“Low Head Hydro Technologies: Selection Criteria and Innovative Applications“

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1 Synopsis

The paper outlines the application range of conventional low head hydro (COMPACT HYDRO) and HYDROMATRIX® technology with regards to the hydraulic boundary conditions and plant layout. The differences of the two technologies and application limits are compared by showing different examples of how these technologies have been applied at reference plants. The paper will subsequently list criteria for the selection of these technologies during the first assessment of potential hydropower sites.

2 Introduction

In the course of the development of low head hydropower projects the developer and/or future owner of the plant often faces the difficulty to choose the best (technically and economically feasible) option among the multitude of available technologies such as (but not limited to):

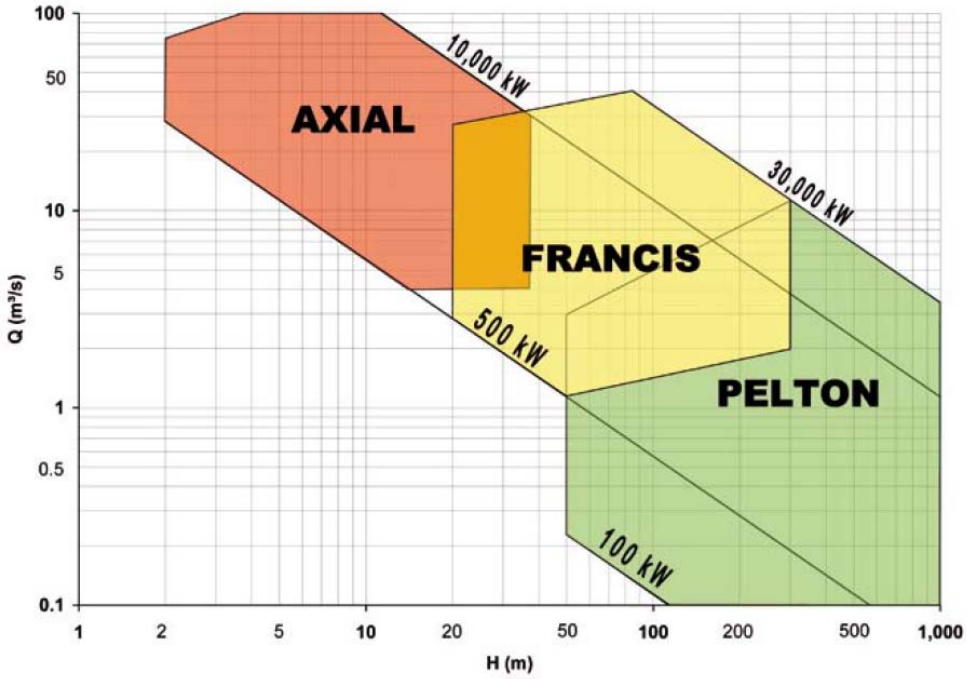
- Bulb turbines (mid size to large size diameters)
- Small axial turbines such as Bevel Gear Turbines
- HYDROMATRIX® turbines
- Other low head technologies such as Archimedes screw or water wheels

The necessary assessment on what technology to chose is a complex and time consuming undertaking where various boundary conditions need to be considered. This paper aims at providing guidance on how to assess a potential low head hydro site (whether it is a greenfield application or an existing structure) and to outline the advantages and restrictions of low head hydro technologies offered by ANDRITZ HYDRO.

3 Low Head Hydro Technology

3.1 Small to mid size axial turbines

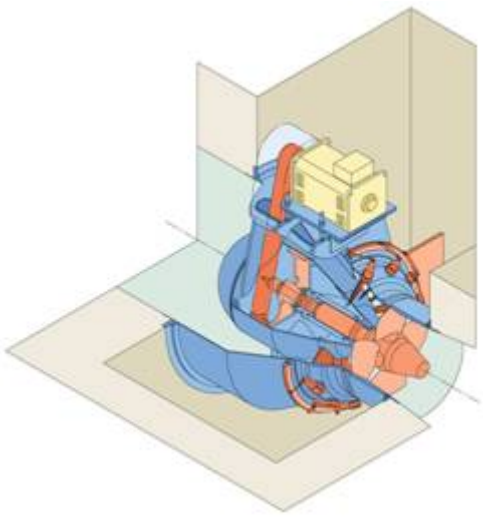
Based on the experience and know-how gained through intensive research & development activities for hydropower plants, ANDRITZ HYDRO has developed a modular design concept for the equipment to be included in small hydropower plants.
COMPACT HYDRO provides solutions with products and services for all types of small hydro power plants up to an output of 30 MW per unit including complete electro-mechanical installation (‘From water to wire’).
The modular design by COMPACT HYDRO minimizes the number of components and sizes, covering all types of turbines with a wide range of applications. It also allows an economic development of small hydro power potentials with power houses perfectly fitting into the landscape.



Picture 1: Application Range of single unit COMPACT HYDRO turbines

For the special requirements of the low head hydro applications ANDRITZ HYDRO has developed several distinctive turbine types. Three of them (Belt Driven Bulb Turbine, Bevel Gear Bulb Turbine and Axial Bulb Turbine) shall be introduced hereafter. All of them are axial Kaplan turbines and are characterized by highest peak efficiencies of 94 % and, due to the double regulation of runner and wicket gates, a wide applicable discharge range of 25 to 100 %.

