HYDROPOWER POTENTIAL IN THE HIMALAYAN REGION

For preparing a master plan for small hydropower development, an estimate of power potential at each prospective site should be known a priory. This estimate of power potential is based on the reliability of water flow at respective sites. Reliability can be estimated from the streamflow record, the characteristics of which can be depicted by a flow duration curve.

Flow duration curves for the sites for which adequate flow data are available can be directly developed. Flows for various levels of dependability for these gauged sites may be estimated from these curves. It is quite obvious that most of the prospective sites for hydropower projects are likely to be ungauged, especially for smaller projects located in developing countries. For such potential sites, there are either insignificant data or no flow data for analyses.

To derive a flow duration curve for a location on a stream for which adequate flow data are not available, regional analysis approach can be adopted. Regional flow duration curves are developed for a region as a whole. This region is a comparatively bigger area, but hydro-meteorologically homogeneous in character. Regional models are developed on the basis of data available for a few other gauged sites in the same region or transposed from similar nearby region. Such models are employed to compute flow duration curves for ungauged locations of interest in a region. Availability of such regional flow duration models is of paramount significance in estimating the potential of hydropower in vast hilly regions of this country and also helps in avoiding time delays in the implementation of individual small hydropower projects.

The primary objective of this technology is to develop flow duration models for regions having potential hydropower sites in various parts of the country.

TECHNOLOGY

A flow duration curve for a site in an ungauged catchment is derived using regionalization procedure. To this end, a region is identified such that it is comparatively a bigger area than the individual ungauged catchment, but adequately small so that homogeneous hydro-meteorological conditions generally exist across the region. And for this purpose, the available classification of hydro-meteorological homogeneous regions in the country (CWC, 1983) can be considered. The National Institute of Hydrology, Roorkee has developed the technology and used it in various States like Jammu & Kashmir, Himachal Pradesh, Bihar, West Bengal, Sikkim, Assam, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram and Tripura. The study area in these states covers the foothills of Himalayan and sub-Himalayan ranges. However, in the State of Bihar, some portion of the hilly region of Hazaribagh Ranges in the Central India is also included in the study area.

The study area is divided into a number of regions. All the gauged sites in a region are first identified. Then, on the basis of the flow characteristics at these sites, a model representing the conditions of flow regime throughout the region is evolved. The flow duration curves are constructed from non-dimensional flows [flows in terms of mean runoff (Q/Q_{mean})] as it is a more convenient form of comparison and in case of inadequate data for some sites, data from all the sites of the region can be pooled up for model development. The power transformation technique is used to transform the non-dimensional flow data to the normally distributed data series. The formulae for power transformation of non-dimensional flows (Q/Q_{mean}) are given by:

when $\lambda \neq 0$, $W = [(Q/Q_{mean})^{\lambda}-1]/\lambda$ ...(1)

when $\lambda = 0$, $W = \ln(Q/Q_{mean})$ ...(2)

where Q and W stand for the corresponding elements of original and transformed series respectively and λ is an exponent which can be determined by trial and error or any other suitable optimization technique so as to yield a normal W series.

The non-dimensional flow for any desired level of dependability may be estimated using the normal probability distribution and subsequently using the inverse of the power transformed regional relationship. The formulae for the inverse power transformation are given by:

when $\lambda \neq 0$, $(Q/Q_{mean}) = (W\lambda + 1)^{1/\lambda}$ ...(3)

when $\lambda = 0$, $(Q/Q_{mean}) = e^{W}$ ...(4)

A regional relationship for mean is developed correlating the mean flow with catchment area. The mean flow for any ungauged catchment can be estimated using the regional relationship for mean. The form of regional model for mean is:

$$Q_{mean} = CA^{m} \qquad ...(5)$$

where A is catchment area in sq. km, Q_{mean} is the mean flow in cumec and C and m are the coefficients. The values of m, C and λ for different regions are given in the Table-1. The flow of desired dependability may be estimated for any ungauged catchment of the region by multiplying the mean flow with the non-dimensional flow of the respective dependability.

Table – 1 Values of parameters m, C, and λ for different regions in India

Region	States Covered	m	C	Coefficient of Correlation (R)	λ
A	Jammu & Kashmir (except Leh & Kargil)	0.06046	3.8189	0.0808	-0.241
B	Jammu & Kashmir (Leh & Kargil)	$Q/A = (1/2)[(Q/A)_{Leh} + (Q/A)_{Kargil}] = 0.05804$			-0.097
C	Himachal Pradesh	0.8611	0.1200	0.8759	-0.184
D	Uttar Pradesh and Uttaranchal	0.89075	0.0463	0.8174	0.131
E	Bihar	0.74795	0.0652	0.7742	-0.260
F	West Bengal and Sikkim	0.98920	0.0577	0.8467	-0.141
G	North Assam & Arunachal Pradesh	0.26817	2.2807	0.3706	0.230
H	South Assam & Meghalaya	0.48589	1.4136	0.6820	0.035
I	Manipur, Nagaland, Mizoram & Tripura	1.22343	0.0151	0.9435	0.138

ENVIRONMENTAL IMPACT

This technology envisages a numerical model development, which does not have any direct bearing on the environment. If some project is constructed based on the results of the model, then there would be some positive impact on the environment.

ECONOMICS

The technology will help in better estimates of water availability at various sites including ungauged sites in the regions under study. Therefore, by the use of this technology, fairly accurate estimates of power potential could be made based on the reliability of flow data at the gauging sites. Application of this technology will prove to be cost effective and it will provide intangible benefits to the people residing in the area.

BENEFICIARIES

Organisations like State Power Corporations, National Hydropower Corporations, and Private Hydropower Corporations would be the main beneficiaries.

INTELLECTUAL PROPERTY RIGHTS

Being the developer of methodology, the National Institute of Hydrology, Roorkee, owns the Intellectual Property Rights.