CHAPTER - 1

TYPE OF HYDRO ELECTRIC DEVELOPMENT AND ENVIRONMENTAL IMPACT ASSESSMENT

1.1 General

Selection of Equipment, their Characteristics and Specifications for design of hydro power station depends upon type and size of hydroelectric development and classification with respect to head and size. Hydropower projects entail change in use of land and water. Mitigation of adverse impacts on this use affects project feasibility, provision of safeguards are required to be considered at planning stage and may affects economic and financial analysis.

1.2 Classification of Hydro Electric Station

Presently in India small hydro size is classified as 25 MW (SHP) and below (station capacity). In the book the classification for Engineering and Design etc. of hydro power project classification is generally as follows:

- 5 MW and above — Large
- 3 MW and below — Small
- 100 kW and below — Micro

This is because International standards of hydro power equipment are as per these classifications. Power houses equipment/design for unit size between 5 MW – 25 MW (small) and 3 MW – 5 MW may be designed accordingly.

Interstate projects of capacity 500 MW (350 MW in Jammu & Kashmir and in North East Stations) have been defined as mega projects. These projects require detailed specific studies for determining equipment parameters.

Small hydro project generally fall into two categories i.e. run of the river projects and Low head/canal fall Schemes.

1.3 Types of Projects

Hydropower schemes are classified into following four categories in terms of how the flow at a given site is controlled or modified. These are:

1. Run-of-river plants without pondage
2. Run-of-river plants with pondage
3. Storage schemes
4. Pumped storage schemes

In a run-of-river project, the natural flow of the river is relatively uncontrolled. In a storage project, the filling and emptying of the impounded storage along with the pattern of the natural stream flow controls the flow in the river downstream from the storage impoundment.

Run-of-river plants can be located at the downstream end of a canal fall, open flume, or pipeline diverting the stream’s flow around a water supply dam or falls. The available flow governs the capacity of the plant. The plant has little or no ability to operate at flow rates higher than that available at the moment.

In plants with significant storage, a dam, which stores water in a reservoir or lake impoundment, controls the river flows. Water is released according to power, irrigation, water supply, or flood control needs. Constructing a dam and storage reservoir can increase the percentage of time that a project can produce a given level of power. Base load plants-those operated at relatively constant output-may have either a small capacity relative to the river flow or may have a significant storage reservoir. Storage reservoirs can be sized for storing water during wet years or wet seasons. Alternatively, they can be sized to provide water for weekly or daily peak generation. A storage reservoir allows using available energy that might otherwise be wasted as spill.

1.3.1 Run of the River Schemes or Diversion Schemes (without pondage)

This type of development aims at utilizing the instantaneous discharge of the stream. So the discharge remains restricted to day to day natural yield from the catchments; characteristics of which will depend on the hydrological features. Development of a river/stream in several steps where tail race discharges from head race inflows for downstream power plants forms an interesting variation of this case and may require sometimes special control measures i.e. Chibro- Khodri Scheme on River Yamuna Figure 1.1 and Figure 1.2

Small scale power generation also generally fall in this category and may have special control requirement especially if the power is not fed into grid. This is typically shown in figure 1.3

1.3.2 Run of the River with Pondage Schemes

This type of development aims at providing daily peaking requirements to the extent pondage is available. It may also be designed for use as grid frequency controlling station if permitted by site parameters. Cascade development on River Yamuna may be seen as an example with pondage at Ichari Dam, Dak Pathar barrage and Ahsan barrage, Chhibro and Khodri plants are in tandem operation. The scheme is shown in fig. 1.2. Dehar power plant on Beas Satluj Link project with a balancing reservoir is another example (figure 1.3).

1.3.3 Storage Schemes

In such schemes annual yield from the catchment is stored in full or partially and then released according to some plan for utilization of storage. Storage may be for single purpose such as power development or may be for multi purpose use which may include irrigation, flood control, etc. therefore, design of storage works and releases from the reservoir will be governed by the intended uses of the stored water. If the scheme is only for power development, then the best use of the water will be by releasing according to the power demand. Schemes with limited storage may be designed as peaking units. If the water project forms a part of the large grid, then the storage is utilized for meeting the peak demands. Such stations could be usefully assigned with the duty of frequency regulation of the system if performance requirement for such an operation permit. Bhakra and Beas dam power projects are examples (figure 1.4).

1.3.4 Peaking, Base Load and Frequency Regulating Capability Of Hydro Plants

Type of schemes and design characteristics for operating capability as peaking, frequency regulation and base load is discussed with special reference to Bhakra Beas river valley development projects schemes as shown in figure 1.3 and figure 1.4.

