Production of electricity

Arthur Guillot - Le Goff

Autumn semester 2021-2022 | Hydroelectric power

In this exercise we will calculate our yearly electricity production in kW.h and the total price of sold electricity.

Our input data for this exercise

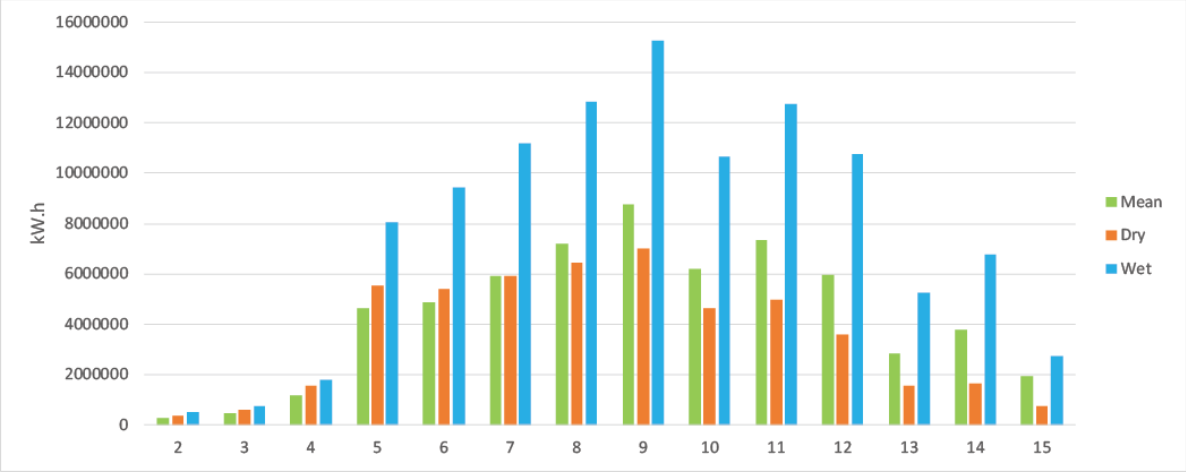
- $Q = 71$, the discharge [$m^3.s^{-1}$];
- $H = 71$, the height of the dam [m];
- $\Delta H = 10$, the hydraulic head losses in the system [m];
- $c = 0,07$ €/Kw.h, the cost of energy;
- $Qb = 40$, the base flow downstream of tailwater [$m^3.s^{-1}$];
- $R_{hmax} = 525,75$, the reservoir maximum level [m.asl];
- $R_{Vmax} = 7785$, the reservoir maximum level [m^3];
- $T_{hmin} = 452,25$, the tailwater minimum level [m.asl];
- $T_{Vmin} = 1556$, the tailwater minimum volume [m^3].

