements of the environmental needs of the river and surrounding areas and also have preliminary plans to mitigate the negative impacts likely to be caused by the SHP projects to the river and its surrounding environment.

4.4 Site selection shall be determined based on the water resources and topography with the purpose of sustainable development, utilization, and along with comprehensive consideration of all other factors.

4.5 Site selection shall consider comprehensively the correlation of hydropower resource development over the entire length of the river, with due attention to the interrelationship of upstream and downstream cascade development, so that the layout of upstream and downstream sites are properly coordinated. For multipurpose requirements for water supply, flood control, irrigation, ecology, tourism, navigation and community development, the SHP projects shall be planned in accordance with the primary and secondary development purposes.

4.6 Site selection shall take into account the long-term electricity demand projection based on the social and economic development of the area. Where indirect selling of electricity to other region(s) is foreseen through the power grid, the current status and development plan of the grid shall be considered, and the growth potential of the external power market shall be evaluated. According to the development needs of the power market, planning should be carried out accordingly to meet the relevant short-, medium- and long-term development goals.

4.7 Site selection shall make a justification of the selection of SHP in relation to other possible rural electrification technologies.

4.8 Site selection shall take into account relevant local, regional and international integrated development plans relevant to the area under study.

4.9 Site selection shall be coordinated with other relevant development plans of the area under study, including planning indicators, terminology, units of quantities and values, implementation plans, and shall be consistent and avoid conflicts.

5 Planning scope

5.1 The planning scope for site selection of SHP development shall be based on the level (local/state/national) of the planning organization of the country.

5.2 If the SHP resource development plan is part of the comprehensive planning of the administrative area (local/state/provinces), the scope of the site selection planning shall be defined in accordance with the administrative divisional plan.

5.3 SHP development planning shall be based on the detailed and homogeneous definition of the river network and catchments in the river basins.

5.4 Within exclusive economic development zone and nature reserve areas, site selection planning of SHP development shall consider the multipurpose needs.

6 Planning methods and steps

The methods and steps described in Clauses 7 to 16 shall be taken according to the actual process of site selection planning of SHP resource development (see Figure 1).