Bhakra left bank and Bhakra right bank power plants (1325 MW) at the toe of concrete straight gravity dam on river Satluj are examples of peaking and frequency controlling station. Pong power plant on Beas dam (high earthfill dam) is suitable for peaking but not suitable for frequency regulation due to very long penstock. Beas Satluj link project linking Beas river at Pandoh with river Satluj at Dehar upstream of Bhakra lake was provided balancing storage and surge tank to make it suitable for peaking and system frequency regulation capacity. Nangal power plant from hydro channel (figure 1.4) is run as base load plants as the water from Nangal dam is released on the basis of irrigations demands.
All canal power houses are run as base load stations.

Koyna stage 3 powerhouse is a typical example of peaking power station with limited storage.

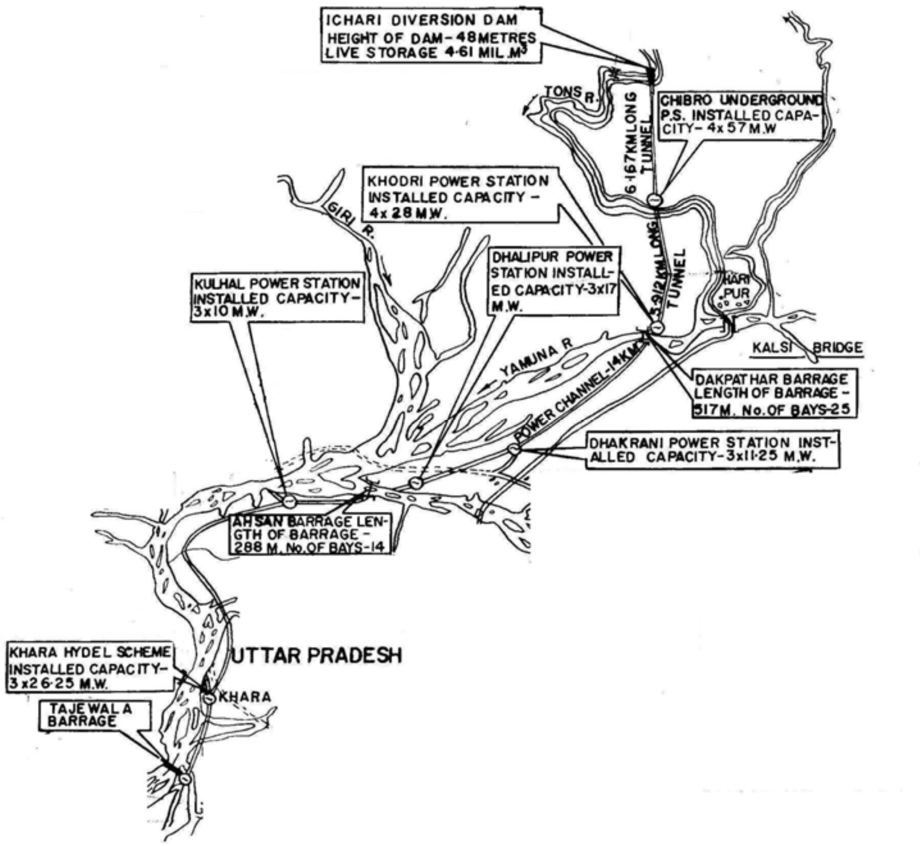


Fig. 1.1: Run of the River Hydro Electric Schemes in Yamuna Valley in cascade and with pondage (Source: CBI&P Publication no. 288 and UPSEB inauguration brochm)