Calculation

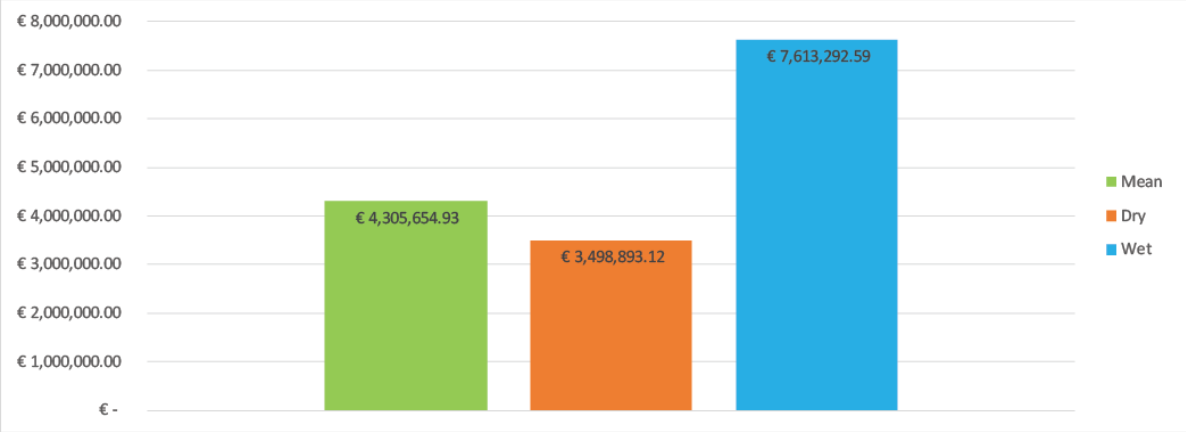
Flow duration curve				Head reservoir				Tail raservoir				Electricity production						
/	Flow [m3/s]	Duration [%]	Days	Daily volume [1000 m3]	Reservoir volume [1000 m3]	Lowest level of the reservoir [m asl]	Mean level of the reservoir [m asl]	Daily volume [1000 m3]	Tail volume [1000 m3]	Highest level [m asl]	Mean level [m asl]	Gross head [m]	Net head [m]	Power [kW]	Days of operation	Daily production [kWh]	Total production [kWh]	Total price of sold electricity [€]
1	1.6	100	365.00	135	7650	524.57	524.66	133	1689	450.64	451.94	72.71	62.71	37,784	9.13	20,435		
2	3.6	97.5	355.88	295	7490	524.30	524.52	283	1839	451.08	452.17	72.36	62.36	37,570	9.13	45,719	301,827	21,127.88 €
3	4.5	95	346.75	364	7421	524.18	524.47	345	1901	451.26	452.26	72.21	62.21	37,481	18.25	57,013	468,713	32,809.91 €
4	5.8	90	328.50	460	7325	524.03	524.39	428	1984	451.51	452.38	72.01	62.01	37,360	54.75	73,247	1,188,626	83,203.82 €
5	7.7	75	273.75	593	7192	523.82	524.28	537	2093	451.83	452.54	71.75	61.75	37,201	45.63	96,827	4,655,799	325,905.95 €
6	9.4	62.5	228.13	705	7080	523.65	524.20	621	2177	452.07	452.66	71.54	61.54	37,075	45.63	117,804	4,896,283	342,739.81 €
7	11.4	50	182.50	827	6958	523.46	524.11	704	2260	452.32	452.78	71.32	61.32	36,946	45.63	142,371	5,935,255	415,467.88 €
8	13.9	37.5	136.88	966	6819	523.26	524.00	784	2340	452.55	452.90	71.10	61.10	36,813	45.63	172,971	7,193,752	503,562.65 €
9	17	25	91.25	1117	6668	523.04	523.89	845	2401	452.73	452.99	70.90	60.90	36,693	27.38	210,855	8,756,034	612,922.41 €
10	19.5	17.5	63.88	1222	6563	522.88	523.82	863	2419	452.78	453.02	70.80	60.80	36,631	27.38	241,452	6,190,955	433,366.83 €
11	23.8	10	36.50	1367	6418	522.68	523.71	833	2389	452.69	452.97	70.74	60.74	36,595	18.25	294,410	7,334,617	513,423.20 €
12	29.2	5	18.25	1485	6300	522.51	523.63	681	2237	452.25	452.75	70.88	60.88	36,678	7.30	362,032	5,990,037	419,302.56 €
13	33.8	3	10.95	1530	6255	522.44	523.60	453	2009	451.58	452.41	71.18	61.18	36,861	7.30	421,154	2,858,631	200,104.15 €
14	49.1	1	3.65	1309	6476	522.76	523.75	0	1556	450.25	451.75	72.01	62.01	37,357	2.56	620,019	3,800,282	266,019.76 €
15	70	0.3	1.10	85	7700	524.65	524.70	0	1556	450.25	451.75	72.95	62.95	37,927	1.10	897,433	1,938,545	135,698.13 €
																total :	61,509,356	4,305,654.93 €

- $R_{DailyVolume} = (Q - Flow) * \frac{Flow.24.3,6}{Q}$, [$m^3$];
- $R_V = R_{Vmax} - R_{DailyVolume}$, the reservoir volume [$m^3$];
- $R_{hlow} = 501,8595 + 0,007054 * R_V - 9,04456 * 10^-7 * R_V^2 + 4,84154 * 10^-11 * R_V^3$, the lowest level of the reservoir [m.asl];
- $R_{hmean} = \frac{R_{hlow} + R_{hmax}}{2}$, the mean level of the reservoir [m.asl];
- $T_{DailyVolume} = (Qb - Flow) * \frac{Flow.24.3,6}{Qb}$, [$m^3$];
- $T_V = T_{Vmin} + T_{DailyVolume}$, the tail volume [$m^3$];
- $T_{h,high} = 0,00293595798661 * T_V + 516,681207587491 - H$, the highest level of the tailwater [m.asl];
- $T_{hmean} = \frac{T_{h,high} + T_{hmin}}{2}$, the mean level of the tail [m.asl];
- $GrossHead = R_{hmean} - T_{hmean}$, [m];
- $NetHead = GrossHead - \Delta H$, [m];
- $Power = 9,81 * NetHead * Q * \mu$, [kW];
- $DailyProduction = \frac{Power * Flow * 24}{Q}$, [kW.h];
- $TotalProduction(t) = \frac{[DailyProduction(t-1) + DailyProduction(t)] * DaysOfOpertation}{2}$, [kW.h];
- $TotalPrice = TotalProduction * 0,07$, [€]

Graph comparison



Comparison of energy production for the 3 scenarios



Total price of sold electricity