Considerations and Challenges in Switchyard Planning of Hydel Power Projects

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Abstract- *In this article, we are discussing planning of switchyards of hydel power stations. The - switchyards are planned depending upon number of units, number of feeders and the voltage level. In case of thermal plants, normally plain area is available near power house building. It is just like to make a drawing on clean black board. We can plan the switchyards as per the established practice of the generating company. However, in the case of hydel power stations, the project is tailor-made. Its layout varies from project site to site. The switchyard, in some cases, may have to be planned quite away from power station depending upon the availability of plain land. Sometimes, due to hard rocks, it is quite costly to create plain area for switchyards. Therefore, the switchyard may have to be planned quite away from power house building. Generator Transformers are generally located near to the power house building from where H.V. feeders are taken to switchyard by installing suitable towers or sometimes suitable anchoring in the dam body.*

Keywords: Switchyard, Switchyard planning; high level, normal level, step formation, hydropower plant switchyard, Location of generator transformer, anchoring of HT conductor to dam and or power house building.

I. INTRODUCTION

A switchyard is the inter-connector between generation and transmission, at same voltage to evacuate generated power. In thermal power plants, switchyard generally exists adjacent to the power station.

Switch yard is HT switching area. Various equipments such as step-down transformers, circuit breakers, isolators, CT, PT, CVT, wave trap are almost the same in a switchyard, transmission or distribution substations. However, their ratings depend on the capacity of generating station, transmission substation, distribution substation. We may call broadly Generating station as bulk producer, Transmission substation bulk purchaser, Distribution substation retailer for consumers. As mentioned above switch yard formation at all places is similar.

The generation voltage is stepped-up to a transmission voltage e.g., 132 kV, 220 kV, 400 kV etc. using a generator transformer. The high voltage power is transmitted to the switchyard. If capacity of generating station is large, then capacity and voltage level of transmission substation may have to be raised, enhanced.

Station transformer to meet all the loads of a of the power plant (other than unit auxiliaries for which a separate transformer is provided). Generally, one station transformer is provided for a hydro power station and two in case of a thermal power station for initial starts. It is also needed during complete shutdown of power house for maintenance or during off peak hours (in case of hydro Power stations designed for peak hours operation). The hydel power projects are tailormade and there is no standard arrangement or locations of the switchyard. It varies from project to project [1-2]. A typical arrangement of the hydel power project showing reservoir, dam, penstock, power house, switchyard and tailrace can be seen in Figure 1.

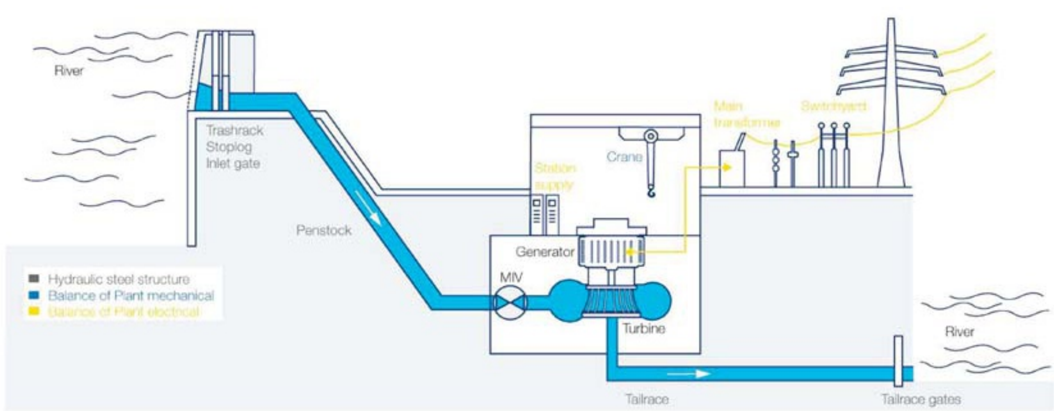


Fig. 1 Typical arrangement of a hydel power project [3]

II. Criterion in Designing Switchyard

Switchyard area requirement depends mainly on number of units, number of feeders and voltage level. It very rarely varies with the unit size. However, the area requirement varies considerably with the voltage level. To some extent it is proportional to voltage level.

The main difference in the switchyards of thermal and Hydel power stations is that the switchyard area in case of thermal power plant is quite adjacent to the power house building. The generator transformers are quite near to the switchyard. The unit size of thermal power station is so large (>200 MW) that generator transformers are to be installed very near to the power house building. It is because of the connection between generating unit and generator transformer is done by the isolated bus ducts. A marginal increase of distance of generator transformer from the generating unit will increase the cost of bus duct considerably. (As compared to this, a very marginal increase would be there in the cost of HT conductor).