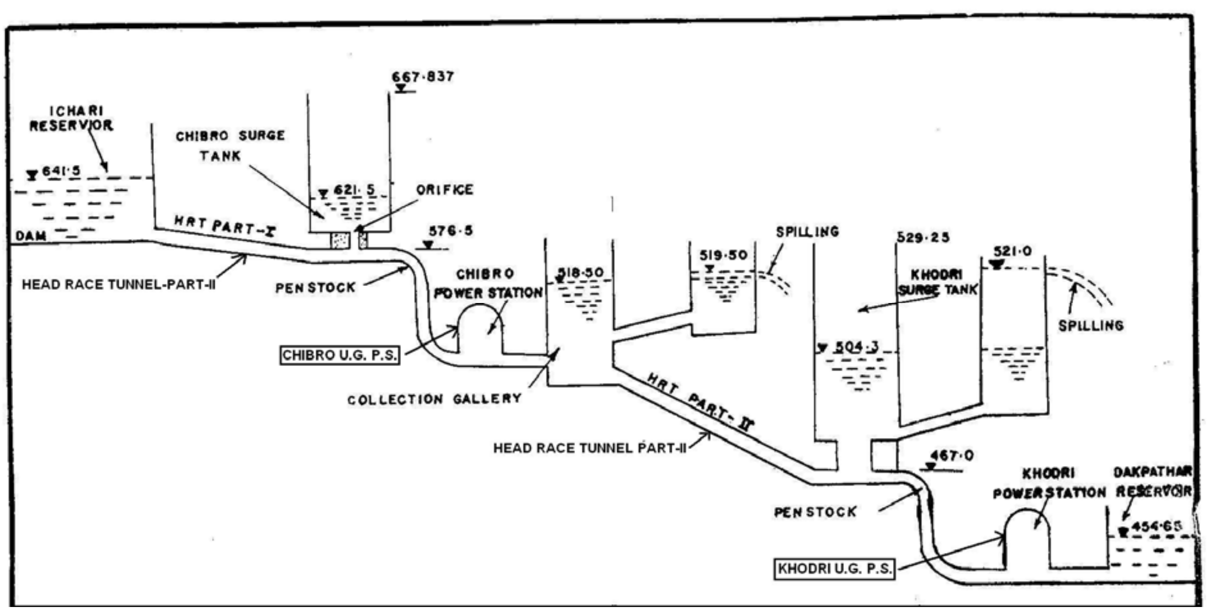


Figure1.2: Chibro – Khodri Under Ground Power Stations (working in tandem) (Source: CBI&P Publication No. 288)

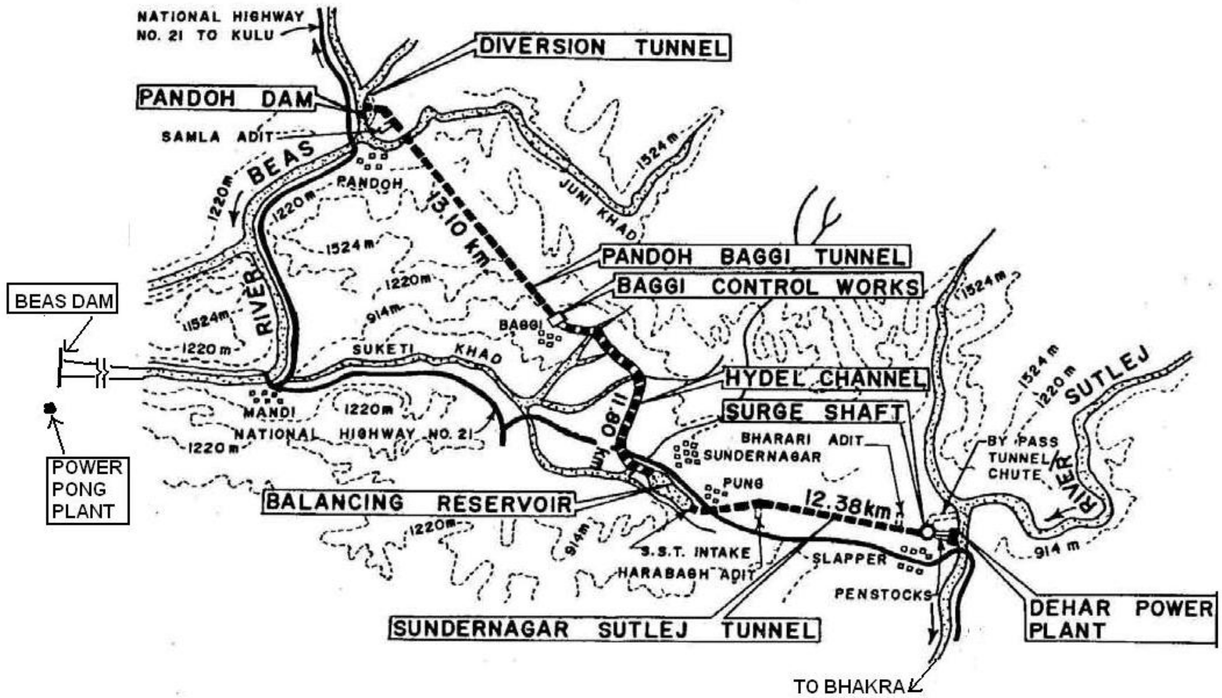


Fig. 1.3: Beas Dam and Beas Satluj Link Projects
(Source: CBI&P Publication No. 288)