3.1.1 Belt Driven Bulb Turbine



Picture 2: Belt Driven Bulb Turbine

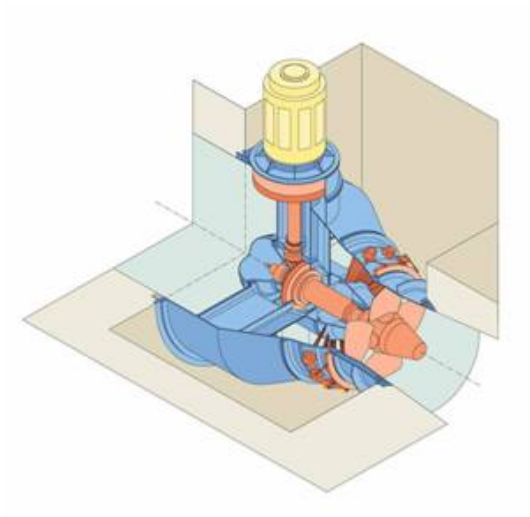
Main Characteristics:

- High speed synchronous generator
- Short installation time
- Compact power house structure
- LV (Low Volt) Application of 400 or 690V
- 27 units installed
  (average output 270 kW)

Typical Application Range:

- Head up to 4 m
- Unit discharge up to 25 m³/s
- Output up to 600 kW
- Runner diameter 1450, 1700 and 1950 mm

3.1.2 Bevel Gear Bulb Turbine



Picture 3: Bevel Gear Bulb Turbine

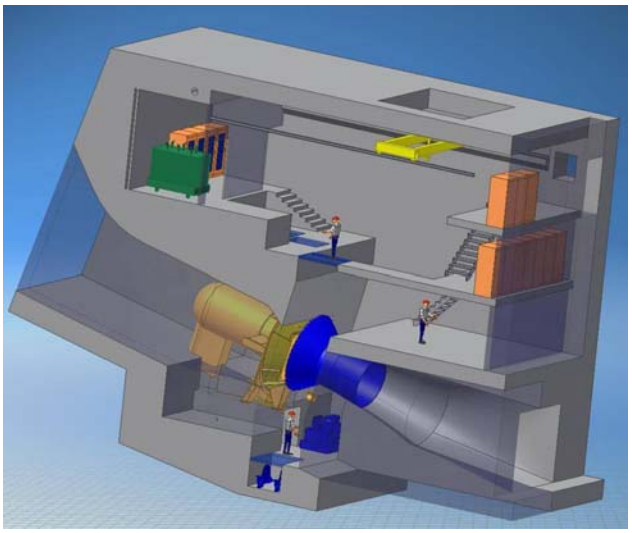
Main Characteristics:

- High speed generator
- Short installation time
- Compact power house structure
- LV (Low Volt) Application of 400 or 690V
- 295 units installed
  (average output 995 kW)

Typical Application Range:

- Head up to 12 m
- Unit discharge up to 46 m³/s
- Output up to 2,600 kW
- Runner diameter 1200 to 2600 mm

3.1.3 Axial Bulb Turbine



Picture 4: Axial Bulb Turbine

Main Characteristics:

- Direct driven synchronous generator
- Horizontal or inclined axis
- Short installation time
- Very low noise level
- MV (Middle Volt) Application of 3,3 kV
- Since 2009 6 Units installed
  (average output 1.67 MW)

Typical Application Range:

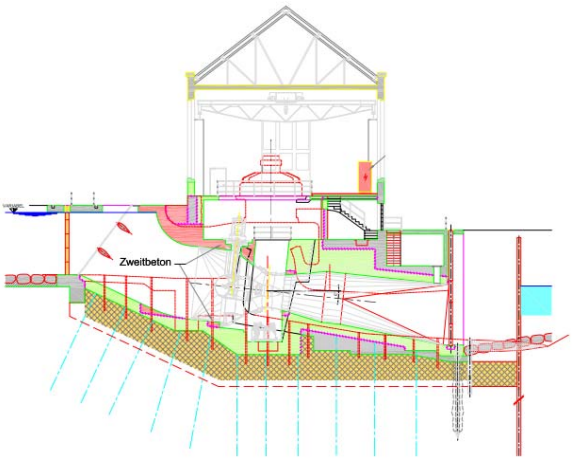
- Head up to 20 m
- Unit discharge 15 to 100 m³/s
- Output up to 5,000 kW
- Runner diameter 1770 to 3650 mm

3.1.4 Project Example 1: Aue Baden, Switzerland

The existing plant was built in 1925. The originally installed vertical Francis turbine shall be refurbished. The main project goals were to replace the aged equipment and to increase the discharge capacity and the power production.

Original equipment:

- Vertical Francis turbine with directly coupled generator (built in 1925)
- 28 m³/sec discharge
- 1.2 MW installed power output



Picture 5: Concept of turbine replacement by BGB2600

Picture 6: Existing powerhouse

Implemented solution for new turbine

- 1 Bevel Gear Bulb turbine, runner diameter 2,600 mm with 2.28 MW installed power output
- Flow rate shall be increased up to 45 m³/sec
- Gross head 5.77 m

Customer criteria for selection of COMPACT HYDRO solution:

- Increase the overall efficiency (wide discharge range) by applying double regulated turbine concept
- Implement low cost solution with a high speed standardized generator
- Keep the existing civil structure as far as possible

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