In case of Hydel plants, the natural location of water fall or dam may be difficult to approach and very small area may be available near to the fall or near the dam location.

The power station has mainly two sections,

(a) Generating units and associated auxiliary services & equipment

(b) Power evacuation equipment system

The broad considerations in planning of switchyard with specific reference to hydro power stations is discussed next.

III. Main Features of a Switchyard

There can be different bus-bar configurations.

i. Double main buses and a transfer bus: Opted in case of large capacity power stations, transmission substations having a greater number of units and feeders. Refer Figure 2 (A).

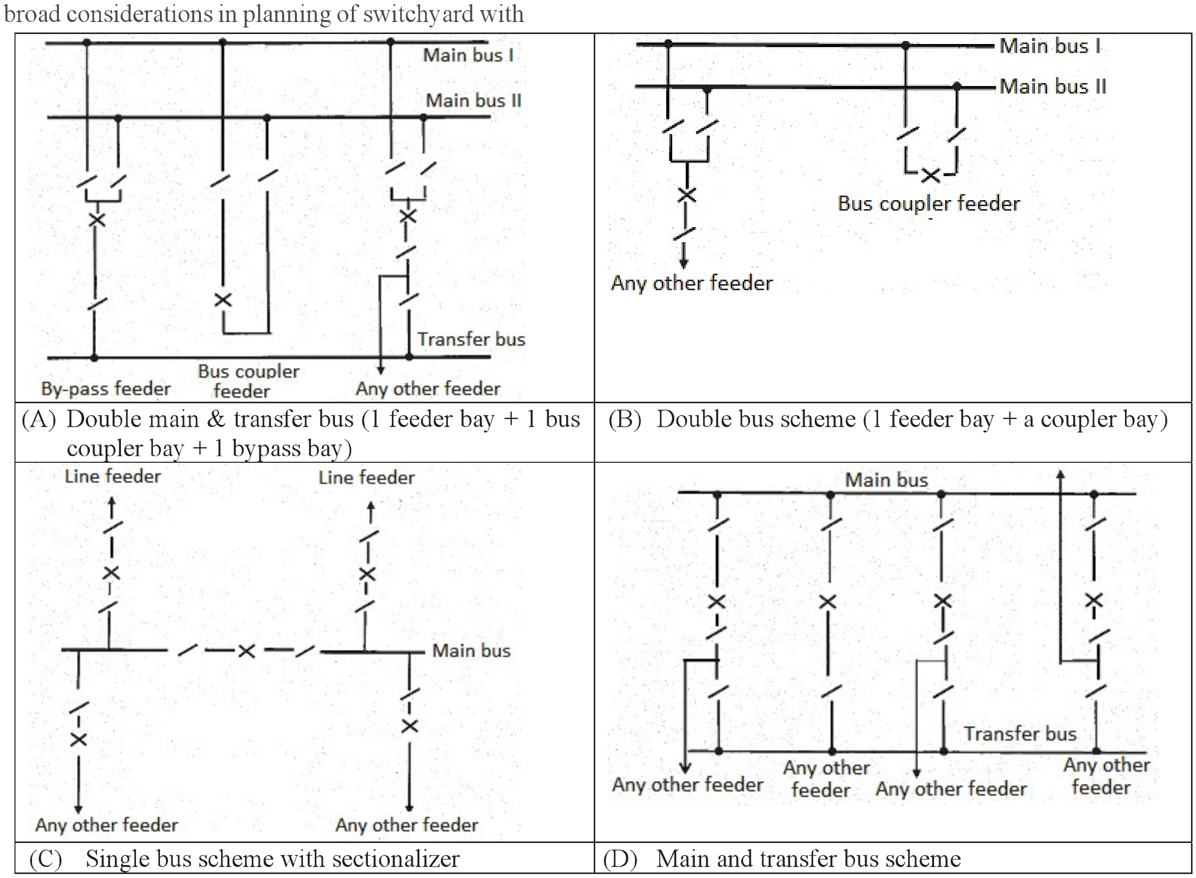
ii. Double main buses scheme: Generally opted for large capacity power stations, substations. Bus fault protection is provided to save tripping of healthy bus. Refer Figure 2 (B).

iii. Single main bus with sectionalizer: It generally opted for small capacity power stations, sub stations. Refer Figure 2 (C).

iv. Single main bus with transfer bus: It is normally opted for medium capacity power stations, substations where number of units and feeders together are more. Transfer bus is provided for maintenance of CB, CT of units or feeders. It is rarely opted in power stations. Refer Figure 2 (D).

v. The transfer bus is normally opted in thermal power stations as:

- It operates round the clock
- Number of units and feeders are, say 8,10 or more.