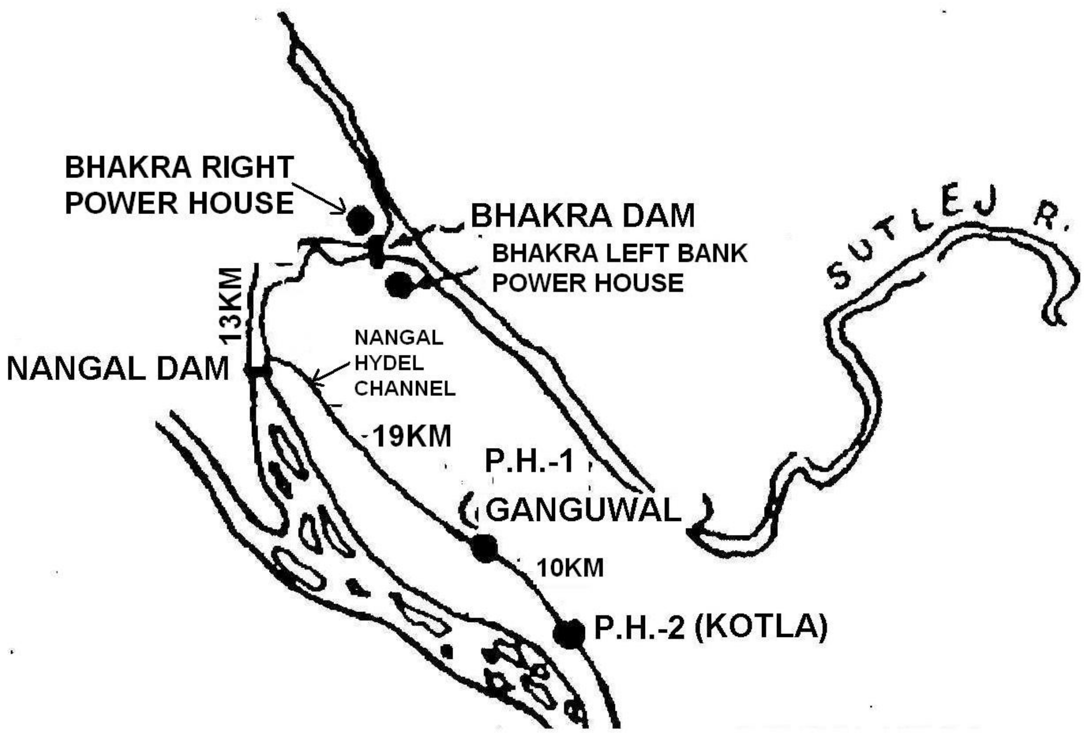


Figure 1.4: Bhakra Power Projects and Ganguwal and Kolta Canal Power Houses

1.3.5 Synchronous Condenser operation

Motoring of a conventional hydro-electric units is sometimes desired so that unit can be utilized as a synchronous condenser for electric system for supplying or absorbing reactive power or for the unit to be in spinning reserve for rapid response to system needs. For this purpose, the generating unit is started in the normal way up to speed no load position, synchronised with the grid and turbine wicket gates are then closed. Draft tube water depression system is utilized in these hydro -electric units (reaction turbine) to depress the water below the runner of the turbine. By depressing the water below the runner, it allows the unit to be motored with minimum power consumed from the system since it is spinning in air as opposed to water. There are not many schemes in India with this facility. It is considered that as far as feasible all schemes near load centre and with reaction turbines may be provided draft tube water depression system to provide this facility for better control of grid voltage regulation and reduce power losses.

1.3.6 Pump Storage Scheme

Principle

The basic principle of pumped storage is to convert the surplus electrical energy available in a system in off-peak periods, to hydraulic potential energy, in order to generate power in periods when the peak demand on the system exceeds the total available capacity of the generating stations.

By using the surplus electrical energy available in the network during low-demand periods, water is pumped from a lower pond to an upper pond. In periods of peak demand, the power station is operated in the generating mode i.e. water from the upper pond is drawn through the same water conduit system to the turbine for generating power.

There are two main types of pumped storage plants:

i) Pumped-storage plants and
ii) Mixed pumped-storage plants

Pump-storage plants

In this type only pumped storage operation is envisaged without any scope for conventional generation of power. These are provided in places where the run-off is poor. Further, they are designed only for operation on a day-to-day basis without room for flexibility in operation. Typical Examples of pumped storage plant in the country are as follows:

Kadamparai pumped storage scheme in Tamil Nadu with an installed capacity of 4 x 100 MW and Kadana in Gujarat 4 x 60 MW are typical examples.

