**DATI TECNICI IMPIANTI**

The purposed hydropower system consists of two modules. The upper one comprises the reservoir A with its relative power station, while the lower one considers the reservoir B with its relative power station. The upper reservoir has a maximum capacity of 12.2 Mm3, while the lower one has a maximum capacity of 3.7 Mm3. The regulation volume for both reservoirs is between the 20% of the maximum volume and its maximum one.

The upper power station is equipped with a Pelton turbine with a maximum capacity of 56.44 MW and a discharge of 8.19 m3/s, while the lower power station has another 39 MW Pelton turbine with a maximum water discharge of 13.23 m3/s.

In the upper powerhouse is placed also a pump used to pump the water from the lower reservoir to the upper reservoir. Its maximum power is 41.6 MW with a derivable discharge of 4.05 m3/s.

In Figure 1 is reported the scheme of the hydropower system.

**INFLOW Z1,K [Mm3]**

**MODULE 1  
Upper reservoir and power house**

**1750 m a.s.l.**

**Spillage f1,K [m3/s]**

**RESERVOIR VOLUME V1,K [Mm3]**

**1722 m a.s.l.**

**Power output p1,K [Mm3]**

**POWER HOUSE 1**

**Power input pp1,K [Mm3]**

**Discharge from turbine q1,K,d [m3/s]**

**Discharge from turbine qp1,K,d [m3/s]**

**INFLOW Z2,K [Mm3]**

**MODULE 2  
Lower reservoir and power house**

**900 m a.s.l.**

**Spillage f2,K [m3/s]**

**MEF b2,K [m3/s]**

**RESERVOIR VOLUME V2,K [Mm3]**

**870 m a.s.l.**

**Discharge from turbine q2,K,d [m3/s]**

**Power output p2,K [Mm3]**

**POWER HOUSE 2**

Reservoir A is the uppermost reservoir and its regulation volume is between 1722 m a.s.l. and 1750 m a.s.l. The bathymetry is shown in Figure 2.

The hydropower plant is placed at 900 m a.s.l., so the maximum head (difference between the maximum water level of reservoir A and the level of the powerhouse) is 872 m.

Reservoir B is placed at a lower height. Its regulation volume is between 870 m a.s.l. and 900 m a.s.l. Bathymetry is reported in Figure 3.

The relative hydropower plant is placed at 520 m a.s.l., so the maximum head is 380 m.

**TURBINES AND PUMP DATA**

For each of the hydraulic machines, the Power [MW], the discharge [m3/s] and the efficiency [%] were given at the maximum head. So, for the upper power house turbine and pump points are reported in Table 1 and Table 2.

The turbine installed in the power house 1 has a minimum power of 5 MW with a relative discharge of 0.98 m3/s and a maximum power of 56.44 MW with a discharge of 8.19 m3/s. Five points were provided and are illustrated in Figure 4.

|  |  |  |
| --- | --- | --- |
| **Turbine 56.44 MW P-Q points (H = 871.875 m)** | | |
| Power P [MW] | Discharge Q [m3/s] | Efficiency [%] |
| 5.00 | 0.98 | 59.7 |
| 44.22 | 6.34 | 81.6 |
| 49.56 | 7.06 | 82.1 |
| 52.31 | 7.51 | 81.4 |
| 56.44 | 8.19 | 80.6 |

Table 1: Data for the 56.44 MW turbine installed in module 1

The pump installed in the power house 1 can works at three different points. The minimum power is set at 38.16 MW with a relative discharge of 3.79 m3/s, while the maximum power is 40 MW with a maximum discharge of 3.95 m3/s. Also in this case points are related to the maximum head of 871.875 m.

|  |  |  |
| --- | --- | --- |
| **Pump 40 MW P-Q points (H = 871.875 m)** | | |
| Power P [MW] | Discharge Q [m3/s] | Efficiency [%] |
| 0 | 0 | - |
| 38.16 | 3.79 | 85 |
| 40.00 | 3.95 | 84.45 |

Table 2: Data for the 40 MW pump installed in module 1

The turbine installed in the power house 2 has a minimum power of 8 MW at a discharge of 3.58 m3/s and a maximum power of 38.92 MW at a discharge of 13.23 m3/s. P-Q points are related to the maximum head of 380 m.

|  |  |  |
| --- | --- | --- |
| **Turbine 38.92 MW P-Q points (H = 380 m)** | | |
| Power P [MW] | Discharge Q [m3/s] | Efficiency [%] |
| 8.00 | 3.58 | 60 |
| 32.25 | 10.72 | 80.7 |
| 34.63 | 11.45 | 81.1 |
| 37.25 | 12.35 | 80.9 |
| 28.92 | 13.23 | 78.9 |

Table 3: Data for the 38.92 MW turbine installed in module 2

**ENVIRONMENTAL CONSTRAINT**

Concerning the lower reservoir, the MEF is required to preserve the ecosystem in the river downstream the dam. Therefore, a constant value of 0.5 m3/s for all the year is set. In the uppermost reservoir, no MEF is required.

|  |  |
| --- | --- |
| **Week** | **Minimum Environmental Flow [m3/s]** |
| 1-52 | 0.5 |

**INFLOWS**

In Figure 7 are reported the inflows of the lower reservoir, recorded for different years. They are expressed in Mm3 and represents the cumulated water for each week. The set of data provided started from 2005 and ended in 2022. Therefore, 18 years of inflows are collected.

With the light blue line are expressed the inflows of the wettest year, while with the yellow line the inflows of the driest one. With the red dotted line the average inflows of the 18 years are represented.

It is possible to observe that for both years (wet and dry) the inflows trend is similar. During the spring period, since the snow is melting, the inflows are higher. In 2014 there is a high peck in autumn due to the high precipitations along that period.

In general, the curves can be divided in four different period:

* First and third periods (winter and summer), when the inflows are lower due to the formation of ice inside the reservoir and the low precipitations respectively.
* Second and third (spring and autumn), when the inflows are higher due to the melting of snow and abundant precipitations respectively.

Since the upper reservoir is located near the lower one the inflows are scaled with a factor of 0.027.

**PRICES**

In Figure 8 are reported the prices recorded for different years. In particular are represented the prices of the 2016, which was the year with the lowest prices, the 2022, which was the year with the highest prices and the average with the red dotted line.

It is possible to observe that for 2022, due to the war in Ukraine which has disrupted exports of Russian gas to Europe. In Italy gas is the main driver of the electricity prices.

In general, it is possible to observe that, not only for inflows but also for prices the curves are divided into four zones:

* First and third periods (winter and summer) where the electricity prices are higher due to the use of air conditioners and heaters.
* Second and third periods (spring and autumn) where the electricity prices are lower due to the medium temperatures