(A) Double main & transfer bus (1 feeder bay + 1 bus coupler bay + 1 bypass bay)

(B) Double bus scheme (1 feeder bay + a coupler bay)

(C) Single bus scheme with sectionalizer

(D) Main and transfer bus scheme

Fig. 2 Switch yard of hydro power projects [4]

Hydel stations generally operate during peak hours, hence get time for maintenance by taking shut down of all the buses or one of the two buses. The remaining units may remain in operation. Therefore, in Hydro Power stations single or double main system is used.

i. In single bus bar arrangement, sections are made for ease of maintenance by taking shutdown on one section. In hydro power stations, one unit and one feeder are included in one section. After opening of bus isolator of feeder or unit, if required the bus section can be taken in operation.

ii. Circuit breaker, isolators, C.T.: As far as possible these equipments are erected in their respective line parallel to main bus bar. Sometimes it may not be not feasible to cross the conductor over the bus bars. In such cases CB, CT etc. of generating units are arranged in one line on side of bus and feeders equipment in respective lines on other side of bus bar. In Pench Hydro power stations such arrangement has been provided.

iii. Bus bar P.T.: Generally, three single phase PTs on each bus are installed. In double bus arrangement, the CT for differential protection of bus is also provided. It is normally provided in thermal power plants and large capacity hydro Power stations. In that case, approximately half number of units and feeders are connected to one bus and remaining to other bus. This protects half number units and feeders from tripping on bus fault.

iv. Feeder CVT, wave trap, feeder isolator with earth switch: These are installed at the entry end of feeder.

The main features of any switchyard are generally their formations and types of arrangements as given below:

(a) Types of switchyards formations

(i) high level (ii) Low / normal level (iii) Step level

i. High level: It is opted in Hydro Power stations where plain land is not possible to create or costly. In this arrangement bus isolators are installed at high level gantry to save land space. However, these are operable from ground level. It has been used in Pench Hydro Power station.

ii. Low or normal level: It is conventional. The bus isolators of generating units and feeders are installed on ground level. It increases width of switchyard and so also area proportionately. The Bargi HPP and Hasdeo-Bango HPP switchyards are of this type.

(b) Types of bus bar arrangement

(i) Single main bus: In this bus arrangement only one bus is there where the generating units and feeders are connected. It is normally used in case of small hydro power stations having one or two generating units and feeders. The loss of power during bus shut down is minimal. Bargi Left Bank Canal small hydro power station has such arrangement. During long shutdown or reservoir level below low-level canal flow is maintained by operation of bye pass gates.

(ii) Single main bus with bus section: This arrangement is provided for comparatively higher capacity power stations. On each section one unit and one feeder are connected. For bus section isolation, breaker is seldom provided, it is achieved by bus isolator. In Rajghat Hydro power station this arrangement has been provided. In this Power Station, 3 units of 20 MW and 2 feeders of 132 kV are there. The project is interstate between U.P. and M.P. The share of U.P. in power is 1/3. Therefore, on one section one unit and feeder of UP are connected, second section one generating unit is connected. Third section third unit and M.P. feeder is connected. This has been done for ease in separate M.P. and U.P. grid operation, if required.

(iii) Double main bus arrangement: It is provided for large capacity power stations, where annual operation period is substantially high, number of units and feeders are more. The power stations are important from grid point of view. Half number units and feeders are connected to one bus and remaining on other bus to avoid tripping of whole power station in case of bus fault. This arrangement has been provided at Bargi HEP in M.P., Hasdeo Bango in Chhattisgarh at normal level and in Pench HEP in M.P. at High level,.All these are 132 kV switchyards.

The Pench Hydro Power station is an interstate project between MP and Maharashtra (M.H.), with the sharing of power 2/3 (M.P.):1/3(M.H.). In case of grid failure, one unit and feeder of one state are connected to one bus to provide starting to each state. Now due to strict norms of grid operation possibility of such situation is very remote.

(iv) Double main bus step type formation: In some hydro power stations, plain land is not available at single stretch or it may be very expensive and not eco-friendly to create plain area by large excavation. In such cases switchyard is constructed in steps, e.g., main bus-1 in first step and second step at higher elevation for bus-2. In case of Tons Hydro Power station due to steep hilly terrain this type of switch yard has been built. There is substantial level difference in levels of GT, bus-1, bus-2.