Mixed pumped-storage plants

In this type, in addition to the pumped storage operation, some amount of extra energy can be generated by utilizing the additional natural run-off during a year. These can be designed for operation on a weekly cycle or other form of a longer period by providing for additional storage and afford some amount of flexibility in operation.

Some stations have both conventional and reversible units. These pumped storage schemes offer greater flexibility in sitting a conventional pumped storage scheme. These are normally used to provide a balancing load to base load thermal and nuclear plants during off peak hours, thus reducing severe cycling of units and improving their efficiency, durability and reliability. Nagarjuna sagar pumped storage scheme with one conventional unit of 110 MW and 7 reversible units of 100 MW each is an example and was incidentally the first pumped storage scheme in India (figure 1.5).

Name of powerhouse	Capacity in MW	Type	Speed in rpm
Conventional hydro generating unit	1 x 110	Vertical shaft Francis turbine driven generator	187.5
Reversible type pump-turbine motor generating units	7 x 100.8	Francis type pump/turbine units	157.9

	Turbine Operation	Pump Operation
Maximum net head	105 m	109.0 m
Minimum net head	71.5 m	75.0 m
Max. level in upper reservoir	+180.0 m	- -
Min. level in upper reservoir	+156.0 m	- -
Max. level in lower reservoir	+83.0 m	- -
Min. level in lower reservoir	+73.0 m	- -

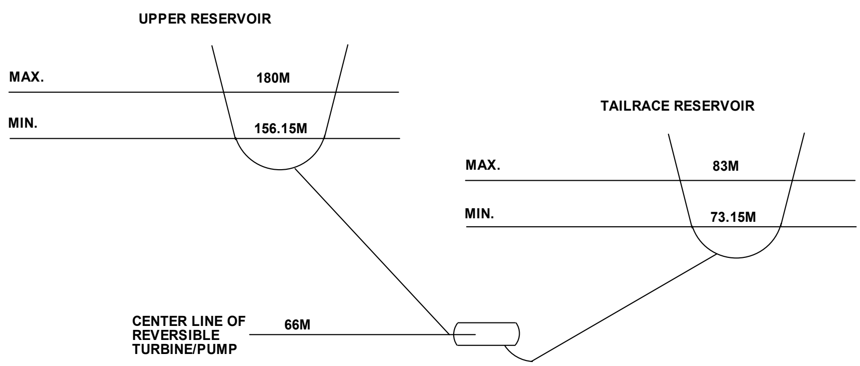


Fig. 1.5 Nagarjuna Sagar Mixed Pump Storage Project
(Source: CBI&P Publication)

1.4 Environmental Impact Assessment (EIA)

Environment impact assessment (EIA) of individual hydro power project is required to assess magnitude of change in land and water use. Such change depends on the selected site configuration. Illustrated site configuration of large hydropower projects is shown from figure 1.1 to figure 1.4 and of a small hydro power scheme is shown in figure 1.6.

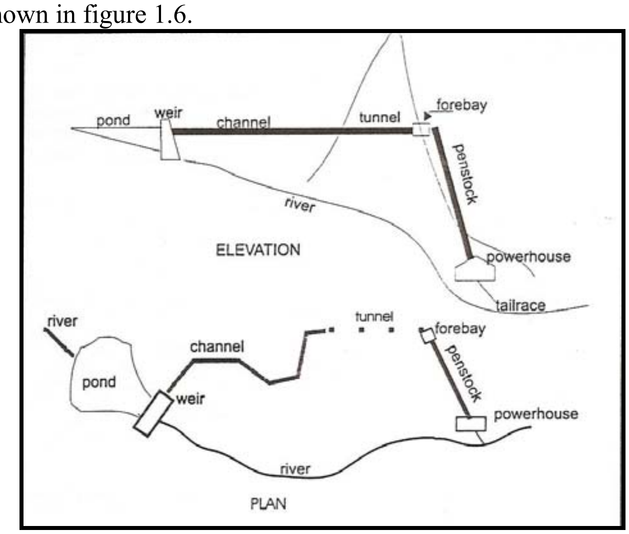


Figure 1.6: Physical components of small hydropower project (up to 25 MW)

The environmental impacts of hydropower project may be summarized as follows:

Table 1.1: Environmental impacts of small hydropower projects

Activity	Adverse Impact
Construction of road, dam, surface power house and switch yard, diversion tunnel, channel	1. Reservoir sedimentation and deterioration of water quality 2. Air and noise pollution and disturbance to flora and fauna by work force 3. Visual intrusion caused by construction activity 4. Disturbance of recreational spots (e.g. waterfalls) and activities 5. Soil erosion due to removal of vegetation and excavation of construction material 6. Alteration in ground water flow
Construction of transmission line	1. Damaging flora due to right of way clearing 2. Endangering the lives of fauna 3. Visual intrusion
Stream diversion through channel and conduit	1. Loss of habitat of fish and other aquatic flora and fauna 2. Decrease in dilution capacity of stream 3. Depletion in ground water recharge where diversion is taken off from effluent stream 4. Loss of waterfalls and other recreational activities
Ponding	1. Flow disruption 2. Channel degradation during generation or spilling and flushing of silt from dam 3. Trapped nutrients and sediments, eutrophication 4. Changed water temperature 5. Changes in land uses: (a) submergence of agricultural and forest land (b) submergence of human settlement and displacement of population (c) submergence of monuments/sites of historic importance (d) loss of whitewater recreation 6. Change in aquatic plant life and fish species 7. High evaporation rate 8. Sedimentation adversely affects fish spawning areas by burying them 9. Provides increased habitat for mosquitoes and snails which are vectors of diseases like malaria, yellow fever, dengue, encephalitis and schistosomiasis
Operation of hydropower station	1. Increase in pollution concentration in the downstream due to release of pollutants from residential areas, hydropower plant 2. Released water containing low dissolved oxygen 3. Fish mortality from turbine passage 4. Sonic impact: noise level may increase
Peaking operation of power station	1. Damage to fish spawning ground and nesting ground for water fowls and other aquatic birds 2. Erosion of banks 3. Transport of nutrients from the shallow water to deeper water in pond 4. Affects recreational facilities due to fluctuating water level 5. Exposure of drawdown zone creates visual intrusion

1.4.1 Positive Impacts

Positive environmental impacts of hydropower projects are somehow ignored as a routine probably due to the fact that these projects are conveniently considered as demanding an environmental price. It is equally important to highlight and quantify (to the extent possible) positive environmental impacts of SHPs.

Positive Socio-Economic Impacts

1. No transmission loss due to commercial availability of power at customers’ door step
2. Multiplier effect of electricity on economy of the area especially in remote areas such as agro-industrial units
3. Improvement of agricultural produce through lift irrigation which requires energy

4. Project related infrastructure (roads, health facilities, education facilities will help the local people as well as project affected people. There will be net improvement in community health
5. Improvement in living standard of local people
6. Creation of reservoir will increase potential for fish and fisheries (catch and income)
7. Generation of employment opportunities locally. Direct employment during construction and indirect employment in allied activities
8. Motivation of higher literacy
9. Check on migration from villages to towns, thereby checking urban concentration of population
10. Increasing tourism potential – water sports, boating, fishing etc.
11. It helps in checking deforestation which is taking place to meet food, fodder and fuel demands in rural, remote areas.
12. It is significant for off-grid, rural, remote area applications in far flung isolated communities having no chances of grid extension for years to come. It is operationally flexible, suitable for peaking support to the local grid as well as for standalone applications in isolated remote areas.
13. Small hydro does not require much expertise to build and operate. Components of small hydro projects are simple and fairly visible at site. They can become centre of education.
14. In specific cases SHPs are eligible for carbon credits through reduction in CO_2 emission and adding sink for CO_2 via plantation schemes.

Positive Ecological/Environmental Impacts

1. Clean and renewable source of energy. SHPs result in saving of non-renewable fuel resources such as coal, liquid fuels and gases.
2. It is benign source of power generation, harnessing only gravitational potential of water to make it yield energy.
3. Decrease of pollution in the area (hydro replacing diesel generation, electricity replacing polluting energy sources)
4. Increased water surface creates habitat for aquatic life in or near the reservoir. Receiving waters create dry mudflats which provide feeding sites for migratory birds and breeding habitat for resident species.
5. Improved ground water table enhancing greenery all around
6. Improvement towards vegetation and plantation associated with the project (compensatory a forestation) and thus providing sink for CO_2 emission
7. Improved habitat
8. Lake shore environment in otherwise dry areas
9. Modification of micro climate due to storage and regulation of water to a more or less uniform pattern. This also leads to a somewhat stabilizing impact on local environment influencing flora and fauna – aquatic as well as terrestrial.
10. SHPs are environmentally more friendlier than conventional large hydro plants:

    a. Non-involvement of setting up of large dams and thus not associated with problems of deforestation, submergence or rehabilitation
    b. Non-polluting and environmentally benign. It is one of the least CO2 emission responsible power sources, even by considering full energy chain right from the impact of production of plant equipment etc.
    c. Least impact on flora and fauna (aquatic and terrestrial) and biodiversity due to localized nature of activities