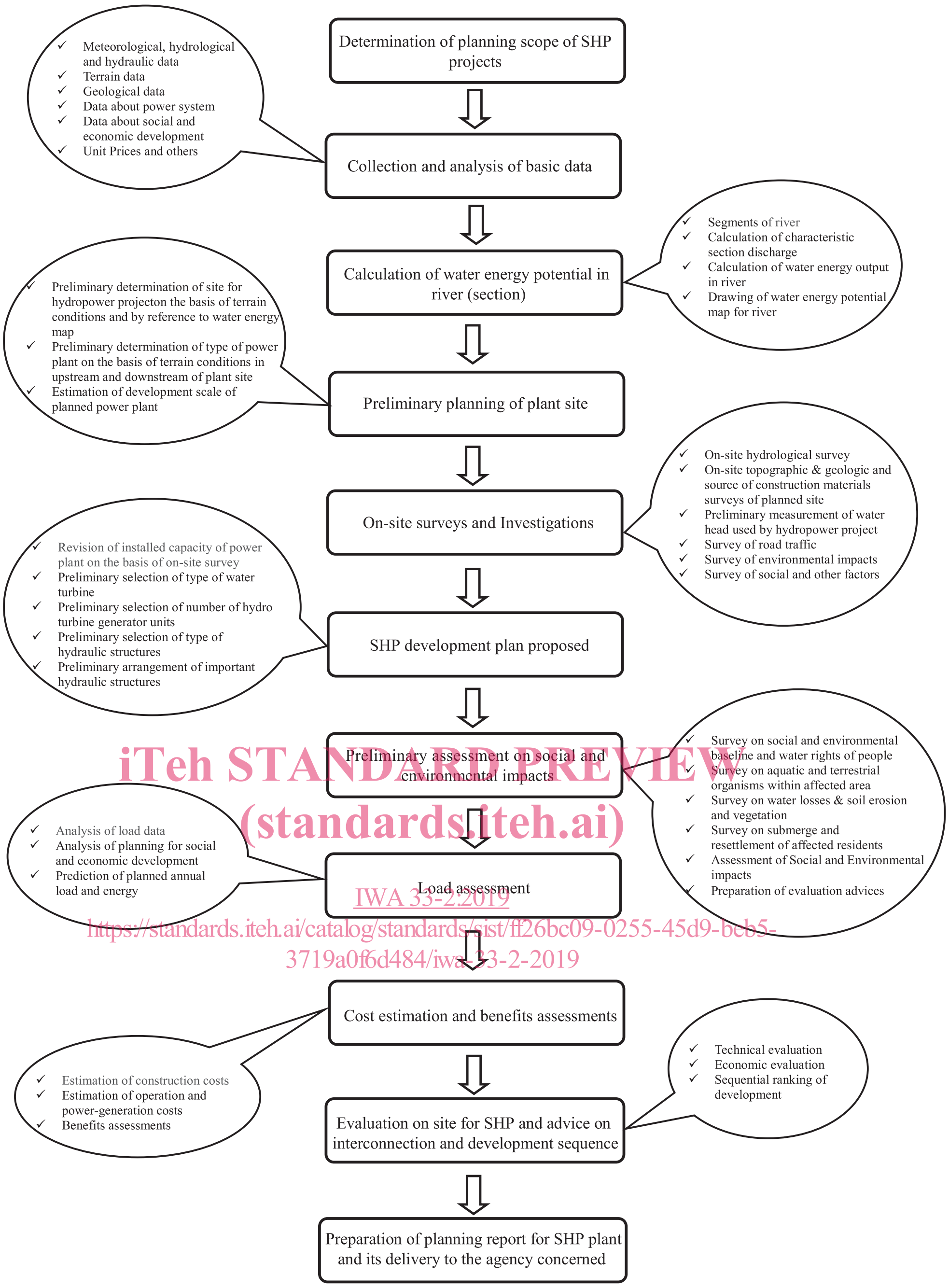

Figure 1 — Flow chart of activities for SHP site selection planning

7 Basic data collection and analysis

7.1 Data collection

7.1.1 Adequate basic data shall be collected and analysed. Consideration shall be given to the use of digital natural resource databases and geomatics technology (remote sensing and Geographical Information System [GIS]). The authenticity, accuracy, timeliness and applicability of the collected data shall be tested and confirmed.

7.1.2 The following basic data shall be included.

a) Hydrometeorological data, including series of measured data, such as precipitation, flow in rivers, evaporation, water level, sediment and ice. For the locations lacking the measured data, relevant data on adjacent river basins and hydrological maps issued by the national or regional authority should be collected.

b) Data of natural geography of river basin and river characteristics, including the topographic map of the river basin (scale not less than 1:50 000), road map of administrative area, longitudinal and cross-sections of river. Data on digital elevation/terrain models are available at 30 m, and better resolution may also be used. If the hydro-meteorological data of adjacent river basins needs to be utilized, the topographic maps of adjacent river basins shall also be collected.

c) Geological data, including regional geological, tectonic, seismic zoning maps, geological reports, and records of major geological events such as earthquakes in the planning area.

d) Resource information, including land use, minerals, energy, forestry, tourism, rare animals and plants.

e) Power system data, including power source, power demand, annual power supply, load structure, load curve, power grid structure, power markets, regulations and power-development planning in the area.

f) Existing facilities data, including as-built design documents of existing hydropower stations, irrigation, water supply, rafting, navigation and other projects within the planning river reach.

g) Socio-economic data, including the demography, industrial and agricultural production, road network, gross national product, per capita income, and national economic development plans in the area.

h) Other data, including natural disaster records, legal requirements, archaeology, historic sites, protected areas and natural heritage.

7.2 Data analysis

7.2.1 Analysis of hydrometeorological data shall include the following.

a) Qualitative analysis

1) The data series shall be accurate, reliable and have no data gaps as far as possible.

2) The data shall be applicable to the river basins under study.

3) The accuracy of the data shall meet the analysis requirements. The precipitation/rainfall data should be, as far as possible, “daily rainfall”. The measured data of flow shall be as precise as “average daily flow”.

4) Appropriate analytical methods shall be used for quality control.

5) A reliable long-term daily discharge series specific to every river reach in the network should be determined, based on distributed hydrologic modelling that is appropriately calibrated.

b) Quantitative analysis

1) Frequency analysis: The measured flow data series should be analysed and calculated according to the probability formula of statistics, and the frequency curve should be drawn according to the analytical results.

2) Correlation analysis: Correlation analysis shall be done when the measured flow data are not on the location of the selected site for SHP development.

3) Average flow duration curve: Based on the data of frequency computation, select the flows corresponding to the frequency of high flow, median flow and low flow. Then select a similar

year from the flow series for annual distribution, if available, and distribute the average daily flow within the next three years, plotted as an "average flow duration curve ".

7.2.2 Topographic map data analysis shall include the following.

a) Scope analysis: The topographic map shall include the drainage area of the river basin under study. If rainfall or flow data of adjacent river basins are utilized, the topographic map shall also provide the drainage area of the adjacent river basin.

b) Accuracy analysis: The scale of the topographic map used for the site selection should be no less than 1:50 000. If the scale of the collected topographic map is smaller than the specified requirements, encryption measures shall be taken to improve the accuracy of contours. Global geometric data of 30 m or better resolution may also be used.