IV. Location of Generator Transformer

The location of GT also varies from project to project depending on the location of switch and/ or availability of space and LT side bus duct for GT.

(a) Draft tube Deck: Bargi Hydro (2 x 45 MW) In this project since switch yard is on tail race side generator terminal also take to tail race side, bus straight way taken up to draft tube deck level, where GTs have been installed. The HT terminals taken to 132 kV tower erected near switch yard. The relative locations of GTs, PH, and switchyard are shown in rough sketch Figure 3.

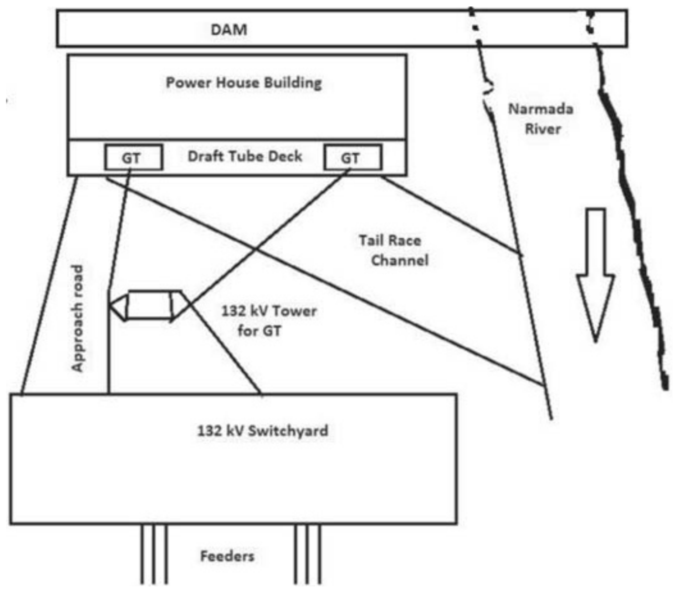


Fig. 3 Relative positions of power house building, G.T., and Switch yard of Bargi HPP

(b) GTs in Switchyard: Pench HEP (2x80 MW) The power house is underground about 100 meter deep below some portion of switchyard. The 100-meter length 11 kV bus ducts brought up to switch yard level through well provided for it and vertically down ward approach to power house. The power station main control room building is near to the well and switch yard. In case of any emergency concerned personal can go to machine hall through the well in about 10 minutes. The GTs have been installed near to well for ease of 11 kV bus duct connection. The relative locations of GTs, PH, and switchyard are roughly shown in Figure 4.

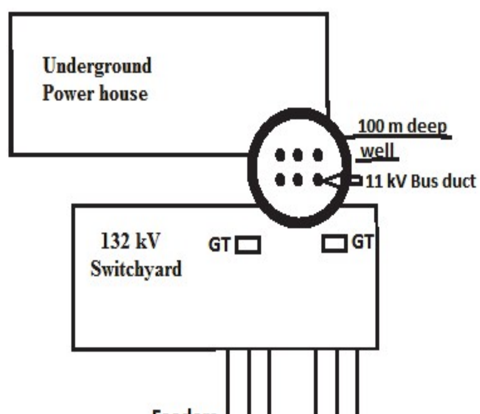


Fig. 4 Relative positions of power house building, G.T., and Switch yard of Pench HPP

In case of Rajghat (3×20 MW) Lalitpur (U.P.) and Marikheda (2×20 + 1×20 MW) Shivpuri (M.P.), GTs have been installed in switchyard and LT connection have been made by 11 kV cables due to low rating of generating units. It is observed that up to 20 MW unit size and 100 m length of HT cable connections are found to be economical

(c) GTs between power dam toe and power house building: In case of Hasdeo Bango HEP due to availability of adequate space between power dam and power house building GTs have been installed in this space.11kv bus ducts have been taken from up-stream side and straight vertically brought up to GT level. This arrangement has reduced length of bus duct considerably and also cost. The 132 kV HT conductors anchored between 132 kV towers near switch yard, to dam blocks, to power house building. The GT terminals have taken vertically upward to connect upper HT conductors for entry into switch yard. Rough setch in Figure 5 shows the relative locations of GTs, PH, and switchyard.