11. There may be overall improvement in biodiversity due to creation of habitats.

1.5 Environmental Acts and Clearance of Hydropower Projects in India

It is mandatory to obtain clearance from appropriate authority for all new hydropower projects or expansion and modernization of existing projects.

Flow chart depicting procedure of environmental clearance is given in Figure 1.7. Flow chart depicting appraisal procedure is shown in Figure 1.8.

1.5.1 Requirements for Environmental Clearance

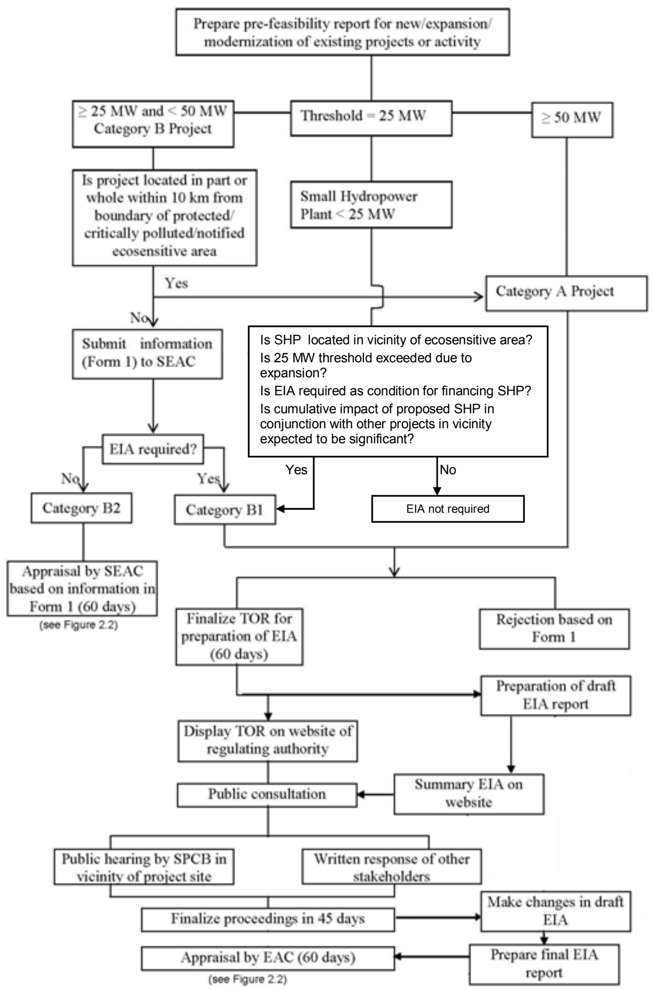
The gazette notification dated 14th September, 2006 stipulate two regulatory authorities to deal with environmental clearance for all new project and expansion/modernization of existing projects.

Central Government in Ministry of Environment and Forests	• for Category A projects ≥ 50 MW • for category B projects if located wholly or partially within 10 km from boundary of notified protected area/critically polluted area/eco-sensitive area
State Environmental Assessment Authority (SEIAA)	for category B projects ≥ 25 MW and <50 MW

The Regulatory Authority (RA) will provide environmental clearance based on recommendation of expert appraisal committee (EAC). In the absence of a duly constituted SEIAA or state level EAC, a category B project shall be treated as a category A project.

1.5.2 General Conditions

Any project or activity specified in category B will be treated as category A if located in whole or in part within 10km from the boundary of (i) protected area notified under Wild Life (Protection) Act, 1972 (ii) critically polluted areas as notified by Central Pollution Control Board from time to time, (iii) notified eco sensitive area, (iv) interstate boundaries and international boundaries.