7.2.3 Geological data analysis shall meet the following requirements.

a) Incorporating the conclusions of the regional geological structural stability assessment, major fault lines and the ground motion parameters determined for the project area.

b) It can reflect regional topography and geomorphology, stratigraphic lithology, geological structure, hydrogeological conditions and physical geological phenomena.

7.2.4 Power system data analysis shall include the following.

a) Present status of the power grid and analysis of the power grid plan: including power grid structure, geographical distribution, voltage levels and the relationship with, and impact on, proposed and planned SHP development.

b) Power source and demand (load) status and planning analysis: including power source and demand (load) structure, annual maximum power demand (load), annual minimum power demand (load), annual demand (load) distribution, annual power supply, power growth rate, power markets, regulations, impact of integration with other renewable energy such as wind and solar.

7.2.5 Other data analysis shall include a comprehensive assessment on the authenticity, timeliness and relevance of the data.

8 Computation of river basin or sub-basin hydropower potential

8.1 The theoretical water energy potential of the river (reach) shall be expressed in terms of average annual output (power) (kW) or average annual energy (kWh). The average annual output and the average annual energy shall be mutually converted by the means of Formula (A.1).

8.2 The theoretical water energy potential of the river (reach) shall be calculated in segments. The river shall be segmented in accordance with the following criteria.

a) A larger tributary entry point should be used as a segmentation point for river water energy computation. Taking the tributary entry point as the interface, the adjacent section upstream is the lower section of the upper reach, and the adjacent section downstream of the entry point is the upper section of the lower reach.

b) The reach with a large change in the longitudinal slope of the riverbed shall be regarded as a segment.

c) The reach having particularly advantageous development conditions shall be regarded as a segment.

8.3 The annual average flow at each analysis segment of the river shall be calculated, with their area ratios based on the collected hydrologic data series of the river and the catchment areas of each analysis segment of the river. If the flow data of the river basin is inadequate or unavailable, the information should be obtained by the following methods.

a) If there is rainfall data on this river basin, the appropriate runoff coefficient should be converted to the runoff in the same period with reference to Formula (A.2) or any other suitable formula or methods.

b) If there is hydrological flow data on an adjacent river basin, the correlation with the river basin shall be analysed, and the relevant data after revision may be used for water energy computation.

c) The hydrological flow parameters of the river basin can be obtained by using the hydrological contours or effective charts issued by the hydrological or relevant department.

d) On-site measurement method.

8.4 The topographic map with a scale of 1:50 000 or higher should be used to verify and calculate the elevation difference between the upper and lower sections of the reach by appropriate interpretation. Use of Digital Elevation Model (DEM)/Digital Terrain Model (DTM) is encouraged.

8.5 Based on the flow rate of the upper and lower sections of the river reach and the elevation difference between the upper and lower sections, the average annual output N_i (kW) of the reach shall be calculated by the means of Formula (A.3). The average annual energy E_i (kWh) is calculated by Formula (A.1).

8.6 With the average annual output of water energy in each reach being accumulated, $\sum N_i$, and the average annual power energy in each reach being accumulated, $\sum E_i$, the theoretical water energy potential of the river (reach) may be obtained.

8.7 According to the above computation results, the theoretical potential of river water energy can be calculated:

a) The relation curve between river elevation Z (m) and river length L (km): $Z = \mathrm{f}(L)$. Calculate the Z and L values and draw the $Z = \mathrm{f}(L)$ curve on the rectangular coordinates. The curve shall show the gradient of river water surface (or thalweg) along the river length.

b) The relation curve between river flow Q (m^3/s) and river length L (km): $Q = \mathrm{f}(L)$. According to the flow rate Q calculated in 8.3, the value L is verified and calculated by using a topographic map or DEM/DTM. Draw $Q = \mathrm{f}(L)$ curve on rectangular coordinates. This curve reflects the variation of river flow along the river length.

c) Accumulation curve of river water energy potential $\sum N_i = \mathrm{f}(L)$; The $\sum N_i$ (kW) value may be obtained by directly using the computation result in 8.6, the value L is verified and calculated by using topographic map/DEM/DTM. Draw $\sum N_i = \mathrm{f}(L)$ curve on rectangular coordinates. The ordinate value of a certain point on the curve indicates the total potential of water energy from the upstream starting point (for example, from the river source) to the section.

d) Curve of unit potential of river: $N_\mathrm{d} = \mathrm{f}(L)$. That is, the distribution of the energy value N_d (kW/km) of the unit river length of the reach along the river length L (km). This curve reflects the energy density of the reach. N_d is calculated by the Formula (A.4). The diagram of theoretical water energy potential is shown in Figure A.1.