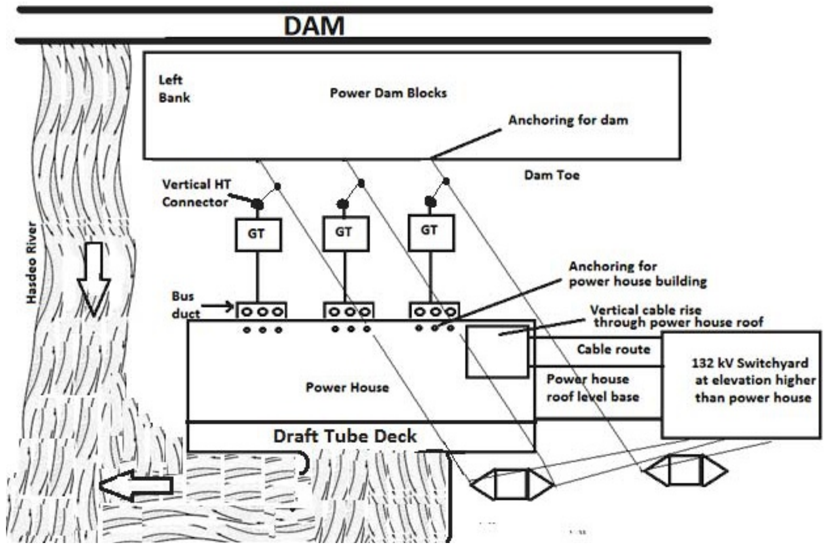


Fig. 5 Relative positions of power house building, G.T., and Switch yard of Hasdeo Bango HPP

(d) GT upstream side outside power house building: In case of Tons Hydro 3x105 the upstream side power house wall is abutting with tapper portion of step switch yard. Therefore, it felt convenient to place GTs near to upstream wall of power house building. The HT conductors have been very conveniently taken to switch yard on suitably located 220 kV towers. The rough sketch in Figure 6 shows relative locations of GTs, PH, and step switchyard.

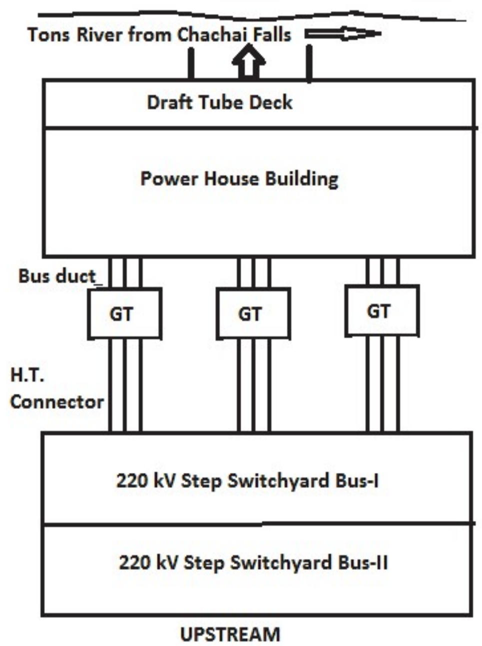


Fig. 6 Relative positions of power house building, G.T., and Switchyard of Tons HPP

(e) Earth Mat planning: As discussed in foregoing paras, the locations of power house building and switchyard may be quite far off and earth strata may also differ considerably. Therefore, earth Mat for power house building and switchyard may have to be designed independently. Sometimes, such apart locations may be advantageous. For example, the power house zero level earth may have almost zero earth resistivity due to seepage of water at that level, whereas switchyard may have to be located on hard rock strata with quit high earth resistance. Strong inter connection between two earth mats is made say by at least 4 riser of mild steel strips to get advantage of low earth resistance at power house zero level along with formation of equipotential area in power house and switch yard premises.

V. Conclusion

The overall planning of a hydropower project is very challenging as power house is taken near to the source of energy to the extent possible.

In case of thermal power plant, the energy source (coal) is transported to the convenient location of power station. Therefore, it is possible to locate thermal power station switchyard on most appropriate plain land near to the power house building where conventional layout of switch yard can be planned.

In case of hydel projects, two or three alternatives are to be examined. The location of generator Transformers also varies from project to protect. All these factors are challenging for designing, planning of switchyard of hydro power stations.

The location of switchyard affects the layout, routing of cable trenches. Sometimes, due to increased length of protection cables, their conductor cross-section needs to be reviewed to limit VA burden on CT or CT VA burden may have to increase to avoid its operation on knee point voltage. Thus, such vital points need consideration before finalizing the switch yard.

The author, as per his experience and memory has tried to highlight vital challenges and considerations faced during finalizing the planning of Switch yards of Hydro power stations. It is very likely that some deviations may be there from actual.

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