Note: Form 1 is as per MoEF, 2006, Environmental Impact Assessment Notification

Figure 1.7: Flow chart describing procedure of environmental clearance

APPRAISAL

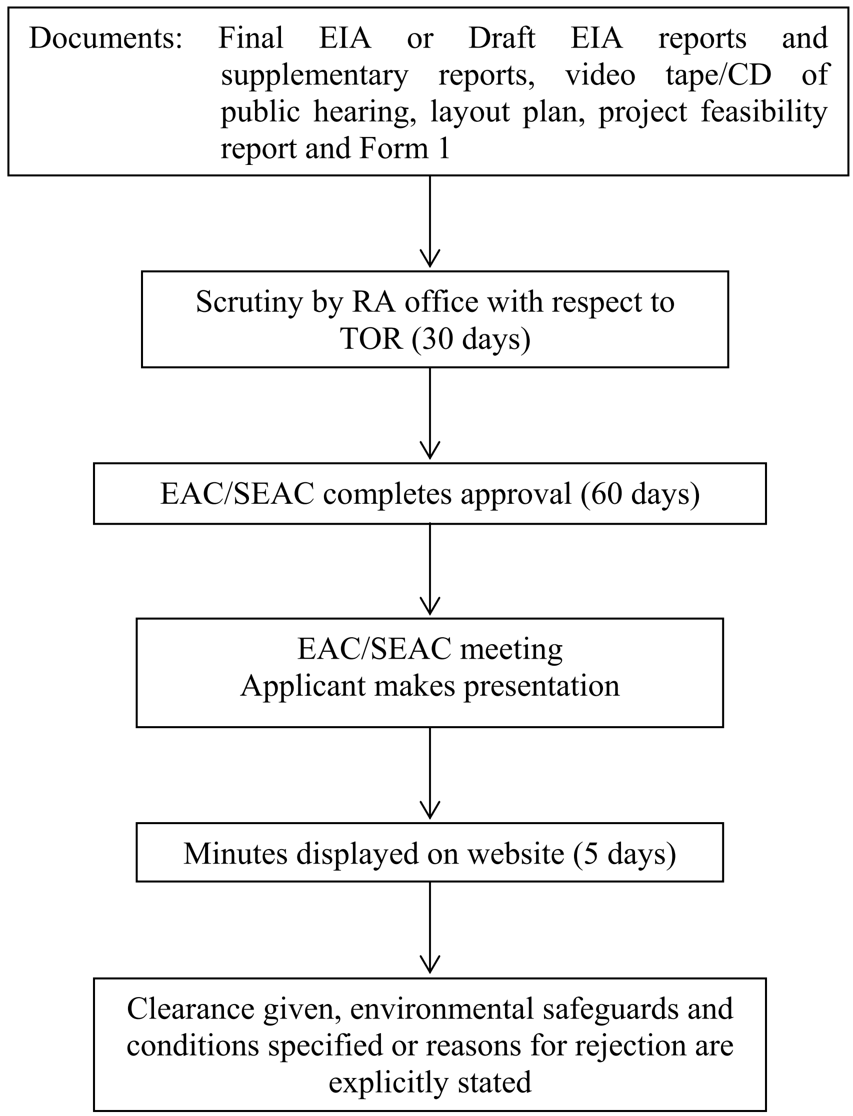


Figure 1.8: Flow chart describing Appraisal procedure by Regulatory Authority (RA)

Projects located in ecologically sensitive/fragile area (e.g. Doon Valley in Uttaranchal and Aravali range in Rajasthan etc.) as notified by the Government of India from time to time may also be required to obtain environmental clearance compulsorily irrespective of the size, cost. All the projects located in/near wildlife sanctuaries, national parks, wetlands, mangroves, biosphere reserve also need environmental clearance.

A small hydropower project (<25 MW) will require environmental clearance from competent authority if:

(i) It is located inside or in vicinity of ecologically sensitive fragile area
(ii) The project in conjunction with existing or proposed hydropower projects may have cumulative adverse impacts.
(iii) Expansion or modernisation for existing unit with increase in production capacity beyond the 25 MW threshold limit.
(iv) The project is funded by an agency which requires EIA as a condition for funding.

References

Govt of India Acts

1. MoEF, 1986, Environmental protection Act, Ministry of Environmental and Forests. Government of India.
2. MoEF, 1947 (amended in 1978 & 1988, Water (Prevention and Control of Pollution) Act.
3. Forest (Conservation) Act, 1980 amended in 1988.
4. Air (Prevention and control of pollution) Act 1981 amended in 1988.

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6. MoEF, 1981, Guidelines for River Valley Projects, Ministry of Environmental & Forests, Government of India.
7. CWC, 1992, Guidelines for Sustainable water resources development and management
8. NEERI, 2003, National Guidance Manual on Environmental Impact Assessment on behalf of MoEF.